



# South Western CFRAM Study

Final Report UoM 18

30 May 2017



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## Final Report UoM 18

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# Executive summary

The Office of Public Works (OPW) are undertaking six catchment-based flood risk assessment and management (CFRAM) studies to identify and map areas with existing and potential future flood risk across Ireland. Mott MacDonald Ireland Limited has been appointed by the OPW to assess flood risk and develop flood risk management options in the South Western River Basin District.

This final report summarises the content of the project deliverables as they relate to the Munster Blackwater River Basin.

Flooding is a significant issue in the following towns in the Munster Blackwater River Basin:

- Kanturk
- Mallow
- Fermoy
- Ballyduff
- Rathcormac
- Aglish
- Youghal

In order to manage flood risk in the Munster Blackwater River Basin the following non-structural flood risk management measures are required:

- Planning Control
- Building Regulations
- Consideration of Flood Risk in Local Adaptation Planning
- Sustainable Urban Drainage Systems (SUDS)
- Flood Forecasting and Warning Systems
  - Build on Mallow / Fermoy Forecasting and Warning System
- Public Awareness
- Individual Property and Community Flood Resilience
- Voluntary Home Relocation
- Land Use Management and Natural Flood Risk Management Measures
- Emergency Response Planning

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

- The preferred option for Kanturk is Storage and Flood Defences.
- The preferred option for Mallow is to maintain the existing flood relief schemes.
- The preferred option for Fermoy is to maintain the existing flood relief schemes.
- The preferred option for Ballyduff is Flood Defences.
- The preferred option for Aglish is Flood Defences.
- The preferred option for Youghal is Monitoring and Flood Defences.
- The preferred option for Rathcormac is Flow Diversion.

# 1 Introduction

## 1.1 Background

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

Flood risk in Ireland has historically been addressed through the use of structural or engineered solutions (arterial drainage schemes and/or flood relief schemes). In line with internationally changing perspectives, the Government adopted a new policy in 2004 that shifted the emphasis in addressing flood risk towards:

- A catchment-based context for managing risk;
- More pro-active flood hazard and risk assessment and management, with a view to avoiding or minimising future increases in risk, such as that which might arise from development in floodplains;
- Increased use of non-structural and flood impact mitigation measures.

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

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

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

## 1.2 SW CFRAM Study Process

The overarching aims of the SW CFRAM Study were as follows:

- Identify and map the existing and potential future flood hazard;
- Assess and map the existing and potential future flood risk; and,
- Identify viable structural and non-structural options and measures for the effective and sustainable management of flood risk in the South Western River Basin District.

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

- Data collection;
- Hydrological analysis;
- Hydraulic analysis;
- Development of flood maps;

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

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

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

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

### 1.3 Report Structure

The structure of this report is set out as follows:

1. Introduction
2. Project Inception
3. Flood Risk Review
4. Hydrology
5. Hydraulic Modelling and Mapping
6. Development of Flood Risk Management Options
7. Strategic Environmental Assessment
8. Appropriate Assessment
9. Flood Risk Management Plans
10. Lessons Learned
11. Health and Safety
12. Review of Project Scope
13. Non-Reported Deliverables
14. Digital Deliverables

A schedule of the deliverables referred to in this report is included in Appendix A.

## 2 Project Inception

At the outset of the South Western CFRAM Study Mott MacDonald set out their proposed approach to the study in UoM 18 in an Inception Report. This report included the following:

- Detailed Methodology
- Data & Data Requirements
- Survey Requirements
- Preliminary Hydrological Approach

## 3 Flood Risk Review

### 3.1 The Preliminary Flood Risk Assessment

The Preliminary Flood Risk Assessment (PFRA) concluded that there was potential significant risk in the following areas in UoM 18:

- Aglish
- Clashmore
- Youghal
- Lismore
- Tallow
- Ballyduff
- Castlelyons
- Mitchelstown
- Fermoy
- Rathcormack
- Killavullen
- Mallow
- New Twopothouse
- Freemount
- Kanturk
- Cappoquin
- Buttevant
- Rathmore

### 3.2 Flood Risk Review

The flood risk in each of these areas was reviewed by on site surveys, interviews with residents and Local Authority Staff and consultation with the SW CFRAM Steering Group. Following the review, it was concluded that the following areas were Areas for Further Assessment and should be included in the SW CFRAM Study:

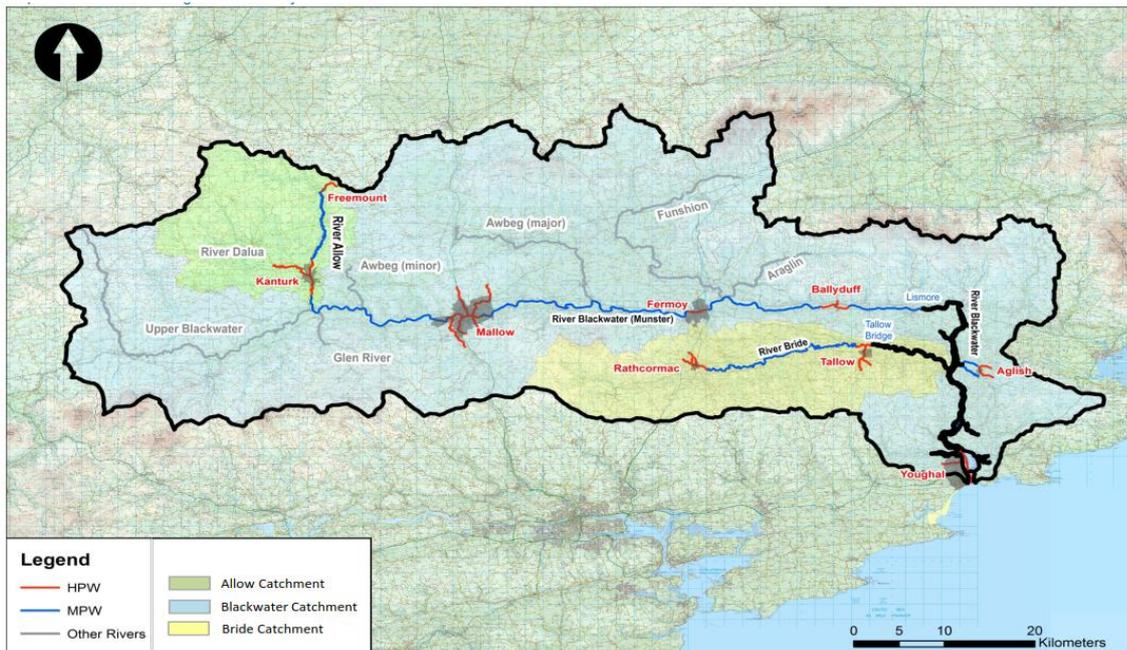
- Aglish
- Youghal
- Tallow
- Ballyduff
- Fermoy
- Rathcormack
- Mallow
- Freemount
- Kanturk

# 4 Hydrology

## 4.1 Sub-Catchments & Coastlines

The Munster Blackwater UoM can be split into sub-catchments covering the AFAs as shown in Figure 1.

**Figure 1: The Munster Blackwater UoM**



Source: UoM 18 Hydrology Report

### 4.1.1 Allow Sub-Catchment (including Freemont and Kanturk AFAs)

The Study considers the River Allow from Freemont to its confluence with the River Blackwater near Banteer. The River Allow/Glashawee River rises near the Mullaghareirk Mountains and flows in a south-easterly direction towards Freemont where it is joined by the Freemont Stream at Allow Bridge. The River Allow then flows southwards towards Kanturk where it is joined by the similarly sized River Dalua immediately downstream of Greenane Bridge in the town. The Allow continues to flow southwards where it is joined by minor tributaries such as the Brogeen Stream before it flows through Riverview gauge to its confluence with the Blackwater at Leaders Bridge. The major tributary of the River Dalua has been considered from Riverview Gauge to its confluence with the River Allow downstream of Greenane Bridge, Kanturk.

Smaller tributaries such as the Greenane Stream in Kanturk AFA and Kilknockane Stream along the Allow MPW have not been considered separately in the hydrology as their contributing area is less than 1km<sup>2</sup> and/or their contributing flow is less than 10% to the downstream reach. The recurring flooding at Greenane was attributed to the urban drainage system which is not within the scope of the Plan.

#### 4.1.2 Blackwater Sub-Catchment (incl. Mallow, Fermoy, Ballyduff & Youghal AFAs)

The River Blackwater rises near Glenatipple flowing southwards to Rathmore, before flowing eastwards to Banteer where it is joined by the River Allow from the north. This upstream reach of the Blackwater was not modelled or mapped as part of this study because there were no AFAs identified upstream. However, the flow contribution from the upper Blackwater was considered.

The River Blackwater continues eastwards, where it is joined by the Glen River from the south and Awbeg Minor from the north before flowing into Mallow. Within Mallow, there is a flood defence scheme that comprises of a number of walls, embankments, penstocks and the extension of the culvert through Tipp O'Neill Park. There are a number of smaller urbanised tributaries that join with the River Blackwater in Mallow. The most significant of these are the Clyda River which joins from the south upstream of Quartertown and Spa Glen which joins downstream of Mallow Town Bridge.

The River Blackwater continues to flow east downstream of Mallow towards the gauge at Killavullen some 10km downstream before being joined by the Awbeg Major from the north downstream of Castletownroche and flowing eastwards into Fermoy. A series of flood embankments and demountable defences form the Fermoy flood defence scheme to mitigate flood risk from the high water levels in the River Blackwater during floods. The River Blackwater is then joined by the River Funshion and Araglin River from the north, 2km and 2.7km downstream of Fermoy.

The gradient of the River Blackwater continues to reduce as it flows eastwards through Ballyduff to Lismore Weir. Downstream of Lismore, the River Blackwater is considered fully tidal. The river channel continues eastwards for another 6km before turning to flow southwards at the confluence with the Glenshealan River. The River Blackwater flows southwards through Villerstown Gap before being joined by the River Bride from the west and River Licky from the east. The River Blackwater then continues to flow southwards to outfall into the Celtic Sea at Youghal.

A review of the peak flows recorded along the Blackwater found that the peak flow did not increase as the flood progresses downstream between Mallow and Killavullen for example, as would normally be expected. This was explained by greater storage in the flood plain as water spills out of bank but does not return to the channel and by karstic features that may cause losses to groundwater during a flood event.

#### 4.1.3 Bride Sub-Catchment (including Rathcormac and Tallow AFAs)

The River Bride is the second largest river within UoM18. The Bride rises from the Nagles Mountains and flows eastwards under the N8 road to Rathcormac where it is joined by the Shanowen River from Rathcormac and the River Flesk from the south. The River Bride continues to meander eastwards where it is joined by a number of smaller tributaries before reaching Mogeely gauge. Downstream of Mogeely, the Bride continues east towards Tallow Bridge where it becomes fully tidal, before joining the River Blackwater some 12km downstream. The much steeper and smaller Glenaboy River flows from the south through Tallow before joining the River Bride upstream of Tallow Bridge.

#### 4.1.4 Aglish AFA

The town of Aglish is situated in a minor sub-catchment of the lower Blackwater on the Ballynaparka River. The small, steep Ballynaparka River rises 2km upstream of the town flowing north-west along the main street through Aglish before joining with the tributary immediately downstream of Ballynaparka Bridge. Downstream of the confluence, the river flows west through Bleach to join the tidal Goish River and the River Blackwater 1km further downstream.

#### 4.1.5 Coastal Features

The River Blackwater can be considered tidal as far as Lismore, some 33km inland and the River Bride can be considered tidal as far as Tallow Bridge, 30km inland. However, the relatively narrow channel and floodplain between the steep valley sides limits the presence of in-channel bars, tidal loop channels and wide estuarine flats until Youghal. Ferry Point, opposite Youghal constrains the incoming tide, and protects Newtown and the eastern bank from extreme wave action. However, the western bank from Youghal Mudlands to Claycastle in Youghal is vulnerable to wave action and storm surges as identified by the Ireland Coastal Water level and Wave Study 2013 (ICWWS).

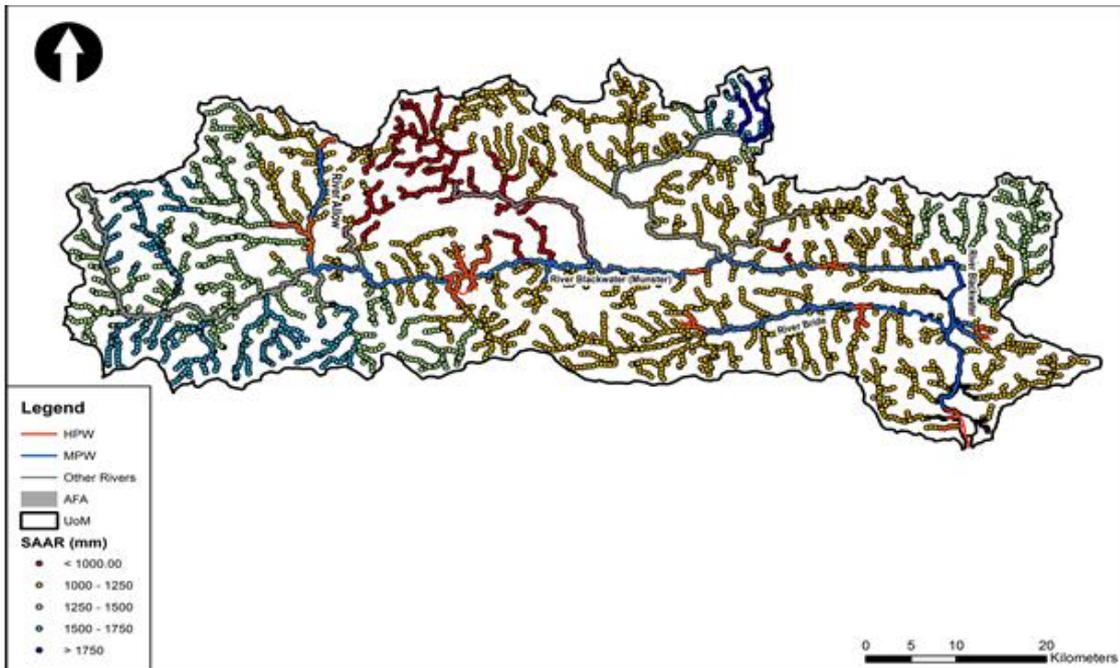
There is 1.7km of open coastline frontage at Claycastle, Youghal which goes across the fluvial watershed between UoM18 and UoM19. This coastline has been considered as part of UoM18 since any coastal flooding arising from this reach would affect the Youghal AFA.

## 4.2 Rainfall Distribution

Rainfall tends to be greater in the west and decreases towards the east. This corresponds with the dominant wind direction in the South West where storms tend to track west to east. Areas of high relief east of Mitchelstown also experience higher Standard Annual Average Rainfall (SAAR). The higher relief in the west combined with the dominant storm track leads to greater rainfall in the headwaters of the Blackwater, Bride and over the higher relief at Cappoquin. The northern catchments of the Awbeg Major and Minor both have lower rainfall totals. Their lower topography and karstic geology leads to much lower flows than would be expected for a catchment of their size.

Given the large size of the Blackwater catchment (>3000km<sup>2</sup>), rainfall and high flows in the upper catchments is unlikely to occur at the same time as rainfall and high flows in the lower catchments as the storm tracks across the catchment. A single storm tracking from west to east can exacerbate flooding as all the flows from the upper catchment converge with the peak flow from tributaries in the lower catchment, raising water levels. However, gauge records indicate that the Bride tends to peak before the Blackwater at Ballyduff.

**Figure 2: Standard Annual Average Rainfall**



### 4.3 Flood Events that occurred after the completion of the Hydrology Report

#### **Flood Event of 4th February 2014 affecting Youghal**

Extreme winds and storm surges coupled with high tides resulted in flooding to parts of Youghal town centre on both the morning of 3rd February and the evening of 4th February. The majority of flooding to properties occurred along Brown Street and North Main Street. Flooding at other areas such as The Mall, Kent Street Market Place Grafton Street and Catherine Street was generally curtailed by flood gates erected by property owners. These areas are prone to frequent flooding, with events typically occurring once every 1 – 2 years. These areas were flooded due to tidal surges breaching quay walls along Buttimer's Quay, MacDonald's Quay Green's Quay, Allin's Quay and the Mall Dock – located immediately east of the aforementioned streets. A tide level of 2.765m AOD Malin was observed on the morning of 3rd February at Ballycotton, slightly higher than the 2.605 m AOD Malin tide recorded on the evening of the 4th.

#### **Flood Event of 29th December 2015 affecting Tallow**

Water levels downstream of West Street Bridge between Tallow and Tallow bridge were significantly high causing the watercourses to overtop and flood the agricultural land and a significant section of the regional road (R634 - entering town from North). The stormwater network along West Street was unable to discharge to the Glenaboy river through a 300mm duckbill valve outfalling from a chamber immediately downstream of the bridge. 3 Nr. properties were flooded (1 to the west of the junction and 2 to the east). A flood level of 10.285mOD was measured.

#### 4.4 Recommendations for Future Analysis

The following recommendations were drawn from the hydrological analysis for future analysis in the catchment:

- Continued effort to obtain concurrent spot gaugings (where safe) for bankfull and out-of-bank conditions at Allen's Bridge, Riverview, CSET Mallow, Mallow Rail Bridge, Killavullen and Ballyduff.
- Spot gaugings at Fermoy Mill Gauge 18117 to verify flow estimates from the Fermoy Bridge gauges. The Fermoy Mill gauge is located away from the complex weir-bridge structure thus avoids any uncertainties associated assumptions taken for these structures during the rating development.
- Concurrent monitoring of sea levels at Ballycotton and Youghal Harbour quayside during storm surge events would help verify the transformation of extreme coastal events.
- The % AEP estimates for total tide plus surge levels should be reviewed periodically at Ballycotton as a longer period of data becomes available.
- The rate of meander migration (erosion) in the River Allow and Dalua should be taken into consideration in the design of any flood mitigation options and sediment yields. It should be noted that the meander migration is part of the rivers natural hydrogeomorphological response to climatic changes in the past few decades.
- The level and frequency of screen maintenance in Mallow should be considered for the operation of the flood relief scheme going forward.

Full details of all the available and reviewed data for the UoM are available in the UoM Hydrology Report.

## 5 Hydraulic Modelling and Mapping

Thirteen hydraulic models were developed for High Priority and Medium Priority Watercourses in UoM18 covering the nine Areas for Further Assessment and four intervening reaches of Medium Priority Watercourses. The river channels were modelled using 1D ISIS software to calculate flows and head loss at hydraulic structures. The 2D TUFLOW software was used to simulate the multi-directional flows within AFAs. The 1D and 2D components of the models are hydrodynamically linked such that water can flow between the river and floodplain during the event to simulate the observed flood mechanisms. The model setup is shown in Figure 3.

The Blackwater catchment was calibrated to flood events of 30th December 1998, 6th November 2000 and 19th November 2009 between Kanturk and Ballyduff. Rathcormac was calibrated to the 30th January 2009 event and Youghal was calibrated to the 17th October 2012 coastal event. Sensitivity tests were undertaken on flow, downstream level and Manning's 'n' for all models.

The calibrated and tested models were then run for eight flood event probabilities under the current design scenario, eight flood event probabilities under the mid-range future scenario, and three flood event probabilities under the high-end future scenario from both fluvial and coastal sources. The joint probability between different tributaries and the sea was considered in defining each event probability. The flood extent, flood zone, flood depth, flood velocity and flood hazard were all mapped for the specified scenarios.

The findings from the modelling results and flood maps were used as inputs to the development of flood risk management measures. The knowledge of the flood mechanisms, critical structures and impact of flooding supported the development of sustainable and appropriate flood risk management options in the flood risk areas.

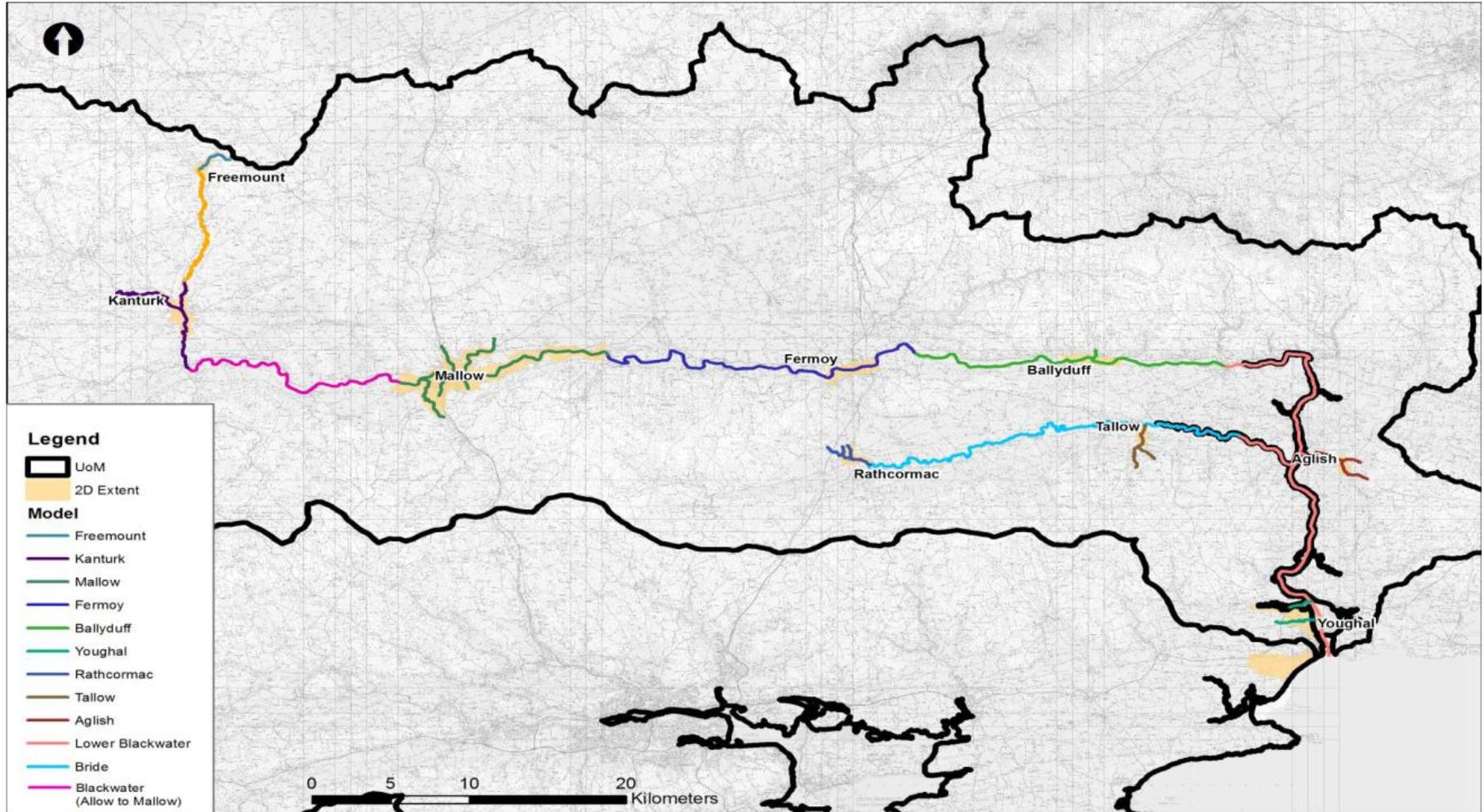
### 5.1 Hydraulic Recommendations

The following recommendations were drawn from the key findings of the Hydraulics Report:

- The uncertainty and sensitivity to peak flow and duration estimates should be considered in the sizing and maintenance of any flood mitigation measures in Kanturk.
- The uncertainty and sensitivity to peak flow and duration estimates should be considered in the future maintenance and performance of flood alleviation schemes in Mallow and Fermoy, particularly with regard to climate change.
- The uncertainty in the total tide plus surge levels should also be considered in the development of any coastal flood mitigation measures in Youghal.
- The capacity of culverts in Rathcormac, Tallow and Aghlish should be carefully considered for increased conveyance options to reduce flood risk upstream.
- It is recommended that post-flood surveys are continued for all significant future flood events where properties and/or infrastructure are affected. Data should be collected shortly after the event and include: sources of flooding, timing of overtopping, any actions taken and at what time, blockages of structures, flood levels in the channel and on the floodplain and accompanying photographs.
- It is recommended that surface water flooding and the interaction of flooding with the urban drainage network is investigated together with fluvial flooding in Rathcormac.

Full details of the hydraulic modelling and mapping are included in the Hydraulics Report for UoM 18.

Figure 3: Model layout



## 6 Development of Flood Risk Management Options

### 6.1 Option Development

The process undertaken to develop flood risk management options for each AFA is set out in the Preliminary Options Report.

In the first instance, a screening and preliminary assessment was carried out to identify which Flood Risk Management (FRM) measures were applicable to each of the Spatial Scales of Assessment (SSA) within UoM 18. The SSAs identified for UoM 18 were the UoM and the AFAs.

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

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

The viability of each of the measures was assessed to a preliminary degree only. The purpose of the screening process was to identify the FRM measures that are clearly not applicable or viable within UoM 18.

A Flood Risk Management (FRM) option consists of one, or more commonly a combination of FRM measures. Potential Flood Risk Management (FRM) options for each of the AFA's within UoM 18 were developed.

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

### 6.2 Cost Estimates

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

The total cost of the option was calculated by adding costs for the following to the basic construction cost:

- Optimism Bias; A percentage add-on was applied to take account of issues unknown at preliminary design stage. This percentage was evaluated separately for each measure.
- Preliminaries
- Design fees
- Archaeology

- Environmental mitigation
- Compensation and land acquisition
- Site investigations and
- Maintenance costs.

## 6.3 Benefit Evaluation

### 6.3.1 Economic damage caused by flooding

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

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

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

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

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

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

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

### 6.3.2 Benefit calculation

The benefit of a flood risk management option (Scheme) was also calculated which is the damage avoided by implementing a scheme to the required Standard of Protection (SOP).

## 6.4 Flood Risk Assessment

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

- Society
- The Environment
- Cultural Heritage
- The Economy

The number of receptors at risk from the various flooding scenarios are listed in the Preliminary Options Report.

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

## 6.5 Preferred Options

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

- Planning Control
- Building Regulations
- Consideration of Flood Risk in Local Adaptation Planning
- Sustainable Urban Drainage Systems (SUDS)
- Flood Forecasting and Warning Systems
  - Build on Mallow / Fermoy Forecasting and Warning System
- Public Awareness
- Individual Property and Community Flood Resilience
- Voluntary Home Relocation
- Land Use Management and Natural Flood Risk Management Measures
- Emergency Response Planning

Planning control and development management can be a viable flood risk management measure. Using flood hazard information developed as part of the CFRAM study, it was possible to identify areas that are zoned for development that are at risk of flooding. The Spatial Planning and Flood Risk Report identifies such areas in UoM 18 and makes recommendations to manage flood risk in these areas for the consideration of the local authorities and the OPW.

As part of the CFRAM study, the applicability of SUDS was assessed for each AFA. It was found that SUDS is not applicable to existing developed areas in these AFAs, as the required area for storage of surface water flows is not available. However, SUDS is applicable to areas that have been zoned by local authorities for future development. By adopting a SUDS approach for containing surface water within new developments, flooding events can be mitigated by storing surface water on-site. The Strategic Sustainable Urban Drainage System Report for UoM 18 outlines natural drainage patterns in each of the AFAs and identifies the volume of storage to be provided for areas zoned for future development.

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

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

with this preferred option. It should be noted however that this option was not the preferred option identified by the MCA. This was Conveyance and flood defences. The latter option achieved a higher Option selection MCA score but was opposed by local stakeholders as it involved the removal of a weir that would interfere with local angling activities.

- The preferred option for Ballyduff as identified in the MCA is Flood Defences. There was limited feedback provided at the Ballyduff PCD which indicated that the public agreed with the preferred option indicated in the MCA. As an interim measure, before the preferred option is implemented, extending the existing Mallow / Fermoy Flood Forecasting and Warning System to Ballyduff would be of benefit.
- The preferred option for Aglish as identified in the MCA is Flood Defences. There was limited feedback provided at the Aglish PCD which indicated that the public agreed with the preferred option indicated in the MCA.
- The preferred option for Youghal as identified in the MCA is Monitoring and Flood Defences. As an interim measure, before the preferred option is implemented, the installation of a tide gauge and a flood forecasting and warning system would be of significant benefit in Youghal.
- The preferred option for Rathcormac is Flow Diversion. This is based on feedback received at the PCD and the MCA including the economic cost benefit ratio. It should be noted however that this option was not the preferred option identified by the MCA. This was storage. The latter option achieved a higher Option selection MCA score but was opposed by local stakeholders for a variety of reasons.

# 7 Strategic Environmental Assessment

## 7.1 The SEA Directive

Strategic Environmental Assessment is required under the EU Council Directive 2001/42/EC on the Assessment of the Effects of Certain Plans and Programmes on the Environment, more commonly known as the “SEA Directive” which has been transposed into Irish law by the following regulations:

- European Communities (Environmental Assessment of Certain Plans and Programmes) Regulations, 2004 (S.I. 435 of 2004) and the
- Planning and Development (Strategic Environmental Assessment) Regulations, 2004 (S.I. 436 of 2004).

Strategic Environmental Assessment (SEA) is a formal, systematic evaluation of the likely significant environmental effects of implementing a plan or programme, prior to a decision being made to adopt a plan or programme.

SEA in Ireland is based on Directive 2001/42/EC (Assessment of the Effects of Certain Plans and Programmes on the Environment), more commonly known as the “SEA Directive” which has been transposed into Irish law by the European Communities (Environmental Assessment of Certain Plans and Programmes) Regulations, 2004 (S.I. 435 of 2004) and the Planning and Development (Strategic Environmental Assessment) Regulations, 2004 (S.I. 436 of 2004). These regulations were replaced in 2011 by the European Communities (Environmental Assessment of Certain Plans and Programmes) (Amendment) Regulations, 2011 (S.I. No. 200 of 2011) and the Planning and Development (Strategic Environmental Assessment) (Amendment) Regulations 2011 (S.I. No. 201 of 2011).

The main objective of the SEA Directive is to:

“Provide for a high level of protection for the environment and to contribute to the integration of environmental considerations into the preparation and adoption of plans and programmes with a view to promoting sustainable development.”

## 7.2 The SEA Process

The SEA process requires the assessment and evaluation of the FRMP measures to identify the potential significant effects of the options on the receiving environment and to identify the preferred options and appropriate mitigation and monitoring required to offset potential impacts. This assessment has been done as part of an overall Multiple Criteria Analysis where the SEA Objectives are utilised to assess the measures proposed in the FRMP for the UoM. The principle steps in the assessment process are as follows:

**Flood Management Option Development and Assessment:** The SEA process has been fully integrated into the overall appraisal process for the identification of flood risk management options. Based on a detailed understanding of the flood risk identified for each Area of Further Assessment (AFA), a number of different flood alleviation risk management options were developed. Each of these options was then assessed based on a multi-criteria option assessment (MCA) process. The MCA used a suite of project objectives, which include the SEA objectives to rate each of the proposed plan options. This assessment was then used to identify the preferred flood risk management options. In order to facilitate a more accurate assessment, a semi-quantitative approach was adopted whereby each plan option was assessed against the

SEA objectives and sub-objectives having regard to the indicators, basic requirements and aspirational targets:

- **Indicator:** The indicators are parameters, measurable and numeric where possible by which the success of an option in meeting a particular objective is gauged;
- **Basic Requirements:** A basic requirement is set for each objective as a measure to gauge whether the proposed option meets a minimum standard with regard to each objective. The Basic requirement is a measure below which the proposed objective would have a negative effect.
- **Aspirational Targets:** This is a target set for each objective and defines the perfect outcome with regard to the potential impact of the objective.

Each option was scored against the objectives and sub-objectives based on the scoring matrix. Once a score was defined for each objective then a global weighting was applied which defined the perceived importance of the objective in question. Furthermore, local conditions were also considered for each AFA whereby a local weighting was applied based on an understanding of the local conditions relevant to the objective in question.

Following the identification of preferred flood risk management options from the MCA process, the next stage of the study comprised the development of an overall flood risk management strategy which would comprise a combination of flood prevention measures, flood protection measures and flood preparedness.

## 8 Appropriate Assessment

### 8.1 The Habitats Directive

In accordance with Article 6(3) of the Habitats Directive (92/43/EEC), Appropriate Assessment is required where a plan or project not directly connected with or necessary to the management of a Natura 2000 site(s), may give rise to significant effects upon a Natura 2000 site(s). The requirement for Article 6 Assessments has been transposed into Irish law by the European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. No. 477 of 2011), herein referred to as the 'Regulations'. Natura 2000 sites include Special Protection Areas (SPAs), Special Areas for Conservation (SACs), which have been adopted by the European Union (EU), but not yet formally designated by the governments of Member States, as well as candidate SPAs and SACs. In accordance with the Regulations, Natura 2000 sites are herein referred to as European sites.

### 8.2 Natura Sites

Flood risk management options in Kanturk are proposed for both the Dalua and Allow Rivers. These watercourses are tributaries of the Blackwater River and are within the Blackwater River SAC (002170).

Flood risk management options in Ballyduff are proposed for the Blackwater River within the boundaries of the Blackwater River SAC (002170) and the Blackwater Callows SPA (004094).

Flood risk management options in Rathcormac are proposed for the Kilbrien stream and the Shanowen River. These waterbodies are tributaries of the River Bride which is part of the Blackwater River SAC (002170). The Shanowen River flows into the River Bride approximately 500m downstream of Rathcormac town.

Flood risk management options in Aglish are proposed for the Aglish stream. The Aglish stream is a tributary of the Goish River which discharges into the Blackwater River SAC (002170).

Flood risk management options in Youghal are proposed for Youghal Estuary which is part of the Blackwater River SAC (002170) and downstream of the Blackwater Estuary SPA (004028).

### 8.3 Potential Impacts on Qualifying Features

The preferred flood risk management option for the Ballyduff AFA was assessed through MCA as Flood Defences. This option includes construction of walls, embankments and road raising within the town ranging in height from 1m to 2.5m. The Screening for Appropriate Assessment concluded that significant effects are likely or uncertain for the following qualifying features of the Blackwater River SAC, resulting from the preferred flood risk management option in Ballyduff AFA:

- Sea Lamprey *Petromyzon marinus*;
- Atlantic Salmon *Salmo salar*;
- Freshwater Pearl Mussel *Margaritifera margaritifera*; and
- Water courses of plain to montane levels with the *Ranunculus fluitantis* and *Callitriche-Batrachion* vegetation.

The preferred flood risk management option for the Kanturk AFA comprises the construction online storage area on the Dalua River and flood defence walls within the town. The Screening for Appropriate Assessment concluded that significant effects on the following qualifying features of the Blackwater River SAC are likely/uncertain resulting from the preferred option in Kanturk AFA:

- Sea Lamprey *Petromyzon marinus*;
- Atlantic Salmon *Salmo salar*;
- Freshwater Pearl Mussel *Margaritifera margaritifera*;
- Otter *Lutra lutra*; and
- Water courses of plain to montane levels with the *Ranunculus fluitantis* and *Callitriche-Batrachion* vegetation.

The preferred flood risk management option for the Youghal AFA is flood walls and barriers. No significant effects were determined in the Screening for Appropriate Assessment given that there will be no personnel or machinery movement within the mudflat habitat.

As significant effects are determined to be likely or uncertain, the Flood Risk Management Plan is statutorily required to be subjected to Appropriate Assessment. Significant effects were determined as likely or uncertain for the Blackwater River SAC due to flood risk management options in Kanturk and Ballyduff AFA's.

#### 8.4 Significance of Impacts

Potential for significant risk of disturbance of birds has been identified for the following AFAs: Kanturk.

Potential for significant risk of spread of invasive species has been identified for the following AFAs: Kanturk.

Significance of impact is unknown in many cases given the absence of information on the presence of certain protected species or their habitat within the locality of the proposed works, namely otter, bats, lamprey, and Atlantic salmon. It is recommended that pre-construction surveys be conducted to fill these data gaps.

- Potential for significant impact on protected fisheries (lamprey and salmon) is uncertain for the following AFAs: Aghlish, Kanturk.
- Potential for significant impact on bats is uncertain for the following AFAs: Aghlish, Kanturk.

## 9 Flood Risk Management Plan

The Flood Risk Management Plan is a public facing document that outlines the process undertaken as part of the CFRAM Study and sets out the flood risk management policies, strategies, actions and measures to be implemented by the OPW, Local Authority and other relevant bodies.

### 9.1 Public Consultation

Following publication of the Draft Plan and associated SEA Environmental Report (SEA ER) and Appropriate Assessment (AA) in July 2016, a series of public consultation events took place to give members of the public an opportunity to discuss the contents of the plan with members of the study team.

**Table 1: Public Consultation Days**

Location	Date	Venue	Nr. of Attendees
Mallow	29/8/16	The Hibernian Hotel	22
Cappoquin	30/8/16	The Community Centre	8
Cork City	31/8/16	Cork County Hall	24

### 9.2 Selected Feedback on the Plan

Observations on the plan, the SEA ER and the AA were received by OPW. Some selected feedback on the documents are summarised below:

#### 9.2.1 Kanturk

Some stakeholders were of the opinion that the measure of removing the weir in Kanturk should be considered, notwithstanding the public feedback that this was not desirable.

#### 9.2.2 Rathcormac

Some stakeholders were opposed to the proposed option of flood defences in Rathcormac. Suggestions were made that flow diversion should be considered in more detail.

#### 9.2.3 Youghal

While the proposed option of flood defences was well received at the Public Consultation Day for flood risk management options in Youghal, negative responses were received to this option during the Draft FRMP consultation. Certain observers expressed their concern that flood defences would have a negative impact on the appearance of the town and that a tidal barrage would be preferable. A tidal barrage is not cost effective.

### 9.3 Changes made to the Plan following public consultation

Following the receipt of observations on the draft plan the measures included in the Final Plan were changed as follows:

The preferred measure for Rathcormac was changed from Flood Defences to Flow Diversion.

# 10 Lessons Learned

## 10.1 Stakeholder Consultation and Engagement

Through the delivery of the South Western CFRAM Study in UoM 18 we have concluded that further iterations of the CFRAM studies could benefit from a revised approach to stakeholder consultation and engagement. Some of the difficulties encountered are listed below:

- People affected by flooding or flood risk management measures did not know about the study or consultation events.
- People felt that their suggested FRM measures had not been considered.
- People attending consultation on Preliminary Options felt that the team had already made their minds up as to what the preferred option was.
- Stakeholders adopted an adversarial approach to their review of the project deliverables.

We would recommend that expert advice is sought in developing a methodology and programme of public and stakeholder engagement to ensure that in future studies, there is a better buy in from the stakeholders. Early stakeholder participation would be of benefit in this. In order to achieve buy in, it would be necessary to demonstrate that the input of stakeholders has been considered and forms part of the analysis. The best way to do this may be through workshops.

Some of the constraints that the OPW currently has to operate within include the environmental and economic feasibility. These constraints, and the parts they play in the decision-making process act as barriers to meaningful public consultation and engagement. Careful consideration should be given to how the conflicting objectives of public will, the environment and the cost benefit ratio, can be resolved to improve the consultation and engagement process.

The consultation and engagement of environmental stakeholders may be improved with targeted workshops. At these, environmental experts could engage directly with environmental stakeholders (SWAN, NPWS).

# 11 Health and Safety

## 11.1 Safety, Health and Welfare at Work Regulations 2013

The South Western CFRAM study includes the preparation of designs that could lead to construction work. In accordance with the 2013 Construction Regulations the OPW are obliged to appoint a Project Supervisor for the Design Process (PSDP). The PSDP is tasked with co-ordinating the work of designers on a project to ensure that they fulfil their duties in respect of the Construction Regulations. The PSDP is also required to prepare a Safety and Health Plan that includes the following:

- A general description of the project
- A description of other work activities ongoing at the site
- A description of the works which will involve particular risks to the safety and health of those constructing the works and
- Information from designers in respect of the decisions they made to mitigate the risk to persons constructing, operating, maintaining and demolishing the works

Mott MacDonald Ireland were appointed by OPW to carry out this role.

The particular risks associated with the preferred options include the following:

- Falling from height
- Drowning
- Electrocutation
- Burial under earthfalls
- Engulfment in swampland
- Chemical and biological agents
- Heavy prefabricated components
- Interaction with traffic

In addition, Mott MacDonald Ireland, as designers, are obliged under the regulations to consider how their designs can be constructed, operated, maintained and demolished safely. As designers Mott MacDonald Ireland are obliged to design out risk in their designs where possible. Decisions made by designers in this regard are documented in Designer's hazard elimination and management record sheets which are appended to the Preliminary Health and Safety Plan for the UoM.

# 12 Review of Project Scope

## 12.1 Hydrology

In viewing the hydrology of an entire catchment, it should be recognised that, for various reasons, the extreme peak flow will not always increase as you progress downstream. In future studies, greater weight should be permitted to single site analysis in areas where there is a significant flood risk.

## 12.2 Hydraulic Modelling

In future studies, it should be recognised that there is little value in modelling steep watercourses that do not give rise to flood risk in their upper reaches. Steep rivers can carry significant volumes of water without giving rise to flood risk. It can be very difficult to construct stable models of steep rivers.

Greater flexibility should be allowed in future studies for consultants to use other methods to calculate flood depths. In certain AFAs it could have been possible to use simple calculations to determine flood depth.

Based on the screening carried out during this study, future studies should include the impact of blockage at high risk structures. This data may not necessarily be reproduced on the flood extent maps but these maps should highlight that there could be a blockage issue and refer to supplementary flood extent maps.

Future studies should focus on more user friendly digital deliverables as opposed to pdf drawings. In particular, GIS deliverables and web mapping could speed up, and reduce the cost of, the delivery of flood data.

# 13 Non-Reported Deliverables

This section contains summaries of deliverables that have not previously been reported in SW CFRAM Deliverables.

## 13.1 Defence Asset Condition Survey

The condition of flood defence assets in AFAs and identified in the project brief was ascertained by on-site inspection. The condition of the assets was recorded in the Flood Defence Asset Database.

## 13.2 Defence Failure Mapping

Defence failure mapping was prepared for locations where existing flood defences could hold more than 1m depth of flood water from defended areas. The mapping was carried out in accordance with GN 24. The areas for which this mapping was prepared are:

- Mallow
- Fermoy
- Youghal

In Mallow, the breaches were simulated for the 1% AEP event.

The breach on the Left Bank was simulated to occur at the demountable flood defence barrier that closes off Mallow Bridge. The breach height was taken to be the height of the flood defence. The breach width was taken to be 20m wide and the breach occurrence was taken to be at the peak of the flood. The duration of the breach was taken to be 36 hours.

On the Right Bank, the breach was simulated to occur in the embankment that protects the properties upstream of the Railway bridge. The breach height was taken to be the height of the flood defence. The breach width was taken to be 40m wide and the breach occurrence was taken to be at the peak of the flood. The duration of the breach was taken to be 36 hours.

In Fermoy, the breaches were simulated for the 1% AEP event.

The breach on the Left Bank was simulated to occur at the demountable flood defence barrier that closes off Fermoy Bridge. The breach height was taken to be the height of the flood defence. The breach width was taken to be 20m wide and the breach occurrence was taken to be at the peak of the flood. The duration of the breach was taken to be 36 hours.

On the Right Bank, the breach was simulated to occur in the demountable flood defence barrier that protects the properties at Ashe Quay upstream of Fermoy bridge. The breach height was taken to be the height of the flood defence. The breach width was taken to be 20m wide and the breach occurrence was taken to be at the peak of the flood. The duration of the breach was taken to be 36 hours.

In Youghal the breach was simulated to occur during the 0.5% AEP coastal flood event.

The breach was simulated to occur at Front Strand where a number of properties could potentially be flooded. The breach height was taken to be the height of the flood defence. The breach width was taken to be 20m wide and the breach occurrence was taken to be at the peak of the flood. The duration of the breach event was taken to be 72 hours. This incorporated six tidal cycles.

### 13.3 Uncertainty Mapping

The uncertainty associated with the flood extents for various models is shown on the uncertainty mapping. The mapping was carried out as per the methodology set out in the RPS Document “Methodology for Uncertainty Mapping Dodder CFRAMS”. The uncertainty associated with flood extents is associated with uncertainty in the hydrology and in the hydraulic modelling.

The uncertainty related to the hydrology for an area was scored based on the method used to derive extreme flows. The scores for hydrology are shown in Table 2.

**Table 2: Hydrological Uncertainty**

Method		Score
Catchment Descriptors – FSR	FSR Rainfall Runoff	4
Catchment Descriptors – FEH	FEH Rainfall Runoff	3
Short record (<10 years)	Calibrated Rainfall Runoff	2
Long record ( $\geq 10$ years)		1

The uncertainty related to the hydraulic modelling for an area was scored based on the complexity of the models. The scores for hydraulic modelling are shown in Table 3.

**Table 3: Hydraulic Complexity**

Model Description		Score
Simple	Few inflows, branches and structures	0
Medium	Some inflows, branches and structures	1
Complex	Reservoir units, many inflows, and/or many branches	2

Large increases in flow for different AEP flood events gives rise to an increase in uncertainty. To take account of this a third score is used, the Return Period Score.

The uncertainty Scores for UoM 18 are shown in table 4.

**Table 4: Uncertainty Scores**

Model	Hydrology Score	Hydraulic Complexity
Freemount	3	0
Allow	3	1
Kanturk	1	2
Blackwater Reach 1	3	2
Mallow	2	2
Blackwater downstream of Mallow	2	1
Fermoy	2	1
Blackwater Reach 3	3	2
Ballyduff	2	1
Ballyduff outside 2D code region	3	1
Blackwater Reach 4	3	2

<b>Model</b>	<b>Hydrology Score</b>	<b>Hydraulic Complexity</b>
Youghal	3	1
Rathcormac	3	2
Bride Reach 1	2	2
Tallow	3	0
Aglis	3	0

The uncertainty line for a flood extent is calculated based on the design flow, the design flood extent, the next extreme flood extent and the uncertainty score.

# 14 Digital Deliverables

Details of deliverables that have been issued in interactive digital formats are described below.

## 14.1 Defence Asset Condition Database

The condition of flood defence assets in AFAs and identified in the project brief was ascertained by on-site inspection. The condition of the assets was recorded in the Flood Defence Asset Database which is an Excel spreadsheet with hyperlinks to photographs of the assets.

## 14.2 River Channel and Structure Survey

AutoCAD drawings of the river channel and structure surveys specified to facilitate the construction of hydraulic models were issued to OPW. Watercourses were given a 6-digit reach code to identify them. The watercourses surveyed in UoM 18 are listed in Table 5.

**Table 5: Surveyed Watercourses**

Watercourse	Reach Code
Allow	18ALLO
Greenane	18GREE
Knockeen	18KEEN
Dalua	18DALU
Dalua Tributary in Kanturk	18DECL
Blackwater	18BLAC
Glashaheagow	18GLAS
Sparteen	18SPAR
Moanroe	18MOAN
Clyda (River)	18CLYD
Quarertown	18QUAB
Mill Race	18RACE
Carrigduff	18CARD
Bearforest	18FORE
Gortnagraiga	18GORT
Curraghaneria	18ANER
Annabella	18BELA
Ballydaniel	18DANI
Dromdowney	18DREY
Dromoe Commons	18DRCO
Keatleyclose	18KEAT

Watercourse	Reach Code
Mallow Castle	18MACA
Fiddane	18FIDD
Knoppoge	18POGE
Ross River	18ROSS
Cullenagh	18CULL
Glenabo Stream	18NABO
Ballyoran	18ORAN
Bride	18BRID
Brogeen	18BROG
Garraveasoge	18GARA
Glounagad	18GLOD
Owennashad	18 SHAD
Ballynaparka	18 ARKA
Ballynaparka	18 PARN
Bride	18 BRID
Glenaboy	18 ABOY
Kilbrien	18 BRIE
Garrynacole	18 NACO
Shanowen	18 OWEN
Toberaneague	18 TOBE
Ballybrowney	18 BROW
Knockaunfargarve	18 FARG
Lisnagar Demensne	18 LISN

### 14.3 Hydraulic Models

The hydraulic models built as part of the South Western CFRAM study were issued to the OPW on a hard disk drive. Separate models were built to prepare flood maps, to analyse flood defence failure and to develop options. These models are contained in folders called DESIGN, BREACH and OPTION. The models relating to the AFAs and MPWS are listed in Table 6.

**Table 6: Hydraulic Models**

Model Number	Name	Location
01	Freemount	Freemount AFA
02	Allow	Allow AFA
03	Kanturk	Kanturk AFA
04	Blackwater Reach 1	Between the Allow and Mallow
05	Mallow	Mallow AFA
06	Mallow MPW	Between Mallow and Fermoy
07	Fermoy	Fermoy AFA
08	Fermoy MPW	Between Fermoy and Ballyduff
09	Ballyduff	Ballyduff AFA
10	Blackwater Reach 4	Between Lismore and Youghal
11	Youghal	Youghal AFA
12	Rathcormac	Rathcormac AFA
13	Bride Reach 1	Between Rathcormac and Tallow
14	Ballyduff MPW	Between Ballyduff and Lismore
16	Tallow	Tallow AFA
17	Aglish	Aglish AFA

## 14.4 Flood Maps

Flood maps were prepared and delivered in pdf and in GIS format.

**Table 7: Flood maps**

Map Nr	Map Type	GIS format	Probabilities mapped per scenario		
			Current	MRFS	HEFS
1	Flood Extent	Polygon	All	All	10,1,0.1
2	Flood Zone	Polygon	1, .01	1, .01	N/A
3	Flood Depth	Raster Grid	All	10,1,0.1	N/A
4	Flood Velocity	Raster Grid	All		N/A
5	Risk to Life	Raster Grid	10,1,0.1		N/A
6	Defence Failure Extent	Polygon	1 Scenario		N/A
	Defence Failure Depth	Raster Grid	1 Scenario		N/A
	Defence Failure Velocity	Raster Grid	1 Scenario		N/A
7	Specific Risk, Inhabitants	Raster Grid	10,1,0.1	10,1,0.1	N/A
8	Specific Risk, Type of Activity	Raster Grid	10,1,0.1	10,1,0.1	N/A

Map Nr	Map Type	GIS format	Probabilities mapped per scenario		
9	Specific Risk, Economic Risk	Raster Grid	.01	.01	N/A
10	General Risk, Social	Point	10,1,0.1	10,1,0.1	N/A
11	General Risk, Environment	Point	10,1,0.1	10,1,0.1	N/A
12	General Risk, Cultural Heritage	Point	10,1,0.1	10,1,0.1	N/A
13	General Risk, Economy	Point	10,1,0.1	10,1,0.1	N/A

# Appendices

A.	Schedule of Reports	33
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# A. Schedule of Reports

**Table 8: Schedule of Reports**

Report Name	Report Nr
Inception Report	296235-IWE-CCW-R03
Flood Risk Review	296235-IWE-CCW-R01
Hydrology Report	296235-IWE-CCW-R14
Hydraulics Report	296235-IWE-CCW-R17
Draft Flood Mapping Consultation Report	296235-IWE-CCW-CR1801
Preliminary Flood Risk Management Options Report	296235-IWE-CCW-R022
Planning and Development Report	296235-IWE-CCW-R37
Preliminary Options Consultation Report	296235-IWE-CCW-CR1802
Preliminary Safety and Health Plan	296235-IWE-CCW-H2002
Strategic Sustainable Urban Drainage Report	296235-IWE-CCW-R42
Strategic Environmental Assessment Scoping Report	296235-IWE-CCW-ES01
Strategic Environmental Assessment Option Appraisal Report	296235-IWE-CCW-ES02
Strategic Environmental Assessment Environmental Report	296235-IWE-CCW-ES02
Strategic Environmental Assessment Non-Technical Summary	296235-IWE-CCW-ES07
Strategic Environmental Assessment Statement	296235-IWE-CCW-ES012
Appropriate Assessment Screening	296235-IWE-CCW-EA01
Natura Impact Statement	296235-IWE-CCW-EN02
Flood Risk Management Plan	296235-IWE-CCW-R32
Draft FRMP Consultation Report	296235-IWE-CCW-CR1803
Defence Asset Database Handover Report	296235-IWE-CCW-R52

