SWRBD CFRAM Study

Inception Report - Unit of Management 18

September 2013

Office of Public Works

The Office of Public Works
Oifig na nOibreacha Poiblí

SOUTH WESTERN CFRAM STUDY
CATCHMENT FLOOD RISK ASSESSMENT AND MANAGEMENT

Mott MacDonald

SWRBD CFRAM Study

Inception Report - Unit of Management 18

September 2013

Office of Public Works

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1. Introduction

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. In order to assess and develop a Flood Risk Management Plan (FRMP) 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, the OPW have commissioned a number of Catchment Flood Risk Assessment and Management (CFRAM) Studies.

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

1.1 Aims and Objectives

The objectives of this Project are to:

- Identify and map the existing and potential future flood hazard within the Study Area.

- Assess and map the existing and potential future flood risk within the Study Area.

- Identify viable structural and non-structural options and measures for the effective and sustainable management of flood risk in the Areas for Further Assessment Risk (AFA's) and within the Study Area as a whole.

- Prepare a FRMP for each Unit of Management within the Study Area, and associated Strategic Environmental and, as necessary, Habitats Directive (Appropriate) Assessment, that sets out the policies, strategies, measures and actions that should be pursued by the relevant bodies, including the OPW, Local Authorities and other Stakeholders, to achieve the most cost-effective and sustainable management of existing and potential future flood risk within the Study Area, taking account of environmental plans, objectives and legislative requirements and other statutory plans and requirements.

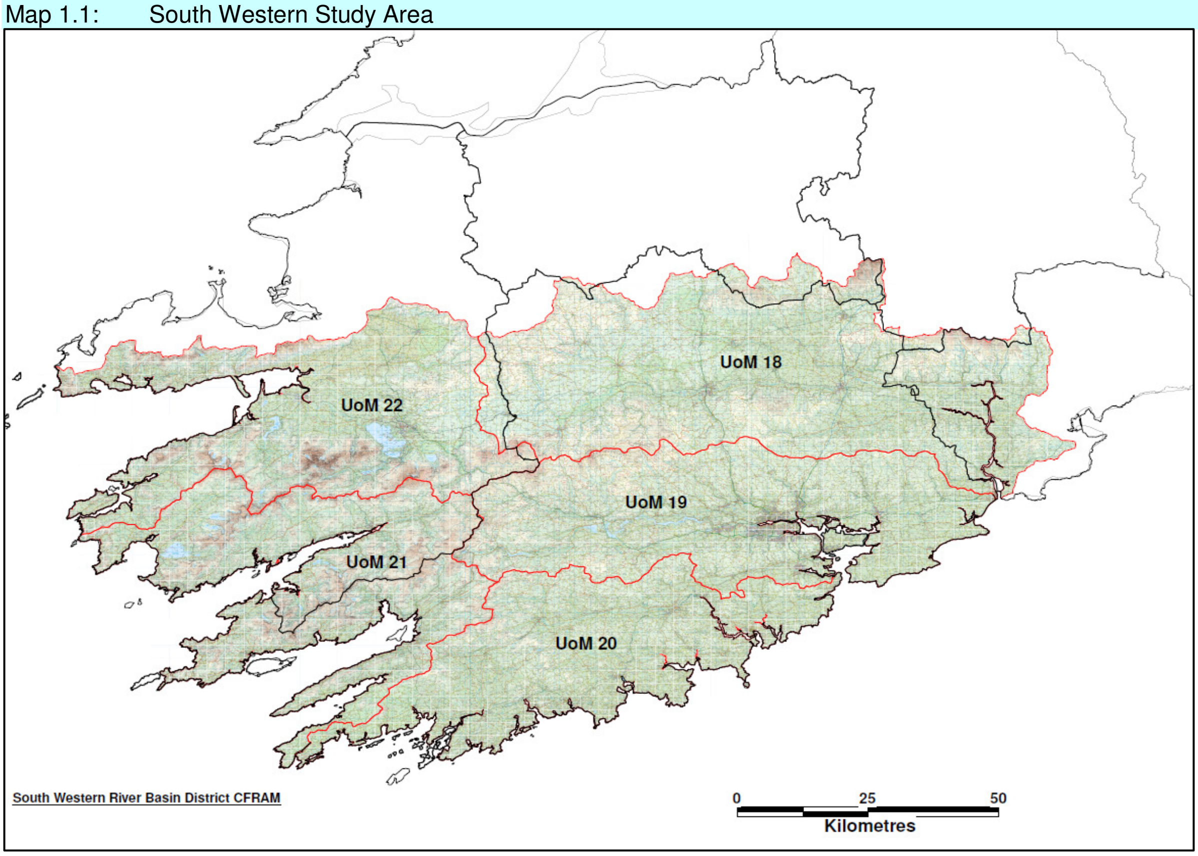
1.2 Description of the South Western Study Area

The South Western River Basin District (SWRBD), which forms the Study Area, covers an area of approximately 11,160 km^2. The Study Area includes most of county Cork, large parts of counties Kerry and Waterford along with small parts of the counties of Tipperary and Limerick. The Study Area contains over 1,800 km of coastline along the Atlantic Ocean and the Celtic Sea. In total, 6 Local Authorities administer the regions within the Study Area: Cork County Council, Cork City Council, Kerry County Council, Waterford County Council, South Tipperary County Council and Limerick County Council. Much of the Study Area is rural and the predominant land usage is agriculture. The Study Area contains Cork City (pop. 119,418) and a number of other large towns such as Killarney (pop. 13,497), Mallow (pop. 7,864) and Bandon (pop. 6,640).

The Study Area includes the rivers, Munster Blackwater, Lee, Bandon, Maine, Laune, their associated tributaries, and a large number of smaller coastal catchments. There are five Units of Management within the Study Area, which are listed below:

- Unit of Management 18
- Unit of Management 19
- Unit of Management 20
- Unit of Management 21
- Unit of Management 22

Map 1.1: South Western Study Area



The Study includes 26 Nr. Areas for Further Assessment (AFA's) which are listed in Table 1.1 below.

Table 1.1: Areas for Further Assessment (AFAs)

UoM	Name	Unique ID	Fluvial	Coastal	County	Easting	Northing
18	Aglish	180247	Yes	No	Waterford	212250	91500
18	Ballyduff	180248	Yes	No	Waterford	196500	99500
18	Fermoy	180252	Yes	No	Cork	182750	99500
18	Freemount	180253	Yes	No	Cork	139500	114250
18	Kanturk	180254	Yes	No	Cork	138250	102750
18	Mallow	180262	Yes	No	Cork	155250	98500
18	Rathcormac	180265	Yes	No	Cork	181750	91000
18	Tallow	180266	Yes	No	Waterford	199750	93750
18	Youghal	180267	Yes	Yes	Cork	210250	78750
19	Killeagh	190274	Yes	No	Cork	200750	75750
19	Castlemartyr	190277	Yes	No	Cork	196250	73250
19	Ballingeary	195499	Yes	No	Cork	115090	67135
20	Clonakilty	200294	Yes	Yes	Cork	138000	41250
20	Dunmanway	200297	Yes	No	Cork	122250	52750
20	Inishannon	200298	Yes	No	Cork	155000	57000
20	Schull	200303	Yes	No	Cork	92500	31500
21	Bantry	210307	Yes	Yes	Cork	99750	48500
21	Castletown Bearhaven	210308	No	Yes	Cork	68000	46000
21	Durrus	210309	Yes	No	Cork	95000	42000
21	Kenmare	210312	Yes	Yes	Kerry	90750	70500
22	Castleisland	220323	Yes	No	Kerry	97750	110000
22	Dingle	220327	Yes	Yes	Kerry	44500	101000
22	Glenflesk	225502	Yes	No	Kerry	106621	85316
22	Killarney	220337	Yes	No	Kerry	97000	90500
22	Milltown	220339	Yes	No	Kerry	82500	101000
22	Portmagee	220340	No	Yes	Kerry	36500	73000

This report outlines how Mott MacDonald proposes to carry out the South Western RBD CFRAM study in respect of the AFAs and the MPWs in **Unit of Management 18**, the Munster Blackwater Catchment.

1.3 Unit of Management 18

Unit of Management 18, which forms part of the SWRBD covers an area of approximately 3,295 km^2. The large majority of the area is in North County Cork with parts in County Waterford. UoM 18 also includes small parts of Limerick, Kerry and Tipperary and has only a few kilometres of coastline at Youghal Bay. The main rivers within UoM 18 are the Blackwater and its tributaries the Allow and the Bride.

1.4 Areas for Further Assessment

Unit of Management 18 contains nine Areas for Further Assessment (AFAs). These are listed in Table 1.2 below. Associated with the AFA's is over 240km of high and medium priority watercourse. Further details are provided in Section 4.0.

Table 1.2: Areas for Further Assessment within Unit of Management 18

UoM	Name	Unique ID	Fluvial	Coastal	County	Easting	Northing
18	Aglish	180247	Yes	No	Waterford	212250	91500
18	Ballyduff	180248	Yes	No	Waterford	196500	99500
18	Fermoy	180252	Yes	No	Cork	182750	99500
18	Freemount	180253	Yes	No	Cork	139500	114250
18	Kanturk	180254	Yes	No	Cork	138250	102750
18	Mallow	180262	Yes	No	Cork	155250	98500
18	Rathcormac	180265	Yes	No	Cork	181750	91000
18	Tallow	180266	Yes	No	Waterford	199750	93750
18	Youghal	180267	Yes	Yes	Cork	210250	78750

1.5 SW CFRAMs Project Delivery

The CFRAM programme is split up into four key steps that have to be completed by certain deadlines. These deadlines are set out in the European Communities (Assessment and Management of Flood Risks) Regulations of 2010 (SI 122/2010). These are:

- The Preliminary Flood Risk Assessment (PFRA) – Completed December 2011
- Flood Risk Review – Completed December 2011
- Flood Risk Mapping – To be completed December 2013
  - This involves the mapping of areas that are at significant risk from flooding. The maps will show the extent of flooding likely, how deep the water could get and how fast the water will flow.
- Flood Risk Management Plans – To be completed December 2015
  - This involves the development of flood risk management options to mitigate the risk of damage resulting from flooding in areas at significant risk. The options considered could include the construction of flood walls or embankments, the installation of a flood warning system of the use of catchment management techniques to reduce the risk from flooding.

Map 1.2: Unit of Management 18

2. Data Availability and Requirements

2.1 Data Collection

This section details the data collected and highlights any data that is currently outstanding or unavailable.

2.2 Hydrometric Data

Hydrometric data for river flow and level gauges in UoM 18 was provided by OPW and the EPA. Table 2.1 summarises the available hydrometric gauges from both OPW and EPA.

Table 2.1: Available Hydrometric Gauges

Type	OPW gauges	EPA gauges (operated by Cork County Council)	Total Gauges Available
River Flow and Water Level Gauges	6	6	12
River Level Gauges	20	1	21
River Flow and Level Observation Locations	0	39	39

River flow data is available from 1955 to 2012 in UoM 18. There are 11 river flow and water level gauges with records over 10 years long. Killavullen (18003) gauge on the Munster Blackwater has the longest flow record dating from 1955 to present. Since 2000 to 2003 all river flow gauges have recorded flows at 15 minute intervals via telemetry. For gauges installed prior to 2000, flows were recorded at irregular intervals up to 2000 although peak flows were captured. The river flow data will be used to inform the derivation of design flows. Therefore, the data quality and coverage of the key flow gauges has been reviewed in Chapter 4 of this report.

EPA has also provided spot river flow and level measurements which are observed manually on a regular basis (2 to 8 measurements per year). These spot gaugings are often observed during periods of low flow to monitor water resource and environmental demands as well as minimise health and safety risks. It is not appropriate to use these observations in the analysis of high flows for the UoM 18. Therefore, these spot gaugings have not been taken forward to the preliminary hydrological assessment described in Chapter 4.

2.3 Meteorological Data

Meteorological data for rainfall gauges in and around UoM 18 was provided by Met Éireann and OPW. Table 2.2 summarises the available meteorological gauges from both Met Éireann and OPW.

Table 2.2: Available Rainfall Gauges

Type	Met Éireann gauges	OPW gauges	Total Gauges Available
Daily Rainfall Gauges	53	0	53
Hourly Rainfall Gauges	0	32	33 (1 synoptic station)
Synoptic Stations (weather forecasting locations including rainfall)	1	0	1

The OPW rain gauges are used to form inflows into the existing Mallow and Fermoy flood forecasting models. 47 of 53 the daily rain gauges have data over 10 years with the longest data record at Mallow (Hazelwood) with 86 years of rainfall records. The Met Éireann rain gauge at Moore Park Fermoy provides

15 min data for the Blackwater catchment with over 50 years of data. Chapter 4 of this report provided further analysis of the rainfall data coverage, quality and suitability for derivation of design rainfall.

2.4 Coastal Data

Tidal and sea level data was provided by OPW for Youghal in UoM 18 along with the calculated points from the national studies on extreme coastal conditions. The only tidal gauge available for the SWRBD CFRAM Study is located at Ballycotton (Station Number 19068). The Ballycotton sea level gauge records total sea level at 15 minute intervals and has been operational since 2007. There was no other observed tidal data available for the SWRBD CFRAM Study. The quality of this gauge is discussed in Chapter 4 of this report.

The Irish Coastal Protection Strategy Study (ICPSS) data has been approved by OPW for use directly as the coastal boundaries for the South Western CFRAM models. The extreme sea levels will be used to define the magnitude of the tidal events at Youghal.

The Irish Coastal Water Level and Wave Study (ICWWS) will also provide extreme water level and wave conditions at Youghal Harbour. This data will be available from late 2012 to early 2013. This will inform the assessment of wave overtopping discharges as discussed in Section 5.2.

2.5 Survey Data (including LIDAR & IFSAR)

Chapter 3 outlines the required survey data which is being procured under Survey Contract 5 which is currently underway. However, final delivery dates are not yet clear due to issues with Fresh Water Pearl Mussels. LIDAR and IFSAR data has been provided.

In addition to the aforementioned survey data, topographic information for Fermoy and Mallow has been made available from previous flood alleviation scheme by Cork County Council. Both studies are based on river channel survey captured in 2003. The as-built drawings for the subsequent Mallow Flood Alleviation Scheme have been provided to inform the latest topography in Mallow.

Table 2.3: Survey Data

Type	Location	Comments	Owner	Survey Date
Munster Blackwater (Mallow) HECRAS and ISIS models	Mallow	HECRAS 1D hydraulic model and underlying survey information for 50%, 20%, 10%, 4%, 2% and 1% design flood event results.	OPW	Various 04/01/2003 to 14/05/2012
Fermoy Drainage Scheme SOBEK Model (2003)	Fermoy	SOBEK 1D hydraulic model and underlying survey information for 50%, 20%, 10%, 4%, 2% and 1% design flood event results.	OPW	01/03/2003

2.6 Environmental Data

An extensive range of environmental and land use information has been gathered for use in the study. We shall draw upon this information for the purpose of meeting our project deliverables. The data will be used to inform environmental site surveys, to cross compare Water Framework Directive and Flood Studies Update catchment boundaries, to inform the Strategic Environmental Assessment and Appropriate Assessment and as necessary to portray relevant information at public consultation. A list of the environmental data collected is contained in Table 2.4 below.

Table 2.4: Environmental Data

Description	Format	Owner	Date	Fitness for purpose / Quality
Abstractions	GIS		17/12/2009	Fit For Purpose
Alien Species	GIS	NPWS	12/05/2005	Needs to be updated
Aquaculture Sites (Licensed)	GIS	-	22/12/2009	Fit For Purpose
Artificial Water Bodies	GIS	SWRBD	23/10/2008	Fit For Purpose
Bat Roosts in South West	GIS	NPWS	03/01/2012	Fit For Purpose
Coastal Water Body Status (as per RBMP)	GIS	EPA	17/02/2010	Fit For Purpose
Combined Sewer Overflows	GIS	EPA	01/03/2005	Needs to be updated
Corine 2006	GIS	EPA	03/09/2009	Fit For Purpose
Ecological Information - confidential information	GIS	NPWS	05/04/2012	Needs to be updated
EPA Biological Stations (Q Stations)	GIS	EPA	16/11/2005	Needs to be updated
EPA Waste facilities (including landfills)	GIS	EPA	20/04/2012	Fit For Purpose
Fresh Water Pearl Mussel	GIS	NPWS	12/05/2005	Needs to be updated
FWPM SAC	GIS	NPWS	19/08/2009	Needs to be updated
Groundwater Bodies	GIS	EPA	02/02/2008	Fit For Purpose
Groundwater Body Status (as per RBMP)	GIS	EPA	17/02/2010	Fit For Purpose
Groundwater Monitoring Stations	GIS	EPA	22/03/2007	Fit For Purpose
Groundwater Status	list	RPS	17/02/2010	Fit For Purpose
Heavily Modified Water Bodies	GIS	SWRBD	12/12/2008	Fit For Purpose
IPPC Licenses	GIS	EPA	20/04/2012	Fit For Purpose
Lake Status	list	RPS	17/02/2010	Fit For Purpose
Lake Topography & Bathymetry	GIS	SWRBD	26/06/2008	Fit For Purpose
Lake Water Bodies	GIS	EPA	04/05/2005	Fit For Purpose
Lake Water Body Status (as per RBMP)	GIS	EPA	17/02/2010	Fit For Purpose
Landscape	pdf	-	02/12/2011	
License Aquaculture	GIS	-	12/12/2009	Fit For Purpose
Main Lakes	GIS	EPA	01/03/2003	Fit For Purpose
Mines	GIS	GSI	01/03/2005	Fit For Purpose
Monuments - Summary of Types in National Monuments Data Series	Excel	OPW	02/12/2011	Fit For Purpose
NHA	GIS	NPWS	04/05/2005	Needs to be updated
Non-EPA Landfills	GIS	LA	01/03/2005	Needs to be updated
Quarries	GIS	LA's to start reporting in June 2010	01/03/2005	Needs to be updated
Recreational Waters	GIS	NPWS	19/07/2006	Needs to be updated
River Segments and Status	list	RPS	17/02/2010	Fit For Purpose
River Water Body Basin Polygons	GIS	EPA	04/05/2005	Fit For Purpose
River Water Body Status (as per RBMP)	GIS	EPA	17/02/2010	Fit For Purpose
River Waterbody Status	list	RPS	17/02/2010	Fit For Purpose
SAC	GIS	NPWS	16/03/2010	Fit For Purpose
SAC Vulnerability Assessment - habitats &	Excel	OPW	02/12/2011	Fit For Purpose

Description	Format	Owner	Date	Fitness for purpose / Quality
species assessment and overall site classification				
Salmonid Waters	GIS	NPWS	12/05/2002	Needs to be updated
SEA Background Information	Excel	OPW	02/12/2011	Fit For Purpose
SEA Background Information - AA EPA feedback	pdf	EPA	02/12/2011	Fit For Purpose
SEA Background Information - emails and feedback	pdf	EPA	02/12/2011	Fit For Purpose
SEA Background Information - emails and non-technical summary with review comments	pdf, Word	OPW	02/12/2011	Fit For Purpose
SEA Background Information - EPA preliminary comments (17.05.10)	Word	EPA	02/12/2011	Fit For Purpose
SEA Background Information - FEMFRAM Scoping Report comments from EPA	pdf	EPA	02/12/2011	Fit For Purpose
SEA Background Information - NPWS comments on FEMFRAM AA	pdf	NPWS	02/12/2011	Fit For Purpose
SEA Background Information - Suir Scoping Report comments from EPA	pdf	EPA	02/12/2011	Fit For Purpose
Section 4 Licenses	GIS	LA	20/04/2012	Fit For Purpose
Shellfish Designated Areas	GIS	DEHLG	27/04/2009	Fit For Purpose
Soils	GIS	Teagasc	30/04/2006	Fit For Purpose
SPA	GIS	NPWS	-	Needs to be updated
SPA Vulnerability Assessment - classification	Excel	OPW	02/12/2011	Fit For Purpose
Subsoils	GIS	Teagasc	30/04/2006	Fit For Purpose
Surface Water Monitoring Stations	GIS	EPA	22/03/2007	Fit For Purpose
SWRBD Onsite Waste Water treatment systems	GIS	-	22/12/2009	Fit For Purpose
SWRBD Private Forestry	GIS	RPS	15/01/2010	Fit For Purpose
SWRBD Public Forestry	GIS	RPS	15/01/2010	Fit For Purpose
Trac Status	list	RPS	17/02/2010	Fit For Purpose
Transitional Water Bodies	GIS	EPA	04/05/2005	Fit For Purpose
Transitional Water Body Status (as per RBMP)	GIS	EPA	17/02/2010	Fit For Purpose
Waste Water Treatment Plants	GIS	EPA	04/11/2009	Needs to be updated
Water Treatment Plants	GIS	LA	-	

2.7 Receptor Data

Extensive receptor data was gathered which when combined with the flood hazard will allow for determination of flood risk. A list of the receptor data is contained in Table 2.5 below.

Table 2.5: Receptor Data

Category	Description	Format	Owner	Date	Fitness for purpose / Quality
Cultural Heritage	Monuments - National Datasets	Mapinfo	DEHLG	02/12/2011	Fit For Purpose
Cultural Heritage	Museum Directory	MapInfo, Excel	IMA	02/12/2011	Fit For Purpose
Cultural Heritage	National Monuments - National Data Series	Excel	OPW	02/12/2011	Fit For Purpose

Category	Description	Format	Owner	Date	Fitness for purpose / Quality
Cultural Heritage	NIAH Buildings - National Dataset	Mapinfo	NIAH	02/12/2011	Fit For Purpose
Economic	Airports	Mapinfo	Irish Aviation Authority	02/12/2011	Fit For Purpose
Economic	EPA Waste Facilities (including landfills)	GIS	EPA	20/04/2012	Fit For Purpose
Economic	Harbours & Slips	GIS	SWRBD	09/05/2005	Fit For Purpose
Economic	IPPC Licenses	GIS	EPA	20/04/2012	Fit For Purpose
Economic	Mines	GIS	GSI	01/03/2005	Fit For Purpose
Economic	Non-EPA Landfills	GIS	LA	01/03/2005	
Economic	NRA Road Network (2010)	ESRI	NRA	02/12/2011	Fit For Purpose
Economic	Ports and Harbours in Ireland	MapInfo, Excel, pdf	Department of Agriculture, Fisheries, Food and Transport	02/12/2011	Fit For Purpose
Economic	Quarries	GIS	LA's to start reporting in June 2010	01/03/2005	Needs to be updated
Economic	Rail Network and Stations	AutoCAD	Iarnrod Éireann	02/12/2011	Fit For Purpose
Economic	Section 4 Licenses	GIS	LA	20/04/2012	Fit For Purpose
Economic	Utilities Data	MapInfo	ESB, Bord Gais, Eircom	02/12/2011	Fit For Purpose
Economic	WWTPs & WTPs Locations	MapInfo	EPA	02/12/2011	
Environmental	Abstractions	GIS	-	17/12/2009	Fit For Purpose
Environmental	Aquaculture Sites (Licensed)	GIS	-	22/12/2009	Fit For Purpose
Environmental	Bat Roosts in South West	GIS	NPWS	03/01/2012	Fit For Purpose
Environmental	Fresh Water Pearl Mussel	GIS	NPWS	12/05/2005	
Environmental	FWPM SAC	GIS	NPWS	19/08/2009	
Environmental	Groundwater Bodies	ESRI & Excel	EPA	02/12/2011	Fit For Purpose
Environmental	Licensed IPPC Facilities	ArcView	EPA / LA	02/12/2011	Fit For Purpose
Environmental	Natural Heritage Areas	Mapinfo	NPWS	02/12/2011	
Environmental	Outstanding Landscapes in Ireland	pdf		02/12/2011	Fit For Purpose
Environmental	Proposed Natural Heritage Areas	Mapinfo	NPWS	02/12/2011	Needs to be updated
Environmental	Recreational Waters	GIS	NPWS	19/07/2006	Needs to be updated
Environmental	SAC	GIS	NPWS	16/03/2010	Needs to be updated
Environmental	SAC Habitats & Species Assessment and Overall Site Classification	Excel	OPW	02/12/2011	Needs to be updated
Environmental	Salmonid Waters	GIS	NPWS	12/05/2002	Needs to be updated

Category	Description	Format	Owner	Date	Fitness for purpose / Quality
Environmental	Shellfish Designated Areas	GIS	DEHLG	27/04/2009	Fit For Purpose
Environmental	SPA	GIS	NPWS	-	Needs to be updated
Environmental	SPA - Classification	Excel	OPW	02/12/2011	Needs to be updated
Environmental	Special Areas of Conservation	Mapinfo	NPWS	02/12/2011	Needs to be updated
Environmental	Special Protection Areas	Mapinfo	NPWS	02/12/2011	Needs to be updated
Social	Civil Defence HQ's	Mapinfo, Word	Department of Defence	02/12/2011	Fit For Purpose
Social	CSO 2006 Census	Excel	An Post GeoDirectory	02/12/2011	Fit For Purpose will need to be updated
Social	Fire Stations	Mapinfo, Excel	DEHLG	02/12/2011	Fit For Purpose
Social	Garda Stations	Mapinfo, Excel	OPW	02/12/2011	Fit For Purpose
Social	Geo-directory (July 2011)	MS Access Database	An Post GeoDirectory	02/12/2011	Fit For Purpose
Social	Government Building under OPW	Mapinfo, Excel	OPW	02/12/2011	Fit For Purpose
Social	Health Centres	Mapinfo, Excel	HSE	02/12/2011	Fit For Purpose
Social	Hospitals	Mapinfo, Excel	HSE	02/12/2011	Fit For Purpose
Social	Nursing Homes	Mapinfo, Excel	HSE	02/12/2011	Fit For Purpose
Social	Post Primary Schools	MapInfo	Department of Education	02/12/2011	Fit For Purpose
Social	Primary Schools	MapInfo	Department of Education	02/12/2011	Fit For Purpose
Social	Public Residential Care for The Elderly	Mapinfo, Excel	HSE	02/12/2011	Fit For Purpose
Social	Third Level Institutions	Mapinfo	Higher Education Authority	02/12/2011	Fit For Purpose

2.8 Flood Event Data

A significant amount of flood event data has been identified and collected from a number of sources. These sources include the OPW Floodmaps website, Local Authorities and other stakeholders. All flood event data including maps, photographs and reports has been downloaded from floodmaps.ie and all available reports and studies from Local Authorities and stakeholders gathered. In addition to the above, flood event data and information was also gathered during the Flood Risk Review stage and following specific Flood Event Reviews. This information / data includes anecdotal evidence and testimonials from landowners, locals etc. A summary list of flood event data sources used is contained in Table 2.6 below.

Table 2.6: Flood Event Data

Description	Format	Owner	Date	Fitness for purpose / Quality
Flood Data Collection	Excel	OPW	02/12/2011	Professional judgement should be applied to the use of data
Historical Flood Data	MapInfo, Excel	OPW	02/12/2011	Professional judgement should be applied to the use of data
PFRA Groundwater Flooding Reports	pdf	OPW	02/12/2011	Professional judgement should be applied to the use of data
Cork – New PFRA data	pdf	OPW	08/02/2012	Fit for purpose
Waterford – New PFRA data	pdf	OPW	08/02/2012	Fit for purpose
Flood Risk Review Reports	MS Word	OPW	01/02/2012	Fit for purpose
Flood Event Review Reports	Excel / pdf	OPW	Ongoing-	Professional judgement should be applied to the use of data

2.9 Flood Defence Asset Data

Data relevant to flood defence assets, which includes data used to identify and locate flood defence assets within AFAs, MPWs and HPWs, has been gathered. A list of the relevant flood defence asset data is contained in Table 2.7 below. This data does not represent the survey requirements for flood defence assets and as stated, contains data used only in identifying and locating defence assets.

Table 2.7: Relevant Flood Defence Asset Data

Description	Format	Owner	Date	Fitness for purpose / Quality
Dredged Area	GIS	SWRBD	09/05/2005	Fit for purpose
HDTM (20m resolution hydrologic correction to DTM)	GIS files	EPA	02/12/2011	Fit for purpose
Lakes	MapInfo	EPA	02/12/2011	Fit for purpose
Marine Embankments	GIS	SWRBD	01/04/2008	Fit for purpose
Marine Shoreline Reinforcement	GIS	SWRBD	15/04/2008	Fit for purpose
NDHM (5m resolution IFSAR)	MapInfo	OPW	02/12/2011	Fit for purpose
Omitted Watercourses	MapInfo	JBA	02/12/2011	Fit for purpose
OPW Benefiting Lands	MapInfo	OPW	02/12/2011	Fit for purpose
OPW Channels	MapInfo	OPW	02/12/2011	Fit for purpose
OPW Embankments	MapInfo	OPW	02/12/2011	Fit for purpose
OSi Maps	Mapinfo	OPW	02/12/2011	Fit for purpose
PFRA Breakdown	MapInfo	OPW	02/12/2011	Fit for purpose
PFRA Combined Point Receptors	MapInfo	Various	02/12/2011	Fit for purpose
PFRA Final Database	Access, MapInfo	OPW	02/12/2011	Fit for purpose
PFRA Pluvial Screening	pdf	OPW	02/12/2011	Fit for purpose
River Centrelines	ESRI	OPW (FSU)	02/12/2011	Generally OK. Some discrepancies.
Tidal Barrages	GIS	SWRBD	09/05/2005	Fit for purpose

2.10 Outstanding Data

Table 2.8 lists the outstanding data that is required for the detailed hydrological and hydraulic assessments.

Table 2.8: Outstanding Data for UoM 18

Type	Location	Comments	Source	Required by	Impact of non provision of data
OPW Flood Warning Rain Gauge Records	Mallow and Fermoy	Hourly rainfall gauges covering Mallow and Fermoy for flood warning purposes. Data period available unknown.	OPW	23/11/2012	Less accurate techniques will have to be used to predict flows.
ICWWS Water Level and Wave Overtopping Data	Youghal	Stage 2 of ICWWS due February 2013 : Water level, Hm0, Tm and mean wave direction for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP events	Irish Coastal Water Level and Wave Study, OPW	08/02/2013	Less accurate techniques will have to be used to predict sea levels. There would be cost implications for this.
Video of Munster Flooding	Blackwater Catchment	Aerial views of the Blackwater and Suir, including Mallow, Fermoy, Youghal – 6th Nov 2000	www.floodmaps.ie	04/01/2013	Less accurate information will be used to calibrate models.
Flooding at Sleveen, Ballyduff	Ballyduff	Set of photos with mapping. From approach north of Sleveen – 05/01/1998	www.floodmaps.ie	04/01/2013	Less accurate information will be used to calibrate model
Youghal Map 2	Garyvoe	Map of locations subject to flooding during recent event in Oct 2004	www.floodmaps.ie	04/01/2013	No serious impact
Lismore Area Engineer Meeting – Map	Lismore	Map accompanying minutes identifying locations subject to flooding.	www.floodmaps.ie	04/01/2013	Less accurate information will be used to calibrate model

2.11 Unavailable Data

It has been determined that some hydrometric data will not be available for the SWRBD CFRAM Study. Table 2.99 lists the data that is not available and suggests how these data gaps will be overcome in the hydrological assessment.

Table 2.9: Unavailable Hydrometric and Coastal Data for UoM 18

Data Type	Impact	Proposed Mitigation
Observed tidal curves at Youghal	Limits accuracy of transformation of astronomic tidal curve to Youghal overtopping volume, duration of flooding and progression of tidal events up the Munster Blackwater	Derive astronomic tidal curves from Admiralty Tide Predictions
Observed surge profiles/residuals at Youghal		Derive simple surge profile based on duration of typical event at Ballycotton gauge
Local Rainfall Data, Flow and Water level for floods prior to 1981 on the River Allow	Limits calibration of hydraulic model	Calibrate to a more recent event with data of similar magnitude based on flood report and local knowledge of the event
Flood levels, extents, and observed flows at Aglish, Youghal, Rathcormac and Freemount	Limits calibration in these key AFAs	Use available photographs to visually calibrate and verify model where possible. Undertake sensitivity testing to assess uncertainty bounds of model results for these AFAs

3. Survey Requirements

3.1 River Channel Survey

The Survey Requirements for Unit of Management 18 are detailed in Table 4.1 below. These include the survey of a total of 1,760 river cross sections, approximately 32.6 linear kilometres of flood defence assets and approximately 240km of water courses.

The required survey information will be gathered as part of Survey Contract Nr. 5 which is currently underway. However, final delivery dates are not yet clear due to issues with Fresh Water Pearl Mussels.

Table 3.1: Survey Requirements within Unit of Management 18

Description	Units	UoM 18
Total Nr. Cross Sections	**Nr.**	**1760**
upstream node at a junction	Nr.	2
downstream node at a junction	Nr.	0
conduit section	Nr.	0
upstream node at a bridge	Nr.	132
downstream node at a bridge	Nr.	130
extended cross section	Nr.	40
upstream node at a floodplain section	Nr.	0
downstream node at a floodplain section	Nr.	0
open channel	Nr.	1382
upstream node at a culvert inlet\outlet unit	Nr.	30
downstream node at a culvert inlet\outlet unit	Nr.	23
lateral spill on the left bank	Nr.	0
upstream node at an orifice	Nr.	0
downstream node at an orifice	Nr.	0
lateral spill on the right bank	Nr.	0
upstream node at a spill	Nr.	0
downstream node at a spill	Nr.	0
upstream node at a weir	Nr.	14
downstream node at a weir	Nr.	7
Total Linear Flood Defences	**km**	**32.6**
Identified	km	32.6
Possible	km	0.0
Total Length of Watercourse	**km**	**239.2**
HPW	km	80.1
MPW	km	159.1

3.2 Floodplain Survey

The floodplain survey includes level and location data for the floodplains of the relevant reaches of the channels in the study area. This survey is necessary for the construction of a hydraulic model adequate to meet the objectives of the study. The floodplain survey will be in the form of DTM and, or, DEM data derived from a survey using LIDAR or similar systems.

This data is to be provided by OPW. Following receipt of the data the survey will be reviewed and assessed to determine if the data is fit for purpose and compatible with the modelled schema.

3.3 Flood Defence Asset Condition Survey

The flood defence asset condition survey is a condition survey of all flood defences identified within AFA's and all defined flood defences along MPW's or in coastal areas. The survey includes the identification, inspection, photographing and assessment of flood defence assets and the entry of all relevant data into the Defence Asset Database. Details of the location and type of flood defence assets to be surveyed as part of the CFRAM Study are contained in a GIS database file entitled SWCFRAM_Flood_Defence_Assets. This file will be made available to the Study team along with this report.

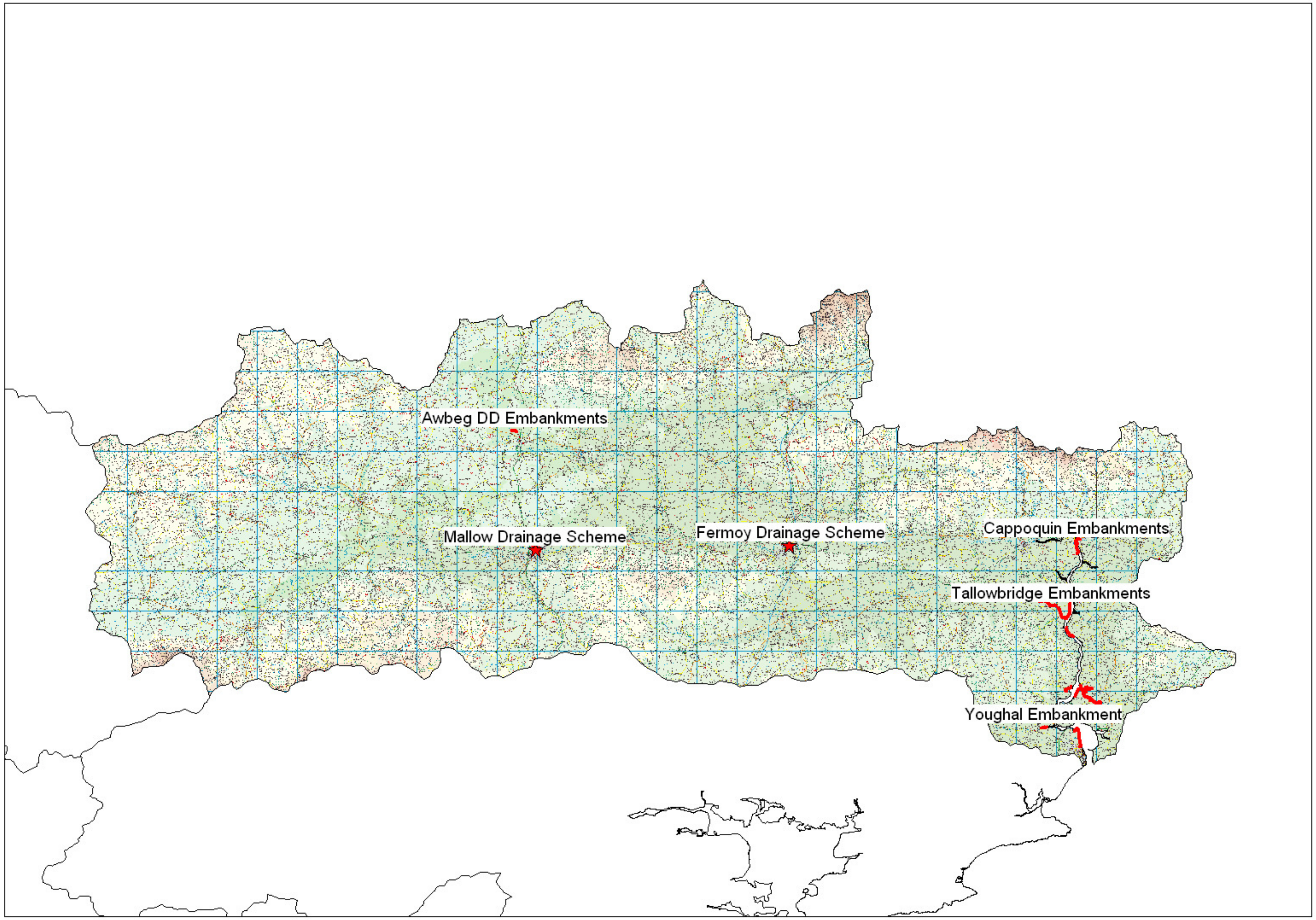
The flood defence asset condition survey has not yet been carried out. The survey will be undertaken following the completion of the river channel survey, which will identify undefined assets, and receipt of the flood plain survey (DTM / DEM data).

The flood defence assets to be surveyed as part of the Study are listed in Table 3.2 below. The locations of these defences are shown in Figure 3.1.

Table 3.2

Name	Type	Description
Awbeg DD Embankment	Embankment	Drainage District
Mallow Drainage Scheme	Wall	Flood defence wall
Mallow Drainage Scheme	Embankment	Road raised as flood defence in this area
Mallow Drainage Scheme	Wall	Flood defence wall inc demountable
Mallow Drainage Scheme	Wall	Flood defence wall inc demountable
Mallow Drainage Scheme	Wall	Local discrete demountable defence at Lidl Door
Mallow Drainage Scheme	Wall	Local demountable at Lidl Door
Mallow Drainage Scheme	Wall	Defence wall inc demountables
Mallow Drainage Scheme	Embankment	Embankment
Mallow Drainage Scheme	Embankment	Embankment and raised road
Mallow Drainage Scheme	Channel	Bank Reprofiling in this area
Mallow Drainage Scheme	Wall	Flood defence wall
Fermoy Drainage Scheme	Wall	Flood defence line, wall, embankment & Demountable
Fermoy Drainage Scheme	Wall	Quay Wall
Fermoy Drainage Scheme	Wall	Quay Wall
Youghal Embankments	Embankment	Historic Embankment
Youghal Embankments	Embankment	Bridgewater Land Commission Embankments
Youghal Embankments	Embankment	Wood Point Land Commission Embankments
Tallowbridge Embankments	Embankment	Tallowbridge Land Commission Embankments
Cappoquin Embankments	Embankment	Cappoquin Land Commission Embankments

Figure 3.1: Location of Flood Defence Assets



3.4 Property Level Survey

The property survey includes gathering information on property location, type, use, etc. for all properties potentially at risk from flooding. The primary purpose of the property survey is to inform the damage / benefit analysis required to meet the project objectives. OPW have provided a licensed copy of the An Post GeoDirectory. Property ground floor levels will be determined using the DTM data and a specific height that will be based on observations / measurements for each AFA along with spot checks.

The property level survey has not yet been carried out. The survey will be undertaken following the completion of the river channel survey and receipt of the floodplain survey (DTM / DEM data).

4. Preliminary Hydrological Assessment

This section details the analysis of river flow, rainfall and tidal level data to be as well as a preliminary review of historical flood events.

This section covers the following requirements of the CFRAM brief:

- Review and analyse recorded water levels, including tidal and surge levels, and estimated flows with a description of the quality, fitness-for-purpose and interpretation of such data.
- Review and analyse recorded rainfall data with a description of the quality, fitness-for-purpose and interpretation of such data.
- Review and analyse all available previous studies and reports and the historic flood data collected in terms of peak levels, flood extents, etc. and rank in terms of magnitude.

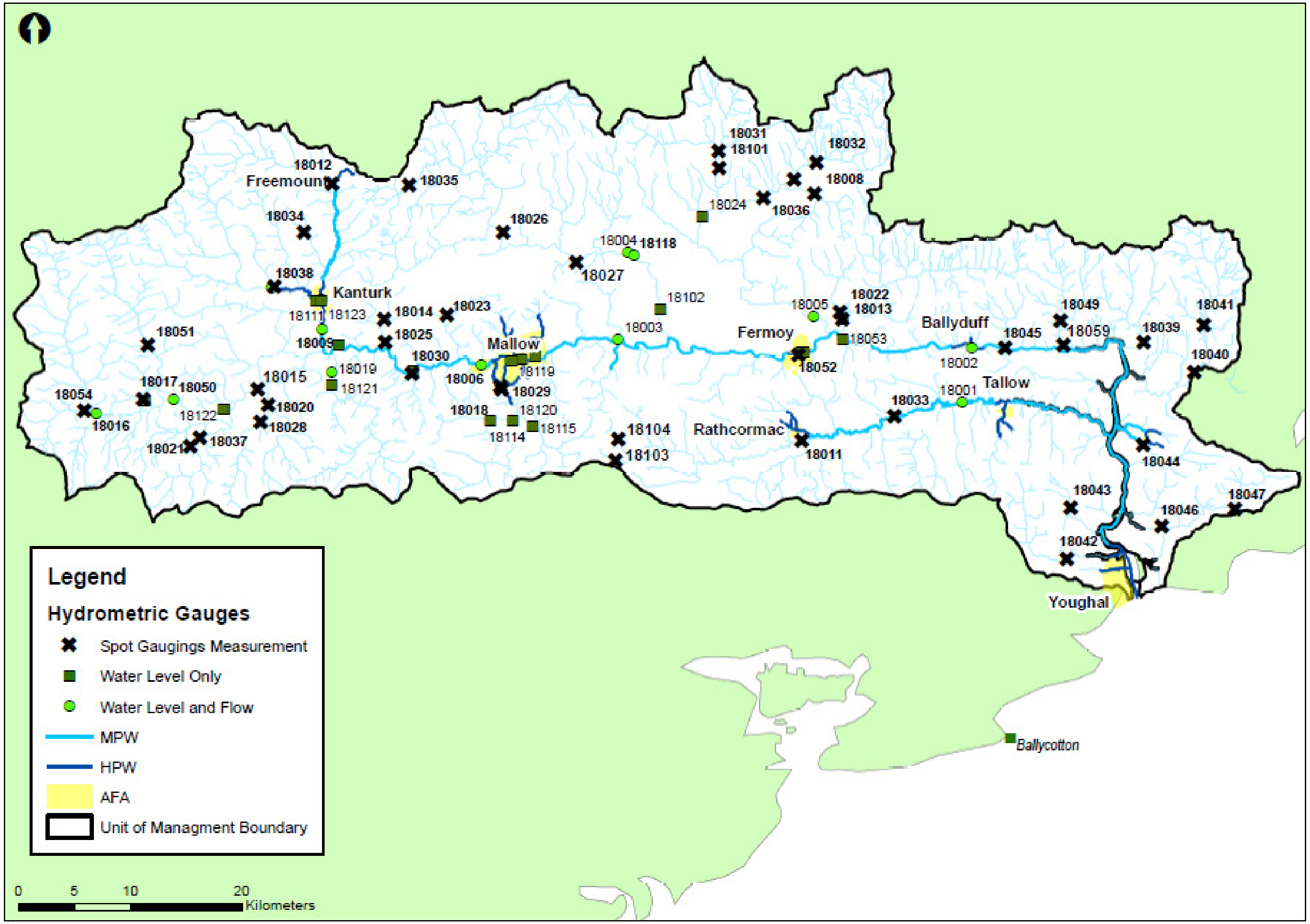
4.1 Hydrometric Data Review

The locations of river gauges in the catchment with available water level and flow data are shown in Map 4.1.

The existing hydrometric data has been assessed for the following common issues:

- Anomalous spike or dips in water level and/or flow from the continuous data records;
- Capping of water level and/or flow, particularly for extreme events at fluvial gauges where extreme flows may be out-of-range;
- Trends in water level or flow over time that might be caused by systematic error of gauging equipment or erosion/sedimentation;
- Sudden shifts in level of the gauging datum;
- Comparison of AMAX flows and levels from digital gauged data with manually extracted AMAX series;
- Length of data record to enable hydrological analysis; and,
- Any significant data gaps.

Map 4.1: Available Hydrometric Data



Source: OPW and EPA

Stations 18050,18048, 18016, 18006,18003 and 18002: Long term flow and level records are available at Duncannon, Duarrigle, Dromcummer, Mallow, Killavullen and Ballyduff on the River/Munster Blackwater. Despite the length of records, there are significant data gaps or periods of unusable data particularly prior to 1972 at Ballyduff and Killavullen and in 2006 at Mallow. The years with missing data have been discarded from the annual maximum series to avoid artificial errors in the statistical analysis. This approach has the benefit of reducing any artificial bias that would otherwise be introduced by using a number of interpolation techniques.

The preliminary hydrometric review of the AMAX flow and level series at CSET Mallow and Killavullen gauges indicates that Mallow consistently experiences higher peak flows than Killavullen despite additional inflows from tributaries such as the River Awbeg (Major) and a 30% increase in contributing area. More detailed analysis by Jacobs Babtie[1] discounted atypical attenuation or floodplain storage as volumes were similar or lower at Killavullen than at Mallow even when considering the intervening storage volume and simple flow routing between the two gauges. Therefore, the routing of the flood hydrograph between Mallow and Killavullen will be based on the latest topographic information and river channel survey to ensure the floodplain attenuation and storage is fully considered. It may also be beneficial to assess the rating curve at the Mallow gauges for out-of-bank flows based on the 1D/2D model results from this CFRAM study.

Stations 18010, 18009, 18005, 18004 and 18001: Long terms records over 10 years are also available on the Munster Blackwater tributaries including: Allen's Bridge on the Dalua; Riverview on the Allow; Downing Bridge on the Funshion; Ballynomona on the Awbeg (Major); and, Mogeely on the Bride respectively. The majority of the flow records have been edited by OPW but are consistent with level records and are suitable for use following the rating review for the Allen's Bridge and Riverview gauges.

Stations 18110, 18019, 18055: Shorter flow records of 10 years or less are available for Kilbrin Road on the Allow, Murphy's Bridge on the Glen and Mallow Rail Bridge on the Blackwater respectively. The preliminary data review has highlighted several missing periods around 2006 and 2007 for Kilbrin Road and Murphy's Bridge, and pre-2005 at Mallow Rail Bridge. Furthermore, flow by-passes Mallow Rail Bridge once out-of-bank and thus extreme flows are considered suspect. Therefore, the flow records at Mallow Rail Bridge will be used with caution and the out-of-bank rating curve for 18055 will be checked against the flow routes predicted by the hydraulic model and historic flood evidence.

The rating curves will be reviewed at four gauges (Ballyduff 18002, Mogeely 18001, Riverview 18010 and Allen's Bridge 18011) as outlined in Section 5.3.2 as in the SWRBD CFRAM Study tender documents. All the other gauges in the catchment are level-only gauges which will be used to inform the calibration of the hydraulic models where data quality is appropriate, based on the data review in Appendix A. However, it is not proposed to develop rating curves for these sites at this time as the locations are either unsuitable due to backwater effects from bridges or provide little added value to improving flow estimates for the hydraulic models.

Appendix A contains a full list of the selected gauges and plots data quality for the preliminary hydrological analysis.

[1] Babtie Group (now known as Jacobs Babtie), 2003. Munster Blackwater River (Fermoy) Drainage Scheme, Hydrology Report. Submitted to the Office of Public Works (OPW), April 2003.

4.2 Metrological Data Review

The locations of rain gauges and synoptic stations with available meteorological data in and near to the catchment are shown in Map 4.2.

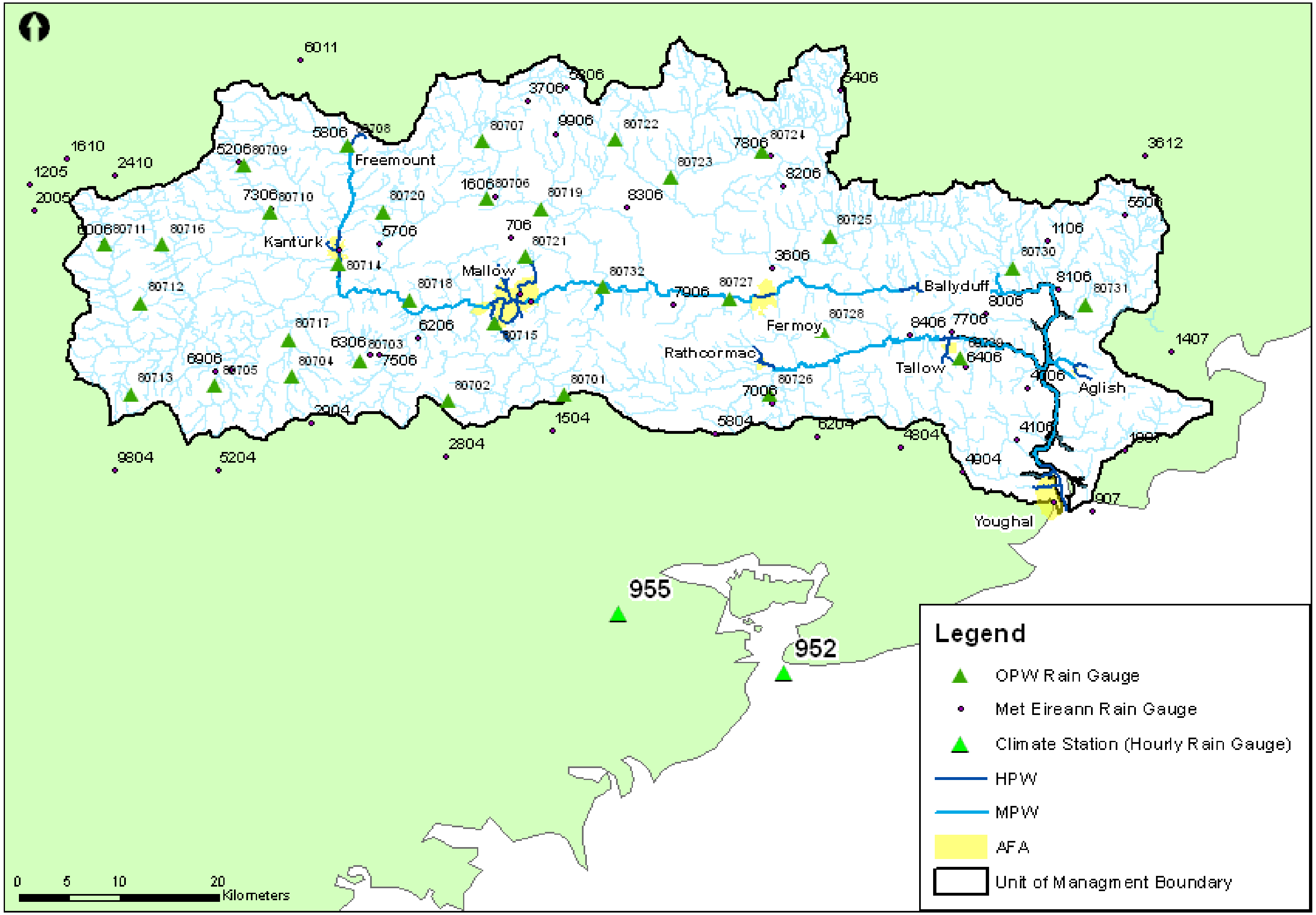
The existing meteorological data has been assessed for the following common issues:
- Spatial distribution of intensity loggers and respective storage gauges (event based);
- Identification of gaps or erroneous data which have been cross-referenced with the Met Eireann climate stations to assess if significant events have been omitted;
- Identification of shifts in rainfall records using temporal and cumulative plots; and,
- Analysis of cumulative rainfall for key historic events.

Appendix A provides as summary of the key rainfall gauges in the catchment.

Based on the available data from Met Éireann and OPW, there are 33 hourly rainfall gauges within UoM18. Additional detailed hourly rainfall data at Cork Airport (3904) and Roches Point (1004) will be used to supplement and validate the rainfall data in UoM 18 in conjunction with the daily rainfall gauges.

Daily rainfall stations 3606,5806,1406,6606 and 4106: The preliminary meteorological analysis found a number of gaps in the data records at Fermoy, Freemount, Kanturk, Mallow and Youghal gauges particularly during summer months. However, it is not expected that this will impact the hydrological analysis significantly as most flood events occur in the winter months (October to March).

Map 4.2: Available Meteorological Data

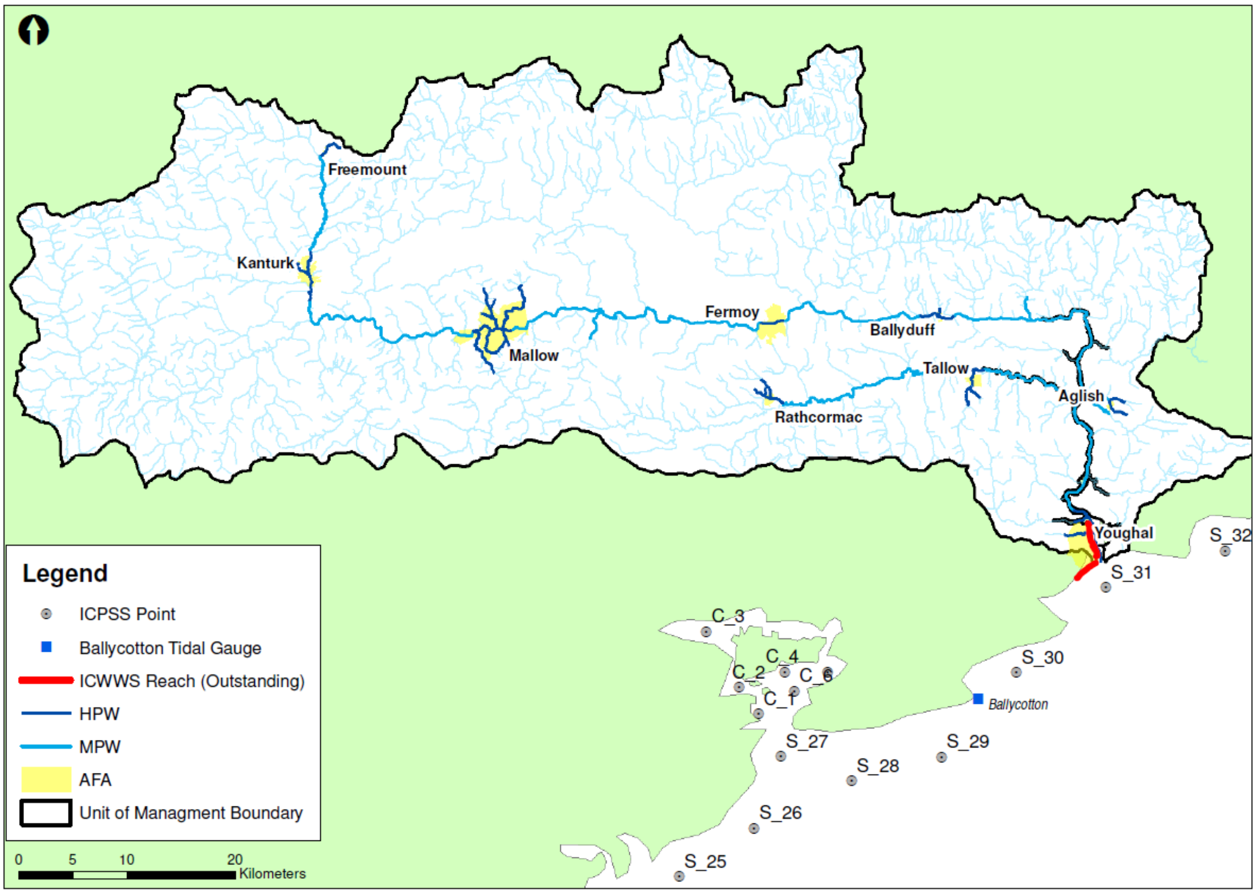


Source: Met Éireann and OPW

4.3 Coastal Data Review

The locations of tidal gauges, extreme water sea level points and extreme wave condition points with available coastal data in and near to catchment are shown in Map 4.3.

Map 4.3: Available Coastal Data



Source: ICPSS, ICWWS and OPW

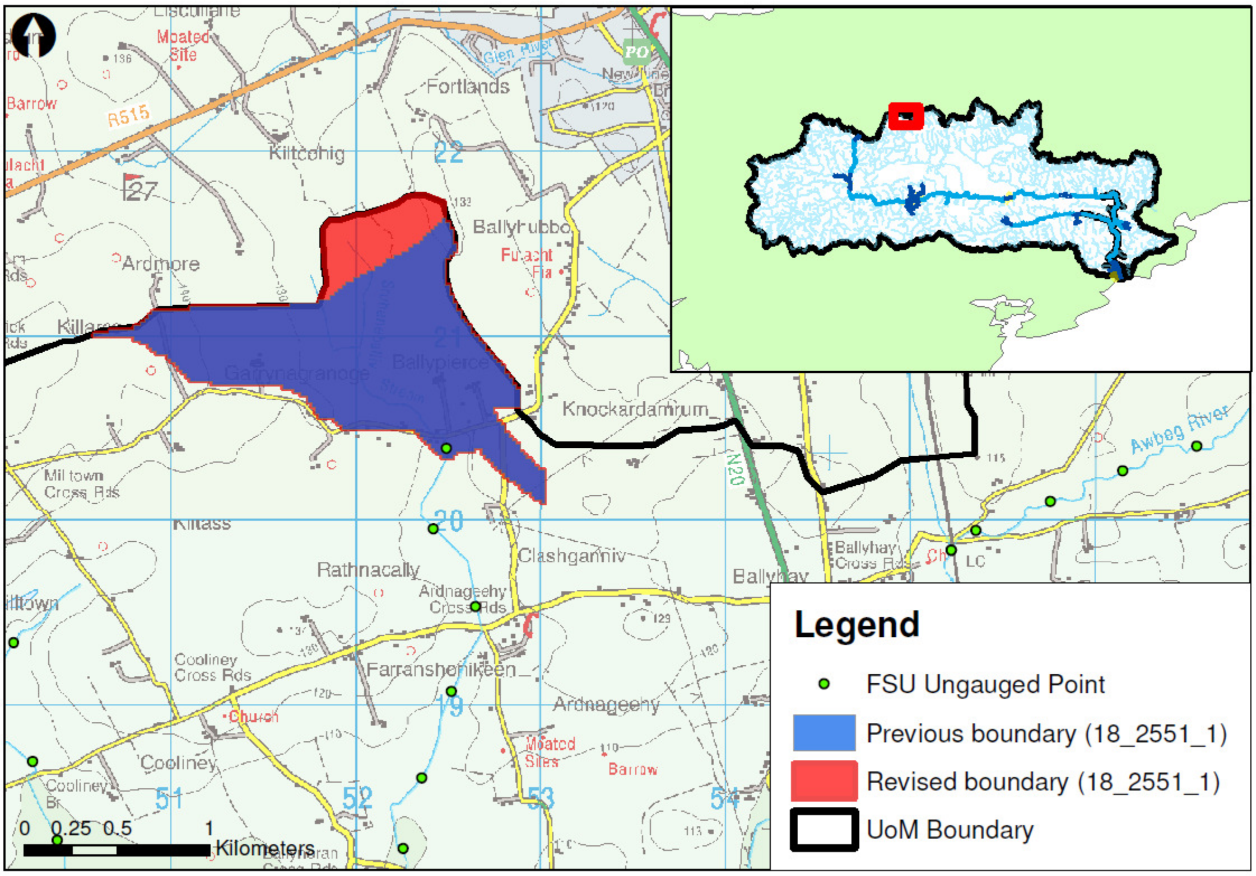
Sea level data is also available at Ballycotton gauge since 2007. The data record was checked for erroneous or poor quality data such as shifts in the datum, anomalous spikes and capping. There was minor variation in the peak tide level and low tide levels, probably as a result of the gauging equipment and variable atmospheric influences. The oscillation was within a 0.1 m tolerance and the data series was deemed fit for purpose.

4.4 Physical Catchment Descriptor Review

GIS spatial analysis was undertaken on the national digital elevation model to determine slope aspect and subsequently used to identify the watersheds for each catchment. The outputs from this GIS analysis was compared with the automated FSU catchment boundaries and verified against manual interpretation from ordnance survey mapping at 1:50,000 scale; previous hydrological reports; and, observations from site visits. Overall, the automated FSU catchment boundaries were found to match the Ordnance Survey Ireland mapping well in areas of steep relief. However, where the terrain is flatter and the watershed less

distinctive, there were some discrepancies between the FSU catchments, those derived from OSI mapping and the more detailed 5m resolution national DTM (see Map 4.4). Therefore, the boundaries were modified and the revisions adopted. However, these modifications were minor, were less than 1km^2 in area and did not significantly change the parameters for the HPW and MPWs reaches assessed as part of this CFRAM study.

Map 4.4: Example Catchment Boundary Modification, Sruhaneballiv Stream



The other physical catchment descriptors were also reviewed including; average slope (S1805); average rainfall (SAAR); runoff indicators (SPR); permeability indicators (BFI); and attenuation (FARL). Information from the Geological Survey of Ireland (GSI) was also used to assess the impact of underlying geology and aquifers on permeability and groundwater dominance, as well as inform those catchments influenced by karstic systems.

Analysis of the catchment parameters for UoM 18 indicates that:

- The upper catchments of the Upper Blackwater, River Allow, River Dalua all have low BFI indicating lower permeability and a faster hydrograph response to rainfall in the North West of UoM 18.
- Catchments to the south of the Munster Blackwater have a higher BFI value indicating much higher permeability and a slower hydrograph to rainfall.
- The River Awbeg Minor, Awbeg Major and Funshion to the north of Mallow and Fermoy are underlain by karst, and these rivers are spring fed in their upper reaches indicating groundwater dominance for low flows.
- The highest standard average rainfall is in the west and north east of the Blackwater UoM but the Awbeg catchment has the lowest rainfall reinforcing the dominance of groundwater for this catchments.

All the modifications made to the original FSU database are highlighted in Table B.1, Appendix B.

4.5 Historical Flood Events

4.5.1 Review of Historical Flood Data

Severe historic flood events in the Blackwater catchment were identified from the following sources:

- OPW Historical Flood Database (floodmaps.ie)
- Flood Risk Review – included discussions with LA's / stakeholders.
- Reports provided by Local Authorities
- Observed water level, flow and meteorological records
- Flood Event Reviews – included discussions with LA's and stakeholders along with reviews of information available on floodmaps.ie.

Table 4.1 summarises and ranks the key catchment-wide flood events reported since 1980 in the Blackwater catchment. The rank refers to peak flow / magnitude only, where flow data is available within the AFA or at a nearby gauge. Details of these events are summarised in the following sections. The hydrographs and historic flood evidence will inform the calibration and verification events for the hydraulic modelling process.

4.5.2 Historical Flood Event Summaries

Flood Event of 4th of August 2012

The most recent flooding to take place in UoM 18 was flash flooding in Rathcormac which was caused by intense rainfall on 24th August 2012 between 2AM and 4AM. Intense rainfall fell, exceeding the capacity of Rathcormac Stream which overtopped its banks at the junction to the north west of the School and flowed down the surrounding roads.

Source: Flood Event Review – Rathcormac "Flood Event Data Collection Report (Mott MacDonald 24.08.12)"

Flood Event 19th November 2009

Widespread flooding occurred across the Munster Blackwater and River Bride catchments in the November 2009 event as a result of prolonged rainfall on already saturated catchments.

This was the first significant flood since the completion of phase 1 of the Mallow flood defence works. The Town Park and Mallow Racecourse areas were flooded which closed the major road N72 for several days. A total of 8 properties (7 residential and 1 commercial) were affected by flooding.

At Fermoy, flooding affected both banks of the river, flooding a total of 22 residential properties, 16 commercial premises and access to the Hospital. There was also partial flooding of the N72 and R666.

Further downstream from Mallow, Killavullen village was flooded to along the northern tributary of the Munster Blackwater. However, this was not reported to damage any properties in this area. Analysis of concurrent gauged flows at Mallow, Killavullen and Ballyduff indicate that the peak flow in the November 2009 event had an annual exceedance probability varied along the catchment (Table 4.1 belwo)%. However, the magnitude of this event is likely to increase at Ballyduff following the rating review of this gauge during the main hydrological analysis phase

Source: Flood Event Report for Fermoy, Mallow, (OPW, 2009) (www.floodmaps.ie)

Table 4.1: Key Historic Flood Events

AFA/ HPW	Nearest Gauging Station: Station No.	Nearest Gauging Station: Location	Historic Flood Event: Date	Peak Flow (m^3/s)	Estimated Duration (hours)	Rank	AEP (%)	Flood Mechanism
Freemount/ Allow	18009	Riverview	26/08/1997	90.06*	<6	20	62.9	Fluvial: Intense rainfall over a short period, overtopping of the Freemount Stream.
Kanturk/	18009	Riverview	02/11/1980	No Data†	<24	-		Fluvial: Overtopping of the River Allow and Dalua at the confluence.
Dalua/Allow/			06/08/1986	135.83	10	7	21.1	Fluvial: Overtopping of the River Allow and Dalua
Brogeen			27/10/2004	156.15	8	3	8.23	Fluvial: Flooding due to overtopping of the Brogeen River.
Fermoy/			22/10/1988	479.5	30	1	1	Fluvial: Prolonged period of rainfall, followed by a high intensity storm.
Blackwater	18002	Ballyduff	19/11/2009	438.3	15	2	2.8	Fluvial: Prolonged period of rainfall. Overtopping of the Blackwater.
Mallow/			02/11/1980	447.16	24	1	1.6	Typically fluvial flooding from the Blackwater following prolonged periods of heavy rain.
Blackwater			21/10/1988	393.1	18.5	3	7.3	
			30/12/1998	367.79	+/-24	5	13	
			06/11/2000	359.4	+/-24	6	15.8	Fluvial: Intense, heavy rainfall. Overtopping of the Blackwater.
	18006	CSET Mallow	19/11/2009	357.6	+/-24	8	21.5	Fluvial: Prolonged period of rainfall. Overtopping of the Blackwater.
Rathcormac/			30/01/2009	99.87	<24	2	3.5	Fluvial: Intense, heavy rainfall.
Bride			19/11/2009	103.99	<24	3	1.2	Fluvial: Prolonged period of rainfall. Overtopping of smaller tributaries of the Bride.
	18001	Mogeely	24/08/2012	No Data	2	-	-	Fluvial: Overtopping at an open top section of a culverted stream closes to the school, a tributary of the River Bride.
Youghal/ Blackwater	OPW Tidal Gauge	Ballycotton	27/10/2004	No Data‡	<24	-	-	Tidal: Extreme high tides combined with an extreme wind surge. Wave overtopping at Youghal sea front.

AFA/	Nearest Gauging Station		Historic Flood Event					
	Station No	Location	Date	Peak Flow	Estimated Duration	Rank	AEP (%)	Flood Mechanism
Aglish/ Goish-Ballynaparka			07/01/1996	No Data	Unknown	-	-	Fluvial: High rainfall events, cause overtopping on the Ballynaparka Stream at the Ballynaparka Bridge. Under sever rainfall conditions Aglish village is also vulnerable.
			04/11/2000	No Data	Unknown	-	-	
	N/A	N/A	2010	No Data	Unknown	-	-	
Tallow/Bride	N/A	N/A	No Event Data	No Data	N/A	-	-	Tidal/fluvial: A combination of high tides and rainfall causes flooding on the River Bride.

*Based on 18009 Riverview, the nearest gauging station located 13km downstream after the confluence of the Dalua, so not directly representative of Freemount.

† Data unavailable due to no gauged records within the catchment at that time.

‡ Tidal water level gauge, Ballycotton. No data available for 1997 (data gap).

Source: Mott MacDonald 2012

Flood Event of 27th October 2004

Youghal was flooded on 27th October 2004 by a combination of extreme high tides and an extreme storm surge (1.5m over the predicted high tide level). Extreme waves damaged and overtopped the sea defences at Youghal, which were known to be in a poor condition at the time. The beach at Front Strand and Claycastle to the rear flooded with much of Youghal's main harbour area inundated with flood waters, flooding Catherine Street, Market Square and reaching up to North Main Street. Water levels were at their highest at Barry's Lane and Youghal Fire Station. Property flooding was reported, but the final damage estimates are unknown.

Other affected nearby areas are Garryvoe, Pilmore and Redbarn towards the south in Ballycotton bay.

The Kanturk area was also affected when flooding occurred downstream of the main town, due to the overtopping of the Brogeen River.

Source: Minutes of Cork County Council meeting 20/04/2005 (www.floodmaps.ie)

Flooding of 6th November 2000

Two large flood events occurred on the 5th and 6th November 2000. The second event caused flooded as the catchment was already saturated and river levels high from the day before. Water levels rose to 2.8 m early on the 6th of November, causing flooding in the Munster Blackwater catchment. In Mallow, Town Park, the Race Course, Bridge Street and the N72 flooded.

Analysis of flow recorded at the Mallow gauges indicates that the November 2000 flood event had an annual exceedance probability of 20%, the seventh largest flood on record.

Source: Cork County Council memo listing flood locations in county in November 2000 (www.floodmaps.ie)

Flood Event of 26th August 1997

Freemount was flooded due to intense rainfall falling over a relatively short period. Between the hours of 6 to 11pm over 90mm of rain fell exceeding the capacity of a tributary to the River Allow, known locally as 'Freemount Stream'. A considerable amount of debris was moved which blocked the 4 main culverts towards the east of the village, resulting in a flood depth of up to 1 m at the right bank. Excess flood waters flowed down the main street and an estimated IR£210,000 worth of damage to private property (houses, cars, gardens) and a further IR£15,000 cost of cleanup (Cork County Council, 1997).[2]

Source: Cork County Council (1997) Freemount Flood Report (www.floodmaps.ie)

Flood Event of 22nd of October 1988

The floods that hit Fermoy and Mallow during October 1988 were due to heavy rainfall after a period of consistently high rainfall events in the weeks preceding. With over 40mm of rain falling over the 21st October, Mallow Town Park alongside the Munster Blackwater was flooded by 11:30 AM and Bridge Street

[2] Cork County Council (1997) Freemount Flood Report [online] www.floodmaps.ie

began to flood by 5:45 PM. Later in the day, flooding began at Ballyhadeen (07:15 PM) and Broom Lane (07:30 PM). The maximum flood depth occurred at Bridge Street, with a depth of 1.6 m. The flood water receded by 06:00 PM the next day. The flood is ranked the 3rd largest on record according to the available data.

At Fermoy, the left bank at Fermoy Bridge to Brian Boru Square, Frances Street and Rathealy Road flooded. Flooding also occurred to the south at Ashe Quay and O'Neil Crowley Quay. The flood event was the largest on gauged record.

Source: Munster Blackwater River: Fermoy Flood Alleviation Scheme (2003)

Flood Event of 6th August 1986

On this date, flash flooding occurred throughout County Cork, Kanturk suffered a large flood in which the River Allow and the River Dalua overtopped the river banks causing flooding to properties around Market Square.

Analysis of recorded water levels and flows on the River Allow at Riverview gauge indicates that this flood event had an annual exceedance probability of 5%, the 7th largest on record. However, the magnitude of this event is likely to increase following the rating review of Riverview gauge during the main hydrological analysis phase.

Source: Fermoy - The Blackwater.pdf extracted from (Fermoy) Drainage Scheme Hydrology Hydraulics Report

Flood Event of the 2nd of November 1980

The largest flood that can be accurately traced, hit Mallow flooding the town park at 11:30 AM then rapidly rising to being flooding into the town at around 12:00 Noon. Peak level occurred at 03:00PM and at this point it was not possible to pass the town bridge. Bridge Street was flooded with water up to 2.5m deep and the flooding has subsided within 24 hours (ARUP, 2002).[3]

Further flooding at Kanturk was caused by the overtopping of the River Allow and Dalua, a short distance to the south of the confluence and the western areas of town flooded to a maximum of 2m. An estimated IR£370,000 of damage was caused with 178 houses affected. R579 Strand Street was also flooded.

Analysis of the Mallow river gauges indicates that this flood event has an annual exceedance probability of 1.6% and is the largest flood on record.

Source: ARUP (2002) Munster Blackwater (Mallow) Drainage Scheme (www.floodmaps.ie)

4.5.3 Selection of Calibration/Verification Events

The calibration and verification of the hydraulic models is important to ensure confidence in the flood modelling and mapping results. The calibration process aims to achieve the best match possible between the model predicted values against observed levels, flood extents and photographic evidence for the out of

[3] ARUP (2002) Munster Blackwater (Mallow) Drainage Scheme [online] www.floodmaps.ie

bank flooding by adjusting key model parameters. The historical events listed in Table 4.1 were assessed for quality and availability of gauge data and supporting historic flood evidence to calibrate water levels and flood extent from photos, reports and anecdotal evidence.

The following three historical events were selected based on the available historic flood evidence that will be used to calibrate the hydraulic models in UoM 18:

- 2nd November 1980 –The largest flood recorded on the Blackwater but has limited flow data. Therefore the analysis at Mallow gauges will inform the magnitude for the other models.
- 6th November 2000 – Catchment wide event with good coverage of gauged data in most AFAs
- 19th November 2009 – Most recent catchment wide event with good quality gauge data available and extensive flood photos aerial photograph and reports to calibrate the models.

Aglish, Tallow and to some extent Rathcormac do not have flow data or historic flood evidence with which to undertake model calibration. Therefore, the rainfall records and estimation of %AEP of key events such as the November 2009 event from other gauges in the Munster Blackwater catchment will be used to calibrate the models for these AFAs.

Extensive sensitivity testing will also be undertaken on the following key parameters to ensure confidence in the results for the hydraulic models:

- Channel and floodplain roughness (Manning's 'n' values)
- Bridge and culvert loss coefficients
- Pre-event catchment conditions/saturation (baseflow levels)

We will seek to verify these sensitivity tests with observed data should any flood event occur during the hydrological stage of SW RBD CFRAM study (completion due in June 2013).

4.6 Flooding Mechanisms

Following the review of the historic reports and other data, the key flood mechanisms identified in UoM 18 include:

- **Fluvial or river flooding:** Fluvial flooding can occur when the capacity of the river channel is exceeded due to excess flow from heavy rainfall . Flood waters typically overtop river banks at low sections or where water is constricted by bridges or culverts forcing water levels to rise upstream and flood surrounding areas. Most of the flooding reported in UoM 18 is attributed to fluvial flooding mechanisms.
- **Pluvial or surface water flooding:** Pluvial flooding can occur when overland flow from intense rainfall or prolonged heavy rainfall is unable to enter the urban drainage network or river channel either because they are already full or there is a blockage. Pluvial flooding is exacerbated by the increase of impermeable areas (such as concrete or tarmac) associated with urbanisation which increases the amount of overland flow. The most recent flooding in Rathcormac was partly attributed to pluvial flooding. It should be noted that the study of pluvial flooding is not included in the scope of the CFRAM Study.
- **Coastal or tidal flooding:** Extreme sea levels, waves and storm surges overtop coastal defences and river banks in tidally influenced reaches, particularly when combined with high river flows for tidal rivers. The risk to people can be very high from this form of flooding as the flood waters can be fast-flowing water. The October 2004 event in Youghal was attributed to wave overtopping and the tide-locking of the urban tributaries. Tallow is also at risk from tidal flooding when combined with high flows on the River Bride according to anecdotal evidence.

In addition to the mechanisms listed above, flooding in Ireland can also occur from the following:

- **Groundwater flooding:** Ground water flooding can occur when waters levels rise above the ground to flood low-lying fields and property basements, typically when the catchment is saturated. The onset of flooding is very slow and therefore hazard to people is limited. The River Funshion and parts of the Blackwater Munster between Dromcummer and Ballyduff are likely to be susceptible to this form of flooding as it underlain by highly permeable karstic systems. However, there are no records of groundwater flooding. Hence, groundwater flooding has been discounted from further analysis. It should be noted that the study of groundwater flooding is not included in the scope of the CFRAM Study.

Based on the historical flood evidence, the key mechanisms for each of the AFAs are as follows:

- **Aglish:** Flooding occurs at the Ballynaparka Bridge of the Ballnaparka Stream at Aglish, regularly affecting several nearby properties. Anecdotal evidence also suggests flooding from the Goish River to Ballycullane when the Munster Blackwater is in flood, and flooding through the AFA from the Ballynaparka Stream. The key mechanisms will be verified during the hydrological and hydraulic modelling analysis.
- **Ballyduff:** Flooding caused by overtopping of the Munster Blackwater flooding surrounding fields but is reported to be contained within the masonry wall on the left bank in the November 2000 event.
- **Fermoy:** Flooding caused overtopping of the Munster Blackwater along the left bank at Thomas Street and along right bank, flooding roads near the hospital. Frequent flooding up to 2006 resulted in the development of flood embankments along the left bank and flood walls along the right bank. Previous studies have shown the weir and town bridge do not significantly affect flood levels.
- **Freemount:** Flooding caused by the overtopping of the River Allow and tributary known as the River Keen that runs through Freemount affecting low-lying properties.
- **Kanturk:** Flooding caused by the overtopping of the rivers particularly at Dalua Footbridge when flooding on the River Dalua interacts with high flows on the River Allow.
- **Mallow:** Recurring flooding, caused by overtopping of the Munster Blackwater and Spa Glen. The constriction of flow at the bridges combined with the inflows from Spa Glen causes flood levels to increase and flood Bridge Street and the park area on the left bank. Rapid runoff and under capacity of the urban drainage systems can also cause flooding on the various urban tributaries that flow through Mallow. The frequent flooding of Mallow led to the development of flood defence walls, embankments and pumping stations at Bridge Street to protect vulnerable properties.
- **Rathcormac:** Flooding occurs when the Millstream overtops the river banks at culverted and bridged sections flooding Main Street. The more recent flood events have been caused by intense rainfall events and under-capacity urban drainage network.
- **Tallow:** Overtopping of the River Bride at Tallow Bridge caused by a combination of high tide and high flows in the River Bride and the Glenaboy River that flows through the town.
- **Youghal:** Primarily coastal flooding from wave overtopping, but a combination of rainfall, high flows in the Munster Blackwater and high tidal levels can also result in flooding along the harbour front. High levels in the Blackwater Estuary can also prevent discharge from the smaller tributaries causing flooding as water "backs up" behind the tidal sluices at Youghal Mudlands.

Mott MacDonald

5. Detailed Method Statement

5.1 Flood Risk Review Approach

The overall flood risk review process ensured that the final definition of the AFA's, which are taken forward for the more detailed aspects of the CFRAM methodology, takes full account of local data. During this process regular feedback was provided to OPW. The Risk Review Report included details on the following aspects:

- The new data received, in addition to the information available during the PFRA stage.
- Details of how the data impacts on the existing AFA's definition.

5.1.1 Site Visits

We carried out walkover surveys of the Communities at Risk and the Areas for Flood Risk Review. We reviewed and updated key aspects of the AFA designation, with particular attention to the preliminary flood hazard and receptor data from the PFRA in each case. This involved the completion of proforma documents during the site visits, for example, to ensure consistency between the reviews of the different areas.

5.1.2 Flooding History

Flooding history taken from anecdotal information from OPW, Local Authorities, previous reports and from the historical analysis for the PFRA was examined as part for the flood risk review. All data on flooding history was given a level of confidence based on the data source and detail. Areas identified as being at flood risk from the flooding history information, but not highlighted within the PFRA, were examined further to see if local characteristics would adversely impact results from the normal depth method. Depending on the level of confidence attached to the data sources the AFA regions were altered to incorporate historical evidence.

5.1.3 Flood Risk Review Report

A Flood Risk Review Report was prepared and submitted to OPW. The report included the following:

- Flood Risk Review methodology (including datasets, information and knowledge used, and details from preliminary risk assessments);
- Outcomes of the Review in areas of significant risk.

5.2 Survey Approach

5.2.1 Channel and Structure Survey

The surveys have been specified and procured. We are currently managing the execution, delivery and quality control of the geometric and geo-referenced survey of channel cross-sections required for the river modelling.

5.2.2 Defence Asset Condition Survey

Once the channel and structure survey is complete (Section 3.3) we shall undertake a condition survey of the flood defence assets as required. This shall include a geometric survey, visual inspection and condition survey of flood defences and their component assets, structures and elements. All data will be inputted to

the Defence Asset Database, including location, photography, flow level and assessment details as well as areas benefiting from protection and the economic value of defended risk receptors.

5.3 Hydrology Approach

5.3.1 Overview

The hydrological approach draws on the data review described in Chapter 4 of this report and the latest Flood Studies Update (FSU) guidance. The following sections state the approach for remaining steps to derive design fluvial hydrographs for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP events as boundary conditions for the hydraulic modelling, including:

- Hydrological Estimation Point (HEP) Conceptualisation;
- Gauging Stations Rating Reviews;
- Derivation of the Index Flood Flow;
- Derivation of the Flood Growth Curves;
- Derivation of the Typical Flood Hydrograph;
- Phasing of inflows; and
- Consideration of Climate Change.

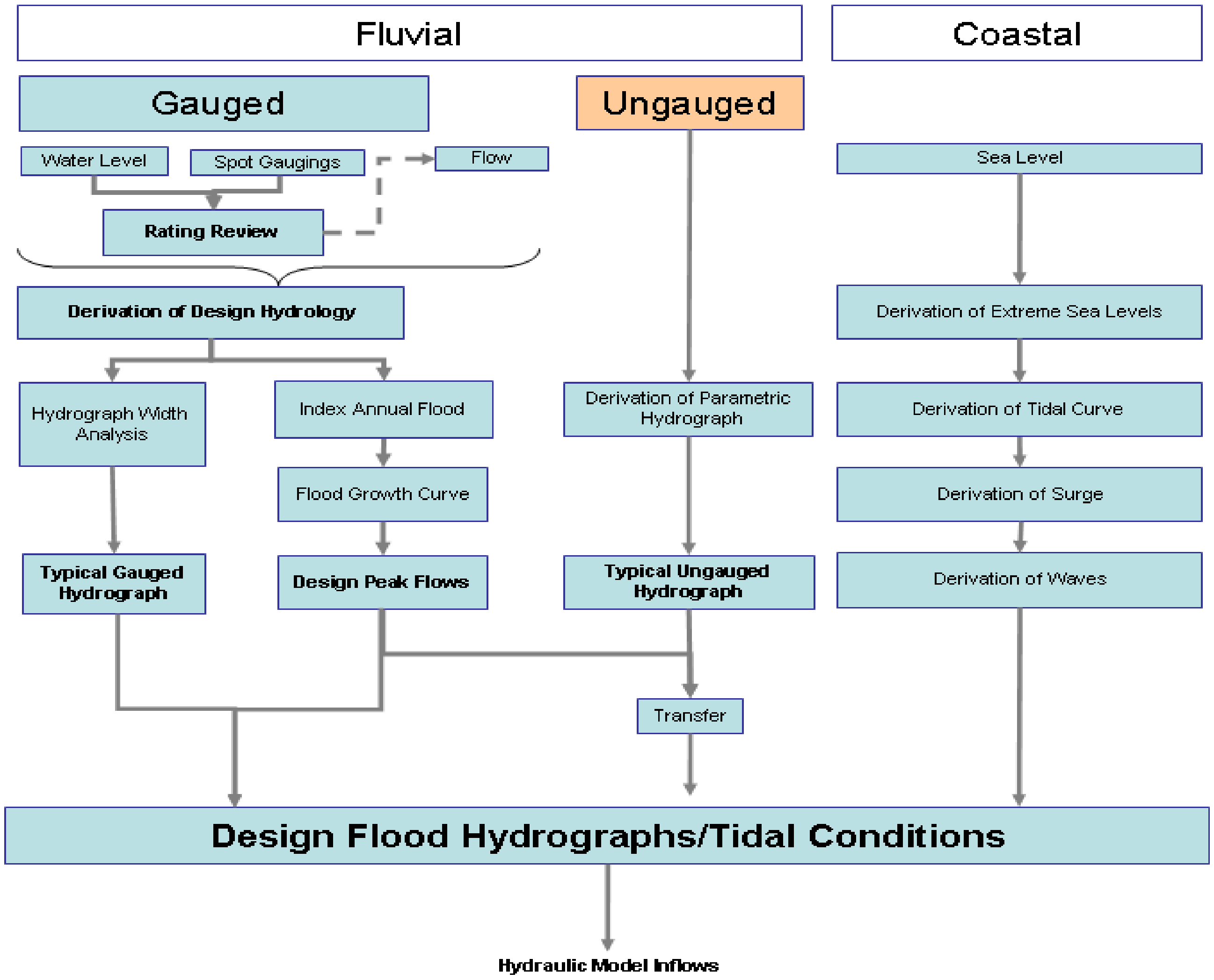
Extreme sea levels will be provided from the Irish Coastal Protection Strategic Study (ICPSS). The design tidal conditions for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP events will be derived using this information and the following analysis:

- Derivation of the typical tidal flood hydrograph;
- Phasing of the tidal, surge and fluvial components; and
- Consideration of Climate Change.

Figure 5.1 outlines the key steps that will be undertaken for each HEP in the hydrological analysis phases as a simplified flow chart.

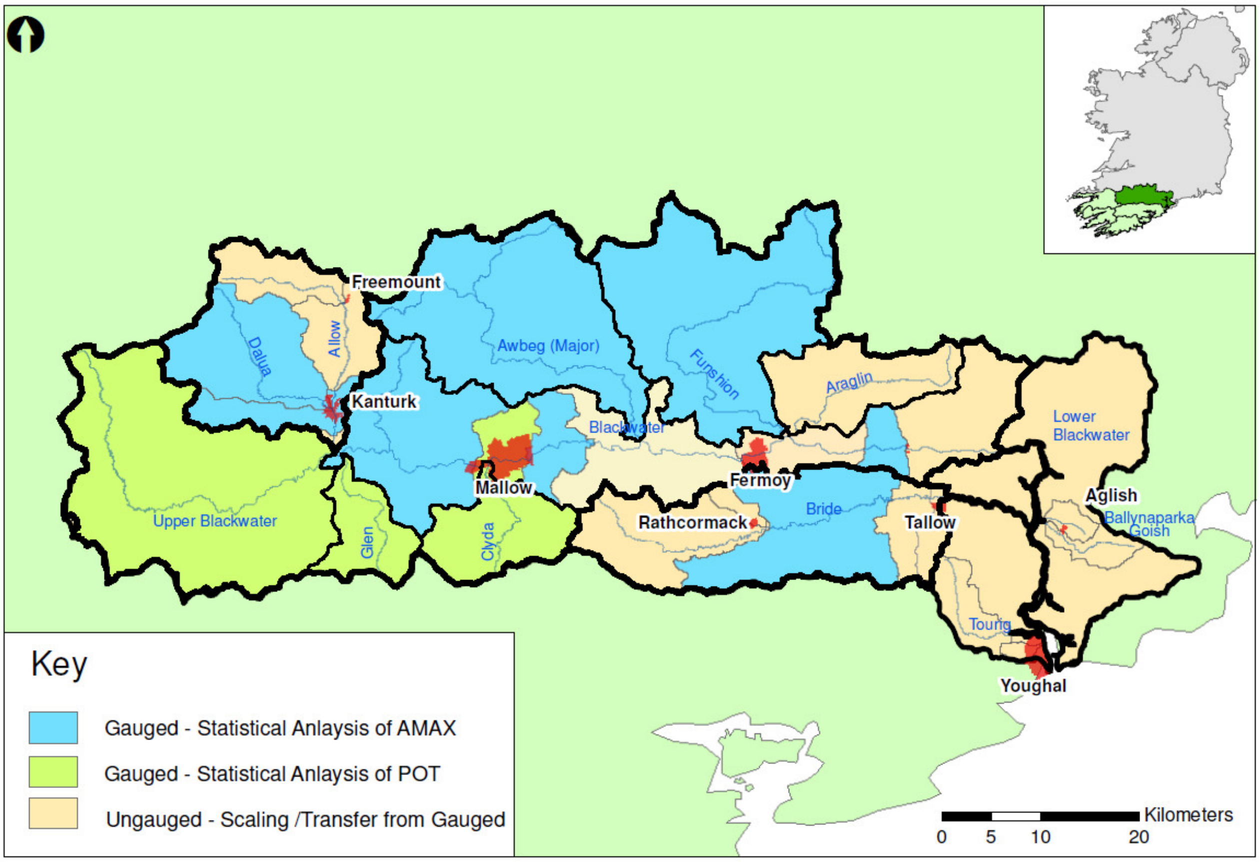
Rainfall-runoff modelling is not required to derive the design hydrology in UoM 18 given availability and quality of hydrometric gauges. Therefore the approach for rainfall-runoff modelling has not been included in this inception report.

Figure 5.1: Flowchart of Hydrological Approach for UoM 18



Map 5.1 details where these different hydrological approaches will be applied to the Munster Blackwater UoM 18. Each approach is discussed in greater detail in the following sections and how it will be applied to derive the design flood hydrographs for UoM 18.

Map 5.1: Hydrological Approach



5.3.2 HEP Conceptualisation

Following this review of catchment descriptors in Section 4.4, hydrological estimation points (HEPs) were selected along each modelled watercourse to represent the inflows to the hydraulic models, intermediate target points to check the models and the downstream boundaries for the hydraulic models. The HEPs were identified through a GIS analysis using the criteria set out in section 6.5.3 of the Project Brief which include;

- Central points within AFAs;
- Flow gauging stations used in the hydrological analysis;
- Upstream and downstream limits of each hydraulic model reach;
- Major confluences which contribute significant flow to the modelled reach*;
- Locations where the physical catchment descriptors significantly change from the upstream catchment i.e. catchment centroid more than 25km away, ±0.15 change in BFI and ±0.07 change in FARL; and,
- At 5km intervals along each watercourse.

The conceptualisation of the HEPs carefully considered the balance between having too many inflows, thus complicating the model, or too few inflows, so misrepresenting the catchment response at key locations such as the AFAs and major tributaries.

The FSU guidelines define a major confluence as any tributary that contributes more than 10% flow to the model reach downstream. This approach can lead to an over representation of HEPs in the upper reaches of the River Allow and an under-representation in the lower Blackwater. Other CFRAM studies have used a different approach to overcome this imbalance by applying a 5km^2 catchment area thresholds to define a major confluence. However, this results in excessive HEPs to calculate model inflows in large catchments such as the Munster Blackwater. Therefore we have applied a threshold of more than 10% flow contribution and reviewed these to limit the number of HEPs upstream along the River Allow and increased the HEPs for the downstream section of the Munster Blackwater especially downstream of Lismore.

There were no HEPs identified where the catchment descriptors varied significantly from the upstream catchment because there are no large reservoirs or Loughs in UoM 18 and there were already sufficient HEPs identified by the previous three guidelines to cover the variation in catchment response along the Blackwater.

Table 5.1 summarises the HEPs identified for the MPW and HPW modelled reaches in UoM 18. Appendix B.1 details the location of these HEPs and sets out the proposed physical catchment descriptors for each of these HEPs considering the modifications described in Section 4.4.

Table 5.1: Summary of Hydrological Estimation Points (HEPs)

Type	Number of HEPs
Gauged HEP	12
Upstream or downstream limit of model HEP	44
Major confluence inflow HEP	71
Significant variation in catchment descriptors HEP	0
TOTAL	**127**

5.3.3 Rating Reviews

Rating reviews will be undertaken for the gauges identified in Table 5.2, as specified by OPW at the tender stage. A desktop review will be undertaken of each location combined with the information from the flood risk review site visits and survey details. The review will focus on the following aspects:

- Consistency in the use of the datum (e.g. compare datum to difference between water level and stage records) and link findings back to assessment of the water level records,
- Assess limitation of ratings (bypassing, floodplain flow, backwater from downstream structures),
- Check rating curves against spot gaugings recorded during the period that rating curve applies;
- Check spot gauging for anomalously high or low flows
- Check spot gaugings for seasonality of vegetation effects
- Check spot gaugings for hysteresis effects i.e. where the rising limb and falling limb of a flood event differ due to floodplain attenuation.

The stage-discharge relationship up to bankfull will be developed from the spot gaugings and used to calibrate the hydraulic model at the gauge. The model calibration will only use those spot gaugings that were captured during the period for the stage- discharge relationship that was applicable at the time of survey to ensure the spot gaugings are representative of the latest hydraulic conditions. It may be difficult or impossible to genuinely represent hydraulic conditions during other periods unless the physical change that caused the change in rating is known and can be simulated (e.g. trim model to extrapolate rating,

where known change was gravel extraction). Therefore, the hydraulic models will only be calibrated for the latest period where spot gaugings are available.

The calibrated hydraulic model will then be used to simulate the extreme flow conditions during the 0.1%AEP and the results used extend the rating for out-of-bank flows.

As discussed in Section 4.1 of this report, there is inconsistency between the gauges at Mallow, Fermoy and Ballyduff for concurrent high flow events. This may warrant a further review of the Mallow rating curves at the CSET Mallow gauge and the Mallow Railway Bridge gauge based on the hydraulic model and spot gaugings available.

The paired gauges at Mallow Town Bridge and Fermoy Bridge do not currently have rating curves to derive flows from the recorded water level. However, these gauges are located at bridge structures and therefore are not ideal to derive flows due to the variable impacts of backwater and blockage. Therefore these gauges will be used to calibrate the water level through these important urban areas rather than for derivation of flows.

Table 5.2: Gauges Requiring Rating Reviews

Gauge Name	Gauge Number	Watercourse	AFA	Approach
Mogeely	18001	River Bride	Tallow	1D model
Ballyduff	18002	Munster Blackwater	Ballyduff	1D-2D model
Riverview	18009	Munster Blackwater	Kanturk	1D-2D model
Allen's Bridge	18010	River Dalua	Kanturk	1D model
CSET Mallow	*18006*	*Munster Blackwater*	*Mallow*	*1D-2D model*
Mallow Railway Bridge	*18055*	*Munster Blackwater*	*Mallow*	*1D-2D model*

The agreed rating reviews will assess spot gaugings, combined with the high flow results from the hydraulic models developed for consistency, seasonality and anomalous points. The stage-discharge relationship up to bankfull will be developed from the spot gaugings and checked for any apparent backwater effects and hysteresis effects within the data.

Separate one-dimensional hydraulic models will be developed for Mogeely and Allen's Bridge gauges. Provisional site visits identified that a v-shaped valley section which constrained the majority of floodplain flows laterally. Additionally, there was no detailed LIDAR available at the time of this study which limits the accuracy of any 2D model. Therefore, a 1D ISIS hydraulic modelling approach was deemed to be sufficient to represent typical one-dimensional nature of the flow at these gauges.

However, it is anticipated that the Ballyduff and Riverview gauges will require 1D/2D hydraulic model to fully represent the floodplain storage and complex interaction of flows, subject to review when the LIDAR data becomes available. The Mallow gauges will be reviewed as part of the 1D/2D hydraulic models developed for Mallow AFA ensuring the by-pass flows, are fully represented at the gauges. The hydraulic models will be run for flows ranging from the lowest spot gaugings up to the 0.1% AEP peak flow. Subsequently, the observed spot gaugings will be used to calibrate in-bank flows and the hydraulic model results will be used to extend the rating curve for high flows. Sensitivity tests will be undertaken to better understand the uncertainty in the rating curve due to changes in key hydraulic and hydrological parameters such as duration, roughness or structure coefficients. Each gauged site in the rating review will be assessed to identify the important parameters or assumptions for sensitivity testing avoiding unnecessary sensitivity testing. For example, where there are high flows are contained within the gauged section there is little benefit of assessing variation in floodplain roughness values.

The revised rating curves will be used to convert the water level series for high flows. The converted flow series will subsequently be used to develop and/or revise the annual maximum flow series (AMAX). The

updated AMAX series feeds back into the statistical hydrological analysis to determine the index flood and relative flood frequency at the gauged fluvial locations, discussed in the following section.

5.3.4 Approach for Gauged Fluvial Locations

Gauged sub-catchments for the MPW and HPW reaches assessed in this CFRAM study are shown in Map 5.1 and Table 5.3 for records of lengths greater than and less than ten years respectively.

There are also three gauges in the catchment which have long flow records but are not in or do not directly feed into the MPW or HPW reaches to be assessed. These are included in our preliminary hydrological approach as potential pivotal sites for the ungauged HEPs and for use in pooling group sites for the flood frequency analysis in the Blackwater UoM18 only.

Table 5.3: Hydrological Approach for Selected Gauges

Number	Name	Watercourse	AFA or Model Reach	Usable Record Length (Years)	Approach
18001	Mogeely	Bride	Mogeely and Tallow	39	■ $QMED_{amax}$ ■ Single site growth curve ■ Statistical hydrograph width analysis
18002	Ballyduff	Blackwater	Ballyduff	56	
18009	Riverview	Allow	Kanturk	12	
18010	Allen's Br.	Dalua	Kanturk	12	
18006	CSET Mallow	Blackwater	Mallow	35	
18003	Killavullen	Blackwater	Blackwater Reach 3	56	
18005	Downing Br.	Funshion	Blackwater Reach 4	39	
18048	Dromcummer	Blackwater	Blackwater Reach 2	12	
18004	Ballynamona	Awbeg	N/A	45	
18016	Duncannon	Upper Blackwater	N/A	20	
18050	Duarrigle	Upper Blackwater	N/A	21	
18110	Kilbrin Road	Allow	Kanturk	6	■ Statistical QMED ■ Pooled growth curve ■ FSU UPO-ERR hydrograph
18019	Fr. Murphy's Br.	Glen	Blackwater Reach 3	6	
18055	Mallow Railway Br.	Blackwater	Mallow	10	
18109	Lombardstown	Blackwater	Mallow	6	

Index Flood

The shorter the gauge record the greater the influence of extreme low or high flows on the statistical analysis of the index flood. Therefore we will use the median descriptor (QMED) from the Annual Maximum Series (AMAX) to minimise outlier skew instead of the average (Q_{BAR}) used in the previous Floods Studies Report. The majority of flood events occur in the winter months (October to March) in Northern Europe, therefore the AMAX series is based on the annual maximum flood that occurs in each water year, i.e. from October to October, to avoid counting two consecutive flood events in December and January if the calendar year was applied.

For gauges with records over ten years in length, such as Ballyduff, the recorded annual maximum flood series will be used to estimate the index flood and compared with the $QMED_{adj}$ from the FSU catchment descriptors methodology (FSU WP 2.3). For gauges with between five years and ten years flow data, the

QMED will be selected from either AMAX methodology described above or FEH peaks above threshold (POT) approach. The POT approach will use an appropriate threshold so that two or three events are selected for each complete water year. For gauges with less than 5 years data, there is insufficient length of data records to represent typical flows at that location. Therefore, gauges with less than 5 years data will be treated as ungauged for the purposes of design hydrology, but will be used to calibrate models where there is sufficient good quality data to cover the calibration event. The ungauged methodology is presented in the following Section 5.3.5.

The estimates of QMED will be checked across the catchment to ensure flows increase consistently with area and contributing inflows.

This will be particularly important for the Mallow to Killavullen to Ballyduff reach of the Blackwater as observed flows indicate peak flows decrease downstream as discussed in Section 4.1 of this report. The impact of the geology, floodplain attenuation and contributing inflows will be considered in the selection of the appropriate index flood flow at each gauged HEP.

Flood Growth Curve

The flood index value and observed AMAX series will then be used to generate a single site flood growth curve using the FSU methodology for AEP events twice the record length at the site. For instance, the 56 year AMAX series at Ballyduff can be used to derive peak flow estimates up to the 1 in 100 year or 1%AEP event.

In accordance with WP 2.2 of the FSU, the single site analysis at gauges will be combined with the recommended pooled analysis with at least five times the target 100 year or 1%AEP event i.e. 500 years of Amax data, to derive a pooled flood growth curve for larger magnitude events up to the 100 year or 0.1%AEP event. The L-moment statistics from the at-sites single site analysis and pooled analysis will then be weighted to interpolate the final flood growth curve for the 1%AEP event up to the 0.1% AEP event.

The design peak flows will be compared with existing hydrology used to develop the Mallow and Fermoy flood alleviation schemes to ensure consistency between the studies in agreement with OPW. Where there are any discrepancies between the latest FSU flood growth curves and existing flood growth curves for Mallow and Fermoy, the latest analysis will be used to derive the final peak flow estimates as these flood growth curves use the latest data, including the significant 2009 flood event.

The joint probability of flows at each confluence where the tributary contributes more than 10% of downstream flow will be guided by Table 13.1 of the FSU WP3.4 to produce the required design AEP downstream. Observed data of AMAX event will be used to validate the estimated joint probability where there is sufficient gauged data on both the tributary and main river. Observed data of AMAX event will be used to validate the estimated joint probability where there is sufficient gauged data on both the tributary and main river. The selection of the AEP flows on the main river and tributary will be based on the relationship between catchment centroids, area and attenuation descriptors as specified by FSU WP 3.4.

Typical Flow Hydrograph Shape and Phasing

The design hydrograph shape is important in determining the volume of flood water routed down the river systems, as well as the duration of flooding for the AFAs once out-of-bank. Therefore, the characteristic flow hydrograph for gauged sites will be derived empirically using the hydrograph width analysis approach

as specified in the FSU WP 3.1. This will be based on AMAX flood events for gauges with over 10 years' record and all flood events exceeding 80% of QMED for sites with less than 10 years' records.

The observed hydrograph widths at river level only gauges will also be assessed to verify the routing of the flood hydrographs for calibration events to inform the design hydrographs. This analysis will focus on the river level gauges at Kilbrin on the Allow, and Mallow Town Bridge, Fermoy Town Bridge and Glandalane on the Blackwater.

An appropriate parametric curve will be fitted to the empirically derived median hydrographs for the whole sample and spilt samples for 1%, 10% and 50% AEP equivalent magnitude events. These characteristic hydrographs will be compared with the symmetrical hydrograph produced from previous FSR/FEH methods for flows above 50% of the peak flow and discussed with OPW to agree the most appropriate design hydrograph. The statistical analysis of flood durations will be informed by Mott MacDonald's development of a similar approach for the South West England Region for flood incident management, Evans et al (2006)[4].

The phasing of inflows will be determined by the statistical analysis of time lag in observed peak flows or levels for AMAX events where there is concurrent gauge data available, such as between Allen's Bridge and Riverview gauges in Kanturk. The typical observed phasing will be used to inform the timing of hydrographs at each confluence across the catchment in combination with the FSU time difference equation (WP 3.4).

5.3.5 Approach for Ungauged Fluvial Locations

Ungauged inflows are shown as yellow or green in Map 5.1. These are typically small inflows into the urban AFAs or intermediates catchments between the major flow gauges on the Munster Blackwater.

Index Flood and Flood Growth Curve

The index flood values for the ungauged fluvial sub-catchments will be transferred from the gauged locations identified in Section 5.3.4. The QMED at the target ungauged site will be adjusted by the ratio between the observed $QMED_{amax}$ and calculated $QMED_{rural}$ at the pivotal site. The selected flood growth curve from the pivotal site will then be used to derive the design peak flows for the ungauged site based on the adjusted QMED.

The design peak flows will be related to historic flood reports for Rathcormac, Freemount and the Lower Blackwater including, Aglish and Youghal, to ensure consistency and perform logical checks.

Alternative methodologies for estimating the design hydrology for small ungauged catchments have been considered and discounted for the following reasons in UoM 18:

- ***Rational Method:*** The rational and modified rational method estimates greenfield (undeveloped) runoff rates from runoff coefficients, rainfall intensity measures and catchment area principally for sewer design. Previous research has shown that these methods tend to overestimate peak flood flows

4 Evans et al. (2006) Paper 10.5.1-11; A new approach to flood estimation using flood peak and duration: a case study informing incident management plans for Exeter. Flood and Coastal Management Conference, 41st, DEFRA, The University of York, Tuesday 4th July to Thursday 6 July 2006 , 2006.

compared to observed data in test small lowland catchments. Therefore, the rational and modified rational methods have been discounted for SW RBD CFRAMs.

- ***IH124 Method:*** The Institute of Hydrology Report 124 Method (IH124) estimates peak flood flows from time to peak (Tp) and index flood (QBAR) equations. The equations were derived from 71 catchments in England and Wales based on data up to 1990. As such, the coefficients may not represent Irish catchments which have far greater annual rainfall and different catchment responses to those catchments in England. Therefore, the IH124 method has been discounted for SW RBD CFRAMs.
- ***ADAS 345 Method:*** The ADAS Report 345 method estimates peak flood flows from land use, soil type and rainfall parameters related to the rational method equations for the purpose of design field drainage systems. Previous research has shown this method tends to underestimate the index flood flow compared to observed data in test catchments and has a higher mean error than other methods possibly due to a smaller database from which the ADAS345 equations were derived. Therefore, the ADAS345 method has been discounted for SW RBD CFRAMs.
- ***Gebre Small Catchment Method:*** Research by OPW in 2012 developed a revised regression equation for $QMED_{rural}$ based on 38 small gauged catchments (Area between 5km2 and 30km2). However, this revised small catchment QMED equation requires further verification before widespread use. Therefore, it was not recommended to replace the original FSU 7 variable $QMED_{rural}$ equation for small catchment.

Characteristic Flow Hydrograph and Phasing

Given the lack of suitable flow or level records at the ungauged locations, the 3 parameter regression-based equations from WP3.1 will be used to derive a representative design hydrograph based on the BFI, FARL, ALLUVIAL soils, ARTDRAIN artificial drainage and S1085 catchment average slope. Local catchment knowledge from anecdotal sources and OPW will be used to modify the derived hydrograph where the catchment response is known to be atypical, such as rapid responding urban catchments in Mallow. The derived hydrograph will then be compared with the symmetrical hydrograph produced from previous FSR/FEH methods for flows above 50% of the peak flow and discussed with OPW to agree the most appropriate design hydrograph.

The phasing of inflows will be based on the observed time difference discussed in Section 5.3.4 above, and compared with the FSU time difference equation (WP 3.4). The timing of hydrograph will be adjusted so that the peak occurs at the time predicted at the gauged location downstream and in the modelled reach.

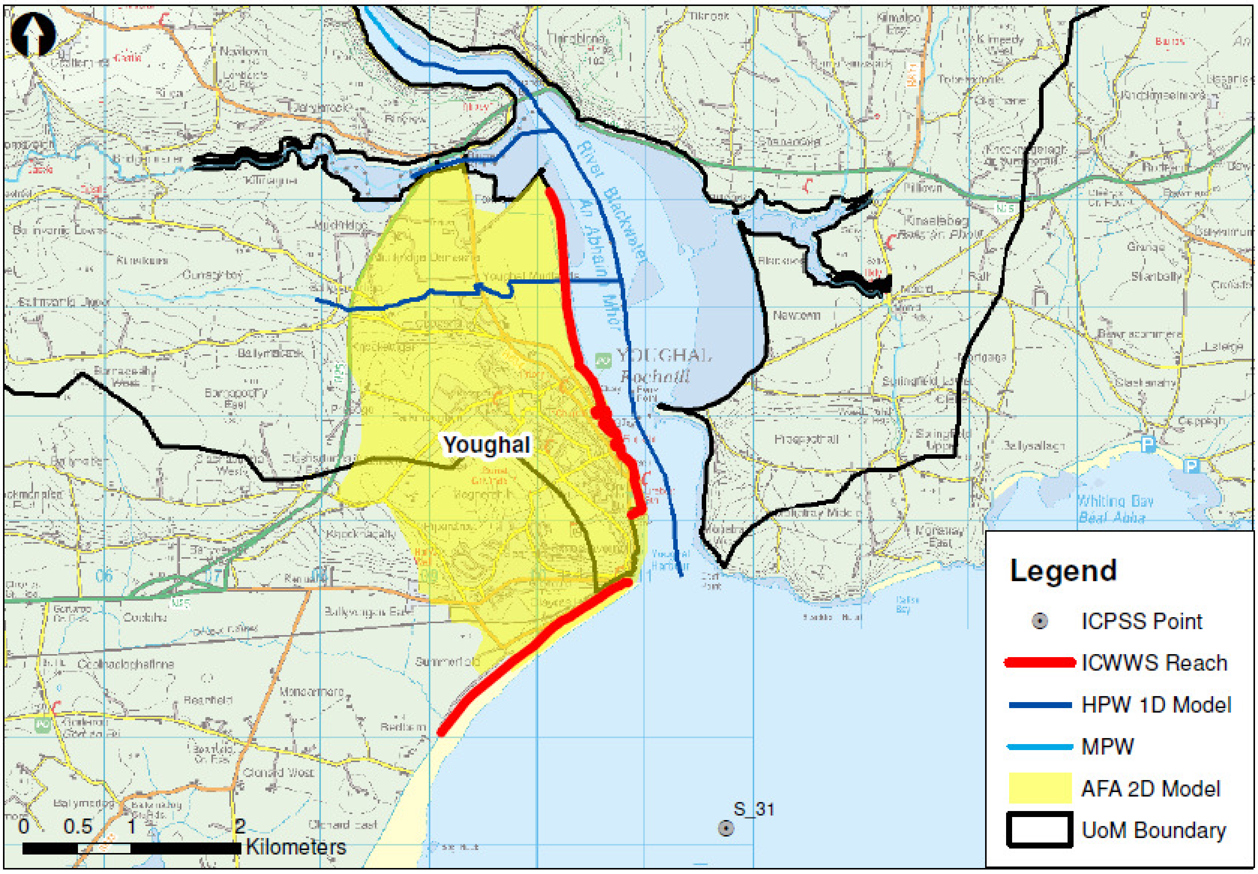
5.3.6 Approach for Tidal Locations

The Munster Blackwater and the River Bride are tidally dominated downstream of Lismore and Tallow respectively. Contributing sub-catchments in the lower reaches for these two rivers will be calculated as for fluvial catchments. However, the downstream tidal conditions will be derived as follows.

Design Extreme Sea Levels

The design extreme sea levels at ICPSS point S_31 will used to inform the tidal conditions at the downstream limit of the Munster Blackwater (211351,76503) for the specified 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP event. The extreme sea levels will be compared with other available information from the ICWWS and the historic flood records of tidal flooding in Youghal to verify the levels and relative frequency of flooding. The hydraulic model of the Blackwater Estuary at Youghal (Map 5.2) will then transform the water levels upstream fully considering the shoaling effects and the combination with the fluvial inflows.

Map 5.2: Proposed Coastal Model Extent at Youghal AFA

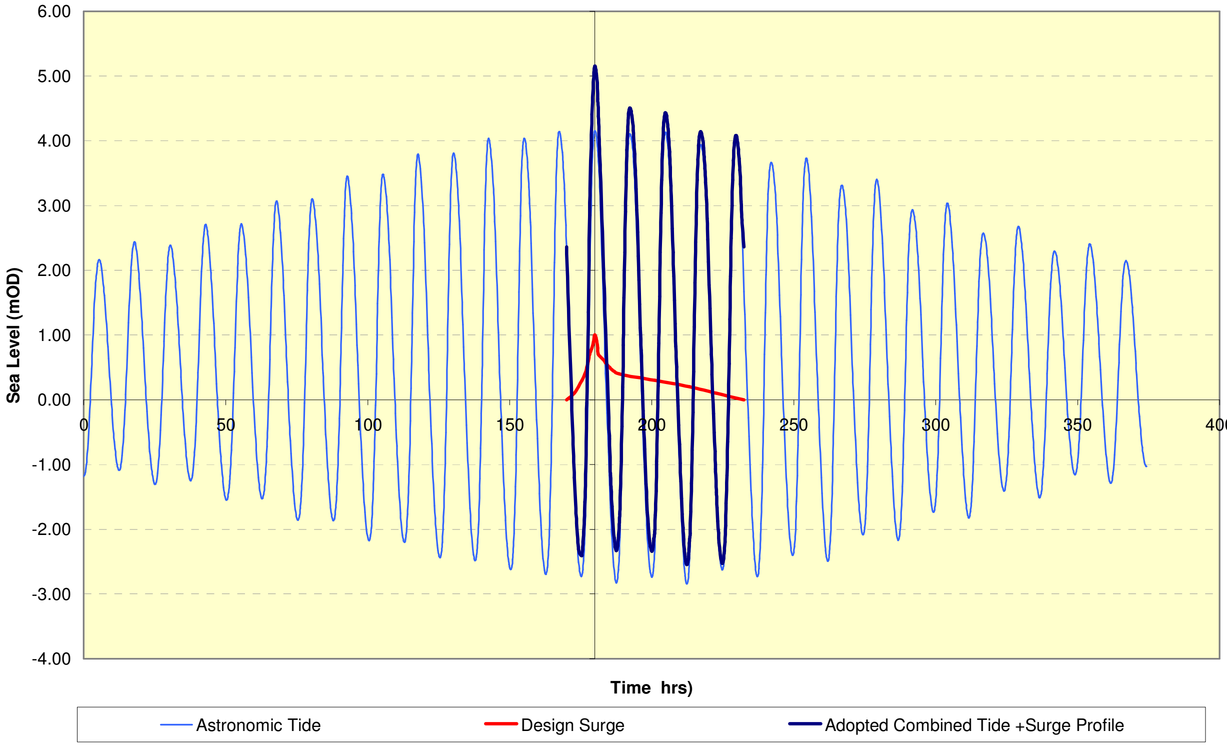


In addition to the peak water levels, the tidal hydrograph shape is key in determining the volume and duration of tidal flooding and tide-locking of the various rivers flowing into the bays. The tidal hydrograph shape for a low surge residual neap to neap cycle at the Ballycotton tidal gauge (in the neighbouring UoM) will be extracted and used to inform typical tidal shapes in Youghal Bay. The observed typical tidal curve will be compared with the predicted tide at Youghal and other studies such as the ICWWS.

The design surge profile will be derived from observed surge residuals at Ballycotton gauge for historic tidal events since 2007. Given the limited length of tidal records, a simplistic triangular surge profile will also be considered based on local knowledge, our experience of surges in locations such as Cornwall and the OPW's knowledge of surge durations. The preferred surge profile will then be agreed with OPW before being standardised and scaled on top of the astronomic curve to meet the design extreme sea levels Figure 5.2. We will phase the peak surge with the peak tidal cycle level as a conservative estimate of flood risk.

Recent research (DEFRA FD2308) indicates that the joint probability of extreme tides and fluvial flood events can be highly variable depending on the meteorological storm pattern that causes these flood events. It is proposed to phase the peak of the fluvial flood with the peak tidal cycle in the Blackwater Estuary at Youghal as the most conservative estimate of flood risk for this reach.

Figure 5.2: Example of Design Tidal Hydrograph for a Coastal Flood Event



Wave Conditions

Youghal Harbour has been identified as a Coastal Area Potentially vulnerable to wave Overtopping (CAPO) by the ICWWS. This study suggests there remains a residual risk from wave overtopping of coastal defences even when the extreme water level is below the flood defence crest levels due to wave run-up. The joint probability of extreme sea level and extreme wave conditions will be discussed and agreed with OPW drawing on recent research such as the DEFRA FD2308 report.

In order to simulate the flood hazard resulting from wave overtopping, the wave height, wave period and mean wave direction will be extracted from the ICWWS at the shoreline. These wave conditions will be used to derive discharge-time hydrographs externally to the hydraulic 2D TUFLOW model of Youghal.

The wave overtopping discharges will be calculated using the methodology Mott MacDonald has successfully developed for the East Coast of England based on Besley (1999) combined with hydraulic principles to estimate discharges for climate change conditions. This approach assesses both current and future risk with climate change which often extends beyond the design life of the existing defences. The resulting discharges will be compared with the HR Wallingford's EurOtop methodology and validated by the experiences of the local maritime communities, the local council and other relevant stakeholders.

5.3.7 Future Scenarios

The design hydrology described in Sections 5.2.4 to 5.2.6 will be based on present day climate conditions (2012). However, climate change is predicted to change the hydrological conditions over the next 100 years. The predicted impacts of climate change over the next 100 years are likely to include:

- Increase in rainfall depth,
- Increase in flow,
- Sea level rise (including land movement),

For the SW RBD CFRAMs, Table 5.4 sets out the predicted changes in the key catchment parameters over the next 100 years. The range of potential impacts of climate change may vary AFA to AFA as there are significant uncertainties associated with global climate predictions and local variation in urbanisation and forestation beyond 20 years. Therefore, two scenarios will be assessed to quantify the sensitivity of flood risk to these uncertainties, namely; the Mid-Range future scenario (MRFS) and the High-Range future scenario (HRFS) as detailed in Table 5.4.

Table 5.4: Allowance for Change in Catchment Parameters Over 100 Years

Catchment Parameter	MRFS	HRFS
Extreme Rainfall Depth	+20%	+30%
Flood Flows[1]	+20%	+30%
Mean Sea Level Rise[1]	+0.5m	+1.0m
Land Movement[2]	-0.5mm/year i.e. -0.05m over 100 years	-0.5mm/year i.e. -0.05m over 100 years
Urbanisation	Specific to each Town	Specific to each Town
Forestation[3]	Tp reduced by factor of 6	Tp reduced by factor of 3 +10% SPR

Note 1: Applies to entire range of flows or tidal levels, not just the peak.

Note 2: Land movements as a result of postglacial rebound since the last ice age. Applies to all locations south of Dublin to Galway which includes the entire SW RBD CFRAM study area.

Note 3: Reduction in time to peak (Tp) and increase in standard percentage runoff (SPR) allows for potential accelerated runoff that may arise as a result of drainage of afforested land.

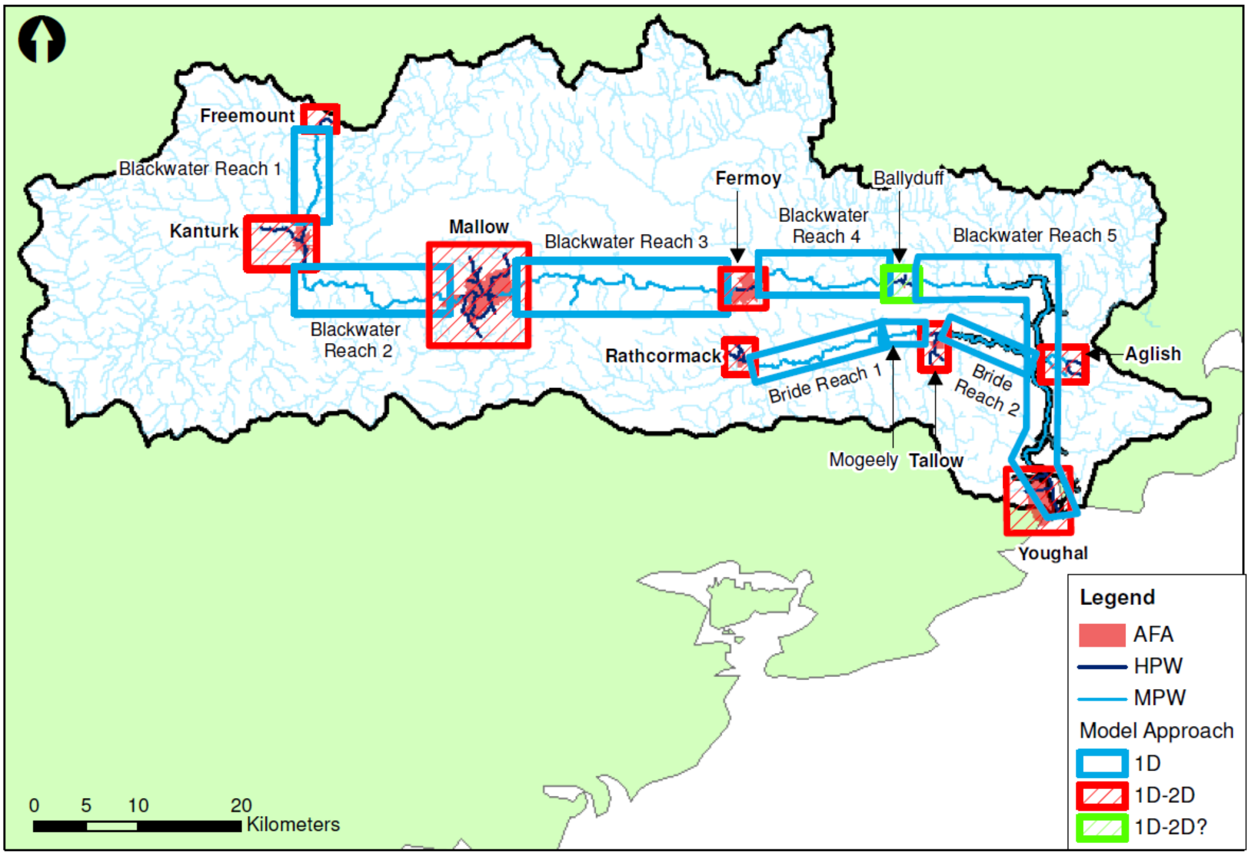
Source: Reproduced from Appendix F of National Flood Risk Assessment and Management Programme, Catchment-Based Flood Risk Assessment and Management (CFRAM) Studies, Stage I Tender Documents: Project Brief.

The urbanisation rates will be based on future development plans from the local councils combined with OPW's local knowledge for each AFA to derive a mid and high annual rate of growth. This will consider a long-term assessment of urbanisation since 1960 (or earlier where records permit) to reduce the influence of the rapid increase from 2000 to 2008 and stagnation in since 2008 in some areas. This will then be extrapolated over 100 years to adjust the extent of urban land cover (URBEXT) for each HEP, adjust the representation of urban extent in the hydraulic models of the floodplain and economical appraisal of flood damages.

5.4 Hydraulic Analysis Approach

The Munster Blackwater catchment has been divided into 17 separate model reaches to produce flood extent mapping for all Medium Priority Watercourses (MPW) and flood extent and flood hazard mapping for all High Priority Watercourses (HPW). Map 5.3 summarises our approach to the assessment of flood risk in the Munster Blackwater catchment.

Map 5.3: Approach to UoM 18



Independent hydraulic models will be developed for each reach to simulate the flood risk for the design flood events as follows:

- **1D Hydraulic Models for MPWs:** A 1D ISIS hydraulic modelling approach will be sufficient to simulate peak water levels and flows for intervening MPWs and downstream reaches of the River Allow, Blackwater and Bride where a less detailed flood risk assessment is required by OPW. This approach will be used to developed hydraulic models for the Blackwater Reach 1, 2, 3, 4 and 5 models as well as the River Bride Reach 1 and 2 models including Mogeely Gauge.
- **1D/2D Hydraulic Models for HPWs:** A 1D/2D ISIS/TUFLOW hydraulic modelling approach will be taken for all the AFAs listed in Table 1.2 to enable a detailed assessment of depth, velocity and hazard across urban areas. This approach will be used to develop detailed hydraulic models for Freemount, Kanturk, Mallow, Fermoy, Rathcormac, Tallow, Aglish and Youghal. It may be necessary for the Ballyduff hydraulic model to also take 1D/2D ISIS/TUFLOW approach following a review of the latest LiDAR and river channel survey data due in late 2012.

The Upper Blackwater catchment (upstream of Dromcummer) will be considered as an inflow into the Blackwater Reach 2 model. Hydraulic modelling is not required for the Upper Blackwater catchment as part of this CFRAMS because there are no areas identified for further assessment in the upper catchment as agreed with OPW.

In each case the HPW and MPW hydraulic models will be developed in seven steps as follows:

1. Model Conceptualisation and Configuration: We will review the available maps, existing models at Mallow and Fermoy and other information from OPW and the Local Authorities to understand and schematise the river network. This will focus on changes in slope and channel morphology based on review of the river channel survey; any hydraulic structures and linking watercourses (such as drains); flow routes and barriers such as roads, railways and embankments; major areas of attenuation such as floodplain depressions; and, any areas of noted concern.

2. Representation of Channels, Structures and Floodplain Interface: River channels will typically be represented by a series of nodes (cross-sections) and reaches. The cross-sections will be adjusted if necessary to best represent changes in channel slope, morphology and flooding mechanisms without compromising the stability and robustness of the hydraulic models. We will make informed use of channel roughness guides, such as by Chow 1959, in conjunction with engineering judgement and the river channel surveyors' observations/photos to assign Manning's 'n' roughness values for each reach.

It is important to incorporate all significant online bridges, weirs and culverts in the channel within the 1D modelling for both MPWs and HPWs, considering losses around and through structures. Only those structures that significantly influence flow for the MPW or HPW reach during flood events will be incorporated as specified for the survey. Parameters such as afflux, weir discharge coefficients and structure losses will initially be set to industry standard values using catchment knowledge from site visits carried out at the flood risk assessment stage and the latest river channel survey. Long culverted watercourses can lack survey details particularly on dimensions, conditions, capacity, and additional inflows. It is important to utilise knowledge (such as drainage strategies) from the Local Authorities in schematising culvert sections.

For both the HPWs and MPWs, the river bank elevations will be based on the river bank surveys collected as part of this CFRAM study, ensuring any known low points are fully represented in the river/floodplain interface. In the case of the HPWs 1D/2D modelling, this will usually form the interface between the 1D river channel and the 2D floodplain model; therefore it is vital to have confidence in the surveyed bank elevations which will be verified by spot checks as part of the survey.

3. Representation of the Floodplain and Floodplain Features: A digital terrain model (DTM) will be created using the extended topographic survey at Ballyduff and Mogeely, the latest LiDAR surveys of the AFAs and the national digital elevation model (IFSAR data) for the more rural areas. The DTM will be used to inform the geometry and formulation of the floodplain model. All topographic data will be cross-checked in areas of overlap to ensure consistency on receipt of data.

For the 1D/2D models of the HPWs, a preliminary grid size of 5m will be applied to accurately represent the urban floodplain without compromising the simulation time and efficiency. Any further revisions to the grid size will be determined by the complexity of the floodplain. Key features less than 5m in size, will be explicitly enforced in the 2D domain using 3D breaklines, regions or flow constrictions to modify the underlying grid.

On the floodplain, we propose to use a combination of the following to classify land use: topographic survey data; photographs captured at the time of the survey; OSi Mapping and the EU Environment Agency's latest CORINE dataset. The photographs captured at the time of survey and available aerial photography will then be used to assign the appropriate Manning's 'n' roughness value to each land use classification.

We will incorporate relevant barriers and potential flow routes as identified in the schematisation using 3D breaklines to represent the effective crest of floodplain features such as roads, railways and embankments.

The urban environment can significantly modify flow paths, depth and velocities; to model this satisfactorily requires, in our experience, paying particular attention to how the buildings are incorporated. Buildings can be represented in the 2D models in variety of ways depending on data availability and output requirements. Buildings will be considered using a combination of building footprints raised to a uniform threshold value of 300mm and assigned with depth variable roughness values to enable simple extraction of results of economic, social and environment assessment at a property level. The buildings footprints have been extracted from the detailed 1:5000 OSi mapping at a national scale for use in the CFRAM studies.

4. Upstream Boundary Conditions We will develop appropriate boundary conditions for fluvial inflows and lateral inflows for intermediate catchments. The upstream boundary conditions will apply the design flows from the hydrological analysis or the outflow from the upstream model where the target model reach is located downstream of another a MPW or HPW.

Upstream boundary conditions will typically be located at the HEPs as derived during the hydrological analysis. Where the target model is located downstream of another MPW or HPW reach, we will seek to located the upstream limit where there is a clear defining feature determining the interaction of flow in the channel and on the floodplain such as weir or road. The adjacent models will be run iteratively to fully consider the interaction of flow and level between the upstream and downstream reaches of a catchment.

The orientation and immediate topography at upstream boundary will be considered in the creation of the 2D domain are important in influencing flow routes and flow distribution. It is also important to carefully consider the location of lateral inflows along the 2D boundary to represent inflows from intermediate catchments and/or drainage catchments, distributing and transferring flows between the various drains where appropriate as identified by the Hydrological Estimation Points.

5. Downstream Boundary Conditions All the hydraulic models will be calibrated for historic flood events where there is sufficient data, as outlined in Section 5.2. For a widespread event, the model predicted flows will be calibrated across catchment where there are several gauges along a river. This will mean iterative calibration across several models for larger catchments.

Reality checks will be undertaken instead of model calibration where there is insufficient gauge data or only anecdotal historic flood evidence as set out in Guidance Note 23. The design flood outlines and water level profiles will be checked against anecdotal flood evidence and estimated frequency of historic events as an indicative measure of what might be considered reasonable.

For fluvial reaches, the downstream boundary will typically be represented using water level-time series for calibration/verification which will inform the design stage-discharge relationship downstream boundary for design events. For tidally influenced reaches, water level-time boundaries will be used. The phasing and timing between river flows and the tidal boundary will be such that the peaks coincide in accordance with the joint probability guidance note (due late 2012).

6. Initial Conditions: Where required, appropriate initial hydraulic conditions will be established prior to model simulation.

7. Calibration: A proportionate approach will be taken to the representation of floodplain features. All the hydraulic models will be calibrated for historic flood events where there is sufficient data, as outlined in Section 4.5. For a widespread event, the model predicted flows will be calibrated across catchment where there are several gauges along a river. This will mean iterative calibration across several models for larger catchments.

Reality checks will be undertaken instead of model calibration where there is insufficient gauge data or only anecdotal historic flood evidence as set out in Guidance Note 23. The design flood outlines and water level profiles will be checked against anecdotal flood evidence and estimated frequency of historic events as an indicative measure of what might be considered reasonable.

This calibration will focus on the structure coefficients and head losses at bridges and weirs, as well as Manning's 'n' roughness values for the river channel and floodplain. Section 4.5 summarises the historic events and available calibration data in UoM 18 for each AFA. The limited availability of flow data at Rathcormac and Freemount means that a full event calibration is unlikely to be feasible. Therefore, sensitivity tests will be carried out for relevant hydrological assumptions and hydraulic parameters including sensitivity tests on roughness values and on key structures for urban HPWs.

The models will be used to simulate and map the current and future flood extents and flood hazard for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP fluvial flood events considering scenarios with existing defences in place and without defences in place, to assess the protection afforded by the existing defences.

We will use the resultant modelled maximum water levels and flows for the HPWs and MPWs in addition to the depth, velocity and hazard results for the HPWs, to produce flood extent and flood hazard maps as follows:

- **1D Model Flood Mapping for MPWs:** We will use our in-house tool, developed in ArcGIS, to generate flood maps from one-dimensional model cross-sections, intersecting the maximum water level with the digital terrain model to produce flood extent and flood depth grids. The resultant GIS files will be converted into the appropriate MapINFO GIS format to produce the specified flood maps.
- **1D/2D Model Flood Mapping for HPWs:** Water level, depth, velocity and flood hazard can be directly extracted from the model and then post-processed into the appropriate MapINFO GIS format to produce flood maps. Flood hazard will not consider the impact of debris as specified by OPW. If information is required for the one-dimensional channel, water level lines will be incorporated into the model so that water level, depth, velocity and hazard function can be mapped for the channel.

The flood extent for Blackwater Reach 5 and Youghal is subject to both fluvial and tidal influence. Joint probability analysis of fluvial and tidal events will be undertaken as set out in Section 5.2 of this report to determine the fluvially-dominated and tidally-dominated scenarios. The resultant flood extents from each scenario will be merged to show the maximum extent of flooding from either source thus meeting the CFRAM requirements for flood mapping. This will be an automated process carried out using the 'union overlay' function in ArcMap. The merged map will then be converted to the appropriate MapINFO GIS format to produce the flood extent map. It will not be produced for the other map formats.

5.5 Flood Risk Assessment (FRA)

Flood risk is a combination of the probability and degree of flooding (the 'hazard') and the damage caused by the flood (the 'consequences'). What constitutes hazard and consequences are described below.

Flood hazard can arise from a range of sources of flooding, the SW CFRAM Study addresses the following sources:

- Rivers (fluvial)
- Sea (coastal and tidal)

The following four risk receptor groups are vulnerable to the potential adverse consequences of flooding:

- Society
- Environment
- Cultural
- Economy

We will assess and map the potential adverse consequences associated with flood hazard in each of the AFAs.

5.5.1 Social Risk

The social flood risk shall be assessed, mapped and reported upon using four methods and indicator sets:

- the location and number of residential properties
- the location, type, and an indicator of vulnerability and number of potentially high vulnerability sites, such as residential homes for children, the elderly or disabled, etc.
- the location, type, and an indicator of vulnerability and number of valuable social infrastructural assets, such as fire stations, Garda stations, ambulance stations, hospitals, government and council buildings, etc.
- the location, type, and an indicator of vulnerability and number of social amenity sites, such as parks, leisure facilities, etc.

5.5.2 Risk to the Environment

The flood risk to the environment shall be assessed and mapped and reported upon using three methods and indicator sets:

- The location, type, an indicator of vulnerability and number of installations referred to in Annex I to EU Directive 96/61/EC (1996) concerning integrated pollution prevention and control and other significant potential sources of pollution.
- The location, extent, nature and an indicator of vulnerability of areas identified in Annex IV (1) (i), (iii) and (v) to the Water Framework Directive (EU Directive 2000/60/EC)
- The nature, location, an indicator of vulnerability and areas of other environmentally valuable sites, such as SACs.

5.5.3 Risk to Cultural Heritage

The flood risk to cultural heritage shall be assessed and mapped and reported upon using one method and indicator set:

- The location, type, an indicator of vulnerability and number of sites or assets of cultural value

5.5.4 Risk to the Economy

The flood risk to the economy shall be assessed and mapped and reported upon using four methods and indicator sets:

- The location, type (residential and classifications of non-residential) and numbers of properties, with associated frequency-depth-damage information based on property type
- The density of economic risk expressed as annual average damage (euro / year) per unit area (e.g., per 100m or 500m square)
- The location, type, an indicator of vulnerability and number (and / or lengths) of transport infrastructural assets, such as airports, ports, motorways, national and regional roads, rail, etc.

- The location, type, an indicator of vulnerability and number of utility infrastructural assets, such as electricity generation and sub-stations, water supply and treatment works, natural gas and oil facilities, important telecom interchanges, data repositories, etc.

5.5.5 Indicators of Vulnerability

Indicators of vulnerability are typically a categorisation of vulnerability (e.g., very high to very low) or, a numerical or economic consequence or depth-consequence curve in the event of flooding. The indicators of vulnerability are to be provided by OPW for each type of social, environmental, cultural and economic risk receptor.

The definition of the indicators of vulnerability shall be reviewed and, if necessary and agreed, refinement of the NTCG, subject to approval of the OPW.

5.5.6 Risk Assessments

We will undertake the risk assessments using relevant information for all of the design flood event probabilities for existing conditions and for the MRFS. We will prepare the Preliminary Options Report where the results of the flood risk assessments under the four risk receptor groups shall be described. For each AFA, we will prepare a range of flood risk maps that present the flood risk in a clear manner.

5.6 Strategic Environmental Assessment (SEA)

We will prepare the SEA to have due regard to best practise guidance in the context of its application to CFRAMS which will include the EPA SEA Pack 2010, the Strategic Environmental Assessment (SEA) And Climate Change: Guidance For Practitioners, 2004, the 'Draft GISEA Manual' updated in 2010 and DEHLG guidance on the Implementation of SEA Directive (2001/42/EC): Assessment of the Effects of Certain Plans and Programmes on the Environment Guidelines for Regional Authorities and Planning Authorities November 2004.

5.6.1 Phase I Screening Assessment

A Screening Assessment has been completed by others for this project. Our first task will be to confirm the basis for and conclusions of the Screening Assessment to ensure that all parties are moving from the same starting position in relation to the basis for the requirement for the SEA. This is an important legal consideration which will need to be clearly documented and tracked in later deliverables as the legal process is completed.

5.6.2 Phase II Constraint and SEA Scoping Study

This phase essentially sets the goalposts for the assessment process to ensure that it remains relevant, focussed and coherent. We will assess other plans and programmes relevant to the South Western District and will determine the aspects of such plans / programmes that should be considered as part of the South Western CFRAM Study in order to ensure consistency across the board.

There are clear interrelationships between the mitigation and monitoring measures committed to the SEA for the South Western River Basin District Management Plan and the CFRAM Study SEA which need to be carefully integrated, particularly where requirements for Appropriate Assessment and other such commitments have been identified as being necessary. Similarly, Freshwater Pearl Mussel Plans and

Shellfish Pollution Reduction Programmes in the SWRBD prescribe measures that will be considered in the CFRAM SEA. The Lee CFRAMS SEA will also be considered.

We will complete the necessary desk studies and preliminary site visits to identify any significant constraints which would have a significant influence on the design and / or implementation of any flood risk management measure. We intend to do this by identifying the key environmental sensitivities in the study area, the basis for these sensitivities and how they can be managed such that options are presented to the Steering Group / Progress Group rather than constraints.

In order to assess the vulnerability of sites and areas to flooding it will be necessary to characterise the sites in terms of their sensitivity. Vulnerability of the designated areas / environmentally valuable sites to pollution loading from licensed discharges will be spatially evaluated against 'flood hazard' areas.

5.6.3 Phase III Option Appraisal Study

We will assess and report on the possible environmental benefits and impacts associated with each measure and option. The evaluation of the 'Do Nothing' or 'Do-Minimum' scenarios will be very important to set the context of the FRMP.

We will assess and rank the options (with and without impact mitigation measures) against the environment objectives, indicators and targets identified at the Scoping Stage.

In assessing the options there is a necessity to ensure that the alternatives are evaluated using clear multi-criteria analysis developed in consultation with the OPW. The selection of the evaluation mechanism, weighting and scoring will need to be carefully analysed and subjected to sensitivity analysis to underpin the robustness of the outputs. We will also have due regard to the experience gained by the OPW in the Lee CFRAMS SEA as the statutory consultees (e.g. EPA) will have reviewed the methodology presented therein. It will be important to demonstrate cross-comparability in the logic applied across individual CFRMPs. We will set out clearly the justification for choosing each of the preferred options.

The environmental benefits / impacts of each measure / option may be ex situ or in situ and may be direct or indirect. The relationship between each measure / option and environmental receptor(s) will be considered and a source-pathway-receptor evaluation made. The impacts / benefits will be evaluated with respect to their duration, scale, extent and nature. Cumulative impacts / benefits will also be assessed. Where negative effects are predicted we will set out recommendations for environmental mitigation. Mitigation will follow the 'mitigation hierarchy' i.e. Avoid at source; Reduce at source; Abate on site; Abate at receptor. We will ensure that all mitigation measures pass the SMART test, i.e. specific, measurable, achievable, with responsibility for their implementation clearly assigned and time limited (i.e. when they are required to be implemented). Mitigation measures will be reflective of any prescribed in the Habitats Directive Assessment and will also incorporate relevant mitigation from protected area/species plans.

Having due regard to the proposed monitoring programme, it is very important that third parties to the process understand the legal interpretation of what is meant by monitoring. Certain parties will consider this to be field investigations, etc. however due to the nature of SEA it is more typical to consist of strategic level datasets and monitoring have they are being effected, in this case, the CFRMP.

In specifying the content of the Monitoring Programme we will ensure that validity, accessibility, frequency of update and ownership of the datasets to determine the applicability and the extent to which they are meaningful or 'fit for purpose'.

5.6.4 Phase IV SEA Report

In parallel and close co-ordination with the identification and development of the preferred flood risk management strategy and the preparation of the Flood Risk Management Plan, we will prepare an SEA Report covering the preferred options and Plan. Very importantly it will also contain a history of the SEA process and how it was conducted particularly emphasising stakeholder and public involvement.

5.6.5 Phase V Update of SEA Report

We will undertake any necessary revisions to the SEA arising from submissions on the draft Final Report of the CFRAM Study, including speedy, yet robust SEA on significant changes to the plan.

5.6.6 Production of the SEA Statement

From a legal and process perspective the production of the SEA Statement is the most important phase in the process. The function of the SEA Statement is to identify how the SEA process has influenced the plan. This requires careful scripting, particularly in the context of how differing opinions from consultees have been managed throughout the process.

5.7 Appropriate Assessment

We shall carry Appropriate Assessments in accordance with the requirements of Articles 6(3) and 6(4) of Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora (Habitats Directive) to inform the Competent Authority of whether the plan will have adverse impacts on the conservation objectives of the relevant Natura 2000 sites within the zone of influence. The Appropriate Assessment shall be conducted in accordance with all relevant guidance and legislation including:

- European Communities (Birds and Natural Habitats) Regulations 2011
- NPWS (2012) Marine Natura Impact Statements in Irish Special Areas of Conservation, A working Document.
- DEHLG (2009) Appropriate Assessment of Plans and Projects in Ireland Guidance for Planning Authorities;
- EC (2000) Managing Natura 2000 Sites: The provisions of Article 6 of the 'Habitats' Directive 92/43/EEC.
- EC (2001) Assessment of plans and projects significantly affecting Natura 2000 sites: Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC.
- EC (2007) Guidance document on Article 6(4) of the 'Habitats Directive' 92/43/EEC: Clarification of the concepts of alternative solutions and imperative reasons of overriding public interest, compensatory measures, overall coherence, opinion of the Commission.

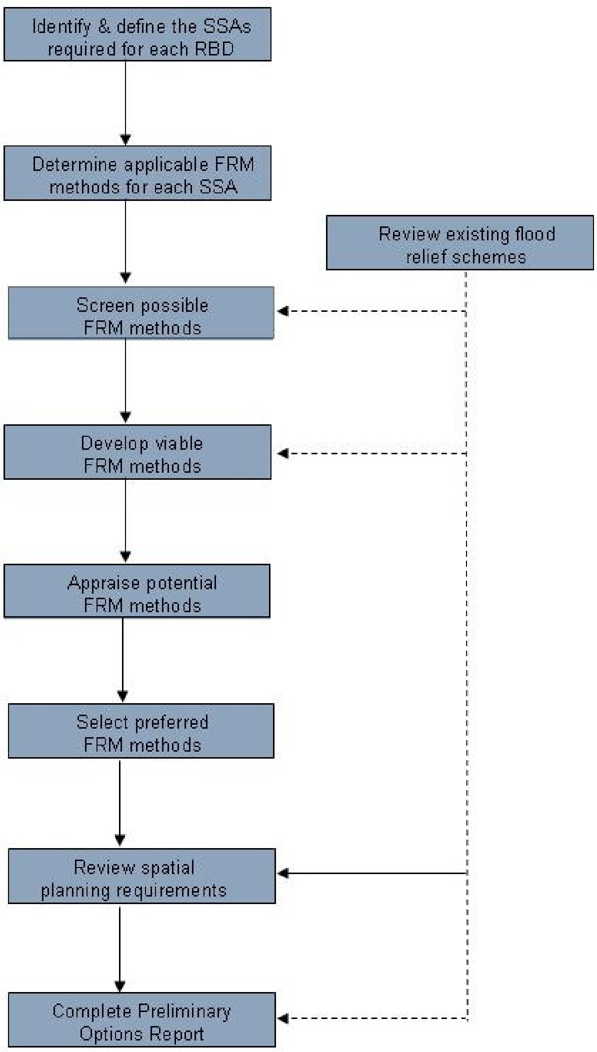
5.8 Development of Flood Risk Management Options

5.8.1 Summary

Each FRMP will set out a list of actions required for various spatial scales. Each action will be supported by a description of the objectives and need for that action, an indicative cost, a timescale for implementing the action, and identification of responsibility.

We will derive these actions from a detailed option appraisal, described in the following Section (and summarised in Figure 5.3). This appraisal will not only identify the recommended way forward, but will also provide robust and clear opinion on why other options were deemed to be inappropriate. This clear and auditable process will provide the requisite sound foundation for future full development of measures to be taken to planning and subsequent implementation.

Figure 5.3: The Flood Risk Management Process



5.8.2 Preferred Design Standards

The preferred design standards that we will adopt for the development of flood risk management options will be the 1% AEP for fluvial flooding and the 0.5% AEP for tidal flooding.

Notwithstanding the above, there may be instances where higher design standards can be accommodated for at little or no additional cost. For example, closure of a low spot, or saddle, within a natural embankment could provide a standard of protection significantly in excess of the required standard for limited additional cost. Where this is the case we will use a benefit:cost analysis to determine appropriate defence levels.

Likewise there may be instances where it is unviable to provide the preferred design standard for every property within an AFA. For example the infilling of gaps in a quay wall may provide a cost effective means of protecting properties from frequent flooding where a 2m high river wall necessary to protect an area from the 1% AEP flood may not be acceptable. In this case we will assess viable options using a benefit:cost model and determine an appropriate way forward.

5.8.3 Flood Risk Management Methods

5.8.3.1 Flood Forecasting Systems

Flood forecasting is one of the commonly used methods of managing flood risk. Although it does not reduce the extent of flooding, it provides a means of reducing the socio-economic impacts of flooding if combined with an efficient action plan.

For each AFA we will investigate the potential for the development of a flood forecasting system. Although envisaged for individual AFAs we consider it important to assess how individual components can be linked. We will use the modelling results from the hydraulic models to initially assess key information such as the travelling time of flow peaks and the relation between flood levels in the AFA and levels recorded at gauges further upstream.

We will develop a conceptual design of rainfall and flow gauges, existing and new, required to provide reliable forecasts. We will gather information as to the availability and accuracy of RADAR rainfall forecasts in the study area which will be pivotal to the accuracy of any water level forecasts. The use of gauge corrected rainfall radar datasets is also being studied by OPW. The output of their study may be of benefit to this study. We will also refer to ongoing studies relating to Storm Surge forecasting to address tidal flood risk forecasting.

As the rainfall – runoff modelling applied for the purpose of flood forecasting requires the consideration of the actual status of the catchment in terms of storages, generally event based approaches such as FSR and FEH techniques are inadequate. We will propose suitable software for the rainfall – runoff modelling based on our and other consultants' experience.

Equally, the hydraulic modelling techniques used for the modelling of flood risk are not necessarily applicable for the purpose of flood forecasting. This is particularly the case where 1D-2D models have been chosen as their run-time renders them unsuitable for flood forecasting. We will propose suitable software and approaches for the routing of flows from catchments to the AFAs.

We will also investigate operational systems which have the ability to link the input data, the rainfall runoff model and routing model together and provide the level predictions in an appropriate format.

Upon agreement of draft conceptual designs we will provide a comprehensive cost estimate for the installation and the operation of the flood forecasting systems.

5.8.3.2 Strategic Sustainable Urban Drainage Systems

The use of SUDS to attenuate discharges and intercept pollution flowing into river and other watercourses, and thus reduce flooding, is a key issue. We would analyse existing information in flood mapping reports on soil types, infiltration drainage capacity, topography, watertable depths and watercourse capacities held by the OPW and other authorities. This baseline information would be used to develop a map showing potential areas in which SUDS might be used.

5.8.3.3 Structural Measures

Storage: In certain circumstances the upstream storage of flood water will be an effective measure to reduce the potential damage that could result from flooding. This is achieved by reducing the peak flow that would be experienced in a watercourse and thereby reducing the depth of flooding experienced for a certain AEP. Flood storage will be effective where the magnitudes of peak flows are relatively small and there are suitable sites upstream of the at risk area to hold the flood water in either a single site or a number of smaller sites. This methodology may be suitable for use in the areas at risk in UoM 20 and 21 which are located on relatively short watercourses. For larger, flatter catchments storage is not always a viable option as the volume of storage required to dampen the peak flow can be very large giving rise to large areas of land that have to be set aside for flood storage. This in turn may lead to the cost of providing storage being prohibitively expensive.

Flow diversion: In certain areas at risk it may be possible to divert peak flows away from areas at risk thus reducing flood depth in those areas during extreme events. Important considerations in deciding whether a flood channel such as this is viable or not include; the topography of the area, the length of by-pass required, the infrastructure that would require diversion (bridges, services, etc.) and the possible backwater effect from where the flood flow rejoins the existing channel.

Flood Defences: In areas where receptors are grouped together it may be feasible to protect them from flooding by the construction of solid flood defences. Earthen embankments can be very effective flood defences as long as the seepage under the defences is not excessive. Embankments require a large footprint and are generally suitable for use in open areas only. Where space for the construction of defences is restricted flood defence walls are required. These can be expensive to construct when compared to embankments as the materials are more expensive and for given ground conditions the depth of groundwater cut-off required for walls is considerably deeper than for embankments. In many AFAs there may be existing flood defences which could be repaired to a useful state. Generally the height of existing defences are much lower than would be required by modern design standards and the level of defence offered by repairing existing defences can be difficult to justify in terms of AEP.

In addition to the above mentioned methodologies we would consider other options for flood risk management including but not limited to works that would lead to improvements in channel conveyance characteristics by the widening and or deepening of river channels, the relocation of properties at risk and the provision of temporary flood barriers where long lead flood forecasting is possible.

5.8.4 Screening of Possible FRM Methods

We will develop flood risk management options for three Spatial Scales of Assessment (SSAs). These are at the Unit of Management Scale, The Sub Catchment or Coastal area scale and the AFA scale. We will develop these options using a defined process which will include:

- An initial high level screening of FRM options
- Development of the screened options to identify tentative scheme solutions
- Appraisal of scheme solutions using a multi-criterion analysis
- Selection of the preferred scheme

The high level screening will look at individual solutions to determine their viability based on a set of criteria, namely: applicability to the relevant area and, economic, environmental, social and cultural aspects. This screening will usually be based upon an assessment of issues and benefits using experience and professional judgement except in specific cases where quantitative data is available. A brief example of an initial screening exercise is provided in Figure 5.4.

Figure 5.4: Example of an Initial Screening Exercise

Identified Risk:	Significant fluvial flooding of 3 residential properties at a calculated rate of occurrence of 2% (on average once in fifty years).
Objective:	Remove flooding to the 3 properties for the 1% AEP
FRM Method:	Construct a Flood Storage Area (FSA) upstream of the properties
Applicability:	Satisfactory. Rural area with geotechnical and geological conditions commensurate with the construction of an impounding embankment. Local construction materials available. Access to construct and maintain the FSA is reasonable.
Economic:	Questionable. The economics of building a FSA to protect only 3 properties are likely to be unviable. There are no realistic opportunities for micro-hydro or amenity benefits.
Environmental:	Slightly positive. Likely to enhance marginal flora and fauna as existing land is used for grazing only.
Social:	Significantly negative. Likely to be extensive land ownership issues with local farmer known to be unwilling to sell. Landowner is an influential local politician.
Cultural:	No known issues
Outcome:	Given the questionable economic outcome of the method and the known issues with land ownership, our recommendation is not to pursue this option.

We recognise the importance at this stage of only ruling out those methods which are clearly inappropriate. For this reason we recommend carrying out an initial review of each method (as above). Where the outcome recommends abandoning the option we will then briefly revisit the screening to expand and

confirm those criteria which are deemed to be critical – in the above example, economics and land acquisition.

5.8.5 Development of Potential Options

When developing options we will utilise those methods which the screening analysis confirmed as being appropriate and develop / combine them into a scheme solution. In most cases we expect that a single solution (e.g. enhancement of flood defences within the urban area) will be unlikely to fully mitigate the identified risk. We will therefore need to combine this with other approved methods, such as implementation of a sustainable urban drainage system, provision of upstream storage, construction of a flood bypass channel or implementation of a catchment wide flood forecasting and warning system.

The intent will be to develop a series of schemes which each satisfy the identified flood risk objective. The number of schemes identified in this development phase will vary according to the particular issues observed at the locale; however, we would endeavour to provide at least three to enable a realistic comparison and appraisal to take place.

Some of the schemes may have sub-options associated with them (i.e. provide a flood bypass channel in open cut or using a culvert) and some may look at alternative flood design standards (2%, 1% and 0.5% AEP). However, our extensive understanding of flood risk engineering will be used to identify sustainable and innovative solutions while rigorously assessing each scheme to ensure that we do not go down the path of “option overload”.

5.8.6 Appraisal of Potential Options

We will discuss and agree with OPW the detailed methodology to be adopted for the appraisal of the different schemes.

We currently see the appraisal as being a two phased approach involving a multi-criteria analysis set against a series of minimum and aspirational targets for each objective, and a detailed benefit:cost analysis. As with all appraisals of this type, we will endeavour to use quantitative evidence where it is available but recognise that in some cases this will not be possible and in these instances a quantitative approach will be developed.

There are two traditional approaches to a multi-criteria appraisal:
- An un-weighted analysis
- A weighted analysis

The un-weighted approach does not attempt to directly compare say, infrastructure benefits with environmental benefits. It merely assigns a score for each objective. Schemes can then be compared at an objective level, but not at an overall scheme level.

A weighted analysis attempts to allow comparison across objectives by, for example, assigning a factor which allows protection of a cultural asset to be directly compared with an environmental asset. This allows a scoring system to be developed for an entire scheme with the objective being that the scheme that scores most highly is deemed the preferred option. This approach has clear advantages over the un-weighted analysis in terms of affording much better comparability, but it suffers from the inevitable qualitative assumptions made when setting the weighting criteria.

The weighted multi-criteria analysis will be followed by a standard benefit:cost analysis for each scheme. We do not anticipate incorporating amenity, environmental or similar potential indirect scheme benefits in the economic benefit:cost appraisal, as the results of doing this are highly qualitative; instead we will consider these issues in the multi-criteria analysis.

We will develop scheme costs to the required level of detail. For this we will utilise our extensive internal cost database of similar construction activities, allied to external sources where required. These will include SPONS, WESSEX and the EA's cost database for river based engineering works. We are fully aware that scheme cost assessments carried out at feasibility and outline design phases traditionally underestimate final outturn costs by up to 60%. We will therefore discuss with OPW a rationale for using an optimisation bias in all cost determinations to offset this.

5.8.7 Selection of Preferred Options

The preferred option shall be identified using the above option appraisal methodology. In addition we are required to confirm that the preferred scheme is:

- Viable against all criteria
- The most beneficial option relative to cost
- Spatially coherent
- Temporally coherent

In terms of spatial coherence we will consider whether the scheme provides advantages or disadvantages to other SSAs in the vicinity and in terms of temporal coherence we recognise the need to consider the timing of additional options required as a result of future variation, such as climate change.

For each preferred option we will identify a series of actions and measures which need to be undertaken to implement the scheme. These will then form the basis of the Flood Risk Management Plan. In addition, and in consultation with OPW and the steering and stakeholder groups, we will prioritise the actions, taking account of potential budgets and time constraints.

5.8.8 Spatial Planning and Impacts of Development

We will review the Development Plans, Local Area Plans and any other spatial planning documents relevant to each AFA and each Unit of Management as a whole, including Plans or documents in force or in draft form at the time of the review.

We will discuss potential land use, spatial planning and development management policies, objectives, zoning and issues with the planning departments of Local Authorities whose jurisdiction falls in part or in whole within the AFAs and / or Units of Management.

On the basis of the review and discussions and with reference to all other work undertaken under the Project, and to the Guidelines on the Planning System and Flood Risk Management, we will develop and discuss the high-level draft recommendations. We note that such recommendations shall, where appropriate, form actions or measures to be included in the FRMP.

5.8.9 Preliminary Options Report

We will prepare and submit the Preliminary Options Reports. In particular we note the requirements to potentially provide copies of the Spatial Planning and Strategic SUDS sections of the report in isolation and the need to prepare separate reports for each Unit of Management within the study area.

5.9 Flood Risk Management Plan (FRMP)

We will prepare a separate Flood Risk Management Plan (FRMP) for each Unit of Management, including a 10-15 page executive summary that can be read in isolation.

The FRMP will briefly outline the Project and the flood risk assessment and analysis, and then clearly set out the flood risk management policies, strategies, actions and measures (proposed) to be implemented by the OPW, Local Authorities and other relevant bodies.

The flood extents generated will be used to assess the flood risk in the study area in terms of the economy, society, the environment and cultural heritage. This will be done using the methodologies outlined in our tender submission in conjunction with the receptor data listed in Section 3.1.6. This data will be supplemented with property occupancy data gathered from each AFA.

Following the completion of the analysis of the potential damage that could be caused by flooding we will investigate the available options to mitigate that damage in each of the AFAs as described in our submission. For Mallow and Fermoy this will be limited to the development of maintenance and monitoring programmes for the existing Flood Relief Schemes.

We will carry out environmental assessments as described in our tender methodology. The Appropriate Assessments carried out will determine the environmental impacts of each of the various potential flood risk management options identified. These assessments will form an integral part of the selection of preferred options.

Throughout the study we will seek to engage with stakeholder as set out in the Communication Plan.

We understand that the FRMP will be publicly available, and should be non-technical and suitable for use by politicians, stakeholders and the public. The main text of the FRMP will typically be in the order of 100 pages in length (excluding the executive summary and appendices).

The hydraulic models developed for the assessment of current and future flood risk will be used to develop and appraise the potential strategic flood risk management options developed in the flood risk management plan. The modelling results will be compared to the existing risk and used to inform the economic, social and environmental impacts for each proposed option.

Subsequently, the model results will be used to develop and assess sustainable flood management options as part of the FRMPs.

5.10 Constraints and Opportunities

The key hydrological constraints for the UoM 18 are associated with water level, flow and rainfall gauge data availability both in terms of spatial and temporal coverage. The data availability and quality has been assessed as part of the data review (Chapter 3 in this report).

The key hydraulic constraints for the UoM 18 are as follows:

- The spatial coverage of the river channel survey which could limit accuracy in more rural areas (see Chapter 4 in this report)
- The spatial coverage and quality of topographical data for the floodplain which could limit accuracy in more rural areas where IFSAR data is used(see Chapter 4 in this report)
- The spatial and temporal coverage of river flow and level data which could limit calibration of the hydraulic models, especially for AFAs such as Freemount, Aglish and Rathcormac which have limited data available (see Chapter 5 in this report). In such data poor locations, the design flood outlines and water level profiles will be compared with anecdotal flood evidence and estimated frequency of historic events as an indicative measure of what might be considered reasonable in place of full calibration.
- The limited timescale in which OPW have to develop the draft flood risk maps ready for the EU Floods Directive deadline of 01 January 2014 constrains the detail in the hydraulic modelling approach for MPWs. Therefore, a strategic approach using 1D modelling has been applied to ensure the EU Flood Directives deadline can be met.

Therefore, the level of assessment outlined in Section 2.1 is proportionate to the level of risk and availability of data so that the EU Floods Directive deadline can be met.

The key opportunities for the UoM 18 arising from the SW RBD CFRAMs are as follows:

- Opportunity to improve understanding on flood risk from fluvial and coastal sources and key flood mechanisms for key AFAs;
- Opportunity to improve underlying topographic and hydrometric data through new surveys and rating reviews of Riverview, Allen’s Bridge, Mogeely and Ballyduff gauges.
- Opportunity to communicate with and build relationship with other stakeholders and local communities, to improve knowledge and understanding of the risk and viable options to mitigate any existing risk.
- Opportunity to improve management of flooding whether through development of flood alleviation schemes, property level protection measures or improve flood forecasting and warning services to better prepare local communities.

6. Summary

6.1 Progress to Date

6.1.1 Flood Risk Review

The Flood Risk Review has been completed and the final AFA definitions agreed. This process included a review of the PFRA outputs, data collection on historical events and consultation with Local Authorities and Stakeholders. Following this, site inspections were carried out which informed the final AFA definitions. These AFA's are listed in Table 1.1.

6.1.2 Hydrological Analysis

Chapter 4 of this report assess the hydrometric, meteorological and historic flood data for UoM 18 Munster Blackwater (Munster). The key findings include:

- There are 5 suitable river flow gauges for the derivation of design flows along the Munster Blackwater, 2 along the River Allow and 1 along the River Bride.
- There are 15 river level gauges out of a total 36 gauges suitable for calibration and assessment of hydrograph shape for the AFAs in UoM 18.
- The Aglish, Rathcormac, and Youghal AFAs do not have any river flow or water level gauges. Freemount AFA also does not have any river flow or water level gauge data but it is anticipated the gauge at Kanturk provides a good proxy for the upper catchment of the River Allow include Freemount.
- There are no tidal gauges within this UoM 18 which limits the tidal analysis at Youghal.
- Preliminary flows and return periods were estimated for 8 historic flood events since reliable records began in 1980.
- The November 2009 flood event is the largest magnitude events which flooded large areas of the Munster Blackwater and Bride catchments and over €100 million in damages within the catchment.
- Three separate catchment-wide calibration events were selected for the hydrological and hydraulic calibration namely; 19th November 2009, 6th November 2000 and 2nd November 1980.
- Typical flooding mechanisms were identified for each of the AFAs based on historic flood evince and the flood risk review reports.

Section 5.2 of this report expands on the proposed hydrological methodology as applied to UoM 18. The hydrological method statement incorporates the latest Flood Studies Update approach and sets out the methodology for the assessment of design flows including:

- Rating reviews at 4 gauging stations to update the extreme flows and subsequently the Annual Maximum Flood Series (AMAX);
- Conceptualisation of 7 MPW and 10 HPW hydraulic model reaches (17 in total);
- Conceptualisation of over 105 HEPs to form the inflows, intermediate targets and downstream conditions to those hydraulics models;
- Estimation of the design index flood value, flood growth curve and typical hydrograph shape at gauged and ungauged fluvial locations;
- Estimate of tidal boundary conditions at Youghal; and,
- Assessment of climate change impacts on design hydrology over the next 50 and 100 years.

6.2 Upcoming Works

Following this inception report, the following tasks will be undertaken for UoM 18 to meet the deadlines set out by the EU Flood Directive:

- River Channel Survey – completion date unknown due to FPM issues
- Hydrological Analysis – to be completed by June 2013
- Draft Flood Maps and Hydraulic Report – to be completed by June 2013
- Public Consultation and Engagement on Draft Flood Maps – September to October 2013
- Final Flood Maps and Hydraulics Report – to be completed by January 2014
- Flood Risk and Strategic Environmental Assessment – to be completed by July 2015
- Development of Draft Flood Risk Management Plans (FRMPs) – to be completed by April 2014
- Public Consultation and Engagement on Draft FRMPs – January to June 2015
- Final Flood Risk Management Plans (FRMPs) – to be completed by November 2015

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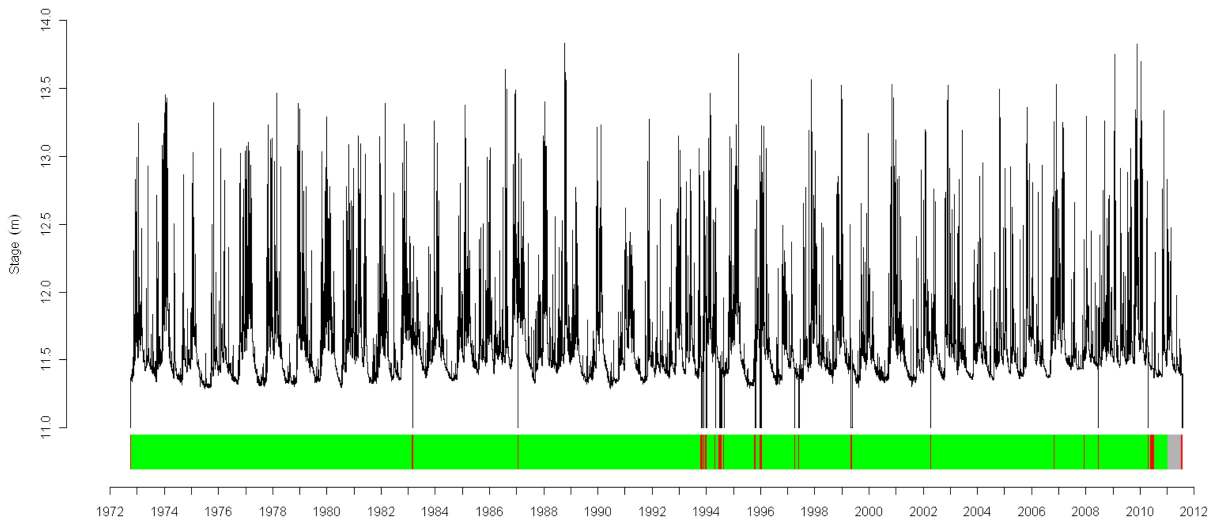
Appendix A. Hydrometric Data Review

Table A.1: Selected Hydrometric Gauge Locations

Stn No.	Station Name	River Name	Model	Easting	Northing	Record Start	Years Data	Owner	Rating Curve	Comments	Fit for Calibration Purposes?	Fit for Statistical Analysis?
18001	Mogeely	Bride	Mogeely & Tallow	195643	94128	01/10/1972	39	OPW	Yes	Majority of flow has been edited by OPW, suitable for use	Yes, following Rating Review	Yes, following Rating Review
18002	Ballyduff	Blackwater	Ballyduff	196493	99111	01/10/1955	56	OPW	Yes	Edited flows prior to 1972 and after 1995 with poor quality flow data since 2011	Yes, following Rating Review	Yes, following Rating Review
18003	Killavullen	Blackwater	Mallow & Blackwater Reach 3	164770	99775	01/10/1955	56	OPW	Yes	Flow quality poor prior to 1972	Yes	Yes, use with caution
18005	Downing Br.	Funshion	Blackwater Reach 4	182331	101833	01/01/1972	39	OPW	Yes	Majority of flow has been edited by OPW, suitable for use	Yes, use with caution	Yes, use with caution
18006	CSET Mallow	Blackwater (Munster)	Mallow	152546	97448	15/06/2000	35	EPA	Yes	Incomplete water years and 2006 missing	Yes	Yes, use with caution
18009	Riverview	Allow	Blackwater Reach 2	138315	100693	27/11/2000	12	EPA	Yes	Peak water level data available from 1982 to 2001 at unequal intervals – can be used in AMAX analysis and calibration Incomplete water years, data missing during winter months of 2004	Yes, following Rating Review	Yes, following Rating Review
18010	Allen's Br.	Dalua	Blackwater Reach 2	133745	104485	22/11/2000	12	EPA	Yes	Peak water level data available from 1982 to 2001 at unequal intervals – can be used in AMAX analysis and calibration	Yes, following Rating Review	Yes, following Rating Review
18019	Fr. Murphy's Br.	Glen	Blackwater Reach 3	139156	96856	01/07/2005	6	OPW	Yes	Missing and suspect data from 2006 to 2007	Yes for events before 2006 and after 2007	Yes, use with caution
18048	Dromcummer	Blackwater (Munster)	Blackwater Reach 2	139796	99320	24/11/2000	12	EPA	Yes	Short record, data corrected for datum shift in 2003, flow data unavailable after 2004	Yes	Yes, use with caution
18053	Glandalane	Blackwater	Blackwater Reach 4	184933	99741	25/06/2002	9	OPW	No	Several missing data periods and anomalous spike in April 2011.Data of good quality during 2009 flood event	Yes for 2009 event only	Hydrograph width analysis only
18055	Mallow Railway Br.	Blackwater	Mallow	155078	97842	29/05/2001	10	OPW	Yes	Several missing periods prior to 2005 and in early 2011, largely in summer months	Yes	Yes, use with caution
18056	Mallow Town Br. U/S	Blackwater	Mallow	156114	97968	18/06/2001	10	OPW	No	Several missing or poor data quality periods, particularly for the downstream gauge. However, good quality and consistency at high flows	Yes	Hydrograph width analysis only
18057	Mallow Town Br. D/S	Blackwater	Mallow	156153	97954	23/05/2001	10	OPW	No		Yes	Hydrograph width analysis only
18102	Castletownroche Weir	Awbeg	Blackwater Reach 3	168562	102476	01/07/2005	6	OPW	No	Short data record, significant missing data periods 2007, 2008 and 2011	Yes for 2009 event only	Hydrograph width analysis only
18106	Fermoy Br. U/S	Blackwater	Fermoy	181109	98503	04/05/2001	10	OPW	No	Missing data for 2004 and suspect data for 2006 shorter suitable record for analysis	Yes	Hydrograph width analysis only
18107	Fermoy Br. D/S	Blackwater	Fermoy	181194	98612	21/06/2001	10	OPW	No	Missing data and suspect data prior to 2004 shortens suitable record for analysis	Yes	Hydrograph width analysis only
18108	Araglin Br.	Araglin	Blackwater Reach 4	184937	101642	21/06/2001	10	OPW	No	Missing data for 2006 and suspect data for 2008 shorter suitable record for analysis	Yes	Hydrograph width analysis only
18109	Lombardstown Br.	Blackwater (Munster)	Blackwater Reach 4	146406	96981	02/07/2005	6	OPW	Yes	Missing data and poor quality data in 2006 shortens record available for analysis	Yes	Yes, use with caution
18110	Kilbrin Road	Allow	Kanturk	138210	103350	01/07/2005	6	OPW	Yes	Missing data and poor quality data in 2006 shortens record available for analysis. Flows outside this period are largely edited to be fit for use	Yes	Yes, use with caution
18111	Church Street	Dalua	Kanturk	137744	103331	01/07/2005	6	OPW	No	Missing data and poor quality data in 2006 shortens record available for analysis.	Yes	Hydrograph width analysis only
18114	Clashmorgan	Lyre	Mallow	153365	92501	02/06/2005	6	OPW	No	Missing data and poor quality data in 2006 shortens record available for analysis.	Yes	Hydrograph width analysis only
18115	Jordans Br.	Clyda	Mallow	157187	91917	01/07/2005	6	OPW	No	Missing data and poor quality data in 2006 shortens record available for analysis.	Yes	Hydrograph width analysis only
18117	Fermoy Mill	Blackwater (Munster)	Fermoy	181430	98630	13/09/2007	4	OPW	No	Short record period of largely good quality data	Yes	No
18119	Ballydahin	Blackwater (Munster)	Mallow	155250	97870	08/06/2009	2	OPW	No	Short record period, data unchecked with anomalous spikes in December 2010/Early 2011	Yes for 2009 event only	Hydrograph width analysis only
18123	Greenane	Allow	Kanturk	138220	103330	23/08/2010	1	OPW	No	Short record period, significant missing data periods in 2010	No	No
18004	Ballynamona	Awbeg	N/A	165657	107552		45	OPW	Yes	Suitable as potential pooling site but not located on any modelled reach AMAX series only available up to 2009 , FSU classed as grade B Detailed flow records not assessed as will only be used for pooling	Not required	Yes, Pooling information only
18016	Duncannon	Upper Blackwater	N/A	118027	93123	03/05/1982	20	EPA	Yes	Suitable as potential pooling site but not located on any modelled reach AMAX series has been checked through FSU, 9 years incomplete so discarded Detailed flow records not assessed as will only be used for pooling	Not required	Yes, Pooling information only
18050	Duarrigle	Upper Blackwater	N/A	124987	94359	05/10/1981	24	EPA	Yes	Suitable as potential pooling site but not located on any modelled reach AMAX series is complete, FSU classed as grade B Detailed flow records not assessed as will only be used for pooling	Not required	Yes, Pooling information only

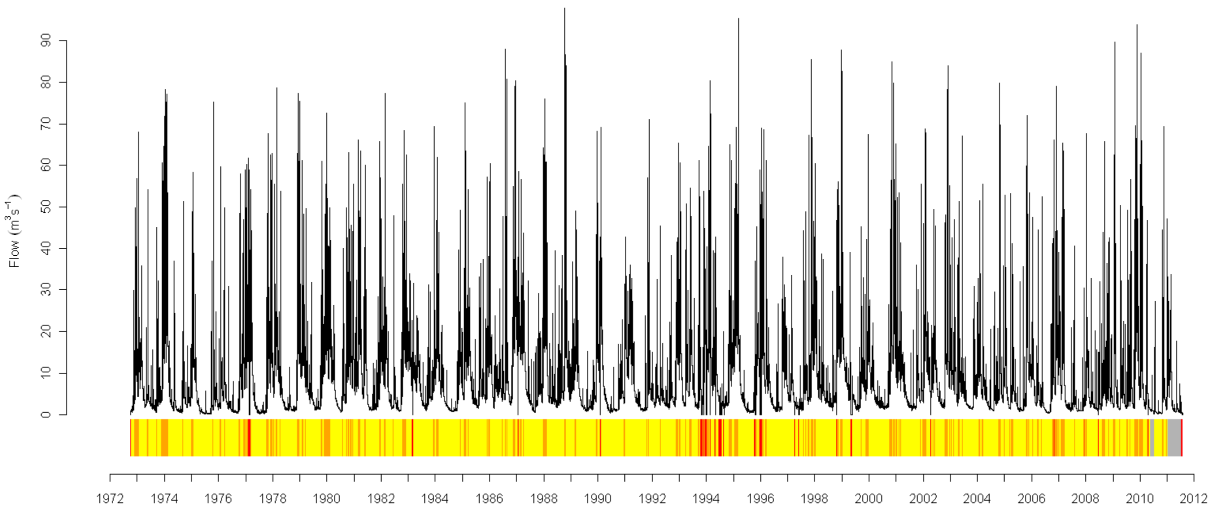
N.B. No plots have been provided for 18004,18016 and 18050 as detailed flow assessment was not required for pooling sites

Figure A.1: Water Level Data Quality Plot for Bride @ Mogeely Gauge (OPW - 18001)



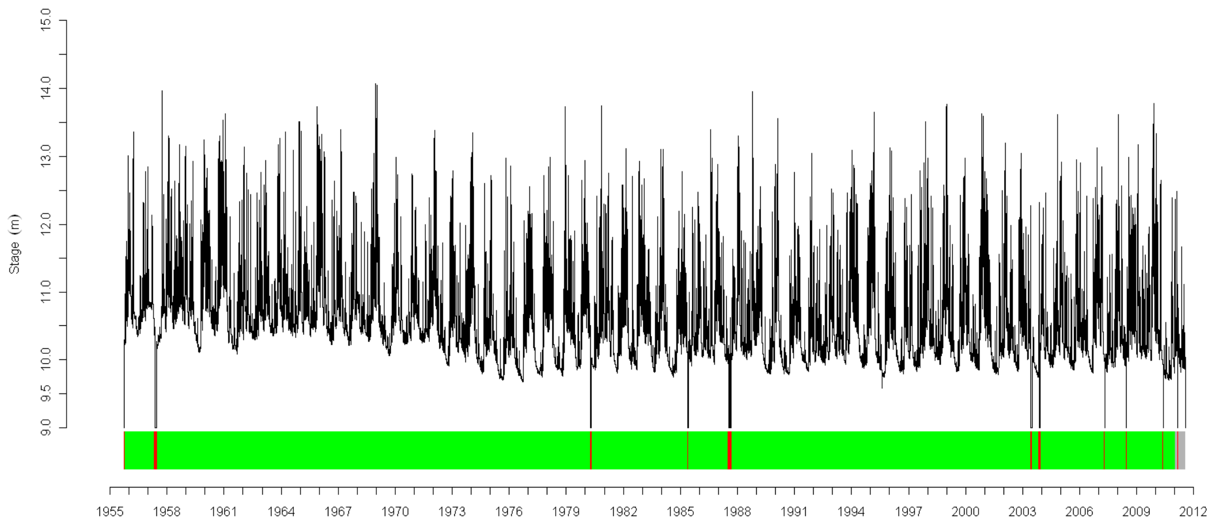
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.2: Flow Data Quality Plot for Bride @ Mogeely Gauge (OPW - 18001)



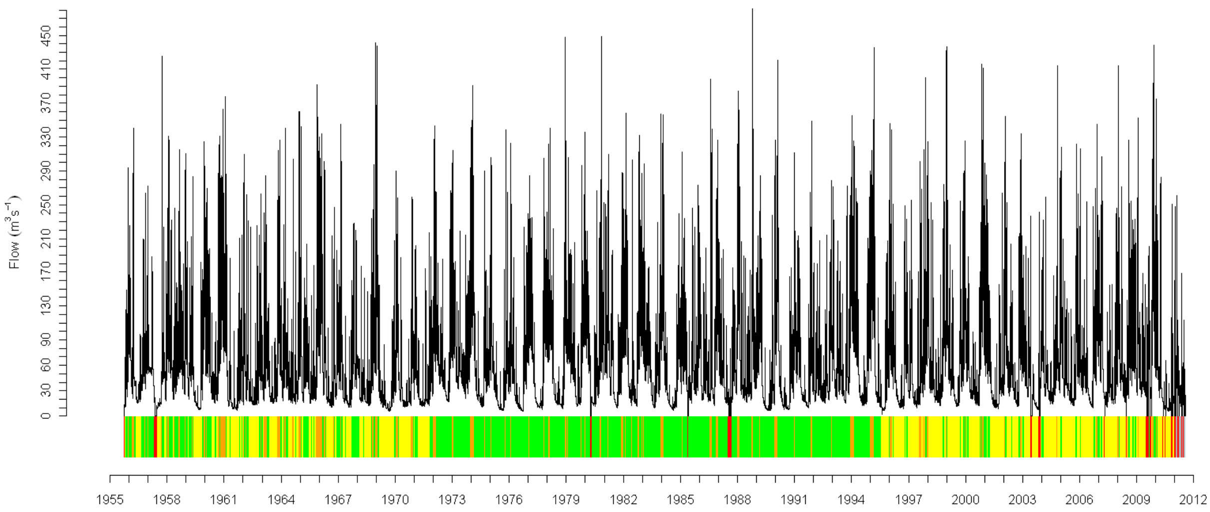
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.3: Water Level Data Quality Plot for Blackwater @ Ballyduff Gauge (OPW - 18002)



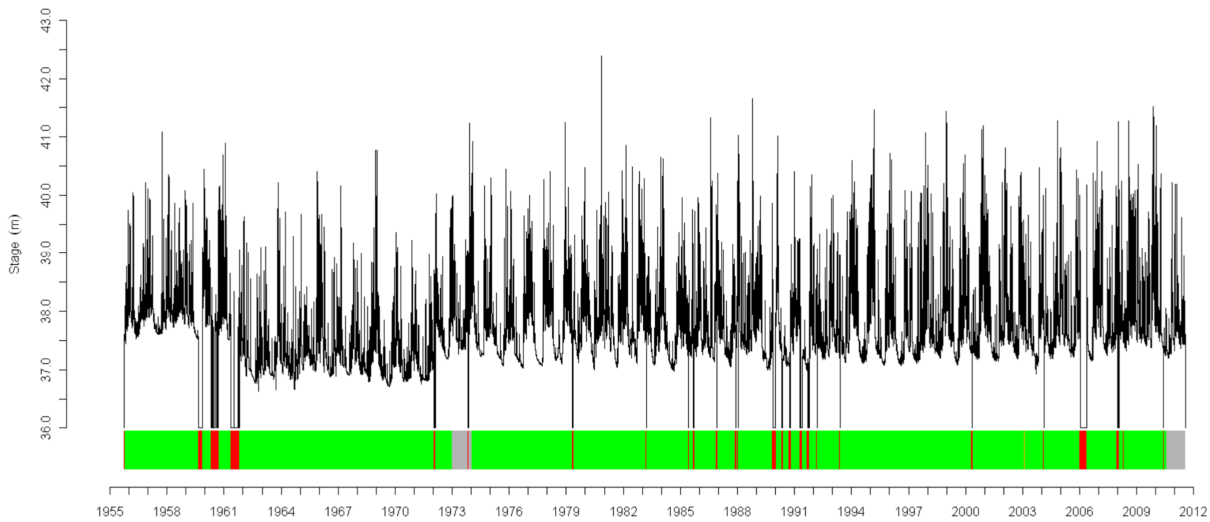
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.4: Flow Data Quality Plot for Blackwater @ Ballyduff Gauge (OPW - 18002)



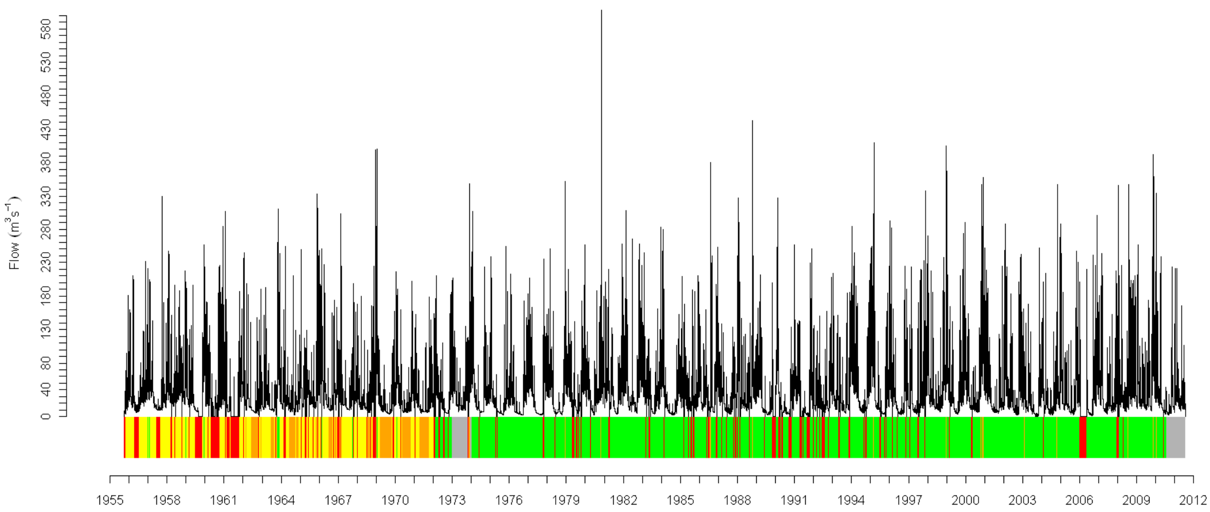
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.5: Water Level Data Quality Plot for Blackwater @ Killavullen Gauge (OPW - 18003)



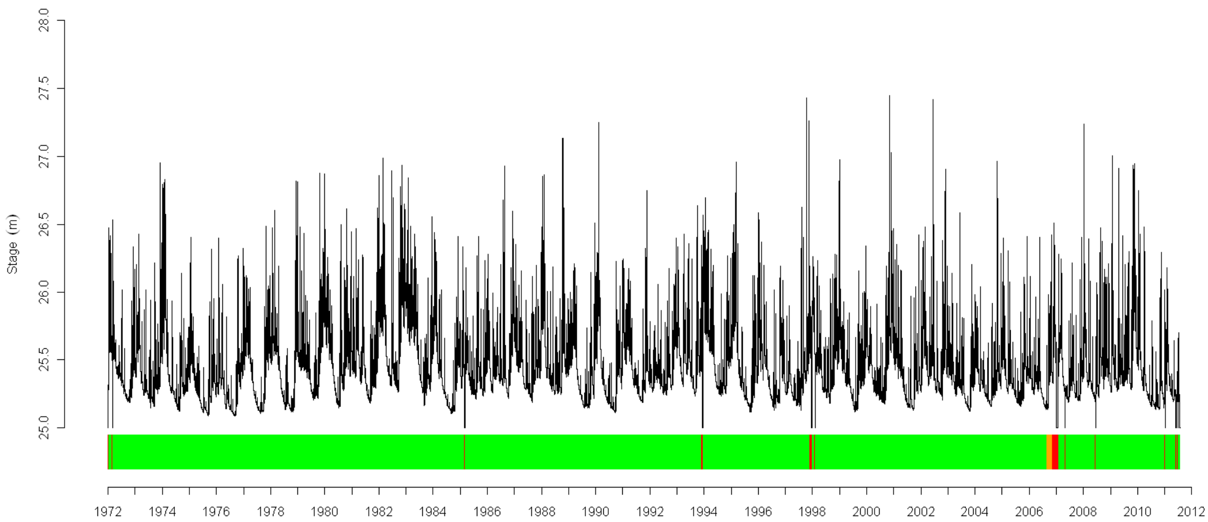
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.6: Flow Data Quality Plot for Blackwater @ Killavullen Gauge (OPW - 18003)



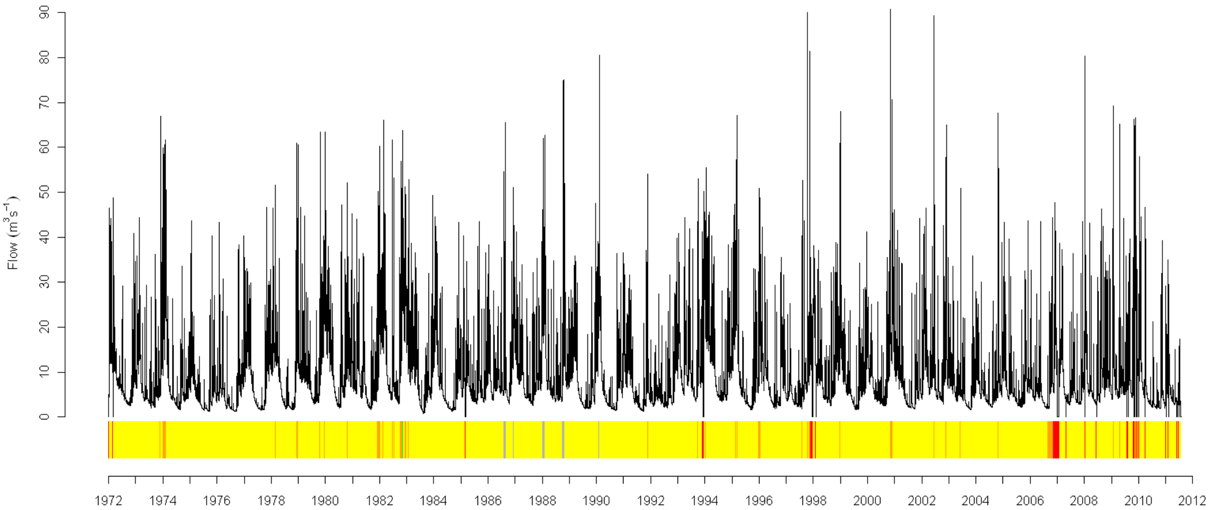
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.7: Water Level Data Quality Plot for Funshion @ Downing Bridge (OPW - 18005)



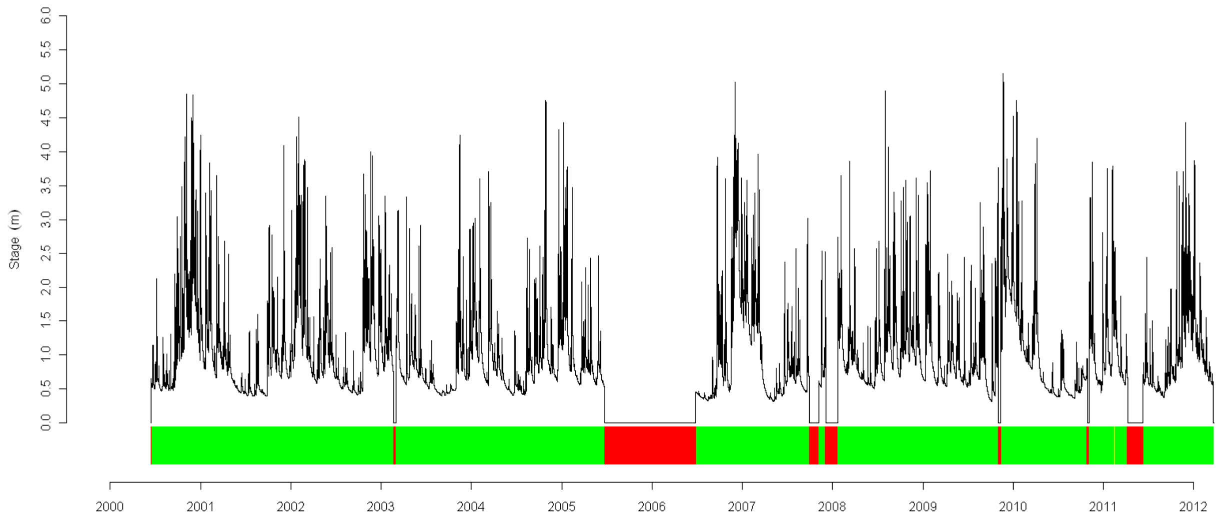
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.8: Flow Data Quality Plot for Funshion @ Downing Bridge (OPW - 18005)



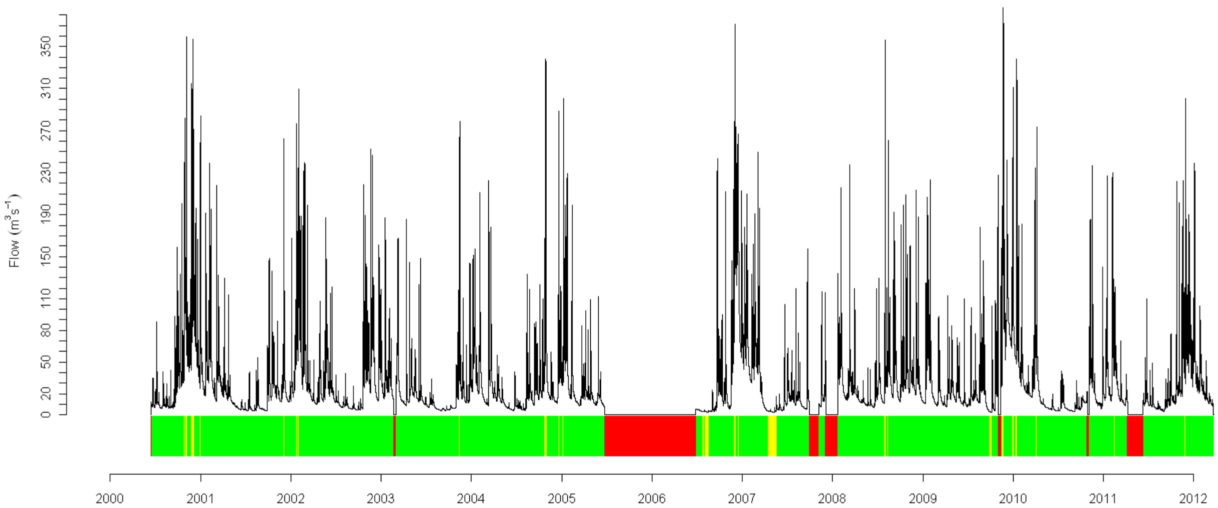
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.9: Water Level Quality Plot for Blackwater @ CSET Mallow (EPA - 18006)



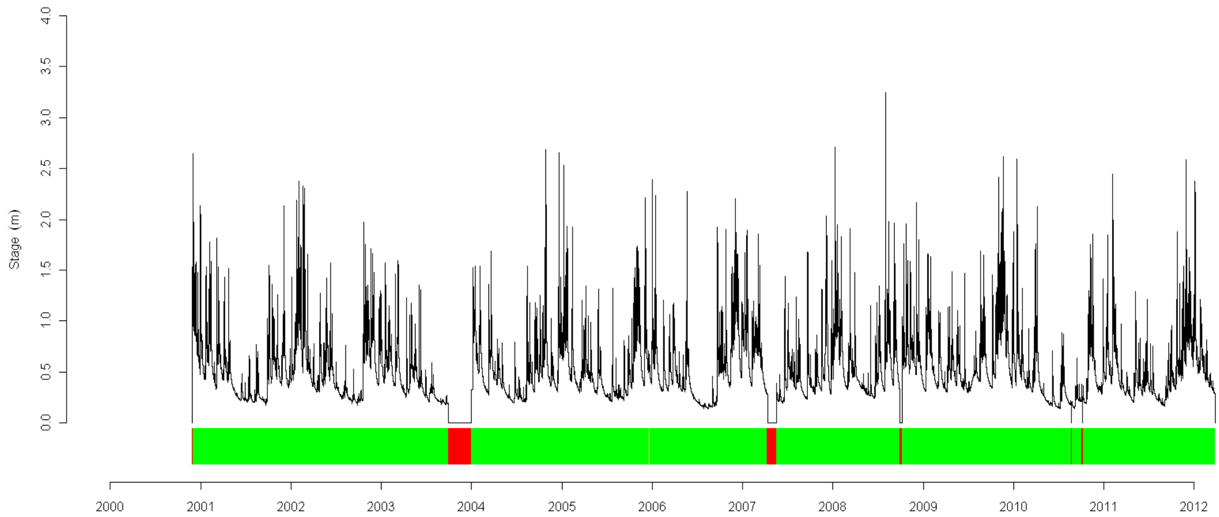
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.10: Flow Quality Plot for Blackwater @ CSET Mallow (EPA - 18006)



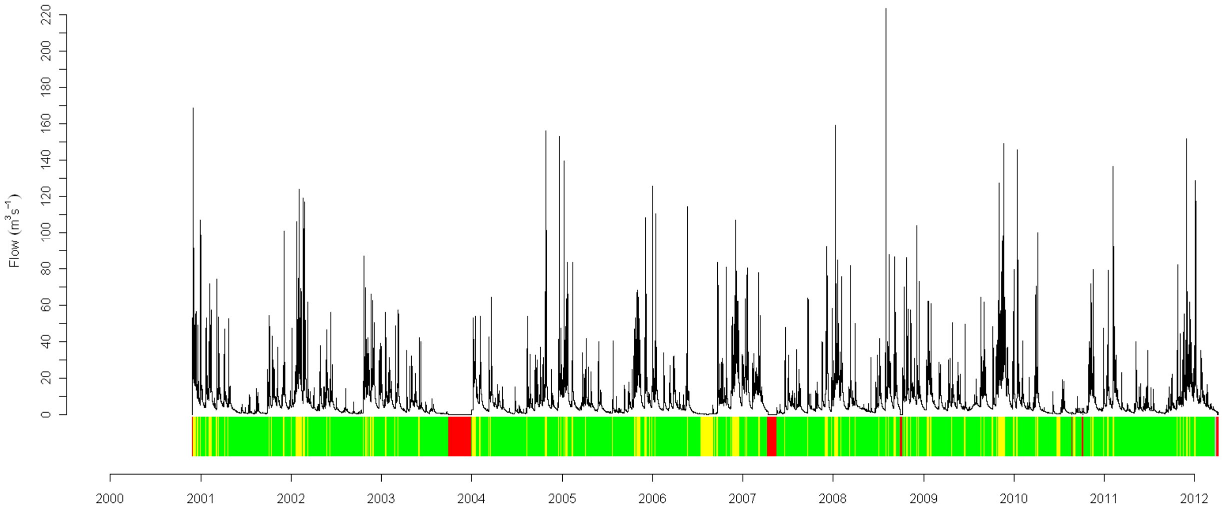
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.11: Water Level Quality Plot for Allow @ Riverview (EPA - 18009)



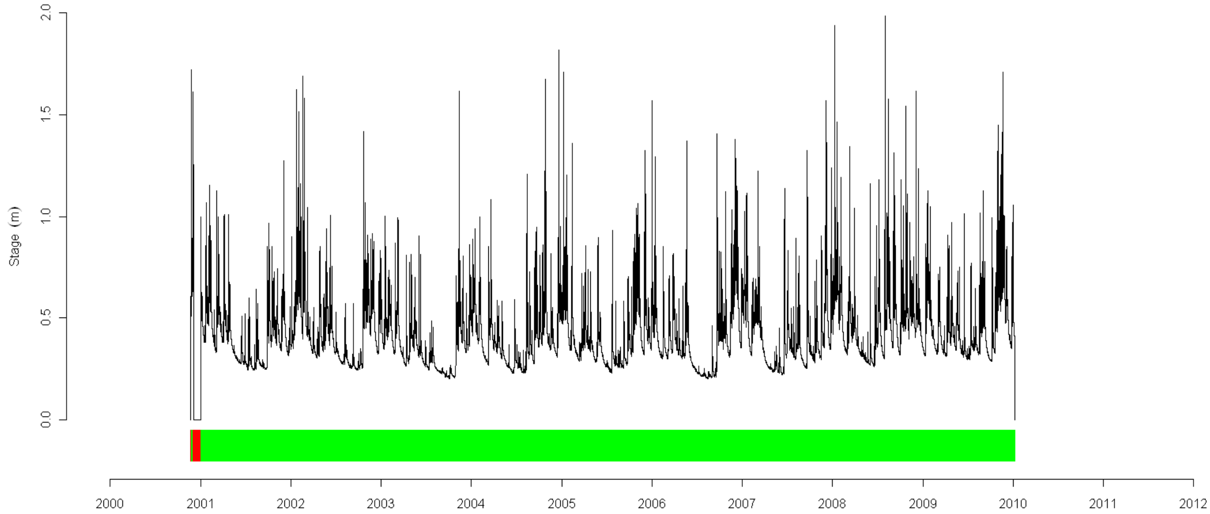
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.12: Flow Quality Plot for Allow @ Riverview (EPA - 18009)



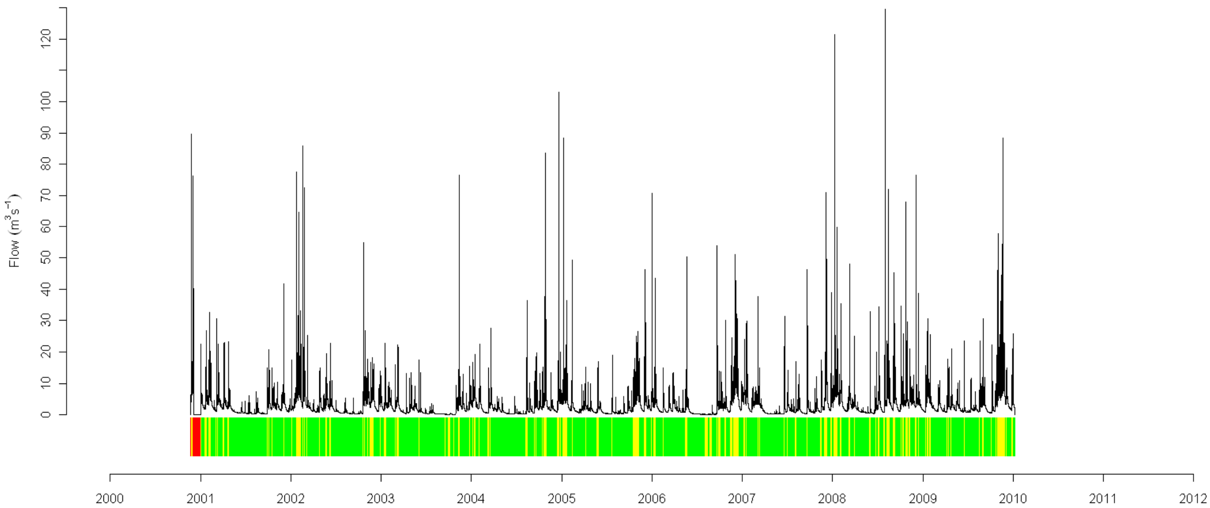
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.13: Water Level Quality Plot for Dalua @ Allen's Bridge (EPA - 18010)



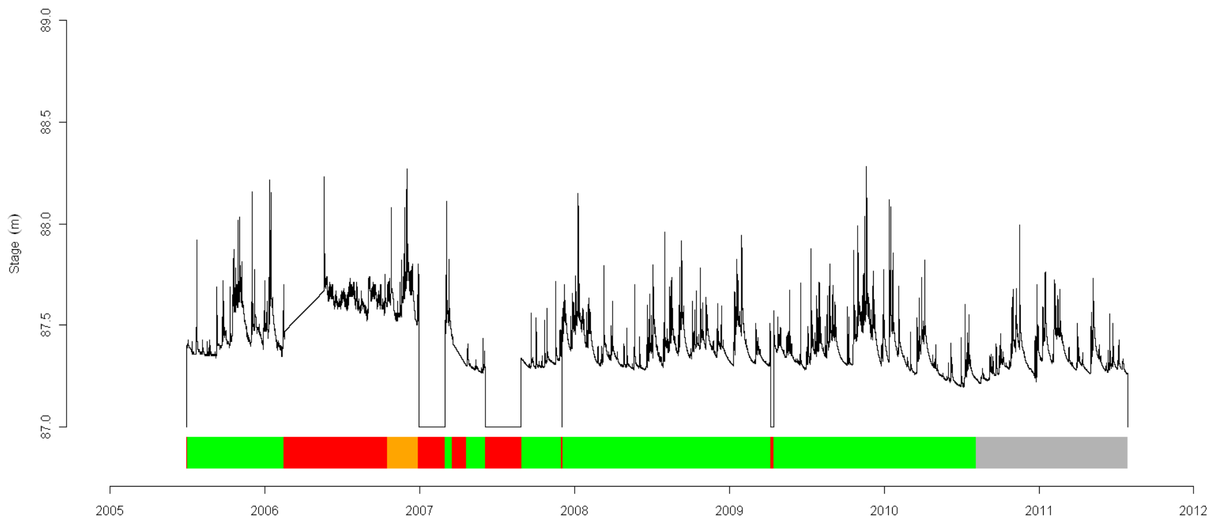
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.14: Flow Quality Plot for Dalua @ Allen's Bridge (EPA - 18010)



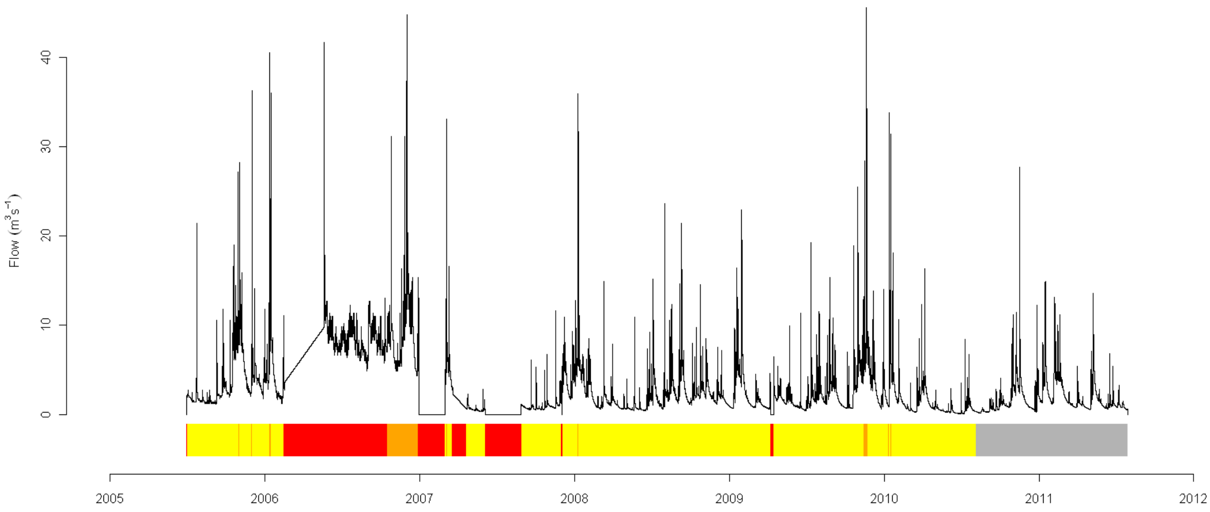
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.15: Water Level Data Quality Plot for Glen @ Murphy's Bridge (OPW - 18019)



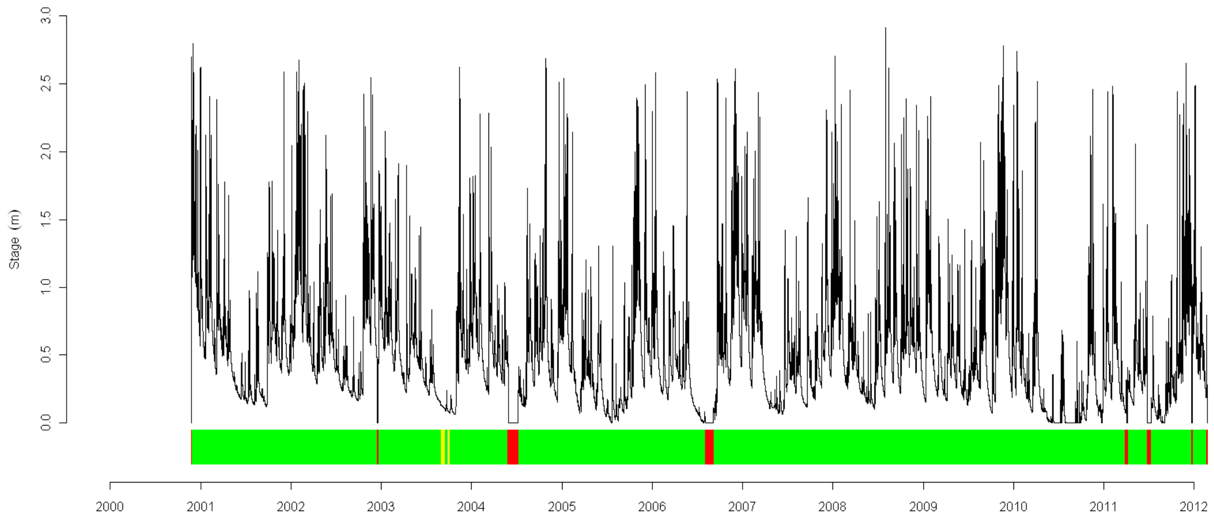
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.16: Flow Data Quality Plot for Glen @ Murphy's Bridge (OPW - 18019)



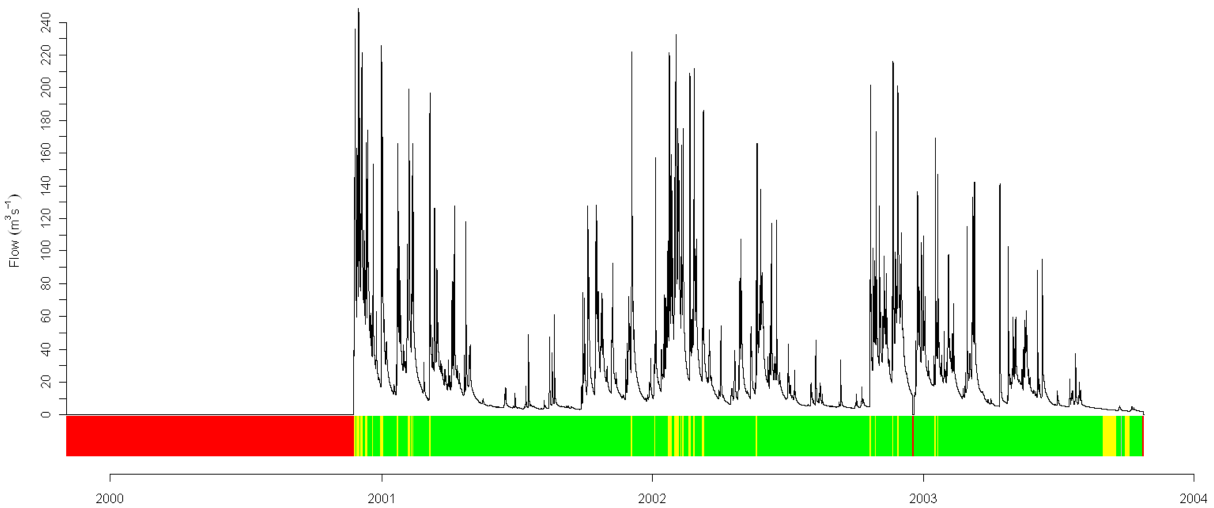
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.17: Water Level Data Quality Plot for Blackwater @ Dromcummer (EPA - 18048)



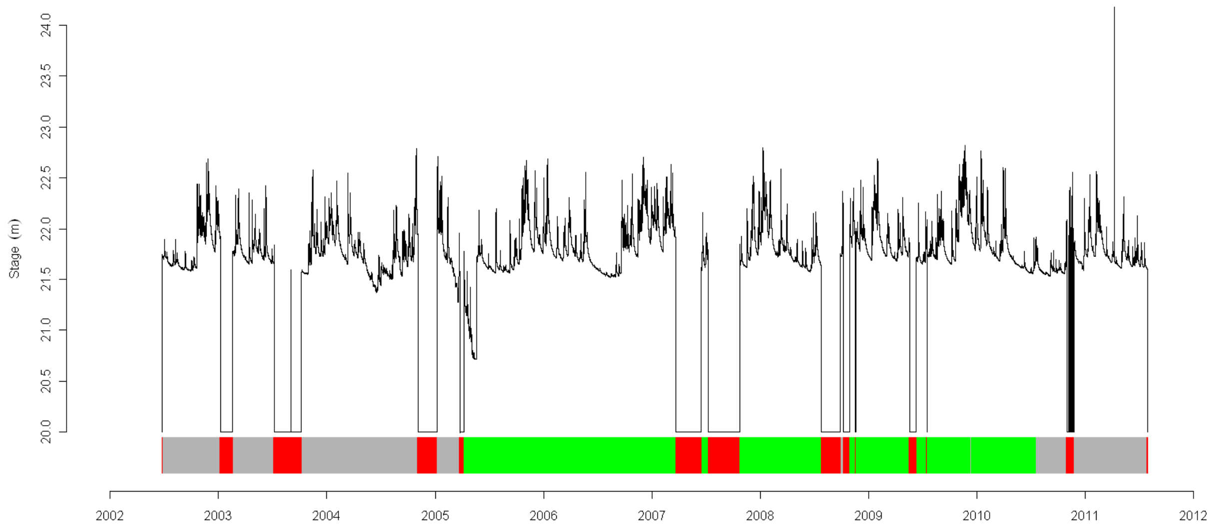
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.18: Flow Data Quality Plot for Blackwater @ Dromcummer (EPA - 18048)



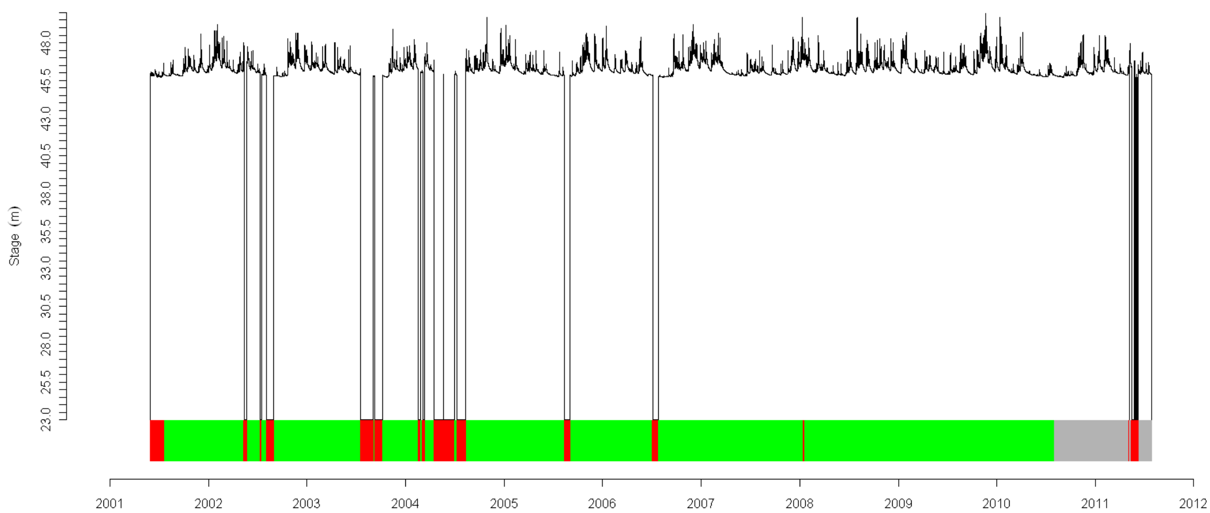
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.19: Water Level Data Quality Plot for Blackwater @ Glandalene (OPW - 18053)



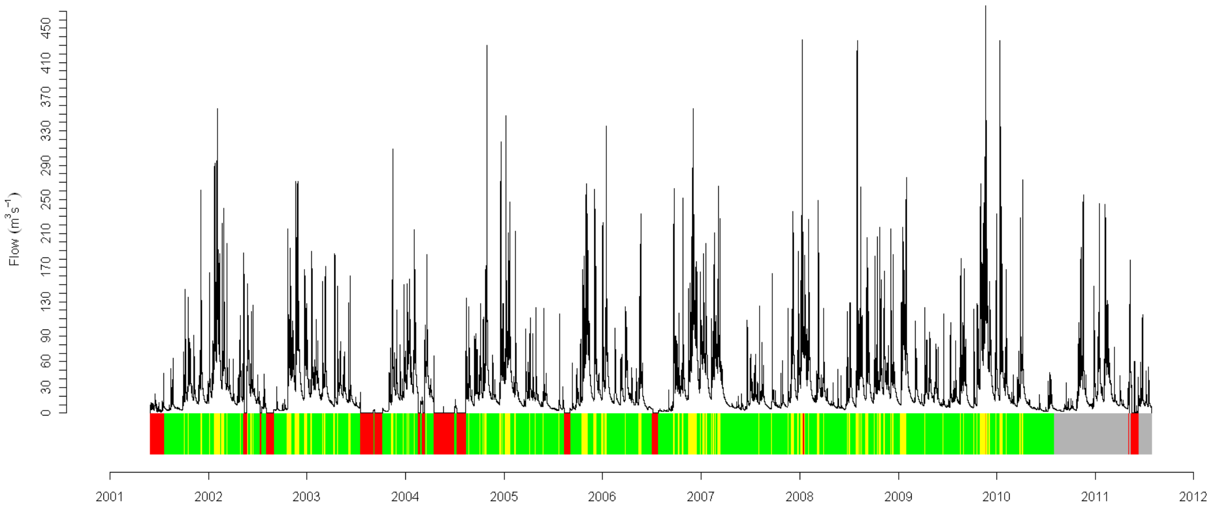
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.20: Water Level Data Quality Plot for Blackwater @ Mallow Railway Bridge (OPW - 18055)



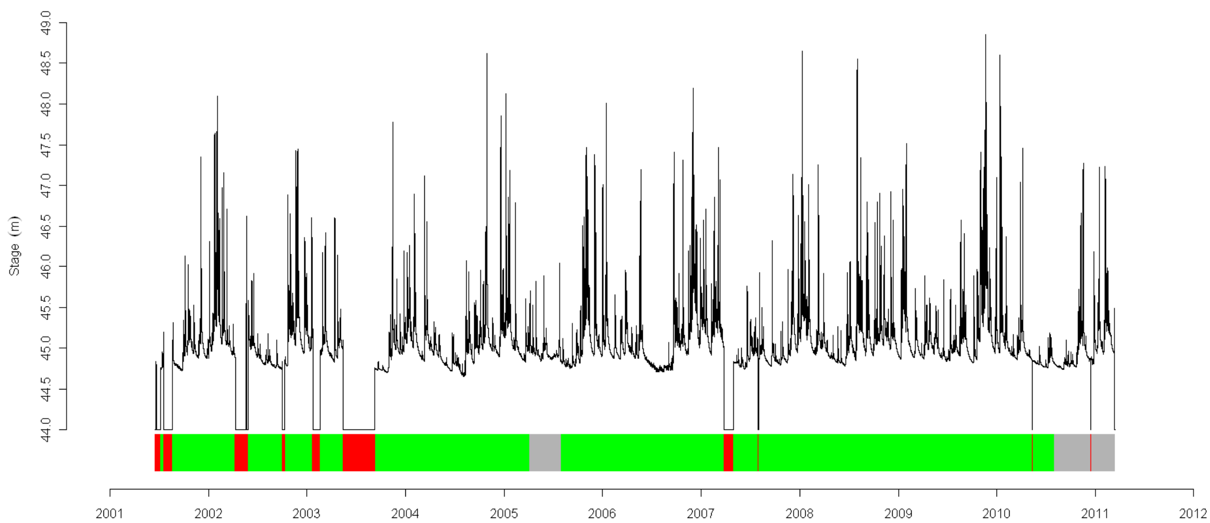
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.21: Flow Data Quality Plot for Blackwater @ Mallow Railway Bridge (OPW - 18055)



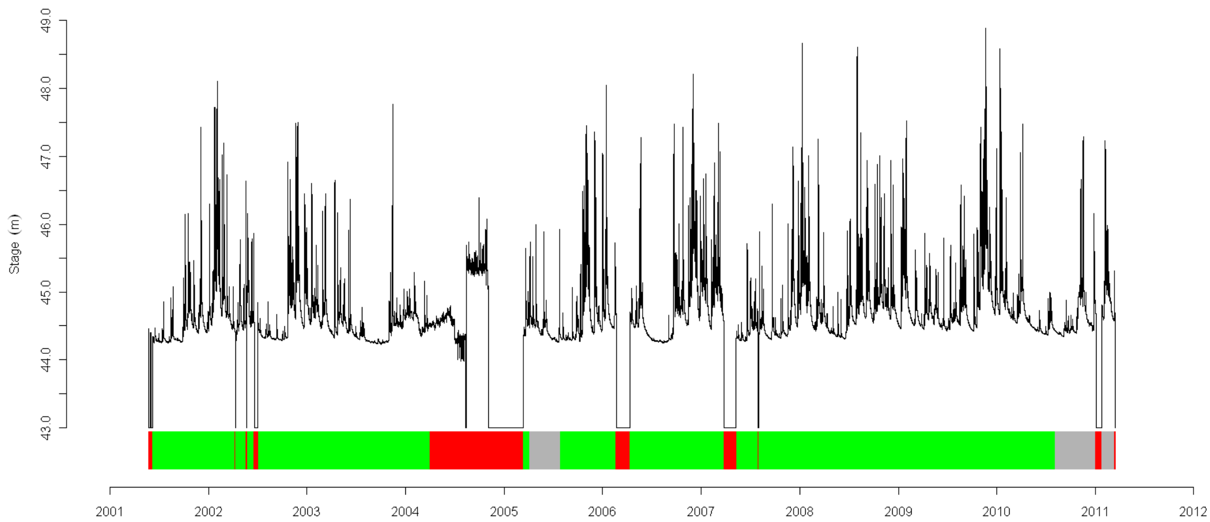
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.22: Water Level Data Quality Plot for Blackwater @ Mallow Town Bridge Upstream (OPW - 18056)



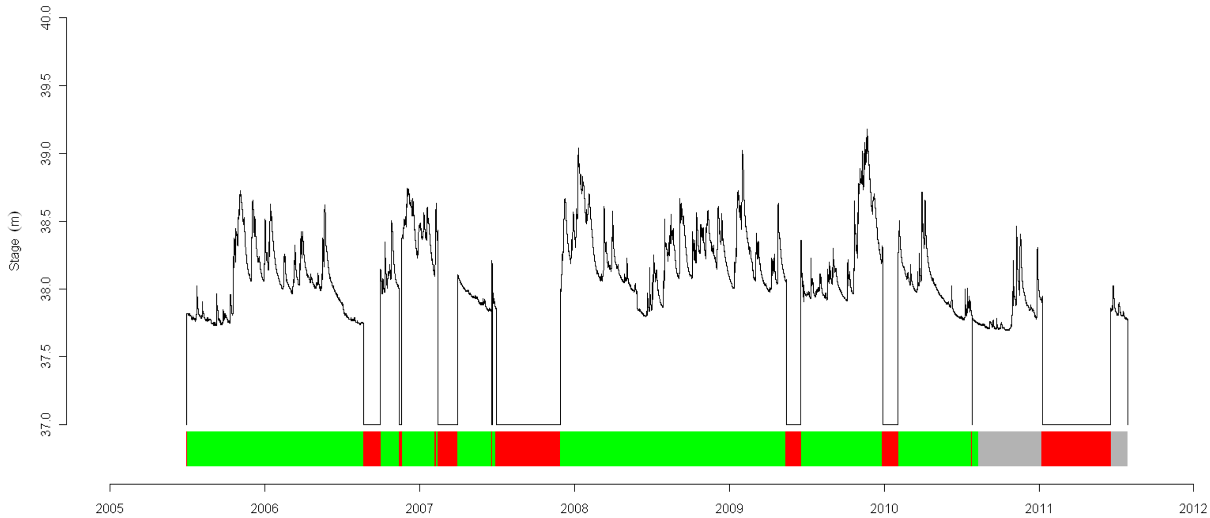
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.23: Water Level Data Quality Plot for Blackwater @ Mallow Town Bridge Downstream (OPW - 18057)



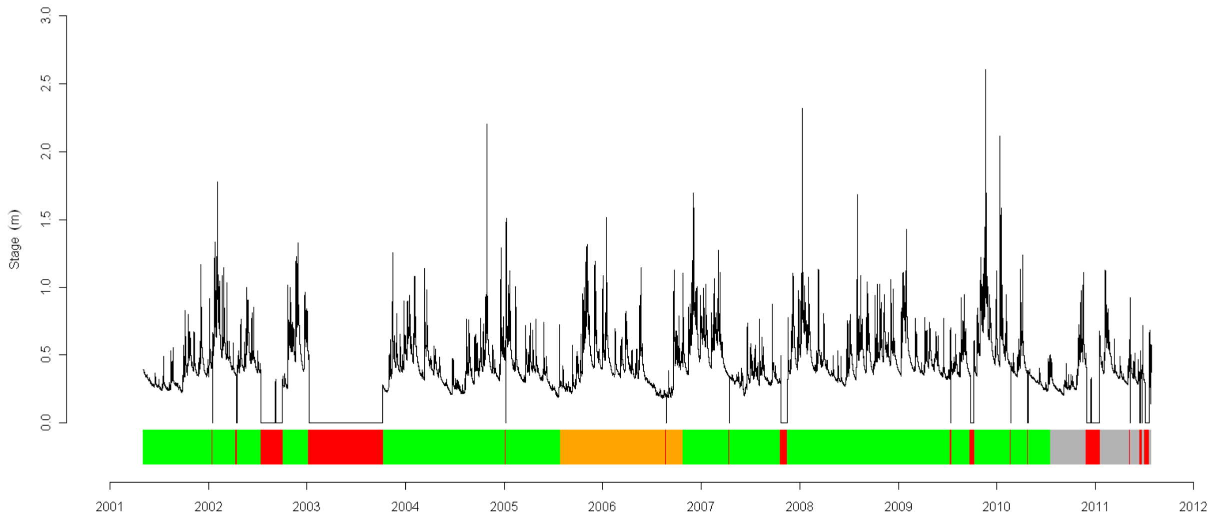
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.24: Water Level Data Quality Plot for Awbeg @ Castletownroche Weir (OPW - 18102)



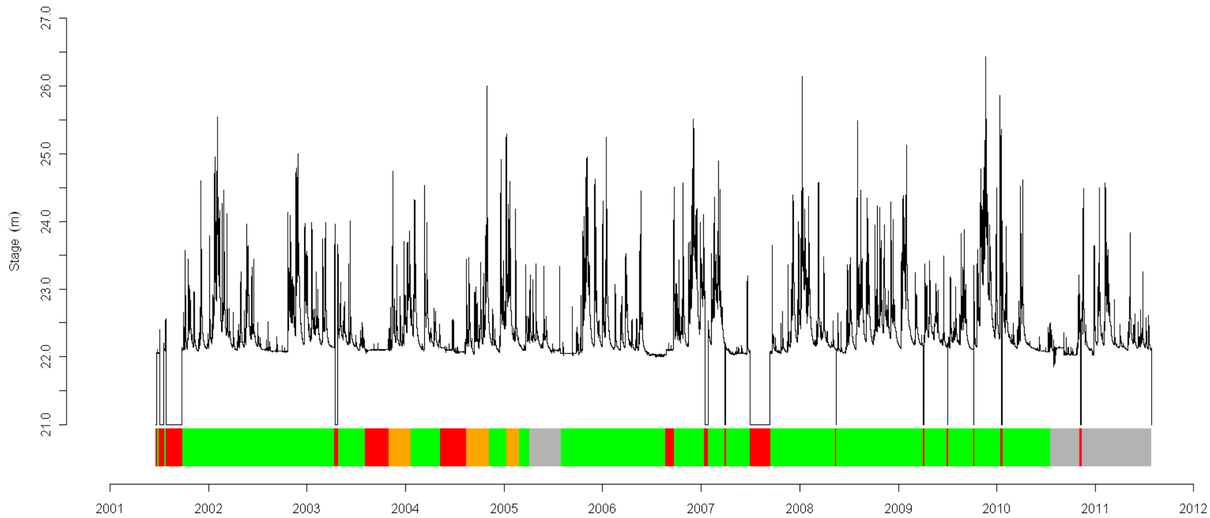
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.25: Water Level Data Quality Plot for Blackwater @ Fermoy Bridge Upstream (OPW - 18106)



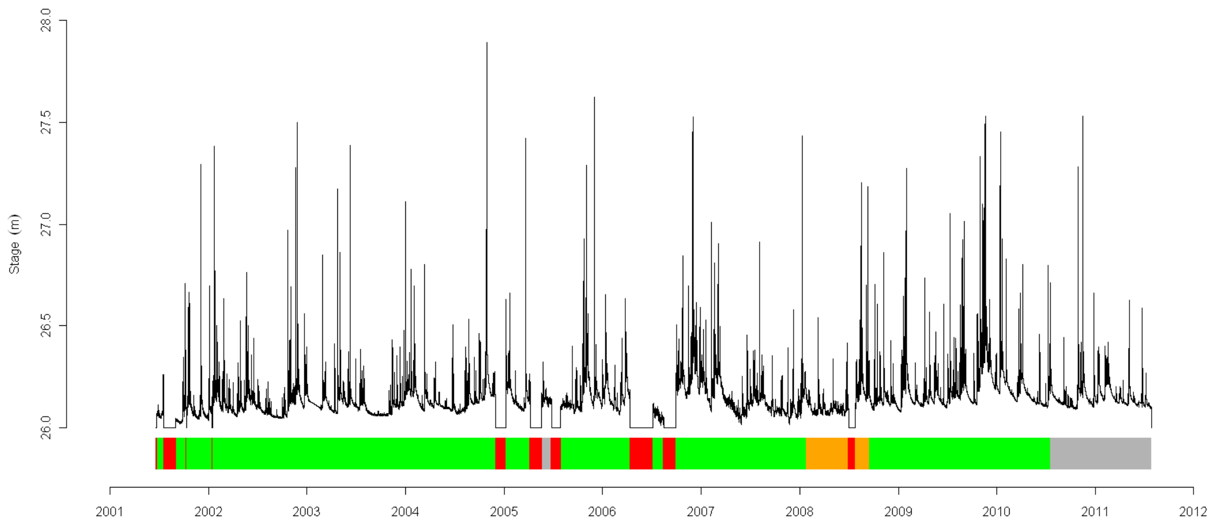
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.26: Water Level Data Quality plot for Blackwater @ Fermoy Bridge Downstream (OPW - 18107)



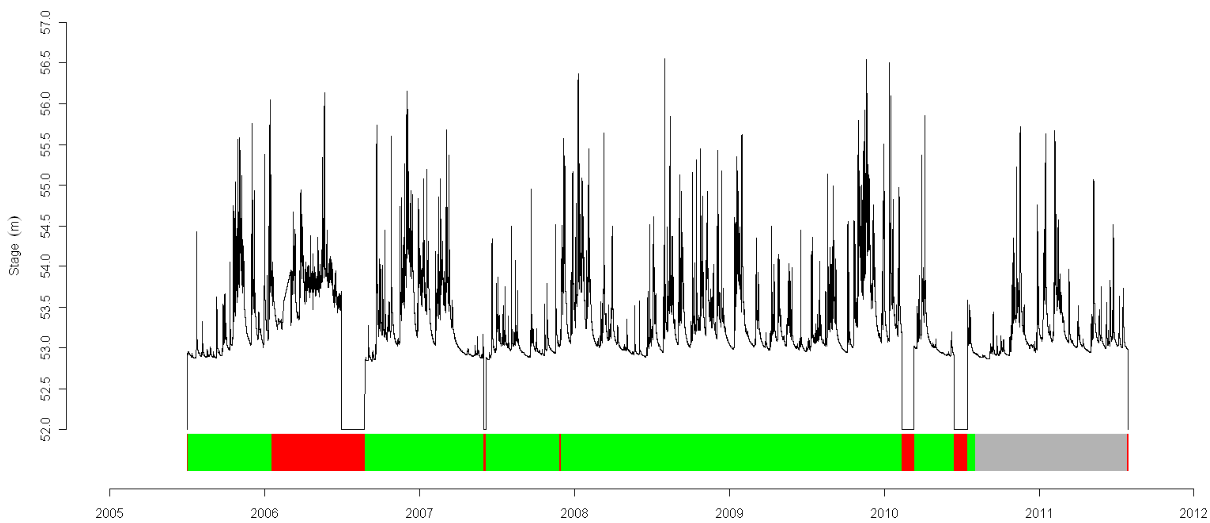
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.27: Water Level Data Quality Plot for Araglin @ Araglin Bridge (OPW - 18108)



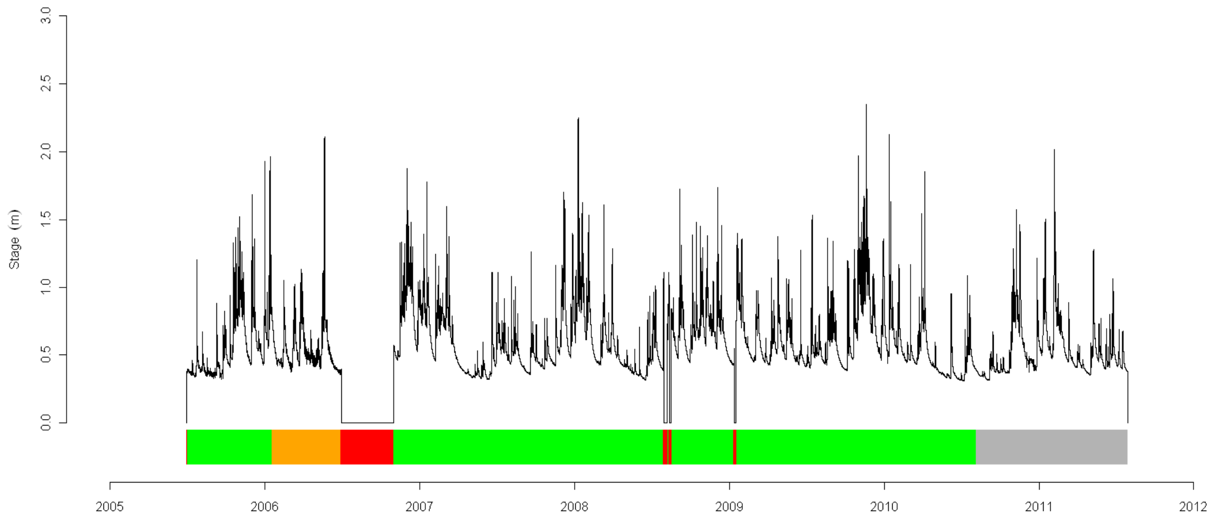
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.28: Water Level Data Quality Plot for Blackwater @ Lombardstown (OPW - 18109)



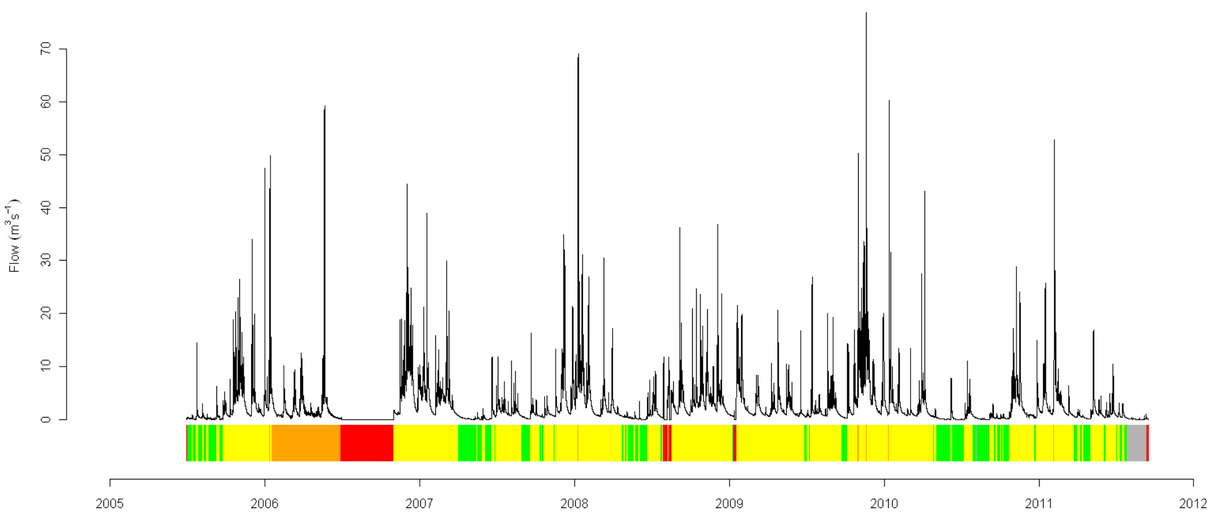
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.29: Water Level Data Quality Plot for Allow @ Kilbrin Road (OPW - 18110)



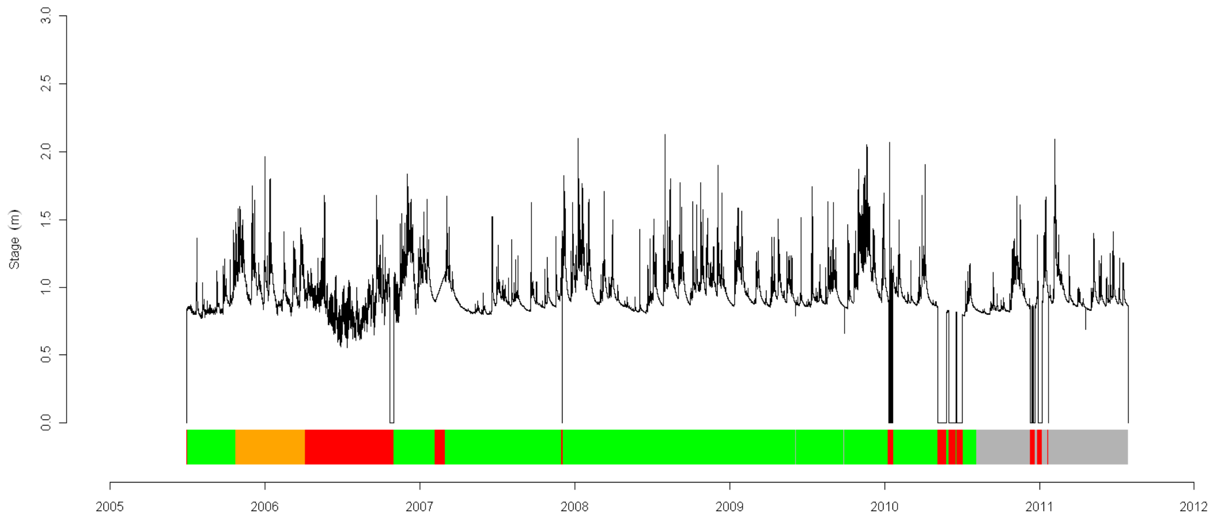
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.30: Flow Data Quality Plot for Allow @ Kilbrin Road (OPW - 18110)



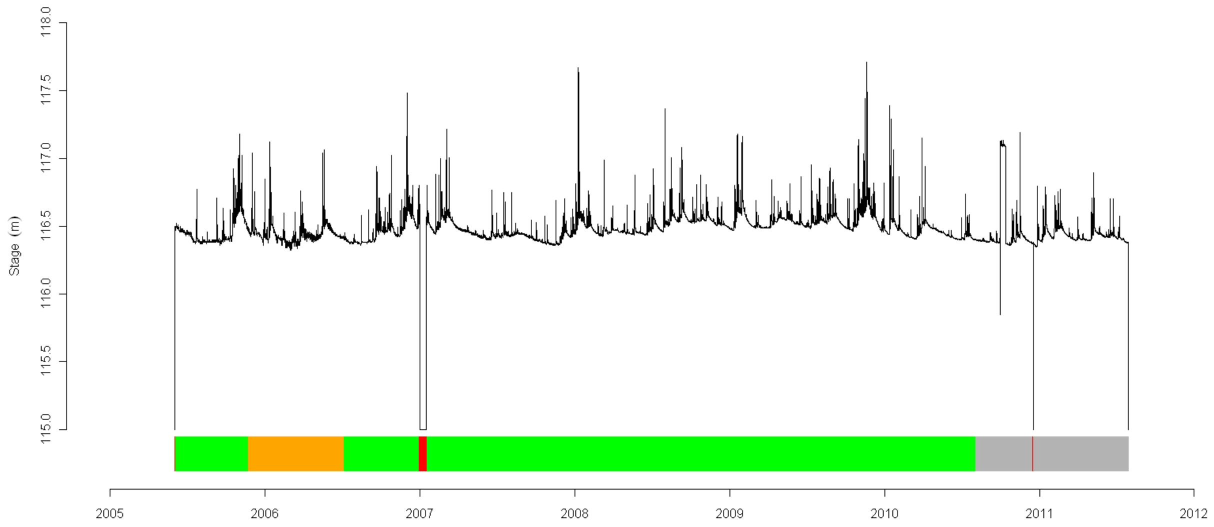
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.31: Water Level Data Quality Plot for Dalua @ Church Street (OPW - 18111)



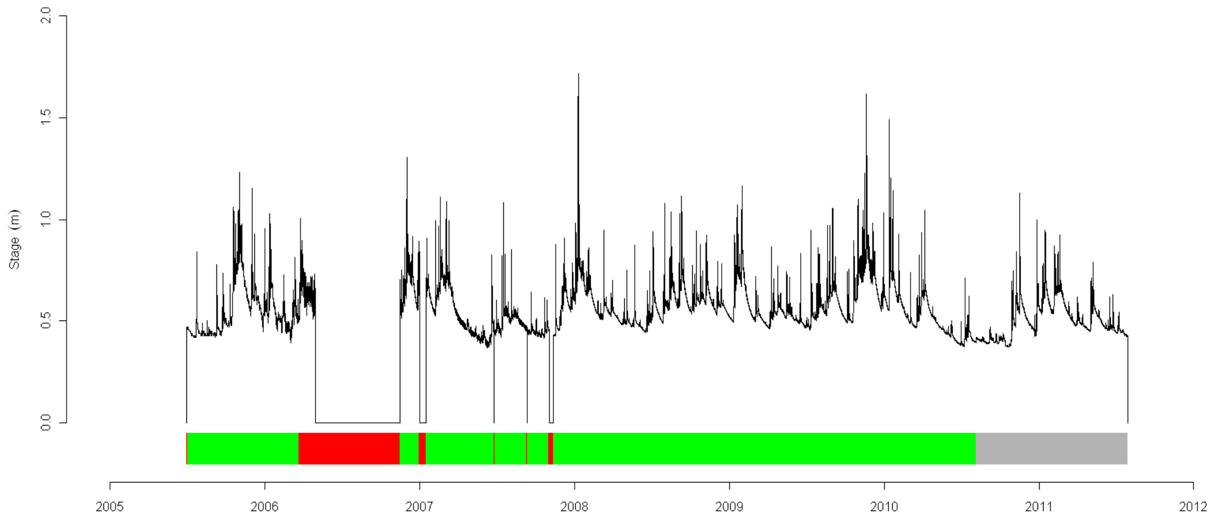
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.32: Water Level Data Quality Plot for Lyre @ Clashmorgan (OPW - 18114)



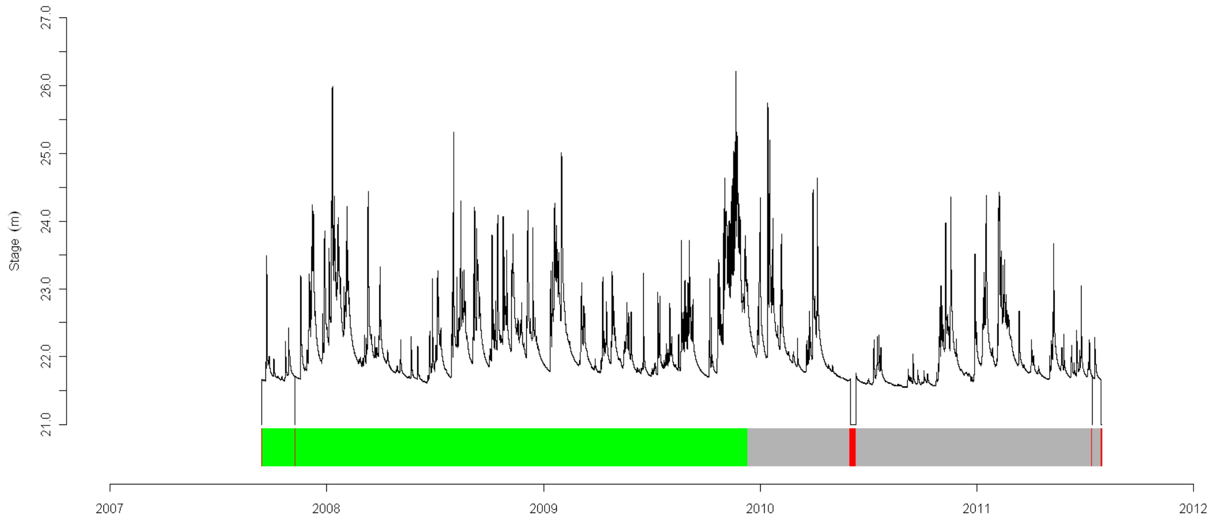
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.33: Water Level Data Quality Plot for Clyda @ Jordans Bridge (OPW - 18115)



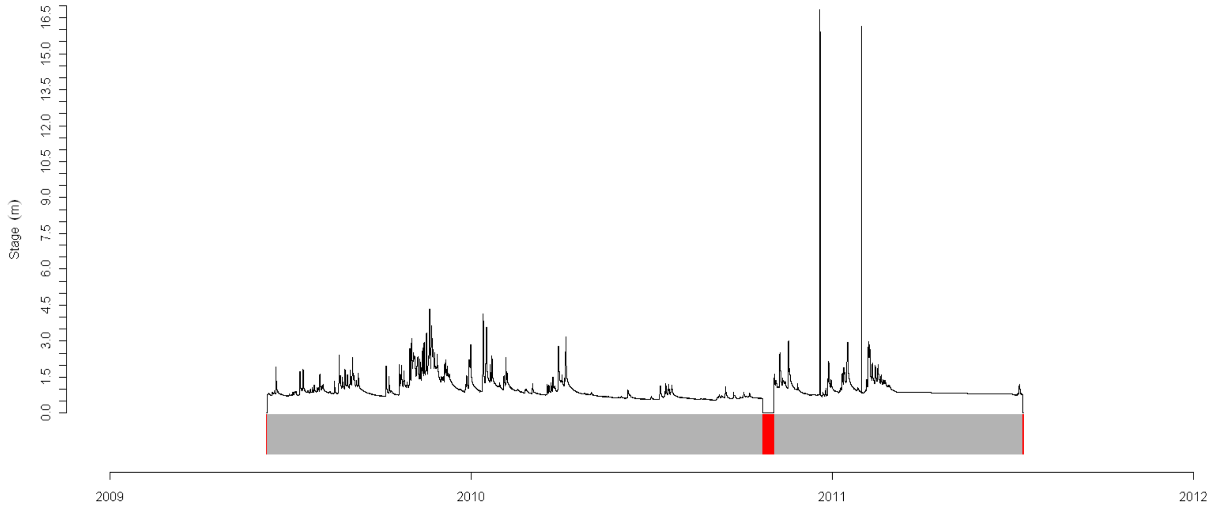
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.34: Water Level Data Quality Plot for Blackwater @ Fermoy Mill (OPW - 18117)



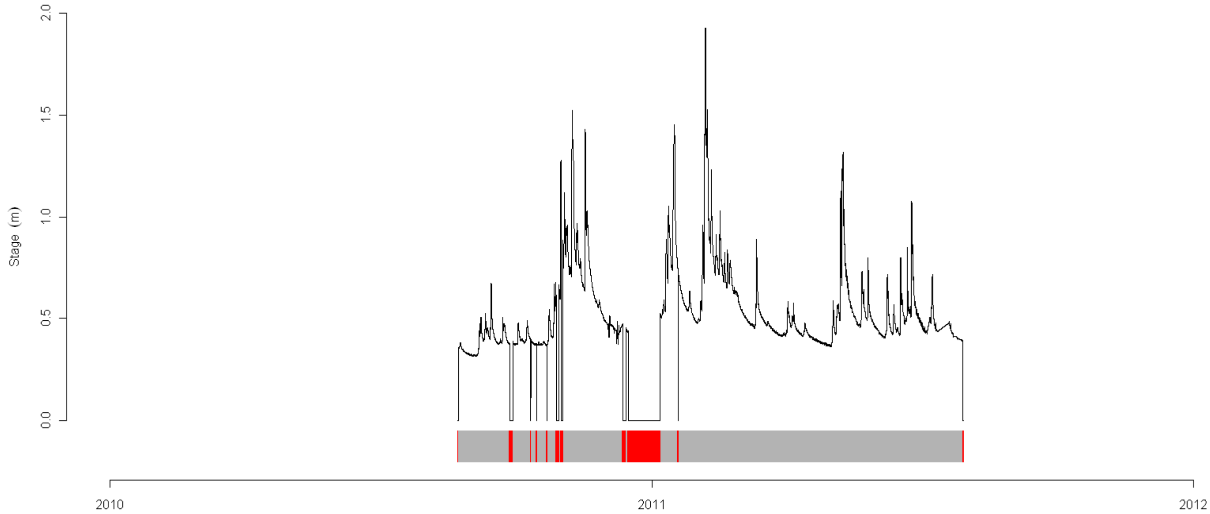
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.35: Water Level Data Quality Plot for Lyre @ Ballydahin (OPW - 18119)



Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.36: Water Level Data Quality Plot for Allow @ Greenane (OPW - 18123)



Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Table A.2: Selected Meteorological Gauge Locations

Station Number	Name	Catchment	Easting	Northing	Elevation (mAOD)	Opened	Years Data	Data Interval	Average Annual Rainfall	Comments	Fit for Calibration?	Fit for Statistical Analysis?
3904	Cork Airport	Owenboy - Douglas	166500	66200	154	1961	51	HOURLY	1215.45	Data quality reasonable and covers the 2009 flood event	Yes	Not Required
7006	Bartlemy	Knoppoge - Bride	181900	87600	98	1992	18	DAILY	997.00	Data quality reasonable and covers the 2009 flood event	Yes	Not Required
4906	Conna (Carrigreen Hill)	Bride - Blackwater	195500	95500	70	1981	22	DAILY	968.77	Paired with 8406 to provide continuous daily rainfall at Mogeely Gauge	Yes	Not Required
8406	Conna (Castleview)	Bride	195600	94500	30	2003	7	DAILY	934.12		Yes	Not Required
3606	Fermoy (Moore Park)	Funshion - Blackwater	181900	101400	55	1961	49	HOURLY	979.75	Several months of missing data often occurring during August and summer months when there is typically little rainfall	Yes	Not Required
5806	Freemount Pumping Station	Allow	139300	113900	137	1984	26	DAILY	1109.60	Several months of missing data often occurring during August and summer months when there is typically little rainfall	Yes	Not Required
1406	Kanturk (Voc.Sch.)	Dalua	138400	103300	104	1944	66	DAILY	997.34	Several months of missing data often occurring during August and summer months when there is typically little rainfall	Yes	Not Required
6606	Mallow (Sewage Treatment Works)	Blackwater	157600	98000	55	1988	22	DAILY	1074.60	Several months of missing data often occurring during August and summer months when there is typically little rainfall	Yes	Not Required
3406	Tallow	Bride	200900	94400	15	1952	48	DAILY	946.00	Data quality reasonable and covers the 2009 flood event	Yes	Not Required
4106	Youghal (Glendine W.W.)	Glendine - Blackwater	206400	83900	107	1964	46	DAILY	1175.13	Several months of missing data often occurring during August and summer months when there is typically little rainfall	Yes	Not Required

To be updated with OPW rain gauges for Blackwater catchment for Hydrological Study.

Appendix B. Preliminary Hydrological Parameters

Table B.1: Catchment Descriptors at HEPs Blackwater Unit of Management (UoM 18)

NODE_ID	WATERCOURSE	PRELIMINARY HYDROLOGICAL APPROACH	EASTING	NORTHING	DTM_AREA	MSL	NETLEN	DRAIND	S1085	TAYSLO	ARTDRAIN2	FARL	SAAR	BFISOILS
18001	Bride	Mogeely Gauged - Statistical Approach	195643	94128	334.08	46.20	283.79	0.85	3.84	0.46	0	1.00	1156	0.639
18002	Blackwater	Ballyduff Gauged - Rating Review & Statistical Approach	196493	99111	2,333.69	129.08	2236.95	0.96	1.34	0.19	0	1.00	1200	0.622
18003	Blackwater	Killavullen Gauged - Statistical Approach	164770	99775	1,256.70	89.94	1274.76	1.01	1.66	0.23	0	1.00	1299	0.461
18004	Awbeg (Major)	Ballynamona Gauged - pooling site	165657	107552	310.30	42.79	290.54	0.94	1.48	0.31	0	1.00	985	0.685
18005	Funshion	Downing Bridge Gauged - Statistical Approach	182331	101833	378.66	53.32	370.84	0.98	2.48	0.38	0	1.00	1190	0.707
18006	Blackwater	CSET Mallow Gauged - Statistical Approach	152546	97448	1,054.78	75.53	1090.69	1.03	1.92	0.27	0	1.00	1332	0.501
18010	Allow	Riverview Gauged - Rating Review & Statistical Approach	138315	100693	307.46	40.75	312.05	1.02	4.07	1.12	0	1.00	1251	0.429
18011	Dalua	Allen's Bridge Gauged - Rating Review & Statistical Approach	133744	104483	87.43	20.88	100.49	1.15	7.22	1.60	0	1.00	1388	0.483
18016	Upper Blackwater	Duncannon Gauged - pooling site	118027	93123	116.73	26.70	119.91	1.03	4.88	0.91	0	1.00	1441	0.351
18048	Blackwater	Dromcummer Gauged - Statistical Approach	139796	99320	867.74	58.91	932.16	1.07	2.35	0.34	0	1.00	1383	0.463
18050	Upper Blackwater	Duarrigle Gauged - pooling site	124987	94359	248.83	36.94	296.39	1.19	3.19	0.53	0	1.00	1469	0.406
18055	Blackwater	Mallow Rail Bridge Gauged - POT	155076	97887	1,178.17	78.73	1202.08	1.02	1.90	0.26	0	1.00	1317	0.459
18_2628_2	Castle Park Tributary	Ungauged - Transfer from Gauged	138268	101443	1.29	2.15	2.15	1.66	30.00	26.92	0	1.00	1158	0.469
18_2744_2	Allow	Ungauged - Transfer from Gauged	139480	113002	63.58	21.93	58.42	0.92	7.16	2.43	0	1.00	1186	0.419
18_2672_1	Allow	Ungauged - Transfer from Gauged	139480	113002	71.44	21.93	66.26	0.93	7.16	2.43	0	1.00	1181	0.417
18_545_4	Allow	Ungauged - Transfer from Gauged	138754	106254	103.18	33.24	102.02	0.99	5.08	1.36	0	1.00	1148	0.416
18_546_1	Allow	Ungauged - Transfer from Gauged	138754	106254	116.08	33.24	113.61	0.98	5.08	1.36	0	1.00	1149	0.388
18_1763_3	Allow	Ungauged - Transfer from Gauged	138754	106254	12.89	6.72	11.60	0.90	15.10	10.01	0	1.00	1154	0.335
18_394_3	Allow	Ungauged - Transfer from Gauged	138487	98739	310.98	42.69	314.74	1.01	3.98	1.17	0	1.00	1250	0.418
18_542_6	Allow	Ungauged - Transfer from Gauged	139652	109351	82.39	27.53	78.07	0.95	6.17	1.88	0	1.00	1172	0.432
18_970_8	Allow	Ungauged - Transfer from Gauged	139652	109351	5.21	3.58	3.58	0.69	25.94	2.78	0	1.00	1036	0.335
18_543_4	Allow	Ungauged - Transfer from Gauged	139885	108388	89.64	28.93	83.05	0.93	5.85	1.69	0	1.00	1163	0.418
18_2077_8	Allow	Ungauged - Transfer from Gauged	139885	108388	5.11	5.31	6.76	1.32	17.68	16.78	0	1.00	1029	0.333
18_545_1	Allow	Ungauged - Transfer from Gauged	139131	106759	102.41	32.14	100.92	0.99	5.28	1.45	0	1.00	1148	0.416
18_2125_5	Allow	Ungauged - Transfer from Gauged	139131	106759	5.42	4.86	7.90	1.46	15.84	10.67	0	1.00	1027	0.336
18_2681_3	Keen	Ungauged - Transfer from Gauged	139992	114814	3.28	1.59	1.59	0.48	24.66	21.19	0	1.00	1038	0.335
18_2672_2	Allow	Ungauged - Transfer from Gauged	139564	112727	71.56	22.43	66.76	0.93	6.87	2.04	0	1.00	1181	0.417
18_2682_6	Allow	Ungauged - Transfer from Gauged	139385	114024	55.51	20.20	51.63	0.93	7.24	2.35	0	1.00	1204	0.430
18_2681_5	Keen	Ungauged - Transfer from Gauged	139385	114024	4.27	2.67	2.67	0.63	20.66	22.15	0	1.00	1052	0.336
18_548_1	Allow	Ungauged - Transfer from Gauged	138411	105082	120.74	35.36	119.76	0.99	4.85	1.40	0	1.00	1147	0.387
18_2682_4	Allow	Ungauged Transfer from Gauged	138821	114331	54.71	19.40	50.83	0.93	7.74	2.37	0	1.00	1206	0.429
18_2647_8	Allow	Ungauged Transfer from Gauged	139480	113002	7.83	5.86	7.84	1.00	19.57	19.29	0	1.00	1147	0.324
18_1131_5	Araglin	Ungauged - Transfer from Gauged	184433	100421	127.55	26.75	154.33	1.21	9.28	1.87	0	1.00	1117	0.612
18_2677_28	Awbeg	Ungauged - Transfer from Gauged	169358	99947	350.66	53.88	290.54	0.83	1.60	0.28	0	1.00	985	0.642
18_2583_1	Ballynaparka	Ungauged - Transfer from Gauged	213140	90427	1.01	0.75	0.75	0.74	55.68	50.00	0	1.00	1178	0.703

NODE_ID	WATERCOURSE	PRELIMINARY HYDROLOGICAL APPROACH	EASTING	NORTHING	DTM_AREA	MSL	NETLEN	DRAIND	S1085	TAYSLO	ARTDRAIN2	FARL	SAAR	BFISOILS
18_1983_2	Ballynaparka	Ungauged - Transfer from Gauged	213317	91374	1.15	1.42	1.42	1.23	54.66	47.60	0	1.00	1178	0.626
18_2367_2	Ballynaparka	Ungauged - Transfer from Gauged	211699	91813	8.39	3.82	8.17	0.97	28.86	21.50	0	1.00	1183	0.703
18_393_4	Blackwater	Ungauged - Transfer from Gauged	138487	98739	477.55	56.96	527.88	1.11	2.48	0.36	0	1.00	1457	0.465
18_1614_3	Blackwater	Ungauged - Transfer from Gauged	169358	99947	1,322.41	96.44	1321.23	1.00	1.59	0.22	0	1.00	1287	0.496
18_2292_6	Blackwater	Ungauged - Transfer from Gauged	183805	100193	1,761.96	114.39	1656.42	0.94	1.38	0.20	0	1.00	1214	0.589
18_2286_3	Blackwater	Ungauged - Transfer from Gauged	184433	100421	2,143.91	115.17	2028.05	0.95	1.33	0.20	0	1.00	1210	0.613
18_2472_2	Blackwater	Ungauged - Transfer from Gauged	154629	99318	1.35	0.50	0.50	0.37	23.18	19.77	0	1.00	1070	0.331
18_982_2	Blackwater	Ungauged - Transfer from Gauged	154280	100448	2.37	2.20	3.36	1.42	27.38	23.42	0	1.00	1030	0.323
18_1835_2	Blackwater	Ungauged - Transfer from Gauged	154632	100820	3.86	2.56	4.96	1.29	21.89	13.85	0	1.00	1023	0.342
18_1629_3	Blackwater	Ungauged - Transfer from Gauged	158184	98054	1.55	1.63	2.17	1.40	49.31	14.07	0	1.00	1042	0.633
18_1104_1	Blackwater	Ungauged - Transfer from Gauged	154605	96523	1.01	2.10	2.43	2.41	28.51	4.05	0	1.00	1114	0.638
18_1151_5	Blackwater	Ungauged - Transfer from Gauged	182157	98798	2.81	2.68	2.68	0.96	31.26	2.20	0	1.00	1022	0.645
18_1158_8	Blackwater	Ungauged - Transfer from Gauged	182157	98798	1,750.90	111.87	1651.03	0.94	1.44	0.20	0	1.00	1215	0.589
18_2311_1	Blackwater	Ungauged - Transfer from Gauged	197060	99335	1.01	2.02	2.03	2.01	110.59	57.21	0	1.00	1096	0.634
18_2310_5	Blackwater	Ungauged - Transfer from Gauged	197702	99195	2,336.41	130.38	2236.95	0.96	1.31	0.20	0	1.00	1200	0.622
18_967_9	Blackwater	Ungauged - Transfer from Gauged	210135	79237	5.88	4.47	4.47	0.76	10.35	0.70	0	1.00	1064	0.693
18_2315_2	Blackwater	Ungauged - Transfer from Gauged	196229	99259	2,328.64	128.77	2229.76	0.96	1.34	0.19	0	1.00	1201	0.621
18_2474_4	Blackwater	Ungauged - Transfer from Gauged	155612	98055	11.11	5.72	14.94	1.35	11.58	3.22	0	1.00	1036	0.343
18_2381_2	Blackwater	Ungauged - Transfer from Gauged	157028	97979	1,208.12	80.78	1237.48	1.02	1.77	0.25	0	1.00	1310	0.460
18_1630_3	Blackwater	Ungauged - Transfer from Gauged	158799	98741	1,212.44	83.07	1241.93	1.02	1.86	0.24	0	1.00	1309	0.459
18_1158_1	Blackwater	Ungauged - Transfer from Gauged	179559	98000	1,744.80	108.70	1647.86	0.94	1.41	0.20	0	1.00	1216	0.588
18_2307_2	Blackwater	Ungauged - Transfer from Gauged	202481	99017	2,377.23	135.43	2277.67	0.96	1.22	0.19	0	1.00	1199	0.618
18_1634_2	Blackwater	Ungauged - Transfer from Gauged	154799	98221	1,175.26	78.28	1196.84	1.02	1.91	0.26	0	1.00	1318	0.459
18_368_3	Blackwater	Ungauged - Transfer from Gauged	142830	98749	882.59	62.75	944.00	1.07	2.41	0.31	0	1.00	1379	0.464
18_374_3	Blackwater	Ungauged - Transfer from Gauged	145868	96753	960.48	67.70	1004.48	1.05	2.10	0.30	0	1.00	1351	0.472
18_2485_2	Blackwater	Ungauged - Transfer from Gauged	150172	97692	1,008.61	72.65	1051.62	1.04	2.06	0.27	0	1.00	1344	0.490
18_2381_4	Blackwater	Ungauged - Transfer from Gauged	157929	98039	1,209.76	81.78	1238.48	1.02	1.91	0.24	0	1.00	1310	0.460
18_1628_8	Blackwater	Ungauged - Transfer from Gauged	161559	99947	1,228.37	86.57	1255.36	1.02	1.75	0.24	0	1.00	1306	0.458
18_2616_3	Blackwater	Ungauged - Transfer from Gauged	166044	99105	1,300.12	91.65	1306.03	1.01	1.61	0.23	0	1.00	1290	0.460
18_353_1	Blackwater	Ungauged - Transfer from Gauged	173094	98735	1,703.35	101.59	1622.62	0.95	1.52	0.22	0	1.00	1220	0.585
18_351_2	Blackwater	Ungauged - Transfer from Gauged	177888	98435	1,737.60	106.86	1642.48	0.95	1.53	0.21	0	1.00	1217	0.588
18_2371_1	Blackwater	Ungauged - Transfer from Gauged	187495	99578	2,287.62	118.84	2193.48	0.96	1.32	0.20	0	1.00	1203	0.618
18_2299_1	Blackwater	Ungauged - Transfer from Gauged	191918	99127	2,302.79	123.76	2206.67	0.96	1.37	0.20	0	1.00	1202	0.619
18_2473_3	Blackwater	Ungauged - Transfer from Gauged	155261	99107	8.56	4.47	12.43	1.45	12.09	9.94	0	1.00	1028	0.385
18_1104_5	Blackwater	Ungauged - Transfer from Gauged	155541	97877	2.35	3.72	4.05	1.72	18.08	2.59	0	1.00	1091	0.643
18_1638_1	Blackwater	Ungauged - Transfer from Gauged	155033	97927	1,175.64	78.67	1197.97	1.02	1.90	0.26	0	1.00	1318	0.459
18_1631_3	Blackwater	Ungauged - Transfer from Gauged	156211	97973	3.44	2.88	4.33	1.26	25.11	24.55	0	1.00	1063	0.643
18_2380_1	Blackwater	Ungauged - Transfer from Gauged	156040	96408	1.09	1.11	1.64	1.51	32.69	2.50	0	1.00	1092	0.633
18_2802_2	Blackwater	Ungauged - Transfer from Gauged	209767	92432	1.07	1.42	1.42	1.32	26.47	25.75	0	1.00	1204	0.655
18_2766_2+	Blackwater	Ungauged - Transfer from Gauged	208977	95077	2,487.84	159.25	2409.87	0.97	1.87	0.45	0	1.00	1200	0.615
18_2770_4+	Blackwater	Ungauged - Transfer from Gauged	210524	96758	114.44	34.61	132.15	1.15	7.62	1.01	0	1.00	1250	0.706
18_1611_1+	Blackwater	Ungauged - Transfer from Gauged	179609	97221	1.075	1.66	1.05	0.50	53.00	36.84	0	1.00	1033	0.645
18_2762_2+	Blackwater	Ungauged - Transfer from Gauged	209850	99315	2,444.55	146.68	2363.48	0.97	1.49	0.31	0	1.00	1199	0.617
18_2755_3+	Blackwater	Ungauged - Transfer from Gauged	206995	98986	2,438.56	139.03	2352.41	0.96	1.31	0.23	0	1.00	1199	0.616
18_2812_5+	Blackwater	Ungauged - Transfer from Gauged	208647	90312	500.18	120.66	420.53	0.84	6.75	1.89	0	1.00	1155	0.659
18_2800_5+	Blackwater	Ungauged - Transfer from Gauged	208833	90531	495.39	116.61	416.48	0.84	6.47	1.66	0	1.00	1154	0.658

NODE_ID	WATERCOURSE	PRELIMINARY HYDROLOGICAL APPROACH	EASTING	NORTHING	DTM_AREA	MSL	NETLEN	DRAIND	S1085	TAYSLO	ARTDRAIN2	FARL	SAAR	BFISOILS
18_2822_7+	Blackwater	Ungauged - Transfer from Gauged	209942	80929	592.36	159.12	496.80	0.84	7.84	2.15	0	1.00	1150	0.659
18BLAC001909 / No FSU node	Blackwater	Ungauged - Transfer from Gauged	209131	94885	2,651.12	212.54	2568.07	2.66	14.75	4.76	0	1.00	1203	0.655
18BLAC002349/ No FSU node	Blackwater	Ungauged - Transfer from Gauged	209362	91776	2,689.65	232.11	2603.61	4.89	57.24	37.06	0	1.00	1168	0.651
18BLAC002211/ No FSU node	Blackwater	Ungauged - Transfer from Gauged	210375	96621	2,602.28	193.86	2542.02	2.12	9.49	1.46	0	1.00	1250	0.706
18BLAC000288/ No FSU node	Blackwater	Ungauged - Transfer from Gauged	210821	79075	3,242.96	178.51	532.62	2.34	27.91	4.63	0	1.00	1250	0.706
18_1611_3	Blackwater	Ungauged - Transfer from Gauged	179559	98000	3.72	2.49	3.54	0.95	42.81	43.03	0	1.00	1030	0.644
18_5_3	Blackwater	Ungauged - Transfer from Gauged	139162	98553	791.26	57.80	843.46	1.07	2.47	0.37	0	1.00	1375	0.473
18_1603_6	Bride	Ungauged - Transfer from Gauged	182096	91188	119.61	26.97	96.24	0.81	7.01	0.92	0	1.00	1196	0.682
18_1600_2	Bride	Ungauged - Transfer from Gauged	182440	91048	130.53	27.41	111.19	0.85	6.95	0.85	0	1.00	1188	0.682
18_347_6	Bride	Ungauged - Transfer from Gauged	184465	91587	190.75	30.38	171.04	0.90	6.29	0.77	0	1.00	1186	0.676
18_349_3	Bride	Ungauged - Transfer from Gauged	188304	91781	227.47	35.47	196.02	0.86	5.34	0.77	0	1.00	1170	0.677
18_2167_1	Bride	Ungauged - Transfer from Gauged	180322	91959	1.12	1.38	2.13	1.89	15.33	9.25	0	1.00	1091	0.688
18_2657_7	Bride	Ungauged - Transfer from Gauged	180243	90640	2.77	3.72	3.72	1.34	17.42	2.05	0	1.00	1117	0.671
18_1605_12	Bride	Ungauged - Transfer from Gauged	178900	89832	94.08	21.91	70.11	0.75	8.33	0.77	0	1.00	1206	0.679
18_343_4	Bride	Ungauged - Transfer from Gauged	199604	94230	351.33	52.54	301.75	0.86	3.50	0.39	0	1.00	1154	0.647
18_2778_1	Bride	Ungauged - Transfer from Gauged	199604	94230	369.48	52.54	320.29	0.87	3.50	0.39	0	1.00	1155	0.647
18_694_4	Bride	Ungauged - Transfer from Gauged	194840	93966	315.94	45.30	268.60	0.85	4.03	0.47	0	1.00	1157	0.648
18_345_1	Bride	Ungauged - Transfer from Gauged	188743	92573	274.02	36.63	234.97	0.86	5.19	0.63	0	1.00	1169	0.652
18_309_3	Bride	Ungauged - Transfer from Gauged	191834	93524	288.88	40.20	245.28	0.85	4.60	0.57	0	1.00	1164	0.655
18_2798_3+	Bride	Ungauged - Transfer from Gauged	208876	91170	408.02	78.36	354.88	0.87	5.69	0.95	0	1.00	1158	0.654
18_2782_2+	Bride	Ungauged - Transfer from Gauged	205247	93567	395.31	69.95	343.45	0.87	4.86	0.71	0	1.00	1156	0.652
18_2778_4+	Bride	Ungauged - Transfer from Gauged	201565	94179	372.55	55.43	323.71	0.87	3.38	0.40	0	1.00	1155	0.649
18_2121_3	Brogeen	Ungauged - Transfer from Gauged	135670	102294	34.50	16.17	28.08	0.81	6.27	3.55	0	1.00	1346	0.340
18_1632_2	Clyda	Ungauged - Transfer from Gauged	156108	98012	107.17	22.02	98.57	0.92	7.26	0.81	0	1.00	1209	0.637
18_2541_9	Clyda	Ungauged - Transfer from Gauged	153417	97786	112.80	26.03	103.85	0.92	6.63	0.78	0	1.00	1206	0.637
18_1756_4	Dalua	Ungauged - Transfer from Gauged	138255	103065	139.93	27.62	151.87	1.09	6.19	1.02	0	1.00	1326	0.476
18_1762_6	Dalua	Ungauged Transfer from Gauged	132324	104415	86.36	19.38	98.98	1.15	8.31	2.34	0	1.00	1389	0.482
18_1601_4	Douglas	Ungauged - Transfer from Gauged	188304	91781	43.48	12.24	36.79	0.85	6.97	2.89	0	1.00	1165	0.691
18_1180_4	*Flesk*	Ungauged - Transfer from Gauged	182018	90772	53.33	14.51	55.83	1.05	7.47	0.81	0	1.00	1194	0.683
18_2244_3	Glashaheagow	Ungauged - Transfer from Gauged	151973	96590	5.60	4.34	7.38	1.32	21.40	10.47	0	1.00	1175	0.638
18_1924_4	Glashaheagow Stream	Ungauged - Transfer from Gauged	152181	97486	8.97	6.24	9.59	1.07	15.06	3.13	0	1.00	1159	0.651
18_910_1	Glenaboy	Ungauged - Transfer from Gauged	199136	92561	17.34	8.56	16.57	0.96	17.33	5.95	0	1.00	1184	0.674
18_910_5	Glenaboy	Ungauged - Transfer from Gauged	199604	94230	18.14	10.53	18.54	1.02	15.92	5.89	0	1.00	1180	0.674
18_2302_2	Glownagad	Ungauged - Transfer from Gauged	196489	99665	4.87	3.77	5.07	1.04	60.23	55.66	0	1.00	1135	0.641
18_2808_2+	Goish	Ungauged - Transfer from Gauged	209562	92012	37.46	18.16	34.12	0.91	16.02	6.55	0	1.00	1162	0.635
18_2920_2+	Licky	Ungauged - Transfer from Gauged	210215	84365	61.49	24.80	52.09	0.85	10.00	1.85	0	1.00	1086	0.633
18_2776_2+	Owbeg	Ungauged - Transfer from Gauged	208977	95077	48.85	18.68	26.06	0.53	5.26	3.30	0	1.00	1118	0.710
18_1964_4	Shanowen	Ungauged - Transfer from Gauged	182096	91188	10.65	6.97	14.50	1.36	16.01	13.16	0	1.00	1104	0.639
18_2237_3	Shanowen	Ungauged - Transfer from Gauged	180611	92693	6.95	4.39	8.99	1.29	25.05	21.67	0	1.00	1105	0.638
18_2221_7	Shanowennadrimina	Ungauged - Transfer from Gauged	184465	91587	20.77	7.42	15.39	0.74	5.34	1.08	0	1.00	1064	0.648
18_2824_5	Touring	Ungauged - Transfer from Gauged	206830	80297	42.44	14.91	31.35	0.74	9.73	1.78	0	1.00	1196	0.679
18_2718_5	Munster Blackwater	Ungauged - Transfer from Gauged	152546	97448	3.84	4.18	5.25	1.37	23.97	2.17	0	1.00	1054	0.389
18_2594_3	Dromoe Commons Stream	Ungauged - Transfer from Gauged	158088	100927	6.63	3.10	8.99	1.36	16.36	14.35	0	1.00	1002	0.334
18_549_2+	Bluepool tributary to Allow	Ungauged - Transfer from Gauged	138700	103039	0.01	1.64	1.31	1.04	4.44	1.17	0	1.00	1242	0.433

Source: FSU Database 2012. Highlighted cells indicate modified physical catchment descriptors based on data review. The + sign after a FSU Node ID indicates a number of catchments lumped together, particularly for inflows in tidal reaches.

Appendix C. Hydrometric Gauges

Station Number	Name	River Name	Model	Easting	Northing	Record Start	Years Data	Owner	Rating Curve	Comments	Fit for Calibration Purposes?	Fit for Statistical Analysis?
18001	Mogeely	Bride	Mogeely & Tallow	195643	94128	01/10/1972	39	OPW	Yes	Majority of flow has been edited by OPW, suitable for use	Yes, following Rating Review	Yes, following Rating Review
18002	Ballyduff	Blackwater	Ballyduff	196493	99111	01/10/1955	56	OPW	Yes	Edited flows prior to 1972 and after 1995 with poor quality flow data since 2011	Yes, following Rating Review	Yes, following Rating Review
18003	Killavullen	Blackwater	Mallow & Blackwater Reach 3	164770	99775	01/10/1955	56	OPW	Yes	Flow quality poor prior to 1972	Yes	Yes, use with caution
18005	Downing Br.	Funshion	Blackwater Reach 4	182331	101833	01/01/1972	39	OPW	Yes	Majority of flow has been edited by OPW, suitable for use	Yes, use with caution	Yes, use with caution
18006	CSET Mallow	Blackwater (Munster)	Mallow	152546	97448	15/06/2000	35	EPA	Yes	Incomplete water years and 2006 missing	Yes	Yes, use with caution
18009	Riverview	Allow	Blackwater Reach 2	138315	100693	27/11/2000	12	EPA	Yes	Peak water level data available from 1982 to 2001 at unequal intervals – can be used in AMAX analysis and calibration Incomplete water years, data missing during winter months of 2004	Yes, following Rating Review	Yes, following Rating Review
18010	Allen's Br.	Dalua	Blackwater Reach 2	133745	104485	22/11/2000	12	EPA	Yes	Peak water level data available from 1982 to 2001 at unequal intervals – can be used in AMAX analysis and calibration	Yes, following Rating Review	Yes, following Rating Review
18019	Fr. Murphy's Br.	Glen	Blackwater Reach 3	139156	96856	01/07/2005	6	OPW	Yes	Missing and suspect data from 2006 to 2007	Yes for events before 2006 and after 2007	Yes, use with caution
18048	Dromcummer	Blackwater (Munster)	Blackwater Reach 2	139796	99320	24/11/2000	12	EPA	Yes	Short record, data corrected for datum shift in 2003, flow data unavailable after 2004	Yes	Yes, use with caution
18053	Glandalane	Blackwater	Blackwater Reach 4	184933	99741	25/06/2002	9	OPW	No	Several missing data periods and anomalous spike in April 2011.Data of good quality during 2009 flood event	Yes for 2009 event only	Hydrograph width analysis only
18055	Mallow Railway Br.	Blackwater	Mallow	155078	97842	29/05/2001	10	OPW	Yes	Several missing periods prior to 2005 and in early 2011, largely in summer months	Yes	Yes, use with caution
18056	Mallow Town Br. U/S	Blackwater	Mallow	156114	97968	18/06/2001	10	OPW	No	Several missing or poor data quality periods, particularly for the downstream gauge. However, good quality and consistency at high flows	Yes	Hydrograph width analysis only
18057	Mallow Town Br. D/S	Blackwater	Mallow	156153	97954	23/05/2001	10	OPW	No	Several missing or poor data quality periods, particularly for the downstream gauge. However, good quality and consistency at high flows	Yes	Hydrograph width analysis only

18102	Castletownroche Weir	Awbeg	Blackwater Reach 3	168562	102476	01/07/2005	6	OPW	No	Short data record, significant missing data periods 2007, 2008 and 2011	Yes for 2009 event only	Hydrograph width analysis only
18106	Fermoy Br. U/S	Blackwater	Fermoy	181109	98503	04/05/2001	10	OPW	No	Missing data for 2004 and suspect data for 2006 shorter suitable record for analysis	Yes	Hydrograph width analysis only
18107	Fermoy Br. D/S	Blackwater	Fermoy	181194	98612	21/06/2001	10	OPW	No	Missing data and suspect data prior to 2004 shortens suitable record for analysis	Yes	Hydrograph width analysis only
18108	Araglin Br.	Araglin	Blackwater Reach 4	184937	101642	21/06/2001	10	OPW	No	Missing data for 2006 and suspect data for 2008 shorter suitable record for analysis	Yes	Hydrograph width analysis only
18109	Lombardstown Br.	Blackwater (Munster)	Blackwater Reach 4	146406	96981	02/07/2005	6	OPW	Yes	Missing data and poor quality data in 2006 shortens record available for analysis	Yes	Yes, use with caution
18110	Kilbrin Road	Allow	Kanturk	138210	103350	01/07/2005	6	OPW	Yes	Missing data and poor quality data in 2006 shortens record available for analysis. Flows outside this period are largely edited to be fit for use	Yes	Yes, use with caution
18111	Church Street	Dalua	Kanturk	137744	103331	01/07/2005	6	OPW	No	Missing data and poor quality data in 2006 shortens record available for analysis.	Yes	Hydrograph width analysis only
18114	Clashmorgan	Lyre	Mallow	153365	92501	02/06/2005	6	OPW	No	Missing data and poor quality data in 2006 shortens record available for analysis.	Yes	Hydrograph width analysis only
18115	Jordans Br.	Clyda	Mallow	157187	91917	01/07/2005	6	OPW	No	Missing data and poor quality data in 2006 shortens record available for analysis.	Yes	Hydrograph width analysis only
18117	Fermoy Mill	Blackwater (Munster)	Fermoy	181430	98630	13/09/2007	4	OPW	No	Short record period of largely good quality data	Yes	No
18119	Ballydahin	Blackwater (Munster)	Mallow	155250	97870	08/06/2009	2	OPW	No	Short record period, data unchecked with anomalous spikes in December 2010/Early 2011	Yes for 2009 event only	Hydrograph width analysis only
18123	Greenane	Allow	Kanturk	138220	103330	23/08/2010	1	OPW	No	Short record period, significant missing data periods in 2010	No	No
18004	Ballynamona	Awbeg	N/A	165657	107552		45	OPW	Yes	Suitable as potential pooling site but not located on any modelled reach AMAX series only available up to 2009 , FSU classed as grade B Detailed flow records not assessed as will only be used for pooling	Not required	Yes, Pooling information only
18016	Duncannon	Upper Blackwater	N/A	118027	93123	03/05/1982	20	EPA	Yes	Suitable as potential pooling site but not located on any modelled reach AMAX series has been checked through FSU, 9 years incomplete so discarded Detailed flow records not assessed as will only be used for pooling	Not required	Yes, Pooling information only

18024	Glenvuddig Br.	Funshion	N/A	172314	110775	16/03/2005	6	OPW	Yes	Short data record. Data to be used with caution	No	No
18050	Duarrigle	Upper Blackwater	N/A	124987	94359	05/10/1981	24	EPA	Yes	Suitable as potential pooling site but not located on any modelled reach AMAX series is complete, FSU classed as grade B Detailed flow records not assessed as will only be used for pooling	Not required	Yes, Pooling information only
18105	Castlelands	Blackwater	N/A	157400	98220	02/06/2005	6	OPW	Yes	Short data record. Period of data missing from January to October 2006	No	No
18112	Keale Bridge	Blackwater	N/A	129520	93520	01/06/2005	6	OPW	Yes	Short data record. Data to be used with caution	No	No
18113	Ahane Bridg	Owentaraglin	N/A	122416	94344	01/06/2005	6	OPW	Yes	Short data record. Data to be used with caution	No	No
18118	Shanbally	Spring	N/A	166242	107358	N/A	N/A	EPA	N/A	Data unavailable	No	No
18120	Nursetown	Lyre	N/A	153365	92501	01/07/2010	1	OPW	No	Short record period	Not required	No
18121	Shronebeh	Glen	N/A	139150	95736	01/07/2010	1	OPW	No	Short record period	Not required	No
18122	Gortageen	Blackwater	N/A	129430	93550	01/07/2010	1	OPW	No	Short record period	Not required	No

Type	OPW gauges	EPA gauges (operated by Cork County Council)	Total Gauges Available
River Flow and Water Level Gauges	18	6	24
River Level Gauges	11	1	12
River Flow and Level Observation Locations	0	39	39

Appendix D. Rainfall Gauges

Station Number	Name	Catchment	Owner	Easting	Northing	Elevation (mAOD)	Opened	Years Data	Data Interval	Comments	Fit for Calibration?	Fit for Statistical Analysis?
3904	Cork Airport	Owenboy-Douglas	Met Éireann	166500	66200	154	1961	51	Hourly	Data quality reasonable and covers the 2009 flood event	Yes	Not Required
7006	Bartlemy	Knoppoge-Bride	Met Éireann	181900	87600	98	1992	18	Daily	Data quality reasonable and covers the 2009 flood event	Yes	Not Required
4906	Conna (Carrigreen Hill)	Bride-Blackwater	Met Éireann	195500	95500	70	1981	22	Daily	Paired with 8406 to provide continuous daily rainfall at Mogeely Gauge	Yes	Not Required
8406	Conna (Castleview)	Bride	Met Éireann	195600	94500	30	2003	7	Daily	Data quality reasonable and covers the 2009 flood event	Yes	Not Required
3606	Fermoy (Moore Park)	Funshion-Blackwater	Met Éireann	181900	101400	55	1961	49	Hourly	Several months of missing data often occurring during August and summer months when there is typically little rainfall	Yes	Not Required
5806	Freemount Pumping Station	Allow	Met Éireann	139300	113900	137	1984	26	Daily	Several months of missing data often occurring during August and summer months when there is typically little rainfall	Yes	Not Required
1406	Kanturk (Voc.Sch.)	Dalua	Met Éireann	138400	103300	104	1944	66	Daily	Several months of missing data often occurring during August and summer months when there is typically little rainfall	Yes	Not Required
6606	Mallow (Sewage Treatment Works)	Blackwater	Met Éireann	157600	98000	55	1988	22	Daily	Several months of missing data often occurring during August and summer months when there is typically little rainfall	Yes	Not Required
3406	Tallow	Bride	Met Éireann	200900	94400	15	1952	48	Daily	Data quality reasonable and covers the 2009 flood event	Yes	Not Required
4106	Youghal (Glendine W.W.)	Glendine-Blackwater	Met Éireann	206400	83900	107	1964	46	Daily	Several months of missing data often occurring during August and summer months when there is typically little rainfall	Yes	Not Required
1007	Grange (Ballylangdon)	Stream	Met Éireann	217200	82700	101	1977	34	Daily	N/A	No	Not Required
1106	Cappoquin (Mt. Melleray)	Monavauga	Met Éireann	209500	104100	213	1944	67	Daily	Long dataset, includes calibration events. Large data gaps present throughout	Yes	Not Required
1504	Rathduff G.S.	Martin-Blarney	Met Éireann	159800	84800	138	1942	69	Daily	Data gaps throughout the record. November 2000 calibration event missing.		Not Required
2804	Donoughmore	Dripsey	Met Éireann	149200	82100	200	1948	63	Daily	Long record but with many data gaps. Cross reference to Cork Airport gauge shows it misses a significant rainfall event during July 1975.	Yes	Not Required
2904	Ballinagree (Mushera)	Laney	Met Éireann	135700	85500	351	1948	63	Daily	Poor quality record with significant data gaps throughout November 2000 calibration event data missing.	No	Not Required
3612	Ballymacarberry G.S.	Nier	Met Éireann	219300	112800	59	1943	68	Daily	Reasonable quality data, data for all flood and calibration events.	Yes	Not Required
3706	Rathluirc (For. Stn.)	Garrane-Blackwater	Met Éireann	157300	118500	131	1962	49	Daily	Frequent data gaps. Particularly in 1977 and 1979.	Yes	Not Required
3806	Youghal (St. Raphael's Shop)	On Coast	Met Éireann	210100	77500	70	1963	48	Daily	Good data quality, with few minor month data gaps	Yes	Not Required
4006	Knoacanore	Blackwater	Met Éireann	207500	89100	122	1964	47	Daily	Good data quality, with few minor gaps	Yes	Not Required
4804	Dungourney	Kiltha	Met Éireann	194800	83100	157	1976	35	Daily	Data gaps throughout. November 2000 and 2009 calibration events missing from data.	No	Not Required
4904	Killeagh (Monabraher)	Dissour-Womanagh	Met Éireann	201000	80600	98	1976	35	Daily	Data gaps throughout.	No	Not Required
5204	Macroom (Curraleigh)	Foherish-Sullane	Met Éireann	126300	80700	229	1977	34	Daily	Reasonable data record with gaps during June 1995, August 1990 and July 1980. Fairly significant rainfall recorded at synoptic stations during late July 1980	Yes	Not Required
5206	Newmarket	Dalua	Met Éireann	128400	112600	192	1982	29	Daily	Good data record with gaps (September 1991 and July 1986). Cotnains 2000 and 2009 calibration data. Synoptic stations show a 'sizeable' rainfall event in late July	Yes	Not Required
5306	Mount Russ	Graigue	Met Éireann	161300	119800	195	1984	27	Daily	Good quality data record covering calibration	Yes	Not

										events.		Required
5406	Galtee Mountains	Funshion	Met Éireann	188700	119500	335	1984	27	Daily	Reasonable data record with a high number of gaps. Contains 2000 and 2009 calibration events. Gaps do not correspond to large events at Cork Airport or Valentia.	Yes	Not Required
5506	Ballinamult	Finisk-Blackwater	Met Éireann	217500	106800	168	1984	27	Daily	Reasonable data series, data gaps in record but covers calibration events. Gaps do not correspond to significant periods of rainfall at Cork Airport or Valentia	Yes	Not Required
5706	Castlemagner	Awebeg-Blackwater	Met Éireann	142500	103800	98	1984	27	Daily	Poor data record, high number of missing periods of data. July 1999 to - February 20001 missing. Does not cover calibration events.	No	Not Required
5804	Watergrasshill (Tinageragh)	Stream-Butlerstown-Lee	Met Éireann	176100	84500	182	1988	23	Daily	Complete data record.	Yes	Not Required
6006	Ballydesmond	Blackwater	Met Éireann	114900	104000	201	1985	26	Daily	Reasonable data series, number of days missing data. January & September 1991 missing. Cork Airport and Valentia show no large events during this period.	Yes	Not Required
6011	Springfield Castle	Bunoke	Met Éireann	134600	122600	110	1994	17	Daily	N/A	No	Not Required
6204	Ballincurig (Peafield)	Templebodan	Met Éireann	186300	84200	158	1995	16	Daily	Good quality data, no gaps.	Yes	Not Required
6206	Lombardstown	Duvglasha	Met Éireann	146300	94200	134	1985	26	Daily	Minimal data gaps, covering flood events.	Yes	Not Required
6306	Batneer Lyre	Glen-Blackwater	Met Éireann	141500	92500	267	1985	26	Daily	Minimal data gaps, covering flood events.	Yes	Not Required
6406	Tallow	Bride-Blackwater	Met Éireann	201200	91300	104	1986	25	Daily	Minimal data gaps, covering flood events.	Yes	Not Required
6506	Millstreet	Stream-Finow	Met Éireann	127500	91000	101	1986	25	Daily	Minimal data gaps, covering flood events.	Yes	Not Required
6906	Millstreet (Coomlogane)	Finow-Blackwater	Met Éireann	126000	90900	113	1991	20	Daily	Minimal data gaps, covering flood events.	Yes	Not Required
706	Mallow (Hazelwood)	Blackwater	Met Éireann	155600	104500	94	1925	86	Daily	Long data record. Minimal gaps, covering all events	Yes	Not Required
7306	Newmarket (New Street)	Dalua	Met Éireann	131600	107500	152	1993	18	Daily	Good data, minimal data gaps.		Not Required
7406	Mallow (Spa House)	Blackwater	Met Éireann	156500	98700	61	1996	15	Daily	April 2000 gap only. Good Data series, covering events.	No	Not Required
7906	Ballyhooly	Blackwater	Met Éireann	171900	97600	140	2001	10	Daily	No data gaps.	Yes	Not Required
8006	Glencairne (Tourtane House)	Owbeg-Blackwater	Met Éireann	203300	96700	34	2001	10	Daily	No data gaps.	Yes	Not Required
8106	Cappoquin	Blackwater	Met Éireann	210600	99200	30	2001	10	Daily	No data gaps.	Yes	Not Required
8206	Mitchelstown	Stream-Funshion	Met Éireann	183000	109700	168	2001	10	Daily	August 2006 & February 2008 missing. Good coverage.	Yes	Not Required
8306	Shanballymore	Awbeg	Met Éireann	167200	107600	75	2002	9	Daily	No data gaps.	Yes	Not Required
907	Monatray East	On Coast	Met Éireann	214000	76600	55	1975	36	Daily	N/A	No	Not Required
9804	M. Ballyvourney (Knockacommeen)	Aughbeg-Suillane	Met Éireann	116000	80700	415	1948	63	Daily	Gauge inactive/No recorded data	No	Not Required
9906	M Mallow Forest	Castlepook	Met Éireann	160200	115100	229	1995	16	Daily	Good data record but covers no calibration events.	No	Not Required
80701	Bottle Hill - Pump House	Stream-Leapford	OPW	161063	88466	205	N/A	N/A	Hourly	Data requested.	N/A	N/A
80702	Bweeng - Pump House	Cummeen	OPW	149360	87869	218	N/A	N/A	Hourly	Data requested.	N/A	N/A
80703	Lyre - Reservoir	Fermoyle	OPW	140596	91936	311	N/A	N/A	Hourly	Data requested.	N/A	N/A
80704	Kilcorney - Reservoir	Rathcool	OPW	133711	90321	174	N/A	N/A	Hourly	Data requested.	N/A	N/A
80705	Millstreet - Reservoir	Finnow	OPW	126049	89393	253	N/A	N/A	Hourly	Data requested.	N/A	N/A
80706	Buttervant - Pump House	Awbeg	OPW	153379	108472	122	N/A	N/A	Hourly	Data requested.	N/A	N/A

80707	Ballyhoura Way - Water intake works	Awbeg	OPW	152888	114398	86	N/A	N/A	Hourly	Data requested.	N/A	N/A
80708	Freemount - Waste water treatment plant	Allow	OPW	139408	113998	135	N/A	N/A	Hourly	Data requested.	N/A	N/A
80709	Meelin - Water treatment plant	Dalua	OPW	129019	111885	250	N/A	N/A	Hourly	Data requested.	N/A	N/A
80710	Newmarket - Reservoir	Dalua	OPW	131637	107079	186	N/A	N/A	Hourly	Data requested.	N/A	N/A
80711	Ballydesmond - Pump house	Blackwater	OPW	115026	103843	223	N/A	N/A	Hourly	Data requested.	N/A	N/A
80712	Knocknagree - Old pump house	Athnaloingebaine	OPW	118577	97862	169	N/A	N/A	Hourly	Data requested.	N/A	N/A
80713	Duhallow Way - Reservoir	Stream-Awnaskirtuan	OPW	117626	88509	424	N/A	N/A	Hourly	Data requested.	N/A	N/A
80714	Kanturk - Waste water treatment plant	Allow	OPW	138451	101775	80	N/A	N/A	Hourly	Data requested.	N/A	N/A
80715	Mallow - Pump house	Clyda	OPW	154104	95791	103	N/A	N/A	Hourly	Data requested.	N/A	N/A
80716	Kishkeam - Waste water treatment	Owentaraglin	OPW	120785	103812	173	N/A	N/A	Hourly	Data requested.	N/A	N/A
80717	Rathcoole - Waste water treatment plant	Rathcool	OPW	133406	94120	107	N/A	N/A	Hourly	Data requested.	N/A	N/A
80718	Pallas - Old pump house	Blackwater	OPW	145573	98161	61	N/A	N/A	Hourly	Data requested.	N/A	N/A
80719	Doneraile - Pumphouse	Awbeg	OPW	158665	107508	75	N/A	N/A	Hourly	Data requested.	N/A	N/A
80720	Kilbrin - Resevoir	Allow	OPW	142907	107149	182	N/A	N/A	Hourly	Data requested.	N/A	N/A
80721	Two Pot House - Resevoir	Stream-Blackwater	OPW	157150	102581	101	N/A	N/A	Hourly	Data requested.	N/A	N/A
80722	Ballygugroe - Landfill	Farahy	OPW	166243	114549	191	N/A	N/A	Hourly	Data requested.	N/A	N/A
80723	Kildorrey - Sewage Works	Funshion	OPW	171727	110626	78	N/A	N/A	Hourly	Data requested.	N/A	N/A
80724	Mitchelstown - Water Treatment Plant	Gradoge	OPW	180920	113349	96	N/A	N/A	Hourly	Data requested.	N/A	N/A
80725	Castlecooke - Pumphouse	Stream-Araglin	OPW	187734	104662	126	N/A	N/A	Hourly	Data requested.	N/A	N/A
80726	Bartlemy - Pumphouse	Knoppoge-Bride	OPW	181733	88500	107	N/A	N/A	Hourly	Data requested.	N/A	N/A
80727	Fermoy - Pumphouse	Cregg-Blackwater	OPW	177618	98283	78	N/A	N/A	Hourly	Data requested.	N/A	N/A
80728	Coole - Pumphouse	Bride	OPW	186894	95063	56	N/A	N/A	Hourly	Data requested.	N/A	N/A
80729	Tallow - Reservoir/Pumphouse	Bride	OPW	200822	92213	119	N/A	N/A	Hourly	Data requested.	N/A	N/A
80730	Lismore - Resevoir/Pumphouse	Stream-Glenakeefe	OPW	206103	101402	165	N/A	N/A	Hourly	Data requested.	N/A	N/A
80731	Cappoquin - Cappoquin	Blackwater	OPW	213336	97704	15	N/A	N/A	Hourly	Data requested.	N/A	N/A
80732	Killavullen - Water Treatment Plant	Ross-Blackwater	OPW	164898	99446	67	N/A	N/A	Hourly	Data requested.	N/A	N/A

Type	Met Éireann gauges within or used for subject catchments	OPW gauges within or used for subject catchments	Total Gauges Available
Daily Rainfall Gauges	47	0	35
Hourly Rainfall Gauges	0	32	33 (1 synoptic station)
Synoptic Stations (weather forecasting locations including rainfall)	1	0	1

Glossary

AEP	Annual Exceedence Probability; this represents the probability of an event being exceeded in any one year and is an alternative method of defining flood probability to 'return periods'. The 10%, 1% and 0.1% AEP events are equivalent to 10-year, 100-year and 1000-year return period events respectively.
AFA	Area for Further Assessment – Areas where, based on the Preliminary Flood Risk Assessment and the CFRAMS Flood Risk Review, the risks associated with flooding are potentially significant, and where further, more detailed assessment is required to determine the degree of flood risk, and develop measures to manage and reduce the flood risk.
AMAX	Annual Maximum Flood
ARR	Area for Risk Review
CAR	Community at Risk
CFRAM	Catchment Flood Risk Assessment and Management – The 'CFRAM' Studies will develop more detailed flood mapping and measures to manage and reduce the flood risk for the AFAs.
DAD	Defence Asset Database
DAS	Defence Asset Survey
DEFRA FD2308	United Kingdom Government Department for Environment, Food and Rural Affairs, Joint probability - dependence mapping and best practice Report (2005)
DTM	Digital Terrain Model (often referred to as 'Bare Earth Model')
EPA	Environmental Protection Agency
EU WFD	European Union Water Framework Directive (2000)
EurOtop	European Wave Overtopping of Sea Defences and Related Structures Manual (HR Wallingford 2008)
FRI	Flood Risk Index - a metric that allows the risk to different types of assets (e.g., home, business, monument, utility asset, etc.) to be expressed numerically, but without attempting to assign monetary values to all types of damage.
FRMP	Flood Risk Management Plan. This is the final output of the CFRAM study. It will contain measures to mitigate flood risk in the AFAs.
FRR	Flood Risk Review – an appraisal of the output from the PFRA involving on site verification of the predictive flood extent mapping, the receptors and historic information.
FSU (WP)	Flood Studies Update (Work Package) (2008)
GIS	Geographical Information Systems
HA	Hydrometric Area. Ireland is divided up into 40 Hydrometric Areas.
HEP	Hydrological Estimation Point
HPW	High Priority Watercourse. A watercourse within an AFA.
ICPSS	Irish Coastal Protection Strategy Study (2012)
ICWWS	Irish Coastal Water Level and Wave Study (2013)
IRR	Individual Risk Receptors
ISIS	One dimensional hydraulic modelling software approved for the CFRAM framework

MPW	Medium Priority Watercourse. A watercourse between AFAs, and between an AFA and the sea.
OPW	Office of Public Works, Ireland
OSI	Ordnance Survey Ireland
PFRA	Preliminary Flood Risk Assessment – A national screening exercise, based on available and readily-derivable information, to identify areas where there may be a significant risk associated with flooding.
SEA	Strategic Environmental Assessment. A high level assessment of the potential of the FRMPs to have an impact on the Environment within a UoM.
SW CFRAM	South Western Catchment Flood Risk Assessment and Management study
UoM	Unit of Management. The divisions into which the RBD is split in order to study flood risk. In this case a HA.
WFD	Water Framework Directive. A European Directive for the protection of water bodies that aims to, prevent further deterioration of our waters, to enhance the quality of our waters, to promote sustainable water use, and to reduce chemical pollution of our waters.