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

Hydraulics Report
Unit of Management 27

Final Report

June 2016

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Glossary

AEP	Annual Exceedance Probability	The probability that a certain flow value will be exceeded in any one year. For example the flow associated with the 1% AEP event at a particularly location has a 1 in 100 chance of being exceeded in any year. A 5% AEP event has a 1 in 20 chance of being exceeded in any year.
AFA	Area for Further Assessment	An area that is considered to be at potentially significant risk of flooding, thereby justifying its inclusion for further assessment. Note that the term AFA is a replacement term for what was previously referred to as an APSR (Area of Potential Significant Risk). AFAs include cities, towns, villages, and individual risk receptors (IRR)
CFRAM Study	Catchment-based Flood Risk Assessment and Management Study	The five year study covering the whole River Shannon catchment area which gives a picture of past flooding and areas at risk of future flooding, and sets out a prioritised set of specific measures for reducing and managing flood risk.
HEP	Hydrological Estimation Point	A location along a watercourse (MPW and HPW) at which flood flows are estimated for a range of flood events of different frequencies.
HEFS	High-End Future Scenario	Potential future scenario representing climate change impacts not significantly outside the range of accepted predictions available, and with the allowances for increased flow, sea level rise etc. at the upper bounds of widely accepted projections
HPW	High Priority Watercourse	Watercourses that could give rise to existing or potential future fluvial or estuarine flooding within an AFA
IRR	Individual Risk Receptor	A receptor that warrants consideration of flood risk in its own right (rather than within an AFA), typically major infrastructure. Note that an IRR is a specific type of AFA
Manning's 'n'	Manning's 'n'	An empirical value used widely in hydraulic modelling to describe the hydraulic roughness of an area along (or over) which water flows. Higher values

		indicate a “rougher” surface.
MPW	Medium Priority Watercourse	Watercourses that could give rise to existing or potential future fluvial or estuarine flooding outside of AFAs. River reaches between AFAs, or between an AFA and the sea are also defined as MPWs.
MRFS	Mid-Range Future Scenario	Represent a ‘likely‘ future scenario based on the wide range of predictions available and with the allowances for increased flow, sea level rise, etc. within the bounds of widely accepted projections
OSi	Ordnance Survey Ireland	The base mapping (ortho aerial imagery, vector data and raster data) used throughout the study and this report is owned by Ordnance Survey Ireland and is reproduced under a licence agreement.
RBD	River Basin District	The natural geographical and hydrological units for water management, as defined during the implementation of the Water Framework Directive.
UoM	Unit of Management	The division of the study area into major catchments and their associated coastal areas.
1D domain	1D domain	The part of a hydraulic model which is defined by flow in 1 dimension. This is used for flow that is within the banks of a watercourse as the flow is essentially in one direction.
2D domain	2D domain	The part of a hydraulic model which is defined by flow in 2 dimensions. This is used for flow that is out of bank, spreading across a floodplain or other area. The flow is characterised by flood water spreading in two dimensions (in plan view) once it overtops the banks of a watercourse. Tidal flooding is also typically in 2 dimensions.

1 Introduction

1.1 Shannon CFRAM Study Area

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

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

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

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

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

As defined under the Water Framework Directive (WFD) a RBD is divided further into Units of Management (UoM). The UoM constitute major catchments or river basins (typically greater than 1000km^2) and their associated coastal areas, or conglomerations of smaller river basins and their associated coastal areas. The Shannon RBD (and by definition the Shannon CFRAM Study Area) and the UoMs within the Shannon RBD are shown in Figure 1.1. There are six UoMs in total with some of the UoMs grouped together, for reporting purposes, as follows, see Figure 1.1.

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

1.2 Hydraulics Report Scope

The specification for the Hydraulics Report is set out in Section 7 of the Catchment – based Flood Risk Assessment and Management (CFRAM) Studies Stage 1 Project

Brief (June 2010) and elements of Sections 2.21 to 2.23 of the Shannon CFRAM Study Stage II Project Brief (October 2010). Relevant extracts are included in Appendix A. It should be noted that programme dates noted in Appendix A are superseded.

The scope requires a single Hydraulics Report for each UoM. Each Hydraulics Report is required to cover both fluvial hydraulic models and coastal flooding models where applicable.

There are no hydraulic models or coastal flooding models required for UoM 28 under the scope of works for the Study Area, so therefore no associated Hydraulics Report for this UoM is required. There are therefore four Hydraulics Reports for the Shannon CFRAM Study Area, one for each UoM in which at least one fluvial hydraulic model or coastal flooding model exists.

1.2.1 Fluvial & Coastal Hydraulic Models

The Shannon CFRAM Study Area is comprised of 38 fluvial and / or coastal hydraulic models, split between the UoM. The model numbers and AFA/IRR names are a unique identifier enabling easy identification of the relevant model covering a particular AFA of interest. The prefix “N” refers to the “North” part of the Shannon RBD which is all models covering UoM 25/26, while the prefix “S” refers to the “South” part of the Shannon RBD covering UoM 23, 24, and 27. The North and South identifiers do not represent any formal administrative or regional boundaries; they are used for convenience within this study due to the study’s large geographic area.

There are two IRRs within the Shannon RBD (Tarbert Power Station and Shannon Airport) which are at risk of flooding from tidal and wave conditions only and therefore are being appraised as standalone coastal flooding models. Table 1.1 summarises the 62 AFAs and 4 IRRs being represented across the 38 hydraulic models.

Table 1.1 List of Hydraulic Fluvial & Coastal Models by UoM

UoM	Model Ref	AFA/IRR names	Fluvial (F) or Coastal (C) models
UoM 23	S14-a	Abbeyfeale, Listowel	F
	S14-b	Moneycashen	F / C
	S14-c	Athea	F
	S15	Abbeydorney	F
	S16	Tralee	F / C
	S17	Banna	F / C
UoM 24	S05	Ballylongford	F / C
	S06	Adare, Clarina	F / C
	S07	Croom	F
	S08	Kilmallock, Charleville	F

UoM	Model Ref	AFA/IRR names	Fluvial (F) or Coastal (C) models
	S09	Foynes	F / C
	S10	Rathkeale, Askeaton	F / C
	S11	Newcastle West	F
	S12	Dromcolliher, Milford	F
	IRR4	Tarbert Power Station (IRR4)	C
UoM 25/26	N01	Boyle, Drumshanbo, Leitrim, Carrick-on-Shannon	F
	N02	Mohill, Dromod, Longford, Cloondara	F
	N03	Edgworthstown, Abbeyshrule, Ballymahon	F
	N04	Roscommon	F
	N05	Mullingar	F
	N06	Kilbeggan, Clara, Pollagh	F
	N07	Clonaslee, Rahan	F
	N08	Castlerea, Athleague	F
	N09	Ahascragh, Ballinasloe	F
	N10	Lanesborough Power Station (IRR1), Athlone, Shannonbridge Power Station (IRR2), Shannon Harbour	F
	N11	Roscrea, Birr	F
	N12	Portumna, Killaloe / Ballina, O'Brien's Bridge, Casteconnell, Springfield	F
	N13	Borrisokane	F
	N14	Nenagh	F
	N15	Cappamore, Newport	F
	N16	Limerick City and Environs	F / C
UoM 27	S01	Ennis	F / C
	S02	Quin	F
	S03	Bunratty, Sixmilebridge	F / C
	S04	Shannon,	F / C
	IRR3	Shannon Airport (IRR3)	C.
	S18	Kilrush	F / C
	S19	Kilkee	F / C

1.3 Context for Hydraulics Report under the EU Floods Directive

The four Shannon CFRAM Study Hydraulics Reports, representing each of the UoM, have all been produced to support the OPW in its legislative role to report flood hazard and develop a management plan for all significant flood risk areas across Ireland. This is required under the EU "Directive on the assessment and management of flood risks" (2007/60/EC), commonly referred to as the "Floods Directive".

1.4 Structure of this Report

1.4.1 Main Report

This Hydraulics Report covers all hydraulic modelling and mapping aspects relating to this UoM 27. The "Main Report" i.e. this document excluding appendices, is structured to reflect the specific reporting requirements of the CFRAM Studies Project Brief as follows:

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

Section 2 Provides a description of the Hydrometric and Hydrological Information used in the Fluvial Hydraulic Modelling and Coastal Flooding Modelling.

Section 3 Describes, in general terms, the approach to Fluvial Hydraulic Model construction and calibration.

Section 4 Describes, in general terms, the approach to Coastal Flooding Model construction and calibration

Section 5 Presents the approach to flood hazard and flood risk mapping.

With specific reference to the detailed requirements of the Hydraulics Report, as set out in the CFRAM Studies Project Brief, Table 1.2 shows how these requirements are met within the structure of this report.

Table 1.2 Project Brief Requirements and Links to this Report

Brief Requirement	Hydraulics Report Section and Description
Surveys	*Section 3.3 - Survey Data and Base Mapping* This section describes the flood defences, the channels, the structures and the floodplain survey data that was collected for the development of the hydraulic models.
Development of Fluvial Hydraulic Models	*Section 3 – Hydraulic Model – Summary of Methodology* This section details the methodology followed in the development of the fluvial hydraulic models.

Model Calibration	*Section 3.5 - Hydraulic Model Calibration and Sensitivity Model Runs* This section details the process involved in the calibration of the hydraulic models. The purpose of the calibration process is to test the confidence of the results and to ultimately identify flood outlines, flood depths, and flood hazards.
Development of Coastal Flooding Models	*Section 4 - Coastal Flooding Model Construction* This section addresses the coastal flooding model construction process in general terms.
Development of Flood Hazard Mapping	*Section 5 – Flood Hazard Mapping* This section describes the methodology behind development of the flood hazard maps.

1.4.2 Report Appendices

A series of appendices to this Hydraulics Report are relevant to summarising our adopted modelling approach. These are:

Appendix A Relevant extracts from CFRAM Studies Project Stages I and II defining the scope of the Hydraulics Report.

Appendices B Fluvial Hydraulic Model Appendices. Each hydraulic model with a fluvial only component has an individual Appendix section numbered B1, B2, B3, B4 etc, covering specified elements of the models for UoM 27.

Appendices C Fluvial/Coastal Hydraulic Model Appendices. Each hydraulic model with coastal only or coastal and fluvial components has an individual Appendix section numbered C1, C2, C3, C4 etc, covering specified elements of the models for UoM 27.

Appendix D Shannon CFRAMS Design Tidal Hydrographs

Appendix E National Technical Co-ordination Group (NTCG) Guidance Note no. 23 (GN23)

Appendix F National Technical Co-ordination Group (NTCG) Guidance Note no. 22 (GN22)

Appendices B and C provide specific information for each respective model. This enables different stakeholders to easily identify the models that may be of interest to them, allowing them to view the **relevant model Appendix section**. Table 1.3 summarises the Appendix section reference for each model and the relevant AFA for UoM 27.

Table 1.3 Fluvial Hydraulic Model and Fluvial/Coastal Model Appendices for UoM 27

Appendix Section	Hydraulic Model Reference	AFA	County
Appendix B1	S02	Quin	Clare
Appendix C1	S01	Ennis	Clare
Appendix C2	S03	Sixmilebridge	Clare
		Bunratty	Clare
Appendix C3	S04	Shannon	Clare
Appendix C4	IRR3	Shannon Airport	Clare
Appendix C5	S18	Kilrush	Clare
Appendix C6	S19	Kilkee	Clare

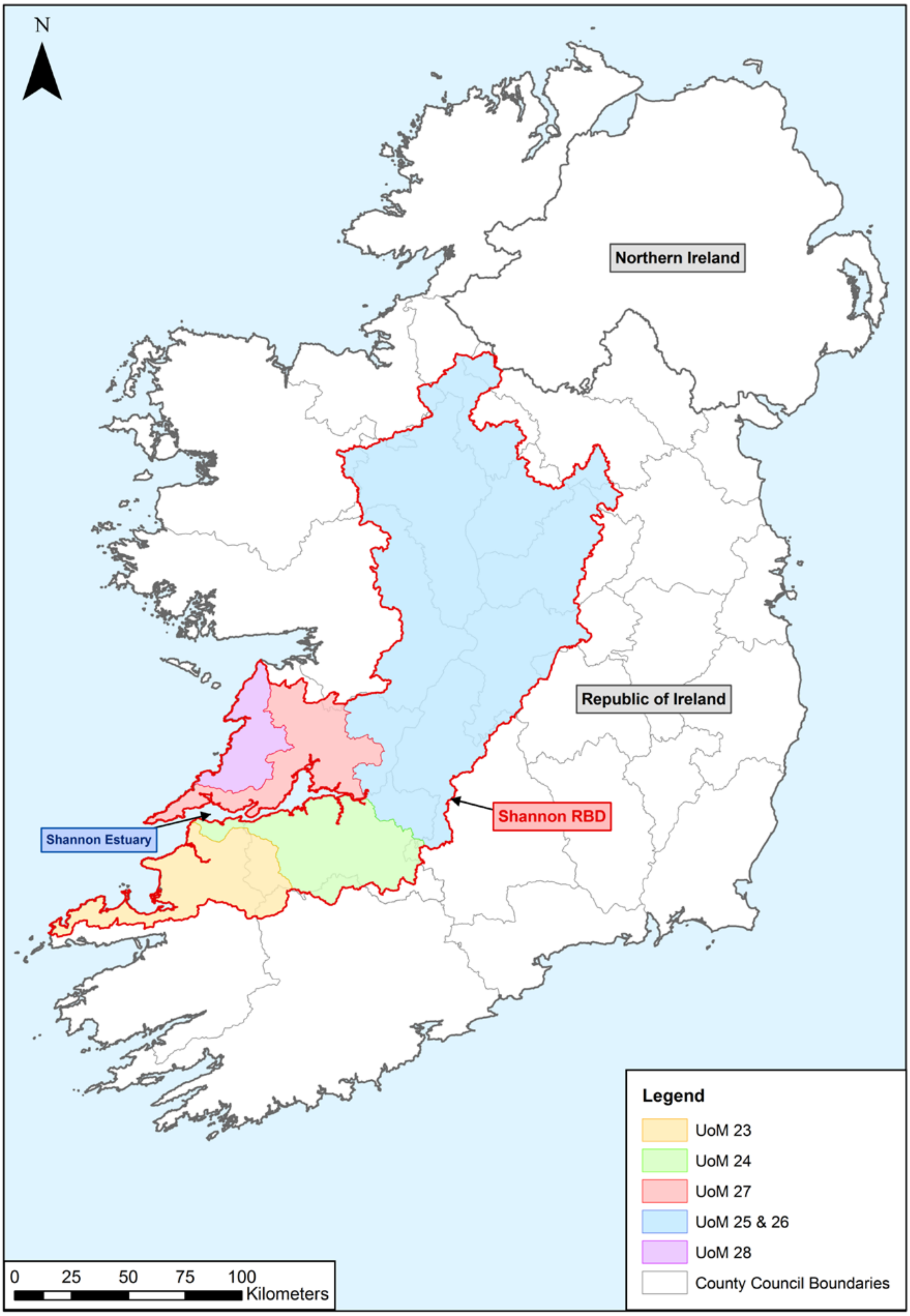

Figure 1.1 Shannon RBD and its Units of Management

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2 Hydrological and Hydrometric Information

2.1 Catchment Description

The Shannon Estuary North (or UoM 27) is located almost entirely within County Clare, with only a very small part of the unit of management within Limerick and Galway. The total area of UoM 27 is approximately 1,650km^2.

The unit of management is dominated by two main river catchments, which are, from east to west, the River Owenogarney (or Ratty) and the River Fergus, both of which discharge into the Shannon Estuary. The largest of these is the River Fergus. Further to the west, the rivers are much smaller, with several rivers draining generally southwards into the Shannon Estuary, such as the Crompaun and the Cloon.

The coastline extends along the Shannon Estuary from Limerick City in the east to where it meets the Atlantic Ocean at Loop Head in the far west of County Clare.

From Loop Head the coastline extends northeast to Kilkee, along which the coastline is exposed to the Atlantic Ocean. UoM 27 is bounded to the east by the Lower Shannon Hydrometric Area (part of UoM 25/26), to the north by the Western RBD and to the west by UoM 28, separated from it by the upland area which creates the catchment divide.

The far north of UoM 27 includes the southern part of The Burren, with its characteristic karst limestone features, and the virtual absence of any surface water features. The southern part of UoM 27 is dominated by the tidal influence of the Shannon Estuary, which is reflected by the extensive flood defence assets (typically tidal embankments) located along the low-lying shoreline for much of its length in the eastern part of UoM 27. In the central part of UoM 27, the River Fergus dominates, rising northwest of Corrofin near Lough Fergus, flowing through Corrofin and then through the central part of UoM 27, where it is dominated by numerous groundwater-fed lakes, heavily influenced by the limestone geology. Just north of Ennis it flows through Ballyallia Lough before splitting into two channels in the northern part of Ennis. The main River Fergus channel flows through the northwestern part of the town and the town centre (where the River Claureen or Inch joins the Fergus from the west) while the smaller channel flows southeast through the northern part of the town. The two parts of the Fergus re-join on the eastern side of Ennis. South of Ennis, the river widens and there is a tidal barrage located at Clarecastle approximately 4km south of the centre of Ennis. 3km south of Clarecastle, the River Rine (or Ardsolus in its lower reaches) flows into the tidal River Fergus before entering the Shannon Estuary.

Towards the eastern boundary of UoM 27, the River Owenogarney (or Ratty) flows into the Shannon Estuary, draining the eastern part of the catchment, and is separated from the Lower Shannon catchment (part of UoM 25/26) by the Slieve Bearnagh Mountains.

Table 2.1 below indicates the main sub-catchments and watercourses modelled in this unit of management. In accordance with the scope, the Crompaun catchment, which includes Limerick AFA, has been included within the Shannon Upper and Lower Unit of Management UoM 25/26.

Table 2.1 Sub-catchment and models within UoM 27

Sub-catchments	Main Watercourses	AFAs	Model Reference
Fergus	Claureen (River), Fergus (River), Gaurus (River), Rine (River)	Ennis	S01
	Rine (River)	Quin	S02
Owenogarney	Owenogarney (River)	Sixmilebridge	S03
		Bunratty	
Shannon	Urlan Beg (Stream), Clonloghan (Stream), Mogullaan (River)	Shannon	S04
Kilrush	Wood (River)	Kilrush	S18
Kilkee	Kilkee Upper and Lower	Kilkee	S19

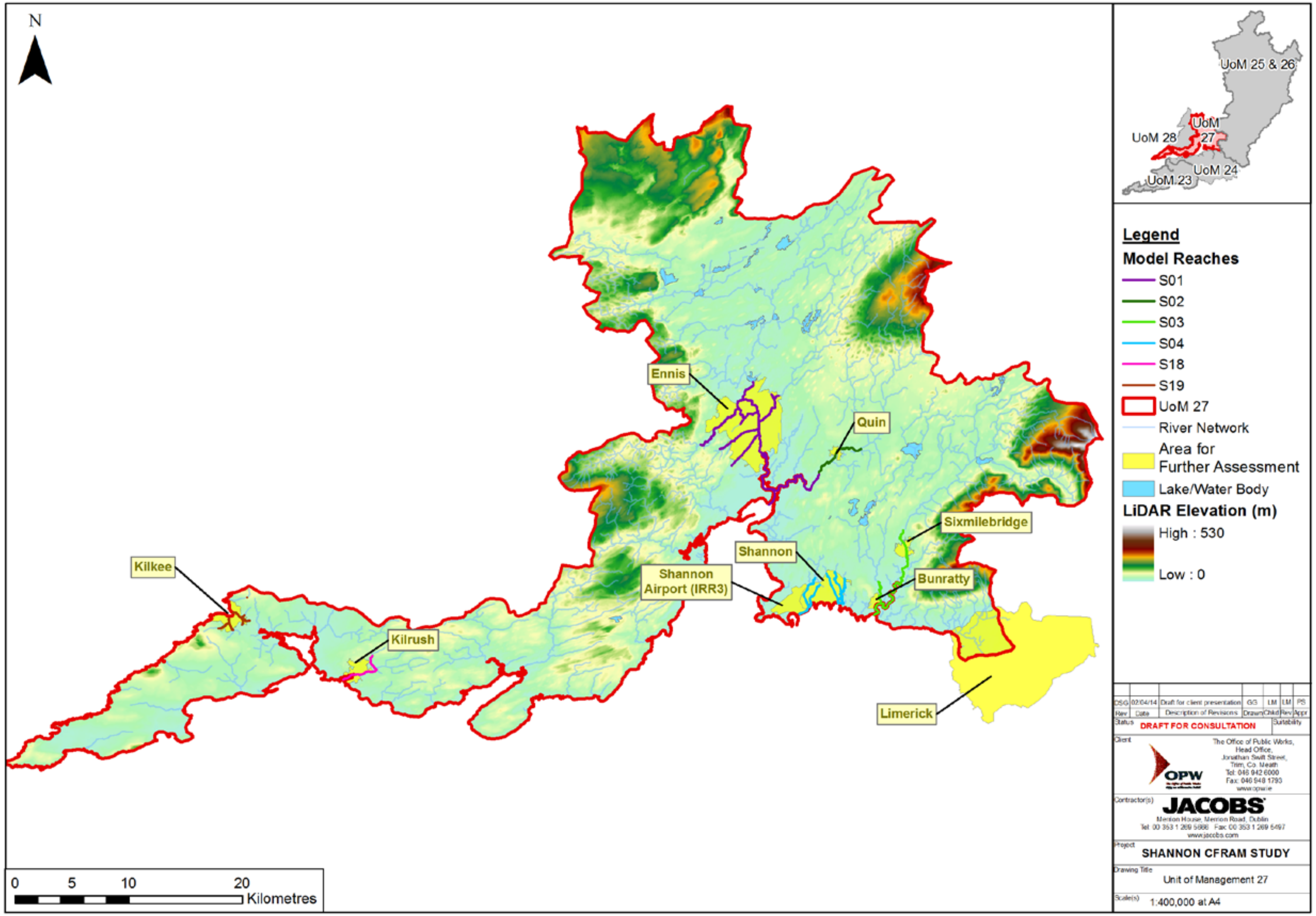

Figure 2.1 UoM 27 Study Area and hydraulic models

2.2 Hydrometric Data

Details of the hydrometric data used in the study, and the relevance to each UoM within the Shannon RBD, are discussed in the Preliminary Hydrological Assessment and Method Statement, produced as part of the **Inception Report** in 2012.

There is also a **Hydrology Report** associated with each UoM prepared in conjunction with this Hydraulics Report, which provides significant information with regard to the hydrometric data used.

Details of the Hydrology Report are not repeated within this Hydraulics Report, although the key aspects are noted.

The focus for the use of hydrometric data within the Shannon RBD is on river gauging stations where there are time series records of both water level and flow. As noted in the Inception Report, there is limited sub-daily rainfall data available within the Shannon RBD, and therefore rainfall-runoff modelling has not been used. The derivation of flow estimates for input to the hydraulic models is therefore based on the statistical analysis of flows across the catchment. This is the case for all UoM's within the Shannon RBD.

Table 2.2 summarises the split of gauging station reviews across each of the UoM, with a full list of the gauging station reviews undertaken for UoM 27 presented as Table 2.3.

Table 2.2 Hydrometric Gauging Stations for review across the Shannon RBD

Unit of Management	Number of GS for rating Review
UoM 23	3
UoM 24	11
UoM 25/26	28
UoM 27	2
UoM 28	0

2.3 Historic Data

In addition to the hydrometric data, historic flood information has also been used where possible, to inform the development of the hydraulic models and to check the validity of the model against historic events.

In principle, this requires recorded water levels and flows at a defined location and time. This can then be verified with flow estimates derived from gauging station data, enabling the accuracy of the hydraulic model to be verified.

Appendix F of the Hydrology Report for UoM 27 contains the relevant historic data available and used for each respective hydraulic model within UoM 27.

Table 2.3 Gauging Stations with a Rating Review within UoM 27

Hydrometric Gauging Station No.	Name of Station		
		River	UoM 27 sub-catchment
27001	Inch Bridge	Claureen	Fergus
27011	Owenogarney	Owenogarney	Owenogarney

2.4 Design Flows

Taking account of the gauging station reviews, historic flood information and the use of appropriate hydrological methods, design flows have been developed across the RBD at specified Hydrological Estimation Points (HEPs). These HEPs are typically at 5km spacing along watercourses, at the confluence of watercourses, and at the upstream and downstream AFA boundaries where the watercourse flows into and out of the AFA.

The design flows for each hydraulic model are provided in the relevant model Appendix section, with further information provided in the Hydrology Report.

2.5 Coastal Aspects of the Catchment

2.5.1 Sites for coastal flooding assessment

Table 2.4 lists the AFA/IRRs within UoM 27 selected by the OPW for being at risk of flooding from coastal sources either through a combination of high tide and surge and/or due to wave overtopping. These areas are shown on Figure 2.3. For completeness, Table 2.4 also shows whether these areas are also at risk of fluvial flooding.

Table 2.4 Sites for coastal flooding assessment within UoM 27

Model reference	Name of AFA/IRR	Source of flood risk		
		Tide +Surge	Wave overtopping	Fluvial
S01	Ennis	Yes	No	Yes
S03	Bunratty	Yes	No	Yes
S04	Shannon	Yes	Yes	Yes
IRR3	Shannon Airport	Yes	Yes	No
S18	Kilrush	Yes	Yes	Yes
S19	Kilkee	Yes	Yes	Yes

2.5.2 Coastal data

OPW have provided the results from the Irish Coastal Protection Strategy Study (ICPSS)[1]. This gives extreme tidal peak levels for the following annual probabilities: 50%, 20%, 10%, 5%, 2%, 1%, 0.5%, 0.1% for the south western coast and the Shannon Estuary. These peak levels along with tidal gauge level data (2003-2007) collected from the Shannon Foynes Port Company at Foynes, Carrigaholt and Limerick along the Shannon Estuary were used to produce design tidal hydrographs. This process is fully explained in Section 4.3 and Appendix D of this report. The design tidal hydrographs were used to inform downstream boundary conditions for the following hydraulic models: S01, S03, S04, IRR3, S18 and S19.

OPW has also provided results from the ICWWS (Irish Coastal Wave & Water Level Modelling Study)[2] screening analysis which highlight coastal locations potentially vulnerable to wave overtopping for the south western coast and the Shannon Estuary.

For these locations, detailed wave and still water level model outputs are available in the form of shoreline prediction points and their associated predicted water level and wave climate (wave height H_{mo}, period T_p and mean direction) combinations for a range of annual probabilities (50%, 20%,10%, 5%, 2%, 1%, 0.5% and 0.1%). These outputs include both the current condition and two future scenarios (Mid Range Future Scenario [MRFS] and High End Future Scenario [HEFS]).

S04, IRR3, S18 and S19 are the models within UoM27 for which wave overtopping simulations have been undertaken. The methodology adopted to carry out wave overtopping modelling is fully explained in Section 4.4 of this report.

[1] Irish Coastal Protection Strategy Study Phase 4 – South West Coast, December 2013 - RPS

[2] Irish Coastal Wave & Water Level Modelling Study – Coastal Areas Potentially Vulnerable to Wave Overtopping, RPS, November 2012

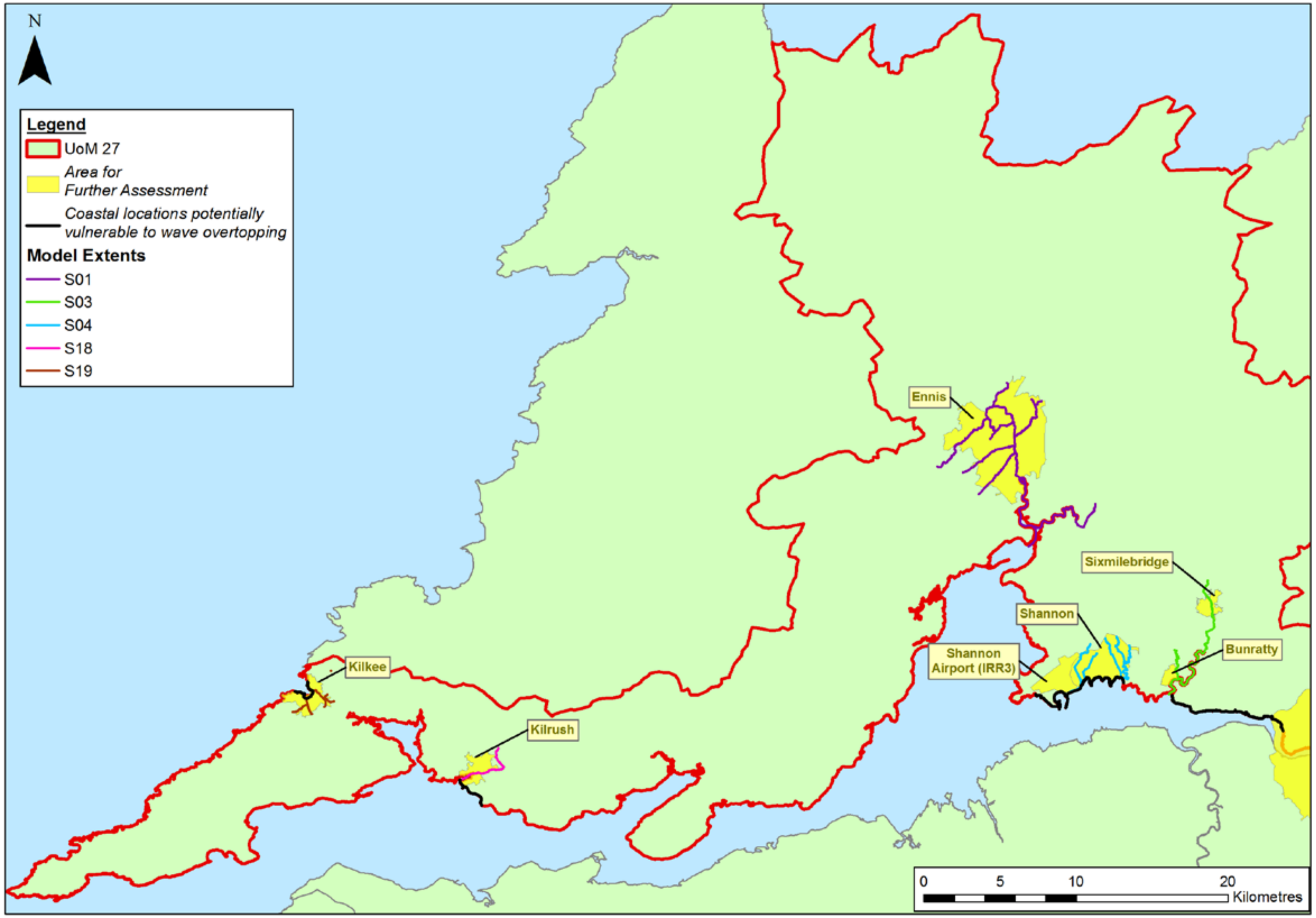

Figure 2.3 – AFAs and Models within UoM 27 for coastal flooding assessment

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3 Fluvial Hydraulic Model – Summary of Methodology

3.1 Introduction

Six hydraulic models (S01, S02, S03, S04, S18 and S19) have been developed for HPWs and MPWs within UoM 27 to estimate fluvial design and potential future flood levels, depths, velocities and extents. Where possible the models have been calibrated and verified against observed flood events. The models have been run for fluvial design flood events with the following range of annual exceedance probabilities (AEPs):

- 50%, 20%, 10%, 4%, 2%, 1%, 0.5% and 0.1% for existing conditions and for the Mid-Range Future Scenario (MRFS)
- 10%, 1% and 0.1% for the High End Future Scenario (HEFS)

This section of the Hydraulics Report provides an overview of the model construction method common to all the Shannon CFRAM fluvial hydraulic models. Further detail on each hydraulic model is then included in the relevant model Appendix section (Appendix B and C), covering specific information on the following elements:

- Basic Model Information
- Survey Data and Base Mapping
- Hydraulic Model Construction and Schematisation
- Hydraulic Model Calibration and Sensitivity
- Model Files and Naming Convention
- Key Model Assumptions

The following sections provide the overview of the relevant data and approach taken with regard to these elements.

3.2 Base Model Information

The base model information provided for each model covers:

- Model ID
- Unit of Management
- AFAs included within the model
- Primary watercourses and water bodies included within the model domain

3.3 Survey Data and Base Mapping

The base data required for the hydraulic model build is as follows:

- Mapping data in suitable formats to provide base mapping for the models
- Survey data for floodplain areas derived from LiDAR survey
- Topographic survey defining key ground levels, channel cross-sections
- Longitudinal sections, and levels and dimensions of critical structures

- Flood defence information[3]: type, extents and crest levels

3.3.1 Base Mapping

The base mapping used throughout is standard OSi mapping at a scale of 1:50,000 provided in raster format. Within each relevant model Appendix section, the relevant 1:50,000 OSi tile reference(s) are noted for the area covered by the model.

To aid with the presentation of the flood mapping, this is supplemented by OSi NTF[4] vector mapping at scales of 1:5,000, 1:2,500 and 1:1,000 covering the entire Shannon RBD. There is no overlap between these mapping files; the scale at which mapping is available depends on the nature of the area. For example, rural areas are typically at 1:5,000 while town centres are typically covered by 1:1,000 map tiles.

3.3.2 Digital Terrain Model for 2D Model domain

For the development of the two dimension (2D) model domain, for those models that are constructed using a 1D-2D (ISIS-TUFLOW) approach, a Digital Terrain Model (DTM) is required.

The data used for the 2D domain is a combination of high resolution LiDAR data covering the AFAs and the HPW reaches, combined with lower resolution IFSAR data for the areas outside of the AFAs and along MPW reaches.

The LiDAR data has a 2m horizontal resolution and a 200mm vertical accuracy. The IFSAR data has a 5m horizontal resolution and an approximate 500mm-1000mm vertical accuracy.

Due to the method by which the LiDAR data has been gathered (by flying defined flight lines over the area for which LiDAR data is to be captured) there is often LiDAR available for reaches outside the defined AFA boundary. Where this higher accuracy LiDAR data is available outside AFAs, it has been incorporated into the hydraulic models in preference to the IFSAR.

3.3.3 River Channel / Structures Survey

The topographic survey of the watercourse channels, estuaries and associated structures for UoM 27 has been undertaken by Blom and Murphy Surveys. The survey was procured by Jacobs from August 2012 to July 2013.

The channel and structure survey includes:

- **Channel cross-sections.** This includes the bank profile extending a short distance into the floodplain, the channel bed profile, the water level at the time of the survey, and an indicative location of the “top of bank”.

- **Longitudinal sections.** This includes sections along both river banks, picking up key features of the river bed profile such as weirs and along the river banks, such as high points, low points, start / end of flood defences walls etc.

[3] The Flood Defence Asset Database is provided as a separate deliverable to this report.
[4] NTF is a vector mapping format provided by OSi. It can be translated into a Mapinfo/ArcGIS compatible format.

- **Structure surveys.** This includes a section at the upstream and downstream faces of all identified structures. It also includes details of the structure and any flood relief features such as shapes, width, height, length, pier details, soffit level, deck level, springing levels.

- **Flood defence surveys.** Long section spot levels along the crest and the toe of formal flood defences.

The survey information has been provided in AutoCad, ArcGIS and ISIS format for the river cross-sections. Full details of survey outputs for each model are provided in the topographic survey deliverables submitted separately to this report.

3.4 Fluvial Hydraulic Model Construction and Schematisation

The model build process includes the following:

- Modelling approach and Software used for the 1D and 2D domains
- Model area covering the modelled reaches and the 2D domain
- River reaches defined within the model, covering both MPW and HPW
- Structures included in the model that have a hydraulic impact
- Floodplain schematisation
- Schematisation of the 2D domain (for 1D-2D models) including 1D elements and breaklines within the 2D domain
- Hydraulic roughness for in bank and out of bank flows
- Model boundaries – Inflows and Downstream conditions

3.4.1 Modelling Approach and Software

The software used and the modelling approach developed can vary, depending principally on the hydraulic complexity and scale of the river system network.

The vast majority of models developed on the Shannon CFRAM Study are dynamically linked 1D-2D models, where:

- 1D approach is adopted for the modelling of in-bank (channel) fluvial reaches for HPWs and for in-bank and out-of-bank (floodplain) modelling for MPWs.
- 2D approach is used for out-of-bank modelling for HPWs.

However in some instances, there are exceptions to these principles where a 1D approach is deemed appropriate for out-of-bank modelling of HPWs. Conversely there are also some examples where a 2D approach is used to undertake the out-of-bank modelling for MPWs.

The modelling approach used for each fluvial hydraulic model within UoM 27 is indicated within the relevant model Appendix section.

The 1D-2D models are constructed using the ISIS-TUFLOW link based on the combination of the one dimensional (1D) river modelling package ISIS (by CH2MHILL Software) and the two dimensional (2D) modelling software TUFLOW (by BMT WBM).

The methodology adopted for the hydraulic modelling of the river systems is based on the approaches described by the TUFLOW modelling manual. The user sets up a model as a combination of 1D network domain representing the river channel, dynamically linked to a 2D domain representing the adjacent floodplain, using the hydrodynamic programme to form a single model.

The 1D and 2D domains can be linked by three separate methods which are as follows:

- Replace part of a 1D model by nesting a 2D domain inside a broader scale 1D model
- Insert 1D networks underneath a 2D domain or through an embankment
- Replace or carve a 1D channel through a 2D domain

The general approach applied within this study is the latter, in which a 1D ISIS model of the river / watercourse system is “carved” through the 2D TUFLOW model of the floodplain as shown schematically in Figure 3.1.

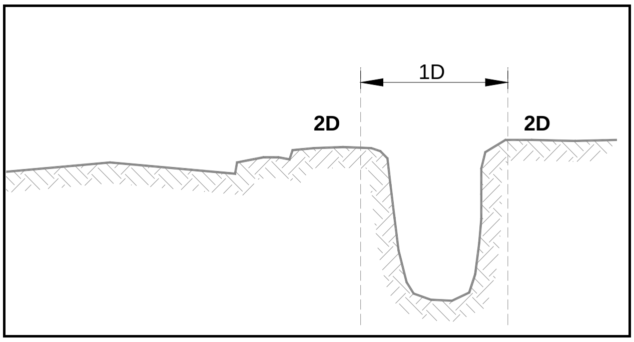

Figure 3.1 Modelling a river channel in one dimension and the floodplain in two dimensions (TUFLOW Manual, 2010)

In addition to this 1D-2D approach, there are also specific 1D elements which can be added within the 2D domain using ESTRY, which is a 1D software embedded within TUFLOW. This may be used, for example, if there is a culvert through a road or railway embankment that may be crossing a 2D represented floodplain. This allows the two sides of the floodplain to be linked via the culvert which is effectively a 1D flow path. This is outlined further under Section 3.4.9.

The specific model software versions used for each model are included within the relevant model Appendix section.

3.4.2 Model Area and Extent

The model area and the extent of both the 1D reaches and the 2D domain are included as an Annex to each relevant model Appendix section. These are in the form of a series of plans as follows:

- **Model extent plans** – These show the full modelled reaches, names of primary watercourses and the AFA boundaries.

- **Model schematic plans** – These show a series of maps at a larger scale than the model extent plan, detailing critical parts of the model schematisation. They include the AFA boundaries, MPW and HPW reaches, the 2D domain extent, cross-section locations and their model reference

number, presence of spill units, reservoir units, flood defences, parallel channels, and other model details pertinent to the specific location.

3.4.3 Model Reaches

Each model is comprised of a series of model reaches. The reaches defined in the model are included in the relevant model Appendix section and are identified by the watercourse name, the reach identification number and the upstream and downstream model nodes.

3.4.4 ISIS river cross-sections

As already mentioned, topographic survey cross-sections across the river reaches have been provided in ISIS format and therefore are directly imported into the ISIS software.

Where required, interpolated cross-sections are added between the topographic survey sections to ensure model convergence where significant change occurs in the water level profile.

Panel markers are set at the top of bank to mark the change between channel and floodplain. Additional panel markers are also used to mark changes in roughness values across the floodplain for extended cross-sections.

Deactivation markers are used to deactivate out-of-bank areas within the cross-sections deemed to be hydraulically inactive in the ISIS model. These are, for example, widely applied across the reaches where out-of-bank areas are modelled in 2D.

3.4.5 Model Structures

The structures surveyed are typically bridges, culverts, weirs, sluices and gates. Not all surveyed structures have been included within the hydraulic model. Those structures not included in the model do not influence water levels during high flow events. For example, a low weir in the river channel becoming drowned out before out of bank flow occurs would not be included in the model unless deemed hydraulically necessary (e.g. part of the in-bank model calibration process).

For each model a structure schedule has been prepared and includes:

- topographic survey reference
- ISIS node reference
- type of structure
- modelling approach
- whether the structure is included in the model

The structure schedule(s) are included in an Annex to each relevant model Appendix section.

3.4.6 Floodplain Schematisation

The schematisation of the floodplain depends on the modelling approach adopted to model a particular reach and its adjacent floodplain. As mentioned previously, 1D approach is generally adopted for the modelling of in-bank (channel) fluvial reaches

for HPWs and for in-bank and out-of-bank (floodplain) modelling for MPWs whilst 2D approach is used for out-of-bank modelling for HPWs.

Transition between 1D only and 1D-2D domains are therefore located near MPW/HPW interfaces; more precisely they are set up according to the local topography depicted by the LiDAR data preferably where the flood flow stays confined to the river channel or where the floodplain flow is well defined and run parallel to the river channel.

For the 1D (ISIS) only reaches, out-of-bank flow areas have been modelled by extending the river channel cross-sections or using reservoir units, spill units or parallel channels within the model.

With regard to the cross-section extension, this is done by using and extending the available cross-section survey using LiDAR or IFSAR, in a direction perpendicular to the 1D floodplain flow. Thus, the final cross-section is a combination of topographically derived ground levels and LiDAR / IFSAR. Where necessary, the LiDAR / IFSAR is adjusted by ground truthing to take account of the lower vertical accuracy of the LiDAR and IFSAR compared to the ground survey. Where such adjustment is made, a comment has been left in the ISIS main model file at the relevant cross-section.

Reservoir units (flood storage areas) or parallel channels are used in combination with spill units where the floodplain ground levels are below the river bank top level (e.g. flood defended reach). In such a situation it is not always appropriate to use extended cross-sections to represent floodplain flooding processes. Reservoir units across the floodplain are interlinked using either spill units or ISIS floodplain sections.

Where the floodplain is represented using a 2D approach, the 2D domain is based on a regular grid comprising individual square cells of a defined size. Each cell is given characteristics relating to the topography such as ground elevation, hydraulic roughness (see Section 3.4.10) and initial water level. For some models there may be more than one 2D domain defined.

On either side of the modelled watercourses, boundary lines define the bank crests. At these locations, there are 2D open flow boundary cells to represent the dynamic links between the 1D network and the 2D TUFLOW domain. 2D cells falling within the 1D network domain are ignored by the model and considered as inactive.

At each 1D ISIS model node, the corresponding river cross-sections are either trimmed or the floodplain area within the cross-sections deactivated at bank top level to match the 2D domain topography. The 1D model nodes are then connected to the 1D-2D boundary cells, allowing flood water to spill to and from the 2D domain when the calculated water level exceeds the banks' crest elevation.

3.4.7 2D Domain Grid Size

For the 1D-2D models, multiple 2D domains can be defined depending on the level of detail required to pick up the appropriate features in the 2D domain that will impact on the local hydraulics. The domain grid square size is typically in the range 5m to 20m, with the smaller grid sizes used in very urbanised areas where there are multiple features that could not be suitably represented in, say, a 10m grid. The model grid is orientated in the main direction of the floodplain flow.

Within each relevant model Appendix section, the number of 2D domains, the grid size and area covered by each domain is given.

3.4.8 Model Breaklines/Z-shape polygons in the 2D Domain

Breaklines are used in the 2D grid to accurately represent any geographical features that could have a significant impact on the propagation of the flood wave across the floodplain. It is particularly useful where the TUFLOW fixed grid discretisation does not guarantee that the crest along, for example, a wall, is picked up from the DTM. Breaklines are also used to incorporate surveyed features into the 2D model grid such as formal flood defences, surveyed bank tops, bridge parapets etc.

In a similar manner Z-shape polygons are used to correct any LiDAR anomalies picked up by the model grid or add additional features such as bridge decks that are often missing in the LiDAR data.

The features represented by the Z lines are listed under Section 3.7 of the individual Hydraulic Model Reports.

3.4.9 Floodplain Structures in the 2D Domain

As noted under Section 3.4.1, 1D elements can be included in the 2D model using ESTRY software to represent structures permitting hydraulic connectivity across the floodplain. These can include a variety of features including: culverts under roads or railways, pedestrian subways, highway underpasses, a road under a railway bridge / viaduct (although these may also be represented as 2D features).

Specific 1D elements included in each model are listed in the relevant model Appendix section.

3.4.10 Hydraulic Roughness

Hydraulic roughness, or friction, is represented by Manning's coefficient "n" in the hydraulic models. The value of 'n' accounts for a range of factors that influence overall roughness either in the channel or across the floodplain. Factors included within the overall evaluation of Manning's 'n' include bed materials and size, vegetation, surface irregularities, channel bed forms, erosional and depositional features, channel sinuosity, and obstructions, all of which influence channel and floodplain conveyance.

Manning's 'n' is a semi-empirical parameter and cannot by directly measured; however a number of established reference literatures such as Chow[5] and UK Environment Agency guidance[6] give advice on the selection of the roughness coefficients for channels and floodplains.

The values adopted in the models are highly variable but are generally in the range 0.025 for a relatively smooth, even, un-vegetated channel, up to 0.090 for out of bank flows across woodland. However, these are not strictly defined limits.

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[5] Chow, V.T., Open Channel Hydraulics, 1984, McGraw Hill, Singapore
[6] Fisher K., Dawson H., Roughness Review, Project W5A-057, July 2003 DEFRA/Environment Agency

Floodplain Roughness

To represent the friction within the floodplain, Manning's 'n' has been defined based on the EPA Land Use classification for the floodplain areas where a 1D approach has been considered. This classification is provided as a GIS file, and for each different land use identified, a value for 'n' has been assigned. Example areas are listed in Table 3.1. The incorporation of this GIS data into the ISIS software allows Manning's 'n' to be specified automatically for every cross-section data set across the floodplain.

Table 3.1 Example of Roughness definition within 1D floodplain areas based on EPA Land Use Classification

Land Use classification Level 3 Code	Manning's 'n' value	Land Use description
231	0.035	Pastures
243	0.045	Heterogeneous agricultural land
122	0.025	Roads
111	0.100	Buildings
324	0.060	Transitional Woodland scrub
313	0.090	Forests
141	0.035	Green urban areas

To represent the friction within the floodplain areas represented in 2D, Manning's 'n' has been defined based on the more refined OSi NTF vector mapping classification. This classification is also provided as a GIS file, and for each different land use identified, a value for 'n' has been assigned, as listed in Table 3.2. The incorporation of this GIS data into the 2D model DTM allows Manning's 'n' to be specified automatically for every grid cell within the 2D domain.

Table 3.2 Example of Roughness definition within 2D models based on OSi NTF Land Use Classification

NTF Land Use classification	Manning's 'n' value	Land Use description
618	0.045	General Rural land
557	0.025	Roads
600	0.100	Buildings
611	0.060	General Urban
527	0.080	Woodland / Dense vegetation
583	0.035	Parkland / Sport grounds

It should be noted that the use of filtered LiDAR data to inform the 2D model DTM means that buildings are not inherently represented in the grid. Given the fact that any building is an obstruction to the flow and would have a major impact on the overland flow routes, a very high roughness value (0.100) has been attributed to

each building/house within the study area to model the effect of the obstruction to flow. This is not a "true" Manning's 'n' value for a building, but is a technique that allows the obstruction from the building to be adequately factored in.

Channel Roughness

Channel roughness is defined for HPWs and MPWs reaches. Each reach is split into sections as appropriate depending on bed material, bank side vegetation and channel sinuosity and irregularities.

For each section of reach, a single Manning's 'n' value is set from left bank to right bank in each ISIS cross-section. This is a compound value which is estimated from photos, survey information and using the previously referenced UK Environment Agency roughness guidance.

For each MPW and HPW reaches within a model a channel roughness schedule is prepared, which includes details of Manning's 'n' values determined for each section of reach as described above.

3.4.11 Model Boundaries - Inflows

For each model, a detailed hydrological analysis of the river system catchment is carried out in order to produce hydrological inflows to the hydraulic model. This analysis is fully discussed in the UoM 27 Hydrology Report. The hydrological assessment also defines how to distribute the catchment flows within the hydraulic model i.e. flow boundaries are generally set at the upstream extents of a model and also distributed laterally at appropriate HEP locations. The flows are reconciled with hydraulic influences during the HEP calibration process described in Section 3.5.2.

The Critical Duration is established intrinsically by virtue of the hydrological methodology employed (taking the maximum levels from the main and tributary flows) and is not established through hydraulic routing. The method is explained in the UoM 27 Hydrology Report.

The peak inflow values used for each modelled design event are included in the relevant model Appendix section, along with the HEP reference name and the model node at which the inflow hydrographs are applied.

3.4.12 Model Boundaries – Downstream Conditions (fluvial model)

The downstream boundary condition selected for the only fluvial model within UoM 27 (i.e. model S02) is a free flow boundary set at the downstream limit in the 1D ISIS model. This equates to the flow being at "normal depth" for the channel slope at the downstream limit of the model. Checks have been made to ensure the normal depth assumption is reasonable and flood flows "leaving" the model are not in reality subject to a backing up effect from hydraulic structure or other floodplain features located downstream.

3.5 Hydraulic Model Calibration and Sensitivity Model Runs

Calibration of hydraulic models and the associated sensitivity analysis to test the confidence of the results based on uncertainty in the model input parameters is a critical part of hydraulic model development.

The following aspects are integral to the approach, as described in the following sections:

- Model Calibration and Verification taking account of relevant gauging stations and historical events
- Calibration to Hydrological Estimation Points (HEP)
- Sensitivity of modelled water level to key parameters – roughness, inflow, influence of structures, downstream boundary condition

3.5.1 Model Calibration and Verification to Historical Events

The approach to model calibration is described in National Technical Co-ordination Group (NTCG) Guidance Note no. 23 (GN23). This is included for reference in Appendix D. The fundamental points to note, with regard to achieving the best model calibration, are that the following data must be known:

- **Flow** at the point of interest
- **Water level** at the point of interest
- **Channel / hydraulic controls influencing the water level** at the location of interest so that the model is representative of the situation

Where there is uncertainty in any of these three variables, the accuracy of the calibration is reduced. As some catchments are gauged and some are ungauged, there is more flood history with reliable flow and water level data in some AFAs than others; and local hydraulic features have more of an influence in some locations than others; the reliability of each model's calibration is varied.

Wherever possible, a range of in bank and out of bank events are used for calibration and verification. However, as noted in GN23, the lack of data in some locations makes calibration of the model unfeasible. Under these circumstances, a reality check against known flooding events (or events that caused flooding elsewhere but are known not to have caused flooding at the location of interest) is a useful part of a qualitative assessment to increase confidence in the model output in the absence of reliable quantitative data.

The use of photographs and anecdotal evidence of past events has also been used to validate flood extents modelled.

For each model, an analysis of available flood event data and high flow data for possible consideration as calibration and verification events has been carried out. Results of these analyses are covered in the Hydrology report.

Within each relevant model Appendix section, a summary of the calibration and verification events along with associated model calibration results is provided.

3.5.2 Verification to HEP

Hydrological Estimation Points (HEPs) are independently derived hydrological values, the details of which are provided within the Hydrology Report. Verification of

the hydraulic models to the HEPs is carried out for the 10%, 1% and 0.1% AEP design events simulated.

The timing of the inflow hydrographs is adjusted to account for the travel time in the modelled reaches. This is done through an iterative process whereby the model is firstly run with the main river upstream inflow, then, at each iteration, the next downstream lateral inflow is added with its peak flow time adjusted to coincide with the peak time of the propagating flood wave as it is routed down the main river. This process is repeated until the most downstream lateral inflow is added. In this manner, the design hydrograph peaks and shapes are preserved within a reasonable degree of accuracy throughout the models. Total peak flows predicted by the hydraulic models at HEPs are then compared to the HEP predictions. Where necessary, hydrological inflows to the hydraulic model are scaled up or down to ensure that the modelled total peak flows remain within ±10% of the HEP predictions.

3.5.3 Model Sensitivity

Sensitivity tests are carried out on the hydraulic models in order to assess the sensitivity of the modelled systems to alterations in a number of key hydraulic parameters.

The results of the sensitivity analysis give an indication of the confidence levels that can be placed in the results being generated by the respective model.

For each model within UoM27, the sensitivity runs are carried out for the 1% AEP fluvial event. The following sensitivity tests have been carried out:

- Sensitivity to hydraulic roughness: Manning's 'n' values are both increased and decreased by 20%
- Sensitivity to hydrological inflows. All hydrological inflows are both increased and decreased by 20%
- Sensitivity to afflux parameters at key structures within an AFA. Afflux parameters are varied to reduce or increase the head loss during a 1% AEP flood event at key structures susceptible to having an impact on the flood extents
- Sensitivity to the downstream conditions. Depending on the type of the downstream boundary conditions chosen for a specific model, changes are made to assess how far upstream the design water levels are affected

Within each relevant model Appendix section, the results of the sensitivity tests for Manning's 'n' and inflows are compared to the base case scenario and processed to determine the average peak water level difference and where the maximum water level difference occurs throughout the models; for other changes, the distance the effect is noticed in the water level results up and downstream of the changed parameter (e.g. downstream boundary conditions) is reported. An assessment is then made of the significance of the change on flood risk. The sensitivity results also inform the Uncertainty mapping, which shows the maximum impact of the sensitivity runs.

3.6 Model files and naming convention

The hydraulic model files associated with each model are provided as a separate deliverable under the contract, as required under Sections 7.8 and 13 of the Stage I

Project Brief. Within each relevant model Appendix section, there are details (names and purpose) on the model files included.

A generic convention is adopted to keep a consistent approach to the naming of the main ISIS (.dat) and where applicable TUFLOW (.tcf) files.

Model naming is as follows:

ModelNumber_QXXX_Source_Scenario_RunType_StatusVersion

Where:

- Model Number is a unique model ID (e.g. N05)
- QXXX is the flood frequency of the event simulated expressed in return period (e.g. Q100 for the 1% AEP event)
- Source is the source of flooding using either Flu for fluvial, Co for coastal, Mi for mixed (fluvial and tidal) and Wa for wave overtopping
- Scenario uses either C for current, M for MRFS and H for HEFS
- Run Type uses either Des for Design runs, Cal for calibration runs, Val for validation runs and Sen for sensitivity testing.
- StatusVersion uses IssV# for any model version that is delivered to the OPW.

Of a particular note, where joint probability runs are simulated, the Source element in the file name uses “FluMi” for fluvially-dominated event and “CoMi” for tidally-dominated event; this for a given flood frequency.

In each ISIS model, the 12-character node labels also follow a naming convention, which is described in Table 3.3.

Table 3.3 ISIS node label naming convention

Character	Description
1	**Model Reach Number** *Model reaches are specific to a watercourse. They are numbered from downstream to upstream. Model reach number is incremented at every confluence with a tributary and also at each model boundary for the watercourses whose full extent is covered by several hydraulic models (e.g. River Shannon).* Example: “01”
2	
3	**Watercourse Reference Name** *Watercourse reference is unique across the entire UoM.except for small bifurcations off a main river (cut, loop) where the letter”X” replaces the last letter of the watercourse reference.* Example: River Brosna = “BRA”, branch off the Brosna = “BRX”
4	
5	
6	**Cross-section chainage (m)** *Cross-section chainage starts at zero at the downstream end of each model reach* Example: “15010”
7	
8	
9	
10	
11	**Structure reference:** *Two letters are usually used to indicate the structure type*
12	

	(bridge, weir, culverts) and the upstream or downstream node Example for a bridge: "bu" for the upstream node and "bd"for the downstream node.

3.7 Key Model Assumptions

Model specific assumptions are described in Section 6 of the relevant model Appendix section. In addition, there are generic assumptions which are summarised below.

3.7.1 Structures

Bridges

- USBPR and Arch Bridge units are used to represent bridges. In both units, the orifice mode is activated to allow for orifice flow when a structure becomes surcharged. For short bridges with a low soffit (e.g. farm or driveway access bridge), orifice units are preferably used as the structure is likely to become rapidly surcharged when the flow increases.
- Each bridge is associated with a spill unit to allow for spilling over the bridge under extreme conditions. When using the extended cross-section approach to model the floodplain area, the spill unit is also extended over a longer distance than the bridge itself to represent flow paths on either side of the structure. Where a 1D-2D approach is adopted, the spill extends up to the 2D domain or is removed if the deck area is large enough to be represented in the 2D domain.
- The calibration coefficient in bridge units is usually set to the default value of 1.0. This value is only changed if supported by observed water level data during the calibration process.

Weirs

- Available ISIS units (e.g. round nose broad crested weir, labyrinth weir, sharp crested weirs etc) are used to represent weirs with a regular crest profile.
- Unless changed during the calibration phase, default weir and velocity coefficients are used.
- For irregular shaped weirs and large steps (>500mm) in the river slope profile, spill units are used.

Culverts

- Long culverts (length > 5m) are modelled using appropriate conduit, inlet and outlet units. Whilst short culverts are modelled as orifice units.
- Roughness coefficients used for the culvert barrel are selected based on the material of construction from the survey photographs, plus reference to publications[7].
- If the inlet and outlet are very different in shape, the first half of the structure is represented using conduit units representative of the inlet and the second half using conduit units representative of the outlet, i.e. the change in section is assumed to occur halfway through the culvert.

[7] HR Wallingford and D.I.H. Barr, Tables for the hydraulic design of pipes, sewers and channels, 6th edition, Volume II, 1994

3.7.2 Spills

- Spill units are used for a number of different purposes (e.g. irregular weir, lateral spilling in the floodplain).
- Spill profile geometry is defined using topographic survey data and LiDAR/IFSAR.
- Spill coefficients used generally vary between 0.9 and 1.5 depending on the type of ground conditions (e.g. rough vegetated, smooth concrete) over which flood flows are spilling. Lower coefficients (<1.0) can also be found to account for lateral spilling perpendicular to the main direction of flow.

3.7.3 Confluences

- ISIS junction units are used at confluences allowing water levels to be considered at each river section connected to a junction.
- If no survey section data is available at the junctions, river sections are determined from the nearest upstream and downstream surveyed sections. Chainage correction and changes in river bed elevation when copying these sections are implemented so that the bed level at all junction sections are identical, i.e. no sudden drop in bed level.

3.8 Quality Assurance

Modelling work carried out as part of the CFRAM study follows the Jacobs Quality Management procedures whereby any work is checked, reviewed and verified before being approved for release to the OPW.

Throughout the hydraulic modelling process, quality checks are being undertaken by the modeller and a senior modeller as checker and reviewer respectively, to ensure that the models accurately represent the river and coastal systems.

Table 3.4 shows the key stages throughout the modelling process when Quality Assurance (QA) audits are carried out.

Table 3.4 Stages at which Quality Assurance Audits are carried out throughout the modelling process

Stage	Purpose
Data Collection	Ensure all data required to carry out the modelling is collected and suitable for use in the models.
Model Input Statement	Defines in detail the modelling approach for each model extent.
Model construction	Ensure each model is built to industry standard, is sufficiently robust and stable, has suitable mass balance conservation and that the schematisation meets the Project brief requirements.
Calibration to historical flood events	Ensure calibration of the hydraulic model to historical events is correctly undertaken and compliant with the Project Brief.
Calibration to HEPs	Ensure calibration of the hydraulic model to HEPs is correctly undertaken and compliant with the Project Brief.
Upon completion of the design runs for each	Ensure model results are appropriate with regards to model performance (i.e. stability, mass balance

scenario: existing, sensitivity tests, optioneering etc	conservation), consistency between events of different severity and “ground truthing” of the outputs.
Flood Mapping	Ensure flood maps are consistent with model results and compliant with the Project Brief.

Each of these quality checks are documented through a series of check list forms populated by the modeller, checker and reviewer to allow for a detailed level of checking whilst providing an audit trail at different stages of a model development.

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4 Coastal Flooding Model Construction

4.1 Introduction

For consistency across the entire Shannon RBD, for those Units of Management for which coastal flooding models have been developed (UoM 23, 24 and 27), this section reports the coastal flooding model construction process in general terms.

In UoM27, Shannon Airport (IRR3) is the only area for which a standalone coastal model has been developed as the risk of flooding is not subject to any fluvial influence. For the areas where flooding is subject to both tidal and fluvial influences, the relevant hydraulic models i.e. the ones with estuarine reaches have been developed to simulate coastal flooding as well as fluvial flooding. As already mentioned, the following sections focus only on the coastal modelling aspects of these models.

4.2 Coastal hydraulic model construction and schematisation

The coastal model build process includes the following:

- Modelling approach and Software used for the coastal floodplain areas
- Model area covering the coastal floodplain
- Coastal Floodplain schematisation
- Hydraulic roughness
- Model boundaries – Tidal and wave conditions

4.2.1 Modelling Approach and Software

As specified in Section 7.3.1 of the CFRAM Studies Project Brief Stage 1, a two dimensional approach is adopted to simulate the propagation of coastal floodwaters inland using TUFLOW modelling software produced by BMT WBM. A 1D approach using the ESTRY software is used to represent small structures (e.g. culverts under road or railway embankment) across the coastal floodplain.

The specific model software versions used for each model are included within the relevant model Appendix section.

4.2.2 Model Area and Extent

The extent of the 2D coastal domain is determined to accommodate the largest expected flood extent using LiDAR data and ICPSS extreme tidal peak levels. Consideration of the AFA boundary is also given to ensure the model area encompasses the AFA areas subject to coastal flooding.

Model area and extent are included as an Annex to each relevant model Appendix section.

4.2.3 Coastal floodplain Schematisation

The 2D coastal domain is based on a regular grid comprising individual square cells of a defined size. Each cell is given characteristics relating to the topography such as ground elevation, hydraulic roughness (see Section 4.2.4) and an initial water level if required.

The data used to inform the 2D grid with ground elevation is a combination of high resolution LiDAR data covering the AFAs, combined with lower resolution IFSAR data for the areas outside of the AFAs.

Due to the method by which the LiDAR data has been gathered (by flying defined flight lines over the area for which LiDAR data is to be captured) there is often LiDAR available for areas outside the defined AFA boundary. Where this higher accuracy LiDAR data is available outside AFAs, it has been incorporated into the hydraulic models in preference to the IFSAR.

As for the fluvial models, the domain grid square size is typically in the range 5m to 20m, with the smaller grid sizes used in very urbanised areas where there are multiple features that could not be suitably represented in, say, a 10m grid. The model grid is orientated in the main direction of the coastal floodwater flows. For the models sharing a fluvial component the orientation of the grid is according to the fluvial floodplain flows.

As for the fluvial models, breaklines/Z-shape polygons and 1D elements are used in the 2D coastal domains in a similar fashion described in Section 3.4.8 and 3.4.9 respectively. In particular breaklines are used to incorporate into the model grid surveyed crest levels of formal coastal flood defences.

Within each relevant model Appendix section, 2D coastal domain area, grid size, breaklines/Z-shape polygons and 1D elements included in each model are given.

4.2.4 Hydraulic Roughness in the coastal floodplains

To represent the hydraulic friction within the coastal floodplains, Manning's 'n' has been defined based on the OSi NTF vector mapping classification which covers all AFA areas subject to coastal flooding. This classification is the same as used in the fluvial model. Refer to Section 3.4.10 and Table 3.2 of this report for a full description.

For coastal floodplain areas outside the AFA boundaries where OSi NTF data is not available, Manning's 'n' has been defined based on the EPA Land Use classification as described in Section 3.4.10 and Table 3.1 of this report.

4.2.5 Coastal Model Boundaries Conditions

As already mentioned the coastal models are developed to simulate flooding from coastal sources either through a combination of high tide and surge and/or due to wave overtopping. Therefore two types of boundary conditions are possible:

- Where coastal flooding arising from the combination of high tide and a meteorological surge is to be simulated, a variable water level (Stage vs.Time) mimicking the sea level motion is applied. Section 4.3 and Appendix D provide a comprehensive description on how such tidal hydrographs are derived. The boundary condition is set along the coastal

fringe of the modelled area including the estuarine section for the models with a fluvial component.

- Where coastal flooding arising from wave overtopping is to be simulated, a flow hydrograph associated with the wave overtopping rate of discharge is applied. Section 4.5 provides a full description on how such flow hydrographs are derived. The boundary condition is set only along the coastlines prone to wave overtopping as identified in the Irish Coastal Wave & Water Level Modelling Study.

Within each relevant model Appendix section, the type of boundary condition and its location are indicated.

4.3 Production of design tidal hydrographs to inform boundary conditions of coastal models

The approach taken to define the tidal boundary conditions in the current situation for the hydraulic models along the Shannon Estuary is fully provided in Appendix D of this report. A summary of the approach specific to UoM27 is provided in this section.

4.3.1 Data used

The following available datasets are used to produce the design tidal surge hydrographs as boundary conditions for the models shown on Figure 2.3.

- ICPSS Predicted Extreme Water Levels (Tide and Surge) for the following design events: 50%AEP, 20%AEP, 10%AEP, 5%AEP, 2%AEP, 1%AEP, 0.5%AEP and 0.1%AEP at various locations along the Shannon Estuary.
- Foynes, Carrigaholt Tidal gauge records (2003-2007) obtained from Shannon – Foynes Port Company
- Admiralty Tide Tables information for port locations along the Shannon Estuary[8]
- OSi Conversion Graphs (Poolbeg-Malin head datum) including levelling information for port locations

4.3.2 Methodology

A four-stage approach is followed to develop the downstream tidal hydrographs assigned to each model.

Stage 1: Production of mean spring tidal cycles at key ports

Tidal records collected at port locations: Carrigaholt and Foynes have been used to extract typical Spring tidal profiles (i.e. level hydrograph shapes). These have been scaled to generate mean spring tide profiles ranging from Mean High Water Spring (MHWS) to Mean Low Water Spring (MLWS) levels using information from the Admiralty Tide Tables for Carrigaholt, Kilrush, Coney Island and Mellon Point classified as secondary ports. These key port locations are shown in Figure 4.1. Details of the calculations carried out to determine MHWS and MLWS levels to Malin Head datum are provided in Appendix D.

[8] Admiralty Tide Tables, United Kingdom and Ireland, Vol 1 NP 201-06, (2006)

Figure 4.1 Key ports listed in the Admiralty Tide Tables for which MHWS and MLWS information is available

Stage 2: Association of ICPSS prediction points with mean Spring tidal cycles at key ports

Each ICPSS prediction point[9] for which extreme water levels, combining tide and surge, have been estimated are shown on Figure 4.2. These have been associated with a mean Spring tidal cycle for the key ports mentioned above. This allocation is based on the nearest port location but also takes into consideration tidal hydrodynamics within the Shannon Estuary.

Table 4.1 below describes the association of the ICPSS prediction points relevant to UoM27 with the mean Spring profiles at the key ports.

Table 4.1 Allocation of prediction points to ports

Port/Spring profile	ICPSS (Prediction Point Reference) relevant to UoM27
Coney Island	S22
Mellon Point	S24
Kilrush	S8
Carrigaholt	SW48 – SW49

[9] Prediction point references used in Figure 4.2 and Table 4.1 are the IPCSS Prediction point references used in the ICPSS report.

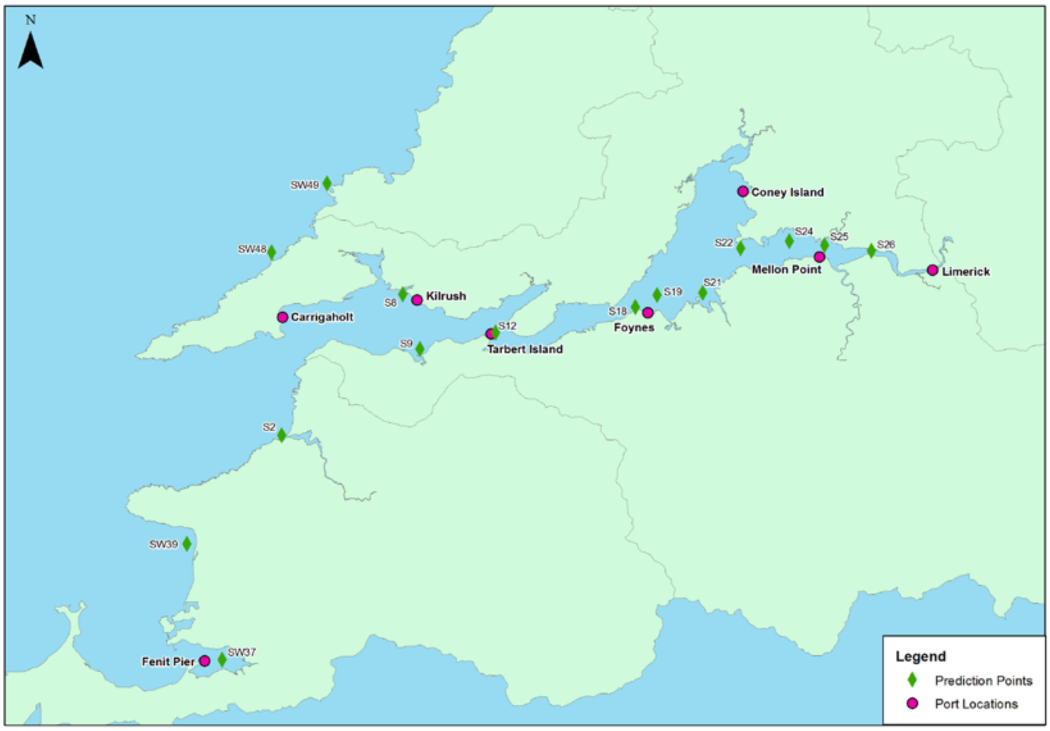

Figure 4.2 ICPSS prediction point and key port locations

Stage 3: Production of design hydrographs at the ICPSS prediction points

Using the spring profiles and the available ICPSS extreme water levels for a range of annual probabilities, a series of design tidal hydrographs have been produced at each prediction point. The tidal hydrographs represent the effect of 30hr meteorological surges of increasing intensity on the mean Spring profile associated with each ICPSS prediction point. The 30hr surge duration means that 3 tide cycles are affected. The surge effect is centred such that middle high tide level matches with the extreme water levels taken from the ICPSS data.

This process is illustrated on Figure 4.3.

It is acknowledged that a 30hr meteorological surge duration is a key, though considered realistic, assumption to the production of the design tidal hydrographs. Sensitivity tests as described in Section 4.6 are carried out with the hydraulic model to assess the effect on predicted flood risk of varying surge duration in the tidal boundaries.

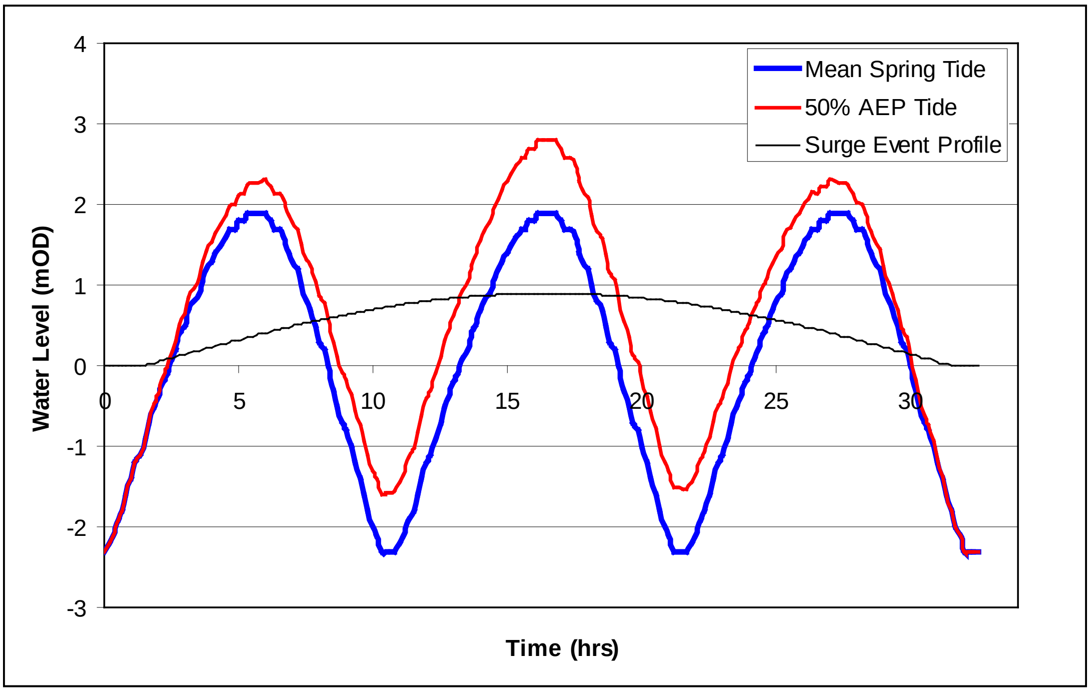

Figure 4.3 Example showing how a design tide hydrograph is produced

Stage 4: Allocation of design tidal hydrographs to the hydraulic model

In a final step, the different model downstream boundaries have been assigned to the closest prediction points and their associated design tidal hydrographs. For most of the models, direct allocation is deemed appropriate except for the hydraulic model S19 (AFA Kilkee) where linear interpolation between two prediction points SW48 and SW 49 has been carried out.

Table 4.2 below lists the prediction points assigned to each model downstream boundary

Table 4.2 Allocation of ICPSS prediction points to model coastal boundary

ICPSS (Prediction Point Reference)	AFAs – Model No
S22	Ennis – Model S01
S25	Bunratty – Model S03
S24	Shannon - Model S04
S24	Shannon Airport – Model IRR3
S8	Kilrush – Model S18
SW48 – SW49	Kilkee – Model S19

Within each relevant model Appendix section, coastal boundary location and associated design tidal hydrographs are indicated.

4.3.3 Changes made to the design tidal hydrographs for future scenario (MRFS and HEFS)

Changes have been made to the design tidal hydrographs for the design events under the MRFS and HEFS scenarios. They consist of a simple increase of the overall hydrograph according to the mean sea level rise and land movement allowances defined in Table F.1 of Appendix F in Shannon CFRAM Study Stage I Project Brief.

These allowances are summarised in Table 4.3 below.

Table 4.3 Future scenario allowances

	MRFS	HEFS
Mean Sea Level Rise (to 2100)	+500 mm	+1000 mm
Land Movement	-50 mm	-50 mm
Total change made to the tidal hydrographs	+550mm	+1050mm

4.4 Joint probability analysis for fluvially- and tidally-influenced models

A joint probability analysis of the coincidence of fluvial flood flows and coastal flood levels in the Shannon Estuary has been carried out. Methodology and outcomes of this analysis are detailed in the Hydrology Report for UoM 27.

Table 4.4 below is the main output of the joint probability analysis. It presents the combinations of design fluvial flood events and design tidal flood events that are used for the modelling of design events in areas of both fluvial and tidal influence. As required by the Project brief, in these areas two set of design runs are required to determine on one hand fluvially-dominated flood risk (odd number scenarios in Table 4.4) and on the other hand tidally-dominated flood risk (even number scenarios in Table 4.4).

Table 4.5 lists the hydraulic models in UoM27 for which such runs are carried out

Table 4.4 Combinations of fluvial and tidal events adopted for modelling in areas of both fluvial and tidal influence.

	Joint Probability Design Event (AEP)	Combinations suggested by the joint probability analysis (AEP)		Combinations adopted for modelling (AEP)	
Scenario	Overall AEP	Fluvial	Tidal	Fluvial	Tidal
1	50%	50%	500%	50%	500%
2	50%	**500%**	50%	50%	50%
3	20%	20%	500%	20%	500%
4	20%	**500%**	20%	50%	20%
5	10%	10%	200%	10%	200%
6	10%	**200%**	10%	50%	10%
7	5%	5%	100%	5%	100%
8	5%	**100%**	5%	50%	5%
9	2%	2%	50%	2%	50%
10	2%	50%	2%	50%	2%
11	1%	1%	20%	1%	20%
12	1%	20%	1%	20%	1%
13	0.5%	0.5%	10%	0.5%	10%
14	0.5%	10%	0.5%	10%	0.5%
15	0.1%	0.1%	2%	0.1%	2%
16	0.1%	2%	0.1%	2%	0.1%

Remarks on the adopted scenarios for modelling:

- For fluvial events of a lower magnitude than that for a 50% AEP event as highlighted in bold in column 3 of Table 4.4, design event data is not available. Therefore the tidally-dominated scenarios 2, 4, 6 and 8 have been run with a 50% AEP fluvial flow as indicated in column 5.

- Peak tidal levels associated with the design tidal events of lower magnitude than a 50% AEP event are not readily available from the ICPSS data. However they have been generated using extrapolation techniques for the relevant prediction point as shown on Figure 4.5 below.

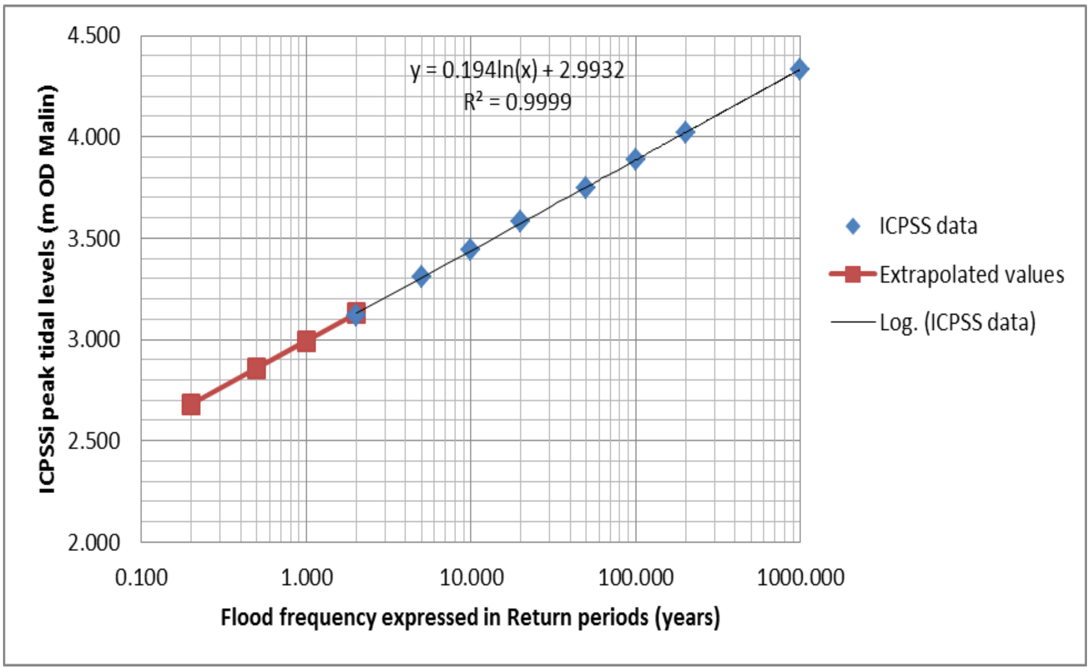

Figure 4.5 Extrapolation of ICPSS data fro high frequency tidal events

Table 4.5 Hydraulic models in UoM27 for which joint probability runs are required

Model No	AFAs affected
S01	Ennis
S03	Bunratty and Sixmilebridge
S04	Shannon
IRR3	Shannon Airport
S18	Kilrush
S19	Kilkee

4.5 Production of design wave overtopping discharge hydrographs to inform boundary conditions of coastal models

ICWWS data supplied by OPW shows areas potentially vulnerable to wave overtopping (see Section 2.5.2 and Figure 2.3). Shannon (model S04), Shannon Airport (model IRR4). Kilrush (model S18) and Kilkee (model S19) are the four AFAs within UoM27 where modelling is required to simulate flooding arising from wave overtopping of coastal defences.

To generate suitable boundary conditions to the hydraulic models, ICWWS data has been used following a four-step approach described below.

4.5.1 Step 1: Selection of coastal defence reaches

At each site, coastal defences vary in height, type and orientation relative to the mean direction of the incident waves. Therefore coastal defences prone to wave overtopping are divided in discrete reaches of similar characteristics (height, type and orientation) and allocated a wave prediction point according to its geographic proximity and the mean direction of the incident waves.

Within each relevant model Appendix section, this allocation is indicated.

Step 2: Wave characteristics selection for the selected reaches of For each flood event annual probability, ICWWS data consists of six combinations of extreme coastal water levels with predicted significant wave heights ('Hmo'), peak wave period ('Tp') and mean wave direction. For each combination, the mean overtopping discharge (in m3/s per m of coastal defence length) associated with the wave characteristics and the type of flood defence (sea dikes, embankments and vertical wall) involved will be calculated. This calculation is to be carried out using the Neural Network method.

It should be noted that for the case when, for a given annual probability event, the water levels provided exceed the average elevation of the coastal defence reach overtopping will no longer occur and there will be tidal flooding. Is this case the tidal flooding the flood risk from wave overtopping will be considered along with the tidal flood risk.

4.5.2 Step 3: Generating a wave overtopping discharge hydrograph for the selected reaches of coastal defences

As quoted from the overtopping manual, "in reality there is no constant discharge over the crest of a defence during overtopping. The process of wave overtopping is very random in time and volume". A simplified approach is followed here to generate a wave overtopping discharge hydrograph (Flow vs. Time) which is input in the hydraulic models at the landward side of the defences.

A wave overtopping discharge hydrograph is to be generated assuming 12 hour storm surge duration. Overtopping is to be assumed to occur for the full 12 hour storm surge duration. As the rate of overtopping varies with freeboard, the height of the crest of the defence above still water level, overtopping discharge rates are to be calculated at 30 points along the tidal curve. These discharge rates will be used to create the inflow hydrographs. The duration of overtopping is to be typically limited to the hours where the tidal water levels are at their peak.

4.5.3 Step 4: Simulating flooding arising from wave overtopping

Once the wave overtopping discharge hydrographs are generated for all the reaches of coastal defences under consideration at a particular site; these flow inputs will be applied directly to the hydraulic model using a flow versus time boundary along the landward side of the flood defences.

Within each relevant model Appendix section, wave overtopping boundary locations and associated discharge hydrographs will be indicated.

The wave overtopping models will be run for the full range of probabilities specified in Section 6.5.1 of the Project Brief for existing conditions and for the MFRS, and for the 10%, 0.5% and 0.1% AEP design events for the HEFS.

4.6 Hydraulic Model Calibration and Sensitivity Model Runs

4.6.1 Model Calibration and Verification to Historical Events

The approach to model calibration for the coastal models is described in Section 3.2.4 of the National Technical Co-ordination Group (NTCG) Guidance Note no. 23 (GN23) in Appendix D. The fundamental points to note, with regard to achieving the best model calibration, are that the following data must be known:

- **Tidal hydrograph and wave conditions** – as the driving force leading to coastal flooding
- **Water levels** recorded on the coastal floodplain and/or within the estuarine reaches
- **Coastal floodplain conditions – any topographic feature influencing the water level** across the floodplain at the time/date when the coastal flooding occurred.

For each model, an analysis of available flood event data for possible consideration as calibration/"reality checking" has been carried out. Results of these analyses are covered in the Hydrology report.

In UoM27 the availability of usable information is very limited and therefore none of the coastal models have been fully calibrated. However, for some models, some form of verification has been possible through "reality checks" carried out on the flood extents obtained and cross referenced with anecdotal evidence of flooding arising from tidal inundation and/or wave overtopping, if it exists.

Within each relevant model Appendix section, a summary of the calibration/"reality checking" process along with associated results is provided.

4.6.2 Model Sensitivity

Sensitivity tests are carried out on the hydraulic models in order to assess the sensitivity of the modelled systems to alterations in a number of key hydraulic parameters.

The results of the sensitivity analysis give an indication of the confidence levels that can be placed in the results being generated by the respective model.

For each coastal model within UoM27, the sensitivity runs are carried out for the 0.5% AEP tidal event. The following sensitivity tests have been carried out:

- Sensitivity to hydraulic roughness: Manning's 'n' values have both been increased and decreased by 20%
- Sensitivity to hydrological inflows. All hydrological inflows have both been increased and decreased by 20%
- Sensitivity to afflux parameters at key structures across the estuarine reaches. Afflux parameters have been varied to reduce or increase the head loss during a 0.5% AEP flood event at key structures susceptible to having an impact on the tidally dominated flood extents
- Sensitivity to the downstream conditions. Changes are made to the tidal boundaries by varying by +/-50% the surge duration component in the design tidal hydrographs to assess how the coastal flood outlines are affected.

Within each relevant model Appendix section, the results of the sensitivity tests are compared to the base case scenario and processed to determine the significance of the change in flood risk.

4.7 Model files and naming convention

The hydraulic model files associated with each coastal model are provided as a separate deliverable under the contract, as required under Sections 7.8 and 13 of the Stage I Project Brief. Details (names and purpose) on the model files are included within each relevant model Appendix section.
The same model naming convention previously described in Section 3.6 is adopted for the coastal models.

4.8 Key Model Assumptions

Model specific assumptions are described in Section 6 of the relevant model Appendix section. In addition, there are generic assumptions which are summarised below.

As already mentioned in Section 4.3, the design tidal hydrographs used as downstream conditions are based on estimated ICPSS extreme water levels and hydrograph shapes derived using a mean Spring profile from the nearest port location and assuming a meteorological surge of 30hr duration.

For the hydraulic model with both fluvial and tidal components, the timing of the tidal hydrograph as downstream condition is adjusted so that the time of the highest tidal level coincides with the time of the maximum water levels within the estuarine reach for fluvial dominated event. This is a conservative approach that allows for a worst case scenario.

4.9 Quality Assurance

The same level of quality checking as previously described in Section 3.8 of this report is carried out on the development of coastal hydraulic models.

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5 Flood Hazard Mapping

The following section describes the development of the flood hazard maps for the Shannon CFRAM study. The flood map type, information and format are provided, along with details relating to the associated processes.

5.1 Flood Map Type

The maps produced fall into one of the following five types:

- **Flood extent:** These maps show the extents of flooding associated with a design flood event for a given annual probability. Additional information such as tabulated peak flows and water levels are also shown (see Section 5.3).
- **Flood zone:** These maps show flood zones A, B and C, to facilitate implementation of the Guidelines on the Planning System and Flood Risk Management (DoEHLG & OPW, November 2009).
- **Flood depth:** These maps show the depths of flooding associated with a design flood event for a given annual probability.
- **Flood velocity:** These maps show the velocities of floodplain flows associated with a design flood event for a given annual probability.
- **Flood hazard:** These maps show the hazard (or 'risk to life') associated with a design flood event for a given annual probability as a function of the depth and velocity (see Section 5.7).

5.2 Flood Map Format

The flood maps are produced in both digital (GIS) and print ready (PDF) format, as follows:

- **GIS Format:** Geographical Information System (GIS) format refers to the display and representation of data produced by the models (and subsequently displayed on the print ready format maps) in digital format with both spatial and not spatial attributes defined. These files can be interrogated by users on their own GIS platforms and software.
- **Print Ready:** This format refers to the printable versions of the maps. This format allows for a wide range of users to access and view a complete standalone map including title block and legend in a single PDF.

Table 5.1A and B sets out the type of maps produced for each of the scenarios (current only) for the design flood event probabilities simulated with the hydraulic model.

Table 5.1 A - Shannon CFRAM Study "Print Ready" flood map outputs

	Current								MRFS								HEFS							
	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.1% AEP	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.1% AEP	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.1% AEP
Flood Extent Maps			✓			✓		✓			✓			✓		✓								
Flood Zone Maps						✓		✓																
Flood Depth Maps			✓			✓		✓																
Flood Velocity Maps			✓			✓		✓																
Flood Hazard Function Maps			✓			✓		✓																

Grey cells indicate that no map is required

Table 5.1 B Shannon CFRAM Study "GIS" format flood map outputs

	Current								MRFS								HEFS							
	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.1% AEP	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.1% AEP	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.1% AEP
Flood Extent Maps	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓			✓		✓
Flood Zone Maps						✓		✓						✓		✓								
Flood Depth Maps	✓	✓	✓	✓	✓	✓	✓	✓			✓			✓		✓								
Flood Velocity Maps	✓	✓	✓	✓	✓	✓	✓	✓																
Flood Hazard Function Maps			✓			✓		✓																

Grey cells indicate that no map is required

5.3 Flood Extent Maps

The flood extent maps are the extents of flooding along the modelled reach. The production technique for these maps differs depending on the model type used (i.e. whether 1D or 2D) and the processing requirements of the results. The procedure for each of model types is provided below.

- **1D Model Results:** First, the peak water levels at each node are extracted from the 1D ISIS model. Then a water surface profile is generated, based on a triangulated interpolation of model results (peak water levels) and model geometry information at each cross-section. The water surface profile is then subtracted from the LiDAR/IFSAR elevation grid at the corresponding location. This results in a 1D flood depth grid being created. This grid is processed into an extent polygon.

2D Model Results: Flood extents are generated by processing the depth grid produced across the 2D domain by the model. In a 1D-2D linked models the 1D and 2D flood depth grids are combined. There is no particular flood depth threshold under which flooding is not reported**.** The combined flood depth grid is then converted into an extent

Where defences are present in the extent maps the standard of protection of the defence and the defended area is shown. The standard of protection is determined as the %AEP event, between the 10% AEP event to the 1% AEP evetn which was closest to the defence level but did not result in flooding. The defended areas were then derived by from the water level for the event, which was equivalent to the standard of protection of the defence, without the defence in place.

In both instances described above, the results require post processing to ensure “Dry” and “Wet” islands are removed. These refer to holes or small areas separated hydraulically from the extents. A clean-up process is carried out to remove polygon islands or small holes (<100m²). Ponding will occur where fluvial flow paths convey water into topographic depressions in the floodplain. As a result areas of ponding will not be removed. Wet islands which are disconnected from the fluvial contributions (which relate to the 1D result processing) have been removed.

With regards to format of the print ready maps, the key requirements of these are provide below:

- **Map scale:** Maps are produced at 1:5,000 scale for AFAs and at 1:25,000 with background mapping at 1:50,000 for areas outside the AFAs, with the mapping in greyscale.
- **Map layers shown:** Fluvial flood events are shown for 10%, 1% and 0.1% AEPs, and are coloured using a transparent fill from dark blue to light blue. Also shown are points along the river centreline, with a table on the map showing the flow for 10%, 1% and 0.1% AEP (at selected locations) and water level at each point for 10%, 1% and 0.1% AEP. Areas benefiting from defences are shown by a grey hatched area.

5.3.1 Flood mapping in tidally- and fluvially-influenced areas

Tidal flood maps are produced for the 10%, 0.5% and 0.1% AEP events using the same methodology described above.

In areas where flooding is subject to both tidal and fluvial influence additional sets of flood maps are produced as defined in Section 7.5.2.1 of the project brief Stage I with an annotation text box showing the tidal/fluvial influence boundary.

5.3.2 Mapping uncertainty

Uncertainty is presented as per the Guidance Note 22 v5.5 (please see Appendix F), relating to sensitivity and uncertainty but is limited to the 1% AEP flood extent (0.5% AEP for coastal model). This is because the sensitivity analysis (described in Sections 3.5.3 and 4.6.2 and compliant with the mandatory suggested sensitivity runs) has been carried out for the 1% AEP event only (0.5% AEP for coastal models).

The sensitivity results have been used to generate outlines which have then been merged to create a single "worst case" outline. This is then compared to the 1% AEP design event on maps in addition to the flood extent maps listed in Table 5.1 A.

5.4 Flood Zone Maps

Flood zone maps show three zones: within the 1% AEP, between the 1% (or 0.5% AEP for coastal areas) and 0.1% AEP and outside the 0.1% AEP. The maps have been developed following the publication of the Guidelines on Planning and Flood Risk Management (Guidance note 33) and are based on the undefended scenario runs for the flood events mentioned above. The flood zone maps are generated using the outer flood extents associated with the undefended runs undertaken.

5.5 Flood Depth Maps

Flood depth maps show where the water would flow and the resulting peak depths that would be achieved for a specified annual exceedence probability. The maps are useful in planning and design to understand the depth of flooding in an area and they allow emergency responders to determine rescue areas, evacuation areas and potential evacuation routes. Flood depths also form the basis for the economic assessment.

The map borders, features and general components of the hardcopy depth maps are the same as the flood extent maps. The key features particular to the depth maps are:

- The 10%, 1% and 0.1% are shown on individual maps
- Depth information is only required for the current situation
- Flood depths are shown on the map in six graduated classes, coloured light blue to purple for low to high depths respectively.

5.6 Velocity Mapping

Flood velocity maps are only required for AFAs and not for MPW reaches.
The 2D models output velocity to the 2D grid which has a cell resolution of typically 5-20m (see Section 3.4.7). The 2D velocity output is therefore readily extracted to generate velocity maps. For the channel and floodplain represented in 1D, velocity distribution map is created using the predicted maximum velocity at each model

node and GIS interpolation. For reservoir units represented in 1D, no velocity will be calculated as by definition the floodplain areas represented by reservoir units are non-conveyance zones and velocity equals zero.

The key features particular to the velocity maps are:

- The 10%, 1% and 0.1% are shown on individual maps
- Velocity information is only required for the current situation and HPW reaches
- Flood velocities are shown on the map in five graduated classes, coloured yellow to red for low to high velocities respectively.

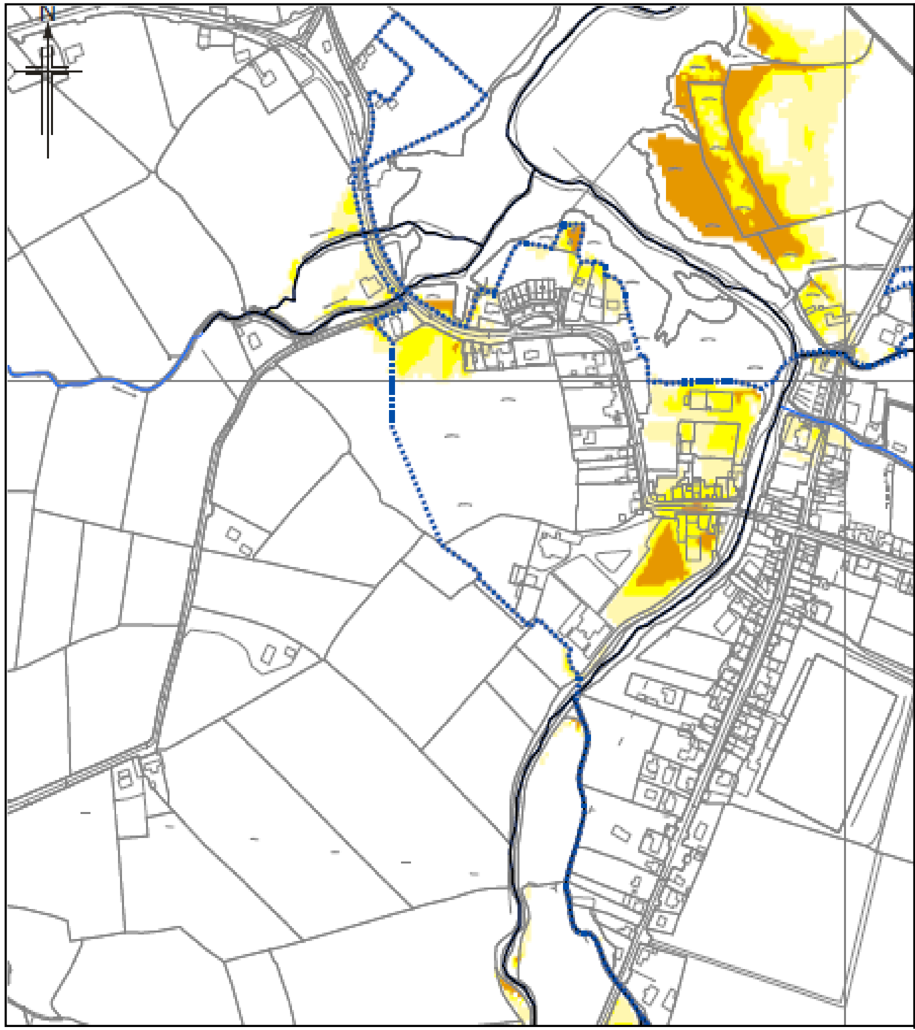
5.7 Flood Hazard Function Mapping

Flood hazard function maps show the risk to life which may be experienced for a particular flood event. This is calculated as a function of the depth and velocity of the flood waters. The Shannon CFRAM Study uses the methodology and concept set out in the Defra / EA guidance Flood Risks to People Phase 2 Study[12] to calculate flood hazard without a debris factor. The flood hazard function maps are created by calculating the hazard from the depth and velocity grids, as follows:

$$\text{Hazard} = \text{depth} \times (0.5 + \text{velocity})$$

The classifications of the degree of flood hazard are shown in Figure 5.1 along with the graduated colours used to display the flood hazard on the maps. An example of a flood hazard map is also shown in Figure 5.1.

[12] DEFRA 2006, Flood Risks to People, Phase 2, FD2321/TR1, The Flood Risks to People Methodology



Flood Hazard

- Low (< 0.75)
- Moderate (0.75 - 1.25)
- Significant (1.25 - 2.0)
- Extreme (> 2.0)

Thresholds for Flood Hazard Rating H = d x (v+ 0.5)	Degree of Flood Hazard	Description
< 0.75	Low	Caution - " Flood zone with shallow flowing water or deep standing water"
0.75 - 1.25	Moderate	Dangerous for some (i.e children)-" Danger : Flood zone with deep or fast flowing water"
1.25 - 2.0	Significant	Dangerous for most people - " Danger : Flood zone with deep fast flowing water"
> 2.0	Extreme	Dangerous for all- " Extreme Danger : Flood zone with deep and/or fast flowing water"

Figure 5.1 Flood hazard map classifications

6 Conclusions and Recommendations

6.1 Conclusions

Calibration and verification using observed gauge data gathered up to Summer 2012, the date the topographic survey was completed, was possible for the S01 model.

It was not possible to complete historical calibration for the S02, S03, S18, S19 or IRR3 models, as there was no available gauge data or other relevant historical data.

The resulting flood maps form a representation of the predicted existing risk using all data made available up to the Summer of 2012 and were displayed at Public Consultation Days (PCD's) held in each AFA. Table 6.1 below provides information on the dates of the PCD and numbers of people attending. Further to these consultation days a national consultation exercise on the Draft Flood Maps was launched in November 2015 where objections could be made on the maps. There were no objections received on the UoM 27 maps.

Table 6.1 - Shannon CFRAM Study UoM 27 Public Consultation Days

AFA	County	Date of Public Consultation	Venue	Number of Attendees
Shannon	Clare	23/03/2015	Hughes Suite	12
Bunratty	Clare	5/03/2015	Bunratty Castle Hotel	0
Sixmilebridge	Clare	5/03/2015	Bridge Complex	4
Ennis	Clare	4/03/2015	Clare County Council Offices	33
Quin	Clare	4/03/2015	Abbey Room, Quin Community Centre	9
Kilrush	Clare	5/11/2014	Kilrush Library	17
Kilkee	Clare	5/11/2014	Sweeney Memorial Public Library	18

6.2 Recommendations

Since the completion of the calibration and verification exercise which used flood event data up to Summer 2012. It is therefore a recommendation of this study that future iterations of the flood model and map are verified against those flood events which have occurred post Summer 2012.

In addition, for those watercourses within AFAs, with a predicted flood risk but not currently benefiting from recorded water levels or flows, it is a recommendation of this study that gauging stations (temporary or permanent) are appropriately installed.

Appendix A Extracts from the Project Brief

Extract from Section 7 of the CFRAM Studies Stage I Project Brief (June 2010)

7.8. HYDRAULICS REPORT

The Consultant shall submit to the OPW detailed, technical Hydraulics Reports that shall set out the work and analysis undertaken in relation to, and the findings and conclusions of, the surveys as defined within Section 5 and the hydraulic analysis as defined within Section 7, except for the work defined in Section 7.6 and 7.7, which shall be reported upon in the Preliminary Options Reports.

The Consultant shall supply the following as part of, or as an accompaniment to, the Draft and Final Hydraulics Reports:

- All survey data, including digital data files, as detailed in Section 5.
- Digital hydraulic model files, including, but not necessarily limited to, calibration, verification, design run and sensitivity analysis model and results files, for the work detailed in Section 7, excluding Section 7.6 and 7.7.
- A copy of the defence asset database with all flood defence asset geometric and condition survey completed and accurately entered, including the defence asset survey deliverables, as detailed in Section 5.1 and 5.2 and Appendices C and D
- Digital copies of the GIS-Format and Print-Ready Format Flood hazard maps, as detailed in Section 7.5

The OPW, assisted by the Steering Group and other experts as deemed necessary by the OPW, shall review the Draft Hydraulics Reports and submit observations to the Consultant within six (6) weeks of receipt.

The Consultant shall review the observations submitted by the OPW, and prepare and submit to the OPW a Draft Final Hydraulics Reports that suitably addresses the observations of the OPW within four (4) weeks of receipt of the observations from the OPW.

The OPW, assisted by the Steering Group and other experts as deemed necessary by the OPW, shall, within four (4) weeks of receipt, review the Draft Final Hydraulics Reports to ensure that all observations have been appropriately addressed. In the event that the OPW does not consider that all observations have been appropriately addressed, the OPW shall submit further observations to the Consultant to be addressed by the Consultant as set out above. In the event that the OPW is satisfied that all observations have been appropriately addressed, the Consultant shall re-submit the Draft Final Hydraulics Reports as the Final Hydraulics Reports.

The Consultant shall prepare and submit separate Draft, Draft Final and Final Hydraulics Reports for each Unit of Management within the Study Area.

The Consultant shall provide a number, as identified in the tender documentation for the Specific Tender Stage (Stage II), of bound sets of printed hardcopies of each set of Draft and of Final flood hazard maps as set out in Section 7.5 and above.

Extract of Sections 2.21 to 2.23 of the Stage II Project Brief (October 2010)

2.21 Section 7.3.1 – Coastal Flooding Model Development

For the APSRs where the OPW shall provide the Consultant with wave data (see Section 2.19 herein, amending Section 6.5.4 of the Generic Specification), the Consultant shall develop the coastal flooding models such that they will be able to simulate flooding from wave overtopping of defences as well as from tide and surge events.

2.22 Section 7.3.3 – Coastal Flooding Model Design Runs

For the APSRs where the OPW shall provide the Consultant with wave data (see Section 2.19 herein, amending Section 6.5.4 of the Generic Specification), the Consultant shall run the coastal flooding models to simulate flooding for the design flood events to determine flood levels, extents and other parameters for flooding that would be projected to arise from wave overtopping [as well as such runs for tide and surge events (i.e., based on data provided as set out in Sections 6.5.4 and 7.3 and Appendix E of the Generic Specification)], for the full range of probabilities specified in Section 6.5.1 of the Generic Specification for existing conditions and for the MRFS, and for the 10%, 0.5% and 0.1% AEP design events for the HEFS. The Consultant shall produce flood mapping for the flooding that would be projected to arise from wave overtopping as set out in Sections 7.5 and 8.3 of the Generic Specification [as well as such mapping for tide and surge events].

2.23 Section 7.8 – Hydraulics Report

The fourth bullet point under the second paragraph of Section 7.8 of the Generic Specification (starting 'Digital copies of the GIS-Format …') is deleted in its entirety and replaced with:

– Digital copies of the GIS-Format and Print-Ready Format flood hazard maps and flood risk maps, as detailed in Section 7.5 and 8.3

The Consultant shall supply as an accompaniment to the Draft and, amended as necessary, Final Hydraulics Report a set of GIS files and summary report for each Unit of Management, providing the information set out in Appendix V.

The fourth paragraph of Section 7.8 of the Generic Specification (starting 'The Consultant shall review the observations submitted …') is deleted in its entirety and replaced with:

> The Consultant shall review the observations submitted by the OPW, and prepare and submit to the OPW a second Draft Final Hydraulics Reports that suitably addresses the observations of the OPW within four (4) weeks of receipt of the observations from the OPW.

The fifth paragraph of Section 7.8 of the Generic Specification (starting 'The OPW, assisted by the Steering Group and other experts as deemed necessary by the OPW, shall, within four (4) weeks of receipt, review the Draft Final Hydraulics Reports …') is deleted in its entirety and replaced with:

> The OPW, assisted by the Steering Group and other experts as deemed necessary by the OPW, shall, within three (3) weeks of receipt, review the second Draft Final Hydraulics Reports to ensure that all observations have been appropriately addressed. In the event that the OPW does not consider that all observations have been appropriately addressed, the OPW shall submit further observations to the Consultant to be addressed by the Consultant as set out above. In the event that the OPW is satisfied that all observations have been appropriately addressed, the Consultant shall re-submit the second Draft Final Hydraulics Reports, and accompanying flood hazard and risk maps, as the Draft Final Hydraulics Reports and the Draft Final Flood Maps.

The Consultant shall provide twenty-five (25) bound and printed hardcopies of the Draft Hydraulics Report.

The Consultant shall provide twenty-five (25) bound and printed hardcopies of the Draft Final Flood Maps.

The Draft Final Flood Maps (including the hazard and risk maps, as set out in Sections 7.5 and 8.3 of the Generic Specification) shall be put out to public and stakeholder consultation for a period of three (3) months.

The Consultant shall review all submissions made during the three (3) month public and stakeholder consultation period, that should close no later than 30/09/2013, and shall provide written appropriate responses to each and all submissions to the OPW within one (1) month (i.e., by 31/10/2013) for review and, subject to clarification of any queries on the response by the Consultant, issue to the submitter.

The Consultant shall submit, no later than 31/10/2013, the first version of the Final Hydraulics Reports and Flood Maps that shall be amended revisions the Draft Final Hydraulics Reports (and all components thereof) and Draft Final Flood Maps that address the submissions and comments raised during the public and stakeholder consultation period, subject to discussions with the OPW and Steering Group.

The OPW, assisted by the Steering Group and other experts as deemed necessary by the OPW, shall, within two (2) weeks of receipt, review the first version of the Final Hydraulics Reports and Flood Maps. In the event that the OPW does not consider that all observations have been appropriately addressed, the OPW shall submit further observations to the Consultant to be addressed by the Consultant, after which the Consultant shall submit a revised version of the Final Hydraulics Reports and Flood Maps within two (2) weeks. In the event that the OPW is satisfied that all observations have been appropriately addressed, the Consultant shall re-submit the Reports and Maps as the final versions of the Final Hydraulics Reports and Final Flood Maps

The Consultant shall provide twenty-five (25) bound and printed hardcopies of the Final Hydraulics Report.

The Consultant shall provide twenty-five (25) bound and printed hardcopies of the Final Flood Maps.

Appendix B Fluvial Hydraulic Model Appendices

Appendix B1
Model S02

Fluvial Hydraulic Modelling Report	
1. Basic Model Information	
1.1 General Information	
Model ID:	S02
Unit of Management	27
AFAs included in the Model	Quin
Primary Watercourses / Water Bodies	River Rine
1.2 Reference to other Relevant Reports	
Catchment Description	Hydrology Report Unit of Management 27 – Appendix A1.1
Model Location	Hydraulics Report Unit of Management 27 – Section 3.4.12
HEP Schematisation	Hydrology Report Unit of Management 27 – Appendix B2 – Figure B2.1

2. Survey Data and Base Mapping	
2.1 Base Mapping:	OSi data base mapping at scale 1:50k Reference: OS14160_D, OS12160_D
2.2 DTM for 2D Model Domain:	**Within AFAs:** LiDAR data with 2m horizontal resolution and approximately 200mm vertical accuracy has been used to inform the hydraulic model with ground elevation in the floodplain areas included in the AFA boundary. **Outside AFAs:** IFSAR data with 5m horizontal resolution and approximately 500mm-1000mm vertical accuracy has been used to inform the ground elevation of the floodplain within the hydraulic model for areas outside the AFA boundary. **Note:** In general there is overlap between the AFA area and areas outside the AFA with regard to the availability of LiDAR data. Therefore some areas outside the AFA are covered by LiDAR to the same resolution as that for the AFA.
2.3 River Channel/Structures Survey	Details of the topographic survey of the river channel and structures are included in the main Hydraulics Report. This includes longitudinal sections and channel cross-sections. Full details of the survey outputs are provided in the topographic survey deliverables, as required under Section 5.2 of the Stage I Project Brief. Number of cross-sections included in this model: 77
2.4 Defence Asset Survey Data	No formal or informal flood defences are present in the S02 model area.
2.5 Survey Interaction	The Lidar, IFSAR and topographic survey were checked for anomalies, and to ensure that interactions between were within expected tolerances. No issues were identified in this model.

3. Hydraulic Model Construction and Schematisation

3.1 Software:	**1D Domain:**	ISIS Version 3.6.0.156 (32 bit - Single Precision)
	2D Domain(s):	TUFLOW Version 2012-05-AE-iSP-w32
3.2 Model Area / Extent:	The extent of the model and its schematisation are shown in Annex A.	

The mapping details for the model extent included in Annex A are as follows:

1. **Full modelled area showing**:
   - River centre lines, HPW/MPW extents, names of watercourses
   - 2D domain area
   - AFA boundary
2. **Maps showing a detailed model schematic of the HPW/MPW reaches are also included**

3.3 Model Reach: The following model reach as shown on the maps referred to above has been represented in the model:

Watercourse Name		Upstream Model Node	Downstream Model Node
River Rine		02RIN5519	02RIN0000

Total model HPW length (km):	3.67	**Total model MPW length (km):**	1.86

3.4 Model Structures: A full schedule of structures included in the model is provided in Schedule A.1 in Annex B. A summary of the structures included is given below

Culverts:	☐	How many?	0
Bridges:	☒	How many?	4
Fixed crest weirs:	☐	How many?	0
Adjustable crest weirs:	☐	How many?	0
Sluice / Gate structures:	☐	How many?	0
Locks:	☐	How many?	0
Dams:	☐	How many?	0
Other (describe):			

3.5 Floodplain Schematisation

Out-of-bank areas for MPW reaches have been modelled using a 1D approach in the ISIS model by extending the river channel cross-sections.

Out-of-bank areas for HPW reaches, within Quin AFA, have been modelled using a 1D approach in the ISIS model by extending the river channel cross-sections.

Extended 1D sections are considered appropriate for HPW extents where floodplain flow paths are simple (e.g, parallel to river flow). 1D-2D modelling is required where HPWs flow through urban areas and out-of-bank flows will form complex flow paths.

An overview of the floodplain schematisation is available in the maps shown in Annex A.

3.6 2D Domain Grid Size: Grid size and extension of the 2D model domain are as follows:

2D domain	Grid cell size (m): 5	Area (km^2): 0.913

2D domains are defined depending on the level of detail required to pick up the appropriate features in the 2D domain that will impact on the local hydraulics. The domain grid square size is typically in the range 5m to 20m, with the smaller grid sizes used in very urbanised areas where there are multiple features that could not be suitably represented in, say, a 10m grid. The model grid is orientated in the main direction of the floodplain flow.

3.7 Model Breaklines in the 2D Domain:	Bank tops are represented as breaklines in the 2D domain. No other breaklines were required.	
3.8 Floodplain Structures in the 2D Domain	No floodplain structures have been included in the 2D model.	
3.9 Hydraulic Roughness	Hydraulic roughness (Manning's 'n') has been defined in accordance with the approaches described in the main Hydraulics Report. Details of the values adopted for this model are included in Schedule B.1 in Annex B. A summary of Manning's n for the model as a whole is as follows:	
MPW in-bank	Minimum 'n' value :	0.035
	Maximum 'n' value:	0.065
HPW in-bank	Minimum 'n' value:	0.035
	Maximum 'n' value:	0.080
Floodplain (ISIS Model)	Manning's 'n' for out of bank areas represented in the ISIS model are as defined by EPA land use characteristics, as described in the main Hydraulics Report. Floodplain land uses and adopted roughness values relevant to the ISIS model are as follows:	
	Land Use	**Manning's 'n' Value**
	Pastures	0.035
	General Rural	0.045
	Dense Vegetation	0.080
Floodplain (TUFLOW Model)	Manning's 'n' for out of bank areas represented in the TUFLOW model are as defined by OSi NTF land use characteristics, as described in the main Hydraulics Report. Floodplain land uses and adopted roughness values relevant to the ISIS model are as follows:	
	Land Use	**Manning's 'n' Value**
	Buildings	0.100
	Short grass, parks	0.030
	General Urban	0.060
	General Rural	0.045
	Dense Vegetation	0.080
	Roads	0.025
	Water bodies	0.020
3.10 Spill Units	Spill units are used for a number of different purposes (e.g. irregular weir, lateral spilling in the floodplain). Spill profile geometry is defined using topographic survey data and LiDAR/IfSAR. Spill coefficients used generally vary between 0.9 and 1.5 depending on the type of ground conditions (e.g. rough vegetated, smooth concrete) over which flood flows are spilling. Lower coefficients (<1.0) can be also found to account for lateral spilling perpendicular to the main direction of flow.	
3.11 Model Boundaries – Inflows	Hydrological flow hydrographs were input to the model at key model locations as indicated in the tables below. For further details on the design hydrograph estimation process please refer to Section 2 of the Hydrology Report for UoM27. For further details on hydrographs and peak flows specifically related to this model please see Appendix A1 and Appendix B2 respectfully of the Hydrology Report for UoM27.	
(a) Current Situation	Peak inflows (m3/s) are summarised in the tables below for the current situation and the design event simulated. These are the final inflows as	

	obtained following calibration to HEPs (see Section 4.2).

HEP Reference Name	Input Node in the Hydraulic Model	Annual Exceedance Probability							
		50%	**20%**	**10%**	**5%**	**2%**	**1%**	**0.5%**	**0.1%**
27_657_1	02RIN5519	20.7	25.4	28.6	31.6	35.5	38.4	41.3	48.0
27_660_3	02RIN4018d	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
27_660_4	02RIN3534d	0.2	0.3	0.3	0.4	0.4	0.4	0.5	0.5
27_661_2	02RIN2706d	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2
27_661_4	02RIN1874d	3.2	3.9	4.4	4.9	5.5	5.9	6.4	7.4
27_1275_2	02RIN1357d	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.6

(b) Future Scenarios	The peak inflows (m^3/s) used as inputs to the model at key model locations are summarised in the table below for both the MRFS and the HEFS.

HEP Reference Name	Input Node in the Hydraulic Model	Annual Exceedance Probability							
		MRFS							
		50%	**20%**	**10%**	**5%**	**2%**	**1%**	**0.5%**	**0.1%**
27_657_1	02RIN5519	24.8	30.5	34.3	37.9	42.6	46.1	49.5	57.6
27_660_3	02RIN4018d	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2
27_660_4	02RIN3534d	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6
27_661_2	02RIN2706d	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
27_661_4	02RIN1874d	3.8	4.7	5.3	5.8	6.6	7.1	7.6	8.9
27_1275_2	02RIN1357d	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.8

HEP Reference Name	Input Node in the Hydraulic Model	Annual Exceedance Probability		
		HEFS		
		10%	**1%**	**0.1%**
27_657_1	02RIN5519	37.1	49.9	62.4
27_660_3	02RIN4018d	0.1	0.2	0.2
27_660_4	02RIN3534d	0.4	0.6	0.7
27_661_2	02RIN2706d	0.1	0.2	0.2
27_661_4	02RIN1874d	5.7	7.7	9.6
27_1275_2	02RIN1357d	0.5	0.7	0.8

3.12 Model Boundaries – Downstream Conditions	Downstream boundary conditions adopted in the model are as follows:
	A normal depth boundary was chosen to provide a free flow condition at the downstream end of the model. This is appropriate as the River Rine is not tidally influenced at the location. The slope parameter was taken from the local river bed slope. Sensitivity to this assumption is discussed in the relevant section below.

4. Hydraulic Model Calibration and Sensitivity

4.1 Model Calibration and Verification to Historical Events

The approach to model calibration is documented in the Main Hydraulics Report for UoM 27.

There is only one gauging station (27021) located just downstream of the S02 modelling extent. However, the station is currently inactive and no records were found available for the times when the station was active.

Due to the absence of hydrometric data across the catchment, hydraulic calibration of model S02 was deemed not possible. However a broad verification of the model was undertaken as follows.

The National Hazard flood mapping website (floodmaps.ie) reports on a recurring flood incident (twice per year) to the L8180 at Dangan Bridge (146106,177641) and also to the land adjacent to the river upstream of Danganbrack (143039,174862) all the way through to the South of Quin. Whilst the first location is located 4km upstream of the model extent, the latter information indicates that the functional floodplain throughout S02 model extent is extensive. This is consistent with the model predictions for the lowest flood event simulated (i.e. 50% AEP flood event) which are presented in Figure 1a to 1d below.

4.2 Calibration to HEP

Calibration of the hydraulic model to the HEP target flows has been carried out for all AEP fluvial events. Section 2.7.2 of the Hydrology Report for UoM27 provides a summary of the calibration to HEP process.

Preliminary inflow hydrographs derived from the hydrological analysis and input to the model were adjusted in time so that their respective peak flows coincide with the peak time of the propagating flood wave as it is routed down the model. Total peak flows predicted by the hydraulic model at HEP locations were then compared to the HEP target flows estimated during the hydrological analysis.

Modelled total peak flows at all HEP locations were found to be within ±10% of the HEP target flows. Therefore no inflow scaling of the original hydrology was deemed necessary.

This ±10% target allows for good agreement between the hydrological estimates and the hydraulic results without the addition/removal of unrealistic volumes of flow from the model. The robustness of this has been verified by the agreement of the design flood maps.

The table below shows the percentage difference between the modelled and target flows at each HEP location. The average percentage differences for all of the HEP nodes are as follows: -5.2%, -5.2%, -3.1%, -2.3%, -1.7%, -1.3%, -1.3% and -1.0% for the 50%, 20%,10%, 5%, 2%, 1%, 0.5% and 0.1% AEP events respectively.

HEP Reference Name	Node in the Hydraulic Model	Annual Exceedance Probability Percentage Difference (%)							
		50%	20%	10%	5%	2%	1%	0.5%	0.1%
27_657_1	02RIN5519	2.0	1.7	2.0	1.8	1.9	1.8	1.9	1.9
27_660_3	02RIN4018u	-5.6	-5.8	-5.5	-5.6	-5.1	-4.6	-4.3	-3.4
27_660_4	02RIN3534u	-5.8	-5.9	-5.5	-5.6	-5.1	-4.0	-4.2	-3.7
27_661_2	02RIN2706u	-6.3	-6.6	-6.3	-6.3	-6.2	-5.5	-6.2	-5.0
27_1275_2	02RIN1357u	-7.8	-7.4	-1.6	1.0	2.2	2.4	2.5	2.3
27_1275_4	02RIN0375u	-7.8	-7.3	-1.4	0.9	2.0	2.1	2.5	2.1

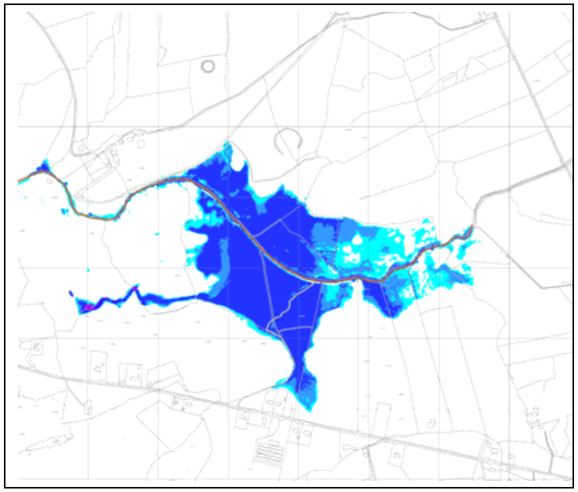


Figure 1a – Flood Extent upstream of the Quin AFA for a 2yr (50% AEP) event

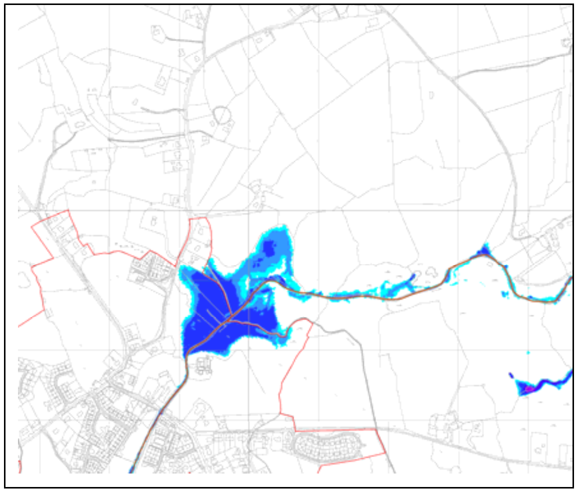


Figure 1b – Flood Extent in the Quin AFA for a 2yr (50% AEP) event

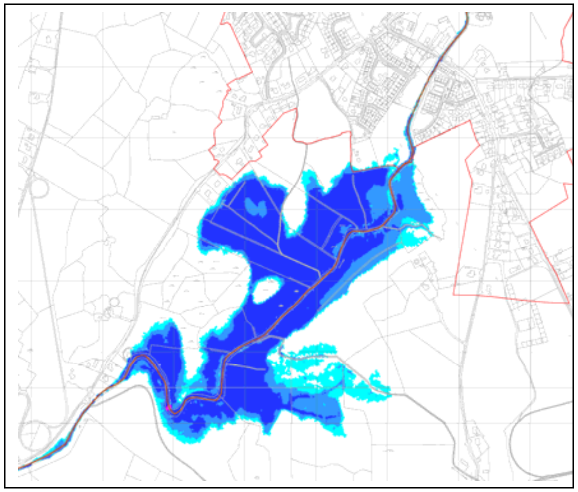


Figure 1c – Flood Extent at the downstream boundary of the Quin AFA for a 2yr (50% AEP) event

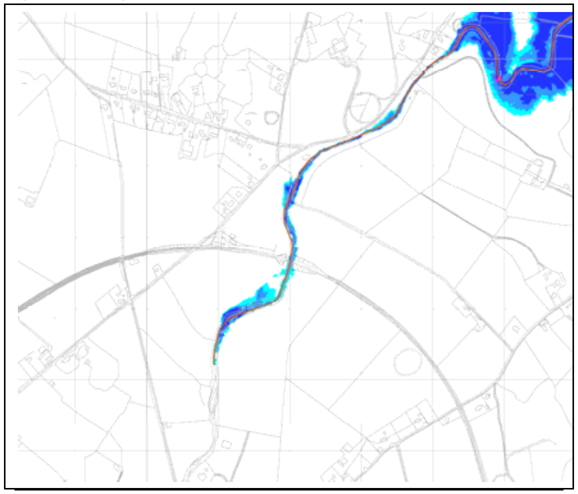


Figure 1d – Flood Extent downstream of the Quin AFA for a 2yr (50% AEP) event

<table>
<tr><td>4.3 Model Sensitivity</td><td colspan="4">Sensitivity tests have been carried out in order to assess the sensitivity of the predicted peak water levels to alterations in roughness (Manning's 'n'), fluvial flow and downstream conditions. In each case the sensitivity run was carried out for the 1% AEP fluvial event. Sensitivity test results are provided in the following tables.
Uncertainty maps illustrating the results of the sensitivity analysis will be delivered as part of the final stage of this work.</td></tr>
<tr><td rowspan="2">+20% Manning's 'n'</td><td>Watercourse</td><td>Average Water Level Difference (mm)</td><td>Maximum Water Level Difference (mm)</td><td>Cross-section / Reach where the Maximum Difference occurs</td></tr>
<tr><td>River Rine</td><td>+198</td><td>+334</td><td>02RIN3026u</td></tr>
<tr><td rowspan="2">-20% Manning's 'n'</td><td>Watercourse</td><td>Average Water Level Difference (mm)</td><td>Maximum Water Level Difference (mm)</td><td>Cross-section where the Maximum Difference occurs</td></tr>
<tr><td>River Rine</td><td>-230</td><td>-447</td><td>02RIN1460</td></tr>
<tr><td rowspan="2">+20% inflows</td><td>Watercourse</td><td>Average Water Level Difference (mm)</td><td>Maximum Water Level Difference (mm)</td><td>Cross-section where the Maximum Difference occurs</td></tr>
<tr><td>River Rine</td><td>+247</td><td>+512</td><td>02RIN3026u</td></tr>
<tr><td rowspan="2">-20% inflows</td><td>Watercourse</td><td>Average Water Level Difference (mm)</td><td>Maximum Water Level Difference (mm)</td><td>Cross-section where the Maximum Difference occurs</td></tr>
<tr><td>River Rine</td><td>-270</td><td>-370</td><td>02RIN1265</td></tr>
<tr><td>Afflux at Key Structure</td><td colspan="4">No significant afflux was apparent at the hydraulic structures represented in the model therefore no sensitivity test was carried out.</td></tr>
<tr><td>Downstream Conditions
Normal Depth downstream boundary slope doubled</td><td colspan="4">The change to the downstream boundary condition has resulted in a decrease in maximum water level by 203mm at the downstream limit of the model (ISIS node 02RIN0000). The diminishing effects can be seen 0.109km upstream of the downstream model limit on the River Rine. The change in the boundary condition has no impact on the water level in Quin AFA.</td></tr>
<tr><td>Downstream Conditions
Normal Depth downstream boundary slope halved</td><td colspan="4">The change to the downstream boundary condition has resulted in an increase in maximum water level by 240mm at the downstream model limit (ISIS node 02RIN0000). The diminishing effects can be seen 0.109km upstream of downstream mode limit on the River Rine. The change in the boundary condition has no impact on the water level in Quin AFA.</td></tr>
<tr><td>4.4 Model Files</td><td colspan="4">The hydraulic model files associated with this model are provided as a separate deliverable under the contract, as required under Sections 7.8 and 13 of the Stage I Project Brief. The model files included are detailed in Annex C.</td></tr>
</table>

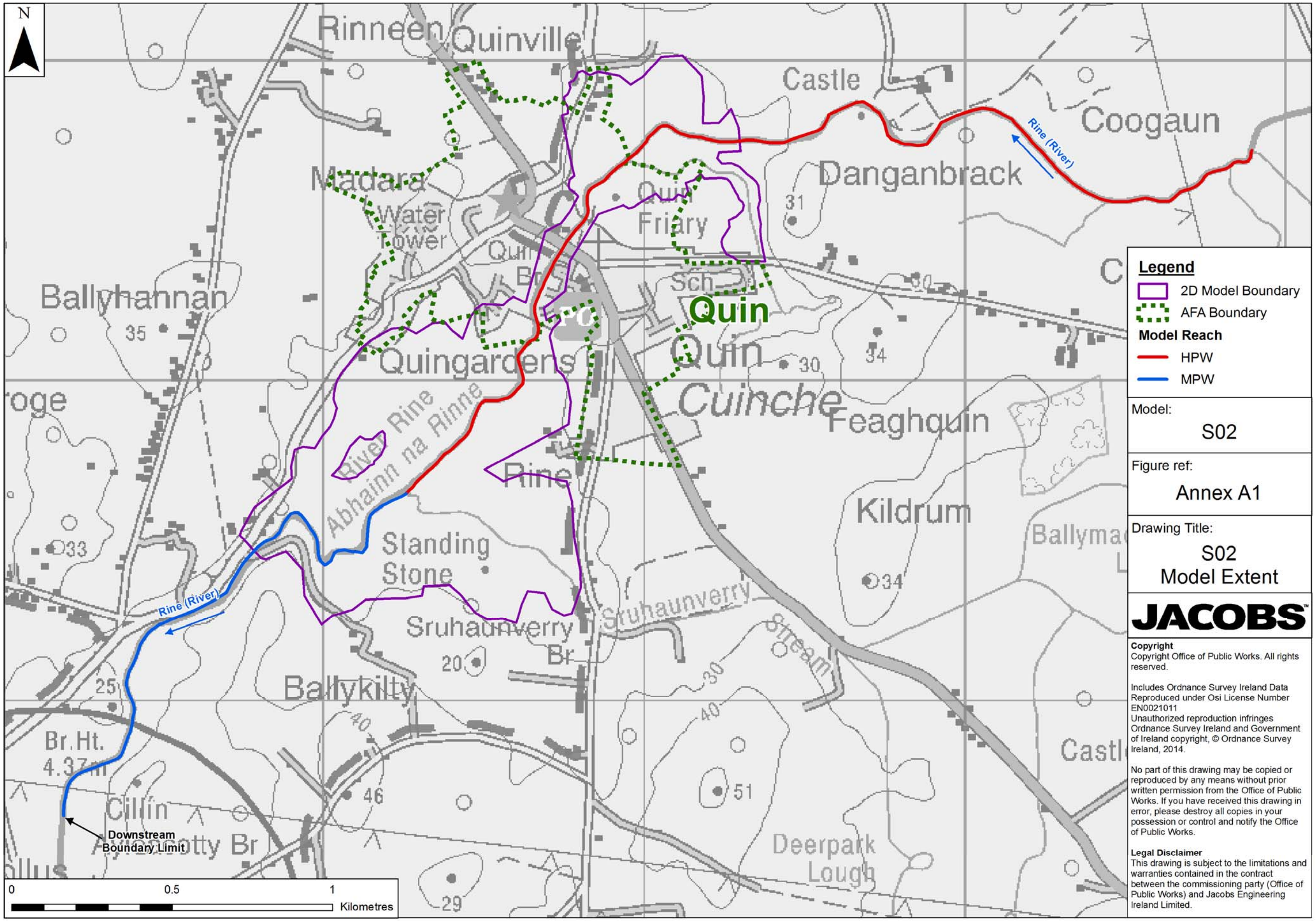
5. Hydraulic Model Outputs	
5.1 Mapping	Model outputs were processed to produce a series of flood maps according to the requirements stated in the Stage I Project Brief under Section 7.5.2. This includes mapping outputs covering: • Flood extents • Flood depth and velocity • Flood hazard Mapping outputs corresponding to the 10%, 1% and 0.1% AEP flood events are shown in Annex D for flood extent and depth.

6. Key Model Assumption and Limitations

- Due to the absence of hydrometric data, hydraulic calibration of model S02 was not possible.
- Photographs and videos taken on site show a flood relief culvert on the left bank of the railway bridge at surveyed cross section 27RINE00826D (ISIS node 2RIN0402bu). The flood relief culvert has been included in the hydraulic model. However its dimensions were estimated based on photographs since no survey data was available for this culvert.

Annex A – Model Extent and Schematisation Maps

A1 – S02 Model Extent



N
Rinneen
Quinville
Castle
Coogaun
Rine (River)
Danganbrack
Madara
Water Tower
Quin Friary
Ballyhannan
Quin
Quingardens
Cuinche
Feaghquin
River Rine
Abhainn na Rinne
Rine
Kildrum
Standing Stone
Ballymac
Sruhaunverry
Sruhaunverry Br
Stream
Rine (River)
Ballykilty
Br. Ht. 4.37m
Cillín
Downstream Boundary Limit
Deerpark Lough
Castl
0
0.5
1
Kilometres
Legend
2D Model Boundary
AFA Boundary
Model Reach
HPW
MPW
Model:
S02
Figure ref:
Annex A1
Drawing Title:
S02
Model Extent
JACOBS
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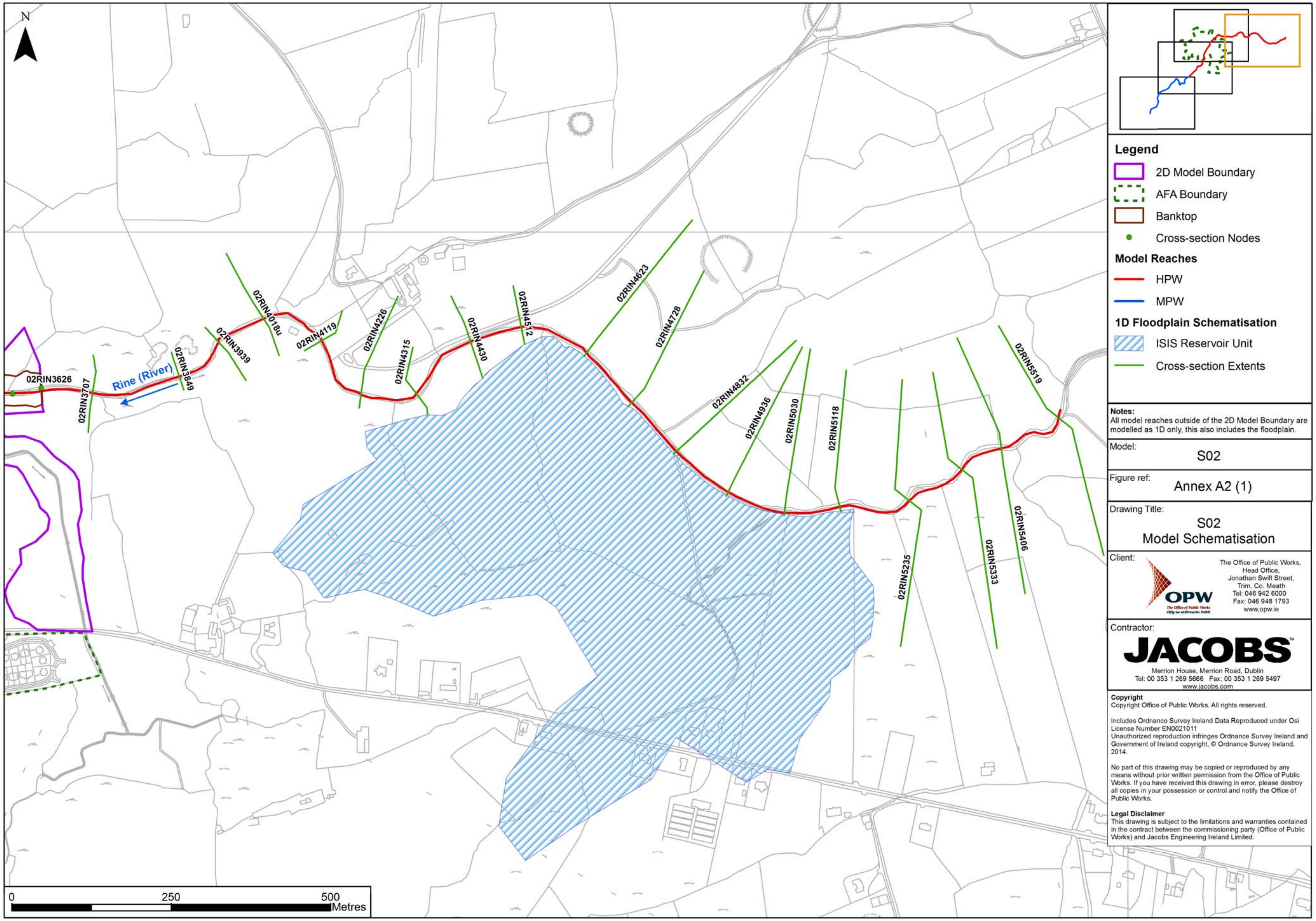
A2 – S02 Model Schematisation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02RIN3707
Rine (River)
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02RIN4018u
02RIN4119
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02RIN4512
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02RIN5406
02RIN5519
0
250
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Metres
Legend
2D Model Boundary
AFA Boundary
Banktop
Cross-section Nodes
Model Reaches
HPW
MPW
1D Floodplain Schematisation
ISIS Reservoir Unit
Cross-section Extents
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S02
Figure ref:
Annex A2 (1)
Drawing Title:
S02
Model Schematisation
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www.opw.ie
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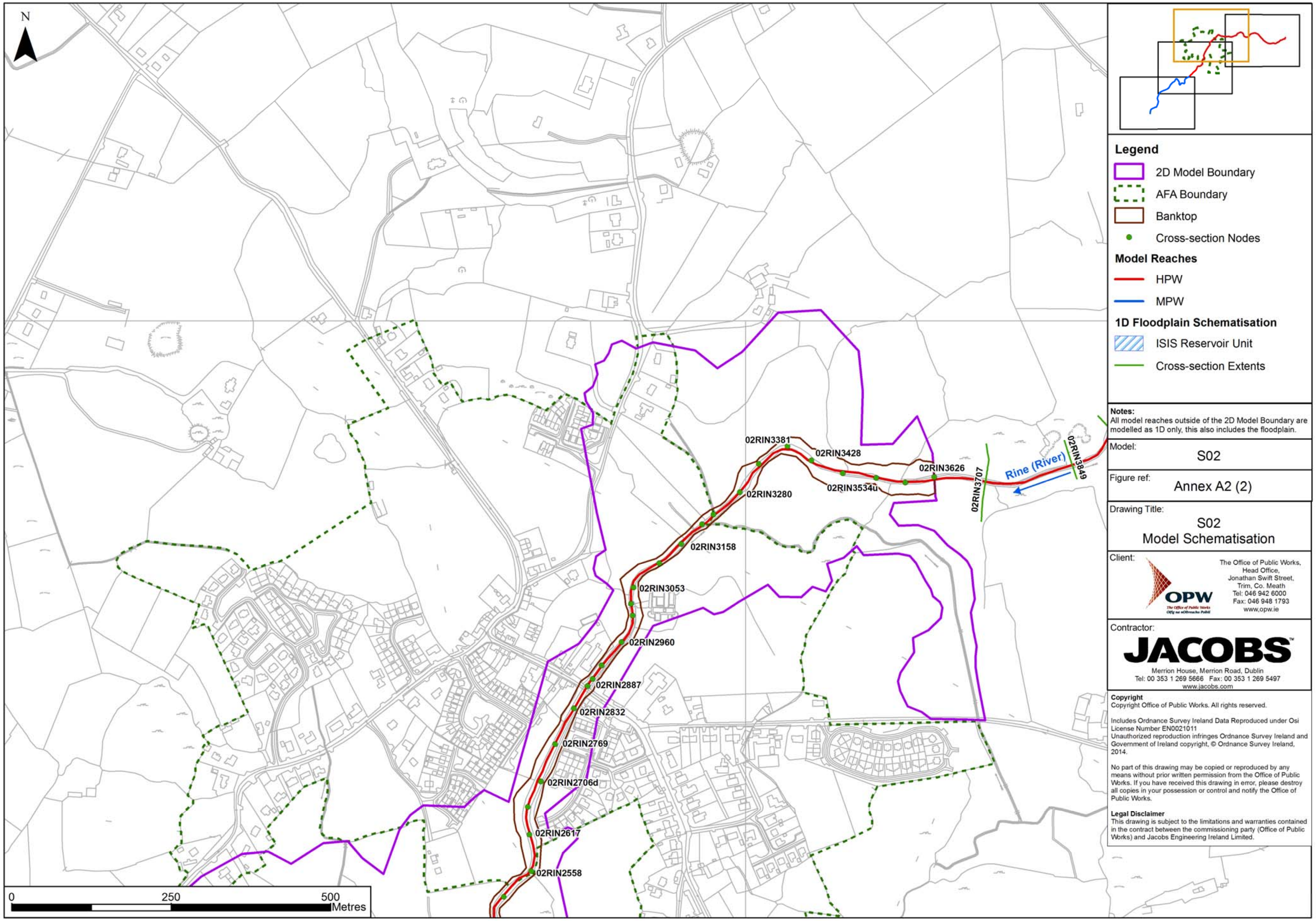
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Legend
2D Model Boundary
AFA Boundary
Banktop
Cross-section Nodes
Model Reaches
HPW
MPW
1D Floodplain Schematisation
ISIS Reservoir Unit
Cross-section Extents
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Model:
S02
Figure ref:
Annex A2 (2)
Drawing Title:
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Rine (River)
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02RIN3626
02RIN3534u
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02RIN3381
02RIN3280
02RIN3158
02RIN3053
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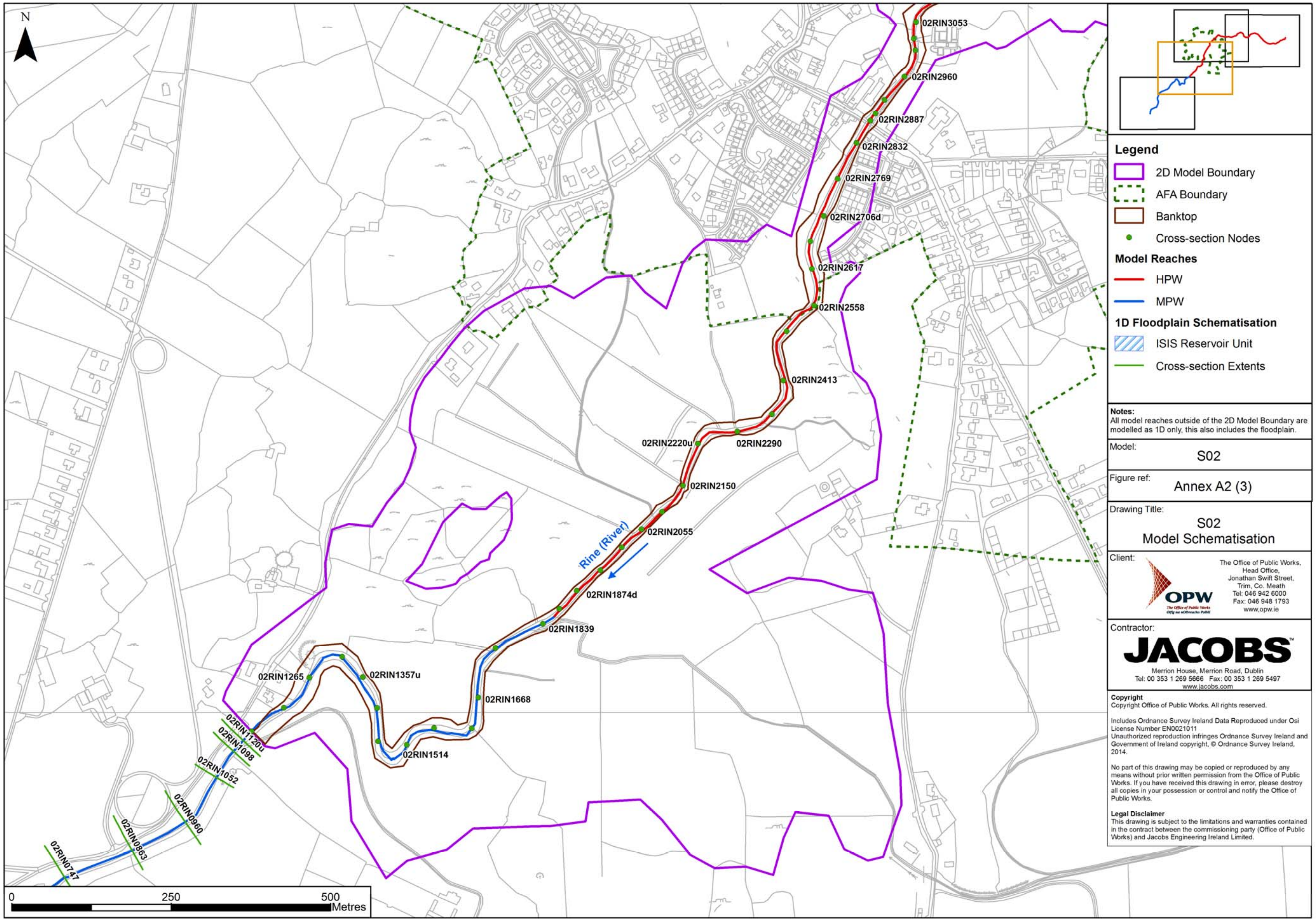
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02RIN2413
02RIN2220u
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02RIN1265
02RIN1668
02RIN1514
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02RIN0747
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Legend
2D Model Boundary
AFA Boundary
Banktop
Cross-section Nodes
Model Reaches
HPW
MPW
1D Floodplain Schematisation
ISIS Reservoir Unit
Cross-section Extents
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S02
Figure ref:
Annex A2 (3)
Drawing Title:
S02
Model Schematisation
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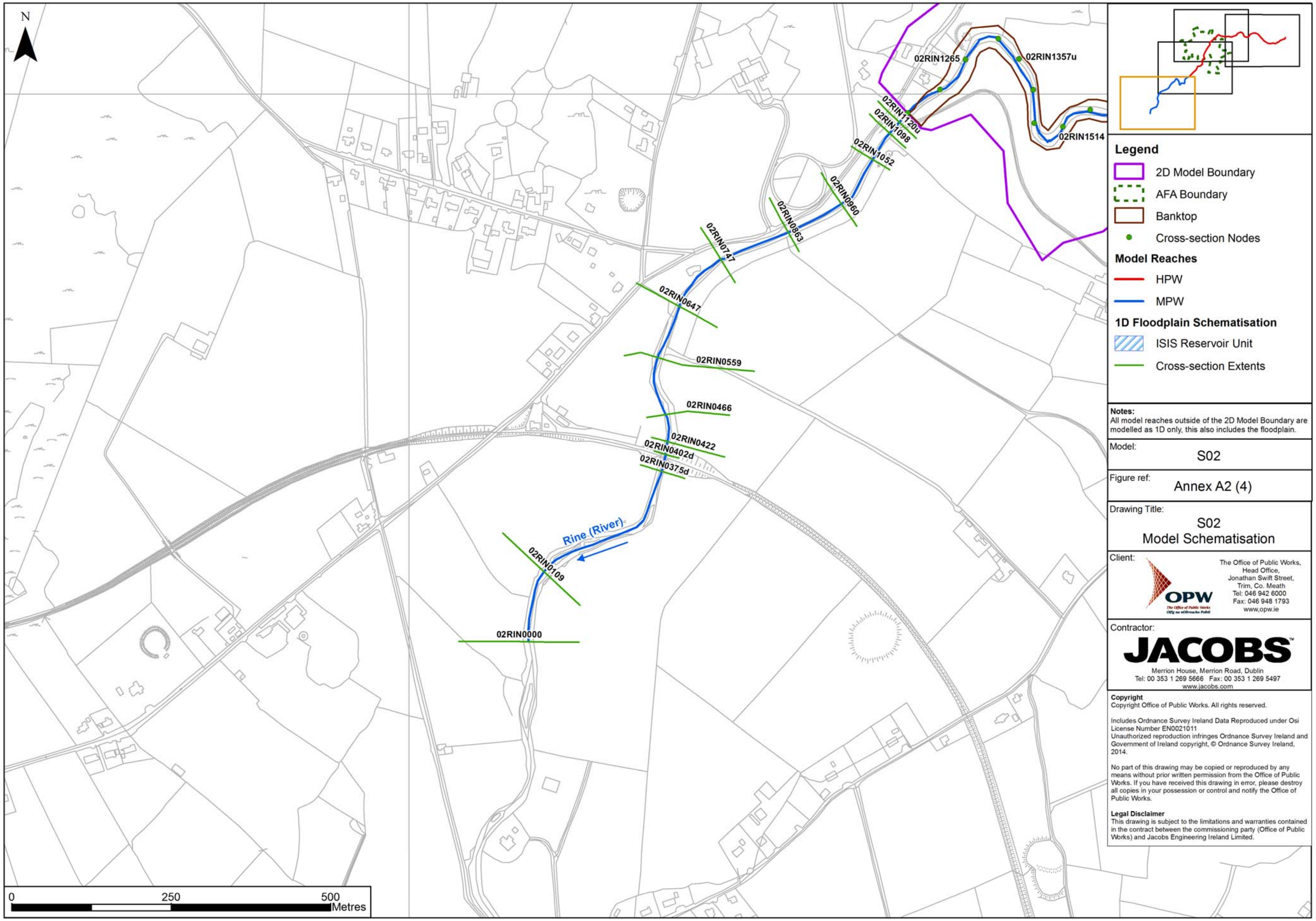
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02RIN0466
02RIN0422
02RIN0402d
02RIN0375d
Rine (River)
02RIN0109
02RIN0000
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Metres
Legend
2D Model Boundary
AFA Boundary
Banktop
Cross-section Nodes
Model Reaches
HPW
MPW
1D Floodplain Schematisation
ISIS Reservoir Unit
Cross-section Extents
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S02
Figure ref:
Annex A2 (4)
Drawing Title:
S02
Model Schematisation
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Annex B – Structure and Hydraulic Roughness Schedules

Schedule A.1 - Structure Schedule for River Rine

Survey Reference	ISIS Node Reference	Type of Structure	Modelling Approach	Structure included in Model (Y/N)
27RINE01089D	02RIN3026u	Bridge 10.84m wide.	Arch bridge with one opening + spill unit.	Y
27RINE01073D	02RIN2873u	Multiple arch bridge (3 openings).	Arch bridge with 3 openings + spill unit.	Y
27RINE00898D	02RIN1120u	Arch Bridge 5.66m wide.	Arch bridge with one opening + spill unit.	Y
27RINE00826D	02RIN0402u	Arch Bridge 9.14m wide.	USBPR bridge unit	Y

Schedule B.1 – Manning's 'n' for HPW Network

River Name	ISIS Node Reference	Bed Roughness	Estimated Bank Side Roughness	Estimated Floodplain Roughness
Rine	02RIN5519 to 02RIN2706d	0.040	Determined on a case by case basis using photos, videos and survey drawings	2D Domain : based on OSi NTF land use polygons 1D Domain: Land use EPA data has been used for assigning the floodplain roughness.
	02RIN2617 to 02RIN1874d	0.035		

Schedule B.2 – Manning's 'n' for MPW Network

River Name	ISIS Node Reference	Bed Roughness	Estimated Bank Side Roughness	Estimated Floodplain Roughness
Rine	02RIN1839 to 02RIN1265	0.035	Determined on a case by case basis using photos, videos and survey drawing	2D Domain : based on OSi NTF land use polygons 1D Domain: Land use EPA data has been used for assigning the floodplain roughness.
	02RIN1138 to 02RIN0000	0.040		

Annex C – Model Calibration

Not used as calibration to historical events was not possible.

Annex D - Hydraulic Model Files

Model Files Folders Structure	

ISIS	Model S02
	  ISIS
	    Design Runs
	    IED
	    Sensitivity Analysis
	      Boundary
	      Flow
	      Roughness
	  Tuflow

TUFLOW	Model S02
	  ISIS
	  Tuflow
	    bc_dbase
	    checks
	    model
	      bg
	      cs
	      mi
	        Boundaries
	        Breaklines
	        Landuse
	        Location
	        POlines
	        River
	        Topography
	      xs
	    results
	    runs

ISIS Files	
Model Geometry (.dat) and Associated Files (e.g.: .ief, .zzl, .zzd, .zzu,.zzx)	**Design Runs – Current Scenario:** S02_Quin_Flu_C_Des_Iss1.DAT S02_Quin_Q2_Flu_C_Des_Iss1.ief S02_Quin_Q5_Flu_C_Des_Iss1.ief S02_Quin_Q10_Flu_C_Des_Iss1.ief S02_Quin_Q20_Flu_C_Des_Iss1.ief S02_Quin_Q50_Flu_C_Des_Iss1.ief S02_Quin_Q100_Flu_C_Des_Iss1.ief S02_Quin_Q200_Flu_C_Des_Iss1.ief S02_Quin_Q1000_Flu_C_Des_Iss1.ief **Sensitivity Runs – Current Scenario** S02_Quin_Flu_C_Sen_BoDo_v1.DAT S02_Quin_Flu_C_Sen_BoHlf_v1.DAT S02_Quin_Flu_C_Des_Sen_FlDe_v1.DAT S02_Quin_Flu_C_Des_Sen_FlIn_v1.DAT S02_Quin_Flu_C_Sen_RoDe_v1.DAT S02_Quin_Flu_C_Sen_RoIn_v1.DAT
Hydrological Inflow Files	**Design Runs – Current Scenario:** S02_Quin_2yr.IED S02_Quin_5yr.IED S02_Quin_10yr.IED S02_Quin_20yr.IED S02_Quin_50yr.IED S02_Quin_100yr.IED S02_Quin_200yr.IED S02_Quin_1000yr.IED **Sensitivity Runs – Current Scenario** S02_Quin_100yr_FlDe.IED S02_Quin_100yr_FlIn.IED

TUFLOW Files	
TUFLOW Control Files (.tcf) and Associated Files (e.g.: ecf, tgc, tbc)	**Design Runs – Current Scenario:** S02_Quin_Q2_Flu_C_Des_Iss1.tcf S02_Quin_Q5_Flu_C_Des_Iss1.tcf S02_Quin_Q10_Flu_C_Des_Iss1.tcf S02_Quin_Q20_Flu_C_Des_Iss1.tcf S02_Quin_Q50_Flu_C_Des_Iss1.tcf S02_Quin_Q100_Flu_C_Des_Iss1.tcf S02_Quin_Q200_Flu_C_Des_Iss1.tcf S02_Quin_Q1000_Flu_C_Des_Iss1.tcf **Sensitivity Runs – Current Scenario** S02_Quin_Q100_Flu_C_Sen_BoDo_v1.tcf S02_Quin_Q100_Flu_C_Sen_BoHlf_v1.tcf S02_Quin_Q100_Flu_C_Sen_FlDe_v1.tcf S02_Quin_Q100_Flu_C_Sen_FlIn_v1.tcf S02_Quin_Q100_Flu_C_Sen_RoDe_v1.tcf S02_Quin_Q100_Flu_C_Sen_RoIn_v1.tcf
Grid Orientation File	2d_loc_5m_S02_Quin.MIF
Material Files	**Design Runs – Current Scenario:** Landuse_S02_Quin.tmf **Sensitivity Runs – Current Scenario** Landuse_S02_Quin_Sen_RoDe.tmf Landuse_S02_Quin_Sen_RoIn.tmf 2d_mat_General_Rural_S02_Quin.MIF 2d_mat_Dense_Vegetation_S02_Quin.MIF 2d_mat_Short_Grass_S02_Quin.MIF 2d_mat_General_Urban_S02_Quin.MIF 2d_mat_Water_S02_Quin.MIF 2d_mat_Avenues_Footpaths_S02_Quin.MIF 2d_mat_Roads_S02_Quin.MIF 2d_mat_Buildings_S02_Quin.MIF
Zpt Files, Model DTM (.asc)	S02_Quin_2m_dtm.asc
Breaklines Files	2d_zln_unsurv_banktop_5m_S02_Quin.MIF 2d_zln_surv_banktop_5m_S02_Quin.MIF
Boundary Files	2d_bc_hxe_5m_S02_Quin.MIF 2d_bc_hxi_5m_S02_Quin.MIF
Flow/Head Files in bc_dbase	No Flow/Head boundaries provided in 2D domain.
Initial Water Level Files	N/A

Time Series Files	N/A
One Dimensional Network Files	1d_ISIS_nodes_5m_S02_Quin.MIF
Available 2D Result Files	Depth, stage, hazard and velocity 2D results in ASCII file format for all available design return periods.

Model Run Log						
Sr. No.	**Model File Name**	**Start Time**	**End Time**	**Time Step**	**Advanced Options /Other Information**	**Comments on Model Stability**
			Design Runs – Current scenario			
1	S02_Quin_Q2_Flu_C_Des_Iss1.ief	0	45	1 sec 1D 2 sec 2D	“Automated Preissmann Slot for River Sections” is checked, “minitr” value is set to 2 and “maxitr” value is set to 6, ISIS Flow Engine Version “Single Precision” is checked.	Convergence within manufacturer tolerance.
2	S02_Quin_Q5_Flu_C_Des_Iss1.ief	0	45	1 sec 1D 2 sec 2D	“Automated Preissmann Slot for River Sections” is checked, “minitr” value is set to 2 and “maxitr” value is set to 6, ISIS Flow Engine Version “Single Precision” is checked.	Convergence within manufacturer tolerance.
3	S02_Quin_Q10_Flu_C_Des_Iss1.ief	0	45	1 sec 1D 2 sec 2D	“Automated Preissmann Slot for River Sections” is checked, “minitr” value is set to 2 and “maxitr” value is set to 6, ISIS Flow Engine Version “Single Precision” is checked.	Convergence within manufacturer tolerance.
4	S02_Quin_Q20_Flu_C_Des_Iss1.ief	0	45	1 sec 1D 2 sec 2D	“Automated Preissmann Slot for River Sections” is checked, “minitr” value is set to 2 and “maxitr” value is set to 6, ISIS Flow Engine Version “Single Precision” is checked.	Convergence within manufacturer tolerance.
5	S02_Quin_Q50_Flu_C_Des_Iss1.ief	0	45	1 sec 1D 2 sec 2D	“Automated Preissmann Slot for River Sections” is checked, “minitr” value is set to 2 and “maxitr” value is set to 6, ISIS Flow Engine Version “Single Precision” is checked.	Convergence within manufacturer tolerance.
6	S02_Quin_Q100_Flu_C_Des_Iss1.ief	0	45	1 sec 1D 2 sec 2D	“Automated Preissmann Slot for River Sections” is checked, “minitr” value is set to 2 and “maxitr” value is set to 6, ISIS Flow Engine Version “Single Precision” is checked.	Convergence within manufacturer tolerance.

7	S02_Quin_Q200_Flu_C_Des_Iss1.ief	0	45	1 sec 1D 2 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 6, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
8	S02_Quin_Q1000_Flu_C_Des_Iss1.ief	0	45	1 sec 1D 2 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 6, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
Sensitivity Analysis						
9	S02_Quin_Q100_Flu_C_Sen_BoDo_v1.ief	0	45	1 sec 1D 2 sec 2D	Normal depth downstream boundary slope doubled	Convergence within manufacturer tolerance.
10	S02_Quin_Q100_Flu_C_Sen_BoIn_v1.ief	0	45	1 sec 1D 2 sec 2D	Normal depth downstream boundary slope halved	Convergence within manufacturer tolerance.
11	S02_Quin_Q100_Flu_C_Sen_FlDe_v1.ief	0	45	1 sec 1D 2 sec 2D	Flow decreased by 20%	Convergence within manufacturer tolerance.
12	S02_Quin_Q100_Flu_C_Sen_FlIn_v1.ief	0	45	1 sec 1D 2 sec 2D	Flow increased by 20%	Convergence within manufacturer tolerance.
13	S02_Quin_Q100_Flu_C_Sen_RoDe_v1.ief	0	45	1 sec 1D 2 sec 2D	Roughness decreased by 20%	Convergence within manufacturer tolerance.
14	S02_Quin_Q100_Flu_C_Sen_RoIn_v1.ief	0	45	1 sec 1D 2 sec 2D	Roughness increased by 20%	Convergence within manufacturer tolerance.

Parameters changed from Default	Justification
Automated Preismann slot for River Sections turned on.	Automated Preismann slot are a standard parameter used to aid model stability particularly in low flows. These Preismann slots have negligible to no impact on the water levels during flood events.
Minitr	Increased to 2 to improve model stability.*
Maxitr	Increased to 6 to improve model stability.*
Matrix Dummy Coefficient set to 0.0001	Set to 0.0001 to solve IFAG error. *

*Stage and Flow profiles at all cross sections have been checked to ensure results are sensible and to ensure any changes to the default model run parameters has not impacted on the model results.

Annex E - Flood Mapping

Flood Maps are available through the OPW flood mapping website; http://maps.opw.ie/fhrm/

Appendix C Fluvial/Coastal Hydraulic Model Appendices

Fluvial and Coastal Hydraulic Modelling Report

1. Basic Model Information

1.1 General Information	
Model ID:	S01
Unit of Management	27
AFA included in the Model	Ennis
Primary Watercourses / Water Bodies	River Fergus River Fergus Minor River Claureen River Gaurus River Rine River Cahircalla
1.2 Reference to other Relevant Reports	
Catchment Description	Hydrology Report Unit of Management 27 – Appendix A1.1
Model Location	Hydraulics Report Unit of Management 27 – Section 3.4.12
HEP Schematisation	Hydrology Report Unit of Management 27 – Appendix B1 – Figure B1.1

2. Survey Data and Base Mapping

2.1 Base Mapping:	OSi data base mapping at scale 1:50k Reference: OS1216_D OS1218_D OS1416_D OS1418_D
2.2 DTM for 2D Model Domain:	**Within AFAs:** LiDAR with 2m resolution (horizontal) and 200mm accuracy (vertical) has been used, where available, for the 2D domain of the hydraulic model.
	Outside AFAs: The supplied LiDAR data covers the area to be modelled outside the AFA. Therefore this has been used instead of SAR, given the much greater accuracy.
2.3 River Channel/Structures Survey	General information on the topographic survey of the river channel and structures are included in the main Hydraulics Report. Full details of the survey outputs are provided in the topographic survey deliverables, as required under Section 5.2 of the Stage I Project Brief. Number of cross-sections included in this model: 842
2.4 Defence Asset Survey Data	The defence asset database has been completed for this model area and is provided as a separate deliverable to this report. Formal flood defences have been surveyed and included into the model. They consist of: 1. Tidal embankment along the estuarine reaches of the River Fergus and the River Rine. 2. A series of flood walls running on both banks of the River Fergus and River Fergus Minor within Ennis. All defences have been included in the model schematisation as shown on the maps presented in Annex A.

2.5 Survey Interaction	The Lidar, IFSAR and topographic survey were checked for anomalies, and to ensure that interactions between were within expected tolerances. No issues were identified in this model.

3. Hydraulic Model Construction and Schematisation

3.1 Software:	**1D domain:** ISIS Version 3.6.0.156 (32 bit - Single Precision) **2D domain(s):** TUFLOW Version: 2012-05-AE-iSP-w32
3.2 Model Area / Extent:	The modelled area is within the Fergus catchment. A detailed catchment description of the catchments is provided in Appendix A1.1 of the Hydrology Report. The area extent of the model and its schematisation are shown in Annex A. • S01 is four separate models and a geographic description of each is given below: The Main model comprises the River Fergus, the River Fergus Minor and the River Gaurus. • The Karst Model comprises the River Cahircalla, Cahircalla Lough and Ballybeg Lough stream. • The Claureen model comprises the river Claureen and a section of the River Fergus down to the Ennis Mill. • The Rine model comprises the river Rine and a section of the estuarine section of the River Fergus up to the tidal barrage. The four separate model results were then merged to generate a single set of deliverables.

The mapping details for the model extent included in Annex A are as follows:

1. **Full modelled area showing**:
   - River centre lines, HPW/MPW extents, names of watercourses
   - 2D domain area including coastal and fluvial floodplains
   - AFA boundary
2. **Maps showing a detailed model schematic of the HPW/MPW reaches are also included.**

3.3 Model Reaches:	The following model reaches as shown on the maps referred to above have been defined in the model:

Watercourse Name	Reach	Upstream Model Node	Downstream Model Node
River Fergus	09FER	09FER01993	09FER00000
	08FER	08FER01238	08FER00000
	07FER	07FER01156	07FER00000
	06FER	06FER01453	06FER00000
	05FER	05FER00930	05FER00000
	04FER	04FER01221	04FER00000
	03FER	03FER02547	03FER00000
	02FER	02FER04119	02FER00000
	01FER	01FER00771	01FER00000
River Fergus Minor	01FEM	01FEM02139	01FEM00000

River Claureen	01CLR	01CLR05800	01CLR00000
River Gaurus	02GAU	02GAU00617	02GAU00000

River Gaurus Unnamed Tributary	01GAX	01GAX00515	01GAX00000
Cahircalla Lough	01CAH	01CAH00824	01CAH00737
River Cahircalla	02EDN	02EDN01164	02EDN00000
	01EDN	01EDN03477	01EDN00000
Ballybeg Lough Stream	02CLC	27_2_2	02CLC00000
	01CLC	01CLC00019	01CLC00000od
River Rine	01RIN	01RIN07992	01RIN00000

A schematic of the modelled river reach is available in the .GXY file provided in conjunction with each ISIS .DAT file (see Annex C)

Total model HPW length (km):	34.12	**Total model MPW length (km):**	11.19

3.4 Model Structures:

A full schedule of structures included in the model is provided in Schedule A in Annex B. A summary of the structures included is given below

Culverts:	☒	How many?	73
Bridges:	☒	How many?	30
Fixed crest weirs:	☒	How many?	2
Adjustable crest weirs:	☐	How many?	0
Sluice / Gate structures:	☒	How many?	7
Locks:	☐	How many?	
Dams:	☐	How many?	0
Other (describe):			

3.5 Floodplain Schematisation

Out-of-bank areas for MPW reaches have been modelled using a 1D approach in the ISIS model by extending the river channel cross-sections.

Out-of-bank areas for HPW reaches, within Ennis AFA, have been modelled using a 1D approach in the ISIS model by extending the river channel cross-sections.

Extended 1D sections are considered appropriate for HPW extents where floodplain flow paths are simple (e.g, parallel to river flow). 1D-2D modelling is required where HPWs flow through urban areas and out-of-bank flows will form complex flow paths.

An overview of the floodplain schematisation is available in the maps shown in Annex A.

3.6 2D Domain Grid Size:

The number of 2D domains defined and the grid sizes of the model domain are as follows:

Number of 2D domains: 2

Domain 1:	Grid cell size:10 m	Area: 7.827 km^2
Domain 2	Grid cell size: 40 m	Area: 21.99 km^2

2D domains are defined depending on the level of detail required to pick up the appropriate features in the 2D domain that will impact on the local hydraulics. The domain grid square size is typically in the range 5m to 20m, with the smaller grid sizes used in very urbanised areas where there are multiple features that could not be suitably represented in, say, a 10m grid. The model grid is orientated in the main direction of the floodplain flow.

3.7 Model Breaklines in the 2D Domain:	Bank tops, flood defences and road/railway embankment that impede the floodplain flows are represented as breaklines in the 2D domains.

3.8 Floodplain Structures in the 2D Domain	Sixteen 1D elements across the 2D domains have been included in the model to represent the culverts under road embankments to allow hydraulic connectivity across the floodplain. Since no survey data was available for these structures, the dimensions were estimated based on site survey photographs, site knowledge and best engineering judgement.	
3.9 Hydraulic Roughness	Hydraulic roughness (Manning's 'n') has been defined in accordance with the approaches described in the main Hydraulics Report. Details of the values adopted for this model are included in Schedule B in Annex B. A summary of Manning's 'n' for the model as a whole is as follows:	
MPW in-bank	Minimum 'n' value:	0.030
	Maximum 'n' value:	0.035
HPW in-bank	Minimum 'n' value:	0.020
	Maximum 'n' value:	0.055
Floodplain (ISIS Model)	Manning's 'n' for out-of-bank areas represented in the ISIS model are as defined by EPA land use characteristics, as described in the main Hydraulics Report. Floodplain land uses and adopted roughness values in ISIS are as follows:	
	Land Use	**Manning's 'n' Value**
	Pastures	0.035
	Dense Vegetation	0.080
	Road Network	0.025
	Buildings	0.100
Floodplain (TUFLOW Model)	Manning's 'n' for the coastal and fluvial floodplain areas represented in the TUFLOW model are as defined by OSi NTF land use characteristics, as described in the main Hydraulics Report. Floodplain land uses and adopted roughness values in TUFLOW are as follows:	
	Land Use	**Manning's 'n' Value**
	Buildings	0.100
	Short grass, parks	0.035
	General Rural	0.045
	Pastures, Short Grass	0.035
	Dense Vegetation	0.080
	Roads	0.025
	Flat Rock	0.025
	Water bodies	0.020
	Avenues or footpaths	0.05
	Sloping masonry	0.025
3.10 Spill Units	Spill units are used for a number of different purposes (e.g. irregular weir, lateral spilling in the floodplain). Spill profile geometry is defined using topographic survey data and LiDAR/IfSAR. Spill coefficients used generally vary between 0.9 and 1.5 depending on the	

	type of ground conditions (e.g. rough vegetated, smooth concrete) over which flood flows are spilling. Lower coefficients (<1.0) can be also be found to account for lateral spilling perpendicular to the main direction of flow.
3.11 Model Boundaries – Fluvial Inflows	Hydrological flow hydrographs were input to the model at key model locations as indicated in the tables below. For further details on the design hydrograph estimation process please refer to Section 2 of the Hydrology Report for UoM27. For further details on hydrographs and peak flows specifically related to this model please see Appendix A1 and Appendix B1 respectfully of the Hydrology Report for UoM27.
(a) Current Scenario	All peak fluvial inflows (m^3/s) are summarised in the tables below for the current situation and the design event simulated. These peak inflows did not change following calibration to HEPs. However, an additional flow was added at the junction between the river Gaurus and its unnamed tributary to ensure that the modelled total peak flows at HEP 27_1118_2 remained within ±10% of the HEP target flows (as explained in Section 4.2). Where required, inflows to the hydraulic model were scaled up/down to ensure that the modelled total peak flows remain within ±10% of the HEP target flows.

HEP Reference Name	Input Node in the Hydraulic Model	Annual Exceedance Probability							
		50%	20%	10%	5%	2%	1%	0.5%	0.1%
27_1195_1	09FER01993	33.8	43.1	49.1	54.8	62.2	67.7	73.2	86.0
27_1195_2	09FER01664u	0.8	1.1	1.2	1.4	1.5	1.7	1.8	2.1
27_1195_5	09FER00161u	9.0	11.6	13.2	14.7	16.7	18.1	19.6	23.0
27_1181_1	01CAH00824	0.6	0.8	0.9	1.0	1.1	1.3	1.4	1.6
27_1195_9	01FEM00220u	1.9	2.4	2.8	3.1	3.6	3.9	4.2	5.0
27_1088_5	02GAU00617	3.3	4.3	4.9	5.5	6.3	6.9	7.5	8.9
27_1118_2	01GAU02993u	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7
27_1118_4	01GAU01912u	0.3	0.4	0.4	0.5	0.6	0.6	0.7	0.8
27_518_1	01GAX00515	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4
27_1148_1	02EDN01164	0.1	0.4	0.7	0.8	1.1	1.3	1.5	1.7
27_1148_2	02EDN00675u	0.2	0.3	0.4	0.3	0.4	0.4	0.5	0.7
27_1050_1	02EDN00000	0.8	1.0	1.0	1.3	1.5	1.6	1.8	2.2
27_1050_6	01EDN00820u	0.4	0.5	0.5	0.6	0.7	0.8	0.8	1.0
27_2_2	27_2_2	0.4	0.5	0.5	0.6	0.7	0.8	0.8	1.0
27_801_2	01CLR05800	20.3	25.9	29.4	32.7	36.8	39.8	42.8	49.7
27_1275_6	01RIN07085u	25.1	30.8	34.6	38.2	42.9	46.5	50.0	58.1

(b) Future Scenarios	The peak inflows (m^3/s) used as inputs to the model at key model locations are summarised in the table below for both the MRFS and the HEFS. These events are selected as these are the MRFS and HEFS that are to be mapped.

HEP Reference Name	Input Node in the Hydraulic Model	Annual Exceedance Probability							
		MRFS							
		50%	20%	10%	5%	2%	1%	0.5%	0.1%
27_1195_1	09FER01993	40.5	51.7	58.9	65.7	74.6	81.2	87.9	103.2
27_1195_2	09FER01664u	1.0	1.3	1.5	1.6	1.9	2.0	2.2	2.6
27_1195_5	09FER00161u	10.9	13.9	15.8	17.6	20.0	21.8	23.5	27.7
27_1181_1	01CAH00824	0.7	0.9	1.1	1.2	1.4	1.5	1.6	1.9
27_1195_9	01FEM00220u	2.2	2.9	3.3	3.7	4.3	4.7	5.1	6.0
27_1088_5	02GAU00617	4.0	5.1	5.9	6.6	7.6	8.3	9.0	10.6
27_1118_2	01GAU02993u	0.3	0.4	0.5	0.6	0.6	0.7	0.7	0.9
27_1118_4	01GAU01912u	0.4	0.4	0.5	0.6	0.7	0.7	0.8	0.9
27_518_1	01GAX00515	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.5

27_1148_1	02EDN01164	0.1	0.5	0.9	1.0	1.3	1.6	1.8	2.1
27_1148_2	02EDN00675u	0.2	0.3	0.4	0.4	0.4	0.4	0.6	0.8
27_1050_1	02EDN00000	1.0	1.2	1.2	1.6	1.8	2.0	2.1	2.7
27_1050_6	01EDN00820u	0.4	0.6	0.7	0.7	0.8	0.9	1.0	1.2
27_2_2	27_2_2	0.4	0.6	0.6	0.7	0.8	0.9	1.0	1.2
27_801_2	01CLR05800	24.4	31.1	35.3	39.2	44.2	47.8	51.4	59.7
27_1275_6	01RIN07085u	30.1	37.0	41.5	45.9	51.5	55.8	60.0	69.8

HEP Reference Name	Input Node in the Hydraulic Model	Annual Exceedance Probability		
		HEFS		
		10%	1%	0.1%
27_1195_1	09FER01993	63.8	88.0	111.8
27_1195_2	09FER01664u	1.6	2.2	2.8
27_1195_5	09FER00161u	17.1	23.6	30.0
27_1181_1	01CAH00824	1.2	1.6	2.1
27_1195_9	01FEM00220u	3.6	5.1	6.5
27_1088_5	02GAU00617	6.4	9.0	11.5
27_1118_2	01GAU02993u	0.5	0.7	1.0
27_1118_4	01GAU01912u	0.6	0.8	1.0
27_518_1	01GAX00515	0.3	0.4	0.6
27_1148_1	02EDN01164	1.0	1.7	2.3
27_1148_2	02EDN00675u	0.5	0.5	0.9
27_1050_1	02EDN00000	1.3	2.1	2.9
27_1050_6	01EDN00820u	0.7	1.0	1.3
27_2_2	27_2_2	0.7	1.0	1.3
27_801_2	01CLR05800	38.3	51.8	64.6
27_1275_6	01RIN07085u	45.0	60.4	75.6

3.12 Model Boundaries – Downstream Conditions

Downstream boundary conditions adopted in the model are as follows:

- Main model: tidal conditions were applied at the downstream end of the main model as the River Fergus discharges into the Shannon estuary. Tidal level hydrographs at the downstream boundary have been adjusted in time so that the highest tidal level coincides with the fluvial peak flow at the downstream extent of the model.
- The Karst Model: at locations where karstic features occurs within the modelled reaches suitable flow abstraction boundary were set (see Section 6). For the Cahircalla Lough and Ballybeg Lough stream nominal constant Head boundaries were applied as model results demonstrated that these assumptions have not impacted on predicted flood levels. Further details are provided in Volume 2 Part 2 – Hydrogeology Report – Ennis Main Drainage and Flood Study.
- River Claureen Model: a normal depth boundary was applied at the downstream end of the model which is located downstream of Ennis Mill weirs on the River Fergus. This assumption is valid as flood levels with the River Claureen are not affected by water level on the River Fergus downstream of Ennis Mill. Further details are provided in Volume 2 Part 2 – Hydrogeology Report – Ennis Main Drainage and Flood Study.
- River Rine Model: this model shares the same downstream boundary as the main model (i.e. estuary end of the River Fergus). Therefore the same tidal conditions were used as downstream boundary conditions.

Tidal level hydrographs at the Fergus Estuary were produced for a series of design events using the Irish Coastal Protection Strategy Study (ICPSS) extreme tidal peak levels data. The time series were set up as boundary conditions for the hydraulic model along the coastal boundary of the hydraulic model (see maps in Annex A). Full details on how these tidal level hydrographs were derived are provided in Appendix D of the main Hydraulics Report.. Peak tidal levels are summarised in the table below for the current and future situations.

	Annual Exceedance Probability										
Peak Tidal Levels (m AOD)	**500 %**	**200 %**	**100 %**	**50%**	**20%**	**10%**	**5%**	**2%**	**1%**	**0.5 %**	**0.1 %**
	2.7	2.9	3.0	3.1	3.3	3.4	3.6	3.8	3.9	4.0	4.3
	MRFS Annual Exceedance Probability										
Peak tidal levels (m OD)	500 %	200 %	100 %	50%	20%	10%	5%	2%	1%	0.5 %	0.1 %
	3.3	3.5	3.6	3.7	3.9	4.0	4.2	4.4	4.5	4.6	4.9
	HEFS Annual Exceedance Probability										
Peak tidal levels (m OD	500 %	200 %	100 %	50%	20%	10%	5%	2%	1%	0.5 %	0.1 %
	3.8	4.0	4.1	4.2	4.4	4.5	4.7	4.9	5.0	5.1	5.4

4. Hydraulic Model Calibration and Sensitivity

4.1 Model Calibration and Verification to Historical Events

The approach to model calibration is documented in the main Hydraulics Report.

The analysis of available flood event data and high flow data for possible consideration as calibration and verification events is covered in detail in the Hydrology Report (Appendix F). The results of this analysis concluded that the model could be calibrated to two fluvial events along a section of the HPW network of watercourses that included the River Claureen and the River Fergus from upstream extent to the tidal barrage.

A full account of the model calibration approach and results is provided in Annex C.

A summary of the calibration and verification events along with associated model calibration results is as follows:

Catchment Gauging

Is modelled catchment: Gauged ☒ Ungauged ☐

Gauging Stations used for Calibration

Station Number	Watercourse	Location	ISIS Node Reference
27066	River Fergus	Ennis Bridge	06FER01097
27060	River Fergus	Doora Bridge	04FER00832u
27023	River Fergus	Victoria Bridge	07FER00783u
27024	River Fergus	Mill bridge	07FER00463
27064	River Fergus	Tidal barrage u/s	03FER00754u

Calibration Event

Event Date	Station Number	Difference between Modelled and Observed Water Level (mm)	Root Mean Square Error (mm) HPW	Root Mean Square Error (mm) MPW
November 2009	27066	-191	193	N/A
November 2009	27060	+33		
December 2006	27023	-114	182	N/A

	December 2006	27024	-141		
	December 2006	27060	+13		

Summary of Findings	For both historical events the calibration results suggest that the model calibrates well with the difference between predicted and observed peak water levels within the acceptable range of +/-0.2m for a HPW watercourse. There was a 191mm stage difference between the modelled peak water level and observed peak water level at gauging station 27066 for the November 2009 event and a 141mm stage difference at gauging station 27024 for the December 2006 event. At gauging stations 27066 and 27060 there was also a good fit on the times to peak with no time difference between the observed time to peak and the modelled time to peak. A successful verification was also carried out for the November 2009 event by comparing the modelled flood outline for this event against photographs taken during and following the event. Further details on the verifications is contained in Annex C.
4.2 Calibration to HEP	Calibration of the hydraulic model to the HEP target flows has been carried out for all of the AEP design events for the River Fergus, the River Claureen and the River Rine. The River Cahircalla, Cahircalla Lough and Ballybeg Lough present Karstic features and hence the calibration to HEP for these tributaries was deemed not possible. The Fergus Minor is a branch of the River Fergus and the hydrological model used to generate target flows cannot provide realistic estimates of target flow that should be diverted through this channel. Therefore no calibration to HEP was carried out along this reach. Section 2.7.2 of the Hydrology Report for UoM27 provides a summary of the calibration to HEP process. Preliminary inflow hydrographs derived from the hydrological analysis and input to the model were adjusted in time so that their respective peak flows coincide with the peak time of the propagating flood wave as it is routed down the model. Total peak flows predicted by the hydraulic model at HEP locations were then compared to the HEP target flows estimated during the hydrological analysis. Modelled total peak flows at all HEP locations along the Fergus and along the Claureen were found to be within ±10% of the HEP target flows. Therefore no inflow scaling was deemed necessary. Along the Gaurus, an additional flow was added at the junction between the river and its unnamed tributary to ensure that the modelled total peak flows at HEP 27_1118_2 remained within ±10% of the HEP target flows. This ±10% target allows for good agreement between the hydrological estimates and the hydraulic results without the addition/removal of unrealistic volumes of flow from the model. The robustness of this has been verified by the agreement of the design flood maps.HEP 27_1118_4, 27_1118_6 and 27_1118_7 were seen to be unsuitable for flow comparison due to complex flow paths (recirculation) within the adjacent floodplain. Along the river Rine, HEP 27_1275_10 was seen to be unsuitable for flow comparison due to the flow leaving the channel and ponding at Dromoland Castle Golf Course, on the left bank of the watercourse, around cross section 01RIN5358. The table below shows the percentage difference between the target flows and the modelled flows at each HEP location.

HEP Reference Name	Water course	Node in the Hydraulic Model	Annual Exceedance Probability Percentage Difference (%)							
			50%	20%	10%	5%	2%	1%	0.5%	0.1%
27_1195_1	Fergus	09FER01993	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
27_1195_2		09FER01664u	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
27_1195_5		09FER00161u	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.2	-0.1
27_1245_2		06FER00984u	-7.9	-9.4	-10.2	-10.5	-10.6	-10.3	-10.3	-13.8

27_207_2		05FER00529u	7.1	6.9	6.8	6.6	6.1	6.4	6.4	5.9
27_1253_2		04FER00701u	7.0	6.5	7.8	7.5	6.9	6.9	7.9	5.8
27_1254_2		04FER00000	4.4	3.8	5.0	4.8	4.3	4.2	5.4	3.2
27_1122_2		03FER02048u	3.9	3.2	4.4	4.0	3.4	3.4	4.4	2.2
27_1122_5		03FER00524u	3.8	3.2	4.3	3.9	3.4	3.4	4.3	2.2
27_1088_5	Gaurus	02GAU00617	6.5	6.4	6.4	6.6	6.5	6.5	6.4	6.4
27_1118_2		01GAU02993u	9.2	1.8	2.8	1.7	-1.7	-1.8	10.6	3.6
27_1118_4		01GAU01912u	10.2	3.6	3.7	0.6	-1.4	-1.2	7.0	-1.8
27_518_1		01GAX00515	0.9	-2.4	1.9	-1.9	-1.0	-0.5	0.0	1.0
27_1118_6		01GAU00830u	-14.1	-22.9	-12.5	-14.2	-15.8	-17.4	-9.6	-28.3
27_1118_7		01GAU00318u	-16.7	-17.7	-6.1	-7.1	-9.2	-11.5	-0.2	-21.0
27_801_2	Clauree	01CLR05800	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27_801_3		01CLR05323u	-0.6	-0.6	-0.6	-0.6	-0.5	-0.5	-0.5	-0.5
27_1275_6	Rine	01RIN07085u	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.7
27_1275_10		01RIN05687	-15.0	-11.5	-11.4	-11.0	-12.4	-10.1	-9.9	22.2

4.3 Fluvial and Tidal Events Simulated

The River Fergus is influenced by the tidal levels along the Fergus Estuary. As such, a joint probability analysis of the coincidence of fluvial flood flows and coastal flood levels was carried out to determine the appropriate combinations of flows and sea levels to be used for the design probability events, as required under Section 6.5.6 of the Stage I Project Brief.

Methodology and outcomes of this analysis are detailed in the main Hydraulic Report and in the Hydrology Report. A summary of the joint probability of fluvial and tidal conditions used for the hydraulic modelling in the Ennis AFA is reported in the table overleaf.

Combination of Fluvial and Tidal Events

	Joint Probability Design Event	AEP adopted for Fluvial Flows and Tidal Levels	
Scenario	**Overall AEP**	**Fluvial**	**Tidal**
1	50%	50%	500%
2	50%	50%	50%
3	20%	20%	500%
4	20%	50%	20%
5	10%	10%	200%
6	10%	50%	10%
7	5%	5%	100%
8	5%	50%	5%
9	2%	2%	50%
10	2%	50%	2%
11	1%	1%	20%
12	1%	20%	1%
13	0.5%	0.5%	10%
14	0.5%	10%	0.5%
15	0.1%	0.1%	2%
16	0.1%	2%	0.1%

4.4 Model Sensitivity

Sensitivity tests have been carried out in order to assess the sensitivity of the predicted peak water levels to alterations in roughness (Manning's 'n'), fluvial flow, afflux at key structures and downstream conditions. The sensitivity runs were carried out for the 1% AEP fluvial dominated event with the corresponding tidal event from the joint probability study in all cases with the only exception of the tests on the downstream boundary conditions, which were carried out for the 0.5% AEP tidal dominated events with the corresponding fluvial event (see Section 4.3).

Sensitivity test results are provided in the following tables. Uncertainty maps illustrating the results of the sensitivity analysis will be delivered as part of the final stage of this work.

+20% Manning's 'n'	Watercourse	Average Water Level Difference (m)	Maximum Water Level Difference (m)	Cross-section/ Reach where the Maximum Difference occurs
	Claureen	+0.13	+0.19	01CLR04275u
	Fergus	+0.06	+0.33	01FED00060
	Kars	+0.02	+0.21	27CLAR00002J
	Rine	+0.04	+0.25	01RIN06053d

-20% Manning's 'n'	Watercourse	Average Water Level Difference	Maximum Water Level Difference	Cross-section where the Maximum Difference occurs
	Claureen	-0.14	-0.01	01CLR03493
	Fergus	-0.06	+0.51	01GAU00343
	Kars	-0.03	+0.01	01CLC00014
	Rine	-0.04	+0.08	NA
+20% inflows	**Watercourse**	**Average Water Level Difference**	**Maximum Water Level Difference**	**Cross-section where the Maximum Difference occurs**
	Claureen	+0.25	+0.43	01CLR00424
	Fergus	+0.14	+0.93	01FED00060
	Kars	+0.06	+0.19	01EDN00524
	Rine	+0.10	+0.38	01RIN05218
-20% inflows	**Watercourse**	**Average Water Level Difference**	**Maximum Water Level Difference**	**Cross-section where the Maximum Difference occurs**
	Claureen	-0.27	-0.07	01CLR05144
	Fergus	-0.17	0	03FER00352
	Kars	-0.08	0	02CLC00854
	Rine	-0.10	+0.02	01RIN02263d
Increased Afflux at Key Structure Orifice discharge coefficient decreased by 20%	Along the river Claureen, bridge at ISIS node 01CLR0399bu presents a significant head loss during a 1% AEP flood event therefore a sensitivity test was carried out on the afflux at this structure. The bridge orifice discharge coefficient was then adjusted by -20% (to a value of 0.8). This resulted in an increase of 248mm to the maximum water level immediately upstream of the bridge, at cross section 01CLR00424. The increased afflux effect extended up to cross section 01CLR03030, where the model calculated an increased water level of 3mm. Along the river Fergus, the sluice gates upstream of Mill Road is a critical structure in the city centre therefore a sensitivity test was carried to test the effect of a total closure of all 4 gates. This resulted in an increased water level of 537mm at cross section 01FED00073d, immediately downstream of			

	the bridge at the Mill wheel.

	Watercourse	Average Water Level Difference	Maximum Water Level Difference	Cross-section where the Maximum Difference occurs
	Claureen	+0.07	+0.25	01CLR00424
	Fergus	+0.04	+0.54	01FED00073d
	Kars	N/A	N/A	N/A
	Rine	N/A	N/A	N/A

Decreased Afflux at key Structure Orifice discharge coefficient increased by 20%	The orifice discharge coefficient at the critical bridge along the Claureen was increased by 20% and this resulted in a decrease of 165mm to the maximum water level immediately upstream of bridge at cross section 01CLR00424.

	Watercourse	Average Water Level Difference	Maximum Water Level Difference	Cross-section where the Maximum Difference occurs
	Claureen	-0.04	-0.17	01CLR00424
	Fergus	N/A	N/A	N/A
	Kars	N/A	N/A	N/A
	Rine	N/A	N/A	N/A

Downstream Conditions Duration of surge component of tidal boundary is increased by 100% (i.e. 60 hours)	To investigate the impact of the duration of high tide levels for a given upstream flood flow condition, the duration of the surge component of the 0.5% AEP tidal boundary applied at the downstream end of the Main model and the Rine model was increased by 100% (i.e. 60 hours). In the Main model, the increase in the downstream boundary condition resulted in an increase in maximum water level by 106mm along the river Gaurus, at cross section 01GAU01017. In the Rine model, the increase in the downstream boundary condition resulted in an increase in maximum water level by 42mm, at cross section 01RIN05265.

	Watercourse	Average Water Level Difference	Maximum Water Level Difference	Cross-section where the Maximum Difference occurs
	Claureen	0	0	N/A
	Fergus	-0.03	+0.11	01GAU01017
	Kars	N/A	N/A	N/A
	Rine	+0.01	+0.04	01RIN05265

Downstream Conditions Duration of surge component of tidal boundary is decreased by 50% (i.e. 15 hours)	In the Main model, the decrease in the duration of the surge for the 0.5% AEP tidal boundary resulted in a decrease in maximum water level by 97mm along the river Gaurus, at cross section 01GAU01312. In the Rine model, the increase in the downstream boundary condition resulted in an increase in maximum water level by 4mm, at cross section 01RIN01942.

	Watercourse	Average Water Level	Maximum Water Level	Cross-section where the Maximum

		Difference	Difference	Difference occurs
	Claureen	+0.01	+0.04	01CLR00000
	Fergus	-0.01	-0.10	01GAU01312
	Kars	N/A	N/A	N/A
	Rine	0	0	01RIN01942
4.6 Model Files	The hydraulic model files associated with this model are provided as a separate deliverable under the contract, as required under Sections 7.8 and 13 of the Stage I Project Brief. The model files included are detailed in Annex C.			

5. Hydraulic Model Outputs

5.1 Mapping	The model outputs were processed to produce a series of flood maps according to the requirements stated in the Stage I Project Brief under Section 7.5.2 and, more specifically, under Section 7.5.2.1, Ennis being an area where flooding is subject to both tidal and fluvial influence (see Section 6). This includes mapping outputs covering: • Flood extents • Flood depth and velocity • Flood hazard Flood mapping outputs corresponding to the **defended** current scenario for the 10%, 1% and 0.1% AEP fluvial dominated flood events with the corresponding tidal boundary conditions and to the **defended** current scenario for the 10%, 0.5% and 0.1% AEP tidal dominated events with the corresponding fluvial events are shown in Annex E for flood extent and depth only.

6. Key Model Assumptions and Limitations

As detailed in the Hydrology Report, the hydrological approach to the study catchment requires the main river and its tributaries to be treated separately in order to produce flood extents for the design events considered in this study. The River Fergus, the River Fergus Minor and the River Gaurus are classified as the main stream. The River Claureen, the River Rine, the River Cahircalla, Lough Cahircalla and Lough Ballybeg Stream are classified as tributaries. Inflow hydrographs were purposely produced for both the main stream and tributaries and four models were run (see Section 3.2). The model outputs from all models were then merged picking up the maximum flood depths and extents to create the flood maps. (see section 4.3 for further details of the joint probability analysis used to produce hydraulic model outputs.)

There are a significant number of informal effective and formal effective defences in the model area. However, top of banks survey was not available for all defences, hence at some locations (e.g. Fergus Minor and Ennis City Centre) top of banks had to be either extracted from the ISIS model and interpolated in areas between contiguous cross sections or extracted from the LiDAR, after inspection of site visit photographs and maps.

At some locations along the River Fergus between the junction with the Minor and the tidal barrage with the quality of the LiDAR was very poor, probably due to dense vegetation. Consequently there is an uncertainty on some crest level of the tidal embankments included in the model which may lead to overestimation or underestimation of the predicted flood extents for the design events simulated.

Tidal level hydrographs applied at the downstream end of the Main model and the Rine model were obtained as per the design tide levels analysis described in the main Hydraulic Report and in the Hydrology Report. Tidal level hydrographs at the downstream boundary have been adjusted in time so that the highest tidal level coincides with the fluvial peak flow at the downstream extent of the model.

The sluice gates upstream of the Mill in Ennis City Centre were assumed fully open during heavy rainfalls/storm conditions, as per OPW's answer to Jacobs query in March 2014.

Since no survey data was available, the dimensions of the 1D elements across the 2D domains to represent the culverts under road embankments were estimated based on site survey photographs, site knowledge and best engineering judgement.

Survey of the tidal barrage was not detailed enough to allow for a correct representation of this structure in the hydraulic model. Instead some information extracted from the *"Ennis Main Drainage and Flooding Study – Preliminary Report, OPW, 1999"* was used to represent the tidal flaps and fish pass structure of the barrage. It is assumed that the extracted information is correct.

Potential flooding from Lough Girroga is being treated as surface water flooding and since this type of flooding is not being considered under CFRAM then flooding from Lough Girroga is not considered in the modelling of flood risk for Ennis AFA.

The main flood area in the lower Fergus reach is the area to the south of the Quin road and generally to the north of the N85 road East of the Fergus. This area is generally known as the flood zone for the Fergus and all comprises a marshy area. The defence on the left bank of this reach has been included in the model as surveyed. There are several sluice gates on this defence and these have been assumed to be operating correctly. Works have been carried out on these sluice gates since 2009 as there are reports of backflow at some of these gates. The area to the east of the defences is low lying and can suffer from surface water flooding due to local drainage issues when rainwater cannot flow into the River Fergus. However, surface water flooding is not considered in the CFRAM Study.

The Lower Fergus Certified Drainage Scheme is providing protection to area shown 1% AEP at College Road. The flood risk shown on the maps in this area originates from the left bank of the River Fergus between the Banks Place bridge and the Abbey Street bridge where there is no protection.

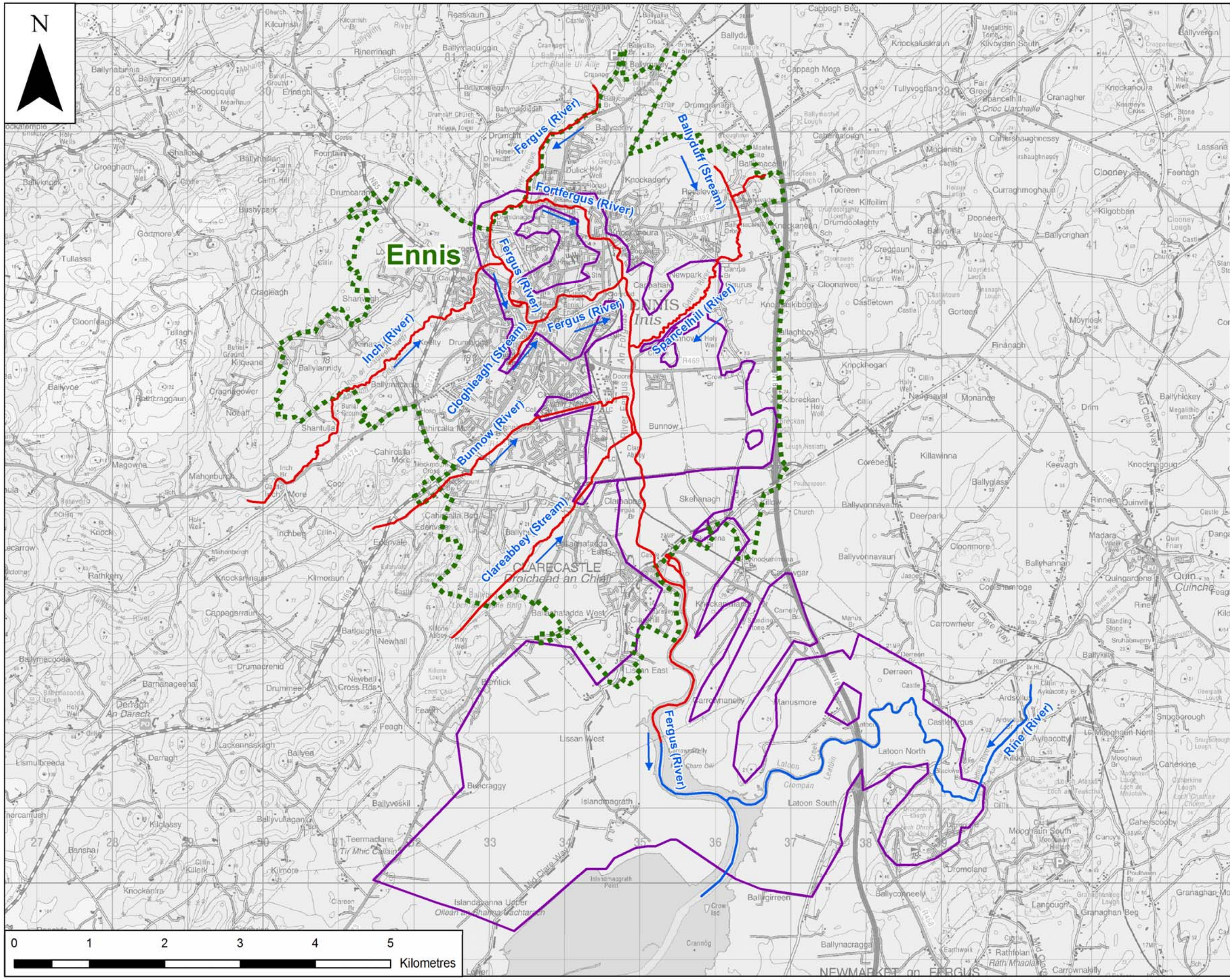
There is a stone wall in the area to the south west of Knoxes Bridge which has not been included in the model as it is not classified as an effective defence. The presence of this wall may have eliminated risk in the past but this does not mean that this area is not at risk of flooding in the future.

Karstic features: there are two locations where abstraction units were set in the model to represent the loss of flow through underground Karstic conduits. These were at:

- St Flannans on the River Cahircalla (ISIS node ref: Abs_Karst) where a value of 0.1 m^3/s was abstracted (source: Volume 3 Part 2 – Hydrogeology Report – Ennis Main Drainage and Flood Study). The flow extracted at the swallow hole in Flannans college was then reintroduced to the model further downstream. An Extraction until has also been set up to allow loss of flow from this area to an adjacent culvert.
- Ballybeg Bridge on the Ballybeg Lough reach (ISIS node ref: Abs_CLC) where a value of 0.25 m^3/s was abstracted (source: Volume 3 Part 2 – "Hydrogeology Report – Ennis Main Drainage and Flood Study).
- The flow from the karstic catchment will be attenuated by the reservoir. The abstraction represents the karstic features, however 0.1m3/s has been added to prevent the model running try. The model has been run for 150hrs and illustrates that this is limited flood risk in this portion of the watercourse.

Annex A – Model Extent and Schematisation Maps

Annex A1 – Model Extent



Legend

- 2D Model Boundary
- AFA Boundary

Model Reaches

- HPW
- MPW

Model: S01

Figure ref: Annex A1

Drawing Title: S01 Model Extent

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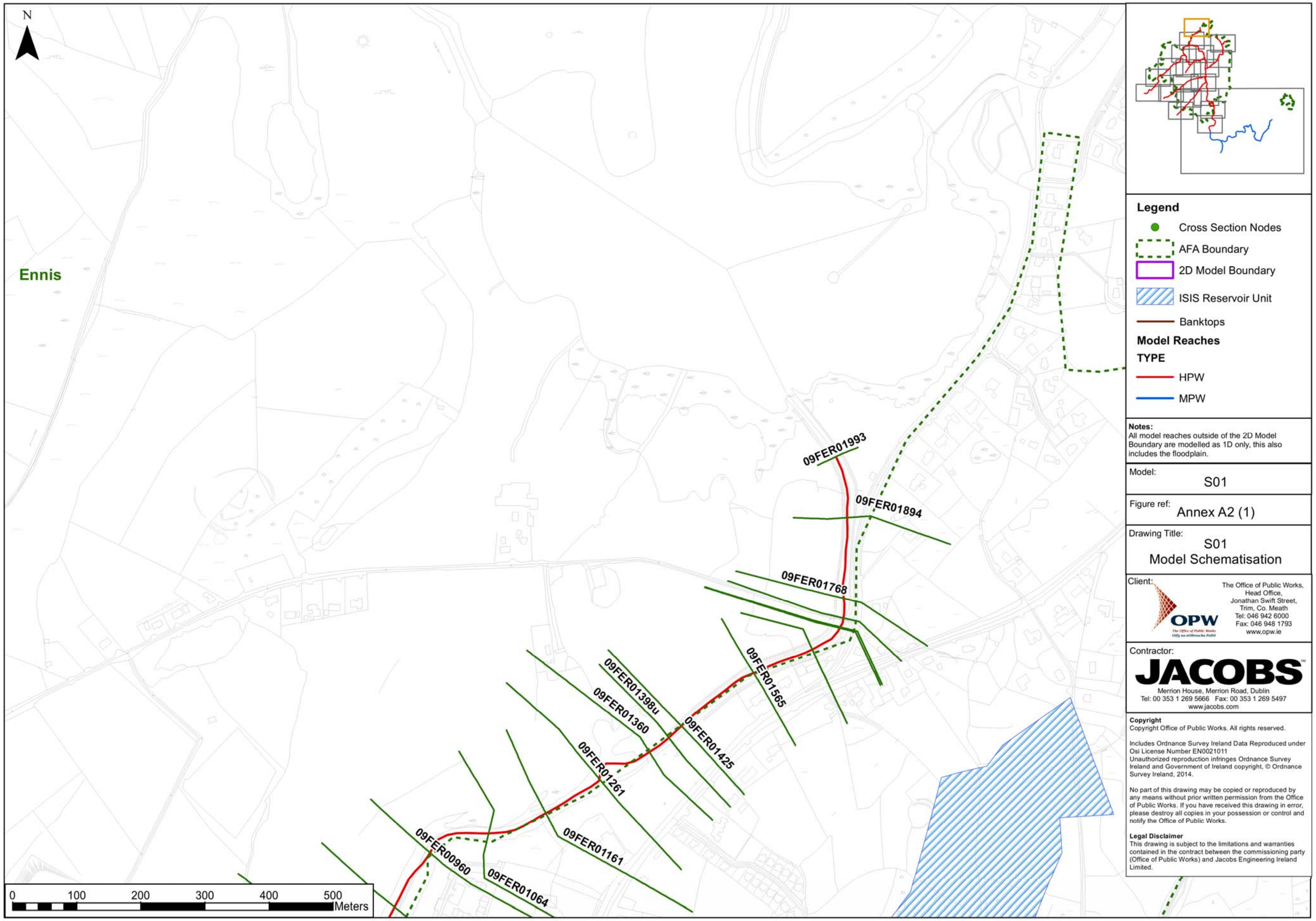
Annex A2 – Schematisation Maps



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200
300
400
500
Meters
Legend
Cross Section Nodes
AFA Boundary
2D Model Boundary
ISIS Reservoir Unit
Banktops
Model Reaches
TYPE
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S01
Figure ref:
Annex A2 (1)
Drawing Title:
S01
Model Schematisation
Client:
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Contractor:
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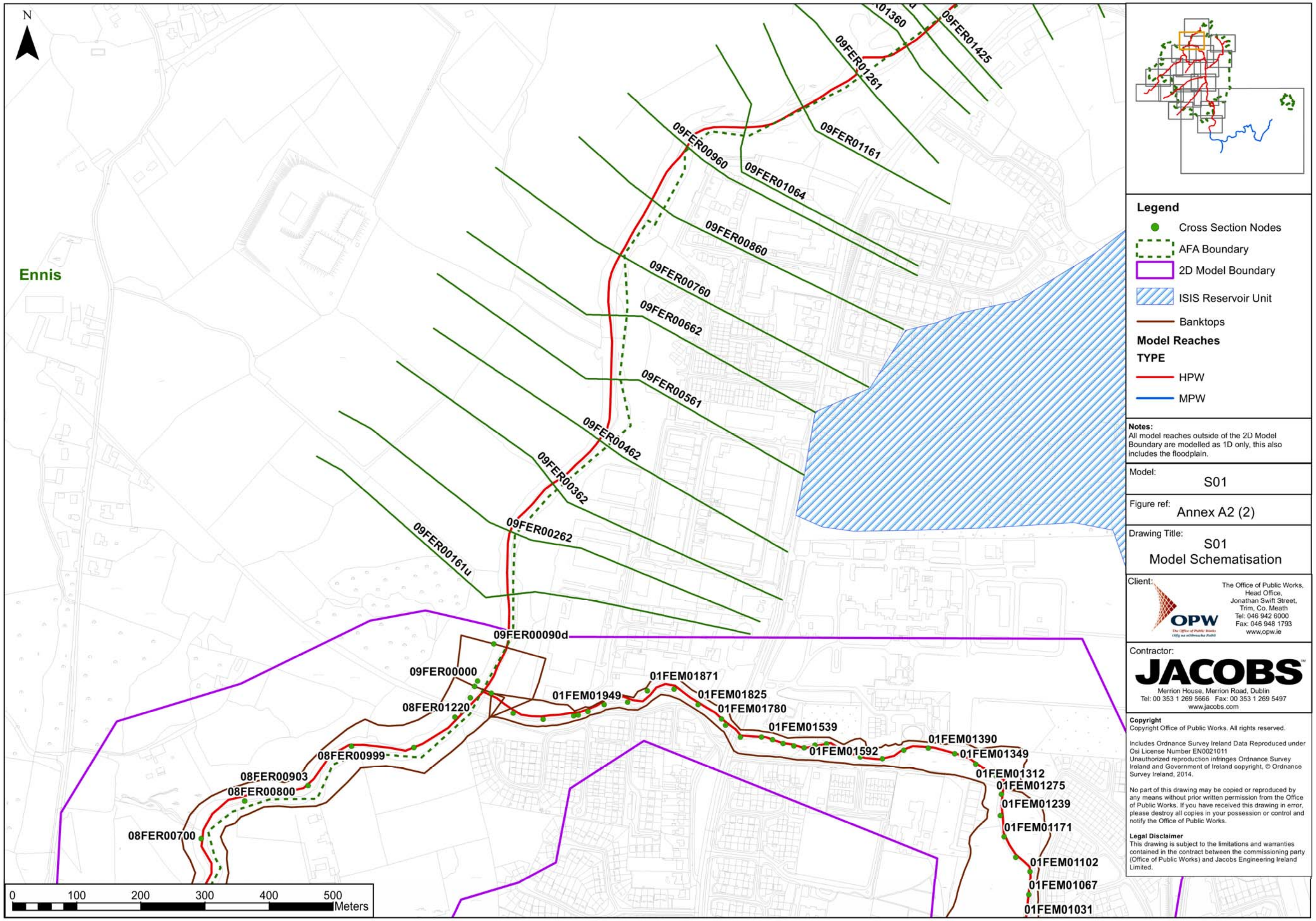

Legend

- Cross Section Nodes
- AFA Boundary
- 2D Model Boundary
- ISIS Reservoir Unit
- Banktops

Model Reaches

TYPE

- HPW
- MPW

Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.

Model: S01

Figure ref: Annex A2 (2)

Drawing Title: S01 Model Schematisation

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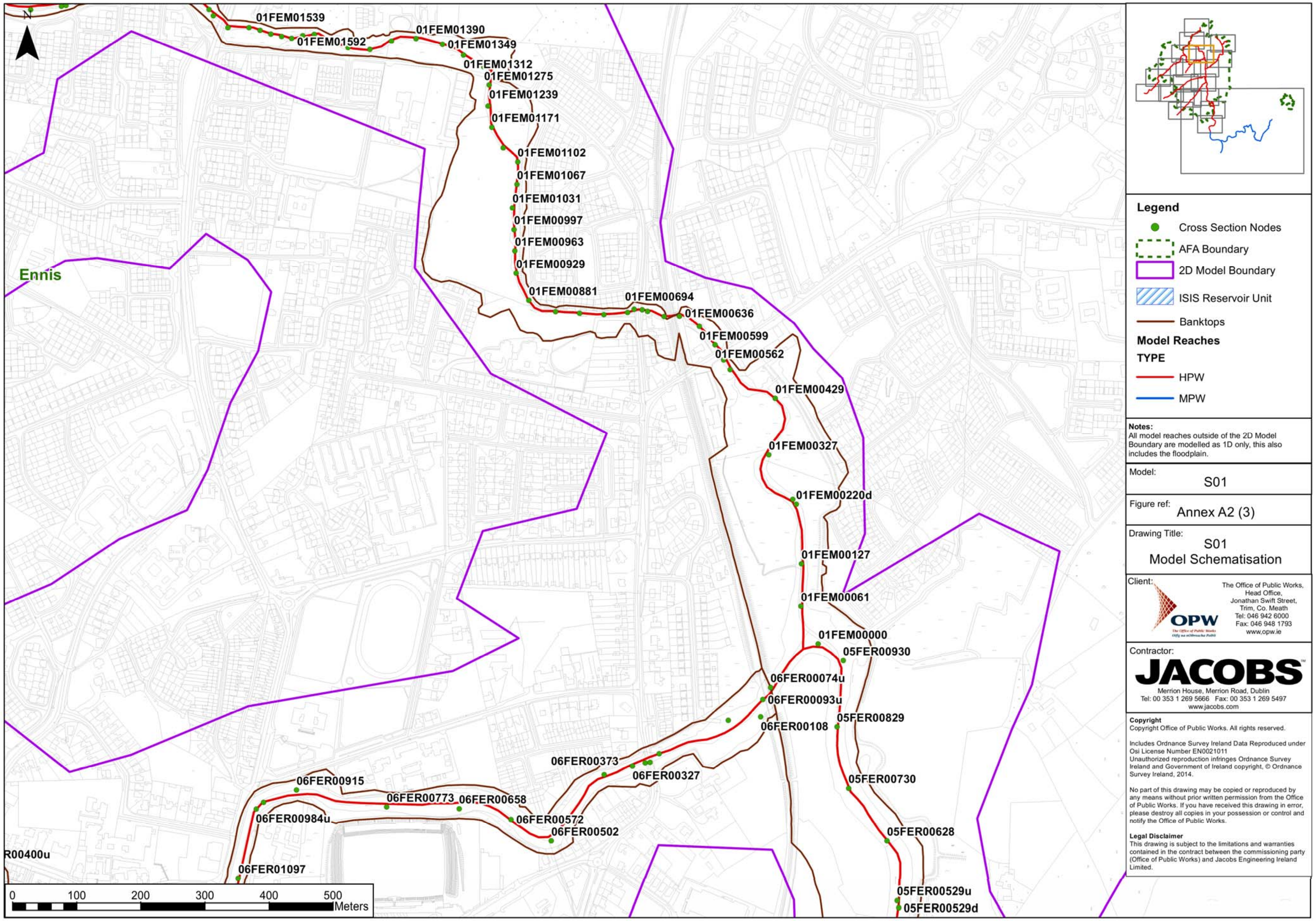
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Meters
Legend
Cross Section Nodes
AFA Boundary
2D Model Boundary
ISIS Reservoir Unit
Banktops
Model Reaches
TYPE
HPW
MPW
Notes:
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Model:
S01
Figure ref:
Annex A2 (3)
Drawing Title:
S01
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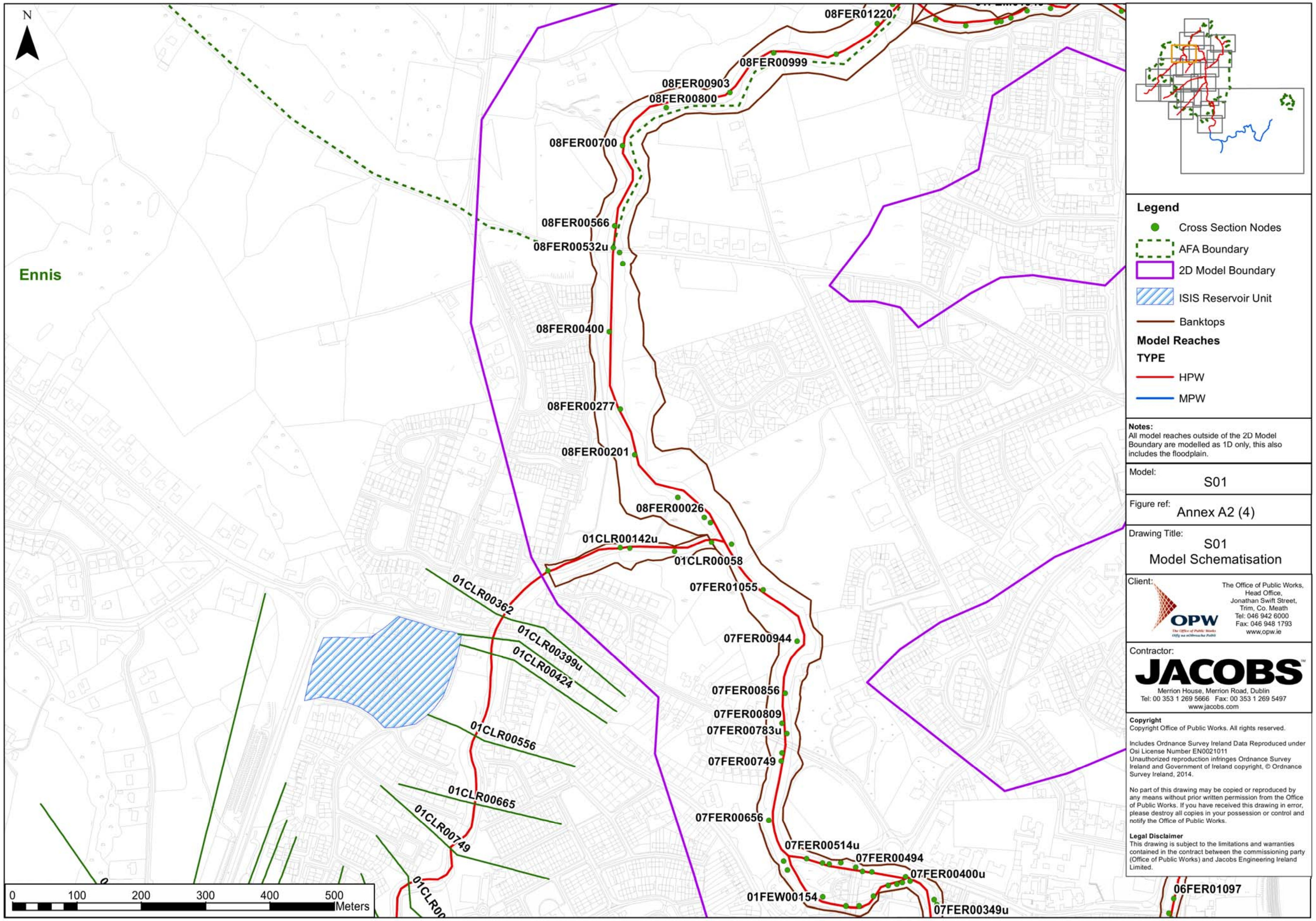

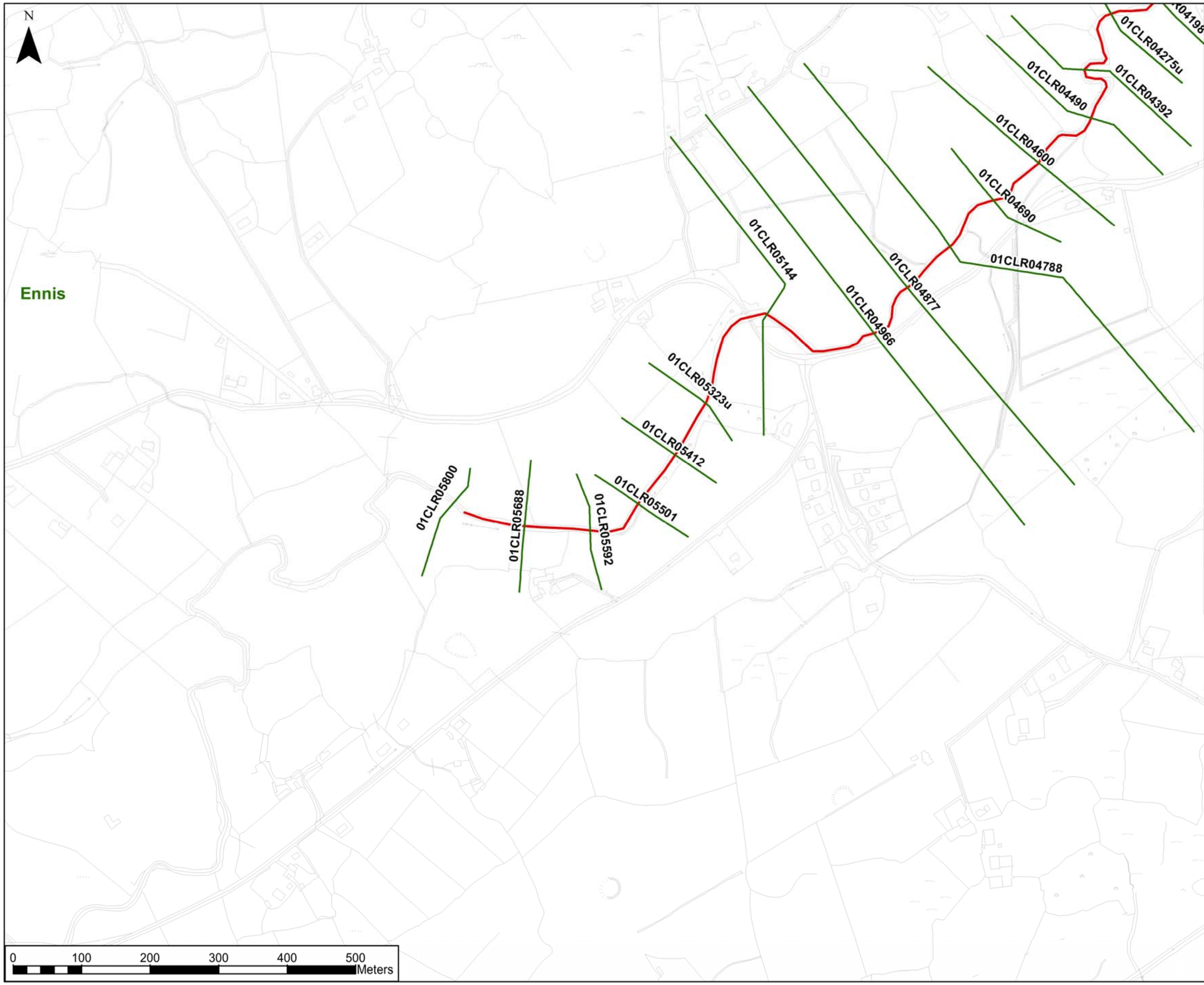

Legend

- Cross Section Nodes
- AFA Boundary
- 2D Model Boundary
- ISIS Reservoir Unit
- Banktops

Model Reaches

TYPE

- HPW
- MPW

Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.

Model: S01

Figure ref: Annex A2 (5)

Drawing Title: S01 Model Schematisation

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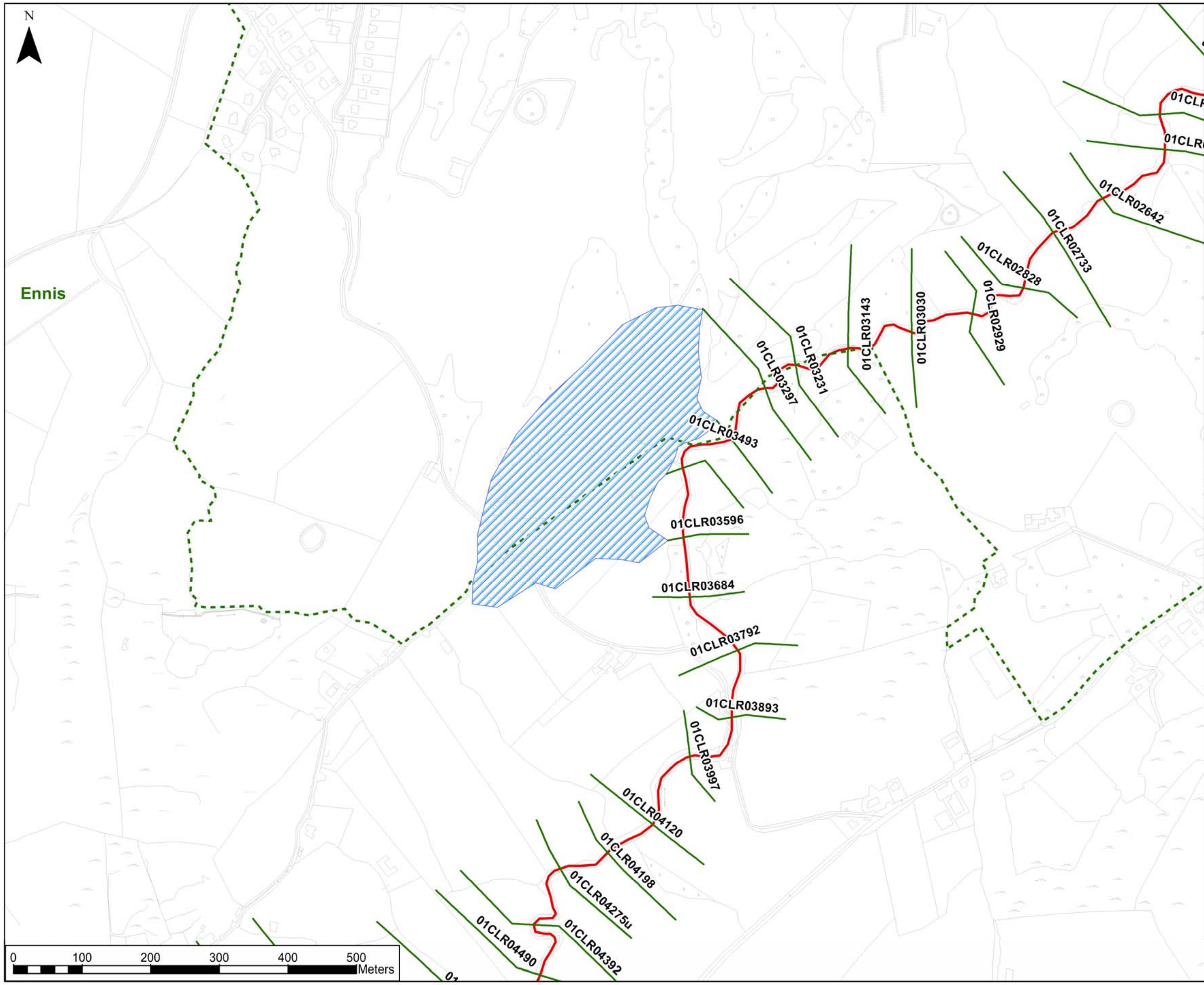

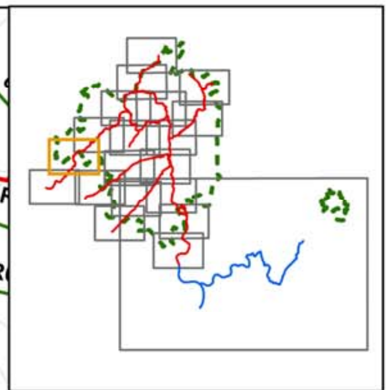

Legend

- Cross Section Nodes
- AFA Boundary
- 2D Model Boundary
- ISIS Reservoir Unit
- Banktops

Model Reaches

TYPE

- HPW
- MPW

Notes:
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Model: S01

Figure ref: Annex A2 (6)

Drawing Title: S01 Model Schematisation

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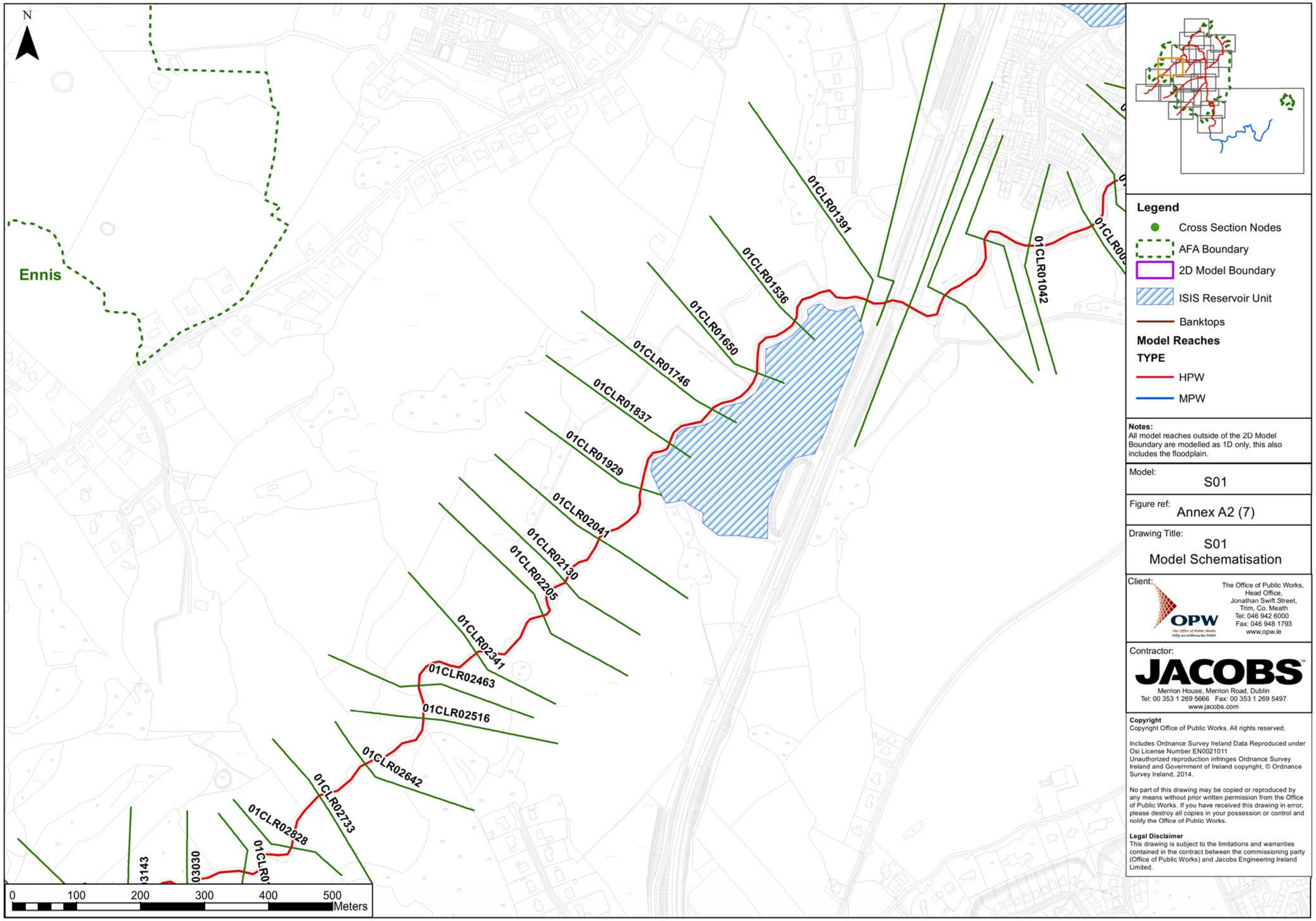
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Legend
Cross Section Nodes
AFA Boundary
2D Model Boundary
ISIS Reservoir Unit
Banktops
Model Reaches
TYPE
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S01
Figure ref: Annex A2 (7)
Drawing Title:
S01
Model Schematisation
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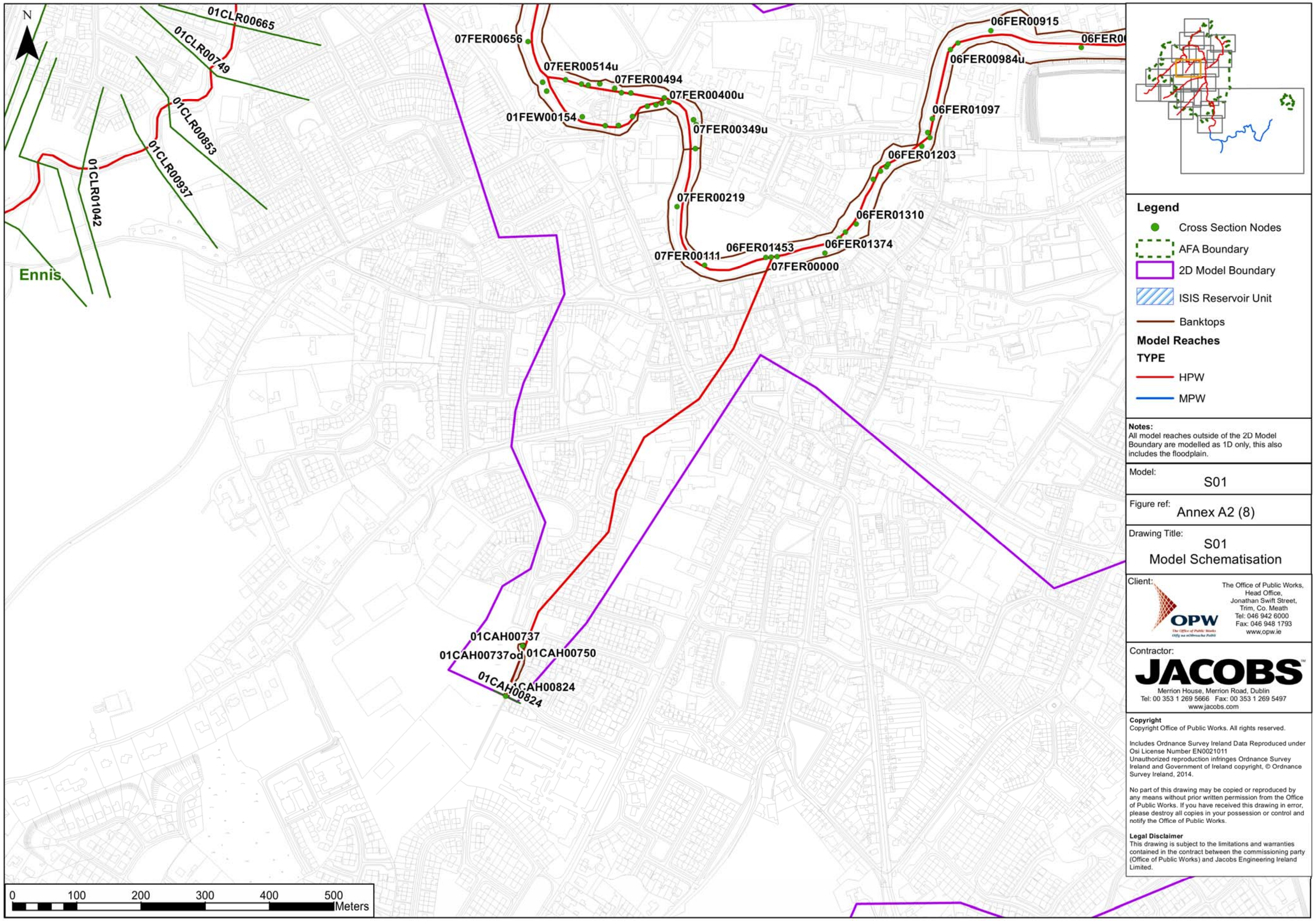
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Legend
Cross Section Nodes
AFA Boundary
2D Model Boundary
ISIS Reservoir Unit
Banktops
Model Reaches
TYPE
HPW
MPW
Notes:
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Model:
S01
Figure ref:
Annex A2 (8)
Drawing Title:
S01
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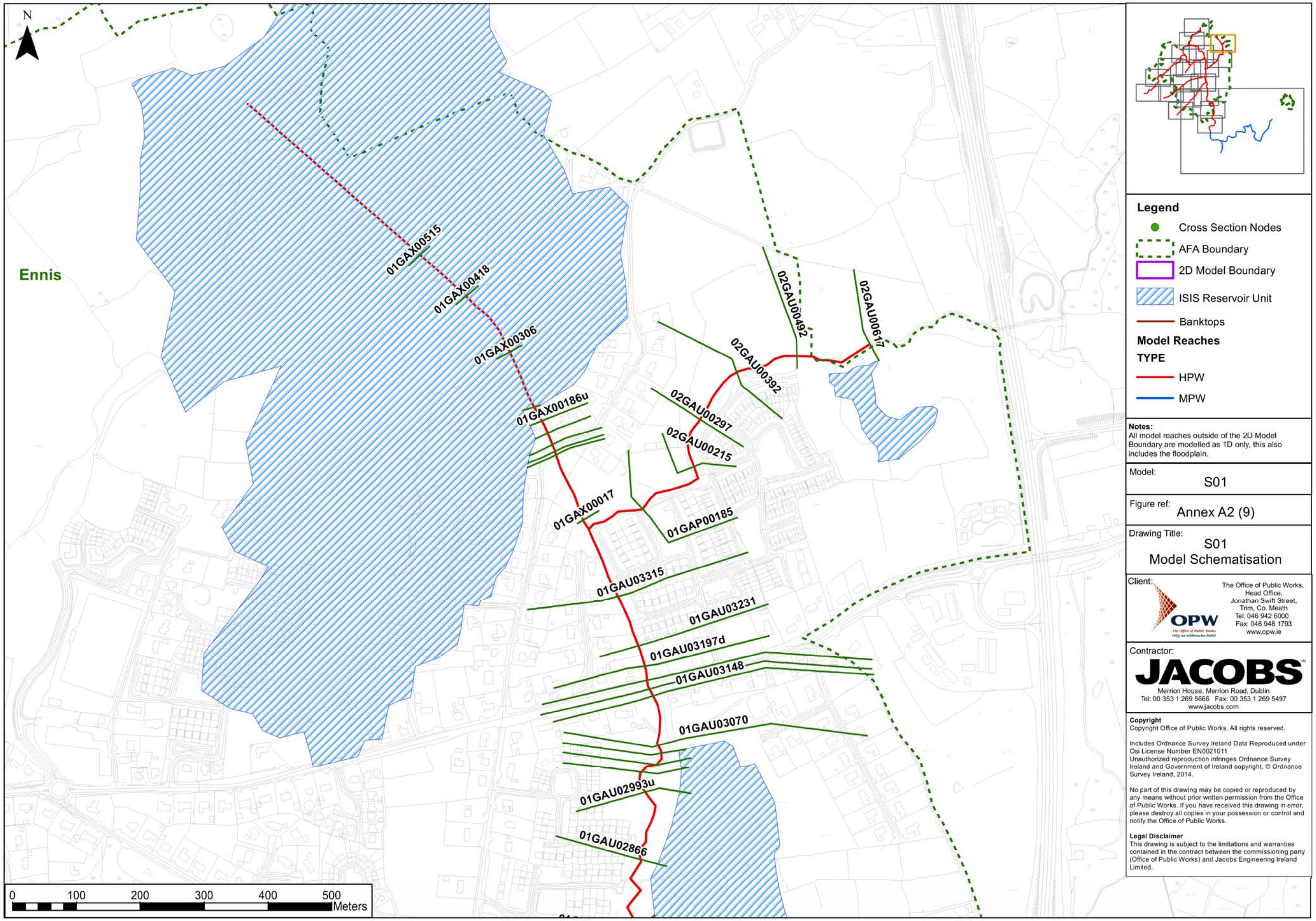
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100
200
300
400
500
Meters
Legend
Cross Section Nodes
AFA Boundary
2D Model Boundary
ISIS Reservoir Unit
Banktops
Model Reaches
TYPE
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S01
Figure ref:
Annex A2 (9)
Drawing Title:
S01
Model Schematisation
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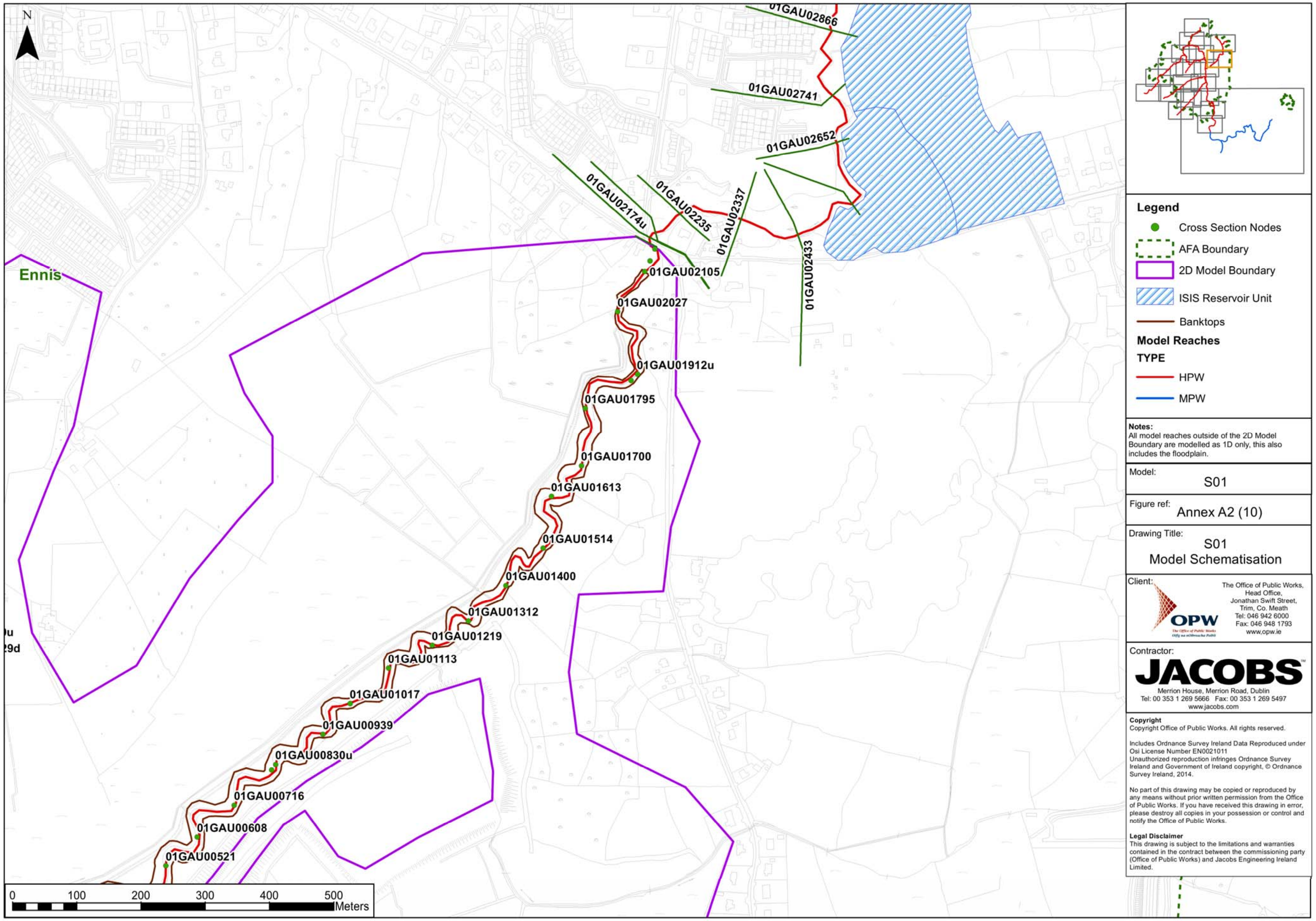
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Meters
Legend
Cross Section Nodes
AFA Boundary
2D Model Boundary
ISIS Reservoir Unit
Banktops
Model Reaches
TYPE
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S01
Figure ref:
Annex A2 (10)
Drawing Title:
S01
Model Schematisation
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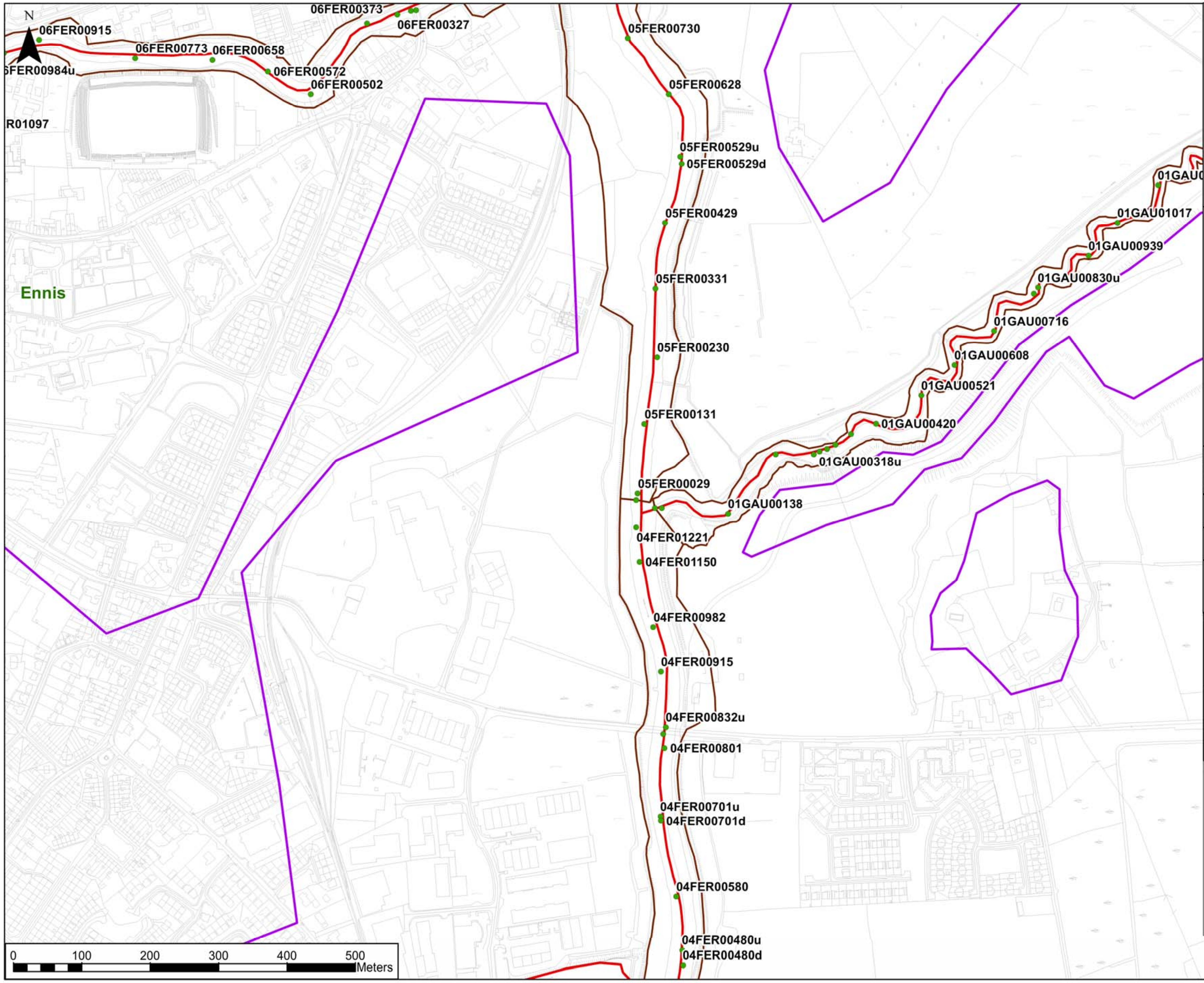

Legend

- Cross Section Nodes
- AFA Boundary
- 2D Model Boundary
- ISIS Reservoir Unit
- Banktops

Model Reaches

TYPE

- HPW
- MPW

Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.

Model: S01

Figure ref: Annex A2 (11)

Drawing Title: S01 Model Schematisation

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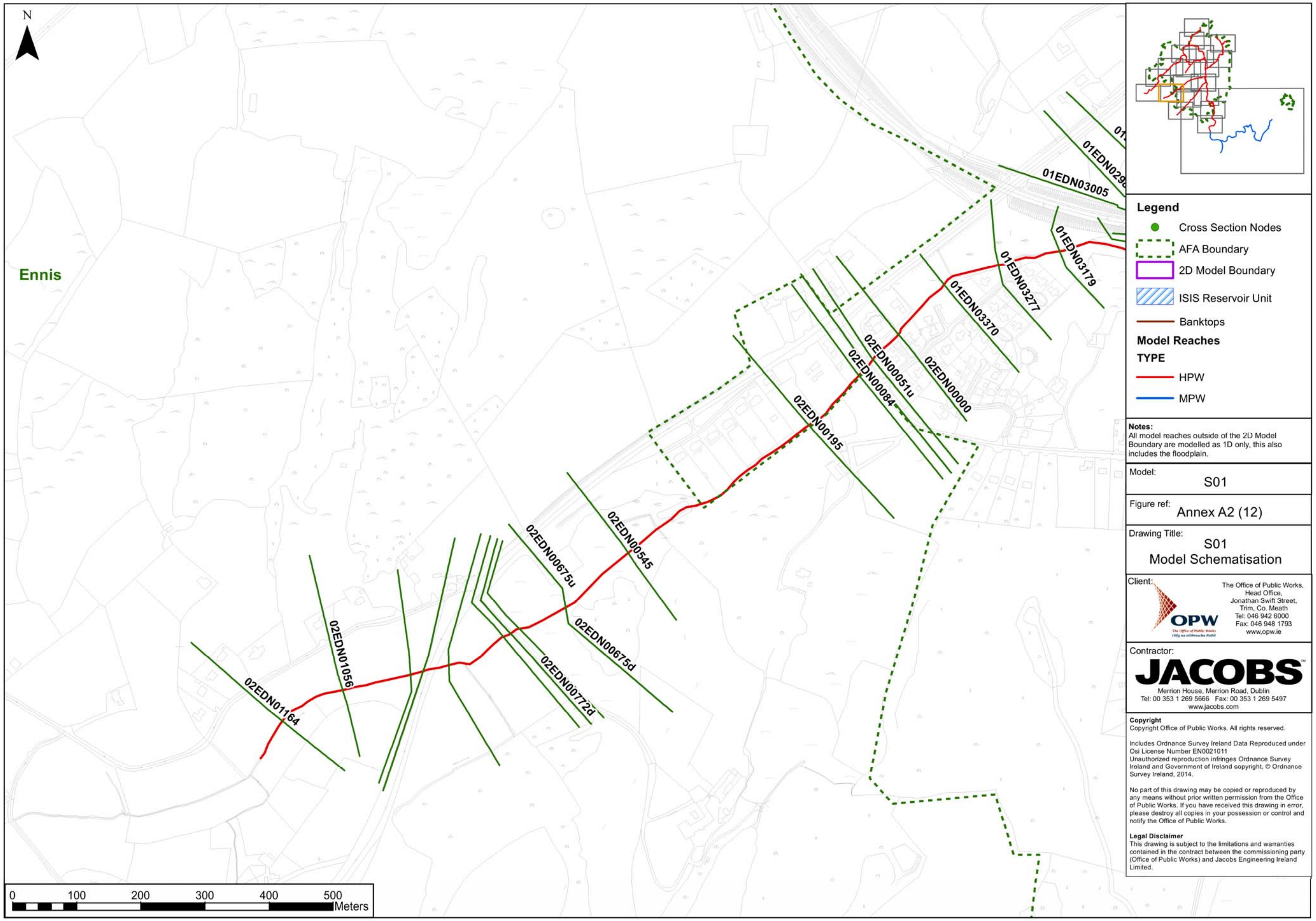

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Legend
Cross Section Nodes
AFA Boundary
2D Model Boundary
ISIS Reservoir Unit
Banktops
Model Reaches
TYPE
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S01
Figure ref:
Annex A2 (12)
Drawing Title:
S01
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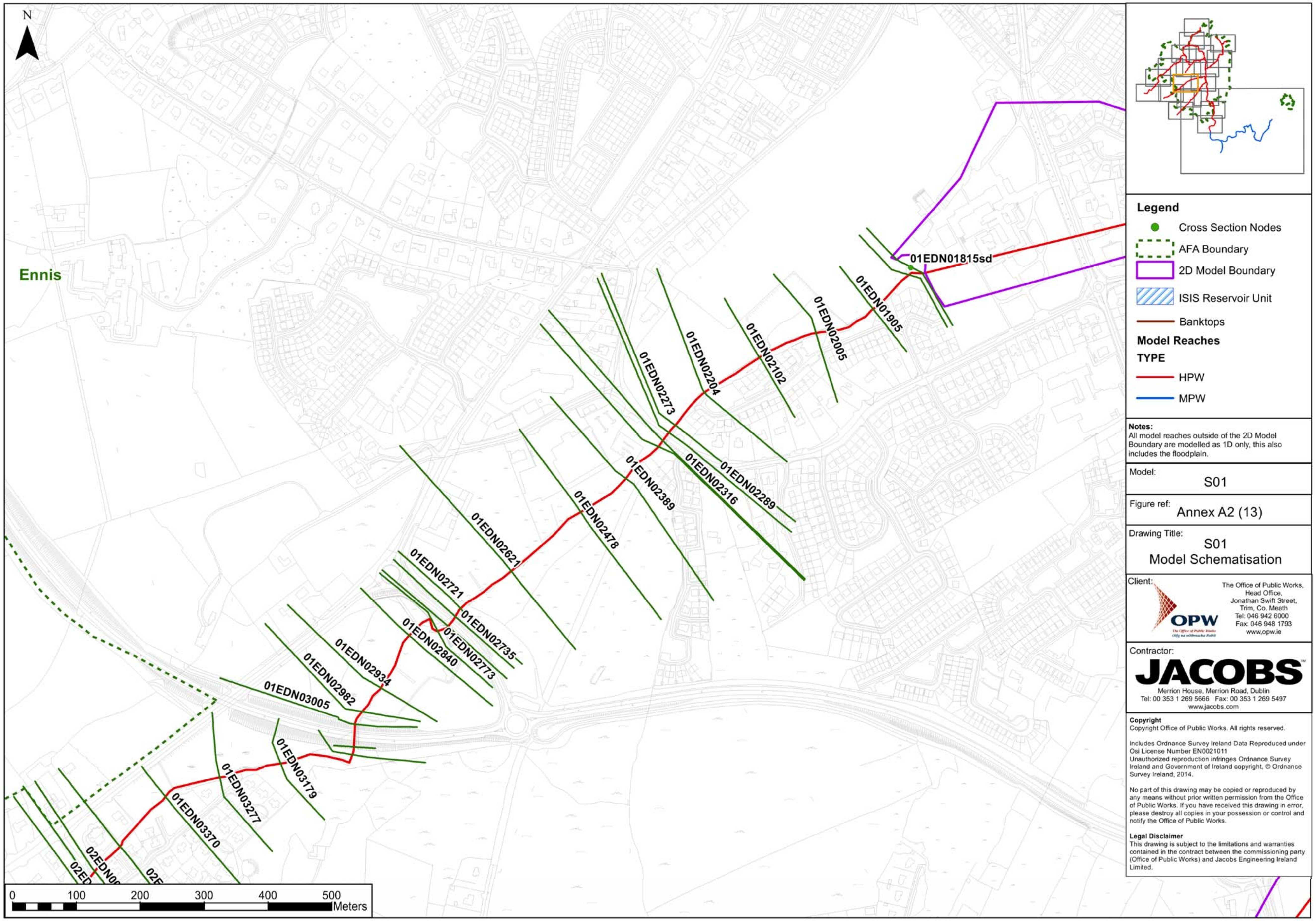
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Meters
Legend
Cross Section Nodes
AFA Boundary
2D Model Boundary
ISIS Reservoir Unit
Banktops
Model Reaches
TYPE
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S01
Figure ref:
Annex A2 (13)
Drawing Title:
S01
Model Schematisation
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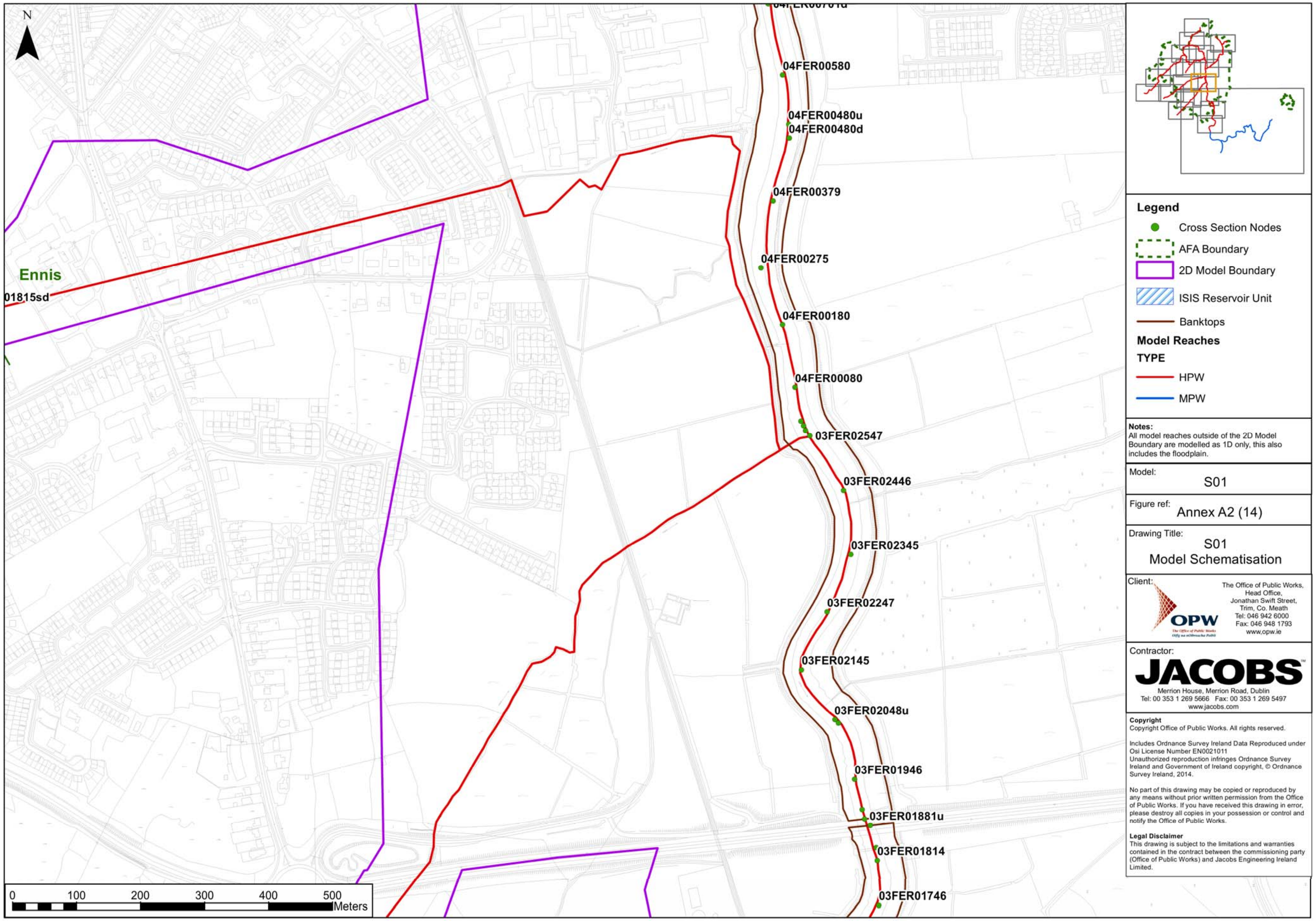
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Legend
Cross Section Nodes
AFA Boundary
2D Model Boundary
ISIS Reservoir Unit
Banktops
Model Reaches
TYPE
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S01
Figure ref:
Annex A2 (14)
Drawing Title:
S01
Model Schematisation
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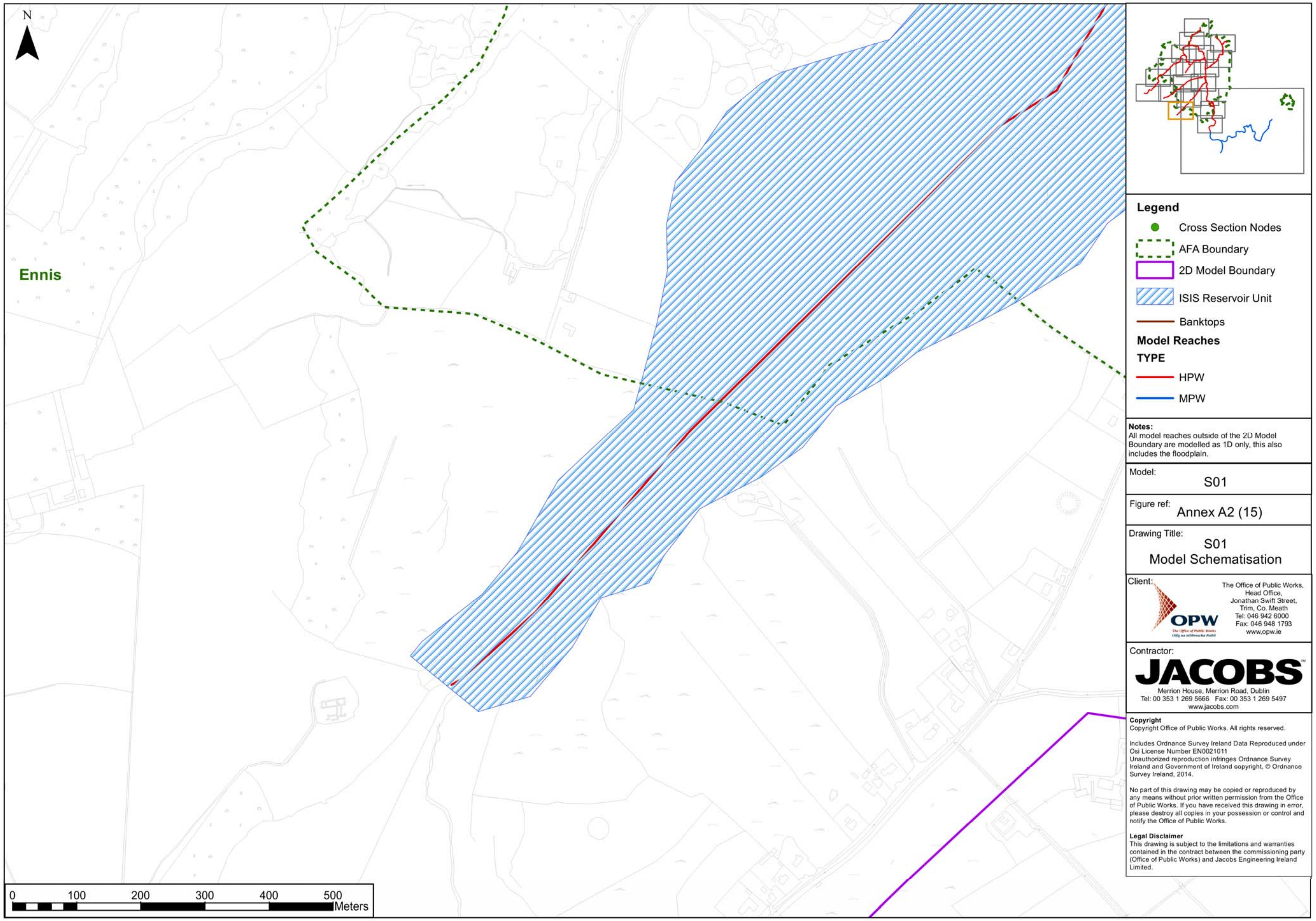
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Meters
Legend
Cross Section Nodes
AFA Boundary
2D Model Boundary
ISIS Reservoir Unit
Banktops
Model Reaches
TYPE
HPW
MPW
Notes:
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Model:
S01
Figure ref:
Annex A2 (15)
Drawing Title:
S01
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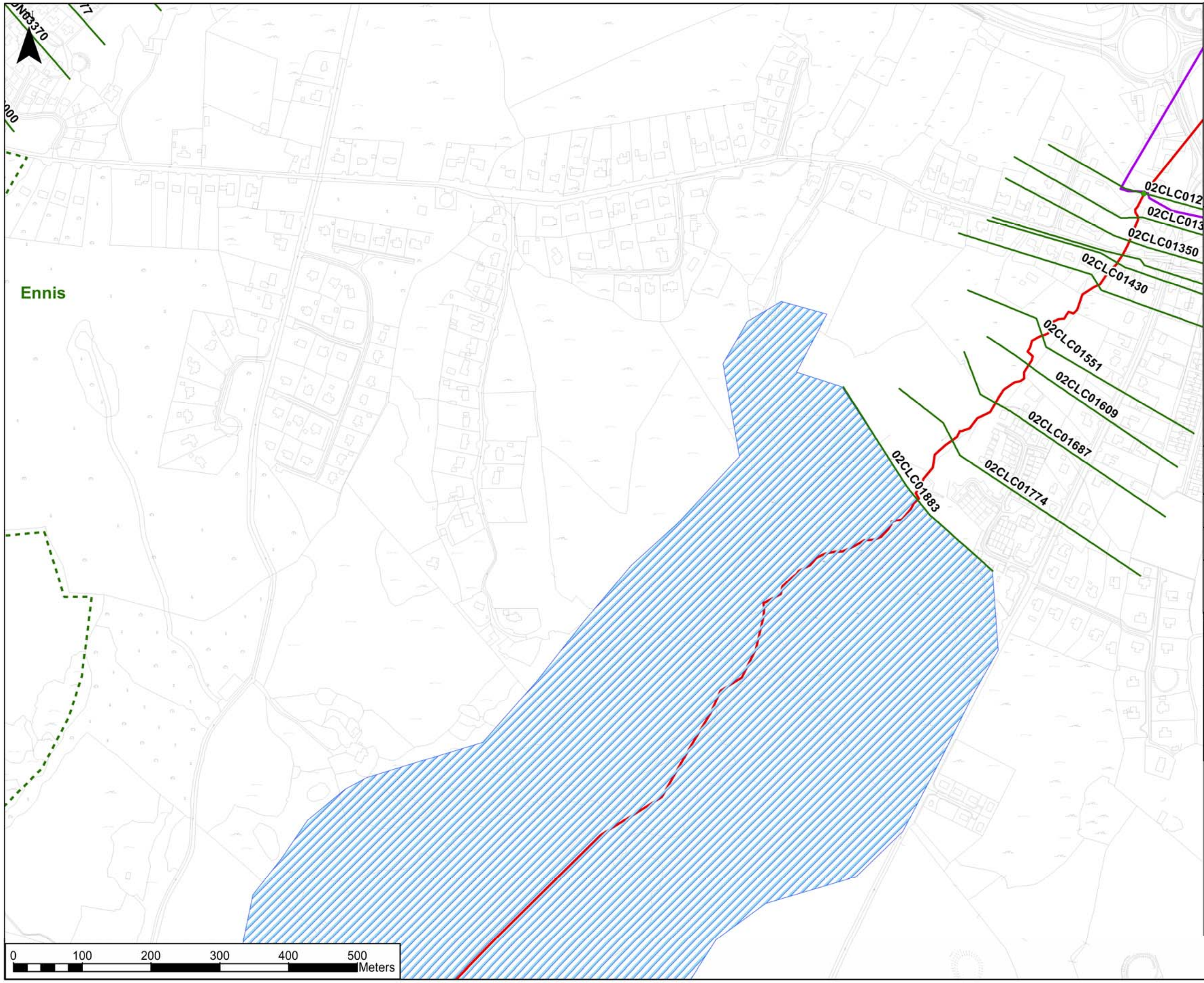

Legend

- Cross Section Nodes
- AFA Boundary
- 2D Model Boundary
- ISIS Reservoir Unit
- Banktops

Model Reaches

TYPE

- HPW
- MPW

Notes:
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Model: S01

Figure ref: Annex A2 (16)

Drawing Title: S01 Model Schematisation

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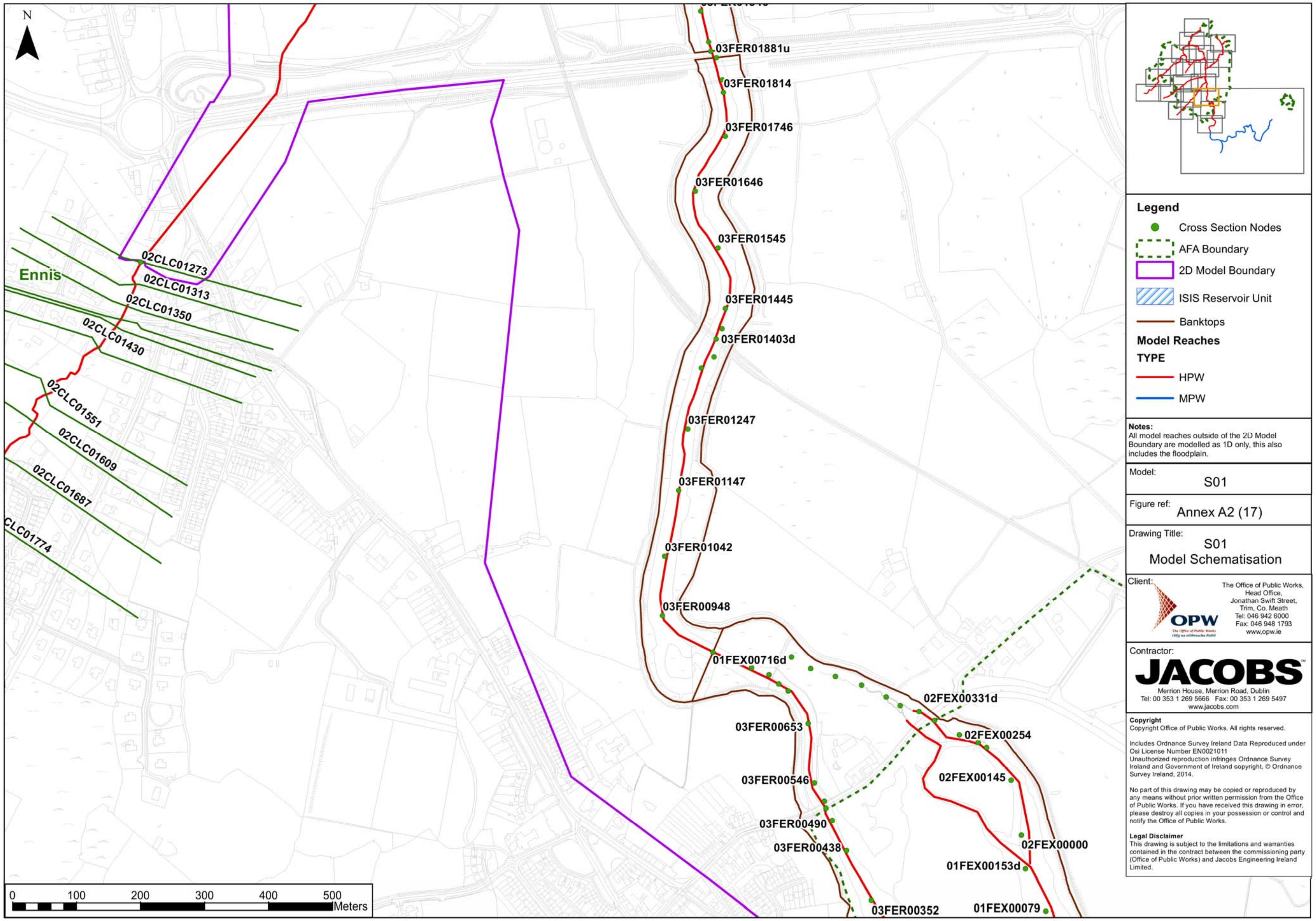
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01FEX00153d
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Cross Section Nodes
AFA Boundary
2D Model Boundary
ISIS Reservoir Unit
Banktops
Model Reaches
TYPE
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S01
Figure ref:
Annex A2 (17)
Drawing Title:
S01
Model Schematisation
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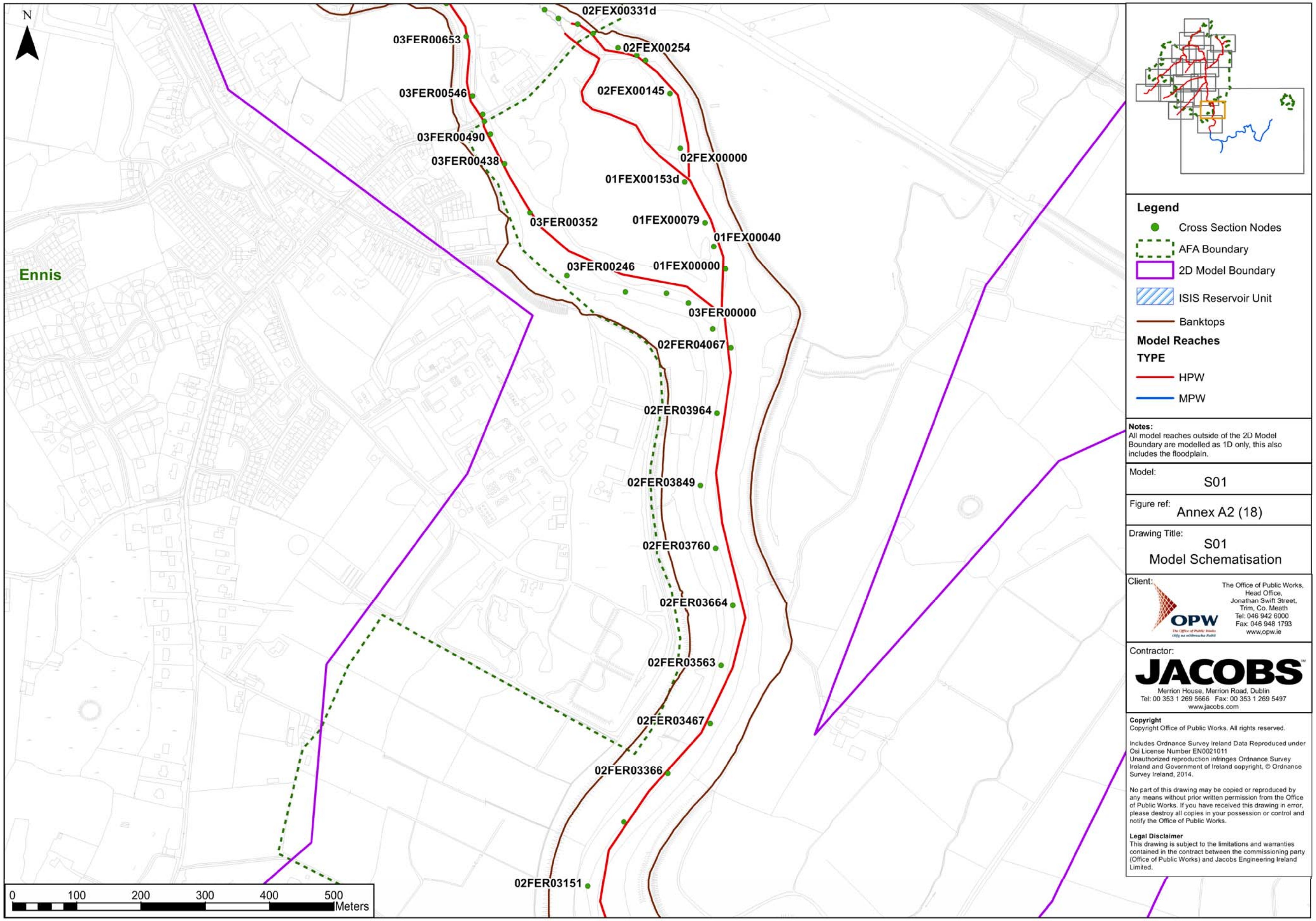
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02FER04067
02FER03964
02FER03849
02FER03760
02FER03664
02FER03563
02FER03467
02FER03366
02FER03151
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Legend
Cross Section Nodes
AFA Boundary
2D Model Boundary
ISIS Reservoir Unit
Banktops
Model Reaches
TYPE
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S01
Figure ref:
Annex A2 (18)
Drawing Title:
S01
Model Schematisation
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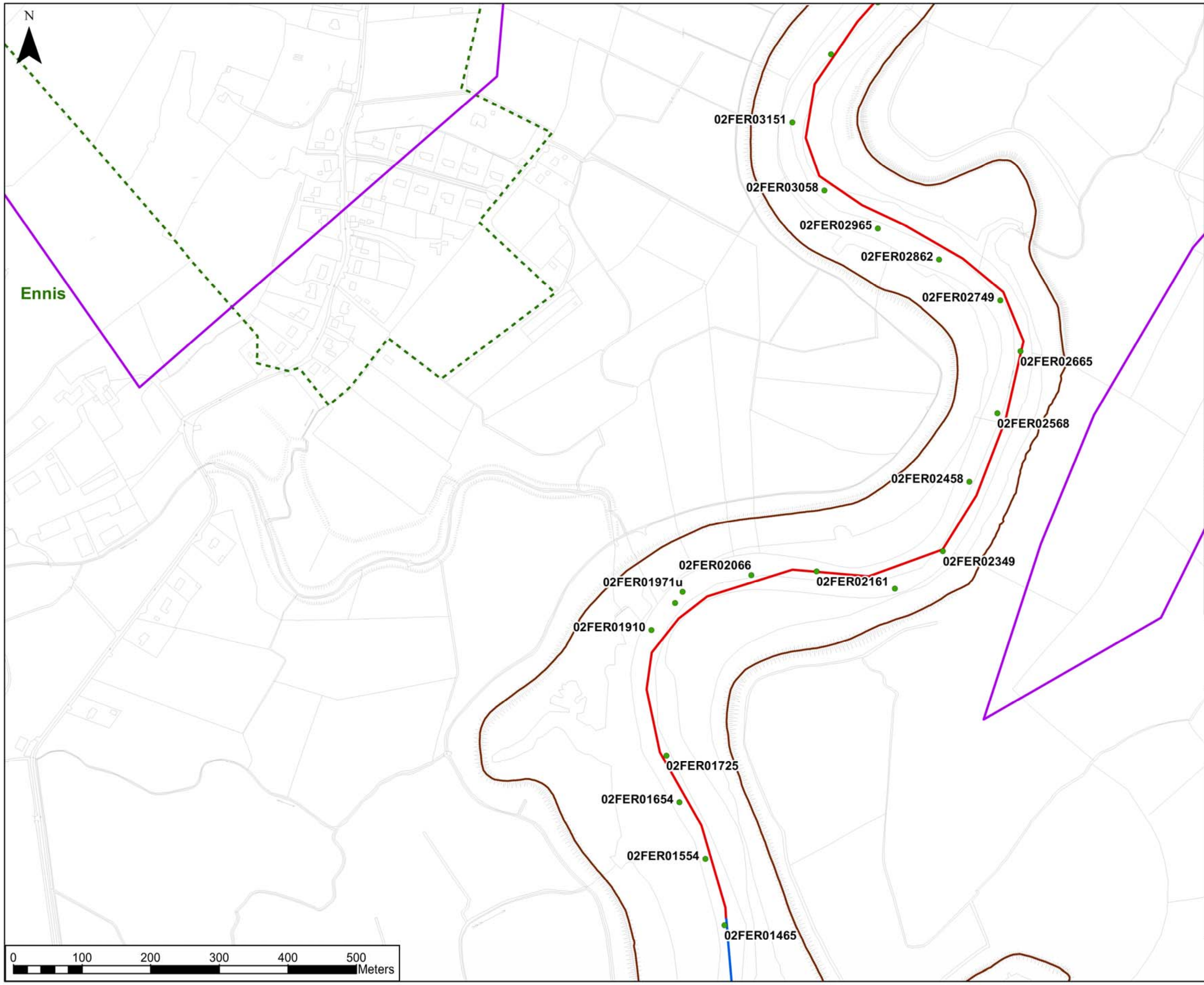

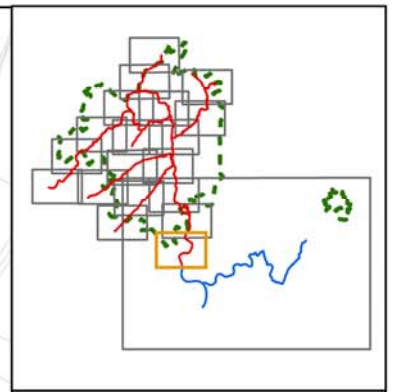

Legend

- Cross Section Nodes
- AFA Boundary
- 2D Model Boundary
- ISIS Reservoir Unit
- Banktops

Model Reaches

TYPE

- HPW
- MPW

Notes:
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Model: S01

Figure ref: Annex A2 (19)

Drawing Title: S01 Model Schematisation

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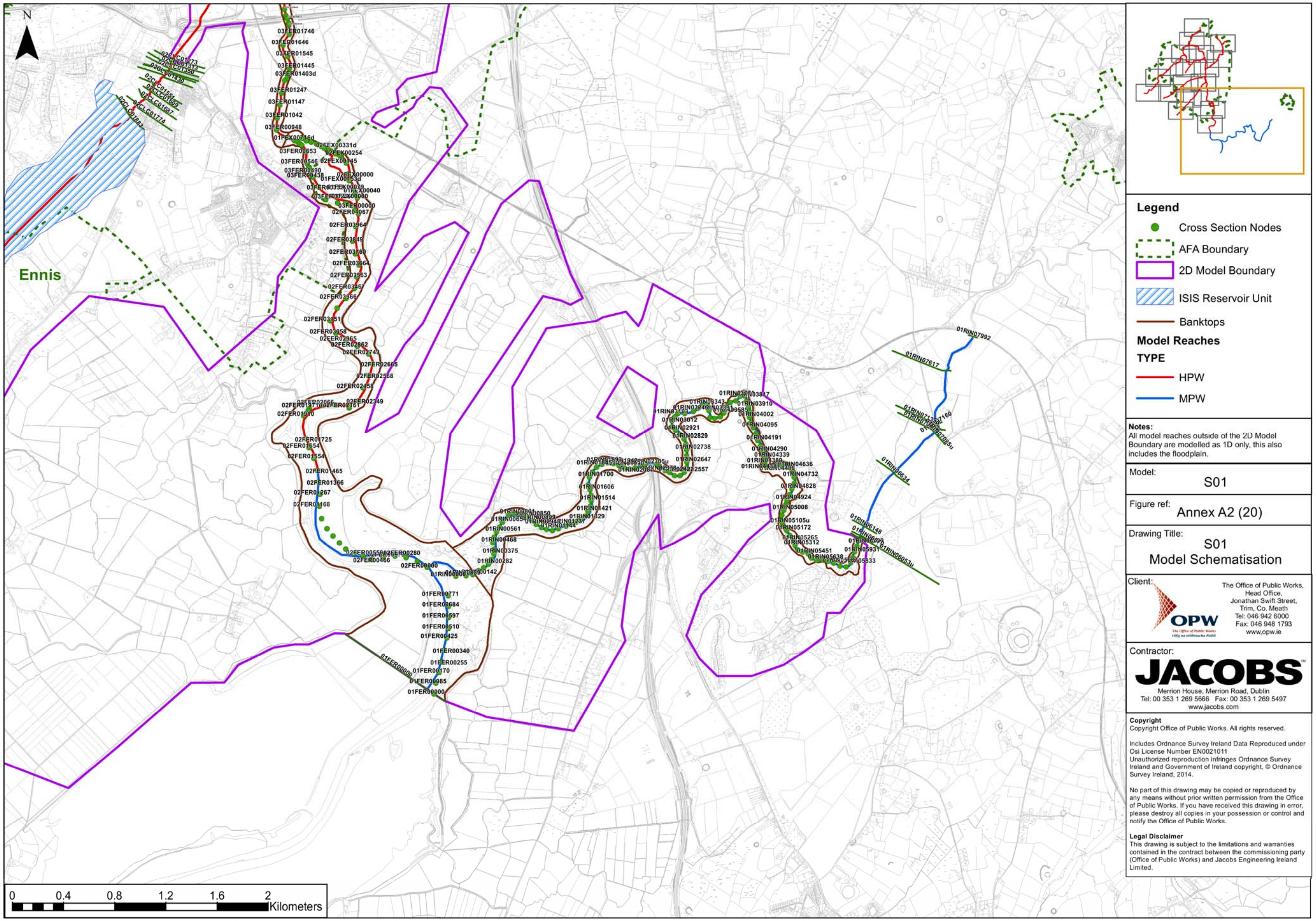

N
Ennis
Legend
Cross Section Nodes
AFA Boundary
2D Model Boundary
ISIS Reservoir Unit
Banktops
Model Reaches
TYPE
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S01
Figure ref:
Annex A2 (20)
Drawing Title:
S01
Model Schematisation
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0 0.4 0.8 1.2 1.6 2
Kilometers

Annex B – Structure and Hydraulic Roughness Schedules

Schedule A.1 - Structure Schedule for River Fergus

Survey Reference	ISIS Node Reference	Type of Structure	Modelling Approach	Structure included in Model (Y/N)
27FERG01594D	09FER01737u	Road Bridge	Arch Bridge + Spill	Y
27FERG01593W & 27FERG01593X	09FER01722u	Weir	Spill unit	Y
27FERG01561D	09FER01398u	Road Bridge	Arch Bridge + Spill	Y
27FERG01417D	08FER01202u	Road Bridge	USBPR Bridge + Spill	Y
27FERG01350D	08FER00532u	Road Bridge	Arch Bridge + Spill	Y
27FERG01259D	07FER00783u	R352 Bridge	Arch Bridge + Spill	Y
27FERG01227D	01FEW00116	R458 Bridge	Culvert + Spill	Y
27FERG01223D	01FEW00069	Foot Bridge	Arch Bridge + Spill	N*
27FERG01223	01FEW00061u	Penstock Gate (not operative)	Spill representing top of sluice gate	Y
27FERG01164D	06FER01344u	R871 Bridge	Arch Bridge + Spill	Y
27FERG01152D	06FER01220u	Foot Bridge	Arch Bridge + Spill	Y
27FERG01143D	06FER01126u	R352 Bridge	Arch Bridge + Spill	Y
27FERG01061D	06FER00305u	Road Bridge	USBPR Bridge + Spill	Y
27FERG01041D	06FER00093u	Pipe Convey Bridge	USBPR Bridge + Spill	Y
27FERG01039E	06FER00074u	Railway Bridge	Arch Bridge + Spill	Y
27FERG00898D	04FER00832u	R469 Bridge	USBPR Bridge + Spill	Y
27FERG00748D	03FER01881u	N85 bridge	USBPR Bridge + Spill	Y
27FERG00744D	03FER01834u	Footbridge	Arch Bridge + Spill	Y
27FERG00700D	03FER01403u	Railway Bridge	USBPR Bridge + Spill	Y
27FERG00635	03FER00754u	Tidal Barrage plus Fish Pass	Orifices + Spill	Y
27FERG00612D	03FER00524u	R458 bridge	USBPR Bridge + Spill	Y
27FERC00011W	07FER00514u	4 Sluice Gates	Sluice gates	Y
27FERC00011W-2	07FER0514w1u	Weir	Weir	Y
27FERC00011X	07FER0503w2u	Weir	Weir	Y
27FERC00008D	07FER00494r	Bridge	Sprung Arch Conduit + Spill	Y
27FERC00008D	07FER00494	Bridge	Sprung Arch Conduit + Spill	Y
27FERD00002	01FED00073u	Wooden gate at the Mill wheel	Spill representing top of sluice gate	Y
27FERD00000I	01FED00060	Conduit	Circular Conduit + flapped orifice	Y

Survey Reference	ISIS Node Reference	Type of Structure	Modelling Approach	Structure included in Model (Y/N)
27FERA00055I & 27FERA00054J	01FEX00491	0.9m dia. circular culverts	Twin Circular Culvert + Spill	Y
27FERB00031I & 27FERB00029J	02FEX00331u	5 Circular Culverts of 0.9m dia	Orifice + Spill	Y
27FERB00022D	02FEX00224u	Bridge (No opening)	Spill	Y

* Considering the size of the structure relative to the watercourse it was determined that the structure would have little or no hydraulic impact on the model during flood flows.

Schedule A.2 - Structure Schedule for River Fergus Minor

Survey Reference	ISIS Node Reference	Type of Structure	Modelling Approach	Structure included in Model (Y/N)
27FERMOO202	01FEM01998u	450mm dia pipe obstructing flow	Orifice +Spill	Y
27FERM00172D	01FEM01722	Gort Road Bridge (R458 bridge)	Double Sprung Arch Conduit + Spill	Y
27FERM00071D	01FEM00710u	Road Bridge	Arch Bridge + Spill	Y
27FERM00066D	01FEM00657	Rail Bridge	Sprung Arch Conduit	Y
27FERM00057	01FEM00562	Road Bridge	Sprung Arch Conduit + Spill	Y

Schedule A.3 - Structure Schedule for River Fergus Claureen

Survey Reference	ISIS Node Reference	Type of Structure	Modelling Approach	Structure included in Model (Y/N)
27CLAU00138D	01CLR1361u	N85 Road Bridge	USBPR Bridge + Spill	Y
27CLAU00041D	01CLR0399u	R352 Road Bridge	Arch Bridge + Spill	Y

Schedule A.4 - Structure Schedule for River Gaurus

Survey Reference	ISIS Node Reference	Type of Structure	Modelling Approach	Structure included in Model (Y/N)
27SPAN00322D & 27SPAN00320J	01GAU03175	Culverts at R352 bridge	Twin Culvert + Spill	Y
27SPAN00309D & 27SPAN00308E	01GAU03056	Road Bridge	Rectangular Culvert + Spill	Y
27SPAN00220D	01GAU02174u	Road Bridge	Arch Bridge + Spill	Y
27SPAN00036I & 27SPAN00033J	01GAU00343	Culvert at Road Bridge	Rectangular Culvert + Spill	Y

Schedule A.5 - Structure Schedule for River Gaurus unnamed tributary

Survey Reference	ISIS Node Reference	Type of Structure	Modelling Approach	Structure included in Model (Y/N)
27SPAN00367D	01GAX00186u	Road Bridge	Orifice + Spill	Y
27SPAN00362D & 27SPAN00360J	01GAX00145	Road Bridge	Culvert + Spill	Y

Schedule A.6 - Structure Schedule for Cahircalla Lough

Survey Reference	ISIS Node Reference	Type of Structure	Modelling Approach	Structure included in Model (Y/N)
27CAHI00074I	01CAH00737	0.6 Dia pipe	Orifice	Y

Schedule A.7 - Structure Schedule for River Cahircalla

Survey Reference	ISIS Node Reference	Type of Structure	Modelling Approach	Structure included in Model (Y/N)
27EDEA00091D	02EDN00927	N68 Road Bridge	Rectangular conduit + Spill	Y
27EDEA00077D	02EDN00772u	Road Bridge	Arch Bridge + Spill	Y
27EDEA00006D	02EDN00066	R475 Road Bridge	Sprung arch conduit + Spill	Y
27EDEN00303I & 27EDEN00301J	01EDN03041	Box culvert under Road N85	Rectangular culvert + Spill	Y
27EDEN00276I & 27EDEN00275J	01EDN02755	Box culvert under Road N68	Rectangular culvert + Spill	Y
27EDEN00231I & 27EDEN00230J	01EDN02305	0.9m dia. twin circular culvert	Circular culverts + spill	Y
27EDEN00096D	01EDN00950	Box culvert under Railway	Rectangular culvert + Spill	Y
27EDEN00082I & 27EDEN00081J	01EDN00807	0.3 m dia. Circular Culvert	Circular culvert + spill	Y

Schedule A.8 - Structure Schedule for Ballybeg Lough Stream

Survey Reference	ISIS Node Reference	Type of Structure	Modelling Approach	Structure included in Model (Y/N)
27CLAR00140D	02CLC01373	R475 bridge	Culvert + Spill	Y
27CLAR00078I	02CLC00732	0.5m dia. twin circular culvert	Circular culverts + spill	Y
27CLAR00034D	02CLC00289u	Railway Bridge	Arch Bridge + Spill	Y
27CLAR00032I	02CLC00275	Conduit	Circular culverts + spill	Y
27CLAR00004I	01CLC00014	Conduit upstream of confluence with River Fergus	Rectangular culvert + flapped orifice	Y

Schedule A.9 - Structure Schedule for River Rine

Survey Reference	ISIS Node Reference	Type of Structure	Modelling Approach	Structure included in Model (Y/N)
27RINE00738D	01RIN07139u	Three arch stone bridge	Arch Bridge + Spill	Y
27RINE00630D	01RIN06053u	Stone bridge	Arch Bridge + Spill	Y
27RINE00534D	01RIN05105u	Steel bridge	Arch Bridge + Spill	Y
27RINE00519E	01RIN04949u	Arch bridge	Arch Bridge + Spill	Y
27RINE00253D	01RIN02305u	M18 Road Bridge	USBPR Bridge + Spill	Y
27RINE00250D	01RIN02263u	Road Bridge	Arch Bridge + Spill	Y
27RINE00248D	01RIN02248u	R458 Road Bridge	USBPR Bridge + Spill	Y

Schedule B.1 – Manning's 'n' for HPW Network

River Name	Cross Sections	In-bank Roughness	Estimated Floodplain Roughness
River Fergus	09FER02089 to 09FER01261	0.040	2D domain : based on OSi NTF land use polygons 1D extended cross sections : Land use EPA data has been used for assigning the floodplain roughness.
River Fergus	09FER01261 to 03FER00754	0.035	
River Fergus	03FER00754 to 01FER00000	0.030	
River Fergus Minor	01FEM02188 to 01FEM00127	0.045	
River Fergus Minor	01FEM00127 to 01FEM00000	0.035	
River Claureen	01CLR06285 to 01CLR03297	0.040	
River Claureen	01CLR03297 to 01CLR00000	0.035	
River Gaurus	02GAU00617 to 01GAU03070	0.040	
River Gaurus	01GAU03070 to 01GAU02741	0.030	
River Gaurus	01GAU02741 to 01GAU00000	0.040	
River Gaurus unnamed tributary	01GAX00515 to 01GAX00211	0.040	
River Gaurus unnamed tributary	01GAX00211 to 01GAX00165	0.020	
River Gaurus unnamed tributary	01GAX00165 to 01GAX00000	0.040	
Cahircalla Lough	01CAH00824 to 01CAH00737	0.050	

River Cahircalla	02EDN01164 to 01EDN00962	0.050	
River Cahircalla	01EDN00962 to 01EDN00000	0.035	
Ballybeg Lough Stream	02CLC01883 to 02CLC01273	0.045	
Ballybeg Lough Stream	02CLC01273 to 02CLC00275	0.055	
Ballybeg Lough Stream	02CLC00275 to	0.040	
River Rine	01RIN07992 to 01RIN04636	0.035	
River Rine	01RIN04636 to 01RIN00000	0.030	

Schedule B.2 – Manning's 'n' for MPW Network

River Name	ISIS Node Reference	In-Bank Roughness	Estimated Floodplain Roughness
River Rine	01RIN07992 to 01RIN04636	0.035	<u>2D domain</u> : based on OSi NTF land use polygons <u>1D extended cross sections</u> : Land use EPA data has been used for assigning the floodplain roughness.
River Rine	01RIN04636 to 01RIN00000	0.030	
River Fergus	03FER00754 to 01FER00000	0.030	

Annex C - Model Calibration Summary Note

The aim of this technical note is to describe the calibration methodology applied to the S01 model and report on the results.

Calibration Methodology:

The analysis of available flood event data and high flow data for possible consideration as calibration and verification events is covered in detail in the Hydrology Report (Appendix F). The results of this analysis concluded that there was sufficient hydrometric data coupled with sufficient flood level\extent information to allow calibration and verification of the S01 model against two fluvial events along the River Fergus and the River Claureen.

The hydrometric data recorded at a gauging station on the River Fergus (Ballycorey 27002) and at a gauging station on the River Claureen (Inch Bridge 27001) and the tidal levels recorded upstream of the

tidal barrage (Clarecastle U/S) for two historical events (November 2009 and December 2006) were found to be suitable for calibrating the S01 model along a section of HPW shown on Figure C.1. The model has been calibrated using the November 2009 and the December 2006 out-of-bank events.

The section of HPW found suitable for calibration include the River Fergus, the River Fergus Minor and the River Claureen and terminates immediately upstream of the tidal barrage. All historical calibration runs were carried out with this truncated model. The contributions from the other tributaries were accounted for as a lateral inflow applied at the confluence with the River Gaurus. The inflow location is shown in Figure C.1 as a blue circle.

The gauged flows at 27002 and 27001 were input into the model at cross sections “09FER01993” and “01CLR05800” respectively. Observed tidal levels were input into the model at cross section “03FER00754u” (gauging station 27064). These locations are shown in Figure C.1.

For the November 2009 event the water levels hydrographs predicted by the hydraulic model were then compared against the observed hydrographs at gauging stations 27066 and 27060.

For the December 2006 event peak water levels predicted by the hydraulic model were compared against the observed peak water levels at gauging stations 27023 (Victoria Bridge) and 27024 (Mill Bridge). For the December 2006 event a comparison between the full hydrographs was only possible at gauging station 27060.

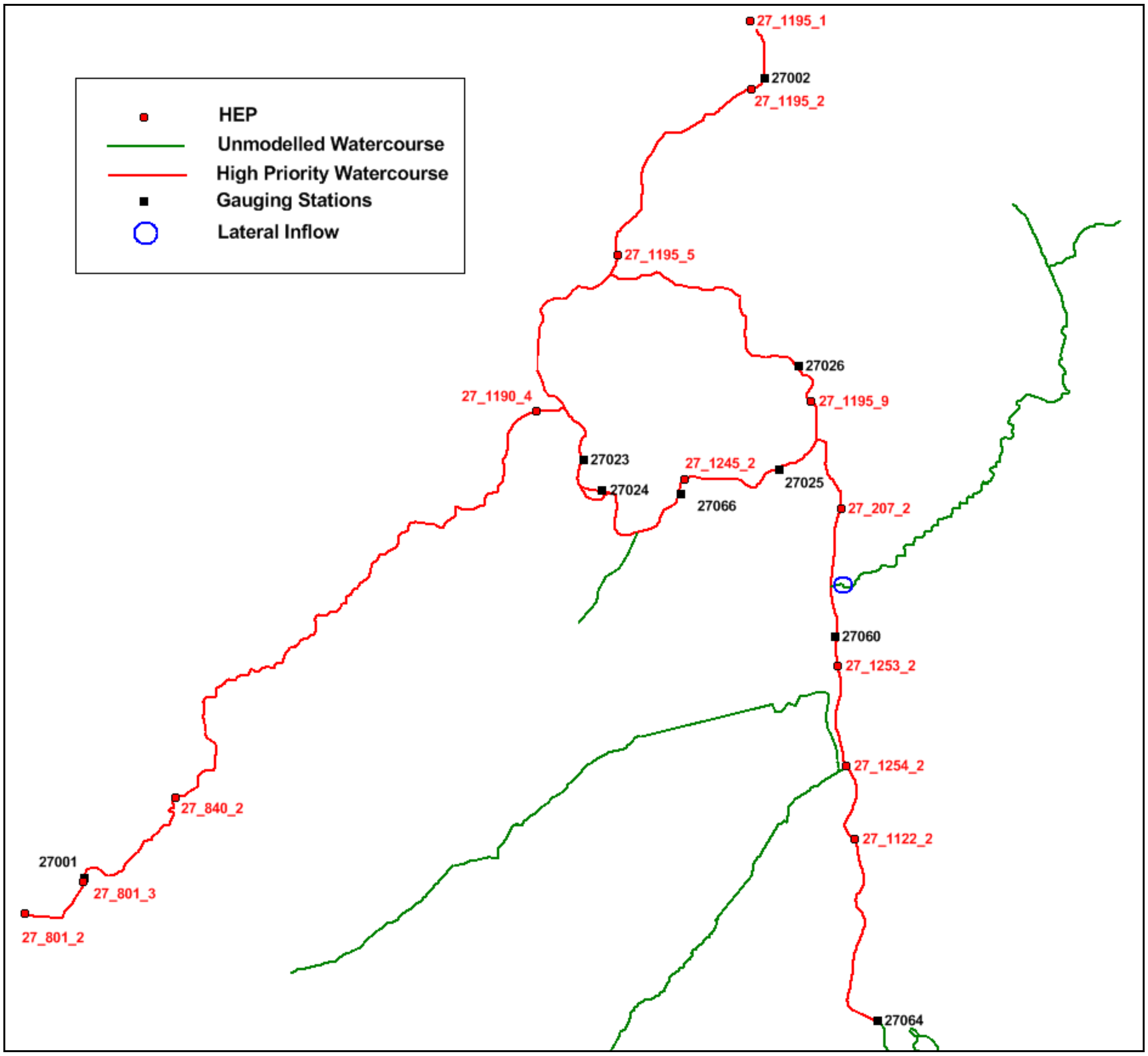


Figure C.1: S01 model– Calibration map

Calibration Results for the November 2009 Historical Event

Calibration was carried out at gauging station 27066 (Ennis Bridge) and 27060 (Doora Bridge). The nearest ISIS cross sections to the gauging stations are cross section “06FER01097” and cross section “04FER00832u”, respectively. The comparison between observed and calculated water levels is shown in Table C.1.and C.2 for peak levels and in Figure C.2 and C.3 for the stage hydrographs. The maximum observed water level for the November 2009 flood event was 3.609 mOD at gauging station 27066 and 2.816mOD at gauging station 27060.

Table C.1: Calibration Results at Gauging Station 27066

Historical Flood Event	Model Maximum Stage (mAOD)	Observed Maximum Stage (mAOD)	Difference (mm)
November 2009	3.418	3.609	-191

Table C.2: Calibration Results at Gauging Station 27060

Historical Flood Event	Model Maximum S0tage (mAOD)	Observed Maximum Stage (mAOD)	Difference (mm)
November 2009	2.849	2.816	+33

The timing of the hydrographs is almost identical and the difference between the modelled and observed maximum stages is -191 mm at gauging station 27066 and +0.033 at gauging station 27060.

The difference between predicted peak water level and observed level is within the required tolerance of +/-0.2m for a HPW reach at both gauging stations and as a result there was no justification for altering the hydraulic model.

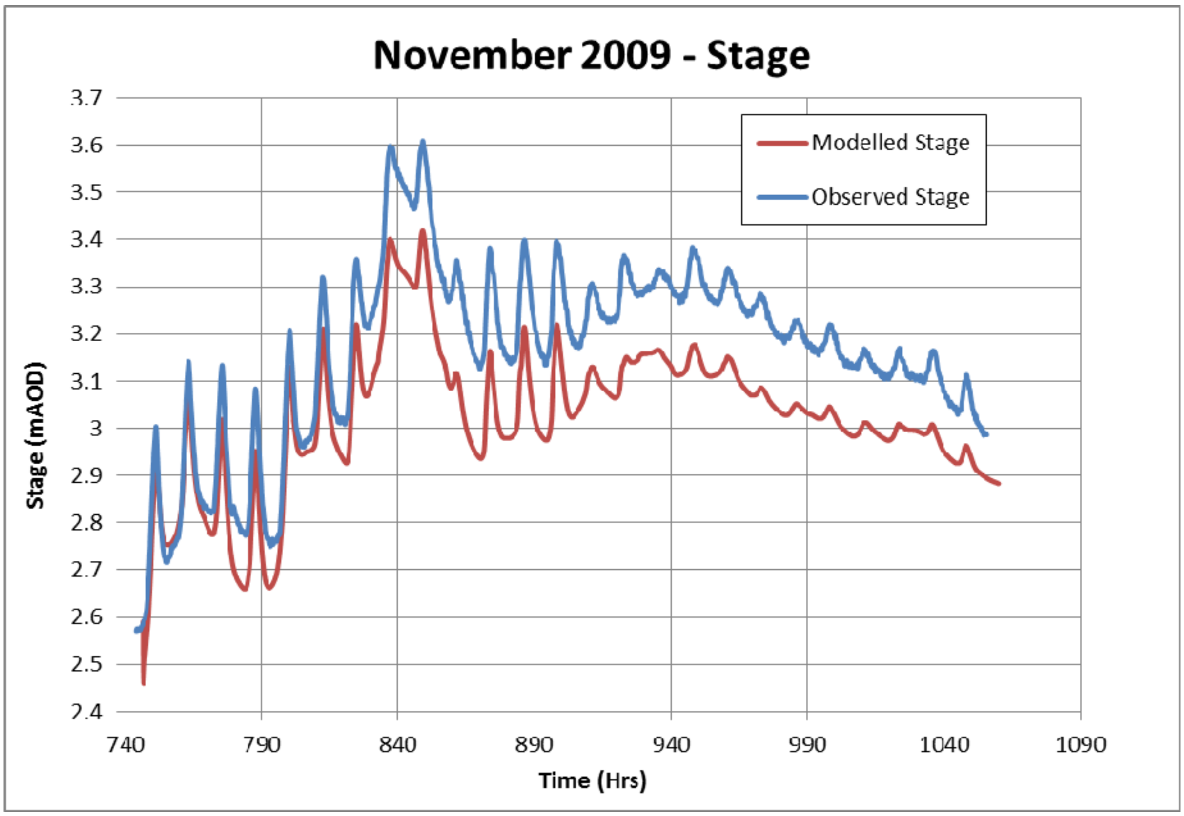


Figure C.2 - Modelled and observed water levels at gauging station 27066

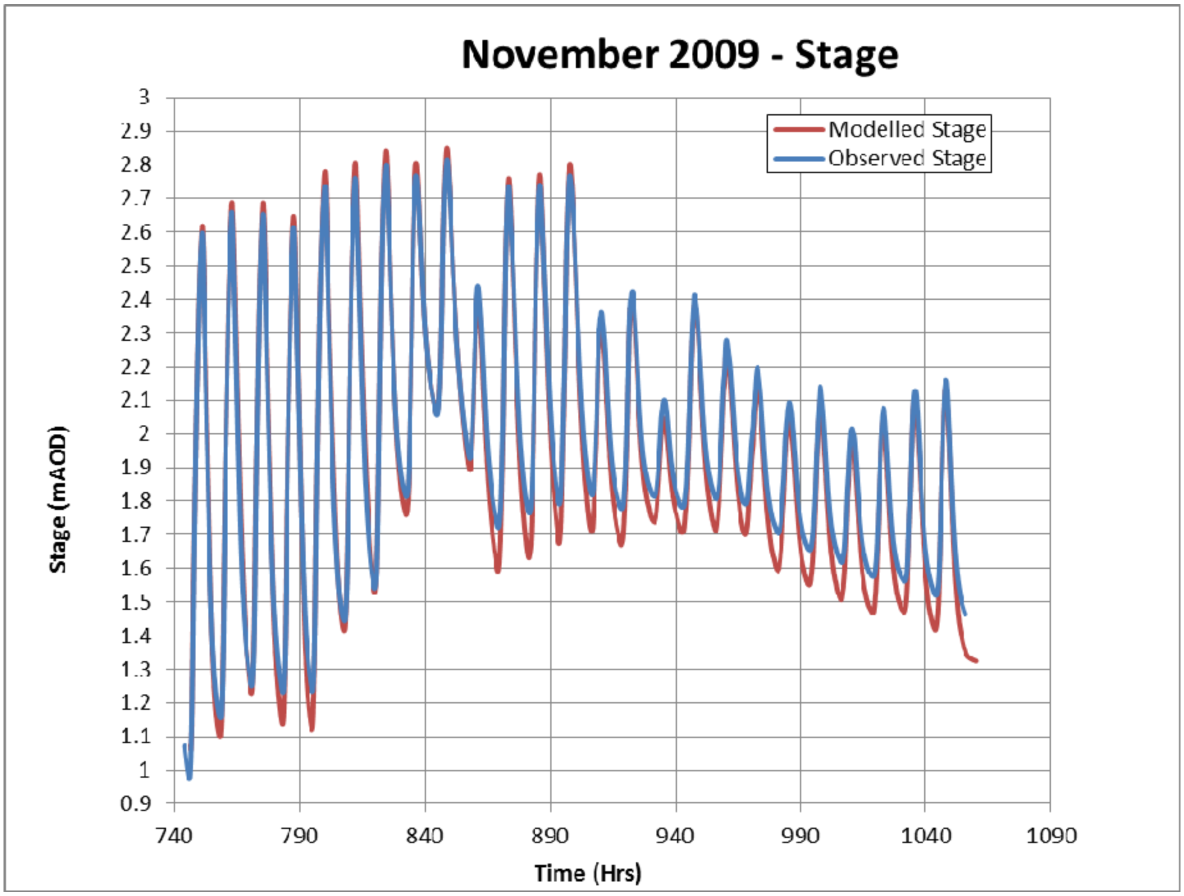


Figure C.3 - Modelled and observed water levels at gauging station 27060

Calibration Results - December 2006 Out-of-bank Historical Event:

Calibration was carried out at gauging station 27023 (Victoria Bridge Bridge), 27024 (Mill Bridge) and 27060 (Doora Bridge). The nearest ISIS cross sections to the gauging stations are cross section "07FER00783u", cross section "07FER00463" and cross section "04FER00832u", respectively. The comparison between observed and modelled peak water levels is shown in Table C.3, C.4 and C.5. Figure C.4 shows a comparison between the observed and the modelled hydrographs at gauging station 27060. The maximum difference between observed and modelled water levels is at gauging station 27024 (-141mm).

Table C.3: Calibration Results at Gauging Station 27023

Historical Flood Event	Model Maximum Stage (mAOD)	Observed Maximum Stage (mAOD)	Difference (mm)
December 2006	5.086	5.2	-114

Table C.4: Calibration Results at Gauging Station 27024

Historical Flood Event	Model Maximum Stage (mAOD)	Observed Maximum Stage (mAOD)	Difference (mm)
December 2006	3.559	3.7	-141

Table C.5: Calibration Results at Gauging Station 27060

Historical Flood Event	Model Maximum Stage (mAOD)	Observed Maximum Stage (mOD)	Difference (mm)
December 2006	2.294	2.281	+13

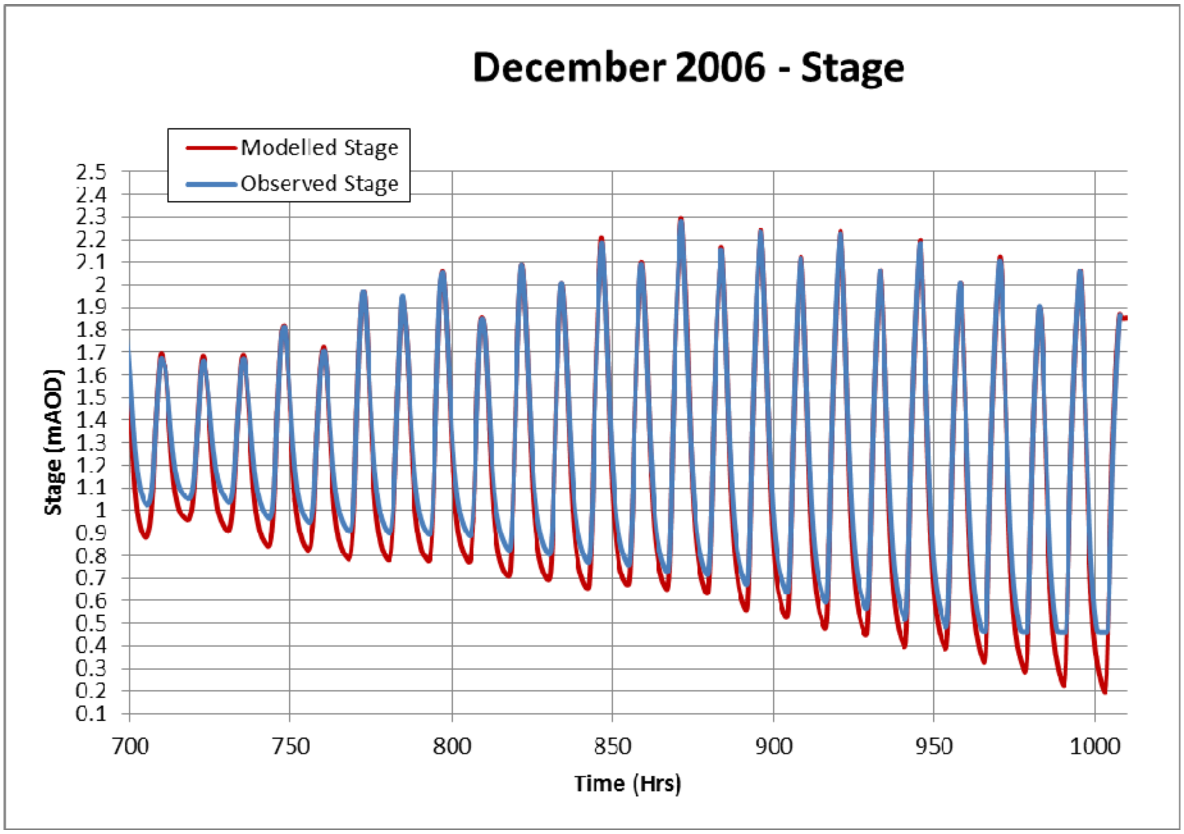


Figure C.4 - Modelled and observed water levels at gauging station 27060

The difference between predicted peak water level and observed level is within the required tolerance of +/-0.2m for a HPW reach at all three gauging stations and as a result there was no justification for altering the hydraulic model.

Verification of the model using anecdotal evidence collected during the November 2009 historical event at Ennis

Model outputs along the River Fergus were compared against photographs taken during the November 2009 flood event.

The photos P1- P12 were taken during the November 2009 event. Figure C.5 shows the locations of areas shown to be flooded in the photographs along with the modelled flood extents for this event.

From this figure it can been seen that the modelled November 2009 flood extent show flooding at the same locations as seen in the photos except for the area near Abbey Street Car Park and the area between Abbey Street and Francis Street (Photographs H, I, J). Possible explanation for these two discrepancies could be that flooding in these areas could have occurred due to a defence failure (breach) at Abbey Street Car Park.
In November 2009 the flooding was not as extensive in some areas as the flooding shown on the 10% This flood risk is due to the fact that the wall at Flannans college has not been included in the model. It is our understanding that the wall at St Flannans held back water during the 2009 event.

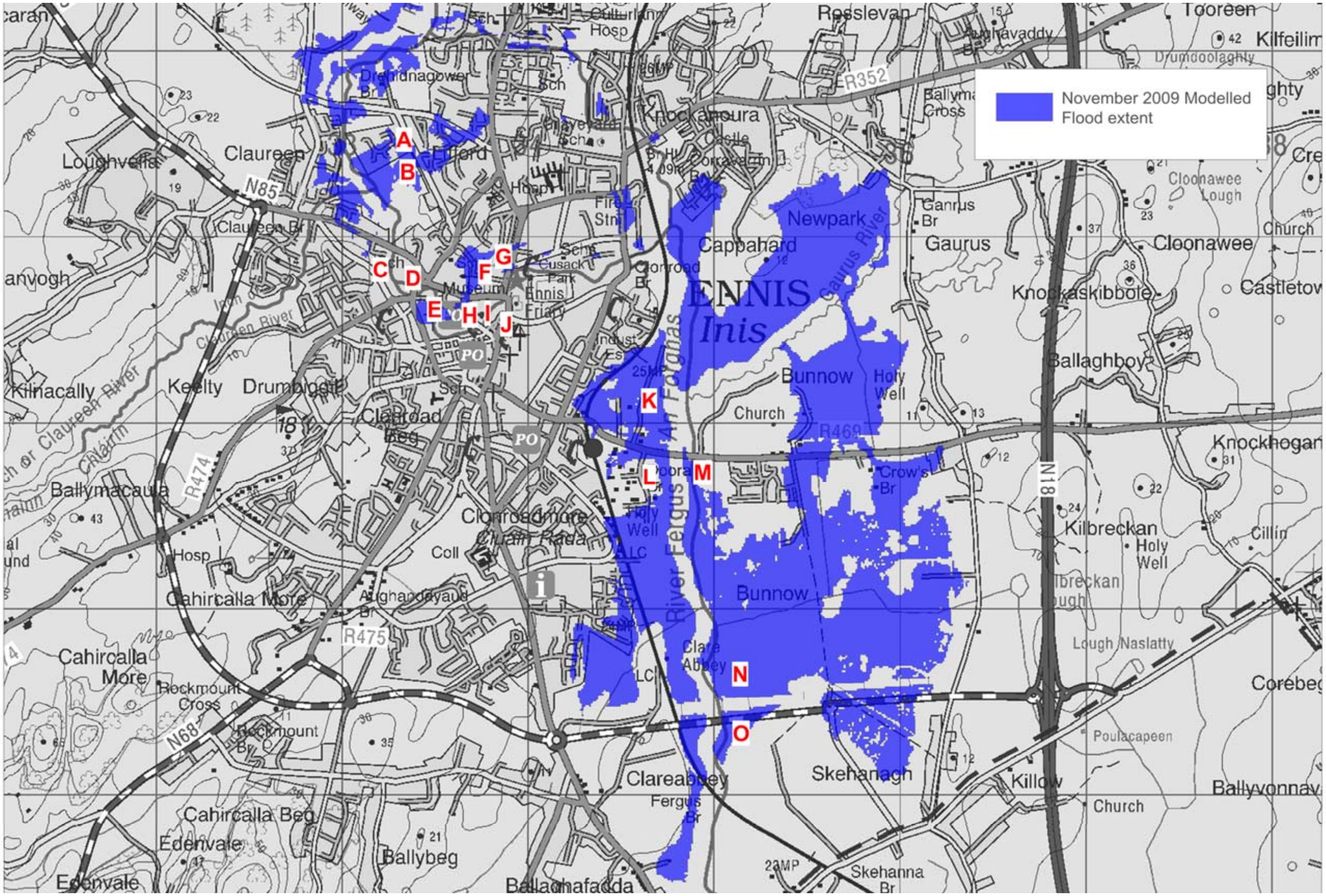
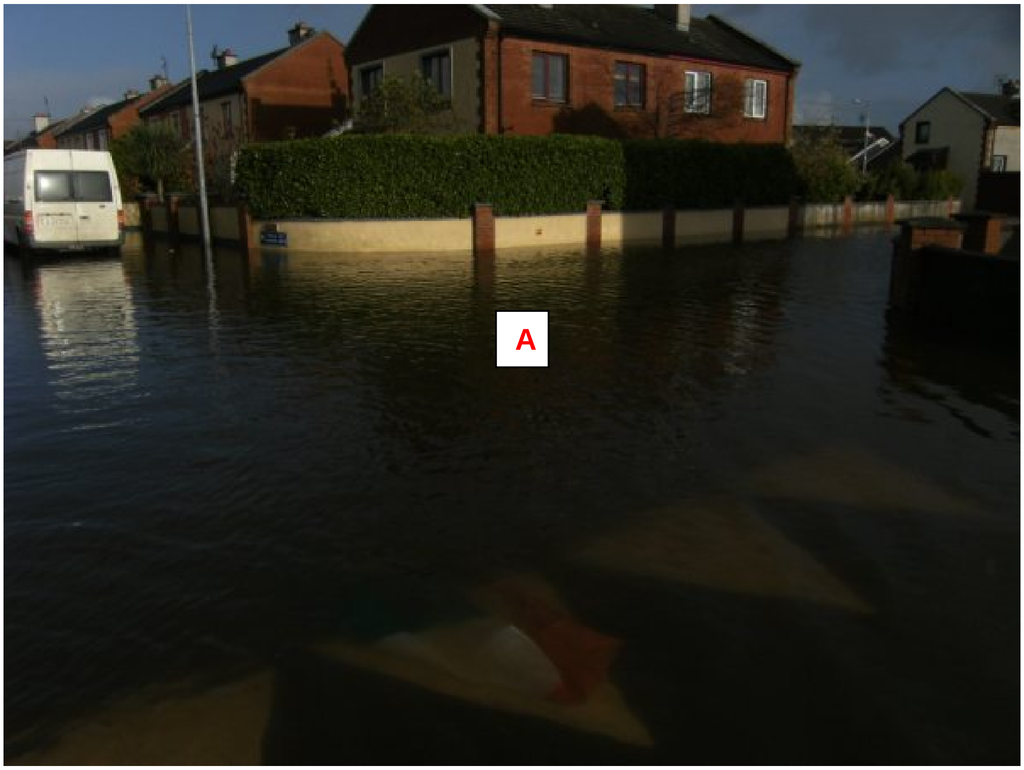


Figure C.5 – Modelled November 2009 flood extents and spot locations of photographs showing the observed flooding

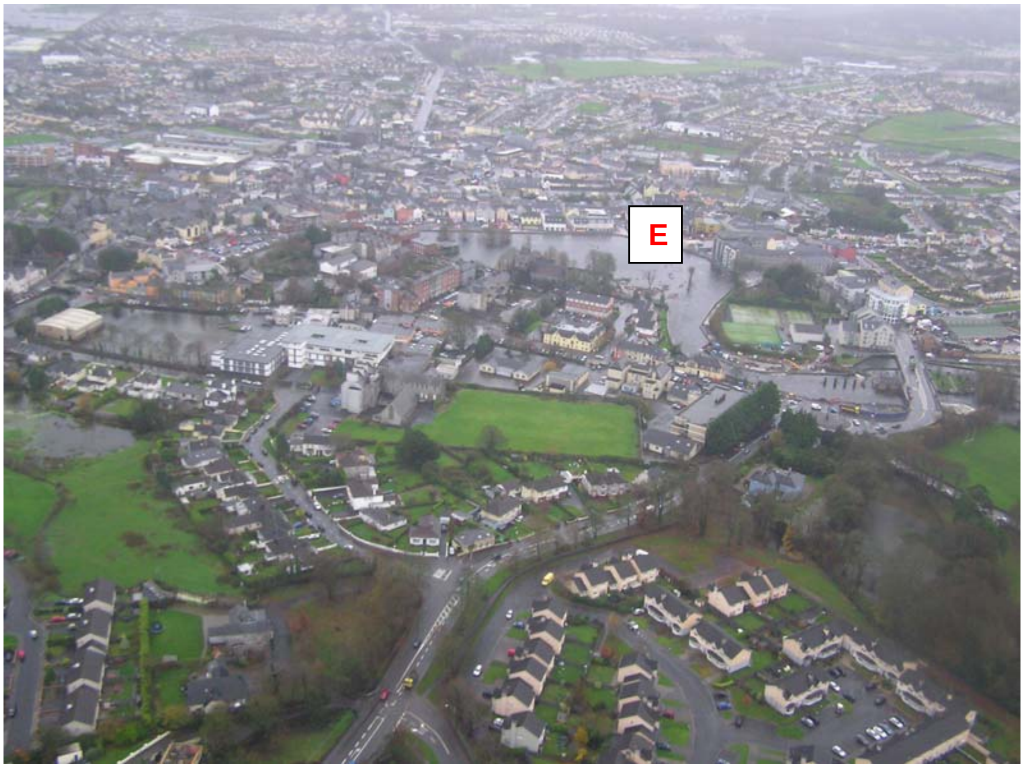


Photograph P1

Photograph P2

Photograph P3

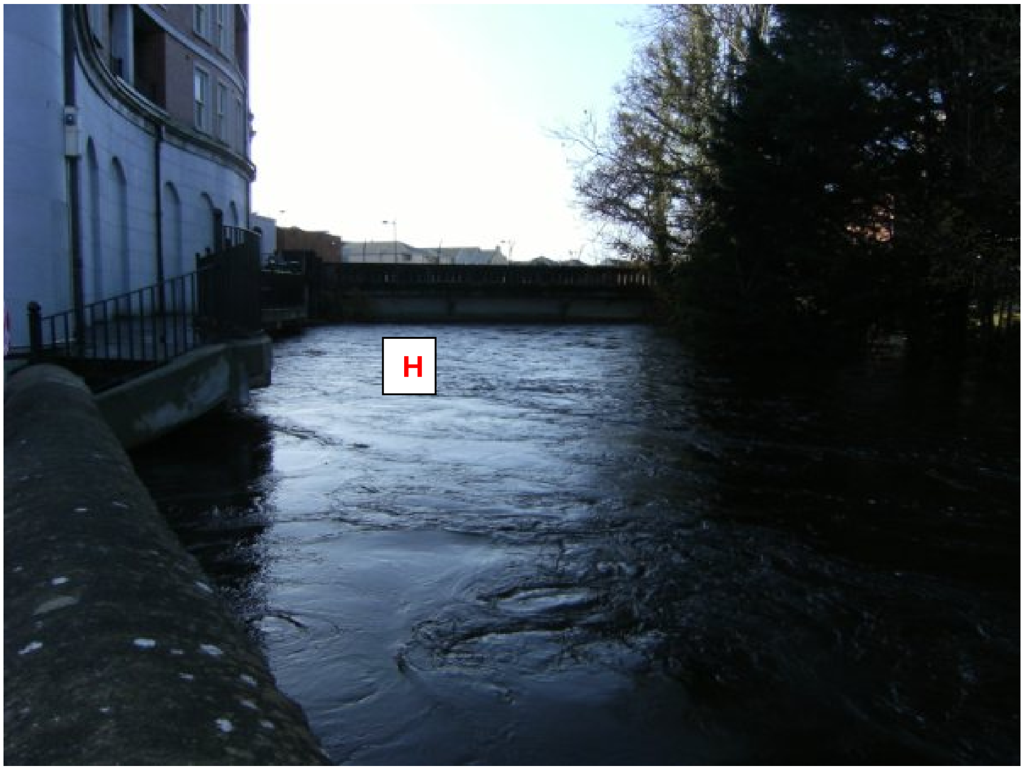
Photograph P4



Photograph P5

Photograph P6

Photograph P7



Photograph P8

Photograph P9

Photograph P10

Photograph P11

Photograph P12

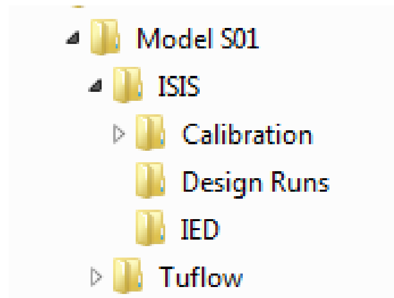
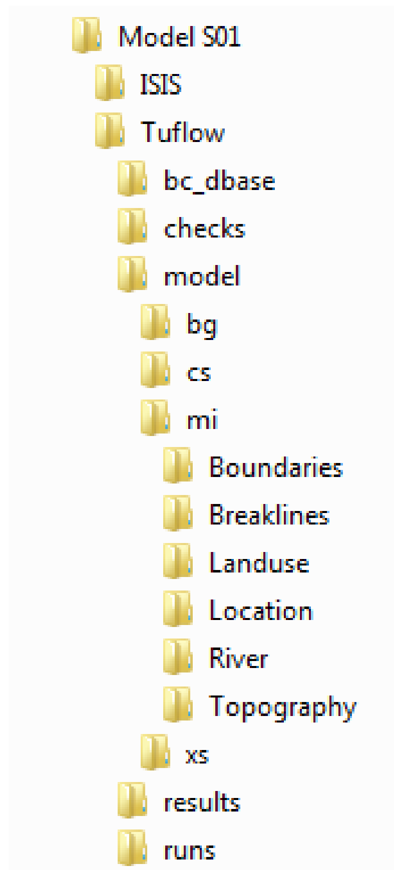
Conclusions

It has been possible to calibrate a section of HPW (River Fergus down to the tidal barrage and river Claureen) for two out-of-bank events: the November 2009 and the December 2006 event.

The results suggest that the model calibrates well for both the out of bank historical events. A successful verification was carried out for the November 2009 event by comparing the modelled flood outline for this event against photographs taken during and following the event.

No hydrometric data was deemed suitable for calibrating the other tributaries.

Annex D - Hydraulic Model Files

Model Files Folders Structure	
ISIS	
TUFLOW	

ISIS Files

Model Geometry (.dat) and Associated Files (e.g.: .ief, .zzl, .zzd, .zzu,.zzx)	**Design Runs – Fluvial scenarios:** S01_Main_Q1000_FluMi_C_Des_Iss2.DAT S01_Main_Q200_FluMi_C_Des_Iss2.DAT S01_Main_Q100_FluMi_C_Des_Iss2.DAT S01_Main_Q50_FluMi_C_Des_Iss2.DAT S01_Main_Q20_FluMi_C_Des_Iss2.DAT S01_Main_Q10_FluMi_C_Des_Iss2.DAT S01_Main_Q5_FluMi_C_Des_Iss2.DAT S01_Main_Q2_FluMi_C_Des_Iss2.DAT S01_Clau_Q1000_Flu_C_Des_Iss1.DAT S01_Clau_Q200_Flu_C_Des_Iss1.DAT S01_Clau_Q100_Flu_C_Des_Iss1.DAT S01_Clau_Q50_Flu_C_Des_Iss1.DAT S01_Clau_Q20_Flu_C_Des_Iss1.DAT S01_Clau_Q10_Flu_C_Des_Iss1.DAT S01_Clau_Q5_Flu_C_Des_Iss1.DAT S01_Clau_Q2_Flu_C_Des_Iss1.DAT S01_Kars_Q1000_Flu_C_Des_Iss1.DAT S01_Kars_Q200_Flu_C_Des_Iss1.DAT S01_Kars_Q100_Flu_C_Des_Iss1.DAT S01_Kars_Q50_Flu_C_Des_Iss1.DAT S01_Kars_Q20_Flu_C_Des_Iss1.DAT S01_Kars_Q10_Flu_C_Des_Iss1.DAT S01_Kars_Q5_Flu_C_Des_Iss1.DAT S01_Kars_Q2_Flu_C_Des_Iss1.DAT S01_Rine_Q1000_FluMi_C_Des_Iss1.DAT S01_Rine_Q200_FluMi_C_Des_Iss1.DAT S01_Rine_Q100_FluMi_C_Des_Iss1.DAT S01_Rine_Q50_FluMi_C_Des_Iss1.DAT S01_Rine_Q20_FluMi_C_Des_Iss1.DAT S01_Rine_Q10_FluMi_C_Des_Iss1.DAT S01_Rine_Q5_FluMi_C_Des_Iss1.DAT S01_Rine_Q2_FluMi_C_Des_Iss1.DAT **Design Runs – Tidal Scenarios:** S01_Main_Q1000_CoMi_C_Des_Iss2.DAT S01_Main_Q200_CoMi_C_Des_Iss2.DAT S01_Main_Q100_CoMi_C_Des_Iss2.DAT S01_Main_Q50_CoMi_C_Des_Iss2.DAT S01_Main_Q20_CoMi_C_Des_Iss2.DAT S01_Main_Q10_CoMi_C_Des_Iss2.DAT S01_Main_Q5_CoMi_C_Des_Iss2.DAT

	S01_Main_Q2_CoMi_C_Des_Iss2.DAT S01_Rine_Q1000_CoMi_C_Des_Iss1.DAT S01_Rine_Q200_CoMi_C_Des_Iss1.DAT S01_Rine_Q100_CoMi_C_Des_Iss1.DAT S01_Rine_Q50_CoMi_C_Des_Iss1.DAT S01_Rine_Q20_CoMi_C_Des_Iss1.DAT S01_Rine_Q10_CoMi_C_Des_Iss1.DAT S01_Rine_Q5_CoMi_C_Des_Iss1.DAT S01_Rine_Q2_CoMi_C_Des_Iss1.DAT **Calibration Runs:** S01_Nov2009_Flu_C_Cal_Bld_v012.DAT S01_Dec2006_Flu_C_Cal_Bld_v003.DAT **Sensitivity Runs** S01_Main_Q100_FluMi_C_Sen_AfIn.dat S01_Main_Q100_FluMi_C_Sen_FlDe.dat S01_Main_Q100_FluMi_C_Sen_FlIn.dat S01_Main_Q200_CoMi_C_Sen_DeSurDu.dat S01_Main_Q200_CoMi_C_Sen_InSurDu.dat S01_Clau_Q100_Flu_C_Sen_AfDe.dat S01_Clau_Q100_Flu_C_Sen_AfIn.dat S01_Clau_Q100_Flu_C_Sen_BoDo.dat S01_Clau_Q100_Flu_C_Sen_BoHa.dat S01_Clau_Q100_Flu_C_Sen_FlDe.dat S01_Clau_Q100_Flu_C_Sen_FlIn.dat S01_Kars_Q100_Flu_C_Sen_FlDe.dat S01_Kars_Q100_Flu_C_Sen_FlIn.dat S01_Rine_Q100_FluMi_C_Sen_FlDe.dat S01_Rine_Q100_FluMi_C_Sen_FlIn.dat S01_Rine_Q200_CoMi_C_Sen_DeSurDu.DAT S01_Rine_Q200_CoMi_C_Sen_InSurDu.dat **ABD Runs** S01_Main_Q200_FluMi_ABD_RHSDef1_Iss1.DAT S01_Main_Q200_FluMi_ABD_RHSDef2_Iss1.dat S01_Main_Q1000_FluMi_ABD_RHSDef3_Iss1.dat S01_Main_Q1000_FluMi_ABD_LHSDef4_Iss1.dat S01_Main_Q1000_FluMi_ABD_LHSDef5_Iss1.dat S01_Main_Q100_FluMi_ABD_LHSDef6_Iss1.DAT S01_Main_Q1000_FluMi_ABD_RHSDef7_Iss1.dat S01_Main_Q100_CoMi_ABD_TidalDef_Iss1.dat

	S01_Rine_Q1000_CoMi_ABD_RHSTidalDef_Iss1.dat S01_Rine_Q1000_CoMi_ABD_TidalDef_Iss1.dat
Hydrological Inflow Files	**Design Runs – Current Scenarios:** **Current Fluvial Scenarios:** S01_Main_Flu1000yr_Co50yr_Iss2.IED S01_Main _Flu200yr_Co10yr_Iss2.IED S01_Main _Flu100yr_Co5yr_Iss2.IED S01_Main _Flu50yr_Co2yr_Iss2.IED S01_Main _Flu20yr_Co1yr_Iss2.IED S01_Main _Flu10yr_Co0.5yr_Iss2.IED S01_Main _Flu5yr_Co0.2yr_Iss2.IED S01_Main _Flu2yr_Co0.2yr_Iss2.IED S01_Clau_Flu1000yr_Iss2.IED S01_Clau _Flu200yr_Iss2.IED S01_Clau _Flu100yr_Iss2.IED S01_Clau _Flu50yr_Iss2.IED S01_Clau _Flu20yr_Iss2.IED S01_Clau _Flu10yr_Iss2.IED S01_Clau _Flu5yr_Iss2.IED S01_Clau _Flu2yr_Iss2.IED S01_Kars_Flu1000yr_v2.IED S01_Kars_Flu200yr_v2.IED S01_Kars_Flu100yr_v2.IED S01_Kars_Flu50yr_v2.IED S01_Kars_Flu20yr_v2.IED S01_Kars_Flu10yr_v2.IED S01_Kars_Flu5yr_v2.IED S01_Kars_Flu2yr_v2.IED S01_Rine_Flu1000yr_Co50yr.IED S01_Rine _Flu200yr_Co10yr.IED S01_Rine _Flu100yr_Co5yr.IED S01_Rine _Flu50yr_Co2yr.IED S01_Rine _Flu20yr_Co1yr.IED S01_Rine _Flu10yr_Co0.5yr.IED S01_Rine _Flu5yr_Co0.2yr.IED S01_Rine _Flu2yr_Co0.2yr.IED **Current Tidal Scenarios** S01_Main _Flu50yr_Co1000yr_Iss2.IED S01_Main _Flu10yr_Co200yr_Iss2.IED S01_Main _Flu5yr_Co100yr_Iss2.IED S01_Main _Flu2yr_Co50yr_Iss2.IED

	S01_Main _Flu2yr_Co20yr_Iss2.IED S01_Main _Flu2yr_Co10yr_Iss2.IED S01_Main _Flu2yr_Co5yr_Iss2.IED S01_Main _Flu2yr_Co2yr_Iss2.IED S01_Rine _Flu50yr_Co1000yr.IED S01_Rine _Flu10yr_Co200yr.IED S01_Rine _Flu5yr_Co100yr.IED S01_Rine _Flu2yr_Co50yr.IED S01_Rine _Flu2yr_Co20yr.IED S01_Rine _Flu2yr_Co10yr.IED S01_Rine _Flu2yr_Co5yr.IED S01_Rine _Flu2yr_Co2yr.IED **Calibration Runs** November_2009_NoEden_Tribs_v009.IED December_2006_NoEden_Tribs_v002.IED **Sensitivity Runs** S01_Main_Flu100yr_Co5yr_FlDe.IED S01_Main_Flu100yr_Co5yr_FlIn.IED S01_Main_Flu10yr_Co200yr_DeSurDu.IED S01_Main_Flu10yr_Co200yr_InSurDu.IED S01_Clau_Flu100yr_Sen_FlDe.IED S01_Clau_Flu100yr_Sen_FlIn.IED S01_Kars_Flu100yr_Sen_FlDe.IED S01_Kars_Flu100yr_Sen_FlIn.IED S01_Rine_Flu100yr_Co5yr_Sen_FlDe.IED S01_Rine_Flu100yr_Co5yr_Sen_FlIn.IED S01_Rine_Flu10yr_Co200yr_DeSurDu.IED S01_Rine_Flu10yr_Co200yr_InSurDu.IED

TUFLOW Files	
TUFLOW Control Files (.tcf) and Associated Files (e.g.: ecf, tgc, tbc)	**Design Runs – Current Fluvial Scenarios:** S01_Main_Q1000_FluMi_C_Des_Iss2.tcf S01_Main_Q200_FluMi_C_Des_Iss2.tcf S01_Main_Q100_FluMi_C_Des_Iss2.tcf S01_Main_Q50_FluMi_C_Des_Iss2.tcf S01_Main_Q20_FluMi_C_Des_Iss2.tcf S01_Main_Q10_FluMi_C_Des_Iss2.tcf S01_Main_Q5_FluMi_C_Des_Iss2.tcf S01_Main_Q2_FluMi_C_Des_Iss2.tcf S01_Clau_Q1000_Flu_C_Des_Iss1.tcf S01_Clau_Q200_Flu_C_Des_Iss1.tcf S01_Clau_Q100_Flu_C_Des_Iss1.tcf S01_Clau_Q50_Flu_C_Des_Iss1.tcf S01_Clau_Q20_Flu_C_Des_Iss1.tcf S01_Clau_Q10_Flu_C_Des_Iss1.tcf S01_Clau_Q5_Flu_C_Des_Iss1.tcf S01_Clau_Q2_Flu_C_Des_Iss1.tcf S01_Kars_Q1000_Flu_C_Des_Iss1.tcf S01_Kars_Q200_Flu_C_Des_Iss1.tcf S01_Kars_Q100_Flu_C_Des_Iss1.tcf S01_Kars_Q50_Flu_C_Des_Iss1.tcf S01_Kars_Q20_Flu_C_Des_Iss1.tcf S01_Kars_Q10_Flu_C_Des_Iss1.tcf S01_Kars_Q5_Flu_C_Des_Iss1.tcf S01_Kars_Q2_Flu_C_Des_Iss1.tcf S01_Rine_Q1000_FluMi_C_Des_Iss1.tcf S01_Rine_Q200_FluMi_C_Des_Iss1.tcf S01_Rine_Q100_FluMi_C_Des_Iss1.tcf S01_Rine_Q50_FluMi_C_Des_Iss1.tcf S01_Rine_Q20_FluMi_C_Des_Iss1.tcf S01_Rine_Q10_FluMi_C_Des_Iss1.tcf S01_Rine_Q5_FluMi_C_Des_Iss1.tcf S01_Rine_Q2_FluMi_C_Des_Iss1.tcf **Design Runs – Current Tidal Scenarios:** S01_Main_Q1000_CoMi_C_Des_Iss2.tcf S01_Main_Q200_CoMi_C_Des_Iss2.tcf S01_Main_Q100_CoMi_C_Des_Iss2.tcf S01_Main_Q50_CoMi_C_Des_Iss2.tcf S01_Main_Q20_CoMi_C_Des_Iss2.tcf S01_Main_Q10_CoMi_C_Des_Iss2.tcf S01_Main_Q5_CoMi_C_Des_Iss2.tcf S01_Main_Q2_CoMi_C_Des_Iss2.tcf

	S01_Rine_Q1000_CoMi_C_Des_Iss1.tcf S01_Rine_Q200_CoMi_C_Des_Iss1.tcf S01_Rine_Q100_CoMi_C_Des_Iss1.tcf S01_Rine_Q50_CoMi_C_Des_Iss1.tcf S01_Rine_Q20_CoMi_C_Des_Iss1.tcf S01_Rine_Q10_CoMi_C_Des_Iss1.tcf S01_Rine_Q5_CoMi_C_Des_Iss1.tcf S01_Rine_Q2_CoMi_C_Des_Iss1.tcf **Calibration Runs** S01_Nov2009_Flu_C_Cal_Bld_v012.tcf S01_Dec2006_Flu_C_Cal_Bld_v003.tcf **Sensitivity Runs** S01_Main_Q100_FluMi_C_Sen_AfIn.tcf S01_Main_Q100_FluMi_C_Sen_FlDe.tcf S01_Main_Q100_FluMi_C_Sen_FlIn.tcf S01_Main_Q200_CoMi_C_Sen_DeSurDu.tcf S01_Main_Q200_CoMi_C_Sen_InSurDu.tcf S01_Clau_Q100_Flu_C_Sen_AfDe.tcf S01_Clau_Q100_Flu_C_Sen_AfIn.tcf S01_Clau_Q100_Flu_C_Sen_BoDo.tcf S01_Clau_Q100_Flu_C_Sen_BoHa.tcf S01_Clau_Q100_Flu_C_Sen_FlDe.tcf S01_Clau_Q100_Flu_C_Sen_FlIn.tcf S01_Kars_Q100_Flu_C_Sen_FlDe.tcf S01_Kars_Q100_Flu_C_Sen_FlIn.tcf S01_Rine_Q100_FluMi_C_Sen_FlDe.tcf S01_Rine_Q100_FluMi_C_Sen_FlIn.tcf S01_Rine_Q200_CoMi_C_Sen_DeSurDu.tcf S01_Rine_Q200_CoMi_C_Sen_InSurDu.tcf **ABD Runs** S01_Main_Q200_FluMi_ABD_RHSDef1_Iss1.tcf S01_Main_Q200_FluMi_ABD_RHSDef2_Iss1.tcf S01_Main_Q1000_FluMi_ABD_RHSDef3_Iss1.tcf S01_Main_Q1000_FluMi_ABD_LHSDef4_Iss1.tcf S01_Main_Q1000_FluMi_ABD_LHSDef5_Iss1.tcf S01_Main_Q100_FluMi_ABD_LHSDef6_Iss1.tcf S01_Main_Q1000_FluMi_ABD_RHSDef7_Iss1.tcf S01_Main_Q100_CoMi_ABD_TidalDef_Iss1.tcf S01_Rine_Q1000_CoMi_ABD_RHSTidalDef_Iss1.tcf S01_Rine_Q1000_CoMi_ABD_TidalDef_Iss1.tcf

Grid Orientation File	2d_loc_10m_S01_Ennis.MIF 2d_loc_40m_S01_Ennis.MIF 2d_loc_Clau_10m_S01_Ennis.MIF 2d_loc_Karstic_10m_S01_Ennis.MIF 2d_loc_Rine_40m_S01_Ennis.MIF 2d_loc_Calib_10m_S01_Ennis.MIF
Material Files	2d_mat_S01_Ennis_Rural.MIF 2d_mat_S01_Ennis_Dense_Vegetation.MIF 2d_mat_S01_Ennis_Short_Grass.MIF 2d_mat_S01_Ennis_Urban.MIF 2d_mat_S01_Ennis_Water.MIF 2d_mat_S01_Ennis_Avenues_Footpaths.MIF 2d_mat_S01_Ennis_Roads.MIF 2d_mat_S01_Ennis_Buildings.MIF 2d_mat_S01_Ennis_Masonry.MIF 2d_mat_S01_Ennis_Flat_Rock.MIF S01_Ennis_Landuse.tmf **Sensitivity runs** S01_Ennis_Landuse_Sen_RoDe.tmf S01_Ennis_Landuse_Sen_RoIn.tmf S01_Ennis_Landuse_Kars.tmf
Zpt Files, Model DTM (.asc)	ennis_2m_dtm.asc S02_Quin_2m_dtm.asc S01 SAR.asc
Breaklines Files	2d_zln_notsurv_banktop_10m_S01_Ennis.mif 2d_zln_Def_ISIS.MIF 2d_zln_Breaklines_10m_S01_Ennis.MIF 2d_zln_surv_banktop_10m_S01_Ennis.MIF 2d_zln_notsurv_banktop_40m_S01_Ennis.mif 2d_zln_Breaklines_40m_S01_Ennis.MIF 2d_zln_surv_banktop_40m_S01_Ennis.MIF 2d_zln_notsurv_banktop_Clau_10m_S01_Ennis.mif 2d_zln_Def_ISIS_Clau.MIF 2d_zln_notsurv_banktop_Karstic_10m_S01_Ennis.mif 2d_zln_notsurv_banktop_Rine_40m_S01_Ennis.mif 2d_zln_Breaklines_Rine_40m_S01_Ennis.MIF 2d_zln_surv_banktop_Rine_40m_S01_Ennis.mif 2d_zln_notsurv_banktop_Calib_10m_S01_Ennis.mif 2d_zln_Breaklines_Calib_40m_S01_Ennis.MIF

	ABD Runs 2d_zln_Def_ISIS_ABD_RHSDef1.MIF 2d_zsh_S01_Ennis_ABD_10m_ABD_RHSDef1.MIF 2d_zln_notsurv_banktop_10m_S01_Ennis_Iss2_ABD_RHSDef1.MIF 2d_zsh_S01_Ennis_ABD_40m.MIF 2d_zln_Def_ISIS_ABD_RHSDef2.MIF 2d_zln_Def_ISIS_ABD_RHSDef3.MIF 2d_zln_Def_ISIS_ABD_LHSDef4.MIF 2d_zln_Def_ISIS_ABD_LHSDef5.MIF 2d_zln_Def_ISIS_ABD_LHSDef6.MIF 2d_zln_Def_ISIS_ABD_RHSDef7.MIF 2d_zln_surv_banktop_40m_S01_Ennis_ABD_TidalDef.MIF 2d_zln_notsurv_banktop_40m_S01_Ennis_ABD_TidalDef.MIF 2d_zsh_S01_Ennis_ABD_40m_TidalDef.MIF 2d_zln_notsurv_banktop_Rine_40m_S01_Ennis_ABD_RHSTidalDef.MIF 2d_zln_surv_banktop_Rine_40m_S01_Ennis_ABD_RHSTidalDef.MIF 2d_zsh_S01_Rine_ABD_40m_RHSTidalDef.MIF 2d_zln_notsurv_banktop_Rine_40m_S01_Ennis_ABD_TidaDef.MIF 2d_zln_surv_banktop_Rine_40m_S01_Ennis_ABD_TidalDef.MIF 2d_zsh_S01_Rine_ABD_40m_TidalDef.MIF
Boundary Files	2d_bc_hxe_10m_S01_Ennis.MIF 2d_bc_hxi_10m_S01_Ennis.MIF 2d_bc_sx_Underpasses_10m_S01_Ennis.MIF 2d_bc_QT_10m_S01_Ennis.MIF 2d_bc_hxe_40m_S01_Ennis.MIF 2d_bc_hxi_40m_S01_Ennis.MIF 2d_bc_sx_Underpasses_40m_S01_Ennis.MIF 2d_bc_hxe_Clau_10m_S01_Ennis.MIF 2d_bc_hxi_Clau_10m_S01_Ennis.MIF 2d_bc_hxe_Karstic_10m_S01_Ennis.MIF 2d_bc_hxi_Karstic_10m_S01_Ennis.MIF 2d_bc_sx_Karstic_10m_S01_Ennis.MIF 2d_bc_hxe_Rine_40m_S01_Ennis.MIF 2d_bc_hxi_Rine_40m_S01_Ennis.MIF 2d_bc_sx_Underpasses_Rine_40m_S01_Ennis.MIF 2d_bc_hxe_Calib_10m_S01_Ennis.MIF 2d_bc_hxi_Calib_10m_S01_Ennis.MIF 2d_bc_hxi_Calib_40m_S01_Ennis.MIF 2d_bc_sx_Underpasses_Calib_10m_S01_Ennis.MIF

	ABD Runs 2d_bc_HQ_40m_S01_Ennis_ABD_TidalDef.MIF 2d_bc_HQ_40m_S01_Rine_ABD_TidalDef.MIF 2d_bc_hxe_10m_S01_Ennis_ABD.MIF 2d_bc_hxe_40m_S01_Ennis_ABD_TidalDef.MIF 2d_bc_hxe_Rine_40m_S01_Ennis_ABD_RHSTidalDef.MIF 2d_bc_hxe_Rine_40m_S01_Ennis_ABD_TidalDef.MIF
Flow/Head Files in bc_dbase	**Design Runs:** **Current Fluvial Scenarios:** bc_dbase_S01_Eden_Q1000.csv bc_dbase_S01_Eden_Q100.csv bc_dbase_S01_Eden_Q50.csv bc_dbase_S01_Eden_Q10.csv bc_dbase_S01_Eden_Q5.csv bc_dbase_S01_Eden_Q2.csv
Initial Water Level Files	NA
Time Series Files	**Design Runs – Current Scenario:** QT_S01_27_1050_6.csv
One Dimensional Network Files	1d_ISIS_nodes_10m_S01_Ennis.MIF 1d_ISIS_nodes_40m_S01_Ennis.MIF 1d_ISIS_nodes_Clau_10m_S01_Ennis.MIF 1d_ISIS_nodes_Karstic_10m_S01_Ennis.MIF 1d_ISIS_nodes_Rine_40m_S01_Ennis.MIF 1d_ISIS_nodes_Calib_10m_S01_Ennis.MIF
Available 2D Result Files	Depth, stage, hazard and velocity 2d results in ASCII file format for all available design return periods.

Model Run Log						
Sr. No.	**Model File Name**	**Start Time**	**End Time**	**Time Step**	**Advanced Options /Other Information**	**Comments on Model Stability**
Design Runs						
1	S01_Main_Q1000_FluMi_C_Des_Iss2.DAT	350	800	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. Dflood =10m Maxitr =29 Matrix Dummy Coefficient =0.001 Global Matrix Dummy Coefficient = 0.001 All other run parameters = default.	Convergence within manufacturer tolerance.
2	S01_Main_Q200_FluMi_C_Des_Iss2.DAT	350	700	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
3	S01_Main_Q100_FluMi_C_Des_Iss2.DAT	350	700	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
4	S01_Main_Q50_FluMi_C_Des_Iss2.DAT	350	700	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.

Model Run Log

Sr. No.	Model File Name	Start Time	End Time	Time Step	Advanced Options /Other Information	Comments on Model Stability
Design Runs						
5	S01_Main_Q20_FluMi_C_Des_Iss2.DAT	350	700	2 sec 1D 4 sec 2D	“Automated Preissmann Slot for River Sections” is checked and “perform corrective 1d timestep” is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
6	S01_Main_Q10_FluMi_C_Des_Iss2.DAT	350	700	2 sec 1D 4 sec 2D	“Automated Preissmann Slot for River Sections” is checked and “perform corrective 1d timestep” is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
7	S01_Main_Q5_FluMi_C_Des_Iss2.DAT	350	700	2 sec 1D 4 sec 2D	“Automated Preissmann Slot for River Sections” is checked and “perform corrective 1d timestep” is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
8	S01_Main_Q2_FluMi_C_Des_Iss2.DAT	350	700	2 sec 1D 4 sec 2D	“Automated Preissmann Slot for River Sections” is checked and “perform corrective 1d timestep” is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
9	S01_Main_Q1000_CoMi_C_Des_Iss2.DAT	350	700	2 sec 1D	“Automated Preissmann Slot for River Sections” is checked and “perform	Convergence within manufacturer tolerance.

Sr. No.	Model File Name	Start Time	End Time	Time Step	Advanced Options /Other Information	Comments on Model Stability
Design Runs						
				4 sec 2D	corrective 1d timestep" is checked. Dflood =10m Maxitr =29 All other run parameters = default.	
10	S01_Main_Q200_CoMi_C_Des_Iss2.DAT	350	700	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
11	S01_Main_Q100_CoMi_C_Des_Iss2.DAT	350	700	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
12	S01_Main_Q50_CoMi_C_Des_Iss2.DAT	350	700	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
13	S01_Main_Q20_CoMi_C_Des_Iss2.DAT	350	700	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. Dflood =10m	Convergence within manufacturer tolerance.

Model Run Log						
Sr. No.	**Model File Name**	**Start Time**	**End Time**	**Time Step**	**Advanced Options /Other Information**	**Comments on Model Stability**
Design Runs						
					Maxitr =29 All other run parameters = default.	
14	S01_Main_Q10_CoMi_C_Des_Iss2.DAT	350	800	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
15	S01_Main_Q5_CoMi_C_Des_Iss2.DAT	350	800	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
16	S01_Main_Q2_CoMi_C_Des_Iss2.DAT	350	800	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
17	S01_Clau_Q1000_Flu_C_Des_ISS2.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
18	S01_Clau_Q200_Flu_C_Des_ISS2.DAT	0	50	2 sec 1D	"Automated Preissmann Slot for River Sections" is checked and "perform	Convergence within manufacturer tolerance.

Model Run Log						
Sr. No.	**Model File Name**	**Start Time**	**End Time**	**Time Step**	**Advanced Options /Other Information**	**Comments on Model Stability**
Design Runs						
				4 sec 2D	corrective 1d timestep" is checked. All other run parameters = default.	
19	S01_Clau_Q100_Flu_C_Des_ISS2.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
20	S01_Clau_Q50_Flu_C_Des_ISS2.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
21	S01_Clau_Q20_Flu_C_Des_ISS2.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
22	S01_Clau_Q10_Flu_C_Des_ISS2.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
23	S01_Clau_Q5_Flu_C_Des_ISS2.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
24	S01_Clau_Q2_Flu_C_Des_ISS2.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.

Model Run Log

Sr. No.	Model File Name	Start Time	End Time	Time Step	Advanced Options /Other Information	Comments on Model Stability
Design Runs						
25	S01_Kars_Q1000_Flu_C_Des_Iss2.DAT	0	60	2 sec 1D 4 sec 2D	“Automated Preissmann Slot for River Sections” is checked and “perform corrective 1d timestep” is checked. Dflood =5m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
26	S01_Kars_Q200_Flu_C_Des_Iss2.DAT	0	60	2 sec 1D 4 sec 2D	“Automated Preissmann Slot for River Sections” is checked and “perform corrective 1d timestep” is checked. Dflood =5m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
27	S01_Kars_Q100_Flu_C_Des_Iss2.DAT	0	60	2 sec 1D 4 sec 2D	“Automated Preissmann Slot for River Sections” is checked and “perform corrective 1d timestep” is checked. Dflood =5m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
28	S01_Kars_Q50_Flu_C_Des_Iss2.DAT	0	60	2 sec 1D 4 sec 2D	“Automated Preissmann Slot for River Sections” is checked and “perform corrective 1d timestep” is checked. Dflood =5m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
29	S01_Kars_Q20_Flu_C_Des_Iss2.DAT	0	60	2 sec 1D	“Automated Preissmann Slot for River Sections” is checked and “perform	Convergence within manufacturer tolerance.

Model Run Log						
Sr. No.	**Model File Name**	**Start Time**	**End Time**	**Time Step**	**Advanced Options /Other Information**	**Comments on Model Stability**
Design Runs						
				4 sec 2D	corrective 1d timestep" is checked. Dflood =5m Maxitr =29 All other run parameters = default.	
30	S01_Kars_Q10_Flu_C_Des_Iss2.DAT	0	60	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. Dflood =5m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
31	S01_Kars_Q5_Flu_C_Des_Iss2.DAT	0	60	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. Dflood =5m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
32	S01_Kars_Q2_Flu_C_Des_Iss2.DAT	0	60	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. Dflood =5m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
33	S01_Rine_Q1000_FluMi_C_Des_Iss1.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.

Model Run Log						
Sr. No.	**Model File Name**	**Start Time**	**End Time**	**Time Step**	**Advanced Options /Other Information**	**Comments on Model Stability**
Design Runs						
34	S01_Rine_Q200_FluMi_C_Des_Iss1.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
35	S01_Rine_Q100_FluMi_C_Des_Iss1.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
36	S01_Rine_Q50_FluMi_C_Des_Iss1.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
37	S01_Rine_Q20_FluMi_C_Des_Iss1.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
38	S01_Rine_Q10_FluMi_C_Des_Iss1.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
39	S01_Rine_Q5_FluMi_C_Des_Iss1.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
40	S01_Rine_Q2_FluMi_C_Des_Iss1.DAT	0	50	2 sec 1D	"Automated Preissmann Slot for River Sections" is checked and "perform	Convergence within manufacturer tolerance.

Model Run Log

Sr. No.	Model File Name	Start Time	End Time	Time Step	Advanced Options /Other Information	Comments on Model Stability
Design Runs						
				4 sec 2D	corrective 1d timestep" is checked. All other run parameters = default.	
41	S01_Rine_Q1000_CoMi_C_Des_Iss1.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
42	S01_Rine_Q200_CoMi_C_Des_Iss1.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
43	S01_Rine_Q100_CoMi_C_Des_Iss1.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
44	S01_Rine_Q50_CoMi_C_Des_Iss1.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
45	S01_Rine_Q20_CoMi_C_Des_Iss1.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
46	S01_Rine_Q10_CoMi_C_Des_Iss1.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.

Model Run Log

Sr. No.	Model File Name	Start Time	End Time	Time Step	Advanced Options /Other Information	Comments on Model Stability
Design Runs						
47	S01_Rine_Q5_CoMi_C_Des_Iss1.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
48	S01_Rine_Q2_CoMi_C_Des_Iss1.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.

Model Run Log

Sr. No.	Model File Name	Start Time	End Time	Time Step	Advanced Options /Other Information	Comments on Model Stability
Calibration						
49	S01_Nov2009_Flu_C_Cal_Bld_v012.DAT	746.5	1060	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
50	S01_Dec2006_Flu_C_Cal_Bld_v003.DAT	696	1010	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.

Model Run Log

Sr. No.	Model File Name	Start Time	End Time	Time Step	Advanced Options /Other Information	Comments on Model Stability
	Sensitivity Runs					
	S01_Main_Q100_FluMi_C_Sen_AfIn.DAT	350	800	2 sec 1D 4 sec 2D	“Automated Preissmann Slot for River Sections” is checked and “perform corrective 1d timestep” is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
	S01_Main_Q200_CoMi_C_Sen_InSurDu.DAT	350	800	2 sec 1D 4 sec 2D	“Automated Preissmann Slot for River Sections” is checked and “perform corrective 1d timestep” is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
	S01_Main_Q200_CoMi_C_Sen_DeSurDu.DAT	350	800	2 sec 1D 4 sec 2D	“Automated Preissmann Slot for River Sections” is checked and “perform corrective 1d timestep” is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
	S01_Main_Q100_FluMi_C_Sen_FlDe.DAT	350	800	2 sec 1D 4 sec 2D	“Automated Preissmann Slot for River Sections” is checked and “perform corrective 1d timestep” is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
	S01_Main_Q100_FluMi_C_Sen_FlIn.DAT	350	800	2 sec 1D 4 sec 2D	“Automated Preissmann Slot for River Sections” is checked and “perform corrective 1d timestep” is checked.	Convergence within manufacturer tolerance.

Model Run Log						
Sr. No.	**Model File Name**	**Start Time**	**End Time**	**Time Step**	**Advanced Options /Other Information**	**Comments on Model Stability**
			Sensitivity Runs			
					Dflood =10m Maxitr =29 All other run parameters = default.	
	S01_Clau_Q100_Flu_C_Sen_AfIn.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
	S01_Clau_Q100_Flu_C_Sen_AfDe.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
	S01_Clau_Q100_Flu_C_Sen_BoDo.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
	S01_Clau_Q100_Flu_C_Sen_BoHa.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
	S01_Clau_Q100_Flu_C_Sen_FlIn.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
	S01_Clau_Q100_Flu_C_Sen_FlDe.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.

Model Run Log						
Sr. No.	**Model File Name**	**Start Time**	**End Time**	**Time Step**	**Advanced Options /Other Information**	**Comments on Model Stability**
			Sensitivity Runs			
	S01_Kars_Q100_Flu_C_Sen_FlIn.DAT	0	60	2 sec 1D	"Perform corrective 1d timestep" is checked. Dflood =5m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
	S01_Kars_Q100_Flu_C_Sen_FlDe.DAT	0	60	4 sec 2D	"Perform corrective 1d timestep" is checked. Dflood =5m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
	S01_Rine_Q200_CoMi_C_Sen_InSurDu.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
	S01_Rine_Q200_CoMi_C_Sen_DeSurDu.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
	S01_Rine_Q100_FluMi_C_Sen_FlIn.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
	S01_Rine_Q100_FluMi_C_Sen_FlDe.DAT	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.

Model Run Log						
Sr. No.	**Model File Name**	**Start Time**	**End Time**	**Time Step**	**Advanced Options /Other Information**	**Comments on Model Stability**
			ABD runs			
	S01_Main_Q200_FluMi_ABD_RHSDef1_Iss1.DAT	350	700	2 sec 1D 4 sec 2D	“Automated Preissmann Slot for River Sections” is checked and “perform corrective 1d timestep” is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
	S01_Main_Q200_FluMi_ABD_RHSDef2_Iss1.dat	350	700	2 sec 1D 4 sec 2D	“Automated Preissmann Slot for River Sections” is checked and “perform corrective 1d timestep” is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
	S01_Main_Q1000_FluMi_ABD_RHSDef3_Iss1.dat	350	700	2 sec 1D 4 sec 2D	“Automated Preissmann Slot for River Sections” is checked and “perform corrective 1d timestep” is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
	S01_Main_Q1000_FluMi_ABD_LHSDef4_Iss1.dat	350	700	2 sec 1D 4 sec 2D	“Automated Preissmann Slot for River Sections” is checked and “perform corrective 1d timestep” is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
	S01_Main_Q1000_FluMi_ABD_LHSDef5_Iss1.dat	350	700	2 sec 1D	“Automated Preissmann Slot for River Sections” is checked and “perform	Convergence within manufacturer tolerance.

Model Run Log						
Sr. No.	**Model File Name**	**Start Time**	**End Time**	**Time Step**	**Advanced Options /Other Information**	**Comments on Model Stability**
ABD runs						
				4 sec 2D	corrective 1d timestep" is checked. Dflood =10m Maxitr =29 All other run parameters = default.	
	S01_Main_Q100_FluMi_ABD_LHSDef6_Iss1.DAT	350	700	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
	S01_Main_Q1000_FluMi_ABD_RHSDef7_Iss1.dat	350	700	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
	S01_Main_Q100_CoMi_ABD_TidalDef_Iss1.dat	350	700	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. Dflood =10m Maxitr =29 All other run parameters = default.	Convergence within manufacturer tolerance.
	S01_Rine_Q1000_CoMi_ABD_RHSTidalDef_Iss1.da t	0	50	2 sec 1D 4 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.

Model Run Log

Sr. No.	Model File Name	Start Time	End Time	Time Step	Advanced Options /Other Information	Comments on Model Stability
ABD runs						
	S01_Rine_Q1000_CoMi_ABD_TidalDef_Iss1.dat	0	50	2 sec 1D 4 sec 2D	“Automated Preissmann Slot for River Sections” is checked and “perform corrective 1d timestep” is checked. All other run parameters = default.	Convergence within manufacturer tolerance.

Parameters changed from Default	Justification
Automated Preismann slot for River Sections turned on.	Automated Preismann slot are a standard parameter used to aid model stability particularly in low flows. These Preismann slots have negligible to no impact on the water levels during flood events.
Matrix Dummy Coefficient set to 0.0001	Set to 0.0001 to solve IFAG error. *

*Stage and Flow profiles at all cross sections have been checked to ensure results are sensible and to ensure any changes to the default model run parameters has not impacted on the model results.

Annex E - Flood Mapping

Flood Maps are available through the OPW flood mapping website; http://maps.opw.ie/fhrm/

Fluvial and Coastal Hydraulic Modelling Report

1. Basic Model Information

1.1 General Information	
Model ID:	S03
Unit of Management	27
AFAs included in the Model	Bunratty Sixmilebridge
Primary Watercourses / Water Bodies	Owenagarney River Clovemill
1.2 Reference to other Relevant Reports	
Catchment Description	Hydrology Report Unit of Management 27 – Appendix A2.1
Model Location	Hydraulics Report Unit of Management 27 – Section 3.4.2
HEP Schematisation	Hydrology Report Unit of Management 27 – Appendix B3 – Figure B3.1

2. Survey Data and Base Mapping

2.1 Base Mapping:	OSi data base mapping at scale 1:50k Reference: OS1414_D_BW, OS1416_D_BW
2.2 DTM for 2D Model Domain:	**Within AFAs:** LiDAR data with 2m horizontal resolution and approximately 200mm vertical accuracy has been used to inform the hydraulic model with ground elevation in the floodplain areas included in the AFA boundary.
	Outside AFAs: The supplied LiDAR data covers the area to be modelled outside the AFA. Therefore this has been used instead of SAR, given the much greater accuracy.
2.3 River Channel/Structures Survey	The modelling methodology for all structures within the modelled reaches is detailed in Annex B, and the variety of structures is detailed in Section 3.4. Number of cross sections in the model: 170
2.4 Defence Asset Survey Data	There are two defence schemes present on the Owenagarney River. One is in Sixmilebridge, and the other in Bunratty. Both consist of earthen embankments along both banks of the channel and of the Clovemill. All defences have been included in the model schematisation as shown on the maps presented in Annex A2. The flows and levels in the Clovemill are controlled by a flapped outfall into the Owenagarney River to prevent tidal inundation. A sluice unit in ISIS has been used to represent the flapped outfall. This represents the hydraulics of the flapped outfall accurately. All structure representation and control rules are detailed in Annex B. Further details of the defences are contained in the defence asset database.
2.5 Survey Interaction	The Lidar, IFSAR and topographic survey were checked for anomalies, and to ensure that interactions between were within expected tolerances. No issues were identified in this model.

3. Hydraulic Model Construction and Schematisation

3.1 Software:	**1D domain : ISIS v3.7.0.223**
	2D domain(s): TUFLOW Build 2013-12-AB-iDP-w64
3.2 Model Area / Extent:	

The mapping details for the model extent included in Annex A are as follows:

1. **Full modelled area showing**:
   - River centre lines, HPW/MPW extents, names of watercourses
   - 2D domain area
   - AFA boundary
2. **Maps showing a detailed model schematic of the HPW/MPW reaches are also included**

3.3 Model Reaches: The following model reaches as shown on the maps referred above have been defined in the model:

Watercourse Name	Reach	Upstream Model Node	Downstream Model Node
Owenagarney River	02OWG	02OWG10534	02OWG00000
Owenagarney River	01OWG	01OWG01725	01OWG00000
Clovemill	01CVM	01CVM02684	01CVM00000
Unnamed Trib	27OWH	27OWH00007	27OWH00000
Total model HPW length (km):	**11.91**	**Total model MPW length (km):**	**3.21**

3.4 Model Structures: A full schedule of structures included in the model is provided in Schedule A in Annex B. A summary of the structures included is given below

Culverts:	☒	How many?	1
Bridges:	☒	How many?	6
Fixed crest weirs:	☒	How many?	3
Adjustable crest weirs:	☐	How many?	0
Sluice / Gate structures:	☒	How many?	1
Locks:	☐	How many?	0
Dams:	☐	How many?	0

Other (describe):

Orifice x 4 (1 to represent a bridge, 1 to represent a culvert, 2 to represent a compound overflow structure)

NB: Sluice gate represents a flapped outfall

3.5 Floodplain Schematisation

Out-of-bank areas for MPW reaches have been modelled using a 1D approach in the ISIS model by extending the river channel cross-sections.

Out-of-bank areas for HPW reaches, within Bunratty/Sixmilebridge AFA's, have been modelled using a 1D approach in the ISIS model by extending the river channel cross-sections.

Extended 1D sections are considered appropriate for HPW extents where floodplain flow paths are simple (e.g, parallel to river flow). 1D-2D modelling is required where HPWs flow through urban areas and out-of-bank flows will form complex flow paths.

An overview of the floodplain schematisation is available in the maps shown in Annex A.

3.6 2D Domain Grid Size:	The number of 2D domains defined and the grid sizes of each 2D model domain are as follows:		
	Number of 2D domains: 3		
	Domain 1:	Grid cell size (m) 5	Area (km^2) 3.28
	Domain 2:	Grid cell size (m) 5	Area (km^2) 6.24
	Domain 3:	Grid cell size (m) 40	Area (km^2) 5.31
	2D domains are defined depending on the level of detail required to pick up the appropriate features in the 2D domain that will impact on the local hydraulics. The domain grid square size is typically in the range 5m to 20m, with the smaller grid sizes used in very urbanised areas where there are multiple features that could not be suitably represented in, say, a 10m grid. The model grid is orientated in the main direction of the floodplain flow.		
3.7 Model Breaklines in the 2D Domain:	None		
3.8 Floodplain Structures in the 2D Domain	The spills over the top of the bridge in Sixmilebridge, and the embankment at the downstream end of Clovemill are represented in the 2D domain.		
3.9 Hydraulic Roughness	Hydraulic roughness (Manning's 'n') has been defined in accordance with the approaches described in the main Hydraulics Report. Details of the values adopted for this model are included in Schedule B in Annex B. A summary of Manning's 'n' for the model as a whole is as follows:		

MPW in-bank	Minimum 'n' value:	0.042
	Maximum 'n' value:	0.060
HPW in-bank	Minimum 'n' value:	0.040
	Maximum 'n' value:	0.060
Floodplain (ISIS Model)	No floodplain is represented in ISIS.	
Floodplain (TUFLOW Model)	Manning's 'n' for out of bank areas represented in the TUFLOW model are as defined by OSi NTF land use characteristics, as described in the main Hydraulics Report. Floodplain land uses and adopted roughness values in TUFLOW are as follows:	
	Land Use	**Manning's 'n' Value**
	Buildings	0.100
	Short grass, parks	0.035
	General Urban	0.060
	General Rural	0.045
	Pastures	0.035
	Dense Vegetation	0.080
	Roads	0.025
	Water bodies	0.020

3.10 Spill Units	Spill units are used for a number of different purposes (e.g. irregular weir, lateral spilling in the floodplain).Spill profile geometry is defined using topographic survey data and LiDAR/IfSAR. Spill coefficients used generally vary between 0.9 and 1.5 depending on the type of ground conditions (e.g. rough vegetated, smooth concrete) over which flood flows are spilling. Lower coefficients (<1.0) can be also found to account for lateral spilling perpendicular to the main direction of flow.

3.11 Model Boundaries - Inflows	Hydrological flow hydrographs were input to the model at key model locations as indicated in the tables below. The production of peak flow estimates and flow hydrograph shapes is fully explained in Section 2.3 of the Hydrology Report for Unit of Management 27. For further details on hydrographs and peak flows specifically related to this model please see Appendix A2 and Appendix B3 respectfully of the Hydrology Report for UoM 27. Peak inflows (m^3/s) are summarised in the tables below for the current situation and the design event simulated. These are the final inflows as obtained following calibration to HEPs (see Section 4.2)
(a) Current Situation	Following HEP calibration, the peak inflows (m^3/s) used as inputs to the model at key model locations are summarised in the table below for the current situation.

HEP Reference Name	Input Node in the Hydraulic Model	Annual Exceedance Probability							
		50%	20%	10%	5%	2%	1%	0.5%	0.1%
27_634_4	02OWG10534	26.1	31.8	35.5	39.2	43.9	47.4	50.9	59.0
27_634_5	02OWG09753	26.1	31.8	35.6	39.3	44.0	47.5	51.0	59.1
27_634_7	02OWG09152	26.2	31.9	35.7	39.4	44.1	47.6	51.2	59.3
27_634_8	02OWG08490bu	26.2	32.0	35.8	39.4	44.2	47.7	51.2	59.4
27_634_9	02OWG07864	26.2	32.0	35.8	39.4	44.2	47.7	51.2	59.4
27_634_10	02OWG07293d	26.6	32.4	36.3	40.0	44.8	48.3	51.9	60.2
27_634_11	02OWG07031	26.6	32.4	36.3	40.0	44.8	48.4	52.0	60.3
27_1274_1	02OWG06963d	30.2	36.8	41.1	45.3	50.8	54.8	58.9	68.3
27_1261_2	02OWG04646d	31.4	38.3	42.8	47.2	52.8	57.1	61.3	71.1
27_1193_4	01CVM02684	2.3	2.8	3.2	3.5	3.9	4.2	4.5	5.2
27_1193_5	01CVM01764d	2.4	2.9	3.3	3.6	4.0	4.3	4.7	5.4
27_1193_7	01CVM01148d	2.6	3.1	3.5	3.8	4.3	4.6	5.0	5.7
27_1193_8	01CVM00630d	2.6	3.2	3.5	3.9	4.3	4.7	5.0	5.8
27_1193_9	01CVM00080a	2.6	3.2	3.6	3.9	4.4	4.8	5.1	5.9

(b) Future Scenarios	The peak inflows (m^3/s) used as inputs to the model at key model locations are summarised in the table below for all return periods for the MRFS. These events are selected as these are the MRFS that are to be mapped

HEP Reference Name	Input Node in the Hydraulic Model	MRFS Annual Exceedance Probability							
		50%	20%	10%	5%	2%	1%	0.5%	0.1%
27_634_4	02OWG10534	31.3	38.2	42.6	47.0	52.7	56.9	61.1	70.8
27_634_5	02OWG09753	31.3	38.2	42.7	47.2	52.8	57.0	61.2	70.9
27_634_7	02OWG09152	31.4	38.3	42.8	47.3	52.9	57.1	61.4	71.2
27_634_8	02OWG08490bu	31.4	38.4	43.0	47.3	53.0	57.2	61.4	71.3
27_634_9	02OWG07864	31.4	38.4	43.0	47.3	53.0	57.2	61.4	71.3
27_634_10	02OWG07293d	31.9	38.9	43.6	48.0	53.8	58.0	62.3	72.2
27_634_11	02OWG07031	31.9	38.9	43.6	48.0	53.8	58.1	62.4	72.4
27_1274_1	02OWG06963d	36.2	44.2	49.3	54.4	61.0	65.8	70.7	82.0
27_1261_2	02OWG04646d	37.7	46.0	51.4	56.6	63.4	68.5	73.6	85.3

27_1193_4	01CVM02684	2.8	3.4	3.8	4.2	4.7	5.0	5.4	6.2
27_1193_5	01CVM01764d	2.9	3.5	4.0	4.3	4.8	5.2	5.6	6.5
27_1193_7	01CVM01148d	3.1	3.7	4.2	4.6	5.2	5.5	6.0	6.8
27_1193_8	01CVM00630d	3.1	3.8	4.2	4.7	5.2	5.6	6.0	7.0
27_1193_9	01CVM00080a	3.1	3.8	4.3	4.7	5.3	5.8	6.1	7.1

(b) Future Scenarios

The peak inflows (m^3/s) used as inputs to the model at key model locations are summarised in the table below for 10%, 1% and 0.1% events for the HEFS. These events are selected as these are the HEFS that are to be mapped.

HEP Reference Name	Input Node in the Hydraulic Model	HEFS Annual Exceedance Probability		
		10%	1%	0.1%
27_634_4	02OWG10534	46.2	61.6	76.7
27_634_5	02OWG09753	46.3	61.8	76.8
27_634_7	02OWG09152	46.4	61.9	77.1
27_634_8	02OWG08490bu	46.5	62.0	77.2
27_634_9	02OWG07864	46.5	62.0	77.2
27_634_10	02OWG07293d	47.2	62.8	78.3
27_634_11	02OWG07031	47.2	62.9	78.4
27_1274_1	02OWG06963d	53.4	71.2	88.8
27_1261_2	02OWG04646d	55.6	74.2	92.4
27_1193_4	01CVM02684	4.2	5.5	6.8
27_1193_5	01CVM01764d	4.3	5.6	7.0
27_1193_7	01CVM01148d	4.6	6.0	7.4
27_1193_8	01CVM00630d	4.6	6.1	7.5
27_1193_9	01CVM00080a	4.7	6.2	7.7

3.12 Model Boundaries – Downstream Conditions

Downstream boundary conditions adopted in the model are as follows:

A static low water tidal boundary was used for the HEP calibration. All other models have tidal HTBDY curves as boundary units.

Tidal level hydrographs at the outlet of the Owenagarney River were produced for a series of design events. . The time series were set up as boundary conditions for the hydraulic model along the coastal boundary of the 2D model and also at the downstream extents of the HPW reaches in the ISIS model (see maps in Annex A). Full details on how these tidal level hydrographs were derived are provided in Appendix D of the main Hydraulics Report. Peak tidal levels are summarised in the table below for the current and future situations.

	Annual Exceedance Probability										
Peak Tidal Levels (mOD)	500%	200%	100%	50%	20%	10%	5%	2%	1%	0.5%	0.1%
	2.9	3.0	3.1	3.3	3.5	3.7	3.8	4.0	4.2	4.3	4.7

	MRFS Annual Exceedance Probability										
Peak Tidal Levels (mOD)	500%	200%	100%	50%	20%	10%	5%	2%	1%	0.5%	0.1%
	3.5	3.6	3.7	3.9	4.1	4.3	4.4	4.6	4.8	4.9	5.3

	HEFS Annual Exceedance Probability										
Peak Tidal Levels (mOD)	**500%**	**200%**	**100%**	**50%**	**20%**	**10%**	**5%**	**2%**	**1%**	**0.5%**	**0.1%**
	4.0	4.1	4.2	4.4	4.6	4.8	4.9	5.1	5.3	5.4	5.8

4. Hydraulic Model Calibration and Sensitivity

4.1 Model Calibration and Verification to Historical Events	The approach to model calibration is documented in the main Hydraulics Report. The analysis of available flood event data and high flow data for possible consideration as calibration and verification events is covered in detail in the Hydrology Report. A summary of the calibration and verification events along with associated model calibration results is as follows:
Catchment Gauging	Is modelled catchment: Gauged ☒ Ungauged ☐ check one box only
Calibration Events	None are available for this catchment
Conclusion	Calibration was not possible due to lack of information as outlined in Appendix F of the main Hydrology Report.
4.2 Calibration to HEP	Calibration of the hydraulic model to the HEP target flows has been carried out for all of the AEP design events. Section 2.7.2 of the hydrology report for UoM 27 provides a summary of the calibration to HEP process. Preliminary inflow hydrographs derived from the hydrological analysis and input to the model were adjusted in time so that their respective peak flows coincide with the peak time of the propagating flood wave as it is routed down the model. Total peak flows predicted by the hydraulic model at HEP locations were then compared to the HEP target flows estimated during the hydrological analysis. Calibration results were deemed appropriate and within the 10% error for calibration, with exceptions that had documented reasons behind them. Therefore the calibration to HEP has been passed for the main channel. The ±10% target allows for good agreement between the hydrological estimates and the hydraulic results without the addition/removal of unrealistic volumes of flow from the model. The robustness of this has been verified by the agreement of the design flood maps. Calibration has not been passed for the tributary of the Clovemill because of interaction between the upstream of this channel and the Owenagarney through a series of drainage ditches, vastly increasing flows in the Clovemill. Therefore this is flagged as unsuitable for calibration.

HEP Reference Name	**Input Node in the Hydraulic Model**	**Annual Exceedance Probability**							
		Percentage Difference (%)							
		50%	**20%**	**10%**	**5%**	**2%**	**1%**	**0.5%**	**0.1%**
27_634_4	02OWG10534	0.6%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
27_634_5	02OWG09753	0.4%	0.5%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%
27_634_7	02OWG09152	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
27_634_8	02OWG08490bu	-0.1%	0.0%	-0.1%	-0.1%	-0.1%	0.0%	0.0%	0.0%
27_634_9	02OWG07864	-0.9%	0.3%	0.1%	-0.2%	-0.4%	-0.8%	-1.2%	-2.3%
27_634_10	02OWG07293d	-0.9%	0.4%	0.2%	-0.1%	-0.3%	-0.7%	-1.0%	-2.2%
27_634_11	02OWG07031	-1.0%	0.2%	0.1%	-0.2%	-0.5%	-0.8%	-1.2%	-2.3%
27_1274_1	02OWG06963d	-0.9%	0.2%	0.0%	-0.2%	-0.4%	-0.7%	-1.0%	-2.0%
27_1261_2	02OWG04646d	-0.9%	0.2%	0.0%	-0.2%	-0.4%	-0.6%	-0.9%	-3.5%
27_1193_4	01CVM02684	3.2%	2.9%	3.1%	3.2%	3.0%	3.0%	3.1%	3.0%

27_1193_5	01CVM01764d	0.1%	-0.2%	0.1%	0.1%	0.0%	0.0%	0.1%	-0.2%
27_1193_7	01CVM01148d	-0.1%	-0.1%	0.1%	0.1%	0.0%	0.1%	0.1%	-0.5%
27_1193_8	01CVM00630d	0.0%	0.1%	0.1%	0.0%	0.1%	0.0%	0.1%	-0.5%
27_1193_9	01CVM00080a	0.1%	0.2%	0.0%	0.1%	0.2%	0.0%	0.3%	-0.5%

4.3 Fluvial and Tidal Events Simulated

The River Owenagarney is influenced by the tidal levels along the Shannon Estuary. As such, a joint probability analysis of the coincidence of fluvial flood flows and coastal flood levels was carried out to determine the appropriate combinations of flows and sea levels to be used for the design probability events, as required under Section 6.5.6 of the Stage I Project Brief.

Methodology and outcomes of this analysis are detailed in the main Hydraulic Report and in the Hydrology Report. A summary of the joint probability of fluvial and tidal conditions used for the hydraulic modelling in the Bunratty and Sixmilebridge AFA's is reported in the table below.

Combination of Fluvial and Tidal Events

	Joint Probability Design Event	AEP adopted for Fluvial Flows and Tidal Levels	
Scenario	**Overall AEP**	**Fluvial**	**Tidal**
1	50%	50%	500%
2	50%	50%	50%
3	20%	20%	500%
4	20%	50%	20%
5	10%	10%	200%
6	10%	50%	10%
7	5%	5%	100%
8	5%	50%	5%
9	2%	2%	50%
10	2%	50%	2%
11	1%	1%	20%
12	1%	20%	1%
13	0.5%	0.5%	10%
14	0.5%	10%	0.5%
15	0.1%	0.1%	2%
16	0.1%	2%	0.1%

4.4 Model Sensitivity

Sensitivity tests have been carried out in order to assess the sensitivity of the predicted peak water levels to alterations in roughness (Manning's 'n'), fluvial flow, afflux at key structures and downstream conditions. The sensitivity runs were carried out for the 1% AEP fluvial dominated event with the corresponding tidal event from the joint probability study in all cases with the only exception of the tests on the downstream boundary conditions, which were carried out for the 0.5% AEP tidal dominated events with the corresponding fluvial event (see Section 4.3).

Uncertainty maps illustrating the results of the sensitivity analysis will be delivered as part of the final stage of this work.

+20% Manning's n	Watercourse	Average Water Level Difference (m)	Maximum Water Level Difference (m)	Cross-section / Reach where the Maximum Difference occurs
	Owenagarney River	0.00	0.00	02OWG04776
	Owenagarney River	0.00	0.00	01OWG00738
	Clovemill	0.03	0.04	01CVM01764

	Unnamed Trib	0.00	0.00	27OWH00004

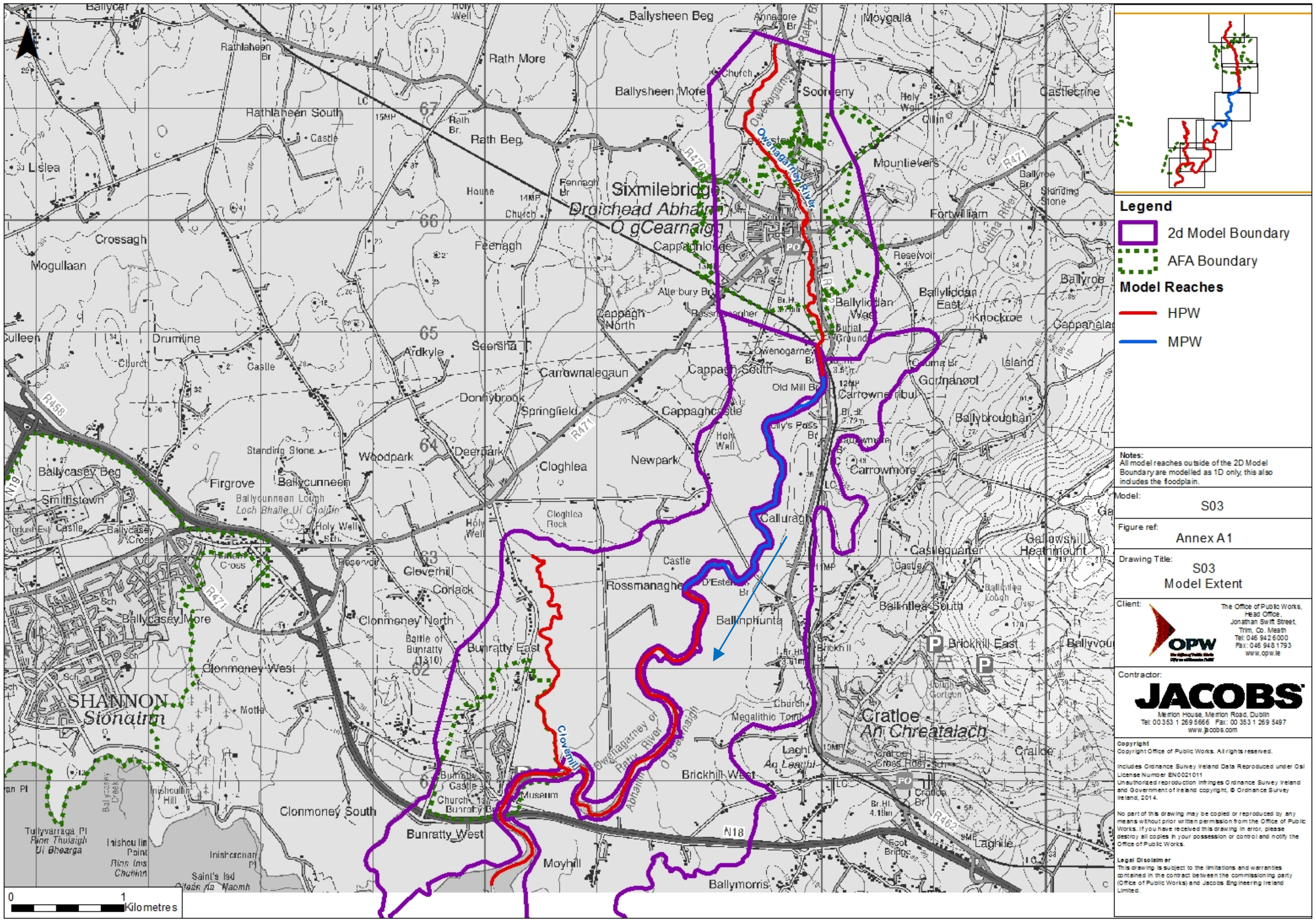
-20% Manning's n	**Watercourse**	**Average Water Level Difference**	**Maximum Water Level Difference**	**Cross-section where the Maximum Difference occurs**
	Owenagarney River	0.00	0.00	02OWG04776
	Owenagarney River	0.00	0.00	01OWG00738
	Clovemill	-0.03	-0.04	01CVM01764
	Unnamed Trib	0.00	0.00	27OWH00004
+20% inflows	**Watercourse**	**Average Water Level Difference**	**Maximum Water Level Difference**	**Cross-section where the Maximum Difference occurs**
	Owenagarney River	0.06	0.21	02OWG07397
	Owenagarney River	0.00	0.00	01OWG01643
	Clovemill	1.09	1.37	01CVM02684
	Unnamed Trib	0.08	0.09	27OWH00004ds
-20% inflows	**Watercourse**	**Average Water Level Difference**	**Maximum Water Level Difference**	**Cross-section where the Maximum Difference occurs**
	Owenagarney River	-0.06	-0.23	02OWG07397
	Owenagarney River	0.00	0.00	01OWG01725
	Clovemill	-0.37	-0.46	01CVM01060
	Unnamed Trib	-0.10	-0.12	27OWH00004ds
Afflux at Key Structure	No structures were identified with significant afflux within the AFA.			
Downstream Conditions Duration of the surge component of tidal boundary is decreased by 50%	The change to the downstream conditions has resulted in a decrease in maximum water level of 185mm at the downstream boundary (01OWG0000). The water level response extends to cross section 02OWG03096 where the decrease is 60mm. The change in water level causes no significant effect on the modelled flood extent.			
Downstream Conditions Duration of the surge component of tidal boundary is increased by 100%	The change to the downstream conditions has resulted in an increase in maximum water level of 210mm at the downstream boundary (01OWG0000). The water level response extends to cross section 02OWG03096 where the increase is 30mm. The change in water level causes no significant effect on the modelled flood extent.			
4.5 Model Files	The hydraulic model files associated with this model are provided as a separate deliverable under the contract, as required under Sections 7.8 and 13 of the Stage I Project Brief. The model files included are detailed in Annex D.			

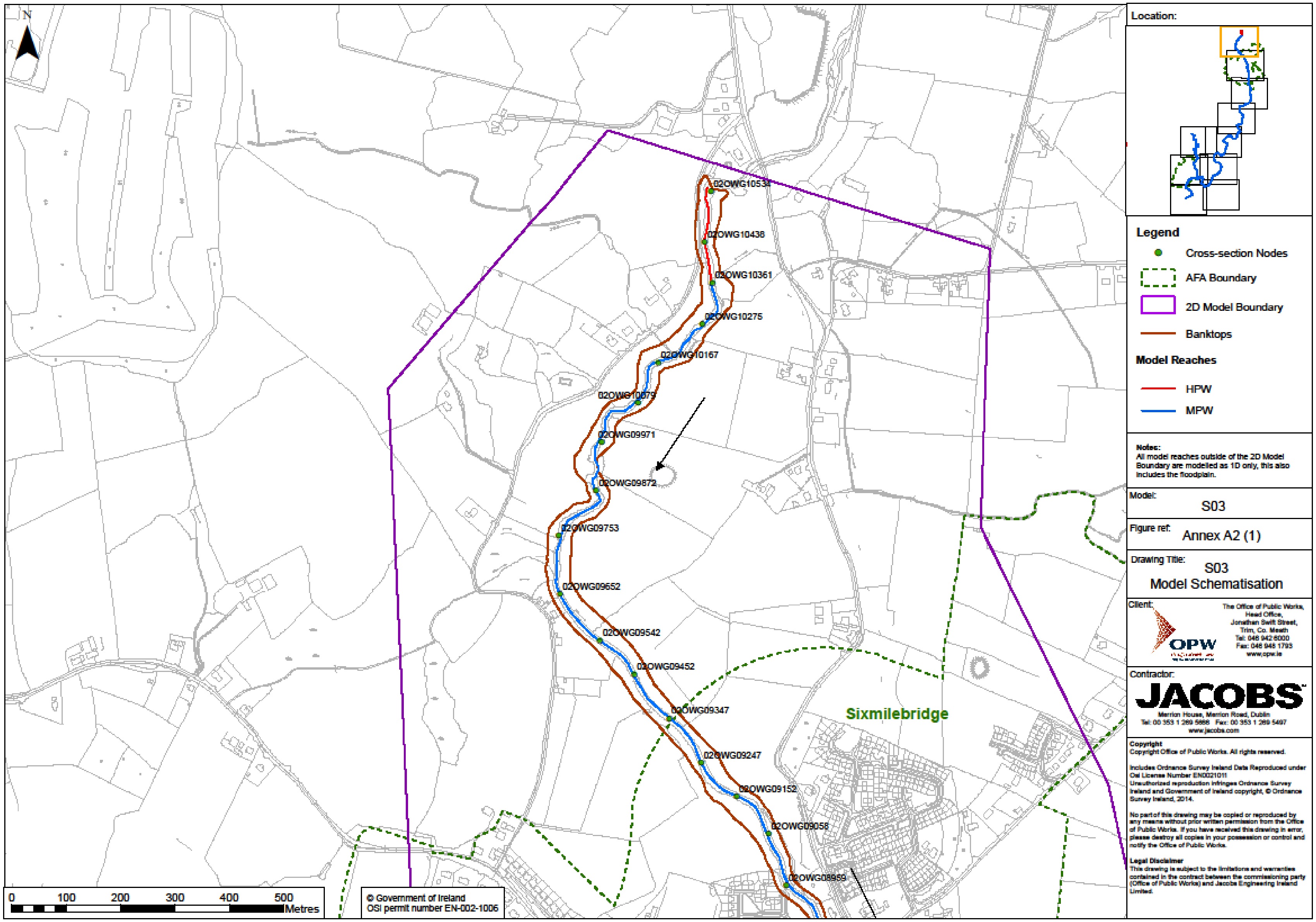
5. Hydraulic Model Outputs	
5.1 Mapping	Model outputs were processed to produce a series of flood maps according to the requirements stated in the Stage I Project Brief under Section 7.5.2. These include mapping outputs covering: • Flood extent • Flood depth and velocity • Flood hazard Mapping outputs corresponding to the 10%, 1% and 0.1% AEP flood events are shown in Annex E for flood extent and depth.

6. Key Model Assumption and Limitations
The failure of the calibration on the Clovemill for documented reasons related to linking channels has to be assumed to be correct. No survey was taken of this linking channel and it is assumed that the LiDAR represents this correctly. Simplifications had to be made to the complicated structures through Sixmilebridge: The sluice gates adjacent to the compound weir have been assumed closed in the model and the overtopping of the sluice gate was considered by the round nose weir unit. This is an appropriate and conservative assumption. This is due to a lack of survey in this area, and a lack of operational control rule data. See Annex B, Schedule A.1 for further details on modelling approach.

Annex A – Model Extent and Schematisation Maps

Annex A1 – Model Extent





N
02OWG10534
02OWG10438
02OWG10361
02OWG10275
02OWG10167
02OWG10079
02OWG09971
02OWG09872
02OWG09753
02OWG09652
02OWG09542
02OWG09452
02OWG09347
02OWG09247
02OWG09152
02OWG09058
02OWG08959
Sixmilebridge
0 100 200 300 400 500 Metres
© Government of Ireland
OSi permit number EN-002-1006
Location:
Legend
Cross-section Nodes
AFA Boundary
2D Model Boundary
Banktops
Model Reaches
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S03
Figure ref:
Annex A2 (1)
Drawing Title:
S03
Model Schematisation
Client:
The Office of Public Works,
Head Office,
Jonathan Swift Street,
Trim, Co. Meath
Tel: 046 942 6000
Fax: 046 948 1793
www.opw.ie
Contractor:
Merrion House, Merrion Road, Dublin
Tel: 00 353 1 269 5666 Fax: 00 353 1 269 5497
www.jacobs.com
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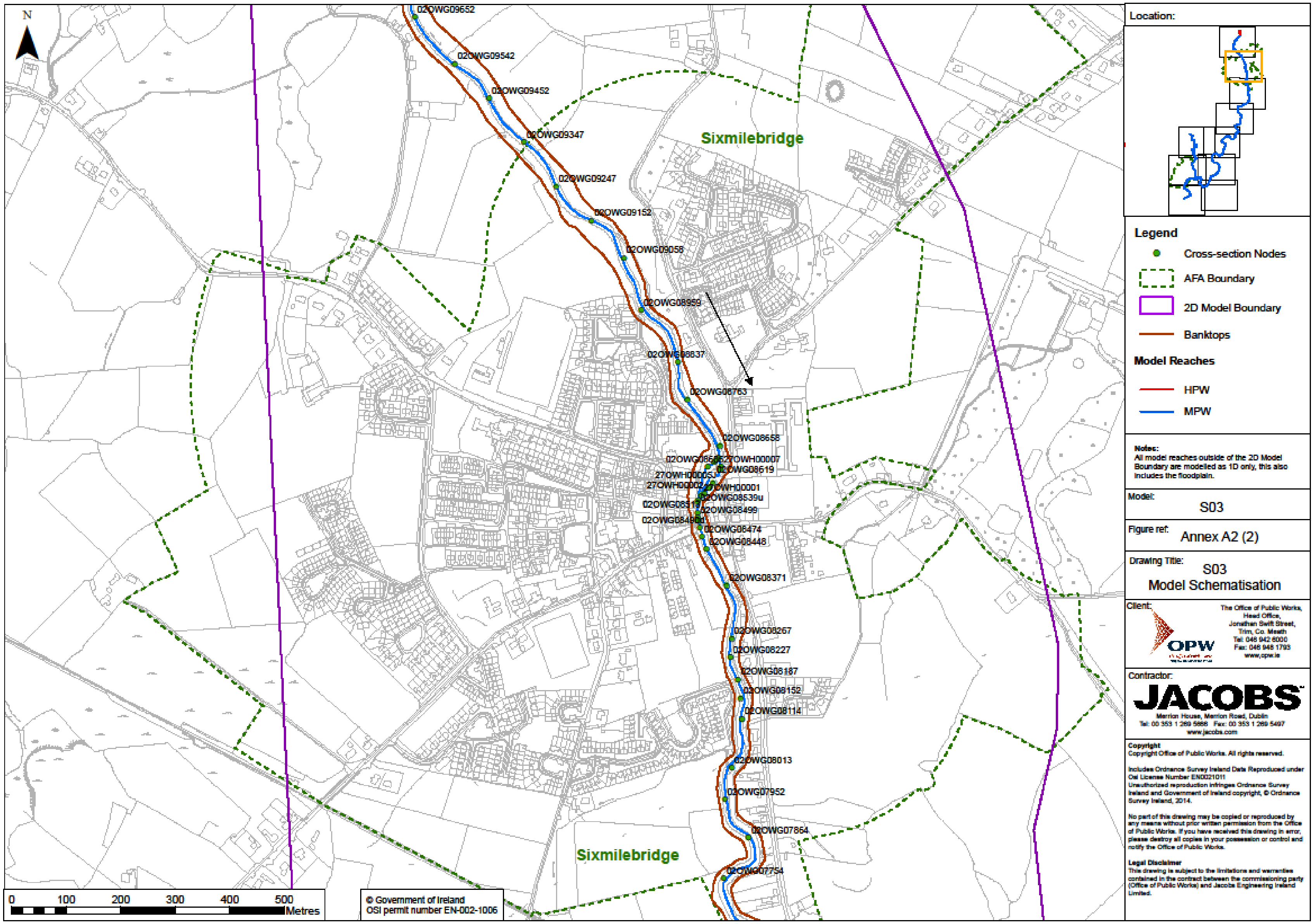

N
Sixmilebridge
02OWG09652
02OWG09542
02OWG09452
02OWG09347
02OWG09247
02OWG09152
02OWG09058
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27OWH00005
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27OWH00001
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0 100 200 300 400 500 Metres
© Government of Ireland
OSI permit number EN-002-1006
Location:
Legend
Cross-section Nodes
AFA Boundary
2D Model Boundary
Banktops
Model Reaches
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model: S03
Figure ref: Annex A2 (2)
Drawing Title: S03 Model Schematisation
Client: The Office of Public Works, Head Office, Jonathan Swift Street, Trim, Co. Meath. Tel: 046 942 6000 Fax: 046 948 1793 www.opw.ie
Contractor: JACOBS
Merrion House, Merrion Road, Dublin
Tel: 00 353 1 269 5666 Fax: 00 353 1 269 5497
www.jacobs.com
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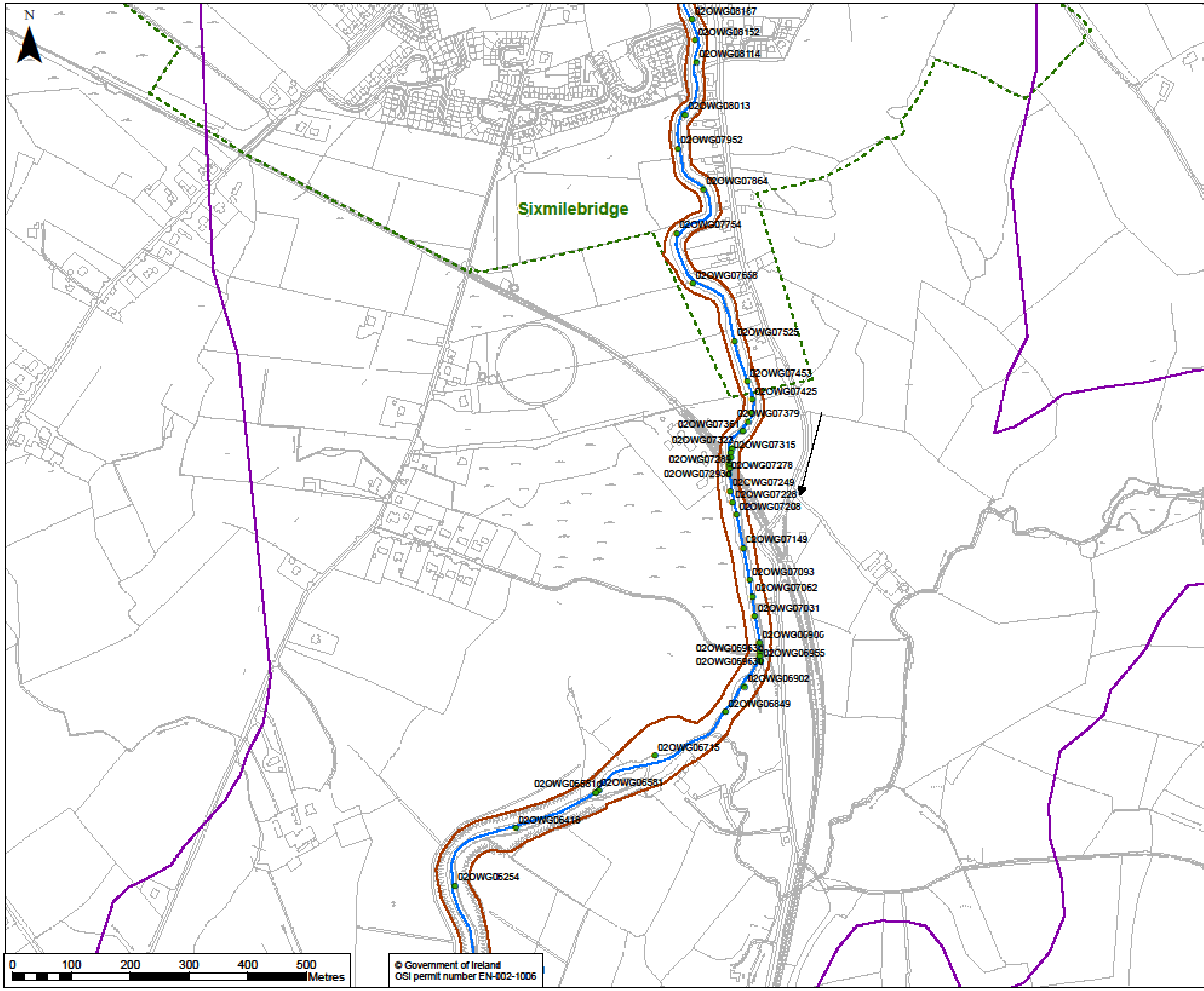

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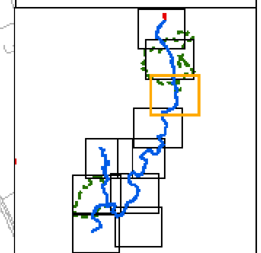

Legend

- Cross-section Nodes
- AFA Boundary
- 2D Model Boundary
- Banktops

Model Reaches

- HPW
- MPW

Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.

Model: S03

Figure ref: Annex A2 (3)

Drawing Title: S03 Model Schematisation

Client:
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Head Office,
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Trim, Co. Meath
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www.opw.ie

Contractor:
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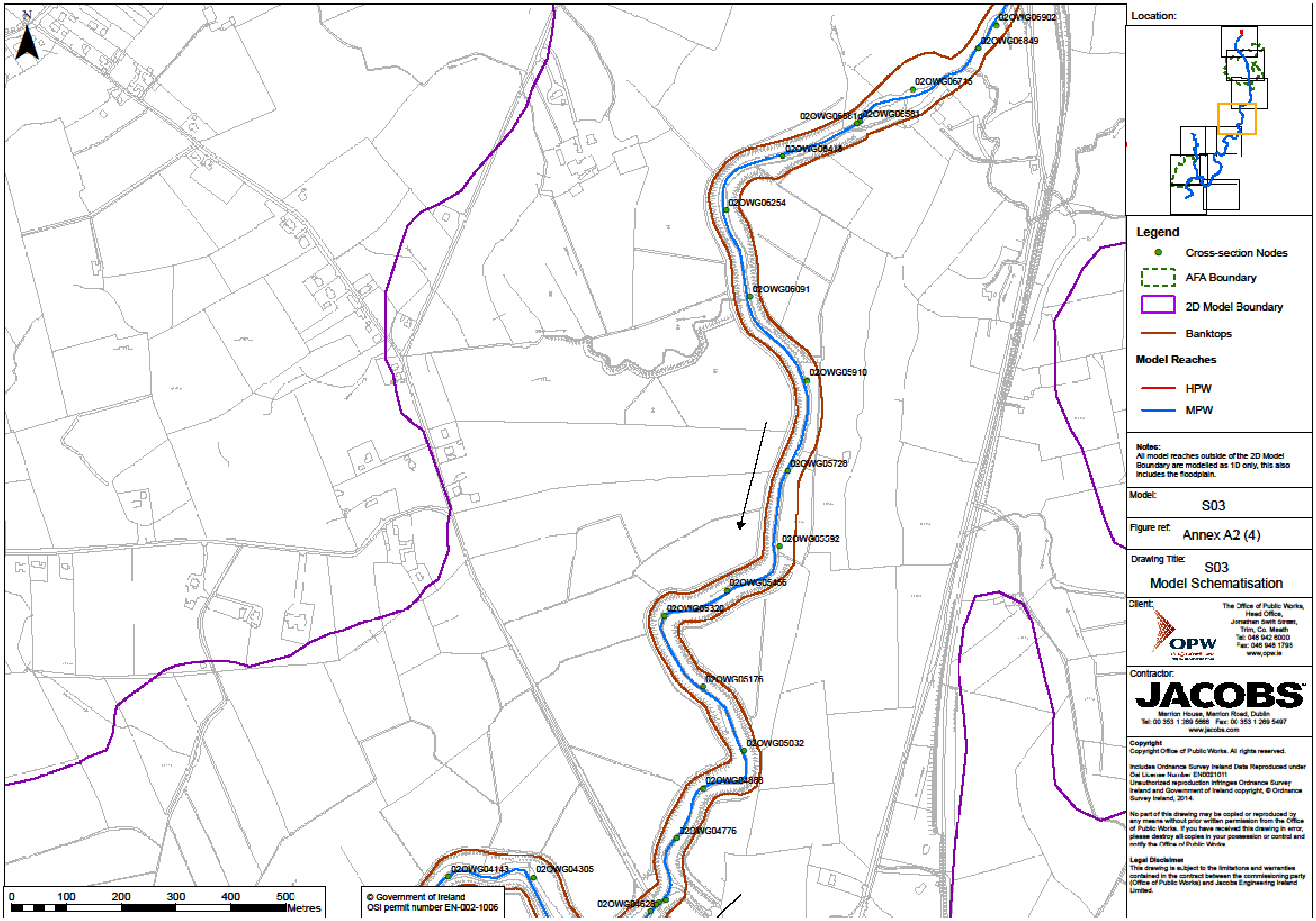

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02OWG04143
02OWG04305
0 100 200 300 400 500 Metres
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Location:
Legend
Cross-section Nodes
AFA Boundary
2D Model Boundary
Banktops
Model Reaches
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model: S03
Figure ref: Annex A2 (4)
Drawing Title: S03 Model Schematisation
Client:
The Office of Public Works, Head Office, Jonathan Swift Street, Trim, Co. Meath
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Contractor:
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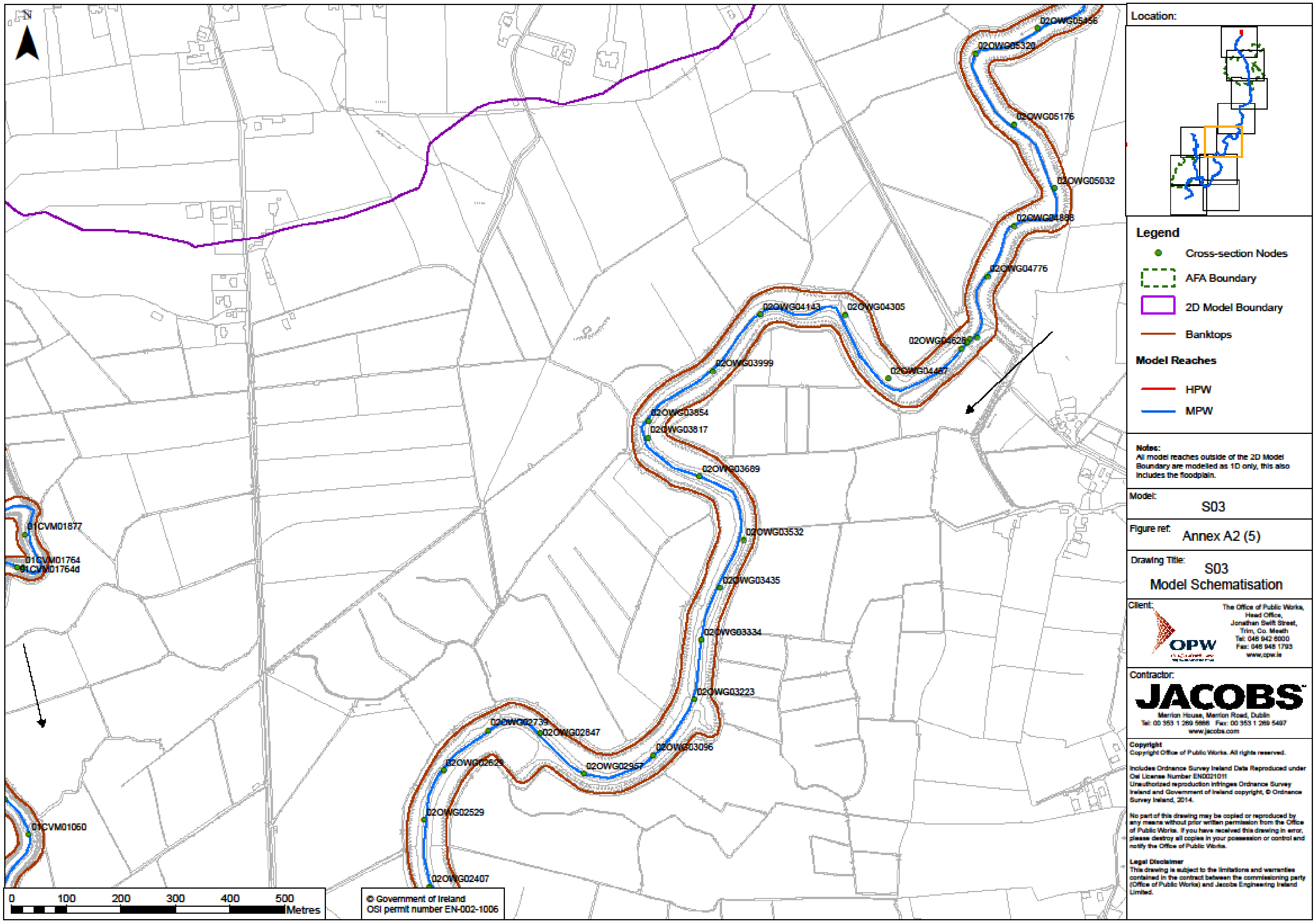

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Location:
Legend
Cross-section Nodes
AFA Boundary
2D Model Boundary
Banktops
Model Reaches
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S03
Figure ref:
Annex A2 (5)
Drawing Title:
S03
Model Schematisation
Client:
The Office of Public Works, Head Office, Jonathan Swift Street, Trim, Co. Meath
OPW
Contractor:
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200
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500
Metres
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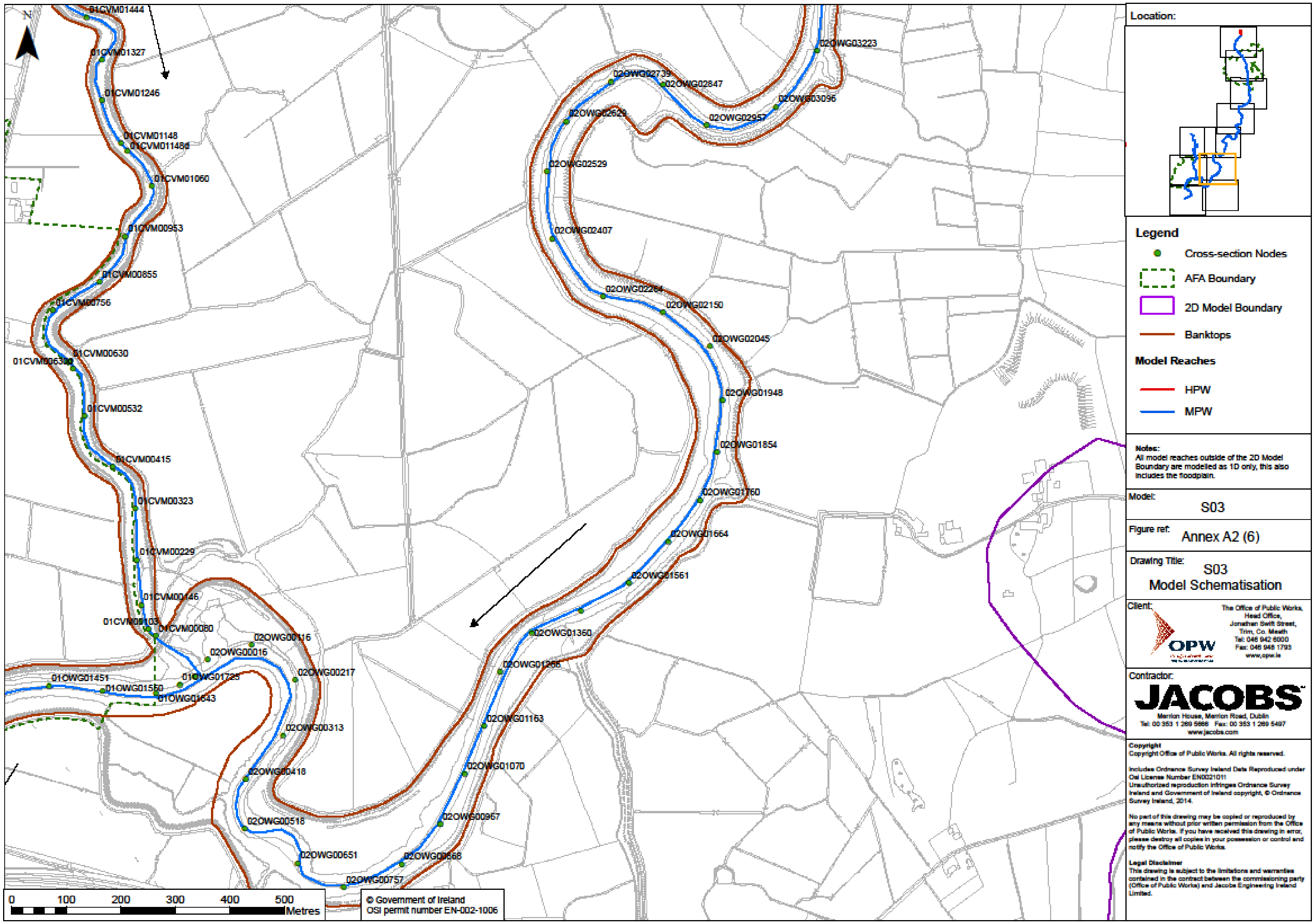

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Location:
Legend
Cross-section Nodes
AFA Boundary
2D Model Boundary
Banktops
Model Reaches
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S03
Figure ref:
Annex A2 (6)
Drawing Title:
S03
Model Schematisation
Client:
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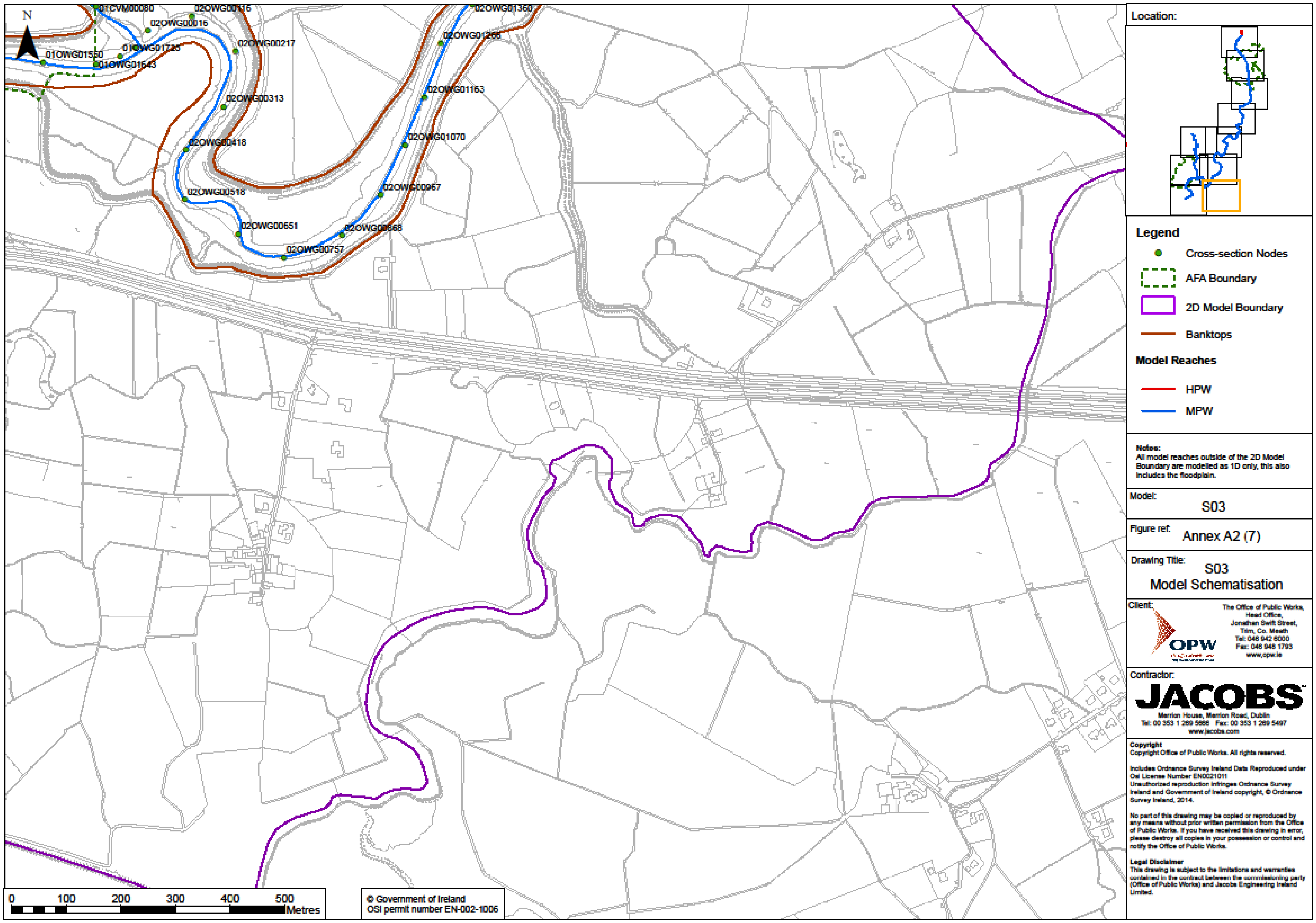
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0 100 200 300 400 500 Metres
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OSi permit number EN-002-1006
Location:
Legend
Cross-section Nodes
AFA Boundary
2D Model Boundary
Banktops
Model Reaches
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S03
Figure ref:
Annex A2 (7)
Drawing Title:
S03
Model Schematisation
Client:
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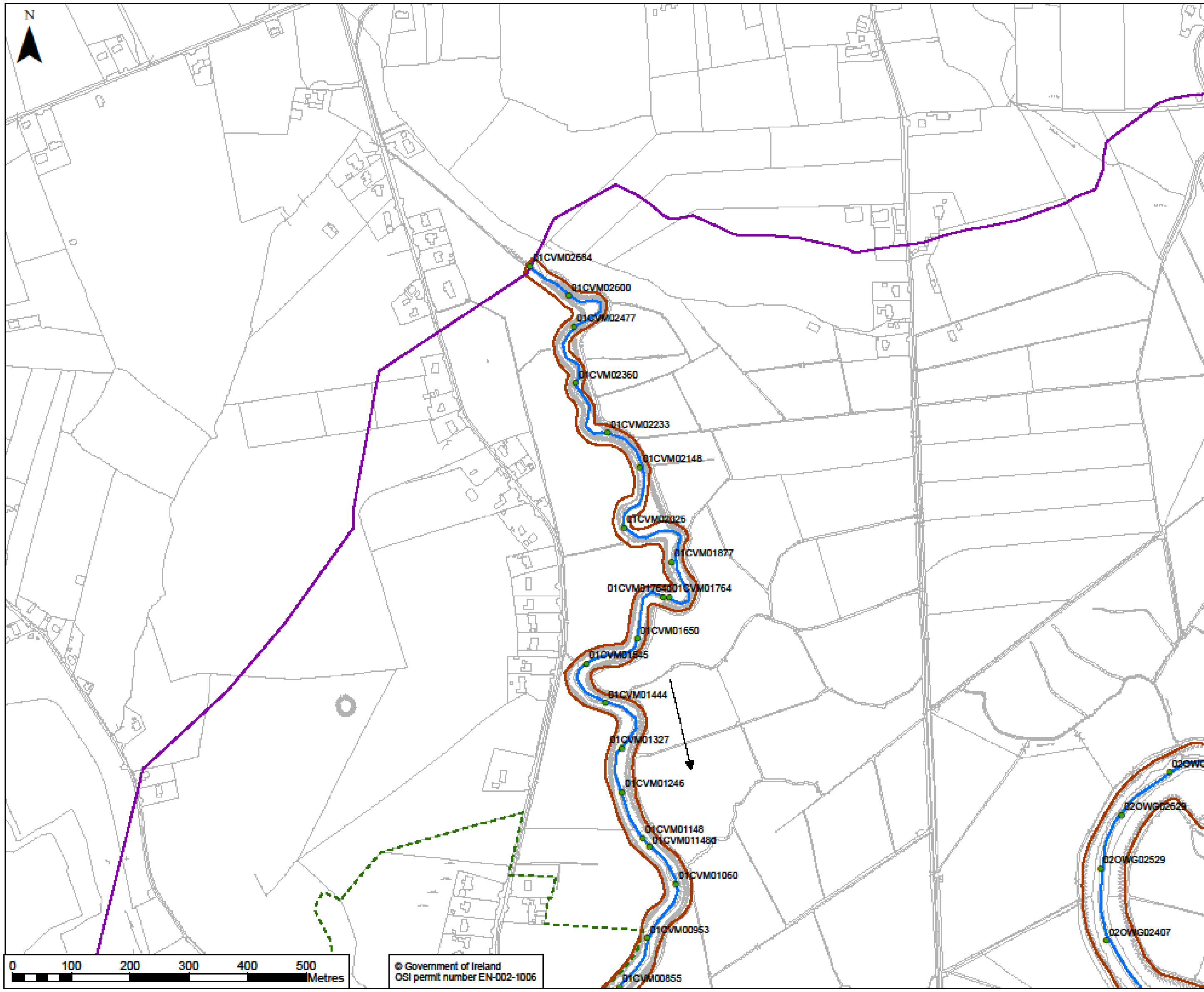

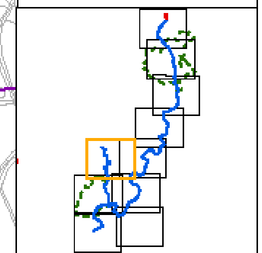

Legend

- Cross-section Nodes
- AFA Boundary
- 2D Model Boundary
- Banktops

Model Reaches

- HPW
- MPW

Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.

Model: S03

Figure ref: Annex A2 (8)

Drawing Title: S03 Model Schematisation

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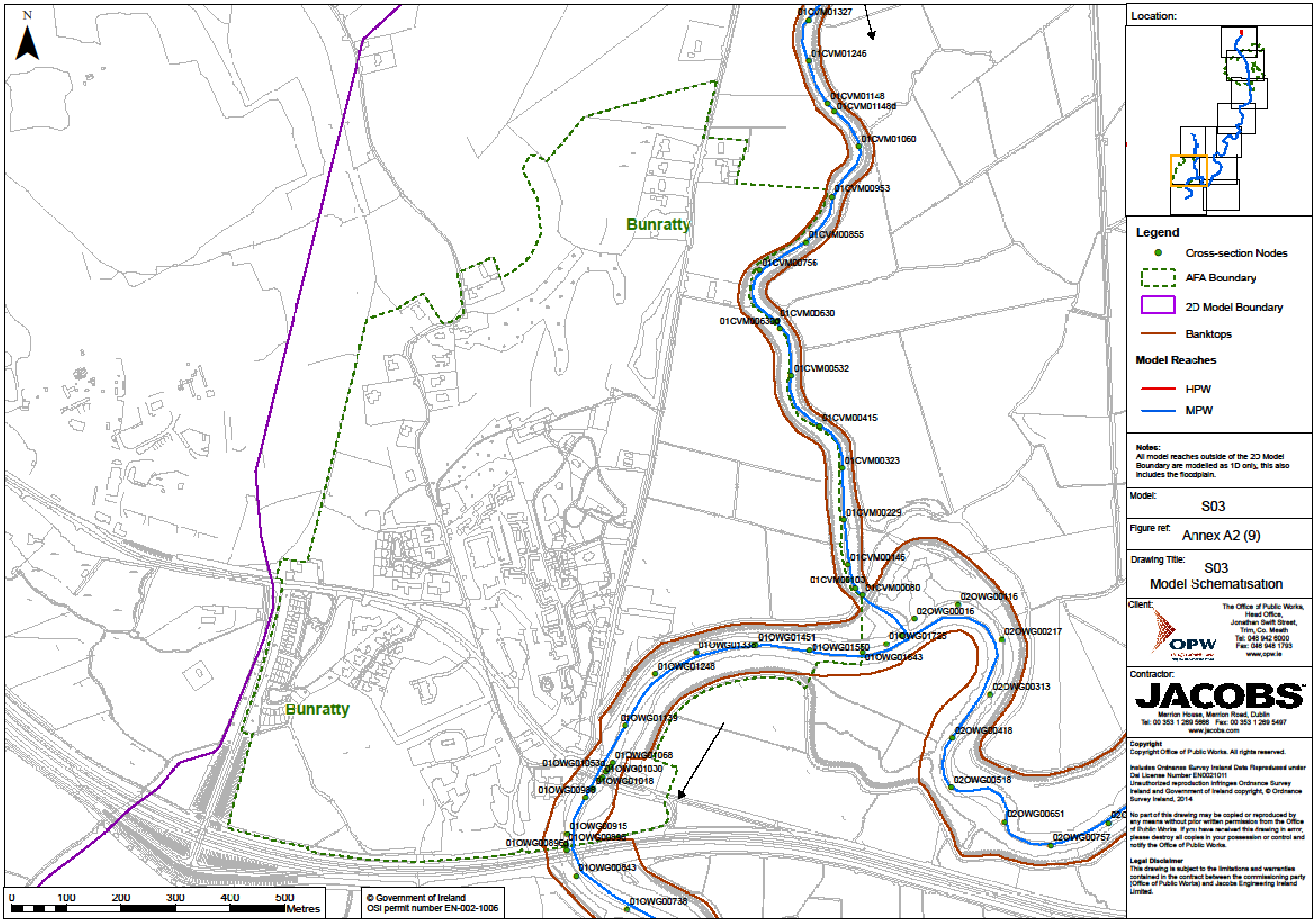
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Bunratty
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0 100 200 300 400 500 Metres
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OSI permit number EN-002-1006
Location:
Legend
Cross-section Nodes
AFA Boundary
2D Model Boundary
Banktops
Model Reaches
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S03
Figure ref:
Annex A2 (9)
Drawing Title:
S03
Model Schematisation
Client:
OPW
The Office of Public Works,
Head Office,
Jonathan Swift Street,
Trim, Co. Meath
Tel: 046 942 6000
Fax: 046 948 1793
www.opw.ie
Contractor:
JACOBS
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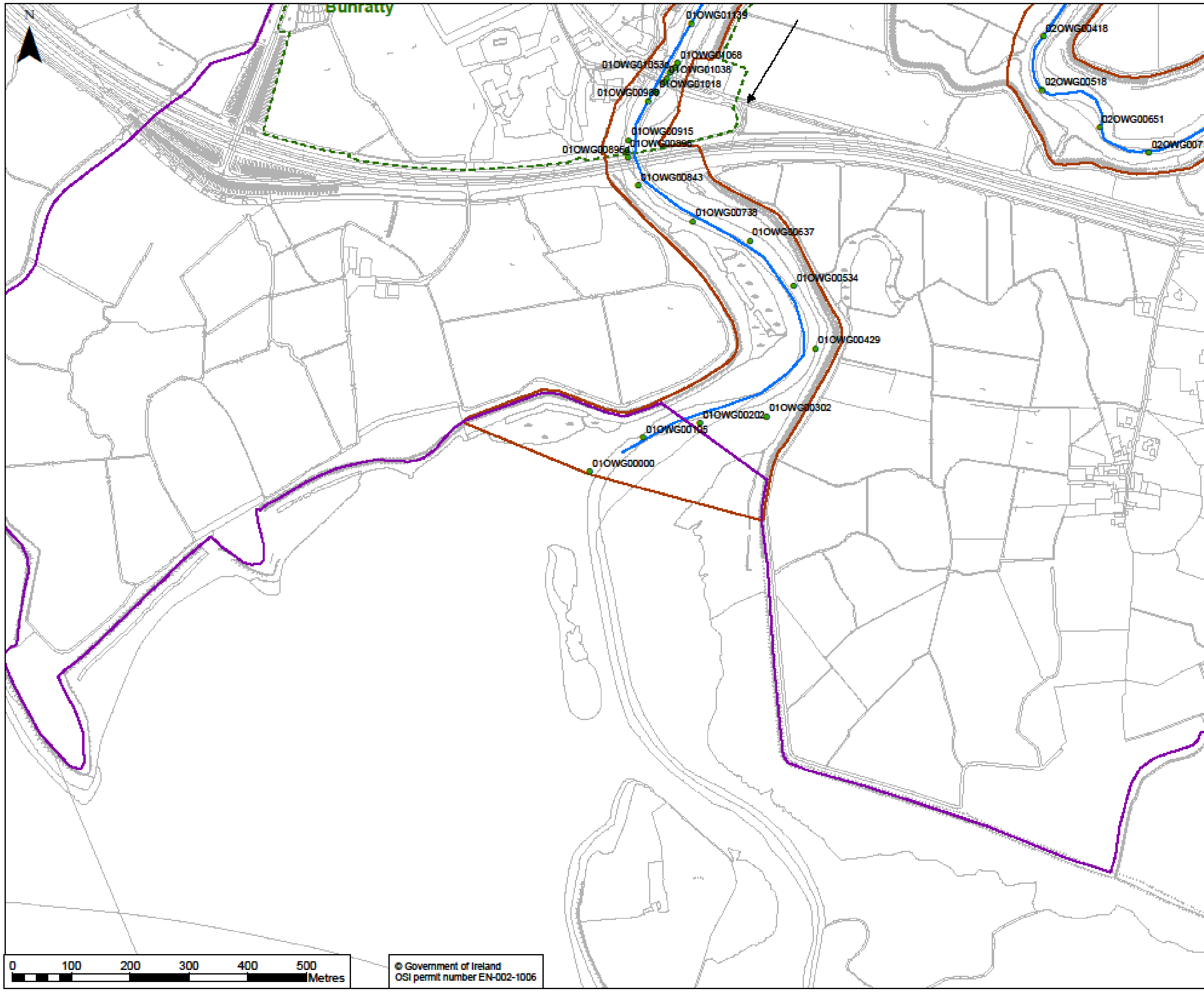

Location:

Legend

- Cross-section Nodes
- AFA Boundary
- 2D Model Boundary
- Banktops

Model Reaches

- HPW
- MPW

Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.

Model: S03

Figure ref: Annex A2 (10)

Drawing Title: S03
Model Schematisation

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Annex B – Structure and Hydraulic Roughness Schedules

Schedule A.1 - Structure Schedule for Owenagarney River

Survey Reference	ISIS Node Reference	Type of Structure	Modelling Approach	Structure included in Model (Y/N)
27OWEN01040X	02OWG08622wc 02OWG08622fp 02OWG08622ww	Compound weir with three levels and sluice gates adjacent	(wc) represents the main crest, (fp) the fish pass, and (ww) the piers. The adjacent sluice gates have been assumed closed in the model and the overtopping of the sluice gate was considered by the round nose weir unit. This is an appropriate and conservative assumption.	Y
27OWEN01028D	02OWG08490bu	Complex Bridge (3 arches on upstream face, and 3 boxes on downstream)	Modelled as 3 a USBPR bridge due to all 3 boxes being surveyed, and only one arch being surveyed on the upstream face	Y
Chain_3438	02OWG07293bu	Flat Deck Bridge	Represented as a USBPR bridge. No spill included due to embankment height carrying the railway	Y
Chain_3109	02OWG06963u	Arch Bridge	Arch Bridge with an overtopping spill.	Y
Chain_792	02OWG04646ou	Flat Deck Bridge	Modelled as an Orifice. Bridge bed level is far above that of the channel both upstream and downstream and therefore acting as a weir, making a bridge unit unstable.	Y
27OWEN00111D	01OWG01053bu	Arch Bridge	Modelled as an Arch Bridge with an overtopping spill.	Y
27OWEN00109D	01OWG01038bu	Flat Deck Bridge	Modelled as a USBPR bridge with overtopping spill	Y
27OWEN00094D	01OWG00896bu	Arch Bridge	Modelled as an Arch Bridge with an overtopping spill.	Y

Schedule A.2 - Structure Schedule for Owenagarney Trib

Survey Reference	ISIS Node Reference	Type of Structure	Modelling Approach	Structure included in Model (Y/N)
27OWEH00006W	270WH00006W	Two tier Overflow structure	Modelled as two orifices to represent the different levels	Y
27OWEH00005J	27OWH00006u	Double culvert from chamber	Solitary orifice to reduce possibility of crashing due to a dry culvert	Y
27OWEH00004D	27OWH00004bu	Bridge over two channels	Modelled as one bridge with a double section	Y

Schedule A.3 - Structure Schedule for Clovemill

Survey Reference	ISIS Node Reference	Type of Structure	Modelling Approach	Structure included in Model (Y/N)
27OWEA00010I & 27OWEA00008J	01CVM00080a – 01CVM00049a	Culvert into a flapped orifice	Modelled as a culvert with a spill for the inlet due to stability problems with an inlet unit and a general headloss unit. A sluice unit in ISIS has been used to represent the flapped outfall due to stability issues. This represents the hydraulics of the flapped outfall accurately.	Y

Schedule B.1 – Manning's 'n' for HPW Network

River Name	ISIS Node Reference	Bed Roughness*	Estimated Bank Side Roughness	Estimated Floodplain Roughness
Owenagarney	02OWG10534 to 02OWG6963u, 02OWG03532 to 01OWG00000	0.04	Determined on a case by case basis using photos, videos and survey drawing	Based on OSi NTF land use polygons
Owenagarney Trib	27OWH00007 to 27OWH00000	0.04		
Clovemill	01CVM02684 to 01CVM00000	0.04		

*In some cross-sections a different bed roughness coefficient may have been used to represent specific bed material (e.g. engineered concrete sections).

Schedule B.2 – Manning's 'n' for MPW Network

River Name	ISIS Node Reference	Bed Roughness	Estimated Bank Side Roughness	Estimated Floodplain Roughness
Owenagar ney	02OWG06963u to 02OWG03532	0.042	Determined on a case by case basis using photos, videos and survey drawing	2D: Based on OSi NTF land use polygons Land use EPA data has been used for assigning the floodplain roughness.

Annex C – Model Calibration

Not used as insufficient data was available for calibration

Annex D - Hydraulic Model Files

Model Files Folders Structure

ISIS

- S03_Bunratty
  - BCs
    - Superseded
  - Checks
  - Data
  - Model
    - GIS
      - empty_mi
      - empty_shp
      - Superseded
      - Terrain
        - Superseded
      - xf
    - ISIS
      - IEDs
      - Superseded
    - Superseded
  - Results
  - Runs
  - Workspaces

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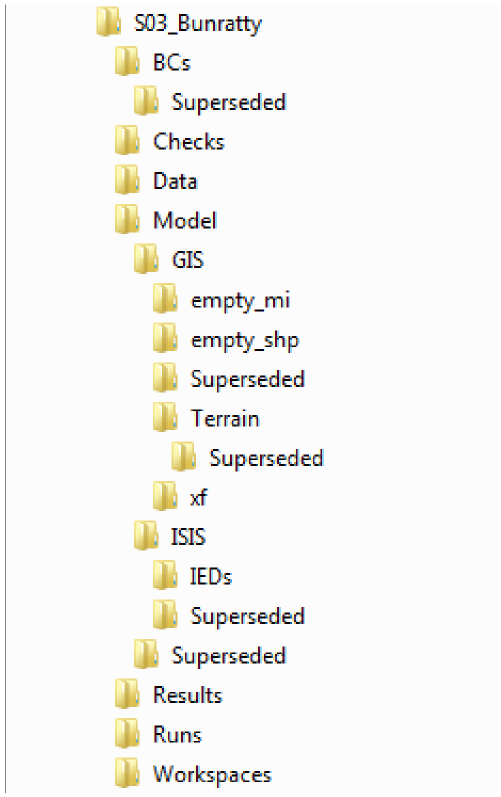
<tr><td>TUFLOW</td><td>
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ISIS Files	
Model Geometry (.dat) and Associated Files (e.g.: .ief, .zzl, .zzd, .zzu,.zzx)	**Calibration Runs** S03_Bunratty_Mi_C_v7.DAT, Q100_Cal.ZZL, .ZZN, .ZZU Q1000_Cal.ZZL, .ZZN, .ZZU **Design Runs – Current Scenario:** S03_Bunratty_Mi_C_v9.DAT S03_Q10_CoMi_C_Des_ISS1.IEF S03_Q10_FluMi_C_Des_ISS1.IEF S03_Q200_CoMi_C_Des_ISS1.IEF S03_Q1000_CoMi_C_Des_ISS1.IEF S03_Q100_FluMi_C_Des_ISS1.IEF S03_Q1000_FluMi_C_Des_ISS1.IEF S03_Q10_CoMi_C_Des_ISS1.ZZL, ZZU, ZZX, ZZD S03_Q10_FluMi_C_Des_ISS1.ZZL, ZZU, ZZX, ZZD S03_Q200_CoMi_C_Des_ISS1.ZZL, ZZU, ZZX, ZZD S03_Q1000_CoMi_C_Des_ISS1.ZZL, ZZU, ZZX, ZZD S03_Q100_FluMi_C_Des_ISS1.ZZL, ZZU, ZZX, ZZD S03_Q1000_FluMi_C_Des_ISS1.ZZL, ZZU, ZZX, ZZD

Hydrological Inflow Files	**Design Runs – Current Scenario:** S03_Q10_CoMi_C_Des_ISS1.IED S03_Q10_FluMi_C_Des_ISS1.IED S03_Q200_CoMi_C_Des_ISS1.IED S03_Q1000_CoMi_C_Des_ISS1.IED S03_Q100_FluMi_C_Des_ISS1.IED S03_Q1000_FluMi_C_Des_ISS1.IED

TUFLOW files	
TUFLOW Control Files (.tcf) and Associated Files (e.g.: ecf, tgc, tbc)	**Design Runs – Current Scenario:** S03_Q10_CoMi_C_Des_ISS1.TCF S03_Q10_FluMi_C_Des_ISS1.TCF S03_Q200_CoMi_C_Des_ISS1.TCF S03_Q1000_CoMi_C_Des_ISS1.TCF S03_Q100_FluMi_C_Des_ISS1.TCF S03_Q1000_FluMi_C_Des_ISS1.TCF S03_Bunratty_HiRes_v01-A.TBC S03_Bunratty_HiRes_v01-A.TGC S03_Sixmilebridge_HiRes_v01-A.TBC S03_Sixmilebridge_HiRes_v01-A.TGC S03_Bunratty_LoRes_v01-A.TBC S03_Bunratty_LoRes_v01-A.TGC
Grid Orientation Files	2d_loc_S03_HiRes_BUN.shp 2d_loc_S03_HiRes_SMB_v2.shp 2d_loc_S03_LoRes.shp
Material Files	**Design Runs – Current Scenario:** S03_Bunratty_MAT.tmf
Zpt Files, Model DTM (.asc)	Bunratty_2m_dtm.asc
Breaklines Files	2d_z_bridge_parapets_S03_SMB__v2_L.shp 2d_z_bridge_parapets_S03_SMB__v2_P.shp 2d_z_defences_BUN_v03_L.shp 2d_z_defences_BUN_v03_P.shp 2d_z_defences_SMB_v02_L.shp 2d_z_defences_SMB_v02_P.shp
Boundary Files	2d_bc_S03_Bunratty_HiRes_2D_2D.shp 2d_bc_S03_Bunratty_HiRes_LoRes_2D_2D.shp 2d_bc_S03_HiRes_BUN_v2.shp 2d_bc_S03_LoRes_v2.shp 2d_bc_S03_HiRes_SMB.shp
Flow/Head Files in bc_dbase	No Flow/Head Boundaries

Initial Water Level Files	No files provided
Time Series Files	No files provided
One Dimensional Network Files	1d_x1d_ISISNodes_S03_Bunratty.shp
Available 2D Result Files	Depth, stage, hazard and velocity 2d results in ASCII file format for all available design return periods.

Model Run Log						
Sr. No.	**Model File Name**	**Start Time**	**End Time**	**Time Step**	**Advanced Options /Other Information**	**Comments on Model Stability**
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2	S03_Bunratty_Mi_C_v7.DAT	0	110	0.5 1D 1 2D	Model Calibration Exercise 1000yr	Within manufacturer's tolerances
Design Runs						
1	S03_Bunratty_Mi_C_v9.DAT	0	120	0.5 1D 1 2D	Running with the CoMi_Q10 Event	Within manufacturer's tolerances
2	S03_Bunratty_Mi_C_v9.DAT	0	120	0.5 1D 1 2D	Running with the FluMi_Q10 Event	Within manufacturer's tolerances
3	S03_Bunratty_Mi_C_v9.DAT	0	120	0.5 1D 1 2D	Running with the FluMi_Q100 Event	Within manufacturer's tolerances
4	S03_Bunratty_Mi_C_v9.DAT	0	120	0.5 1D 1 2D	Running with the CoMi_Q200 Event	Within manufacturer's tolerances

5	S03_Bunratty_Mi_C_v9.DAT	0	120	0.5 1D 1 2D	Running with the CoMi_Q1000 Event	Within manufacturer’s tolerances
6	S03_Bunratty_Mi_C_v9.DAT	0	120	0.5 1D 1 2D	Running with the FluMi_Q1000 Event	Within manufacturer’s tolerances

Parameters changed from Default	Justification
Automated Preismann slot for River Sections turned on.	Automated Preismann slot are a standard parameter used to aid model stability particularly in low flows. These Preismann slots have negligible to no impact on the water levels during flood events.
Matrix Dummy Coefficient set to 0.0001	Set to 0.0001 to solve IFAG error. *

*Stage and Flow profiles at all cross sections have been checked to ensure results are sensible and to ensure any changes to the default model run parameters has not impacted on the model results.

Annex E - Flood Mapping

Flood Maps are available through the OPW flood mapping website; http://maps.opw.ie/fhrm/

Fluvial and Coastal Hydraulic Modelling Report

1. Basic Model Information

1.1 General Information	
Model ID:	S04
Unit of Management	27
AFA included in the Model	Shannon and Shannon Airport
Primary Watercourses / Water Bodies	Ballycasey Creek Drumgeely Creek
1.2 Reference to other Relevant Reports	
Catchment Description	Hydrology Report Unit of Management 27 – Appendix A3.1
Model Location	Hydraulics Report Unit of Management 27 – Section 3.4.12
HEP Schematisation	Hydrology Report Unit of Management 27 – Appendix B4 – Figure B4.1

2. Survey Data and Base Mapping

2.1 Base Mapping:	OSi data base mapping at scale 1:50k Reference: OS_1216_D, OS_1214_D, OS_1416_D, OS_1414_D
2.2 DTM for 2D Model Domain:	**Full domain** LiDAR data with 2m horizontal resolution and approximately 200mm vertical accuracy has been used to inform the hydraulic model with ground elevation in the floodplain areas included in the AFA boundary and wider HPW extents.
2.3 River Channel/Structures Survey	General information on the topographic survey of the river channel and structures are included in the main Hydraulics Report. Full details of the survey outputs are provided in the topographic survey deliverables, as required under Section 5.2 of the Stage I Project Brief. Number of cross-sections included in this model: 290
2.4 Defence Asset Survey Data	The defence asset database has been completed for this model area and is provided as a separate deliverable to this report. There is a continuous flood defence (raised embankment) running along the coastal defence between the urban areas and the Shannon Estuary. This borders the model domain to the south. Elevations from crest survey of this structure have been applied throughout the 2D model domain. All defences have been included in the model schematisation as shown on the maps presented in annex A2. Further details on defences are contained in the defence asset database.
2.5 Survey Interaction	The Lidar, IFSAR and topographic survey were checked for anomalies, and to ensure that interactions between were within expected tolerances. No issues were identified in this model.

3. Hydraulic Model Construction and Schematisation

3.1 Software:	**1D domain:**	ISIS Version 3.6.0.156 (64 bit)
	2D domain(s):	TUFLOW Version: 2012-05-AE-iSP-w64
3.2 Model Area / Extent:	The areal extent of the model and its schematisation are shown in Annex A.	

The mapping details for the model extent included in Annex A are as follows:

1. **Full modelled area showing**:
   - River centre lines, HPW extents, names of watercourses
   - 2D domain area
   - AFA boundary
2. **Maps showing a detailed model schematic of the HPW reaches are also included**

3.3 Model Reaches: The following model reaches as shown on the maps referred above have been defined in the ISIS model:

Watercourse Name	Reach	Upstream Model Node	Downstream Model Node
Ballacasey Tributary	01HUR	01HUR01402	01HUR00012
Ballacasey (Upper)	01BAM	01BAM02357	01BAM00000
Ballacasey (Lower)	02BAM	02BAM02207	02BAM00000
Urlan Beg	01CRT	01CRT03331	01CRT00000
Clonloghan Tributary	CLON	01DMG02210	01DMG00000
Diversion channel at headwater of Urlan Beg – borders airport	01AIR	01AIR01726	01AIR00000
Unknown river name - runs through Smithstown	01SHN	01SHN02917	01SHN00000

Total model HPW length (km):	16.53	**Total model MPW length (km):**	0

3.4 Model Structures: A full schedule of structures included in the model is provided in Schedule A in Annex B. A summary of the structures included is given below:

Culverts:	☒	How many?	42
Bridges:	☒	How many?	3
Fixed crest weirs:	☐	How many?	0
Adjustable crest weirs:	☐	How many?	0
Outfalls:	☒	How many?	4
Locks:	☐	How many?	0
Dams:	☐	How many?	0

3.5 Floodplain Schematisation Out-of-bank areas for MPW reaches have been modelled using a 1D approach in the ISIS model by extending the river channel cross-sections. Out-of-bank areas for HPW reaches, within the AFA, have been modelled using a 1D approach in the ISIS model by extending the river channel cross-sections. Extended 1D sections are considered appropriate for HPW extents

<table>
<tr><td></td><td colspan="3">where floodplain flow paths are simple (e.g, parallel to river flow). 1D-2D modelling is required where HPWs flow through urban areas and out-of-bank flows will form complex flow paths.
An overview of the floodplain schematisation is available in the maps shown in Annex A.</td></tr>
<tr><td rowspan="4">3.6 2D Domain Grid Size:</td><td colspan="3">The number of 2D domains defined and the grid sizes of each 2D domain are as follows:</td></tr>
<tr><td colspan="3">Number of 2D domains: 1</td></tr>
<tr><td>Domain 1:</td><td>Grid cell size: 5m</td><td>Area: 20.58 km^2</td></tr>
<tr><td colspan="3">2D domains are defined depending on the level of detail required to pick up the appropriate features in the 2D domain that will impact on the local hydraulics. The domain grid square size is typically in the range 5m to 20m, with the smaller grid sizes used in very urbanised areas where there are multiple features that could not be suitably represented in, say, a 10m grid. The model grid is orientated in the main direction of the floodplain flow.</td></tr>
<tr><td>3.7 Model Breaklines in the 2D Domain:</td><td colspan="3">Bank tops and flood defence walls are represented as breaklines in the 2D domain. Bridge parapets are represented either as spill units in the 1D model, spill units linked to the 2D model via SX linking or as breaklines in the 2D domain.</td></tr>
<tr><td>3.8 Floodplain Structures in the 2D Domain</td><td colspan="3">Raised defences are represented in the TUFLOW domain explicitly using TUFLOW geometry control features.</td></tr>
<tr><td>3.9 Hydraulic Roughness</td><td colspan="3">Hydraulic roughness (Manning's 'n') has been defined in accordance with the approaches described in the main Hydraulics Report. Details of the values adopted for this model are included in Schedule B in Annex B. A summary of Manning's 'n' for the model as a whole is as follows:</td></tr>
<tr><td rowspan="2">HPW in-bank</td><td>Minimum 'n' value:</td><td colspan="2">0.037</td></tr>
<tr><td>Maximum 'n' value:</td><td colspan="2">0.065</td></tr>
<tr><td rowspan="10">Floodplain (TUFLOW Model)</td><td colspan="3">Manning's 'n' for out of bank areas represented in the TUFLOW model are as defined by OSi NTF land use characteristics. Floodplain land uses and adopted roughness values in TUFLOW are as follows:</td></tr>
<tr><td>Land Use</td><td colspan="2">Manning's 'n' Value</td></tr>
<tr><td>Buildings</td><td colspan="2">0.100</td></tr>
<tr><td>Short grass, parks</td><td colspan="2">0.035</td></tr>
<tr><td>General Urban</td><td colspan="2">0.060</td></tr>
<tr><td>General Rural</td><td colspan="2">0.045</td></tr>
<tr><td>Dense Vegetation</td><td colspan="2">0.080</td></tr>
<tr><td>Roads</td><td colspan="2">0.025</td></tr>
<tr><td>Railways</td><td colspan="2">0.050</td></tr>
<tr><td>Water bodies</td><td colspan="2">0.020</td></tr>
<tr><td>3.10 Spill Units</td><td colspan="3">Spill units are used for a number of different purposes (e.g. irregular weir, lateral spilling in the floodplain).Spill profile geometry is defined using topographic survey data and LiDAR/IfSAR.
Spill coefficients used generally vary between 0.9 and 1.5 depending on the type of ground conditions (e.g. rough vegetated, smooth concrete) over which flood flows are spilling. Lower coefficients (<1.0) can be also found to account for lateral spilling perpendicular to the main direction of flow.</td></tr>
</table>

3.11 Model Boundaries – Fluvial Inflows	Hydrological flow hydrographs were input to the model at key model locations as indicated in the tables below. For further details on the design hydrograph estimation process please refer to Section 2 of the Hydrology Report for UoM27. For further details on hydrographs and peak flows specifically related to this model please see Appendix A3 and Appendix B4 respectfully of the Hydrology Report for UoM27.
(a) Current Situation	Peak inflows (m3/s) are summarised in the tables below for the current situation and the design event simulated. These are the final inflows as obtained following calibration to HEPs (see Section 4.2)

HEP Reference Name	Input Node in the Hydraulic Model	Annual Exceedance Probability							
		50%	20%	10%	5%	2%	1%	0.5%	0.1%
27_1160_2	02BAM02207	1.0	1.4	1.7	1.9	2.2	2.5	2.7	3.3
27_1160_5	02BAM00946	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.5
27_1161_2	01BAM02052	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
27_805_1	01HUR00128	0.6	0.8	1.0	1.1	1.3	1.4	1.6	1.9
27_1134_3	01SHN01889	0.7	0.9	1.1	1.3	1.5	1.6	1.8	2.2
27_369_5	01CRT02812	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4
27_369_6	01CRT02417	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6
27_1147_2	01CRT01902	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4
27_1147_3	01CRT01402	0.6	0.8	0.9	1.0	1.1	1.3	1.4	1.6
27_1164_1	01DMG01574	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5

*50% and 2% fluvial flows were utilised for the joint tidal and fluvial event simulation.

(b) Future Scenarios	The peak inflows (m^3/s) used as inputs to the model at key model locations are summarised in the table below for all return periods for the MRFS. These events are selected as these are the MRFS that are to be mapped.

HEP Reference Name	Input Node in the Hydraulic Model	MRFS Annual Exceedance Probability							
		50%	20%	10%	5%	2%	1%	0.5%	0.1%
27_1160_2	02BAM02207	1.2	1.7	2.0	2.3	2.7	3.0	3.3	3.9
27_1160_5	02BAM00946	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6
27_1161_2	01BAM02052	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
27_805_1	01HUR00128	0.7	1.0	1.2	1.3	1.6	1.7	1.9	2.3
27_1134_3	01SHN01889	0.8	1.1	1.3	1.5	1.8	1.9	2.1	2.6
27_369_5	01CRT02812	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5
27_369_6	01CRT02417	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7
27_1147_2	01CRT01902	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4
27_1147_3	01CRT01402	0.7	0.9	1.1	1.2	1.4	1.5	1.6	1.9
27_1164_1	01DMG01574	0.2	0.3	0.3	0.4	0.4	0.4	0.5	0.6

(b) Future Scenarios	The peak inflows (m^3/s) used as inputs to the model at key model locations are summarised in the table below for 10%, 1% and 0.1% events for the HEFS. These events are selected as these are the HEFS that are to be mapped.

HEP Reference Name	Input Node in the Hydraulic Model	HEFS Annual Exceedance Probability		
		10%	1%	0.1%
27_1160_2	02BAM02207	2.1	3.2	4.3
27_1160_5	02BAM00946	0.4	0.5	0.7
27_1161_2	01BAM02052	0.1	0.1	0.1
27_805_1	01HUR00128	1.2	1.9	2.5
27_1134_3	01SHN01889	1.4	2.1	2.8

27_369_5	01CRT02812	0.3	0.4	0.5
27_369_6	01CRT02417	0.4	0.6	0.8
27_1147_2	01CRT01902	0.3	0.4	0.5
27_1147_3	01CRT01402	1.2	1.6	2.1
27_1164_1	01DMG01574	0.3	0.5	0.6

3.12 Model Boundaries – Downstream Conditions	Downstream boundary conditions adopted in the model are as follows: Tidal level hydrographs at the downstream boundary of each watercourse are shared. These were produced for a series of design events using the Irish Coastal Protection Strategy Study (ICPSS) extreme tidal peak levels data. The time series were set up as boundary conditions for the hydraulic model along the coastal boundary of the 2D model and also at the downstream extents of the HPW reaches in the ISIS model. Full details on how these tidal level hydrographs were derived are provided in Appendix D of the main Hydraulics Report. Peak tidal levels are summarised in the table below for the current and future situations. For the wave overtopping model, wave overtopping hydrographs have been applied directly to the hydraulic model using a flow versus time boundary along the landward side of the flood defences. The hydrographs vary for different points along the defence as shown in Annex F. Full details on how these tidal level hydrographs were derived are provided in section 4.4 of the main Hydraulics Report. The tidal hydrographs applied for wave overtopping are available in Annex F of this report.

	Annual Exceedance Probability										
Peak Tidal Levels (m AOD)	**500%**	**200%**	**100%**	**50%**	**20%**	**10%**	**5%**	**2%**	**1%**	**0.5%**	**0.1%**
	2.7	2.9	3.1	3.2	3.4	3.6	3.7	3.9	4.1	4.2	4.6
	MRFS Annual Exceedance Probability										
Peak tidal levels (m OD)	500 %	200 %	100 %	50%	20%	10%	5%	2%	1%	0.5 %	0.1%
	3.3	3.5	3.7	3.8	4.0	4.2	4.3	4.5	4.7	4.8	5.2
	HEFS Annual Exceedance Probability										
Peak tidal levels (m OD)	500 %	200 %	100 %	50%	20%	10%	5%	2%	1%	0.5 %	0.1%
	3.8	4.0	4.2	4.3	4.5	4.7	4.8	5.0	5.2	5.3	5.7

4. Hydraulic Model Calibration and Sensitivity

4.1 Model Calibration and Verification to Historical Events

The analysis of available flood event data and high flow data for possible consideration as calibration and verification events is covered in detail in the Hydrology Report for UoM27 (Appendix F). The results of this analysis concluded that no calibration or verification could be performed within the modelled area. A broad verification of the model using anecdotal evidence of flooding was also deemed not possible due to a lack of data.

Catchment Gauging

Is modelled catchment: Gauged ☐ Ungauged ☒ *check one box only*

4.2 Calibration to HEP

Calibration of the hydraulic model to the HEP target flows has been carried out for the 10%, 1% and 0.1% AEP fluvial events. Section 2.7.2 of the Hydrology Report for UoM27 provides a summary of the calibration to HEP process.

Preliminary inflow hydrographs derived from the hydrological analysis and input to the model were adjusted in time so that their respective peak flows coincide with the peak time of the propagating flood wave as it is routed down the model. Total peak flows predicted by the hydraulic model at HEP locations were then compared to the HEP target flows estimated during the hydrological analysis.

Inflows at HEP nodes 27_1147_3 to 27_1164_1 were increased by varying amounts to ensure that the modelled total peak flows downstream of this location achieved an average of ±10% of the HEP target flows. This ±10% target allows for good agreement between the hydrological estimates and the hydraulic results without the addition/removal of unrealistic volumes of flow from the model. The robustness of this has been verified by the agreement of the design flood maps.

The table below shows the percentage difference between the modelled and target flows at each HEP location. The average percentage differences for all of the HEP nodes are as follows: 1, -2, -1, 0, -2, -2, -4 and -8 for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP events respectively.

For the 2% AEP and greater RPs, flows at 27_1147_3 came in outside of the ± 10% target. This was deemed acceptable at this location due to the upstream culvert being at capacity meaning any scaling upstream does not impact upon this HEP. Additionally, actual error for these RPs is shown to be ~1 m^3/s or less. The same is true of 27_1164_1 for the 0.5% and 0.1% AEP events. Finally, flows checked against 27_1161_2 were influenced by interactions by other floodplain flows for the 0.5% and 0.1% AEP events. Because of the complexity of the floodplain flows at this location, -11% and -12% of target flows was deemed acceptable for these events.

HEP Reference Name	Node in the Hydraulic Model	Annual Exceedance Probability Percentage Difference (%)							
		50%	20%	10%	5%	2%	1%	0.5%	0.1%
27_1147_3	01CRT01402	4	-8	10	0	-12	-19	-26	-37
27_1147_2	01CRT01902	0	-5	-2	3	3	3	5	-7
27_369_6	01CRT02417	0	-3	-4	-3	-2	-2	-2	-2
27_369_5	01CRT02812	0	-3	-4	-3	-2	-2	-2	-2
27_1164_1	01DMG01574	6	5	3	3	2	-3	-11	-24
27_1160_5	02BAM00946	-2	-2	-2	-2	-3	5	7	19
27_805_4	01HUR00128	0	1	0	3	8	11	10	3
27_1161_2	01BAM02052	-1	0	-4	0	-9	-10	-11	-12

NB. 27_1160_2 and 27_1134_3 were not applied as test locations due to the influence of upstream culverts on the flow at these locations and as both were situated at areas where complex out of bank flow routes are indicated by the model, including some recirculation of flows and interactions with flow routes from other watercourses. Consequently, these locations were deemed unsuitable for flow comparison.

4.3 Fluvial and Tidal Events Simulated	The watercourses in the model reach are influenced by the tidal levels in the River Shannon. As such, a joint probability analysis of the coincidence of fluvial flood flows and coastal flood levels was carried out to determine the appropriate combinations of flows and sea levels to be used for the design probability events, as required under Section 6.5.6 of the Stage I Project Brief. Methodology and outcomes of this analysis are detailed in the main Hydraulic Report and in the Hydrology Report. A summary of the joint probability of fluvial and tidal conditions used for the hydraulic modelling in this reach is reported in the table below.

Combination of Fluvial and Tidal Events

	Joint Probability Design Event	AEP adopted for Fluvial Flows and Tidal Levels	
Scenario	**Overall AEP**	**Fluvial**	**Tidal**
1	50%	50%	500%
2	50%	50%	50%
3	20%	20%	500%
4	20%	50%	20%
5	10%	10%	200%
6	10%	50%	10%
7	5%	5%	100%
8	5%	50%	5%
9	2%	2%	50%
10	2%	50%	2%
11	1%	1%	20%
12	1%	20%	1%
13	0.5%	0.5%	10%
14	0.5%	10%	0.5%
15	0.1%	0.1%	2%
16	0.1%	2%	0.1%

4.4 Model Sensitivity	Sensitivity tests have been carried out in order to assess the sensitivity of the predicted peak water levels to alterations in roughness (Manning's 'n'), fluvial flow, afflux at key structures and downstream conditions. The sensitivity runs were carried out for the 1% AEP fluvial dominated event with the corresponding tidal event from the joint probability study in all cases with the only exception of the tests on the downstream boundary conditions, which were carried out for the 0.5% AEP tidal dominated events with the corresponding fluvial event (see Section 4.3). Sensitivity test results are provided in the following tables. Uncertainty maps illustrating the results of the sensitivity analysis will be delivered as part of the final stage of this work.

+20% Manning's 'n'	**Watercourse**	**Average Water level difference (m)**	**Maximum water level difference (m)**	**Cross-section / reach where the maximum difference occurs**
	CRT	0.031	+0.17	01CRT02960
	AIR	0.000	0.00	ALL
	DMG	0.007	+0.02	DMG1538_D 01DMG00793 DMG0793_D
	SHN	0.011	+0.08	01SHN02917
	HUR	0.038	+0.08	01HUR01248 01HUR00695
	BAM	0.025	+0.09	BAM1362_D 02BAM01332 02BAM01305
-20% Manning's 'n'	**Watercourse**	**Average Water level difference**	**Maximum water level difference**	**Cross-section where the maximum difference occurs**
	CRT	-0.027	-0.15	01CRT02909
	AIR	0.000	0.00	ALL
	DMG	-0.008	-0.02	01DMG00860
	SHN	-0.009	-0.08	01SHN02917
	HUR	-0.038	-0.09	01HUR00725
	BAM	-0.021	-0.09	02BAM01879 BAM1362_D
+20% inflows	**Watercourse**	**Average Water level difference**	**Maximum water level difference**	**Cross-section where the maximum difference occurs**
	CRT	0.058	+0.31	01CRT02960
	AIR	0.000	0.00	ALL
	DMG	0.042	+0.07	01DMG01914 01DMG01899 01DMG01853 DMG1793_EST
	SHN	0.100	+0.44	01SHN02228 01SHN02143 01SHN02133
	HUR	0.045	+0.09	01HUR00841 01HUR00773 01HUR00753
	BAM	0.049	+0.16	02BAM01305 02BAM01293
-20% inflows	**Watercourse**	**Average Water level difference**	**Maximum water level difference**	**Cross-section where the maximum difference occurs**
	CRT	-0.066	-0.30	01CRT02066
	AIR	0.000	0.00	ALL
	DMG	-0.062	-0.13	01DMG02210 01DMG02191
	SHN	-0.082	-0.27	01SHN02276 01SHN02267

<table>
<tr><td rowspan="3"></td><td></td><td></td><td></td><td>01SHN02228
01SHN02143
01SHN02133</td></tr>
<tr><td>HUR</td><td>-0.059</td><td>-0.11</td><td>01HUR00773
01HUR00753</td></tr>
<tr><td>BAM</td><td>-0.061</td><td>-0.23</td><td>02BAM02111</td></tr>
<tr><td>Afflux at Key Structure
Inlet coefficients of culverts and discharge coefficients of bridge and orifice increased by 20%</td><td colspan="4">Increasing coefficients by 20% at key structures throughout the model showed relatively minor changes in peak levels and extents throughout the model reach.
The most significant impact was noted at 02BAM01362, where flow into the 2D domain over the bridge crossing downstream is controlled by a spill structure representing the bridge deck. Increasing the weir coefficient of this structure caused a decrease in peak levels upstream of the structure of ~45mm. However, the impact upon the maximum extent of flooding was relatively minor. A similar response was observed at the structure downstream of 01SHN02133.
This pattern is reflected throughout the reach in general the impact upon extents resulting from this sensitivity test is relatively minor.</td></tr>
<tr><td>Afflux at Key Structure
Inlet coefficients of culverts and discharge coefficients of bridge and orifice decreased by 20%</td><td colspan="4">Similarly, decreasing coefficients by 20% at key structures throughout the model showed relatively minor changes in peak levels and extents throughout the model reach.
The most significant impact of this test was also noted at 02BAM01362, where flow into the 2D domain over the bridge crossing downstream is controlled by a spill structure representing the bridge deck. Decreasing the weir coefficient of this structure caused an increase in peak levels upstream of the structure of ~55mm. However, the impact upon the maximum extent of flooding was relatively minor. A similar response was observed at the structure downstream of 01SHN02133.
This pattern is reflected throughout the reach in general the impact upon extents resulting from this sensitivity test is relatively minor.</td></tr>
<tr><td>Downstream Conditions
Duration of surge component of tidal boundary is increased by 100% (i.e. 60hours)</td><td colspan="4">To test the effect of the duration of high tide levels for a given upstream flood flow condition, the duration of the surge component of the 0.5% AEP tidal boundary was increased by 100% (i.e. 60 hours). The impact was noted throughout the lower reaches of the modelled watercourses with a variation in peak water levels of up to 130mm noted, however there were no noticeable effects on the flood extents.</td></tr>
<tr><td>Downstream Conditions
Duration of surge component of tidal boundary is decreased by 100% (i.e. 15hours)</td><td colspan="4">To test the effect of the duration of high tide levels for a given upstream flood flow condition, the duration of the surge component of the 0.5% AEP tidal boundary was decreased by 50%. The impact was noted throughout the lower reaches of the modelled watercourses, including a decrease in peak water levels of up to 440mm was noted at the downstream reach of the easterly watercourses. However, the impact upon extents for this simulation was minor.</td></tr>
<tr><td>4.5 Model Files</td><td colspan="4">The hydraulic model files associated with this model are provided as a separate deliverable under the contract, as required under Sections 7.8 and 13 of the Stage I Project Brief. The model files included are detailed in Annex D.</td></tr>
</table>

5. Hydraulic Model Outputs

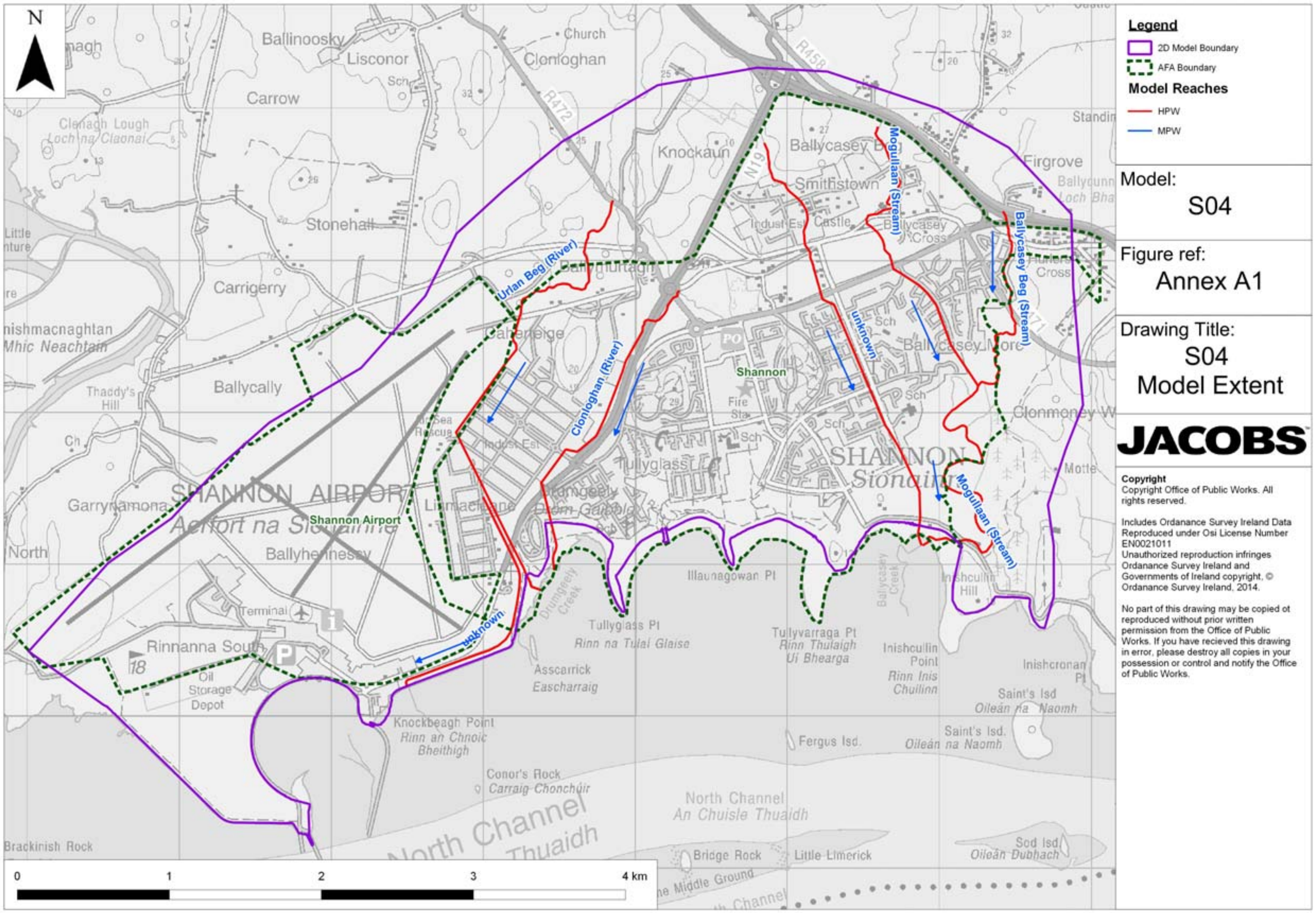
5.1 Mapping	The model outputs were processed to produce a series of flood maps according to the requirements stated in the Stage I Project Brief under Section 7.5.2 and, more specifically, under Section 7.5.2.1, with both AFAs in the model reach being an area where flooding is subject to both tidal and fluvial influence (see Section 6). This includes mapping outputs covering: • Flood extents • Flood depth and velocity • Flood hazard • Wave Overtopping Flood mapping outputs corresponding to the **defended** current scenario for the 10%, 1% and 0.1% AEP fluvial dominated flood events with the corresponding tidal boundary conditions and to the **defended** current scenario for the 10%, 0.5% and 0.1% AEP tidal dominated events with the corresponding fluvial events are shown in Annex E for flood extent and depth only.

6. Key Model Assumption and Limitations

- There are numerous locations within the modelled reaches for which topographical data were not available leading to a need to estimate details of several hydraulically-significant structures and cross sections. For this reason, it is strongly advised that models are updated with additional survey data and re-run as soon as possible.
- Where topographic survey exists for defences these have been applied as surveyed using geometry modification features in TUFLOW. Where defences are known to exist and survey was not available, crest elevations have been taken from LiDAR.
- At a number of structures cross sections at upstream or downstream faces were missing from the channel survey. These have been copied from the nearest location up or downstream, with elevations amended if appropriate to represent local channel geometry gradients. Where this has been carried out, clear comments are provided in the ISIS datafile.
- The Airport diversion channel seems to start further upstream then indicated by the topographical survey provided. The channel has been started at the upstream end of the available information in the model, but it is recommended that additional survey of this reach is collected if available.
- At the downstream end of the Ballacasey reach a structure is shown by aerial photography and mapping data to pass through the coastal flood defence. It seems likely that this is the course of the Ballacasey, however survey indicates that it flows to the east, along the defence before crossing the defence to the east. This path of the watercourse has not been verified by review of photos or aerial photography – consequently it is recommended that this reach is revisited and additional survey collected/ model updated if required.
- No survey details were available for the structures through the coastal flood defence at the downstream extent of this reach, due to restrictions in access. Details have been estimated from photographs, additional data provided by Shannon Airport, the Local Authority and interpretation of the survey successfully collected on site.

Annex A – Model Extent and Schematisation Maps

Annex A1 – Model Extent



Legend
2D Model Boundary
AFA Boundary
Model Reaches
HPW
MPW
Model:
S04
Figure ref:
Annex A1
Drawing Title:
S04
Model Extent
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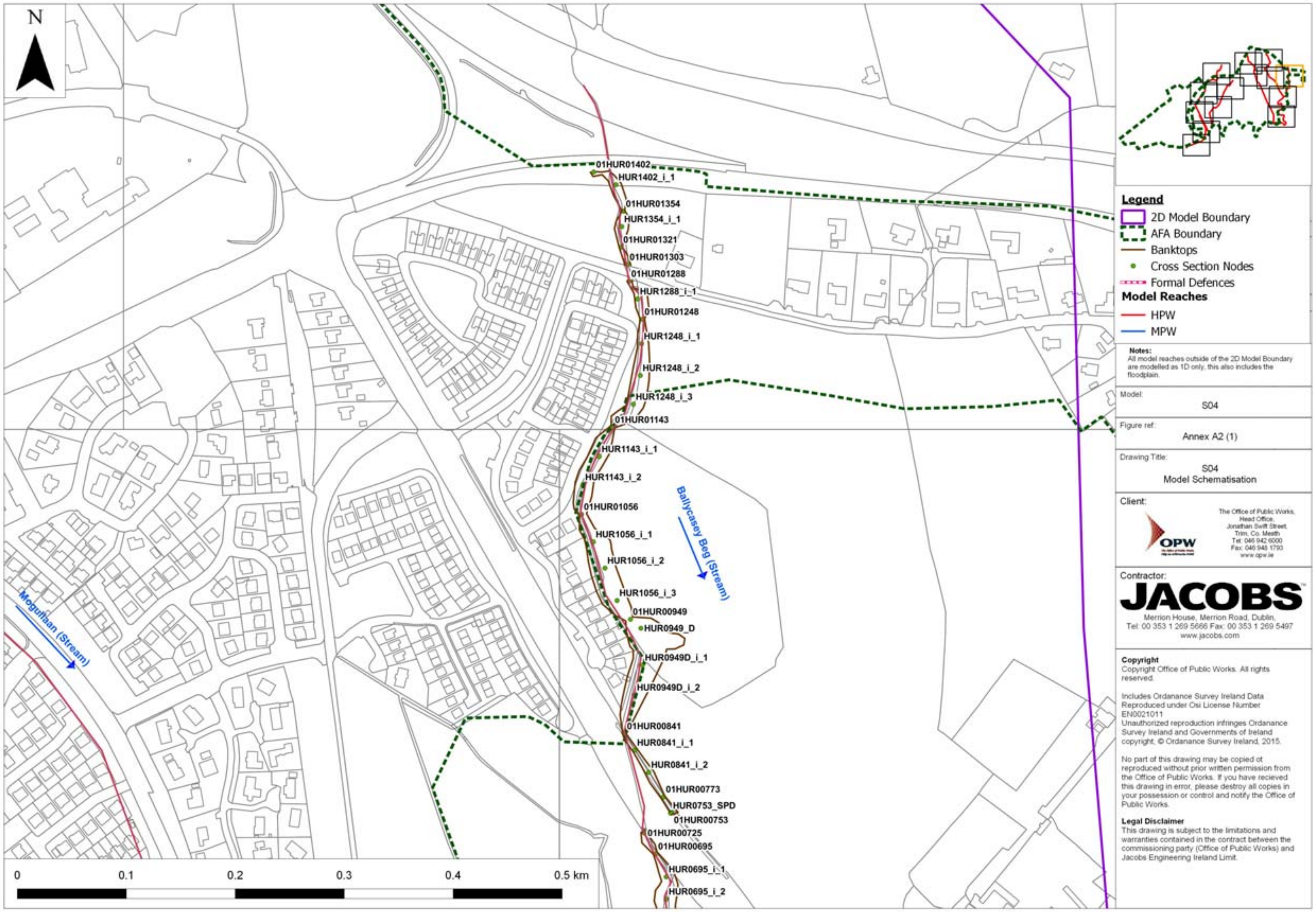
Urlan Beg (River)
Clonloghan (River)
Mogullaan (Stream)
Ballycasey Beg (Stream)
unknown
Shannon Airport
Shannon
0
1
2
3
4 km

Annex A2 – Schematisation Maps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HUR1402_i_1
01HUR01354
HUR1354_i_1
01HUR01321
01HUR01303
01HUR01288
HUR1288_i_1
01HUR01248
HUR1248_i_1
HUR1248_i_2
HUR1248_i_3
01HUR01143
HUR1143_i_1
HUR1143_i_2
01HUR01056
HUR1056_i_1
HUR1056_i_2
HUR1056_i_3
01HUR00949
HUR0949_D
HUR0949D_i_1
HUR0949D_i_2
01HUR00841
HUR0841_i_1
HUR0841_i_2
01HUR00773
HUR0753_SPD
01HUR00753
01HUR00725
01HUR00695
HUR0695_i_1
HUR0695_i_2
Ballycasey Beg (Stream)
Moguffaan (Stream)
0
0.1
0.2
0.3
0.4
0.5 km
Legend
2D Model Boundary
AFA Boundary
Banktops
Cross Section Nodes
Formal Defences
Model Reaches
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S04
Figure ref:
Annex A2 (1)
Drawing Title:
S04
Model Schematisation
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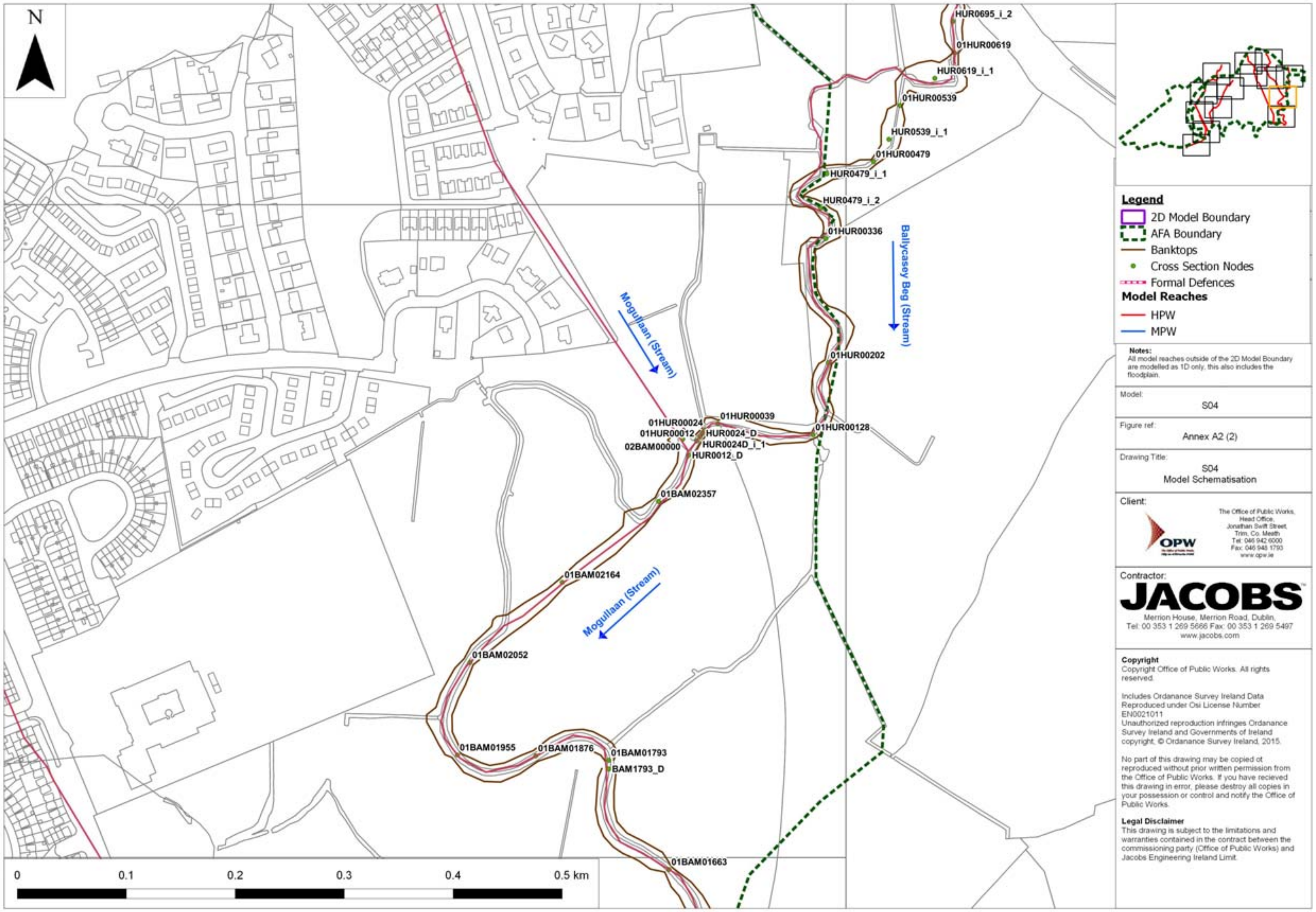
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01HUR00619
HUR0619_i_1
01HUR00539
HUR0539_i_1
01HUR00479
HUR0479_i_1
HUR0479_i_2
01HUR00336
Ballycasey Beg (Stream)
Mogullaan (Stream)
01HUR00202
01HUR00039
01HUR00024
01HUR00012
HUR0024_D
HUR0024D_i_1
02BAM00000
HUR0012_D
01HUR00128
01BAM02357
01BAM02164
Mogullaan (Stream)
01BAM02052
01BAM01955
01BAM01876
01BAM01793
BAM1793_D
01BAM01663
0
0.1
0.2
0.3
0.4
0.5 km
Legend
2D Model Boundary
AFA Boundary
Banktops
Cross Section Nodes
Formal Defences
Model Reaches
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S04
Figure ref:
Annex A2 (2)
Drawing Title:
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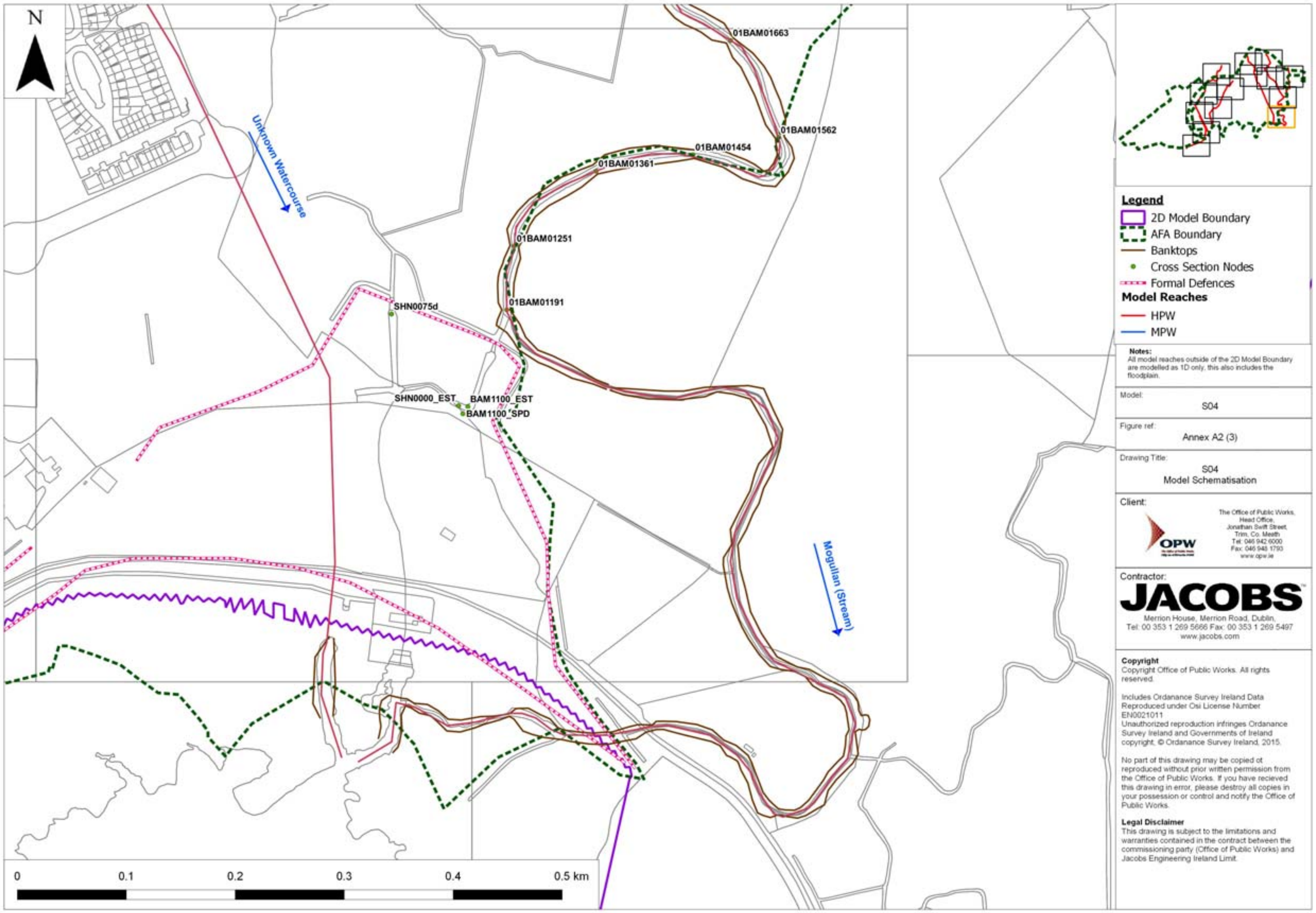
N
01BAM01663
01BAM01562
01BAM01454
01BAM01361
01BAM01251
01BAM01191
SHN0075d
SHN0000_EST
BAM1100_EST
BAM1100_SPD
Unknown Watercourse
Mogullan (Stream)
0
0.1
0.2
0.3
0.4
0.5 km
Legend
2D Model Boundary
AFA Boundary
Banktops
Cross Section Nodes
Formal Defences
Model Reaches
HPW
MPW
Notes:
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Model:
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Figure ref:
Annex A2 (3)
Drawing Title:
S04
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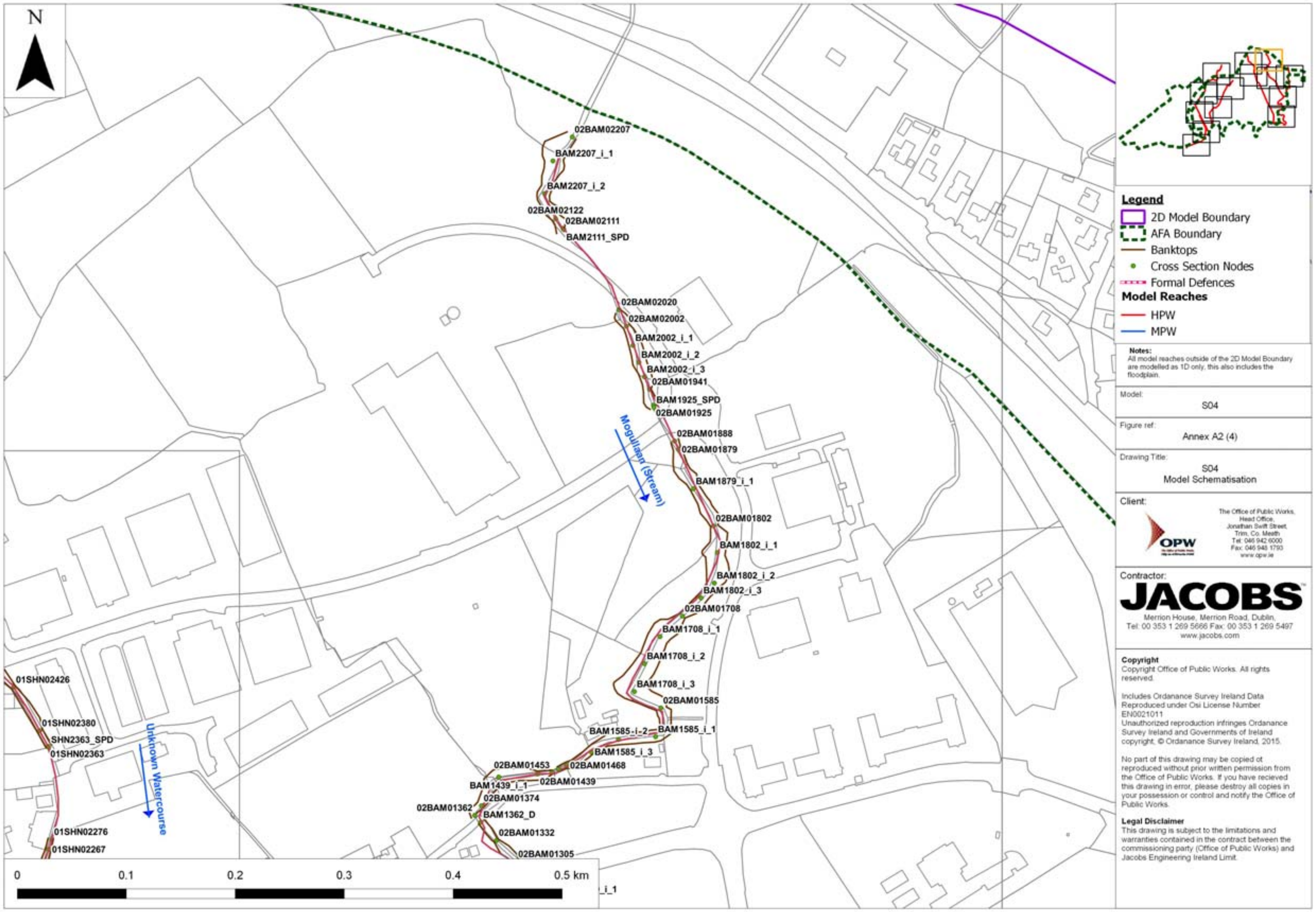

N
02BAM02207
BAM2207_i_1
BAM2207_i_2
02BAM02122
02BAM02111
BAM2111_SPD
02BAM02020
02BAM02002
BAM2002_i_1
BAM2002_i_2
BAM2002_i_3
02BAM01941
BAM1925_SPD
02BAM01925
Mogullaun (Stream)
02BAM01888
02BAM01879
BAM1879_i_1
02BAM01802
BAM1802_i_1
BAM1802_i_2
BAM1802_i_3
02BAM01708
BAM1708_i_1
BAM1708_i_2
BAM1708_i_3
02BAM01585
BAM1585_i_2
BAM1585_i_1
BAM1585_i_3
02BAM01453
02BAM01468
BAM1439_i_1
02BAM01439
02BAM01374
02BAM01362
BAM1362_D
02BAM01332
02BAM01305
01SHN02426
01SHN02380
SHN2363_SPD
01SHN02363
Unknown Watercourse
01SHN02276
01SHN02267
0
0.1
0.2
0.3
0.4
0.5 km
Legend
2D Model Boundary
AFA Boundary
Banktops
Cross Section Nodes
Formal Defences
Model Reaches
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S04
Figure ref:
Annex A2 (4)
Drawing Title:
S04
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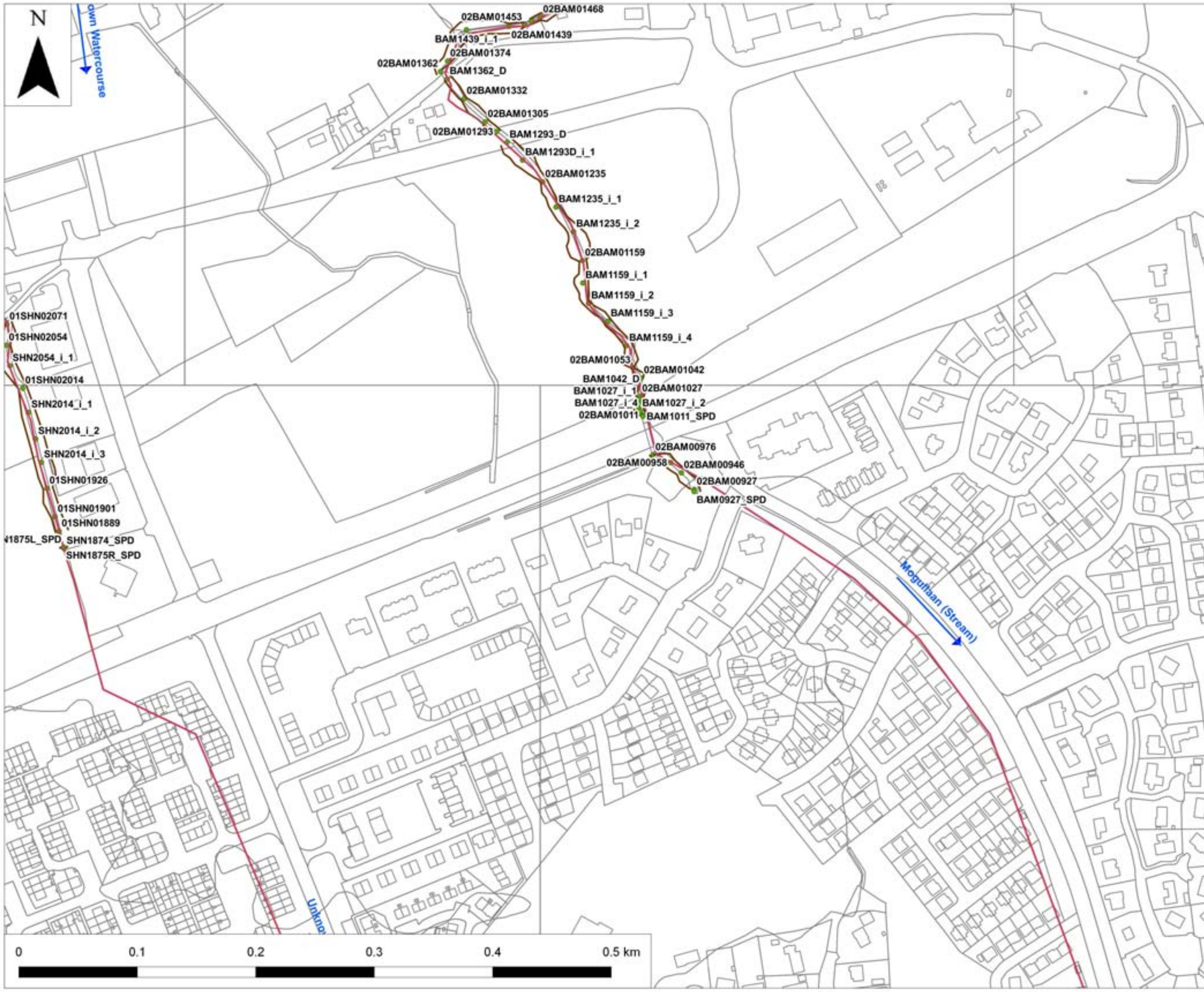

Legend

- 2D Model Boundary
- AFA Boundary
- Banktops
- Cross Section Nodes
- Formal Defences

Model Reaches

- HPW
- MPW

Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.

Model: S04

Figure ref: Annex A2 (5)

Drawing Title: S04 Model Schematisation

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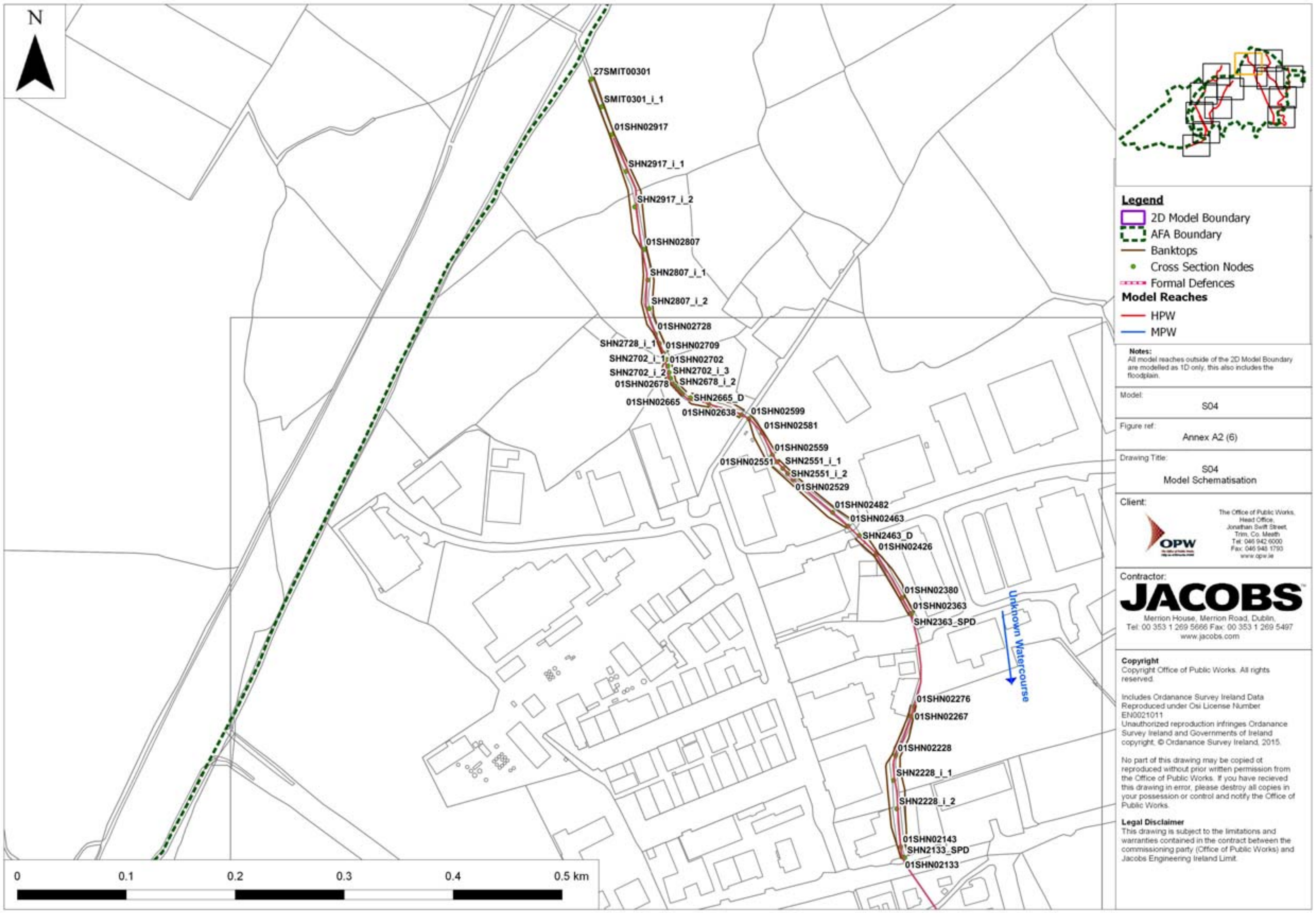

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27SMIT00301
SMIT0301_i_1
01SHN02917
SHN2917_i_1
SHN2917_i_2
01SHN02807
SHN2807_i_1
SHN2807_i_2
01SHN02728
SHN2728_i_1
01SHN02709
SHN2702_i_1
01SHN02702
SHN2702_i_2
SHN2702_i_3
01SHN02678
SHN2678_i_2
01SHN02665
SHN2665_D
01SHN02638
01SHN02599
01SHN02581
01SHN02559
01SHN02551
SHN2551_i_1
SHN2551_i_2
01SHN02529
01SHN02482
01SHN02463
SHN2463_D
01SHN02426
01SHN02380
01SHN02363
SHN2363_SPD
Unknown Watercourse
01SHN02276
01SHN02267
01SHN02228
SHN2228_i_1
SHN2228_i_2
01SHN02143
SHN2133_SPD
01SHN02133
0
0.1
0.2
0.3
0.4
0.5 km
Legend
2D Model Boundary
AFA Boundary
Banktops
Cross Section Nodes
Formal Defences
Model Reaches
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S04
Figure ref:
Annex A2 (6)
Drawing Title:
S04
Model Schematisation
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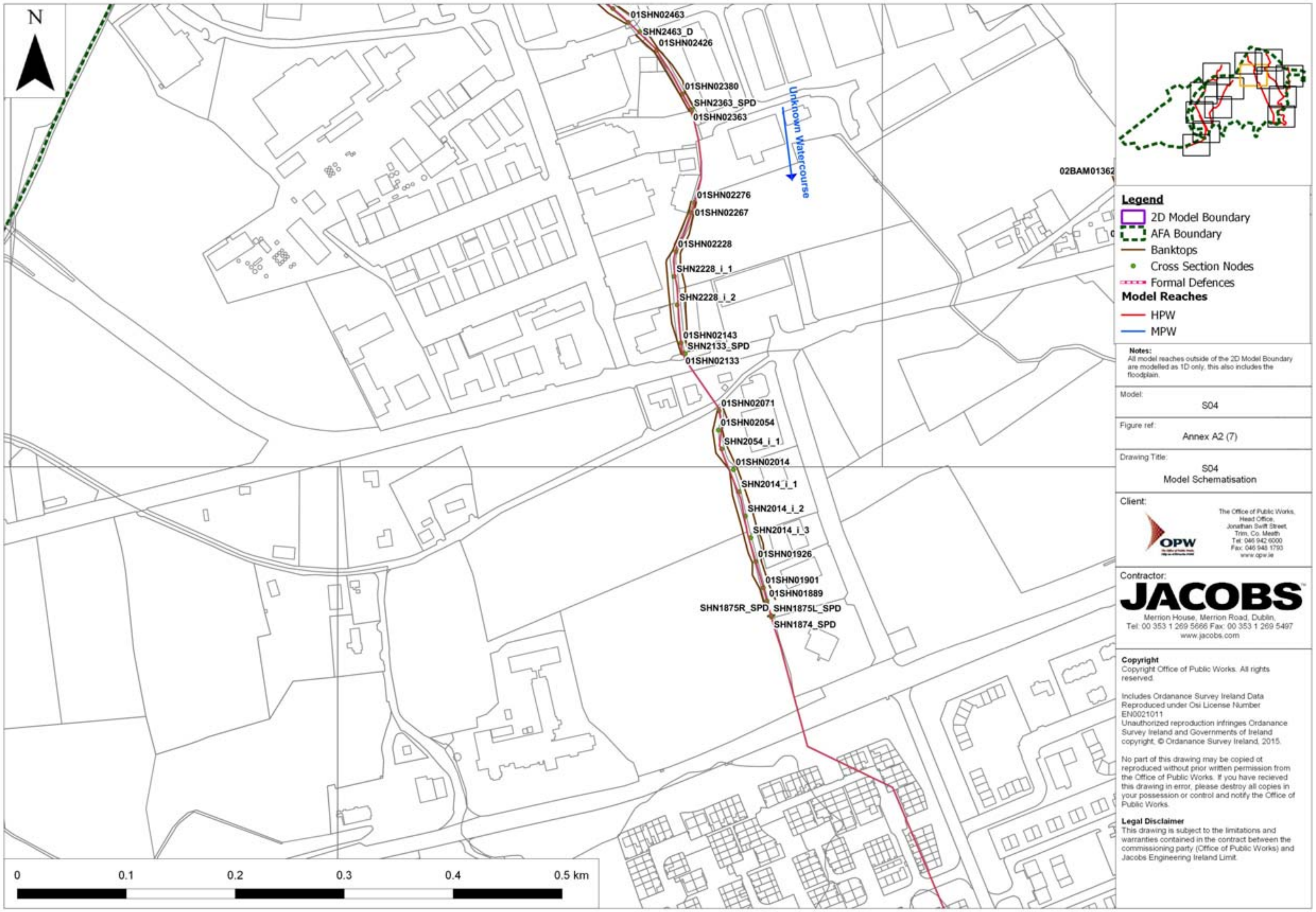

N
01SHN02463
SHN2463_D
01SHN02426
01SHN02380
SHN2363_SPD
01SHN02363
Unknown Watercourse
02BAM01362
01SHN02276
01SHN02267
01SHN02228
SHN2228_i_1
SHN2228_i_2
01SHN02143
SHN2133_SPD
01SHN02133
01SHN02071
01SHN02054
SHN2054_i_1
01SHN02014
SHN2014_i_1
SHN2014_i_2
SHN2014_i_3
01SHN01926
01SHN01901
01SHN01889
SHN1875R_SPD
SHN1875L_SPD
SHN1874_SPD
0
0.1
0.2
0.3
0.4
0.5 km
Legend
2D Model Boundary
AFA Boundary
Banktops
Cross Section Nodes
Formal Defences
Model Reaches
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S04
Figure ref:
Annex A2 (7)
Drawing Title:
S04
Model Schematisation
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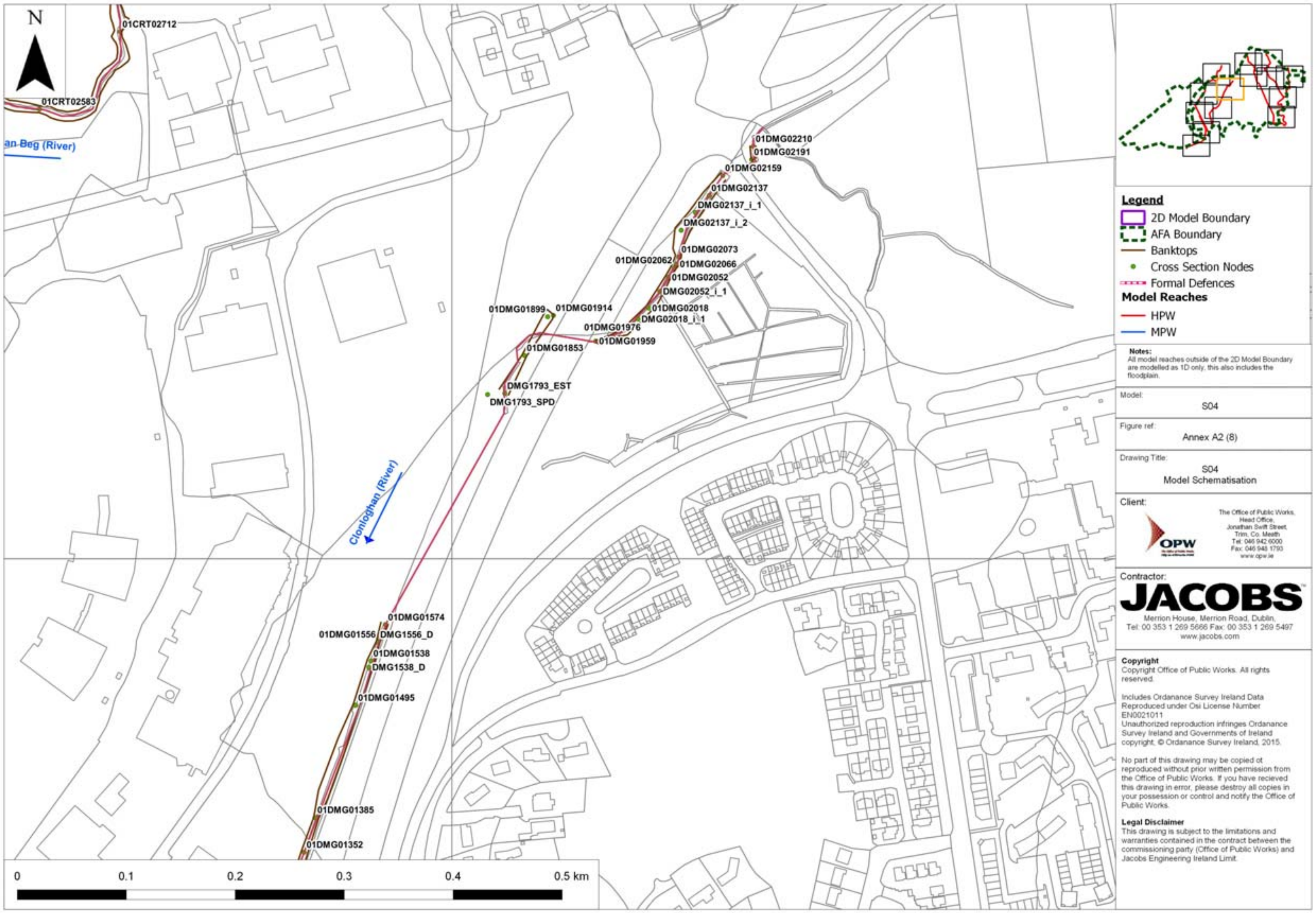

N
01CRT02712
01CRT02583
an Beg (River)
01DMG02210
01DMG02191
01DMG02159
01DMG02137
DMG02137_i_1
DMG02137_i_2
01DMG02073
01DMG02062
01DMG02066
01DMG02052
DMG02052_i_1
01DMG02018
DMG02018_i_1
01DMG01899
01DMG01914
01DMG01976
01DMG01959
01DMG01853
DMG1793_EST
DMG1793_SPD
Clonloghan (River)
01DMG01574
01DMG01556
DMG1556_D
01DMG01538
DMG1538_D
01DMG01495
01DMG01385
01DMG01352
0
0.1
0.2
0.3
0.4
0.5 km
Legend
2D Model Boundary
AFA Boundary
Banktops
Cross Section Nodes
Formal Defences
Model Reaches
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S04
Figure ref:
Annex A2 (8)
Drawing Title:
S04
Model Schematisation
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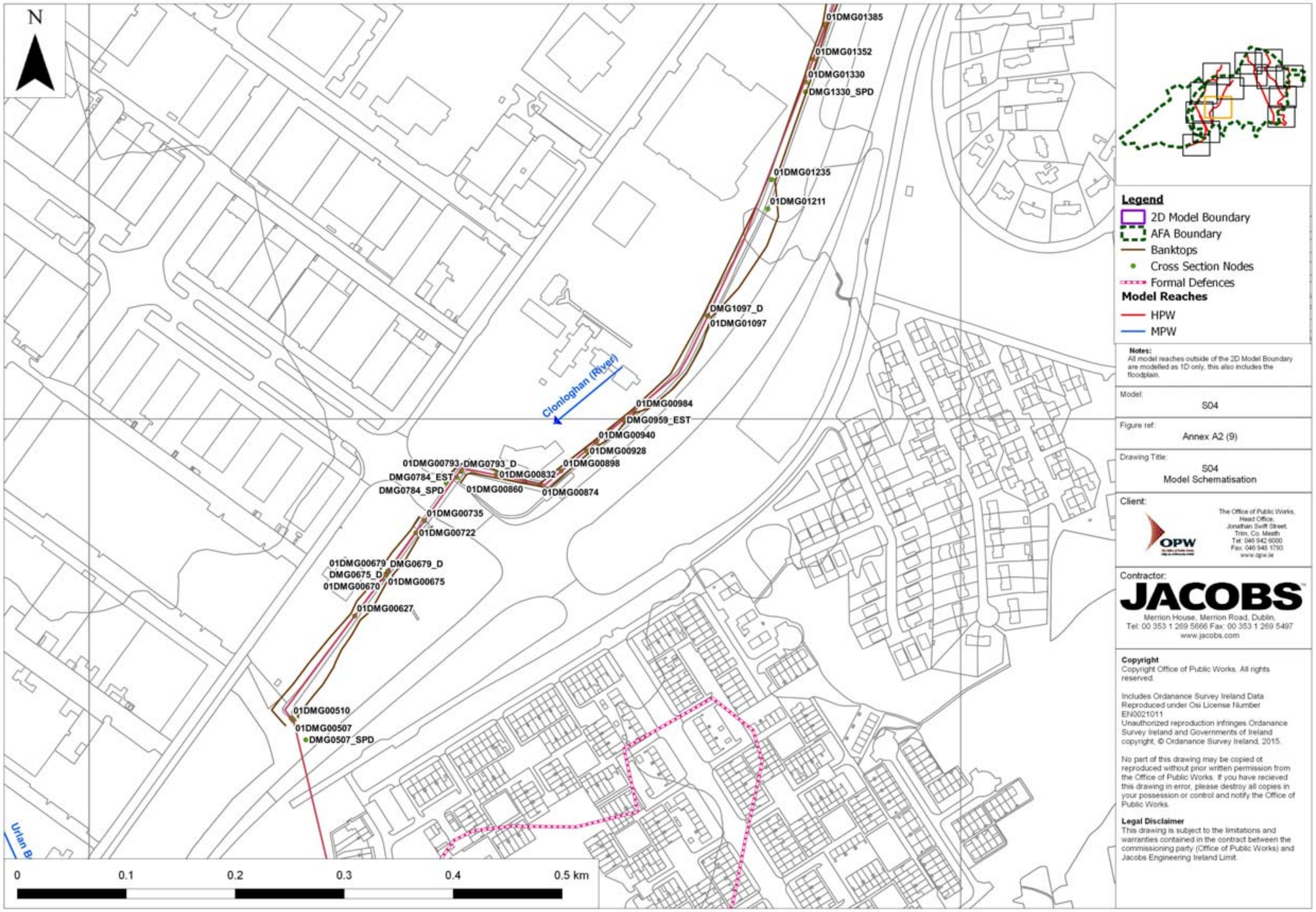

N
01DMG01385
01DMG01352
01DMG01330
DMG1330_SPD
01DMG01235
01DMG01211
DMG1097_D
01DMG01097
Clonloghan (River)
01DMG00984
DMG0959_EST
01DMG00940
01DMG00928
01DMG00898
01DMG00793
DMG0793_D
01DMG00832
DMG0784_EST
DMG0784_SPD
01DMG00860
01DMG00874
01DMG00735
01DMG00722
01DMG00679
DMG0679_D
DMG0675_D
01DMG00670
01DMG00675
01DMG00627
01DMG00510
01DMG00507
DMG0507_SPD
Urlan B
0
0.1
0.2
0.3
0.4
0.5 km
Legend
2D Model Boundary
AFA Boundary
Banktops
Cross Section Nodes
Formal Defences
Model Reaches
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S04
Figure ref:
Annex A2 (9)
Drawing Title:
S04
Model Schematisation
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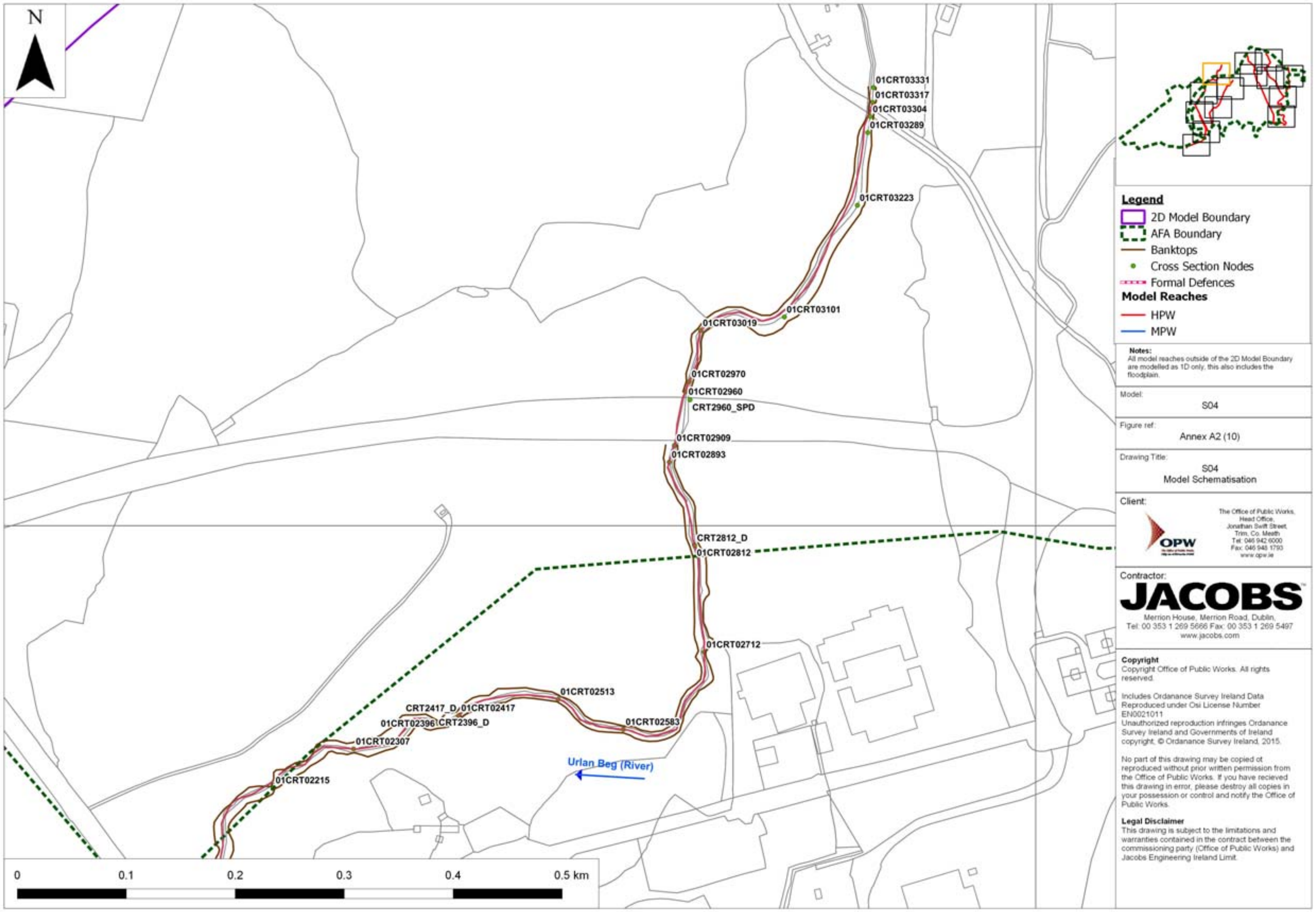
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01CRT03331
01CRT03317
01CRT03304
01CRT03289
01CRT03223
01CRT03101
01CRT03019
01CRT02970
01CRT02960
CRT2960_SPD
01CRT02909
01CRT02893
CRT2812_D
01CRT02812
01CRT02712
01CRT02513
CRT2417_D
01CRT02417
01CRT02396
CRT2396_D
01CRT02583
01CRT02307
01CRT02215
Urlan Beg (River)
0
0.1
0.2
0.3
0.4
0.5 km
Legend
2D Model Boundary
AFA Boundary
Banktops
Cross Section Nodes
Formal Defences
Model Reaches
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S04
Figure ref:
Annex A2 (10)
Drawing Title:
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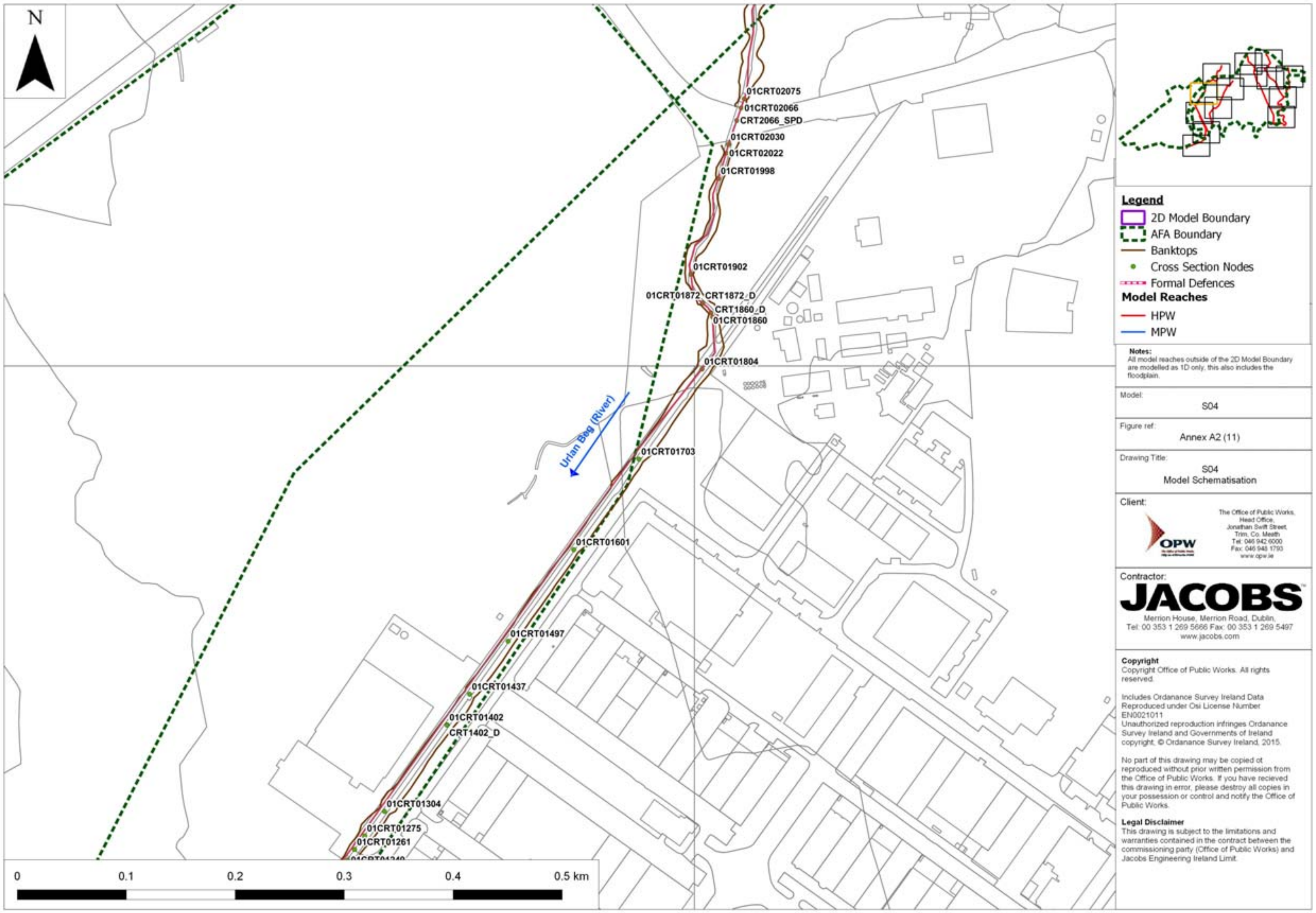
N
01CRT02075
01CRT02066
CRT2066_SPD
01CRT02030
01CRT02022
01CRT01998
01CRT01902
01CRT01872
CRT1872_D
CRT1860_D
01CRT01860
01CRT01804
Urlan Beg (River)
01CRT01703
01CRT01601
01CRT01497
01CRT01437
01CRT01402
CRT1402_D
01CRT01304
01CRT01275
01CRT01261
0
0.1
0.2
0.3
0.4
0.5 km
Legend
2D Model Boundary
AFA Boundary
Banktops
Cross Section Nodes
Formal Defences
Model Reaches
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S04
Figure ref:
Annex A2 (11)
Drawing Title:
S04
Model Schematisation
Client:
The Office of Public Works, Head Office, Jonathan Swift Street, Trim, Co. Meath
Tel: 046 942 6000
Fax: 046 948 1793
www.opw.ie
Contractor:
JACOBS
Merrion House, Merrion Road, Dublin.
Tel: 00 353 1 269 5666 Fax: 00 353 1 269 5497
www.jacobs.com
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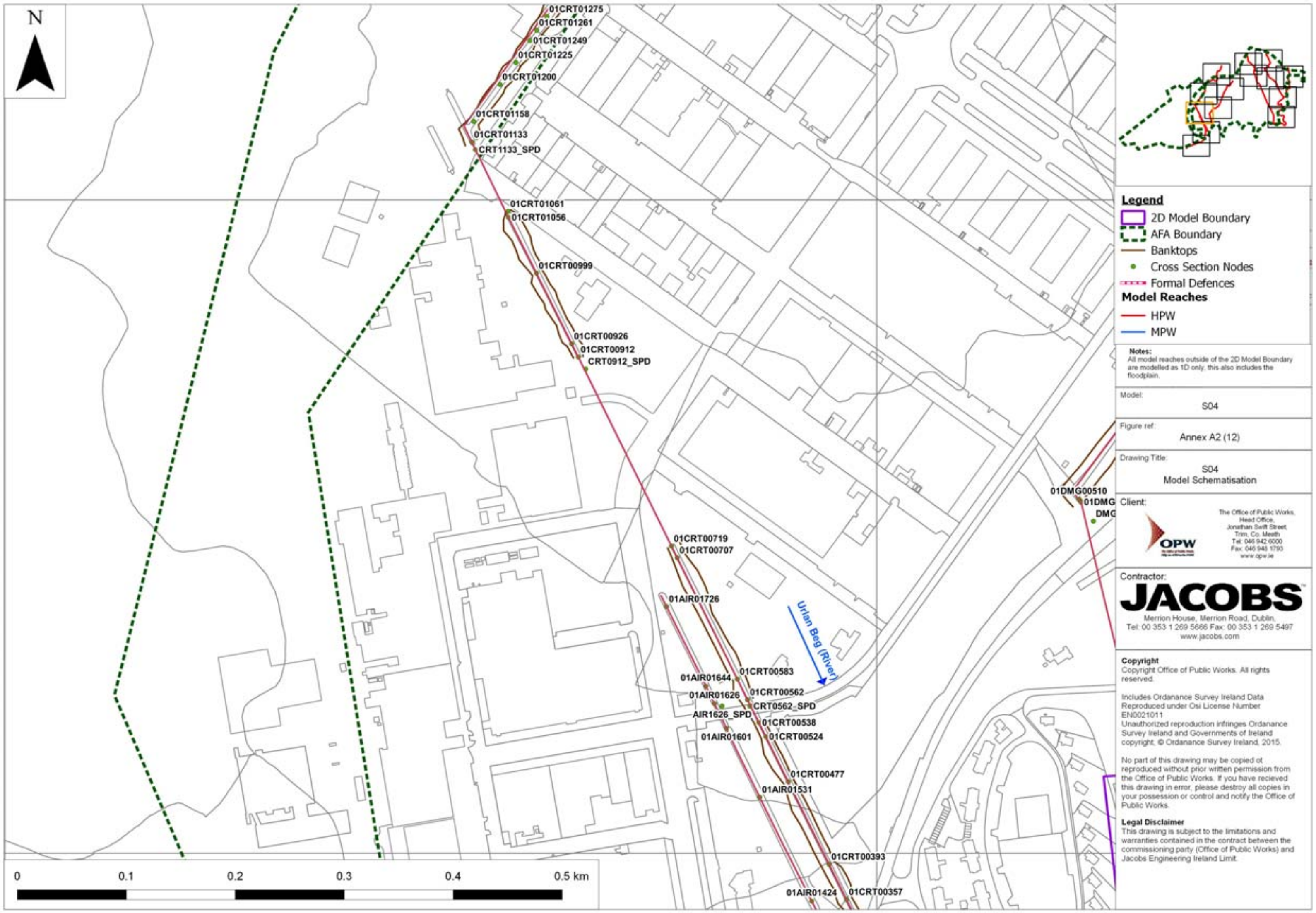
N
01CRT01275
01CRT01261
01CRT01249
01CRT01225
01CRT01200
01CRT01158
01CRT01133
CRT1133_SPD
01CRT01061
01CRT01056
01CRT00999
01CRT00926
01CRT00912
CRT0912_SPD
01CRT00719
01CRT00707
01AIR01726
Urlan Beg (River)
01AIR01644
01CRT00583
01AIR01626
01CRT00562
CRT0562_SPD
AIR1626_SPD
01CRT00538
01AIR01601
01CRT00524
01CRT00477
01AIR01531
01CRT00393
01AIR01424
01CRT00357
01DMG00510
01DMG
DMG
0
0.1
0.2
0.3
0.4
0.5 km
Legend
2D Model Boundary
AFA Boundary
Banktops
Cross Section Nodes
Formal Defences
Model Reaches
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S04
Figure ref:
Annex A2 (12)
Drawing Title:
S04
Model Schematisation
Client:
The Office of Public Works, Head Office, Jonathan Swift Street, Trim, Co. Meath
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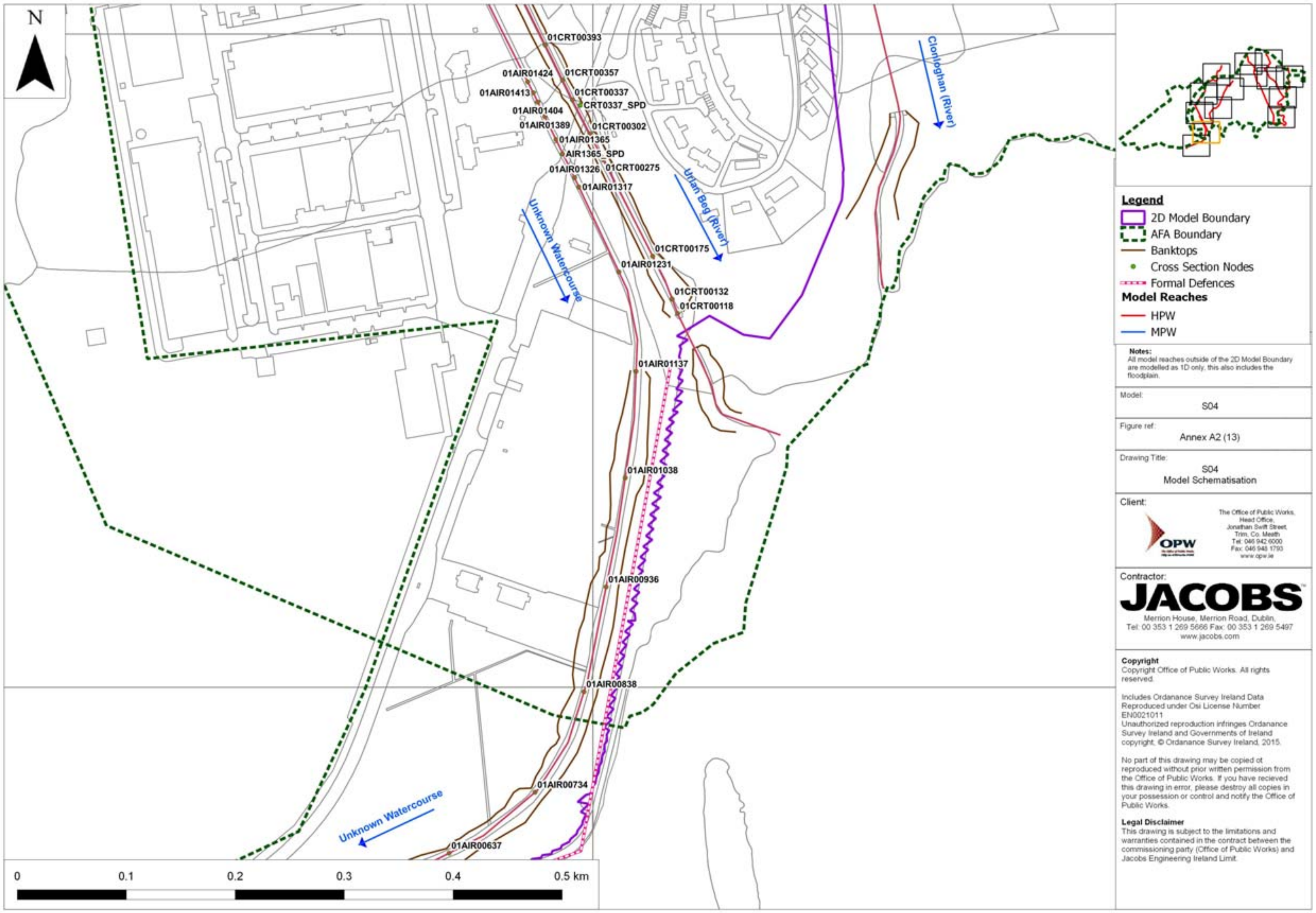
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01AIR01424
01CRT00357
01AIR01413
01CRT00337
01AIR01404
CRT0337_SPD
01AIR01389
01CRT00302
01AIR01365
AIR1365_SPD
01AIR01326
01CRT00275
01AIR01317
01CRT00175
01AIR01231
01CRT00132
01CRT00118
01AIR01137
01AIR01038
01AIR00936
01AIR00838
01AIR00734
01AIR00637
Unknown Watercourse
Urlan Beg (River)
Clonloghan (River)
Unknown Watercourse
0
0.1
0.2
0.3
0.4
0.5 km
Legend
2D Model Boundary
AFA Boundary
Banktops
Cross Section Nodes
Formal Defences
Model Reaches
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S04
Figure ref:
Annex A2 (13)
Drawing Title:
S04
Model Schematisation
Client:
The Office of Public Works, Head Office, Jonathan Swift Street, Trim, Co. Meath
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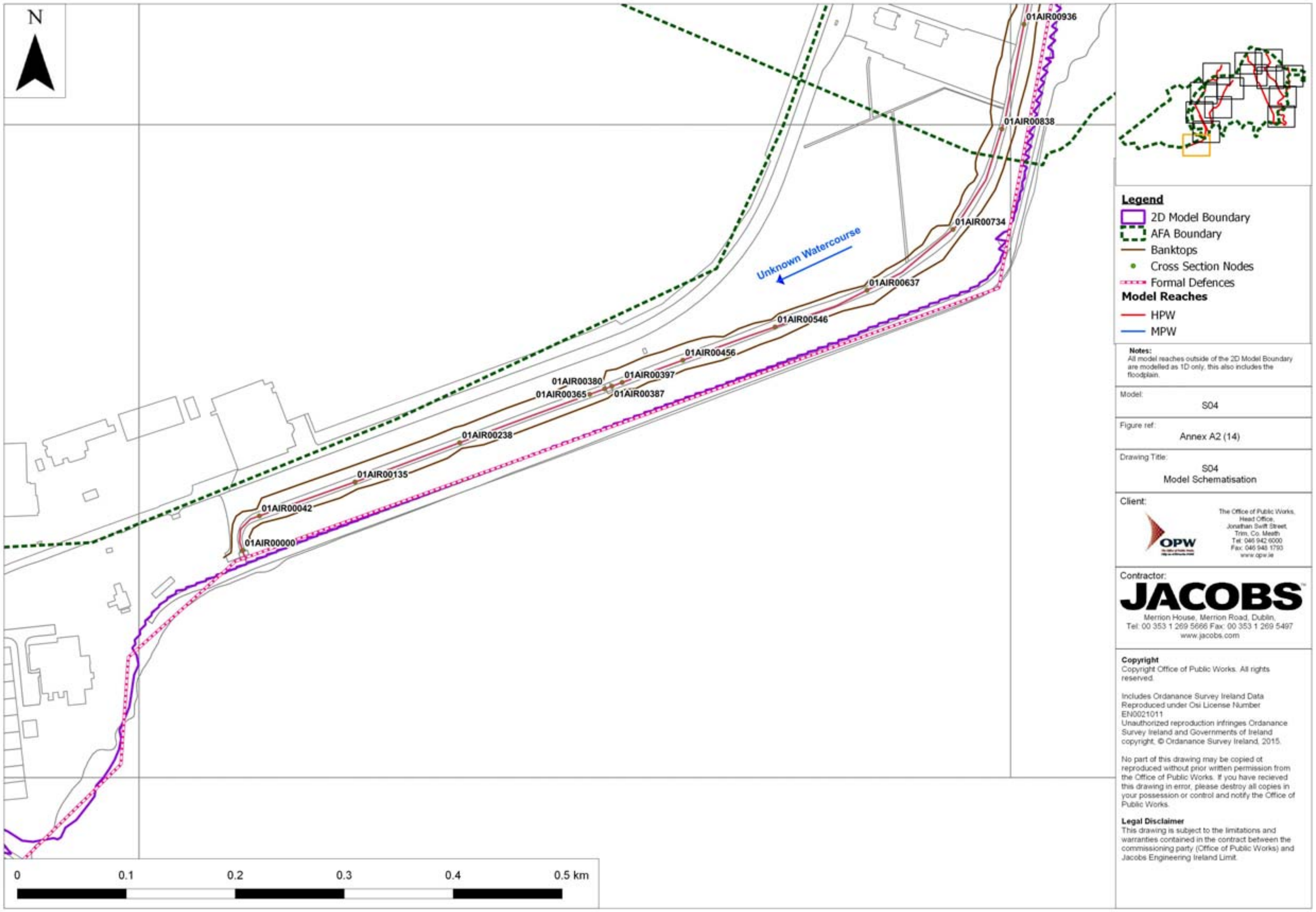

N
01AIR00936
01AIR00838
01AIR00734
Unknown Watercourse
01AIR00637
01AIR00546
01AIR00456
01AIR00397
01AIR00380
01AIR00365
01AIR00387
01AIR00238
01AIR00135
01AIR00042
01AIR00000
0
0.1
0.2
0.3
0.4
0.5 km
Legend
2D Model Boundary
AFA Boundary
Banktops
Cross Section Nodes
Formal Defences
Model Reaches
HPW
MPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S04
Figure ref:
Annex A2 (14)
Drawing Title:
S04
Model Schematisation
Client:
The Office of Public Works, Head Office, Jonathan Swift Street, Trim, Co. Meath
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Annex B – Structure and Hydraulic Roughness schedules

Survey Reference	ISIS Node reference	Type of structure	Modelling approach	Structure included in model (Y/N)
Schedule A.1 - Structure Schedule for AIR reach				
27KNOC00163I	01AIR01626	1.88 m x 1.46 m Culvert	Rectangular Culvert	Y
27KNOC00142I	01AIR01413	1.78 m x 1.40 m Culvert	Rectangular Culvert	Y
27KNOC00136I	01AIR01365	1.53 m x 1.24 m Culvert	Rectangular Culvert	Y
27KNOC00039I	01AIR00387	1.80 m x 1.15 m Culvert	Rectangular Culvert	Y
na	Airport_P1U, Airport_P2U	Pumps	Represented with pump units	Y
na	AIR0000a_CU, AIR0000b_CU	Outfall	ISIS flapped outfall unit	Y
Schedule A.3 - Structure Schedule for CRT reach				
27CAHE00335I	CRT3317a_CU, CRT3317b_CU	0.77 m x 0.77 m Culvert 0.77 m x 0.84 m Culvert	Rectangular Culvert, double barrelled	Y
27CAHE00299I	CRT2960a_CU, CRT2960b_CU, CRT2960c_CU	2*0.35m diameter culverts Central barrel of 1.25m diameter	Circular Conduit * 3	Y
27CAHE00243I	CRT2396a_BU, CRT2396b_BU	Short bridge structures (<5m) - 0.071sq m opening * 2	2 * orifice units	Y
27CAHE00212I	CRT2066a_CU, CRT2066b_CU, CRT2066c_CU, CRT2066d_CU	4 circular pipes in parallel	Circular Conduit * 4	Y
27CAHE00190I	CRT1860_CU	Short culvert < 10m in length	Orifice unit	Y
na	CRT1437_FRCU	Flood relief culvert – details estimated with information provided by Jacobs	A taken is to spill from the orifice representing the culvert entrance directly to a dummy reservoir unit Culvert inlet is located 3.675 metres d/s 01CRT01437. Lateral spill located at the	Y

Survey Reference	ISIS Node reference	Type of structure	Modelling approach	Structure included in model (Y/N)
			surveyed location of 01CRT01437 for ease of configuration. Head loss in the reach over 3.675 metres judged negligible.	
27CAHE00129D	CRT1261_BU	4.35 * 2.08m culvert	Rectangular culvert	Y
27CAHE00117I	CRT1133_CU	1.510 * 1.445m culvert with projecting barrel	Rectangular culvert	Y
27CAHE00095I	CRT0912_CU	1.77 * 1.575m culvert	Rectangular culvert	Y
27CAHE00059I	CRT0562_CU	1.77 * 1.510m culvert with projecting barrel	Rectangular culvert	Y
27CAHE00036I	CRT0337_CU	1.76 * 1.455m culvert	Rectangular culvert	Y
27CAHE00016I	CRT0118a_CU, CRT0118b_CU	Double barrel outfall	2 * rectangular conduit reaches, 2* ISIS outfall units	Y
Schedule A.3 - Structure Schedule for DMG reach				
27DRUM00223I	DMG2191_CU	0.90 m diameter Culvert	Circular Conduit	Y
27DRUM00210I	DMG2066_CUI	Short crossing, <10m length.	Orifice	Y
27DRUM00200I	DMG1959_CU	0.90 m diameter Culvert	Circular Conduit	Y
27DRUM00191	DMG1793_CU	0.90 m diameter Culvert (estimated)	Circular Conduit	Y
27DRUM00161I	DMG1538_CU	Short culvert (10.44 metres)	Orifice applied due to length and lack of survey at DS face	Y
27DRUM00139I	DMG1330_CU	1.5 m diameter Culvert	Circular Conduit	Y
27DRUM00101J	DMG0959_CU	0.96 m diameter Culvert	Circular Conduit	Y
27DRUM00093I	DMG0874_CU	1.5 m diameter Culvert	Circular Conduit	Y
27DRUM00086D	DMG0793_BU	Short structure (0.97 metre) - poss. large utility pipes. Mean soffit level used.	Orifice	Y
na	DMG0784_CU	2.97. * 1.075m rectangular culvert – estimated data	Rectangular conduit	Y

Survey Reference	ISIS Node reference	Type of structure	Modelling approach	Structure included in model (Y/N)
27DRUM00075D	DMG0679_BU	Short bridge/utility structure (0.85 metre) - mean soffit level used	Orifice	Y
27DRUM00074D	DMG0675_BU	Short bridge/utility structure (1.1 metre) - mean soffit level used	Orifice	Y
27DRUM00057I	DMG0507_CU	Long rectangular culvert – estimated data from aerial photography and LiDAR	Rectangular culvert and ISIS outfall units	Y
Schedule A.4 - Structure Schedule for the HUR reach				
27BALL00396I	HUR1303a_CU HUR1303b_CU	2 x 0.6 m Diameter Pipe Culverts (Upstream Faces) (14.89 m Long)	Parallel Circular Conduits	Y
27BALL00343I	HUR0753_CU	2.48 m x 1.195 m Culvert (Upstream Face) (28.385 m Long)	Rectangular Conduit	Y
27BALL00267D	HUR0024_BU	Bridge (3.57 m Long)	Arch Bridge + Orifice Switch	Y
N/A - ESTIMATED	BAM1100_CU	Culvert	Symmetrical Conduit	Y
N/A - ESTIMATED	BAM0875_CD	Outfall Sluice	Flapped Outfall	Y
27BALL00109I	N/A	0.45 m Diameter Pipe Culvert (Upstream Face) (4.22 m Long)	N/A	N
Schedule A.5 - Structure Schedule for the BAM reach				
27BALA00200I	BAM2111_CU	1 m Diameter Pipe Culvert (90.58 m Long)	Circular Conduit	Y
27BALA00179I	BAM1925_CU	0.9 m Diameter Pipe Culvert (36.59 m Long)	Symmetrical Conduit	Y
27BALA00134I	BAM1459_BU	Culvert – Rectangular Upstream Face, Circular Downstream Face – Downstream Face (Smaller	Orifice	Y

Survey Reference	ISIS Node reference	Type of structure	Modelling approach	Structure included in model (Y/N)
		Area Used) (6.49 m Long)		
27BALA00125D	BAM1362a_BU BAM1362b_BU BAM1362a_BU	3 x 0.6 m Diameter Pipe Bridge (8.44 m Long)	Parallel Orifice Units	Y
27BALA00117D	BAM1293_BU	Bridge (12.78 m Long)	Arch Bridge + Orifice Switch	Y
27BALA00093I	BAM1042_BU	0.6 m Diameter Pipe Culvert (7.5 m Long)	Orifice	Y
27BALA00088I	BAM1011a_CU BAM1011b_CU	2 x 1 m Diameter Pipe Culvert (34.94 m Long)	Parallel Symmetrical Conduits	Y
27BALA00082I	BAM0927_CU	Rectangular Culvert (926.63 m Long)	Symmetrical Conduit	Y
Schedule A.6 - Structure Schedule for the SHN reach				
27SMIT00274I	SHN2709_BU	0.6 m Diameter Pipe Culvert (6.721 m Long)	Orifice	Y
27SMIT00269I	SHN2665a_BU SHN2665b_BU	2 x 0.48 m Diameter Pipe Culverts (8.35 m Long)	Parallel Orifice Units	Y
27SMIT00264I	SHN2607a_BU SHN2607b_BU	2 x 0.45 m Diameter Pipe Culverts (7.985 m Long)	Parallel Orifice Units	Y
27SMIT00259I	SHN2559_BU	0.45 m Diameter Pipe Culvert (7.464 m Long)	Orifice	Y
27SMIT00249D	SHN2463_BU	Bridge (13.51 m Length)	Arch Bridge + Orifice Switch	Y
27SMIT00239I	SHN2363_CU	0.6 m Diameter Pipe Culvert (Upstream Face) 0.3 m Diameter Pipe Culvert (Downstream Face) (85.56 m Long)	Symmetrical Conduit	Y
27SMIT00217I	SHN2133_CU	1 x 1 m Diameter Pipe Culvert (Upstream Face) 2 x 0.6 m Diameter Pipe	Symmetrical Conduit	Y

Survey Reference	ISIS Node reference	Type of structure	Modelling approach	Structure included in model (Y/N)
		Culverts (Downstream Face) (58.83 m Long)		
27SMIT00192I	SHN1889a_CU SHN1889b_CU	2 x 1.2 m Diameter Pipe Culverts (13.65 m Long)	Parallel Symmetrical Conduits	Y
27SMIT00191I	SHN1874_CU	ESTIMATED Culvert (1799.83 m Long)	Symmetrical Conduit	Y

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Annex C – Model Calibration

Not used as calibration to historical events was not possible.

Annex D - Hydraulic Model files

ISIS files	
Model geometry (.dat) and associated files (e.g.: .ief, .zzl, .zzd, .zzu,.zzx)	**Design runs – Fluvial and Tidal scenarios:** **Fluvial Mainstem:** S04_Qxxx_MiFlu_C_Des_Iss4_3.dat S04_Q10_FluMi_C_Issv4_1.ief S04_Q100_FluMi_C_Issv4_1.ief S04_Q1000_FluMi_C_Issv4_1.ief S04_Q5_FluMi_C_Issv4_1.ief S04_Q20_FluMi_C_Issv4_1.ief S04_Q50_FluMi_C_Issv4_1.ief S04_Q200_FluMi_C_Issv4_1.ief **Tidal:** S04_Qxxx_MiFlu_C_Des_Iss4_3.dat S04_Q10_TiMi_C_Issv4_1.ief S04_Q100_TiMi_C_Issv4_1.ief S04_Q1000_TiMi_C_Issv4_1.ief S04_Q2_TiMi_C_Issv4_1.ief S04_Q5_TiMi_C_Issv4_1.ief S04_Q20_TiMi_C_Issv4_1.ief S04_Q50_TiMi_C_Issv4_1.ief S04_Q200_TiMi_C_Issv4_1.ief **Sensitivity runs:** **Roughness (±20%):** S04_Qxxx_MiFlu_C_Sen_RoIn_Iss4_3.DAT S04_Qxxx_MiFlu_C_Sen_RoDec_Iss4_3.DAT S04_Q100_FluMi_C_Sens_RoDIn_Issv4_1.ief S04_Q100_FluMi_C_Sens_RoDec_Issv4_1.ief **Flow (±20%):** S04_Qxxx_MiFlu_C_Des_Iss4_3.dat S04_Q100_FluMi_C_Sens_FloIn_Issv4_1.ief S04_Q100_FluMi_C_Sens_FloDec_Issv4_1.ief **Structure Coefficients (±20%):** S04_Qxxx_MiFlu_C_Sen_CoIn_Iss4_3.DAT S04_Qxxx_MiFlu_C_Sen_CoDec_Iss4_3.DAT S04_Q100_FluMi_C_Sen_CoInc_Issv4_1.ief S04_Q100_FluMi_C_Sen_CoDec_Issv4_1.ief

	DS Tidal 200% Duration S04_Qxxx_MiFlu_C_Des_Iss4_3.dat S04_Q200_TiMi_C_Sens_SuDu200%_Issv4_1.ief **DS Tidal 50% Duration** S04_Qxxx_MiFlu_C_Des_Iss4_3.dat S04_Q200_TiMi_C_Sens_SuDu50%_Issv4_1.ief **MRFS** **Fluvial:** S04_Qxxx_MiFlu_C_Des_Iss4_3.dat S04_Q5_FluMi_MRFS_Iss4_1.ief S04_Q10_FluMi_MRFS_Iss4_1.ief S04_Q20_FluMi_MRFS_Iss4_1.ief S04_Q50_FluMi_MRFS_Iss4_1.ief S04_Q100_FluMi_MRFS_Iss4_1.ief S04_Q200_FluMi_MRFS_Iss4_1.ief S04_Q1000_FluMi_MRFS_Iss4_1.ief **Tidal:** S04_Qxxx_MiFlu_C_Des_Iss4_3.dat S04_Q2_Timi_MRFS_Iss4_1.ief S04_Q5_Timi_MRFS_Iss4_1.ief S04_Q10_Timi_MRFS_Iss4_1.ief S04_Q20_Timi_MRFS_Iss4_1.ief S04_Q50_Timi_MRFS_Iss4_1.ief S04_Q100_Timi_MRFS_Iss4_1.ief S04_Q200_Timi_MRFS_Iss4_1.ief S04_Q1000_Timi_MRFS_Iss4_1.ief **HEFS** **Fluvial:** S04_Qxxx_MiFlu_C_Des_Iss4_3.dat S04_Q10_FluMi_HEFS_Iss4_1.ief S04_Q100_FluMi_HEFS_Iss4_1.ief S04_Q1000_FluMi_HEFS_Iss4_1.ief **Tidal:** S04_Qxxx_MiFlu_C_Des_Iss4_3.dat S04_Q10_Timi_HEFS_Iss4_1.ief S04_Q200_Timi_HEFS_Iss4_1.ief S04_Q1000_Timi_HEFS_Iss4_1.ief

Hydrological Inflow files	**Design runs – Fluvial and Tidal scenarios:** **Fluvial Mainstem:** S04_S5.IED S04_S11.IED S04_S15.IED S04_S3.IED S04_S7.IED S04_S9.IED S04_S13.IED **Tidal:** S04_S6.IED S04_S12.IED S04_S16.IED S04_S2.IED S04_S4.IED S04_S8.IED S04_S10.IED S04_S14.IED **Sensitivity runs:** **Roughness (±20%):** S04_S11.IED **Flow (±20%):** S04_S11_FlInc.IED S04_S11_FlDec.IED **Structure Coefficients (±20%):** S04_S11.IED **DS Tidal 200% Duration** S04_S14_SensTest_TidalBdy_Inc200%.IED **DS Tidal 50% Duration** S04_S14_SensTest_TidalBdy_Dec50%.IED **MRFS:** **Fluvial Mainstem:** S04_S5_MRFS.IED S04_S11_MRFS.IED S04_S15_MRFS.IED S04_S3_MRFS.IED S04_S7_MRFS.IED S04_S9_MRFS.IED S04_S13_MRFS.IED **Tidal:** S04_S6_MRFS.IED S04_S12_MRFS.IED S04_S16_MRFS.IED

	S04_S2_MRFS.IED S04_S4_MRFS.IED S04_S8_MRFS.IED S04_S10_MRFS.IED S04_S14_MRFS.IED

TUFLOW files	
TUFLOW Control Files (.tcf) and associated files (e.g.: ecf, tgc, tbc)	**Design runs – Fluvial and Tidal scenarios:** **Fluvial Mainstem:** S04_Q10_FluMi_C_Issv4_1.tcf S04_Q100_FluMi_C_Issv4_1.tcf S04_Q1000_FluMi_C_Issv4_1.tcf S04_Q5_FluMi_C_Issv4_1.tcf S04_Q20_FluMi_C_Issv4_1.tcf S04_Q50_FluMi_C_Issv4_1.tcf S04_Q200_FluMi_C_Issv4_1.tcf **Tidal:** S04_Q10_TiMi_C_Issv4_1.tcf S04_Q100_TiMi_C_Issv4_1.tcf S04_Q1000_TiMi_C_Issv4_1.tcf S04_Q2_TiMi_C_Issv4_1.tcf S04_Q5_TiMi_C_Issv4_1.tcf S04_Q20_TiMi_C_Issv4_1.tcf S04_Q50_TiMi_C_Issv4_1.tcf S04_Q200_TiMi_C_Issv4_1.tcf S04_defended_Iss4_1.tgc S04_defended_Iss4_1.tbc S04_landuse.tmf S04_bc_dbase.csv **Sensitivity runs:** **Roughness (±20%):** S04_Q100_FluMi_C_Sen_RoIn_Issv4_1.tcf S04_Q100_FluMi_C_Sen_RoDec_Issv4_1.tcf **Flow (±20%):** S04_Q100_FluMi_C_Sen_FloIn_Issv4_1.tcf S04_Q100_FluMi_C_Sen_CoDec_Issv4_1.tcf **Structure Coefficients (±20%):** S04_Q100_FluMi_C_Sen_FloDec_Issv4_1.tcf S04_Q100_FluMi_C_Sen_CoInc_Issv4_1.tcf **DS Tidal 200% Duration** S04_Q200_TiMi_C_Sens_SuDu200%_Issv4_1.tcf **DS Tidal 50% Duration** S04_Q200_TiMi_C_Sens_SuDu50%_Issv4_1.tcf

	Boundary Files S04_defended_Iss4_1.tbc S04_bc_dbase.csv **Geometry and Materials files – Fluvial and Tidal scenarios:** S04_defended_Iss4_1.tgc S04_landuse.tmf **MRFS** **Fluvial Mainstem:** S04_Q10_FluMi_MRFS_C_Issv4_1.tcf S04_Q100_FluMi_ MRFS_C_Issv4_1.tcf S04_Q1000_FluMi_ MRFS_C_Issv4_1.tcf S04_Q5_FluMi_ MRFS_C_Issv4_1.tcf S04_Q20_FluMi_ MRFS_C_Issv4_1.tcf S04_Q50_FluMi_ MRFS_C_Issv4_1.tcf S04_Q200_FluMi_ MRFS_C_Issv4_1.tcf **Tidal:** S04_Q10_TiMi_ MRFS_C_Issv4_1.tcf S04_Q100_TiMi_ MRFS_C_Issv4_1.tcf S04_Q1000_TiMi_ MRFS_C_Issv4_1.tcf S04_Q2_TiMi_ MRFS_C_Issv4_1.tcf S04_Q5_TiMi_ MRFS_C_Issv4_1.tcf S04_Q20_TiMi_ MRFS_C_Issv4_1.tcf S04_Q50_TiMi_ MRFS_C_Issv4_1.tcf S04_Q200_TiMi_ MRFS_C_Issv4_1.tcf S04_defended_Iss4_1.tgc S04_defended_Iss4_1.tbc S04_landuse.tmf S04_bc_dbase.csv **HEFS** **Fluvial Mainstem:** S04_Q10_FluMi_HEFS_C_Issv4_1.tcf S04_Q100_FluMi_ HEFS _C_Issv4_1.tcf S04_Q1000_FluMi_ HEFS _C_Issv4_1.tcf **Tidal:** S04_Q10_TiMi_HEFS_C_Issv4_1.tcf S04_Q200_TiMi_HEFS_C_Issv4_1.tcf S04_Q1000_TiMi_HEFS_C_Issv4_1.tcf S04_defended_Iss4_1.tgc S04_defended_Iss4_1.tbc S04_landuse.tmf S04_bc_dbase.csv
Grid Orientation file	2d_loc_S04_0-03.MIF
Material files	2d_mat_S04_NTF_0-03.MIF
Zpt files, model DTM (.asc)	s04_sar.asc limera2m_dtm.asc
Breaklines files	2d_zlr_S04_EAST_banksfromxs_1-01.MIF 2d_bc_hxi_S04_WEST_0-08.mif 2d_zlr_S04_WEST_banksfromxs_0-03.mif

	2d_zlr_S04_defencesfromLiDAR_0-01.mif 2d_zlr_S04_defencesfromsurvey_0-03.mif
Boundary files	2d_bc_hxi_S04_EAST_1-01.MIF 2d_bc_sxi_S04_EAST_1-00.MIF 2d_bc_hxi_S04_WEST_0-08.mif 2d_bc_sxi_S04_WEST_0-01.MIF 2d_bc_hxe_S04_dsbdy_0-02.MIF
Flow/Head files in bc_dbase	S04_S2.csv S04_S3.csv S04_S4.csv S04_S5.csv S04_S6.csv S04_S7.csv S04_S8.csv S04_S9.csv S04_S10.csv S04_S11.csv S04_S12.csv S04_S13.csv S04_S14.csv S04_S15.csv S04_S16.csv
Initial Water Level files	No initial water level file was used for 2D domain
Time Series Files	No time series files provided to the 2d domain.
One dimensional network files	1d_isisnodes_S04_EAST_1-02.MIF 1d_isisnodes_S04_WEST_0-05.MIF
Available 2D result files	Depth, stage, hazard and velocity 2d results in ASCII file format for all available design return periods.

Model Run Log						
SR No.	**Model file name**		**Start Time**	**End Time**	**Advanced Options /Other information**	**Comments on model stability**
Fluvial Mainstem						
1	S04_Q10_FluMi_C_Issv4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
2	S04_Q100_FluMi_C_Issv4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
3	S04_Q1000_FluMi_C_Issv4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
4	S04_Q5_FluMi_C_Issv4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
5	S04_Q20_FluMi_C_Issv4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation

6	S04_Q50_FluMi_C_Issv4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
7	S04_Q200_FluMi_C_Issv4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
Tidal:						
8	S04_Q10_TiMi_C_Issv4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	-6	24	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
9	S04_Q100_TiMi_C_Issv4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	-6	24	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
10	S04_Q1000_TiMi_C_Issv4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	-6	24	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
11	S04_Q2_TiMi_C_Issv4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	-6	24	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
12	S04_Q5_TiMi_C_Issv4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	-6	24	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
13	S04_Q20_TiMi_C_Issv4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	-6	24	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation

14	S04_Q50_TiMi_C_Issv4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	-6	24	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
15	S04_Q200_TiMi_C_Issv4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	-6	24	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
Sensitivity runs:						
Roughness (±20%):						
16	S04_Q100_FluMi_C_Sens_RoDIn_Issv4_1.ief	S04_Qxxx_MiFlu_C_Sen_RoIn_Iss4_3.DAT	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
17	S04_Q100_FluMi_C_Sens_RoDec_Issv4_1.ief	S04_Qxxx_MiFlu_C_Sen_RoDec_Iss4_3.DAT	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
Flow (±20%):						
18	S04_Q100_FluMi_C_Sens_FloIn_Issv4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
19	S04_Q100_FluMi_C_Sens_FloDec_Issv4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
Structure Coefficients (±20%):						
20	S04_Q100_FluMi_C_Sen_CoInc_Issv4_1.ief S04_Q100_FluMi_C_Sen_CoInc_Issv4_1.ief	S04_Qxxx_MiFlu_C_Sen_CoIn_Iss4_3.DAT	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation

21	S04_Q100_FluMi_C_Sen_CoInc_Issv4_1.ief S04_Q100_FluMi_C_Sen_CoDec_Issv4_1.ief	S04_Qxxx_MiFlu_C_Sen_CoDec_Iss4_3.DAT	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
DS Tidal 200% Duration						
22	S04_Q200_TiMi_C_Sens_SuDu200%_Issv4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	-6	24	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
DS Tidal 50% Duration						
23	S04_Q200_TiMi_C_Sens_SuDu50%_Issv4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	-6	24	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
MRFS						
Fluvial:						
24	S04_Q5_FluMi_MRFS_Iss4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
25	S04_Q10_FluMi_MRFS_Iss4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
26	S04_Q20_FluMi_MRFS_Iss4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
27	S04_Q50_FluMi_MRFS_Iss4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation

28	S04_Q100_FluMi_MRFS_Iss4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
29	S04_Q200_FluMi_MRFS_Iss4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
30	S04_Q1000_FluMi_MRFS_Iss4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
Tidal:						
31	S04_Q2_Timi_MRFS_Iss4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	-6	24	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
32	S04_Q5_Timi_MRFS_Iss4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	-6	24	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
33	S04_Q10_Timi_MRFS_Iss4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	-6	24	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
34	S04_Q20_Timi_MRFS_Iss4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	-6	24	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
35	S04_Q50_Timi_MRFS_Iss4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	-6	24	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation

36	S04_Q100_Timi_MRFS_Iss4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	-6	24	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
37	S04_Q200_Timi_MRFS_Iss4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	-6	24	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
38	S04_Q1000_Timi_MRFS_Iss4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	-6	24	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
HEFS						
Fluvial:						
39	S04_Q10_FluMi_HEFS_Iss4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
40	S04_Q100_FluMi_HEFS_Iss4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
41	S04_Q1000_FluMi_HEFS_Iss4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	1.4	20	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
Tidal:						
42	S04_Q10_Timi_HEFS_Iss4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	-6	24	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation

43	S04_Q200_Timi_HEFS_Iss4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	-6	24	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation
44	S04_Q1000_Timi_HEFS_Iss4_1.ief	S04_Qxxx_MiFlu_C_Des_Iss4_3.dat	-6	24	dflood set to 5. Maxitr set to 17. All other run parameters = default.	Convergence within manufacturer tolerance for the majority of the simulation

Parameters changed from Default	Justification
Automated Preismann slot for River Sections turned on.	Automated Preismann slot are a standard parameter used to aid model stability particularly in low flows. These Preismann slots have negligible to no impact on the water levels during flood events.
Maxitr	Increased to 17 to improve model stability.*
Dflood	Increased to 5 to improve model stability.*
Matrix Dummy Coefficient set to 0.0001	Set to 0.0001 to solve IFAG error. *

*Stage and Flow profiles at all cross sections have been checked to ensure results are sensible and to ensure any changes to the default model run parameters has not impacted on the model result.

Annex E - Flood Mapping

Flood Maps are available through the OPW flood mapping website; http://maps.opw.ie/fhrm/

Annex F– Wave Overtopping

ICWWS CAPO Shannon
Prediction Locations

Location D1 - Shannon

CURRENT

	AEP																							
	0.500			0.200			0.100			0.050			0.020			0.010			0.005			0.001		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
11.00	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61
11.17	-	0.00	-2.59	-	0.00	-2.58	-	0.00	-2.58	-	0.00	-2.57	-	0.00	-2.56	-	0.00	-2.55	-	0.00	-2.55	-	0.00	-2.55
11.33	-	0.00	-2.58	-	0.00	-2.56	-	0.00	-2.55	-	0.00	-2.53	-	0.00	-2.52	-	0.00	-2.50	-	0.00	-2.49	-	0.00	-2.49
11.50	-	0.00	-2.36	-	0.00	-2.34	-	0.00	-2.32	-	0.00	-2.30	-	0.00	-2.27	-	0.00	-2.25	-	0.00	-2.23	-	0.00	-2.23
11.67	-	0.00	-2.15	-	0.00	-2.11	-	0.00	-2.09	-	0.00	-2.06	-	0.00	-2.03	-	0.00	-2.00	-	0.00	-1.98	-	0.00	-1.98
11.83	-	0.00	-1.93	-	0.00	-1.89	-	0.00	-1.86	-	0.00	-1.83	-	0.00	-1.78	-	0.00	-1.75	-	0.00	-1.72	-	0.00	-1.72
12.00	-	0.00	-1.72	-	0.00	-1.67	-	0.00	-1.63	-	0.00	-1.59	-	0.00	-1.54	-	0.00	-1.50	-	0.00	-1.46	-	0.00	-1.46
12.17	-	0.00	-1.51	-	0.00	-1.45	-	0.00	-1.40	-	0.00	-1.36	-	0.00	-1.30	-	0.00	-1.25	-	0.00	-1.21	-	0.00	-1.21
12.33	-	0.00	-1.29	-	0.00	-1.22	-	0.00	-1.17	-	0.00	-1.12	-	0.00	-1.06	-	0.00	-1.00	-	0.00	-0.95	-	0.00	-0.95
12.50	-	0.00	-0.98	-	0.00	-0.90	-	0.00	-0.85	-	0.00	-0.79	-	0.00	-0.71	-	0.00	-0.66	-	0.00	-0.60	-	0.00	-0.60
12.67	-	0.00	-0.77	-	0.00	-0.68	-	0.00	-0.62	-	0.00	-0.56	-	0.00	-0.47	-	0.00	-0.41	-	0.00	-0.35	-	0.00	-0.35
12.83	-	0.00	-0.55	-	0.00	-0.46	-	0.00	-0.39	-	0.00	-0.32	-	0.00	-0.23	-	0.00	-0.16	-	0.00	-0.10	-	0.00	-0.10
13.00	-	0.00	-0.24	-	0.00	-0.14	-	0.00	-0.07	-	0.00	0.01	-	0.00	0.11	-	0.00	0.18	-	0.00	0.25	-	0.00	0.25
13.17	-	0.00	-0.03	-	0.00	0.08	-	0.00	0.16	-	0.00	0.24	-	0.00	0.34	-	0.00	0.42	-	0.00	0.50	-	0.00	0.50
13.33	-	0.00	0.18	-	0.00	0.30	-	0.00	0.38	-	0.00	0.47	-	0.00	0.58	-	0.00	0.67	-	0.00	0.75	-	0.00	0.75
13.50	-	0.00	0.39	-	0.00	0.52	-	0.00	0.61	-	0.00	0.70	-	0.00	0.82	-	0.00	0.91	-	0.00	1.00	-	0.00	1.00
13.67	-	0.00	0.61	-	0.00	0.73	-	0.00	0.83	-	0.00	0.93	-	0.00	1.05	-	0.00	1.15	-	0.00	1.24	-	0.00	1.24
13.83	-	0.00	0.82	-	0.00	0.95	-	0.00	1.05	-	0.00	1.15	-	0.00	1.29	-	0.00	1.39	-	0.00	1.49	-	0.00	1.49
14.00	-	0.00	1.03	-	0.00	1.17	-	0.00	1.27	-	0.00	1.38	-	0.00	1.52	-	0.00	1.62	0.01	0.01	1.73	-	0.00	1.73
14.17	-	0.00	1.24	-	0.00	1.38	-	0.00	1.49	-	0.00	1.60	-	0.00	1.75	0.01	0.01	1.86	0.02	0.01	1.97	0.07	0.06	1.97
14.33	-	0.00	1.35	-	0.00	1.50	-	0.00	1.61	-	0.00	1.73	-	0.00	1.88	0.01	0.01	1.99	0.02	0.02	2.11	0.10	0.08	2.11
14.50	-	0.00	1.56	-	0.00	1.71	-	0.00	1.83	-	0.00	1.95	0.01	0.01	2.11	0.02	0.02	2.22	0.03	0.03	2.34	0.19	0.16	2.34
14.67	-	0.00	1.76	-	0.00	1.93	-	0.00	2.05	0.01	0.01	2.17	0.02	0.02	2.33	0.03	0.03	2.45	0.06	0.05	2.58	0.44	0.36	2.58
14.83	-	0.00	1.87	-	0.00	2.04	-	0.00	2.17	0.02	0.01	2.29	0.03	0.02	2.46	0.04	0.04	2.58	0.09	0.07	2.71	0.72	0.60	2.71
15.00	-	0.00	2.08	-	0.00	2.25	0.01	0.01	2.38	0.02	0.02	2.51	0.05	0.04	2.68	0.10	0.08	2.81	0.24	0.20	2.94	1.76	1.47	2.94
15.17	-	0.00	2.29	0.01	0.01	2.46	0.02	0.02	2.60	0.04	0.04	2.73	0.11	0.09	2.90	0.27	0.22	3.03	0.74	0.62	3.16	3.93	3.29	3.16
15.33	-	0.00	2.39	0.01	0.01	2.57	0.02	0.02	2.71	0.07	0.06	2.84	0.19	0.16	3.02	0.50	0.42	3.16	1.36	1.14	3.29	6.15	5.14	3.29
15.50	0.01	0.01	2.60	0.03	0.02	2.78	0.05	0.04	2.92	0.18	0.15	3.06	0.60	0.50	3.24	1.52	1.27	3.38	3.78	3.16	3.51	13.06	10.92	3.51
15.67	0.01	0.01	2.70	0.04	0.03	2.89	0.08	0.07	3.03	0.31	0.26	3.17	1.09	0.91	3.36	2.69	2.25	3.50	6.35	5.31	3.63	19.26	16.11	3.63
15.83	0.02	0.01	2.81	0.06	0.05	3.00	0.13	0.11	3.14	0.58	0.48	3.28	1.92	1.61	3.47	4.59	3.84	3.61	10.12	8.46	3.75	28.45	23.79	3.75
16.00	0.02	0.02	2.91	0.09	0.08	3.11	0.24	0.20	3.25	1.03	0.86	3.39	3.32	2.77	3.58	7.43	6.22	3.73	16.12	13.48	3.87	42.18	35.28	3.87
16.17	0.03	0.03	3.02	0.16	0.13	3.21	0.43	0.36	3.36	1.80	1.50	3.50	5.43	4.54	3.69	11.76	9.84	3.84	25.32	21.18	3.98	61.52	51.45	3.98
16.33	0.05	0.04	3.12	0.27	0.23	3.31	0.77	0.65	3.46	3.05	2.55	3.61	8.62	7.21	3.80	18.44	15.42	3.95	39.63	33.15	4.09	88.21	73.78	4.09
16.50	0.08	0.07	3.22	0.49	0.41	3.42	1.36	1.14	3.57	4.94	4.13	3.71	13.54	11.32	3.91	28.82	24.10	4.06	60.81	50.86	4.20	-	0.00	4.20
16.67	0.08	0.07	3.22	0.49	0.41	3.42	1.39	1.16	3.57	5.03	4.21	3.72	13.83	11.57	3.91	29.55	24.71	4.06	62.22	52.04	4.21	-	0.00	4.21
16.83	0.08	0.07	3.22	0.50	0.42	3.42	1.40	1.17	3.57	5.10	4.27	3.72	14.00	11.71	3.92	29.93	25.03	4.06	63.17	52.83	4.21	-	0.00	4.21
17.00	0.08	0.07	3.22	0.50	0.42	3.42	1.41	1.18	3.57	5.12	4.28	3.72	14.06	11.76	3.92	30.18	25.24	4.07	63.40	53.03	4.21	-	0.00	4.21
17.17	0.08	0.07	3.22	0.50	0.42	3.42	1.40	1.17	3.57	5.10	4.27	3.72	14.00	11.71	3.92	29.93	25.03	4.06	63.17	52.83	4.21	-	0.00	4.21
17.33	0.08	0.07	3.22	0.49	0.41	3.42	1.39	1.16	3.57	5.03	4.21	3.72	13.83	11.57	3.91	29.55	24.71	4.06	62.22	52.04	4.21	-	0.00	4.21
17.50	0.05	0.04	3.12	0.28	0.23	3.32	0.80	0.67	3.47	3.12	2.61	3.61	8.88	7.42	3.81	18.98	15.87	3.96	41.09	34.37	4.10	90.74	75.89	4.10
17.67	0.03	0.03	3.02	0.16	0.13	3.21	0.45	0.37	3.36	1.86	1.56	3.51	5.65	4.72	3.70	12.25	10.25	3.85	26.46	22.13	3.99	63.81	53.37	3.99
17.83	0.02	0.02	2.92	0.09	0.08	3.11	0.25	0.21	3.26	1.08	0.91	3.40	3.47	2.91	3.59	7.80	6.53	3.74	16.97	14.19	3.88	44.06	36.85	3.88
18.00	0.02	0.01	2.81	0.06	0.05	3.01	0.14	0.12	3.15	0.61	0.51	3.29	2.05	1.71	3.48	4.90	4.10	3.63	10.83	9.06	3.77	30.12	25.19	3.77
18.17	0.01	0.01	2.61	0.03	0.02	2.80	0.05	0.04	2.94	0.20	0.17	3.08	0.70	0.59	3.27	1.80	1.51	3.41	4.49	3.76	3.55	14.80	12.38	3.55
18.33	-	0.00	2.40	0.02	0.01	2.59	0.03	0.02	2.73	0.07	0.06	2.87	0.23	0.19	3.06	0.62	0.52	3.20	1.67	1.39	3.33	7.19	6.01	3.33
18.50	-	0.00	2.30	0.01	0.01	2.48	0.02	0.02	2.62	0.05	0.04	2.76	0.13	0.11	2.94	0.33	0.28	3.08	0.95	0.79	3.21	4.67	3.91	3.21
18.67	-	0.00	2.09	-	0.00	2.27	0.01	0.01	2.41	0.03	0.02	2.54	0.05	0.04	2.72	0.12	0.10	2.86	0.31	0.26	2.99	2.14	1.79	2.99
18.83	-	0.00	1.89	-	0.00	2.06	-	0.00	2.20	0.02	0.01	2.33	0.03	0.03	2.50	0.05	0.04	2.63	0.11	0.09	2.76	0.90	0.75	2.76
19.00	-	0.00	1.68	-	0.00	1.85	-	0.00	1.98	0.01	0.01	2.11	0.02	0.02	2.28	0.03	0.03	2.41	0.05	0.04	2.54	0.38	0.32	2.54
19.17	-	0.00	1.47	-	0.00	1.64	-	0.00	1.77	-	0.00	1.89	0.01	0.01	2.06	0.02	0.02	2.18	0.03	0.03	2.31	0.17	0.14	2.31
19.33	-	0.00	1.26	-	0.00	1.43	-	0.00	1.55	-	0.00	1.67	-	0.00	1.83	0.01	0.01	1.95	0.02	0.02	2.08	0.09	0.08	2.08
19.50	-	0.00	0.96	-	0.00	1.11	-	0.00	1.23	-	0.00	1.35	-	0.00	1.51	-	0.00	1.62	0.01	0.01	1.74	-	0.00	1.74
19.67	-	0.00	0.75	-	0.00	0.90	-	0.00	1.01	-	0.00	1.13	-	0.00	1.28	-	0.00	1.39	-	0.00	1.51	-	0.00	1.51
19.83	-	0.00	0.54	-	0.00	0.68	-	0.00	0.79	-	0.00	0.90	-	0.00	1.05	-	0.00	1.16	-	0.00	1.27	-	0.00	1.27
20.00	-	0.00	0.33	-	0.00	0.47	-	0.00	0.57	-	0.00	0.68	-	0.00	0.82	-	0.00	0.92	-	0.00	1.03	-	0.00	1.03
20.17	-	0.00	0.02	-	0.00	0.15	-	0.00	0.25	-	0.00	0.35	-	0.00	0.49	-	0.00	0.59	-	0.00	0.69	-	0.00	0.69
20.33	-	0.00	-0.19	-	0.00	-0.07	-	0.00	0.03	-	0.00	0.13	-	0.00	0.25	-	0.00	0.35	-	0.00	0.44	-	0.00	0.44
20.50	-	0.00	-0.51	-	0.00	-0.38	-	0.00	-0.29	-	0.00	-0.20	-	0.00	-0.08	-	0.00	0.01	-	0.00	0.10	-	0.00	0.10
20.67	-	0.00	-0.72	-	0.00	-0.60	-	0.00	-0.52	-	0.00	-0.43	-	0.00	-0.32	-	0.00	-0.23	-	0.00	-0.15	-	0.00	-0.15
20.83	-	0.00	-0.93	-	0.00	-0.82	-	0.00	-0.74	-	0.00	-0.66	-	0.00	-0.56	-	0.00	-0.48	-	0.00	-0.40	-	0.00	-0.40
21.00	-	0.00	-1.24	-	0.00	-1.14	-	0.00	-1.07	-	0.00	-0.99	-	0.00	-0.89	-	0.00	-0.82	-	0.00	-0.75	-	0.00	-0.75
21.17	-	0.00	-1.45	-	0.00	-1.36	-	0.00	-1.29	-	0.00	-1.22	-	0.00	-1.13	-	0.00	-1.06	-	0.00	-1.00	-	0.00	-1.00
21.33	-	0.00	-1.67	-	0.00	-1.58	-	0.00	-1.52	-	0.00	-1.46	-	0.00	-1.37	-	0.00	-1.31	-	0.00	-1.25	-	0.00	-1.25
21.50	-	0.00	-1.88	-	0.00	-1.80	-	0.00	-1.75	-	0.00	-1.69	-	0.00	-1.61	-	0.00	-1.56	-	0.00	-1.50	-	0.00	-1.50
21.67	-	0.00	-2.09	-	0.00	-2.02	-	0.00	-1.97	-	0.00	-1.92	-	0.00	-1.86	-	0.00	-1.80	-	0.00	-1.75	-	0.00	-1.75
21.83	-	0.00	-2.31	-	0.00	-2.25	-	0.00	-2.20	-	0.00	-2.16	-	0.00	-2.10	-	0.00	-2.05	-	0.00	-2.01	-	0.00	-2.01
22.00	-	0.00	-2.52	-	0.00	-2.47	-	0.00	-2.43	-	0.00	-2.39	-	0.00	-2.34	-	0.00	-2.30	-	0.00	-2.26	-	0.00	-2.26
22.17	-	0.00	-2.53	-	0.00	-2.49	-	0.00	-2.46	-	0.00	-2.43	-	0.00	-2.38	-	0.00	-2.35	-	0.00	-2.32	-	0.00	-2.32
22.33	-	0.00	-2.55	-	0.00	-2.51	-	0.00	-2.49	-	0.00	-2.46	-	0.00	-2.43	-	0.00	-2.40	-	0.00	-2.38	-	0.00	-2.38
22.50	-	0.00	-2.36	-	0.00	-2.34	-	0.00	-2.32	-	0.00	-2.30	-	0.00	-2.27	-	0.00	-2.25	-	0.00	-2.23	-	0.00	-2.23
22.67	-	0.00	-2.18	-	0.00	-2.16	-	0.00	-2.15	-	0.00	-2.13	-	0.00	-2.12	-	0.00	-2.10	-	0.00	-2.09	-	0.00	-2.09
22.83	-	0.00	-1.99	-	0.00	-1.98	-	0.00	-1.98	-	0.00	-1.97	-	0.00	-1.96	-	0.00	-1.95	-	0.00	-1.95	-	0.00	-1.95
23.00	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81

MID RANGE RUNS

	50% Mid Range			20% Mid Range			10% Mid Range			5% Mid Range			2% Mid Range			1% Mid Range			0.5% Mid Range			0.1% Mid Range		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
11.00	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61
11.17	-	0.00	-2.57	-	0.00	-2.56	-	0.00	-2.55	-	0.00	-2.55	-	0.00	-2.54	-	0.00	-2.53	-	0.00	-2.53	-	0.00	-2.53
11.33	-	0.00	-2.53	-	0.00	-2.52	-	0.00	-2.50	-	0.00	-2.49	-	0.00	-2.47	-	0.00	-2.46	-	0.00	-2.45	-	0.00	-2.45
11.50	-	0.00	-2.30	-	0.00	-2.27	-	0.00	-2.25	-	0.00	-2.23	-	0.00	-2.21	-	0.00	-2.19	-	0.00	-2.17	-	0.00	-2.17
11.67	-	0.00	-2.06	-	0.00	-2.03	-	0.00	-2.00	-	0.00	-1.97	-	0.00	-1.94	-	0.00	-1.91	-	0.00	-1.89	-	0.00	-1.89
11.83	-	0.00	-1.83	-	0.00	-1.78	-	0.00	-1.75	-	0.00	-1.72	-	0.00	-1.68	-	0.00	-1.64	-	0.00	-1.61	-	0.00	-1.61
12.00	-	0.00	-1.59	-	0.00	-1.54	-	0.00	-1.50	-	0.00	-1.46	-	0.00	-1.41	-	0.00	-1.37	-	0.00	-1.33	-	0.00	-1.33
12.17	-	0.00	-1.36	-	0.00	-1.30	-	0.00	-1.25	-	0.00	-1.21	-	0.00	-1.15	-	0.00	-1.10	-	0.00	-1.06	-	0.00	-1.06
12.33	-	0.00	-1.12	-	0.00	-1.05	-	0.00	-1.00	-	0.00	-0.95	-	0.00	-0.88	-	0.00	-0.83	-	0.00	-0.78	-	0.00	-0.78
12.50	-	0.00	-0.79	-	0.00	-0.71	-	0.00	-0.65	-	0.00	-0.60	-	0.00	-0.52	-	0.00	-0.47	-	0.00	-0.41	-	0.00	-0.41
12.67	-	0.00	-0.56	-	0.00	-0.47	-	0.00	-0.41	-	0.00	-0.34	-	0.00	-0.26	-	0.00	-0.20	-	0.00	-0.14	-	0.00	-0.14
12.83	-	0.00	-0.32	-	0.00	-0.23	-	0.00	-0.16	-	0.00	-0.09	-	0.00	0.00	-	0.00	0.07	-	0.00	0.13	-	0.00	0.13
13.00	-	0.00	0.01	-	0.00	0.11	-	0.00	0.18	-	0.00	0.26	-	0.00	0.36	-	0.00	0.43	-	0.00	0.50	-	0.00	0.50
13.17	-	0.00	0.24	-	0.00	0.35	-	0.00	0.43	-	0.00	0.51	-	0.00	0.61	-	0.00	0.69	-	0.00	0.77	-	0.00	0.77
13.33	-	0.00	0.47	-	0.00	0.58	-	0.00	0.67	-	0.00	0.76	-	0.00	0.87	-	0.00	0.95	-	0.00	1.04	-	0.00	1.04
13.50	-	0.00	0.70	-	0.00	0.82	-	0.00	0.91	-	0.00	1.00	-	0.00	1.12	-	0.00	1.21	-	0.00	1.30	-	0.00	1.30
13.67	-	0.00	0.93	-	0.00	1.06	-	0.00	1.15	-	0.00	1.25	-	0.00	1.37	-	0.00	1.47	-	0.00	1.56	-	0.00	1.56
13.83	-	0.00	1.15	-	0.00	1.29	-	0.00	1.39	-	0.00	1.49	-	0.00	1.62	0.01	0.01	1.72	0.02	0.02	1.82	0.07	0.06	1.82
14.00	-	0.00	1.38	-	0.00	1.52	-	0.00	1.63	-	0.00	1.73	-	0.00	1.87	0.02	0.02	1.98	0.03	0.03	2.08	0.13	0.11	2.08
14.17	-	0.00	1.61	-	0.00	1.75	-	0.00	1.86	-	0.00	1.97	0.01	0.01	2.12	0.03	0.02	2.23	0.06	0.05	2.34	0.29	0.24	2.34
14.33	-	0.00	1.73	-	0.00	1.88	-	0.00	2.00	0.01	0.01	2.11	0.02	0.02	2.26	0.04	0.03	2.38	0.08	0.07	2.49	0.49	0.41	2.49
14.50	-	0.00	1.95	-	0.00	2.11	0.01	0.01	2.23	0.02	0.01	2.35	0.03	0.02	2.50	0.07	0.06	2.62	0.20	0.17	2.74	1.22	1.02	2.74
14.67	-	0.00	2.17	0.01	0.01	2.34	0.01	0.01	2.46	0.03	0.02	2.58	0.06	0.05	2.74	0.18	0.15	2.86	0.62	0.52	2.99	2.91	2.43	2.99
14.83	-	0.00	2.29	0.02	0.01	2.46	0.02	0.02	2.59	0.04	0.03	2.71	0.10	0.08	2.88	0.36	0.30	3.00	1.21	1.01	3.13	4.66	3.89	3.13
15.00	0.01	0.01	2.51	0.03	0.02	2.69	0.03	0.03	2.81	0.09	0.07	2.94	0.30	0.25	3.11	1.17	0.98	3.24	3.33	2.78	3.37	10.42	8.72	3.37
15.17	0.02	0.01	2.73	0.06	0.05	2.91	0.08	0.07	3.04	0.27	0.22	3.17	1.01	0.85	3.35	3.40	2.85	3.48	8.68	7.26	3.61	21.66	18.12	3.61
15.33	0.02	0.02	2.85	0.10	0.08	3.03	0.15	0.13	3.16	0.53	0.44	3.30	1.94	1.62	3.48	6.04	5.05	3.61	14.27	11.94	3.74	33.19	27.76	3.74
15.50	0.06	0.05	3.06	0.29	0.24	3.24	0.50	0.42	3.38	1.71	1.43	3.52	5.56	4.65	3.70	14.86	12.43	3.84	34.04	28.47	3.98	70.00	58.55	3.98
15.67	0.10	0.08	3.17	0.56	0.47	3.36	0.97	0.81	3.50	3.13	2.62	3.64	9.39	7.85	3.83	24.57	20.55	3.97	55.11	46.09	4.10	104.20	87.15	4.10
15.83	0.18	0.15	3.28	1.04	0.87	3.48	1.80	1.51	3.62	5.40	4.52	3.76	15.63	13.07	3.95	40.19	33.61	4.09	-	0.00	4.23	-	0.00	4.23
16.00	0.32	0.26	3.39	1.87	1.57	3.59	3.23	2.70	3.73	9.06	7.58	3.88	26.05	21.79	4.07	64.26	53.75	4.21	-	0.00	4.35	-	0.00	4.35
16.17	0.58	0.48	3.50	3.28	2.74	3.70	5.57	4.66	3.84	15.01	12.55	3.99	42.77	35.77	4.18	-	0.00	4.33	-	0.00	4.47	-	0.00	4.47
16.33	1.06	0.88	3.61	5.46	4.57	3.81	9.42	7.88	3.95	24.74	20.69	4.10	-	0.00	4.29	-	0.00	4.44	-	0.00	4.59	-	0.00	4.59
16.50	1.92	1.61	3.72	8.97	7.50	3.91	15.64	13.08	4.06	40.45	33.83	4.21	-	0.00	4.40	-	0.00	4.55	-	0.00	4.70	-	0.00	4.70
16.67	1.97	1.65	3.72	9.18	7.68	3.92	16.09	13.46	4.07	41.54	34.74	4.22	-	0.00	4.41	-	0.00	4.56	-	0.00	4.71	-	0.00	4.71
16.83	2.00	1.67	3.72	9.31	7.78	3.92	16.32	13.65	4.07	42.27	35.35	4.22	-	0.00	4.42	-	0.00	4.56	-	0.00	4.71	-	0.00	4.71
17.00	2.01	1.68	3.72	9.35	7.82	3.92	16.40	13.72	4.07	42.45	35.50	4.22	-	0.00	4.42	-	0.00	4.57	-	0.00	4.71	-	0.00	4.71
17.17	2.00	1.67	3.72	9.31	7.78	3.92	16.32	13.65	4.07	42.27	35.35	4.22	-	0.00	4.42	-	0.00	4.56	-	0.00	4.71	-	0.00	4.71
17.33	1.97	1.65	3.72	9.18	7.68	3.92	16.09	13.46	4.07	41.54	34.74	4.22	-	0.00	4.41	-	0.00	4.56	-	0.00	4.71	-	0.00	4.71
17.50	1.09	0.91	3.62	5.64	4.72	3.81	9.74	8.14	3.96	25.78	21.56	4.11	-	0.00	4.30	-	0.00	4.45	-	0.00	4.60	-	0.00	4.60
17.67	0.60	0.50	3.51	3.42	2.86	3.71	5.85	4.89	3.85	15.77	13.19	4.00	45.17	37.78	4.19	-	0.00	4.34	-	0.00	4.49	-	0.00	4.49
17.83	0.33	0.28	3.40	1.99	1.66	3.60	3.44	2.88	3.74	9.64	8.06	3.89	27.81	23.26	4.08	68.48	57.27	4.23	-	0.00	4.37	-	0.00	4.37
18.00	0.18	0.15	3.29	1.11	0.93	3.49	1.94	1.62	3.63	5.80	4.85	3.78	16.93	14.16	3.97	43.68	36.53	4.11	-	0.00	4.25	-	0.00	4.25
18.17	0.07	0.05	3.08	0.35	0.29	3.28	0.61	0.51	3.42	2.10	1.75	3.56	6.73	5.63	3.75	18.11	15.15	3.89	41.72	34.89	4.03	82.94	69.37	4.03
18.33	0.03	0.02	2.87	0.11	0.10	3.06	0.19	0.16	3.20	0.67	0.56	3.34	2.48	2.08	3.53	7.56	6.32	3.67	17.93	15.00	3.80	40.43	33.81	3.80
18.50	0.02	0.02	2.76	0.07	0.06	2.94	0.10	0.09	3.08	0.34	0.29	3.22	1.35	1.13	3.40	4.47	3.74	3.54	11.11	9.29	3.68	26.70	22.33	3.68
18.67	0.01	0.01	2.55	0.03	0.03	2.73	0.04	0.03	2.86	0.11	0.09	3.00	0.41	0.34	3.18	1.59	1.33	3.31	4.52	3.78	3.44	13.09	10.95	3.44
18.83	-	0.00	2.33	0.02	0.01	2.51	0.02	0.02	2.64	0.04	0.04	2.77	0.13	0.11	2.95	0.52	0.43	3.08	1.70	1.42	3.21	6.07	5.08	3.21
19.00	-	0.00	2.11	0.01	0.01	2.29	0.01	0.01	2.41	0.02	0.02	2.54	0.05	0.04	2.71	0.17	0.14	2.84	0.58	0.48	2.97	2.76	2.31	2.97
19.17	-	0.00	1.89	-	0.00	2.06	-	0.00	2.19	0.02	0.01	2.31	0.03	0.02	2.48	0.07	0.06	2.60	0.19	0.16	2.73	1.18	0.99	2.73
19.33	-	0.00	1.67	-	0.00	1.84	-	0.00	1.96	0.01	0.01	2.08	0.02	0.01	2.24	0.04	0.03	2.36	0.08	0.07	2.49	0.49	0.41	2.49
19.50	-	0.00	1.35	-	0.00	1.51	-	0.00	1.63	-	0.00	1.75	0.01	0.01	1.90	0.02	0.02	2.02	0.04	0.03	2.14	0.16	0.13	2.14
19.67	-	0.00	1.13	-	0.00	1.28	-	0.00	1.40	-	0.00	1.51	-	0.00	1.66	0.01	0.01	1.78	0.02	0.02	1.89	0.08	0.07	1.89
19.83	-	0.00	0.91	-	0.00	1.05	-	0.00	1.16	-	0.00	1.27	-	0.00	1.42	-	0.00	1.53	-	0.00	1.64	-	0.00	1.64
20.00	-	0.00	0.68	-	0.00	0.82	-	0.00	0.93	-	0.00	1.03	-	0.00	1.17	-	0.00	1.28	-	0.00	1.38	-	0.00	1.38
20.17	-	0.00	0.35	-	0.00	0.49	-	0.00	0.59	-	0.00	0.69	-	0.00	0.82	-	0.00	0.92	-	0.00	1.02	-	0.00	1.02
20.33	-	0.00	0.13	-	0.00	0.26	-	0.00	0.35	-	0.00	0.45	-	0.00	0.57	-	0.00	0.67	-	0.00	0.76	-	0.00	0.76
20.50	-	0.00	-0.20	-	0.00	-0.08	-	0.00	0.01	-	0.00	0.10	-	0.00	0.22	-	0.00	0.31	-	0.00	0.40	-	0.00	0.40
20.67	-	0.00	-0.43	-	0.00	-0.32	-	0.00	-0.23	-	0.00	-0.14	-	0.00	-0.03	-	0.00	0.05	-	0.00	0.14	-	0.00	0.14
20.83	-	0.00	-0.66	-	0.00	-0.55	-	0.00	-0.47	-	0.00	-0.39	-	0.00	-0.29	-	0.00	-0.21	-	0.00	-0.13	-	0.00	-0.13
21.00	-	0.00	-0.99	-	0.00	-0.89	-	0.00	-0.82	-	0.00	-0.74	-	0.00	-0.64	-	0.00	-0.57	-	0.00	-0.50	-	0.00	-0.50
21.17	-	0.00	-1.22	-	0.00	-1.13	-	0.00	-1.06	-	0.00	-0.99	-	0.00	-0.90	-	0.00	-0.83	-	0.00	-0.77	-	0.00	-0.77
21.33	-	0.00	-1.46	-	0.00	-1.37	-	0.00	-1.31	-	0.00	-1.24	-	0.00	-1.16	-	0.00	-1.10	-	0.00	-1.04	-	0.00	-1.04
21.50	-	0.00	-1.69	-	0.00	-1.61	-	0.00	-1.55	-	0.00	-1.50	-	0.00	-1.42	-	0.00	-1.37	-	0.00	-1.31	-	0.00	-1.31
21.67	-	0.00	-1.92	-	0.00	-1.85	-	0.00	-1.80	-	0.00	-1.75	-	0.00	-1.68	-	0.00	-1.63	-	0.00	-1.58	-	0.00	-1.58
21.83	-	0.00	-2.16	-	0.00	-2.10	-	0.00	-2.05	-	0.00	-2.01	-	0.00	-1.95	-	0.00	-1.90	-	0.00	-1.86	-	0.00	-1.86
22.00	-	0.00	-2.39	-	0.00	-2.34	-	0.00	-2.30	-	0.00	-2.26	-	0.00	-2.21	-	0.00	-2.17	-	0.00	-2.13	-	0.00	-2.13
22.17	-	0.00	-2.43	-	0.00	-2.38	-	0.00	-2.35	-	0.00	-2.32	-	0.00	-2.28	-	0.00	-2.24	-	0.00	-2.21	-	0.00	-2.21
22.33	-	0.00	-2.46	-	0.00	-2.43	-	0.00	-2.40	-	0.00	-2.37	-	0.00	-2.34	-	0.00	-2.31	-	0.00	-2.29	-	0.00	-2.29
22.50	-	0.00	-2.30	-	0.00	-2.27	-	0.00	-2.25	-	0.00	-2.23	-	0.00	-2.21	-	0.00	-2.19	-	0.00	-2.17	-	0.00	-2.17
22.67	-	0.00	-2.13	-	0.00	-2.12	-	0.00	-2.10	-	0.00	-2.09	-	0.00	-2.07	-	0.00	-2.06	-	0.00	-2.05	-	0.00	-2.05
22.83	-	0.00	-1.97	-	0.00	-1.96	-	0.00	-1.95	-	0.00	-1.95	-	0.00	-1.94	-	0.00	-1.93	-	0.00	-1.93	-	0.00	-1.93
23.00	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81

HIGH END RUNS

	10% High End			0.5% High End			0.1% High End		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
11.00	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61
11.17	-	0.00	-2.53	-	0.00	-2.50	-	0.00	-2.50
11.33	-	0.00	-2.46	-	0.00	-2.40	-	0.00	-2.40
11.50	-	0.00	-2.19	-	0.00	-2.10	-	0.00	-2.10
11.67	-	0.00	-1.91	-	0.00	-1.80	-	0.00	-1.80
11.83	-	0.00	-1.64	-	0.00	-1.50	-	0.00	-1.50
12.00	-	0.00	-1.37	-	0.00	-1.20	-	0.00	-1.20
12.17	-	0.00	-1.10	-	0.00	-0.91	-	0.00	-0.91
12.33	-	0.00	-0.83	-	0.00	-0.61	-	0.00	-0.61
12.50	-	0.00	-0.46	-	0.00	-0.22	-	0.00	-0.22
12.67	-	0.00	-0.20	-	0.00	0.08	-	0.00	0.08
12.83	-	0.00	0.07	-	0.00	0.37	-	0.00	0.37
13.00	-	0.00	0.43	-	0.00	0.75	-	0.00	0.75
13.17	-	0.00	0.70	-	0.00	1.04	-	0.00	1.04
13.33	-	0.00	0.96	-	0.00	1.33	-	0.00	1.33
13.50	-	0.00	1.22	-	0.00	1.61	-	0.00	1.61
13.67	-	0.00	1.47	0.03	0.02	1.89	0.11	0.09	1.89
13.83	-	0.00	1.73	0.04	0.04	2.16	0.23	0.19	2.16
14.00	-	0.00	1.98	0.08	0.07	2.43	0.57	0.48	2.43
14.17	0.01	0.01	2.23	0.21	0.17	2.70	1.47	1.23	2.70
14.33	0.02	0.02	2.38	0.42	0.35	2.87	2.57	2.15	2.87
14.50	0.03	0.03	2.63	1.41	1.18	3.13	5.88	4.92	3.13
14.67	0.07	0.06	2.87	4.09	3.42	3.39	13.40	11.21	3.39
14.83	0.14	0.11	3.01	7.61	6.36	3.55	21.20	17.73	3.55
15.00	0.46	0.39	3.25	19.22	16.08	3.80	45.93	38.41	3.80
15.17	1.60	1.34	3.48	48.07	40.20	4.05	98.42	82.32	4.05
15.33	3.09	2.58	3.61	80.37	67.22	4.20	-	0.00	4.20
15.50	8.61	7.20	3.84	-	0.00	4.44	-	0.00	4.44
15.67	14.89	12.45	3.97	-	0.00	4.57	-	0.00	4.57
15.83	25.79	21.57	4.09	-	0.00	4.71	-	0.00	4.71
16.00	43.84	36.67	4.21	-	0.00	4.83	-	0.00	4.83
16.17	-	0.00	4.33	-	0.00	4.96	-	0.00	4.96
16.33	-	0.00	4.45	-	0.00	5.08	-	0.00	5.08
16.50	-	0.00	4.56	-	0.00	5.19	-	0.00	5.19
16.67	-	0.00	4.57	-	0.00	5.21	-	0.00	5.21
16.83	-	0.00	4.57	-	0.00	5.21	-	0.00	5.21
17.00	-	0.00	4.57	-	0.00	5.21	-	0.00	5.21
17.17	-	0.00	4.57	-	0.00	5.21	-	0.00	5.21
17.33	-	0.00	4.57	-	0.00	5.21	-	0.00	5.21
17.50	-	0.00	4.46	-	0.00	5.09	-	0.00	5.09
17.67	-	0.00	4.35	-	0.00	4.98	-	0.00	4.98
17.83	47.35	39.60	4.23	-	0.00	4.86	-	0.00	4.86
18.00	28.21	23.59	4.11	-	0.00	4.73	-	0.00	4.73
18.17	10.71	8.96	3.89	-	0.00	4.51	-	0.00	4.51
18.33	4.01	3.35	3.67	-	0.00	4.27	-	0.00	4.27
18.50	2.19	1.83	3.54	65.52	54.80	4.14	-	0.00	4.14
18.67	0.67	0.56	3.31	27.11	22.67	3.90	61.34	51.30	3.90
18.83	0.19	0.16	3.08	11.02	9.22	3.65	28.66	23.97	3.65
19.00	0.07	0.06	2.85	4.24	3.55	3.40	13.77	11.52	3.40
19.17	0.03	0.03	2.61	1.51	1.26	3.15	6.20	5.18	3.15
19.33	0.02	0.02	2.37	0.47	0.39	2.89	2.76	2.31	2.89
19.50	0.01	0.01	2.03	0.11	0.09	2.53	0.81	0.68	2.53
19.67	-	0.00	1.78	0.05	0.05	2.27	0.33	0.27	2.27
19.83	-	0.00	1.53	0.03	0.03	2.00	0.15	0.12	2.00
20.00	-	0.00	1.28	0.02	0.02	1.73	-	0.00	1.73
20.17	-	0.00	0.93	-	0.00	1.36	-	0.00	1.36
20.33	-	0.00	0.67	-	0.00	1.09	-	0.00	1.09
20.50	-	0.00	0.32	-	0.00	0.71	-	0.00	0.71
20.67	-	0.00	0.06	-	0.00	0.43	-	0.00	0.43
20.83	-	0.00	-0.20	-	0.00	0.14	-	0.00	0.14
21.00	-	0.00	-0.57	-	0.00	-0.25	-	0.00	-0.25
21.17	-	0.00	-0.83	-	0.00	-0.53	-	0.00	-0.53
21.33	-	0.00	-1.10	-	0.00	-0.82	-	0.00	-0.82
21.50	-	0.00	-1.36	-	0.00	-1.12	-	0.00	-1.12
21.67	-	0.00	-1.63	-	0.00	-1.41	-	0.00	-1.41
21.83	-	0.00	-1.90	-	0.00	-1.71	-	0.00	-1.71
22.00	-	0.00	-2.17	-	0.00	-2.00	-	0.00	-2.00
22.17	-	0.00	-2.24	-	0.00	-2.10	-	0.00	-2.10
22.33	-	0.00	-2.31	-	0.00	-2.20	-	0.00	-2.20
22.50	-	0.00	-2.19	-	0.00	-2.10	-	0.00	-2.10
22.67	-	0.00	-2.06	-	0.00	-2.00	-	0.00	-2.00
22.83	-	0.00	-1.93	-	0.00	-1.90	-	0.00	-1.90
23.00	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81

Location E

CURRENT RUNS

	AEP								
	10%			0.50%			0.10%		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
11.000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11.167	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11.333	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11.500	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11.667	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11.833	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12.000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12.167	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12.333	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12.500	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12.667	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12.833	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13.000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13.167	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13.333	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13.500	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13.667	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13.833	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
14.000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
14.167	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
14.333	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
14.500	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
14.667	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
14.833	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15.000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15.167	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15.333	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15.500	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15.667	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15.833	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16.000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16.167	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16.333	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16.500	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16.667	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16.833	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17.000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17.167	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17.333	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17.500	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17.667	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17.833	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
18.000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
18.167	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
18.333	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
18.500	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
18.667	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
18.833	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19.000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19.167	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19.333	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19.500	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19.667	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19.833	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20.000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20.167	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20.333	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20.500	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20.667	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20.833	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
21.000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
21.167	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
21.333	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
21.500	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
21.667	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
21.833	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22.000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22.167	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22.333	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22.500	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22.667	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22.833	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23.000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

HIGH END RUNS

	0.1% High End		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
11.000	-	0.00000	-2.605
11.167	-	0.00000	-2.504
11.333	-	0.00000	-2.403
11.500	-	0.00000	-2.102
11.667	-	0.00000	-1.802
11.833	-	0.00000	-1.503
12.000	-	0.00000	-1.205
12.167	-	0.00000	-0.908
12.333	-	0.00000	-0.612
12.500	-	0.00000	-0.218
12.667	-	0.00000	0.075
12.833	-	0.00000	0.366
13.000	-	0.00000	0.754
13.167	-	0.00000	1.041
13.333	-	0.00000	1.325
13.500	-	0.00000	1.607
13.667	-	0.00000	1.886
13.833	-	0.00000	2.162
14.000	-	0.00000	2.435
14.167	-	0.00000	2.705
14.333	-	0.00000	2.871
14.500	0.008	0.00270	3.135
14.667	0.009	0.00304	3.395
14.833	0.010	0.00331	3.551
15.000	0.011	0.00387	3.803
15.167	0.014	0.00465	4.052
15.333	0.016	0.00526	4.197
15.500	0.020	0.00668	4.437
15.667	0.023	0.00784	4.574
15.833	0.027	0.00931	4.707
16.000	0.033	0.01119	4.835
16.167	0.040	0.01362	4.959
16.333	0.050	0.01680	5.079
16.500	0.062	0.02109	5.194
16.667	0.064	0.02158	5.205
16.833	0.065	0.02191	5.212
17.000	0.065	0.02200	5.214
17.167	0.065	0.02191	5.212
17.333	0.064	0.02158	5.205
17.500	0.051	0.01728	5.094
17.667	0.042	0.01408	4.979
17.833	0.034	0.01161	4.859
18.000	0.029	0.00968	4.735
18.167	0.021	0.00723	4.507
18.333	0.017	0.00565	4.274
18.500	0.015	0.00498	4.137
18.667	0.012	0.00413	3.897
18.833	0.010	0.00351	3.652
19.000	0.009	0.00306	3.403
19.167	0.008	0.00272	3.151
19.333	-	0.00000	2.895
19.500	-	0.00000	2.535
19.667	-	0.00000	2.271
19.833	-	0.00000	2.005
20.000	-	0.00000	1.735
20.167	-	0.00000	1.362
20.333	-	0.00000	1.086
20.500	-	0.00000	0.707
20.667	-	0.00000	0.425
20.833	-	0.00000	0.141
21.000	-	0.00000	-0.246
21.167	-	0.00000	-0.534
21.333	-	0.00000	-0.825
21.500	-	0.00000	-1.118
21.667	-	0.00000	-1.412
21.833	-	0.00000	-1.708
22.000	-	0.00000	-2.005
22.167	-	0.00000	-2.103
22.333	-	0.00000	-2.202
22.500	-	0.00000	-2.102
22.667	-	0.00000	-2.003
22.833	-	0.00000	-1.904
23.000	-	0.00000	-1.805

Location F
CURRENT RUNS

	AEP																	
	0.10			0.05			0.02			0.01			0.01			0.00		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
11.00	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61
11.17	-	0.00	-2.58	-	0.00	-2.57	-	0.00	-2.56	-	0.00	-2.55	-	0.00	-2.55	-	0.00	-2.55
11.33	-	0.00	-2.55	-	0.00	-2.53	-	0.00	-2.52	-	0.00	-2.50	-	0.00	-2.49	-	0.00	-2.49
11.50	-	0.00	-2.32	-	0.00	-2.30	-	0.00	-2.27	-	0.00	-2.25	-	0.00	-2.23	-	0.00	-2.23
11.67	-	0.00	-2.09	-	0.00	-2.06	-	0.00	-2.03	-	0.00	-2.00	-	0.00	-1.98	-	0.00	-1.98
11.83	-	0.00	-1.86	-	0.00	-1.83	-	0.00	-1.78	-	0.00	-1.75	-	0.00	-1.72	-	0.00	-1.72
12.00	-	0.00	-1.63	-	0.00	-1.59	-	0.00	-1.54	-	0.00	-1.50	-	0.00	-1.46	-	0.00	-1.46
12.17	-	0.00	-1.40	-	0.00	-1.36	-	0.00	-1.30	-	0.00	-1.25	-	0.00	-1.21	-	0.00	-1.21
12.33	-	0.00	-1.17	-	0.00	-1.12	-	0.00	-1.06	-	0.00	-1.00	-	0.00	-0.95	-	0.00	-0.95
12.50	-	0.00	-0.85	-	0.00	-0.79	-	0.00	-0.71	-	0.00	-0.66	-	0.00	-0.60	-	0.00	-0.60
12.67	-	0.00	-0.62	-	0.00	-0.56	-	0.00	-0.47	-	0.00	-0.41	-	0.00	-0.35	-	0.00	-0.35
12.83	-	0.00	-0.39	-	0.00	-0.32	-	0.00	-0.23	-	0.00	-0.16	-	0.00	-0.10	-	0.00	-0.10
13.00	-	0.00	-0.07	-	0.00	0.01	-	0.00	0.11	-	0.00	0.18	-	0.00	0.25	-	0.00	0.25
13.17	-	0.00	0.16	-	0.00	0.24	-	0.00	0.34	-	0.00	0.42	-	0.00	0.50	-	0.00	0.50
13.33	-	0.00	0.38	-	0.00	0.47	-	0.00	0.58	-	0.00	0.67	-	0.00	0.75	-	0.00	0.75
13.50	-	0.00	0.61	-	0.00	0.70	-	0.00	0.82	-	0.00	0.91	-	0.00	1.00	-	0.00	1.00
13.67	-	0.00	0.83	-	0.00	0.93	-	0.00	1.05	-	0.00	1.15	-	0.00	1.24	-	0.00	1.24
13.83	-	0.00	1.05	-	0.00	1.15	-	0.00	1.29	-	0.00	1.39	-	0.00	1.49	-	0.00	1.49
14.00	-	0.00	1.27	-	0.00	1.38	-	0.00	1.52	-	0.00	1.62	-	0.00	1.73	-	0.00	1.73
14.17	-	0.00	1.49	-	0.00	1.60	-	0.00	1.75	-	0.00	1.86	-	0.00	1.97	-	0.00	1.97
14.33	-	0.00	1.61	-	0.00	1.73	-	0.00	1.88	-	0.00	1.99	-	0.00	2.11	-	0.00	2.11
14.50	-	0.00	1.83	-	0.00	1.95	-	0.00	2.11	-	0.00	2.22	-	0.00	2.34	-	0.00	2.34
14.67	-	0.00	2.05	-	0.00	2.17	-	0.00	2.33	-	0.00	2.45	-	0.00	2.58	-	0.00	2.58
14.83	-	0.00	2.17	-	0.00	2.29	-	0.00	2.46	-	0.00	2.58	-	0.00	2.71	-	0.00	2.71
15.00	-	0.00	2.38	-	0.00	2.51	-	0.00	2.68	-	0.00	2.81	-	0.00	2.94	-	0.00	2.94
15.17	-	0.00	2.60	-	0.00	2.73	-	0.00	2.90	-	0.00	3.03	-	0.00	3.16	-	0.00	3.16
15.33	-	0.00	2.71	-	0.00	2.84	-	0.00	3.02	-	0.00	3.16	-	0.00	3.29	-	0.00	3.29
15.50	-	0.00	2.92	-	0.00	3.06	-	0.00	3.24	-	0.00	3.38	-	0.00	3.51	-	0.00	3.51
15.67	-	0.00	3.03	-	0.00	3.17	-	0.00	3.36	-	0.00	3.50	1.03	0.90	3.63	-	0.00	3.63
15.83	-	0.00	3.14	-	0.00	3.28	-	0.00	3.47	0.49	0.43	3.61	2.24	1.96	3.75	8.05	7.04	3.75
16.00	-	0.00	3.25	-	0.00	3.39	0.39	0.34	3.58	1.14	1.00	3.73	4.59	4.01	3.87	13.29	11.62	3.87
16.17	-	0.00	3.36	0.05	0.04	3.50	0.87	0.77	3.69	2.47	2.16	3.84	8.33	7.28	3.98	20.34	17.79	3.98
16.33	0.04	0.03	3.46	0.12	0.11	3.61	1.89	1.65	3.80	4.89	4.27	3.95	13.73	12.01	4.09	29.76	26.03	4.09
16.50	0.09	0.08	3.57	0.31	0.27	3.71	3.80	3.32	3.91	8.59	7.51	4.06	21.65	18.93	4.20	42.33	37.02	4.20
16.67	0.09	0.08	3.57	0.32	0.28	3.72	3.91	3.42	3.91	8.84	7.73	4.06	22.18	19.40	4.21	43.12	37.71	4.21
16.83	0.09	0.08	3.57	0.33	0.29	3.72	3.98	3.48	3.92	8.97	7.85	4.06	22.55	19.72	4.21	43.68	38.20	4.21
17.00	0.09	0.08	3.57	0.33	0.29	3.72	4.01	3.51	3.92	9.02	7.88	4.07	22.63	19.79	4.21	43.81	38.31	4.21
17.17	0.09	0.08	3.57	0.33	0.29	3.72	3.98	3.48	3.92	8.97	7.85	4.06	22.55	19.72	4.21	43.68	38.20	4.21
17.33	0.09	0.08	3.57	0.32	0.28	3.72	3.91	3.42	3.91	8.84	7.73	4.06	22.18	19.40	4.21	43.12	37.71	4.21
17.50	0.04	0.03	3.47	0.13	0.11	3.61	1.98	1.73	3.81	5.09	4.45	3.96	14.27	12.48	4.10	30.67	26.82	4.10
17.67	-	0.00	3.36	0.05	0.05	3.51	0.93	0.82	3.70	2.64	2.31	3.85	8.77	7.67	3.99	21.15	18.50	3.99
17.83	-	0.00	3.26	-	0.00	3.40	0.42	0.37	3.59	1.24	1.08	3.74	4.94	4.32	3.88	13.99	12.23	3.88
18.00	-	0.00	3.15	-	0.00	3.29	-	0.00	3.48	0.55	0.48	3.63	2.50	2.18	3.77	8.69	7.60	3.77
18.17	-	0.00	2.94	-	0.00	3.08	-	0.00	3.27	-	0.00	3.41	-	0.00	3.55	-	0.00	3.55
18.33	-	0.00	2.73	-	0.00	2.87	-	0.00	3.06	-	0.00	3.20	-	0.00	3.33	-	0.00	3.33
18.50	-	0.00	2.62	-	0.00	2.76	-	0.00	2.94	-	0.00	3.08	-	0.00	3.21	-	0.00	3.21
18.67	-	0.00	2.41	-	0.00	2.54	-	0.00	2.72	-	0.00	2.86	-	0.00	2.99	-	0.00	2.99
18.83	-	0.00	2.20	-	0.00	2.33	-	0.00	2.50	-	0.00	2.63	-	0.00	2.76	-	0.00	2.76
19.00	-	0.00	1.98	-	0.00	2.11	-	0.00	2.28	-	0.00	2.41	-	0.00	2.54	-	0.00	2.54
19.17	-	0.00	1.77	-	0.00	1.89	-	0.00	2.06	-	0.00	2.18	-	0.00	2.31	-	0.00	2.31
19.33	-	0.00	1.55	-	0.00	1.67	-	0.00	1.83	-	0.00	1.95	-	0.00	2.08	-	0.00	2.08
19.50	-	0.00	1.23	-	0.00	1.35	-	0.00	1.51	-	0.00	1.62	-	0.00	1.74	-	0.00	1.74
19.67	-	0.00	1.01	-	0.00	1.13	-	0.00	1.28	-	0.00	1.39	-	0.00	1.51	-	0.00	1.51
19.83	-	0.00	0.79	-	0.00	0.90	-	0.00	1.05	-	0.00	1.16	-	0.00	1.27	-	0.00	1.27
20.00	-	0.00	0.57	-	0.00	0.68	-	0.00	0.82	-	0.00	0.92	-	0.00	1.03	-	0.00	1.03
20.17	-	0.00	0.25	-	0.00	0.35	-	0.00	0.49	-	0.00	0.59	-	0.00	0.69	-	0.00	0.69
20.33	-	0.00	0.03	-	0.00	0.13	-	0.00	0.25	-	0.00	0.35	-	0.00	0.44	-	0.00	0.44
20.50	-	0.00	-0.29	-	0.00	-0.20	-	0.00	-0.08	-	0.00	0.01	-	0.00	0.10	-	0.00	0.10
20.67	-	0.00	-0.52	-	0.00	-0.43	-	0.00	-0.32	-	0.00	-0.23	-	0.00	-0.15	-	0.00	-0.15
20.83	-	0.00	-0.74	-	0.00	-0.66	-	0.00	-0.56	-	0.00	-0.48	-	0.00	-0.40	-	0.00	-0.40
21.00	-	0.00	-1.07	-	0.00	-0.99	-	0.00	-0.89	-	0.00	-0.82	-	0.00	-0.75	-	0.00	-0.75
21.17	-	0.00	-1.29	-	0.00	-1.22	-	0.00	-1.13	-	0.00	-1.06	-	0.00	-1.00	-	0.00	-1.00
21.33	-	0.00	-1.52	-	0.00	-1.46	-	0.00	-1.37	-	0.00	-1.31	-	0.00	-1.25	-	0.00	-1.25
21.50	-	0.00	-1.75	-	0.00	-1.69	-	0.00	-1.61	-	0.00	-1.56	-	0.00	-1.50	-	0.00	-1.50
21.67	-	0.00	-1.97	-	0.00	-1.92	-	0.00	-1.86	-	0.00	-1.80	-	0.00	-1.75	-	0.00	-1.75
21.83	-	0.00	-2.20	-	0.00	-2.16	-	0.00	-2.10	-	0.00	-2.05	-	0.00	-2.01	-	0.00	-2.01
22.00	-	0.00	-2.43	-	0.00	-2.39	-	0.00	-2.34	-	0.00	-2.30	-	0.00	-2.26	-	0.00	-2.26
22.17	-	0.00	-2.46	-	0.00	-2.43	-	0.00	-2.38	-	0.00	-2.35	-	0.00	-2.32	-	0.00	-2.32
22.33	-	0.00	-2.49	-	0.00	-2.46	-	0.00	-2.43	-	0.00	-2.40	-	0.00	-2.38	-	0.00	-2.38
22.50	-	0.00	-2.32	-	0.00	-2.30	-	0.00	-2.27	-	0.00	-2.25	-	0.00	-2.23	-	0.00	-2.23
22.67	-	0.00	-2.15	-	0.00	-2.13	-	0.00	-2.12	-	0.00	-2.10	-	0.00	-2.09	-	0.00	-2.09
22.83	-	0.00	-1.98	-	0.00	-1.97	-	0.00	-1.96	-	0.00	-1.95	-	0.00	-1.95	-	0.00	-1.95
23.00	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81

MID RANGE RUNS

	50% Mid Range			20% Mid Range			10% Mid Range			5% Mid Range			2% Mid Range			1% Mid Range			0.5% Mid Range			0.1% Mid Range		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
11.00	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61
11.17	-	0.00	-2.57	-	0.00	-2.56	-	0.00	-2.55	-	0.00	-2.55	-	0.00	-2.54	-	0.00	-2.53	-	0.00	-2.53	-	0.00	-2.53
11.33	-	0.00	-2.53	-	0.00	-2.52	-	0.00	-2.50	-	0.00	-2.49	-	0.00	-2.47	-	0.00	-2.46	-	0.00	-2.45	-	0.00	-2.45
11.50	-	0.00	-2.30	-	0.00	-2.27	-	0.00	-2.25	-	0.00	-2.23	-	0.00	-2.21	-	0.00	-2.19	-	0.00	-2.17	-	0.00	-2.17
11.67	-	0.00	-2.06	-	0.00	-2.03	-	0.00	-2.00	-	0.00	-1.97	-	0.00	-1.94	-	0.00	-1.91	-	0.00	-1.89	-	0.00	-1.89
11.83	-	0.00	-1.83	-	0.00	-1.78	-	0.00	-1.75	-	0.00	-1.72	-	0.00	-1.68	-	0.00	-1.64	-	0.00	-1.61	-	0.00	-1.61
12.00	-	0.00	-1.59	-	0.00	-1.54	-	0.00	-1.50	-	0.00	-1.46	-	0.00	-1.41	-	0.00	-1.37	-	0.00	-1.33	-	0.00	-1.33
12.17	-	0.00	-1.36	-	0.00	-1.30	-	0.00	-1.25	-	0.00	-1.21	-	0.00	-1.15	-	0.00	-1.10	-	0.00	-1.06	-	0.00	-1.06
12.33	-	0.00	-1.12	-	0.00	-1.05	-	0.00	-1.00	-	0.00	-0.95	-	0.00	-0.88	-	0.00	-0.83	-	0.00	-0.78	-	0.00	-0.78
12.50	-	0.00	-0.79	-	0.00	-0.71	-	0.00	-0.65	-	0.00	-0.60	-	0.00	-0.52	-	0.00	-0.47	-	0.00	-0.41	-	0.00	-0.41
12.67	-	0.00	-0.56	-	0.00	-0.47	-	0.00	-0.41	-	0.00	-0.34	-	0.00	-0.26	-	0.00	-0.20	-	0.00	-0.14	-	0.00	-0.14
12.83	-	0.00	-0.32	-	0.00	-0.23	-	0.00	-0.16	-	0.00	-0.09	-	0.00	0.00	-	0.00	0.07	-	0.00	0.13	-	0.00	0.13
13.00	-	0.00	0.01	-	0.00	0.11	-	0.00	0.18	-	0.00	0.26	-	0.00	0.36	-	0.00	0.43	-	0.00	0.50	-	0.00	0.50
13.17	-	0.00	0.24	-	0.00	0.35	-	0.00	0.43	-	0.00	0.51	-	0.00	0.61	-	0.00	0.69	-	0.00	0.77	-	0.00	0.77
13.33	-	0.00	0.47	-	0.00	0.58	-	0.00	0.67	-	0.00	0.76	-	0.00	0.87	-	0.00	0.95	-	0.00	1.04	-	0.00	1.04
13.50	-	0.00	0.70	-	0.00	0.82	-	0.00	0.91	-	0.00	1.00	-	0.00	1.12	-	0.00	1.21	-	0.00	1.30	-	0.00	1.30
13.67	-	0.00	0.93	-	0.00	1.06	-	0.00	1.15	-	0.00	1.25	-	0.00	1.37	-	0.00	1.47	-	0.00	1.56	-	0.00	1.56
13.83	-	0.00	1.15	-	0.00	1.29	-	0.00	1.39	-	0.00	1.49	-	0.00	1.62	-	0.00	1.72	-	0.00	1.82	-	0.00	1.82
14.00	-	0.00	1.38	-	0.00	1.52	-	0.00	1.63	-	0.00	1.73	-	0.00	1.87	-	0.00	1.98	-	0.00	2.08	-	0.00	2.08
14.17	-	0.00	1.61	-	0.00	1.75	-	0.00	1.86	-	0.00	1.97	-	0.00	2.12	-	0.00	2.23	-	0.00	2.34	-	0.00	2.34
14.33	-	0.00	1.73	-	0.00	1.88	-	0.00	2.00	-	0.00	2.11	-	0.00	2.26	-	0.00	2.38	-	0.00	2.49	-	0.00	2.49
14.50	-	0.00	1.95	-	0.00	2.11	-	0.00	2.23	-	0.00	2.35	-	0.00	2.50	-	0.00	2.62	-	0.00	2.74	-	0.00	2.74
14.67	-	0.00	2.17	-	0.00	2.34	-	0.00	2.46	-	0.00	2.58	-	0.00	2.74	-	0.00	2.86	-	0.00	2.99	-	0.00	2.99
14.83	-	0.00	2.29	-	0.00	2.46	-	0.00	2.59	-	0.00	2.71	-	0.00	2.88	-	0.00	3.00	-	0.00	3.13	-	0.00	3.13
15.00	-	0.00	2.51	-	0.00	2.69	-	0.00	2.81	-	0.00	2.94	-	0.00	3.11	-	0.00	3.24	-	0.00	3.37	-	0.00	3.37
15.17	-	0.00	2.73	-	0.00	2.91	-	0.00	3.04	-	0.00	3.17	-	0.00	3.35	-	0.00	3.48	0.74	0.65	3.61	-	0.00	3.61
15.33	-	0.00	2.85	-	0.00	3.03	-	0.00	3.16	-	0.00	3.30	-	0.00	3.48	0.60	0.52	3.61	1.71	1.49	3.74	-	0.00	3.74
15.50	-	0.00	3.06	-	0.00	3.24	-	0.00	3.38	0.12	0.11	3.52	0.89	0.78	3.70	2.54	2.22	3.84	6.36	5.56	3.98	-	0.00	3.98
15.67	-	0.00	3.17	-	0.00	3.36	0.07	0.06	3.50	0.30	0.26	3.64	1.99	1.74	3.83	5.26	4.60	3.97	11.81	10.33	4.10	-	0.00	4.10
15.83	-	0.00	3.28	0.04	0.03	3.48	0.18	0.16	3.62	0.71	0.62	3.76	4.14	3.62	3.95	9.78	8.55	4.09	20.79	18.18	4.23	-	0.00	4.23
16.00	-	0.00	3.39	0.08	0.07	3.59	0.43	0.38	3.73	1.60	1.40	3.88	7.83	6.85	4.07	17.30	15.13	4.21	35.05	30.65	4.35	-	0.00	4.35
16.17	0.02	0.02	3.50	0.20	0.18	3.70	0.98	0.86	3.84	3.38	2.95	3.99	13.80	12.07	4.18	29.14	25.48	4.33	-	0.00	4.47	-	0.00	4.47
16.33	0.04	0.04	3.61	0.49	0.43	3.81	2.13	1.86	3.95	6.51	5.69	4.10	23.37	20.44	4.29	-	0.00	4.44	-	0.00	4.59	-	0.00	4.59
16.50	0.11	0.09	3.72	1.11	0.97	3.91	4.31	3.77	4.06	11.69	10.22	4.21	37.66	32.93	4.40	-	0.00	4.55	-	0.00	4.70	-	0.00	4.70
16.67	0.11	0.10	3.72	1.15	1.00	3.92	4.48	3.91	4.07	12.06	10.55	4.22	38.93	34.04	4.41	-	0.00	4.56	-	0.00	4.71	-	0.00	4.71
16.83	0.11	0.10	3.72	1.17	1.03	3.92	4.56	3.99	4.07	12.32	10.77	4.22	39.58	34.61	4.42	-	0.00	4.56	-	0.00	4.71	-	0.00	4.71
17.00	0.11	0.10	3.72	1.18	1.03	3.92	4.59	4.01	4.07	12.38	10.83	4.22	39.89	34.88	4.42	-	0.00	4.57	-	0.00	4.71	-	0.00	4.71
17.17	0.11	0.10	3.72	1.17	1.03	3.92	4.56	3.99	4.07	12.32	10.77	4.22	39.58	34.61	4.42	-	0.00	4.56	-	0.00	4.71	-	0.00	4.71
17.33	0.11	0.10	3.72	1.15	1.00	3.92	4.48	3.91	4.07	12.06	10.55	4.22	38.93	34.04	4.41	-	0.00	4.56	-	0.00	4.71	-	0.00	4.71
17.50	0.05	0.04	3.62	0.52	0.45	3.81	2.23	1.95	3.96	6.84	5.99	4.11	24.45	21.38	4.30	-	0.00	4.45	-	0.00	4.60	-	0.00	4.60
17.67	0.02	0.02	3.51	0.22	0.19	3.71	1.06	0.92	3.85	3.62	3.16	4.00	14.68	12.84	4.19	30.93	27.05	4.34	-	0.00	4.49	-	0.00	4.49
17.83	-	0.00	3.40	0.09	0.08	3.60	0.47	0.41	3.74	1.75	1.53	3.89	8.45	7.39	4.08	18.70	16.35	4.23	37.69	32.96	4.37	-	0.00	4.37
18.00	-	0.00	3.29	0.04	0.03	3.49	0.20	0.17	3.63	0.80	0.70	3.78	4.61	4.03	3.97	10.82	9.46	4.11	23.00	20.11	4.25	-	0.00	4.25
18.17	-	0.00	3.08	-	0.00	3.28	-	0.00	3.42	0.17	0.15	3.56	1.19	1.04	3.75	3.42	2.99	3.89	8.29	7.25	4.03	-	0.00	4.03
18.33	-	0.00	2.87	-	0.00	3.06	-	0.00	3.20	-	0.00	3.34	-	0.00	3.53	0.86	0.75	3.67	2.47	2.16	3.80	-	0.00	3.80
18.50	-	0.00	2.76	-	0.00	2.94	-	0.00	3.08	-	0.00	3.22	-	0.00	3.40	-	0.00	3.54	1.12	0.98	3.68	-	0.00	3.68
18.67	-	0.00	2.55	-	0.00	2.73	-	0.00	2.86	-	0.00	3.00	-	0.00	3.18	-	0.00	3.31	-	0.00	3.44	-	0.00	3.44
18.83	-	0.00	2.33	-	0.00	2.51	-	0.00	2.64	-	0.00	2.77	-	0.00	2.95	-	0.00	3.08	-	0.00	3.21	-	0.00	3.21
19.00	-	0.00	2.11	-	0.00	2.29	-	0.00	2.41	-	0.00	2.54	-	0.00	2.71	-	0.00	2.84	-	0.00	2.97	-	0.00	2.97
19.17	-	0.00	1.89	-	0.00	2.06	-	0.00	2.19	-	0.00	2.31	-	0.00	2.48	-	0.00	2.60	-	0.00	2.73	-	0.00	2.73
19.33	-	0.00	1.67	-	0.00	1.84	-	0.00	1.96	-	0.00	2.08	-	0.00	2.24	-	0.00	2.36	-	0.00	2.49	-	0.00	2.49
19.50	-	0.00	1.35	-	0.00	1.51	-	0.00	1.63	-	0.00	1.75	-	0.00	1.90	-	0.00	2.02	-	0.00	2.14	-	0.00	2.14
19.67	-	0.00	1.13	-	0.00	1.28	-	0.00	1.40	-	0.00	1.51	-	0.00	1.66	-	0.00	1.78	-	0.00	1.89	-	0.00	1.89
19.83	-	0.00	0.91	-	0.00	1.05	-	0.00	1.16	-	0.00	1.27	-	0.00	1.42	-	0.00	1.53	-	0.00	1.64	-	0.00	1.64
20.00	-	0.00	0.68	-	0.00	0.82	-	0.00	0.93	-	0.00	1.03	-	0.00	1.17	-	0.00	1.28	-	0.00	1.38	-	0.00	1.38
20.17	-	0.00	0.35	-	0.00	0.49	-	0.00	0.59	-	0.00	0.69	-	0.00	0.82	-	0.00	0.92	-	0.00	1.02	-	0.00	1.02
20.33	-	0.00	0.13	-	0.00	0.26	-	0.00	0.35	-	0.00	0.45	-	0.00	0.57	-	0.00	0.67	-	0.00	0.76	-	0.00	0.76
20.50	-	0.00	-0.20	-	0.00	-0.08	-	0.00	0.01	-	0.00	0.10	-	0.00	0.22	-	0.00	0.31	-	0.00	0.40	-	0.00	0.40
20.67	-	0.00	-0.43	-	0.00	-0.32	-	0.00	-0.23	-	0.00	-0.14	-	0.00	-0.03	-	0.00	0.05	-	0.00	0.14	-	0.00	0.14
20.83	-	0.00	-0.66	-	0.00	-0.55	-	0.00	-0.47	-	0.00	-0.39	-	0.00	-0.29	-	0.00	-0.21	-	0.00	-0.13	-	0.00	-0.13
21.00	-	0.00	-0.99	-	0.00	-0.89	-	0.00	-0.82	-	0.00	-0.74	-	0.00	-0.64	-	0.00	-0.57	-	0.00	-0.50	-	0.00	-0.50
21.17	-	0.00	-1.22	-	0.00	-1.13	-	0.00	-1.06	-	0.00	-0.99	-	0.00	-0.90	-	0.00	-0.83	-	0.00	-0.77	-	0.00	-0.77
21.33	-	0.00	-1.46	-	0.00	-1.37	-	0.00	-1.31	-	0.00	-1.24	-	0.00	-1.16	-	0.00	-1.10	-	0.00	-1.04	-	0.00	-1.04
21.50	-	0.00	-1.69	-	0.00	-1.61	-	0.00	-1.55	-	0.00	-1.50	-	0.00	-1.42	-	0.00	-1.37	-	0.00	-1.31	-	0.00	-1.31
21.67	-	0.00	-1.92	-	0.00	-1.85	-	0.00	-1.80	-	0.00	-1.75	-	0.00	-1.68	-	0.00	-1.63	-	0.00	-1.58	-	0.00	-1.58
21.83	-	0.00	-2.16	-	0.00	-2.10	-	0.00	-2.05	-	0.00	-2.01	-	0.00	-1.95	-	0.00	-1.90	-	0.00	-1.86	-	0.00	-1.86
22.00	-	0.00	-2.39	-	0.00	-2.34	-	0.00	-2.30	-	0.00	-2.26	-	0.00	-2.21	-	0.00	-2.17	-	0.00	-2.13	-	0.00	-2.13
22.17	-	0.00	-2.43	-	0.00	-2.38	-	0.00	-2.35	-	0.00	-2.32	-	0.00	-2.28	-	0.00	-2.24	-	0.00	-2.21	-	0.00	-2.21
22.33	-	0.00	-2.46	-	0.00	-2.43	-	0.00	-2.40	-	0.00	-2.37	-	0.00	-2.34	-	0.00	-2.31	-	0.00	-2.29	-	0.00	-2.29
22.50	-	0.00	-2.30	-	0.00	-2.27	-	0.00	-2.25	-	0.00	-2.23	-	0.00	-2.21	-	0.00	-2.19	-	0.00	-2.17	-	0.00	-2.17
22.67	-	0.00	-2.13	-	0.00	-2.12	-	0.00	-2.10	-	0.00	-2.09	-	0.00	-2.07	-	0.00	-2.06	-	0.00	-2.05	-	0.00	-2.05
22.83	-	0.00	-1.97	-	0.00	-1.96	-	0.00	-1.95	-	0.00	-1.95	-	0.00	-1.94	-	0.00	-1.93	-	0.00	-1.93	-	0.00	-1.93
23.00	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81

HIGH END RUNS

	10% High End			0.5% High End			0.1% High End		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
11.00	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61
11.17	-	0.00	-2.53	-	0.00	-2.50	-	0.00	-2.50
11.33	-	0.00	-2.46	-	0.00	-2.40	-	0.00	-2.40
11.50	-	0.00	-2.19	-	0.00	-2.10	-	0.00	-2.10
11.67	-	0.00	-1.91	-	0.00	-1.80	-	0.00	-1.80
11.83	-	0.00	-1.64	-	0.00	-1.50	-	0.00	-1.50
12.00	-	0.00	-1.37	-	0.00	-1.20	-	0.00	-1.20
12.17	-	0.00	-1.10	-	0.00	-0.91	-	0.00	-0.91
12.33	-	0.00	-0.83	-	0.00	-0.61	-	0.00	-0.61
12.50	-	0.00	-0.46	-	0.00	-0.22	-	0.00	-0.22
12.67	-	0.00	-0.20	-	0.00	0.08	-	0.00	0.08
12.83	-	0.00	0.07	-	0.00	0.37	-	0.00	0.37
13.00	-	0.00	0.43	-	0.00	0.75	-	0.00	0.75
13.17	-	0.00	0.70	-	0.00	1.04	-	0.00	1.04
13.33	-	0.00	0.96	-	0.00	1.33	-	0.00	1.33
13.50	-	0.00	1.22	-	0.00	1.61	-	0.00	1.61
13.67	-	0.00	1.47	-	0.00	1.89	-	0.00	1.89
13.83	-	0.00	1.73	-	0.00	2.16	-	0.00	2.16
14.00	-	0.00	1.98	-	0.00	2.43	-	0.00	2.43
14.17	-	0.00	2.23	-	0.00	2.70	-	0.00	2.70
14.33	-	0.00	2.38	-	0.00	2.87	-	0.00	2.87
14.50	-	0.00	2.63	-	0.00	3.13	-	0.00	3.13
14.67	-	0.00	2.87	-	0.00	3.39	-	0.00	3.39
14.83	-	0.00	3.01	-	0.00	3.55	-	0.00	3.55
15.00	-	0.00	3.25	3.30	2.89	3.80	-	0.00	3.80
15.17	-	0.00	3.48	11.34	9.92	4.05	-	0.00	4.05
15.33	0.26	0.22	3.61	21.25	18.58	4.20	-	0.00	4.20
15.50	1.35	1.18	3.84	-	0.00	4.44	-	0.00	4.44
15.67	3.13	2.74	3.97	-	0.00	4.57	-	0.00	4.57
15.83	6.54	5.72	4.09	-	0.00	4.71	-	0.00	4.71
16.00	12.36	10.81	4.21	-	0.00	4.83	-	0.00	4.83
16.17	22.19	19.41	4.33	-	0.00	4.96	-	0.00	4.96
16.33	37.31	32.63	4.45	-	0.00	5.08	-	0.00	5.08
16.50	-	0.00	4.56	-	0.00	5.19	-	0.00	5.19
16.67	-	0.00	4.57	-	0.00	5.21	-	0.00	5.21
16.83	-	0.00	4.57	-	0.00	5.21	-	0.00	5.21
17.00	-	0.00	4.57	-	0.00	5.21	-	0.00	5.21
17.17	-	0.00	4.57	-	0.00	5.21	-	0.00	5.21
17.33	-	0.00	4.57	-	0.00	5.21	-	0.00	5.21
17.50	39.11	34.20	4.46	-	0.00	5.09	-	0.00	5.09
17.67	23.72	20.74	4.35	-	0.00	4.98	-	0.00	4.98
17.83	13.54	11.84	4.23	-	0.00	4.86	-	0.00	4.86
18.00	7.30	6.38	4.11	-	0.00	4.73	-	0.00	4.73
18.17	1.90	1.67	3.89	-	0.00	4.51	-	0.00	4.51
18.33	0.39	0.34	3.67	29.33	25.65	4.27	-	0.00	4.27
18.50	0.15	0.13	3.54	16.53	14.46	4.14	-	0.00	4.14
18.67	-	0.00	3.31	5.45	4.76	3.90	-	0.00	3.90
18.83	-	0.00	3.08	1.36	1.19	3.65	-	0.00	3.65
19.00	-	0.00	2.85	-	0.00	3.40	-	0.00	3.40
19.17	-	0.00	2.61	-	0.00	3.15	-	0.00	3.15
19.33	-	0.00	2.37	-	0.00	2.89	-	0.00	2.89
19.50	-	0.00	2.03	-	0.00	2.53	-	0.00	2.53
19.67	-	0.00	1.78	-	0.00	2.27	-	0.00	2.27
19.83	-	0.00	1.53	-	0.00	2.00	-	0.00	2.00
20.00	-	0.00	1.28	-	0.00	1.73	-	0.00	1.73
20.17	-	0.00	0.93	-	0.00	1.36	-	0.00	1.36
20.33	-	0.00	0.67	-	0.00	1.09	-	0.00	1.09
20.50	-	0.00	0.32	-	0.00	0.71	-	0.00	0.71
20.67	-	0.00	0.06	-	0.00	0.43	-	0.00	0.43
20.83	-	0.00	-0.20	-	0.00	0.14	-	0.00	0.14
21.00	-	0.00	-0.57	-	0.00	-0.25	-	0.00	-0.25
21.17	-	0.00	-0.83	-	0.00	-0.53	-	0.00	-0.53
21.33	-	0.00	-1.10	-	0.00	-0.82	-	0.00	-0.82
21.50	-	0.00	-1.36	-	0.00	-1.12	-	0.00	-1.12
21.67	-	0.00	-1.63	-	0.00	-1.41	-	0.00	-1.41
21.83	-	0.00	-1.90	-	0.00	-1.71	-	0.00	-1.71
22.00	-	0.00	-2.17	-	0.00	-2.00	-	0.00	-2.00
22.17	-	0.00	-2.24	-	0.00	-2.10	-	0.00	-2.10
22.33	-	0.00	-2.31	-	0.00	-2.20	-	0.00	-2.20
22.50	-	0.00	-2.19	-	0.00	-2.10	-	0.00	-2.10
22.67	-	0.00	-2.06	-	0.00	-2.00	-	0.00	-2.00
22.83	-	0.00	-1.93	-	0.00	-1.90	-	0.00	-1.90
23.00	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81

Location G
CURRENT

	AEP								
	1.0			0.5			0.1		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
11.00							-	0.00	-2.61
11.17							-	0.00	-2.55
11.33							-	0.00	-2.49
11.50							-	0.00	-2.23
11.67							-	0.00	-1.98
11.83							-	0.00	-1.72
12.00							-	0.00	-1.46
12.17							-	0.00	-1.21
12.33							-	0.00	-0.95
12.50							-	0.00	-0.60
12.67							-	0.00	-0.35
12.83							-	0.00	-0.10
13.00							-	0.00	0.25
13.17							-	0.00	0.50
13.33							-	0.00	0.75
13.50							-	0.00	1.00
13.67							-	0.00	1.24
13.83							-	0.00	1.49
14.00							-	0.00	1.73
14.17							-	0.00	1.97
14.33							-	0.00	2.11
14.50							-	0.00	2.34
14.67							-	0.00	2.58
14.83							-	0.00	2.71
15.00							-	0.00	2.94
15.17							0.01	0.00	3.16
15.33							0.01	0.00	3.29
15.50							0.01	0.00	3.51
15.67							0.01	0.00	3.63
15.83							0.02	0.01	3.75
16.00							0.02	0.01	3.87
16.17							0.03	0.01	3.98
16.33							0.04	0.01	4.09
16.50							0.06	0.02	4.20
16.67							0.06	0.02	4.21
16.83							0.06	0.02	4.21
17.00							0.06	0.02	4.21
17.17							0.06	0.02	4.21
17.33							0.06	0.02	4.21
17.50							0.04	0.01	4.10
17.67							0.03	0.01	3.99
17.83							0.02	0.01	3.88
18.00							0.02	0.01	3.77
18.17							0.01	0.00	3.55
18.33							0.01	0.00	3.33
18.50							0.01	0.00	3.21
18.67							0.01	0.00	2.99
18.83							-	0.00	2.76
19.00							-	0.00	2.54
19.17							-	0.00	2.31
19.33							-	0.00	2.08
19.50							-	0.00	1.74
19.67							-	0.00	1.51
19.83							-	0.00	1.27
20.00							-	0.00	1.03
20.17							-	0.00	0.69
20.33							-	0.00	0.44
20.50							-	0.00	0.10
20.67							-	0.00	-0.15
20.83							-	0.00	-0.40
21.00							-	0.00	-0.75
21.17							-	0.00	-1.00
21.33							-	0.00	-1.25
21.50							-	0.00	-1.50
21.67							-	0.00	-1.75
21.83							-	0.00	-2.01
22.00							-	0.00	-2.26
22.17							-	0.00	-2.32
22.33							-	0.00	-2.38
22.50							-	0.00	-2.23
22.67							-	0.00	-2.09
22.83							-	0.00	-1.95
23.00							-	0.00	-1.81

Future Runs

	1% Mid Range			0.5% Mid Range			0.1% Mid Range			10% High End			0.5% High End			0.1% High End		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
11.00	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	n/a	n/a	n/a	-	0.00	-2.61	-	0.00	-2.61
11.17	-	0.00	-2.53	-	0.00	-2.53	-	0.00	-2.53	n/a	n/a	n/a	-	0.00	-2.50	-	0.00	-2.50
11.33	-	0.00	-2.46	-	0.00	-2.45	-	0.00	-2.45	n/a	n/a	n/a	-	0.00	-2.40	-	0.00	-2.40
11.50	-	0.00	-2.19	-	0.00	-2.17	-	0.00	-2.17	n/a	n/a	n/a	-	0.00	-2.10	-	0.00	-2.10
11.67	-	0.00	-1.91	-	0.00	-1.89	-	0.00	-1.89	n/a	n/a	n/a	-	0.00	-1.80	-	0.00	-1.80
11.83	-	0.00	-1.64	-	0.00	-1.61	-	0.00	-1.61	n/a	n/a	n/a	-	0.00	-1.50	-	0.00	-1.50
12.00	-	0.00	-1.37	-	0.00	-1.33	-	0.00	-1.33	n/a	n/a	n/a	-	0.00	-1.20	-	0.00	-1.20
12.17	-	0.00	-1.10	-	0.00	-1.06	-	0.00	-1.06	n/a	n/a	n/a	-	0.00	-0.91	-	0.00	-0.91
12.33	-	0.00	-0.83	-	0.00	-0.78	-	0.00	-0.78	n/a	n/a	n/a	-	0.00	-0.61	-	0.00	-0.61
12.50	-	0.00	-0.47	-	0.00	-0.41	-	0.00	-0.41	n/a	n/a	n/a	-	0.00	-0.22	-	0.00	-0.22
12.67	-	0.00	-0.20	-	0.00	-0.14	-	0.00	-0.14	n/a	n/a	n/a	-	0.00	0.08	-	0.00	0.08
12.83	-	0.00	0.07	-	0.00	0.13	-	0.00	0.13	n/a	n/a	n/a	-	0.00	0.37	-	0.00	0.37
13.00	-	0.00	0.43	-	0.00	0.50	-	0.00	0.50	n/a	n/a	n/a	-	0.00	0.75	-	0.00	0.75
13.17	-	0.00	0.69	-	0.00	0.77	-	0.00	0.77	n/a	n/a	n/a	-	0.00	1.04	-	0.00	1.04
13.33	-	0.00	0.95	-	0.00	1.04	-	0.00	1.04	n/a	n/a	n/a	-	0.00	1.33	-	0.00	1.33
13.50	-	0.00	1.21	-	0.00	1.30	-	0.00	1.30	n/a	n/a	n/a	-	0.00	1.61	-	0.00	1.61
13.67	-	0.00	1.47	-	0.00	1.56	-	0.00	1.56	n/a	n/a	n/a	-	0.00	1.89	-	0.00	1.89
13.83	-	0.00	1.72	-	0.00	1.82	-	0.00	1.82	n/a	n/a	n/a	-	0.00	2.16	-	0.00	2.16
14.00	-	0.00	1.98	-	0.00	2.08	-	0.00	2.08	n/a	n/a	n/a	-	0.00	2.43	-	0.00	2.43
14.17	-	0.00	2.23	-	0.00	2.34	-	0.00	2.34	n/a	n/a	n/a	-	0.00	2.70	-	0.00	2.70
14.33	-	0.00	2.38	-	0.00	2.49	-	0.00	2.49	n/a	n/a	n/a	0.00	0.00	2.87	-	0.00	2.87
14.50	-	0.00	2.62	-	0.00	2.74	-	0.00	2.74	n/a	n/a	n/a	0.00	0.00	3.13	0.01	0.00	3.13
14.67	0.00	0.00	2.86	0.00	0.00	2.99	-	0.00	2.99	n/a	n/a	n/a	0.00	0.00	3.39	0.02	0.01	3.39
14.83	0.00	0.00	3.00	0.00	0.00	3.13	0.01	0.00	3.13	n/a	n/a	n/a	0.01	0.00	3.55	0.03	0.01	3.55
15.00	0.00	0.00	3.24	0.00	0.00	3.37	0.01	0.00	3.37	n/a	n/a	n/a	0.01	0.00	3.80	0.05	0.01	3.80
15.17	0.00	0.00	3.48	0.01	0.00	3.61	0.02	0.01	3.61	n/a	n/a	n/a	0.02	0.01	4.05	0.10	0.03	4.05
15.33	0.00	0.00	3.61	0.01	0.00	3.74	0.03	0.01	3.74	n/a	n/a	n/a	0.03	0.01	4.20	0.14	0.04	4.20
15.50	0.01	0.00	3.84	0.01	0.00	3.98	0.06	0.02	3.98	n/a	n/a	n/a	0.05	0.02	4.44	0.29	0.08	4.44
15.67	0.01	0.00	3.97	0.02	0.00	4.10	0.08	0.02	4.10	n/a	n/a	n/a	0.09	0.03	4.57	0.45	0.13	4.57
15.83	0.01	0.00	4.09	0.02	0.01	4.23	0.12	0.03	4.23	n/a	n/a	n/a	0.14	0.04	4.71	0.72	0.21	4.71
16.00	0.01	0.00	4.21	0.03	0.01	4.35	0.16	0.05	4.35	n/a	n/a	n/a	0.25	0.07	4.83	1.16	0.33	4.83
16.17	0.02	0.01	4.33	0.05	0.01	4.47	0.23	0.07	4.47	n/a	n/a	n/a	0.44	0.13	4.96	1.88	0.54	4.96
16.33	0.03	0.01	4.44	0.07	0.02	4.59	0.34	0.10	4.59	n/a	n/a	n/a	0.79	0.23	5.08	2.99	0.86	5.08
16.50	0.04	0.01	4.55	0.11	0.03	4.70	0.51	0.15	4.70	n/a	n/a	n/a	1.36	0.39	5.19	4.56	1.31	5.19
16.67	0.04	0.01	4.56	0.11	0.03	4.71	0.53	0.15	4.71	n/a	n/a	n/a	1.44	0.41	5.21	4.74	1.37	5.21
16.83	0.04	0.01	4.56	0.11	0.03	4.71	0.54	0.15	4.71	n/a	n/a	n/a	1.48	0.43	5.21	4.86	1.40	5.21
17.00	0.04	0.01	4.57	0.11	0.03	4.71	0.54	0.16	4.71	n/a	n/a	n/a	1.50	0.43	5.21	4.90	1.41	5.21
17.17	0.04	0.01	4.56	0.11	0.03	4.71	0.54	0.15	4.71	n/a	n/a	n/a	1.48	0.43	5.21	4.86	1.40	5.21
17.33	0.04	0.01	4.56	0.11	0.03	4.71	0.53	0.15	4.71	n/a	n/a	n/a	1.44	0.41	5.21	4.74	1.37	5.21
17.50	0.03	0.01	4.45	0.07	0.02	4.60	0.36	0.10	4.60	n/a	n/a	n/a	0.84	0.24	5.09	3.16	0.91	5.09
17.67	0.02	0.01	4.34	0.05	0.01	4.49	0.24	0.07	4.49	n/a	n/a	n/a	0.49	0.14	4.98	2.04	0.59	4.98
17.83	0.02	0.00	4.23	0.03	0.01	4.37	0.17	0.05	4.37	n/a	n/a	n/a	0.28	0.08	4.86	1.27	0.37	4.86
18.00	0.01	0.00	4.11	0.02	0.01	4.25	0.12	0.04	4.25	n/a	n/a	n/a	0.16	0.05	4.73	0.79	0.23	4.73
18.17	0.01	0.00	3.89	0.01	0.00	4.03	0.07	0.02	4.03	n/a	n/a	n/a	0.07	0.02	4.51	0.36	0.10	4.51
18.33	0.00	0.00	3.67	0.01	0.00	3.80	0.04	0.01	3.80	n/a	n/a	n/a	0.03	0.01	4.27	0.18	0.05	4.27
18.50	0.00	0.00	3.54	0.01	0.00	3.68	0.03	0.01	3.68	n/a	n/a	n/a	0.02	0.01	4.14	0.12	0.04	4.14
18.67	0.00	0.00	3.31	0.00	0.00	3.44	0.02	0.00	3.44	n/a	n/a	n/a	0.01	0.00	3.90	0.06	0.02	3.90
18.83	0.00	0.00	3.08	0.00	0.00	3.21	0.01	0.00	3.21	n/a	n/a	n/a	0.01	0.00	3.65	0.03	0.01	3.65
19.00	0.00	0.00	2.84	0.00	0.00	2.97	-	0.00	2.97	n/a	n/a	n/a	0.01	0.00	3.40	0.02	0.01	3.40
19.17	-	0.00	2.60	-	0.00	2.73	-	0.00	2.73	n/a	n/a	n/a	0.00	0.00	3.15	0.01	0.00	3.15
19.33	-	0.00	2.36	-	0.00	2.49	-	0.00	2.49	n/a	n/a	n/a	0.00	0.00	2.89	-	0.00	2.89
19.50	-	0.00	2.02	-	0.00	2.14	-	0.00	2.14	n/a	n/a	n/a	-	0.00	2.53	-	0.00	2.53
19.67	-	0.00	1.78	-	0.00	1.89	-	0.00	1.89	n/a	n/a	n/a	-	0.00	2.27	-	0.00	2.27
19.83	-	0.00	1.53	-	0.00	1.64	-	0.00	1.64	n/a	n/a	n/a	-	0.00	2.00	-	0.00	2.00
20.00	-	0.00	1.28	-	0.00	1.38	-	0.00	1.38	n/a	n/a	n/a	-	0.00	1.73	-	0.00	1.73
20.17	-	0.00	0.92	-	0.00	1.02	-	0.00	1.02	n/a	n/a	n/a	-	0.00	1.36	-	0.00	1.36
20.33	-	0.00	0.67	-	0.00	0.76	-	0.00	0.76	n/a	n/a	n/a	-	0.00	1.09	-	0.00	1.09
20.50	-	0.00	0.31	-	0.00	0.40	-	0.00	0.40	n/a	n/a	n/a	-	0.00	0.71	-	0.00	0.71
20.67	-	0.00	0.05	-	0.00	0.14	-	0.00	0.14	n/a	n/a	n/a	-	0.00	0.43	-	0.00	0.43
20.83	-	0.00	-0.21	-	0.00	-0.13	-	0.00	-0.13	n/a	n/a	n/a	-	0.00	0.14	-	0.00	0.14
21.00	-	0.00	-0.57	-	0.00	-0.50	-	0.00	-0.50	n/a	n/a	n/a	-	0.00	-0.25	-	0.00	-0.25
21.17	-	0.00	-0.83	-	0.00	-0.77	-	0.00	-0.77	n/a	n/a	n/a	-	0.00	-0.53	-	0.00	-0.53
21.33	-	0.00	-1.10	-	0.00	-1.04	-	0.00	-1.04	n/a	n/a	n/a	-	0.00	-0.82	-	0.00	-0.82
21.50	-	0.00	-1.37	-	0.00	-1.31	-	0.00	-1.31	n/a	n/a	n/a	-	0.00	-1.12	-	0.00	-1.12
21.67	-	0.00	-1.63	-	0.00	-1.58	-	0.00	-1.58	n/a	n/a	n/a	-	0.00	-1.41	-	0.00	-1.41
21.83	-	0.00	-1.90	-	0.00	-1.86	-	0.00	-1.86	n/a	n/a	n/a	-	0.00	-1.71	-	0.00	-1.71
22.00	-	0.00	-2.17	-	0.00	-2.13	-	0.00	-2.13	n/a	n/a	n/a	-	0.00	-2.00	-	0.00	-2.00
22.17	-	0.00	-2.24	-	0.00	-2.21	-	0.00	-2.21	n/a	n/a	n/a	-	0.00	-2.10	-	0.00	-2.10
22.33	-	0.00	-2.31	-	0.00	-2.29	-	0.00	-2.29	n/a	n/a	n/a	-	0.00	-2.20	-	0.00	-2.20
22.50	-	0.00	-2.19	-	0.00	-2.17	-	0.00	-2.17	n/a	n/a	n/a	-	0.00	-2.10	-	0.00	-2.10
22.67	-	0.00	-2.06	-	0.00	-2.05	-	0.00	-2.05	n/a	n/a	n/a	-	0.00	-2.00	-	0.00	-2.00
22.83	-	0.00	-1.93	-	0.00	-1.93	-	0.00	-1.93	n/a	n/a	n/a	-	0.00	-1.90	-	0.00	-1.90
23.00	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	n/a	n/a	n/a	-	0.00	-1.81	-	0.00	-1.81

Location H

Current Runs

	AEP																	
	10%			5%			2%			1%			0.50%			0.10%		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
11.000	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61
11.167	-	0.00	-2.58	-	0.00	-2.57	-	0.00	-2.56	-	0.00	-2.55	-	0.00	-2.55	-	0.00	-2.55
11.333	-	0.00	-2.55	-	0.00	-2.53	-	0.00	-2.52	-	0.00	-2.50	-	0.00	-2.49	-	0.00	-2.49
11.500	-	0.00	-2.32	-	0.00	-2.30	-	0.00	-2.27	-	0.00	-2.25	-	0.00	-2.23	-	0.00	-2.23
11.667	-	0.00	-2.09	-	0.00	-2.06	-	0.00	-2.03	-	0.00	-2.00	-	0.00	-1.98	-	0.00	-1.98
11.833	-	0.00	-1.86	-	0.00	-1.83	-	0.00	-1.78	-	0.00	-1.75	-	0.00	-1.72	-	0.00	-1.72
12.000	-	0.00	-1.63	-	0.00	-1.59	-	0.00	-1.54	-	0.00	-1.50	-	0.00	-1.46	-	0.00	-1.46
12.167	-	0.00	-1.40	-	0.00	-1.36	-	0.00	-1.30	-	0.00	-1.25	-	0.00	-1.21	-	0.00	-1.21
12.333	-	0.00	-1.17	-	0.00	-1.12	-	0.00	-1.06	-	0.00	-1.00	-	0.00	-0.95	-	0.00	-0.95
12.500	-	0.00	-0.85	-	0.00	-0.79	-	0.00	-0.71	-	0.00	-0.66	-	0.00	-0.60	-	0.00	-0.60
12.667	-	0.00	-0.62	-	0.00	-0.56	-	0.00	-0.47	-	0.00	-0.41	-	0.00	-0.35	-	0.00	-0.35
12.833	-	0.00	-0.39	-	0.00	-0.32	-	0.00	-0.23	-	0.00	-0.16	-	0.00	-0.10	-	0.00	-0.10
13.000	-	0.00	-0.07	-	0.00	0.01	-	0.00	0.11	-	0.00	0.18	-	0.00	0.25	-	0.00	0.25
13.167	-	0.00	0.16	-	0.00	0.24	-	0.00	0.34	-	0.00	0.42	-	0.00	0.50	-	0.00	0.50
13.333	-	0.00	0.38	-	0.00	0.47	-	0.00	0.58	-	0.00	0.67	-	0.00	0.75	-	0.00	0.75
13.500	-	0.00	0.61	-	0.00	0.70	-	0.00	0.82	-	0.00	0.91	-	0.00	1.00	-	0.00	1.00
13.667	-	0.00	0.83	-	0.00	0.93	-	0.00	1.05	-	0.00	1.15	-	0.00	1.24	-	0.00	1.24
13.833	-	0.00	1.05	-	0.00	1.15	-	0.00	1.29	-	0.00	1.39	-	0.00	1.49	-	0.00	1.49
14.000	-	0.00	1.27	-	0.00	1.38	-	0.00	1.52	-	0.00	1.62	-	0.00	1.73	-	0.00	1.73
14.167	-	0.00	1.49	-	0.00	1.60	-	0.00	1.75	-	0.00	1.86	-	0.00	1.97	-	0.00	1.97
14.333	-	0.00	1.61	-	0.00	1.73	-	0.00	1.88	-	0.00	1.99	-	0.00	2.11	-	0.00	2.11
14.500	-	0.00	1.83	-	0.00	1.95	-	0.00	2.11	-	0.00	2.22	-	0.00	2.34	-	0.00	2.34
14.667	-	0.00	2.05	-	0.00	2.17	-	0.00	2.33	-	0.00	2.45	-	0.00	2.58	-	0.00	2.58
14.833	-	0.00	2.17	-	0.00	2.29	-	0.00	2.46	-	0.00	2.58	-	0.00	2.71	-	0.00	2.71
15.000	-	0.00	2.38	-	0.00	2.51	-	0.00	2.68	-	0.00	2.81	-	0.00	2.94	-	0.00	2.94
15.167	-	0.00	2.60	-	0.00	2.73	-	0.00	2.90	-	0.00	3.03	-	0.00	3.16	-	0.00	3.16
15.333	-	0.00	2.71	-	0.00	2.84	-	0.00	3.02	-	0.00	3.16	-	0.00	3.29	-	0.00	3.29
15.500	-	0.00	2.92	-	0.00	3.06	-	0.00	3.24	-	0.00	3.38	-	0.00	3.51	-	0.00	3.51
15.667	-	0.00	3.03	-	0.00	3.17	-	0.00	3.36	-	0.00	3.50	-	0.00	3.63	-	0.00	3.63
15.833	-	0.00	3.14	-	0.00	3.28	-	0.00	3.47	1.83	1.31	3.61	5.10	3.66	3.75	-	0.00	3.75
16.000	-	0.00	3.25	-	0.00	3.39	1.16	0.83	3.58	3.30	2.37	3.73	8.53	6.12	3.87	20.13	14.44	3.87
16.167	-	0.00	3.36	-	0.00	3.50	2.11	1.52	3.69	5.67	4.07	3.84	13.23	9.49	3.98	28.04	20.12	3.98
16.333	-	0.00	3.46	0.62	0.44	3.61	3.69	2.65	3.80	9.15	6.56	3.95	19.23	13.80	4.09	37.82	27.13	4.09
16.500	0.29	0.21	3.57	1.19	0.86	3.71	6.14	4.40	3.91	13.78	9.89	4.06	26.82	19.24	4.20	50.03	35.89	4.20
16.667	0.29	0.21	3.57	1.22	0.88	3.72	6.28	4.50	3.91	14.02	10.06	4.06	27.41	19.66	4.21	50.95	36.55	4.21
16.833	0.30	0.21	3.57	1.24	0.89	3.72	6.36	4.57	3.92	14.22	10.20	4.06	27.66	19.84	4.21	51.33	36.82	4.21
17.000	0.30	0.21	3.57	1.25	0.89	3.72	6.39	4.59	3.92	14.27	10.24	4.07	27.83	19.96	4.21	51.60	37.02	4.21
17.167	0.30	0.21	3.57	1.24	0.89	3.72	6.36	4.57	3.92	14.22	10.20	4.06	27.66	19.84	4.21	51.33	36.82	4.21
17.333	0.29	0.21	3.57	1.22	0.88	3.72	6.28	4.50	3.91	14.02	10.06	4.06	27.41	19.66	4.21	50.95	36.55	4.21
17.500	-	0.00	3.47	0.64	0.46	3.61	3.82	2.74	3.81	9.45	6.78	3.96	19.72	14.15	4.10	38.61	27.70	4.10
17.667	-	0.00	3.36	-	0.00	3.51	2.22	1.59	3.70	5.94	4.26	3.85	13.80	9.90	3.99	28.98	20.79	3.99
17.833	-	0.00	3.26	-	0.00	3.40	1.22	0.88	3.59	3.51	2.52	3.74	9.00	6.46	3.88	20.96	15.04	3.88
18.000	-	0.00	3.15	-	0.00	3.29	-	0.00	3.48	1.98	1.42	3.63	5.50	3.94	3.77	-	0.00	3.77
18.167	-	0.00	2.94	-	0.00	3.08	-	0.00	3.27	-	0.00	3.41	-	0.00	3.55	-	0.00	3.55
18.333	-	0.00	2.73	-	0.00	2.87	-	0.00	3.06	-	0.00	3.20	-	0.00	3.33	-	0.00	3.33
18.500	-	0.00	2.62	-	0.00	2.76	-	0.00	2.94	-	0.00	3.08	-	0.00	3.21	-	0.00	3.21
18.667	-	0.00	2.41	-	0.00	2.54	-	0.00	2.72	-	0.00	2.86	-	0.00	2.99	-	0.00	2.99
18.833	-	0.00	2.20	-	0.00	2.33	-	0.00	2.50	-	0.00	2.63	-	0.00	2.76	-	0.00	2.76
19.000	-	0.00	1.98	-	0.00	2.11	-	0.00	2.28	-	0.00	2.41	-	0.00	2.54	-	0.00	2.54
19.167	-	0.00	1.77	-	0.00	1.89	-	0.00	2.06	-	0.00	2.18	-	0.00	2.31	-	0.00	2.31
19.333	-	0.00	1.55	-	0.00	1.67	-	0.00	1.83	-	0.00	1.95	-	0.00	2.08	-	0.00	2.08
19.500	-	0.00	1.23	-	0.00	1.35	-	0.00	1.51	-	0.00	1.62	-	0.00	1.74	-	0.00	1.74
19.667	-	0.00	1.01	-	0.00	1.13	-	0.00	1.28	-	0.00	1.39	-	0.00	1.51	-	0.00	1.51
19.833	-	0.00	0.79	-	0.00	0.90	-	0.00	1.05	-	0.00	1.16	-	0.00	1.27	-	0.00	1.27
20.000	-	0.00	0.57	-	0.00	0.68	-	0.00	0.82	-	0.00	0.92	-	0.00	1.03	-	0.00	1.03
20.167	-	0.00	0.25	-	0.00	0.35	-	0.00	0.49	-	0.00	0.59	-	0.00	0.69	-	0.00	0.69
20.333	-	0.00	0.03	-	0.00	0.13	-	0.00	0.25	-	0.00	0.35	-	0.00	0.44	-	0.00	0.44
20.500	-	0.00	-0.29	-	0.00	-0.20	-	0.00	-0.08	-	0.00	0.01	-	0.00	0.10	-	0.00	0.10
20.667	-	0.00	-0.52	-	0.00	-0.43	-	0.00	-0.32	-	0.00	-0.23	-	0.00	-0.15	-	0.00	-0.15
20.833	-	0.00	-0.74	-	0.00	-0.66	-	0.00	-0.56	-	0.00	-0.48	-	0.00	-0.40	-	0.00	-0.40
21.000	-	0.00	-1.07	-	0.00	-0.99	-	0.00	-0.89	-	0.00	-0.82	-	0.00	-0.75	-	0.00	-0.75
21.167	-	0.00	-1.29	-	0.00	-1.22	-	0.00	-1.13	-	0.00	-1.06	-	0.00	-1.00	-	0.00	-1.00
21.333	-	0.00	-1.52	-	0.00	-1.46	-	0.00	-1.37	-	0.00	-1.31	-	0.00	-1.25	-	0.00	-1.25
21.500	-	0.00	-1.75	-	0.00	-1.69	-	0.00	-1.61	-	0.00	-1.56	-	0.00	-1.50	-	0.00	-1.50
21.667	-	0.00	-1.97	-	0.00	-1.92	-	0.00	-1.86	-	0.00	-1.80	-	0.00	-1.75	-	0.00	-1.75
21.833	-	0.00	-2.20	-	0.00	-2.16	-	0.00	-2.10	-	0.00	-2.05	-	0.00	-2.01	-	0.00	-2.01
22.000	-	0.00	-2.43	-	0.00	-2.39	-	0.00	-2.34	-	0.00	-2.30	-	0.00	-2.26	-	0.00	-2.26
22.167	-	0.00	-2.46	-	0.00	-2.43	-	0.00	-2.38	-	0.00	-2.35	-	0.00	-2.32	-	0.00	-2.32
22.333	-	0.00	-2.49	-	0.00	-2.46	-	0.00	-2.43	-	0.00	-2.40	-	0.00	-2.38	-	0.00	-2.38
22.500	-	0.00	-2.32	-	0.00	-2.30	-	0.00	-2.27	-	0.00	-2.25	-	0.00	-2.23	-	0.00	-2.23
22.667	-	0.00	-2.15	-	0.00	-2.13	-	0.00	-2.12	-	0.00	-2.10	-	0.00	-2.09	-	0.00	-2.09
22.833	-	0.00	-1.98	-	0.00	-1.97	-	0.00	-1.96	-	0.00	-1.95	-	0.00	-1.95	-	0.00	-1.95
23.000	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81

Mid Range Runs

	50% Mid Range			20% Mid Range			10% Mid Range			5% Mid Range			2% Mid Range			1% Mid Range			0.5% Mid Range			0.1% Mid Range		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	r Level (m	q (l/m/s)	q (m^3/s)	r Level (m
11.000	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61
11.167	-	0.00	-2.57	-	0.00	-2.56	-	0.00	-2.55	-	0.00	-2.55	-	0.00	-2.54	-	0.00	-2.53	-	0.00	-2.53	-	0.00	-2.53
11.333	-	0.00	-2.53	-	0.00	-2.52	-	0.00	-2.50	-	0.00	-2.49	-	0.00	-2.47	-	0.00	-2.46	-	0.00	-2.45	-	0.00	-2.45
11.500	-	0.00	-2.30	-	0.00	-2.27	-	0.00	-2.25	-	0.00	-2.23	-	0.00	-2.21	-	0.00	-2.19	-	0.00	-2.17	-	0.00	-2.17
11.667	-	0.00	-2.06	-	0.00	-2.03	-	0.00	-2.00	-	0.00	-1.97	-	0.00	-1.94	-	0.00	-1.91	-	0.00	-1.89	-	0.00	-1.89
11.833	-	0.00	-1.83	-	0.00	-1.78	-	0.00	-1.75	-	0.00	-1.72	-	0.00	-1.68	-	0.00	-1.64	-	0.00	-1.61	-	0.00	-1.61
12.000	-	0.00	-1.59	-	0.00	-1.54	-	0.00	-1.50	-	0.00	-1.46	-	0.00	-1.41	-	0.00	-1.37	-	0.00	-1.33	-	0.00	-1.33
12.167	-	0.00	-1.36	-	0.00	-1.30	-	0.00	-1.25	-	0.00	-1.21	-	0.00	-1.15	-	0.00	-1.10	-	0.00	-1.06	-	0.00	-1.06
12.333	-	0.00	-1.12	-	0.00	-1.05	-	0.00	-1.00	-	0.00	-0.95	-	0.00	-0.88	-	0.00	-0.83	-	0.00	-0.78	-	0.00	-0.78
12.500	-	0.00	-0.79	-	0.00	-0.71	-	0.00	-0.65	-	0.00	-0.60	-	0.00	-0.52	-	0.00	-0.47	-	0.00	-0.41	-	0.00	-0.41
12.667	-	0.00	-0.56	-	0.00	-0.47	-	0.00	-0.41	-	0.00	-0.34	-	0.00	-0.26	-	0.00	-0.20	-	0.00	-0.14	-	0.00	-0.14
12.833	-	0.00	-0.32	-	0.00	-0.23	-	0.00	-0.16	-	0.00	-0.09	-	0.00	0.00	-	0.00	0.07	-	0.00	0.13	-	0.00	0.13
13.000	-	0.00	0.01	-	0.00	0.11	-	0.00	0.18	-	0.00	0.26	-	0.00	0.36	-	0.00	0.43	-	0.00	0.50	-	0.00	0.50
13.167	-	0.00	0.24	-	0.00	0.35	-	0.00	0.43	-	0.00	0.51	-	0.00	0.61	-	0.00	0.69	-	0.00	0.77	-	0.00	0.77
13.333	-	0.00	0.47	-	0.00	0.58	-	0.00	0.67	-	0.00	0.76	-	0.00	0.87	-	0.00	0.95	-	0.00	1.04	-	0.00	1.04
13.500	-	0.00	0.70	-	0.00	0.82	-	0.00	0.91	-	0.00	1.00	-	0.00	1.12	-	0.00	1.21	-	0.00	1.30	-	0.00	1.30
13.667	-	0.00	0.93	-	0.00	1.06	-	0.00	1.15	-	0.00	1.25	-	0.00	1.37	-	0.00	1.47	-	0.00	1.56	-	0.00	1.56
13.833	-	0.00	1.15	-	0.00	1.29	-	0.00	1.39	-	0.00	1.49	-	0.00	1.62	-	0.00	1.72	-	0.00	1.82	-	0.00	1.82
14.000	-	0.00	1.38	-	0.00	1.52	-	0.00	1.63	-	0.00	1.73	-	0.00	1.87	-	0.00	1.98	-	0.00	2.08	-	0.00	2.08
14.167	-	0.00	1.61	-	0.00	1.75	-	0.00	1.86	-	0.00	1.97	-	0.00	2.12	-	0.00	2.23	-	0.00	2.34	-	0.00	2.34
14.333	-	0.00	1.73	-	0.00	1.88	-	0.00	2.00	-	0.00	2.11	-	0.00	2.26	-	0.00	2.38	-	0.00	2.49	-	0.00	2.49
14.500	-	0.00	1.95	-	0.00	2.11	-	0.00	2.23	-	0.00	2.35	-	0.00	2.50	-	0.00	2.62	-	0.00	2.74	-	0.00	2.74
14.667	-	0.00	2.17	-	0.00	2.34	-	0.00	2.46	-	0.00	2.58	-	0.00	2.74	-	0.00	2.86	-	0.00	2.99	-	0.00	2.99
14.833	-	0.00	2.29	-	0.00	2.46	-	0.00	2.59	-	0.00	2.71	-	0.00	2.88	-	0.00	3.00	-	0.00	3.13	-	0.00	3.13
15.000	-	0.00	2.51	-	0.00	2.69	-	0.00	2.81	-	0.00	2.94	-	0.00	3.11	-	0.00	3.24	-	0.00	3.37	-	0.00	3.37
15.167	-	0.00	2.73	-	0.00	2.91	-	0.00	3.04	-	0.00	3.17	-	0.00	3.35	-	0.00	3.48	-	0.00	3.61	-	0.00	3.61
15.333	-	0.00	2.85	-	0.00	3.03	-	0.00	3.16	-	0.00	3.30	-	0.00	3.48	-	0.00	3.61	8.16	5.85	3.74	-	0.00	3.74
15.500	-	0.00	3.06	-	0.00	3.24	-	0.00	3.38	-	0.00	3.52	3.25	2.33	3.70	9.15	6.56	3.84	19.27	13.82	3.98	40.49	29.05	3.98
15.667	-	0.00	3.17	-	0.00	3.36	-	0.00	3.50	1.24	0.89	3.64	5.93	4.25	3.83	14.84	10.65	3.97	28.14	20.19	4.10	55.06	39.50	4.10
15.833	-	0.00	3.28	-	0.00	3.48	0.85	0.61	3.62	2.44	1.75	3.76	9.98	7.16	3.95	21.99	15.78	4.09	39.74	28.51	4.23	73.31	52.59	4.23
16.000	-	0.00	3.39	0.43	0.31	3.59	1.69	1.21	3.73	4.46	3.20	3.88	15.42	11.06	4.07	31.31	22.46	4.21	55.81	40.04	4.35	96.56	69.27	4.35
16.167	0.10	0.07	3.50	0.90	0.65	3.70	3.13	2.25	3.84	7.57	5.43	3.99	22.41	16.08	4.18	44.01	31.57	4.33	77.23	55.40	4.47	-	0.00	4.47
16.333	0.20	0.15	3.61	1.77	1.27	3.81	5.42	3.89	3.95	11.89	8.53	4.10	31.93	22.91	4.29	61.43	44.07	4.44	-	0.00	4.59	-	0.00	4.59
16.500	0.44	0.32	3.72	3.20	2.29	3.91	8.79	6.30	4.06	17.44	12.51	4.21	45.28	32.48	4.40	84.12	60.35	4.55	-	0.00	4.70	-	0.00	4.70
16.667	0.45	0.33	3.72	3.28	2.35	3.92	8.97	6.44	4.07	17.87	12.82	4.22	46.30	33.21	4.41	85.99	61.69	4.56	-	0.00	4.71	-	0.00	4.71
16.833	0.46	0.33	3.72	3.33	2.39	3.92	9.12	6.54	4.07	18.05	12.95	4.22	46.89	33.64	4.42	87.18	62.54	4.56	-	0.00	4.71	-	0.00	4.71
17.000	0.47	0.33	3.72	3.35	2.40	3.92	9.16	6.57	4.07	18.18	13.04	4.22	47.19	33.85	4.42	-	0.00	4.57	-	0.00	4.71	-	0.00	4.71
17.167	0.46	0.33	3.72	3.33	2.39	3.92	9.12	6.54	4.07	18.05	12.95	4.22	46.89	33.64	4.42	87.18	62.54	4.56	-	0.00	4.71	-	0.00	4.71
17.333	0.45	0.33	3.72	3.28	2.35	3.92	8.97	6.44	4.07	17.87	12.82	4.22	46.30	33.21	4.41	85.99	61.69	4.56	-	0.00	4.71	-	0.00	4.71
17.500	0.21	0.15	3.62	1.84	1.32	3.81	5.63	4.04	3.96	12.25	8.79	4.11	32.95	23.64	4.30	63.41	45.49	4.45	-	0.00	4.60	-	0.00	4.60
17.667	0.10	0.07	3.51	0.96	0.69	3.71	3.30	2.37	3.85	7.98	5.72	4.00	23.34	16.74	4.19	45.86	32.90	4.34	80.39	57.67	4.49	-	0.00	4.49
17.833	-	0.00	3.40	0.46	0.33	3.60	1.81	1.30	3.74	4.78	3.43	3.89	16.27	11.67	4.08	32.89	23.59	4.23	58.83	42.20	4.37	100.70	72.24	4.37
18.000	-	0.00	3.29	-	0.00	3.49	0.93	0.67	3.63	2.66	1.91	3.78	10.75	7.71	3.97	23.40	16.79	4.11	42.35	30.38	4.25	77.24	55.41	4.25
18.167	-	0.00	3.08	-	0.00	3.28	-	0.00	3.42	0.76	0.54	3.56	4.07	2.92	3.75	11.18	8.02	3.89	22.71	16.29	4.03	46.13	33.09	4.03
18.333	-	0.00	2.87	-	0.00	3.06	-	0.00	3.20	-	0.00	3.34	-	0.00	3.53	4.19	3.01	3.67	10.48	7.52	3.80	-	0.00	3.80
18.500	-	0.00	2.76	-	0.00	2.94	-	0.00	3.08	-	0.00	3.22	-	0.00	3.40	-	0.00	3.54	-	0.00	3.68	-	0.00	3.68
18.667	-	0.00	2.55	-	0.00	2.73	-	0.00	2.86	-	0.00	3.00	-	0.00	3.18	-	0.00	3.31	-	0.00	3.44	-	0.00	3.44
18.833	-	0.00	2.33	-	0.00	2.51	-	0.00	2.64	-	0.00	2.77	-	0.00	2.95	-	0.00	3.08	-	0.00	3.21	-	0.00	3.21
19.000	-	0.00	2.11	-	0.00	2.29	-	0.00	2.41	-	0.00	2.54	-	0.00	2.71	-	0.00	2.84	-	0.00	2.97	-	0.00	2.97
19.167	-	0.00	1.89	-	0.00	2.06	-	0.00	2.19	-	0.00	2.31	-	0.00	2.48	-	0.00	2.60	-	0.00	2.73	-	0.00	2.73
19.333	-	0.00	1.67	-	0.00	1.84	-	0.00	1.96	-	0.00	2.08	-	0.00	2.24	-	0.00	2.36	-	0.00	2.49	-	0.00	2.49
19.500	-	0.00	1.35	-	0.00	1.51	-	0.00	1.63	-	0.00	1.75	-	0.00	1.90	-	0.00	2.02	-	0.00	2.14	-	0.00	2.14
19.667	-	0.00	1.13	-	0.00	1.28	-	0.00	1.40	-	0.00	1.51	-	0.00	1.66	-	0.00	1.78	-	0.00	1.89	-	0.00	1.89
19.833	-	0.00	0.91	-	0.00	1.05	-	0.00	1.16	-	0.00	1.27	-	0.00	1.42	-	0.00	1.53	-	0.00	1.64	-	0.00	1.64
20.000	-	0.00	0.68	-	0.00	0.82	-	0.00	0.93	-	0.00	1.03	-	0.00	1.17	-	0.00	1.28	-	0.00	1.38	-	0.00	1.38
20.167	-	0.00	0.35	-	0.00	0.49	-	0.00	0.59	-	0.00	0.69	-	0.00	0.82	-	0.00	0.92	-	0.00	1.02	-	0.00	1.02
20.333	-	0.00	0.13	-	0.00	0.26	-	0.00	0.35	-	0.00	0.45	-	0.00	0.57	-	0.00	0.67	-	0.00	0.76	-	0.00	0.76
20.500	-	0.00	-0.20	-	0.00	-0.08	-	0.00	0.01	-	0.00	0.10	-	0.00	0.22	-	0.00	0.31	-	0.00	0.40	-	0.00	0.40
20.667	-	0.00	-0.43	-	0.00	-0.32	-	0.00	-0.23	-	0.00	-0.14	-	0.00	-0.03	-	0.00	0.05	-	0.00	0.14	-	0.00	0.14
20.833	-	0.00	-0.66	-	0.00	-0.55	-	0.00	-0.47	-	0.00	-0.39	-	0.00	-0.29	-	0.00	-0.21	-	0.00	-0.13	-	0.00	-0.13
21.000	-	0.00	-0.99	-	0.00	-0.89	-	0.00	-0.82	-	0.00	-0.74	-	0.00	-0.64	-	0.00	-0.57	-	0.00	-0.50	-	0.00	-0.50
21.167	-	0.00	-1.22	-	0.00	-1.13	-	0.00	-1.06	-	0.00	-0.99	-	0.00	-0.90	-	0.00	-0.83	-	0.00	-0.77	-	0.00	-0.77
21.333	-	0.00	-1.46	-	0.00	-1.37	-	0.00	-1.31	-	0.00	-1.24	-	0.00	-1.16	-	0.00	-1.10	-	0.00	-1.04	-	0.00	-1.04
21.500	-	0.00	-1.69	-	0.00	-1.61	-	0.00	-1.55	-	0.00	-1.50	-	0.00	-1.42	-	0.00	-1.37	-	0.00	-1.31	-	0.00	-1.31
21.667	-	0.00	-1.92	-	0.00	-1.85	-	0.00	-1.80	-	0.00	-1.75	-	0.00	-1.68	-	0.00	-1.63	-	0.00	-1.58	-	0.00	-1.58
21.833	-	0.00	-2.16	-	0.00	-2.10	-	0.00	-2.05	-	0.00	-2.01	-	0.00	-1.95	-	0.00	-1.90	-	0.00	-1.86	-	0.00	-1.86
22.000	-	0.00	-2.39	-	0.00	-2.34	-	0.00	-2.30	-	0.00	-2.26	-	0.00	-2.21	-	0.00	-2.17	-	0.00	-2.13	-	0.00	-2.13
22.167	-	0.00	-2.43	-	0.00	-2.38	-	0.00	-2.35	-	0.00	-2.32	-	0.00	-2.28	-	0.00	-2.24	-	0.00	-2.21	-	0.00	-2.21
22.333	-	0.00	-2.46	-	0.00	-2.43	-	0.00	-2.40	-	0.00	-2.37	-	0.00	-2.34	-	0.00	-2.31	-	0.00	-2.29	-	0.00	-2.29
22.500	-	0.00	-2.30	-	0.00	-2.27	-	0.00	-2.25	-	0.00	-2.23	-	0.00	-2.21	-	0.00	-2.19	-	0.00	-2.17	-	0.00	-2.17
22.667	-	0.00	-2.13	-	0.00	-2.12	-	0.00	-2.10	-	0.00	-2.09	-	0.00	-2.07	-	0.00	-2.06	-	0.00	-2.05	-	0.00	-2.05
22.833	-	0.00	-1.97	-	0.00	-1.96	-	0.00	-1.95	-	0.00	-1.95	-	0.00	-1.94	-	0.00	-1.93	-	0.00	-1.93	-	0.00	-1.93
23.000	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81

High End Runs

	10% High End			0.5% High End			0.1% High End		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
11.000	-	0.00	-2.61	-	0.00	-2.61	-	0.00	-2.61
11.167	-	0.00	-2.53	-	0.00	-2.50	-	0.00	-2.50
11.333	-	0.00	-2.46	-	0.00	-2.40	-	0.00	-2.40
11.500	-	0.00	-2.19	-	0.00	-2.10	-	0.00	-2.10
11.667	-	0.00	-1.91	-	0.00	-1.80	-	0.00	-1.80
11.833	-	0.00	-1.64	-	0.00	-1.50	-	0.00	-1.50
12.000	-	0.00	-1.37	-	0.00	-1.20	-	0.00	-1.20
12.167	-	0.00	-1.10	-	0.00	-0.91	-	0.00	-0.91
12.333	-	0.00	-0.83	-	0.00	-0.61	-	0.00	-0.61
12.500	-	0.00	-0.46	-	0.00	-0.22	-	0.00	-0.22
12.667	-	0.00	-0.20	-	0.00	0.08	-	0.00	0.08
12.833	-	0.00	0.07	-	0.00	0.37	-	0.00	0.37
13.000	-	0.00	0.43	-	0.00	0.75	-	0.00	0.75
13.167	-	0.00	0.70	-	0.00	1.04	-	0.00	1.04
13.333	-	0.00	0.96	-	0.00	1.33	-	0.00	1.33
13.500	-	0.00	1.22	-	0.00	1.61	-	0.00	1.61
13.667	-	0.00	1.47	-	0.00	1.89	-	0.00	1.89
13.833	-	0.00	1.73	-	0.00	2.16	-	0.00	2.16
14.000	-	0.00	1.98	-	0.00	2.43	-	0.00	2.43
14.167	-	0.00	2.23	-	0.00	2.70	-	0.00	2.70
14.333	-	0.00	2.38	-	0.00	2.87	-	0.00	2.87
14.500	-	0.00	2.63	-	0.00	3.13	-	0.00	3.13
14.667	-	0.00	2.87	-	0.00	3.39	-	0.00	3.39
14.833	-	0.00	3.01	-	0.00	3.55	-	0.00	3.55
15.000	-	0.00	3.25	14.29	10.25	3.80	-	0.00	3.80
15.167	-	0.00	3.48	30.90	22.17	4.05	65.62	47.07	4.05
15.333	1.03	0.74	3.61	44.88	32.20	4.20	88.64	63.59	4.20
15.500	3.76	2.70	3.84	82.75	59.36	4.44	-	0.00	4.44
15.667	6.94	4.98	3.97	-	0.00	4.57	-	0.00	4.57
15.833	11.51	8.26	4.09	-	0.00	4.71	-	0.00	4.71
16.000	17.66	12.67	4.21	-	0.00	4.83	-	0.00	4.83
16.167	26.35	18.90	4.33	-	0.00	4.96	-	0.00	4.96
16.333	39.17	28.10	4.45	-	0.00	5.08	-	0.00	5.08
16.500	57.25	41.07	4.56	-	0.00	5.19	-	0.00	5.19
16.667	58.80	42.18	4.57	-	0.00	5.21	-	0.00	5.21
16.833	59.79	42.89	4.57	-	0.00	5.21	-	0.00	5.21
17.000	60.18	43.17	4.57	-	0.00	5.21	-	0.00	5.21
17.167	59.79	42.89	4.57	-	0.00	5.21	-	0.00	5.21
17.333	58.80	42.18	4.57	-	0.00	5.21	-	0.00	5.21
17.500	40.70	29.20	4.46	-	0.00	5.09	-	0.00	5.09
17.667	27.65	19.84	4.35	-	0.00	4.98	-	0.00	4.98
17.833	18.71	13.42	4.23	-	0.00	4.86	-	0.00	4.86
18.000	12.44	8.92	4.11	-	0.00	4.73	-	0.00	4.73
18.167	4.84	3.47	3.89	98.07	70.35	4.51	-	0.00	4.51
18.333	1.44	1.03	3.67	54.75	39.28	4.27	103.90	74.54	4.27
18.500	-	0.00	3.54	38.57	27.67	4.14	78.48	56.30	4.14
18.667	-	0.00	3.31	19.67	14.11	3.90	-	0.00	3.90
18.833	-	0.00	3.08	-	0.00	3.65	-	0.00	3.65
19.000	-	0.00	2.85	-	0.00	3.40	-	0.00	3.40
19.167	-	0.00	2.61	-	0.00	3.15	-	0.00	3.15
19.333	-	0.00	2.37	-	0.00	2.89	-	0.00	2.89
19.500	-	0.00	2.03	-	0.00	2.53	-	0.00	2.53
19.667	-	0.00	1.78	-	0.00	2.27	-	0.00	2.27
19.833	-	0.00	1.53	-	0.00	2.00	-	0.00	2.00
20.000	-	0.00	1.28	-	0.00	1.73	-	0.00	1.73
20.167	-	0.00	0.93	-	0.00	1.36	-	0.00	1.36
20.333	-	0.00	0.67	-	0.00	1.09	-	0.00	1.09
20.500	-	0.00	0.32	-	0.00	0.71	-	0.00	0.71
20.667	-	0.00	0.06	-	0.00	0.43	-	0.00	0.43
20.833	-	0.00	-0.20	-	0.00	0.14	-	0.00	0.14
21.000	-	0.00	-0.57	-	0.00	-0.25	-	0.00	-0.25
21.167	-	0.00	-0.83	-	0.00	-0.53	-	0.00	-0.53
21.333	-	0.00	-1.10	-	0.00	-0.82	-	0.00	-0.82
21.500	-	0.00	-1.36	-	0.00	-1.12	-	0.00	-1.12
21.667	-	0.00	-1.63	-	0.00	-1.41	-	0.00	-1.41
21.833	-	0.00	-1.90	-	0.00	-1.71	-	0.00	-1.71
22.000	-	0.00	-2.17	-	0.00	-2.00	-	0.00	-2.00
22.167	-	0.00	-2.24	-	0.00	-2.10	-	0.00	-2.10
22.333	-	0.00	-2.31	-	0.00	-2.20	-	0.00	-2.20
22.500	-	0.00	-2.19	-	0.00	-2.10	-	0.00	-2.10
22.667	-	0.00	-2.06	-	0.00	-2.00	-	0.00	-2.00
22.833	-	0.00	-1.93	-	0.00	-1.90	-	0.00	-1.90
23.000	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.81

Coastal Hydraulic Modelling Report

1. Basic Model Information

1.1 General Information	
Model ID:	IRR3
Unit of Management	27
AFAs included in the model	Shannon Airport
Primary Watercourses / Water Bodies	Not applicable – No watercourses in this model
1.2 Reference to other Relevant Reports	
Catchment Description	Hydrology Report Unit of Management 27 – Appendix A
Model Location	Hydraulics Report Unit of Management 27 – Section 3.4.2
HEP Schematisation	N/A

2. Survey Data and Base Mapping

2.1 Base Mapping:	OSi data base mapping at scale 1:50k Reference: OS1216_D and OS1214_D
2.2 DTM for 2D Model domains:	**Within AFAs:** LIDAR data with 2m horizontal resolution and approximately 200mm vertical accuracy has been used to inform the hydraulic model with ground elevation in the floodplain areas included in the AFA boundary.
	Outside AFAs: IFSAR data with 5m horizontal resolution and approximately 500mm-1000mm vertical accuracy has been used to inform the hydraulic model with ground elevation in the floodplain areas outside the AFA boundary. **Note:** In general, there is overlap between the AFA area and area outside the AFA with regard to the availability of LIDAR data. Therefore, some areas outside the AFA are covered by LIDAR to the same resolution as that for the AFA.
2.3 Defence Asset Survey Data	The defence asset database has been completed for this model area and is provided as a separate deliverable to this report. Formal flood defences have been surveyed and included into the model. They consist of 27AIRB00227 and 27AIRP00191C stretching from east to west along the coastline. The approximate total length of the formal coastal defences in IRR3 is 5.56km. The maximum crest levels for the formal flood defences are 5.970mAD and 8.620mAD for 27AIRB00227 and 27AIRP00191C respectively. The average elevation as measured across the full length of the formal defences is 4.99mAD. All defences have been included in the model schematisation as shown on the maps presented in Annex A.
2.4 Survey Interaction	The Lidar, IFSAR and topographic survey were checked for anomalies, and to ensure that interactions between were within expected tolerances. No issues were identified in this model.

3. Hydraulic Model Construction and Schematisation		
3.1 Software:	**1D Domain:** N/A	
	2D Domain(s): TUFLOW Version: 2013-12-AA-iSP-w64	
3.2 Model area / extent:	The extent of the model and its schematisation are shown in Annex A.	

The mapping details for the model extent included in Annex A are as follows:

1. **Full modelled area showing**:
   - IRR extent
   - 2D domain area
2. **Maps showing a detailed model schematic of the floodplain are also included**

3.3 Floodplain schematisation	The floodplain area within and outside the AFA boundary has been modelled using a 2D approach as set in the TUFLOW model. An overview of the floodplain schematisation is available in the maps shown in Annex A.		
3.4 2D domain grid size:	A single 2D domain was defined and the grid size of the 2D model domain is as follows:		
	Number of 2D domains: 1		
	Domain 1: Shannon	Grid cell size (m): 4	Area (km^2): 7.818
	2D domains are defined depending on the level of detail required to pick up the appropriate features in the 2D domain that will impact on the local hydraulics. The domain grid square size is typically in the range 5m to 20m, with the smaller grid sizes used in very urbanised areas where there are multiple features that could not be suitably represented in, say, a 10m grid. The model grid is orientated in the main direction of the floodplain flow.		
3.5 Model breaklines in the 2D domain:	Coastal flood defence embankments, embanked roads and drains are represented as breaklines in the 2D domain.		
3.6 Floodplain structures in the 2D domain	1D elements have been included in the 2D model to represent culverts across several open drains to allow hydraulic connectivity throughout the drainage network. Since the above structures were not surveyed, their dimensions were estimated based on site knowledge and site visit photographs. Information gathered during the defence asset survey confirmed that one outfall is flapped and one is pumped. The pumped outfall has been represented as a flapped outfall as there will be no return flow. Tidal flaps were assumed at the drain outfalls into the Shannon estuary.		
3.7 Hydraulic Roughness	Hydraulic roughness (Manning's 'n') has been defined in accordance with the approaches described in the main report. A summary of Manning's 'n' for the model as a whole is as follows:		
Floodplain (TUFLOW model)	Manning's 'n' for floodplain areas represented in the TUFLOW model are as defined by OSi NTF land use characteristics, as described in the main report. Floodplain land uses and adopted roughness values in TUFLOW are as follows:		
	Land use	**Manning's 'n' value**	
	General Rural	0.045	
	General Urban	0.060	
	Dense Vegetation	0.080	

	Short grass, parks, sports grounds	0.035
	Water bodies	0.020
	Flat Rock	0.025
	Roads	0.025
	Buildings	0.100
3.8 Spill Units	Spill units are used for a number of different purposes (e.g. irregular weir, lateral spilling in the floodplain). Spill profile geometry is defined using topographic survey data and LiDAR/IfSAR. Spill coefficients used generally vary between 0.9 and 1.5 depending on the type of ground conditions (e.g. rough vegetated, smooth concrete) over which flood flows are spilling. Lower coefficients (<1.0) can be also found to account for lateral spilling perpendicular to the main direction of flow.	
3.9 Model Boundaries - Inflows	Tidal level hydrographs for Shannon Airport were produced for a series of design events using the Irish Coastal Protection Strategy Study (ICPSS) extreme tidal peak levels data. The time series were set up as boundary conditions for the hydraulic model along the coastal boundary of the hydraulic model (see maps in Annex A). Full details on how these tidal level hydrographs were derived are provided in Appendix D of the main Hydraulics Report. Peak tidal levels are summarised in the table below for the current and future situations. For the wave overtopping model, wave overtopping hydrographs have been applied directly to the hydraulic model using a flow versus time boundary along the landward side of the flood defences. The hydrographs vary for different points along the defence as shown in Annex F. Full details on how these tidal level hydrographs were derived are provided in section 4.4 of the main Hydraulics Report. The tidal hydrographs applied for wave overtopping are available in Annex F of this report.	

	Annual Exceedance Probability							
	50%	**20%**	**10%**	**5%**	**2%**	**1%**	**0.5%**	**0.1%**
Peak tidal levels (m AD)	3.22	3.42	3.57	3.72	3.92	4.07	4.21	4.56
	MRFS Annual Exceedance Probability							
	50%	**20%**	**10%**	**5%**	**2%**	**1%**	**0.5%**	**0.1%**
Peak tidal levels (m AD)	3.77	3.97	4.12	4.27	4.47	4.62	4.76	5.11
	HEFS Annual Exceedance Probability							
	50%	**20%**	**10%**	**5%**	**2%**	**1%**	**0.5%**	**0.1%**
Peak tidal levels (m AD)	4.27	4.47	4.62	4.77	4.97	5.12	5.26	5.61

4. Hydraulic Model Calibration and Sensitivity

4.1 Model Calibration and Verification to historical events	The approach to model calibration is documented in the Main Hydraulics Report for UoM 27. Model calibration and verification was not possible due to lack of information available.
4.2 Model Sensitivity	Sensitivity tests have been carried out in order to assess the sensitivity of the predicted peak water levels to alterations in roughness (Manning's 'n'), and tidal levels. In each case the sensitivity run was carried out for the 0.5% AEP tidal event. Sensitivity test results are provided in the section below:
4.2.1 Hydraulic Roughness	Model outputs show that increasing or decreasing the roughness has a marginal effect on the predicted flood extents. However, predicted flood depths are affected and when compared to the baseline situation they can vary from approximately 0 to +/-200mm. The table below provides examples of flood depth variations at several key locations across the model domain.

Location				Max Flood Depth (m)		
Description		Grid reference		Existing	+20%	-20%
		X	**Y**			
1	Open field, 400m north of Shannon Aerospace.	137699	162767	1.182	1.181	1.163
2	Open field, 500m northwest of Shannon Aerospace.	137340	162479	2.479	2.474	2.470
3	Shannon Aerospace runway entrance.	138022	162255	0.565	0.527	0.599
4	Shannon Airport Car park 450m southwest of Main terminal.	137381	160235	0.680	0.525	0.872
5	Waterbody at 900m south east of Shannon Golf Club inside the coastline.	137350	159581	1.963	1.809	2.154
6	Open Field 400m south east of Shannon Golf Club.	136960	159999	1.248	1.094	1.439

4.2.2 Downstream Conditions	Model outputs show that increasing or decreasing the duration of the surge component of the tidal boundary has a marginal effect on the predicted flood extents and flood depths. When compared to the baseline situation, maximum flood depths predicted by the model vary from approximately 0 to +/-137mm although in most areas are within a much smaller range. The table below provides examples of flood depth variation at several key locations across the model domain.

Location				Max Flood Depth (m)		
Description		Grid Reference		Existing	Doubled	Halved
		X	**Y**			
1	Open field, 400m north of Shannon Aerospace.	137699	162767	1.179	1.183	1.175
2	Open field, 500m northwest of Shannon Aerospace.	137340	162479	2.485	2.489	2.478
3	Shannon Aerospace runway entrance.	138022	162255	0.554	0.559	0.548
4	Shannon Airport Car park 450m southwest of Main terminal.	137381	160235	0.686	0.810	0.638

5	Waterbody at 900m south east of Shannon Golf Club inside the coastline.	137350	159581	1.242	1.379	1.206
6	Open Field 400m south east of Shannon Golf Club.	136960	159999	1.974	2.099	1.927

4.3 Model Files	The hydraulic model files associated with this model are provided as a separate deliverable under the contract, as required under Sections 7.8 and 13 of the Stage I Project Brief. The model files included are detailed in Annex D.

5. Hydraulic Model Outputs

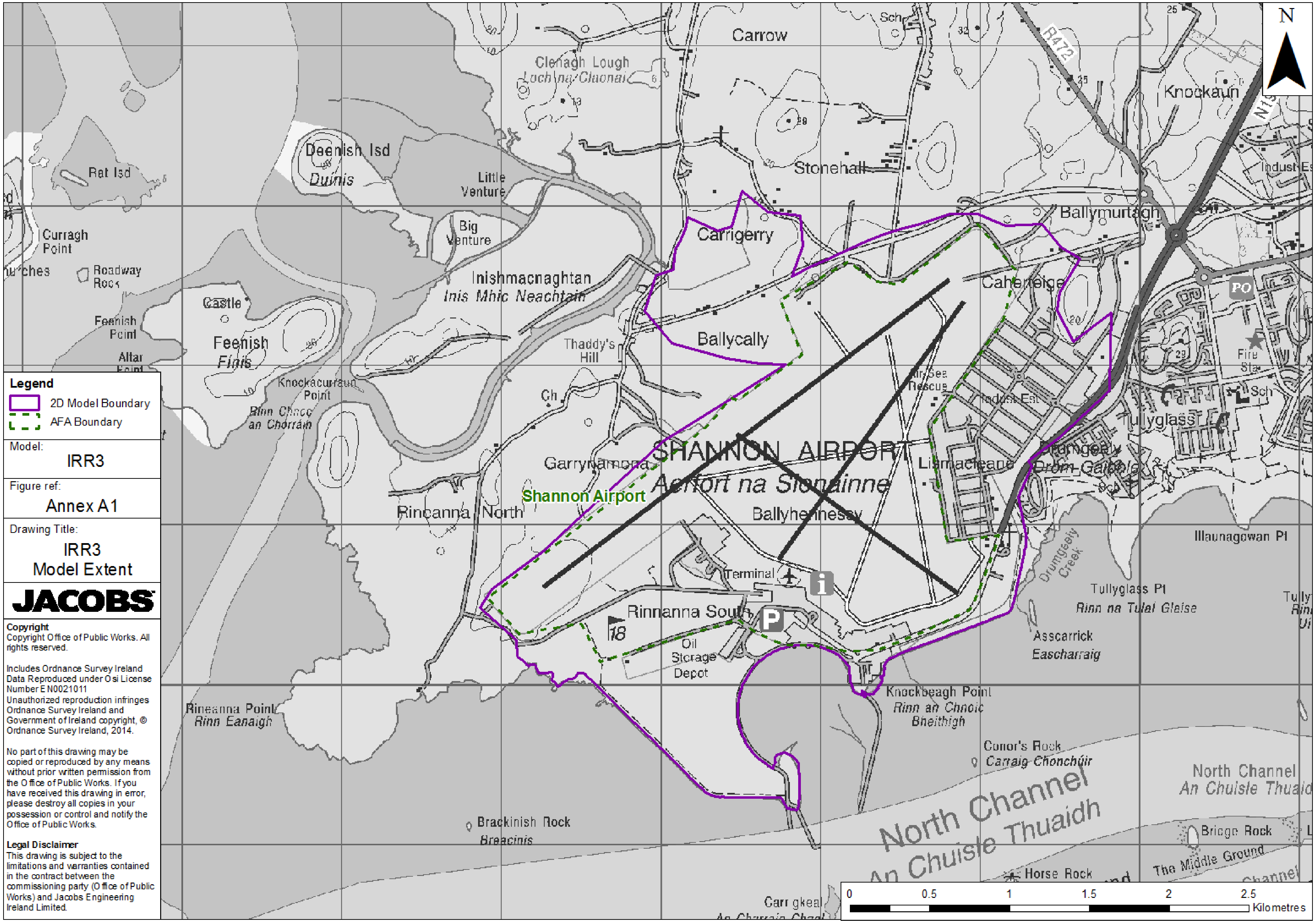
5.1 Mapping	Model outputs were processed to produce a series of flood maps according to the requirements stated in the Stage I Project Brief under Section 7.5.2. This includes mapping outputs covering: • Flood extents • Flood depth Mapping outputs corresponding to the **defended**, **current** scenario for the 10%, 0.5% and 0.1% AEP flood events are shown in Annex E for flood extent and depth only.

6. Key model assumption and limitations

- Due to lack of survey information, drain channels and drainage culverts were represented coarsely (breaklines and 1D elements) in the hydraulic model. This was deemed acceptable as these features do not have a significant impact on the flood mechanisms and resulting flood extents.
- No LiDAR data was available at the north limit of the 2D domain near the tidal reach of Carrigerry Creek. Instead SAR data was used to inform the 2D model ground elevations. Model grid manipulations were required to reconcile ground levels at the interface of the two datasets. It should be noted that in the area where SAR data was used in the 2D model there is a higher uncertainty on the predicted flood extents due to the lower vertical accuracy of the SAR data.

Annex A – Model Extent and Schematisation Maps

Annex A1 – Model Extent



Legend

- 2D Model Boundary
- AFA Boundary

Model:

IRR3

Figure ref:

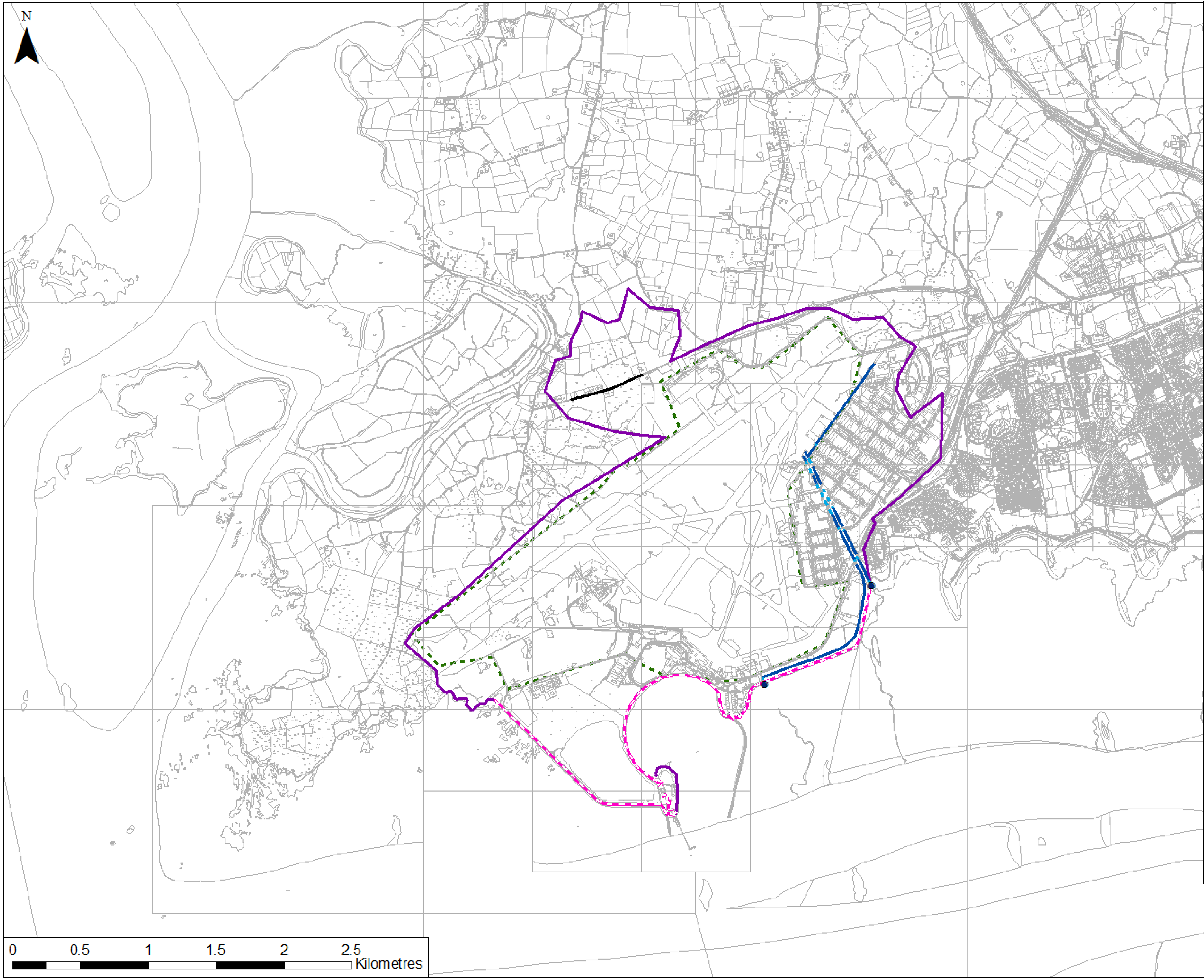
Annex A1

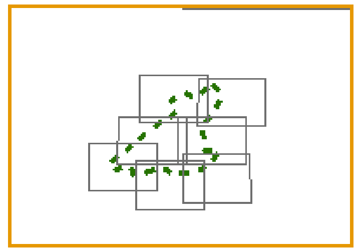
Drawing Title:

IRR3
Model Extent

JACOBS

Annex A2 – Schematisation Maps





Legend

- AFA Boundary
- 2D Model Boundary

2D Floodplain Schematisation

- Formal Defences
- Drainage Channels
- Drain Culverts
- Drain Outfalls
- Road Breakline

Notes:
The 2D model boundary represents the floodplain. The 1D elements represent drainage into and out of the floodplain

Model: IRR3

Figure ref: Annex A2 (1)

Drawing Title: IRR3 Model Schematisation

Client:
The Office of Public Works,
Head Office,
Jonathan Swift Street,
Trim, Co. Meath
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JACOBS
Merrion House, Merrion Road, Dublin
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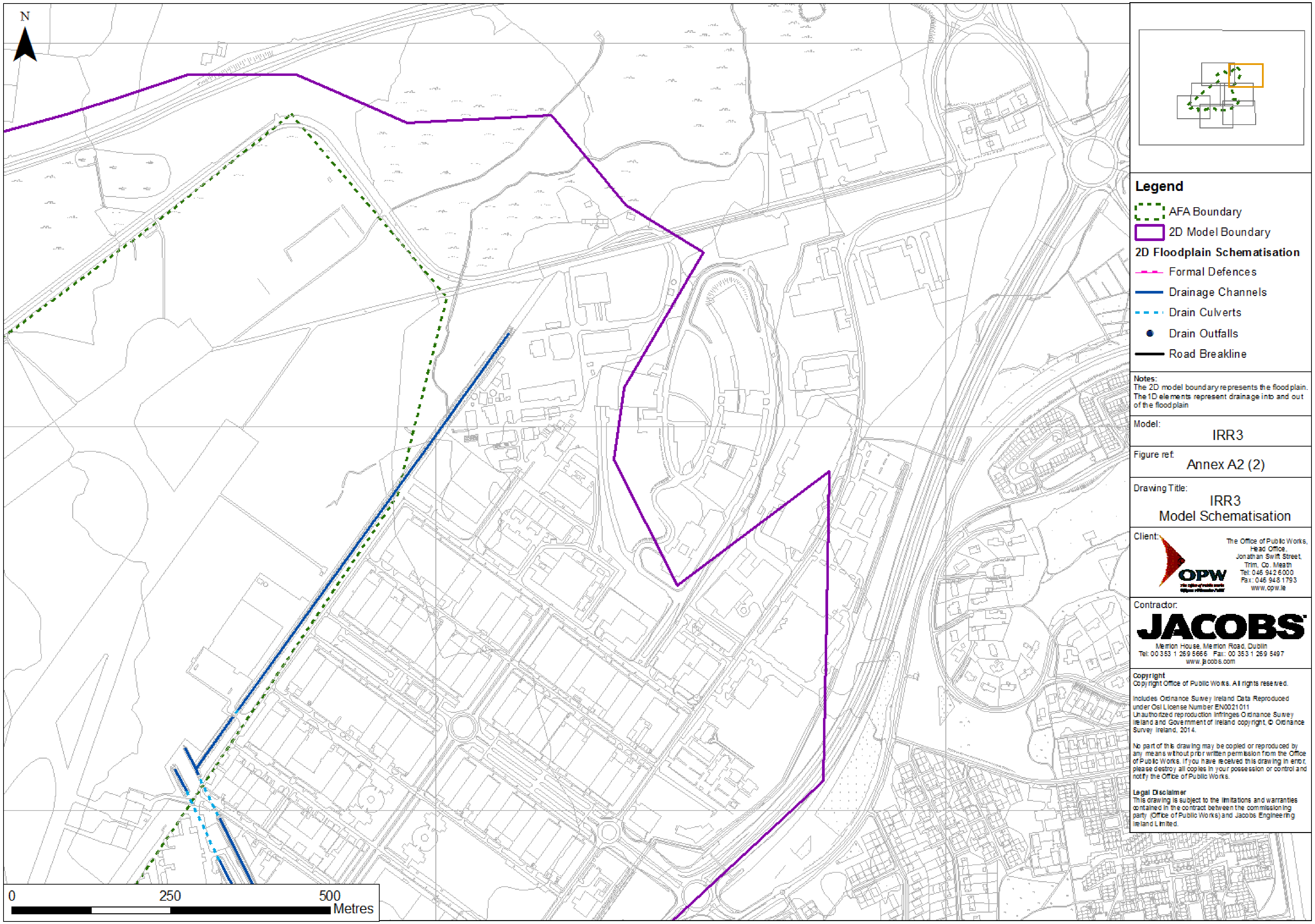
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Legend
AFA Boundary
2D Model Boundary
2D Floodplain Schematisation
Formal Defences
Drainage Channels
Drain Culverts
Drain Outfalls
Road Breakline
Notes:
The 2D model boundary represents the floodplain. The 1D elements represent drainage into and out of the floodplain
Model:
IRR3
Figure ref.
Annex A2 (2)
Drawing Title:
IRR3
Model Schematisation
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Tel: 046 942 6000
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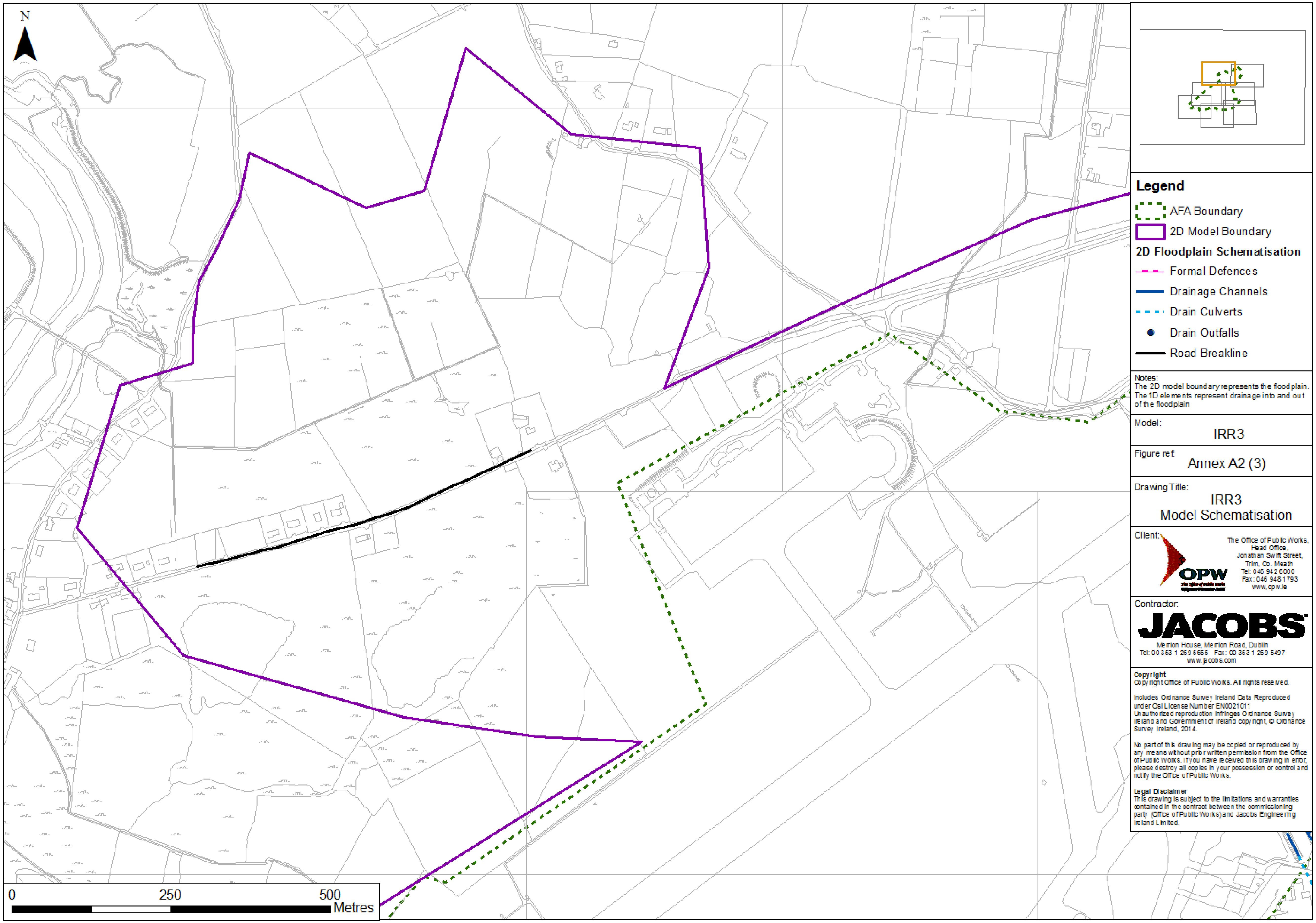
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AFA Boundary
2D Model Boundary
2D Floodplain Schematisation
Formal Defences
Drainage Channels
Drain Culverts
Drain Outfalls
Road Breakline
Notes:
The 2D model boundary represents the floodplain. The 1D elements represent drainage into and out of the floodplain
Model:
IRR3
Figure ref:
Annex A2 (3)
Drawing Title:
IRR3
Model Schematisation
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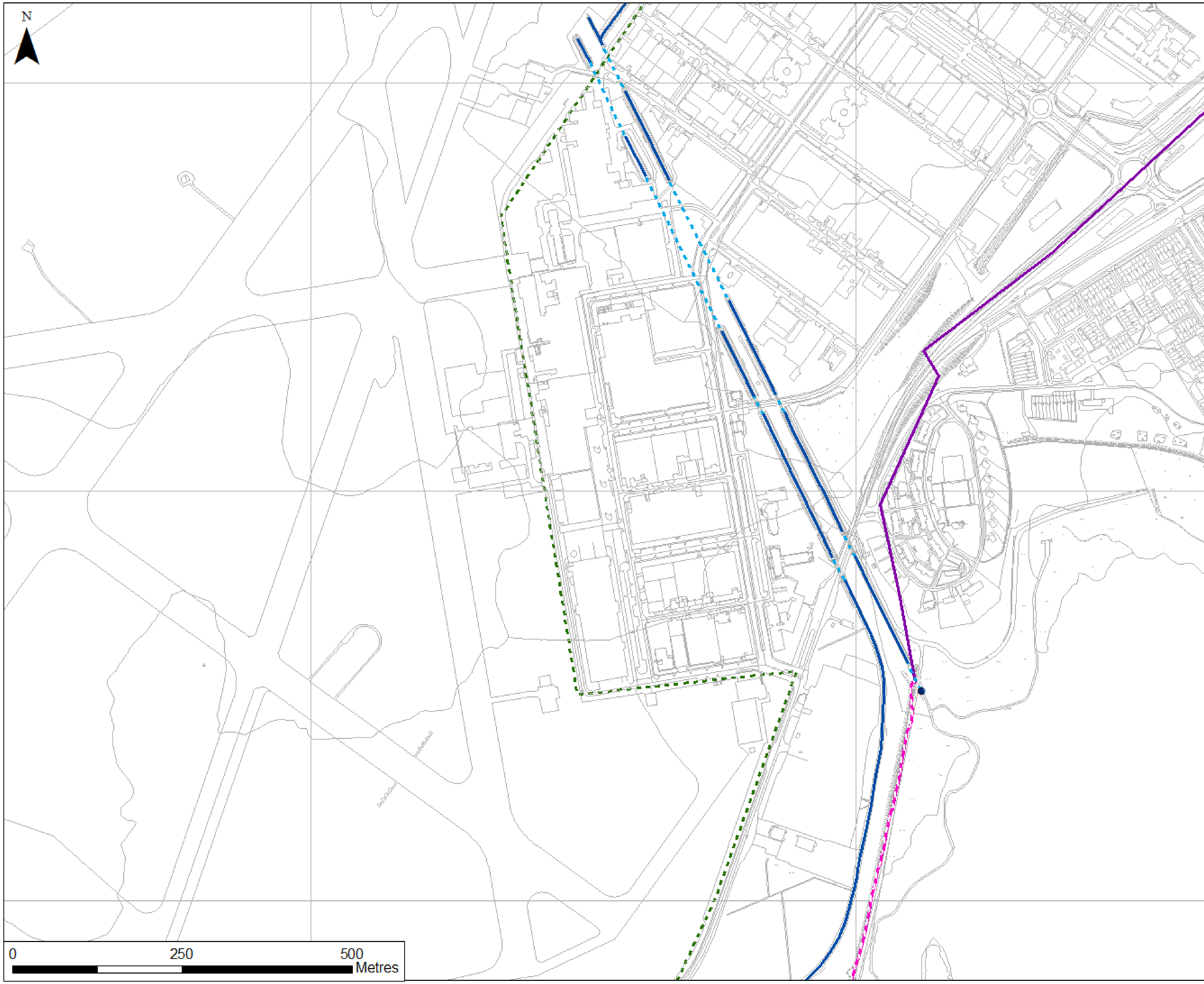

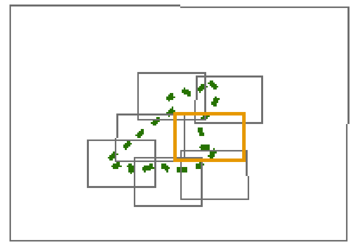

Legend

- AFA Boundary
- 2D Model Boundary

2D Floodplain Schematisation

- Formal Defences
- Drainage Channels
- Drain Culverts
- Drain Outfalls
- Road Breakline

Notes:
The 2D model boundary represents the floodplain. The 1D elements represent drainage into and out of the floodplain

Model: IRR3

Figure ref: Annex A2 (4)

Drawing Title: IRR3 Model Schematisation

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AFA Boundary
2D Model Boundary
2D Floodplain Schematisation
Formal Defences
Drainage Channels
Drain Culverts
Drain Outfalls
Road Breakline
Notes:
The 2D model boundary represents the floodplain. The 1D elements represent drainage into and out of the floodplain
Model:
IRR3
Figure ref.
Annex A2 (5)
Drawing Title:
IRR3
Model Schematisation
Client:
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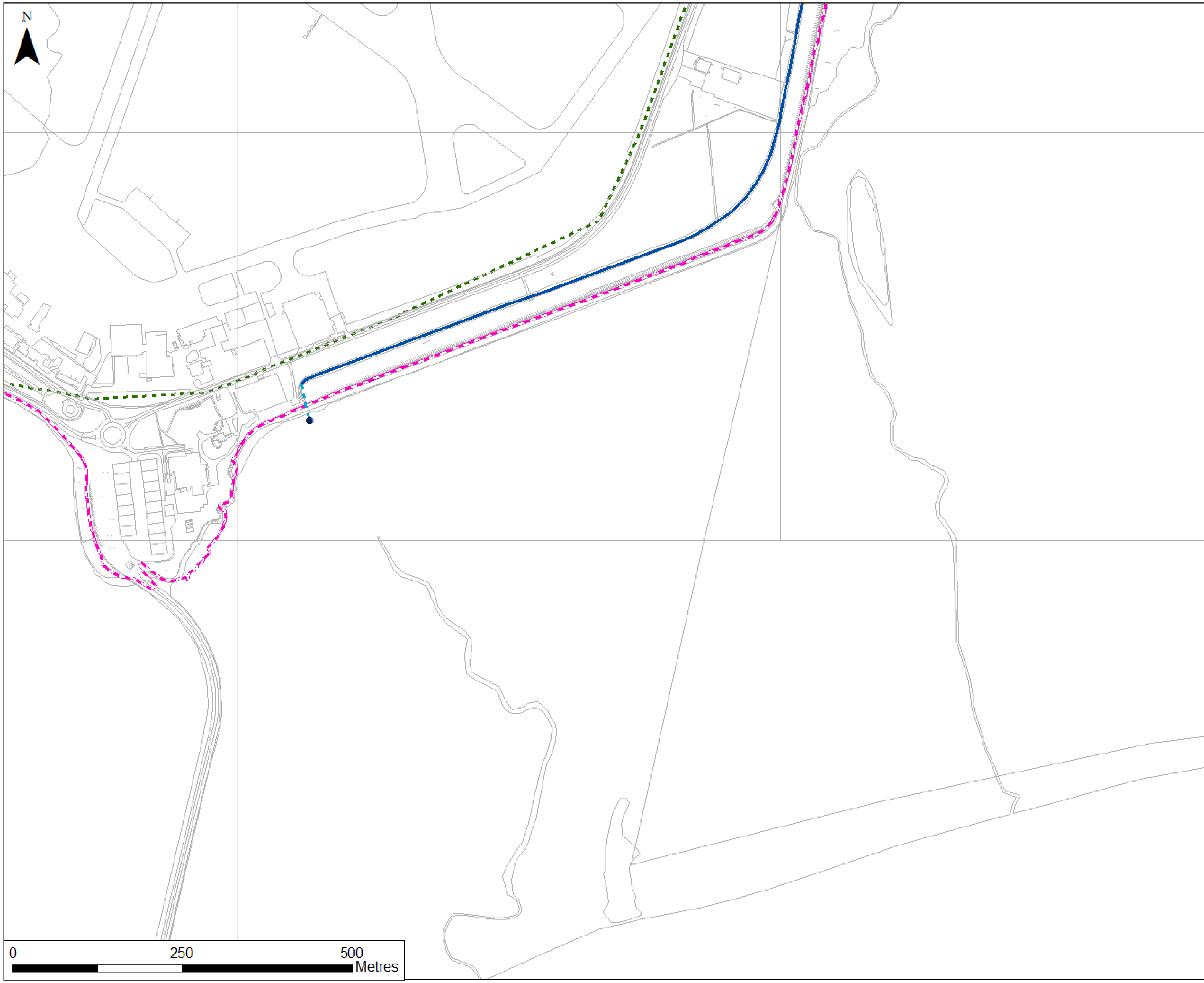

Legend

- AFA Boundary
- 2D Model Boundary

2D Floodplain Schematisation

- Formal Defences
- Drainage Channels
- Drain Culverts
- Drain Outfalls
- Road Breakline

Notes:
The 2D model boundary represents the flood plain. The 1D elements represent drainage into and out of the flood plain

Model: IRR3

Figure ref: Annex A2 (6)

Drawing Title: IRR3 Model Schematisation

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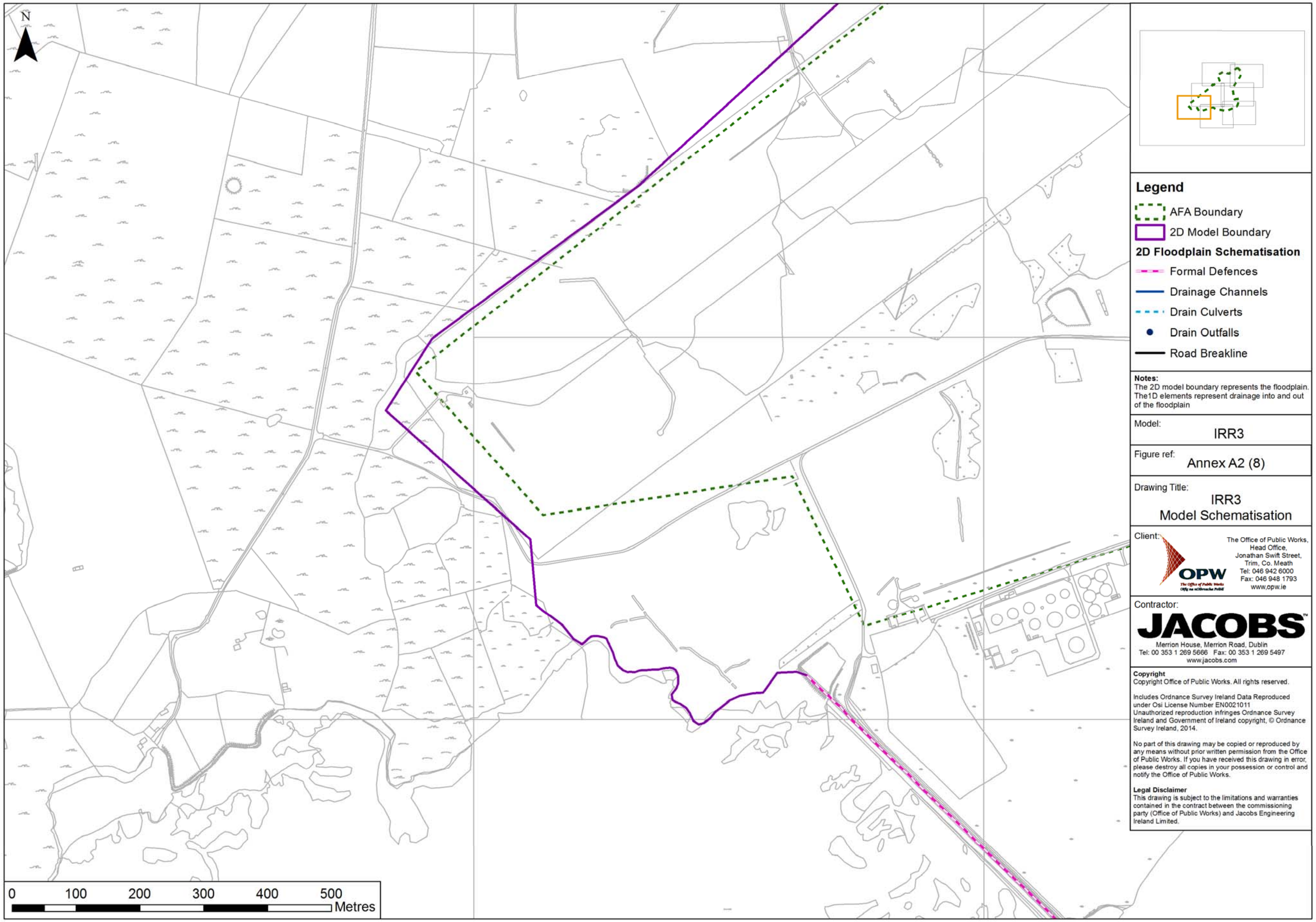

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Legend
AFA Boundary
2D Model Boundary
2D Floodplain Schematisation
Formal Defences
Drainage Channels
Drain Culverts
Drain Outfalls
Road Breakline
Notes:
The 2D model boundary represents the floodplain. The1D elements represent drainage into and out of the floodplain
Model:
IRR3
Figure ref:
Annex A2 (8)
Drawing Title:
IRR3
Model Schematisation
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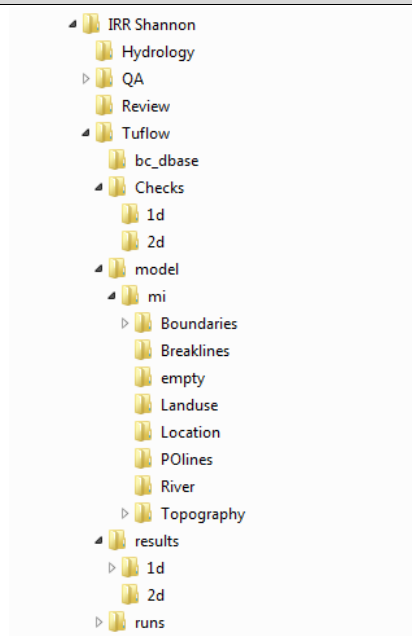
Annex C – Calibration

Not Used.

Annex D - Hydraulic Model files

Model files folders structure	
TUFLOW	

TUFLOW files	
TUFLOW Control Files (.tcf) and associated files (e.g.: ecf, tgc, tbc)	**Design runs – Current scenario:** IRR3_Q2_Co_C_Des_Iss1.tcf IRR3_Q5_Co_C_Des_Iss1.tcf IRR3_Q10_Co_C_Des_Iss1.tcf IRR3_Q20_Co_C_Des_Iss1.tcf IRR3_Q50_Co_C_Des_Iss1.tcf IRR3_Q100_Co_C_Des_Iss1.tcf IRR3_Q200_Co_C_Des_Iss1.tcf IRR3_Q1000_Co_C_Des_Iss1.tcf **Sensitivity runs – Current scenario** IRR3_Q200_Co_C_Sen_RoIn.tcf IRR3_Q200_Co_C_Sen_RoDe.tcf IRR3_ShanA.tgc IRR3_ShanA.tbc
Grid Orientation file	2d_loc_ShanA.MIF
Material files	**Design runs – Current scenario:** IRR3_ShanA_Landuse.tmf **Sensitivity runs – Current scenario** IRR3_ShanA_Landuse_RoIn.tmf

	IRR3_ShanA_Landuse_RoDe.tmf 2d_mat_rural_ShanA.MIF 2d_mat_ind_ShanA.MIF 2d_mat_vegetation_ShanA.MIF 2d_mat_water_ShanA.MIF 2d_mat_roads_ShanA.MIF 2d_mat_buildings_ShanA.MIF 2d_mat_flatrock_ShanA.MIF
Zpt files, model DTM (.asc)	limera2m_dtm_trim.asc S04_sar_trim.asc 2d_zsh_topopatch_ShanA.MIF
Breaklines files	2d_zln_defence_ShanA_v1.MIF 2d_zln_road_ShanA.MIF 2d_zln_gully_ShanA.MIF
Boundary files	2d_bc_HT_ShanA.MIF 2d_bc_hxe_ShanA.MIF 2d_bc_SX_Culverts_ShanA.MIF 1d_bc_gully_ShanA.MIF
1D elements files	1d_nwk_gully_ShanA.MIF
Files in bc_dbase	bc_dbase_50AEP_ShanA.csv bc_dbase_20AEP_ShanA.csv bc_dbase_10AEP_ShanA.csv bc_dbase_5AEP_ShanA.csv bc_dbase_2AEP_ShanA.csv bc_dbase_1AEP_ShanA.csv bc_dbase_0.1AEP_ShanA.csv
Initial Water Level files	NA
Time Series Files	HT_ShanA.csv
Available 2D result files	Depth, stage, hazard and velocity 2D results in ASCII file format for all available design return periods.

Model Run Log

Sr. No.	Model File Name	Start Time	End Time	Time step	Advanced Options /Other information	Comments on model stability
Design Runs – Current scenario						
1	IRR3_Q2_Co_C_des_Iss1.tcf	4	34	0.25 sec 1D 1 sec 2D		Convergence within manufacturer tolerance.
2	IRR3_Q5_Co_C_Des_Iss1.tcf	4	34	0.25 sec 1D 1 sec 2D		Convergence within manufacturer tolerance.
3	IRR3_Q10_Co_C_Des_Iss1.tcf	4	34	0.25 sec 1D 1 sec 2D		Convergence within manufacturer tolerance.
4	IRR3_Q20_Co_C_Des_Iss1.tcf	4	34	0.25 sec 1D 1 sec 2D		Convergence within manufacturer tolerance.
5	IRR3_Q50_Co_C_Des_Iss1.tcf	4	34	0.25 sec 1D 1 sec 2D		Convergence within manufacturer tolerance.
6	IRR3_Q100_Co_C_Des_Iss1.tcf	4	34	0.25 sec 1D 1 sec 2D		Convergence within manufacturer tolerance.
7	IRR3_Q200_Co_C_Des_Iss1.tcf	4	34	0.25 sec 1D 1 sec 2D		Convergence within manufacturer tolerance.
8	IRR3_Q1000_Co_C_Des_Iss1.tcf	4	34	0.25 sec 1D 1 sec 2D		Convergence within manufacturer tolerance.
Sensitivity Analysis						
9	IRR3_Q200_Co_C_Sen_RoIn.tcf	4	34	0.25 sec 1D 1 sec 2D	The roughness is increased by 20% in the model	Convergence within manufacturer tolerance.
10	IRR3_Q200_Co_C_Sen_RoDe.tcf	4	34	0.25 sec 1D 1 sec 2D	The roughness is decreased by 20% in the model	Convergence within manufacturer tolerance.

Annex E - Flood Mapping

Flood Maps are available through the OPW flood mapping website; http://maps.opw.ie/fhrm/

Annex F – Wave Overtopping

ICWWS CAPO Shannon
Prediction Locations

Location A
CURRENT

	AEP															
	50%		20%		10%		5.00%		0.10%		10%		0.50%		0.10%	
Time	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60
13.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60
13.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60	0.00	3.20
14.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60	0.00	1.60	0.00	4.80
14.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60	0.00	1.60	0.00	1.60	0.00	6.40
14.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60	0.00	1.60	0.00	3.20	0.01	9.59
14.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60	0.00	1.60	0.00	3.20	0.00	4.80	0.01	14.39
14.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60	0.00	3.20	0.00	4.80	0.00	6.40	0.01	17.59
15	0.00	0.00	0.00	0.00	0.00	1.60	0.00	1.60	0.00	4.80	0.00	6.40	0.01	11.19	0.02	25.58
15.167	0.00	0.00	0.00	1.60	0.00	1.60	0.00	3.20	0.01	8.00	0.01	11.19	0.01	15.99	0.02	38.38
15.333	0.00	0.00	0.00	1.60	0.00	3.20	0.00	4.80	0.01	9.59	0.01	14.39	0.01	22.39	0.03	47.97
15.5	0.00	0.00	0.00	1.60	0.00	4.80	0.00	6.40	0.01	14.39	0.01	22.39	0.02	33.58	0.04	70.36
15.667	0.00	1.60	0.00	3.20	0.00	4.80	0.01	8.00	0.01	19.19	0.02	27.18	0.03	43.17	0.05	86.35
15.833	0.00	1.60	0.00	3.20	0.00	6.40	0.01	11.19	0.02	23.99	0.02	35.18	0.03	54.37	0.07	105.53
16	0.00	1.60	0.00	4.80	0.01	9.59	0.01	14.39	0.02	30.38	0.03	44.77	0.04	68.76	0.08	131.12
16.167	0.00	1.60	0.00	6.40	0.01	11.19	0.01	17.59	0.02	38.38	0.04	55.97	0.05	86.35	0.10	158.30
16.333	0.00	3.20	0.01	8.00	0.01	14.39	0.01	22.39	0.03	47.97	0.04	70.36	0.07	108.73	0.12	190.28
16.5	0.00	3.20	0.01	11.19	0.01	19.19	0.02	28.78	0.04	60.76	0.06	89.54	0.08	134.32	0.14	230.26
16.667	0.00	3.20	0.01	11.19	0.01	19.19	0.02	28.78	0.04	60.76	0.06	89.54	0.09	137.51	0.15	235.05
16.833	0.00	3.20	0.01	11.19	0.01	19.19	0.02	28.78	0.04	62.36	0.06	89.54	0.09	137.51	0.15	235.05
17	0.00	3.20	0.01	11.19	0.01	19.19	0.02	28.78	0.04	62.36	0.06	91.14	0.09	137.51	0.15	235.05
17.167	0.00	3.20	0.01	11.19	0.01	19.19	0.02	28.78	0.04	62.36	0.06	89.54	0.09	137.51	0.15	235.05
17.333	0.00	3.20	0.01	11.19	0.01	19.19	0.02	28.78	0.04	60.76	0.06	89.54	0.09	137.51	0.15	235.05
17.5	0.00	3.20	0.01	8.00	0.01	14.39	0.01	22.39	0.03	49.57	0.05	71.96	0.07	110.33	0.12	193.48
17.667	0.00	1.60	0.00	6.40	0.01	11.19	0.01	17.59	0.02	38.38	0.04	57.56	0.06	87.95	0.10	159.90
17.833	0.00	1.60	0.00	4.80	0.01	9.59	0.01	14.39	0.02	30.38	0.03	46.37	0.04	70.36	0.08	132.72
18	0.00	1.60	0.00	3.20	0.01	8.00	0.01	11.19	0.02	23.99	0.02	36.78	0.04	55.97	0.07	110.33
18.167	0.00	0.00	0.00	1.60	0.00	4.80	0.00	6.40	0.01	15.99	0.01	22.39	0.02	36.78	0.05	75.15
18.333	0.00	0.00	0.00	1.60	0.00	3.20	0.00	4.80	0.01	9.59	0.01	14.39	0.02	23.99	0.03	51.17
18.5	0.00	0.00	0.00	1.60	0.00	1.60	0.00	3.20	0.01	8.00	0.01	11.19	0.01	19.19	0.03	41.57
18.667	0.00	0.00	0.00	0.00	0.00	1.60	0.00	1.60	0.00	4.80	0.01	8.00	0.01	11.19	0.02	28.78
18.833	0.00	0.00	0.00	0.00	0.00	1.60	0.00	1.60	0.00	3.20	0.00	4.80	0.01	8.00	0.01	19.19
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60	0.00	3.20	0.00	4.80	0.01	12.79
19.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60	0.00	1.60	0.00	3.20	0.01	8.00
19.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60	0.00	1.60	0.00	6.40
19.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60	0.00	3.20
19.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60
19.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60
20.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Mid Range Future Scenario

	AEP															
	50%		20%		10%		5.00%		0.10%		10%		0.50%		0.10%	
Time	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
11.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
11.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
12.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

High End Future Scenario

	AEP					
	10%		0.50%		0.10%	
Time	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22.167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22.333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22.667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22.833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Location B1

CURRENT

	AEP															
	50%		20%		10%		5.00%		0.10%		10%		0.50%		0.10%	
Time	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.23
15.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.01	3.09
15.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.23	0.01	5.55
15.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00	1.23	0.01	6.79	0.03	17.28
15.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.23	0.01	3.70	0.02	14.81	0.05	32.08
15.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.47	0.01	8.64	0.05	32.70	0.10	58.62
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.01	6.17	0.03	19.74	0.12	72.81	0.17	107.36
16.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.23	0.02	14.81	0.07	45.04	0.25	152.40	0.30	186.95
16.333	0.00	0.00	0.00	0.00	0.00	0.62	0.01	3.70	0.06	34.55	0.17	104.27	0.52	318.99	0.53	325.16
16.5	0.00	0.00	0.00	0.00	0.00	1.85	0.02	9.26	0.13	80.83	0.39	240.01	1.08	668.21	0.92	566.41
16.667	0.00	0.00	0.00	0.00	0.00	1.85	0.02	9.26	0.13	80.83	0.42	258.52	1.08	668.21	0.92	566.41
16.833	0.00	0.00	0.00	0.00	0.00	1.85	0.02	10.49	0.13	80.83	0.42	258.52	1.16	714.49	0.97	595.41
17	0.00	0.00	0.00	0.00	0.00	1.85	0.02	10.49	0.13	80.83	0.42	258.52	1.16	714.49	0.97	595.41
17.167	0.00	0.00	0.00	0.00	0.00	1.85	0.02	10.49	0.13	80.83	0.42	258.52	1.16	714.49	0.97	595.41
17.333	0.00	0.00	0.00	0.00	0.00	1.85	0.02	9.26	0.13	80.83	0.42	258.52	1.08	668.21	0.92	566.41
17.5	0.00	0.00	0.00	0.00	0.00	0.62	0.01	3.70	0.06	37.02	0.18	112.29	0.55	341.20	0.55	341.82
17.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.23	0.03	16.04	0.08	48.74	0.26	162.89	0.32	196.82
17.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.01	6.79	0.03	20.98	0.13	77.74	0.18	112.91
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	3.09	0.02	9.26	0.06	37.02	0.11	64.79
18.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00	1.85	0.01	8.64	0.04	21.60
18.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00	1.85	0.01	6.79
18.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.01	3.70
18.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.23
18.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Mid Range Future Scenario

	AEP															
	50%		20%		10%		5.00%		0.10%		10%		0.50%		0.10%	
Time	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
14.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.13
14.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.26
14.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.07	0.00	0.79
14.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.11	0.00	0.34	0.00	2.41
14.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.08	0.00	0.28	0.00	0.86	0.01	4.70
15	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.04	0.00	0.40	0.00	1.32	0.01	3.78	0.02	13.66
15.167	0.00	0.00	0.00	0.01	0.00	0.06	0.00	0.26	0.00	1.94	0.01	5.82	0.03	15.58	0.06	37.98
15.333	0.00	0.00	0.00	0.02	0.00	0.16	0.00	0.66	0.01	4.69	0.02	14.37	0.06	36.90	0.11	70.76
15.5	0.00	0.01	0.00	0.14	0.00	0.96	0.01	3.94	0.04	22.46	0.10	59.46	0.25	152.08	0.32	196.70
15.667	0.00	0.02	0.00	0.43	0.00	2.58	0.02	9.99	0.08	50.84	0.22	137.61	0.55	338.59	0.57	350.57
15.833	0.00	0.07	0.00	1.17	0.01	6.38	0.04	25.31	0.19	115.08	0.48	298.60	1.22	753.86	1.01	624.80
16	0.00	0.22	0.01	3.20	0.03	17.13	0.10	59.35	0.42	260.51	1.12	691.11	2.56	1578.22	1.73	1065.13
16.167	0.00	0.71	0.01	8.80	0.07	42.38	0.24	150.38	0.96	589.71	2.28	1405.86	5.35	3304.01	2.94	1815.77
16.333	0.00	2.28	0.04	24.16	0.17	104.82	0.57	352.63	2.02	1247.06	4.94	3050.51	10.54	6503.93	4.80	2960.86
16.5	0.01	6.61	0.11	66.34	0.42	259.26	1.34	826.89	4.27	2637.17	10.06	6205.35	20.75	12802.98	7.83	4828.06
16.667	0.01	7.35	0.12	72.72	0.42	259.26	1.34	826.89	4.58	2822.97	10.73	6619.15	22.07	13616.03	8.18	5047.51
16.833	0.01	7.35	0.12	72.72	0.46	281.51	1.45	893.50	4.58	2822.97	10.73	6619.15	23.47	14480.71	8.55	5276.95
17	0.01	7.35	0.12	72.72	0.46	281.51	1.45	893.50	4.58	2822.97	10.73	6619.15	23.47	14480.71	8.55	5276.95
17.167	0.01	7.35	0.12	72.72	0.46	281.51	1.45	893.50	4.58	2822.97	10.73	6619.15	23.47	14480.71	8.55	5276.95
17.333	0.01	7.35	0.12	72.72	0.42	259.26	1.34	826.89	4.58	2822.97	10.73	6619.15	22.07	13616.03	8.18	5047.51
17.5	0.00	2.28	0.04	26.49	0.18	113.81	0.62	381.04	2.16	1334.92	5.27	3253.93	11.21	6916.97	5.02	3095.44
17.667	0.00	0.79	0.02	9.65	0.07	46.02	0.26	162.49	1.02	631.26	2.59	1599.61	5.70	3513.83	3.08	1898.31
17.833	0.00	0.24	0.01	3.51	0.03	18.60	0.11	69.30	0.48	298.51	1.19	737.20	2.89	1785.03	1.89	1164.16
18	0.00	0.08	0.00	1.28	0.01	7.52	0.04	27.35	0.21	131.87	0.59	362.40	1.38	852.65	1.11	682.89
18.167	0.00	0.01	0.00	0.19	0.00	1.23	0.01	5.37	0.05	29.49	0.13	82.10	0.36	220.04	0.42	256.83
18.333	0.00	0.00	0.00	0.03	0.00	0.22	0.00	0.98	0.01	6.59	0.03	19.84	0.09	53.39	0.15	92.39
18.5	0.00	0.00	0.00	0.01	0.00	0.08	0.00	0.39	0.00	2.91	0.01	8.57	0.04	23.98	0.08	51.84
18.667	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.06	0.00	0.61	0.00	2.07	0.01	5.82	0.03	18.65
18.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.13	0.00	0.44	0.00	1.33	0.01	6.42
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.10	0.00	0.32	0.00	2.31
19.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.07	0.00	0.79
19.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.26
19.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06
19.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
19.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

High End Future Scenario

	AEP					
	10%		0.50%		0.10%	
Time	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)
11	0.00	0.00	0.00	0.00	0.00	0.00
11.167	0.00	0.00	0.00	0.00	0.00	0.00
11.333	0.00	0.00	0.00	0.00	0.00	0.00
11.5	0.00	0.00	0.00	0.00	0.00	0.00
11.667	0.00	0.00	0.00	0.00	0.00	0.00
11.833	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00
12.167	0.00	0.00	0.00	0.00	0.00	0.00
12.333	0.00	0.00	0.00	0.00	0.00	0.00
12.5	0.00	0.00	0.00	0.00	0.00	0.00
12.667	0.00	0.00	0.00	0.00	0.00	0.00
12.833	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00
13.167	0.00	0.00	0.00	0.00	0.00	0.00
13.333	0.00	0.00	0.00	0.00	0.00	0.00
13.5	0.00	0.00	0.00	0.00	0.00	0.01
13.667	0.00	0.00	0.00	0.00	0.00	0.03
13.833	0.00	0.00	0.00	0.01	0.00	0.11
14	0.00	0.00	0.00	0.03	0.00	0.34
14.167	0.00	0.00	0.00	0.13	0.00	1.05
14.333	0.00	0.00	0.00	0.33	0.00	2.13
14.5	0.00	0.01	0.00	1.43	0.01	6.29
14.667	0.00	0.03	0.01	6.19	0.03	18.56
14.833	0.00	0.10	0.02	15.26	0.06	36.13
15	0.00	0.55	0.10	62.42	0.17	102.31
15.167	0.01	3.33	0.41	255.41	0.47	289.73
15.333	0.01	8.83	0.91	562.21	0.84	518.98
15.5	0.08	49.62	3.52	2174.33	2.28	1409.73
15.667	0.21	131.65	7.76	4786.22	4.09	2525.20
15.833	0.53	324.07	16.14	9958.25	7.03	4338.83
16	1.29	797.73	33.58	20719.21	12.08	7455.04
16.167	3.18	1963.64	69.87	43108.57	20.76	12809.34
16.333	7.27	4484.05	129.87	80131.21	32.82	20250.61
16.5	16.60	10239.48	255.41	157585.37	54.09	33375.85
16.667	17.89	11037.70	270.21	166721.68	56.39	34794.87
16.833	19.28	11898.15	285.88	176387.69	58.79	36274.22
17	19.28	11898.15	285.88	176387.69	58.79	36274.22
17.167	19.28	11898.15	285.88	176387.69	58.79	36274.22
17.333	17.89	11037.70	270.21	166721.68	56.39	34794.87
17.5	7.83	4833.60	145.37	89692.07	35.67	22009.18
17.667	3.43	2116.72	73.92	45607.88	21.64	13353.95
17.833	1.50	926.95	39.77	24535.89	13.69	8446.92
18	0.61	376.57	19.11	11792.65	7.97	4916.11
18.167	0.12	72.22	5.23	3225.96	3.06	1886.76
18.333	0.02	13.85	1.43	882.48	1.17	724.12
18.5	0.01	5.22	0.65	400.90	0.66	404.25
18.667	0.00	0.93	0.17	103.66	0.24	148.82
18.833	0.00	0.17	0.04	26.80	0.09	54.79
19	0.00	0.03	0.01	6.55	0.03	19.35
19.167	0.00	0.00	0.00	1.60	0.01	6.83
19.333	0.00	0.00	0.00	0.37	0.00	2.31
19.5	0.00	0.00	0.00	0.05	0.00	0.52
19.667	0.00	0.00	0.00	0.01	0.00	0.18
19.833	0.00	0.00	0.00	0.00	0.00	0.06
20	0.00	0.00	0.00	0.00	0.00	0.02
20.167	0.00	0.00	0.00	0.00	0.00	0.00
20.333	0.00	0.00	0.00	0.00	0.00	0.00
20.5	0.00	0.00	0.00	0.00	0.00	0.00
20.667	0.00	0.00	0.00	0.00	0.00	0.00
20.833	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00
21.167	0.00	0.00	0.00	0.00	0.00	0.00
21.333	0.00	0.00	0.00	0.00	0.00	0.00
21.5	0.00	0.00	0.00	0.00	0.00	0.00
21.667	0.00	0.00	0.00	0.00	0.00	0.00
21.833	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00
22.167	0.00	0.00	0.00	0.00	0.00	0.00
22.333	0.00	0.00	0.00	0.00	0.00	0.00
22.5	0.00	0.00	0.00	0.00	0.00	0.00
22.667	0.00	0.00	0.00	0.00	0.00	0.00
22.833	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00

Location B2

CURRENT

	AEP															
	50%		20%		10%		5.00%		0.10%		10%		0.50%		0.10%	
Time	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77
15.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77
15.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.30
15.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.01	3.84
15.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.53	0.01	5.37
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.00	2.30	0.01	8.44
16.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.01	3.84	0.02	13.04
16.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.00	1.53	0.01	6.90	0.03	19.94
16.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.53	0.00	3.07	0.02	12.27	0.04	30.68
16.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.53	0.00	3.07	0.02	12.27	0.04	30.68
16.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.53	0.01	3.84	0.02	13.04	0.04	32.21
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.53	0.01	3.84	0.02	13.04	0.04	32.21
17.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.53	0.01	3.84	0.02	13.04	0.04	32.21
17.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.53	0.00	3.07	0.02	12.27	0.04	30.68
17.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.00	1.53	0.01	7.67	0.03	20.71
17.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.01	3.84	0.02	13.81
17.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.00	2.30	0.01	9.20
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.53	0.01	5.37
18.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.00	2.30
18.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77
18.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77
18.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Mid Range Future Scenario

	AEP															
	50%		20%		10%		5.00%		0.10%		10%		0.50%		0.10%	
Time	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
13.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
14.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
14.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.13
14.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.31
14.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.05	0.00	0.71
14.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.04	0.00	0.11	0.00	1.14
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.13	0.00	0.32	0.00	2.56
15.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.14	0.00	0.39	0.00	0.99	0.01	5.75
15.333	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.00	0.27	0.00	0.74	0.00	1.91	0.01	9.22
15.5	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.12	0.00	0.88	0.00	2.28	0.01	5.60	0.03	20.02
15.667	0.00	0.00	0.00	0.01	0.00	0.07	0.00	0.25	0.00	1.63	0.01	4.31	0.01	10.28	0.04	31.05
15.833	0.00	0.00	0.00	0.02	0.00	0.14	0.00	0.51	0.00	3.02	0.01	7.76	0.02	18.01	0.06	46.54
16	0.00	0.00	0.00	0.05	0.00	0.28	0.00	1.02	0.01	5.62	0.02	13.97	0.04	33.06	0.09	72.15
16.167	0.00	0.01	0.00	0.10	0.00	0.59	0.00	1.96	0.01	9.92	0.03	25.15	0.07	55.27	0.14	104.57
16.333	0.00	0.01	0.00	0.21	0.00	1.17	0.00	3.73	0.02	18.45	0.06	43.11	0.13	96.83	0.20	156.75
16.5	0.00	0.03	0.00	0.46	0.00	2.19	0.01	7.13	0.04	32.56	0.10	73.89	0.21	161.90	0.30	227.18
16.667	0.00	0.03	0.00	0.46	0.00	2.33	0.01	7.56	0.04	34.29	0.10	77.60	0.22	169.64	0.31	234.97
16.833	0.00	0.04	0.00	0.50	0.00	2.33	0.01	7.56	0.04	34.29	0.11	81.49	0.23	177.76	0.32	243.03
17	0.00	0.04	0.00	0.50	0.00	2.33	0.01	7.56	0.04	34.29	0.11	81.49	0.23	177.76	0.32	243.03
17.167	0.00	0.04	0.00	0.50	0.00	2.33	0.01	7.56	0.04	34.29	0.11	81.49	0.23	177.76	0.32	243.03
17.333	0.00	0.03	0.00	0.46	0.00	2.33	0.01	7.56	0.04	34.29	0.10	77.60	0.22	169.64	0.31	234.97
17.5	0.00	0.01	0.00	0.23	0.00	1.17	0.01	3.96	0.03	19.42	0.06	45.27	0.13	101.47	0.21	162.13
17.667	0.00	0.01	0.00	0.11	0.00	0.63	0.00	2.07	0.01	11.00	0.03	26.41	0.08	60.69	0.15	111.87
17.833	0.00	0.00	0.00	0.05	0.00	0.32	0.00	1.09	0.01	5.92	0.02	15.41	0.05	34.64	0.10	74.63
18	0.00	0.00	0.00	0.02	0.00	0.15	0.00	0.57	0.00	3.35	0.01	8.56	0.03	20.72	0.07	51.49
18.167	0.00	0.00	0.00	0.01	0.00	0.04	0.00	0.16	0.00	1.08	0.00	2.91	0.01	7.07	0.03	23.70
18.333	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.04	0.00	0.35	0.00	0.99	0.00	2.53	0.01	11.29
18.5	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.19	0.00	0.52	0.00	1.38	0.01	7.28
18.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.06	0.00	0.17	0.00	0.47	0.00	3.35
18.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.06	0.00	0.15	0.00	1.49
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.05	0.00	0.66
19.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.30
19.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.13
19.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
19.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
19.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

High End Future Scenario

	AEP					
	10%		0.50%		0.10%	
Time	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)
11	0.00	0.00	0.00	0.00	0.00	0.00
11.167	0.00	0.00	0.00	0.00	0.00	0.00
11.333	0.00	0.00	0.00	0.00	0.00	0.00
11.5	0.00	0.00	0.00	0.00	0.00	0.00
11.667	0.00	0.00	0.00	0.00	0.00	0.00
11.833	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00
12.167	0.00	0.00	0.00	0.00	0.00	0.00
12.333	0.00	0.00	0.00	0.00	0.00	0.00
12.5	0.00	0.00	0.00	0.00	0.00	0.00
12.667	0.00	0.00	0.00	0.00	0.00	0.00
12.833	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00
13.167	0.00	0.00	0.00	0.00	0.00	0.00
13.333	0.00	0.00	0.00	0.00	0.00	0.01
13.5	0.00	0.00	0.00	0.00	0.00	0.01
13.667	0.00	0.00	0.00	0.00	0.00	0.03
13.833	0.00	0.00	0.00	0.00	0.00	0.08
14	0.00	0.00	0.00	0.01	0.00	0.19
14.167	0.00	0.00	0.00	0.04	0.00	0.45
14.333	0.00	0.00	0.00	0.07	0.00	0.75
14.5	0.00	0.00	0.00	0.22	0.00	1.76
14.667	0.00	0.00	0.00	0.68	0.01	4.00
14.833	0.00	0.01	0.00	1.30	0.01	6.42
15	0.00	0.03	0.01	3.95	0.02	14.60
15.167	0.00	0.13	0.01	11.02	0.04	31.17
15.333	0.00	0.28	0.03	20.92	0.07	50.07
15.5	0.00	1.04	0.08	58.40	0.14	106.88
15.667	0.00	2.05	0.14	106.29	0.22	166.35
15.833	0.01	4.31	0.24	185.33	0.33	250.85
16	0.01	8.54	0.42	323.15	0.49	378.28
16.167	0.02	16.91	0.70	539.88	0.72	552.69
16.333	0.04	31.64	1.18	901.97	1.05	807.52
16.5	0.08	59.21	1.96	1506.90	1.54	1179.85
16.667	0.08	62.68	2.05	1572.75	1.59	1217.72
16.833	0.08	62.68	2.05	1572.75	1.59	1217.72
17	0.08	62.68	2.14	1641.47	1.64	1256.81
17.167	0.08	62.68	2.05	1572.75	1.59	1217.72
17.333	0.08	62.68	2.05	1572.75	1.59	1217.72
17.5	0.04	33.49	1.28	982.52	1.12	860.20
17.667	0.02	17.90	0.77	588.10	0.77	588.75
17.833	0.01	9.57	0.46	352.01	0.53	402.96
18	0.01	4.83	0.27	210.70	0.36	275.80
18.167	0.00	1.38	0.10	78.79	0.17	133.34
18.333	0.00	0.37	0.04	29.46	0.08	64.47
18.5	0.00	0.19	0.02	16.19	0.05	41.42
18.667	0.00	0.05	0.01	5.80	0.03	19.40
18.833	0.00	0.01	0.00	1.99	0.01	8.81
19	0.00	0.00	0.00	0.71	0.01	4.13
19.167	0.00	0.00	0.00	0.23	0.00	1.81
19.333	0.00	0.00	0.00	0.08	0.00	0.82
19.5	0.00	0.00	0.00	0.02	0.00	0.26
19.667	0.00	0.00	0.00	0.01	0.00	0.11
19.833	0.00	0.00	0.00	0.00	0.00	0.05
20	0.00	0.00	0.00	0.00	0.00	0.02
20.167	0.00	0.00	0.00	0.00	0.00	0.01
20.333	0.00	0.00	0.00	0.00	0.00	0.00
20.5	0.00	0.00	0.00	0.00	0.00	0.00
20.667	0.00	0.00	0.00	0.00	0.00	0.00
20.833	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00
21.167	0.00	0.00	0.00	0.00	0.00	0.00
21.333	0.00	0.00	0.00	0.00	0.00	0.00
21.5	0.00	0.00	0.00	0.00	0.00	0.00
21.667	0.00	0.00	0.00	0.00	0.00	0.00
21.833	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00
22.167	0.00	0.00	0.00	0.00	0.00	0.00
22.333	0.00	0.00	0.00	0.00	0.00	0.00
22.5	0.00	0.00	0.00	0.00	0.00	0.00
22.667	0.00	0.00	0.00	0.00	0.00	0.00
22.833	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00

Location C
CURRENT

	AEP															
	50%		20%		10%		5.00%		0.10%		10%		0.50%		0.10%	
Time	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51
14.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51
15.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.01
15.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	4.52
15.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	3.01	0.01	9.04
15.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	3.01	0.01	12.05
15.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	3.01	0.00	4.52	0.01	16.57
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	3.01	0.01	7.53	0.02	22.59
16.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	4.52	0.01	10.54	0.02	30.12
16.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	3.01	0.01	7.53	0.01	15.06	0.03	40.66
16.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	4.52	0.01	10.54	0.01	21.08	0.04	52.71
16.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	4.52	0.01	12.05	0.01	21.08	0.04	52.71
16.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	4.52	0.01	12.05	0.02	22.59	0.04	54.22
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	4.52	0.01	12.05	0.02	22.59	0.04	54.22
17.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	4.52	0.01	12.05	0.02	22.59	0.04	54.22
17.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	4.52	0.01	12.05	0.01	21.08	0.04	52.71
17.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	3.01	0.01	7.53	0.01	15.06	0.03	40.66
17.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	6.02	0.01	10.54	0.02	30.12
17.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	3.01	0.01	7.53	0.02	22.59
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	3.01	0.00	6.02	0.01	18.07
18.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	3.01	0.01	9.04
18.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	6.02
18.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	4.52
18.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.01
18.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Mid Range Future Scenario

	AEP															
	50%		20%		10%		5.00%		0.10%		10%		0.50%		0.10%	
Time	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
13.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
13.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
13.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.06
13.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.12
13.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.00	0.23
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.07	0.00	0.43
14.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.05	0.00	0.14	0.00	0.78
14.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.00	0.08	0.00	0.22	0.00	1.13
14.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.06	0.00	0.18	0.00	0.45	0.00	2.06
14.667	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.04	0.00	0.14	0.00	0.37	0.00	0.93	0.00	3.77
14.833	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.06	0.00	0.23	0.00	0.58	0.00	1.45	0.00	5.43
15	0.00	0.00	0.00	0.01	0.00	0.03	0.00	0.15	0.00	0.49	0.00	1.23	0.00	2.92	0.01	9.69
15.167	0.00	0.00	0.00	0.03	0.00	0.08	0.00	0.33	0.00	1.06	0.00	2.53	0.00	5.73	0.01	16.90
15.333	0.00	0.01	0.00	0.05	0.00	0.14	0.00	0.51	0.00	1.65	0.00	3.93	0.01	8.63	0.02	23.71
15.5	0.00	0.02	0.00	0.12	0.00	0.33	0.00	1.18	0.00	3.57	0.01	8.10	0.01	16.91	0.03	41.35
15.667	0.00	0.03	0.00	0.20	0.00	0.53	0.00	1.83	0.00	5.33	0.01	11.81	0.02	24.74	0.04	56.62
15.833	0.00	0.06	0.00	0.32	0.00	0.82	0.00	2.82	0.01	7.98	0.01	17.22	0.02	36.19	0.05	77.53
16	0.00	0.10	0.00	0.51	0.00	1.33	0.00	4.19	0.01	11.94	0.02	25.90	0.03	51.41	0.07	103.63
16.167	0.00	0.16	0.00	0.81	0.00	2.06	0.00	6.47	0.01	17.86	0.02	36.60	0.05	73.04	0.09	138.51
16.333	0.00	0.27	0.00	1.29	0.00	3.20	0.01	9.64	0.02	25.84	0.04	53.36	0.07	100.78	0.12	180.71
16.5	0.00	0.42	0.00	2.04	0.00	4.96	0.01	14.34	0.02	37.39	0.05	75.39	0.09	139.05	0.16	235.76
16.667	0.00	0.44	0.00	2.13	0.00	4.96	0.01	14.34	0.03	38.66	0.05	77.79	0.10	143.18	0.16	241.53
16.833	0.00	0.44	0.00	2.13	0.00	5.17	0.01	14.87	0.03	38.66	0.05	77.79	0.10	147.43	0.16	247.45
17	0.00	0.44	0.00	2.13	0.00	5.17	0.01	14.87	0.03	38.66	0.05	77.79	0.10	147.43	0.16	247.45
17.167	0.00	0.44	0.00	2.13	0.00	5.17	0.01	14.87	0.03	38.66	0.05	77.79	0.10	147.43	0.16	247.45
17.333	0.00	0.44	0.00	2.13	0.00	4.96	0.01	14.34	0.03	38.66	0.05	77.79	0.10	143.18	0.16	241.53
17.5	0.00	0.27	0.00	1.34	0.00	3.33	0.01	9.99	0.02	26.72	0.04	55.06	0.07	103.77	0.12	185.13
17.667	0.00	0.17	0.00	0.85	0.00	2.14	0.00	6.71	0.01	18.47	0.03	38.97	0.05	75.21	0.09	141.90
17.833	0.00	0.10	0.00	0.53	0.00	1.38	0.00	4.51	0.01	12.77	0.02	26.73	0.04	54.51	0.07	108.76
18	0.00	0.06	0.00	0.34	0.00	0.89	0.00	2.92	0.01	8.53	0.01	18.92	0.03	38.37	0.05	81.37
18.167	0.00	0.02	0.00	0.14	0.00	0.37	0.00	1.37	0.00	4.08	0.01	9.19	0.01	20.15	0.03	47.80
18.333	0.00	0.01	0.00	0.06	0.00	0.16	0.00	0.62	0.00	1.95	0.00	4.60	0.01	10.28	0.02	27.41
18.5	0.00	0.01	0.00	0.03	0.00	0.10	0.00	0.40	0.00	1.30	0.00	3.16	0.00	7.03	0.01	20.02
18.667	0.00	0.00	0.00	0.01	0.00	0.04	0.00	0.17	0.00	0.60	0.00	1.53	0.00	3.59	0.01	11.48
18.833	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.08	0.00	0.28	0.00	0.72	0.00	1.78	0.00	6.43
19	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.00	0.13	0.00	0.35	0.00	0.91	0.00	3.68
19.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.06	0.00	0.16	0.00	0.45	0.00	2.06
19.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.00	0.08	0.00	0.22	0.00	1.13
19.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.00	0.08	0.00	0.48
19.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.04	0.00	0.26
19.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.14
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.08
20.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
20.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
20.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
20.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

High End Future Scenario

	AEP					
	10%		0.50%		0.10%	
Time	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)
11	0.00	0.00	0.00	0.00	0.00	0.00
11.167	0.00	0.00	0.00	0.00	0.00	0.00
11.333	0.00	0.00	0.00	0.00	0.00	0.00
11.5	0.00	0.00	0.00	0.00	0.00	0.00
11.667	0.00	0.00	0.00	0.00	0.00	0.00
11.833	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00
12.167	0.00	0.00	0.00	0.00	0.00	0.00
12.333	0.00	0.00	0.00	0.00	0.00	0.00
12.5	0.00	0.00	0.00	0.00	0.00	0.00
12.667	0.00	0.00	0.00	0.00	0.00	0.01
12.833	0.00	0.00	0.00	0.00	0.00	0.01
13	0.00	0.00	0.00	0.00	0.00	0.03
13.167	0.00	0.00	0.00	0.01	0.00	0.05
13.333	0.00	0.00	0.00	0.01	0.00	0.10
13.5	0.00	0.00	0.00	0.03	0.00	0.19
13.667	0.00	0.00	0.00	0.06	0.00	0.36
13.833	0.00	0.00	0.00	0.13	0.00	0.69
14	0.00	0.00	0.00	0.28	0.00	1.29
14.167	0.00	0.01	0.00	0.59	0.00	2.43
14.333	0.00	0.01	0.00	0.95	0.00	3.62
14.5	0.00	0.03	0.00	1.96	0.00	6.66
14.667	0.00	0.08	0.00	4.06	0.01	12.24
14.833	0.00	0.14	0.00	6.35	0.01	17.80
15	0.00	0.34	0.01	12.78	0.02	31.95
15.167	0.00	0.83	0.02	25.73	0.04	57.37
15.333	0.00	1.34	0.03	38.08	0.05	79.61
15.5	0.00	3.16	0.05	74.55	0.09	139.62
15.667	0.00	5.13	0.07	110.31	0.13	193.76
15.833	0.01	8.03	0.11	158.72	0.17	262.68
16	0.01	12.55	0.15	228.39	0.24	356.11
16.167	0.01	19.63	0.22	328.62	0.32	482.76
16.333	0.02	29.57	0.31	459.80	0.42	639.32
16.5	0.03	44.54	0.42	625.59	0.55	827.06
16.667	0.03	46.23	0.43	643.34	0.56	846.65
16.833	0.03	47.99	0.44	661.61	0.58	866.70
17	0.03	47.99	0.44	661.61	0.58	866.70
17.167	0.03	47.99	0.44	661.61	0.58	866.70
17.333	0.03	46.23	0.43	643.34	0.56	846.65
17.5	0.02	30.69	0.31	472.85	0.43	654.46
17.667	0.01	20.37	0.23	347.55	0.34	505.90
17.833	0.01	13.52	0.16	248.39	0.25	382.01
18	0.01	8.65	0.11	172.63	0.19	281.79
18.167	0.00	3.81	0.06	90.68	0.11	164.48
18.333	0.00	1.68	0.03	47.64	0.06	96.01
18.5	0.00	1.03	0.02	32.19	0.05	69.18
18.667	0.00	0.44	0.01	16.44	0.03	39.45
18.833	0.00	0.19	0.01	8.40	0.01	22.49
19	0.00	0.08	0.00	4.17	0.01	12.53
19.167	0.00	0.03	0.00	2.07	0.00	6.98
19.333	0.00	0.01	0.00	1.00	0.00	3.80
19.5	0.00	0.00	0.00	0.37	0.00	1.63
19.667	0.00	0.00	0.00	0.18	0.00	0.89
19.833	0.00	0.00	0.00	0.08	0.00	0.47
20	0.00	0.00	0.00	0.04	0.00	0.25
20.167	0.00	0.00	0.00	0.01	0.00	0.11
20.333	0.00	0.00	0.00	0.01	0.00	0.05
20.5	0.00	0.00	0.00	0.00	0.00	0.02
20.667	0.00	0.00	0.00	0.00	0.00	0.01
20.833	0.00	0.00	0.00	0.00	0.00	0.01
21	0.00	0.00	0.00	0.00	0.00	0.00
21.167	0.00	0.00	0.00	0.00	0.00	0.00
21.333	0.00	0.00	0.00	0.00	0.00	0.00
21.5	0.00	0.00	0.00	0.00	0.00	0.00
21.667	0.00	0.00	0.00	0.00	0.00	0.00
21.833	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00
22.167	0.00	0.00	0.00	0.00	0.00	0.00
22.333	0.00	0.00	0.00	0.00	0.00	0.00
22.5	0.00	0.00	0.00	0.00	0.00	0.00
22.667	0.00	0.00	0.00	0.00	0.00	0.00
22.833	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00

Location D
CURRENT

	AEP															
	50%		20%		10%		5.00%		0.10%		10%		0.50%		0.10%	
Time	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	1.42
16.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	1.42	0.01	3.78
16.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.94	0.01	3.78	0.02	8.97
16.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.01	2.36	0.02	11.33	0.05	21.71
16.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.01	2.83	0.02	11.33	0.05	21.71
16.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.01	2.83	0.03	12.27	0.05	23.60
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.01	2.83	0.03	12.27	0.05	23.60
17.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.01	2.83	0.03	12.27	0.05	23.60
17.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.01	2.83	0.02	11.33	0.05	21.71
17.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.94	0.01	4.25	0.02	9.91
17.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	1.42	0.01	4.25
17.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	1.89
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47
18.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Mid Range Future Scenario

	AEP															
	50%		20%		10%		5.00%		0.10%		10%		0.50%		0.10%	
Time	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.05
15.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.09	0.00	0.29
15.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.05	0.00	0.27	0.00	0.79
15.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.06	0.00	0.41	0.00	2.23	0.01	4.84
15.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.23	0.00	1.38	0.01	6.37	0.03	11.99
15.833	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.07	0.00	0.78	0.01	4.27	0.04	19.91	0.07	32.05
16	0.00	0.00	0.00	0.01	0.00	0.03	0.00	0.26	0.01	2.58	0.03	13.19	0.12	56.99	0.17	79.45
16.167	0.00	0.00	0.00	0.03	0.00	0.12	0.00	0.84	0.02	7.76	0.09	40.71	0.35	163.13	0.42	196.94
16.333	0.00	0.00	0.00	0.10	0.00	0.39	0.01	2.69	0.05	23.32	0.24	114.40	0.99	466.94	1.03	488.16
16.5	0.00	0.02	0.00	0.29	0.00	1.34	0.02	8.60	0.15	70.09	0.68	321.53	2.59	1224.44	2.38	1121.86
16.667	0.00	0.02	0.00	0.32	0.00	1.49	0.02	9.56	0.16	77.46	0.75	353.19	2.83	1336.60	2.56	1210.02
16.833	0.00	0.02	0.00	0.32	0.00	1.49	0.02	9.56	0.18	85.62	0.75	353.19	2.83	1336.60	2.56	1210.02
17	0.00	0.02	0.00	0.32	0.00	1.49	0.02	9.56	0.18	85.62	0.82	387.98	2.83	1336.60	2.56	1210.02
17.167	0.00	0.02	0.00	0.32	0.00	1.49	0.02	9.56	0.18	85.62	0.75	353.19	2.83	1336.60	2.56	1210.02
17.333	0.00	0.02	0.00	0.32	0.00	1.49	0.02	9.56	0.16	77.46	0.75	353.19	2.83	1336.60	2.56	1210.02
17.5	0.00	0.00	0.00	0.10	0.00	0.44	0.01	2.99	0.05	25.77	0.27	125.67	1.08	509.71	1.12	526.52
17.667	0.00	0.00	0.00	0.03	0.00	0.13	0.00	0.93	0.02	8.57	0.09	44.72	0.41	194.38	0.49	229.11
17.833	0.00	0.00	0.00	0.01	0.00	0.04	0.00	0.29	0.01	2.85	0.03	15.91	0.14	67.91	0.20	92.43
18	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.09	0.00	0.95	0.01	5.15	0.05	23.72	0.08	37.29
18.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.11	0.00	0.65	0.01	3.45	0.01	7.06
18.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.08	0.00	0.46	0.00	1.24
18.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.16	0.00	0.50
18.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.08
18.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.167	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.333	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.667	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.833	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

High End Future Scenario

	AEP					
	10%		0.50%		0.10%	
Time	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)	q (l/m/s)	q (m^3/s)
11	0.00	0.00	0.00	0.00	0.00	0.00
11.167	0.00	0.00	0.00	0.00	0.00	0.00
11.333	0.00	0.00	0.00	0.00	0.00	0.00
11.5	0.00	0.00	0.00	0.00	0.00	0.00
11.667	0.00	0.00	0.00	0.00	0.00	0.00
11.833	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00
12.167	0.00	0.00	0.00	0.00	0.00	0.00
12.333	0.00	0.00	0.00	0.00	0.00	0.00
12.5	0.00	0.00	0.00	0.00	0.00	0.00
12.667	0.00	0.00	0.00	0.00	0.00	0.00
12.833	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00
13.167	0.00	0.00	0.00	0.00	0.00	0.00
13.333	0.00	0.00	0.00	0.00	0.00	0.00
13.5	0.00	0.00	0.00	0.00	0.00	0.00
13.667	0.00	0.00	0.00	0.00	0.00	0.00
13.833	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00
14.167	0.00	0.00	0.00	0.00	0.00	0.00
14.333	0.00	0.00	0.00	0.00	0.00	0.00
14.5	0.00	0.00	0.00	0.00	0.00	0.01
14.667	0.00	0.00	0.00	0.02	0.00	0.08
14.833	0.00	0.00	0.00	0.06	0.00	0.25
15	0.00	0.00	0.00	0.52	0.00	1.56
15.167	0.00	0.01	0.01	4.47	0.02	9.64
15.333	0.00	0.02	0.03	16.24	0.06	28.72
15.5	0.00	0.21	0.27	128.12	0.35	164.77
15.667	0.00	0.81	0.83	392.17	0.90	424.44
15.833	0.01	2.76	2.77	1308.37	2.49	1175.93
16	0.02	9.48	7.79	3674.76	5.97	2816.56
16.167	0.07	32.53	23.83	11248.74	15.37	7255.56
16.333	0.24	111.61	66.94	31593.92	36.82	17378.44
16.5	0.73	345.56	172.50	81419.47	82.00	38702.48
16.667	0.81	382.95	204.90	96711.52	94.85	44767.42
16.833	0.81	382.95	204.90	96711.52	94.85	44767.42
17	0.81	382.95	204.90	96711.52	94.85	44767.42
17.167	0.81	382.95	204.90	96711.52	94.85	44767.42
17.333	0.81	382.95	204.90	96711.52	94.85	44767.42
17.5	0.26	123.69	72.95	34433.29	39.60	18690.56
17.667	0.08	39.95	28.31	13361.46	17.78	8392.56
17.833	0.02	11.64	10.08	4757.23	7.42	3503.92
18	0.01	3.39	3.29	1554.10	2.88	1360.20
18.167	0.00	0.35	0.50	234.01	0.58	274.25
18.333	0.00	0.04	0.06	29.66	0.10	47.80
18.5	0.00	0.01	0.02	9.69	0.04	18.56
18.667	0.00	0.00	0.00	1.23	0.01	3.23
18.833	0.00	0.00	0.00	0.14	0.00	0.52
19	0.00	0.00	0.00	0.02	0.00	0.08
19.167	0.00	0.00	0.00	0.00	0.00	0.01
19.333	0.00	0.00	0.00	0.00	0.00	0.00
19.5	0.00	0.00	0.00	0.00	0.00	0.00
19.667	0.00	0.00	0.00	0.00	0.00	0.00
19.833	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00
20.167	0.00	0.00	0.00	0.00	0.00	0.00
20.333	0.00	0.00	0.00	0.00	0.00	0.00
20.5	0.00	0.00	0.00	0.00	0.00	0.00
20.667	0.00	0.00	0.00	0.00	0.00	0.00
20.833	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00
21.167	0.00	0.00	0.00	0.00	0.00	0.00
21.333	0.00	0.00	0.00	0.00	0.00	0.00
21.5	0.00	0.00	0.00	0.00	0.00	0.00
21.667	0.00	0.00	0.00	0.00	0.00	0.00
21.833	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00
22.167	0.00	0.00	0.00	0.00	0.00	0.00
22.333	0.00	0.00	0.00	0.00	0.00	0.00
22.5	0.00	0.00	0.00	0.00	0.00	0.00
22.667	0.00	0.00	0.00	0.00	0.00	0.00
22.833	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00

Fluvial and Coastal Hydraulic Modelling Report

1. Basic Model Information

1.1 General Information	
Model ID:	S18
Unit of Management	27
AFAs included in the model	Kilrush
Primary Watercourses / Water Bodies	Parknamoney Stream/ River Wood
1.2 Reference to other Relevant Reports	
Catchment Description	Hydrology Report Unit of Management 27 – Appendix A5.1
Model Location	Hydraulics Report Unit of Management 27 – Section 3.4.12
HEP Schematisation	Hydrology Report Unit of Management 27 – Appendix B5 – Figure B5.1

2. Survey Data and Base Mapping

2.1 Base Mapping:	OSi data base mapping at scale 1:50k Reference: OS1014_D OS0814_D
2.2 DTM for 2D Model Domain:	**Within AFA:** LiDAR data with 2m horizontal resolution and approximately 200mm vertical accuracy has been used to inform the hydraulic model with ground elevation in the floodplain areas included in the AFA boundary.
	Outside AFA: IFSAR data with 5m horizontal resolution and approximately 500mm-1000mm vertical accuracy has been used to inform the hydraulic model with ground elevation in the floodplain areas outside the AFA boundary. **Note:** In general, there is overlap between the AFA area and area outside the AFA with regard to the availability of LiDAR data. Therefore, some areas outside the AFA are covered by LiDAR to the same resolution as that for the AFA.
2.3 River Channel/Structures Survey	Details of the topographic survey of the river channel and structures are included in the main Hydraulics Report. This includes longitudinal sections and channel cross-sections. Full details of the survey outputs are provided in the topographic survey deliverables, as required under Section 5.2 of the Stage I Project Brief. Number of cross-sections included in this model: 89

2.4 Defence Asset Survey Data	The defence asset database has been completed for this model area and is provided as a separate deliverable to this report. Formal flood defences have been surveyed and included into the model. They consist of: 1. Tidal embankment along the western border of the Kilrush Creek Marina. The embankment has a lock gate mid-way along it to allow vessel access into Kilrush harbour. 2. Sea wall running along Cappagh road (R473) to the south of the marina in Cappa village. All defences have been included in the model schematisation as shown on the maps presented in Annex A2.
2.5 Survey Interaction	The Lidar, IFSAR and topographic survey were checked for anomalies, and to ensure that interactions between were within expected tolerances. No issues were identified in this model.

3. Hydraulic Model Construction and Schematisation

3.1 Software:	**1D domain:**	ISIS Version 3.6.0.156 (32 bit - Single Precision)
	2D domain(s):	TUFLOW Version: 2012-05-AE-iSP-w32
3.2 Model Area / Extent:	The extent of the model and its schematisation are shown in Annex A.	

The mapping details for the model extent included in Annex A are as follows:

1. **Full modelled area showing**:
   - River centre lines, HPW/MPW extents, names of watercourses
   - 2D domain area including coastal and fluvial floodplains
   - AFA boundary

2. **Maps showing a detailed model schematic of the HPW/MPW reaches are also included in Annex A.**

3.3 Model Reaches: The following model reaches as shown on the maps referred to above have been defined in the model:

Watercourse Name	Reach	Upstream Model Node	Downstream Model Node
River Wood and Parknamoney Stream combined in a single reach	01WOO	01WOO04754	01WOO00000

A schematic of the modelled river reach is available in the .GXY file provided in conjunction with each ISIS .DAT file (see Annex C)

Total model HPW length (km):	4.76	**Total model MPW length (km):**	0

3.4 Model Structures:

A full schedule of structures included in the model is provided in Schedule A in Annex B. A summary of the structures included is given below

Culverts:	☒	How many?	5
Bridges:	☒	How many?	6
Fixed crest weirs:	☒	How many?	1
Adjustable crest weirs:	☐	How many?	0
Sluice / Gate structures:	☒	How many?	1
Locks:	☐	How many?	0
Dams:	☐	How many?	0
Other (describe):			

3.5 Floodplain Schematisation

Out-of-bank areas for MPW reaches have been modelled using a 1D approach in the ISIS model by extending the river channel cross-sections. Out-of-bank areas for HPW reaches, within Kilrush AFA, have been modelled using a 1D approach in the ISIS model by extending the river channel cross-sections.

Extended 1D sections are considered appropriate for HPW extents where floodplain flow paths are simple (e.g, parallel to river flow). 1D-2D modelling is required where HPWs flow through urban areas and out-of-bank flows will form complex flow paths.

An overview of the floodplain schematisation is available in the maps shown in Annex A.

3.6 2D Domain Grid Size: The number of 2D domains defined and the grid sizes of each 2D model domain are as follows:

<table>
<tr><td rowspan="3"></td><td colspan="3">Number of 2D domains: one domain encompassing both fluvial and coastal floodplains</td></tr>
<tr><td>Domain 1:</td><td>Grid cell size 4m</td><td>Area 1.694 km^2</td></tr>
<tr><td colspan="3">2D domains are defined depending on the level of detail required to pick up the appropriate features in the 2D domain that will impact on the local hydraulics. The domain grid square size is typically in the range 5m to 20m, with the smaller grid sizes used in very urbanised areas where there are multiple features that could not be suitably represented in, say, a 10m grid. The model grid is orientated in the main direction of the floodplain flow.</td></tr>
<tr><td>3.7 Model Breaklines in the 2D Domain:</td><td colspan="3">Bank tops and flood defences are represented as breaklines in the 2D domain. Bridge parapets are represented either as spill units in the 1D model or as breaklines in the 2D domain (bridge 01WOO01025bu).</td></tr>
<tr><td>3.8 Floodplain Structures in the 2D Domain</td><td colspan="3">None</td></tr>
<tr><td>3.9 Hydraulic Roughness</td><td colspan="3">Hydraulic roughness (Manning's 'n') has been defined in accordance with the approaches described in the main Hydraulics Report. Details of the values adopted for this model are included in Schedule B in Annex B. A summary of Manning's 'n' for the model as a whole is as follows:</td></tr>
<tr><td rowspan="2">HPW in-bank</td><td>Minimum 'n' value:</td><td colspan="2">0.030</td></tr>
<tr><td>Maximum 'n' value:</td><td colspan="2">0.050</td></tr>
<tr><td rowspan="10">Floodplain (TUFLOW Model)</td><td colspan="3">Manning's 'n' for the coastal and fluvial floodplain areas represented in the TUFLOW model are as defined by OSi NTF land use characteristics, as described in the main Hydraulics Report. Floodplain land uses and adopted roughness values in TUFLOW are as follows:</td></tr>
<tr><td>Land Use</td><td colspan="2">Manning's 'n' Value</td></tr>
<tr><td>Buildings</td><td colspan="2">0.100</td></tr>
<tr><td>Short grass, parks</td><td colspan="2">0.035</td></tr>
<tr><td>General Rural</td><td colspan="2">0.045</td></tr>
<tr><td>Pastures, Short Grass</td><td colspan="2">0.035</td></tr>
<tr><td>Dense Vegetation</td><td colspan="2">0.080</td></tr>
<tr><td>Roads</td><td colspan="2">0.025</td></tr>
<tr><td>Flat Rock</td><td colspan="2">0.025</td></tr>
<tr><td>Water bodies</td><td colspan="2">0.020</td></tr>
<tr><td>3.10 Spill Units</td><td colspan="3">Spill units are used for a number of different purposes (e.g. irregular weir, lateral spilling in the floodplain). Spill profile geometry is defined using topographic survey data and LiDAR/IfSAR.
Spill coefficients used generally vary between 0.9 and 1.5 depending on the type of ground conditions (e.g. rough vegetated, smooth concrete) over which flood flows are spilling. Lower coefficients (<1.0) can be also found to account for lateral spilling perpendicular to the main direction of flow.</td></tr>
<tr><td>3.11 Model Boundaries – Fluvial Inflows</td><td colspan="3">Hydrological flow hydrographs were input to the model at key model locations as indicated in the tables below.
For further details on the design hydrograph estimation process please refer to Section 2 of the Hydrology Report for UoM27. For further details on hydrographs and peak flows specifically related to this model please see Appendix A5 and Appendix B5 respectfully of the Hydrology Report for UoM27.</td></tr>
</table>

(a) Current Situation	Peak fluvial inflows (m^3/s) are summarised in the tables below for the current situation and the design event simulated. These are the final inflows as obtained following calibration to HEPs (see Section 4.2).

HEP Reference Name	Input Node in the Hydraulic Model	Annual Exceedance Probability							
		50%	20%	10%	5%	2%	1%	0.5%	0.1%
27_967_1	01WOO04754	0.7	0.9	1.0	1.1	1.2	1.3	1.4	1.6
27_967_3	01WOO03783u	4.9	6.2	7.0	7.6	8.6	9.2	9.9	11.4
27_968_1	01WOO03197u	0.4	0.4	0.5	0.6	0.6	0.7	0.7	0.8
27_968_2	01WOO02734u	0.5	0.6	0.7	0.7	0.8	0.9	1.0	1.1
27_968_4	01WOO01735u	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
27_968_5	01WOO01190u	0.4	0.5	0.6	0.6	0.7	0.8	0.8	0.9

(b) Future Scenarios	The peak inflows (m^3/s) used as inputs to the model at key model locations are summarised in the table below for both the MRFS and the HEFS.

HEP Reference Name	Input Node in the Hydraulic Model	Annual Exceedance Probability MRFS							
		50%	20%	10%	5%	2%	1%	0.5%	0.1%
27_967_1	01WOO04754	0.8	1.0	1.2	1.3	1.4	1.5	1.6	1.9
27_967_3	01WOO03783u	5.9	7.4	8.4	9.2	10.3	11.1	11.9	13.6
27_968_1	01WOO03197u	0.4	0.5	0.6	0.7	0.7	0.8	0.9	1.0
27_968_2	01WOO02734u	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3
27_968_4	01WOO01735u	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3
27_968_5	01WOO01190u	0.5	0.6	0.7	0.8	0.9	0.9	1.0	1.1

HEP Reference Name	Input Node in the Hydraulic Model	Annual Exceedance Probability HEFS		
		10%	1%	0.1%
27_967_1	01WOO04754	1.3	1.7	2.1
27_967_3	01WOO03783u	9.1	12.0	14.8
27_968_1	01WOO03197u	0.7	0.9	1.1
27_968_2	01WOO02734u	0.9	1.2	1.4
27_968_4	01WOO01735u	0.2	0.2	0.3
27_968_5	01WOO01190u	0.7	1.0	1.2

3.12 Model Boundaries – Downstream Conditions

Downstream boundary conditions adopted in the model are as follows: Tidal level hydrographs at the outlet of the Kilrush Creek Marina were produced for a series of design events using the Irish Coastal Protection Strategy Study (ICPSS) extreme tidal peak levels data. The time series were set up as boundary conditions for the hydraulic model along the coastal boundary of the hydraulic model (see maps in Annex A). Full details on how these tidal level hydrographs were derived are provided in Appendix D of the main Hydraulics Report. Peak tidal levels are summarised in the table below for the current and future situations.

For the wave overtopping model, wave overtopping hydrographs have been applied directly to the hydraulic model using a flow versus time boundary along the landward side of the flood defences. The hydrographs vary for different points along the defence as shown in Annex F. Full details on how these tidal level hydrographs were derived are provided in section 4.4 of the main Hydraulics Report. The tidal hydrographs applied for wave overtopping are available in Annex F of this report.

	Annual Exceedance Probability										
Peak Tidal Levels (m AOD)	**500%**	**200%**	**100%**	**50%**	**20%**	**10%**	**5%**	**2%**	**1%**	**0.5%**	**0.1%**
	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.6
	MRFS Annual Exceedance Probability										
Peak tidal levels (m OD)	500%	200%	100%	50%	20%	10%	5%	2%	1%	0.5%	0.1%
	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.2
	HEFS Annual Exceedance Probability										
Peak tidal levels (m OD)	500%	200%	100%	50%	20%	10%	5%	2%	1%	0.5%	0.1%
	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.6	4.7

4. Hydraulic Model Calibration and Sensitivity

4.1 Model Calibration and Verification to Historical Events

The analysis of available flood event data and high flow data for possible consideration as calibration and verification events is covered in detail in the Hydrology Report for UoM27 (Appendix F). The results of this analysis concluded that no calibration or verification could be performed within the modelled area. A broad verification of the model using anecdotal evidence of flooding was also deemed not possible due to a lack of data.

4.2 Calibration to HEP

Calibration of the hydraulic model to the HEP target flows has been carried out for all AEP fluvial events. Section 2.7.2 of the Hydrology Report for UoM27 provides a summary of the calibration to HEP process.

Preliminary inflow hydrographs derived from the hydrological analysis and input to the model were adjusted in time so that their respective peak flows coincide with the peak time of the propagating flood wave as it is routed down the model. Total peak flows predicted by the hydraulic model at HEP locations were then compared to the HEP target flows estimated during the hydrological analysis. Modelled total peak flows at all HEP locations were found to be within ±10% of the HEP target flows. Therefore no inflow scaling was deemed necessary. This ±10% target allows for good agreement between the hydrological estimates and the hydraulic results without the addition/removal of unrealistic volumes of flow from the model. The robustness of this has been verified by the agreement of the design flood maps.

The table below shows the percentage difference between the modelled flows and the target flows at each HEP location.

HEP Reference Name	Node in the Hydraulic Model	Annual Exceedance Probability							
		Percentage Difference (%)							
		50%	20%	10%	5%	2%	1%	0.5%	0.1%
27_967_1	01WOO04754	0.1	0.5	-0.5	0.0	0.1	0.2	-0.2	0.2
27_967_3	01WOO03783u	0.6	-1.5	-0.9	-0.9	-0.2	-0.5	-1.2	-6.7
27_968_1	01WOO03197u	-4.9	-6.4	-6.0	-6.6	-6.3	-6.7	-7.0	-7.6
27_968_2	01WOO02734u	-4.9	-6.5	-6.2	-6.4	-6.7	-5.9	-6.4	-6.9
27_968_4	01WOO01735u	-5.0	-6.2	-6.2	-6.7	-6.6	-5.4	-5.0	-4.7
27_968_5	01WOO01190u	-4.9	-6.1	-6.3	-6.9	-6.9	-6.7	-7.2	-8.0
27_968_6	01WOO01003u	-4.6	-5.7	-6.4	-6.6	-6.6	-6.4	-6.9	-8.0

4.3 Fluvial and Tidal Events Simulated

The River Wood is influenced by the tidal levels along the Shannon Estuary. As such, a joint probability analysis of the coincidence of fluvial flood flows and coastal flood levels was carried out to determine the appropriate combinations of flows and sea levels to be used for the design probability events, as required under Section 6.5.6 of the Stage I Project Brief.

Methodology and outcomes of this analysis are detailed in the main Hydraulic Report and in the Hydrology Report. A summary of the joint probability of fluvial and tidal conditions used for the hydraulic modelling in the Kilrush AFA is reported in the table overleaf.

Combination of Fluvial and Tidal Events			
	Joint Probability Design Event	AEP adopted for Fluvial Flows and Tidal Levels	
Scenario	Overall AEP	Fluvial	Tidal
1	50%	50%	500%
2	50%	50%	50%
3	20%	20%	500%

	4	20%	50%	20%
	5	10%	10%	200%
	6	10%	50%	10%
	7	5%	5%	100%
	8	5%	50%	5%
	9	2%	2%	50%
	10	2%	50%	2%
	11	1%	1%	20%
	12	1%	20%	1%
	13	0.5%	0.5%	10%
	14	0.5%	10%	0.5%
	15	0.1%	0.1%	2%
	16	0.1%	2%	0.1%

4.4 Model Sensitivity	Sensitivity tests have been carried out in order to assess the sensitivity of the predicted peak water levels to alterations in roughness (Manning's 'n'), fluvial flow, afflux at key structures and downstream conditions. The sensitivity runs were carried out for the 1% AEP fluvial dominated event with the corresponding tidal event from the joint probability study in all cases with the only exception of the tests on the downstream boundary conditions, which were carried out for the 0.5% AEP tidal dominated events with the corresponding fluvial event (see Section 4.3). Sensitivity test results are provided in the following tables. Uncertainty maps illustrating the results of the sensitivity analysis will be delivered as part of the final stage of this work.

+20% Manning's 'n'	**Watercourse**	**Average Water Level Difference (m)**	**Maximum Water Level Difference (m)**	**Cross-section / Reach where the Maximum Difference occurs**
	River Wood/ Parknamoney Stream	+0.06	+0.16	01WOO03594d

-20% Manning's 'n'	**Watercourse**	**Average Water Level Difference (m)**	**Maximum Water Level Difference (m)**	**Cross-section where the Maximum Difference occurs**
	River Wood/ Parknamoney Stream	-0.04	-0.19	01WOO03594d

+20% inflows	**Watercourse**	**Average Water Level Difference (m)**	**Maximum Water Level Difference (m)**	**Cross-section where the Maximum Difference occurs**
	River Wood/ Parknamoney Stream	+0.12	+0.25	01WOO00966i

-20% inflows	**Watercourse**	**Average Water Level Difference (m)**	**Maximum Water Level Difference (m)**	**Cross-section where the Maximum Difference occurs**
	River Wood/ Parknamoney Stream	-0.15	-0.29	01WOO00080

Afflux at Key Structure Bridge calibration	Bridges at ISIS nodes 01WOO03594bu and at 01WOO01767bu present a significant head loss during a 1% AEP fluvial dominated flood event

coefficient increased by 20%	therefore a sensitivity test was carried out on the afflux of both structures. The bridge calibration coefficients were then adjusted by +20% (to a value of 1.2). This resulted in an increase of 47mm to the maximum water level immediately upstream of bridge 01WOO03594bu and of 26mm at bridge 01WOO01767bu. The increase in stage caused a very small effect on the predicted flood extent in the immediate vicinity of the two bridges. This is explained as the two bridge structures are bypassed on the left bank and on the right bank, respectively, during flood conditions.
Afflux at Key Structure Bridge calibration coefficient decreased by 20%	The calibration coefficient of the two critical bridges was decreased by 20% (to a value of 0.8) and this resulted in a decrease of 64mm to the maximum water level immediately upstream of bridge 01WOO03594bu and of 31mm at bridge 01WOO01767bu. Similarly to the case above, the decrease in stage resulted in a very minor decrease in the predicted flood extents in the immediate vicinity of the bridges.
Downstream Conditions Duration of surge component of tidal boundary is increased by 100% (i.e. 60 hours)	To test the effect of the duration of high tide levels for a given upstream flood flow condition, the duration of the surge component of the 0.5% AEP tidal boundary was increased by 100% (i.e. 60 hours). The increase in the downstream boundary condition resulted in an increase in maximum water level by 11mm at the downstream limit of the model and its effect extended up to cross section 01WOO01025d, where the model calculated an increased water level of 13mm. There were no noticeable effects on the flood extents.
Downstream Conditions Duration of surge component of tidal boundary is decreased by 50% (i.e. 15 hours)	The decrease in the duration of the surge for the 0.5% AEP tidal boundary resulted in a decrease in maximum water level by 24mm at the downstream limit of the model and the effect of the decreased surge duration extended up to cross section 01WOO01025d, where the model predicted a decreased water level of 16mm. Similarly to the case above, the change in downstream boundary condition had no impact on the flood extents.
4.5 Model Files	The hydraulic model files associated with this model are provided as a separate deliverable under the contract, as required under Sections 7.8 and 13 of the Stage I Project Brief. The model files included are detailed in Annex C.

5. Hydraulic Model Outputs

5.1 Mapping	The model outputs were processed to produce a series of flood maps according to the requirements stated in the Stage I Project Brief under Section 7.5.2 and, more specifically, under Section 7.5.2.1, Kilrush being an area where flooding is subject to both tidal and fluvial influence (see Section 6). This includes mapping outputs covering: • Flood extents • Flood depth and velocity • Flood hazard • Wave Overtopping All of the maps contain the maximum extent, depth, velocity and flood hazard for the combined main stream inflows and the tributary inflows. An explanation for the main stream inflows and the tributary inflows is provided in Section 6. Flood mapping outputs corresponding to the **defended** current scenario for the 10%, 1% and 0.1% AEP fluvial dominated flood events with the corresponding tidal boundary conditions and to the **defended** current scenario for the 10%, 0.5% and 0.1% AEP tidal dominated events with the corresponding fluvial events are shown in Annex D for flood extent and depth only.

6. Key Model Assumption and Limitations

- Tidal lock at the outlet of the Kilrush Creek has been represented as a vertical sluice gate in the ISIS 1D model.

- The operating rules of the tidal lock at Kilrush Harbour during heavy rainfalls/storm conditions, as provided to Jacobs by OPW, are quoted below:

  "Kilrush Creek Marina (KCM, the company who operate the tidal gate) likes to maintain a water level of 3m CD (~ 0 m AD[1]) within the marina facility at all times but it is not always safe or prudent to do so. The water levels are monitored daily and raised or lowered depending on weather conditions i.e. heavy rainfall, gales, vessels transiting with deep draught etc. The marina complex is serviced by the Wood River at the eastern end and as this can lead to excessive water levels within the marina, water is usually let out with the ebbing tide to acceptable levels. KCM have water level gauges both inside and outside the lock gates to determine this...During storm/gale conditions levels within the marina are kept to 2m CD (-1m AD) to prevent excessive fetch developing on open water between berths and lock gates and also to help prevent excessive movement of vessels at moorings."

  For the hydraulic modelling of the design defended scenario (current situation), the operating rules described above were slightly adapted and translated into logical rules controlling the opening of the ISIS sluice gate as follows:

  - Initial water levels conditions within the Kilrush Marina were set to -1m AD
  - If the water level within the Marina facility (**WL**) <= Tidal level (**TL**) then the gate is closed to prevent tidal water from entering the Marina.
  - If **WL** > **TL** then:

[1] To Malin Head datum

- If **WL** < -1m AD then the gate is closed (to prevent the Marina from emptying)
- If **WL** > 0m AD then the gate is opened (to prevent the water level within the Marina from increasing excessively)
- If -1m AD <= **WL**<= 0m AD then the gate does not move (so if the gate is closed then the gate remains closed until the level in the Marina reaches 0m AD, if the gate is open then the gate remains open until the level in the Marina falls below -1m AD).

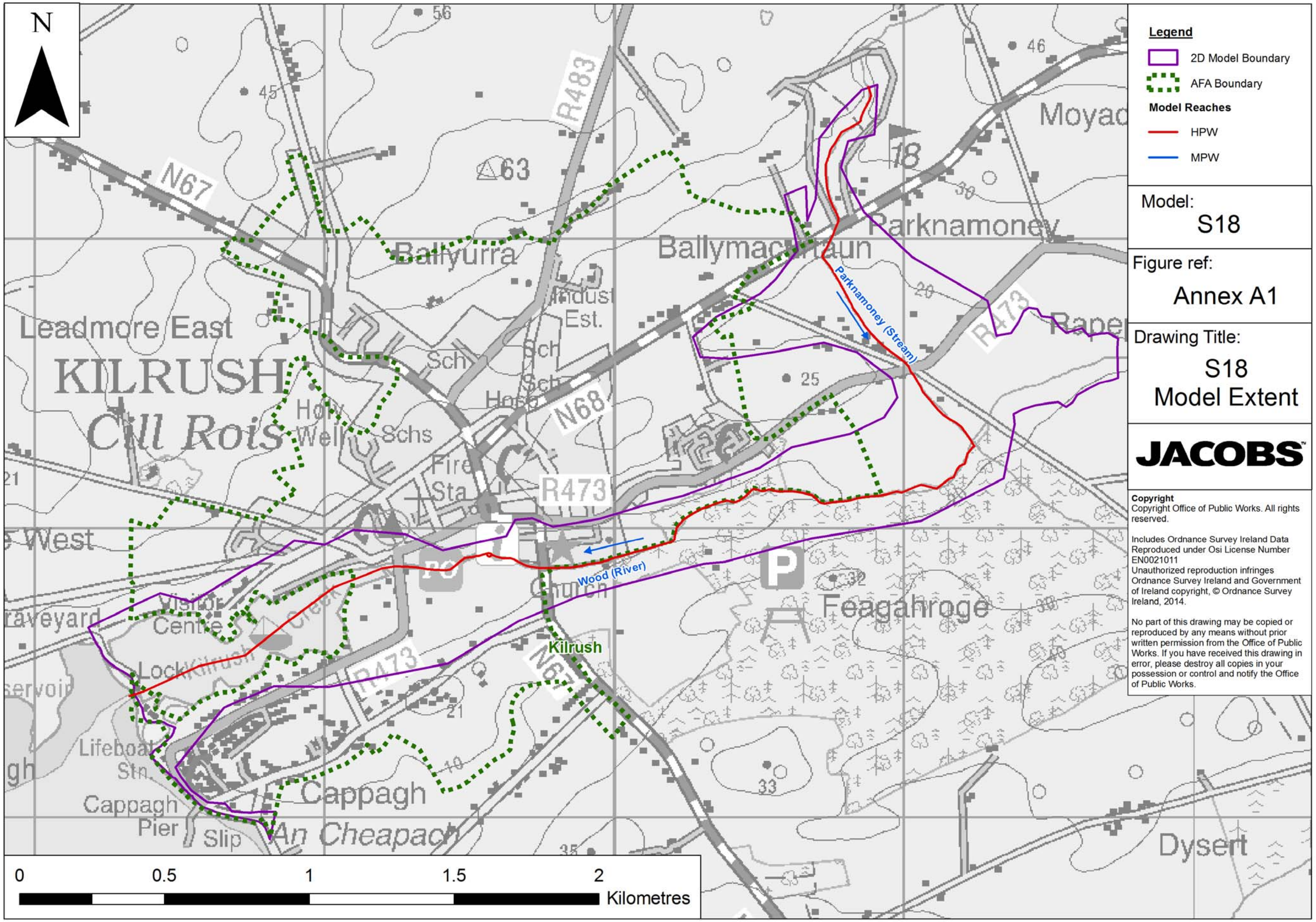
- Tidal level hydrographs at the downstream boundary of the model have been adjusted in time so that the highest tidal level coincides with the fluvial peak flow upstream of the Kilrush Marina (conservative approach).

- The formal flood defences listed in Section 2.4 are included in the model schematisation. Therefore the model and outputs presented in this report represent a **defended scenario**.

- Due to the absence of hydrometric data, hydraulic calibration of model S18 was not possible.

Annex A – Model Extent and Schematisation Maps

Annex A1 – Model Extent


N
Legend
2D Model Boundary
AFA Boundary
Model Reaches
HPW
MPW
Model:
S18
Figure ref:
Annex A1
Drawing Title:
S18
Model Extent
JACOBS
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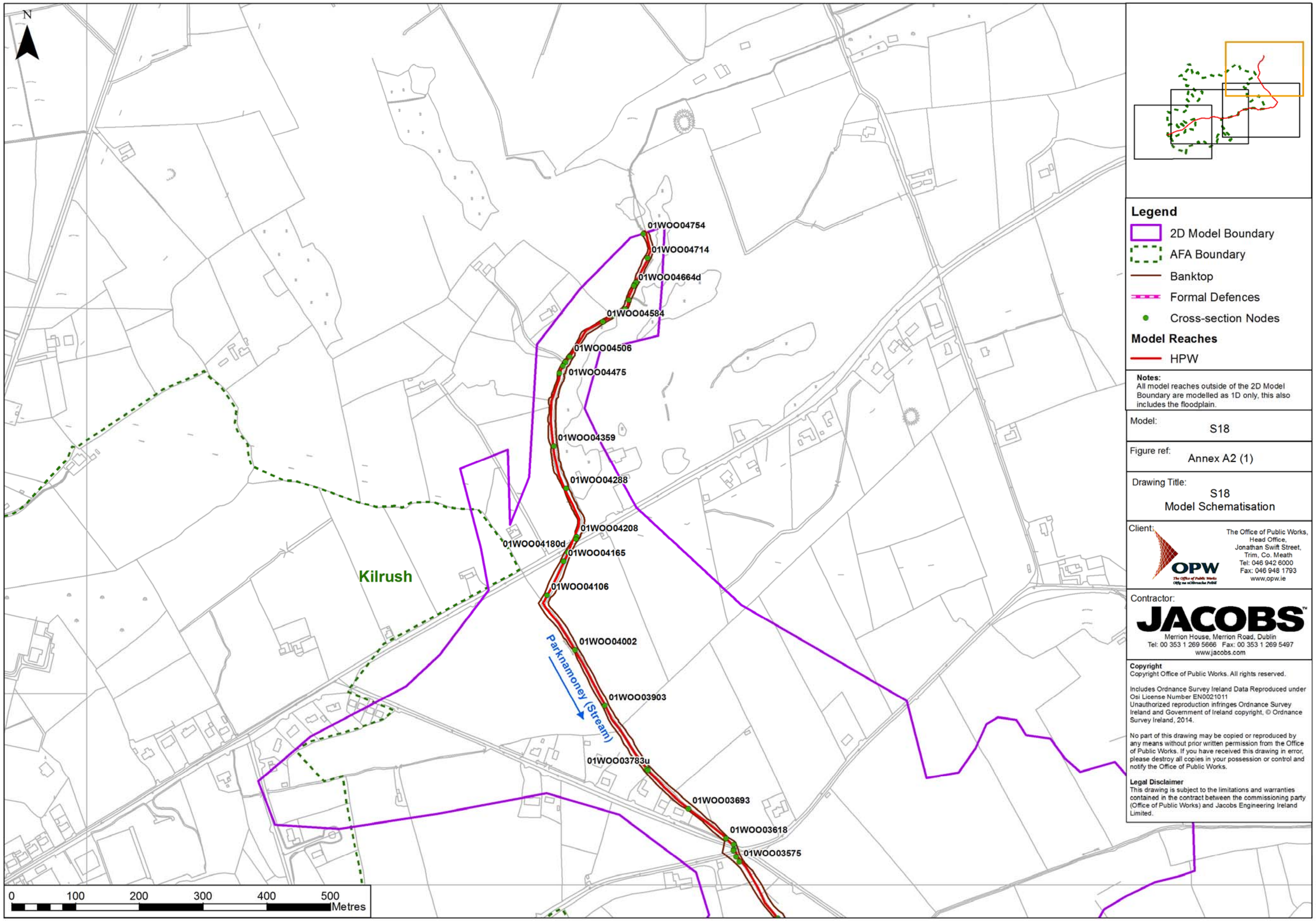
Parknamoney (Stream)
Wood (River)
Kilrush
KILRUSH
Cill Rois
Leadmore East
Ballyurra
Parknamoney
Feagahroge
Cappagh
An Cheapach
Dysert
N67
N68
R473
R483
0
0.5
1
1.5
2
Kilometres

Annex A2 – Schematisation Maps


N
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01WOO04714
01WOO04664d
01WOO04584
01WOO04506
01WOO04475
01WOO04359
01WOO04288
01WOO04208
01WOO04180d
01WOO04165
01WOO04106
01WOO04002
01WOO03903
01WOO03783u
01WOO03693
01WOO03618
01WOO03575
Kilrush
Parknamoney (Stream)
0
100
200
300
400
500
Metres
Legend
2D Model Boundary
AFA Boundary
Banktop
Formal Defences
Cross-section Nodes
Model Reaches
HPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model: S18
Figure ref: Annex A2 (1)
Drawing Title: S18 Model Schematisation
Client:
The Office of Public Works, Head Office, Jonathan Swift Street, Trim, Co. Meath
Tel: 046 942 6000
Fax: 046 948 1793
www,opw.ie
Contractor:
Merrion House, Merrion Road, Dublin
Tel: 00 353 1 269 5666 Fax: 00 353 1 269 5497
www.jacobs.com
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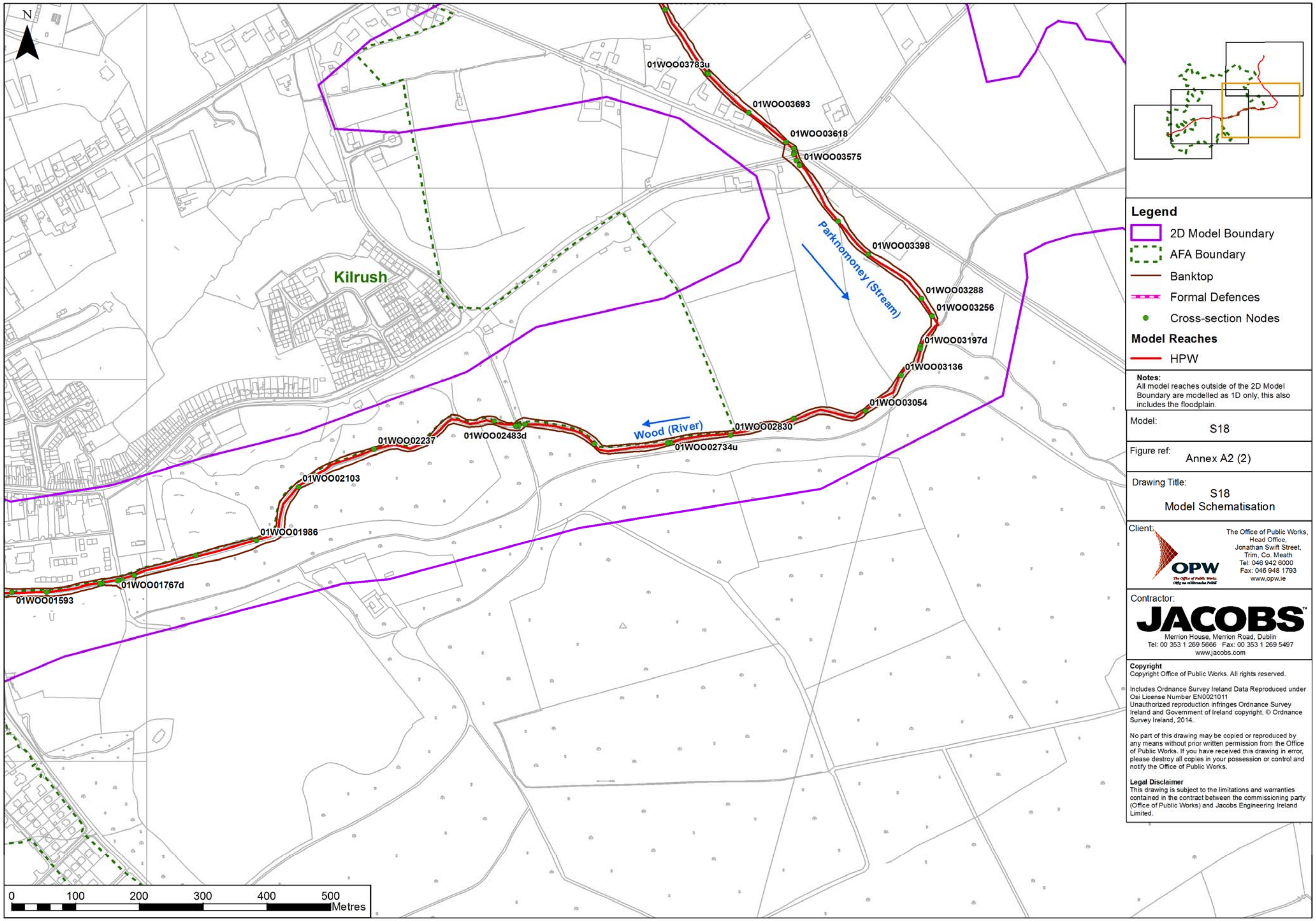
N
Kilrush
Parknomoney (Stream)
Wood (River)
01WOO03783u
01WOO03693
01WOO03618
01WOO03575
01WOO03398
01WOO03288
01WOO03256
01WOO03197d
01WOO03136
01WOO03054
01WOO02830
01WOO02734u
01WOO02483d
01WOO02237
01WOO02103
01WOO01986
01WOO01767d
01WOO01593
0
100
200
300
400
500
Metres
Legend
2D Model Boundary
AFA Boundary
Banktop
Formal Defences
Cross-section Nodes
Model Reaches
HPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model:
S18
Figure ref:
Annex A2 (2)
Drawing Title:
S18
Model Schematisation
Client:
The Office of Public Works, Head Office, Jonathan Swift Street, Trim, Co. Meath
Tel: 046 942 6000
Fax: 046 948 1793
www.opw.ie
Contractor:
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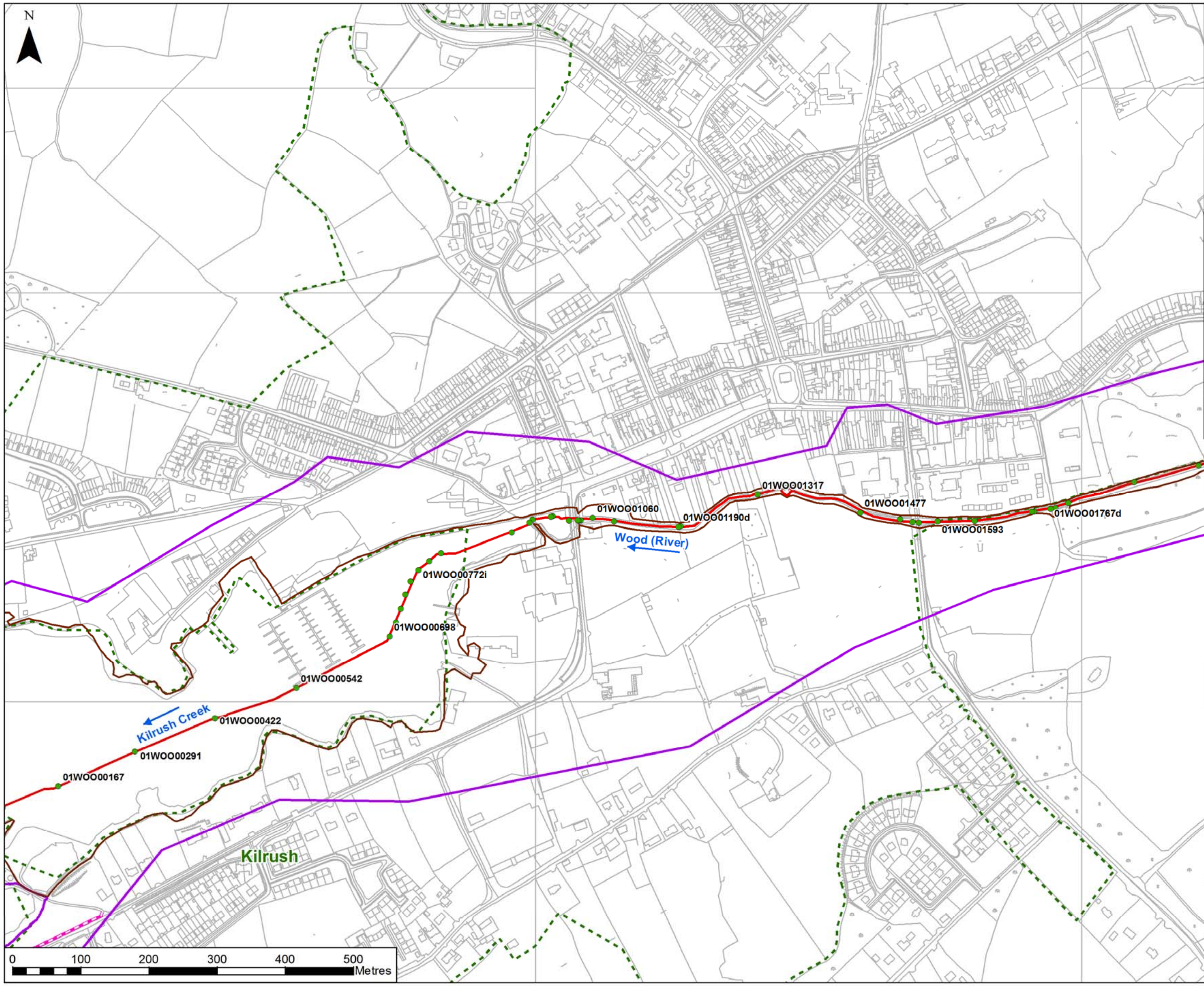

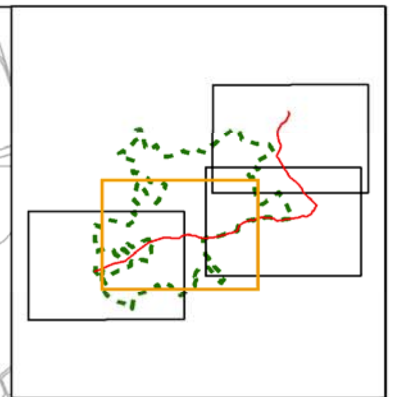

Legend

- 2D Model Boundary
- AFA Boundary
- Banktop
- Formal Defences
- Cross-section Nodes

Model Reaches

- HPW

Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.

Model: S18

Figure ref: Annex A2 (3)

Drawing Title: S18 Model Schematisation

Client: The Office of Public Works, Head Office, Jonathan Swift Street, Trim, Co. Meath
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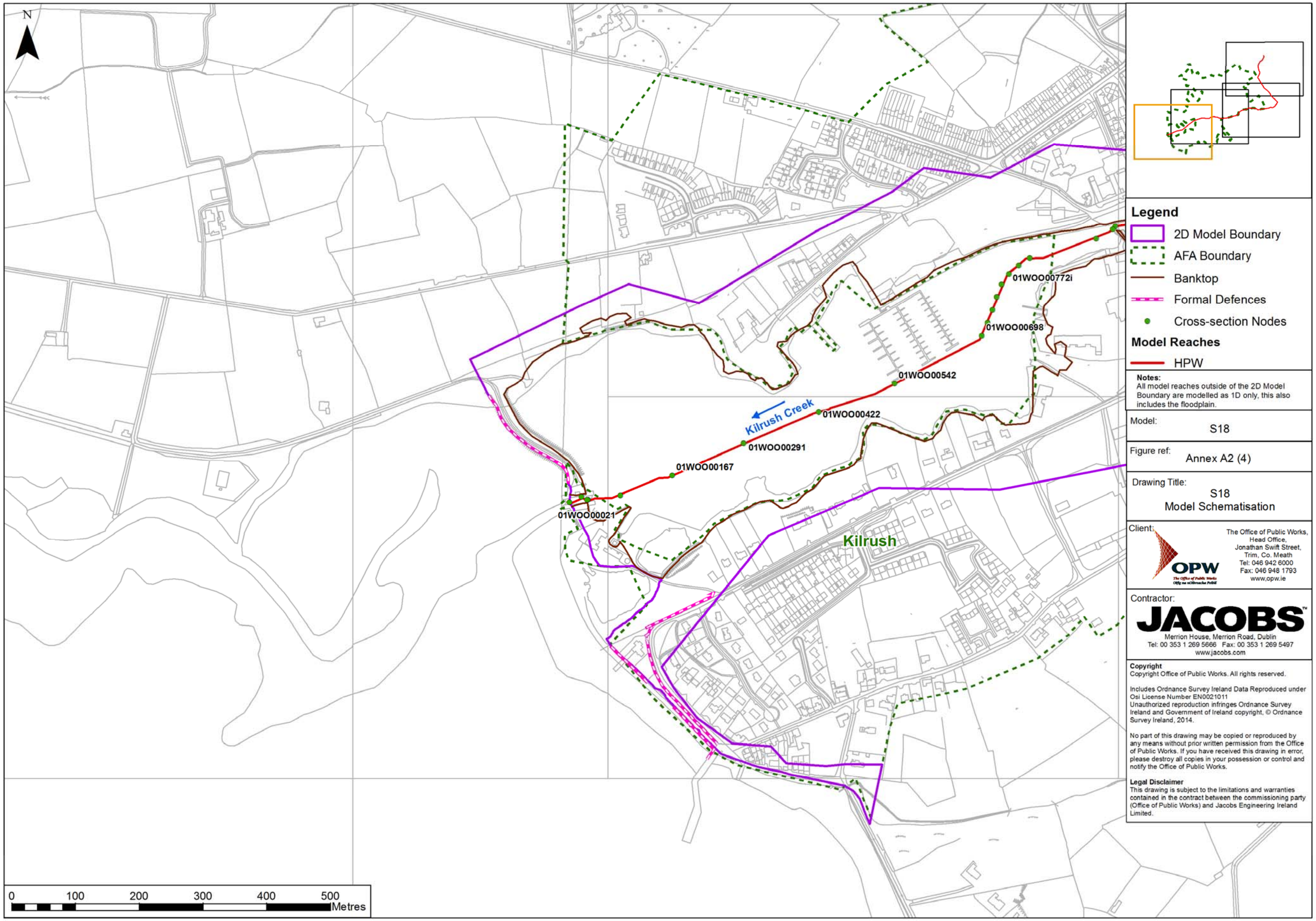
N
Kilrush Creek
Kilrush
01WOO00021
01WOO00167
01WOO00291
01WOO00422
01WOO00542
01WOO00698
01WOO00772i
0 100 200 300 400 500
Metres
Legend
2D Model Boundary
AFA Boundary
Banktop
Formal Defences
Cross-section Nodes
Model Reaches
HPW
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Model: S18
Figure ref: Annex A2 (4)
Drawing Title: S18 Model Schematisation
Client:
The Office of Public Works, Head Office, Jonathan Swift Street, Trim, Co. Meath
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www,opw.ie
Contractor:
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Annex B – Structure and Hydraulic Roughness Schedules

Schedule A.1 - Structure Schedule for River Wood

Survey Reference	ISIS Node Reference	Type of Structure	Modelling Approach	Structure included in Model (Y/N)
27KILA00144I	01WOO04670u	Culvert 6.16 m long	0.9m Circular Conduit + Spill	Y
27KILA00138I	01WOO04609u	Culvert 6.51 m long	Two Circular Conduits (one 0.6m and one 0.3m) + Spill	Y**
27KILA00125I	01WOO04495u	Culvert 7.47 m long	0.6m Circular Conduit + Spill	Y
27KILA00095I	01WOO04200u	N68 ENNIS Road Culvert 19.83 m long	0.9m Circular Conduit + Spill	Y
27KILA00036D	01WOO03607u	Monvana Road Bridge 7.19 m wide	Arch Bridge Unit	Y
27KILA00035D	01WOO03594u	R473 Road Bridge 5.45 m wide	Arch Bridge Unit	Y
27KILR00250D	01WOO02483u	Bridge 5.00 m wide	Arch Bridge Unit + Spill	Y
27KILR00178D	01WOO01767u	Bridge 5.59 m wide	Arch Bridge Unit + Spill	Y
27KILR00157D	01WOO01565u	N67 Bridge 10.94 m wide	Arch Bridge Unit + Spill	Y
27KILR00107W	01WOO01040u	Weir + small sluice	Round nose crest weir + spill for bank sides	Y
27KILR00104E	01WOO01025u	Cappagh Road Bridge 9.34 m wide	Arch Bridge Unit	Y
27KILR00099D	N/A	Footbridge 1.12 m wide	NA	N*
27KILR00001	01WOO00030u	Kilrush Tidal gate	Sluice unit + Spill	Y

* Considering the size of the structure relative to the watercourse it was determined that the structure would have little or no hydraulic impact on the model during flood flows.
** This structure is formed from two parallel (same length) culverts

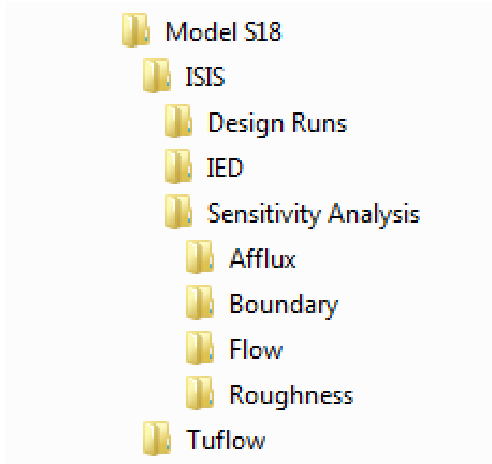
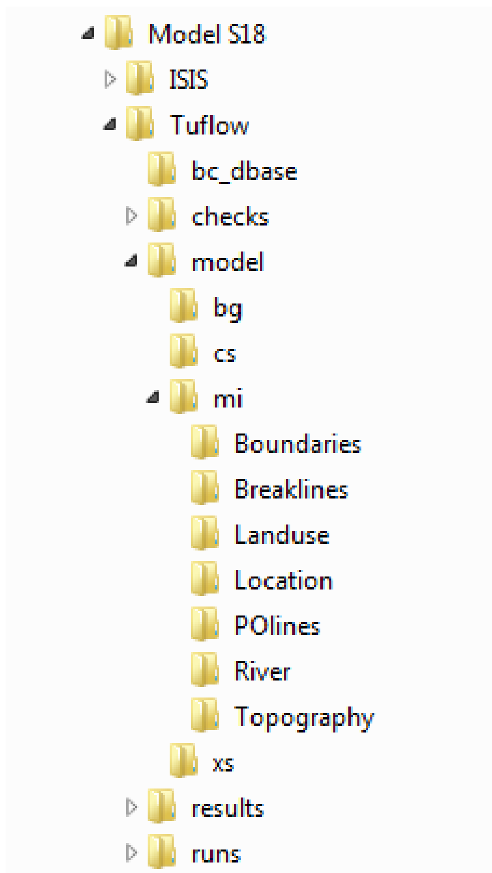
Schedule B.1 – In-bank Manning's 'n' for HPW Network

River Name	Cross Sections	In-bank Roughness
27KILA00151J to 27KILA00134	01WOO04754 to 01WOO04584	0.045
27KILA00126 to 27KILA00001	01WOO04506 to 01WOO03256	0.050
27KILR00323 to 27KILR00107X	01WOO03197 to 01WOO01039	0.040
27KILR00104E to 27KILR00001	01WOO01025 to 01WOO00000	0.030

Annex C – Model Calibration

Not used as calibration to historical events was not possible.

Annex D - Hydraulic Model Files

<table>
<tr><th colspan="2">Model Files Folders Structure</th></tr>
<tr><td>ISIS</td><td>
</td></tr>
<tr><td>TUFLOW</td><td>
</td></tr>
</table>

ISIS Files	
Model Geometry (.dat) and Associated Files (e.g.: .ief, .zzl, .zzd, .zzu,.zzx)	**Design Runs – Fluvial Scenarios:** S18_Q1000_FluMi_C_Des_Iss1.DAT S18_Q200_FluMi_C_Des_Iss1.DAT S18_Q100_FluMi_C_Des_Iss1.DAT S18_Q50_FluMi_C_Des_Iss1.DAT S18_Q20_FluMi_C_Des_Iss1.DAT S18_Q10_FluMi_C_Des_Iss1.DAT S18_Q5_FluMi_C_Des_Iss1.DAT S18_Q2_FluMi_C_Des_Iss1.DAT **Design Runs – Tidal Scenarios:** S18_Q1000_CoMi_C_Des_Iss1.DAT S18_Q200_CoMi_C_Des_Iss1.DAT S18_Q100_CoMi_C_Des_Iss1.DAT S18_Q50_CoMi_C_Des_Iss1.DAT S18_Q20_CoMi_C_Des_Iss1.DAT S18_Q10_CoMi_C_Des_Iss1.DAT S18_Q5_CoMi_C_Des_Iss1.DAT S18_Q2_CoMi_C_Des_Iss1.DAT **Sensitivity Runs –Current Scenarios:** S18_Q100_FluMi_C_Sen_AfIn.DAT (Afflux increased by 20%) S18_Q100_FluMi_C_Sen_AfDe.DAT (Afflux decreased by 20%) S18_Q200_CoMi_C_Sen_InSurDu.DAT (Surge duration increased by 100%) S18_Q200_CoMi_C_Sen_DeSurDu.DAT (Surge duration decreased by 50%) S18_Q100_FluMi_C_Sen_FlIn.DAT (Inflows increased by 20%) S18_Q100_FluMi_C_Sen_FlDe.DAT (Inflows decreased by 20%) S18_Q100_FluMi_C_Sen_RoIn.DAT (Roughness increased by 20%) S18_Q100_FluMi_C_Sen_RoDe.DAT (Roughness decreased by 20%)
Hydrological Inflow Files	**Design Runs – Current Scenarios:** **Current Fluvial Scenarios:** S18_Kilr_Flu1000yr_Co50yr.IED S18_Kilr_Flu200yr_Co10yr.IED S18_Kilr_Flu100yr_Co5yr.IED S18_Kilr_Flu50yr_Co2yr.IED S18_Kilr_Flu20yr_Co1yr.IED S18_Kilr_Flu10yr_Co0.5yr.IED S18_Kilr_Flu5yr_Co0.2yr.IED S18_Kilr_Flu2yr_Co0.2yr.IED

	Current Tidal Scenarios S18_Kilr_Flu50yr_Co1000yr.IED S18_Kilr_Flu10yr_Co200yr.IED S18_Kilr_Flu5yr_Co100yr.IED S18_Kilr_Flu2yr_Co50yr.IED S18_Kilr_Flu2yr_Co20yr.IED S18_Kilr_Flu2yr_Co10yr.IED S18_Kilr_Flu2yr_Co5yr.IED S18_Kilr_Flu2yr_Co2yr.IED **Sensitivity Runs – Current Scenarios** S18_Kilr_Flu10yr_Co200yr_InSurDu.IED (Surge duration increased by 100%) S18_Kilr_Flu10yr_Co200yr_DeSurDu.IED (Surge duration decreased by 50%) S18_Kilr_Flu100yr_Co5yr_FlIn.IED (Inflows increased by 20%) S18_Kilr_Flu100yr_Co5yr_FlDe.IED (Inflows decreased by 20%)

TUFLOW Files	
TUFLOW Control Files (.tcf) and Associated Files (e.g.: ecf, tgc, tbc)	**Design Runs – Current Fluvial Scenarios:** S18_Q1000_FluMi_C_Des_Iss1.tcf S18_Q200_FluMi_C_Des_Iss1.tcf S18_Q100_FluMi_C_Des_Iss1.tcf S18_Q50_FluMi_C_Des_Iss1.tcf S18_Q20_FluMi_C_Des_Iss1.tcf S18_Q10_FluMi_C_Des_Iss1.tcf S18_Q5_FluMi_C_Des_Iss1.tcf S18_Q2_FluMi_C_Des_Iss1.tcf **Design Runs – Current Tidal Scenarios:** S18_Q1000_CoMi_C_Des_Iss1.tcf S18_Q200_CoMi_C_Des_Iss1.tcf S18_Q100_CoMi_C_Des_Iss1.tcf S18_Q50_CoMi_C_Des_Iss1.tcf S18_Q20_CoMi_C_Des_Iss1.tcf S18_Q10_CoMi_C_Des_Iss1.tcf S18_Q5_CoMi_C_Des_Iss1.tcf S18_Q2_CoMi_C_Des_Iss1.tcf **Sensitivity Runs – Current Scenarios:** S18_Q100_FluMi_C_Sen_AfIn.tcf (Afflux increased by 20%) S18_Q100_FluMi_C_Sen_AfDe.tcf (Afflux decreased by 20%) S18_Q200_CoMi_C_Sen_InSurDu.tcf (Surge duration increased by 100%) S18_Q200_CoMi_C_Sen_DeSurDu.tcf (Surge duration decreased by 50%)

	S18_Q100_FluMi_C_Sen_FlIn.tcf (Inflows increased by 20%) S18_Q100_FluMi_C_Sen_FlDe.tcf (Inflows decreased by 20%) S18_Q100_FluMi_C_Sen_RoIn.tcf (Roughness increased by 20%) S18_Q100_FluMi_C_Sen_RoDe.tcf (Roughness decreased by 20%)
Grid Orientation File	2d_loc_4m_S18_Kilr.TAB
Material Files	2d_mat_rural_S18_Kilr.MIF 2d_mat_vegetation_S18_Kilr.MIF 2d_mat_water_S18_kilr.MIF 2d_mat_roads_S18_Kilr.MIF 2d_mat_buildings_S18_Kilr.MIF 2d_mat_flatrock_S18_Kilr.MIF S18_Kilr_Landuse.tmf S18_Kilr_Landuse_RoIn.tmf S18_Kilr_Landuse_RoDe.tmf
Zpt Files, Model DTM (.asc)	kilrush2m_dtm.asc
Breaklines Files	2d_zln_Thick_defence_4m_S18_Kilr.MIF 2d_zln_Thin_defence_4m_S18_Kilr.MIF 2d_zln_unsurv_banktop_4m_S18_Kilr.MIF 2d_zln_gully_4m_S18_Kilr.MIF 2d_zln_bridge_parapets_4m_S18_Kilr.MIF
Boundary Files	2d_bc_hxe_4m_S18_Kilr.MIF 2d_bc_hxi_4m_S18_Kilr.TAB 2d_bc_HT_4m_S18_Kilr.MIF 2d_bc_HQ_4m_S18_Kilr.MIF
Flow/Head Files in bc_dbase	**Design Runs:** **Current Fluvial Scenarios:** bc_dbase_S18_Kilr_Flu1000yr_Co50yr.csv bc_dbase_S18_Kilr_Flu200yr_Co10yr.csv bc_dbase_S18_Kilr_Flu100yr_Co5yr.csv bc_dbase_S18_Kilr_Flu50yr_Co2yr.csv bc_dbase_S18_Kilr_Flu20yr_Co1yr.csv bc_dbase_S18_Kilr_Flu10yr_Co0.5yr.csv bc_dbase_S18_Kilr_Flu5yr_Co0.2yr.csv bc_dbase_S18_Kilr_Flu2yr_Co0.2yr.csv **Current Tidal Scenarios:** bc_dbase_S18_Kilr_Flu50yr_Co1000yr.csv bc_dbase_S18_Kilr_Flu10yr_Co200yr.csv bc_dbase_S18_Kilr_Flu5yr_Co100yr.csv bc_dbase_S18_Kilr_Flu2yr_Co50yr.csv bc_dbase_S18_Kilr_Flu2yr_Co20yr.csv bc_dbase_S18_Kilr_Flu2yr_Co10yr.csv bc_dbase_S18_Kilr_Flu2yr_Co5yr.csv bc_dbase_S18_Kilr_Flu2yr_Co2yr.csv

	Sensitivity Runs – Current Scenario bc_dbase_S18_Kilr_Flu10yr_Co200yr_InSurDu.csv (Surge duration increased by 100%) bc_dbase_S18_Kilr_Flu10yr_Co200yr_DeSurDu.csv (Surge duration decreased by 50%)
Initial Water Level Files	NA
Time Series Files	**Design runs – Current scenario:** HT_S18_Kilr_Tidal.csv **Sensitivity runs – Current scenario** HT_S18_Kilr_Tidal_Sens.csv
One Dimensional Network Files	1d_ISIS_nodes_4m_S18_Kilr.MIF
Available 2D Result Files	Depth, stage, hazard and velocity 2d results in ASCII file format for all available design return periods.

Model Run Log						
Sr. No.	**Model File Name**	**Start Time**	**End Time**	**Time Step**	**Advanced Options /Other Information**	**Comments on Model Stability**
Design Runs						
1	S18_Q1000_FluMi_C_Des_Iss1.DAT	0	20	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
2	S18_Q200_FluMi_C_Des_Iss1.DAT	0	20	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
3	S18_Q100_FluMi_C_Des_Iss1.DAT	0	20	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
4	S18_Q50_FluMi_C_Des_Iss1.DAT	0	20	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
5	S18_Q20_FluMi_C_Des_Iss1.DAT	0	20	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
6	S18_Q10_FluMi_C_Des_Iss1.DAT	0	20	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.

Sr. No.	Model File Name	Start Time	End Time	Time Step	Advanced Options /Other Information	Comments on Model Stability
7	S18_Q5_FluMi_C_Des_Iss1.DAT	0	20	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
8	S18_Q2_FluMi_C_Des_Iss1.DAT	0	20	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
9	S18_Q1000_CoMi_C_Des_Iss1.DAT	0	20	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
10	S18_Q200_CoMi_C_Des_Iss1.DAT	0	20	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
11	S18_Q100_CoMi_C_Des_Iss1.DAT	0	20	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
12	S18_Q50_CoMi_C_Des_Iss1.DAT	0	20	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
13	S18_Q20_CoMi_C_Des_Iss1.DAT	0	20	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.

Sr. No.	Model File Name	Start Time	End Time	Time Step	Advanced Options /Other Information	Comments on Model Stability
14	S18_Q10_CoMi_C_Des_Iss1.DAT	0	20	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
15	S18_Q5_CoMi_C_Des_Iss1.DAT	0	20	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
16	S18_Q2_CoMi_C_Des_Iss1.DAT	0	20	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked and "perform corrective 1d timestep" is checked. All other run parameters = default.	Convergence within manufacturer tolerance.
Sensitivity Analysis						
Sr. No.	**Model File Name**	**Start Time**	**End Time**	**Time Step**	**Advanced Options /Other Information**	**Comments on Model Stability**
1	S18_Q100_FluMi_C_Sens_AfIn.DAT	0	20	1 sec 1D 1 sec 2D	Run parameters as Design Runs above. Calibration coefficients of bridges 01WOO03594bu and 01WOO01767bu increased to 1.2	Convergence within manufacturer tolerance.
2	S18_Q100_FluMi_C_Sens_AfDe.DAT	0	20	1 sec 1D 1 sec 2D	Run parameters as Design Runs above. Calibration coefficients of bridges 01WOO03594bu and 01WOO01767bu decreased to 0.8	Convergence within manufacturer tolerance.
3	S18_Q200_CoMi_C_Sens_InSurDu.DAT	0	20	1 sec 1D 1 sec 2D	Run parameters as Design Runs above. Surge duration increased by 100%	Convergence within manufacturer tolerance.
4	S18_Q200_CoMi_C_Sens_DeSurDu.DAT	0	20	1 sec 1D 1 sec 2D	Run parameters as Design Runs above. Surge duration decreased by 50%	Convergence within manufacturer tolerance.

Sr. No.	Model File Name	Start Time	End Time	Time Step	Advanced Options /Other Information	Comments on Model Stability
5	S18_Q100_FluMi_C_Sens_FlIn.DAT	0	20	1 sec 1D 1 sec 2D	Run parameters as Design Runs above. Model inflows have been increased by 20%	Convergence within manufacturer tolerance.
6	S18_Q100_FluMi_C_Sens_FlDe.DAT	0	20	1 sec 1D 1 sec 2D	Run parameters as Design Runs above. Model inflows have been decreased by 20%	Convergence within manufacturer tolerance.
7	S18_Q100_FluMi_C_Sens_RoIn.DAT	0	20	1 sec 1D 1 sec 2D	Run parameters as Design Runs above. The roughness has been increased by 20% in 1D and 2D model	Convergence within manufacturer tolerance.
8	S18_Q100_FluMi_C_Sens_RoDe.DAT	0	20	1 sec 1D 1 sec 2D	Run parameters as Design Runs above. The roughness has been decreased by 20% in 1D and 2D model	Convergence within manufacturer tolerance.

Parameters changed from Default	Justification
Automated Preismann slot for River Sections turned on.	Automated Preismann slot are a standard parameter used to aid model stability particularly in low flows. These Preismann slots have negligible to no impact on the water levels during flood events.
Matrix Dummy Coefficient set to 0.0001	Set to 0.0001 to solve IFAG error. *

*Stage and Flow profiles at all cross sections have been checked to ensure results are sensible and to ensure any changes to the default model run parameters has not impacted on the model results

Annex E - Flood Mapping

Flood Maps are available through the OPW flood mapping website; http://maps.opw.ie/fhrm/

Annex F - Wave Overtopping

ICWWS CAPO Kilrush
Prediction Locations

Location A2
Current

	AEP																							
	50%			20%			10%			5%			2%			1%			0.50%			0.10%		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
14.0	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30
14.2	-	0.00	-2.17	-	0.00	-2.17	-	0.00	-2.17	-	0.00	-2.16	-	0.00	-2.15	-	0.00	-2.14	-	0.00	-2.14	-	0.00	-2.14
14.3	-	0.00	-2.04	-	0.00	-2.03	-	0.00	-2.03	-	0.00	-2.01	-	0.00	-2.00	-	0.00	-1.99	-	0.00	-1.98	-	0.00	-1.98
14.5	-	0.00	-1.91	-	0.00	-1.90	-	0.00	-1.90	-	0.00	-1.87	-	0.00	-1.84	-	0.00	-1.83	-	0.00	-1.82	-	0.00	-1.82
14.7	-	0.00	-1.78	-	0.00	-1.77	-	0.00	-1.77	-	0.00	-1.73	-	0.00	-1.69	-	0.00	-1.68	-	0.00	-1.66	-	0.00	-1.66
14.8	-	0.00	-1.66	-	0.00	-1.63	-	0.00	-1.63	-	0.00	-1.59	-	0.00	-1.54	-	0.00	-1.52	-	0.00	-1.50	-	0.00	-1.50
15.0	-	0.00	-1.53	-	0.00	-1.50	-	0.00	-1.50	-	0.00	-1.45	-	0.00	-1.39	-	0.00	-1.37	-	0.00	-1.34	-	0.00	-1.34
15.2	-	0.00	-1.40	-	0.00	-1.37	-	0.00	-1.37	-	0.00	-1.30	-	0.00	-1.24	-	0.00	-1.21	-	0.00	-1.19	-	0.00	-1.19
15.3	-	0.00	-1.27	-	0.00	-1.24	-	0.00	-1.24	-	0.00	-1.16	-	0.00	-1.09	-	0.00	-1.06	-	0.00	-1.03	-	0.00	-1.03
15.5	-	0.00	-1.04	-	0.00	-1.01	-	0.00	-1.01	-	0.00	-0.92	-	0.00	-0.84	-	0.00	-0.81	-	0.00	-0.77	-	0.00	-0.77
15.7	-	0.00	-0.92	-	0.00	-0.88	-	0.00	-0.88	-	0.00	-0.78	-	0.00	-0.69	-	0.00	-0.66	-	0.00	-0.62	-	0.00	-0.62
15.8	-	0.00	-0.79	-	0.00	-0.75	-	0.00	-0.75	-	0.00	-0.65	-	0.00	-0.55	-	0.00	-0.51	-	0.00	-0.46	-	0.00	-0.46
16.0	-	0.00	-0.57	-	0.00	-0.52	-	0.00	-0.52	-	0.00	-0.41	-	0.00	-0.30	-	0.00	-0.26	-	0.00	-0.21	-	0.00	-0.21
16.2	-	0.00	-0.44	-	0.00	-0.39	-	0.00	-0.39	-	0.00	-0.27	-	0.00	-0.16	-	0.00	-0.11	-	0.00	-0.06	-	0.00	-0.06
16.3	-	0.00	-0.22	-	0.00	-0.16	-	0.00	-0.16	-	0.00	-0.04	-	0.00	0.09	-	0.00	0.14	-	0.00	0.19	-	0.00	0.19
16.5	-	0.00	0.01	-	0.00	0.06	-	0.00	0.06	-	0.00	0.20	-	0.00	0.33	-	0.00	0.38	-	0.00	0.44	-	0.00	0.44
16.7	-	0.00	0.13	-	0.00	0.19	-	0.00	0.19	-	0.00	0.33	-	0.00	0.47	-	0.00	0.53	-	0.00	0.59	-	0.00	0.59
16.8	-	0.00	0.35	-	0.00	0.42	-	0.00	0.42	-	0.00	0.56	-	0.00	0.71	-	0.00	0.77	-	0.00	0.83	-	0.00	0.83
17.0	-	0.00	0.57	-	0.00	0.64	-	0.00	0.64	-	0.00	0.80	-	0.00	0.95	-	0.00	1.01	-	0.00	1.07	-	0.00	1.07
17.2	-	0.00	0.69	-	0.00	0.76	-	0.00	0.76	-	0.00	0.92	-	0.00	1.08	-	0.00	1.15	-	0.00	1.22	-	0.00	1.22
17.3	-	0.00	0.91	-	0.00	0.98	-	0.00	0.98	-	0.00	1.15	-	0.00	1.32	-	0.00	1.39	-	0.00	1.46	-	0.00	1.46
17.5	-	0.00	1.13	-	0.00	1.21	-	0.00	1.21	-	0.00	1.38	-	0.00	1.55	-	0.00	1.62	0.02	0.00	1.69	0.07	0.01	1.69
17.7	-	0.00	1.25	-	0.00	1.33	-	0.00	1.33	-	0.00	1.51	-	0.00	1.68	0.02	0.00	1.75	0.03	0.00	1.83	0.09	0.01	1.83
17.8	-	0.00	1.46	-	0.00	1.54	-	0.00	1.54	-	0.00	1.73	0.02	0.00	1.91	0.03	0.00	1.99	0.05	0.01	2.06	0.16	0.02	2.06
18.0	-	0.00	1.68	-	0.00	1.76	0.02	0.00	1.76	0.02	0.00	1.95	0.03	0.00	2.14	0.06	0.01	2.21	0.09	0.01	2.29	0.28	0.03	2.29
18.2	-	0.00	1.79	0.01	0.00	1.88	0.02	0.00	1.88	0.03	0.00	2.07	0.05	0.01	2.26	0.09	0.01	2.34	0.13	0.02	2.42	0.39	0.05	2.42
18.3	0.01	0.00	1.91	0.01	0.00	1.99	0.03	0.00	1.99	0.04	0.00	2.19	0.07	0.01	2.38	0.12	0.01	2.47	0.19	0.02	2.55	0.54	0.06	2.55
18.5	0.01	0.00	2.02	0.02	0.00	2.10	0.04	0.00	2.10	0.06	0.01	2.31	0.10	0.01	2.50	0.17	0.02	2.59	0.27	0.03	2.67	0.73	0.09	2.67
18.7	0.01	0.00	2.13	0.03	0.00	2.22	0.06	0.01	2.22	0.08	0.01	2.42	0.14	0.02	2.62	0.24	0.03	2.71	0.37	0.04	2.79	1.00	0.12	2.79
18.8	0.02	0.00	2.24	0.04	0.00	2.33	0.08	0.01	2.33	0.12	0.01	2.54	0.20	0.02	2.74	0.33	0.04	2.83	0.52	0.06	2.91	1.34	0.16	2.91
19.0	0.03	0.00	2.35	0.06	0.01	2.44	0.10	0.01	2.44	0.16	0.02	2.65	0.28	0.03	2.86	0.47	0.06	2.94	0.73	0.09	3.03	1.81	0.21	3.03
19.2	0.04	0.00	2.45	0.08	0.01	2.54	0.14	0.02	2.54	0.22	0.03	2.76	0.39	0.05	2.97	0.66	0.08	3.06	1.04	0.12	3.15	2.44	0.29	3.15
19.3	0.05	0.01	2.56	0.11	0.01	2.65	0.19	0.02	2.65	0.30	0.04	2.87	0.56	0.07	3.08	0.94	0.11	3.17	1.48	0.17	3.26	3.29	0.39	3.26
19.5	0.05	0.01	2.56	0.11	0.01	2.66	0.19	0.02	2.66	0.31	0.04	2.87	0.58	0.07	3.09	0.97	0.11	3.18	1.52	0.18	3.27	3.37	0.40	3.27
19.7	0.05	0.01	2.57	0.11	0.01	2.66	0.19	0.02	2.66	0.31	0.04	2.88	0.59	0.07	3.09	0.98	0.12	3.18	1.55	0.18	3.27	3.43	0.40	3.27
19.8	0.07	0.01	2.66	0.15	0.02	2.76	0.26	0.03	2.76	0.42	0.05	2.98	0.81	0.10	3.19	1.36	0.16	3.28	2.14	0.25	3.37	4.47	0.53	3.37
20.0	0.07	0.01	2.66	0.15	0.02	2.76	0.26	0.03	2.76	0.42	0.05	2.98	0.81	0.10	3.19	1.36	0.16	3.28	2.14	0.25	3.37	4.48	0.53	3.37
20.2	0.07	0.01	2.66	0.15	0.02	2.76	0.26	0.03	2.76	0.42	0.05	2.98	0.81	0.10	3.19	1.36	0.16	3.28	2.14	0.25	3.37	4.47	0.53	3.37
20.3	0.07	0.01	2.66	0.15	0.02	2.76	0.26	0.03	2.76	0.41	0.05	2.97	0.80	0.09	3.19	1.34	0.16	3.28	2.11	0.25	3.37	4.42	0.52	3.37
20.5	0.05	0.01	2.56	0.11	0.01	2.66	0.19	0.02	2.66	0.31	0.04	2.87	0.58	0.07	3.09	0.97	0.11	3.18	1.52	0.18	3.27	3.37	0.40	3.27
20.7	0.05	0.01	2.56	0.11	0.01	2.65	0.19	0.02	2.65	0.30	0.04	2.87	0.56	0.07	3.08	0.94	0.11	3.17	1.48	0.17	3.26	3.29	0.39	3.26
20.8	0.04	0.00	2.45	0.08	0.01	2.54	0.14	0.02	2.54	0.22	0.03	2.76	0.39	0.05	2.97	0.66	0.08	3.06	1.04	0.12	3.15	2.44	0.29	3.15
21.0	0.03	0.00	2.35	0.06	0.01	2.44	0.10	0.01	2.44	0.16	0.02	2.65	0.28	0.03	2.86	0.47	0.06	2.94	0.73	0.09	3.03	1.81	0.21	3.03
21.2	0.02	0.00	2.24	0.04	0.00	2.33	0.08	0.01	2.33	0.12	0.01	2.54	0.20	0.02	2.74	0.33	0.04	2.83	0.52	0.06	2.91	1.34	0.16	2.91
21.3	0.01	0.00	2.13	0.03	0.00	2.22	0.06	0.01	2.22	0.08	0.01	2.42	0.14	0.02	2.62	0.24	0.03	2.71	0.37	0.04	2.79	1.00	0.12	2.79
21.5	0.01	0.00	1.92	0.02	0.00	2.00	0.03	0.00	2.00	0.04	0.01	2.21	0.08	0.01	2.40	0.13	0.02	2.49	0.20	0.02	2.57	0.57	0.07	2.57
21.7	-	0.00	1.81	0.01	0.00	1.89	0.02	0.00	1.89	0.03	0.00	2.09	0.05	0.01	2.28	0.09	0.01	2.37	0.14	0.02	2.45	0.42	0.05	2.45
21.8	-	0.00	1.59	-	0.00	1.68	-	0.00	1.68	0.02	0.00	1.87	0.03	0.00	2.06	0.05	0.01	2.14	0.08	0.01	2.22	0.24	0.03	2.22
22.0	-	0.00	1.38	-	0.00	1.46	-	0.00	1.46	-	0.00	1.65	0.01	0.00	1.84	0.03	0.00	1.91	0.04	0.00	1.99	0.14	0.02	1.99
22.2	-	0.00	1.26	-	0.00	1.34	-	0.00	1.34	-	0.00	1.53	-	0.00	1.71	0.02	0.00	1.79	0.03	0.00	1.86	0.10	0.01	1.86
22.3	-	0.00	1.05	-	0.00	1.13	-	0.00	1.13	-	0.00	1.31	-	0.00	1.48	-	0.00	1.55	-	0.00	1.63	0.06	0.01	1.63
22.5	-	0.00	0.83	-	0.00	0.91	-	0.00	0.91	-	0.00	1.08	-	0.00	1.25	-	0.00	1.32	-	0.00	1.39	-	0.00	1.39
22.7	-	0.00	0.71	-	0.00	0.78	-	0.00	0.78	-	0.00	0.95	-	0.00	1.12	-	0.00	1.19	-	0.00	1.26	-	0.00	1.26
22.8	-	0.00	0.49	-	0.00	0.56	-	0.00	0.56	-	0.00	0.72	-	0.00	0.88	-	0.00	0.95	-	0.00	1.02	-	0.00	1.02
23.0	-	0.00	0.27	-	0.00	0.34	-	0.00	0.34	-	0.00	0.50	-	0.00	0.65	-	0.00	0.71	-	0.00	0.77	-	0.00	0.77
23.2	-	0.00	0.15	-	0.00	0.22	-	0.00	0.22	-	0.00	0.36	-	0.00	0.51	-	0.00	0.57	-	0.00	0.63	-	0.00	0.63
23.3	-	0.00	-0.07	-	0.00	-0.01	-	0.00	-0.01	-	0.00	0.13	-	0.00	0.27	-	0.00	0.33	-	0.00	0.39	-	0.00	0.39
23.5	-	0.00	-0.29	-	0.00	-0.24	-	0.00	-0.24	-	0.00	-0.10	-	0.00	0.03	-	0.00	0.08	-	0.00	0.14	-	0.00	0.14
23.7	-	0.00	-0.52	-	0.00	-0.46	-	0.00	-0.46	-	0.00	-0.34	-	0.00	-0.21	-	0.00	-0.16	-	0.00	-0.11	-	0.00	-0.11
23.8	-	0.00	-0.64	-	0.00	-0.59	-	0.00	-0.59	-	0.00	-0.47	-	0.00	-0.36	-	0.00	-0.31	-	0.00	-0.26	-	0.00	-0.26
24.0	-	0.00	-0.87	-	0.00	-0.82	-	0.00	-0.82	-	0.00	-0.71	-	0.00	-0.60	-	0.00	-0.56	-	0.00	-0.51	-	0.00	-0.51
24.2	-	0.00	-1.09	-	0.00	-1.05	-	0.00	-1.05	-	0.00	-0.95	-	0.00	-0.85	-	0.00	-0.81	-	0.00	-0.76	-	0.00	-0.76
24.3	-	0.00	-1.22	-	0.00	-1.18	-	0.00	-1.18	-	0.00	-1.08	-	0.00	-0.99	-	0.00	-0.96	-	0.00	-0.92	-	0.00	-0.92
24.5	-	0.00	-1.44	-	0.00	-1.41	-	0.00	-1.41	-	0.00	-1.32	-	0.00	-1.24	-	0.00	-1.21	-	0.00	-1.17	-	0.00	-1.17
24.7	-	0.00	-1.67	-	0.00	-1.64	-	0.00	-1.64	-	0.00	-1.56	-	0.00	-1.49	-	0.00	-1.46	-	0.00	-1.43	-	0.00	-1.43
24.8	-	0.00	-1.80	-	0.00	-1.77	-	0.00	-1.77	-	0.00	-1.70	-	0.00	-1.64	-	0.00	-1.61	-	0.00	-1.59	-	0.00	-1.59
25.0	-	0.00	-2.03	-	0.00	-2.00	-	0.00	-2.00	-	0.00	-1.95	-	0.00	-1.89	-	0.00	-1.87	-	0.00	-1.84	-	0.00	-1.84
25.2	-	0.00	-2.16	-	0.00	-2.13	-	0.00	-2.13	-	0.00	-2.09	-	0.00	-2.04	-	0.00	-2.02	-	0.00	-2.00	-	0.00	-2.00
25.3	-	0.00	-2.28	-	0.00	-2.27	-	0.00	-2.27	-	0.00	-2.23	-	0.00	-2.19	-	0.00	-2.18	-	0.00	-2.16	-	0.00	-2.16
25.5	-	0.00	-2.31	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.27	-	0.00	-2.24	-	0.00	-2.23	-	0.00	-2.22	-	0.00	-2.22
25.7	-	0.00	-2.45	-	0.00	-2.44	-	0.00	-2.44	-	0.00	-2.42	-	0.00	-2.40	-	0.00	-2.39	-	0.00	-2.38	-	0.00	-2.38
25.8	-	0.00	-2.48	-	0.00	-2.47	-	0.00	-2.47	-	0.00	-2.46	-	0.00	-2.45	-	0.00	-2.45	-	0.00	-2.44	-	0.00	-2.44
26.0	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51

Mid range Future Scenario

	50%			20%			10%			5%			2%			1%			0.50%			0.10%		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
14.0	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30
14.2	-	0.00	-2.15	-	0.00	-2.14	-	0.00	-2.14	-	0.00	-2.13	-	0.00	-2.13	-	0.00	-2.12	-	0.00	-2.12	-	0.00	-2.12
14.3	-	0.00	-2.01	-	0.00	-1.98	-	0.00	-1.97	-	0.00	-1.96	-	0.00	-1.95	-	0.00	-1.94	-	0.00	-1.94	-	0.00	-1.94
14.5	-	0.00	-1.86	-	0.00	-1.82	-	0.00	-1.81	-	0.00	-1.79	-	0.00	-1.78	-	0.00	-1.77	-	0.00	-1.75	-	0.00	-1.75
14.7	-	0.00	-1.71	-	0.00	-1.66	-	0.00	-1.64	-	0.00	-1.63	-	0.00	-1.61	-	0.00	-1.59	-	0.00	-1.57	-	0.00	-1.57
14.8	-	0.00	-1.57	-	0.00	-1.50	-	0.00	-1.48	-	0.00	-1.46	-	0.00	-1.44	-	0.00	-1.41	-	0.00	-1.39	-	0.00	-1.39
15.0	-	0.00	-1.42	-	0.00	-1.34	-	0.00	-1.32	-	0.00	-1.29	-	0.00	-1.26	-	0.00	-1.24	-	0.00	-1.21	-	0.00	-1.21
15.2	-	0.00	-1.28	-	0.00	-1.18	-	0.00	-1.15	-	0.00	-1.13	-	0.00	-1.09	-	0.00	-1.06	-	0.00	-1.04	-	0.00	-1.04
15.3	-	0.00	-1.13	-	0.00	-1.02	-	0.00	-0.99	-	0.00	-0.96	-	0.00	-0.92	-	0.00	-0.89	-	0.00	-0.86	-	0.00	-0.86
15.5	-	0.00	-0.89	-	0.00	-0.77	-	0.00	-0.73	-	0.00	-0.70	-	0.00	-0.65	-	0.00	-0.62	-	0.00	-0.58	-	0.00	-0.58
15.7	-	0.00	-0.75	-	0.00	-0.61	-	0.00	-0.57	-	0.00	-0.53	-	0.00	-0.48	-	0.00	-0.44	-	0.00	-0.41	-	0.00	-0.41
15.8	-	0.00	-0.60	-	0.00	-0.46	-	0.00	-0.42	-	0.00	-0.37	-	0.00	-0.32	-	0.00	-0.27	-	0.00	-0.23	-	0.00	-0.23
16.0	-	0.00	-0.36	-	0.00	-0.21	-	0.00	-0.16	-	0.00	-0.11	-	0.00	-0.05	-	0.00	-0.01	-	0.00	0.04	-	0.00	0.04
16.2	-	0.00	-0.22	-	0.00	-0.05	-	0.00	0.00	-	0.00	0.05	-	0.00	0.11	-	0.00	0.16	-	0.00	0.21	-	0.00	0.21
16.3	-	0.00	0.02	-	0.00	0.20	-	0.00	0.25	-	0.00	0.30	-	0.00	0.37	-	0.00	0.42	-	0.00	0.48	-	0.00	0.48
16.5	-	0.00	0.25	-	0.00	0.45	-	0.00	0.50	-	0.00	0.56	-	0.00	0.63	-	0.00	0.69	-	0.00	0.74	-	0.00	0.74
16.7	-	0.00	0.39	-	0.00	0.59	-	0.00	0.65	-	0.00	0.71	-	0.00	0.79	-	0.00	0.85	-	0.00	0.91	-	0.00	0.91
16.8	-	0.00	0.63	-	0.00	0.84	-	0.00	0.90	-	0.00	0.96	-	0.00	1.05	-	0.00	1.11	-	0.00	1.17	-	0.00	1.17
17.0	-	0.00	0.86	-	0.00	1.08	-	0.00	1.15	-	0.00	1.21	-	0.00	1.30	-	0.00	1.36	-	0.00	1.43	-	0.00	1.43
17.2	-	0.00	0.99	-	0.00	1.22	-	0.00	1.29	-	0.00	1.36	-	0.00	1.45	-	0.00	1.52	-	0.00	1.58	0.06	0.01	1.58
17.3	-	0.00	1.22	-	0.00	1.46	-	0.00	1.54	-	0.00	1.61	-	0.00	1.70	0.02	0.00	1.77	0.03	0.00	1.84	0.12	0.01	1.84
17.5	-	0.00	1.45	-	0.00	1.70	-	0.00	1.78	0.01	0.00	1.85	0.02	0.00	1.95	0.04	0.00	2.02	0.06	0.01	2.09	0.21	0.03	2.09
17.7	-	0.00	1.58	-	0.00	1.84	0.01	0.00	1.92	0.02	0.00	1.99	0.04	0.00	2.09	0.06	0.01	2.16	0.09	0.01	2.24	0.30	0.04	2.24
17.8	0.01	0.00	1.81	0.01	0.00	2.07	0.02	0.00	2.15	0.04	0.00	2.21	0.07	0.01	2.33	0.12	0.01	2.41	0.18	0.02	2.48	0.55	0.06	2.48
18.0	0.02	0.00	2.03	0.03	0.00	2.30	0.05	0.01	2.38	0.08	0.01	2.46	0.14	0.02	2.57	0.23	0.03	2.65	0.36	0.04	2.73	1.00	0.12	2.73
18.2	0.03	0.00	2.15	0.04	0.01	2.43	0.07	0.01	2.52	0.11	0.01	2.60	0.21	0.02	2.70	0.34	0.04	2.79	0.53	0.06	2.87	1.40	0.17	2.87
18.3	0.05	0.01	2.27	0.06	0.01	2.56	0.11	0.01	2.64	0.17	0.02	2.73	0.30	0.04	2.84	0.49	0.06	2.92	0.77	0.09	3.00	1.97	0.23	3.00
18.5	0.06	0.01	2.39	0.09	0.01	2.68	0.15	0.02	2.77	0.24	0.03	2.86	0.44	0.05	2.97	0.72	0.09	3.05	1.14	0.13	3.14	2.76	0.33	3.14
18.7	0.09	0.01	2.51	0.13	0.02	2.81	0.22	0.03	2.89	0.36	0.04	2.98	0.66	0.08	3.09	1.08	0.13	3.18	1.70	0.20	3.26	3.86	0.46	3.26
18.8	0.13	0.02	2.62	0.19	0.02	2.93	0.33	0.04	3.01	0.53	0.06	3.10	0.99	0.12	3.22	1.61	0.19	3.30	2.53	0.30	3.39	5.33	0.63	3.39
19.0	0.18	0.02	2.74	0.29	0.03	3.04	0.49	0.06	3.13	0.80	0.09	3.22	1.48	0.17	3.34	2.40	0.28	3.43	3.75	0.44	3.51	7.33	0.87	3.51
19.2	0.25	0.03	2.85	0.43	0.05	3.16	0.73	0.09	3.25	1.20	0.14	3.34	2.21	0.26	3.46	3.55	0.42	3.54	5.47	0.65	3.63	10.00	1.18	3.63
19.3	0.35	0.04	2.96	0.64	0.08	3.27	1.09	0.13	3.36	1.78	0.21	3.45	3.25	0.38	3.57	5.15	0.61	3.66	7.77	0.92	3.75	13.44	1.59	3.75
19.5	0.35	0.04	2.96	0.66	0.08	3.28	1.13	0.13	3.37	1.85	0.22	3.46	3.38	0.40	3.58	5.35	0.63	3.67	8.07	0.95	3.76	13.88	1.64	3.76
19.7	0.36	0.04	2.97	0.68	0.08	3.28	1.16	0.14	3.38	1.90	0.22	3.47	3.48	0.41	3.59	5.48	0.65	3.68	8.29	0.98	3.77	14.20	1.68	3.77
19.8	0.49	0.06	3.07	0.97	0.12	3.38	1.67	0.20	3.48	2.70	0.32	3.57	4.83	0.57	3.69	7.47	0.88	3.78	11.09	1.31	3.87	18.14	2.14	3.87
20.0	0.49	0.06	3.07	0.98	0.12	3.39	1.67	0.20	3.48	2.71	0.32	3.57	4.86	0.57	3.69	7.51	0.89	3.78	11.15	1.32	3.87	18.23	2.15	3.87
20.2	0.49	0.06	3.07	0.97	0.12	3.38	1.67	0.20	3.48	2.70	0.32	3.57	4.83	0.57	3.69	7.47	0.88	3.78	11.09	1.31	3.87	18.14	2.14	3.87
20.3	0.49	0.06	3.06	0.96	0.11	3.38	1.64	0.19	3.47	2.65	0.31	3.56	4.77	0.56	3.68	7.36	0.87	3.78	10.93	1.29	3.87	17.92	2.11	3.87
20.5	0.35	0.04	2.96	0.66	0.08	3.28	1.13	0.13	3.37	1.85	0.22	3.46	3.38	0.40	3.58	5.35	0.63	3.67	8.07	0.95	3.76	13.88	1.64	3.76
20.7	0.35	0.04	2.96	0.64	0.08	3.27	1.09	0.13	3.36	1.78	0.21	3.45	3.25	0.38	3.57	5.15	0.61	3.66	7.77	0.92	3.75	13.44	1.59	3.75
20.8	0.25	0.03	2.85	0.43	0.05	3.16	0.73	0.09	3.25	1.20	0.14	3.34	2.21	0.26	3.46	3.55	0.42	3.54	5.47	0.65	3.63	10.00	1.18	3.63
21.0	0.18	0.02	2.74	0.29	0.03	3.04	0.49	0.06	3.13	0.80	0.09	3.22	1.48	0.17	3.34	2.40	0.28	3.43	3.75	0.44	3.51	7.33	0.87	3.51
21.2	0.13	0.02	2.62	0.19	0.02	2.93	0.33	0.04	3.01	0.53	0.06	3.10	0.99	0.12	3.22	1.61	0.19	3.30	2.53	0.30	3.39	5.33	0.63	3.39
21.3	0.09	0.01	2.51	0.13	0.02	2.81	0.22	0.03	2.89	0.36	0.04	2.98	0.66	0.08	3.09	1.08	0.13	3.18	1.70	0.20	3.26	3.86	0.46	3.26
21.5	0.05	0.01	2.29	0.07	0.01	2.58	0.11	0.01	2.67	0.18	0.02	2.76	0.33	0.04	2.87	0.54	0.06	2.95	0.85	0.10	3.04	2.14	0.25	3.04
21.7	0.03	0.00	2.17	0.05	0.01	2.46	0.08	0.01	2.54	0.12	0.01	2.63	0.23	0.03	2.74	0.37	0.04	2.82	0.58	0.07	2.90	1.53	0.18	2.90
21.8	0.02	0.00	1.95	0.02	0.00	2.23	0.04	0.00	2.32	0.06	0.01	2.40	0.12	0.01	2.50	0.19	0.02	2.59	0.30	0.04	2.67	0.86	0.10	2.67
22.0	-	0.00	1.73	0.01	0.00	2.00	0.02	0.00	2.08	0.03	0.00	2.16	0.06	0.01	2.27	0.10	0.01	2.35	0.16	0.02	2.43	0.48	0.06	2.43
22.2	-	0.00	1.61	0.01	0.00	1.87	0.01	0.00	1.95	0.02	0.00	2.03	0.04	0.00	2.13	0.07	0.01	2.21	0.11	0.01	2.28	0.34	0.04	2.28
22.3	-	0.00	1.38	-	0.00	1.64	-	0.00	1.71	0.01	0.00	1.79	0.02	0.00	1.89	0.03	0.00	1.96	0.05	0.01	2.04	0.19	0.02	2.04
22.5	-	0.00	1.15	-	0.00	1.40	-	0.00	1.48	-	0.00	1.55	-	0.00	1.65	0.02	0.00	1.72	0.03	0.00	1.79	0.10	0.01	1.79
22.7	-	0.00	1.02	-	0.00	1.26	-	0.00	1.34	-	0.00	1.41	-	0.00	1.50	-	0.00	1.57	-	0.00	1.64	0.07	0.01	1.64
22.8	-	0.00	0.79	-	0.00	1.02	-	0.00	1.09	-	0.00	1.16	-	0.00	1.25	-	0.00	1.32	-	0.00	1.38	-	0.00	1.38
23.0	-	0.00	0.56	-	0.00	0.78	-	0.00	0.85	-	0.00	0.91	-	0.00	1.00	-	0.00	1.06	-	0.00	1.13	-	0.00	1.13
23.2	-	0.00	0.43	-	0.00	0.64	-	0.00	0.70	-	0.00	0.76	-	0.00	0.85	-	0.00	0.91	-	0.00	0.97	-	0.00	0.97
23.3	-	0.00	0.19	-	0.00	0.39	-	0.00	0.45	-	0.00	0.51	-	0.00	0.59	-	0.00	0.65	-	0.00	0.71	-	0.00	0.71
23.5	-	0.00	-0.05	-	0.00	0.15	-	0.00	0.20	-	0.00	0.26	-	0.00	0.33	-	0.00	0.39	-	0.00	0.44	-	0.00	0.44
23.7	-	0.00	-0.28	-	0.00	-0.10	-	0.00	-0.05	-	0.00	0.00	-	0.00	0.07	-	0.00	0.12	-	0.00	0.18	-	0.00	0.18
23.8	-	0.00	-0.42	-	0.00	-0.25	-	0.00	-0.20	-	0.00	-0.15	-	0.00	-0.09	-	0.00	-0.04	-	0.00	0.01	-	0.00	0.01
24.0	-	0.00	-0.66	-	0.00	-0.51	-	0.00	-0.46	-	0.00	-0.41	-	0.00	-0.35	-	0.00	-0.31	-	0.00	-0.26	-	0.00	-0.26
24.2	-	0.00	-0.90	-	0.00	-0.76	-	0.00	-0.72	-	0.00	-0.67	-	0.00	-0.62	-	0.00	-0.57	-	0.00	-0.53	-	0.00	-0.53
24.3	-	0.00	-1.05	-	0.00	-0.91	-	0.00	-0.87	-	0.00	-0.83	-	0.00	-0.78	-	0.00	-0.74	-	0.00	-0.71	-	0.00	-0.71
24.5	-	0.00	-1.29	-	0.00	-1.17	-	0.00	-1.13	-	0.00	-1.10	-	0.00	-1.05	-	0.00	-1.02	-	0.00	-0.98	-	0.00	-0.98
24.7	-	0.00	-1.53	-	0.00	-1.42	-	0.00	-1.39	-	0.00	-1.36	-	0.00	-1.32	-	0.00	-1.29	-	0.00	-1.26	-	0.00	-1.26
24.8	-	0.00	-1.68	-	0.00	-1.58	-	0.00	-1.55	-	0.00	-1.53	-	0.00	-1.49	-	0.00	-1.46	-	0.00	-1.44	-	0.00	-1.44
25.0	-	0.00	-1.92	-	0.00	-1.84	-	0.00	-1.82	-	0.00	-1.79	-	0.00	-1.76	-	0.00	-1.74	-	0.00	-1.71	-	0.00	-1.71
25.2	-	0.00	-2.07	-	0.00	-2.00	-	0.00	-1.98	-	0.00	-1.96	-	0.00	-1.93	-	0.00	-1.91	-	0.00	-1.89	-	0.00	-1.89
25.3	-	0.00	-2.21	-	0.00	-2.16	-	0.00	-2.14	-	0.00	-2.13	-	0.00	-2.11	-	0.00	-2.09	-	0.00	-2.07	-	0.00	-2.07
25.5	-	0.00	-2.26	-	0.00	-2.22	-	0.00	-2.21	-	0.00	-2.19	-	0.00	-2.18	-	0.00	-2.17	-	0.00	-2.15	-	0.00	-2.15
25.7	-	0.00	-2.41	-	0.00	-2.38	-	0.00	-2.38	-	0.00	-2.37	-	0.00	-2.36	-	0.00	-2.35	-	0.00	-2.34	-	0.00	-2.34
25.8	-	0.00	-2.46	-	0.00	-2.44	-	0.00	-2.44	-	0.00	-2.44	-	0.00	-2.43	-	0.00	-2.43	-	0.00	-2.42	-	0.00	-2.42
26.0	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51

High End Future Scenario

	10%			0.50%			0.10%		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
14.0	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30
14.2	-	0.00	-2.11	-	0.00	-2.10	-	0.00	-2.10
14.3	-	0.00	-1.93	-	0.00	-1.89	-	0.00	-1.89
14.5	-	0.00	-1.74	-	0.00	-1.69	-	0.00	-1.69
14.7	-	0.00	-1.56	-	0.00	-1.49	-	0.00	-1.49
14.8	-	0.00	-1.37	-	0.00	-1.29	-	0.00	-1.29
15.0	-	0.00	-1.19	-	0.00	-1.08	-	0.00	-1.08
15.2	-	0.00	-1.00	-	0.00	-0.88	-	0.00	-0.88
15.3	-	0.00	-0.82	-	0.00	-0.69	-	0.00	-0.69
15.5	-	0.00	-0.54	-	0.00	-0.39	-	0.00	-0.39
15.7	-	0.00	-0.36	-	0.00	-0.20	-	0.00	-0.20
15.8	-	0.00	-0.18	-	0.00	0.00	-	0.00	0.00
16.0	-	0.00	0.09	-	0.00	0.29	-	0.00	0.29
16.2	-	0.00	0.27	-	0.00	0.48	-	0.00	0.48
16.3	-	0.00	0.54	-	0.00	0.76	-	0.00	0.76
16.5	-	0.00	0.81	-	0.00	1.05	-	0.00	1.05
16.7	-	0.00	0.97	-	0.00	1.23	-	0.00	1.23
16.8	-	0.00	1.24	-	0.00	1.51	0.07	0.01	1.51
17.0	-	0.00	1.50	0.03	0.00	1.78	0.13	0.02	1.78
17.2	-	0.00	1.66	0.05	0.01	1.95	0.19	0.02	1.95
17.3	0.01	0.00	1.92	0.11	0.01	2.22	0.36	0.04	2.22
17.5	0.03	0.00	2.17	0.21	0.03	2.49	0.66	0.08	2.49
17.7	0.05	0.01	2.32	0.33	0.04	2.65	0.97	0.11	2.65
17.8	0.10	0.01	2.57	0.67	0.08	2.91	1.81	0.21	2.91
18.0	0.20	0.02	2.82	1.37	0.16	3.16	3.38	0.40	3.16
18.2	0.31	0.04	2.96	2.16	0.25	3.31	4.91	0.58	3.31
18.3	0.49	0.06	3.10	3.40	0.40	3.46	7.04	0.83	3.46
18.5	0.78	0.09	3.23	5.30	0.63	3.60	10.03	1.18	3.60
18.7	1.24	0.15	3.36	8.00	0.94	3.73	14.11	1.66	3.73
18.8	1.94	0.23	3.49	11.71	1.38	3.87	19.36	2.28	3.87
19.0	3.01	0.35	3.62	16.71	1.97	4.00	25.95	3.06	4.00
19.2	4.57	0.54	3.74	23.56	2.78	4.12	34.12	4.03	4.12
19.3	6.76	0.80	3.85	32.57	3.84	4.24	-	0.00	4.24
19.5	7.06	0.83	3.87	33.99	4.01	4.26	-	0.00	4.26
19.7	7.27	0.86	3.88	34.99	4.13	4.27	-	0.00	4.27
19.8	10.17	1.20	3.98	-	0.00	4.37	-	0.00	4.37
20.0	10.24	1.21	3.98	-	0.00	4.37	-	0.00	4.37
20.2	10.17	1.20	3.98	-	0.00	4.37	-	0.00	4.37
20.3	9.97	1.18	3.97	-	0.00	4.36	-	0.00	4.36
20.5	7.06	0.83	3.87	33.99	4.01	4.26	-	0.00	4.26
20.7	6.76	0.80	3.85	32.57	3.84	4.24	-	0.00	4.24
20.8	4.57	0.54	3.74	23.56	2.78	4.12	34.12	4.03	4.12
21.0	3.01	0.35	3.62	16.71	1.97	4.00	25.95	3.06	4.00
21.2	1.94	0.23	3.49	11.71	1.38	3.87	19.36	2.28	3.87
21.3	1.24	0.15	3.36	8.00	0.94	3.73	14.11	1.66	3.73
21.5	0.55	0.07	3.13	3.88	0.46	3.50	7.81	0.92	3.50
21.7	0.36	0.04	3.00	2.49	0.29	3.36	5.50	0.65	3.36
21.8	0.17	0.02	2.76	1.18	0.14	3.11	2.99	0.35	3.11
22.0	0.08	0.01	2.52	0.59	0.07	2.86	1.62	0.19	2.86
22.2	0.05	0.01	2.37	0.39	0.05	2.71	1.12	0.13	2.71
22.3	0.03	0.00	2.12	0.19	0.02	2.45	0.60	0.07	2.45
22.5	0.01	0.00	1.87	0.10	0.01	2.19	0.33	0.04	2.19
22.7	-	0.00	1.72	0.06	0.01	2.02	0.22	0.03	2.02
22.8	-	0.00	1.46	0.03	0.00	1.75	0.12	0.01	1.75
23.0	-	0.00	1.20	-	0.00	1.48	0.07	0.01	1.48
23.2	-	0.00	1.04	-	0.00	1.31	-	0.00	1.31
23.3	-	0.00	0.77	-	0.00	1.03	-	0.00	1.03
23.5	-	0.00	0.51	-	0.00	0.75	-	0.00	0.75
23.7	-	0.00	0.24	-	0.00	0.46	-	0.00	0.46
23.8	-	0.00	0.07	-	0.00	0.28	-	0.00	0.28
24.0	-	0.00	-0.21	-	0.00	-0.01	-	0.00	-0.01
24.2	-	0.00	-0.48	-	0.00	-0.30	-	0.00	-0.30
24.3	-	0.00	-0.66	-	0.00	-0.50	-	0.00	-0.50
24.5	-	0.00	-0.94	-	0.00	-0.79	-	0.00	-0.79
24.7	-	0.00	-1.22	-	0.00	-1.09	-	0.00	-1.09
24.8	-	0.00	-1.40	-	0.00	-1.28	-	0.00	-1.28
25.0	-	0.00	-1.69	-	0.00	-1.58	-	0.00	-1.58
25.2	-	0.00	-1.87	-	0.00	-1.79	-	0.00	-1.79
25.3	-	0.00	-2.06	-	0.00	-1.99	-	0.00	-1.99
25.5	-	0.00	-2.14	-	0.00	-2.09	-	0.00	-2.09
25.7	-	0.00	-2.33	-	0.00	-2.30	-	0.00	-2.30
25.8	-	0.00	-2.42	-	0.00	-2.40	-	0.00	-2.40
26.0	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51

Location B1
Current

							AEP																	
	50%			20%			10%			5%			2%			1%			0.50%			0.10%		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
14.0	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30
14.2	-	0.00	-2.17	-	0.00	-2.16	-	0.00	-2.16	-	0.00	-2.15	-	0.00	-2.15	-	0.00	-2.14	-	0.00	-2.14	-	0.00	-2.14
14.3	-	0.00	-2.03	-	0.00	-2.02	-	0.00	-2.01	-	0.00	-2.01	-	0.00	-2.00	-	0.00	-1.99	-	0.00	-1.98	-	0.00	-1.98
14.5	-	0.00	-1.90	-	0.00	-1.88	-	0.00	-1.87	-	0.00	-1.86	-	0.00	-1.84	-	0.00	-1.83	-	0.00	-1.82	-	0.00	-1.82
14.7	-	0.00	-1.77	-	0.00	-1.75	-	0.00	-1.73	-	0.00	-1.71	-	0.00	-1.69	-	0.00	-1.68	-	0.00	-1.66	-	0.00	-1.66
14.8	-	0.00	-1.63	-	0.00	-1.61	-	0.00	-1.59	-	0.00	-1.57	-	0.00	-1.54	-	0.00	-1.52	-	0.00	-1.50	-	0.00	-1.50
15.0	-	0.00	-1.50	-	0.00	-1.47	-	0.00	-1.45	-	0.00	-1.42	-	0.00	-1.39	-	0.00	-1.37	-	0.00	-1.34	-	0.00	-1.34
15.2	-	0.00	-1.37	-	0.00	-1.33	-	0.00	-1.30	-	0.00	-1.28	-	0.00	-1.24	-	0.00	-1.21	-	0.00	-1.19	-	0.00	-1.19
15.3	-	0.00	-1.24	-	0.00	-1.20	-	0.00	-1.16	-	0.00	-1.13	-	0.00	-1.09	-	0.00	-1.06	-	0.00	-1.03	-	0.00	-1.03
15.5	-	0.00	-1.01	-	0.00	-0.96	-	0.00	-0.92	-	0.00	-0.89	-	0.00	-0.84	-	0.00	-0.81	-	0.00	-0.77	-	0.00	-0.77
15.7	-	0.00	-0.88	-	0.00	-0.82	-	0.00	-0.78	-	0.00	-0.75	-	0.00	-0.69	-	0.00	-0.66	-	0.00	-0.62	-	0.00	-0.62
15.8	-	0.00	-0.75	-	0.00	-0.69	-	0.00	-0.65	-	0.00	-0.60	-	0.00	-0.55	-	0.00	-0.51	-	0.00	-0.46	-	0.00	-0.46
16.0	-	0.00	-0.52	-	0.00	-0.46	-	0.00	-0.41	-	0.00	-0.36	-	0.00	-0.30	-	0.00	-0.26	-	0.00	-0.21	-	0.00	-0.21
16.2	-	0.00	-0.39	-	0.00	-0.32	-	0.00	-0.27	-	0.00	-0.22	-	0.00	-0.16	-	0.00	-0.11	-	0.00	-0.06	-	0.00	-0.06
16.3	-	0.00	-0.16	-	0.00	-0.09	-	0.00	-0.04	-	0.00	0.02	-	0.00	0.09	-	0.00	0.14	-	0.00	0.19	-	0.00	0.19
16.5	-	0.00	0.06	-	0.00	0.14	-	0.00	0.20	-	0.00	0.25	-	0.00	0.33	-	0.00	0.38	-	0.00	0.44	-	0.00	0.44
16.7	-	0.00	0.19	-	0.00	0.27	-	0.00	0.33	-	0.00	0.39	-	0.00	0.47	-	0.00	0.53	-	0.00	0.59	-	0.00	0.59
16.8	-	0.00	0.42	-	0.00	0.50	-	0.00	0.56	-	0.00	0.63	-	0.00	0.71	-	0.00	0.77	-	0.00	0.83	-	0.00	0.83
17.0	-	0.00	0.64	-	0.00	0.73	-	0.00	0.80	-	0.00	0.86	-	0.00	0.95	-	0.00	1.01	-	0.00	1.07	-	0.00	1.07
17.2	-	0.00	0.76	-	0.00	0.86	-	0.00	0.92	-	0.00	0.99	-	0.00	1.08	-	0.00	1.15	-	0.00	1.22	-	0.00	1.22
17.3	-	0.00	0.98	-	0.00	1.08	-	0.00	1.15	-	0.00	1.22	-	0.00	1.32	-	0.00	1.39	-	0.00	1.46	-	0.00	1.46
17.5	-	0.00	1.21	-	0.00	1.31	-	0.00	1.38	-	0.00	1.45	-	0.00	1.55	-	0.00	1.62	-	0.00	1.69	-	0.00	1.69
17.7	-	0.00	1.33	-	0.00	1.43	-	0.00	1.51	-	0.00	1.58	-	0.00	1.68	-	0.00	1.75	-	0.00	1.83	-	0.00	1.83
17.8	-	0.00	1.54	-	0.00	1.65	-	0.00	1.73	-	0.00	1.81	0.07	0.01	1.91	0.14	0.01	1.99	0.28	0.02	2.06	1.13	0.10	2.06
18.0	-	0.00	1.76	0.02	0.00	1.87	0.04	0.00	1.95	0.09	0.01	2.03	0.23	0.02	2.14	0.51	0.05	2.21	1.11	0.10	2.29	3.73	0.33	2.29
18.2	0.01	0.00	1.88	0.04	0.00	1.99	0.08	0.01	2.07	0.17	0.02	2.15	0.48	0.04	2.26	1.18	0.10	2.34	2.49	0.22	2.42	6.72	0.59	2.42
18.3	0.02	0.00	1.99	0.07	0.01	2.11	0.16	0.01	2.19	0.36	0.03	2.27	1.13	0.10	2.38	2.65	0.23	2.47	5.29	0.47	2.55	11.69	1.03	2.55
18.5	0.05	0.00	2.10	0.13	0.01	2.22	0.34	0.03	2.31	0.85	0.07	2.39	2.62	0.23	2.50	5.71	0.50	2.59	10.80	0.95	2.67	19.81	1.74	2.67
18.7	0.09	0.01	2.22	0.28	0.03	2.34	0.82	0.07	2.42	2.05	0.18	2.51	5.83	0.51	2.62	11.70	1.03	2.71	20.53	1.81	2.79	32.09	2.82	2.79
18.8	0.18	0.02	2.33	0.71	0.06	2.45	2.04	0.18	2.54	4.75	0.42	2.63	12.20	1.07	2.74	21.82	1.92	2.83	-	0.00	2.91	-	0.00	2.91
19.0	0.44	0.04	2.44	1.83	0.16	2.56	4.82	0.42	2.65	10.24	0.90	2.74	22.33	1.97	2.86	-	0.00	2.94	-	0.00	3.03	-	0.00	3.03
19.2	1.19	0.10	2.54	4.49	0.40	2.67	10.40	0.92	2.76	19.34	1.70	2.85	-	0.00	2.97	-	0.00	3.06	-	0.00	3.15	-	0.00	3.15
19.3	3.06	0.27	2.65	9.79	0.86	2.78	19.06	1.68	2.87	-	0.00	2.96	-	0.00	3.08	-	0.00	3.17	-	0.00	3.26	-	0.00	3.26
19.5	3.19	0.28	2.66	10.18	0.90	2.78	19.71	1.73	2.87	-	0.00	2.97	-	0.00	3.09	-	0.00	3.18	-	0.00	3.27	-	0.00	3.27
19.7	3.30	0.29	2.66	10.52	0.93	2.79	20.08	1.77	2.88	-	0.00	2.97	-	0.00	3.09	-	0.00	3.18	-	0.00	3.27	-	0.00	3.27
19.8	7.11	0.63	2.76	18.01	1.58	2.88	-	0.00	2.98	-	0.00	3.07	-	0.00	3.19	-	0.00	3.28	-	0.00	3.37	-	0.00	3.37
20.0	7.16	0.63	2.76	18.10	1.59	2.89	-	0.00	2.98	-	0.00	3.07	-	0.00	3.19	-	0.00	3.28	-	0.00	3.37	-	0.00	3.37
20.2	7.11	0.63	2.76	18.01	1.58	2.88	-	0.00	2.98	-	0.00	3.07	-	0.00	3.19	-	0.00	3.28	-	0.00	3.37	-	0.00	3.37
20.3	7.01	0.62	2.76	17.84	1.57	2.88	-	0.00	2.97	-	0.00	3.07	-	0.00	3.19	-	0.00	3.28	-	0.00	3.37	-	0.00	3.37
20.5	3.19	0.28	2.66	10.18	0.90	2.78	19.71	1.73	2.87	-	0.00	2.97	-	0.00	3.09	-	0.00	3.18	-	0.00	3.27	-	0.00	3.27
20.7	3.06	0.27	2.65	9.79	0.86	2.78	19.06	1.68	2.87	-	0.00	2.96	-	0.00	3.08	-	0.00	3.17	-	0.00	3.26	-	0.00	3.26
20.8	1.19	0.10	2.54	4.49	0.40	2.67	10.40	0.92	2.76	19.34	1.70	2.85	-	0.00	2.97	-	0.00	3.06	-	0.00	3.15	-	0.00	3.15
21.0	0.44	0.04	2.44	1.83	0.16	2.56	4.82	0.42	2.65	10.24	0.90	2.74	22.33	1.97	2.86	-	0.00	2.94	-	0.00	3.03	-	0.00	3.03
21.2	0.18	0.02	2.33	0.71	0.06	2.45	2.04	0.18	2.54	4.75	0.42	2.63	12.20	1.07	2.74	21.82	1.92	2.83	-	0.00	2.91	-	0.00	2.91
21.3	0.09	0.01	2.22	0.28	0.03	2.34	0.82	0.07	2.42	2.05	0.18	2.51	5.83	0.51	2.62	11.70	1.03	2.71	20.53	1.81	2.79	32.09	2.82	2.79
21.5	0.03	0.00	2.00	0.07	0.01	2.12	0.18	0.02	2.21	0.41	0.04	2.29	1.31	0.12	2.40	3.06	0.27	2.49	6.09	0.54	2.57	12.96	1.14	2.57
21.7	0.01	0.00	1.89	0.04	0.00	2.01	0.09	0.01	2.09	0.19	0.02	2.17	0.56	0.05	2.28	1.38	0.12	2.37	2.93	0.26	2.45	7.57	0.67	2.45
21.8	-	0.00	1.68	-	0.00	1.79	0.03	0.00	1.87	0.06	0.01	1.95	0.15	0.01	2.06	0.33	0.03	2.14	0.71	0.06	2.22	2.62	0.23	2.22
22.0	-	0.00	1.46	-	0.00	1.57	-	0.00	1.65	-	0.00	1.73	-	0.00	1.84	0.10	0.01	1.91	0.20	0.02	1.99	-	0.00	1.99
22.2	-	0.00	1.34	-	0.00	1.45	-	0.00	1.53	-	0.00	1.61	-	0.00	1.71	-	0.00	1.79	-	0.00	1.86	-	0.00	1.86
22.3	-	0.00	1.13	-	0.00	1.23	-	0.00	1.31	-	0.00	1.38	-	0.00	1.48	-	0.00	1.55	-	0.00	1.63	-	0.00	1.63
22.5	-	0.00	0.91	-	0.00	1.01	-	0.00	1.08	-	0.00	1.15	-	0.00	1.25	-	0.00	1.32	-	0.00	1.39	-	0.00	1.39
22.7	-	0.00	0.78	-	0.00	0.88	-	0.00	0.95	-	0.00	1.02	-	0.00	1.12	-	0.00	1.19	-	0.00	1.26	-	0.00	1.26
22.8	-	0.00	0.56	-	0.00	0.66	-	0.00	0.72	-	0.00	0.79	-	0.00	0.88	-	0.00	0.95	-	0.00	1.02	-	0.00	1.02
23.0	-	0.00	0.34	-	0.00	0.43	-	0.00	0.50	-	0.00	0.56	-	0.00	0.65	-	0.00	0.71	-	0.00	0.77	-	0.00	0.77
23.2	-	0.00	0.22	-	0.00	0.30	-	0.00	0.36	-	0.00	0.43	-	0.00	0.51	-	0.00	0.57	-	0.00	0.63	-	0.00	0.63
23.3	-	0.00	-0.01	-	0.00	0.07	-	0.00	0.13	-	0.00	0.19	-	0.00	0.27	-	0.00	0.33	-	0.00	0.39	-	0.00	0.39
23.5	-	0.00	-0.24	-	0.00	-0.16	-	0.00	-0.10	-	0.00	-0.05	-	0.00	0.03	-	0.00	0.08	-	0.00	0.14	-	0.00	0.14
23.7	-	0.00	-0.46	-	0.00	-0.39	-	0.00	-0.34	-	0.00	-0.28	-	0.00	-0.21	-	0.00	-0.16	-	0.00	-0.11	-	0.00	-0.11
23.8	-	0.00	-0.59	-	0.00	-0.52	-	0.00	-0.47	-	0.00	-0.42	-	0.00	-0.36	-	0.00	-0.31	-	0.00	-0.26	-	0.00	-0.26
24.0	-	0.00	-0.82	-	0.00	-0.76	-	0.00	-0.71	-	0.00	-0.66	-	0.00	-0.60	-	0.00	-0.56	-	0.00	-0.51	-	0.00	-0.51
24.2	-	0.00	-1.05	-	0.00	-0.99	-	0.00	-0.95	-	0.00	-0.90	-	0.00	-0.85	-	0.00	-0.81	-	0.00	-0.76	-	0.00	-0.76
24.3	-	0.00	-1.18	-	0.00	-1.12	-	0.00	-1.08	-	0.00	-1.05	-	0.00	-0.99	-	0.00	-0.96	-	0.00	-0.92	-	0.00	-0.92
24.5	-	0.00	-1.41	-	0.00	-1.36	-	0.00	-1.32	-	0.00	-1.29	-	0.00	-1.24	-	0.00	-1.21	-	0.00	-1.17	-	0.00	-1.17
24.7	-	0.00	-1.64	-	0.00	-1.60	-	0.00	-1.56	-	0.00	-1.53	-	0.00	-1.49	-	0.00	-1.46	-	0.00	-1.43	-	0.00	-1.43
24.8	-	0.00	-1.77	-	0.00	-1.73	-	0.00	-1.70	-	0.00	-1.68	-	0.00	-1.64	-	0.00	-1.61	-	0.00	-1.59	-	0.00	-1.59
25.0	-	0.00	-2.00	-	0.00	-1.97	-	0.00	-1.95	-	0.00	-1.92	-	0.00	-1.89	-	0.00	-1.87	-	0.00	-1.84	-	0.00	-1.84
25.2	-	0.00	-2.13	-	0.00	-2.11	-	0.00	-2.09	-	0.00	-2.07	-	0.00	-2.04	-	0.00	-2.02	-	0.00	-2.00	-	0.00	-2.00
25.3	-	0.00	-2.27	-	0.00	-2.25	-	0.00	-2.23	-	0.00	-2.21	-	0.00	-2.19	-	0.00	-2.18	-	0.00	-2.16	-	0.00	-2.16
25.5	-	0.00	-2.30	-	0.00	-2.28	-	0.00	-2.27	-	0.00	-2.26	-	0.00	-2.24	-	0.00	-2.23	-	0.00	-2.22	-	0.00	-2.22
25.7	-	0.00	-2.44	-	0.00	-2.43	-	0.00	-2.42	-	0.00	-2.41	-	0.00	-2.40	-	0.00	-2.39	-	0.00	-2.38	-	0.00	-2.38
25.8	-	0.00	-2.47	-	0.00	-2.47	-	0.00	-2.46	-	0.00	-2.46	-	0.00	-2.45	-	0.00	-2.45	-	0.00	-2.44	-	0.00	-2.44
26.0	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51

Mid Range Future Scenario

	50%			20%			10%			5%			2%			1%			0.50%			0.10%		
Time	q (l/m/s)	q (m3/s)	Water Level (mAOD)	q (l/m/s)	q (m3/s)	Water Level (mAOD)	q (l/m/s)	q (m3/s)	Water Level (mAOD)	q (l/m/s)	q (m3/s)	Water Level (mAOD)	q (l/m/s)	q (m3/s)	Water Level (mAOD)	q (l/m/s)	q (m3/s)	Water Level (mAOD)	q (l/m/s)	q (m3/s)	Water Level (mAOD)	q (l/m/s)	q (m3/s)	Water Level (mAOD)
14.0	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30
14.2	-	0.00	-2.14	-	0.00	-2.14	-	0.00	-2.14	-	0.00	-2.13	-	0.00	-2.13	-	0.00	-2.12	-	0.00	-2.12	-	0.00	-2.12
14.3	-	0.00	-1.99	-	0.00	-1.98	-	0.00	-1.97	-	0.00	-1.96	-	0.00	-1.95	-	0.00	-1.94	-	0.00	-1.94	-	0.00	-1.94
14.5	-	0.00	-1.84	-	0.00	-1.82	-	0.00	-1.81	-	0.00	-1.79	-	0.00	-1.78	-	0.00	-1.77	-	0.00	-1.75	-	0.00	-1.75
14.7	-	0.00	-1.68	-	0.00	-1.66	-	0.00	-1.64	-	0.00	-1.63	-	0.00	-1.61	-	0.00	-1.59	-	0.00	-1.57	-	0.00	-1.57
14.8	-	0.00	-1.53	-	0.00	-1.50	-	0.00	-1.48	-	0.00	-1.46	-	0.00	-1.43	-	0.00	-1.41	-	0.00	-1.39	-	0.00	-1.39
15.0	-	0.00	-1.37	-	0.00	-1.34	-	0.00	-1.32	-	0.00	-1.29	-	0.00	-1.26	-	0.00	-1.24	-	0.00	-1.21	-	0.00	-1.21
15.2	-	0.00	-1.22	-	0.00	-1.18	-	0.00	-1.15	-	0.00	-1.13	-	0.00	-1.09	-	0.00	-1.06	-	0.00	-1.04	-	0.00	-1.04
15.3	-	0.00	-1.07	-	0.00	-1.02	-	0.00	-0.99	-	0.00	-0.96	-	0.00	-0.92	-	0.00	-0.89	-	0.00	-0.86	-	0.00	-0.86
15.5	-	0.00	-0.82	-	0.00	-0.77	-	0.00	-0.73	-	0.00	-0.70	-	0.00	-0.65	-	0.00	-0.62	-	0.00	-0.58	-	0.00	-0.58
15.7	-	0.00	-0.67	-	0.00	-0.61	-	0.00	-0.57	-	0.00	-0.53	-	0.00	-0.48	-	0.00	-0.44	-	0.00	-0.41	-	0.00	-0.41
15.8	-	0.00	-0.52	-	0.00	-0.46	-	0.00	-0.42	-	0.00	-0.37	-	0.00	-0.32	-	0.00	-0.27	-	0.00	-0.23	-	0.00	-0.23
16.0	-	0.00	-0.27	-	0.00	-0.21	-	0.00	-0.16	-	0.00	-0.11	-	0.00	-0.05	-	0.00	-0.01	-	0.00	0.04	-	0.00	0.04
16.2	-	0.00	-0.12	-	0.00	-0.05	-	0.00	0.00	-	0.00	0.05	-	0.00	0.11	-	0.00	0.16	-	0.00	0.21	-	0.00	0.21
16.3	-	0.00	0.12	-	0.00	0.20	-	0.00	0.25	-	0.00	0.30	-	0.00	0.37	-	0.00	0.42	-	0.00	0.48	-	0.00	0.48
16.5	-	0.00	0.37	-	0.00	0.45	-	0.00	0.50	-	0.00	0.56	-	0.00	0.63	-	0.00	0.69	-	0.00	0.74	-	0.00	0.74
16.7	-	0.00	0.51	-	0.00	0.59	-	0.00	0.65	-	0.00	0.71	-	0.00	0.79	-	0.00	0.85	-	0.00	0.91	-	0.00	0.91
16.8	-	0.00	0.75	-	0.00	0.84	-	0.00	0.90	-	0.00	0.96	-	0.00	1.05	-	0.00	1.11	-	0.00	1.17	-	0.00	1.17
17.0	-	0.00	0.99	-	0.00	1.08	-	0.00	1.15	-	0.00	1.21	-	0.00	1.30	-	0.00	1.36	-	0.00	1.43	-	0.00	1.43
17.2	-	0.00	1.13	-	0.00	1.22	-	0.00	1.29	-	0.00	1.36	-	0.00	1.45	-	0.00	1.52	-	0.00	1.58	-	0.00	1.58
17.3	-	0.00	1.37	-	0.00	1.46	-	0.00	1.54	-	0.00	1.61	-	0.00	1.70	-	0.00	1.77	-	0.00	1.84	-	0.00	1.84
17.5	-	0.00	1.60	-	0.00	1.70	-	0.00	1.78	-	0.00	1.85	0.10	0.01	1.95	0.21	0.02	2.02	0.42	0.04	2.09	0.42	0.04	2.09
17.7	-	0.00	1.73	0.02	0.00	1.84	0.05	0.00	1.91	0.09	0.01	1.99	0.21	0.02	2.09	0.47	0.04	2.16	0.98	0.09	2.24	0.98	0.09	2.24
17.8	0.03	0.00	1.97	0.08	0.01	2.07	0.16	0.01	2.15	0.34	0.03	2.23	0.94	0.08	2.33	2.17	0.19	2.41	4.26	0.37	2.48	4.26	0.37	2.48
18.0	0.10	0.01	2.19	0.31	0.03	2.30	0.77	0.07	2.38	1.79	0.16	2.46	4.64	0.41	2.57	9.13	0.80	2.65	16.01	1.41	2.73	16.01	1.41	2.73
18.2	0.22	0.02	2.32	0.84	0.07	2.43	2.08	0.18	2.52	4.53	0.40	2.60	10.76	0.95	2.70	19.21	1.69	2.79	30.40	2.68	2.87	30.40	2.68	2.87
18.3	0.60	0.05	2.44	2.33	0.20	2.56	5.35	0.47	2.64	10.66	0.94	2.73	22.06	1.94	2.84	-	0.00	2.92	-	0.00	3.00	-	0.00	3.00
18.5	1.76	0.16	2.57	6.01	0.53	2.68	12.38	1.09	2.77	21.54	1.90	2.86	-	0.00	2.97	-	0.00	3.05	-	0.00	3.14	-	0.00	3.14
18.7	4.82	0.42	2.69	13.51	1.19	2.81	23.48	2.07	2.89	-	0.00	2.98	-	0.00	3.09	-	0.00	3.18	-	0.00	3.26	-	0.00	3.26
18.8	11.15	0.98	2.80	24.27	2.14	2.93	-	0.00	3.01	-	0.00	3.10	-	0.00	3.22	-	0.00	3.30	-	0.00	3.39	-	0.00	3.39
19.0	20.30	1.79	2.92	-	0.00	3.04	-	0.00	3.13	-	0.00	3.22	-	0.00	3.34	-	0.00	3.43	-	0.00	3.51	-	0.00	3.51
19.2	-	0.00	3.03	-	0.00	3.16	-	0.00	3.25	-	0.00	3.34	-	0.00	3.46	-	0.00	3.54	-	0.00	3.63	-	0.00	3.63
19.3	-	0.00	3.14	-	0.00	3.27	-	0.00	3.36	-	0.00	3.45	-	0.00	3.57	-	0.00	3.66	-	0.00	3.75	-	0.00	3.75
19.5	-	0.00	3.15	-	0.00	3.28	-	0.00	3.37	-	0.00	3.46	-	0.00	3.58	-	0.00	3.67	-	0.00	3.76	-	0.00	3.76
19.7	-	0.00	3.16	-	0.00	3.28	-	0.00	3.38	-	0.00	3.47	-	0.00	3.59	-	0.00	3.68	-	0.00	3.77	-	0.00	3.77
19.8	-	0.00	3.26	-	0.00	3.38	-	0.00	3.48	-	0.00	3.57	-	0.00	3.69	-	0.00	3.78	-	0.00	3.87	-	0.00	3.87
20.0	-	0.00	3.26	-	0.00	3.39	-	0.00	3.48	-	0.00	3.57	-	0.00	3.69	-	0.00	3.78	-	0.00	3.87	-	0.00	3.87
20.2	-	0.00	3.26	-	0.00	3.38	-	0.00	3.48	-	0.00	3.57	-	0.00	3.69	-	0.00	3.78	-	0.00	3.87	-	0.00	3.87
20.3	-	0.00	3.25	-	0.00	3.38	-	0.00	3.47	-	0.00	3.56	-	0.00	3.68	-	0.00	3.78	-	0.00	3.87	-	0.00	3.87
20.5	-	0.00	3.15	-	0.00	3.28	-	0.00	3.37	-	0.00	3.46	-	0.00	3.58	-	0.00	3.67	-	0.00	3.76	-	0.00	3.76
20.7	-	0.00	3.14	-	0.00	3.27	-	0.00	3.36	-	0.00	3.45	-	0.00	3.57	-	0.00	3.66	-	0.00	3.75	-	0.00	3.75
20.8	-	0.00	3.03	-	0.00	3.16	-	0.00	3.25	-	0.00	3.34	-	0.00	3.46	-	0.00	3.54	-	0.00	3.63	-	0.00	3.63
21.0	20.30	1.79	2.92	-	0.00	3.04	-	0.00	3.13	-	0.00	3.22	-	0.00	3.34	-	0.00	3.43	-	0.00	3.51	-	0.00	3.51
21.2	11.15	0.98	2.80	24.27	2.14	2.93	-	0.00	3.01	-	0.00	3.10	-	0.00	3.22	-	0.00	3.30	-	0.00	3.39	-	0.00	3.39
21.3	4.82	0.42	2.69	13.51	1.19	2.81	23.48	2.07	2.89	-	0.00	2.98	-	0.00	3.09	-	0.00	3.18	-	0.00	3.26	-	0.00	3.26
21.5	0.73	0.06	2.47	2.81	0.25	2.58	6.42	0.56	2.67	12.65	1.11	2.76	25.26	2.22	2.87	-	0.00	2.95	-	0.00	3.04	-	0.00	3.04
21.7	0.27	0.02	2.34	1.05	0.09	2.46	2.58	0.23	2.54	5.55	0.49	2.63	13.06	1.15	2.74	22.71	2.00	2.82	-	0.00	2.90	-	0.00	2.90
21.8	0.06	0.01	2.12	0.20	0.02	2.23	0.46	0.04	2.32	1.10	0.10	2.40	3.04	0.27	2.50	6.33	0.56	2.59	11.67	1.03	2.67	11.67	1.03	2.67
22.0	0.02	0.00	1.89	0.05	0.00	2.00	0.11	0.01	2.08	0.23	0.02	2.16	0.63	0.06	2.27	1.50	0.13	2.35	3.07	0.27	2.43	3.07	0.27	2.43
22.2	-	0.00	1.77	0.03	0.00	1.87	0.06	0.00	1.95	0.11	0.01	2.03	0.27	0.02	2.13	0.61	0.05	2.21	1.31	0.12	2.28	1.31	0.12	2.28
22.3	-	0.00	1.53	-	0.00	1.64	-	0.00	1.71	-	0.00	1.79	-	0.00	1.89	0.16	0.01	1.96	0.31	0.03	2.04	0.31	0.03	2.04
22.5	-	0.00	1.30	-	0.00	1.40	-	0.00	1.48	-	0.00	1.55	-	0.00	1.65	-	0.00	1.72	-	0.00	1.79	-	0.00	1.79
22.7	-	0.00	1.17	-	0.00	1.26	-	0.00	1.34	-	0.00	1.41	-	0.00	1.50	-	0.00	1.57	-	0.00	1.64	-	0.00	1.64
22.8	-	0.00	0.93	-	0.00	1.02	-	0.00	1.09	-	0.00	1.16	-	0.00	1.25	-	0.00	1.32	-	0.00	1.38	-	0.00	1.38
23.0	-	0.00	0.69	-	0.00	0.78	-	0.00	0.85	-	0.00	0.91	-	0.00	1.00	-	0.00	1.06	-	0.00	1.13	-	0.00	1.13
23.2	-	0.00	0.55	-	0.00	0.64	-	0.00	0.70	-	0.00	0.76	-	0.00	0.85	-	0.00	0.91	-	0.00	0.97	-	0.00	0.97
23.3	-	0.00	0.31	-	0.00	0.39	-	0.00	0.45	-	0.00	0.51	-	0.00	0.59	-	0.00	0.65	-	0.00	0.71	-	0.00	0.71
23.5	-	0.00	0.07	-	0.00	0.15	-	0.00	0.20	-	0.00	0.26	-	0.00	0.33	-	0.00	0.39	-	0.00	0.44	-	0.00	0.44
23.7	-	0.00	-0.18	-	0.00	-0.10	-	0.00	-0.05	-	0.00	0.00	-	0.00	0.07	-	0.00	0.12	-	0.00	0.18	-	0.00	0.18
23.8	-	0.00	-0.32	-	0.00	-0.25	-	0.00	-0.20	-	0.00	-0.15	-	0.00	-0.09	-	0.00	-0.04	-	0.00	0.01	-	0.00	0.01
24.0	-	0.00	-0.57	-	0.00	-0.51	-	0.00	-0.46	-	0.00	-0.41	-	0.00	-0.35	-	0.00	-0.31	-	0.00	-0.26	-	0.00	-0.26
24.2	-	0.00	-0.82	-	0.00	-0.76	-	0.00	-0.72	-	0.00	-0.67	-	0.00	-0.62	-	0.00	-0.57	-	0.00	-0.53	-	0.00	-0.53
24.3	-	0.00	-0.97	-	0.00	-0.91	-	0.00	-0.87	-	0.00	-0.83	-	0.00	-0.78	-	0.00	-0.74	-	0.00	-0.71	-	0.00	-0.71
24.5	-	0.00	-1.22	-	0.00	-1.17	-	0.00	-1.13	-	0.00	-1.10	-	0.00	-1.05	-	0.00	-1.02	-	0.00	-0.98	-	0.00	-0.98
24.7	-	0.00	-1.47	-	0.00	-1.42	-	0.00	-1.39	-	0.00	-1.36	-	0.00	-1.32	-	0.00	-1.29	-	0.00	-1.26	-	0.00	-1.26
24.8	-	0.00	-1.62	-	0.00	-1.58	-	0.00	-1.55	-	0.00	-1.53	-	0.00	-1.49	-	0.00	-1.46	-	0.00	-1.44	-	0.00	-1.44
25.0	-	0.00	-1.87	-	0.00	-1.84	-	0.00	-1.82	-	0.00	-1.79	-	0.00	-1.76	-	0.00	-1.74	-	0.00	-1.71	-	0.00	-1.71
25.2	-	0.00	-2.03	-	0.00	-2.00	-	0.00	-1.98	-	0.00	-1.96	-	0.00	-1.93	-	0.00	-1.91	-	0.00	-1.89	-	0.00	-1.89
25.3	-	0.00	-2.18	-	0.00	-2.16	-	0.00	-2.14	-	0.00	-2.13	-	0.00	-2.11	-	0.00	-2.09	-	0.00	-2.07	-	0.00	-2.07
25.5	-	0.00	-2.24	-	0.00	-2.22	-	0.00	-2.21	-	0.00	-2.19	-	0.00	-2.18	-	0.00	-2.17	-	0.00	-2.15	-	0.00	-2.15
25.7	-	0.00	-2.39	-	0.00	-2.38	-	0.00	-2.38	-	0.00	-2.37	-	0.00	-2.36	-	0.00	-2.35	-	0.00	-2.34	-	0.00	-2.34
25.8	-	0.00	-2.45	-	0.00	-2.44	-	0.00	-2.44	-	0.00	-2.44	-	0.00	-2.43	-	0.00	-2.43	-	0.00	-2.42	-	0.00	-2.42
26.0	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51

High End Future Scenario

	10%			0.50%			0.10%		
Time	q (l/m/s)	q (m3/s)	Water Level (mAOD)	q (l/m/s)	q (m3/s)	Water Level (mAOD)	q (l/m/s)	q (m3/s)	Water Level (mAOD)
14.0	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30
14.2	-	0.00	-2.11	-	0.00	-2.10	-	0.00	-2.10
14.3	-	0.00	-1.93	-	0.00	-1.89	-	0.00	-1.89
14.5	-	0.00	-1.74	-	0.00	-1.69	-	0.00	-1.69
14.7	-	0.00	-1.56	-	0.00	-1.49	-	0.00	-1.49
14.8	-	0.00	-1.37	-	0.00	-1.29	-	0.00	-1.29
15.0	-	0.00	-1.19	-	0.00	-1.08	-	0.00	-1.08
15.2	-	0.00	-1.00	-	0.00	-0.88	-	0.00	-0.88
15.3	-	0.00	-0.82	-	0.00	-0.69	-	0.00	-0.69
15.5	-	0.00	-0.54	-	0.00	-0.39	-	0.00	-0.39
15.7	-	0.00	-0.36	-	0.00	-0.20	-	0.00	-0.20
15.8	-	0.00	-0.18	-	0.00	0.00	-	0.00	0.00
16.0	-	0.00	0.09	-	0.00	0.29	-	0.00	0.29
16.2	-	0.00	0.27	-	0.00	0.48	-	0.00	0.48
16.3	-	0.00	0.54	-	0.00	0.76	-	0.00	0.76
16.5	-	0.00	0.81	-	0.00	1.05	-	0.00	1.05
16.7	-	0.00	0.97	-	0.00	1.23	-	0.00	1.23
16.8	-	0.00	1.24	-	0.00	1.51	-	0.00	1.51
17.0	-	0.00	1.50	-	0.00	1.78	-	0.00	1.78
17.2	-	0.00	1.66	-	0.00	1.95	-	0.00	1.95
17.3	0.06	0.01	1.92	1.15	0.10	2.22	3.98	0.35	2.22
17.5	0.25	0.02	2.17	5.16	0.45	2.49	11.94	1.05	2.49
17.7	0.66	0.06	2.32	12.02	1.06	2.65	22.22	1.96	2.65
17.8	3.83	0.34	2.57	-	0.00	2.91	-	0.00	2.91
18.0	17.88	1.57	2.82	-	0.00	3.16	-	0.00	3.16
18.2	-	0.00	2.96	-	0.00	3.31	-	0.00	3.31
18.3	-	0.00	3.10	-	0.00	3.46	-	0.00	3.46
18.5	-	0.00	3.23	-	0.00	3.60	-	0.00	3.60
18.7	-	0.00	3.36	-	0.00	3.73	-	0.00	3.73
18.8	-	0.00	3.49	-	0.00	3.87	-	0.00	3.87
19.0	-	0.00	3.62	-	0.00	4.00	-	0.00	4.00
19.2	-	0.00	3.74	-	0.00	4.12	-	0.00	4.12
19.3	-	0.00	3.85	-	0.00	4.24	-	0.00	4.24
19.5	-	0.00	3.87	-	0.00	4.26	-	0.00	4.26
19.7	-	0.00	3.88	-	0.00	4.27	-	0.00	4.27
19.8	-	0.00	3.98	-	0.00	4.37	-	0.00	4.37
20.0	-	0.00	3.98	-	0.00	4.37	-	0.00	4.37
20.2	-	0.00	3.98	-	0.00	4.37	-	0.00	4.37
20.3	-	0.00	3.97	-	0.00	4.36	-	0.00	4.36
20.5	-	0.00	3.87	-	0.00	4.26	-	0.00	4.26
20.7	-	0.00	3.85	-	0.00	4.24	-	0.00	4.24
20.8	-	0.00	3.74	-	0.00	4.12	-	0.00	4.12
21.0	-	0.00	3.62	-	0.00	4.00	-	0.00	4.00
21.2	-	0.00	3.49	-	0.00	3.87	-	0.00	3.87
21.3	-	0.00	3.36	-	0.00	3.73	-	0.00	3.73
21.5	-	0.00	3.13	-	0.00	3.50	-	0.00	3.50
21.7	-	0.00	3.00	-	0.00	3.36	-	0.00	3.36
21.8	12.97	1.14	2.76	-	0.00	3.11	-	0.00	3.11
22.0	2.61	0.23	2.52	31.92	2.81	2.86	-	0.00	2.86
22.2	0.93	0.08	2.37	16.13	1.42	2.71	27.59	2.43	2.71
22.3	0.19	0.02	2.12	4.19	0.37	2.45	10.23	0.90	2.45
22.5	-	0.00	1.87	0.94	0.08	2.19	3.38	0.30	2.19
22.7	-	0.00	1.72	0.38	0.03	2.02	-	0.00	2.02
22.8	-	0.00	1.46	-	0.00	1.75	-	0.00	1.75
23.0	-	0.00	1.20	-	0.00	1.48	-	0.00	1.48
23.2	-	0.00	1.04	-	0.00	1.31	-	0.00	1.31
23.3	-	0.00	0.77	-	0.00	1.03	-	0.00	1.03
23.5	-	0.00	0.51	-	0.00	0.75	-	0.00	0.75
23.7	-	0.00	0.24	-	0.00	0.46	-	0.00	0.46
23.8	-	0.00	0.07	-	0.00	0.28	-	0.00	0.28
24.0	-	0.00	-0.21	-	0.00	-0.01	-	0.00	-0.01
24.2	-	0.00	-0.48	-	0.00	-0.30	-	0.00	-0.30
24.3	-	0.00	-0.66	-	0.00	-0.50	-	0.00	-0.50
24.5	-	0.00	-0.94	-	0.00	-0.79	-	0.00	-0.79
24.7	-	0.00	-1.22	-	0.00	-1.09	-	0.00	-1.09
24.8	-	0.00	-1.40	-	0.00	-1.28	-	0.00	-1.28
25.0	-	0.00	-1.69	-	0.00	-1.58	-	0.00	-1.58
25.2	-	0.00	-1.87	-	0.00	-1.79	-	0.00	-1.79
25.3	-	0.00	-2.06	-	0.00	-1.99	-	0.00	-1.99
25.5	-	0.00	-2.14	-	0.00	-2.09	-	0.00	-2.09
25.7	-	0.00	-2.33	-	0.00	-2.30	-	0.00	-2.30
25.8	-	0.00	-2.42	-	0.00	-2.40	-	0.00	-2.40
26.0	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51

Location B2

Current

													AEP											
	50%			20%			10%			5%			2%			1%			0.50%			0.10%		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
14.0	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30
14.2	-	0.00	-2.17	-	0.00	-2.16	-	0.00	-2.16	-	0.00	-2.15	-	0.00	-2.15	-	0.00	-2.14	-	0.00	-2.14	-	0.00	-2.14
14.3	-	0.00	-2.03	-	0.00	-2.02	-	0.00	-2.01	-	0.00	-2.01	-	0.00	-2.00	-	0.00	-1.99	-	0.00	-1.98	-	0.00	-1.98
14.5	-	0.00	-1.90	-	0.00	-1.88	-	0.00	-1.87	-	0.00	-1.86	-	0.00	-1.84	-	0.00	-1.83	-	0.00	-1.82	-	0.00	-1.82
14.7	-	0.00	-1.77	-	0.00	-1.75	-	0.00	-1.73	-	0.00	-1.71	-	0.00	-1.69	-	0.00	-1.68	-	0.00	-1.66	-	0.00	-1.66
14.8	-	0.00	-1.63	-	0.00	-1.61	-	0.00	-1.59	-	0.00	-1.57	-	0.00	-1.54	-	0.00	-1.52	-	0.00	-1.50	-	0.00	-1.50
15.0	-	0.00	-1.50	-	0.00	-1.47	-	0.00	-1.45	-	0.00	-1.42	-	0.00	-1.39	-	0.00	-1.37	-	0.00	-1.34	-	0.00	-1.34
15.2	-	0.00	-1.37	-	0.00	-1.33	-	0.00	-1.30	-	0.00	-1.28	-	0.00	-1.24	-	0.00	-1.21	-	0.00	-1.19	-	0.00	-1.19
15.3	-	0.00	-1.24	-	0.00	-1.20	-	0.00	-1.16	-	0.00	-1.13	-	0.00	-1.09	-	0.00	-1.06	-	0.00	-1.03	-	0.00	-1.03
15.5	-	0.00	-1.01	-	0.00	-0.96	-	0.00	-0.92	-	0.00	-0.89	-	0.00	-0.84	-	0.00	-0.81	-	0.00	-0.77	-	0.00	-0.77
15.7	-	0.00	-0.88	-	0.00	-0.82	-	0.00	-0.78	-	0.00	-0.75	-	0.00	-0.69	-	0.00	-0.66	-	0.00	-0.62	-	0.00	-0.62
15.8	-	0.00	-0.75	-	0.00	-0.69	-	0.00	-0.65	-	0.00	-0.60	-	0.00	-0.55	-	0.00	-0.51	-	0.00	-0.46	-	0.00	-0.46
16.0	-	0.00	-0.52	-	0.00	-0.46	-	0.00	-0.41	-	0.00	-0.36	-	0.00	-0.30	-	0.00	-0.26	-	0.00	-0.21	-	0.00	-0.21
16.2	-	0.00	-0.39	-	0.00	-0.32	-	0.00	-0.27	-	0.00	-0.22	-	0.00	-0.16	-	0.00	-0.11	-	0.00	-0.06	-	0.00	-0.06
16.3	-	0.00	-0.16	-	0.00	-0.09	-	0.00	-0.04	-	0.00	0.02	-	0.00	0.09	-	0.00	0.14	-	0.00	0.19	-	0.00	0.19
16.5	-	0.00	0.06	-	0.00	0.14	-	0.00	0.20	-	0.00	0.25	-	0.00	0.33	-	0.00	0.38	-	0.00	0.44	-	0.00	0.44
16.7	-	0.00	0.19	-	0.00	0.27	-	0.00	0.33	-	0.00	0.39	-	0.00	0.47	-	0.00	0.53	-	0.00	0.59	-	0.00	0.59
16.8	-	0.00	0.42	-	0.00	0.50	-	0.00	0.56	-	0.00	0.63	-	0.00	0.71	-	0.00	0.77	-	0.00	0.83	-	0.00	0.83
17.0	-	0.00	0.64	-	0.00	0.73	-	0.00	0.80	-	0.00	0.86	-	0.00	0.95	-	0.00	1.01	-	0.00	1.07	-	0.00	1.07
17.2	-	0.00	0.76	-	0.00	0.86	-	0.00	0.92	-	0.00	0.99	-	0.00	1.08	-	0.00	1.15	-	0.00	1.22	-	0.00	1.22
17.3	-	0.00	0.98	-	0.00	1.08	-	0.00	1.15	-	0.00	1.22	-	0.00	1.32	-	0.00	1.39	-	0.00	1.46	-	0.00	1.46
17.5	-	0.00	1.21	-	0.00	1.31	-	0.00	1.38	-	0.00	1.45	-	0.00	1.55	-	0.00	1.62	-	0.00	1.69	-	0.00	1.69
17.7	-	0.00	1.33	-	0.00	1.43	-	0.00	1.51	-	0.00	1.58	-	0.00	1.68	-	0.00	1.75	-	0.00	1.83	-	0.00	1.83
17.8	-	0.00	1.54	-	0.00	1.65	-	0.00	1.73	-	0.00	1.81	0.01	0.00	1.91	0.04	0.00	1.99	0.11	0.01	2.06	0.54	0.06	2.06
18.0	-	0.00	1.76	0.00	0.00	1.87	0.01	0.00	1.95	0.02	0.00	2.03	0.08	0.01	2.14	0.23	0.02	2.21	0.56	0.06	2.29	2.24	0.23	2.29
18.2	0.00	0.00	1.88	0.01	0.00	1.99	0.02	0.00	2.07	0.05	0.01	2.15	0.21	0.02	2.26	0.61	0.06	2.34	1.51	0.16	2.42	4.94	0.52	2.42
18.3	0.00	0.00	1.99	0.01	0.00	2.11	0.05	0.01	2.19	0.15	0.02	2.27	0.58	0.06	2.38	1.65	0.17	2.47	3.97	0.42	2.55	9.89	1.04	2.55
18.5	0.01	0.00	2.10	0.04	0.00	2.22	0.14	0.01	2.31	0.41	0.04	2.39	1.63	0.17	2.50	4.28	0.45	2.59	8.65	0.91	2.67	17.44	1.83	2.67
18.7	0.02	0.00	2.22	0.11	0.01	2.34	0.39	0.04	2.42	1.18	0.12	2.51	4.21	0.44	2.62	8.92	0.94	2.71	15.15	1.59	2.79	27.34	2.87	2.79
18.8	0.06	0.01	2.33	0.31	0.03	2.45	1.13	0.12	2.54	3.16	0.33	2.63	8.53	0.90	2.74	14.89	1.56	2.83	22.54	2.37	2.91	39.05	4.10	2.91
19.0	0.18	0.02	2.44	0.94	0.10	2.56	2.99	0.31	2.65	6.62	0.69	2.74	13.69	1.44	2.86	21.58	2.27	2.94	30.91	3.25	3.03	51.72	5.43	3.03
19.2	0.53	0.06	2.54	2.48	0.26	2.67	6.06	0.64	2.76	10.86	1.14	2.85	19.50	2.05	2.97	29.26	3.07	3.06	40.47	4.25	3.15	-	0.00	3.15
19.3	1.47	0.15	2.65	4.95	0.52	2.78	9.66	1.01	2.87	15.58	1.64	2.96	26.46	2.78	3.08	-	0.00	3.17	-	0.00	3.26	-	0.00	3.26
19.5	1.53	0.16	2.66	5.10	0.54	2.78	9.91	1.04	2.87	15.92	1.67	2.97	27.03	2.84	3.09	-	0.00	3.18	-	0.00	3.27	-	0.00	3.27
19.7	1.59	0.17	2.66	5.24	0.55	2.79	10.05	1.06	2.88	16.17	1.70	2.97	27.39	2.88	3.09	-	0.00	3.18	-	0.00	3.27	-	0.00	3.27
19.8	3.24	0.34	2.76	7.93	0.83	2.88	13.99	1.47	2.98	21.69	2.28	3.07	-	0.00	3.19	-	0.00	3.28	-	0.00	3.37	-	0.00	3.37
20.0	3.26	0.34	2.76	7.96	0.84	2.89	14.04	1.47	2.98	21.75	2.28	3.07	-	0.00	3.19	-	0.00	3.28	-	0.00	3.37	-	0.00	3.37
20.2	3.24	0.34	2.76	7.93	0.83	2.88	13.99	1.47	2.98	21.69	2.28	3.07	-	0.00	3.19	-	0.00	3.28	-	0.00	3.37	-	0.00	3.37
20.3	3.20	0.34	2.76	7.87	0.83	2.88	13.86	1.46	2.97	21.50	2.26	3.07	-	0.00	3.19	-	0.00	3.28	-	0.00	3.37	-	0.00	3.37
20.5	1.53	0.16	2.66	5.10	0.54	2.78	9.91	1.04	2.87	15.92	1.67	2.97	27.03	2.84	3.09	-	0.00	3.18	-	0.00	3.27	-	0.00	3.27
20.7	1.47	0.15	2.65	4.95	0.52	2.78	9.66	1.01	2.87	15.58	1.64	2.96	26.46	2.78	3.08	-	0.00	3.17	-	0.00	3.26	-	0.00	3.26
20.8	0.53	0.06	2.54	2.48	0.26	2.67	6.06	0.64	2.76	10.86	1.14	2.85	19.50	2.05	2.97	29.26	3.07	3.06	40.47	4.25	3.15	-	0.00	3.15
21.0	0.18	0.02	2.44	0.94	0.10	2.56	2.99	0.31	2.65	6.62	0.69	2.74	13.69	1.44	2.86	21.58	2.27	2.94	30.91	3.25	3.03	51.72	5.43	3.03
21.2	0.06	0.01	2.33	0.31	0.03	2.45	1.13	0.12	2.54	3.16	0.33	2.63	8.53	0.90	2.74	14.89	1.56	2.83	22.54	2.37	2.91	39.05	4.10	2.91
21.3	0.02	0.00	2.22	0.11	0.01	2.34	0.39	0.04	2.42	1.18	0.12	2.51	4.21	0.44	2.62	8.92	0.94	2.71	15.15	1.59	2.79	27.34	2.87	2.79
21.5	0.00	0.00	2.00	0.02	0.00	2.12	0.06	0.01	2.21	0.17	0.02	2.29	0.69	0.07	2.40	1.99	0.21	2.49	4.69	0.49	2.57	11.15	1.17	2.57
21.7	0.00	0.00	1.89	0.01	0.00	2.01	0.02	0.00	2.09	0.06	0.01	2.17	0.26	0.03	2.28	0.73	0.08	2.37	1.87	0.20	2.45	5.77	0.61	2.45
21.8	-	0.00	1.68	-	0.00	1.79	0.00	0.00	1.87	0.01	0.00	1.95	0.04	0.00	2.06	0.13	0.01	2.14	0.33	0.03	2.22	1.43	0.15	2.22
22.0	-	0.00	1.46	-	0.00	1.57	-	0.00	1.65	-	0.00	1.73	-	0.00	1.84	0.02	0.00	1.91	0.06	0.01	1.99	-	0.00	1.99
22.2	-	0.00	1.34	-	0.00	1.45	-	0.00	1.53	-	0.00	1.61	-	0.00	1.71	-	0.00	1.79	-	0.00	1.86	-	0.00	1.86
22.3	-	0.00	1.13	-	0.00	1.23	-	0.00	1.31	-	0.00	1.38	-	0.00	1.48	-	0.00	1.55	-	0.00	1.63	-	0.00	1.63
22.5	-	0.00	0.91	-	0.00	1.01	-	0.00	1.08	-	0.00	1.15	-	0.00	1.25	-	0.00	1.32	-	0.00	1.39	-	0.00	1.39
22.7	-	0.00	0.78	-	0.00	0.88	-	0.00	0.95	-	0.00	1.02	-	0.00	1.12	-	0.00	1.19	-	0.00	1.26	-	0.00	1.26
22.8	-	0.00	0.56	-	0.00	0.66	-	0.00	0.72	-	0.00	0.79	-	0.00	0.88	-	0.00	0.95	-	0.00	1.02	-	0.00	1.02
23.0	-	0.00	0.34	-	0.00	0.43	-	0.00	0.50	-	0.00	0.56	-	0.00	0.65	-	0.00	0.71	-	0.00	0.77	-	0.00	0.77
23.2	-	0.00	0.22	-	0.00	0.30	-	0.00	0.36	-	0.00	0.43	-	0.00	0.51	-	0.00	0.57	-	0.00	0.63	-	0.00	0.63
23.3	-	0.00	-0.01	-	0.00	0.07	-	0.00	0.13	-	0.00	0.19	-	0.00	0.27	-	0.00	0.33	-	0.00	0.39	-	0.00	0.39
23.5	-	0.00	-0.24	-	0.00	-0.16	-	0.00	-0.10	-	0.00	-0.05	-	0.00	0.03	-	0.00	0.08	-	0.00	0.14	-	0.00	0.14
23.7	-	0.00	-0.46	-	0.00	-0.39	-	0.00	-0.34	-	0.00	-0.28	-	0.00	-0.21	-	0.00	-0.16	-	0.00	-0.11	-	0.00	-0.11
23.8	-	0.00	-0.59	-	0.00	-0.52	-	0.00	-0.47	-	0.00	-0.42	-	0.00	-0.36	-	0.00	-0.31	-	0.00	-0.26	-	0.00	-0.26
24.0	-	0.00	-0.82	-	0.00	-0.76	-	0.00	-0.71	-	0.00	-0.66	-	0.00	-0.60	-	0.00	-0.56	-	0.00	-0.51	-	0.00	-0.51
24.2	-	0.00	-1.05	-	0.00	-0.99	-	0.00	-0.95	-	0.00	-0.90	-	0.00	-0.85	-	0.00	-0.81	-	0.00	-0.76	-	0.00	-0.76
24.3	-	0.00	-1.18	-	0.00	-1.12	-	0.00	-1.08	-	0.00	-1.05	-	0.00	-0.99	-	0.00	-0.96	-	0.00	-0.92	-	0.00	-0.92
24.5	-	0.00	-1.41	-	0.00	-1.36	-	0.00	-1.32	-	0.00	-1.29	-	0.00	-1.24	-	0.00	-1.21	-	0.00	-1.17	-	0.00	-1.17
24.7	-	0.00	-1.64	-	0.00	-1.60	-	0.00	-1.56	-	0.00	-1.53	-	0.00	-1.49	-	0.00	-1.46	-	0.00	-1.43	-	0.00	-1.43
24.8	-	0.00	-1.77	-	0.00	-1.73	-	0.00	-1.70	-	0.00	-1.68	-	0.00	-1.64	-	0.00	-1.61	-	0.00	-1.59	-	0.00	-1.59
25.0	-	0.00	-2.00	-	0.00	-1.97	-	0.00	-1.95	-	0.00	-1.92	-	0.00	-1.89	-	0.00	-1.87	-	0.00	-1.84	-	0.00	-1.84
25.2	-	0.00	-2.13	-	0.00	-2.11	-	0.00	-2.09	-	0.00	-2.07	-	0.00	-2.04	-	0.00	-2.02	-	0.00	-2.00	-	0.00	-2.00
25.3	-	0.00	-2.27	-	0.00	-2.25	-	0.00	-2.23	-	0.00	-2.21	-	0.00	-2.19	-	0.00	-2.18	-	0.00	-2.16	-	0.00	-2.16
25.5	-	0.00	-2.30	-	0.00	-2.28	-	0.00	-2.27	-	0.00	-2.26	-	0.00	-2.24	-	0.00	-2.23	-	0.00	-2.22	-	0.00	-2.22
25.7	-	0.00	-2.44	-	0.00	-2.43	-	0.00	-2.42	-	0.00	-2.41	-	0.00	-2.40	-	0.00	-2.39	-	0.00	-2.38	-	0.00	-2.38
25.8	-	0.00	-2.47	-	0.00	-2.47	-	0.00	-2.46	-	0.00	-2.46	-	0.00	-2.45	-	0.00	-2.45	-	0.00	-2.44	-	0.00	-2.44
26.0	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51

Mid Range Future Scenario

	50%			20%			10%			5%			2%			1%			0.50%			0.10%		
Time	q (l/m/s)	q (m3/s)	Water Level (mAOD)	q (l/m/s)	q (m3/s)	Water Level (mAOD)	q (l/m/s)	q (m3/s)	Water Level (mAOD)	q (l/m/s)	q (m3/s)	Water Level (mAOD)	q (l/m/s)	q (m3/s)	Water Level (mAOD)	q (l/m/s)	q (m3/s)	Water Level (mAOD)	q (l/m/s)	q (m3/s)	Water Level (mAOD)	q (l/m/s)	q (m3/s)	Water Level (mAOD)
14.0	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30
14.2	-	0.00	-2.14	-	0.00	-2.14	-	0.00	-2.14	-	0.00	-2.13	-	0.00	-2.13	-	0.00	-2.12	-	0.00	-2.12	-	0.00	-2.12
14.3	-	0.00	-1.99	-	0.00	-1.98	-	0.00	-1.97	-	0.00	-1.96	-	0.00	-1.95	-	0.00	-1.94	-	0.00	-1.94	-	0.00	-1.94
14.5	-	0.00	-1.84	-	0.00	-1.82	-	0.00	-1.81	-	0.00	-1.79	-	0.00	-1.78	-	0.00	-1.77	-	0.00	-1.75	-	0.00	-1.75
14.7	-	0.00	-1.68	-	0.00	-1.66	-	0.00	-1.64	-	0.00	-1.63	-	0.00	-1.61	-	0.00	-1.59	-	0.00	-1.57	-	0.00	-1.57
14.8	-	0.00	-1.53	-	0.00	-1.50	-	0.00	-1.48	-	0.00	-1.46	-	0.00	-1.43	-	0.00	-1.41	-	0.00	-1.39	-	0.00	-1.39
15.0	-	0.00	-1.37	-	0.00	-1.34	-	0.00	-1.32	-	0.00	-1.29	-	0.00	-1.26	-	0.00	-1.24	-	0.00	-1.21	-	0.00	-1.21
15.2	-	0.00	-1.22	-	0.00	-1.18	-	0.00	-1.15	-	0.00	-1.13	-	0.00	-1.09	-	0.00	-1.06	-	0.00	-1.04	-	0.00	-1.04
15.3	-	0.00	-1.07	-	0.00	-1.02	-	0.00	-0.99	-	0.00	-0.96	-	0.00	-0.92	-	0.00	-0.89	-	0.00	-0.86	-	0.00	-0.86
15.5	-	0.00	-0.82	-	0.00	-0.77	-	0.00	-0.73	-	0.00	-0.70	-	0.00	-0.65	-	0.00	-0.62	-	0.00	-0.58	-	0.00	-0.58
15.7	-	0.00	-0.67	-	0.00	-0.61	-	0.00	-0.57	-	0.00	-0.53	-	0.00	-0.48	-	0.00	-0.44	-	0.00	-0.41	-	0.00	-0.41
15.8	-	0.00	-0.52	-	0.00	-0.46	-	0.00	-0.42	-	0.00	-0.37	-	0.00	-0.32	-	0.00	-0.27	-	0.00	-0.23	-	0.00	-0.23
16.0	-	0.00	-0.27	-	0.00	-0.21	-	0.00	-0.16	-	0.00	-0.11	-	0.00	-0.05	-	0.00	-0.01	-	0.00	0.04	-	0.00	0.04
16.2	-	0.00	-0.12	-	0.00	-0.05	-	0.00	0.00	-	0.00	0.05	-	0.00	0.11	-	0.00	0.16	-	0.00	0.21	-	0.00	0.21
16.3	-	0.00	0.12	-	0.00	0.20	-	0.00	0.25	-	0.00	0.30	-	0.00	0.37	-	0.00	0.42	-	0.00	0.48	-	0.00	0.48
16.5	-	0.00	0.37	-	0.00	0.45	-	0.00	0.50	-	0.00	0.56	-	0.00	0.63	-	0.00	0.69	-	0.00	0.74	-	0.00	0.74
16.7	-	0.00	0.51	-	0.00	0.59	-	0.00	0.65	-	0.00	0.71	-	0.00	0.79	-	0.00	0.85	-	0.00	0.91	-	0.00	0.91
16.8	-	0.00	0.75	-	0.00	0.84	-	0.00	0.90	-	0.00	0.96	-	0.00	1.05	-	0.00	1.11	-	0.00	1.17	-	0.00	1.17
17.0	-	0.00	0.99	-	0.00	1.08	-	0.00	1.15	-	0.00	1.21	-	0.00	1.30	-	0.00	1.36	-	0.00	1.43	-	0.00	1.43
17.2	-	0.00	1.13	-	0.00	1.22	-	0.00	1.29	-	0.00	1.36	-	0.00	1.45	-	0.00	1.52	-	0.00	1.58	-	0.00	1.58
17.3	-	0.00	1.37	-	0.00	1.46	-	0.00	1.54	-	0.00	1.61	-	0.00	1.70	-	0.00	1.77	-	0.00	1.84	-	0.00	1.84
17.5	-	0.00	1.60	-	0.00	1.70	-	0.00	1.78	-	0.00	1.85	0.02	0.00	1.95	0.07	0.01	2.02	0.17	0.02	2.09	0.80	0.08	2.09
17.7	-	0.00	1.73	0.00	0.00	1.84	0.01	0.00	1.91	0.02	0.00	1.99	0.07	0.01	2.09	0.20	0.02	2.16	0.49	0.05	2.24	1.94	0.20	2.24
17.8	0.00	0.00	1.97	0.02	0.00	2.07	0.05	0.01	2.15	0.14	0.01	2.23	0.47	0.05	2.33	1.27	0.13	2.41	3.02	0.32	2.48	8.09	0.85	2.48
18.0	0.02	0.00	2.19	0.12	0.01	2.30	0.37	0.04	2.38	1.01	0.11	2.46	3.33	0.35	2.57	7.27	0.76	2.65	12.87	1.35	2.73	23.53	2.47	2.73
18.2	0.08	0.01	2.32	0.40	0.04	2.43	1.20	0.13	2.52	3.12	0.33	2.60	8.04	0.84	2.70	14.18	1.49	2.79	21.79	2.29	2.87	37.01	3.89	2.87
18.3	0.26	0.03	2.44	1.31	0.14	2.56	3.56	0.37	2.64	7.35	0.77	2.73	14.44	1.52	2.84	22.38	2.35	2.92	31.84	3.34	3.00	52.27	5.49	3.00
18.5	0.87	0.09	2.57	3.68	0.39	2.68	7.64	0.80	2.77	12.78	1.34	2.86	21.64	2.27	2.97	31.72	3.33	3.05	43.21	4.54	3.14	-	0.00	3.14
18.7	2.53	0.27	2.69	7.27	0.76	2.81	12.45	1.31	2.89	18.92	1.99	2.98	30.28	3.18	3.09	-	0.00	3.18	-	0.00	3.26	-	0.00	3.26
18.8	5.16	0.54	2.80	11.44	1.20	2.93	18.11	1.90	3.01	26.64	2.80	3.10	-	0.00	3.22	-	0.00	3.30	-	0.00	3.39	-	0.00	3.39
19.0	8.29	0.87	2.92	16.80	1.76	3.04	25.66	2.69	3.13	-	0.00	3.22	-	0.00	3.34	-	0.00	3.43	-	0.00	3.51	-	0.00	3.51
19.2	12.56	1.32	3.03	24.08	2.53	3.16	-	0.00	3.25	-	0.00	3.34	-	0.00	3.46	-	0.00	3.54	-	0.00	3.63	-	0.00	3.63
19.3	18.62	1.96	3.14	-	0.00	3.27	-	0.00	3.36	-	0.00	3.45	-	0.00	3.57	-	0.00	3.66	-	0.00	3.75	-	0.00	3.75
19.5	19.14	2.01	3.15	-	0.00	3.28	-	0.00	3.37	-	0.00	3.46	-	0.00	3.58	-	0.00	3.67	-	0.00	3.76	-	0.00	3.76
19.7	19.54	2.05	3.16	-	0.00	3.28	-	0.00	3.38	-	0.00	3.47	-	0.00	3.59	-	0.00	3.68	-	0.00	3.77	-	0.00	3.77
19.8	-	0.00	3.26	-	0.00	3.38	-	0.00	3.48	-	0.00	3.57	-	0.00	3.69	-	0.00	3.78	-	0.00	3.87	-	0.00	3.87
20.0	-	0.00	3.26	-	0.00	3.39	-	0.00	3.48	-	0.00	3.57	-	0.00	3.69	-	0.00	3.78	-	0.00	3.87	-	0.00	3.87
20.2	-	0.00	3.26	-	0.00	3.38	-	0.00	3.48	-	0.00	3.57	-	0.00	3.69	-	0.00	3.78	-	0.00	3.87	-	0.00	3.87
20.3	-	0.00	3.25	-	0.00	3.38	-	0.00	3.47	-	0.00	3.56	-	0.00	3.68	-	0.00	3.78	-	0.00	3.87	-	0.00	3.87
20.5	19.14	2.01	3.15	-	0.00	3.28	-	0.00	3.37	-	0.00	3.46	-	0.00	3.58	-	0.00	3.67	-	0.00	3.76	-	0.00	3.76
20.7	18.62	1.96	3.14	-	0.00	3.27	-	0.00	3.36	-	0.00	3.45	-	0.00	3.57	-	0.00	3.66	-	0.00	3.75	-	0.00	3.75
20.8	12.56	1.32	3.03	24.08	2.53	3.16	-	0.00	3.25	-	0.00	3.34	-	0.00	3.46	-	0.00	3.54	-	0.00	3.63	-	0.00	3.63
21.0	8.29	0.87	2.92	16.80	1.76	3.04	25.66	2.69	3.13	-	0.00	3.22	-	0.00	3.34	-	0.00	3.43	-	0.00	3.51	-	0.00	3.51
21.2	5.16	0.54	2.80	11.44	1.20	2.93	18.11	1.90	3.01	26.64	2.80	3.10	-	0.00	3.22	-	0.00	3.30	-	0.00	3.39	-	0.00	3.39
21.3	2.53	0.27	2.69	7.27	0.76	2.81	12.45	1.31	2.89	18.92	1.99	2.98	30.28	3.18	3.09	-	0.00	3.18	-	0.00	3.26	-	0.00	3.26
21.5	0.32	0.03	2.47	1.64	0.17	2.58	4.28	0.45	2.67	8.47	0.89	2.76	16.02	1.68	2.87	24.44	2.57	2.95	34.51	3.62	3.04	56.07	5.89	3.04
21.7	0.10	0.01	2.34	0.51	0.05	2.46	1.55	0.16	2.54	3.91	0.41	2.63	9.52	1.00	2.74	16.21	1.70	2.82	24.30	2.55	2.90	40.91	4.30	2.90
21.8	0.01	0.00	2.12	0.07	0.01	2.23	0.20	0.02	2.32	0.56	0.06	2.40	1.98	0.21	2.50	4.89	0.51	2.59	9.62	1.01	2.67	18.76	1.97	2.67
22.0	0.00	0.00	1.89	0.01	0.00	2.00	0.03	0.00	2.08	0.08	0.01	2.16	0.29	0.03	2.27	0.80	0.08	2.35	1.96	0.21	2.43	5.92	0.62	2.43
22.2	-	0.00	1.77	0.00	0.00	1.87	0.01	0.00	1.95	0.03	0.00	2.03	0.10	0.01	2.13	0.28	0.03	2.21	0.68	0.07	2.28	2.57	0.27	2.28
22.3	-	0.00	1.53	-	0.00	1.64	-	0.00	1.71	-	0.00	1.79	-	0.00	1.89	0.05	0.00	1.96	0.12	0.01	2.04	-	0.00	2.04
22.5	-	0.00	1.30	-	0.00	1.40	-	0.00	1.48	-	0.00	1.55	-	0.00	1.65	-	0.00	1.72	-	0.00	1.79	-	0.00	1.79
22.7	-	0.00	1.17	-	0.00	1.26	-	0.00	1.34	-	0.00	1.41	-	0.00	1.50	-	0.00	1.57	-	0.00	1.64	-	0.00	1.64
22.8	-	0.00	0.93	-	0.00	1.02	-	0.00	1.09	-	0.00	1.16	-	0.00	1.25	-	0.00	1.32	-	0.00	1.38	-	0.00	1.38
23.0	-	0.00	0.69	-	0.00	0.78	-	0.00	0.85	-	0.00	0.91	-	0.00	1.00	-	0.00	1.06	-	0.00	1.13	-	0.00	1.13
23.2	-	0.00	0.55	-	0.00	0.64	-	0.00	0.70	-	0.00	0.76	-	0.00	0.85	-	0.00	0.91	-	0.00	0.97	-	0.00	0.97
23.3	-	0.00	0.31	-	0.00	0.39	-	0.00	0.45	-	0.00	0.51	-	0.00	0.59	-	0.00	0.65	-	0.00	0.71	-	0.00	0.71
23.5	-	0.00	0.07	-	0.00	0.15	-	0.00	0.20	-	0.00	0.26	-	0.00	0.33	-	0.00	0.39	-	0.00	0.44	-	0.00	0.44
23.7	-	0.00	-0.18	-	0.00	-0.10	-	0.00	-0.05	-	0.00	0.00	-	0.00	0.07	-	0.00	0.12	-	0.00	0.18	-	0.00	0.18
23.8	-	0.00	-0.32	-	0.00	-0.25	-	0.00	-0.20	-	0.00	-0.15	-	0.00	-0.09	-	0.00	-0.04	-	0.00	0.01	-	0.00	0.01
24.0	-	0.00	-0.57	-	0.00	-0.51	-	0.00	-0.46	-	0.00	-0.41	-	0.00	-0.35	-	0.00	-0.31	-	0.00	-0.26	-	0.00	-0.26
24.2	-	0.00	-0.82	-	0.00	-0.76	-	0.00	-0.72	-	0.00	-0.67	-	0.00	-0.62	-	0.00	-0.57	-	0.00	-0.53	-	0.00	-0.53
24.3	-	0.00	-0.97	-	0.00	-0.91	-	0.00	-0.87	-	0.00	-0.83	-	0.00	-0.78	-	0.00	-0.74	-	0.00	-0.71	-	0.00	-0.71
24.5	-	0.00	-1.22	-	0.00	-1.17	-	0.00	-1.13	-	0.00	-1.10	-	0.00	-1.05	-	0.00	-1.02	-	0.00	-0.98	-	0.00	-0.98
24.7	-	0.00	-1.47	-	0.00	-1.42	-	0.00	-1.39	-	0.00	-1.36	-	0.00	-1.32	-	0.00	-1.29	-	0.00	-1.26	-	0.00	-1.26
24.8	-	0.00	-1.62	-	0.00	-1.58	-	0.00	-1.55	-	0.00	-1.53	-	0.00	-1.49	-	0.00	-1.46	-	0.00	-1.44	-	0.00	-1.44
25.0	-	0.00	-1.87	-	0.00	-1.84	-	0.00	-1.82	-	0.00	-1.79	-	0.00	-1.76	-	0.00	-1.74	-	0.00	-1.71	-	0.00	-1.71
25.2	-	0.00	-2.03	-	0.00	-2.00	-	0.00	-1.98	-	0.00	-1.96	-	0.00	-1.93	-	0.00	-1.91	-	0.00	-1.89	-	0.00	-1.89
25.3	-	0.00	-2.18	-	0.00	-2.16	-	0.00	-2.14	-	0.00	-2.13	-	0.00	-2.11	-	0.00	-2.09	-	0.00	-2.07	-	0.00	-2.07
25.5	-	0.00	-2.24	-	0.00	-2.22	-	0.00	-2.21	-	0.00	-2.19	-	0.00	-2.18	-	0.00	-2.17	-	0.00	-2.15	-	0.00	-2.15
25.7	-	0.00	-2.39	-	0.00	-2.38	-	0.00	-2.38	-	0.00	-2.37	-	0.00	-2.36	-	0.00	-2.35	-	0.00	-2.34	-	0.00	-2.34
25.8	-	0.00	-2.45	-	0.00	-2.44	-	0.00	-2.44	-	0.00	-2.44	-	0.00	-2.43	-	0.00	-2.43	-	0.00	-2.42	-	0.00	-2.42
26.0	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51

High End Future Scenario

	10%			0.50%			0.10%		
Time	q (l/m/s)	q (m3/s)	Water Level (mAOD)	q (l/m/s)	q (m3/s)	Water Level (mAOD)	q (l/m/s)	q (m3/s)	Water Level (mAOD)
14.0	-	0.00	-2.30	-	0.00	-2.30	-	0.00	-2.30
14.2	-	0.00	-2.11	-	0.00	-2.10	-	0.00	-2.10
14.3	-	0.00	-1.93	-	0.00	-1.89	-	0.00	-1.89
14.5	-	0.00	-1.74	-	0.00	-1.69	-	0.00	-1.69
14.7	-	0.00	-1.56	-	0.00	-1.49	-	0.00	-1.49
14.8	-	0.00	-1.37	-	0.00	-1.29	-	0.00	-1.29
15.0	-	0.00	-1.19	-	0.00	-1.08	-	0.00	-1.08
15.2	-	0.00	-1.00	-	0.00	-0.88	-	0.00	-0.88
15.3	-	0.00	-0.82	-	0.00	-0.69	-	0.00	-0.69
15.5	-	0.00	-0.54	-	0.00	-0.39	-	0.00	-0.39
15.7	-	0.00	-0.36	-	0.00	-0.20	-	0.00	-0.20
15.8	-	0.00	-0.18	-	0.00	0.00	-	0.00	0.00
16.0	-	0.00	0.09	-	0.00	0.29	-	0.00	0.29
16.2	-	0.00	0.27	-	0.00	0.48	-	0.00	0.48
16.3	-	0.00	0.54	-	0.00	0.76	-	0.00	0.76
16.5	-	0.00	0.81	-	0.00	1.05	-	0.00	1.05
16.7	-	0.00	0.97	-	0.00	1.23	-	0.00	1.23
16.8	-	0.00	1.24	-	0.00	1.51	-	0.00	1.51
17.0	-	0.00	1.50	-	0.00	1.78	-	0.00	1.78
17.2	-	0.00	1.66	-	0.00	1.95	-	0.00	1.95
17.3	0.01	0.00	1.92	0.58	0.06	2.22	2.32	0.24	2.22
17.5	0.09	0.01	2.17	3.83	0.40	2.49	9.84	1.03	2.49
17.7	0.31	0.03	2.32	10.16	1.07	2.65	19.87	2.09	2.65
17.8	2.57	0.27	2.57	27.51	2.89	2.91	45.62	4.79	2.91
18.0	11.15	1.17	2.82	-	0.00	3.16	-	0.00	3.16
18.2	17.88	1.88	2.96	-	0.00	3.31	-	0.00	3.31
18.3	26.43	2.78	3.10	-	0.00	3.46	-	0.00	3.46
18.5	-	0.00	3.23	-	0.00	3.60	-	0.00	3.60
18.7	-	0.00	3.36	-	0.00	3.73	-	0.00	3.73
18.8	-	0.00	3.49	-	0.00	3.87	-	0.00	3.87
19.0	-	0.00	3.62	-	0.00	4.00	-	0.00	4.00
19.2	-	0.00	3.74	-	0.00	4.12	-	0.00	4.12
19.3	-	0.00	3.85	-	0.00	4.24	-	0.00	4.24
19.5	-	0.00	3.87	-	0.00	4.26	-	0.00	4.26
19.7	-	0.00	3.88	-	0.00	4.27	-	0.00	4.27
19.8	-	0.00	3.98	-	0.00	4.37	-	0.00	4.37
20.0	-	0.00	3.98	-	0.00	4.37	-	0.00	4.37
20.2	-	0.00	3.98	-	0.00	4.37	-	0.00	4.37
20.3	-	0.00	3.97	-	0.00	4.36	-	0.00	4.36
20.5	-	0.00	3.87	-	0.00	4.26	-	0.00	4.26
20.7	-	0.00	3.85	-	0.00	4.24	-	0.00	4.24
20.8	-	0.00	3.74	-	0.00	4.12	-	0.00	4.12
21.0	-	0.00	3.62	-	0.00	4.00	-	0.00	4.00
21.2	-	0.00	3.49	-	0.00	3.87	-	0.00	3.87
21.3	-	0.00	3.36	-	0.00	3.73	-	0.00	3.73
21.5	29.06	3.05	3.13	-	0.00	3.50	-	0.00	3.50
21.7	19.98	2.10	3.00	-	0.00	3.36	-	0.00	3.36
21.8	8.68	0.91	2.76	45.01	4.73	3.11	-	0.00	3.11
22.0	1.62	0.17	2.52	23.90	2.51	2.86	40.14	4.21	2.86
22.2	0.46	0.05	2.37	13.43	1.41	2.71	24.64	2.59	2.71
22.3	0.06	0.01	2.12	2.91	0.31	2.45	8.11	0.85	2.45
22.5	-	0.00	1.87	0.45	0.05	2.19	1.90	0.20	2.19
22.7	-	0.00	1.72	0.15	0.02	2.02	-	0.00	2.02
22.8	-	0.00	1.46	-	0.00	1.75	-	0.00	1.75
23.0	-	0.00	1.20	-	0.00	1.48	-	0.00	1.48
23.2	-	0.00	1.04	-	0.00	1.31	-	0.00	1.31
23.3	-	0.00	0.77	-	0.00	1.03	-	0.00	1.03
23.5	-	0.00	0.51	-	0.00	0.75	-	0.00	0.75
23.7	-	0.00	0.24	-	0.00	0.46	-	0.00	0.46
23.8	-	0.00	0.07	-	0.00	0.28	-	0.00	0.28
24.0	-	0.00	-0.21	-	0.00	-0.01	-	0.00	-0.01
24.2	-	0.00	-0.48	-	0.00	-0.30	-	0.00	-0.30
24.3	-	0.00	-0.66	-	0.00	-0.50	-	0.00	-0.50
24.5	-	0.00	-0.94	-	0.00	-0.79	-	0.00	-0.79
24.7	-	0.00	-1.22	-	0.00	-1.09	-	0.00	-1.09
24.8	-	0.00	-1.40	-	0.00	-1.28	-	0.00	-1.28
25.0	-	0.00	-1.69	-	0.00	-1.58	-	0.00	-1.58
25.2	-	0.00	-1.87	-	0.00	-1.79	-	0.00	-1.79
25.3	-	0.00	-2.06	-	0.00	-1.99	-	0.00	-1.99
25.5	-	0.00	-2.14	-	0.00	-2.09	-	0.00	-2.09
25.7	-	0.00	-2.33	-	0.00	-2.30	-	0.00	-2.30
25.8	-	0.00	-2.42	-	0.00	-2.40	-	0.00	-2.40
26.0	-	0.00	-2.51	-	0.00	-2.51	-	0.00	-2.51

Fluvial and Coastal Hydraulic Modelling Report

1. Basic Model Information

1.1 General Information	
Model ID:	S19
Unit of Management	27
AFA included in the Model	Kilkee
Primary Watercourses / Water Bodies	There is no significant river in the area. However there are a number of small streams forming two distinct systems of watercourses flowing from the eastern and western side of the area. The main watercourses are Kilkee Upper (Stream), Kilkee Lower (River) and Kilkee Upper (River).
1.2 Reference to other Relevant Reports	
Catchment Description	Hydrology Report Unit of Management 27 – Appendix A4.1
Model Location	Hydraulics Report Unit of Management 27 – Section 3.4.12
HEP Schematisation	Hydrology Report Unit of Management 27 – Appendix B6 – Figure B6.1

2. Survey Data and Base Mapping

2.1 Base Mapping:	OSi data base mapping at scale 1:50k Reference: OS_0816_D, OS_0814_D
2.2 DTM for 2D Model Domain:	**Within AFA:** LiDAR data with 2m horizontal resolution and approximately 200mm vertical accuracy has been used to inform the hydraulic model with ground elevation in the floodplain areas included in the AFA boundary.
	Outside AFA: IFSAR data with 5m horizontal resolution and approximately 500mm-1000mm vertical accuracy has been used to inform the hydraulic model with ground elevation in the floodplain areas outside the AFA boundary. **Note:** In general, there is overlap between the AFA area and area outside the AFA with regard to the availability of LiDAR data. Therefore, some areas outside the AFA are covered by LiDAR to the same resolution as that for the AFA.
2.3 River Channel/Structures Survey	General information on the topographic survey of the river channel and structures are included in Section 3.3.3 of the main Hydraulics Report. Full details of the survey outputs are provided in the topographic survey deliverables, as required under Section 5.2 of the Stage I Project Brief. Number of cross-sections included in this model: 96
2.4 Defence Asset Survey Data	The defence asset database has been completed for this model area and is provided as a separate deliverable to this report. There is only one formal flood defence within the modelled extent. This is a sea wall running along the sea front (i.e. West End, Marine Parade and Strand Line) and protecting the area from coastal flooding. The defence has been included in the model schematisation as shown on the maps presented in Annex A2.
2.5 Survey Interaction	The Lidar, IFSAR and topographic survey were checked for anomalies, and to ensure that interactions between were within expected tolerances. No issues were identified in this model.

3. Hydraulic Model Construction and Schematisation

3.1 Software:	**1D domain:**	ISIS Version 3.6.0.156 (32 bit)
	2D domain(s):	TUFLOW Version: 2012-05-AE-iSP-w32
3.2 Model Area / Extent:	The areal extent of the model and its schematisation are shown in Annex A.	

The mapping details for the model extent included in Annex A are as follows:

1. **Full modelled area showing**:
   - River centre lines, HPW extents, names of watercourses
   - 2D domain area
   - AFA boundary
2. **Maps showing a detailed model schematic of the HPW reaches are also included**

3.3 Model Reaches: The following model reaches as shown on the maps referred above have been defined in the ISIS model:

Watercourse Name	Reach	Upstream Model Node	Downstream Model Node
Kilkee East 3	01KLE	01KLE00332	01KLE00000
Kilkee East 2	02ROA	02ROA00670	02ROA00000
	01ROA	01ROA00085	01ROA00000
Kilkee East 1	02KLK	02KLK00635	02KLK00000
	01KLK	01KLK00950	01KLK00000
Kilkee Upper (River)	02DNG	02DNG00759	02DNG00000
Kilkee Lower (River)	01DNG	01DNG00332	01DNG00050
Kilkee Upper (Stream)	01FHG	01FHG011000	01FHG00000

Total model HPW length (km):	4.84	**Total model MPW length (km):**	0.0

3.4 Model Structures: A full schedule of structures included in the model is provided in Schedule A in Annex B. A summary of the structures included is given below:

Culverts:	☒	How many?	11
Bridges:	☒	How many?	3
Fixed crest weirs:	☐	How many?	0
Adjustable crest weirs:	☐	How many?	0
Sluice / Gate structures:	☐	How many?	0
Locks:	☐	How many?	0
Dams:	☐	How many?	0
Other (describe):			
Vertical trash screen	☒	How many?	1

3.5 Floodplain Schematisation

Out-of-bank areas for MPW reaches have been modelled using a 1D approach in the ISIS model by extending the river channel cross-sections.

Out-of-bank areas for HPW reaches, within Kilkee AFA, have been modelled using a 1D approach in the ISIS model by extending the river channel cross-sections.

Extended 1D sections are considered appropriate for HPW extents where floodplain flow paths are simple (e.g, parallel to river flow). 1D-2D modelling is required where HPWs flow through urban areas and out-of-bank flows will form complex flow paths.

	An overview of the floodplain schematisation is available in the maps shown in Annex A.		
3.6 2D Domain Grid Size:	The number of 2D domains defined and the grid sizes of each 2D domain are as follows:		
	Number of 2D domains: 1		
	Domain 1:	Grid cell size: 5m	Area: 1.95 km^2
	2D domains are defined depending on the level of detail required to pick up the appropriate features in the 2D domain that will impact on the local hydraulics. The domain grid square size is typically in the range 5m to 20m, with the smaller grid sizes used in very urbanised areas where there are multiple features that could not be suitably represented in, say, a 10m grid. The model grid is orientated in the main direction of the floodplain flow.		
3.7 Model Breaklines in the 2D Domain:	Bank tops and flood defence walls are represented as breaklines in the 2D domain. The elevation of the bank tops along the line of the defences has been taken from the defence asset survey. Bridge parapets are represented either as spill units in the 1D model or as breaklines in the 2D domain.		
3.8 Floodplain Structures in the 2D Domain	None		
3.9 Hydraulic Roughness	Hydraulic roughness (Manning's 'n') has been defined in accordance with the approaches described in the main Hydraulics Report. Details of the values adopted for this model are included in Schedule B in Annex B. A summary of Manning's 'n' for the model as a whole is as follows:		
HPW in-bank	Minimum 'n' value:	0.050	
	Maximum 'n' value:	0.060	
Floodplain (TUFLOW Model)	Manning's 'n' for out of bank areas represented in the TUFLOW model are as defined by OSi NTF land use characteristics. Floodplain land uses and adopted roughness values in TUFLOW are as follows:		
	Land Use	**Manning's 'n' Value**	
	Buildings	0.100	
	Short grass, parks	0.035	
	General Urban	0.060	
	General Rural	0.045	
	Dense Vegetation	0.080	
	Roads	0.025	
	Railways	0.050	
	Water bodies	0.020	
3.10 Spill Units	Spill units are used for a number of different purposes (e.g. irregular weir, lateral spilling in the floodplain). Spill profile geometry is defined using topographic survey data and LiDAR/IfSAR. Spill coefficients used generally vary between 0.9 and 1.5 depending on the type of ground conditions (e.g. rough vegetated, smooth concrete) over which flood flows are spilling. Lower coefficients (<1.0) can be also found to account for lateral spilling perpendicular to the main direction of flow.		
3.11 Model Boundaries – Fluvial Inflows	Hydrological flow hydrographs were input to the model at key model locations as indicated in the tables below. For further details on the design hydrograph estimation process please refer to Section 2 of the Hydrology Report for UoM27. For further details on hydrographs and peak flows specifically related to this model please see		

	Appendix A4 and Appendix B6 respectfully of the Hydrology Report for UoM27. To improve the hydraulic model stability, the inflow 27_966_1 has been divided into two parts: 27-966_1 and 27_966_1B. The inflow 27_966_1 has been assigned to ISIS node 01KLK00814 and the inflow 27_966_1B has been moved further downstream and assigned to ISIS node 01KLK00349d.
(a) Current Scenario (Main Stream)	Peak inflows (m3/s) are summarised in the tables below for the design events simulated. These are the final inflows as obtained following calibration to HEPs (see Section 4.2)

HEP Reference Name	Input Node in the Hydraulic Model	Annual Exceedance Probability							
		50%	20%	10%	5%	2%	1%	0.5%	0.1%
27_1006_2	01KLK00332	0.7	0.9	1.0	1.1	1.2	1.3	1.4	1.6
27_1006_3	01ROA00085	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.8
27_1008_2	01ROA00003	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
27_1007_1a	02ROA00670	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
27_966_1	01KLK00814	0.5	0.6	0.7	0.8	0.9	1.0	1.0	1.2
27_966_1B	01KLK00349d	0.9	1.2	1.5	1.6	1.9	2.1	2.3	2.8
27_966_2	01KLK00349d	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4
27_298_1	02DNG00759	1.7	2.1	2.4	2.6	2.9	3.1	3.3	3.8
27_298_2	02DNG00244d	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6
27_298_3	01DNG00332	3.1	3.8	4.3	4.7	5.3	5.7	6.1	6.9

(a) Current Scenario (Tributary)

HEP Reference Name	Input Node in the Hydraulic Model	Annual Exceedance Probability							
		50%	20%	10%	5%	2%	1%	0.5%	0.1%
27_346_2	01FHG01100	1.9	2.3	2.6	2.8	3.2	3.4	3.6	4.2
27_346_5	01DNG00332	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
27_965_1a	02KLK00635	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.8

(b) Future Scenario (Main Stream)	The peak inflows (m^3/s) used as inputs to the model at key model locations are summarised in the table below for both the MRFS and the HEFS.

HEP Reference Name	Input Node in the Hydraulic Model	Annual Exceedance Probability							
		MRFS							
		50%	20%	10%	5%	2%	1%	0.5%	0.1%
27_1006_2	01KLK00332	0.9	1.1	1.2	1.3	1.5	1.6	1.7	1.9
27_1006_3	01ROA00085	0.4	0.5	0.6	0.6	0.7	0.8	0.8	0.9
27_1008_2	01ROA00003	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3
27_1007_1a	02ROA00670	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
27_966_1	01KLK00814	0.6	0.8	0.9	1.0	1.1	1.1	1.2	1.4
27_966_1B	01KLK00349d	1.1	1.4	1.7	1.9	2.2	2.5	2.7	3.3
27_966_2	01KLK00349d	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5
27_298_1	02DNG00759	2.0	2.5	2.8	3.1	3.5	3.7	4.0	4.5

27_298_2	02DNG00244d	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7
27_298_3	01DNG00332	3.7	4.6	5.2	5.7	6.3	6.8	7.3	8.3

(b) **Future Scenario (Tributary)**

HEP Reference Name	**Input Node in the Hydraulic Model**	**Annual Exceedance Probability**							
		MRFS							
		50%	**20%**	**10%**	**5%**	**2%**	**1%**	**0.5%**	**0.1%**
27_346_2	01FHG01100	2.2	2.8	3.1	3.4	3.8	4.1	4.4	5.0
27_346_5	01DNG00332	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
27_965_1a	02KLK00635	0.4	0.5	0.6	0.6	0.7	0.8	0.8	0.9

HEP Reference Name	**Input Node in the Hydraulic Model**	**Annual Exceedance Probability**		
		HEFS		
		10%	**1%**	**0.1%**
27_1006_2	01KLK00332	1.3	1.7	2.1
27_1006_3	01ROA00085	0.6	0.8	1.0
27_1008_2	01ROA00003	0.2	0.2	0.3
27_1007_1a	02ROA00670	0.2	0.2	0.3
27_966_1	01KLK00814	1.0	1.2	1.5
27_966_1B	01KLK00349d	1.9	2.7	3.6
27_966_2	01KLK00349d	0.3	0.4	0.5
27_298_1	02DNG00759	3.1	4.0	4.9
27_298_2	02DNG00244d	0.5	0.6	0.7
27_298_3	01DNG00332	5.6	7.4	9.0

(b) Future Scenario (Tributary)

HEP Reference Name	**Input Node in the Hydraulic Model**	**Annual Exceedance Probability**		
		HEFS		
		10%	**1%**	**0.1%**
27_346_2	27_346_2	3.4	4.4	5.4
27_346_5	27_346_5	0.1	0.1	0.2
27_965_1a	27_965_1a	0.6	0.8	1.0

3.12 Model Boundaries – Downstream Conditions	Downstream boundary conditions adopted in the model are as follows:
	Tidal level hydrographs within Kilkee Bay were produced for a series of design events using the Irish Coastal Protection Strategy Study (ICPSS) extreme tidal peak levels data. The time series were set up as boundary conditions for the hydraulic model along the coastal boundary of the 2D model and also at the downstream extents of the HPW reaches in the ISIS model. Full details on how these tidal level hydrographs were derived are provided in Appendix D of the main Hydraulics Report. Peak tidal levels are summarised in the table below for the current and future situations. For the wave overtopping model, wave overtopping hydrographs have been applied directly to the hydraulic model using a flow versus time boundary along the landward side of the flood defences. The hydrographs vary for different points along the defence as shown in Annex F. Full details on how these tidal

	level hydrographs were derived are provided in section 4.4 of the main Hydraulics Report. The tidal hydrographs applied for wave overtopping are available in Annex F of this report.

	Annual Exceedance Probability										
Peak Tidal Levels (m AOD)	**500%**	**200%**	**100%**	**50%**	**20%**	**10%**	**5%**	**2%**	**1%**	**0.5%**	**0.1%**
	2.3	2.5	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.4
	MRFS Annual Exceedance Probability										
Peak tidal levels (m OD)	500%	200%	100%	50%	20%	10%	5%	2%	1%	0.5%	0.1%
	2.9	3.1	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	4.0
	HEFS Annual Exceedance Probability										
Peak tidal levels (m OD)	500%	200%	100%	50%	20%	10%	5%	2%	1%	0.5%	0.1%
	3.4	3.5	3.5	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.5

4. Hydraulic Model Calibration and Sensitivity

4.1 Model Calibration and Verification to Historical Events	The analysis of available flood event data and high flow data for possible consideration as calibration and verification events is covered in detail in the Hydrology Report for UoM27 (Appendix F). The results of this analysis concluded that no calibration or verification could be performed within the modelled area. A broad verification of the model using anecdotal evidence of flooding was also deemed not possible due to a lack of data.
Catchment Gauging	Is modelled catchment: Gauged ☐ Ungauged ☒ *check one box only*
4.2 Calibration to HEP	Calibration of the hydraulic model to the HEP target flows has been carried out for all AEP fluvial events. Section 2.7.2 of the Hydrology Report for UoM27 provides a summary of the calibration to HEP process. Preliminary inflow hydrographs derived from the hydrological analysis and input to the model were adjusted in time so that their respective peak flows coincide with the peak time of the propagating flood wave as it is routed down the model. Total peak flows predicted by the hydraulic model at HEP locations were then compared to the HEP target flows estimated during the hydrological analysis. Inflows at HEP node 27_966_1B were increased by varying amounts to ensure that the modelled total peak flows at this node remain within ±10% of the HEP target flows. This ±10% target allows for good agreement between the hydrological estimates and the hydraulic results without the addition/removal of unrealistic volumes of flow from the model. The robustness of this has been verified by the agreement of the design flood maps. Modelled total peak flows at all other HEP locations were found to be within ±10% of the HEP target flows. Therefore no inflow scaling of the original hydrology was deemed necessary. The table below shows the percentage difference between the modelled and target flows at each HEP location.

HEP Reference Name	**Node in the Hydraulic Model**	**Annual Exceedance Probability**							
		Percentage Difference (%)							
		50%	**20%**	**10%**	**5%**	**2%**	**1%**	**0.5%**	**0.1%**
27_1006_2	01KLE00332	0.0	0.0	-0.2	0.0	-0.2	0.0	0.0	0.0
27_1006_3	01KLE00000	0.0	0.0	-0.2	0.0	-0.2	0.0	0.1	0.0
27_1008_1	01ROA00085	4.8	3.8	7.3	3.2	2.7	4.7	2.5	3.9

27_1008_2	01ROA00038	-3.6	-4.3	-1.4	-5.1	-5.7	-3.3	-5.8	-4.4
27_966_1	01KLK00824	7.5	3.5	3.6	-3.9	-5.3	-1.9	-6.9	-4.4
27_966_2	01KLK00349d	7.8	4.3	3.0	7.1	-3.3	-2.9	-5.9	-7.5
27_966_3	01KLK00093	7.8	4.3	3.0	-0.9	-3.3	-2.9	-5.9	-7.5
27_298_1	02DNG00759	0.0	-0.1	0.0	-0.1	0.0	-0.1	-0.1	-0.1
27_298_2	02DNG00352I2	0.0	0.0	-0.2	-0.1	0.0	-0.5	-0.2	-0.1
27_298_3	01DNG00332	1.8	1.5	1.3	1.2	0.8	0.7	0.4	-0.2
27_232_1	01DNG00332	1.8	1.5	1.3	1.2	0.8	0.7	0.4	-0.2
*27_232_2	01DNG00050	-2.2	-5.8	-11.3	-13.3	-14.8	-15.7	-17.0	-14.6
**27_1007_1a	02ROA00670	100.0	66.7	42.9	33.3	17.6	11.1	5.3	-9.1
**27_1007_1b	02ROA00000	131.0	91.7	60.7	62.7	34.7	30.0	25.8	8.6
27_965_1a	02KLK00635	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27_965_1b	02KLK00000	0.3	0.0	-0.2	0.0	-0.2	-0.2	-0.3	0.0
27_346_2	01FHG01100	-0.1	-0.1	-0.1	-0.1	0.0	-0.1	-0.1	-0.1
27_346_4	01FHG00000	0.8	-2.8	-1.7	-1.7	-1.3	-2.1	-2.2	-3.2
27_346_5	01FHG00000	-1.8	-5.3	-4.3	-4.4	-4.0	-4.6	-4.8	-5.6

*HEP 27_232_2 was seen to be unsuitable for flow comparison due to complex flow paths (recirculation) within the adjacent floodplain.

** The modelled reach at HEP points 27_10007_1a and 27_10007_1b require a minimum flow of 0.2m^3/s for model stability. This causes high percentage errors. Peak flows remain in bank for all events simulated.

4.3 Fluvial and Tidal Events Simulated

The Watercourses in the area are influenced by the tidal levels in Kilkee Bay. As such, a joint probability analysis of the coincidence of fluvial flood flows and coastal flood levels was carried out to determine the appropriate combinations of flows and sea levels to be used for the design probability events, as required under Section 6.5.6 of the Stage I Project Brief.

Methodology and outcomes of this analysis are detailed in the main Hydraulic Report and in the Hydrology Report. A summary of the joint probability of fluvial and tidal conditions used for the hydraulic modelling in the Kilkee AFA is reported in the table below.

Combination of Fluvial and Tidal Events

	Joint Probability Design Event	AEP adopted for Fluvial Flows and Tidal Levels	
Scenario	**Overall AEP**	**Fluvial**	**Tidal**
1	50%	50%	500%
2	50%	50%	50%
3	20%	20%	500%
4	20%	50%	20%
5	10%	10%	200%
6	10%	50%	10%
7	5%	5%	100%
8	5%	50%	5%
9	2%	2%	50%

	10	2%	50%	2%
	11	1%	1%	20%
	12	1%	20%	1%
	13	0.5%	0.5%	10%
	14	0.5%	10%	0.5%
	15	0.1%	0.1%	2%
	16	0.1%	2%	0.1%

4.4 Model Sensitivity	Sensitivity tests have been carried out in order to assess the sensitivity of the predicted peak water levels to alterations in roughness (Manning's 'n'), fluvial flow, afflux at key structures and downstream conditions. The sensitivity runs were carried out for the 1% AEP fluvial dominated event with the corresponding tidal event from the joint probability study in all cases with the only exception of the tests on the downstream boundary conditions, which were carried out for the 0.5% AEP tidal dominated events with the corresponding fluvial event (see Section 4.3). Sensitivity test results are provided in the following tables. Uncertainty maps illustrating the results of the sensitivity analysis will be delivered as part of the final stage of this work

+20% Manning's 'n'	**Watercourse**	**Average Water Level Difference (m)**	**Maximum Water Level Difference (m)**	**Cross-section / Reach where the Maximum Difference occurs**
	Kilkee East 3	0.09	0.11	01KLE00124
	Kilkee East 2	0.04	0.05	01ROA00003
	Kilkee East 1	0.03	0.09	01KLK00460
	Kilkee Lower (River)	0.15	0.22	R4 (Replicated section of Culvert DNG00050C1)
	Kilkee Upper (Stream)	0.03	0.18	01FHG00089I2
-20% Manning's 'n'	**Watercourse**	**Average Water Level Difference (m)**	**Maximum Water Level Difference (m)**	**Cross-section where the Maximum Difference occurs**
	Kilkee East 3	0.10	0.11	KLE129C2
	Kilkee East 2	0.04	0.06	ROA13C2
	Kilkee East 1	0.04	0.12	01KLK00303
	Kilkee Upper (River)	0.08	0.21	02DNG00759I2
	Kilkee Upper (Stream)	0.03	0.05	01FHG00089
+20% inflows	**Watercourse**	**Average Water Level Difference (m)**	**Maximum Water Level Difference (m)**	**Cross-section where the Maximum Difference occurs**
	Kilkee East 3	0.09	0.11	KLE129C2
	Kilkee East 2	0.07	0.13	01ROA00013
	Kilkee East 1	0.06	0.15	01KLK00480
	Kilkee Lower (River)	0.17	0.24	01DNG00060
	Kilkee Upper (Stream)	0.01	0.21	01FHG00000

-20% inflows	Watercourse	Average Water Level Difference (m)	Maximum Water Level Difference (m)	Cross-section where the Maximum Difference occurs
	Kilkee East 3	0.13	0.21	01KLE00129
	Kilkee East 2	0.04	0.11	01ROA00000
	Kilkee East 1	0.06	0.16	01KLK00480
	Kilkee Lower (River)	0.19	0.34	01DNG00060
	Kilkee Upper (Stream)	0.01	0.22	01FHG00089I3

Afflux at Key Structure Inlet coefficients of culverts and discharge coefficients of bridge and orifice increased by 20%	There are three culverts (ROA13C1, KLK00476C1 and KLK00093C1), one bridge (01KLK00465B) and one orifice (KLK00816OR) unit which are located within the 1%AEP fluvial flood extent and hence were selected for checking afflux sensitivity. For the culvert units the inlet coefficients (ki) were increased by 20%. For the bridge unit the orifice discharge coefficient was increased by 20% and for the orifice unit the discharge coefficient was increased by 20%. The maximum water levels were compared at the upstream and downstream of the structures. Model results show that the increases of coefficients have very insignificant impacts on water levels and the maximum observed increase is 6mm. The small changes in water level are localised and have no significant influence on the predicted flood extent.
Afflux at Key Structure Inlet coefficients of culverts and discharge coefficients of bridge and orifice decreased by 20%	Model results show that the impact of decreasing coefficients on the predicted flood extent is also insignificant and the maximum decrease in water level is 6mm.
Downstream Conditions Duration of surge component of tidal boundary is increased by 100% (i.e. 60hours)	To investigate the impact of the duration of high tide levels for a given upstream flood flow condition, the duration of the surge component of the 0.5% AEP tidal boundary was increased by 100% (i.e. 60 hours). Model results show that due to increase in tidal surge duration, the water level increases on the downstream reach of the Kilkee Lower watercourse and the maximum observed increase is 34mm at the cross section DNG00050IN. The water level response extends to cross section 02DNG000332, where the increase is 1 mm. Model result demonstrates that the increase of water level is limited to the downstream reach of Kilkee Lower (River) and does not have any significant influence on the predicted flood extent. Model results also show that water levels on Kilkee East 1 are not affected by the increase in surge duration.
Downstream Conditions Duration of surge component of tidal boundary is decreased by 100% (i.e. 15hours)	The decrease of the surge duration for the 0.5% AEP tidal boundary caused a decrease in maximum water level of 8mm at model section 01DNG00096 on the Kilkee Lower watercourse. The water level response extends to cross section 01DNG00313 where the decrease is 1mm. The change in water level causes no significant effect on the modelled flood extent. Model results also show that water levels on Kilkee East 1 are not affected by the decrease in surge duration.
4.5 Model Files	The hydraulic model files associated with this model are provided as a separate deliverable under the contract, as required under Sections 7.8 and 13 of the Stage I Project Brief. The model files included are detailed in Annex C.

5. Hydraulic Model Outputs

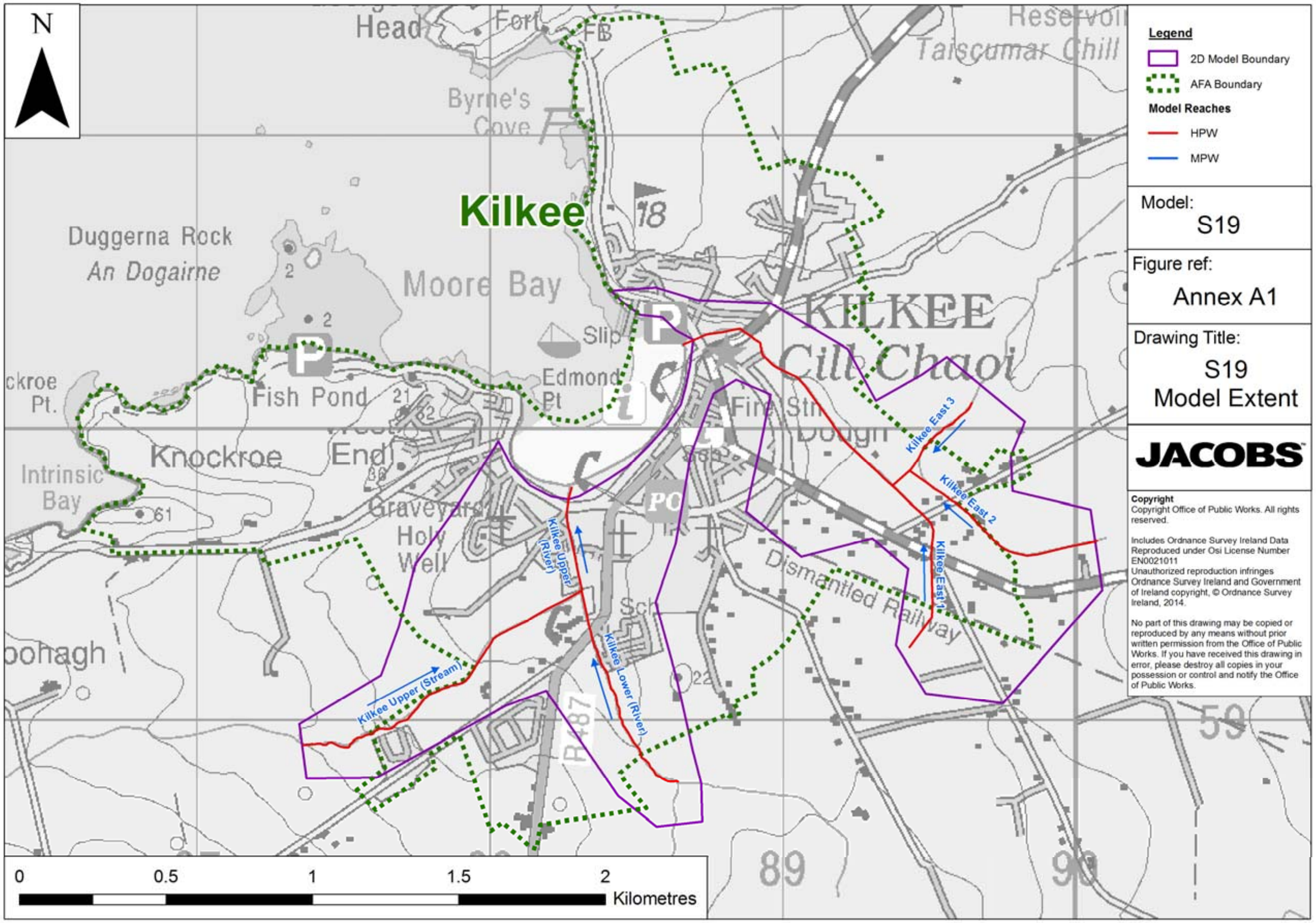
5.1 Mapping	The model outputs were processed to produce a series of flood maps according to the requirements stated in the Stage I Project Brief under Section 7.5.2 and, more specifically, under Section 7.5.2.1, Kilkee being an area where flooding is subject to both tidal and fluvial influence (see Section 6). This includes mapping outputs covering: • Flood extents • Flood depth and velocity • Flood hazard • Wave Overtopping Flood mapping outputs corresponding to the **defended** current scenario for the 10%, 1% and 0.1% AEP fluvial dominated flood events with the corresponding tidal boundary conditions and to the **defended** current scenario for the 10%, 0.5% and 0.1% AEP tidal dominated events with the corresponding fluvial events are shown in Annex D for flood extent and depth only.

6. Key Model Assumption and Limitations

- As detailed in the Hydrology Report, the hydrological approach to the study catchment requires the main river and its tributaries to be treated separately in order to produce flood extents for the design events considered in this study. The watercourse Kilkee Upper (Stream) (Model reach "01FHG") and Kilkee East 1 (Model Reach, "02KLK") was considered as a tributary. All the other watercourses are main stream. Inflow hydrographs were produced for both the main stream and tributary; and two models were run, the first containing only the main stream inflows and then the second containing only the tributary inflows. Both Main Stream and Tributary models share exactly the same geometry (structures and topography). The model outputs for both runs (Main and Tributary) were then merged picking up the maximum flood depths and extents to create the flood maps.
- The only defence included in the model is the formal flood defence wall along the sea side.
- For generating floodplain roughness, the NTF data was used as defined in the main Hydraulics Report. However, recent satellite imagery shows new buildings and development near the North of Kilkee industrial state, Church Road and Circular Road which are not shown in the NTF data provided and therefore are not represented in the model.

Annex A – Model Extent and Schematisation Maps

Annex A1 – Model Extent



Legend
2D Model Boundary
AFA Boundary
Model Reaches
HPW
MPW
Model:
S19
Figure ref:
Annex A1
Drawing Title:
S19
Model Extent
JACOBS
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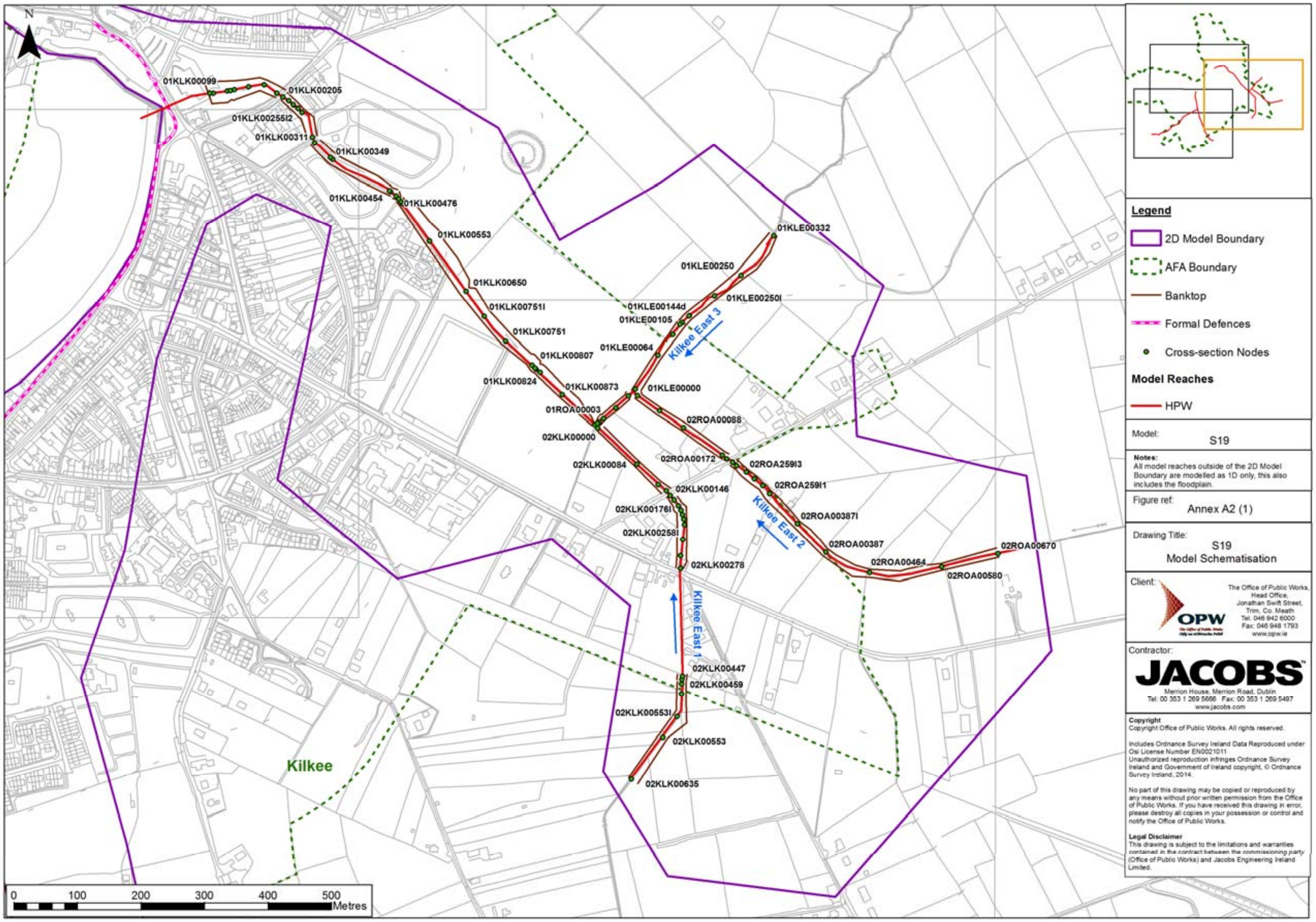
Kilkee
Kilkee Upper (Stream)
Kilkee Upper (River)
Kilkee Lower (River)
Kilkee East 1
Kilkee East 2
Kilkee East 3
0
0.5
1
1.5
2
Kilometres

Annex A2 – Schematisation Maps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01KLK00205
01KLK00255I2
01KLK00311
01KLK00349
01KLK00454
01KLK00476
01KLK00553
01KLK00650
01KLK00751I
01KLK00751
01KLK00807
01KLK00824
01KLK00873
01ROA00003
02KLK00000
02KLK00084
01KLE00332
01KLE00250
01KLE00250I
01KLE00144d
01KLE00105
01KLE00064
01KLE00000
Kilkee East 3
02ROA00088
02ROA00172
02ROA259I3
02ROA259I1
Kilkee East 2
02ROA00387I
02ROA00387
02ROA00464
02ROA00580
02ROA00670
02KLK00146
02KLK00176I
02KLK00258I
02KLK00278
Kilkee East 1
02KLK00447
02KLK00459
02KLK00553I
02KLK00553
02KLK00635
Kilkee
0 100 200 300 400 500 Metres
Legend
2D Model Boundary
AFA Boundary
Banktop
Formal Defences
Cross-section Nodes
Model Reaches
HPW
Model: S19
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Figure ref: Annex A2 (1)
Drawing Title: S19 Model Schematisation
Client:
The Office of Public Works, Head Office, Jonathan Swift Street, Trim, Co. Meath
Tel: 046 942 6000
Fax: 046 948 1793
www.opw.ie
Contractor:
JACOBS
Merrion House, Merrion Road, Dublin
Tel: 00 353 1 269 5666 Fax: 00 353 1 269 5497
www.jacobs.com
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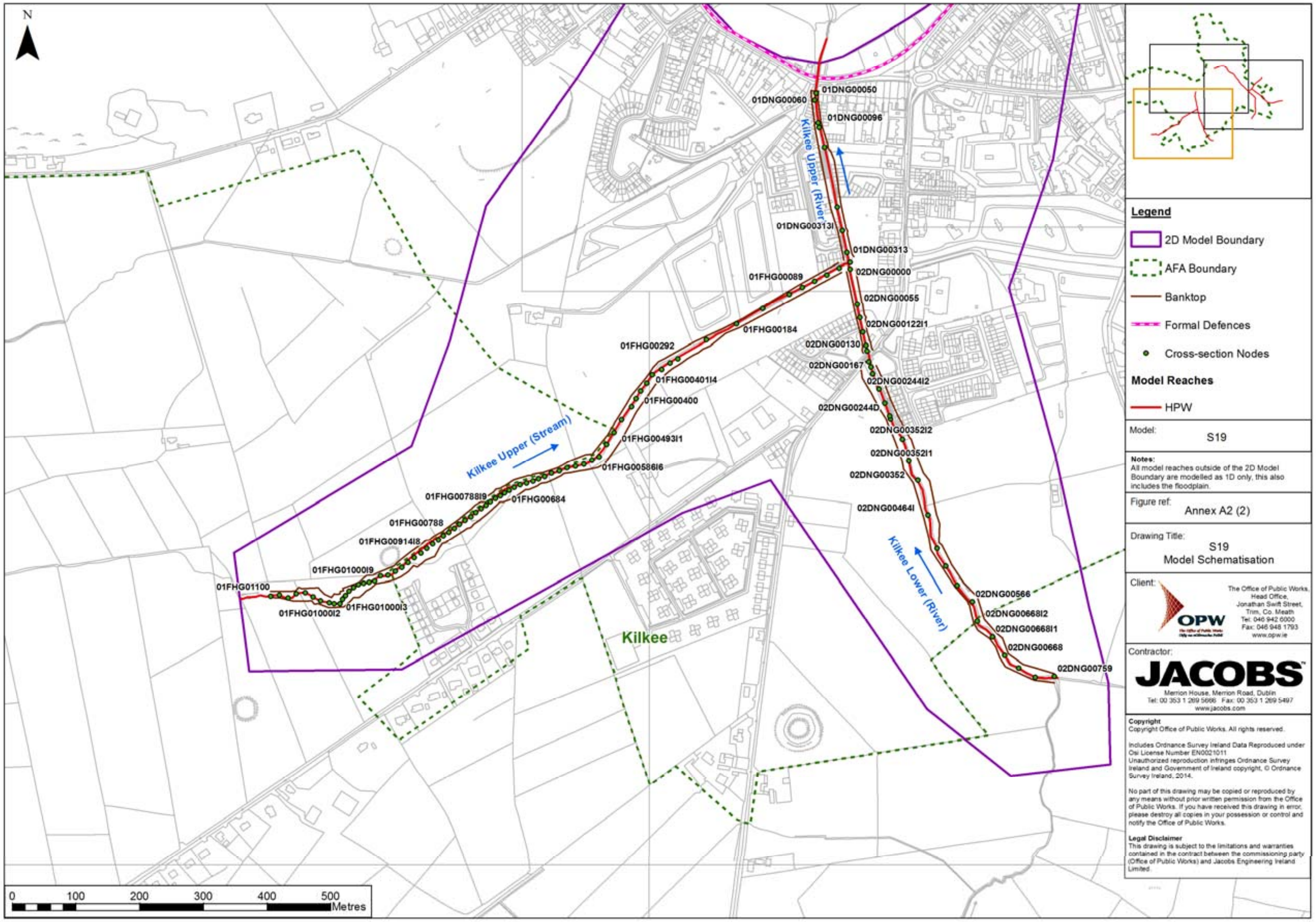
N
01DNG00050
01DNG00060
01DNG00096
Kilkee Upper (River)
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01DNG00313
02DNG00000
01FHG00089
02DNG00055
02DNG00122I1
01FHG00184
01FHG00292
02DNG00130
02DNG00167
01FHG00401I4
02DNG00244I2
01FHG00400
02DNG00244D
02DNG00352I2
01FHG00493I1
Kilkee Upper (Stream)
02DNG00352I1
01FHG00586I6
02DNG00352
01FHG00788I9
01FHG00684
02DNG00464I
01FHG00788
01FHG00914I8
Kilkee Lower (River)
01FHG01000I9
01FHG01100
02DNG00566
01FHG01000I2
01FHG01000I3
02DNG00668I2
02DNG00668I1
Kilkee
02DNG00668
02DNG00759
0 100 200 300 400 500 Metres
Legend
2D Model Boundary
AFA Boundary
Banktop
Formal Defences
Cross-section Nodes
Model Reaches
HPW
Model: S19
Notes:
All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Figure ref: Annex A2 (2)
Drawing Title: S19 Model Schematisation
Client:
The Office of Public Works, Head Office, Jonathan Swift Street, Trim, Co. Meath Tel: 046 942 6000 Fax: 046 948 1793 www.opw.ie
Contractor:
JACOBS
Merrion House, Merrion Road, Dublin Tel: 00 353 1 269 5666 Fax: 00 353 1 269 5497 www.jacobs.com
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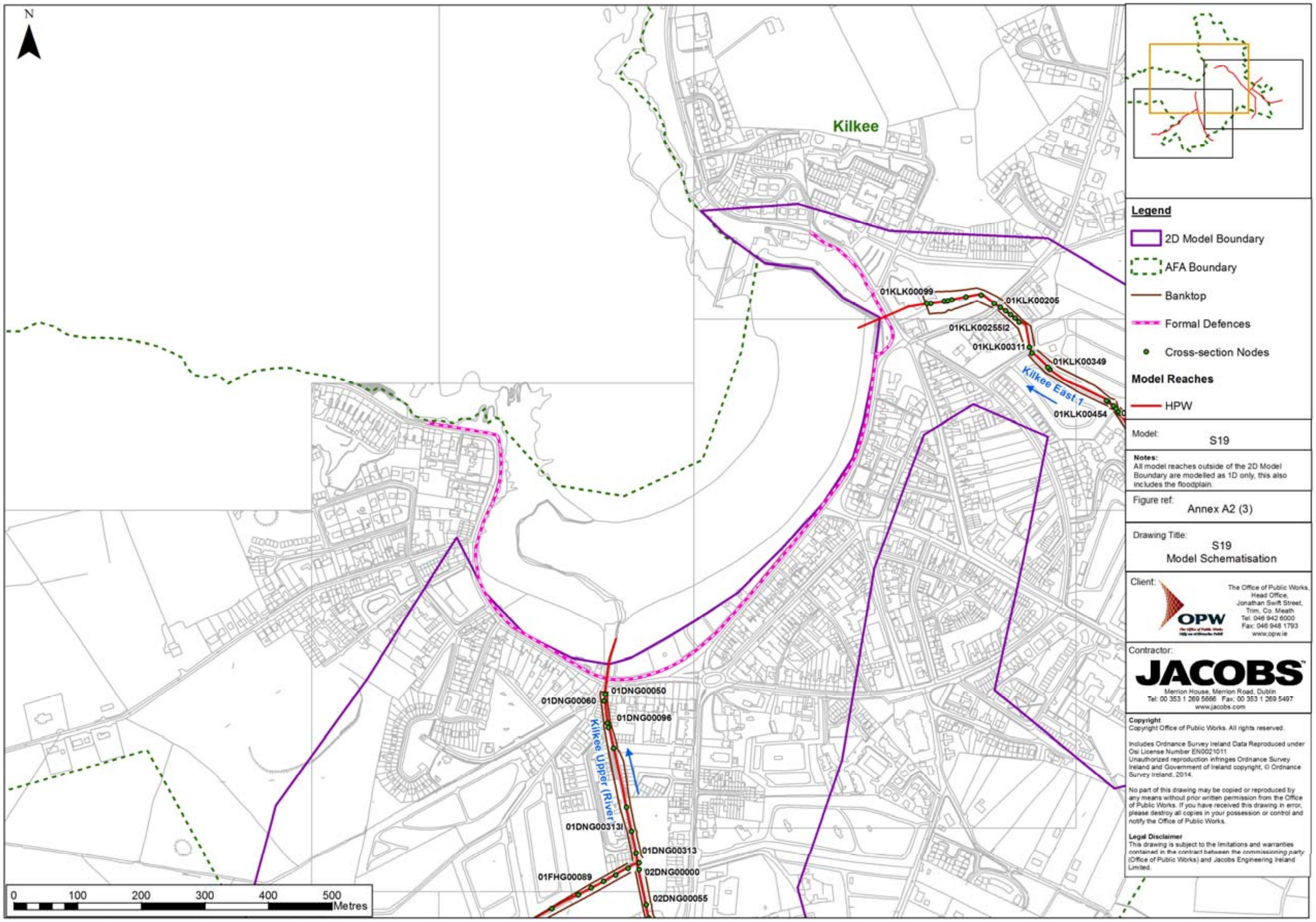

N
Kilkee
01KLK00099
01KLK00205
01KLK00255I2
01KLK00311
01KLK00349
Kilkee East_1
01KLK00454
01DNG00050
01DNG00060
01DNG00096
Kilkee Upper (River
01DNG00313I
01DNG00313
02DNG00000
01FHG00089
02DNG00055
0 100 200 300 400 500 Metres
Legend
2D Model Boundary
AFA Boundary
Banktop
Formal Defences
Cross-section Nodes
Model Reaches
HPW
Model: S19
Notes: All model reaches outside of the 2D Model Boundary are modelled as 1D only, this also includes the floodplain.
Figure ref: Annex A2 (3)
Drawing Title: S19 Model Schematisation
Client:
OPW
Contractor:
JACOBS

Annex B – Structure and Hydraulic Roughness Schedules

Schedule A.1 - Structure Schedule for the River Kilkee East 1

Survey Reference	ISIS Node Reference	Type of Structure	Modelling Approach	Structure included in Model (Y/N)
27KILK00142I	KLK00459C1	0.92 m x 1.05 m Culvert	Rectangular Culvert	Y
27KILK00141I	KLK00447C1	1.2 m dia conduit, 170 m length	Circular conduit	Y
27KILK00112I	KLK00156C1	0.9 m dia conduit & 2No 0.3m conduit at higher elevation	0.9 m diameter circular conduit for main conduit Orifice unit for 2 conduits at higher level	Y
27KILK00084I	KLK00816OR	2 numbers 0.9 m diameter pipe	Orifice unit	Y
27KILK00050I	KLK00476C1	1.2 m dia pipe	Circular conduit	Y
27KILK00048D	01KLK00465B	Arch Bridge	Arch bridge	Y
27KILK00033D	01KLK00311	Bridge 7.81 m long	Arch bridge	Y
27KILK00023E	KLK00205B	Bridge (10 m Length)	Arch bridge	Y
27KILK00014D	01KLK00121	Foot Bridge		N*
27KILK00012	01KLK00099	Trash Screen		Y
27KILK00011I	KLK00093C1	Bridge (85 m Long)	Rectangular Culvert	Y
27KILK0003J	KLK00043C1	0.6m dia pipe culvert	Circular conduit	Y

* Considering the size of the structure relative to the watercourse it was determined that the structure would have little or no hydraulic impact on the model during flood flows.

Schedule A.3 - Structure Schedule for the River Kilkee East 2

Survey Reference	ISIS Node Reference	Type of Structure	Modelling Approach	Structure included in Model (Y/N)
27KILD00027I	ROA183C1	1.20 m Dia Culvert	Circular Conduit	Y
27KILD0002I	ROA13C1	1.20 m Dia Culvert	Circular Conduit	Y

Schedule A.3 - Structure Schedule for the River Kilkee East 3

Survey Reference	ISIS Node Reference	Type of Structure	Modelling Approach	Structure included in Model (Y/N)
27KILE00013I	KLE129C1	0.90 m diameter Culvert	Circular Conduit	Y

Schedule A.2 - Structure Schedule for the River Kilkee Lower (River)

Survey Reference	ISIS Node Reference	Type of Structure	Modelling Approach	Structure included in Model (Y/N)
27KILF00051I	DNG147C1 DNG147C3	2 numbers 1.2 m diameter conduit (16.8 m long)	Parallel circular conduits	Y
27KILF00009I	DNG00050C1	4.88 m x 2.50m culvert (50m long)	Rectangular Culvert	Y

Schedule B.1 – Manning's 'n' for HPW Network

River Name	ISIS Node Reference	In Bank Roughness
Kilkee East 1	02KLK00635 to 01KLK00000	0.050
Kilkee East 2	02ROA00670 to 01ROA00000	0.050
Kilkee East 3	01KLE00332 to 01KLE00000	0.050
Kilkee Upper (Stream)	01FHG01100 to 01FHG00000	0.050
Kilkee Upper (River)	02DNG00759 to 01DNG00000	0.060
Kilkee Lower (River)	01DNG00332 to 01DNG00050	0.060

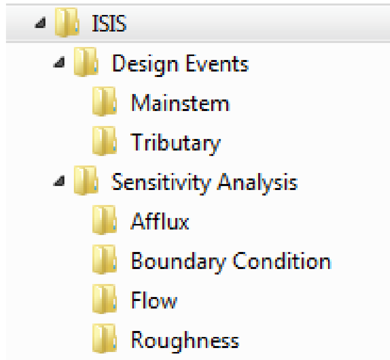
Annex C – Model Calibration

Not used as calibration to historical events was not possible.

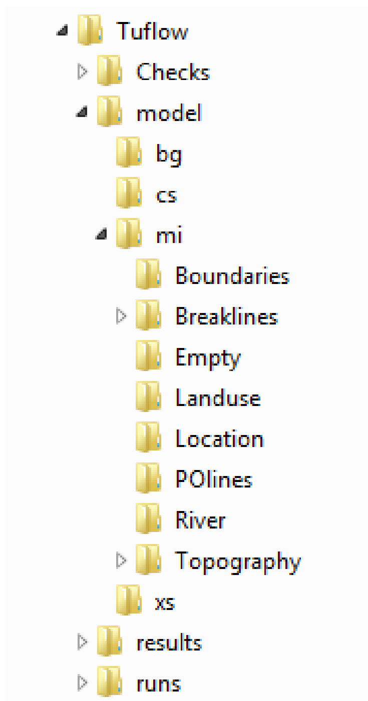
Annex D - Hydraulic Model Files

Model Files Folders Structure

ISIS



TUFLOW



ISIS Files	
Model Geometry (.dat) and Associated Files (e.g.: .ief, .zzl, .zzd, .zzu,.zzx)	**Design Runs** **Main Stream Model Fluvial** S19_Q2_FluMi_C_Des_ISS2.DAT S19_Q5_FluMi_C_Des_ISS2.DAT S19_Q10_FluMi_C_Des_ISS2.DAT S19_Q20_FluMi_C_Des_ISS2.DAT S19_Q50_FluMi_C_Des_ISS2.DAT S19_Q100_FluMi_C_Des_ISS2.DAT S19_Q200_FluMi_C_Des_ISS2.DAT S19_Q1000_FluMi_C_Des_ISS2.DAT **Tributary Model Fluvial** S19_Q2_FluTr_C_Des_ISS2.DAT S19_Q5_FluTr_C_Des_ISS2.DAT S19_Q10_FluTr_C_Des_ISS2.DAT S19_Q20_FluTr_C_Des_ISS2.DAT S19_Q50_FluTr_C_Des_ISS2.DAT S19_Q100_FluTr_C_Des_ISS2.DAT S19_Q200_FluTr_C_Des_ISS2.DAT S19_Q1000_FluTr_C_Des_ISS2.DAT **Main Stream Model Tidal** S19_Q2_CoMi_C_Des_ISS2.DAT S19_Q5_CoMi_C_Des_ISS2.DAT S19_Q10_CoMi_C_Des_ISS2.DAT S19_Q20_CoMi_C_Des_ISS2.DAT S19_Q50_CoMi_C_Des_ISS2.DAT S19_Q100_CoMi_C_Des_ISS2.DAT S19_Q200_CoMi_C_Des_ISS2.DAT S19_Q1000_CoMi_C_Des_ISS2.DAT **Tributary Model Tidal** S19_Q2_CoTr_C_Des_ISS2.DAT S19_Q5_CoTr_C_Des_ISS2.DAT S19_Q10_CoTr_C_Des_ISS2.DAT S19_Q20_CoTr_C_Des_ISS2.DAT S19_Q50_CoTr_C_Des_ISS2.DAT S19_Q100_CoTr_C_Des_ISS2.DAT S19_Q200_CoTr_C_Des_ISS2.DAT S19_Q1000_CoTr_C_Des_ISS2.DAT **Sensitivity Runs –** **Main Stream Model** S19_Q100_FluMi_C_Sen_AfIn_ISS1.DAT S19_Q100_FluMi_C_Sen_AfDe_ISS1.DAT S19_Q200_CoMi_C_Sen_InSurDu_ISS1.DAT

	S19_Q200_CoMi_C_Sen_DeSurDu_ISS1.DAT S19_Q100_FluMi_C_Sen_FlIn_ISS1.DAT S19_Q100_FluMi_C_Sen_FlDe_ISS1.DAT S19_Q100_FluMi_C_Sen_RoIn_ISS1.DAT S19_Q100_Flu_Mi_C_Sen_RoDe_ISS1.DAT

TUFLOW Files	
TUFLOW Control Files (.tcf) and Associated Files (e.g.: ecf, tgc, tbc)	**Design Runs :** **Main Stream Model** S19_Q2_FluMi_C_Des_ISS2.tcf S19_Q5_FluMi_C_Des_ISS2.tcf S19_Q10_FluMi_C_Des_ISS2.tcf S19_Q20_FluMi_C_Des_ISS2.tcf S19_Q50_FluMi_C_Des_ISS2.tcf S19_Q100_FluMi_C_Des_ISS2.tcf S19_Q200_FluMi_C_Des_ISS2.tcf S19_Q1000_FluMi_C_Des_ISS2.tcf S19_Q2_CoMi_C_Des_ISS2.tcf S19_Q5_CoMi_C_Des_ISS2.tcf S19_Q10_CoMi_C_Des_ISS2.tcf S19_Q20_CoMi_C_Des_ISS2.tcf S19_Q50_CoMi_C_Des_ISS2.tcf S19_Q100_CoMi_C_Des_ISS2.tcf S19_Q200_CoMi_C_Des_ISS2.tcf S19_Q1000_CoMi_C_Des_ISS2.tcf } 2d_5m_grid_S19_V27.tgc 2d_5m_grid_S19_V26.tbc landuse.tmf **Tributary Model** S19_Q2_FluTr_C_Des_ISS2.tcf S19_Q5_FluTr_C_Des_ISS2.tcf S19_Q10_FluTr_C_Des_ISS2.tcf S19_Q20_FluTr_C_Des_ISS2.tcf S19_Q50_FluTr_C_Des_ISS2.tcf S19_Q100_FluTr_C_Des_ISS2.tcf S19_Q200_FluTr_C_Des_ISS2.tcf S19_Q1000_FluTr_C_Des_ISS2.tcf S19_Q2_CoTr_C_Des_ISS2.tcf S19_Q5_CoTr_C_Des_ISS2.tcf S19_Q10_CoTr_C_Des_ISS2.tcf S19_Q20_CoTr_C_Des_ISS2.tcf S19_Q50_CoTr_C_Des_ISS2.tcf S19_Q100_CoTr_C_Des_ISS2.tcf S19_Q200_CoTr_C_Des_ISS2.tcf S19_Q1000_CoTr_C_Des_ISS2.tcf } 2d_5m_grid_S19_V27.tgc 2d_5m_grid_S19_V26.tbc landuse.tmf

	Sensitivity Runs **Main Stream Model** S19_Q100_FluMi_C_Sen_AfIn_Iss1.tcf S19_Q100_FluMi_C_Sen_AfDe_Iss1.tcf S19_Q100_FluMi_C_Sen_FlIn_Iss1.tcf S19_Q100_FluMi_C_Sen_FlDe_IssV1.tcf S19_Q200_CoMi_C_Sen_InSurDu_Iss1.tcf S19_Q200_CoMi_C_Sen_DeSurDu_Iss1.tcf } 2d_5m_grid_S19_V27.tgc 2d_5m_grid_S19_V26.tbc Landuse.tmf S19_Q100_FluMi_C_Sen_RoIn_Iss1.tcf S19_Q100_FluMi_C_Sen_RoDe_Iss1.tcf } 2d_5m_grid_S19_V27.tgc 2d_5m_grid_S19_V26.tbc landuse_Ro_20In.tmf landuse_Ro_20De.tmf
Grid Orientation File	2d_loc_S19_abby.MIF
Material Files	2d_mat_urban.MIF 2d_landuse_others.MIF
Zpt Files, Model DTM (.asc)	kilkee2m_dtm.asc
Breaklines Files	2d_zln_Banktop_05.MIF 2d_zln_Parapet_Wall_Mar10.MIF 2d_zsh_DECK.MIF 2d_zln_Kilkee_defence_03.MIF
Boundary Files	2d_bc_hxe_27FEB01.MIF 2d_bc_20MAR_hxi.MIF
Flow/Head Files in bc_dbase	2d_bc_HQ_V02.MIF
Initial Water Level Files	No initial water level file was used for 2D domain
Time Series Files	No time series files provided to the 2d domain.
One Dimensional Network Files	ISIS_nodes_S19_19MAR.MIF
Available 2D Result Files	Depth, stage, hazard and velocity 2d results in ASCII file format for all available design return periods.

Model Run Log

Sr. No.	Model File Name	Start Time	End Time	Time Step	Advanced Options /Other Information	Comments on Model Stability
Design Runs						
1	S19_Q2_FluMi_C_Des_ISS2.DAT S19_Q2_FluMi_C_Des_ISS2.TCF	3	38	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
2	S19_Q5_FluMi_C_Des_ISS2.DAT S19_Q5_FluMi_C_Des_ISS2.TCF	3	38	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
3	S19_Q10_FluMi_C_Des_ISS2.DAT S19_Q10_FluMi_C_Des_ISS2.TCF	3	38	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
4	S19_Q20_FluMi_C_Des_ISS2.DAT S19_Q20_FluMi_C_Des_ISS2.TCF	3	38	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
5	S19_Q50_FluMi_C_Des_ISS2.DAT S19_Q50_FluMi_C_Des_ISS2.TCF	3	38	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.

Design Runs						
Sr. No.	**Model File Name**	**Start Time**	**End Time**	**Time Step**	**Advanced Options /Other Information**	**Comments on Model Stability**
6	S19_Q100_FluMi_C_Des_ISS2.DAT S19_Q100_FluMi_C_Des_ISS2.TCF	3	38	1 sec 1D 2 sec 2D	Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
7	S19_Q200_FluMi_C_Des_ISS2.DAT S19_Q200_FluMi_C_Des_ISS2.TCF	3	38	1 sec 1D 2 sec 2D	Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
8	S19_Q1000_FluMi_C_Des_ISS2.DAT S19_Q1000_FluMi_C_Des_ISS2.TCF	3	38	1 sec 1D 2 sec 2D	Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
9	S19_Q2_CoMi_C_Des_ISS2.DAT S19_Q2_CoMi_C_Des_ISS2.TCF	3	38	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
10	S19_Q5_CoMi_C_Des_ISS2.DAT S19_Q5_CoMi_C_Des_ISS2.TCF	3	38	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
11	S19_Q10_CoMi_C_Des_ISS2.DAT S19_Q10_CoMi_C_Des_ISS2.TCF	3	32	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.

Design Runs						
Sr. No.	**Model File Name**	**Start Time**	**End Time**	**Time Step**	**Advanced Options /Other Information**	**Comments on Model Stability**
12	S19_Q20_CoMi_C_Des_ISS2.DAT S19_Q20_CoMi_C_Des_ISS2.TCF	3	38	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
13	S19_Q50_CoMi_C_Des_ISS2.DAT S19_Q50_CoMi_C_Des_ISS2.TCF	3	38	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
14	S19_Q100_CoMi_C_Des_ISS2.DAT S19_Q100_CoMi_C_Des_ISS2.TCF	3	32	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
15	S19_Q200_CoMi_C_Des_ISS2.DAT S19_Q200_CoMi_C_Des_ISS2.TCF	3	38	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
16	S19_Q1000_CoMi_C_Des_ISS2.DAT S19_Q1000_CoMi_C_Des_ISS2.TCF	3	38	1 sec 1D 1 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
17	S19_Q2_FluTr_C_Des_ISS2.DAT S19_Q2_FluTr_C_Des_ISS2.TCF	3	38	1 sec 1D 2 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.

Design Runs						
Sr. No.	**Model File Name**	**Start Time**	**End Time**	**Time Step**	**Advanced Options /Other Information**	**Comments on Model Stability**
18	S19_Q5_FluTr_C_Des_ISS2.DAT S19_Q5_FluTr_C_Des_ISS2.TCF	3	38	1 sec 1D 2 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
19	S19_Q10_FluTr_C_Des_ISS2.DAT S19_Q10_FluTr_C_Des_ISS2.TCF	3	38	1 sec 1D 2 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
20	S19_Q20_FluTr_C_Des_ISS2.DAT S19_Q20_FluTr_C_Des_ISS2.TCF	3	38	1 sec 1D 2 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
21	S19_Q50_FluTr_C_Des_ISS2.DAT S19_Q50_FluTr_C_Des_ISS2.TCF	3	38	1 sec 1D 2 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
22	S19_Q100_FluTr_C_Des_ISS2.DAT S19_Q100_FluTr_C_Des_ISS2.TCF	3	38	1 sec 1D 2 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
23	S19_Q200_FluTr_C_Des_ISS2.DAT S19_Q200_FluTr_C_Des_ISS2.TCF	3	38	1 sec 1D 2 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.

Design Runs						
Sr. No.	**Model File Name**	**Start Time**	**End Time**	**Time Step**	**Advanced Options /Other Information**	**Comments on Model Stability**
24	S19_Q1000_FluTr_C_Des_ISS2.DAT S19_Q1000_FluTr_C_Des_ISS2.TCF	3	38	1 sec 1D 2 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
25	S19_Q2_CoTr_C_Des_ISS2.DAT S19_Q2_CoTr_C_Des_ISS2.TCF	3	38	1 sec 1D 2 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
26	S19_Q5_CoTr_C_Des_ISS2.DAT S19_Q5_CoTr_C_Des_ISS2.TCF	3	38	1 sec 1D 2 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
27	S19_Q10_CoTr_C_Des_ISS2.DAT S19_Q10_CoTr_C_Des_ISS2.TCF	3	38	1 sec 1D 2 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
28	S19_Q20_CoTr_C_Des_ISS2.DAT S19_Q20_CoTr_C_Des_ISS2.TCF	3	38	1 sec 1D 2 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
29	S19_Q50_CoTr_C_Des_ISS2.DAT S19_Q50_CoTr_C_Des_ISS2.TCF	3	38	1 sec 1D 2 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.

Design Runs						
Sr. No.	**Model File Name**	**Start Time**	**End Time**	**Time Step**	**Advanced Options /Other Information**	**Comments on Model Stability**
30	S19_Q100_CoTr_C_Des_ISS2.DAT S19_Q100_CoTr_C_Des_ISS2.TCF	3	38	1 sec 1D 2 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
31	S19_Q200_CoTr_C_Des_ISS2.DAT S19_Q200_CoTr_C_Des_ISS2.TCF	3	38	1 sec 1D 2 sec 2D	"Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
32	S19_Q1000_CoTr_C_Des_ISS2.DAT S19_Q1000_CoTr_C_Des_ISS2.TCF	3	38	sec 1D 2 sec 2D	Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
Sensitivity Analysis						
Sr. No.	**Model File Name**	**Start Time**	**End Time**	**Time Step**	**Advanced Options /Other Information**	**Comments on Model Stability**
33	S19_Q100_FLUMi_C_Sen_AfIn_Iss1.DAT S19_Q100_FLUMi_C_Sen_AfIn_Iss1.TCF	3	18	sec 1D 2 sec 2D	Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.
34	S19_Q100_FLUMi_C_Sen_AfDe_Iss1.DAT S19_Q100_FLUMi_C_Sen_AfDe_Iss1.TCF	3	18	sec 1D 2 sec 2D	Automated Preissmann Slot for River Sections" is checked, "minitr" value is set to 2 and "maxitr" value is set to 17, ISIS Flow Engine Version "Single Precision" is checked.	Convergence within manufacturer tolerance.

Sensitivity Analysis						
Sr. No.	**Model File Name**	**Start Time**	**End Time**	**Time Step**	**Advanced Options /Other Information**	**Comments on Model Stability**
35	S19_Q100_FLUMi_C_Sen_RoIn_Iss1.DAT S19_Q100_FLUMi_C_Sen_RoIn_Iss1.TCF	3	18	sec 1D 2 sec 2D	Automated Preissmann Slot for River Sections” is checked, “minitr” value is set to 2 and “maxitr” value is set to 17, ISIS Flow Engine Version “Single Precision” is checked.	Convergence within manufacturer tolerance.
36	S19_Q100_FLUMi_C_Sen_RoDe_Iss1.DAT S19_Q100_FLU_C_Sen_RoDe_Iss1.TCF	3	18	sec 1D 2 sec 2D	Automated Preissmann Slot for River Sections” is checked, “minitr” value is set to 2 and “maxitr” value is set to 17, ISIS Flow Engine Version “Single Precision” is checked.	Convergence within manufacturer tolerance.
37	S19_Q100_FLUMi_C_Sen_FlIn_Iss1.DAT S19_Q100_FLUMi_C_Sen_FlIn_Iss1.TCF	3	18	sec 1D 2 sec 2D	Automated Preissmann Slot for River Sections” is checked, “minitr” value is set to 2 and “maxitr” value is set to 17, ISIS Flow Engine Version “Single Precision” is checked.	Convergence within manufacturer tolerance.
38	S19_Q100_FLUMi_C_Sen_FlDe_Iss1.DAT S19_Q100_FLUMi_C_Sen_FlDe_Iss1.TCF	3	18	sec 1D 2 sec 2D	Automated Preissmann Slot for River Sections” is checked, “minitr” value is set to 2 and “maxitr” value is set to 17, ISIS Flow Engine Version “Single Precision” is checked.	Convergence within manufacturer tolerance.
39	S19_Q200_CoMi_C_InSurDu_Iss1.DAT S19_Q200_CoMi_C_InSurDu_Iss1.TCF	3	16	sec 1D 2 sec 2D	Automated Preissmann Slot for River Sections” is checked, “minitr” value is set to 2 and “maxitr” value is set to 17, ISIS Flow Engine Version “Single Precision” is checked.	Convergence within manufacturer tolerance.
40	S19_Q200_CoMi_C_Sen_DeSurDu_Iss1.DAT S19_Q200_CoMi_C_Sen_DesurDu_Iss1.TCF	3	16	sec 1D 2 sec 2D	Automated Preissmann Slot for River Sections” is checked, “minitr” value is set to 2 and “maxitr” value is set to 17, ISIS Flow Engine Version “Single Precision” is checked.	Convergence within manufacturer tolerance.

Parameters changed from Default	Justification
Automated Preismann slot for River Sections turned on.	Automated Preismann slot are a standard parameter used to aid model stability particularly in low flows. These Preismann slots have negligible to no impact on the water levels during flood events.
Minitr	Increased to 2 to improve model stability.*
Maxitr	Increased to 17 to improve model stability.*
Matrix Dummy Coefficient set to 0.0001	Set to 0.0001 to solve IFAG error. *

*Stage and Flow profiles at all cross sections have been checked to ensure results are sensible and to ensure any changes to the default model run parameters has not impacted on the model results

Annex E - Flood Mapping

Flood Maps are available through the OPW flood mapping website; http://maps.opw.ie/fhrm/

Annex F – Wave Overtopping

ICWWS CAPO Kilkee
Prediction Locations

Location A1

Current

AEP

	50%			20%			10%			5%			2%			1%			0.50%			0.10%		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
13.67	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10
13.83	-	0.00	-1.98	-	0.00	-1.97	-	0.00	-1.96	-	0.00	-1.96	-	0.00	-1.95	-	0.00	-1.95	-	0.00	-1.95	-	0.00	-1.94
14.00	-	0.00	-1.85	-	0.00	-1.84	-	0.00	-1.82	-	0.00	-1.82	-	0.00	-1.81	-	0.00	-1.80	-	0.00	-1.80	-	0.00	-1.78
14.17	-	0.00	-1.73	-	0.00	-1.71	-	0.00	-1.68	-	0.00	-1.68	-	0.00	-1.66	-	0.00	-1.64	-	0.00	-1.64	-	0.00	-1.62
14.33	-	0.00	-1.60	-	0.00	-1.58	-	0.00	-1.55	-	0.00	-1.55	-	0.00	-1.51	-	0.00	-1.49	-	0.00	-1.49	-	0.00	-1.46
14.50	-	0.00	-1.48	-	0.00	-1.45	-	0.00	-1.41	-	0.00	-1.41	-	0.00	-1.37	-	0.00	-1.34	-	0.00	-1.34	-	0.00	-1.30
14.67	-	0.00	-1.35	-	0.00	-1.33	-	0.00	-1.27	-	0.00	-1.27	-	0.00	-1.22	-	0.00	-1.19	-	0.00	-1.19	-	0.00	-1.15
14.83	-	0.00	-1.23	-	0.00	-1.20	-	0.00	-1.13	-	0.00	-1.13	-	0.00	-1.08	-	0.00	-1.04	-	0.00	-1.04	-	0.00	-0.99
15.00	-	0.00	-1.10	-	0.00	-1.07	-	0.00	-1.00	-	0.00	-1.00	-	0.00	-0.93	-	0.00	-0.89	-	0.00	-0.89	-	0.00	-0.83
15.17	-	0.00	-0.88	-	0.00	-0.84	-	0.00	-0.76	-	0.00	-0.76	-	0.00	-0.69	-	0.00	-0.64	-	0.00	-0.64	-	0.00	-0.58
15.33	-	0.00	-0.76	-	0.00	-0.72	-	0.00	-0.62	-	0.00	-0.62	-	0.00	-0.55	-	0.00	-0.50	-	0.00	-0.50	-	0.00	-0.42
15.50	-	0.00	-0.64	-	0.00	-0.59	-	0.00	-0.49	-	0.00	-0.49	-	0.00	-0.41	-	0.00	-0.35	-	0.00	-0.35	-	0.00	-0.27
15.67	-	0.00	-0.41	-	0.00	-0.36	-	0.00	-0.25	-	0.00	-0.25	-	0.00	-0.16	-	0.00	-0.10	-	0.00	-0.10	-	0.00	-0.01
15.83	-	0.00	-0.29	-	0.00	-0.24	-	0.00	-0.12	-	0.00	-0.12	-	0.00	-0.02	-	0.00	0.04	-	0.00	0.04	-	0.00	0.14
16.00	-	0.00	-0.07	-	0.00	-0.02	-	0.00	0.11	-	0.00	0.11	-	0.00	0.21	-	0.00	0.28	-	0.00	0.28	-	0.00	0.39
16.17	-	0.00	0.15	-	0.00	0.21	-	0.00	0.34	-	0.00	0.34	-	0.00	0.45	-	0.00	0.53	-	0.00	0.53	-	0.00	0.63
16.33	-	0.00	0.27	-	0.00	0.33	-	0.00	0.47	-	0.00	0.47	-	0.00	0.59	-	0.00	0.67	-	0.00	0.67	-	0.00	0.78
16.50	-	0.00	0.49	-	0.00	0.55	-	0.00	0.70	-	0.00	0.70	-	0.00	0.82	-	0.00	0.90	-	0.00	0.90	-	0.00	1.03
16.67	-	0.00	0.60	-	0.00	0.67	-	0.00	0.83	-	0.00	0.83	-	0.00	0.96	-	0.00	1.04	-	0.00	1.04	-	0.00	1.17
16.83	-	0.00	0.82	-	0.00	0.89	-	0.00	1.06	-	0.00	1.06	-	0.00	1.19	-	0.00	1.28	-	0.00	1.28	-	0.00	1.41
17.00	-	0.00	1.04	-	0.00	1.11	-	0.00	1.28	-	0.00	1.28	-	0.00	1.42	-	0.00	1.51	-	0.00	1.51	-	0.00	1.65
17.17	-	0.00	1.15	-	0.00	1.23	-	0.00	1.41	-	0.00	1.41	-	0.00	1.55	0.75	0.19	1.64	-	0.00	1.64	-	0.00	1.79
17.33	0.15	0.04	1.37	0.25	0.06	1.45	0.33	0.08	1.63	0.51	0.13	1.63	0.76	0.19	1.78	1.01	0.25	1.88	1.18	0.29	1.88	2.65	0.66	2.02
17.50	0.17	0.04	1.48	0.29	0.07	1.57	0.39	0.10	1.75	0.60	0.15	1.75	0.89	0.22	1.90	1.20	0.30	2.00	1.40	0.35	2.00	3.12	0.77	2.16
17.67	0.20	0.05	1.59	0.34	0.09	1.68	0.47	0.12	1.87	0.70	0.17	1.87	1.05	0.26	2.03	1.41	0.35	2.13	1.65	0.41	2.13	3.66	0.91	2.29
17.83	0.24	0.06	1.71	0.40	0.10	1.80	0.55	0.14	1.99	0.82	0.20	1.99	1.24	0.31	2.15	1.67	0.42	2.26	1.95	0.48	2.26	4.29	1.06	2.42
18.00	0.28	0.07	1.82	0.47	0.12	1.91	0.65	0.16	2.11	0.97	0.24	2.11	1.47	0.36	2.27	1.97	0.49	2.38	2.29	0.57	2.38	4.99	1.24	2.54
18.17	0.33	0.08	1.93	0.55	0.14	2.02	0.77	0.19	2.22	1.14	0.28	2.22	1.72	0.43	2.39	2.32	0.57	2.50	2.68	0.66	2.50	5.79	1.44	2.67
18.33	0.38	0.10	2.04	0.65	0.16	2.13	0.91	0.22	2.34	1.33	0.33	2.34	2.02	0.50	2.51	2.71	0.67	2.62	3.12	0.77	2.62	6.72	1.67	2.79
18.50	0.45	0.11	2.14	0.76	0.19	2.24	1.07	0.26	2.45	1.56	0.39	2.45	2.35	0.58	2.62	3.15	0.78	2.74	3.63	0.90	2.74	7.80	1.93	2.91
18.67	0.53	0.13	2.25	0.89	0.22	2.35	1.25	0.31	2.56	1.81	0.45	2.56	2.73	0.68	2.73	3.66	0.91	2.85	4.21	1.04	2.85	9.04	2.24	3.02
18.83	0.62	0.15	2.36	1.04	0.26	2.46	1.45	0.36	2.67	2.10	0.52	2.67	3.17	0.79	2.85	4.27	1.06	2.96	4.91	1.22	2.96	10.48	2.60	3.14
19.00	0.62	0.15	2.36	1.05	0.26	2.46	1.47	0.36	2.68	2.12	0.53	2.68	3.21	0.80	2.85	4.33	1.07	2.97	4.97	1.23	2.97	10.62	2.63	3.15
19.17	0.63	0.16	2.37	1.05	0.26	2.47	1.48	0.37	2.68	2.14	0.53	2.68	3.24	0.80	2.86	4.38	1.09	2.98	5.03	1.25	2.98	10.75	2.67	3.16
19.33	0.72	0.18	2.46	1.21	0.30	2.56	1.71	0.42	2.78	2.46	0.61	2.78	3.72	0.92	2.96	5.04	1.25	3.08	5.78	1.43	3.08	12.25	3.04	3.26
19.50	0.72	0.18	2.47	1.22	0.30	2.57	1.72	0.43	2.79	2.47	0.61	2.79	3.74	0.93	2.96	5.07	1.26	3.08	5.81	1.44	3.08	12.31	3.05	3.26
19.67	0.72	0.18	2.47	1.22	0.30	2.57	1.72	0.43	2.79	2.47	0.61	2.79	3.74	0.93	2.97	5.07	1.26	3.09	5.82	1.44	3.09	12.33	3.06	3.27
19.83	0.72	0.18	2.47	1.22	0.30	2.57	1.72	0.43	2.79	2.47	0.61	2.79	3.74	0.93	2.96	5.07	1.26	3.08	5.81	1.44	3.08	12.31	3.05	3.26
20.00	0.63	0.16	2.37	1.06	0.26	2.47	1.49	0.37	2.69	2.16	0.53	2.69	3.26	0.81	2.87	4.41	1.09	2.99	5.06	1.26	2.99	10.85	2.69	3.17
20.17	0.63	0.16	2.37	1.05	0.26	2.47	1.48	0.37	2.68	2.14	0.53	2.68	3.24	0.80	2.86	4.38	1.09	2.98	5.03	1.25	2.98	10.75	2.67	3.16
20.33	0.54	0.13	2.26	0.91	0.22	2.36	1.28	0.32	2.58	1.85	0.46	2.58	2.81	0.70	2.75	3.77	0.94	2.87	4.34	1.08	2.87	9.34	2.32	3.05
20.50	0.46	0.11	2.16	0.78	0.19	2.26	1.10	0.27	2.47	1.60	0.40	2.47	2.43	0.60	2.65	3.26	0.81	2.76	3.76	0.93	2.76	8.11	2.01	2.94
20.67	0.39	0.10	2.05	0.67	0.17	2.15	0.94	0.23	2.36	1.38	0.34	2.36	2.09	0.52	2.53	2.82	0.70	2.65	3.25	0.81	2.65	7.02	1.74	2.82
20.83	0.34	0.08	1.94	0.57	0.14	2.04	0.80	0.20	2.25	1.18	0.29	2.25	1.80	0.45	2.42	2.43	0.60	2.54	2.81	0.70	2.54	6.09	1.51	2.71
21.00	0.25	0.06	1.74	0.43	0.11	1.83	0.59	0.15	2.04	0.88	0.22	2.04	1.34	0.33	2.21	1.82	0.45	2.32	2.12	0.53	2.32	4.67	1.16	2.49
21.17	0.21	0.05	1.63	0.36	0.09	1.72	0.50	0.12	1.92	0.75	0.19	1.92	1.14	0.28	2.09	1.55	0.38	2.20	1.81	0.45	2.20	4.04	1.00	2.37
21.33	0.16	0.04	1.42	0.27	0.07	1.51	0.37	0.09	1.71	0.56	0.14	1.71	0.85	0.21	1.87	1.16	0.29	1.98	1.35	0.34	1.98	3.07	0.76	2.14
21.50	-	0.00	1.31	-	0.00	1.40	0.31	0.08	1.59	0.48	0.12	1.59	0.73	0.18	1.75	0.98	0.24	1.86	1.16	0.29	1.86	2.63	0.65	2.02
21.67	-	0.00	1.09	-	0.00	1.18	-	0.00	1.37	-	0.00	1.37	-	0.00	1.53	-	0.00	1.63	-	0.00	1.63	-	0.00	1.79
21.83	-	0.00	0.88	-	0.00	0.97	-	0.00	1.15	-	0.00	1.15	-	0.00	1.30	-	0.00	1.40	-	0.00	1.40	-	0.00	1.56
22.00	-	0.00	0.67	-	0.00	0.75	-	0.00	0.93	-	0.00	0.93	-	0.00	1.08	-	0.00	1.18	-	0.00	1.18	-	0.00	1.32
22.17	-	0.00	0.45	-	0.00	0.53	-	0.00	0.71	-	0.00	0.71	-	0.00	0.85	-	0.00	0.94	-	0.00	0.94	-	0.00	1.09
22.33	-	0.00	0.34	-	0.00	0.41	-	0.00	0.58	-	0.00	0.58	-	0.00	0.72	-	0.00	0.81	-	0.00	0.81	-	0.00	0.95
22.50	-	0.00	0.12	-	0.00	0.19	-	0.00	0.36	-	0.00	0.36	-	0.00	0.49	-	0.00	0.58	-	0.00	0.58	-	0.00	0.71
22.67	-	0.00	-0.10	-	0.00	-0.03	-	0.00	0.13	-	0.00	0.13	-	0.00	0.26	-	0.00	0.34	-	0.00	0.34	-	0.00	0.47
22.83	-	0.00	-0.31	-	0.00	-0.25	-	0.00	-0.10	-	0.00	-0.10	-	0.00	0.02	-	0.00	0.10	-	0.00	0.10	-	0.00	0.23
23.00	-	0.00	-0.43	-	0.00	-0.37	-	0.00	-0.23	-	0.00	-0.23	-	0.00	-0.11	-	0.00	-0.03	-	0.00	-0.03	-	0.00	0.08
23.17	-	0.00	-0.65	-	0.00	-0.59	-	0.00	-0.46	-	0.00	-0.46	-	0.00	-0.35	-	0.00	-0.27	-	0.00	-0.27	-	0.00	-0.17
23.33	-	0.00	-0.77	-	0.00	-0.72	-	0.00	-0.59	-	0.00	-0.59	-	0.00	-0.49	-	0.00	-0.42	-	0.00	-0.42	-	0.00	-0.31
23.50	-	0.00	-0.99	-	0.00	-0.94	-	0.00	-0.82	-	0.00	-0.82	-	0.00	-0.72	-	0.00	-0.66	-	0.00	-0.66	-	0.00	-0.56
23.67	-	0.00	-1.11	-	0.00	-1.06	-	0.00	-0.95	-	0.00	-0.95	-	0.00	-0.86	-	0.00	-0.80	-	0.00	-0.80	-	0.00	-0.71
23.83	-	0.00	-1.34	-	0.00	-1.29	-	0.00	-1.19	-	0.00	-1.19	-	0.00	-1.11	-	0.00	-1.05	-	0.00	-1.05	-	0.00	-0.97
24.00	-	0.00	-1.46	-	0.00	-1.42	-	0.00	-1.32	-	0.00	-1.32	-	0.00	-1.25	-	0.00	-1.20	-	0.00	-1.20	-	0.00	-1.12
24.17	-	0.00	-1.58	-	0.00	-1.54	-	0.00	-1.46	-	0.00	-1.46	-	0.00	-1.39	-	0.00	-1.34	-	0.00	-1.34	-	0.00	-1.28
24.33	-	0.00	-1.80	-	0.00	-1.77	-	0.00	-1.70	-	0.00	-1.70	-	0.00	-1.63	-	0.00	-1.59	-	0.00	-1.59	-	0.00	-1.53
24.50	-	0.00	-1.93	-	0.00	-1.90	-	0.00	-1.83	-	0.00	-1.83	-	0.00	-1.78	-	0.00	-1.74	-	0.00	-1.74	-	0.00	-1.69
24.67	-	0.00	-2.05	-	0.00	-2.03	-	0.00	-1.97	-	0.00	-1.97	-	0.00	-1.92	-	0.00	-1.89	-	0.00	-1.89	-	0.00	-1.85
24.83	-	0.00	-2.08	-	0.00	-2.05	-	0.00	-2.01	-	0.00	-2.01	-	0.00	-1.97	-	0.00	-1.94	-	0.00	-1.94	-	0.00	-1.90
25.00	-	0.00	-2.21	-	0.00	-2.19	-	0.00	-2.15	-	0.00	-2.15	-	0.00	-2.12	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.07
25.17	-	0.00	-2.23	-	0.00	-2.22	-	0.00	-2.19	-	0.00	-2.19	-	0.00	-2.17	-	0.00	-2.15	-	0.00	-2.15	-	0.00	-2.13
25.33	-	0.00	-2.26	-	0.00	-2.25	-	0.00	-2.23	-	0.00	-2.23	-	0.00	-2.21	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.19
25.50	-	0.00	-2.28	-	0.00	-2.28	-	0.00	-2.27	-	0.00	-2.27	-	0.00	-2.26	-	0.00	-2.25	-	0.00	-2.25	-	0.00	-2.25
25.67	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20

Mid Range Runs

	50% Mid Range			20% Mid Range			10% Mid Range			5% Mid Range			2% Mid Range			1% Mid Range			0.5% Mid Range			0.1% Mid Range		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
13.67	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10
13.83	-	0.00	-1.96	-	0.00	-1.95	-	0.00	-1.95	-	0.00	-1.94	-	0.00	-1.94	-	0.00	-1.93	-	0.00	-1.93	-	0.00	-1.92
14.00	-	0.00	-1.82	-	0.00	-1.80	-	0.00	-1.80	-	0.00	-1.78	-	0.00	-1.77	-	0.00	-1.76	-	0.00	-1.75	-	0.00	-1.74
14.17	-	0.00	-1.68	-	0.00	-1.65	-	0.00	-1.65	-	0.00	-1.62	-	0.00	-1.61	-	0.00	-1.59	-	0.00	-1.58	-	0.00	-1.56
14.33	-	0.00	-1.53	-	0.00	-1.50	-	0.00	-1.50	-	0.00	-1.46	-	0.00	-1.44	-	0.00	-1.43	-	0.00	-1.41	-	0.00	-1.38
14.50	-	0.00	-1.39	-	0.00	-1.35	-	0.00	-1.35	-	0.00	-1.30	-	0.00	-1.28	-	0.00	-1.26	-	0.00	-1.23	-	0.00	-1.20
14.67	-	0.00	-1.25	-	0.00	-1.20	-	0.00	-1.20	-	0.00	-1.14	-	0.00	-1.12	-	0.00	-1.09	-	0.00	-1.06	-	0.00	-1.02
14.83	-	0.00	-1.11	-	0.00	-1.05	-	0.00	-1.05	-	0.00	-0.98	-	0.00	-0.95	-	0.00	-0.93	-	0.00	-0.89	-	0.00	-0.84
15.00	-	0.00	-0.97	-	0.00	-0.90	-	0.00	-0.90	-	0.00	-0.82	-	0.00	-0.79	-	0.00	-0.76	-	0.00	-0.72	-	0.00	-0.66
15.17	-	0.00	-0.74	-	0.00	-0.65	-	0.00	-0.65	-	0.00	-0.57	-	0.00	-0.53	-	0.00	-0.50	-	0.00	-0.45	-	0.00	-0.38
15.33	-	0.00	-0.60	-	0.00	-0.51	-	0.00	-0.51	-	0.00	-0.41	-	0.00	-0.37	-	0.00	-0.34	-	0.00	-0.29	-	0.00	-0.21
15.50	-	0.00	-0.46	-	0.00	-0.36	-	0.00	-0.36	-	0.00	-0.26	-	0.00	-0.22	-	0.00	-0.17	-	0.00	-0.12	-	0.00	-0.04
15.67	-	0.00	-0.22	-	0.00	-0.11	-	0.00	-0.11	-	0.00	0.00	-	0.00	0.04	-	0.00	0.09	-	0.00	0.15	-	0.00	0.24
15.83	-	0.00	-0.09	-	0.00	0.03	-	0.00	0.03	-	0.00	0.15	-	0.00	0.20	-	0.00	0.24	-	0.00	0.31	-	0.00	0.41
16.00	-	0.00	0.15	-	0.00	0.27	-	0.00	0.27	-	0.00	0.40	-	0.00	0.45	-	0.00	0.50	-	0.00	0.57	-	0.00	0.67
16.17	-	0.00	0.38	-	0.00	0.51	-	0.00	0.51	-	0.00	0.65	-	0.00	0.70	-	0.00	0.76	-	0.00	0.83	-	0.00	0.94
16.33	-	0.00	0.51	-	0.00	0.65	-	0.00	0.65	-	0.00	0.79	-	0.00	0.85	-	0.00	0.91	-	0.00	0.99	-	0.00	1.10
16.50	-	0.00	0.74	-	0.00	0.89	-	0.00	0.89	-	0.00	1.04	-	0.00	1.10	-	0.00	1.16	-	0.00	1.24	-	0.00	1.36
16.67	-	0.00	0.87	-	0.00	1.03	-	0.00	1.03	-	0.00	1.18	-	0.00	1.25	-	0.00	1.31	-	0.00	1.40	-	0.00	1.52
16.83	-	0.00	1.10	-	0.00	1.26	-	0.00	1.26	-	0.00	1.43	-	0.00	1.49	-	0.00	1.56	-	0.00	1.65	-	0.00	1.78
17.00	-	0.00	1.33	-	0.00	1.50	-	0.00	1.50	-	0.00	1.67	-	0.00	1.73	-	0.00	1.80	1.91	0.47	1.90	4.23	1.05	2.03
17.17	-	0.00	1.45	0.61	0.15	1.63	-	0.00	1.63	1.12	0.28	1.80	1.67	0.42	1.87	2.20	0.55	1.95	2.29	0.57	2.04	5.04	1.25	2.18
17.33	0.56	0.14	1.68	0.82	0.20	1.86	1.19	0.29	1.86	1.51	0.37	2.04	2.26	0.56	2.11	2.97	0.74	2.19	3.11	0.77	2.29	6.72	1.67	2.43
17.50	0.66	0.16	1.80	0.97	0.24	1.99	1.40	0.35	1.99	1.80	0.45	2.17	2.69	0.67	2.25	3.52	0.87	2.32	3.70	0.92	2.43	7.92	1.96	2.58
17.67	0.78	0.19	1.92	1.16	0.29	2.11	1.65	0.41	2.11	2.14	0.53	2.30	3.18	0.79	2.38	4.16	1.03	2.46	4.38	1.09	2.56	9.32	2.31	2.72
17.83	0.92	0.23	2.04	1.37	0.34	2.24	1.95	0.48	2.24	2.53	0.63	2.43	3.74	0.93	2.51	4.87	1.21	2.59	5.17	1.28	2.70	10.95	2.72	2.86
18.00	1.08	0.27	2.16	1.62	0.40	2.36	2.29	0.57	2.36	2.98	0.74	2.56	4.38	1.09	2.64	5.71	1.42	2.72	6.10	1.51	2.83	12.84	3.18	3.00
18.17	1.27	0.32	2.28	1.91	0.47	2.48	2.68	0.66	2.48	3.48	0.86	2.69	5.12	1.27	2.77	6.68	1.66	2.85	7.20	1.78	2.96	15.03	3.73	3.13
18.33	1.49	0.37	2.39	2.23	0.55	2.60	3.12	0.77	2.60	4.07	1.01	2.81	5.99	1.49	2.89	7.83	1.94	2.98	8.49	2.11	3.09	17.50	4.34	3.26
18.50	1.74	0.43	2.51	2.61	0.65	2.72	3.62	0.90	2.72	4.77	1.18	2.93	7.01	1.74	3.01	9.17	2.27	3.10	9.99	2.48	3.21	20.30	5.03	3.38
18.67	2.03	0.50	2.62	3.04	0.75	2.83	4.19	1.04	2.83	5.59	1.39	3.04	8.21	2.03	3.13	10.69	2.65	3.22	11.69	2.90	3.33	23.42	5.81	3.51
18.83	2.35	0.58	2.73	3.54	0.88	2.94	4.86	1.21	2.94	6.55	1.62	3.16	9.56	2.37	3.25	12.43	3.08	3.33	13.63	3.38	3.45	26.93	6.68	3.63
19.00	2.38	0.59	2.74	3.59	0.89	2.95	4.93	1.22	2.95	6.65	1.65	3.17	9.73	2.41	3.26	12.64	3.13	3.35	13.89	3.44	3.47	27.44	6.81	3.64
19.17	2.40	0.60	2.74	3.63	0.90	2.96	4.98	1.24	2.96	6.74	1.67	3.18	9.84	2.44	3.27	12.82	3.18	3.36	14.11	3.50	3.48	27.82	6.90	3.65
19.33	2.75	0.68	2.84	4.20	1.04	3.06	5.73	1.42	3.06	7.76	1.92	3.28	11.27	2.79	3.37	14.62	3.63	3.46	16.16	4.01	3.58	31.39	7.78	3.76
19.50	2.76	0.69	2.85	4.21	1.04	3.06	5.75	1.43	3.06	7.80	1.93	3.28	11.34	2.81	3.37	14.72	3.65	3.46	16.24	4.03	3.58	31.58	7.83	3.76
19.67	2.77	0.69	2.85	4.22	1.05	3.07	5.76	1.43	3.07	7.81	1.94	3.29	11.36	2.82	3.38	14.74	3.66	3.47	16.28	4.04	3.59	31.65	7.85	3.77
19.83	2.76	0.69	2.85	4.21	1.04	3.06	5.75	1.43	3.06	7.80	1.93	3.28	11.34	2.81	3.37	14.72	3.65	3.46	16.24	4.03	3.58	31.58	7.83	3.76
20.00	2.41	0.60	2.75	3.66	0.91	2.97	5.02	1.25	2.97	6.80	1.69	3.19	9.93	2.46	3.28	12.94	3.21	3.37	14.25	3.53	3.48	28.12	6.97	3.66
20.17	2.40	0.60	2.74	3.63	0.90	2.96	4.98	1.24	2.96	6.74	1.67	3.18	9.84	2.44	3.27	12.82	3.18	3.36	14.11	3.50	3.48	27.82	6.90	3.65
20.33	2.08	0.52	2.64	3.13	0.78	2.85	4.31	1.07	2.85	5.80	1.44	3.07	8.52	2.11	3.16	11.12	2.76	3.25	12.18	3.02	3.37	24.42	6.06	3.54
20.50	1.79	0.44	2.53	2.70	0.67	2.74	3.74	0.93	2.74	4.97	1.23	2.96	7.33	1.82	3.05	9.60	2.38	3.13	10.50	2.60	3.25	21.34	5.29	3.43
20.67	1.55	0.38	2.42	2.33	0.58	2.63	3.24	0.80	2.63	4.27	1.06	2.84	6.30	1.56	2.93	8.25	2.05	3.02	9.00	2.23	3.13	18.54	4.60	3.31
20.83	1.32	0.33	2.31	2.00	0.50	2.52	2.80	0.69	2.52	3.67	0.91	2.73	5.41	1.34	2.81	7.09	1.76	2.90	7.69	1.91	3.01	16.04	3.98	3.18
21.00	0.98	0.24	2.09	1.49	0.37	2.30	2.11	0.52	2.30	2.78	0.69	2.51	4.12	1.02	2.59	5.39	1.34	2.68	5.77	1.43	2.79	12.28	3.05	2.96
21.17	0.84	0.21	1.98	1.27	0.31	2.18	1.81	0.45	2.18	2.38	0.59	2.39	3.54	0.88	2.47	4.63	1.15	2.55	4.94	1.22	2.66	10.57	2.62	2.83
21.33	0.63	0.16	1.76	0.94	0.23	1.96	1.35	0.34	1.96	1.77	0.44	2.16	2.66	0.66	2.24	3.52	0.87	2.32	3.74	0.93	2.43	8.09	2.01	2.60
21.50	0.54	0.13	1.64	0.80	0.20	1.84	1.16	0.29	1.84	1.50	0.37	2.03	2.26	0.56	2.11	2.99	0.74	2.19	3.17	0.79	2.30	6.93	1.72	2.46
21.67	-	0.00	1.42	0.60	0.15	1.61	-	0.00	1.61	1.12	0.28	1.80	1.69	0.42	1.88	2.24	0.56	1.96	2.36	0.58	2.06	5.25	1.30	2.22
21.83	-	0.00	1.20	-	0.00	1.39	-	0.00	1.39	-	0.00	1.57	-	0.00	1.65	-	0.00	1.72	1.75	0.43	1.83	-	0.00	1.98
22.00	-	0.00	0.98	-	0.00	1.16	-	0.00	1.16	-	0.00	1.34	-	0.00	1.41	-	0.00	1.49	-	0.00	1.59	-	0.00	1.73
22.17	-	0.00	0.75	-	0.00	0.93	-	0.00	0.93	-	0.00	1.10	-	0.00	1.17	-	0.00	1.25	-	0.00	1.34	-	0.00	1.48
22.33	-	0.00	0.63	-	0.00	0.80	-	0.00	0.80	-	0.00	0.97	-	0.00	1.03	-	0.00	1.10	-	0.00	1.20	-	0.00	1.33
22.50	-	0.00	0.40	-	0.00	0.56	-	0.00	0.56	-	0.00	0.73	-	0.00	0.79	-	0.00	0.86	-	0.00	0.95	-	0.00	1.08
22.67	-	0.00	0.17	-	0.00	0.33	-	0.00	0.33	-	0.00	0.48	-	0.00	0.55	-	0.00	0.61	-	0.00	0.70	-	0.00	0.82
22.83	-	0.00	-0.06	-	0.00	0.09	-	0.00	0.09	-	0.00	0.24	-	0.00	0.30	-	0.00	0.36	-	0.00	0.44	-	0.00	0.56
23.00	-	0.00	-0.19	-	0.00	-0.05	-	0.00	-0.05	-	0.00	0.09	-	0.00	0.15	-	0.00	0.21	-	0.00	0.29	-	0.00	0.40
23.17	-	0.00	-0.42	-	0.00	-0.29	-	0.00	-0.29	-	0.00	-0.15	-	0.00	-0.10	-	0.00	-0.04	-	0.00	0.03	-	0.00	0.14
23.33	-	0.00	-0.55	-	0.00	-0.43	-	0.00	-0.43	-	0.00	-0.30	-	0.00	-0.25	-	0.00	-0.20	-	0.00	-0.13	-	0.00	-0.03
23.50	-	0.00	-0.79	-	0.00	-0.67	-	0.00	-0.67	-	0.00	-0.55	-	0.00	-0.50	-	0.00	-0.46	-	0.00	-0.39	-	0.00	-0.29
23.67	-	0.00	-0.92	-	0.00	-0.81	-	0.00	-0.81	-	0.00	-0.70	-	0.00	-0.66	-	0.00	-0.61	-	0.00	-0.55	-	0.00	-0.46
23.83	-	0.00	-1.16	-	0.00	-1.06	-	0.00	-1.06	-	0.00	-0.96	-	0.00	-0.92	-	0.00	-0.87	-	0.00	-0.82	-	0.00	-0.74
24.00	-	0.00	-1.30	-	0.00	-1.21	-	0.00	-1.21	-	0.00	-1.11	-	0.00	-1.07	-	0.00	-1.04	-	0.00	-0.99	-	0.00	-0.91
24.17	-	0.00	-1.44	-	0.00	-1.35	-	0.00	-1.35	-	0.00	-1.27	-	0.00	-1.23	-	0.00	-1.20	-	0.00	-1.15	-	0.00	-1.08
24.33	-	0.00	-1.67	-	0.00	-1.60	-	0.00	-1.60	-	0.00	-1.52	-	0.00	-1.49	-	0.00	-1.46	-	0.00	-1.42	-	0.00	-1.36
24.50	-	0.00	-1.81	-	0.00	-1.75	-	0.00	-1.75	-	0.00	-1.68	-	0.00	-1.65	-	0.00	-1.63	-	0.00	-1.59	-	0.00	-1.54
24.67	-	0.00	-1.95	-	0.00	-1.90	-	0.00	-1.90	-	0.00	-1.84	-	0.00	-1.82	-	0.00	-1.79	-	0.00	-1.76	-	0.00	-1.72
24.83	-	0.00	-1.99	-	0.00	-1.95	-	0.00	-1.95	-	0.00	-1.90	-	0.00	-1.88	-	0.00	-1.86	-	0.00	-1.83	-	0.00	-1.80
25.00	-	0.00	-2.14	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.06	-	0.00	-2.05	-	0.00	-2.03	-	0.00	-2.01	-	0.00	-1.98
25.17	-	0.00	-2.18	-	0.00	-2.15	-	0.00	-2.15	-	0.00	-2.12	-	0.00	-2.11	-	0.00	-2.10	-	0.00	-2.08	-	0.00	-2.06
25.33	-	0.00	-2.22	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.18	-	0.00	-2.18	-	0.00	-2.17	-	0.00	-2.16	-	0.00	-2.14
25.50	-	0.00	-2.26	-	0.00	-2.25	-	0.00	-2.25	-	0.00	-2.24	-	0.00	-2.24	-	0.00	-2.24	-	0.00	-2.23	-	0.00	-2.22
25.67	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20

High End Runs

	10% High End			0.5% High End			0.1% High End		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
13.67	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10
13.83	-	0.00	-1.93	-	0.00	-1.91	-	0.00	-1.90
14.00	-	0.00	-1.75	-	0.00	-1.73	-	0.00	-1.69
14.17	-	0.00	-1.58	-	0.00	-1.54	-	0.00	-1.49
14.33	-	0.00	-1.41	-	0.00	-1.36	-	0.00	-1.29
14.50	-	0.00	-1.24	-	0.00	-1.17	-	0.00	-1.09
14.67	-	0.00	-1.07	-	0.00	-0.99	-	0.00	-0.89
14.83	-	0.00	-0.90	-	0.00	-0.80	-	0.00	-0.69
15.00	-	0.00	-0.73	-	0.00	-0.62	-	0.00	-0.49
15.17	-	0.00	-0.46	-	0.00	-0.34	-	0.00	-0.19
15.33	-	0.00	-0.29	-	0.00	-0.16	-	0.00	0.00
15.50	-	0.00	-0.13	-	0.00	0.01	-	0.00	0.19
15.67	-	0.00	0.14	-	0.00	0.29	-	0.00	0.49
15.83	-	0.00	0.30	-	0.00	0.46	-	0.00	0.67
16.00	-	0.00	0.56	-	0.00	0.74	-	0.00	0.96
16.17	-	0.00	0.82	-	0.00	1.01	-	0.00	1.24
16.33	-	0.00	0.97	-	0.00	1.17	-	0.00	1.42
16.50	-	0.00	1.23	-	0.00	1.44	-	0.00	1.70
16.67	-	0.00	1.38	-	0.00	1.60	-	0.00	1.88
16.83	-	0.00	1.63	-	0.00	1.86	-	0.00	2.15
17.00	1.97	0.49	1.88	5.11	1.27	2.12	9.16	2.27	2.42
17.17	2.37	0.59	2.03	6.10	1.51	2.27	10.95	2.72	2.58
17.33	3.20	0.79	2.27	8.11	2.01	2.52	14.53	3.60	2.84
17.50	3.81	0.94	2.41	9.59	2.38	2.67	17.26	4.28	3.00
17.67	4.50	1.12	2.55	11.31	2.80	2.82	20.41	5.06	3.15
17.83	5.29	1.31	2.68	13.31	3.30	2.96	24.06	5.97	3.30
18.00	6.23	1.54	2.81	15.62	3.87	3.10	28.27	7.01	3.45
18.17	7.33	1.82	2.94	18.28	4.53	3.23	33.02	8.19	3.59
18.33	8.62	2.14	3.07	21.30	5.28	3.36	38.31	9.50	3.73
18.50	10.13	2.51	3.19	24.65	6.11	3.49	44.17	10.95	3.86
18.67	11.84	2.94	3.31	28.41	7.05	3.61	50.59	12.55	3.99
18.83	13.76	3.41	3.43	32.62	8.09	3.73	57.56	14.27	4.11
19.00	14.03	3.48	3.45	33.26	8.25	3.75	58.75	14.57	4.13
19.17	14.23	3.53	3.46	33.75	8.37	3.76	59.71	14.81	4.15
19.33	16.27	4.03	3.56	37.91	9.40	3.87	66.48	16.49	4.26
19.50	16.35	4.05	3.56	38.16	9.46	3.87	66.95	16.60	4.26
19.67	16.39	4.06	3.57	38.25	9.49	3.88	67.09	16.64	4.27
19.83	16.35	4.05	3.56	38.16	9.46	3.87	66.95	16.60	4.26
20.00	14.38	3.57	3.46	34.09	8.45	3.77	60.39	14.98	4.16
20.17	14.23	3.53	3.46	33.75	8.37	3.76	59.71	14.81	4.15
20.33	12.33	3.06	3.35	29.68	7.36	3.65	53.01	13.15	4.03
20.50	10.63	2.64	3.23	25.95	6.44	3.53	46.76	11.60	3.91
20.67	9.13	2.26	3.11	22.59	5.60	3.41	40.95	10.16	3.79
20.83	7.82	1.94	2.99	19.58	4.86	3.29	35.63	8.84	3.66
21.00	5.90	1.46	2.77	15.03	3.73	3.06	27.62	6.85	3.43
21.17	5.06	1.25	2.64	12.90	3.20	2.93	23.75	5.89	3.29
21.33	3.83	0.95	2.41	9.86	2.44	2.70	18.21	4.52	3.05
21.50	3.26	0.81	2.28	8.43	2.09	2.56	15.53	3.85	2.90
21.67	2.43	0.60	2.05	6.41	1.59	2.32	11.84	2.94	2.65
21.83	-	0.00	1.81	4.85	1.20	2.07	9.00	2.23	2.40
22.00	-	0.00	1.57	-	0.00	1.82	-	0.00	2.14
22.17	-	0.00	1.33	-	0.00	1.57	-	0.00	1.88
22.33	-	0.00	1.18	-	0.00	1.42	-	0.00	1.72
22.50	-	0.00	0.93	-	0.00	1.16	-	0.00	1.45
22.67	-	0.00	0.68	-	0.00	0.90	-	0.00	1.18
22.83	-	0.00	0.43	-	0.00	0.64	-	0.00	0.90
23.00	-	0.00	0.27	-	0.00	0.47	-	0.00	0.72
23.17	-	0.00	0.02	-	0.00	0.21	-	0.00	0.44
23.33	-	0.00	-0.14	-	0.00	0.04	-	0.00	0.26
23.50	-	0.00	-0.40	-	0.00	-0.24	-	0.00	-0.03
23.67	-	0.00	-0.56	-	0.00	-0.41	-	0.00	-0.21
23.83	-	0.00	-0.83	-	0.00	-0.69	-	0.00	-0.51
24.00	-	0.00	-0.99	-	0.00	-0.86	-	0.00	-0.70
24.17	-	0.00	-1.16	-	0.00	-1.04	-	0.00	-0.89
24.33	-	0.00	-1.43	-	0.00	-1.32	-	0.00	-1.19
24.50	-	0.00	-1.60	-	0.00	-1.50	-	0.00	-1.39
24.67	-	0.00	-1.77	-	0.00	-1.69	-	0.00	-1.59
24.83	-	0.00	-1.84	-	0.00	-1.77	-	0.00	-1.69
25.00	-	0.00	-2.01	-	0.00	-1.96	-	0.00	-1.89
25.17	-	0.00	-2.09	-	0.00	-2.05	-	0.00	-2.00
25.33	-	0.00	-2.16	-	0.00	-2.13	-	0.00	-2.10
25.50	-	0.00	-2.23	-	0.00	-2.22	-	0.00	-2.20
25.67	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20

Location A2

Current

	AEP																							
	50%			20%			10%			5%			2%			1%			0.50%			0.10%		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
13.67	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10
13.83	-	0.00	-1.97	-	0.00	-1.96	-	0.00	-1.96	-	0.00	-1.95	-	0.00	-1.95	-	0.00	-1.94	-	0.00	-1.94	-	0.00	-1.94
14.00	-	0.00	-1.84	-	0.00	-1.82	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.80	-	0.00	-1.79	-	0.00	-1.78	-	0.00	-1.78
14.17	-	0.00	-1.71	-	0.00	-1.68	-	0.00	-1.67	-	0.00	-1.66	-	0.00	-1.64	-	0.00	-1.63	-	0.00	-1.62	-	0.00	-1.62
14.33	-	0.00	-1.58	-	0.00	-1.55	-	0.00	-1.53	-	0.00	-1.51	-	0.00	-1.49	-	0.00	-1.48	-	0.00	-1.46	-	0.00	-1.46
14.50	-	0.00	-1.45	-	0.00	-1.41	-	0.00	-1.39	-	0.00	-1.37	-	0.00	-1.34	-	0.00	-1.32	-	0.00	-1.30	-	0.00	-1.30
14.67	-	0.00	-1.33	-	0.00	-1.27	-	0.00	-1.25	-	0.00	-1.22	-	0.00	-1.19	-	0.00	-1.17	-	0.00	-1.15	-	0.00	-1.15
14.83	-	0.00	-1.20	-	0.00	-1.13	-	0.00	-1.11	-	0.00	-1.08	-	0.00	-1.04	-	0.00	-1.01	-	0.00	-0.99	-	0.00	-0.99
15.00	-	0.00	-1.07	-	0.00	-1.00	-	0.00	-0.96	-	0.00	-0.93	-	0.00	-0.89	-	0.00	-0.86	-	0.00	-0.83	-	0.00	-0.83
15.17	-	0.00	-0.84	-	0.00	-0.76	-	0.00	-0.72	-	0.00	-0.69	-	0.00	-0.64	-	0.00	-0.61	-	0.00	-0.58	-	0.00	-0.58
15.33	-	0.00	-0.72	-	0.00	-0.62	-	0.00	-0.59	-	0.00	-0.55	-	0.00	-0.50	-	0.00	-0.46	-	0.00	-0.42	-	0.00	-0.42
15.50	-	0.00	-0.59	-	0.00	-0.49	-	0.00	-0.45	-	0.00	-0.41	-	0.00	-0.35	-	0.00	-0.31	-	0.00	-0.27	-	0.00	-0.27
15.67	-	0.00	-0.36	-	0.00	-0.25	-	0.00	-0.21	-	0.00	-0.16	-	0.00	-0.10	-	0.00	-0.06	-	0.00	-0.01	-	0.00	-0.01
15.83	-	0.00	-0.24	-	0.00	-0.12	-	0.00	-0.07	-	0.00	-0.02	-	0.00	0.04	-	0.00	0.09	-	0.00	0.14	-	0.00	0.14
16.00	-	0.00	-0.02	-	0.00	0.11	-	0.00	0.16	-	0.00	0.21	-	0.00	0.28	-	0.00	0.33	-	0.00	0.39	-	0.00	0.39
16.17	-	0.00	0.21	-	0.00	0.34	-	0.00	0.40	-	0.00	0.45	-	0.00	0.53	-	0.00	0.58	-	0.00	0.63	-	0.00	0.63
16.33	-	0.00	0.33	-	0.00	0.47	-	0.00	0.53	-	0.00	0.59	-	0.00	0.67	-	0.00	0.72	-	0.00	0.78	-	0.00	0.78
16.50	-	0.00	0.55	-	0.00	0.70	-	0.00	0.76	-	0.00	0.82	-	0.00	0.90	-	0.00	0.97	-	0.00	1.03	-	0.00	1.03
16.67	-	0.00	0.67	-	0.00	0.83	-	0.00	0.89	-	0.00	0.96	-	0.00	1.04	-	0.00	1.11	-	0.00	1.17	-	0.00	1.17
16.83	-	0.00	0.89	-	0.00	1.06	-	0.00	1.12	-	0.00	1.19	-	0.00	1.28	-	0.00	1.34	-	0.00	1.41	-	0.00	1.41
17.00	-	0.00	1.11	-	0.00	1.28	-	0.00	1.35	-	0.00	1.42	-	0.00	1.51	-	0.00	1.58	4.87	1.76	1.65	-	0.00	1.65
17.17	-	0.00	1.23	1.30	0.47	1.41	1.88	0.68	1.48	2.64	0.95	1.55	4.05	1.46	1.64	5.44	1.97	1.72	5.94	2.15	1.79	-	0.00	1.79
17.33	1.28	0.46	1.45	1.88	0.68	1.63	2.69	0.97	1.70	3.77	1.36	1.78	5.74	2.07	1.88	7.67	2.77	1.95	8.45	3.05	2.02	17.54	6.33	2.02
17.50	1.55	0.56	1.57	2.31	0.83	1.75	3.31	1.20	1.83	4.64	1.67	1.90	7.01	2.53	2.00	9.35	3.37	2.08	10.34	3.73	2.16	20.68	7.47	2.16
17.67	1.88	0.68	1.68	2.86	1.03	1.87	4.10	1.48	1.95	5.70	2.06	2.03	8.55	3.09	2.13	11.35	4.10	2.21	12.58	4.54	2.29	24.27	8.76	2.29
17.83	2.29	0.83	1.80	3.55	1.28	1.99	5.04	1.82	2.07	6.98	2.52	2.15	10.39	3.75	2.26	13.67	4.93	2.34	15.15	5.47	2.42	28.30	10.22	2.42
18.00	2.82	1.02	1.91	4.39	1.59	2.11	6.19	2.24	2.19	8.52	3.07	2.27	12.51	4.52	2.38	16.33	5.90	2.46	18.14	6.55	2.54	32.75	11.82	2.54
18.17	3.47	1.25	2.02	5.40	1.95	2.22	7.57	2.73	2.31	10.29	3.71	2.39	14.95	5.40	2.50	19.39	7.00	2.58	21.58	7.79	2.67	37.71	13.61	2.67
18.33	4.26	1.54	2.13	6.63	2.39	2.34	9.19	3.32	2.42	12.36	4.46	2.51	17.80	6.43	2.62	22.96	8.29	2.70	25.60	9.24	2.79	43.33	15.64	2.79
18.50	5.20	1.88	2.24	8.08	2.92	2.45	11.08	4.00	2.54	14.80	5.34	2.62	21.14	7.63	2.74	27.12	9.79	2.82	30.36	10.96	2.91	49.82	17.99	2.91
18.67	6.33	2.28	2.35	9.79	3.53	2.56	13.30	4.80	2.65	17.68	6.38	2.73	25.02	9.03	2.85	31.89	11.51	2.94	35.70	12.89	3.02	56.94	20.56	3.02
18.83	7.65	2.76	2.46	11.79	4.26	2.67	15.88	5.73	2.76	20.99	7.58	2.85	29.52	10.66	2.96	37.31	13.47	3.05	41.74	15.07	3.14	64.81	23.40	3.14
19.00	7.73	2.79	2.46	11.93	4.31	2.68	16.09	5.81	2.77	21.28	7.68	2.85	29.95	10.81	2.97	37.87	13.67	3.06	42.36	15.29	3.15	65.61	23.69	3.15
19.17	7.79	2.81	2.47	12.05	4.35	2.68	16.27	5.87	2.77	21.51	7.77	2.86	30.30	10.94	2.98	38.29	13.82	3.07	42.87	15.48	3.16	66.27	23.92	3.16
19.33	9.25	3.34	2.56	14.24	5.14	2.78	19.07	6.88	2.87	25.11	9.06	2.96	34.93	12.61	3.08	43.80	15.81	3.17	49.01	17.69	3.26	74.14	26.76	3.26
19.50	9.28	3.35	2.57	14.29	5.16	2.79	19.16	6.92	2.88	25.22	9.10	2.96	35.13	12.68	3.08	44.03	15.89	3.17	49.27	17.79	3.26	74.46	26.88	3.26
19.67	9.30	3.36	2.57	14.31	5.17	2.79	19.19	6.93	2.88	25.26	9.12	2.97	35.18	12.70	3.09	44.09	15.92	3.18	49.33	17.81	3.27	74.54	26.91	3.27
19.83	9.28	3.35	2.57	14.29	5.16	2.79	19.16	6.92	2.88	25.22	9.10	2.96	35.13	12.68	3.08	44.03	15.89	3.17	49.27	17.79	3.26	74.46	26.88	3.26
20.00	7.83	2.83	2.47	12.15	4.39	2.69	16.37	5.91	2.78	21.68	7.83	2.87	30.52	11.02	2.99	38.60	13.93	3.08	43.27	15.62	3.17	66.79	24.11	3.17
20.17	7.79	2.81	2.47	12.05	4.35	2.68	16.27	5.87	2.77	21.51	7.77	2.86	30.30	10.94	2.98	38.29	13.82	3.07	42.87	15.48	3.16	66.27	23.92	3.16
20.33	6.48	2.34	2.36	10.06	3.63	2.58	13.70	4.95	2.67	18.23	6.58	2.75	25.88	9.34	2.87	33.02	11.92	2.96	37.00	13.36	3.05	58.65	21.17	3.05
20.50	5.34	1.93	2.26	8.37	3.02	2.47	11.49	4.15	2.56	15.39	5.56	2.65	22.00	7.94	2.76	28.25	10.20	2.85	31.71	11.45	2.94	51.64	18.64	2.94
20.67	4.39	1.59	2.15	6.92	2.50	2.36	9.60	3.46	2.45	12.94	4.67	2.53	18.63	6.73	2.65	24.05	8.68	2.74	26.95	9.73	2.82	45.18	16.31	2.82
20.83	3.60	1.30	2.04	5.67	2.05	2.25	7.97	2.88	2.34	10.82	3.91	2.42	15.76	5.69	2.54	20.47	7.39	2.62	22.86	8.25	2.71	39.52	14.27	2.71
21.00	2.45	0.88	1.83	3.87	1.40	2.04	5.52	1.99	2.12	7.66	2.76	2.21	11.43	4.13	2.32	15.07	5.44	2.40	16.79	6.06	2.49	30.76	11.10	2.49
21.17	2.01	0.72	1.72	3.14	1.13	1.92	4.52	1.63	2.01	6.31	2.28	2.09	9.53	3.44	2.20	12.66	4.57	2.28	14.13	5.10	2.37	26.71	9.64	2.37
21.33	1.40	0.51	1.51	2.14	0.77	1.71	3.10	1.12	1.79	4.40	1.59	1.87	6.74	2.43	1.98	9.08	3.28	2.06	10.14	3.66	2.14	20.35	7.35	2.14
21.50	1.16	0.42	1.40	1.76	0.63	1.59	2.54	0.92	1.67	3.61	1.30	1.75	5.56	2.01	1.86	7.53	2.72	1.94	8.36	3.02	2.02	17.38	6.27	2.02
21.67	-	0.00	1.18	1.23	0.44	1.37	1.80	0.65	1.45	2.55	0.92	1.53	3.96	1.43	1.63	5.39	1.95	1.71	5.94	2.14	1.79	-	0.00	1.79
21.83	-	0.00	0.97	-	0.00	1.15	-	0.00	1.23	-	0.00	1.30	-	0.00	1.40	-	0.00	1.48	-	0.00	1.56	-	0.00	1.56
22.00	-	0.00	0.75	-	0.00	0.93	-	0.00	1.00	-	0.00	1.08	-	0.00	1.18	-	0.00	1.25	-	0.00	1.32	-	0.00	1.32
22.17	-	0.00	0.53	-	0.00	0.71	-	0.00	0.78	-	0.00	0.85	-	0.00	0.94	-	0.00	1.02	-	0.00	1.09	-	0.00	1.09
22.33	-	0.00	0.41	-	0.00	0.58	-	0.00	0.65	-	0.00	0.72	-	0.00	0.81	-	0.00	0.88	-	0.00	0.95	-	0.00	0.95
22.50	-	0.00	0.19	-	0.00	0.36	-	0.00	0.42	-	0.00	0.49	-	0.00	0.58	-	0.00	0.64	-	0.00	0.71	-	0.00	0.71
22.67	-	0.00	-0.03	-	0.00	0.13	-	0.00	0.19	-	0.00	0.26	-	0.00	0.34	-	0.00	0.41	-	0.00	0.47	-	0.00	0.47
22.83	-	0.00	-0.25	-	0.00	-0.10	-	0.00	-0.04	-	0.00	0.02	-	0.00	0.10	-	0.00	0.17	-	0.00	0.23	-	0.00	0.23
23.00	-	0.00	-0.37	-	0.00	-0.23	-	0.00	-0.17	-	0.00	-0.11	-	0.00	-0.03	-	0.00	0.02	-	0.00	0.08	-	0.00	0.08
23.17	-	0.00	-0.59	-	0.00	-0.46	-	0.00	-0.40	-	0.00	-0.35	-	0.00	-0.27	-	0.00	-0.22	-	0.00	-0.17	-	0.00	-0.17
23.33	-	0.00	-0.72	-	0.00	-0.59	-	0.00	-0.54	-	0.00	-0.49	-	0.00	-0.42	-	0.00	-0.37	-	0.00	-0.31	-	0.00	-0.31
23.50	-	0.00	-0.94	-	0.00	-0.82	-	0.00	-0.77	-	0.00	-0.72	-	0.00	-0.66	-	0.00	-0.61	-	0.00	-0.56	-	0.00	-0.56
23.67	-	0.00	-1.06	-	0.00	-0.95	-	0.00	-0.91	-	0.00	-0.86	-	0.00	-0.80	-	0.00	-0.76	-	0.00	-0.71	-	0.00	-0.71
23.83	-	0.00	-1.29	-	0.00	-1.19	-	0.00	-1.15	-	0.00	-1.11	-	0.00	-1.05	-	0.00	-1.01	-	0.00	-0.97	-	0.00	-0.97
24.00	-	0.00	-1.42	-	0.00	-1.32	-	0.00	-1.29	-	0.00	-1.25	-	0.00	-1.20	-	0.00	-1.16	-	0.00	-1.12	-	0.00	-1.12
24.17	-	0.00	-1.54	-	0.00	-1.46	-	0.00	-1.42	-	0.00	-1.39	-	0.00	-1.34	-	0.00	-1.31	-	0.00	-1.28	-	0.00	-1.28
24.33	-	0.00	-1.77	-	0.00	-1.70	-	0.00	-1.66	-	0.00	-1.63	-	0.00	-1.59	-	0.00	-1.56	-	0.00	-1.53	-	0.00	-1.53
24.50	-	0.00	-1.90	-	0.00	-1.83	-	0.00	-1.81	-	0.00	-1.78	-	0.00	-1.74	-	0.00	-1.71	-	0.00	-1.69	-	0.00	-1.69
24.67	-	0.00	-2.03	-	0.00	-1.97	-	0.00	-1.95	-	0.00	-1.92	-	0.00	-1.89	-	0.00	-1.87	-	0.00	-1.85	-	0.00	-1.85
24.83	-	0.00	-2.05	-	0.00	-2.01	-	0.00	-1.99	-	0.00	-1.97	-	0.00	-1.94	-	0.00	-1.92	-	0.00	-1.90	-	0.00	-1.90
25.00	-	0.00	-2.19	-	0.00	-2.15	-	0.00	-2.13	-	0.00	-2.12	-	0.00	-2.10	-	0.00	-2.08	-	0.00	-2.07	-	0.00	-2.07
25.17	-	0.00	-2.22	-	0.00	-2.19	-	0.00	-2.18	-	0.00	-2.17	-	0.00	-2.15	-	0.00	-2.14	-	0.00	-2.13	-	0.00	-2.13
25.33	-	0.00	-2.25	-	0.00	-2.23	-	0.00	-2.22	-	0.00	-2.21	-	0.00	-2.20	-	0.00	-2.19	-	0.00	-2.19	-	0.00	-2.19
25.50	-	0.00	-2.28	-	0.00	-2.27	-	0.00	-2.26	-	0.00	-2.26	-	0.00	-2.25	-	0.00	-2.25	-	0.00	-2.25	-	0.00	-2.25
25.67	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20

Mid Range

	50% Mid Range			20% Mid Range			10% Mid Range			5% Mid Range			2% Mid Range			1% Mid Range			0.5% Mid Range			0.1% Mid Range		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
13.67	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10
13.83	-	0.00	-1.95	-	0.00	-1.95	-	0.00	-1.94	-	0.00	-1.93	-	0.00	-1.93	-	0.00	-1.92	-	0.00	-1.92	-	0.00	-1.92
14.00	-	0.00	-1.80	-	0.00	-1.79	-	0.00	-1.78	-	0.00	-1.76	-	0.00	-1.75	-	0.00	-1.74	-	0.00	-1.74	-	0.00	-1.74
14.17	-	0.00	-1.65	-	0.00	-1.64	-	0.00	-1.62	-	0.00	-1.59	-	0.00	-1.58	-	0.00	-1.57	-	0.00	-1.56	-	0.00	-1.56
14.33	-	0.00	-1.50	-	0.00	-1.48	-	0.00	-1.46	-	0.00	-1.43	-	0.00	-1.41	-	0.00	-1.39	-	0.00	-1.38	-	0.00	-1.38
14.50	-	0.00	-1.35	-	0.00	-1.33	-	0.00	-1.30	-	0.00	-1.26	-	0.00	-1.23	-	0.00	-1.21	-	0.00	-1.20	-	0.00	-1.20
14.67	-	0.00	-1.20	-	0.00	-1.17	-	0.00	-1.14	-	0.00	-1.09	-	0.00	-1.06	-	0.00	-1.04	-	0.00	-1.02	-	0.00	-1.02
14.83	-	0.00	-1.05	-	0.00	-1.02	-	0.00	-0.98	-	0.00	-0.93	-	0.00	-0.89	-	0.00	-0.86	-	0.00	-0.84	-	0.00	-0.84
15.00	-	0.00	-0.90	-	0.00	-0.87	-	0.00	-0.82	-	0.00	-0.76	-	0.00	-0.72	-	0.00	-0.69	-	0.00	-0.66	-	0.00	-0.66
15.17	-	0.00	-0.65	-	0.00	-0.62	-	0.00	-0.57	-	0.00	-0.50	-	0.00	-0.45	-	0.00	-0.42	-	0.00	-0.38	-	0.00	-0.38
15.33	-	0.00	-0.51	-	0.00	-0.47	-	0.00	-0.41	-	0.00	-0.34	-	0.00	-0.29	-	0.00	-0.25	-	0.00	-0.21	-	0.00	-0.21
15.50	-	0.00	-0.36	-	0.00	-0.32	-	0.00	-0.26	-	0.00	-0.17	-	0.00	-0.12	-	0.00	-0.08	-	0.00	-0.04	-	0.00	-0.04
15.67	-	0.00	-0.11	-	0.00	-0.07	-	0.00	0.00	-	0.00	0.09	-	0.00	0.15	-	0.00	0.19	-	0.00	0.24	-	0.00	0.24
15.83	-	0.00	0.03	-	0.00	0.08	-	0.00	0.15	-	0.00	0.24	-	0.00	0.31	-	0.00	0.36	-	0.00	0.41	-	0.00	0.41
16.00	-	0.00	0.27	-	0.00	0.32	-	0.00	0.40	-	0.00	0.50	-	0.00	0.57	-	0.00	0.62	-	0.00	0.67	-	0.00	0.67
16.17	-	0.00	0.51	-	0.00	0.57	-	0.00	0.65	-	0.00	0.76	-	0.00	0.83	-	0.00	0.88	-	0.00	0.94	-	0.00	0.94
16.33	-	0.00	0.65	-	0.00	0.71	-	0.00	0.79	-	0.00	0.91	-	0.00	0.99	-	0.00	1.04	-	0.00	1.10	-	0.00	1.10
16.50	-	0.00	0.89	-	0.00	0.95	-	0.00	1.04	-	0.00	1.16	-	0.00	1.24	-	0.00	1.30	-	0.00	1.36	-	0.00	1.36
16.67	-	0.00	1.03	-	0.00	1.09	-	0.00	1.18	-	0.00	1.31	-	0.00	1.40	-	0.00	1.46	-	0.00	1.52	-	0.00	1.52
16.83	-	0.00	1.26	-	0.00	1.33	-	0.00	1.43	-	0.00	1.56	-	0.00	1.65	-	0.00	1.71	7.85	2.83	1.78	-	0.00	1.78
17.00	2.25	0.81	1.50	3.63	1.31	1.57	4.82	1.74	1.67	5.58	2.01	1.80	8.13	2.94	1.90	10.58	3.82	1.96	11.20	4.04	2.03	24.34	8.79	2.03
17.17	2.76	1.00	1.63	4.44	1.60	1.70	5.89	2.12	1.80	6.93	2.50	1.95	10.05	3.63	2.04	13.01	4.70	2.11	13.86	5.00	2.18	28.80	10.40	2.18
17.33	4.01	1.45	1.86	6.33	2.29	1.93	8.39	3.03	2.04	10.03	3.62	2.19	14.27	5.15	2.29	18.19	6.57	2.36	19.45	7.02	2.43	37.68	13.60	2.43
17.50	4.98	1.80	1.99	7.77	2.80	2.06	10.29	3.71	2.17	12.33	4.45	2.32	17.35	6.26	2.43	22.00	7.94	2.50	23.59	8.52	2.58	43.84	15.83	2.58
17.67	6.16	2.22	2.11	9.49	3.42	2.19	12.53	4.52	2.30	15.02	5.42	2.46	20.97	7.57	2.56	26.45	9.55	2.64	28.45	10.27	2.72	50.82	18.35	2.72
17.83	7.59	2.74	2.24	11.52	4.16	2.32	15.09	5.45	2.43	18.17	6.56	2.59	25.24	9.11	2.70	31.64	11.42	2.78	34.20	12.35	2.86	58.81	21.23	2.86
18.00	9.28	3.35	2.36	13.84	5.00	2.44	18.08	6.53	2.56	21.93	7.92	2.72	30.22	10.91	2.83	37.65	13.59	2.91	40.83	14.74	3.00	67.82	24.48	3.00
18.17	11.26	4.06	2.48	16.55	5.97	2.57	21.56	7.78	2.69	26.33	9.51	2.85	35.94	12.97	2.96	44.46	16.05	3.05	48.30	17.44	3.13	77.77	28.07	3.13
18.33	13.58	4.90	2.60	19.73	7.12	2.68	25.65	9.26	2.81	31.47	11.36	2.98	42.43	15.32	3.09	52.10	18.81	3.17	56.61	20.44	3.26	-	0.00	3.26
18.50	16.33	5.90	2.72	23.47	8.47	2.80	30.43	10.99	2.93	37.24	13.44	3.10	49.67	17.93	3.21	60.54	21.85	3.30	65.86	23.78	3.38	-	0.00	3.38
18.67	19.52	7.05	2.83	27.79	10.03	2.92	35.82	12.93	3.04	43.64	15.75	3.22	57.62	20.80	3.33	-	0.00	3.42	-	0.00	3.51	-	0.00	3.51
18.83	23.26	8.40	2.94	32.70	11.80	3.03	41.76	15.08	3.16	50.78	18.33	3.33	-	0.00	3.45	-	0.00	3.54	-	0.00	3.63	-	0.00	3.63
19.00	23.63	8.53	2.95	33.21	11.99	3.04	42.43	15.32	3.17	51.63	18.64	3.35	-	0.00	3.47	-	0.00	3.55	-	0.00	3.64	-	0.00	3.64
19.17	23.92	8.64	2.96	33.59	12.13	3.05	42.94	15.50	3.18	52.37	18.91	3.36	-	0.00	3.48	-	0.00	3.57	-	0.00	3.65	-	0.00	3.65
19.33	27.93	10.08	3.06	38.63	13.95	3.15	49.03	17.70	3.28	-	0.00	3.46	-	0.00	3.58	-	0.00	3.67	-	0.00	3.76	-	0.00	3.76
19.50	28.05	10.13	3.06	38.85	14.02	3.15	49.29	17.79	3.28	-	0.00	3.46	-	0.00	3.58	-	0.00	3.67	-	0.00	3.76	-	0.00	3.76
19.67	28.09	10.14	3.07	38.90	14.04	3.16	49.35	17.82	3.29	-	0.00	3.47	-	0.00	3.59	-	0.00	3.68	-	0.00	3.77	-	0.00	3.77
19.83	28.05	10.13	3.06	38.85	14.02	3.15	49.29	17.79	3.28	-	0.00	3.46	-	0.00	3.58	-	0.00	3.67	-	0.00	3.76	-	0.00	3.76
20.00	24.15	8.72	2.97	33.87	12.23	3.06	43.34	15.65	3.19	52.84	19.08	3.37	-	0.00	3.48	-	0.00	3.57	-	0.00	3.66	-	0.00	3.66
20.17	23.92	8.64	2.96	33.59	12.13	3.05	42.94	15.50	3.18	52.37	18.91	3.36	-	0.00	3.48	-	0.00	3.57	-	0.00	3.65	-	0.00	3.65
20.33	20.20	7.29	2.85	28.78	10.39	2.94	37.11	13.40	3.07	45.38	16.38	3.25	59.91	21.63	3.37	-	0.00	3.45	-	0.00	3.54	-	0.00	3.54
20.50	17.01	6.14	2.74	24.46	8.83	2.83	31.79	11.48	2.96	39.09	14.11	3.13	52.08	18.80	3.25	63.49	22.92	3.34	-	0.00	3.43	-	0.00	3.43
20.67	14.26	5.15	2.63	20.71	7.48	2.72	27.04	9.76	2.84	33.33	12.03	3.02	44.89	16.21	3.13	55.08	19.88	3.22	60.07	21.69	3.31	-	0.00	3.31
20.83	11.90	4.30	2.52	17.50	6.32	2.60	22.89	8.26	2.73	28.17	10.17	2.90	38.45	13.88	3.01	47.53	17.16	3.10	51.71	18.67	3.18	82.20	29.67	3.18
21.00	8.40	3.03	2.30	12.71	4.59	2.38	16.75	6.05	2.51	20.47	7.39	2.68	28.47	10.28	2.79	35.75	12.91	2.87	38.88	14.04	2.96	65.17	23.53	2.96
21.17	6.90	2.49	2.18	10.62	3.83	2.27	14.07	5.08	2.39	17.11	6.18	2.55	23.97	8.65	2.66	30.24	10.92	2.75	32.83	11.85	2.83	56.94	20.56	2.83
21.33	4.76	1.72	1.96	7.52	2.71	2.04	10.10	3.65	2.16	12.31	4.44	2.32	17.51	6.32	2.43	22.35	8.07	2.51	24.16	8.72	2.60	44.67	16.13	2.60
21.50	3.88	1.40	1.84	6.19	2.24	1.92	8.33	3.01	2.03	10.12	3.65	2.19	14.57	5.26	2.30	18.70	6.75	2.38	20.16	7.28	2.46	38.76	13.99	2.46
21.67	2.69	0.97	1.61	4.38	1.58	1.69	5.90	2.13	1.80	7.09	2.56	1.96	10.38	3.75	2.06	13.55	4.89	2.14	14.57	5.26	2.22	29.95	10.81	2.22
21.83	-	0.00	1.39	-	0.00	1.46	-	0.00	1.57	4.97	1.79	1.72	7.36	2.66	1.83	9.71	3.50	1.90	10.36	3.74	1.98	-	0.00	1.98
22.00	-	0.00	1.16	-	0.00	1.23	-	0.00	1.34	-	0.00	1.49	-	0.00	1.59	-	0.00	1.66	7.37	2.66	1.73	-	0.00	1.73
22.17	-	0.00	0.93	-	0.00	1.00	-	0.00	1.10	-	0.00	1.25	-	0.00	1.34	-	0.00	1.41	-	0.00	1.48	-	0.00	1.48
22.33	-	0.00	0.80	-	0.00	0.87	-	0.00	0.97	-	0.00	1.10	-	0.00	1.20	-	0.00	1.26	-	0.00	1.33	-	0.00	1.33
22.50	-	0.00	0.56	-	0.00	0.63	-	0.00	0.73	-	0.00	0.86	-	0.00	0.95	-	0.00	1.01	-	0.00	1.08	-	0.00	1.08
22.67	-	0.00	0.33	-	0.00	0.39	-	0.00	0.48	-	0.00	0.61	-	0.00	0.70	-	0.00	0.76	-	0.00	0.82	-	0.00	0.82
22.83	-	0.00	0.09	-	0.00	0.15	-	0.00	0.24	-	0.00	0.36	-	0.00	0.44	-	0.00	0.50	-	0.00	0.56	-	0.00	0.56
23.00	-	0.00	-0.05	-	0.00	0.01	-	0.00	0.09	-	0.00	0.21	-	0.00	0.29	-	0.00	0.34	-	0.00	0.40	-	0.00	0.40
23.17	-	0.00	-0.29	-	0.00	-0.23	-	0.00	-0.15	-	0.00	-0.04	-	0.00	0.03	-	0.00	0.08	-	0.00	0.14	-	0.00	0.14
23.33	-	0.00	-0.43	-	0.00	-0.38	-	0.00	-0.30	-	0.00	-0.20	-	0.00	-0.13	-	0.00	-0.08	-	0.00	-0.03	-	0.00	-0.03
23.50	-	0.00	-0.67	-	0.00	-0.62	-	0.00	-0.55	-	0.00	-0.46	-	0.00	-0.39	-	0.00	-0.34	-	0.00	-0.29	-	0.00	-0.29
23.67	-	0.00	-0.81	-	0.00	-0.77	-	0.00	-0.70	-	0.00	-0.61	-	0.00	-0.55	-	0.00	-0.51	-	0.00	-0.46	-	0.00	-0.46
23.83	-	0.00	-1.06	-	0.00	-1.02	-	0.00	-0.96	-	0.00	-0.87	-	0.00	-0.82	-	0.00	-0.78	-	0.00	-0.74	-	0.00	-0.74
24.00	-	0.00	-1.21	-	0.00	-1.17	-	0.00	-1.11	-	0.00	-1.04	-	0.00	-0.99	-	0.00	-0.95	-	0.00	-0.91	-	0.00	-0.91
24.17	-	0.00	-1.35	-	0.00	-1.32	-	0.00	-1.27	-	0.00	-1.20	-	0.00	-1.15	-	0.00	-1.12	-	0.00	-1.08	-	0.00	-1.08
24.33	-	0.00	-1.60	-	0.00	-1.57	-	0.00	-1.52	-	0.00	-1.46	-	0.00	-1.42	-	0.00	-1.39	-	0.00	-1.36	-	0.00	-1.36
24.50	-	0.00	-1.75	-	0.00	-1.72	-	0.00	-1.68	-	0.00	-1.63	-	0.00	-1.59	-	0.00	-1.56	-	0.00	-1.54	-	0.00	-1.54
24.67	-	0.00	-1.90	-	0.00	-1.87	-	0.00	-1.84	-	0.00	-1.79	-	0.00	-1.76	-	0.00	-1.74	-	0.00	-1.72	-	0.00	-1.72
24.83	-	0.00	-1.95	-	0.00	-1.93	-	0.00	-1.90	-	0.00	-1.86	-	0.00	-1.83	-	0.00	-1.81	-	0.00	-1.80	-	0.00	-1.80
25.00	-	0.00	-2.10	-	0.00	-2.09	-	0.00	-2.06	-	0.00	-2.03	-	0.00	-2.01	-	0.00	-2.00	-	0.00	-1.98	-	0.00	-1.98
25.17	-	0.00	-2.15	-	0.00	-2.14	-	0.00	-2.12	-	0.00	-2.10	-	0.00	-2.08	-	0.00	-2.07	-	0.00	-2.06	-	0.00	-2.06
25.33	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.18	-	0.00	-2.17	-	0.00	-2.16	-	0.00	-2.15	-	0.00	-2.14	-	0.00	-2.14
25.50	-	0.00	-2.25	-	0.00	-2.25	-	0.00	-2.24	-	0.00	-2.24	-	0.00	-2.23	-	0.00	-2.23	-	0.00	-2.22	-	0.00	-2.22
25.67	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20

High End

	10% High End			0.5% High End			0.1% High End		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
13.67	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10
13.83	-	0.00	-1.91	-	0.00	-1.90	-	0.00	-1.90
14.00	-	0.00	-1.73	-	0.00	-1.69	-	0.00	-1.69
14.17	-	0.00	-1.54	-	0.00	-1.49	-	0.00	-1.49
14.33	-	0.00	-1.36	-	0.00	-1.29	-	0.00	-1.29
14.50	-	0.00	-1.17	-	0.00	-1.09	-	0.00	-1.09
14.67	-	0.00	-0.99	-	0.00	-0.89	-	0.00	-0.89
14.83	-	0.00	-0.80	-	0.00	-0.69	-	0.00	-0.69
15.00	-	0.00	-0.62	-	0.00	-0.49	-	0.00	-0.49
15.17	-	0.00	-0.34	-	0.00	-0.19	-	0.00	-0.19
15.33	-	0.00	-0.16	-	0.00	0.00	-	0.00	0.00
15.50	-	0.00	0.01	-	0.00	0.19	-	0.00	0.19
15.67	-	0.00	0.29	-	0.00	0.49	-	0.00	0.49
15.83	-	0.00	0.46	-	0.00	0.67	-	0.00	0.67
16.00	-	0.00	0.74	-	0.00	0.96	-	0.00	0.96
16.17	-	0.00	1.01	-	0.00	1.24	-	0.00	1.24
16.33	-	0.00	1.17	-	0.00	1.42	-	0.00	1.42
16.50	-	0.00	1.44	-	0.00	1.70	-	0.00	1.70
16.67	-	0.00	1.60	11.22	4.05	1.88	-	0.00	1.88
16.83	6.46	2.33	1.86	16.07	5.80	2.15	-	0.00	2.15
17.00	9.51	3.43	2.12	22.71	8.20	2.42	45.35	16.37	2.42
17.17	11.96	4.32	2.27	27.98	10.10	2.58	53.33	19.25	2.58
17.33	17.18	6.20	2.52	38.68	13.96	2.84	68.72	24.81	2.84
17.50	21.18	7.65	2.67	46.97	16.96	3.00	80.01	28.88	3.00
17.67	25.98	9.38	2.82	56.29	20.32	3.15	-	0.00	3.15
17.83	31.64	11.42	2.96	66.86	24.14	3.30	-	0.00	3.30
18.00	38.14	13.77	3.10	-	0.00	3.45	-	0.00	3.45
18.17	45.48	16.42	3.23	-	0.00	3.59	-	0.00	3.59
18.33	53.80	19.42	3.36	-	0.00	3.73	-	0.00	3.73
18.50	-	0.00	3.49	-	0.00	3.86	-	0.00	3.86
18.67	-	0.00	3.61	-	0.00	3.99	-	0.00	3.99
18.83	-	0.00	3.73	-	0.00	4.11	-	0.00	4.11
19.00	-	0.00	3.75	-	0.00	4.13	-	0.00	4.13
19.17	-	0.00	3.76	-	0.00	4.15	-	0.00	4.15
19.33	-	0.00	3.87	-	0.00	4.26	-	0.00	4.26
19.50	-	0.00	3.87	-	0.00	4.26	-	0.00	4.26
19.67	-	0.00	3.88	-	0.00	4.27	-	0.00	4.27
19.83	-	0.00	3.87	-	0.00	4.26	-	0.00	4.26
20.00	-	0.00	3.77	-	0.00	4.16	-	0.00	4.16
20.17	-	0.00	3.76	-	0.00	4.15	-	0.00	4.15
20.33	-	0.00	3.65	-	0.00	4.03	-	0.00	4.03
20.50	-	0.00	3.53	-	0.00	3.91	-	0.00	3.91
20.67	57.40	20.72	3.41	-	0.00	3.79	-	0.00	3.79
20.83	49.04	17.70	3.29	-	0.00	3.66	-	0.00	3.66
21.00	36.50	13.18	3.06	-	0.00	3.43	-	0.00	3.43
21.17	30.48	11.00	2.93	65.96	23.81	3.29	-	0.00	3.29
21.33	21.91	7.91	2.70	49.82	17.99	3.05	83.82	30.26	3.05
21.50	18.03	6.51	2.56	41.71	15.06	2.90	72.89	26.31	2.90
21.67	12.75	4.60	2.32	30.61	11.05	2.65	57.21	20.65	2.65
21.83	8.86	3.20	2.07	22.25	8.03	2.40	44.64	16.12	2.40
22.00	6.10	2.20	1.82	15.95	5.76	2.14	-	0.00	2.14
22.17	-	0.00	1.57	11.28	4.07	1.88	-	0.00	1.88
22.33	-	0.00	1.42	-	0.00	1.72	-	0.00	1.72
22.50	-	0.00	1.16	-	0.00	1.45	-	0.00	1.45
22.67	-	0.00	0.90	-	0.00	1.18	-	0.00	1.18
22.83	-	0.00	0.64	-	0.00	0.90	-	0.00	0.90
23.00	-	0.00	0.47	-	0.00	0.72	-	0.00	0.72
23.17	-	0.00	0.21	-	0.00	0.44	-	0.00	0.44
23.33	-	0.00	0.04	-	0.00	0.26	-	0.00	0.26
23.50	-	0.00	-0.24	-	0.00	-0.03	-	0.00	-0.03
23.67	-	0.00	-0.41	-	0.00	-0.21	-	0.00	-0.21
23.83	-	0.00	-0.69	-	0.00	-0.51	-	0.00	-0.51
24.00	-	0.00	-0.86	-	0.00	-0.70	-	0.00	-0.70
24.17	-	0.00	-1.04	-	0.00	-0.89	-	0.00	-0.89
24.33	-	0.00	-1.32	-	0.00	-1.19	-	0.00	-1.19
24.50	-	0.00	-1.50	-	0.00	-1.39	-	0.00	-1.39
24.67	-	0.00	-1.69	-	0.00	-1.59	-	0.00	-1.59
24.83	-	0.00	-1.77	-	0.00	-1.69	-	0.00	-1.69
25.00	-	0.00	-1.96	-	0.00	-1.89	-	0.00	-1.89
25.17	-	0.00	-2.05	-	0.00	-2.00	-	0.00	-2.00
25.33	-	0.00	-2.13	-	0.00	-2.10	-	0.00	-2.10
25.50	-	0.00	-2.22	-	0.00	-2.20	-	0.00	-2.20
25.67	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20

Location A4
Current

	AEP																							
	50%			20%			10%			5%			2%			1%			0.50%			0.10%		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
13.67	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10
13.83	-	0.00	-1.98	-	0.00	-1.97	-	0.00	-1.97	-	0.00	-1.96	-	0.00	-1.96	-	0.00	-1.95	-	0.00	-1.95	-	0.00	-1.94
14.00	-	0.00	-1.86	-	0.00	-1.84	-	0.00	-1.83	-	0.00	-1.82	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.80	-	0.00	-1.78
14.17	-	0.00	-1.74	-	0.00	-1.71	-	0.00	-1.70	-	0.00	-1.68	-	0.00	-1.67	-	0.00	-1.66	-	0.00	-1.64	-	0.00	-1.62
14.33	-	0.00	-1.62	-	0.00	-1.58	-	0.00	-1.57	-	0.00	-1.55	-	0.00	-1.53	-	0.00	-1.51	-	0.00	-1.49	-	0.00	-1.46
14.50	-	0.00	-1.50	-	0.00	-1.45	-	0.00	-1.44	-	0.00	-1.41	-	0.00	-1.39	-	0.00	-1.37	-	0.00	-1.34	-	0.00	-1.30
14.67	-	0.00	-1.38	-	0.00	-1.33	-	0.00	-1.30	-	0.00	-1.27	-	0.00	-1.25	-	0.00	-1.22	-	0.00	-1.19	-	0.00	-1.15
14.83	-	0.00	-1.26	-	0.00	-1.20	-	0.00	-1.17	-	0.00	-1.13	-	0.00	-1.11	-	0.00	-1.08	-	0.00	-1.04	-	0.00	-0.99
15.00	-	0.00	-1.15	-	0.00	-1.07	-	0.00	-1.04	-	0.00	-1.00	-	0.00	-0.96	-	0.00	-0.93	-	0.00	-0.89	-	0.00	-0.83
15.17	-	0.00	-0.93	-	0.00	-0.84	-	0.00	-0.81	-	0.00	-0.76	-	0.00	-0.72	-	0.00	-0.69	-	0.00	-0.64	-	0.00	-0.58
15.33	-	0.00	-0.81	-	0.00	-0.72	-	0.00	-0.68	-	0.00	-0.62	-	0.00	-0.59	-	0.00	-0.55	-	0.00	-0.50	-	0.00	-0.42
15.50	-	0.00	-0.69	-	0.00	-0.59	-	0.00	-0.55	-	0.00	-0.49	-	0.00	-0.45	-	0.00	-0.41	-	0.00	-0.35	-	0.00	-0.27
15.67	-	0.00	-0.47	-	0.00	-0.36	-	0.00	-0.32	-	0.00	-0.25	-	0.00	-0.21	-	0.00	-0.16	-	0.00	-0.10	-	0.00	-0.01
15.83	-	0.00	-0.36	-	0.00	-0.24	-	0.00	-0.19	-	0.00	-0.12	-	0.00	-0.07	-	0.00	-0.02	-	0.00	0.04	-	0.00	0.14
16.00	-	0.00	-0.14	-	0.00	-0.02	-	0.00	0.04	-	0.00	0.11	-	0.00	0.16	-	0.00	0.21	-	0.00	0.28	-	0.00	0.39
16.17	-	0.00	0.07	-	0.00	0.21	-	0.00	0.26	-	0.00	0.34	-	0.00	0.40	-	0.00	0.45	-	0.00	0.53	-	0.00	0.63
16.33	-	0.00	0.19	-	0.00	0.33	-	0.00	0.39	-	0.00	0.47	-	0.00	0.53	-	0.00	0.59	-	0.00	0.67	-	0.00	0.78
16.50	-	0.00	0.40	-	0.00	0.55	-	0.00	0.61	-	0.00	0.70	-	0.00	0.76	-	0.00	0.82	-	0.00	0.90	-	0.00	1.03
16.67	-	0.00	0.52	-	0.00	0.67	-	0.00	0.74	-	0.00	0.83	-	0.00	0.89	-	0.00	0.96	-	0.00	1.04	-	0.00	1.17
16.83	-	0.00	0.73	-	0.00	0.89	-	0.00	0.96	-	0.00	1.06	-	0.00	1.12	-	0.00	1.19	-	0.00	1.28	-	0.00	1.41
17.00	-	0.00	0.95	-	0.00	1.11	-	0.00	1.18	-	0.00	1.28	-	0.00	1.35	-	0.00	1.42	-	0.00	1.51	-	0.00	1.65
17.17	-	0.00	1.06	-	0.00	1.23	-	0.00	1.30	-	0.00	1.41	-	0.00	1.48	-	0.00	1.55	-	0.00	1.64	-	0.00	1.79
17.33	-	0.00	1.27	0.07	0.03	1.45	0.11	0.04	1.52	0.18	0.07	1.63	0.33	0.12	1.70	0.49	0.18	1.78	0.55	0.20	1.88	1.66	0.62	2.02
17.50	0.04	0.02	1.38	0.08	0.03	1.57	0.13	0.05	1.64	0.21	0.08	1.75	0.38	0.14	1.83	0.58	0.22	1.90	0.65	0.24	2.00	1.95	0.73	2.16
17.67	0.05	0.02	1.49	0.09	0.04	1.68	0.15	0.06	1.76	0.24	0.09	1.87	0.45	0.17	1.95	0.68	0.25	2.03	0.77	0.29	2.13	2.29	0.85	2.29
17.83	0.06	0.02	1.60	0.11	0.04	1.80	0.18	0.07	1.88	0.29	0.11	1.99	0.53	0.20	2.07	0.80	0.30	2.15	0.90	0.34	2.26	2.69	1.00	2.42
18.00	0.07	0.02	1.71	0.13	0.05	1.91	0.21	0.08	1.99	0.34	0.13	2.11	0.62	0.23	2.19	0.94	0.35	2.27	1.07	0.40	2.38	3.15	1.18	2.54
18.17	0.08	0.03	1.82	0.15	0.06	2.02	0.24	0.09	2.10	0.40	0.15	2.22	0.73	0.27	2.31	1.10	0.41	2.39	1.26	0.47	2.50	3.70	1.38	2.67
18.33	0.09	0.03	1.92	0.17	0.06	2.13	0.29	0.11	2.22	0.47	0.18	2.34	0.85	0.32	2.42	1.29	0.48	2.51	1.48	0.55	2.62	4.31	1.61	2.79
18.50	0.10	0.04	2.03	0.20	0.08	2.24	0.34	0.13	2.33	0.55	0.21	2.45	1.00	0.37	2.54	1.51	0.57	2.62	1.75	0.65	2.74	5.03	1.88	2.91
18.67	0.12	0.04	2.14	0.24	0.09	2.35	0.40	0.15	2.44	0.65	0.24	2.56	1.18	0.44	2.65	1.77	0.66	2.73	2.05	0.77	2.85	5.84	2.18	3.02
18.83	0.14	0.05	2.24	0.28	0.11	2.46	0.47	0.17	2.54	0.77	0.29	2.67	1.38	0.52	2.76	2.07	0.78	2.85	2.41	0.90	2.96	6.77	2.53	3.14
19.00	0.14	0.05	2.24	0.28	0.11	2.46	0.47	0.18	2.55	0.77	0.29	2.68	1.40	0.52	2.77	2.10	0.79	2.85	2.45	0.91	2.97	6.87	2.57	3.15
19.17	0.14	0.05	2.25	0.29	0.11	2.47	0.47	0.18	2.55	0.78	0.29	2.68	1.41	0.53	2.77	2.12	0.79	2.86	2.47	0.93	2.98	6.95	2.60	3.16
19.33	0.16	0.06	2.34	0.33	0.12	2.56	0.55	0.21	2.65	0.91	0.34	2.78	1.63	0.61	2.87	2.45	0.91	2.96	2.85	1.07	3.08	7.95	2.97	3.26
19.50	0.16	0.06	2.35	0.33	0.13	2.57	0.55	0.21	2.66	0.91	0.34	2.79	1.64	0.61	2.88	2.46	0.92	2.96	2.87	1.07	3.08	7.99	2.99	3.26
19.67	0.16	0.06	2.35	0.34	0.13	2.57	0.55	0.21	2.66	0.91	0.34	2.79	1.64	0.61	2.88	2.46	0.92	2.97	2.87	1.07	3.09	8.00	2.99	3.27
19.83	0.16	0.06	2.35	0.33	0.13	2.57	0.55	0.21	2.66	0.91	0.34	2.79	1.64	0.61	2.88	2.46	0.92	2.96	2.87	1.07	3.08	7.99	2.99	3.26
20.00	0.14	0.05	2.25	0.29	0.11	2.47	0.48	0.18	2.56	0.79	0.29	2.69	1.42	0.53	2.78	2.14	0.80	2.87	2.49	0.93	2.99	7.02	2.62	3.17
20.17	0.14	0.05	2.25	0.29	0.11	2.47	0.47	0.18	2.55	0.78	0.29	2.68	1.41	0.53	2.77	2.12	0.79	2.86	2.47	0.93	2.98	6.95	2.60	3.16
20.33	0.12	0.04	2.14	0.24	0.09	2.36	0.40	0.15	2.45	0.67	0.25	2.58	1.21	0.45	2.67	1.82	0.68	2.75	2.12	0.79	2.87	6.04	2.26	3.05
20.50	0.10	0.04	2.04	0.21	0.08	2.26	0.34	0.13	2.34	0.57	0.21	2.47	1.03	0.39	2.56	1.56	0.58	2.65	1.82	0.68	2.76	5.23	1.96	2.94
20.67	0.09	0.03	1.94	0.18	0.07	2.15	0.29	0.11	2.24	0.48	0.18	2.36	0.88	0.33	2.45	1.34	0.50	2.53	1.55	0.58	2.65	4.51	1.69	2.82
20.83	0.08	0.03	1.83	0.15	0.06	2.04	0.25	0.09	2.13	0.41	0.15	2.25	0.76	0.28	2.34	1.15	0.43	2.42	1.32	0.49	2.54	3.89	1.46	2.71
21.00	0.06	0.02	1.62	0.11	0.04	1.83	0.19	0.07	1.92	0.31	0.11	2.04	0.57	0.21	2.12	0.86	0.32	2.21	0.98	0.37	2.32	2.94	1.10	2.49
21.17	0.05	0.02	1.52	0.10	0.04	1.72	0.16	0.06	1.80	0.26	0.10	1.92	0.48	0.18	2.01	0.74	0.28	2.09	0.84	0.31	2.20	2.53	0.94	2.37
21.33	-	0.00	1.31	0.08	0.03	1.51	0.12	0.05	1.59	0.20	0.07	1.71	0.36	0.14	1.79	0.55	0.21	1.87	0.63	0.23	1.98	1.92	0.72	2.14
21.50	-	0.00	1.20	-	0.00	1.40	-	0.00	1.48	0.17	0.06	1.59	0.31	0.12	1.67	0.48	0.18	1.75	0.53	0.20	1.86	1.64	0.61	2.02
21.67	-	0.00	0.99	-	0.00	1.18	-	0.00	1.26	-	0.00	1.37	-	0.00	1.45	-	0.00	1.53	-	0.00	1.63	-	0.00	1.79
21.83	-	0.00	0.78	-	0.00	0.97	-	0.00	1.04	-	0.00	1.15	-	0.00	1.23	-	0.00	1.30	-	0.00	1.40	-	0.00	1.56
22.00	-	0.00	0.57	-	0.00	0.75	-	0.00	0.82	-	0.00	0.93	-	0.00	1.00	-	0.00	1.08	-	0.00	1.18	-	0.00	1.32
22.17	-	0.00	0.36	-	0.00	0.53	-	0.00	0.60	-	0.00	0.71	-	0.00	0.78	-	0.00	0.85	-	0.00	0.94	-	0.00	1.09
22.33	-	0.00	0.25	-	0.00	0.41	-	0.00	0.48	-	0.00	0.58	-	0.00	0.65	-	0.00	0.72	-	0.00	0.81	-	0.00	0.95
22.50	-	0.00	0.03	-	0.00	0.19	-	0.00	0.26	-	0.00	0.36	-	0.00	0.42	-	0.00	0.49	-	0.00	0.58	-	0.00	0.71
22.67	-	0.00	-0.18	-	0.00	-0.03	-	0.00	0.04	-	0.00	0.13	-	0.00	0.19	-	0.00	0.26	-	0.00	0.34	-	0.00	0.47
22.83	-	0.00	-0.40	-	0.00	-0.25	-	0.00	-0.19	-	0.00	-0.10	-	0.00	-0.04	-	0.00	0.02	-	0.00	0.10	-	0.00	0.23
23.00	-	0.00	-0.51	-	0.00	-0.37	-	0.00	-0.31	-	0.00	-0.23	-	0.00	-0.17	-	0.00	-0.11	-	0.00	-0.03	-	0.00	0.08
23.17	-	0.00	-0.73	-	0.00	-0.59	-	0.00	-0.54	-	0.00	-0.46	-	0.00	-0.40	-	0.00	-0.35	-	0.00	-0.27	-	0.00	-0.17
23.33	-	0.00	-0.84	-	0.00	-0.72	-	0.00	-0.66	-	0.00	-0.59	-	0.00	-0.54	-	0.00	-0.49	-	0.00	-0.42	-	0.00	-0.31
23.50	-	0.00	-1.06	-	0.00	-0.94	-	0.00	-0.89	-	0.00	-0.82	-	0.00	-0.77	-	0.00	-0.72	-	0.00	-0.66	-	0.00	-0.56
23.67	-	0.00	-1.17	-	0.00	-1.06	-	0.00	-1.02	-	0.00	-0.95	-	0.00	-0.91	-	0.00	-0.86	-	0.00	-0.80	-	0.00	-0.71
23.83	-	0.00	-1.39	-	0.00	-1.29	-	0.00	-1.25	-	0.00	-1.19	-	0.00	-1.15	-	0.00	-1.11	-	0.00	-1.05	-	0.00	-0.97
24.00	-	0.00	-1.51	-	0.00	-1.42	-	0.00	-1.38	-	0.00	-1.32	-	0.00	-1.29	-	0.00	-1.25	-	0.00	-1.20	-	0.00	-1.12
24.17	-	0.00	-1.63	-	0.00	-1.54	-	0.00	-1.51	-	0.00	-1.46	-	0.00	-1.42	-	0.00	-1.39	-	0.00	-1.34	-	0.00	-1.28
24.33	-	0.00	-1.85	-	0.00	-1.77	-	0.00	-1.74	-	0.00	-1.70	-	0.00	-1.66	-	0.00	-1.63	-	0.00	-1.59	-	0.00	-1.53
24.50	-	0.00	-1.96	-	0.00	-1.90	-	0.00	-1.87	-	0.00	-1.83	-	0.00	-1.81	-	0.00	-1.78	-	0.00	-1.74	-	0.00	-1.69
24.67	-	0.00	-2.08	-	0.00	-2.03	-	0.00	-2.00	-	0.00	-1.97	-	0.00	-1.95	-	0.00	-1.92	-	0.00	-1.89	-	0.00	-1.85
24.83	-	0.00	-2.10	-	0.00	-2.05	-	0.00	-2.04	-	0.00	-2.01	-	0.00	-1.99	-	0.00	-1.97	-	0.00	-1.94	-	0.00	-1.90
25.00	-	0.00	-2.23	-	0.00	-2.19	-	0.00	-2.17	-	0.00	-2.15	-	0.00	-2.13	-	0.00	-2.12	-	0.00	-2.10	-	0.00	-2.07
25.17	-	0.00	-2.25	-	0.00	-2.22	-	0.00	-2.21	-	0.00	-2.19	-	0.00	-2.18	-	0.00	-2.17	-	0.00	-2.15	-	0.00	-2.13
25.33	-	0.00	-2.27	-	0.00	-2.25	-	0.00	-2.24	-	0.00	-2.23	-	0.00	-2.22	-	0.00	-2.21	-	0.00	-2.20	-	0.00	-2.19
25.50	-	0.00	-2.29	-	0.00	-2.28	-	0.00	-2.27	-	0.00	-2.27	-	0.00	-2.26	-	0.00	-2.26	-	0.00	-2.25	-	0.00	-2.25
25.67	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20

HIGH END

	50% Mid Range			20% Mid Range			10% Mid Range			5% Mid Range			2% Mid Range			1% Mid Range			0.5% Mid Range			0.1% Mid Range		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
13.67	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10
13.83	-	0.00	-1.96	-	0.00	-1.95	-	0.00	-1.95	-	0.00	-1.95	-	0.00	-1.94	-	0.00	-1.94	-	0.00	-1.94	-	0.00	-1.92
14.00	-	0.00	-1.82	-	0.00	-1.81	-	0.00	-1.80	-	0.00	-1.79	-	0.00	-1.78	-	0.00	-1.77	-	0.00	-1.77	-	0.00	-1.74
14.17	-	0.00	-1.68	-	0.00	-1.66	-	0.00	-1.65	-	0.00	-1.64	-	0.00	-1.62	-	0.00	-1.61	-	0.00	-1.61	-	0.00	-1.56
14.33	-	0.00	-1.53	-	0.00	-1.51	-	0.00	-1.50	-	0.00	-1.48	-	0.00	-1.46	-	0.00	-1.44	-	0.00	-1.44	-	0.00	-1.38
14.50	-	0.00	-1.39	-	0.00	-1.37	-	0.00	-1.35	-	0.00	-1.33	-	0.00	-1.30	-	0.00	-1.28	-	0.00	-1.28	-	0.00	-1.20
14.67	-	0.00	-1.25	-	0.00	-1.22	-	0.00	-1.20	-	0.00	-1.17	-	0.00	-1.14	-	0.00	-1.12	-	0.00	-1.12	-	0.00	-1.02
14.83	-	0.00	-1.11	-	0.00	-1.08	-	0.00	-1.05	-	0.00	-1.02	-	0.00	-0.98	-	0.00	-0.95	-	0.00	-0.95	-	0.00	-0.84
15.00	-	0.00	-0.97	-	0.00	-0.93	-	0.00	-0.90	-	0.00	-0.87	-	0.00	-0.82	-	0.00	-0.79	-	0.00	-0.79	-	0.00	-0.66
15.17	-	0.00	-0.74	-	0.00	-0.69	-	0.00	-0.65	-	0.00	-0.62	-	0.00	-0.57	-	0.00	-0.53	-	0.00	-0.53	-	0.00	-0.38
15.33	-	0.00	-0.60	-	0.00	-0.55	-	0.00	-0.51	-	0.00	-0.47	-	0.00	-0.41	-	0.00	-0.37	-	0.00	-0.37	-	0.00	-0.21
15.50	-	0.00	-0.46	-	0.00	-0.41	-	0.00	-0.36	-	0.00	-0.32	-	0.00	-0.26	-	0.00	-0.22	-	0.00	-0.22	-	0.00	-0.04
15.67	-	0.00	-0.22	-	0.00	-0.16	-	0.00	-0.11	-	0.00	-0.07	-	0.00	0.00	-	0.00	0.04	-	0.00	0.04	-	0.00	0.24
15.83	-	0.00	-0.09	-	0.00	-0.02	-	0.00	0.03	-	0.00	0.08	-	0.00	0.15	-	0.00	0.20	-	0.00	0.20	-	0.00	0.41
16.00	-	0.00	0.15	-	0.00	0.21	-	0.00	0.27	-	0.00	0.32	-	0.00	0.40	-	0.00	0.45	-	0.00	0.45	-	0.00	0.67
16.17	-	0.00	0.38	-	0.00	0.45	-	0.00	0.51	-	0.00	0.57	-	0.00	0.65	-	0.00	0.70	-	0.00	0.70	-	0.00	0.94
16.33	-	0.00	0.51	-	0.00	0.59	-	0.00	0.65	-	0.00	0.71	-	0.00	0.79	-	0.00	0.85	-	0.00	0.85	-	0.00	1.10
16.50	-	0.00	0.74	-	0.00	0.82	-	0.00	0.89	-	0.00	0.95	-	0.00	1.04	-	0.00	1.10	-	0.00	1.10	-	0.00	1.36
16.67	-	0.00	0.87	-	0.00	0.96	-	0.00	1.03	-	0.00	1.09	-	0.00	1.18	-	0.00	1.25	-	0.00	1.25	-	0.00	1.52
16.83	-	0.00	1.10	-	0.00	1.19	-	0.00	1.26	-	0.00	1.33	-	0.00	1.43	-	0.00	1.49	-	0.00	1.49	-	0.00	1.78
17.00	-	0.00	1.33	-	0.00	1.42	-	0.00	1.50	-	0.00	1.57	-	0.00	1.67	-	0.00	1.73	-	0.00	1.73	3.20	1.20	2.03
17.17	-	0.00	1.45	-	0.00	1.55	-	0.00	1.63	-	0.00	1.70	1.04	0.39	1.80	1.45	0.54	1.87	1.67	0.63	1.87	3.79	1.42	2.18
17.33	0.20	0.08	1.68	0.36	0.14	1.78	0.56	0.21	1.86	0.83	0.31	1.93	1.38	0.52	2.04	1.93	0.72	2.11	2.21	0.83	2.11	5.07	1.89	2.43
17.50	0.24	0.09	1.80	0.43	0.16	1.90	0.66	0.25	1.99	0.98	0.37	2.06	1.63	0.61	2.17	2.27	0.85	2.25	2.61	0.98	2.25	6.01	2.25	2.58
17.67	0.28	0.10	1.92	0.50	0.19	2.03	0.78	0.29	2.11	1.16	0.43	2.19	1.92	0.72	2.30	2.68	1.00	2.38	3.07	1.15	2.38	7.11	2.66	2.72
17.83	0.33	0.12	2.04	0.59	0.22	2.15	0.92	0.34	2.24	1.36	0.51	2.32	2.26	0.84	2.43	3.16	1.18	2.51	3.61	1.35	2.51	8.39	3.14	2.86
18.00	0.39	0.14	2.16	0.70	0.26	2.27	1.09	0.41	2.36	1.60	0.60	2.44	2.66	1.00	2.56	3.72	1.39	2.64	4.24	1.59	2.64	9.86	3.69	3.00
18.17	0.46	0.17	2.28	0.82	0.31	2.39	1.28	0.48	2.48	1.88	0.70	2.57	3.13	1.17	2.69	4.36	1.63	2.77	4.97	1.86	2.77	11.53	4.31	3.13
18.33	0.54	0.20	2.39	0.97	0.36	2.51	1.50	0.56	2.60	2.22	0.83	2.68	3.67	1.37	2.81	5.11	1.91	2.89	5.80	2.17	2.89	13.41	5.02	3.26
18.50	0.64	0.24	2.51	1.14	0.43	2.62	1.77	0.66	2.72	2.60	0.97	2.80	4.29	1.61	2.93	5.95	2.23	3.01	6.75	2.52	3.01	15.57	5.82	3.38
18.67	0.75	0.28	2.62	1.34	0.50	2.73	2.08	0.78	2.83	3.05	1.14	2.92	5.01	1.87	3.04	6.93	2.59	3.13	7.85	2.94	3.13	18.04	6.75	3.51
18.83	0.88	0.33	2.73	1.58	0.59	2.85	2.43	0.91	2.94	3.56	1.33	3.03	5.82	2.18	3.16	8.05	3.01	3.25	9.10	3.40	3.25	20.84	7.79	3.63
19.00	0.90	0.33	2.74	1.60	0.60	2.85	2.47	0.92	2.95	3.61	1.35	3.04	5.92	2.21	3.17	8.19	3.06	3.26	9.25	3.46	3.26	21.25	7.95	3.64
19.17	0.90	0.34	2.74	1.61	0.60	2.86	2.50	0.93	2.96	3.65	1.37	3.05	5.99	2.24	3.18	8.28	3.10	3.27	9.36	3.50	3.27	21.55	8.06	3.65
19.33	1.05	0.39	2.84	1.87	0.70	2.96	2.88	1.08	3.06	4.20	1.57	3.15	6.87	2.57	3.28	9.47	3.54	3.37	10.69	4.00	3.37	24.37	9.11	3.76
19.50	1.05	0.39	2.85	1.87	0.70	2.96	2.89	1.08	3.06	4.22	1.58	3.15	6.90	2.58	3.28	9.54	3.57	3.37	10.77	4.03	3.37	24.51	9.17	3.76
19.67	1.06	0.39	2.85	1.88	0.70	2.97	2.89	1.08	3.07	4.22	1.58	3.16	6.91	2.59	3.29	9.55	3.57	3.38	10.78	4.03	3.38	24.57	9.19	3.77
19.83	1.05	0.39	2.85	1.87	0.70	2.96	2.89	1.08	3.06	4.22	1.58	3.15	6.90	2.58	3.28	9.54	3.57	3.37	10.77	4.03	3.37	24.51	9.17	3.76
20.00	0.91	0.34	2.75	1.63	0.61	2.87	2.52	0.94	2.97	3.68	1.38	3.06	6.05	2.26	3.19	8.36	3.13	3.28	9.45	3.53	3.28	21.79	8.15	3.66
20.17	0.90	0.34	2.74	1.61	0.60	2.86	2.50	0.93	2.96	3.65	1.37	3.05	5.99	2.24	3.18	8.28	3.10	3.27	9.36	3.50	3.27	21.55	8.06	3.65
20.33	0.77	0.29	2.64	1.38	0.52	2.75	2.14	0.80	2.85	3.15	1.18	2.94	5.19	1.94	3.07	7.19	2.69	3.16	8.13	3.04	3.16	18.84	7.05	3.54
20.50	0.66	0.25	2.53	1.18	0.44	2.65	1.83	0.69	2.74	2.70	1.01	2.83	4.47	1.67	2.96	6.22	2.33	3.05	7.05	2.64	3.05	16.39	6.13	3.43
20.67	0.56	0.21	2.42	1.01	0.38	2.53	1.57	0.59	2.63	2.32	0.87	2.72	3.85	1.44	2.84	5.37	2.01	2.93	6.09	2.28	2.93	14.21	5.31	3.31
20.83	0.48	0.18	2.31	0.86	0.32	2.42	1.34	0.50	2.52	1.98	0.74	2.60	3.31	1.24	2.73	4.61	1.72	2.81	5.25	1.96	2.81	12.30	4.60	3.18
21.00	0.35	0.13	2.09	0.64	0.24	2.21	1.00	0.37	2.30	1.48	0.55	2.38	2.48	0.93	2.51	3.49	1.30	2.59	3.98	1.49	2.59	9.42	3.52	2.96
21.17	0.30	0.11	1.98	0.55	0.20	2.09	0.86	0.32	2.18	1.27	0.47	2.27	2.12	0.79	2.39	2.98	1.12	2.47	3.41	1.28	2.47	8.08	3.02	2.83
21.33	0.23	0.08	1.76	0.41	0.15	1.87	0.64	0.24	1.96	0.96	0.36	2.04	1.60	0.60	2.16	2.25	0.84	2.24	2.59	0.97	2.24	6.14	2.30	2.60
21.50	0.19	0.07	1.64	0.35	0.13	1.75	0.55	0.20	1.84	0.82	0.31	1.92	1.37	0.51	2.03	1.93	0.72	2.11	2.22	0.83	2.11	5.23	1.96	2.46
21.67	-	0.00	1.42	-	0.00	1.53	-	0.00	1.61	-	0.00	1.69	1.04	0.39	1.80	1.47	0.55	1.88	1.69	0.63	1.88	3.95	1.48	2.22
21.83	-	0.00	1.20	-	0.00	1.30	-	0.00	1.39	-	0.00	1.46	-	0.00	1.57	-	0.00	1.65	-	0.00	1.65	-	0.00	1.98
22.00	-	0.00	0.98	-	0.00	1.08	-	0.00	1.16	-	0.00	1.23	-	0.00	1.34	-	0.00	1.41	-	0.00	1.41	-	0.00	1.73
22.17	-	0.00	0.75	-	0.00	0.85	-	0.00	0.93	-	0.00	1.00	-	0.00	1.10	-	0.00	1.17	-	0.00	1.17	-	0.00	1.48
22.33	-	0.00	0.63	-	0.00	0.72	-	0.00	0.80	-	0.00	0.87	-	0.00	0.97	-	0.00	1.03	-	0.00	1.03	-	0.00	1.33
22.50	-	0.00	0.40	-	0.00	0.49	-	0.00	0.56	-	0.00	0.63	-	0.00	0.73	-	0.00	0.79	-	0.00	0.79	-	0.00	1.08
22.67	-	0.00	0.17	-	0.00	0.26	-	0.00	0.33	-	0.00	0.39	-	0.00	0.48	-	0.00	0.55	-	0.00	0.55	-	0.00	0.82
22.83	-	0.00	-0.06	-	0.00	0.02	-	0.00	0.09	-	0.00	0.15	-	0.00	0.24	-	0.00	0.30	-	0.00	0.30	-	0.00	0.56
23.00	-	0.00	-0.19	-	0.00	-0.11	-	0.00	-0.05	-	0.00	0.01	-	0.00	0.09	-	0.00	0.15	-	0.00	0.15	-	0.00	0.40
23.17	-	0.00	-0.42	-	0.00	-0.35	-	0.00	-0.29	-	0.00	-0.23	-	0.00	-0.15	-	0.00	-0.10	-	0.00	-0.10	-	0.00	0.14
23.33	-	0.00	-0.55	-	0.00	-0.49	-	0.00	-0.43	-	0.00	-0.38	-	0.00	-0.30	-	0.00	-0.25	-	0.00	-0.25	-	0.00	-0.03
23.50	-	0.00	-0.79	-	0.00	-0.72	-	0.00	-0.67	-	0.00	-0.62	-	0.00	-0.55	-	0.00	-0.50	-	0.00	-0.50	-	0.00	-0.29
23.67	-	0.00	-0.92	-	0.00	-0.86	-	0.00	-0.81	-	0.00	-0.77	-	0.00	-0.70	-	0.00	-0.66	-	0.00	-0.66	-	0.00	-0.46
23.83	-	0.00	-1.16	-	0.00	-1.11	-	0.00	-1.06	-	0.00	-1.02	-	0.00	-0.96	-	0.00	-0.92	-	0.00	-0.92	-	0.00	-0.74
24.00	-	0.00	-1.30	-	0.00	-1.25	-	0.00	-1.21	-	0.00	-1.17	-	0.00	-1.11	-	0.00	-1.07	-	0.00	-1.07	-	0.00	-0.91
24.17	-	0.00	-1.44	-	0.00	-1.39	-	0.00	-1.35	-	0.00	-1.32	-	0.00	-1.27	-	0.00	-1.23	-	0.00	-1.23	-	0.00	-1.08
24.33	-	0.00	-1.67	-	0.00	-1.63	-	0.00	-1.60	-	0.00	-1.57	-	0.00	-1.52	-	0.00	-1.49	-	0.00	-1.49	-	0.00	-1.36
24.50	-	0.00	-1.81	-	0.00	-1.78	-	0.00	-1.75	-	0.00	-1.72	-	0.00	-1.68	-	0.00	-1.65	-	0.00	-1.65	-	0.00	-1.54
24.67	-	0.00	-1.95	-	0.00	-1.92	-	0.00	-1.90	-	0.00	-1.87	-	0.00	-1.84	-	0.00	-1.82	-	0.00	-1.82	-	0.00	-1.72
24.83	-	0.00	-1.99	-	0.00	-1.97	-	0.00	-1.95	-	0.00	-1.93	-	0.00	-1.90	-	0.00	-1.88	-	0.00	-1.88	-	0.00	-1.80
25.00	-	0.00	-2.14	-	0.00	-2.12	-	0.00	-2.10	-	0.00	-2.09	-	0.00	-2.06	-	0.00	-2.05	-	0.00	-2.05	-	0.00	-1.98
25.17	-	0.00	-2.18	-	0.00	-2.17	-	0.00	-2.15	-	0.00	-2.14	-	0.00	-2.12	-	0.00	-2.11	-	0.00	-2.11	-	0.00	-2.06
25.33	-	0.00	-2.22	-	0.00	-2.21	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.18	-	0.00	-2.18	-	0.00	-2.18	-	0.00	-2.14
25.50	-	0.00	-2.26	-	0.00	-2.26	-	0.00	-2.25	-	0.00	-2.25	-	0.00	-2.24	-	0.00	-2.24	-	0.00	-2.24	-	0.00	-2.22
25.67	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20

HIGH END

	10% High End			0.5% High End			0.1% High End		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
13.67	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10
13.83	-	0.00	-1.93	-	0.00	-1.91	-	0.00	-1.90
14.00	-	0.00	-1.76	-	0.00	-1.73	-	0.00	-1.70
14.17	-	0.00	-1.59	-	0.00	-1.54	-	0.00	-1.50
14.33	-	0.00	-1.43	-	0.00	-1.36	-	0.00	-1.30
14.50	-	0.00	-1.26	-	0.00	-1.17	-	0.00	-1.11
14.67	-	0.00	-1.09	-	0.00	-0.99	-	0.00	-0.91
14.83	-	0.00	-0.93	-	0.00	-0.80	-	0.00	-0.71
15.00	-	0.00	-0.76	-	0.00	-0.62	-	0.00	-0.52
15.17	-	0.00	-0.50	-	0.00	-0.34	-	0.00	-0.23
15.33	-	0.00	-0.34	-	0.00	-0.16	-	0.00	-0.04
15.50	-	0.00	-0.17	-	0.00	0.01	-	0.00	0.15
15.67	-	0.00	0.09	-	0.00	0.29	-	0.00	0.44
15.83	-	0.00	0.24	-	0.00	0.46	-	0.00	0.63
16.00	-	0.00	0.50	-	0.00	0.74	-	0.00	0.91
16.17	-	0.00	0.76	-	0.00	1.01	-	0.00	1.19
16.33	-	0.00	0.91	-	0.00	1.17	-	0.00	1.37
16.50	-	0.00	1.16	-	0.00	1.44	-	0.00	1.64
16.67	-	0.00	1.31	-	0.00	1.60	-	0.00	1.81
16.83	-	0.00	1.56	-	0.00	1.86	-	0.00	2.08
17.00	-	0.00	1.80	3.99	1.49	2.12	8.37	3.13	2.35
17.17	1.57	0.59	1.95	4.75	1.77	2.27	9.99	3.74	2.51
17.33	2.09	0.78	2.19	6.35	2.37	2.52	13.19	4.93	2.77
17.50	2.48	0.93	2.32	7.55	2.82	2.67	15.61	5.84	2.92
17.67	2.93	1.10	2.46	8.93	3.34	2.82	18.38	6.87	3.08
17.83	3.47	1.30	2.59	10.53	3.94	2.96	21.52	8.05	3.22
18.00	4.09	1.53	2.72	12.37	4.63	3.10	25.09	9.38	3.37
18.17	4.81	1.80	2.85	14.46	5.41	3.23	29.18	10.91	3.51
18.33	5.64	2.11	2.98	16.86	6.31	3.36	33.86	12.66	3.64
18.50	6.59	2.47	3.10	19.59	7.33	3.49	39.09	14.62	3.78
18.67	7.68	2.87	3.22	22.69	8.49	3.61	44.77	16.74	3.90
18.83	8.94	3.34	3.33	26.14	9.78	3.73	50.91	19.04	4.03
19.00	9.09	3.40	3.35	26.65	9.97	3.75	51.92	19.42	4.05
19.17	9.23	3.45	3.36	27.05	10.12	3.76	52.74	19.72	4.06
19.33	10.55	3.95	3.46	30.42	11.38	3.87	58.87	22.02	4.17
19.50	10.62	3.97	3.46	30.63	11.46	3.87	59.30	22.18	4.17
19.67	10.64	3.98	3.47	30.70	11.48	3.88	59.43	22.23	4.18
19.83	10.62	3.97	3.46	30.63	11.46	3.87	59.30	22.18	4.17
20.00	9.31	3.48	3.37	27.33	10.22	3.77	53.34	19.95	4.07
20.17	9.23	3.45	3.36	27.05	10.12	3.76	52.74	19.72	4.06
20.33	7.98	2.99	3.25	23.73	8.88	3.65	46.81	17.51	3.95
20.50	6.90	2.58	3.13	20.66	7.73	3.53	41.33	15.46	3.83
20.67	5.94	2.22	3.02	17.91	6.70	3.41	36.16	13.52	3.70
20.83	5.10	1.91	2.90	15.49	5.79	3.29	31.43	11.75	3.58
21.00	3.85	1.44	2.68	11.90	4.45	3.06	24.45	9.14	3.34
21.17	3.29	1.23	2.55	10.20	3.81	2.93	21.16	7.91	3.21
21.33	2.47	0.92	2.32	7.76	2.90	2.70	16.36	6.12	2.97
21.50	2.11	0.79	2.19	6.61	2.47	2.56	14.00	5.24	2.82
21.67	1.60	0.60	1.96	4.99	1.87	2.32	10.71	4.01	2.58
21.83	-	0.00	1.72	3.78	1.42	2.07	8.16	3.05	2.32
22.00	-	0.00	1.49	-	0.00	1.82	-	0.00	2.07
22.17	-	0.00	1.25	-	0.00	1.57	-	0.00	1.81
22.33	-	0.00	1.10	-	0.00	1.42	-	0.00	1.65
22.50	-	0.00	0.86	-	0.00	1.16	-	0.00	1.38
22.67	-	0.00	0.61	-	0.00	0.90	-	0.00	1.11
22.83	-	0.00	0.36	-	0.00	0.64	-	0.00	0.84
23.00	-	0.00	0.21	-	0.00	0.47	-	0.00	0.67
23.17	-	0.00	-0.04	-	0.00	0.21	-	0.00	0.39
23.33	-	0.00	-0.20	-	0.00	0.04	-	0.00	0.21
23.50	-	0.00	-0.46	-	0.00	-0.24	-	0.00	-0.07
23.67	-	0.00	-0.61	-	0.00	-0.41	-	0.00	-0.26
23.83	-	0.00	-0.87	-	0.00	-0.69	-	0.00	-0.55
24.00	-	0.00	-1.04	-	0.00	-0.86	-	0.00	-0.74
24.17	-	0.00	-1.20	-	0.00	-1.04	-	0.00	-0.93
24.33	-	0.00	-1.46	-	0.00	-1.32	-	0.00	-1.22
24.50	-	0.00	-1.63	-	0.00	-1.50	-	0.00	-1.41
24.67	-	0.00	-1.79	-	0.00	-1.69	-	0.00	-1.61
24.83	-	0.00	-1.86	-	0.00	-1.77	-	0.00	-1.71
25.00	-	0.00	-2.03	-	0.00	-1.96	-	0.00	-1.91
25.17	-	0.00	-2.10	-	0.00	-2.05	-	0.00	-2.01
25.33	-	0.00	-2.17	-	0.00	-2.13	-	0.00	-2.11
25.50	-	0.00	-2.24	-	0.00	-2.22	-	0.00	-2.21
25.67	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20

Location A5
Current

	AEP																							
	50%			20%			10%			5%			2%			1%			0.50%			0.10%		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
13.67	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10
13.83	-	0.00	-1.97	-	0.00	-1.97	-	0.00	-1.96	-	0.00	-1.96	-	0.00	-1.95	-	0.00	-1.94	-	0.00	-1.94	-	0.00	-1.94
14.00	-	0.00	-1.84	-	0.00	-1.83	-	0.00	-1.82	-	0.00	-1.81	-	0.00	-1.80	-	0.00	-1.79	-	0.00	-1.78	-	0.00	-1.78
14.17	-	0.00	-1.71	-	0.00	-1.70	-	0.00	-1.68	-	0.00	-1.67	-	0.00	-1.64	-	0.00	-1.63	-	0.00	-1.62	-	0.00	-1.62
14.33	-	0.00	-1.58	-	0.00	-1.57	-	0.00	-1.55	-	0.00	-1.53	-	0.00	-1.49	-	0.00	-1.48	-	0.00	-1.46	-	0.00	-1.46
14.50	-	0.00	-1.45	-	0.00	-1.44	-	0.00	-1.41	-	0.00	-1.39	-	0.00	-1.34	-	0.00	-1.32	-	0.00	-1.30	-	0.00	-1.30
14.67	-	0.00	-1.33	-	0.00	-1.30	-	0.00	-1.27	-	0.00	-1.25	-	0.00	-1.19	-	0.00	-1.17	-	0.00	-1.15	-	0.00	-1.15
14.83	-	0.00	-1.20	-	0.00	-1.17	-	0.00	-1.13	-	0.00	-1.11	-	0.00	-1.04	-	0.00	-1.01	-	0.00	-0.99	-	0.00	-0.99
15.00	-	0.00	-1.07	-	0.00	-1.04	-	0.00	-1.00	-	0.00	-0.96	-	0.00	-0.89	-	0.00	-0.86	-	0.00	-0.83	-	0.00	-0.83
15.17	-	0.00	-0.84	-	0.00	-0.81	-	0.00	-0.76	-	0.00	-0.72	-	0.00	-0.64	-	0.00	-0.61	-	0.00	-0.58	-	0.00	-0.58
15.33	-	0.00	-0.72	-	0.00	-0.68	-	0.00	-0.62	-	0.00	-0.59	-	0.00	-0.50	-	0.00	-0.46	-	0.00	-0.42	-	0.00	-0.42
15.50	-	0.00	-0.59	-	0.00	-0.55	-	0.00	-0.49	-	0.00	-0.45	-	0.00	-0.35	-	0.00	-0.31	-	0.00	-0.27	-	0.00	-0.27
15.67	-	0.00	-0.36	-	0.00	-0.32	-	0.00	-0.25	-	0.00	-0.21	-	0.00	-0.10	-	0.00	-0.06	-	0.00	-0.01	-	0.00	-0.01
15.83	-	0.00	-0.24	-	0.00	-0.19	-	0.00	-0.12	-	0.00	-0.07	-	0.00	0.04	-	0.00	0.09	-	0.00	0.14	-	0.00	0.14
16.00	-	0.00	-0.02	-	0.00	0.04	-	0.00	0.11	-	0.00	0.16	-	0.00	0.28	-	0.00	0.33	-	0.00	0.39	-	0.00	0.39
16.17	-	0.00	0.21	-	0.00	0.26	-	0.00	0.34	-	0.00	0.40	-	0.00	0.53	-	0.00	0.58	-	0.00	0.63	-	0.00	0.63
16.33	-	0.00	0.33	-	0.00	0.39	-	0.00	0.47	-	0.00	0.53	-	0.00	0.67	-	0.00	0.72	-	0.00	0.78	-	0.00	0.78
16.50	-	0.00	0.55	-	0.00	0.61	-	0.00	0.70	-	0.00	0.76	-	0.00	0.90	-	0.00	0.97	-	0.00	1.03	-	0.00	1.03
16.67	-	0.00	0.67	-	0.00	0.74	-	0.00	0.83	-	0.00	0.89	-	0.00	1.04	-	0.00	1.11	-	0.00	1.17	-	0.00	1.17
16.83	-	0.00	0.89	-	0.00	0.96	-	0.00	1.06	-	0.00	1.12	-	0.00	1.28	-	0.00	1.34	-	0.00	1.41	-	0.00	1.41
17.00	-	0.00	1.11	-	0.00	1.18	-	0.00	1.28	-	0.00	1.35	-	0.00	1.51	-	0.00	1.58	2.74	0.77	1.65	-	0.00	1.65
17.17	-	0.00	1.23	-	0.00	1.30	-	0.00	1.41	-	0.00	1.48	2.21	0.62	1.64	3.13	0.88	1.72	3.43	0.96	1.79	-	0.00	1.79
17.33	0.59	0.17	1.45	1.04	0.29	1.52	1.53	0.43	1.63	2.23	0.62	1.70	3.27	0.91	1.88	4.58	1.28	1.95	5.05	1.41	2.02	12.27	3.44	2.02
17.50	0.73	0.20	1.57	1.29	0.36	1.64	1.90	0.53	1.75	2.75	0.77	1.83	4.06	1.14	2.00	5.68	1.59	2.08	6.31	1.77	2.16	14.76	4.13	2.16
17.67	0.90	0.25	1.68	1.59	0.44	1.76	2.35	0.66	1.87	3.39	0.95	1.95	5.05	1.41	2.13	7.04	1.97	2.21	7.87	2.20	2.29	17.64	4.94	2.29
17.83	1.12	0.31	1.80	1.96	0.55	1.88	2.91	0.82	1.99	4.19	1.17	2.07	6.28	1.76	2.26	8.72	2.44	2.34	9.78	2.74	2.42	20.97	5.87	2.42
18.00	1.40	0.39	1.91	2.43	0.68	1.99	3.61	1.01	2.11	5.17	1.45	2.19	7.79	2.18	2.38	10.72	3.00	2.46	12.05	3.37	2.54	24.87	6.96	2.54
18.17	1.75	0.49	2.02	3.01	0.84	2.10	4.46	1.25	2.22	6.36	1.78	2.31	9.58	2.68	2.50	13.08	3.66	2.58	14.70	4.12	2.67	29.37	8.22	2.67
18.33	2.17	0.61	2.13	3.71	1.04	2.22	5.50	1.54	2.34	7.81	2.19	2.42	11.68	3.27	2.62	15.84	4.44	2.70	17.74	4.97	2.79	34.46	9.65	2.79
18.50	2.70	0.76	2.24	4.58	1.28	2.33	6.75	1.89	2.45	9.50	2.66	2.54	14.11	3.95	2.74	18.98	5.31	2.82	21.28	5.96	2.91	40.19	11.25	2.91
18.67	3.34	0.93	2.35	5.61	1.57	2.44	8.22	2.30	2.56	11.46	3.21	2.65	16.90	4.73	2.85	22.56	6.32	2.94	25.31	7.09	3.02	46.49	13.02	3.02
18.83	4.10	1.15	2.46	6.82	1.91	2.54	9.92	2.78	2.67	13.71	3.84	2.76	20.15	5.64	2.96	26.71	7.48	3.05	29.99	8.40	3.14	53.63	15.02	3.14
19.00	4.15	1.16	2.46	6.90	1.93	2.55	10.04	2.81	2.68	13.89	3.89	2.77	20.47	5.73	2.97	27.14	7.60	3.06	30.48	8.53	3.15	54.37	15.22	3.15
19.17	4.18	1.17	2.47	6.96	1.95	2.55	10.14	2.84	2.68	14.05	3.93	2.77	20.72	5.80	2.98	27.47	7.69	3.07	30.88	8.65	3.16	54.98	15.39	3.16
19.33	5.04	1.41	2.56	8.31	2.33	2.65	12.01	3.36	2.78	16.47	4.61	2.87	24.14	6.76	3.08	31.84	8.92	3.17	35.87	10.04	3.26	62.34	17.46	3.26
19.50	5.06	1.42	2.57	8.34	2.33	2.66	12.05	3.37	2.79	16.55	4.63	2.88	24.29	6.80	3.08	32.02	8.97	3.17	36.08	10.10	3.26	62.64	17.54	3.26
19.67	5.07	1.42	2.57	8.35	2.34	2.66	12.07	3.38	2.79	16.58	4.64	2.88	24.33	6.81	3.09	32.07	8.98	3.18	36.13	10.12	3.27	62.72	17.56	3.27
19.83	5.06	1.42	2.57	8.34	2.33	2.66	12.05	3.37	2.79	16.55	4.63	2.88	24.29	6.80	3.08	32.02	8.97	3.17	36.08	10.10	3.26	62.64	17.54	3.26
20.00	4.21	1.18	2.47	7.01	1.96	2.56	10.23	2.86	2.69	14.14	3.96	2.78	20.88	5.85	2.99	27.71	7.76	3.08	31.20	8.74	3.17	55.46	15.53	3.17
20.17	4.18	1.17	2.47	6.96	1.95	2.55	10.14	2.84	2.68	14.05	3.93	2.77	20.72	5.80	2.98	27.47	7.69	3.07	30.88	8.65	3.16	54.98	15.39	3.16
20.33	3.42	0.96	2.36	5.75	1.61	2.45	8.45	2.37	2.58	11.80	3.30	2.67	17.52	4.91	2.87	23.41	6.55	2.96	26.30	7.36	3.05	48.02	13.45	3.05
20.50	2.78	0.78	2.26	4.73	1.32	2.34	7.00	1.96	2.47	9.86	2.76	2.56	14.73	4.12	2.76	19.83	5.55	2.85	22.29	6.24	2.94	41.79	11.70	2.94
20.67	2.25	0.63	2.15	3.86	1.08	2.24	5.75	1.61	2.36	8.17	2.29	2.45	12.29	3.44	2.65	16.67	4.67	2.74	18.74	5.25	2.82	36.10	10.11	2.82
20.83	1.82	0.51	2.04	3.14	0.88	2.13	4.69	1.31	2.25	6.71	1.88	2.34	10.18	2.85	2.54	13.92	3.90	2.62	15.67	4.39	2.71	31.02	8.69	2.71
21.00	1.20	0.34	1.83	2.11	0.59	1.92	3.17	0.89	2.04	4.59	1.28	2.12	7.01	1.96	2.32	9.76	2.73	2.40	11.02	3.09	2.49	23.10	6.47	2.49
21.17	0.97	0.27	1.72	1.72	0.48	1.80	2.58	0.72	1.92	3.74	1.05	2.01	5.70	1.59	2.20	7.97	2.23	2.28	9.01	2.52	2.37	19.64	5.50	2.37
21.33	0.66	0.18	1.51	1.17	0.33	1.59	1.76	0.49	1.71	2.58	0.72	1.79	3.89	1.09	1.98	5.50	1.54	2.06	6.17	1.73	2.14	14.50	4.06	2.14
21.50	0.54	0.15	1.40	0.96	0.27	1.48	1.43	0.40	1.59	2.10	0.59	1.67	3.16	0.88	1.86	4.48	1.25	1.94	4.99	1.40	2.02	12.15	3.40	2.02
21.67	-	0.00	1.18	-	0.00	1.26	-	0.00	1.37	-	0.00	1.45	2.16	0.60	1.63	3.09	0.86	1.71	3.43	0.96	1.79	-	0.00	1.79
21.83	-	0.00	0.97	-	0.00	1.04	-	0.00	1.15	-	0.00	1.23	-	0.00	1.40	-	0.00	1.48	-	0.00	1.56	-	0.00	1.56
22.00	-	0.00	0.75	-	0.00	0.82	-	0.00	0.93	-	0.00	1.00	-	0.00	1.18	-	0.00	1.25	-	0.00	1.32	-	0.00	1.32
22.17	-	0.00	0.53	-	0.00	0.60	-	0.00	0.71	-	0.00	0.78	-	0.00	0.94	-	0.00	1.02	-	0.00	1.09	-	0.00	1.09
22.33	-	0.00	0.41	-	0.00	0.48	-	0.00	0.58	-	0.00	0.65	-	0.00	0.81	-	0.00	0.88	-	0.00	0.95	-	0.00	0.95
22.50	-	0.00	0.19	-	0.00	0.26	-	0.00	0.36	-	0.00	0.42	-	0.00	0.58	-	0.00	0.64	-	0.00	0.71	-	0.00	0.71
22.67	-	0.00	-0.03	-	0.00	0.04	-	0.00	0.13	-	0.00	0.19	-	0.00	0.34	-	0.00	0.41	-	0.00	0.47	-	0.00	0.47
22.83	-	0.00	-0.25	-	0.00	-0.19	-	0.00	-0.10	-	0.00	-0.04	-	0.00	0.10	-	0.00	0.17	-	0.00	0.23	-	0.00	0.23
23.00	-	0.00	-0.37	-	0.00	-0.31	-	0.00	-0.23	-	0.00	-0.17	-	0.00	-0.03	-	0.00	0.02	-	0.00	0.08	-	0.00	0.08
23.17	-	0.00	-0.59	-	0.00	-0.54	-	0.00	-0.46	-	0.00	-0.40	-	0.00	-0.27	-	0.00	-0.22	-	0.00	-0.17	-	0.00	-0.17
23.33	-	0.00	-0.72	-	0.00	-0.66	-	0.00	-0.59	-	0.00	-0.54	-	0.00	-0.42	-	0.00	-0.37	-	0.00	-0.31	-	0.00	-0.31
23.50	-	0.00	-0.94	-	0.00	-0.89	-	0.00	-0.82	-	0.00	-0.77	-	0.00	-0.66	-	0.00	-0.61	-	0.00	-0.56	-	0.00	-0.56
23.67	-	0.00	-1.06	-	0.00	-1.02	-	0.00	-0.95	-	0.00	-0.91	-	0.00	-0.80	-	0.00	-0.76	-	0.00	-0.71	-	0.00	-0.71
23.83	-	0.00	-1.29	-	0.00	-1.25	-	0.00	-1.19	-	0.00	-1.15	-	0.00	-1.05	-	0.00	-1.01	-	0.00	-0.97	-	0.00	-0.97
24.00	-	0.00	-1.42	-	0.00	-1.38	-	0.00	-1.32	-	0.00	-1.29	-	0.00	-1.20	-	0.00	-1.16	-	0.00	-1.12	-	0.00	-1.12
24.17	-	0.00	-1.54	-	0.00	-1.51	-	0.00	-1.46	-	0.00	-1.42	-	0.00	-1.34	-	0.00	-1.31	-	0.00	-1.28	-	0.00	-1.28
24.33	-	0.00	-1.77	-	0.00	-1.74	-	0.00	-1.70	-	0.00	-1.66	-	0.00	-1.59	-	0.00	-1.56	-	0.00	-1.53	-	0.00	-1.53
24.50	-	0.00	-1.90	-	0.00	-1.87	-	0.00	-1.83	-	0.00	-1.81	-	0.00	-1.74	-	0.00	-1.71	-	0.00	-1.69	-	0.00	-1.69
24.67	-	0.00	-2.03	-	0.00	-2.00	-	0.00	-1.97	-	0.00	-1.95	-	0.00	-1.89	-	0.00	-1.87	-	0.00	-1.85	-	0.00	-1.85
24.83	-	0.00	-2.05	-	0.00	-2.04	-	0.00	-2.01	-	0.00	-1.99	-	0.00	-1.94	-	0.00	-1.92	-	0.00	-1.90	-	0.00	-1.90
25.00	-	0.00	-2.19	-	0.00	-2.17	-	0.00	-2.15	-	0.00	-2.13	-	0.00	-2.10	-	0.00	-2.08	-	0.00	-2.07	-	0.00	-2.07
25.17	-	0.00	-2.22	-	0.00	-2.21	-	0.00	-2.19	-	0.00	-2.18	-	0.00	-2.15	-	0.00	-2.14	-	0.00	-2.13	-	0.00	-2.13
25.33	-	0.00	-2.25	-	0.00	-2.24	-	0.00	-2.23	-	0.00	-2.22	-	0.00	-2.20	-	0.00	-2.19	-	0.00	-2.19	-	0.00	-2.19
25.50	-	0.00	-2.28	-	0.00	-2.27	-	0.00	-2.27	-	0.00	-2.26	-	0.00	-2.25	-	0.00	-2.25	-	0.00	-2.25	-	0.00	-2.25
25.67	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20

Mid Range

	50% Mid Range			20% Mid Range			10% Mid Range			5% Mid Range			2% Mid Range			1% Mid Range			0.5% Mid Range			0.1% Mid Range		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
13.67	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10
13.83	-	0.00	-1.95	-	0.00	-1.95	-	0.00	-1.94	-	0.00	-1.94	-	0.00	-1.93	-	0.00	-1.92	-	0.00	-1.92	-	0.00	-1.92
14.00	-	0.00	-1.81	-	0.00	-1.80	-	0.00	-1.78	-	0.00	-1.77	-	0.00	-1.76	-	0.00	-1.74	-	0.00	-1.74	-	0.00	-1.74
14.17	-	0.00	-1.66	-	0.00	-1.65	-	0.00	-1.62	-	0.00	-1.61	-	0.00	-1.59	-	0.00	-1.57	-	0.00	-1.57	-	0.00	-1.56
14.33	-	0.00	-1.51	-	0.00	-1.50	-	0.00	-1.46	-	0.00	-1.44	-	0.00	-1.43	-	0.00	-1.39	-	0.00	-1.39	-	0.00	-1.38
14.50	-	0.00	-1.37	-	0.00	-1.35	-	0.00	-1.30	-	0.00	-1.28	-	0.00	-1.26	-	0.00	-1.21	-	0.00	-1.21	-	0.00	-1.20
14.67	-	0.00	-1.22	-	0.00	-1.20	-	0.00	-1.14	-	0.00	-1.12	-	0.00	-1.09	-	0.00	-1.04	-	0.00	-1.04	-	0.00	-1.02
14.83	-	0.00	-1.08	-	0.00	-1.05	-	0.00	-0.98	-	0.00	-0.95	-	0.00	-0.93	-	0.00	-0.86	-	0.00	-0.86	-	0.00	-0.84
15.00	-	0.00	-0.93	-	0.00	-0.90	-	0.00	-0.82	-	0.00	-0.79	-	0.00	-0.76	-	0.00	-0.69	-	0.00	-0.69	-	0.00	-0.66
15.17	-	0.00	-0.69	-	0.00	-0.65	-	0.00	-0.57	-	0.00	-0.53	-	0.00	-0.50	-	0.00	-0.42	-	0.00	-0.42	-	0.00	-0.38
15.33	-	0.00	-0.55	-	0.00	-0.51	-	0.00	-0.41	-	0.00	-0.37	-	0.00	-0.34	-	0.00	-0.25	-	0.00	-0.25	-	0.00	-0.21
15.50	-	0.00	-0.41	-	0.00	-0.36	-	0.00	-0.26	-	0.00	-0.22	-	0.00	-0.17	-	0.00	-0.08	-	0.00	-0.08	-	0.00	-0.04
15.67	-	0.00	-0.16	-	0.00	-0.11	-	0.00	0.00	-	0.00	0.04	-	0.00	0.09	-	0.00	0.19	-	0.00	0.19	-	0.00	0.24
15.83	-	0.00	-0.02	-	0.00	0.03	-	0.00	0.15	-	0.00	0.20	-	0.00	0.24	-	0.00	0.36	-	0.00	0.36	-	0.00	0.41
16.00	-	0.00	0.21	-	0.00	0.27	-	0.00	0.40	-	0.00	0.45	-	0.00	0.50	-	0.00	0.62	-	0.00	0.62	-	0.00	0.67
16.17	-	0.00	0.45	-	0.00	0.51	-	0.00	0.65	-	0.00	0.70	-	0.00	0.76	-	0.00	0.88	-	0.00	0.88	-	0.00	0.94
16.33	-	0.00	0.59	-	0.00	0.65	-	0.00	0.79	-	0.00	0.85	-	0.00	0.91	-	0.00	1.04	-	0.00	1.04	-	0.00	1.10
16.50	-	0.00	0.82	-	0.00	0.89	-	0.00	1.04	-	0.00	1.10	-	0.00	1.16	-	0.00	1.30	-	0.00	1.30	-	0.00	1.36
16.67	-	0.00	0.96	-	0.00	1.03	-	0.00	1.18	-	0.00	1.25	-	0.00	1.31	-	0.00	1.46	-	0.00	1.46	-	0.00	1.52
16.83	-	0.00	1.19	-	0.00	1.26	-	0.00	1.43	-	0.00	1.49	-	0.00	1.56	-	0.00	1.71	-	0.00	1.71	4.81	1.35	1.78
17.00	-	0.00	1.42	-	0.00	1.50	2.72	0.76	1.67	3.80	1.06	1.73	18.38	5.15	1.80	4.58	1.28	1.96	6.28	1.76	1.96	7.16	2.01	2.03
17.17	1.63	0.46	1.55	2.75	0.77	1.63	3.42	0.96	1.80	4.75	1.33	1.87	22.23	6.22	1.95	5.68	1.59	2.11	7.85	2.20	2.11	9.07	2.54	2.18
17.33	2.40	0.67	1.78	4.00	1.12	1.86	5.04	1.41	2.04	6.95	1.95	2.11	30.10	8.43	2.19	8.21	2.30	2.36	11.37	3.18	2.36	13.36	3.74	2.43
17.50	2.99	0.84	1.90	4.94	1.38	1.99	6.31	1.77	2.17	8.66	2.43	2.25	35.93	10.06	2.32	10.12	2.83	2.50	14.05	3.93	2.50	16.71	4.68	2.58
17.67	3.72	1.04	2.03	6.08	1.70	2.11	7.88	2.21	2.30	10.76	3.01	2.38	42.73	11.96	2.46	12.42	3.48	2.64	17.30	4.84	2.64	20.72	5.80	2.72
17.83	4.61	1.29	2.15	7.50	2.10	2.24	9.79	2.74	2.43	13.26	3.71	2.51	50.59	14.17	2.59	15.16	4.24	2.78	21.14	5.92	2.78	25.37	7.10	2.86
18.00	5.73	1.60	2.27	9.20	2.58	2.36	12.07	3.38	2.56	16.21	4.54	2.64	59.34	16.62	2.72	18.40	5.15	2.91	25.58	7.16	2.91	30.78	8.62	3.00
18.17	7.07	1.98	2.39	11.24	3.15	2.48	14.72	4.12	2.69	19.64	5.50	2.77	69.12	19.35	2.85	22.18	6.21	3.05	30.68	8.59	3.05	36.99	10.36	3.13
18.33	8.67	2.43	2.51	13.60	3.81	2.60	17.79	4.98	2.81	23.58	6.60	2.89	80.01	22.40	2.98	26.40	7.39	3.17	36.42	10.20	3.17	44.15	12.36	3.26
18.50	10.54	2.95	2.62	16.34	4.58	2.72	21.35	5.98	2.93	28.04	7.85	3.01	92.11	25.79	3.10	31.25	8.75	3.30	43.00	12.04	3.30	52.48	14.69	3.38
18.67	12.72	3.56	2.73	19.46	5.45	2.83	25.43	7.12	3.04	33.22	9.30	3.13	105.50	29.54	3.22	36.73	10.28	3.42	50.41	14.11	3.42	62.26	17.43	3.51
18.83	15.23	4.26	2.85	23.01	6.44	2.94	30.10	8.43	3.16	39.06	10.94	3.25	120.30	33.68	3.33	42.93	12.02	3.54	58.96	16.51	3.54	73.20	20.50	3.63
19.00	15.46	4.33	2.85	23.35	6.54	2.95	30.64	8.58	3.17	39.78	11.14	3.26	122.40	34.27	3.35	43.63	12.22	3.55	60.16	16.84	3.55	74.79	20.94	3.64
19.17	15.63	4.38	2.86	23.63	6.62	2.96	31.05	8.69	3.18	40.30	11.28	3.27	124.00	34.72	3.36	44.21	12.38	3.57	61.06	17.10	3.57	76.11	21.31	3.65
19.33	18.33	5.13	2.96	27.43	7.68	3.06	36.10	10.11	3.28	46.57	13.04	3.37	138.90	38.89	3.46	50.66	14.18	3.67	70.12	19.63	3.67	87.43	24.48	3.76
19.50	18.41	5.15	2.96	27.55	7.71	3.06	36.32	10.17	3.28	46.90	13.13	3.37	139.70	39.12	3.46	51.00	14.28	3.67	70.50	19.74	3.67	88.02	24.65	3.76
19.67	18.44	5.16	2.97	27.59	7.73	3.07	36.37	10.18	3.29	46.96	13.15	3.38	140.00	39.20	3.47	51.07	14.30	3.68	70.69	19.79	3.68	88.25	24.71	3.77
19.83	18.41	5.15	2.96	27.55	7.71	3.06	36.32	10.17	3.28	46.90	13.13	3.37	139.70	39.12	3.46	51.00	14.28	3.67	70.50	19.74	3.67	88.02	24.65	3.76
20.00	15.76	4.41	2.87	23.84	6.68	2.97	31.37	8.78	3.19	40.70	11.40	3.28	125.30	35.08	3.37	44.57	12.48	3.57	61.73	17.28	3.57	77.04	21.57	3.66
20.17	15.63	4.38	2.86	23.63	6.62	2.96	31.05	8.69	3.18	40.30	11.28	3.27	124.00	34.72	3.36	44.21	12.38	3.57	61.06	17.10	3.57	76.11	21.31	3.65
20.33	13.14	3.68	2.75	20.11	5.63	2.85	26.43	7.40	3.07	34.56	9.68	3.16	109.70	30.72	3.25	38.11	10.67	3.45	52.60	14.73	3.45	65.31	18.29	3.54
20.50	10.99	3.08	2.65	17.01	4.76	2.74	22.37	6.26	2.96	29.44	8.24	3.05	96.59	27.05	3.13	32.70	9.16	3.34	45.17	12.65	3.34	55.69	15.59	3.43
20.67	9.12	2.55	2.53	14.29	4.00	2.63	18.83	5.27	2.84	24.95	6.99	2.93	84.54	23.67	3.02	27.89	7.81	3.22	38.64	10.82	3.22	47.26	13.23	3.31
20.83	7.48	2.09	2.42	11.90	3.33	2.52	15.72	4.40	2.73	20.96	5.87	2.81	73.59	20.61	2.90	23.60	6.61	3.10	32.85	9.20	3.10	39.93	11.18	3.18
21.00	5.10	1.43	2.21	8.31	2.33	2.30	11.05	3.09	2.51	15.00	4.20	2.59	56.79	15.90	2.68	17.01	4.76	2.87	24.03	6.73	2.87	29.23	8.18	2.96
21.17	4.14	1.16	2.09	6.82	1.91	2.18	9.02	2.53	2.39	12.33	3.45	2.47	48.75	13.65	2.55	14.13	3.96	2.75	19.99	5.60	2.75	24.30	6.80	2.83
21.33	2.83	0.79	1.87	4.73	1.32	1.96	6.18	1.73	2.16	8.57	2.40	2.24	36.73	10.28	2.32	9.98	2.79	2.51	14.16	3.96	2.51	17.20	4.82	2.60
21.50	2.29	0.64	1.75	3.87	1.08	1.84	5.00	1.40	2.03	6.97	1.95	2.11	31.10	8.71	2.19	8.19	2.29	2.38	11.59	3.25	2.38	13.95	3.91	2.46
21.67	1.57	0.44	1.53	2.68	0.75	1.61	3.43	0.96	1.80	4.81	1.35	1.88	23.23	6.50	1.96	5.73	1.61	2.14	8.10	2.27	2.14	9.62	2.69	2.22
21.83	-	0.00	1.30	-	0.00	1.39	-	0.00	1.57	-	0.00	1.65	-	0.00	1.72	-	0.00	1.90	5.63	1.58	1.90	6.58	1.84	1.98
22.00	-	0.00	1.08	-	0.00	1.16	-	0.00	1.34	-	0.00	1.41	-	0.00	1.49	-	0.00	1.66	-	0.00	1.66	4.49	1.26	1.73
22.17	-	0.00	0.85	-	0.00	0.93	-	0.00	1.10	-	0.00	1.17	-	0.00	1.25	-	0.00	1.41	-	0.00	1.41	-	0.00	1.48
22.33	-	0.00	0.72	-	0.00	0.80	-	0.00	0.97	-	0.00	1.03	-	0.00	1.10	-	0.00	1.26	-	0.00	1.26	-	0.00	1.33
22.50	-	0.00	0.49	-	0.00	0.56	-	0.00	0.73	-	0.00	0.79	-	0.00	0.86	-	0.00	1.01	-	0.00	1.01	-	0.00	1.08
22.67	-	0.00	0.26	-	0.00	0.33	-	0.00	0.48	-	0.00	0.55	-	0.00	0.61	-	0.00	0.76	-	0.00	0.76	-	0.00	0.82
22.83	-	0.00	0.02	-	0.00	0.09	-	0.00	0.24	-	0.00	0.30	-	0.00	0.36	-	0.00	0.50	-	0.00	0.50	-	0.00	0.56
23.00	-	0.00	-0.11	-	0.00	-0.05	-	0.00	0.09	-	0.00	0.15	-	0.00	0.21	-	0.00	0.34	-	0.00	0.34	-	0.00	0.40
23.17	-	0.00	-0.35	-	0.00	-0.29	-	0.00	-0.15	-	0.00	-0.10	-	0.00	-0.04	-	0.00	0.08	-	0.00	0.08	-	0.00	0.14
23.33	-	0.00	-0.49	-	0.00	-0.43	-	0.00	-0.30	-	0.00	-0.25	-	0.00	-0.20	-	0.00	-0.08	-	0.00	-0.08	-	0.00	-0.03
23.50	-	0.00	-0.72	-	0.00	-0.67	-	0.00	-0.55	-	0.00	-0.50	-	0.00	-0.46	-	0.00	-0.34	-	0.00	-0.34	-	0.00	-0.29
23.67	-	0.00	-0.86	-	0.00	-0.81	-	0.00	-0.70	-	0.00	-0.66	-	0.00	-0.61	-	0.00	-0.51	-	0.00	-0.51	-	0.00	-0.46
23.83	-	0.00	-1.11	-	0.00	-1.06	-	0.00	-0.96	-	0.00	-0.92	-	0.00	-0.87	-	0.00	-0.78	-	0.00	-0.78	-	0.00	-0.74
24.00	-	0.00	-1.25	-	0.00	-1.21	-	0.00	-1.11	-	0.00	-1.07	-	0.00	-1.04	-	0.00	-0.95	-	0.00	-0.95	-	0.00	-0.91
24.17	-	0.00	-1.39	-	0.00	-1.35	-	0.00	-1.27	-	0.00	-1.23	-	0.00	-1.20	-	0.00	-1.12	-	0.00	-1.12	-	0.00	-1.08
24.33	-	0.00	-1.63	-	0.00	-1.60	-	0.00	-1.52	-	0.00	-1.49	-	0.00	-1.46	-	0.00	-1.39	-	0.00	-1.39	-	0.00	-1.36
24.50	-	0.00	-1.78	-	0.00	-1.75	-	0.00	-1.68	-	0.00	-1.65	-	0.00	-1.63	-	0.00	-1.56	-	0.00	-1.56	-	0.00	-1.54
24.67	-	0.00	-1.92	-	0.00	-1.90	-	0.00	-1.84	-	0.00	-1.82	-	0.00	-1.79	-	0.00	-1.74	-	0.00	-1.74	-	0.00	-1.72
24.83	-	0.00	-1.97	-	0.00	-1.95	-	0.00	-1.90	-	0.00	-1.88	-	0.00	-1.86	-	0.00	-1.81	-	0.00	-1.81	-	0.00	-1.80
25.00	-	0.00	-2.12	-	0.00	-2.10	-	0.00	-2.06	-	0.00	-2.05	-	0.00	-2.03	-	0.00	-2.00	-	0.00	-2.00	-	0.00	-1.98
25.17	-	0.00	-2.17	-	0.00	-2.15	-	0.00	-2.12	-	0.00	-2.11	-	0.00	-2.10	-	0.00	-2.07	-	0.00	-2.07	-	0.00	-2.06
25.33	-	0.00	-2.21	-	0.00	-2.20	-	0.00	-2.18	-	0.00	-2.18	-	0.00	-2.17	-	0.00	-2.15	-	0.00	-2.15	-	0.00	-2.14
25.50	-	0.00	-2.26	-	0.00	-2.25	-	0.00	-2.24	-	0.00	-2.24	-	0.00	-2.24	-	0.00	-2.23	-	0.00	-2.23	-	0.00	-2.22
25.67	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20

High End

	10% High End			0.5% High End			0.1% High End		
Time	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)	q (l/m/s)	q (m^3/s)	Water Level (mAOD)
13.67	-	0.00	-2.10	-	0.00	-2.10	-	0.00	-2.10
13.83	-	0.00	-1.92	-	0.00	-1.90	-	0.00	-1.90
14.00	-	0.00	-1.74	-	0.00	-1.70	-	0.00	-1.69
14.17	-	0.00	-1.55	-	0.00	-1.50	-	0.00	-1.49
14.33	-	0.00	-1.37	-	0.00	-1.30	-	0.00	-1.29
14.50	-	0.00	-1.19	-	0.00	-1.11	-	0.00	-1.09
14.67	-	0.00	-1.01	-	0.00	-0.91	-	0.00	-0.89
14.83	-	0.00	-0.83	-	0.00	-0.71	-	0.00	-0.69
15.00	-	0.00	-0.65	-	0.00	-0.52	-	0.00	-0.49
15.17	-	0.00	-0.38	-	0.00	-0.23	-	0.00	-0.19
15.33	-	0.00	-0.20	-	0.00	-0.04	-	0.00	0.00
15.50	-	0.00	-0.03	-	0.00	0.15	-	0.00	0.19
15.67	-	0.00	0.25	-	0.00	0.44	-	0.00	0.49
15.83	-	0.00	0.42	-	0.00	0.63	-	0.00	0.67
16.00	-	0.00	0.68	-	0.00	0.91	-	0.00	0.96
16.17	-	0.00	0.95	-	0.00	1.19	-	0.00	1.24
16.33	-	0.00	1.12	-	0.00	1.37	-	0.00	1.42
16.50	-	0.00	1.38	-	0.00	1.64	-	0.00	1.70
16.67	-	0.00	1.54	-	0.00	1.81	-	0.00	1.88
16.83	4.81	1.35	1.79	12.81	3.59	2.08	-	0.00	2.15
17.00	7.16	2.01	2.05	18.44	5.16	2.35	38.12	10.67	2.42
17.17	9.07	2.54	2.20	23.00	6.44	2.51	45.88	12.85	2.58
17.33	13.36	3.74	2.45	32.65	9.14	2.77	61.61	17.25	2.84
17.50	16.71	4.68	2.59	40.07	11.22	2.92	73.48	20.57	3.00
17.67	20.72	5.80	2.74	48.50	13.58	3.08	86.65	24.26	3.15
17.83	25.37	7.10	2.88	58.22	16.30	3.22	101.50	28.42	3.30
18.00	30.78	8.62	3.01	69.38	19.43	3.37	118.10	33.07	3.45
18.17	36.99	10.36	3.15	82.28	23.04	3.51	136.40	38.19	3.59
18.33	44.15	12.36	3.28	97.21	27.22	3.64	156.60	43.85	3.73
18.50	52.48	14.69	3.40	114.20	31.98	3.78	179.10	50.15	3.86
18.67	62.26	17.43	3.53	132.90	37.21	3.90	203.60	57.01	3.99
18.83	73.20	20.50	3.65	153.50	42.98	4.03	230.10	64.43	4.11
19.00	74.79	20.94	3.66	156.80	43.90	4.05	234.60	65.69	4.13
19.17	76.11	21.31	3.67	159.50	44.66	4.06	238.30	66.72	4.15
19.33	87.43	24.48	3.78	179.50	50.26	4.17	263.60	73.81	4.26
19.50	88.02	24.65	3.78	180.90	50.65	4.17	265.30	74.28	4.26
19.67	88.25	24.71	3.79	181.30	50.76	4.18	265.80	74.42	4.27
19.83	88.02	24.65	3.78	180.90	50.65	4.17	265.30	74.28	4.26
20.00	77.04	21.57	3.68	161.50	45.22	4.07	240.80	67.42	4.16
20.17	76.11	21.31	3.67	159.50	44.66	4.06	238.30	66.72	4.15
20.33	65.31	18.29	3.56	139.80	39.14	3.95	212.80	59.58	4.03
20.50	55.69	15.59	3.45	121.50	34.02	3.83	189.00	52.92	3.91
20.67	47.26	13.23	3.33	104.60	29.29	3.70	166.80	46.70	3.79
20.83	39.93	11.18	3.20	89.42	25.04	3.58	146.40	40.99	3.66
21.00	29.23	8.18	2.98	67.39	18.87	3.34	115.60	32.37	3.43
21.17	24.30	6.80	2.85	57.09	15.99	3.21	100.30	28.08	3.29
21.33	17.20	4.82	2.61	42.34	11.86	2.97	77.51	21.70	3.05
21.50	13.95	3.91	2.48	35.13	9.84	2.82	65.98	18.47	2.90
21.67	9.62	2.69	2.24	25.12	7.03	2.58	49.76	13.93	2.65
21.83	6.58	1.84	1.99	17.87	5.00	2.32	37.44	10.48	2.40
22.00	4.49	1.26	1.75	12.56	3.52	2.07	-	0.00	2.14
22.17	-	0.00	1.50	-	0.00	1.81	-	0.00	1.88
22.33	-	0.00	1.35	-	0.00	1.65	-	0.00	1.72
22.50	-	0.00	1.09	-	0.00	1.38	-	0.00	1.45
22.67	-	0.00	0.84	-	0.00	1.11	-	0.00	1.18
22.83	-	0.00	0.58	-	0.00	0.84	-	0.00	0.90
23.00	-	0.00	0.42	-	0.00	0.67	-	0.00	0.72
23.17	-	0.00	0.15	-	0.00	0.39	-	0.00	0.44
23.33	-	0.00	-0.02	-	0.00	0.21	-	0.00	0.26
23.50	-	0.00	-0.28	-	0.00	-0.07	-	0.00	-0.03
23.67	-	0.00	-0.45	-	0.00	-0.26	-	0.00	-0.21
23.83	-	0.00	-0.73	-	0.00	-0.55	-	0.00	-0.51
24.00	-	0.00	-0.90	-	0.00	-0.74	-	0.00	-0.70
24.17	-	0.00	-1.08	-	0.00	-0.93	-	0.00	-0.89
24.33	-	0.00	-1.35	-	0.00	-1.22	-	0.00	-1.19
24.50	-	0.00	-1.53	-	0.00	-1.41	-	0.00	-1.39
24.67	-	0.00	-1.71	-	0.00	-1.61	-	0.00	-1.59
24.83	-	0.00	-1.79	-	0.00	-1.71	-	0.00	-1.69
25.00	-	0.00	-1.98	-	0.00	-1.91	-	0.00	-1.89
25.17	-	0.00	-2.06	-	0.00	-2.01	-	0.00	-2.00
25.33	-	0.00	-2.14	-	0.00	-2.11	-	0.00	-2.10
25.50	-	0.00	-2.22	-	0.00	-2.21	-	0.00	-2.20
25.67	-	0.00	-2.20	-	0.00	-2.20	-	0.00	-2.20

Appendix D Shannon CFRAMS Design Tidal Hydrographs

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Shannon CFRAMS Design Tidal Hydrographs – Technical Note

1 Background and Aims

Following the definition of the model extents in the Shannon RBD (as part of the Shannon CFRAMs Study) several hydraulic models have been identified for which downstream tidal boundary conditions will have to be defined to pilot the downstream levels during the required design event simulations. This note details the approach taken to define the downstream boundary conditions at the model extents (see Figure 1) along the Shannon Estuary using the ICPSS (Irish Coastal Protection Strategy Study) extreme water levels associated with combined tide and surge information provided by the OPW.

2 Data Used

The following available datasets were used to produce the design tidal surge hydrographs as boundary conditions for the models shown on Figure 1. (All the information associated with these files is contained in the annexes of this technical note):

- Predicted Extreme Water Levels (Tide and Surge) [13] for the following design events: 50%AEP, 20%AEP, 10%AEP, 5%AEP, 2%AEP, 1%AEP, 0.5%AEP and 0.1%AEP
- Foynes, Carrigaholt and Limerick Tidal gauge level data (2003-2007) [14]
- Admiralty Tide Tables information for port locations along the Shannon Estuary[15]
- OSi Conversion Graphs (Poolbeg-Malin head) including levelling information for port locations
- Shannon CFRAMS Model Extents for the downstream tidal models

[13]OPW - RPS Irish Coastal Protection Strategy Study Phase IV South West Coast
[14] Shannon – Foynes Port Company
[15] Admiralty Tide Tables, United Kingdom and Ireland, Vol 1 NP 201-06, (2006)

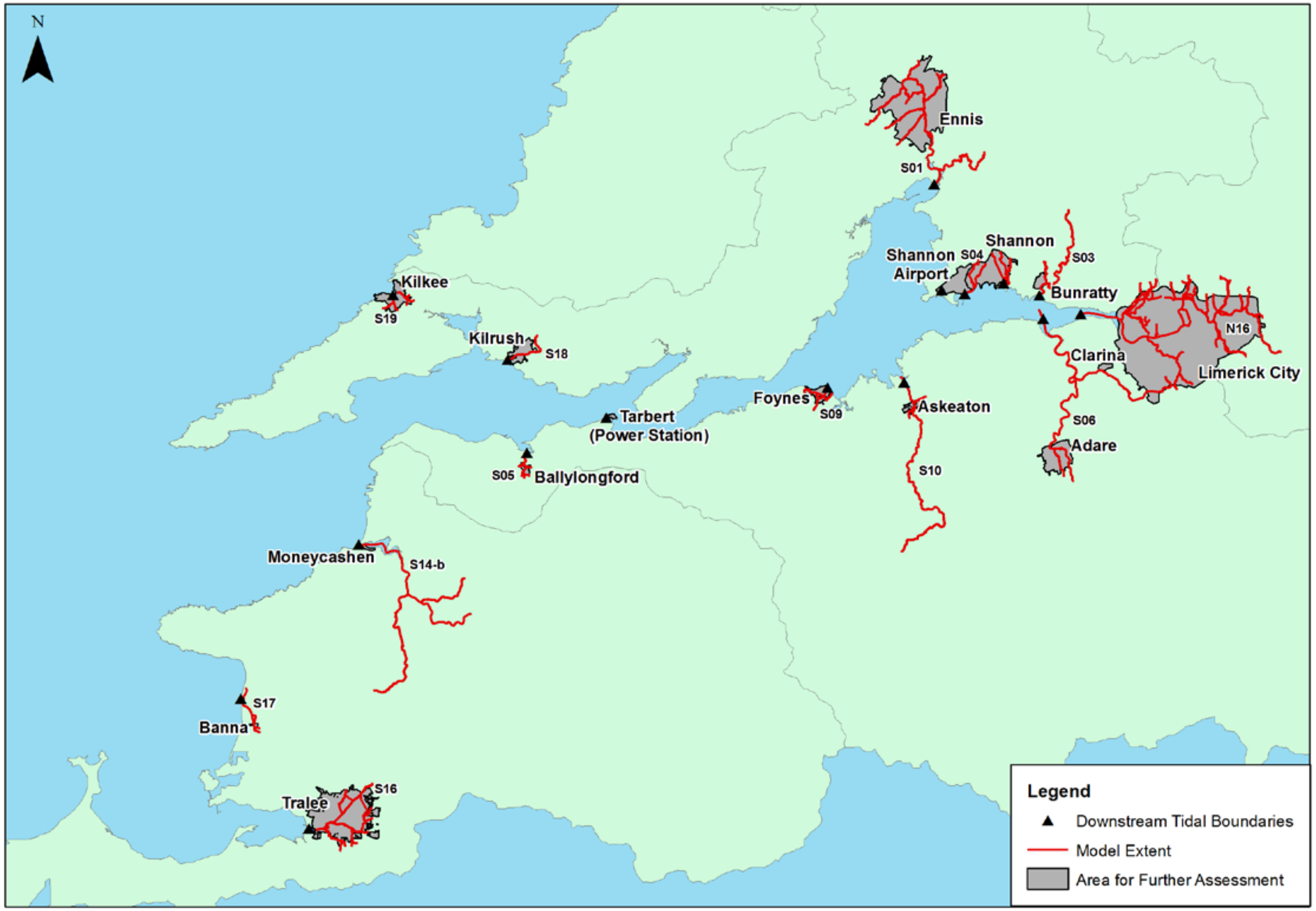


Figure 1: Shannon CFRAM models where tidal boundary conditions are required

3 Methodology

The following section details the different stages followed to develop the downstream tidal hydrographs assigned to each model.

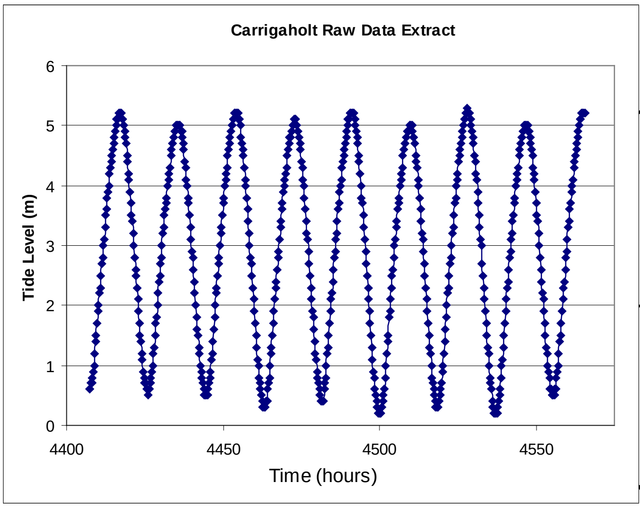
Stage 1

Following a data collection exercise tidal records at port locations: Carrigaholt, Limerick and Foynes (see Figure 2 below) were collated (Please refer to appendix A). These were used to extract tidal profiles which have been subsequently used and scaled to generate mean Spring tide profile ranging from Mean High Water Spring (MHWS) to Mean Low Water Spring (MLWS) levels at the nine port locations (see Figure 3) listed in the Admiralty Tide Tables as standard and secondary ports and located within the Shannon Estuary and Tralee Bay. These locations are Tarbert Island (Standard port), Carrigaholt, Kilrush, Foynes Island, Mellon Point, Limerick Dock, Coney Island and Fenit Pier (Tralee Bay). Details of the calculations carried out to determine MHWS and MLWS levels are provided in Annex B of Appendix D.

Figure 2: Shannon Estuary

Figure 3: Port locations as listed in the Admiralty Tide Tables

Figure 4 below is an example of how the raw data collected from the tidal gauges at Carrigaholt, Limerick and Foynes have been scaled to produce tidal data for the ports outlined above with the exception of Tarbert Island. The scaling factors that have been used for each port are detailed in Annex B of Appendix D. The raw data was extracted to define the shape of the hydrograph and scaled based on the MHWS/MLWS levels at each port location. For the case of Tarbert Island, as it is a standard port, a typical Spring tide curve is available in the Admiralty Tide Tables and was therefore used.



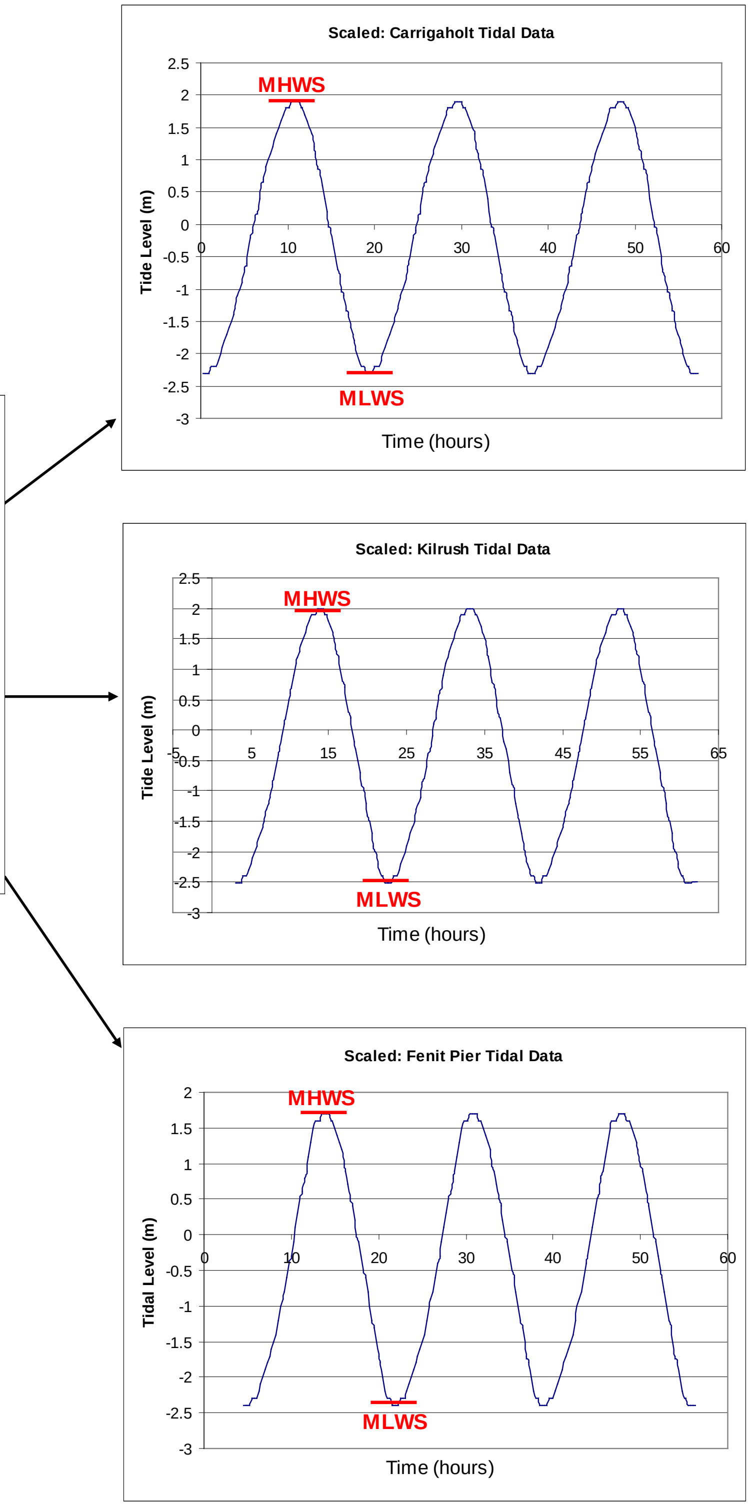


Figure 4: Example of Scaling of Raw Data

Stage 2

One of the outputs of the Irish Coastal Protection Strategy Study (ICPSS) was a series of prediction points for which extreme water levels combining tide and surge have been estimated. Each of the prediction points[16], as shown on Figure 5, has been allocated one of the mean spring profiles described above. This allocation was based on the nearest port location and tidal hydrodynamics within the Shannon Estuary.

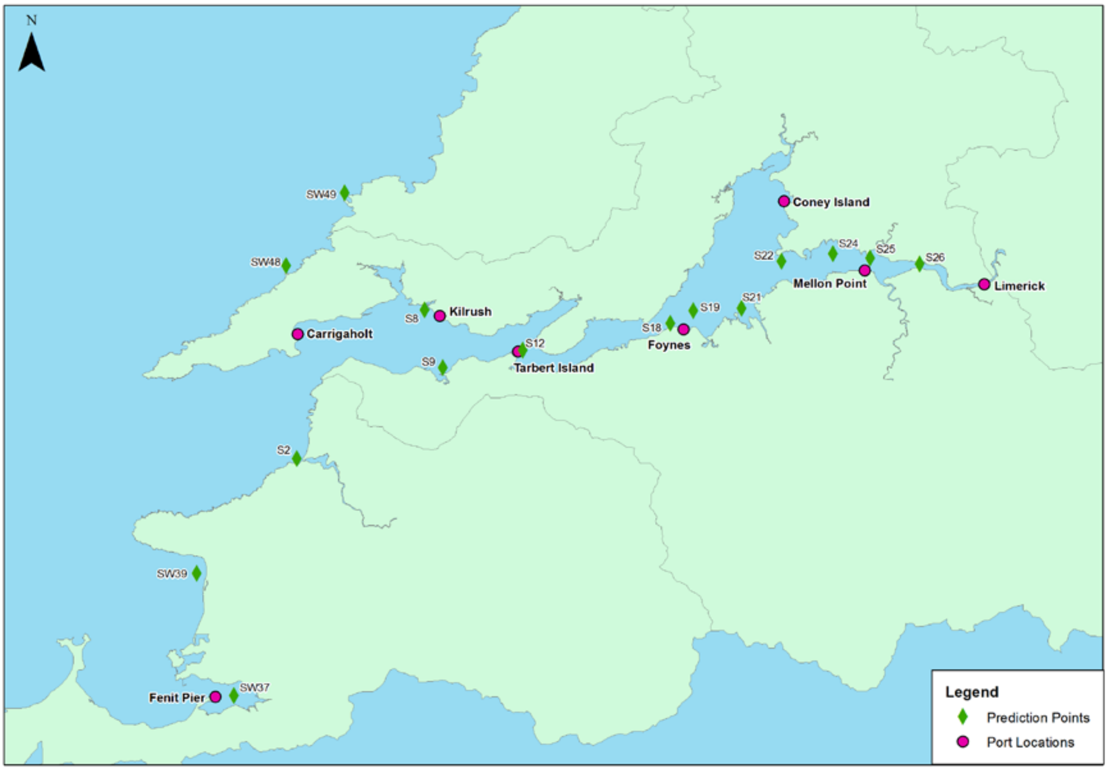


Figure 5: Prediction Point Locations

Table 1 below describes the allocation of the prediction points to each of the associated ports.

Table 1: Allocated of Prediction Points to Ports

Port	ICPSS (Prediction Point Reference)
Mellon Point	S25
	S24
Coney Island	S22
Kilrush	S9
	S8

Table 1: Allocated of Prediction Points to Ports

Port	ICPSS (Prediction Point Reference)
Limerick	S26
Foynes	S18
	S19
	S21
Carrigaholt	S2
	SW48-SW49
Fenit Pier	SW37
	SW39
Tarbert	S12

[16] Prediction point references used in Figure 5 and Table 1 are the ICPSS Prediction point references

Stage 3

Using the spring profiles and the available ICPSS extreme water levels for a range of annual probabilities, a series of design tidal hydrographs have been produced at each prediction point. The tidal hydrographs represent the effect of 30hr meteorological surges of increasing intensity on the mean Spring profile associated with each ICPSS prediction point. The 30hr surge duration means that 3 tide cycles are affected. The surge effect is centred such that middle high tide level matches with the extreme water levels taken from the ICPSS data.

This process is illustrated on Figure 6 below

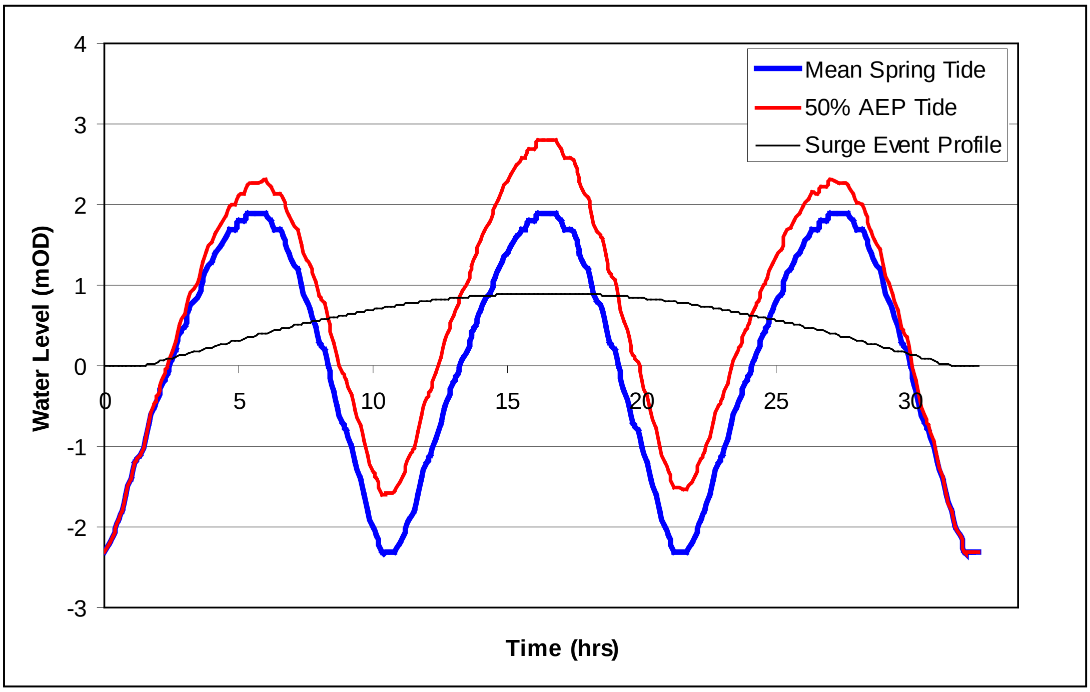


Figure 6: Example showing how an extreme event tide hydrograph has been produced

Stage 4

In the final step, the different model downstream boundaries were assigned to the closest prediction points and their associated design tidal hydrographs. For most of the models direct allocation was deemed appropriate except for the model S19 (AFA Kilkee) and S09 (AFA Foynes) where linear interpolation between two prediction points was carried out. An example of this is shown in Figure 7 below.

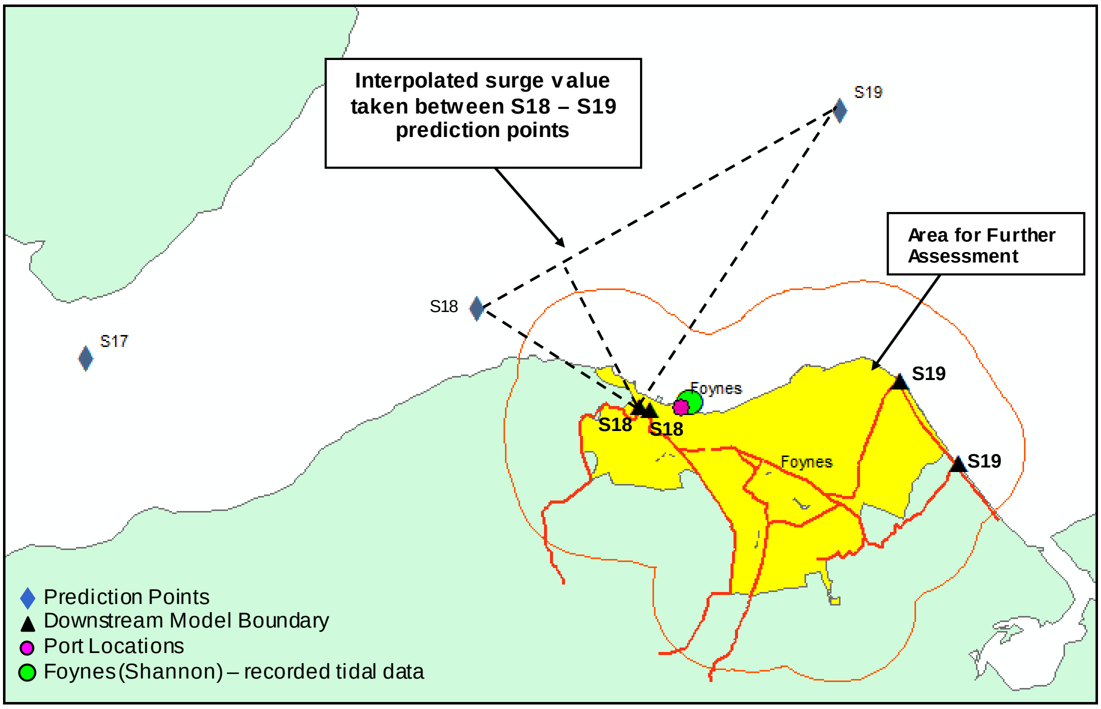


Figure 7: Model downstream boundary assignment for Foynes AFA (model S09)

Table 2 below lists the prediction points assigned to each model downstream boundary

Table 2: Allocation of Prediction Points to Model Downstream Boundaries	
ICPSS (Prediction Point Reference)	**AFAs – Model No**
S25	Adare / Clarina - Model S06
	Bunratty – Model S03
S24	Shannon Airport – IRR3
	Shannon - Model S04
S22	Ennis Model S01[17]

Table 2: Allocation of Prediction Points to Model Downstream Boundaries	
ICPSS (Prediction Point Reference)	**AFAs – Model No**
S9	Ballylongford – S05
S8	Kilrush – S18
S26	Limerick – Model N16
S18 - S19	Foynes - Model S09
S21	Askeaton – Model S10
S2	Moneycashen – Model S14b
SW48-SW49	Kilkee – Model S19
SW37	Tralee – Model S16
SW39	Banna – Model S17
S12	Tarbert – IRR4

Figure 8 shows the predictions points, the model extents and the area affected by the tidal conditions

[17] For the S01 model, the obtained design tidal boundary will be reviewed against the one used in the Ennis Main Drainage and Flood Study, Ennis urban District Council, 2001

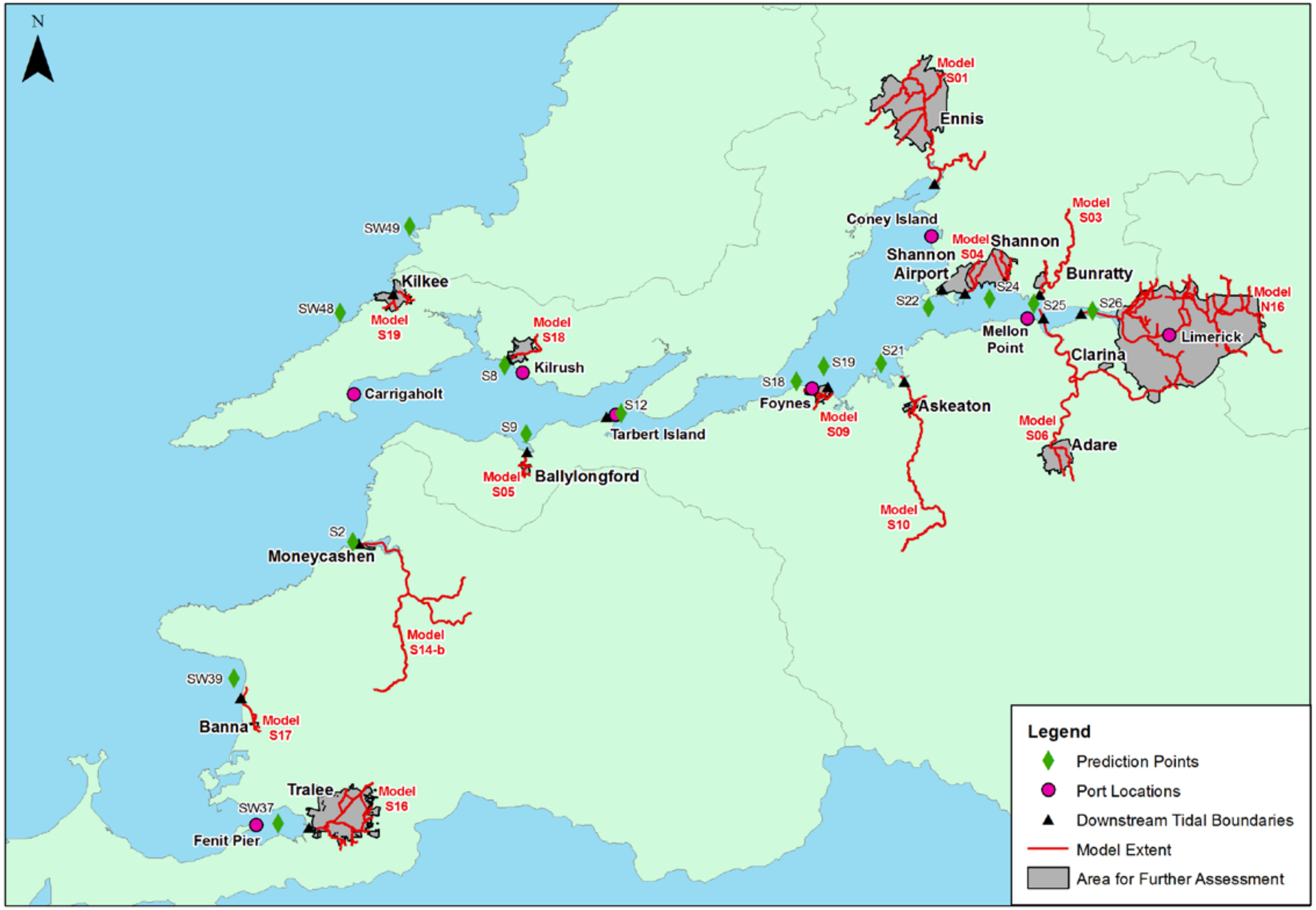


Figure 8 – Prediction point, model extents and AFAs

4 Conclusion

A summary of the methodology described in detail above is shown as a flow chart on Figure 9 below. For each model, a summary table of the assigned prediction point along with the data used to derive the downstream boundary tide profiles is also available in Annex C.

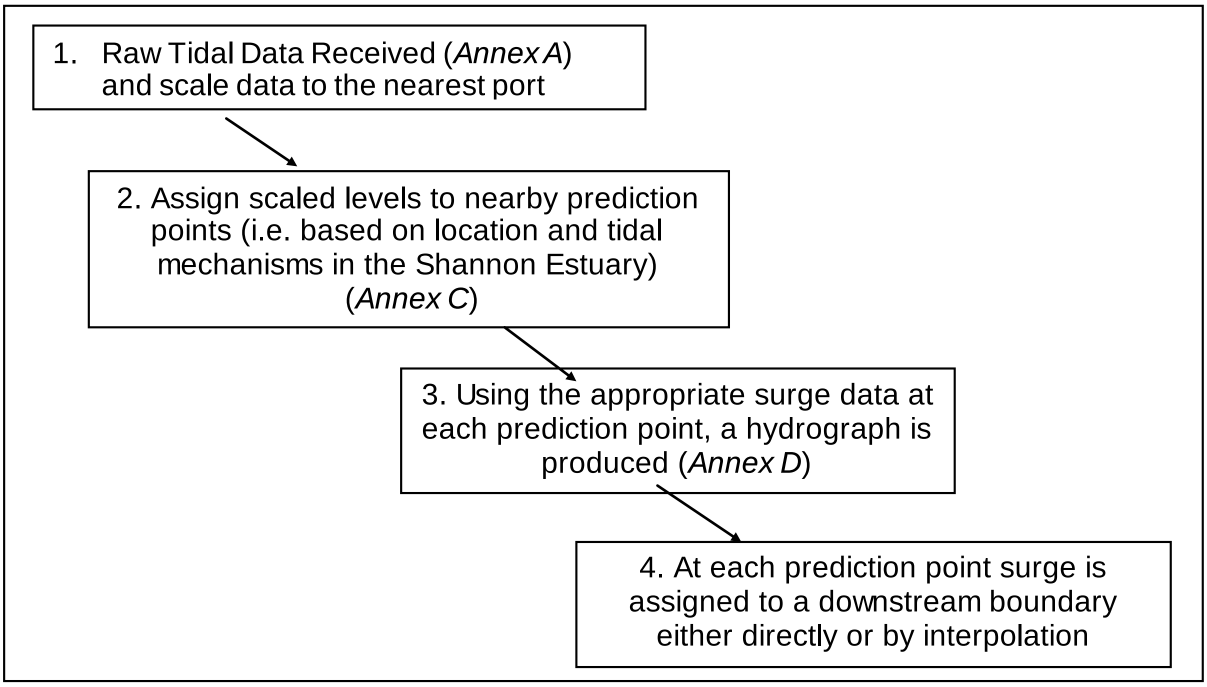
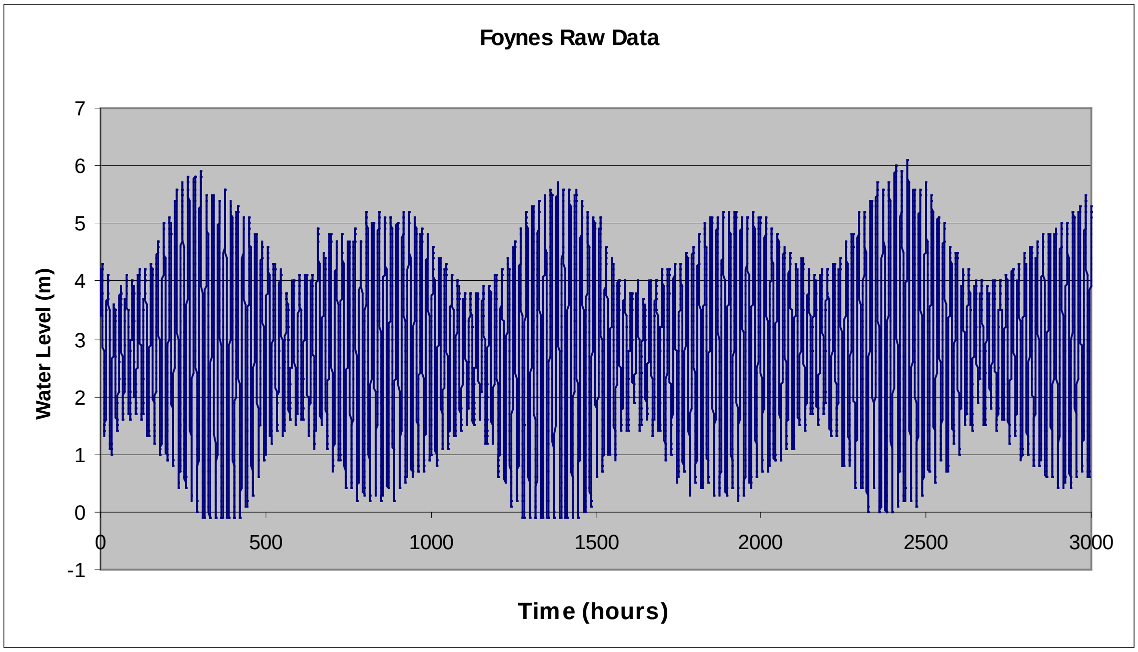
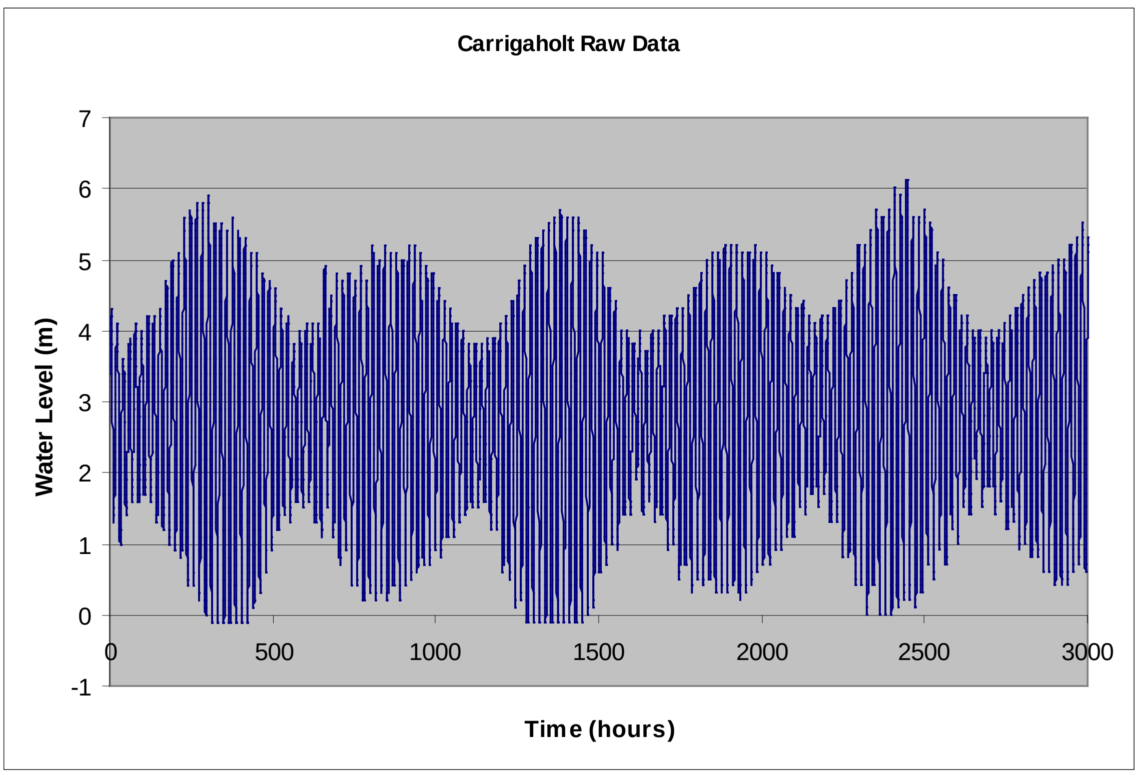
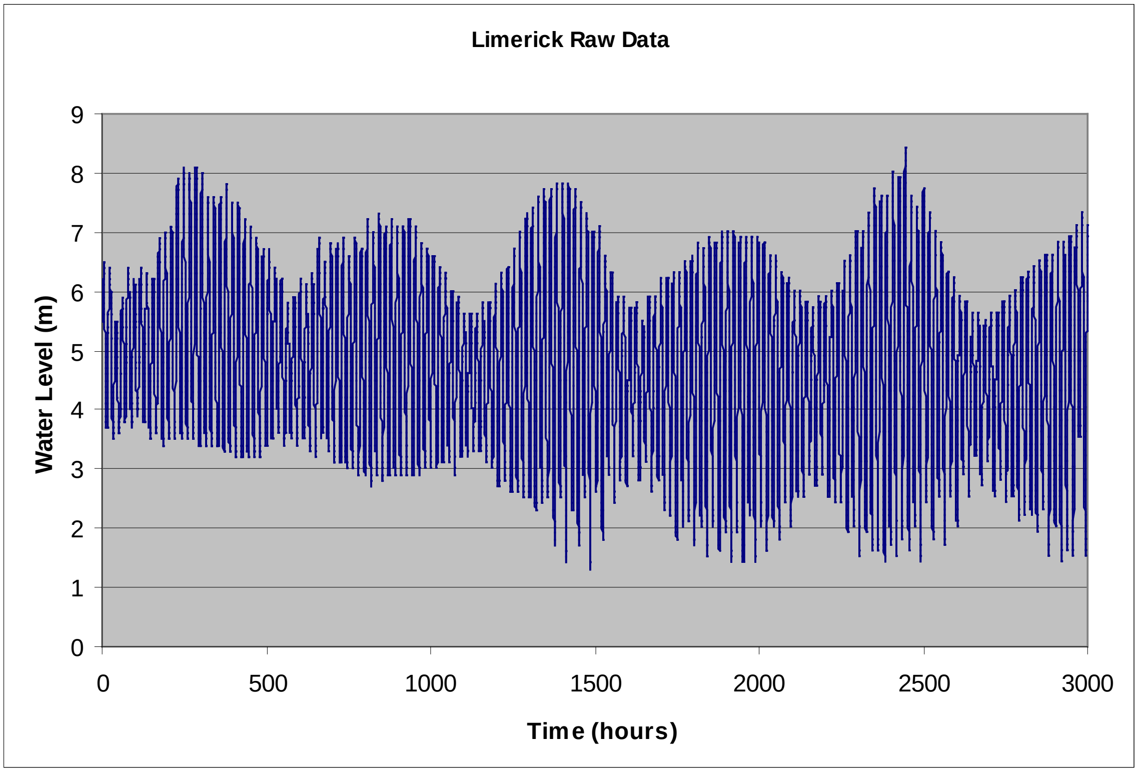


Figure 9: Flow Diagram of the Methodology

Annex A – Raw Tidal Data Extract







Limerick Raw Data
Water Level (m)
0
1
2
3
4
5
6
7
8
9
0
500
1000
1500
2000
2500
3000
Time (hours)

JACOBS

OPW
The Office of Public Works
Oifig na nOibreacha Poiblí

Annex B – MHWS/MHWL (Port Scaling Table)

		Height difference in meters					Water level in meters (Chart Datum Local)					Water level in meters (Malin Head)				
Tidal record used to derive tidal hydrograph		**MHWS**	**MHWN**	**MLWN**	**MLWS**	**ML (m)**	**MHWS**	**MHWN**	**MLWN**	**MLWS**	**ML (m)**	**MHWS**	**MHWN**	**MLWN**	**MLWS**	**ML (m)**
(Foynes)	**Tarbert Island (Standard Port)**	5.00	3.80	1.70	0.50	2.77	5.00	3.80	1.70	0.50	2.77	1.995	0.795	-1.305	-2.505	-0.235
(Carrigaholt)	Carrigaholt	-0.10	-0.10	0.20	0.20		4.90	3.70	1.90	0.70	2.73	1.895	0.695	-1.105	-2.305	-0.275
(Carrigaholt)	Kilrush	0.00	-0.10	0.00	0.00		5.00	3.70	1.70	0.50	2.64	1.995	0.695	-1.305	-2.505	-0.365
(Foynes)	Foynes Island	0.20	0.20	0.10	-0.20		5.20	4.00	1.80	0.30		2.195	0.995	-1.205	-2.705	
(Foynes)	Mellon Point	0.90	0.70	0.20	-0.10		5.90	4.50	1.90	0.40		2.895	1.495	-1.105	-2.605	
(Limerick)	Limerick Dock	1.10	0.80	-0.50	-0.10		6.10	4.60	1.20	0.40		2.977	1.477	-1.923	-2.723	
(Foynes)	River Fergus (Coney Island)	0.20	0.10				5.20	3.90				2.195	0.895			

	Height difference in meters					Water level in meters					Water level in meters (Malin Head)				
	MHWS	**MHWN**	**MLWN**	**MLWS**	**ML (m)**	**MHWS**	**MHWN**	**MLWN**	**MLWS**	**ML (m)**	**MHWS**	**MH WN**	**MLWN**	**MLWS**	**ML (m)**
COBH (Standard Port)	4.10	3.20	1.30	0.40	2.25	4.10	3.20	1.30	0.40	2.25					
Fenit Pier - Tralee Bay	0.50	0.20	0.30	0.10		4.60	3.40	1.60	0.50	2.53	1.70	0.50	-1.30	-2.40	-0.38
Difference	4.6	3.4	1.6	0.5	2.525						-2.90				

	Land Leveling (Height in Meters)
Tarbert Island	-0.30
Carrigaholt	-0.30
Kilrush	-0.30
Foyes Island	-0.30
Limerick Dock	-0.46
Fenit Pier	-0.21

Poolbeg (Datum) - Malin Head Conversion
-2.663
-2.693

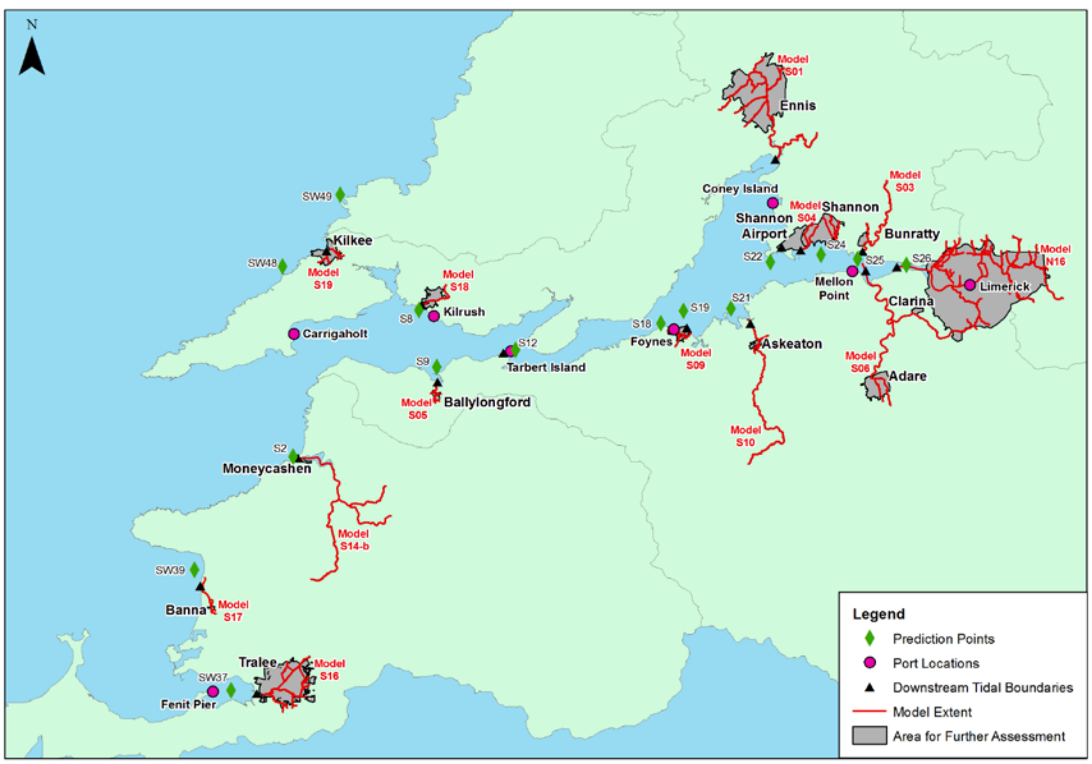
Poolbeg (Datum) - Malin Head Conversion	
-2.705	(Futher refinement Based on OSI data/sheets)

Note: The above table denotes the ports allocated the scaled recorded tidal data to produce the MHWS (Mean High Water Spring) and MLWS (Mean Low water Spring). The spring tides are highlighted in yellow as these are key in determining flood risk.

The tables below the MHWS and MLWS denotes the Land Levelling used.

Annex C – Prediction Point Assignment

AFA Applicable to	ICPSS (Prediction Point Reference)	Method	Port	Tidal_Data
Adare / Clarina	S25	Direct Assignment	Mellon Point	Foynes
Bunratty	S25	Direct Assignment	Mellon Point	Foynes
Shannon Airport	S24	Direct Assignment	Mellon Point	Foynes
Shannon	S24	Direct Assignment	Mellon Point	Foynes
Ennis	S22	Direct Assignment	Coney Island	Foynes
Ballylongford	S9	Direct Assignment	Kilrush	Carrigaholt
Kilrush	S8	Direct Assignment	Kilrush	Carrigaholt
Limerick	S26	Direct Assignment	Limerick	Limerick
Foynes	S18-S19	Interpolated	Foynes	Foynes
Foynes	S19	Direct Assignment	Foynes	Foynes
Askeaton	S21	Direct Assignment	Foynes	Foynes
Moneycashen	S2	Direct Assignment	Carrigaholt	Carrigaholt
Kilkee	SW48-49	Interpolated	Carrigaholt	Carrigaholt
Tralee	SW37	Direct Assignment	Fenit Pier	Carrigaholt
Banna	SW39	Direct Assignment	Fenit Pier	Carrigaholt
Tarbert	S12	Direct Assignment	Tarbert	Foynes



Annex D – ICPSS Predicted Extreme Water Levels Associated with Combined Tide and Surge

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RPS

ICPSS PHASE IV - SOUTH WEST COAST

OPW

Predicted Extreme Water Levels Associated with Combined Tide and Surge

PREDICTION POINT ID	ANNUAL EXCEEDENCE PROBABILITY (AEP) 50%	20%	10%	5%	2%	1%	0.5%	0.1%	COORDINATES OF PREDICTION POINTS EASTINGS	NORTHINGS
SW27	2.32	2.42	2.49	2.56	2.65	2.71	2.78	2.93	30635	104299
SW28	2.38	2.48	2.56	2.63	2.73	2.80	2.87	3.04	36361	109676
SW29	2.42	2.53	2.61	2.68	2.78	2.85	2.92	3.09	41593	112847
SW30	2.47	2.58	2.66	2.74	2.84	2.91	2.98	3.15	48882	116516
SW31	2.52	2.63	2.70	2.77	2.86	2.93	3.00	3.16	54279	114238
SW32	2.53	2.64	2.71	2.78	2.87	2.94	3.00	3.16	59207	115106
SW33	2.56	2.67	2.75	2.82	2.92	3.00	3.08	3.25	60950	120616
SW34	2.68	2.79	2.86	2.93	3.01	3.08	3.15	3.30	64289	115512
SW35	2.69	2.79	2.86	2.94	3.03	3.10	3.17	3.33	68777	112162
SW36	2.72	2.83	2.91	2.98	3.08	3.15	3.22	3.39	73381	113155
SW37	2.83	2.94	3.02	3.10	3.21	3.29	3.36	3.55	78171	113613
SW38	2.63	2.74	2.81	2.89	2.98	3.05	3.12	3.29	72867	119737
SW39	2.63	2.74	2.82	2.90	3.00	3.08	3.16	3.33	74265	126382
SW40	2.59	2.71	2.79	2.86	2.97	3.04	3.12	3.29	67371	131016
SW41	2.63	2.74	2.82	2.90	3.00	3.07	3.15	3.32	74926	133602
SW42	2.67	2.79	2.87	2.96	3.07	3.15	3.23	3.42	84187	139720
SW43	2.64	2.77	2.86	2.95	3.07	3.16	3.25	3.45	86181	149471
SW44	2.62	2.75	2.83	2.92	3.03	3.12	3.20	3.40	74602	147527
SW45	2.57	2.69	2.78	2.86	2.97	3.06	3.14	3.33	67807	147150
SW46	2.59	2.71	2.79	2.88	2.98	3.07	3.15	3.33	73800	151815
SW47	2.60	2.72	2.80	2.88	2.99	3.07	3.15	3.34	78108	154787
SW48	2.61	2.73	2.82	2.90	3.01	3.10	3.18	3.37	83599	158464
SW49	2.62	2.74	2.83	2.92	3.03	3.12	3.20	3.40	89719	166059
SW50	2.64	2.77	2.86	2.95	3.06	3.15	3.24	3.44	97955	167774
SW51	2.65	2.78	2.87	2.96	3.08	3.17	3.26	3.46	98414	173525
SW52	2.66	2.79	2.88	2.97	3.08	3.17	3.26	3.46	101090	178980
SW53	2.70	2.83	2.93	3.02	3.15	3.24	3.33	3.55	107926	187640
SW54	2.69	2.82	2.92	3.01	3.13	3.22	3.31	3.52	100223	189240
SW55	2.72	2.85	2.95	3.04	3.16	3.24	3.33	3.54	104725	195829
SW56	2.82	2.97	3.07	3.17	3.30	3.39	3.49	3.72	112752	208923

Notes

All water levels shown are in metres and referenced to Ordnance Datum Malin
Prediction Point Coordinates are referenced to Irish Grid TM65

ICPSS PHASE IV - SOUTH WEST COAST

Predicted Extreme Water Levels Associated with Combined Tide and Surge

PREDICTION POINT ID	ANNUAL EXCEEDENCE PROBABILITY (AEP) 50%	20%	10%	5%	2%	1%	0.5%	0.1%	COORDINATES OF PREDICTION POINTS EASTINGS	NORTHINGS
S1	2.64	2.76	2.85	2.94	3.06	3.15	3.23	3.43	82688	148391
S2	2.71	2.82	2.91	2.99	3.10	3.18	3.26	3.44	84845	138260
S3	2.73	2.85	2.93	3.02	3.13	3.22	3.30	3.49	85474	144422
S4	2.71	2.83	2.92	3.01	3.12	3.21	3.30	3.50	86013	151950
S5	2.72	2.84	2.92	3.01	3.12	3.20	3.29	3.48	88695	148419
S6	2.74	2.86	2.95	3.03	3.15	3.24	3.32	3.52	91646	152584
S7	2.77	2.89	2.98	3.07	3.18	3.27	3.35	3.55	95785	147777
S8	2.76	2.89	2.98	3.07	3.19	3.28	3.37	3.58	98052	153862
S9	2.79	2.91	3.00	3.09	3.20	3.29	3.37	3.57	99936	147831
S10	2.75	2.87	2.96	3.05	3.17	3.26	3.35	3.55	103931	150900
S11	2.77	2.89	2.99	3.08	3.20	3.29	3.38	3.59	106638	150798
S12	2.72	2.84	2.93	3.02	3.13	3.21	3.29	3.48	108294	149661
S13	2.70	2.83	2.92	3.01	3.12	3.21	3.30	3.50	109699	148606
S14	2.72	2.85	2.94	3.03	3.15	3.24	3.33	3.53	112483	148567
S15	2.72	2.86	2.96	3.06	3.20	3.30	3.40	3.63	115609	151987
S16	2.75	2.89	3.00	3.10	3.24	3.34	3.45	3.69	118265	150532
S17	2.78	2.93	3.04	3.16	3.30	3.42	3.53	3.79	121126	152131
S18	2.83	2.99	3.11	3.22	3.38	3.50	3.62	3.89	123686	152457
S19	2.89	3.04	3.17	3.29	3.45	3.57	3.69	3.97	126062	153757
S20	2.93	3.09	3.22	3.34	3.51	3.63	3.76	4.05	127363	157071
S21	3.03	3.20	3.32	3.45	3.61	3.74	3.86	4.15	131090	154017
S22	3.12	3.31	3.44	3.58	3.75	3.89	4.02	4.33	135251	158930
S23	3.18	3.37	3.52	3.66	3.86	4.00	4.15	4.48	138731	157900
S24	3.22	3.42	3.57	3.72	3.92	4.07	4.21	4.56	140612	159730
S25	3.29	3.50	3.66	3.81	4.02	4.17	4.33	4.68	144515	159263
S26	3.40	3.64	3.82	4.00	4.24	4.41	4.59	5.00	149662	158626

Notes

All water levels shown are in metres and referenced to Ordnance Datum Malin
Prediction Point Coordinates are referenced to Irish Grid TM65

Annex E – Ordnance Survey Conversion Tables (Poolbeg-Malin Head)

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POOLBEG:MALIN HEAD DIFFS COUNTRYWIDE

AREA	DIFF (MEAN)	AREA	DIFF (MEAN)
ARTHURSTOWN (WEX)	2.578 mts	DUNDALK	2.640 mts
ATHLONE	2.766 mts	DUNGARVAN	2.697 mts
BALLINA	2.810 mts	DUN LAOGHAIRE	2.722 mts
BALLINACOLLIG	2.739 mts	DUNMORE EAST	2.610 mts
BALLINROBE	2.773 mts	EDENDERRY	2.670 mts
BALLYBOFEY	2.747 mts	EDGEWORTHSTOWI	2.780 mts
BALLYBUNION	2.704 mts	ENNISCORTHY	2.645 mts
BALLYHAUNIS	2.759 mts	FERBANE	2.717 mts
BALLYSADARE (SLIGO)	2.792 mts	GALWAY	2.732 mts
BALLYSHANNON	2.744 mts	GEASHILL	2.784 mts
BANTRY	2.756 mts	GORMANSTOWN-ST	2.716 mts
BLANCHARDSTOWN	2.744 mts	GREENHILLS RD. (D	2.722 mts
BOYLE	2.797 mts	KILKENNY	2.674 mts
CAHIR	2.705 mts	KILLARNEY	2.686 mts
CARLOW	2.713 mts	KINSALE	2.704 mts
CARRICKMACROSS	2.647 mts	LETTERKENNY	2.719 mts
CARRICK-ON-SUIR	2.665 mts	LIMERICK	2.663 mts
CARRIGTOHILL	2.701 mts	LISTOWEL	2.737 mts
CASTLEBAR	2.840 mts	LONGFORD	2.760 mts
CASTLEBLANEY	2.744 mts	LUCAN-LEIXLIP	2.719 mts
CASTLEISLAND	2.689 mts	MACROOM	2.762 mts
CHARLEVILLE	2.669 mts	MALIN HEAD	2.598 mts
CLARA	2.698 mts	MANORHAMILTON	2.781 mts
CLAREMORRIS	2.764 mts	MAYNOOTH	2.746 mts
CLONAKILTY	2.719 mts	MOATE	2.782 mts
CLONEE	2.763 mts	MONASTEBOICE (L(	2.689 mts
CLONES	2.775 mts	MONASTERVIN	2.682 mts
CLONMEL	2.714 mts	MULLINGAR	2.777 mts
COBH	2.690 mts	NAAS	2.685 mts
CORK	2.701 mts	NAVAN	2.732 mts
DONEGAL TOWN	2.700 mts	NENAGH	2.644 mts
DROGHEDA	2.680 mts	NEWCASTLEWEST	2.699 mts

AREA	DIFF (MEAN)
NEW ROSS	2.573 mts
PORT LAOISE	2.703 mts
RATHKEALE	2.695 mts
SHANNON	2.705 mts
SLIGO	2.790 mts
SKERRIES	2.700 mts
SKIBBEREEN	2.737 mts
SWINFORD	2.839 mts
SWORDS	2.694 mts
TEMPLEMORE	2.726 mts
TRALEE	2.693 mts
TRAMORE	2.643 mts
TULLAMORE (CLARA ROAD)	2.701 mts
WATERFORD	2.702 mts
WESTPORT	2.818 mts
WEXFORD TOWN	2.662 mts

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Appendix E National Technical Co-ordination Group (NTCG) Guidance Note no. 23 (GN23)

Technical Note

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Date	**17th June 2013**
To	John Martin, Office of Public Works
From	Peter Smyth, Jacobs
Project	**Shannon CFRAM Study**
Subject	NTCG Guidance Note No.23 (GN23) - Hydraulic Model Calibration
Reference	32103000/TD_HYDO_0330_V2_0_JAC_GN23_Model_Calib_130617

1.0 Introduction

This Guidance Note (GN23) outlines Jacobs' proposed approach for calibrating the fluvial hydraulic models and the tidal inundation models, and the reasoning behind the approach to be adopted. Throughout the Guidance Note any references to "we" implies that it is Jacobs' approach on the Shannon CFRAM Study.

This note only covers calibration of the main hydraulic model deliverables. It excludes the calibration of the hydraulic models required for the Gauging Station Rating Reviews: which are to be calibrated using the recorded check gaugings (spot flows) as deemed reliable, up to the maximum gauged flows.

This Guidance Note has been produced for circulation amongst all CFRAM Study Consultants for information. The approaches outlined in this Guidance Note apply specifically to the Shannon CFRAM Study, although each CFRAM Study Consultant may adopt the approach where the methodology lends itself suitably to application elsewhere. However, it is emphasised that differences in approach, such as the possible application of rainfall-runoff modelling in other CFRAM Studies, will require additional consideration by other CFRAM Study consultants.

2.0 Summary of Stage I Tender Documents

Stage I Tender Documents: Project Brief states:

6. HYDROLOGICAL ANALYSIS

6.1. LEVEL OF DETAIL

The hydrological analysis of the whole Study Area should be comprehensive and taken to a high level of detail, such that no further hydrological analysis should be required after completion of the Project (other than to confirm findings of the Project, assess minor design variations or update the analysis after a number of years or the occurrence of an extreme event) for the OPW or other authorities to have justifiable confidence in the implementation of the strategy and specific measures identified through the Project to manage the flood risk within the APSRs. The hydrological analysis should place particular emphasis on flood flow estimation for the APSRs and HPWs in terms of, for example, statistical flood frequency estimation and the calibration of hydrological models.

6.5. ESTIMATION OF DESIGN FLOOD PARAMETERS

6.5.5. Hydrological Calibration and Validation

The Consultant shall calibrate and validate the estimates of the design flood parameters (other than extreme peak sea levels) to recorded data as far as reasonably possible, based on historic or recorded flood event data.

7. HYDRAULIC ANALYSIS

7.1. LEVEL OF DETAIL

The level of detail of the hydraulic analysis to be undertaken under this Project should be sufficient to enable the Consultant to fully meet the requirements and objectives of the flood mapping, flood risk assessment, development and appraisal of flood risk management actions and measures (and associated assessments) and the preparation of a Flood Risk Management Plan, as set out herein.

Within APSRs, the hydraulic analysis should be comprehensive and taken to a high level of detail, such that no further hydraulic analysis should be required after completion of the Project (other than to confirm findings of the Project, assess minor design variations or for validation and / or re-calibration after the occurrence of an extreme event) for the OPW or other authorities to have justifiable confidence in the implementation of the strategy and specific measures identified through the Project to manage the flood risk within the APSRs. The level of detail of the hydraulic analysis for MPWs does not need to be as high as that required for the APSRs, but nonetheless should be the best achievable within the constraints of the survey specification and available calibration data for MPWs to enable reasonable estimates of flood hazard and risk.

7.2. DEVELOPMENT OF FLUVIAL HYDRAULIC MODELS

7.2.1. Fluvial Model Development

The Consultant shall develop dynamic hydraulic models for the HPWs and MPWs and their associated floodplains, based on the definitions of HPWs and MPWs set out herein, and the APSRs associated with fluvial flood risk, as identified in the tender documentation of the Specific Tender Stage (Stage II), to analyse historic flood events and estimate design and potential future flood levels, depths, velocities and extents.

The Consultant shall develop models to a high level of detail for the HPWs, but to a lower level of detail for MPWs, making full and best use of the survey, calibration and other information captured, provided or developed as specified herein……

7.2.2. Fluvial Model Calibration

The Consultant shall appropriately ensure that the flood flows within the hydraulic models along HPW and MPW reaches are calibrated to the flood flow estimates at the Hydrological Estimation Points to ensure hydrological continuity (taking account of flood attenuation explicitly simulated within the hydraulic modelling) and that the design flood flows for each AEP are maintained along all lengths of relevant watercourses. Such adjustment might, for example, be by the provision of appropriate lateral inflows and ensuring appropriate inflow from tributaries, or by running the hydraulic models for individual reaches.

The Consultant shall calibrate and verify the fluvial hydraulic models against a number of suitable past flood events (not less than four (4) events for each APSR if relevant data is

available). The calibration and verification of the models shall make use of the best available data including, but not limited to, hydrometric data, photographs, videos, press articles and anecdotal information provided by local authority staff and other Stakeholders. The models should be verified to vertical accuracies of not less than 0.2m and 0.4m for HPWs and MPWs respectively, subject to the availability of suitable calibration data.

7.3. DEVELOPMENT OF COASTAL FLOODING MODELS

7.3.1. Coastal Flooding Model Development

The Consultant shall develop models for the APSRs associated with risk of flooding from coastal sources, as identified in the tender documentation of the Specific Tender Stage (Stage II), to analyse the inland propagation of coastal or estuarine flood waters and to analyse historic flood events and estimate design and potential future flood levels, depths, velocities and extents. It is reiterated that the Consultant shall not be required to develop hydrodynamic storm surge models, or off-shore models, under this Project and shall instead use the peak design extreme coastal water levels provided by the OPW as the basis for the inland (overland) propagation modelling of flood waters.

The Consultant shall develop models to a high level of detail making full and best use of the survey and other information captured, provided or developed as specified herein. The modelling shall be undertaken using 2-dimensional modelling or other equivalent types of flood spreading modelling capable of accurately simulating the propagation of coastal floodwaters over tidal cycles and storm surge events inland.

The hydraulic models shall be developed using one of the following modelling software packages:

- *ISIS-2D / Tuflow*
- *Mike 21, Mike Flood*
- *JFlow*

Hydraulic modelling software packages other than those listed above may not be used in undertaking this element of the Project.

7.3.2. Coastal Flooding Model Calibration

The Consultant shall calibrate and verify the coastal flooding models against a number of suitable past flood events (not less than four (4) events for each APSR if relevant data is available). The calibration and verification of the models shall make use of the best available data including, but not limited to, hydrometric data, photographs, videos, press articles and anecdotal information provided by local authority staff and other Stakeholders. The models should be verified to vertical accuracies of not less than 0.2m, subject to the availability of suitable calibration data.

3.0 Proposed Approach

3.1 Technical Requirements for Calibration

Calibration of the hydrological and hydraulic models is required to give confidence in the results of the models.

The calibration and verification of the models will make appropriate use of the available data including, but not necessarily limited to, hydrometric data, photographs, videos, press articles and anecdotal information provided by local authority staff and other Stakeholders. Reliable calibration can only be achieved within the constraints of the available data, taking account of both its relevance and reliability.

The hydraulic models need to be calibrated and verified against a number of suitable past flood events representing both in-bank and out-of-bank events (not less than two of each for each AFA if relevant data is available).

The hydraulic models should be verified to vertical accuracies of 0.2m and 0.4m or less for High Priority Watercourses (HPWs) and Medium Priority Watercourses (MPWs) respectively, subject to the availability of suitable calibration data. This calibration accuracy will be measured based on the RMSE compared to observed levels along HPWs associated with a given AFA, or along a reach of MPW. A degree of flexibility and pragmatism is required with this approach taking account of the reliability of data provided at various locations along a reach. The focus will be on achieving a better calibration against the more reliable data sources, rather than allowing less reliable data points to unreasonably influence the calibration.

In considering the above requirements, the following data must be known in order to give a reliable model calibration:

- **Flow** at the point of interest;
- **Water level** at the point of interest;
- **Channel / hydraulic controls** influencing the water level at the location of interest so that the model is representative of the situation.

Where there is uncertainty in any of these three variables, the accuracy of the calibration is reduced.

3.2 Methodology

3.2.1 General

The dearth of sub-daily rainfall records for the Shannon RBD Study area in particular severely limits the application and accuracy of traditional rainfall-runoff techniques to simulate historical events. The uncertainty arising in the calibration of such models and the subsequent need to adjust the model flood flow predictions, to align with the flood frequencies derived from local flow gauge records, renders rainfall-runoff modelling ineffective. Rainfall-runoff modelling of historical events has therefore been discounted. It is noted that the contract recognises this eventuality and does not require the use of rainfall-runoff modelling for historic events.

Hence a combination of Hydrological Estimation Point calibration and hydraulic calibration is proposed as detailed in the sections below.

3.2.2 Hydrological Estimation Point (HEP) Calibration

Within the broader context of hydraulic model calibration, there is the need consistency and continuity moving downstream through the catchments with regard to flows and flow frequency. This means that, for example, the 2% AEP event at one location as given in the hydraulic model, should be cross-checked against the 2% AEP event derived from the hydrological analysis at the same location, and there should be only a small discrepancy between the estimates. This is explicitly covered in Step 8 below, but is of fundamental importance with regard to the model output – the flood maps themselves.

A sequence of tasks proposed to undertake the HEP calibration is provided below. It is emphasised that this is the proposed approach in the absence of any rainfall-runoff modelling.

1) Undertake gauging station rating reviews to provide increased confidence in high flows gauged at specific gauging stations in the catchment. These gauging station reviews are critical in providing reliable information to be used as pivotal sites for hydrological adjustments to flood estimates at ungauged sites.

2) Rework the annual maxima series of flood flows as required following Step 1 at reviewed gauging stations.

3) Estimate Qmed for key gauging stations (ideally ones that have been subject to a rating review) in or near the model domain from the gauged annual maxima at the site and compare this to the outcome of the FSU regression equation at the gauging station. If no suitable "pivotal" site can be found in or near the model domain, then FSU Guidance on the approach to choosing appropriate pivotal sites based on hydrological similarity (Area, BFI and SAAR) should be followed. Divide the two Qmed estimates at these stations to obtain an adjustment factor ($Qmed_{observed}$/ $Qmed_{synthetic}$)

4) Estimate Qmed at all HEPs using the FSU regression equation and adjust these using the adjustment factor found in Step 3 for the key gauging station in the vicinity of the HEPs. This is done in line with implementation guidance on the FSU with respect to pivotal sites, with the determination of adjustment factors for any model length being guided by the number, quality and similarity of the gauging stations available for selection as pivotal sites.

5) Produce flood frequency estimates at the key gauging stations. This is done by pooling group analysis and single site analysis. The results of these two methods are then compared and a view is taken on the best choice of distribution. Generally the selected distribution will be one of two distributions which come out of the pooling group analysis as the best fits to the pooled data. Pooled analysis is favoured over single site analysis for higher return period (e.g. 100 year) because the single site analysis is not normally based on a sufficiently long record. If the single site analysis is based on sufficiently reliable data (with a relatively long record and a few extreme floods), the pooled distribution which matches closest with the single site growth curve will be favoured as the latter is based on local flood data. The comparison of single site analysis with pooling group analysis allows a check on the validity of the design floods. A combined approach may also be appropriate in some instances, in which a composite growth curve is developed that takes account of both the pooling group and single site growth curves. In the unlikely event that further adjustments to the pooled (or combined) growth factors are deemed appropriate Steps 5 to 7 could be repeated.

6) Estimate hydrograph shape for the watercourse from gauged data or analogue sites.

7) Combine output from Steps 4, 5 and 6 above to estimate design flood hydrographs at each HEP.

8) Run hydraulic models (with appropriate amendments to the models where required) to give consistency of design flows between the hydrological and hydraulic estimates, within a reasonable degree of accuracy.

9) Once calibrated, the timings of the downstream tidal boundary will be adjusted such that the flood peak at the downstream end of the model coincides with the tidal peak, taking account of the Guidance Note on Joint Probability Analysis (GN20).

3.2.3 Hydraulic Model Calibration

As there is insufficient sub-daily raingauge coverage within the Shannon RBD, it will not be possible to reliably calibrate a rainfall-runoff model to supply flood flows to the hydraulic models and run calibration events through the model.

The approach taken will therefore depend on the level of data availability, and its quality. Fundamentally, the critical information required to calibrate a model is:

- **Flow**
- **Level** – this may come from a gauging station record (where available) or a reliable recorded water level at a specific location.
- **Hydraulic controls** – a knowledge of the conditions in the channel at the time / date of the recorded flow and level.

The approach taken for different locations and situations is described below based on four categories.

Category 1 - Gauged locations within AFAs or immediately u/s or d/s of the AFA

Where a flow gauge is located at a suitable location upstream or downstream of an AFA and suitable historic flood data exists, we will select not less than two in-bank events and not less than two out of bank events, obtain the relevant flow hydrographs from the gauging station and apply it to the hydraulic model to allow the gauged reach through (or very close to) the AFA to be calibrated and verified. Intervening ungauged catchments contributing to the watercourse through the AFA will be scaled according to the ratio of the peaks of the gauged calibration event and design event at the gauged location. Clearly, the closer the gauge is to the AFA and the fewer the number of ungauged contributing catchments between the gauge and the AFA, the more successful the calibration is likely to be.

The focus of the calibration must be on locations within the AFAs where there is a reliable estimate of flow, level and hydraulic controls.

- **Flow** – this will come from the gauging station record (using the rating curves as recommended from the rating review or existing rating elsewhere)
- **Level** – this will come from a suitable gauging station record and (where available) a reliable recorded water level at specific locations in the AFA that can be linked to a location on the modelled reach. The water level results from a hydraulic model which uses the direct gauged flow from a given gauging station as input inflow, should not in

turn be directly calibrated against gauged water levels from that gauging station as this would constitute circular calibration.

- **Hydraulic controls** – these will be as constructed in the model to represent conditions in the channel as at present (based on the channel survey). Where specific, reliable information is available with regard to issues such as blocked culverts, blockage at bridges, and changes to hydraulic controls between the event date and conditions now, this will be taken into account. However, it is noted that the availability of such information is likely to be extremely limited.

Where reaches that are suitable for calibration are tidally influenced, and suitable historic tidal hydrographs exist, we will apply these to the models as part of the calibration process. However, this introduces another level of uncertainty to the calibration.

It should also be noted that the accuracy of the information relating to these three factors can be influenced by the size of the river (and its responsiveness) at the gauging station.

Category 2 - Gauged locations significantly outside of the AFA i.e. on MPWs

Where suitable historic flood flow and level data exists on MPWs, i.e. at a gauging station, we will follow the same method outlined for the AFAs (Category 1). The primary difference between the level of information available on these reaches is that there is unlikely to be any reliable information on flood history in the vicinity, or reliable observed levels away from the gauge location.

As for gauged locations within the AFAs, where reaches that are suitable for calibration are tidally influenced, and suitable historic tidal hydrographs exist, we will apply these to the models as part of the calibration process. As noted above, this introduces another level of uncertainty to the calibration.

Category 3 - Ungauged locations within an AFA

Where the gauge is too far removed from an AFA to enable reliable calibration, or in the case of tidally affected reaches where the tidal hydrograph data is unsuitable, we will compare anecdotal and historical flood information (if suitably reliable information is available) to the flood outlines derived from the design events. This can serve as a reality check and help determine whether the frequency of flooding experienced in the past is replicated by the model. It is emphasised that the calibration at these locations is reliant on the same three factors identified for gauged locations, namely: (1) flow, (2) water level, and (3) knowledge of the channel conditions that led to the particular water level at the point of interest. Typically, reliable information of this nature is rare, and by definition, flow is not measured at these locations so at best it can only ever be a "best estimate".

It should also be noted that calibration based on observed flood frequency is highly variable and can only ever be treated as indicative. For example, if there is a reliable flood history over 50 years, and there have been 7 reliably recorded flood events at a specific location e.g. a level on a wall of a house, it is **likely** that the threshold event for flooding at that location is in the range 20% to 10% AEP event (5 year to 10 year return period). It is statistically very unlikely that Qmed would flood the property, and equally, it is very unlikely that the threshold event would be as high as the 5% AEP event (20 year return period). Linking this to the flood mapping, it would be anticipated that the Qmed flood outline would not show the property as being flooded and that the 5% AEP event outline would show it as flooded. Both the 20% and 10% AEP could, not unreasonably, potentially show the property as either flooded or not flooded. Hence this high level assessment does not constitute a calibration –

it is merely a high level indicator of what may be considered reasonable. An alternative example would be a location with a long known history with very few flood events recorded. These can be even more difficult to assign threshold events for flooding, giving a greater range of what might be considered reasonable in terms of the flood outline that shows a location to be flooded.

Category 4 - Ungauged locations outside of the AFA i.e. on MPWs

The approach here is similar in principle to the ungauged locations within an AFA. However, there is likely to be even less usable information on known levels in known events, and hence use of the term “calibration” in these areas would generally be misleading. Consideration of the question “is it believable?” is most appropriate as a reality check (see Section 3.2.5).

Summary of Approaches Considered

The above sections outline what can be considered for each type of location. This is summarised in terms of the focus for hydraulic model calibration in Table 1, and the approach likely to be adopted for different situations.

With regard to data gathering for use within the model calibration exercise, the focus is to draw on data included within www.floodmaps.ie where this provides sufficient information, supplemented with additional data provided by Local Authorities where details are known. To facilitate the data collection and provide an indication of when flooding may have occurred, the dates of the AMAX data for specific gauges have been used as a guide to possible (or likely) high flows within particular AFAs. Clearly, this depends on the size of the catchment and proximity to the AFA and it is quite possible that the dates of the highest ranked AMAX events at nearby gauges do not correspond to flood events. However, it can provide a useful pointer for the Local Authorities as to when there may have been flood events, particularly when coupled with data included from events recorded in the floodmaps.ie database.

Technical Note

1		2	3	4	5	6	7	8
Location description		**Likely accuracy of Flow estimate**	**Likely accuracy of Gauged Level estimate**	**Known hydraulic conditions** (1)	**Supplement-ary known, useful flood levels**(2)	**Reliable flood history (levels, locations, dates)** (3)	**Indicative calibration score (sum of columns 2-6)**	**Calibration comment**
Category 1	Large gauged river within an AFA (HPW)	3	3	2 - 3	2	2	12 - 13	Calibrate main channel to large events on the river. E.g Croom using Station 24001 (Maigue @ Croom)
	Small gauged river within an AFA (HPW)	2	3	2	1	1	9	Calibrate main channel to large events on the river. E.g Dromcolliher using Station 24015 (Ahavarragh @ Dromcolliher). Take note of uncertainties due to channel blockages etc.
Category 3	Large ungauged river within an AFA (HPW)	1 - 2	0	2	2	2	7 - 8	Calibrate main channel to best estimate of flow with known level in AFA (if available). If no dates / levels, then modelled outline to reflect "reasonable" historic flood frequency (if available). Otherwise not calibrated – use reasonable hydraulic parameters.
	Small ungauged river within an AFA (HPW)	0 - 1	0	1 - 2	1	1	3 - 5	Modelled outline to reflect "reasonable" historic flood frequency (if available). Otherwise not calibrated – use reasonable hydraulic parameters
Category 2	Gauged MPW	3	3	2 - 3	0	0	8 – 9	Calibrate main channel to large events on the river – this will have been done for the gauging station review (for those stations included for review).
Category 4	Ungauged MPW	0 - 2	0	0 - 2	0	0	0 - 4	Reach uncalibrated – use reasonable hydraulic parameters. Reliant on better calibration at u/s and d/s AFAs, and other gauged MPW reaches.

Scores for columns 2 to 6: 0 = Not available; 1 = Poor / Unlikely; 2 = Fair / Possible; 3 = Good / Likely. Total score in column 7 provides an overall indicative guide as to how good the calibration may be, based on the data quality for columns 2 to 6.

Notes:

(1) Hydraulic conditions relates to hydraulic controls influencing water level during a flood e.g. level of blockage at a bridge, culvert trashscreen blockage; any new works since flood event. It is a statement regarding whether the conditions in the flood can be accurately reflected in the hydraulic model.

(2) Flood levels – these are levels during a known flood NOT at the gauged location that represent the true flood level at that location e.g. they must not be due to a very localised hydraulic issue such as flow around a building.

(3) Flood history – for this information to be useful it must include a date, precise location and level as per note (2).

3.2.4 Tidal Inundation Model Calibration

In the event that a suitable tidal hydrograph for a past flood event (and associated details of the resultant flood consequences) exists, we would carry out at least 4 event runs to calibrate and verify the model. However, we would note that to date, we have not found sufficient information relating to a tidal inundation event that could be used as a true calibration event, although sources such as ICPSS or Proudman Oceanographic Laboratory may yield some data.

Where a suitable tidal hydrograph does not exist – which we consider will be the norm for the tidal inundation modelling - we will compare any suitable flood data with the design flood outlines, in a similar way to the fluvial model calibration methodology, outlined in Section 3.2.3 for Categories 3 and 4 – i.e. in an ungauged location. This will serve as a reality check and help determine whether the frequency of flooding experienced in the past is replicated by the model.

It should be noted that all tidal inundation model calibration requires the following fundamental information:

- Tidal hydrograph – as the driving force leading to the tidal inundation
- Water levels – peak flood level recorded on the tidal flood plain
- Tidal flood plain conditions – the ground profile in the model must replicate the situation for the time / date when the tidal inundation occurred.

Given these requirements we anticipate that (as for Category 4 in the fluvial model calibration) the availability of usable information is likely to be very limited and hence the term "calibration" in these areas would generally be misleading. Consideration of the question "is it believable?" is therefore likely to be the level of detail for the calibration, as a reality check against known tidal flooding.

The accuracy of the tidal flooding inundation is likely to be best at locations where the threshold event for inundation is low e.g. events up to around the 20% AEP event tide level, assuming this relatively frequent level of flooding is observed.

3.2.5 Reality Checking of Mapping as and Aid to Calibration

We note that within the Stage I Tender Documents Sections 7.2.2 and 7.3.2 state:

'The calibration and verification of the models shall make use of the best available data including, but not limited to, hydrometric data, photographs, videos, press articles and anecdotal information provided by local authority staff and other Stakeholders.'

Our approach outlined above will do this. However, we do anticipate based on the lack of calibration data available to date through many AFAs, along MPW reaches, and in tidal locations, that a reality check on the flood mapping could add value to the process prior to the formal public consultation on the draft flood mapping. Those with the best local knowledge within the Local Authorities and OPW Regional Staff could be engaged in the process. Typical questions to address will include:

- Are there areas that you (LA and OPW) know flood (i.e. have flooded once or more in the past), which are not shown by the design event extents?
- Are there areas shown as flooded, that you believe are highly unlikely to ever flood? If so, why do you believe they are highly unlikely to ever flood?
- Is there evidence of the range of design event flood profile levels having been met or exceeded? If so, how often?

This type of local review providing a reality check on the mapping could be usefully facilitated through a flood-mapping workshop (or series of workshops) focused on different groupings of AFAs. For example, there could be a mapping workshop for each Local Authority or each UoM. Although these Local Authority / Regional OPW flood mapping workshops are not identified as an activity within the Stage I or Stage II tender documents, the Progress and Steering / Advisory Group meetings may be suitable fora for such workshops, noting that additional workshops with individual Local Authorities, OPW Regional Staff and/or other Stakeholders may need to be considered as well. These meetings / workshops within the context of the Progress and Steering / Advisory Group meetings do not replace the formal requirement for stakeholder workshops for flood mapping.

Appendix F National Technical Co-ordination Group (NTCG) Guidance Note no. 22 (GN22)

GUIDANCE NOTE 22 V5.0

JBA Project Code	2011s5232
Contract	Western CFRAM
Client	OPW
Day, Date and Time	17 February 2014
Author	Sam Willis
Subject	Guidance Note 22 – Sensitivity Analysis and Uncertainty Mapping Guidance Note

1 Overview

This note updates Guidance Note 22 on Sensitivity Analysis and Uncertainty and supersedes all previous guidance notes issued on these topics. The revised Guidance Note 22 now includes alternative recommendations for the representation of uncertainty in the flood maps.

The objective of the proposed approach to representing uncertainty is to incorporate the best available knowledge of the modelling limitations into the analysis without requiring significant additional input from the CFRAM consultants. To do this the approach will use the understanding provided by the sensitivity analyses to determine the level of uncertainty. The proposed approach is an alternative option only and consultants are free to continue to use the approach outlined in the project brief if preferred.

The proposed representation of uncertainty will be through a second flood extent developed for the 10%, and 1% flood extents only. These extents will not be presented on the standard flood maps but will only be provided online as separate uncertainty maps with the relevant best estimate flood extent. There would therefore be no requirements to include the alternative line-type around the design extents as currently outlined in the project brief. This should simplify the presentation of the flood maps whilst allowing uncertainty maps to be made available as required.

The development of the uncertainty bounds will utilise only the results from those sensitivity tests that are found to produce the largest increase in the predicted flood extent. Where two sensitivity tests are producing a comparable increase in the predicted flood extent in an area of interest then further consideration of the appropriate uncertainty bound as described below in Section 3 is required.

The key steps are as follows:

1. Prepare screening assessment from knowledge of model build and its calibration
2. Undertake sensitivity tests on hydrological parameters
3. Undertake sensitivity tests on core hydraulic parameters
4. Undertake additional hydraulic testing where it is scoped in
5. Assess which test or combination is to be displayed on the maps

To minimise the work load associated with the alternative approach it has been agreed to represent uncertainty on the medium priority flood extents using the alternative line-type approach and classify the full medium priority reach as highly uncertain. Similarly it has been agreed that uncertainty mapping will not be required for the Flood Zone maps as there is no guarantee that this information would be utilised if made available.

This note first discusses the required approach to completing the sensitivity analysis before highlighting how the results from this analysis can be incorporated into the uncertainty mapping.

2 Sensitivity Analysis

Section 7.4 of the project brief states that:

The Consultant shall undertake sensitivity tests for each and all forms of modelling as described above as appropriate to determine the robustness and sensitivity of the models and the design flood levels, extents, etc. estimated using the models. Such tests should include, but not necessarily be limited to, variations in roughness parameters, flow values, boundary conditions and (within APSRs) afflux parameters at hydraulically-significant structures.

The nature of the sensitivity analysis and the model parameters assessed means that any analysis will be based on engineering judgement only, however by maximising the hydraulic modellers knowledge of the site, sensitivity assessments can be representative of the limitations of the data availability for the site.

It is not appropriate to adopt a generic approach to the sensitivity analysis, rather a screening judgement should be made as to those tests that are applicable and required for a given AFA. Once decided, analyses should be AFA specific and utilise knowledge of the site. Decisions and justification will need to

be recorded as part of the hydraulics reporting.

Typically, sensitivity analyses will be run for the 1% AEP event, however to support the development of uncertainty bounds described in Section 3 it will also be necessary to run the 10% AEP event. In some instances this will require a variation to the sensitivity tests applied for the 1% AEP event.

The following sections discuss the range of the sensitivity tests required and provide examples of how parameters should be adjusted to reflect known uncertainties. In all cases it is important to consider the sensitivity tests as a sensible shift within the bounds of reasonableness. Therefore, if through the calibration/validation process, parameters have been increased towards the upper limits of reasonableness for a given parameter then the additional shift for a review of sensitivity will be less than if no calibration/validation process has been carried out and default parameters have been applied. Increased confidence in model results will be directly linked to the calibration classifications discussed in Guidance Note 23 and reference to these classifications will support and guide the level of sensitivity tests required.

The following sensitivity tests are outlined for consideration:

Table 2-1: Sensitivity tests for consideration

Mandatory	Optional tests following Screening Assessment
Flow (1% AEP Event)	Building representation (1% and 10% AEP Event)
Roughness (1% AEP Event)	Flow volume (1% and 10% AEP Event)
Water level boundaries (1% AEP Event)	Afflux/head loss at key structures (1% and 10% AEP Event)
	Timing of tributaries (1% and 10% AEP Event)
	Flow, roughness and water level boundaries (10% AEP Event)

This list is not exhaustive and where predicted flood risk is dependent on additional parameters or modelling assumptions, these should be highlighted in the model report and investigated through further sensitivity tests.

Sensitivity tests to flow, roughness and water level boundaries should be carried out on all models for the 1% AEP event. Sensitivity tests to building representation, flow volume, afflux at key structures and timing of tributaries for the 1% AEP event and for all tests listed in Table 2-1 for the 10% AEP event should be carried out where a screening exercise has identified that there remains significant uncertainty and models may be underestimating flood risk.

2.1 Flow

As flow is probably the most critical of all the sensitivity tests it will be important to consider the quality of data available in the derivation of the design flows.

Table 2-2 provides a scoring mechanism through which each watercourse is attributed a score from each row of the table reflecting the level of confidence in the hydrology. The resulting scores are summed to provide an overall indication of uncertainty and used to look up in Table 2-3 the uncertainty weighting to apply.

The uncertainty in QMED can be assessed using the equations for SE and FSE provided in the FSU WP2.2 report. These are provided for estimates derived from catchment descriptors, which will give a scaling factor of 1.37, and can be calculated at gauge sites which have been typically found to be around 1.06. Site with donor adjustments will be in between these values and it is recommended an adjustment factor of 1.2 is applied.

This QMED adjustment factor reflects the uncertainty in the index flood but does not reflect the uncertainty in the growth curve, for this reason an additional adjustment factor is included for the 1% AEP

event. A review of single site analyses with greater than 40 years of data produced an uncertainty adjustment factor for the growth curve of approximately 1.2. Use of pooling groups would reduce this uncertainty suggesting an adjustment factor of 1.1 is appropriate. Uncertainty at the upper end is harder to quantify and consultants should review the adjustment factors produced using this scoring system to confirm they are appropriate.

Table 2-2: Flow sensitivity scoring system

Scoring Parameter	Score of 1	Score of 3	Score of 5	Score of 7
Is there a local recording gauge/s that have been used as a donor for the hydrology or to provide confidence in the hydrology by other means?	Within 5km of the AFA and on the same watercourse with no significant other inflows between the gauge and the AFA OR Upstream and downstream of the AFA with no significant other inflows between and routing of flows supports the hydrology	Within 5km of the AFA but not on the same watercourse or with significant other inflows between the gauge and the AFA	Beyond 5km or with significant other inflows between the gauge and the AFA	No useable gauge
What is the length of record of the local gauge?	Greater than 40 years	Between 20 and 40 years	Between 2 and 20 years.	No useable gauge
What quality is the record from the gauge?	Rating review carried out, high confidence	Rating review carried out, moderate confidence or no rating review carried out but gauge is FSU class A	All other sites.	N/A.
What unusual features are there in the catchment hydrology?	None – a rural catchment typical of many in the gauged datasets	Some lakes (0.99>FARL>0.9) or urbanisation (0.05<URBEXT< 0.15)	Some karst or extensive lakes (FARL<0.9) or urbanisation (URBEXT>0.15) or arterial drainage	N/A
What is the size of the catchment	N/A	N/A	<25km	N/A

Table 2-3: Flow sensitivity adjustment factors

	Summed Scores			
Return Period of Event	**Score up to 6**	**Score of between 7 and 14**	**Score of between 15 and 22**	**Score above 23**
10%	No sensitivity test required.	Use QMED uncertainty	Use QMED uncertainty	Use QMED uncertainty
1%*	Use QMED uncertainty then apply adjustment factor of 1.1	Use QMED uncertainty then apply adjustment factor of 1.2	Use QMED uncertainty then apply adjustment factor of 1.3	Use QMED uncertainty then apply adjustment factor of 1.5.
*** Where extensive areas of karst with connections to the surface water system is present then use QMED uncertainty then multiply flows by 2.0 to reflect the uncertainty in the 1% event flow.**				

2.2 Roughness

As part of the hydraulic modelling work completed it is expected that channels will have been assessed for typical vegetation cover. Using these descriptions and an understanding of the maintenance regime carried out by the local authorities and OPW it should be possible to determine high and low end roughness values for each channel. The hydraulic modeller should justify the variations to this parameter based on the known conditions on site.

If one or more large events have been observed and sufficient data is available with which to calibrate the roughness within the channel then it will not be necessary to vary Manning's n to the full extent suggested in the tables below. It is also noted that in large events with greater depths the influence of channel roughness will often reduce. Again in these instances a variation to the maximum upper bound may not be applicable.

The following tables provide typical roughness values and upper and lower bounds for various surfaces. These can be used as a guide or, if preferred, alternative data sources can be referenced and applied when determining appropriate sensitivity tests. It is not proposed that upper values are applied with no consideration of local factors as discussed above.

Table 2-4: Typical roughness bounds for river channels

Channel Substrate	**Roughness Values (Manning's n)**		
	Typical Value	**Lower Bound Value**	**Upper Bound Value**
Bedrock	0.025	0.023	0.028
Cobbles (64-256mm)	0.055	0.04	0.07
Coarse Gravel	0.035	0.022	0.04
Gravel (2-64mm)	0.03	0.028	0.035
Sands	0.025	0.023	0.032
Silt	0.022	0.02	0.025
Clay	0.02	0.018	0.023
Concrete	0.02	0.018	0.022

Simplified version of Table 10 from Reducing Uncertainty in River Flood Conveyance. Roughness Review. By Karen Fisher and Hugh Dawson. DEFRA / Environment Agency Flood and Coastal Defence R&D Programme, Project W5A-057. July 2003.

Table 2-5: Typical roughness bounds for river banks

Bank Material	Roughness Values (Manning's n)		
	Typical Value	**Lower Bound Value**	**Upper Bound Value**
Scrub/Long Grass	0.04		
Bushes	0.06		
Trees – flood level not reaching branches	0.07	0.05	0.13
Trees – flood level reaching branches	0.15	0.1	0.2

Simplified version of Table 16 and 23 from Reducing Uncertainty in River Flood Conveyance. Roughness Review. By Karen Fisher and Hugh Dawson. DEFRA / Environment Agency Flood and Coastal Defence R&D Programme, Project W5A-057. July 2003.

Table 2-6: Typical roughness bounds for rivers to flood stage

General Channel	Roughness Values (Manning's n)		
	Typical Value	**Lower Bound Value**	**Upper Bound Value**
Clean, straight, full stage, no rifts or deep pools	0.030	0.025	0.033
As above but more stones and weeds	0.035	0.030	0.040
Clean, winding, some pools and riffles	0.040	0.033	0.045
As above but some weeds and stones	0.045	0.035	0.050
As above but lower stages, more ineffective slopes and sections	0.048	0.040	0.055
As above but more stones	0.050	0.045	0.060
Sluggish reaches. Weedy deep pools	0.070	0.050	0.080
Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.100	0.075	0.150
Mountainous streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high water levels. Bed: gravels, cobbles and a few boulders.	0.040	0.030	0.050
Mountainous streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high water levels. Bed: cobbles and with large boulders.	0.050	0.040	0.070

Simplified version of Table A1.1 from Culvert design and operation guide, CIRIA C689, 2010.

Floodplain Manning's n values should be adjusted in the same roughness sensitivity test. Digital data on floodplain surface types is generally limited however a suggested range of typical floodplain roughness values are provided below.

Table 2-7: Typical Roughness Values in the Floodplain

Floodplain Material	Roughness Values (Manning's n)		
	Typical Value	**Lower Bound Value**	**Upper Bound Value**
General Natural Surfaces	0.040	0.030	0.050
Buildings	0.300	0.100	1.000
Inland Water	0.035	0.025	0.045
Roads, Tracks and Paths	0.015	0.013	0.017
Non-coniferous Woodland	0.070	0.060	0.100
Coniferous Trees	0.100	0.080	0.120
General Manmade Surfaces	0.017	0.015	0.020
Glasshouses	0.200	0.100	0.300
Rock	0.050	0.040	0.070
Mixed Vegetation	0.080	0.060	0.110

2.3 Building Representation

Buildings in the floodplain can dictate flow paths and some consideration of how the preferred representation of buildings influences the flood extent is required.

The preferred methods for floodplain and building representation appear to be AFA specific. For example, a major conurbation could utilise a generic roughness approach whereas a small AFA outline could be heavily influenced by an individual riverside or floodplain building and hence a bespoke method may be appropriate.

The key aim of the sensitivity tests is to ascertain whether the selected approach is appropriate and whether by changing the level to which buildings dictate flow routes, alternative routes are identified. For example if a generic roughness approach is used full storage within buildings is available from ground level, raising thresholds in the sensitivity would divert low flows around buildings and reduce the storage available in the floodplain and potentially cause flooding elsewhere; modelling buildings as voids would be an extreme example of this where there is no floodplain storage within buildings.

Building representation will be different for different CFRAMs and different AFAs within each CFRAM but the essential approach to this sensitivity should be to;

- increase the influence of buildings where they have a low influence, (i.e. have been modelled as reduced hydraulic conveyance only with full floodplain storage allowed), either by increasing thresholds or modelling buildings as voids in the active floodplain,
- or reduce the influence where they have a high influence (i.e. have been modelled with raised thresholds or as voids) by modelling a bare earth scenario where the influence of buildings is represented by reduced hydraulic conveyance only.

The results of the sensitivity test will determine if the alternate approach needs to be adopted for all model runs for the AFA or if it can remain as a demonstration of sensitivity only.

2.4 Water Level Boundaries

The effect of rising sea levels is being investigated through the climate change scenarios and it is recommended that the change quoted for the MRFS is used to test sensitivity to sea levels.

Requiring further consideration may be the initial conditions in lakes within hydraulic models. Where long term level data from gauges on the lake, or historic data is available, this should be reviewed to determine

levels in a typical year and in an extreme year during winter months. Where no long term or historic data is available an estimate of appropriate changes in water levels is required; an increase in lake levels of 1m is proposed.

Where the water level boundary is situated on a river, the potential implications associated with changes to this boundary should be considered given Section 1.2.2.4 of the project brief requires HPWs to extend a sufficient distance downstream of an AFA to minimise the risk of any downstream boundary uncertainty. For this reason sensitivity tests for downstream boundaries on watercourses will not generally be required. Where there is potential for downstream water levels to impact sites within an AFA (typically on large flat watercourses), then MPW models should be used in conjunction with the flow sensitivity test to determine potential increases in water levels. Where tributaries join larger watercourses, increases in levels can be extracted from these models however care should be taken not to apply unrealistic joint probability events, i.e. coinciding a 1% AEP peak flow on a small tributary with the same event on a larger watercourse.

2.5 Flow Volume

Hydrograph durations will have in some cases been developed from observed data. Where this data consists of multiple hydrographs in excess of the 10% AEP event it is considered a reasonable approximation of the flood duration has been made and a significant increase in flow volume will not be required.

In other cases flood durations may have been developed from single events or from catchment descriptors only, in these cases there will be much more uncertainty in the flood duration applied. Because of the different approaches being used to develop hydrographs across the CFRAM it is not possible to be prescriptive for this sensitivity test. Instead it is assumed that some analysis will have been done comparing hydrographs generated from catchment descriptors at gauge sites and indicative scaling factors can be extracted from this analysis

Table 2-8: Adjustment Factors for Flood Duration

Description of Site	Sensitivity Adjustment Factor applied to Flood Duration
Flood duration has been developed from a single observed event data or multiple events below the 10% AEP.	1.2
Flood duration has been developed from catchment descriptors and there are few or no lakes in the upstream catchment (FARL>0.9)	Adjustment factors to be developed by CFRAM consultants reflecting preferred approach for hydrograph generation.
Flood duration has been developed from catchment descriptors and there are extensive lakes in the upstream catchment (FARL<0.9)	

2.6 Afflux/Head loss at Key Structures

General modelling units and parameters can often not fully represent the head loss that can occur at atypical or complex structures. Whilst it is not realistic to model these structures exactly as observed on site it is feasible to investigate if additional flooding could result from variability in head loss away from the standard representation included in the modelling software. This sensitivity test will review the potential implications of additional head losses at a structure above those predicted through normal modelling methods.

It is recommended that this analysis is completed for those structures that are likely to have an impact on either the scale of flood risk or future flood risk management measures only.

Head losses at a given structure are related to the velocity head and as a preliminary screening

assessment, local flow velocities can be reviewed to determine if the head losses required to cause additional flooding can be realistically achieved.

Where additional flooding appears to be a risk, a review of the maximum potential head loss at peak velocity needs to be completed. Published head loss coefficients describe losses associated with the expansion and contraction of flows at structures. It is therefore proposed that the structure be remodelled using a conservative estimate of head loss based on published values, either as a series of loss units or by adjusting calibration coefficients in the model to reflect the expected head loss calculated using this method.

For example losses across a bridge could be calculated using the typical bridge expansion and contraction coefficients detailed below and then, if these are greater than currently predicted, should be re- modelled by adjusting calibration parameters to deliver this loss at peak velocity. Alternatively losses at an inlet controlled culvert could be calculated using the culvert contraction loss and compared to the modelled representation of the culvert inlet.

Where there are additional complexities within the structure additional losses associated with further contractions and expansions of flows would need to be incorporated.

Table 2-9: Typical Head Loss Coefficents

	K Value
Calculated expansion loss	$K = (1 - \frac{W1}{W2})$ where W1 and W1 are the upstream and downstream widths
Typical bridge expansion	K = 0.5
Culvert contraction	K = 0.44
Abrupt expansion	K = 0.8
Square edged contraction	K = 0.3 (lower bound 0.23, upper bound 0.35)
Round edged contraction	K = 0.15 (lower bound 0.1, upper bound 0.2)
Typical bridge contraction	K = 0.3
Abrupt contraction	K = 0.6

Based on Table 5-2 in the HEC-RAS manual

Note: expansion losses are applied to upstream velocities and contraction losses are applied to downstream velocities.

2.7 Timing of Tributaries

Design events assume a consistent storm falls across a river basin and allow the response and size of each catchment to determine the occurrence of peak flows in the watercourse. Understanding this response is particularly important at the confluence of tributaries where downstream flows are the product of the combined response of two upstream catchments. This sensitivity test aims to understand the potential implications of a different catchment response resulting in higher peak flows downstream of a confluence, i.e. the peak flows on two contributing watercourses occur closer together.

It is not considered realistic to simply adjust inflow hydrographs from separate watercourses so that peak flows coincide, effectively making downstream flows the sum of the maximum flow on each tributary. Instead the timing of the inflow hydrograph peak of the smaller watercourse will be moved closer to peak of the larger watercourse by up to 10% of the overall duration of the smaller watercourse hydrograph. This will prevent moving smaller tributary inflows to 'sit' on the peak of a larger watercourse.

Flows at all confluences should be screened however it will not be necessary to complete this sensitivity test if the increase in flows resulting from the adjusting the timing of tributaries is less than the increase in flows being assessed in the flow sensitivity test.

3 Presentation of uncertainty

3.1 Scope

The objective of any alternative methodology is to deliver more representative uncertainty bounds than are currently produced using the RPS/Halcrow methodology whilst not increasing the work load required to produce these bounds.

This approach is applicable for the representation of uncertainty on flood maps. In determining uncertainty and freeboard in scheme investigations a more detailed site specific analysis will be required.

3.2 Data

The proposed approach will utilise readily available information developed as part of the sensitivity analyses discussed above, thereby limiting the additional work to be completed. Confidence in how these sensitivity assessments are undertaken is therefore an important consideration in the expected accuracy of the confidence bounds. The process requires thought and justification on the part of the hydraulic modeller for the variation in modelling parameters but the reporting of this should provide an auditable trail for the basis of the resulting flood maps.

It is noted that a similar justification would be required for the development of the data quality/confidence parameters that are fed into the RPS/Halcrow tool without the benefit of visualising the implications of any decisions.

3.3 Methodology

In developing an uncertainty bound from the sensitivity tests it is proposed that the sensitivity test resulting in the greatest flood extent for a given location be used as the uncertainty bound in all cases. The final uncertainty bound will therefore be the result of all sensitivity tests overlain using a GIS package to produce a final merged uncertainty bound. This suits the 2d modelling packages being used on the CFRAMs, and avoids extending a random ΔH across cross sections to form an outer outline.

This approach, which applies the single most sensitive parameter adjustment in all locations, is different from a typical sum of squares approach which applies a proportional allowance for each source of uncertainty.

It is noted that in the majority of cases the hydrology sensitivity test will produce the greatest uncertainty extents, reflecting the fact that hydrology is usually the greatest source of uncertainty in modelling. However, in the particular locations where multiple uncertainties are present to equivalent extents, a review should be undertaken, and if necessary an additional model run completed to incorporate a greater worst case scenario by modelling a combination of uncertainties for that specific location.

The approach for combining uncertainties has been developed in response to the unlikely eventuality that multiple sensitivity tests are producing similarly large increases in flood extents. Combinations will not be required where sensitivity test extents are close to the baseline. Only those combinations the consultant considers appropriate will need to be assessed and these can all be included in a single model run if desired. Therefore whilst there are a large number of possible combinations the consultant should attempt to minimise additional runs where possible.

The following points highlight examples where it may be possible to scope out combinations of uncertainties:

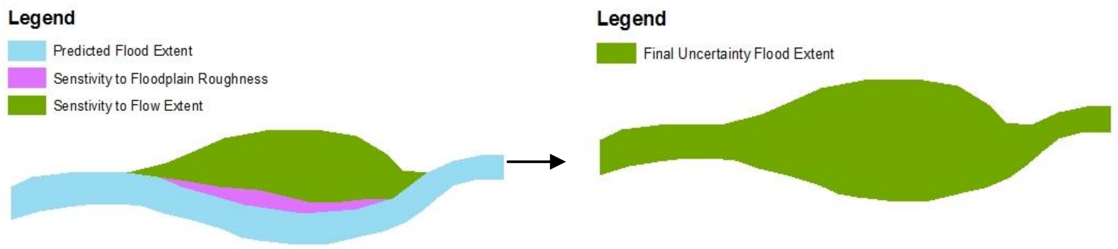
- The sensitivity tests for flow, water level boundary within lakes and timing of tributaries will all have the effect of increasing downstream flows. As such it is likely only the worst of these will be required in any combination event unless the sensitivity tests demonstrate that increases in downstream flows from these are of equivalent magnitude, in which case some combination event will need to be considered.
- Where the combination of flow and tidal boundaries is reviewed in depth in the joint probability analysis this test will not be required.
- Building representation is reviewed to determine the most appropriate method for representing buildings in a given AFA, however if significant variation is apparent between methods and there is cause to justify either approach then a combination of the alternative method with the most significant sensitivity test will likely be required. In this example the uncertainty bound could vary significantly from the best estimate of the extent.

The critical joint sensitivity tests will therefore likely be an increase in flow of one form or another in conjunction with an increase in flow volume and additional losses at structures. If each of these are found to produce similarly large extents in one location it is recommended a worst case combination event is run to provide a conservative uncertainty bound.

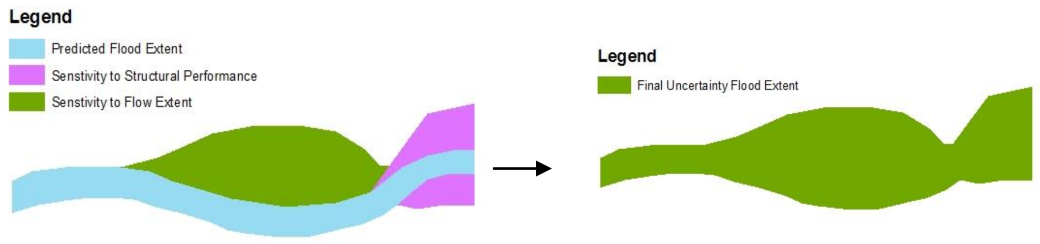
In summary the approach is as follows:

1. Complete hydraulic modeller led sensitivity assessments and document findings
2. Map 2D model results and review extents to identify where multiple sensitivity tests produce similarly extreme outlines.
3. Run extreme sensitivity model run if required.
4. Overlay and merge in GIS to develop a final uncertainty bound.

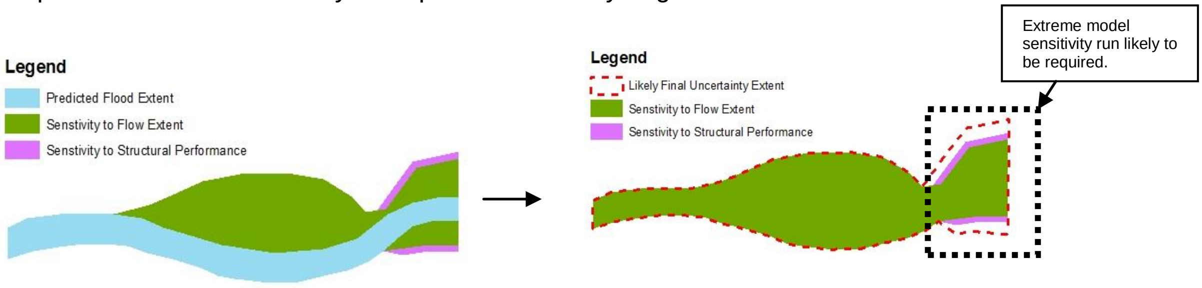
Example 1 – A single sensitivity test produces the greatest bound



Example 2 – Different locations are sensitive to different sensitivity tests



Example 3 – Different sensitivity tests produce similarly large extents in critical areas



3.4 Discussion

The benefits of this approach are as follows:

- The use of the hydraulic modelling outputs effectively allows uncertainty to be assessed in detail at all locations rather than on a reach scale. This is the benefit of the application of 2D modelling in HPW reaches.
- The production of the uncertainty map by building on the sensitivity tests allows modellers/reviewers to see 'behind' the uncertainty bounds in the final map to understand where there are large changes in the extent and why. This compares to the original approach as indicated in the CFRAM Generic Specification that develops an increase in water levels based on an empirical formula derived from a limited number of watercourses.
- Hydraulic modeller input into the sensitivity analysis and the process of the sensitivity testing allows the implications of changes to model assumptions to be better understood and reduces the risk of unwanted outcomes from the current approach, for example a large uncertainty bound where hydraulic modellers feel there is good certainty in the output.
- Less work associated with splitting the watercourse into uncertainty reaches.

The disadvantages of this approach are as follows:

- Potential for inconsistent application between CFRAMS as it relies on professional judgement for suitable parameter shifts. This guidance note attempts to mitigate this risk but it remains a reasonable caveat that different watercourses will be sensitive to different assumptions. This will always be a challenge.
- More work associated with model runs for the Q10 design event where the need for these sensitivity tests have been identified as required as part of the screening assessment.