Shannon Catchment-based Flood Risk Assessment and Management (CFRAM) Study

Preliminary Options Report
Unit of Management 24

Option Appraisal

Final Report

July 2016

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Contents

Appendix C7 Option Appraisal Report - Dromcolliher

Appendix C8 Option Appraisal Report - Kilmallock

Appendix C9 Option Appraisal Report - Tarbert

Appendix C10 Option Appraisal Report - Clarina

Appendix C11 Option Appraisal Report - Charleville

Appendix C12 Option Appraisal Report - Milford

Appendix C13 Option Appraisal Report - Ballylongford

Appendix D Economic Damage & Benefit Calculation and Cost Benefit Analysis

Appendix E Option Development Meeting - Minutes

Appendix F MCA objectives and Scoring Methodology

Appendix G Freeboard

Appendix H Cost Database

Appendix I Flood Defence Asset Failure Maps

Appendix J Relevant OPW Guidance Notes

Appendix M Economic Sensitivity Analysis

Abbreviations

A full glossary explaining abbreviations frequently used in the CFRAM Programme and more widely in flood risk management is provided in Appendix A. Set out below are abbreviations used herein.

AEP	Annual Exceedance Probability (expressed as a percentage)
AFA	Area for Further Assessment
APMR	Areas of Potential Moderate Risk
CFRAM	Catchment Flood Risk Assessment and Management
EU	European Union
FRM	Flood Risk Management
FRMP	Flood Risk Management Plan
GIS	Geographic Information System
IRR	Individual Risk Receptors
OPW	The Office of Public Works
RBD	River Basin District
SI	Statutory Instrument (SI No. 122 of 2010)
SOP	Standard of Protection
SSA	Spatial Scale of Assessment
UoM	Unit of Management
WFD	Water Framework Directive

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1 Introduction

1.1 Shannon CFRAM Study Area

The Shannon (the "Study Area") is the largest River Basin District (RBD) in Ireland, covering approximately 17,800km^2 and more than 20% of the island of Ireland. The RBD includes the entire catchment of the River Shannon and its estuary as well as some catchments in North Kerry and West Clare that discharge directly to the Atlantic.

The Shannon River rises in the Cuilcagh Mountains, at a location known as the Shannon Pot in the counties of Cavan and Fermanagh. The river flows in a southerly direction before turning west and discharging through the Shannon Estuary to the Atlantic Ocean between counties Clare and Limerick. Whilst the River Shannon is 260km long from its source to the head of the Shannon Estuary in Limerick City, over its course the river falls less than 200m in elevation. The Shannon RBD is characterised as an 'International RBD' as it extends into Northern Ireland. However, there are no areas identified as being at significant flood risk in the Shannon RBD within Northern Ireland, and no significant cross-border issues.

Significant tributaries of the Shannon include the Inny, Suck, and Brosna. There are several lakes in the RBD, including Lough Ree, Lough Derg, and Lough Allen.

Other important rivers within the RBD include the Maigue, Deel and Feale discharging into the Shannon Estuary from the south, and the Fergus, Owenogarney (or Ratty) and Cloon discharging into the estuary from the north.

The RBD includes parts of 17 counties: Limerick, Clare, Tipperary, Offaly, Westmeath, Longford, Roscommon, Kerry, Galway, Leitrim, Cavan, Sligo, Mayo, Cork, Laois, Meath, and Fermanagh. While much of the settlement in the RBD is rural, there are six significant urban centres within the RBD - Limerick City, Ennis, Tralee, Mullingar, Athlone, and Tullamore.

The RBDs that were defined under the Water Framework Directive (WFD) were further divided into a number of Units of Management (UoM) for the purposes of the National CFRAM Programme. The UoMs constitute major catchments or river basins (typically greater than 1000km2) and their associated coastal areas, or conglomerations of smaller river basins and their associated coastal areas. The Shannon RBD (and by definition the Shannon CFRAM Study Area) and the UoM within the Shannon RBD are shown in Figure 1.1. There are six hydrometric areas in total, these hydrometric areas have been grouped together to form four UoMs, as follows;

- Tralee Bay – Feale (Hydrometric Area 23 – 'HA23') – UoM 23;
- Shannon Estuary South - (Hydrometric Area 24 – 'HA24') – UoM 24;
- Shannon Upper and Lower (Hydrometric Area 25 & 26 – 'HA25 & 26') – UoM 25/26;
- Shannon Estuary North and Mal Bay (Hydrometric Area 27& 28 – 'HA27 & 28') – UoM 27/28

1.2 Preliminary Options Report Scope

The specification for the Preliminary Options Report is set out in Section 1 of the Catchment – based Flood Risk Assessment and Management (CFRAM) Studies Stage 1 Project Brief (June 2010) and elements of Sections 2.25 to 2.27 of the Shannon CFRAM Study Stage II Project Brief (October 2010). There are four Preliminary Options Reports for the Shannon CFRAM Study Area, one for each UoM in which at least one fluvial hydraulic model or coastal flooding model exists.

1.2.1 AFAs for different SSAs

The development of flood risk management options has been carried out at four Spatial Scales of Assessments (SSAs). The four SSAs are;

- The UoM
- Each sub-catchment (SUB) or coastal area within the UoM
- AFAs
- IRRs

The Shannon CFRAM Study Area is comprised of six UoMs. Table 1.1 and figure 2.1 provides a summary of UoM 24, with a complete list of the associated SSA's considered.

Table 1.1 List of SSA by UoM

UoM	SSA level	AFA/IRR names	Fluvial (F) or Coastal (C) models
UoM 24	UoM	UoM 24	F / C
	SUB	Deel Sub Catchment	F / C
	SUB	Maigue Sub Catchment	F / C
	SUB	Ballyline	F / C
	SUB	Foynes	F / C
	SUB	Tarbert	C
	AFA	Newcastle West	F
	AFA	Askeaton	F / C
	AFA	Rathkeale	F
	AFA	Foynes	F / C
	AFA	Adare	F / C
	AFA	Croom	F
	AFA	Dromcolliher	F
	AFA	Kilmallock	F
	IRR	Tarbert	C
	AFA	Clarina	F / C
	AFA	Charleville	F
	AFA	Milford	F
	AFA	Ballylongford	F / C

1.3 Structure of this Report

1.3.1 Overview of Report

The Preliminary Options Report sets out the work and analysis undertaken in the development of flood risk management options for all the Spatial Scales of Assessment (SSA) within Unit of Management (UoM) 24.

1.3.2 Report Structure

This report, excluding appendices, is structured to reflect the specific reporting requirements of the CFRAM Studies Project Brief as follows:

Section 1 Provides an introduction to the Preliminary Options Report and sets the context and scope of this activity within the Shannon RBD.

Section 2 Provides an overview of the study area and the history of flooding.

Section 3 Describes, in general terms, the approach taken in to development of the flood risk management measures and the options assessment process.

Section 4 Describes the options appraisal results.

Section 5 Presents the preferred options, prioritisation, and other recommendations for the flood risk management plan.

1.3.3 Report Appendices

A series of appendices to this POR 'Option Assessment' report are relevant to summarising our adopted optioneering approach. These are:

Appendix A Glossary of Terms

Appendix B Flood Risk Management Definitions and the general methodology of how these measures are appraised.

Appendices C Detailed description of the work and analysis carried out in the development of the flood risk management options for each AFA/IRR.

Appendix D Detailed description the Economic Damage and Benefit Calculations and the Cost Benefit Analysis methodology

Appendix E Minutes from the option development meeting with the relevant Stakeholders

Appendix F MCA objectives and scoring methodology.

Appendix G This Appendix provides a detailed assessment of the freeboard allowances adopted in the outline design of embankments and flood walls for this study.

Appendix H CFRAM Unit Cost Development Project Final Report – Outlines the methodology used in determining the PV costs for the options.

Appendix I Flood defence asset failure maps

Appendix J Relevant Guidance Notes produced by the OPW which are referenced in this process.

Appendix M Economic Sensitivity Analysis

Appendices C provide specific information for each respective AFA. This enables different stakeholders to easily identify the AFAs that may be of interest, allowing them to view the **relevant Appendix section**. Table 1.2 summarises the Appendix section reference for each AFA within UoM 24.

Table 1.2 Summary of Appendices C

Appendix Section	AFA	County
Appendix C1	Newcastle West	Limerick
Appendix C2	Askeaton	Limerick
Appendix C3	Rathkeale	Limerick
Appendix C4	Foynes	Limerick
Appendix C5	Adare	Limerick
Appendix C6	Croom	Limerick
Appendix C7	Dromcolliher	Limerick
Appendix C8	Kilmallock	Limerick
Appendix C9	Tarbert	Kerry
Appendix C10	Clarina	Limerick
Appendix C11	Charleville	Cork
Appendix C12	Milford	Cork
Appendix C13	Ballylongford	Kerry

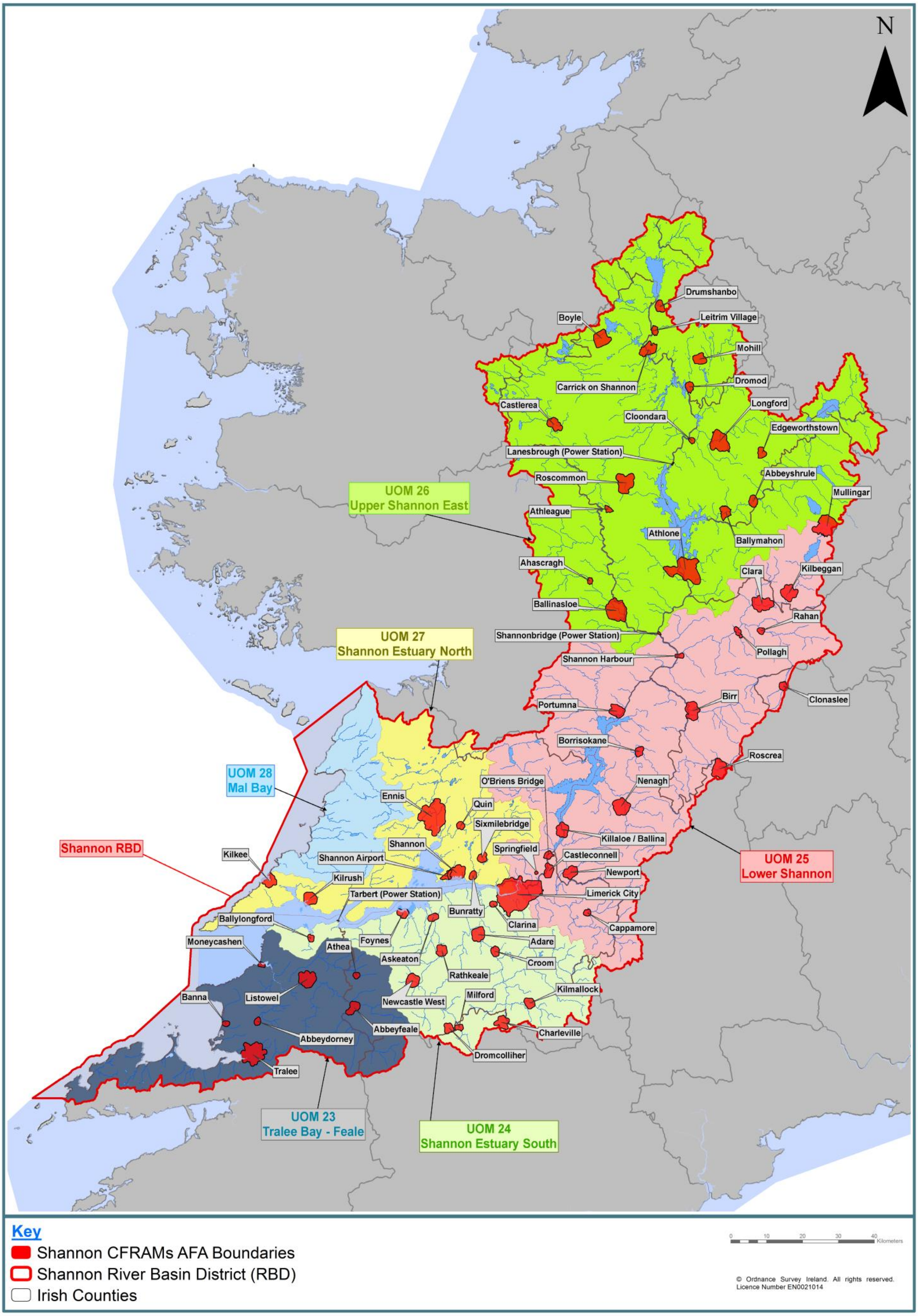


Figure 1.1 Shannon RBD and its Units of Management

2 Report Study Area and Data Collected

2.1 UoM Study Area

The Shannon Estuary South Unit of Management (UoM) 24 is shown in its wider context within the Shannon RBD in Figure 1.1, and in more detail in Figure 2.1. It encompasses areas of four counties; Kerry, Limerick, Cork and Tipperary. It consists of a fertile limestone plain, known as the 'Golden Vale' bounded on the north by the Shannon Estuary and on the west, south and east by the Mullaghareirk Mountains, Ballyhoura Mountains, Galtee Mountains and Slieve Felim Mountains. The total area of UoM 24 is approximately 2000 km^2.

The unit of management is dominated by two main river catchments, the River Deel and the River Maigue, which together cover 65% of the unit of management. The coastline extends along the Shannon Estuary from the outskirts of Limerick City in the east to where it meets the Atlantic Ocean between Loop Head (County Clare) and Kerry Head (County Kerry), west of this unit of management.

The River Deel rises in the Mullaghareirk Mountains near Dromina. It flows roughly in the north-westerly direction though the mountains, where it is joined by numerous tributaries, including the Finglasha River and the Ahavarragh Stream which drains the lands upstream of Dromcolliher. Downstream of Newcastle West, the River Deel is joined by the rivers Arra, Dooally, and Daar, which drain the steep topography of the Knockanimpaha Mountains which bound the west of the catchment. Downstream of the confluence the River Deel flows northeast, through agricultural plains and roughly follows the direction of the N21 towards and through the centre of Rathkeale. Flowing north from Rathkeale the Deel flows through Askeaton, and on to the Shannon Estuary. Where the River Deel enters the Shannon Estuary, the catchment area is approximately 486.1 km^2.

The River Deel catchment drainage scheme was completed in 1968 and focused on improved drainage for agricultural purposes. Arterial Drainage schemes have historically been undertaken at various locations within the River Maigue and River Deel catchments for agricultural purposes.

East of the River Deel catchment, and bounded to the south by the River Blackwater catchment, lies the River Maigue catchment. The River Maigue drains an area of approximately 806 km^2, from its source in the Ballyhoura Mountains (County Cork) to where it enters the Shannon Estuary approximately 10km north of Adare.

Rising north of Milford in North Cork, the River Maigue flows east to join the River Loobagh approximately 3km north of Charleville, and then flows north through Bruree. Just downstream of Bruree, the River Maigue is joined by the significant tributary of the Morningstar River, which drains a catchment area of approximately 131.9 km^2. Continuing northwards, just upstream of Croom, the River Maigue is joined by the third significant tributary of the River Camogue. From Croom, the River Maigue flows north-west towards Adare where the River Maigue becomes tidally influenced.

Table 2.1 below indicates the main sub-catchments and watercourses modelled in this unit of management. As already mentioned, the main sub-catchments consist primarily of the River Deel and the River Maigue catchment to the Shannon estuary. All outstanding catchments are classified as 'Other'. In accordance with the scope,

the Ballinacura catchment, which includes Limerick, has been included within the Shannon Upper and Lower Unit of Management UoM 25/26.

Table 2.1 AFAs and Hydrological Catchments

AFA	Sub-catchment	County
Newcastle West	Deel	Limerick
Askeaton	Deel	Limerick
Rathkeale	Deel	Limerick
Foynes	Other	Limerick
Adare	Maigue	Limerick
Croom	Maigue	Limerick
Dromcolliher	Deel	Limerick
Kilmallock	Maigue	Limerick
Tarbert	Other	Kerry
Clarina	Maigue	Limerick
Charleville	Maigue	Cork
Milford	Deel	Cork
Ballylongford	Other	Kerry

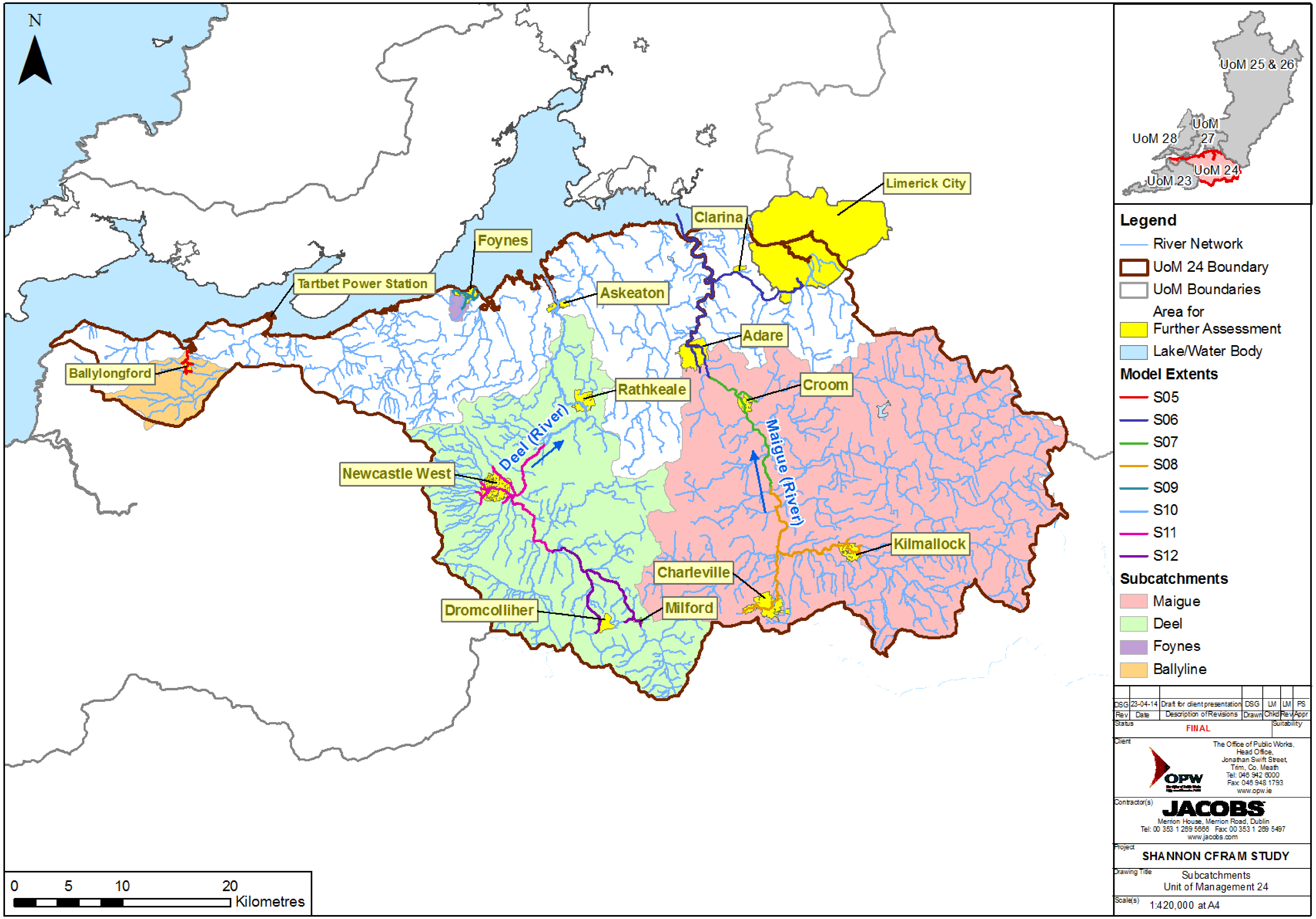


Figure 2.1 UoM 24 Sub-catchments

2.2 History of Flooding

Flood records were studied as part of the Inception Study to determine a flood history for the sub-catchments making up UoM 24. The findings are summarised below.

2.2.1 Maigue Catchment

In the Maigue catchment, flooding has been recorded in Adare, Croom, and Clarina AFAs. The sources of flooding appeared to be a mixture of fluvial and coastal flooding. The historical flooding event record in this catchment goes back to 1946, with the latest flood recorded in February 2002.

Adare AFA

There are reports of major floods occurring in the AFA as far back as August 1946. Other events of flooding occurring in the AFA include January 1995, February 1996, January 1999, and in February 2002.

Clarina AFA

On 15 September 1992 an area called Corcamore to the south west of Clarina, close to the mouth of the River Maigue, was flooded.

Croom AFA

Flooding affecting various part of the Limerick County occurred on 5 and 6 August 1986. One of those areas was Croom. This flooding event coincided with the storm Hurricane Charley, a major meteorological event that occurred across Ireland in August 1986.

The data obtained from the floodmaps.ie website indicated that areas of Adare and Croom were flooded on 1 December 1973. This flood event was identified as a Major Weather Event by Met Éireann on their website www.met.ie.

In January 1995, areas including Croom were recorded to have flooded. It was reported that a high tide in combination with low barometric pressure caused this flood.

Charleville AFA

No records of flooding within the AFA

Milford AFA

No records of flooding within the AFA

Kilmallock AFA

No records of flooding within the AFA

2.2.2 Deel Catchment

Different areas of the catchment have been affected by different events. Major events are known to have occurred in the Deel catchment that affected Askeaton,

Dromcolliher, Newcastle West, and Rathkeale AFAs in the winter of 1968, August 1997 and August 2008. The 1968 winter flood affected the Rathkeale area. In August 1997, Dromcolliher was flooded. Heavy rainfall and flooding affected many parts of Ireland in the summer of 2008. One of the areas known to have been affected by this event in the Deel catchment was Newcastle West.

2.2.3 Foynes and Ballylongford

Both Ballyline and Foynes catchments are within the Shannon tidal extent. They were both affected by the February 2002 event, reportedly caused by high tides, low pressure, and strong south-westerly winds.

Other minor flooding was documented in Ballylongford AFA in October 1927, October 1961, August 2001, January 2002, March 2002, April 2002, January 2004 and December 2007.

Other flood events in Foynes occurred in January 1995, February 1995, January 2002, and January 2005. These floods were caused by the rainfall runoff combined with inadequate culvert capacity through the main street in Foynes.

2.2.4 IRR Tarbert

There is no record of flooding at the Tarbert Power Station and its immediate surroundings. However, the 1 December 2005 records suggest that the N67 road, which connects Tarbert village to the car ferry, floods at least twice a year.

3 Flood Defence Asset Failure

3.1 Background

Flood Defence Assets are defined as structures or features that were constructed to provide a formal flood defence function (‘formal flood defences’), including those that may be in poor condition, and also those that may have been built for other purposes but would provide a flood defence function (‘informal effective flood defences’). They do not include structures that were not constructed to provide a formal flood defence function and would fail to provide a flood defence function due to structural weakness, porosity or other such reasons (‘informal ineffective flood defences’), such as garden walls or embankments perforated by uncontrolled culverts.

The standard of protection of a flood defence asset refers to the most severe (lowest AEP) of the 8 predefined AEP events that does not overtop the defence / defence group along its length. Therefore, by way of an example, if the 10% AEP is fully contained within the defence, but the 5% AEP overtops the defence / defence group at any point, then the effective standard of protection of the defence can be considered to be the 10% AEP event. The associated AEP is referred to as the Effective Standard of Protection, or SOP of the flood defence asset , see figure 3.1

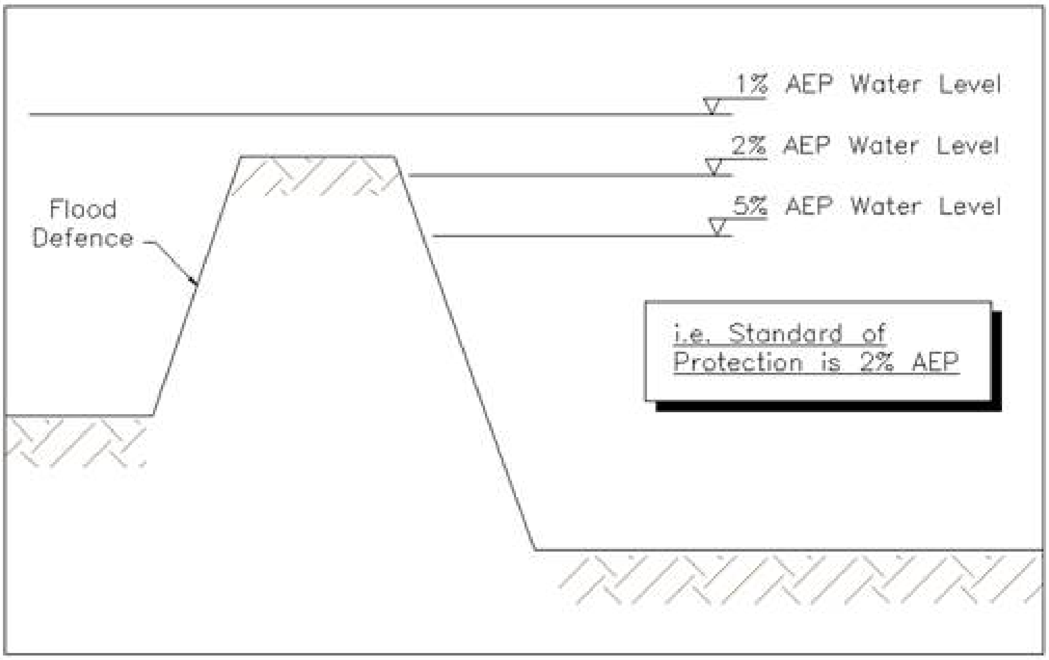


Figure 3.1 - Flood Defence Standard of Protection (SOP)

In the event of a failure of flood defence assets such as the localised breach of an embankment or a wall, areas that would otherwise be defended from flooding during a given event severity might become subject to flooding. Analysis has been carried out to identify the flood hazard and risk (with due consideration for flow velocities, rate of onset of flooding, likely flood volumes and potential flood damage), from the occurrence of failures to flood defence assets.

3.2 Identifying the Potential Failure Locations

There are approximately 400km of flood defences assets within the entire Shannon CFRAM study area. The risk of breach to these varies throughout. To comply with the CFRAM project brief the following was required:

I. Identify effective flood defence assets where flooding within an AFA would occur if the flood defence failed.

II. Identify the most suitable breach location.

The first step in identifying if defence failure analysis is required is to determine if there are there effective defences providing a level of protection to an AFA. Next the ground level adjacent to the defence is assessed based on the CFRAM LiDAR data. If the difference between the maximum water level for the SOP of the defence and the lowest ground elevation on the food plain adjacent to the defences is greater than 1m, defence failure analysis is required. If not no analysis is required. The following process has been applied to identify the need for breach analysis:

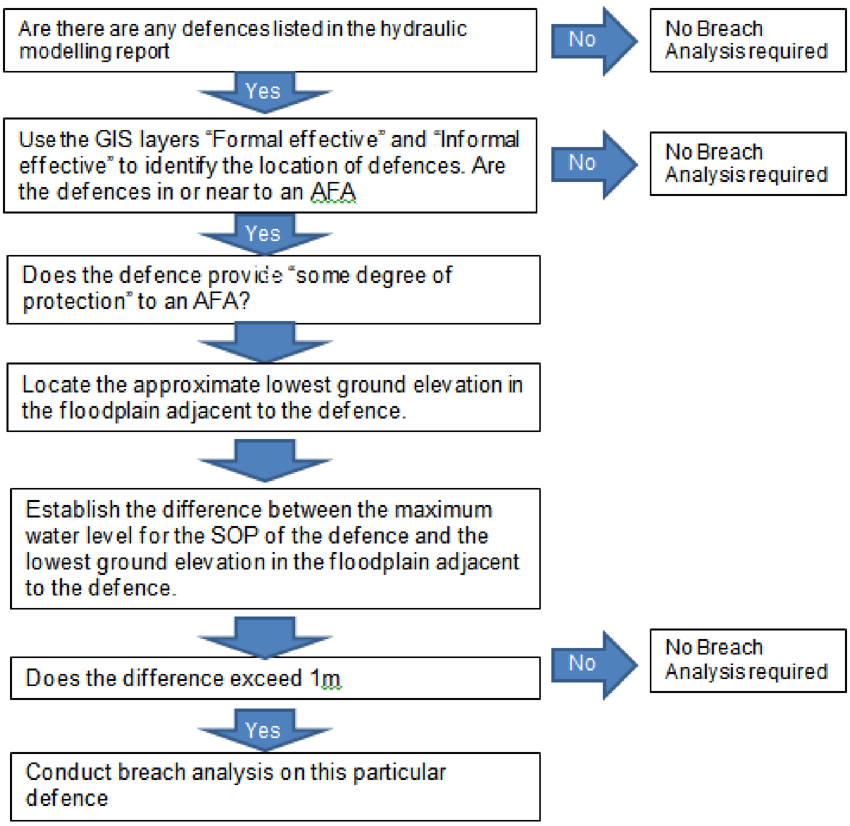


Figure 3.2 - Breach Analysis Flow Chart

Once the need for breach modelling has been established, the next step is to identify the most suitable breach locations. The project brief specified that each fluvial defence requires two breach locations, whereas coastal defences require only one. The following aspects were considered where possible during the selection of the breach location:

- Known problem embankments;
- Areas where failures have previously occurred;

- Current asset condition and rate of deterioration from the asset conditions survey;
- Topographic survey data;
- The lowest ground elevation in the floodplain adjacent to the defence;
- Presence of strategic receptors at risk downstream such as; hospitals, Garda stations, other emergency service stations, care homes, nurseries, schools or areas of high population density relative to the rest of the AFA.
- For coastal embankments, the Irish Coastal Protection Strategy Study (ICPSS) has been used as this identifies sections at risk from erosion in the future

The purpose of the analysis is to identify the hazard and risk from a potential defence failure; therefore, the aim was to select breach locations that would produce the worst possible scenario (i.e. greatest differential between ground level and maximum water level). Furthermore, particular emphasis was placed on vulnerable infrastructure (i.e. hospitals, schools, or areas of high population density) currently protected by flood defences.

3.3 Defence Failure Modelling

Defence failure analysis is carried out for the design event equivalent to the SOP of the defence. The timing of the breach is assumed to commence when at the peak water level of the event. This will result in the greatest head differential and produce the highest velocity rates.

The time it takes for the failure to occur is set to 0.5hrs within the defence failure model. This approach provided a conservative approach, as it promotes a rapid failure.

Analysis is undertaken at two failure scenarios for each of the existing flood defence assets selected for assessment. The scenarios considered depend on the defence and its location. For each defence the two scenarios could be a breach at two different locations on the defence or it could be two breaches at the same location but each of a different width.

3.4 Breach dimensions

The breach height or depth is defined as the distance from the defence crest to minimum elevation through the breach. To be conservative the entire height of the defence is removed (reduced to the same elevation as the adjacent floodplain) and the sides of the breach are assumed to be vertical.

Suitable breach dimensions were determined using the Environment Agency Strategic Flood Risk Assessment (SFRA) Guidance. The breach width is determined on the location and type of embankment as indicated in Table 3.1.

Table 3.1 – Breach Width and Time to Closure

Location	Defence Type	Breach width (m)
Open Coast	Earth embankment	200
	Dunes	100
	Hard	50
Estuary	Earth embankment	50
	Hard	20
Tidal River	Earth embankment	50
	Hard	20
Fluvial River	Earth embankment	40
	Hard	20

3.5 UoM24 Flood Defence Asset Failure

Following the screening process set out in section 3.2, above, the following AFA's/IRR's within UoM 24 were identified as requiring flood defence failure analysis:

- Adare
- Clarina
- Foynes

For each of the AFA's/IRR's two flood defence failure scenarios were carried out. Maximum flood extent, depth, and flow velocity maps have been produced and are reported in Appendix I. The maps also show the defence failure location relevant to the failure scenario.

4 Appraisal Methodology

4.1 Overview of the Option Appraisal Methodology

The Option Appraisal methodology is a multi-staged approach to ensure the over-riding objectives for this phase of the project are achieved, namely:

- Identify appropriate flood risk management measures / options for the different SSAs;
- These measures / options should be robust and form the basis for any future planning stage associated with its implementation; and
- The rejection of any measure / option should be robust with clear and transparent reasoning.

Note; flood risk management measures/options were considered for AFAs to protect properties at risk of flooding from both fluvial and coastal sources. Flood risk management measures/options were not considered for properties at risk of wave overtopping.

To achieve these objectives, a five-stage Option Appraisal methodology has been developed which combines industry standard practices, specialist appraisal software, stakeholder engagement and professional judgement, to ensure a consistent approach to the decision making process.

Figure 4.1 provides the five-stage Option Appraisal process as a flow chart. Each stage comprises a number of sub-stages, with a summary of these provided in Table 4.1 below.

Table 4.1: Option Appraisal Stage and Sub-Stage

Stage	Description	
Stage 1	**Current Flood Risk**	
	Sub-stage 1.1	SSA / AFA and Watercourse Details
	Sub-stage 1.2	Summary of Flood Risk in 1%/0.5% AEP Event
	Sub-stage 1.3	Existing Flood Risk Management Measures
	Sub-stage 1.4	Summary of PV Damages/Potential PV Benefits for 1%/0.5% SOP
	Sub-stage 1.5	Summary of Social receptors at risk of flooding
	Sub-stage 1.6	Summary of Environmental receptors at risk of flooding
	Sub-stage 1.7	Summary of Cultural Heritage receptors at risk of flooding
	Sub-stage 1.8	Summary of Economic receptors at risk of flooding
Stage 2	**Screening of Measures**	
	Sub-stage 2.1	Baseline, Structural Measures and Non-Structural measures – Viability Assessment
	Sub-stage 2.2	Justification Screened Out Baseline, Structural and Non – Structural Measures
	Sub-stage 2.3	Summary of 'Screened In' Measures
Stage 3	**Development of Options**	
	Sub-stage 3.1	Consideration of Options

Stage 4	**Appraisal of Options**	
	Sub-stage 4.1	Options Appraisal
Stage 5	**Multi-Criterial Assessment**	
	Sub-stage 5.1	Summary of MCA results for each option
	Sub-stage 5.2	Comparison of MCA Scores
	Sub-stage 5.3	Recommendation of Preferred Option

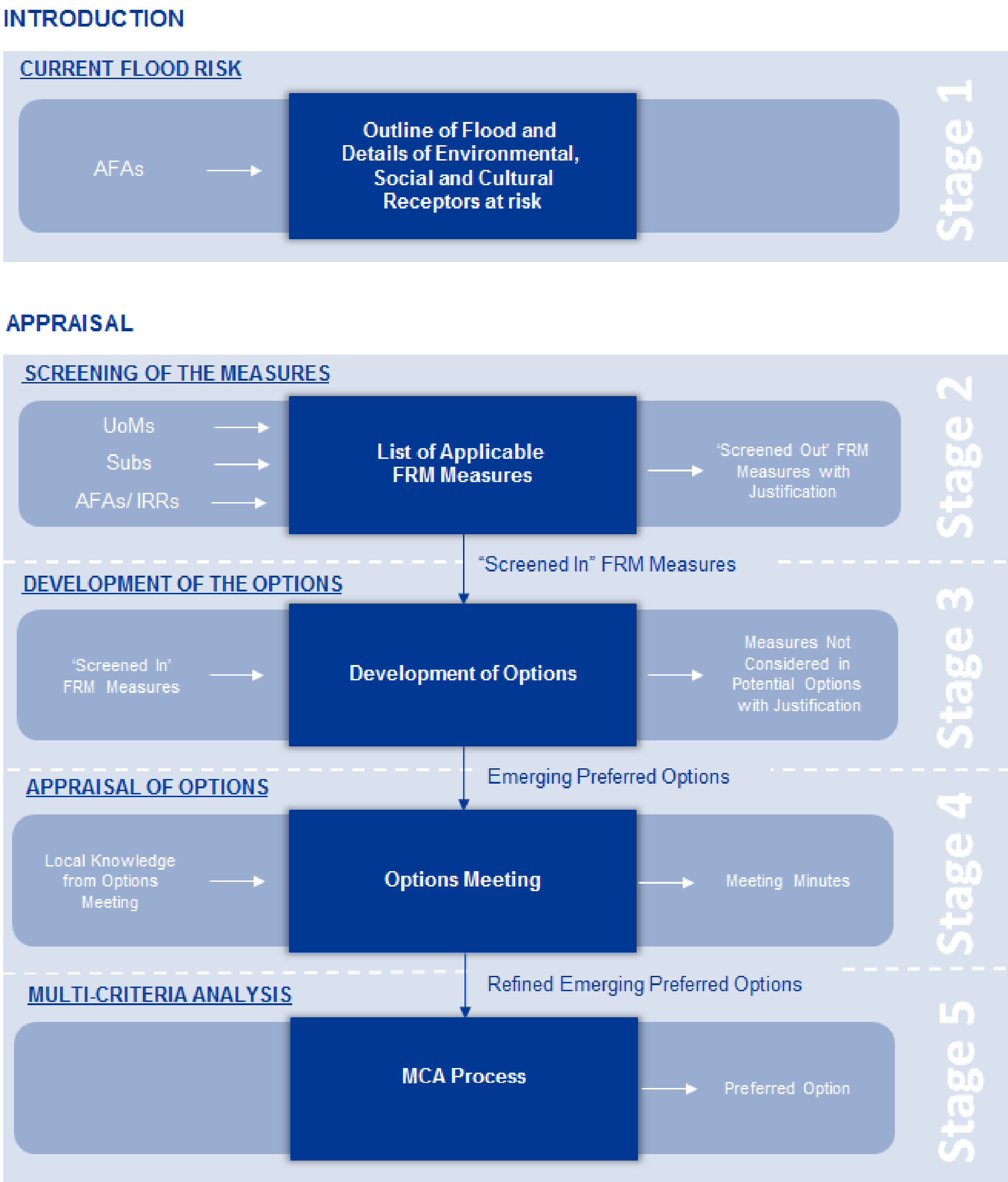
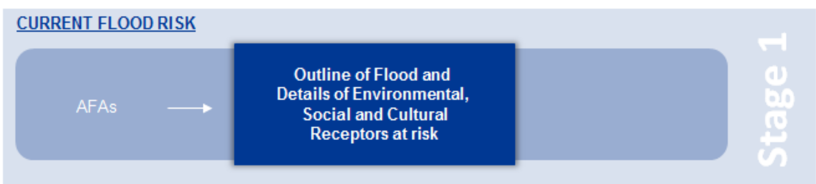


Figure 4.1: Option Appraisal Multi-Stage Process

To record the outcomes from each of these Option Appraisal stages / sub-stages, and ensure consistency in approach, we have developed a standard Option Appraisal Report format. The remainder of Section 3 provides more information on the purpose, method, and assumptions associated with each of the stages / sub-stages.

4.2 Stage 1: Summary of Current Flood Risk & MCA Approach



Relevant Extract from Option Appraisal Flow Chart

The purpose of this Stage 1 is to determine the significance of the flood risk within the SSA, summarise the potential economic damage and the impacts to key receptors.

To achieve these objectives, Stage 1 has been divided into the eight sub-stages, which are summarised in Table 4.2.

Table 4.2: Summary of Sub-stages for Stage 1

Ref	Title
1.1	SSA / AFA and Watercourse Details
1.2	Summary of Flood Risk in 1% AEP Event
1.3	Existing Flood Risk Management Measures
1.4	Summary of PV Damages/Potential PV Benefits for 1% SOP
1.5	Summary of Social receptors at risk of flooding
1.6	Summary of Environmental receptors at risk of flooding
1.7	Summary of Cultural Heritage receptors at risk of flooding
1.8	Summary of Economic receptors at risk of flooding

A Stage 1 assessment has been undertaken for all AFAs. Following this, for those AFAs deemed to have an insignificant flood risk the choice not to proceed through Stages 2 to 5, was available. Appendix C provides information on the Option Appraisal Stages completed for each AFA.

The Option Appraisal Report records the information and decisions from each of these sub-stages; the following sections describe each of the sub-stages individually.

4.2.1 Sub-stage 1.1 SSA / AFA and Watercourse Details

This stage provides summary details of the SSA, the applicable AFAs / IRRs and the associated watercourse details.

4.2.2 Sub-stage 1.2 Summary of Flood Risk

This stage determines the significance of the flood risk by appraising the number of properties at risk in the 1% AEP Fluvial and 0.5% AEP Tidal, along with the number of individual flood cells. Table 4.3 provides a relevant extract from the Option Appraisal Report, for a worked example.

Table 4.3: Option Appraisal Report – Report Section 1.2

1.2 Summary of Flood Risk in 1% Fluvial / 0.5% Coastal AEP Event				
Source of flood risk	Fluvial	Coastal		**Both**
Total Number of Properties at risk in AFA in 1% Fluvial / 0.5% Coastal AEP Event:		**Residential**	**Non-Residential**	**Total**
	Fluvial	85	32	117
	Coastal	82	31	113
	Combined	86	33	119
AFA Flood Cells:	**Total Number:**	3		
	Flood Cell Titles:	ADE_A, ADE_B, ADE_C		
Breakdown of properties at (combined) risk per Flood Cell:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	ADE_A	30	84	114
	ADE_B	0	1	1
	ADE_C	2	2	4
Relevant Comments:	Adare is at risk from both a 1% AEP fluvial and 0.5% coastal flood source.			

Only those properties whose centroid is within the 1% fluvial / 0.5% tidal AEP flood extent, has been counted as 'at risk' in this Option Appraisal Sub-stage 1.2. This is to ensure consistency with the approach to the calculation of the PV Damages.

4.2.3 Sub-stage 1.3 Summary of Existing Flood Risk Management Measures

This stage summarises our understanding of the existing flood management measures within the SSA. This information is available in the collect datasets, including the defence database and the arterial drainage maintenance schemes.

4.2.4 Sub-stage 1.4 Summary of PV Damages

This stage provides the economic, capped and uncapped, Present Value Damages (PVd), including a breakdown between residential and commercial across each flood cell.

The economic PVd is the discounted annual average damages sum. It is calculated using the Flood Hazard Research Centre Handbook of 2010 (FHRC, 2010) and the Multi-Coloured Manual" of 2005 (FHRC, 2005), based on the following:

- Direct damages based on flood depth, duration and property characteristics;
- Intangible damages, infrastructural utility damages and emergency services;
- The economic PVd does not include an allowance for Traffic disruption.

The following are important assumptions in our approach to the calculation of the PVd to ensure compliance with the project objectives:

- The property centroid must lie within the appropriate AEP flood extent to contribute a PVd;
- For residential properties, direct damages (PVd) commence at 0.3m below the property threshold level. This threshold is set at 0.15m above the LiDAR (bare earth) level at the property centroid;

- For non-residential properties, direct damages (PVd) commence at the property threshold level; This threshold is set at the LiDAR (bare earth) level at the property centroid;
- Site visits, including specific property inspections were carried out across all AFAs before adopting this approach to determining threshold level;
- Visual surveys have also been carried out of all non-residential properties contributing more than €500,000 PVd to ensure this property threshold assumption is appropriate. Where inappropriate, the property threshold has been adjusted and noted in the supplied datasets.

PVds were calculated for properties at risk of flooding from both Coastal and Fluvial sources. The PVds for properties at risk of wave overtopping sources was not assessed as part of the CFRAM Study.

Appendix D of this Report provides more detail on the data used, tools developed, and assumptions made in calculating the economic PVd.

The PVd is calculated as the discounted sum of the annual average damages over the project horizon, where:

- The discount rate to be applied is 4%, and
- The project horizon is 50 years

Sensitivity tests were carried out on the PVd using higher and lower discount rates, 5% and 3% respectively. The results of these sensitivity tests are summarised in Appendix M of this Report.

4.2.5 Sub-stage 1.5 Summary of Social receptors at risk of flooding

This stage (Section 1.5) reports the social receptors at risk of flooding within the SSA/AFA. These features may provide constraints to the proposed measures and it is important that the consequences of any recommendations are identified early in the appraisal process.

4.2.6 Sub-stage 1.6 Summary of Environmental receptors at risk of flooding

This stage (Section 1.6) reports the environmental receptors at risk of flooding within the SSA/AFA. These features may provide constraints to the proposed measures and it is important that the consequences of any recommendations are identified early in the appraisal process.

4.2.7 Sub-stage 1.7 Summary of Cultural Heritage receptors at risk of flooding

This stage (Section 1.7) reports the cultural heritage receptors at risk of flooding within the SSA/AFA. These features may provide constraints to the proposed measures and it is important that the consequences of any recommendations are identified early in the appraisal process.

4.2.8 Sub-stage 1.8 Summary of Economic receptors at risk of flooding

This stage (Section 1.8) reports the economic receptors at risk of flooding within the SSA/AFA. These features may provide constraints to the proposed measures and it is important that the consequences of any recommendations are identified early in the appraisal process.

4.3 Stage 2: Screening of the Measures

Relevant Extract from Option Appraisal Flow Chart

The purpose of this Stage 2 is twofold:

- Determine the viability of Baseline, Structural and Non-Structural Flood Risk Management Measures for each SSA / AFA; and
- Provide robust, transparent reasoning for those measures identified as unviable.

To achieve these objectives, Stage 2 has been divided into the three sub-stages, which are summarised in Table 4.4.

In the case where no measures are found to be viable, the MCA process will not be carried out and no further work will be undertaken.

Table 4.4: Summary of Sub-stages for Stage 2

Ref	Title
2.1	Baseline, Structural Measures and Non-Structural measures – Viability Assessment
2.2	Justification Screened Out Baseline, Structural and Non – Structural Measures
2.3	Summary of 'Screened In' Measures

The 'screening' process essentially involves the identification of Flood Risk Management (FRM) measures which are deemed unviable. The FRM Measures which are 'screened out' will not provide applicable, acceptable, or viable measures, either alone or in combination with other measures.

For the UoM and sub-catchment SSA's FRM measures which provide benefits to multiple AFAs/IRRs within the UoM and other areas should be considered, along with the spatial and temporal coherence of methods being considered at AFA/IRR scales. Therefore, certain measures such as "relocation of properties" are not applicable at the UoM and sub-catchment scale.

Table 4.5 is the list of the FRM measures considered for this study and the spatial scale for which they are applicable, categorised into Baseline, Structural, and Non-Structural measures. Appendix B provides a definition for each of the FRM measures and reasoning for their categorisation.

Table 4.5: FRM Measures and applicable SSA

Flood Risk Management Measure		Applicable SSA
Ref	**Title**	
Baseline		
A	Do Nothing	AFA/IRR
B	Existing Regime	AFA/IRR
C	Do Minimum	AFA/IRR
Structural		
D	Storage	All
E	Flow Diversion	All
F	Increase Conveyance	All
G	Construct Flood Defences	All
H	Relocation of Properties	AFA/IRR
I	Other Measures	All
Non Structural		
J	Flood Forecasting / Warning / Response	All
K	Public Awareness	All
L	Individual property resistance	AFA/IRR
M	Individual property resilience	AFA/IRR
N	Planning and development control measures	UoM
O	Building regulations	UoM
P	Sustainable urban drainage systems	AFA/IRR
Q	Land use management	All
R	Strategic development management	UoM
S	Additional Monitoring (rain and river level/flow gauges)	UoM

The FRM measures have been assessed for their potential viability (screening) against the following five assessment criteria:

i. Applicability to the Relevant Area (Appl.)
ii. Economic (Econ.)
iii. Environmental (Envir.)
iv. Social (Soc.)
v. Cultural (Cult.)

The 1% Annual Exceedance Probability (AEP) fluvial event and the 0.5% AEP tidal event are the preferred design standards for this screening assessment. However, other design standards should be considered under certain circumstances and the screening appraisal processes should consider this potential flexibility.

It should be noted from Table 4.5 that whilst measures P and Q are included as measures to be considered, they specifically considered within Report III of the Preliminary Options Report. As such, these measures are excluded from the analysis within this Options Appraisal Report.

The Option Appraisal Report records the information and decisions from each of the Stage 2, sub-stages; the following sections describe each of the sub-stages individually.

4.3.1 Stage 2.1 Baseline, Structural and Non-Structural Measures – Viability Assessment

This stage determines the viability for each of the Baseline and Structural FRM measures, using the 5 assessment criteria:

i. Appl.:
ii. Econ.:
iii. Envir.:
iv. Soc.:
v. Cult.;

If the determination for any of these five criteria is 'unviable', then the FRM measure is 'Screened Out'. Only those FRM measures which are determined 'viable' for all five criteria are 'Screened In' for inclusion in the development of options in Stage 3. Table 4.6 provides a relevant extract from the Option Appraisal Report, for a worked example.

Table 4.6: Option Appraisal Report – Stage 2.1

2.1 Baseline, Structural and Non-Structural Measures							
Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.							
Measures		**Appl.**	**Econ.**	**Envir.**	**Soc.**	**Cult.**	**Overall Viability**
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
B	Existing Regime	Viable	Viable	Viable	Viable	Viable	**Screened In**
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
Structural							
D	Storage	Viable	Viable	Viable	Viable	Viable	**Screened In**
E	Flow Diversion	Viable	Viable	Viable	Viable	Viable	**Screened In**
F	Increase Conveyance	Viable	Viable	Viable	Viable	Viable	**Screened In**
G	Flood Defences	Viable	Viable	Viable	Viable	Viable	**Screened In**
H	Relocation of Properties	Unviable	Viable	Viable	Inviable	Viable	**Screened Out**
I	Other Measures	Unviable	Unviable	Unviable	Unviable	Unviable	**Screened Out**
Non-Structural							
J	Flood Forecasting / Warning / Response	Viable	Viable	Viable	Viable	Viable	**Screened In**
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	**Screened In**
L	Individual Property Resistance	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
M	Individual Property Resilience	Unviable	Viable	Viable	Viable	Viable	**Screened Out**

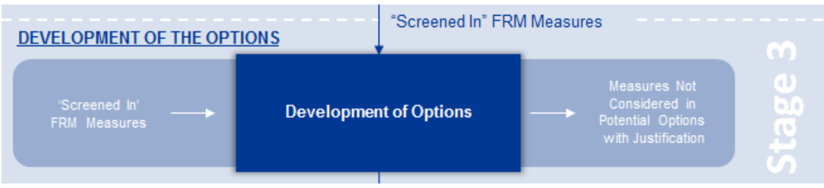
4.3.2 Stage 2.2 Justification for Screened Out Baseline, Structural and Non-Structural Measures

For those Baseline and Structural Measures 'screened out' in Stage 2.1, a robust and transparent reasoning for this conclusion is provided.

4.3.3 Stage 2.3 Summary of 'Screened In' Measures

This stage provides a summary of the Baseline, Structural, and Non Structural FRAM Measures which have been 'Screened in' as viable and have therefore be taken forward and used in Stage 3 – Development of Options.

4.4 Stage 3: Development of the Options



Relevant Extract from Option Appraisal Flow Chart

The purpose of this Stage 3 is to develop the concept designs for the potential FRM Options from the 'screened in' FRM measures.

Structural, Non Structural and Baseline FRM measures are considered both independently and in combination with other measures to develop FRM Options.

For the development of FRM Options, certain structural FRM measures including Storage, Flow Diversion, Increase Conveyance and Construct Flood Defences, are considered with regard to different variations of these measures to ensure applicability to site conditions; refer to Table 4.7.

The concept design of all likely FRM Options are identified and taken forward to Stage 4 – Appraisal of Options.

Table 4.7: Specific Detailed FRM Measures considered at Stage 3

Ref	Title	Ref	Specific Detailed Description
D	Storage	Di	On-line Storage
		Dii	Off-line Storage
		Diii	Other Storage
E	Flow Diversion	Ei	Full Diversion
		Eii	Flood Relief Channel
		Eiii	Other Diversion/Channel
F	Increase Conveyance	Fi	Channel Dredging
		Fii	Channel Widening
		Fiii	Structure Enhancement
G	Construct Flood Defences	Gi	New Flood Defences
		Gii	Raise Existing Flood Defences
		Giii	Rehabilitate or improve Existing Flood Defences
		Giv	Demountable Defences
		Gv	Other Defences

At this concept design phase a general freeboard allowance has been applied to all structural defences. This general allowance is outlined in Table 4.8 below and has

been calculated using the Environment Agency's Fluvial Freeboard Guidance Note, R&D Technical Report W187 (2000). The freeboard calculation is based on two elements, the uncertainties relating to the physical processes that affect the defence and the uncertainty in the prediction of the existing flood risk in terms of the hydrology and hydraulic modelling. Details of how the freeboard has been calculated are contained in Appendix G.

Table 4.8: Freeboard Allowance

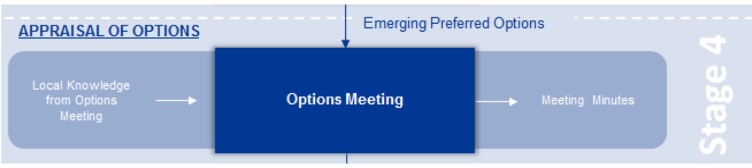
Defence Type	Fluvial	Coastal
Storage	210mm	n/a
Flow Diversion	210mm	n/a
Defences - Wall	210mm	210mm
Defences - Embankments	400mm	900mm

The following approach has been adopted when considering the replacement of existing formal effective flood defences as part of the option development:

- No existing flood defences are recommended for replacement, if their crest height currently provides the required design standard.
- If the crest height of an existing flood defence does not provide the required design standard, then the recommendation is for a new flood defence to be constructed as part of any option

Where existing defence form part of an option a geotechnical analysis of the existing defence should be carried out as part of the detailed design.

4.5 Stage 4: Appraisal of Options



Relevant Extract from Option Appraisal Flow Chart

The purpose of this Stage 4 is twofold:

- Develop each option and to consider its viability and applicability to site;
- Gain local knowledge that may influence the local weightings.

Stage 4.1 provides details of each option considered, including a breakdown of the measures included in the options and specification of any of the structural measures where appropriate.

Modelling of the option, if required, is also carried out at this stage to ascertain if the option is viable technically, and gain an understanding of the impacts on the upstream or downstream water levels.

Table 4.9: Option Appraisal Report – Stage 4.1

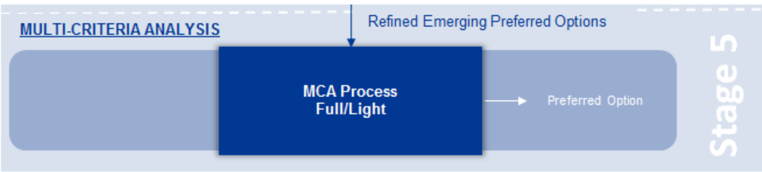
<table>
<tr><th colspan="7">STAGE 4: Appraisal of Options</th></tr>
<tr><td colspan="7">4.1 Options Appraisal
Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Development Meeting. Below describes this concept design of each options and provides a summary of any significant comments/issues which were raised by LA staff at the Options Development Meetings. These comments will be considered in the local weightings and the MCA scores.</td></tr>
<tr><td colspan="2">Option Ref:</td><td colspan="5">ADE_01</td></tr>
<tr><td rowspan="8">Option Measures</td><td>Baseline</td><td>B</td><td colspan="4">Existing Regime</td></tr>
<tr><td rowspan="5">Structural</td><td>Dii</td><td colspan="4">Storage: Offline Storage</td></tr>
<tr><td>Eiii</td><td colspan="4">Flow Diversion: Other Diversion</td></tr>
<tr><td>Fiii</td><td colspan="4">Increase Conveyance: Structure Enhancement / Works</td></tr>
<tr><td>Gi</td><td colspan="4">Flood Defences: New Flood Defences</td></tr>
<tr><td>Giii</td><td colspan="4">Flood Defences: Demountable Defences</td></tr>
<tr><td>Non Structural</td><td colspan="2">J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="5">This option will provide a 1% Fluvial and 0.5% Coastal AEP Design standard to all properties within the AFA, identified as being at risk from both these sources.
Diversion of flow, via a floodway, from River Maigue, upstream of the N21 road bridge, to a natural storage area (see figure 5.1) via an overland floodway. Embankment and weir required at the outfall from the River Maigue to enable flow into the floodway. Floodway to be created by re-profiling the natural ground. Two culverts, one under the N21 and one under the old railway are required.
Natural storage area to be provided as shown in figure 5.1. This storage will be sub-divided into separate storage cells, by new dividing embankments. This maximises storage capacity while minimising impact on agricultural land. Flow from the storage area will naturally return to the River Maigue via flapped outfalls.
Replace the existing footbridge at Adare manor to a single span bridge, as shown in figure 5.1.
The upstream and downstream parapets on the N21 Bridge will need to be replaced to ensure they can provide a flood defence function to the required design standard. They will also need to be tied into the embankments either side, as shown in figure 5.1.
Construct new flood defence walls and embankments as shown in figure 5.1.
A demountable flood gate will be required across the old railway line and should be tied into the new flood defence wall and embankment, as shown in figure 5.1. Flood forecasting will also be required as part of this measure.
Existing arterial drainage maintenance scheme will need to be maintained as part of this option.
</td></tr>
</table>

Options Development Meeting:	Date:	30/09/2015
	Summary:	The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.

Detailed costing of the option is carried out at this stage using the unit cost database spreadsheets (version 1.1) created for the CFRAM project. This database provides unit costs for common method of flood risk management, for a range of conditions and scales. The whole life present value costs (PVc) is determined from the sum of the Present Value costs over the project horizon of 50 years, with the future costs discounted by 4%. The Construction Price Index (CPI) is set at 0.987 for each option, as recommended in the CFRAM Unit Cost Development Project Final Report. This report has been included in Appendix H.

The whole life present value costs (PVc) are subject to sensitivity tests using higher and lower discount rates, 5% and 3% respectively. These are presented in Appendix M of this report.

4.6 Stage 5: Multi Criteria Assessment



Relevant Extract from Option Appraisal Flow Chart

The purpose of this Stage 5 is threefold:

- Obtain MCA and economic scores for each viable option;
- Provide a comparison of the options using the MCA and economic scores;
- Make a recommendation on the preferred option.

To achieve these objectives, Stage 5 has been divided into three sub-stages, which are summarised in Table 4.10.

Table 4.10: Summary of Sub-stages for Stage 5

Ref	Title
5.1	Options selected for the Multi Criteria Assessment
5.2	Comparison of Multi Criteria Assessment Scores
5.3	Recommendation of Preferred Option

The MCA scores the performance of each option in managing flood risk relative to the baseline under the four objectives:

- Technical;
- Economic;
- Social and;
- Environmental.

Each objective has been weighted, globally and locally to reflect the objectives importance and to ensure that those objectives most relevant to the SSA were given priority in the decision making process.

Appendix F provides an outlines of the scoring system under each objective. It also provides details of the global and local weightings applied to each score. The global weights are always set and are consistent with the other CFRAM studies. Some local weighting are set and constant whiles others are calculated or based on engineering judgement. This approach is outlined in further detail in Appendix F.

As outlined in Table 4.10, the Option Appraisal Report records the information and decisions from three sub-stages; the following sections describe each of the sub-stages individually.

4.6.1 Stage 5.1 Options selected for the Multi Criteria Assessment

This stage provides an overview of the options considered for MCA and provides specification details of the structural measures.

The outcome of the MCA includes:

- Criteria Scores for each objective
- Economic Scores
- MCA Scores

A brief outline for these scores is given in Table 4.11. Stage 5.1 of the Option Appraisal Report provides these scores for each option.

Table 4.11 MCA and Economic Analysis outcome

		Ref
Criteria Score		
Technical	Sum of the Technical Sub Objectives Score Range (-299700 to 1500)	GN 28 App F
Economic	Sum of the Economic Sub Objectives Score Range (-299700 to 1500)	GN 28 App F
Social	Sum of the Social Sub Objectives Score Range (-299700 to 1500)	GN 28 App F
Environmental	Sum of the Environmental Sub Objectives Score Range (-299700 to 1500)	GN 28 App F
Economic Score		
PV Cost	Present Value cost (PVc) of the option including ongoing maintenance and optimism bias.	GN 27 App D
Economic PV Benefits	The economic PV Benefits (PVb) are the reduction in the economic damages the option will provide.	GN 27 App D
Economic BCR	The capped PVb, divided by the PVc.	GN 27 App D
Net Present Value of Benefits	The capped PVb less the PVc.	GN 27 App D
MCA Scores		
MCA PV Benefits	The economic MCA PV Benefits are the reduction in the MCA economic damages the option will provide. These values are capped. For more detail refer to section in GN.	GN 27 App D
MCA Benefit Score	The sum of the economic, social, and environmental criteria scores. Range (-899100 to 4500)	GN 28
MCA BCR	The MCA Benefit Score per €1,000,000 PV Cost.	GN 28
Option Selection MCA	The sum of the technical, economic, social, and environmental criteria scores. Range (-1198800 to 6000)	GN 28

4.6.2 Stage 5.2 Comparison of Multi Criteria Assessment Scores

Stage 5.2 of the Option Appraisal Report provides a comparison of the option scores.

Table 4.12 provides a relevant extract from the Option Appraisal Report, for a worked example.

Table 4.12 Option Appraisal Report – Stage 5.2

5.2 Comparison of Multi Criteria Assessment Scores Each option taken forward for further consideration through the Option Development Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).		
Categories	**Option Reference and Results**	
	ADE_01	ADE_02
Criteria Scores		
Technical	1043	350
Economic	765	816
Social	1276	737
Environmental	-507	-69
Economic Values		
Economic PV Benefits	€ 16,070,435	€16,070,435
PV Cost	€ 15,829,922	€ 10,075,466
NPV Benefits	€ 240,513	€ 5994,969
Economic BCR	**1.02**	**1.60**
Outcome Scores		
MCA PV Benefits	€ 7,690,720	€ 7,690,720
MCA Benefit Score	1534	1485
MCA BCR	96.94	147.38
Option Selection MCA	2577	1835

4.6.3 Stage 5.3 Recommendation of the Preferred Option

The MCA scores provided by the MCA assessment are used to guide the decision making process for the preferred option. The MCA BCR has been given the greatest weight in determining the preferred option. The MCA BCR provides a measure of the overall benefits per euro investment.

Whilst the MCA BCR carries the greatest weight, and in general, the preferred option is the option with the highest MCA BCR score, other factors are also taken into account. This is particularly the case when MCA BCR scores are similar, but a comparison of other scores shows a significant difference, for example, a lower capital cost or a higher technical score. These differences are difficult to predict and hence, if the preferred option is selected on criteria other than the MCA BCR score, a clear justification for the recommendation of the preferred option is provided.

5 Option Appraisal Results

Section 5 outlines how the five-stage option appraisal process has been applied in the Spatial Scales of Assessment (SSAs) within UoM 24. UoM 24 comprises the following SSAs, which are outlined in Table 5.1:

- Unit of Management (UoM);
- Sub-catchment;
- Areas for Further Assessment (AFA) and;
- Individual Risk Receptor (IRR).

Table 5.1 SSAs for UoM24.

Spatial Scale			
UoM	**Sub-catchment**	**AFA / IRR**	
UoM 24	Deel	Newcastle West	AFA
		Askeaton	AFA
		Rathkeale	AFA
		Dromcolliher	AFA
		Milford	AFA
	Maigue	Adare	AFA
		Croom	AFA
		Kilmallock	AFA
		Clarina	AFA
		Charleville	AFA
	Foynes	Foynes	AFA
	Tarbert	Tarbert Power Station	IRR
	Ballyline	Ballylongford	AFA

As outlined in Section 4.3, for the UoM and sub-catchment SSAs, FRM measures which provide benefits to multiple AFAs/IRRs are only considered. Therefore, certain measures such as "relocation of properties" which are impractical to implement at this scale, are not considered at the UoM and sub-catchment SSAs.

FRM measures providing benefits to multiple AFAs/IRRs are considered at the sub-catchment SSA while, FRM measures providing benefits to multiple sub-catchments are considered at the UoM SSA.

Table 4.5 outlines the list of the FRM measures considered for this study and the spatial scale for which they are applicable, categorised into Baseline, Structural, and Non-Structural measures. Appendix B provides a definition for each of the FRM measures and reasoning for their categorisation.

The 1% AEP fluvial event and the 0.5% AEP tidal event are the preferred design standards for the development of the FRM options. However, other design

standards have been considered where there is a clear technical, economic, social or environmental case as to why the preferred standards would not be appropriate.

5.1 Option Appraisal Results SSA: UoM 24

As outlined in Section 4.1 the option appraisal methodology is a multi-staged process. Stage 1, summary of the current flood risk for UoM 24, Stage 2, screening of the measures for UoM 24 and Stage 3: Development of Options for UoM 24 are outlined in Sections 5.2.1 to 5.2.3 below.

At the UoM SSA there are no FRM structural measures viable for UoM 24. Although there are viable non-structural FRM measures for UoM 24 at this SSA, Stage 4: Appraisal of Options for UoM 24 and Stage 5: Multi-Criteria Assessment has not been carried out as monetary or measurable benefits cannot be determined for such non-structural FRM measures at this SSA.

5.1.1 Stage 1: Summary of Current Flood Risk

The purpose of Stage 1 is to determine the significance of the flood risk within the UoM 24 and summarise the potential economic damage and the impacts to the key receptors. Stage 1 comprises 8 sub stages;

Stage 1.1: Sub-Catchment and Watercourse Details

Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal & AEP Event Sub-Catchments and Watercourses Details

Stage 1.3: Summary of Existing Flood Risk Management Measures Sub-Catchment and Watercourse Details

Stage 1.4: Summary of PV damages

Stage 1.5: Summary of Social Receptors at Risk of Flooding

Stage 1.6: Summary of Environmental Receptors at Risk of Flooding

Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding

Stage 1.8: Summary of Economic Receptors at Risk of Flooding

Tables 5.2 to 5.9 below outline the results of sub-stages 1.1 to 1.8 for UoM 24. All studied areas within the UoM but outside the AFAs/ IRRs are referred to as areas of potential moderate risk (APMRs). Details of the flood risk to the APMRs are provided at sub-catchment SSA along with summary details of flood risk within the AFAs. For further details of flood risk within each AFA, refer to the relevant Appendix C.

Table 5.2 Stage 1.1: Sub-Catchment and Watercourse Details

Stage 1.1: Sub-Catchment and Watercourse Details	
Sub-Catchments within UoM	Maigue, Deel, Foynes, Ballyline, Tarbert
Primary Watercourse(s):	Maigue (River), Deel (River).

Table 5.3 Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details

Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details					
	Sub-Catchments	**Event Type**	**Res**	**Non-Res**	**Total**
Properties at risk:	**APMR_Maigue**	**Fluvial**	4	4	8
		Coastal	3	3	6
		Combined	7	7	14
	APMR_ Deel	**Fluvial**	2	2	4
		Coastal	18	2	20
		Combined	20	4	24
	APMR_ Foynes	**Fluvial**	0	0	0
		Coastal	0	0	0
		Combined	0	0	0
	APMR_Ballyline	**Fluvial**	2	0	2
		Coastal	2	0	2
		Combined	3	0	3
	APMR_Tarbert	**Fluvial**	0	0	0
		Coastal	0	0	0
		Combined	0	0	0
Properties at risk:	**Within AFAs**	**Fluvial**	218	100	318
		Coastal	305	126	431
		Combined	357	168	525
	Total for UoM	**Fluvial**	242	106	348
		Coastal	312	131	443
		Combined	387	168	566
Relevant Comments:	For AFA level breakdown see specific AFA reports.				

Table 5.4 Stage 1.3: Summary of Existing Flood Risk Management Measures

1.3 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	**Storage**	**Flow Diversion**	**Flood Defences**	**Level Control**	**Other**
Yes	None	None	**Yes**	None	None

Table 5.5 Stage 1.4: Summary of PV damages

Stage 1.4: Summary of PV Damages

Fluvial and coastal damages calculated based on flood depths for all return periods up to the 0.1% AEP. Combined damages are a sum of the fluvial and coastal capped at value of the property.

		Event Type	Capped Res	Capped Non-Res	Capped Total	Uncapped Res	Uncapped Non-Res	Uncapped Total
Total PV Damages	APMR_Maigue	Fluvial	€ 242,126	€ 323,886	€ 566,012	€ 242,126	€ 323,886	€ 566,012
		Coastal	€ 525,288	€ 591,059	€ 1,116,347	€ 564,000	€ 591,059	€ 1,155,059
		Combined	€ 756,829	€ 914,941	€ 1,671,770	€ 806,126	€ 914,945	€ 1,721,071
	APMR_Deel	Fluvial	€ 2,394,265	€ 10,466	€ 2,404,731	€ 5,458,589	€ 10,466	€ 5,469,055
		Coastal	€ 297,263	€ 25,492	€ 322,755	€ 297,263	€ 25,492	€ 322,755
		Combined	€ 2,691,528	€ 35,958	€ 2,727,486	€ 5,755,852	€ 35,958	€ 5,791,810
	APMR_Foynes	Fluvial	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
		Coastal	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
		Combined	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
	APMR_Ballyline	Fluvial	€ 271,009	€ 0	€ 271,009	€ 282,547	€ 0	€ 282,547
		Coastal	€ 306,429	€ 0	€ 306,429	€ 946,552	€ 0	€ 946,552
		Combined	€ 527,636	€ 0	€ 527,636	€ 1,229,099	€ 0	€ 1,229,099
	APMR_Tarbert	Fluvial	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
		Coastal	€ 13,854	€ 0	€ 13,854	€ 13,854	€ 0	€ 13,854
		Combined	€ 13,854	€ 0	€ 13,854	€ 13,854	€ 0	€ 13,854
	Within AFAs	Fluvial	€ 16,526,908	€ 24,374,974	€ 40,901,882	€ 20,186,009	€ 41,105,553	€ 61,291,562
		Coastal	€ 17,926,921	€ 21,159,737	€ 39,086,658	€ 29,628,400	€ 32,621,575	€ 62,249,975
		Combined	€ 31,680,455	€ 41,572,460	€ 73,252,915	€ 49,814,409	€ 73,727,128	€ 123,541,537
	Total for UoM	Fluvial	€ 19,434,308	€ 24,709,326	€ 44,143,634	€ 26,169,271	€ 41,439,905	€ 67,609,176
		Coastal	€ 19,069,755	€ 21,776,288	€ 40,846,043	€ 31,450,069	€ 33,238,126	€ 64,688,195
		Combined	€ 35,670,302	€ 42,523,359	€ 78,193,661	€ 57,619,340	€ 74,678,031	€ 132,297,371

Table 5.6 Stage 1.5: Summary of Social Receptors at Risk of Flooding

Stage 1.5: Summary of Social Receptors at Risk of Flooding			
High Vulnerability Properties at risk :		**Type**	**Number**
	APMR_Maigue	N/A	None
	APMR_Deel	N/A	None
	APMR_Foynes	N/A	None
	APMR_Ballyline	N/A	None
	APMR_Tarbert	N/A	None
	Within AFAs	School	2
		Health Centre	2
	Total for UoM	School	2
		Health Centre	2
Social Infrastructure Assets:		**Type**	**Number**
	APMR_Maigue	N/A	None
	APMR_Deel	N/A	None
	APMR_Foynes	N/A	None
	APMR_Ballyline	N/A	None
	APMR_Tarbert	N/A	None
	Within AFAs	Garda Station	1
		Fire Station	2
		Post Office	1
		Government Office	1
		Church	1
	Total for UoM	Church	1
		Garda Station	1
		Fire Station	2
		Post Office	1
		Government Office	1
Social Amenity Sites:		**Type**	**Number**
	APMR_ Maigue	N/A	None
	APMR_Deel	N/A	None
	APMR_Foynes	N/A	None
	APMR_Ballyline	N/A	None
	APMR_Tarbert	N/A	None

	Within AFAs	Community Centre	3
		Museum	1
		GAA Club / Pitch	2
	Total for UoM	Community Centre	3
		Museum	1
		GAA Club / Pitch	2
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Social		

Table 5.7 Stage 1.6: Summary of Environmental Receptors at Risk of Flooding

Stage 1.6: Summary of Environmental Receptors at Risk of Flooding			
Risk to WFD Annex IV :		**Type**	**Number**
	APMR_ Maigue	WFD Drinking Water	1
	APMR_Deel	WFD Drinking Water	2
	APMR_Foynes	N/A	None
	APMR_Ballyline	N/A	None
	APMR_Tarbert	N/A	None
	Within AFAs	WFD Drinking Water	1
	Total for UoM	WFD Drinking Water	4
Risk to cSACs, SPAs, & SACs :		**Type**	**Number**
	APMR_Maigue	SPA	1
		SAC	1
	APMR_Deel	N/A	None
	APMR_Foynes	N/A	None
	APMR_Ballyline	N/A	None
	APMR_Tarbert	SAC	1
	Within AFAs	SPA	1
		SAC	4
	Total for UoM	SPA	2
		SAC	6
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Environment		

Table 5.8 Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding

Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding			
Risk to Sites of Cultural Heritage:		**Type**	**Number**
	APMR_Maigue	NIAH	12
		Recorded Monuments	6
	APMR_Deel	NIAH	8
		Recorded Monuments	31
	APMR_Foynes	N/A	None
	APMR_Ballyline	Recorded Monuments	2
	APMR_Tarbert	Proposed Natural Heritage Area	1
	Within AFAs	NIAH	64
		Recorded Monuments	21
		Proposed Natural Heritage Area	1
	Total for UoM	NIAH	84
		Recorded Monuments	60
		Proposed Natural Heritage Area	2
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk – Cultural Heritage		

Table 5.9 Stage 1.8: Summary of Economic Receptors at Risk of Flooding

Stage 1.8: Summary of Economic Receptors at Risk of Flooding			
		Type	**Number**
Risk to Transport Infrastructure:	**APMR_Maigue**	Primary Road	3
		Regional Road	4
		Local Road	22
		Residential Road	39
		Railway	1
	APMR_Deel	Primary Road	2
		Regional Road	6
		Local Road	21
		Residential Road	49
		Railway	1
	APMR_Foynes	N/A	None
	APMR_Ballyline	Local Road	4
		Residential Road	3
	APMR_Tarbert	Primary Road	1
	Within AFAs	Primary Road	7
		Regional Road	16
		Local Road	21
		Residential Road	4
		Railway	1
		Port	1
	Total for UoM	Primary Road	13
		Regional Road	26
		Local Road	68
		Residential Road	95
		Railway	3
		Port	1

Risk to Utility Infrastructure:		Type	Number
	APMR_Maigue	N/A	None
	APMR_Deel	Water Treatment Plants	3
	APMR_ Foynes	N/A	None
	APMR_ Ballylongford	N/A	None
	APMR_Tarbert	N/A	None
	Within AFAs	Infrastructure	3
		Water Treatment Plants	1
		Substation	1
	Total for UoM	Infrastructure	3
		Water Treatment Plants	4
		Substation	1
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Economy		

5.1.2 Stage 2: Screening of the Measures UoM 24

The purpose of Stage 2 is to determine the viability of FRM measures for UoM 24 and to provide robust, transparent reasoning for those measures identified as unviable. The is achieved through 3 sub-stages;

Stage 2.1: Screening of the Measures Viability Assessment

Stage 2.2: Justification for Screened Out Baseline and Structural Measures

Stage 2.3: Summary of 'Screened In' Measures

Tables 5.10 to 5.12 below outline the results for each of these sub-stages.

Table 5.10 Stage 2.1: Screening of the Measures Viability Assessment

STAGE 2: Screening of the Measures							
Baseline, Structural and Non-Structural Measures Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.							
Measures		**Appl.**	**Econ.**	**Envir.**	**Soc.**	**Cult.**	**Overall Viability**
Baseline							
A	Do Nothing	Not considered at this SSA refer to Table 4.5					
B	Existing Regime	Not considered at this SSA refer to Table 4.5					
C	Do Minimum	Not considered at this SSA refer to Table 4.5					
Structural							
D	Storage	Unviable	N/A	N/A	N/A	N/A	**Screened Out**
E	Flow Diversion	Unviable	N/A	N/A	N/A	N/A	**Screened Out**
F	Increase Conveyance	Unviable	N/A	N/A	N/A	N/A	**Screened Out**
G	Flood Defences	Unviable	N/A	N/A	N/A	N/A	**Screened Out**
H	Relocation of Properties	Not considered at this SSA refer to Table 4.5					
I	Other Measures	Unviable	N/A	N/A	N/A	N/A	**Screened Out**
Non-Structural							
J	Flood Forecasting / Warning / Response	Viable	Viable	Viable	Viable	Viable	**Screened In**
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	**Screened In**
L	Individual property resistance	Not considered at this SSA refer to Table 4.5					
M	Individual property resilience	Not considered at this SSA refer to Table 4.5					
N	Planning and development control measures	Viable	Viable	Viable	Viable	Viable	**Screened In**
O	Building Regulations	Viable	Viable	Viable	Viable	Viable	**Screened In**
P	Sustainable Urban Drainage Systems	Not considered at this SSA refer to Table 4.5					
Q	Land use Management	Viable	Viable	Viable	Viable	Viable	**Screened In**
R	Strategic development management	Viable	Viable	Viable	Viable	Viable	**Screened In**
S	Additional Monitoring (rain and river level/flow gauges)	Viable	Viable	Viable	Viable	Viable	**Screened In**

Table 5.11 Stage 2.2: Justification for Screened Out Baseline and Structural Measures

Stage 2.2 Justification for Screened Out Baseline and Structural Measures			
The following provides justification on Measures with an overall viability 'Screened Out' categorisation. At this SSA, only measures that will reduce flood risk to multiple sub-catchments within the UoM are considered viable.			
D	Storage	Applicability Economic Environmental Social Cultural	At this SSA, only methods that can provide benefits to multiple sub-catchments within the UoMs should be considered. The sub-catchments within UoM24 are not hydraulically connected, therefore, the storage FRM method will not provide benefits to more than one sub-catchments.
E	Flow Diversion	Applicability Economic Environmental Social Cultural	At this SSA, only methods that can provide benefits to multiple sub-catchments within the UoMs should be considered. The sub-catchments within UoM24 are not hydraulically connected, therefore, the flow diversion FRM method will not provide benefits to more than one sub-catchments.
F	Increase Conveyance	Applicability Economic Environmental Social Cultural	At this SSA, only methods that can provide benefits to multiple sub-catchments within the UoMs should be considered. The sub-catchments within UoM24 are not hydraulically connected, therefore, the increase conveyance FRM method will not provide benefits to more than one sub-catchments.
G	Flood Defences	Applicability Economic Environmental Social Cultural	At this SSA, only methods that can provide benefits to multiple sub-catchments within the UoMs should be considered. The sub-catchments within UoM24 are not hydraulically connected, therefore, the flood defences FRM method will not provide benefits to more than one sub-catchments.
I	Other Measures	Applicability Economic Environmental Social Cultural	There were no other measures considered which would have benefits to all AFAs within the UoM.

Table 5.12 Stage 2.3: Summary of 'Screened In' Measures

Stage 2.3 Summary of 'Screened In' Measures			
The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.			
Non - Structural Measures			
J	Flood Forecasting / Warning / Response	N	Planning and development control measures
K	Public Awareness	O	Building Regulations
R	Strategic development management	S	Additional Monitoring (rain and river level/flow gauges)

5.1.3 Stage 3: Development of Options for UoM 24

The purpose of Stage 3 is to develop FRM options from the 'Screened In Measures'

As there were no viable structural measures for UoM 24 therefore this stage focuses on the development of the Non-Structural FRM measures into options, which is outlined in Table 5.13 below.

Table 5.13 Stage 3: Development of FRM measures to Options

Stage 3: Development of FRM measures to Options		
FRM Measure		Descriptions
J	Flood Forecasting / Warning / Response	A forecasting system combining rain gauge and water levels data could potentially be used to give warning of potential flood events for the UoM. Tidal flood forecasting systems could also be used to provide warning of any coastal flood risk to the areas at risk of flooding from tidal sources. More information about flood forecasting at an AFA level is available in the AFA Option Appraisal Reports in Appendix C.
K	Public Awareness	Regional public awareness campaigns should be considered to provide information to the public of potential measures and actions local residents, business owners and landowners could take to reduce flood risk to their properties and allow them to prepare themselves, their properties, businesses, and land. However, awareness campaigns are better targeted at AFA level, rather than at UoM (or sub-catchment) SSAs.
N	Planning and development control measures	Considered in the Spatial Planning & Impacts to the Development report.
O	Building Regulations	Building Regulations could be applied in the construction of properties in areas of low or residual flood risk, to limit the damage to the properties in a flood event. These regulations would focus on the use of suitable materials and construction details. Guidelines on constructing

		in areas of flood risk are provided in the "Improving the Flood Performance of New Buildings" by the Department for Communities and Local Government, UK. Use of these measures would ensure the buildings are either flood resistant or flood resilient.
Q	Land use Management	Considered in separate report on SUDs and Land Use Management
R	Strategic development management	The proper application of the Guidelines on the Planning System and Flood Risk Management 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. Flood Zones Mapping for the MRFS future scenarios are provided as part of the FRMP and will facilitate the application of the Guidelines.
S	Additional Monitoring (rain and river level/flow gauges)	Across UoM 24, there is a varying degree of certainty on the flood risk assessment, due to the distribution of the catchment gauging stations. It is therefore a recommendation from this Study that additional gauging stations should be considered along watercourses where there is historical evidence of flood risk or properties are identified as being at risk in the 1% fluvial AEP event. Figures 5.1 and table 5.14 identify indicative locations where gauging stations are recommended. These include several locations across the UoM (and in this regard this is a UoM measure), one of which would also have a benefit at a sub-catchment level. It is important to note however that the primary benefit of each gauging station will be for the AFA in which it is located

Recommendations for all the above "Screened In" measures will be made in the Flood Risk Management Plan (FRMP).

As previously noted Stage 4: Appraisal of Options for UoM 24 and Stage 5: Multi-Criteria Assessment has not been carried out, as monetary or measurable benefits cannot be determined for any of the 'Screened In' FRM non-structural measures at this SSA.

Table 5.14 Location of Recommended Gauging Stations

ID	Eastings	Northing
GS01	99656.42	144327.11
GS02	150759.71	153324.61
GS03	161298.00	127727.00
GS04	153525.13	122374.73
GS05	125159.27	151324.31
GS06	125580.62	151028.85
GS07	126186.30	150891.67
GS08	128494.30	133467.70
GS09	141186.00	121415.00

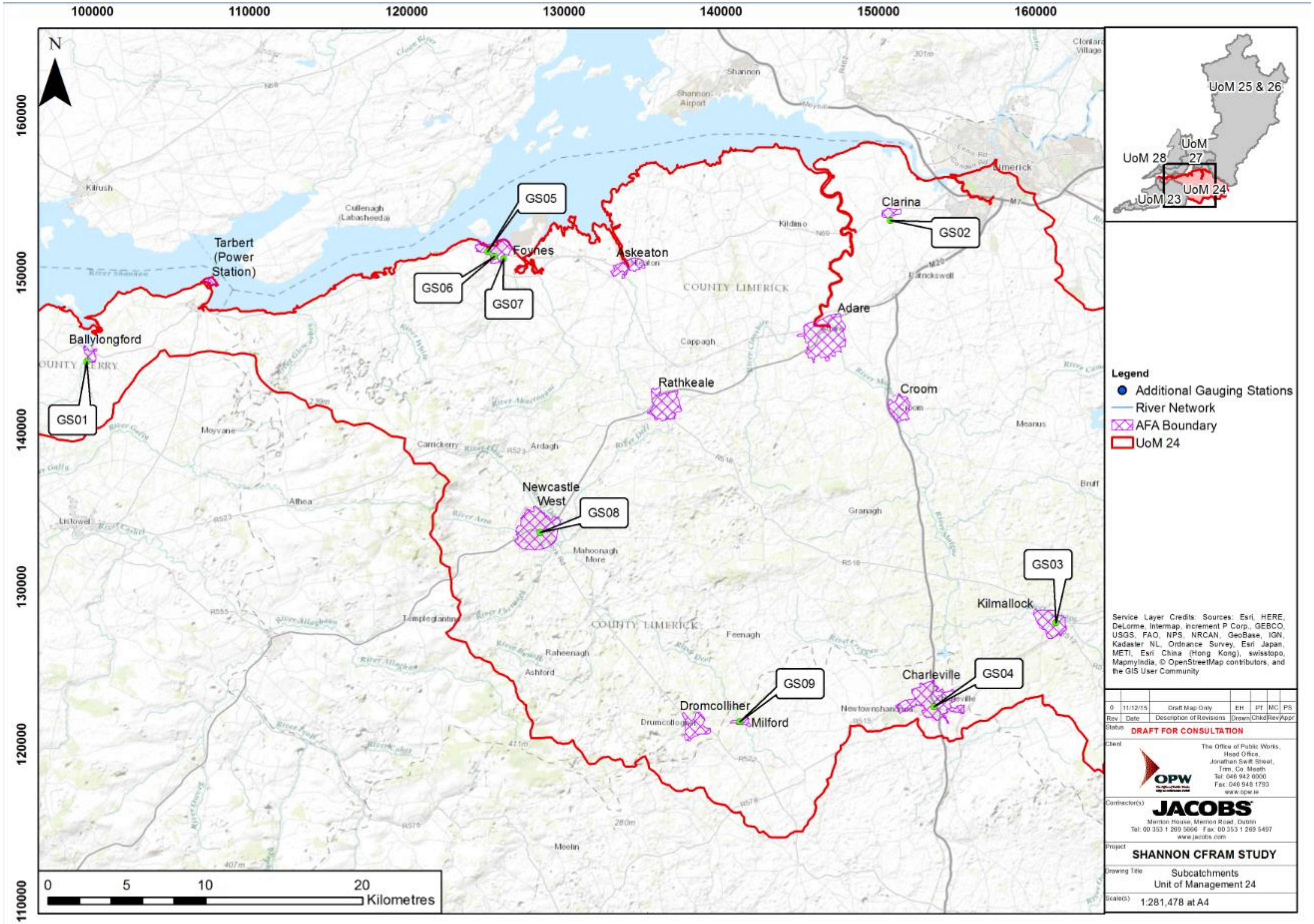


Figure 5.1 –Location of Recommended Gauging Stations

5.2 Option Appraisal Results SSA: Sub-Catchment

As outlined in Section 2.1, UoM 24 comprises 5 sub-catchments. The 5 sub-catchments represent key hydrological/ hydraulic breakpoints within UoM 24 and naturally lend themselves to being split into these sub-catchments for the purposes of assessing FRM options.

The multi-stage option appraisal process, as outlined in Section 4.1, has been applied to each sub-catchment;

- Deel;
- Maigue;
- Foynes;
- Ballyline;
- Tarbert Power Station.

5.2.1 Deel Sub-Catchment

Tables 5.15 to 5.22 below outline the results of sub-stages 1.1 to 1.8 for the Deel Sub-catchment.

5.2.1.1 Stage 1: Summary of Current Flood Risk for Deel Sub-Catchment

Table 5.15 Stage 1.1: Sub-Catchment and Watercourse Details

Stage 1.1: AFA and Watercourse Details	
AFAs	Newcastle West, Askeaton, Rathkeale, Dromcolliher and Milford.
Major Watercourses:	Deel (River), Killeline (River), Knockane (River), Doally (River), Arra (River), Ehernagh (Stream), Daar (River), Deegerty (River), Ahavarragh Stream.

Table 5.16 Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details

Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details					
Properties at risk:		Event Type	Res	Non-Res	Total
	APMR_Deel	Fluvial	18	2	20
		Coastal	2	2	4
		Combined	20	4	24
	Within AFAs	Fluvial	54	43	97
		Coastal	27	11	38
		Combined	57	44	101
	Total for Sub-catchment	Fluvial	72	45	117
		Coastal	29	13	42
		Combined	77	48	125
Relevant Comments:	For AFA level breakdown see specific AFA reports.				

Table 5.17 Stage 1.3: Summary of Existing Flood Risk Management Measures

1.3 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
Yes	None	None	Yes	None	None

Table 5.18 Stage 1.4: Summary of PV damages

Stage 1.4: Summary of PV Damages								
Fluvial and coastal damages calculated based on flood depths for all return periods up to the 0.1% AEP. Combined damages are a sum of the fluvial and coastal capped at value of the property.								
Total PV Damages		Event Type	Capped Residential	Capped Non-Res	Capped Total	Uncapped Residential	Uncapped Non-Res	Uncapped Total
	APMR_Deel	Fluvial	€ 2,394,265	€ 10,466	€ 2,404,731	€ 5,458,589	€ 10,466	€ 5,469,055
		Coastal	€ 297,263	€ 25,492	€ 322,755	€ 297,263	€ 25,492	€ 322,755
		Combined	€ 2,691,528	€ 35,958	€ 2,727,486	€ 5,755,852	€ 35,958	€ 5,791,810
	Within AFAs	Fluvial	€ 2,937,448	€ 14,547,587	€ 17,485,035	€ 4,244,270	€ 28,102,118	€ 32,346,388
		Coastal	€ 1,944,765	€ 2,735,116	€ 4,679,881	€ 4,063,771	€ 7,755,590	€ 11,819,361
		Combined	€ 4,338,125	€ 16,235,960	€ 20,574,085	€ 8,308,041	€ 35,857,708	€ 44,165,749
	Total for Sub-catchment	Fluvial	€ 5,331,713	€ 14,558,053	€ 19,889,766	€ 9,702,859	€ 28,112,584	€ 37,815,443
		Coastal	€ 2,242,028	€ 2,760,608	€ 5,002,636	€ 4,361,034	€ 7,781,082	€ 12,142,116
		Combined	€ 7,029,653	€ 16,271,918	€ 23,301,571	€ 14,063,893	€ 35,893,666	€ 49,957,559
Relevant Comments:		For AFA level breakdown see specific AFA reports.						

Table 5.19 Stage 1.5: Summary of Social Receptors at Risk of Flooding

Stage 1.5: Summary of Social Receptors at Risk of Flooding			
High Vulnerability Properties at risk :		Type	Number
	APMR_Deel	N/A	None
	Within AFAs	N/A	None
	Total for Sub-catchment	N/A	None
Social Infrastructure Assets:		Type	Number
	APMR_Deel	N/A	None
	Within AFAs	N/A	None
	Total for Sub-catchment	N/A	None
Social Amenity Sites:		Type	Number
	APMR_Deel	N/A	None
	Within AFAs	Community Centre	1
	Total for Sub-catchment	Community Centre	1
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Social		

Table 5.20 Stage 1.6: Summary of Environmental Receptors at Risk of Flooding

Stage 1.6: Summary of Environmental Receptors at Risk of Flooding			
Risk to WFD Annex IV :		Type	Number
	APMR_Deel	WFD Drinking Water	2
	Within AFAs	N/A	None
	Total for Sub-catchment	WFD Drinking Water	2
Risk to cSACs, SPAs, & SACs :		Type	Number
	APMR_Deel	N/A	None
	Within AFAs	N/A	None
	Total for Sub-catchment	N/A	None
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Environment		

Table 5.21 Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding

Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding			
Risk to Sites of Cultural Heritage:		**Type**	**Number**
	APMR_Deel	NIAH	8
		Recorded Monuments	31
	Within AFAs	NIAH	16
		Recorded Monuments	5
	Total for Sub-catchment	NIAH	24
		Recorded Monuments	36
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk – Cultural Heritage		

Table 5.22 Stage 1.8: Summary of Economic Receptors at Risk of Flooding

Stage 1.8: Summary of Economic Receptors at Risk of Flooding			
Risk to Transport Infrastructure:		**Type**	**Number**
	APMR_Deel	Primary Road	2
		Regional Road	6
		Local Road	21
		Residential Road	49
		Railway	1
	Within AFAs	Primary Road	3
		Regional Road	9
		Local Road	11
		Residential Road	3
	Total for Sub-catchment	Primary Road	5
		Regional Road	15
		Local Road	32
		Residential Road	52
		Railway	1
Risk to Utility Infrastructure:		**Type**	**Number**
	APMR_Deel	Water Treatment Plants	3
	Within AFAs	Water Treatment Plants	1
		Substation	1

	Total for UoM	Water Treatment Plants	4
		Substation	1
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Economy		

5.2.1.2 Stage 2: Screening of the Measures Deel Sub-catchment

The purpose of Stage 2 is to determine the viability of FRM measures for this sub-catchment and to provide robust, transparent reasoning for those measures identified as unviable. The is achieved through 3 sub-stages;

Stage 2.1: Screening of the Measures Viability Assessment

Stage 2.2: Justification for Screened Out Baseline and Structural Measures

Stage 2.3: Summary of 'Screened In' Measures

Tables 5.23 to 5.25 below outline the results for each of these sub-stages.

Table 5.23 Stage 2.1: Screening of the Measures Viability Assessment

STAGE 2.1 Screening of the Measures Viability Assessment							
Baseline, Structural and Non-Structural Measures Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.							
Measures		**Appl.**	**Econ.**	**Envir.**	**Soc.**	**Cult.**	**Overall Viability**
Structural							
D	Storage	Unviable	Not Assessed	Not Assessed	Viable	Viable	**Screened Out**
E	Flow Diversion	Unviable	Not Assessed	Not Assessed	Viable	Viable	**Screened Out**
F	Increase Conveyance	Unviable	Not Assessed	Not Assessed	Viable	Viable	**Screened Out**
G	Flood Defences	Unviable	Not Assessed	Not Assessed	Viable	Viable	**Screened Out**
I	Other Measures	Unviable	Not Assessed	Not Assessed	Not Assessed	Not Assessed	**Screened Out**
Non-Structural							
J	Flood Forecasting / Warning / Response	Viable	Not Assessed	Viable	Viable	Viable	**Screened In**
K	Public Awareness	Viable	Not Assessed	Viable	Viable	Viable	**Screened In**

Table 5.24 Stage 2.2: Justification for Screened Out Baseline and Structural Measures

Stage 2.2 Justification for Screened Out Baseline and Structural Measures			
The following provides justification on Measures with an overall viability 'Screened Out' categorisation. At this SSA, only measures that will reduce flood risk multiple AFAs within the sub-catchment and other areas are considered viable.			
D	Storage	Applicability Economic Environmental Social Cultural	At this SSA, only methods that can provide benefits to multiple AFAs within the sub-catchment and other areas are considered. For each AFA within the sub-catchment storage has been found unviable and no offline storage area was identified that could provide protection to more than one AFA. Therefore, the storage FRM method will not provide benefits to multiple AFA's within the sub-catchment.
E	Flow Diversion	Applicability Economic Environmental Social Cultural	At this SSA, only methods that can provide benefits to multiple AFAs within the sub - catchment and other areas are considered. No suitable flow diversion route was found that would provide benefits to multiple AFA's within the sub-catchment.
F	Increase Conveyance	Applicability Economic Environmental Social Cultural	At this SSA, only methods that can provide benefits to multiple AFAs within the sub - catchment and other areas are considered. Increasing conveyance by means of removing a structure or localised dredging will not influence the flood extents of any other AFA. Therefore, the increase conveyance FRM method will not provide benefits to all AFA's within the sub-catchment.
G	Flood Defences	Applicability Economic Environmental Social Cultural	At this SSA, only methods that can provide benefits to multiple AFAs within the sub - catchment and other areas are considered. Flood Defences will not influence the flood extents of any other AFA. Therefore, the increase conveyance FRM method will not provide benefits to all AFA's within the sub-catchment.
I	Other Measures	Applicability Economic Environmental Social Cultural	Construction of a tidal barrage at the mouth of the River Deel would not have any benefits to the flood risk at the AFAs upstream of Askeaton as these AFAs are outside the tidal influence. Therefore, the other FRM method will not provide benefits to more than one AFA within the sub catchment. In addition constructing a tidal barrage in the Shannon Estuary could not avoid IRPOI because any instream construction in the estuary would require permanent loss of Qualifying Interest habitat within the Lower River Shannon cSAC (estuaries and mudflats). The presence of a feasible alternative (i.e., walls, as discussed) means that IROPI could not be pursued. There are several possible IROPI risks from this measure; the mudflat/estuary loss is only one. Therefore, this measure has not been considered further in the option assessment stage.

Table 5.25 Stage 2.3: Summary of 'Screened In' Measures

Stage 2.3 Summary of 'Screened In' Measures	
The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.	
Non-Structural Measures	
J	Flood Forecasting / Warning / Response
K	Public Awareness

Non – structural measures such as; flood forecasting and public awareness have been considered for the sub-catchment and are addressed in the UoM spatial scale.

Recommendations for all the above "Screened In" measures will be made in the Flood Risk Management Plan (FRMP).

Stage 4: Appraisal of Options for the Deel sub-catchment and Stage 5: Multi-Criteria Assessment has not been carried out, as monetary or measurable benefits cannot be determined for any of the 'Screened In' FRM non-structural measures at this SSA.

5.2.2 Maigue Sub-Catchment

Tables 5.26 to 5.33 below outline the results of sub-stages 1.1 to 1.8 for the Maigue Sub-catchment.

5.2.2.1 Stage 1: Summary of Current Flood Risk for Deel Sub-Catchment

Table 5.26 Stage 1.1: AFA and Watercourse Details

Stage 1.1: AFA and Watercourse Details	
AFAs	Adare, Croom, Kilmallock, Clarina, and Charleville.
Major Watercourses:	Maigue (River), Adare River, River Maigue, Barnakyle (River), Laskiltagh (River), River Loobagh, Ahatrishnaun Stream, Ahnagluggin Stream, Barnakyle (River), Glen River.

Table 5.27 Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details

Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details					
Properties at risk:		**Event Type**	**Res**	**Non-Res**	**Total**
	APMR_Maigue	**Fluvial**	4	4	8
		Coastal	3	3	6
		Combined	7	7	14
	Within AFAs	**Fluvial**	104	39	143
		Coastal	82	31	113
		Combined	104	40	144
	Total for Sub-catchment	**Fluvial**	108	43	151
		Coastal	85	34	119
		Combined	111	47	158
Relevant Comments:	For AFA level breakdown see specific AFA reports.				

Table 5.28 Stage 1.3: Summary of Existing Flood Risk Management Measures

Stage 1.3: Summary of Existing Flood Risk Management Measures					
Arterial Drainage	**Storage**	**Flow Diversion**	**Flood Defences**	**Level Control**	**Other**
Yes	None	None	**Yes**	None	None

Table 5.29 Stage 1.4: Summary of PV damages

Stage 1.4: Summary of PV Damages									
Fluvial and coastal damages calculated based on flood depths for all return periods up to the 0.1% AEP. Combined damages are a sum of the fluvial and coastal capped at value of the property.									
		Event Type	**Capped Residential**	**Capped Non-Res**	**Capped Total**	**Uncapped Residential**	**Uncapped Non-Res**	**Uncapped Total**
Total PV Damages	**APMR_Maigue**	**Fluvial**	€ 242,126	€ 323,886	€ 566,012	€ 242,126	€ 323,886	€ 566,012
		Coastal	€ 525,288	€ 591,059	€ 1,116,347	€ 564,000	€ 591,059	€ 1,155,059
		Combined	€ 756,829	€ 914,941	€ 1,671,770	€ 806,126	€ 914,945	€ 1,721,071
	Within AFAs	**Fluvial**	€ 10,618,776	€ 7,883,087	€ 18,501,863	€ 12,527,215	€ 11,059,135	€ 23,586,350
		Coastal	€ 3,279,903	€ 3,752,738	€ 7,032,641	€ 3,279,903	€ 6,948,554	€ 10,228,457
		Combined	€ 13,563,478	€ 10,050,820	€ 23,614,298	€ 15,807,118	€ 18,007,689	€ 33,814,807
	Total for Sub-catchment	**Fluvial**	€ 10,860,902	€ 8,206,973	€ 19,067,875	€ 12,769,341	€ 11,383,021	€ 24,152,362
		Coastal	€ 3,805,191	€ 4,343,797	€ 8,148,988	€ 3,843,903	€ 7,539,613	€ 11,383,516
		Combined	€ 14,320,307	€ 10,965,761	€ 25,286,068	€ 16,613,244	€ 18,922,634	€ 35,535,878
Relevant Comments:		For AFA level breakdown see specific AFA reports.						

Table 5.30 Stage 1.5: Summary of Social Receptors at Risk of Flooding

Stage 1.5: Summary of Social Receptors at Risk of Flooding			
High Vulnerability Properties at risk :		**Type**	**Number**
	APMR_Maigue	N/A	None
	Within AFAs	School	1
	Total for Sub-catchment	School	1
Social Infrastructure Assets:		**Type**	**Number**
	APMR_Maigue	N/A	None
	Within AFAs	N/A	None
	Total for Sub-catchment	N/A	None
Social Amenity Sites:		**Type**	**Number**
	APMR_Maigue	N/A	None
	Within AFAs	GAA Pitch	1
	Total for Sub-catchment	GAA Pitch	1
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Social		

Table 5.31 Stage 1.6: Summary of Environmental Receptors at Risk of Flooding

Stage 1.6: Summary of Environmental Receptors at Risk of Flooding			
Risk to WFD Annex IV :		**Type**	**Number**
	APMR_Maigue	WFD Drinking Water	1
	Within AFAs	WFD Drinking Water	1
	Total for Sub-catchment	WFD Drinking Water	2
Risk to cSACs, SPAs, & SACs :		**Type**	**Number**
	APMR_Maigue	SPA	1
		SAC	1
	Within AFAs	SAC	1
	Total for Sub-catchment	SPA	1
		SAC	2
Relevant Comments:	For AFA level breakdown see specific AFA reports.		

Relevant Figure Ref:	General Risk - Environment

Table 5.32 Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding

Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding			
Risk to Sites of Cultural Heritage:		**Type**	**Number**
	APMR_Maigue	NIAH	12
		Recorded Monuments	6
	Within AFAs	NIAH	23
		Recorded Monuments	16
	Total for Sub-catchment	NIAH	35
		Recorded Monuments	22
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk – Cultural Heritage		

Table 5.33 Stage 1.8: Summary of Economic Receptors at Risk of Flooding

Stage 1.8: Summary of Economic Receptors at Risk of Flooding			
Risk to Transport Infrastructure:		**Type**	**Number**
	APMR_Maigue	Primary Road	3
		Regional Road	4
		Local Road	22
		Residential Road	39
		Railway	1
	Within AFAs	Primary Road	2
		Regional Road	3
		Local Road	3
		Residential Road	1
	Total for Sub-catchment	Primary Road	5
		Regional Road	7
		Local Road	25
		Residential Road	40
		Railway	1
Risk to Utility Infrastructure:		**Type**	**Number**
	APMR_Maigue	N/A	None

	Within AFAs	Utility Infrastructure	2
	Total for Sub-catchment	Utility Infrastructure	2
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Economy		

5.2.2.2 Stage 2: Screening of the Measures for Maigue Sub-Catchment

The purpose of Stage 2 is to determine the viability of FRM measures for this sub-catchment and to provide robust, transparent reasoning for those measures identified as unviable. The is achieved through 3 sub-stages;

Stage 2.1: Screening of the Measures Viability Assessment

Stage 2.2: Justification for Screened Out Baseline and Structural Measures

Stage 2.3: Summary of 'Screened In' Measures

Tables 5.34 to 5.36 below outline the results for each of these sub-stages.

Table 5.34 Stage 2.1: Screening of the Measures Viability Assessment

STAGE 2.1 Screening of the Measures Viability Assessment							
Baseline, Structural and Non-Structural Measures Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being Screened Out.							
Measures		**Appl.**	**Econ.**	**Envir.**	**Soc.**	**Cult.**	**Overall Viability**
Structural							
D	Storage	Unviable	Not Assessed	Not Assessed	Viable	Viable	**Screened Out**
E	Flow Diversion	Unviable	Not Assessed	Not Assessed	Viable	Viable	**Screened Out**
F	Increase Conveyance	Unviable	Not Assessed	Not Assessed	Viable	Viable	**Screened Out**
G	Flood Defences	Unviable	Not Assessed	Not Assessed	Viable	Viable	**Screened Out**
I	Other Measures	Unviable	Not Assessed	Not Assessed	Not Assessed	Not Assessed	**Screened Out**
Non-Structural							
J	Flood Forecasting / Warning / Response	Viable	Not Assessed	Viable	Viable	Viable	**Screened In**
K	Public Awareness	Viable	Not Assessed	Viable	Viable	Viable	**Screened In**

Table 5.35 Stage 2.2: Justification for Screened Out Structural Measures

Stage 2.2 Justification for Screened Out Measures			
The following provides justification on Measures with an overall viability 'Screened Out' categorisation. At this SSA, only measures that will reduce flood risk multiple AFAs within the sub-catchment and other areas are considered viable.			
D	Storage	Applicability Economic Environmental Social Cultural	At this SSA, only methods that can provide benefits to multiple AFAs within the sub-catchment and other areas are considered. For each AFA within the sub-catchment storage has been found unviable and no offline storage area was identified that could provide protection to more than one AFA. Therefore, the storage FRM method will not provide benefits to multiple AFA's within the sub-catchment.
E	Flow Diversion	Applicability Economic Environmental Social Cultural	At this SSA, only methods that can provide benefits to multiple AFAs within the sub - catchment and other areas are considered. No suitable flow diversion route was found that would provide benefits to multiple AFA's within the sub-catchment.
F	Increase Conveyance	Applicability Economic Environmental Social Cultural	At this SSA, only methods that can provide benefits to multiple AFAs within the sub - catchment and other areas are considered. Increasing conveyance by means of removing a structure or localised dredging will not influence the flood extents of any other AFA. Therefore, the increase conveyance FRM method will not provide benefits to all AFA's within the sub-catchment.
G	Flood Defences	Applicability Economic Environmental Social Cultural	At this SSA, only methods that can provide benefits to multiple AFAs within the sub - catchment and other areas are considered. Flood Defences by means of removing a structure or localised dredging will not influence the flood extents of any other AFA. Therefore, the increase conveyance FRM method will not provide benefits to all AFA's within the sub-catchment.

I	Other Measures	Applicability Economic Environmental Social Cultural	Construction of a tidal barrage at the month of the River Maigue would not have any benefits to the flood risk at the AFAs upstream of Adare as this area AFAs are outside the tidal influence. Therefore, the Tidal Barage FRM method will not provide benefits to more than one AFA within the sub-catchment. In addition constructing a tidal barrage in the Shannon Estuary could not avoid IRPOI because any instream construction in the estuary would require permanent loss of Qualifying Interest habitat within the Lower River Shannon cSAC (estuaries and mudflats). The presence of a feasible alternative (i.e., walls, as discussed) means that IROPI could not be pursued. There are several possible IROPI risks from this measure; the mudflat/estuary loss is only one. Therefore, this measure has not been considered further in the option assessment stage.

Table 5.36 Stage 2.3: Summary of 'Screened In' Measures

Stage 2.3 Summary of 'Screened In' Measures	
The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.	
Non-Structural Measures	
J	Flood Forecasting / Warning / Response
K	Public Awareness

Non – structural measures such as; flood forecasting and public awareness have been considered for the sub-catchment and are addressed in the UoM spatial scale.

Recommendations for all the above "Screened In" measures will be made in the Flood Risk Management Plan (FRMP).

Stage 4: Appraisal of Options for the Maigue sub-catchment and Stage 5: Multi-Criteria Assessment has not been carried out, as monetary or measurable benefits cannot be determined for any of the 'Screened In' FRM non-structural measures at this SSA.

5.2.3 Foynes Sub-Catchment

Tables 5.37 to 5.44 below outline the results of sub-stages 1.1 to 1.8 for the Foynes Sub-catchment.

5.2.3.1 Stage 1: Summary of Current Flood Risk for Foynes Sub-Catchment

Table 5.37 Stage 1.1: AFA and Watercourse Details

Stage 1.1: AFA and Watercourse Details	
AFAs	Foynes
Major Watercourses:	Shanagolden (Stream), Ardineer (Stream), Durnish (Stream), Foynes (River), Ardineer (Stream).

Table 5.38 Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details

1.2 Summary of Flood Risk in 1% Fluvial / 0.5% Coastal AEP Event					
Properties at risk:		**Event Type**	**Res**	**Non-Res**	**Total**
	APMR_Foynes	**Fluvial**	0	0	0
		Coastal	0	0	0
		Combined	0	0	0
	Within AFAs	**Fluvial**	38	9	47
		Coastal	155	66	221
		Combined	155	66	221
	Total for Sub-catchment	**Fluvial**	38	9	47
		Coastal	155	66	221
		Combined	155	66	221
Relevant Comments:	For AFA level breakdown see specific AFA reports.				

Table 5.39 Stage 1.3: Summary of Existing Flood Risk Management Measures

Stage 1.3: Summary of Existing Flood Risk Management Measures					
Arterial Drainage	**Storage**	**Flow Diversion**	**Flood Defences**	**Level Control**	**Other**
Yes	None	None	**Yes**	None	None

Table 5.40 Stage 1.4: Summary of PV damages

Stage 1.4: Summary of PV Damages								
Fluvial and coastal damages calculated based on flood depths for all return periods up to the 0.1% AEP. Combined damages are a sum of the fluvial and coastal capped at value of the property.								
Total PV Damages		**Event Type**	**Capped Residential**	**Capped Non-Res**	**Capped Total**	**Uncapped Residential**	**Uncapped Non-Res**	**Uncapped Total**
	APMR_Foynes	**Fluvial**	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
		Coastal	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
		Combined	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
	Within AFAs	**Fluvial**	€ 2,376,185	€ 1,519,664	€ 3,895,849	€ 2,820,025	€ 1,519,664	€ 4,339,689
		Coastal	€ 7,354,545	€ 9,792,575	€ 17,147,120	€ 10,548,787	€ 10,422,771	€ 20,971,558
		Combined	€ 8,306,746	€ 10,253,514	€ 18,560,260	€ 13,368,812	€ 11,942,435	€ 25,311,247
	Total for Sub-catchment	**Fluvial**	€ 2,376,185	€ 1,519,664	€ 3,895,849	€ 2,820,025	€ 1,519,664	€ 4,339,689
		Coastal	€ 7,354,545	€ 9,792,575	€ 17,147,120	€ 10,548,787	€ 10,422,771	€ 20,971,558
		Combined	€ 8,306,746	€ 10,253,514	€ 18,560,260	€ 13,368,812	€ 11,942,435	€ 25,311,247
Relevant Comments:		For AFA level breakdown see specific AFA reports.						

Table 5.41 Stage 1.5: Summary of Social Receptors at Risk of Flooding

Stage 1.5: Summary of Social Receptors at Risk of Flooding			
High Vulnerability Properties at risk :		**Type**	**Number**
	APMR_Foynes	N/A	None
	Within AFAs	School	1
		Health Centre	2
	Total for Sub-catchment	School	1
		Health Centre	2
Social Infrastructure Assets:		**Type**	**Number**
	APMR_Foynes	N/A	None
	Within AFAs	Church	1
		Garda Station	1
		Fire Station	1
		Government Office	1
	Total for Sub-catchment	Church	1
		Garda Station	1
		Fire Station	1
		Government Office	1
Social Amenity Sites:		**Type**	**Number**
	APMR_ Foynes	N/A	None
	Within AFAs	Community Centre	1
		Museum	1
		GAA Pitch	1
	Total for Sub-catchment	Community Centre	1
		Museum	1
		GAA Pitch	1
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Social		

Table 5.42 Stage 1.6: Summary of Environmental Receptors at Risk of Flooding

Stage 1.6: Summary of Environmental Receptors at Risk of Flooding			
Risk to WFD Annex IV :		Type	Number
	APMR_ Foynes	N/A	None
	Within AFAs	N/A	None
	Total for Sub-catchment	N/A	None
Risk to cSACs, SPAs, & SACs :		Type	Number
	APMR_ Foynes	N/A	None
	Within AFAs	SPA	1
		SAC	1
	Total for Sub-catchment	SPA	1
		SAC	1
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Environment		

Table 5.43 Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding

Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding			
Risk to Sites of Cultural Heritage:		Type	Number
	APMR_ Foynes	N/A	None
	Within AFAs	NIAH	22
		Proposed National Heritage Area	1
	Total for Sub-catchment	NIAH	22
		Proposed National Heritage Area	1
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk – Cultural Heritage		

Table 5.44 Stage 1.8: Summary of Economic Receptors at Risk of Flooding

Stage 1.8: Summary of Economic Receptors at Risk of Flooding			
Risk to Transport Infrastructure:		**Type**	**Number**
	APMR_ Foynes	N/A	None
	Within AFAs	Primary Road	1
		Local Road	6
		Railway	1
		Port	1
	Total for Sub-catchment	Primary Road	1
		Local Road	6
		Railway	1
		Port	1
Risk to Utility Infrastructure:		**Type**	**Number**
	APMR_ Foynes	N/A	None
	Within AFAs	Utility Infrastructure	1
	Total for Sub-catchment	Utility Infrastructure	1
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Economy		

Conclusion:

As there is only one AFA within this sub catchment/coastal area there are no measures that will provide benefits to multiple AFA's therefore screening of the measures was not carried out. Non – structural measures such as; flood forecasting and public awareness have been considered for the sub-catchment and are addressed in the UoM spatial scale

5.2.4 Ballyline Sub-Catchment

Tables 5.45 to 5.52 below outline the results of sub-stages 1.1 to 1.8 for the Ballyline Sub-catchment.

5.2.4.1 Stage 1: Summary of Current Flood Risk for Ballyline Sub-Catchment

Table 5.45 Stage 1.1: Sub-Catchment and Watercourse Details

Stage 1.1: AFA and Watercourse Details	
AFAs	Ballylongford
Major Watercourses:	Rusheen Park (River), Lower Aghanagran (Stream), Lislaughtin (Stream), Well Tributary, Ballyline (River), Ballyline East Tributary, Ballyline West Tributary, Ballyline (River), Rusheen Park (River).

Table 5.46 Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details

Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details					
Properties at risk:		**Event Type**	**Res**	**Non-Res**	**Total**
	APMR_Ballyline	**Fluvial**	2	0	2
		Coastal	2	0	2
		Combined	3	0	3
	Within AFAs	**Fluvial**	22	9	31
		Coastal	41	13	54
		Combined	41	13	54
	Total for Sub-catchment	**Fluvial**	24	9	33
		Coastal	43	13	56
		Combined	44	13	57
Relevant Comments:	For AFA level breakdown see specific AFA reports.				

Table 5.47 Stage 1.3: Summary of Existing Flood Risk Management Measures

1.3 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	**Storage**	**Flow Diversion**	**Flood Defences**	**Level Control**	**Other**
Yes	**None**	**None**	**Yes**	**None**	**None**

Table 5.48 Stage 1.4: Summary of PV damages

Stage 1.4: Summary of PV Damages

Fluvial and coastal damages calculated based on flood depths for all return periods up to the 0.1% AEP. Combined damages are a sum of the fluvial and coastal capped at value of the property.

		Event Type	Capped Residential	Capped Non-Res	Capped Total	Uncapped Residential	Uncapped Non-Res	Uncapped Total
Total PV Damages	APMR_Ballyline	Fluvial	€ 271,009	€ 0	€ 271,009	€ 282,547	€ 0	€ 282,547
		Coastal	€ 306,429	€ 0	€ 306,429	€ 946,552	€ 0	€ 946,552
		Combined	€ 527,636	€ 0	€ 527,636	€ 1,229,099	€ 0	€ 1,229,099
	Within AFAs	Fluvial	€ 594,499	€ 424,636	€ 1,019,135	€ 594,499	€ 424,636	€ 1,019,135
		Coastal	€ 5,347,708	€ 4,879,308	€ 10,227,021	€ 11,735,939	€ 7,494,660	€ 19,230,599
		Combined	€ 5,472,106	€ 5,032,166	€ 10,504,272	€ 12,330,438	€ 7,919,296	€ 20,249,734
	Total for Sub-catchment	Fluvial	€ 865,508	€ 424,636	€ 1,290,144	€ 877,046	€ 424,636	€ 1,301,682
		Coastal	€ 5,654,137	€ 4,879,308	€ 10,533,445	€ 12,682,491	€ 7,494,660	€ 20,177,151
		Combined	€ 5,999,742	€ 5,032,166	€ 11,031,908	€ 13,559,537	€ 7,919,296	€ 21,478,833
Relevant Comments:		For AFA level breakdown see specific AFA reports.						

Table 5.49 Stage 1.5: Summary of Social Receptors at Risk of Flooding

Stage 1.5: Summary of Social Receptors at Risk of Flooding			
High Vulnerability Properties at risk :		**Type**	**Number**
	APMR_Ballyline	N/A	None
	Within AFAs	N/A	None
	Total for Sub-catchment	N/A	None
Social Infrastructure Assets:		**Type**	**Number**
	APMR_ Ballyline	N/A	None
	Within AFAs	Fire Station	1
		Post Office	1
	Total for Sub-catchment	Fire Station	1
		Post Office	1
Social Amenity Sites:		**Type**	**Number**
	APMR_ Ballyline	N/A	None
	Within AFAs	Community Centre	1
	Total for Sub-catchment	Community Centre	1
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Social		

Table 5.50 Stage 1.6: Summary of Environmental Receptors at Risk of Flooding

Stage 1.6: Summary of Environmental Receptors at Risk of Flooding			
Risk to WFD Annex IV :		**Type**	**Number**
	APMR_ Ballyline	N/A	None
	Within AFAs	N/A	None
	Total for Sub-catchment	N/A	None
Risk to cSACs, SPAs, & SACs :		**Type**	**Number**
	APMR_ Ballyline	N/A	None
	Within AFAs	SAC	1
	Total for Sub-catchment	SAC	1
Relevant Comments:	For AFA level breakdown see specific AFA reports.		

Relevant Figure Ref:	General Risk - Environment

Table 5.51 Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding

Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding			
Risk to Sites of Cultural Heritage:		**Type**	**Number**
	APMR_ Ballyline	Recorded Monuments	2
	Within AFAs	NIAH	3
	Total for Sub-catchment	NIAH	3
		Recorded Monuments	2
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk – Cultural Heritage		

Table 5.52 Stage 1.8: Summary of Economic Receptors at Risk of Flooding

Stage 1.8: Summary of Economic Receptors at Risk of Flooding			
Risk to Transport Infrastructure:		**Type**	**Number**
	APMR_ Ballyline	Local Road	4
		Residential Road	3
	Within AFAs	Regional Road	4
		Local Road	1
	Total for Sub-catchment	Local Road	5
		Regional Road	4
		Residential Road	3
Risk to Utility Infrastructure:		**Type**	**Number**
	APMR_ Ballyline	N/A	None
	Within AFAs	N/A	None
	Total for Sub-catchment	N/A	None
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Economy		

Conclusion:

As there is only one AFA within this sub catchment/coastal area there are no measures that will provide benefits to multiple AFA's therefore screening of the measures was not carried out. Non – structural measures such as; flood forecasting and public awareness have been considered for the sub-catchment and are addressed in the UoM spatial scale.

5.2.5 Tarbert Power Station Sub-Catchment

Tables 5.53 to 5.60 below outline the results of sub-stages 1.1 to 1.8 for the Tarbert Power Station Sub-catchment.

5.2.5.1 Stage 1: Summary of Current Flood Risk for Tarbert Sub-Catchment

Table 5.53 Stage 1.1: Sub-Catchment and Watercourse Details

Stage 1.1: AFA and Watercourse Details	
IRR	Tarbert Power Station
Primary Watercourse(s):	Shannon Estuary

Table 5.54 Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details

Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details					
Properties at risk:		**Event Type**	**Res**	**Non-Res**	**Total**
	APMR_Tarbert	**Fluvial**	0	0	0
		Coastal	0	0	0
		Combined	0	0	0
	Within AFAs	**Fluvial**	0	0	0
		Coastal	0	5	5
		Combined	0	5	5
	Total for Sub-catchment	**Fluvial**	0	0	0
		Coastal	0	5	5
		Combined	0	5	5
Relevant Comments:	For AFA level breakdown see specific AFA reports.				

Table 5.55 Stage 1.3: Summary of Existing Flood Risk Management Measures

1.3 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	**Storage**	**Flow Diversion**	**Flood Defences**	**Level Control**	**Other**
Yes	None	None	**Yes**	None	None

Table 5.56 Stage 1.4: Summary of PV damages

1.4 Total PV Damages									
		Event Type	**Capped Residential**	**Capped Non-Res**	**Capped Total**	**Uncapped Residential**	**Uncapped Non-Res**	**Uncapped Total**
Total PV Damages	**APMR_Tarbert**	**Fluvial**	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
		Coastal	€ 13,854	€ 0	€ 13,854	€ 13,854	€ 0	€ 13,854
		Combined	€ 13,854	€ 0	€ 13,854	€ 13,854	€ 0	€ 13,854
	Within AFAs	**Fluvial**	€ 0	N/A	€ 0	€ 0	N/A	€ 0
		Coastal	€ 0	N/A	€ 0	€ 0	N/A	€ 0
		Combined	€ 0	N/A	€ 0	€ 0	N/A	€ 0
	Total for Sub-catchment	**Fluvial**	€ 0	N/A	€ 0	€ 0	N/A	€ 0
		Coastal	€ 13,854	N/A	€ 13,854	€ 13,854	N/A	€ 13,854
		Combined	€ 13,854	N/A	€ 13,854	€ 13,854	N/A	€ 13,854
Relevant Comments:	For AFA level breakdown see specific AFA reports.								

Table 5.57 Stage 1.5: Summary of Social Receptors at Risk of Flooding

Stage 1.5: Summary of Social Receptors at Risk of Flooding			
High Vulnerability Properties at risk :		**Type**	**Number**
	APMR_Tarbert	N/A	None
	Within AFAs	N/A	None
	Total for Sub-catchment	N/A	None
Social Infrastructure Assets:		**Type**	**Number**
	APMR_ Tarbert	N/A	None
	Within AFAs	N/A	None
	Total for Sub-catchment	N/A	None
Social Amenity Sites:		**Type**	**Number**
	APMR_ Tarbert	N/A	None
	Within AFAs	N/A	None
	Total for Sub-catchment	N/A	None
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Social		

Table 5.58 Stage 1.6: Summary of Environmental Receptors at Risk of Flooding

Stage 1.6: Summary of Environmental Receptors at Risk of Flooding			
Risk to WFD Annex IV :		**Type**	**Number**
	APMR_ Tarbert	N/A	None
	Within AFAs	N/A	None
	Total for Sub-catchment	N/A	None
Risk to cSACs, SPAs, & SACs :		**Type**	**Number**
	APMR_ Tarbert	SAC	1
	Within AFAs	SAC	1
	Total for Sub-catchment	SAC	2
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Environment		

Table 5.59 Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding

Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding			
Risk to Sites of Cultural Heritage:		**Type**	**Number**
	APMR_ Tarbert	Proposed National Heritage Areas	1
	Within AFAs	N/A	None
	Total for Sub-catchment	Proposed National Heritage Areas	1
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk – Cultural Heritage		

Table 5.60 Stage 1.8: Summary of Economic Receptors at Risk of Flooding

Stage 1.8: Summary of Economic Receptors at Risk of Flooding			
Risk to Transport Infrastructure:		**Type**	**Number**
	APMR_ Tarbert	Primary Road	1
	Within AFAs	N/A	None
	Total for Sub-catchment	Primary Road	1
Risk to Utility Infrastructure:		**Type**	**Number**
	APMR_ Tarbert	N/A	None
	Within AFAs	N/A	None
	Total for Sub-catchment	N/A	None
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Economy		

Conclusion:

As there is only one AFA within this sub catchment/coastal area there are no measures that will provide benefits to multiple AFA's therefore screening of the measures was not carried out. Non – structural measures such as; flood forecasting and public awareness have been considered for the sub-catchment and are addressed in the UoM spatial scale.

5.3 Option Appraisal Results SSA: AFA/IRR

The AFA and IRR SSA's assessed and reported in this section, is as follows:

- Newcastle West AFA
- Askeaton AFA
- Rathkeale AFA
- Foynes AFA
- Adare AFA
- Croom AFA
- Dromcolliher AFA
- Kilmallock AFA
- Tarbert (IRR)
- Clarina AFA
- Charleville AFA
- Milford AFA
- Ballylongford AFA

Appendix C provides individual Option Appraisal Reports for each AFA/ IRR within this Unit of Management. Each Option Appraisal Report provides a clear and robust assessment of the Option Appraisal process.

The following sections provide an overview of the results for each AFA/ IRR, at each of the six Option Appraisal Stages.

JACOBS

OPW The Office of Public Works Oifig na nOibreacha Poiblí

5.3.1 Stage 1: Summary of Current Flood Risk & MCA Approach - Results

Table 5.61 Results for Stage 1: Summary of Current Flood Risk & MCA Approach

AFA/ IRR	Relevant Sub-Stage and Outcome[1]					
	Sub-Stage 1.2			Sub-Stage 1.4		
	No. Properties at Risk			Total Capped PV Damages		
	F	C	Comb.	F	C	Combined
Newcastle West	43	0	43	€ 5,449,585	€ 0	€ 5,449,585
Askeaton	41	38	45	€ 10,713,935	€ 4,679,881	€ 13,802,985
Rathkeale	7	0	7	€ 733,522	€ 0	€ 733,522
Foynes	47	221	221	€ 3,895,849	€ 17,147,120	€ 18,560,260
Adare	118	113	119	€ 15,906,687	€ 7,002,109	€ 20,988,590
Croom	19	0	19	€ 2,458,545	€ 0	€ 2,458,545
Dromcolliher	1	0	1	€ 167,174	€ 0	€ 167,174
Kilmallock	3	0	3	€ 79,805	€ 0	€ 79,805
Tarbert (IRR)	0	5	5	€ 0	N/A	N/A
Clarina	0	0	0	€ 0	€ 30,532	€ 30,532
Charleville	3	0	3	€ 56,826	€ 0	€ 56,826
Milford	5	0	5	€ 420,819	€ 0	€ 420,819
Ballylongford	31	54	54	€ 1,019,135	€ 10,227,016	€ 10,504,272

Note[1]: Only sub-stages with defined outcomes are summarised in this Table. Refer to Appendix C for a full report.

Table 5.62 Results for Stage 1: Summary of Current Flood Risk & MCA Approach

AFA/ IRR	Relevant Sub-Stage and Outcome[1]			
	Sub-Stage 1.5	Sub-Stage 1.6	Sub-Stage 1.7	Sub-Stage 1.8
	Social Features	Environmental Features	Cultural Features	Economic Features
Newcastle West	No	No	Yes	Yes
Askeaton	No	No	Yes	Yes
Rathkeale	No	No	Yes	Yes
Foynes	Yes	Yes	Yes	Yes
Adare	Yes	Yes	Yes	Yes
Croom	No	No	Yes	Yes
Dromcolliher	No	No	No	Yes
Kilmallock	No	No	Yes	Yes
Tarbert (IRR)	No	Yes	No	No
Clarina	Yes	No	No	Yes
Charleville	No	No	No	Yes
Milford	Yes	No	Yes	Yes
Ballylongford	Yes	Yes	Yes	Yes

Note[1]: Only sub-stages with defined outcomes are summarised in this Table. Refer to Appendix C for a full report.

5.3.2 Stage 2: Screening of the measures - Results

Table 5.63 below outlines the screened in measures for each AFA/ IRR.

Dromcolliher is identified as an AFA that benefits from an existing flood relief scheme and therefore no further assessment to identify potentially viable flood risk management measures or options is required through this CFRAM Study. Recommendations will be made in the FRMP that the existing flood relief scheme must be monitored and maintained.

With the existing arterial drainage scheme in place in Clarina, there is no flood risk to any properties in the AFA for the 1% AEP fluvial and the 0.5% AEP coastal events. Therefore, no optioneering has been carried out in Clarina. The AFAs of Dromcolliher and Clarina are not reported in the stages below but are included in Appendix C.

Table 5.63 Summary of Screened in Measures

Flood Risk Management Measure												
Ref	**Title**	**Newcastle West**	**Askeaton**	**Rathkeale**	**Foynes**	**Adare**	**Croom**	**Kilmallock**	**Tarbert**	**Charleville**	**Milford**	**Bally-longford**
Baseline												
A	Do Nothing	×	×	×	×	×	×	×	×	✓	×	×
B	Existing Regime	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	×
C	Do Minimum	×	×	×	×	×	×	×	×	×	×	×
Structural												
D	Storage	×	×	×	×	✓	×	×	×	×	×	×
E	Flow Diversion	×	×	×	×	✓	×	×	×	×	×	×
F	Increase Conveyance	✓	✓	×	×	✓	×	×	×	×	×	×
G	Flood Defences	✓	✓	✓	✓	✓	✓	×	×	×	×	✓
H	Relocation of Properties	×	×	✓	×	×	×	×	×	×	×	×
I	Other Measures	×	×	×	✓	×	×	×	×	×	×	×
Non Structural												
J	Flood F'ing / Warning / Response	✓	✓	✓	✓	✓	✓	×	×	×	×	✓
K	Public Awareness	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓
L	Individual Property Resistance	✓	✓	✓	×	×	✓	×	×	×	×	✓
M	Individual Property Resilience	✓	✓	✓	×	×	✓	×	×	×	✓	✓

5.3.3 Stage 3 & 4: Development of the Options and Appraisal - Results

Newcastle West

For Newcastle West a total of three options were considered, see Table 5.64. For more details of these options and the associated appraisal, refer to the Sections 3 and 4 of Appendix C1.

Table 5.64 Summary of Screened in Measures for Newcastle West

Measures		**Different composition of measures per option**						
Baseline Measures								
B	Existing Regime	✓	✓	✓				
Structural Measures								
F	Increase Conveyance							
Fi	Channel Dredging							
Fii	Channel Widening			✓				
Fiii	Structure Enhancement / Works			✓				
G	Flood Defences							
Gi	New Flood Defences	✓	✓	✓				
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
J	Flood Forecasting / Warning / Response	✓						
K	Public Awareness	✓						
L	Individual Property Resistance	✓						
M	Individual Property Resilience							
Option Reference		NWT_01	NWT_02	NWT_03				

Measures not screened out but not included in options		
Measures		**Justification**
M	Individual Property Resilience	Individual Property Resilience was not considered as either an independent measure or in combination with other measures, as the option being appraised would provide the required 1% Fluvial AEP standard of protection. Individual Property Resilience does not improve the viability of the options under consideration.

Askeaton

For Askeaton a total of three options were considered, see Table 5.65. For more details of these options and the associated appraisal, refer to the Sections 3 and 4 of Appendix C2.

Table 5.65 Summary of Screened in Measures for Askeaton

Measures		**Different composition of measures per option**						
Baseline Measures								
B	Existing Regime	✓	✓	✓				
Structural Measures								
F	Increase Conveyance							
Fi	Channel Dredging	✓	✓	✓				
Fii	Channel Widening	✓	✓	✓				
Fiii	Structure Enhancement / Works	✓	✓	✓				
G	Flood Defences							
Gi	New Flood Defences	✓	✓	✓				
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
J	Flood Forecasting / Warning / Response			✓				
K	Public Awareness			✓				
L	Individual Property Resistance			✓				
Option Reference		ASN_01	ASN_02	ASN_03				
Measures not screened out but not included in options								
Measures		**Justification**						
M	Individual Property Resilience	Individual Property Resilience was not considered as either an independent measure or in combination with other measures, as the option being appraised would provide the required 1% Fluvial / 0.5% Coastal AEP standard of protection. Individual Property Resilience does not improve the viability of the option under consideration.						

Rathkeale

For Rathkeale a total of two options were considered, Table 5.66. For more details of these options and the associated appraisal, refer to the Sections 3 and 4 of Appendix C3.

Table 5.66 Summary of Screened in Measures for Rathkeale

<table>
<tr><th colspan="2">Measures</th><th colspan="7">Different composition of measures per option</th></tr>
<tr><td colspan="9">Baseline Measures</td></tr>
<tr><td>B</td><td>Existing Regime</td><td>✓</td><td>✓</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="9">Structural Measures</td></tr>
<tr><td>G</td><td colspan="8">Flood Defences</td></tr>
<tr><td>Gi</td><td>New Flood Defences</td><td></td><td>✓</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Gii</td><td>Raise Existing Flood Defences</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Giii</td><td>Demountable Defences</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Giv</td><td>Other Defences</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="9">Non-Structural Measures</td></tr>
<tr><td>J</td><td>Flood Forecasting / Warning / Response</td><td>✓</td><td>✓</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>K</td><td>Public Awareness</td><td>✓</td><td>✓</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>L</td><td>Individual Property Resistance</td><td>✓</td><td>✓</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Option Reference</td><td>RAE_01</td><td>RAE_02</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="9">Measures not screened out but not included in options</td></tr>
<tr><td colspan="2">Measures</td><td colspan="7">Justification</td></tr>
<tr><td>H</td><td>Relocation of Properties</td><td colspan="7">Relocation of Properties was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required 1% Fluvial AEP standard of protection. Relocation of Properties does not improve the viability of the options under consideration.</td></tr>
<tr><td>M</td><td>Individual Property Resilience</td><td colspan="7">Individual Property Resilience was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required 1% Fluvial AEP standard of protection. Individual Property Resilience does not improve the viability of the options under consideration.</td></tr>
</table>

Foynes

For Foynes a total of two options were considered, see Table 5.67. For more details of this option and the associated appraisal, refer to the Sections 3 and 4 of Appendix C4.

Table 5.67 Summary of Screened in Measures for Foynes

Measures		**Different composition of measures per option**						
Baseline Measures								
B	Existing Regime	✓	✓					
Structural Measures								
G	Flood Defences:							
Gi	New Flood Defences	✓	✓					
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences		✓					
Giv	Other Defences							
I	Other: Flapped Outfall	✓	✓					
Non-Structural Measures								
J	Flood Forecasting / Warning / Response							
K	Public Awareness							
Option Reference		FOS_01	FOS_02					

Measures not screened out but not included in options		
Measures		**Justification**
J	Flood Forecasting / Warning / Response	Flood Forecasting was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required 0.5% coastal AEP standard of protection. Flood Forecasting does not improve the viability of the options under consideration.
K	Public Awareness	Public Awareness was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required 0.5% coastal AEP standard of protection. Public Awareness does not improve the viability of the options under consideration.

Adare

For Adare a total of two options were considered, see Table 5.68. For more details of these options and the associated appraisal, refer to the Sections 3 and 4 of Appendix C5.

Table 5.68 Summary of Screened in Measures for Adare

Measures		**Different composition of measures per option**						
Baseline Measures								
B	Existing Regime	✓	✓					
Structural Measures								
D	Storage							
Di	Online Storage							
Dii	Offline Storage	✓						
Diii	Other Storage							
E	Flow Diversion							
Ei	Full Diversion							
Eii	Flood Relief Channel							
Eiii	Other Diversion	✓						
F	Increase Conveyance							
Fi	Channel Dredging							
Fii	Channel Widening							
Fiii	Structure Enhancement/Works	✓						
G	Flood Defences							
Gi	New Flood Defences	✓	✓					
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences	✓	✓					
Giv	Other Defences							
Non-Structural Measures								
J	Flood Forecasting / Warning / Response	✓	✓					
K	Public Awareness							
Option Reference		ADE_01	ADE_02					

Measures not screened out but not included in options		
Measures		**Justification**
K	Public Awareness	Public Awareness was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required 1% Fluvial AEP standard of protection. Public Awareness does not improve the viability of the options under consideration.

Croom

In Croom one option was considered at the options development meeting, see Table 5.69. For more details of this option and the associated appraisal, refer to the Sections 3 and 4 of Appendix C6.

Table 5.69 Summary of Screened in Measures for Croom

Measures		**Different composition of measures per option**						
Baseline Measures								
B	Existing Regime	✓						
Structural Measures								
G	Flood Defences							
Gi	New Flood Defences	✓						
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
J	Flood Forecasting / Warning / Response	✓						
K	Public Awareness	✓						
L	Individual Property Resistance	✓						
M	Individual Property Resilience	✓						
Option Reference		CRM_01						
Measures not screened out but not included in options								
Measures		**Justification**						
	None	N/A						

Kilmallock

The only viable measures identified are the Baseline “Existing Regime” and the Public Awareness. Neither of these measures can form an option that will provide the required 1% AEP event design standard. Therefore, no appraisal of options or multi criteria analysis has been carried out for this AFA. For more details on Kilmallock, refer to Appendix C8.

Tarbert (IRR)

Following consultation with the Operations Manager at Tarbert Power Station on the Draft Flood Maps, it was confirmed that that the flood risk to the areas/receptors of the IRR constitutes no operational concern or difficulties to the power station. The operations manager stated that “The areas identified as at flood risk are in the vicinity of their water treatment plant. Given that the flood would be tidal and therefore short term, it would not cause us any great difficulty”. As the flood risk presents no operational difficulties or concerns, no PV damages can be assigned. The baseline measure “Existing Regime” applies to the IRR and all other measures have been screened out. Recommendations will be made in the FRMP that the existing flood defences must be monitored and maintained. Flood risk management methods, options or measures will not be assessed any further. Therefore, no appraisal of options or multi criteria analysis has been carried out for this IRR. For more details on Tarbert refer to Appendix C9.

Charleville

The only viable measures identified are “Do Nothing” and the “Public Awareness”. Neither of these measures can form an option that will provide the required 1%AEP event design standard. Therefore, no appraisal of options or multi criteria analysis has been carried out for this AFA.

It will be recommended in the FRMP that a gauging station should be installed in Charleville to confirm the current risk is as represented. Gauge data will also determine if flood forecasting is a viable measure. For more details of these options and the associated appraisal, refer to the Sections 3 and 4 of Appendix C11.

Milford

In Milford one option was considered at the options development meeting, see Table 5.70. For more details of these options and the associated appraisal, refer to the Sections 3 and 4 of Appendix C12.

Table 5.70 Summary of Screened in Measures for Milford

Measures		Different composition of measures per option						
Baseline Measures								
B	Existing Regime	✓						
Non-Structural Measures								
K	Public Awareness	✓						
M	Individual Property Resilience	✓						
Option Reference		MID_01						

Ballylongford

In Ballylongford two options were considered at the options development meeting, see Table 5.71. For more details of these options and the associated appraisal, refer to the Sections 3 and 4 of Appendix C13.

Table 5.71 Summary of Screened in Measures for Ballylongford

Measures		**Different composition of measures per option**						
Structural Measures								
G	Flood Defences:							
Gi	New Flood Defences	✓	✓					
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
J	Flood Forecasting / Warning / Response		✓					
K	Public Awareness		✓					
L	Individual Property Resistance		✓					
Option Reference		BLD_01	BLD_02					

Measures not screened out but not included in options		
Measures		**Justification**
M	Individual Property Resilience	Individual Property Resilience was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required 1% Fluvial AEP standard of protection. Individual Property Resilience does not improve the viability of the options under consideration.

5.3.4 Stage 5: Multi Criteria Assessment - Results

The MCA was carried out for all AFAs within UoM24**.** Further to this assessment, the MCA and economic scores as outlined in Section 4 have been compared. Tables 5.72 to 5.79 below show summary results for the options for all AFAs.

Table 5.72 Comparison of Options for Newcastle West

5.2 Comparison of Multi Criteria Assessment Scores			
Each option taken forward for further consideration through the Option Development Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).			
Categories	**Option Reference and Results**		
	NWT_01	NWT_02	NWT_03
Criteria Scores			
Technical	850	1100	850
Economic	518	540	541
Social	537	558	558
Environmental	-234	-306	-406
Economic Values			
Economic PV Benefits	€ 4,756,674	€ 4,815,737	€ 4,829,323
PV Cost	€ 2,162,440	€ 2,746,357	€ 3,922,559
NPV Benefits	€ 2,594,234	€ 2,069,380	€ 906,764
Economic BCR	**2.20**	**1.75**	**1.23**
Outcome Scores			
MCA PV Benefits	€ 2,345,544	€ 2,362,568	€ 2,369,007
MCA Benefit Score	821	792	692
MCA BCR	379.47	288.35	176.51
Option Selection MCA	1671	1892	1542

Table 5.73 Comparison of Options for Askeaton

5.1 Comparison of Multi Criteria Assessment Scores

Each option taken forward for further consideration through the Option Development Meeting, has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).

Categories	Option Reference and Results		
	ASN_01	ASN_02	ASN_03
Criteria Scores			
Technical	620	620	586
Economic	717	688	711
Social	839	839	839
Environmental	-538	-461	-501
Economic Values			
Economic PV Benefits	€ 11,684,894	€ 11,684,894	€ 10,845,041
PV Cost	€ 7,215,603	€ 5,948,539	€ 7,331,295
NPV Benefits	€ 4,469,291	€ 5,736,355	€ 3,513,746
Economic BCR	**1.62**	**1.96**	**1.48**
Outcome Scores			
MCA PV Benefits	€ 6,236,850	€ 6,236,850	€ 5,994,758
MCA Benefit Score	1018	1065	1049
MCA BCR	141.07	179.09	143.09
Option Selection MCA	1638	1685	1635

Table 5.74 Comparison of Options for Rathkeale

5.2 Comparison of Multi Criteria Assessment Scores		
Each option taken forward for further consideration through the Option Development Meeting, has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).		
Categories	**Option Reference and Results**	
	RAE_01	RAE_02
Criteria Scores		
Technical	967	1000
Economic	49	49
Social	41	38
Environmental	0	-50
Economic Values		
Economic PV Benefits	€ 307,720	€ 311,774
PV Cost	€ 261,021	€ 295,020
NPV Benefits	€ 46,699	€ 16,754
Economic BCR	**1.18**	**1.06**
Outcome Scores		
MCA PV Benefits	€ 279,026	€ 280,195
MCA Benefit Score	90	37
MCA BCR	343.45	124.92
Option Selection MCA	1056	1037

Table 5.75 Comparison of Options for Foynes

5.2 Comparison of Multi Criteria Assessment Scores		
Each option taken forward for further consideration through the Option Development Meeting, has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).		
Categories	**Option Reference and Results**	
	FOS_01	FOS_02
Criteria Scores		
Technical	633	567
Economic	740	479
Social	1483	1440
Environmental	-424	-514
Economic Values		
Economic PV Benefits	€ 14,390,127	€ 10,995,574
PV Cost	€ 8,501,093	€ 9,246,593
NPV Benefits	€ 5,889,034	€ 1,748,981
Economic BCR	**1.69**	**1.19**
Outcome Scores		
MCA PV Benefits	€ 8,530,369	€ 5,665,798
MCA Benefit Score	1800	1406
MCA BCR	211.70	152.01
Option Selection MCA	2433	1972

Table 5.76 Comparison of Options for Adare

5.2 Comparison of Multi Criteria Assessment Scores		
Each option taken forward for further consideration through the Option Development Meeting, has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).		
Categories	**Option Reference and Results**	
	ADE_01	ADE_02
Criteria Scores		
Technical	1043	350
Economic	765	816
Social	1276	737
Environmental	-507	-69
Economic Values		
Economic PV Benefits	€ 16,070,435	€ 16,070,435
PV Cost	€ 15,829,922	€ 10,075,466
NPV Benefits	€ 240,513	€ 5994,969
Economic BCR	**1.02**	**1.60**
Outcome Scores		
MCA PV Benefits	€ 7,690,720	€ 7,690,720
MCA Benefit Score	1534	1485
MCA BCR	96.94	147.38
Option Selection MCA	2577	1835

Table 5.77 Comparison of Options for Croom

5.2 Comparison of Multi Criteria Assessment Scores	
Each option taken forward for further consideration through the Option Development Meeting, has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).	
Categories	**Option Reference and Results**
	CRM_01
Criteria Scores	
Technical	880
Economic	457
Social	331
Environmental	-135
Economic Values	
Economic PV Benefits	€ 1,392,108
PV Cost	€ 643,235
NPV Benefits	€ 748,873
Economic BCR	**2.16**
Outcome Scores	
MCA PV Benefits	€ 746,553
MCA Benefit Score	653
MCA BCR	1015.10
Option Selection MCA	1533

Table 5.78 Comparison of Options for Milford

5.2 Comparison of Multi Criteria Assessment Scores Each option taken forward for further consideration through the Option Development Meeting, has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).	
Categories	**Option Reference and Results**
	MID_01
Criteria Scores	
Technical	900
Economic	18
Social	221
Environmental	0
Economic Values	
Economic PV Benefits	€ 263,754
PV Cost	€ 257,001
NPV Benefits	€ 6,753
Economic BCR	**1.03**
Outcome Scores	
MCA PV Benefits	€ 253,758
MCA Benefit Score	239
MCA BCR	931.81
Option Selection MCA	1139

Table 5.79 Comparison of Options for Ballylongford

5.2 Comparison of Multi Criteria Assessment Scores Each option taken forward for further consideration through the Option Development Meeting, has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).		
Categories	**Option Reference and Results**	
	BLD_01	BLD_02
Criteria Scores		
Technical	1200	867
Economic	849	840
Social	609	622
Environmental	-842	- 705
Economic Values		
Economic PV Benefits	€ 9,651,868	€ 9,329,478
PV Cost	€ 9,587,821	€ 8,573,095
NPV Benefits	€ 64,047	€ 756,383
Economic BCR	**1.01**	**1.09**
Outcome Scores		
MCA PV Benefits	€ 4,520,306	€ 4,427,375
MCA Benefit Score	617	757
MCA BCR	64.31	88.26
Option Selection MCA	1817	1623

6 Summary of Recommended Measures and Options

6.1 Recommendations at SSA: Unit of Management

The Flood Risk Management measures considered viable and therefore recommended for inclusion in the Flood Risk Management Plan at this Unit of Management SSA are:

- Flood Forecasting / Warning / Response
- Public Awareness;
- Planning and development control measures;
- Building Regulations;
- Land Use Management;
- Strategic development Management; and
- Additional Monitoring.

No Flood Risk Management options were considered viable at this Unit of Management SSA.

6.2 Recommendations at SSA: Sub-Catchment

The Flood Risk Management measures considered viable and therefore recommended for inclusion in the Flood Risk Management Plan at this sub-catchment SSA are:

- Flood Forecasting / Warning / Response
- Public Awareness;

No Flood Risk Management options were considered viable at this sub-catchment SSA.

6.3 Recommendations at SSA: AFA

Different Flood Risk Management measures were considered viable and therefore recommended for inclusion in the Flood Risk Management Plan, for each of the AFAs. A summary of these recommendations with the outcomes of the MCA process for each AFA is presented in Table 6.1.

Consultation days were held in all AFAs. Any comments that were made at these consultation days have been considered in both the development of the options and the selection of the preferred option for each AFA.

Table 6.1 Summary of MCA Outcomes for each AFA/ IRR

AFA/ IRR	MCA outcomes				
	Summary of Existing Risk / MCA		Recommended Measure		
	Total PV Damages		Baseline	Structural	Non Structural
	Capped	Uncapped			
Newcastle West	€ 5,449,585	€ 8,912,394	✓	✓	
Askeaton	€ 13,802,985	€ 33,832,933	✓	✓	
Rathkeale	€ 733,522	€ 733,522	✓		✓
Foynes	€ 18,560,260	€ 25,311,247	✓	✓	
Adare	€ 20,988,590	€ 29,233,925	✓	✓	✓
Croom	€ 2,458,545	€ 4,413,719	✓	✓	✓
Dromcolliher	€ 167,174	€ 266,081	Existing FRS		
Kilmallock	€ 79,805	€ 79,805	N/A	N/A	N/A
Tarbert	N/A	N/A	N/A	N/A	N/A
Clarina	€ 30,532	€ 30,532	N/A	N/A	N/A
Charleville	€ 56,826	€ 56,826	N/A	N/A	N/A
Milford	€ 420,819	€ 420,819	✓		✓
Ballylongford	€ 10,504,272	€ 20,249,734		✓	

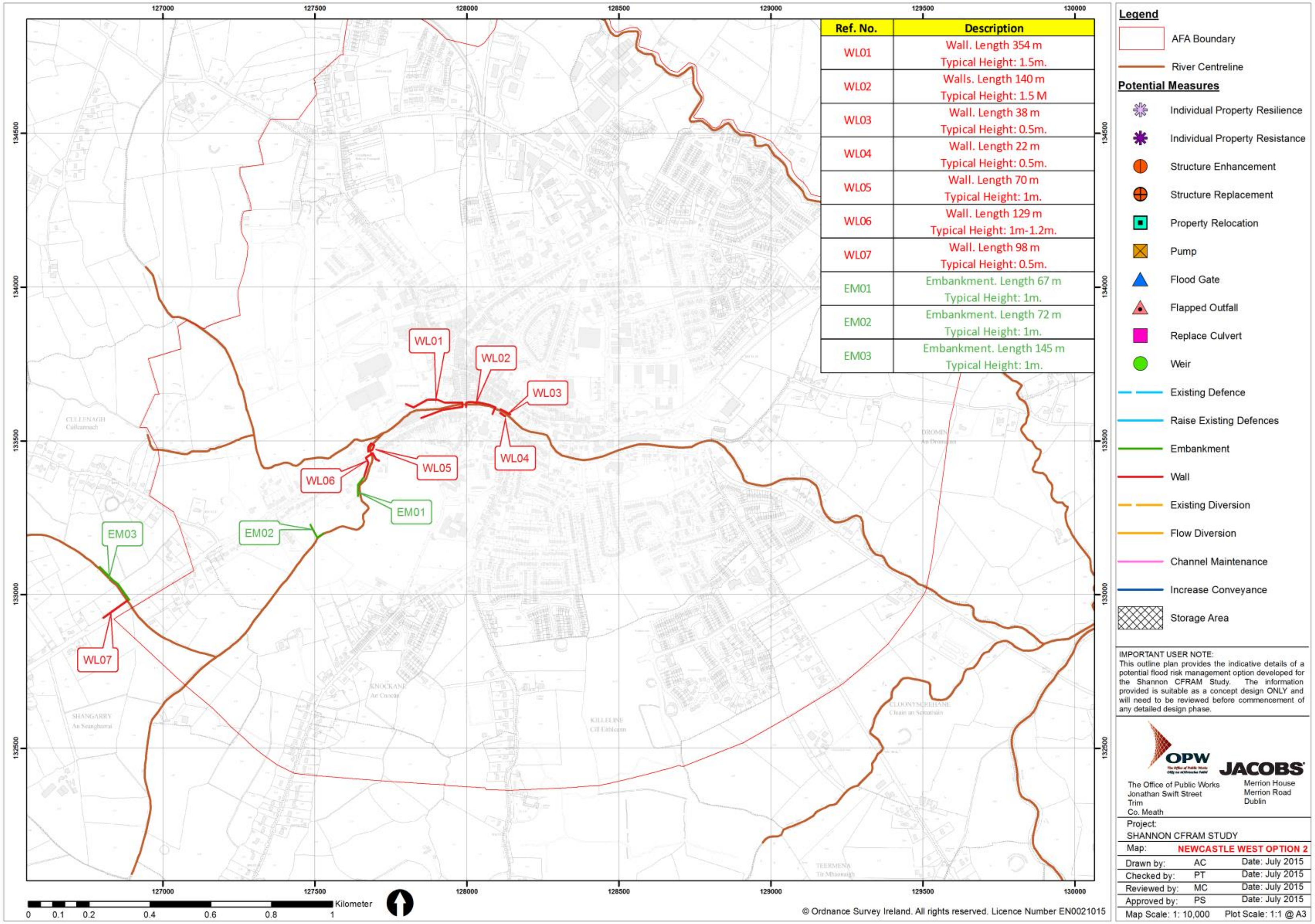
The following sections summarise the preferred Flood Risk Management option being recommended for inclusion in the Flood Risk Management Plan, for each AFA/ IRR respectively.

6.3.1 Newcastle West

The preferred option for Newcastle West with a MCA BCR of 294.20 is NWT_02. A summary of the option is provided in Table 6.2 and Figure 6.1 below.

Table 6.2 Summary of the preferred option for Newcastle West

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Newcastle West	Option Ref:	NWT_02
Option Measures			
Baseline	B	Existing Regime	
Structural	Gi	Flood Defences: New Flood Defences	
Non-Structural		N/A	
Criteria Scores			
Technical	1100		
Economic	540		
Social	558		
Environmental	-306		
Economic Values			
Economic PV Benefits	€ 4,815,737		
PV Cost	€ 2,746,357		
NPV Benefits	€ 2,069,380		
Economic BCR	**1.75**		
Outcome Scores			
MCA PV Benefits	€ 2,362,568		
MCA Benefit Score	792		
MCA BCR	288.35		
Option Selection MCA	1892		
Relevant Figure	Figure 6.1		



Ref. No.	Description
WL01	Wall. Length 354 m Typical Height: 1.5m.
WL02	Walls. Length 140 m Typical Height: 1.5 M
WL03	Wall. Length 38 m Typical Height: 0.5m.
WL04	Wall. Length 22 m Typical Height: 0.5m.
WL05	Wall. Length 70 m Typical Height: 1m.
WL06	Wall. Length 129 m Typical Height: 1m-1.2m.
WL07	Wall. Length 98 m Typical Height: 0.5m.
EM01	Embankment. Length 67 m Typical Height: 1m.
EM02	Embankment. Length 72 m Typical Height: 1m.
EM03	Embankment. Length 145 m Typical Height: 1m.

Figure 6.1 Summary of the preferred option for Newcastle West

6.3.2 Askeaton

The preferred option for Askeaton with a MCA BCR of 180.12 is ASN_02. A summary of the option is provided in Table 6.3 and Figure 6.2 below.

Table 6.3 Summary of the preferred option for Askeaton

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Askeaton	Option Ref:	ASN_02
Option Measures			
Baseline	B	Existing Regime	
Structural	Fi	Increase Conveyance: Channel Dredging	
	Fii	Increase Conveyance: Channel Widening	
	Fiii	Increase Conveyance: Structure Enhancement / Works	
	Gi	Flood Defences: New Flood Defences	
Non-Structural		N/A	
Criteria Scores			
Technical	620		
Economic	688		
Social	839		
Environmental	-461		
Economic Values			
Economic PV Benefits	€ 11,684,894		
PV Cost	€ 5,948,539		
NPV Benefits	€ 5,736,355		
Economic BCR	**1.96**		
Outcome Scores			
MCA PV Benefits	€ 6,236,850		
MCA Benefit Score	1065		
MCA BCR	179.09		
Option Selection MCA	1685		
Relevant Figure	Figure 6.2		

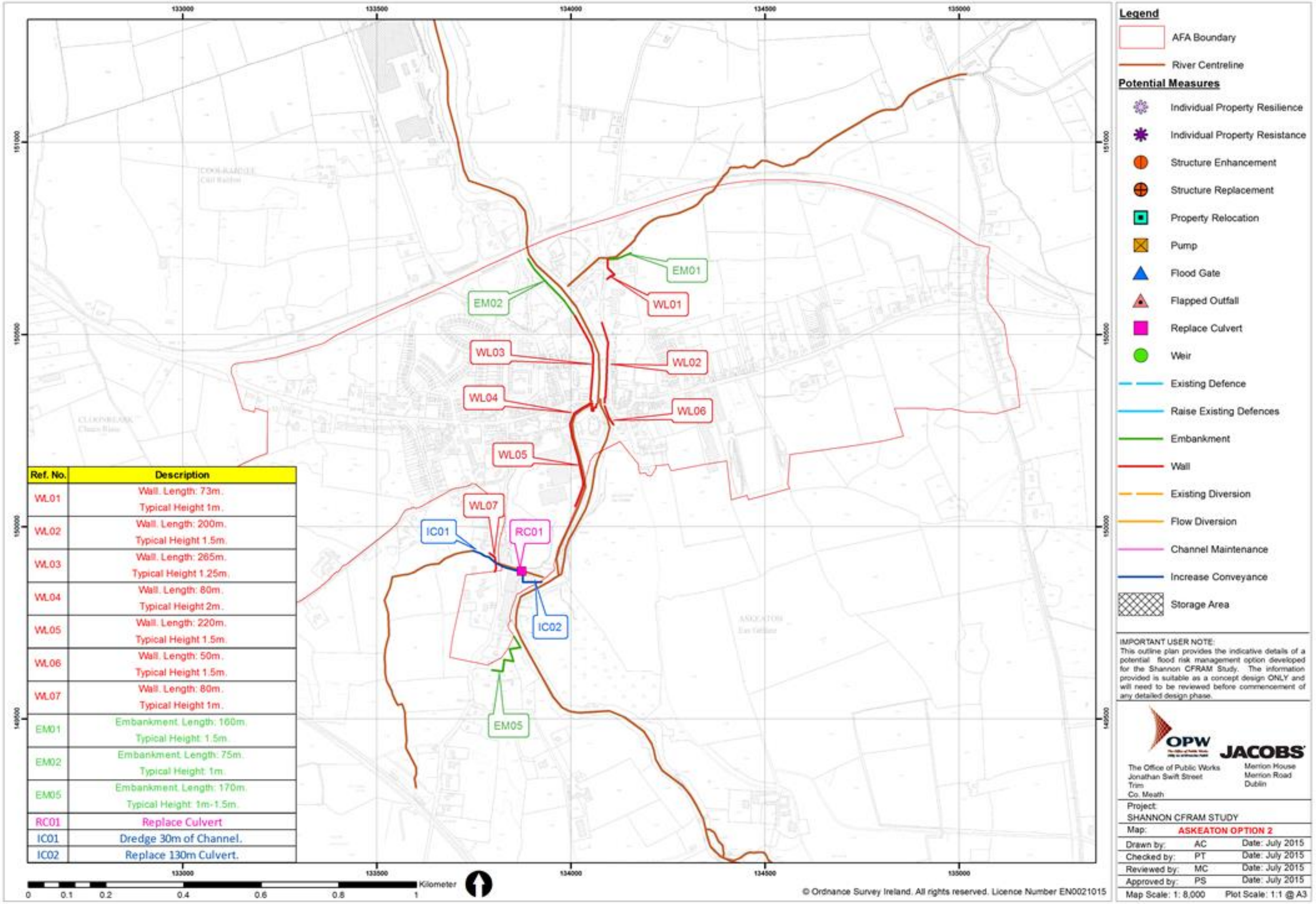


Figure 6.2 Summary of the preferred option for Askeaton

6.3.3 Rathkeale

The preferred option for Rathkeale with a MCA BCR of 257.24 is RAE_01. A summary of the option is provided in Table 6.4 below.

Table 6.4 Summary of the preferred option for Rathkeale

<table>
<tr><td colspan="4">Multi Criteria Assessment
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.</td></tr>
<tr><td>AFA</td><td>Rathkeale</td><td>Option Ref:</td><td>RAE_01</td></tr>
<tr><td colspan="4">Option Measures</td></tr>
<tr><td>Baseline</td><td>B</td><td colspan="2">Existing Regime</td></tr>
<tr><td>Structural</td><td></td><td colspan="2">None</td></tr>
<tr><td rowspan="3">Non-Structural</td><td>J</td><td colspan="2">Flood Forecasting / Warning / Response</td></tr>
<tr><td>K</td><td colspan="2">Public Awareness</td></tr>
<tr><td>L</td><td colspan="2">Individual Property Resistance</td></tr>
<tr><td colspan="4">Criteria Scores</td></tr>
<tr><td colspan="2">Technical</td><td colspan="2">967</td></tr>
<tr><td colspan="2">Economic</td><td colspan="2">49</td></tr>
<tr><td colspan="2">Social</td><td colspan="2">41</td></tr>
<tr><td colspan="2">Environmental</td><td colspan="2">0</td></tr>
<tr><td colspan="4">Economic Values</td></tr>
<tr><td colspan="2">Economic PV Benefits</td><td colspan="2">€ 307,720</td></tr>
<tr><td colspan="2">PV Cost</td><td colspan="2">€ 261,021</td></tr>
<tr><td colspan="2">NPV Benefits</td><td colspan="2">€ 46,699</td></tr>
<tr><td colspan="2">Economic BCR</td><td colspan="2">1.18</td></tr>
<tr><td colspan="4">Outcome Scores</td></tr>
<tr><td colspan="2">MCA PV Benefits</td><td colspan="2">€ 279,026</td></tr>
<tr><td colspan="2">MCA Benefit Score</td><td colspan="2">90</td></tr>
<tr><td colspan="2">MCA BCR</td><td colspan="2">343.45</td></tr>
<tr><td colspan="2">Option Selection MCA</td><td colspan="2">1056</td></tr>
<tr><td colspan="2">Relevant Figure</td><td colspan="2">Figure 6.3</td></tr>
</table>

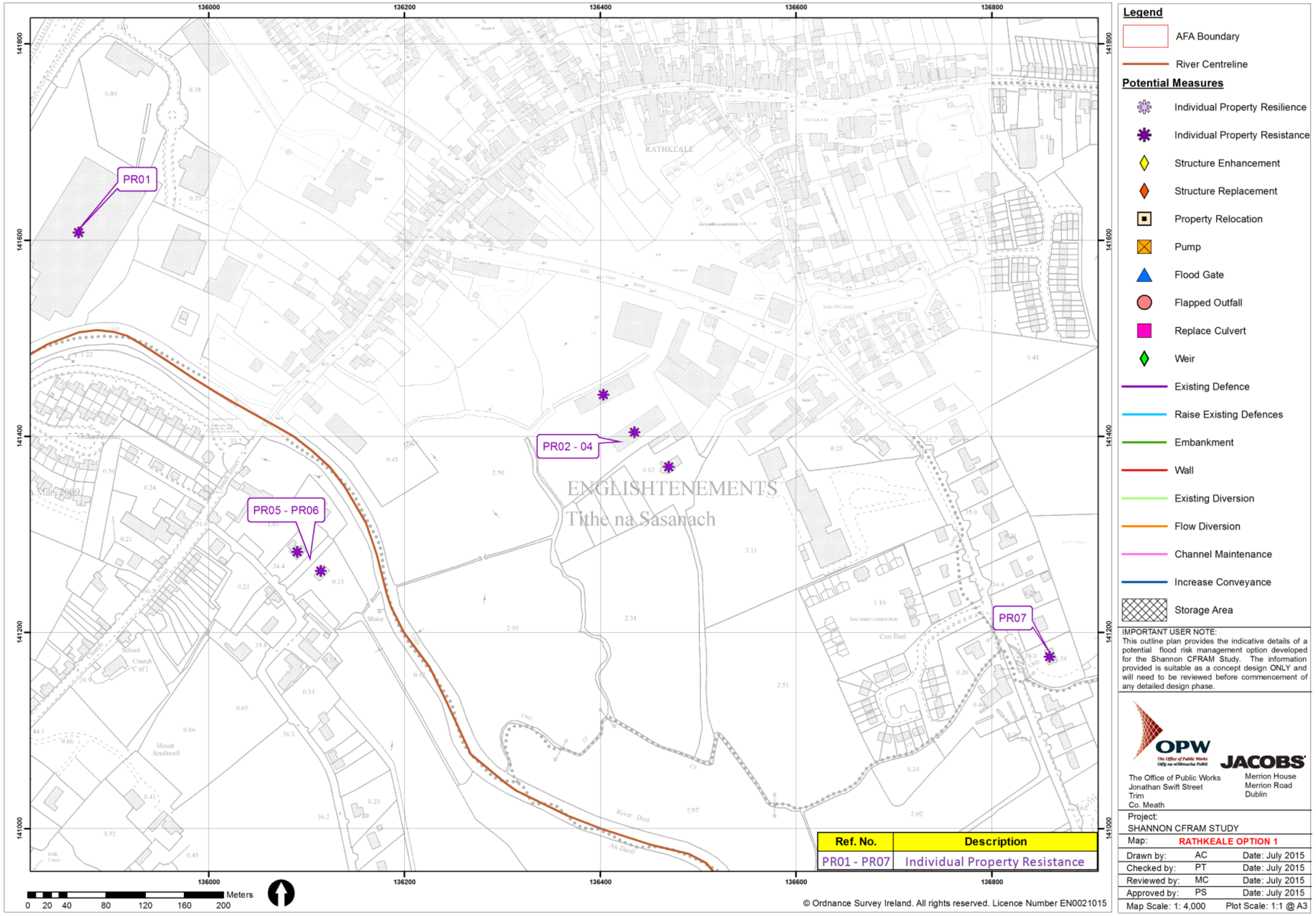


Figure 6.3 Summary of the preferred option for Rathkeale

6.3.4 Foynes

The preferred option for Foynes with a MCA BCR of 211.70 is FOS_01. A summary of the option is provided in Table 6.5 and Figure 6.4 below.

Table 6.5 Summary of the preferred option for Foynes

<table>
<tr><td colspan="4">Multi Criteria Assessment
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.</td></tr>
<tr><td>AFA</td><td>Foynes</td><td>Option Ref:</td><td>FOS_01</td></tr>
<tr><td colspan="4">Option Measures</td></tr>
<tr><td>Baseline</td><td>B</td><td colspan="2">Existing Regime</td></tr>
<tr><td rowspan="2">Structural</td><td>Gi</td><td colspan="2">Flood Defences: New Flood Defences</td></tr>
<tr><td>I</td><td colspan="2">Other: Flapped Outfall</td></tr>
<tr><td>Non-Structural</td><td colspan="3">N/A</td></tr>
<tr><td colspan="4">Criteria Scores</td></tr>
<tr><td colspan="2">Technical</td><td colspan="2">633</td></tr>
<tr><td colspan="2">Economic</td><td colspan="2">740</td></tr>
<tr><td colspan="2">Social</td><td colspan="2">1483</td></tr>
<tr><td colspan="2">Environmental</td><td colspan="2">-424</td></tr>
<tr><td colspan="4">Economic Values</td></tr>
<tr><td colspan="2">Economic PV Benefits</td><td colspan="2">€ 14,390,127</td></tr>
<tr><td colspan="2">PV Cost</td><td colspan="2">€ 8,501,093</td></tr>
<tr><td colspan="2">NPV Benefits</td><td colspan="2">€ 5,889,034</td></tr>
<tr><td colspan="2">Economic BCR</td><td colspan="2">1.69</td></tr>
<tr><td colspan="4">Outcome Scores</td></tr>
<tr><td colspan="2">MCA PV Benefits</td><td colspan="2">€ 8,530,369</td></tr>
<tr><td colspan="2">MCA Benefit Score</td><td colspan="2">1800</td></tr>
<tr><td colspan="2">MCA BCR</td><td colspan="2">211.70</td></tr>
<tr><td colspan="2">Option Selection MCA</td><td colspan="2">2433</td></tr>
<tr><td colspan="2">Relevant Figure</td><td colspan="2">Figure 6.4</td></tr>
</table>

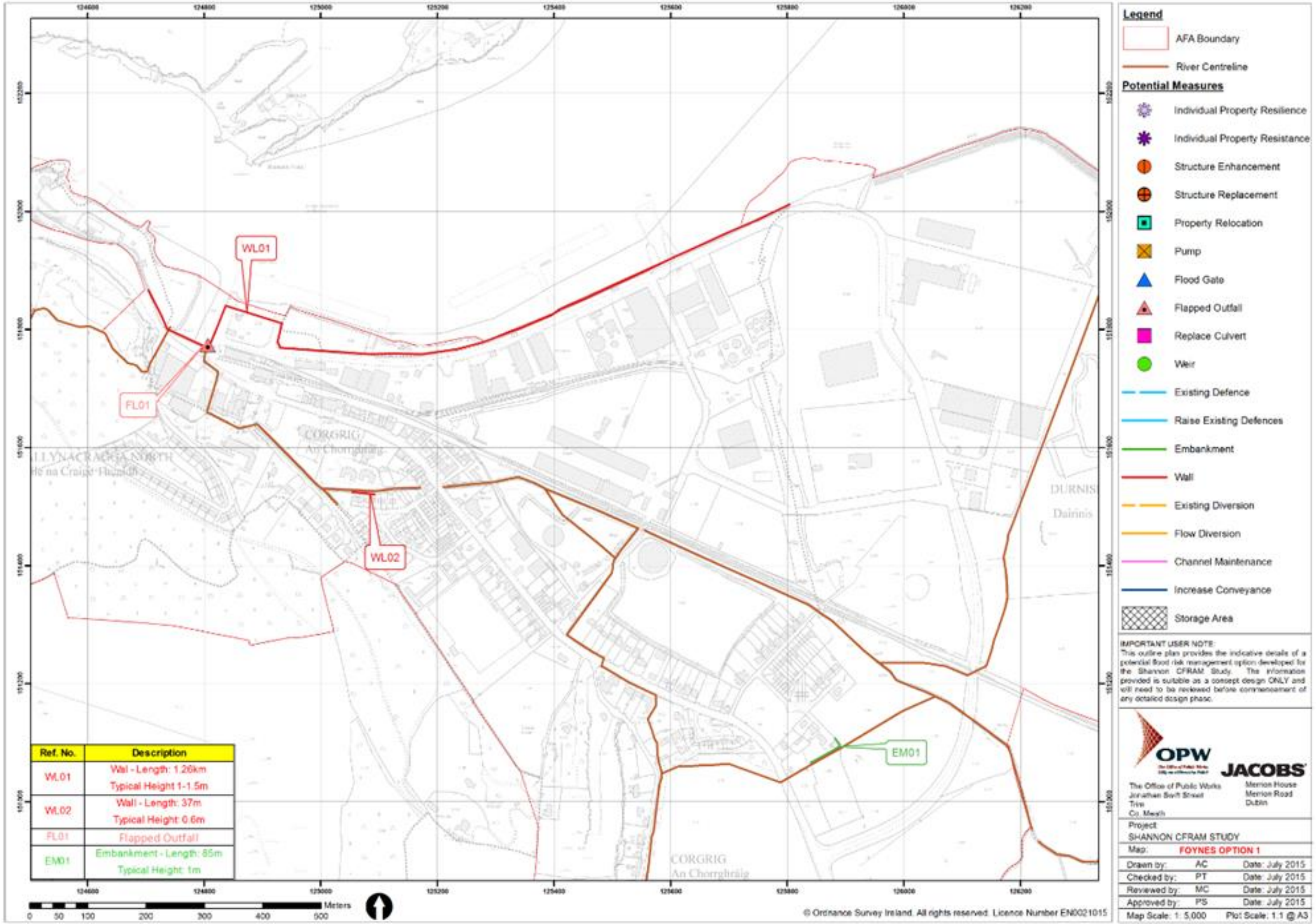


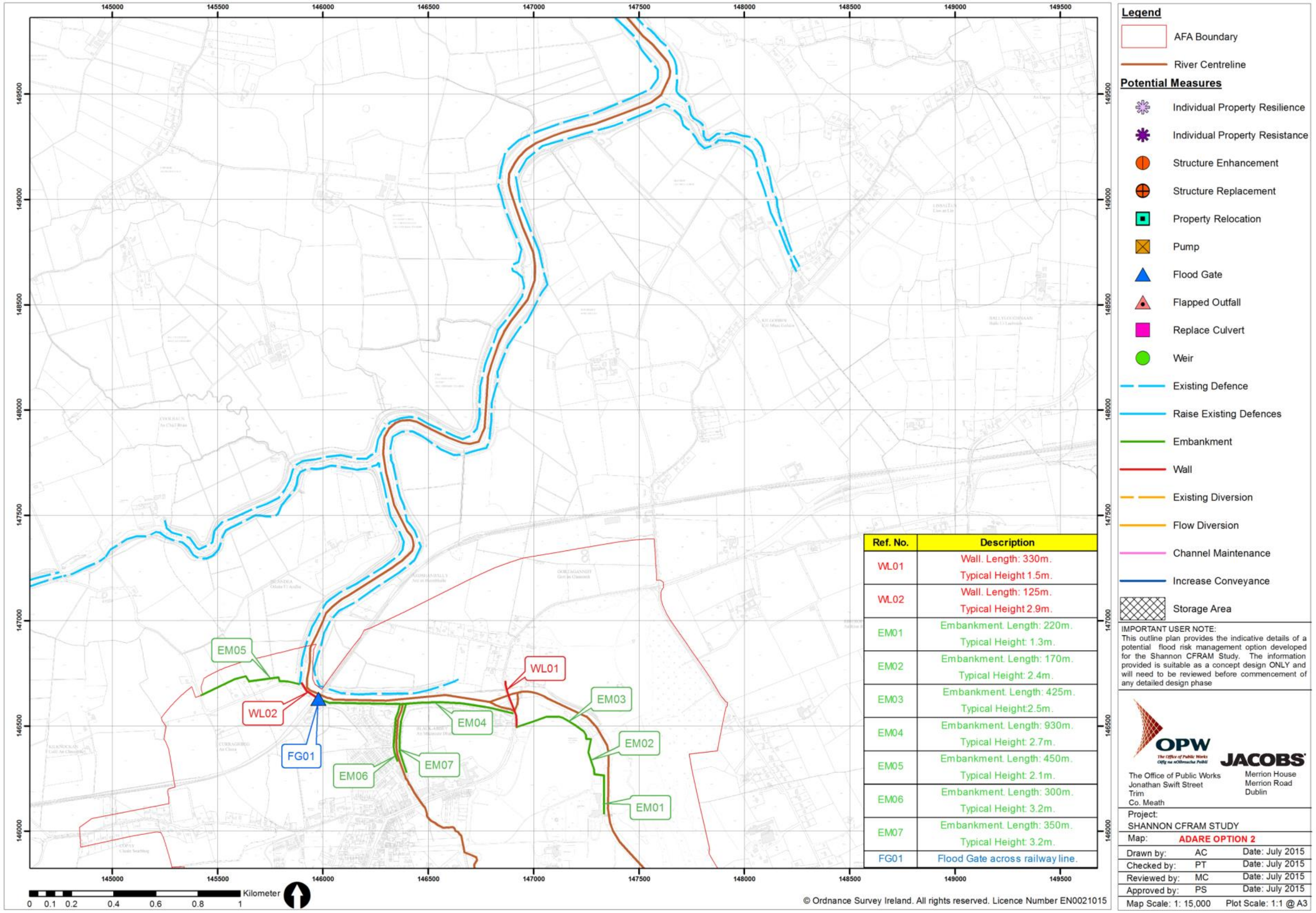
Figure 6.4 Summary of the preferred option for Foynes

6.3.5 Adare

The preferred option for Adare with a MCA BCR of 147.38 is ADE_02. A summary of the option is provided in Table 6.6 and Figure 6.5 below.

Table 6.6 Summary of the preferred option for Adare

<table>
<tr><td colspan="4">Multi Criteria Assessment
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.</td></tr>
<tr><td>AFA</td><td>Adare</td><td>Option Ref:</td><td>ADE_02</td></tr>
<tr><td colspan="4">Option Measures</td></tr>
<tr><td>Baseline</td><td>B</td><td colspan="2">Existing Regime</td></tr>
<tr><td rowspan="2">Structural</td><td>Gi</td><td colspan="2">Flood Defences: New Flood Defences</td></tr>
<tr><td>Giii</td><td colspan="2">Flood Defences: Demountable Defences</td></tr>
<tr><td>Non-Structural</td><td>J</td><td colspan="2">Flood Forecasting</td></tr>
<tr><td colspan="4">Criteria Scores</td></tr>
<tr><td colspan="2">Technical</td><td colspan="2">350</td></tr>
<tr><td colspan="2">Economic</td><td colspan="2">816</td></tr>
<tr><td colspan="2">Social</td><td colspan="2">737</td></tr>
<tr><td colspan="2">Environmental</td><td colspan="2">-69</td></tr>
<tr><td colspan="4">Economic Values</td></tr>
<tr><td colspan="2">Economic PV Benefits</td><td colspan="2">€ 16,070,435</td></tr>
<tr><td colspan="2">PV Cost</td><td colspan="2">€ 10,075,466</td></tr>
<tr><td colspan="2">NPV Benefits</td><td colspan="2">€ 5,994,969</td></tr>
<tr><td colspan="2">Economic BCR</td><td colspan="2">1.60</td></tr>
<tr><td colspan="4">Outcome Scores</td></tr>
<tr><td colspan="2">MCA PV Benefits</td><td colspan="2">€ 7,690,720</td></tr>
<tr><td colspan="2">MCA Benefit Score</td><td colspan="2">1485</td></tr>
<tr><td colspan="2">MCA BCR</td><td colspan="2">147.38</td></tr>
<tr><td colspan="2">Option Selection MCA</td><td colspan="2">1835</td></tr>
<tr><td colspan="2">Relevant Figure</td><td colspan="2">Figure 6.5</td></tr>
</table>



Ref. No.	Description
WL01	Wall. Length: 330m. Typical Height 1.5m.
WL02	Wall. Length: 125m. Typical Height 2.9m.
EM01	Embankment. Length: 220m. Typical Height: 1.3m.
EM02	Embankment. Length: 170m. Typical Height: 2.4m.
EM03	Embankment. Length: 425m. Typical Height:2.5m.
EM04	Embankment. Length: 930m. Typical Height: 2.7m.
EM05	Embankment. Length: 450m. Typical Height: 2.1m.
EM06	Embankment. Length: 300m. Typical Height: 3.2m.
EM07	Embankment. Length: 350m. Typical Height: 3.2m.
FG01	Flood Gate across railway line.

Figure 6.5 Summary of the preferred option for Adare

6.3.6 Croom

The preferred option for Croom with a MCA BCR of 1070.84 is CRM_01. A summary of the option is provided in Table 6.7 and Figure 6.6 below.

Table 6.7 Summary of the preferred option for Croom

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Croom	Option Ref:	CRM_01
Option Measures			
Baseline	B	Existing Regime	
Structural	Gi	New Flood Defences	
Non-Structural	J	Flood Forecasting / Warning / Response	
	K	Public Awareness	
	L	Individual Property Resistance	
	M	Individual Property Resilience	
Criteria Scores			
Technical	880		
Economic	457		
Social	331		
Environmental	-135		
Economic Values			
Economic PV Benefits	€ 1,392,108		
PV Cost	€ 643,235		
NPV Benefits	€ 748,873		
Economic BCR	**2.16**		
Outcome Scores			
MCA PV Benefits	€ 746,553		
MCA Benefit Score	653		
MCA BCR	1015.10		
Option Selection MCA	1533		
Relevant Figure	Figure 6.6		

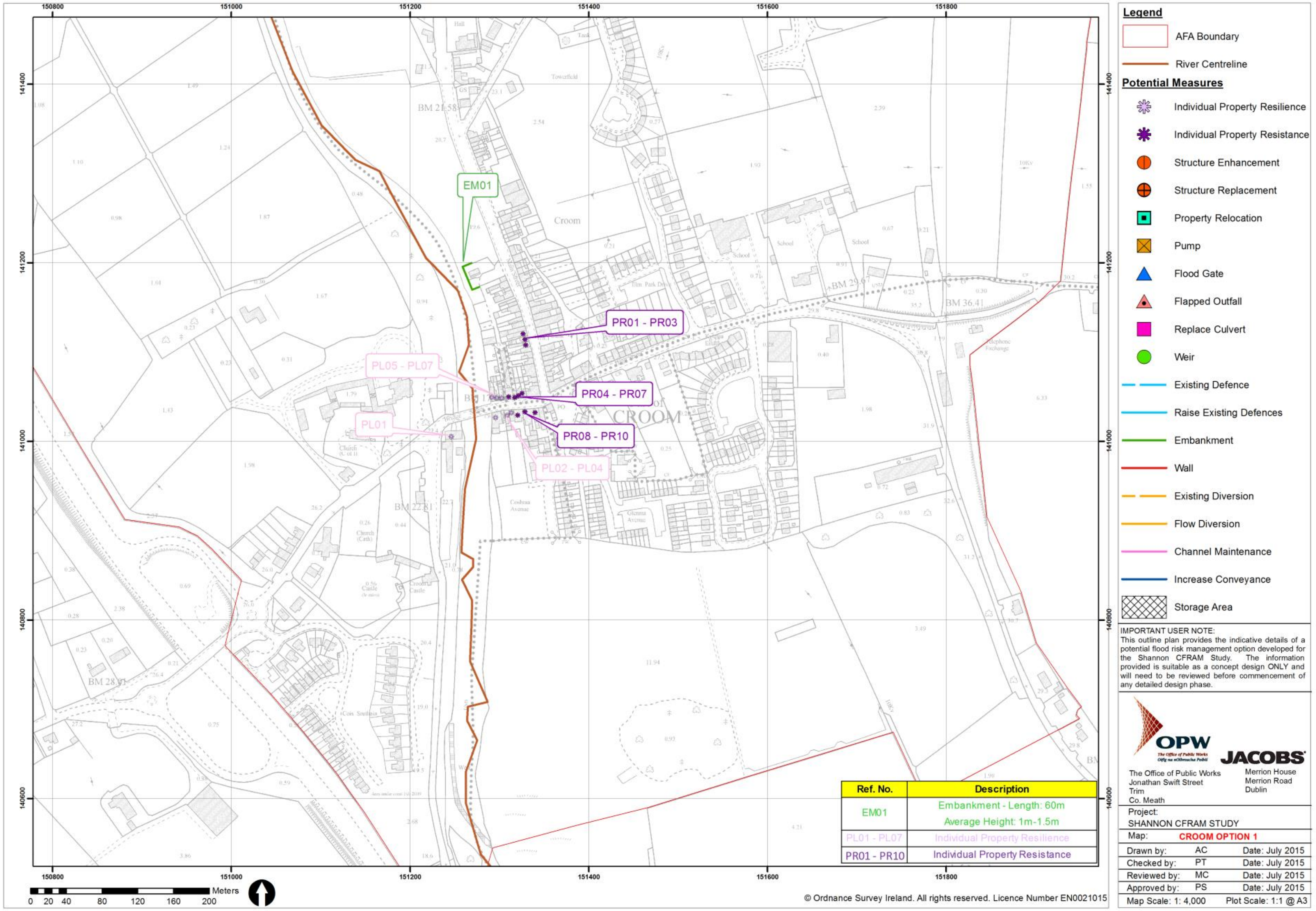


Figure 6.6 Summary of the preferred option for Croom

6.3.7 Milford

The preferred option for Milford with a MCA BCR of 863.71 is MID_01. A summary of the option is provided in Table 6.8 and Figure 6.7 below.

Table 6.8 Summary of the preferred option for Milford

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Milford	Option Ref:	MID_01
Option Measures			
Baseline	B	Existing Regime	
Structural		N\A	
Non-Structural	K	Public Awareness	
	M	Individual Property Resilience	
Criteria Scores			
Technical	900		
Economic	18		
Social	221		
Environmental	0		
Economic Values			
Economic PV Benefits	€ 263,754		
PV Cost	€ 257,001		
NPV Benefits	€ 6,753		
Economic BCR	**1.03**		
Outcome Scores			
MCA PV Benefits	€ 253,758		
MCA Benefit Score	239		
MCA BCR	931.81		
Option Selection MCA	1139		
Relevant Figure	Figure 6.7		

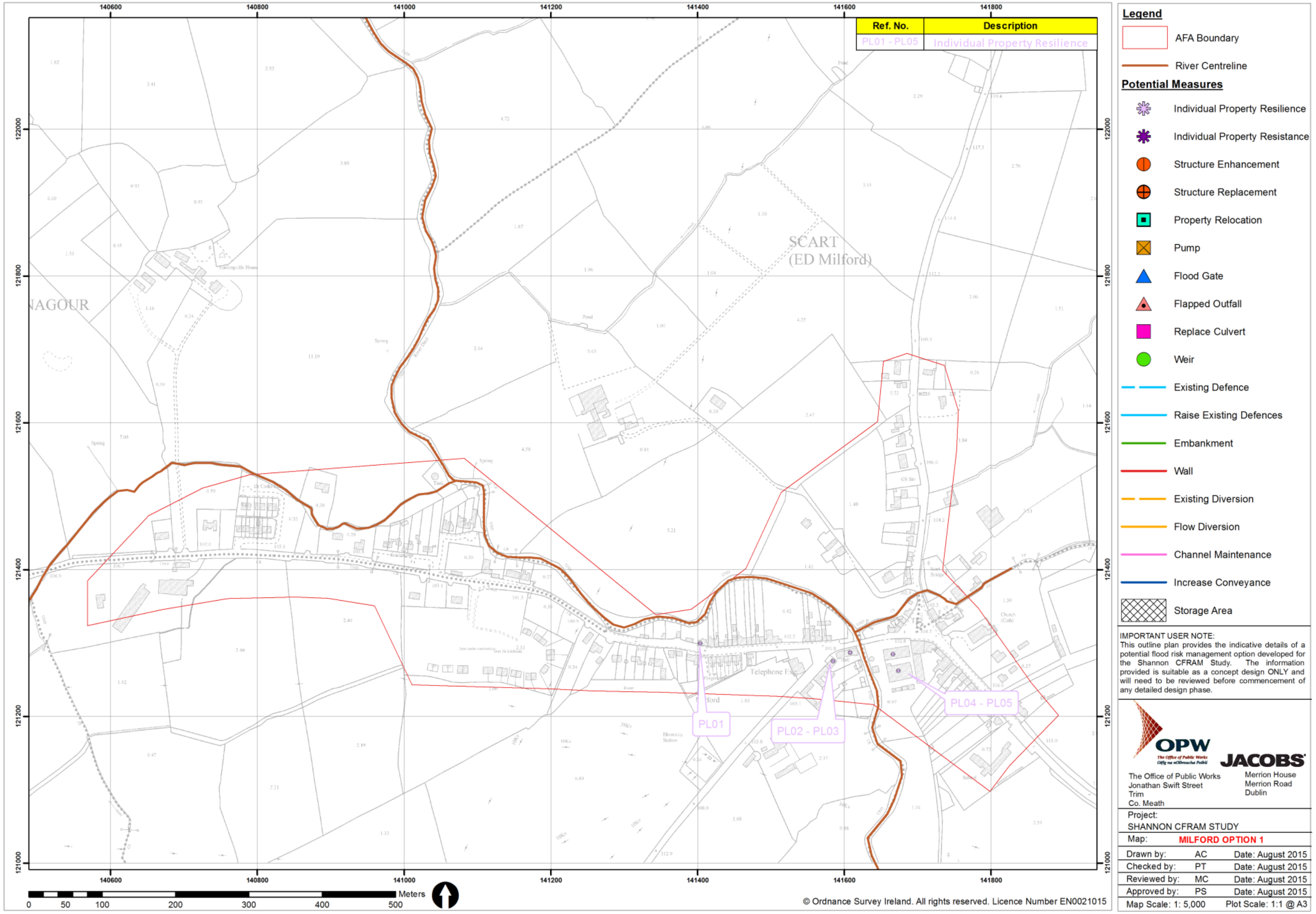


Figure 6.7 Summary of the preferred option for Milford

6.3.8 Ballylongford

The preferred option for Ballylongford with a MCA BCR of 69.52 is BLD_01. A summary of the option is provided in Table 6.9 and Figure 6.8 below.

Table 6.9 Summary of the preferred option for Ballylongford

<table>
<tr><td colspan="6">Multi Criteria Assessment
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.</td></tr>
<tr><td>AFA</td><td colspan="2">Ballylongford</td><td>Option Ref:</td><td colspan="2">BLD_01</td></tr>
<tr><td colspan="6">Option Measures</td></tr>
<tr><td>Baseline</td><td></td><td>None</td><td rowspan="2">Non Structural</td><td></td><td></td></tr>
<tr><td>Structural</td><td>Gi</td><td>New Flood Defences</td><td></td><td></td></tr>
<tr><td colspan="6">Criteria Scores</td></tr>
<tr><td colspan="3">Technical</td><td colspan="3">1200</td></tr>
<tr><td colspan="3">Economic</td><td colspan="3">849</td></tr>
<tr><td colspan="3">Social</td><td colspan="3">609</td></tr>
<tr><td colspan="3">Environmental</td><td colspan="3">-842</td></tr>
<tr><td colspan="6">Economic Values</td></tr>
<tr><td colspan="3">Economic PV Benefits</td><td colspan="3">€ 9,651,868</td></tr>
<tr><td colspan="3">PV Cost</td><td colspan="3">€ 9,587,821</td></tr>
<tr><td colspan="3">NPV Benefits</td><td colspan="3">€ 64,047</td></tr>
<tr><td colspan="3">Economic BCR</td><td colspan="3">1.01</td></tr>
<tr><td colspan="6">Outcome Scores</td></tr>
<tr><td colspan="3">MCA PV Benefits</td><td colspan="3">€ 4,520,306</td></tr>
<tr><td colspan="3">MCA Benefit Score</td><td colspan="3">617</td></tr>
<tr><td colspan="3">MCA BCR</td><td colspan="3">64.31</td></tr>
<tr><td colspan="3">Option Selection MCA</td><td colspan="3">1817</td></tr>
<tr><td colspan="3">Relevant Figure</td><td colspan="3">Figure 6.8</td></tr>
</table>

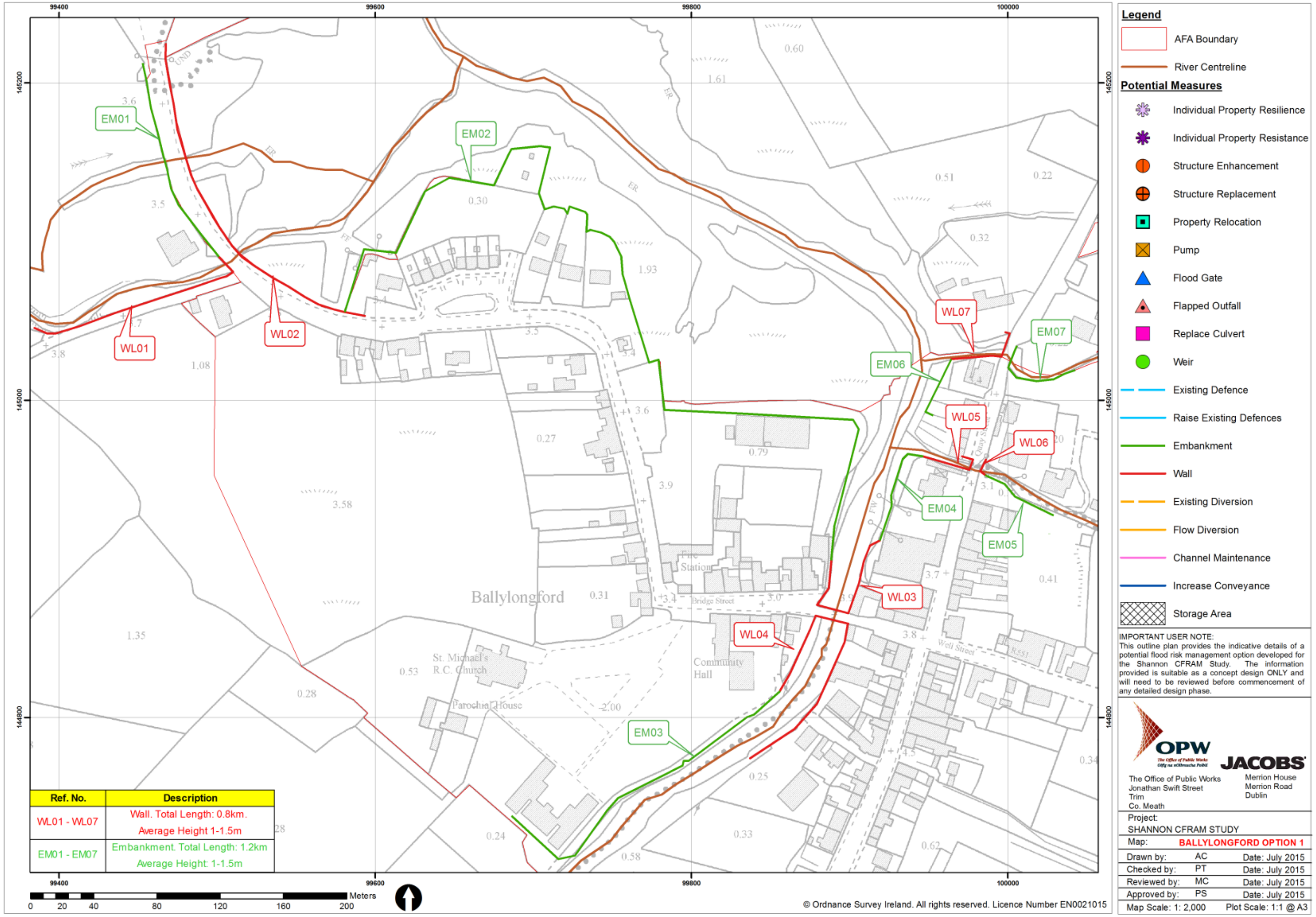


Figure 6.8 Summary of the preferred option for Ballylongford

Appendix A Glossary

Annual Exceedance Probability Or AEP	The probability that a certain flow value will be exceeded in any one year. For example the flow associated with the 1% AEP event at a particular location has a 1 in 100 chance of being exceeded in any year. A 5% AEP event has a 1 in 20 chance of being exceeded in any year.
Area for Further Assessment Or AFA	An area that is considered to be at potentially significant risk, thereby justifying its inclusion for further assessment. Note that the term AFA is a replacement term for what was previously referred to as an APSR (Area of Potential Significant Risk). AFAs include cities, towns and villages.
Areas of Potential Moderate Risk Or APMR	The areas to which the MPWs could give to rise existing or potential future fluvial and estuarine flooding are defined as the Fluvial Areas of Potential Moderate Risk (APMRs). Areas outside of APSRs that could be prone to coastal flooding are defined as Coastal APMRs.
Benefit – Cost Ratio	Present Value Benefits divided by the Present Value Costs
Catchment Flood Risk Assessment and Management Study Or CFRAM Study	The five-year study covering the whole River Shannon catchment area which gives a picture of past flooding and areas at risk of future flooding, and sets out a prioritised set of specific measures for reducing and managing flood risk.
Flood Cell	Discrete areas of flood risk within a given AFA are referred to as ‘flood cells
Flood Risk Management Measure (FRM Measure)	A flood risk management strategy option (‘option’) consists of one or more flood risk management measures.
Habitats Directive	The Habitats Directive [92/43/EEC] aims at securing biodiversity through the provision of protection for animal and plant species and habitat types of European importance.
High – End Future Scenario Or HEFS	Potential future scenario representing climate change impacts not significantly outside the range of accepted predictions available, and with the allowances for increased flow, sea level rise etc. at the upper bounds of widely accepted projections
Individual Risk Receptor Or IRR	A single receptor (see below) that has been determined to represent a potentially significant flood risk (as opposed to a community or other area at potentially significant flood risk AFA).

Multi Criteria Assessment Or MCA	It is the framework which has been developed to assess the different range of potential impacts that the implementation of a measure/option will provide.
Mid – Range Future Scenario Or MRFS	Represents a 'likely' future scenario based on the wide range of predictions available and with the allowances for increased flow, sea level rise, etc. within the bounds of widely accepted projections
NIAH	National Inventory of Architectural Heritage
Present Value Damages Or PVd	The present value of damages associated with the current flood risk.
Present Value Benefits Or PVb	The reduction of the PVd a flood risk management option will provide
River Basin District Or RBD	The natural geographical and hydrological units for water management, as defined during the implementation of the Water Framework Directive.
Spatial Scale of Assessment Or SSA	The scale at which an assessment is to be undertaken. There are four SSAs for this study: - UoM - Sub-catchment - AFA - IRR
Unit of Management Or UoM	The division of the study area into major catchments and their associated coastal areas.

Appendix B Flood Risk Management Measures

The flood risk management (FRM) measures are set out in Table 3.7 of the main report, and presented again below in Table B.1 for clarity. These FRM measures will form the FRM option or options.

Table B.1: FRM Measures and applicable SSA

Flood Risk Management Measure		Applicable SSA
Ref	**Title**	
Baseline		
A	Do Nothing	AFA/IRR
B	Existing Regime	AFA/IRR
C	Do Minimum	AFA/IRR
Structural		
D	Storage	All
E	Flow Diversion	All
F	Increase Conveyance	All
G	Construct Flood Defences	All
H	Relocation of Properties	AFA/IRR
I	Other Measures	All
Non Structural		
J	Flood Forecasting / Warning / Response	All
K	Public Awareness	All
L	Individual property resistance	AFA/IRR
M	Individual property resilience	AFA/IRR
N	Planning and development control measures	UoM
O	Building regulations	UoM
P	Sustainable urban drainage systems	AFA/IRR
Q	Land use management	All
R	Strategic development management	UoM
S	Additional Monitoring (rain and river level/flow gauges)	UoM

This Appendix provides:

- Definition for each FRM measure;
- How each FRM measure is considered and specified; and
- Assumptions made on the viability of FRM measures at the "screening of measures" stage.

Appendix B1: Baseline Measures

A - Do Nothing

Definition

Implement no new flood risk management measures and abandon any existing practices.

Screening of the Measure

The Do Nothing FRM measure can only be considered as an independent measure; it cannot be considered in combination with another FRM measures.

The Do Nothing FRM measure has only been considered in the following scenarios;

- Where there is 'low' flood risk categorisation; and
- Abandoning any existing works (maintenance or capital) will not have a negative impact on the existing flood risk; and
- There are no location-specific reasons as to why measures need to be investigated; and
- There are no other viable measures, including the Existing Regime (Measure B) and Do minimum (Measure C) measures.

The Do Nothing FRM measure cannot be screened out until all other FRM methods have been assessed.

B - Existing Regime

Definition

Continue with any existing flood risk management practices, such as reactive maintenance.

Screening of the Measure

The Existing Regime FRM measure has been considered as an independent viable measure in the following scenarios:

- Where there is 'low' flood risk categorisation; and
- There are no location-specific reasons as to why measures need to be investigated; and
- There are no other viable measures, including the Do minimum (Measure C) measures.

The Existing Regime FRM measure has also been considered in combination with other FRM measures and has generally been considered 'viable', as to discontinue with existing flood risk management practices is likely to have a negative impact to the existing flood risk.

Where the Existing Regime FRM measure has been considered 'unviable' in combination with other FRM measures, is:

- When the existing flood risk management practices have been found to be economically unsustainable; and
- There are other viable FRM measures which will mitigate any negative impact resulting from the abandonment of the existing flood risk management practices.

The Existing Regime FRM measure cannot be screened out until all other FRM methods have been assessed.

C - Do Minimum

Definition

Implement additional minimal maintenance type works to reduce the flood risk in specific locations. This includes implementing reactive maintenance where it has

not previously being implemented i.e. removal of debris at structures, cutting of grass/ clearing hedgerows/ low lying branches along the river bank, removal of loose debris and rubbish from the channel bed.

Screening of the Measure

The Do Minimum FRM measure has been considered as an independent viable measure in the following scenarios:

- Where there is 'low' flood risk categorisation; and
- There are no location-specific reasons as to why measures need to be investigated; and
- There are no other viable measures,

The Do Minimum FRM measure has also been considered in combination with other FRM measures.

Assessing the likely reduction in flood risk from the Do Minimum FRM measure has been based on the following factors:

- Engineering judgement using site photographs and survey data. If this dataset indicates no build-up of debris/rubbish in channel, the conclusion can be drawn that the introduction of a reactive maintenance is likely not to have a significant impact on flood risk; and
- Sensitivity tests have been carried out using the hydraulic models which indicates the reduction in channel water levels subject to a 20% reduction in Manning's n. While it has not been anticipated that the introduction of reactive maintenance will provide a 20% reduction to Manning's n, the results of this sensitivity tests have provided an indication of the watercourse's sensitivity to an improvement of in channel conveyance.

The Do Minimum FRM measure cannot be screened out until all other FRM methods have been assessed.

Appendix B2: Structural Measures

D - Storage

Definition

Single or multiple site, online or offline flood water storage, flood retardation, etc. Detention basins and ponds are not considered as storage as these are considered as SuDS FRM measures.

There are different sub-types of Storage FRM Measures, which are summarised in Table B.2.

Table B-2 Types of Storage FRM measures

D – Storage	Di – On-line Storage
	Dii – Off-line Storage
	Diii – Other Storage

Concept Design

The concept design for any storage measure will be unique and dependant on the existing ground topography, location from watercourses, and volume of flood water to be stored.

Consideration has been given to all these parameters, along with health and safety, operation and maintenance issues, when determining the viability of this FRM Measure.

Freeboard Allowance

A freeboard allowance has been applied to the retaining structures needed as part of the concept design for any storage measure. This freeboard is to allow for model and construction uncertainty with these allowances summarised in Table B.3.

Table B-3 Freeboard applied to retaining structure for Storage

Defence Type	Freeboard – Fluvial (m)	Freeboard – Tidal (m)
Storage reservoir walls	0.220	N/A

Climate change

Where possible, an allowance has been made in the concept designs for adaptability to the HEFS. This has primarily used the sensitivity results from the hydraulic modelling exercise where allowances to account for Climate Change, have been included.

Screening of the Measure

The Storage FRM measure can be assessed as a viable FRM measure independently or in combination with other FRM measures.

The three key parameters when determining the viability of storage as a FRM measure are:

- Technically acceptable – Will the storing and attenuation of floodwater significantly reduce flood risk.
- Suitable topography – Is the topography suitable to store the desired volume of flood water (either online of offline).
- Economics - What are the likely construction and maintenance costs for such a concept design.

Storage has not been considered viable where the source of flood risk is coastal.

The economic viability of the storage FRM measure has been estimated at the screening of measures phase (Stage 2 of the Optioneering Assessment). The PV benefits of the storage FRM measure have been calculated as the PV damages of the properties protected for all return periods up to the standard of protection of the storage unit.

Modelling of viable options

When a storage FRM measure has been considered a viable option independently or in combination with other measures, hydraulic modelling of the storage feature has been carried out:

- To confirm the required dimension of the storage area; and
- To confirm the dimensions of any weir structures required to divert flow; and
- To determine the standard of protection to be provided; and
- To understand the impact of water levels upstream and downstream of the storage area.

E - Flow Diversion

Definition

The diversion of flood waters to either increase conveyance or avoid area at risk. There are different sub-types of the Flow Diversion FRM Measure, which are summarised in Table B.4.

Table B-4 Types of Flow Diversion FRM measures

E – Flow Diversion	Ei – Full Diversion
	Eii – Flood Relief Channel
	Eiii – Other Diversion/Channel

Concept Design

The parameters used for the concept designs of this FRM Measure are as follows:

- Flow diversion channels have been specified as inverted channels where the excavated fill is used to form embankments along the side of the channel to allow additional storage. The formed embankments are considered as flood defences.

Freeboard

A freeboard allowance has been applied to any associated flood defence to allow for model and construction uncertainty with these allowances summarised in Table B.5.

Table B-5 Freeboard applied to Defences

Defence Type	Freeboard – Fluvial (m)	Freeboard – Tidal (m)
Storage reservoir walls	0.220	N/A

Climate change

Where possible, the measure has been designed to be adaptable for the HEFS. This has taken the form of over-designing the channel capacity and considerations for any associated flood defences.

Screening of the Measure

The Flow Diversion FRM measure can be assessed as a viable FRM measure independently or in combination with other FRM measures.

The three key parameters when determining the viability of flow diversion as a FRM measure are:

- Technically acceptable – Will a Flow Diversion measure reduce flood risk.
- Suitable topography – Is the topography suitable for a Flow Diversion measure i.e. is there an acceptable route.
- Economics - What are the likely construction and maintenance costs for such a concept design.

Flow Diversion has not been considered viable where the source of flood risk is coastal.

The economic viability of this measure has been estimated at the screening of measures phase (Stage 2 of the Optioneering Assessment). The PV benefits of the measure have been calculated as the cumulative PV damages of the properties protected for all return periods up to the standard of protection of the flow diversion channel.

Modelling of viable options
When a Flow Diversion FRM measure has been considered viable either independently or in combination with other measures, modelling of the flow diversion channel has been carried out;

- To confirm the flow diversion is technically feasible.
- To confirm the dimensions of the channel and any associated flood defences.
- To determine the standard of protection to be provided.
- To understand the impact on water levels upstream and downstream of the diversion channel.

F - Increase Conveyance

Definition
In-channel works, floodplain earthworks, removal of constraints / constrictions, increasing culvert/bridge openings, channel / floodplain clearance, etc. In-channel works included localised removal of bed material, localised widening of the channel or the construction of a two-stage channel.

There are different sub-types of the Increase Conveyance FRM Measure, *which are summarised in Table B.5.*

Table B-5 Types of Flow Diversion FRM measures

F – Increase Conveyance	Fi – Channel Dredging
	Fii – Channel Widening
	Fiii – Structure Enhancement / Works

Concept Design
As works associated with this Measure are 'local', the design concepts are typically unique, but could include:

- Additional bridge arches
- Localised removal of a known constraint – either in channel or on floodplain.
- Two stage channel.
- Underpinning of structures.

Climate change
Due to the nature of this FRM measure, including an allowance or adaptability for climate change may be difficult.

Consideration will be given, where possible, for example if an additional bridge arch is required it will be designed using the sensitivity results for climate change (HEFS). In addition, if a two-stage channel is required, the two-stage channel will allow for the measure to be adaptable for the HEFS.

Screening of the Measure
The Increase Conveyance FRM measure can be assessed as a viable FRM measure independently or in combination with other FRM measures.

In-channel works are likely to have a significant negative environmental impact. Therefore, such measures have only been considered viable in locations where it will eliminate / significantly reduce the flood risk and there are no other viable options.

The two key parameters when determining the viability of Increased Conveyance as a FRM measure are:

- Technically acceptable – Will Increasing Conveyance measure reduce flood risk.
- Economics - What are the likely construction and maintenance costs for such a concept design.

The economic viability of this measure has been estimated at the screening of measures phase (Stage 2 of the Optioneering Assessment). The PV benefits of the Increased Conveyance FRM measure have been calculated as the PV damages of the properties protected for all return periods up to the standard of protection of the in channel works.

Modelling of viable options

When an increase conveyance FRM measure has been considered a viable option independently or in combination with other measure modelling of the increased conveyance is carried out if required;

- To determine if the option is technically feasible.
- To determine the standard of protection to be provided.
- To understand the impact on waterlevels upstream and downstream of the works.

The requirement of modelling has been determined based on engineering judgement.

G – Flood Defences: Construct flood defences/ Rehabilitate, improve existing defences/ Localised protection works (e.g., minor raising of existing defences / levels)

Definition

All forms of flood defence. This includes construction of new flood defences (wall and embankment) raising existing flood defences (wall and embankment), rehabilitate or improve existing flood defences or demountable defences. There are therefore different sub-types of Flood Defence Measures, which are summarised in Table B.6.

Table B-6 Types of Construct Flood Defence FRM measures

G – Construct Flood Defences	Gi – New Flood Defences
	Gii – Raise Existing Flood Defences
	Giii – Rehabilitate or improve Existing Flood Defences
	Giv – Demountable Defences
	Gv – Other Defences

Concept Design

The parameters used for the concept designs of this FRM Measure are as follows:

- Embankments: at least 1m wide on top to allow for the safe constructability and maintenance of the embankments. They will have a slope of 1:3 on the river side for stability and 1;5 on the landward side to allow for safe maintenance and cutting of grass. Modification of these dimensions has been considered on a site-by-site basis, using engineering judgement, if the above slope and dimensions cannot be maintained due to site space constraints.

- Raising existing. In locations where raising existing flood defences is the proposed measure, the type of structure to be provided has been dictated by the existing structure.

Freeboard
Freeboard has been applied to design height of the defences to allow for model and construction uncertainty; the allowances are provided in Table B.7.

Table B-7 Freeboard applied to Defences

Defence Type	Freeboard – Fluvial (m)	Freeboard – Tidal (m)
Walls	0.22	0.22
Embankment	0.4	0.9

Climate change
Where possible, defences have been specified to be adaptable for the HEFS.

Foundations for walls have been specified to provide a foundation that can be adaptable for the HEFS if economically viable.
The width of the top of the embankments have been specified to be wide enough to provide a sufficient foundation for the height of the embankments to be increased to the HEFS level and allow for the required slopes and embankment dimensions to be maintained.

Screening of the Measure
This FRM measure can be assessed as a viable FRM measure independently or in combination with other FRM measures.

The three key parameters when determining the viability of flood defences as a FRM measure are:

- Technically acceptable – Will a Flood Defence measure reduce flood risk.
- Suitable topography – Is the topography suitable for Flood Defences
- Economics - What are the likely construction and maintenance costs for such a concept design.

The type of flood defence selected is specified depended on site suitability and any existing defences. Demountable defences have only been considered viable in catchments where flood forecasting is a viable FRM measure. Similarly, set back defences which require demountable gates or sections have only been considered viable in catchment where flood forecasting is viable.

The economic viability of this measure has been estimated at the screening of measures phase (Stage 2 of the Optioneering Assessment). The PV benefits of the Defences measure have been calculated as the PV damages of the properties protected for all return periods up to the standard of protection of the flood defences.

Modelling of viable options
When a Flood Defences FRM measure has been considered viable, either independently or in combination with other measure, modelling of the Flood Defence is carried out if required;

- To determine if the defence is technically feasible;
- To determine the required height of the defence;
- To determine the standard of protection to be provided; and
- To understand the impact of water levels upstream and downstream of the structures.

The requirement of whether modelling is needed has been determined based on engineering judgement.

H - Relocation of properties

Definition

The relocation of properties to outside the area at risk from the 1% AEP Fluvial and 0.5% Tidal flooding.

Concept Design

Will be the demolition of existing property and construction of new, on a 'like for like' basis.

Freeboard

Using the sensitivity results, the relocation of the property will be outside the area at risk from the HEFS assessment.

Screening of the Measure

This FRM measure can be assessed as a viable FRM measure independently or in combination with other FRM measures.

Relocation of properties is considered a less desirable measure, as it does not make any attempt to reduce the existing flood risk to the existing properties, and should only be considered a viable measure independently or in combination with other FRM measures when there is no other viable measure.

Appendix B3: Non-Structural Measures

Non-structural measures have only been considered as viable FRM measures in combination with either a baseline or structural measure. Non-structural FRM measures assist in dealing with the existing flood risk, by reducing the impact of the hazard; the exposure to the hazard remains the same. In the circumstances where neither a baseline nor structural measure is viable, non– structural measures are considered independently and if viable are recommended in the Flood Risk Management Plan.

Table B.8 below is a summary of the Applicable SSA's for the Non Structural measures. The description of these Non Structural Measures are categorised in the different SSAs.

Flood Risk Management Measure		Applicable SSA
Ref	**Title**	
Non Structural		
J	Flood Forecasting / Warning / Response	All
K	Public Awareness	All
L	Individual property resistance	AFA/IRR
M	Individual property resilience	AFA/IRR
N	Planning and development control measures	UoM
O	Building regulations	UoM
P	Sustainable urban drainage systems	AFA/IRR
Q	Land use management	All
R	Strategic development management	UoM
S	Additional Monitoring (rain and river level/flow gauges)	UoM

Table B-8 Different SSAs for the Non-Structural FRM Measures

J – Flood Forecasting/ Warning/ Response

Definition

Installation of a flood forecasting system to predict the onset of flooding, and an accompanying warning system. To support this, the development of emergency flood response procedures are included.

Applicable SSA

FRM Measure is applicable at all SSAs.

Concept Design

The flood forecasting and warning system FRM measure has only been considered viable in a catchment when the time between baseflow water levels and peak water levels, is greater or equal to 5 hours. This time is required to allow for the evacuation of properties and the implementation of any temporary flood defences such as demountable defences and flood gates.

Screening of the Measure

This FRM measure has only be assessed as a viable FRM measure in combination with other FRM measures, particularly targeted public awareness and preparedness campaign, individual property protection and demountable defences.

K - Targeted public awareness and preparedness campaign

Definition
Raising awareness within the communities at risk through public campaigns; these would be targeted, regular and would involve meetings, workshops, and information leaflets. The purpose of the campaign is to make residents aware of what they can do to stay safe in a flood event.

Applicable SSA
FRM Measure is applicable at all SSAs.

Concept Design
The targeted public awareness and preparedness campaign has been considered a viable measure in all AFAs where there is flood risk. The extent of the campaign depends on the level of flood risk within the AFA and the FRM measures considered along with the campaign. The aim of the campaign will be to make residents in the AFA aware of the existing flood risk and existing FRM measures and the operation protocol in the case of flood forecasting or demountable defences.

Screening of the Measure
This FRM measure can be assessed as a viable FRM measure independently or in combination with other FRM measures.

L - Individual property flood resistance

Definition
Individual property flood resistance is defined as a measure to prevent flood waters entering a property e.g. flood barriers, air brick covers, building skirts and non-return valves.

Applicable SSA
FRM Measure is applicable at all SSAs.

Concept Design
Individual property flood resistance has also only been considered suitable in areas where flood depths are less than 600mm. This assumption provides 400mm freeboard on a max permissible height of flood resistance of 1m. Flood resistance has not been provided in areas where flood risk in the 1% AEP event is greater than 1m due to the following factors;

- The risk of an ordinary masonry wall collapsing when the water pressure difference indoor and outdoor goes over 1m.
- An adult cannot easily step over an obstacle of greater than 1m in height.

Screening of the Measure
This FRM measure has only be assessed as a viable FRM measure in combination with the following FRM measures:

- J – Flood Forecasting/ Warning/ Response
- K - targeted public awareness and preparedness campaign,

M - Individual property flood resilience

Definition
Individual property flood resilience is defined as wet proofing a property by changing the materials use within the building and relocating vulnerable building services, in order to mitigate the flood vulnerability of a property and/or repair works. It does not prevent flood water from entering the property.

Applicable SSA
FRM Measure is applicable at all SSAs.

Concept Design
Flood resilience has only been considered suitable in areas where flood depths are less than 1m as it not considered feasible to relocate all building services such as sockets at levels greater than 1.4m from ground level.

Screening of the Measure
Individual property flood resilience measures can be assessed as a viable FRM measure independently or in combination with other FRM measures.
Individual property flood resilience does not require time to implement immediately prior to a flood. Therefore, this FRM measure does not require Measure J – Flood Forecasting/ Warning/ Response.
Flood resilience has been considered a less desirable FRM measure, as it does not make any attempt to reduce the exposure of the properties to the flood hazard, and has only been considered a viable measure when there are no other viable measures.

N - Planning and development control measures

Definition
Zoning of land for flood risk appropriate development, prevention of inappropriate incremental development, review of existing Local Authority policies in relation to planning and development and of inter-jurisdictional co-operation within the catchment, etc.

Applicable SSA
FRM Measure is applicable at sub-catchment and UoM Scale only. It has not been considered at AFA scale, as it is being recommended for implementation at sub-catchment and UoM Scale.

O - Building regulations

Definition
Regulations relating to floor levels, flood-proofing, flood - resilience, sustainable drainage systems, prevention of reconstruction or redevelopment in flood-risk areas, etc.

Applicable SSA
FRM Measure is applicable at sub-catchment and UoM Scale only. It has not been considered at AFA scale, as it is being recommended for implementation at sub-catchment and UoM Scale.

P - Sustainable Urban Drainage Systems (SUDS)

Definition
Potential sustainable urban drainage systems, which will alleviate fluvial flood risk, at a strategic level.

Applicable SSA
FRM Measure is applicable at AFA/IRR Scale only.

Q - Land use management, including creation of wetlands, riparian buffer zones, etc.

Definition
Potential management practices within the catchment to attenuate existing runoff.

Applicable SSA
FRM Measure is applicable at all SSAs.

R - Strategic development management for necessary floodplain development

Definition
Proactive integration of structural measures into development designs and zoning, regulation on developer-funded communal retention, drainage and / or protection systems, etc.

Applicable SSA
FRM Measure is applicable at sub-catchment and UoM Scale only. It has not been considered at AFA scale, as it is being recommended for implementation at sub-catchment and UoM Scale.

Appendix C Option Appraisal Reports - AFA Spatial Scale

Appendix C1 Option Appraisal Report – Newcastle West

1. Preliminary Report: Summary of Current Flood Risk

1.1 AFA and Watercourse Details

AFA	Newcastle West
Unit of Management:	24
Primary Watercourse(s):	Killeline (River), Knockane (River), Doally (River), Arra (River), Ehernagh (Stream), Daar (River), Deel (River)

1.2 Summary of Flood Risk in 1% Fluvial AEP Event

Source of flood risk	**Fluvial**	Coastal	Both

Total Number of Properties at risk in AFA in 1% Fluvial AEP Event:		**Residential**	**Non-Residential**	**Total**
	Fluvial	23	20	43

AFA Flood Cells:		
	Total Number:	3
	Flood Cell Titles:	NWT_A, NWT_B, NWT_C

Breakdown of properties at risk per Flood Cell:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	NWT_A	5	0	5
	NWT_B	11	6	17
	NWT_C	7	14	22

Relevant Figure Ref: Figure 1.1 and 1.2

1.3 Summary of Existing Flood Risk Management Measures

Arterial Drainage	**Storage**	**Flow Diversion**	**Flood Defences**	**Level Control**	**Other**
None	None	None	**Yes**	None	None

Relevant Comments:	There are approximately 900m of existing flood defence walls on the left and right bank of the River Doally which are typically providing a 0.1% SOP. There is a flood alarm system also in operation which notifies those within this reach of high river levels.
Relevant Figure Ref:	Figure 1.1

1.4 Summary of PV Damages/Potential PV Benefits for 1% Fluvial SOP

Total PV Damages:		**Uncapped**	**Capped**
	Fluvial	€ 8,912,394	€ 5,449,585

Max Capped Benefits for 1% Fluvial AEP Event*:	€ 4,815,737

Breakdown of Max Capped PV benefits per Flood Cell for 1% Fluvial AEP Event:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	NWT_A	€ 84,586	€ 0	€ 84,586
	NWT_B	€ 284,789	€ 106,039	€ 390,828
	NWT_C	€ 634,959	€ 3,705,364	€ 4,340,323

Relevant Figure Ref: Figure 1.2

*These are the maximum benefits available if a FRM option with a 1% Fluvial AEP SOP is provided to all properties within the AFA.

1.5 Social Risk		
	Type	**Description**
High Vulnerability Properties at risk:	None	N/A
Social Infrastructure Assets:	None	N/A
Social Amenity Sites:	Sports Facility	**5% AEP Fluvial Flood Extent**
		Newcastle West Rugby Football Club – Clubhouse
		Newcastle West Rugby Football Club - Pitch
Relevant Figure Ref:	General Risk - Social	

1.6 Risk to the Environment		
	Type	**Description**
Risk to WFD Annex IV:	None	N/A
Risk to SACs:	None	N/A
Relevant Figure Ref:	General Risk - Environment	

1.7 Risk to Cultural Heritage		
	Type	**Description**
Risk to Sites of Cultural Heritage:	NIAH Buildings	**50% AEP Fluvial Flood Extent**
		House (McCarthy Insurances), Bridge Street. Regionally important.
		Shop/retail outlet, Bridge Street. Regionally important.
		10% AEP Fluvial Flood Extent
		Bridge, Bridge Street. Regionally important.
		2% AEP Fluvial Flood Extent
		Foot Bridge, North Quay. Regionally important
Relevant Figure Ref:	General Risk – Cultural Heritage	

1.8 Risk to the Economy		
	Type	**Description**
Risk to Transport Infrastructure:	National Road	**10% AEP Fluvial Flood Extent**
		N21 (Mary's Road)
	Regional Road	**50% AEP Fluvial Flood Extent**
		R522
	Tertiary Road	**50% AEP Fluvial Flood Extent**
		North Quay
		Bridge Street
		10% AEP Fluvial Flood Extent
		Killoughteen Road
		2% AEP Fluvial Flood Extent
		Dromin Road
		0.5% AEP Fluvial Flood Extent
		Maiden Street

Risk to Utility Infrastructure:	None	
Relevant Figure Ref:	General Risk - Economy	

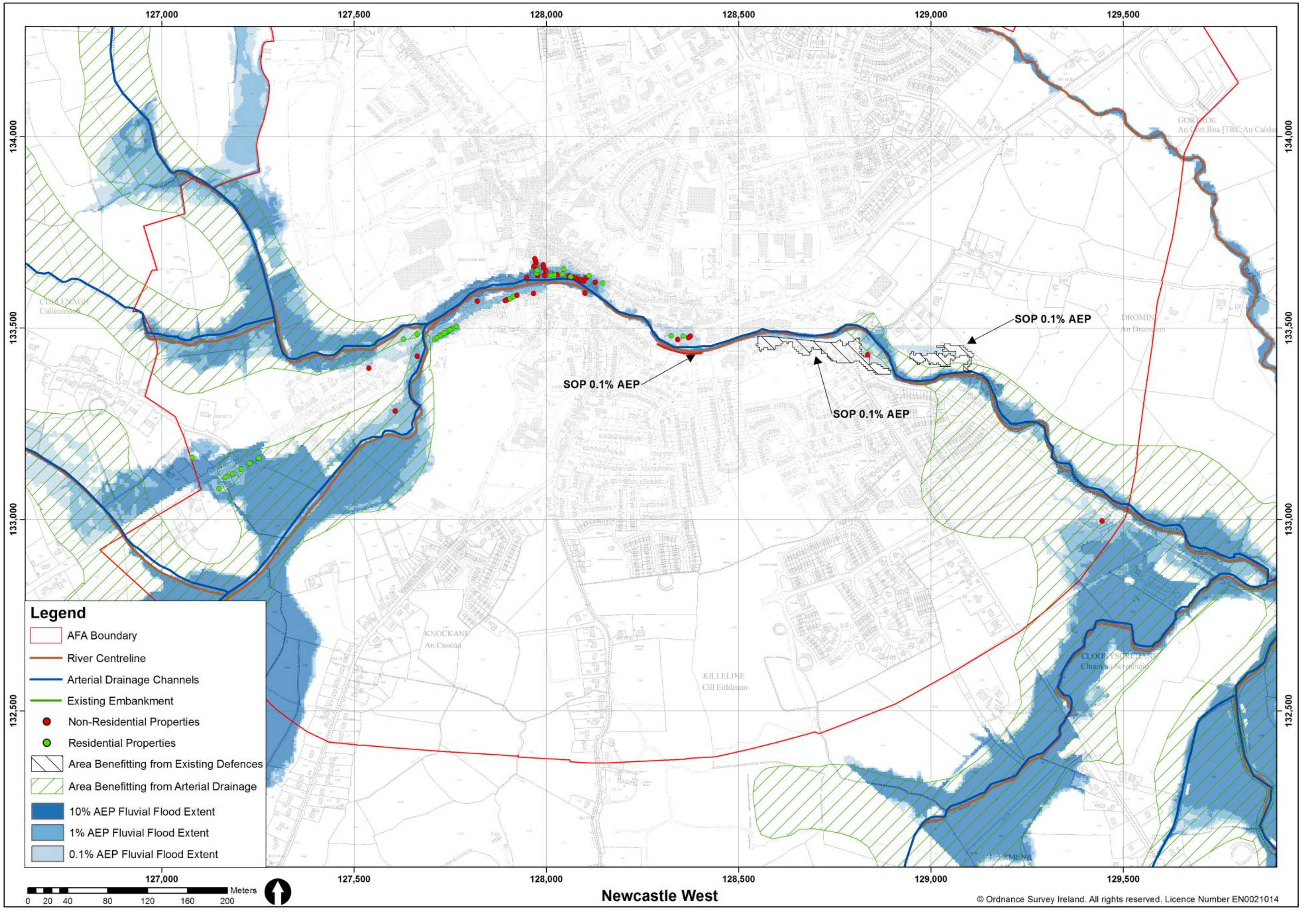


Figure 1.1 – Newcastle West Fluvial Flood Risk to Properties

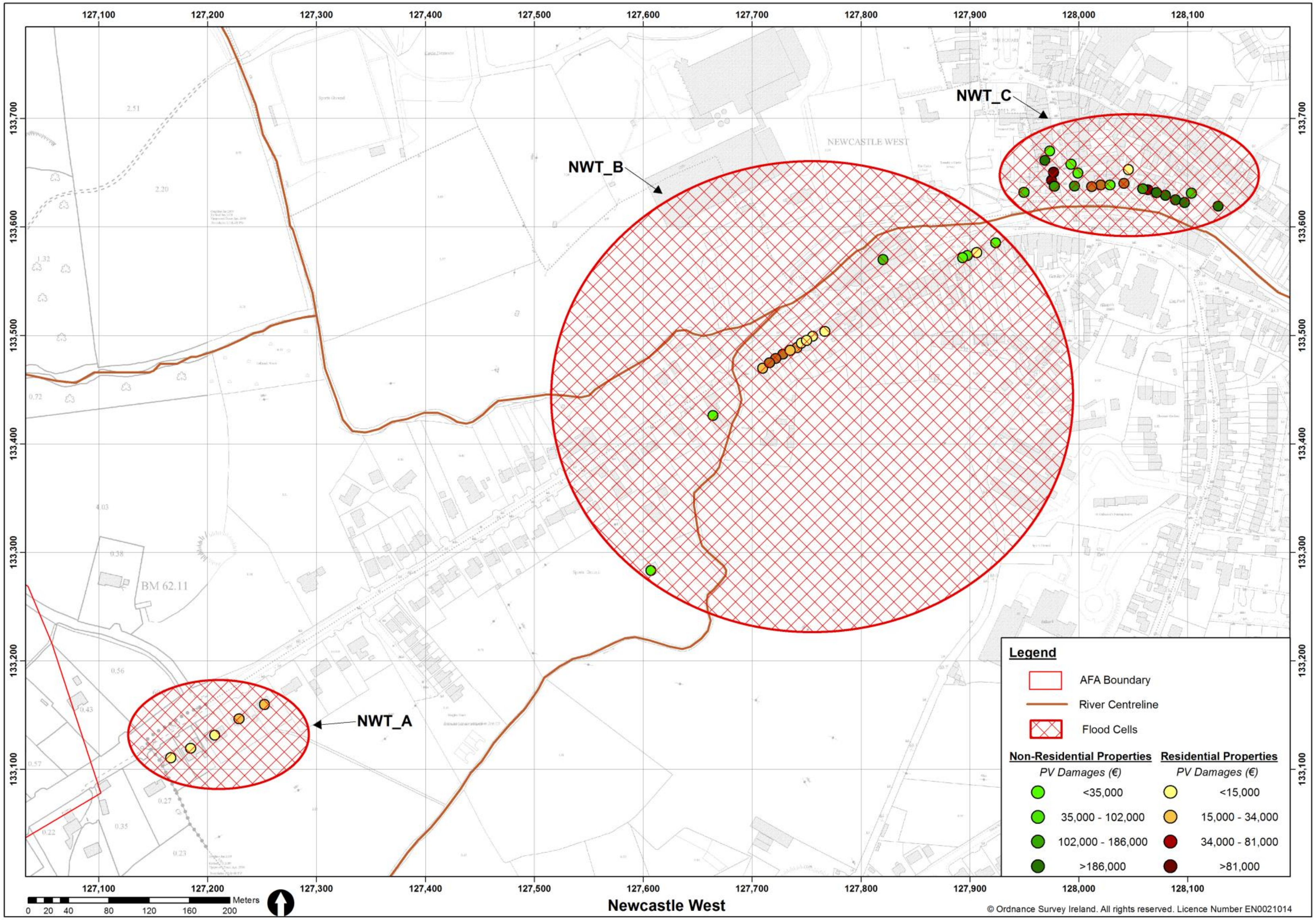


Figure 1.2 – Newcastle West Total PV Damages for properties within 1% AEP Fluvial Flood Event and Flood Cells. Flood Cells are groupings of properties that are likely to be hydraulically linked

2. STAGE 2: Screening of the Measures

2.1 Baseline, Structural and Non-Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

	Measures	Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
B	Existing Regime	Viable	Viable	Viable	Viable	Viable	**Screened In**
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
Structural							
D	Storage	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
E	Flow Diversion	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
F	Increase Conveyance	Viable	Viable	Viable	Viable	Viable	**Screened In**
G	Flood Defences	Viable	Viable	Viable	Viable	Viable	**Screened In**
H	Relocation of Properties	Unviable	Viable	Viable	Unviable	Viable	**Screened Out**
I	Other Measures	Unviable	Unviable	Unviable	Unviable	Unviable	**Screened Out**
Non-Structural							
J	Flood Forecasting / Warning / Response	Viable	Viable	Viable	Viable	Viable	**Screened In**
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	**Screened In**
L	Individual Property Resistance	Viable	Viable	Viable	Viable	Viable	**Screened In**
M	Individual Property Resilience	Viable	Viable	Viable	Viable	Viable	**Screened In**

2.2 Justification for Screened Out Baseline and Structural Measures

The following provides justification on Measures with an overall viability 'Screened Out' categorisation.

A	Do Nothing	Applicability Economic Environmental Social Cultural	Screened out due to the number of properties currently at risk of flooding.
C	Do Minimum	Applicability Economic Environmental Social Cultural	Screened out, as the "Do Minimum" FRM measure would have a negligible impact to the existing flood risk.
D	Storage	Applicability Economic Environmental Social Cultural	The hydraulic gradient of the river and the general profile of the surrounding catchment is very steep. A number of potential storage locations were identified in the surrounding catchment but due to this topographic constraint were found to provide insufficient storage and therefore were unsuitable. Any existing floodplains identified on the flood extent mapping will need to be retained to avoid increasing flood risk within the AFA.

E	Flow Diversion	Applicability Economic Environmental Social Cultural	Flow diversion from the Knockane/Killeline watercourse to the Ehernagh stream was considered as a measure, see figure 2.1 below. However, this measure was screened out as the current extent maps show extensive flooding along the Ehernagh stream. There is an ESB site and a wastewater treatment plant currently within the 1% AEP flood extent of the Ehernagh. Therefore, adding any extra flow to this watercourse could not be justified and considerable excavation would be needed due to the local topography.
H	Relocation of Properties	Applicability Economic Environmental Social Cultural	The relocation of 43 properties is not applicable to the area as it would be socially unviable.
I	Other Measures	Applicability Economic Environmental Social Cultural	No other measures have been identified.

2.3 Summary of 'Screened In' Measures

The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.

Baseline Measures		**Non-Structural Measures**	
B	Existing Regime	J	Flood Forecasting / Warning / Response
Structural Measures		K	Public Awareness
F	Increase Conveyance	L	Individual Property Resistance
G	Flood Defences	M	Individual Property Resilience

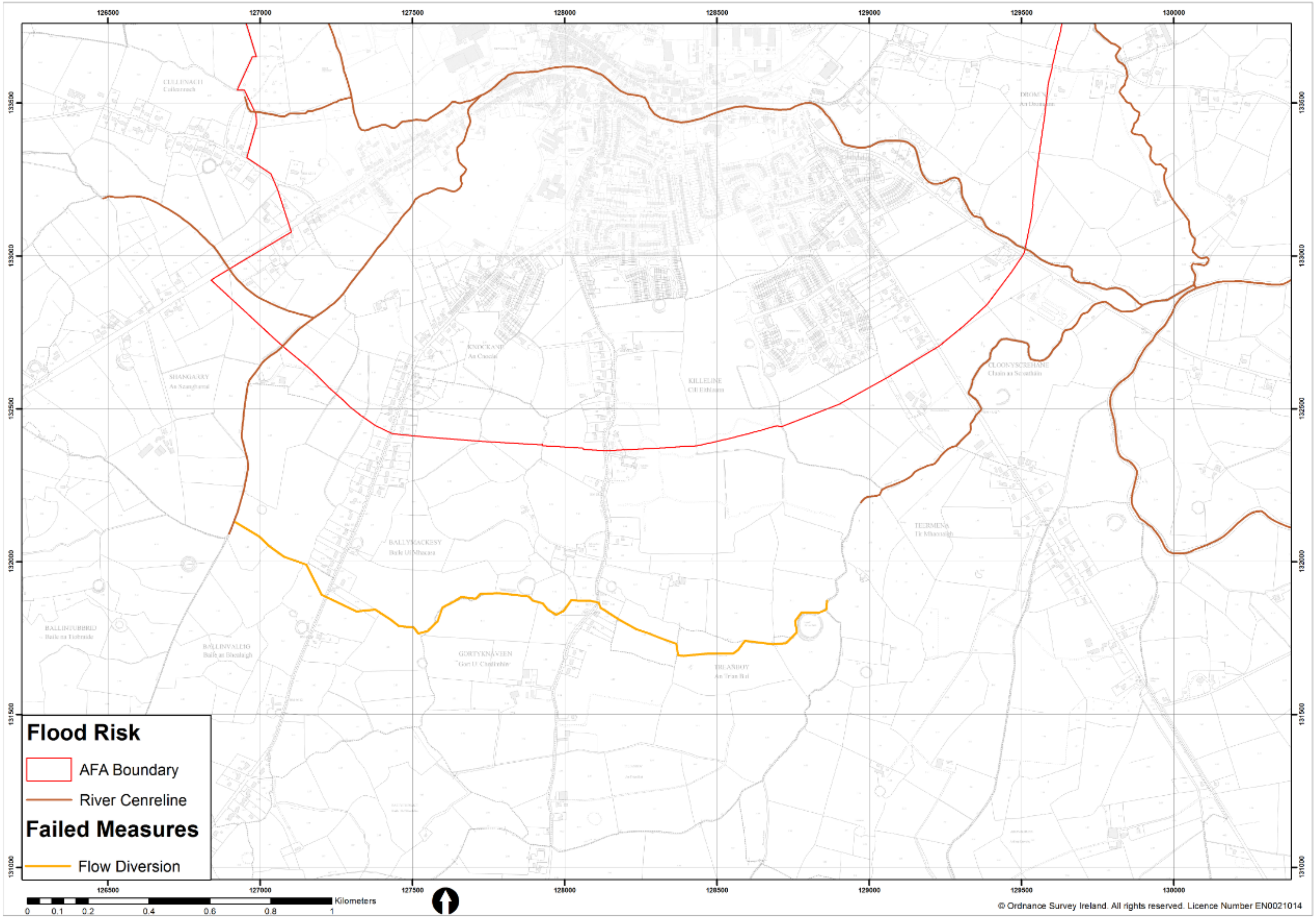


Figure 2.1 – Flow diversion measure not included in Options

3 STAGE 3: Selection of Options

3.1 Consideration of Options

The following are the agreed combination of 'Screened In' measures that comprise each of the Options being taken forward for further consideration.

Where appropriate, the 'Screened In' measures have been sub-divided into separate specific measures to ensure applicability to site conditions.

Measures		**Different composition of measures per option**						
Baseline Measures								
B	Existing Regime	✓	✓	✓				
Structural Measures								
F	Increase Conveyance							
Fi	Channel Dredging							
Fii	Channel Widening			✓				
Fiii	Structure Enhancement / Works			✓				
G	Flood Defences							
Gi	New Flood Defences	✓	✓	✓				
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
J	Flood Forecasting / Warning / Response	✓						
K	Public Awareness	✓						
L	Individual Property Resistance	✓						
M	Individual Property Resilience							
Option Reference		NWT_01	NWT_02	NWT_03				
Relevant Figure Ref:		Figure 3.1						

Measures not screened out but not included in options		
Measures		**Justification**
M	Individual Property Resilience	Individual Property Resilience was not considered as either an independent measure or in combination with other measures, as the option being appraised would provide the required 1% Fluvial AEP standard of protection. Individual Property Resilience does not improve the viability of the options under consideration.

4 STAGE 4: Appraisal of Options

4.1 Options Appraisal

Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Meeting. Below describes this concept design of each options and provides a summary of any significant comments/issues which were raised by LA staff at the Options Meetings. These comments will be considered in the local weightings and the MCA scores.

Option Ref:	NWT_01				
Option Measures – **Baseline**	**B**	**Existing Regime**			
Option Measures – **Structural**	**Gi**	**Flood Defences: New Flood Defences**			
Option Measures – **Non Structural**	**J** Flood Forecasting	**K** Public Awareness	**L** Property Resistance	M Property Resilience	
Option Description:	This option will provide a 1% Fluvial AEP design standard to 22 of 43 properties within the AFA, identified as being at risk, and reduce the risk to 21 properties, and includes; • Construction of 554m of new flood defence walls and individual property resistance applied to 21 properties; • Existing regime is to be maintained; • Flood forecasting and raising public awareness also form part of this option.				
Options Development Meeting:	Date:	03/09/2015			
	Summary:	The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.			

Option Ref:	NWT_02				
Option Measures – **Baseline**	**B**	**Existing Regime**			
Option Measures – **Structural**	**Gi**	**Flood Defences: New Flood Defences**			
Option Measures – **Non Structural**	J Flood Forecasting	K Public Awareness	L Property Resistance	M Property Resilience	
Option Description:	This option will provide a 1% Fluvial AEP design standard to all properties within the AFA, identified as being at risk. • Construction of new flood walls and embankments as shown in Figure 5.2. • Existing regime is to be maintained.				
Options Meeting:	Date:	03/09/2015			
	Summary:	The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting..			

<table>
<tr><td colspan="2">Option Ref:</td><td colspan="4">NWT_03</td></tr>
<tr><td rowspan="5">Option Measures</td><td>Baseline</td><td>B</td><td colspan="3">Existing Regime</td></tr>
<tr><td rowspan="3">Structural</td><td>Fii</td><td colspan="3">Increased Conveyance: Channel Widening</td></tr>
<tr><td>Fiii</td><td colspan="3">Increased Conveyance: Structure Enhancement / Works</td></tr>
<tr><td>Gi</td><td colspan="3">Flood Defences: New Flood Defences</td></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="4">This option will provide a 1% Fluvial AEP design standard to all properties within the AFA, identified as being at risk.

• Construction of new flood defence walls and embankments as shown in Figure 5.3.
• Replacing the bridges and widening the channel at the downstream end of the Killeline River.
• Removing the Bedding Store property that is currently straddling the Doally river in the centre of the town. The only change in flood defence heights and levels for this option is Flood defence wall downstream of the main bridge in Newcastle west. The levels and required flood defence heights have dropped due to the removal of the shop.
• Existing regime is to be maintained.
• Note: the heights of the flood defence walls and embankments within the centre of the town are lower than those presented within options NWT_01 and NWT_02 due to the removal of the Bedding Store constraint on flows.</td></tr>
<tr><td colspan="2" rowspan="2">Option Meeting:</td><td>Date:</td><td colspan="3">03/09/2015</td></tr>
<tr><td>Summary:</td><td colspan="3">The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.</td></tr>
<tr><td colspan="6"></td></tr>
</table>

5 STAGE 5: Multi Criteria Assessment

5.1 Options selected for the Multi Criteria Assessment

Following the Option Meeting, the following options are the refined options for the Multi-Criteria Assessment (MCA) stage. This is the final of a five-stage MCA process.

Option Reference		NWT_01	NWT_02	NWT_03
Baseline				
B	Existing Regime	Maintain existing regime.	Maintain existing regime.	Maintain existing regime.
Structural Measures				
Fii	Channel Widening			Replacing the bridges and widening the channel at the downstream end of the Killeline River. Removing part of the Bedding Store property that is straddling the Doally river in the centre of the town.
Fiii	Structure Enhancement / Works			
Gi	New Flood Defences	Construction of new flood defence walls as shown in figure 5.1.	Construction of new flood defences. Walls and embankments as shown in figure 5.2 will provide the 1% fluvial AEP event design standard.	Construction of new flood defence walls and embankments. These measures (shown in figure 5.3) will provide the 1% fluvial AEP event design standard.
Non-Structural Measures				
J	Flood Forecasting / Warning / Response	This will apply to all properties on the right bank of the main river as shown in figure 5.1.		
K	Public Awareness	This will apply to all properties on the right bank of the main river as shown in figure 5.1.		
L	Individual Property Resistance	This will apply to all properties on the right bank of the main river as shown in figure 5.1.		
Table reference A summary of the outcome from the MCA is presented in the following table		Table 5.1	Table 5.2	Table 5.3

Table 5.1: Multi Criteria Assessment Outcome for Option NWT_01

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Newcastle West	Option Ref:	NWT_01

Option Measures		
Baseline	B	Existing Regime
Structural	Gi	Flood Defences: New Flood Defences
Non-Structural	J	Flood Forecasting / Warning / Response
	K	Public Awareness
	L	Individual Property Protection

Criteria Scores	
Technical	850
Economic	518
Social	537
Environmental	-238
Economic Values	
Economic PV Benefits	€ 4,756,674
PV Cost	€ 2,162,440
NPV Benefits	€ 2,594,234
Economic BCR	**2.20**
Outcome Scores	
MCA PV Benefits	€ 2,345,544
MCA Benefit Score	817
MCA Benefit Score Ratio	377.62
Option Selection MCA	1667
Relevant Figure	Figure 5.1

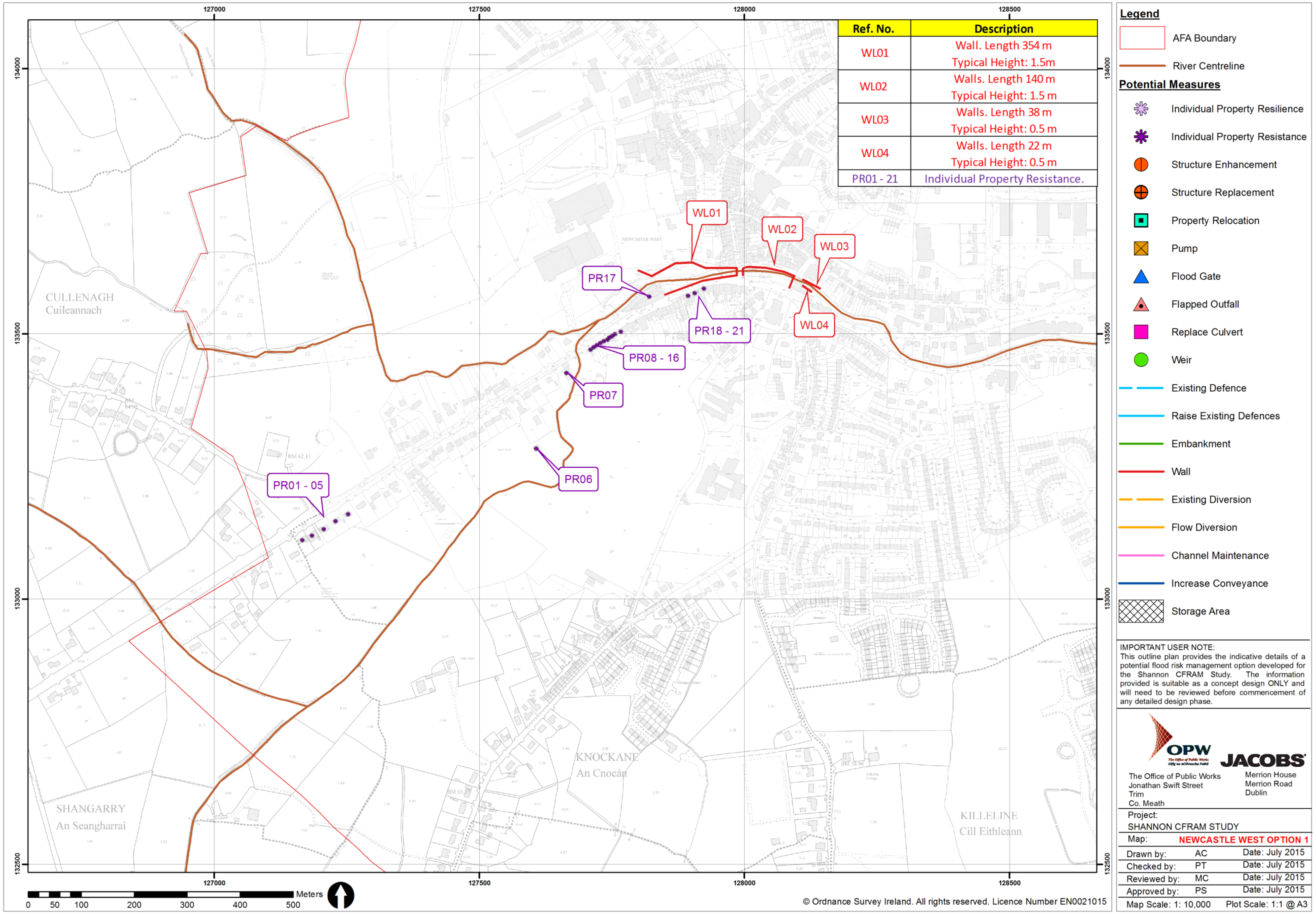


Figure 5.1 Option NWT_01

Table 5.2: Multi Criteria Assessment Outcome for Option NWT_02

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**				
AFA	Newcastle West		Option Ref:	NWT_02
Option Measures				
Baseline	B	Existing Regime		
Structural	Gi	Flood Defences: New Flood Defences		
Non-Structural		N/A		
Criteria Scores				
Technical			1100	
Economic			540	
Social			558	
Environmental			-310	
Economic Values				
Economic PV Benefits			€ 4,815,737	
PV Cost			€ 2,746,357	
NPV Benefits			€ 2,069,380	
Economic BCR			**1.75**	
Outcome Scores				
MCA PV Benefits			€ 2,362,568	
MCA Benefit Score			788	
MCA Benefit Score Ratio			286.90	
Option Selection MCA			1888	
Relevant Figure			Figure 5.2	

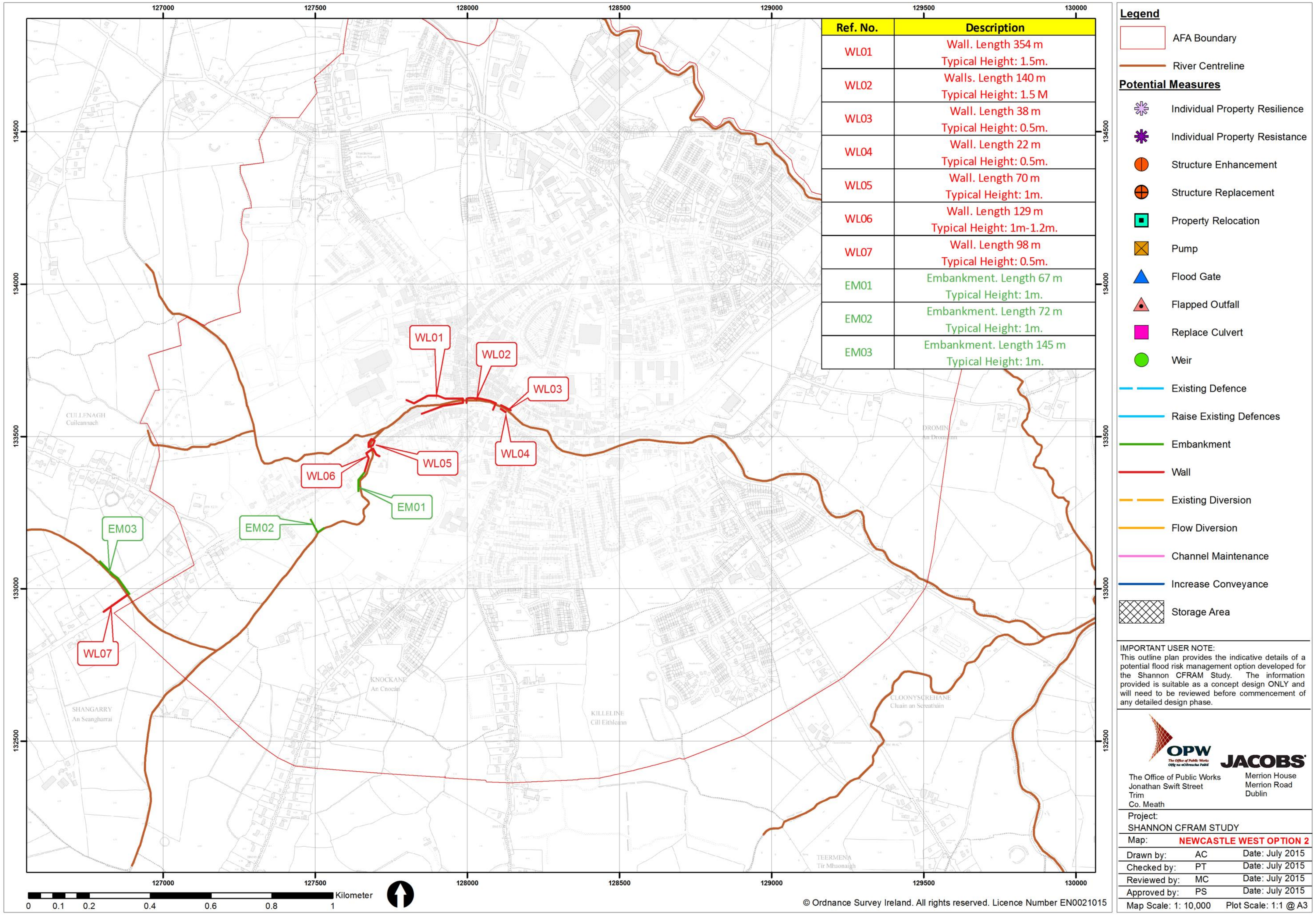
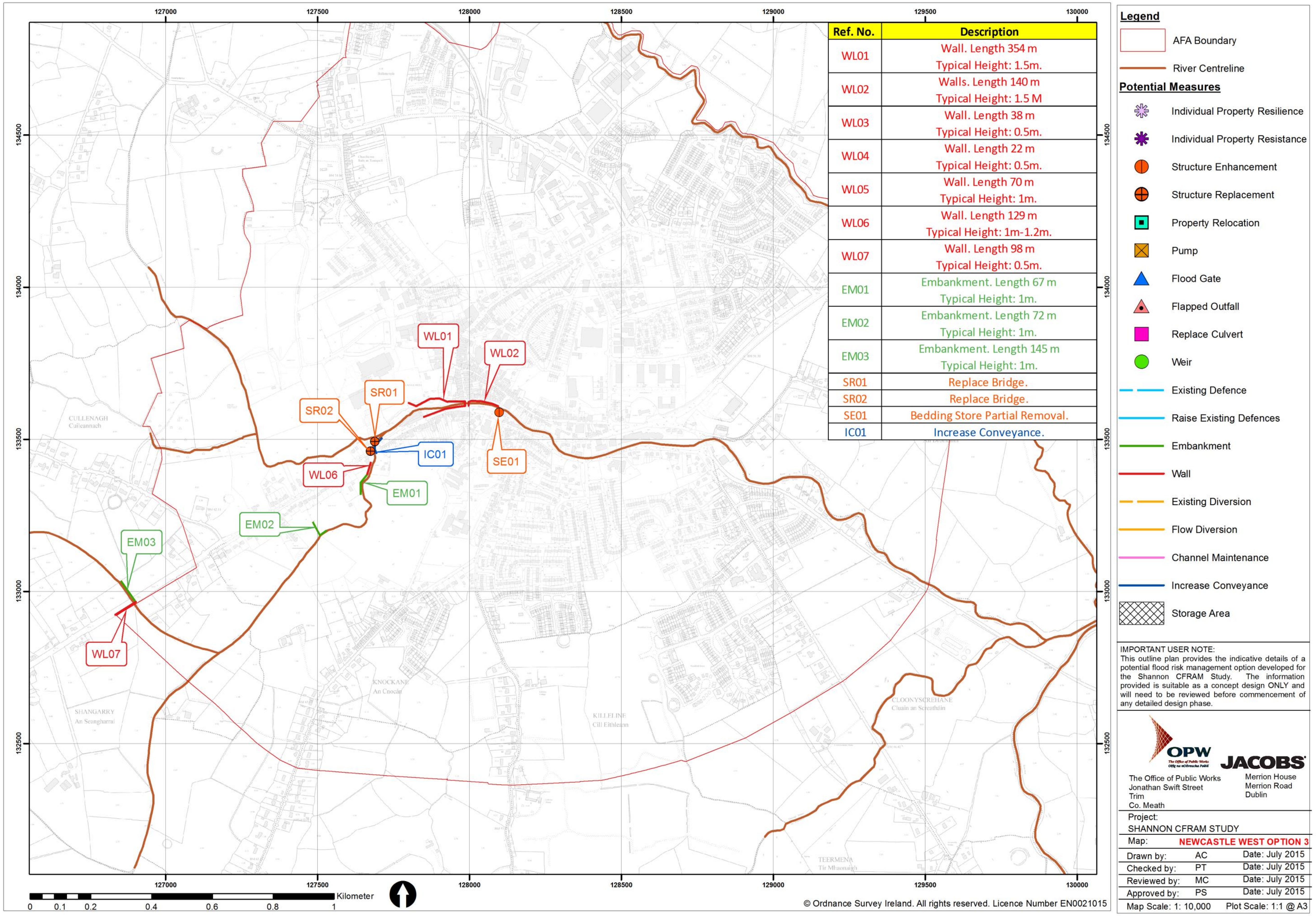


Figure 5.2 Option NWT_02

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Newcastle West	Option Ref:	NWT_03

Option Measures		
Baseline	B	Existing Regime
Structural	Gi	Flood Defences: New Flood Defences
	Fii	Increase Conveyance: Channel Widening
	Fiii	Increase Conveyance: Structure Enhancement / Works
Non-Structural		N/A

Criteria Scores	
Technical	850
Economic	541
Social	558
Environmental	-410
Economic Values	
Economic PV Benefits	€ 4,829,323
PV Cost	€ 3,922,559
NPV Benefits	€ 906,764
Economic BCR	**1.23**
Outcome Scores	
MCA PV Benefits	€ 2,369,007
MCA Benefit Score	688
MCA Benefit Score Ratio	175.49
Option Selection MCA	1538
Relevant Figure	Figure 5.3



Ref. No.	Description
WL01	Wall. Length 354 m Typical Height: 1.5m.
WL02	Walls. Length 140 m Typical Height: 1.5 M
WL03	Wall. Length 38 m Typical Height: 0.5m.
WL04	Wall. Length 22 m Typical Height: 0.5m.
WL05	Wall. Length 70 m Typical Height: 1m.
WL06	Wall. Length 129 m Typical Height: 1m-1.2m.
WL07	Wall. Length 98 m Typical Height: 0.5m.
EM01	Embankment. Length 67 m Typical Height: 1m.
EM02	Embankment. Length 72 m Typical Height: 1m.
EM03	Embankment. Length 145 m Typical Height: 1m.
SR01	Replace Bridge.
SR02	Replace Bridge.
SE01	Bedding Store Partial Removal.
IC01	Increase Conveyance.

Figure 5.3 Option NWT_03

5.2 Comparison of Multi Criteria Assessment Scores

Each option taken forward for further consideration through the Option Decision Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Decision Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).

Categories	Option Reference and Results		
	NWT_01	NWT_02	NWT_03
Criteria Scores			
Technical	850	1100	850
Economic	518	540	541
Social	537	558	558
Environmental	-238	-310	-410
Economic Values			
Economic PV Benefits	€ 4,756,674	€ 4,815,737	€ 4,829,323
PV Cost	€ 2,162,440	€ 2,746,357	€ 3,922,559
NPV Benefits	€ 2,594,234	€ 2,069,380	€ 906,764
Economic BCR	**2.20**	**1.75**	**1.23**
Outcome Scores			
MCA PV Benefits	€ 2,345,544	€ 2,362,568	€ 2,369,007
MCA Benefit Score	817	788	688
MCA BCR	377.92	286.90	175.49
Option Selection MCA	1667	1888	1538

5.3 Recommendation of Preferred Option

It forms part of the CFRAM process for the recommendation of a preferred option for each AFA. The prioritised selection criteria used in this recommendation process is detailed in Section 3.7.3 of the Main Report.

Therefore, following the five stage Multi Criteria Assessment process, the preferred option is as outlined below

<table>
<tr><td colspan="2">Option Ref:</td><td colspan="4">NWT_02</td></tr>
<tr><td rowspan="3">Option Measures</td><td>Baseline</td><td>B</td><td colspan="3">Existing Regime</td></tr>
<tr><td>Structural</td><td>Gi</td><td colspan="3">New Flood Defences</td></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Comments</td><td colspan="4">This option will provide a 1% Fluvial AEP design standard to all properties within the AFA, identified as being at risk.

Although the MCA BCR is highest for NWT_01, NWT_02 offers direct flood protection to more properties and is economically viable. Therefore NWT_02 is the preferred option.</td></tr>
</table>

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

<table>
<tr><th colspan="5">Fluvial Flood Forecasting Potential</th></tr>
<tr><td rowspan="3">Catchment Information</td><td colspan="2">Gauging Station</td><td rowspan="2">Catchment size (km ^{2})</td><td rowspan="2">Potential available forecast accuracy and reliability period</td></tr>
<tr><td>Fluvial</td><td>Rainfall</td></tr>
<tr><td>GS 24030
GS 24011
GS 24031</td><td>No*</td><td>260 (River Deel)
342 (River Deel)
40 (River Arra)</td><td>3-6 hours</td></tr>
<tr><td>Relevant Information:</td><td colspan="4">Deel bridge (GS 24011, 1.5 km upstream of AFA)
Newcastle West (GS 24031, lies within the AFA)
Danganbeg Bridge (GS 24030, 8.5 km upstream of AFA)</td></tr>
<tr><td rowspan="3">Additional Infrastructure Recommended</td><td colspan="2">Gauging Station</td><td colspan="2" rowspan="2">Other</td></tr>
<tr><td>Fluvial</td><td>Rainfall</td></tr>
<tr><td>n/a</td><td>n/a</td><td colspan="2">n/a</td></tr>
<tr><td>Relevant Comments:</td><td colspan="4">Due to the number of equal sized tributaries which confluence within the AFA, an accurate and reliable flood forecasting warning system would require a series of rainfall gauges feeding into a rainfall-runoff model and river gauges. However, it is unlikely that the forecast period would justify the introduction of such a system. A simple flood forecasting system on the River Arra has potential to provide a small flood forecasting period based on a level trigger. As the gauge is within the AFA the forecast period is small.</td></tr>
</table>

*For this assessment only 15 minute tipping bucket gauge were considered.

Annex A - Multi-Criteria Analysis Summary and Whole Life Cost Summaries for FRM Option(s)

CRITERIA		OBJECTIVE		Global Weighting	Local Weighting	Comments	NWT_01 B – Existing Regime Gi – New Flood Defences J – Flood Forecasting / Warning / Response K – Public Awareness L – Individual Property Resistance	Option Score	Weighted Score	NWT_02 B – Existing Regime Gi – New Flood Defences	Option Score	Weighted Score	NWT_03 B – Existing Regime Gi – New Flood Defences Fii – Channel Widening Fiii – Structure Enhancement / Works	Option Score	Weighted Score
1	Technical	a	Ensure flood risk management options are operationally robust	20	5.00	The option scores are determined based on the level of operational risk to operate or perform successfully. Each measure is scored independently and the average of the measure scores is used as the score for the option.	None – Manageable Negligible – Moderate / high Very low – High Low – Failure likely Low / moderate – Unacceptable B 5.00 Gi 5.00 J 3.00 K L 2.00	3.75	375	None – Manageable Negligible – Moderate / high Very low – High Low – Failure likely Low / moderate – Unacceptable B 5.00 Gi 5.00	5.00	500	None – Manageable Negligible – Moderate / high Very low – High Low – Failure likely Low / moderate – Unacceptable B 5.00 Gi 5.00 Fii 5.00 Fiii 5.00	5.00	500
		b	Minimise health and safety risks associated with the construction and operation of flood risk management options	20	5.00	H&S risks are considered for construction and maintenance of flood risk management measures. The indicative aspirational score is set at five, with a point then deducted for each specific H&S risk in either construction or maintenance.	None – Manageable Negligible – Moderate / high Very low – High Low – Very High Low / moderate – Unacceptable Work near/in water Work near services or buildings	1.00	100	No risks – Moderate Negligible – Moderate / high Very low – High Low – Very High Low / moderate – Unacceptable Work near/in water	3.00	300	No risks – Moderate Negligible – Moderate / high Very low – High Low – Very High Low / moderate – Unacceptable Work near/in water Work near traffic	1.00	100
		c	Ensure flood risk management options are adaptable to future flood risk	20	5.00	The options scores are determined based on the sustainability and adaptability of the flood risk management measures in the face of potential future changes, including the potential impact of climate change. Each measure is scored independently and the average of the measure scores is used as the score for the option.	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. B 3.00 Gi 3.00 J 5.00 K L 4.00	3.75	375	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. B 3.00 Gi 3.00	3.00	300	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. B 3.00 Gi 3.00 Fii 2.00 Fiii 2.00	2.50	250
			TECHNICAL CRITERIA SCORE						850			1100			850
2	Economic	a	Minimise economic risk	24	2.67		The score is calculated based on the reduction in AAD, following the full implementation of option.	4.65	298	The score is calculated based on the reduction in AAD, following the full implementation of option.	4.64	298	The score is calculated based on the reduction in AAD, following the full implementation of option.	4.65	298
		b	Minimise risk to transport infrastructure	10	5.00		Scoring is based on the reduction in flood risk to transport routes, following the full implementation of option.	4.09	205	Scoring is based on the reduction in flood risk to transport routes , following the full implementation of option.	4.85	242	Scoring is based on the reduction in flood risk to transport routes , following the full implementation of option.	4.85	242
		c	Minimise risk to utility infrastructure	14	0.00		Scoring is calculate based on a reduction in flood risk to utility infrastructure, following the full implementation of option.			Scoring is calculate based on a reduction in flood risk to utility infrastructure, following the full implementation of option.			Scoring is calculate based on a reduction in flood risk to utility infrastructure, following the full implementation of option.		
		d	Minimise risk to agriculture	12	1.28	Source of Flooding – Fresh Water Percentage of AFA that is rural land – 25.65%	Area of Agricultural Land Flooded – No Change Frequency & Seasonality of Flooding – No Change Duration of Flooding – No Change Risk to Agicultrual Infrastructure – No Change Flood Warning – Applicable Agricultural Production Enhanced – No Change Other (Please Specify) – Not Applicable	1.00	15	Area of Agricultural Land Flooded – No Change Frequency & Seasonality of Flooding – No Change Duration of Flooding – No Change Risk to Agicultrual Infrastructure – No Change Flood Warning – Not Applicable Agricultural Production Enhanced – No Change Other (Please Specify) – Not Applicable	0.00	0	Area of Agricultural Land Flooded – No Change Frequency & Seasonality of Flooding – No Change Duration of Flooding – No Change Risk to Agicultrual Infrastructure – No Change Flood Warning – Not Applicable Agricultural Production Enhanced – No Change Other (Please Specify) – Not Applicable	0.00	0
			ECONOMIC CRITERIA SCORE						518			540			541
3	Social	a i)	Minimise risk to human health and life - Residents	27	2.24	Flood Depths & Velocities – Assumed low risk to life Known Areas of Highly Vulnerable People – Reasonable Cross Section of Society	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	4.86	293	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	4.42	267	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	4.42	267
		a ii)	Minimise risk to human health and life - High vulnerability properties	17	0.00	Rate of Onset of flooding – Assumed 1-2 hours for evacuation	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	4.00	0	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	0.00	0	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	0.00	0
		b i)	Minimise risk to community - Social Infrastructure & Amenity	9	3.00	Assets of Particular Social Value – Yes	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	2.10	57	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	4.50	122	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	4.50	122
		b ii)	Minimise risk to community - Local employment	7	5.00	Asset of Particular Employment Value – No	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	5.33	187	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	4.84	170	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	4.84	170
			SOCIAL CRITERIA SCORE						537			558			558
4	Environmental	a	Support the objectives of the WFD	16	5.00	There are a number of WFD water bodies within the AFA associated with the Deel River, including the Daar River and Doally River. The WFD status of these water bodies ranges from bad to good. There are no potentially polluting sources within the 1% AEP Fluvial. There is one Annex IV area within the AFA, the Deel River, which is an SPA waterbody. Local weighting to be applied for this objective is constant, and should always be set equal to 5 as WFD objectives must be achieved and are relevant to all waterbodies.	This option consists of construction of flood defence walls within Newcastle West and Individual Property Resistance. Construction - Related impacts due to significant construction works in and adjacent to the Doally River due to the construction of the flood defence walls. Operational - The proposed wall and embankment will permanently replace the natural bank in a short section along the Doally River (mainly upstream of main bridge in Newcastle West). This section of the Doally River is already modified through Newcastle West. However, these measures could cause potential changes to the hydrological and morphological regime of the waterbody. Reduced flooding in an area with no significant polluting sources in 1% AEP Fluvial. Therefore, short-term or intermittent impediment to the achievement of the waterbodies objective.	-2.00	-160	This option consists of construction of flood defence walls and flood defence embankments. Construction - Related impacts due to significant construction works in and adjacent to the Doally River and Killeline River due to the construction of the flood defence walls and flood defence embankments. Operational - The proposed walls and embankments will permanently replace the natural bank in a short section along the Deel River and Killeline River. Sections of both rivers are already modified through Newcastle West. However, these measures could cause potential changes to the hydrological and morphological regime of the waterbody. Reduced flooding in an area with no significant polluting sources in 1% AEP Fluvial. Therefore, short-term or intermittent impediment to the achievement of the waterbodies objective.	-2.50	-200	This option consists of construction of walls, embankments, removal of a building, bridge replacement and widening of a channel. Construction - Related impacts due to significant construction works in and adjacent to the Doally River and Killeline River due to the construction of the flood defence wall, flood defence embankments, removal of a building over the Doally River and widening of channel at the down stream end of Killeline River. Operational - The proposed wall, embankments, building removal and channel widening will permanently replace sections of the natural bank on the Doally River and Killeline River. This measures could cause potential changes to the hydrological and morphological regime of the waterbody, hydromorphological and physico-chemical impacts due to sediment release. Reduced flooding in area with no significant polluting sources in 1% AEP extent. Therefore permanent or long-term impediment to the achievement of waterbody objective.	-3.00	-240
		b	Support the objectives of the Habitats Directive	10	2.00	There are no cSACs or SPAs within the AFA. The Lower Shannon cSAC [002165] is c. 25 km downstream. The Lower River Shannon cSAC qualifying interests likely to occur within the AFA include otter, river, brook and sea lamprey, Atlantic salmon, and floating river vegetation. Stack's to Mullaghareirks, West Limerick Hills and MountEagle SPA [004161] is 5.6km west of the AFA along the River Daar. Hen Harriers are a feature of interest of this SPA. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are no designated sites but habitats/species are likely to be present that could be affected.	This option consists of wall construction of flood defence walls within Newcastle West and Individual Property Resistance. Potential construction effects due to surface water connection with the Lower River Shannon cSAC, approx. 25km downstream, such as the following: - Increases in suspended sediment; - Pollution risks to the River Deel which is linked to Lower River Shannon cSAC; - Disturbance to otter outside the cSAC. Potential construction effects due to disturbance to Hen Harrier outside the SPA. Therefore, this option has the potential to have a detrimental impact on existing cSAC and SPA site, including a delay in recovery of the site, but excluding impacts on the conservation objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	-1.00	-20	This option consists of the construction of flood defence walls and flood defence embankments. Potential construction effects due to surface water connection with the Lower River Shannon cSAC, such as the following: - Increases in suspended sediment; - Pollution risks to the River Deel which is linked to Lower River Shannon cSAC; - Disturbance to otter outside the cSAC. Potential construction effects due to disturbance to Hen Harrier outside the SPA. Therefore, this option has the potential to have a detrimental impact on existing cSAC and SPA site, including a delay in recovery of the site, but excluding impacts on the conservation objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	-1.50	-30	This option consists of construction of walls, embankments, removal of a building, Bridge Replacement and widening of a channel. Potential construction effects due to surface water connection with the Lower River Shannon cSAC, such as the following: - Increases in suspended sediment; - Pollution risks to the River Deel which is linked to Lower River Shannon cSAC; - Disturbance to otter outside the cSAC. Potential construction effects due to disturbance to Hen Harrier outside the SPA. Therefore, this option has the potential to cause a detrimental impact on existing cSAC and SPA site, including a delay in recovery of the site, but excluding impacts on the conservation objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	-2.00	-40
		c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	5	2.00	There are no nationally designated sites within the AFA, but there is potential for significant habitats and populations of European and nationally protected species. Glenastar Wood pNHA [001431] is 5.5km downstream of the AFA. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are no designated sites but habitats/species are likely to be present that could be affected	This option consists of construction of flood defence walls within Newcastle West and Individual Property Resistance. Potential effects are construction impacts of the embankments, which has the potential to impact as follows: - Disturbance to protected bird species - Disturbance to fish species - Disturbance to protected mammals including otter Therefore, there is potential localised loss of, or disturbance to, flora/fauna limited by the already modified nature of channel/shoreline.	-1.00	-10	This option consists of construction of flood defence walls and flood defence embankments. Potential effects are construction impacts of the embankments, which has the potential to impact as follows: - Disturbance to protected bird species - Disturbance to fish species - Disturbance to protected mammals including otter Therefore, there is potential localised loss of, or disturbance to, flora/fauna limited by the already modified nature of channel/shoreline.	-1.50	-15	This option consists of construction of walls, embankments, removal of a building, bridge replacement and widening of a channel. Potential effects are construction impacts of the embankments, which has the potential to impact as follows: - Disturbance to protected bird species - Disturbance to fish species - Disturbance to protected mammals including otter Therefore, there is potential for localised loss of, or disturbance to, flora/fauna.	-2.00	-20
		d	Protect, and where possible enhance, fisheries resource within the catchment	13	2.00	The Deel River is not designated as a Salmonid River but is an angling area of medium importance. Local weighting of 2 set by professional judgement. Weighting of 2 applied where a waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.	This option consists of construction of flood defence walls within Newcastle West and Individual Property Resistance. Construction related impacts on water quality and subsequent fish species. Construction works of embankments adjacent to the Doally River may impact water quality. Therefore, there is a short-term minor impacts to fisheries habitat.	-2.00	-52	This option consists of construction of flood defence walls and flood defence embankments. Construction related impacts on water quality and subsequent fish species. Construction works of embankments and walls adjacent to and along the Doally River and Killeline River may impact water quality. Therefore, there is potential for short-term minor impacts to fisheries habitat.	-2.50	-65	This option consists of construction of walls, embankments, removal of a building, bridge replacement and widening of a channel. Construction related impacts on water quality and subsequent fish species. Therefore, there is potential for medium to long-term alternation of fisheries habitat.	-4.00	-104
		e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	8	1.00	There are no designated landscape features within the AFA. There is one Undesignated Route, The Great Southern Trail which crosses the Daar River. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected.	This option consists of the construction of flood defence walls within Newcastle West and Individual Property Resistance. Localised impact in the immediate area of the measures. However, where The Great Southern Way crosses the Daar River there are no proposed flood risk management measures. No impact is anticipated to The Great Southern Way. Therefore, this option has minimal potential to change existing landscape character/features in the zone of influence of the selected measure.	-0.50	-4	This option consists of construction of flood defence walls and flood defence embankments. Localised impact in the immediate area of the measures. However, where The Great Southern Way crosses the Daar River there are no proposed flood risk management measures. No impact is anticipated to The Great Southern Way. Therefore, this option has minimal potential to change existing landscape character/features in the zone of influence of the selected measure.	-1.00	-8	This option consists of construction of walls, embankments, removal of a building, bridge replacement and widening of a channel. Localised impact in the immediate area of the measures. However, where The Great Southern Way crosses the Daar River there are no proposed flood risk management measures. No impact is anticipated to The Great Southern Way. Therefore, this option has minimal potential to change existing landscape character/features in the zone of influence of the selected measure.	-1.00	-8
		f i)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of architectural value	4	3.00	Newcastle West is not a heritage town. 0.006 km2 of the ACA falls within or partly within the 1% AEP Fluvial. 12 RPS and 4 NIAH fall within the 1% AEP Fluvial. Local weighting of 3 set by professional judgement. Weighting of 3 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a high to moderate vulnerability.	This option consists of wall construction of flood defence walls within Newcastle West and Individual Property Resistance. The option will reduce the potential for flooding in the 1% AEP Fluvial for seven RPS and three NIAH and 0.006km2 of ACA. Wall construction is proposed on the Main Bridge in Newcastle West which is an NIAH. In addition the property resistance will include work on 3 RPS. Therefore, overall there is a potential for an increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.	1.00	12	This option consists of construction of flood defence walls and flood defence embankments. The option will reduce the potential for flooding in the 1% AEP Fluvial for twelve RPS and five NIAH and 0.006km2 of ACA. Wall construction is proposed on the Main Bridge in Newcastle West which is an NIAH. Therefore, overall there is a potential for an increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.	1.00	12	This option consists of construction of walls, embankments, removal of a building, bridge replacement and widening of a channel. The option will reduce the potential for flooding in the 1% AEP Fluvial for twelve RPS and four NIAH and 0.006km2 of ACA. Wall construction is proposed on the Main Bridge in Newcastle West which is an NIAH Regional rated structure. Additionally, the building proposed to be removed is adjacent to an NIAH building (Foot Bridge) and has the potential to be impacted, visually and/or restricting access. Therefore, overall there is a potential for an increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.	0.50	6
		f ii)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of archaeological value	4	1.00	Newcastle West is not a heritage town and contains no protected features of archaeological value within the 1% AEP Fluvial. However, Desmond Hall & Great Hall Medieval Castle Complex which is a national monument is located 40m outside the 1% AEP Fluvial, some of the grounds may fall within the 1% AEP. Although there are no archaeological features at risk Weighting of 1 applied due to National Monument.	This option consists of wall construction of flood defence walls within Newcastle West and Individual Property Resistance. There is a one National Monument in State Care in the AFA, however is not within the 1% AEP Fluvial flood extent. Potential impact to the setting of a national monument due to the construction of flood defence walls near Desmond Castle. Therefore, potential changes to the setting of archaeological features (Recorded Monument or National Monument) such that it is slightly changed.	-1.00	-4	This option consists of construction of flood defence walls and flood defence embankments. There is a one National Monument in State Care in the AFA, however is not within the 1% AEP Fluvial flood extent. Potential impact to the setting of a national monument due to the construction of flood defence walls near Desmond Castle. Therefore, potential changes to the setting of archaeological features (Recorded Monument or National Monument) such that it is slightly changed.	-1.00	-4	This option consists of construction of walls, embankments, removal of a building, bridge replacement and widening of a channel. There is a one National Monument in State Care in the AFA, however is not within the 1% AEP Fluvial flood extent. Potential impact to the setting of a national monument due to the construction of flood defence walls near Desmond Castle. Therefore, potential changes to the setting of archaeological features (Recorded Monument or National Monument) such that it is slightly changed.	-1.00	-4
			ENVIRONMENTAL CRITERIA SCORE						-238			-310			-410
Economic Values			Economic PV Benefits					€4,756,674			€4,815,737			€4,829,323	
			Cost					€2,162,440			€2,746,357			€3,922,559	
			NPV Benefits					€2,594,234			€2,069,380			€906,764	
			Economic BCR					2.20			1.75			1.23	
Outcome Scores			MCA PV Benefits					€2,345,544			€2,362,568			€2,369,007	
			MCA Benefit Score					817			788			688	
			MCA BCR					377.62			286.90			175.49	
			Option Selection MCA					1667			1888			1538	

Objective	Global Weightings (fixed)	Local Weightings		Baseline Comments	Option 1 Comments	Option 2 Comments	Option 3 Comments
1.A	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has negligible operational risks to operate or perform successfully.	This score is determined for this option as it has no operational risks to operate or perform successfully.	This score is determined for this option as it has no operational risks to operate or perform successfully.
1.B	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has low/moderate health and safety risks associated with the construction and operation of flood risk management option.	This score is determined for this option as it has very low health and safety risks associated with the construction and operation of flood risk management option.	This score is determined for this option as it has low/moderate health and safety risks associated with the construction and operation of flood risk management option.
1.C	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it can be adapted only at negligible to limited cost and difficulty, but provides no impediment to future interventions.	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.
2.A	24	2.67	calculated	Local weighting is calculated based on the baseline AAD.	This score is calculated based on the reduction in AAD, following the full implementation of option.	This score is calculated based on the reduction in AAD, following the full implementation of option.	This score is calculated based on the reduction in AAD, following the full implementation of option.
2.B	10	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to transport infrastructure. Local weighting already at maximum.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.
2.C	14	0.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to utility infrastructure.	This score is calculated based on a reduction in flood risk to utility infrastructure, following full implementation of option.	This score is calculated based on a reduction in flood risk to utility infrastructure, following full implementation of option.	This score is calculated based on a reduction in flood risk to utility infrastructure, following full implementation of option.
2.D	12	0.00	Professional judgement	Local weighting is calculated based on the percentage of rural land within the AFA.	This score is determined based on application of flood forecasting, following full implementation of the option.	This score is determined based on no change to the area of agricultural land flooded, following full implementation of the option.	This score is determined based on no change to the area of agricultural land flooded, following full implementation of the option.
3.A (i)	17	2.24	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to residential properties.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option. The Preliminary Option Score has been increased by 10% to account for presence of flood forecasting.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option.
3.A (ii)	17	0.00	calculated but adjusted by professional judgement if necessary	There are no high vulnerability properties at risk.	There is no risk to high vulnerability properties within the AFA.	There is no risk to high vulnerability properties within the AFA.	There is no risk to high vulnerability properties within the AFA.
3.B (i)	9	3.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to social infrastructure but adjusted by professional judgement. Local weighting increased by 20% due to presence of Assets of Particular Social Value.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option. The calculated score was then increased by 10% to account for the presence of flood forecasting but then reduced by 15% as assets of particular social value are still at risk.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option.
3.B (ii)	7	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to local employment. The local weighting is capped at the maximum value of 5.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option. The Option Score has been increased by 10% to account for the presence of flood forecasting.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option.
4.A	16	5.00	fixed	There are no cSACs or SPAs within the AFA. The Lower Shannon cSAC [002165] is c. 25 km downstream. The Lower River Shannon cSAC qualifying interests likely to occur within the AFA include otter, river, brook and sea lamprey, Atlantic salmon, and floating river vegetation. Stack's to Mullaghareirks, West Limerick Hills and MountEagle SPA [004161] is 5.6km west of the AFA along the River Daar. Hen Harriers are a feature of interest of this SPA. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are no designated sites but habitats/species are likely to be present that could be affected.	This option consists of construction of flood defence walls within Newcastle West and Individual Property Resistance. Construction - Related impacts due to significant construction works in and adjacent to the Doally River due to the construction of the flood defence walls. Operational - The proposed wall and embankment will permanently replace the natural bank in a short section along the Doally River (mainly upstream of main bridge in Newcastle West). This section of the Doally River is already modified through Newcastle West. However, these measures could cause potential changes to the hydrological and morphological regime of the waterbody. Reduced flooding in an area with no significant polluting sources in 1% AEP Fluvial. Therefore, short-term or intermittent impediment to the achievement of the waterbodies objective.	This option consists of construction of flood defence walls and flood defence embankments. Construction - Related impacts due to significant construction works in and adjacent to the Doally River and Killeline River due to the construction of the flood defence walls and flood defence embankments. Operational - The proposed walls and embankments will permanently replace the natural bank in a short section along the Deel River and Killeline River. Sections of both rivers are already modified through Newcastle West. However, these measures could cause potential changes to the hydrological and morphological regime of the waterbody. Reduced flooding in an area with no significant polluting sources in 1% AEP Fluvial. Therefore, short-term or intermittent impediment to the achievement of the waterbodies objective.	This option consists of construction of walls, embankments, removal of a building, bridge replacement and widening of a channel. Construction - Related impacts due to significant construction works in and adjacent to the Doally River and Killeline River due to the construction of the flood defence wall, flood defence embankments, removal of a building over the Doally River and widening of channel at the down stream end of Killeline River. Operational - The proposed wall, embankments, building removal and channel widening will permanently replace sections of the natural bank on the Doally River and Killeline River. This measures could cause potential changes to the hydrological and morphological regime of the waterbody, hydromorphological and physico-chemical impacts due to sediment release. Reduced flooding in area with no significant polluting sources in 1% AEP extent. Therefore permanent or long-term impediment to the achievement of waterbody objective.
4.B	10	2.00	Professional judgement	There are no cSACs or SPAs within the AFA. The Lower Shannon cSAC [002165] is c. 25 km downstream. The Lower River Shannon cSAC qualifying interests likely to occur within the AFA include otter, river, brook and sea lamprey, Atlantic salmon, and floating river vegetation. Stack's to Mullaghareirks, West Limerick Hills and MountEagle SPA [004161] is 5.6km west of the AFA along the River Daar. Hen Harriers are a feature of interest of this SPA. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are no designated sites but habitats/species are likely to be present that could be affected.	This option consists of wall construction of flood defence walls within Newcastle West and Individual Property Resistance. Potential construction effects due to surface water connection with the Lower River Shannon cSAC, approx. 25km downstream, such as the following: - Increases in suspended sediment; - Pollution risks to the River Deel which is linked to Lower River Shannon cSAC; - Disturbance to otter outside the cSAC. Potential construction effects due to disturbance to Hen Harrier outside the SPA. Therefore, this option has the potential to have a detrimental impact on existing cSAC and SPA site, including a delay in recovery of the site, but excluding impacts on the conservation objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	This option consists of the construction of flood defence walls and flood defence embankments. Potential construction effects due to surface water connection with the Lower River Shannon cSAC, such as the following: - Increases in suspended sediment; - Pollution risks to the River Deel which is linked to Lower River Shannon cSAC; - Disturbance to otter outside the cSAC. Potential construction effects due to disturbance to Hen Harrier outside the SPA. Therefore, this option has the potential to have a detrimental impact on existing cSAC and SPA site, including a delay in recovery of the site, but excluding impacts on the conservation objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	This option consists of construction of walls, embankments, removal of a building, Bridge Replacement and widening of a channel. Potential construction effects due to surface water connection with the Lower River Shannon cSAC, such as the following: - Increases in suspended sediment; - Pollution risks to the River Deel which is linked to Lower River Shannon cSAC; - Disturbance to otter outside the cSAC. Potential construction effects due to disturbance to Hen Harrier outside the SPA. Therefore, this option has the potential to cause a detrimental impact on existing cSAC and SPA site, including a delay in recovery of the site, but excluding impacts on the conservation objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.
4.C	5	2.00	Professional judgement	There are no nationally designated sites within the AFA, but there is potential for significant habitats and populations of European and nationally protected species. Glenastar Wood pNHA [001431] is 5.5km downstream of the AFA. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are no designated sites but habitats/species are likely to be present that could be affected	This option consists of construction of flood defence walls within Newcastle West and Individual Property Resistance. Potential effects are construction impacts of the embankments, which has the potential to impact as follows: - Disturbance to protected bird species - Disturbance to fish species - Disturbance to protected mammals including otter Therefore, there is potential localised loss of, or disturbance to, flora/fauna limited by the already modified nature of channel/shoreline.	This option consists of construction of flood defence walls and flood defence embankments. Potential effects are construction impacts of the embankments, which has the potential to impact as follows: - Disturbance to protected bird species - Disturbance to fish species - Disturbance to protected mammals including otter Therefore, there is potential localised loss of, or disturbance to, flora/fauna limited by the already modified nature of channel/shoreline.	This option consists of construction of walls, embankments, removal of a building, bridge replacement and widening of a channel. Potential effects are construction impacts of the embankments, which has the potential to impact as follows: - Disturbance to protected bird species - Disturbance to fish species - Disturbance to protected mammals including otter Therefore, there is potential for localised loss of, or disturbance to, flora/fauna.
4.D	13	2.00	Professional judgement	The Deel River is not designated as a Salmonid River but is an angling area of medium importance. Local weighting of 2 set by professional judgement. Weighting of 2 applied where a waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.	This option consists of construction of flood defence walls within Newcastle West and Individual Property Resistance. Construction related impacts on water quality and subsequent fish species. Construction works of embankments adjacent to the Doally River may impact water quality. Therefore, there is a short-term minor impacts to fisheries habitat.	This option consists of construction of flood defence walls and flood defence embankments. Construction related impacts on water quality and subsequent fish species. Construction works of embankments and walls adjacent to and along the Doally River and Killeline River may impact water quality. Therefore, there is potential for short-term minor impacts to fisheries habitat.	This option consists of construction of walls, embankments, removal of a building, bridge replacement and widening of a channel. Construction related impacts on water quality and subsequent fish species. Therefore, there is potential for medium to long-term alternation of fisheries habitat.
4.E	8	1.00	Professional judgement	There are no designated landscape features within the AFA. There is one Undesignated Route, The Great Southern Trail which crosses the Daar River. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected.	This option consists of the construction of flood defence walls within Newcastle West and Individual Property Resistance. Localised impact in the immediate area of the measures. However, where The Great Southern Way crosses the Daar River there are no proposed flood risk management measures. No impact is anticipated to The Great Southern Way. Therefore, this option has minimal potential to change existing landscape character/features in the zone of influence of the selected measure.	This option consists of construction of flood defence walls and flood defence embankments. Localised impact in the immediate area of the measures. However, where The Great Southern Way crosses the Daar River there are no proposed flood risk management measures. No impact is anticipated to The Great Southern Way. Therefore, this option has minimal potential to change existing landscape character/features in the zone of influence of the selected measure.	This option consists of construction of walls, embankments, removal of a building, bridge replacement and widening of a channel. Localised impact in the immediate area of the measures. However, where The Great Southern Way crosses the Daar River there are no proposed flood risk management measures. No impact is anticipated to The Great Southern Way. Therefore, this option has minimal potential to change existing landscape character/features in the zone of influence of the selected measure.
4.F(i)	4	3.00	Professional judgement	Newcastle West is not a heritage town. 0.006 km2 of the ACA falls within or partly within the 1% AEP Fluvial. 12 RPS and 4 NIAH fall within the 1% AEP Fluvial. Local weighting of 3 set by professional judgement. Weighting of 3 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a high to moderate vulnerability.	This option consists of wall construction of flood defence walls within Newcastle West and Individual Property Resistance. The option will reduce the potential for flooding in the 1% AEP Fluvial for seven RPS and three NIAH and 0.006km2 of ACA. Wall construction is proposed on the Main Bridge in Newcastle West which is an NIAH. In addition the property resistance will include work on 3 RPS. Therefore, overall there is a potential for an increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.	This option consists of construction of flood defence walls and flood defence embankments. The option will reduce the potential for flooding in the 1% AEP Fluvial for twelve RPS and five NIAH and 0.006km2 of ACA. Wall construction is proposed on the Main Bridge in Newcastle West which is an NIAH. Therefore, overall there is a potential for an increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.	This option consists of construction of walls, embankments, removal of a building, bridge replacement and widening of a channel. The option will reduce the potential for flooding in the 1% AEP Fluvial for twelve RPS and four NIAH and 0.006km2 of ACA. Wall construction is proposed on the Main Bridge in Newcastle West which is an NIAH Regional rated structure. Additionally, the building proposed to be removed is adjacent to an NIAH building (Foot Bridge) and has the potential to be impacted, visually and/or restricting access. Therefore, overall there is a potential for an increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.
4.F(ii)	4	1.00	Professional judgement	Newcastle West is not a heritage town and contains no protected features of archaeological value within the 1% AEP Fluvial. However, Desmond Hall & Great Hall Medieval Castle Complex which is a national monument is located 40m outside the 1% AEP Fluvial, some of the grounds may fall within the 1% AEP. Although there are no archaeological features at risk Weighting of 1 applied due to National Monument.	This option consists of wall construction of flood defence walls within Newcastle West and Individual Property Resistance. There is a one National Monument in State Care in the AFA, however is not within the 1% AEP Fluvial flood extent. Potential impact to the setting of a national monument due to the construction of flood defence walls near Desmond Castle. Therefore, potential changes to the setting of archaeological features (Recorded Monument or National Monument) such that it is slightly changed.	This option consists of construction of flood defence walls and flood defence embankments. There is a one National Monument in State Care in the AFA, however is not within the 1% AEP Fluvial flood extent. Potential impact to the setting of a national monument due to the construction of flood defence walls near Desmond Castle. Therefore, potential changes to the setting of archaeological features (Recorded Monument or National Monument) such that it is slightly changed.	This option consists of construction of walls, embankments, removal of a building, bridge replacement and widening of a channel. There is a one National Monument in State Care in the AFA, however is not within the 1% AEP Fluvial flood extent. Potential impact to the setting of a national monument due to the construction of flood defence walls near Desmond Castle. Therefore, potential changes to the setting of archaeological features (Recorded Monument or National Monument) such that it is slightly changed.

Option 1 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis						Notes to CFRAM Consultants
			€	€	€	
(1)	**Basic Construction Costs (Estimate)**				**871,954**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2)	**Preliminaries**	18.7%			**163,289**	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**1,035,243**	
(3)	**Optimism Bias**	40.0%			**414,097**	Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**1,449,340**	
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13.0%			**188,414**	Set at 13%
	Construction Costs and Fees				**1,637,755**	
(6)	**Other Items**					
(a)	Allowance for Archaeology & Environmental Mitigation Measures	12.0%		173,921		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	13.0%		188,414		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation	3% assumed		43,480		Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance			25,500		See “Guidance E – Per Cent for Art Note”
(e)	Est. NPV Operation & Maintenance		66,693			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	40.0%	26,677	93,370	**524,685**	Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**2,162,440**	

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DONNACHADH O'BRIEN & ASSOCIATES CONSULTING ENGINEERS

OPW The Office of Public Works Oifig na nOibreacha Poiblí

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	PT	Date:	05/06/2015
Checked by:		Date:	

Project reference	S11	Project name:	Shannon CFRAMS - S11 Newcastle West

Base date for estimates (year 0)	Dec-2013	Construction Price Index (CPI)	0.987
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues /constraints	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	Cost (€)	Comment
Total wall costs	€730,144	
Total embankment costs		
Total demountable barriers/gates costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge removal costs		
Total bridge construction costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs	€135,800	
Total hydrometric gauging station costs		
Total flood forecasting costs	€17,900	
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€883,844	
Apply update to unit rate (CPI) if appropriate (cell N15)	€871,954	
Enter appropriate preliminaries estimate (%)	18.73%	*ref: Preliminaries and other costs v1.0*
Enter other applicable costs (€)		
Total capital cost (€)	€1,035,243	
Consider amendments based on site issues/constraints (cell N16)	€1,035,243	
Total capital cost (€)	**€1,035,243**	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs	€209	
Total embankment O&M costs		
Total demountable barriers/gates O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs	€2,716	
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs	€200	
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€3,125	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€1,101,936	
Optimism bias rate (from external sheet)	40%	*ref: Optimism Bias Tool v.2.0 - medium risk assumed.*
Total Cost including Optimism Bias	**€1,542,710**	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	€0
Year of capital works (year)	
Capital cost (€)	€1,035,243
Annual maintenance cost (€)	€3,125
Other cost (€)	€0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	4.0%	Present Value Factor:		22.341	Total PVc (€k):		1101936
	Cash sum	0	1035243	153127	0	1188370	1101936
	Discount	Cost Elements				TOTALS:	
year	Factor	Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0	1035243			1035243.1	1035243.1
1	0.962			3125		3125.0	3004.8
2	0.925			3125		3125.0	2889.3
3	0.889			3125		3125.0	2778.1
4	0.855			3125		3125.0	2671.3
5	0.822			3125		3125.0	2568.6
6	0.790			3125		3125.0	2469.8
7	0.760			3125		3125.0	2374.8
8	0.731			3125		3125.0	2283.4
9	0.703			3125		3125.0	2195.6
10	0.676			3125		3125.0	2111.2
11	0.650			3125		3125.0	2030.0
12	0.625			3125		3125.0	1951.9
13	0.601			3125		3125.0	1876.8
14	0.577			3125		3125.0	1804.6
15	0.555			3125		3125.0	1735.2
16	0.534			3125		3125.0	1668.5
17	0.513			3125		3125.0	1604.3
18	0.494			3125		3125.0	1542.6
19	0.475			3125		3125.0	1483.3
20	0.456			3125		3125.0	1426.2
21	0.439			3125		3125.0	1371.4
22	0.422			3125		3125.0	1318.6
23	0.406			3125		3125.0	1267.9
24	0.390			3125		3125.0	1219.1
25	0.375			3125		3125.0	1172.3
26	0.361			3125		3125.0	1127.2
27	0.347			3125		3125.0	1083.8
28	0.333			3125		3125.0	1042.1
29	0.321			3125		3125.0	1002.0
30	0.308			3125		3125.0	963.5
31	0.296			3125		3125.0	926.4
32	0.285			3125		3125.0	890.8
33	0.274			3125		3125.0	856.6
34	0.264			3125		3125.0	823.6
35	0.253			3125		3125.0	791.9
36	0.244			3125		3125.0	761.5
37	0.234			3125		3125.0	732.2
38	0.225			3125		3125.0	704.0
39	0.217			3125		3125.0	676.9
40	0.208			3125		3125.0	650.9
41	0.200			3125		3125.0	625.9
42	0.193			3125		3125.0	601.8
43	0.185			3125		3125.0	578.7
44	0.178			3125		3125.0	556.4
45	0.171			3125		3125.0	535.0
46	0.165			3125		3125.0	514.4
47	0.158			3125		3125.0	494.6
48	0.152			3125		3125.0	475.6
49	0.146			3125		3125.0	457.3

Option 2 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis					Notes to CFRAM Consultants
		€	€	€	
(1) Basic Construction Costs (Estimate)				**1,141,003**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2) Preliminaries	17.5%			**199,865**	Refer to UCD for selecting Preliminaries. %
Sub-Total:				**1,340,868**	
(3) Optimism Bias	40.0%			**536,347**	Refer to UCD for selecting OB %
(4) Construction Costs (Excl VAT)				**1,877,215**	
(5) Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)	13.0%			**244,038**	Set at 13%
Construction Costs and Fees				**2,121,253**	
(6) Other Items					
(a) Allowance for Archaeology & Environmental Mitigation Measures	13.0%		244,038		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b) Allowance for compensation and land acquisition	13.0%		244,038		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c) Site investigation	4% assumed		75,089		Professional judgement to be applied in estimating a suitable sum.
(d) Art Allowance			25,500		See "Guidance E – Per Cent for Art Note"
(e) Est. NPV Operation & Maintenance		26,028			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
Optimism Bias	40.0%	10,411	36,439	**625,104**	Refer to UCD for selecting OB %
Option Cost for Cost Benefit Analysis				**2,746,357**	

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OPW The Office of Public Works Oifig na nOibreacha Poiblí

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	PT	Date:	05/06/2015
Checked by:		Date:	

Project reference	S11_NWT_02	Project name:	Shannon CFRAMS - S11 Newcastle West

Base date for estimates (year 0)	Dec-2013	Construction Price Index (CPI)	0.987
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues /constraints	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	Cost (€)	Comment
Total wall costs	€1,117,086	
Total embankment costs	€39,476	
Total demountable barriers/gates costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge removal costs		
Total bridge construction costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€1,156,562	
Apply update to unit rate (CPI) if appropriate (cell N15)	€1,141,003	
Enter appropriate preliminaries estimate (%)	17.52%	*ref: Preliminaries and other costs v1.0*
Enter other applicable costs (€)		
Total capital cost (€)	€1,340,868	
Consider amendments based on site issues/constraints (cell N16)	€1,340,868	
Total capital cost (€)	**€1,340,868**	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs	€321	
Total embankment O&M costs	€898	
Total demountable barriers/gates O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€1,220	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€1,366,896	
Optimism bias rate (from external sheet)	40%	*ref: Optimism Bias Tool v.2.0 - medium risk assumed.*
Total Cost including Optimism Bias	**€1,913,655**	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	€0
Year of capital works (year)	
Capital cost (€)	€1,340,868
Annual maintenance cost (€)	€1,220
Other cost (€)	€0
Other works frequency (years)	

Key

- Information
- Calculation
- Cost input
- User information

Discount rate:	4.0%	Present Value Factor:		22.341	Total PVc (€k):		1366896
	Cash sum	0	1340868	59760	0	1400628	1366896
	Discount	Cost Elements				TOTALS:	
year	Factor	Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0	1340868			1340868.0	1340868.0
1	0.962			1220		1219.6	1172.7
2	0.925			1220		1219.6	1127.6
3	0.889			1220		1219.6	1084.2
4	0.855			1220		1219.6	1042.5
5	0.822			1220		1219.6	1002.4
6	0.790			1220		1219.6	963.9
7	0.760			1220		1219.6	926.8
8	0.731			1220		1219.6	891.2
9	0.703			1220		1219.6	856.9
10	0.676			1220		1219.6	823.9
11	0.650			1220		1219.6	792.2
12	0.625			1220		1219.6	761.8
13	0.601			1220		1219.6	732.5
14	0.577			1220		1219.6	704.3
15	0.555			1220		1219.6	677.2
16	0.534			1220		1219.6	651.2
17	0.513			1220		1219.6	626.1
18	0.494			1220		1219.6	602.0
19	0.475			1220		1219.6	578.9
20	0.456			1220		1219.6	556.6
21	0.439			1220		1219.6	535.2
22	0.422			1220		1219.6	514.6
23	0.406			1220		1219.6	494.8
24	0.390			1220		1219.6	475.8
25	0.375			1220		1219.6	457.5
26	0.361			1220		1219.6	439.9
27	0.347			1220		1219.6	423.0
28	0.333			1220		1219.6	406.7
29	0.321			1220		1219.6	391.1
30	0.308			1220		1219.6	376.0
31	0.296			1220		1219.6	361.6
32	0.285			1220		1219.6	347.7
33	0.274			1220		1219.6	334.3
34	0.264			1220		1219.6	321.4
35	0.253			1220		1219.6	309.1
36	0.244			1220		1219.6	297.2
37	0.234			1220		1219.6	285.7
38	0.225			1220		1219.6	274.8
39	0.217			1220		1219.6	264.2
40	0.208			1220		1219.6	254.0
41	0.200			1220		1219.6	244.3
42	0.193			1220		1219.6	234.9
43	0.185			1220		1219.6	225.8
44	0.178			1220		1219.6	217.1
45	0.171			1220		1219.6	208.8
46	0.165			1220		1219.6	200.8
47	0.158			1220		1219.6	193.0
48	0.152			1220		1219.6	185.6
49	0.146			1220		1219.6	178.5

Option 3 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis			€	€	€	Notes to CFRAM Consultants
(1)	**Basic Construction Costs (Estimate)**				**1,649,722**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2)	**Preliminaries**	15.9%			**261,604**	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**1,911,326**	
(3)	**Optimism Bias**	40.0%			**764,530**	Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**2,675,856**	
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13.0%			**347,861**	Set at 13%
	Construction Costs and Fees				**3,023,717**	
(6)	**Other Items**					
(a)	Allowance for Archaeology & Environmental Mitigation Measures	14%		374,620		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	13%		357,517		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation	4% assumed		107,034		Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance			25,500		See "Guidance E – Per Cent for Art Note"
(e)	Est. NPV Operation & Maintenance		24,408			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	40.0%	9,763	34,171	**898,842**	Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**3,922,559**	

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OPW The Office of Public Works / Oifig na nOibreacha Poiblí

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	PT	Date:	05/06/2015
Checked by:		Date:	

Project reference	S11_NWT_03	Project name:	Shannon CFRAMS - S11 Newcastle West

Base date for estimates (year 0)	Dec-2013	Construction Price Index (CPI)	0.987
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues /constraints	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	Cost (€)	Comment
Total wall costs	€1,121,476	
Total embankment costs	€36,140	
Total demountable barriers/gates costs		
Total in-channel excavation costs	€18,870	
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge removal costs	€41,643	*Include cost of removing 168m2 of building across the maain channel*
Total bridge construction costs	€166,808	
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs	€287,280	*Cost of removing 168m2 of building across the main channel. 168x171x10.*
Total Construction costs	€1,672,218	
Apply update to unit rate (CPI) if appropriate (cell N15)	€1,649,722	
Enter appropriate preliminaries estimate (%)	15.86%	*ref: Preliminaries and other costs v1.0*
Enter other applicable costs (€)		
Total capital cost (€)	€1,911,326	
Consider amendments based on site issues/constraints (cell N16)	€1,911,326	
Total capital cost (€)	**€1,911,326**	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs	€321	
Total embankment O&M costs	€823	
Total demountable barriers/gates O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€1,144	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€1,935,733	
Optimism bias rate (from external sheet)	40%	*ref: Optimism Bias Tool v.2.0 - medium risk assumed.*
Total Cost including Optimism Bias	**€2,710,027**	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	€0
Year of capital works (year)	
Capital cost (€)	€1,911,326
Annual maintenance cost (€)	€1,144
Other cost (€)	€0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	4.0%	Present Value Factor:		22.341	Total PVc (€k):		1935733
	Cash sum	0	1911326	56040	0	1967366	**1935733**
	Discount	Cost Elements				TOTALS:	
year	Factor	Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0	1911326			1911325.7	1911325.7
1	0.962			1144		1143.7	1099.7
2	0.925			1144		1143.7	1057.4
3	0.889			1144		1143.7	1016.7
4	0.855			1144		1143.7	977.6
5	0.822			1144		1143.7	940.0
6	0.790			1144		1143.7	903.9
7	0.760			1144		1143.7	869.1
8	0.731			1144		1143.7	835.7
9	0.703			1144		1143.7	803.5
10	0.676			1144		1143.7	772.6
11	0.650			1144		1143.7	742.9
12	0.625			1144		1143.7	714.3
13	0.601			1144		1143.7	686.9
14	0.577			1144		1143.7	660.4
15	0.555			1144		1143.7	635.0
16	0.534			1144		1143.7	610.6
17	0.513			1144		1143.7	587.1
18	0.494			1144		1143.7	564.5
19	0.475			1144		1143.7	542.8
20	0.456			1144		1143.7	522.0
21	0.439			1144		1143.7	501.9
22	0.422			1144		1143.7	482.6
23	0.406			1144		1143.7	464.0
24	0.390			1144		1143.7	446.2
25	0.375			1144		1143.7	429.0
26	0.361			1144		1143.7	412.5
27	0.347			1144		1143.7	396.6
28	0.333			1144		1143.7	381.4
29	0.321			1144		1143.7	366.7
30	0.308			1144		1143.7	352.6
31	0.296			1144		1143.7	339.1
32	0.285			1144		1143.7	326.0
33	0.274			1144		1143.7	313.5
34	0.264			1144		1143.7	301.4
35	0.253			1144		1143.7	289.8
36	0.244			1144		1143.7	278.7
37	0.234			1144		1143.7	268.0
38	0.225			1144		1143.7	257.7
39	0.217			1144		1143.7	247.7
40	0.208			1144		1143.7	238.2
41	0.200			1144		1143.7	229.1
42	0.193			1144		1143.7	220.2
43	0.185			1144		1143.7	211.8
44	0.178			1144		1143.7	203.6
45	0.171			1144		1143.7	195.8
46	0.165			1144		1143.7	188.3
47	0.158			1144		1143.7	181.0
48	0.152			1144		1143.7	174.1
49	0.146			1144		1143.7	167.4

Appendix C2 Option Appraisal Report - Askeaton

JACOBS

OPW The Office of Public Works / Oifig na nOibreacha Poiblí

1. Preliminary Report: Summary of Current Flood Risk

1.1 AFA and Watercourse Details

AFA	Askeaton
Unit of Management:	24
Primary Watercourse(s):	River Deel , River Deegerty

1.2 Summary of Flood Risk in 1% Fluvial / 0.5% Coastal AEP Event

Source of flood risk	Fluvial	Coastal	**Both**

Total Number of Properties at risk in AFA in 1% Fluvial / 0.5% Coastal AEP Event:		**Residential**	**Non-Residential**	**Total**
	Fluvial	25	16	41
	Coastal	27	11	38
	Combined	29	18	47

AFA Flood Cells:	**Total Number:**	6
	Flood Cell Titles:	ASN_A, ASN_B, ASN_C, ASN_D, ASN_E, ASN_F

Breakdown of properties at (combined) risk per Flood Cell:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	ASN_A	0	4	4
	ASN_B	0	1	1
	ASN_C	14	4	18
	ASN_D	2	0	2
	ASN_E	1	1	2
	ASN_F	10	6	16
	ASN_G	0	2	2
	ASN_H	2	0	2

Relevant Comments:	Askeaton is at risk from both a 1% AEP fluvial and 0.5% AEP coastal flood source.
Relevant Figure Ref:	Figures 1.1, 1.2, and 1.3

1.3 Summary of Existing Flood Risk Management Measures

Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
Yes	None	None	None	None	None

Relevant Figure Ref:	Figures 1.1 and 1.2

1.4 Summary of PV Damages/Potential PV Benefits

Total PV Damages:		**Uncapped**	**Capped**
	Fluvial	€ 22,013,572	€ 10,713,935
	Coastal	€ 11,819,361	€ 4,679,881
	Combined	€ 33,832,933	€ 13,802,985

Max Combined Capped Benefits for 1% Fluvial and 0.5% Coastal AEP Event*:	€ 11,684,894

Breakdown of Max Combined Capped PV Benefits per Flood Cell for 1% Fluvial and 0.5% Coastal AEP Event:	Flood Cell Ref	Residential	Non-Res	Total
	ASN_A	€ 0	€ 1,665,044	€ 1,665,044
	ASN_B	€ 0	€ 1,950,443	€ 1,950,443
	ASN_C	€ 1,150,212	€ 859,313	€ 2,009,525
	ASN_D	€ 13,921	€ 0	€ 13,921
	ASN_E	€ 47,821	€ 11,814	€ 59,635
	ASN_F	€ 1,308,504	€ 3,371,982	€ 4,680,486
	ASN_G	€ 0	€ 1,387,742	€ 1,387,742
	ASN_H	€ 5,720	€ 0	€ 5,720
Relevant Figure Ref:	Figures 1.1, 1.2, and 1.3			

*These are the maximum benefits available if a FRM option with a 1% Fluvial / 0.5% Coastal AEP SOP is provided to all properties within the AFA.

1.5 Social Risk		
	Type	**Description**
High Vulnerability Properties at risk:	None	N/A
Social Infrastructure Assets:	None	N/A
Social Amenity Sites:	None	N/A
Relevant Figure Ref:	General Risk - Social	
1.6 Risk to the Environment		
	Type	**Description**
Risk to WFD Annex IV:	None	N/A
Risk to SACs:	None	N/A
Relevant Figure Ref:	General Risk - Environment	
1.7 Risk to Cultural Heritage		
	Type	**Description**
Risk to Sites of Cultural Heritage:	Recorded Monuments	**50% AEP Fluvial &Coastal Food Extent**
		Moig South
		Ahalacka, Askeaton, Cloonreask
	NIAH Building	**50% AEP Fluvial & Coastal Flood Extent**
		Askeaton Bridge
		House
		Water Pump, The Quay
		2% AEP Fluvial & Coastal Flood Extent
		House, The Square
		Store/Warehouse, The Quay
		2% AEP Fluvial Flood Extent
		Butcher, Main Street
		House

		1% Fluvial & Coastal Flood Extent
		Deel Bridge, Church Street
		1% AEP Coastal Flood Extent
		Abbey Mill (water)
		0.1% AEP Fluvial & Coastal Flood Extent
		House
Relevant Figure Ref:	General Risk – Cultural Heritage	
1.8 Risk to the Economy		
	Type	**Description**
Risk to Transport Infrastructure:	National Road	**50% AEP Coastal & Fluvial Flood Extent**
		N69
	Regional Road	**50% AEP Fluvial Flood Extent**
		R518 (Main Street)
		R518 (Church Street)
		50% AEP Coastal Flood Extent
		R518 (Church Street)
	Local Road	**50% AEP Fluvial Flood Extent**
		The Quay
		Milltown
		Aghalacka
		50% AEP Coastal Flood Extent
		The Quay
		Brewery Lane
		0.5% AEP Fluvial Flood Extent
		Abbey View
Risk to Utility Infrastructure:	None	N/A
Relevant Figure Ref:	General Risk - Economy	

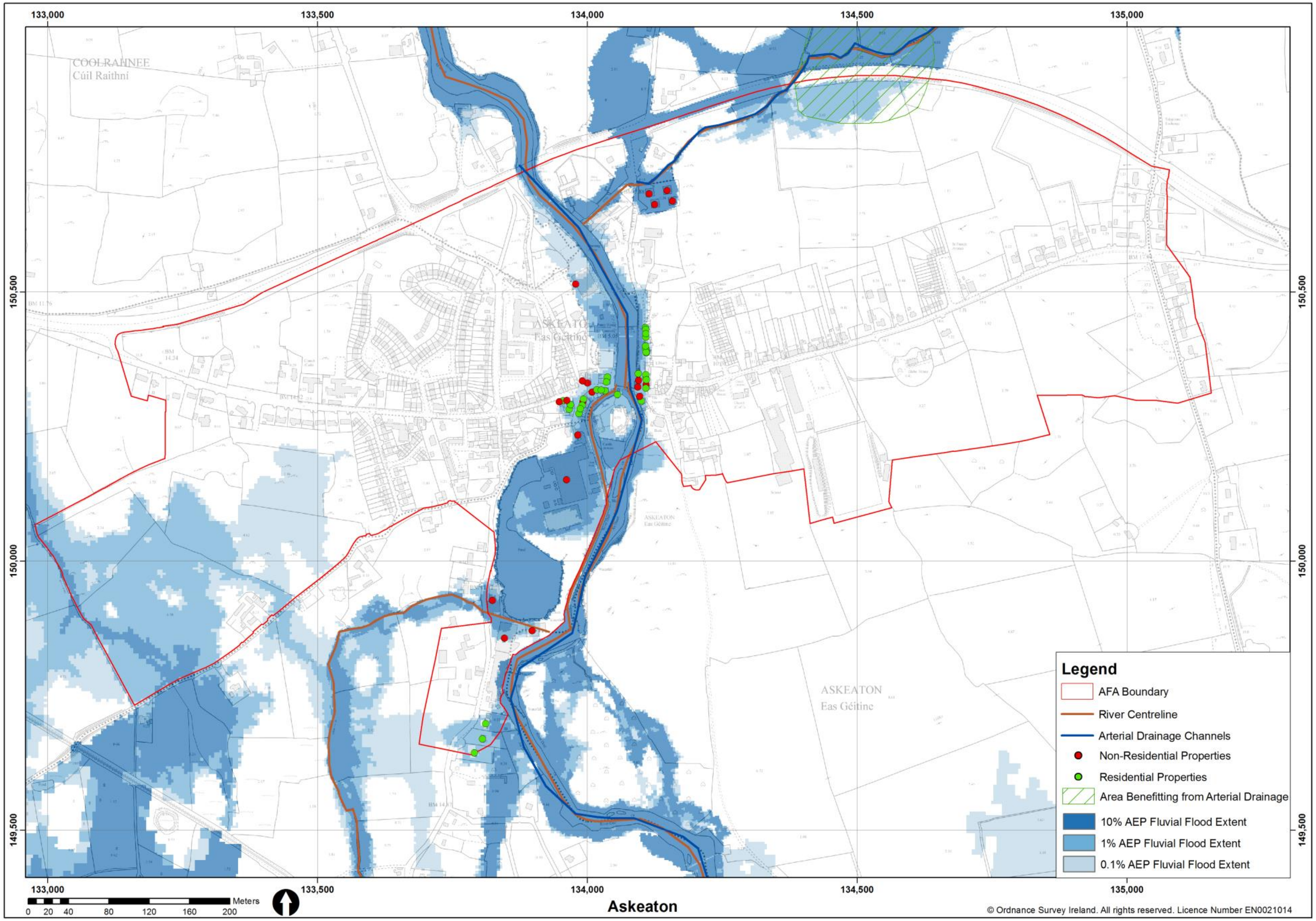


Figure 1.1 – Fluvial Flood Risk in Askeaton

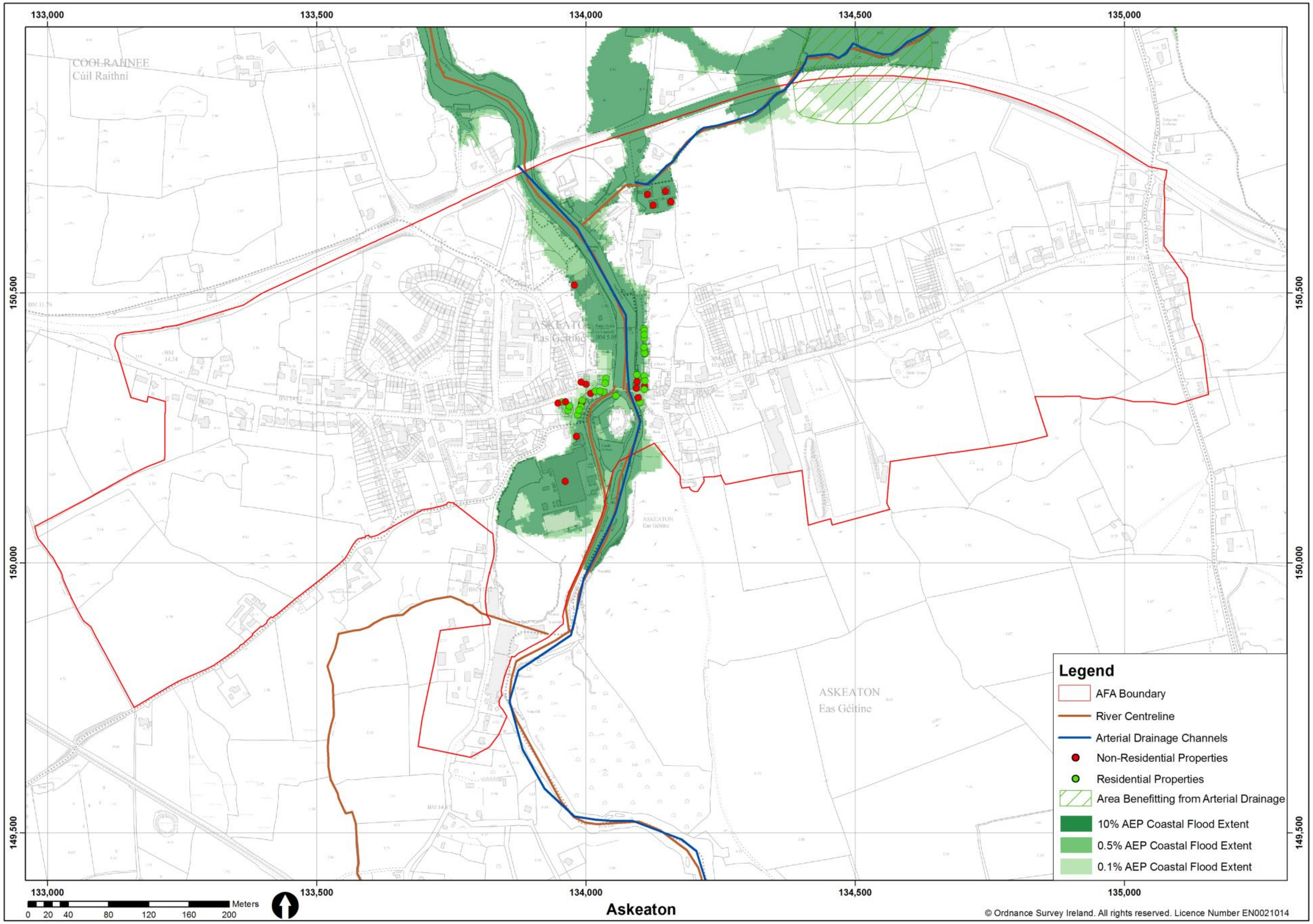


Figure 1.2 – Coastal Flood Risk in Askeaton

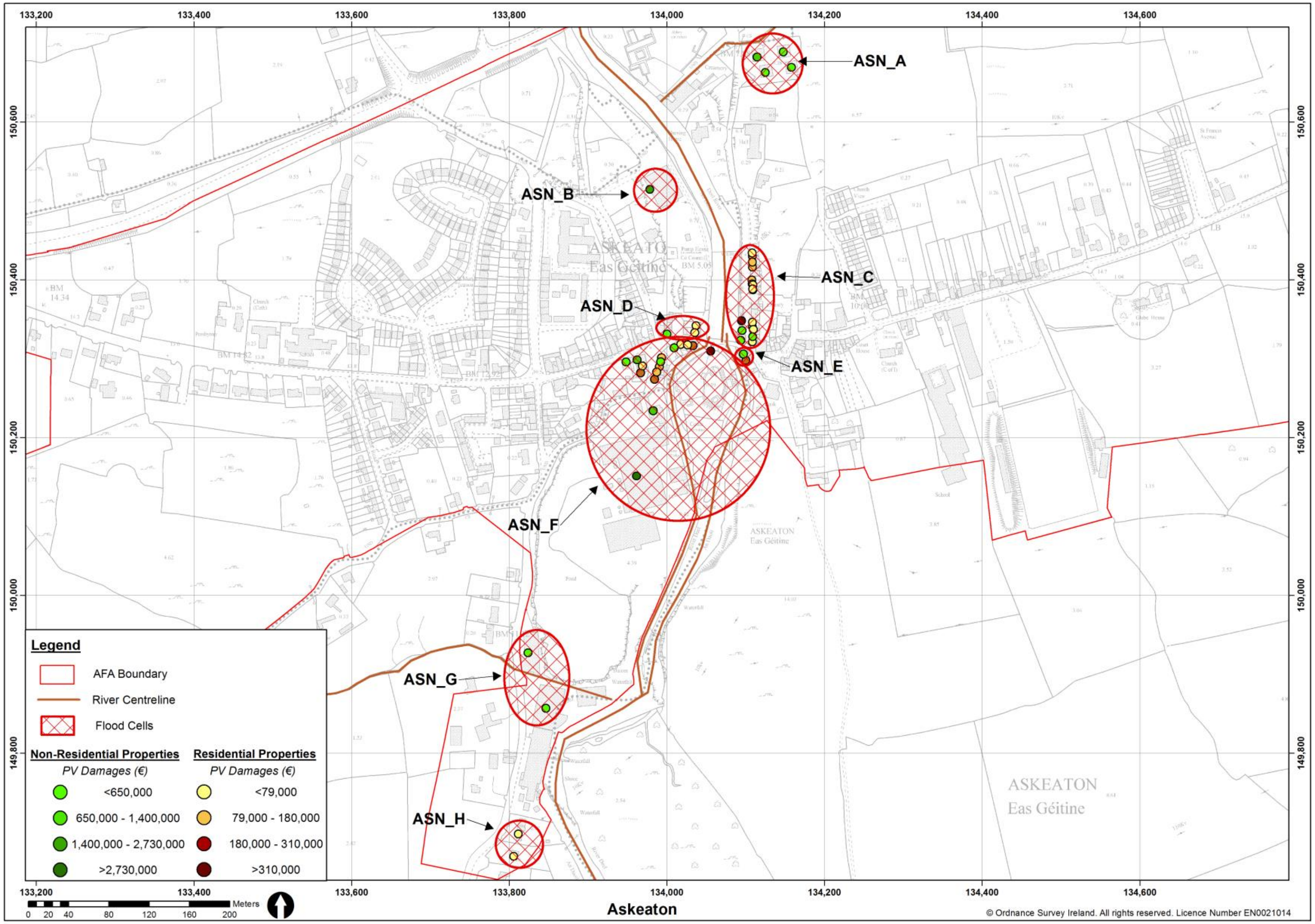


Figure 1.3 – Askeaton Total Combined PV Damages for Properties in the 1% Fluvial & 0.5% Coastal AEP Events and Flood Cells
Flood Cells are groupings of properties that are likely to be hydraulically linked

STAGE 2: Screening of the Measures

2.1 Baseline, Structural and Non-Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	Screened Out
B	Existing Regime	Viable	Viable	Viable	Viable	Viable	Screened In
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	Screened Out
Structural							
D	Storage	Unviable	Viable	Viable	Viable	Viable	Screened Out
E	Flow Diversion	Unviable	Viable	Viable	Viable	Viable	Screened Out
F	Increase Conveyance	Viable	Viable	Viable	Viable	Viable	Screened In
G	Flood Defences	Viable	Viable	Viable	Viable	Viable	Screened In
H	Relocation of Properties	Unviable	Viable	Viable	Viable	Viable	Screened Out
I	Other: Tidal Barrage	Unviable	Viable	Unviable	Viable	Viable	Screened Out
Non-Structural							
J	Flood Forecasting / Warning / Response	Viable	Viable	Viable	Viable	Viable	Screened In
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	Screened In
L	Individual Property Resistance	Viable	Viable	Viable	Viable	Viable	Screened In
M	Individual Property Resilience	Viable	Viable	Viable	Viable	Viable	Screened In

2.2 Justification for Screened Out Baseline and Structural Measures

The following provides justification on Measures with an overall viability 'Screened Out' categorisation.

A	Do Nothing	Applicability Economic Environmental Social Cultural	Screened out due to the number of properties currently at risk of flooding.
C	Do Minimum	Applicability Economic Environmental Social Cultural	Screened out, as the "Do Minimum" FRM measure would have a negligible impact to the existing flood risk.
D	Storage	Applicability Economic Environmental Social Cultural	There are two potential storage areas that may be suitable for managing the fluvial flood risk throughout the AFA; the locations of these are shown on Figure 2.1. However, the majority of the properties potentially benefiting from these storage areas are also at risk from coastal flooding. Therefore, this option was not progressed as it offers no improved flood risk management condition during coastal events. A storage option for properties only at risk from fluvial flooding was considered; refer to Figure 2.2. However when the water level is increased behind the proposed retaining embankment, the flood risk is

			increased to a number of properties upstream. Therefore, this measure has not been considered further in the option assessment stage.
E	Flow Diversion	Applicability Economic Environmental Social Cultural	Flow diversion was considered as a measure with potential routes shown as Figures 2.3 and 2.4. However, both these flow diversions would increase the flood risk to properties along their proposed route and neither addresses the coastal flood risk within the AFA. Therefore, this measure has not been considered further in the option assessment stage.
H	Relocation of Properties	Applicability Economic Environmental Social Cultural	The relocation of 45 properties is not applicable to the area as it would be socially unviable.
I	Other: Tidal Barrage	Applicability Economic Environmental Social Cultural	Constructing a tidal barrage in the Shannon Estuary could not avoid IRPOI because any instream construction in the estuary would require permanent loss of Qualifying Interest habitat within the Lower River Shannon cSAC (estuaries and mudflats). The presence of a feasible alternative (i.e., walls, as discussed) means that IROPI could not be pursued. There are several possible IROPI risks from this measure; the mudflat/estuary loss is only one. Therefore this measure has not been considered further in the option assessment stage.

2.3 Summary of 'Screened In' Measures

The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.

Baseline Measures		**Non-Structural Measures**	
B	Existing Regime	J	Flood Forecasting / Warning / Response
Structural Measures		K	Public Awareness
F	Increase Conveyance	L	Individual Property Resistance
G	Flood Defences	M	Individual Property Resilience

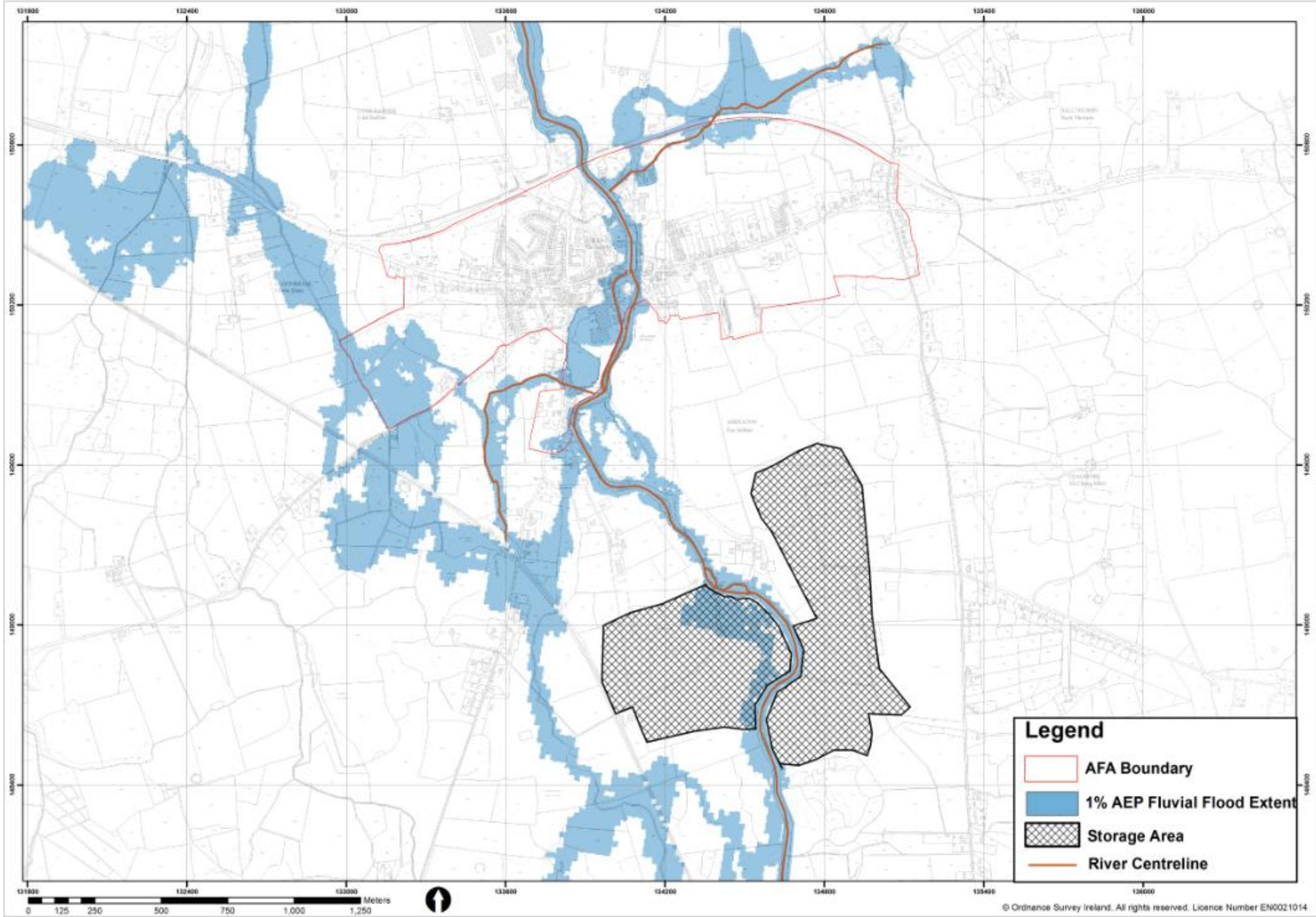


Figure 2.1 – Potential floodplain storage not included in options

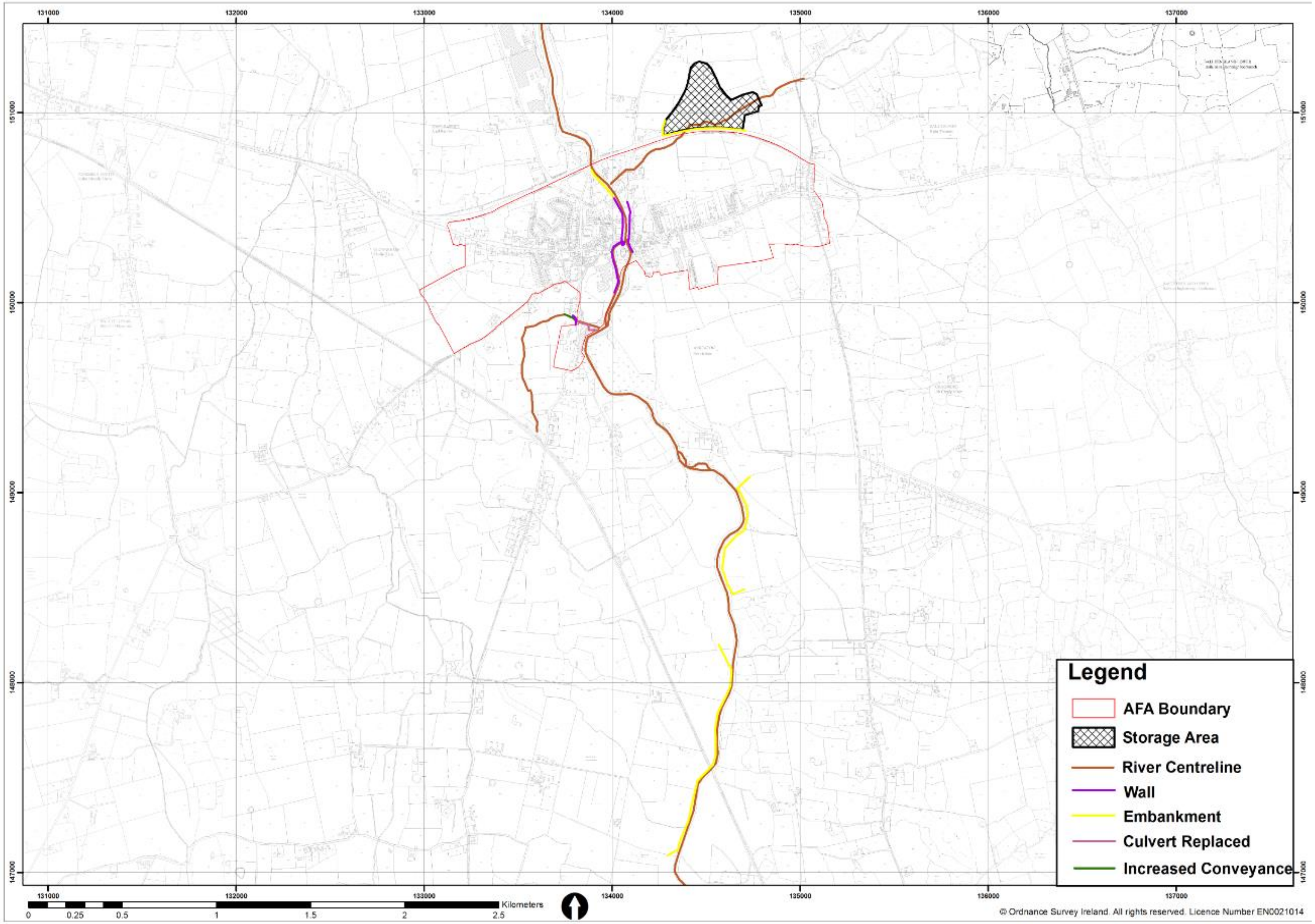


Figure 2.2 – Potential floodplain storage not included in options

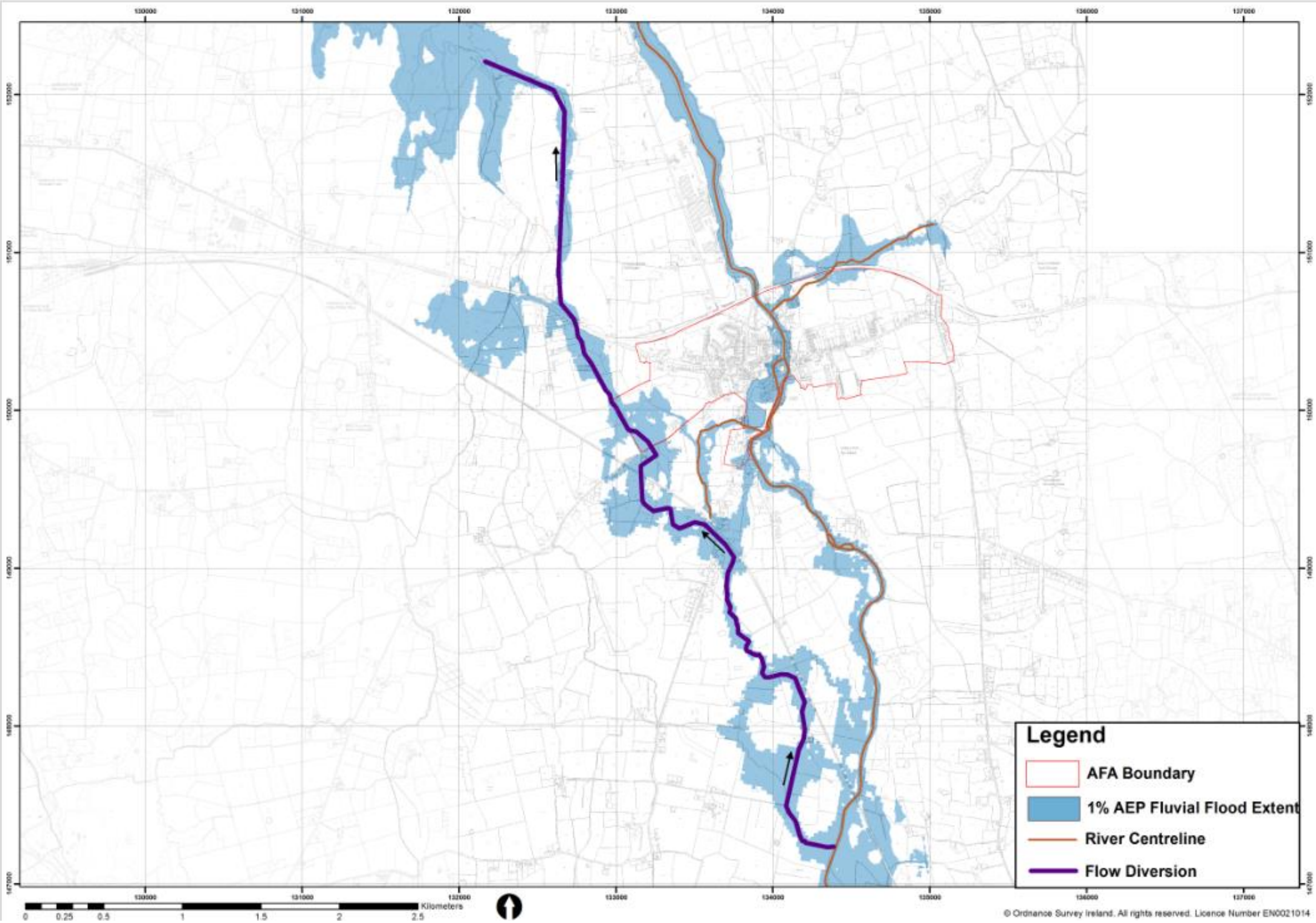


Figure 2.3 – Flow diversion measure not included in Options

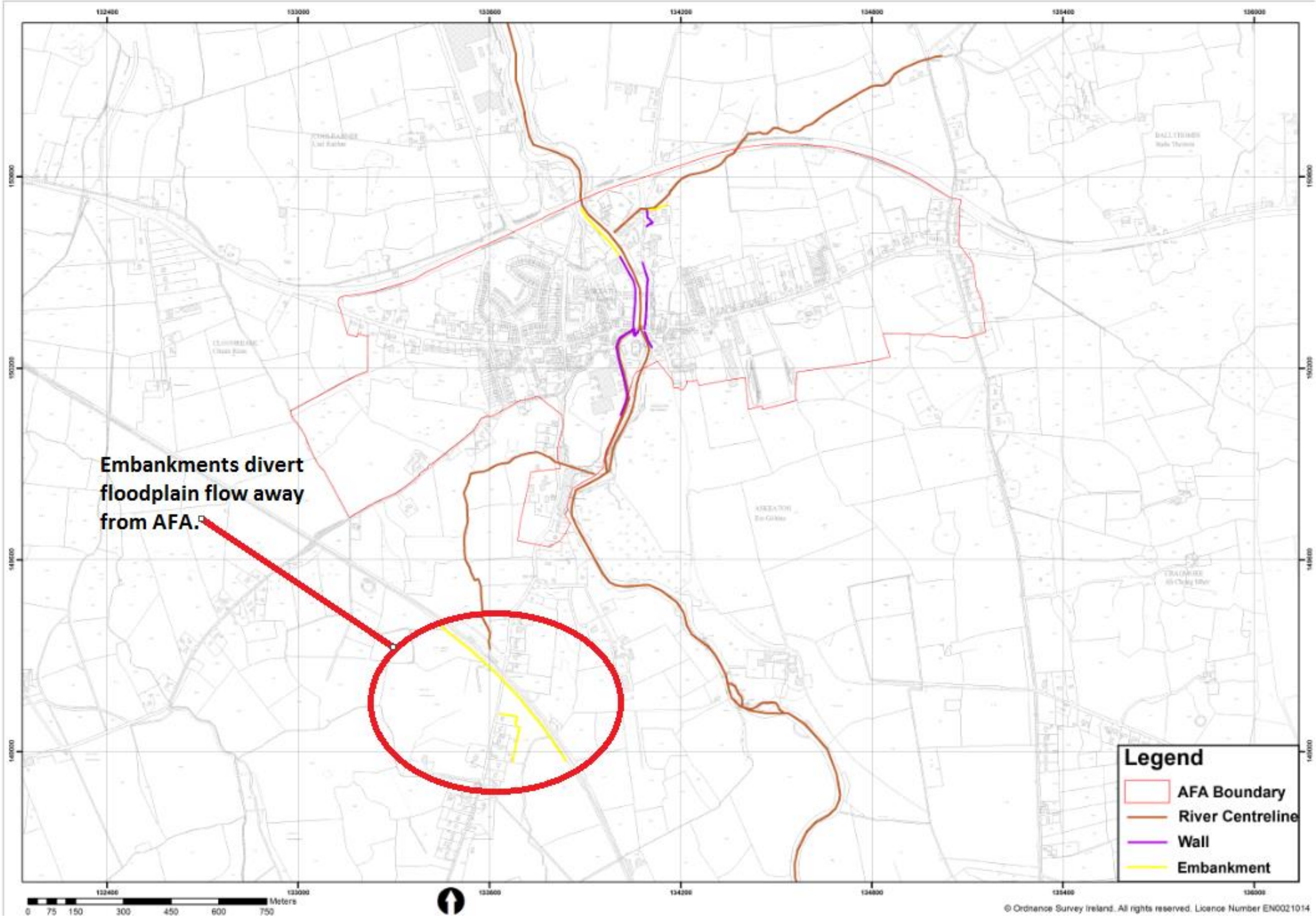


Figure 2.4 – Floodplain flow diversion measure not included in options

STAGE 3: Selection of Options

3.1 Consideration of Options

The following are the agreed combination of 'Screened In' measures that comprise each of the Options being taken forward for further consideration.

Where appropriate, the 'Screened In' measures have been sub-divided into separate specific measures to ensure applicability to site conditions.

<table>
<tr><th colspan="2">Measures</th><th colspan="7">Different composition of measures per option</th></tr>
<tr><td colspan="9">Baseline Measures</td></tr>
<tr><td>B</td><td>Existing Regime</td><td>✓</td><td>✓</td><td>✓</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="9">Structural Measures</td></tr>
<tr><td>F</td><td colspan="8">Increase Conveyance</td></tr>
<tr><td>Fi</td><td>Channel Dredging</td><td>✓</td><td>✓</td><td>✓</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Fii</td><td>Channel Widening</td><td>✓</td><td>✓</td><td>✓</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Fiii</td><td>Structure Enhancement / Works</td><td>✓</td><td>✓</td><td>✓</td><td></td><td></td><td></td><td></td></tr>
<tr><td>G</td><td colspan="8">Flood Defences</td></tr>
<tr><td>Gi</td><td>New Flood Defences</td><td>✓</td><td>✓</td><td>✓</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Gii</td><td>Raise Existing Flood Defences</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Giii</td><td>Demountable Defences</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Giv</td><td>Other Defences</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="9">Non-Structural Measures</td></tr>
<tr><td>J</td><td>Flood Forecasting / Warning / Response</td><td></td><td></td><td>✓</td><td></td><td></td><td></td><td></td></tr>
<tr><td>K</td><td>Public Awareness</td><td></td><td></td><td>✓</td><td></td><td></td><td></td><td></td></tr>
<tr><td>L</td><td>Individual Property Resistance</td><td></td><td></td><td>✓</td><td></td><td></td><td></td><td></td></tr>
<tr><td>M</td><td>Individual Property Resilience</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Option Reference</td><td>ASN_01</td><td>ASN_02</td><td>ASN_03</td><td></td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="3">Measures not screened out but not included in options</th></tr>
<tr><td colspan="2">Measures</td><td>Justification</td></tr>
<tr><td>M</td><td>Individual Property Resilience</td><td>Individual Property Resilience was not considered as either an independent measure or in combination with other measures, as the option being appraised would provide the required 1% Fluvial / 0.5% Coastal AEP standard of protection. Individual Property Resilience does not improve the viability of the option under consideration.</td></tr>
</table>

STAGE 4: Appraisal of Options

4.1 Options Appraisal

Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Meeting. Below describes this concept design of each options and provides a summary of any significant comments/issues which were raised by LA staff at the Options Meetings. These comments will be considered in the local weightings and the MCA scores.

<table>
<tr><td colspan="2">Option Ref:</td><td colspan="4">ASN_01</td></tr>
<tr><td rowspan="6">Option Measures</td><td>Baseline</td><td>B</td><td colspan="3">Existing Regime</td></tr>
<tr><td rowspan="4">Structural</td><td>Fi</td><td colspan="3">Increased Conveyance: Channel Dredging</td></tr>
<tr><td>Fii</td><td colspan="3">Increased Conveyance: Channel Widening</td></tr>
<tr><td>Fiii</td><td colspan="3">Increased Conveyance: Structure Enhancement / Works</td></tr>
<tr><td>Gi</td><td colspan="3">Flood Defences: New Flood Defences</td></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="4">This option will provide a 1% Fluvial and 0.5% Coastal AEP Design standard to all properties within the AFA, identified as being at risk from both these sources.
• Construction of new flood defence walls and embankments as shown in figure 5.1.
• Increased conveyance from the tributary (Unknown River) to the Deel main channel. This involves widening and deepening approximately 30m of the tributary channel and replacing 130m culvert linking the tributary to the main channel. The replacement culvert would flow underneath the road and the Aeroboard factory premises, and requires a new headwall at the upstream extent to prevent overtopping.
The existing arterial drainage scheme needs to be maintained as part of this option.</td></tr>
<tr><td colspan="2" rowspan="2">Options Development Meeting:</td><td>Date:</td><td colspan="3">03/09/2015</td></tr>
<tr><td>Summary:</td><td colspan="3">The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="2">Option Ref:</td><td colspan="4">ASN_02</td></tr>
<tr><td></td><td>Baseline</td><td>B</td><td colspan="3">Existing Regime</td></tr>
<tr><td rowspan="5"></td><td rowspan="4">Structural</td><td>Fi</td><td colspan="3">Increased Conveyance: Channel Dredging</td></tr>
<tr><td>Fii</td><td colspan="3">Increased Conveyance: Channel Widening</td></tr>
<tr><td>Fiii</td><td colspan="3">Increased Conveyance: Structure Enhancement / Works</td></tr>
<tr><td>Gi</td><td colspan="3">Flood Defences: New Flood Defences</td></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="4">This option will provide a 1% Fluvial and 0.5% Coastal AEP Design standard to all properties within the AFA, identified as being at risk from both these sources.</td></tr>
</table>

<table>
<tr><td colspan="2"></td><td colspan="5">

- Construction of new flood defence walls and embankments as shown in figure 5.2.
- Increased conveyance from the tributary (Unknown River) to the Deel main channel. This involves widening and deepening approximately 30m of the tributary channel and replacing 130m culvert linking the tributary to the main channel. The replacement culvert would flow underneath the road and the Aeroboard factory premises, and requires a new headwall at the upstream extent to prevent overtopping. The existing arterial drainage scheme needs to be maintained as part of this option.
- This option differs from ASN_01 in that the two embankments upstream of the AFA are removed and the flood embankment on the Deel left bank upstream of the AFA boundary are included as a replacement.

</td></tr>
<tr><td colspan="2" rowspan="2">Options Development Meeting:</td><td>Date:</td><td colspan="4">03/09/2015</td></tr>
<tr><td>Summary:</td><td colspan="4">The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="2">Option Ref:</td><td colspan="5">ASN_03</td></tr>
<tr><td rowspan="6">Option Measures</td><td>Baseline</td><td>B</td><td colspan="4">Existing Regime</td></tr>
<tr><td rowspan="4">Structural</td><td>Fi</td><td colspan="4">Increased Conveyance: Channel Dredging</td></tr>
<tr><td>Fii</td><td colspan="4">Increased Conveyance: Channel Widening</td></tr>
<tr><td>Fiii</td><td colspan="4">Increased Conveyance: Structure Enhancement / Works</td></tr>
<tr><td>Gi</td><td colspan="4">Flood Defences: New Flood Defences</td></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td colspan="2">M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="5">

This option will provide a 1% Fluvial and 0.5% Coastal AEP Design standard to 43 of 47 properties within the AFA and reduce the risk to 4 properties, identified as being at risk from both these sources, and includes;

- Construction of 968 m of new flood defence walls and 2156 m of embankments;
- Increased conveyance from the tributary (Unknown River) to the Deel main channel. This involves widening and deepening approximately 30m of the tributary channel and replacing 130m culvert linking the tributary to the main channel;
- Individual property resistance and flood forecasting will apply to certain properties;
- The existing arterial drainage scheme needs to be maintained as part of this option. This option differs ASN_01 in that the wall and embankment on the Deegerty have been removed and replaced with individual property resistance.

</td></tr>
<tr><td colspan="2" rowspan="2">Options Development Meeting:</td><td>Date:</td><td colspan="4">03/09/2015</td></tr>
<tr><td>Summary:</td><td colspan="4">The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.</td></tr>
<tr><td colspan="7"></td></tr>
</table>

STAGE 5: Multi Criteria Assessment

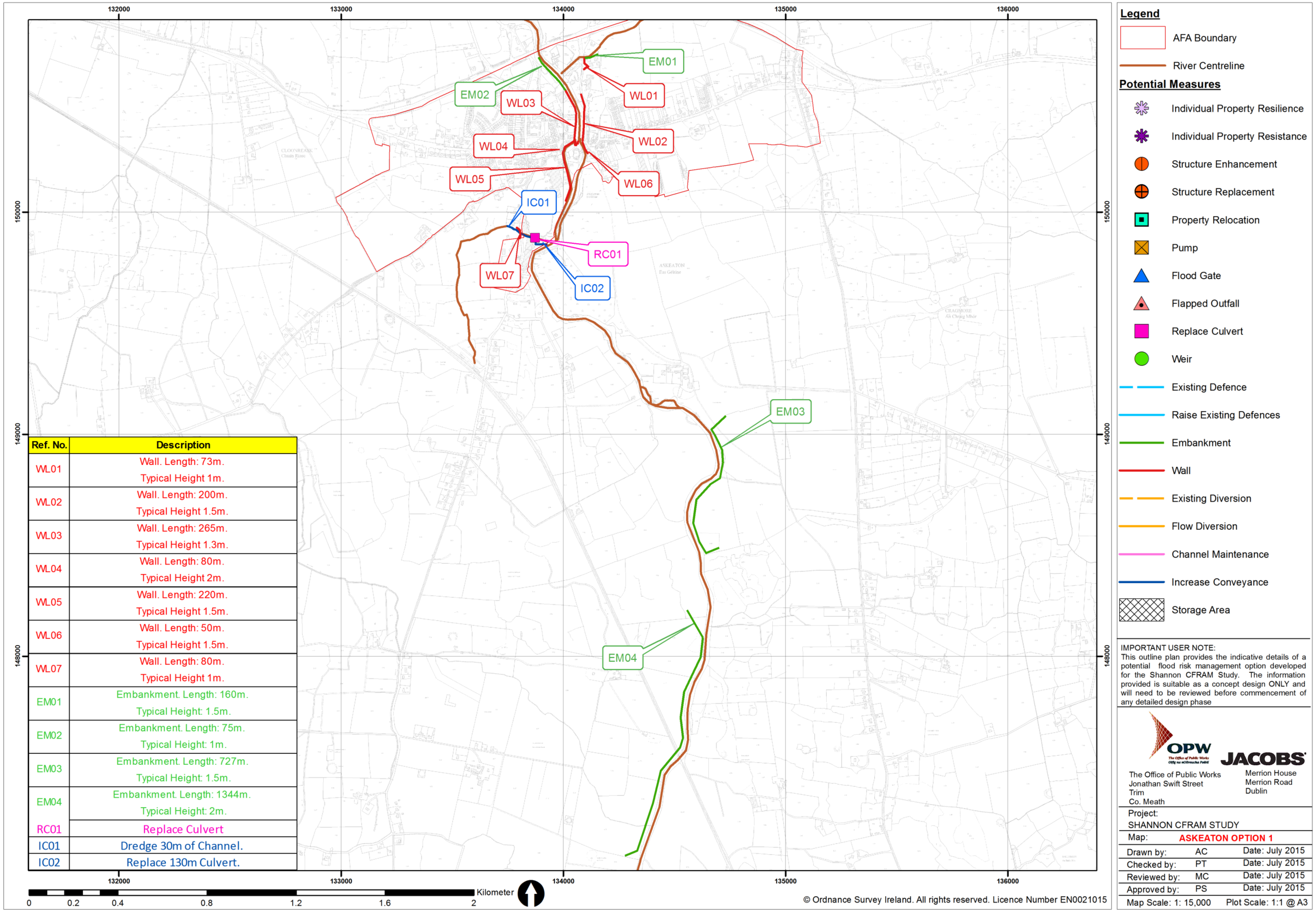
5.1 Options selected for the Multi Criteria Assessment

Following the Option Meeting, the following options are the refined options for the Multi-Criteria Assessment (MCA) stage. This is the final of a five-stage MCA process.

Option Reference		ASN_01	ASN_02	ASN_03
Baseline				
B	Existing Regime	Maintain existing regime.	Maintain existing regime.	Maintain existing regime.
Structural Measures				
Fi	Channel Dredging	30m of the unknown river upstream of the culvert entrance will be dredged.	30m of the unknown river upstream of the culvert entrance will be dredged.	30m of the unknown river upstream of the culvert entrance will be dredged.
Fii	Channel Widening	30m of the unknown river upstream of the culvert entrance will be widened.	30m of the unknown river upstream of the culvert entrance will be widened.	30m of the unknown river upstream of the culvert entrance will be widened.
Fiii	Structure Enhancement / Works	Replacing the 130m culvert that links the Unknown River to the main channel. A new headwall would also be required at the entrance to the culvert to ensure all flow enters the culvert.	Replacing the 130m culvert that links the Unknown River to the main channel. A new headwall would also be required at the entrance to the culvert to ensure all flow enters the culvert.	Replacing the 130m culvert that links the Unknown River to the main channel. A new headwall would also be required at the entrance to the culvert to ensure all flow enters the culvert.
Gi	New Flood Defences	Construction of new flood defence walls as shown in figure 5.1.	Construction of new flood defence walls as shown in figure 5.2.	Construction of new flood defence walls as shown in figure 5.3.
Non-Structural Measures				
J	Flood Forecasting / Warning / Response			This will apply to all properties in flood cell ASN_A as shown in figure 5.3.
K	Public Awareness			This will apply to all properties in flood cell ASN_A as shown in figure 5.3.
L	Individual Property Resistance			This will apply to all properties in flood cell ASN_A as shown in figure 5.3.
Table reference A summary of the outcome from the MCA is presented in the following table		Table 5.1	Table 5.2	Table 5.3

Table 5.1 – Multi Criteria Assessment Outcome for Option ASN_01

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**				
AFA	Askeaton		Option Ref:	ASN_01
Option Measures				
Baseline	B	Existing Regime		
Structural	Fi	Increase Conveyance: Channel Dredging		
	Fii	Increase Conveyance: Channel Widening		
	Fiii	Increase Conveyance: Structure Enhancement / Works		
	Gi	Flood Defences: New Flood Defences		
Non-Structural		N/A		
Criteria Scores				
Technical			620	
Economic			717	
Social			842	
Environmental			-538	
Economic Values				
Economic PV Benefits			€ 11,684,894	
PV Cost			€ 7,215,603	
NPV Benefits			€ 4,469,291	
Economic BCR			**1.62**	
Outcome Scores				
MCA PV Benefits			€ 6,236,850	
MCA Benefit Score			1021	
MCA Benefit Score Ratio			141.55	
Option Selection MCA			1641	
Relevant Figure			Figure 5.1	

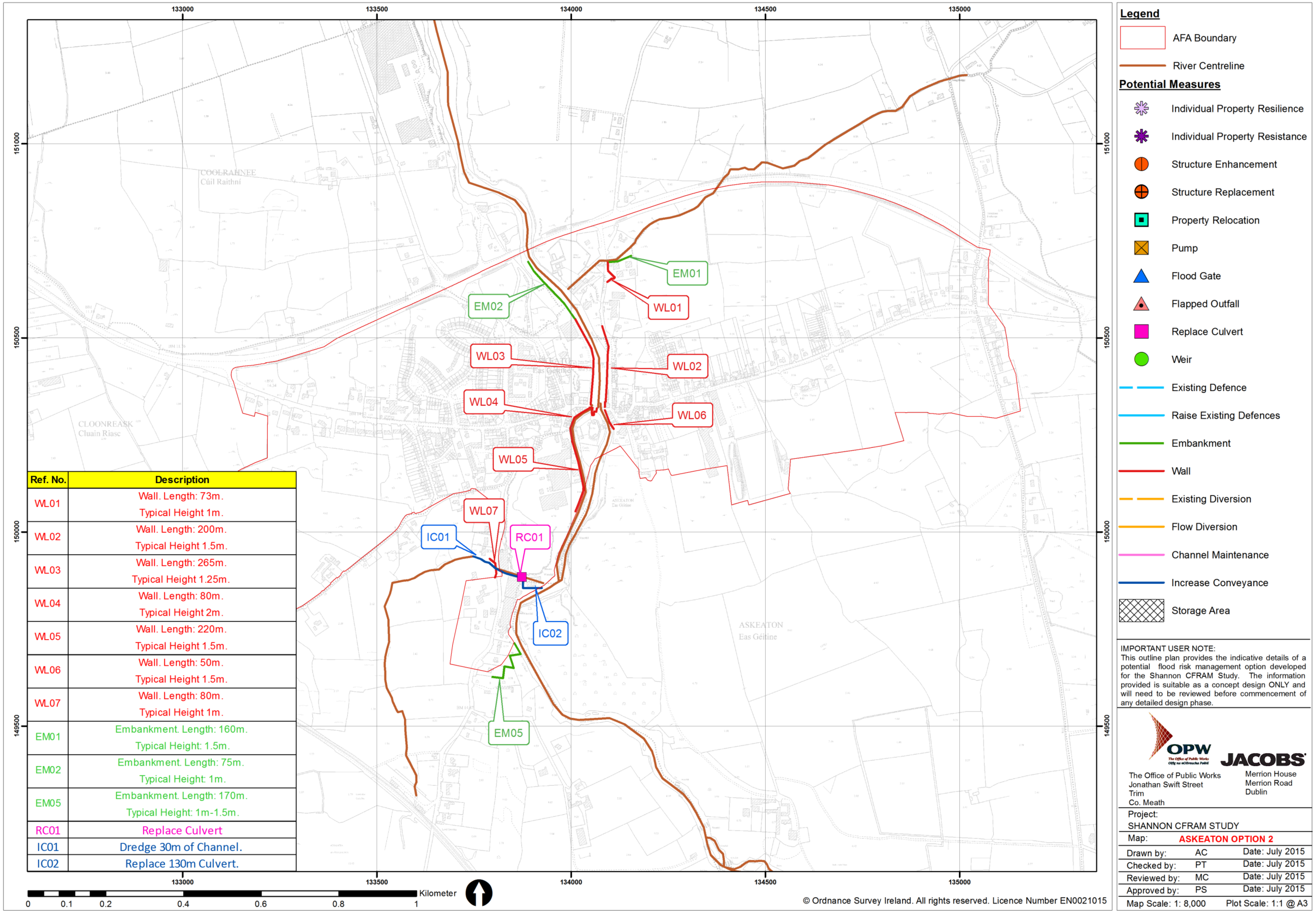


Ref. No.	Description
WL01	Wall. Length: 73m. Typical Height 1m.
WL02	Wall. Length: 200m. Typical Height 1.5m.
WL03	Wall. Length: 265m. Typical Height 1.3m.
WL04	Wall. Length: 80m. Typical Height 2m.
WL05	Wall. Length: 220m. Typical Height 1.5m.
WL06	Wall. Length: 50m. Typical Height 1.5m.
WL07	Wall. Length: 80m. Typical Height 1m.
EM01	Embankment. Length: 160m. Typical Height: 1.5m.
EM02	Embankment. Length: 75m. Typical Height: 1m.
EM03	Embankment. Length: 727m. Typical Height: 1.5m.
EM04	Embankment. Length: 1344m. Typical Height: 2m.
RC01	Replace Culvert
IC01	Dredge 30m of Channel.
IC02	Replace 130m Culvert.

Figure 5.1 – Option ASN_01

Table 5.2 – Multi Criteria Assessment Outcome for Option ASN_02

<table>
<tr><td colspan="5">Multi Criteria Assessment
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.</td></tr>
<tr><td>AFA</td><td colspan="2">Askeaton</td><td>Option Ref:</td><td>ASN_02</td></tr>
<tr><td colspan="5">Option Measures</td></tr>
<tr><td>Baseline</td><td>B</td><td colspan="3">Existing Regime</td></tr>
<tr><td rowspan="4">Structural</td><td>Fi</td><td colspan="3">Increase Conveyance: Channel Dredging</td></tr>
<tr><td>Fii</td><td colspan="3">Increase Conveyance: Channel Widening</td></tr>
<tr><td>Fiii</td><td colspan="3">Increase Conveyance: Structure Enhancement / Works</td></tr>
<tr><td>Gi</td><td colspan="3">Flood Defences: New Flood Defences</td></tr>
<tr><td>Non-Structural</td><td></td><td colspan="3">N/A</td></tr>
<tr><td colspan="5">Criteria Scores</td></tr>
<tr><td colspan="3">Technical</td><td colspan="2">620</td></tr>
<tr><td colspan="3">Economic</td><td colspan="2">688</td></tr>
<tr><td colspan="3">Social</td><td colspan="2">842</td></tr>
<tr><td colspan="3">Environmental</td><td colspan="2">-461</td></tr>
<tr><td colspan="5">Economic Values</td></tr>
<tr><td colspan="3">Economic PV Benefits</td><td colspan="2">€ 11,684,894</td></tr>
<tr><td colspan="3">PV Cost</td><td colspan="2">€ 5,948,539</td></tr>
<tr><td colspan="3">NPV Benefits</td><td colspan="2">€ 5,736,355</td></tr>
<tr><td colspan="3">Economic BCR</td><td colspan="2">1.96</td></tr>
<tr><td colspan="5">Outcome Scores</td></tr>
<tr><td colspan="3">MCA PV Benefits</td><td colspan="2">€ 6,236,850</td></tr>
<tr><td colspan="3">MCA Benefit Score</td><td colspan="2">1069</td></tr>
<tr><td colspan="3">MCA Benefit Score Ratio</td><td colspan="2">179.67</td></tr>
<tr><td colspan="3">Option Selection MCA</td><td colspan="2">1689</td></tr>
<tr><td colspan="3">Relevant Figure</td><td colspan="2">Figure 5.2</td></tr>
</table>



Ref. No.	Description
WL01	Wall. Length: 73m. Typical Height 1m.
WL02	Wall. Length: 200m. Typical Height 1.5m.
WL03	Wall. Length: 265m. Typical Height 1.25m.
WL04	Wall. Length: 80m. Typical Height 2m.
WL05	Wall. Length: 220m. Typical Height 1.5m.
WL06	Wall. Length: 50m. Typical Height 1.5m.
WL07	Wall. Length: 80m. Typical Height 1m.
EM01	Embankment. Length: 160m. Typical Height: 1.5m.
EM02	Embankment. Length: 75m. Typical Height: 1m.
EM05	Embankment. Length: 170m. Typical Height: 1m-1.5m.
RC01	Replace Culvert
IC01	Dredge 30m of Channel.
IC02	Replace 130m Culvert.

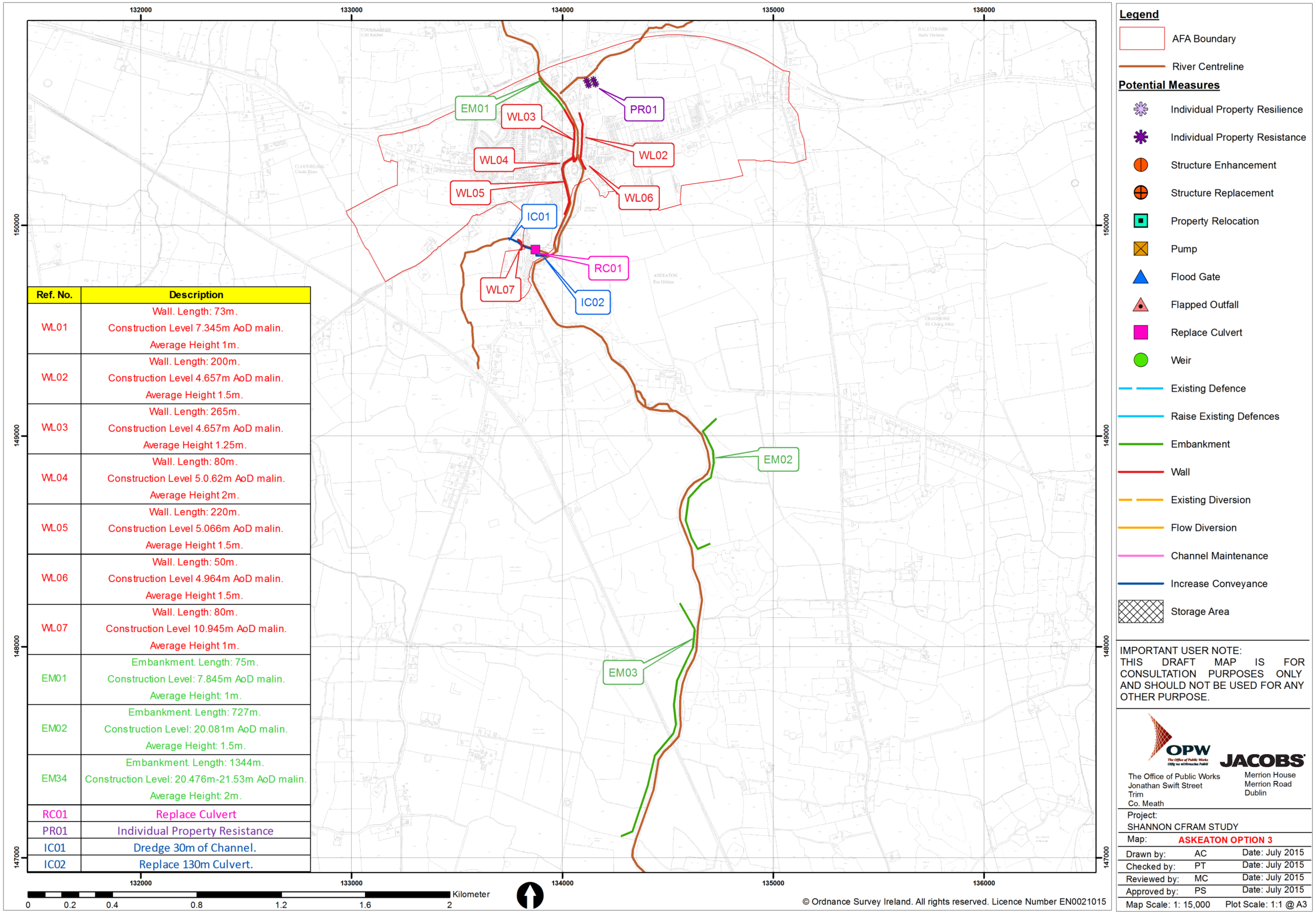
Figure 5.2 – Option ASN_02

Table 5.3 – Multi Criteria Assessment Outcome for Option ASN_03

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Askeaton	Option Ref:	ASN_03

Option Measures		
Baseline	B	Existing Regime
Structural	Fi	Increase Conveyance: Channel Dredging
	Fii	Increase Conveyance: Channel Widening
	Fiii	Increase Conveyance: Structure Enhancement / Works
	Gi	Flood Defences: New Flood Defences
Non-Structural	J	Flood Forecasting / Warning / Response
	K	Public Awareness
	L	Individual Property Protection

Criteria Scores	
Technical	586
Economic	711
Social	842
Environmental	-501
Economic Values	
Economic PV Benefits	€ 10,845,041
PV Cost	€ 7,331,295
NPV Benefits	€ 3,513,746
Economic BCR	**1.48**
Outcome Scores	
MCA PV Benefits	€ 5,994,758
MCA Benefit Score	1053
MCA Benefit Score Ratio	143.57
Option Selection MCA	1638
Relevant Figure	Figure 5.3



Ref. No.	Description
WL01	Wall. Length: 73m. Construction Level 7.345m AoD malin. Average Height 1m.
WL02	Wall. Length: 200m. Construction Level 4.657m AoD malin. Average Height 1.5m.
WL03	Wall. Length: 265m. Construction Level 4.657m AoD malin. Average Height 1.25m.
WL04	Wall. Length: 80m. Construction Level 5.0.62m AoD malin. Average Height 2m.
WL05	Wall. Length: 220m. Construction Level 5.066m AoD malin. Average Height 1.5m.
WL06	Wall. Length: 50m. Construction Level 4.964m AoD malin. Average Height 1.5m.
WL07	Wall. Length: 80m. Construction Level 10.945m AoD malin. Average Height 1m.
EM01	Embankment. Length: 75m. Construction Level: 7.845m AoD malin. Average Height: 1m.
EM02	Embankment. Length: 727m. Construction Level: 20.081m AoD malin. Average Height: 1.5m.
EM34	Embankment. Length: 1344m. Construction Level: 20.476m-21.53m AoD malin. Average Height: 2m.
RC01	Replace Culvert
PR01	Individual Property Resistance
IC01	Dredge 30m of Channel.
IC02	Replace 130m Culvert.

Figure 5.3 – Option ASN_03

5.2 Comparison of Multi Criteria Assessment Scores

Each option taken forward for further consideration through the Option Decision Meeting, has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Decision Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).

Categories	**Option Reference and Results**		
	ASN_01	ASN_02	ASN_03
Criteria Scores			
Technical	620	620	586
Economic	717	688	711
Social	842	842	842
Environmental	-538	-461	-501
Economic Values			
Economic PV Benefits	€ 11,684,894	€ 11,684,894	€ 10,845,041
PV Cost	€ 7,215,603	€ 5,948,539	€ 7,331,295
NPV Benefits	€ 4,469,291	€ 5,736,355	€ 3,513,746
Economic BCR	**1.62**	**1.96**	**1.48**
Outcome Scores			
MCA PV Benefits	€ 6,236,850	€ 6,236,850	€ 5,994,758
MCA Benefit Score	1021	1069	1053
MCA BCR	141.55	179.67	143.57
Option Selection MCA	1641	1689	1638

5.3 Recommendation of Preferred Option

It forms part of the CFRAM process for the recommendation of a preferred option for each AFA. The prioritised selection criteria used in this recommendation process is detailed in Section 3.7.3 of the Main Report.

Therefore, following the five stage Multi Criteria Assessment process, the preferred option is as outlined below

<table>
<tr><td colspan="2">Option Ref:</td><td colspan="5">ASN_02</td></tr>
<tr><td rowspan="7">Option Measures</td><td>Baseline</td><td>B</td><td colspan="4">Existing Regime</td></tr>
<tr><td rowspan="5">Structural</td><td>Fi</td><td colspan="4">Increased Conveyance: Channel Dredging</td></tr>
<tr><td>Fii</td><td colspan="4">Increased Conveyance: Channel Widening</td></tr>
<tr><td>Fiii</td><td colspan="4">Increased Conveyance: Structure Enhancement / Works</td></tr>
<tr><td>Gi</td><td colspan="4">Flood Defences: New Flood Defences</td></tr>
<tr></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td><td></td></tr>
<tr><td colspan="2">Comments</td><td colspan="5">This option will provide a 1% Fluvial and 0.5% Coastal AEP Design standard to all properties within the AFA, identified as being at risk from both these sources.

The MCA BCR is highest for ASN_02 and therefore this is the recommended emerging preferred option.

However, it should be noted that the embankments upstream of the AFA in option ASN_01 and ASN_03 not only reduce fluvial flood risk within the AFA but also protect 8 properties, the N69, the old railway line, and a very significant area of agricultural land outside the AFA.</td></tr>
</table>

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

<table>
<tr><th colspan="5">Fluvial Flood Forecasting Potential</th></tr>
<tr><th rowspan="3">Catchment Information</th><th colspan="2">Gauging Station</th><th rowspan="2">Catchment size (km ^{2})</th><th rowspan="2">Potential available forecast accuracy and reliability period</th></tr>
<tr><th>Fluvial</th><th>Rainfall</th></tr>
<tr><td>GS 24013</td><td>No*</td><td>488</td><td>9-12 hours</td></tr>
<tr><th>Relevant Information:</th><td colspan="4">Rathkeale Bridge (GS 24013) 19 km upstream of Askeaton</td></tr>
<tr><th rowspan="3">Additional Infrastructure Recommended</th><th colspan="2">Gauging Station</th><th colspan="2" rowspan="2">Other</th></tr>
<tr><th>Fluvial</th><th>Rainfall</th></tr>
<tr><td>No</td><td>No</td><td colspan="2">n/a</td></tr>
<tr><th>Relevant Comments:</th><td colspan="4">The existing fluvial gauging station could provide reasonably accurate and reliable predictions for flooding from the River Deel based on level/level relationships. GS 24013 represents 90% of the total catchment area at Askeaton.
Askeaton is tidally influenced an understanding of the coincidence of peak tide level would have to be included in the fluvial flood forecasting.
There is no requirement for additional fluvial or rainfall gauges to provide flood forecasting for this AFA.</td></tr>
</table>

Annex A - Multi-Criteria Analysis Summary and Whole Life Cost Summaries for FRM Option(s)

CRITERIA		OBJECTIVE		Global Weighting	Local Weighting	Comments	ASN_01 B – Existing Regime Fi – Channel Dredging Fii – Channel Widening Fiii – Structure Enhancement / Works Gi – New Flood Defences	Option Score	Weighted Score	ASN_02 B – Existing Regime Fi – Channel Dredging Fii – Channel Widening Fiii – Structure Enhancement / Works Gi – New Flood Defences	Option Score	Weighted Score	ASN_03 B – Existing Regime Fi – Channel Dredging Fii – Channel Widening Fiii – Structure Enhancement / Works Gi – New Flood Defences J – Flood Forecasting / Warning / Response K – Public Awareness L – Individual Property Resistance	Option Score	Weighted Score
1	Technical	a	Ensure flood risk management options are operationally robust	20	5.00	The option scores are determined based on the level of operational risk to operate or perform successfully. Each measure is scored independently and the average of the measure scores is used as the score for the option.	None / Manageable Negligible / Moderate / high Very low / High Low / Failure likely Low / moderate / Unacceptable B 4.00; Fi 4.00; Fii 4.00; Fiii 5.00; Gi 4.00	4.20	420	None / Manageable Negligible / Moderate / high Very low / High Low / Failure likely Low / moderate / Unacceptable B 4.00; Fi 4.00; Fii 4.00; Fiii 5.00; Gi 4.00	4.20	420	None / Manageable Negligible / Moderate / high Very low / High Low / Failure likely Low / moderate / Unacceptable B 4.00; Fi 4.00; Fii 4.00; Fiii 5.00; Gi 4.00; J 3.00; K; L 0.00	3.43	343
		b	Minimise health and safety risks associated with the construction and operation of flood risk management options	20	5.00	H&S risks are considered for construction and maintenance of flood risk management measures. The indicative aspirational score is set at five, with a point then deducted for each specific H&S risk in either construction or maintenance.	No risks / Moderate Negligible / Moderate / high Very low / High Low / Very High Low / moderate / Unacceptable Work near/in water Work near services or buildings	1.00	100	No risks / Moderate Negligible / Moderate / high Very low / High Low / Very High Low / moderate / Unacceptable Work near/in water Work near services or buildings	1.00	100	No risks / Moderate Negligible / Moderate / high Very low / High Low / Very High Low / moderate / Unacceptable Work near/in water Work near services or buildings	1.00	100
		c	Ensure flood risk management options are adaptable to future flood risk	20	5.00	The options scores are determined based on the sustainability and adaptability of the flood risk management measures in the face of potential future changes, including the potential impact of climate change. Each measure is scored independently and the average of the measure scores is used as the score for the option.	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. B 4.00; Fi 1.00; Fii 1.00; Fiii -3.00; Gi 2.00	1.00	100	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. B 4.00; Fi 1.00; Fii 1.00; Fiii -3.00; Gi 2.00	1.00	100	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. B 4.00; Fi 1.00; Fii 1.00; Fiii -3.00; Gi 2.00; J 5.00; K; L 0.00	1.43	143
			TECHNICAL CRITERIA SCORE						620			620			586
2	Economic	a	Minimise economic risk	24	5.00		The score is calculated based on the reduction in AAD, following the full implementation of option.	4.69	563	The score is calculated based on the reduction in AAD, following the full implementation of option.	4.69	563	The score is calculated based on the reduction in AAD, following the full implementation of option.	4.64	557
		b	Minimise risk to transport infrastructure	10	5.00		Scoring is based on the reduction in flood risk to transport routes, following the full implementation of option.	2.50	125	Scoring is based on the reduction in flood risk to transport routes , following the full implementation of option.	2.50	125	Scoring is based on the reduction in flood risk to transport routes , following the full implementation of option.	2.50	125
		c	Minimise risk to utility infrastructure	14	0.00		Scoring is calculate based on a reduction in flood risk to utility infrastructure, following the full implementation of option.			Scoring is calculate based on a reduction in flood risk to utility infrastructure, following the full implementation of option.			Scoring is calculate based on a reduction in flood risk to utility infrastructure, following the full implementation of option.		
		d	Minimise risk to agriculture	12	2.47	Source of Flooding: Both Fresh & Salt Water Percentage of AFA that is rural land: 49.31%	Area of Agricultural Land Flooded: Decreased Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Not Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable	1.00	30	Area of Agricultural Land Flooded: No Change Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Not Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable	0.00	0	Area of Agricultural Land Flooded: No Change Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable	1.00	30
			ECONOMIC CRITERIA SCORE						717			688			711
3	Social	a i)	Minimise risk to human health and life - Residents	27	5.00	Flood Depths & Velocities: Assumed low risk to life Known Areas of Highly Vulnerable People: Reasonable Cross Section of Society	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	4.95	668	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	4.95	668	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	4.95	668
		a ii)	Minimise risk to human health and life - High vulnerability properties	17	0.00	Rate of Onset of flooding: Assumed 1-2 hours for evacuation	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	0.00	0	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	0.00	0	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	0.00	0
		b i)	Minimise risk to community - Social Infrastructure & Amenity	9	0.00	Assets of Particular Social Value: No	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.			The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.			The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.		
		b ii)	Minimise risk to community - Local employment	7	5.00	Asset of Particular Employment Value: No	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	4.98	174	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	4.98	174	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	4.98	174
			SOCIAL CRITERIA SCORE						842			842			842
4	Environmental	a	Support the objectives of the WFD	16	5.00	There are a number of WFD waterbodies within the AFA. The Shannon Estuary South Deel Trib 1 Askeaton East and Deel Main 1 Lower Mid are of poor status. There is one Section 4 discharge within the 1% AEP Fluvial &/or 0.5% AEP Coastal. There are a number of WFD Annex IV areas within the AFA. The Deel is a drinking waterbody. The Shannon estuary south is an SAC waterbody and the Deel Estuary is an SAC/SPA waterbody. Local weighting to be applied for this objective is constant, and should always be set equal to 5 as WFD objectives must be achieved and are relevant to all waterbodies.	Construction - Related impacts due to significant construction works in and adjacent to the Deel River, Deegerty River and unnamed Deel tributary due to the construction of the flood defence walls, flood defence embankments, replacement culvert and channel dredging and widening. Operational - The proposed walls, embankments and channel work will permanently replace the natural bank in places along the Deel River, Deegerty River and unnamed Deel tributary. These measures could cause potential changes to the hydrological and morphological regime of the waterbody, hydromorphological and physico-chemical impacts due to sediment release. Reduced flooding in area with limited polluting sources (Section 4) in 1% AEP Fluvial &/or 0.5% AEP Coastal extents. Therefore, there is potential for medium-term or recurring impediment to the achievement of wb objectives.	-3.00	-240	This option proposes similar construction of embankments and walls as Option ASN_01 with a reduced length of embankments on the upstream side of the Deel River (outside the AFA). Construction - Related impacts due to significant construction works in and adjacent to the Deel River, Deegerty River and unnamed Deel tributary due to the construction of the flood defence walls, flood defence embankments, replacement culvert and channel dredging and widening. Operational - The proposed walls, embankments and channel work will permanently replace the natural bank in places along the Deel River, Deegerty River and unnamed Deel tributary. These measures could cause potential changes to the hydrological and morphological regime of the waterbody, hydromorphological and physico-chemical impacts due to sediment release. Reduced flooding in area with limited polluting sources (Section 4) in 1% AEP Fluvial &/or 0.5% AEP Coastal extents. Therefore, there is potential for medium-term or recurring impediment to the achievement of wb objectives.	-2.50	-200	This option is similar to Option ASN_01, however a wall and embankment is removed from the Deegerty River and replaced with individual property resistance. Construction - Related impacts due to significant construction works in and adjacent to the Deel River, Deegerty River and unnamed Deel tributary due to the construction of the flood defence walls, flood defence embankments, replacement culvert and channel dredging and widening. Operational - The proposed walls, embankments and channel work will permanently replace the natural bank in places along the Deel River, Deegerty River and unnamed Deel tributary. These measures could cause potential changes to the hydrological and morphological regime of the waterbody, hydromorphological and physico-chemical impacts due to sediment release. Reduced flooding in area with limited polluting sources (Section 4) in 1% AEP Fluvial &/or 0.5% AEP Coastal extents. Therefore, there is potential for medium-term or recurring impediment to the achievement of wb objectives.	-3.00	-240
		b	Support the objectives of the Habitats Directive	10	3.00	There are no European sites within the AFA. The Lower River Shannon cSAC [002165] is c. 1.8 km downstream and the cSAC Askeaton Fen Complex [002279] is c. 4.6 km upstream. Their qualifying interests which may occur within the AFA include otter, river, brook and sea lamprey, Atlantic salmon, and floating river vegetation. The Rivers Shannon and River Fergus Estuaries SPA [004077] is c. 0.02km downstream. There are no European sites within the AFA but there are a number of European sites in close vicinity to the AFA. Local weighting of 3 set by professional judgement. Weighting of 3 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (outside AFA) and potentially affected.	There are proposed works adjacent and upstream of the SPA and upstream of the cSAC. The proposed works include construction of earth embankments, flood defence walls, replacement culvert, dredging and channel widening. Potentially significant impacts are: - Increases in suspended solids during construction works - Risk of disturbance to various otter and bird species associated with the cSAC and SPA - Impacts to fish species including salmon and lamprey - Risk of invasive species spread during proposed works Therefore, there is potential for detrimental impact upon conservation objectives of existing SAC, SPA or Ramsar sites, including a delay in recovery of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	-5.00	-150	This option proposes similar construction of embankments and walls as Option ASN_01 with a reduced length of embankments on the upstream side of the Deel River (outside the AFA). There are proposed works adjacent and upstream of the SPA and upstream of the cSAC. The proposed works include construction of earth embankments, flood defence walls, replacement culvert, dredging and channel widening. Potentially significant impacts are: - Increases in suspended solids during construction works - Risk of disturbance to various otter and bird species associated with the cSAC and SPA - Impacts to fish species including salmon and lamprey - Risk of invasive species spread during proposed works Therefore, there is potential for detrimental impact upon conservation objectives of existing SAC, SPA or Ramsar sites, including a delay in recovery of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	-4.50	-135	This option is similar to Option ASN_01, however a wall and embankment is removed from the Deegerty River and replaced with individual property resistance. There are proposed works adjacent and upstream of the SPA and upstream of the cSAC. The proposed works include construction of earth embankments, flood defence walls, replacement culvert, dredging and channel widening. Potentially significant impacts are: - Increases in suspended solids during construction works - Risk of disturbance to various otter and bird species associated with the cSAC and SPA - Impacts to fish species including salmon and lamprey - Risk of invasive species spread during proposed works Therefore, there is potential for detrimental impact upon conservation objectives of existing SAC, SPA or Ramsar sites, including a delay in recovery of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	-4.50	-135
		c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	5	2.00	There are no designated ecological sites within the AFA. However, there are a number of pNHAs within c. 4 km of the AFA. The Inner Shannon Estuary - South Shore pNHA [000435] is c. 1.8km from the AFA and is hydrologically connected. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are no designated sites but habitats/species are likely to be present that could be affected	Potential significant effects related to construction works taking place along the Deel River, Deegerty River and an unnamed tributary of the Deel River, which is hydrologically connected to Inner Shannon Estuary, South Shore pNHA. Potential impacts include: - Increase in suspended solids entering the watercourse during construction works - Risk of a pollution event impacting the watercourse - Loss of habitat - Risk of mortality and disturbance to various protected species - Risk of mortality and disturbance to fish species including salmon and lamprey - Risk of invasive species spread during proposed works Therefore, there is a potential localised loss of, or disturbance to, flora/fauna.	-3.00	-30	This option proposes similar construction of embankments and walls as Option ASN_01 with a reduced length of embankments on the upstream side of the Deel River (outside the AFA). Potential significant effects are related to works taking place along the Deel River, Deegerty River and an unnamed tributary of the Deel River, which is hydrologically connected to Inner Shannon Estuary, South Shore pNHA. Potential impacts include: - Increase in suspended solids entering the watercourse during construction works - Risk of a pollution event impacting the watercourse - Loss of habitat - Risk of mortality and disturbance to various protected species - Risk of mortality and disturbance to fish species including salmon and lamprey - Risk of invasive species spread during proposed works The only change from Option ASN_01 is there is a shorter distance of embankments on the up-stream side of the AFA (outside the AFA). Therefore, there is a potential localised loss of, or disturbance to, flora/fauna.	-2.50	-25	This option is similar to Option ASN_01, however a wall is removed from the Deegerty River and replaced with individual property resistance. Potential significant effects are related to works taking place along the Deel River, Deegerty River and an unnamed tributary of the Deel River, which is hydrologically connected to Inner Shannon Estuary, South Shore pNHA. Potential impacts include: - Increase in suspended solids entering the watercourse during construction works - Risk of a pollution event impacting the watercourse - Loss of habitat - Risk of mortality and disturbance to various protected species - Risk of mortality and disturbance to fish species including salmon and lamprey - Risk of invasive species spread during proposed works Therefore, there is a potential localised loss of, or disturbance to, flora/fauna.	-2.50	-25
		d	Protect, and where possible enhance, fisheries resource within the catchment	13	2.00	Neither of the two waterbodies are designated as Salmonid Rivers. The estuary is within a medium activity angling area. Local weighting of 2 set by professional judgement. Weighting of 2 applied where a waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.	Construction works (such as wall, embankment, widening and deeping channel and replacement of a culvert) in-stream and adjacent to the waterbody may impact fish habitat, water quality and cause access issues. Therefore, there is potential for permanent loss or removal of fisheries habitat and/or introducing of barriers to upstream migration.	-5.00	-130	This option proposes similar construction of embankments and walls as Option ASN_01 with a reduced length of embankments on the upstream side of the Deel River (outside the AFA). Construction works in-stream and adjacent to the waterbody may impact fish habitat, water quality and cause access issues. The only change from Option ASN_01 is there is a shorter distance of embankments on the up-stream side of the AFA. Therefore, there is potential for permanent loss or removal of fisheries habitat and/or introducing of barriers to upstream migration.	-4.50	-117	This option is similar to Option ASN_01, however a wall and embankment is removed from the Deegerty River and replaced with individual property resistance. Construction works (such as wall, embankment, widening and deepening channel and replacement of a culvert) in-stream and adjacent to the waterbody may impact fish habitat, water quality and cause access issues. Therefore, there is potential for permanent loss or removal of fisheries habitat and/or introducing of barriers to upstream migration.	-4.50	-117
		e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	8	1.00	Askeaton has no landscape planning designations within the AFA. No specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected.	There is potential to have a impact on the local visual amenity, such as the construction of permanent embankment, walls and increasing channel conveyance within the AFA and outside the AFA There is work proposed adjacent to and within the watercourses (Deel River, Deegerty River and unnamed tributary) which will also alter the visual amenity in the area. No landscape designation with Askeaton AFA. Therefore, there is potential for medium term impact on low sensitivity landscape character / feature in the zone of visibility of the selected measure.	-2.00	-16	This option proposes similar construction of embankments and walls as Option ASN_01 with a reduced length of embankments on the upstream side of the Deel River (outside the AFA). Permanent embankment, walls and increasing channel conveyance within the AFA and outside the AFA, work proposed adjacent to and within the watercourses (Deel River, Deegerty River and unnamed tributary) will alter the visual amenity in the area. No landscape designation with Askeaton AFA. Therefore, there is potential for medium term impact on low sensitivity landscape character / feature in the zone of visibility of the selected measure.	-1.50	-12	This option is the similar to Option ASN_01, however a wall and embankment is removed from the Deegerty River and replaced with individual property resistance. Permanent embankment, walls and increasing channel conveyance within the AFA and outside the AFA, work proposed adjacent to and within the watercourses (Deel River, Deegerty River and unnamed tributary) will alter the visual amenity in the area. No landscape designation with Askeaton AFA. Therefore, there is potential for medium term impact on low sensitivity landscape character / feature in the zone of visibility of the selected measure.	-1.50	-12
		f i)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of architectural value	4	3.00	Askeaton is not a heritage town. 0.035 km2 of the ACA falls within the 1% AEP. 9 RPS and 9 NIAH fall within the 1% AEP Fluvial & 0.5% AEP Coastal. Local weighting of 3 set by professional judgement. Weighting of 3 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a high to moderate vulnerability.	The option will reduce the potential for flooding in the 1% AEP Fluvial &/or 0.5% AEP Coastal for eight RPS, eight NIAH and 0.035km2 of ACA. There is a potential to impact the setting of a number of RPS/NIAH and the ACA. There is potential for impacts on individual architectural features. However overall an increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.	1.00	12	This option proposes similar construction of embankments and walls as Option ASN_01 with a reduced length of embankments on the upstream side of the Deel River (outside the AFA). The option will reduce the potential for flooding in the 1% AEP Fluvial &/or 0.5% AEP Coastal for eight RPS, eight NIAH and 0.035km2 of ACA. There is a potential to impact the setting of a number of RPS/NIAH and the ACA. The only change from Option ASN_01 is there is a shorter distance of embankments on the up-stream side of the AFA. There is potential for impacts on individual architectural features. However overall an increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.	1.00	12	This option is similar to Option ASN_01, however a wall and embankment is removed from the Deegerty River and replaced with individual property resistance. The option will reduce the potential for flooding in the 1% AEP Fluvial &/or 0.5% AEP Coastal for eight RPS, eight NIAH and 0.035km2 of ACA. There is a potential to impact the setting of a number of RPS/NIAH and the ACA. There is potential for impacts on individual architectural features. However overall an increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.	1.00	12
		f ii)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of archaeological value	4	4.00	Askeaton is not a heritage town. There are six RMP and two National Monuments (Askeaton Castle and Askeaton Abbey) within the 1% AEP Fluvial &/or 0.5% AEP Coastal. Local weighting of 4 set by professional judgement. Weighting of 4 applied where there are nationally important archaeological feature(s) (e.g. National Monument in State Care, sites on which Preservation Orders or Temporary Preservation Orders have been served) present and potentially affected.	This option will reduce the potential for flooding in the 1% AEP Fluvial &/or 0.5% AEP Coastal in the vicinity of a National Monument in State Care and RMPs. The walls in the vicinity of the Nation Monument in State Care, Askeaton Castle, will alter the setting of this feature. There is a potential for impacts on individual archaeological features. However, overall there is an increase in the level of protection for archaeological features (Recorded Monuments incl National Monument) from flooding, such that it is less vulnerable to flood damage.	1.00	16	This option proposes similar construction of embankments and walls as Option ASN_01 with a reduced length of embankments on the upstream side of the Deel River (outside the AFA). The option will reduce the potential for flooding in the 1% AEP Fluvial &/or 0.5% AEP Coastal in the vicinity of a National Monument in State care and RMPs. There is a potential for impacts on individual archaeological features. However, overall there is an Increase in the level of protection for archaeological features (Recorded Monuments incl National Monument) from flooding, such that it is less vulnerable to flood damage.	1.00	16	This option is similar to Option ASN_01, however a wall and embankment is removed from the Deegerty River and replaced with individual property resistance. The option will reduce the potential for flooding in the 1% AEP Fluvial &/or 0.5% AEP Coastal in the vicinity of a National Monument in State Care and RMPs. There is a potential for impacts on individual archaeological features. However, overall there is an Increase in the level of protection for archaeological features (Recorded Monuments incl National Monument) from flooding, such that it is less vulnerable to flood damage.	1.00	16
			ENVIRONMENTAL CRITERIA SCORE						-538			-461			-501
	Economic Values		Economic PV Benefits					€11,684,894			€11,684,894			€10,845,041	
			Cost					€7,215,603			€5,948,539			€7,331,295	
			NPV Benefits					€4,469,291			€5,736,355			€3,513,746	
			Economic BCR					1.62			1.96			1.48	
	Outcome Scores		MCA PV Benefits					€6,236,850			€6,236,850			€5,994,758	
			MCA Benefit Score					1021			1069			1053	
			MCA BCR					141.55			179.67			143.57	
			Option Selection MCA					1641			1689			1638	

Option 1 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis			€	€	€	Notes to CFRAM Consultants
(1)	**Basic Construction Costs (Estimate)**				**2,931,999**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2)	**Preliminaries**	13.3%			**389,065**	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**3,321,064**	
(3)	**Optimism Bias**	40.0%			**1,328,425**	Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**4,649,489**	
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13.0%			**604,434**	Set at 13%
	Construction Costs and Fees				**5,253,923**	
(6)	**Other Items**					
(a)	Allowance for Archaeology & Environmental Mitigation Measures	15.0%		697,423		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	15.0%		697,423		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation	5% assumed		232,474		Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance			38,000		See "Guidance E – Per Cent for Art Note"
(e)	Est. NPV Operation & Maintenance		211,685			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	40.0%	84,674	296,359	**1,961,680**	Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**7,215,603**	

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	**PT**	**Date:**	**15/06/2015**
Checked by:	**J. Reynolds**	**Date:**	**08/12/2015**

Project reference	ASN-01	**Project name:**	Shannon CFRAMS - S10

Base date for estimates (year 0)	Dec-2013
Scaling factor (e.g. €m, €k, €)	€

Construction Price Index (CPI)	**0.987**
Method Factor - to take into account particular site issues /constraints	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	**Cost (€)**	**Comment**
Total wall costs	€2,186,339	
Total embankment costs	€565,879	
Total demountable barriers/gates costs		
Total in-channel excavation costs	€10,826	
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge removal costs		
Total bridge construction costs		
Total bridge underpinning costs		
Total culvert costs	€208,937	
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€2,971,980	
Apply update to unit rate (CPI) if appropriate (cell N15)	€2,931,999	
Enter appropriate preliminaries estimate (%)	13.27%	*ref: Preliminaries and other costs v1.0*
Enter other applicable costs (€)		
Total capital cost (€)	€3,321,064	
Consider amendments based on site issues/constraints (cell N16)	€3,321,064	
Total capital cost (€)	**€3,321,064**	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs	€365	
Total embankment O&M costs	€7,296	
Total demountable barriers/gates O&M costs		
Total in-channel excavation O&M costs	N/A	
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs	€2,258	
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€9,919	

Other costs	**Cost (€)**	**Comment**
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€3,532,749	
Optimism bias rate (from external sheet)	40%	*ref: Optimism Bias Tool v.2.0 - medium risk assumed.*
Total Cost including Optimism Bias	**€4,945,848**	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	€0
Year of capital works (year)	
Capital cost (€)	€3,321,064
Annual maintenance cost (€)	€9,919
Other cost (€)	€0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**		**Total PVc (€k):**	**3532749**
	Cash sum	0	3321064	486028	0	3807092	**3532749**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	3321064			3321063.7	3321063.7
1	0.962			9919		9918.9	9537.4
2	0.925			9919		9918.9	9170.6
3	0.889			9919		9918.9	8817.9
4	0.855			9919		9918.9	8478.8
5	0.822			9919		9918.9	8152.7
6	0.790			9919		9918.9	7839.1
7	0.760			9919		9918.9	7537.6
8	0.731			9919		9918.9	7247.7
9	0.703			9919		9918.9	6968.9
10	0.676			9919		9918.9	6700.9
11	0.650			9919		9918.9	6443.2
12	0.625			9919		9918.9	6195.3
13	0.601			9919		9918.9	5957.1
14	0.577			9919		9918.9	5727.9
15	0.555			9919		9918.9	5507.6
16	0.534			9919		9918.9	5295.8
17	0.513			9919		9918.9	5092.1
18	0.494			9919		9918.9	4896.3
19	0.475			9919		9918.9	4708.0
20	0.456			9919		9918.9	4526.9
21	0.439			9919		9918.9	4352.8
22	0.422			9919		9918.9	4185.4
23	0.406			9919		9918.9	4024.4
24	0.390			9919		9918.9	3869.6
25	0.375			9919		9918.9	3720.8
26	0.361			9919		9918.9	3577.7
27	0.347			9919		9918.9	3440.1
28	0.333			9919		9918.9	3307.7
29	0.321			9919		9918.9	3180.5
30	0.308			9919		9918.9	3058.2
31	0.296			9919		9918.9	2940.6
32	0.285			9919		9918.9	2827.5
33	0.274			9919		9918.9	2718.7
34	0.264			9919		9918.9	2614.2
35	0.253			9919		9918.9	2513.6
36	0.244			9919		9918.9	2416.9
37	0.234			9919		9918.9	2324.0
38	0.225			9919		9918.9	2234.6
39	0.217			9919		9918.9	2148.6
40	0.208			9919		9918.9	2066.0
41	0.200			9919		9918.9	1986.5
42	0.193			9919		9918.9	1910.1
43	0.185			9919		9918.9	1836.7
44	0.178			9919		9918.9	1766.0
45	0.171			9919		9918.9	1698.1
46	0.165			9919		9918.9	1632.8
47	0.158			9919		9918.9	1570.0
48	0.152			9919		9918.9	1509.6
49	0.146			9919		9918.9	1451.5

Option 2 Costs for CBA

							Notes to CFRAM Consultants
CFRAM Programme – Option Costs for Cost Benefit Analysis							
			€	**€**	**€**		
(1)	**Basic Construction Costs (Estimate)**				**2,451,246**		Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2)	**Preliminaries**	14.1%			**345,026**		Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**2,796,271**		
(3)	**Optimism Bias**	40.0%			**1,118,509**		Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**3,914,780**		
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13.0%			**508,921**		Set at 13%
	Construction Costs and Fees				**4,423,701**		
(6)	**Other Items**						
(a)	Allowance for Archaeology & Environmental Mitigation Measures	15.0%		587,217			Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	15.0%		587,217			Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation	5% assumed		195,739			Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance			38,000			See "Guidance E – Per Cent for Art Note"
(e)	Est. NPV Operation & Maintenance		83,332				From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	40.0%	33,333	116,665	**1,524,838**		Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**5,948,539**		

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	PT	**Date:**	15/06/2015
Checked by:		**Date:**	

Project reference	ASN-02	**Project name:**	Shannon CFRAMS - S10
Base date for estimates (year 0)	Dec-2013	**Construction Price Index (CPI)**	0.987
Scaling factor (e.g. €m, €k, €)	€	**Method Factor - to take into account particular site issues /constraints**	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	**Cost (€)**	**Comment**
Total wall costs	€2,186,339	
Total embankment costs	€78,570	
Total demountable barriers/gates costs		
Total in-channel excavation costs	€10,826	
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge removal costs		
Total bridge construction costs		
Total bridge underpinning costs		
Total culvert costs	€208,937	
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€2,484,672	
Apply update to unit rate (CPI) if appropriate (cell N15)	€2,451,246	
Enter appropriate preliminaries estimate (%)	14.08%	*ref: Preliminaries and other costs v1.0*
Enter other applicable costs (€)		
Total capital cost (€)	€2,796,271	
Consider amendments based on site issues/constraints (cell N16)	€2,796,271	
Total capital cost (€)	**€2,796,271**	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs	€365	
Total embankment O&M costs	€1,281	
Total demountable barriers/gates O&M costs		
Total in-channel excavation O&M costs	N/A	
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs	€2,258	
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€3,905	

Other costs	**Cost (€)**	**Comment**
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€2,879,603	
Optimism bias rate (from external sheet)	40%	*ref: Optimism Bias Tool v.2.0 - medium risk assumed.*
Total Cost including Optimism Bias	**€4,031,445**	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	€0
Year of capital works (year)	
Capital cost (€)	€2,796,271
Annual maintenance cost (€)	€3,905
Other cost (€)	€0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**	**Total PVc (€k):**		**2879603**
	Cash sum	0	2796271	191331	0	2987602	**2879603**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	2796271			2796271.3	2796271.3
1	0.962			3905		3904.7	3754.5
2	0.925			3905		3904.7	3610.1
3	0.889			3905		3904.7	3471.3
4	0.855			3905		3904.7	3337.8
5	0.822			3905		3904.7	3209.4
6	0.790			3905		3904.7	3085.9
7	0.760			3905		3904.7	2967.3
8	0.731			3905		3904.7	2853.1
9	0.703			3905		3904.7	2743.4
10	0.676			3905		3904.7	2637.9
11	0.650			3905		3904.7	2536.4
12	0.625			3905		3904.7	2438.9
13	0.601			3905		3904.7	2345.1
14	0.577			3905		3904.7	2254.9
15	0.555			3905		3904.7	2168.1
16	0.534			3905		3904.7	2084.8
17	0.513			3905		3904.7	2004.6
18	0.494			3905		3904.7	1927.5
19	0.475			3905		3904.7	1853.3
20	0.456			3905		3904.7	1782.1
21	0.439			3905		3904.7	1713.5
22	0.422			3905		3904.7	1647.6
23	0.406			3905		3904.7	1584.2
24	0.390			3905		3904.7	1523.3
25	0.375			3905		3904.7	1464.7
26	0.361			3905		3904.7	1408.4
27	0.347			3905		3904.7	1354.2
28	0.333			3905		3904.7	1302.1
29	0.321			3905		3904.7	1252.0
30	0.308			3905		3904.7	1203.9
31	0.296			3905		3904.7	1157.6
32	0.285			3905		3904.7	1113.1
33	0.274			3905		3904.7	1070.3
34	0.264			3905		3904.7	1029.1
35	0.253			3905		3904.7	989.5
36	0.244			3905		3904.7	951.5
37	0.234			3905		3904.7	914.9
38	0.225			3905		3904.7	879.7
39	0.217			3905		3904.7	845.8
40	0.208			3905		3904.7	813.3
41	0.200			3905		3904.7	782.0
42	0.193			3905		3904.7	751.9
43	0.185			3905		3904.7	723.0
44	0.178			3905		3904.7	695.2
45	0.171			3905		3904.7	668.5
46	0.165			3905		3904.7	642.8
47	0.158			3905		3904.7	618.0
48	0.152			3905		3904.7	594.3
49	0.146			3905		3904.7	571.4

Option 3 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis			€	€	€	Notes to CFRAM Consultants
(1)	**Basic Construction Costs (Estimate)**				**2,962,538**	Construction Cost of each measure <u>including</u> Method Factor and CPI Adjustment but <u>excluding</u> Preliminaries
(2)	**Preliminaries**	13.2%			**391,736**	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**3,354,274**	
(3)	**Optimism Bias**	40.0%			**1,341,710**	Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**4,695,984**	
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13.0%			**610,478**	Set at 13%
	Construction Costs and Fees				**5,306,462**	
(6)	**Other Items**					
(a)	Allowance for Archaeology & Environmental Mitigation Measures	15.0%		704,398		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	15.0%		704,398		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation	5% assumed		234,799		Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance			38,000		See “Guidance E – Per Cent for Art Note”
(e)	Est. NPV Operation & Maintenance		245,170			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	40.0%	98,068	343,239	**2,024,833**	Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**7,331,295**	

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	PT	Date:	15/06/2015
Checked by:		Date:	

Project reference	ASN-03	Project name:	Shannon CFRAMS - S10

Base date for estimates (year 0)	Dec-2013	Construction Price Index (CPI)	0.987
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues /constraints	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	Cost (€)	Comment
Total wall costs	€2,186,339	
Total embankment costs	€532,839	
Total demountable barriers/gates costs		
Total in-channel excavation costs	€10,826	
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge removal costs		
Total bridge construction costs		
Total bridge underpinning costs		
Total culvert costs	€208,937	
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs	€40,800	
Total hydrometric gauging station costs		
Total flood forecasting costs	€17,900	
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs	€5,296	*2 weeks Public Awareness initially.*
Total Construction costs	€3,002,936	
Apply update to unit rate (CPI) if appropriate (cell N15)	€2,962,538	
Enter appropriate preliminaries estimate (%)	13.22%	*ref: Preliminaries and other costs v1.0*
Enter other applicable costs (€)		
Total capital cost (€)	€3,354,274	
Consider amendments based on site issues/constraints (cell N16)	€3,354,274	
Total capital cost (€)	**€3,354,274**	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs	€365	
Total embankment O&M costs	€6,789	
Total demountable barriers/gates O&M costs		
Total in-channel excavation O&M costs	N/A	
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs	€2,258	
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs	€816	
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs	€200	
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs	€1,059	*2 days Public Awareness annually.*
Total Operation and Maintenance costs	€11,488	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€3,599,445	
Optimism bias rate (from external sheet)	40%	*ref: Optimism Bias Tool v.2.0 - medium risk assumed.*
Total Cost including Optimism Bias	**€5,039,223**	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	€0
Year of capital works (year)	
Capital cost (€)	€3,354,274
Annual maintenance cost (€)	€11,488
Other cost (€)	€0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**		**Total PVc (€k):**	**3599445**
	Cash sum	0	3354274	562911	0	3917186	**3599445**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	3354274			3354274.5	3354274.5
1	0.962			11488		11488.0	11046.1
2	0.925			11488		11488.0	10621.3
3	0.889			11488		11488.0	10212.8
4	0.855			11488		11488.0	9820.0
5	0.822			11488		11488.0	9442.3
6	0.790			11488		11488.0	9079.1
7	0.760			11488		11488.0	8729.9
8	0.731			11488		11488.0	8394.2
9	0.703			11488		11488.0	8071.3
10	0.676			11488		11488.0	7760.9
11	0.650			11488		11488.0	7462.4
12	0.625			11488		11488.0	7175.4
13	0.601			11488		11488.0	6899.4
14	0.577			11488		11488.0	6634.0
15	0.555			11488		11488.0	6378.9
16	0.534			11488		11488.0	6133.5
17	0.513			11488		11488.0	5897.6
18	0.494			11488		11488.0	5670.8
19	0.475			11488		11488.0	5452.7
20	0.456			11488		11488.0	5243.0
21	0.439			11488		11488.0	5041.3
22	0.422			11488		11488.0	4847.4
23	0.406			11488		11488.0	4661.0
24	0.390			11488		11488.0	4481.7
25	0.375			11488		11488.0	4309.3
26	0.361			11488		11488.0	4143.6
27	0.347			11488		11488.0	3984.2
28	0.333			11488		11488.0	3831.0
29	0.321			11488		11488.0	3683.6
30	0.308			11488		11488.0	3542.0
31	0.296			11488		11488.0	3405.7
32	0.285			11488		11488.0	3274.7
33	0.274			11488		11488.0	3148.8
34	0.264			11488		11488.0	3027.7
35	0.253			11488		11488.0	2911.2
36	0.244			11488		11488.0	2799.3
37	0.234			11488		11488.0	2691.6
38	0.225			11488		11488.0	2588.1
39	0.217			11488		11488.0	2488.5
40	0.208			11488		11488.0	2392.8
41	0.200			11488		11488.0	2300.8
42	0.193			11488		11488.0	2212.3
43	0.185			11488		11488.0	2127.2
44	0.178			11488		11488.0	2045.4
45	0.171			11488		11488.0	1966.7
46	0.165			11488		11488.0	1891.1
47	0.158			11488		11488.0	1818.3
48	0.152			11488		11488.0	1748.4
49	0.146			11488		11488.0	1681.2

Appendix C3 Option Appraisal Report - Rathkeale

1. Preliminary Report: Summary of Current Flood Risk

1.1 AFA and Watercourse Details

AFA:	Rathkeale
Unit of Management:	24
Primary Watercourse(s):	Deel (River), Deegerty (River)

1.2 Summary of Flood Risk in 1% AEP Fluvial Event

Source of flood risk	**Fluvial**	Coastal	Both

Total Number of Properties at risk in AFA in 1% Fluvial AEP Event		**Residential**	**Non-Residential**	**Total**
	Fluvial	4	3	7

AFA Flood Cells:		
	Total Number:	4
	Flood Cell Titles:	RAE_A, RAE_B, RAE_C, RAE_D

Breakdown of properties at (combined) risk per Flood Cell:	**Flood Cell Ref**	**Residential**	**Non-Residential**	**Total**
	RAE_A	0	1	1
	RAE_B	2	2	2
	RAE_C	1	2	3
	RAE_D	1	0	1

Relevant Figure Ref: Figure 1.1 and 1.2

1.3 Summary of Existing Flood Risk Management Measures

Arterial Drainage	**Storage**	**Flow Diversion**	**Flood Defences**	**Level Control**	**Other**
Yes	None	None	None	None	None

Relevant Figure Ref: Figure 1.1 and 1.2

1.4 Summary of PV Damages/Potential PV Benefits for 1% Fluvial SOP

Total PV Damages:		**Uncapped**	**Capped**
	Fluvial	€ 733,522	€ 733,522

Max Capped Benefits for 1% Fluvial AEP Event*:	€ 374,016

Breakdown of Max Capped PV benefits per flood cell for 1% AEP Fluvial Event:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	RAE_A	€ 0	€ 326,194	€ 326,194
	RAE_B	€ 20,845	€ 0	€ 20,845
	RAE_C	€ 15,099	€ 9,999	€ 25,098
	RAE_D	€ 1,879	€ 0	€ 1,879

Relevant Figure Ref: Figure 1.2

*These are the maximum benefits available if a FRM option with a 1% Fluvial / 0.5% Coastal AEP SOP is provided to all properties within the AFA.

<table>
<tr><th colspan="3">1.5 Social Risk</th></tr>
<tr><td></td><td>Type</td><td>Description</td></tr>
<tr><td>High Vulnerability Properties at risk:</td><td>None</td><td>N/A</td></tr>
<tr><td>Social Infrastructure Assets:</td><td>None</td><td>N/A</td></tr>
<tr><td>Social Amenity Sites:</td><td>None</td><td>N/A</td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="2">General Risk - Social</td></tr>
<tr><th colspan="3">1.6 Risk to the Environment</th></tr>
<tr><td></td><td>Type</td><td>Description</td></tr>
<tr><td>Risk to WFD Annex IV:</td><td>None</td><td>N/A</td></tr>
<tr><td>Risk to SACs:</td><td>None</td><td>N/A</td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="2">General Risk - Environment</td></tr>
<tr><th colspan="3">1.7 Risk to Cultural Heritage</th></tr>
<tr><td></td><td>Type</td><td>Description</td></tr>
<tr><td rowspan="6">Risk to Sites of Cultural Heritage:</td><td rowspan="4">Limerick National Monuments</td><td>50% AEP Fluvial Flood Extent</td></tr>
<tr><td>Deel Bridge, Church Street</td></tr>
<tr><td>5% AEP Fluvial Flood Extent</td></tr>
<tr><td>Enclosure, Abbeylands</td></tr>
<tr><td rowspan="2">NIAH Buildings</td><td>50% AEP Fluvial Flood Extent</td></tr>
<tr><td>Deel Bridge, Church Street. Regionally important.</td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="2">General Risk – Cultural Heritage</td></tr>
<tr><th colspan="3">1.8 Risk to the Economy</th></tr>
<tr><td></td><td>Type</td><td>Description</td></tr>
<tr><td rowspan="11">Risk to Transport Infrastructure:</td><td rowspan="2">National Primary Road</td><td>50% AEP Fluvial Flood Extent</td></tr>
<tr><td>N21</td></tr>
<tr><td rowspan="4">Regional Road</td><td>50% AEP Fluvial Flood Extent</td></tr>
<tr><td>R523</td></tr>
<tr><td>2% AEP Fluvial Flood Extent</td></tr>
<tr><td>R518</td></tr>
<tr><td rowspan="5">Local Urban Street</td><td>1% AEP Fluvial Flood Extent</td></tr>
<tr><td>Orchard Avenue</td></tr>
<tr><td>0.1% AEP Fluvial Flood Extent</td></tr>
<tr><td>Cois Deel</td></tr>
<tr><td>Rathkeale Industrial Estate</td></tr>
<tr><td>Risk to Utility Infrastructure:</td><td>None</td><td>N/A</td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="2">General Risk - Economy</td></tr>
</table>

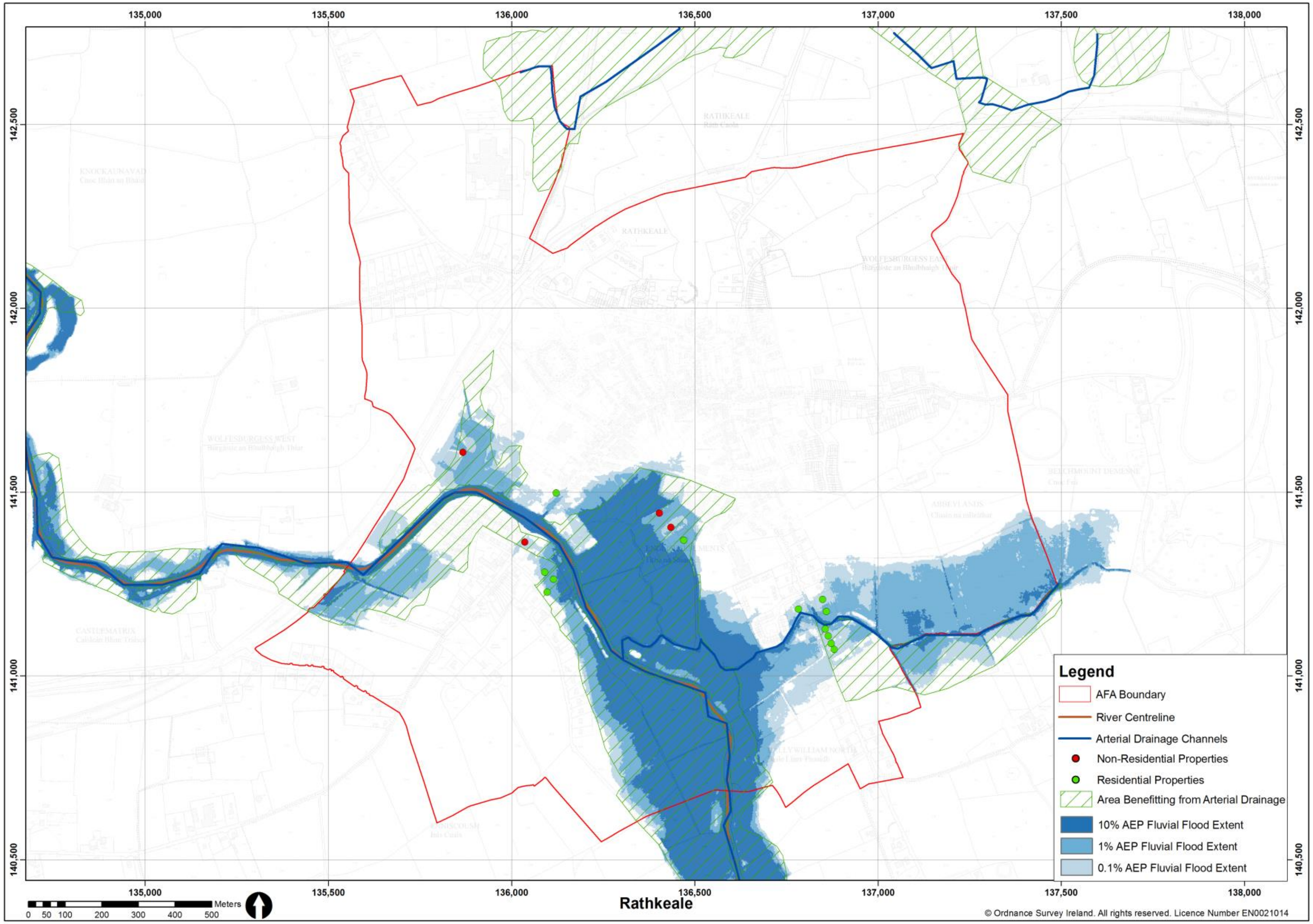


Figure 1.1 – Rathkeale Fluvial Flood Risk to Properties

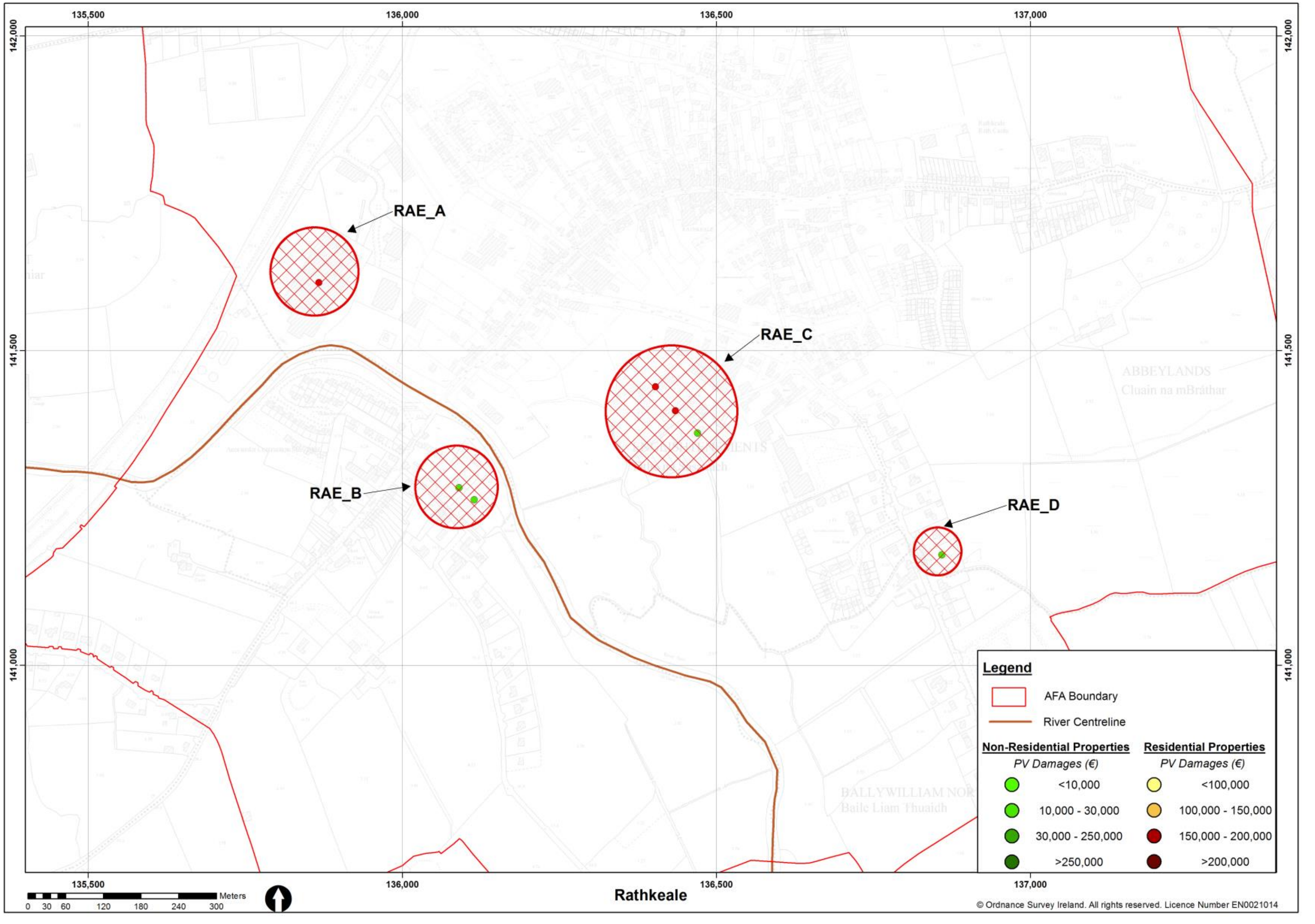


Figure 1.2 – Rathkeale Total PV Damages for Properties within 1% AEP Fluvial Flood Event and Flood Cells
Flood Cells are groupings of properties that are likely to be hydraulically linked

JACOBS

OPW The Office of Public Works / Oifig na nOibreacha Poiblí

STAGE 2: Screening of the Measures

2.1 Baseline, Structural and Non-Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
B	Existing Regime	Viable	Viable	Viable	Viable	Viable	**Screened In**
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
Structural							
D	Storage	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
E	Flow Diversion	Viable	Unviable	Viable	Viable	Viable	**Screened Out**
F	Increase Conveyance	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
G	Flood Defences	Viable	Viable	Viable	Viable	Viable	**Screened In**
H	Relocation of Properties	Viable	Viable	Viable	Viable	Viable	**Screened In**
I	Other Measures	Unviable	Unviable	Unviable	Unviable	Unviable	**Screened Out**
Non-Structural							
J	Flood Forecasting / Warning / Response	Viable	Viable	Viable	Viable	Viable	**Screened In**
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	**Screened In**
L	Individual Property Resistance	Viable	Viable	Viable	Viable	Viable	**Screened In**
M	Individual Property Resilience	Viable	Viable	Viable	Viable	Viable	**Screened In**

2.2 Justification for Screened Out Baseline and Structural Measures

The following provides justification on Measures with an overall viability 'Screened Out' categorisation.

A	Do Nothing	Applicability Economic Environmental Social Cultural	Screened out as there are other viable measures.
C	Do Minimum	Applicability Economic Environmental Social Cultural	Screened out, as the "Do Minimum" FRM measure would have a negligible impact to the existing flood risk.
D	Storage	Applicability Economic Environmental Social Cultural	Screened out. To provide a 1% Fluvial AEP standard of protection would require a 10,861,579m^3 storage area. This would need to be positioned upstream of the AFA in an area currently not at risk of flooding. No such area exists.
E	Flow Diversion	Applicability Economic Environmental Social Cultural	Screened out. A potential 2km flow diversion route is shown in Figure 2.1. However, the option would be prohibitively expensive due to a required deep excavation, and the possibility of increasing the flood risk to properties in the Castlemix area, which is near the route of the proposed flow diversion.

F	Increase Conveyance	Applicability Economic Environmental Social Cultural	Screened out. Dredging the channel by 500mm for a length of 2 km through the AFA does not significantly reduce the existing flood risk. There is some afflux at the main bridge in the town, however replacing this bridge to increase conveyance, does not remove all flood risk within the 1% Fluvial AEP event.
I	Other Measures	Applicability Economic Environmental Social Cultural	No other measures have been identified.

2.3 Summary of 'Screened In' Measures

The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.

Baseline Measures		**Non-Structural Measures**	
B	Existing Regime	J	Flood Forecasting / Warning / Response
Structural Measures		K	Public Awareness
G	Flood Defences	L	Individual Property Resistance
H	Relocation of Properties	M	Individual Property Resilience

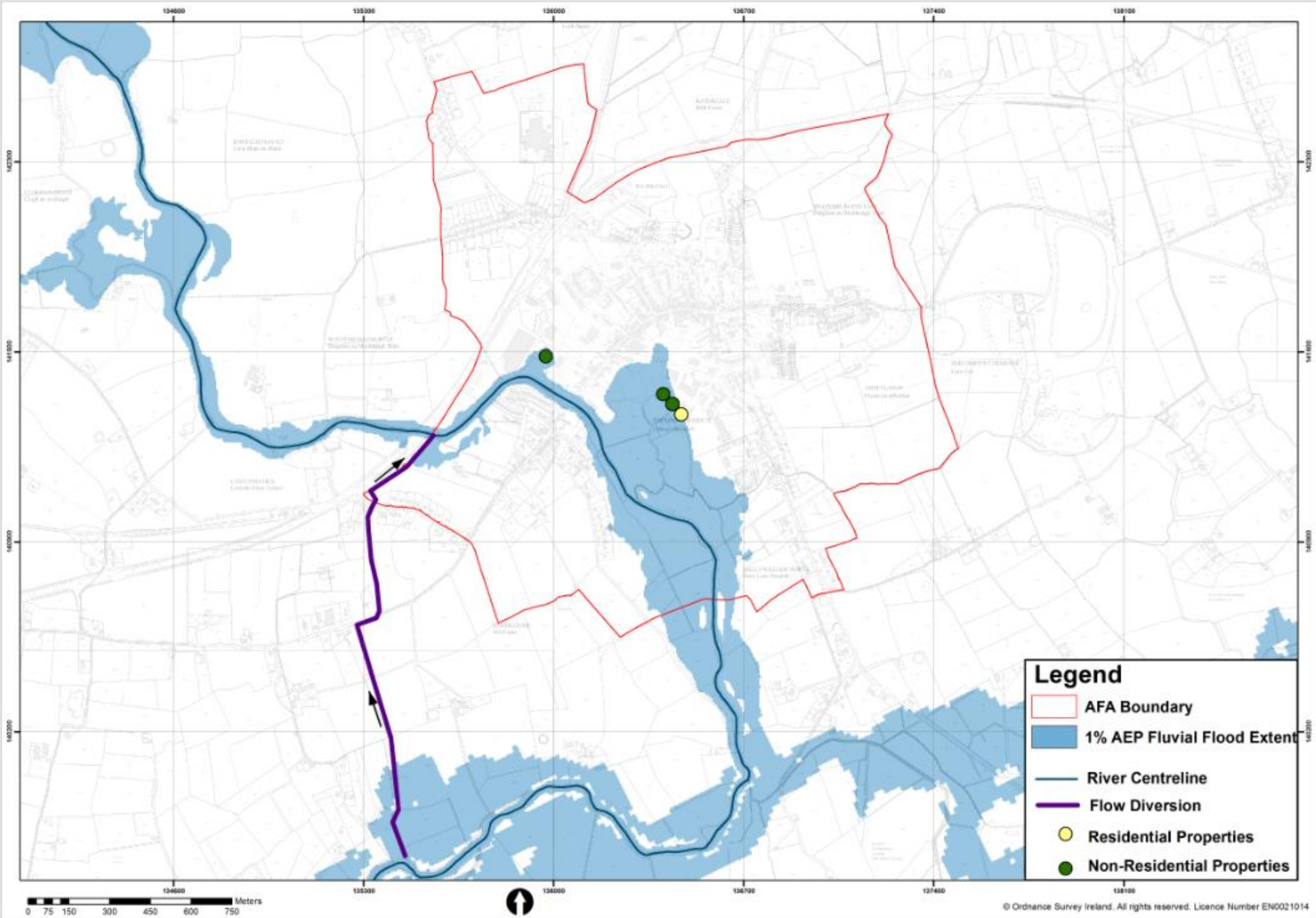


Figure 2.1 – Screened Out Potential Flow Diversion Route

STAGE 3: Selection of Options								
3.1 Consideration of Options The following are the agreed combination of 'Screened In' measures that comprise each of the Options being taken forward for further consideration. Where appropriate, the 'Screened In' measures have been sub-divided into separate specific measures to ensure applicability to site conditions.								
Measures		**Different composition of measures per option**						
Baseline Measures								
B	Existing Regime	✓	✓					
Structural Measures								
G	Flood Defences							
Gi	New Flood Defences		✓					
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences							
Giv	Other Defences							
H	Relocation of Properties							
Non-Structural Measures								
J	Flood Forecasting / Warning / Response	✓	✓					
K	Public Awareness	✓	✓					
L	Individual Property Resistance	✓	✓					
M	Individual Property Resilience							
Option Reference		RAE_01	RAE_02					

Measures not screened out but not included in options		
Measures		**Justification**
H	Relocation of Properties	Relocation of Properties was not considered as either an independent measure or in combination with other measures, as the option being appraised would provide the required 1% Fluvial AEP standard of protection. Relocation of Properties does not improve the viability of the options under consideration.
M	Individual Property Resilience	Individual Property Resilience was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required 1% Fluvial AEP standard of protection. Individual Property Resilience does not improve the viability of the options under consideration.

STAGE 4: Appraisal of Options

4.1 Options Appraisal

Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Meeting. Below describes this concept design of each options and provides a summary of any significant comments/issues which were raised by LA staff at the Options Meetings. These comments will be considered in the local weightings and the MCA scores.

<table>
<tr><td colspan="2">Option Ref:</td><td colspan="4">RAE_01</td></tr>
<tr><td rowspan="3">Option Measures</td><td>Baseline</td><td>B</td><td colspan="3">Existing Regime</td></tr>
<tr><td>Structural</td><td></td><td colspan="3">None</td></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="4">This option reduces the risk to all 7 properties within the AFA, identified as being at risk, and includes;

• Individual property resistance, flood forecasting and public awareness will apply to all properties at risk of flooding.
• Existing arterial drainage maintenance scheme will need to be maintained as part of this option.</td></tr>
<tr><td colspan="2" rowspan="2">Options Meeting:</td><td>Date:</td><td colspan="3">03/09/2015</td></tr>
<tr><td>Summary:</td><td colspan="3">The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="2">Option Ref:</td><td colspan="4">RAE_02</td></tr>
<tr><td rowspan="3">Option Measures</td><td>Baseline</td><td>B</td><td colspan="3">Existing Regime</td></tr>
<tr><td>Structural</td><td>Gi</td><td colspan="3">Flood Defences: New Flood Defences</td></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="4">This option will provide a 1% Fluvial AEP design standard to 3 properties within the AFA, identified as being at risk, and will reduce the risk to the remaining 4 properties within the AFA, identified as being at risk. The option includes:

• One earth embankment, 400m in length. The embankment will typically be between 1.0m - 1.5m above the existing ground level.
• Individual property resistance, flood forecasting and public awareness will apply to the 4 remaining properties at risk of flooding.
• Existing arterial drainage maintenance scheme will need to be maintained as part of this option.</td></tr>
<tr><td colspan="2" rowspan="2">Options Meeting:</td><td>Date:</td><td colspan="3">03/09/2015</td></tr>
<tr><td>Summary:</td><td colspan="3">The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting</td></tr>
</table>

STAGE 5: Multi Criteria Assessment			
5.1 Options selected for the Multi Criteria Assessment Following the Option Meeting, the following options are the refined options for the Multi-Criteria Assessment (MCA) stage. This is the final of a five stage MCA process.			
Option Reference		RAE_01	RAE_02
Baseline Measures			
B	Existing Regime	Existing arterial drainage maintenance scheme	Existing arterial drainage maintenance scheme
Structural Measures			
Gi	New Flood Defences		Construction of an earth embankment 400m long to provide a 1% AEP fluvial design standard to 3 properties.
Non-Structural Measures			
L	Individual Property Resistance	This will apply to all 7 properties at risk in the 1% AEP event	This will apply to 4 properties at risk in the 1% AEP event
J	Flood Forecasting / Warning / Response	This will apply to all 7 properties at risk in the 1% AEP event	This will apply to 4 properties at risk in the 1% AEP event
K	Public Awareness	This will apply to all 7 properties at risk in the 1% AEP event	This will apply to 4 properties at risk in the 1% AEP event
Table reference A summary of the outcome from the MCA is presented in the following table		Table 5.1	Table 5.2

Table 5.1: Multi Criteria Assessment Outcome for Option RAE_01

<table>
<tr><td colspan="4">Multi Criteria Assessment
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.</td></tr>
<tr><td>AFA</td><td>Rathkeale</td><td>Option Ref:</td><td>RAE_01</td></tr>
<tr><td colspan="4">Option Measures</td></tr>
<tr><td>Baseline</td><td>B</td><td colspan="2">Existing Regime</td></tr>
<tr><td>Structural</td><td></td><td colspan="2">None</td></tr>
<tr><td rowspan="3">Non-Structural</td><td>J</td><td colspan="2">Flood Forecasting / Warning / Response</td></tr>
<tr><td>K</td><td colspan="2">Public Awareness</td></tr>
<tr><td>L</td><td colspan="2">Individual Property Resistance</td></tr>
<tr><td colspan="4">Criteria Scores</td></tr>
<tr><td colspan="2">Technical</td><td colspan="2">967</td></tr>
<tr><td colspan="2">Economic</td><td colspan="2">49</td></tr>
<tr><td colspan="2">Social</td><td colspan="2">38</td></tr>
<tr><td colspan="2">Environmental</td><td colspan="2">0</td></tr>
<tr><td colspan="4">Economic Values</td></tr>
<tr><td colspan="2">Economic PV Benefits</td><td colspan="2">€ 307,720</td></tr>
<tr><td colspan="2">PV Cost</td><td colspan="2">€ 261,021</td></tr>
<tr><td colspan="2">NPV Benefits</td><td colspan="2">€ 46,699</td></tr>
<tr><td colspan="2">Economic BCR</td><td colspan="2">1.18</td></tr>
<tr><td colspan="4">Outcome Scores</td></tr>
<tr><td colspan="2">MCA PV Benefits</td><td colspan="2">€ 279,026</td></tr>
<tr><td colspan="2">MCA Benefit Score</td><td colspan="2">87</td></tr>
<tr><td colspan="2">MCA Benefit Score Ratio</td><td colspan="2">335.14</td></tr>
<tr><td colspan="2">Option Selection MCA</td><td colspan="2">1054</td></tr>
</table>

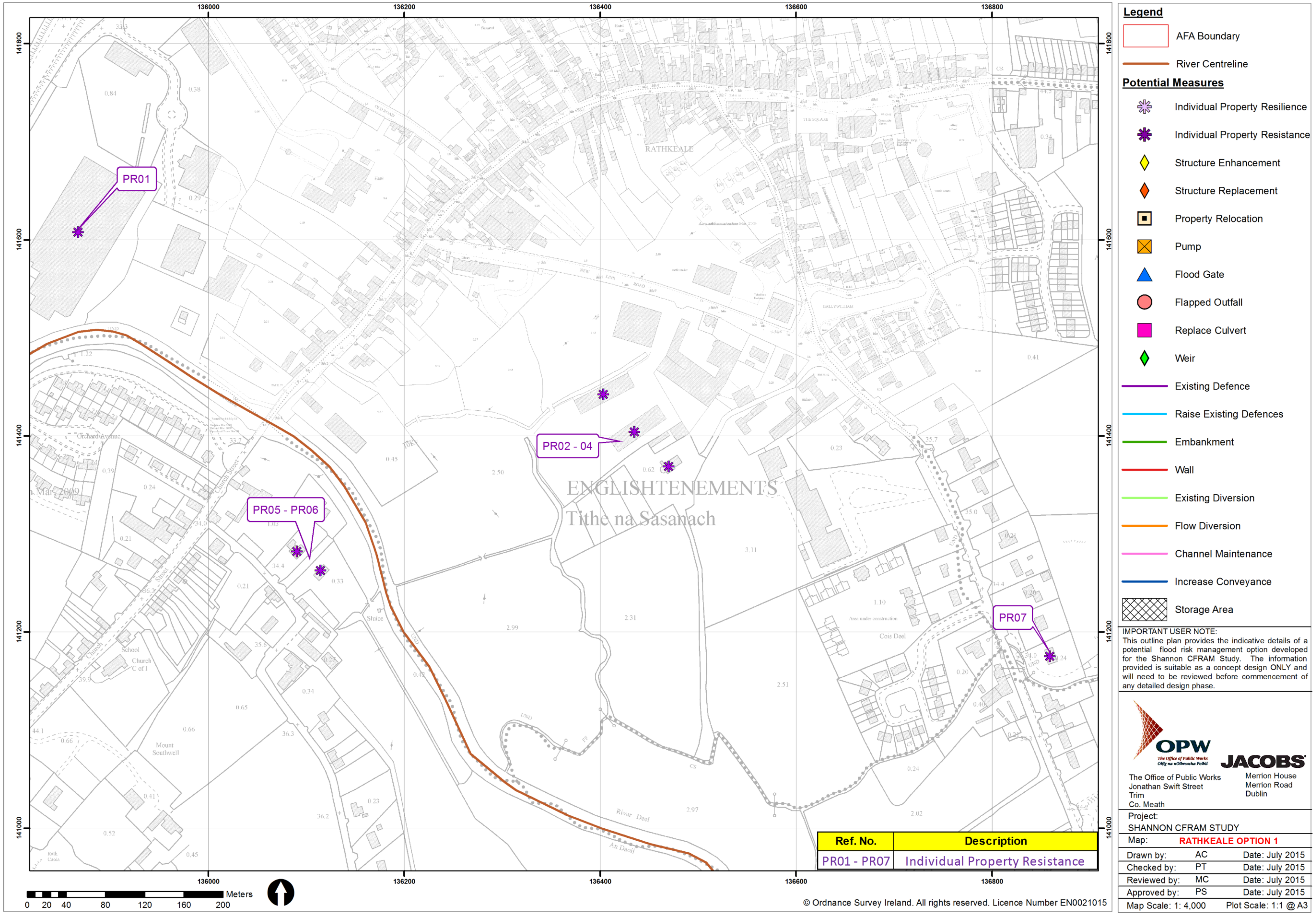
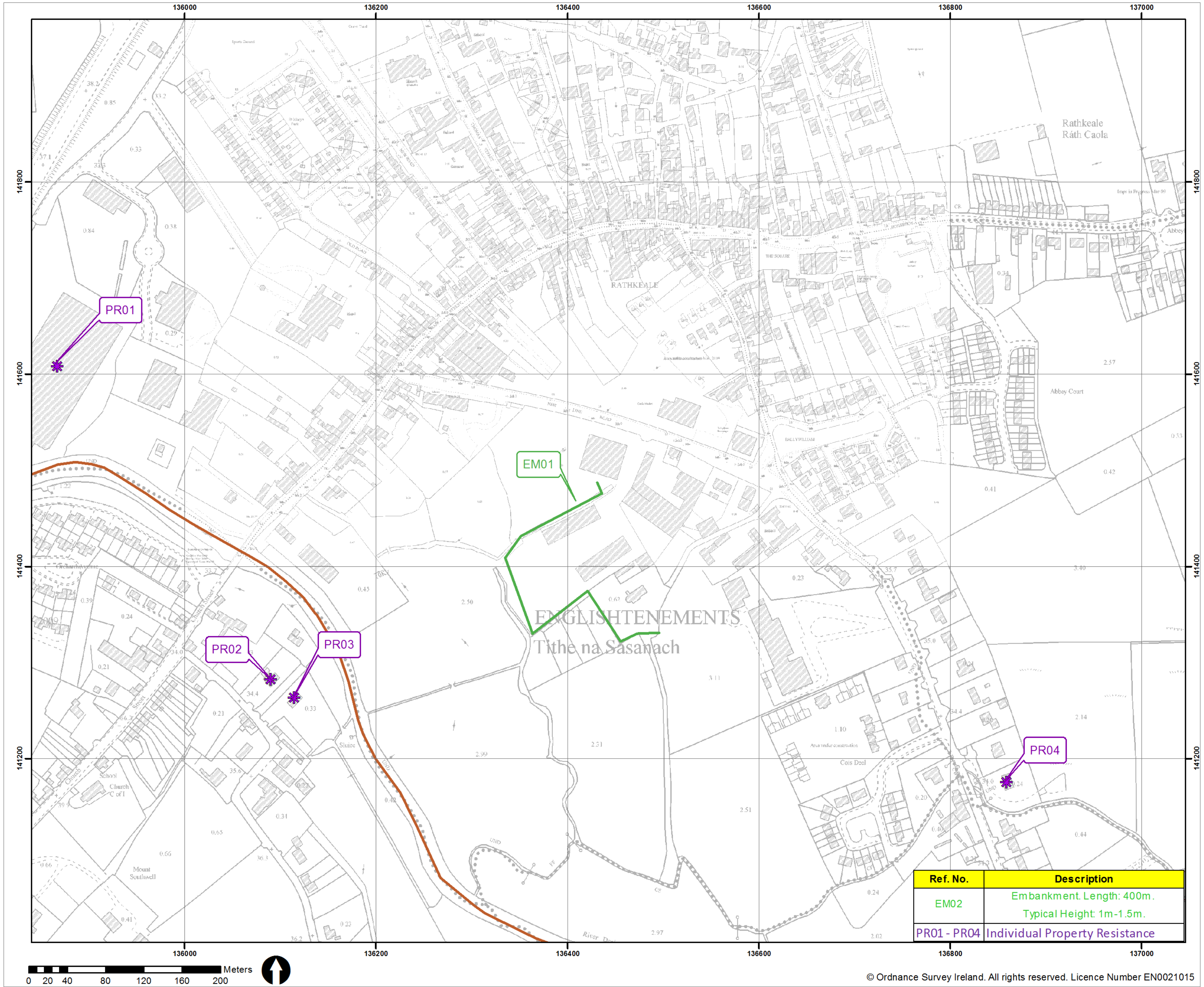


Figure 5.1 – Option RAE_01

Table 5.2: Multi Criteria Assessment Outcome for Option RAE_02

<table>
<tr><td colspan="4">Multi Criteria Assessment
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.</td></tr>
<tr><td>AFA</td><td>Rathkeale</td><td>Option Ref:</td><td>RAE_02</td></tr>
<tr><td colspan="4">Option Measures</td></tr>
<tr><td>Baseline</td><td>B</td><td colspan="2">Existing Regime</td></tr>
<tr><td>Structural</td><td>Gi</td><td colspan="2">New Flood Defences</td></tr>
<tr><td rowspan="3">Non-Structural</td><td>J</td><td colspan="2">Flood Forecasting / Warning / Response</td></tr>
<tr><td>K</td><td colspan="2">Public Awareness</td></tr>
<tr><td>L</td><td colspan="2">Individual Property Resistance</td></tr>
<tr><td colspan="4">Criteria Scores</td></tr>
<tr><td colspan="2">Technical</td><td colspan="2">1000</td></tr>
<tr><td colspan="2">Economic</td><td colspan="2">49</td></tr>
<tr><td colspan="2">Social</td><td colspan="2">38</td></tr>
<tr><td colspan="2">Environmental</td><td colspan="2">-50</td></tr>
<tr><td colspan="4">Economic Values</td></tr>
<tr><td colspan="2">Economic PV Benefits</td><td colspan="2">€ 311,774</td></tr>
<tr><td colspan="2">PV Cost</td><td colspan="2">€ 295,020</td></tr>
<tr><td colspan="2">NPV Benefits</td><td colspan="2">€ 16,754</td></tr>
<tr><td colspan="2">Economic BCR</td><td colspan="2">1.06</td></tr>
<tr><td colspan="4">Outcome Scores</td></tr>
<tr><td colspan="2">MCA PV Benefits</td><td colspan="2">€ 280,195</td></tr>
<tr><td colspan="2">MCA Benefit Score</td><td colspan="2">37</td></tr>
<tr><td colspan="2">MCA Benefit Score Ratio</td><td colspan="2">124.92</td></tr>
<tr><td colspan="2">Option Selection MCA</td><td colspan="2">1037</td></tr>
</table>



Ref. No.	Description
EM02	Embankment. Length: 400m. Typical Height: 1m-1.5m.
PR01 - PR04	Individual Property Resistance

Legend

- AFA Boundary
- River Centreline

Potential Measures

- Individual Property Resilience
- Individual Property Resistance
- Structure Enhancement
- Structure Replacement
- Property Relocation
- Pump
- Flood Gate
- Flapped Outfall
- Replace Culvert
- Weir
- Existing Defence
- Raise Existing Defences
- Embankment
- Wall
- Existing Diversion
- Flow Diversion
- Channel Maintenance
- Increase Conveyance
- Storage Area

IMPORTANT USER NOTE:
This outline plan provides the indicative details of a potential flood risk management option developed for the Shannon CFRAM Study. The information provided is suitable as a concept design ONLY and will need to be reviewed before commencement of any detailed design phase.

OPW
The Office of Public Works
Oifig na nOibreacha Poiblí
The Office of Public Works
Jonathan Swift Street
Trim
Co. Meath

JACOBS
Merrion House
Merrion Road
Dublin

Project:
SHANNON CFRAM STUDY

Map: RATHKEALE OPTION 2

Drawn by:	AC	Date: July 2015
Checked by:	PT	Date: July 2015
Reviewed by:	MC	Date: July 2015
Approved by:	PS	Date: July 2015
Map Scale: 1: 4,000		Plot Scale: 1:1 @ A3

Figure 5.2 – Option RAE_02

5.2 Comparison of Multi Criteria Assessment Scores

Each option taken forward for further consideration through the Option Decision Meeting, has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Decision Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).

Categories	**Option Reference and Results**	
	RAE_01	RAE_02
Criteria Scores		
Technical	967	1000
Economic	49	49
Social	38	38
Environmental	0	-50
Economic Values		
Economic PV Benefits	€ 307,720	€ 311,774
PV Cost	€ 261,021	€ 295,020
NPV Benefits	€ 46,699	€ 16,754
Economic BCR	**1.18**	**1.06**
Outcome Scores		
MCA PV Benefits	€ 279,026	€ 280,195
MCA Benefit Score	87	37
MCA BCR	335.14	124.92
Option Selection MCA	1054	1037

5.3 Recommendation of Preferred Option

It forms part of the CFRAM process for the recommendation of a preferred option for each AFA. The prioritised selection criteria used in this recommendation process is detailed in Section 3.7.3 of the Main Report.

Therefore, following the five stage Multi Criteria Assessment process, the preferred option is as outlined below

<table>
<tr><td colspan="2">Option Ref:</td><td colspan="4">RAE_02</td></tr>
<tr><td rowspan="3">Option Measures</td><td>Baseline</td><td>B</td><td colspan="3">Existing Regime</td></tr>
<tr><td>Structural</td><td>Gi</td><td colspan="3">Flood Defences: New Flood Defences</td></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Comments</td><td colspan="4">Although the MCA BCR is higher for RAE_01, RAE_02 provides a 1% AEP fluvial design standard to a greater number of properties and is therefore the preferred option.</td></tr>
</table>

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

<table>
<tr><th colspan="5">Fluvial Flood Forecasting Potential</th></tr>
<tr><th rowspan="3">Catchment Information</th><th colspan="2">Gauging Station</th><th rowspan="2">Catchment size (km ^{2})</th><th rowspan="2">Potential available forecast accuracy and reliability period</th></tr>
<tr><th>Fluvial</th><th>Rainfall</th></tr>
<tr><td>GS 24011
GS 24012
GS 24030</td><td>No*</td><td>438</td><td>9-12 hours</td></tr>
<tr><th>Relevant Information:</th><td colspan="4">Grange Bridge (GS 24012) 14 km upstream of Rathkeale
Deel Bridge (GS 24011, 19 km upstream of Rathkeale)
Danganbeg Bridge (GS 24030, 19 km upstream of Rathkeale)</td></tr>
<tr><th rowspan="3">Additional Infrastructure Recommended</th><th colspan="2">Gauging Station</th><th colspan="2" rowspan="2">Other</th></tr>
<tr><th>Fluvial</th><th>Rainfall</th></tr>
<tr><td>No</td><td>No</td><td colspan="2">n/a</td></tr>
<tr><th>Relevant Comments:</th><td colspan="4">The existing fluvial gauging station could provide reasonably accurate and reliable predictions for flooding from the River Deel based on level/level relationships. GS 24012 represents 75% of the total catchment area. There is no requirement for additional fluvial or rainfall gauges to provide flood forecasting for this AFA.</td></tr>
</table>

*For this assessment only 15 minute tipping bucket gauge were considered.

Annex A - Multi-Criteria Analysis Summary and Whole Life Cost Summaries for FRM Option(s)

CRITERIA		OBJECTIVE		Global Weighting	Local Weighting	Comments	RAE_01	Option Score	Weighted Score	RAE_02	Option Score	Weighted Score
							B Existing Regime J Flood Forecasting / Warning / Response K Public Awareness L Individual Property Resistance			B Existing Regime Gi New Flood Defences J Flood Forecasting / Warning / Response K Public Awareness L Individual Property Resistance		
1	Technical	a	Ensure flood risk management options are operationally robust	20	5.00	The option scores are determined based on the level of operational risk to operate or perform successfully. Each measure is scored independently and the average of the measure scores is used as the score for the option.	None / Manageable Negligible / Moderate / high Very low / High Low / Failure likely Low / moderate / Unacceptable B 4.00 J 3.00 K L 3.00	3.33	333	None / Manageable Negligible / Moderate / high Very low / High Low / Failure likely Low / moderate / Unacceptable B 4.00 Gi 5.00 J 3.00 K L 3.00	3.75	375
		b	Minimise health and safety risks associated with the construction and operation of flood risk management options	20	5.00	H&S risks are considered for construction and maintenance of flood risk management measures. The indicative aspirational score is set at five, with a point then deducted for each specific H&S risk in either construction or maintenance.	No risks / Moderate Negligible / Moderate / high Very low / High Low / Very High Low / moderate / Unacceptable Work near services or buildings Work near/in water	2.00	200	No risks / Moderate Negligible / Moderate / high Very low / High Low / Very High Low / moderate / Unacceptable Work near/in water Work near services or buildings	2.00	200
		c	Ensure flood risk management options are adaptable to future flood risk	20	5.00	The options scores are determined based on the sustainability and adaptability of the flood risk management measures in the face of potential future changes, including the potential impact of climate change. Each measure is scored independently and the average of the measure scores is used as the score for the option.	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. B 5.00 J 5.00 K L 3.00	4.33	433	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. B 5.00 Gi 4.00 J 5.00 K L 3.00	4.25	425
					TECHNICAL CRITERIA SCORE				967			1000
2	Economic	a	Minimise economic risk	24	0.35		The score is calculated based on the reduction in AAD, following the full implementation of option.	2.65	22	The score is calculated based on the reduction in AAD, following the full implementation of option.	2.66	22
		b	Minimise risk to transport infrastructure	10	5.00		Scoring is based on the reduction in flood risk to transport routes, following the full implementation of option.	0.50	25	Scoring is based on the reduction in flood risk to transport routes , following the full implementation of option.	0.50	25
		c	Minimise risk to utility infrastructure	14	0.00		Scoring is calculate based on a reduction in flood risk to utility infrastructure, following the full implementation of option.			Scoring is calculate based on a reduction in flood risk to utility infrastructure, following the full implementation of option.		
		d	Minimise risk to agriculture	12	0.15	Source of Flooding: Fresh Water Percentage of AFA that is rural land: 3.07%	Area of Agricultural Land Flooded: No Change Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Applicable Agricultural Production Enhanced: Not Applicable Other (Please Specify): Not Applicable	1.00	2	Area of Agricultural Land Flooded: No Change Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Applicable Agricultural Production Enhanced: Not Applicable Other (Please Specify): Not Applicable	1.00	2
					ECONOMIC CRITERIA SCORE				49			49
3	Social	a i)	Minimise risk to human health and life - Residents	27	0.08	Flood Depths & Velocities: Assumed low risk to life	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	4.00	9	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	4.00	9
						Known Areas of Highly Vulnerable People: Reasonable Cross Section of Society						
		a ii)	Minimise risk to human health and life - High vulnerability properties	17	0.00	Rate of Onset of flooding: Significantly Lower Rate of Onset	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	4.00	0	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	4.00	0
		b i)	Minimise risk to community - Social Infrastructure & Amenity	9	0.00	Assets of Particular Social Value: No	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.			The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.		
		b ii)	Minimise risk to community - Local employment	7	0.84	Asset of Particular Employment Value: No	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	5.00	29	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	4.88	29
					SOCIAL CRITERIA SCORE				38			38
4	Environmental	a	Support the objectives of the WFD	16	5.00	There is a WFD waterbody within the AFA, the Deel River. The WFD status of the waterbody is poor. There are no potentially polluting sources within the 1% AEP Fluvial. There are no WFD Annex IV areas within the AFA and in proximity to the AFA. Local weighting to be applied for this objective is constant, and should always be set equal to 5 as WFD objectives must be achieved and are relevant to all waterbodies.	The implementation of flood forecasting, individual property resistance and increased public awareness is unlikely to impact the achievement of water body objectives. Therefore, no constraint to the achievement of waterbody objective.	0.00	0	Construction related impacts due to construction of embankments adjacent to the Deel River. However, the proposed embankments at their closest point are 75 metres from the centre line of the river and are unlikely to be significant. Reduced flooding in area with no significant polluting sources in 1% AEP Fluvial extents. Therefore, overall no constraint to the achievement of wb objectives.	0.00	0
		b	Support the objectives of the Habitats Directive	10	3.00	There are no SACs or SPAs within the AFA. Te lower River Shannon cSAC [002165] is c. 21 km downstream. The Lower River Shannon cSAC qualifying interests that could potentially occur within the AFA include otter, river, brook and sea lamprey, Atlantic salmon, and floating river vegetation. There are no SPAs within the AFA. The Rivers Shannon and River Fergus Estuaries SPA [004077] is c. 5km from the AFA to the north and the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA [004161] is c. 5km from the AFA to the west. Local weighting of 3 set by professional judgement. Weighting of 3 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (outside AFA) and potentially affected.	The implementation of flood forecasting, individual property resistance and increased public awareness is unlikely to increase or reduce pollution risk to European Sites. Therefore, no impact on existing SAC, SPA or Ramsar sites as a result of the flood risk management measures.	0.00	0	Potential construction effects due to surface water connection with the Lower River Shannon cSAC, such as: - Increases in suspended sediment; - Pollution risks to the River Deel which is linked to Lower River Shannon cSAC; - Disturbance to otter outside the cSAC. However, it is noted that the proposed embankments at their closest point are 75 metres from the centre line of the river and are unlikely to be significant. Therefore, there is potential for detrimental impact upon existing cSAC and SPA site, including a delay in recovery of the site, but excluding impacts on the conservation objectives of the site, as a result of flood risk management measures, where suitable mitigation	-0.50	-15
		c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	5	1.00	There are no nationally designated sites within the AFA, but there is potential for significant habitats and populations of European and nationally protected species. The River Deel drains into the Inner Shannon Estuary pNHA [000435], approx. 10km north of AFA. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no designated sites but habitats/species are likely to be present that could be affected	The implementation of flood forecasting, individual property resistance and increased public awareness is unlikely to significantly impact or enhance the flora and fauna of the catchment. Therefore, no impact on existing national, regional, and local sites as a result of flood risk management measures.	0.00	0	Construction impact on the water body associated with the construction of embankments, such as: - Pollution risks to the pNHA; - Disturbance to bird species; - Disturbance to otter. However, it is noted that the proposed embankments at their closest point are 75 metres from the centre line of the river and are unlikely to be significant. Therefore, there is a potential localised loss of or disturbance to flora	-1.00	-5
		d	Protect, and where possible enhance, fisheries resource within the catchment	13	2.00	The Deel River is not designated as a Salmonid River; however the river is a medium activity angling area. Local weighting of 2 set by professional judgement. Weighting of 2 applied where a waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.	The implementation of flood forecasting, individual property resistance and increased public awareness is unlikely to significantly impact or enhance fisheries resource within the catchment. Therefore, no change to fisheries potential of the waterbody.	0.00	0	Construction related impacts on water quality and subsequent fish species. Construction works of embankments adjacent to the River Deel may impact water quality. However, it is noted that the proposed embankments at their closest point are 75 metres from the centre line of the river and are unlikely to be significant.	-1.00	-26
		e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	8	1.00	Rathkeale has no landscape planning designations within the AFA. No specific landscape sensitivity/value areas, but landscape features/views which are important at a local level and could potentially be affected. A section of the Great Southern Trail goes into Rathkeale and crosses the River Deel. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected.	The implementation of flood forecasting, individual property resistance and increased public awareness is unlikely to result in a change to the existing landscape character/features. Therefore, no change to existing landscape character / feature in the zone of influence of the selected measure.	0.00	0	Potential localised intermittent impacts due to thef embankment. Therefore, potential short-term impact (construction) on moderate sensitivity landscape character / feature in the zone of visibility of selected measure.	-0.50	-4
		f i)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of architectural value	4	2.00	Rathkeale is not a heritage town. 0.003 km2 of ACA falls within the 1% AEP Fluvial. There are no RPS and 1 NIAH within the 1% AEP Fluvial. A number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a moderate to low vulnerability. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a moderate to low vulnerability.	The implementation of flood forecasting, individual property resistance and increased public awareness is unlikely to result in a change to the architectural features. Therefore, no effects on architectural features.	0.00	0	Proposed embankments do not encroach on any architectural feature. The ACA will not be removed from the 1% Fluvial AEP. Therefore, no effects on architectural features.	0.00	0
		f ii)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of archaeological value	4	2.00	Rathkeale is not a heritage town with only one RMP, an English Tenements Bridge, within the 1% AEP Fluvial. There are no other protected features of archaeological value within the 1% AEP Fluvial. A number of sites listed on the RMP/RPS present and potentially affected. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are a number of sites listed on the RMP/RPS present and potentially affected (moderate to low vulnerability).	The implementation of flood forecasting, individual property resistance and increased public awareness is unlikely to result in a change to the archaeological features. Therefore, no effects on archaeological features are predicted.	0.00	0	There are no RMPs within the AFA therefore, no significant impacts are predicted. There is potential for unknown archaeological features to be impacted but these are not known. Therefore, no effects on archaeological features are predicted.	0.00	0
					ENVIRONMENTAL CRITERIA SCORE				0			-50
Economic Values			Economic PV Benefits					€307,720			€311,774	
			Cost					€261,021			€295,020	
			NPV Benefits					€46,699			€16,754	
			Economic BCR					**1.18**			**1.06**	
Outcome Scores			MCA PV Benefits					€279,026			€280,195	
			MCA Benefit Score					87			37	
			MCA BCR					**335.14**			**124.92**	
			Option Selection MCA					1054			1037	

Objective	Global Weightings (fixed)	Local Weightings		Baseline Comments	Option 1 Comments	Option 2 Comments
1.A	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has negligible operational risks to operate or perform successfully.	This score is determined for this option as it has negligible operational risks to operate or perform successfully.
1.B	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has low health and safety risks associated with the construction and operation of flood risk management option.	This score is determined for this option as it has low health and safety risks associated with the construction and operation of flood risk management option.
1.C	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions.	This score is determined for this option as it can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions.
2.A	24	0.35	calculated	Local weighting is calculated based on the baseline AAD.	This score is calculated based on the reduction in AAD, following the full implementation of option.	This score is calculated based on the reduction in AAD, following the full implementation of option.
2.B	10	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to transport infrastructure. Local weighting already calculated as maximum score 5.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.
2.C	14	0.00	calculated but adjusted by professional judgement if necessary	There are no assets of utility infrastructure at risk within this AFA.	There is no risk to utility infrastructure within the AFA.	There is no risk to utility infrastructure within the AFA.
2.D	12	0.15	Professional judgement	Local weighting is calculated based on the percentage of rural land within the AFA.	This score is determined based on application of flood forecasting, following full implementation of the option.	This score is determined based on application of flood forecasting, following full implementation of the option.
3.A (i)	27	0.08	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to residential properties but adjusted by professional judgement; reduced by 25% due to slow rate of onset.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option. The option score was not increased due to significant lower rate of onset as the presence of flood forecasting has increased the score to 4 (from 0.86).	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option. The option score was not increased due to significant lower rate of onset as the presence of flood forecasting has increased the score to 4 (from 0.86).
3.A (ii)	17	0.00	calculated but adjusted by professional judgement if necessary	There are no high vulnerability properties at risk within this AFA.	There is no risk to high vulnerability properties within the AFA.	There is no risk to high vulnerability properties within the AFA.
3.B (i)	9	0.00	calculated but adjusted by professional judgement if necessary	There is no risk to social infrastructure within this AFA.	There is no risk to social infrastructure within the AFA.	There is no risk to social infrastructure within the AFA.
3.B (ii)	7	0.84	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to local employment.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option. The option score has been increased by 10% due to presence of flood forecasting.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option. The option score has been increased by 10% due to presence of flood forecasting.
4.A	16	5.00	fixed	There are no SACs or SPAs within the AFA. Te lower River Shannon cSAC [002165] is c. 21 km downstream. The Lower River Shannon cSAC qualifying interests that could potentially occur within the AFA include otter, river, brook and sea lamprey, Atlantic salmon, and floating river vegetation. There are no SPAs within the AFA. The Rivers Shannon and River Fergus Estuaries SPA [004077] is c. 5km from the AFA to the north and the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA [004161] is c. 5km from the AFA to the west. Local weighting of 3 set by professional judgement. Weighting of 3 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (outside AFA) and potentially affected.	The implementation of flood forecasting, individual property resistance and increased public awareness is unlikely to impact the achievement of water body objectives. Therefore, no constraint to the achievement of waterbody objective.	Construction related impacts due to construction of embankments adjacent to the Deel River. However, the proposed embankments at their closest point are 75 metres from the centre line of the river and are unlikely to be significant. Reduced flooding in area with no significant polluting sources in 1% AEP Fluvial extents. Therefore, overall no constraint to the achievement of wb objectives.
4.B	10	3.00	Professional judgement	There are no SACs or SPAs within the AFA. Te lower River Shannon cSAC [002165] is c. 21 km downstream. The Lower River Shannon cSAC qualifying interests that could potentially occur within the AFA include otter, river, brook and sea lamprey, Atlantic salmon, and floating river vegetation. There are no SPAs within the AFA. The Rivers Shannon and River Fergus Estuaries SPA [004077] is c. 5km from the AFA to the north and the Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA [004161] is c. 5km from the AFA to the west. Local weighting of 3 set by professional judgement. Weighting of 3 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (outside AFA) and potentially affected.	The implementation of flood forecasting, individual property resistance and increased public awareness is unlikely to increase or reduce pollution risk to European Sites. Therefore, no impact on existing SAC, SPA or Ramsar sites as a result of the flood risk management measures.	Potential construction effects due to surface water connection with the Lower River Shannon cSAC, such as: - Increases in suspended sediment; - Pollution risks to the River Deel which is linked to Lower River Shannon cSAC; - Disturbance to otter outside the cSAC. However, it is noted that the proposed embankments at their closest point are 75 metres from the centre line of the river and are unlikely to be significant. Therefore, there is potential for detrimental impact upon existing cSAC and SPA site, including a delay in recovery of the site, but excluding impacts on the conservation objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.
4.C	5	1.00	Professional judgement	There are no nationally designated sites within the AFA, but there is potential for significant habitats and populations of European and nationally protected species. The River Deel drains into the Inner Shannon Estuary pNHA [000435], approx. 10km north of AFA. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no designated sites but habitats/species are likely to be present that could be affected	The implementation of flood forecasting, individual property resistance and increased public awareness is unlikely to significantly impact or enhance the flora and fauna of the catchment. Therefore, no impact on existing national, regional, and local sites as a result of flood risk management measures.	Construction impact on the water body associated with the construction of embankments, such as: - Pollution risks to the pNHA; - Disturbance to bird species; - Disturbance to otter. However, it is noted that the proposed embankments at their closest point are 75 metres from the centre line of the river and are unlikely to be significant. Therefore, there is a potential localised loss of or disturbance to flora / fauna.
4.D	13	2.00	Professional judgement	The Deel River is not designated as a Salmonid River; however the river is a medium activity angling area. Local weighting of 2 set by professional judgement. Weighting of 2 applied where a waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.	The implementation of flood forecasting, individual property resistance and increased public awareness is unlikely to significantly impact or enhance fisheries resource within the catchment. Therefore, no change to fisheries potential of the waterbody.	Construction related impacts on water quality and subsequent fish species. Construction works of embankments adjacent to the River Deel may impact water quality. However, it is noted that the proposed embankments at their closest point are 75 metres from the centre line of the river and are unlikely to be significant. Therefore, short-term minor impacts to fisheries habitat.
4.E	8	1.00	Professional judgement	Rathkeale has no landscape planning designations within the AFA. No specific landscape sensitivity/value areas, but landscape features/views which are important at a local level and could potentially be affected. A section of the Great Southern Trail goes into Rathkeale and crosses the River Deel. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected.	The implementation of flood forecasting, individual property resistance and increased public awareness is unlikely to result in a change to the existing landscape character/features. Therefore, no change to existing landscape character / feature in the zone of influence of the selected measure.	Potential localised intermittent impacts due to thef embankment. Therefore, potential short-term impact (construction) on moderate sensitivity landscape character / feature in the zone of visibility of selected measure.
4.F(i)	4	2.00	Professional judgement	Rathkeale is not a heritage town. 0.003 km2 of ACA falls within the 1% AEP Fluvial. There are no RPS and 1 NIAH within the 1% AEP Fluvial. A number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a moderate to low vulnerability. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a moderate to low vulnerability.	The implementation of flood forecasting, individual property resistance and increased public awareness is unlikely to result in a change to the architectural features. Therefore, no effects on architectural features.	Proposed embankments do not encroach on any architectural feature. The ACA will not be removed from the 1% Fluvial AEP. Therefore, no effects on architectural features.
4.F(ii)	4	2.00	Professional judgement	Rathkeale is not a heritage town with only one RMP, an English Tenements Bridge, within the 1% AEP Fluvial. There are no other protected features of archaeological value within the 1% AEP Fluvial. A number of sites listed on the RMP/RPS present and potentially affected. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are a number of sites listed on the RMP/RPS present and potentially affected (moderate to low vulnerability).	The implementation of flood forecasting, individual property resistance and increased public awareness is unlikely to result in a change to the archaeological features. Therefore, no effects on archaeological features are predicted.	There are no RMPs within the AFA therefore, no significant impacts are predicted. There is potential for unknown archaeological features to be impacted but these are not known. Therefore, no effects on archaeological features are predicted.

Option 1 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis			€	€	€	Notes to CFRAM Consultants
(1)	**Basic Construction Costs (Estimate)**				**70,671**	Construction Cost of each measure <u>including</u> Method Factor and CPI Adjustment but <u>excluding</u> Preliminaries
(2)	**Preliminaries**	30.0%			**21,225**	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**91,896**	
(3)	**Optimism Bias**	40.0%			**36,758**	Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**128,655**	
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13.0%			**16,725**	Set at 13%
	Construction Costs and Fees				**145,380**	
(6)	**Other Items**					
(a)	Allowance for Archaeology & Environmental Mitigation Measures	10.0%		12,865		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	12.0%		15,439		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation	3% assumed		3,860		Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance			N/A		See "Guidance E – Per Cent for Art Note"
(e)	Est. NPV Operation & Maintenance		42,974			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	40.0%	17,190	60,164	**92,327**	Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**237,707**	

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	PT	Date:	15/06/2015
Checked by:	JR	Date:	15/06/2015

Project reference	S11	Project name:	Shannon CFRAMS - S10
Base date for estimates (year 0)	Dec-2013	Construction Price Index (CPI)	0.987
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues /constraints	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	Cost (€)	Comment
Total wall costs		
Total embankment costs		
Total demountable barriers/gates costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge removal costs		
Total bridge construction costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs	€49,400	
Total hydrometric gauging station costs		
Total flood forecasting costs	€17,900	
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs	€4,335	*1.5weeks PA initially*
Total Construction costs	€71,635	
Apply update to unit rate (CPI) if appropriate (cell N15)	€70,671	
Enter appropriate preliminaries estimate (%)	30.03%	*ref: Preliminaries and other costs v1.0*
Enter other applicable costs (€)		
Total capital cost (€)	€91,896	
Consider amendments based on site issues/constraints (cell N16)	€91,896	
Total capital cost (€)	**€91,896**	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs		
Total embankment O&M costs		
Total demountable barriers/gates O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs	€988	
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs	€200	
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs	€826	*2days PA annually*
Total Operation and Maintenance costs	€2,014	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€134,870	
Optimism bias rate (from external sheet)	40%	*ref: Optimism Bias Tool v.2.0 - medium risk assumed.*
Total Cost including Optimism Bias	**€188,818**	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	€0
Year of capital works (year)	
Capital cost (€)	€91,896
Annual maintenance cost (€)	€2,014
Other cost (€)	€0
Other works frequency (years)	

Key

- Information
- Calculation
- Cost input
- User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**		**Total PVc (€k):**	**134870**
	Cash sum	0	91896	98668	0	190565	**134870**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	91896			91896.2	91896.2
1	0.962			2014		2013.6	1936.2
2	0.925			2014		2013.6	1861.7
3	0.889			2014		2013.6	1790.1
4	0.855			2014		2013.6	1721.3
5	0.822			2014		2013.6	1655.1
6	0.790			2014		2013.6	1591.4
7	0.760			2014		2013.6	1530.2
8	0.731			2014		2013.6	1471.3
9	0.703			2014		2013.6	1414.8
10	0.676			2014		2013.6	1360.3
11	0.650			2014		2013.6	1308.0
12	0.625			2014		2013.6	1257.7
13	0.601			2014		2013.6	1209.3
14	0.577			2014		2013.6	1162.8
15	0.555			2014		2013.6	1118.1
16	0.534			2014		2013.6	1075.1
17	0.513			2014		2013.6	1033.7
18	0.494			2014		2013.6	994.0
19	0.475			2014		2013.6	955.8
20	0.456			2014		2013.6	919.0
21	0.439			2014		2013.6	883.7
22	0.422			2014		2013.6	849.7
23	0.406			2014		2013.6	817.0
24	0.390			2014		2013.6	785.6
25	0.375			2014		2013.6	755.4
26	0.361			2014		2013.6	726.3
27	0.347			2014		2013.6	698.4
28	0.333			2014		2013.6	671.5
29	0.321			2014		2013.6	645.7
30	0.308			2014		2013.6	620.8
31	0.296			2014		2013.6	597.0
32	0.285			2014		2013.6	574.0
33	0.274			2014		2013.6	551.9
34	0.264			2014		2013.6	530.7
35	0.253			2014		2013.6	510.3
36	0.244			2014		2013.6	490.7
37	0.234			2014		2013.6	471.8
38	0.225			2014		2013.6	453.6
39	0.217			2014		2013.6	436.2
40	0.208			2014		2013.6	419.4
41	0.200			2014		2013.6	403.3
42	0.193			2014		2013.6	387.8
43	0.185			2014		2013.6	372.9
44	0.178			2014		2013.6	358.5
45	0.171			2014		2013.6	344.7
46	0.165			2014		2013.6	331.5
47	0.158			2014		2013.6	318.7
48	0.152			2014		2013.6	306.5
49	0.146			2014		2013.6	294.7

Option 2 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis			€	€	€	Notes to CFRAM Consultants
(1)	**Basic Construction Costs (Estimate)**				**107,767**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2)	**Preliminaries**	28.1%			**30,320**	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**138,087**	
(3)	**Optimism Bias**	40.0%			**55,235**	Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**193,322**	
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13.0%			**25,132**	Set at 13%
	Construction Costs and Fees				**218,454**	
(6)	**Other Items**					
(a)	Allowance for Archaeology & Environmental Mitigation Measures	10.0%		19,332		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	10.0%		19,332		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation	2% assumed		3,866		Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance			N/A		See "Guidance E – Per Cent for Art Note"
(e)	Est. NPV Operation & Maintenance		24,311			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	40.0%	9,725	34,036	**76,567**	Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**295,020**	

JBA consulting

DONNACHADH O'BRIEN & ASSOCIATES CONSULTING ENGINEERS

OPW The Office of Public Works Oifig na nOibreacha Poiblí

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	PT	Date:	15/06/2015
Checked by:	JR	Date:	15/06/2015

Project reference	S11	Project name:	Shannon CFRAMS - S10
Base date for estimates (year 0)	Dec-2013	Construction Price Index (CPI)	0.987
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues /constraints	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	Cost (€)	Comment
Total wall costs		
Total embankment costs	€65,563	
Total demountable barriers/gates costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge removal costs		
Total bridge construction costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs	€22,400	
Total hydrometric gauging station costs		
Total flood forecasting costs	€17,900	
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs	€3,373	*1weeks PA initially*
Total Construction costs	€109,236	
Apply update to unit rate (CPI) if appropriate (cell N15)	€107,767	
Enter appropriate preliminaries estimate (%)	28.14%	*ref: Preliminaries and other costs v1.0*
Enter other applicable costs (€)		
Total capital cost (€)	€138,087	
Consider amendments based on site issues/constraints (cell N16)	€138,087	
Total capital cost (€)	**€138,087**	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs		
Total embankment O&M costs	€9	*low o&m assumed*
Total demountable barriers/gates O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs	€448	
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs	€200	
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs	€482	*1days PA annually*
Total Operation and Maintenance costs	€1,139	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€162,398	
Optimism bias rate (from external sheet)	40%	*ref: Optimism Bias Tool v.2.0 - medium risk assumed.*
Total Cost including Optimism Bias	**€227,358**	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	€0
Year of capital works (year)	
Capital cost (€)	€138,087
Annual maintenance cost (€)	€1,139
Other cost (€)	€0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	4.0%	Present Value Factor:	22.341		Total PVc (€k):		162398
	Cash sum	0	138087	55819	0	193906	162398
	Discount	Cost Elements				TOTALS:	
year	Factor	Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0	138087			138087.0	138087.0
1	0.962			1139		1139.2	1095.3
2	0.925			1139		1139.2	1053.2
3	0.889			1139		1139.2	1012.7
4	0.855			1139		1139.2	973.8
5	0.822			1139		1139.2	936.3
6	0.790			1139		1139.2	900.3
7	0.760			1139		1139.2	865.7
8	0.731			1139		1139.2	832.4
9	0.703			1139		1139.2	800.4
10	0.676			1139		1139.2	769.6
11	0.650			1139		1139.2	740.0
12	0.625			1139		1139.2	711.5
13	0.601			1139		1139.2	684.1
14	0.577			1139		1139.2	657.8
15	0.555			1139		1139.2	632.5
16	0.534			1139		1139.2	608.2
17	0.513			1139		1139.2	584.8
18	0.494			1139		1139.2	562.3
19	0.475			1139		1139.2	540.7
20	0.456			1139		1139.2	519.9
21	0.439			1139		1139.2	499.9
22	0.422			1139		1139.2	480.7
23	0.406			1139		1139.2	462.2
24	0.390			1139		1139.2	444.4
25	0.375			1139		1139.2	427.3
26	0.361			1139		1139.2	410.9
27	0.347			1139		1139.2	395.1
28	0.333			1139		1139.2	379.9
29	0.321			1139		1139.2	365.3
30	0.308			1139		1139.2	351.2
31	0.296			1139		1139.2	337.7
32	0.285			1139		1139.2	324.7
33	0.274			1139		1139.2	312.2
34	0.264			1139		1139.2	300.2
35	0.253			1139		1139.2	288.7
36	0.244			1139		1139.2	277.6
37	0.234			1139		1139.2	266.9
38	0.225			1139		1139.2	256.6
39	0.217			1139		1139.2	246.8
40	0.208			1139		1139.2	237.3
41	0.200			1139		1139.2	228.1
42	0.193			1139		1139.2	219.4
43	0.185			1139		1139.2	210.9
44	0.178			1139		1139.2	202.8
45	0.171			1139		1139.2	195.0
46	0.165			1139		1139.2	187.5
47	0.158			1139		1139.2	180.3
48	0.152			1139		1139.2	173.4
49	0.146			1139		1139.2	166.7

Appendix C4 Option Appraisal Report - Foynes

1. Preliminary Report: Summary of Current Flood Risk

1.1 AFA and Watercourse Details

AFA	Foynes
Unit of Management:	24
Primary Watercourse(s):	Shanagolden (Stream), Ardineer (Stream), Durnish (Stream), Foynes (River), Ardineer (Stream)

1.2 Summary of Flood Risk in 1% Fluvial / 0.5% Coastal AEP Event

Source of flood risk:	Fluvial	Coastal	**Both**

Total Number of Properties at risk in AFA in 1% Fluvial / 0.5% Coastal AEP Event:		Residential	Non-Residential	Total
	Fluvial	38	9	47
	Coastal	155	66	221
	Combined	155	66	221

AFA Flood Cells:	**Total Number:**	As all properties are at risk from coastal flooding it is not possible to divide the AFA into hydraulically distinct flood cells.
	Flood Cell Titles:	N/A
Relevant Figure Ref:	Figure 1.1, 1.2, and 1.3	

1.3 Summary of Existing Flood Risk Management Measures

Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
Yes	None	None	Yes	None	None

Relevant Comments:	There is arterial drainage of Ardineer Stream to the east of the town.
Relevant Figure Ref:	Figure 1.1

1.4 Summary of PV Damages/Potential PV Benefits

Total PV Damages:		Uncapped	Capped
	Fluvial	€ 4,339,689	€ 3,895,849
	Coastal	€ 20,971,558	€ 17,147,120
	Combined	€ 25,311,247	€ 18,560,260

Max Combined Capped Benefits for 1% Fluvial and 0.5% Coastal AEP Event*:	€ 14,390,127

Breakdown of Max Combined Capped PV Benefits per Flood Cell for 1% Fluvial and0.5% Coastal AEP Event:	Flood Cell Ref	Residential	Non-Res	Total
	All Properties	€ 6,857,291	€ 7,532,836	€ 14,390,127

Relevant Comments:	As all properties are at risk from coastal flooding it is not possible to divide the AFA into hydraulically distinct flood cells.
Relevant Figure Ref:	Figure 1.3

*These are the maximum benefits available if a FRM option with a 1% Fluvial / 0.5% Coastal AEP SOP is provided to all properties within the AFA.

1.5 Social Risk		
	Type	**Description**
High Vulnerability Properties at risk:	School	**50% AEP Coastal Flood Extent**
		Scoil Náisiúnta Sheanáin an Fhaing
Social Infrastructure Assets:	Community Centre	**20% AEP Coastal Flood Extent**
		Foynes Community Centre
	Government Office	**2% AEP Coastal Flood Extent**
		Customs Office
	Health Centre/Clinic	**2% AEP Coastal Flood Extent**
		Foynes Health Centre, Main Street
		1% AEP Coastal Flood Extent
		Foynes Clinic
	Church	0.5% AEP Coastal Flood Extent
		Saint Senan's Church
	Garda Station	**0.5% AEP Coastal Flood Extent**
		Foynes Garda Station
	Museum	**0.5% AEP Coastal Flood Extent**
		Foynes Flying Boat Museum
	Fire Station	**0.1% AEP Coastal Flood Extent**
		Foynes Fire Station
Social Amenity Sites:	GAA Club	**1% AEP Coastal Flood Extent**
		Foynes GAA Club
Relevant Figure Ref:	General Risk - Social	
1.6 Risk to the Environment		
	Type	**Description**
Risk to WFD Annex IV:	None	N/A
Risk to SACs:	Special Area of Conservation	Lower River Shannon
	Special Protection Areas	River Shannon and River Fergus Estuaries SPA
Relevant Figure Ref:	General Risk - Environment	
1.7 Risk to Cultural Heritage		
	Type	**Description**
Risk to Sites of Cultural Heritage:	NIAH Buildings	**50% AEP Coastal Flood Extent**
		E. O' Connor (house), Main Street. Regionally important.
		M. Fitzgerald (house), Main Street. Regionally important.
		3 No. houses, Main Street. Regionally important.
		2% AEP Coastal Flood Extent
		Post Office/ Foynes Health Centre, Main Street. Regionally important.
		The Shannon House, Main Street. Regionally important.
		O' Connor (house), Main Street. Regionally important.

		House, Woodvale. Regionally important.
		1% AEP Coastal Flood Extent
		Foynes Railway Station - signal box. Regionally important.
		Foynes Railway Station - water tower. Regionally important.
		0.5% AEP Coastal Flood Extent
		Flying Boat Museum, Main Street. Regionally important.
		St. Senan's Roman Catholic Church. Regionally important.
		No. 1 - 6 Creeveen Cottages, Main Street. Regionally important.
		0.1% AEP Coastal Flood Extent
		Foynes Railway Station - station building. Regionally important.
		De Vere Fountain, Main Street. Regionally important.
		House, adjacent to Corgrig Lodge. Regionally important.
	Proposed Natural Heritage Area	Inner Shannon Estuary - South Shore
Relevant Figure Ref:	General Risk – Cultural Heritage	
1.8 Risk to the Economy		
	Type	**Description**
Risk to Transport Infrastructure:	Railway line (disused)	**10% AEP Coastal Flood Extent**
		Limerick-Foynes rail line
	National Primary Road	**50% AEP Coastal Flood Extent**
		N69 (Main Street)
	Major Port	**50% AEP Coastal Flood Extent**
		Foynes Port
	Local Urban Street	**50% AEP Coastal Flood Extent**
		Woodvale
		Dock Road
		1% AEP Fluvial Flood Extent
		Dernish Avenue
		Brendan Cottages
		0.5% AEP Fluvial Flood Extent
		Corgrig Wood
		0.1% AEP Coastal Flood Extent
		Marine Cove
Risk to Utility Infrastructure:	Non-core Telecommunication Exchange	**0.1% AEP Coastal Flood Extent**
		Dernish Avenue
Relevant Figure Ref:	General Risk - Economy	

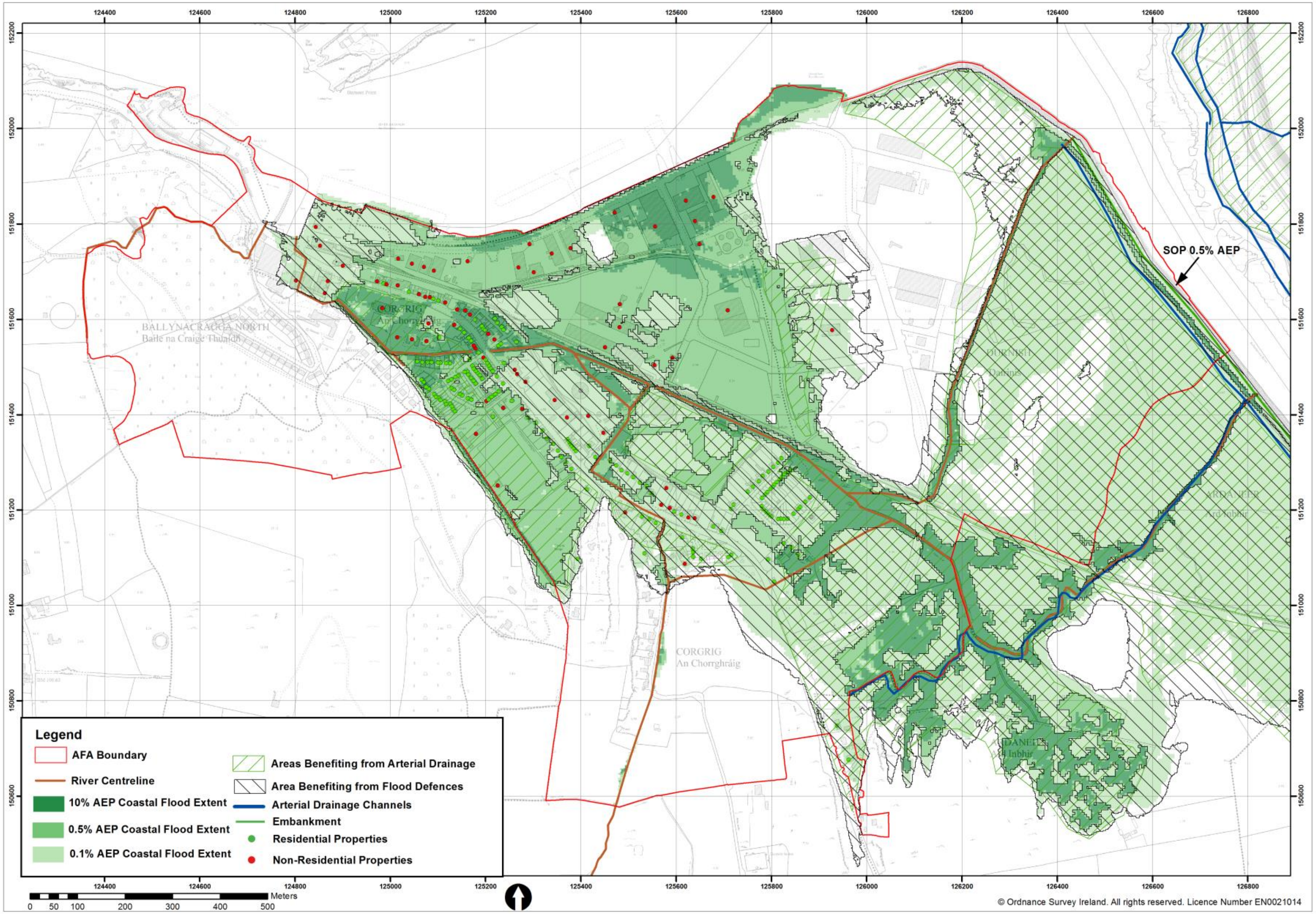


Figure 1.1 – Foynes Coastal Flood Risk to Properties

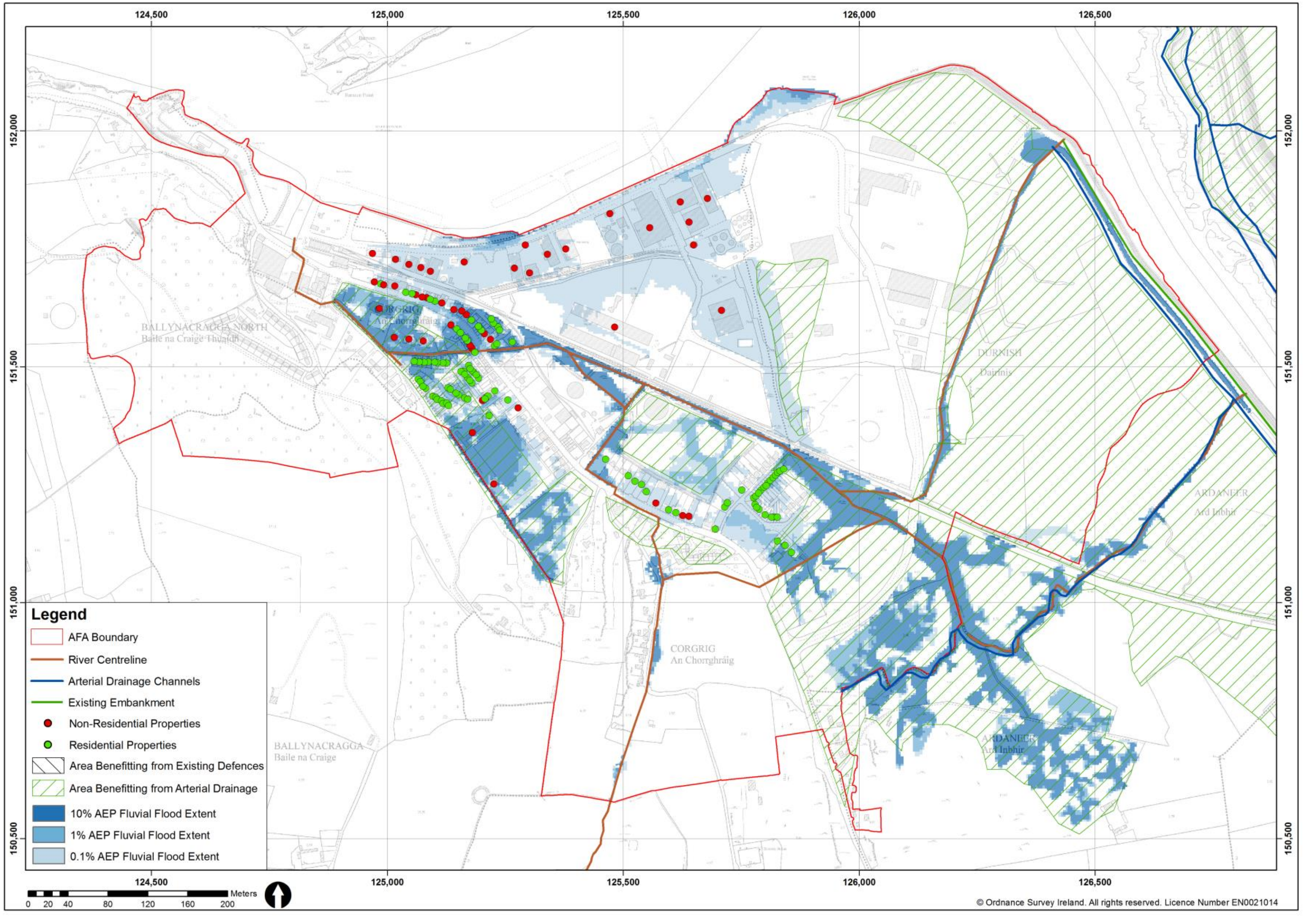


Figure 1.2 – Foynes Fluvial Flood Risk to Properties

JACOBS

OPW The Office of Public Works Oifig na nOibreacha Poiblí

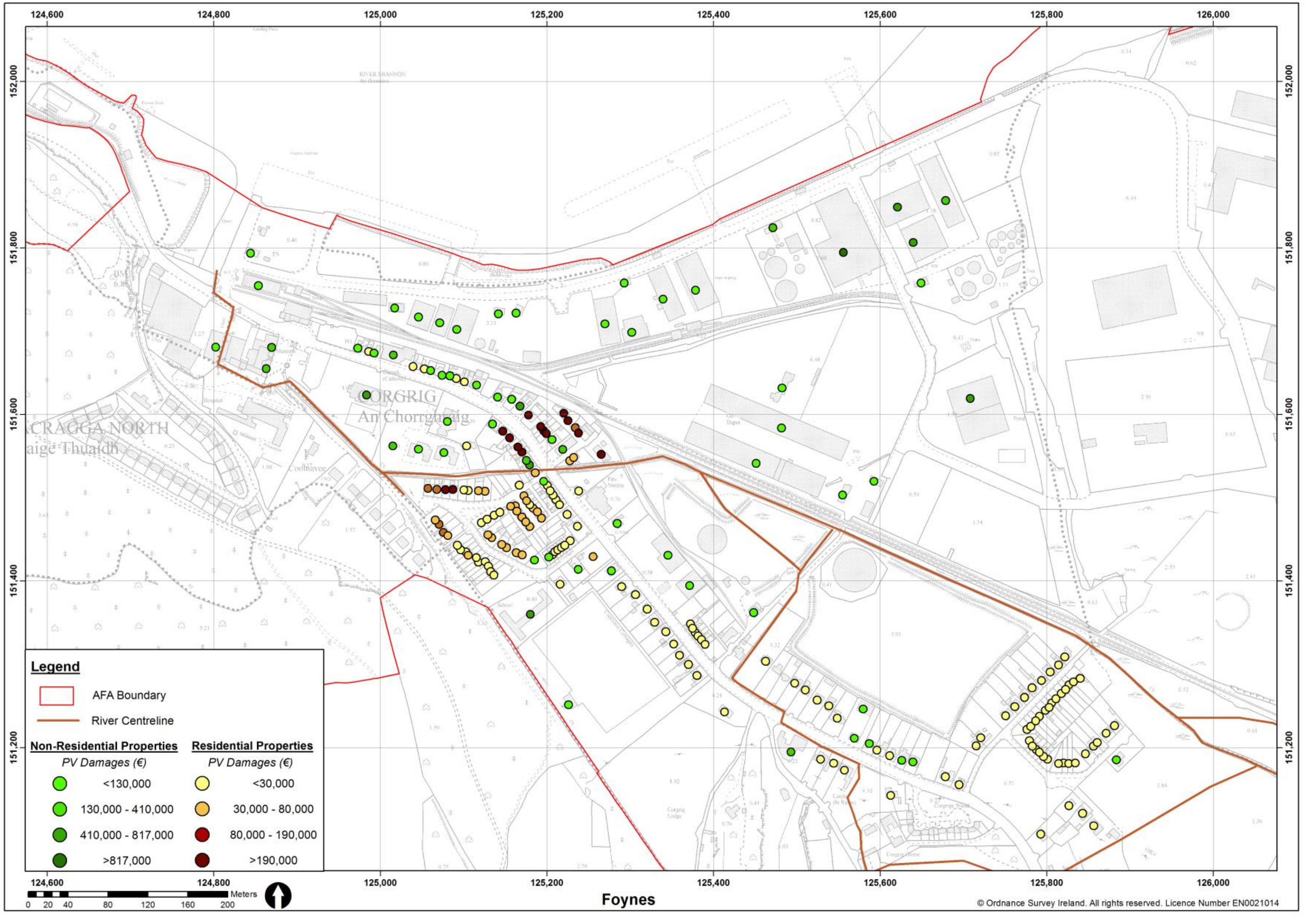


Figure 1.3 – Total Combined PV Damages for Properties in the 1% Fluvial & 0.5% Coastal AEP Events

STAGE 2: Screening of the Measures

2.1 Baseline, Structural and Non-Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
B	Existing Regime	Viable	Viable	Viable	Viable	Viable	**Screened In**
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
Structural							
D	Storage	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
E	Flow Diversion	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
F	Increase Conveyance	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
G	Flood Defences	Viable	Viable	Viable	Viable	Viable	**Screened In**
H	Relocation of Properties	Unviable	Viable	Viable	Unviable	Viable	**Screened Out**
I	Other: Flapped Outfall	Viable	Viable	Viable	Viable	Viable	**Screened In**
Non-Structural							
J	Flood Forecasting / Warning / Response	Viable	Viable	Viable	Viable	Viable	**Screened In**
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	**Screened In**
L	Individual Property Resistance	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
M	Individual Property Resilience	Unviable	Viable	Viable	Viable	Viable	**Screened Out**

2.2 Justification for Screened Out Baseline and Structural Measures

The following provides justification on Measures with an overall viability 'Screened Out' categorisation.

A	Do Nothing	Applicability Economic Environmental Social Cultural	Screened out due to the number of properties currently at risk of flooding.
C	Do Minimum	Applicability Economic Environmental Social Cultural	Screened out, as the "Do Minimum" FRM measure would have a negligible impact on the existing flood risk.
D	Storage	Applicability Economic Environmental Social Cultural	Storage is not applicable to this AFA as the coastal risk is dominant.
E	Flow Diversion	Applicability Economic Environmental Social Cultural	Flow Diversion is not applicable to this AFA as the coastal risk is dominant.
F	Increased Conveyance	Applicability Economic Environmental Social Cultural	Increased Conveyance is not applicable to this AFA as the coastal risk is dominant.

H	Relocation of Properties	Applicability Economic Environmental Social Cultural	The relocation of 221 properties is not applicable to the area as it would be socially unviable.
L	Individual Property Resistance	Applicability Economic Environmental Social Cultural	There are 221 properties at costal risk that are clustered together. There are a significant number of commercial properties at flood risk that contain large commercial fuel storage tanks and a coal yard. It would be impractical for this number and diverse usage of properties, to ensure the desired design standard was achieved through this measure.
M	Individual Property Resilience	Applicability Economic Environmental Social Cultural	There are 221 properties at costal risk that are clustered together. There are a significant number of commercial properties at flood risk that contain large commercial fuel storage tanks and a coal yard. It would be impractical for this number and diverse usage of properties, to ensure the desired design standard was achieved through this measure.

2.3 Summary of 'Screened In' Measures

The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.

Baseline Measures		**Non-Structural Measures**	
B	Existing Regime	J	Flood Forecasting / Warning / Response
Structural Measures		K	Public Awareness
G	Flood Defences		
I	Other: Flapped Outfall		

STAGE 3: Selection of Options

3.1 Consideration of Options

The following are the agreed combination of 'Screened In' measures that comprise each of the Options being taken forward for further consideration.

Where appropriate, the 'Screened In' measures have been sub-divided into separate specific measures to ensure applicability to site conditions.

Measures		**Different composition of measures per option**						
Baseline Measures								
B	Existing Regime	✓	✓					
Structural Measures								
G	Flood Defences:							
Gi	New Flood Defences	✓	✓					
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences		✓					
Giv	Other Defences							
I	Other: Flapped Outfall	✓	✓					
Non-Structural Measures								
J	Flood Forecasting / Warning / Response							
K	Public Awareness							
Option Reference		FOS_01	FOS_02					

Measures not screened out but not included in options		
Measures		**Justification**
J	Flood Forecasting / Warning / Response	Flood Forecasting was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required 0.5% coastal AEP standard of protection. Flood Forecasting does not improve the viability of the options under consideration.
K	Public Awareness	Public Awareness was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required 0.5% coastal AEP standard of protection. Public Awareness does not improve the viability of the options under consideration.

STAGE 4: Appraisal of Options

4.1 Options Appraisal

Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Meeting. Below describes this concept design of each options and provides a summary of any significant comments/issues which were raised by LA staff at the Options Meetings. These comments will be considered in the local weightings and the MCA scores.

<table>
<tr><td colspan="2">Option Ref:</td><td colspan="4">FOS_01</td></tr>
<tr><td rowspan="4">Option Measures</td><td>Baseline</td><td>B</td><td colspan="3">Existing Regime</td></tr>
<tr><td rowspan="2">Structural</td><td>Gi</td><td colspan="3">Flood Defences: New Flood Defences</td></tr>
<tr><td>I</td><td colspan="3">Other: Flapped Outfall</td></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="4">This option will provide a 0.5% Coastal AEP Design standard to all properties within the AFA and it will also protect the properties from the 1% Fluvial event.

• A 1.26km long quay/sea wall is required to defend the AFA from the 0.5% AEP event. Floodgates would also be required at a number of locations along the wall to maintain access to the port. It is important to note that the exact positioning of the wall would need to be determined during detailed design stage following consultation with all the relevant stakeholders, as there are a number of pipeline and other utility services within the working corridor of the proposed defence wall. The defence wall route shown in the figure 5.1 is therefore only indicative and is typically between 1m – 1.5m above the existing port side ground level.

• An improved outfall structure is required on the Foynes River where it discharges at the quay, to prevent tidal ingress. It was noted at the Public Consultation Day in Foynes during the Draft Flood Mapping stage that “the sluice gate at this location is not currently maintained and there is silt build up, maintaining and removing the silt would help reduce flood risk”. Therefore, this measure should be an improved sluice or flapped outfall arrangement with an accompanying active inspection and maintenance regime.

• A 37m long flood defence wall with a typical height of 0.6m above ground level as shown in Figure 5.1.

• A 85m long flood embankment with a typical height of 1m above ground level as shown in Figure 5.1.

• Existing arterial drainage maintenance scheme will need to be maintained as part of this option.</td></tr>
<tr><td colspan="2" rowspan="2">Options Development Meeting:</td><td>Date:</td><td colspan="3">03/09/2015</td></tr>
<tr><td>Summary:</td><td colspan="3">The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.</td></tr>
</table>

<table>
<tr><td colspan="2">Option Ref:</td><td colspan="4">FOS_02</td></tr>
<tr><td rowspan="5">Option Measures</td><td>Baseline</td><td>B</td><td colspan="3">Existing Regime</td></tr>
<tr><td rowspan="3">Structural</td><td>Gi</td><td colspan="3">Flood Defences: New Flood Defences</td></tr>
<tr><td>Giii</td><td colspan="3">Flood Defences: Demountable Defences</td></tr>
<tr><td>I</td><td colspan="3">Other: Flapped Outfall</td></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="4">This option will provide a 0.5% Coastal AEP Design standard to all residential properties within the AFA and it will also protect the properties from the 1% Fluvial event. However, a number of commercial properties within the port are not protected by this option.

• A 1.345km long quay wall/ flood defence wall is required to defend the AFA from the 0.5% AEP event as shown on Figure 5.2.

• Demountable Tidal Flood Barriers would also be required at a number of locations along the wall to maintain access to the port. It is important to note that the exact positioning of the wall would need to be determined during detailed design stage following consultation with all the relevant stakeholders, as there are a number of pipeline and other utility services within the working corridor of the proposed defence wall. The defence wall route shown in the Figure 5.2 is therefore only indicative and is typically between 1.6m – 2.4m in height.

• An improved outfall structure is required on the Foynes River where it discharges at the quay, to prevent tidal ingress. It was noted at the Public Consultation Day in Foynes during the Draft Flood Mapping stage that “the sluice gate at this location is not currently maintained and there is silt build up, maintaining and removing the silt would help reduce flood risk”. Therefore, this measure should be an improved sluice or flapped outfall arrangement with an accompanying active inspection and maintenance regime.

• A 37m long flood defence wall with a typical height of 0.6m above ground level as shown in Figure 5.1.

• A 85m long flood embankment with a typical height of 1m above ground level as shown in Figure 5.1.

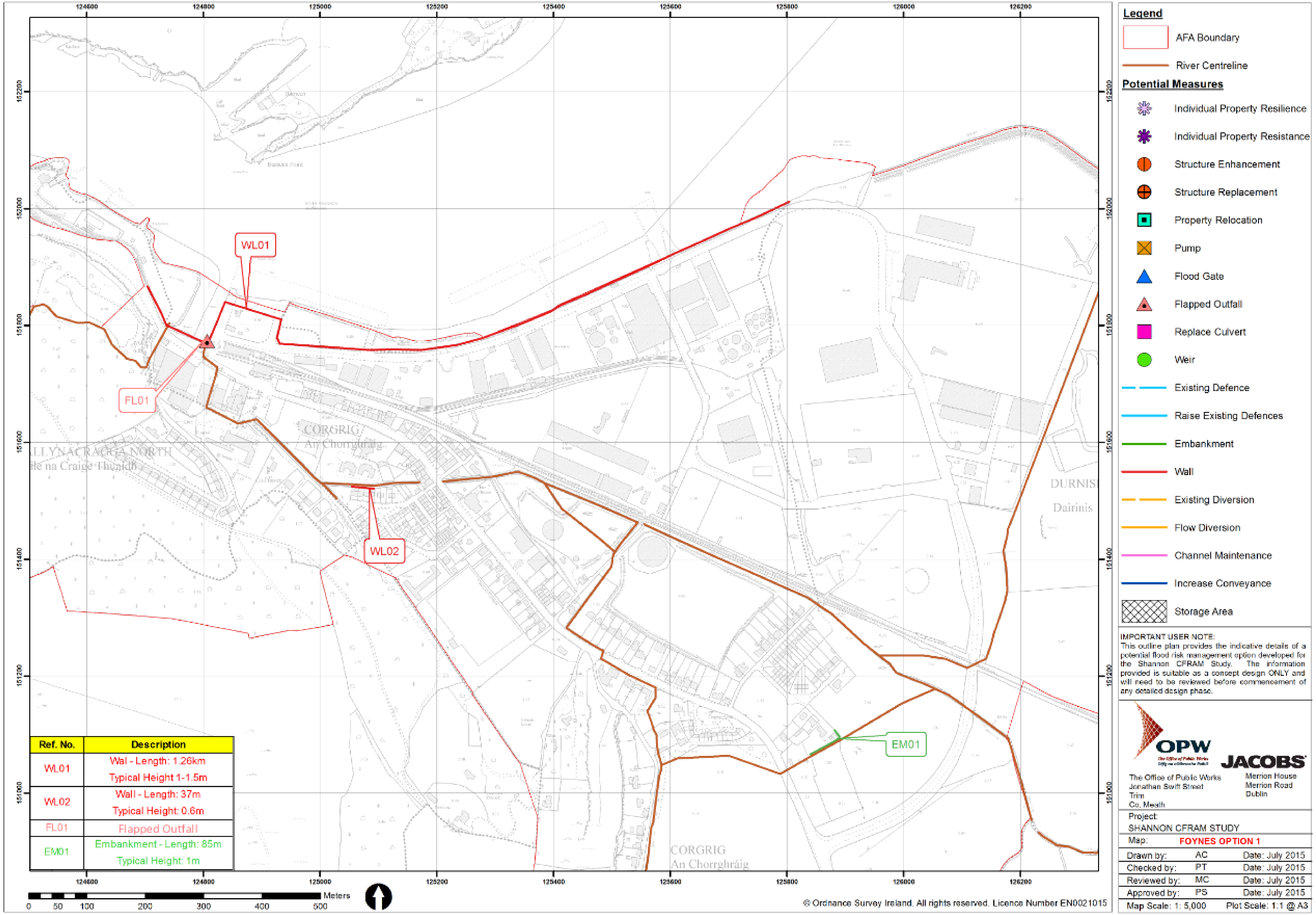
• Realignment of existing culvert at Dock Road level crossing.

• Existing arterial drainage maintenance scheme will need to be maintained as part of this option.</td></tr>
<tr><td colspan="2" rowspan="2">Options Development Meeting:</td><td>Date:</td><td colspan="3">03/09/2015</td></tr>
<tr><td>Summary:</td><td colspan="3">The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting..</td></tr>
</table>

STAGE 5: Multi Criteria Assessment			
5.1 Options selected for the Multi Criteria Assessment Following the Option Meeting, the following options are the refined options for the Multi-Criteria Assessment (MCA) stage. This is the final of a five-stage MCA process.			
Option Reference		FOS_01	FOS_02
Baseline Measures			
B	Existing Regime	Existing regime to be maintained in conjunction with new FRM options.	Existing regime to be maintained in conjunction with new FRM options.
Structural Measures			
Gi	New Flood Defences	Construction of new flood defence as shown in figure 5.1.	Construction of new flood defence as shown in figure 5.2.
Giii	Demountable Defences		Demountable Tidal Flood Barriers would also be required at a number of locations along the wall to maintain access to the port.
I	Other: Flapped Outfall	A flapped outfall is required on the Foynes River where it discharges at the quay.	A flapped outfall is required on the Foynes River where it discharges at the quay.
Table reference A summary of the outcome from the MCA is presented in the following table		Table 5.1	Table 5.2

Table 5.1: Multi Criteria Assessment Outcome for Option FOS_01

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**				
AFA	Foynes		Option Ref:	FOS_01
Option Measures				
Baseline	B	Existing Regime		
Structural	Gi	Flood Defences: New Flood Defences		
	I	Other: Flapped Outfall		
Non-Structural	N/A			
Criteria Scores				
Technical	633			
Economic	740			
Social	1478			
Environmental	-424			
Economic Values				
Economic PV Benefits	€ 14,390,127			
PV Cost	€ 8,501,093			
NPV Benefits	€ 5,889,034			
Economic BCR	**1.69**			
Outcome Scores				
MCA PV Benefits	€ 8,530,369			
MCA Benefit Score	1794			
MCA Benefit Score Ratio	211.08			
Option Selection MCA	2428			



Ref. No.	Description
WL01	Wal - Length: 1.26km Typical Height 1-1.5m
WL02	Wall - Length: 37m Typical Height: 0.6m
FL01	Flapped Outfall
EM01	Embankment - Length: 85m Typical Height: 1m

Figure 5.1 – Option FOS_01

Table 5.2: Multi Criteria Assessment Outcome for Option FOS_02

<table>
<tr><td colspan="4">Multi Criteria Assessment
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.</td></tr>
<tr><td>AFA</td><td>Foynes</td><td>Option Ref:</td><td>FOS_02</td></tr>
<tr><td colspan="4">Option Measures</td></tr>
<tr><td>Baseline</td><td>B</td><td colspan="2">Existing Regime</td></tr>
<tr><td rowspan="3">Structural</td><td>Gi</td><td colspan="2">Flood Defences: New Flood Defences</td></tr>
<tr><td>Giii</td><td colspan="2">Flood Defences: Demountable Defences</td></tr>
<tr><td>I</td><td colspan="2">Other: Flapped Outfall</td></tr>
<tr><td>Non-Structural</td><td colspan="3">N/A</td></tr>
<tr><td colspan="4">Criteria Scores</td></tr>
<tr><td colspan="2">Technical</td><td colspan="2">567</td></tr>
<tr><td colspan="2">Economic</td><td colspan="2">479</td></tr>
<tr><td colspan="2">Social</td><td colspan="2">1432</td></tr>
<tr><td colspan="2">Environmental</td><td colspan="2">-514</td></tr>
<tr><td colspan="4">Economic Values</td></tr>
<tr><td colspan="2">Economic PV Benefits</td><td colspan="2">€ 10,995,574</td></tr>
<tr><td colspan="2">PV Cost</td><td colspan="2">€ 9,246,593</td></tr>
<tr><td colspan="2">NPV Benefits</td><td colspan="2">€ 1,748,981</td></tr>
<tr><td colspan="2">Economic BCR</td><td colspan="2">1.19</td></tr>
<tr><td colspan="4">Outcome Scores</td></tr>
<tr><td colspan="2">MCA PV Benefits</td><td colspan="2">€ 5,665,798</td></tr>
<tr><td colspan="2">MCA Benefit Score</td><td colspan="2">1397</td></tr>
<tr><td colspan="2">MCA Benefit Score Ratio</td><td colspan="2">151.08</td></tr>
<tr><td colspan="2">Option Selection MCA</td><td colspan="2">1964</td></tr>
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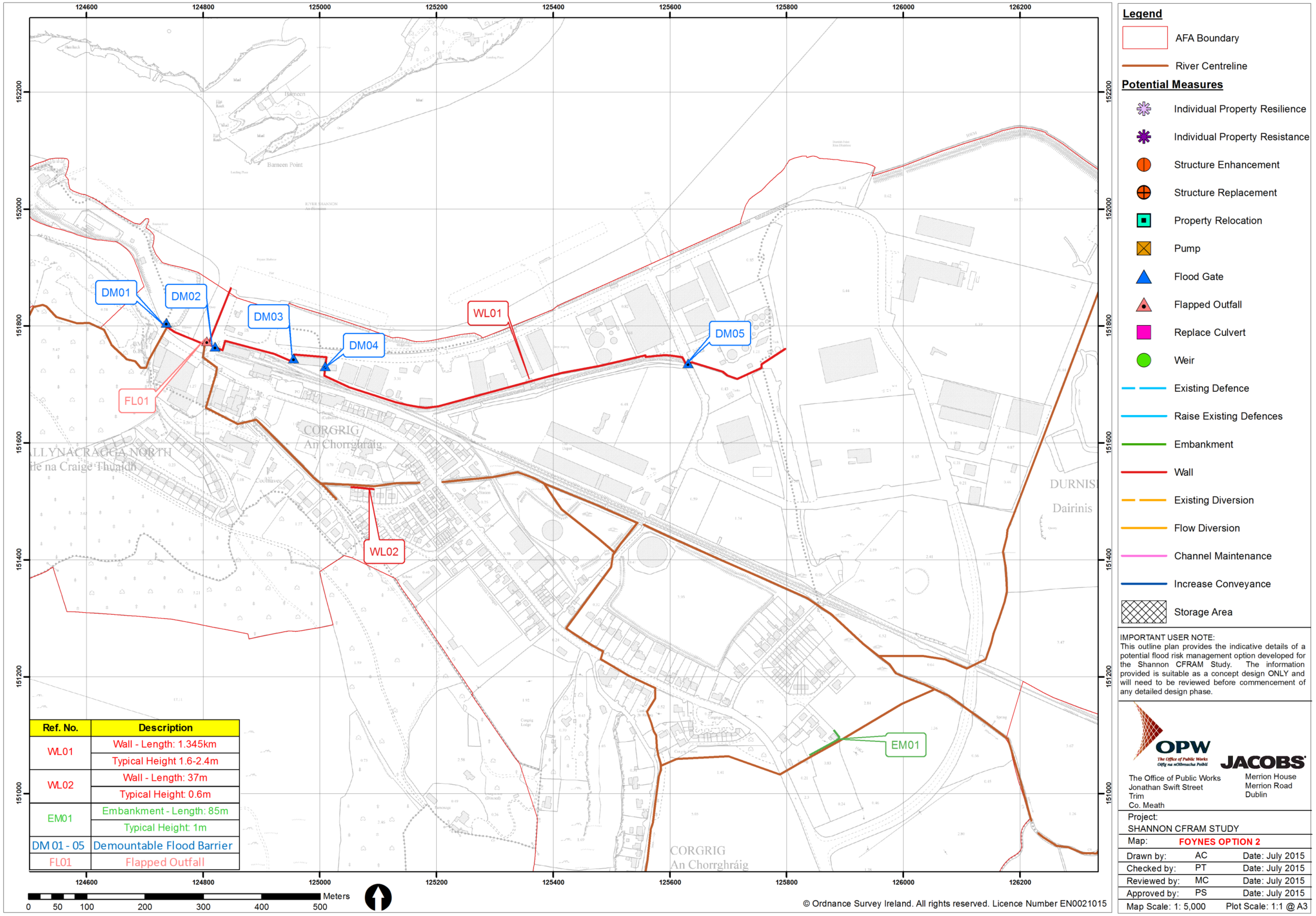


Figure 5.2 – Option FOS_02

5.2 Comparison of Multi Criteria Assessment Scores

Each option taken forward for further consideration through the Option Decision Meeting, has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Decision Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).

Categories	Option Reference and Results	
	FOS_01	FOS_02
Criteria Scores		
Technical	633	567
Economic	740	479
Social	1478	1432
Environmental	-424	-514
Economic Values		
Economic PV Benefits	€ 14,390,127	€ 10,995,574
PV Cost	€ 8,501,093	€ 9,246,593
NPV Benefits	€ 5,889,034	€ 1,748,981
Economic BCR	**1.69**	**1.19**
Outcome Scores		
MCA PV Benefits	€ 8,530,369	€ 5,665,798
MCA Benefit Score	1794	1397
MCA BCR	211.08	151.08
Option Selection MCA	2428	1964

5.3 Recommendation of Preferred Option					
It forms part of the CFRAM process for the recommendation of a preferred option for each AFA. The prioritised selection criteria used in this recommendation process is detailed in Section 3.7.3 of the Main Report. Therefore, following the five stage Multi Criteria Assessment process, the preferred option is as outlined below					
Option Ref:		FOS_01			
Option Measures	**Baseline**	B	Existing Regime		
	Structural	Gi	Flood Defences: New Flood Defences		
		I	Other: Flapped Outfall		
	Non Structural	J Flood Forecasting	K Public Awareness	L Property Resistance	M Property Resilience
Comments		This option has been designed to protect all properties at risk of flooding in the 0.5% AEP coastal event as this is the most dominant source of flood risk. However, this option will also protect the properties from flooding in a 1% fluvial AEP event. The MCA BCR is highest for FOS_01 and therefore this is the recommended emerging preferred option.			

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

<table>
<tr><th colspan="5">Fluvial Flood Forecasting Potential</th></tr>
<tr><td rowspan="3">Catchment Information</td><td colspan="2">Gauging Station</td><td rowspan="2">Catchment size (km ^{2})</td><td rowspan="2">Potential available forecast accuracy and reliability period</td></tr>
<tr><td>Fluvial</td><td>Rainfall</td></tr>
<tr><td>n/a</td><td>n/a</td><td>3</td><td>n/a</td></tr>
<tr><td>Relevant Information:</td><td colspan="4">No gauging station.</td></tr>
<tr><td rowspan="3">Additional Infrastructure Recommended</td><td colspan="2">Gauging Station</td><td colspan="2" rowspan="2">Other</td></tr>
<tr><td>Fluvial</td><td>Rainfall</td></tr>
<tr><td>No</td><td>No</td><td colspan="2">n/a</td></tr>
<tr><td>Relevant Comments:</td><td colspan="4">As the catchment is small any potential flood forecasting early warning system would be unlikely to provide accurate and reliable predictions. There is little to no potential for the development of an effective flood forecasting system for Foynes. Tidal flooding could be predicted by a simple forecasting system.</td></tr>
</table>

*For this assessment only 15 minute tipping bucket gauge were considered.

Annex A - Multi-Criteria Analysis Summary and Whole Life Cost Summaries for FRM Option(s)

CRITERIA		OBJECTIVE		Global Weighting	Local Weighting	Comments	FOS_01 B – Existing Regime Gi – New Flood Defences I – Other Measure	Option Score	Weighted Score	FOS_02 B – Existing Regime Gi – New Flood Defences Giii – Demountable Defences	Option Score	Weighted Score
1	Technical	a	Ensure flood risk management options are operationally robust	20	5.00	The option scores are determined based on the level of operational risk to operate or perform successfully. Each measure is scored independently and the average of the measure scores is used as the score for the option.	None / Manageable Negligible / Moderate / high Very low / High Low / Failure likely Low / moderate / Unacceptable B 4.00 Gi 5.00 I 3.00	4.00	400	None / Manageable Negligible / Moderate / high Very low / High Low / Failure likely Low / moderate / Unacceptable B 4.00 Gi 5.00 Giii 2.00	3.67	367
		b	Minimise health and safety risks associated with the construction and operation of flood risk management options	20	5.00	H&S risks are considered for construction and maintenance of flood risk management measures. The indicative aspirational score is set at five, with a point then deducted for each specific H&S risk in either construction or maintenance.	None / Moderate Negligible / Moderate / high Very low / High Low / Very High Low / moderate / Unacceptable Work near/in water Work near services or buildings Work near traffic	-1.00	-100	None / Moderate Negligible / Moderate / high Very low / High Low / Very High Low / moderate / Unacceptable Work near services or buildings Work near services or buildings Work near/in water	-1.00	-100
		c	Ensure flood risk management options are adaptable to future flood risk	20	5.00	The options scores are determined based on the sustainability and adaptability of the flood risk management measures in the face of potential future changes, including the potential impact of climate change. Each measure is scored independently and the average of the measure scores is used as the score for the option.	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. B 5.00 Gi 1.00 I 4.00	3.33	333	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. B 5.00 Gi 1.00 Giii 3.00	3.00	300
				TECHNICAL CRITERIA SCORE					633			567
2	Economic	a	Minimise economic risk	24	5.00		The score is calculated based on the reduction in AAD, following the full implementation of option.	4.09	491	The score is calculated based on the reduction in AAD, following the full implementation of option.	3.14	377
		b	Minimise risk to transport infrastructure	10	5.00		Scoring is based on the reduction in flood risk to transport routes, following the full implementation of option.	4.99	249	Scoring is based on the reduction in flood risk to transport routes , following the full implementation of option.	2.04	102
		c	Minimise risk to utility infrastructure	14	0.03		Scoring is calculate based on the reduction in flood risk to utility infrastructure, following the full implementation of option.	0.00	0	Scoring is calculate based on a reduction in flood risk to utility infrastructure, following the full implementation of option.	0.00	0
		d	Minimise risk to agriculture	12	2.41	Source of Flooding: Both Fresh & Salt Water Percentage of AFA that is rural land: 48.14%	Area of Agricultural Land Flooded: No Change Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agricultural Infrastructure: No Change Flood Warning: Not Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable	0.00	0	Area of Agricultural Land Flooded: No Change Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agricultural Infrastructure: No Change Flood Warning: Not Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable	0.00	0
				ECONOMIC CRITERIA SCORE					740			479
3	Social	a i)	Minimise risk to human health and life - Residents	27	5.00	Flood Depths & Velocities: Assumed low risk to life Known Areas of Highly Vulnerable People: Reasonable Cross Section of Society	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	4.89	660	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	4.89	660
		a ii)	Minimise risk to human health and life - High vulnerability properties	17	5.00	Rate of Onset of flooding: Assumed 1-2 hours for evacuation	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	4.99	424	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	4.99	424
		b i)	Minimise risk to community - Social Infrastructure & Amenity	9	5.00	Assets of Particular Social Value: Yes	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	4.94	222	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	4.62	208
		b ii)	Minimise risk to community - Local employment	7	5.00	Asset of Particular Employment Value: No	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	4.91	172	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	4.00	140
				SOCIAL CRITERIA SCORE					1478			1432
4	Environmental	a	Support the objectives of the WFD	16	5.00	There are a number of WFD water bodies within the AFA. Foynes Harbour and Lower Shannon Estuary are of moderate WFD status. There are three potential polluting sources within the 0.5% AEP Coastal; one section 4 discharge and two Seveso Sites. There is WFD RPA - Shellfish Waterbodies within the AFA. Lower River Shannon Estuary is a SAC/SPA waterbody. Foynes Harbour has been classed as a HMWBs due to the presence of hard defences and port activities. Local weighting to be applied for this objective is constant, and should always be set equal to 5 as WFD objectives must be achieved and are relevant to all waterbodies.	Reduced flooding in areas with significant polluting sources in 1% AEP Fluvial &/or 0.5% AEP Coastal extents (Seveso Sites Atlantic Fuel Supply & Irish Bulk Liquid Storage) . Construction related impacts due to significant construction works in and adjacent to Foynes Harbour (sea wall), Foynes River (wall) and Ardineer Stream (embankment). The proposed wall (WL02) will permanently replace the natural bank in a section of one waterbody. The proposed sea wall (WL01) in Foynes Harbour is located on existing hardstanding. Therefore, overall a potential short-term or intermittent contribution to the achievement of wb objectives.	1.00	80	This option will not provide protection to the 2 Seveso Sites (Atlantic Fuel Supply & Irish Bulk Liquid Storage) but will have reduced flooding in an area with no significant polluting sources in 1% AEP Fluvial &/or 0.5% AEP Coastal extents. Construction related impacts but less than Option 1 as the majority of these will be set back from Foynes Harbour. The proposed wall (WL02) will permanently replace the natural bank in a section of one waterbody. The proposed wall (WL01) is located on existing hardstanding. Therefore, overall a potential short-term or intermittent impediment to the achievement of wb objectives.	-1.00	-80
		b	Support the objectives of the Habitats Directive	10	5.00	The Lower River Shannon cSAC [002165] and the River Shannon and River Fergus Estuaries SPA [004077] is within the AFA, qualifying interests likely to occur within the AFA include otter, mudflats and sandflats, reefs, saltmarsh, wetland and waterbirds. Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.	There are proposed works within and adjacent to the cSAC and SPA. Proposed works include construction of a sea wall (1.26km long), an earth embankment on the Ardineer Stream and a wall on Foynes River. The sea wall falls within sections of both the cSAC and SPA. Potentially significant effects are: - Increases in suspended sediment - Pollution risks to the estuary - Disturbance to bird species within and outside the SPA - Disturbance to otter and dolphin within and outside the cSAC Therefore, there is potential for a detrimental impact upon conservation objectives of existing SAC, SPA or Ramsar site, including a delay in recovery of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	-5.00	-250	There are proposed works as part of the construction of a wall (WL01) near the quay. These works will are proposed within/ adjacent to the cSAC and SPA. However the main portion of WL01 will be set back from the harbour edge. The wall, an earth embankment on the Ardineer Stream and a wall on Foynes River have the potential to cause impacts. Potentially significant effects are: - Increases in suspended sediment - Pollution risks to the estuary - Disturbance to bird species within and outside the SPA - Disturbance to otter and dolphin within and outside the cSAC Therefore, there is potential for a detrimental impact upon conservation objectives of existing SAC, SPA or Ramsar site, including a delay in recovery of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	-4.00	-200
		c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	5	5.00	There are designated ecological sites within the AFA. The Inner Shannon Estuary - South Shore pNHA [000435] is within the AFA. The Sturamus Island pNHA [001436] is c. 1.5 km from the AFA. Local weighting of 5 set by professional judgement. Weighting of 5 applied where a nationally important site (pNHA, NHA etc.) is present (within AFA) and potentially affected.	Potential significant effects are related to works within the boundary of the Inner Shannon Estuary - South Shore pNHA in relation to construction of a sea wall. However, it is noted this is an area of existing hardstanding. Earth embankment on Ardineer Stream and wall on Foynes river have the potential to effect the pNHA due to waterbody connection. Potential impacts include: - Pollution risks to the pNHA; - Disturbance to bird species; - Disturbance to otter. Therefore, there is a potential for a detrimental impact upon the condition of existing national, regional or local sites as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	-4.50	-113	Option 2 has less construction works adjacent to Foynes Harbour waterbody. Potential significant effects are related to works within the boundary of the Inner Shannon Estuary - South Shore pNHA in relation to construction of a wall (WL01). However, it is noted this is an area of existing hardstanding. The construction of the earth embankment on Ardineer Stream and wall on Foynes river have the potential to significantly effect pNHA due to waterbody connection. Potential impacts include: - Pollution risks to the pNHA; - Disturbance to bird species; - Disturbance to otter. Therefore, there is a potential for a detrimental impact upon the condition of existing national, regional or local sites as a result of flood risk management measures, where suitable mitigation are technically feasible.	-4.00	-100
		d	Protect, and where possible enhance, fisheries resource within the catchment	13	3.00	Neither of the two waterbodies are designated as a Salmonid River. Foynes and Foynes Piers have been identified as angling 'hot spots' in a IFI report from the 1980's. Local weighting of 3 set by professional judgement. Weighting of 3 applied where a waterbody supports substantial fisheries/shellfisheries and is of regional value for fishing/angling.	Construction works adjacent to the waterbody may impact water quality and cause access issues. Operational impact may include changes to angling locations. A flapped outfall is proposed where the Foynes River discharges to the quay, this may cause a barrier to fish migration. However these impacts area unlikely given the nature of the area (industrial). Therefore, there is potential for medium to long-term alteration of fisheries habitat.	-3.00	-117	Construction works adjacent to the waterbody may impact water quality and cause access issues. Operational impact may include changes to angling locations. A flapped outfall is proposed where the Foynes River discharges to the quay, this may cause a barrier to fish migration. However these impacts area unlikely given the nature of the area (industrial). Therefore, there is potential for medium to long-term alteration of fisheries habitat.	-2.50	-98
		e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	8	2.00	The AFA contains two views/prospects and one N69 Scenic View included in the Limerick Development Plan which are within the 0.5% AEP Coastal. The tourism trail the Wild Atlantic Way passes through the 0.5% AEP Coastal within the AFA. Local weighting of 2 set by professional judgement. Weighting of 2 applied where landscape character type is designated at a county level as low sensitivity and/or low value and potentially affected.	There will be construction related impacts adjacent to the three scenic views / prospect and Wild Atlantic Way. The option will require the construction of sea wall along the quay which has significant impact on Foynes port view. Therefore, there is potential for permanent impact on local / moderate value landscape character/feature in the zone of influence of the selected measure.	-3.00	-48	There will be construction related impacts adjacent to the three scenic views / prospect and Wild Atlantic Way. The option will require the construction of sea wall along the quay which has significant impact on Foynes port view. Therefore, there is potential for permanent impact on local / moderate value landscape character/feature in the zone of influence of the selected measure.	-3.00	-48
		f i)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of architectural value	4	3.00	Foynes is not a heritage town. 0.06 km2 of the ACA falls within the 0.5% AEP Coastal. Eleven RPS and fifteen NIAH fall within the 0.5% AEP Coastal. Local weighting of 3 set by professional judgement. Weighting of 3 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a high to moderate vulnerability.	The option will reduce the potential for flooding in the 0.5% AEP Coastal for ten RPS, four NIAH and 0.6km2 of ACA. Therefore, there is a potential to increase in the level of protection for a number of architectural features (Record of Protected Structures and NIAH) from flooding, such that they are significantly less vulnerable to flood damage.	2.00	24	The option will reduce the potential for flooding in the 0.5% AEP Coastal for ten RPS, four NIAH and 0.6km2 of ACA. However, the location of WL01 may impact on the setting of a number of NIAH/RPS and the ACA. Therefore, there is a potential to increase in the level of protection for a number of architectural features (Record of Protected Structures and NIAH) from flooding, such that they are less vulnerable to flood damage.	1.00	12
		f ii)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of archaeological value	4	0.00	Foynes is not a heritage town. There are no protected features of archaeological value within the 0.5% AEP Coastal. Local weighting of 0 set by professional judgement. Weighting of 0 applied where there are no archaeological features at risk.	There are no RMPs in the AFA therefore, no significant impacts are predicted. There is a potential for unknown archaeological features to be impacted but these are not known. Therefore, no effects on archaeological features are predicted.	0.00	0	There are no RMPs in the AFA therefore, no significant impacts are predicted. There is a potential for unknown archaeological features to be impacted but these are not known. Therefore, no effects on archaeological features are predicted.	0.00	0
				ENVIRONMENTAL CRITERIA SCORE					-424			-514

		FOS_01	FOS_02
Economic Values	Economic PV Benefits	€14,390,127	€10,995,574
	Cost	€8,501,093	€9,246,593
	NPV Benefits	€5,889,034	€1,748,981
	Economic BCR	**1.69**	**1.19**
Outcome Scores	MCA PV Benefits	€8,530,369	€5,665,798
	MCA Benefit Score	1794	1397
	MCA BCR	**211.08**	**151.08**
	Option Selection MCA	2428	1964

Objective	Global Weightings (fixed)	Local Weightings		Baseline Comments	Option 1 Comments	Option 2 Comments
1.A	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has negligible operational risks to operate or perform successfully.	This score is determined for this option as it has negligible operational risks to operate or perform successfully.
1.B	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has moderate health and safety risks associated with the construction and operation of flood risk management option.	This score is determined for this option as it has moderate health and safety risks associated with the construction and operation of flood risk management option.
1.C	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions.	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.
2.A	24	5.00	calculated	Local weighting is calculated based on the baseline AAD.	This score is calculated based on the reduction in AAD, following the full implementation of option.	This score is calculated based on the reduction in AAD, following the full implementation of option.
2.B	10	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to transport infrastructure. Local weighting capped at maximum value of 5.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.
2.C	14	0.03	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to utility infrastructure.	This score is calculated based on a reduction in flood risk to utility infrastructure, following full implementation of option.	This score is calculated based on a reduction in flood risk to utility infrastructure, following full implementation of option.
2.D	12	0.00	Professional judgement	Local weighting is calculated based on the percentage of rural land within the AFA.	This score is determined to be zero as the option has no effect on flood risk to agriculture.	This score is determined to be zero as the option has no effect on flood risk to agriculture.
3.A (i)	27	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to residential properties. Local weighting capped at maximum value of 5.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option.
3.A (ii)	17	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on based on the baseline risk to high vulnerability properties. Local weighting capped at maximum value of 5.	This score is calculated based on a reduction in flooding to high vulnerability properties, following full implementation of the option.	This score is calculated based on a reduction in flooding to high vulnerability properties, following full implementation of the option.
3.B (i)	9	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to social infrastructure. Local weighting capped at maximum value of 5.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option.
3.B (ii)	7	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to local employment. Local weighting capped at maximum value of 5.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option.
4.A	16	5.00	fixed	The Lower River Shannon cSAC [002165] and the River Shannon and River Fergus Estuaries SPA [004077] is within the AFA, qualifying interests likely to occur within the AFA include otter, mudflats and sandflats, reefs, saltmarsh, wetland and waterbirds. Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.	Reduced flooding in areas with significant polluting sources in 1% AEP Fluvial &/or 0.5% AEP Coastal extents (Seveso Sites Atlantic Fuel Supply & Irish Bulk Liquid Storage) . Construction related impacts due to significant construction works in and adjacent to Foynes Harbour (sea wall), Foynes River (wall) and Ardineer Stream (embankment). The proposed wall (WL02) will permanently replace the natural bank in a section of one waterbody. The proposed sea wall (WL01) in Foynes Harbour is located on existing hardstanding. Therefore, overall a potential short-term or intermittent contribution to the achievement of wb objectives.	This option will not provide protection to the 2 Seveso Sites (Atlantic Fuel Supply & Irish Bulk Liquid Storage) but will have reduced flooding in an area with no significant polluting sources in 1% AEP Fluvial &/or 0.5% AEP Coastal extents. Construction related impacts but less than Option 1 as the majority of these will be set back from Foynes Harbour. The proposed wall (WL02) will permanently replace the natural bank in a section of one waterbody. The proposed wall (WL01) is located on existing hardstanding. Therefore, overall a potential short-term or intermittent impediment to the achievement of wb objectives.
4.B	10	5.00	Professional judgement	The Lower River Shannon cSAC [002165] and the River Shannon and River Fergus Estuaries SPA [004077] is within the AFA, qualifying interests likely to occur within the AFA include otter, mudflats and sandflats, reefs, saltmarsh, wetland and waterbirds. Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.	There are proposed works within and adjacent to the cSAC and SPA. Proposed works include construction of a sea wall (1.26km long), an earth embankment on the Ardineer Stream and a wall on Foynes River. The sea wall falls within sections of both the cSAC and SPA. Potentially significant effects are: - Increases in suspended sediment - Pollution risks to the estuary - Disturbance to bird species within and outside the SPA - Disturbance to otter and dolphin within and outside the cSAC Therefore, there is potential for a detrimental impact upon conservation objectives of existing SAC, SPA or Ramsar site, including a delay in recovery of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	There are proposed works as part of the construction of a wall (WL01) near the quay. These works will are proposed within/ adjacent to the cSAC and SPA. However the main portion of WL01 will be set back from the harbour edge. The wall, an earth embankment on the Ardineer Stream and a wall on Foynes River have the potential to cause impacts. Potentially significant effects are: - Increases in suspended sediment - Pollution risks to the estuary - Disturbance to bird species within and outside the SPA - Disturbance to otter and dolphin within and outside the cSAC Therefore, there is potential for a detrimental impact upon conservation objectives of existing SAC, SPA or Ramsar site, including a delay in recovery of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.
4.C	5	5.00	Professional judgement	There are designated ecological sites within the AFA. The Inner Shannon Estuary - South Shore pNHA [000435] is within the AFA. The Sturamus Island pNHA [001436] is c. 1.5 km from the AFA. Local weighting of 5 set by professional judgement. Weighting of 5 applied where a nationally important site (pNHA, NHA etc.) is present (within AFA) and potentially affected.	Potential significant effects are related to works within the boundary of the Inner Shannon Estuary - South Shore pNHA in relation to construction of a sea wall. However, it is noted this is an area of existing hardstanding. Earth embankment on Ardineer Stream and wall on Foynes river have the potential to effect the pNHA due to waterbody connection. Potential impacts include: - Pollution risks to the pNHA; - Disturbance to bird species; - Disturbance to otter. Therefore, there is a potential for a detrimental impact upon the condition of existing national, regional or local sites as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	Option 2 has less construction works adjacent to Foynes Harbour waterbody. Potential significant effects are related to works within the boundary of the Inner Shannon Estuary - South Shore pNHA in relation to construction of a wall (WL01). However, it is noted this is an area of existing hardstanding. The construction of the earth embankment on Ardineer Stream and wall on Foynes river have the potential to significantly effect pNHA due to waterbody connection. Potential impacts include: - Pollution risks to the pNHA; - Disturbance to bird species; - Disturbance to otter. Therefore, there is a potential for a detrimental impact upon the condition of existing national, regional or local sites as a result of flood risk management measures, where suitable mitigation are technically feasible.
4.D	13	3.00	Professional judgement	Neither of the two waterbodies are designated as a Salmonid River. Foynes and Foynes Piers have been identified as angling 'hot spots' in a IFI report from the 1980's. Local weighting of 3 set by professional judgement. Weighting of 3 applied where a waterbody supports substantial fisheries/shellfisheries and is of regional value for fishing/angling.	Construction works adjacent to the waterbody may impact water quality and cause access issues. Operational impact may include changes to angling locations. A flapped outfall is proposed where the Foynes River discharges to the quay, this may cause a barrier to fish migration. However these impacts area unlikely given the nature of the area (industrial). Therefore, there is potential for medium to long-term alteration of fisheries habitat.	Construction works adjacent to the waterbody may impact water quality and cause access issues. Operational impact may include changes to angling locations. A flapped outfall is proposed where the Foynes River discharges to the quay, this may cause a barrier to fish migration. However these impacts area unlikely given the nature of the area (industrial). Therefore, there is potential for medium to long-term alteration of fisheries habitat.
4.E	8	2.00	Professional judgement	The AFA contains two views/prospects and one N69 Scenic View included in the Limerick Development Plan which are within the 0.5% AEP Coastal. The tourism trail the Wild Atlantic Way passes through the 0.5% AEP Coastal within the AFA. Local weighting of 2 set by professional judgement. Weighting of 2 applied where landscape character type is designated at a county level as low sensitivity and/or low value and potentially affected.	There will be construction related impacts adjacent to the three scenic views / prospect and Wild Atlantic Way. The option will require the construction of sea wall along the quay which has significant impact on Foynes port view. Therefore, there is potential for permanent impact on local / moderate value landscape character/feature in the zone of influence of the selected measure.	There will be construction related impacts adjacent to the three scenic views / prospect and Wild Atlantic Way. The option will require the construction of sea wall along the quay which has significant impact on Foynes port view. Therefore, there is potential for permanent impact on local / moderate value landscape character/feature in the zone of influence of the selected measure.
4.F(i)	4	3.00	Professional judgement	Foynes is not a heritage town. 0.06 km2 of the ACA falls within the 0.5% AEP Coastal. Eleven RPS and fifteen NIAH fall within the 0.5% AEP Coastal. Local weighting of 3 set by professional judgement. Weighting of 3 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a high to moderate vulnerability.	The option will reduce the potential for flooding in the 0.5% AEP Coastal for ten RPS, four NIAH and 0.6km2 of ACA. Therefore, there is a potential to increase in the level of protection for a number of architectural features (Record of Protected Structures and NIAH) from flooding, such that they are significantly less vulnerable to flood damage.	The option will reduce the potential for flooding in the 0.5% AEP Coastal for ten RPS, four NIAH and 0.6km2 of ACA. However, the location of WL01 may impact on the setting of a number of NIAH/RPS and the ACA. Therefore, there is a potential to increase in the level of protection for a number of architectural features (Record of Protected Structures and NIAH) from flooding, such that they are less vulnerable to flood damage.
4.F(ii)	4	0.00	Professional judgement	Foynes is not a heritage town. There are no protected features of archaeological value within the 0.5% AEP Coastal. Local weighting of 0 set by professional judgement. Weighting of 0 applied where there are no archaeological features at risk.	There are no RMPs in the AFA therefore, no significant impacts are predicted. There is a potential for unknown archaeological features to be impacted but these are not known. Therefore, no effects on archaeological features are predicted.	There are no RMPs in the AFA therefore, no significant impacts are predicted. There is a potential for unknown archaeological features to be impacted but these are not known. Therefore, no effects on archaeological features are predicted.

Option 1 Costs for CBA

	CFRAM Programme – Option Costs for Cost Benefit Analysis		€	€	€	Notes to CFRAM Consultants
(1)	**Basic Construction Costs (Estimate)**				**3,536,721**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2)	**Preliminaries**	14.3%			**503,997**	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**4,040,718**	
(3)	**Optimism Bias**	40.0%			**1,616,287**	Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**5,657,005**	
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13.0%			**735,411**	Set at 13%
	Construction Costs and Fees				**6,392,416**	
(6)	**Other Items**					
(a)	Allowance for Archaeology & Environmental Mitigation Measures	15%		820,266		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	12%		678,841		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation	5% assumed		282,850		Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance			38,000		See "Guidance E – Per Cent for Art Note"
(e)	Est. NPV Operation & Maintenance		206,228			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	40.0%	82,491	288,720	**2,108,677**	Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**8,501,093**	

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	J. Reynolds	Date:	
Checked by:	P.Travers	Date:	

Project reference	S09	Project name:	Foynes - Option 1

Base date for estimates (year 0)	Oct-2013	Construction Price Index (CPI)	0.987
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues /constraints	1.50

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	Cost (€)	Comment
Total wall costs	€2,366,860	
Total embankment costs	€11,787	
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs	€11,320	
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€2,389,966	
Apply update to unit rate (CPI) if appropriate (cell N15)	€2,357,814	
Enter appropriate preliminaries estimate (%)	14%	
Enter other applicable costs (€)		
Total capital cost (€)	€2,693,812	
Consider amendments based on site issues/constraints (cell N16)	€4,040,718	
Total capital cost (€)	€4,040,718	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs	€840	
Total embankment O&M costs	€269	
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs	€3,423	
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs	€5,131	
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€9,663	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€4,246,947	
Optimism bias rate (from external sheet)	40%	
Total Cost including Optimism Bias	€5,945,725	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€4,040,718
Annual maintenance cost (€)	€9,663
Other cost (€)	€0
Other works frequency (years)	

Key

- Information
- Calculation
- Cost input
- User information

Discount rate:	4.0%	Present Value Factor:	22.341		Total PVc (€k):		4246947
	Cash sum	0	4040718	473500	0	4514218	4246947
	Discount	Cost Elements				TOTALS:	
year	Factor	Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0	4040718			4040718.2	4040718.2
1	0.962			9663		9663.3	9291.6
2	0.925			9663		9663.3	8934.2
3	0.889			9663		9663.3	8590.6
4	0.855			9663		9663.3	8260.2
5	0.822			9663		9663.3	7942.5
6	0.790			9663		9663.3	7637.0
7	0.760			9663		9663.3	7343.3
8	0.731			9663		9663.3	7060.9
9	0.703			9663		9663.3	6789.3
10	0.676			9663		9663.3	6528.2
11	0.650			9663		9663.3	6277.1
12	0.625			9663		9663.3	6035.7
13	0.601			9663		9663.3	5803.5
14	0.577			9663		9663.3	5580.3
15	0.555			9663		9663.3	5365.7
16	0.534			9663		9663.3	5159.3
17	0.513			9663		9663.3	4960.9
18	0.494			9663		9663.3	4770.1
19	0.475			9663		9663.3	4586.6
20	0.456			9663		9663.3	4410.2
21	0.439			9663		9663.3	4240.6
22	0.422			9663		9663.3	4077.5
23	0.406			9663		9663.3	3920.6
24	0.390			9663		9663.3	3769.8
25	0.375			9663		9663.3	3624.9
26	0.361			9663		9663.3	3485.4
27	0.347			9663		9663.3	3351.4
28	0.333			9663		9663.3	3222.5
29	0.321			9663		9663.3	3098.5
30	0.308			9663		9663.3	2979.4
31	0.296			9663		9663.3	2864.8
32	0.285			9663		9663.3	2754.6
33	0.274			9663		9663.3	2648.6
34	0.264			9663		9663.3	2546.8
35	0.253			9663		9663.3	2448.8
36	0.244			9663		9663.3	2354.6
37	0.234			9663		9663.3	2264.1
38	0.225			9663		9663.3	2177.0
39	0.217			9663		9663.3	2093.3
40	0.208			9663		9663.3	2012.8
41	0.200			9663		9663.3	1935.3
42	0.193			9663		9663.3	1860.9
43	0.185			9663		9663.3	1789.3
44	0.178			9663		9663.3	1720.5
45	0.171			9663		9663.3	1654.3
46	0.165			9663		9663.3	1590.7
47	0.158			9663		9663.3	1529.5
48	0.152			9663		9663.3	1470.7
49	0.146			9663		9663.3	1414.1

Option 2 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis			€	€	€	Notes to CFRAM Consultants
(1)	**Basic Construction Costs (Estimate)**				**3,357,937**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2)	**Preliminaries**	12.7%			**425,089**	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**3,783,026**	
(3)	**Optimism Bias**	40.0%			**1,513,210**	Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**5,296,236**	
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13.0%			**688,511**	Set at 13%
	Construction Costs and Fees				**5,984,747**	
(6)	**Other Items**					
(a)	Allowance for Archaeology & Environmental Mitigation Measures	15%		794,435		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	12%		635,548		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation			264,812		Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance			51,000		See "Guidance E – Per Cent for Art Note"
(e)	Est. NPV Operation & Maintenance		1,082,893			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	40.0%	433,157	1,516,050	**3,261,846**	Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**9,246,593**	

DONNACHADH O'BRIEN & ASSOCIATES CONSULTING ENGINEERS

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:		**Date:**	
Checked by:		**Date:**	

Project reference	S09	**Project name:**	Foynes - Option 2

Base date for estimates (year 0)	Oct-2013	**Construction Price Index (CPI)**	0.987
Scaling factor (e.g. €m, €k, €)	€	**Method Factor - to take into account particular site issues /constraints**	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	**Cost (€)**	**Comment**
Total wall costs	€3,233,630	
Total embankment costs	€11,787	
Total demountable barrier costs	€108,990	
Total demountable gate costs	€38,000	
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs	€11,320	
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€3,403,727	
Apply update to unit rate (CPI) if appropriate (cell N15)	€3,357,937	
Enter appropriate preliminaries estimate (%)	13%	
Enter other applicable costs (€)		
Total capital cost (€)	€3,783,026	
Consider amendments based on site issues/constraints (cell N16)	€3,783,026	
Total capital cost (€)	€3,783,026	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs	€907	
Total embankment O&M costs	€269	
Total demountable barrier O&M costs	€46,143	
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs	€3,423	
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€50,741	

Other costs	**Cost (€)**	**Comment**
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€4,865,919	
Optimism bias rate (from external sheet)	40%	
Total Cost including Optimism Bias	€6,812,286	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€3,783,026
Annual maintenance cost (€)	€50,741
Other cost (€)	€0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**	**Total PVc (€k):**		**4865919**
	Cash sum	0	3783026	2486321	0	6269347	**4865919**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	3783026			3783025.8	3783025.8
1	0.962			50741		50741.3	48789.7
2	0.925			50741		50741.3	46913.1
3	0.889			50741		50741.3	45108.8
4	0.855			50741		50741.3	43373.8
5	0.822			50741		50741.3	41705.6
6	0.790			50741		50741.3	40101.5
7	0.760			50741		50741.3	38559.2
8	0.731			50741		50741.3	37076.1
9	0.703			50741		50741.3	35650.1
10	0.676			50741		50741.3	34279.0
11	0.650			50741		50741.3	32960.6
12	0.625			50741		50741.3	31692.8
13	0.601			50741		50741.3	30473.9
14	0.577			50741		50741.3	29301.8
15	0.555			50741		50741.3	28174.8
16	0.534			50741		50741.3	27091.2
17	0.513			50741		50741.3	26049.2
18	0.494			50741		50741.3	25047.3
19	0.475			50741		50741.3	24084.0
20	0.456			50741		50741.3	23157.6
21	0.439			50741		50741.3	22267.0
22	0.422			50741		50741.3	21410.5
23	0.406			50741		50741.3	20587.1
24	0.390			50741		50741.3	19795.3
25	0.375			50741		50741.3	19033.9
26	0.361			50741		50741.3	18301.8
27	0.347			50741		50741.3	17597.9
28	0.333			50741		50741.3	16921.1
29	0.321			50741		50741.3	16270.3
30	0.308			50741		50741.3	15644.5
31	0.296			50741		50741.3	15042.8
32	0.285			50741		50741.3	14464.2
33	0.274			50741		50741.3	13907.9
34	0.264			50741		50741.3	13373.0
35	0.253			50741		50741.3	12858.6
36	0.244			50741		50741.3	12364.1
37	0.234			50741		50741.3	11888.5
38	0.225			50741		50741.3	11431.3
39	0.217			50741		50741.3	10991.6
40	0.208			50741		50741.3	10568.8
41	0.200			50741		50741.3	10162.4
42	0.193			50741		50741.3	9771.5
43	0.185			50741		50741.3	9395.7
44	0.178			50741		50741.3	9034.3
45	0.171			50741		50741.3	8686.8
46	0.165			50741		50741.3	8352.7
47	0.158			50741		50741.3	8031.5
48	0.152			50741		50741.3	7722.6
49	0.146			50741		50741.3	7425.5

Appendix C5 Option Appraisal Report - Adare

1. Preliminary Report: Summary of Current Flood Risk

1.1 AFA and Watercourse Details

AFA	Adare
Unit of Management:	24
Primary Watercourse(s):	Adare River, River Maigue, Barnakyle (River)

1.2 Summary of Flood Risk in 1% Fluvial / 0.5% Coastal AEP Event

Source of flood risk	Fluvial	Coastal	**Both**	
Total Number of Properties at risk in AFA in 1% Fluvial / 0.5% Coastal AEP Event:		**Residential**	**Non-Residential**	**Total**
	Fluvial	85	32	117
	Coastal	82	30	112
	Combined	88	32	120
AFA Flood Cells:	**Total Number:**	3		
	Flood Cell Titles:	ADE_A, ADE_B, ADE_C		
Breakdown of properties at (combined) risk per Flood Cell:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	ADE_A	85	30	115
	ADE_B	1	0	1
	ADE_C	2	2	4
Relevant Comments:	Adare is at risk from both a 1% AEP fluvial and 0.5% coastal flood source.			
Relevant Figure Ref:	Figure 1.1 to 1.3			

1.3 Summary of Existing Flood Risk Management Measures

Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
Yes	None	None	**Yes**	None	None

Relevant Comments:	For the purposes of this Study, the existing left bank flood embankment upstream of the N21 bridge (constructed in 2014/2015) have been omitted in the assessment of the areas at risk of flooding, but have been included when considering flood risk management options.
Relevant Figure Ref:	Figure 1.1 and 1.2

1.4 Summary of PV Damages/Potential PV Benefits

Total PV Damages:		**Uncapped**	**Capped**
	Fluvial	€ 19,036,000	€ 15,906,687
	Coastal	€ 10,197,925	€ 7,002,109
	Combined	€ 29,233,925	€ 20,988,590
Max Combined Capped Benefits for 1% Fluvial and 0.5% Coastal AEP Event*:	€ 16,070,435		

*These are the maximum benefits available if a FRM option with a 1% Fluvial / 0.5% Coastal AEP SOP is provided to all properties within the AFA.

Breakdown of Max Combined Capped PV Benefits per Flood Cell for 1% Fluvial and 0.5% Coastal AEP Event:	Flood Cell Ref	Residential	Non-Res	Total
	ADE_A	€ 9,329,658	€ 4,765,812	€ 14,095,470
	ADE_B	€ 0	€ 82,399	€ 82,399
	ADE_C	€ 230,149	€ 1,662,417	€ 1,892,566
Relevant Figure Ref:	Figure 1.3			

1.5 Social Risk		
	Type	**Description**
High Vulnerability Properties at risk:	School	**20% AEP Flood Extent**
		St. Nicholas Church of Ireland School, Adare
Social Infrastructure Assets:	None	N/A
Social Amenity Sites:	None	N/A
Relevant Figure Ref:	General Risk - Social	

1.6 Risk to the Environment		
	Type	**Description**
Risk to WFD Annex IV:	WFD RPA Drinking Water WB Lines	Maigue (River)
Risk to SACs:	Special Area of Conservation	Lower River Shannon
Relevant Figure Ref:	General Risk - Environment	

1.7 Risk to Cultural Heritage		
	Type	**Description**
Risk to Sites of Cultural Heritage:	NIAH Buildings	**50% AEP Coastal Flood Extent**
		Bridge, Adare. Regionally important.
		20% AEP Coastal Flood Extent
		St Nicholas's Church of Ireland Church, Blackabbey. Nationally important.
		St Nicholas's School, Blackabbey. Regionally important.
		Dunraven Mausoleum, Blackabbey. Regionally important.
		2% AEP Coastal Flood Extent
		Bridge, Curragh Beg, Regionally important.
		Milepost, Blackabbey, Regionally important.
		2% AEP Fluvial Flood Extent
		2 No. Houses, Blackabbey. Regionally important.
		Adare Courthouse. Regionally important.
		Dovecote, Blackabbey. Regionally important.
		1% AEP Fluvial Flood Extent
		Countess Dunraven Fountain. Regionally important.

	NIAH Buildings	**0.1% AEP Coastal Flood Extent**
		Railway Station, Curragh Beg. Regionally important.

<table>
<tr><td rowspan="13"></td><td rowspan="13">Recorded Monuments</td><td>50% AEP Coastal Flood Extent</td></tr>
<tr><td>Adare Bridge</td></tr>
<tr><td>Castle (Anglo-Norman masonry castle)</td></tr>
<tr><td>20% AEP Coastal Flood Extent</td></tr>
<tr><td>Font, Blackabbey</td></tr>
<tr><td>Religious House (Augustin friars), Blackabbey</td></tr>
<tr><td>2% AEP Fluvial Flood Extent</td></tr>
<tr><td>Amorial plaque</td></tr>
<tr><td>Dovecote</td></tr>
<tr><td>0.5% AEP Coastal Flood Extent</td></tr>
<tr><td>2 no. enclosure, Ardshanbally</td></tr>
<tr><td>0.1% AEP Fluvial Flood Extent</td></tr>
<tr><td>Church, northeast of town</td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="2">General Risk – Cultural Heritage</td></tr>
<tr><td colspan="3">1.8 Risk to the Economy</td></tr>
<tr><td></td><td>Type</td><td>Description</td></tr>
<tr><td rowspan="8">Risk to Transport Infrastructure:</td><td rowspan="2">National Road</td><td>50% AEP Coastal Flood Extent</td></tr>
<tr><td>N21</td></tr>
<tr><td rowspan="2">Tertiary Road</td><td>50% AEP Coastal Flood Extent</td></tr>
<tr><td>Curraghbeg / Islandea road</td></tr>
<tr><td rowspan="4">Local Urban Road</td><td>5% AEP Fluvial Flood Extent</td></tr>
<tr><td>Manor Court</td></tr>
<tr><td>2% AEP Fluvial Flood Extent</td></tr>
<tr><td>Abbey View</td></tr>
<tr><td>Risk to Utility Infrastructure:</td><td>None</td><td>N/A</td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="2">General Risk - Economy</td></tr>
</table>

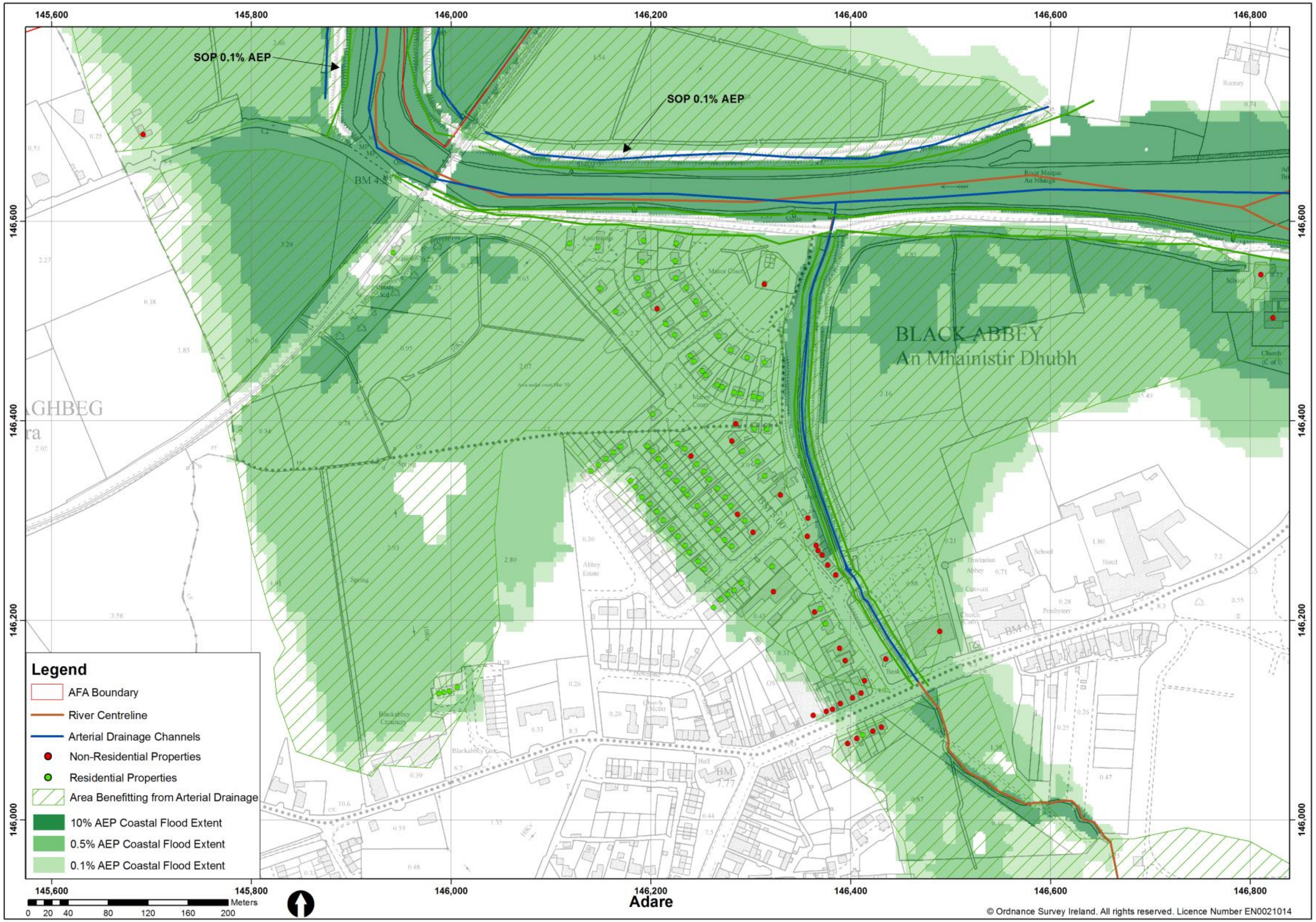


Figure 1.1 – Adare Coastal Flood Risk to Properties

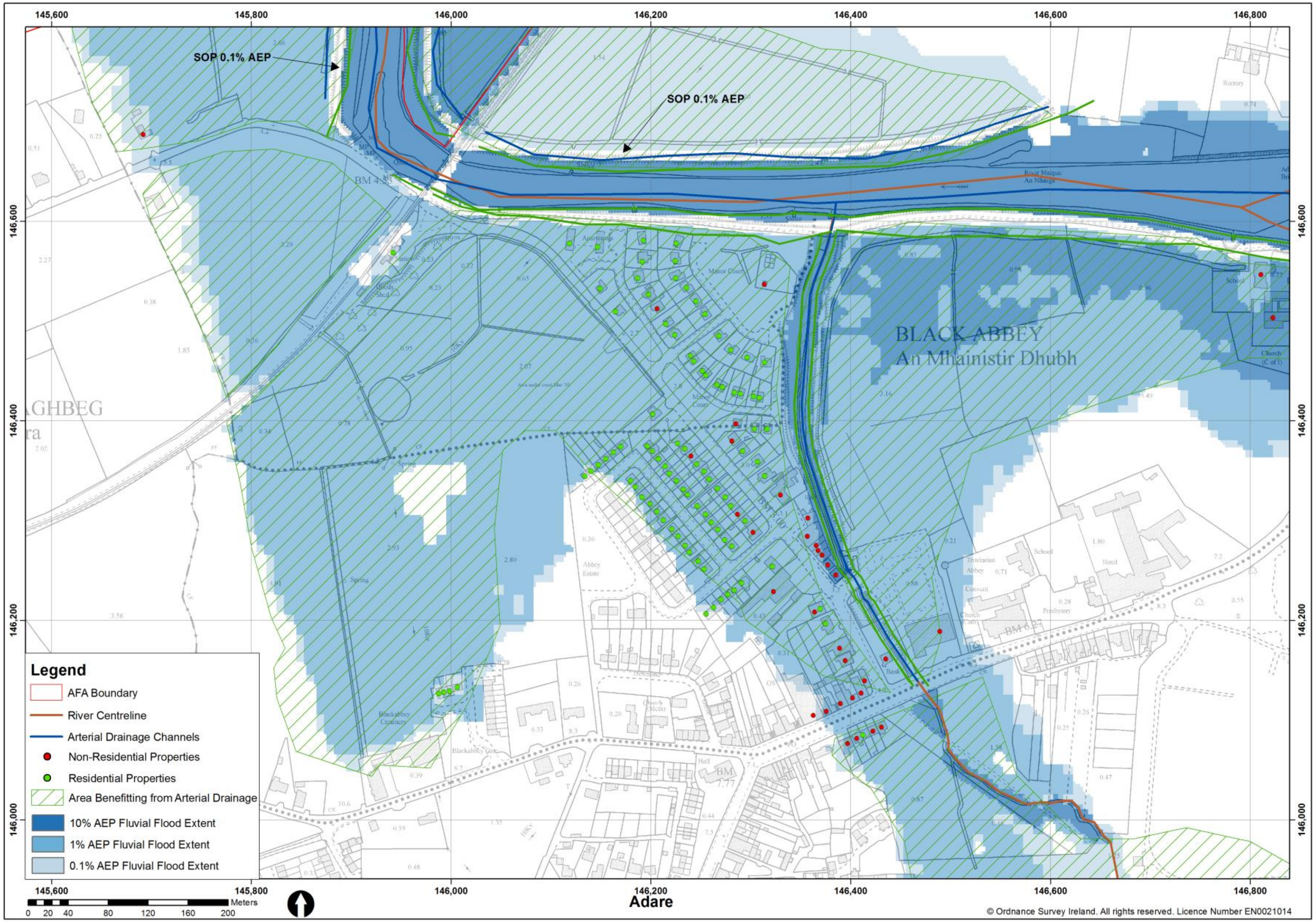


Figure 1.2 – Adare Fluvial Flood Risk to Properties

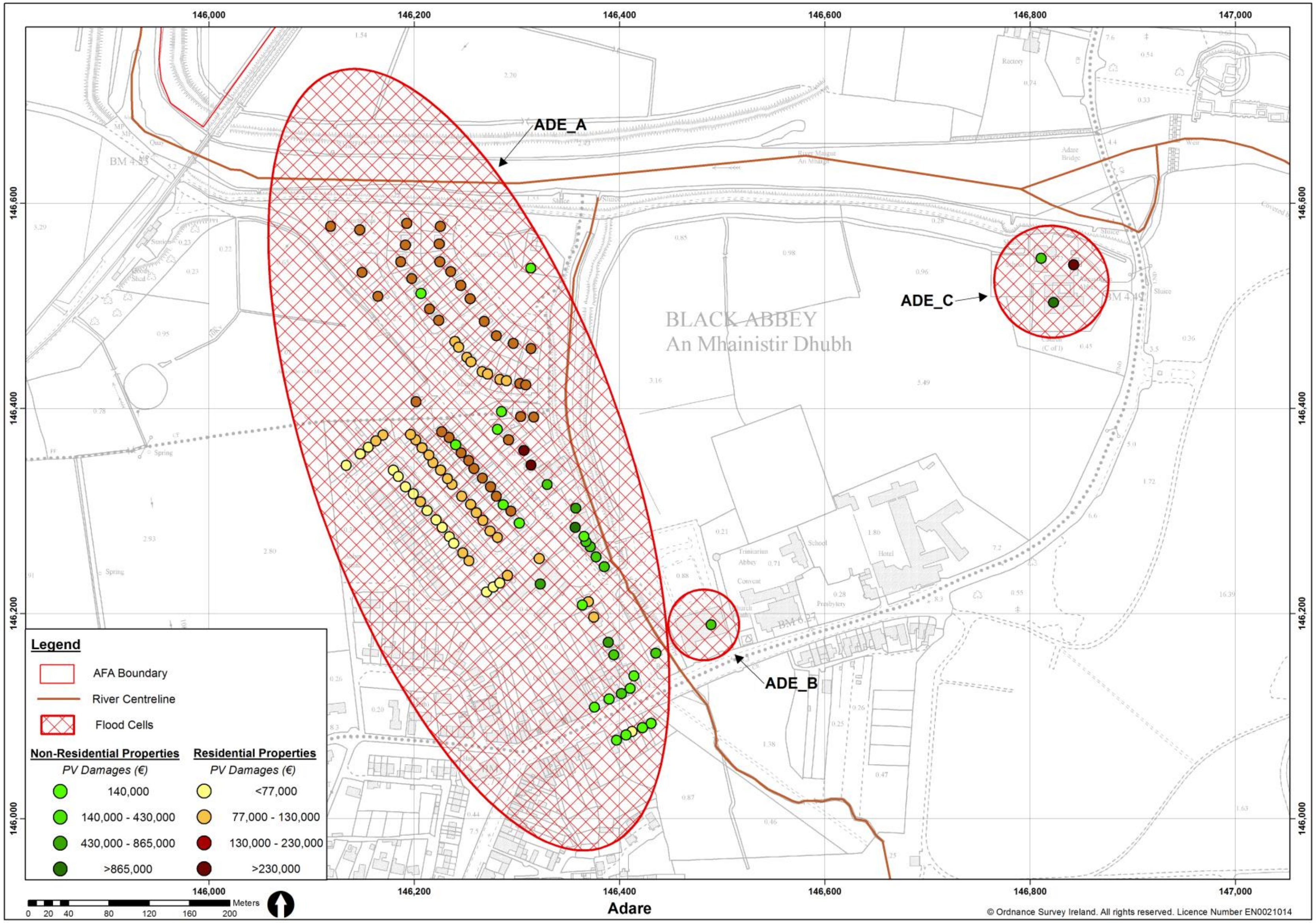


Figure 1.3 – Adare Total Combined PV Damages for Properties in the 1% Fluvial & 0.5% Coastal AEP Flood Event and Flood Cells. Flood Cells are groupings of properties that are likely to be hydraulically linked

STAGE 2: Screening of the Measures

2.1 Baseline, Structural and Non-Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
B	Existing Regime	Viable	Viable	Viable	Viable	Viable	**Screened In**
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
Structural							
D	Storage	Viable	Viable	Viable	Viable	Viable	**Screened In**
E	Flow Diversion	Viable	Viable	Viable	Viable	Viable	**Screened In**
F	Increase Conveyance	Viable	Viable	Viable	Viable	Viable	**Screened In**
G	Flood Defences	Viable	Viable	Viable	Viable	Viable	**Screened In**
H	Relocation of Properties	Unviable	Viable	Viable	Unviable	Viable	**Screened Out**
I	Other Measures	Unviable	Unviable	Unviable	Unviable	Unviable	**Screened Out**
Non-Structural							
J	Flood Forecasting / Warning / Response	Viable	Viable	Viable	Viable	Viable	**Screened In**
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	**Screened In**
L	Individual Property Resistance	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
M	Individual Property Resilience	Unviable	Viable	Viable	Viable	Viable	**Screened Out**

2.2 Justification for Screened Out Baseline and Structural Measures

The following provides justification on Measures with an overall viability 'Screened Out' categorisation.

A	Do Nothing	Applicability Economic Environmental Social Cultural	Screened out due to the number of properties currently at risk of flooding.
C	Do Minimum	Applicability Economic Environmental Social Cultural	Screened out, as the "Do Minimum" FRM measure would have a negligible impact to the existing flood risk.
H	Relocation of Properties	Applicability Economic Environmental Social Cultural	The relocation of 119 properties is not applicable to the area as it would be socially unviable.
I	Other Measures	Applicability Economic Environmental Social Cultural	No other Measures have been identified.

L	Individual Property Resistance	Applicability Economic Environmental Social Cultural	This measure is unviable in Adare as there are 113 properties at risk of coastal flooding at flood depths in excess of 1.5m.
M	Individual Property Resilience	Applicability Economic Environmental Social Cultural	This measure is unviable in Adare as there are 113 properties at risk of coastal flooding at flood depths in excess of 1.5m.

2.3 Summary of 'Screened In' Measures

The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.

Baseline Measures		**Non-Structural Measures**	
B	Existing Regime	J	Flood Forecasting / Warning / Response
Structural Measures		K	Public Awareness
D	Storage		
E	Flow Diversion		
F	Increase Conveyance		
G	Flood Defences		

STAGE 3: Selection of Options

3.1 Consideration of Options

The following are the agreed combination of 'Screened In' measures that comprise each of the Options being taken forward for further consideration.

Where appropriate, the 'Screened In' measures have been sub-divided into separate specific measures to ensure applicability to site conditions.

Measures		Different composition of measures per option						
Baseline Measures								
B	Existing Regime	✓	✓					
Structural Measures								
D	Storage							
Di	Online Storage							
Dii	Offline Storage	✓						
Diii	Other Storage							
E	Flow Diversion							
Ei	Full Diversion							
Eii	Flood Relief Channel							
Eiii	Other Diversion	✓						
F	Increase Conveyance							
Fi	Channel Dredging							
Fii	Channel Widening							
Fiii	Structure Enhancement/Works	✓						
G	Flood Defences							
Gi	New Flood Defences	✓	✓					
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences	✓	✓					
Giv	Other Defences							
Non-Structural Measures								
J	Flood Forecasting / Warning / Response	✓	✓					
K	Public Awareness							
Option Reference		ADE_01	ADE_02					

Measures not screened out but not included in options		
Measures		**Justification**
K	Public Awareness	Public Awareness was not considered as either an independent measure or in combination with other measures, as the option being appraised would provide the required 1% Fluvial / 0.5% Coastal AEP standard of protection. Public Awareness does not improve the viability of the options under consideration.

<table>
<tr><td colspan="7">STAGE 4: Appraisal of Options</td></tr>
<tr><td colspan="7">4.1 Options Appraisal
Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Meeting. Below describes this concept design of each options and provides a summary of any significant comments/issues which were raised by LA staff at the Options Meetings. These comments will be considered in the local weightings and the MCA scores.</td></tr>
<tr><td colspan="2">Option Ref:</td><td colspan="5">ADE_01</td></tr>
<tr><td rowspan="7">Option Measures</td><td>Baseline</td><td>B</td><td colspan="4">Existing Regime</td></tr>
<tr><td rowspan="5">Structural</td><td>Dii</td><td colspan="4">Storage: Offline Storage</td></tr>
<tr><td>Eiii</td><td colspan="4">Flow Diversion: Other Diversion</td></tr>
<tr><td>Fiii</td><td colspan="4">Increase Conveyance: Structure Enhancement / Works</td></tr>
<tr><td>Gi</td><td colspan="4">Flood Defences: New Flood Defences</td></tr>
<tr><td>Giii</td><td colspan="4">Flood Defences: Demountable Defences</td></tr>
<tr><td>Non Structural</td><td colspan="2">J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="5">This option will provide a 1% Fluvial and 0.5% Coastal AEP Design standard to all properties within the AFA, identified as being at risk from both these sources.
• Diversion of flow, via a floodway, from River Maigue, upstream of the N21 road bridge, to a natural storage area (see figure 5.1) via an overland floodway. Embankment and weir required at the outfall from the River Maigue to enable flow into the floodway. Floodway to be created by re-profiling the natural ground. Two culverts, one under the N21 and one under the old railway are required.
• Natural storage area to be provided as shown in figure 5.1. This storage will be sub-divided into separate storage cells, by new dividing embankments. This maximises storage capacity while minimising impact on agricultural land. Flow from the storage area will naturally return to the River Maigue via flapped outfalls.
• Replace the existing footbridge at Adare manor to a single span bridge, as shown in figure 5.1.
• The upstream and downstream parapets on the N21 Bridge will need to be replaced to ensure they can provide a flood defence function to the required design standard. They will also need to be tied into the embankments either side, as shown in figure 5.1.
• Construct new flood defence walls and embankments as shown in figure 5.1.
• A demountable flood gate will be required across the old railway line and should be tied into the new flood defence wall and embankment, as shown in figure 5.1. Flood forecasting will also be required as part of this measure.
• Existing arterial drainage maintenance scheme will need to be maintained as part of this option.</td></tr>
<tr><td colspan="2" rowspan="2">Options Meeting:</td><td colspan="2">Date:</td><td colspan="3">30/09/2015</td></tr>
<tr><td colspan="2">Summary:</td><td colspan="3">The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.</td></tr>
</table>

<table>
<tr><td colspan="2">Option Ref:</td><td colspan="4">ADE_02</td></tr>
<tr><td rowspan="4">Option Measures</td><td>Baseline</td><td>B</td><td colspan="3">Existing Regime</td></tr>
<tr><td>Structural</td><td>Gi</td><td colspan="3">Flood Defences: New Flood Defences</td></tr>
<tr><td>Structural</td><td>Giii</td><td colspan="3">Flood Defences: Demountable Defences</td></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="4">This option will provide a 1% Fluvial and 0.5% Coastal AEP Design standard to all properties within the AFA, identified as being at risk from both these sources.
• Construct new flood defence walls and embankments as shown in figure 5.2.
• A demountable flood gate will be required across the old railway line and should be tied into the new flood defence wall and embankment, as shown in figure 5.2. Flood forecasting will also be required as part of this measure.
• Adare Bridge is a Protected Monument of National Importance. The parapet wall on the upstream face will need able to provide a flood defence function up to the required design standard. It has been assumed that the entire parapet wall will need to be rebuilt, with the average height being 1.5m above existing road level. It has also been assumed that the bridge is structurally sound and capable of withstanding the loading forces of a 1% AEP fluvial flood event. The new embankments on the left bank will need to tie into the parapet wall.
• Existing arterial drainage maintenance scheme will need to be maintained as part of this option.</td></tr>
<tr><td colspan="2" rowspan="2">Options Development Meeting:</td><td>Date:</td><td colspan="3">30/09/2015</td></tr>
<tr><td>Summary:</td><td colspan="3">The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.</td></tr>
</table>

STAGE 5: Multi Criteria Assessment

5.1 Options selected for the Multi Criteria Assessment

Following the Option Meeting, the following options are the refined options for the Multi-Criteria Assessment (MCA) stage. This is the final of a five-stage MCA process.

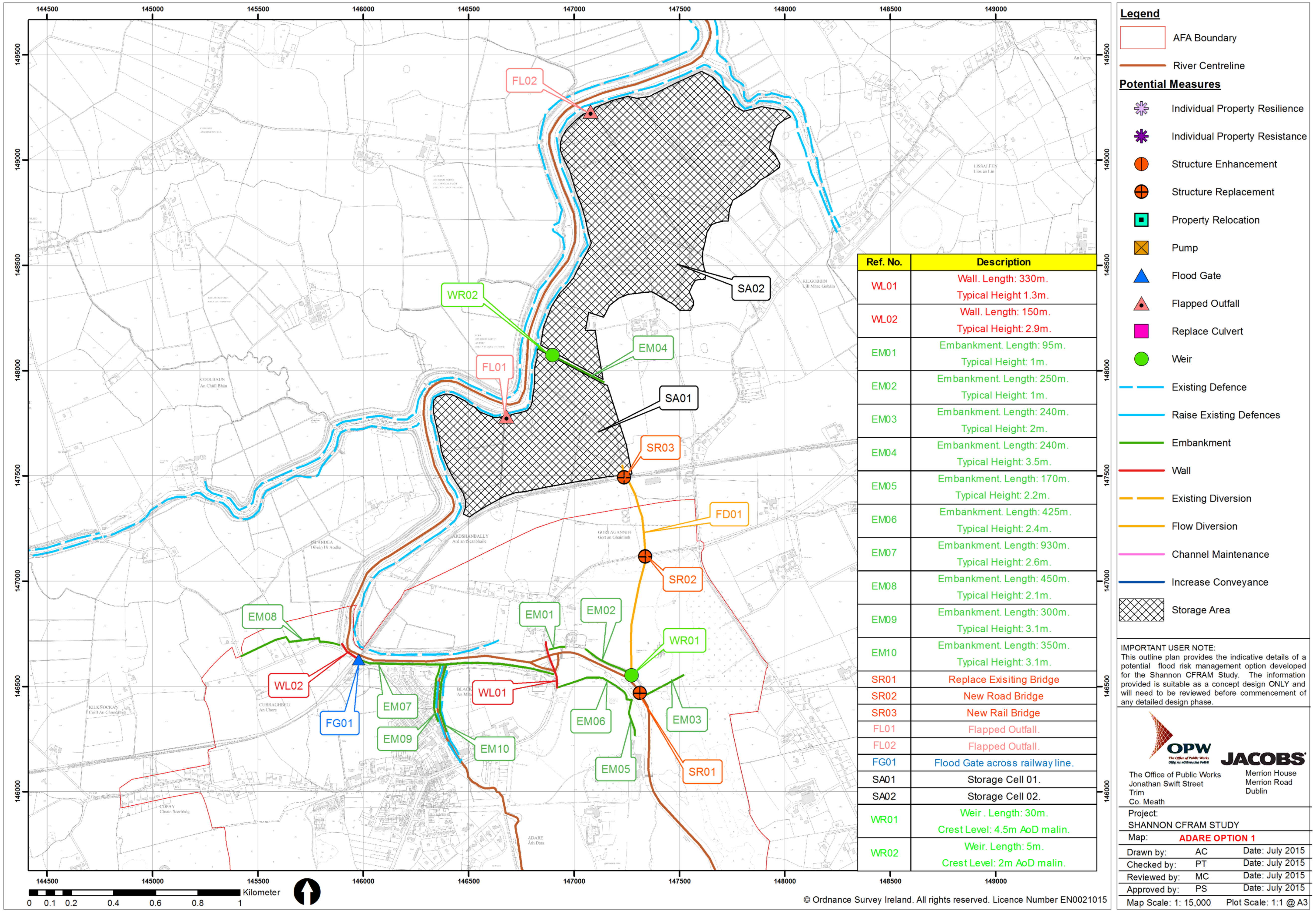
Option Reference		ADE_01	ADE_02
Baseline Measures			
B	Existing Regime	Existing arterial drainage maintenance scheme.	Existing arterial drainage maintenance scheme.
Structural Measures			
D	Storage		
Di	Online Storage		
Dii	Offline Storage	Storage as shown in figure 5.1.	
Diii	Other Storage		
E	Flow Diversion		
Ei	Full Diversion		
Eii	Flood Relief Channel	An overland floodway will connect the River Maigue to a storage area as shown in figure 5.1.	
Eiii	Other Diversion		
F	Increased Conveyance		
Fi	Channel Dredging		
Fii	Channel Widening		
Fiii	Structure Enhancement/Works	Bridge downstream of Adare Manor to be replaced.	
G	Flood Defences		
Gi	New Flood Defences	New flood defences as shown in figure 5.1.	New flood defences as shown in figure 5.2.
Gii	Raise Existing Flood Defences		
Giv	Demountable Defences	Demountable flood gate as shown in figure 5.1.	Demountable flood gate as shown in figure 5.2.
Gv	Other Defences		
Non-Structural Measures			
J	Flood Forecasting	Flood Forecasting will be required as part of the Demountable Defences measure.	Flood Forecasting will be required as part of the Demountable Defences measure.
Table reference A summary of the outcome from the MCA is presented in the following table		Table 5.1	Table 5.2

Table 5.1: Multi Criteria Assessment Outcome for Option ADE_01

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Adare	Option Ref:	ADE_01

Option Measures		
Baseline	B	Existing Regime
Structural	Dii	Storage: Offline Storage
	Eiii	Flow Diversion; Other Diversion
	Fiii	Increase Conveyance: Structure Enhancement/Works
	Gi	Flood Defences: New Flood Defences
	Giii	Flood Defences: Demountable Defences
Non-Structural	J	Flood Forecasting

Criteria Scores	
Technical	1043
Economic	765
Social	1274
Environmental	-507
Economic Values	
Economic PV Benefits	€ 16,070,435
PV Cost	€ 15,829,922
NPV Benefits	€ 240,513
Economic BCR	**1.02**
Outcome Scores	
MCA PV Benefits	€ 7,690,720
MCA Benefit Score	1532
MCA Benefit Score Ratio	96.80
Option Selection MCA	2575
Relevant Figure	Figure 5.1

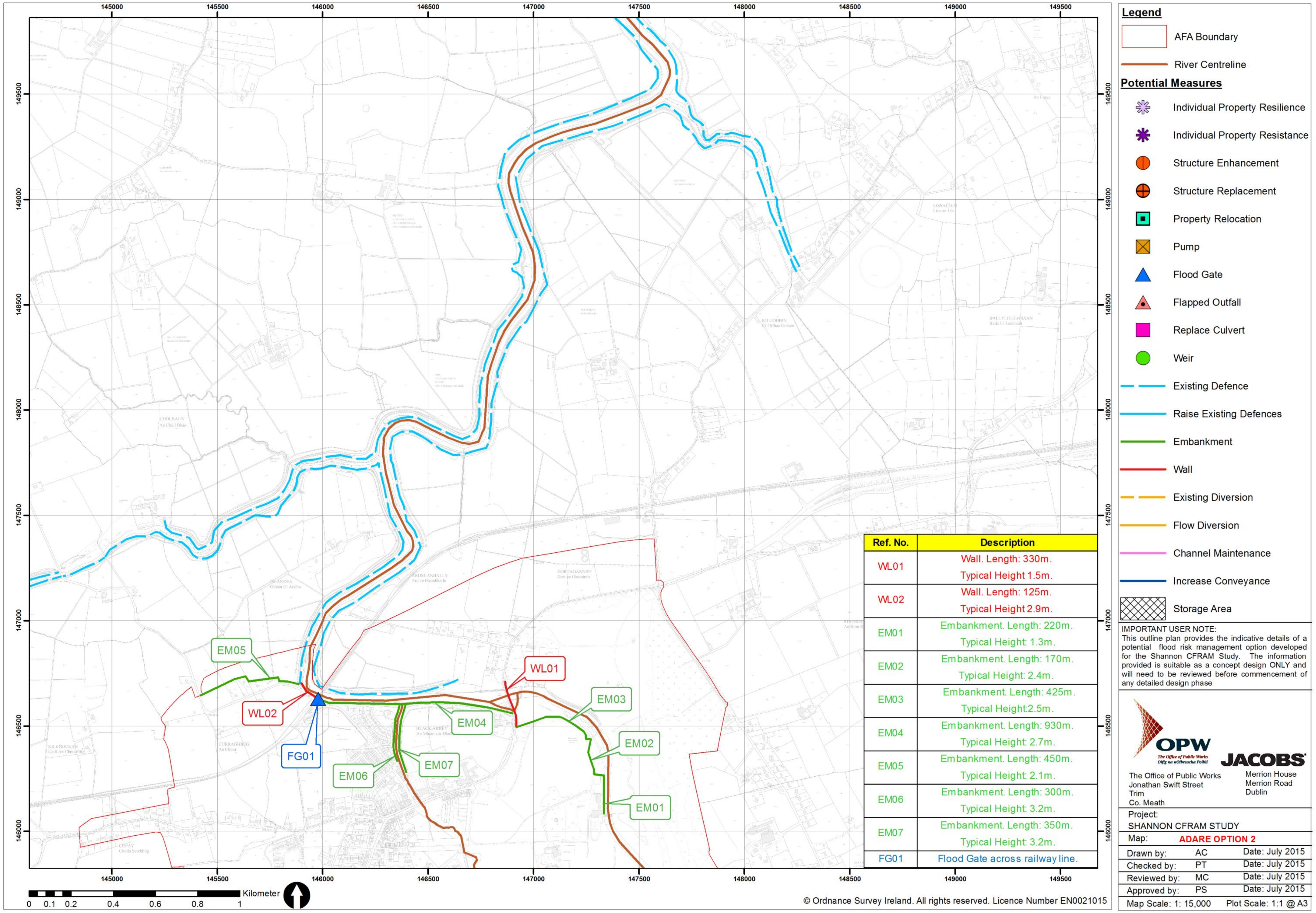


Ref. No.	Description
WL01	Wall. Length: 330m. Typical Height 1.3m.
WL02	Wall. Length: 150m. Typical Height: 2.9m.
EM01	Embankment. Length: 95m. Typical Height: 1m.
EM02	Embankment. Length: 250m. Typical Height: 1m.
EM03	Embankment. Length: 240m. Typical Height: 2m.
EM04	Embankment. Length: 240m. Typical Height: 3.5m.
EM05	Embankment. Length: 170m. Typical Height: 2.2m.
EM06	Embankment. Length: 425m. Typical Height: 2.4m.
EM07	Embankment. Length: 930m. Typical Height: 2.6m.
EM08	Embankment. Length: 450m. Typical Height: 2.1m.
EM09	Embankment. Length: 300m. Typical Height: 3.1m.
EM10	Embankment. Length: 350m. Typical Height: 3.1m.
SR01	Replace Exisiting Bridge
SR02	New Road Bridge
SR03	New Rail Bridge
FL01	Flapped Outfall.
FL02	Flapped Outfall.
FG01	Flood Gate across railway line.
SA01	Storage Cell 01.
SA02	Storage Cell 02.
WR01	Weir . Length: 30m. Crest Level: 4.5m AoD malin.
WR02	Weir. Length: 5m. Crest Level: 2m AoD malin.

Figure 5.1 Option ADE_01

Table 5.2: Multi Criteria Assessment Outcome for Option ADE_02

<table>
<tr><td colspan="4">Multi Criteria Assessment
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.</td></tr>
<tr><td>AFA</td><td>Adare</td><td>Option Ref:</td><td>ADE_02</td></tr>
<tr><td colspan="4">Option Measures</td></tr>
<tr><td>Baseline</td><td>B</td><td colspan="2">Existing Regime</td></tr>
<tr><td rowspan="2">Structural</td><td>Gi</td><td colspan="2">Flood Defences: New Flood Defences</td></tr>
<tr><td>Giii</td><td colspan="2">Flood Defences: Demountable Defences</td></tr>
<tr><td>Non-Structural</td><td>J</td><td colspan="2">Flood Forecasting</td></tr>
<tr><td colspan="4">Criteria Scores</td></tr>
<tr><td colspan="2">Technical</td><td colspan="2">350</td></tr>
<tr><td colspan="2">Economic</td><td colspan="2">816</td></tr>
<tr><td colspan="2">Social</td><td colspan="2">735</td></tr>
<tr><td colspan="2">Environmental</td><td colspan="2">-69</td></tr>
<tr><td colspan="4">Economic Values</td></tr>
<tr><td colspan="2">Economic PV Benefits</td><td colspan="2">€16,070,435</td></tr>
<tr><td colspan="2">PV Cost</td><td colspan="2">€ 10,075,466</td></tr>
<tr><td colspan="2">NPV Benefits</td><td colspan="2">€ 5,994,969</td></tr>
<tr><td colspan="2">Economic BCR</td><td colspan="2">1.60</td></tr>
<tr><td colspan="4">Outcome Scores</td></tr>
<tr><td colspan="2">MCA PV Benefits</td><td colspan="2">€ 7,690,720</td></tr>
<tr><td colspan="2">MCA Benefit Score</td><td colspan="2">1483</td></tr>
<tr><td colspan="2">MCA Benefit Score Ratio</td><td colspan="2">147.22</td></tr>
<tr><td colspan="2">Option Selection MCA</td><td colspan="2">1833</td></tr>
<tr><td colspan="2">Relevant Figure</td><td colspan="2">Figure 5.2</td></tr>
</table>



Ref. No.	Description
WL01	Wall. Length: 330m. Typical Height 1.5m.
WL02	Wall. Length: 125m. Typical Height 2.9m.
EM01	Embankment. Length: 220m. Typical Height: 1.3m.
EM02	Embankment. Length: 170m. Typical Height: 2.4m.
EM03	Embankment. Length: 425m. Typical Height:2.5m.
EM04	Embankment. Length: 930m. Typical Height: 2.7m.
EM05	Embankment. Length: 450m. Typical Height: 2.1m.
EM06	Embankment. Length: 300m. Typical Height: 3.2m.
EM07	Embankment. Length: 350m. Typical Height: 3.2m.
FG01	Flood Gate across railway line.

Figure 5.2 Option ADE_02

5.2 Comparison of Multi Criteria Assessment Scores

Each option taken forward for further consideration through the Option Decision Meeting, has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Decision Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).

Categories	**Option Reference and Results**	
	ADE_01	ADE_02
Criteria Scores		
Technical	1043	350
Economic	765	816
Social	1274	735
Environmental	-507	-69
Economic Values		
Economic PV Benefits	€ 16,070,435	€16,070,435
PV Cost	€ 15,829,922	€ 10,075,466
NPV Benefits	€ 240,513	€ 5994,969
Economic BCR	**1.02**	**1.60**
Outcome Scores		
MCA PV Benefits	€ 7,690,720	€ 7,690,720
MCA Benefit Score	1532	1483
MCA BCR	96.80	147.22
Option Selection MCA	2575	1833

<table>
<tr><td colspan="7">5.3 Recommendation of Preferred Option
It forms part of the CFRAM process for the recommendation of a preferred option for each AFA. The prioritised selection criteria used in this recommendation process is detailed in Section 3.7.3 of the Main Report.
Therefore, following the five stage Multi Criteria Assessment process, the preferred option is as outlined below</td></tr>
<tr><td colspan="2">Option Ref:</td><td colspan="5">ADE_02</td></tr>
<tr><td rowspan="4">Option Measures</td><td>Baseline</td><td>B</td><td colspan="4">Existing Regime</td></tr>
<tr><td rowspan="2">Structural</td><td>Gi</td><td colspan="4">Flood Defences: New Flood Defences</td></tr>
<tr><td>Giii</td><td colspan="4">Flood Defences: Demountable Defences</td></tr>
<tr><td>Non Structural</td><td colspan="2">J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Comments</td><td colspan="5">This option has been designed to protect all properties at risk of flooding in the 1% AEP fluvial event as this is the most dominant source of flood risk. However this option will also protect the properties from flooding in a 0.5% Coastal AEP event.

With a MCA BCR score of 147.22, this is the highest-ranking option following the five-stage Multi Criteria Assessment.

However, it should be noted that the Option Selection MCA is much higher for ADE_01.</td></tr>
</table>

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

<table>
<tr><th colspan="5">Fluvial Flood Forecasting Potential</th></tr>
<tr><th rowspan="3">Catchment Information</th><th colspan="2">Gauging Station</th><th rowspan="2">Catchment size (km ^{2})</th><th rowspan="2">Potential available forecast accuracy and reliability period</th></tr>
<tr><th>Fluvial</th><th>Rainfall</th></tr>
<tr><td>GS24082</td><td>No*</td><td>830</td><td>6 hours</td></tr>
<tr><th>Relevant Information:</th><td colspan="4">Islandmore bridge (GS 24082) lies 12 km upstream of Adare</td></tr>
<tr><th rowspan="3">Additional Infrastructure Recommended</th><th colspan="2">Gauging Station</th><th colspan="2" rowspan="2">Other</th></tr>
<tr><th>Fluvial</th><th>Rainfall</th></tr>
<tr><td>No</td><td>Yes</td><td colspan="2">n/a</td></tr>
<tr><th>Relevant Comments:</th><td colspan="4">Islandmore bridge (GS 24082) lies 12 km upstream of Adare on the River Maigue. GS 24082 represents 90% of the total catchment at Adare. To further improve the potential forecast period rainfall gauges would be required to develop a rainfall –runoff model on the large tributaries upstream of GS 24082.

It must be noted that Adare is tidally influenced an understanding of the coincidence of peak tide level would have to be included in the fluvial flood forecasting system</td></tr>
</table>

*For this assessment only 15 minute tipping bucket gauge were considered.

Annex A - Multi-Criteria Analysis Summary and Whole Life Cost Summaries for FRM Option(s)

CRITERIA			OBJECTIVE	Global Weighting	Local Weighting	Comments	ADE_01 Gi – New Flood Defences Fiii – Structure Enhancement / Works Giii – Demountable Defences Dii – Offline Storage Eiii – Other Diversion J – Flood Forecasting / Warning / Response B – Existing Regime	Option Score	Weighted Score	ADE_02 Gi – New Flood Defences J – Flood Forecasting / Warning / Response Giii – Demountable Defences B – Existing Regime	Option Score	Weighted Score
1	Technical	a	Ensure flood risk management options are operationally robust	20	5.00	The option scores are determined based on the level of operational risk to operate or perform successfully. Each measure is scored independently and the average of the measure scores is used as the score for the option.	None / Manageable / Negligible / Moderate / high / Very low / High / Low / Failure likely / Low / moderate / Unacceptable Gi 5.00 Fiii 5.00 Giii 2.00 Dii 3.00 Eiii 5.00 J 2.00 B 4.00	3.71	371	None / Manageable / Negligible / Moderate / high / Very low / High / Low / Failure likely / Low / moderate / Unacceptable Gi 5.00 J 2.00 Giii 2.00 B 4.00	3.25	325
		b	Minimise health and safety risks associated with the construction and operation of flood risk management options	20	5.00	H&S risks are considered for construction and maintenance of flood risk management measures. The indicative aspirational score is set at five, with a point then deducted for each specific H&S risk in either construction or maintenance.	No risks / Moderate / Negligible / Moderate / high / Very low / High / Low / Very High / Low / moderate / Unacceptable Work near/in water	3.00	300	No risks / Moderate / Negligible / Moderate / high / Very low / High / Low / Very High / Low / moderate / Unacceptable Work near/in water Work near services or buildings Other (please specify)	-1.00	-100
		c	Ensure flood risk management options are adaptable to future flood risk	20	5.00	The options scores are determined based on the sustainability and adaptability of the flood risk management measures in the face of potential future changes, including the potential impact of climate change. Each measure is scored independently and the average of the measure scores is used as the score for the option.	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. Gi 3.00 Fiii 3.00 Giii 3.00 Dii 5.00 Eiii 5.00 J 5.00 B 2.00	3.71	371	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. Gi -5.00 J 5.00 Giii 3.00 B 2.00	1.25	125
			TECHNICAL CRITERIA SCORE						1043			350
2	Economic	a	Minimise economic risk	24	5.00		The score is calculated based on the reduction in AAD, following the full implementation of option.	4.30	516	The score is calculated based on the reduction in AAD, following the full implementation of option.	4.30	516
		b	Minimise risk to transport infrastructure	10	5.00		Scoring is based on the reduction in flood risk to transport routes, following the full implementation of option.	4.99	249	Scoring is based on the reduction in flood risk to transport routes , following the full implementation of option.	4.99	249
		c	Minimise risk to utility infrastructure	14	0.00	There is no risk to utility infrastructure within this AFA for the baseline scenario.	Scoring is calculated based on a reduction in flood risk to utility infrastructure, following the full implementation of option.			Scoring is calculate based on a reduction in flood risk to utility infrastructure, following the full implementation of option.		
		d	Minimise risk to agriculture	12	4.25	Source of Flooding: Both Fresh & Salt Water Percentage of AFA that is rural land: 84.94%	Area of Agricultural Land Flooded: Increased Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable	0.00	0	Area of Agricultural Land Flooded: No Change Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable	1.00	51
			ECONOMIC CRITERIA SCORE						765			816
3	Social	a i)	Minimise risk to human health and life - Residents	27	5.00	Flood Depths & Velocities: Medium to high risk to life Known Areas of Highly Vulnerable People: Reasonable Cross Section of Society	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	4.00	540	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	2.00	270
		a ii)	Minimise risk to human health and life - High vulnerability properties	17	5.00	Rate of Onset of flooding: Significantly Greater Rate of Onset	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	4.00	340	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	2.00	170
		b i)	Minimise risk to community - Social Infrastructure & Amenity	9	5.00	Assets of Particular Social Value: No	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	4.98	224	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	3.73	168
		b ii)	Minimise risk to community - Local employment	7	5.00	Asset of Particular Employment Value: No	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	4.86	170	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	3.64	127
			SOCIAL CRITERIA SCORE						1274			735
4	Environmental	a	Support the objectives of the WFD	16	5.00	The River Maigue and Maigue Estuary are of moderate WFD status. There is one polluting point source a WWTP within the 1% AEP Fluvial and the 0.5% AEP Coastal. The River Maigue is part of the part of the Lower River Shannon cSAC [002165]. Local weighting to be applied for this objective is constant, and should always be set equal to 5 as WFD objectives must be achieved and are relevant to all waterbodies.	The WWTP will be removed from the 1% AEP Fluvial and 0.5% AEP Coastal. Construction related impacts due to significant construction works adjacent to waterbodies, the construction of the floodway and associated weirs and flapped outfalls and due to the construction of a new wall/parapet on Adare Bridge. This option proposes an alternative route for excess flows, via a floodway channel, diverting water from the Maigue main channel to be stored downstream. This measure could cause potential changes in the hydrological and morphological regime of the waterbody in high flows, and where flows are allowed, via flapped outfalls, back from the storage areas into the river there could be physico-chemical changes. Overall, there is a potential short-term or intermittent impediment to the achievement of the WFD objectives and this option has the potential to remove one WWTP and one Section 4 discharge location from the 1% AEP Fluvial &/or 0.5% AEP Coastal.	-1.00	-80	The WWTP will be removed from the 1% AEP Fluvial and 0.5% AEP Coastal. Construction related impacts due to construction works adjacent to watercourses and due to the construction of a new wall/parapet on Adare Bridge. However, much less construction required than Option ADE_01. This option proposes alteration of existing embankments and of a flood defence wall, the development of new embankments and construction of a new wall/parapet on Adare Bridge. The construction works have the potential to result in short term physico-chemical changes. Overall a potential short-term or intermittent contribution to the achievement of wb objectives.	1.00	80
		b	Support the objectives of the Habitats Directive	10	5.00	The Lower River Shannon cSAC [002165] is within the AFA and hydrologically connected to it. Lower River Shannon cSAC Qualifying interests likely to occur within the AFA include otter, river, brook and sea lamprey, Atlantic salmon, estuaries and floating river vegetation. The biological water quality of the Maigue Estuary and Maigue River in Listowel is of "Moderate Status". The River Maigue is not within any FWPM catchment. There are no SPAs within the AFA. The Rivers Shannon and River Fergus Estuaries SPA [004077] are c. 5km from the AFA to the north. Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.	Potentially significant impacts are: - Increases in suspended solids during construction works - Risk of disturbance to various otter and bird species associated with the cSAC - Impacts to fish species including salmon and lamprey - Risk of invasive species spread during proposed works Therefore, there is the potential for a detrimental impact upon existing cSAC site, including a delay in recovery of the site, but excluding impacts on the conservation objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	-2.00	-100	Option ADE_02 has less construction requirements than Option ADE_01. Potentially significant impacts are: - Increase in suspended solids during construction works - Risk of disturbance to various otter and bird species associated with the cSAC - Risk of disturbance to various mammal species - Impacts to fish species including salmon and lamprey - Risk of invasive species spread during proposed works Therefore there is a potential for a detrimental impact upon existing cSAC site, including a delay in recovery of the site, but excluding impacts on the conservation objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	-1.00	-50
		c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	5	5.00	There is a pNHA located within the AFA. Two areas of Adare Woods pNHA [000429] are located within the AFA but outside of the 1.0% AEP Fluvial and 0.5% AEP Coastal. There is potential for significant habitats and populations of European and nationally protected species, particularly associated with woodland and river habitats. Local weighting of 5 set by professional judgement. Weighting of 5 applied where a nationally important site (pNHA, NHA etc) is present (within AFA) and potentially affected.	The Adare Woodland pNHA is unlikely to be impact by the proposed option. The division of the floodplain into storage "cells" with dividing embankments, the development of embankments, the alterations in height of existing embankments, flood defence wall, bridge parapet and the installation of weirs and flapped outfalls together present a risk of localised impacts. Potentially significant impacts are associated with protected flora and fauna, including: - Increase in suspended solids entering the watercourse during construction works - Risk of a pollution event impacting the watercourse - Loss of habitat - Risk of mortality and disturbance to various protected species - Risk of mortality and disturbance to fish species including salmon and lamprey - Risk of invasive species spread during proposed works	-3.00	-75	The Adare Woodland pNHA is unlikely to be impacted by the proposed option. The alterations in height of existing embankments, the raising of the flood defence wall at the old railway line and the alteration of the bridge parapet together present a risk of localised impacts. However less construction works are required for this option. Potentially significant impacts are associated with protected flora and fauna, including: - Increase in suspended solids entering the watercourse during construction works - Risk of a pollution event impacting the watercourse - Loss of habitat - Risk of mortality and disturbance to various protected species - Risk of mortality and disturbance to fish species including salmon and lamprey - Risk of invasive species spread during proposed works	-2.50	-63
		d	Protect, and where possible enhance, fisheries resource within the catchment	13	2.00	The Maigue Estuary is not designated as a Salmonid River; however the Maigue Greenagh Main 1 Lower intersects a cSAC that contains Atlantic Salmon as a qualifying interest 1.2 km downstream of the AFA. The estuary is a high activity angling area. Local weighting of 2 set by professional judgement. Weighting of 2 applied where a waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.	Potential short term construction impacts associated with the development of embankments, the alterations in height of existing embankments, wall and bridge parapet, and the installation of weirs and flapped outfalls that can be mitigated. There is also flow diversion to the same river. Therefore, a potential for medium term alteration to fisheries habitat.	-4.00	-104	Potential short term construction impacts associated with the alterations in height of existing embankments, the raising of the flood defence wall at the old railway line and the alteration of the bridge parapet, which can be mitigated. However, there are less construction works required than Option ADE_01. Therefore, a potential for short-term minor impacts to fisheries habitat.	-2.00	-52
		e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	8	3.00	Adare has no landscape planning designations within the AFA. Adare is a Heritage Town. No specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected. There are many protected structures and an ACA in the AFA. In the absence of landscape designations and a character assessment Adare has been considered to be of medium sensitivity. Local weighting of 3 set by professional judgement. Weighting of 3 applied where landscape character type designated at a county level as moderate sensitivity and/or medium value; protected views present that could be affected	There is no impact on designated landscape features associated with this option. The division of the floodplain into storage "cells" with dividing embankments, the development of embankments, the alterations in height of existing embankments, wall, bridge parapet and the installation of weirs and flapped outfalls will alter the visual amenity of the area. Therefore, there is a potential for long term impact to a moderate sensitivity landscape character/feature in the zone of visibility of the selected features.	-3.00	-72	There is no impact on designated landscape features associated with this option. The alterations in height of existing embankments, the raising of the flood defence wall at the old railway line and the alteration of the bridge parapet will alter the visual amenity of the area. However, there is less potential impacts associated with Option ADE_02 over Option ADE_01. Therefore, there is a potential for medium term impact to a low sensitivity landscape character/feature in the zone of visibility of the selected features.	-1.00	-24
		f i)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of architectural value	4	3.00	Adare is a heritage town. Approximately 0.64km2 of the ACA falls within the 1% AEP Fluvial & 0.5% AEP Coastal area. There are 11 RPS and 14 NIAH within the 1% AEP Fluvial & 0.5% AEP Coastal. A number of sites/features listed on the Record of Protected Structures and/or recorded by NIAH are present and potentially affected with a high to moderate vulnerability. Local weighting of 3 set by professional judgement. Weighting of 3 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a high to moderate vulnerability.	The option would reduce the potential for flooding in the 1% AEP Fluvial and the 0.5% AEP Coastal for a number of RPS and NIAH features, as well as reducing the potential for flooding for a portion of the ACA. The flow diversion channel and Embankments (EM01-EM03) are through a particularly important area; Desmond Castle which is an NIAH/RPS (and a National Monument see Obj f(ii)) therefore there is a potential to alter the setting of this nationally important feature. The replacement of the Desmond Castle Bridge and NIAH/RPS would result in a physical effect on architectural features (nationally important features, Record of Protected Structures and NIAH) such that the structure is completely removed. Other works including raising existing defences and new embankment will alter the setting of a number of other RPS/NIAH in the vicinity of Adare Bridge. The new wall/parapet proposed on the upstream face of Adare Bridge, to achieve an average height about the bridge deck of 1.25m, would result in a physical effect on an architectural feature of national importance such that the structure is altered. Under this option there are potential significant impacts on individual architectural features. However there is a potential to increase in the level of protection for architectural features (RPS, NIAH and ACA) from flooding, such that they are less vulnerable to flood damage. Overall this option will have a negative effect.	-3.00	-36	The option will reduce the potential for flooding in the 1% AEP Fluvial and the 0.5% AEP Coastal for a number of RPS and NIAH features, as well as reducing the potential for flooding for a portion of the ACA. The new wall/parapet proposed on the upstream face of Adare Bridge, to achieve an average height about the bridge deck of 1.5m, would result in a physical effect on an architectural feature of national importance such that the structure is altered. The embankment (EM05) would result in a change in setting for Adare Manor. There are potential significant impacts on individual architectural features. However, overall there is a potential increase in the level of protection for architectural features (RPS, NIAH and ACA) from flooding, such that they are less vulnerable to flood damage.	2.00	24
		f ii)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of archaeological value	4	4.00	Adare is a heritage town with ten RMP and one National Monument (Desmond Castle [LI021-032003-]0) within the 1% AEP Fluvial & 0.5% AEP coastal. Local weighting of 4 set by professional judgement. Weighting of 4 applied where there are nationally important archaeological feature(s) (e.g. National Monument in State Care, sites on which Preservation Orders or Temporary Preservation Orders have been served) present and potentially affected.	The option will reduce the potential for flooding in the 1% AEP Fluvial and 0.5% AEP Coastal in the vicinity of a number of Recorded Monuments, and will increase the level of protection from flooding for these monuments. The flood measures proposed as part of this option do have the potential to change the setting of a National Monument Desmond Castle due to embankments and flow diversion channel, removal of the Desmond Castle Bridge. The new wall/parapet proposed on the upstream face of Adare Bridge, to achieve an average height above the bridge deck of 1.25m, would result in a physical effect on an archaeological feature such that the structure is altered. Therefore overall changes to the setting of archaeological features such that it is completely altered.	-2.50	-40	The option will reduce the potential for flooding in the 1% AEP Fluvial and 0.5% AEP Coastal in the vicinity of a number of Recorded Monuments, and will increase the level of protection from flooding for these monuments. The flood measures proposed as part of this option do have the potential to change the setting of these archaeological features as the new wall/parapet proposed on the upstream face of Adare Bridge, to achieve an average height above the bridge deck of 1.5m, would result in a physical effect on an archaeological feature such that the structure is altered. Therefore, overall an increase in the level of protection for archaeological features (Recorded Monuments) from flooding, such that it is less vulnerable to flood damage.	1.00	16
			ENVIRONMENTAL CRITERIA SCORE						-507			-69
Economic Values			**Economic PV Benefits**					€16,070,435			€16,070,435	
			Cost					€15,829,922			€10,075,466	
			NPV Benefits					€240,513			€5,994,969	
			Economic BCR					**1.02**			**1.60**	
Outcome Scores			**MCA PV Benefits**					€7,690,720			€7,690,720	
			MCA Benefit Score					1532			1483	
			MCA BCR					**96.80**			**147.22**	
			Option Selection MCA					2575			1833	

Objective	Global Weightings (fixed)	Local Weightings		Baseline Comments	Option 1 Comments	Option 2 Comments
1.A	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has negligible operational risks to operate or perform successfully.	This score is determined for this option as it has negligible operational risks to operate or perform successfully.
1.B	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has very low health and safety risks associated with the construction and operation of flood risk management option.	This score is determined for this option as it has moderate health and safety risks associated with the construction and operation of flood risk management option.
1.C	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it can be adapted only at negligible to limited cost and difficulty, but provides no impediment to future interventions.	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.
2.A	24	5.00	calculated	Local weighting is calculated based on the baseline AAD.	This score is calculated based on the reduction in AAD, following the full implementation of option.	This score is calculated based on the reduction in AAD, following the full implementation of option.
2.B	10	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to transport infrastructure. Local weighting capped at maximum value of 5.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.
2.C	14	0.00	calculated but adjusted by professional judgement if necessary	There are no utility infrastructure receptors at risk within this AFA.	There is no risk to utility infrastructure within this AFA.	There is no risk to utility infrastructure within this AFA.
2.D	12	0.00	Professional judgement	Local weighting is calculated based on the percentage of rural land within the AFA.	This score is determined based on the increased area of agricultural land flooded and the presence of flood forecasting, following full implementation of the option.	This score is determined based on the presence of flood forecasting, following full implementation of the option.
3.A (i)	27	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to residential properties. Local weighting capped at maximum value of 5.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option. The option score has been reduced by 50% to account for the high rate of onset and medium to high risk to life.
3.A (ii)	17	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on based on the baseline risk to high vulnerability properties. Local weighting capped at maximum value of 5.	This score is calculated based on a reduction in flooding to high vulnerability properties, following full implementation of the option.	This score is calculated based on a reduction in flooding to high vulnerability properties, following full implementation of the option. The options score has been reduced by 50% due to the high rate of onset and medium to high risk to life.
3.B (i)	9	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to social infrastructure.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option. The option score has been reduced by 25% due to the high rate of onset.
3.B (ii)	7	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to local employment. Local weighting capped at maximum value of 5.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option. The option score has been redued by 25% due to the high rate of onset.
4.A	16	5.00	fixed	The Lower River Shannon cSAC [002165] is within the AFA and hydrologically connected to it. Lower River Shannon cSAC Qualifying interests likely to occur within the AFA include otter, river, brook and sea lamprey, Atlantic salmon, estuaries and floating river vegetation. The biological water quality of the Maigue Estuary and Maigue River in Listowel is of "Moderate Status". The River Maigue is not within any FWPM catchment. There are no SPAs within the AFA. The Rivers Shannon and River Fergus Estuaries SPA [004077] are c. 5km from the AFA to the north. Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.	The WWTP will be removed from the 1% AEP Fluvial and 0.5% AEP Coastal. Construction related impacts due to significant construction works adjacent to waterbodies, the construction of the floodway and associated weirs and flapped outfalls and due to the construction of a new wall/parapet on Adare Bridge. This option proposes an alternative route for excess flows, via a floodway channel, diverting water from the Maigue main channel to be stored downstream. This measure could cause potential changes in the hydrological and morphological regime of the waterbody in high flows, and where flows are allowed, via flapped outfalls, back from the storage areas into the river there could be physico-chemical changes. Overall, there is a potential short-term or intermittent impediment to the achievement of the WFD objectives and this option has the potential to remove one WWTP and one Section 4 discharge location from the 1% AEP Fluvial &/or 0.5% AEP Coastal.	The WWTP will be removed from the 1% AEP Fluvial and 0.5% AEP Coastal. Construction related impacts due to construction works adjacent to watercourses and due to the construction of a new wall/parapet on Adare Bridge. However, much less construction required than Option ADE_01. This option proposes alteration of existing embankments and of a flood defence wall, the development of new embankments and construction of a new wall/parapet on Adare Bridge. The construction works have the potential to result in short term physico-chemical changes. Overall a potential short-term or intermittent contribution to the achievement of wb objectives.
4.B	10	5.00	Professional judgement	The Lower River Shannon cSAC [002165] is within the AFA and hydrologically connected to it. Lower River Shannon cSAC Qualifying interests likely to occur within the AFA include otter, river, brook and sea lamprey, Atlantic salmon, estuaries and floating river vegetation. The biological water quality of the Maigue Estuary and Maigue River in Listowel is of "Moderate Status". The River Maigue is not within any FWPM catchment. There are no SPAs within the AFA. The Rivers Shannon and River Fergus Estuaries SPA [004077] are c. 5km from the AFA to the north. Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.	Potentially significant impacts are: - Increases in suspended solids during construction works - Risk of disturbance to various otter and bird species associated with the cSAC - Impacts to fish species including salmon and lamprey - Risk of invasive species spread during proposed works Therefore, there is the potential for a detrimental impact upon existing cSAC site, including a delay in recovery of the site, but excluding impacts on the conservation objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	Option ADE_02 has less construction requirements than Option ADE_01. Potentially significant impacts are: - Increase in suspended solids during construction works - Risk of disturbance to various otter and bird species associated with the cSAC - Risk of disturbance to various mammal species - Impacts to fish species including salmon and lamprey - Risk of invasive species spread during proposed works Therefore there is a potential for a detrimental impact upon existing cSAC site, including a delay in recovery of the site, but excluding impacts on the conservation objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.
4.C	5	5.00	Professional judgement	There is a pNHA located within the AFA. Two areas of Adare Woods pNHA [000429] are located within the AFA but outside of the 1.0% AEP Fluvial and 0.5% AEP Coastal. There is potential for significant habitats and populations of European and nationally protected species, particularly associated with woodland and river habitats. Local weighting of 5 set by professional judgement. Weighting of 5 applied where a nationally important site (pNHA, NHA etc) is present (within AFA) and potentially affected.	The Adare Woodland pNHA is unlikely to be impact by the proposed option. The division of the floodplain into storage "cells" with dividing embankments, the development of embankments, the alterations in height of existing embankments, flood defence wall, bridge parapet and the installation of weirs and flapped outfalls together present a risk of localised impacts. Potentially significant impacts are associated with protected flora and fauna, including: - Increase in suspended solids entering the watercourse during construction works - Risk of a pollution event impacting the watercourse - Loss of habitat - Risk of mortality and disturbance to various protected species - Risk of mortality and disturbance to fish species including salmon and lamprey - Risk of invasive species spread during proposed works	The Adare Woodland pNHA is unlikely to be impacted by the proposed option. The alterations in height of existing embankments, the raising of the flood defence wall at the old railway line and the alteration of the bridge parapet together present a risk of localised impacts. However less construction works are required for this option. Potentially significant impacts are associated with protected flora and fauna, including: - Increase in suspended solids entering the watercourse during construction works - Risk of a pollution event impacting the watercourse - Loss of habitat - Risk of mortality and disturbance to various protected species - Risk of mortality and disturbance to fish species including salmon and lamprey - Risk of invasive species spread during proposed works
4.D	13	2.00	Professional judgement	The Maigue Estuary is not designated as a Salmonid River; however the Maigue Greenagh Main 1 Lower intersects a cSAC that contains Atlantic Salmon as a qualifying interest 1.2 km downstream of the AFA. The estuary is a high activity angling area. Local weighting of 2 set by professional judgement. Weighting of 2 applied where a waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.	Potential short term construction impacts associated with the development of embankments, the alterations in height of existing embankments, wall and bridge parapet, and the installation of weirs and flapped outfalls that can be mitigated. There is also flow diversion to the same river. Therefore, a potential for medium term alteration to fisheries habitat.	Potential short term construction impacts associated with the alterations in height of existing embankments, the raising of the flood defence wall at the old railway line and the alteration of the bridge parapet, which can be mitigated. However, there are less construction works required than Option ADE_01. Therefore, a potential for short-term minor impacts to fisheries habitat.
4.E	8	3.00	Professional judgement	Adare has no landscape planning designations within the AFA. Adare is a Heritage Town. No specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected. There are many protected structures and an ACA in the AFA. In the absence of landscape designations and a character assessment Adare has been considered to be of medium sensitivity. Local weighting of 3 set by professional judgement. Weighting of 3 applied where landscape character type designated at a county level as moderate sensitivity and/or medium value; protected views present that could be affected	There is no impact on designated landscape features associated with this option. The division of the floodplain into storage "cells" with dividing embankments, the development of embankments, the alterations in height of existing embankments, wall, bridge parapet and the installation of weirs and flapped outfalls will alter the visual amenity of the area. Therefore, there is a potential for long term impact to a moderate sensitivity landscape character/feature in the zone of visibility of the selected features.	There is no impact on designated landscape features associated with this option. The alterations in height of existing embankments, the raising of the flood defence wall at the old railway line and the alteration of the bridge parapet will alter the visual amenity of the area. However, there is less potential impacts associated with Option ADE_02 over Option ADE_01. Therefore, there is a potential for medium term impact to a low sensitivity landscape character/feature in the zone of visibility of the selected features.
4.F(i)	4	3.00	Professional judgement	Adare is a heritage town. Approximately 0.64km2 of the ACA falls within the 1% AEP Fluvial & 0.5% AEP Coastal area. There are 11 RPS and 14 NIAH within the 1% AEP Fluvial & 0.5% AEP Coastal. A number of sites/features listed on the Record of Protected Structures and/or recorded by NIAH are present and potentially affected with a high to moderate vulnerability. Local weighting of 3 set by professional judgement. Weighting of 3 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a high to moderate vulnerability.	The option would reduce the potential for flooding in the 1% AEP Fluvial and the 0.5% AEP Coastal for a number of RPS and NIAH features, as well as reducing the potential for flooding for a portion of the ACA. The flow diversion channel and Embankments (EM01-EM03) are through a particularly important area; Desmond Castle which is an NIAH/RPS (and a National Monument see Obj f(ii)) therefore there is a potential to alter the setting of this nationally important feature. The replacement of the Desmond Castle Bridge and NIAH/RPS would result in a physical effect on architectural features (nationally important features, Record of Protected Structures and NIAH) such that the structure is completely removed. Other works including raising existing defences and new embankment will alter the setting of a number of other RPS/NIAH in the vicinity of Adare Bridge. The new wall/parapet proposed on the upstream face of Adare Bridge, to achieve an average height about the bridge deck of 1.25m, would result in a physical effect on an architectural feature of national importance such that the structure is altered. Under this option there are potential significant impacts on individual architectural features. However there is a potential to increase in the level of protection for architectural features	The option will reduce the potential for flooding in the 1% AEP Fluvial and the 0.5% AEP Coastal for a number of RPS and NIAH features, as well as reducing the potential for flooding for a portion of the ACA. The new wall/parapet proposed on the upstream face of Adare Bridge, to achieve an average height about the bridge deck of 1.5m, would result in a physical effect on an architectural feature of national importance such that the structure is altered. The embankment (EM05) would result in a change in setting for Adare Manor. There are potential significant impacts on individual architectural features. However, overall there is a potential increase in the level of protection for architectural features (RPS, NIAH and ACA) from flooding, such that they are less vulnerable to flood damage.
4.F(ii)	4	4.00	Professional judgement	Adare is a heritage town with ten RMP and one National Monument (Desmond Castle [LI021-032003-]0) within the 1% AEP Fluvial & 0.5% AEP coastal. Local weighting of 4 set by professional judgement. Weighting of 4 applied where there are nationally important archaeological feature(s) (e.g. National Monument in State Care, sites on which Preservation Orders or Temporary Preservation Orders have been served) present and potentially affected.	The option will reduce the potential for flooding in the 1% AEP Fluvial and 0.5% AEP Coastal in the vicinity of a number of Recorded Monuments, and will increase the level of protection from flooding for these monuments. The flood measures proposed as part of this option do have the potential to change the setting of a National Monument Desmond Castle due to embankments and flow diversion channel, removal of the Desmond Castle Bridge. The new wall/parapet proposed on the upstream face of Adare Bridge, to achieve an average height above the bridge deck of 1.25m, would result in a physical effect on an archaeological feature such that the structure is altered. Therefore overall changes to the setting of archaeological features such that it is completely altered.	The option will reduce the potential for flooding in the 1% AEP Fluvial and 0.5% AEP Coastal in the vicinity of a number of Recorded Monuments, and will increase the level of protection from flooding for these monuments. The flood measures proposed as part of this option do have the potential to change the setting of these archaeological features as the new wall/parapet proposed on the upstream face of Adare Bridge, to achieve an average height above the bridge deck of 1.5m, would result in a physical effect on an archaeological feature such that the structure is altered. Therefore, overall an increase in the level of protection for archaeological features (Recorded Monuments) from flooding, such that it is less vulnerable to flood damage.

Option 1 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis			€	€	€	Notes to CFRAM Consultants
(1)	**Basic Construction Costs (Estimate)**				**6,219,479**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2)	**Preliminaries**	9.9%			**618,624**	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**6,838,103**	
(3)	**Optimism Bias**	50.8%			**3,471,343**	Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**10,309,446**	
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13.0%			**1,340,228**	Set at 13%
	Construction Costs and Fees				**11,649,674**	
(6)	**Other Items**					
(a)	Allowance for Archaeology & Environmental Mitigation Measures	15.0%		1,546,417		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	15.0%		1,546,417		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation	approx 4% assumed		412,378		Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance			51,000		See "Guidance E – Per Cent for Art Note"
(e)	Est. NPV Operation & Maintenance		413,914			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	50.8%	210,122	624,036	**4,180,248**	Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**15,829,922**	

JBA consulting

DONNACHADH O'BRIEN & ASSOCIATES CONSULTING ENGINEERS

OPW The Office of Public Works Oifig na nOibreacha Poiblí

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	J. Cunniffe	Date:	15/07/2015
Checked by:	P. Travers	Date:	15/07/2015

Project reference	S06	Project name:	Shannon CFRAMS - S06 Adare
Base date for estimates (year 0)	Oct-2013	Construction Price Index (CPI)	0.987
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues /constraints	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	Cost (€)	Comment
Total wall costs	€927,551	*assumed rural non-clad walls and stone clad bridge parapet.*
Total embankment costs	€2,693,776	*assumed imported material.*
Total demountable barrier costs		
Total demountable gate costs	€190,000	*assumed double 2x3m Lift Hinge Gate (1.8m high)*
Total in-channel excavation costs		
Total excavation on land costs	€47,880	
Total weir construction costs	€136,338	
Total weir removal costs		
Total bridge construction costs	€2,073,790	
Total bridge removal costs	€147,560	
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs	€2,584	
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Targeted Public Awareness Campaign		
Total Construction costs	€6,219,479	
Apply update to unit rate (CPI) if appropriate (cell N15)	€6,135,809	
Enter appropriate preliminaries estimate (%)	9.95%	*ref: Preliminaries and other costs v1.0*
Enter other applicable costs (€)		
Total capital cost (€)	€6,838,103	
Consider amendments based on site issues/constraints (cell N16)	€6,838,103	
Total capital cost (€)	€6,838,103	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs	€181	*average o&m assumed.*
Total embankment O&M costs	€8,858	*average o&m assumed.*
Total demountable barrier O&M costs		
Total demountable gate O&M costs	€432	*average o&m assumed.*
Total in-channel excavation O&M costs		
Total excavation on land O&M costs	€0	
Total weir O&M costs	€3,750	
Total weir removal O&M costs		
Total bridge O&M costs	€2,400	*average o&m assumed.*
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs	€3,773	*average o&m assumed.*
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Targeted Public Awareness Campaign		
Total Operation and Maintenance costs	€19,395	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€7,252,017	
Optimism bias rate (from external sheet)	51%	*Calculated using Optimism Bias Tool v2.0*
Total Cost including Optimism Bias	€10,933,482	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€6,838,103
Annual maintenance cost (€)	€19,395
Other cost (€)	€0
Other works frequency (years)	

Key
- Information
- Calculation
- Cost input
- User information

Discount rate:	4.0%	Present Value Factor:		22.341		Total PVc (€k):	7252017
	Cash sum	0	6838103	950346	0	7788450	7252017
	Discount	Cost Elements				TOTALS:	
year	Factor	Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0	6838103			6838103.1	6838103.1
1	0.962			19395		19394.8	18648.9
2	0.925			19395		19394.8	17931.6
3	0.889			19395		19394.8	17241.9
4	0.855			19395		19394.8	16578.8
5	0.822			19395		19394.8	15941.1
6	0.790			19395		19394.8	15328.0
7	0.760			19395		19394.8	14738.5
8	0.731			19395		19394.8	14171.6
9	0.703			19395		19394.8	13626.5
10	0.676			19395		19394.8	13102.4
11	0.650			19395		19394.8	12598.5
12	0.625			19395		19394.8	12114.0
13	0.601			19395		19394.8	11648.0
14	0.577			19395		19394.8	11200.0
15	0.555			19395		19394.8	10769.3
16	0.534			19395		19394.8	10355.1
17	0.513			19395		19394.8	9956.8
18	0.494			19395		19394.8	9573.8
19	0.475			19395		19394.8	9205.6
20	0.456			19395		19394.8	8851.5
21	0.439			19395		19394.8	8511.1
22	0.422			19395		19394.8	8183.8
23	0.406			19395		19394.8	7869.0
24	0.390			19395		19394.8	7566.3
25	0.375			19395		19394.8	7275.3
26	0.361			19395		19394.8	6995.5
27	0.347			19395		19394.8	6726.4
28	0.333			19395		19394.8	6467.7
29	0.321			19395		19394.8	6219.0
30	0.308			19395		19394.8	5979.8
31	0.296			19395		19394.8	5749.8
32	0.285			19395		19394.8	5528.6
33	0.274			19395		19394.8	5316.0
34	0.264			19395		19394.8	5111.5
35	0.253			19395		19394.8	4914.9
36	0.244			19395		19394.8	4725.9
37	0.234			19395		19394.8	4544.1
38	0.225			19395		19394.8	4369.4
39	0.217			19395		19394.8	4201.3
40	0.208			19395		19394.8	4039.7
41	0.200			19395		19394.8	3884.4
42	0.193			19395		19394.8	3735.0
43	0.185			19395		19394.8	3591.3
44	0.178			19395		19394.8	3453.2
45	0.171			19395		19394.8	3320.4
46	0.165			19395		19394.8	3192.7
47	0.158			19395		19394.8	3069.9
48	0.152			19395		19394.8	2951.8
49	0.146			19395		19394.8	2838.3

Option 2 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis					Notes to CFRAM Consultants
		€	€	€	
(1) Basic Construction Costs (Estimate)				**4,025,783**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2) Preliminaries	11.9%			**479,226**	Refer to UCD for selecting Preliminaries. %
Sub-Total:				**4,505,009**	
(3) Optimism Bias	51.6%			**2,326,704**	Refer to UCD for selecting OB %
(4) Construction Costs (Excl VAT)				**6,831,713**	
(5) Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)	13.0%			**888,123**	Set at 13%
Construction Costs and Fees				**7,719,836**	
(6) Other Items					
(a) Allowance for Archaeology & Environmental Mitigation Measures	15.0%		1,024,757		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b) Allowance for compensation and land acquisition	10.0%		683,171		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c) Site investigation	4% assumed		273,269		Professional judgement to be applied in estimating a suitable sum.
(d) Art Allowance			38,000		See "Guidance E – Per Cent for Art Note"
(e) Est. NPV Operation & Maintenance		221,853			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
Optimism Bias	51.6%	114,581	336,434	**2,355,631**	Refer to UCD for selecting OB %
Option Cost for Cost Benefit Analysis				**10,075,466**	

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	J. Cunniffe	**Date:**	15/07/2015
Checked by:	P. Travers	**Date:**	

Project reference	S06	**Project name:**	Shannon CFRAMS - S06 Adare
Base date for estimates (year 0)	Oct-2013	**Construction Price Index (CPI)**	**0.987**
Scaling factor (e.g. €m, €k, €)	€	**Method Factor - to take into account particular site issues /constraints**	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	**Cost (€)**	**Comment**
Total wall costs	€900,523	*assumed rural non-clad walls and stone clad bridge parapet.*
Total embankment costs	€2,935,260	*assumed imported material.*
Total demountable barrier costs		
Total demountable gate costs	€190,000	*assumed double 2x3m Lift Hinge Gate (1.8m high)*
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Targeted Public Awareness Campaign		
Total Construction costs	€4,025,783	
Apply update to unit rate (CPI) if appropriate (cell N15)	€3,971,624	
Enter appropriate preliminaries estimate (%)	11.90%	*ref: Preliminaries and other costs v1.0*
Enter other applicable costs (€)		
Total capital cost (€)	€4,505,009	
Consider amendments based on site issues/constraints (cell N16)	€4,505,009	
Total capital cost (€)	€4,505,009	

Operation and Maintenance Cost Tool	**Cost (€)**	**Comment**
Total wall O&M costs	€172	*average o&m assumed.*
Total embankment O&M costs	€9,792	*average o&m assumed.*
Total demountable barrier O&M costs		
Total demountable gate O&M costs	€432	*average o&m assumed.*
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Targeted Public Awareness Campaign		
Total Operation and Maintenance costs	€10,395	

Other costs	**Cost (€)**	**Comment**
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	**Cost (€)**	**Comment**
Total PVc costs (see PVc calculator below)	€4,726,862	
Optimism bias rate (from external sheet)	52%	*Calculated using Optimism Bias Tool v2.0*
Total Cost including Optimism Bias	€7,168,147	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€4,505,009
Annual maintenance cost (€)	€10,395
Other cost (€)	€0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	**4.0%**	**Present Value Factor:**	**22.341**			**Total PVc (€k):**	**4726862**
	Cash sum	0	4505009	509375	0	5014384	**4726862**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	0	4505009			4505008.5	4505008.5
1	0.962			10395		10395.4	9995.6
2	0.925			10395		10395.4	9611.1
3	0.889			10395		10395.4	9241.5
4	0.855			10395		10395.4	8886.0
5	0.822			10395		10395.4	8544.3
6	0.790			10395		10395.4	8215.6
7	0.760			10395		10395.4	7899.7
8	0.731			10395		10395.4	7595.8
9	0.703			10395		10395.4	7303.7
10	0.676			10395		10395.4	7022.8
11	0.650			10395		10395.4	6752.7
12	0.625			10395		10395.4	6492.9
13	0.601			10395		10395.4	6243.2
14	0.577			10395		10395.4	6003.1
15	0.555			10395		10395.4	5772.2
16	0.534			10395		10395.4	5550.2
17	0.513			10395		10395.4	5336.7
18	0.494			10395		10395.4	5131.5
19	0.475			10395		10395.4	4934.1
20	0.456			10395		10395.4	4744.3
21	0.439			10395		10395.4	4561.9
22	0.422			10395		10395.4	4386.4
23	0.406			10395		10395.4	4217.7
24	0.390			10395		10395.4	4055.5
25	0.375			10395		10395.4	3899.5
26	0.361			10395		10395.4	3749.5
27	0.347			10395		10395.4	3605.3
28	0.333			10395		10395.4	3466.6
29	0.321			10395		10395.4	3333.3
30	0.308			10395		10395.4	3205.1
31	0.296			10395		10395.4	3081.8
32	0.285			10395		10395.4	2963.3
33	0.274			10395		10395.4	2849.3
34	0.264			10395		10395.4	2739.7
35	0.253			10395		10395.4	2634.4
36	0.244			10395		10395.4	2533.0
37	0.234			10395		10395.4	2435.6
38	0.225			10395		10395.4	2341.9
39	0.217			10395		10395.4	2251.9
40	0.208			10395		10395.4	2165.3
41	0.200			10395		10395.4	2082.0
42	0.193			10395		10395.4	2001.9
43	0.185			10395		10395.4	1924.9
44	0.178			10395		10395.4	1850.9
45	0.171			10395		10395.4	1779.7
46	0.165			10395		10395.4	1711.2
47	0.158			10395		10395.4	1645.4
48	0.152			10395		10395.4	1582.1
49	0.146			10395		10395.4	1521.3

Appendix C6 Option Appraisal Report – Croom

1. Preliminary Report: Summary of Current Flood Risk

1.1 AFA and Watercourse Details

AFA	Croom
Unit of Management:	24
Primary Watercourse(s):	River Maigue, River Laskiltagh

1.2 Summary of Flood Risk in 1% Fluvial AEP Event

Source of flood risk	**Fluvial**	Coastal	Both

Total Number of Properties at risk in AFA in 1% Fluvial AEP Event:		**Residential**	**Non-Residential**	**Total**
	Fluvial	13	6	19
AFA Flood Cells:	**Total Number:**	3		
	Flood Cell Titles:	CRM_A, CRM_B, CRM_C		
Breakdown of properties at risk per Flood Cell:	**Flood Cell Ref**	**Residential**	**Non-Residential**	**Total**
	CRM_A	10	2	12
	CRM_B	3	3	6
	CRM_C	0	1	1
Relevant Figure Ref:	Figures 1.1 to 1.4			

1.3 Summary of Existing Flood Risk Management Measures

Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
Yes	None	None	None	None	None
Relevant Figure Ref:	Figures 1.1 and 1.2				

1.4 Summary of PV Damages/Potential PV Benefits

Total PV Damages:		**Uncapped**	**Capped**	
	Fluvial	€ 4,413,719	€ 2,458,545	
Max Capped PV Benefits for 1% Fluvial AEP Event*:	€ 1,882,809			
Breakdown of Max Capped PV Benefits per Flood Cell for 1% Fluvial AEP Event:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	CRM_A	€ 851,829	€ 196,486	€ 1,048,315
	CRM_B	€ 617,646	€ 155,132	€ 772,778
	CRM_C	€ 0	€ 61,716	€ 61,716
Relevant Figure Ref:	Figures 1.3 and 1.4			

*These are the maximum benefits available if a FRM option with a 1% Fluvial AEP SOP is provided to all properties within the AFA.

1.5 Social Risk		
	Type	**Description**
High Vulnerability Properties at risk:	None	N/A
Social Infrastructure Assets:	None	N/A
Social Amenity Sites:	None	N/A
Relevant Figure Ref:	General Risk - Social	
1.6 Risk to the Environment		
	Type	**Description**
Risk to WFD Annex IV:	None	N/A
Risk to SACs:	None	N/A
Relevant Figure Ref:	General Risk - Environment	
1.7 Risk to Cultural Heritage		
	Type	**Description**
Risk to Sites of Cultural Heritage:	Limerick National Monuments	**50% AEP Fluvial Flood Extent**
		Bridge, Bridge Street
		20% AEP Fluvial Flood Extent
		Ritual site (holy well)
		0.5% AEP Fluvial Flood Extent
		Historic town (Croom Town)
		0.1% AEP Fluvial Flood Extent
		Fulacht fia, Croom
	NIAH Buildings	**50% AEP Fluvial Flood Extent**
		Bridge, Bridge Street, regionally important
		House, Bridge Street, regionally important
		10% AEP Fluvial Flood Extent
		Mill (water), regionally important
		5% AEP Fluvial Flood Extent
		Jays & Kays Foodstores, Bridge Street, regionally important
		2% AEP Fluvial Flood Extent
		2 No. Houses, Bridge Street, regionally important
		0.5% AEP Fluvial Flood Extent
		Mill (water), regionally important
		0.1% AEP Fluvial Flood Extent
		Croom Stores, Main Street
		Hogan (house), Main Street, regionally important
Relevant Figure Ref:	General Risk – Cultural Heritage	

1.8 Risk to the Economy		
	Type	**Description**
Risk to Transport Infrastructure:	Regional Road	**50% AEP Fluvial Flood Extent**
		R516 (Bridge Street)
	Tertiary Road	**0.1% AEP Fluvial Flood Extent**
		Main Street
Risk to Utility Infrastructure:	Pumping Station	**2% AEP Fluvial Flood Extent**
		Croom Pumping Station, Main Street
Relevant Figure Ref:	General Risk - Economy	

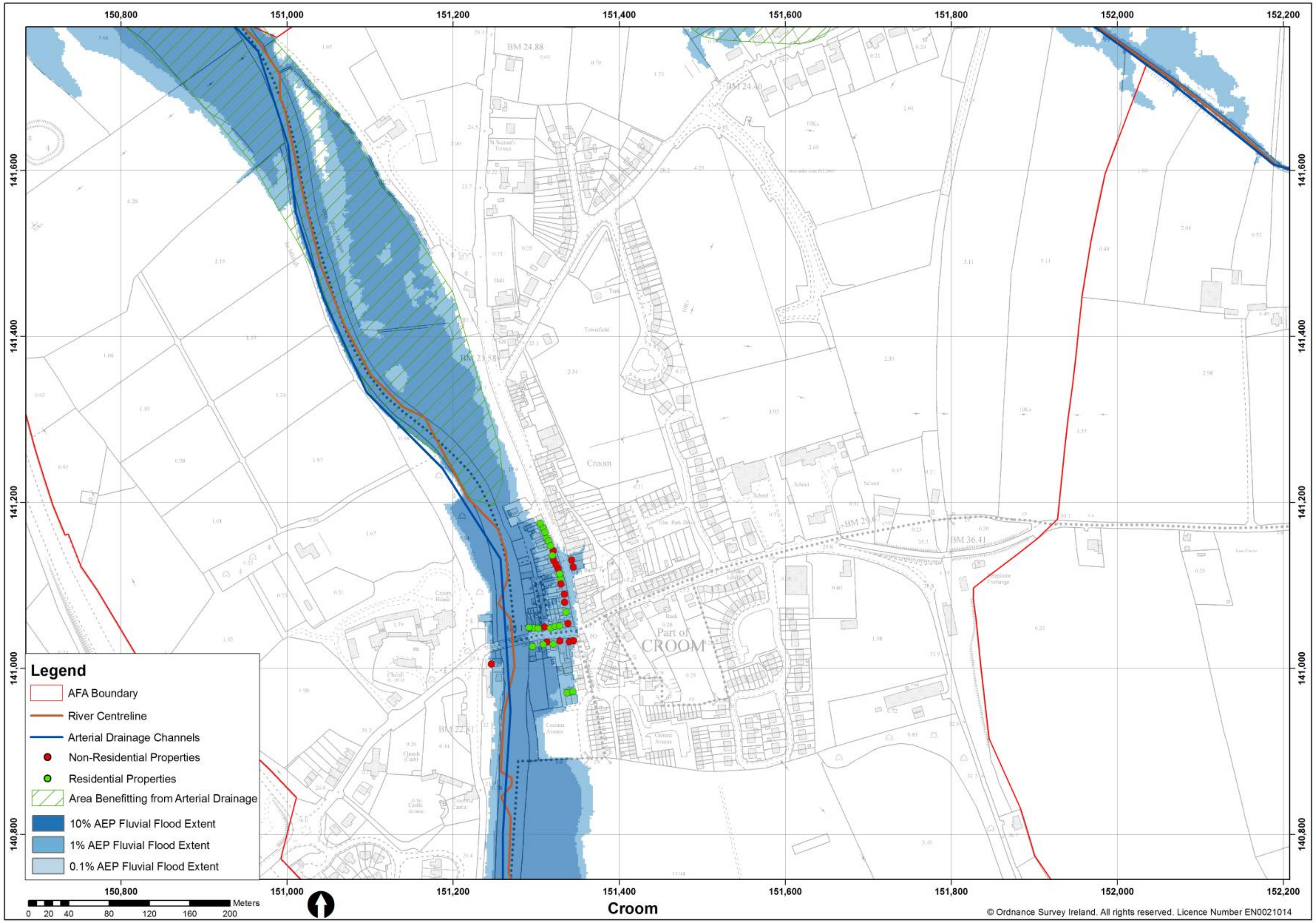


Figure 1.1 – Croom Fluvial Flood Risk to Properties

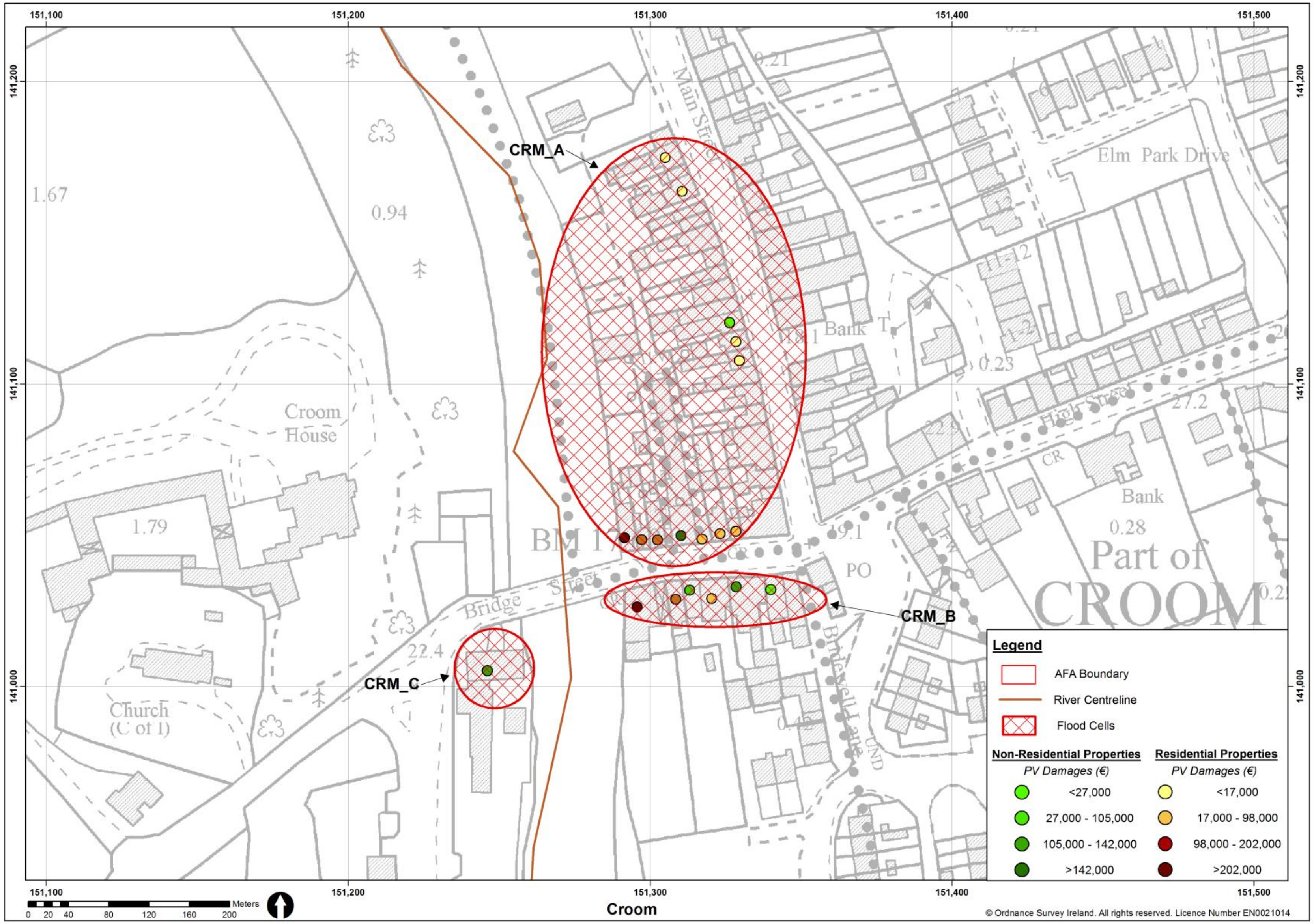


Figure 1.2 – Croom Total PV Damages for Properties within the 1% AEP Fluvial Flood Event and Flood Cells
Flood Cells are groupings of properties that are likely to be hydraulically linked

STAGE 2: Screening of the Measures

2.1 Baseline, Structural and Non-Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
B	Existing Regime	Viable	Viable	Viable	Viable	Viable	**Screened In**
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
Structural							
D	Storage	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
E	Flow Diversion	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
F	Increase Conveyance	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
G	Flood Defences	Viable	Viable	Viable	Viable	Viable	**Screened In**
H	Relocation of Properties	Unviable	Viable	Unviable	Viable	Viable	**Screened Out**
I	Other Measures	Unviable	Unviable	Unviable	Unviable	Unviable	**Screened Out**
Non-Structural							
J	Flood Forecasting / Warning / Response	Viable	Viable	Viable	Viable	Viable	**Screened In**
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	**Screened In**
L	Individual Property Resistance	Viable	Viable	Viable	Viable	Viable	**Screened In**
M	Individual Property Resilience	Viable	Viable	Viable	Viable	Viable	**Screened In**

2.2 Justification for Screened Out Baseline and Structural Measures

The following provides justification on Measures with an overall viability 'Screened Out' categorisation.

A	Do Nothing	Applicability Economic Environmental Social Cultural	Screened out due to the number of properties currently at risk of flooding.
C	Do Minimum	Applicability Economic Environmental Social Cultural	Screened out, as the "Do Minimum" FRM measure would have a negligible impact to the existing flood risk.
D	Storage	Applicability Economic Environmental Social Cultural	Screened out. A potential storage area, upstream of Croom was identified; see Figure 2.1. A storage capacity of approximately 300,000m^3 could be engineered for this area by using retaining embankments and a spill weir. However, this is only approximately 25% of the required storage to provide the 1% Fluvial AEP standard of protection to the AFA.

E	Flow Diversion	Applicability Economic Environmental Social Cultural	Screened out. No viable route for a diversion channel could be identified.
F	Increased Conveyance	Applicability Economic Environmental Social Cultural	Dredging the channel in this area was considered as shown in Figure 2.2 below. However, the measure was screened out as dredging the channel in this area would undermine the walls of existing properties along the river banks.
H	Relocation of Properties	Applicability Economic Environmental Social Cultural	Given the nature of the town relocation of 19 properties is not applicable to the area or socially acceptable.
L	Other Measures	Applicability Economic Environmental Social Cultural	No other Measures have been identified.

2.3 Summary of 'Screened In' Measures

The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.

Baseline Measures		**Non-Structural Measures**	
B	Existing Regime	J	Flood Forecasting / Warning / Response
Structural Measures		K	Public Awareness
G	Flood Defences	L	Individual Property Resistance
		M	Individual Property Resilience

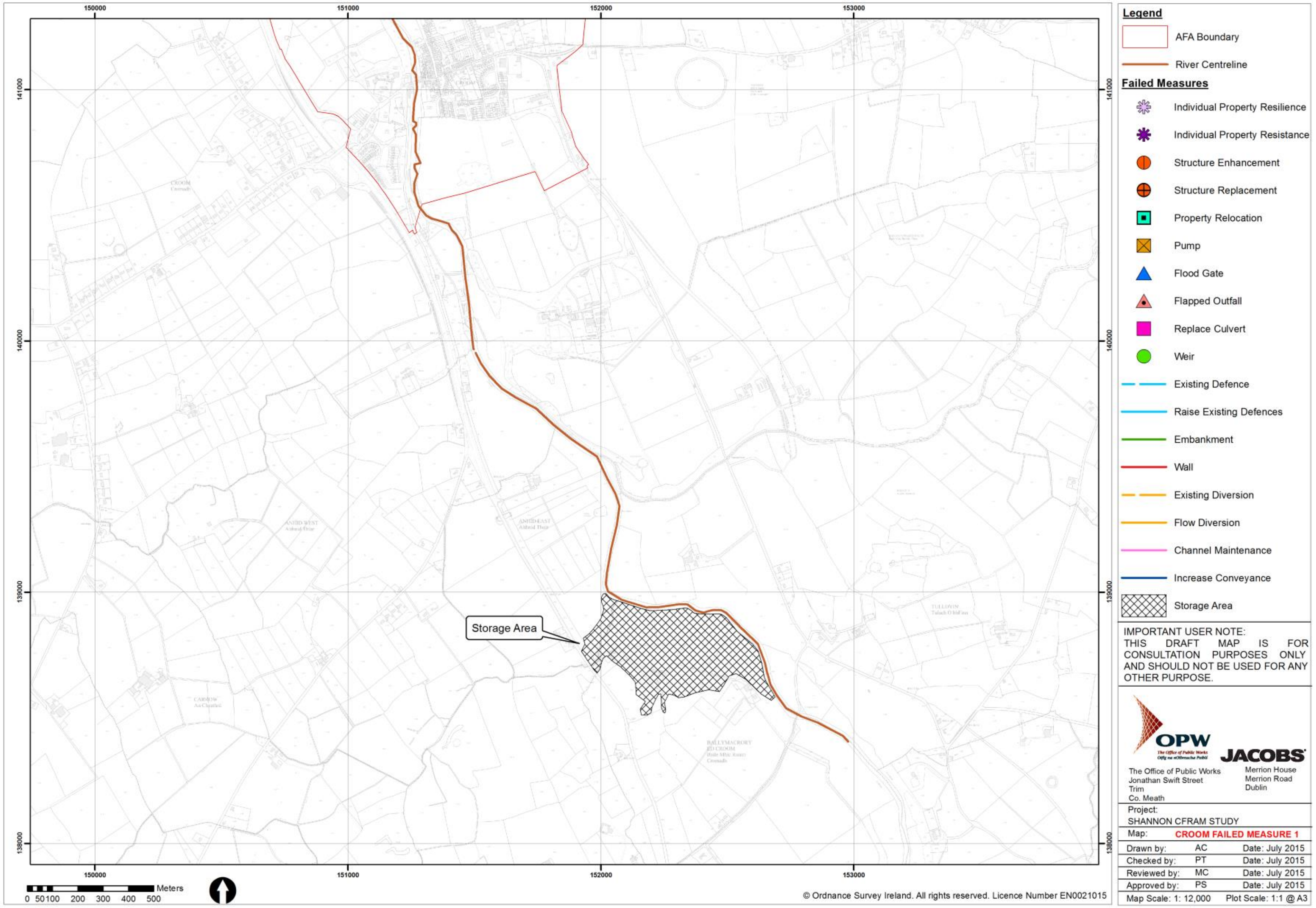


Figure 2.1 – Croom Failed Measure 1

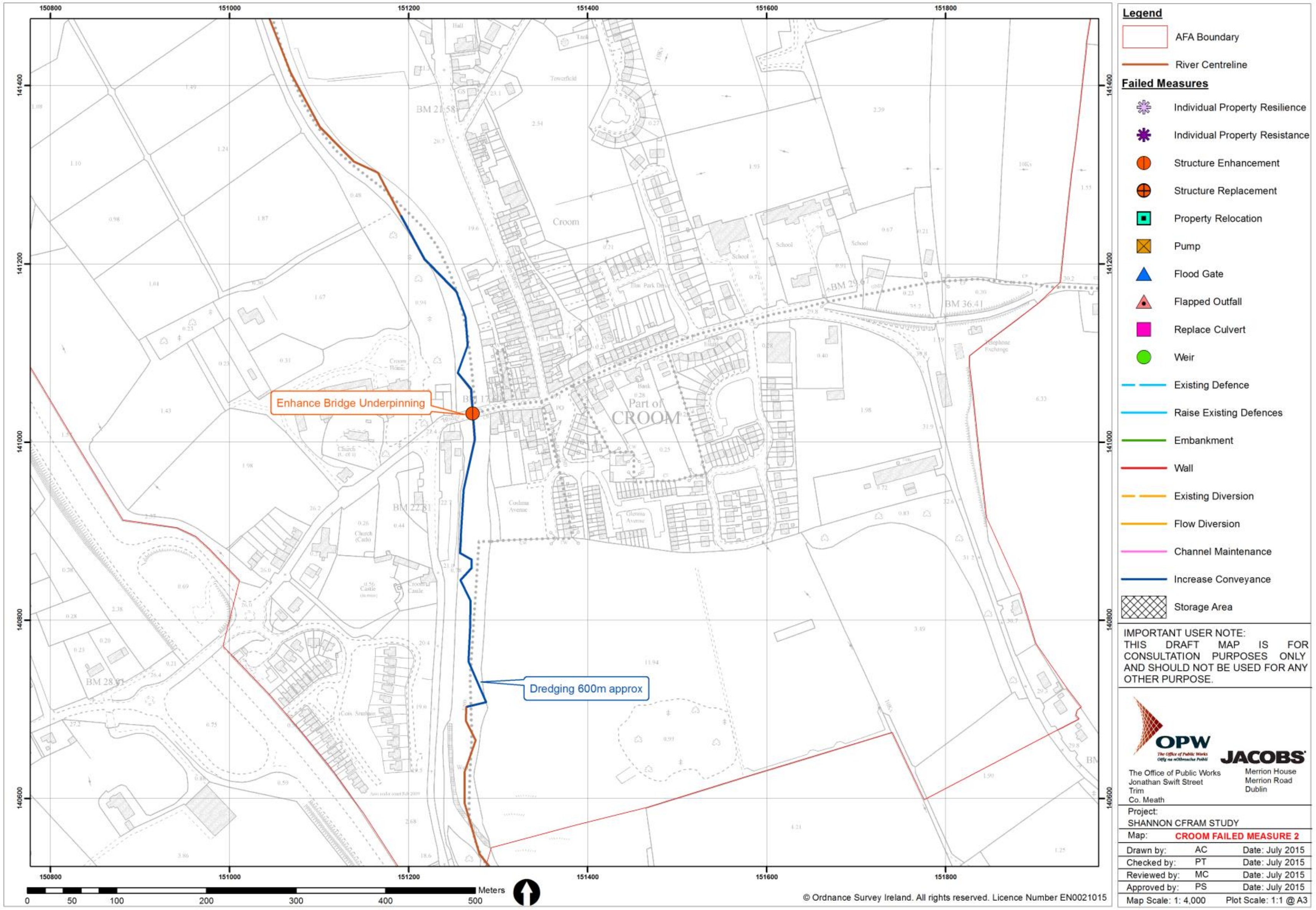


Figure 2.2 – Croom Failed Measure 2

STAGE 3: Selection of Options

3.1 Consideration of Options

The following are the agreed combination of 'Screened In' measures that comprise each of the Options being taken forward for further consideration.

Where appropriate, the 'Screened In' measures have been sub-divided into separate specific measures to ensure applicability to site conditions.

Measures		Different composition of measures per option						
Baseline Measures								
B	Existing Regime	✓						
Structural Measures								
G	Flood Defences							
Gi	New Flood Defences	✓						
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
J	Flood Forecasting / Warning / Response	✓						
K	Public Awareness	✓						
L	Individual Property Resistance	✓						
M	Individual Property Resilience	✓						
Option Reference		CRM_01						

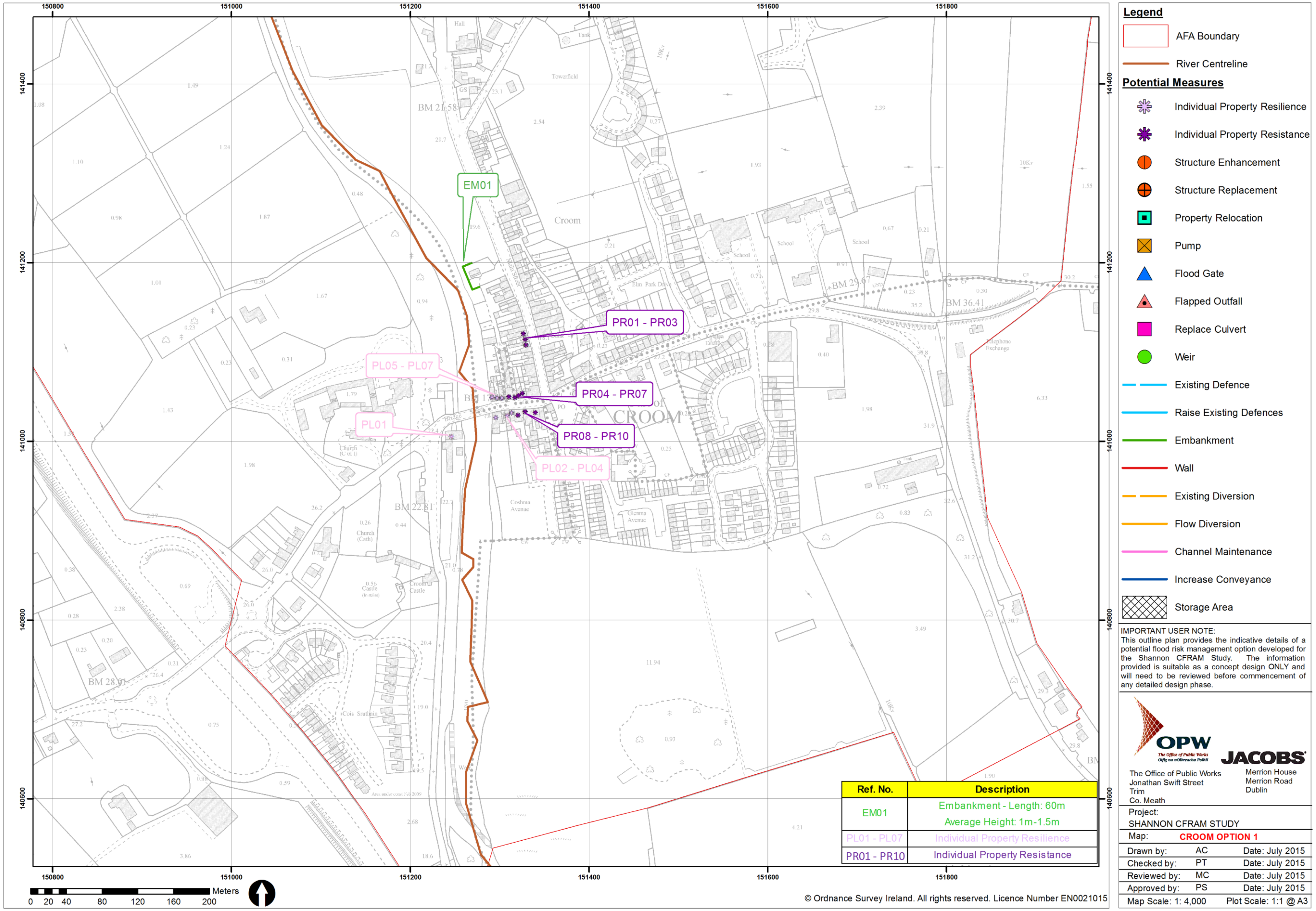
Measures not screened out but not included in options		
Measures		**Justification**
	None	N/A

<table>
<tr><td colspan="6">STAGE 4: Appraisal of Options</td></tr>
<tr><td colspan="6">4.1 Options Appraisal
Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Meeting. Below describes this concept design of each options and provides a summary of any significant comments/issues which were raised by LA staff at the Options Meetings. These comments will be considered in the local weightings and the MCA scores.</td></tr>
<tr><td colspan="2">Option Ref:</td><td colspan="4">CRM_01</td></tr>
<tr><td rowspan="3">Option Measures</td><td>Baseline</td><td>B</td><td colspan="3">Existing Regime</td></tr>
<tr><td>Structural</td><td>Gi</td><td colspan="3">New Flood Defences</td></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="4">This option will reduce from a 1% Fluvial AEP event to all 19 properties within the AFA, identified as being at risk from this source, and includes;
This option will provide a 1% Fluvial AEP Design standard to all properties within the AFA, identified as being at risk from this source.
Flood Forcasting and Public Awareness will apply to all properties within the AFA.
Individual property resielience will apply to all properties as shown in figure 5.1 below.
Individual property resistance will apply to all properties as shown in figure 5.1 below.
Existing arterial drainage maintenance scheme will need to be maintained as part of this option</td></tr>
<tr><td colspan="2" rowspan="2">Options Meeting:</td><td>Date:</td><td colspan="3">3rd Sept 2015</td></tr>
<tr><td>Summary:</td><td colspan="3">The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.</td></tr>
<tr><td colspan="6"></td></tr>
</table>

STAGE 5: Multi Criteria Assessment		
5.1 Options selected for the Multi Criteria Assessment Following the Option Meeting, the following options are the refined options for the Multi-Criteria Assessment (MCA) stage. This is the final of a five-stage MCA process.		
Option Reference		CRM_01
Baseline		
B	Existing Regime	Maintain existing arterial drainage.
Structural Measures		
Gi	New Flood Defences	Construct a flood defence embankment as shown in figure 5.1 below.
Non-Structural Measures		
J	Flood Forecasting / Warning / Response	Flood Forcasting and Public Awareness will apply to all properties within the AFA.
K	Public Awareness	Flood Forcasting and Public Awareness will apply to all properties within the AFA.
L	Individual Property Resistance	Individual property resistance will apply to all properties as shown in figure 5.1 below.
M	Individual Property Resilience	Individual property resilience will apply to all properties as shown in figure 5.1 below.
Table reference A summary of the outcome from the MCA is presented in the following table		Table 5.1

Table 5.1 – Multi Criteria Assessment Outcome for Option CRM_01

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Croom	Option Ref:	CRM_01
Option Measures			
Baseline	B	Existing Regime	
Structural	Gi	New Flood Defences	
Non-Structural	J	Flood Forecasting / Warning / Response	
	K	Public Awareness	
	L	Individual Property Resistance	
	M	Individual Property Resilience	
Criteria Scores			
Technical	880		
Economic	457		
Social	331		
Environmental	-135		
Economic Values			
Economic PV Benefits	€ 1,392,108		
PV Cost	€ 643,235		
NPV Benefits	€ 748,873		
Economic BCR	**2.16**		
Outcome Scores			
MCA PV Benefits	€ 746,553		
MCA Benefit Score	653		
MCA Benefit Score Ratio	1015.10		
Option Selection MCA	1533		
Relevant Figure	Figure 5.1		



Ref. No.	Description
EM01	Embankment - Length: 60m Average Height: 1m-1.5m
PL01 - PL07	Individual Property Resilience
PR01 - PR10	Individual Property Resistance

Figure 5.1 – Option CRM_01

5.2 Comparison of Multi Criteria Assessment Scores

Each option taken forward for further consideration through the Option Decision Meeting, has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Decision Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).

Categories	**Option Reference and Results**
	CRM_01
Criteria Scores	
Technical	880
Economic	457
Social	331
Environmental	-135
Economic Values	
Economic PV Benefits	€ 1,392,108
PV Cost	€ 643,235
NPV Benefits	€ 748,873
Economic BCR	2.16
Outcome Scores	
MCA PV Benefits	€ 746,553
MCA Benefit Score	653
MCA BCR	1015.10
Option Selection MCA	1533

<table>
<tr><td colspan="7">5.3 Recommendation of Preferred Option
It forms part of the CFRAM process for the recommendation of a preferred option for each AFA. The prioritised selection criteria used in this recommendation process is detailed in Section 3.7.3 of the Main Report.
Therefore, following the five stage Multi Criteria Assessment process, the preferred option is as outlined below</td></tr>
<tr><td colspan="2">Option Ref:</td><td colspan="5">CRM_01</td></tr>
<tr><td rowspan="3">Option Measures</td><td>Baseline</td><td>B</td><td colspan="4">Existing Regime</td></tr>
<tr><td>Structural</td><td>Gi</td><td colspan="4">Flood Defences: New Flood Defences</td></tr>
<tr><td>Non Structural</td><td colspan="2">J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Comments</td><td colspan="5">Providing individual property resistance and resilience will reduce the flood risk to the properties for the 1% AEP fluvial event. However, it will not completely eliminate the risk.

The economic BCR is greater than 1 for CRM_01 therefore this is a viable option.</td></tr>
</table>

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

<table>
<tr><th colspan="5">Fluvial Flood Forecasting Potential</th></tr>
<tr><th rowspan="3">Catchment Information</th><th colspan="2">Gauging Station</th><th rowspan="2">Catchment size (km ^{2})</th><th rowspan="2">Potential available forecast accuracy and reliability period</th></tr>
<tr><th>Fluvial</th><th>Rainfall</th></tr>
<tr><td>Yes</td><td>n/a</td><td>770</td><td>6 hours</td></tr>
<tr><th>Relevant Information:</th><td colspan="4">Bruree gauging station (GS 24004) lies 22 km upstream of Croom</td></tr>
<tr><th rowspan="3">Additional Infrastructure Recommended</th><th colspan="2">Gauging Station</th><th colspan="2" rowspan="2">Other</th></tr>
<tr><th>Fluvial</th><th>Rainfall</th></tr>
<tr><td>No</td><td>Yes</td><td colspan="2">n/a</td></tr>
<tr><th>Relevant Comments:</th><td colspan="4">GS 24004 represents only 30% of the total catchment at Croom. A flood forecasting scheme would have to be supplemented by inclusion of gauged tributaries (GS 24005 & 24083) which when included represent 80% of the total catchment area of Croom. To further improve the potential forecast period rainfall gauges would be required to develop a rainfall – runoff model on the large tributaries. This is required to provide additional reliability and accuracy to the forecast due to the number of distinct tributaries upstream of Croom.</td></tr>
</table>

Annex - Multi-Criteria Analysis Summary and Whole Life Cost Summaries for FRM Option(s)

CRITERIA		OBJECTIVE		Global Weighting	Local Weighting	Comments	CRM_01 B – Existing Regime Gi – New Flood Defences K – Public Awareness M – Individual Property Resilience L – Individual Property Resistance J – Flood Forecasting / Warning / Response	Option Score	Weighted Score
1	Technical	a	Ensure flood risk management options are operationally robust	20	5.00	The option scores are determined based on the level of operational risk to operate or perform successfully. Each measure is scored independently and the average of the measure scores is used as the score for the option.	None / Manageable; Negligible / Moderate / high; Very low / High; Low / Failure likely; Low / moderate / Unacceptable B 5.00; Gi 5.00; K; M 4.00; L 3.00; J 3.00	4.00	400
		b	Minimise health and safety risks associated with the construction and operation of flood risk management options	20	5.00	H&S risks are considered for construction and maintenance of flood risk management measures. The indicative aspirational score is set at five, with a point then deducted for each specific H&S risk in either construction or maintenance.	No risks / Moderate; Negligible / Moderate / high; Very low / High; Low / Very High; Low / moderate / Unacceptable Work near/in water Work near services or buildings	1.00	100
		c	Ensure flood risk management options are adaptable to future flood risk	20	5.00	The options scores are determined based on the sustainability and adaptability of the flood risk management measures in the face of potential future changes, including the potential impact of climate change. Each measure is scored independently and the average of the measure scores is used as the score for the option.	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. B 5.00; Gi 3.00; K; M 3.00; L 3.00; J 5.00	3.80	380
			TECHNICAL CRITERIA SCORE						**880**
2	Economic	a	Minimise economic risk	24	1.31		The score is calculated based on the reduction in AAD, following the full implementation of option.	4.07	128
		b	Minimise risk to transport infrastructure	10	5.00		Scoring is based on the reduction in flood risk to transport routes, following the full implementation of option.	0.50	25
		c	Minimise risk to utility infrastructure	14	5.00		Scoring is calculate based on a reduction in flood risk to utility infrastructure, following the full implementation of option.	3.88	271
		d	Minimise risk to agriculture	12	2.67	Source of Flooding: Fresh Water Percentage of AFA that is rural land: 53.38%	Area of Agricultural Land Flooded: No Change Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable	1.00	32
			ECONOMIC CRITERIA SCORE						**457**
3	Social	a i)	Minimise risk to human health and life - Residents	27	2.35	Flood Depths & Velocities: Assumed low risk to life Known Areas of Highly Vulnerable People: Reasonable Cross Section of Society	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	4.00	254
		a ii)	Minimise risk to human health and life - High vulnerability properties	17	0.00	Rate of Onset of flooding: Assumed 1-2 hours for evacuation	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	4.00	0
		b i)	Minimise risk to community - Social Infrastructure & Amenity	9	1.50	Assets of Particular Social Value: No	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	4.17	56
		b ii)	Minimise risk to community - Local employment	7	0.84	Asset of Particular Employment Value: No	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	3.59	21
			SOCIAL CRITERIA SCORE						**331**
4	Environmental	a	Support the objectives of the WFD	16	5.00	There are a number of WFD water bodies within the AFA associated with the Maigue River. The status of these water bodies are classified as Moderate. There are no potentially polluting sources within the 1% AEP Fluvial. The tributrary of the Maigue is a SAC waterbody. Local weighting to be applied for this objective is constant, and should always be set equal to 5 as WFD objectives must be achieved and are relevant to all waterbodies.	Construction - The construction of the embankment in close proximity to the Maigue River could cause potential changes physico-chemical impacts due to sediment release. There will be reduced flooding in areas with no significant polluting sources in 1% AEP Fluvial in the AFA. Flood Forecasting & Public Awareness, individual property resilience and individual property resistance are unlikely to impact the achievement of water body objectives. Therefore a potential for short term impediment to the achievement of WB objectives.	-1.00	-80
		b	Support the objectives of the Habitats Directive	10	3.00	No SACs within the AFA, the Lower River Shannon cSAC is c. 7.1 km downstream and Tory Hills cSAC is 1.1km east of the AFA. The Lower River Shannon cSAC Qualifying Interests that could occur within the AFA include otter, river, brook and sea lamprey, Atlantic salmon, and floating river vegetation. There are no SPAs within the AFA. The Rivers Shannon and River Fergus Estuaries SPA is c. 10km from the AFA to the north. There are no European sites within the AFA but there are a number of European Sites in close proximity to the AFA. Local weighting of 3 set by professional judgement. Weighting of 3 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (outside AFA) and potentially affected.	... associated with the construction of the embankment are: - Increases in suspended sediment - Pollution risks to the Maigue - Risk of invasive species spread during proposed works. - Impact to fish species Flood Forecasting & Public Awareness, individual property resilience and individual property resistance are unlikely to pose a detrimental impact upon European Sites. Therefore, potential detrimental impact upon cSAC and SPA sites, including a delay in the recovery of the site, but excluding impacts on the conservation objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible."	-1.00	-30
		c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	5	3.00	There are no designated ecological sites within the the AFA. The Tory Hill pNHA [000439] is c. 1 km from the AFA and the Adare Woods pNHA[000429] and are hydrologically connected Local weighting of 3 set by professional judgement. Weighting of 3 applied where a nationally important site (pNHA, NHA etc) is present (outside AFA) and potentially affected	Potential significant effects associated with the construction of the embankment are: - Increase in suspended solids - Pollution risks to the Maigue - Risk of invasive species spread during proposed works. - Impact to fish species Flood Forecasting & Public Awareness, individual property resilience and individual property resistance are unlikely to pose a detrimental impact upon European Sites. Therefore, potential for localised loss of or disturbance to flora/fauna.	-1.00	-15
		d	Protect, and where possible enhance, fisheries resource within the catchment	13	2.00	The Maigue River is not designated as a Salmonid River; however the river is considered to be a medium activity angling area. Local weighting of 2 set by professional judgement. Weighting of 2 applied where a waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.	Potential short term construction impacts that can be mitigated. Therefore, potential short-term minor impacts to fisheries habitat. Flood Forecasting & Public Awareness, individual property resilience and individual property resistance are unlikely to pose a detrimental impact upon fisheries.	-1.00	-26
		e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	8	1.00	Croom has no landscape planning designations within the AFA. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected.	There will be construction related impacts associated with the embankment and medium term associated with the embankment prior to establisment of vegetation . Therefore, there is a potential for short term impact to a low sensitivity landscape character/feature in the zone of visibility of the selected measure. Flood Forecasting & Public Awareness, individual property resilience and individual property resistance are unlikely to pose a detrimental impact upon the local landscape.	-1.00	-8
		f i)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of architectural value	4	3.00	Croom is not a heritage town. The 0.03 km2 ACA fall within the 1 % AEP Fluvial. There are 8 RPS and seven NIAH within the 1 % AEP Fluvial. Local weighting of 3 set by professional judgement. Weighting of 3 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a high to moderate vulnerability.	The option will reduce the potential for flooding in the 1% AEP for 3 NIAH through individual property resistance. There are also 2 NIAH properties where Individual Propoerty Resilience is recommended which will help to protect them. The option could increase the level of protection for a number of architectural features.	2.00	24
		f ii)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of archaeological value	4	2.00	Croom is not a heritage town, there are two RMP but no other protected features of archaeological value within the 1% AEP Fluvial. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are a number of sites listed on the RMP/RPS present and potentially affected. (moderate to low vulnerability).	There is no anticipated change to the risk of flooding for the holy well or the bridge. Therefore no effects on Archaeological Features.	0.00	0
			ENVIRONMENTAL CRITERIA SCORE						**-135**

Economic Values	**Economic PV Benefits**	€1,392,108
	Cost	€643,235
	NPV Benefits	€748,873
	Economic BCR	**2.16**
Outcome Scores	**MCA PV Benefits**	€746,553
	MCA Benefit Score	653
	MCA BCR	**1015.10**
	Option Selection MCA	1533

Objective	Global Weightings (fixed)	Local Weightings		Baseline Comments	Option 1 Comments
1.A	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has negligible operational risks to operate or perform successfully.
1.B	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has low/moderate health and safety risks associated with the construction and operation of flood risk management option.
1.C	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions.
2.A	24	1.31	calculated	Local weighting is calculated based on the baseline AAD.	This score is calculated based on the reduction in AAD, following the full implementation of option.
2.B	10	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to transport infrastructure. Local weighting capped at maximum value of 5.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.
2.C	14	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to utility infrastructure. Local weighting capped at maximum value of 5.	This score is calculated based on a reduction in flood risk to utility infrastructure, following full implementation of option.
2.D	12	0.00	Professional judgement	Local weighting is calculated based on the percentage of rural land within the AFA.	This score is determined based on the presence of flood forecasting, following full implementation of the option.
3.A (i)	27	2.35	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to residential properties.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option.
3.A (ii)	17	0.00	calculated but adjusted by professional judgement if necessary	There are no high vulnerability properties at risk within this AFA.	There is no risk to high vulnerability properties within the AFA.
3.B (i)	9	1.50	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to social infrastructure.	There is no risk to social infrastructure or amenity within this AFA.
3.B (ii)	7	0.84	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to local employment	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option.
4.A	16	5.00	fixed	No SACs within the AFA, the Lower River Shannon cSAC is c. 7.1 km downstream and Tory Hills cSAC is 1.1km east of the AFA. The Lower River Shannon cSAC Qualifying Interests that could occur within the AFA include otter, river, brook and sea lamprey, Atlantic salmon, and floating river vegetation. There are no SPAs within the AFA. The Rivers Shannon and River Fergus Estuaries SPA is c. 10km from the AFA to the north. There are no European sites within the AFA but there are a number of European Sites in close proximity to the AFA. Local weighting of 3 set by professional judgement. Weighting of 3 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (outside AFA) and potentially affected.	Construction - The construction of the embankment in close proximity to the Maigue River could cause potential changes physico-chemical impacts due to sediment release. There will be reduced flooding in areas with no significant polluting sources in 1% AEP Fluvial in the AFA. Flood Forecasting & Public Awareness, individual property resilience and individual property resistance are unlikely to impact the achievement of water body objectives. Therefore a potential for short term impediment to the achievement of WB objectives.
4.B	10	3.00	Professional judgement	No SACs within the AFA, the Lower River Shannon cSAC is c. 7.1 km downstream and Tory Hills cSAC is 1.1km east of the AFA. The Lower River Shannon cSAC Qualifying Interests that could occur within the AFA include otter, river, brook and sea lamprey, Atlantic salmon, and floating river vegetation. There are no SPAs within the AFA. The Rivers Shannon and River Fergus Estuaries SPA is c. 10km from the AFA to the north. There are no European sites within the AFA but there are a number of European Sites in close proximity to the AFA. Local weighting of 3 set by professional judgement. Weighting of 3 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (outside AFA) and potentially affected.	Potentially significant effects associated with the construction of the embankment are: - Increases in suspended sediment - Pollution risks to the Maigue - Risk of invasive species spread during proposed works. - Impact to fish species Flood Forecasting & Public Awareness, individual property resilience and individual property resistance are unlikely to pose a detrimental impact upon European Sites. Therefore, potential detrimental impact upon cSAC and SPA sites, including a delay in the recovery of the site, but excluding impacts on the conservation objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible."
4.C	5	3.00	Professional judgement	There are no designated ecological sites within the the AFA. The Tory Hill pNHA [000439] is c. 1 km from the AFA and the Adare Woods pNHA[000429] and are hydrologically connected Local weighting of 3 set by professional judgement. Weighting of 3 applied where a nationally important site (pNHA, NHA etc) is present (outside AFA) and potentially affected	Potential significant effects associated with the construction of the embankment are: - Increase in suspended solids - Pollution risks to the Maigue - Risk of invasive species spread during proposed works. - Impact to fish species Flood Forecasting & Public Awareness, individual property resilience and individual property resistance are unlikely to pose a detrimental impact upon European Sites. Therefore, potential for localised loss of or disturbance to flora/fauna.
4.D	13	2.00	Professional judgement	The Maigue River is not designated as a Salmonid River; however the river is considered to be a medium activity angling area. Local weighting of 2 set by professional judgement. Weighting of 2 applied where a waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.	Potential short term construction impacts that can be mitigated. Therefore, potential short-term minor impacts to fisheries habitat. Flood Forecasting & Public Awareness, individual property resilience and individual property resistance are unlikely to pose a detrimental impact upon fisheries.
4.E	8	1.00	Professional judgement	Croom has no landscape planning designations within the AFA. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected.	There will be construction related impacts associated with the embankment and medium term associated with the embankment prior to establisment of vegetation . Therefore, there is a potential for short term impact to a low sensitivity landscape character/feature in the zone of visibility of the selected measure. Flood Forecasting & Public Awareness, individual property resilience and individual property resistance are unlikely to pose a detrimental impact upon the local landscape.
4.F(i)	4	3.00	Professional judgement	Croom is not a heritage town. The 0.03 km2 ACA fall within the 1 % AEP Fluvial. There are 8 RPS and seven NIAH within the 1 % AEP Fluvial. Local weighting of 3 set by professional judgement. Weighting of 3 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a high to moderate vulnerability.	The option will reduce the potential for flooding in the 1% AEP for 3 NIAH through individual property resistance. There are also 2 NIAH properties where Individual Propoerty Resilience is recommended which will help to protect them. The option could increase the level of protection for a number of architectural features.
4.F(ii)	4	2.00	Professional judgement	Croom is not a heritage town, there are two RMP but no other protected features of archaeological value within the 1% AEP Fluvial. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are a number of sites listed on the RMP/RPS present and potentially affected. (moderate to low vulnerability).	There is no anticipated change to the risk of flooding for the holy well or the bridge. Therefore no effects on Archaeological Features.

Option 1 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis						Notes to CFRAM Consultants
			€	€	€	
(1)	**Basic Construction Costs (Estimate)**				**215,397**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2)	**Preliminaries**	25.1%			**54,021**	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**269,419**	
(3)	**Optimism Bias**	40.0%			**107,767**	Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**377,186**	
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13.0%			**49,034**	Set at 13%
	Construction Costs and Fees				**426,220**	
(6)	**Other Items**					
(a)	Allowance for Archaeology & Environmental Mitigation Measures	12.0%		45,262		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	15.0%		56,578		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation	4% assumed		15,087		Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance			25,500		See "Guidance E – Per Cent for Art Note"
(e)	Est. NPV Operation & Maintenance		53,277			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	40.0%	21,311	74,587	**217,015**	Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**643,235**	

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	J. Reynolds	Date:	04/08/2015
Checked by:		Date:	

Project reference	S07	Project name:	Croom - Option 1

Base date for estimates (year 0)	Oct-2013	Construction Price Index (CPI)	0.987
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues /constraints	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	Cost (€)	Comment
Total wall costs		
Total embankment costs	€18,062	*Embankment to protect substation. Assumed imported material, no piles.*
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs	€190,116	*Individual Property Resilience for all properties.*
Total user specified method costs	€7,219	*3 week public awareness campaign.*
Total Construction costs	€215,397	
Apply update to unit rate (CPI) if appropriate (cell N15)	€212,499	
Enter appropriate preliminaries estimate (%)	25%	
Enter other applicable costs (€)		
Total capital cost (€)	€269,419	
Consider amendments based on site issues/constraints (cell N16)	€269,419	
Total capital cost (€)	€269,419	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs		
Total embankment O&M costs	€190	*average O&M assumed.*
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs	€1,344	
Total user specified method O&M costs	€963	*2 day annual refresher public awareness campaign.*
Total Operation and Maintenance costs	€2,496	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€322,695	
Optimism bias rate (from external sheet)	40%	*Default CFRAMs Optimism Bias.*
Total Cost including Optimism Bias	€451,773	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€269,419
Annual maintenance cost (€)	€2,496
Other cost (€)	€0
Other works frequency (years)	

Key

- Information
- Calculation
- Cost input
- User information

Discount rate:	4.0%	Present Value Factor:		22.341	Total PVc (€k):		322695
	Cash sum	0	269419	122323	0	391742	322695
	Discount	Cost Elements				TOTALS:	
year	Factor	Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0	269419			269418.5	269418.5
1	0.962			2496		2496.4	2400.4
2	0.925			2496		2496.4	2308.1
3	0.889			2496		2496.4	2219.3
4	0.855			2496		2496.4	2133.9
5	0.822			2496		2496.4	2051.8
6	0.790			2496		2496.4	1972.9
7	0.760			2496		2496.4	1897.0
8	0.731			2496		2496.4	1824.1
9	0.703			2496		2496.4	1753.9
10	0.676			2496		2496.4	1686.5
11	0.650			2496		2496.4	1621.6
12	0.625			2496		2496.4	1559.2
13	0.601			2496		2496.4	1499.3
14	0.577			2496		2496.4	1441.6
15	0.555			2496		2496.4	1386.2
16	0.534			2496		2496.4	1332.8
17	0.513			2496		2496.4	1281.6
18	0.494			2496		2496.4	1232.3
19	0.475			2496		2496.4	1184.9
20	0.456			2496		2496.4	1139.3
21	0.439			2496		2496.4	1095.5
22	0.422			2496		2496.4	1053.4
23	0.406			2496		2496.4	1012.9
24	0.390			2496		2496.4	973.9
25	0.375			2496		2496.4	936.4
26	0.361			2496		2496.4	900.4
27	0.347			2496		2496.4	865.8
28	0.333			2496		2496.4	832.5
29	0.321			2496		2496.4	800.5
30	0.308			2496		2496.4	769.7
31	0.296			2496		2496.4	740.1
32	0.285			2496		2496.4	711.6
33	0.274			2496		2496.4	684.2
34	0.264			2496		2496.4	657.9
35	0.253			2496		2496.4	632.6
36	0.244			2496		2496.4	608.3
37	0.234			2496		2496.4	584.9
38	0.225			2496		2496.4	562.4
39	0.217			2496		2496.4	540.8
40	0.208			2496		2496.4	520.0
41	0.200			2496		2496.4	500.0
42	0.193			2496		2496.4	480.7
43	0.185			2496		2496.4	462.3
44	0.178			2496		2496.4	444.5
45	0.171			2496		2496.4	427.4
46	0.165			2496		2496.4	410.9
47	0.158			2496		2496.4	395.1
48	0.152			2496		2496.4	379.9
49	0.146			2496		2496.4	365.3

Appendix C7 Option Appraisal Report - Dromcolliher

1. Preliminary Report: Summary of Current Flood Risk					
1.1 AFA and Watercourse Details					
AFA	Dromcolliher				
Unit of Management:	23				
Primary Watercourse(s):	Ahavarragh Stream				
1.2 Summary of Flood Risk in 1% AEP Event					
Source of flood risk	**Fluvial**	Coastal	Both		
Total Number of Properties at risk in AFA:		**Residential**	**Non-Residential**	**Total**	
	Fluvial	0	1	1	
AFA Flood Cells:	**Total Number:**	1			
	Flood Cell Titles:	DRR_A			
Breakdown of properties at (combined) risk per Flood Cell:	**Flood Cell Ref**	**Residential**	**Non-Residential**	**Total**	
	DRR_A	0	1	1	
Relevant Comments:	None				
Relevant Figure Ref:	Figure 1.1				

1.3 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	**Storage**	**Flow Diversion**	**Flood Defences**	**Level Control**	**Other**
None	None	**Yes**	**Yes**	None	None
Relevant Comments:	None				
Relevant Figure Ref:	Figure 1.1				

1.4 Summary of PV Damages				
Total PV Damages:		**Uncapped**	**Capped**	
	Fluvial	€ 266,081	€ 167,174	
Max Capped Benefits for 1% AEP Fluvial Event:	€ 155,748			
Breakdown of Max Capped PV benefits per Flood Cell for 1% Fluvial AEP Event:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	DRR_A	€ 0	€ 155,748	€ 155,748
Relevant Comments:	None			
Relevant Figure Ref:				

1.5 Social Risk		
	Type	**Description**
High Vulnerability Properties at risk :	None	N/A
Social Infrastructure Assets:	None	N/A
Social Amenity Sites:	None	N/A
Relevant Figure Ref:	General Risk - Social	

1.6 Risk to the Environment		
	Type	**Description**
Risk to WFD Annex IV	None	N/A
Risk to SACs	None	N/A
Relevant Figure Ref:	General Risk - Environment	
1.7 Risk to Cultural Heritage		
	Type	**Description**
Risk to Sites of Cultural Heritage:	None	N/A
Relevant Figure Ref:	General Risk – Cultural Heritage	
1.8 Risk to the Economy		
	Type	**Description**
Risk to Transport Infrastructure	Regional Road	**50% AEP Fluvial Flood Extent**
		R522
		0.1% AEP Fluvial Flood Extent
		R515
Risk to Utility Infrastructure	None	**N/A**
Relevant Figure Ref:	General Risk – Economy	

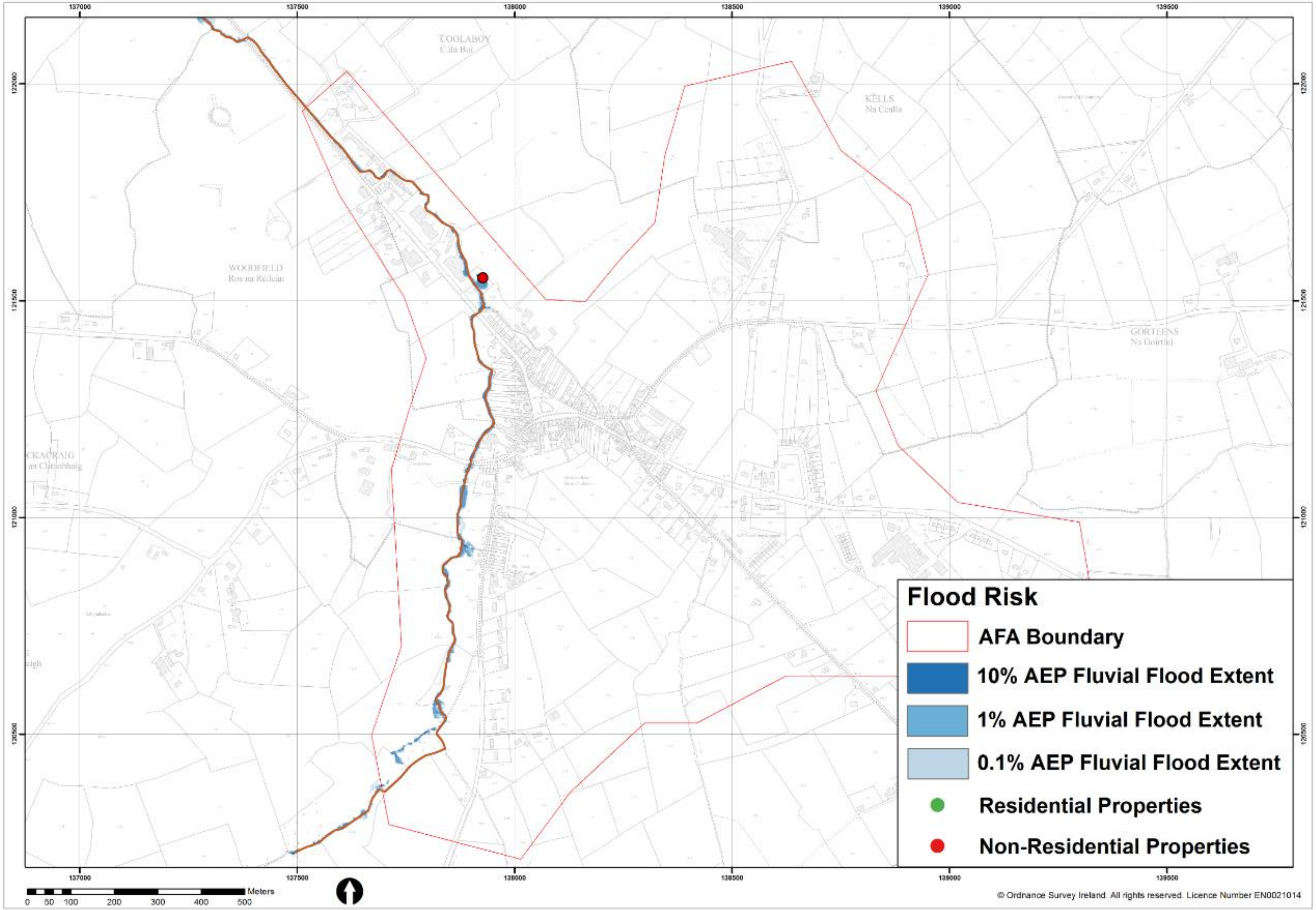


Figure 1.1 – Dromcolliher Flood Risk to Properties

Dromcolliher is identified as an AFA that benefits from an existing flood relief scheme and therefore no further assessment to identify potentially viable flood risk management measures or options is required through this CFRAM Study. Recommendations will be made in the FRMP that the existing flood relief scheme must be monitored and maintained.

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

<table>
<tr><th colspan="6">Fluvial Flood Forecasting Potential</th></tr>
<tr><th rowspan="3">Catchment Information</th><th colspan="2">Gauging Station</th><th rowspan="2">Catchment size (km ^{2})</th><th rowspan="2">Potential available forecast accuracy and reliability period</th></tr>
<tr><th>Fluvial</th><th>Rainfall</th></tr>
<tr><td>No</td><td>No*</td><td>5.4</td><td>Unknown</td></tr>
<tr><th>Relevant Information:</th><td colspan="4">This is determined unknown for the following reasons;
• No suitable rain gauge
• No suitable gauging station</td></tr>
<tr><th rowspan="3">Additional Infrastructure Recommended</th><th colspan="2">Gauging Station</th><th colspan="2" rowspan="2">Other</th></tr>
<tr><th>Fluvial</th><th>Rainfall</th></tr>
<tr><td>n/a</td><td>n/a</td><td colspan="2">n/a</td></tr>
<tr><th>Relevant Comments:</th><td colspan="4">Dromcolliher lies towards the upstream reach of the catchment. As the catchment is small any potential flood forecasting early warning system would be unlikely to provide accurate and reliable predictions. Moreover, the potential forecast period is small. There is little to no potential for the development of an effective flood forecasting system for Dromcolliher.</td></tr>
</table>

*For this assessment only 15 minute tipping bucket gauge were considered.

Appendix C8 Option Appraisal Report - Kilmallock

1. Preliminary Report: Summary of Current Flood Risk				
1.1 AFA and Watercourse Details				
AFA	Kilmallock			
Unit of Management:	24			
Primary Watercourse(s):	River Loobagh, Ahatrishnaun Stream, Ahnagluggin Stream			

1.2 Summary of Flood Risk in 1% AEP Fluvial Event

Source of flood risk	**Fluvial**	Coastal	Both	
Total Number of Properties at risk in AFA in 1% Fluvial AEP Event		**Residential**	**Non-Residential**	**Total**
	Fluvial	3	0	3
AFA Flood Cells:	**Total Number:**	2		
	Flood Cell Titles:	KIL_A, KIL_B		
Breakdown of properties at risk per Flood Cell:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	KIL_A	1	0	1
	KIL_B	2	0	2
Relevant Figure Ref:	Figure 1.1 and 1.2			

1.3 Summary of Existing Flood Risk Management Measures

Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
Yes	None	None	None	None	None
Relevant Figure Ref:	Figure 1.2				

1.4 Summary of PV Damages/Potential PV Benefits

Total PV Damages:		**Uncapped**	**Capped**	
	Fluvial	€ 79,805	€ 79,805	
Max Capped Benefits for 1% AEP Fluvial Event*:	€ 29,294			
Breakdown of Max Capped PV Benefits per Flood Cell for 1% AEP Fluvial Event:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	KIL_A	€ 6,819	€ 0	€ 6,819
	KIL_B	€ 22,475	€ 0	€ 22,475
Relevant Figure Ref:	Figure 1.2			

*These are the maximum benefits available if a FRM option with a 1% Fluvial AEP SOP is provided to all properties within the AFA.

1.5 Social Risk

	Type	Description
High Vulnerability Properties at risk:	None	N/A
Social Infrastructure Assets:	None	N/A
Social Amenity Sites:	None	N/A
Relevant Figure Ref:	General Risk - Social	

<table>
<tr><th colspan="3">1.6 Risk to the Environment</th></tr>
<tr><td></td><td>Type</td><td>Description</td></tr>
<tr><td>Risk to WFD Annex IV</td><td>None</td><td>N/A</td></tr>
<tr><td>Risk to SACs</td><td>None</td><td>N/A</td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="2">General Risk - Environment</td></tr>
<tr><th colspan="3">1.7 Risk to Cultural Heritage</th></tr>
<tr><td></td><td>Type</td><td>Description</td></tr>
<tr><td rowspan="7">Risk to Sites of Cultural Heritage:</td><td rowspan="3">NIAH</td><td>50% AEP Fluvial Flood Extent</td></tr>
<tr><td>North Bridge carrying the Limerick Road over the River Loobagh, classed as regionally important.</td></tr>
<tr><td>Wolfe Tone Street Bridge over the River Loobagh classed as regionally important.</td></tr>
<tr><td rowspan="4">Limerick National Monument Record</td><td>5% AEP Fluvial Flood Extent</td></tr>
<tr><td>2 No. Archaeological excavations at site between Wolfe Tone Street and the River Loobagh.</td></tr>
<tr><td>0.5% AEP Fluvial Flood Extent</td></tr>
<tr><td>Dominican friars house at Abbeyfarm.</td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="2">General Risk – Cultural Heritage</td></tr>
<tr><th colspan="3">1.8 Risk to the Economy</th></tr>
<tr><td></td><td>Type</td><td>Description</td></tr>
<tr><td rowspan="2">Risk to Transport Infrastructure:</td><td rowspan="2">Regional Route</td><td>50% AEP Fluvial Flood Extent</td></tr>
<tr><td>R512</td></tr>
<tr><td>Risk to Utility Infrastructure:</td><td>None</td><td>N/A</td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="2">General Risk - Economy</td></tr>
</table>

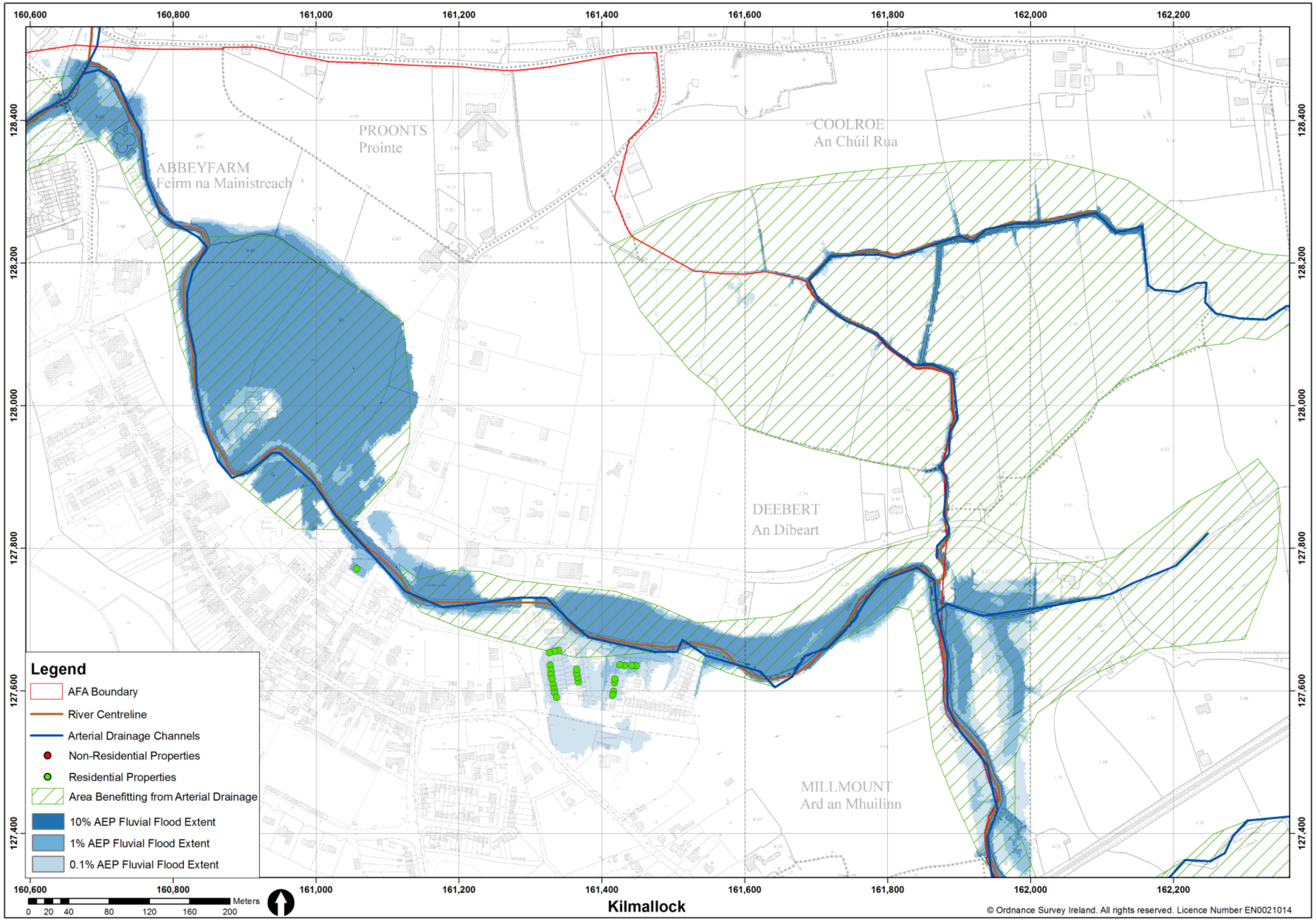


Figure 1.1 – Kilmallock Flood Risk to Properties

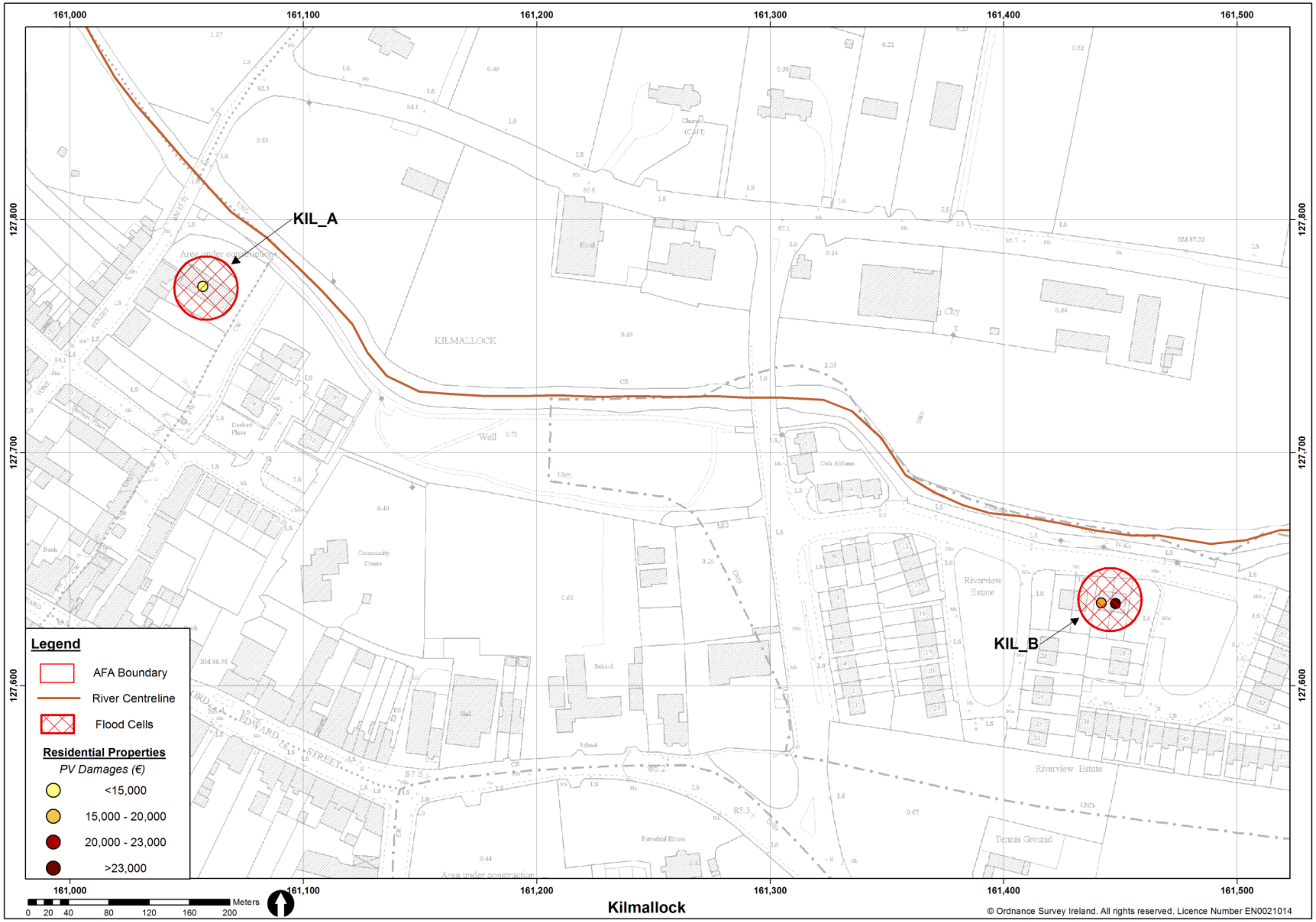


Figure 1.2 – Kilmallock Total PV Damages for properties within 1% AEP Fluvial Flood Event and Flood Cells
Flood Cells are groupings of properties that are likely to be hydraulically linked

STAGE 2: Screening of the Measures							
2.1 Baseline, Structural and Non-Structural Measures Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.							
Measures		**Appl.**	**Econ.**	**Envir.**	**Soc.**	**Cult.**	**Overall Viability**
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
B	Existing Regime	Viable	Viable	Viable	Viable	Viable	**Screened In**
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
Structural							
D	Storage	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
E	Flow Diversion	Unviable	Unviable	Viable	Viable	Viable	**Screened Out**
F	Increase Conveyance	Viable	Unviable	Viable	Viable	Viable	**Screened Out**
G	Flood Defences	Viable	Unviable	Viable	Viable	Viable	**Screened Out**
H	Relocation of Properties	Viable	Unviable	Viable	Unviable	Viable	**Screened Out**
I	Other	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
Non-Structural							
J	Flood Forecasting / Warning / Response	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	**Screened In**
L	Individual Property Resistance	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
M	Individual Property Resilience	Unviable	Unviable	Viable	Viable	Viable	**Screened Out**

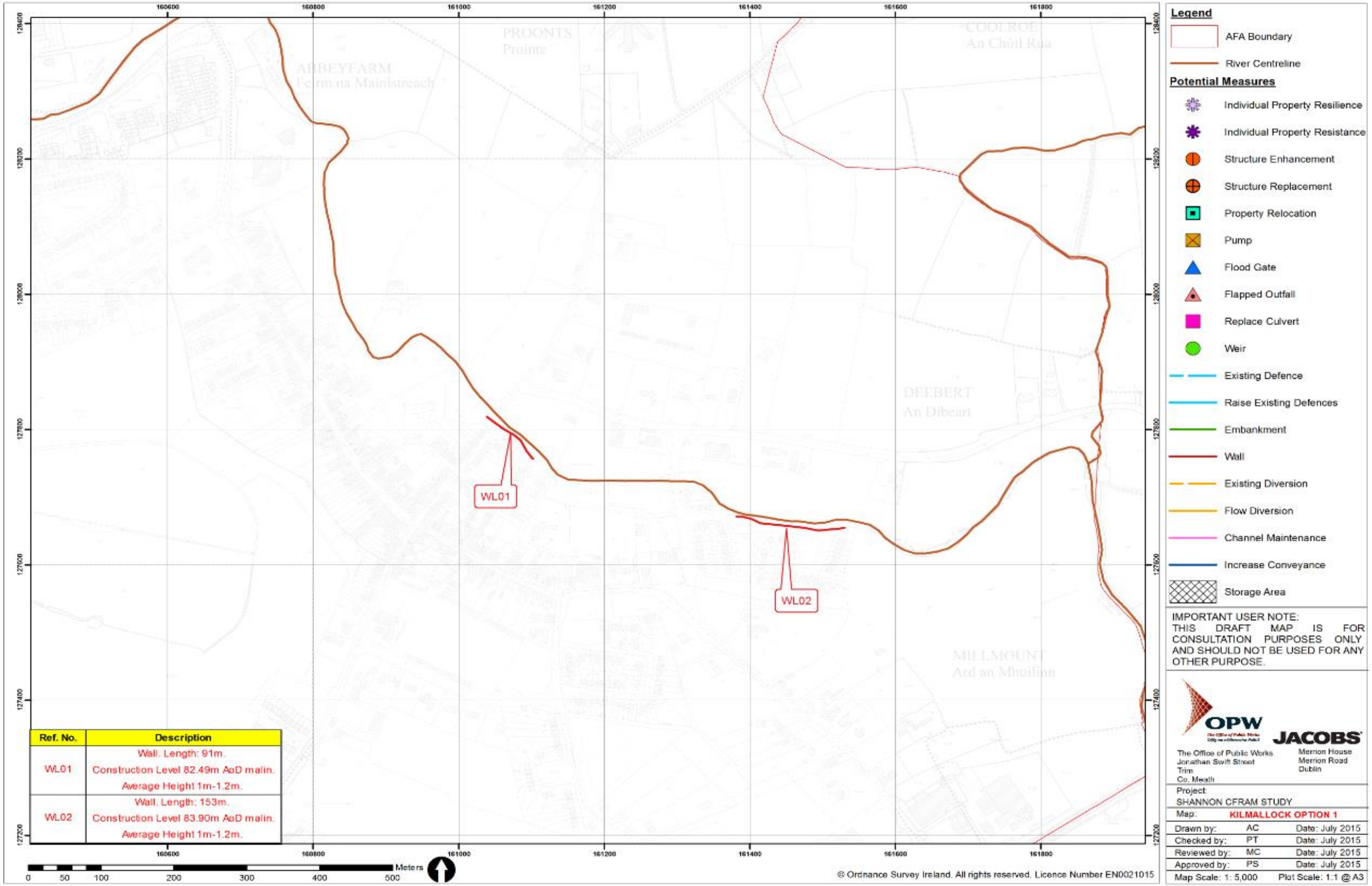
2.2 Justification for Screened Out Baseline and Structural Measures			
The following provides justification on Measures with an overall viability 'Screened Out' categorisation.			
A	Do Nothing	Applicability Economic Environmental Social Cultural	Screened out due to the number of properties currently at risk of flooding.
C	Do Minimum	Applicability Economic Environmental Social Cultural	Screened out, as the "Do Minimum" FRM measure would have a negligible impact to the existing flood risk.
D	Storage	Applicability Economic Environmental Social Cultural	Screened out. No suitable storage areas were identified.
E	Flow Diversion	Applicability Economic Environmental Social Cultural	Screened out. No viable route could be identified for a flow diversion channel.

F	Increase Conveyance	Applicability Economic Environmental Social Cultural	Screened out. Dredging 1.5km dredging of the River Loobagh was considered. The cost of the dredging works is estimated at €250,000 using the cost database. Considering the max PV benefits are € 29,294 this measure was considered economically unviable as there would be clearly insufficient PV benefits to promote an increase conveyance FRM measure at this SSA.
G	Flood Defences	Applicability Economic Environmental Social Cultural	Screened out. Construction of flood defence walls were considered. The cost of the construction of the walls is estimated at €244,713 using the cost database. Considering the max PV benefits are €29,294 this measure was considered economically unviable as there would be clearly insufficient PV benefits to promote a flood defence FRM measure at this SSA.
H	Relocation of Properties	Applicability Economic Environmental Social Cultural	Considering the max PV benefits are €29,294 this measure was considered economically unviable as there would be clearly insufficient PV benefits to relocate the property at risk.
J	Flood Forecasting / Warning / Response	Applicability Economic Environmental Social Cultural	Screened out as there are no current gauging stations in place on the watercourses in the AFA or upstream. A gauging station in Killmallock will be recommended in the FRMP to determine if a flood forecasting system could be viable in the future.
L	Individual property resistance	Applicability Economic Environmental Social Cultural	Screened out. Individual property resistance is not considered independently of flood forecasting, which has been deemed unviable.
M	Individual property resilience	Applicability Economic Environmental Social Cultural	Considering the max PV benefits are €29,294 this measure was considered economically unviable as there would be clearly insufficient PV benefits to promote a individual property resilience FRM measure at this SSA.

2.3 Summary of 'Screened In' Measures

The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.

Baseline Measures		Non-Structural Measures	
B	Existing Regime	K	Public Awareness



Ref. No.	Description
WL01	Wall. Length: 91m. Construction Level 82.49m AoD malin. Average Height 1m-1.2m.
WL02	Wall. Length: 153m. Construction Level 83.90m AoD malin. Average Height 1m-1.2m.

Figure 2.1 – Screened Out Measure - Flood Defences

The only viable measures identified are the Baseline Measure “Existing Regime” and the Non-Structural Measure “Public Awareness”. Neither of these measures can form an option that will provide the required 1% AEP event design standard. Therefore, no appraisal of options or multi criteria analysis has been carried out for this AFA.

With maximum PV benefits of €29,294 if the 1% AEP design standard was provided, the adoption of an alternative standard would not provide significant additional benefit in relation to costs and impact therefore alternative design standard was not considered.

It will be recommended in the FRMP that a gauging station should be installed in Kilmallock to confirm the current risk is as represented. Gauge data will also determine if flood forecasting is a viable measure.

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

Fluvial Flood Forecasting Potential				
Catchment Information	**Gauging Station**		**Catchment size (km^2)**	**Potential available forecast accuracy and reliability period**
	Fluvial	**Rainfall**		
	GS 24034	n/a	76	n/a
Relevant Information:	Riversfield Weir (GS 24034) 5 km upstream of Kilmallock			
Additional Infrastructure Recommended	**Gauging Station**		**Other**	
	Fluvial	**Rainfall**		
	No	No	n/a	
Relevant Comments:	From the available historical data it is not been to possible to determine whether the existing fluvial gauging station could provide reasonably accurate and reliable predictions for flooding. There is no model reaches between the gauge and Killmallock the travel time is unknown. As the distance between the gauge and Killmallock is relatively small it is unlikely to provide significant warning time.			

*For this assessment only 15 minute tipping bucket gauge were considered.

Appendix C9 Option Appraisal Report - Tarbert

1. Preliminary Report: Summary of Current Flood Risk

1.1 IRR and Watercourse Details

IRR	Tarbert Power Station
Unit of Management:	24
Primary Watercourse(s):	Shannon Estuary

1.2 Summary of Flood Risk in 1% Fluvial / 0.5% Coastal AEP Event

Source of flood risk:	Fluvial	**Coastal**	Both	
Total Number of Properties at risk in AFA in 0.5% Coastal AEP Event:		**Residential**	**Non-Residential**	**Total**
	Coastal	0	5	5
IRR Flood Cells:	**Total Number:**	1		
	Flood Cell Titles:	TAR_A		
Breakdown of properties at (combined) risk per Flood Cell:	**Flood Cell Ref**	**Residential**	**Non-Residential**	**Total**
	TAR_A	0	5	5
Relevant Comments:	Only coastal flood risk to Tarbert Power Station.			
Relevant Figure Ref:	Figure 1.1			

1.3 Summary of Existing Flood Risk Management Measures

Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
None	None	None	**Yes**	None	None

Relevant Comments:	There is an existing flood defence wall in Tarbert that provides protection as shown in figure 1.1 up to the 0.5% AEP coastal event.
Relevant Figure Ref:	Figure 1.1

1.4 Summary of PV Damages/Potential PV Benefits

Total PV Damages:		**Uncapped**	**Capped**	
	Coastal	€ 0	€ 0	
Max Capped Benefits for 0.5% Coastal AEP Event*:	€ 0			
Breakdown of Max Capped PV benefits per Flood Cell For 0.5% Coastal AEP Event:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	TAR_A	€ 0	€ 0	€ 0
Relevant Comments:	The only buildings within the IRR and 0.5% Coastal AEP extent are auxiliary buildings to Tarbert Power Station. Following consultation with the Operations Manager with regard to the areas/receptors potentially at risk from flooding, it was confirmed that that the flood risk to these areas/receptors constitutes no operational concern or difficulties to the power station. The operations manager stated that "The areas identified as a flood risk are in the vicinity of our water treatment plant. Given that the flood would be tidal and therefore short term, it would not cause us any great difficulty". As the flood risk presents no operational difficulties or concerns, no PV damages can be assigned.			
Relevant Figure Ref:	Figure 1.1			

*These are the maximum benefits available if a FRM option with a 1% Fluvial / 0.5% Coastal AEP SOP is provided to all properties within the AFA.

1.5 Social Risk		
	Type	**Description**
High Vulnerability Properties at risk:	None	N/A
Social Infrastructure Assets:	None	N/A
Social Amenity Sites:	None	N/A
Relevant Figure Ref:	General Risk - Social	
1.6 Risk to the Environment		
	Type	**Description**
Risk to WFD Annex IV:	None	N/A
Risk to SACs:	SAC	Shannon Estuary Special Area of Conservation nearly fully encompasses Tarbert Power Station AFA.
Relevant Figure Ref:	General Risk - Environment	
1.7 Risk to Cultural Heritage		
	Type	**Description**
Risk to Sites of Cultural Heritage:	None	N/A
Relevant Figure Ref:	General Risk – Cultural Heritage	
1.8 Risk to the Economy		
	Type	**Description**
Risk to Transport Infrastructure:	None	N/A
Risk to Utility Infrastructure:	None	N/A
Relevant Figure Ref:	General Risk - Economy	

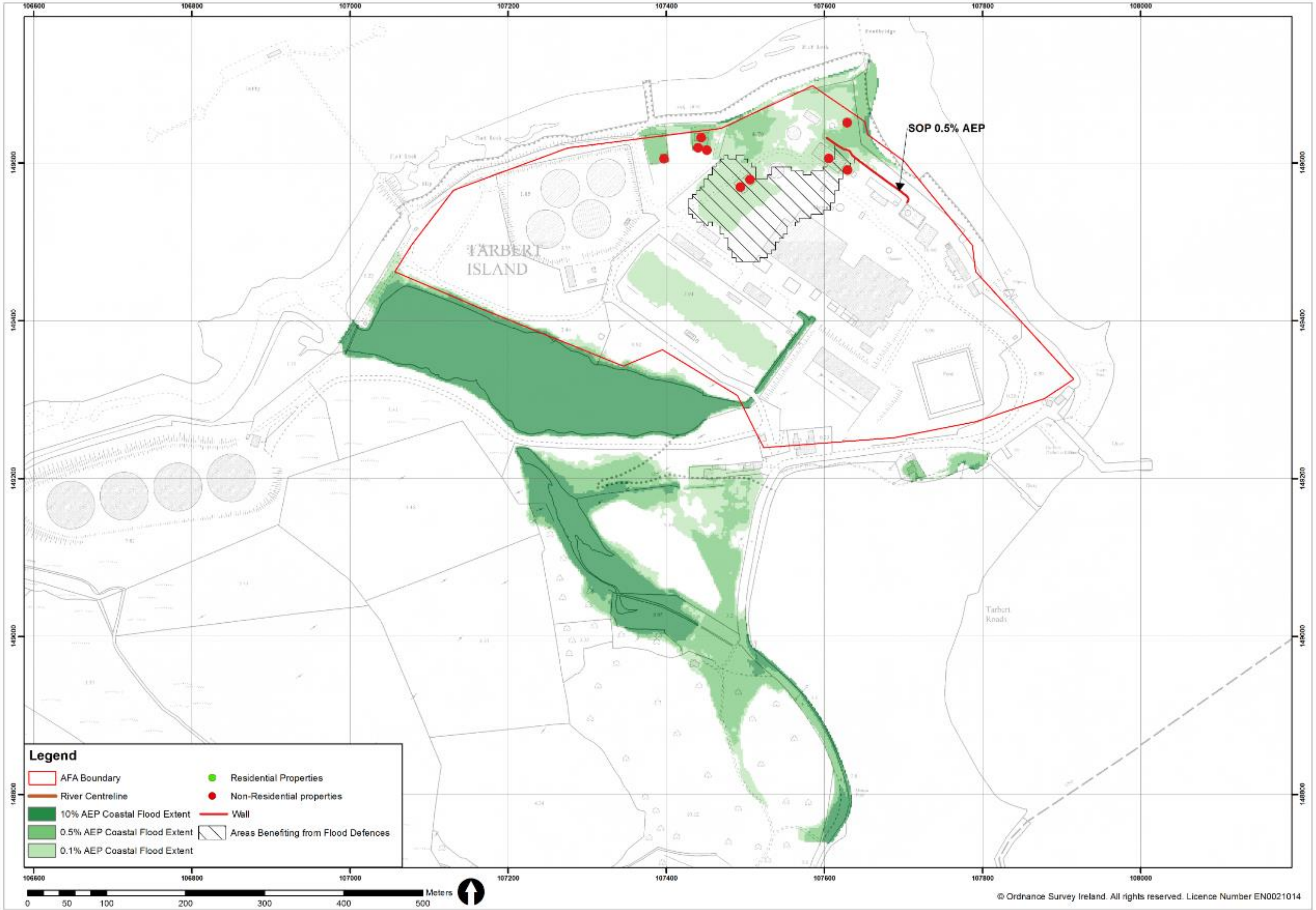


Figure 1.1 – Tarbert Power Station Coastal Flood Risk to Receptors

Following consultation with the Operations Manager at Tarbert Power Station on the Draft Flood Maps, it was confirmed that that the flood risk to the areas/receptors of the IRR constitutes no operational concern or difficulties to the power station. The operations manager stated that "The areas identified as a flood risk are in the vicinity of our water treatment plant. Given that the flood would be tidal and therefore short term, it would not cause us any great difficulty". As the flood risk presents no operational difficulties or concerns, no PV damages can be assigned. The baseline measure "Existing Regime" applies to the IRR and all other measures have been screened out. Recommendations will be made in the FRMP that the existing flood defences must be monitored and maintained. Flood risk management methods, options or measures will not be assessed any further. Therefore, no appraisal of options or multi criteria analysis has been carried out for this IRR.

There is no potential for the development of an effective fluvial flood forecasting system for Tarbert as there is only tidal flooding in this IRR. Tidal flooding could be predicted by a simple forecasting system.

Appendix C10 Option Appraisal Report - Clarina

1. Preliminary Report: Summary of Current Flood Risk

1.1 AFA and Watercourse Details

AFA	Clarina
Unit of Management:	24
Primary Watercourse(s):	Adare River, River Maigue, Barnakyle (River)

1.2 Summary of Flood Risk in 1% Fluvial / 0.5% Coastal AEP Event

Source of flood risk	Fluvial	Coastal	**Both**

Total Number of Properties at risk in AFA in 1% Fluvial / 0.5% Coastal AEP Event:		**Residential**	**Non-Residential**	**Total**
	Fluvial	0	0	0
	Coastal	0	0	0
	Combined	0	0	0

AFA Flood Cells:		
	Total Number:	0
	Flood Cell Titles:	N/A

Breakdown of properties at (combined) risk per Flood Cell:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	N/A	0	0	0

Relevant Comments:	The dominant source of flooding is coastal, with 5 properties flooding in the 0.1% AEP event only. There are no properties at risk from fluvial flooding up to, and including, the 0.1% AEP flood event.
Relevant Figure Ref:	Figure 1.1 and 1.2

1.3 Summary of Existing Flood Risk Management Measures

Arterial Drainage	**Storage**	**Flow Diversion**	**Flood Defences**	**Level Control**	**Other**
Yes	None	None	None	None	None

Relevant Figure Ref:	Figure 1.1 and 1.2

1.4 Summary of PV Damages/Potential PV Benefits

Total PV Damages:		**Uncapped**	**Capped**
	Fluvial	€ 0	€ 0
	Coastal	€ 30,532	€ 30,532
	Combined	€ 30,532	€ 30,532

Max Combined Capped Benefits for 1% Fluvial and 0.5% Coastal AEP Event*:	€ 0

Breakdown of Max Combined PV Benefits per Flood Cell for 1% Fluvial and 0.5% Coastal AEP Event:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	N/A	€ 0	€ 0	€ 0

*These are the maximum benefits available if a FRM option with a 1% Fluvial / 0.5% Coastal AEP SOP is provided to all properties within the AFA.

1.5 Social Risk		
	Type	**Description**
High Vulnerability Properties at risk:	None	N/A
Social Infrastructure Assets:	None	N/A
Social Amenity Sites:	GAA Clubhouse	**0.1% Coastal AEP Flood Extent**
		Ballybrown Clubhouse
Relevant Figure Ref:	General Risk - Social	
1.6 Risk to the Environment		
	Type	**Description**
Risk to WFD Annex IV:	None	N/A
Risk to SACs:	None	N/A
Relevant Figure Ref:	General Risk - Environment	
1.7 Risk to Cultural Heritage		
	Type	**Description**
Risk to Sites of Cultural Heritage:	None	N/A
Relevant Figure Ref:	General Risk – Cultural Heritage	
1.8 Risk to the Economy		
	Type	**Description**
Risk to Transport Infrastructure:	National road	**0.1% Coastal AEP Flood Extent**
		N69 to the west of Clarina
Risk to Utility Infrastructure:	None	N/A
Relevant Figure Ref:	General Risk - Economy	

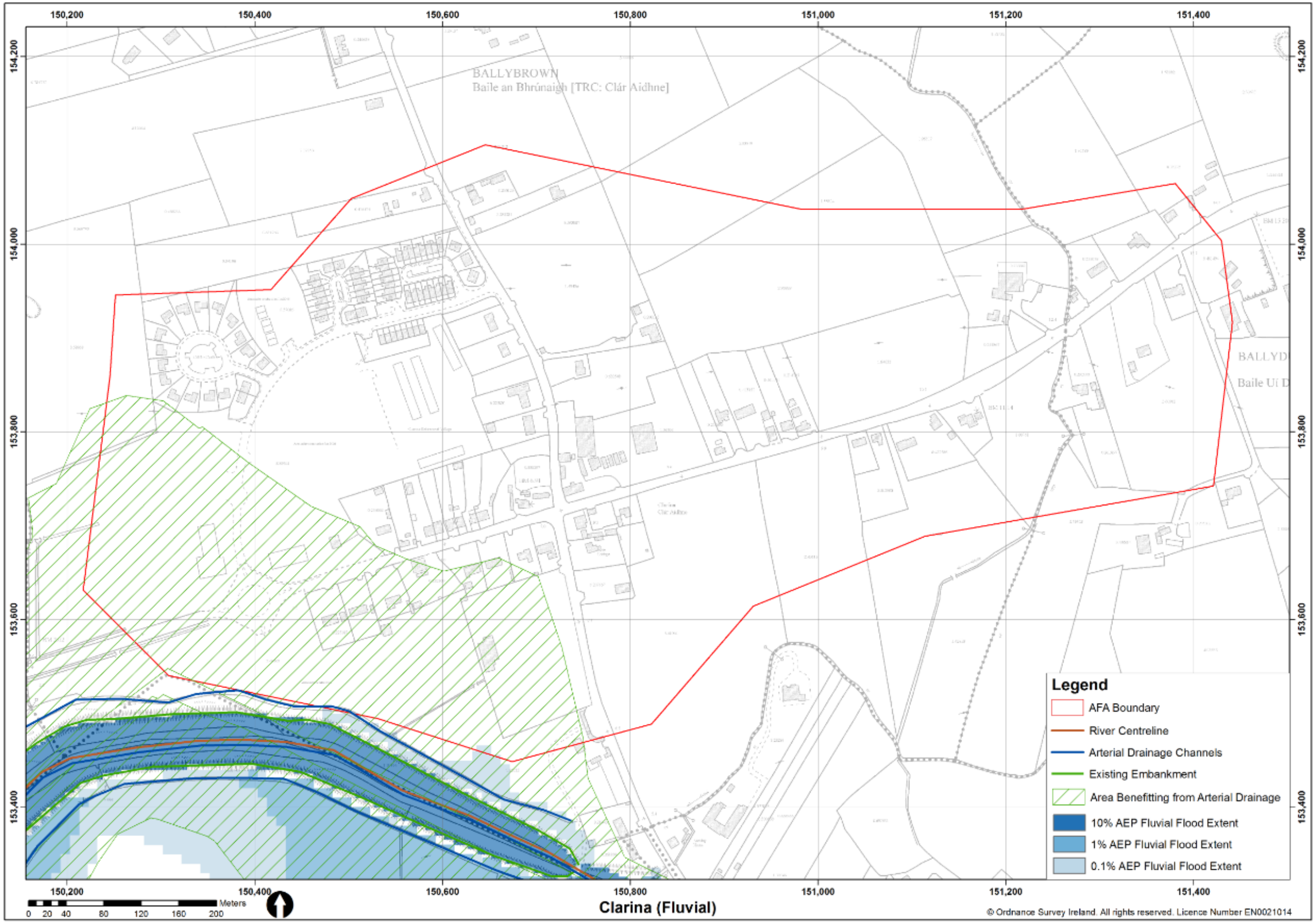


Figure 1.1 – Clarina Fluvial Flood Risk to Properties

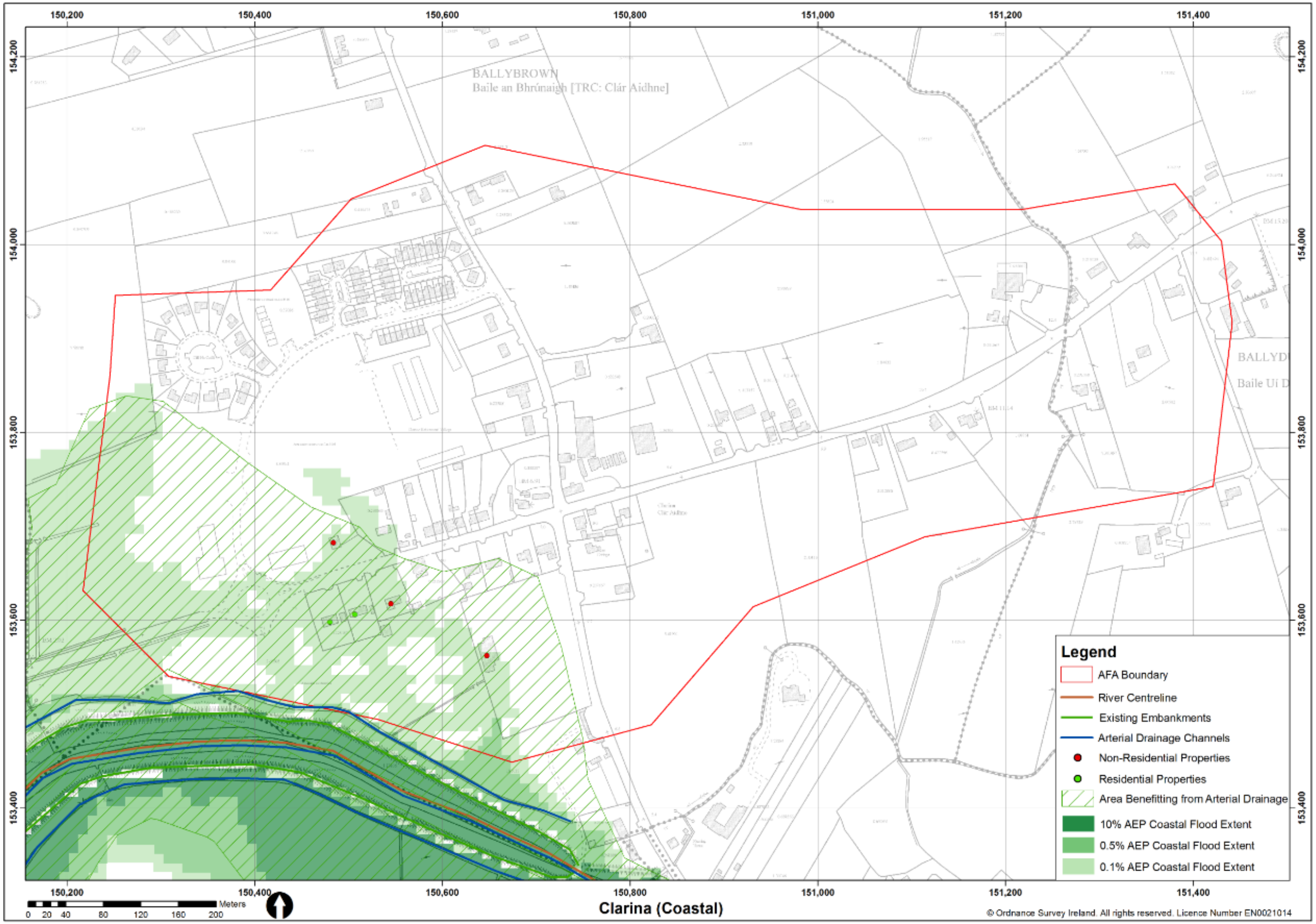


Figure 1.2 - Clarina Coastal Flood Risk to Properties

With the existing arterial drainage scheme in place there is no flood risk to any properties in the AFA for the 1% AEP fluvial and the 0.5% AEP coastal events. There are not sufficient PV damages to promote any flood risk management measures for the Clarina at this SSA. Therefore, no optioneering has been carried out in Clarina. OPW regional staff stated that the arterial drainage embankments were constructed principally for the protection of agricultural land. Approximately 1.2km of these embankments protect the Clarina AFA. The construction cost of replacing this length of embankment, using imported material with 5m deep sheet piling, is estimated at € 1,820,400.

It will be recommended in the FRMP that the existing arterial drainage scheme needs to be maintained and the embankments must be maintained in good condition at their existing level.

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

Fluvial Flood Forecasting Potential				
Catchment Information	**Gauging Station**		**Catchment size (km^2)**	**Potential available forecast accuracy and reliability period**
	Fluvial	**Rainfall**		
	n/a	n/a	47	6-9 hours
Relevant Information:	No gauging station			
Additional Infrastructure Recommended	**Gauging Station**		**Other**	
	Fluvial	**Rainfall**		
	No	No	n/a	
Relevant Comments:	A fluvial gauging could be included upstream of Clarina to provide fluvial forecasting. However, it must be noted that Clarina is tidally dominated and the addition of a fluvial forecasting system would provide little benefit. Tidal flooding could be predicted by a simple forecasting system.			

*For this assessment only 15 minute tipping bucket gauge were considered.

Appendix C11 Option Appraisal Report - Charleville

1. Preliminary Report: Summary of Current Flood Risk

1.1 AFA and Watercourse Details

AFA	Charleville
Unit of Management:	24
Primary Watercourse(s):	Glen River

1.2 Summary of Flood Risk in 1% Fluvial AEP Event

Source of flood risk	**Fluvial**	Coastal	Both	
Total Number of Properties at risk in AFA:		**Residential**	**Non-Residential**	**Total**
	Fluvial	2	1	3
AFA Flood Cells:	**Total Number:**	3		
	Flood Cell Titles:	CHA_A, CHA_B, CHA_C		
Breakdown of properties at (combined) risk per Flood Cell:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	CHA_A	1	0	1
	CHA_B	1	0	1
	CHA_C	0	1	1
Relevant Comments:				
Relevant Figure Ref:	Figure 1.1 and 1.2			

1.3 Summary of Existing Flood Risk Management Measures

Arterial Drainage	**Storage**	**Flow Diversion**	**Flood Defences**	**Level Control**	**Other**
None	None	None	None	None	None

Relevant Comments:	None
Relevant Figure Ref:	N/A

1.4 Summary of PV Damages/Potential PV Benefits

Total PV Damages:		**Uncapped**	**Capped**	
	Fluvial	€ 56,826	€ 56,826	
Max Capped Benefits for 1% AEP Fluvial Event:	€ 12,128			
Breakdown of Max Capped PV benefits per Flood Cell for 1% Fluvial AEP Event:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	CHA_A	€ 1,429	€ 0	€ 1,429
	CHA_B	€ 1,524	€ 0	€ 1,524
	CHA_C	€ 0	€ 9,175	€ 9,175
Relevant Comments:				
Relevant Figure Ref:	Figure 1.2			

1.5 Social Risk		
	Type	**Description**
High Vulnerability Properties at risk:	None	N/A
Social Infrastructure Assets:	None	N/A
Social Amenity Sites:	None	N/A
Relevant Figure Ref:	General Risk – Social	
1.6 Risk to the Environment		
	Type	**Description**
Risk to WFD Annex IV:	None	N/A
Risk to SACs:	None	N/A
Relevant Figure Ref:	General Risk – Environment	
1.7 Risk to Cultural Heritage		
	Type	**Description**
Risk to Sites of Cultural Heritage:	None	N/A
Relevant Figure Ref:	General Risk – Cultural Heritage	
1.8 Risk to the Economy		
	Type	**Description**
Risk to Transport Infrastructure:	National Primary Route	**50% AEP Flood Extent**
		N20
	Regional Route	**50% AEP Flood Extent**
		R515
Risk to Utility Infrastructure:	Low vulnerability utility	**20% AEP Flood Extent**
		Bord Gáis Station
Relevant Figure Ref:	General Risk – Economy	

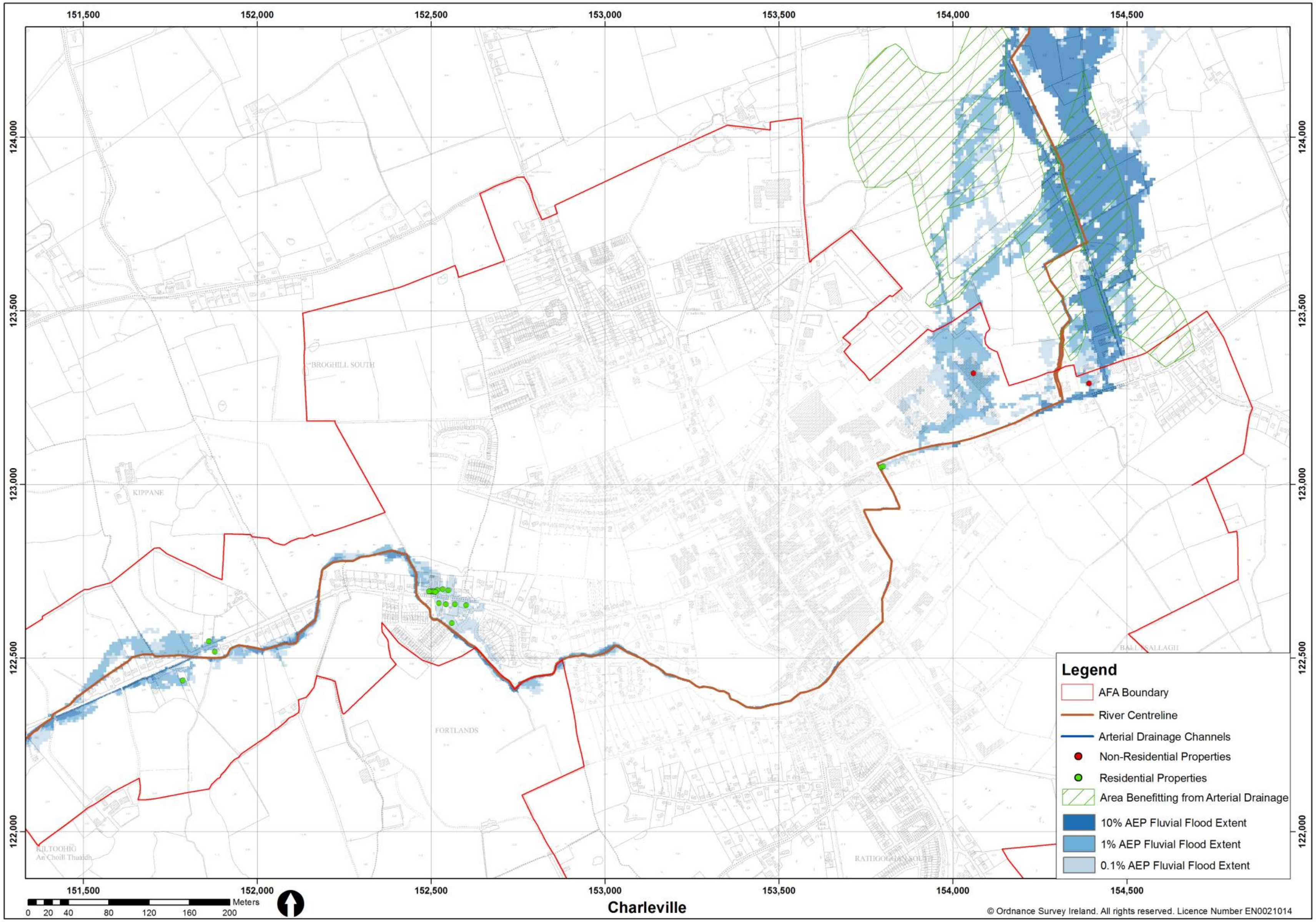


Figure 1.1 - Charleville Flood Risk to Properties

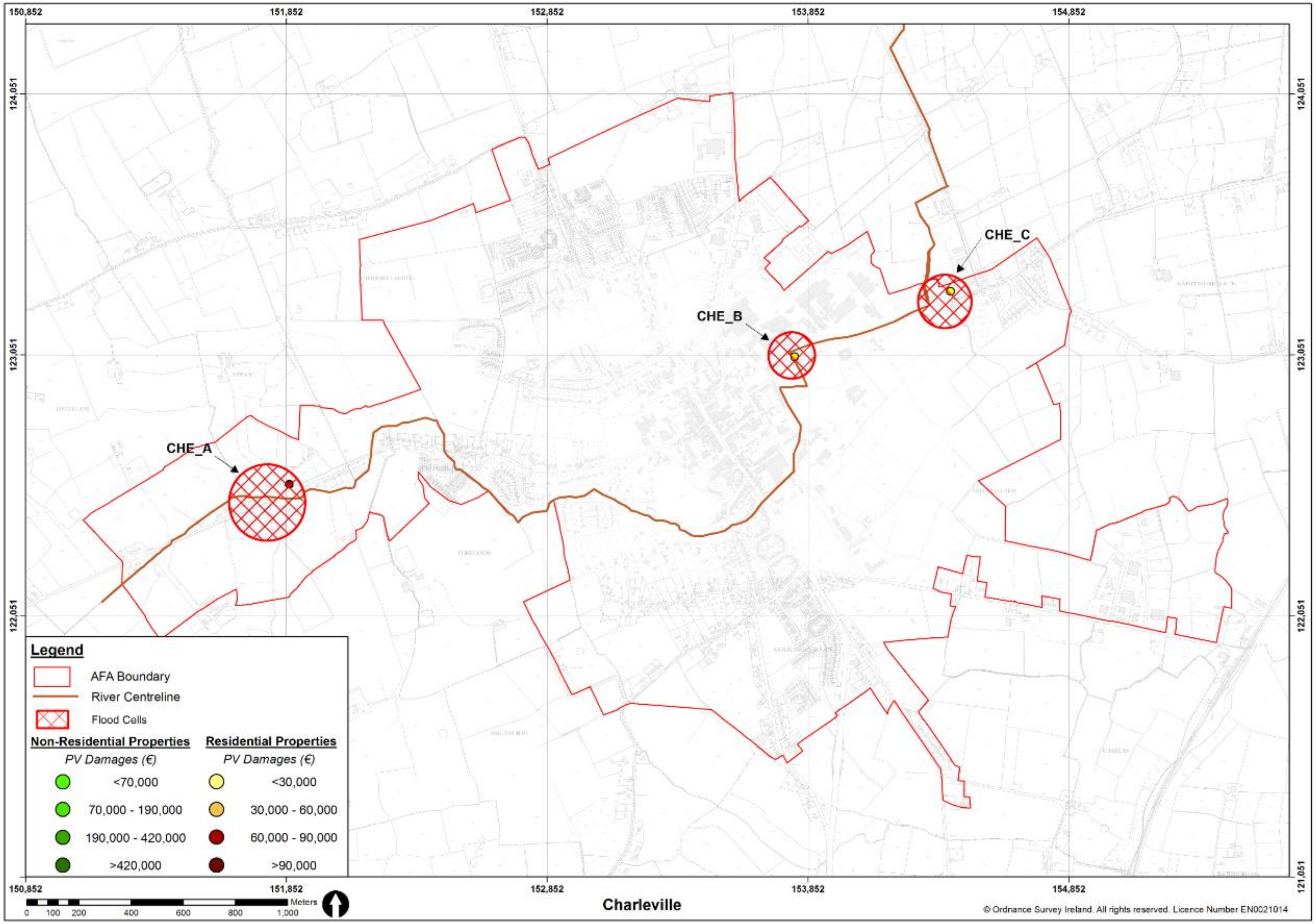


Figure 1.2 - Charleville Total PV Damages for Properties within 1% AEP Fluvial Flood Event and Flood Cells
Flood Cells are groupings of properties that are likely to be hydraulically linked

STAGE 2: Screening of the Measures

2.1 Baseline, Structural and Non-Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Viable	Viable	Viable	Viable	Viable	Screened In
B	Existing Regime	Unviable	Viable	Viable	Viable	Viable	Screened Out
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	Screened Out
Structural							
D	Storage	Unviable	Viable	Viable	Viable	Viable	Screened Out
E	Flow Diversion	Unviable	Viable	Viable	Viable	Viable	Screened Out
F	Increase Conveyance	Viable	Unviable	Viable	Viable	Viable	Screened Out
G	Flood Defences	Viable	Unviable	Viable	Viable	Viable	Screened Out
H	Relocation of Properties	Viable	Unviable	Viable	Viable	Viable	Screened Out
I	Other Measures	Unviable	Unviable	Unviable	Unviable	Unviable	Screened Out
Non-Structural							
J	Flood Forecasting / Warning / Response	Unviable	Viable	Viable	Viable	Viable	Screened Out
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	Screened In
L	Individual Property Resistance	Unviable	Viable	Viable	Viable	Viable	Screened Out
M	Individual Property Resilience	Unviable	Unviable	Viable	Viable	Viable	Screened Out

2.2 Justification for Screened Out Baseline and Structural Measures

The following provides justification on Measures with an overall viability 'Screened Out' categorisation.

B	Existing Regime	Applicability Economic Environmental Social Cultural	Screened out. No existing flood risk management measures are currently undertaken in the AFA.
C	Do Minimum	Applicability Economic Environmental Social Cultural	Screened out, as the "Do Minimum" FRM measure would have a negligible impact to the existing flood risk.
D	Storage	Applicability Economic Environmental Social Cultural	Screened out. No suitable storage areas were identified.
E	Flow Diversion	Applicability Economic Environmental Social Cultural	Screened out. No viable route for a diversion channel could be identified.

F	Increase Conveyance	Applicability Economic Environmental Social Cultural	Screened out. Replacing 2 structures was considered to increase conveyance in the channel. , see figure 2.1. The construction cost of this work was estimated at € 1,000,000 using the unit cost database. Considering the max PV benefits are € 12,128 this measure was considered economically unviable as there would be clearly insufficient PV benefits to promote this FRM measure at this SSA.
G	Flood Defences	Applicability Economic Environmental Social Cultural	Screened out. Considering the max PV benefits of € 12,128 this measure was considered economically unviable as there would be clearly insufficient PV benefits to promote an increase conveyance FRM measure at this SSA..
H	Relocation of Properties	Applicability Economic Environmental Social Cultural	Considering the max PV benefits are € 12,128 this measure was considered economically unviable as there would be clearly insufficient PV benefits to relocate the property at risk.
I	Other Measures	Applicability Economic Environmental Social Cultural	No other Measures have been identified.
J	Flood Forecasting / Warning / Response	Applicability Economic Environmental Social Cultural	Screened out as there are no current gauging stations in place on the River Glen in the AFA or upstream. A gauging station in Charleville will be recommended in the FRMP to determine if a flood forecasting system could be viable in the future.
L	Individual Property Resistance	Applicability Economic Environmental Social Cultural	Individual property resistance is not considered independently of flood forecasting, which has been deemed unviable.
M	Individual Property Resilience	Applicability Economic Environmental Social Cultural	Screened out. Considering the max PV benefits of € 12,128 this measure was considered economically unviable as there would be clearly insufficient PV benefits to promote an increase conveyance FRM measure at this SSA.

2.3 Summary of 'Screened In' Measures

The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.

Baseline Measures		**Non-Structural Measures**	
A	Do Nothing	K	Public Awareness

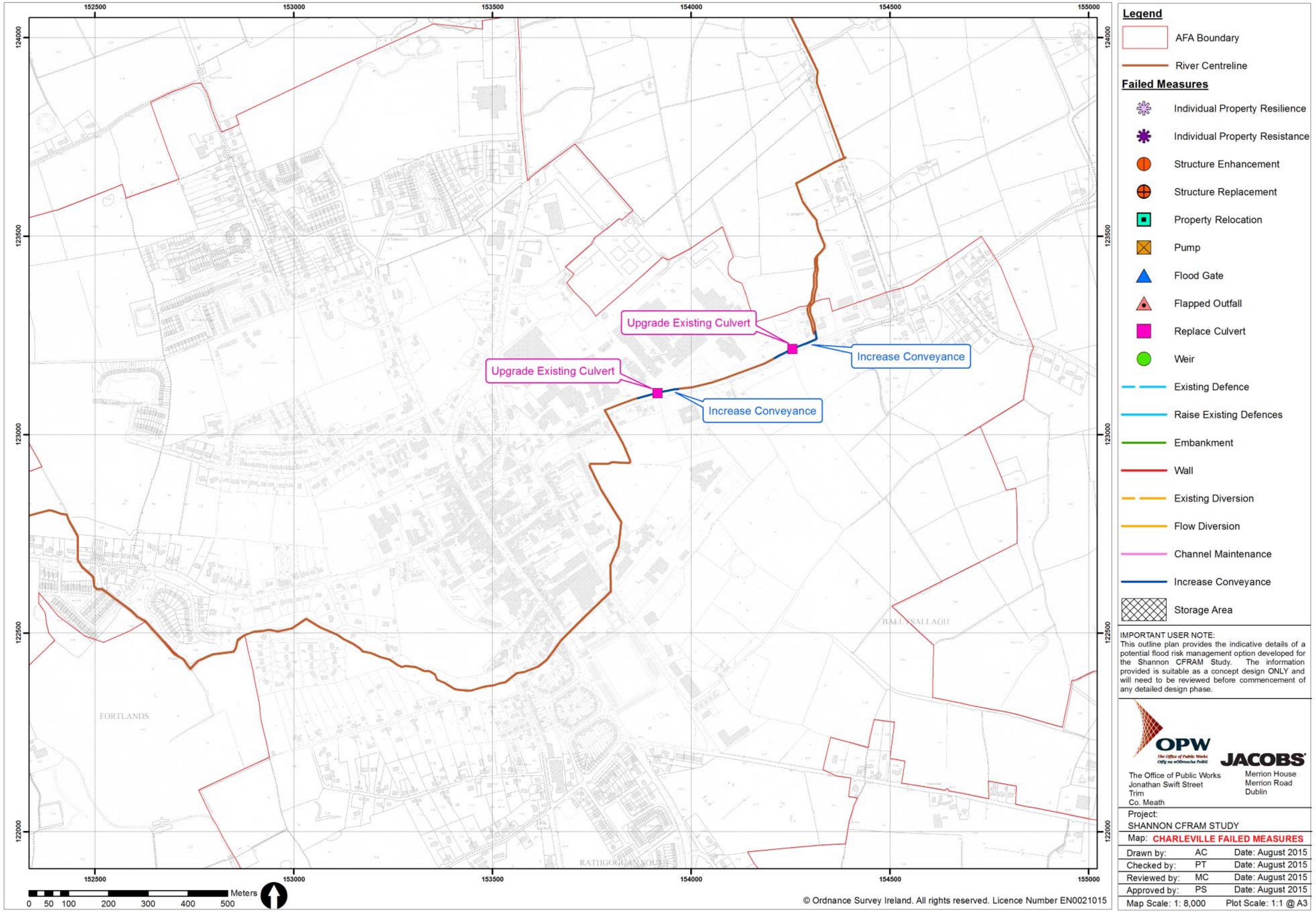


Figure 2.1 – Charleville Failed Measure

The only viable measures identified are the Baseline Measure "Do Nothing" and the Non-Structural Measure "Public Awareness". Neither of these measures can form an option that will provide the required 1% AEP event design standard. Therefore, no appraisal of options or multi criteria analysis has been carried out for this AFA.

With maximum PV benefits of € 12,128 if the 1% AEP design standard was provided, the adoption of an alternative standard would not provide significant additional benefit in relation to costs and impact therefore alternative design standard was not considered.

It will be recommended in the FRMP that a gauging station should be installed in Charleville to confirm the current risk is as represented. Gauge data will also determine if flood forecasting is a viable measure.

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

<table>
<tr><th colspan="5">Fluvial Flood Forecasting Potential</th></tr>
<tr><th rowspan="3">Catchment Information</th><th colspan="2">Gauging Station</th><th rowspan="2">Catchment size (km ^{2})</th><th rowspan="2">Potential available forecast accuracy and reliability period</th></tr>
<tr><th>Fluvial</th><th>Rainfall</th></tr>
<tr><td>No</td><td>No*</td><td>5</td><td>n/a</td></tr>
<tr><th>Relevant Information:</th><td colspan="4">This is determined unknown for the following reasons;
• No suitable rain gauge
• No suitable gauging station</td></tr>
<tr><th rowspan="3">Additional Infrastructure Recommended</th><th colspan="2">Gauging Station</th><th colspan="2" rowspan="2">Other</th></tr>
<tr><th>Fluvial</th><th>Rainfall</th></tr>
<tr><td>No</td><td>No</td><td colspan="2">n/a</td></tr>
<tr><th>Relevant Comments:</th><td colspan="4">Charleville lies towards the upstream reach of the catchment. As the catchment is small any potential flood forecasting early warning system would be unlikely to provide accurate and reliable predictions. Moreover, the potential forecast period is small.
There is little to no potential for the development of an effective flood forecasting system for Charleville.</td></tr>
</table>

*For this assessment only 15 minute tipping bucket gauge were considered.

Appendix C12 Option Appraisal Report - Milford

1. STAGE 1: Summary of Current Flood Risk & MCA Approach

1.1 AFA and Watercourse Details

AFA	Milford
Unit of Management:	24
Primary Watercourse(s):	River Deel

1.2 Summary of Flood Risk in 1% Fluvial AEP Event

Source of flood risk	**Fluvial**	Coastal	Both

Total Number of Properties at risk in AFA in 1% Fluvial AEP Event:		**Residential**	**Non-Residential**	**Total**
	Fluvial	2	3	5
AFA Flood Cells:	**Total Number:**	3		
	Flood Cell Titles:	MID_A, MID_B, MID_C		
Breakdown of properties at risk per Flood Cell:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	MID_A	1	0	1
	MID _B	1	1	2
	MID _C	0	2	2
Relevant Figure Ref:	Figure 1.1 and 1.2			

1.3 Summary of Existing Flood Risk Management Measures

Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
Yes	None	None	None	None	None

Relevant Figure Ref:	Figure 1.1

1.4 Summary of PV Damages/Potential PV Benefits

Total PV Damages:		**Uncapped**	**Capped**
	Fluvial	€ 420,819	€ 420,819
Max Capped Benefits for 1% Fluvial AEP Event:	€ 335,059		

Breakdown of Max Capped PV Benefits per Flood Cell for 1% Fluvial AEP Event:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	MID_A	€ 21,365	€ 0	€ 21,365
	MID _B	€ 1,439	€ 72,941	€ 74,380
	MID _C	€ 0	€ 239,314	€ 239,314
Relevant Figure Ref:	Figure 1.2			

1.5 Social Risk

	Type	Description
High Vulnerability Properties at risk:	None	N/A
Social Infrastructure Assets:	Community Centre	**10% AEP Fluvial Flood Extent** Milford Community Centre
Social Amenity Sites:	None	N/A
Relevant Figure Ref:	General Risk - Social	

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<table>
<tr><th colspan="3">1.6 Risk to the Environment</th></tr>
<tr><td></td><td>Type</td><td>Description</td></tr>
<tr><td>Risk to WFD Annex IV:</td><td>None</td><td>N/A</td></tr>
<tr><td>Risk to SACs:</td><td>None</td><td>N/A</td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="2">General Risk - Environment</td></tr>
<tr><th colspan="3">1.7 Risk to Cultural Heritage</th></tr>
<tr><td></td><td>Type</td><td>Description</td></tr>
<tr><td rowspan="4">Risk to Sites of Cultural Heritage:</td><td rowspan="2">NIAH</td><td>50% AEP Fluvial Flood Extent</td></tr>
<tr><td>Scart Bridge</td></tr>
<tr><td rowspan="2">Cork Recorded Monuments</td><td>50% AEP Fluvial Flood Extent</td></tr>
<tr><td>Scart Bridge</td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="2">General Risk – Cultural Heritage</td></tr>
<tr><th colspan="3">1.8 Risk to the Economy</th></tr>
<tr><td></td><td>Type</td><td>Description</td></tr>
<tr><td rowspan="2">Risk to Transport Infrastructure:</td><td rowspan="2">Regional Road</td><td>50% AEP Fluvial Flood Extent</td></tr>
<tr><td>R515</td></tr>
<tr><td>Risk to Utility Infrastructure:</td><td>None</td><td>N/A</td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="2">General Risk - Economy</td></tr>
</table>

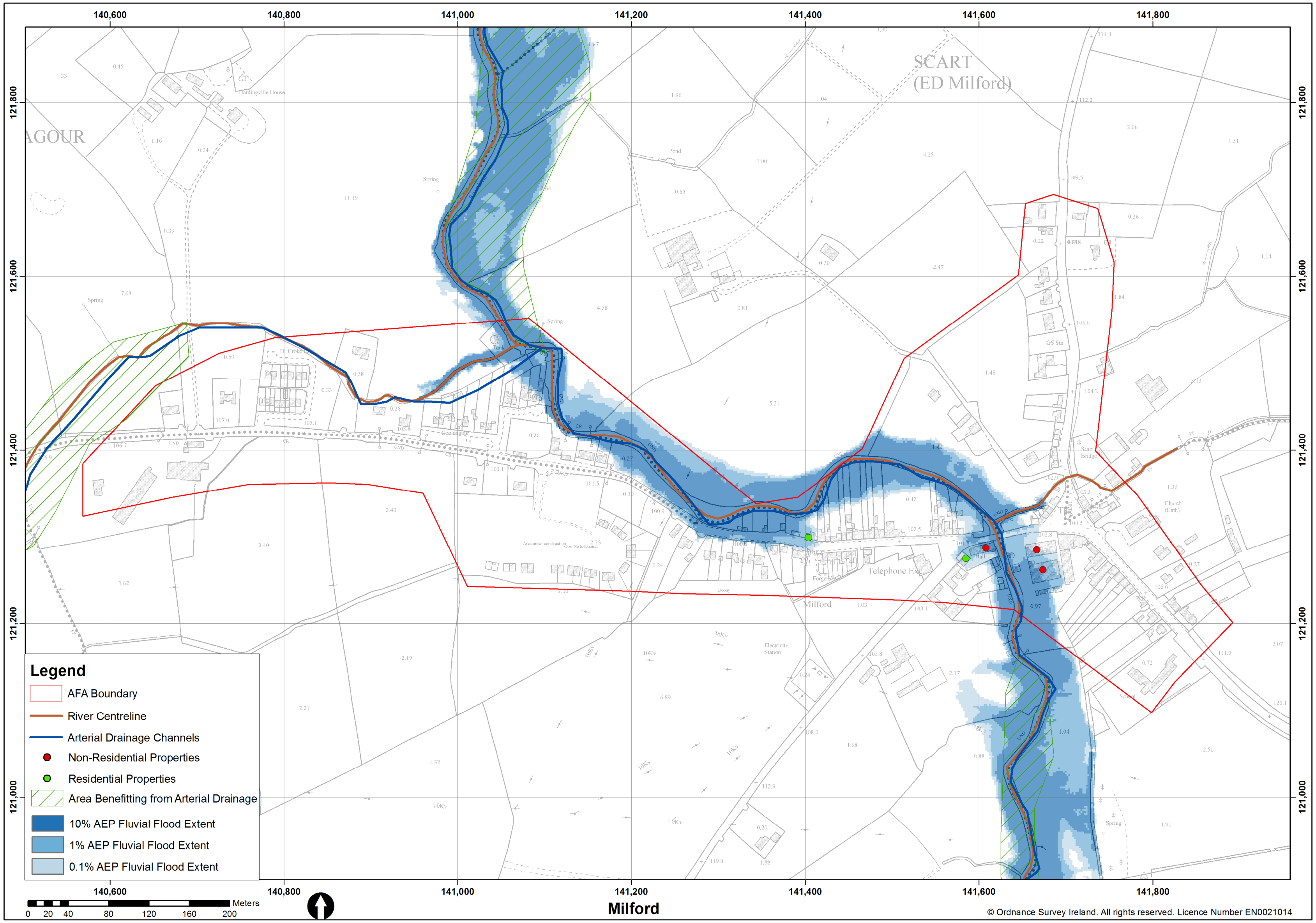


Figure 1.1 – Milford Fluvial Flood Risk to Properties

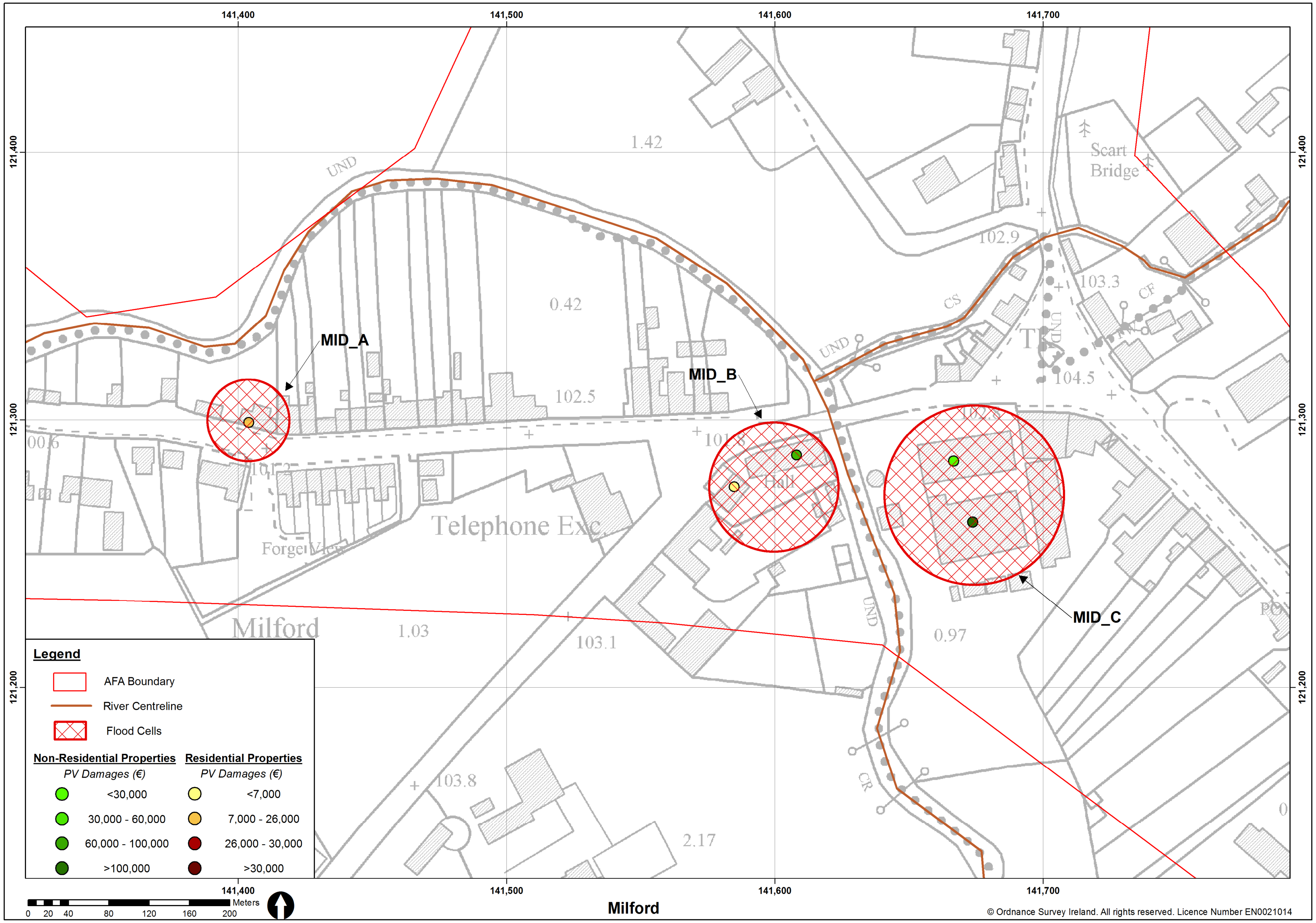


Figure 1.2 – Milford Total PV Damages for Properties within 1% AEP Fluvial Flood Event and Flood Cells
Flood Cells are groupings of properties that are likely to be hydraulically linked

1 STAGE 2: Screening of the Measures

2.1 Baseline, Structural and Non-Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
B	Existing Regime	Viable	Viable	Viable	Viable	Viable	**Screened In**
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
Structural							
D	Storage	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
E	Flow Diversion	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
F	Increase Conveyance	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
G	Flood Defences	Viable	Unviable	Viable	Viable	Viable	**Screened Out**
H	Relocation of Properties	Unviable	Unviable	Viable	Unviable	Viable	**Screened Out**
I	Other Measures	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
Non-Structural							
J	Flood Forecasting / Warning / Response	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	**Screened In**
L	Individual Property Resistance	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
M	Individual Property Resilience	Viable	Viable	Viable	Viable	Viable	**Screened In**

2.2 Justification for Screened Out Baseline and Structural Measures

The following provides justification on Measures with an overall viability 'Screened Out' categorisation.

A	Do Nothing	Applicability Economic Environmental Social Cultural	Screened out due to the number of properties currently at risk of flooding.
C	Do Minimum	Applicability Economic Environmental Social Cultural	Screened out, as the "Do Minimum" FRM measure would have a negligible impact on the existing flood risk.
D	Storage	Applicability Economic Environmental Social Cultural	Screened out. No suitable storage areas were identified.
E	Flow Diversion	Applicability Economic Environmental Social Cultural	Screened out. No viable route could be identified for a flow diversion channel.
F	Increase Conveyance	Applicability Economic Environmental Social Cultural	Screened out. Under-sized, existing structures not significantly contributing to flood risk. Local dredging of the river to increase conveyance was deemed to be unviable as it cannot fully mitigate the flood risk to the AFA.

G	Flood Defences	Applicability Economic Environmental Social Cultural	Screened out. A flood defence embankment was considered, see figure 2.1. The construction cost of the embankment and walls required is estimated at € 525,387 using the cost database. Considering the max PV benefits are € 335,059 this measure was considered economically unviable as there would clearly be insufficient PV benefits to promote a defence FRM measure at this SSA.
H	Relocation of Properties	Applicability Economic Environmental Social Cultural	The relocation of 5 properties is not applicable to the area as it would be socially and economically unviable.
I	Other Measures	Applicability Economic Environmental Social Cultural	No other measures identified.
J	Flood Forecasting / Warning / Response	Applicability Economic Environmental Social Cultural	Screened out as there are no current gauging stations in place on the River Deel in the AFA or upstream. A gauging station in Milford will be recommended in the FRMP to determine if a flood forecasting system could be viable in the future.
L	Individual Property Resistance	Applicability Economic Environmental Social Cultural	Individual property resistance is not considered independently of flood forecasting, which has been deemed unviable.

2.3 Summary of 'Screened In' Measures

The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.

Baseline Measures		**Non-Structural Measures**	
B	Existing Regime	K	Public Awareness
		M	Individual Property Resilience

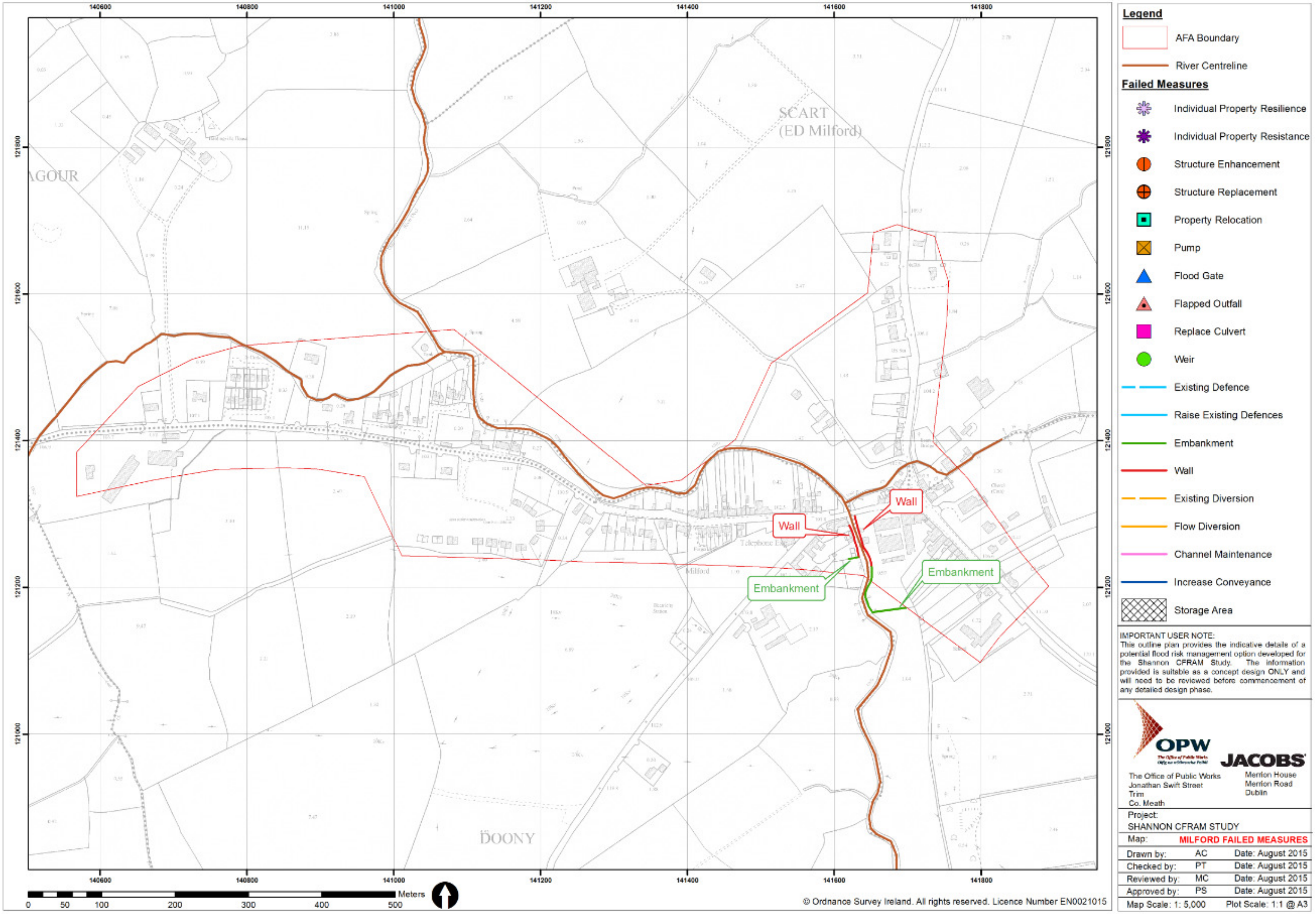


Figure 2.1 – Milford Failed Measure

3 STAGE 3: Selection of Options

3.1 Consideration of Options

The following are the agreed combination of 'Screened In' measures that comprise each of the Options being taken forward for further consideration.

Where appropriate, the 'Screened In' measures have been sub-divided into separate specific measures to ensure applicability to site conditions.

Measures		Different composition of measures per option						
Baseline Measures								
B	Existing Regime	✓						
Non-Structural Measures								
K	Public Awareness	✓						
M	Individual Property Resilience	✓						
Option Reference		MID_01						

4 STAGE 4: Appraisal of Options

4.1 Options Appraisal

Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Meeting. Below describes this concept design of each options and provides a summary of any significant comments/issues which were raised by LA staff at the Options Meetings. These comments will be considered in the local weightings and the MCA scores.

<table>
<tr><td colspan="2">Option Ref:</td><td colspan="5">MID_01</td></tr>
<tr><td rowspan="3">Option Measures</td><td>Baseline</td><td>B</td><td colspan="4">Existing Regime</td></tr>
<tr><td>Structural</td><td></td><td colspan="4">N/A</td></tr>
<tr><td>Non Structural</td><td colspan="2">J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Option Description:</td><td colspan="5">This option will not provide 1% Fluvial AEP design standard protection to any of the properties in Milford but it will reduce the impact of the flood risk to the 5 properties at risk

• Individual property resilience and public awareness will apply to all properties as shown in Figure 5.1.

• Existing regime (Arterial Drainage) to be maintained.

It will be recommended in the FRMP that a gauging station should be installed in Milford to confirm the current risk is accurate. Gauge data will also determine if flood forecasting is a viable measure.</td></tr>
<tr><td colspan="2" rowspan="2">Options Development Meeting:</td><td>Date:</td><td colspan="4">03/09/2015</td></tr>
<tr><td>Summary:</td><td colspan="4">Although a meeting was not held with Cork County Council comments from Cork Co.Co. in regard to the options were obtained via email correspondence. The email is provided in Appendix E.</td></tr>
</table>

5 STAGE 5: Multi Criteria Assessment

5.1 Options selected for the Multi Criteria Assessment

Following the Option Meeting, the following options are the refined options for the Multi-Criteria Assessment (MCA) stage. This is the final of a five-stage MCA process.

Option Reference		MID_01
Baseline		
B	Existing Regime	Maintain existing regime.
Structural Measures		
	N/A	N/A
Non Structural Measures		
K	Public Awareness	Public awareness campaign.
M	Individual Property Resilience	Public awareness for residential property as shown in Figure 5.1.
Table reference A summary of the outcome from the MCA is presented in the following table		Table 5.1

Table 5.1: Multi Criteria Assessment Outcome for Option MID_01

Multi Criteria Assessment **The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.**			
AFA	Milford	Option Ref:	MID_01
Option Measures			
Baseline	B	Existing Regime	
Structural		N\A	
Non-Structural	K	Public Awareness	
	M	Individual Property Resilience	
Criteria Scores			
Technical	900		
Economic	18		
Social	168		
Environmental	0		
Economic Values			
Economic PV Benefits	€ 263,754		
PV Cost	€ 257,001		
NPV Benefits	€ 6,753		
Economic BCR	**1.03**		
Outcome Scores			
MCA PV Benefits	€ 253,758		
MCA Benefit Score	186		
MCA Benefit Score Ratio	723.54		
Option Selection MCA	1086		

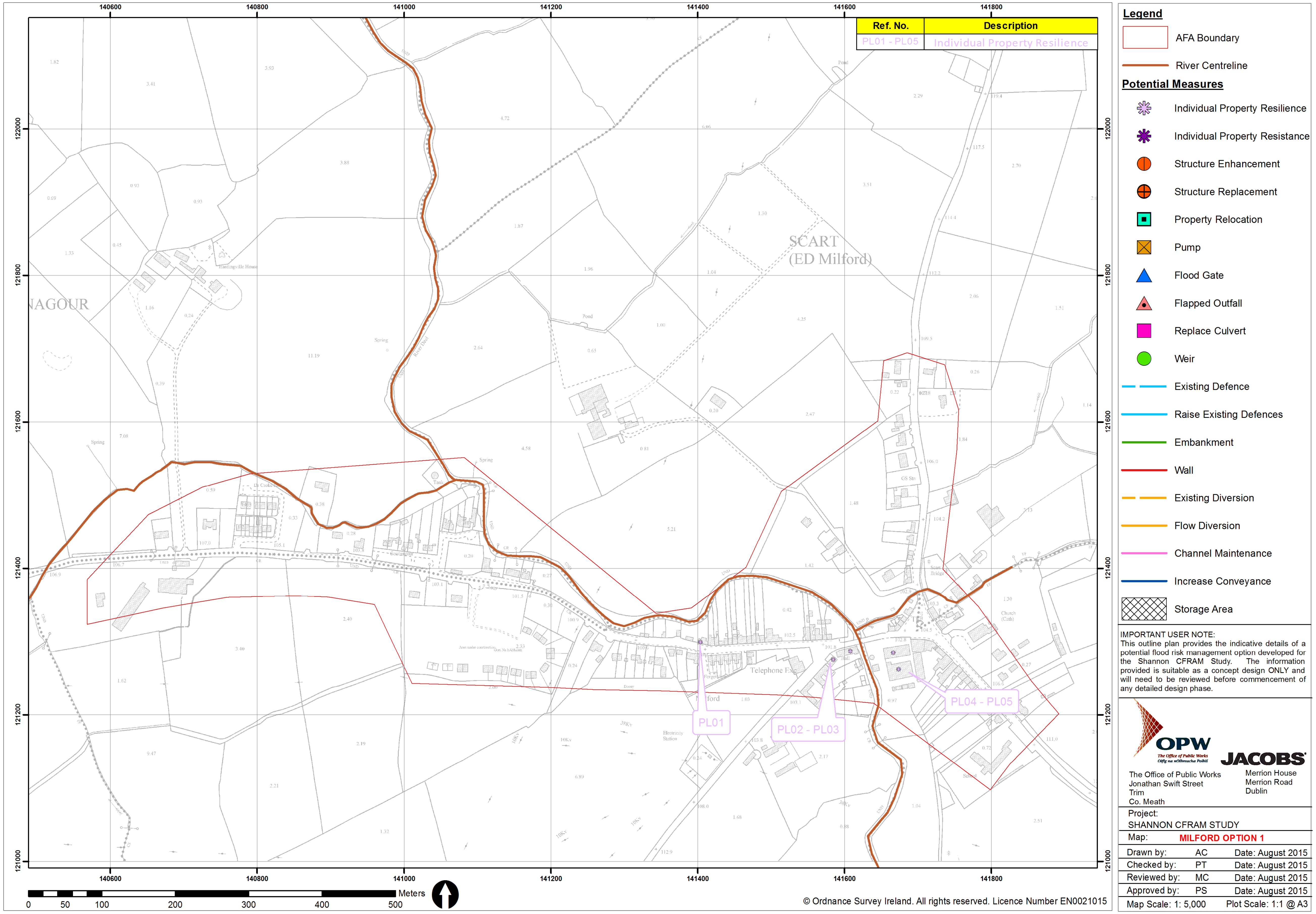


Figure 5.1 – Option MID_01

5.2 Comparison of Multi Criteria Assessment Scores

Each option taken forward for further consideration through the Option Decision Meeting, has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Decision Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).

Categories	**Option Reference and Results**
	MID_01
Criteria Scores	
Technical	900
Economic	18
Social	168
Environmental	0
Economic Values	
Economic PV Benefits	€ 263,754
PV Cost	€ 257,001
NPV Benefits	€ 6,753
Economic BCR	**1.03**
Outcome Scores	
MCA PV Benefits	€ 253,758
MCA Benefit Score	186
MCA BCR	723.54
Option Selection MCA	1086

<table>
<tr><td colspan="6">5.3 Recommendation of Preferred Option
It forms part of the CFRAM process for the recommendation of a preferred option for each AFA. The prioritised selection criteria used in this recommendation process is detailed in Section 3.7.3 of the Main Report.
Therefore, following the five stage Multi Criteria Assessment process, the preferred option is as outlined below</td></tr>
<tr><td colspan="2">Option Ref:</td><td colspan="4">MID_01</td></tr>
<tr><td rowspan="3">Option Measures</td><td>Baseline</td><td>B</td><td colspan="3">Existing Regime</td></tr>
<tr><td>Structural</td><td></td><td colspan="3">N/A</td></tr>
<tr><td>Non Structural</td><td>J
Flood Forecasting</td><td>K
Public Awareness</td><td>L
Property Resistance</td><td>M
Property Resilience</td></tr>
<tr><td colspan="2">Comments</td><td colspan="4">It will be recommended in the FRMP that a gauging station should be installed in Milford to confirm the current risk is accurate. Gauge data will also determine if flood forecasting is a viable measure.

Providing individual property resilience will reduce the flood risk for the 1% AEP fluvial event, although not completely eliminate it.

The economic BCR is 1.03 and the MCA BCR is 723.54 for MID_01 therefore this is a viable emerging option.</td></tr>
</table>

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

<table>
<tr><td colspan="5">Fluvial Flood Forecasting Potential</td></tr>
<tr><td rowspan="3">Catchment Information</td><td colspan="2">Gauging Station</td><td rowspan="2">Catchment size (km ^{2})</td><td rowspan="2">Potential available forecast accuracy and reliability period</td></tr>
<tr><td>Fluvial</td><td>Rainfall</td></tr>
<tr><td>No</td><td>No*</td><td>58</td><td>Unknown</td></tr>
<tr><td>Relevant Information:</td><td colspan="4">This is determined unknown for the following reasons;
• No suitable rain gauge
• No suitable gauging station</td></tr>
<tr><td rowspan="3">Additional Infrastructure Recommended</td><td colspan="2">Gauging Station</td><td colspan="2" rowspan="2">Other</td></tr>
<tr><td>Fluvial</td><td>Rainfall</td></tr>
<tr><td>n/a</td><td>n/a</td><td colspan="2">n/a</td></tr>
<tr><td>Relevant Comments:</td><td colspan="4">As no MPW is modelled upstream of Milford it is not possible to accurately predict the potential available forecast period. 4 km upstream of Milford a tributaries joins contributing 30% of the catchment area; this complicates any flood forecasting system. To provide accurate and reliable predictions a gauging station and/or rainfall gauging stations would more than likely on both watercourses/catchments.</td></tr>
</table>

Annex A - Multi-Criteria Analysis Summary and Whole Life Cost Summaries for FRM Option(s)

CRITERIA		OBJECTIVE		Global Weighting	Local Weighting	Comments	MID_01 M: Individual Property Resilience K: Public Awareness	Option Score	Weighted Score
1	Technical	a	Ensure flood risk management options are operationally robust	20	5.00	The option scores are determined based on the level of operational risk to operate or perform successfully. Each measure is scored independently and the average of the measure scores is used as the score for the option.	None / Manageable Negligible / Moderate / high Very low / High Low / Failure likely Low / moderate / Unacceptable M: 4.00 K	4.00	400
		b	Minimise health and safety risks associated with the construction and operation of flood risk management options	20	5.00	H&S risks are considered for construction and maintenance of flood risk management measures. The indicative aspirational score is set at five, with a point then deducted for each specific H&S risk in either construction or maintenance.	No risks / Moderate Negligible / Moderate / high Very low / High Low / Very High Low / moderate / Unacceptable Work near services or buildings	3.00	300
		c	Ensure flood risk management options are adaptable to future flood risk	20	5.00	The options scores are determined based on the sustainability and adaptability of the flood risk management measures in the face of potential future changes, including the potential impact of climate change. Each measure is scored independently and the average of the measure scores is used as the score for the option.	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. M: 2.00 K	2.00	200
			TECHNICAL CRITERIA SCORE						**900**
2	Economic	a	Minimise economic risk	24	0.20		The score is calculated based on the reduction in AAD, following the full implementation of option.	3.71	18
		b	Minimise risk to transport infrastructure	10	5.00		Scoring is based on the reduction in flood risk to transport routes, following the full implementation of option.	0.00	0
		c	Minimise risk to utility infrastructure	14	0.00	There are no assets of utility infrastructure at risk.	Scoring is calculate based on a reduction in flood risk to utility infrastructure, following the full implementation of option.		
		d	Minimise risk to agriculture	12	2.11	Source of Flooding: Fresh Water	Area of Agricultural Land Flooded: No Change Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Not Applicable Agricultural Production Enhanced: No Change Other (Please Specify): No Change	0.00	0
			ECONOMIC CRITERIA SCORE						**18**
3	Social	a i)	Minimise risk to human health and life - Residents	27	0.06	Flood Depths & Velocities: Assumed low risk to life Known Areas of Highly Vulnerable People: Reasonable Cross Section of Society	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	3.33	5
		a ii)	Minimise risk to human health and life - High vulnerability properties	17	0.00	Rate of Onset of flooding: Assumed 1-2 hours for evacuation	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	0.00	0
		b i)	Minimise risk to community - Social Infrastructure & Amenity	9	3.00	Assets of Particular Social Value: Yes	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	4.75	128
		b ii)	Minimise risk to community - Local employment	7	1.05	Asset of Particular Employment Value: No	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	4.64	34
			SOCIAL CRITERIA SCORE						**168**
4	Environmental	a	Support the objectives of the WFD	16	5.00	There is one WFD waterbody, the Deel River within the AFA. The status of the WFD waterbody is poor. There is a WWTP located within the 1% AEP Fluvial &/or 0.5% AEP Coastal. Local weighting to be applied for this objective is constant, and should always be set equal to 5 as WFD objectives must be achieved and are relevant to all waterbodies.	The implementation of individual property resilience is unlikely to impact the achievement of water body objectives. Therefore, no constraint to the achievement of waterbody objective.	0.00	0
		b	Support the objectives of the Habitats Directive	10	2.00	There are no cSACs within the AFA. However, the Lower River Shannon cSAC [002165], located 45 km from the AFA, is hydrologically connected to the AFA. There are no SPAs within the AFA. The nearest SPA to the AFA is Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA [004161] which located c.10 km from the AFA to the west. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are no designated sites but habitats/species are likely to be present that could be affected.	The implementation of individual property resilience is unlikely to cause any detrimental impact upon cSAC or SPA sites. Therefore, no impact on existing SAC, SPA or Ramsar sites as a result of the flood risk management measures.	0.00	0
		c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	5	2.00	There are no designated ecological sites within the AFA. There are a number of NHAs/pNHAs within 20km of the AFA. There are no NHA/pNHA located within the AFA. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are no designated sites but habitats/species are likely to be present that could be affected.	The implementation of individual property resilience is unlikely to impact or disturb flora/fauna. Therefore, no impact on existing national, regional, and local sites as a result of flood risk management measures.	0.00	0
		d	Protect, and where possible enhance, fisheries resource within the catchment	13	2.00	The River Deel is not designated as a Salmonid River. The river is a low activity angling area. Local weighting of 2 set by professional judgement. Weighting of 2 applied where a waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.	The implementation of individual property resilience is unlikely to significantly impact or enhance fisheries resource within the catchment. Therefore, no change to fisheries potential of the waterbody.	0.00	0
		e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	8	1.00	There are no protected / valued landscape areas within the AFA. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected.	The implementation of individual property resilience is unlikely to result in a change to the existing landscape character/features. Therefore, no change to existing landscape character / feature in the zone of influence of the selected measure.	0.00	0
		f i)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of architectural value	4	1.00	Milford is not a heritage town. There are 2 NIAHs within the 1% AEP Fluvial, Scart Bridge (20900104) and Detached three-bay single-storey (20900103). Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no architectural features are at risk from flooding but potential effects on the settings of designated architectural features.	The implementation of individual property resilience is unlikely to result in a change to the architectural features. Therefore, no effects on architectural features.	0.00	0
		f ii)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of archaeological value	4	0.00	Milford is not a heritage town. There is one RMP of archaeological value within the 1% AEP Fluvial, Scart Bridge. Local weighting of 0 set by professional judgement. Weighting of 0 applied where no archaeological features at risk.	The implementation of individual property resilience is unlikely to result in a change to the archaeological features. Therefore, no effects on archaeological features are predicted.	0.00	0
			ENVIRONMENTAL CRITERIA SCORE						**0**
	Economic Values		**Economic PV Benefits**					€263,754	
			Cost					€257,001	
			NPV Benefits					€6,753	
			Economic BCR					**1.03**	
	Outcome Scores		**MCA PV Benefits**					€253,758	
			MCA Benefit Score					186	
			MCA BCR					**723.54**	
			Option Selection MCA					1086	

Objective	Global Weightings (fixed)	Local Weightings		Baseline Comments	Option 1 Comments
1.A	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has negligible operational risks to operate or perform successfully.
1.B	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has very low health and safety risks associated with the construction and operation of flood risk management option.
1.C	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions.
2.A	24	0.20	calculated	Local weighting is calculated based on the baseline AAD	This score is calculated based on the reduction in AAD, following the full implementation of option.
2.B	10	5.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to transport infrastructure. Local weighting capped at maximum value of 5.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.
2.C	14	0.00	calculated but adjusted by professional judgement if necessary	There are no utility infrastructure assets at risk within this AFA.	There is no risk to utility infrastructure within this AFA.
2.D	12	2.11	Professional judgement	Local weighting is calculated based on the percentage of rural land within the AFA.	This score is determined based on reduction to area of agricultural land flooded, following full implementation of the option.
3.A (i)	27	0.48	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on based on the baseline risk to high vulnerability properties.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option.
3.A (ii)	17	0.00	calculated but adjusted by professional judgement if necessary	There is no risk to high vulnerability properties within this AFA.	There is no risk to high vulnerability properties within this AFA.
3.B (i)	9	3.00	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to social infrastructure. Local weighting increased by 20% as asset of particular social importance at flood risk.	Thought there is an asset of particular social importance, it is not protected to the design standard therefore no amendment to option score was made.
3.B (ii)	7	1.05	calculated but adjusted by professional judgement if necessary	Local weighting is calculated based on the baseline risk to local employment.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option.
4.A	16	5.00	fixed	There are no cSACs within the AFA. However, the Lower River Shannon cSAC [002165], located 45 km from the AFA, is hydrologically connected to the AFA. There are no SPAs within the AFA. The nearest SPA to the AFA is Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA [004161] which located c.10 km from the AFA to the west. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are no designated sites but habitats/species are likely to be present that could be affected.	The implementation of individual property resilience is unlikely to impact the achievement of water body objectives. Therefore, no constraint to the achievement of waterbody objective.
4.B	10	2.00	Professional judgement	There are no cSACs within the AFA. However, the Lower River Shannon cSAC [002165], located 45 km from the AFA, is hydrologically connected to the AFA. There are no SPAs within the AFA. The nearest SPA to the AFA is Stack's to Mullaghareirk Mountains, West Limerick Hills and Mount Eagle SPA [004161] which located c.10 km from the AFA to the west. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are no designated sites but habitats/species are likely to be present that could be affected.	The implementation of individual property resilience is unlikely to cause any detrimental impact upon cSAC or SPA sites. Therefore, no impact on existing SAC, SPA or Ramsar sites as a result of the flood risk management measures.
4.C	5	2.00	Professional judgement	There are no designated ecological sites within the AFA. There are a number of NHAs/pNHAs within 20km of the AFA. There are no NHA/pNHA located within the AFA. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are no designated sites but habitats/species are likely to be present that could be affected.	The implementation of individual property resilience is unlikely to impact or disturb flora/fauna. Therefore, no impact on existing national, regional, and local sites as a result of flood risk management measures.
4.D	13	2.00	Professional judgement	The River Deel is not designated as a Salmonid River. The river is a low activity angling area. Local weighting of 2 set by professional judgement. Weighting of 2 applied where a waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.	The implementation of individual property resilience is unlikely to significantly impact or enhance fisheries resource within the catchment. Therefore, no change to fisheries potential of the waterbody.
4.E	8	1.00	Professional judgement	There are no protected / valued landscape areas within the AFA. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected.	The implementation of individual property resilience is unlikely to result in a change to the existing landscape character/features. Therefore, no change to existing landscape character / feature in the zone of influence of the selected measure.
4.F(i)	4	1.00	Professional judgement	Milford is not a heritage town. There are 2 NIAHs within the 1% AEP Fluvial, Scart Bridge (20900104) and Detached three-bay single-storey (20900103). Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no architectural features are at risk from flooding but potential effects on the settings of designated architectural features.	The implementation of individual property resilience is unlikely to result in a change to the architectural features. Therefore, no effects on architectural features.
4.F(ii)	4	0.00	Professional judgement	Milford is not a heritage town. There is one RMP of archaeological value within the 1% AEP Fluvial, Scart Bridge. Local weighting of 0 set by professional judgement. Weighting of 0 applied where no archaeological features at risk.	The implementation of individual property resilience is unlikely to result in a change to the archaeological features. Therefore, no effects on archaeological features are predicted.

Option 1 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis						Notes to CFRAM Consultants
			€	€	€	
(1)	**Basic Construction Costs (Estimate)**				**110,794**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2)	**Preliminaries**	28.1%			**31,099**	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**141,893**	
(3)	**Optimism Bias**	35.2%			**49,997**	Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**191,890**	
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13.0%			**24,946**	Set at 13%
	Construction Costs and Fees				**216,836**	
(6)	**Other Items**					
(a)	Allowance for Archaeology & Environmental Mitigation Measures	n/a				Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	n/a				Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation	5% assumed		9,595		Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance			n/a		See “Guidance E – Per Cent for Art Note”
(e)	Est. NPV Operation & Maintenance		22,606			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	35.2%	7,965	30,571	**40,165**	Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**257,001**	

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:		Date:	
Checked by:		Date:	

Project reference		Project name:	
Base date for estimates (year 0)	Oct-2013	Construction Price Index (CPI)	0.987
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues /constraints	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	Cost (€)	Comment
Total wall costs		
Total embankment costs		
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs	€105,498	
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs	€5,296	
Total Construction costs	€110,794	
Apply update to unit rate (CPI) if appropriate (cell N15)	€109,354	
Enter appropriate preliminaries estimate (%)	28%	
Enter other applicable costs (€)	0	
Total capital cost (€)	€141,893	
Consider amendments based on site issues/constraints (cell N16)	€141,893	
Total capital cost (€)	€141,893	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs		
Total embankment O&M costs		
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs	€1,059	
Total Operation and Maintenance costs	€1,059	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€164,499	
Optimism bias rate (from external sheet)	35%	
Total Cost including Optimism Bias	€222,461	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€141,893.5
Annual maintenance cost (€)	€1,059.2
Other cost (€)	€0.0
Other works frequency (years)	

Key

- Information
- Calculation
- Cost input
- User information

Discount rate:	4.0%	Present Value Factor:		22.341		Total PVc (€k):	164499
	Cash sum	0	141893	51902	0	193796	164499
	Discount	Cost Elements				TOTALS:	
year	Factor	Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0	141893			141893.5	141893.5
1	0.962			1059		1059.2	1018.5
2	0.925			1059		1059.2	979.3
3	0.889			1059		1059.2	941.7
4	0.855			1059		1059.2	905.4
5	0.822			1059		1059.2	870.6
6	0.790			1059		1059.2	837.1
7	0.760			1059		1059.2	804.9
8	0.731			1059		1059.2	774.0
9	0.703			1059		1059.2	744.2
10	0.676			1059		1059.2	715.6
11	0.650			1059		1059.2	688.1
12	0.625			1059		1059.2	661.6
13	0.601			1059		1059.2	636.1
14	0.577			1059		1059.2	611.7
15	0.555			1059		1059.2	588.2
16	0.534			1059		1059.2	565.5
17	0.513			1059		1059.2	543.8
18	0.494			1059		1059.2	522.9
19	0.475			1059		1059.2	502.8
20	0.456			1059		1059.2	483.4
21	0.439			1059		1059.2	464.8
22	0.422			1059		1059.2	446.9
23	0.406			1059		1059.2	429.8
24	0.390			1059		1059.2	413.2
25	0.375			1059		1059.2	397.3
26	0.361			1059		1059.2	382.1
27	0.347			1059		1059.2	367.4
28	0.333			1059		1059.2	353.2
29	0.321			1059		1059.2	339.6
30	0.308			1059		1059.2	326.6
31	0.296			1059		1059.2	314.0
32	0.285			1059		1059.2	301.9
33	0.274			1059		1059.2	290.3
34	0.264			1059		1059.2	279.2
35	0.253			1059		1059.2	268.4
36	0.244			1059		1059.2	258.1
37	0.234			1059		1059.2	248.2
38	0.225			1059		1059.2	238.6
39	0.217			1059		1059.2	229.5
40	0.208			1059		1059.2	220.6
41	0.200			1059		1059.2	212.1
42	0.193			1059		1059.2	204.0
43	0.185			1059		1059.2	196.1
44	0.178			1059		1059.2	188.6
45	0.171			1059		1059.2	181.3
46	0.165			1059		1059.2	174.4
47	0.158			1059		1059.2	167.7
48	0.152			1059		1059.2	161.2
49	0.146			1059		1059.2	155.0

Appendix C13 Option Appraisal Report - Ballylongford

1. Preliminary Report: Summary of Current Flood Risk

1.1 AFA and Watercourse Details

AFA	Ballylongford
Unit of Management:	24
Primary Watercourse(s):	Rusheen Park (River), Lower Aghanagran (Stream), Lislaughtin (Stream), Well Tributary, Ballyline (River), Ballyline East Tributary, Ballyline West Tributary, Ballyline (River), Rusheen Park (River)

1.2 Summary of Flood Risk in 1% Fluvial / 0.5% Coastal AEP Event

Source of flood risk	Fluvial	Coastal	**Both**	
Total Number of Properties at risk in AFA in 1% Fluvial / 0.5% Coastal AEP Event:		**Residential**	**Non-Residential**	**Total**
	Fluvial	22	9	31
	Coastal	41	13	54
	Combined	41	13	54
AFA Flood Cells:	**Total Number:**	3		
	Flood Cell Titles:	BLD_A, BLD_B, BLD_C		
Breakdown of properties at (combined) risk per Flood Cell:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	BLD_A	25	9	34
	BLD_B	10	4	14
	BLD_C	6	0	6
Relevant Figure Ref:	Figure 1.1 to 1.3			

1.3 Summary of Existing Flood Risk Management Measures

Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
None	None	None	None	None	None
Relevant Figure Ref:	N/A				

1.4 Summary of PV Damages/Potential PV Benefits

Total PV Damages:		**Uncapped**	**Capped**
	Fluvial	€ 1,019,135	€ 1,019,135
	Coastal	€ 19,230,599	€ 10,227,016
	Combined	€ 20,249,734	€ 10,504,272
Max Combined Capped Benefits for 1% Fluvial and 0.5% Coastal AEP Event*:	€ 9,651,868		

Breakdown of Max Combined Capped PV Benefits per Flood Cell for 1% Fluvial and 0.5% Coastal AEP Event:	**Flood Cell Ref**	**Residential**	**Non-Res**	**Total**
	BLD_A	€ 3,893,231	€ 4,341,280	€ 8,234,511
	BLD_B	€ 841,688	€ 320,660	€ 1,162,348
	BLD_C	€ 255,009	€ 0	€ 255,009
Relevant Figure Ref:	Figure 1.3			

*These are the maximum benefits available if a FRM option with a 1% Fluvial / 0.5% Coastal AEP SOP is provided to all properties within the AFA.

<table>
<tr><th colspan="3">1.5 Social Risk</th></tr>
<tr><td></td><td>Type</td><td>Description</td></tr>
<tr><td>High Vulnerability Properties at risk:</td><td>None</td><td>N/A</td></tr>
<tr><td rowspan="4">Social Infrastructure Assets:</td><td rowspan="2">Fire Station</td><td>20% AEP Coastal Flood Extent</td></tr>
<tr><td>Ballylongford Fire Station</td></tr>
<tr><td rowspan="2">Community Centre</td><td>50% AEP Coastal Flood Extent</td></tr>
<tr><td>Ballylongford Community Centre</td></tr>
<tr><td>Social Amenity Sites:</td><td>None</td><td>N/A</td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="2">General Risk - Social</td></tr>
<tr><th colspan="3">1.6 Risk to the Environment</th></tr>
<tr><td></td><td>Type</td><td>Description</td></tr>
<tr><td>Risk to WFD Annex IV:</td><td>None</td><td>N/A</td></tr>
<tr><td>Risk to SACs:</td><td>Special Area of Conservation</td><td>Lower River Shannon</td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="2">General Risk - Environment</td></tr>
<tr><th colspan="3">1.7 Risk to Cultural Heritage</th></tr>
<tr><td></td><td>Type</td><td>Description</td></tr>
<tr><td rowspan="5">Risk to Sites of Cultural Heritage:</td><td rowspan="5">NIAH Buildings</td><td>50% AEP Coastal Flood Extent</td></tr>
<tr><td>Mill (water), Quay Street, Ballylongford</td></tr>
<tr><td>Mill (water), Bridge Street, Ballylongford</td></tr>
<tr><td>5% AEP Coastal Flood Extent</td></tr>
<tr><td>House, Ballylongford</td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="2">General Risk – Cultural Heritage</td></tr>
<tr><th colspan="3">1.8 Risk to the Economy</th></tr>
<tr><td></td><td>Type</td><td>Description</td></tr>
<tr><td rowspan="8">Risk to Transport Infrastructure:</td><td rowspan="6">Regional Road</td><td>50% AEP Coastal Flood Extent</td></tr>
<tr><td>Quay Street (R551),</td></tr>
<tr><td>Bridge Street (R551)</td></tr>
<tr><td>0.5% AEP Coastal Flood Extent</td></tr>
<tr><td>Main Street (R552)</td></tr>
<tr><td>Well Street (R552)</td></tr>
<tr><td rowspan="2">Local Urban (Street)</td><td>50% AEP Coastal Flood Extent</td></tr>
<tr><td>L1010 (opposite Main Street)</td></tr>
<tr><td>Risk to Utility Infrastructure:</td><td>None</td><td>N/A</td></tr>
<tr><td>Relevant Figure Ref:</td><td colspan="2">General Risk - Economy</td></tr>
</table>

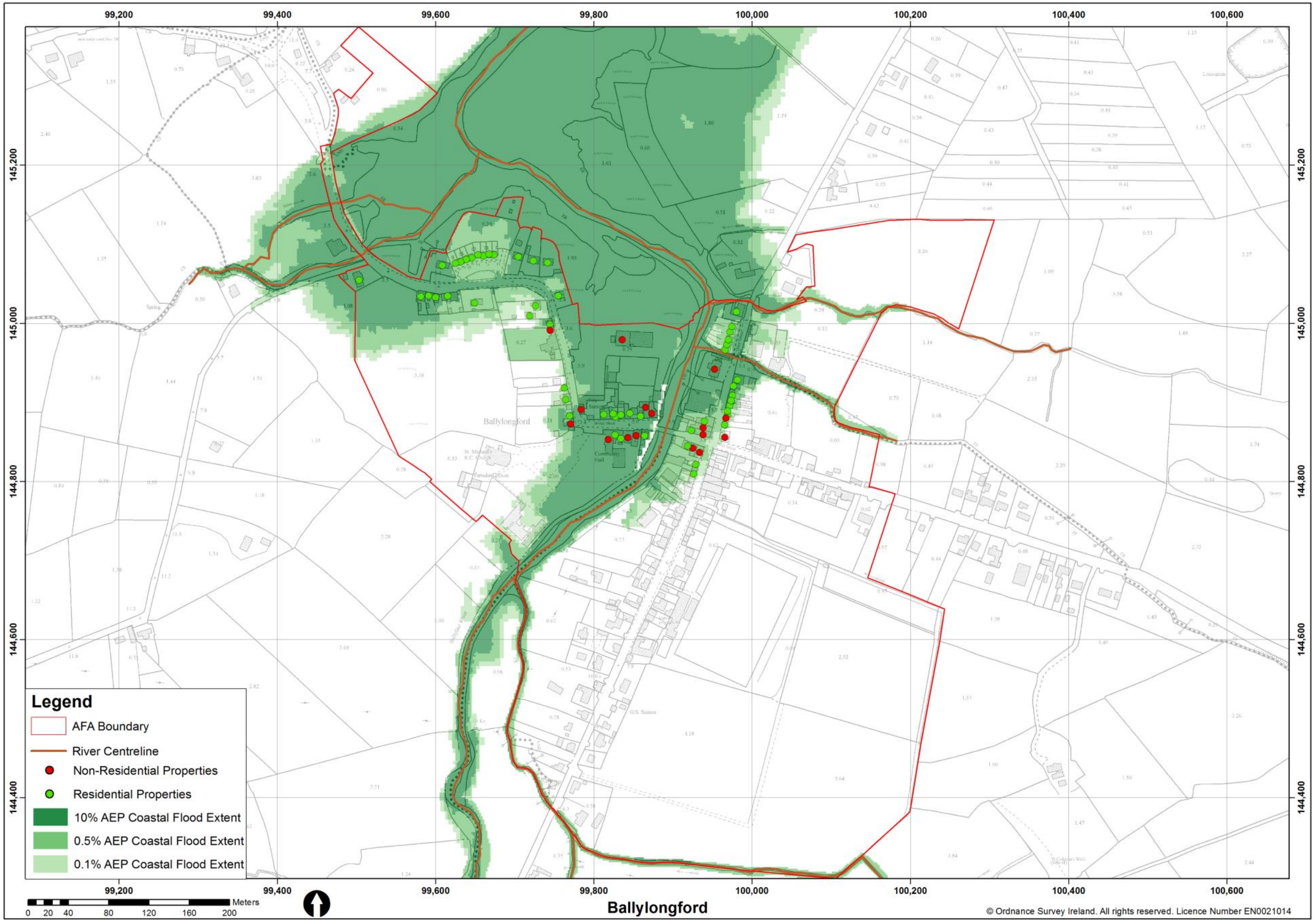


Figure 1.1 Ballylongford Coastal Flood Risk to Properties

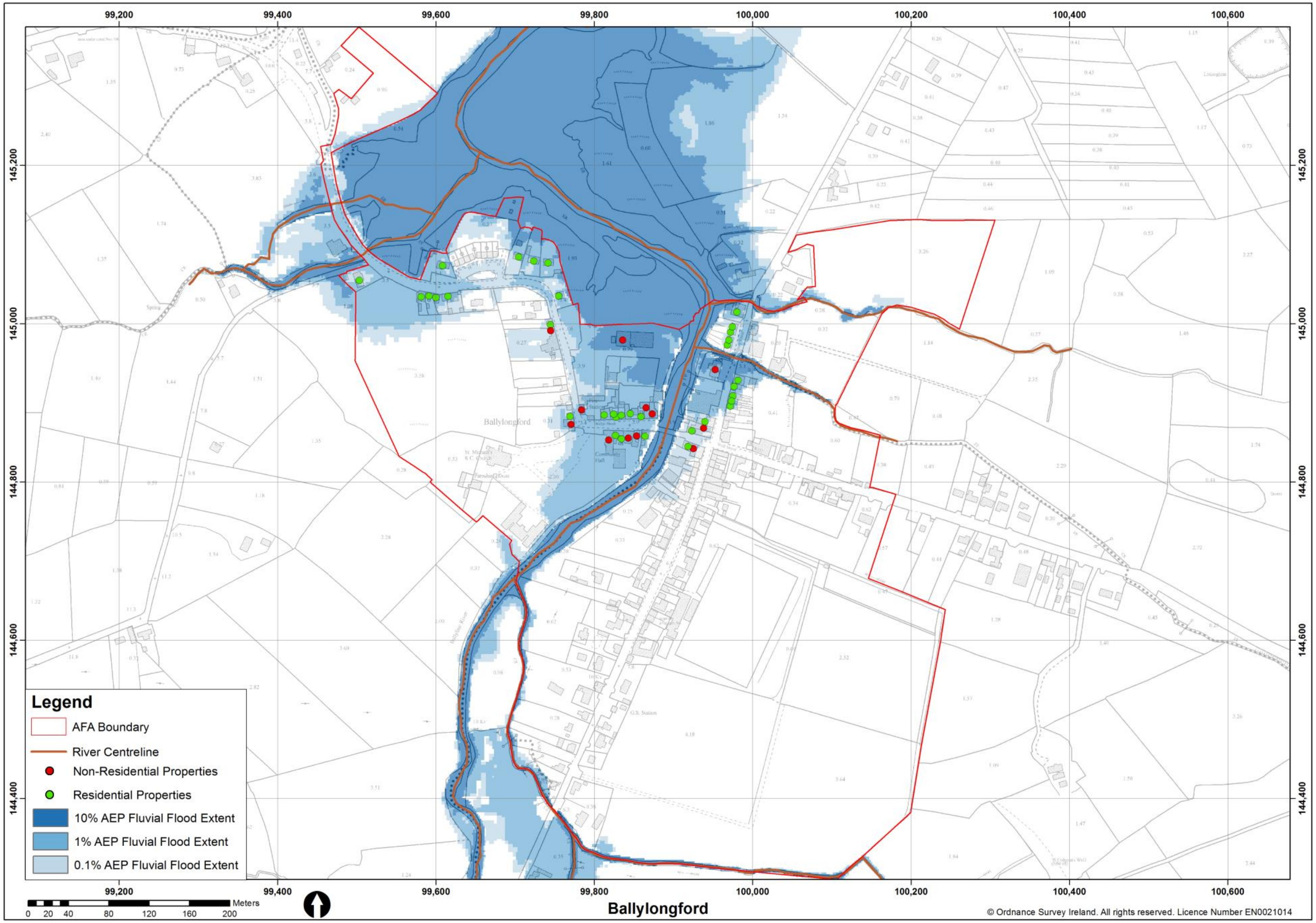


Figure 1.2– Ballylongford Fluvial Flood Risk to Properties

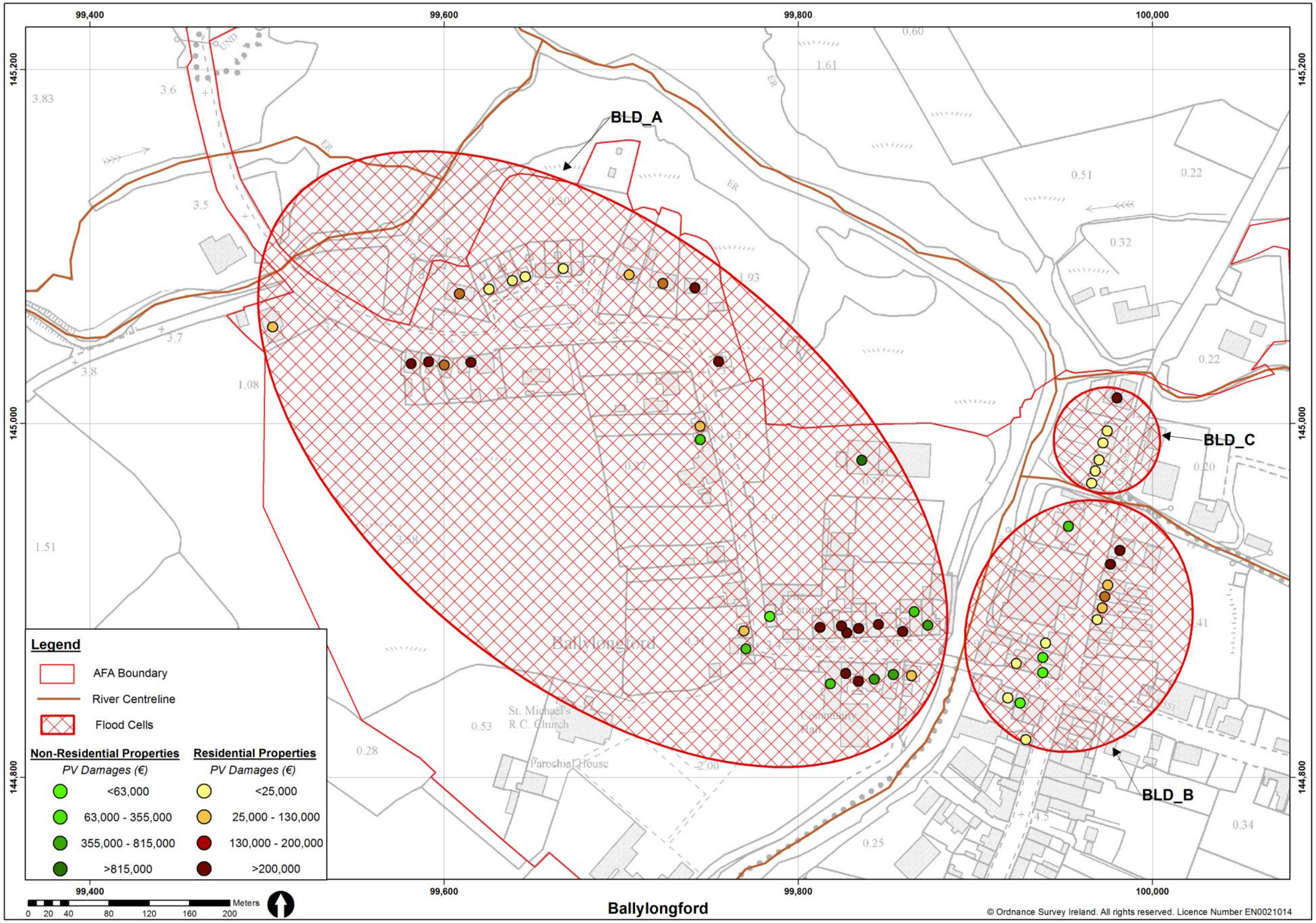


Figure 1.3 – Ballylongford Total Combined PV Damages for Properties in the 1% Fluvial & 0.5% Coastal AEP Flood Event and Flood Cells
Flood Cells are groupings of properties that are likely to be hydraulically linked

STAGE 2: Screening of the Measures

2.1 Baseline, Structural and Non-Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
B	Existing Regime	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
Structural							
D	Storage	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
E	Flow Diversion	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
F	Increase Conveyance	Unviable	Viable	Viable	Viable	Viable	**Screened Out**
G	Flood Defences	Viable	Viable	Viable	Viable	Viable	**Screened In**
H	Relocation of Properties	Unviable	Viable	Viable	Unviable	Viable	**Screened Out**
I	Other	Unviable	Unviable	Unviable	Unviable	Unviable	**Screened Out**
Non-Structural							
J	Flood Forecasting / Warning / Response	Viable	Viable	Viable	Viable	Viable	**Screened In**
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	**Screened In**
L	Individual Property Resistance	Viable	Viable	Viable	Viable	Viable	**Screened In**
M	Individual Property Resilience	Viable	Viable	Viable	Viable	Viable	**Screened In**

2.2 Justification for Screened Out Baseline and Structural Measures

The following provides justification on Measures with an overall viability 'Screened Out' categorisation.

A	Do Nothing	Applicability Economic Environmental Social Cultural	Screened out due to the number of properties currently at risk of flooding.
B	Existing Regime	Applicability Economic Environmental Social Cultural	Screened out as there is no existing regime.
C	Do Minimum	Applicability Economic Environmental Social Cultural	Screened out, as the 'Do Minimum' measure would have negligible impact on the existing 1% AEP flood risk within the AFA.
D	Storage	Applicability Economic Environmental Social Cultural	As the dominate source of risk to the AFA is coastal, storage is not considered applicable to the AFA.

E	Flow Diversion	Applicability Economic Environmental Social Cultural	As the dominate source of risk to the AFA is coastal, flow diversion is not considered applicable to the AFA.
F	Increase Conveyance	Applicability Economic Environmental Social Cultural	As the dominant source of risk to the AFA is coastal, increase conveyance is not considered applicable to the AFA.
H	Relocation of Properties	Applicability Economic Environmental Social Cultural	The relocation of 54 properties is not applicable to the area and is neither socially nor culturally viable.
I	Other	Applicability Economic Environmental Social Cultural	No other Measures have been identified.

2.3 Summary of 'Screened In' Measures

The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.

Structural Measures		**Non-Structural Measures**	
G	Flood Defences	J	Flood Forecasting / Warning / Response
		K	Public Awareness
		L	Individual Property Resistance
		M	Individual Property Resilience

STAGE 3: Selection of Options								
3.1 Consideration of Options The following are the agreed combination of 'Screened In' measures that comprise each of the Options being taken forward for further consideration. Where appropriate, the 'Screened In' measures have been sub-divided into separate specific measures to ensure applicability to site conditions.								
Measures		**Different composition of measures per option**						
Structural Measures								
G	Flood Defences:							
Gi	New Flood Defences	✓	✓					
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
J	Flood Forecasting / Warning / Response		✓					
K	Public Awareness		✓					
L	Individual Property Resistance		✓					
M	Individual Property Resilience							
Option Reference		BLD_01	BLD_02					

Measures not screened out but not included in options		
Measures		**Justification**
M	Individual Property Resilience	Individual Property Resilience was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required 1% Fluvial AEP standard of protection. Individual Property Resilience does not improve the viability of the options under consideration.

STAGE 4: Appraisal of Options

4.1 Options Appraisal

Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Meeting. Below describes this concept design of each option and provides a summary of any significant comments/issues which were raised by LA staff at the Options Meetings. These comments will be considered in the local weightings and the MCA scores.

Option Ref:		BLD_01				
Option Measures	**Baseline**		**None**			
	Structural	Gi	**Flood Defences: New Flood Defences**			
	Non Structural	J Flood Forecasting	K Public Awareness	L Property Resistance	M Property Resilience	
Option Description:		Construction of new flood defence walls and embankments as shown in figure 5.1, will eliminate the flood risk within the AFA for the 0.5% AEP coastal event and the 1% fluvial AEP event.				
Option Meeting:		Date:	10^{th} June 2015			
		Summary:	The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.			
Option Ref:		BLD_02				
Option Measures	**Baseline**		**None**			
	Structural	Gi	**Flood Defences: New Flood Defences**			
	Non Structural	**J** **Flood Forecasting**	**K** **Public Awareness**	**L** **Property Resistance**	M Property Resilience	
Option Description:		Construction of new flood defence walls and embankments to protect properties in flood cell BLD_A. Individual property resistance, flood forecasting, and public awareness will apply to properties in flood cells BLD_B and BLD_C. See figure 5.2. These measures will eliminate the flood risk within the AFA for the 0.5% AEP coastal event and the 1% fluvial AEP event.				
Option Meeting:		Date:	10^{th} June 2015			
		Summary:	The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.			

STAGE 5: Multi Criteria Assessment

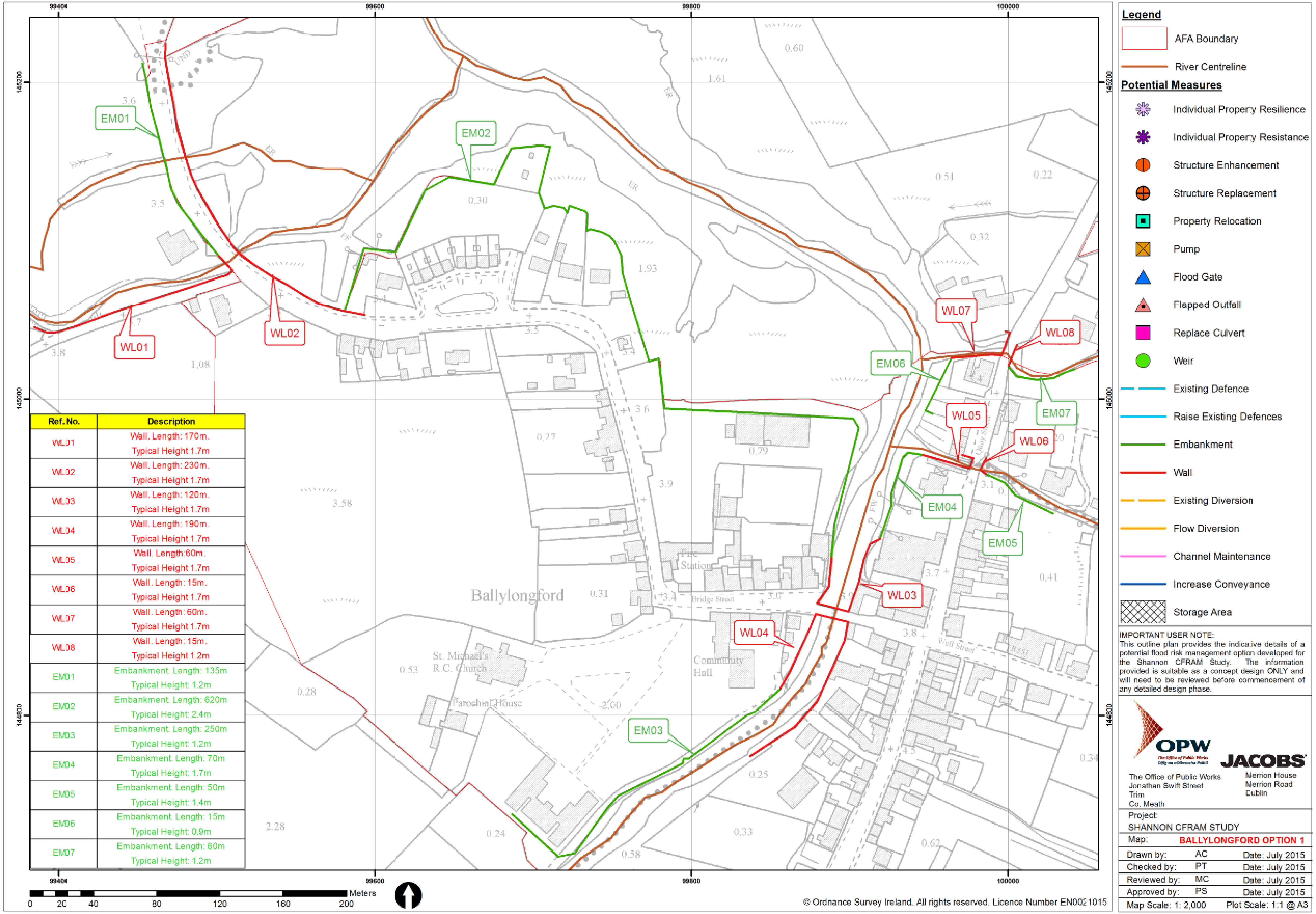
5.1 Options selected for the Multi Criteria Assessment

Following the Option Meeting, the following options are the refined options for the Multi-Criteria Assessment (MCA) stage. This is the final of a five-stage MCA process.

Option Reference		BLD_01	BLD_02
Structural Measures			
Gi	New Flood Defences	Construct 1.2km of earth embankments at various locations as shown in figure 5.1. The height of the embankments will be between 1 - 1.5 m above ground level depending on location. Construct 0.80km of stone faced flood defence walls as shown in figure 5.1. The height of the walls will be between 1-1.5m above ground level depending on location. In addition, there is a NIAH Mill building on the right bank just below the main bridge. The wall of the mill will need to be waterproofed and maintained as part of the defences.	Construct 0.92km of earth embankments at various locations as shown in figure 5.2. The height of the embankments will be between 1 - 1.5 m above ground level depending on location. Construct 0.550km of stone faced flood defence walls as shown in figure 5.2. The height of the walls will be between 1-1.5m above ground level depending on location.
Non-Structural Measures			
J	Flood Forecasting / Warning / Response		This will apply to all properties on the right bank of the main river as shown in figure 5.2.
K	Public Awareness		This will apply to all properties on the right bank of the main river as shown in figure 5.2.
L	Individual Property Resistance		This will apply to all properties on the right bank of the main river as shown in figure 5.2.
Table reference A summary of the outcome from the MCA is presented in the following table		Table 5.1	Table 5.2

Table 5.1: Multi Criteria Assessment Outcome for Option BLD_01

<table>
<tr><td colspan="6">Multi Criteria Assessment
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.</td></tr>
<tr><td>AFA</td><td colspan="2">Ballylongford</td><td>Option Ref:</td><td colspan="2">BLD_01</td></tr>
<tr><td colspan="6">Option Measures</td></tr>
<tr><td>Baseline</td><td></td><td>None</td><td rowspan="2">Non Structural</td><td></td><td></td></tr>
<tr><td>Structural</td><td>Gi</td><td>New Flood Defences</td><td></td><td></td></tr>
<tr><td colspan="6">Criteria Scores</td></tr>
<tr><td colspan="2">Technical</td><td colspan="4">1200</td></tr>
<tr><td colspan="2">Economic</td><td colspan="4">849</td></tr>
<tr><td colspan="2">Social</td><td colspan="4">1068</td></tr>
<tr><td colspan="2">Environmental</td><td colspan="4">-842</td></tr>
<tr><td colspan="6">Economic Values</td></tr>
<tr><td colspan="2">Economic PV Benefits</td><td colspan="4">€ 9,651,868</td></tr>
<tr><td colspan="2">PV Cost</td><td colspan="4">€ 9,587,821</td></tr>
<tr><td colspan="2">NPV Benefits</td><td colspan="4">€ 64,047</td></tr>
<tr><td colspan="2">Economic BCR</td><td colspan="4">1.01</td></tr>
<tr><td colspan="6">Outcome Scores</td></tr>
<tr><td colspan="2">MCA PV Benefits</td><td colspan="4">€ 4,520,306</td></tr>
<tr><td colspan="2">MCA Benefit Score</td><td colspan="4">1076</td></tr>
<tr><td colspan="2">MCA Benefit Score Ratio</td><td colspan="4">112.18</td></tr>
<tr><td colspan="2">Option Selection MCA</td><td colspan="4">2276</td></tr>
</table>

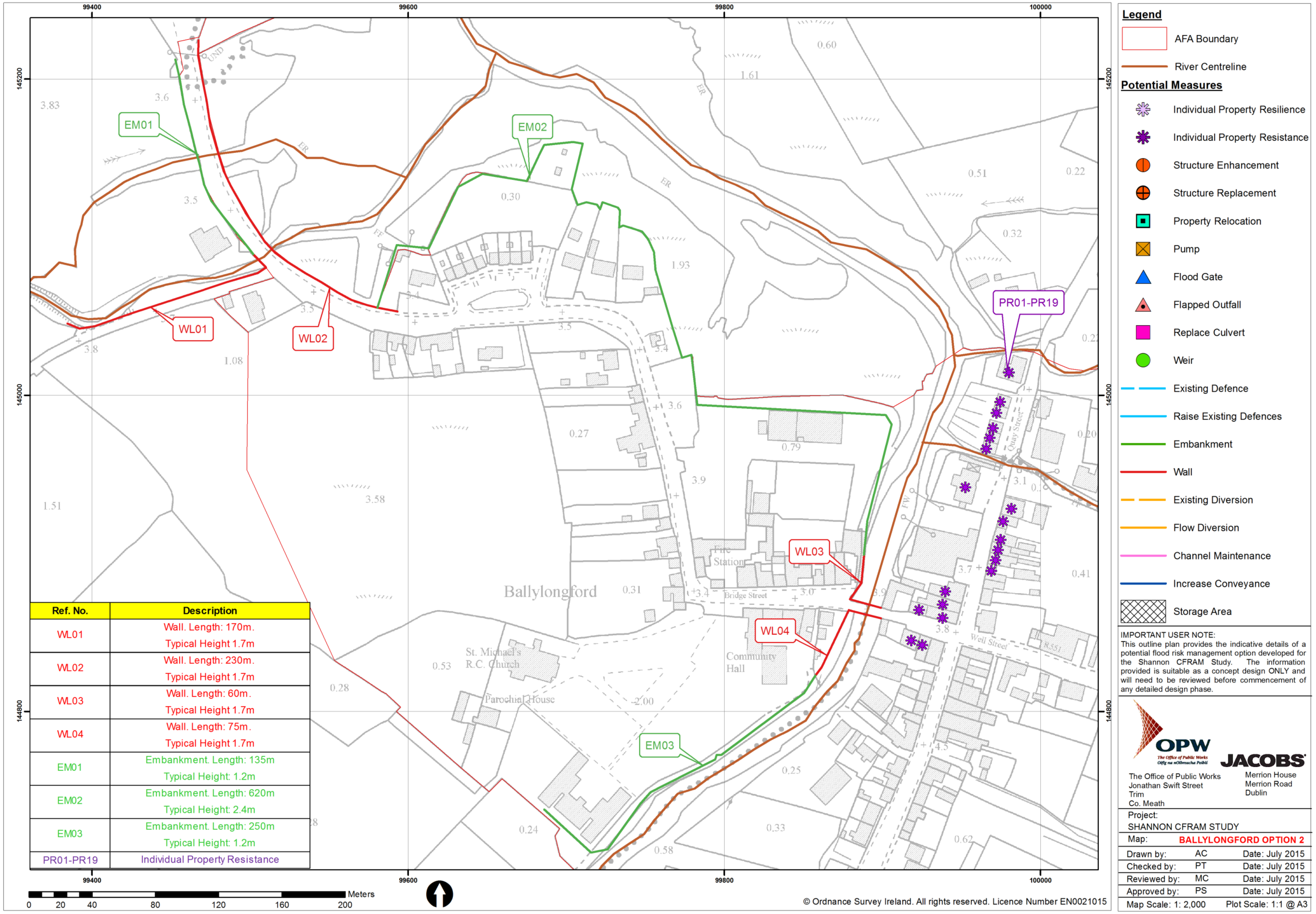


Ref. No.	Description
WL01	Wall. Length: 170m. Typical Height 1.7m
WL02	Wall. Length: 230m. Typical Height 1.7m
WL03	Wall. Length: 120m. Typical Height 1.7m
WL04	Wall. Length: 190m. Typical Height 1.7m
WL05	Wall. Length:60m. Typical Height 1.7m
WL06	Wall. Length: 15m. Typical Height 1.7m
WL07	Wall. Length: 60m. Typical Height 1.7m
WL08	Wall. Length: 15m. Typical Height 1.2m
EM01	Embankment. Length: 135m Typical Height: 1.2m
EM02	Embankment. Length: 620m Typical Height: 2.4m
EM03	Embankment. Length: 250m Typical Height: 1.2m
EM04	Embankment. Length: 70m Typical Height: 1.7m
EM05	Embankment. Length: 50m Typical Height: 1.4m
EM06	Embankment. Length: 15m Typical Height: 0.9m
EM07	Embankment. Length: 60m Typical Height: 1.2m

Figure 5.1 Option BLD_01

Table 5.2: Multi Criteria Assessment Outcome for Option BLD_02

<table>
<tr><td colspan="6">Multi Criteria Assessment
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.</td></tr>
<tr><td>AFA</td><td colspan="2">Ballylongford</td><td>Option Ref:</td><td colspan="2">BLD_02</td></tr>
<tr><td colspan="6">Option Measures</td></tr>
<tr><td>Baseline</td><td></td><td>None</td><td rowspan="3">Non Structural</td><td>M</td><td>Individual Property Resilience</td></tr>
<tr><td rowspan="2">Structural</td><td rowspan="2">Gi</td><td rowspan="2">New Flood Defences</td><td>J</td><td>Flood Forecasting / Warning / Response</td></tr>
<tr><td>K</td><td>Public Awareness</td></tr>
<tr><td colspan="6">Criteria Scores</td></tr>
<tr><td colspan="2">Technical</td><td colspan="4">867</td></tr>
<tr><td colspan="2">Economic</td><td colspan="4">840</td></tr>
<tr><td colspan="2">Social</td><td colspan="4">1048</td></tr>
<tr><td colspan="2">Environmental</td><td colspan="4">-705</td></tr>
<tr><td colspan="6">Economic Values</td></tr>
<tr><td colspan="2">Economic PV Benefits</td><td colspan="4">€ 9,329,478</td></tr>
<tr><td colspan="2">PV Cost</td><td colspan="4">€ 8,573,095</td></tr>
<tr><td colspan="2">NPV Benefits</td><td colspan="4">€ 756,383</td></tr>
<tr><td colspan="2">Economic BCR</td><td colspan="4">1.09</td></tr>
<tr><td colspan="6">Outcome Scores</td></tr>
<tr><td colspan="2">MCA PV Benefits</td><td colspan="4">€ 4,427,375</td></tr>
<tr><td colspan="2">MCA Benefit Score</td><td colspan="4">1183</td></tr>
<tr><td colspan="2">MCA Benefit Score Ratio</td><td colspan="4">138</td></tr>
<tr><td colspan="2">Option Selection MCA</td><td colspan="4">2050</td></tr>
</table>



Ref. No.	Description
WL01	Wall. Length: 170m. Typical Height 1.7m
WL02	Wall. Length: 230m. Typical Height 1.7m
WL03	Wall. Length: 60m. Typical Height 1.7m
WL04	Wall. Length: 75m. Typical Height 1.7m
EM01	Embankment. Length: 135m Typical Height: 1.2m
EM02	Embankment. Length: 620m Typical Height: 2.4m
EM03	Embankment. Length: 250m Typical Height: 1.2m
PR01-PR19	Individual Property Resistance

Figure 5.2 Option BLD_02

5.2 Comparison of Multi Criteria Assessment Scores

Each option taken forward for further consideration through the Option Decision Meeting, has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Decision Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).

Categories	**Option Reference and Results**	
	BLD_01	BLD_02
Criteria Scores		
Technical	1200	867
Economic	849	840
Social	1068	1048
Environmental	-842	- 705
Economic Values		
Economic PV Benefits	€ 9,651,868	€ 9,329,478
PV Cost	€ 9,587,821	€ 8,573,095
NPV Benefits	€ 64,047	€ 756,383
Economic BCR	**1.01**	**1.09**
Outcome Scores		
MCA PV Benefits	€ 4,520,306	€ 4,427,375
MCA Benefit Score	1076	1183
MCA BCR	112.18	138
Option Selection MCA	2276	2050

5.3 Recommendation of Preferred Option

It forms part of the CFRAM process for the recommendation of a preferred option for each AFA. The prioritised selection criteria used in this recommendation process is detailed in Section 3.7.3 of the Main Report.

Therefore, following the five stage Multi Criteria Assessment process, the preferred option is as outlined below

Option Ref:		BLD_01				
Option Measures	**Baseline**		**None**			
	Structural	**Gi**	**New Flood Defences**			
	Non Structural	J Flood Forecasting		K Public Awareness	L Property Resistance	M Property Resilience
Comments		Although The MCA BCR is highest for BLD_02, BLD_01 offers direct flood protection to more properties and is economically viable. Therefore BLD_01 is the preferred option.				

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

Fluvial Flood Forecasting Potential				
Catchment Information	**Gauging Station**		**Catchment size (km ^{2})**	**Potential available forecast accuracy and reliability period**
	Fluvial	**Rainfall**		
	n/a	n/a	37	3-6 hours
Relevant Information:	No gauging station			
Additional Infrastructure Recommended	**Gauging Station**		**Other**	
	Fluvial	**Rainfall**		
	No	No	n/a	
Relevant Comments:	A fluvial gauging could be included upstream of Ballylongford to provide fluvial forecasting. However, it must be noted that Ballylongford is tidally dominated and the addition of a fluvial forecasting system would provide little benefit. Tidal flooding could be predicted by a simple forecasting system.			

*For this assessment only 15 minute tipping bucket gauge were considered.

Annex A - Multi-Criteria Analysis Summary and Whole Life Cost Summaries for FRM Option(s)

CRITERIA			OBJECTIVE	Global Weighting	Local Weighting	Comments	BLD_01 Gi: New Flood Defences	Option Score	Weighted Score	BLD_02 Gi: New Flood Defences J: Flood Forecasting / Warning / Response K: Public Awareness M: Individual Property Resilience	Option Score	Weighted Score
1	Technical	a	Ensure flood risk management options are operationally robust	20	5.00	The option scores are determined based on the level of operational risk to operate or perform successfully. Each measure is scored independently and the average of the measure scores is used as the score for the option.	None; Manageable; Negligible; Moderate / high; Very low; High; Low; Failure likely; Low / moderate; Unacceptable Gi: 5.00	5.00	500	None; Manageable; Negligible; Moderate / high; Very low; High; Low; Failure likely; Low / moderate; Unacceptable Gi: 5.00 J: 3.00 K: M: 3.00	3.67	367
		b	Minimise health and safety risks associated with the construction and operation of flood risk management options	20	5.00	H&S risks are considered for construction and maintenance of flood risk management measures. The indicative aspirational score is set at five, with a point then deducted for each specific H&S risk in either construction or maintenance.	No risks; Moderate; Negligible; Moderate / high; Very low; High; Low; Very High; Low / moderate; Unacceptable Work near/in water	3.00	300	No risks; Moderate; Negligible; Moderate / high; Very low; High; Low; Very High; Low / moderate; Unacceptable Work near/in water Work near services or buildings	1.00	100
		c	Ensure flood risk management options are adaptable to future flood risk	20	5.00	The options scores are determined based on the sustainability and adaptability of the flood risk management measures in the face of potential future changes, including the potential impact of climate change. Each measure is scored independently and the average of the measure scores is used as the score for the option.	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. Gi: 4.00	4.00	400	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions. Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. Option cannot be adapted, but provides no to minor impediment to potential future interventions. Option cannot be adapted, and provides moderate to major impediment to potential future interventions. Gi: 4.00 J: 5.00 K: M: 3.00	4.00	400
			TECHNICAL CRITERIA SCORE						1200			867
2	Economic	a	Minimise economic risk	24	5.00		The score is calculated based on the reduction in AAD, following the full implementation of option.	4.79	575	The score is calculated based on the reduction in AAD, following the full implementation of option.	4.77	572
		b	Minimise risk to transport infrastructure	10	5.00		The score is calculated based on the reduction in flood risk to transport routes following the full implementation of option.	4.98	249	The score is calculated based on the reduction in flood risk to transport routes following the full implementation of option.	4.34	217
		c	Minimise risk to utility infrastructure	14	0.00	There is no risk to utility infrastructure in the baseline scenario.	The score is calculated based on a reduction in flood risk to utility infrastructure, following the full implementation of option.			The score is calculated based on a reduction in flood risk to utility infrastructure, following the full implementation of option.		
		d	Minimise risk to agriculture	12	2.11	Source of Flooding: Both Fresh & Salt Water Percentage of AFA that is rural land: 42.24%	Area of Agricultural Land Flooded: Decreased Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Not Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable	1.00	25	Area of Agricultural Land Flooded: Decreased Frequency & Seasonality of Flooding: No Change Duration of Flooding: No Change Risk to Agicultrual Infrastructure: No Change Flood Warning: Applicable Agricultural Production Enhanced: No Change Other (Please Specify): Not Applicable	2.00	51
			ECONOMIC CRITERIA SCORE						849			840
3	Social	a i)	Minimise risk to human health and life - Residents	27	5.00	Flood Depths & Velocities: Assumed low risk to life Known Areas of Highly Vulnerable People: Reasonable Cross Section of Society	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	4.97	671	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	4.80	648
		a ii)	Minimise risk to human health and life - High vulnerability properties	17	0.00	Rate of Onset of flooding: Assumed 1-2 hours for evacuation	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	0.00	0	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	5.00	0
		b i)	Minimise risk to community - Social Infrastructure & Amenity	9	5.00	Assets of Particular Social Value: Yes	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	4.95	223	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	5.00	225
		b ii)	Minimise risk to community - Local employment	7	5.00	Asset of Particular Employment Value: No	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	4.98	174	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	5.00	175
			SOCIAL CRITERIA SCORE						1068			1048
4	Environmental	a	Support the objectives of the WFD	16	5.00	There is one WFD waterbody within the AFA, the Ballyline River. The status of this waterbody is moderate. There are no potentially polluting sources within the 1% AEP Fluvial &/or 0.5% AEP Coastal within the AFA. There is 1 WWTP within the 1% AEP Fluvial &/or 0.5% AEP Coastal but outside the AFA. There are a number of WFD Annex V areas within the AFA and in proximity to the AFA: The Ballyline River is a Salmonid Waterbody (that intersects an SAC) and SPA and SAC waterbody. Local weighting to be applied for this objective is constant, and should always be set equal to 5 as WFD objectives must be achieved and are relevant to all waterbodies.	Construction related impacts due to significant construction works in and adjacent to the Ballyline River, Rusheen Park River, Lower Aghanagran Stream, Lislaughtin Stream and Well Tributary for the construction of flood defence walls and flood defence embankments. The proposed walls and embankments will permanently replace the natural bank in the Ballyline River, Rusheen Park River, Lower Aghanagran Stream, Lislaughtin Stream and Well Tributary. These measures could cause potential changes to the hydrological and morphological regime of the waterbody, hydromorphological and physico-chemical impacts due to sediment release. There will be reduced flooding in an area with no significant polluting sources in 1% AEP Fluvial &/or 0.5% AEP Coastal extents. Therefore, there is potential for medium-term or recurring impediment to the achievement of waterbody objectives.	-3.00	-240	Construction related impacts due to significant construction works in and adjacent to the Ballyline River, Rusheen Park River and Lower Aghanagran Stream due to the construction of flood defence walls and flood defence embankments. Option BLD_02 has a reduced length of embankment compared with Option BLD_01. The proposed walls and embankments will permanently replace the natural bank in the Ballyline River, Rusheen Park River and Lower Aghanagran Stream. These measures could cause potential changes to the hydrological and morphological regime of the waterbody, hydromorphological and physico-chemical impacts due to sediment release. There will be reduced flooding in an area with no significant polluting sources in 1% AEP Fluvial &/or 0.5% AEP Coastal extents. Therefore, there is potential for medium-term or recurring impediment to the achievement of waterbody objectives.	-2.50	-200
		b	Support the objectives of the Habitats Directive	10	5.00	Two European sites are within the AFA and are hydrologically connected to it. The Rivers Shannon and River Fergus Estuaries SPA are within the AFA and the Lower River Shannon cSAC[002165] - Qualifying Interests likely to occur within the AFA include saltmarsh habitats, otter, river, brook and sea lamprey and Atlantic salmon. Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.	This option proposes the construction of flood defence walls and flood defence embankments along the Ballyline River and Rusheen Park River. There are proposed works within and adjacent the cSAC and SPA. Proposed works include construction of earth embankments and stone faced flood defence walls. These measure fall within the cSAC and adjacent to the SPA. Potentially significant effects are: - Increases in suspended sediment; - Pollution risks to the estuary; - Loss of intertidal habitat adjacent to River Shannon and River Fergus Estuaries SPA and within the Lower River Shannon SAC; - Disturbance to bird species within and outside the SPA; - Disturbance to otter within and outside the cSAC. Therefore, there is potential for detrimental impact upon conservation objectives of existing SAC, SPA or Ramsar site, including a delay in recovery of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	-5.00	-250	This option has a reduced length of construction of embankments and walls and has individual property resistance, however it is still likely to cause potentially significant effects during construction, such as: - Increases in suspended sediment; - Pollution risks to the estuary; - Loss of intertidal habitat adjacent to River Shannon and River Fergus Estuaries SPA and within the Lower River Shannon SAC; - Disturbance to bird species within and outside the SPA; - Disturbance to otter within and outside the cSAC. Therefore, there is potential for detrimental impact upon conservation objectives of existing SAC, SPA or Ramsar site, including a delay in recovery of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	-4.50	-225
		c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	5	5.00	The Ballylongford Bay pNHA is a nationally designated site within the AFA. The scientific interest of the area lies in the large concentrations of waterfowl that feed on the mudflats there. Local weighting of 5 set by professional judgement. Weighting of 5 applied where a nationally important site (pNHA, NHA etc.) is present (within AFA) and potentially affected.	This option proposes construction of flood defence walls and flood defence embankments along the Ballyline River and Rusheen Park River. Potential significant effects in relation to works within the boundary of the Ballylongford Bay pNHA, in particular the flood defence earth embankments and flood walls on the boundary and in places within the pNHA. Potentially significant impacts are associated with protected flora and fauna, including: - Increase in suspended solids entering the watercourse during construction works - Risk of a pollution event impacting the watercourse - Loss of habitat - Risk of mortality and disturbance to various protected species - Impacts to fish species including salmon and lamprey - Risk of invasive species spread during proposed works Therefore a potential detrimental impact upon the condition of existing national, regional or local sites as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	-5.00	-125	This option has reduced length of construction for embankments and walls, and has individual property resistance. Potential significant effects in relation to works within the boundary of the Ballylongford Bay pNHA, in particular the flood defence earth embankments and flood walls on the boundary and in places within the pNHA. Potentially significant impacts are associated with protected flora and fauna, including: - Increase in suspended solids entering the watercourse during construction works - Risk of a pollution event impacting the watercourse - Loss of habitat - Risk of mortality and disturbance to various protected species - Impacts to fish species including salmon and lamprey - Risk of invasive species spread during proposed works Therefore a potential detrimental impact upon the condition of existing national, regional or local sites as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	-4.50	-113
		d	Protect, and where possible enhance, fisheries resource within the catchment	13	3.00	The Ballyline River is designated as a Salmonid River and a 0.43 km stretch of the River falls within the AFA. The estuary is a medium activity angling area. Local weighting of 3 set by professional judgement. Weighting of 3 applied where a waterbody supports substantial fisheries/shellfisheries and is of regional value for fishing/angling	This option proposes construction of flood defence walls and flood defence embankments along the Ballyline River and Rusheen Park River. This will involve the permanent replacement of bank with wall in some cases. Construction works adjacent to the waterbody may impact water quality and cause access issues. Operational impact may include changes to angling locations. Therefore, a potential permanent loss or removal of fisheries habitat and / or introduction of barriers to upstream migration.	-5.00	-195	This option has reduced length of construction of embankments and walls, and has individual property resistance. This option still proposes construction of flood defence walls and flood defence embankments along the Ballyline River and Rusheen Park River. This will involve the permanent replacement of bank with wall in some cases. Construction works adjacent to the waterbody may impact water quality and cause access issues. Operational impact may include changes to angling locations. Therefore, a potential permanent loss or removal of fisheries habitat and / or introduction of barriers to upstream migration.	-4.50	-176
		e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	8	1.00	Ballylongford has no landscape planning designations within the AFA. The Shannon Way is a national walking trail within the 1% AEP Fluvial &/or 0.5% AEP Coastal. Also a section of the Wild Atlantic Way goes through Ballylongford and is within the 1% AEP Fluvial &/or 0.5% AEP Coastal. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected.	This option proposes construction of flood defence walls and flood defence embankments along the Ballyline River and Rusheen Park River. There will be potential construction related impact to the Shannon Way and Wild Atlantic Way. This option will require the construction of earth embankments and flood walls adjacent to the Shannon Way and Wild Atlantic Way and where the routes crosses over the Ballyline River in Ballylongford. Therefore, there is potential for a short and long term impacts on local sensitivity landscape character / feature in the zone of visibility of the selected measure.	-1.00	-8	This option has reduced length of construction of embankments and walls, and has individual property resistance. However, there will be potential for construction related impact to the Shannon Way and Wild Atlantic Way. This option requires less construction of earth embankments and flood walls. However proposed construction is adjacent to the Shannon Way and Wild Atlantic Way, and where the Shannon Way crosses over the Ballyline River in Ballylongford. Therefore, there is potential for a short-term (construction) impact on local sensitivity landscape character / feature in the zone of visibility of the selected measure.	-0.50	-4
		f i)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of architectural value	4	3.00	Ballylongford is not a heritage town. 0.004 km2 of the ACA falls within the1% AEP Fluvial and / or 0.5% AEP Coastal. Four RPS and three NIAH fall within the 1% AEP Fluvial &/or 0.5% AEP Coastal. Local weighting of 3 set by professional judgement. Weighting of 3 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a high to moderate vulnerability.	This option proposes construction of flood defence walls and flood defence embankments along the Ballyline River and Rusheen Park River. These may impact the setting on a number of architectural features. In addition WL03 will significantly impact on 1 RPS as it will potentially completely remove it. The option will reduce the potential for flooding in the 1% AEP Fluvial and/or 0.5% AEP Coastal for four RPS, three NIAH and 400m2 of ACA. Therefore, overall an increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.	-2.00	-24	This option has reduced length of construction of embankments and walls, and has individual property resistance. The option will reduce the potential for flooding in the 1% AEP Fluvial &/or 0.5% AEP Coastal for one NIAH and 200m2 of ACA. However this options has individual property resistance which does not include all RPS and NIAH. Four RPS and two NIAH are at risk of flooding in the 1% AEP Fluvial &/or 0.5% AEP Coastal. Therefore, an increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.	1.00	12
		f ii)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of archaeological value	4	0.00	Ballylongford is not a heritage town and there are no protected features of architectural value within the 1% AEP Fluvial &/or 0.5% AEP Coastal flood extent. Local weighting of 0 set by professional judgement. Weighting of 0 applied where there are no archaeological features at risk.	This option proposes construction of flood defence walls and flood defence embankments along the Ballyline River and Rusheen Park River. There are no RMPs in the AFA, therefore, no significant impacts are predicted . There is a potential for unknown archaeological features to be impacted but these are not known. Therefore, no effects on archaeological features are predicted.	0.00	0	This option has reduced length of construction of embankments and walls and has individual property resistance. There are no RMPs in the AFA therefore, no significant impacts are predicted. There is a potential for unknown archaeological features to be impacted but these are not known. Therefore, no effects on archaeological features are predicted.	0.00	0
			ENVIRONMENTAL CRITERIA SCORE						-842			-705

		BLD_01	BLD_02
Economic Values	Economic PV Benefits	€9,651,868	€9,329,478
	Cost	€9,587,821	€8,573,095
	NPV Benefits	€64,047	€756,383
	Economic BCR	**1.01**	**1.09**
Outcome Scores	MCA PV Benefits	€4,520,306	€4,427,375
	MCA Benefit Score	1076	1183
	MCA BCR	**112.18**	**138.00**
	Option Selection MCA	2276	2050

Option 1 Costs for CBA

	CFRAM Programme – Option Costs for Cost Benefit Analysis		€	€	€	Notes to CFRAM Consultants
(1)	**Basic Construction Costs (Estimate)**				**4,378,152**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2)	**Preliminaries**	11.5%			**504,640**	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**4,882,792**	
(3)	**Optimism Bias**	40.0%			**1,953,117**	Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**6,835,909**	
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13.0%			**888,668**	Set at 13%
	Construction Costs and Fees				**7,724,577**	
(6)	**Other Items**					
(a)	Allowance for Archaeology & Environmental Mitigation Measures	10.0%		683,591		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	12.0%		820,309		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation	3% assumed		205,077		Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance			38,000		See "Guidance E – Per Cent for Art Note"
(e)	Est. NPV Operation & Maintenance		83,048			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	40.0%	33,219	116,267	**1,863,244**	Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**9,587,821**	

DONNACHADH O'BRIEN & ASSOCIATES CONSULTING ENGINEERS

OPW The Office of Public Works Oifig na nOibreacha Poiblí

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	J. Reynolds	Date:	14/12/2015
Checked by:	P.Travers	Date:	14/12/2015

Project reference	S05	Project name:	Ballylongford - Option 1

Base date for estimates (year 0)	Oct-2013	Construction Price Index (CPI)	0.987
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues /constraints	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)	€0	

Capital costs	Cost (€)	Comment
Total wall costs	€3,474,555	
Total embankment costs	€903,597	
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€4,378,152	
Apply update to unit rate (CPI) if appropriate (cell N15)	€4,319,253	
Enter appropriate preliminaries estimate (%)	12%	
Enter other applicable costs (€)		
Total capital cost (€)	€4,882,792	
Consider amendments based on site issues/constraints (cell N16)	€4,882,792	
Total capital cost (€)	€4,882,792	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs	€0	
Total embankment O&M costs	€3,891	
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€3,891	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€4,965,840	
Optimism bias rate (from external sheet)	40%	
Total Cost including Optimism Bias	€6,952,175	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€4,882,791.8
Annual maintenance cost (€)	€3,891.4
Other cost (€)	€0.0
Other works frequency (years)	

Key

Information
Calculation
Cost input
User information

Discount rate:	4.0%	Present Value Factor:		22.341		Total PVc (€k):	4965840
	Cash sum	0	4882792	190678	0	5073470	4965840
	Discount	Cost Elements				TOTALS:	
year	Factor	Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0	4882792			4882791.8	4882791.8
1	0.962			3891		3891.4	3741.7
2	0.925			3891		3891.4	3597.8
3	0.889			3891		3891.4	3459.4
4	0.855			3891		3891.4	3326.4
5	0.822			3891		3891.4	3198.4
6	0.790			3891		3891.4	3075.4
7	0.760			3891		3891.4	2957.1
8	0.731			3891		3891.4	2843.4
9	0.703			3891		3891.4	2734.0
10	0.676			3891		3891.4	2628.9
11	0.650			3891		3891.4	2527.8
12	0.625			3891		3891.4	2430.5
13	0.601			3891		3891.4	2337.1
14	0.577			3891		3891.4	2247.2
15	0.555			3891		3891.4	2160.7
16	0.534			3891		3891.4	2077.6
17	0.513			3891		3891.4	1997.7
18	0.494			3891		3891.4	1920.9
19	0.475			3891		3891.4	1847.0
20	0.456			3891		3891.4	1776.0
21	0.439			3891		3891.4	1707.7
22	0.422			3891		3891.4	1642.0
23	0.406			3891		3891.4	1578.8
24	0.390			3891		3891.4	1518.1
25	0.375			3891		3891.4	1459.7
26	0.361			3891		3891.4	1403.6
27	0.347			3891		3891.4	1349.6
28	0.333			3891		3891.4	1297.7
29	0.321			3891		3891.4	1247.8
30	0.308			3891		3891.4	1199.8
31	0.296			3891		3891.4	1153.6
32	0.285			3891		3891.4	1109.3
33	0.274			3891		3891.4	1066.6
34	0.264			3891		3891.4	1025.6
35	0.253			3891		3891.4	986.1
36	0.244			3891		3891.4	948.2
37	0.234			3891		3891.4	911.7
38	0.225			3891		3891.4	876.7
39	0.217			3891		3891.4	843.0
40	0.208			3891		3891.4	810.5
41	0.200			3891		3891.4	779.4
42	0.193			3891		3891.4	749.4
43	0.185			3891		3891.4	720.6
44	0.178			3891		3891.4	692.8
45	0.171			3891		3891.4	666.2
46	0.165			3891		3891.4	640.6
47	0.158			3891		3891.4	615.9
48	0.152			3891		3891.4	592.2
49	0.146			3891		3891.4	569.5

Option 2 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis			€	€	€	Notes to CFRAM Consultants
(1)	**Basic Construction Costs (Estimate)**				**3,755,063**	Construction Cost of each measure including Method Factor and CPI Adjustment but excluding Preliminaries
(2)	**Preliminaries**	12.2%			**458,763**	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				**4,213,825**	
(3)	**Optimism Bias**	40.0%			**1,685,530**	Refer to UCD for selecting OB %
(4)	**Construction Costs (Excl VAT)**				**5,899,356**	
(5)	**Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)**	13.0%			**766,916**	Set at 13%
	Construction Costs and Fees				**6,666,272**	
(6)	**Other Items**					
(a)	Allowance for Archaeology & Environmental Mitigation Measures	10.0%		589,936		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b)	Allowance for compensation and land acquisition	12.0%		707,923		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c)	Site investigation	3% assumed		176,981		Professional judgement to be applied in estimating a suitable sum.
(d)	Art Allowance			38,000		See "Guidance E – Per Cent for Art Note"
(e)	Est. NPV Operation & Maintenance		281,417			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	40.0%	112,567	393,984	**1,906,823**	Refer to UCD for selecting OB %
	Option Cost for Cost Benefit Analysis				**8,573,095**	

CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	J. Reynolds	Date:	14/12/2015
Checked by:	P.Travers	Date:	14/12/2015

Project reference	S05	Project name:	Ballylongford - Option 2
Base date for estimates (year 0)	Oct-2013	Construction Price Index (CPI)	0.987
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues /constraints	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)	€0	

Capital costs	Cost (€)	Comment
Total wall costs	€2,719,034	
Total embankment costs	€859,929	
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs	€171,900	
Total hydrometric gauging station costs		
Total flood forecasting costs	€4,200	
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€3,755,063	
Apply update to unit rate (CPI) if appropriate (cell N15)	€3,704,546	
Enter appropriate preliminaries estimate (%)	12%	
Enter other applicable costs (€)		
Total capital cost (€)	€4,213,825	
Consider amendments based on site issues/constraints (cell N16)	€4,213,825	
Total capital cost (€)	€4,213,825	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs	€202	
Total embankment O&M costs	€3,180	
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs	€8,595	
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs	€1,210	
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€13,186	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€4,495,243	
Optimism bias rate (from external sheet)	40%	
Total Cost including Optimism Bias	€6,293,340	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€4,213,825.5
Annual maintenance cost (€)	€13,186.4
Other cost (€)	€0.0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	4.0%	Present Value Factor:		22.341		Total PVc (€k):	4495243
	Cash sum	0	4213825	646134	0	4859960	**4495243**
	Discount	Cost Elements				TOTALS:	
year	Factor	Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0	4213825			4213825.5	4213825.5
1	0.962			13186		13186.4	12679.2
2	0.925			13186		13186.4	12191.6
3	0.889			13186		13186.4	11722.7
4	0.855			13186		13186.4	11271.8
5	0.822			13186		13186.4	10838.3
6	0.790			13186		13186.4	10421.4
7	0.760			13186		13186.4	10020.6
8	0.731			13186		13186.4	9635.2
9	0.703			13186		13186.4	9264.6
10	0.676			13186		13186.4	8908.3
11	0.650			13186		13186.4	8565.6
12	0.625			13186		13186.4	8236.2
13	0.601			13186		13186.4	7919.4
14	0.577			13186		13186.4	7614.8
15	0.555			13186		13186.4	7321.9
16	0.534			13186		13186.4	7040.3
17	0.513			13186		13186.4	6769.6
18	0.494			13186		13186.4	6509.2
19	0.475			13186		13186.4	6258.8
20	0.456			13186		13186.4	6018.1
21	0.439			13186		13186.4	5786.6
22	0.422			13186		13186.4	5564.1
23	0.406			13186		13186.4	5350.1
24	0.390			13186		13186.4	5144.3
25	0.375			13186		13186.4	4946.4
26	0.361			13186		13186.4	4756.2
27	0.347			13186		13186.4	4573.3
28	0.333			13186		13186.4	4397.4
29	0.321			13186		13186.4	4228.2
30	0.308			13186		13186.4	4065.6
31	0.296			13186		13186.4	3909.2
32	0.285			13186		13186.4	3758.9
33	0.274			13186		13186.4	3614.3
34	0.264			13186		13186.4	3475.3
35	0.253			13186		13186.4	3341.6
36	0.244			13186		13186.4	3213.1
37	0.234			13186		13186.4	3089.5
38	0.225			13186		13186.4	2970.7
39	0.217			13186		13186.4	2856.4
40	0.208			13186		13186.4	2746.6
41	0.200			13186		13186.4	2640.9
42	0.193			13186		13186.4	2539.4
43	0.185			13186		13186.4	2441.7
44	0.178			13186		13186.4	2347.8
45	0.171			13186		13186.4	2257.5
46	0.165			13186		13186.4	2170.7
47	0.158			13186		13186.4	2087.2
48	0.152			13186		13186.4	2006.9
49	0.146			13186		13186.4	1929.7

Appendix D: Economic Damage & Benefit Calculation and Cost Benefit Analysis

Contents

1 Introduction

This Appendix explains the process and methodology for the calculation of economic flood damages and the use of these economic damages for option benefit analysis. This methodology is based on OPW Guidance Note 27 (Rev.C).

The aim of OPW Guidance Note 27, and this Appendix, is to apply a common approach to the calculation of monetarised, economic flood damages, and the economic benefits of floor risk management options. These are then used for undertaking cost-benefit analysis, with a view to ensuring that damages, benefits, and benefit-cost calculations are determined in a nationally consistent manner, to enable inter-comparability of proposed measures across the country.

2 Economic Damage and Benefit Calculation

2.1 Introduction

The calculation of economic benefits is undertaken using standardised guidelines and figures, provided in the Flood Hazard Research Centre Handbook of 2010 (FHRC, 2010) and the 'Multi-Coloured Manual' of 2005 (FHRC, 2005) as referred to in FHRC, subject to caveats, amendment and clarification set out in the OPW Guidance Note 27 'Economic Damage and Benefit Calculation and Cost-Benefit Analysis' Rev. C.

The approach provides an economic, as opposed to financial assessment. For example, residential property damages take account of depreciation of the value of contents (e.g. replacing items like-for-like, as opposed to purchasing new items). Indirect damages to non-residential properties are included for some types (e.g. damage to small, individually, or family owned businesses) whereas loss of business is generally not included as this is assumed to be displaced to elsewhere within the economy.

2.2 Methodology

The assessment of the overall economic damages associated with flooding is composed of the following components:

- **Principal Direct Damages:** Direct property damage to residential and non-residential properties
- **Intangible and Intangible damage**
- **Emergency services**
- **Infrastructural Utility Assets**

2.2.1 Direct Property Damage – Residential and Non-Residential

(a) Residential Properties

Direct property damages to Residential Properties are calculated according to the depth-damage data presented in the 2010 Handbook for economic appraisal. The data is matched to each property based on the depth of flooding and the MCM code which categorises the property into various residential categories (e.g. detached, semi-detached, terraced, Bungalow). Details of the property types are provided in the GeoDirectory for Ireland.

Flood damages for residential properties begin at flood depths of -0.3 m relative to threshold levels. This only applies however, to properties whose footprint lies within the flooded area.

For properties with basements, the flood damages for the property assume a depth of 2.4m once the flood depth exceeds the threshold level for the basement. This damage is in addition to the normal depth-damage calculation for the ground floor of the property.

Different depth damage curves are used for the different property types dependant on the duration of flooding;

- >12 hours
- <12 hours

An additional 10% is applied to the damages for non –residential properties at risk of flooding from coastal sources.

The damages from the depth damage curve are converted to Euros using £1 = €1.279 conversion rate and an inflation multiplication factor of 1.051 has been applied. This is derived from inflation rates based on the CPI in Ireland for the period 2010 - 2013.

(b) Non Residential Properties

Direct property damages to Non - Residential Properties are calculated according to the indicative susceptibility depth-damage data presented in the 2010 Handbook for economic appraisal. The data is matched to each property based on the depth of flooding and the "MCM code" as referred to the FHRC 2005 and 2010 which categorises the property into various non- residential categories (e.g. high street shop, warehouse). There are different depth-damage curves for each MCM code.

Although, the GeoDirectory for Ireland does not provide a MCM code for each non-residential property type, it does provide a NACE code which has been used to determine the representative MCM code for each Non-Residential Property. In instances where the NACE code is not provided in the Geodirectory it is determined manually using professional judgement and a combination of site visits and remote data, such as 'Google Street Map'.

Direct flood damages for non-residential properties are calculated on a £/m^2 basis (converted to €/m^2).

Flood damages for non-residential properties begin at flood depths of 0m relative to threshold levels.

Depth damage curves for non-residential properties are only available for durations less than 12 hours in the FHRC 2010.

An additional 10% is applied to the damages for non –residential properties at risk of flooding from coastal sources.

Where the property type is mixed i.e. there is both residential and non-residential classification applied to the property, it has been assumed that the non-residential element of the property is located on the ground floor and damages associated with non-residential properties has been applied. Spot checks of this have been carried out using 'Google Street Map'.

As for residential properties the damages from the depth damage curve are converted to Euros using £1 = €1.279 conversion rate and an inflation multiplication factor of 1.051 has been applied. This is derived from inflation rates based on the CPI in Ireland for the period 2010 - 2013.

2.2.2 Principal Direct Damage

Principal Direct Damages are the sum of the residential and non-residential property damages.

The Average Annual Damages (AAD) are based on the modelled probability events occurring in any given year. A minimum of three events are required to generate a meaningful result, and a maximum of eight events can be considered. The total PV direct damages are then calculated by discounting the AAD over the specified appraisal period.

2.2.3 Intangible and Indirect Damages

Flood events can cause significant stress, anxiety, and ill health to potentially affected people, during and hen after a flood. Individuals generally incur some costs due to their properties flooding that are not directly related to damage, such as evacuation, temporary accommodation, loss of earnings, increased travel and shopping costs, etc.

While these negative impacts are difficult to monetarise or quantify, it is recognised that these impacts are significant, and professional opinion has indicated that they could well be greater than the direct damages to residential properties.

For residential properties, the intangible and indirect flood damages shall together be set equal to the total (direct) property damages.

Intangible damages may also be applied in the case of small, individually, or family-owned businesses where the intangible impact would be personal and similar in nature to that which might be experienced were the property residential.

2.2.4 Emergency Services

Costs to emergency services (which include evacuation costs) are included in the economic damages, and are calculated as 8.1% of the total Principal Direct Damage (PDD) Costs.

2.2.5 Infrastructural Utility Assets

Economic damages to infrastructural utility assets (e.g. electrical sub-stations, gas installations and pipe-work, telecommunications assets, etc.) are calculated as 20% of total PDD Costs.

2.2.6 Annual Average Damage

Damages are calculated for each property residential and non-residential for each of the following AEP events;

- 50%, 20%, 10%, 4%, 2%, 1%, 0.5% and 0.1%

The Annual Average Damage (AAD) is calculated using linear interpolation between damage values for each of these defined design events; i.e. with a damage value calculated for each 'slice' based on the average of the damages for the design event damages that form the probability boundaries for the 'slice', and the probability range of the 'slice'.

The AAD is calculated as the sum of the damage values of each slice, up to and including the 'slice' with the 0.1% AEP event as the upper bounding event.

The AAD is also calculated for the MRFS and the HEFS scenarios. For The HEFS as the depth are only available for the 10%, 1% (0.5% for coastal flooding) and 0.1% AEP events the damages for these events are calculated these values are used to shift the MRFS damage curve to derive an indicative damage curve for the HEFS.

2.2.7 Present Value Damages

The PVd are calculated as the discounted sum of the annual average damages over the project horizon, where:

- The discount rate to be applied is 4%
- The project horizon is 50 years

2.2.8 Capped Present Value Damages

Capped PV Damages are the damages capped at the value of the properties contributing to the damages.

The capping value of the direct damages for a residential property is the value of that property. The value of the property has been based on the property price guide[1] see annex B1.

The capping value of the intangible and indirect damage for a residential property is also the value of the property.

The capping value of the direct damages for a non- residential property is 10 time the rateable value of the property multiplied by the floor area and the yield value, see annex B2.

2.3 ArcGIS Tool

An ArcGIS tool has been developed for this project that rapidly calculates the economic cost of flooding to properties, based on model predictions of flood depth. Compared with the alternative calculation methods based in Excel, the ArcGIS tool offers a number of benefits, including efficiency and robustness.

2.3.1 Parameters

The tool is set up to use hydraulic model predictions of flood depth at individual property locations that have already been incorporated into a property database (ArcGIS point layer). Each unique property point in the GeoDirectory is assigned a flood depth for each modelled probability event.

The following key information, used by the tool, is provided in the Geodirectory for each address point:

- Unique geo-database ID

[1] "Property Price Guide" - The Sunday Times 11/01/2015

- Building use type (residential, non-residential, or unknown)
- Residential property type
- Non-Residential property type
- Location coordinates (Easting and Northing)
- European industrial activity classification (NACE) code

In addition to the above parameters the floor area for non-residential properties are required.

Note that where any of the above data is not available, assumptions using professional judgement have been used in order to approximate the damages.

The following parameters must be specified as the tool is run:

- Region of Study – select from 14 regions in the Shannon RBD[2] to load approximate market values for each type of residential property (see Annex B). This is to allow damage estimates to be capped at market prices.
- Appraisal period – the default project horizon is 50 years and the default discount rate is specified as 4%. Additional discount rates of 3% and 5% can be selected. As specified in OPW GN27 Section 3.8.
- Emergency service costs – specified value of 8.1% is applied as a default (see Section 2.2.4).
- Property threshold – The default values are 0.15 m for residential and 0.0 m for non-residential. When surveyed thresholds are available then the tool will revert to that value.
- Duration of flooding – specify shorter or longer than 12 hours as there are different depth-damage datasets for residential property types depending on the duration (see Section 2.2.5).
- Coastal uplift – an uplift (10%) to account for increased property damages due to coastal (saltwater) inundation.

[2] Clare, Cork, Galway, Galway City, Kerry, Laois, Leitrim, Limerick, Limerick City, Longford, Offaly, Roscommon, Tipperary, and Westmeath

3 Cost Benefit Analysis

3.1 General Methodology

As detailed in OPW Guidance Note 27, the benefit-cost ratio (BCR) is produced as the output of the cost-benefit analysis. This is calculated by dividing the Present Value Benefits (PVb) for an option or measure, capped as appropriate, by the whole life costs (PVc) of that option or measure. Measures are only recommended as measures to be put forward in the Flood Risk Management Plan if their BCR is greater than unity.

In addition, the Net Present Value of the benefits (NPVb) of the option is calculated by deduction the PVc from the capped PVb.

Table C.1, below, taken from OPW Guidance Note 27 - Appendix B, and sets out which parameters are applicable for each use (Economic CBA, Economic Risk Mapping, and appraisal against MCA Objective 2.1), and how some of the parameters (e.g. Total damages for a given event, AAD) are calculated based on previous parameters.

As set out in the Generic CFRAM Project Brief, sensitivity tests are undertaken to determine the BCR using higher or lower discount rates, which are 5% and 3% respectively.

Further guidance on deriving costs for options or measures is provided in the OPW Guidance Note on the use of Unit Cost Database.

Table C.1 Cost Benefit Analysis Explanatory Table

Parameter		Application		
		Economic CBA	**Economic Risk Mapping**	**MCA Appraisal Objective 2.a**
1.	Residential Damages	Yes	Yes	Yes
2.	Non-Residential Damages	Yes	Yes	Yes
3.	Principal Direct Damages (PDD)	1 + 2	1 + 2	1 + 2
4.	Intangible Damages	Yes	Yes	No
5.	Infrastructural Utility Damages	Yes	Yes	No
6.	Emergency Services	Yes	Yes	Yes
7.	Traffic Disruption	Possibly	Possibly	No
8.	Event Damage	3 + 4 + 5 + 6 + 7	3 + 4 + 5 + 6 + 7	3 + 6
9.	Annual Average Damage (AAD)	Annualise 8	Annualise 8	Annualise 8
10.	Present Value of Damages (PVd)	Discounted sum of 9 over the Project Horizon	N/A	Discounted sum of 9 over the Project Horizon
11.	Un-capped PVb	Reduction in PVd (10) provided by option	N/A	Reduction in PVd (10) provided by option
12.	Capping Value	Double Residential Property Value, or, = Non-Residential Property Value	N/A	N/A
13.	Capped PVb	11, but not > 12	N/A	11
14.	PVc	Whole Life Scheme Cost	N/A	Whole Life Scheme Cost
15.	BCR	13 / 14	N/A	13 / 14
16.	NPVb	13 - 14	N/A	13 - 14

Annex A Direct Damage Values (2014-15 Price Base)

A.1 Residential Properties Short Duration Flooding (<12 Hours)

		MCM Damage Data - Direct Damage (€/m depth)														
MCM Code	Property Type	-0.30	0.00	0.05	0.10	0.20	0.30	0.60	0.90	1.20	1.50	1.80	2.10	2.40	2.70	3.00
110	DETACHED	1103	1103	13005	19238	32571	39371	47997	52439	57472	61986	69524	73807	77613	86219	90731
120	SEMI DETACHED	1476	1476	10851	14867	23799	27912	34399	36779	40156	42834	48214	51137	54220	60437	63476
130	TERRACE	1282	1282	9410	12949	21119	24786	30710	32823	35777	37968	42326	44515	46862	52628	54995
140	BUNGALOW	1030	1030	12888	18962	30643	36171	44664	48956	54063	58684	66296	70888	75340	84196	88899
150	FLAT	861	861	10824	14849	23924	27917	34748	37071	39797	41628	46074	47802	49213	54121	56054

A.2 Residential Properties Long Duration Flooding (<12 Hours)

		MCM Damage Data - Direct Damage (€/m depth)														
MCM Code	Property Type	-0.30	0.00	0.05	0.10	0.20	0.30	0.60	0.90	1.20	1.50	1.80	2.10	2.40	2.70	3.00
110	DETACHED	1690	5271	23909	34105	47730	57471	64134	68302	72318	79174	87493	97363	102668	108187	114594
120	SEMI DETACHED	1853	3891	17130	24836	34171	40770	45135	47766	50338	54547	60061	66876	70418	74255	78534
130	TERRACE	1655	3327	14721	21463	29974	35913	39799	42183	44369	47579	51967	58035	60317	62817	65677
140	BUNGALOW	1768	5043	22843	33627	46399	54661	61385	66185	70367	77501	85955	96665	102804	108436	115519
150	FLAT	1168	3086	16548	24169	33165	39272	43581	46087	48008	50290	54780	60141	62162	64256	66891

A.3 Non-Residential Properties Short Duration Flooding (<12 Hours)

		MCM Damage Data - Direct Damage (€/m^2/m depth)																
MCM Code	**Property Type**	**-1.00**	**-0.75**	**-0.5**	**-0.25**	**0.00**	**0.25**	**0.50**	**0.75**	**1.00**	**1.25**	**1.50**	**1.75**	**2.00**	**2.25**	**2.50**	**2.75**	**3.00**
210	Shop/Store (Weighted mean)	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
211	(High Street) Shop	0	0	0	0	0	249	540	811	1022	1167	1291	1384	1469	1534	1597	1640	1686
213	Superstore/Hypermarket	0	0	0	0	0	441	991	1421	1794	2210	2430	2525	2619	2659	2703	2729	2758
214	Retail Warehouse	0	0	0	0	0	600	804	997	1142	1267	1383	1457	1524	1578	1629	1677	1717
215	Showroom	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
216	Kiosk	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
217	Outdoor market	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
218	Indoor Market	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
220	Vehicle Services (Weighted mean)	0	0	0	0	0	111	255	374	456	514	571	607	640	666	693	715	741
221	Vehicle Repair Garage	0	0	0	0	0	75	209	315	385	437	489	520	548	572	596	615	638
222	Petrol Filling Station	0	0	0	0	0	190	352	481	586	644	701	731	758	779	801	818	839
223	Car Showroom	0	0	0	0	0	220	394	568	691	778	860	929	989	1036	1084	1125	1172
224	Plant Hire	0	0	0	0	0	71	147	246	320	723	1124	1509	1891	1930	1969	1989	2013
230	Retail Services (Weighted mean)	0	0	0	0	0	205	395	608	772	897	1009	1097	1169	1219	1271	1311	1361
231	Hairdressing Salon	0	0	0	0	0	56	141	199	274	364	420	461	485	511	541	568	605
232	Betting Shop	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
233	Laundrette	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
234	Pub/Social club/wine bar	0	0	0	0	0	202	371	582	732	836	939	1018	1087	1133	1182	1219	1264
235	Restaurant	0	0	0	0	0	210	433	712	928	1098	1236	1349	1450	1522	1596	1656	1728
236	Café/Food Court	0	0	0	0	0	379	713	985	1204	1366	1528	1663	1745	1793	1838	1872	1914
237	Post Office	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
238	Garden Centre	0	0	0	0	0	53	112	148	184	215	245	273	299	309	317	325	334
300	Office (Weighted mean)	0	0	0	0	0	197	378	585	738	830	915	978	1033	1077	1123	1159	1202
310	Offices (non-specific)	0	0	0	0	0	196	376	581	733	824	909	972	1027	1070	1116	1151	1194
311	Computer Centres (Hi-Tech)	0	0	0	0	0	1854	3482	4589	5410	6061	6364	6458	6543	6609	6679	6732	6796
320	Bank	0	0	0	0	0	172	340	546	683	782	875	943	1006	1060	1120	1169	1219
400	Distribution/Logistics (Mean-all 4 w/h codes)	0	0	0	0	0	198	394	614	796	950	1101	1237	1371	1489	1607	1720	1824
410	Warehouse (including store)	0	0	0	0	0	76	141	218	275	317	358	389	417	436	455	470	488
420	Land Used for Storage	0	0	0	0	0	1	9	86	137	189	239	269	294	311	327	340	353
430	Road Haulage	0	0	0	0	0	76	141	218	275	317	358	389	417	436	455	470	488
411	Warehouse	0	0	0	0	0	254	487	713	919	1109	1298	1486	1679	1856	2034	2210	2332
412	Warehouse	0	0	0	0	0	100	200	332	432	505	583	648	702	755	806	847	899
413	Warehouse	0	0	0	0	0	360	747	1195	1556	1868	2165	2426	2684	2909	3132	3354	3577
510	Leisure (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
511	Hotel	0	0	0	0	0	217	400	652	922	1034	1144	1222	1292	1346	1404	1448	1502
512	Boarding House	0	0	0	0	0	68	113	362	588	733	862	944	1010	1058	1104	1140	1174
513	Caravan Mobile	0	0	0	0	0	0	0	448	611	724	913	1042	1100	1147	1188	1224	1269

514	Caravan Static	0	0	0	0	0	53	95	178	229	296	359	422	464	487	502	524	537
515	Self-catering Unit	0	0	0	0	0	247	326	433	511	566	619	660	696	724	754	777	805
516	Hostel (including prisons)	0	0	0	0	0	247	326	433	511	566	619	660	696	724	754	777	805
517	Bingo hall	0	0	0	0	0	801	1597	2474	2622	2725	2826	2897	2962	3012	3065	3105	3154
518	Theatre/Cinema	0	0	0	0	0	416	736	1086	1345	1525	1656	1748	1833	1903	1971	2023	2078
519	Beach Hut	0	0	0	0	0	29	68	113	169	187	194	199	203	204	204	204	205
520	Sport (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
521	Sports Grounds and Playing Fields	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
522	Golf Courses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
523	Sports and Leisure centres	0	0	0	0	0	181	369	558	715	800	884	951	1013	1051	1088	1119	1156
524	Amusement Arcade/Park	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
525	Football Ground and Stadia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
526	Mooring/Wharf/Marina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
527	Swimming Pool	0	0	0	0	0	181	369	558	715	800	884	951	1013	1051	1088	1119	1156
600	Public Building (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
610	School/College/University/Nursery	0	0	0	0	0	432	786	1164	1440	1673	1838	1969	2085	2191	2295	2371	2458
620	Surgery/Health Centre	0	0	0	0	0	332	465	559	647	790	874	923	970	1015	1049	1093	1136
625	Residential Home	0	0	0	0	0	247	326	433	511	566	619	660	696	724	754	777	805
630	Community Centres/Halls	0	0	0	0	0	73	169	245	325	370	417	460	506	532	538	543	546
640	Library	0	0	0	0	0	244	490	889	1146	1346	1536	1697	1844	1889	1936	1972	2016
650	Fire/Ambulance station	0	0	0	0	0	120	255	419	552	668	791	868	983	1013	1044	1068	1098
651	Police Station	0	0	0	0	0	196	376	581	733	824	909	972	1027	1070	1116	1151	1194
660	Hospital	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
670	Museum	0	0	0	0	0	244	490	889	1146	1346	1536	1697	1844	1889	1936	1972	2016
680	Law court	0	0	0	0	0	196	376	581	733	824	909	972	1027	1070	1116	1151	1194
690	Church	0	0	0	0	0	70	144	205	266	298	332	364	398	419	424	428	431
800	Industry (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
810	Workshop	0	0	0	0	0	204	519	728	861	941	1006	1046	1082	1113	1140	1169	1203
820	Factory/Works/Mill	0	0	0	0	0	204	519	728	861	941	1006	1046	1082	1113	1140	1169	1203
830	Extractive/heavy Industry	0	0	0	0	0	3	45	146	201	271	335	386	425	455	486	545	581
840	Sewage treatment works	0	0	0	0	0	3	45	146	201	271	335	386	425	455	486	545	581
850	Laboratory	0	0	0	0	0	3456	3970	4544	5007	5513	6018	6440	6907	6957	7010	7050	7100
900	Miscellaneous (Weighted mean)	0	2	5	17	32	32	32	32	32	32	32	32	32	32	32	32	32
910	Car Park	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
920	Public Convenience	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
930	Cemetery/Crematorium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
940	Bus Station	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
950	Dock Hereditament	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
960	Electricity Hereditament	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

A.4 Non-Residential Properties Long Duration Flooding (>12 Hours)

		MCM Damage Data - Direct Damage (€/m²/m depth)																
MCM Code	**Property Type**	**-1.00**	**-0.75**	**-0.5**	**-0.25**	**0.00**	**0.25**	**0.50**	**0.75**	**1.00**	**1.25**	**1.50**	**1.75**	**2.00**	**2.25**	**2.50**	**2.75**	**3.00**
210	Shop/Store (Weighted mean)	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
211	(High Street) Shop	0	0	0	0	0	328	702	1022	1246	1400	1536	1633	1733	1795	1869	1919	1972
213	Superstore/Hypermarket	0	0	0	0	0	582	1288	1790	2188	2652	2892	2979	3090	3111	3162	3193	3227
214	Retail Warehouse	0	0	0	0	0	793	1045	1256	1394	1520	1646	1720	1798	1846	1906	1962	2009
215	Showroom	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
216	Kiosk	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
217	Outdoor market	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
218	Indoor Market	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
220	Vehicle Services (Weighted mean)	0	0	0	0	0	147	332	471	557	617	679	716	755	779	811	836	867
221	Vehicle Repair Garage	0	0	0	0	0	99	272	397	469	524	581	613	647	669	697	719	746
222	Petrol Filling Station	0	0	0	0	0	251	458	606	715	773	834	863	894	912	938	958	982
223	Car Showroom	0	0	0	0	0	290	513	716	843	933	1023	1097	1167	1212	1268	1317	1371
224	Plant Hire	0	0	0	0	0	94	192	310	390	867	1338	1781	2231	2258	2304	2327	2355
230	Retail Services (Weighted mean)	0	0	0	0	0	270	513	766	942	1076	1200	1294	1379	1426	1487	1534	1593
231	Hairdressing Salon	0	0	0	0	0	75	183	250	334	436	499	544	573	598	633	665	707
232	Betting Shop	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
233	Laundrette	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
234	Pub/Social club/wine bar	0	0	0	0	0	266	482	733	893	1004	1118	1201	1282	1326	1383	1426	1479
235	Restaurant	0	0	0	0	0	277	563	897	1132	1318	1471	1592	1711	1781	1867	1938	2022
236	Café/Food Court	0	0	0	0	0	501	927	1241	1469	1639	1818	1962	2059	2098	2151	2190	2239
237	Post Office	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
238	Garden Centre	0	0	0	0	0	69	146	187	224	258	292	322	353	361	371	380	390
300	Office (Weighted mean)	0	0	0	0	0	260	492	737	900	995	1089	1154	1219	1260	1314	1356	1406
310	Offices (non-specific)	0	0	0	0	0	258	488	732	895	989	1082	1147	1212	1252	1305	1347	1396
311	Computer Centres (Hi-Tech)	0	0	0	0	0	2448	4526	5782	6600	7273	7574	7621	7720	7732	7814	7876	7952
320	Bank	0	0	0	0	0	227	441	688	833	939	1041	1112	1187	1240	1311	1368	1427
400	Distribution/Logistics (Mean-all 4 w/h codes)	0	0	0	0	0	261	512	774	971	1140	1310	1460	1617	1742	1880	2012	2134
410	Warehouse (including store)	0	0	0	0	0	101	183	274	336	380	426	459	492	510	532	549	571
420	Land Used for Storage	0	0	0	0	0	1	12	108	167	227	285	317	347	364	383	398	413
430	Road Haulage	0	0	0	0	0	101	183	274	336	380	426	459	492	510	532	549	571
411	Warehouse	0	0	0	0	0	336	633	898	1121	1331	1545	1754	1981	2172	2380	2585	2728
412	Warehouse	0	0	0	0	0	132	260	418	527	607	694	765	829	883	943	991	1052
413	Warehouse	0	0	0	0	0	475	972	1506	1898	2242	2576	2862	3167	3404	3665	3924	4185
510	Leisure (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
511	Hotel	0	0	0	0	0	286	520	822	1125	1241	1361	1442	1524	1575	1643	1694	1757
512	Boarding House	0	0	0	0	0	89	146	456	718	879	1026	1114	1192	1238	1291	1333	1374
513	Caravan Mobile	0	0	0	0	0	0	0	564	746	869	1087	1230	1298	1342	1390	1432	1484

514	Caravan Static	0	0	0	0	0	70	124	224	280	355	427	498	547	570	587	613	629
515	Self-catering Unit	0	0	0	0	0	326	424	546	623	679	737	779	821	848	882	909	942
516	Hostel (including prisons)	0	0	0	0	0	326	424	546	623	679	737	779	821	848	882	909	942
517	Bingo hall	0	0	0	0	0	1057	2077	3117	3199	3270	3363	3419	3495	3524	3586	3633	3691
518	Theatre/Cinema	0	0	0	0	0	550	957	1369	1640	1830	1971	2063	2163	2227	2306	2367	2431
519	Beach Hut	0	0	0	0	0	38	88	143	206	224	231	235	239	239	239	239	240
520	Sport (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
521	Sports Grounds and Playing Fields	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
522	Golf Courses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
523	Sports and Leisure centres	0	0	0	0	0	240	480	703	872	959	1052	1122	1195	1229	1273	1310	1353
524	Amusement Arcade/Park	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
525	Football Ground and Stadia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
526	Mooring/Wharf/Marina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
527	Swimming Pool	0	0	0	0	0	240	480	703	872	959	1052	1122	1195	1229	1273	1310	1353
600	Public Building (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
610	School/College/University/Nursery	0	0	0	0	0	570	1022	1466	1756	2008	2187	2324	2461	2563	2685	2774	2876
620	Surgery/Health Centre	0	0	0	0	0	439	604	705	789	948	1040	1089	1145	1187	1228	1279	1329
625	Residential Home	0	0	0	0	0	326	424	546	623	679	737	779	821	848	882	909	942
630	Community Centres/Halls	0	0	0	0	0	96	220	308	396	444	496	543	598	623	629	635	639
640	Library	0	0	0	0	0	322	637	1120	1399	1615	1828	2003	2175	2210	2265	2307	2359
650	Fire/Ambulance station	0	0	0	0	0	158	331	528	673	801	942	1024	1160	1185	1222	1250	1284
651	Police Station	0	0	0	0	0	258	488	732	895	989	1082	1147	1212	1252	1305	1347	1396
660	Hospital	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
670	Museum	0	0	0	0	0	322	637	1120	1399	1615	1828	2003	2175	2210	2265	2307	2359
680	Law court	0	0	0	0	0	258	488	732	895	989	1082	1147	1212	1252	1305	1347	1396
690	Church	0	0	0	0	0	92	188	258	325	358	395	429	469	490	496	501	505
800	Industry (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
810	Workshop	0	0	0	0	0	269	675	917	1051	1129	1197	1235	1276	1302	1333	1367	1407
820	Factory/Works/Mill	0	0	0	0	0	269	675	917	1051	1129	1197	1235	1276	1302	1333	1367	1407
830	Extractive/heavy Industry	0	0	0	0	0	4	58	184	245	325	399	456	501	533	569	637	679
840	Sewage treatment works	0	0	0	0	0	4	58	184	245	325	399	456	501	533	569	637	679
850	Laboratory	0	0	0	0	0	4562	5161	5725	6109	6616	7161	7599	8150	8140	8202	8249	8307
900	Miscellaneous (Weighted mean)	0	2	5	17	32	43	42	41	39	39	38	38	38	38	38	38	38
910	Car Park	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
920	Public Convenience	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
930	Cemetery/Crematorium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
940	Bus Station	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
950	Dock Hereditament	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
960	Electricity Hereditament	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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Annex B Default Market Values

B.1 Residential Property Market Values

The value of residential properties has been based on the price guide from the "Property Price Guide" - The Sunday Times (11/01/2015).

Table B.1 Residential Property Market Values

Region	Bungalow	Detached	Semi-detached	Terrace	Duplex
Leitrim	€ 95,271	€ 112,308	€ 56,822	€ 49,521	€ 0
Roscommon	€ 68,667	€ 83,750	€ 76,800	€ 62,500	€ 0
Longford	€ 89,700	€ 103,400	€ 63,800	€ 27,500	€ 49,500
Westmeath	€ 111,700	€ 239,100	€ 107,325	€ 76,100	€ 82,475
Offaly	€ 122,500	€ 176,800	€ 137,700	€ 52,200	€ 56,000
Laois	€ 126,200	€ 107,300	€ 172,640	€ 64,000	€ 0
Tipperary	€ 90,100	€ 250,700	€ 103,500	€ 47,303	€ 0
Galway	€ 80,660	€ 171,000	€ 105,525	€ 99,800	€ 165,600
Galway City	€ 390,750	€ 313,829	€ 255,969	€ 212,300	€ 187,900
Clare	€ 117,226	€ 143,000	€ 98,300	€ 56,700	€ 83,500
Limerick	€ 77,980	€ 136,400	€ 120,700	€ 72,720	€ 146,450
Limerick City	€ 160,040	€ 225,300	€ 126,660	€ 69,300	€ 0
Kerry	€ 110,100	€ 93,200	€ 125,800	€ 78,400	€ 74,000
Cork (Charleville & Milford only)	€ 132,200	€ 102,110	€ 52,800	€ 38,000	€ 0

B.2 Non-Residential Property Values

Non-residential rateable values are taken from the 'Commercial and Industrial Floorspace and Rateable Value Statistics' - April 2008 values. (https://www.gov.uk/government/statistical-data-sets/live-tables-on-commercial-and-industrial-floorspace-and-rateable-value-statistics).

It has been determined that non-residential rateable values for the South West of England provide the most representative rates for Irish rates.

An inflation rate of 1.052 was applied to these rates to obtain the 2010 rateable values. Once the 2010 values were obtained a currency conversion of 1.279 and inflation rate of 1.051 was applied as for the direct property damages.

No rateable information is provided for property classes of Leisure or Public Buildings, therefore the assumption was made that Leisure and Public Building are set to be equal to the 'Other' category.

An EY factor is used to convert the rateable value into an estimated market value for non-residential properties. The market value is estimated by the following calculation:

Market Value (£/m2) = Rateable Value (£/m2) * 100/EY

For all non-residential property types the EY factor has been set at 10%.

Table B.2 Rateable Values

Region	Retail	Office	Warehouse	Leisure & Public	Industry
London	267	252	86	74	72
South East	195	146	74	47	57
Eastern	181	137	64	49	51
South West	161	115	51	37	41
East Midlands	148	99	49	42	38
West Midlands	158	120	51	47	37
Wales	139	96	40	31	31
North West	161	108	44	41	34
Yorkshire & Humberside	160	107	42	37	33
North East	157	96	37	28	31

Appendix E Option Development Meeting - Minutes

Appendix F MCA objectives and Scoring Methodology

MCA Objectives

The MCA objectives are outlined in GN 28. GN 28 has been provided for reference in Appendix I of this report. The FRM objectives reflect what the overall flood risk management programme is seeking to achieve, expanding on the requirements of the National Flood Policy Review and the European Unions (EUs) 'Floods' Directive.

At a local level, and for the purposes of the MCA, the objectives set out an aim that the each flood risk management option should be seeking to achieve, if possible. The degree to which an option achieves the objective is an indication of the 'success' of the option, and equally, the more an option achieves across all of the objectives, then the greater the preference that will be given to that option relative to others, taking account also of the cost of each of the options.

The flood risk management objectives are split into four categories:

- Technical
- Economic
- Social
- Environmental

These objectives have been split into sub-objective. The sub-objective for each category and the scoring mechanism used are outlined in Tables F.1 to Tables F.4 overleaf.

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Table F.1 Technical Objective

Technical Objective				
Objective	**Description of Scoring**	**Global Weighting**	**Local Weighting**	**Scoring Range**
Technical 1A – Ensure flood risk management options are operationally robust	Scoring is to be by professional judgement, based on the guidance, taking into account the degree of reliance of the option on mechanical, electrical or electronic systems ('systems'), or on human intervention, action or decision ('intervention') to operate or perform successfully.	20	5 (Constant)	5 : No Operation Risk 4 to 5 : Negligible Operational Risk 3 to 4 : Very Low Operational Risk 2 to 3 : Low Operational Risk 1 to 2 : Low / Moderate Operational Risk 0 to 1 : Moderate but Manageable Operational Risk -1 to 0 : Moderate / High Operational Risk -3 to -1 : High Operational Risk -5 to -3 : Foreseeable likelihood of failure -999 to -5 : Unacceptable Risk
Technical 1B – Minimise health and safety risk in construction and operation of the flood risk management option	Scoring is to be by professional judgement, The indicative score under this objective should be set at five, and then have a point deducted for each specific risk (as defined under the Safety, Health and Welfare at work (Construction) Regulations) likely to be encountered in a) construction and then again in b) operation and maintenance.	20	5 (Constant)	5 : No H&S Risk 4 to 5 : Negligible H&S Risk 3 to 4 : Very Low H&S Risk 2 to 3 : Low H&S Risk 1 to 2 : Low / Moderate H&S Risk 0 to 1 : Moderate but Manageable H&S Risk -1 to 0 : Moderate / High H&S Risk -3 to -1 : High H&S Risk -5 to -3 : High H&S Risk -999 to -5 : Unacceptable Risk
Technical 1C – Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change	Scoring is to be by professional judgement, based on guidance.	20	5 (Constant)	>3 : Option can be adapted at no to limited cost and difficulty, and provides no impediment to future interventions. 0 to 3 : Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. -3 to 0 : Option cannot be adapted, but provides no to minor impediment to potential future interventions. -999 to -3 : Option cannot be adapted, and provides moderate to major impediment to potential future interventions.

Table F.2 Economic Objective

Economic Objective				
Objective	**Description of Scoring**	**Global Weighting**	**Local Weighting**	**Scoring Range**
Economic 2A – Reduce economic damages	Option Score = 0.05 X Percentage Reduction in AAD. The following values should apply as the percentage reduction in AAD for non-structural options (i.e. those that do no reduce hazard, but can reduce it) % Reduction in AAD 10 % : >12 hours warning 6% : 6-12 hours warning 4% : 2-6 hours warning 0% : < 2 hours warning	24	AAD for the SSA / € 75,000. Subject to a maximum local weighting of 5.	5 : 100 % reduction in AAD 0 : No change in AAD < 0 : A negative score indicates that AAD has increased
Economic 2B – Minimise risk to transport infrastructure	Scoring is based on degree of reduction of flood risk to transport receptors at risk from flooding. Each type of transport receptor is assigned a score and scoring is calculated based on a score derived from the number and type of transport infrastructure receptors potentially affected by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of that receptor. This score can be adjusted by professional judgement.	10	Based on calculated assessment, adjusted by professional judgement, subject to a maximum local weighting of 5.	N/A : No transport infrastructure at risk 5 : The risk to transport infrastructure is reduced to zero 0 : No change in risk to transport infrastructure < 0 : A negative score indicates an increased risk to transport infrastructure.
Economic 2C – Minimise risk to utility infrastructure	Scoring is based on degree of reduction of flood risk to utility receptors at risk from flooding. Each type of utility receptor is assigned a score and scoring is calculated based on a score derived from the number and type of utility infrastructure receptors potentially affected by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of that receptor. This score can be adjusted by professional judgement.	14	Based on calculated assessment, adjusted by professional judgement, subject to a maximum local weighting of 5.	N/A : No utility infrastructure at risk 5 : The risk to utility infrastructures is reduced to zero 0 : No change in risk to utility infrastructure < 0 : A negative score indicates an increase in risk to utility infrastructure
Economic 2D – Manage risk to agriculture	Scoring is by professional judgement, taking into account local advice.	12	By professional judgement, taking account of the value and social importance of the agricultural industry in the area (this is aided by the percentage of non-urban land in the AFA). Subject to a maximum local weighting of 5.	Scoring is by professional judgement, taking into account local advice.

Table F.3 Social Objective

Social Objective

Objective	Description of Scoring	Global Weighting	Local Weighting	Scoring Range
Social 3A(i) – Minimise risk to human health and life – Residents	Scoring is calculated based on a score derived from the number of residential properties potentially affected by flooding and the highest probability (lowest magnitude) of a flood event that causes flooding of each property. This score can be adjusted by professional judgement.	27	Based on calculated assessment, adjusted by professional judgement. Subject to a maximum score of 5	5 : 100 % reduction in the number of residential properties at risk 0 : No change to the number or probability of flooding to residential properties at risk < 0 : A negative score indicates the number of residential properties at risk or the probability of flooding is increased
Social 3A(ii) – Minimise risk to human health and life – High Vulnerability	Scoring is calculated based on a score derived from the number and type of high vulnerability properties potentially affected by flooding, and the highest probability (lowest magnitude), adjusted by professional judgement of a flood event that causes flooding of that property. This score can be adjusted by professional judgement	17	Based on calculated assessment, adjusted by professional judgement. Subject to a maximum score of 5	5 : 100 % reduction in the number of high vulnerability properties at risk 0 : No change to the number of high vulnerability properties at risk < 0 : A negative score indicates the number of high vulnerability properties at risk is increased or the probability of flooding is increased
Social 3B(i) – Minimise risk to community – Social Infrastructure	Scoring is calculated based on a score derived from the number of social infrastructure assets potentially affected by flooding, and the highest probability (lowest magnitude) of a flood event that causes flooding of each asset. This score can be adjusted by professional judgement.	9	Based on calculated assessment, adjusted by professional judgement. Subject to a maximum score of 5	5 : 100 % reduction in the number of social infrastructure assets at risk 0 : No change to the number of social infrastructure assets at risk < 0 : A negative score indicates the number of social infrastructure assets at risk is increased or the probability of flooding is increased
Social 3B(ii) – Minimise risk to community – Local Employment	Scoring is calculated based on a score derived from the number of non-residential properties (taken as a place of employment) potentially affected by flooding, and the highest probability (lowest magnitude) of a flood event that causes flooding of each property. This score can be adjusted by professional judgement.	7	Based on calculated assessment, adjusted by professional judgement. Subject to a maximum score of 5	5 : 100 % reduction in the number of non-residential properties at risk 0 : No change to the number of non-residential properties at risk < 0 : A negative score indicates the number of non-residential properties at risk is increased or the probability of flooding is increased

Table F.3 Environmental Objective

Environmental Objective				
Objective	**Description of Scoring**	**Global Weighting**	**Local Weighting**	**Scoring Range**
Environmental 4A – Support the objectives of the WFD	Scoring is guided by professional judgement with reference to a specified scoring system which takes into account the duration and permanence of likely impacts of the options on water body status elements, the sensitivity of the receiving bodies and the potential sources of pollution in the flood extent area. A generic description of the likely impacts of measures of water body status is also taken into account	16	5 (Constant)	5 : Permanent or long term contribution to the achievement of wb objectives 0 : No constraint of the achievement of wb objectives -999 : Unacceptable negative impact where feasible alternative exists
Environmental 4B – Support the objectives of the Habitat and Birds Directives	Scoring by professional judgement based upon the following key datasets: - Natura 2000 sites (SACs, SPAs) - Ramsar Site - Annex IV (Habitats Directive) species of flora and fauna and their key habitats	10	By professional judgement, taking into account local advice. Subject to a maximum local weighting of 5.	5 : Potential to create or enhance NHA sites to SAC, SPA or Ramsar status 0 : No impact on existing SAC, SPA or Ramsar sites -999 : Any detrimental impact upon existing SAC, SPA or Ramsar sites
Environmental 4C – Avoid damage to, and where possible enhance the flora and fauna of the catchment	Scoring by professional judgement based upon the following key datasets: - Natural Heritage Areas (& proposed Natural Heritage Areas) - Nature Reserves - Wildfowl Sanctuary - OSPAR - National Parks	5	By professional judgement, taking into account local advice. Subject to a maximum local weighting of 5.	5 : Potential to create new national, regional and local conservation sites 0 : No impact on existing national, regional and local sites -999 : Any detrimental impact upon national, regional or local sites
Environmental 4D – Protect and where possible enhance fisheries resource within the catchment	Scoring is guided by professional judgement with reference to a specified scoring system which takes into account the duration and permanence of likely impacts of the options on fisheries and fisheries potential and the sensitivity of the receiving bodies and species	13	By professional judgement, taking into account local advice. Subject to a maximum local weighting of 5.	5 : Creation of fisheries habitat or removal of barrier to upstream migration for wb where sensitive species are known to be present 0 : No change to fisheries potential of wb -999 : Unacceptable negative impact where a feasible alternative exists
Environmental 4E – Protect, and where possible, enhance landscape character and visual amenity within zone of influence	Scoring is guided by professional judgement taking into account the duration and permanence of the likely impacts of the options on landscape value and the sensitivity of landscape to change	8	By professional judgement, taking into account local advice. Subject to a maximum local weighting of 5.	5 : Permanent significant enhancement of high sensitivity landscape character/feature in the zone of visibility of the selected measure 0 : No change to existing landscape character/feature in the zone of influence of the selected measure -999 : Unacceptable negative impact where feasible options exist
Environmental 4F(i) – Avoid damage to or loss of architectural features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods	Scoring is guided by professional judgement taking into account the number of architectural features, institutions and collections subject to flooding and the impact of the flood risk management measure on architectural features, institutions and collections.	4	By professional judgement, taking into account local advice. Subject to a maximum local weighting of 5.	5 : Complete removal of all architectural features, institutions, and collections form the risk of harm by extreme floods and enhanced protection and value of architectural features, institutions, and collections importance arising from the implementation of the FRM. 0 : No effects on architectural features, institutions, and collections. -999 : Unacceptable negative impact where feasible options exist

Environmental 4F(ii) – Avoid damage to or loss of archaeological features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods	Scoring is guided by professional judgement taking into account the number of archaeological features, institutions and collections subject to flooding and the impact of the flood risk management measure on architectural features, institutions and collections.	4	By professional judgement, taking into account local advice. Subject to a maximum local weighting of 5.	5 : Complete removal of all architectural features, institutions, and collections form the risk of harm by extreme floods and enhanced protection and value of archaeological features, institutions, and collections importance arising from the implementation of the FRM. 0 : No effects on architectural features, institutions, and collections. -999 :Unacceptable negative impact where feasible options exist

Appendix G Freeboard

Introduction

This Appendix provides a detailed assessment of the freeboard allowances adopted in the outline design of embankments and flood walls for this Shannon CFRAM Study. The assessment is based on the Environment Agency's Fluvial Freeboard Guidance Note, R&D Technical Report W187 (2000) which provides practical guidance on the determination of freeboard allowances during the design of flood defences and is therefore appropriate for use in the design of all embankments and flood walls for this Study. The guidance note divides freeboard into two elements, with an allowance to take account of the physical processes that affect the defence level and an allowance to account for the uncertainty in the prediction of physical processes.

Methodology

The Guidance Note details a 'Quick' and 'Detailed' method. Given the catchment scale assessment of CFRAMs, it is appropriate that the 'Quick' method is used. However, it is recommended that during the future detailed design stages, the freeboard allowances should be rechecked using the 'Detailed' method.

The 'Quick' method involves two stages. Firstly, the physical processes affecting the defence performance is determined. Secondly, the uncertainty is quantified.

The assessment is applicable to the following four design scenarios:

1. Embankment design (fluvial)
    - Physical processes: Settlement of embankment foundations (consolidation settlement).
    - Uncertainty allowance
2. Embankment design (coastal)
    - Physical processes: Settlement of embankment foundations, wave overtopping (surcharge) allowance
    - Uncertainty allowance
3. Flood wall design (fluvial)
    - Physical processes: N/A
    - Uncertainty allowance
4. Flood wall design (coastal)
    - Physical processes: Wave overtopping (surcharge) allowance
    - Uncertainty allowance

Physical Processes

As outlined above, there are the following two physical processes which can apply during the design scenarios:

- Settlement (consolidation settlement)
- Wave overtopping (surcharge).

Settlement

The settlement (consolidation settlement) is calculated using the below formulae. This takes account of the coefficient of volume compressibility, the shape of the foundation and the applied pressure.

$$\rho_c = \mu_g \rho_{oed}$$

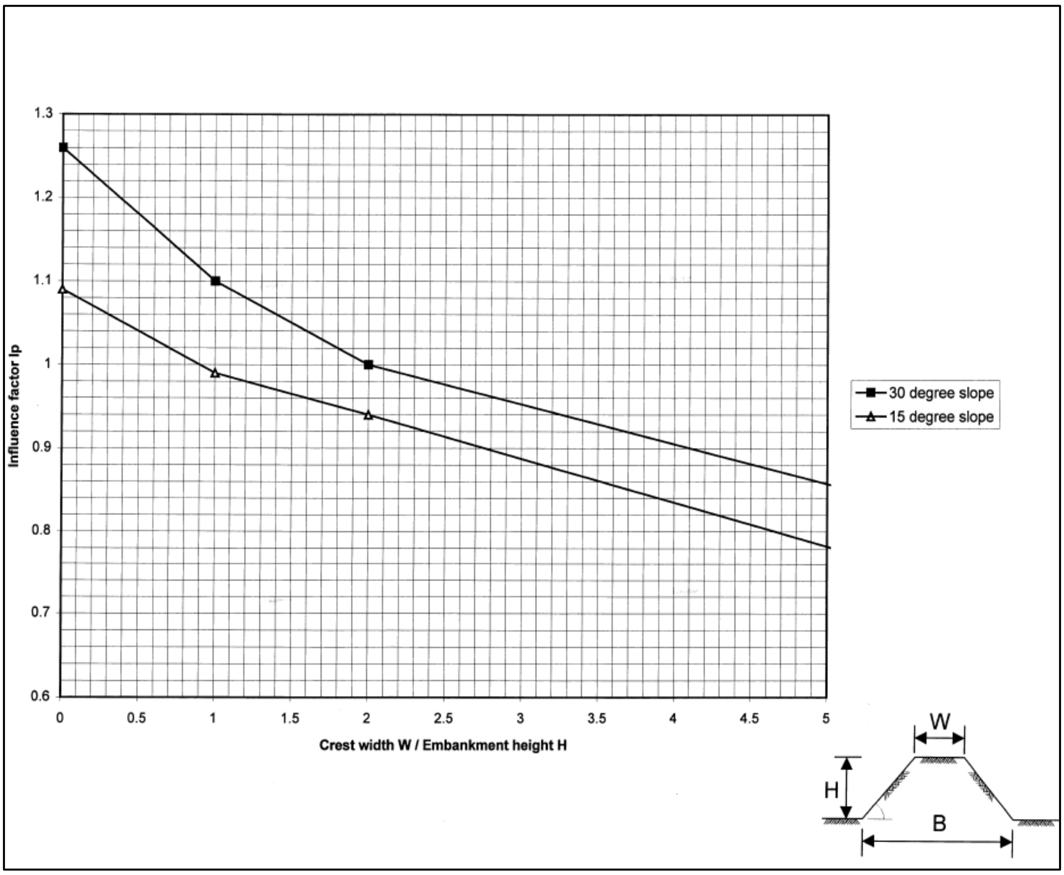
$$\rho_{oed} = I_p m_v p B$$

Where:

I_p = influence factor
m_v = average coefficient of volume compressibility
p = applied pressure (kN/m²)
B = foundation width (m)

For CRFAMS the following typical embankment design has been adopted: height of the embankment at 1.5m (which is the typical height of high embankments), the crest width of 4m and side slopes as 1:3. The influence factor is determined from Figure 1 below.

Figure 1: Influencing Factor Graph



The underlying material is assumed to be normally consolidated alluvial clay. The coefficients μ_g and m_v are dependent on this clay selection, with the range of values detailed in Tables 1 and 2 below.

Table 1: Values of coefficient μ_g

Type of Clay	μ_g
Heavily over-consolidated clays (glacial till, Keuper Marl)	0.2 - 0.5
Over-consolidated clays (London Clay, Weald, Kimmeridge, Oxford, and Lias Clays)	0.5 - 0.7
Normally-consolidated clays	0.7 - 1.0
Very sensitive clays (soft alluvial, estuarine, and marine clays)	1.0 - 1.2

Table 2: Typical values of the coefficient of compressibility mv

Type	Qualititative Description	m_v (m^2/kN)
Heavily over-consolidated boulder clays (e.g. many Scottish boulder clays) and stiff weathered rocks (e.g. weathered siltstone), hard London Clay, Gault Clay, and Oxford Clay	Very low compressibility	Below 0.05 x 10^{-3}
Boulder Clays (e.g. Tees-side, Chesire) and very stiff 'blue' London Clay, Oxford Clay, Keuper Marl	Low compressibility	(0.05 to 0.10) x 10^{-3}
Upper 'blue' London Clay, weathered 'brown' London Clay, fluvio-glacial clays, Lake Clays, weathered Oxford Clay, weathered Boulder Clay, weathered Keuper Marl, normally consolidated clays (at depth)	Medium compressibility	(0.10 to 0.30) x 10^{-3}
Normally-consolidated alluvial clays (e.g. estuarine clays of Thames, Firth of Forth, Bristol Channel)	High compressibility	(0.30 to 1.50) x 10^{-3}
Very organic alluvial clays and peats	Very high compressibility	Above 1.50 x 10^{-3}

Based on the normally consolidated alluvial clay assumption, the value of μ_g assumed to be 0.8, and m_v as $1x10^{-3}$.The soil weight is assumed to be 20kN/m^3. This yields a value of 19.62 kN/m^2 for the applied pressure coefficient.

Wave Overtopping

The Guidance Note assumes that the wave overtopping associated with non-erodible defences (sheet pile walls or concrete retaining walls) is unlikely to cause failure of the defence. Therefore a wave surcharge allowance of nil for the flood wall design scenario is assumed.

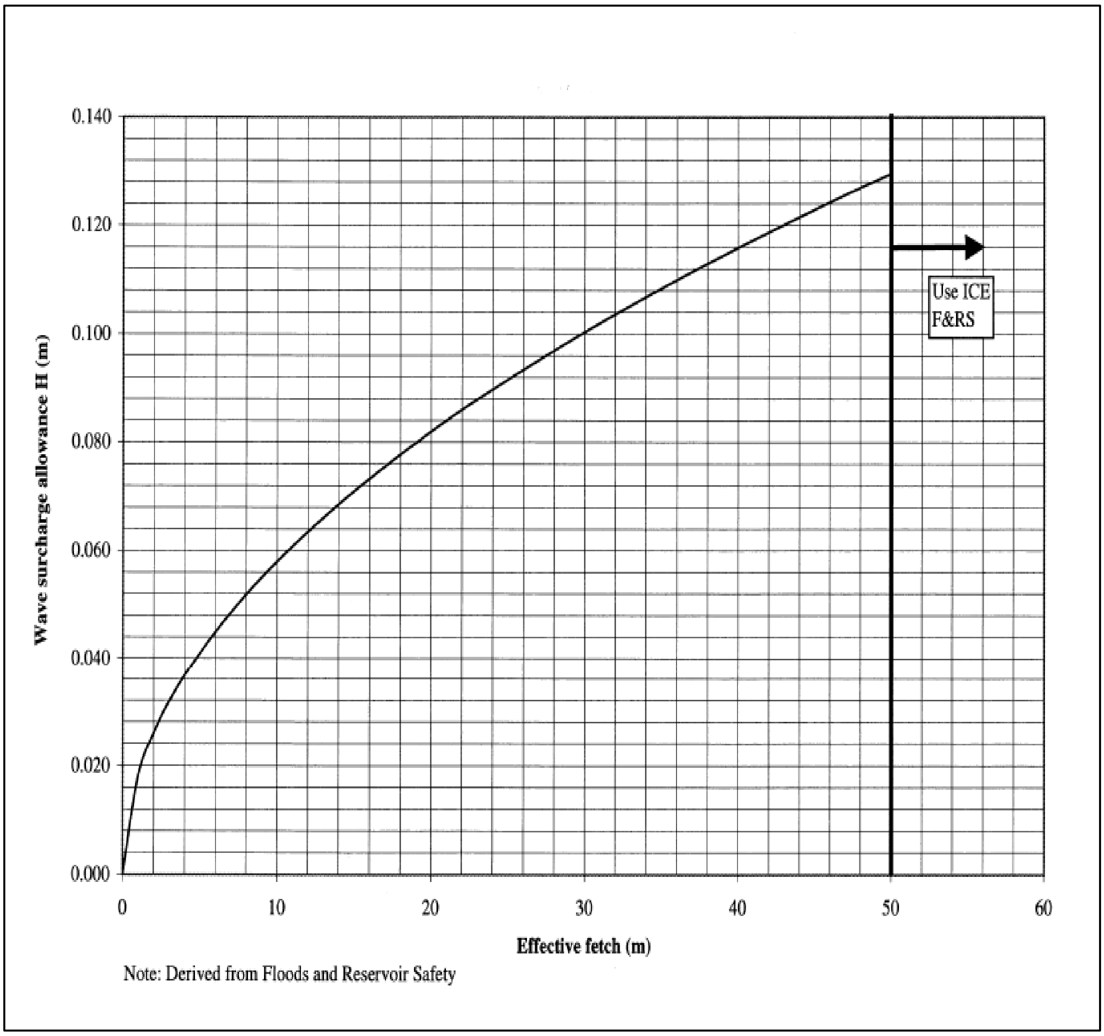
Regarding embankment design, the wave surcharge allowance for erodible defences is broken down into four conditions, as detailed in the below Table 3. Depending on the wave surcharge calculated, the actual surcharge to be provided is 0m, 0.05m or 0.1m.

Table 3: Surcharge Calculation

Calculated wave surcharge allowance H (m)	Actual wave surcharge allowance to be provided (m)
0.000 < H < 0.025	0
0.025 < H < 0.075	0.05
0.075 < H < 0.125	0.10
0.125 < H	Recalculate using ICE's Floods and Reservoirs Safety

The wave surcharge is determined from Figure 2 below. The figure is based on a grassed embankment with a 1:2.5 slope, a typical average annual maximum wind speed of 16m/s and a non-worst case scenario of the river in relation to the predominant wind direction.

Figure 2: Wave Surcharge



If the defence being considered does not conform with the above description the estimated wave surcharge value is multiplied by the factors in the below Table 4 to take account of different embankment slopes and embankment types (with the values chosen highlighted).

Table 4: Multiplication Factors

Type	Factor
Embankment Slope	
1:2.0 slope	1.13
1:3.0 slope	0.9
1:3.5 slope	0.81
Embankment Type	
Crest protected	0.92
Crest and backslope protected	0.85

The determination of wave surcharge is dependent on the effective fetch of the river. A value of 0.05m is chosen for the actual wave surcharge allowance, which is the value to be used if the calculated wave surcharge allowance falls in the range of 0.025m to 0.075m. Taking account of the embankment type and slope, this range corresponds to an effective fetch in the range of 2.5m to 24m, which is deemed a suitable range.

Uncertainty Assessment

Having determined the physical processes affecting the flood defence level, the next step is to quantify the level of uncertainty associated with the prediction of the physical processes, using the following calculation.

$$Uncertainty\ Allowance\ (\mathrm{m}) = k \times \frac{Overall\ Score\ (in\ range\ 6-30)}{30} \times (FL - MAMWL)$$

Overall Score

The Guidance Note sets out that the Overall Score should be assessed by allowing for the uncertainty associated with the following six parameters:

- Accuracy of hydrological data
- Accuracy of hydrological analysis
- Accuracy of hydraulic data
- Accuracy of hydraulic model
- Consequences of failure
- Accuracy of the physical processes

Each parameter is assigned a score from 1 to 5, where 1 represents a low level of impact and 5 a high level of impact. For each of the parameters a description is provided against each score, this is provided below with the adopted score for each parameter highlighted below.

Accuracy of Hydrological Data

1	Hydrological conditions throughout catchment well defined or reliable continuous flow gauging records on river at area of interest
2	Hydrological conditions throughout catchment fairly well defined or flow gauging records available on river at some distance from area of interest or water level records available at area of interest
3	Some variability in hydrological conditions in catchment or water level records available at more than one site at some distance from area of interest or flow gauging records available for similar nearby catchment flow
4	Hydrological conditions in catchment fairly variable or water level records available at one site some distance from area of interest
5	Complex catchment with wide variation in hydrological conditions or limited water level records

Accuracy of Hydrological Method

1	Rainfall runoff analysis give consistent results using different methods, or greater than 75 years of flow records for statistical analysis
2	Rainfall runoff analysis give consistent results using different methods, long duration storm gives greatest discharge or 50 to 75 years of flow records available for statistical analysis
3	Rainfall runoff analysis give fairly consistent results using different methods, moderate duration storm gives greatest discharge or 25 to 50 years of flow records available for statistical analysis
4	Rainfall runoff analysis gives poor correlation between results using different methods, short duration storm gives greatest discharge or 10 to 25 years of flow records available for statistical analysis
5	Rainfall runoff analysis gives very poor correlation between results using different methods, very short duration storm gives greatest discharge or less than 10 years of flow records available for statistical analysis

Accuracy of Hydraulic Data

1	Very well defined channel, no floodplain flow, channel roughness low and consistent seasonally along river and across river section
2	Well defined channel, no floodplain flow, channel roughness fairly low, only small changes in roughness likely
3	Minor floodplain flow, moderate changes in roughness likely
4	Poorly defined channel, some floodplain flow, changes in roughness likely
5	Very poorly defined channel with mobile bed, considerable complex floodplain flow, channel roughness very variable seasonally, along river and across river section

Accuracy of Hydraulic Method

1	Well defined boundary data, well defined flood routing, transient model
2	Fairly well defined boundary data and flood routing, transient model
3	Moderately well-defined boundary data and flood routing, steady state model
4	Fairly poorly defined boundary data and flood routing, steady state model
5	Poorly defined or complex boundary data and flood routing, simple backwater analysis

Significance of Physical Parameters

1	Uncertainties in physical processes are negligible, allowance is < 5% of (FL - MAMWL)
2	Uncertainties in physical processes are of marginal significance, allowance is = 5 to 10% of (FL - MAMWL)
3	Uncertainties in physical processes are of some significance, allowance is = 10 to 20% of (FL - MAMWL)
4	Uncertainties in physical processes are significant, allowance is = 20 to 30% of (FL - MAMWL)
5	Uncertainties in physical processes are very significant, allowance is > 30% of (FL - MAMWL)

Consequences of Failure

1	Typically low grade agricultural land, often grass, at risk from flooding or impeded land drainage, with isolated agricultural properties at risk from flooding, or environmental assets at little risk frequent inundation
2	Typically mixed agricultural land with occasional, often agriculturally related, properties at risk from flooding. Agricultural land may be prone to flooding or water-logging. May also apply to environmental assets of local significance
3	Typically large areas of high grade agricultural land and/or environmental assets of national significance at risk from flooding or impeded drainage with some properties also at risk from flooding
4	Typically less extensive urban areas with some high grade agricultural land and/or environmental assets of international importance requiring protection
5	Typically large urban areas at risk from flooding

For the purposes of this assessment, conservative figures are chosen, ranging from 4 to 5. As equal weight is given to each parameter, the scores are then accumulated to give an overall score out of a total of 30.

FL-MAMWL

This is the difference between the flood level and mean annual maximum water level. The Q_2 and Q_{100} mean water levels for the Shannon River Basin District were reviewed and the differences between these mean water levels is in summarised in the below table for the different UoMs.

Location	Average Diff
UOM23	0.6m
UOM24	0.4m
River Shannon	0.5m
UoM25/26 (Tribs of the Shannon)	0.4m
Overall Average	**0.5m**

0.5m was the overall average, and this has therefore been used as the FL – MAMWL value throughout.

K coefficient

The uncertainty allowance is calculated using the below formula, in which the coefficient k is assumed to be 0.5, based on advice provided within the Guidance Note

$$Uncertainty\ Allowance\ (\mathrm{m})\ = k\ \times \frac{Overall\ Score\ (in\ range\ 6-30)}{30}\ \times (FL\ - MAMWL)$$

Results

The freeboard allowance figures yielded from the model for the four scenarios are set out below:

1. Embankment design
   - Physical processes: Settlement of embankment foundations
   - Uncertainty allowance

Freeboard allowance = 0.396m, therefore take freeboard allowance as 400mm

2. Embankment design (coastal)
   - Physical processes: Settlement of embankment foundations, wave overtopping (surcharge) allowance
   - Uncertainty allowance

Freeboard allowance = 0.896m, therefore take freeboard allowance as 900mm

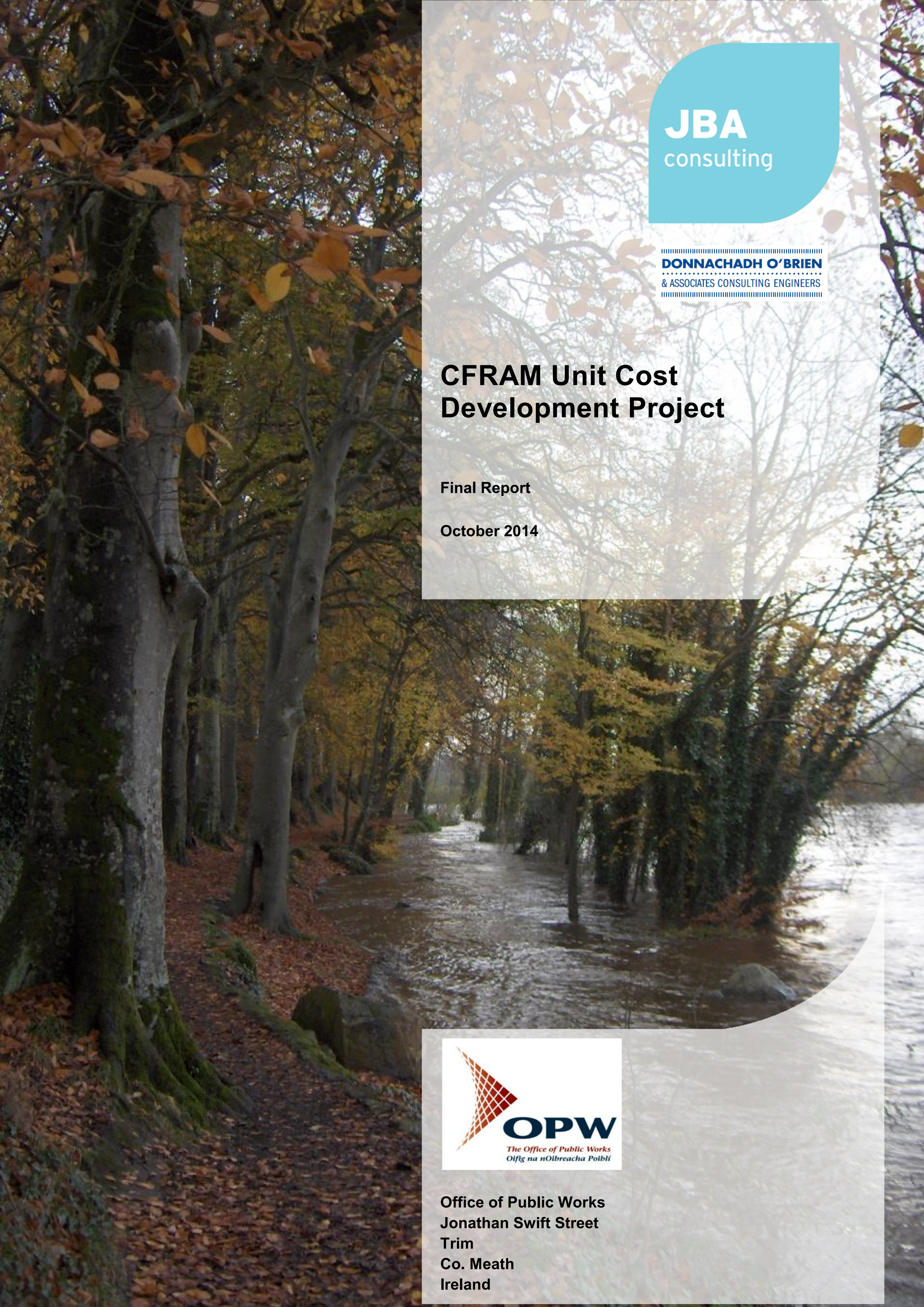
3. Flood wall design
   - Physical processes: N/A
   - Uncertainty allowance

Freeboard allowance = 0.208m, therefore take freeboard allowance as 210mm

4. Flood wall design (coastal)
   - Physical processes: Wave overtopping (surcharge) allowance
   - Uncertainty allowance

Freeboard allowance = 0.208m, therefore take freeboard allowance as 210mm

Appendix H Cost Database



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CFRAM Unit Cost Development Project

Final Report

October 2014

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Draft Report / 21-2-2014	-	OPW
Final Report / 25-7-2014	Amendments to report and all associated cost sheets.	OPW
Final Report / 08-10-2014	Final Amendments to report	OPW
Final Report / 09-01-2015	Minor amendment to copyright reference	OPW

Contract

This report describes work commissioned by Eileen Hughes, on behalf of the OPW, by a letter dated 18/09/2013. The OPW's representative for the contract was Conor Galvin. Angus Pettit, Deirdre McDonnell and Jonathan Garrett of JBA Consulting and Donnachadh O'Brien of Donnachadh O'Brien & Associates carried out this work.

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Purpose

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

JBA Consulting has no liability regarding the use of this report except to OPW.

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Mr. Tony Moran	JBA Consulting

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Executive Summary

This report provides a summary of the methodology and the approach to estimating costs for flood risk management measures to support the CFRAM studies. This report provides background to whole life costing and details the methodology for each method and factor.

A range of costing approaches have been presented and used depending on the availability of information, costing requirements and future needs. Nineteen further method specific summary spreadsheets are provided separately and contain all relevant costing information and whole life cost tools.

In addition JBA have provided explanatory text on the approach adopted for whole life costing which included key cost components (where applicable and proportional) to include the following:

- Enabling costs (if applicable)
- Capital costs
- Operation and maintenance costs
- Other costs (e.g. event costs for demountables or running costs for pumping stations)

This document also outlines some of the key assumptions and factors that need to be considered at this stage to ensure a consistent approach across all CFRAM studies. This included factors such as:

- Discounting
- Financial periods
- Base dates
- Timing of works

In addition, an optimism bias tool is provided to ensure that a standard approach to construction risk is undertaken across all CFRAM studies.

Cost calibration has been completed for 4 separate projects illustrating that the tools and unit costs provided adequately estimate construction and whole life costs for real flood defence works in Ireland. Confidence can therefore be given to the results and costs provided for use within early stage appraisals as part of the wider CFRAM process.

Contents

Contents

List of Figures

List of Tables

Abbreviations

CFRAM	Catchment-based Flood Risk Assessment and Management
CIRIA	Company providing research and training in the construction industry
CPI	Consumer Price Index
EA	Environment Agency
FRM	Flood Risk Management
JBA	JBA Consulting – Engineers & Scientists
LA	Local Authority
MCM	Multi-Coloured Manual (Flood Hazard Research Centre damage data)
MCA	Multi-criteria Analysis
OPW	Office of Public Works
PV	Present Value
R&D	Research and Development
RPI	Retail Price Index
SUDS	Sustainable Urban Drainage Systems
PVc	Present Value Cost
WLC	Whole Life Costing

1 Introduction

1.1 Background

The Office of Public Works (OPW) has commissioned six Catchment-based Flood Risk Assessment and Management (CFRAM) studies to assess and determine viable measures for managing flood risk in a large number of locations around Ireland. To determine the viability of the selected measures at each location and to help prioritise budgetary spend, it is necessary to determine their likely costs of construction and long term maintenance.

Once the preferred measures have been determined, they will need to be prioritised to ensure that communities most at risk are protected. It is therefore important that measures in different parts of the country are comparable in the terms of their viability, which in turn requires a consistent approach to determining the likely costs of construction and long term maintenance.

The OPW has commissioned JBA Consulting to undertake this project to prepare a database of unit costs to enhance consistency in determining the likely costs of construction and maintenance of measures under the CFRAM project.

1.2 Purpose of this report

The objective of the project is to determine appropriate unit costs for common methods of flood risk management, for a range of conditions and scales, calibrated against actual costs (taking into account the date, condition and scale of construction), and to present the costs in a simple database for easy use by the OPW and the consultants appointed to undertake the CFRAM studies.

This report provides a summary of the project and an introduction to whole life costing for those consultants undertaking the appraisal of flood risk management measures. The report summarises the approach to costing for each mitigation method and gives indicative costs for each. This report should be read in accordance with the summary MS Excel templates produced for each flood risk method.

1.3 Generic cost guidance

The OPW are currently developing guidance notes on appraisal and the assessment of flood risk damages and cost estimation (Guidance Note 27). This report is primarily aimed at providing information and guidance to support cost estimation at the CFRAM level of assessment. The approach takes into account standard approaches currently used within the industry and provides the necessary level of accuracy for the regional and initial level of appraisal of options within a CFRAM study.

1.4 Whole life cost estimation

Whole life cost (WLC) estimation is a process that helps to combine cost elements incurred over time for different asset types and alternative approaches to flood risk management (FRM) intervention. The use of whole life cost estimation procedures will help to achieve the following aims for flood and coastal erosion management:

- Good decision making about FRM options.
- Consistent approach across different areas for CFRAM appraisal.
- Helps to determine the longer term expenditure budget for the OPW.
- Encourages efficient resource allocation.

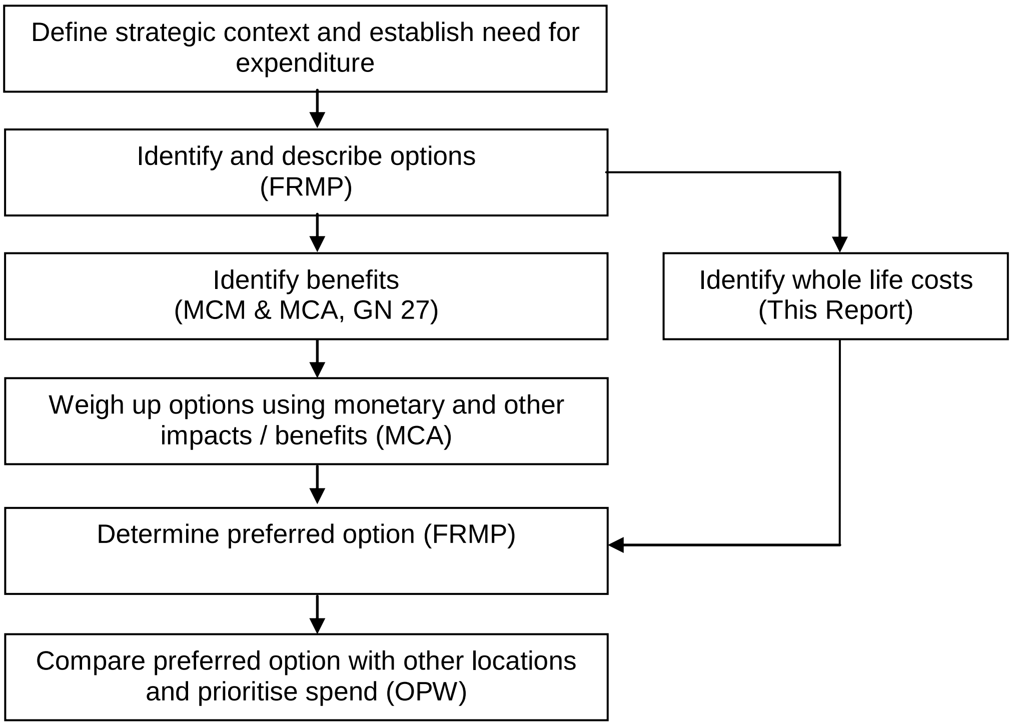
Whole life costing is an essential tool to help manage future and ongoing costs associated with capital and expenditure/operational costs and to help make informed choices between different approaches of delivering an option that meets the needs of communities at risk. The choice is often one between high capital and low maintenance or vice versa and the use of whole life costing and the consistent comparison between options allows an economic valuation of these aspects to be considered.

1.5 Cost estimation within the appraisal process

Whole life cost estimation forms part of the overall CFRAM appraisal process, as shown in the figure below. Each of the steps below forms part of standard appraisal processes. This report

and the costs derived aim to assist those undertaking cost estimates and provides guidance and data to support cost estimation and the appraisal process.

Figure 1-1: Cost estimation within the wider appraisal process



2 Categorisation of methods and factors

Whole life cost estimates should be based on data appropriate and proportional to the level of assessment of options. Costs are typically based on data assembled from recent tenders, completed projects, published articles and estimating price books, estimates and quotations from companies for specialist work and the estimator's own experience.

2.1 Generic cost estimation methodologies

At different stages of an analysis, different data will be appropriate for cost estimation, as indicated below. There are four general approaches to estimating project costs:

1. Estimation of labour, plant and materials costs for each specific activity.
2. Estimation of costs from first principles using industry or specific unit costs for materials and construction activities to derive a unit cost per unit.
3. Reliance on existing outturn costs or cost relationships from previous projects that hide certain internal costs such as overheads, minor and temporary works.
4. Engineering judgement in cases where existing data are unobtainable or measures are poorly understood / tested.

In addition to this there are obviously target costs for tendering purposes and recorded quantities. These are the most accurate as they are based on site specifics or real costs, however the recording of this information varies between and within organisations.

Each of the above approaches has benefits and constraints for the application on the CFRAM. None of the approaches is applicable to all flood risk management methods, however Option 2 is preferred for the majority of methods as this will provide the most applicable costs for Ireland at the level of detailed required.

2.2 Cost methodology approach

In total, 19 key flood risk management methods were investigated and costed. With the inclusion of key asset factors (e.g. cost variations by defence height or length) a total of over 220 combinations have unit costs mapped out within the database provided.

The methodology undertaken varies with each measure due to the varied nature of the measures and the fact that they cover both structural and non structural options. Both core unit costs and factors have some uncertainty that is presented in this report and the cost database assumptions. This uncertainty needs to be understood and accepted by CFRAM consultants in order to ensure that consultants apply the costs appropriately.

Ideally, costing would be undertaken through a robust review of previous OPW schemes. Unfortunately, data sources from past OPW schemes are statistically limited and not recorded in a way that specific asset or flood risk mitigation method costs can be extracted to enable past scheme costs as a guide to the future. As a result 'bottom-up' pricing was the preferred option for this study. Furthermore, this approach allowed the extrapolation of costs to account for the specified range of factors required.

Thus our preferred approach was to generate a series of 'typical' engineered elements for each method that can be costed by an experienced quantity surveyor using local rates reflecting the market. Once complete for each method, variations in costs for each factor have been generated either from variations in key elements or by scaling and weighting approaches from other available unit costs. This latter approach helps to identify economies of scale and other cost savings (or risks), where appropriate.

In some instances, alternative approaches have been taken to provide the necessary coverage of costs for all methods and factors required. This includes:

- The use of outturn costs from existing projects collated within available unit cost reports (option 3 above). The risk is that these outturn costs do not necessarily reflect the costs associated with schemes constructed in Ireland. It should be noted that the applicability of costing databases derived using UK data in Ireland may significantly under-predict costs.
- The scaling of unit rates derived for this project based on weightings provided in available UK cost databases (e.g. the Environment Agency unit cost handbook).

- A 'top down' approach whereby cost estimates gathered purely from example projects and case studies is used to inform and provide indicative unit costs.

Full details of the costing approach used for each method and the level of detail and confidence that can be applied are discussed further in Section 4.

2.3 Flood risk management methods and factors

Unit costs for a range of methods have been determined to support the CFRAM process. The costs relate to the construction and implementation of each method and include relevant annual operation and maintenance costs (if applicable). The range of factors cover a range of flood risk management activities covering both structural and non-structural approaches. A full list of the methods and factors costed is provided in Table 2-1.

The list is not exhaustive but cover the majority of measures likely to be required as part of the CFRAM process. Unit costs have been defined for a range of factors that cover the typical range of method variables (e.g. length and height).

The unit costs are intended to be indicative, generic costs that might be expected for the implementation of a method in typical conditions. They are not intended to be accurate across the full range of potential application of such methods, and the CFRAM Consultants will review the local context for application and adjust the Unit Cost accordingly, where necessary.

It should be noted that the unit costs are intended to be for outline design and pricing only, and are applicable for a common, representative type of each method and factor listed. It should be noted that the CFRAM Consultants are required to use their professional judgement in using the unit costs, and should vary costs to take into account local requirements or conditions that are not provided for explicitly in the methods and factors.

Other methods or factors outside the range costed here, may be applicable in some sites or special circumstances. In these instances, the CFRAM consultants will need to prepare bespoke cost estimated using experienced engineers and/or specialist advice.

Table 2-1: Summary of flood risk methods and factors assessed within this report

Method	Relevant Factor Types				
Flood Protection Wall	Urban / Rural	Quay / Floodplain / Coastal sea wall	Structure	Height	Length
Embankment	Rural	Structure	Height	Length	Material
Demountable Barriers	Length	Height	Wall/Gate	With/without Ground Beam	
In-Channel Excavation	Urban / Rural	Material	Volume	Material disposal	
Excavation on Land	Rural	Material	Volume		
Weir	Height	Weir Length			
Weir Removal	Weir Length				
Bridge Removal	Bridge Type				
Bridge Construction	Bridge Type				
Bridge Underpinning					
New Culvert	Urban / Rural	Size	Length	Depth of Invert	Material
Sluice Gate	Flap Gate / Vertical Sluice		Size		
Road Raising	Urban / Rural	Height	Length		
Pumping Station	Capacity				

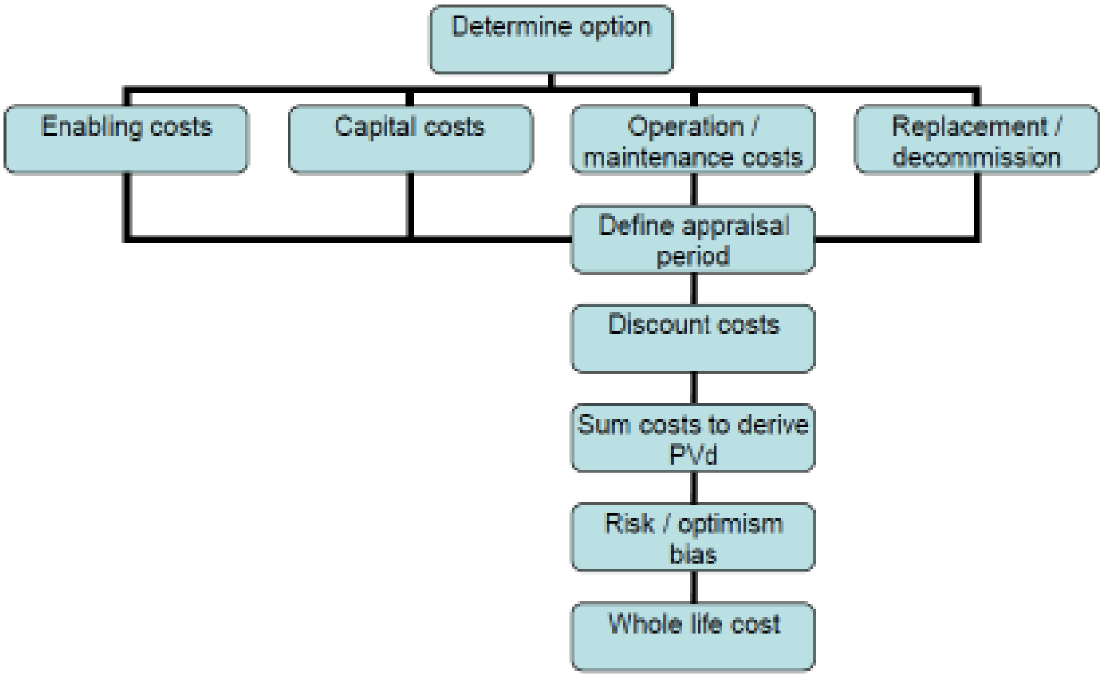
Method	Relevant Factor Types				
Individual Property Protection	Property Type	PLP Type (Manual / Automatic			
Hydrometric Gauging Station					
Flood Forecasting System	Simple Alarm / Simple Forecast / Complex Forecast				
River Maintenance	Channel Width	Urban / Rural			
Bank Protection	Coastal Erosion Protection / River Bank Protection				Length
Manhole Sealing					
Mobilisation and Site Set-Up	Urban / Rural	Construction Cost			

3 Whole life costing and methodology

Whole life costs enable investment options to be more effectively evaluated through the consideration of all costs rather than just the initial capital costs. This facilitates the choice between competing alternative options/strategies and ensures planning decisions and sustainable solutions are sufficiently robust and backed up by consistent and accurate costed programmes of activities.

Whole life estimation will require costs of acquiring the solution (consultancy, design, construction etc), operating the system, and maintaining the system over the whole life through to disposal (as shown in the figure below).

Figure 3-1: Whole life cost estimation



Whole life cost estimation needs to identify all activities that constitute flood defence management practice e.g. inspection, vegetation management, repair, operations, incident management, general administration and regulatory activities.

3.1 Cost elements

The four key cost elements that would normally need consideration as part of a whole life cost include the following:

- Acquisition or enabling costs.
- Capital costs.
- Operational costs.
- Other and end of life costs.

This report focuses on the capital and operational cost elements.

3.1.1 Enabling costs

Enabling costs include all pre construction costs and may include planning and administration, scheme feasibility and appraisal, design, project management and consultation costs. Enabling costs can be a significant cost to whole life costs but can also be highly variable. These costs are typically 10-30% of the capital costs.

Appraisers should be aware that land purchase costs can be significant and should be included within capital costs if these have not yet been considered. This can be important for schemes where flood storage, managed retreat or channel diversion is required.

These costs have been ignored by this project as it is assumed that all costs required have already been considered by the OPW and included within the wider CFRAM process. They are thus 'sunk costs' as they represent expenditure on goods and services, or resources that are already irrevocably committed and should be ignored within an appraisal of the schemes.

As such, all unit costs provided as part of this report and associated spreadsheets exclude enabling costs. If this is not appropriate for any given project, the inclusion of these must be confirmed with the OPW.

3.1.2 Capital costs

The construction costs of a project are made up of many elements such as mobilisation, demolition and site clearance, materials, compensation, insurance, diversion of existing facilities, construction and post construction landscaping.

3.1.3 Operation and maintenance costs

Whole life cost estimation needs to identify all activities that constitute flood defence management practice e.g. inspection, vegetation management, repair, operations, incident management, general administration and regulatory activities. Operational costs may include annual maintenance as well as intermittent costs if relevant and proportional and data is available.

3.1.4 Other costs

Other costs are likely to vary by the categories and measures. For example, other costs for demountable barriers such as event response, training and practice sessions are critical and essential to include within the whole life costs. Other costs may also include decommissioning or replacement costs at the end of the design life although these costs may be less important in terms of whole life costs due to the heavy discounting of these costs late in the financial period.

3.2 Whole life costing and present values

3.2.1 Discounting and Present Value Costs (PVc)

Appraisals need to compare options that will impact over a period of years into the future. Discounting is commonly used to compare costs and benefits over this time period and how future cost and benefits should be valued in today's terms. The discount rate used by the OPW assumes a standard rate of 4% over the appraisal period.

This standard discount rate has been used in the calculation of present value costs. The sum of discount rates over the standard 50 year appraisal period (the discount factor) is 22.3415 and can be used by appraisers to calculate PV costs for annual maintenance costs, for example.

3.2.2 Financial period

The estimation of Present Value costs is typically applied over a project financial period. For the case of flood mitigation works for the OPW, this is usually assumed to be a 50 year financial period for consistency. It is anticipated that a 50 year financial period is typical and appropriate for most studies. If a shorter financial period is required, whole life costing will need to be carried out separately.

3.3 Other cost considerations

3.3.1 Cost conversions

Where applicable costs from the UK have been used, a conversion from Euros to Sterling has been applied based on a factor of 1.161 for 2013 (year of latest values). This is based on using Purchasing Power Parities (PPP) with current factors derived from the Organisation for Economic Co-Operation and Development (OECD)[1] using Purchasing Power Parities (PPP) statistics.

This dataset contains Purchasing Power Parities for GDP for OECD countries. PPP table is net of currency conversion with the US$ as the baseline, so to derive the value of £ in € in Ireland,

[1] http://stats.oecd.org/Index.aspx?DataSetCode=PPPGDP

one needs to divide the Ireland value (0.806 for 2013) by the UK value (0.694), which gives 1.161. .

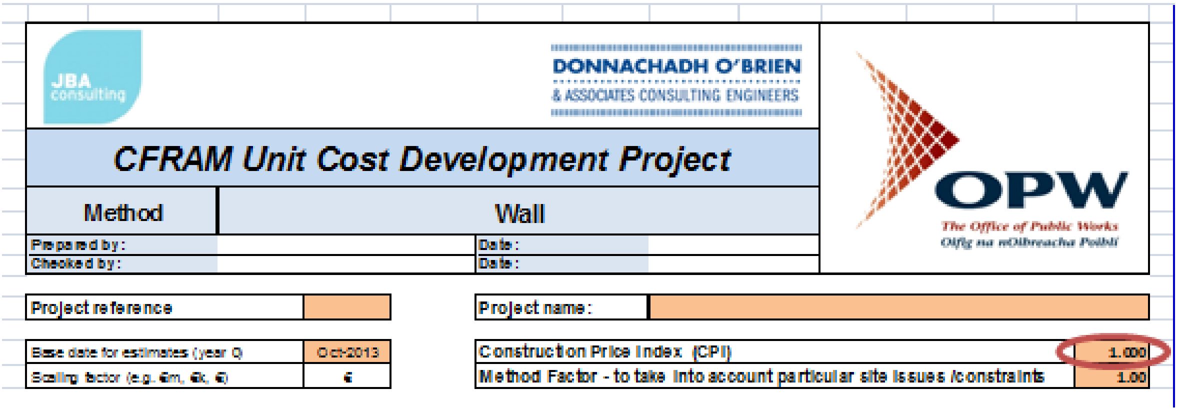
3.3.2 Base dates and updating of costs

Provided inflation for all costs is approximately equal, it is normal practice to exclude inflation effects when undertaking WLC analysis and to only include these aspects as a sensitivity test or when these uncertainties may affect the option choice. As such, inflation has not been considered for the purposes of this project.

The year used as the basis for pricing is 2013 and has been indicated in the summary sheets for each method. This is to ensure consistency across all measures and categories. All costs have been updated using either the Central Statistics Office (CSO) Production in Building and Construction Index[2] or the Consumer Price Index[3].

Future updating of costs can be done for all associated cost summary sheets by applying a weight to the 'Construction Price Index (CPI)' cell (as shown in the figure below). For example, the first quarter 2014 Indices of Production in Civil Engineering is 88.0. The 2013 fourth quarter value was 89.2. Thus a CPI weighting of 0.987 (88.0/89.2) would be used to update costs within the cost spreadsheets.

Figure 3-2: Updating of costs to analysis base date



3.3.3 Design life assumptions

The design life of a measure is the minimum length of time that the asset performs to its intended function. The design life may vary depending upon external factors that impact upon the assets condition or deterioration and the maintenance carried out on the asset. The design life can also be applied to components within an asset where internal structures might have shorter life cycles to the overall asset.

Where design life is thought to be less than the 50 year financial period of assessment an understanding of the design life is critical for the whole life costing. Most assets constructed will have a design life in excess of 50 years and will be maintained over the appraisal period. Therefore is has been assumed that no end of life replacement or decommissioning costs are applicable.

3.4 Risk and optimism bias

There is a demonstrated, systematic, tendency for project appraisers to be overly optimistic. The aim of adding an optimism bias is to allow a contingency on cost estimates to cater for unknowns and help ensure project promoters retain adequate project budget.

An appropriate uplift or optimism bias is recommended at the relevant stage of the appraisal process to negate this optimism. An optimism bias of 60% is typically used for projects at an early stage of consideration, and a value of 30% at the more detailed project stage.

Optimism bias has not been included within the costs provided but will need to be included as part of the appraisal process. Appraisers must ensure that an appropriate allowance for optimism bias is included within the total whole life costs. The reason for excluding optimism

[2] http://www.cso.ie/en/statistics/construction/
[3] http://www.cso.ie/en/releasesandpublications/prices/

bias is that appraisers typically apply a standard uplift at the appraisal or design stage without further proper consideration of project risks.

For the purpose of this project and the CFRAM studies, the OPW wish to apply a more robust appraisal of risk for each site. Rather than to supply a specific rate that would not reflect site specifics, this project has defined a set of standard key components of risk for all projects that typically increase or decrease the construction risk. By presenting these factors, appraisers can then select whether the specific factor is present or applicable and score the risk accordingly. A separate weighting methodology used to weight each individual risk/factor. Total risk scores are generated and used to define an appropriate optimism bias that should be used within pre-defined boundaries.

For example, a site with good access to be constructed in summer months, with low complexity, available funding and good community involvement would have a low optimism bias (for example; between 10-20%). On the other hand, a tidally located site with known invasive species and located on contaminated land, with poor urban access and a highly innovative, complex design would have a higher optimism bias (for example; between 45-60%).

3.4.1 Optimism bias tool

JBA Consulting have developed an optimism bias tool that CFRAM appraisers should use when determining the optimism bias for each appraisal site. The tool forces users to determine the relative risk value for a range of risk components broken down into the following 5 categories:

- Procurement risks
- Project specific risks
- Client specification risks
- Environmental risks
- External influence risks

For each risk component under the above categories the appraiser should select a risk category (Very High to Very Low) from the pull down menu. Additional comments are provided to assist users for each risk component (within the MS Excel 'Comments' functionality). The default value is set to medium risk. There is space for appraisers to add remarks or comments to justify each risk component score.

A pre-defined weighting is also supplied to weight the score based on existing OPW knowledge of relative risks. For example 'Services' and 'Ground Conditions' have a weighting of 3 whereas 'Amenity and Art' have a score of 1 to reflect the impact that these uncertainties can have on the overall project costs.

Once all risk components have been defined, the tool will multiply each risk component by the weight to derive an overall site/option weighting. The weighting is then used to define the optimism bias between pre-selected upper and lower optimism bias bands (currently set at 10% and 70%).

Should a medium weighting be given to all risk components the resulting optimism bias is 40%. Should all risk be set to Very Low (10%) or Very High (90%) the resulting optimism bias are 16% and 64% respectively.

Figure 3-3: Optimism bias tool

DONNACHADH O'BRIEN & ASSOCIATES CONSULTING ENGINEERS

OPW The Office of Public Works Oifig na nOibreacha Poiblí

CFRAM Unit Cost Development Project

Optimism Bias Calculator

Prepared by:	AEP	Date:	December 2013
Site Reference:		Site Name:	

Key: Default weighting defined by OPW for all CFRAM projects; Default risk value defined for all CFRAM projects; Automated function cell (no input required); User defined - risk value, comments, justification

Project risk components that influence total project cost	Weight 1-3 (3 being a higher weight)	Risk value (0-100%) 0% = no risk 100% = risk expected and not mitigated		
Procurement	*Weight*	*Risk score*		*Comment/justification*
Complexity of Contract Structure	1	Medium	50%	
Late Contractor Involvement in Design	2	Medium	50%	
Poor Contractor Capabilities	1	Medium	50%	
Government Guidelines	1	Medium	50%	
Dispute & Claims Occured	3	Medium	50%	
Information Management	1	Medium	50%	
Budgetting	2	Medium	50%	
Other	1	Medium	50%	
Project Specific				
Design Complexity	2	Medium	50%	
Degree of Innovation	2	Medium	50%	
Technology	2	Medium	50%	
Services	3	Medium	50%	
Ground conditions	3	Medium	50%	
Health and Safety	3	Medium	50%	
Other	1	Medium	50%	
Client Specification				
Inadequacy of the Business Case	3	Medium	50%	
Large No. of Stakeholders	2	Medium	50%	
Funding Availability	2	Medium	50%	
Project Management Team	1	Medium	50%	
Poor Project Intelligence	2	Medium	50%	
Other	1	Medium	50%	
Environment				
Public Relations	2	Medium	50%	
Site Characteristics	2	Medium	50%	
Environmental Impact	3	Medium	50%	
Permits / Consents / Approvals	2	Medium	50%	
Amenity and art	1	Medium	50%	
Contaminated land	3	Medium	50%	
Archaeology	3	Medium	50%	
Other	1	Medium	50%	
External Influences				
Political	3	Medium	50%	
Economic	2	Medium	50%	
Legislation / Regulations	1	Medium	50%	
Multiple river users / stakeholders	2	Medium	50%	
Flood events during construction	3	Medium	50%	
Other	1	Medium	50%	
	68	50%		

		Minimum Optimism Bias:	10%
		Maximum Optimism Bias:	70%
Weighting to apply:	0.600	Calculated Optimism bias:	40%

4 Summary of costs

4.1 Overview of summary templates

A summary template is provided for each flood risk management method. These sheets highlight key aspects with regard to each method and provide available information and the derived cost estimates for each of the flood risk methods and factors. Costs are broken down by capital costs and operation and maintenance costs. Each summary sheet prepared contains the following aspects:

- A summary of types of FRM measures covered and method of assessment.
- The assumptions used to derive the costs.
- Unit costs for each Method and Factor.
- Any specific data comments or additional factor considerations that may influence the costs and require adjustments to the costs (using the method factor or as part of the wider project risks in the Optimism Bias adjustment).
- Calibration and validation data used to benchmark the derived costs.
- Operation and maintenance costs applicable for each method.
- Links to any relevant documents used as part of the cost estimation.

It is expected that this information will be useful in developing costs for CFRAM appraisal options. It is not anticipated that the cost information provided will be relevant for detailed scheme estimates where site specific information is required.

Nineteen separate summary sheets have been generated. Each method has differing levels of detail depending on the costing approach and the available data, which are discussed further in the sub-sections below.

4.2 Overview of costing approach and data quality

The summary table below illustrates the costing approach undertaken for each method assessed and the relative data quality. This data should be reviewed by all appraisers to assess the level of detail used within the calculations and to highlight which methods are based on more broad scale data.

As discussed in Section 2.1 most methods have used a more reliable 'bottom up' approach using unit rates defined by an experienced quantity surveyor. However, some methods use a less reliable (top down) methodology due to the limited available data or the fact that some methods are simply too broad to be able to provide sufficiently accurate unit costs. These include methods such as bridges and weir removal.

Those methods where only indicative costs have been provided reflect the fact that unit costs cannot be provided for all sites and asset variations without a more detailed understanding of the design and site constraints. Appraisers should be aware that unit costs provided for these lower quality methods are indicative only and should be treated as a starting point only in terms of cost estimation. Where applicable, appraisers should seek more specialist advice or at least consider varying the costs to account for site specific or asset specific variations.

Table 4-1: Summary of flood risk methods and factors assessed within this report

Method	Costing approach	Quality
Flood Protection Wall	Bottom up analysis for majority of factors, calibrated against out-turn costs. Some scaling used for certain factors.	Best in class
Embankment	Bottom up analysis for all factors, calibrated against out-turn costs.	Best in class
Demountable Barriers	Costs provided by suppliers. O&M costs based on experience and best practice.	Data with known deficiencies
In-Channel Excavation	Bottom up analysis for all factors. Limited calibration data to validate costs.	Data with known deficiencies
Excavation on Land	Bottom up analysis for all factors. Limited	Best in class

Method	Costing approach	Quality
	calibration data to validate costs.	
Weir Construction	Bottom up analysis for all factors. Limited calibration data to validate costs.	Best in class
Weir Removal	Top down approach based on multiple case studies.	Gross assumptions
Bridge Removal	Costs based available but external (non Irish) unit rates.	Gross assumptions
Bridge Construction	Costs based available but external (non Irish) unit rates.	Gross assumptions
Bridge Underpinning	Bottom up analysis, calibrated against out-turn costs. Highly site specific and variable method.	Data with known deficiencies
New Culvert	Bottom up analysis for majority of factors, calibrated against out-turn costs. Some scaling used for certain factors.	Best in class
Sluice Gate	Bottom up analysis with supply informed rates for gate/penstock costs. Limited calibration data to validate costs.	Best in class
Road Raising	Bottom up analysis. Limited calibration data. Highly site specific and variable method.	Data with known deficiencies
Pumping Station	Top down approach based on JBA data for capital, running and O&M costs.	Data with known deficiencies
Individual Property Protection	Top down approach based on available research and internal JBA data, calibrated against Irish studies.	Best in class
Hydrometric Gauging Station	Bottom up analysis, calibrated against out-turn costs.	Best in class
Flood Forecasting System	Top down approach based on OPW research and internal data.	Data with known deficiencies
River Maintenance	Generic cost information based on OPW internal data.	Data with known deficiencies
Bank Protection	Bottom up analysis for all factors. Limited calibration data to validate costs.	Best in class
Manhole Sealing	Bottom up analysis. Limited calibration data to validate costs.	Data with known deficiencies
Mobilisation and Site Set-Up	Bottom up analysis for all factors.	Best in class

4.3 General costing assumptions

A number of assumptions have to be made for any costing approach and particularly for those aspects costed from first principals ('bottom up'). Individual assumptions for each method are provided in the summary sheets. However these are a number of generic assumptions as listed below:

- Rates used are inclusive of labour, plant and materials and assume a competent civil engineering contractor undertakes the work.
- The rates used represent a 'sunny day' scenario and in no way try to cover all possible risks or unseen eventualities. For this reason, consultants should take care when using the rates and applying these to the sites of interest. It will be important to fully consider all possible risks as part of the assessment and to make allowances for these as part of the method factor or optimism bias.

- Rates used are generally based on Dublin region prices, but it is considered that limited regional variations would be warranted, as insufficient data was available to determine this.
- Temporary works have been allowed for based on what we consider to be reasonable, but are not intended to be definitive for all possible eventualities or be a definitive methodology or sequence.
- Health and safety aspects assume a competent contractor, but site specific risks have not been allowed for. This aspect could be covered by the optimism bias risks.

A summary of the methodology and key factors costed for each option is provided in the following sections.

4.4 Walls

Costs have been derived from bottom up analysis using unit rates defined by an experienced quantity surveyor based on a specific set of design requirements for each wall type and factor variation. Full details and all assumptions are given in the summary spreadsheet.

All walls assume a reinforced concrete construction, with urban wall including the option for stone cladding. Costs include hoarding fence, removal of concrete path to facilitate construction and services diversions, wall foundation costs, replacement of paths and reinstatement of area.

Cost information is provided for the following factors:

- **Wall type**. Costs have been provided for rural, urban walls, quay walls and sea walls. Quay walls have been provided for 0.0, 0.6 and 1.2m heights only. Sea walls assume a single height based on the required design for an exposed location with re-curve wall.
- **Rural and urban**. It is assumed that urban walls will include stone cladding and a degree of works associated with services (excavation, lighting, backfill etc.).
- **Height variations of 0.6m, 1.0m, 2m and 3m**. These are typical wall heights used for flood mitigation. Wall heights assume a freeboard is included. Walls heights of 0.6m assume a 0.6m high railing on top.
- **Asset length categories of <100m and >100m**. Efficiencies of scale are anticipated for longer lengths, although analysis based on the above assumptions suggests that this is not as sensitive as expected. Users may wish to apply a factor for very short or much longer asset lengths.
- **Structure type**. An allowance for sheet piling has been included within the urban and quay walls. Sheet piling is not anticipated for rural locations. A sheet piling depth of 2m is included within the sea wall design as standard. Sheet piling costs are highly variable and will depend on site characteristics, ground conditions and the difficulty of installation. For this reason, sheet piling costs for urban walls have been derived based on weighting from an existing unit cost database. Sheet piling costs for quay walls have been estimated from rates supplied by an engineering contractor.

For comparison, we have provided the unit cost results and compared these against unit cost database rates from the Environment Agency. The comparison for urban and rural walls is shown below. The generated urban walls unit costs compare well with the Environment Agency unit costs. The rural walls unit costs are at the lower end of costs available which is to be expected for rural walls.

Figure 4-1: Urban wall cost curve and comparison with Environment Agency unit costs (adjusted to € and preliminaries removed)

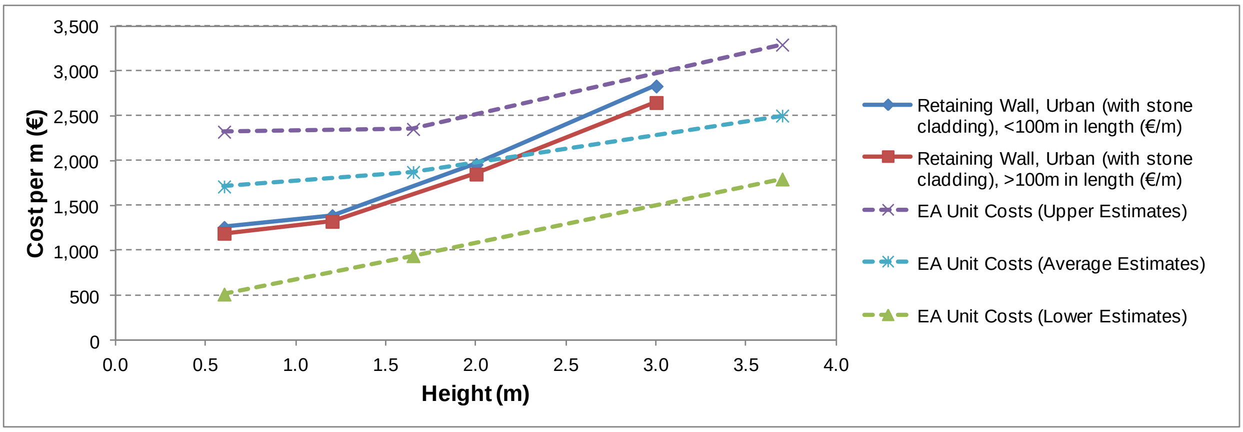
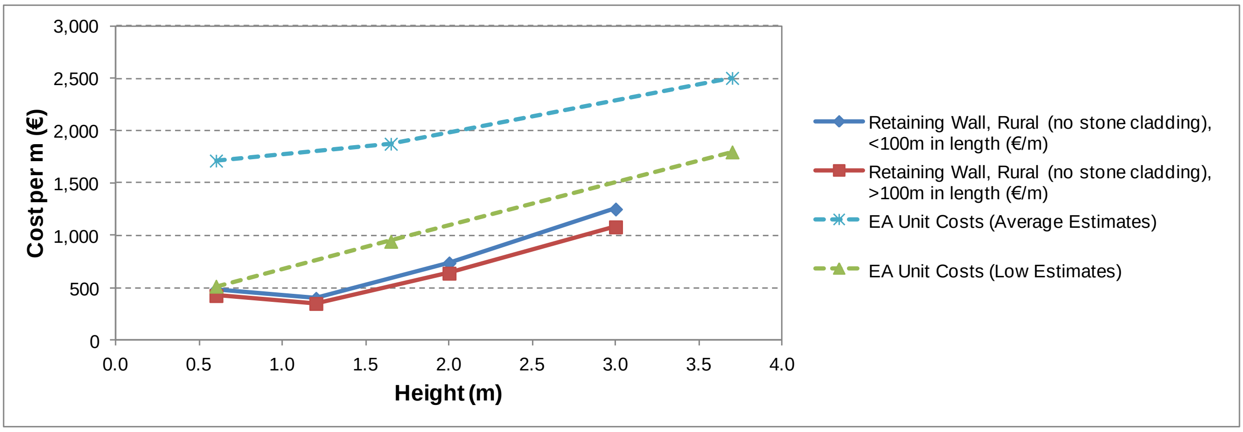


Figure 4-2: Rural wall cost curve and comparison with Environment Agency unit costs (adjusted to € and preliminaries removed)



4.5 Embankments

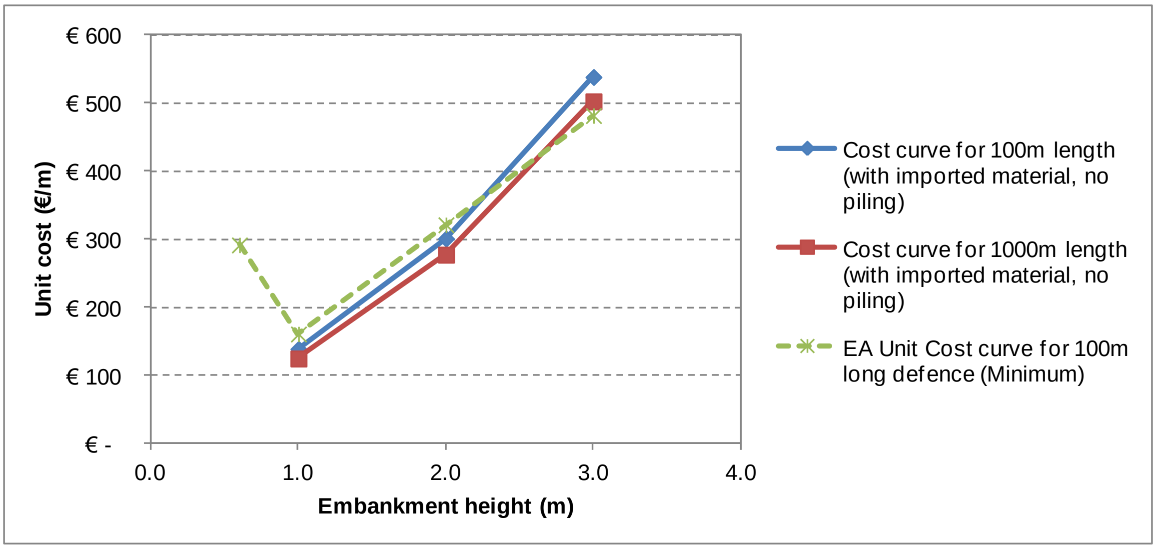
Costs have been derived from bottom up analysis using unit rates defined by an experienced quantity surveyor based on a specific set of design requirements for each embankment type and factor variation. Full details and all assumptions are given in the summary spreadsheet.

It is assumed that embankments will be constructed of suitable soil types, with a top width of 2m and a side-slope of 3:1 (i.e. 3m horizontally for each metre of height).

Cost information is provided for the following asset types:

- **Rural assets only**. It is not anticipated that embankments in urban locations will vary in cost as embankments will only be located in areas of open access.
- **Height variations of 1.0m, 2m and 3m**. These are typical embankment heights used for flood mitigation. Embankment heights assume a freeboard is included.
- **Asset length categories of <100m, 100-1,000m and >1000m**. Efficiencies of scale are anticipated for longer lengths.
- **Embankments formed from imported material and local material.** This is an important aspect that was included as the source of material can impact on costs significantly.
- **Embankment construction type**. Costs for standard embankments, embankments with a 5m pile and embankments with a 10m pile were costed separately as aspects will significantly influence costs.

Figure 4-3: Embankment cost curve and comparison with Environment Agency unit costs (adjusted to € and preliminaries removed)



4.6 Demountable barriers

Costs have been derived and obtained from a number of suppliers of demountable barriers and flood gates. Demountable barrier costs assume a pillar and slat type of construction and include the supply and installation of barriers. Costs for gates have been provided for a range of types.

Cost information is provided for the following factors:

- **Rural and urban**. No cost variation is provided for this aspect. The costs of supply will be the same for both scenarios. The ground work costs may vary due to the need for concrete foundations and possible cut-off, although this factor will depend on ground conditions at site rather than a rural or urban classification.
- **Height variations of 0.6m, 1.2m, 1.8m and 2.1m**. These are typical demountable barrier heights used for flood mitigation. Costs over and above 2.1m are possible but would need bespoke design from a specialist. Gates have been provided for 0.6m, 1.0m, 1.2m and 1.8m.
- **Asset length categories of 1m, 2.5m and 5m**. Costs have been provided by suppliers for very short lengths only. Costs for longer reaches should use the 5m lengths to scale up costs as barrier lengths beyond 5m will have less scale efficiencies unless suppliers choose to provide this. For very long lengths we recommend that costs are obtained from suppliers at an early stage.
- **Foundations**. Supply costs include the installation and supply of a ground beam. This incorporates the fixing plates for the posts and thus takes the onus off the contractor for the accuracy required with these. The greater cost however is the foundation cost. This could be as simple as a 600m x 600m concrete trench, although past experience suggests that costs for cut-offs and poor ground conditions can make up a large proportion of costs for these works.

In some circumstances demountable barriers will be constructed on top of flood walls. In this instance, appraisers should combine the two unit costs making any additional allowance for the works to tie the two together structurally and any additional costs associated with improved or extended foundations.

To aid this combined measure a range of basic additional foundation costs have been provided depending on the approach proposed. The three options where costs are provided include:

- Cost per m for basic foundation
- Cost for low wall (assuming demountables on top)
- Cost for quay wall

It should be noted that the wall unit costs provided do not allow for a further demountable barrier on top and that the wall foundations would need to make an allowance for the additional barrier height. An appropriate contingency should be applied for this aspect unless additional specific engineering design and expertise is provided to inform the design and costs.

All relevant event, operation and maintenance and storage costs are provided. These costs include general administration, storage costs and all inspection costs.

4.7 In-channel excavation

Costs have been derived from bottom up analysis using unit rates defined by an experienced quantity surveyor based on a specific set of design requirements for in-channel excavation works. The above costs have been developed from a breakdown of costs for excavation and disposal costs along with costs for construction of silt traps, replacement of gravel layer post works and the reinstatement of works access and storage areas. Full details and all assumptions are given in the summary spreadsheet.

Cost information is provided for the following factors:

- **Rural and urban**. Costs are broken down into rural and urban locations reflecting the more complex access and obstructions within urban locations.
- **Excavation material**. Costs are provided for excavation in soft soil and rock. Costs assume that all materials excavated are taken to a waste facility.
- **Volume of material**. Costs have been assessed for 3 categories: 100m^3, 500m^3 and 1000m^3.

Operation and maintenance costs are assumed to be zero in the long term and do not add to expenditure budgets. Appraisers should consider initial post works monitoring for a number of years if this is anticipated to be required.

4.8 Excavation on land

Costs have been derived from bottom up analysis using unit rates defined by an experienced Irish quantity surveyor based on a specific set of design requirements for in-channel excavation works. The above costs have been developed from a breakdown of costs for excavation and disposal costs. Excavation on land is anticipated for channel diversions or natural flood management purposes. Full details and all assumptions are given in the summary spreadsheet.

Cost information is provided for the following factors:

- **Rural only**. Costs are broken down into rural locations only as unit costs cannot be provided for excavation of land in urban areas due to the highly variable site conditions and constraints.
- **Excavation material**. Costs are provided for excavation in soft soil and rock.
- **Disposal**. Costs have been provided assuming that all materials excavated are either taken to a waste facility or disposed on site. The latter may be applicable for rural works.
- **Volume of material**. Costs have been assessed for 3 categories: 100m^3, 550m^3 and 1000m^3.

Operation and maintenance costs are assumed to be zero in the long term and do not add to expenditure budgets. Appraisers should consider initial post works monitoring for a number of years if this is anticipated to be required. Additionally, operation and maintenance costs may be required for channel creation aspects. In this instance, channel maintenance costs should be applied.

4.9 Weir construction

It is not anticipated that new in-line weirs would be constructed for flood risk management purposes as part of the CFRAM process, other than for lateral weirs (side spillways) to convey water into new diversion channels or storage areas. Therefore costs have been derived from bottom up analysis using unit rates defined by an experienced quantity surveyor based on a specific set of design requirements for a side weir construction.

Costs assume a reinforced concrete construction (similar to the assumptions used for concrete walls) with all necessary temporary works and bank protection. Full details and all assumptions are given in the summary spreadsheet.

There are considerable uncertainties associated with providing unit rates for all possible weir structures proposed as part of the CFRAM projects. As a result the rates provided should be used with caution and as a starting point only.

Cost information is provided for the following factors:

- **Weir height**. Costs have been provided for 1m and 2m high weirs. Total costs and unit costs are provided.
- **Weir length**. Costs have been assessed for 10m and 20m long weir lengths. Total costs and unit costs are provided.

Operation and maintenance costs have been provided.

4.10 Weir removal

Costing and providing unit rates for weir removal is complicated by the inherent variations in weir design and size, site specifics and site constraints. As a result costs have been derived from top down analysis derived from gathering case studies of weir removal to derive example costs. A number of examples have been sourced and provided to illustrate the range of costs likely. Costs appear to correlate with structure length and an indicative cost curve has been provided. It should be noted however that most sites collated are predominantly rural rather than urban and care should be utilised when applying this cost curve to urban sites as costs could be substantially higher.

There are considerable uncertainties associated with providing unit rates for the removal of weir structures proposed as part of the CFRAM projects. As a result the values used and cost curve provided should be used with caution and as a starting point only.

Operation and maintenance costs have been included to account for post works monitoring to ensure watercourse channels remain stable.

4.11 Bridge construction/removal

Costing and providing unit rates for bridge construction/removal is complicated by the inherent variations in bridge design and size, site specifics and site constraints. As a result costs have been derived from top down analysis, derived from existing unit costs from a range of available sources from the UK and the USA. The UK costs are deemed to be most applicable although data from the USA provides additional confidence in the data used. There are existing National Roads Authority (NRA) cost databases that have this information and could be used to reduce the reliance on non-Irish unit rates. We recommend that access to the cost database is agreed between the NRA and the OPW to improve future bridge costs.

Costs are available for the following:

- Footbridge
- Reinforced concrete bridges
- Bridge removal

These costs are highly indicative and should only be used for early level appraisals where bridge costing is required, and where site details and designs are not yet understood. Costs should therefore be used with care and may not be applicable to all structures. Costs will be highly dependent on the presence of existing services and anticipated traffic loading and these factors should be considered by the CFRAM consultants when using the rates provided.

Appraisers should select an appropriate unit cost from the range provided based on the site characteristics and the risk factors identified.

4.12 Bridge underpinning

Costs have been derived from bottom up analysis using unit rates defined by an experienced quantity surveyor based on a specific set of design requirements for in-channel excavation works. The unit costs have been developed from a breakdown of costs for all associated site works, temporary works and phased construction works. The costing process is based on a theoretical case study: a 3 span bridge with four 13m long support walls. Full details and all assumptions are given in the summary spreadsheet.

No further cost factors have been allowed for, therefore care should be exercised in using these costs for anything other than early level appraisals where bridge underpinning has been identified, but site details and designs are not yet fully understood.

Operation and maintenance costs are assumed to be zero in the long term and do not add to expenditure budgets (these works may actually reduce inspection and maintenance costs for at risk structures). Appraisers should consider initial post works monitoring for a number of years if this is anticipated to be required.

4.13 Culvert

Costs have been derived from bottom up analysis using unit rates defined by an experienced quantity surveyor based on a specific set of design requirements for each culvert type and factor variation. Full details and all assumptions are given in the summary spreadsheet.

All culverts assume a site preparation and trench excavation, disposal, granular bedding, supply and placement of precast culvert, backfilling and reinstatement. In addition to culvert works, the costs of headwall construction are provided separately. Full details and all assumptions are given in the summary spreadsheet.

Cost information is provided for the following factors:

- **Rural and urban**. Culverts in an urban area assume additional works for manhole provision, additional excavation and service diversions, temporary trenching and traffic management, road re-instatement and connection of existing services. Costs for urban culverts relate to new culverts and the replacement of existing culverts. Costs for urban reaches only relate to pipes as it is unlikely that long lengths of box culverts will be needed in urban environments.
- **Culvert sizes for pipes (1.05 and 1.5m dia) and box culverts (2.1x1m, 2.4x2.1m and 3.0x2.1m)**. These are typical culvert sizes applicable for a range of flood mitigation measures. Costs for replacement culvert sizes (pipes of 1.05m and 1.5m diameters) were selected as it is assumed that large culvert online replacement is unlikely in the in the urban environment.
- **Depth of invert (2, 4, 6m)**. The depth of invert can influence the construction costs due to greater excavation and backfilling costs.
- **Excavation material (soil and rock)**. Costs of construction will vary greatly for construction in rock. This variation has been applied to rural culverts only.
- **Disposal of waste material**. Costs for disposal will vary depending on where material is disposed and distance of haulage. Costs have been broken down between disposal on site and disposal at a licensed tip. This variation has been applied to rural culverts only.
- **Asset length**. Costs have been developed for a 100m culvert length. Costs increase substantially for short lengths. To take this aspect into consideration existing unit rates have been used to define factor adjustments for very short culvert lengths. Users may wish to apply a factor for very short or much longer asset lengths.
- **Headwalls**. Costs have been developed for headwalls as a separate item. Costs have been provided for the 5 culvert size dimensions and assume that the total height of the reinforced concrete headwall will be 1500mm above the top of the pipe or culvert.

Operation and maintenance costs are provided for short, medium and long culvert lengths and for 3 categories of culvert size (<1.2m^2, 1.2-4.0m^2 and >4.0m^2).

4.14 Road Raising

Costs have been derived from bottom up analysis using unit rates defined by an experienced quantity surveyor based on a defined set of design requirements for road raising. It is very difficult to provide a unit cost that will be applicable for all sites. Therefore costing process is based on a theoretical road raising approach that allows for the raising of a 7.5m road, kerbs, grass verges and footpath. Full details and all assumptions are given in the summary spreadsheet.

No further cost factors have been allowed for, therefore care should be exercised in using these costs for anything other than early level appraisals where road raising is proposed but specific site details and designs are not yet fully understood.

This operation is not anticipated to have any net increase in existing operation and maintenance costs: indeed it may reduce them.

4.15 Individual property protection

Costs for individual property protection have been derived from existing research into PLP costs and JBA information on survey and administration costs. Unit rates for individual property level protection products have been used and multiplied by standard packages for typical property types in order to derive a unit cost per property. Costs allow for survey and administration, door guards, airbrick covers, sump pumps, waterproofing of external walls, non return valves or toilet bungs. Full details and all assumptions are given in the summary spreadsheet.

Cost information is provided for the following factors:

- **Property type**. Unit costs have been provided for the following property types: Detached, Semi-Detached, Terraced, Flat, Residential Average (where property types are unknown), shops and offices.
- **PLP product type**. Unit costs have been provided for manual products and automatic measures. Manual products need to be fitted manually by residents or homeowners, whereas automatic measures require minimal operation prior to a flood event but are generally more costly.

O&M costs are recommended to be 2% for manual measures and 5% for automatic measures.

4.16 Hydrometric gauging station

Costs have been built up from unit rates for specification/administration, monitoring equipments and installation/communication rates to cover the cost of installation and running of a hydrometric gauging station. It is assumed that this is a relatively simple water level monitoring station fitted with telemetry and costs include annual costs for undertaking flow gaugings.

No further cost factors have been allowed for. Costs do not assume weir, stilling wells, recorder house and cableway construction. Whilst the unit cost for such stations will be significantly greater and are excluded, the summary provides costs for such structures based on other unit rates from the UK for completeness.

4.17 Flood forecasting

Costs for the provision of flood forecasting are highly variable and will depend on the level of existing hydrometric coverage, the size of catchment, the forecasting requirements and the degree of software and hardware to support forecast data and models.

Costs have been broken down into simple alarms and complex forecasting models. Rates for simple alarms have been built up from unit rates for specification/administration, monitoring equipment and installation/communication rates. Costs are broken down into the following factors:

- **Simple alarm system**. Water level monitoring station fitted with public alarm when level reaches specified level(s). Costs are provided per station for gauges with audio alarms and those with signage (e.g. for road crossings liable to flooding).
- **Simple forecast system**. Water level monitoring station fitted with telemetry to send text messages when level reaches specified level(s). Costs are provided per station for gauges with audio alarms and those with signage (e.g. for road crossings liable to flooding).

Costs for complex alarm systems have not been defined although a range of typical costs are provided for key aspects that may be needed depending of the site of catchment and scope required. These costs are predominantly based on existing information provided by the OPW and updated from other sources. Costs include specification, site survey and administration, gauging and telemetry, forecast model set-up, calibration, configuration and testing, forecasting system development, design and plan of training package and public awareness campaigns.

The Present Value cost summary tool allows users to specify the number and rate (guided by typical rates) for each item for a specified forecast model. Obviously there are large uncertainties and the rates used are indicative. Whilst costs include hardware and software costs for new forecasting capabilities (if not already available), appraisers should be aware that if multiple

forecast models and systems are proposed and run regionally or centrally, there may be cost savings that apply.

4.18 Pumping stations

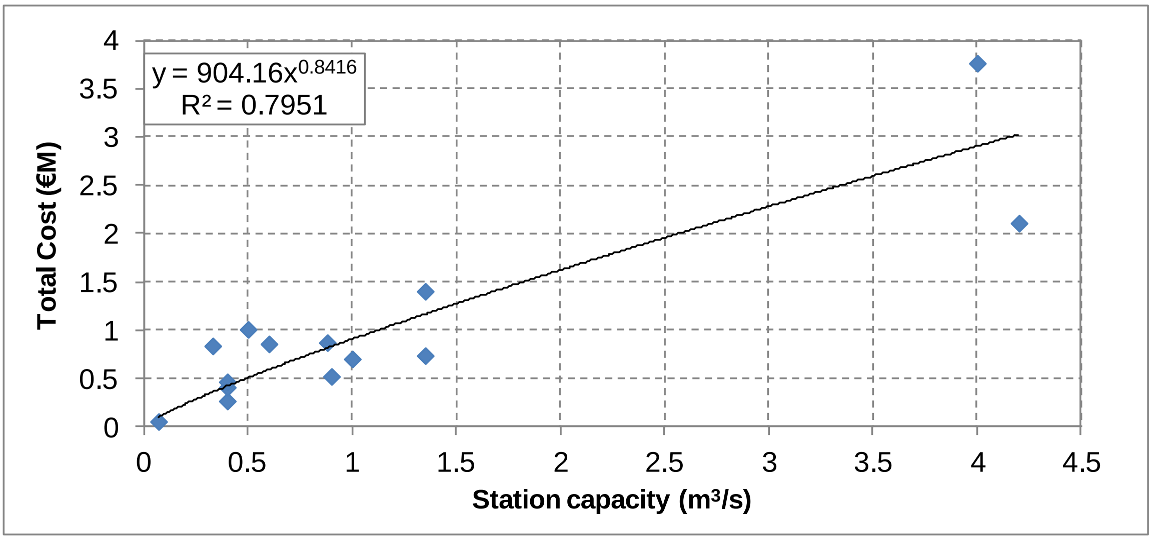
Costs have been derived from top down analysis through the assessment of multiple pumping station case studies. Costs are highly indicative due to the large variation in design of pumping stations and the wide range of factors that need to be considered. Capital costs will relate to the supply of pumps and construction of all pumping station civil works. This may include site clearance, pump installation and ancillary electrical and mechanical equipment, excavation, pipework and manhole construction, kiosk/housing installation/construction, connection with power supplies, and telemetry/cctv installation and testing.

Whilst a range of factors need to be considered for all pumping stations, all costs gathered have been plotted against the pump capacity to determine a cost curve for use at the high level, early stage assessment prior to site specific design (Figure 4-4).

Cost information is provided for the following factors:

- **Capacity**. Based on cost curve derived a series of unit costs have been derived for 7 categories of pump capacity (20l/s, 50l/s, 100l/s, 500l/s, 1,000l/s, 2,000l/s and 3,000l/s).

Figure 4-4: Pumping station construction cost curve



No further cost factors have been allowed for, therefore care should be exercised in using these costs for anything other than early level appraisals where pumping stations have been identified, but site details and designs are not yet fully understood.

Operation and maintenance costs are an important consideration for pumping stations due to the annual running and operational costs and annual/intermittent maintenance costs. Detailed analysis of existing pumping stations assessed by JBA have been used to define unit rates for these aspects for this study. The following aspects are provided:

- **Annual maintenance costs**. These are highly variable and will depend on the need for inspections, condition assessments, repairs and replacement of parts, removal of blockages and telemetry checks. A unit rate for each category of pump station capacity has been provided as well as an upper and lower rate.
- **Running costs**. This will include all electricity costs. Based on the output of JBA analysis a cost curve has been derived to determine costs for the range of pumping station capacities. It should be noted that Maximum Import Capacity (MIC) charges may also apply for larger pumping stations with significant implications for running costs (see below).
- **Intermittent replacement costs**. In addition to annual and periodic maintenance costs, refurbishment works are generally carried out at approximately 15 to 25 year intervals for

mechanical and electrical equipment with any major structural repairs and improvements being carried out. For the purposes of whole life costing we recommend that refurbishment costs are included every 25 years over the appraisal period.

4.18.1 Note on Maximum Import Capacity (MIC) charges

MIC charges are applied for all new pumping stations to cover the energy distributor's costs of connection and meter installation. However, for larger pumping stations MIC charges may also be applied as an annual cost. The current MIC charge is €0.0734/kVA/day. This charge is applied whether the pump is in use or not and is set to cover the demand usage of the pumping station when required. An example is the Ennis FRS which has a pump capacity of 3.8m3/s and a power requirement of 1000KVA. This results in an annual MIC charge of €28965 (including VAT).

These costs are not included in the running costs provided, but need to be included for larger pumping stations to ensure that these important costs are fully considered by the CFRAM consultants. There are options to design out these charges however, that may need to be investigated at an early stage in the appraisal process. Options may include the use of more efficient pumps with lower power requirements (although higher capital costs), the use of generators to power the pump (noting that there may be maintenance and site layout constraints to consider also).

4.19 Channel maintenance

Channel maintenance costs vary considerably depending on the state of watercourse and channel sizes. Unit costs have been derived from a top down approach utilising existing information from the OPW and the Environment Agency (the latter adjusted to Euros).

Costs relate to inspections, bank clearance, obstruction removal, weed control and intermittent works such as bank protection and repairs. A range of costs (broken down by channel type (urban/rural), clearance method (manual/mechanical)) are provided as well as upper and lower bounds for the EA data.

All costs represent annual costs rather than capital costs. Full details and all assumptions are given in the summary spreadsheet. Recommended costs are provided for the following factors:

- **<5m wide channels in rural areas**
- **<5m wide channels in urban areas**
- **5-10m wide channels in rural areas**
- **5-10m wide channels in urban areas**
- **Channels in poor condition requiring heavy maintenance**

4.20 Bank protection

Costs have been derived from bottom up analysis using unit rates defined by an experienced Irish quantity surveyor based on a specific set of design requirements for each bank protection type and factor variation. Full details and all assumptions are given in the summary spreadsheet.

Cost information is provided for the following factors:

- **Fluvial and coastal**. Two alternative designs have been prepared for bank protection in a fluvial environment (4m high gabion protection) and in a coastal environment (rock revetment).
- **Length**. Fluvial bank protection costs have been provided for 3 length categories (<25m, 25 to 100m and >100m). Coastal rock revetments have been costed for a single 100m length although additional unit rates have been used to apply weightings to longer and shorter lengths. .

Operation and maintenance costs are also provided but are anticipated to be minimal.

4.21 Manhole sealing

Manhole sealing costs have been provided by Gerry O'Connell of Dublin City Council for a range of options including alternative pressures and construction methods. Costs include the supply and fit of a pressure manhole cover of 1-2 bar rating (10-20m water head).

4.22 Additional cost elements

4.22.1 Preliminaries

Construction costs do not include preliminaries as these are most likely to be applied to the total cost for a range of asset types rather than per asset. Despite this the user can apply them to the PV cost tool for individual methods or as part of the combined portfolio of methods tool. To assist the inclusion of preliminaries a method of estimating preliminaries has been derived.

Preliminaries and other construction costs have been built up from unit rates for the following items:

- Compound
- Site cabins and services
- Temporary power and generators
- Protection to overhead services
- Protection to underground services
- Road sweeping of public roads
- Preparation of as constructed drawings
- Health and safety
- Security
- Wheel wash provision at exits to public roads
- Manual washing prior to vehicles existing to public roads
- Supervision
- Setting out
- Mobilisation and demobilise
- Insurance

In addition to the above, each of the separate unit costs includes an estimate of some of the additional preliminaries, such as temporary works, environmental mitigation and temporary flow controls. The temporary works costs are based on what would be required on all sites but are not intended to be definitive for all possible eventualities. As a result, CFRAM consultants should increase the preliminary or method costs to take into account those sites where non-standard, difficult, or additional temporary works are likely to be required.

For each of the above factors a representative cost has been determined for a particular project total cost from €100,000 to €15,000,000. These are shown in Table 4-2 below.

Table 4-2: Preliminaries cost curve

Construction cost:	€100k	€250k	€500k	€1m	€2m	€5m	€10m	€15m
Total Preliminaries	€32k	€51k	€89k	€199k	€330k	€512k	€743k	€932k
Preliminaries as a % of total	32%	20%	18%	20%	16%	10%	7%	6%

Based on the above analysis we recommend that typical preliminary estimates should be between 10-30% of total construction costs, although the tool provided allows appraisers to estimate the preliminaries costs for any given total construction cost.

4.22.2 Haul roads

Construction costs do not include method related costs. A method of estimating two key method related costs (haul roads and works access) have been derived to assist CFRAM consultants. These costs have been derived from worked up rates for a range of activities. It is recommended that the above costs are applied to all capital costs estimates where haul roads or works access is required. This has been addressed in the preliminaries summary cost sheet.

5 Cost database structure

5.1 Database files

A number of files have been prepared and provided to OPW and CFRAM consultants. These include the following:

- 20 CFRAM Consultant FRM method summary cost sheets
- CFRAM Consultant Combined Method WLC tool
- CFRAM Consultant Optimism Bias tool (see Section 3.4.1)
- OPW calculation sheets

5.2 CFRAM Consultant summary sheets

The CFRAM consultant spreadsheets provide all necessary unit rates derived, but none of the background base rates or breakdown of costs. These are included in associated OPW calculation spreadsheets. This is to ensure that the OPW remains the keepers of the data and can make updates to specific rates as and when changes and updates are required, without overloading the CFRAM consultants.

5.2.1 Approach to cost estimation

The basic approach to cost estimation is shown in the Figure 5-1 overleaf. It is up to the consultant to review both this report and each of the summary reports to firstly check that the costs provided cover the types of works proposed and include the factors and sizing applicable to the site. If this database of costs does not provide the necessary information, additional bespoke costing may be required.

Consultants should also review the assumptions used for each approach and decide if any additional weighting or adjustments to the unit costs are required to match the particular site, or whether these can be suitably allowed for as part of an overall optimism bias.

5.3 Layout of CFRAM Consultant Summary sheets

For each method a summary MS Excel workbook exists. Within each is a series of sheets as follows:

- **Revision History** sheet. A basic history of revisions to be kept up to date by JBA/OPW.
- **PVc Summary** sheet (See Figure 5-1 as an example). This allows whole life present value costs to be derived for single method cases (e.g. a series of walls). Appraisers can enter a series of assets and apply specific rates and units to develop a total cost. Appraisers must also enter in any applicable preliminaries, enabling, O&M costs and other costs to derive a whole life cost. A separate tool is provided to generate a whole life cost for a portfolio of assets/methods.
- **Cost Summary** sheet. This sheet provides the unit costs derived, information on how the costs were derived, key assumptions and O&M/other costs.
- **Example** sheet. This is provided for methods were costs have been built up from bottom up costing and includes drawings illustrating the asset type.

The PVc summary sheet should not be used to combine method costs as items like preliminaries will be double counted.

Figure 5-1: Example of PVc summary sheet

DONNACHADH O'BRIEN & ASSOCIATES CONSULTING ENGINEERS

OPW The Office of Public Works Oifig na nOibreacha Poiblí

CFRAM Unit Cost Development Project

Method	Embankment		
Prepared by:		Date:	
Checked by:		Date:	

Project reference	XXXXXX
Base date for estimates (year 0)	Oct-2013
Scaling factor (e.g. €m, €k, €)	€

Project name:	EXAMPLE PROJECT
Construction Price Index (CPI)	1.000
Method Factor - to take into account particular site issues/constraints	1.10

This sheet should only be used when assessing single method options as double counting may occur when method costs are added.

Single Method Capital Cost Tool

	1	2	3	4	5	6	Comment/justification
Embankment ref/type	Left bank	Right bank					*Embankments on both banks required*
Embankment length	50	200					*2m high embankment costs*
Embankment unit rate	300	285					*Costs assume imported material*
Total costs						€72,000	
Apply update to unit rate (CPI) if appropriate (cell N15)						€72,000	
Enter appropriate preliminaries estimate (%)						15%	*15% enabling costs assumed*
Enter other applicable costs (€)						10000	*Access over embankment required*
Total capital cost (€)						€92,800	
Consider amendments based on site issues/constraints (cell N16)						€102,080	*Difficult access, 10% uplift assumed*
Total capital cost (€)						€102,080	

Operation and Maintenance Cost Tool

Total annual O&M costs	€100	

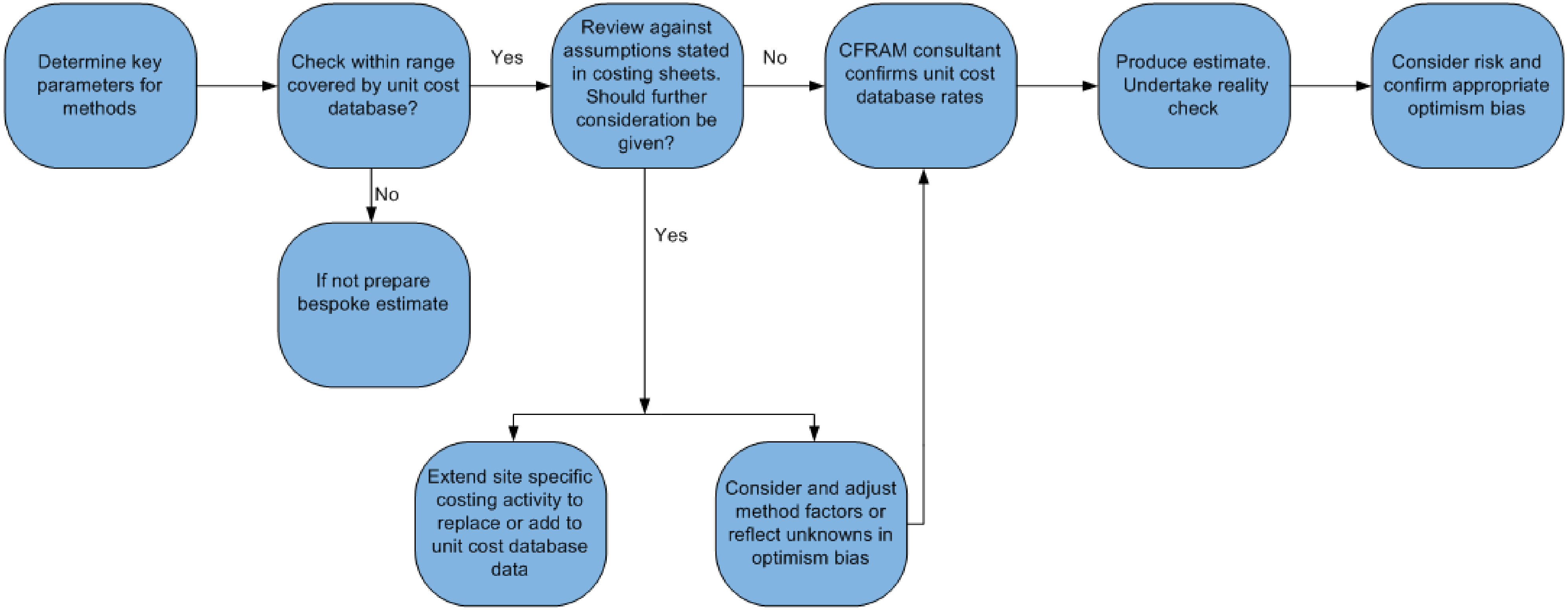
Other costs

Other costs (user defined - consider the need for additional longer term or intermittent costs)		

Total PV Cost

Total PVc costs (see PVc calculator below)	€104,214	
Optimism bias rate (from external sheet)	50%	
Total Cost including Optimism Bias	€156,321	

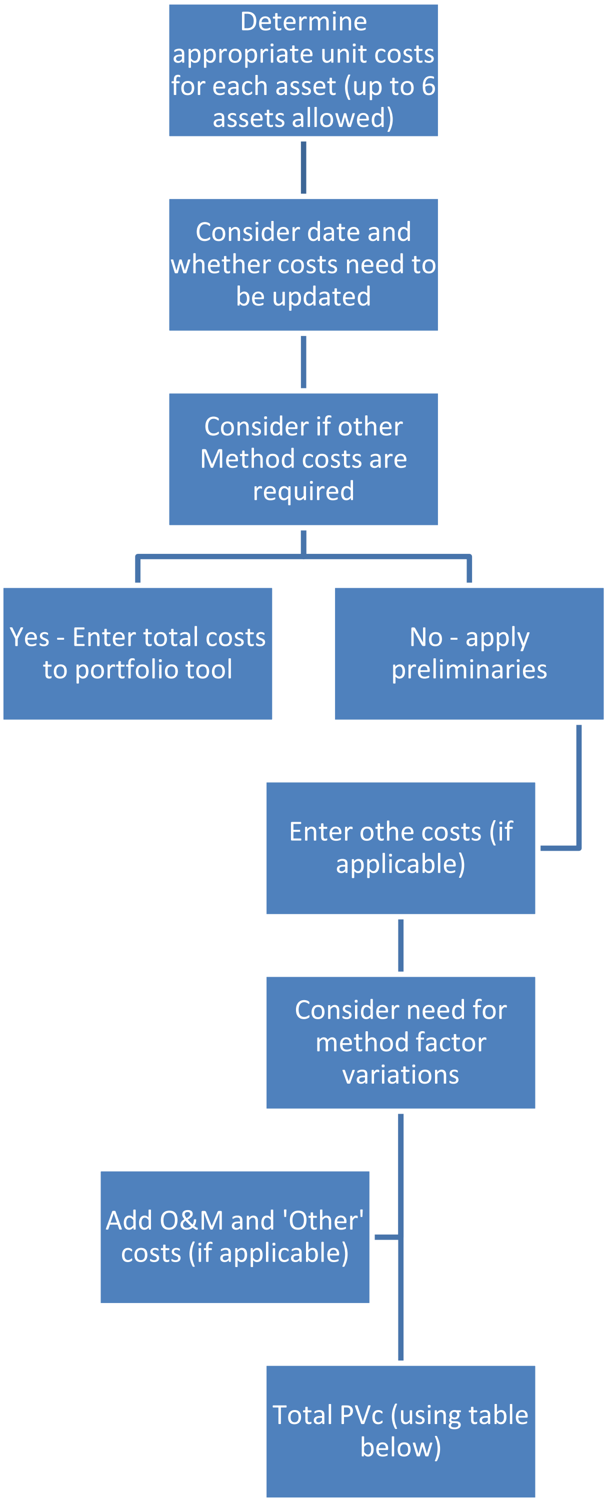
Figure 5-2: CFRAM costing approach



5.3.1 Present Value (whole life cost) summary explanation

The PVc summary is provided in each summary sheet and enables whole life costs for single asset cases to be derived. The following flow path should be followed when entering data from the 'Cost summary' sheet.

Figure 5-3: Present Value Cost tool process



Each stage is provided in the spreadsheet as a separate row with space consultants to enter appropriate comments and/or justification for the values entered as shown in Figure 5-4.

Figure 5-4: Cost summary inputs

Single Method Capital Cost Tool

	1	2	3	4	5	6	Comment/justification
Culvert ref.							
Culvert length (m)	25	50					
Culvert unit rate (€/m)	2500	1800					
Total costs						€152,500	
Apply update to unit rate (CPI) if appropriate (cell N15)						€152,500	
Enter appropriate preliminaries estimate (%)						15%	
Enter other applicable costs (€)						0	
Total capital cost (€)						€175,375	
Consider amendments based on site issues/constraints (cell N16)						€175,375	
Total capital cost (€)						€175,375	

Operation and Maintenance Cost Tool

Total annual O&M costs		

Other costs

Other costs (user defined - consider the need for additional longer term or intermittent costs)		

Total PV Cost

Total PVc costs (see PVc calculator below)	€168,630	
Optimism bias rate (from external sheet)	50%	
Total Cost including Optimism Bias	€252,945	

5.3.2 Data inputs

In each summary sheet the following colour codes apply to cells within the working area:

- Cells normally requiring data entry: Orange
- Cells where data may be amended, if necessary: White
- Main calculation areas where values generated automatically: Light Green
- Titles, etc. outside main calculation areas: Blue

It should be noted that unit costs from the 'Cost Summary' sheets are not linked and need to be added by CFRAM consultants

5.3.3 Present Value cost tool inputs

For the purposes of this project a standard present value spreadsheet has been developed to allow appraisers to input basic cost information and to derive whole life costs by applying standard discount rates over the standard appraisal period. The tool automatically brings in summary costs for each of the applicable cost elements (Capital, O&M, and 'Other' costs).

This tool is provided for each method summary (to allow whole life costing for single asset types, e.g. embankments) and on a separate 'portfolio tool' that allows appraisers to input costs for a range of flood risk management methods. An example of the spreadsheet is shown in Figure 5-4.

Enabling costs (***(a)*** in Figure 5-5), if applicable, are assumed to occur in year 0. If enabling works are likely to extent to 2 or more years, users should enter these manually within the PVc table.

Whilst the user has the ability to define the year of capital costs (***(b)*** in Figure 5-5)[4], the OPW standard for the purposes of CFRAM projects is that this should be set to year 0 as it will not be known when projects will be implemented (this will only be known once prioritisation of schemes has been completed). This application has only been given for completeness and users should only change this value with the consent of the OPW for particularly larger schemes where construction may be delayed or phased.

Maintenance works are assumed to be annual starting the year after capital works. The user has the ability to enter intermittent or other costs. The 'other' costs element is linked to the cost summary, although users should enter the frequency (***(c)*** in Figure 5-5), of these costs (e.g. 1 for annual costs, 5 for 5 yearly repeat costs). These costs are repeated for the full 50 year period starting the year after the capital works are completed.

[4] Entering a value of 2 for example shifts the capital costs to year 1. Should users wish to enter a phased or multi-year construction period, this must be done manually.

Figure 5-5: Whole life cost and PVc analysis tool

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	€10,000	***(a)***
Year of capital works (year)	1	***(b)***
Capital cost (€)	€250,000.0	
Annual maintenance cost (€)	€2,500.0	
Other cost (€)	€10,000.0	
Other works frequency (years)	10	***(c)***

Key

	Information
	Calculation
	Cost input

(e)

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**	**Total PVc (€k):**		**317186**
	Cash sum	10000	250000	120000	40000	420000	**317186**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.00 ***(d)***	10000				10000.0	10000.0
1	0.962		250000			250000.0	240384.6
2	0.925			2500		2500.0	2311.4
3	0.889			2500		2500.0	2222.5
4	0.855			2500		2500.0	2137.0
5	0.822			2500		2500.0	2054.8
6	0.790			2500		2500.0	1975.8
7	0.760			2500		2500.0	1899.8
8	0.731			2500		2500.0	1826.7
9	0.703			2500		2500.0	1756.5
10	0.676			2500		2500.0	1688.9
11	0.650			2500	10000	12500.0	8119.8
12	0.625			2500		2500.0	1561.5
13	0.601			2500		2500.0	1501.4
14	0.577			2500		2500.0	1443.7
15	0.555			2500		2500.0	1388.2
16	0.534			2500		2500.0	1334.8
17	0.513			2500		2500.0	1283.4
18	0.494			2500		2500.0	1234.1
19	0.475			2500		2500.0	1186.6
20	0.456			2500		2500.0	1141.0
21	0.439			2500	10000	12500.0	5485.4
22	0.422			2500		2500.0	1054.9
23	0.406			2500		2500.0	1014.3

The tool enters the annual cash costs for the 50 year appraisal period (years 0 to 49) based on the input data. Standard discount rates (***(d)*** in Figure 5-4) are provided in the second column and total cash and Present Value costs are summed in 'totals' columns to the right. The total PV cost is summed in the upper right cell (***(e)*** in Figure 5-4). PV costs determined can then be added to the optimism bias tool to generate a total PVc including project risks.

5.4 Updating of costs

The unit rates supplied in each individual sheet are intended as a starting point for cost estimation and should be used by experienced staff with knowledge of scheme design and cost estimation. It should be noted that the costs represent common, representative types for each method and factor listed. CFRAM Consultants are required to use their professional judgement in using the unit costs, and should vary costs to take into account local requirements or conditions that are not provided for explicitly in the methods and factors.

Two options have been provided to allow CFRAM Consultants to update costs in the PVc summary sheet:

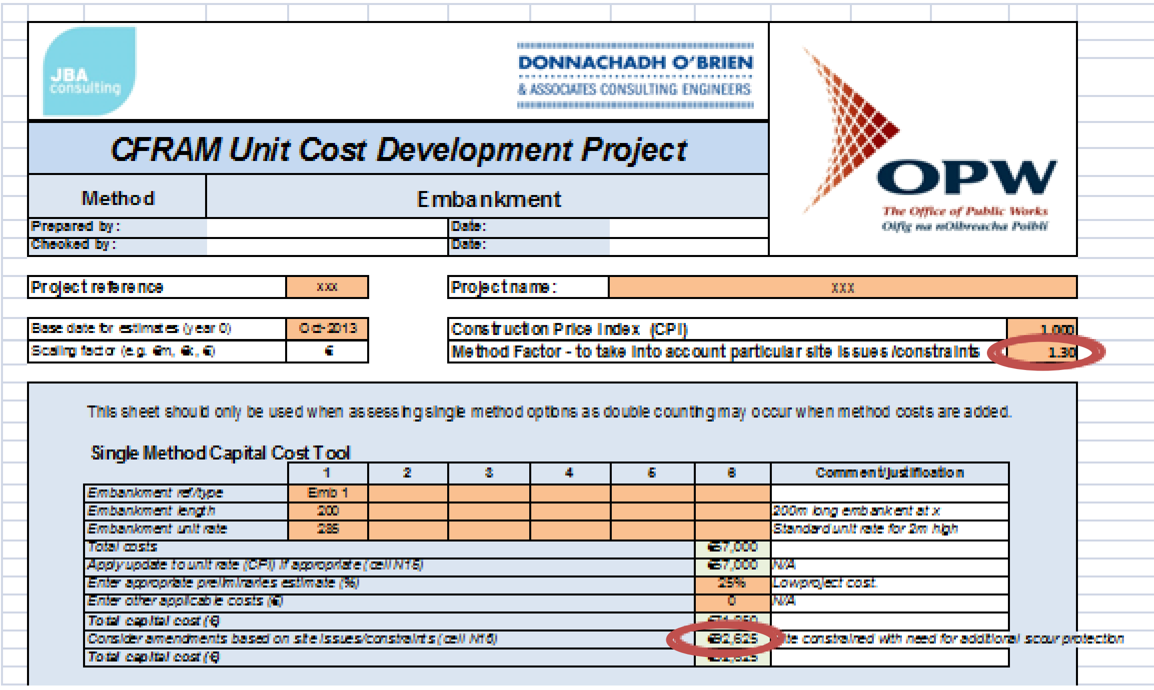
- **Construction Price Index**. This allows appraisers to update costs for future years if a rise in inflation or construction prices occurs.
- **Method factors**. This allows users to apply adjustments to the total capital cost for each method based on known and particular site issues and constraints. This is separate from the optimism bias that tries to take into account of under-predictions due to unforeseen risks in the design and construction.

Whilst method factors may be open to mistreatment and goes against the aim of the project to provide a consistent approach to costing across all CFRAM studies, the costs provided are a single cost for each method and factor that cannot necessarily cover every site and situation. The use of method factors are therefore recommended to enable CFRAM consultants to vary costs for those sites where the standard assumptions for each method and factor will not apply.

For example, a consultant requires a 200m long embankment of 2m height made from imported material with no piling (unit cost of €285 per m length). However, access is constrained and the current watercourse bank is showing signs of erosion so additional scour protection will be required. Based on this knowledge and experience, the consultant applies a 1.3 method related factor to increase the unit cost by 30% to account for these site conditions.

Factors that should be considered by consultants for each method and factor are provided in the summary sheets. Furthermore, for quality control and auditing purposes and in order to allow the OPW to review each cost estimate, consultants should provide justification on the method related factor used (see below).

Figure 5-6: Example use of method factors within PVc cost sheet



	1	2	3	4	5	6	Comment/justification
Embankment ref/type	Emb 1						
Embankment length	200						*200m long embankent at x*
Embankment unit rate	285						*Standard unit rate for 2m high*
Total costs						€57,000	
Apply update to unit rate (CPI) if appropriate (cell N15)						€57,000	*N/A*
Enter appropriate preliminaries estimate (%)						25%	*Low project cost.*
Enter other applicable costs (€)						0	*N/A*
Total capital cost (€)						[illegible]	
Consider amendments based on site issues/constraints (cell N16)						€92,625	*ite constrained with need for additional scour protection*
Total capital cost (€)						[illegible]	

5.5 Portfolio whole life cost tool

In addition to the 20 summary sheets we have provided a whole life cost tool that combines costs from different methods to help build up a total cost for a scheme. This tool allows users to enter in capital and O&M costs for each method defined as well as a user specified entry if required. Total capital costs across all methods are summed, after which users can update to current prices, enter other applicable costs and add appropriate total preliminaries costs. The Present Value calculations undertaken are then applied as per the single method cost tool. This is shown in Figure 5-7.

Figure 5-7: Portfolio tool (to gather multiple asset costs and derive a scheme PVc

Project reference			**Project name:**	
Base date for estimates (year 0)	Oct-2013		**Construction Price Index (CPI)**	**1.000**
Scaling factor (e.g. €m, €k, €)	€		**Method Factor - to take into account particular site issues /constraints**	**1.00**

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	**Cost (€)**	**Comment**
Total wall costs		
Total embankment costs		
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€0	
Apply update to unit rate (CPI) if appropriate (cell N15)	€0	
Enter appropriate preliminaries estimate (%)		
Enter other applicable costs (€)	0	
Total capital cost (€)	€0	
Consider amendments based on site issues/constraints (cell N16)	€0	
Total capital cost (€)	€0	

5.6 OPW calculation sheets

The OPW calculation sheets include the following sheets:

- A summary unit cost sheet
- A base rate sheet holding all rates used in the calculations
- Cost calculation sheets for each method/factor

5.6.1 Updating of costs

In order for the database to remain up to date and applicable, we recommend that certain factors are updated or modified. All costs are applicable to 2013 values. Updating of costs may be needed in the future once updated inflation or construction price indices are released.

The OPW may wish to update the base rates used in the analysis. This may need to be done for particular rates that could change significantly beyond normal construction price indices e.g. rebar costs, sheet piling, pre-cast culverts and fuel costs.

This can be done in the 'base rate' sheet for each of the calculation sheets. A comment specifying the reason for change should be added. Any updates to these base rates will be applied to each relevant cost sheet and relevant summary tables. Manual edits required to update the summary sheets as these are not currently linked to the summary sheets provided to CFRAM Consultants.

6 Cost validation

6.1 Methodology

In order to confirm that the unit costs provided are applicable to real-world examples a number of validation tests have been undertaken on 4 case studies in Ireland. The aim of these validation tests are to independently calculate the costs of the schemes based on initial design proposals using the unit costs and spreadsheet tools provided as part of this project.

This assessment investigates four projects that serve as acceptable surrogates for the work expected as part of any CFRAM flood relief or management scheme.

6.2 Calibration projects

The calibration projects are as follows:

- Deansgrange Flood Alleviation Scheme. Located in Clonkeen Park, South Dublin.
- Rolestown Minor Works Flood Scheme. Located in Rolestown a small village 10 km north-west of Swords in County Dublin.
- Mornington Flood Relief Scheme. Located at the downstream end of the Mornington catchment near the Boyne Estuary.
- Clonmel Drainage Scheme.

6.3 Deansgrange Flood Alleviation Scheme

The purpose of the scheme is to protect residential properties in the Monaloe Way and Little Meadow housing estates from excessive water levels, whilst retaining the public amenity function of the park. Historical flooding has occurred in this area a number of times affecting local residents, with the most severe flooding witnessed on the 24th October 2011. The proposed works include:

- The realignment of the Deansgrange Stream towards the centre of the park, which includes the construction of a wider open channel to provide additional conveyance capacity.
- Re-grading of lands to provide additional flood storage capacity.
- Construction of a section of new culvert, with associated culvert inlet and headwalls to increase inlet capacity.
- Decommission & backfilling of the existing stream channel, a section of existing culvert, headwall and screen.
- Diversion of existing stormwater drainage where required and construction of new stormwater drainage and French drain inclusive of outfalls to new channel.
- Provision of an earth embankment along the left bank of Deansgrange Stream.
- Additional landscaping, fencing, boundary works and realignment of existing cycle track and associated public lighting. Other miscellaneous works (inclusive of fencing, new footpaths, new lighting etc)

The results of the analyses, as tabulated on the Whole Life Cost Tool spreadsheet, are summarised below:

- Total Capital Cost €206,600
- Total O&M Cost (Annual) €4,707
- Total Present Value Cost €322,599
- Total PV Cost inc. Optimism Bias (40%) €451,639

This scheme was designed by JBA and JBA have been involved in the project from concept stage through to construction and completion. The project is now at substantial completion stage. .

In summary, the total sum tendered by the appointed contractors was €239,000 ex. VAT and the actual final account is balancing generally close to the tendered sum. The same figure, as calculated by the Unit Cost database, was €206,600. In general, when comparing the tendered

sums and the total costs calculated by the Unit Cost database, there is an acceptable level of agreement. This is despite large variations in some areas. For example, the appointed Contractor priced the installation of the new culvert at €19,700, significantly less than the tool at €29,700.

The spreadsheet tool lacked the ability in this instance to account for the construction of a new off-line manhole, nor the construction of a new permanent cycle-track. Thus, whilst there are many nuances and project-specific tasks that cannot be accounted for in the spreadsheets that would explain any differences in cost estimations, the overall costs seem to predict the costs well in this instance.

One must also remember that upon application of the Optimism Bias, the total cost of the project becomes €451,639. This an overly conservative figure compared to the tendered sum in this instance.

6.4 Rolestown Minor Works Flood Scheme

The site is a small development consisting of three properties and is bounded by the R125 to the north and the Rolestown Stream to the east, south and west. The Rolestown Stream diverges at the southern boundary of the site and is an artificial watercourse that has been diverted to supply a mill in the village. The proposed works include:

- A concrete spillway
- Embankment stability works
- Western Channel culvert
- New embankment
- Eastern channel spillway wall
- East Channel culvert
- Relief Stream widened
- Spillway service and paving

The results of the analyses, as tabulated on the Whole Life Cost Tool spreadsheet, are summarised below:

- Total Capital Cost €107,344
- Total O&M Cost (Annual) €2,681
- Total Present Value Cost €157,854
- Total PV Cost inc. Optimism Bias (40%) €220,996

This scheme was also designed by JBA Consulting. The OPW constructed this scheme and provided cost estimates.

The actual costs for this projects were circa €105,840. In general, when comparing the build costs (€105,840) and the total costs calculated by the Unit Cost database (€107,344), there is an acceptable level of agreement. The optimism bias adjustment provides a more conservative estimate.

One must also remember that upon application of the Optimism Bias, the total cost of the project becomes €220,996. This an overly conservative figure compared to the tendered sum in this instance.

6.5 Mornington Flood Relief Scheme

Historically, there has been a severe tidal flooding problem at the downstream end of the Mornington catchment near the Boyne Estuary. The completed works include;

- 1540m of flood protection wall
- 4600m of clay embankments
- Construction of a footbridge
- 48 sluice gates
- The underpinning of 2 bridges

- The culvert on the tributary
- Upsizing of minor culverts and the channel capacity increased
- Two minor pumping stations were constructed to alleviate internal drainage problems at the two worst affected areas
- A linear storage channel was installed at Tower Road.
- Where discharge outfalls are located at a level below that of the 1:100 year flood level flap valves were installed
- The number of surface water drainage outlets through the flood defence structures were be minimised by the connection of outlets to a main interceptor pipeline which would discharge at one point
- Temporary river gauge was installed on the Mornington River to help verify the hydrological analysis

The results of the analyses, as tabulated on the Whole Life Cost Tool spreadsheet, are summarised below:

- Total Capital Cost €3,516,971
- Total O&M Cost (Annual) €38,102
- Total Present Value Cost €4,158,219
- Total PV Cost inc. Optimism Bias (40%) €5,821,507

The OPW provided scheme and actual build cost details for this project. The estimated build cost of the project is circa €3,974,343

In summary, the cost to date is €3,974,343. The same figure, as calculated by the Unit Cost database, was €3,516,971 providing confidence in the unit costs used for such a complex scheme. Despite this similarity in total costs, there are many nuances and project-specific tasks that cannot be accounted for in the spreadsheets that explain some of the internal differences for certain asset types. For example, the spreadsheets cannot account for the drainage system in the project and a lack of information regarding the pumping stations, the storage channel and the culvert replacements.

One must also remember that upon application of the Optimism Bias, the total cost of the project becomes €5,821,507. This an overly conservative figure compared to the final cost.

6.6 Clonmel Drainage Scheme

The Clonmel Drainage Scheme was designed to protect the town of Clonmel from flooding from the River Suir, the Whitening Stream and the Auk Streams. A number of works were included as part of the 3 projects including:

- Dredging and widening of the channel
- Construction of a town bypass channel
- Upstream storage
- A channel bypass around Dudley's Mills
- A fully defended urban area
- Replace masonry arch bridges at Old Bridge
- Demountable barriers
- Embankments
- Sheet piled walls
- Rock ramp fish-pass

The results of the analyses, as tabulated on the Whole Life Cost Tool spreadsheet, are summarised below:

- Total Capital Cost €32,232,000
- Total O&M Cost (Annual) €253,105
- Total Present Value Cost €30,922,308
- Total PV Cost inc. Optimism Bias (45%) €44,938,846

The OPW provided scheme and actual build cost details for this project. The estimated build cost of the project is circa €40,000,000

In general, when comparing the final cost of the project and the costs calculated by the Unit Cost Database, there is an acceptable level of agreement with an inclusion of the optimism bias. The estimated cost of the project is €40,000,000. The same figure, as calculated by the Unit Cost database, was €32,232,000.

There are many nuances and project-specific tasks that cannot be accounted for in the spreadsheets that would explain any differences in estimations. For example, the spreadsheets cannot account for the drainage system in the project. Given this and the lack of information for the 3 bridges that were replaced, this explains the key reasons for the price from the database is considerably lower.

One must also remember that upon application of the Optimism Bias, the total cost of the project becomes €44,938,846. This a conservative figure compared to the final cost. Therefore, any decision with regards to project approval would be made using this figure rather than the €32,232,000 total. This demonstrates the importance of the application of the optimism bias.

6.7 Summary of calibration

The above calibration sites cover a wide range of flood protection measures included within the CFRAM unit cost project and a range of project types and spatial extents. Overall the costs derived adequately match the out-turn costs. One of the case studies underestimates the out-turn costs, but are within the optimism bias allowance for all examples, whereas the other three projects derive a similar capital cost but the inclusion of optimism bias would appear to overly estimate total project costs. Despite these variations, a consistent approach is required for CFRAM projects and the need to assess optimism bias as best as can be based on site knowledge and project requirements should be carefully considered.

7 Recommendations

7.1 Cost data and cost capture

This project has delivered cost estimates for a wide range of flood risk management methods and factors. It should be seen as a starting point to inform the CFRAM process as well as a resource that needs to be maintained and kept up to date. Key to this is the updating of the database with new data as and when this becomes available.

The recording of cost information for capital and maintenance activities is essential to ensure that data is recorded in a way that the database can be added to and updated. This will necessitate requirements for the OPW and partners to record and report on cost information in a more detailed way than is currently undertaken. Enabling this and providing procedures to allow this will help to improve cost estimation in the future.

Some cost data uniform or repeated activities should be available to inform future updates, although substantial analysis may be required for other areas where costs are harder to separate out. The collation of this information will need to be consistent with benchmarking required to check information between regions.

It is hoped that this report and cost database forms the baseline for collation of future data and updating of outturn cost information. This could be achieved by initiating procedures to collate outturn costs at the asset level and through the provision of a pro-forma for the collection of future project costs. This would help to build up a longer term database of costs that could eventually be used to update and improve the costs derived as part of this study, for benchmarking future studies and to increase the range of factors and accuracy of cost information.

It may also be worth investigating additional cost factors excluded from this analysis such as regional cost variations.

8 Glossary

The following definitions in relation to cost estimation and useful terms referred to elsewhere in this guidance are provided for completeness below.

Appraisal period – the period over which costs and benefits are assessed. This period is defined by guidance from the OPW and is normally 100 years for capital assessments.

Benefit-Cost Analysis (BCA) - Analysis that seeks to quantify all of the costs and benefits of a proposed scheme in monetary terms, including items for which the market does not provide a satisfactory monetary value. Sometimes referred to as Cost-Benefit Analysis.

Benefit-Cost Ratio (BCR) - A ratio of the present benefits and costs of an option, calculated as the total benefits divided by the total costs. A BCR of >1 indicates benefits are greater than costs.

Capital costs - Costs incurred during detailed planning, design and construction of an asset or service. Also referred to as Capital Expenditure (CAPEX).

Cost-Effectiveness Analysis (CEA) - Analysis that compares the costs of alternative ways of producing the same or similar outputs.

Design life – The design life of a new structure or structural component under normal loading and environmental conditions before replacement or major rehabilitation is expected.

Discounting - The conversion of future costs or benefits to present values using a discount rate. It is often necessary to compare options that will impact over a period of years into the future, which raises the question of how future cost and benefits should be valued in today's terms. Normally people prefer to receive cash sooner rather than later, and pay bills later rather than sooner. This is true even after allowing for inflation. For an individual this time preference may be indicated by the real interest rate on money lent or borrowed. In the public sector, likewise, we reflect social time preference by giving more weight to earlier than to later costs and benefits. This process of “discounting” is usually given effect by applying a "discount rate" to future costs and benefits.

Discount Rate - The annual percentage rate at which the present value of a future Euro, or other unit of account, is assumed to fall away through time. It is currently set at 4% pa in real terms. Mathematically, a discount rate is the opposite of a compound interest rate. The discount rate defines how rapidly the value today of a future Euro declines through time in real terms, just as a real rate of interest determines how fast the real value of a Euro invested now will increase over time.

Enabling costs - Costs those incurred between the decision to proceed with the procurement and the construction of the asset. Some of these may represent sunk costs depending on the point of appraisal within the whole life cost process.

End life costs - Costs associated with the disposal, decommissioning, termination or replacement of the asset or service. These costs can be split between replacement/refurbishment costs (where an assets standard of service is not altered) or change works (where the intention is to alter the standard of service of an asset).

Expenditure budgets - longer term revenue costs outside capital expenditure budgets.

Frequent maintenance – Activities that maintain current defence standards by reducing the rate of deterioration. Frequent maintenance provides for efficient, effective and safe operation in a cost-effective manner. It normally includes annual costs associated with planned proactive activities.

Intermittent maintenance – Infrequent and one-off activities that cover infrequent planned and recurring activities required within an assets design life.

Maintenance – Work that sustains the desired condition and intended performance of an asset. In some circumstances maintenance may accept a gradual decline in standard. For existing assets that have no residual life, maintenance may not result in an acceptable Standard of Service and only refurbishment or replacement will reinstate an acceptable Standard of Service.

Net Present Value (NPV) - The discounted value of a range of costs and benefits. Calculated as the PV benefits minus the PV costs. NPV is used to describe the difference between the

present value of costs and benefits in future years. NPV is a primary investment decision criterion. NPV is defined as the difference between the present value of a stream of benefits and that of a stream of costs. A positive NPV occurs when the sum of the discounted benefits exceeds the sum of the discounted costs. A negative NPV is usually called a Net Present Cost (NPC). The decision rule is to select the option that offers to maximise NPV, or minimise NPC. This is subject to assessment of those impacts that cannot be valued in money terms. NPV takes account not only of social time preference through discounting, but also, by combining capital and recurrent cost and benefits into a single present day value indicator, enables direct comparison of options with very different patterns of costs and benefits over time.

Operational costs - The costs incurred through the day-to-day management of an operation, and maintenance of an asset or a scheme. (Also known as revenue costs or Operational Expenditure - OPEX). See also Expenditure Budgets.

Optimism Bias - The demonstrated systematic tendency for appraisers to be over-optimistic about key project parameters, including capital costs, operating costs, works duration and benefits delivery.

Present Value - The present day value of a future stream of costs or benefits. Calculated by discounting a stream of future costs or benefits. (See also Net Present Value, Discount Rate).

Price Index - A measure of the amount by which prices change over time. General price indices cover a wide range of prices and include the Consumer Price Index (CPI) and the Retail Price Index (RPI).

Residual life – Residual life is the time until assets need replacing. Residual life can be extended or reduced by altering maintenance practices. The point at which the asset requires replacement may be estimated by a condition grade or performance measures that reflect an unacceptable Standard of Service.

Risk Register / Risk log - A useful tool to identify, quantify and value the risks and uncertainties relating to a proposal.

Sensitivity Analysis - Analysis of the effects on an appraisal outcome of varying the projected values of important variables.

Sunk Costs - Expenditures that have already been incurred on goods and services, or resources that are already irrevocably committed. These costs should be ignored in an appraisal. Sunk costs may include items such as previous investment in defences and expenditure on feasibility studies.

Unit rates - The cost per unit measure (number/length/area/volume) to replace an asset or part of an asset.

Whole life cost – The total cost of managing an asset over the design life of the asset. This will include the full cost of construction, use, maintenance and replacement/decommission. All reasonably foreseeable costs over the whole life period should be included.

A Example costs

A.1 Single asset whole life cost example

A.1.1 Example of option

A single pumping station is proposed in an urban area to pump water backing up within a small watercourse over an existing embankment in a tidal location when water levels are high. The pump capacity required from modelling is $2m^3/s$.

A.1.2 Capital costs

Based on the unit rate cost curve provided the anticipated capital costs are €1,620,000. Due to the urban location, existing services and construction through the embankment a method factor of 1.2 is recommended by the appraiser as an uplift to the basic unit cost.

An estimate of preliminaries of 16% is assumed.

Other costs for the replacement of the embankment for a 2m height and 40m length is also assumed at a unit rate of €301/m.

Based on the above a total capital cost of €2,269,500 is assumed.

A.1.3 O&M and other costs

Standard unit rates for operation and maintenance and running costs are applied.

Other costs assume a 25 year pumping station replacement cost of €900,000.

Figure A-1: Example of cost inputs

Project reference	Example 1		**Project name:**	Example Project Name x
Base date for estimates (year 0)	Oct-2013		**Construction Price Index (CPI)**	**1.000**
Scaling factor (e.g. €m, €k, €)	€		**Method Factor - to take into account particular site issues /constraints**	**1.20**

This sheet should only be used when assessing single method options as double counting may occur when method costs are added.

Single Method Capital Cost Tool

	1	2	3	4	5	6	Comment/justification
Pumping Station ref/type	Ref 1						
Pumping Station number	1						*Single 2m3/s pump*
Pumping Station unit rate	1620000						*Rate based on existing cost curve*
Total costs						€1,620,000	
Apply update to unit rate (CPI) if appropriate (cell N15)						€1,620,000	
Enter appropriate preliminaries estimate (%)						16%	
Enter other applicable costs (€)						12040	*Embankment replacement*
Total capital cost (€)						€1,891,240	
Consider amendments based on site issues/constraints (cell N16)						€2,269,488	*Urban site with existing services*
Total capital cost (€)						€2,269,488	

Operation and Maintenance Cost Tool

Total annual O&M costs	€10,600	*Basic cost from cost curve*
Total annual running costs	€18,600	*Basic cost from cost curve*

Other costs

Other costs (user defined - consider the need for additional longer term or intermittent costs)	€900,000	*Refurbishment costs at year 25*

A.1.4 Whole life cost assumptions

Enabling costs assume £100,000 for additional design, consultant, administration and land consultation fees that have not been included within the capital costs and are not yet been incurred as part of the CFRAM process.

The year of capital works is assumed to be year 1, with enabling costs in year 0.

Other works (refurbishment costs) are assumed at a 25 year interval.

The total PVc is assumed to be €3,202,000, exclusive of optimism bias.

Figure A-2: Example of present value cost inputs and calculations

Whole life cost and PVc analysis - for Pumping Station

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	£100,000.0
Year of capital works (year)	1
Capital cost (€)	£2,269,488.0
Annual maintenance cost (€)	£29,200.0
Other cost (€)	£900,000.0
Other works frequency (years)	25

Key

	Information
	Calculation
	Cost input

Discount rate:	**4.0%**	**Present Value Factor:**		**22.341**	**Total PVc (£k):**		**3201914**
	Cash sum	100000	2269488	1401600	900000	4671088	**3201914**
	Discount	**Cost Elements**				**TOTALS:**	
year	**Factor**	**Enabling**	**Capital**	**Maint.**	**Other**	**Cash**	**PV**
0	1.000	100000				100000.0	100000.0
1	0.962		2269488			2269488.0	2182200.0
2	0.925			29200		29200.0	26997.0
3	0.889			29200		29200.0	25958.7
4	0.855			29200		29200.0	24960.3
5	0.822			29200		29200.0	24000.3
6	0.790			29200		29200.0	23077.2
7	0.760			29200		29200.0	22189.6
8	0.731			29200		29200.0	21336.2
9	0.703			29200		29200.0	20515.5
10	0.676			29200		29200.0	19726.5
11	0.650			29200		29200.0	18967.8
12	0.625			29200		29200.0	18238.2
13	0.601			29200		29200.0	17536.8
14	0.577			29200		29200.0	16862.3
15	0.555			29200		29200.0	16213.7
16	0.534			29200		29200.0	15590.1
17	0.513			29200		29200.0	14990.5
18	0.494			29200		29200.0	14413.9
19	0.475			29200		29200.0	13859.6
20	0.456			29200		29200.0	13326.5
21	0.439			29200		29200.0	12813.9
22	0.422			29200		29200.0	12321.1
23	0.406			29200		29200.0	11847.2
24	0.390			29200		29200.0	11391.5
25	0.375			29200		29200.0	10953.4
26	0.361			29200	900000	929200.0	335152.4
27	0.347			29200		29200.0	10127.0
28	0.333			29200		29200.0	9737.5
29	0.321			29200		29200.0	9363.0
30	0.308			29200		29200.0	9002.9
31	0.296			29200		29200.0	8656.6
32	0.285			29200		29200.0	8323.7
33	0.274			29200		29200.0	8003.5
34	0.264			29200		29200.0	7695.7
35	0.253			29200		29200.0	7399.7
36	0.244			29200		29200.0	7115.1
37	0.234			29200		29200.0	6841.5
38	0.225			29200		29200.0	6578.3
39	0.217			29200		29200.0	6325.3
40	0.208			29200		29200.0	6082.0
41	0.200			29200		29200.0	5848.1
42	0.193			29200		29200.0	5623.2
43	0.185			29200		29200.0	5406.9
44	0.178			29200		29200.0	5199.0
45	0.171			29200		29200.0	4999.0
46	0.165			29200		29200.0	4806.7
47	0.158			29200		29200.0	4621.9
48	0.152			29200		29200.0	4444.1
49	0.146			29200		29200.0	4273.2

A.2 Multiple asset whole life cost example

A.2.5 Example of option

The same option as above is assumed, although further investigation has indicated that the embankment is no longer suitable and a new embankment needs to be constructed. The required additional embankment is 3m in height for a length of 80m with a lower section of 2m in height for a length of 200m. Two headwall outlet structures (600mm) with flap valves are also required.

A.2.6 Capital costs

The pumping station costs are the same as in the previous example - €1,620,000. The embankment is made up the following unit costs:

- 80m with a unit rate of €539/m
- 200m with a unit rate of €516/m
- The appraiser also allows for a unit rate of €50/m for the removal of the existing embankment.

The total embankment cost is therefore €160,300.

The headwall structure with flap valves with a unit cost of €9,750 are taken from the sluice gate summary sheet.

The total costs for each asset are added to the portfolio tool to estimate total capital costs as shown below.

Figure A-3: Example of cost inputs

Project reference	Example 1
Base date for estimates (year 0)	Oct-2013
Scaling factor (e.g. €m, €k, €)	€

Project name:	Example Project Name x
Construction Price Index (CPI)	1.000
Method Factor - to take into account particular site issues /constraints	1.20

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	**Cost (€)**	**Comment**
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	**Cost (€)**	**Comment**
Total wall costs		
Total embankment costs	160300	*2 sections of embankent plus removal of existing*
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs	19500	*2 600mm headwall structures with flap valves*
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs	1620000	*2m3/s pumping station*
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€1,799,800	
Apply update to unit rate (CPI) if appropriate (cell N15)	€1,799,800	
Enter appropriate preliminaries estimate (%)	16%	*Based on preliminaries cost curve*
Enter other applicable costs (€)	0	*None assumed*
Total capital cost (€)	€2,087,768	
Consider amendments based on site issues/constraints (cell N16)	€2,505,322	*Uplift for urban area and existing services*
Total capital cost (€)	€2,505,322	

Due to the urban location and existing services a method factor of 1.2 is recommended by the appraiser as an uplift to the basic unit costs.

An estimate of preliminaries of 16% is assumed.

Based on the above a total capital cost of €2,505,300 is assumed.

A.2.7 O&M and other costs

O&M costs assume the following:

- Standard pumping station unit rates for O&M and running costs (€29,200 per annum)
- Other costs assume a 25 year pumping station replacement cost of €900,000
- Embankment O&M costs (€2,725/km, or €763 per annum)
- Sluice gate O&M costs of €2,700 per gate per annum

Figure A-4: Example of O&M cost inputs

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs		
Total embankment O&M costs	763	280m length of embankment
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs	5400	2 No. sluice gates in urban area
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs	29200	O&M and running costs
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€35,363	

A.2.8 Whole life cost assumptions

Enabling costs assume £120,000 for additional design, consultant, administration and land consultation fees that have not been included within the capital costs and are not yet been incurred as part of the CFRAM process.

The year of capital works is assumed to be year 1, with enabling costs in year 0.

Other works (refurbishment costs) are assumed at a 25 year interval.

The total PVc is assumed to be €3,574,000, exclusive of optimism bias.

Figure A-5: Example of present value cost inputs and calculations

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	€120,000
Year of capital works (year)	1
Capital cost (€)	€2,505,321.6
Annual maintenance cost (€)	€35,363.0
Other cost (€)	€900,000.0
Other works frequency (years)	25

Key

	Information
	Calculation
	Cost input

Discount rate:	4.0%	Present Value Factor:		22.341		Total PVc (€k):	3574279
	Cash sum	120000	2505322	1697424	900000	5222746	3574279
	Discount	Cost Elements				TOTALS:	
year	Factor	Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	120000				120000.0	120000.0
1	0.962		2505322			2505321.6	2408963.1
2	0.925			35363		35363.0	32695.1
3	0.889			35363		35363.0	31437.6
4	0.855			35363		35363.0	30228.4
5	0.822			35363		35363.0	29065.8
6	0.790			35363		35363.0	27947.9
7	0.760			35363		35363.0	26873.0
8	0.731			35363		35363.0	25839.4
9	0.703			35363		35363.0	24845.6
10	0.676			35363		35363.0	23890.0
11	0.650			35363		35363.0	22971.1
12	0.625			35363		35363.0	22087.6
13	0.601			35363		35363.0	21238.1
14	0.577			35363		35363.0	20421.3
15	0.555			35363		35363.0	19635.8
16	0.534			35363		35363.0	18880.6
17	0.513			35363		35363.0	18154.4
18	0.494			35363		35363.0	17456.2
19	0.475			35363		35363.0	16784.8
20	0.456			35363		35363.0	16139.2
21	0.439			35363		35363.0	15518.5
22	0.422			35363		35363.0	14921.6
23	0.406			35363		35363.0	14347.7
24	0.390			35363		35363.0	13795.9
25	0.375			35363		35363.0	13265.3
26	0.361			35363	900000	935363.0	337375.4
27	0.347			35363		35363.0	12264.5
28	0.333			35363		35363.0	11792.8
29	0.321			35363		35363.0	11339.2
30	0.308			35363		35363.0	10903.1
31	0.296			35363		35363.0	10483.7
32	0.285			35363		35363.0	10080.5
33	0.274			35363		35363.0	9692.8
34	0.264			35363		35363.0	9320.0
35	0.253			35363		35363.0	8961.5
36	0.244			35363		35363.0	8616.9
37	0.234			35363		35363.0	8285.4
38	0.225			35363		35363.0	7966.8
39	0.217			35363		35363.0	7660.4
40	0.208			35363		35363.0	7365.7
41	0.200			35363		35363.0	7082.4
42	0.193			35363		35363.0	6810.0
43	0.185			35363		35363.0	6548.1
44	0.178			35363		35363.0	6296.3
45	0.171			35363		35363.0	6054.1
46	0.165			35363		35363.0	5821.2
47	0.158			35363		35363.0	5597.3
48	0.152			35363		35363.0	5382.1
49	0.146			35363		35363.0	5175.1

A.3 Optimism Bias example

Risks for the above project have been assessed and noted within the Optimism Bias calculator. For each risk component a risk value (from Very High to Very Low) has been defined with additional user remarks made. These are completely theoretical for this above case study but aim to give CFRAM consultants an indication of the level of detail required.

Based on the assumptions applied for each risk component an optimism bias of 46% is recommended for this scheme.

Figure A-6: Example Optimism Bias calculator

CFRAM Unit Cost Development Project

Optimism Bias Calculator

Prepared by:	AEP	**Date:**	December 2013
Site Reference:	Example 1	**Site Name:**	Example Project Name x

Project risk components that influence total project cost	Weight 1-3 (3 being a higher weight)	Risk value (0-100%) 0% = no risk 100% = risk expected and not mitigated		User remarks/comments/justification
Procurement				
Complexity of Contract Structure	1	High	70%	Contract structure unknown at present - high defined for this reason
Late Contractor Involvement in Design	2	High	70%	Possible risk
Poor Contractor Capabilities	1	Medium	50%	Pumping station design required experienced engineering and conctract team
Government Guidelines	1	Very Low	10%	Not anticipated to alter
Dispute & Claims Occurred	3	Medium	50%	Too early to tell
Information Management	1	Very Low	10%	Not anticipated to alter risk
Budgetting	2	High	70%	Mutliple schemes from CFRAM identified in area - budgetting risk
Other	1	Medium	50%	No other risks identified
Project Specific				
Design Complexity	2	High	70%	Complex design
Degree of Innovation	2	Medium	50%	No complex innovation required at present
Technology	2	Low	30%	Not anticipated to be a key risk
Services	3	High	70%	Urban area - high risk
Ground conditions	3	High	70%	Unknown at present - assume high risk until additional GI undertaken
Other	1	Medium	50%	No other risks identified
Client Specification				
Inadequacy of the Business Case	3	Medium	50%	Not anticipated at this time
Large No. of Stakeholders	2	Medium	50%	Medium risk
Funding Availability	2	High	70%	Mutliple schemes from CFRAM identified in area - funding risk is high
Project Management Team	1	High	70%	Large pumping station requires experience
Poor Project Intelligence	2	Very High	90%	Additional surveys required to reduce this aspect
Other	1	Medium	50%	No other risks identified
Environment				
Public Relations	2	High	70%	Urban area
Site Characteristics	2	High	70%	Urban area
Environmental Impact	3	Medium	50%	Average risk
Permits / Consents / Approvals	2	Medium	50%	CFRAM environmental scoping indicates possible risks with mitigation measures possible
Amenity and art	1	High	70%	Urban area and large pump building required - amenity value needs to be considered
Contaminated land	3	High	70%	Unknown - set at high until investigations can reduce this
Archaeology	3	High	70%	Unknown - set at high until investigations can reduce this
Other	1	Medium	50%	No other risks identified
External Influences				
Political	3	Medium	50%	Unknown - set at medium risk for now
Economic	2	Medium	50%	Unknown - set at medium risk for now
Legislation / Regulations	1	Medium	50%	Unknown - set at medium risk for now
Multiple river users / stakeholders	2	High	70%	Urban site with multiple interested parties
Flood events during construction	3	High	70%	Yes - possible risk even with temporary works
Other	1	Medium	50%	No other risks identified
	65		57%	

		Minimum Optimism Bias:	10%
		Maximum Optimism Bias:	70%
Weighting to apply:	**0.592**	**Calculated Optimism bias:**	**46%**

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JBA Consulting Engineers
and Scientists Limited

Registration number 444752

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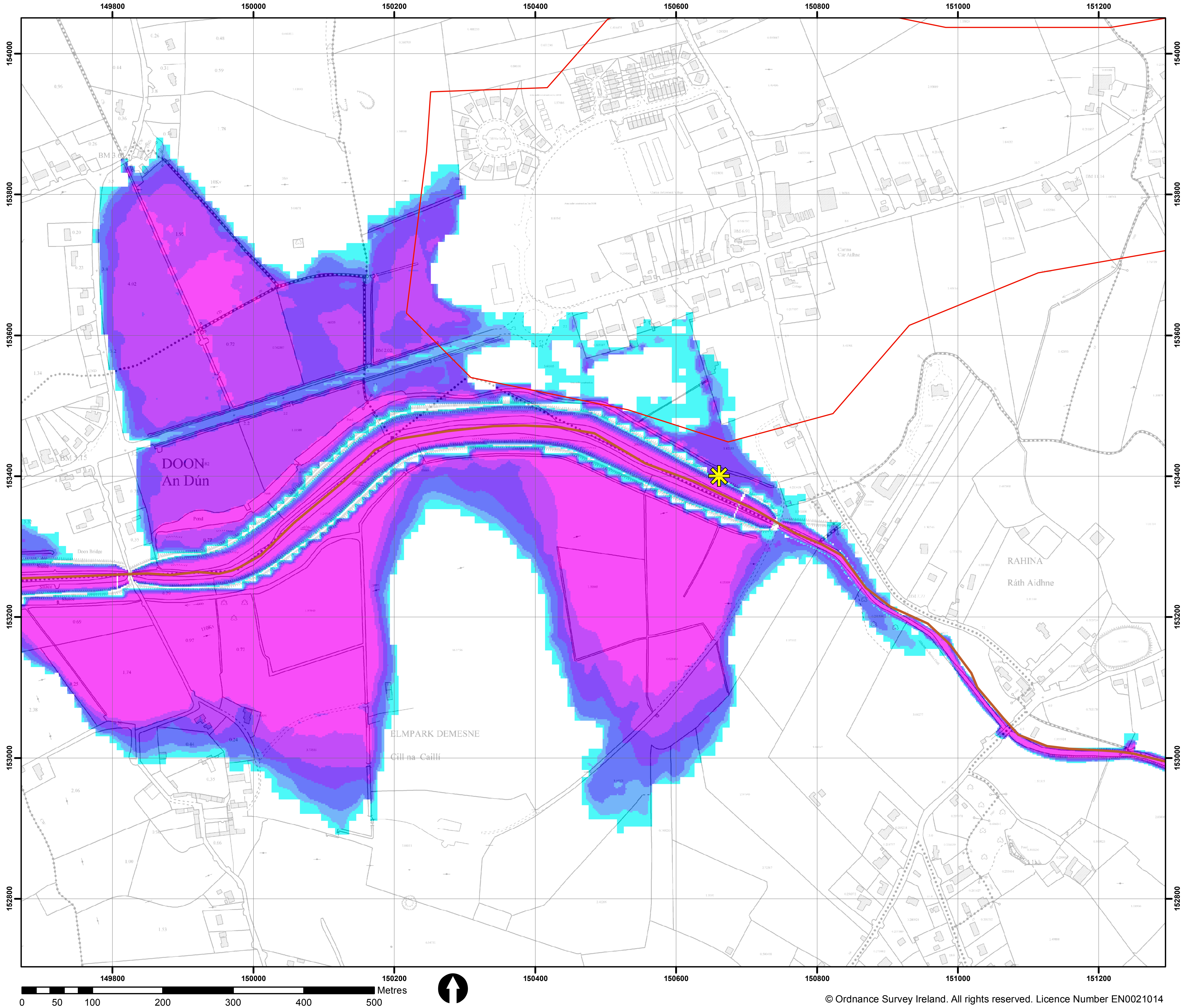
Appendix I Flood Defence Asset Failure Maps



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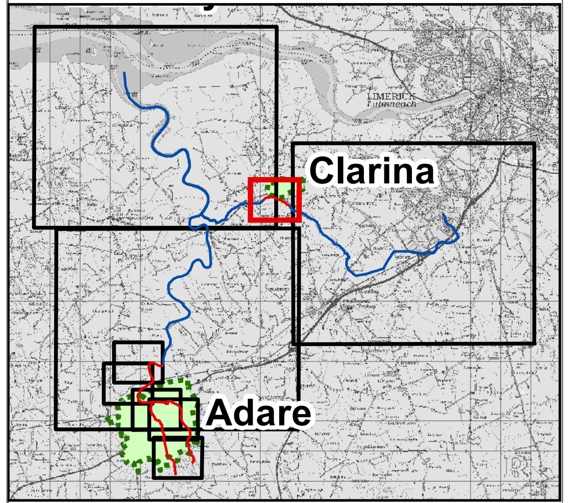

Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

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Trim
Co. Meath

Merrion House
Merrion Road
Dublin

Project:
SHANNON CFRAM STUDY

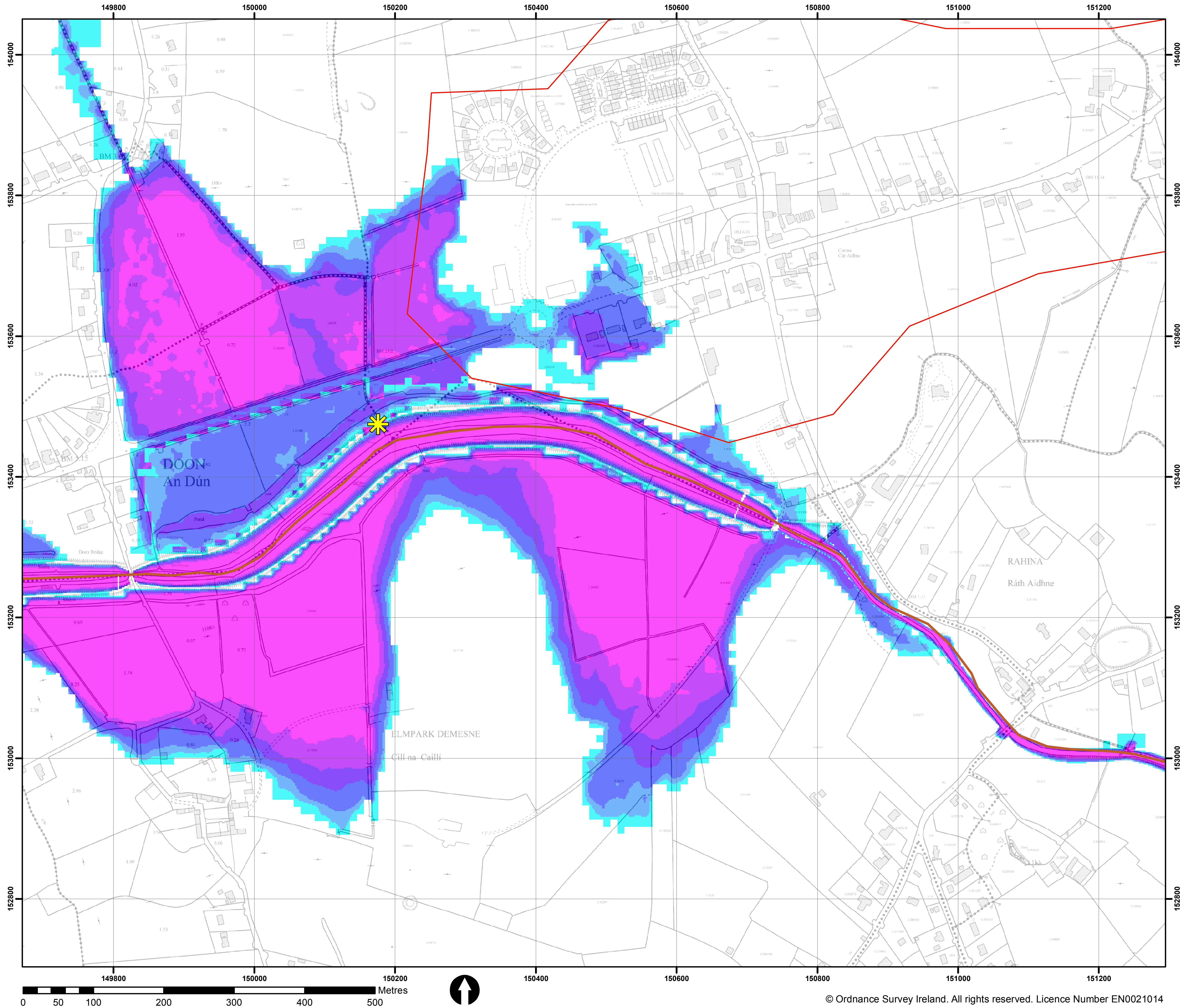
Map: CLARINA

Map Type: DEFENCE FAILURE EXTENT MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: CLARINA
Scenario: EXISTING

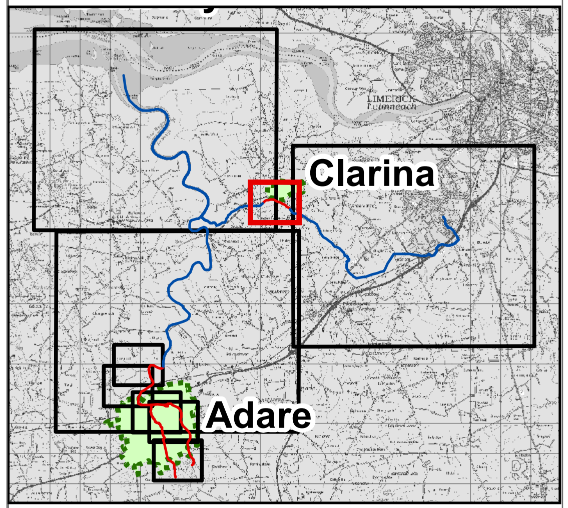
Drawn by: EH	Date: December 2015
Checked by: PT	Date: December 2015
Reviewed by: MC	Date: December 2015
Approved by: PS	Date: December 2015

Map No.:
S06FDCCDC1

Sheet: 8 of 9 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 2 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

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Project:
SHANNON CFRAM STUDY

Map: CLARINA

Map Type: DEFENCE FAILURE DEPTH MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: CLARINA
Scenario: EXISTING

Drawn by: EH	Date: December 2015
Checked by: PT	Date: December 2015
Reviewed by: MC	Date: December 2015
Approved by: PS	Date: December 2015

Map No.:
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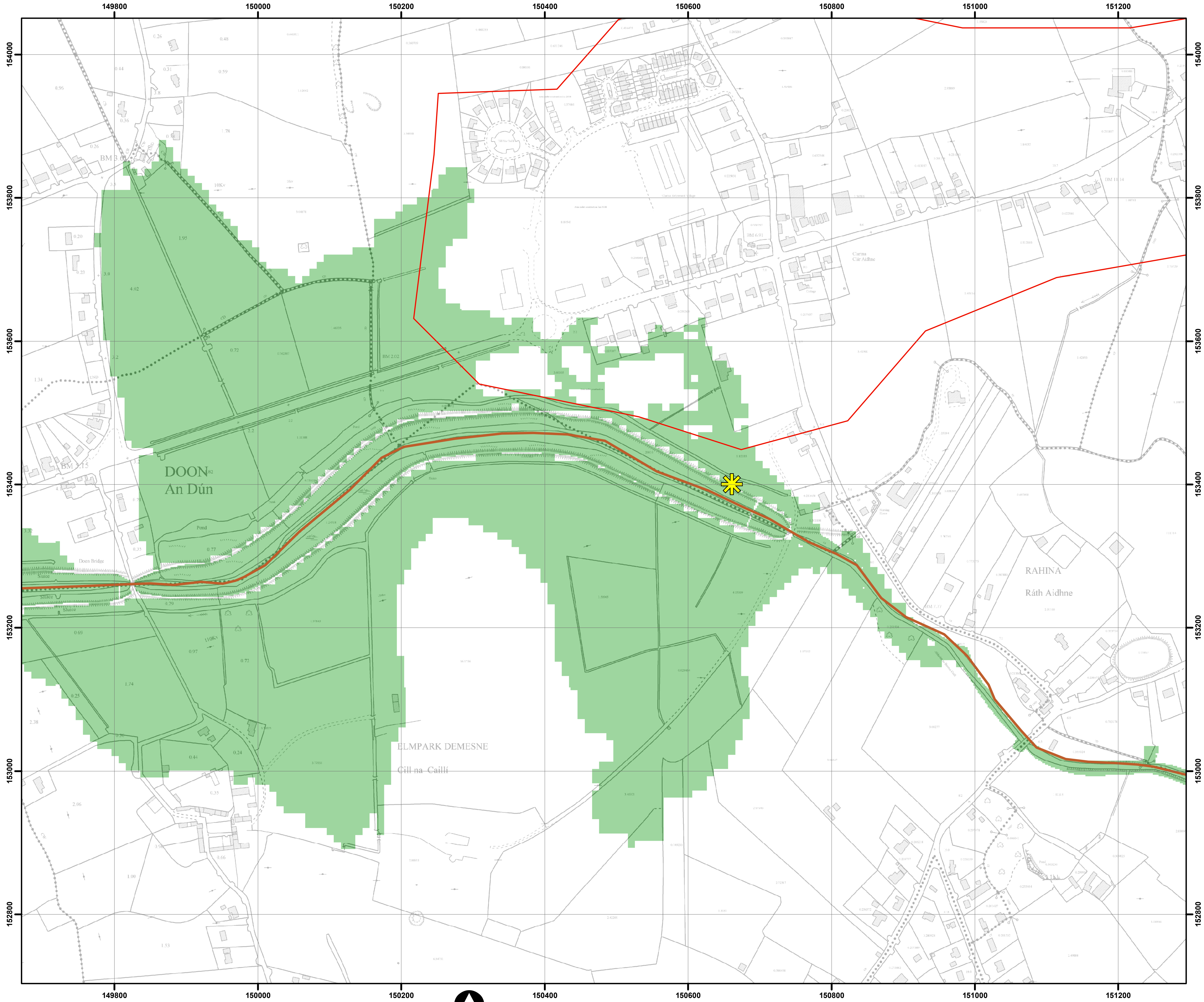
Sheet: 8 of 9 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



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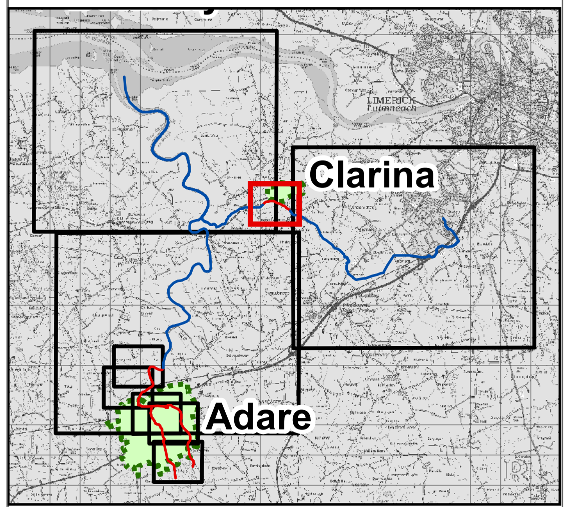
Location Plan:



Legend:

- River Centreline
- AFA Boundary
- Defence - Embankment
- Defence Failure Location
- 0.5% AEP Coastal Failure Scenario 1

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Project:
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Map: CLARINA

Map Type: DEFENCE FAILURE EXTENT MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: CLARINA
Scenario: EXISTING

Drawn by: EH	Date: December 2015
Checked by: PT	Date: December 2015
Reviewed by: MC	Date: December 2015
Approved by: PS	Date: December 2015

Map No.:
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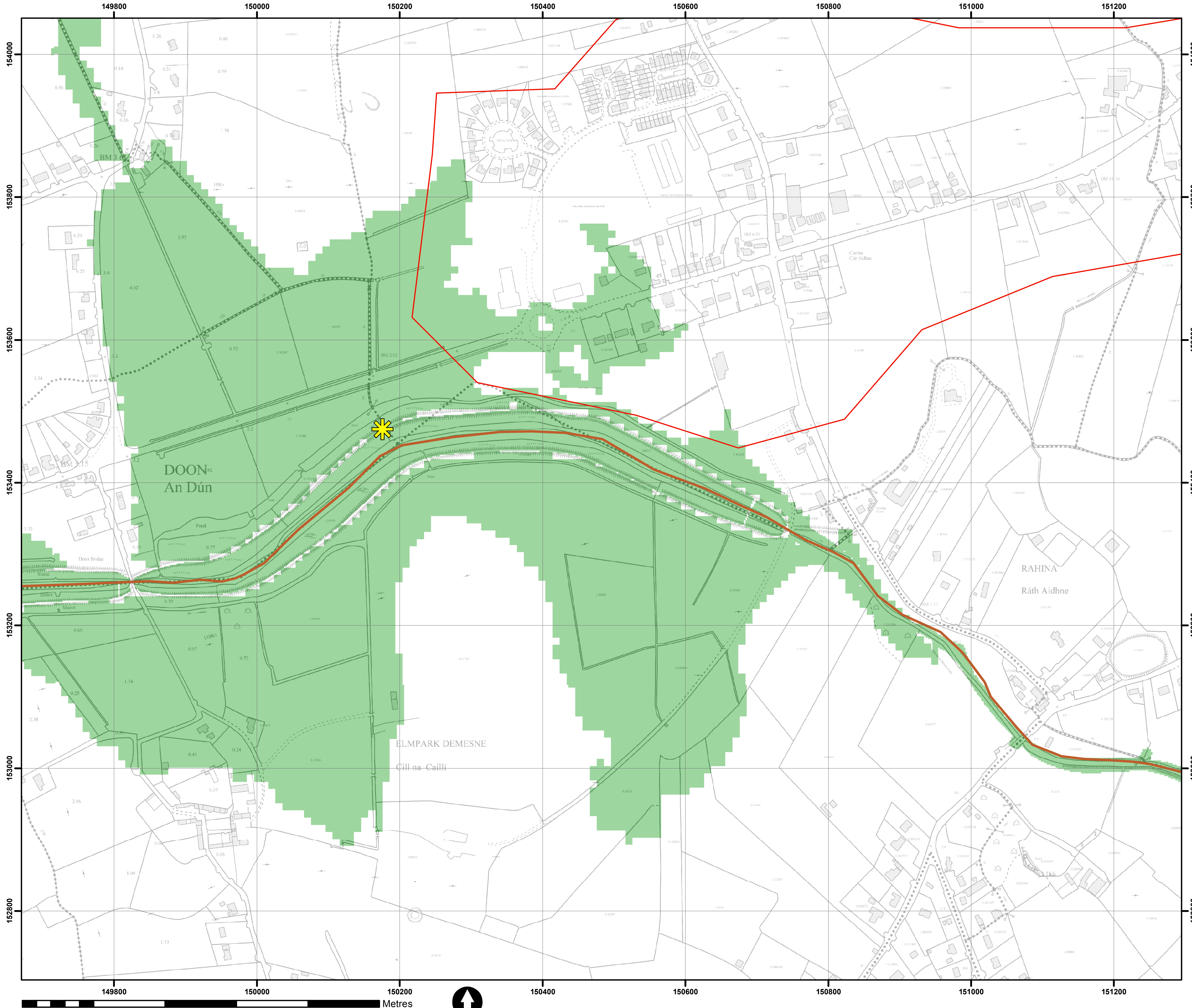
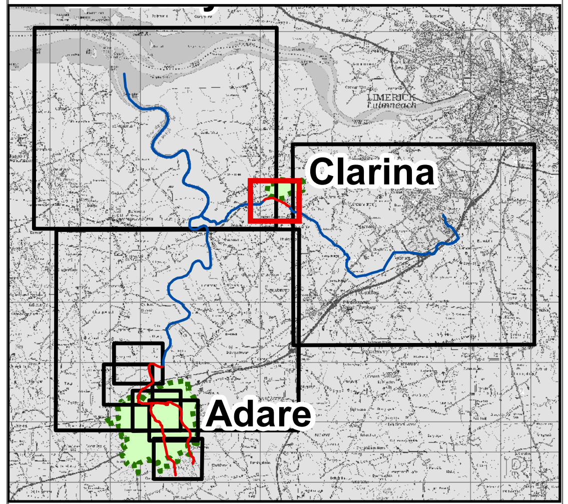
Sheet: 8 of 9 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



0 50 100 200 300 400 500 Metres

Location Plan:



Legend:

- River Centreline
- AFA Boundary
- Defence - Embankment
- Defence Failure Location
- 0.5% AEP Coastal Failure Scenario 2

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Project:
SHANNON CFRAM STUDY

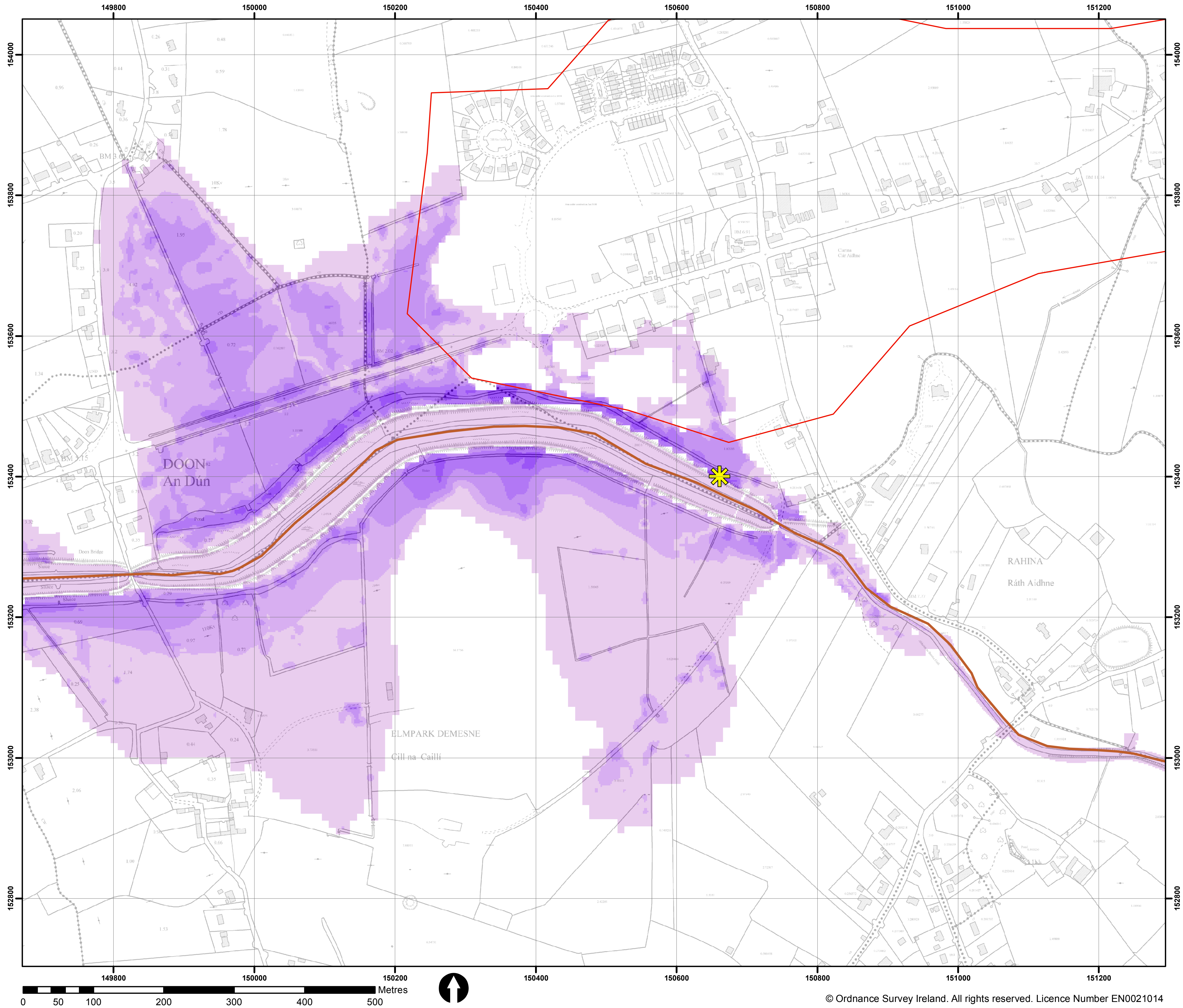
Map: CLARINA

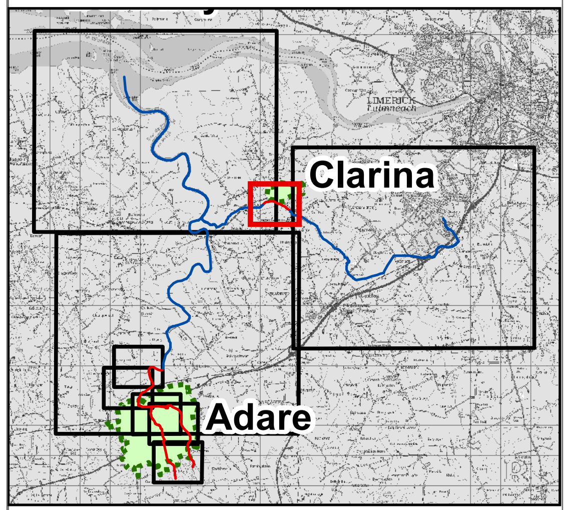
Map Type: DEFENCE FAILURE EXTENT MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: CLARINA
Scenario: EXISTING

Drawn by: EH	Date: December 2015
Checked by: PT	Date: December 2015
Reviewed by: MC	Date: December 2015
Approved by: PS	Date: December 2015

Map No.:
S06FECCDC1

Sheet: 8 of 9 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3





Location Plan:

Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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Project:
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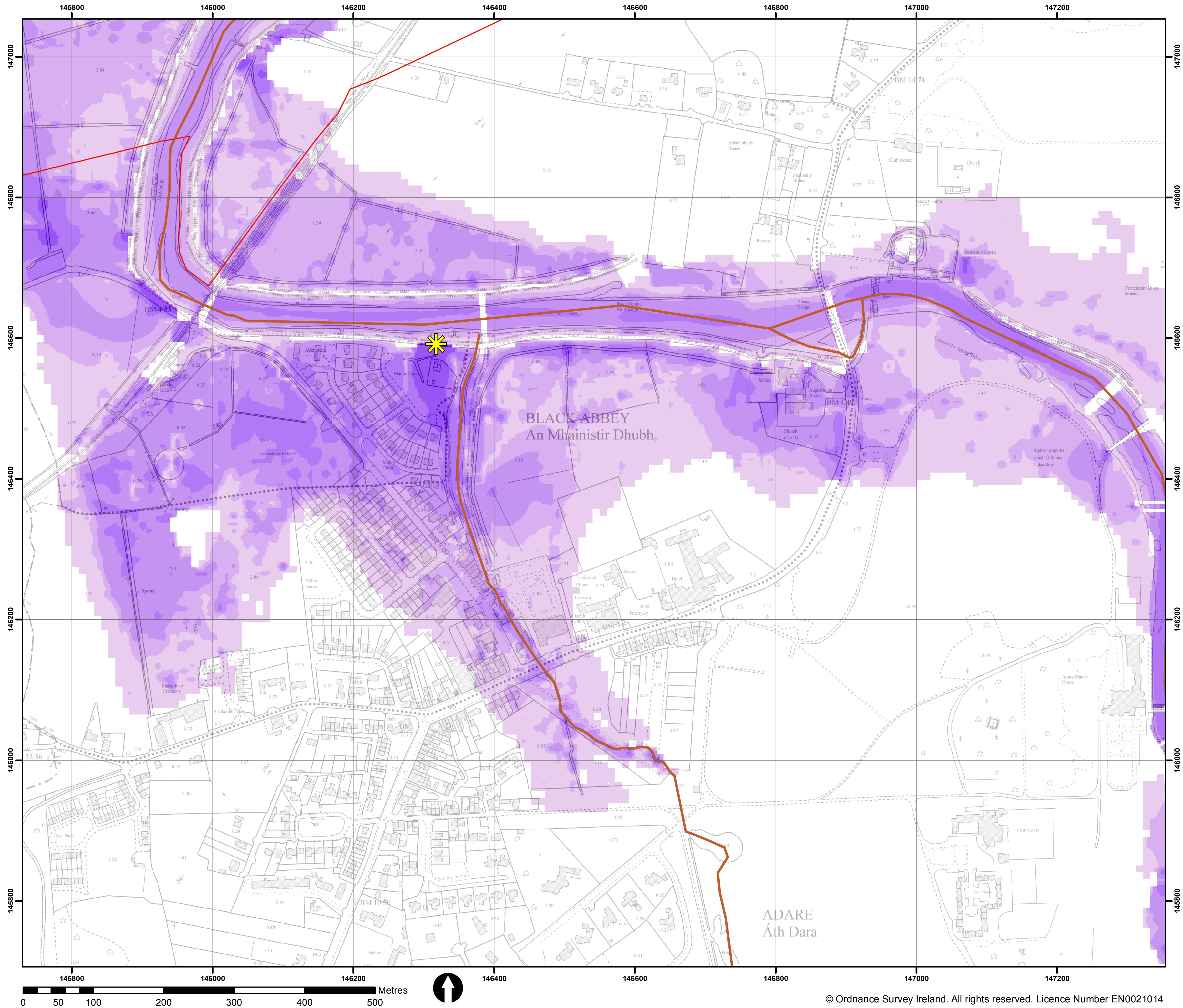
Map: CLARINA

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: CLARINA
Scenario: EXISTING

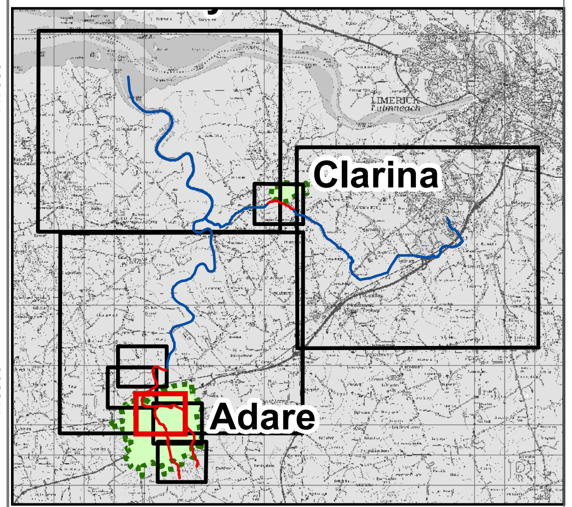
Drawn by: EH	Date: December 2015
Checked by: PT	Date: December 2015
Reviewed by: MC	Date: December 2015
Approved by: PS	Date: December 2015

Map No.:
S06FVCCDC1

Sheet: 8 of 9 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 2 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

IMPORTANT USER NOTE:

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Project:
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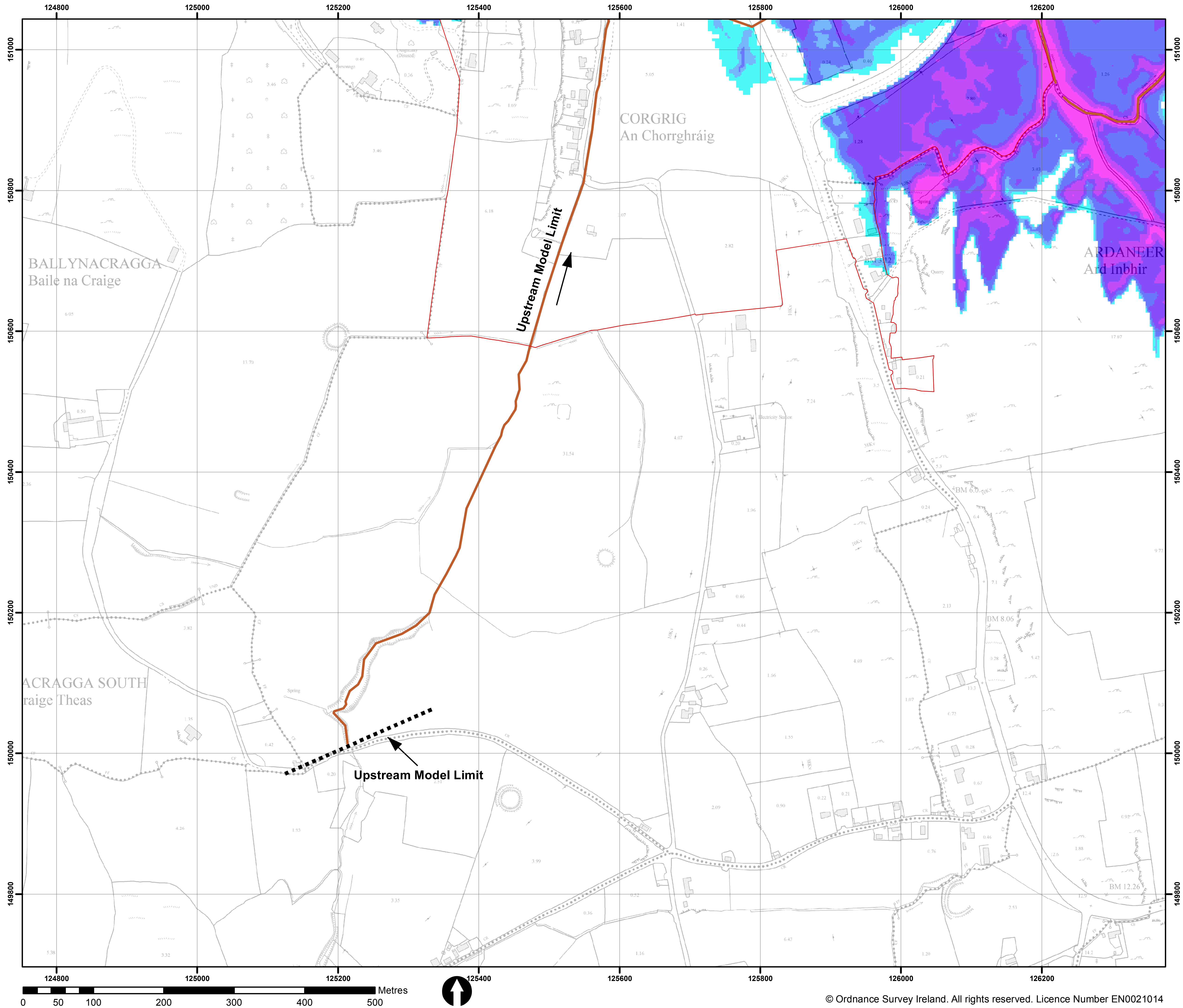
Map: CLARINA

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: CLARINA
Scenario: EXISTING

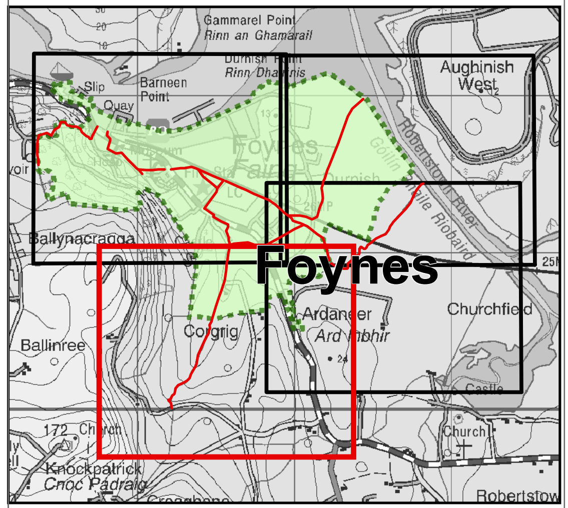
Drawn by: EH	Date: December 2015
Checked by: PT	Date: December 2015
Reviewed by: MC	Date: December 2015
Approved by: PS	Date: December 2015

Map No.:
S06FVCCDC1

Sheet: 3 of 9 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

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Project:
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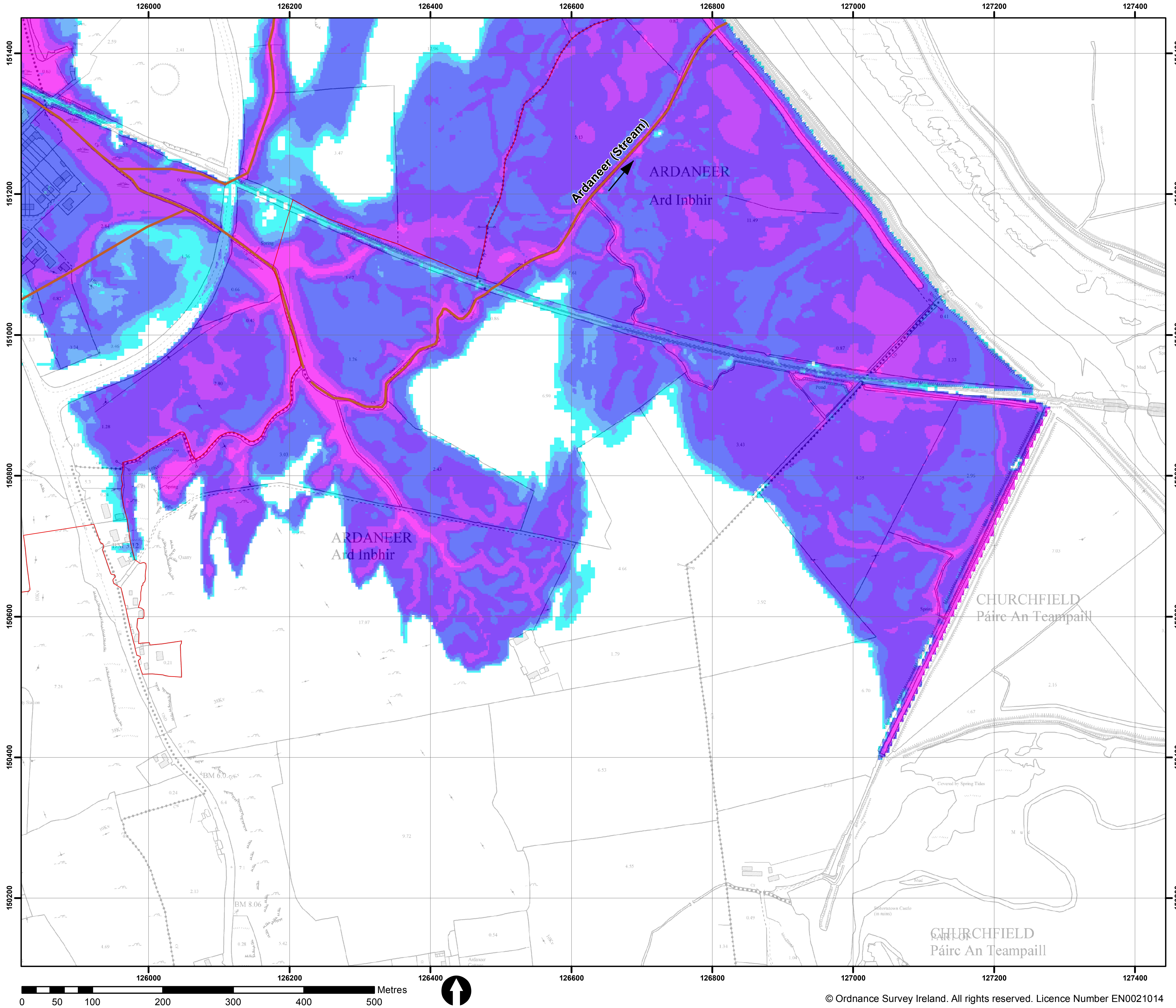
Map: FOYNES

Map Type: DEFENCE FAILURE DEPTH MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: FOYNES
Scenario: EXISTING

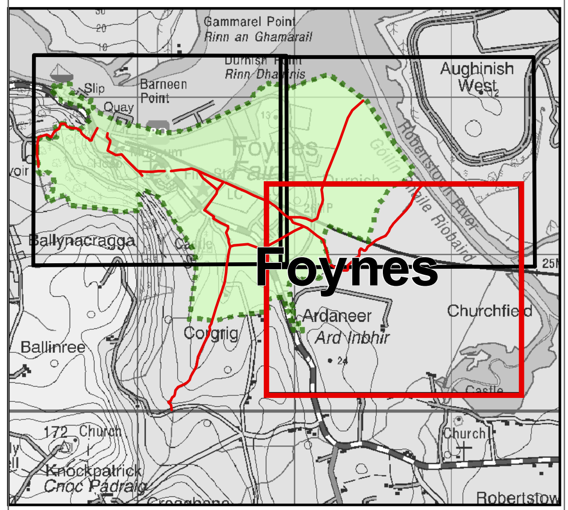
Drawn by:	EH	Date: December 2015
Checked by:	PT	Date: December 2015
Reviewed by:	MC	Date: December 2015
Approved by:	PS	Date: December 2015

Map No.:
S09FDCCDC1

Sheet: 1 of 4 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

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Project:
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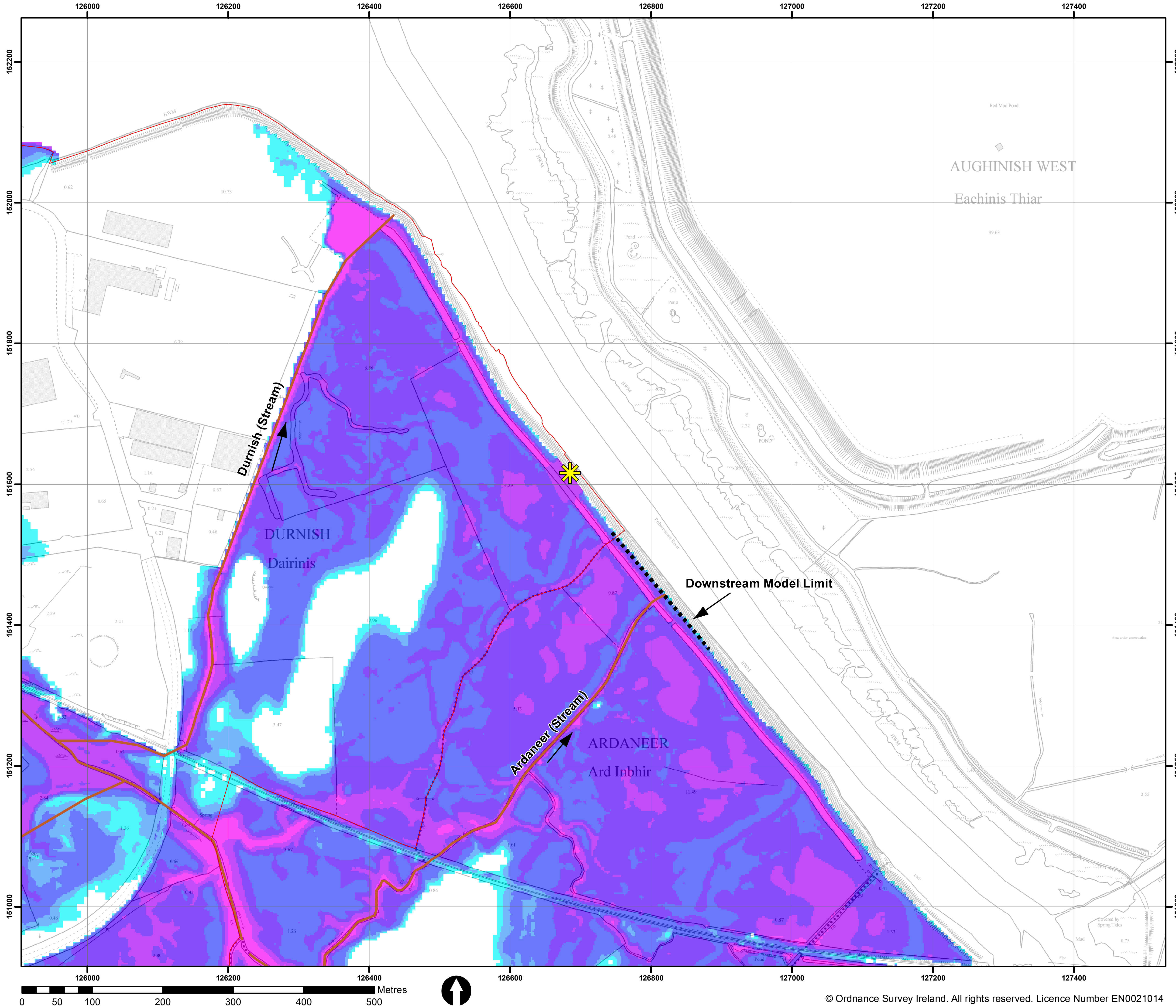
Map: FOYNES

Map Type: DEFENCE FAILURE DEPTH MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: FOYNES
Scenario: EXISTING

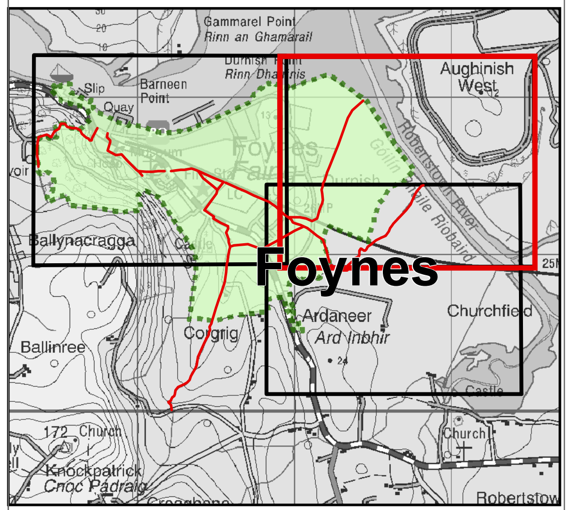
Drawn by: EH	Date: December 2015
Checked by: PT	Date: December 2015
Reviewed by: MC	Date: December 2015
Approved by: PS	Date: December 2015

Map No.:
S09FDCCDC1

Sheet: 2 of 4 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

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Project:
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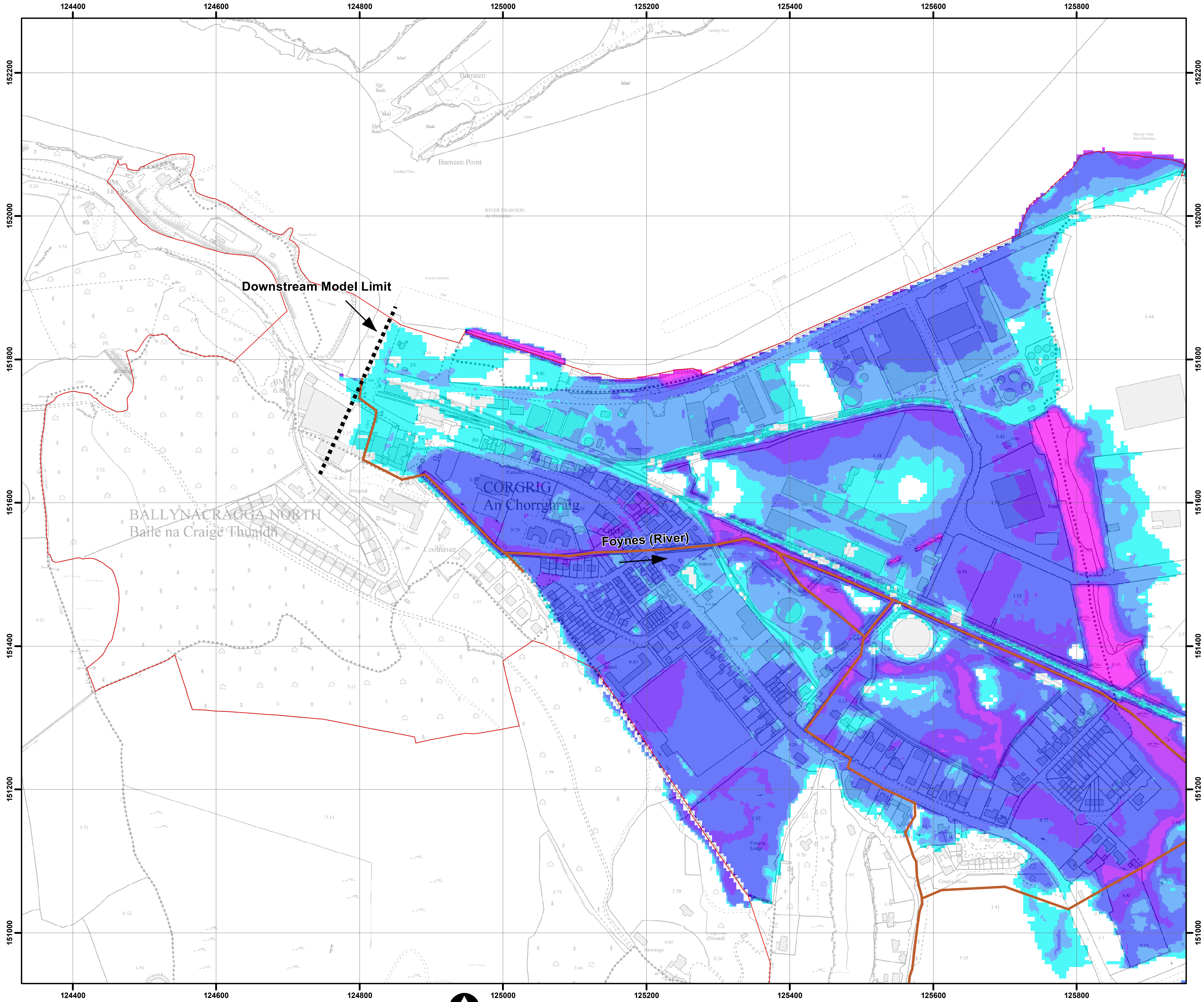
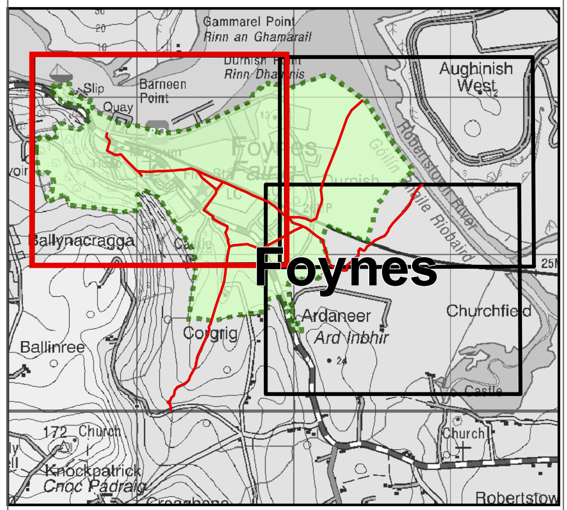
Map: FOYNES

Map Type:	DEFENCE FAILURE DEPTH MAP
Source:	0.5% AEP COASTAL FAILURE SCENARIO 1
Map area:	FOYNES
Scenario:	EXISTING
Drawn by: EH	Date: December 2015
Checked by: PT	Date: December 2015
Reviewed by: MC	Date: December 2015
Approved by: PS	Date: December 2015
Map No.: S09FDCCDC1	
Sheet: 3 of 4	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



0 50 100 200 300 400 500 Metres

Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

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Project:
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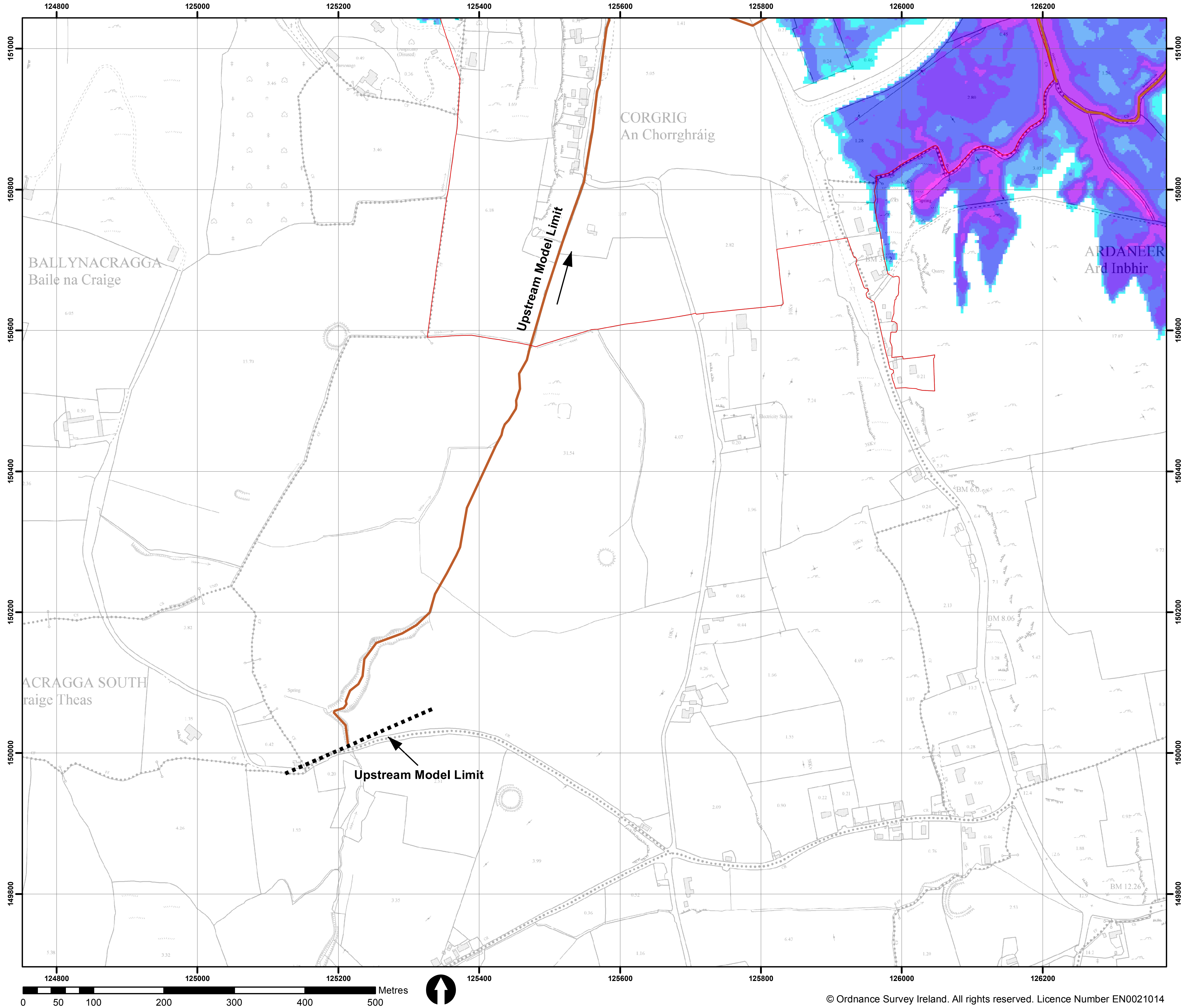
Map: FOYNES

Map Type: DEFENCE FAILURE DEPTH MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: FOYNES
Scenario: EXISTING

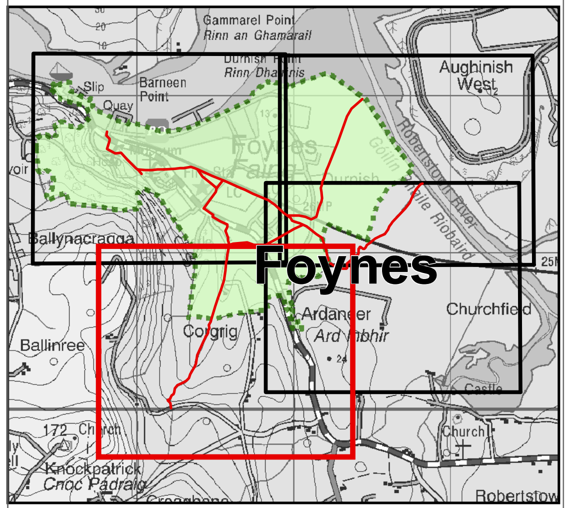
Drawn by: EH	Date: December 2015
Checked by: PT	Date: December 2015
Reviewed by: MC	Date: December 2015
Approved by: PS	Date: December 2015

Map No.:
S09FDCCDC1

Sheet: 4 of 4 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 2 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

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Project:
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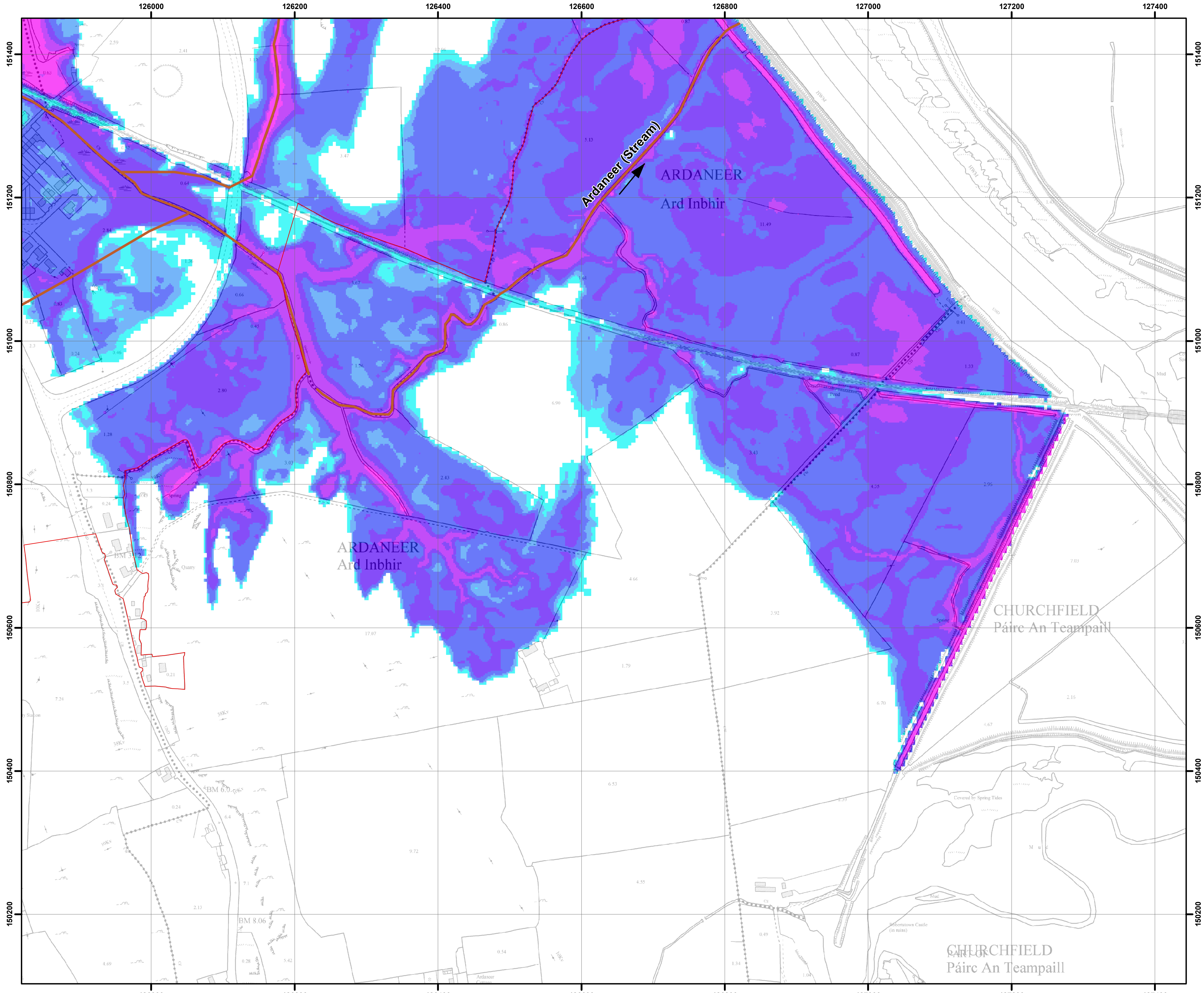
Map: FOYNES

Map Type: DEFENCE FAILURE DEPTH MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: FOYNES
Scenario: EXISTING

Drawn by:	EH	Date: December 2015
Checked by:	PT	Date: December 2015
Reviewed by:	MC	Date: December 2015
Approved by:	PS	Date: December 2015

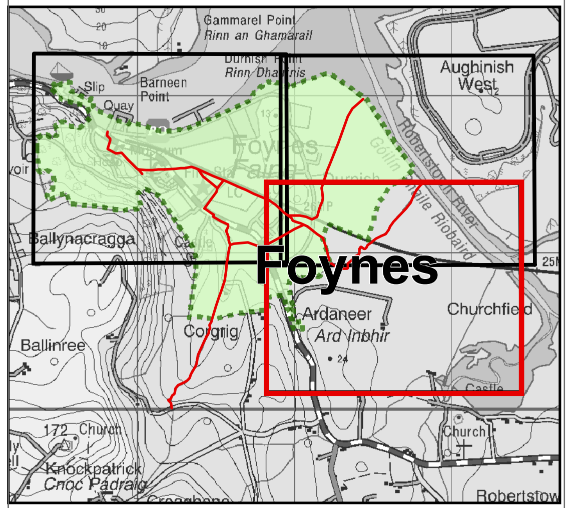
Map No.:
S09FDCCDC1

Sheet: 1 of 4 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



0 50 100 200 300 400 500 Metres

Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 2 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

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Project:
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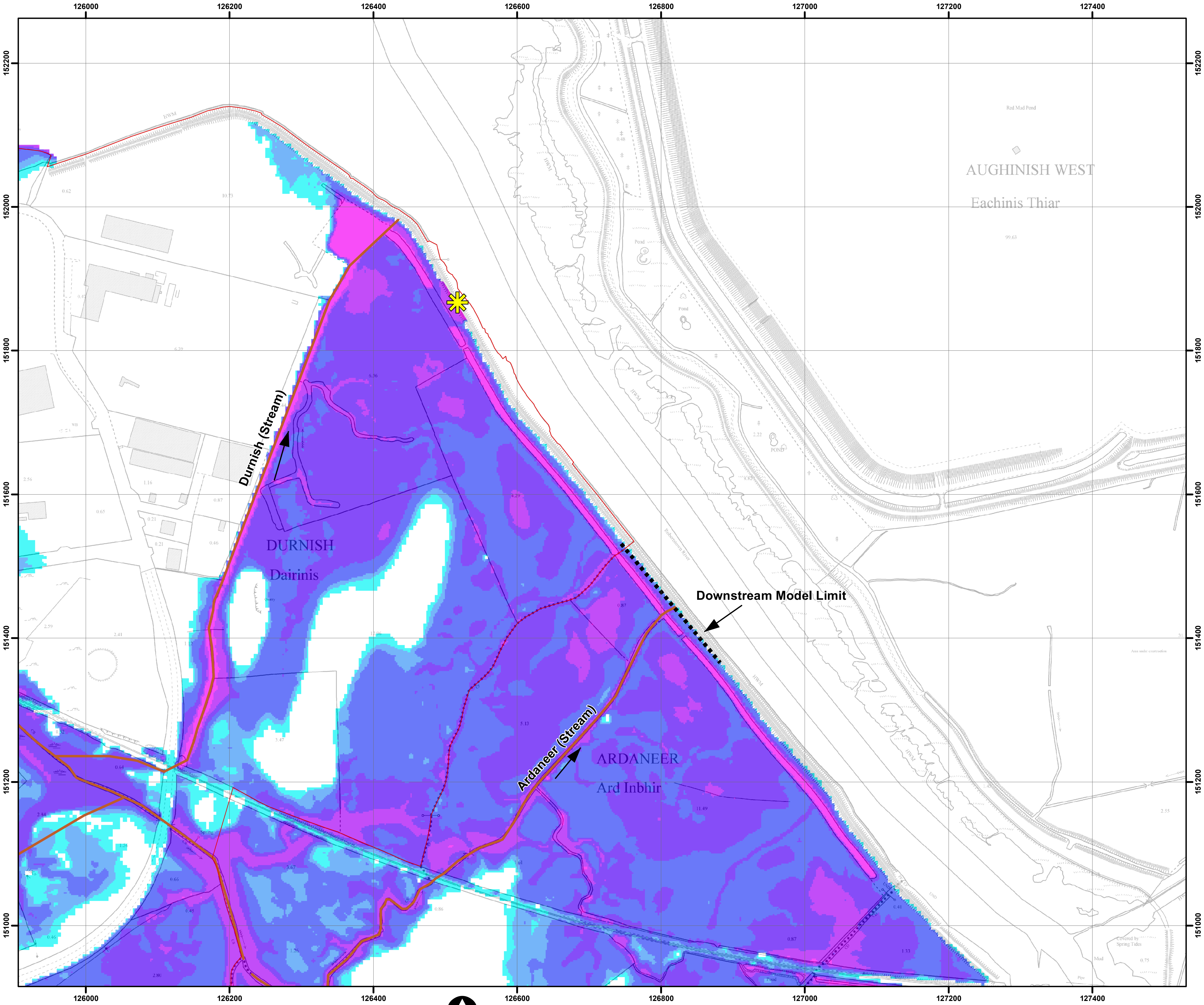
Map: **FOYNES**

Map Type: DEFENCE FAILURE DEPTH MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: FOYNES
Scenario: EXISTING

Drawn by:	EH	Date: December 2015
Checked by:	PT	Date: December 2015
Reviewed by:	MC	Date: December 2015
Approved by:	PS	Date: December 2015

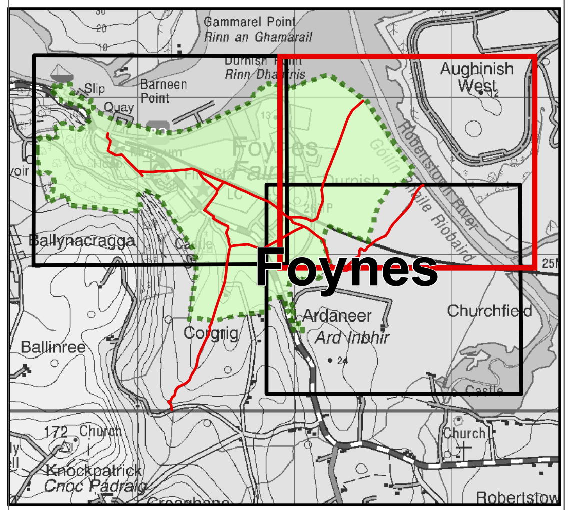
Map No.:
S09FDCCDC1

Sheet: 2 of 4 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



0 50 100 200 300 400 500 Metres

Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 2 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
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Project:
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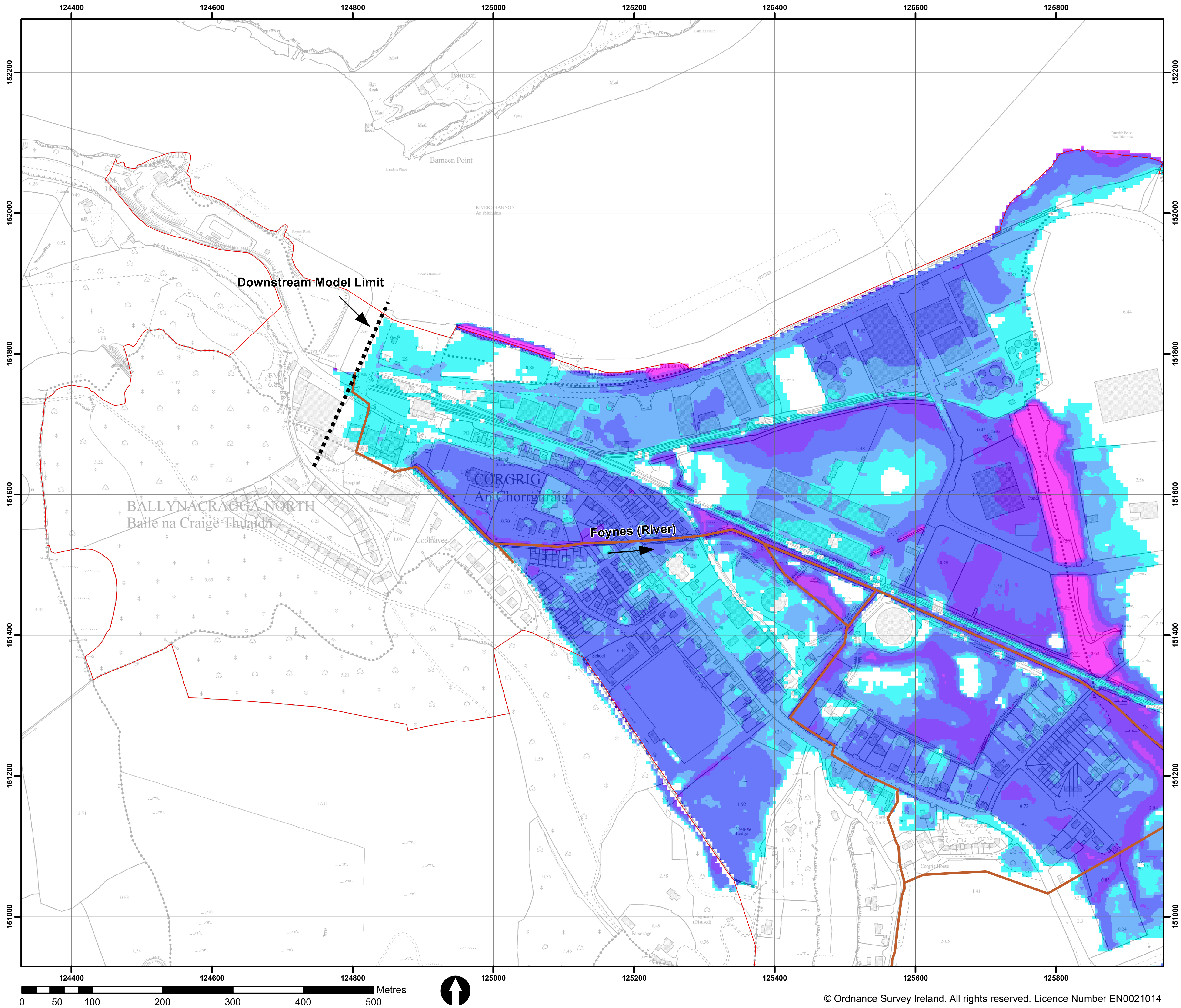
Map: FOYNES

Map Type: DEFENCE FAILURE DEPTH MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: FOYNES
Scenario: EXISTING

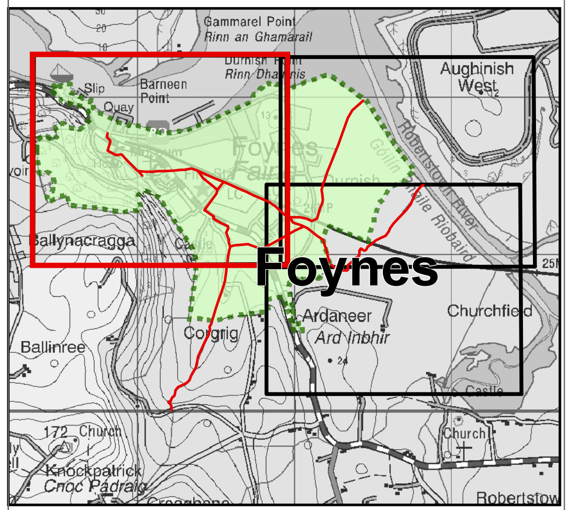
Drawn by:	EH	Date: December 2015
Checked by:	PT	Date: December 2015
Reviewed by:	MC	Date: December 2015
Approved by:	PS	Date: December 2015

Map No.:
S09FDCCDC1

Sheet: 3 of 4 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 2 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

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Project:
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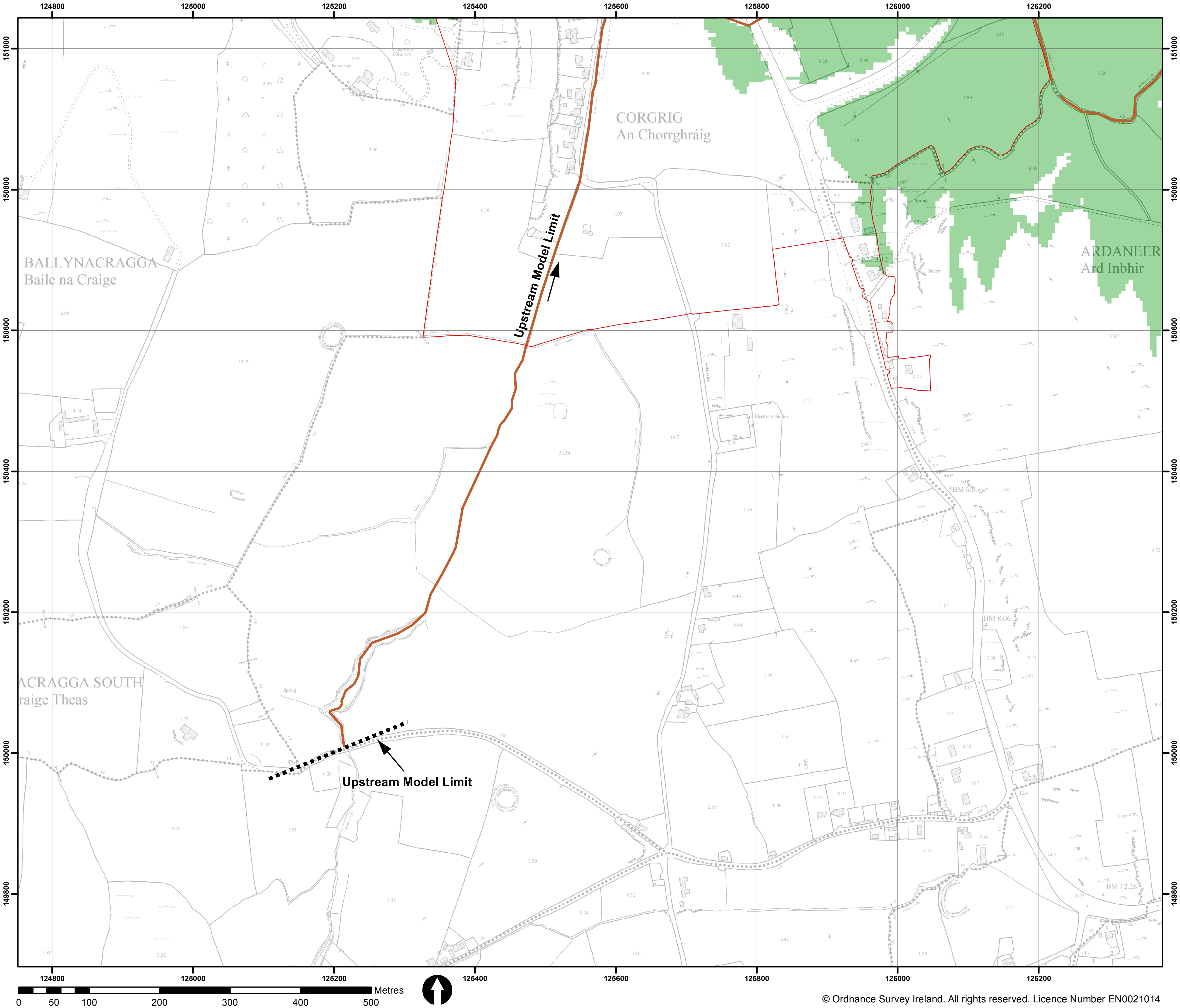
Map: FOYNES

Map Type: DEFENCE FAILURE DEPTH MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: FOYNES
Scenario: EXISTING

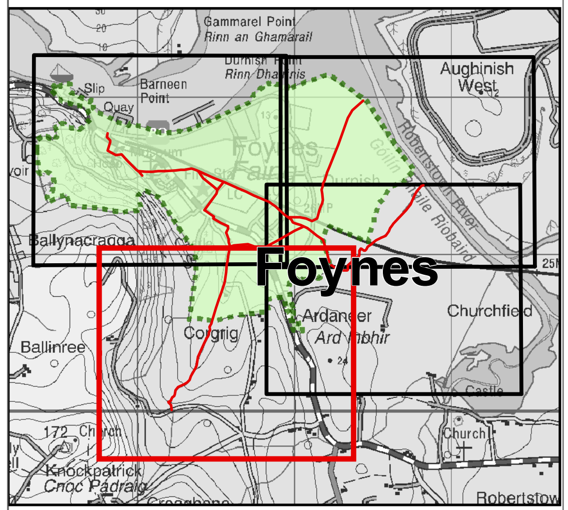
Drawn by: EH	Date: December 2015
Checked by: PT	Date: December 2015
Reviewed by: MC	Date: December 2015
Approved by: PS	Date: December 2015

Map No.:
S09FDCCDC1

Sheet: 4 of 4 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- River Centreline
- AFA Boundary
- Defence - Embankment
- Defence Failure Location
- 0.5% AEP Coastal Failure Scenario 1

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Project:
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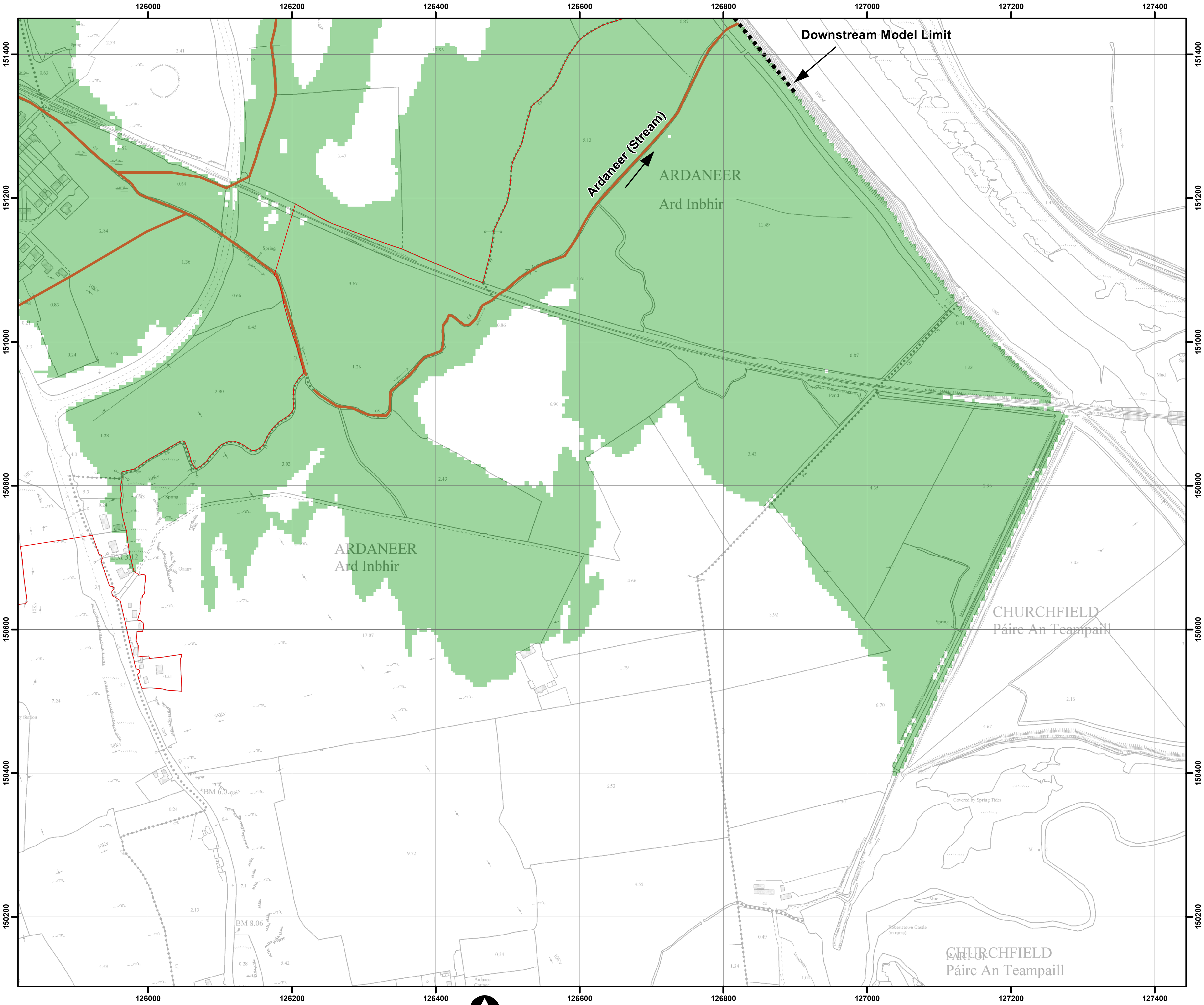
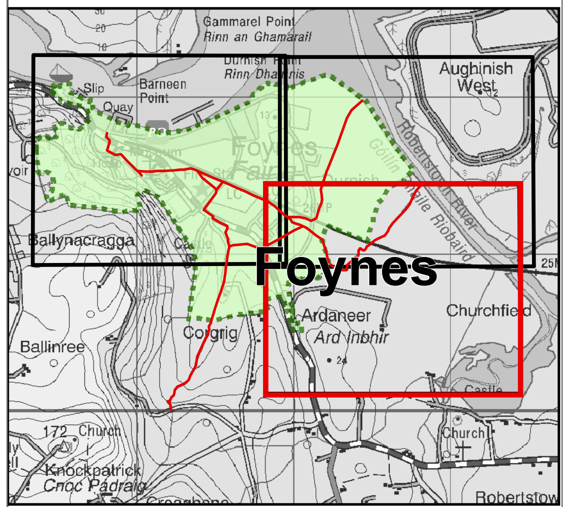
Map: FOYNES

Map Type: DEFENCE FAILURE EXTENT MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1	
Map area: FOYNES	
Scenario: EXISTING	
Drawn by: EH	Date: December 2015
Checked by: PT	Date: December 2015
Reviewed by: MC	Date: December 2015
Approved by: PS	Date: December 2015
Map No.: S09FECCDC1	
Sheet: 1 of 4	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



0 50 100 200 300 400 500 Metres

Location Plan:



Legend:

- River Centreline
- AFA Boundary
- Defence - Embankment
- Defence Failure Location
- 0.5% AEP Coastal Failure Scenario 1

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Project:
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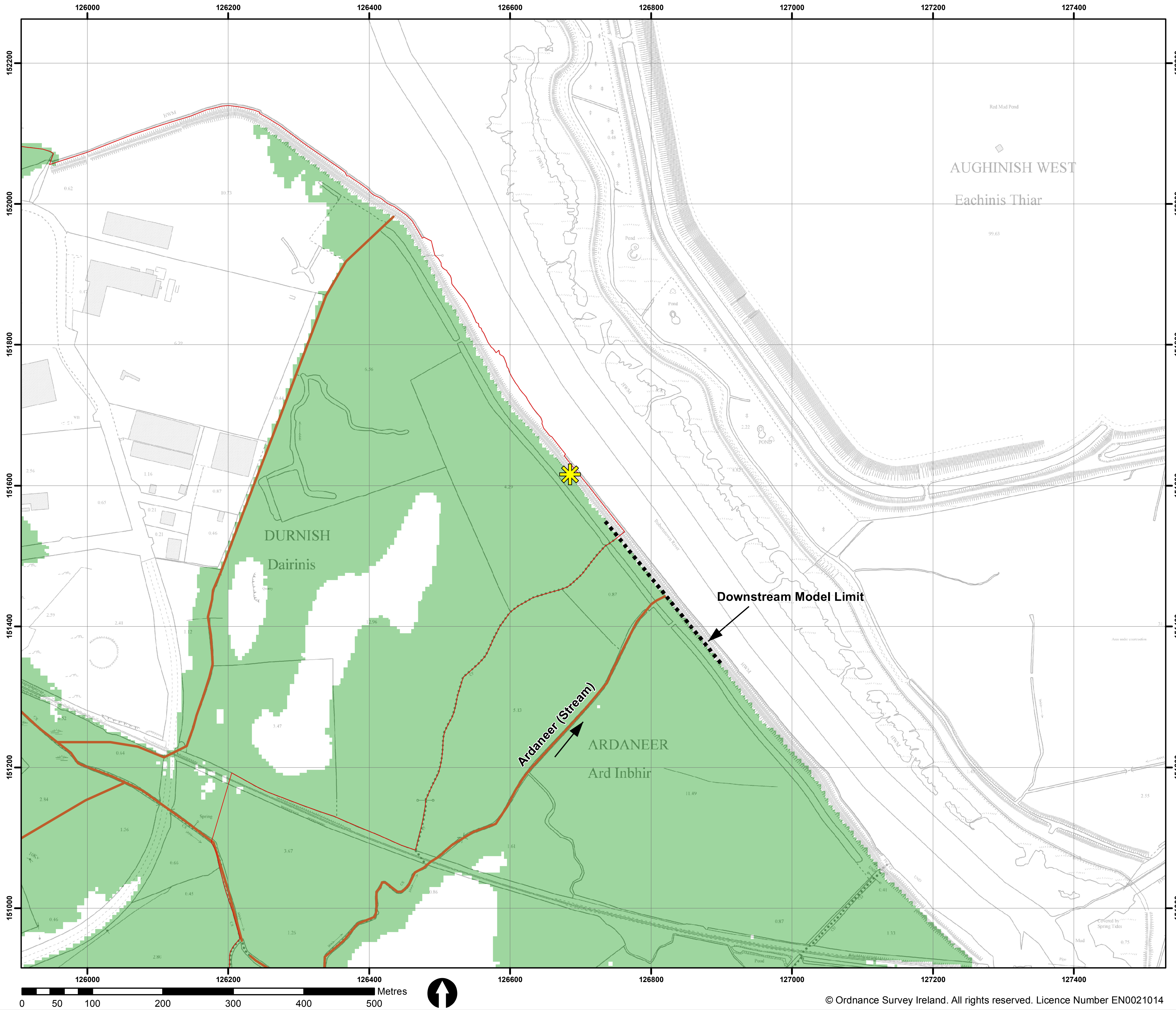
Map: FOYNES

Map Type: DEFENCE FAILURE EXTENT MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: FOYNES
Scenario: EXISTING

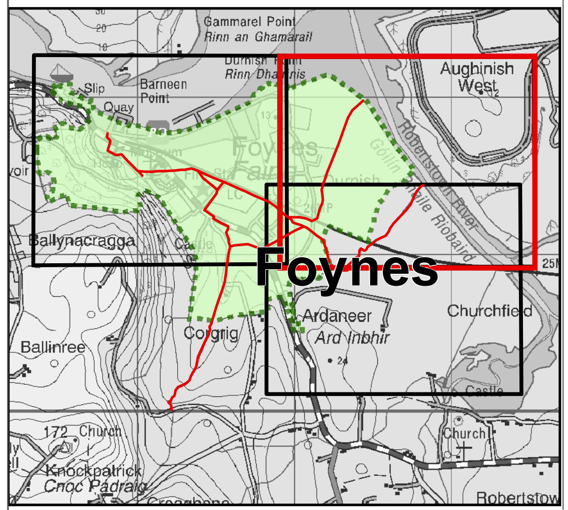
Drawn by: EH	Date: December 2015
Checked by: PT	Date: December 2015
Reviewed by: MC	Date: December 2015
Approved by: PS	Date: December 2015

Map No.:
S09FECCDC1

Sheet: 2 of 4 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- River Centreline
- AFA Boundary
- Defence - Embankment
- Defence Failure Location
- 0.5% AEP Coastal Failure Scenario 1

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Project:
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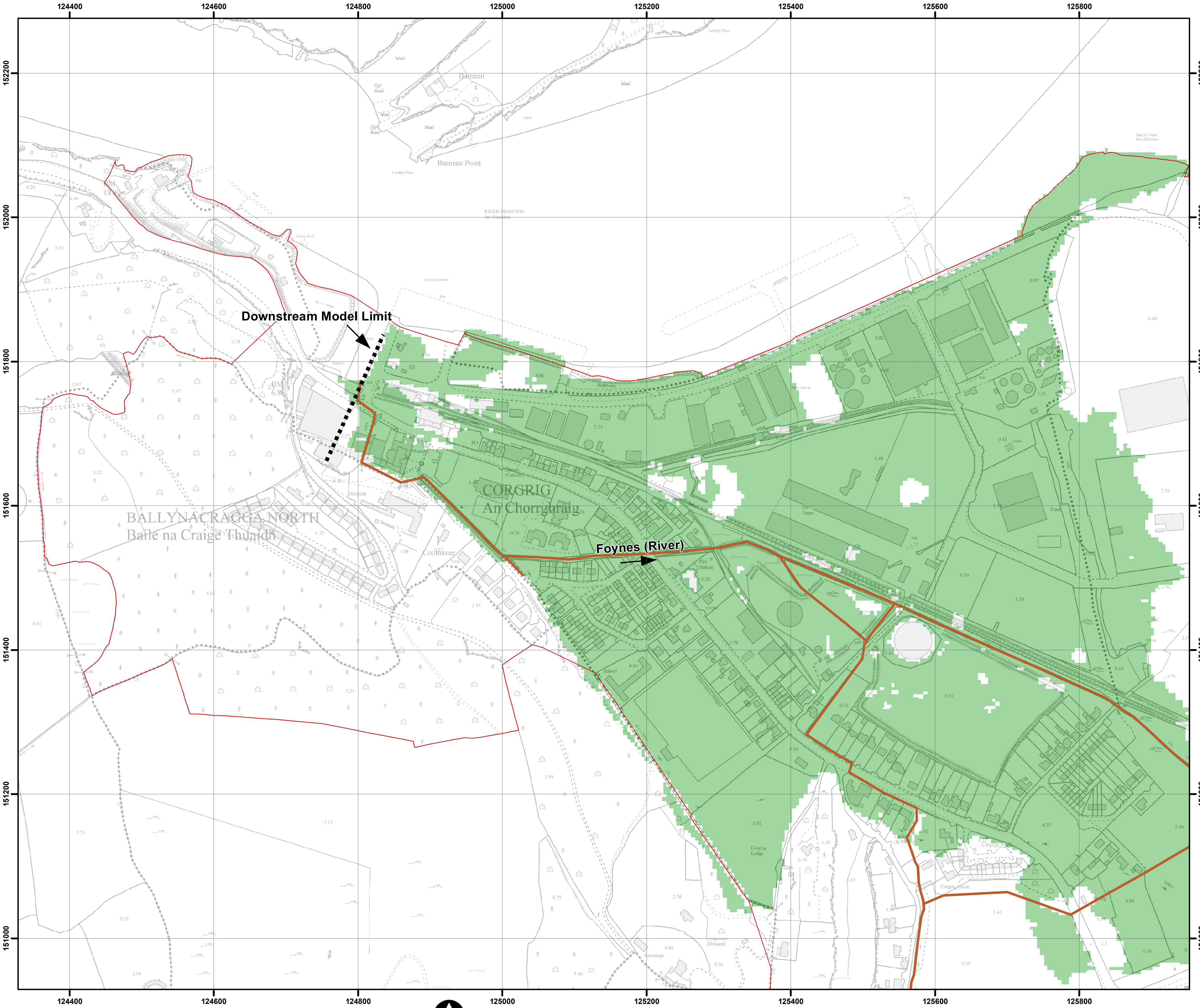
Map: FOYNES

Map Type: DEFENCE FAILURE EXTENT MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: FOYNES
Scenario: EXISTING

Drawn by:	EH	Date: December 2015
Checked by:	PT	Date: December 2015
Reviewed by:	MC	Date: December 2015
Approved by:	PS	Date: December 2015

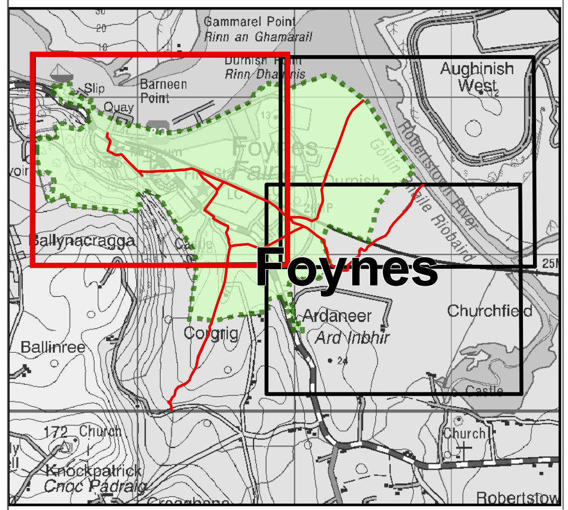
Map No.:
S09FECCDC1

Sheet: 3 of 4 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



0 50 100 200 300 400 500 Metres

Location Plan:



Legend:

- River Centreline
- AFA Boundary
- Defence - Embankment
- Defence Failure Location
- 0.5% AEP Coastal Failure Scenario 1

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Project:
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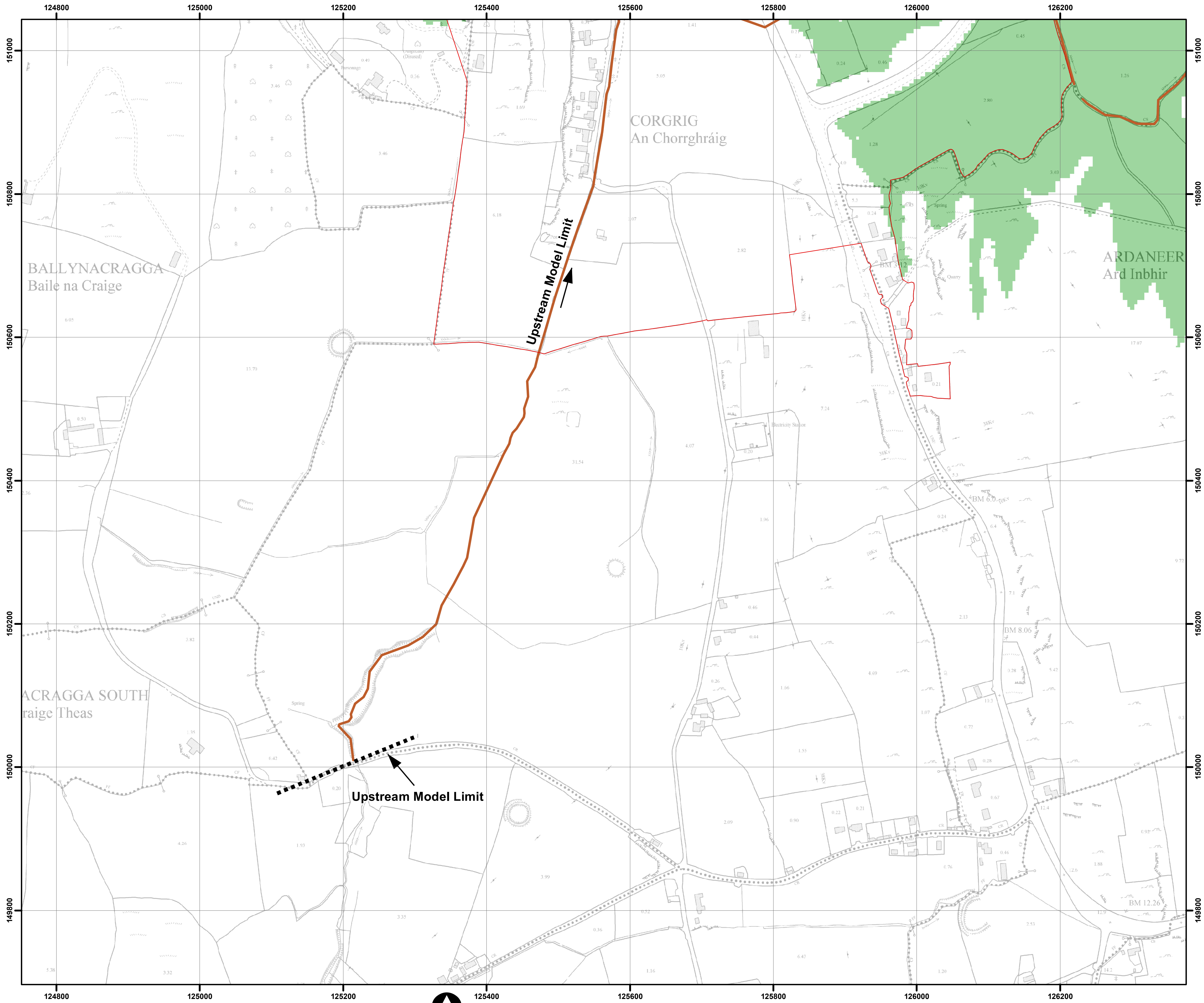
Map: **FOYNES**

Map Type: DEFENCE FAILURE EXTENT MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: FOYNES
Scenario: EXISTING

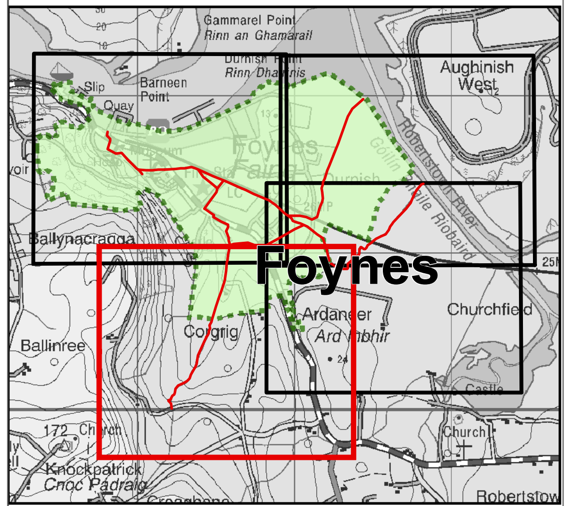
Drawn by: EH	Date: December 2015
Checked by: PT	Date: December 2015
Reviewed by: MC	Date: December 2015
Approved by: PS	Date: December 2015

Map No.:
S09FECCDC1

Sheet: 4 of 4 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- River Centreline
- AFA Boundary
- Defence - Embankment
- Defence Failure Location
- 0.5% AEP Coastal Failure Scenario 2

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Project:
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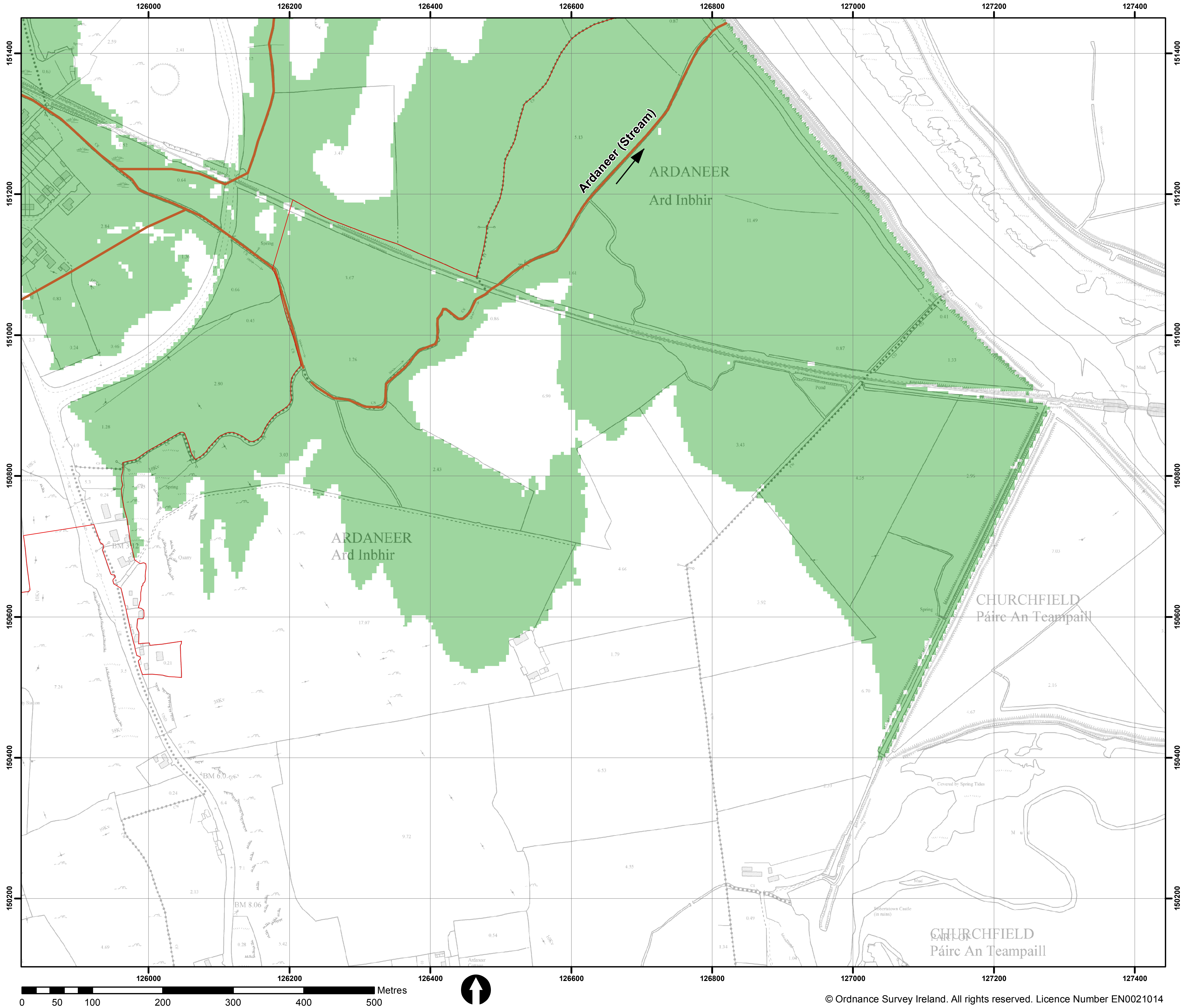
Map: FOYNES

Map Type: DEFENCE FAILURE EXTENT MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: FOYNES
Scenario: EXISTING

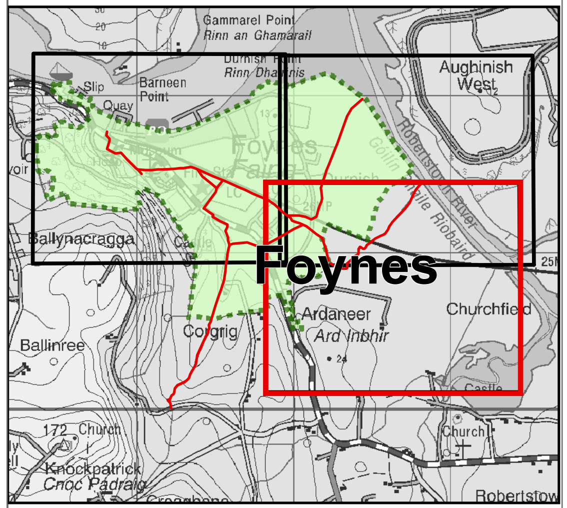
Drawn by:	EH	Date: December 2015
Checked by:	PT	Date: December 2015
Reviewed by:	MC	Date: December 2015
Approved by:	PS	Date: December 2015

Map No.:
S09FECCDC1

Sheet: 1 of 4 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- River Centreline
- AFA Boundary
- Defence - Embankment
- Defence Failure Location
- 0.5% AEP Coastal Failure Scenario 2

IMPORTANT USER NOTE:

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Merrion Road
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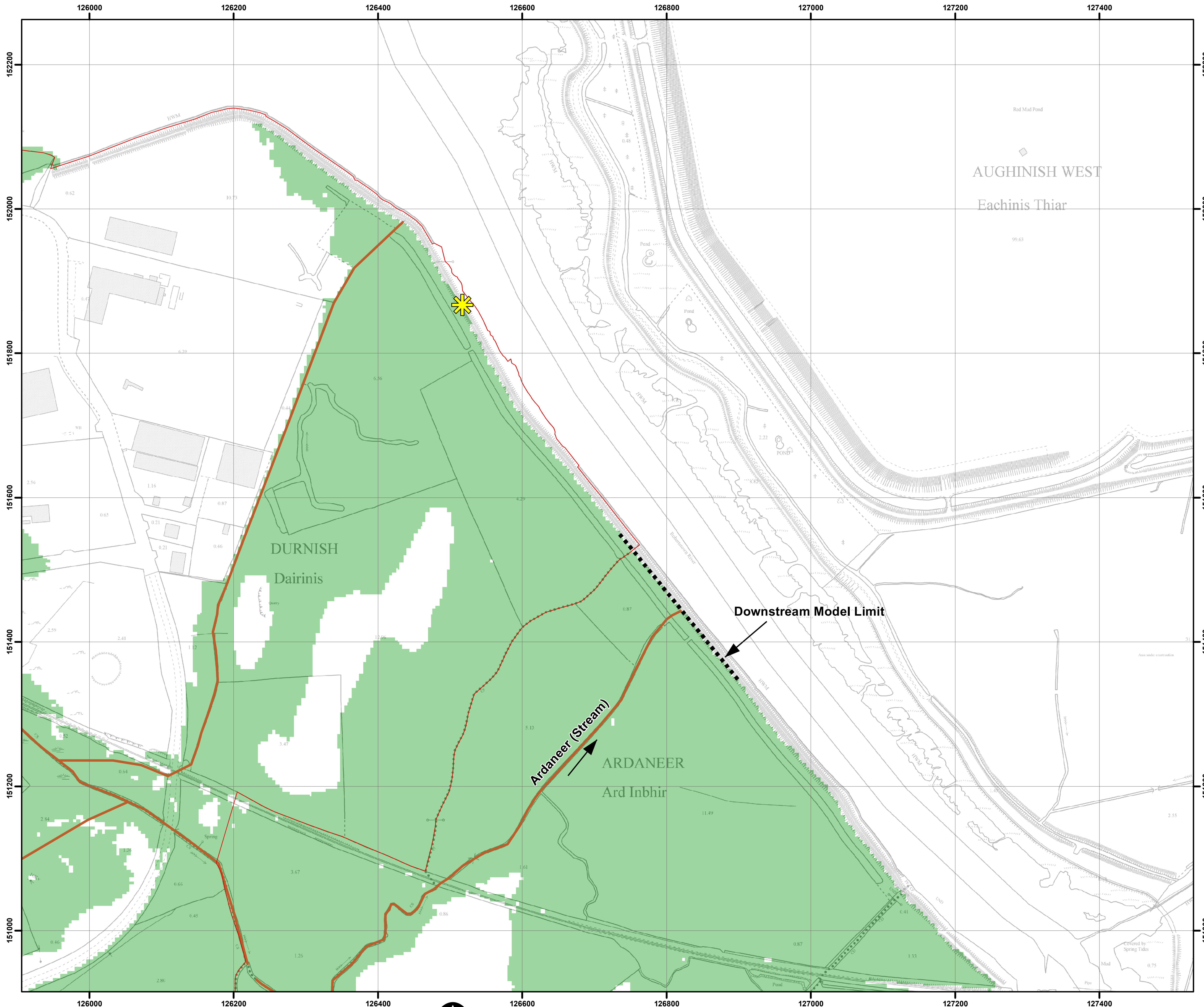
Project:
SHANNON CFRAM STUDY

Map: FOYNES

Map Type:	DEFENCE FAILURE EXTENT MAP
Source:	0.5% AEP COASTAL FAILURE SCENARIO 2
Map area:	FOYNES
Scenario:	EXISTING
Drawn by: EH	Date: December 2015
Checked by: PT	Date: December 2015
Reviewed by: MC	Date: December 2015
Approved by: PS	Date: December 2015
Map No.: S09FECCDC1	
Sheet: 2 of 4	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



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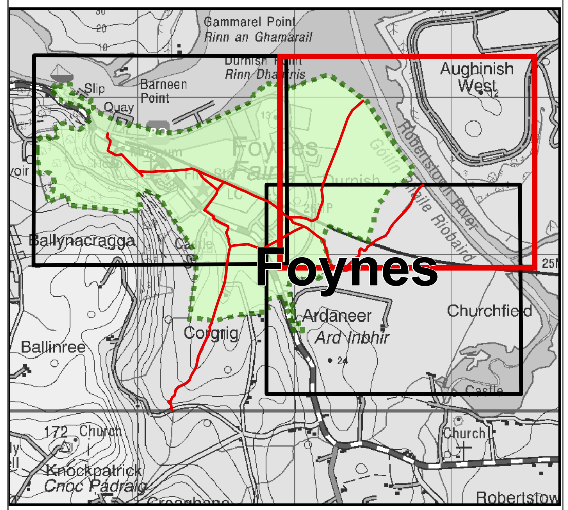
Location Plan:



Legend:

- River Centreline
- AFA Boundary
- Defence - Embankment
- Defence Failure Location
- 0.5% AEP Coastal Failure Scenario 2

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Project:
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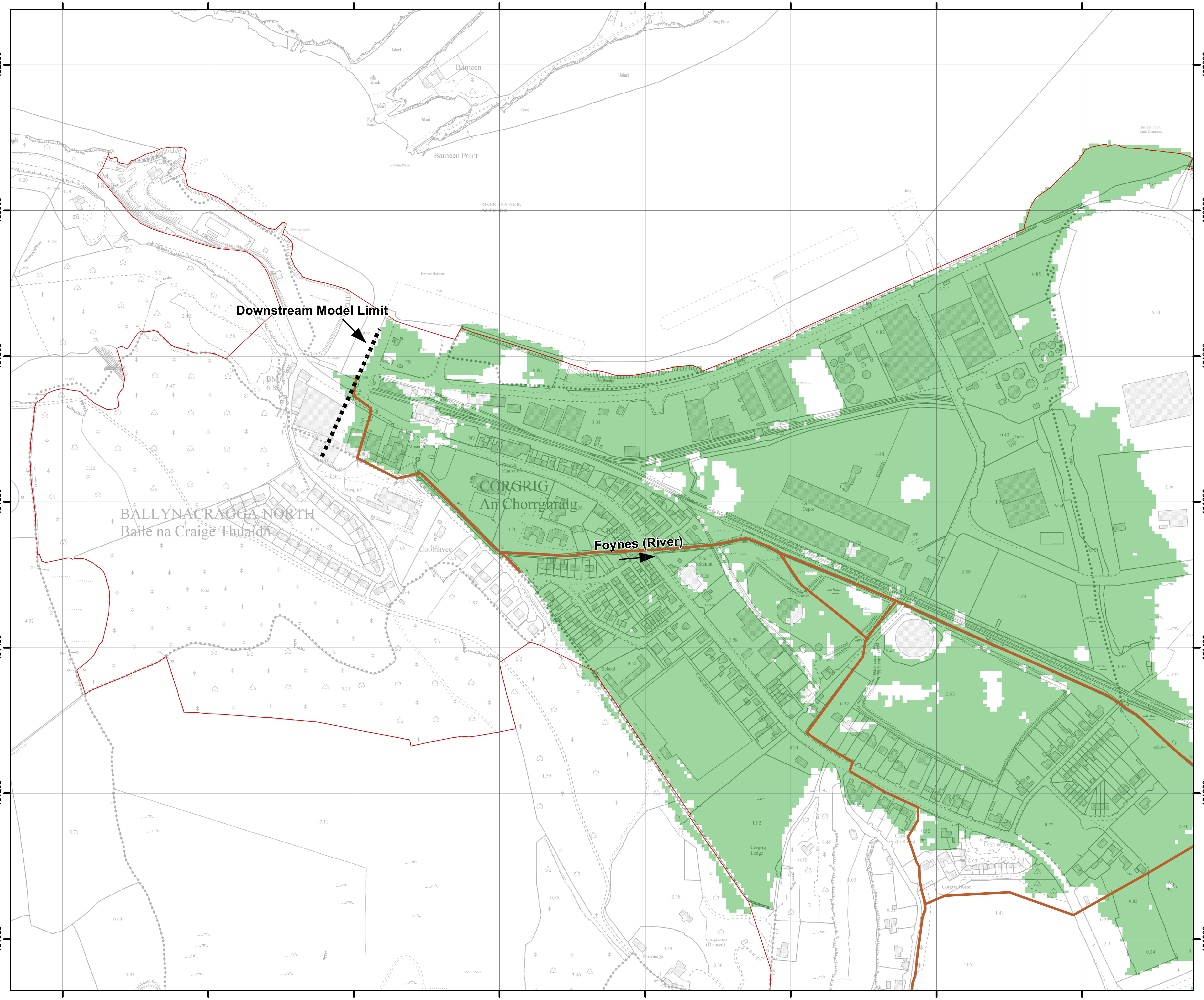
Map: FOYNES

Map Type: DEFENCE FAILURE EXTENT MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: FOYNES
Scenario: EXISTING

Drawn by: EH	Date: December 2015
Checked by: PT	Date: December 2015
Reviewed by: MC	Date: December 2015
Approved by: PS	Date: December 2015

Map No.:
S09FECCDC1

Sheet: 3 of 4 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



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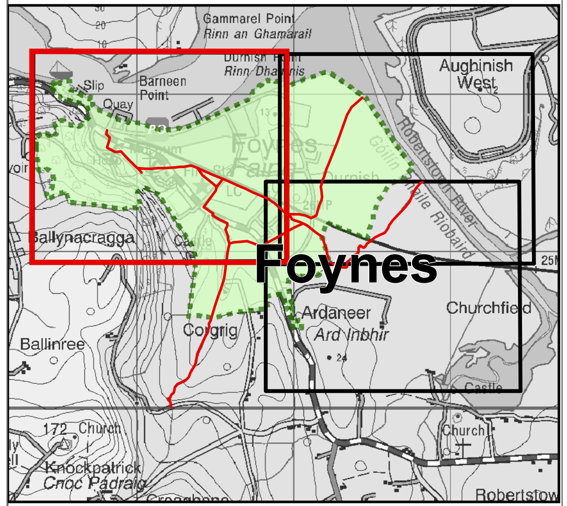
Location Plan:



Legend:

- River Centreline
- AFA Boundary
- Defence - Embankment
- Defence Failure Location
- 0.5% AEP Coastal Failure Scenario 2

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Project:
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Map: FOYNES

Map Type: DEFENCE FAILURE EXTENT MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: FOYNES
Scenario: EXISTING

Drawn by: EH	Date: December 2015
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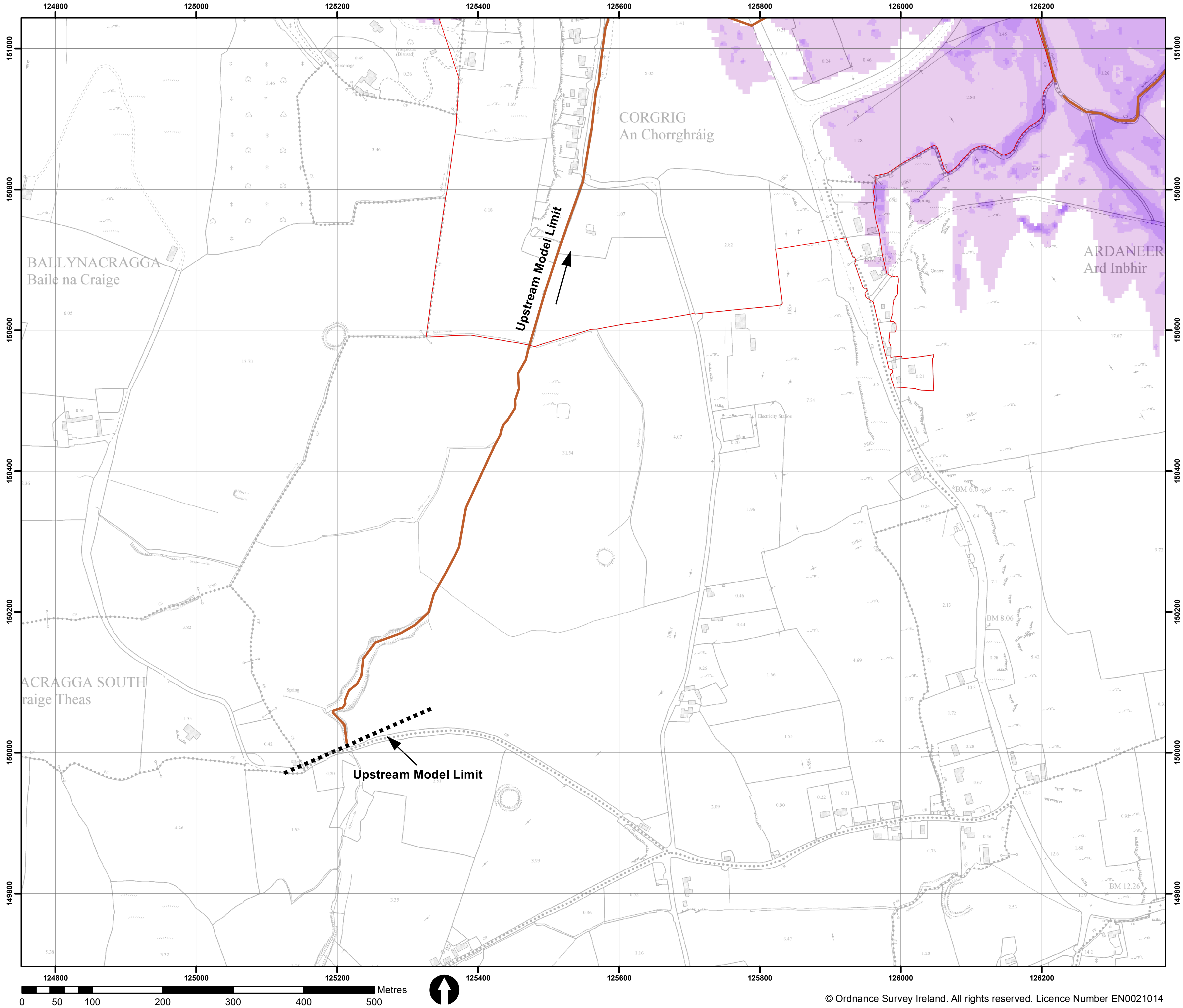
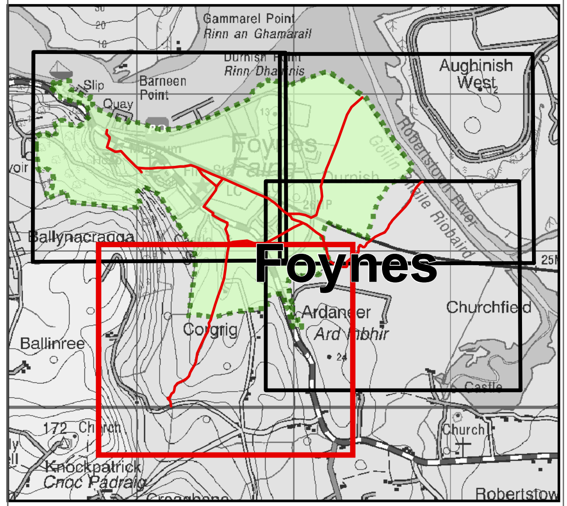
Map No.:
S09FECCDC1

Sheet: 4 of 4 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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Project:
SHANNON CFRAM STUDY

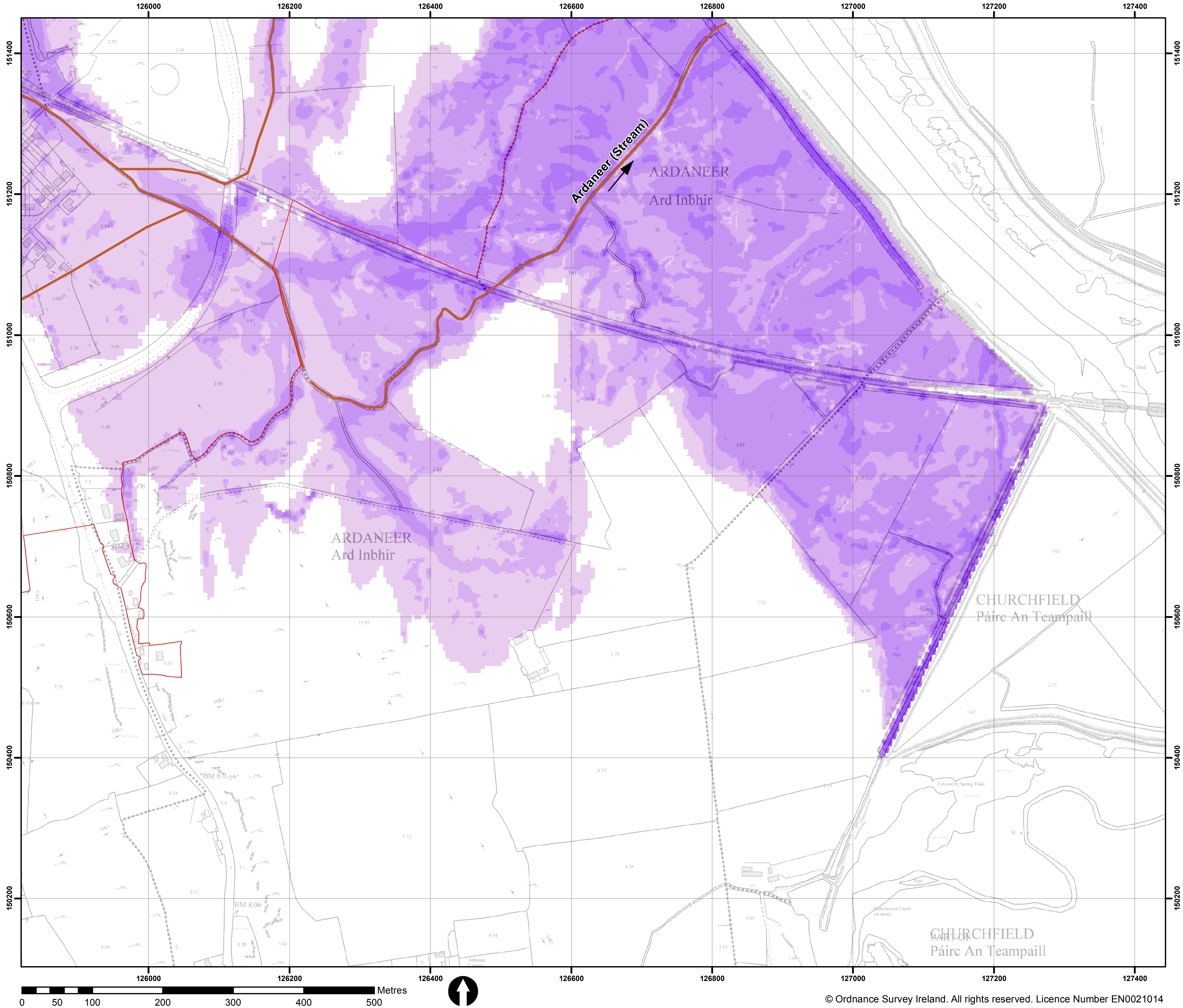
Map: FOYNES

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: FOYNES
Scenario: EXISTING

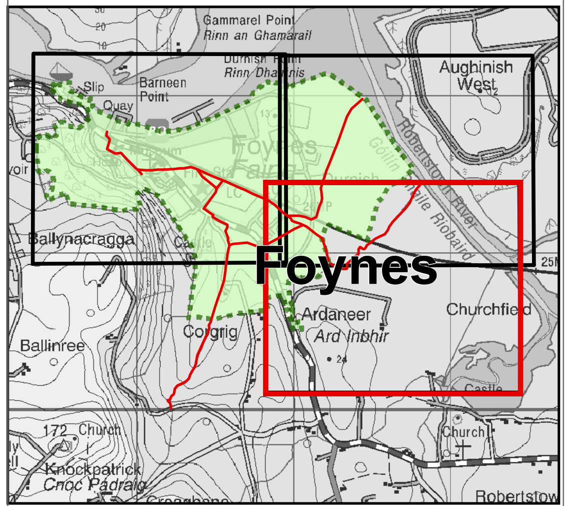
Drawn by:	EH	Date: December 2015
Checked by:	PT	Date: December 2015
Reviewed by:	MC	Date: December 2015
Approved by:	PS	Date: December 2015

Map No.:
S09FVCCDC1

Sheet: 1 of 4 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
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Project:
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Map: FOYNES

Map Type:	DEFENCE FAILURE VELOCITY MAP
Source:	0.5% AEP COASTAL FAILURE SCENARIO 1
Map area:	FOYNES
Scenario:	EXISTING
Drawn by: EH	Date: December 2015
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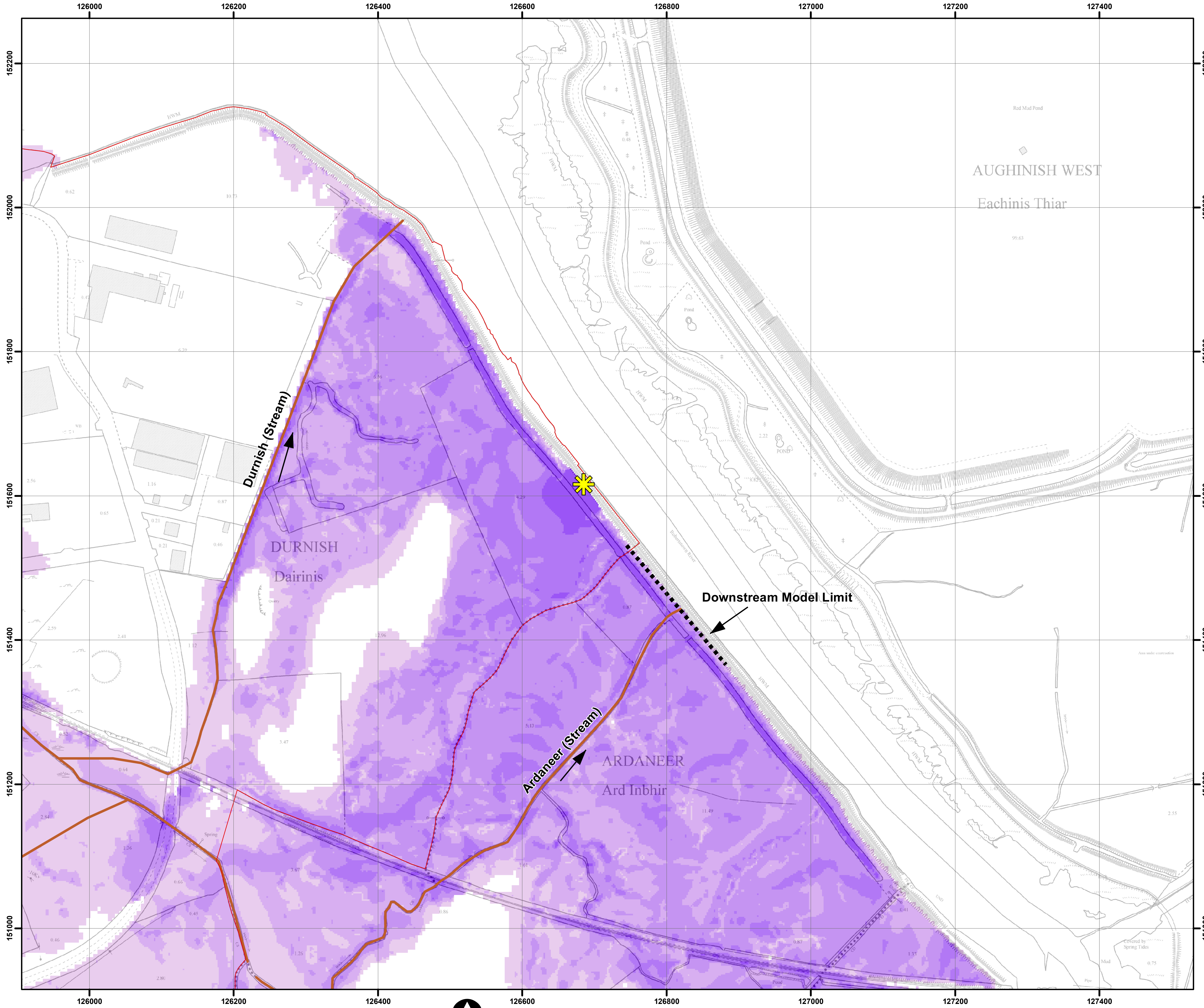
Reviewed by: MC	Date: December 2015
Approved by: PS	Date: December 2015
Map No.:	S09FVCCDC1
Sheet: 2 of 4	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



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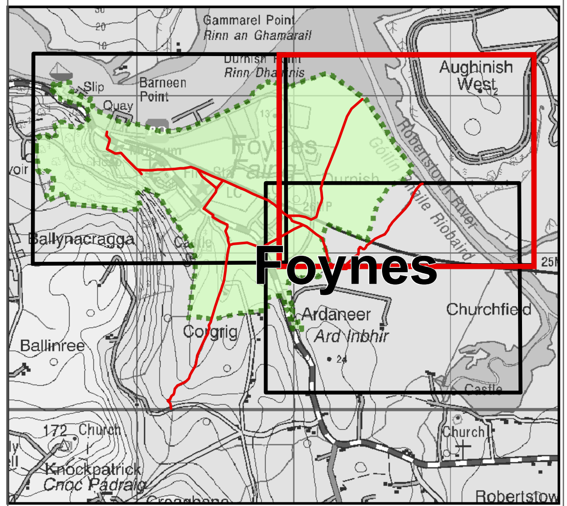
Location Plan:



Legend:

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- Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m/s)

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Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: FOYNES
Scenario: EXISTING

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Map No.:
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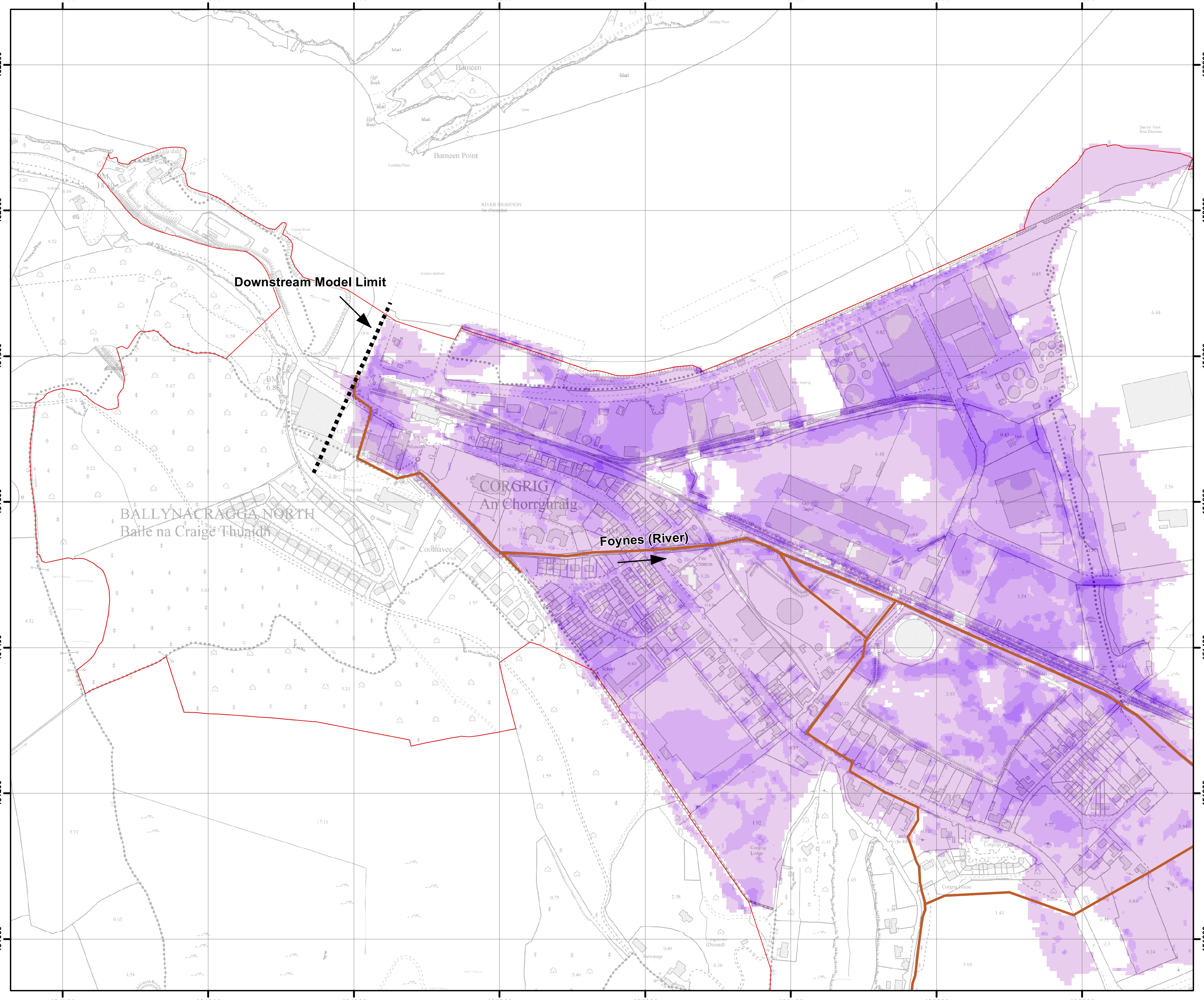
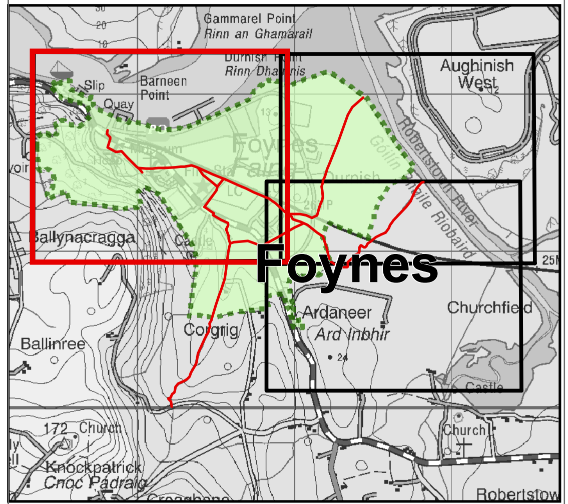
Sheet: 3 of 4 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
- 0.25 - 0.5
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Project: SHANNON CFRAM STUDY

Map: FOYNES

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: FOYNES
Scenario: EXISTING

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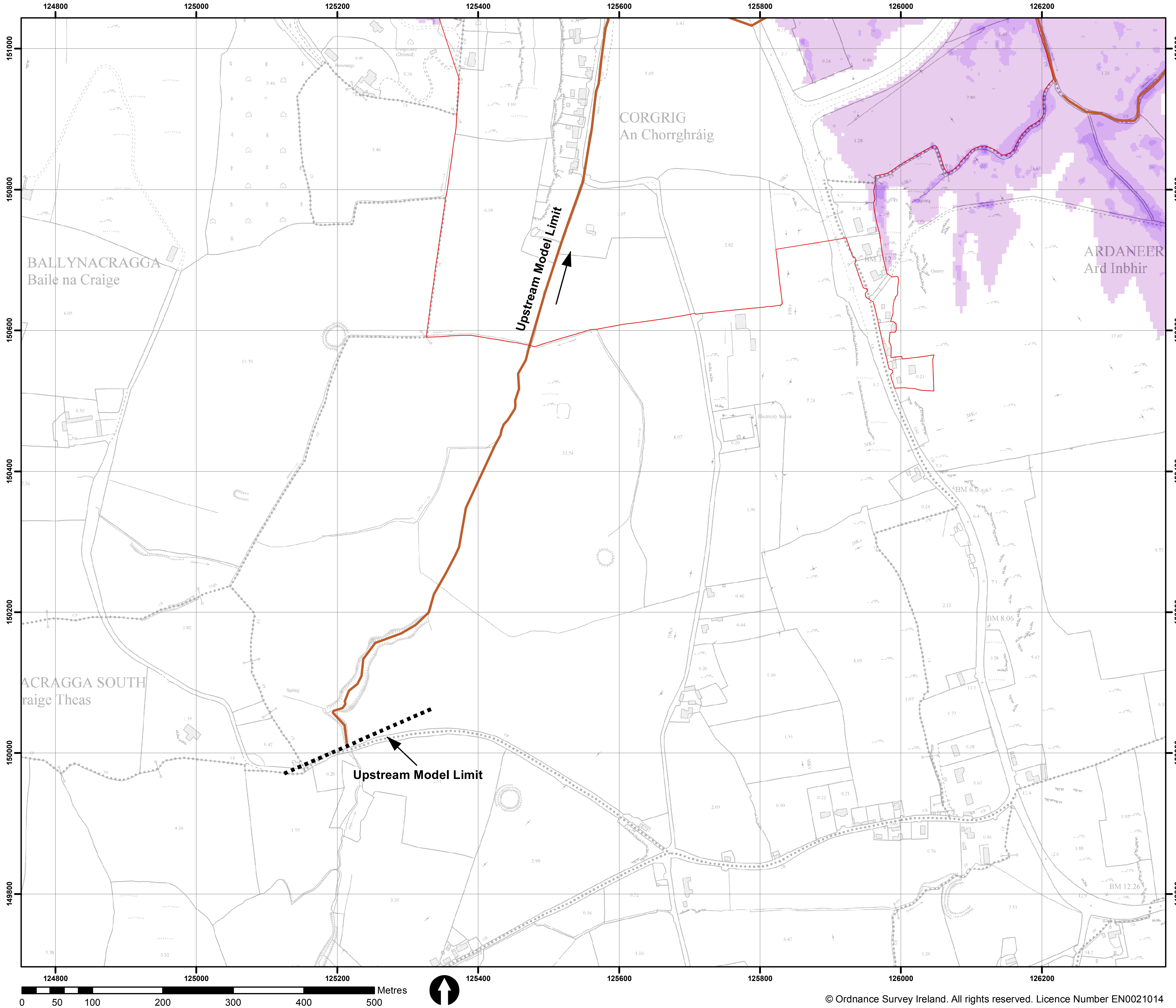
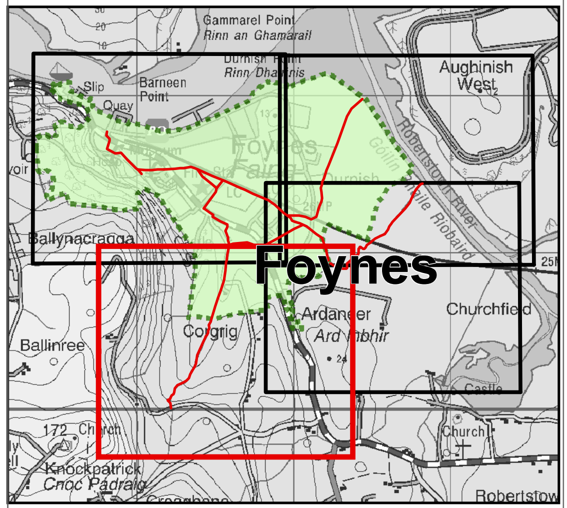
Map No.: S09FVCCDC1

Sheet: 4 of 4 Revision: 0

Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 2 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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Map: FOYNES

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: FOYNES
Scenario: EXISTING

Drawn by:	EH	Date: December 2015
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Map No.:
S09FVCCDC1

Sheet: 1 of 4 Revision: 0

Map Scale: 1: 5000 Plot Scale: 1:1 @ A3

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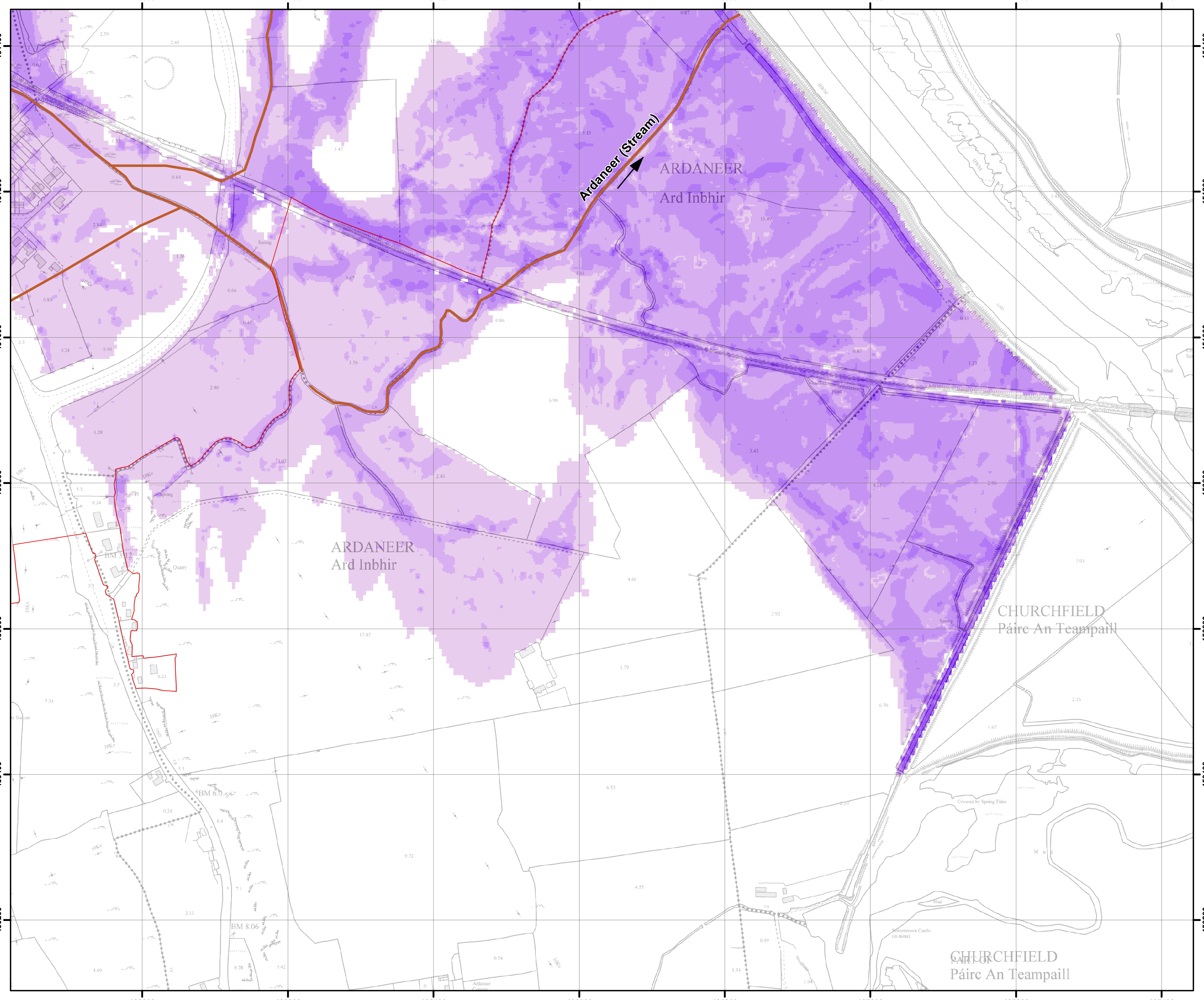

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0 50 100 200 300 400 500 Metres

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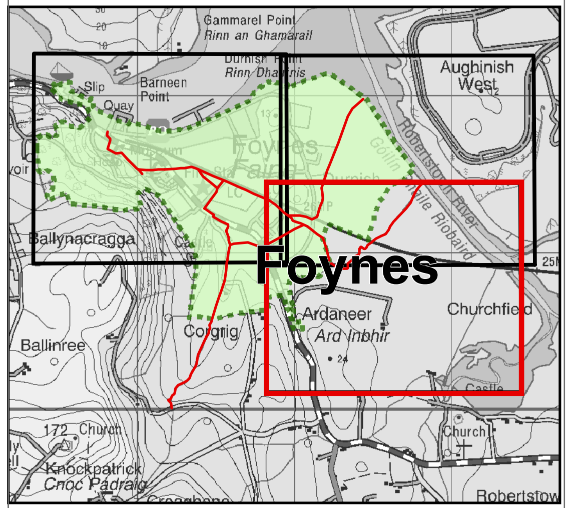
Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 2 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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Project: SHANNON CFRAM STUDY

Map: FOYNES

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: FOYNES
Scenario: EXISTING

Drawn by:	EH	Date: December 2015
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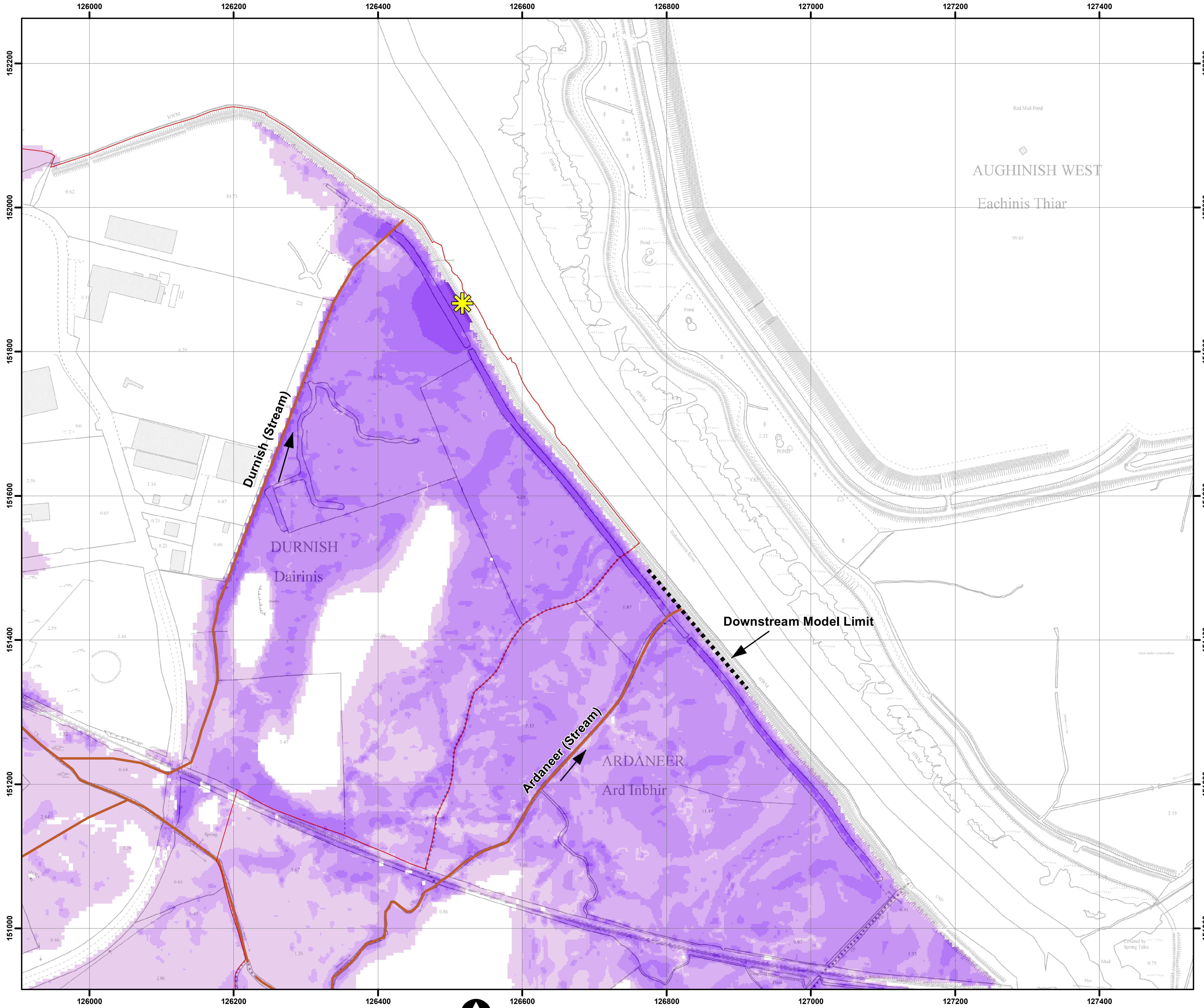
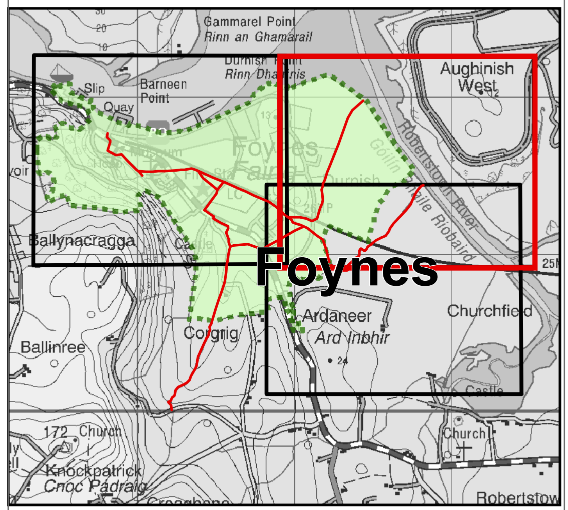
Map No.: S09FVCCDC1

Sheet: 2 of 4 Revision: 0

Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 2 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
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Project: SHANNON CFRAM STUDY

Map: FOYNES

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: FOYNES
Scenario: EXISTING

Drawn by:	EH	Date: December 2015
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Map No.: S09FVCCDC1

Sheet: 3 of 4 — Revision: 0

Map Scale: 1: 5000 — Plot Scale: 1:1 @ A3

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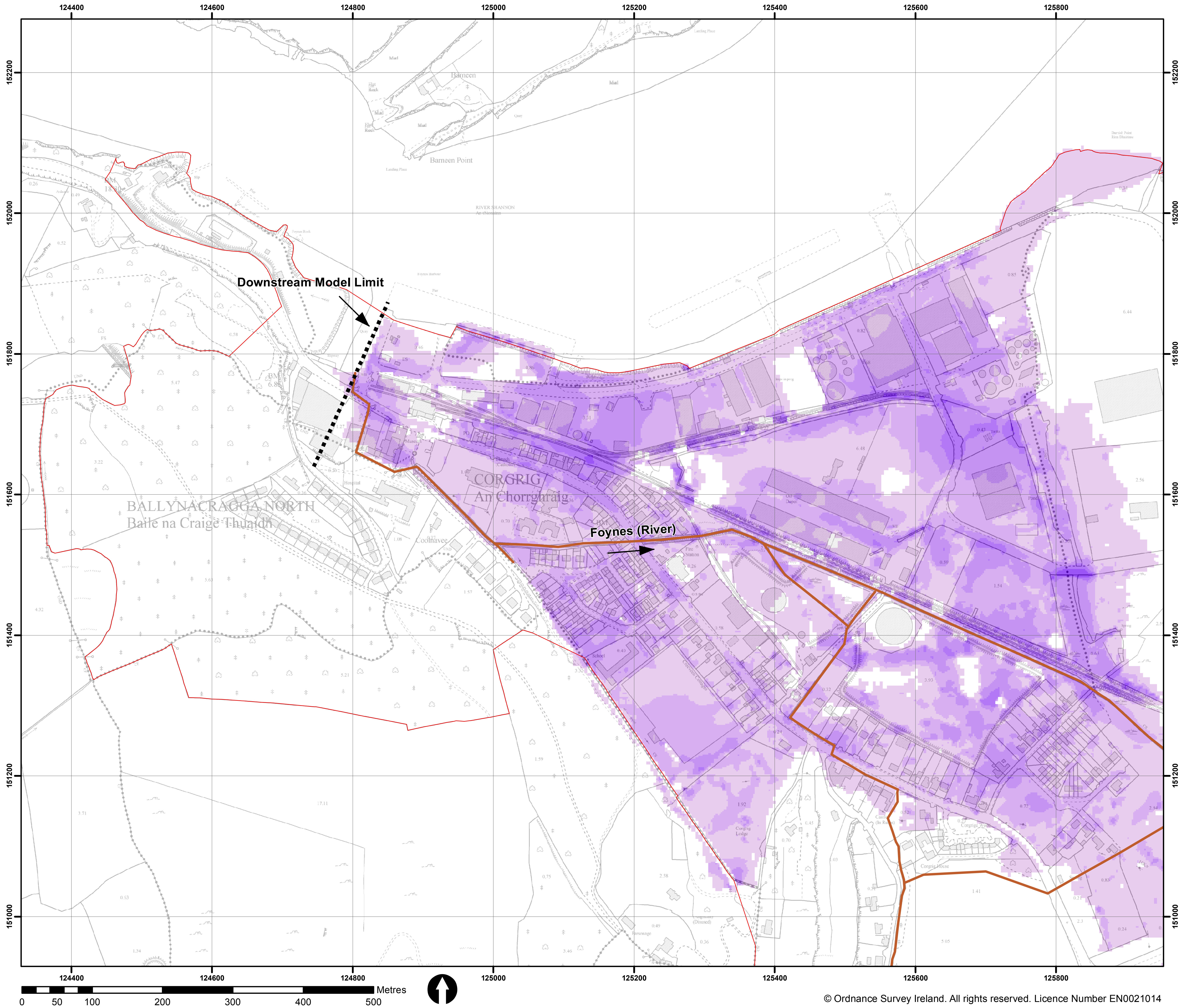

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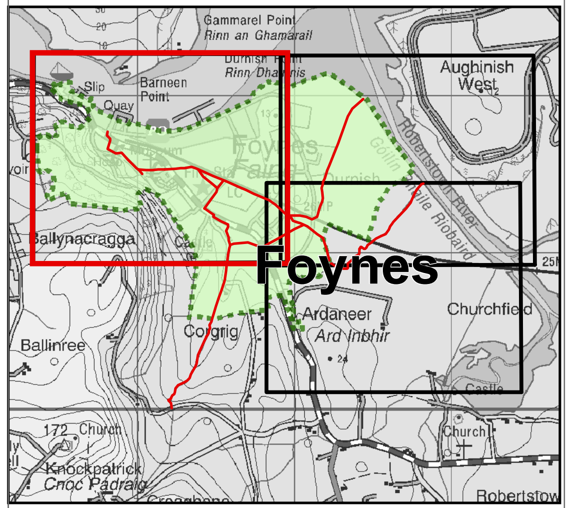
Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 2 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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SHANNON CFRAM STUDY

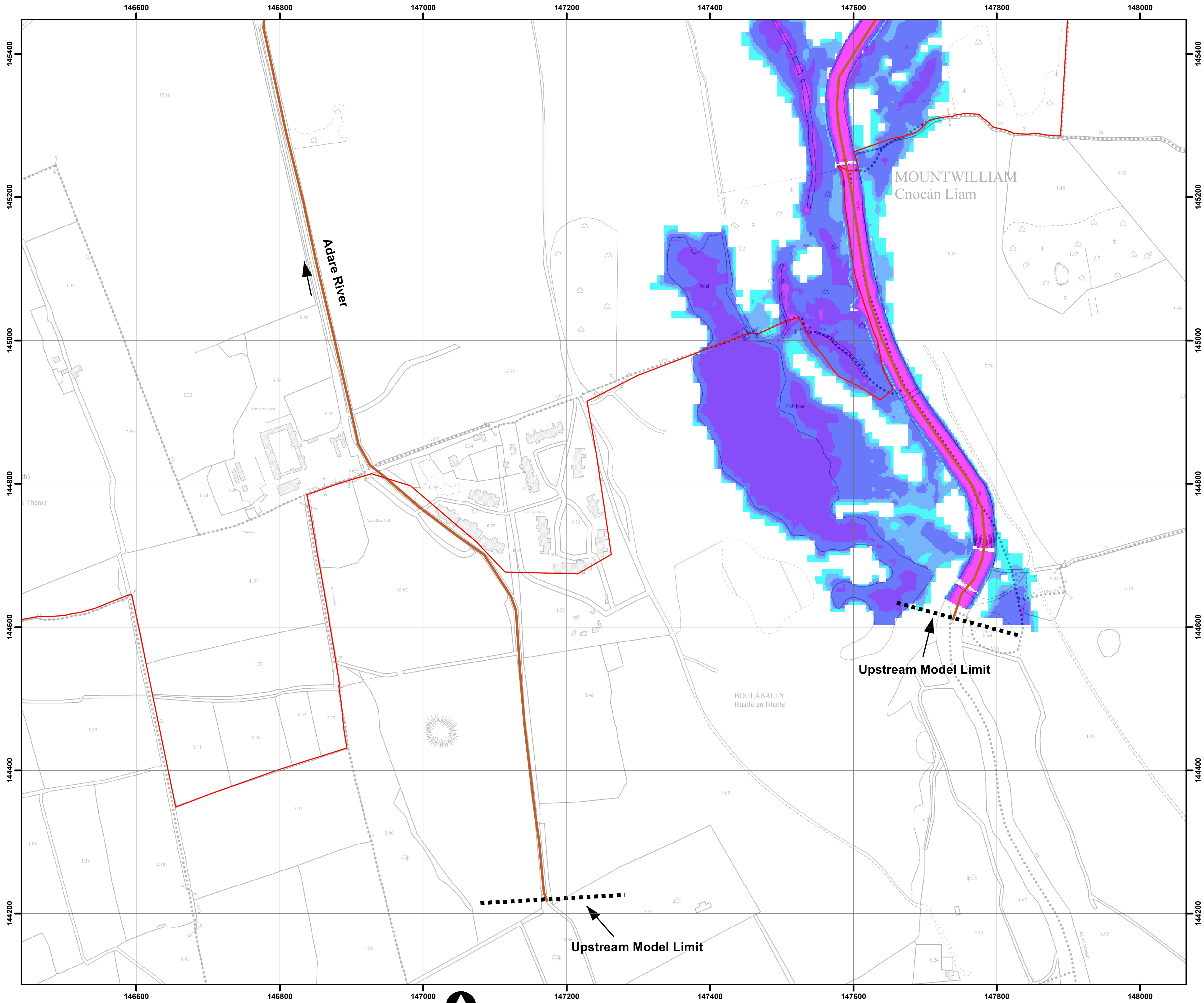
Map: FOYNES

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: FOYNES
Scenario: EXISTING

Drawn by:	EH	Date: December 2015
Checked by:	PT	Date: December 2015
Reviewed by:	MC	Date: December 2015
Approved by:	PS	Date: December 2015

Map No.:
S09FVCCDC1

Sheet: 4 of 4 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



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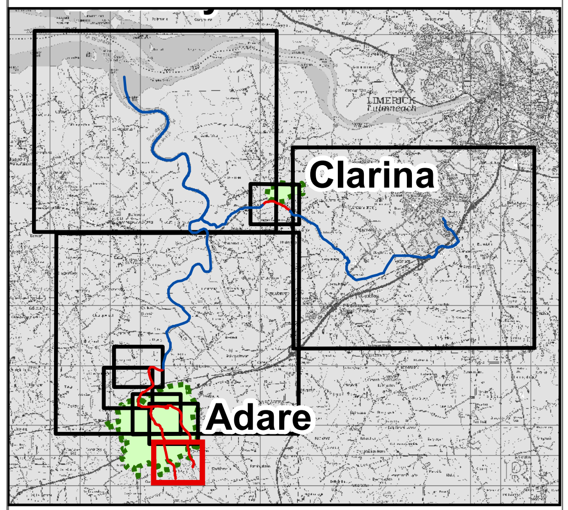
Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

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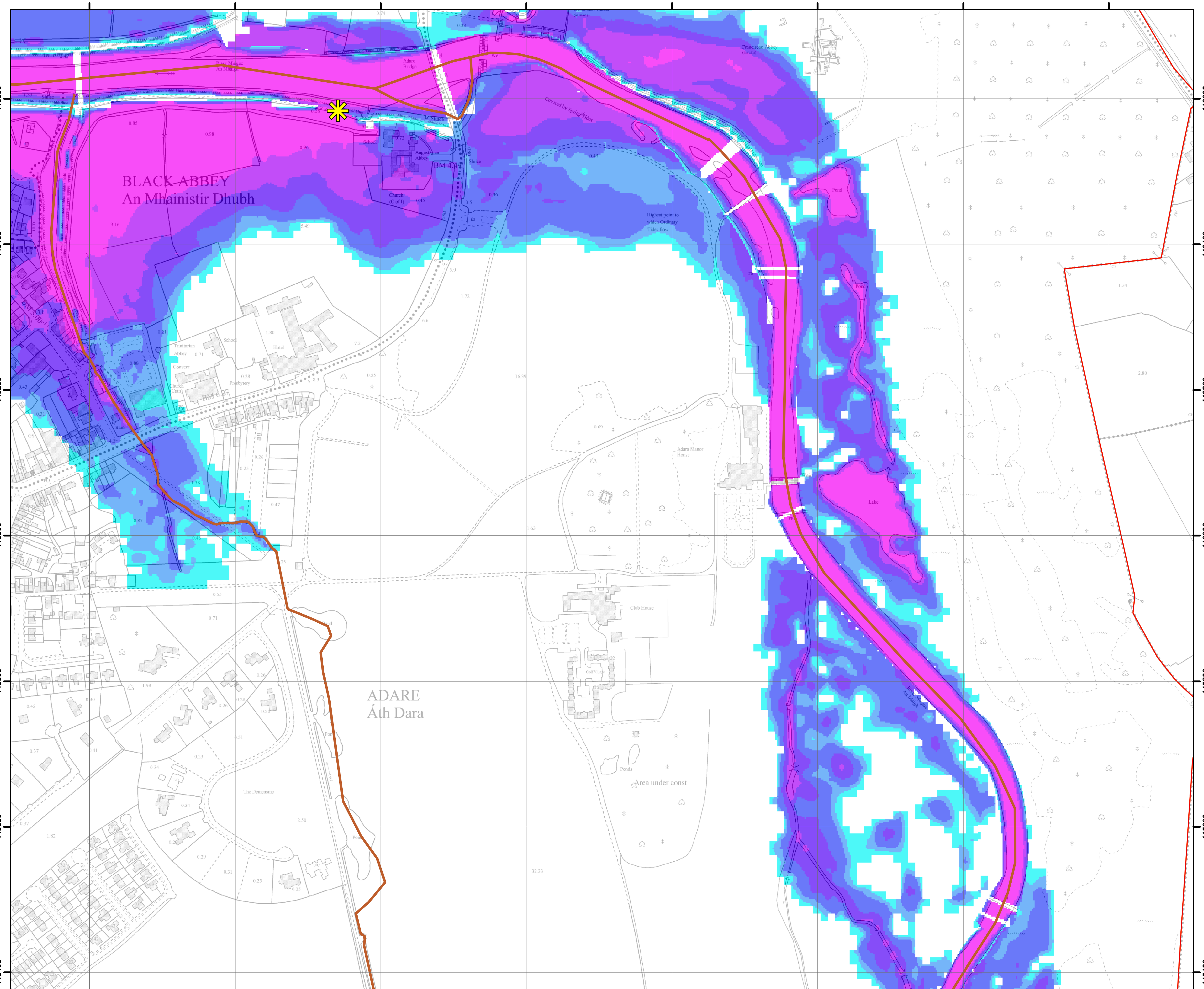
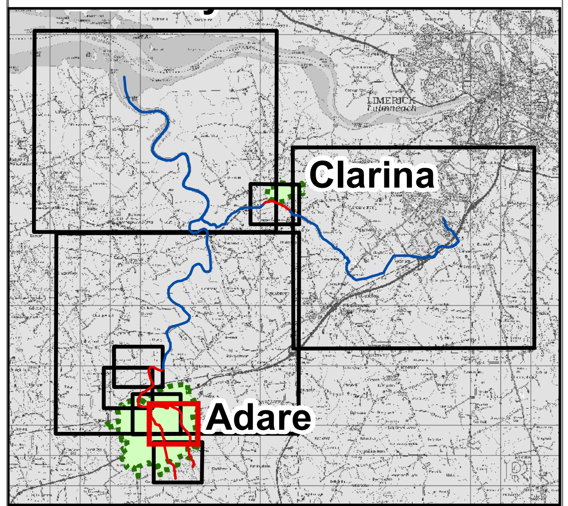
Project:
SHANNON CFRAM STUDY

Map: ADARE

Map Type: DEFENCE FAILURE EXTENT MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1	
Map area: ADARE	
Scenario: EXISTING	
Drawn by: EH	Date: December 2015
Checked by: PT	Date: December 2015
Reviewed by: MC	Date: December 2015
Approved by: PS	Date: December 2015
Map No.: S06FDCCDC1	
Sheet: 1 of 9	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

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Map: ADARE

Map Type: DEFENCE FAILURE EXTENT MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: ADARE
Scenario: EXISTING

Drawn by: EH	Date: December 2015
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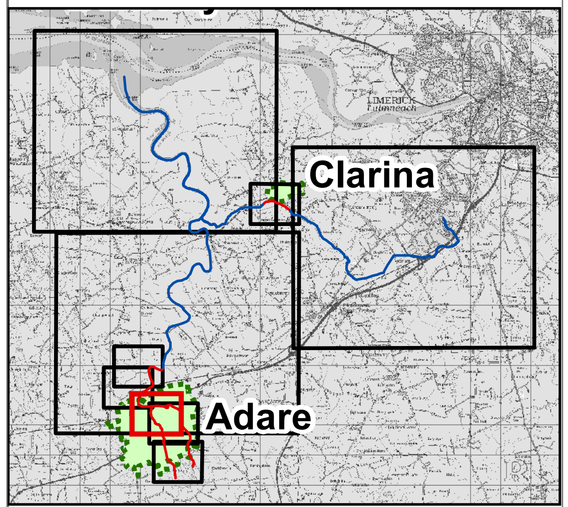
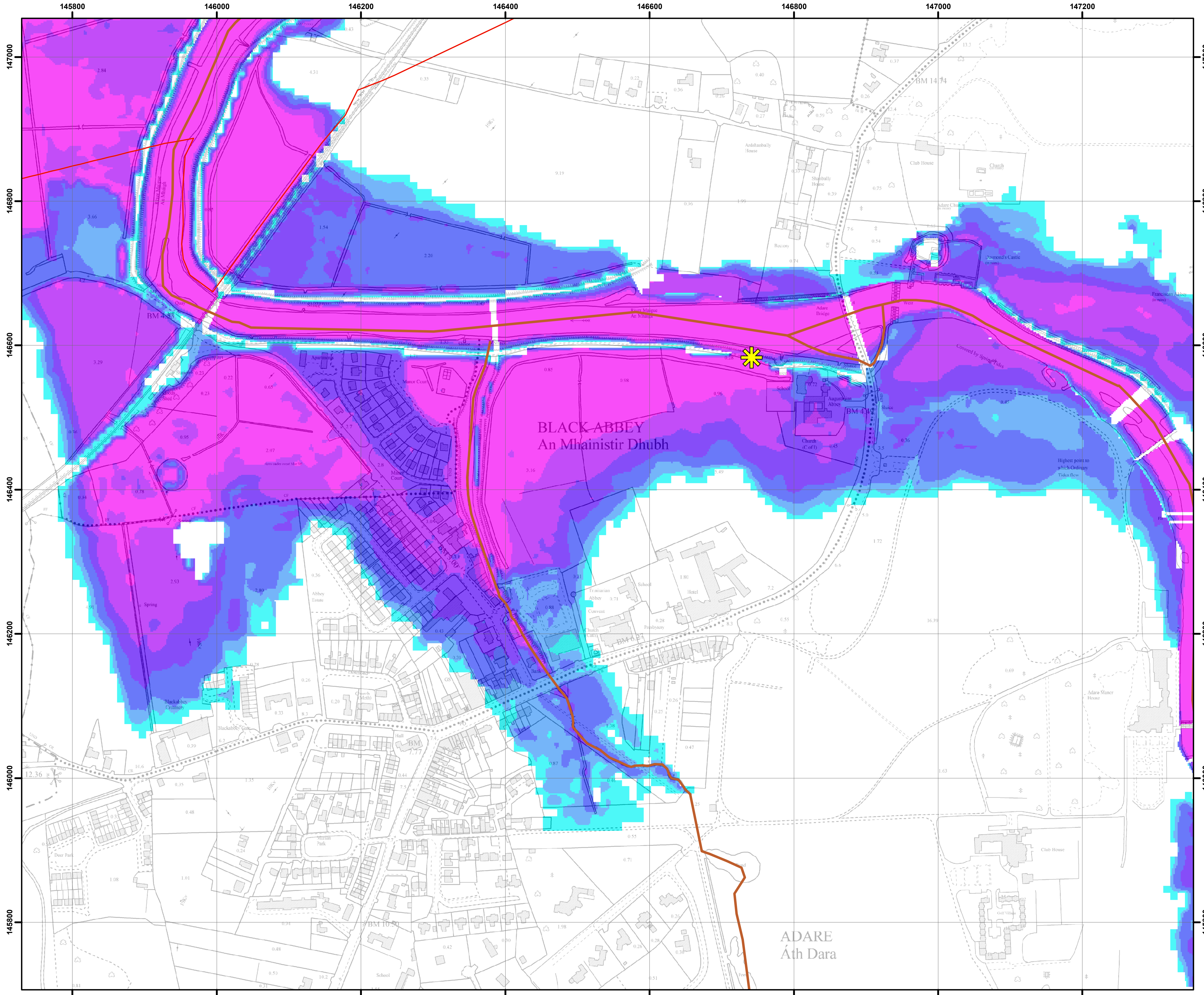
Approved by: PS	Date: December 2015

Map No.:
S06FDCCDC1

Sheet: 2 of 9 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3

Location Plan:





0 50 100 200 300 400 500 Metres

Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

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The Office of Public Works
Jonathan Swift Street
Trim
Co. Meath

Merrion House
Merrion Road
Dublin

Project:
SHANNON CFRAM STUDY

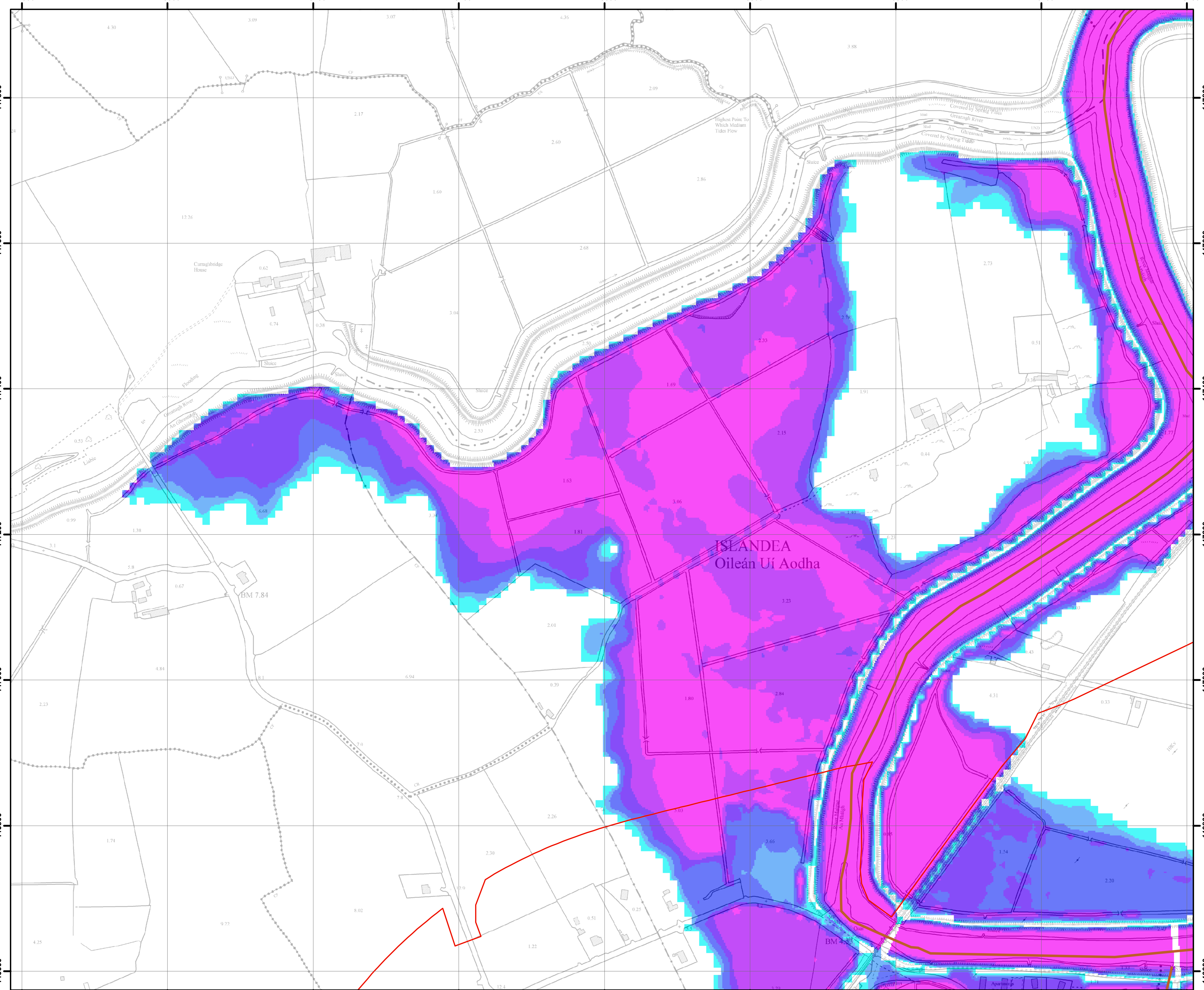
Map: ADARE

Map Type: DEFENCE FAILURE EXTENT MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: ADARE
Scenario: EXISTING

Drawn by:	EH	Date: December 2015
Checked by:	PT	Date: December 2015
Reviewed by:	MC	Date: December 2015
Approved by:	PS	Date: December 2015

Map No.:
S06FDCCDC1

Sheet: 3 of 9 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



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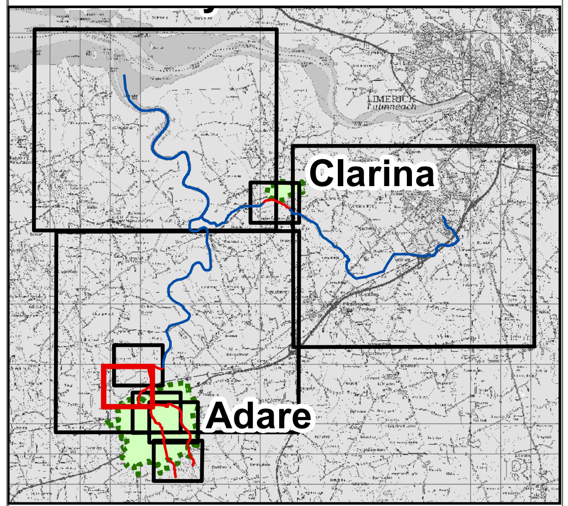
Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

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Project:
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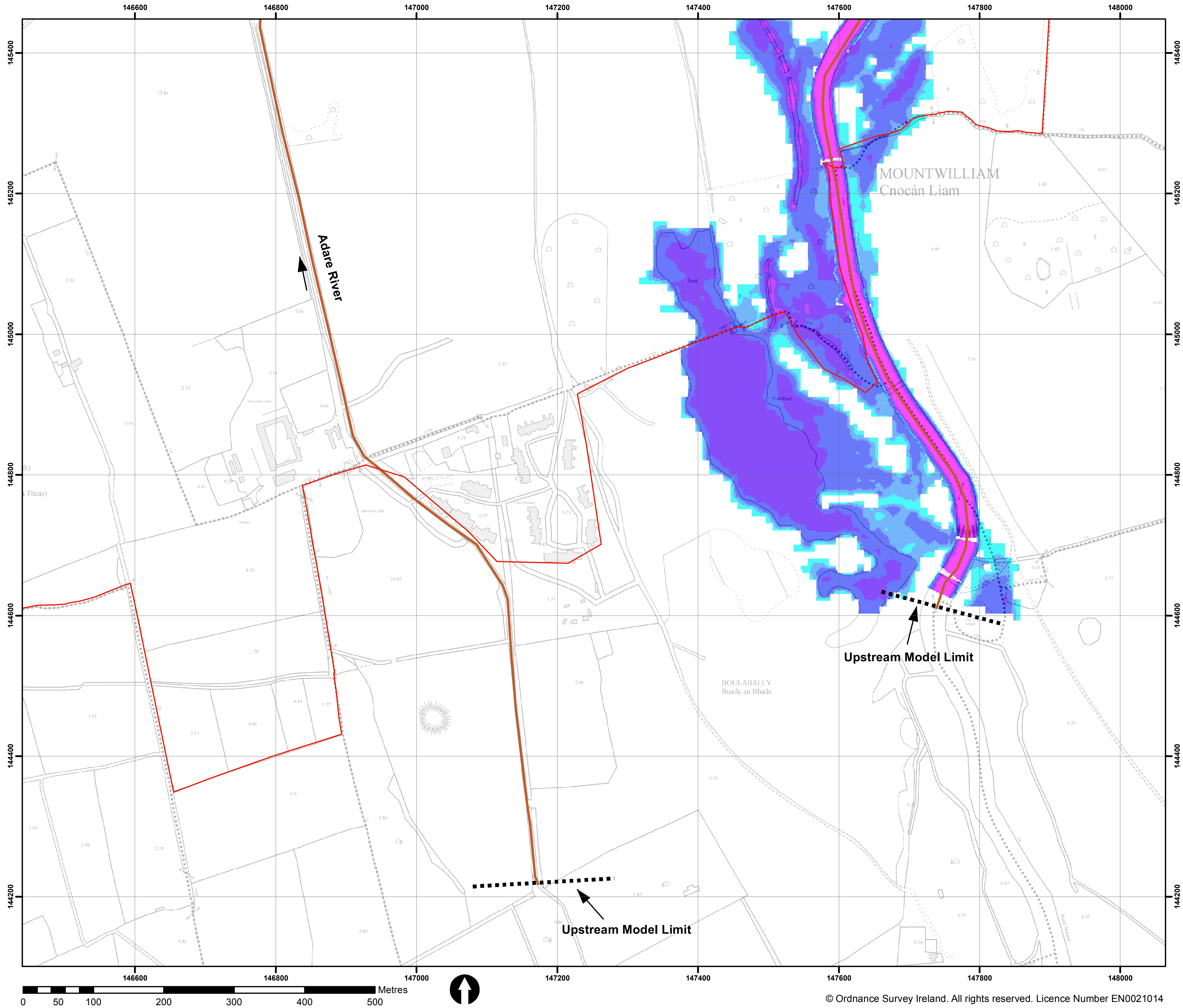
Map:
ADARE

Map Type: DEFENCE FAILURE EXTENT MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: ADARE
Scenario: EXISTING

Drawn by: EH	Date: December 2015
Checked by: PT	Date: December 2015
Reviewed by: MC	Date: December 2015
Approved by: PS	Date: December 2015

Map No.:
S06FDCCDC1

Sheet: 4 of 9 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 2 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

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Project:
SHANNON CFRAM STUDY

Map: ADARE

Map Type: DEFENCE FAILURE DEPTH MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: ADARE
Scenario: EXISTING

Drawn by: EH	Date: December 2015
Checked by: PT	Date: December 2015
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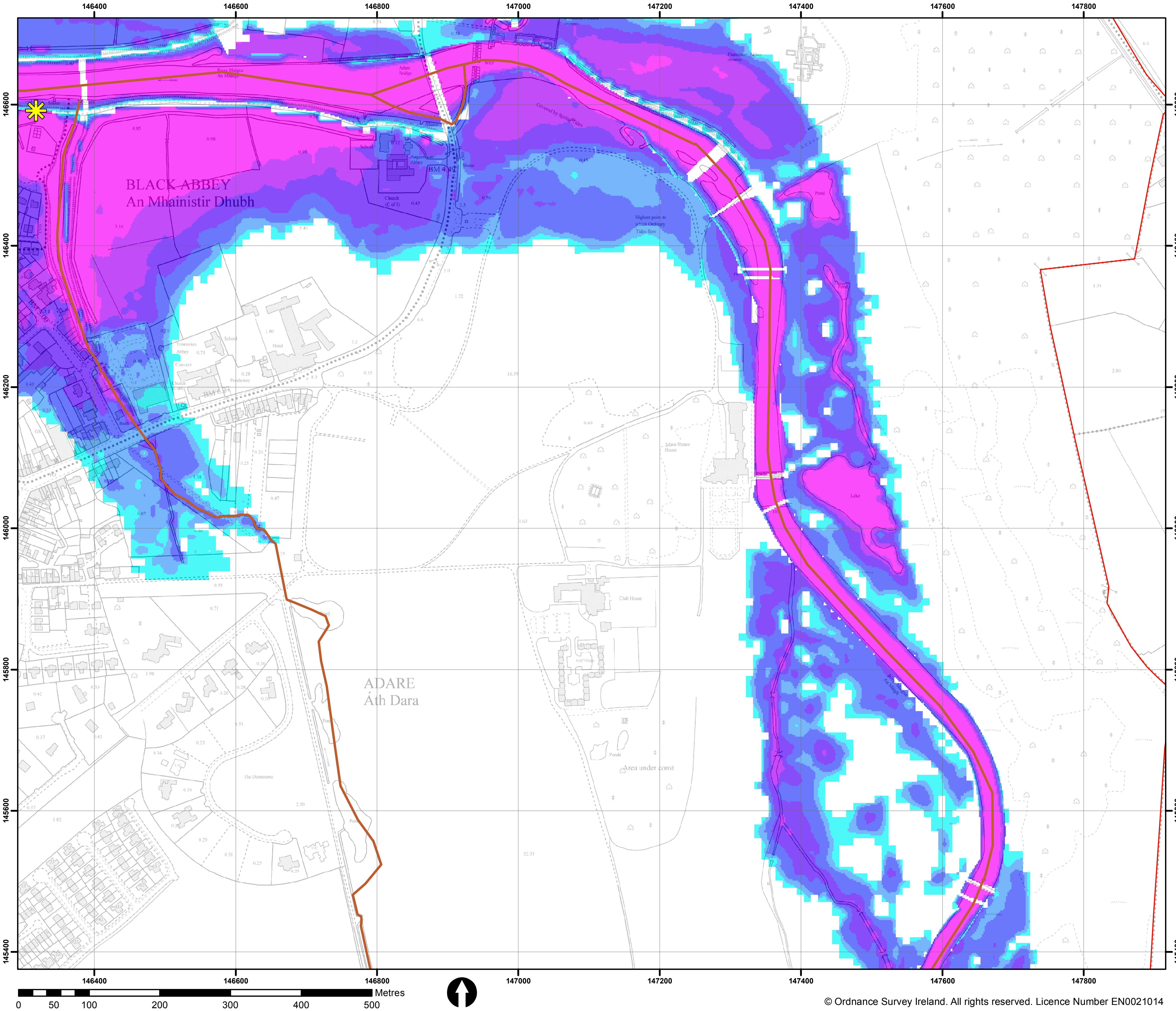
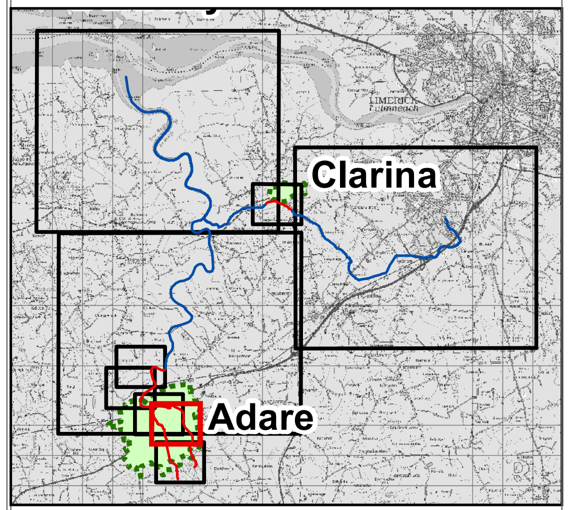
Map No.:
S06FDCCDC1

Sheet: 1 of 9 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 2 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

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Map: ADARE

Map Type: DEFENCE FAILURE DEPTH MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: ADARE
Scenario: EXISTING

Drawn by: EH	Date: December 2015
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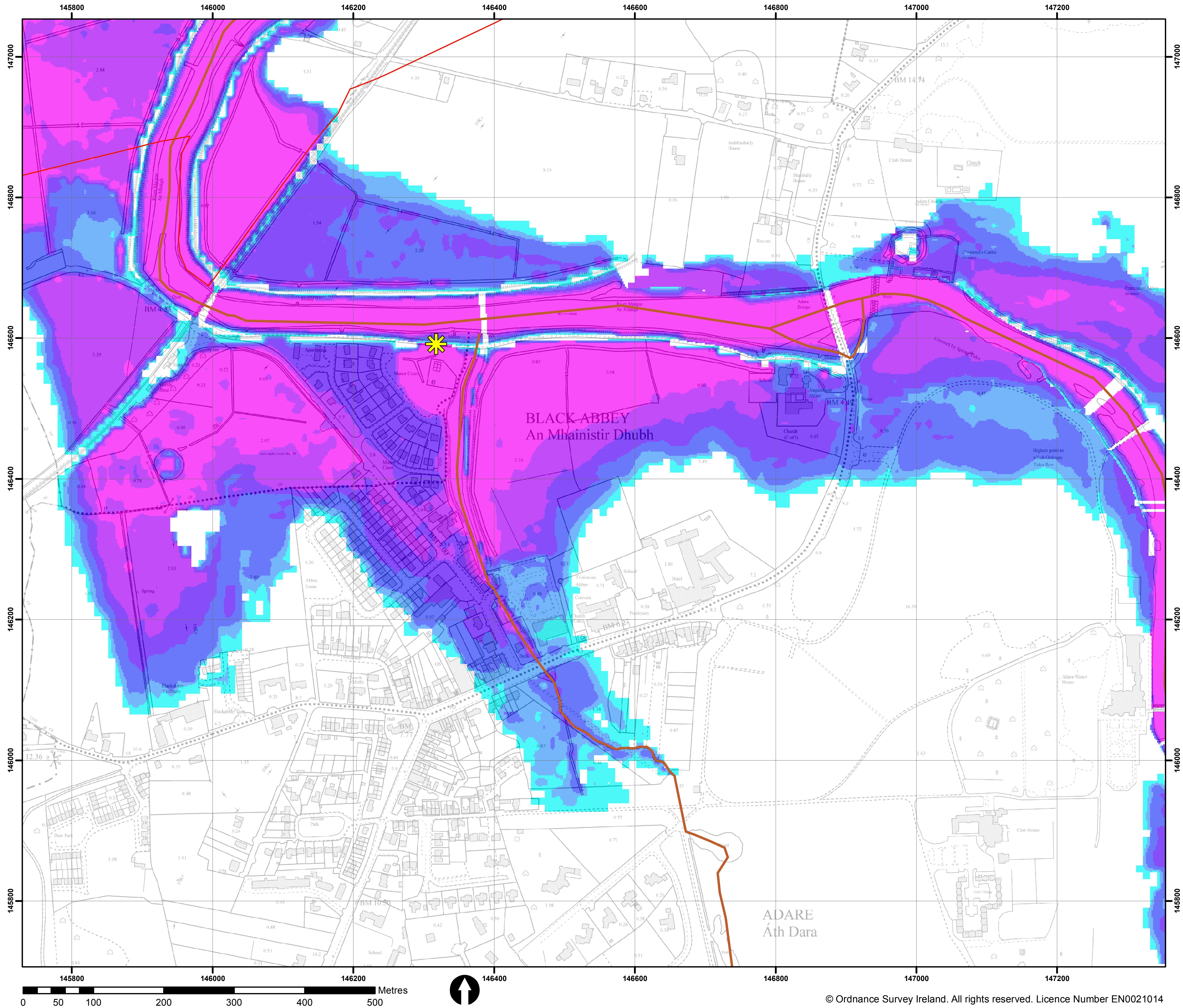
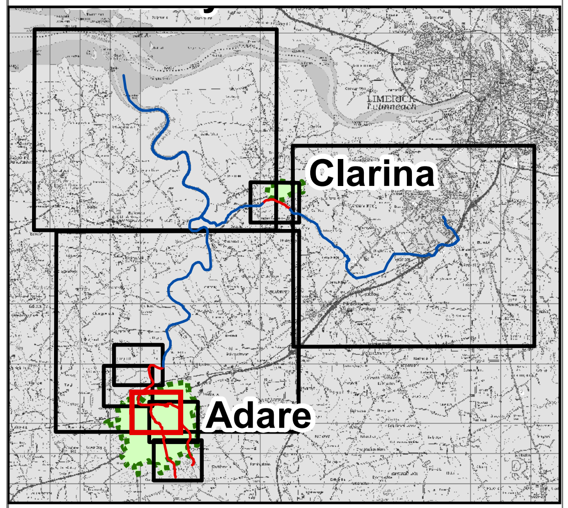
Map No.:
S06FDCCDC1

Sheet: 2 of 9 — Revision: 0
Map Scale: 1: 5000 — Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 2 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
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Map: ADARE

Map Type: DEFENCE FAILURE DEPTH MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: ADARE
Scenario: EXISTING

Drawn by: EH	Date: December 2015
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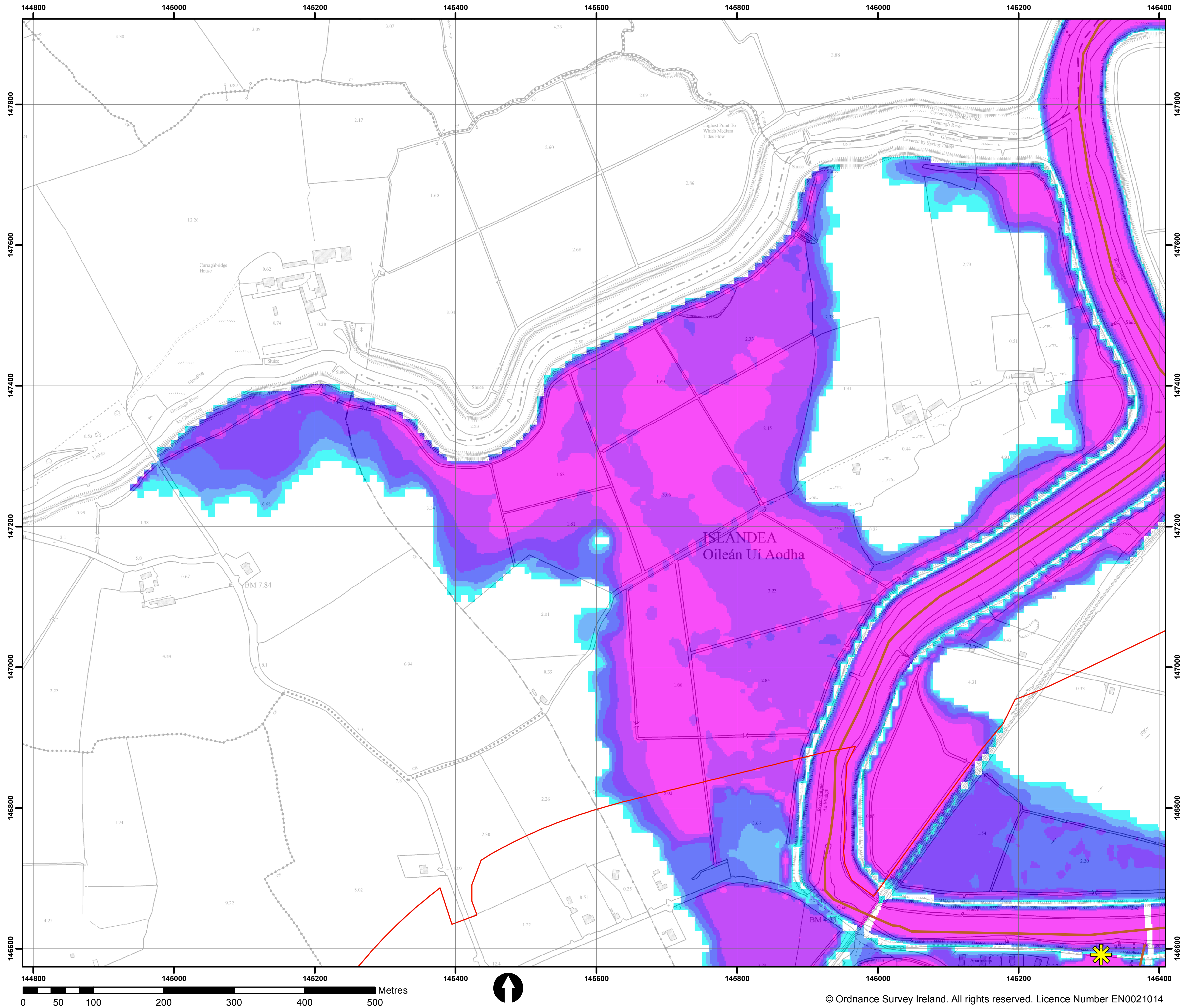
Map No.: S06FDCCDC1

Sheet: 3 of 9 Revision: 0

Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Metres
0 50 100 200 300 400 500

Location Plan:

Clarina
Adare

Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 2 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
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Map: ADARE

Map Type: DEFENCE FAILURE DEPTH MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: ADARE
Scenario: EXISTING

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Sheet: 4 of 9 | Revision: 0
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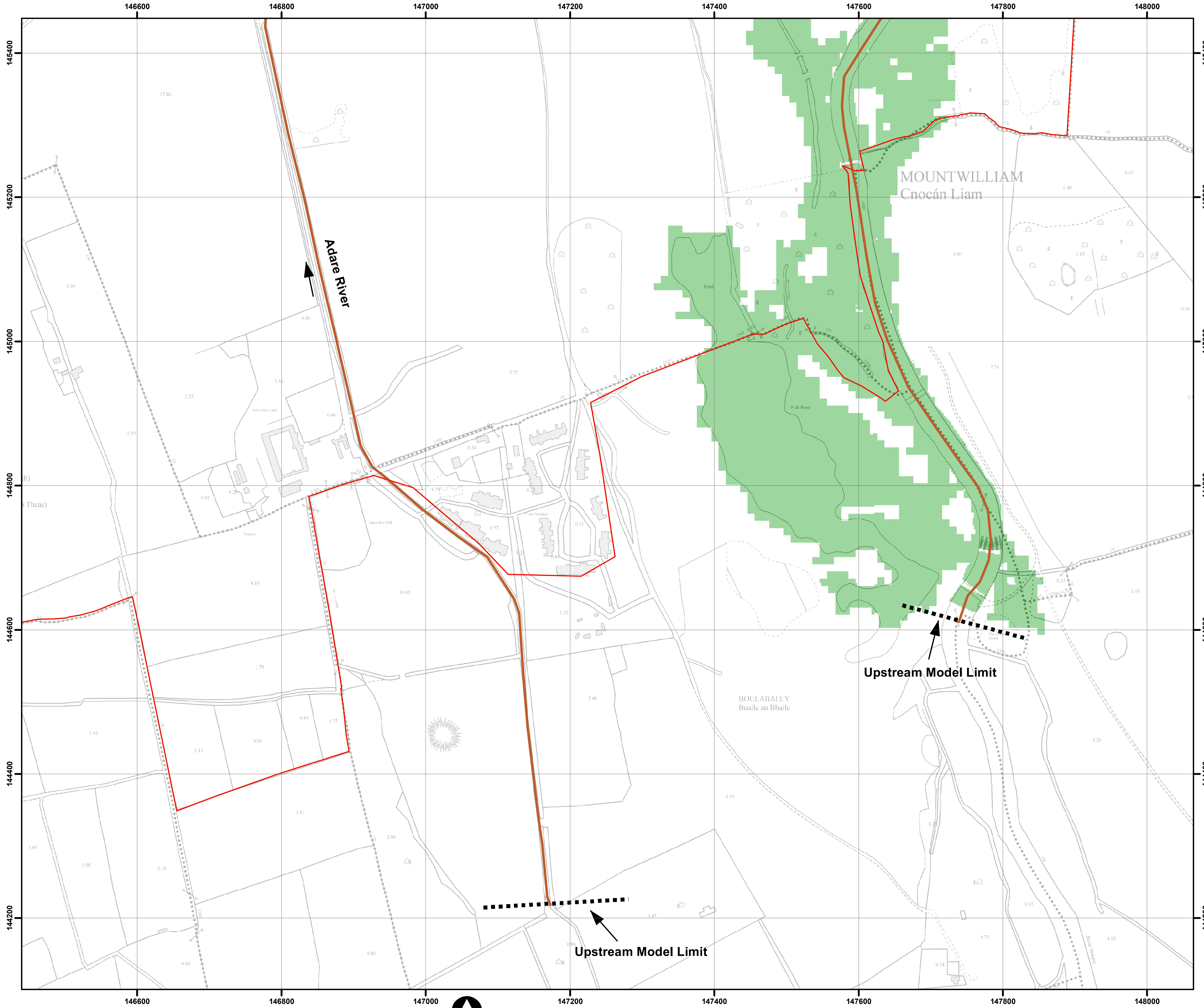
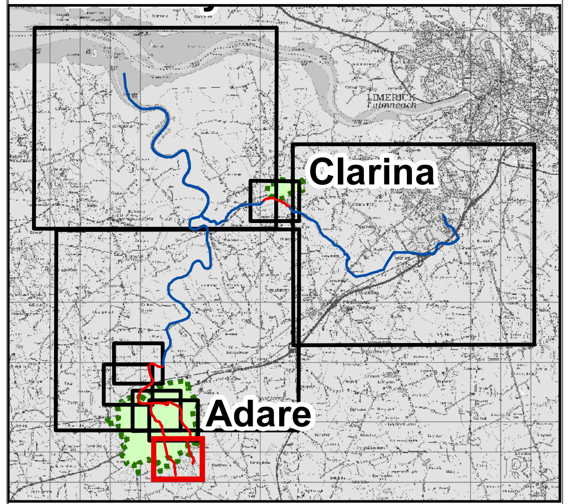


0 50 100 200 300 400 500 Metres

Location Plan:



Legend:

- River Centreline
- AFA Boundary
- Defence - Embankment
- Defence Failure Location
- 0.5% AEP Coastal Failure Scenario 1

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Map: ADARE

Map Type: DEFENCE FAILURE EXTENT MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: ADARE
Scenario: EXISTING

Drawn by:	EH	Date: December 2015
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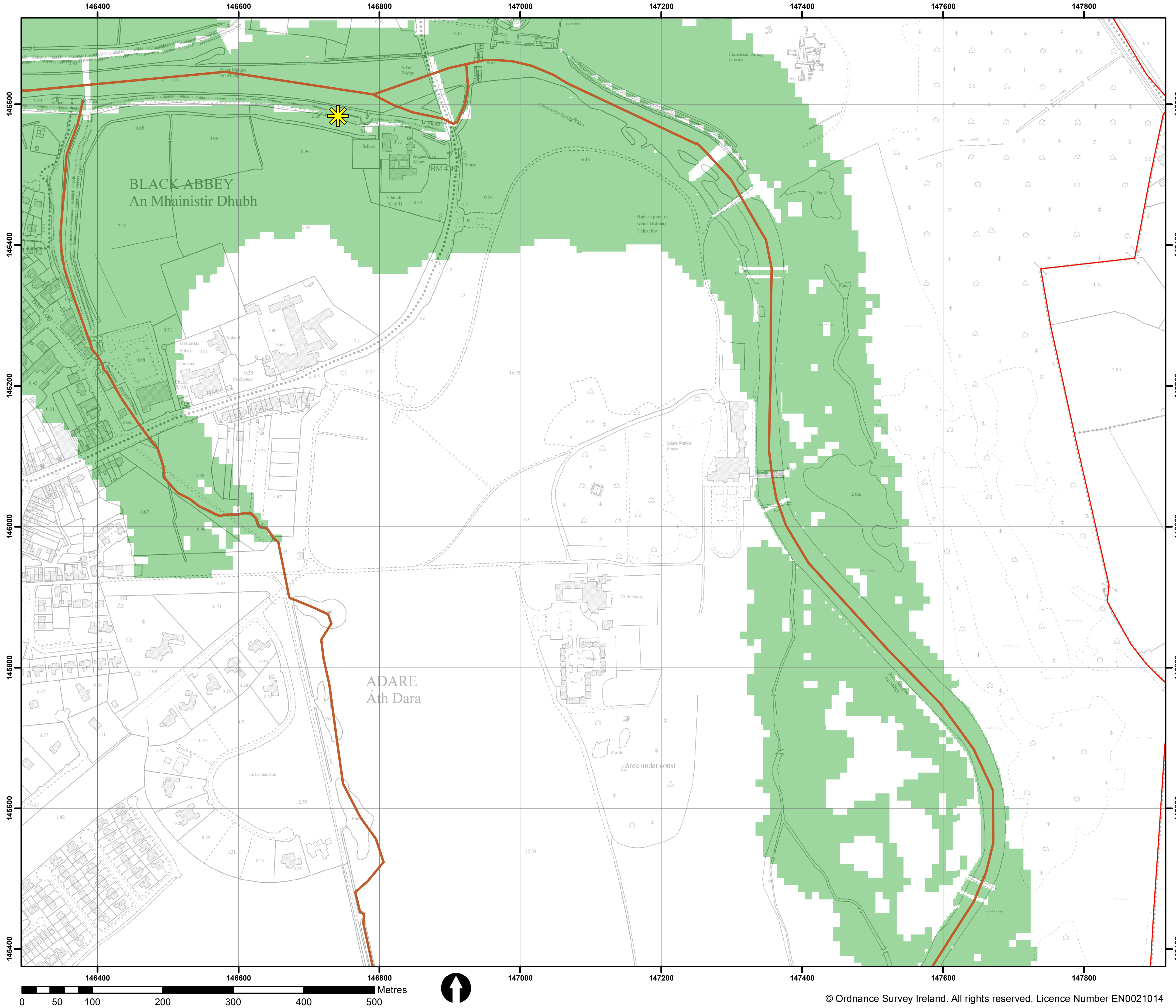
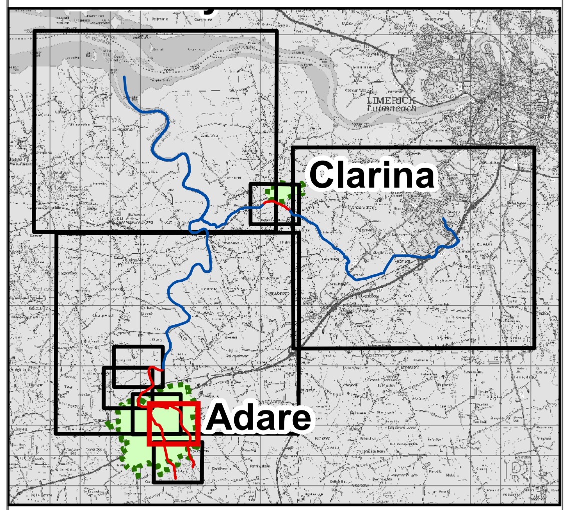
Map No.:
S06FECCDC1

Sheet: 1 of 9 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- River Centreline
- AFA Boundary
- Defence - Embankment
- Defence Failure Location
- 0.5% AEP Coastal Failure Scenario 1

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Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: ADARE
Scenario: EXISTING

Drawn by: EH	Date: December 2015
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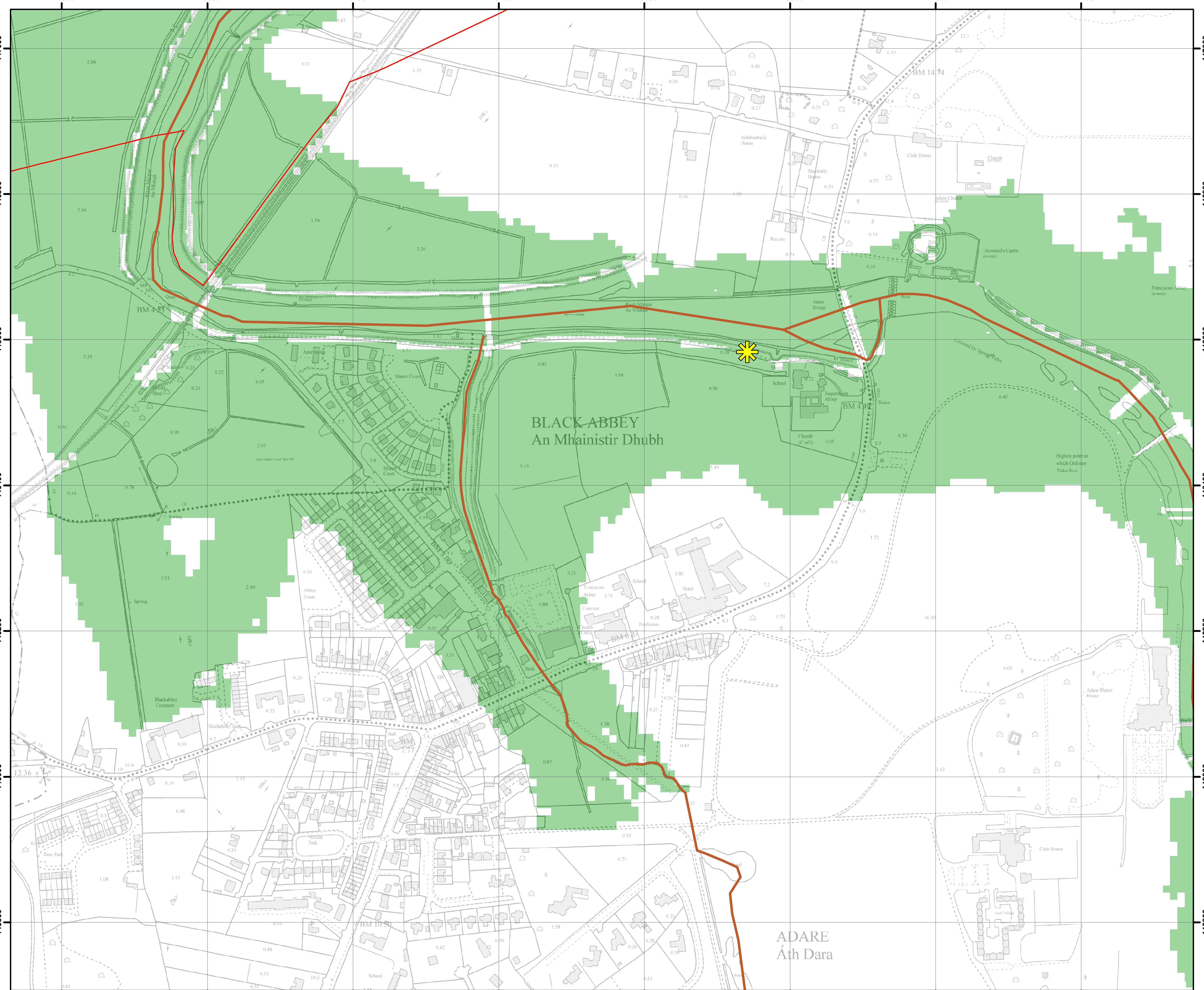
Map No.: S06FECCDC1
Sheet: 2 of 9 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



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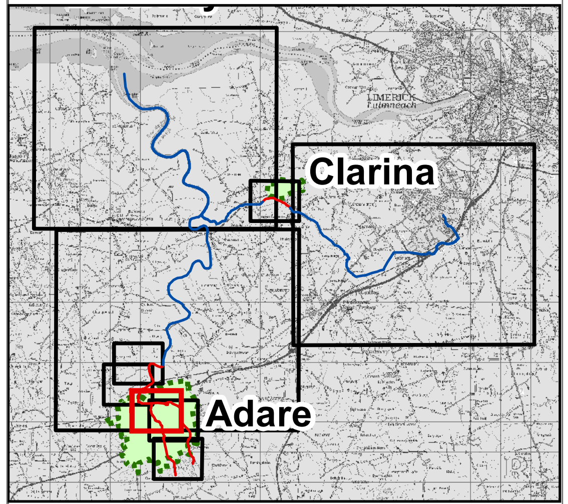
Location Plan:



Legend:

- River Centreline
- AFA Boundary
- Defence - Embankment
- Defence Failure Location
- 0.5% AEP Coastal Failure Scenario 1

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Map Type: DEFENCE FAILURE EXTENT MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
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Scenario: EXISTING

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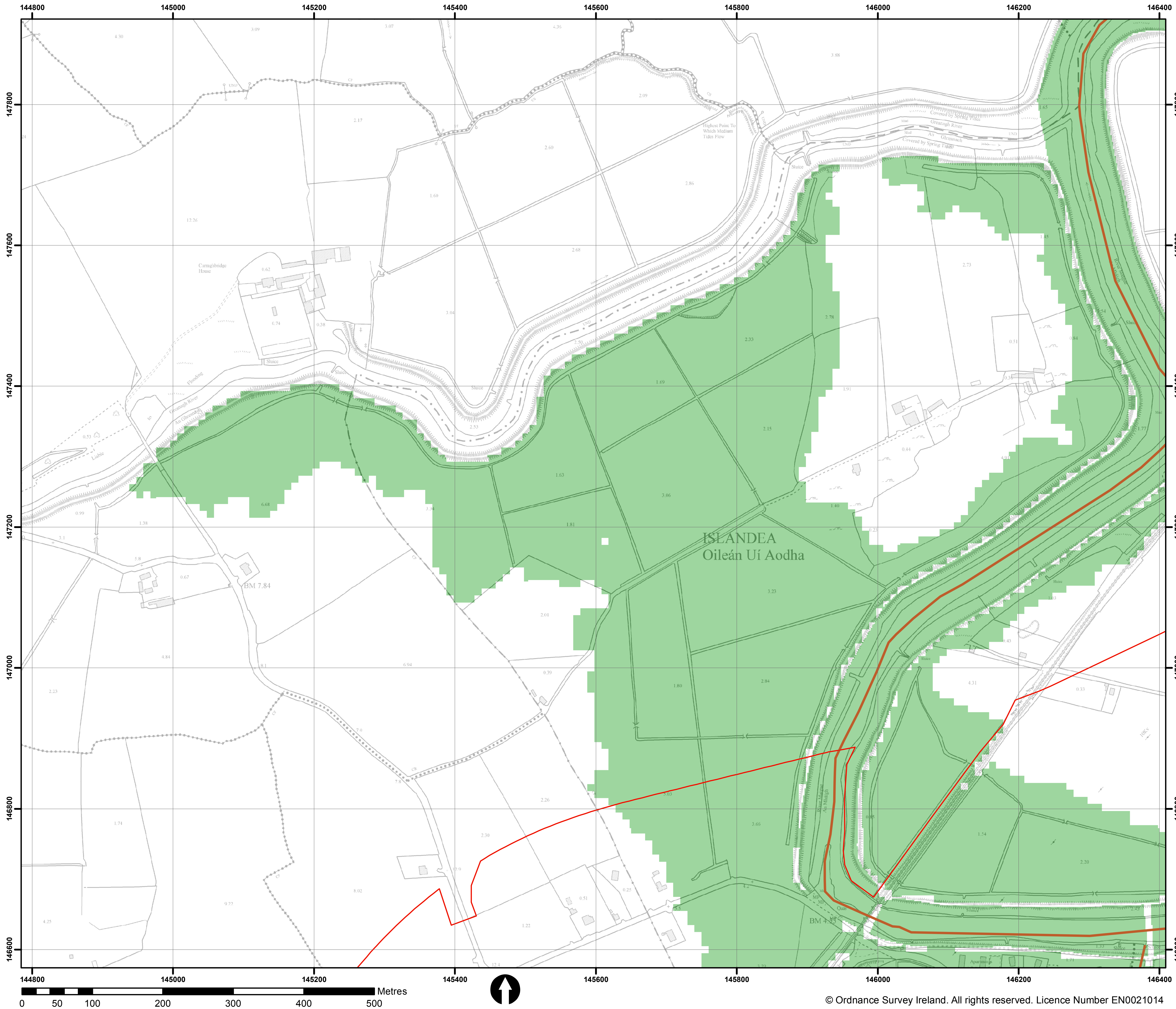
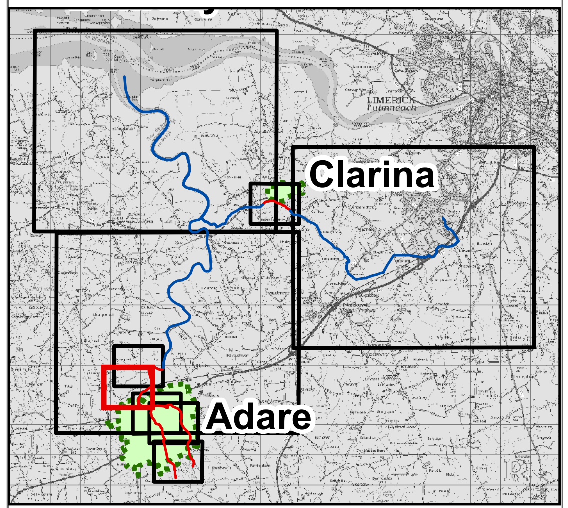
Map No.:
S06FECCDC1

Sheet: 3 of 9 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- River Centreline
- AFA Boundary
- Defence - Embankment
- Defence Failure Location
- 0.5% AEP Coastal Failure Scenario 1

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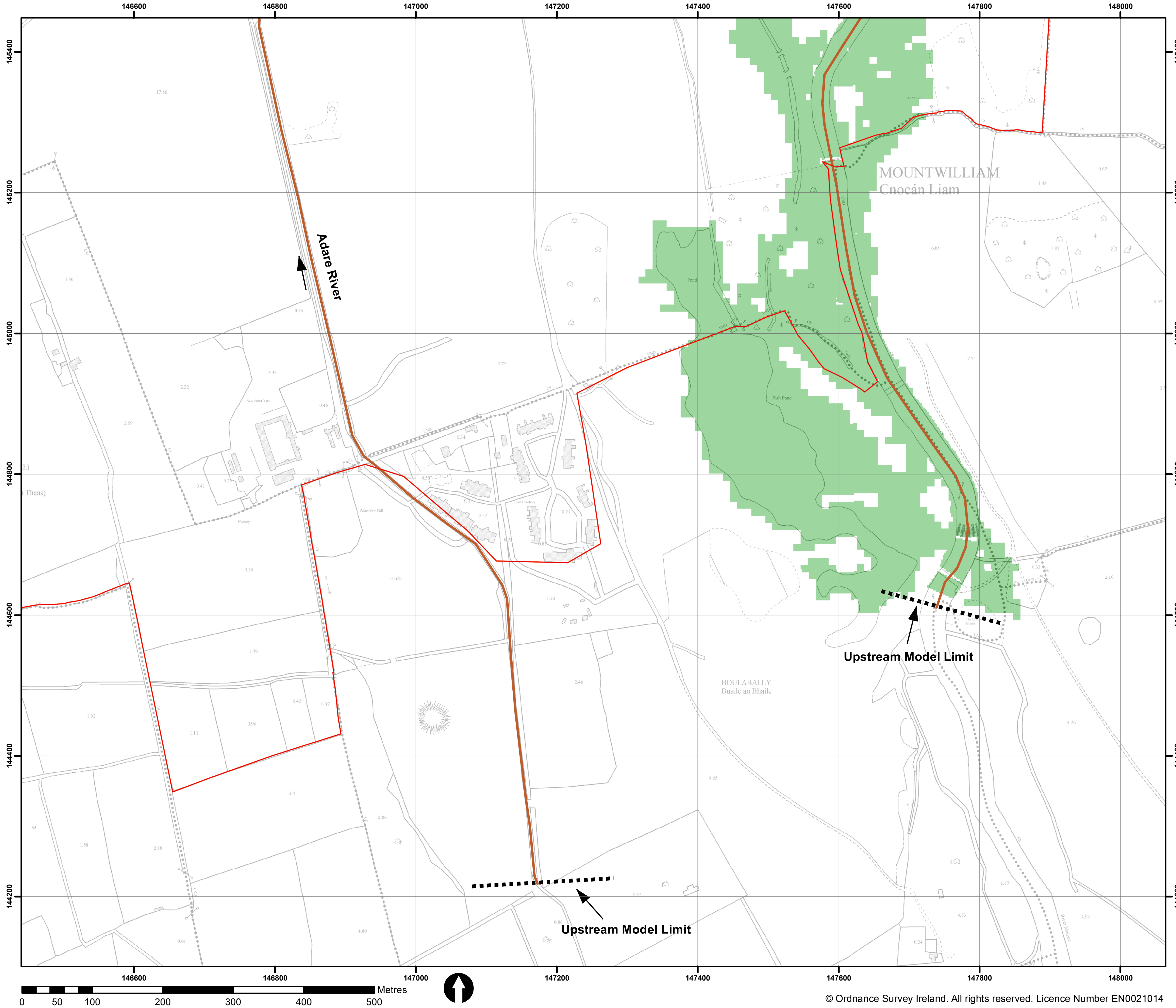
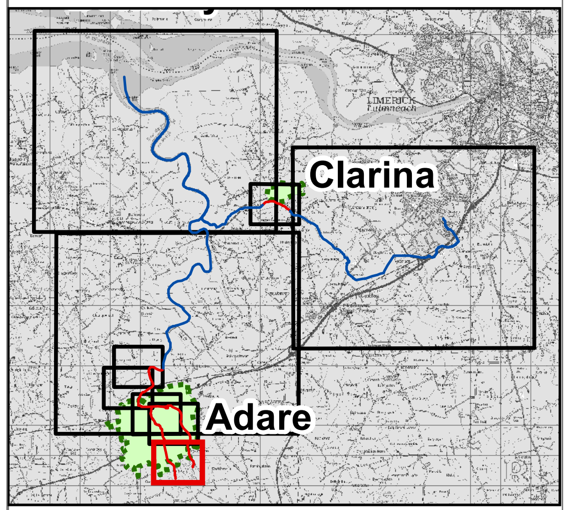
Project:
SHANNON CFRAM STUDY

Map: ADARE

Map Type: DEFENCE FAILURE EXTENT MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1	
Map area: ADARE	
Scenario: EXISTING	
Drawn by: EH	Date: December 2015
Checked by: PT	Date: December 2015
Reviewed by: MC	Date: December 2015
Approved by: PS	Date: December 2015
Map No.: S06FECCDC1	
Sheet: 4 of 9	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- River Centreline
- AFA Boundary
- Defence - Embankment
- Defence Failure Location
- 0.5% AEP Coastal Failure Scenario 2

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Project:
SHANNON CFRAM STUDY

Map: ADARE

Map Type: DEFENCE FAILURE EXTENT MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: ADARE
Scenario: EXISTING

Drawn by:	EH	Date: December 2015
Checked by:	PT	Date: December 2015
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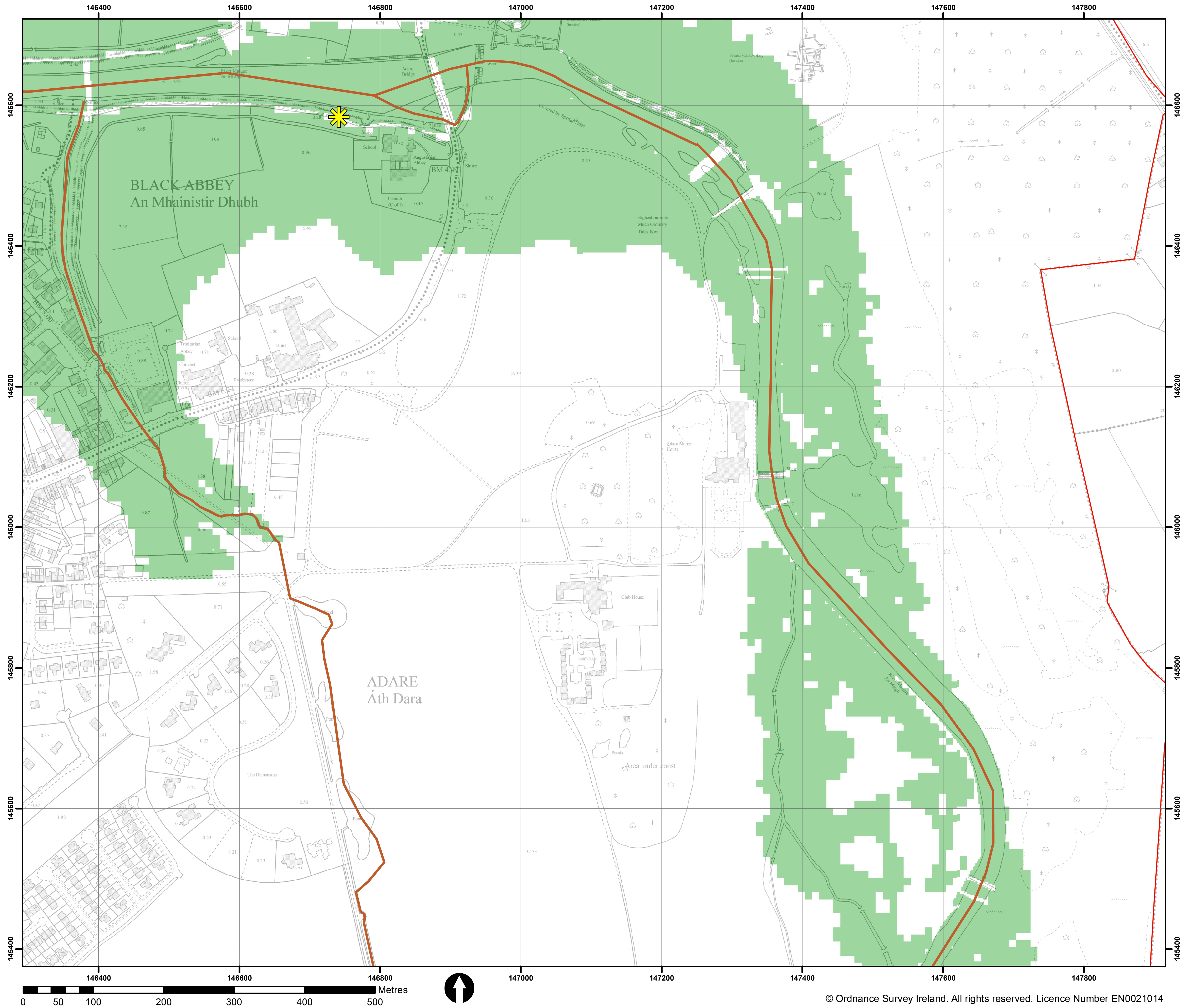
Approved by:	PS	Date: December 2015

Map No.:
S06FECCDC1

Sheet: 1 of 9 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Legend:

- River Centreline
- AFA Boundary
- Defence - Embankment
- Defence Failure Location
- 0.5% AEP Coastal Failure Scenario 2

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Project: SHANNON CFRAM STUDY

Map: ADARE

Map Type: DEFENCE FAILURE EXTENT MAP

Source: 0.5% AEP COASTAL FAILURE SCENARIO 2

Map area: ADARE

Scenario: EXISTING

Drawn by: EH	Date: December 2015
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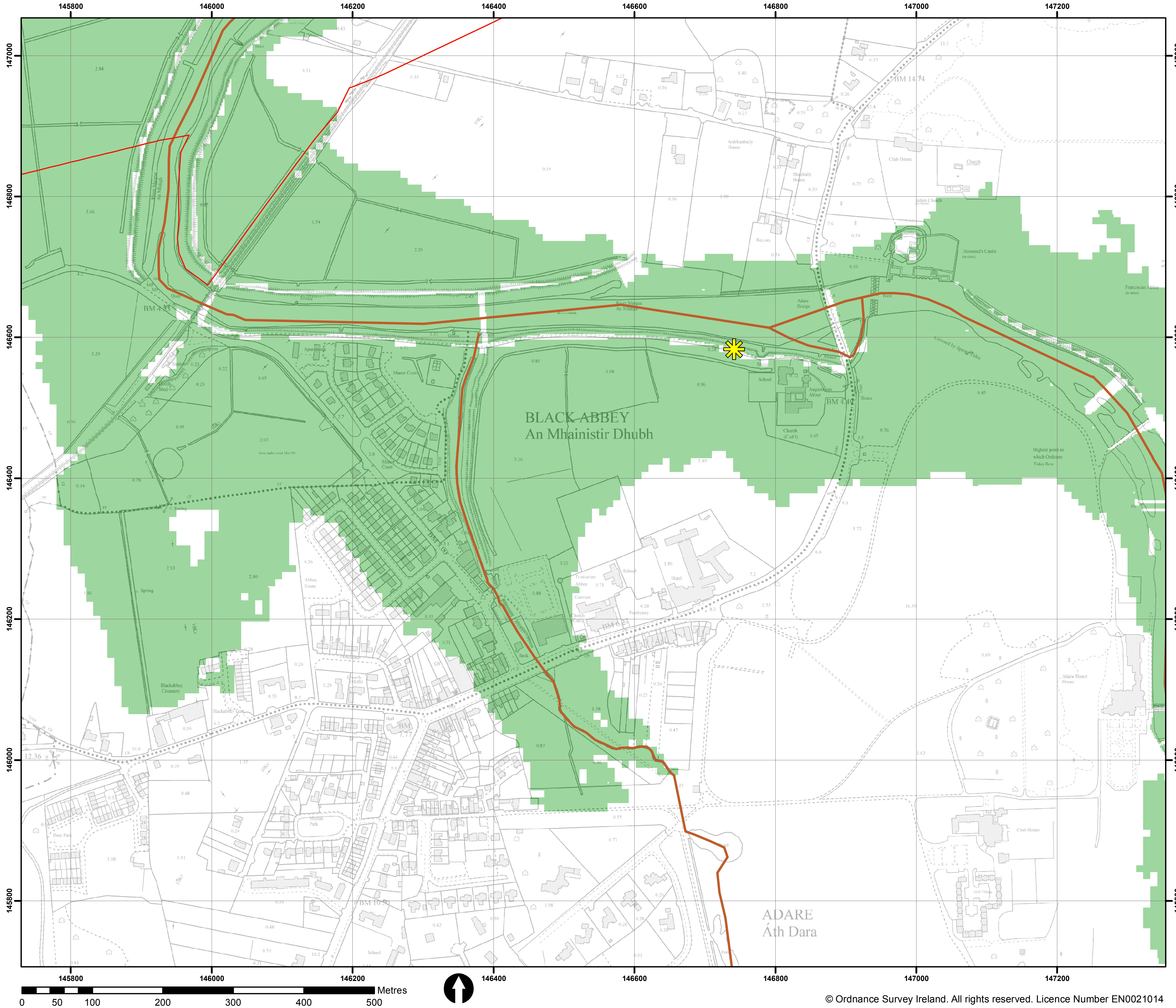
Approved by: PS	Date: December 2015

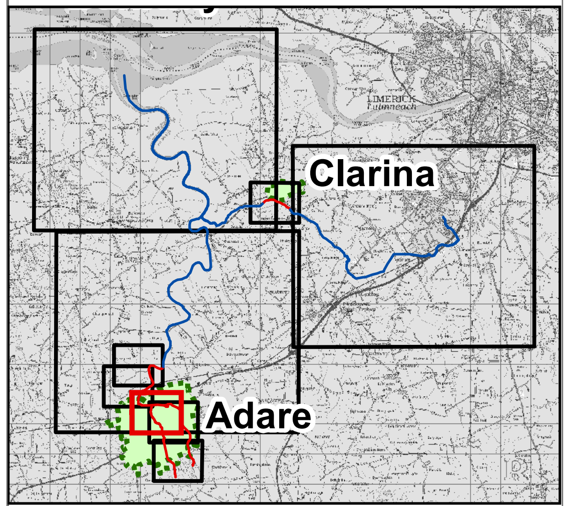
Map No.: S06FECCDC1

Sheet: 2 of 9 Revision: 0

Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- River Centreline
- AFA Boundary
- Defence - Embankment
- Defence Failure Location
- 0.5% AEP Coastal Failure Scenario 2

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Map Type: DEFENCE FAILURE EXTENT MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: ADARE
Scenario: EXISTING

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Reviewed by: MC	Date: December 2015
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Map No.:
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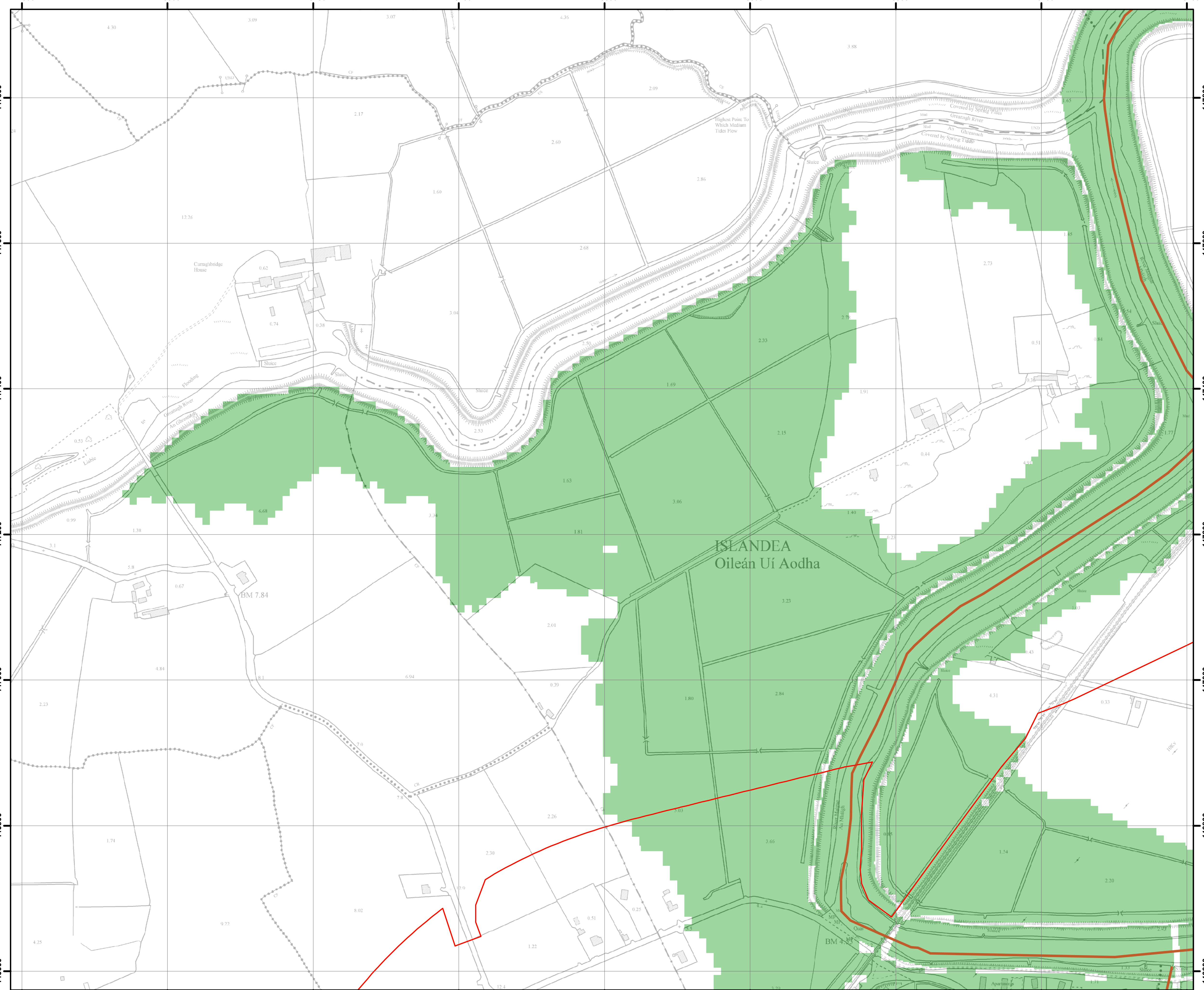
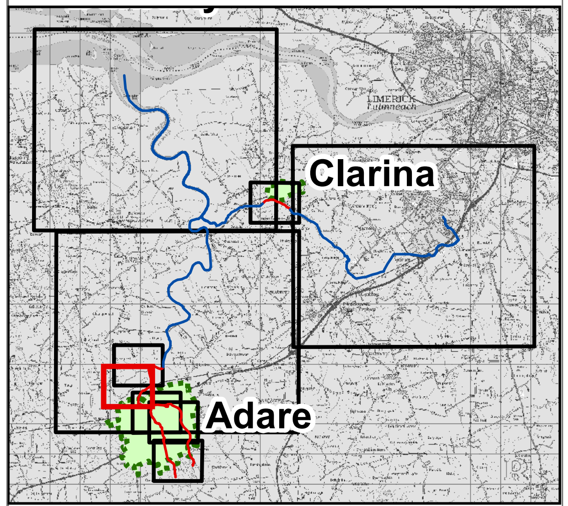
Sheet: 3 of 9 Revision: 0

Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



0 50 100 200 300 400 500 Metres

Location Plan:



Legend:

- River Centreline
- AFA Boundary
- Defence - Embankment
- Defence Failure Location
- 0.5% AEP Coastal Failure Scenario 2

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Map area: ADARE
Scenario: EXISTING

Drawn by:	EH	Date: December 2015
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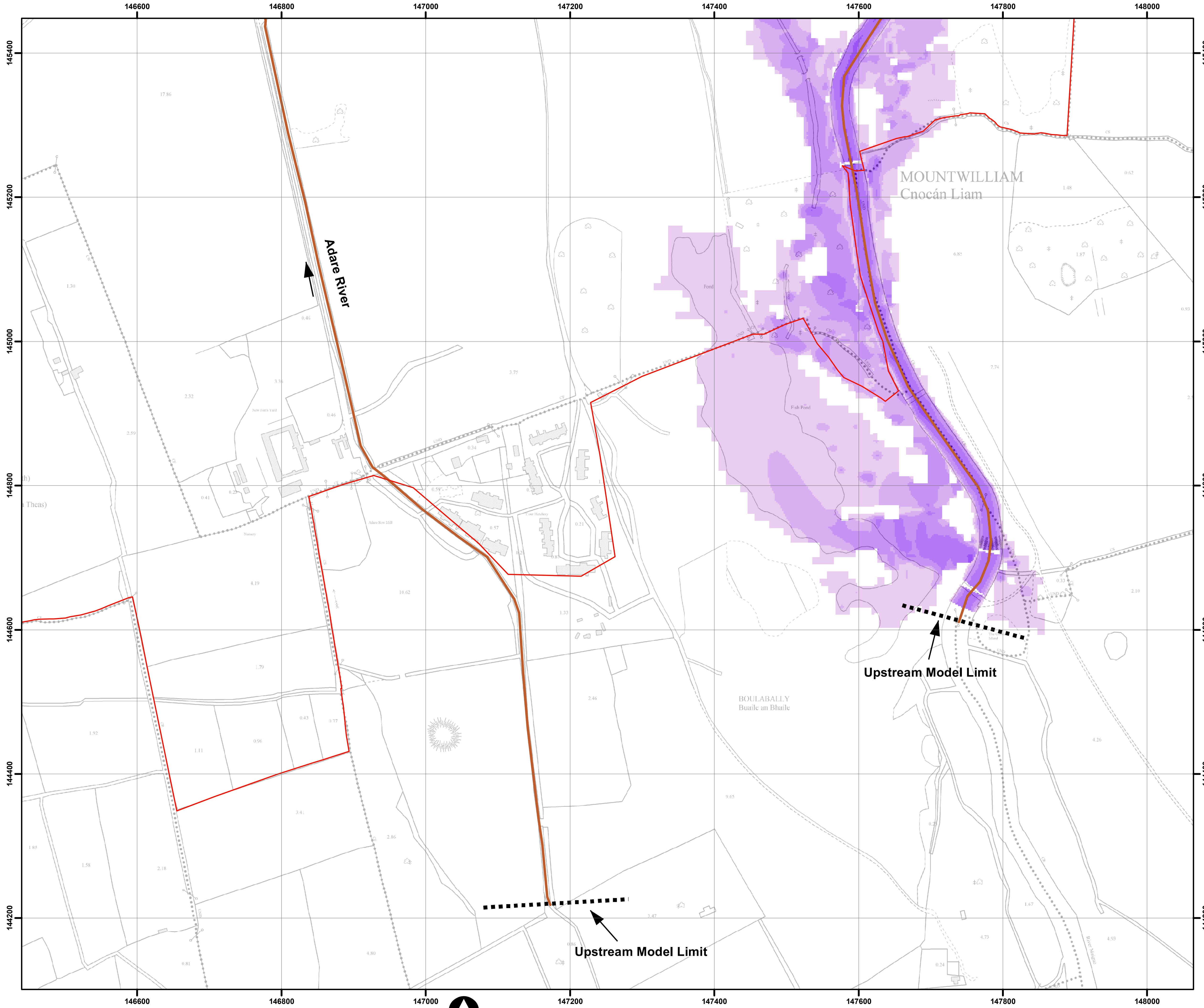
Approved by:	PS	Date: December 2015

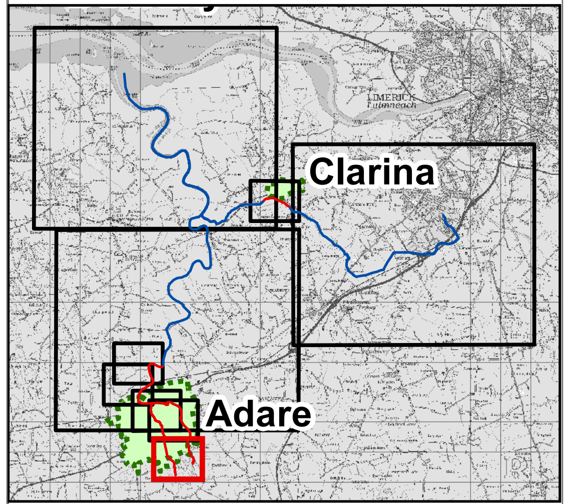
Map No.:
S06FECCDC1

Sheet: 4 of 9 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



0 50 100 200 300 400 500 Metres

Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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Project:
SHANNON CFRAM STUDY

Map: ADARE

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: ADARE
Scenario: EXISTING

Drawn by: EH	Date: December 2015
Checked by: PT	Date: December 2015
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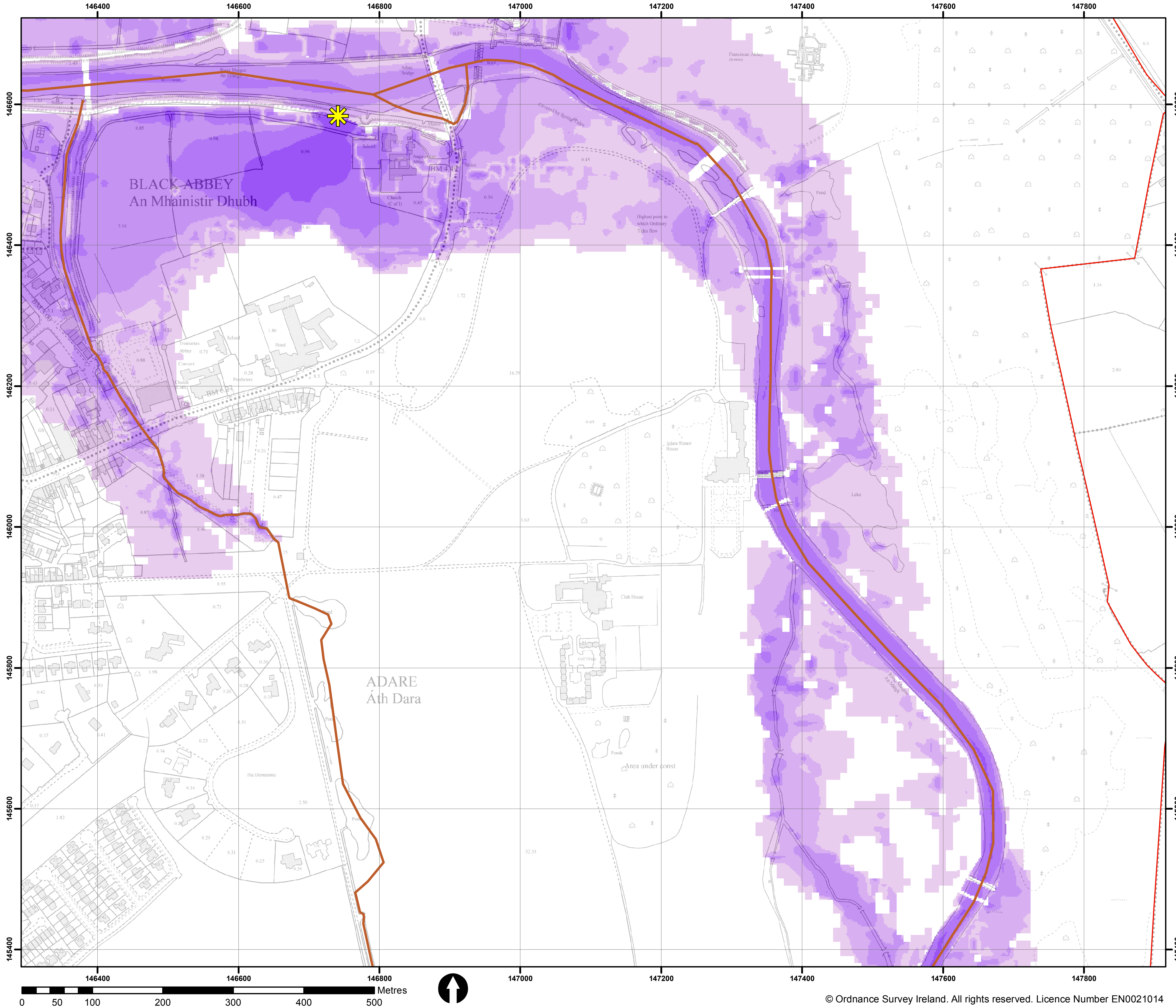
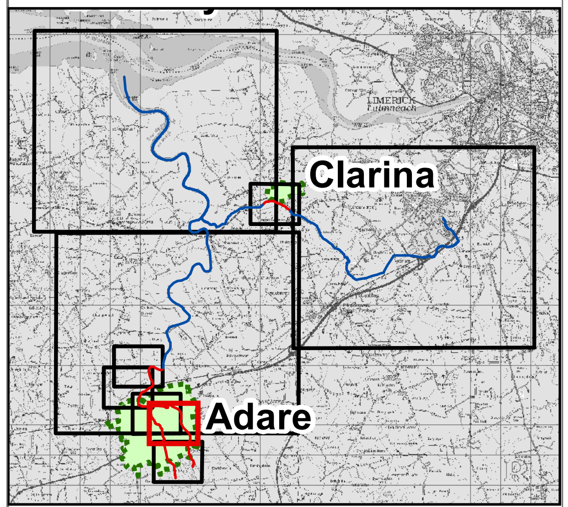
Approved by: PS	Date: December 2015

Map No.:
S06FVCCDC1

Sheet: 1 of 9 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m/s)

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- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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Scenario:	EXISTING
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Reviewed by: MC	Date: December 2015
Approved by: PS	Date: December 2015
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Sheet: 2 of 9	Revision: 0
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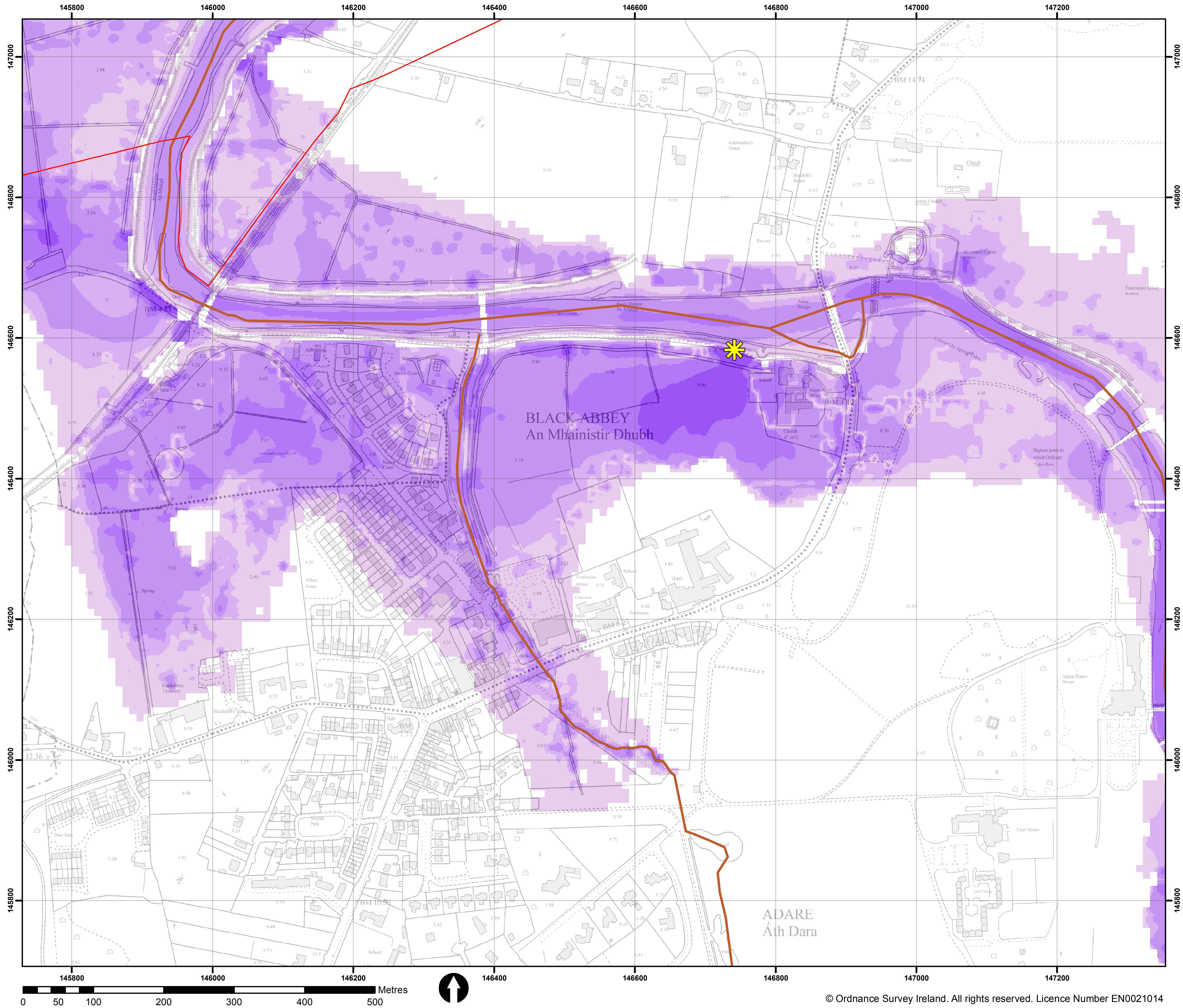

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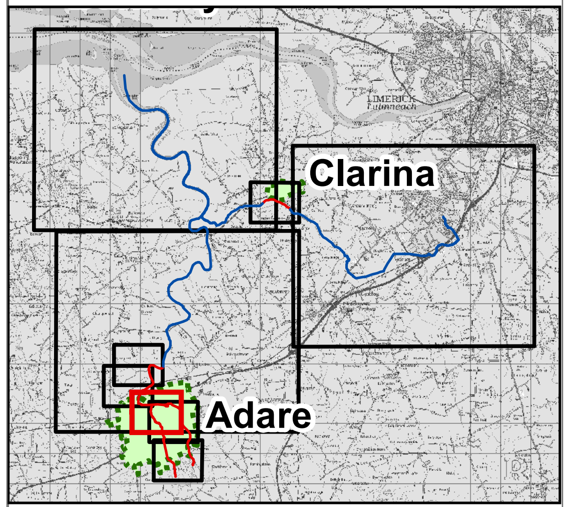

Legend:

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Defence Failure Location

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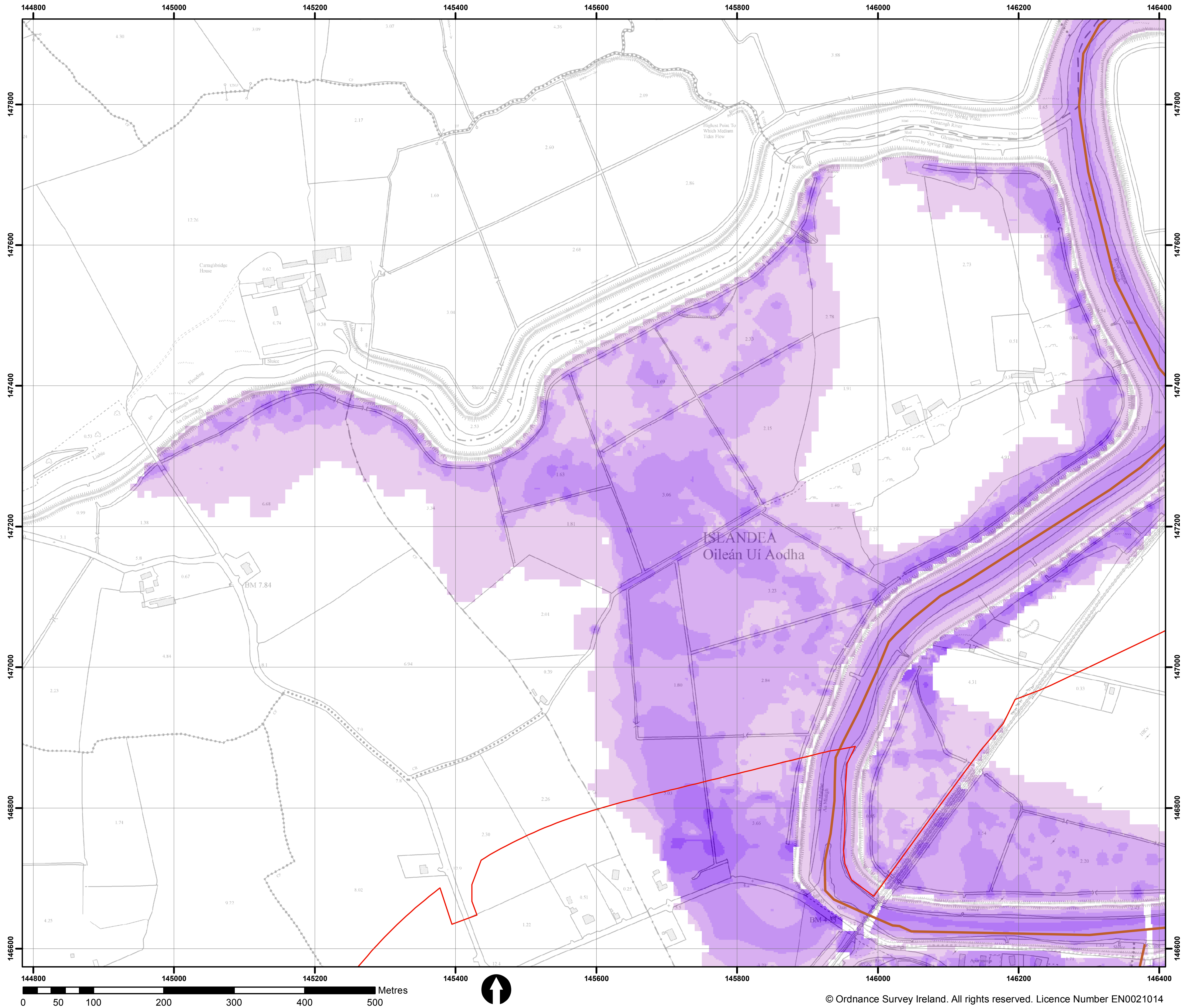

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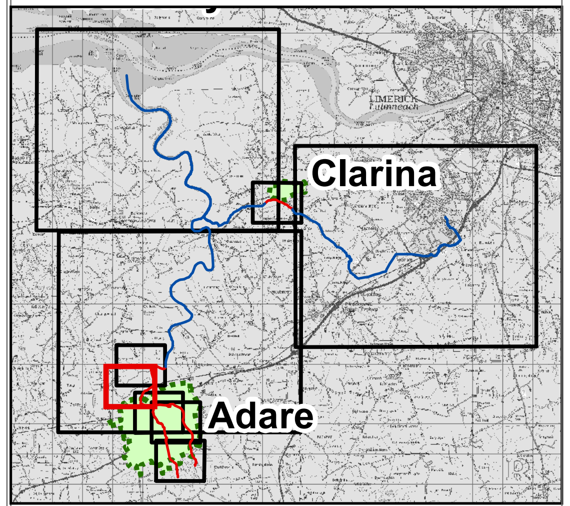

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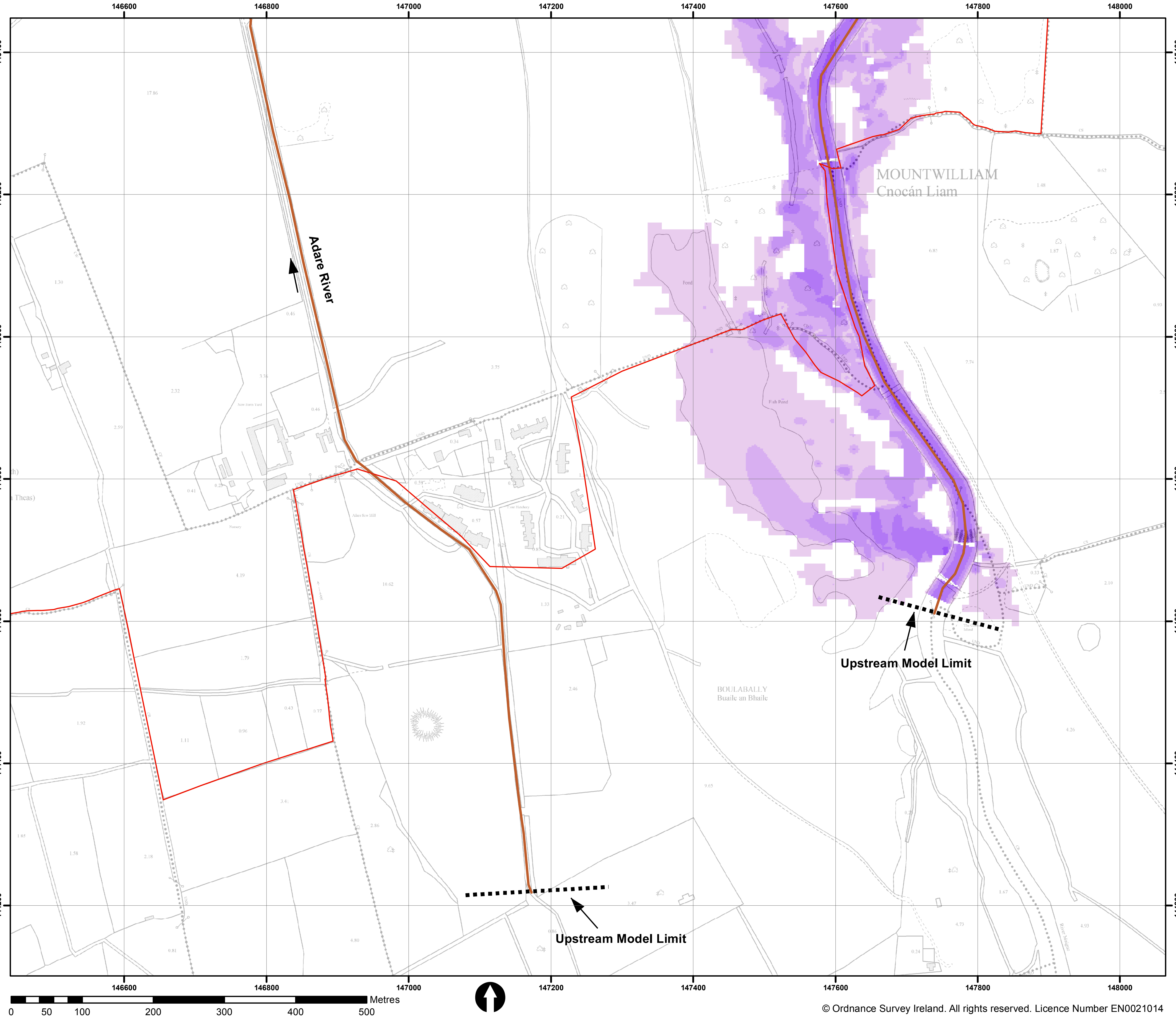

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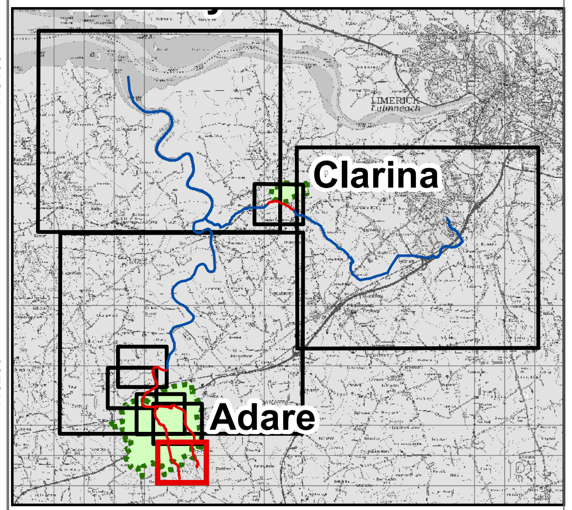

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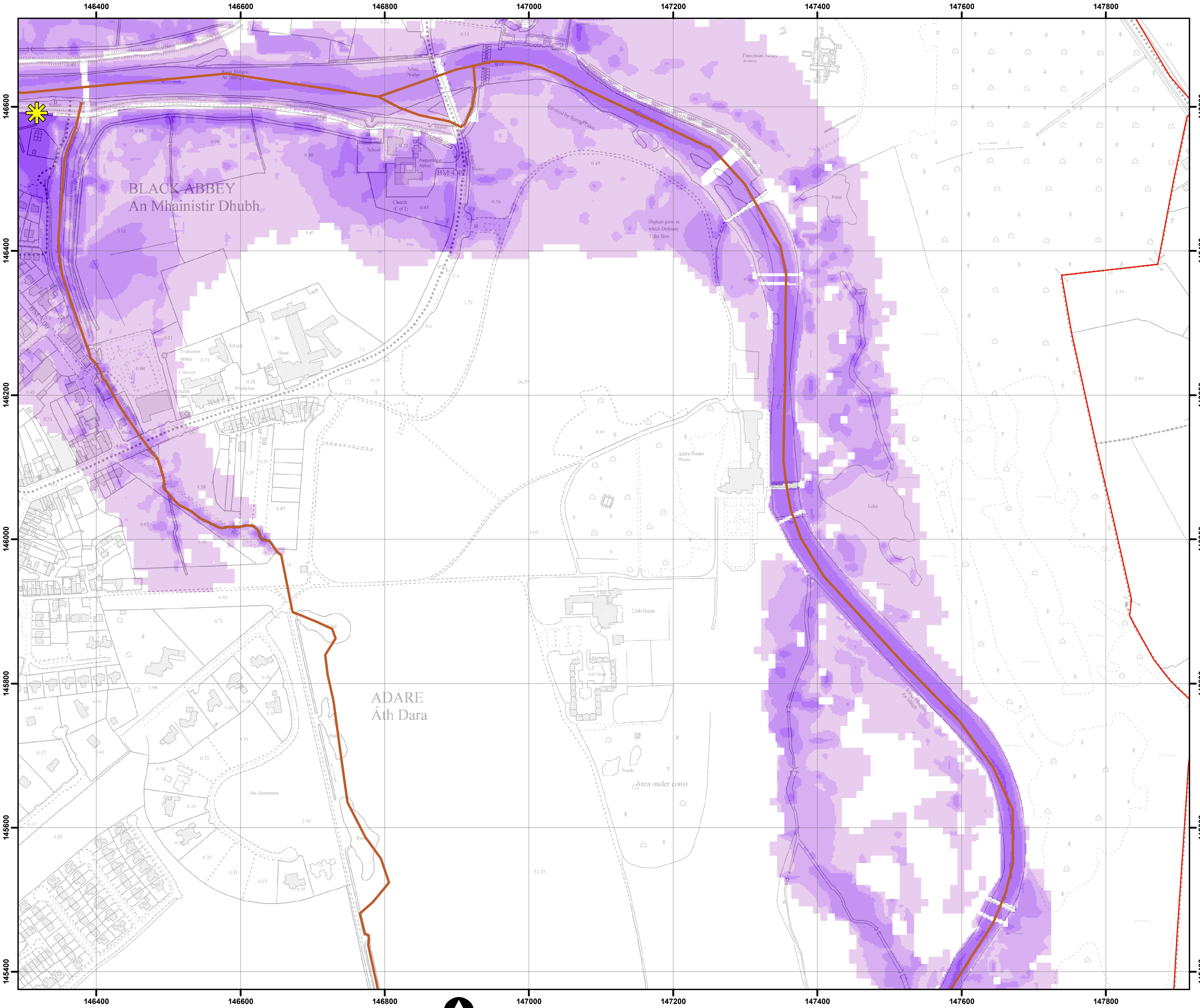

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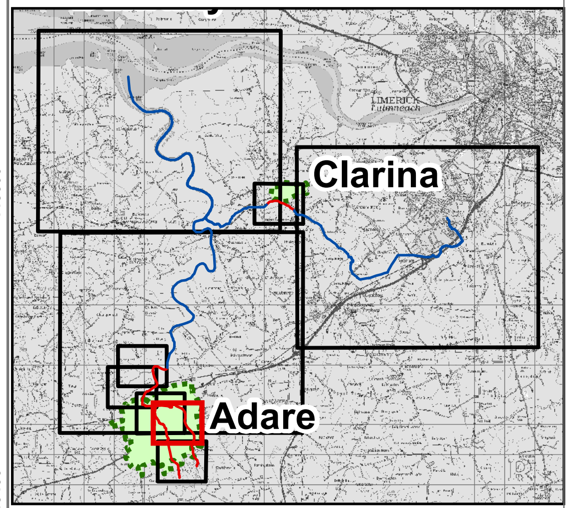

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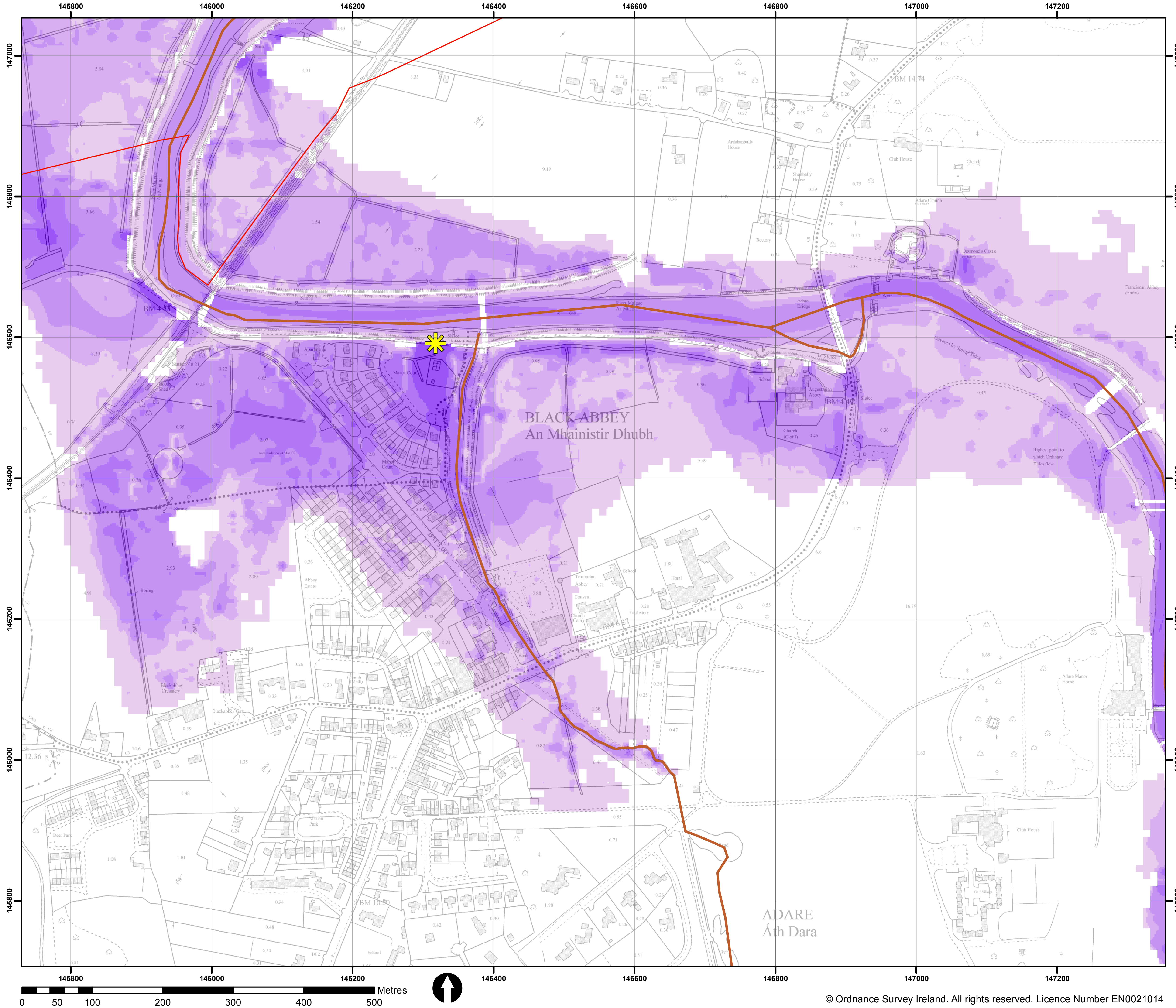

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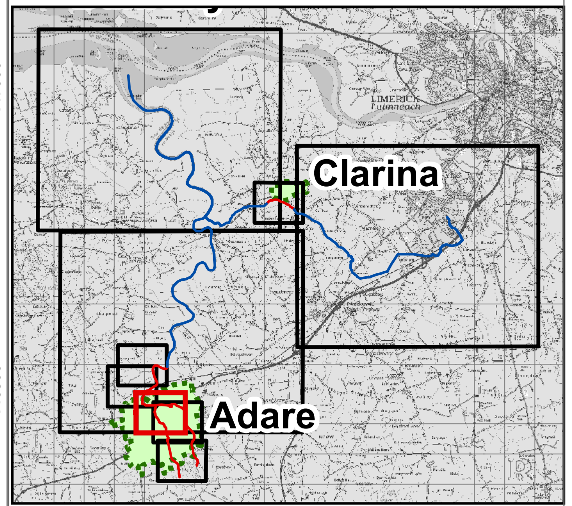

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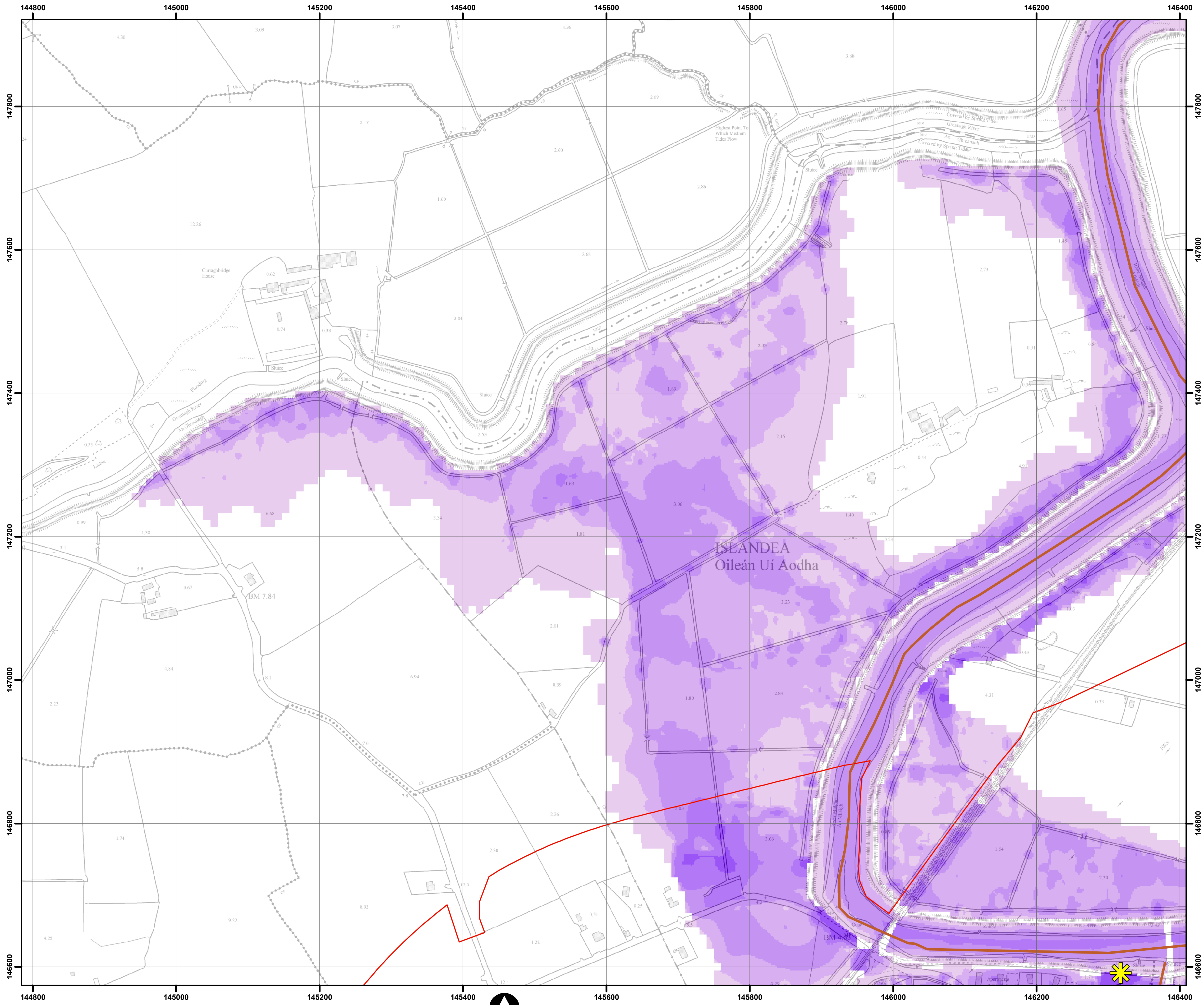

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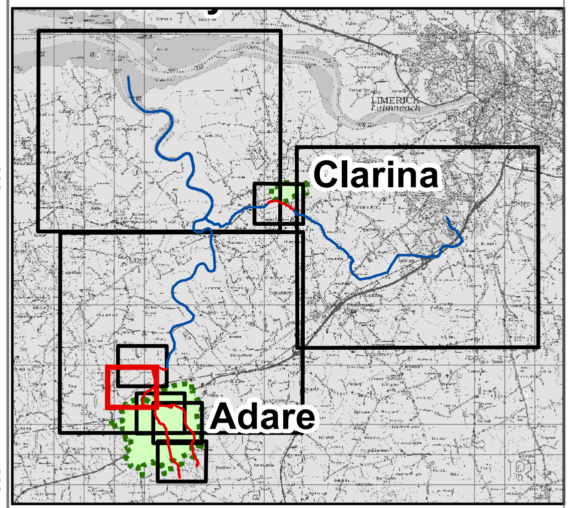

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Appendix J Relevant OPW Guidance Notes

CFRAM Guidance Note 24 – Breach Analysis

Originators: Sun Yan Evans and Marianne Piggott

Revision E Date: 19 June 2013

Mott MacDonald

1.0 Overview

Flooding can be categorised as arising from two main sources: i) Coastal sources when extreme storm surges and/or waves overtop coastal defences or marine infrastructure inundating the areas inland of the coastal defences; (ii) Inland sources, i.e. overland flow from excess rainfall, excess river flows overflowing the river banks or defence; urban drainage flooding; excess groundwater; and, estuarial flooding.

Additionally, flooding can occur due to the failure of flood defence assets or infrastructure during a flood event. Because of the sudden onset, the impacts of this form of flooding can be severe and should be assessed where appropriate. Therefore, all CFRAM studies will assess flooding arising from flood defence asset failure in Areas for Further Assessment.

2.0 Purpose

This note aims to provide a consistent approach for all CFRAM studies to simulate the inundation of the failure of flood defence assets or infrastructure. The model outputs from the flood defence failure scenarios will inform the Preliminary Options Report in the CFRAM studies.

This note focuses on:

(i) The selection of breach parameters;

(ii) The selection of modelling techniques to simulate the inundation due to the failure of flood defence assets.

This guidance note does not address or cover the assessment of flooding from breaches of dams or reservoirs. The assessment of failure or breach scenarios of such structures is NOT included in the scope of the CFRAM Studies. If further information is required, please refer to specific guidelines for assessing dam breach inundation, such as the DEFRA National Reservoir Inundation Mapping Specification (Mott MacDonald June 2009)[1] for general information.

3.0 Requirements for CFRAM Studies

The requirements from the Stage I and Stage II CFRAM Briefs below are clarified in sections 4, 5 and 6 of this guidance note.

The CFRAM Studies Stage I Project Brief [2] Section 7.6 states:

"In the event of a failure of flood defence assets (such as the collapse of a section of wall or breach of an embankment), areas that would otherwise be defended against flooding during a given event severity might become subject to flooding. The Consultant shall undertake analysis to identify and assess the flood hazard and risk that may be caused or significantly increased (with due consideration for flow velocities, rate of onset of flooding, likely flood volumes and potential flood damage), by the occurrence of failures of defence assets providing protection to the areas at risk from flooding. The Consultant shall undertake such analysis using appropriate hydraulic modelling techniques in line with best practice using the models identified in Section 7.2, or the JFlow modelling software."

The CFRAM Studies Stage II Project Brief[3] states:

"The Consultant shall undertake such analysis for two (2) failure scenarios (comprising potential breach extents / breach development scenarios or locations) for each of the existing flood defence assets where the retained depth of water above ground level exceeds 1.0m during a flood event of a probability equal to the standard of defence of the asset, and only for defences providing some degree of protection to APSRs.

The Consultant shall also undertake such analysis for one (1) failure scenarios (comprising potential breach extents / breach development scenarios or locations) for up to two locations that may be at risk from future coastal erosion under either a current scenario or future scenario, and only for defences providing some degree of protection to APSRs."

The required outputs from each defence failure scenario are as follows:

- Maximum flood extent map (excluding degrees of confidence, table of peak flows and levels and defended areas).
- Maximum flood depth map; and
- Maximum flow velocity map.

4.0 Breach Formation

4.1 Flood Defence Asset Types

Flood defence assets can be broadly classified into the following types:

- Flood embankments;
- Flood walls;
- Hydraulic structures, such as flood gates, adjustable weirs, pumps, flapped valves etc.;
- Other naturally occurring features that can provide flood protection; and
- Other infrastructure that can provide flood protection as a secondary purpose.

The type of flood defence asset is important to consider as it partly determines the mode of failure, rate of breach formation and breach dimensions. Other factors such as asset condition and the flood event characteristics also influence mode of failure, rate of breach formation and breach dimensions as discussed below. Naturally occurring and other informal defences, such as sand dunes, should be assessed on a case-by-case basis with OPW to establish the need of breach analysis that is in line with the definition of flood defences in Appendix C of CFRAM Framework Stage I Brief.

4.2 Mode of Failure

Generally speaking, there are two modes of failure: (i)overtopping[a] and (ii) piping[b]. The EU IMPACT study (WP 6, 2005)[4] and Management of Flood Embankments Good Practice Review (FD2411/TR1, 2007)[5] draw together over 100 European examples of historic breaches. Both these studies conclude that overtopping is the dominant failure mechanism for over 70% of cases reported. Analysis by the EU IMPACT study suggests that as flood embankments and walls are raised over time there is an increased risk of failure from piping as the join is exposed leading to the development of hydraulic soil failure or wall collapse.

4.3 Breach Location

The location of a breach depends on a number of factors as outlined by WP 2 of the EU Impact project[6]:

- Internal factors: Understanding of these factors needs a complete knowledge of the geotechnical properties of the interior of each specific asset such as potential lines of weakness in concrete, moisture content, cohesion, permeability, compaction, pore water pressure etc.
- External factors: These factors could be detected by a visual survey, including: settlement of the crest level, localised dipping of the crest, cracking of walls, bulging at the base of the asset, slumping , sink holes, vegetation changes etc.

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[a] Overtopping may be as a result of flood water overtopping the crest of an embankment, or through wave action resulting in periodic overflowing of a coastal defence.

[b] Critical conditions resulting from piping (seepage or leakage) are, typically, when flow increases to a significant level causing erosion of material and progressively creating a larger hole through the embankment. Eventual subsidence of the bank material above the 'pipe' and rapid breaching of the embankment will follow.

- Environmental factors: These factors correspond to the physical elements surrounding embankments and affecting their overall performance, such as, flow velocities, burrowing animals, scour holes at base of the wall or embankment, vegetation cover or vegetation growing in the wall etc.
- Human factors: These factors involve human actions and events and can include the presence of outfall structures through the embankment or wall, footpath erosion or loading by vehicles on roads, wash from boats, grazing animals and lack of maintenance.

There is insufficient research and understanding in the breach formation process to reliably predict breach location. The CFRAM Brief limits breach locations to existing flood defence assets within AFAs where the retained water level exceeds the adjacent ground level by 1.0m during a flood event (Section 2 of this note). However, interviews with expert local engineers and All Panel Reservoir Engineers during the NRIM pilot study[1] found that the setting of any threshold has the following effects;

- Exclusion of important flood defences that were critical to the receptors at risk, e.g. communities, properties and environmentally important sites.
- Inappropriate analysis of flood defences that were not critical to receptors at risk.

Therefore, the consultant is required to validate vulnerable locations and select the most appropriate breach locations based on the knowledge of the factors listed above. Additionally, the Irish Coastal Protection Strategy Study (ICPSS) has identified sections at risk from erosion in the future. This ICPSS data can be used to supplement expert engineering judgement to identify potential breach locations in coastal areas.

Recommendation: Selection of Breach Location

It is recommended that the Consultant identifies potential feasible breach locations considering the following aspects:

- Known problem embankments;
- Areas where failures have previously occurred;
- Current asset condition and rate of deterioration from the asset conditions survey where available;*
- Topographic survey data;
- Presence of strategic receptors at risk downstream such as; hospitals, garda stations, other emergency service stations, carehomes, nurseries, schools or areas of high population density relative to the rest of the AFA.

The most appropriate breach locations for each AFA should then be agreed with OPW prior to modelling.

* Good, fair and poor asset should all be considered in conjunction with estimated rate of deterioration.

4.4 Breach Parameters

4.4.1 Time of Failure

The time at which the breach forms can have a significant impact on the flood conditions downstream of the failure.

Laboratory and field tests by the EU IMPACT study and United States Department of Agriculture experiments[7] indicate that failure may occur rapidly after the onset of overtopping. Conversely, the field data suggests piping failure is a relatively slower process, occurring over a period of weeks before eventual failure of the embankment. Once the piping flow through the embankment becomes turbulent (identifiable as cloudy with sediment), the failure can occur within minutes.

Therefore, any breach can be assumed to form rapidly within minutes of overtopping the defence or the presence of turbulent flow through the defence. These conditions may be formulated prior to the peak flow for an event.

The time at which the failure occurs relative to the peak flow also determines the severity of flood risk to receptor in terms of velocity, hazard rating and flood extent. Mott MacDonald undertook a number of sensitivity tests on the time failure of flood embankments in Lincolnshire[8,9]and found:

- The flood extent is often the greatest if the breach is assumed to occur during the rising limb or close to the peak of the hydrograph as this often provides the greatest volume during the breach.
- The flood velocities and hazard are often the greatest if the breach is assumed to occur at the peak of the hydrograph, especially in the vicinity of the breach. This often provides the greatest potential head for flow through the breach and onto the floodplain.

Recommendation: Selection of Time of Failure

The prediction of the likely time to failure during an event is best made through expert judgement by an experienced engineer familiar with construction of flood embankments, the relevant hydraulics and geotechnical theory and the purposes of the breach analysis[5].

A simplified approach is recommended for the CFRAM studies. This assumes that the breach will initiate when the water level reaches the defence crest level or at its peak level if the peak water level is below the defence crest level.

4.4.2 Breach Dimension

A) Breach Height

The breach height or depth can be defined as the distance from the defence crest to minimum elevation through the breach. In most studies, a conservative estimate of the breach height is taken to be the defence crest to the floodplain level as this provides the largest head through the breach[10].

Datasets complied by Wahl[11] and IMPACT WP 6[4] suggest that breach height varies in historic breach failures depending on the mode of failure, activity taken to repair the breach, and the potential head available.

B) Breach Width

The results from the laboratory and field tests undertaken as part of the EU IMPACT study[10] suggest that: (i) the breach side walls are typically vertical during breach development; (ii) the typical breach width varies with defence type, material and many other factors; (iii) the breach width depends on the number of factors as summarized in the formula below:

L = L (H, G, R, S, Q, A, T)

Where:

- H - head through the breach
- G - the dimensions and geotechnical properties of the dike
- R - river flow conditions in the vicinity of breach
- S - topographic conditions on the protected side
- Q - the discharge of the river
- A - the activity of flood fighters
- T - the function of time

A range of models have been tested in the EU IMPACT project to estimate the breach dimensions and/or discharge hydrographs. The results suggest that all the models have limitations and associated uncertainties in the results predicted. Without local validation of these models, it was difficult to reliably predict breach width. Therefore, Morris et al. (2007)[5] recommend that breach dimensions are estimated

using engineering judgement based on historic failures and conditions surveys. A similar approach was taken to derive parameters for the Environment Agency's Anglian Region breach specification as used in the Northern Area Tidal Modelling Study[8].

4.4.3 Breach Repair and Closure

The repair or closure of a breach during a flood event has not been well documented in historic defence failures[5]. The time it takes to repair or close a breach will ultimately determine the duration of the breach and flow into the floodplain. The time it takes to close a breach in a flood embankment or wall is dependent on the following:

- The discharge and velocities through the breach;
- The duration of high flows and levels in the river or sea;
- The soil conditions;
- Availability of material to repair the breach;
- Access to the breach site;
- Health and safety considerations; and
- The legislation and procedures in place for emergency teams to respond.

For example, a breach in a river embankment may be repaired relatively quickly once the water levels have receded. However, a breach in a coastal embankment may only be repaired during short period at low tide if water levels drop below the breach base level. Therefore, it may take several tidal cycles to repair a coastal breach.

Selection of Breach Dimension (Breach Height and Width) and Time to Closure

The following breach parameters are recommended to inform the selection of breach dimensions and time to closure for the CFRAM studies:

a) Breach Height – as a conservative estimate, the breach height is taken to be the difference between the defence crest and a representative floodplain level adjacent to the breach.

b) Breach Width and Time to Closure as tabulated in the table below:

Location	Defence type	Breach width (m)	Time to Closure (hrs)
Open coast	Earth embankment	200m or the total asset length where < 200m	72
	Dunes*	100 or the total asset length where < 100m	72
	Hard (walls)	50 or the total asset length where < 50m	72
Estuary and Tidal Rivers	Earth embankment	50 or the total asset length where < 50m	72
	Hard (walls)	20 or the total asset length where < 20m	72
Fluvial Rivers	Earth embankment	40 or the total asset length where < 40m	36
	Hard (walls)	20 or the total asset length where < 20m	36

Parameters based on those applied by the Environment Agency, UK.

* Sand dunes and other informal defences should be assessed on a case-by-case basis in consultation with OPW to establish the need for breach analysis that is in line with the definition of flood defences in Appendix C of CFRAM Framework Stage I Brief.

5 Breach Inundation Modelling

5.1 Approach

Flooding arising from a catastrophic failure of a defence is more difficult to simulate than fluvial or tidal flooding over a prolonged event. This is due to the presence of rapidly varying flow conditions including mixed sub, super and transcritical flows, 'shock-wave' propagation, interaction and reflections (EU IMPACT Project 2005).

There are three main approaches to the modelling of inundation resulting from a breach:

- Independent modelling
- Iterative modelling
- Dynamic modelling.

Both 1D and 2D hydraulic models can be used for modelling of flow conditions on the floodplain, but the 1D approach is limited in the prediction of variable floodplain velocities. Therefore, 2D modelling techniques would be the preferred approach to simulate the variable floodplain velocities and other flood conditions arising from a defence failure scenario.

5.2 Independent Modelling

Independent modelling is a simplistic approach that assumes that there is no interaction between the flow through the breach and the floodplain downstream.

Independent modelling was found to be appropriate for breach scenarios where the floodplain downstream does not limit the volume or head through the breach opening i.e. no backwater effect. This approach is applicable to simulate defence failure for the following locations in CFRAM studies:

- Coastal locations where the volume entering through the breach is predominately influenced by the tidal conditions; and,
- Locations where the floodplain topography is low-lying and expansive hence the storage on the floodplain does not limit inundation.

5.3 Iterative Modelling

Iterative modelling uses the same approach as the independent modelling (i.e. separate breach formation and hydraulic model) but attempts to consider scenarios where the floodplain influences flow through the breach by modifying the breach hydrograph based on iterative modelling of the breach formation model and hydraulic model. This approach is applicable to simulate defence failure for the following locations in CFRAM studies:

- Locations where the floodplain topography is constrained with limited storage on the floodplain thus limiting the discharge through the breach due to backwater effects; and
- Locations where the floodplain features form barriers to flow, such as raised roads and other urban infrastructure, thus limiting the discharge through the breach due to backwater effects.

5.4 Dynamic Modelling

Dynamic modelling seeks to dynamically solve the flow through the breach by linking the 1D or 2D model of the river channel to the 2D model of the floodplain. This enables full hydrodynamic calculations through the breach and taking into account any back water effects. This approach is applicable to simulate defence failure for the following locations in CFRAM studies:

- Locations where the floodplain topography is constrained with limited storage on the floodplain thus limiting the discharge through the breach due to backwater effects; and
- Locations where the floodplain features form barriers to flow, such as raised roads and other urban infrastructure, thus limiting the discharge through the breach due to backwater effects.

In the context of the CFRAM studies, the dynamic modelling approach has the advantage of utilising the existing baseline 1D/2D models and only requiring one model simulation for each breach scenario. However, there might be an increased risk of model instability arising from the rapidly varying flow conditions through the breach.

Recommendation: Selection of Modelling Techniques for Breach Inundation Modelling

It is recommended that 2D modelling techniques are used to simulate the variable floodplain velocities and other flood conditions arising from a defence failure scenario. There should be existing 1D/2D models for breach analysis which have been developed for AFAs as part of the CFRAM studies.

The following three modelling techniques are recommended for the predicted of breach inundation:

- Independent modelling for locations where the water levels on the floodplain or floodplain features do not influence flow through breach;
- Iterative modelling for locations where the water levels on the floodplain or floodplain features influence flow through the breach; and
- Dynamic modelling for locations where the water levels on the floodplain or floodplain features influence flow through the breach.

Quality, time and cost implications should be taken into consideration when selecting between iterative and dynamic modelling techniques to effectively assess the impact of a breach. Dynamic modelling is the preferred choice if there is an existing dynamic model such as developed for AFAs in the CFRAM Studies. However, iterative modelling may be more appropriate if the existing dynamic model would take too long to run or has stability issues.

6 Selection of % AEP Flood Event

The discussion with OPW and the CFRAM consultants on the selection of %AEP Flood Event for breach analysis at the recent NTCG3 is summarised below.

The application of a single design %AEP flood event, such as the 1%AEP for fluvial locations and 0.5%AEP for coastal locations, provides a consistent approach and comparable results between different locations for planning purposes. However, this approach may result in inappropriate breach analysis for flood defence assets that are already overwhelmed in the selected %AEP flood event.

To avoid this problem, it was agreed that the %AEP flood event for breach analysis should be that which is closest to defence crest level but does not overtop the defence asset, with a limit of the 1%AEP for fluvial flooding and 0.5%AEP for tidal flooding. It is recognised that this will result in different %AEP events being selected at different breach locations.

Recommendation: Selection of %AEP Flood Event

It is recommended that the %AEP flood event for breach analysis should be that which is closest to defence crest level but does not overtop the defence asset, with a limit of the 1%AEP for fluvial flooding and 0.5%AEP for tidal flooding.

References:

[1] Mott MacDonald (2009) National Reservoir Inundation Modelling Specification. United Kingdom DEFRA/ Environment Agency.

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[5] Morris, Dyer and Smith (2007) Management of Flood Embankments: A good practice review. FD2411/TR1.United Kingdom DEFRA/Environment Agency.

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[9] Mott MacDonald (2013 ongoing) Lincoln Breach Hazard Mapping. Environment Agency.

[10] Morris, Hassan and Vaskinn (2005) Conclusions and Recommendations from the IMPACT project WP2: Breach Formation. EU IMPACT Project.

[11] Wahl (1998) Prediction of embankment dam breach parameters – a literature review and needs assessment. US Bureau of Reclamation Dam Safety Report DSO-98-004.

NATIONAL CFRAM PROGRAMME
GUIDANCE NOTE NO. 27

Title:	**Economic Damage and Benefit Calculation and Cost-Benefit Analysis**
Version:	Rev. C – Final
Author:	Mark Adamson
Date:	21st July 2014
Issued to:	CFRAM Consultants
Date Issued:	21st July 2014

1.0	**PURPOSE**
	The purpose of National CFRAM Programme Guidance Note No. 27 is to set out a common approach to the calculation of monetarised, economic flood damages and the economic benefits of flood risk management options, and for undertaking a cost-benefit analysis, with a view to ensuring that damages, benefits and benefit-cost calculations are determined in a nationally consistent manner, to enable inter-comparability of proposed measures across the country.
2.0	**SCOPE**
	GN 27 relates to the calculation of monetarised, economic flood damages and the potential economic benefits of options for flood risk management measures, for the purposes of: – The calculation of the economic (monetary) benefit-cost ratio for options for flood risk management measures (to be used for option appraisal and economic flood risk mapping – see GP comment on Section 4.3) – Option appraisal against Objective 2.a (Minimise Economic Risk) under the Multi-Criteria Analysis (MCA) Note that there are minor variations in the benefit / damage values to be used for the two purposes above (see Section 4.5 herein). GN 27 does not address to: – The calculation of the costs of options for flood risk management measures, which is outlined in Guidance Note 32, with reference to the OPW Unit Cost Database – The application of the Multi-Criteria Analysis (MCA) to appraise flood risk management measures (except for Objective 2.a), for which guidance is produced in Guidance Note 28 (GN28)

	A glossary of abbreviations / acronyms used for this GN is provided in Appendix A. An explanatory table is provided in Appendix B, that might be useful for clarity.
3.0	**CALCULATION OF ECONOMIC FLOOD DAMAGES**
3.1	**General Requirements** The requirements for the calculation of economic risk, and hence economic flood damages are as set out in Section 8 and Appendix I of the Generic CFRAM Project Brief. ***General Methodology*** The calculation of flood damages should be based on the Flood Hazard Research Centre Handbook of 2010 (FHRC, 2010) and the 'Multi-Coloured Manual' of 2005 (FHRC, 2005) as referred to in FHRC 2010, subject to caveats, amendments and clarifications set out herein ***Price Conversions*** Prices (damage costs) in the data provided by FHRC 2010 should be converted to euro rates applicable to Ireland in 2013 by: - Applying a 'PPP' multiplication factor of 1.279. This is derived from the relative OECD Purchasing Price Parity values for the UK and for Ireland for 2010. The 'PPP' factor is net of currency conversion (i.e., already includes for exchange rates as well as price differences, and so no currency conversion rate should be applied in addition to this factor) - Applying an inflation multiplication factor of 1.051. This is derived from inflation rates based on the CPI in Ireland for the period 2010 - 2013 ***Flood Duration*** The damages should be calculated assuming long duration (>12 hours) flooding for residential properties, except where shorter duration flooding (including the time required for the draining away of flood waters) would clearly be expected, e.g., in small, flashy catchments, where the duration of <12 hours should be applied instead. For non-residential properties, shorter duration flooding (<12 hours) should be assumed, as depth-damage data for longer duration flooding of non-residential properties is not provided in FHRC 2010. ***Coastal Flooding*** The addition of 10% on building fabric damages should be used when assessing flooding from coastal / tidal sources.
3.2	**Scope of Assessment** The calculation of flood damages should be undertaken for: - AFAs and APMRs - The current scenario and MRFS based on each of the range of flood event probabilities as set out in Section 6.5.1 of the Generic CFRAM Project Brief

	- The HEFS in an indicative manner, making use of calculated damages for the 10%, 1% (0.5% for coastal flooding) and 0.1% damages for the HEFS, and using these values to shift the MRFS damage curve to derive an indicative damage curve for the HEFS.
3.3	**Residential Property Damages** ***Residential Property Classifications*** For the purposes of determining the appropriate residential property damages, and the depth-damage curve / data to be used, account should be taken of: - Property type (detached, semi-detached, terraced, bungalow, etc.) but not: - Property age - Social class (and without inclusion of the Distributional Impact Factor) - Property size The use of properties marked as 'unknown' in the GeoDirectory can be confirmed through the site visits and/or by remote data such as Google Street Map ***Property Floor Levels and Flood Depths*** As set out in Section 5.4.2 (and 8.1.4) of the Generic CFRAM Project Brief, residential property floor levels (which is the base-line or zero-depth against for the calculation of flood damages) may be determined, subject to confirmation by the CFRAM Consultant through spot-checks, on the basis that doorstep / floor levels of ground-floor properties are a specific height above ground level as determined from the DTM data. The specific height of the doorstep / floor level adopted for each AFA should be based on observation / measurement for each AFA. Flood damages should be assumed to begin at flood depths of –0.3m relative to floor levels. This only applies however to properties whose foot-print lies within the flooded area, and does not need to be calculated for properties that are situated outside of the flood extents for the given event. For properties with basements, the flood damages for the property assuming a depth of 2.4m (typical ceiling height) should be applied once the flood depth exceeds the threshold level for the basement (i.e., the lowest level that allows significant flood waters to enter). This damage should be in addition to the normal depth-damage calculation for the ground floor of the property.
3.4	**Non-Residential Property Damages** ***Non-Residential Property Classifications*** The Indicative Susceptibility depth-damage curve / data should be used, unless there is a clear and specific reason to use the High or Low Susceptibility Band data for a given property.

	For the purposes of determining the appropriate non-residential property damages, and the depth-damage curve / data to be used, account should be taken of: - Property type (i.e., sub-classes of the 'Bulk Code Class', and with a three-digit 'MCM Code', as referred to in FHRC 2005 & 2010) - Property area ***Property Floor Levels and Flood Depths*** As set out in Section 5.4.2 (and 8.1.4) of the Generic CFRAM Project Brief, non-residential property floor levels may generally be determined, subject to confirmation by the Consultant through spot-checks and the exceptions as set out below, that doorstep / floor levels of ground-floor properties are a specific height above ground level as determined from the DTM data. The specific height adopted for each AFA should be based on observation / measurement for each AFA. Surveys of the threshold levels for flooding of major commercial properties (those with estimated potential damages greater or equal to €500,000 for an event of annual exceedence probability of 0.1% in the AFA), and also for entry points to significant basements or underground car-parks, are however required, and these levels where captured should be used. Flood damages should be assumed to begin at flood depths of 0m. For mixed-use properties, i.e., where the property includes both residential and (non-residential) commercial use, it could be assumed (unless otherwise verified through site visit / remote data) that the ground floor will typically be in non-residential (commercial) use, and so the non-residential approach should be applied, i.e., assume flood damages begin at 0m rather than -0.3m. For converted properties that are now non-residential, the non-residential approach should be applied The 'with basements' or 'without basements' depth-damage data for non-residential properties should be used as appropriate. Where the existence or otherwise of a basement is unknown for a given property, then the 'without basement' depth-damage data should be used. In line with good practice, a 'reality-check' should be undertaken for any property that contributes more than 1% of the total PV damages for an AFA.
3.5	**Other Damage Costs** ***Principal Direct Damage (PDD) Costs*** The PDD Costs are calculated as the sum of the residential and non-residential property damages. The PDD Cost is used as the baseline for the calculation of other damage costs, as set out below. ***Infrastructural Utility Assets*** Economic damages to infrastructural utility assets (e.g., electrical sub-stations, gas installations and pipe-work, telecommunications assets, etc.) should be calculated as 20% of total PDD Costs for the AFA or SSA. *(Note: 20% value has been derived from the analysis of damages of past floods in the UK).*

Infrastructural Utility Damage Costs should be included for the economic CBA, but should not be included in the appraisal against Objective 2.a under the MCA.

Emergency Services

Costs to emergency services (which include evacuation costs) should be included in the economic damages, and should be calculated as 8.1% of the total PDD Costs for the AFA or SSA.

(Note: 8.1% value derived as average of the measured emergency services costs for the 2000 and 2007 floods in the UK).

Traffic Disruption

Costs of traffic disruption may typically be excluded from the calculation of the economic damages, as it will typically not be significant within the overall damages. This would be, for example, where the flooding would be of minor roads or local urban streets and where alternative local routes are available and/or traffic volumes will not be high. Traffic disruption costs may however be included where there are major (high volume) roads affected and / or where deviation routes are of significant distance.

The inclusion or otherwise of traffic disruption costs is at the discretion of the CFRAM Consultants, subject to advice from the Steering / Progress Group.

In the event that traffic disruption costs are calculated, then such damages / costs should be included for the economic CBA, but should not be included in the appraisal against Objective 2.a under the MCA.

Risk to Life

While clearly of significant importance in the overall appraisal under the MCA, the potential damage costs of loss of life in a flood event are not to be included in the assessment of economic damages.

(Note: This is excluded because, while loss of life can occur in flood events, in Ireland loss of life in a community that might be classified as an APSR (AFA) is very rare. As such, it would not materially change the economic analysis.)

Where risk to life is of potentially significant concern (e.g., where there is a prevalence of basements and / or by observation of the flood hazard (risk to life) mapping and the location of residential / high vulnerability properties), this should be noted in the description of flood risk for the AFA, and can be taken into account in option selection and justification.

Other Excluded Damage Costs

Damage costs can arise in relation to various other types of damage, impacts or costs arising in the event of a flood. However, these are either not economic losses (i.e., to the overall national economy), are provided for under another included cost, and / or are typically relatively small as a percentage of the overall damage and hence do not need to be considered in the economic appraisal at this strategic level of assessment.

	Such excluded costs would include: - Damage to roads - Damage to parked cars - Environmental damage - Personal evacuation costs - Temporary accommodation - Extra heating costs - Losses to businesses - Recreational losses Many of the above costs are deemed to be included within the Intangible and Indirect Damages (see Item 3.6 below).
3.6	**Intangible and Indirect Damages** Flood events can cause significant stress, anxiety and ill health to potentially affected people, during and then after a flood. Individuals generally also incur some costs due to their properties flooding that are not directly related to damage, such as evacuation, temporary accommodation, loss of earnings, increased travel and shopping costs, etc. While these negative impacts are difficult to monetarise or quantify, it is recognised that these impacts are significant, and professional opinion (Chatterton, pers. comm) has indicated that they could well be greater than the direct damages to residential properties. For residential properties, the intangible and indirect flood damages shall together be set equal to the total (direct) property damage. Intangible damages may also be applied in the case of small, individually or family-owned businesses where the intangible impact would be personal and similar in nature to that which might be experienced were the property residential. The inclusion of intangible damages for non-residential properties (if included) shall however be justified on a property-by-property basis, and may not be generally applied across an entire sector or sub-sector. While recognising that there will be some impact to those living above ground floor level (e.g., in apartment buildings), the intangible impact will, in line with the economic damages, be quite limited relative to those in properties that are flooded, and so these damages should not be included at the CFRAM level of analysis. Intangible and indirect damages should be included for the economic CBA, but should <u>not</u> be included in the appraisal against Objective 2.a under the MCA (as they are provided for under other MCA objectives).

3.7	**Calculation of Annual Average Damage** The Annual Average Damage (AAD) shall be calculated using linear interpolation between damage values for each of the eight defined design event probabilities, i.e., with a damage value calculated for each 'slice' based on the average of the damages for the design event damages that form the probability boundaries for the 'slice', and the probability range of the 'slice'. The AAD is calculated as the sum of the damage values of each slice, up to and including the 'slice' with the 0.1% AEP event as the upper bounding event.
3.8	**Calculation of the Present Value of Damages (PVd)** The PVd should be calculated as the discounted sum of the annual average damages over the project horizon, where: - The discount rate to be applied is 4% - The project horizon is 50 years The discount rate is subject to sensitivity testing (see Section 5.1).
4.0	**CALCULATION OF ECONOMIC BENEFITS OF FLOOD RISK MANAGEMENT OPTIONS**
4.1	**General Requirements** The economic benefits of an option for a flood risk management measure, or of a proposed flood risk management measure, are calculated as the reduction in the economic damages the option or measure will provide. The benefits / damages should be calculated assuming protection to the defined / proposed Standard of Protection (SoP), i.e., <u>not</u> taking into account freeboard / factor of safety. ***Baseline Scenario*** The baseline scenario against which benefits of an option or measure should be compared is the current situation or 'continue with existing practice' in terms of arterial drainage maintenance, local authority maintenance regimes for urban channels, culvert inlets, etc. *(Note: This is different from the usual 'Do Nothing' baseline scenario against which benefits of further action, or maintaining the status quo, are measured. This is necessary due to the nature of current activities, and the uncertainty associated with damages that would arise should those activities cease).* ***Defence Options or Measures*** For options or measures involving direct flood defence of an area, such as a wall or embankment, the reduction in damages should be calculated as the damages avoided to up and including the standard of protection of the option or measure, with no benefit offered for events greater than standard of protection. *(Note: This approach will tend to under-estimate the benefits of an option or measure, as it ignores the residual benefits for greater-than-design events. However, these residual benefits would be offset to some degree by increased damages that could arise in the event of the failure of the defence, and the above approach simplifies that analysis required.)*

	Other Flood Hazard Reduction Options or Measures For options or measures that involve reducing flood flows or levels through the relevant area, such as flood water retention or increasing in-bank channel capacity, the reduction in damages will need to be calculated by running the model for the flood event probabilities for which flooding and damage will occur to determine the flood damages for those events, and hence the reduction in damages from the current scenario. The event of probability equal to the standard of protection, or for which no flooding or damages would arise, will also need to be run to demonstrate the effectiveness of the option or measure at the intended 'zero-damage' event probability.
4.2	**Present Value of Benefits (PVb)** The PVb of an option or measure is the reduction in the Present Value of damages (PVd) that would be achieved by implementing the option or measure (where the PVd is calculated as set out in Section 3.8 herein based on the discount rate and the project horizon), but also taking into account the capping of benefits as set out in Section 4.3 below.
4.3	**Property Value Capping** The costs of a measure or scheme (i.e., an option) with respect to a particular property should not exceed the total value of that property and, where relevant, the intangible damages that can be avoided through relocation; otherwise the State could end up investing more in protecting an asset than the value of that asset and associated intangible consequences, and a lower cost alternative measure (relocation) could be implemented instead. Capping values are hence applied to PVb of an option when undertaking an economic CBA. Capping should not be applied to the property damages for the appraisal against Objective 2.a under the MCA nor for the economic damage risk maps, as these should reflect the 'Do Nothing' or current situation. ***Residential Property Value Capping*** The capping value of the Principal Direct Damages (PDD) for a residential property is based on the value of that property. The value for a given property can be based on local or regional valuations of that type of property, i.e., a property-specific valuation is not required. Information on residential property prices is available from a number of publicly available sources (e.g., Residential Property Price Register, Daft.ie, etc.). The total capping value should however also take into account the PVd related to the intangible damages for a property, noting that these can be ongoing and not only the direct consequences of a given flood. The PVb capping value for intangible benefits of an option should be set equal to the capping value for the PDD for the property, representing the intangible damages avoided over the project horizon if the property (and it's residents) were to be relocated, but taking into account the capping of the PDD of the property.

	The Total Capping Value for the PVb for a residential property is therefore calculated as the sum of the capping value for the PDD for a property and the capping value of the intangible damages for that property. As the latter is equal to the former, this value is effectively double the capping value for the PDD of a property (i.e., double the property value). **Non-Residential Property Value Capping** The capping value for the PVb for a given non-residential property can be derived from regional valuations of that type of property, taking account of typical stock, or as ten (10) times the current rateable value of the property. **Capping of Other Damages** Capping should be applied to property damages and intangible damages only. Capping should not be applied to damages calculated as a percentage of the Principal Direct Damages (PDD), such as emergency services costs.
4.4	**Exclusions from Benefit Calculations** Potential increases in property value (including land value) arising from the implementation of a scheme may not be counted as scheme benefits.
4.5	**Reduction in Risk (Benefits) for Appraisal against MCA Objective 2.a** The economic benefits used for the economic cost-benefit analysis (CBA) to determine the benefit-cost ratio should be as set out above. The economic benefits used for the appraisal of options or measures under the MCA against Objective 2.a (Minimise Economic Risk) are as set out above, but should not be capped (Section 4.3) and with certain exclusions as referred to above, including: - Benefits to infrastructural utilities (Section 3.5) - Benefits in reduction of disruption to traffic (Section 3.5) - Intangible and indirect benefits (Section 3.6) These exclusions are to avoid double-counting benefits within the MCA. Further guidance on scoring under the MCA against Objective 2.a is given in GN28.
5.0	**COST – BENEFIT ANALYSIS**
5.1	**General Methodology** The benefit-cost ratio (BCR) to be produced as the output of the cost-benefit analysis is calculated by dividing the PVb for an option or measure, capped as appropriate, by the whole life cost (PVc) of that option or measure. The Net Present Value of the benefits (NPVb) of the option should also be calculated by deducting the PVc from the capped PVb.

	Further guidance on deriving costs for options or measures is provided under the guidance on the use of Unit Cost Database. The whole life cost is determined from the sum of the costs over the project horizon, with future costs discounted by the set discount rate (see Section 3.8 herein). It should be noted that residual asset values of potential flood risk management measures (i.e., at the end of the project horizon) should be assumed to be zero. Measures are only likely to be recommended as measures to be put forward in the Flood Risk Management Plan if their BCR is greater than unity. As set out in the Generic CFRAM Project Brief, sensitivity tests should be undertaken to determine the BCR using higher or lower discount rates, which should be 5% and 3% respectively.
6.0	**ECONOMIC RISK MAPPING**
	For the economic risk mapping, the AAD should be calculated in the same way as calculating the economic damages to be used for the economic cost-benefit analysis (CBA) to determine the benefit-cost ratio (i.e., including damages related to infrastructure and traffic disruption (if relevant) and indirect and intangible damages). Capping (as used in calculating PVb – See Section 4.3) is not relevant to, and should <u>not</u> be applied for, the economic risk mapping.
7.0	**REFERENCES AND RESOURCES**
	References – FHRC 2010: The Benefits of Flood and Coastal Risk Management: A Handbook of Assessment Techniques – 2010, Flood Hazard Research Centre, Middlesex University – FHRC 2005: The Benefits of Flood and Coastal Risk Management: A Manual of Assessment Techniques – 2010, Flood Hazard Research Centre, Middlesex University **Resources** – GN28 – Option Appraisal and the Multi-Criteria Analysis Framework – GN32 – Calculation of the Costs of Flood Risk Management Options and Measures – OPW Unit Cost Database

APPENDIX A

GLOSSARY OF ABBREVIATIONS

AAD	Annual Average Damages
AEP	Annual Exceedance Probability
AFA	Area for Further Assessment
APMR	Area of Potentially Moderate Risk (associated with Medium Priority Watercourses, or 'MPWs')
BCR	Benefit – Cost Ratio (Benefits / Costs)
CBA	Cost – Benefit Analysis
CPI	Consumer Price Index
DTM	Digital Terrain Model
FHRC	Flood Hazard Research Centre (Middlesex University, London)
HEFS	High End Future Scenario
MCA	Multi-Criteria Analysis (see GN28)
MCM	Multi-Coloured Manual
MRFS	Mid-Range Future Scenario
NPVb	Net Present Value of the benefits of a potential Scheme (PVb - PVc)
OECD	Organisation of Economic Co-operation and Development
PPD	Principal Direct Damages (sum of direct damages to residential and non-residential damages)
PPP	Purchasing Power Parity
PVb	Net Present Value of Benefits (whole life, discounted benefits)
PVc	Net Present Value of Costs (whole life, discounted costs)
PVd	Net Present Value of Damages (whole life, discounted damages)

APPENDIX B

EXPLANATORY TABLE

The table below sets out which parameters are applicable for each use (Economic CBA, Economic Risk Mapping and appraisal against MCA Objective 2.a), and how some of the parameters (e.g., Total damages for a given event, AAD) are calculated based on previous parameters.

The relevant sections in the Guidance Note are given in parentheses after the comment on application.

Parameter		Application		
		Economic CBA	Economic Risk Mapping	MCA Appraisal: Objective 2.a
1	Residential Damages	Yes (3.3)	Yes (3.3)	Yes (3.3)
2	Non-Residential Damages	Yes (3.4)	Yes (3.4)	Yes (3.4)
3	Principal Direct Damages (PDD)	1 + 2	1 + 2	1 + 2
4	Intangible Damages	Yes (3.6)	Yes (3.6)	No
5	Infrastructural Utility Damages	Yes (3.5)	Yes (3.5)	No
6	Emergency Services	Yes (3.5)	Yes (3.5)	Yes (3.5)
7	Traffic Disruption	Possibly (3.5)	Possibly (3.5)	No
8	Event Damage	3 + 4 + 5 + 6 + 7	3 + 4 + 5 + 6 + 7	3 + 6
9	Annual Average Damage (AAD)	Annualise 8	Annualise 8	Annualise 8
10	Present Value of Damages (PVd)	Discounted sum of 9 over Project Horizon	N / A	Discounted sum of 9 over Project Horizon
11	Un-capped PVb	Reduction in PVd (10) provided by Option (4.2)	N / A	Reduction in PVd (10) provided by Option (4.2)
12	Capping Value	Double Residential Property Value, or, = Non-residential Property Value (4.3)	N / A	N / A
13	Capped PVb	11, but not > 12 (4.3)	N / A	11 (4.3)
14	PVc	Whole Life Scheme Cost	N / A	Whole Life Scheme Cost
15	BCR	13 / 14 (5.1)	N / A	13 / 14 (5.1)
16	NPVb	13 - 14 (5.1)	N / A	13 - 14 (5.1)

NATIONAL CFRAM PROGRAMME
GUIDANCE NOTE NO. 28

Title:	**Option Appraisal and the Multi-Criteria Analysis Framework**
Version:	**Rev. C**
Author:	Mark Adamson, Richael Duffy, CFRAM Consultants
Date:	March 2015
Issued to:	CFRAM Consultants
Date Issued:	March 2015

1.0 PURPOSE

The purpose of National CFRAM Programme Guidance Note (GN) No. 28 is to clarify certain requirements of the process for the development of flood risk management (FRM) options, including screening, and to set a common approach to the multi-criteria analysis (MCA) for option appraisal.

2.0 SCOPE

GN 28 relates to:

– Flood Risk Management Objectives (Section 8.4 and Appendix J),

– Screening of Possible FRM Methods (Section 11.4 of the Stage I [Generic] Project Brief),

– Appraisal of Potential Options (Sections 11.6)

– Selection of Preferred Options (Section 11.7)

GN 28 does not address or cover:

– Defining the Spatial Scales of Assessment (SSAs) for urban areas, which is covered by GN 19

– Methods for the evaluation of adaptability to climate change, which is covered under GN 29.

– Methods for undertaking the Strategic Environmental Assessment (SEA), as the requirements for this are set out in the Project Brief with the consultants employed as experts to undertake the SEA.

– The development of flood risk management options (Section 11.5) from the methods that have been deemed potentially viable through the screening process. This is deemed to be a matter for the Consultants to determine in the manner they deem appropriate.

3.0	OVERVIEW OF SCREENING AND MCA OPTION APPRAISAL FRAMEWORK
3.1	***Framework Overview*** An objective of the CFRAM Projects is to: *"Identify viable structural and non-structural options and measures for the effective and sustainable management of flood risk in the Areas of Potential Significant Risk (APSRs) and within the Study Area as a whole"* (Section 1.2.1, Generic Project Brief), where *"The analysis, and method and option development and appraisal, to derive the set of actions and measures to be defined in the FRMP, as described herein, should form a robust and sound foundation for the future full development (after completion of this Project) of a measure to be taken to public exhibition or planning (as appropriate) and subsequent implementation."* (Section 11.1, Generic Project Brief) and *"The rejection of any method or option shall be robust and with clear and transparent reasoning, as rejected methods and options shall not be reconsidered in future projects."* (Section 11.1, Generic Project Brief) The screening and MCA option appraisal process is intended to provide an efficient, staged approach to achieving the above stated objective in the robust manner required, taking into account the wide range of potential benefits and impacts that flood risk management measures can have, and in coordination with the SEA/AA processes. The MCA appraisal outcomes will also inform the national prioritisation of preferred options and measures. There is hence a strong need for consistency across the CFRAM Programme to ensure that all potential works are considered on an equal basis.
3.2	***Robustness*** Appendix M of the Generic Project Brief sets out a non-exhaustive range of flood risk management (FRM) methods. The purpose of the screening and option appraisal process is to review all possible FRM methods, including those in Appendix M, and to identify the most appropriate suite of FRM options to be set out in the FRMP that the OPW, Local Authorities and other agencies can take forward to full scheme development, exhibition / planning and implementation. The processes <u>must</u> be sufficiently robust such that a re-evaluation of methods and options for a given location or for the Study Area as a whole, in terms of option selection, is <u>not</u> required for the implementing agency to move forward with the measures and strategies set out in the FRMP.

3.3	***Application of Professional Judgement*** In the interests of efficiency, the screening process and option appraisal process should, as far as reasonably possible, be automated, making use of the measurable parameters. However, an automated system cannot always take account of specific or local issues or particular circumstances. It is therefore essential that the processes and all outcomes are subject to the application of professional review and judgement. With respect to all objectives, other than objective 2.A (Reduce Economic Damages), professional judgement needs to be applied within the requirements and guidance provided. Notwithstanding this, with a view to ensuring national consistency, the professional judgement should typically not change the calculated Local Weighting or scoring by more than 1 point, or by more than 2 points in exceptional circumstances. Any changes beyond this limit should be discussed and agreed with OPW (who will have a national overview of weighting and scoring). Wherever professional judgement forms the basis of an amendment to the Local Weighting or score, then the reasoning for this should be recorded and reported.
3.4	***Design Standards*** Section 11.2 of the Generic Brief defines the 1% Annual Exceedance Probability (AEP) event and the 0.5% AEP event as the preferred design standards against which measures should provide protection for fluvial and coastal flooding respectively. However, the Brief also defines that other design standards should be considered under certain circumstances. The screening and option appraisal processes need to keep this potential flexibility in mind. It is not however expected that extensive work will be done at screening stage to re-screen each measure for alternative design standards where a measure fails to meet the screening criteria at the preferred standard, nor that extensive work will be done at appraisal stage to determine the optimum design standard for an option. It is expected that: – Professional judgement be applied at screening to retain a measure that might fail at the preferred design standard, but that could be attractive and viable at other design standards – Professional judgement be applied at appraisal stage, and where it is considered that a scheme might be preferable and / or be more cost – beneficial at a higher or lower design standard then this should be noted in the Preliminary Options Report (and the FRMP if / as appropriate) – A measure be appraised at an alternative design standard if a potentially preferred (or the only potentially viable) option proves not to be viable at the preferred design standard, but, based on professional judgement and the risk information available, is likely to be viable at an alternative standard.

4.0	FLOOD RISK MANAGEMENT OBJECTIVES
4.1	Section 8.4 of the Generic Project Brief introduces the FRM objectives, with provisional objectives then set out in Appendix J, along with indicators that act as a means by which achievement or otherwise of the objectives can be measured or assessed. The objectives are defined under four categories: – Technical – Economic – Social – Environmental Note that the environmental category includes cultural heritage, which is assessed as part of the SEA process. The objectives have been developed to broaden the range of potential impacts of flooding and FRM measures that are taken into account in the development and selection of FRM options and strategies, and their subsequent prioritisation. All four categories are deemed important criteria in the selection of flood risk management measures for a given location. However, only the latter three (i.e., excluding the 'Technical' category) refer to benefits, and so it is only these that should be used to provide an indication of benefit relative to cost, and be used for the purposes of prioritisation (of programme investment to maximise benefit). The OPW have reviewed the provisional objectives, taking into account the lessons learned from the pilot studies and further consultation. A revised set of objectives is set out in Appendix A.
5.0	**SCREEING PROCESS**
5.1	***Overview of the Screening Process*** The purpose of the screening process is to filter out FRM methods that are not going to provide applicable, acceptable or viable options or measures, either alone or in combination with other methods, for a given flood problem for a given location in the SSA under consideration. The screening process requires an indicative appraisal of <u>all</u> possible FRM methods for <u>each</u> of the various SSAs against each of the criteria set out in Section 11.4 of the Generic Brief. Considerations for each of the criteria are set out below. ***A) Applicability to Relevant Area*** Certain FRM methods would simply not be applicable to certain flood risk circumstances, and may be rejected on this basis. Examples might include: – Increasing conveyance or flow diversion in purely coastal flood situations – Rehabilitation of existing defences where no existing defences exist

Methods that may be applicable, even if unlikely to be viable or appropriate for other reasons, should not be rejected on the basis of applicability.

B) Economic
While the screening process is an indicative appraisal, it should make use of available information. The economic risk assessment previously undertaken (as part of the Flood Risk Assessment) will provide an envelope of potential economic benefits. Professional experience, and some simple costing using unit costs, can be used to estimate the possible minimum* costs of a method. On this basis, an indicative benefit – cost ratio for a method, in isolation or potential combination with other methods, can be determined.

In assessing the potential benefits of a method, the standard of protection and the effectiveness of the method in reducing risk should be considered (i.e., it should not be assumed all of that the damages up to the 0.1% AEP event will be prevented, unless that is the standard being considered, and a percentage degree of reduction in risk (e.g. option take-up rate and effectiveness) should be applied for non-structural measures such as flood forecasting and warning).

* On the basis of a precautionary approach to avoid rejecting methods that may prove economically viable, supplementary items used in detailed costing (unmeasured items, optimism bias, archaeology, land purchase / compensation, etc,) may be excluded from the costing at this stage. On the same basis, the threshold for the indicative benefit – cost ratio for rejection of a method should not be set equal to unity, and a threshold of 0.5 should be applied.

C) Environmental
The environmental screening should make use of the SEA scoping and any other environmental assessment work available at the time.

Methods should not be rejected only on the basis that a method may have a detrimental impact on an environmentally or culturally valuable or protected site, as mitigation measures may be available. Screening should take into account the degree of detrimental impact on the site, the scope for mitigation and whether there are apparently viable and acceptable alternative approaches available.

D) Social
In considering the social dimension during the screening process, outcomes of consultation processes previously undertaken (e.g., for start-up / SEA scoping and flood mapping) should be taken into account, along with the application of professional judgement and experience. Rejection of a method should only occur however where all variants of the measure would be unacceptable, for example, a permanent wall of 2m height may be unacceptable along the banks of a river through the middle of an urban area, but a permanent wall of 1.2m height topped with demountables to the 2m height may be acceptable.

	E) Cultural The approach taken to the cultural criteria of the screening should be similar to that undertaken for the environmental criteria, whereby a method should not be rejected only on the basis of a potentially minor negative impact. ***Consideration of Criteria in Combination*** The screening process may need to consider the criteria in combination as well as individually, e.g., for the example given under social criteria above, the permanent plus demountable option may be rejected if there would be a requirement for extensive demountables and the urban area in question is in a flashy catchment where there would not possibly be adequate warning time (based on recorded rather than predicted rainfall) to permit erection of the demountables without an intolerable level of false warnings. As with all rejections, the justification of rejection on the basis of 'in combination' reasons should be robust.
5.2	***Justification of Rejection of Methods at Screening*** In all cases where potential methods are rejected, justification should be provided which is robust, and with a clear and transparent reasoning. Such justification should be self-explanatory, but may vary in detail, with only brief text provided in some instances where the case for rejection is in itself self-evident (and would be so to the public and stakeholders) but with more detailed description required in other circumstances where the case for rejection is not so clear.
5.3	***Automation*** There is only limited scope for automation in the screening process, as much of the decision-making is indicative and will rely heavily on professional judgement and non-numeric factors. The exception to this may be the economic criteria where use may be made of the economic risk outcomes and unit costs. If an automated process is used, consideration should be given to the use of lookup tables for values or parameters that are used frequently (e.g., for multiple locations or multiple methods) to facilitate a single point amendment approach that, based on experience, can make significant savings in time as consultation and review processes lead to amendments in such values or parameters.
5.4	***Design Standards*** Given the potential for flexibility in the design standard, or standard or protection that may be adopted, methods or measures that might be effective and potentially viable at design standards other than those preferred, even if not so at the preferred standards, should not be rejected. This would apply in particular where: – A certain method is very likely to form (part of) a preferred option, but needs to be to a higher or lower standard due to factors such as health and safety requirements, available space for the method, social factors, etc. – There appears to be no viable methods that could achieve the preferred standard of protection

	– A method at a lower or higher standard of protection may become (part of) the preferred option overall, even if another option might (at this screening stage) appear to be more beneficial at the preferred standard.
5.5	***Requirements for Modelling*** The screening process is intended to be indicative and the OPW does not require that hydraulic modelling of all methods be undertaken at this stage. However, modelling may be appropriate in some instances to provide the required sound and robust justification for rejection, or indeed may be desirable, depending on the approach taken, to reduce the work required at the appraisal stage.
5.6	***Non-Structural FRM Methods*** Some non-structural FRM methods may be rejected during screening for various reasons. However, it should be noted that many non-structural methods are complimentary to structural methods in providing residual flood risk management, as well as providing stand-alone options in their own right, and some may represent the implementation of national policy (e.g., spatial planning, preparation of emergency response plans – See Section 6.6). As such, non-structural measures should not be rejected on the basis that other structural measures appear to be viable, but only on the basis that they are not applicable, appropriate or viable in the same manner as other methods. Land use management, natural flood management, green infrastructure, river restoration, etc. are terms used to cover (some of) 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 others measures to achieve flood risk management targets. At screening, such measures should not be rejected on the basis that other structural measures appear to be viable, but only on the basis that they are not applicable, appropriate or viable in the same manner as other methods.
6.0	**MCA OPTION APPRAISAL PROCESS**
6.1	**Overview of MCA Option Appraisal Process** The option appraisal process is set out in Section 11.6 of the Generic Brief, with reference made to Section 8.4 and Appendix J in relation to the FRM objectives that will form part of the appraisal process. Section 8 of the Generic Brief notes that both the Flood Risk Management Objectives set out in Appendix J, and the descriptions of the local weightings provided in Section 8.4, are subject to review and refinement, with guidelines to be issued by the OPW for consultation with the NTCG. As stated in Section 1 herein, the purpose of this GN is to clarify the requirements of the option appraisal process, and to set a common approach to the multi-criteria analysis (MCA) for option appraisal, and hence provide the guidelines referred to above.

This section outlines the overall structure of the MCA framework, which forms the core of option appraisal, and provides a description of each component of the framework. The objectives are set out in Appendix A herein, with detailed guidance on the approach to be taken with respect to each objective then set out in Appendix B, including definition of global weightings and indicators, and guidance on assessing local weightings. Guidance on scoring the performance of different options under the MCA with respect to each objective is set out in Appendix C.

Overall Framework

The appraisal of flood relief scheme options in the past has been primarily based on economic costs and benefits, with an EIA undertaken to minimise negative impacts on the environment and public consultation undertaken to ensure social acceptability. The National Flood Policy Review (OPW, 2004) set a broader range of objectives for flood risk management in Ireland, that was subsequently reinforced by the EU 'Floods' Directive [2006/60/EC].

The MCA framework has been developed to broaden the range of potential impacts that flooding and the implementation of FRM measures can have that are taken into account in the development and selection of FRM options and strategies, and their subsequent prioritisation. It is based on the numeric, but non-monetarised assessment of options against a range of objectives, whereby indicators are set for each objective. These indicators are then used to define scores for that objective on the basis of the degree to which the option being appraised goes beyond the Basic Requirement for that objective towards meeting the Aspirational Target. Weightings are applied globally (nationally) for each objective, with local weightings then applied to reflect the local importance of that objective in the context of the respective SSA, and these weightings are applied to the scores derived as above.

The sums of the scores, set against the total costs of their achievement, represent the preference for a given option (using all criteria) or the net benefits of an option (using only the economic, social and environmental criteria). These total scores can be used to inform the decision on the selection of (a) preferred option(s) for a given location and the prioritisation of potential schemes between locations.

Each component of the MCA Framework is explained in more detail below.

Objectives

The FRM objectives reflect what the overall flood risk management programme is seeking to achieve, expanding on the requirements of the National Flood Policy Review and the EU 'Floods' Directive.

At a local level, and for the purposes of the MCA, the objectives set out an aim that each flood risk management option should be seeking to achieve, if possible. The degree to which an option achieves the objective is an indication of the 'success' of the option, and equally, the more an option achieves across all of the objectives, then the greater the preference that will be given to that option relative to others, taking account also of the cost of each of the options.

	Indicators The indicators are parameters, measurable and numeric where possible, by which the ‘success’ of an option in meeting a particular objective can be gauged. **Basic Requirements and Aspirational Targets** The objectives are termed as general aims for the management or reduction of flood risk, or for other benefits that can be accrued through the implementation of flood risk management measures. To enable the assessment of the degree to which an option ‘succeeds’ in meeting the stated aims, a more defined aim needs to be set, along with a benchmark for neutral status (i.e., no impact). The Basic Requirements and Aspirational Targets are set in terms of the defined indictor, i.e., make use of the same parameter for setting target or threshold values as that used for scoring against the objective. ***Aspirational Targets*** The aim is defined as an Aspirational Target, whereby an option would be deemed as perfect with respect to the given objective if it were to meet the Aspirational Target. Typically this will represent complete removal of a risk, or the full achievement of another benefit, and it will be rare that any option will meet such Aspirational Targets for even one, let alone all, objectives. The Aspirational Targets are therefore NOT requirements that must be met, and very effective options may still fail to meet the Aspirational Targets. ***Basic Requirements*** The Basic Requirement represents a neutral status or ‘no change’, whereby if an option has no impact on the matter the objective relates to, or meets what might be termed for some objectives as minimum requirements for acceptability, then that option will have met the Basic Requirement. If an option performs worse than the Basic Requirement, i.e., has a negative impact (a dis-benefit) or does not meet the minimum requirements for acceptability, it will score a negative-value score for that objective, but might still be considered further, depending on the degree of the dis-benefit or failure to meet the requirements. The Basic Requirement is therefore NOT an absolute minimum requirement for acceptability, but a benchmark to define positive versus negative impacts or performance. **Scoring Against Objectives** An option may be scored against the objective by determining the degree to which it performs, measured using the defined indicator, in going beyond the Basic Requirement towards meeting the Aspirational Target (which are both expressed in the same terms as the indicator). The following generic rules should be applied in scoring, although specific guidance is given in Appendix B:

- An option that meets the Basic Requirement only should be given a score of zero.
- An option that meets the Aspirational Target should be given a score of five.
- An option that performs somewhere between the Basic Requirement and the Aspirational Target should be given a score proportional to the degree to which it achieves the objective beyond the Basic Requirement towards meeting the Aspirational Target.
- An option that performs better than the Aspirational Target (which for most objectives will not be possible) should still only be limited to a maximum score of five.
- An option that performs worse than the Basic Requirement, i.e., creates a dis-benefit or does perform to an acceptable standard, should be given a negative score down to –5 using, where possible, the same scoring mechanism as that used for scoring options that achieve between the Basic Requirement and the Aspirational Target.
- There are exceptions to the negative scoring where the performance or impact of the option becomes unacceptable, and the option should be rejected on the basis of its performance on the given objective alone. In such circumstances the option should be given a '-999' score and be rejected from further consideration. The thresholds for unacceptability of an option are defined where relevant in the detailed objective description sheets in Appendix B.

The resultant scores should only be considered as initial guidance for decision-making, and the arithmetic calculation of scores can sometimes give misleading results that do not take account of all relevant issues. The application of professional judgement in reviewing and confirming or amending all of the derived scores is essential.

Justification of the score assigned should be provided which is robust, and with a clear and transparent reasoning that should include quantitative evidence where reasonably possible. Such justification should be self-explanatory, but may vary in detail, with only brief text (potentially a standard comment) provided in instances where the basis for score is clear (and would be so to the public and stakeholders) but with more detailed description required in other circumstances where the basis for the score assigned is not so clear, such as where amendments have been made to numerically-derived scores or where the scoring has varied from the guidance for certain reasons.

Global Weightings
Global Weightings are assigned to each objective to give it more or less weight in the overall assessment of the suitability or value of the option. The Global Weightings are fixed nationally to ensure a consistent approach and basis for prioritisation, and are intended to represent the 'societal value' for the objective relative to the others, i.e., with those of most weight representing the most important objectives.

	Local Weightings The Local Weightings are assigned to each objective for each location under consideration (i.e., each SSA), and are intended to represent the local importance of that objective within the local context. They are very important within the framework as they provide scale to the process, whereby if the subject of a given objective is of much greater significance than another in the same location, and should have a greater influence on the choice of option, then this can be provided for through the Local Weightings. Similarly, the importance of an issue / objective in one location relative to another can also be provided for through the Local Weightings. Local Weightings for some objectives will be numerically determined according to the degree of risk (e.g., economic annual average damages, number of properties, etc.), but for some others will need to be set by professional judgement. In both instances however, the assignment should take into account local knowledge provided at the stakeholder and public consultation events (primarily for events during the mapping stage, but account may also need to be taken of significant issues raised during the optioneering stage PCDs). Guidance is provided on assigning Local Weightings in the detailed objective description sheets in Appendix B. Justification should be provided to the degree necessary to permit defence for the Local Weighting assigned in the face of public or stakeholder questioning. Such justification should be self-explanatory, but may vary in detail, with only brief text (potentially a standard comment) provided in instances where the basis for weighting is clear (and would be so to the public and stakeholders) but with more detailed description required in other circumstances where the basis for the weighting assigned is not so clear, and / or varies from the guidance provided or the numerical value derived.
6.2	***MCA Outcomes*** **Criteria Scores:** Once the MCA has been applied, each option will have a weighted score for each objective. For each option, the scores for each of the four criteria should be summed to provide the Criteria Scores. **MCA Benefit Score:** To derive the MCA Benefit Score, the scores for the economic, social and environmental Criteria Scores should be summed. This score represents the net benefits of the option. **Option Selection MCA Score:** To derive the Option Selection MCA Score, the scores for all four of the criteria should be summed. This score compliments the MCA Benefit Score with the Technical Criteria Score, and hence includes all of the aspects that should be taken into account in considering the preferred option for a given location.

	MCA Benefit – Cost Ratio (BCR): The MCA Benefit Score should then be divided by the cost of the option to provide a numerical, but non-monetarised, MCA Benefit - Cost Ratio that provides an indication of the overall benefits that can be delivered per Euro invested. The **Economic Benefit – Cost Ratio (BCR)** should also be calculated using the more traditional techniques (i.e., the FHRC Multi-Coloured Manual, rather than the option appraisal MCA set out herein). The above scores and ratio can be used to inform decisions on which option might be preferred for each SSA, as set out in Section 7 herein.
6.3	***Automation*** With the exception of most of the environmental objectives, there is significant scope for automation in the application of the MCA given the numeric nature of many of the indicators and function-based approach to scoring for many of the objectives. Where an automated process is used, serious consideration should be given to the use of lookup tables for values or parameters that are used frequently (e.g., for multiple locations or multiple methods) to facilitate a single point amendment approach that, based on experience, can make very significant savings in time in application of the MCA as consultation and review processes lead to amendments in such values or parameters.
6.4	***Application of Professional Judgement*** As noted in Section 3.1, an automated system can be prone to error and cannot take always account of specific or local issues. It is therefore essential, particularly for the option appraisal process, that the processes and all outcomes are subject to the application of professional review and judgement. The decisions on recommendations for preferred options is one to be made by the consultant, not by the MCA process.
6.5	***Design Standards*** As set out in Section 3.4, while the 1% AEP event and the 0.5% AEP event have been identified as the preferred design standards against which measures should provide protection for fluvial and coastal flooding respectively, other design standards should be considered under certain circumstances. In the event that professional judgement and / or consultation feedback indicates that alternative standards of protection might be preferred, then the appraisal should be undertaken for a sample alternative standard. It is not however expected that a full analysis be undertaken to optimise and define the alternative standard of protection for each option, but the appraisal should be undertaken on at least one alternative standard to demonstrate that alternative standards could provide (or

	indeed would not provide) greater benefit or return on investment, or provide benefits / viability in a manner that is more socially or environmentally acceptable, which in turn should inform the outline design of the option and be reported in the FRMP. The post-CFRAM full scheme development process can then undertake the more detailed analysis to identify the optimal standard of protection for the preferred option.
6.6	**Measures Required under National Policy** Certain non-structural flood risk management measures are required as matters of national policy. These would include: - Application of the Guidelines on the Planning System and Flood Risk Management (DoECLG & OPW, November 2009) - Preparation of emergency response plans for severe weather events, including flood events (A Framework for Major Emergency Management, DoECLG) As these measures are required to be applied regardless of other proposed measures, or of the outcomes of an appraisal under the MCA process, then they do not need to be subjected to an MCA appraisal, but may be assumed to be applicable and required for all AFAs and other SSAs. Standard texts can be prepared for the inclusion of these measures in the Preliminary Options Reports and the FRMPs.
7.0	**SELECTION OF PREFERRED OPTIONS AND PRIORITISATION**
7.1	***Option Selection*** The option selection process is set out in Section 11.7 of the Generic Brief. The following outcomes of the MCA process should be used to guide the decision-making process, subject to the application of professional judgement and consultation with the Steering and Progress Groups (and subsequently stakeholder and public consultation): – The Technical Criteria Score – The MCA Benefit Score – The Option Selection MCA Score – The MCA BCR – The Economic BCR Noting other considerations outlined below, greatest weight should be given in the option selection to the MCA BCR, which provides a measure of the overall benefits per euro investment. However, professional judgement must be applied at this stage, taking into account local consultation outcomes. The reasoning for the selection of a given option should be recorded and reported.

	All proposed measures (i.e., options selected as preferred options for a given AFA or SSA) should have a economic BCR in excess of unity, unless clear and robust justification can be given as to why an option that is not economically cost-beneficial is being proposed for implementation. The options should also be considered across all SSAs to check for spatial coherence, as set out in Section 11.7 of the Generic Project Brief. The options should also be considered across the SSAs with consideration of the potential impacts of future changes, such as climate change, as set out in Section 11.7 of the Generic Project Brief, and is discussed in further detail in GN 29.
7.2	***Prioritisation*** The prioritisation of recommended options across all SSAs will be lead by the OPW as an inter-project, i.e., national, assessment taking account of projected multi-annual budgets. This will make use of the following MCA outcomes: – The MCA Benefit Score – The MCA BCR – The Economic BCR While the national prioritisation process will be lead by the OPW, the consultants should annotate the preferred options during the option selection process with any particular factors that they consider should be taken into account in the prioritisation process. Such factors might include special risks that have not been properly accounted for in the standardised MCA process.
8.0	**DEFINITIONS**
	No new definitions are established herein.
9.0	**REFERENCES AND RESOURCES**
	References – National CFRAM Programme – Stage I Tender Documents: Project Brief – 2149/RP/002/F, May 2010 – Report of the Flood Policy Review Group – OPW, 2009 – Directive on the assessment and management of flood risks (the EU ‘Floods’ Directive) – 2006/60/EC – Guidelines on the Planning System and Flood Risk Management (DoECLG & OPW, 2009) – A Framework for Major Emergency Management (DoECLG)

APPENDIX A TABLE OF FLOOD RISK MANAGEMENT OBJECTIVES

CRITERIA		OBJECTIVE		SUB-OBJECTIVE		GLOBAL WEIGHTING
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	
		b	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	

CRITERIA		OBJECTIVE		SUB-OBJECTIVE		GLOBAL WEIGHTING
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.	
		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.	

APPENDIX B DETAILED DESCRIPTIONS OF INDIVIDUAL OBJECTIVES

OBJECTIVE 1.A.	
Objective	**Ensure flood risk management options are operationally robust**
Indicator	Level of operational risk of option - Degree of reliance on mechanical, electrical or electronic systems, or on human intervention, action or decision, for the option to operate or perform successfully
Scoring	By professional judgement, based on the guidance and criteria set out below
Basic Requirement	Moderate to high, but manageable, degree of operational risk, i.e., an option with a high degree of reliance on mechanical, electrical or electronic systems, or on human intervention, action or decision, but which, with the allocation of adequate resources, could be operated with an acceptable degree of risk of failure
Aspirational Target	No operational risk, i.e., no reliance on mechanical, electrical or electronic systems, or on human intervention, action or decision for the option to operate or perform successfully
Global Weighting	20
Local Weighting	Constant and equal to 5, i.e., no amendment to local weighting
Guidance on Assignment of Local Weightings	
The Local Weighting to be applied for this objective is constant, and should always be set equal to 5, as it always a consideration in option design and selection.	
Guidance on Scoring	
Scoring is to be by professional judgement, based on the guidance and criteria set out below, taking into account the degree of reliance of the option on mechanical, electrical or electronic systems ('systems'), or on human intervention, action or decision ('intervention') to operate or perform successfully (i.e., to design). The scoring should also consider and be adjusted where necessary other relevant factors, such as: - The risks / consequences of failure of the system or intervention (with a higher risk, and hence lower score, being given where failure would result in total or major failure and resultant flooding, as opposed to partial failure leading to only localised or minor flooding) - Whether the interventions required are during times of flood (e.g., erection of demountables) or at other times (e.g., routine maintenance), where interventions required during a flood event would be deemed to represent a higher risk, and hence be assigned a lower score, due to potential travel or communications difficulties	

- The frequency that interventions would be required, with a higher risk, and hence lower score, being assigned to measures that require frequent interventions
- Whether institutional changes will be required to effectively implement and operate a measure, with a higher risk, and hence lower score, if change is required
- Other locally context-specific issues that should give cause to deviate from the guidance below

Indicative Scoring for Objective 1.A
Description of operational risk for relevant score, with examples given in italics

Score	Description / *Examples*
5	No operational risk, i.e., no reliance on systems or intervention, with limited monitoring / maintenance requirements *Fixed flood defence walls, Increased conveyance in self-cleansing rivers or diversion channels, Relocation*
4	Negligible operational risk, i.e., no reliance on systems or intervention, with more regular monitoring and intermittent, but potentially substantial, maintenance requirements *Fixed flood defence embankments, Uncontrolled storage, Increased conveyance measures (incl. diversion channels) where maintenance required*
3	Very low operational risk, i.e., there is a requirement for simple systems or interventions for the option to operate, with regular monitoring and maintenance required, but a very low likelihood of system / operation failure *Pumping systems, Tidal barriers, Storage with controlled inflow / outflow mechanisms, Simple flood forecasting and warning systems with long advance warning periods available (appx. 12 hours+)*
2	Low risk, i.e., there is a requirement for systems or interventions for the option to operate, with regular monitoring and maintenance required, and / or a low to moderate likelihood of system / operation failure *Complex flood forecasting and warning systems with long advance warning periods available, with a limited number of rapidly deployed in-situ flood defences (e.g., flood gates, tipping defences)*
1	Low / moderate risk, i.e., options that are fully reliant on systems or interventions for the option to operate, with regular monitoring and maintenance required, and a low to moderate likelihood of system / operation failure *Simple flood forecasting and warning systems with medium-range advance warning periods available (appx. 6 hours), with several rapidly deployed in-situ flood defences (e.g., flood gates, tipping defences)*

0	Moderate, but manageable, risk, i.e., options that are fully reliant on systems or interventions for the option to operate, with regular monitoring and maintenance required, and a moderate likelihood of system / operation failure *Complex flood forecasting and warning systems with medium-range advance warning periods available (appx. 6 hours), with several rapidly deployed in-situ flood defences (e.g., flood gates, tipping defences) or limited demountable defences that are stored on-site*
-1	Moderate / high risk, i.e., options that are fully reliant on systems or interventions for the option to operate, with regular monitoring and maintenance required, and a moderate to high likelihood of system / operation failure *Flood forecasting and warning system of long advance warning periods with substantial demountable defences requiring transport from off-site*
-3	High risk, i.e., options that are fully reliant on systems or interventions for the option to operate, with regular monitoring and maintenance required, and a high likelihood of system / operation failure *Flood forecasting and warning systems of medium-range advance warning periods with substantial demountable defences requiring transport from off-site*
-5	Foreseeable likelihood of failure that would render the measure ineffective *Flood forecasting and warning systems with short advance warning periods available (appx. 3 hours or less) and interventions or actions by the public required for damage to be avoided*
-999	Unacceptable risk, i.e., options that are fully reliant on systems or interventions for the option to operate that will be difficult to achieve, and for which failure of the system / intervention is likely and would have unacceptable consequences

Note: Where systems / interventions are required, it is assumed that redundancy and / or back-up systems will be included as part of the option design, e.g., manual overrides for automated systems, duplicate telemetry / communication systems, etc.

OBJECTIVE 1.B	
Objective	**Minimise health and safety risk in construction, maintenance and operation of the flood risk management option**
Indicator	Degree of health and safety risk during construction, maintenance and operation
Scoring	By professional judgement, taking into account the guidance and criteria set out below, with review of candidate preferred options by PSDP
Basic Requirement	Moderate to high, but acceptable and manageable, level of health and safety risk during construction, maintenance or operation
Aspirational Target	Negligible risk to health and safety during construction, maintenance or operation
Global Weighting	20
Local Weighting	Constant and equal to 5, i.e., no amendment to local weighting

Guidance on Assignment of Local Weightings

The Local Weighting to be applied for this objective is constant, and should always be set equal to 5, as it always a consideration in option design and selection.

Guidance on Scoring

Scoring is to be by professional judgement, taking into account the guidance and criteria set out below.

The indicative score under this objective should be set at five, and then have a point deducted for each specific risk (as defined under the Safety, Health and Welfare at work (Construction) Regulations) likely to be encountered in a) construction and then again in b) operation and maintenance.

As an example, a measure requiring deep excavation and working near water during construction, and then working near water during operation / maintenance, would have a score of 2 (5 – 2 (construction stage) – 1 (operation / maintenance stage) = 3).

Professional judgement needs then to be applied to take into account any locally or context-specific issues, e.g., specific hazards, or a potentially higher risk for construction in an urban environment.

The PSDP (or person assigned the duties of PSDP where a company is nominated as PSDP) should review the scoring afforded to the preferred option(s) and other options that would be realistically in contention to be adopted as a preferred option based on other objectives, to ensure that the scoring is appropriate and reasonable.

Note: It should be assumed in assigning scores that good construction health and safety practices will be implemented.

OBJECTIVE 1.C	
Objective	**Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change**
Indicator	Sustainability and adaptability of the flood risk management measure in the face of potential future changes, including the potential impacts of climate change
Scoring	By professional judgement, based on the guidance and criteria set out below
Basic Requirement	Option should not hinder future interventions that may be required to manage potential future increases in risk
Aspirational Target	Option to provide for, or be adaptable to, the HEFS in terms of maintaining the standard of protection at no or negligible cost
Global Weighting	20
Local Weighting	Constant and equal to 5, i.e., no amendment to local weighting

Guidance on Assignment of Local Weightings

The Local Weighting to be applied for this objective is constant, and should always be set equal to 5, as it always a consideration in option design and selection.

It is recognised that the impacts of, and vulnerability to, potential future changes will vary significantly from community to community. However, this objective is used only for option selection, and is not used for prioritisation, and so the relative significance of the impacts and vulnerability to potential future change between communities is not relevant. As promoting adaptability is always important, the local weighting is to be kept constant.

Guidance on Scoring

Scoring is to be by professional judgement, taking into account the guidance and criteria set out below.

The scoring for a given measure should reflect the cost and the degree of difficulty and potential impacts (technically, socially, environmentally, legislatively, etc.) of potential future adaptations that would be necessary to maintain the Standard of Protection of the measure under the MRFS and/or HEFS, whereby the greater the cost, difficulty and impact, the lower the score.

This assignment of a score should reflect the findings of the application of GN29 on climate change adaptation, and account should be taken of the robustness of the option in terms of the need for possible future interventions that may be through additional measures as well direct adaptation of the option under consideration. For example, an option may not be, nor need to, adaptable itself, but may nonetheless score highly if it is shown through a decision-tree analysis this it is very robust in terms of options for future interventions.

The guidance given below gives examples for certain scores. Other scores (between 5 and -5) should also be used, where appropriate, interpolating between the scores for which examples are given, where the costs and degree of difficulty and impact may be at the high or low relative to the examples given.

Score	Description / *Examples*
5	Option is inherently adaptable at no / negligible cost, difficulty and impact and provides no impediment to future interventions to address new potential future risk areas (i.e., that are separate from the area benefitting from the option in question). This would include Non-Structural measures, and Structural measures designed using the assumptive approach to the HEFS and / or that would be able to maintain the standard of protection / risk reduction under the HEFS with no or negligible further cost or intervention
4	Option is readily adaptable at limited cost, difficulty and impact, and provides no impediment to future interventions to address new potential future risk areas, e.g.: • *Walls where the foundations and wall are built to permit an extension in height to maintain the required level of protection / risk reduction for the HEFS, which would be acceptable locally (e.g., typically less than 1.2-1.5m height in public areas after being raised)* • *Structural measures (e.g., walls) designed using the assumptive approach to the MRFS and / or that would be able to maintain the standard of protection / risk reduction under the MRFS with no or negligible further cost or intervention* • *Embankments, earth flow diversion channels or other such structures that could be readily topped-up / enhanced*

3	Option is adaptable at moderate cost, difficulty and impact, and provides no impediment to future interventions to address new potential future risk areas, e.g.:
	• *Walls where the foundations and wall are built to permit an extension in height to maintain the required standard of protection / risk reduction for :*
	  o *the HEFS, which would be acceptable locally but where adaptation would have other negative implications / costs (e.g., more than 1.2-1.5m height in public areas after being raised, but with demountable defences necessary to provide protection above 1.2-1.5m)*
	  o *the MRFS, which would be acceptable locally (e.g., typically less than 1.2-1.5m height in public areas after being raised)*
	• *Conveyance enhancement, major earth storage structures or similar measures where substantial earthworks would be required to enhance performance, but where adaptation would not require replacement of structural works*

Score	Description / *Examples*
2	Option is adaptable at moderate to significant cost, difficulty and impact, and provides no impediment to future interventions to address new potential future risk areas, e.g.: • *Walls where the foundations and wall are built to permit an extension in height to maintain the required standard of protection / risk reduction for the MRFS, which would be acceptable locally but where adaptation would have other negative implications / costs (e.g., more than 1.2-1.5m height in public areas after being raised, but with demountable defences necessary to provide protection above 1.2-1.5m)*
1	Option is adaptable only at significant cost, difficulty and impact, and provides no impediment to future interventions to address new potential future risk areas, e.g.: • *Conveyance enhancement (including flow diversions), flow retention or similar measures where significant structural replacement works would be required* • *Protection measures which, once adapted, would exceed 1.2-1.5m in height in public areas with no scope for demountable barriers*
0	Option is not adaptable, but provides no impediment to future interventions to address new potential future risk areas. *Options that are not adaptable, although additional works (e.g., separate measures) may need to be undertaken to address potential future increases in risk to the area benefitting from the option in question, e.g.,:* • *Coastal / tidal defence walls that can not be raised (e.g., due to visual impact, and / or where demountables are not a viable option), but where a tidal barrage could be implemented as a separate future intervention* *Option does not hinder future interventions to address new potential future risk areas*
-1	Option is not adaptable, and will create a minor interference or impediment to with potential future measures *Options that will cause a minor impediment and some additional cost to future interventions that may be needed to address the MRFS or HEFS.*
-3	Option is not adaptable, and will create a moderate interference with or impediment to potential future measures *Options that will cause a moderate impediment and additional cost to future interventions that may be needed to address the MRFS or HEFS.*
-5	Option is not adaptable, and will create a major interference with or impediment to potential future measures *Options that will cause a major impediment and substantial additional cost to future interventions that may be needed to address the MRFS or HEFS.*
-999	Unacceptable interference with potential future measures

OBJECTIVE 2.A	
Objective	**Reduce economic damages**
Indicator	Annual Average Damage (AAD) expressed in Euro / year, calculated in accordance with the economic risk assessment methods, but with no allowance for social / intangible benefits
Scoring	0.05 X percentage reduction in AAD
Basic Requirement	AAD is not increased
Aspirational Target	100% reduction in AAD
Global Weighting	30
Local Weighting	AAD for the SSA / €75,000

Guidance on Assignment of Local Weightings

The Local Weighting should be calculated as:

Local Weighting = AAD for the SSA / €75,000

Where:

The Local Weighting may not exceed the ceiling value of 5, and,

AAD is the Annual Average (economic) Damages, excluding any allowances for social and intangible benefits

'€75,000' is a factor that has been selected to set the Local Weighting equal to 5 in SSAs / AFAs where economic damages are among the highest typically encountered in Ireland, i.e., it has been set to ensure that there will not be a large number of locations where the ceiling value of 5 is exceeded. This factor has been selected based on trial application on a number of test cases to ensure that the factor meets the above criteria.

The above calculation process is automated, and in this instance the outcome should be used as calculated. Professional judgement does however need to be applied within the requirements and guidance provided in relation to the calculation of the Annual Average Damages.

Guidance on Scoring

Indicator Calculation

The indicator should be calculated on the basis of the economic damage analysis, to be undertaken in accordance with Appendix I of the Generic Project Brief and guided by Guidance Note 27, but with no allowance for social / intangible benefits as these are provided for under other objectives within the MCA.

Option Scoring
The score for a given option should be calculated as:

Score = 0.05 X Percentage Reduction in AAD

Standard of Protection Factor
A Standard of Protection Factor is not applicable to this objective, as it is implicit within the scoring process.

Non-Structural Option Risk Reduction
The following values should apply as the percentage reduction in AAD for non-structural options (i.e., those that do not reduce hazard, but can reduce risk):

Non-Structural Measure	**% Reduction in AAD**
Flood Forecasting and Warning: Warning Period > 12 hrs	10%
Flood Forecasting and Warning: Warning Period 6 - 12 hrs	6%
Flood Forecasting and Warning: Warning Period 2 - 6 hrs	4%
Flood Forecasting and Warning: Warning Period < 2 hrs	0%

OBJECTIVE 2.B	
Objective	**Minimise risk to transport infrastructure**
Indicator	Number and type of transport routes at risk from flooding
Scoring	Based on calculated assessment, adjusted by professional judgement
Basic Requirement	No increase in risk to transport infrastructure
Aspirational Target	Reduce risk to transport infrastructure to zero
Global Weighting	10
Local Weighting	Based on calculated assessment, adjusted by professional judgement

Guidance on Assignment of Local Weightings

The local weightings should be calculated based on a score derived from the number and type of transport routes potentially blocked by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of that route, taking account of the duration of flooding and the diversion time (in relation to road flooding).

Route and Airport Scoring

Each type of transport route and airport is assigned a score. The types of transport routes and airports are categorised and scored as follows:

Type	Road	Rail	Airports	Score
IRR			International	500
A	Motorway	Main line / DART / Luas		250
B	National Primary		Regional	150
C	National Secondary	Branch Line		75
D	Regional			25
E	Local Rural			10
F	Local Urban (Street)			See below

Local Urban Roads (Streets)

Within an AFA there may be multiple local roads (streets) at risk from flooding, and the flooding of these does not necessarily have a proportional cumulative effect in terms of impact on transport. As such, a maximum value of 25 should be applied with respect to the flooding of urban streets, with professional judgement applied in determining the score up to this maximum score.

Note that each road joining a junction should be treated as an individual road, and similarly train stations / rail junctions prone to flooding might reflect interruption to multiple routes.

Probability Factoring

For each route, the score is then factored by the probability of the highest probability (least severe) flood event that causes flooding of that route, where the factor applied is calculated as:

Factor = Probability of flooding (expressed as the AEP, e.g., 0.01 for 1% / 100-yr)

For example, a National Primary road at risk from flooding in events of probability of 0.02 and less, then the factored score would be = 150 X 0.02 = 3

Other Factors

Duration of Flooding

The damages associated with the flooding of transport routes are related to the duration of the flooding. It is assumed that substantive flooding of the route will last approximately 6 to 12 hours. However, if the duration of flooding, and hence disruption, is significantly greater or less than this, then professional judgement should be applied to increase or decrease the score accordingly, noting amended or compensatory behaviours when flooding is known but also the impact of long-term isolation of properties.

Diversion Time for Road Flooding

The damages associated with the flooding of roads are related to the length of diversion in terms of additional journey time. It is assumed that diversion would typically increase journey time by approximately 15 to 30 minutes. However, if the duration of flooding, and hence disruption, is significantly greater or less than this, then professional judgement should be applied to increase or decrease the score accordingly. In determining diversion time, advice should be sought on which routes are likely to remain open during a flood.

Calculation of Other Factors

Note that the factors for duration and diversion time do **NOT** need to be calculated based on distance, speed, etc., but may be estimated based on professional judgement taking into account local anecdotal information derived from local authority staff and public observations.

Total AFA Score (Local Weighting)

For the given AFA, the total AFA score is calculated as the sum of the factored scores for each transport route at risk from flooding, subject to a maximum score of 5.

For example, an AFA with a national secondary road and regional road at risk from flooding in events of probability of 0.01 and 0.05 respectively, and multiple urban streets at risk from flooding in events of probability from 0.1, then the factored score would be:

(National secondary road: 75 X 0.01 = 0.75) + (Regional road: = 25 X 0.05 = 1.25) + (Multiple urban streets) = 25 X 0.1 = 2.5 = Total AFA Score (i.e., Local Weighting) = 4.50

Note that final local weighting taking into account the application of the factors for duration and diversion time should still not exceed a maximum of 5.

The above provides guidance on the setting of local weightings for this objective. However, professional judgement should also be applied as per Section 3.3, taking account of other local factors.

Guidance on Option Scoring

Residual Risk Score

The residual risk score for a flood risk management option should be calculated in the same manner as the local weighting, but based on the flood hazard with the option applied.

In the case of measures providing flood defence, then the residual risk score can be calculated simply by adjusting the factor for probability to that of the standard of protection (following the simplistic assumption that once the standard of protection is exceeded for a given flood defence, then no defence is provided).

Option Scoring

Options are scored based on the degree of reduction in the risk to transport routes, calculated using the residual risk score as determined for the relevant option, and the final local weighting, and multiplied by a factor of 5.

The score for a given option should be calculated as:

Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]

The other factors detailed under the guidance on the assignment of Local Weighting should also be taken into account in assigning the score for a measure.

Standard of Protection Factor

A Standard of Protection Factor is not applicable to this objective, as it is implicit within the scoring process.

Non-Structural Option Risk Reduction

Flood warning does not reduce hazard, but generally can reduce risk. While transport routes will still be blocked in the event of a flood regardless of the advance warning of the flooding, the negative impact (delay and disruption) could be slightly reduced if advance warning were available. As such, non-structural measures should afforded the percentage reduction in score as set out below:

Non-Structural Measure	% Reduction in Factored Score
Flood Forecasting and Warning: Warning Period > 12 hrs	10%
Flood Forecasting and Warning: Warning Period 6 - 12 hrs	6%
Flood Forecasting and Warning: Warning Period 2 - 6 hrs	4%
Flood Forecasting and Warning: Warning Period < 2 hrs	0%

Professional judgement should be applied to review and confirm scores as per Section 3.3.

OBJECTIVE 2.C	
Objective	**Minimise risk to utility infrastructure**
Indicator	Number and type of infrastructure assets at risk from flooding
Scoring	Based on calculated assessment, adjusted by professional judgement
Basic Requirement	No increase in risk to utility infrastructure
Aspirational Target	Reduce risk to utility infrastructure to zero
Global Weighting	10
Local Weighting	Based on calculated assessment, adjusted by professional judgement

Guidance on Assignment of Local Weightings

The local weightings should be calculated based on a score derived from the number and type of utility infrastructure receptors potentially affected by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of that receptor.

Receptor Scoring

Each type of utility receptor is assigned a score. The types of utility receptors are categorised and scored as follows:

Receptor Type	Score
Power Stations	500
HV Sub-Stations	250
Gas Assets – High Priority	100
Gas Assets – Medium Priority	25
Water Treatment Plants & Primary Pumping Facilities	250
Waste Water Treatment Plants & Primary Pumping Facilities	250
Core Telecommunication Exchanges	100
Non-Core Telecommunication Exchanges	25

Probability Factoring

For each receptor, the score is then factored by the probability of the highest probability (least severe) flood event that causes flooding of that receptor, where the factor applied is calculated as:

Factor = Probability of flooding (expressed as the AEP, e.g., 0.01 for 1%)

For example, a Water Treatment Plant at risk from flooding in events of probability of 0.02 and less, then the factored score would be:

Factored score = 250 X 0.02 = 5

Other Factors

Service Area / Population

The impact of flooding of a utility asset, and the associated damage and disruption of service, is related to the population and/or area it serves. It is assumed that an asset would be typical of its classification. However, if the population and/or area served is significantly greater or less than this, then professional judgement should be applied to increase or decrease the score accordingly.

Calculation of Other Factors

Note that the factors for service area / population do **NOT** need to be calculated based on the area or population served, but may be estimated based on professional judgement taking into account local anecdotal information derived from local authority staff and public observations. (Note: The OPW will seek industry standard data re typical service numbers).

Total AFA Score (Local Weighting)

For the given AFA, the total AFA score is calculated as the sum of the factored scores for each receptor at risk from flooding, subject to a maximum score of 5.

Note that final local weighting taking into account the application of the factors for service area / population should still not exceed a maximum of 5.

The above provides guidance on the setting of local weightings for this objective. However, professional judgement should also be applied as per Section 3.3.

Guidance on Option Scoring

Residual Risk Score

The residual risk score for a flood risk management option should be calculated in the same manner as the local weighting, but based on the flood hazard with the option applied.

In the case of measures providing flood defence, then the residual risk score can be calculated simply by adjusting the factor for probability to that of the standard of protection (following the simplistic assumption that once the standard of protection is exceeded for a given flood defence, then no defence is provided).

Option Scoring
Options are scored based on the degree of reduction in the risk to utility receptors, calculated using the residual risk score as determined for the relevant option, and the final local weighting, and multiplied by a factor of 5.

The score for a given option should be calculated as:

Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]

The other factors detailed under the guidance on the assignment of Local Weighting should also be taken into account in assigning the score for a measure.

Standard of Protection Factor
A Standard of Protection Factor is not applicable to this objective, as it is implicit within the scoring process.

Non-Structural Option Risk Reduction
Flood warning does not reduce hazard, but generally can reduce risk. While utility receptors could still be flooded in the event of a flood regardless of the advance warning of the flooding, the negative impact (damage to the utility and disruption to the service the utility provides) could be slightly reduced if advance warning were available. As such, non-structural measures should afforded the percentage reduction in score as set out below:

Non-Structural Measure	% Reduction in Factored Score
Flood Forecasting and Warning: Warning Period > 12 hrs	10%
Flood Forecasting and Warning: Warning Period 6 - 12 hrs	6%
Flood Forecasting and Warning: Warning Period 2 - 6 hrs	4%
Flood Forecasting and Warning: Warning Period < 2 hrs	0%

The above provides guidance on the setting of local weightings and scoring for this objective. However, professional judgement should also be applied as per Section 3.3.

OBJECTIVE 2.D	
Objective	**Manage risk to agriculture**
Indicator	Agricultural production
Scoring	By professional judgement, taking account of local advice
Basic Requirement	No increase in the negative impact of flooding on agricultural production
Aspirational Target	Provide the potential for enhanced agricultural production
Global Weighting	10
Local Weighting	By professional judgement, taking account of local advice

Guidance on Assignment of Local Weightings

Setting of the Local Weighting is to be by professional judgement, taking account of the value and social importance of the agricultural industry in the area guided by advice from the steering and progress groups and via submissions from the public.

Guidance on Scoring

Option Scoring

Scoring is to be professional judgement, taking into account local advice.

Consideration in setting the scores for an option should include:

- An increase or decrease in the area of agricultural land subject to flooding
- The frequency and seasonality of flooding, and the seasonality of agricultural production and land use in the area
- The duration of flooding
- The source of floodwaters, noting that salt water flooding can cause significantly more damage to agricultural production than river flooding
- The overland flow velocity
- The existing and potential other agricultural uses of the land
- The potential for flood warning to mitigate the impacts of flooding on agriculture
- Factors that may not affect the area of land flooding but that could otherwise impact positively or negatively on agricultural production (e.g., risk to local dairy factory, long-term isolation of farms, etc.)
- The potential to enhanced agricultural production, such as through the reduction of the frequency or extent of flooding of agricultural land.

OBJECTIVE 3.A (i)	
Objective	**Minimise risk to human health and life – Residents**
Indicator	Annual Average Number of residential properties at risk from flooding
Scoring	Based on calculated assessment, adjusted by professional judgement
Basic Requirement	Number of properties at risk is not increased
Aspirational Target	100% reduction in number of residential properties at risk
Global Weighting	30
Local Weighting	Based on calculated assessment, adjusted by professional judgement

Guidance on Assignment of Local Weightings

The local weightings should be calculated based on a score derived from the number of residential properties potentially affected by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of each property.

Receptor Scoring

All residential properties should be treated as equal for the purposes of the calculated score. To ensure that the local weighting on this category is appropriately scaled, each ground floor property should be afforded a score of 2, and each property above ground floor should be afforded a score of 1.

Probability Factoring

For each property, the score (2) is then factored by the probability of the highest probability (least severe) flood event that causes flooding of that property, where the factor applied is calculated as:

Factor = Probability of flooding (expressed as the AEP, e.g., 0.01 for 1%)

Total AFA Score (Local Weighting)

For the given AFA, the total AFA score is calculated as the sum of the factored scores for all of the residential properties at risk from flooding, subject to a maximum score of 5.

Other Factors

Known Areas of Highly Vulnerable People

The risk to life associated with the flooding of residential properties is related to the vulnerability of the people living in that property, with the elderly and very young particularly vulnerable.

The scoring should typically assume that a reasonable cross section of society exists in those that inhabit all of the properties at risk within an AFA. However, if it is known that an area is occupied by particularly vulnerable or resilient set of people then professional judgement should be applied to increase or decrease the score accordingly.

Rate of Onset
The risk to health and life is associated with the flooding of residential properties is related to the rate of onset of flooding and hence the time available to evacuate the vulnerable people. It is assumed that typically it will be evident that flooding may occur with a 1 to 2 hours available to then evacuate the vulnerable people before the depth / velocity of flood water creates difficulties for evacuation and / or a moderate risk to life. However, if the rate of onset is significantly greater or less than this, then professional judgement should be applied to decrease or increase the score accordingly.

Flood Depths and Velocities (Risk to Life)
The risk to life associated with the flooding of residential properties is related to the projected depths of flooding and the velocity of overland flood flow (i.e., the risk to life). It is assumed that typically a Low risk to life will exist for the community in general and residential areas within a community in particular. However, if the risk to life is greater than this, then professional judgement should be applied to increase or the score accordingly.

Existing Flood Warning Schemes
Where an existing flood warning scheme is in place, then the local weighting should be multiplied by a factor of 0.5, 0.7 and 0.9 for effective advance warning periods in excess of 6 hours, 4 hours and 2 hours respectively.

Final Local Weighting
Note that final local weighting taking into account the application of the factors for known areas of highly vulnerable people, the rate of onset, flood depths and velocities and the presence of existing flood warning schemes should still not exceed a maximum of 5.

The above provides guidance on the setting of local weightings for this objective. However, professional judgement should also be applied as per Section 3.3, and should take into account other factors that may influence the risk to life, such as the presence of basement properties.

Guidance on Option Scoring

Residual Risk Score
The residual risk score for a flood risk management option should be calculated in the same manner as the local weighting, but based on the flood hazard with the option applied.

In the case of measures providing flood defence, then the residual risk score can be calculated simply by adjusting the factor for probability to that of the standard of protection (following the simplistic assumption that once the standard of protection is exceeded for a given flood defence, then no defence is provided).

Option Scoring
Options are scored based on the degree of reduction in the risk to residential properties, calculated using the residual risk score as determined for the relevant option, and the final local weighting, and multiplied by a factor of 5.

The score for a given option should be calculated as:

Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]

The other factors detailed under the guidance on the assignment of Local Weighting should also be taken into account in assigning the score for a measure.

Standard of Protection Factor
A Standard of Protection Factor is not applicable to this objective, as it is implicit within the scoring process.

Non-Structural Option Risk Reduction
Flood warning does not reduce hazard, but generally can reduce risk. In the case of risk to people in residential properties, advance warning of an impending flood can be vital in providing sufficient time to evacuate the residents, and so flood forecasting and warning can significantly reduce the risk to life. The option score for non-structural measures involving advance warning should therefore be 4, 2 and 1 for effective advance warning periods in excess of 6 hours, 4 hours and 2 hours respectively.

The above provides guidance on the setting of local weightings and scoring for this objective. However, professional judgement should also be applied as per Section 3.3.

OBJECTIVE 3.A (ii)	
Objective	**Minimise risk to human health and life – High vulnerability properties**
Indicator	Number and type of high vulnerability properties at risk from flooding
Scoring	Based on calculated assessment, adjusted by professional judgement
Basic Requirement	Number of high vulnerability properties at risk not increased
Aspirational Target	100% reduction in number of high vulnerability properties at risk
Global Weighting	10
Local Weighting	Based on calculated assessment, adjusted by professional judgement

Guidance on Assignment of Local Weightings

The local weightings should be calculated based on a score derived from the number and type of high vulnerability properties potentially affected by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of that property.

Property Scoring

Each type of high vulnerability property is assigned a score. The types of high vulnerability properties are categorised and scored as follows:

Property Type	Score
Hospitals	500 (IRR)
Nursing / Residential Homes	250
Prisons	250
Camping / Caravan / Halting Sites	100
Schools	50

Probability Factoring

For each property, the score is then factored by the probability of the highest probability (least severe) flood event that causes flooding of that property, where the factor applied is calculated as:

Factor = Probability of flooding (expressed as the AEP, e.g., 0.01 for 1%)

Other Factors

Rate of Onset of Flooding

The risk to life associated with the flooding of high vulnerability properties is related to the rate of onset of flooding and hence the time available to evacuate the vulnerable people. It is assumed that typically it will be evident that flooding may occur with 1 to 2 hours advance warning available to evacuate the vulnerable people before the depth / velocity of flood water creates difficulties for evacuation and / or a moderate risk to life. However, if the rate of onset is significantly greater or less than this, then professional judgement should be applied to decrease or increase the score accordingly.

Flood Depths and Velocities (Risk to Life)

The risk to life associated with the flooding of high vulnerability properties is related to the projected depths of flooding and the velocity of overland flood flow (i.e., the risk to life). It is assumed that typically a Low risk to life will exist for high vulnerability properties. However, if the risk to life is greater than this, then professional judgement should be applied to increase or the score accordingly.

Calculation of Other Factors

The rate of onset of flooding and the risk to life at the high vulnerability property can be determined from the outputs of the hydraulic modelling and flood mapping.

Total AFA Score (Local Weighting)

For the given AFA, the total AFA score is calculated as the sum of the factored scores for each property at risk from flooding, subject to a maximum score of 5.

Note that final local weighting taking into account the application of the factors for Rate of Onset of Flooding and Flood Depths and Velocities (Risk to Life) should still not exceed a maximum of 5.

The above provides guidance on the setting of local weightings for this objective. However, professional judgement should also be applied as per Section 3.3.

Guidance on Option Scoring

Residual Risk Score

The residual risk score for a flood risk management option should be calculated in the same manner as the local weighting, but based on the flood hazard with the option applied.

In the case of measures providing flood defence, then the residual risk score can be calculated simply by adjusting the factor for probability to that of the standard of protection (following the simplistic assumption that once the standard of protection is exceeded for a given flood defence, then no defence is provided).

Option Scoring
Options are scored based on the degree of reduction in the risk to high vulnerability properties, calculated using the residual risk score as determined for the relevant option, and the final local weighting, and multiplied by a factor of 5.

The score for a given option should be calculated as:

Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]

The other factors detailed under the guidance on the assignment of Local Weighting should also be taken into account in assigning the score for a measure.

Standard of Protection Factor
A Standard of Protection Factor is not applicable to this objective, as it is implicit within the scoring process.

Non-Structural Option Risk Reduction
Flood warning does not reduce hazard, but generally can reduce risk. In the case of high vulnerability properties, advance warning of an impending flood can be vital in providing sufficient time to evacuate the vulnerable people, and so flood forecasting and warning can significantly reduce the risk to life. The option score for non-structural warnings involving advance warning should therefore be 4, 2 and 1 for effective advance warning periods in excess of 6 hours, 4 hours and 2 hours respectively.

The above provides guidance on the setting of local weightings and scoring for this objective. However, professional judgement should also be applied as per Section 3.3.

OBJECTIVE 3.B (i)	
Objective	**Minimise risk to community – Social Infrastructure and Amenity**
Indicator	Number of social infrastructure assets at risk from flooding
Scoring	Based on calculated assessment, adjusted by professional judgement
Basic Requirement	Number of social infrastructure assets at risk not increased
Aspirational Target	100% reduction in number of social infrastructure assets at risk
Global Weighting	5
Local Weighting	Based on calculated assessment, adjusted by professional judgement

Guidance on Assignment of Local Weightings

The local weightings should be calculated based on a score derived from the number of social infrastructure and amenity assets potentially affected by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of each asset.

Receptor Scoring

All social infrastructure and amenity assets should be treated as equal for the purposes of the calculated score. To ensure that the local weighting on this category is appropriately scaled, each asset should be afforded a score of 25.

A weighing has not been applied to the scores, as all social infrastructure and amenity assets (where included) were designated during the PFRA vulnerability assessment as being of 'moderate' vulnerability, except for schools where a 'high' vulnerability classification was assigned due to elevated risk to human health and life arising from the concentration of children, which is provided for under Objective 3.A. (ii).

The relevant social infrastructure and amenity assets include:

- Schools and educational facilities
- Libraries
- Community centres
- Local and central government offices, including post offices
- Emergency services facilities (fire, Garda, civil defence, RNLI and coast guard stations)
- Health centres (other than hospitals and nursing homes)
- Churches and other religious centres

- Parks and public gardens, sports facilities, playgrounds
- Local cultural heritage sites or collections, sites of ecological interest or other sites of social amenity

Probability Factoring

For each asset, the score (25) is then factored by the probability of the highest probability (least severe) flood event that causes flooding of that asset, where the factor applied is calculated as:

Factor = Probability of flooding (expressed as the AEP, e.g., 0.01 for 1%)

Total AFA Score (Local Weighting)

For the given AFA, the total AFA score is calculated as the sum of the factored scores for all of the social infrastructure and amenity assets at risk from flooding, subject to a maximum score of 5.

Other Factors

Assets of Particular Social Value

A particular social infrastructure and amenity asset may be of exceptional local importance, i.e., where the loss of the asset (permanently or over a long period of time) would have a very severe detrimental impact on the functioning of the community as a whole and on the day-today lives of the people in the community (i.e., well beyond the normal expected impact that the loss of one of the listed social infrastructure assets might have. In such cases, professional judgement should be applied to increase the weighting accordingly.

Note that final local weighting taking into account the application of the factors for assets of particular social value should still not exceed a maximum of 5.

The above provides guidance on the setting of local weightings for this objective. However, professional judgement should also be applied as per Section 3.3.

Guidance on Option Scoring

Residual Risk Score

The residual risk score for a flood risk management option should be calculated in the same manner as the local weighting, but based on the flood hazard with the option applied.

In the case of measures providing flood defence, then the residual risk score can be calculated simply by adjusting the factor for probability to that of the standard of protection (following the simplistic assumption that once the standard of protection is exceeded for a given flood defence, then no defence is provided).

Option Scoring
Options are scored based on the degree of reduction in the risk to social infrastructure and amenity, calculated using the residual risk score as determined for the relevant option, and the final local weighting, and multiplied by a factor of 5.

The score for a given option should be calculated as:

Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]

The other factors detailed under the guidance on the assignment of Local Weighting should also be taken into account in assigning the score for a measure.

Standard of Protection Factor
A Standard of Protection Factor is not applicable to this objective, as it is implicit within the scoring process.

Non-Structural Option Risk Reduction
Flood warning does not reduce hazard, but generally can reduce risk. However, social infrastructure and amenity assets will still be damaged in the event of a flood regardless of the advance warning of the flooding (unless combined with individual protection measures), and so the negative impact (damage to the fabric and disruption to the service the asset provides) will still occur. While it is recognised that advance warning gives more time to prepare damage reduction measures, etc., it is considered that such mitigation measures should be part of a well-formed flood event emergency response plan, and so the advance warning will bring limited benefit. As such, a zero degree of reduction of risk to social infrastructure and amenity should be assumed in relation to non-structural options.

Enhancement or Creation of Social Amenity Sites
Where an option would enhance an existing social amenity site, or involve the creation of a new site, then professional judgement should be used to increase the score afforded that option under this Objective, taking account of the number and value of the sites involved.

The above provides guidance on the setting of local weightings and scoring for this objective. However, professional judgement should also be applied as per Section 3.3.

OBJECTIVE 3.B (ii)	
Objective	**Minimise risk to community - Local Employment**
Indicator	Number of non-residential (i.e., commercial) properties at risk from flooding
Scoring	Based on calculated assessment, adjusted by professional judgement
Basic Requirement	Number of non-residential properties at risk not increased
Aspirational Target	100% reduction in number of non-residential properties at risk
Global Weighting	10
Local Weighting	Based on calculated assessment, adjusted by professional judgement

Guidance on Assignment of Local Weightings

The local weightings should be calculated based on a score derived from the number of non-residential properties (taken as a place of employment) potentially affected by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of each property.

Receptor Scoring

All non-residential properties that are not derelict should be treated as equal for the purposes of the calculated score. To ensure that the local weighting on this category is appropriately scaled, each property should be afforded a score of 5.

A differential weighting has not been applied to the count, as reliable information would not be available as to the number of employees for any given property, nor of the indirect employment associated with that property / business

The relevant non-residential properties include:

- Offices
- Shops
- Services (Restaurants, Pubs, Hotels, etc.)
- Factories, Workshops and other Manufacturing Facilities
- Warehouses
- Health Centres (including hospitals and nursing homes)
- Other places of employment

Probability Factoring

For each property, the score (5) is then factored by the probability of the highest probability (least severe) flood event that causes flooding of that property, where the factor applied is calculated as:

Factor = Probability of flooding (expressed as the AEP, e.g., 0.01 for 1%)

Total AFA Score (Local Weighting)

For the given AFA, the total AFA score is calculated as the sum of the factored scores for all of the non-residential properties at risk from flooding, subject to a maximum score of 5.

Other Factors

Properties of Particular Importance for Local Employment

A particular non-residential property may be of exceptional local importance, i.e., where the property is the location for the employment of a particularly large number of people or a very high proportion of the people employed within the local area. Flooding of such a property (and the interruption to business and potential closure) would have a very severe detrimental impact on the community and could lead to a significant rise in local unemployment. In such cases, professional judgement should be applied to increase the weighting accordingly.

Local Employment Generated through Tourism

Local employment may be generated through local features and assets that are not based in particular buildings (and hence not included as non-residential properties). Such features may include local angling sites, tourist features or walks, sites of ecological value, heritage sites, etc. Flooding of such features and assets may negatively impact on local employment. In such cases, professional judgement should be applied to increase the weighting accordingly.

Note that final local weighting taking into account the application of the factors for properties of particular importance for local employment should still not exceed a maximum of 5.

The above provides guidance on the setting of local weightings for this objective. However, professional judgement should also be applied as per Section 3.3.

Guidance on Option Scoring

Residual Risk Score

The residual risk score for a flood risk management option should be calculated in the same manner as the local weighting, but based on the flood hazard with the option applied.

In the case of measures providing flood defence, then the residual risk score can be calculated simply by adjusting the factor for probability to that of the standard of protection (following the simplistic assumption that once the standard of protection is exceeded for a given flood defence, then no defence is provided).

Option Scoring

Options are scored based on the degree of reduction in the risk to local employment, calculated using the residual risk score as determined for the relevant option, and the final local weighting, and multiplied by a factor of 5.

The score for a given option should be calculated as:

Option Score = 5 X [(Local Weighting – Residual Risk Score) / Local Weighting]

The other factors detailed under the guidance on the assignment of Local Weighting should also be taken into account in assigning the score for a measure.

Standard of Protection Factor

A Standard of Protection Factor is not applicable to this objective, as it is implicit within the scoring process.

Non-Structural Option Risk Reduction

Flood warning does not reduce hazard, but generally can reduce risk. However, non-residential properties will still be damaged in the event of a flood regardless of the advance warning of the flooding (unless combined with individual property protection measures), and so the negative impact (damage to the fabric and disruption to the employment the property provides) will still occur. While it is recognised that advance warning gives more time to prepare damage reduction measures, etc., it is considered that such mitigation measures should be part of a well-formed flood event emergency response plan, and so the advance warning will bring limited benefit. As such, a zero degree of reduction of risk to local employment should be assumed in relation to non-structural options.

The above provides guidance on the setting of local weightings and scoring for this objective. However, professional judgement should also be applied as per Section 3.3.

OBJECTIVE 4.A	
Objective	**Support the objectives of the WFD**
Sub-Objective	Provide no impediment to the achievement of water body objectives and, if possible, contribute to the achievement of water body objectives.
Scoring	Likelihood to impact on water body status elements: – Biology; – Physico-chemical; – Hydrology and morphology; – Priority substances and priority hazardous substances.
Basic Requirement	Provide no constraint to the achievement of water body objectives.
Aspirational Target	Contribute to the achievement of water body objectives.
Global Weighting	15
Local Weighting	5

Guidance on Assignment of Local Weightings

The Local Weighting to be applied for this objective is constant, and should always be set equal to 5 as WFD objectives must be achieved and are relevant to all waterbodies.

Guidance on Option Scoring

Scoring should be guided by professional judgement with reference to the scoring guidance below and the generic desciption of the likely impacts of measures on water body status.

The scoring of the options for this objective should take into account the <u>duration and permanence</u> of the likely impact(s) of the options on water body status elements, the <u>sensitivity</u> of the receiving water bodies, and the <u>potential sources of pollution</u> in the flood extent area.

Duration is defined in terms of:

- long term;
- medium term;
- short term.

Permanence is defined in terms of:

- permanent;
- recurring;
- intermittent.

Sensitive water bodies include:

- water bodies listed in the register of protected areas;
- high status water bodies.

Significant polluting sources include:

- plants licensed under Directives 96/61/EC and 91/271/EC;
- septic tanks greater than 500 PE;
- significant slurry storage facilities.
- establishments defined under Directive 2012/18/EU

Combining positive and negative scores

Most options will have the potential for both positive and negative impacts on water body status as, regardless of the nature of the options, they will all be designed to reduce flood risk which in turn will reduce pollution risk (by reducing the occurence of flood waters carrying pollutants from inundated areas back into the river – the significance of this positive impact varies depending on the potential sources of pollution within the inundated area and the sensitivity of the water body). Therefore, the overall score applied should be a combination of the best case positive score and the worst case negative score.

Example of combining scores

Option = hard defences and flow diversion

- +2 due to reduction of pollution risk to sensitive water bodies
- -2 due to construction stage impacts associated with walls
- -5 associated with diversion of flow into another river

In this case, the overall score should be '-3', combining the best case positive score and the worst case negative score.

Comparing options

When scoring multiple options for one AFA, it may happen that the options score the same even if they have varying degrees of impact. Professional judgement should be used to ensure that the scores reflect the varying degrees of impact between the options i.e. the scores should be manually adjusted to reflect the different degrees of impact associated with the different options.

Example of manual adjustment

Option 1 = flow diversion

- +2 due to reduction of pollution risk to sensitive water bodies
- -5 associated with diversion of flow into another river

Overall score = -3

Option 2 = flow diversion plus walls

- +2 due to reduction of pollution risk to sensitive water bodies
- -2 due to construction stage impacts to sensitive water bodies associated with walls
- -4 due to excavation and restoration of natural banks in sensitive water bodies
- -5 associated with diversion of flow into another river

Overall score = -3 (combining best case positive score and worst case negative score)

These options score the same even though Option 2 has more negative impacts associated with it. In this example, using professional judgement, Option 2 should be manually adjusted downwards by 1 point to reflect the comparitive difference in impacts between the options. If more than two options are being compared, and all differ in terms of the severity of their likely impacts on this objective, but all score the same using this methodology, the options should be manually adjusted upwards or downwards by a maximum of two points in either direction to reflect the comparitive difference in impacts between the options. Such adjustments will ensure that the overall MCA scores for the options reflect their differing degree of potential impact on this objective and will therefore ensure that this objective will have an influence in terms of the choice of a preferred option. In such cases a clear rationale should be recorded for the adjustment. It should be noted that such adjustments may have a significant impact on the overall MCA score of the preferred option (perhaps up to 10% of the overall MCA score).

Scoring Table

Score	Duration of impact	WB sensitivity	Examples
5	Permanent or long-term contribution to the achievement of wb objectives	All	Reinstatement of natural hydrological or morphological regime.
4	Medium-term or recurring contribution to the achievement of wb objectives	Sensitive	Reduced flooding in area with significant polluting sources in 1% AEP extent.
3		Non-sensitive	
2	Short-term or intermittent contribution to the achievement of wb objectives	Sensitive	Reduced flooding in area with no significant polluting sources in 1% AEP extent.
1		Non-sensitive	
0	No constraint to the achievement of wb objectives	All	No connectivity between measure and channel or flow.
-1	Short-term or intermittent impediment to the achievement of wb objectives	Non-sensitive	Construction phase impacts. In-stream or on-bank maintenance impacts. Overland floodways. Off-line storage. Rehabilitation of existing in-stream or on-bank defences.
-2		Sensitive	
-3	Medium-term or recurring impediment to the achievement of wb objectives	Non-sensitive	Excavation and restoration of banks. Flow diversion within the same river. One-off or very occasional dredging. Short culverts (e.g. under a road).
-4		Sensitive	
-5	Permanent or long-term impediment to the achievement of wb objectives	All	Channelisation / realignment that does not constitute a reinstatement of natural hydrological or morphological regimes. Regular dredging. Flow diversion to a different river (See futher guidance in tabvle below). Extensive culverting. Tidal barrage. On-line storage (dams and reservoirs). Improvement of channel conveyance. Permanent removal of natural banks.
-999	Unacceptable negative impact where feasible alternative exists		

The table below describes the likely impacts of flood risk management measures on the objectives of the WFD. It sets out a description of likely impacts that can be referred to when undertaking the scoring process to help ensure consistency between studies.

Category	Measure	Code	Likely Impacts (WFD)
NFM Protect	Land Use Management	LM	Effective land use management has the potential for positive impacts on water body status through the reduction of pollutants entering rivers and the restoration of natural hydrological and morphological regimes.
Protect	Maintenance Programme	MP	The maintenance of existing in-stream or on-bank flood defences has the potential for short-term and intermittent negative impacts on water status.
Protect	Upstream storage / Storage	S	On-line storage: creation of a dam and reservoir across the floodplain of a river, often with an outlet control structure such as an undershot culvert or sluices, to control outlet flow, and with an overflow weir and spillway. Positive impacts include reduced flooding and therefore reduced pollution. Negative impacts include permanent changes to hydrological and morphological regimes, barrier to migration. There is also the potential for eutrophication within the reservoir which can affect the channel downstream. Off-line storage: area of floodplain embanked to prevent or control flooding within the storage area or wash-land during minor events. Positive impacts include reduced flooding and therefore reduced pollution. Negative impacts include changes to hydrological (and to a lesser extent morphological) regimes.
Protect	Tidal Barrage	TB	Tidal barrages have the potential for significant negative impacts on migratory fish and other water dependent species and are a permanent change to hydrological and morphological regimes.
Protect	Improvement of Channel Conveyance	IC	Increased conveyance improves the efficiency of the channel, and thereby reduces the water levels for a given flow. This is often done by deepening or widening a channel, cutting berms to take more flow during flood events, realigning the bed profile (e.g. removing outcrops) or lining the channel with an artificial or soft (but low resistance) material (ranging from concrete or steel piles to low grass over geotextile). These measures all have the potential for negative effects to hydrological and morphological regimes (permanent or long term), physico-chemical conditions (short-term during construction), biology (arising from other impacts described).

Category	Measure	Code	Likely Impacts (WFD)
Protect	Hard Defences	D	Embankments are unlikely to have negative impacts upon water bodies except in areas where embankments extend right up to the channel bank in which case there may be short-term construction phase impacts. Flood walls have the potential for impacts depending on the distance of the wall from the channel. Some walls will require excavation of the bank during the construction phase followed by bank restoration – wwith short-term effects associated with construction and medium-term associated with bank recovery. There would also potentially be long-term hydrological or morphological impacts. In some areas, walls may replace natural banks and this would represent a permanent impact on the hydrological and morphological regime of the channel.
Protect	Culverting	C	Culverting represents a permanent morphological and hydrological impact. The extent of culverting is important is assessing the impact.
Protect	Diversion of Flow	DF	Flow diversion measures include realigning the entire river or creating by-pass channels. Realigning a river in a way that does not constitute a reinstatement of more natural hydrological or morphological regimes constitutes a permanent negative impact to the hydrological and morphological regime of a river and is also associated with short term construction-related water status impacts. Flow diversion via a bypass chanell from one point of a river to another point of the same river would have short-term and intermittent negative impacts to the hydrological and morphological regime of a river during periods of overflow. However, it represents a significant change to the river regime, even when the diversion is not taking place. Flow diversion from one river to another is an interbasin transfer and can therefore affects the flow regime in both the contributing and receiving rivers and can also affect water quality in the receiving river. When scoring this option consider the quality of the water in receiving river versus the quality of water in the contibuting river, the quantity of water being transfered and whether there is any contaminant/invasicse specises in the contributing water that isn't present in the receving water.
Protect	Overland Floodways	OF	Overland floodways consitute a short-term and intermittent negative impact to the hydrological and morphological regime of the river and could also impact on the physico-chemical condition of the river as well as on the biology due to pollutants on the floodways being carried into the river during periods of operation.

Protect	Rehabilitation of Existing Defences	ED	Rehabilitation of existing in-stream and on-bank defences has the potential for short-term and occasional impacts of the physcio-chemical conditions of the river associated with the works phase.

OBJECTIVE 4.B	
Objective	**Support the objectives of the Habitats and Birds Directives**
Sub-Objective	Avoid detrimental effects to, and where possible enhance, Natura 2000 network, protected species and their key habitats, recognising relevant landscape features and stepping stones
Scoring	Area of Natura 2000 site at risk of flooding and qualitative assessment of impact (flooding may have a positive, neutral or negative impact) Loss of, or significant changes to habitat of, riverine and wetland species associated with Natura 2000 sites.
Basic Requirement	No deterioration in the conservation status of designated sites as a result of flood risk management measures
Aspirational Target	Improvement in the conservation status of designated sites as a result of flood risk management measures
Global Weighting	15
Local Weighting	By professional judgement, taking account of local advice

Guidance on Assignment of Local Weightings

The local weighting may not exceed a ceiling value of 5. Professional judgement should be applied in assigning this weighting. After consultations with progress group, steering group and members of the stakeholder group, this weighting may change.

The presence of Annex IV (Habitats Directive) species of flora and fauna, and their key habitats, which are strictly protected wherever they occur, whether inside or outside the SAC/SPA, will have an impact on this weighting.

Guidance on Option Scoring

Scoring by professional judgement, based upon the following key datasets:

- Natura 2000 sites (SACs, SPAs)
- Ramsar Sites
- Annex IV (Habitats Directive) species of flora and fauna, and their key habitats

Note that the scoring allows a negative score of -5 to reflect the importance of avoiding environmental impacts. The positive scores reflect the opportunities for environmental enhancement. <u>The network of sites must also be considered together with the impact upon the individual site.</u>

Score	Description
+5	Potential to create new candidate SAC, SPA or Ramsar sites or enhance NHA sites to SAC, SPA or Ramsar status, which extend the existing network of international and European designations as a result of flood risk management measures.
+3	Improvement or enhancement of the condition or management of existing SAC, SPA or Ramsar sites and network as a result of flood risk management measures.
+1	Localised improvement or enhancement of the condition or management of existing SAC, SPA or Ramsar sites and network as a result of flood risk management measures.
0	No impact on existing SAC, SPA or Ramsar sites as a result of flood risk management measures.
-1	Any detrimental impact upon existing SAC or SPA site, including a delay in recovery of the site, but excluding impacts on the conservations objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.
-3	Any detrimental impact upon existing SAC or SPA site, including a delay in recovery of the site, but excluding impacts on the conservations objectives of the site, as a result of flood risk management measures, where there are no suitable mitigation measures.
-5	Any detrimental impact upon conservation objectives of existing SAC, SPA or Ramsar site, including a delay in recovery of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.
-999	Any detrimental impact upon existing conservation objectives of SAC, SPA or Ramsar site, as a result of flood risk management measures, where there are no suitable mitigation measures.

OBJECTIVE 4.C	
Objective	**Avoid damage to, and where possible enhance, the flora and fauna of the catchment**
Sub-Objective	Avoid damage to, and where possible enhance, legally protected sites / habitats and other sites / habitats of national, regional and local nature conservation importance
Scoring	Area of national, regional or local conservation designations at risk of flooding and qualitative assessment of impact (flooding may have a positive, neutral or negative impact) Loss of, or significant changes to habitat of, riverine and wetland species associated with national, regional and local conservation designations.
Basic Requirement	No deterioration of in condition of existing sites due to the implementation of flood risk management option
Aspirational Target	Creation of new or improvement in condition of existing sites due to the implementation of flood risk management option
Global Weighting	5
Local Weighting	By professional judgement, taking account of local advice

Guidance on Assignment of Local Weightings

The local weighting may not exceed a ceiling value of 5. Professional judgement should be applied in assigning this weighting. After consultations with progress group, steering group and members of the stakeholder group, this weighting may change.

Guidance on Option Scoring

Scoring by professional judgement, based upon the following key datasets:

- Natural Heritage Areas (& proposed Natural Heritage Areas)
- Nature Reserves
- Wildfowl Sanctuary
- OSPAR
- National Parks

Note that the scoring allows a negative score of -5 to reflect the importance of avoiding environmental impacts. The positive scores reflect the opportunities for environmental enhancement. The network of sites must also be considered together with the impact upon the individual site.

Score	Description
+5	Potential to create new national, regional and local conservation sites as a result of flood risk management measures.
+3	Improvement or enhancement of the condition or management of existing national, regional and local sites as a result of flood risk management measures.
+1	Potential for localised improvement of flora/fauna
0	No impact on existing national, regional and local sites as a result of flood risk management measures.
-1	Potential localised loss of or disturbance to flora/fauna limited by the already modified nature of the channel/shoreline.
-3	Potential localised loss of or disturbance to flora/fauna
-5	Any detrimental impact upon the condition of existing national, regional or local sites as a result of flood risk management measures, where suitable mitigation measures are technically feasible.
-999	Any detrimental impact upon national, regional or local sites as a result of flood risk management measures, where there are no suitable mitigation measures.

OBJECTIVE 4.D	
Objective	Protect and where possible enhance fisheries resource within the catchment
Sub-Objective	Maintain existing and where possible create new fisheries habitat including the maintenance or improvement of conditions that allow upstream migration for fish species.
Scoring	• Area of suitable habitat supporting salmonid and other fish species • Number of upstream barriers
Basic Requirement	• No loss of integrity of fisheries habitat • Maintenance of upstream accessibility
Aspirational Target	• No loss of fisheries habitat • Improvement in habitat quality / quantity • Enhanced upstream accessibility
Global Weighting	5
Local Weighting	By professional judgement, taking account of local advice

Guidance on Assignment of Local Weightings

The local weighting may not exceed a ceiling value of 5. Professional judgement should be applied in assigning this weighting. After consultations with progress group, steering group and members of the stakeholder group, this weighting may change.

The following weighting system may be adopted.

Weighting	Description
5	Where there are designated waters (e.g. under EU Shellfish Waters Directive; EU Freshwater Fish Directive)
4	Waterbody supports substantial salmonid fisheries/shellfisheries and is of national value for fishing/angling
3	Waterbody supports substantial fisheries/shellfisheries and is of regional value for fishing/angling
2	Waterbody supports fisheries/shellfisheries and is of local value for fishing/angling
1	Fisheries could be present but unlikely given the modified nature of the channel/presence of barriers to movement; no known angling/fishing activities
0	No fisheries or angling areas present

Guidance on Option Scoring
Scoring by professional judgement with reference to the scoring guidance below and the generic desciption of the likely impacts of measures. It is noted that this objective only relates to inland fisheries and not marine fisheries. Shellfish waters in particular are included under the register of protected areas under the WFD and as such are included in Objective 4a. The scoring of the options for this objective should take into account the <u>duration and permanence</u> of the likely impact(s) of the options on on fisheries and fisheries potential, the <u>sensitivity</u> of the receiving water bodies, and species e.g. salmonid sp. and designated salmonid waters. **Duration is defined in terms of:** • long term; • medium term; • short term. **Permanence is defined in terms of:** • permanent; • recurring; • intermittent. **Sensitive waters include:** • designated salmonid waters **Sensitive species include*:** • Atlantic Salmon • Lamprey • Shad • Pollan • Arctic Char • Smelt *Based on 2011 IFI National Programme: Habitats Directive and Red Data Book Fish species **Combining positive and negative scores** Instream and bank options have the greatest potential to impact negatively on fisheries, however some options may offer improvements and as such the overall score applied should be a combination of the positive and negative scores with reference to the worst case and best case scores. ***Example of combining scores*** Option = hard defences and flow diversion • +2 due to reduction of pollution risk to sensitive water bodies and sensitive species • -2 due to construction stage impacts associated with walls • -5 associated with diversion of flow into another river In this case, the overall score should be '-3', combining the best case positive score and the worst case negative score.

Comparing options

When scoring multiple options for one AFA, it may happen that the options score the same even if they have varying degrees of impact. Professional judgement should be used to ensure that the scores reflect the varying degrees of impact between the options i.e. the scores should be manually adjusted to reflect the different degrees of impact associated with the different options.

Example of manual adjustment

Option 1 = flow diversion

- +2 due to improved fisheries potential as a result of reduction of pollution risk to sensitive water bodies and species
- -5 associated with diversion of flow into another river

Overall score = - 3

Option 2 = flow diversion plus walls

- +2 due to improved fisheries potential as a result of reduction of pollution risk to sensitive water bodies and species
- -2 due to construction stage impacts to sensitive water bodies and species associated with walls
- -4 due to excavation and restoration of natural banks in sensitive water bodies
- -5 associated with diversion of flow into another river

Overall score = - 3 (combining best case positive score and worst case negative score)

These options score the same even though Option 2 has more negative impacts associated with it. In this example, using professional judgement, Option 2 should be manually adjusted downwards by 1 point to reflect the comparitive difference in impacts between the options. If more than two options are being compared, and all differ in terms of the severity of their likely impacts on this objective, but all score the same using this methodology, the options should be manually adjusted upwards or downwards by a maximum of two points in either direction to reflect the comparitive difference in impacts between the options. Such adjustments will ensure that the overall MCA scores for the options reflect their differing degree of potential impact on this objective and will therefore ensure that this objective will have an influence in terms of the choice of a preferred option. In such cases a clear rationale should be recorded for the adjustment. It should be noted that such adjustments may have a significant impact on the overall MCA score of the preferred option.

Scoring Table

<table>
<tr><th>Score</th><th>Duration of impact</th><th>Sensitivity</th><th>Examples</th></tr>
<tr><td>5</td><td>Creation of fisheries habitat or removal of barrier to upstream migration for wb where sensitive species are known to be present e.g. salmonids</td><td>Any wb</td><td>Reinstatement of natural hydrological or morphological regime.</td></tr>
<tr><td>4</td><td rowspan="2">Creation of fisheries habitat or removal of barrier to upstream migration for wb where other species are present e.g. coarse fish</td><td rowspan="2">Any wb</td><td rowspan="2">Reinstatement of natural hydrological or morphological regime.</td></tr>
<tr><td>3</td></tr>
<tr><td>2</td><td rowspan="2">Creation of fisheries potential</td><td rowspan="2">Any wb</td><td rowspan="2">Land Use Management</td></tr>
<tr><td>1</td></tr>
<tr><td>0</td><td>No change to fisheries potential of the wb</td><td>Any wb</td><td>Measures with no connection to channel, flow, bank side vegetation</td></tr>
<tr><td>-1</td><td rowspan="2">Short-term minor impacts to fisheries habitat</td><td>Non-sensitive wb</td><td rowspan="2">Construction phase impacts.</td></tr>
<tr><td>-2</td><td>Sensitive wb</td></tr>
<tr><td>-3</td><td rowspan="2">Medium to long-term alternation of fisheries habitat</td><td>Non-sensitive wb</td><td rowspan="2">In-stream or on-bank maintenance impacts.
Walls that require excavation and restoration of banks.
Flow diversion within the same river.
Rehabilitation of existing in-stream or on-bank defences.
Dredging</td></tr>
<tr><td>-4</td><td>Sensitive wb</td></tr>
<tr><td>-5</td><td>Permanent loss or removal of fisheries habitat and / or introduction of barriers to upstream migration.</td><td>Any wb</td><td>Channelisation/realignment.
Regular dredging.
Extensive culverting.
Tidal barrage.
On-line storage (dams).
Improvement of channel conveyance.
Walls that replace natural banks.
Flow diversion to a different river.</td></tr>
<tr><td>-999</td><td>Unacceptable negative impact where feasible alternative exists</td><td></td><td></td></tr>
</table>

The table below describes the likely impacts flood risk management measures fisheries. It can be referred to when undertaking the scoring process to help ensure consistency between studies.

Category	Measure	Code	Likely Impacts (Fisheries)
NFM Protect	Land Use Management	LM	Effective land use management has the potential for positive impacts on fisheries through the reduction of pollutants entering rivers and the restoration of natural hydrological and morphological regimes with the possibility of restoration and / or creation of fisheries potential.
Protect	Maintenance Programme	MP	The maintenance of existing flood defense measures is likely to result in some positive impacts to fisheries through removal of debris and other physical obstructions etc, particularly following flood events. There is however potential for negative impacts where management of vegetation leads to loss of habitat or disturbance to species. All in-stream works have potential to negatively impact directly on fish species and as such would have to be carried out with due care and attention. On-bank works also have potential for negative impacts, particularly with regard to release of sediment and other organic matter.
Protect	Upstream storage / Storage	S	On-line storage refers to creating a dam and reservoir across the floodplain of a river, often with an outlet control structure such as an undershot culvert or sluices, to control outlet flow, and with an overflow weir and spillway. Such a measure has the potential to negatively impact on fisheries through disturbance or loss of habitat and blockage to migratory routes. This will be particularly significant in sensitive waters and for sensitive species. Creation of eutrophic conditions in the reservoirs could also impact on fisheries down-stream. Off-line storage refers to an area of floodplain that is embanked to prevent or control flooding within the storage area or wash-land during minor events. This can produce positive effects including creation of new habitat. Negative impacts may occur where the storage interferes with the existing riparian zone.
Protect	Tidal Barrage	TB	Tidal barrages have the potential for significant negative impacts on migratory fish and other water dependent species and are a permanent change to hydrological and morphological regimes.
Protect	Improvement of Channel Conveyance	IC	Increased conveyance improves the efficiency of the channel, and thereby reduces the water levels for a given flow. This is often done by deepening or widening a channel, cutting berms to take more flow during flood events, realigning the bed profile (e.g. removing outcrops) or lining the channel with an artificial or soft (but low resistance) material (ranging from concrete or steel piles to low grass over geotextile). This measure includes primarily in-stream work elements and as such represents one of the measures with most negative possibility in terms of fisheries potential.

Protect (cont'd)	Improvement of Channel Conveyance (cont'd)	IC (cont'd)	All aspects are likely to result in short-term construction related impacts however, some, over the medium to long term will have significant potential to cause loss of habitat, disturbance of species through changes to hydrological and morphological regimes (permanent or long term), physico-chemical conditions (short-term during construction) and biology . In the medium to long-term there may be the possibility for positive impacts where new habitat can be generated.
Protect	Hard Defences	D	Flood walls have the potential for impacts for fisheries depending on the distance of the wall from the channel. Some walls will require excavation of the bank during the construction phase followed by bank restoration – with short-term effects associated with construction and medium-term associated with bank recovery. There would also potentially be long-term hydrological or morphological impacts. In some areas, walls may replace natural banks and this would represent a permanent impact on the hydrological and morphological regime of the channel and in turn on the habitats and species present.
Protect	Culverting	C	Culverting represents a permanent morphological and hydrological impact with has the potential to permanent impact on fisheries habitat and species particularly with regard to upstream movement of fish species. The extent of culverting is important is assessing the impact.
Protect	Diversion of Flow	DF	Realigning a river constitutes a permanent negative impact to the hydrological and morphological regime of a river which have potential for both short and medium term impacts to fisheries through loss of habitat and disturbance to species. Flow diversion via a bypass chanell from one point of a river to another point of the same river would have short-term and intermittent negative impacts to the hydrological and morphological regime of a river and consequently fish species during periods of overflow but this impact may have longer term consequences on fisheries habitat also. Flow diversion from one river to another is an interbasin transfer and can therefore affects the flow regime in both the contributing and receiving rivers and can also affect water quality in the receiving river. Such a measure should always be considered of maximum significance with respect to fisheries protection.
Protect	Overland Floodways	OF	Overland floodways consitute a short-term and intermittent negative impact to the hydrological and morphological regime of the river and could also impact on the physico-chemical condition of the river as well as on the biology due to pollutants on the floodways being carried into the river during periods of operation.

Protect	Rehabilitation of Existing Defences	ED	The rehabilitation of existing flood defense measures is likely to result in some negative impacts to fisheries where management of vegetation leads to loss of habitat or disturbance to species. All in-stream works have potential to negatively impact directly on fish species and as such would have to be carried out with due care and attention. On-bank works also have potential for negative impacts, particularly with regard to release of sediment and other organic matter. This measure has the potential for short-term and occasional impacts to the physcio-chemical conditions of the river associated with the works phase.

OBJECTIVE 4.E	
Objective	**Protect, and where possible enhance, landscape character and visual amenity within the zone of influence.**
Sub-Objective	Protect, and where possible enhance, visual amenity, landscape protection zones and views into/from designated scenic areas within the zone of influence.
Scoring	1. Length of waterway corridor qualifying as a landscape protection zone within urban areas 2. Change of quality in existing scenic areas and routes 3. Loss of public landscape amenities
Basic Requirement	1. No significant impact on landscape designation (protected site, scenic route/amenity, natural landscape form) within zone of visibility of measures 2. No significant change in the quality of existing landscape characteristics of the receiving environment
Aspirational Target	1. No change to the existing landscape form 2. Enhancement of existing landscape or landscape feature
Global Weighting	10
Local Weighting	By professional judgement, taking account of local advice

Guidance on Assignment of Local Weightings

The local weighting may not exceed a ceiling value of 5. Professional judgement should be applied in assigning this weighting. After consultations with progress group, steering group and members of the stakeholder group, and with the local community, this weighting may change.

Consideration may be given to the public use of landscape and cultural associations, history and memories. The following weighting system may be adopted.

Weighting	Description
5	Landscape designated as a internationally/nationally important landscape and potentially affected
4	Landscape character type designated at a county level as highly sensitive and/or exceptional/high value and potentially affected
3	Landscape character type designated at a county level as moderate sensitivity and/or medium value; protected views present that could be affected
2	Landscape character type designated at a county level as low sensitivity and/or low value and potentially affected
1	No specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected
0	No specific landscape designation, and no landscape value/sensitivity

Guidance on Option Scoring

Scoring should be guided by professional judgement with reference to the scoring guidance below and the generic description of the likely impacts of measures.

The scoring of the options for this objective should take into account the duration and permanence of the likely impact(s) of the options on landscape value and the sensitivity of the landscape to change.

Duration is defined in terms of; • Long term; • Medium term; • Short term.	**Permanence is defined in terms of;** • Permanent; • Recurrent; • Intermittent.
Range of Sensitivities include; • High (International/National); • Moderate (Regional/County/City; • Low (County/City/Local)	**Permanence is defined in terms of;** • Permanent; • Recurrent; • Intermittent.

Examples of Sensitive Landscapes include;

- World Heritage Sites (International);
- National Parks (International/National);
- Sensitive/Vulnerable Landscapes (National/Regional/County);
- High Amenity Landscapes/Areas (County);
- Scenic Views/Prospects and Routes (County/Local);
- Sensitive Riverscapes/Seascapes/Streetscapes/Local Amenity Walks (County/City/Local).

Combining Positive and Negative Scores

Constructing hard defences adjacent to watercourses has the potential to impact positively and negatively on landscape. A negative impact may arise from the construction of a visible man-made structure on the opposite bank of a river with a scenic walkway. A positive impact may arise from the removal of invasive species encroaching on the river bank.

+2 due to enhancement of local landscape feature (e.g. removal of invasive vegetative species)

-5 due to construction of hard defence where no defence existed prior

In the above example the overall score should be '-3', combining the best positive score with the worst negative score.

Comparing Options
When scoring multiple options for one AFA, it may happen that the options score the same even if they have varying degrees of impact. Professional judgement should be used to ensure that the scores reflect the varying degrees of impact between the options, i.e. the scores should be manually adjusted to reflect the different degrees of impact associated with the different options.

Example of manual adjustment
Option 1= flood storage

- +1 due to clearance of natural flood storage area
- -1 short term construction stage impacts
- -4 due to change in existing landscape form in the locality

  Overall Score = -3 (highest positive added to highest negative)

Option 2 = river morphology changes

- -3 due to construction stage impacts in a riverscape recognised as being of high value in a County/City Development Plan

  Overall Score = -3

The above options score the same even though Option 2 is more likely to be perceived to have the more significant negative impact arising from the inclusion of the riverscape in a County or City Development Plan. Option 2 should then be manually adjusted downwards by 1 point to reflect the comparative difference in impacts between the options. If more than two options are being compared, and all differ in terms of the severity of their likely impacts on this objective, but all score the same using this methodology, the options should be manually adjusted upwards or downwards by a maximum of 2 points in either direction to reflect the comparative difference between the options.

Scoring Table

Score	Duration of Impact	Sensitivity	Examples
5	Permanent significant enhancement of high sensitivity landscape character/feature in the zone of visibility of the selected measure	High	Reinstatement of natural river corridor morphology in a riverscape recognised as being of high value included in a County/City Development Plan
4	Permanent significant enhancement of moderate sensitivity landscape character/feature in the zone of visibility of the selected measure	Moderate	Clearance of significant extent of riparian vegetation/man-made obstructions in a river corridor of high landscape/amenity value included in a County/City Development Plan
3	Permanent localised enhancement of high value landscape/feature in the zone of visibility of the selected measure	High	Channel widening and deepening at specific location on a watercourse of high landscape value removing risk of flow restriction and visual impacts from blockages with detritus (vegetative/rubbish).
2	Permanent localised enhancement of moderate value landscape character/feature in the zone of visibility of the selected measure	Medium	Clearance of local area for use as temporary overland flow storage returning land-use to natural function.
1	Permanent localised enhancement of local sensitivity landscape character/feature in the zone of visibility of the selected measure	Low	Removal of artificial visible man-made flow restriction from local amenity view (screens from under bridge on local amenity walk).
0	No change to existing landscape character/feature in the zone of influence of the selected measure	-	No change to existing landscape character or features.
-1	Short term impact (construction) on local sensitivity landscape character/feature in the zone of visibility of the selected measure.	Low	Construction or extension to local flood embankment prior to establishment of vegetative mitigation (i.e. screening).
-2	Short term impact (construction) on moderate sensitivity landscape character/feature in the zone of visibility of the selected measure.	Low	Construction of significant flood storage area in large area of natural landscape prior to mitigation establishment
-3	Short term impact (construction) on high/moderate value landscape character/feature in the zone of visibility of the selected measure	Medium	Re-establishment of natural river corridor morphology in a riverscape recognised as being of high value in a County/City Development Plan
-4	Permanent impact on local/moderate value landscape character/feature in the zone of influence of the selected measure	Medium	Construction of permanent hard defences (flood walls) adjacent to a local amenity walkway in a historic garden/demesne
-5	Permanent impact on high value landscape character/feature in the zone of influence of the selected measure	High	Construction of tidal barrage in high amenity seascape which is the subject matter of a protected view/prospect
-999	Unacceptable negative impact where feasible options exist	High	Site specific.

OBJECTIVE 4.F.i	
Objective	**Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.**
Sub-Objective	Avoid damage to or loss of features, institutions and collections of **architectural** value and their setting, and improve their protection from extreme floods where this is beneficial.
Scoring	a) The number of architectural features, institutions and collections subject to flooding. b) The impact of flood risk management measures on architectural features, institutions and collections.
Basic Requirement	a) No increase in risk to architectural features, institutions and collections at risk from flooding. b) No detrimental impacts from flood risk management measures on architectural features, institutions and collections.
Aspirational Target	a) Complete removal of all relevant architectural features, institutions and collections from the risk of harm by extreme floods. b) Enhanced protection and value of architectural features, institutions and collections importance arising from the implementation of the selected measures.
Global Weighting	5
Local Weighting	By professional judgement, taking account of local advice

Guidance on Assignment of Local Weightings

The local weighting may not exceed a ceiling value of 5. Professional judgement should be applied in assigning a value to this weighting but some guidance has been provided below. After consultations with progress group, steering group and members of the stakeholder group, this weighting may change.

Reference should be made to the PRFA Methodology for Classifying the Vulnerability of National Monuments from Flooding in the Republic of Ireland (OPW, 2011).

Score	Description
5	Internationally important feature(s) (i.e. Structures or sites of sufficient architectural heritage importance to be considered in an international context. These are exceptional structures that can be compared to and contrasted with the finest architectural heritage in other countries) present and potentially affected.
4	Nationally important feature(s) (e.g. Structures or sites that make a significant contribution to the architectural heritage of Ireland. These are structures and sites that are considered to be of great architectural heritage significance in an Irish context) present and potentially affected with a high to moderate vulnerability.
3	A number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a high to moderate vulnerability.
2	A number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a moderate to low vulnerability.
1	No architectural features are at risk from flooding but potential effects on the settings of designated architectural features.
0	No sites/features at risk.

Guidance on Option Scoring

FRM measures may have both positive and negative effects on features of cultural heritage, and these need to be taken into account when identifying and scoping potential effects. Scoring should be based on professional judgement guided by the criteria provided below.

Score	Description / *Examples*		
5	No negative effects on architectural features and a number of architectural features (Internationally and Nationally important features) completely saved from what would otherwise have been inevitable loss from flooding.	Creation of elements which significantly enhance the setting of architectural features (Internationally and Nationally important features).	Creation of amenity value for a number of architectural features (Internationally and Nationally important features) which was previously not present.
4	Architectural features (Nationally important features, Record of Protected Structures and NIAH) partially saved from what would otherwise have been inevitable loss from flooding.	Creation of elements which enhance the setting of architectural features (Nationally important features, Record of Protected Structures and NIAH).	Creation of amenity value for a number of architectural features (Nationally important features, Record of Protected Structures and NIAH) which was previously not present.
3	Increase in the level of protection for a number of architectural features (Record of Protected Structures and NIAH) from flooding, such that they are substantially less vulnerable to flood damage.	Removal of negative elements from the setting of architectural features (Record of Protected Structures and NIAH) so that the setting of the features is significantly enhanced.	Protection of the existing amenity for a number of architectural features (Record of Protected Structures and NIAH).
2	Increase in the level of protection for a number of architectural features (Record of Protected Structures and NIAH) from flooding, such that they are significantly less vulnerable to flood damage.	Removal of negative elements from the setting of a number architectural features (Record of Protected Structures and NIAH) so that the setting of the architectural features is noticeably enhanced.	Partial protection of the existing amenity for a number architectural features (Record of Protected Structures and NIAH).
1	Increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.	Removal of negative elements from the setting of architectural features (Record of Protected Structures and NIAH) so that its setting is enhanced.	Protection of the existing amenity for architectural features (Record of Protected Structures and NIAH).
0	**No effects on architectural features**		

-1	No physical effects on architectural features (Record of Protected Structures and NIAH)	Changes to the setting of architectural features (Record of Protected Structures and NIAH) such that it is slightly changed.	Partial loss of access to architectural features (Record of Protected Structures and NIAH) which does not affect their existing amenity value.
-2	Multiple effects which score -1 individually and/or Physical effects on architectural features (Record of Protected Structures and NIAH) such that the structure is partially removed.	Changes to the setting of architectural features (Record of Protected Structures and NIAH) such that it is clearly modified.	Loss of access to architectural features (Record of Protected Structures and NIAH) such that its current amenity value is altered.
-3	Multiple effects which score -2 individually and/or Physical effects on architectural features (Record of Protected Structures and NIAH) such that the structure is completely removed.	Changes to the setting of architectural features (Record of Protected Structures and NIAH) such that it is completely altered.	Loss of access to architectural features (Record of Protected Structures and NIAH) such that its current amenity value is completely lost.
-4	Multiple effects which score -3 individually and/or Physical effect on architectural features (Nationally important features, Record of Protected Structures and NIAH) such that the structure is partially removed.	Changes to the setting of architectural features (Nationally important features, Record of Protected Structures and NIAH) such that it is clearly modified.	Loss of access to architectural features (Nationally important features, Record of Protected Structures and NIAH) such that its current amenity value altered.
-5	Physical effect on architectural features (Nationally important features, Record of Protected Structures and NIAH) such that the structure is completely removed.	Changes to the setting of architectural features (Nationally important features, Record of Protected Structures and NIAH) such that it is completely altered.	Loss of access to architectural features (Nationally important features, Record of Protected Structures and NIAH) such that its current amenity value is completely lost.
-999	Physical effects on architectural features (Internationally important) such that its Outstanding Universal Value (OUV) is altered.	Effects on the setting of an architectural features (Internationally important) such that its Outstanding Universal Value (OUV) is altered.	

OBJECTIVE 4.F.ii	
Objective	**Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.**
Sub-Objective	Avoid damage to or loss of features, institutions and collections of **archaeological** value and their setting, and improve their protection from extreme floods where this is beneficial.
Scoring	a) The number of archaeological features, institutions and collections subject to flooding. b) The impact of flood risk management measures on archaeological features, institutions and collections.
Basic Requirement	a) No increase in risk to archaeological features, institutions and collections at risk from flooding. b) No detrimental impacts from flood risk management measures on archaeological features, institutions and collections.
Aspirational Target	a) Complete removal of all relevant archaeological features, institutions and collections from the risk of harm by extreme floods. b) Enhanced protection and value of archaeological features, institutions and collections arising from the implementation of the selected measures.
Global Weighting	5
Local Weighting	By professional judgement, taking account of local advice

Guidance on Assignment of Local Weightings

The local weighting may not exceed a ceiling value of 5. Professional judgement should be applied in assigning a value to this weighting but some guidance has been provided below. After consultations with progress group, steering group and members of the stakeholder group, this weighting may change.

Reference should be made to the PRFA Methodology for Classifying the Vulnerability of National Monuments from Flooding in the Republic of Ireland (OPW, 2011).

Score	Description
5	Internationally important archaeological feature(s) (i.e. World Heritage Site including those on the tentative list present and potentially affected.
4	Nationally important archaeological feature(s) (e.g. National Monument in State Care, sites on which Preservation Orders or Temporary Preservation Orders have been served) present and potentially affected.
3	A number of sites listed on the RMP/RPS present and potentially affected. (high to moderate vulnerability)
2	A number of sites listed on the RMP/RPS present and potentially affected. (moderate to low vulnerability)
1	Limited potential for effects on archaeological features and their setting.
0	No archaeological features at risk.

Guidance on Option Scoring

FRM measures may have both positive and negative effects on archaeological features, and these need to be taken into account when identifying and scoping potential effects. Scoring should be based on professional judgement guided by the criteria provided below

Score	Description / *Examples*		
5	No negative effects on archaeological features, and, A number of archaeological features (Recorded Monuments or National Monuments) completely saved from what would otherwise have been inevitable loss from flooding.	Creation of elements which significantly enhance the setting of archaeological features (Recorded Monuments or National Monuments).	Creation of amenity value for a number of archaeological features (Recorded Monuments or National Monuments) which was previously not present.
4	Archaeological features (Recorded Monuments or National Monuments) partially saved from what would otherwise have been inevitable loss from flooding.	Creation of elements which enhance the setting of an archaeological feature (Recorded Monuments or National Monuments).	Creation of amenity value for a number archaeological feature (Recorded Monuments or National Monuments) which was previously not present.
3	Increase in the level of protection for a number of archaeological features (Recorded Monuments) from flooding, such that they are substantially less vulnerable to flood damage.	Removal of negative elements from the setting of archaeological features (Recorded Monuments) so that the setting of the features is significantly enhanced.	Protection of the existing amenity for a number of archaeological features (Recorded Monuments).
2	Increase in the level of protection for a number of archaeological features (Recorded Monuments) from flooding, such that they are significantly less vulnerable to flood damage.	Removal of negative elements from the setting of a number archaeological features (Recorded Monuments) so that the setting of the archaeological features is noticeably enhanced.	Partial protection of the existing amenity for a number of archaeological features (Recorded Monuments).
1	Increase in the level of protection for archaeological features (Recorded Monuments) from flooding, such that it is less vulnerable to flood damage.	Removal of negative elements from the setting of archaeological features (Recorded Monuments) so that it's setting is enhanced.	Protection of the existing amenity for archaeological features (Recorded Monuments).
0	**No effects on archaeological features**		

-1	No physical effects on archaeological features (Recorded Monuments or National Monuments)	Changes to the setting of archaeological features (Recorded Monument or National Monument) such that it is slightly changed.	Partial loss of access to archaeological features (Recorded Monuments or National Monuments) which does not affect their existing amenity value.
-2	Multiple effects which score -1 individually and/or Physical effects on archaeological features (Recorded Monuments) such that the monument is partially removed.	Changes to the setting of archaeological features (Recorded Monuments) such that it is clearly modified.	Loss of access to archaeological features (Recorded Monuments) such that its current amenity value is altered.
-3	Multiple effects which score -2 individually and/or Physical effects on archaeological features (Recorded Monuments) such that the monument is completely removed.	Changes to the setting of archaeological features (Recorded Monuments) such that it is completely altered.	Loss of access to archaeological features (Recorded Monuments) such that its current amenity value is completely lost.
-4	Multiple effects which score -3 individually and/or Physical effect on archaeological features (National Monuments) such that the monument is partially removed.	Changes to the setting of archaeological features (National Monuments) such that it is clearly modified.	Loss of access to archaeological features (National Monuments) such that its current amenity value altered.
-5	Physical effect on archaeological features (National Monuments) such that the monument is completely removed.	Changes to the setting of archaeological features (National Monuments) such that it is completely altered.	Loss of access to archaeological features (National Monuments) such that its current amenity value is completely lost.
-999	Physical effects on archaeological features (a World Heritage Site) such that its Outstanding Universal Value (OUV) is altered.	Effects on the setting of an archaeological feature (a World Heritage Site) such that its Outstanding Universal Value (OUV) is altered.	

Appendix M Economic Sensitivity Analysis

Only AFAs with options are displayed below.

AFA	Option	3%	4%	5%
Ballylongford	Option 1	€ 9,610,485	€ 9,587,821	€ 9,570,536
	Option 2	€ 8,649,896	€ 8,573,095	€ 8,514,523
Adare	Option 1	€ 15,951,568	€ 15,829,922	€ 15,737,149
	Option 2	€ 10,141,049	€ 10,075,466	€ 10,025,450
Croom	Option 1	€ 657,775	€ 643,235	€ 632,146
Foynes	Option 1	€ 8,557,374	€ 8,501,093	€ 8,458,170
	Option 2	€ 9,542,123	€ 9,246,593	€ 9,021,208
Askeaton	Option 1	€ 7,273,373	€ 7,215,603	€ 7,171,544
	Option 2	€ 5,971,281	€ 5,948,539	€ 5,931,195
	Option 3	€ 7,398,204	€ 7,331,295	€ 7,280,267
Rathkeale	Option 1	€ 275,949	€ 261,021	€ 249,636
	Option 2	€ 301,655	€ 295,020	€ 289,960
Newcastle West	Option 1	€ 2,180,641	€ 2,162,440	€ 2,148,559
	Option 2	€ 2,753,460	€ 2,746,357	€ 2,740,940
	Option 3	€ 3,929,220	€ 3,922,559	€ 3,917,479
Milford	Option 1	€ 262,960	€ 257,001	€ 252,456

AFA	Total Capped CBA								
	3%			4%			5%		
	Coastal	Fluvial	Combined	Coastal	Fluvial	Combined	Coastal	Fluvial	Combined
Ballylongford	€ 11,068,424	€ 1,208,908	€ 11,318,361	€ 10,227,016	€ 1,019,135	€ 10,504,272	€ 9,471,607	€ 874,517	€ 874,515
Clarina	€ 36,219			€ 30,532			€ 26,200		
Adare	€ 8,225,290	€ 18,219,373	€ 23,795,981	€ 7,002,109	€ 15,906,687	€ 20,988,590	€ 6,068,519	€ 14,034,200	€ 18,631,650
Croom		€ 2,801,371			€ 2,458,545			€ 2,197,302	
Kilmallock		€ 94,664			€ 79,805			€ 68,481	
Charleville		€ 67,406			€ 56,826			€ 48,761	
Foynes	€ 19,694,273	€ 4,453,095	€ 21,141,196	€ 17,147,120	€ 3,895,849	€ 18,560,260	€ 15,113,732	€ 3,404,953	€ 16,522,119
Askeaton	€ 5,294,942	€ 11,804,454	€ 15,328,768	€ 4,679,881	€ 10,713,935	€ 13,802,985	€ 4,211,198	€ 9,855,506	€ 12,586,209
Rathkeale		€ 870,117			€ 733,522			€ 629,437	
Newcastle West		€ 5,955,191			€ 5,449,585			€ 5,009,510	
Dromcolliher		€ 178,043			€ 167,174			€ 158,892	
Milford		€ 499,182			€ 420,819			€ 361,106	