Appendix 12.1. Site Specific Flood Risk Assessment

Mortarstown WwTP Upgrade

Proposed Outfall Pipe & Headwall

Site Specific Flood Risk Assessment

March 2026

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

Mortarstown WwTP Upgrade

Proposed Outfall Pipe & Headwall

Site Specific Flood Risk Assessment

Client: Uisce Éireann

Location: Kilkenny Road, Mortarstown, County Carlow

Date: 3rd March 2026

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Contents

Appendices

1. Introduction

IE Consulting was requested by AtkinsRéalis, on behalf of Uisce Éireann, to undertake a Site Specific Flood Risk Assessment (SSFRA) in support of a planning application for the proposed Mortarstown Wastewater Treatment Plant (WwTP) upgrade project at Kilkenny Road, Mortarstown, Co Carlow. The primary objective of the proposed upgrade project is to deliver an upgraded WwTP to service the current and future agglomeration loading, ensuring the scheme complies with the Urban Wastewater Treatment Regulations 2001, the conditions enforced by the WWDA licence and to maintain the designation and status of the receiving waters.

This SSFRA has been undertaken specifically in relation to the proposed new outfall pipe and headwall element of the overall proposed upgrade project. In this regard it is proposed to replace the existing 600mm diameter outfall pipe with a new 900mm diameter gravity outfall pipe approximately 205m in length. The new outfall pipe will discharge to the main channel of the River Barrow Watercourse. The new outfall pipe will be constructed to the south side of the existing outfall. The proposed outfall pipe will enter the main channel of the River Barrow circa. 1.5m below the low water level.

The purpose of this SSFRA is to assess the potential flood risk to the proposed new outfall pipe and headwall element of the overall proposed upgrade project and to assess the impact that this element of the development as proposed may or may not have on the hydrological regime of the area.

A hydrologist from IE Consulting undertook a survey of the site area and surrounding catchment on the 25th of March 2025.

Quoted ground levels or estimated flood levels relate to Ordnance Datum (Malin) unless stated otherwise.

This flood risk assessment study has been undertaken in consideration of the following guidance document:

'The Planning System and Flood Risk Management – Guidelines for Planning Authorities' DOEHLG 2009.'

2. Proposed Site Description

2.1. General

The proposed outfall pipe and associated headwall is located approximately 81m beyond the western side of the Kilkenny Road, Mortarstown, County Carlow, 2.2km south of Carlow Town. The site is bounded to the north and east by existing residential dwellings, to the south by Tyndall College Carlow and to the east by Kilkenny Road and the River Barrow. The proposed outfall pipe to service the proposed WwTP development site is located in the south western corner of the site boundary, adjacent to the left hand bank of the River Barrow. The proposed outfall pipe will travel in a north western direction from the existing WwTP, underneath Kilkenny Road and will discharge into the River Barrow with a total length of approximately 205m.

The total area of the proposed WwTP development site is approximately 12.1265 ha. The location of the proposed WwTP development site is illustrated on *Figure 1* below and shown on *Drawing Number IE3120-001-A, Appendix A*.

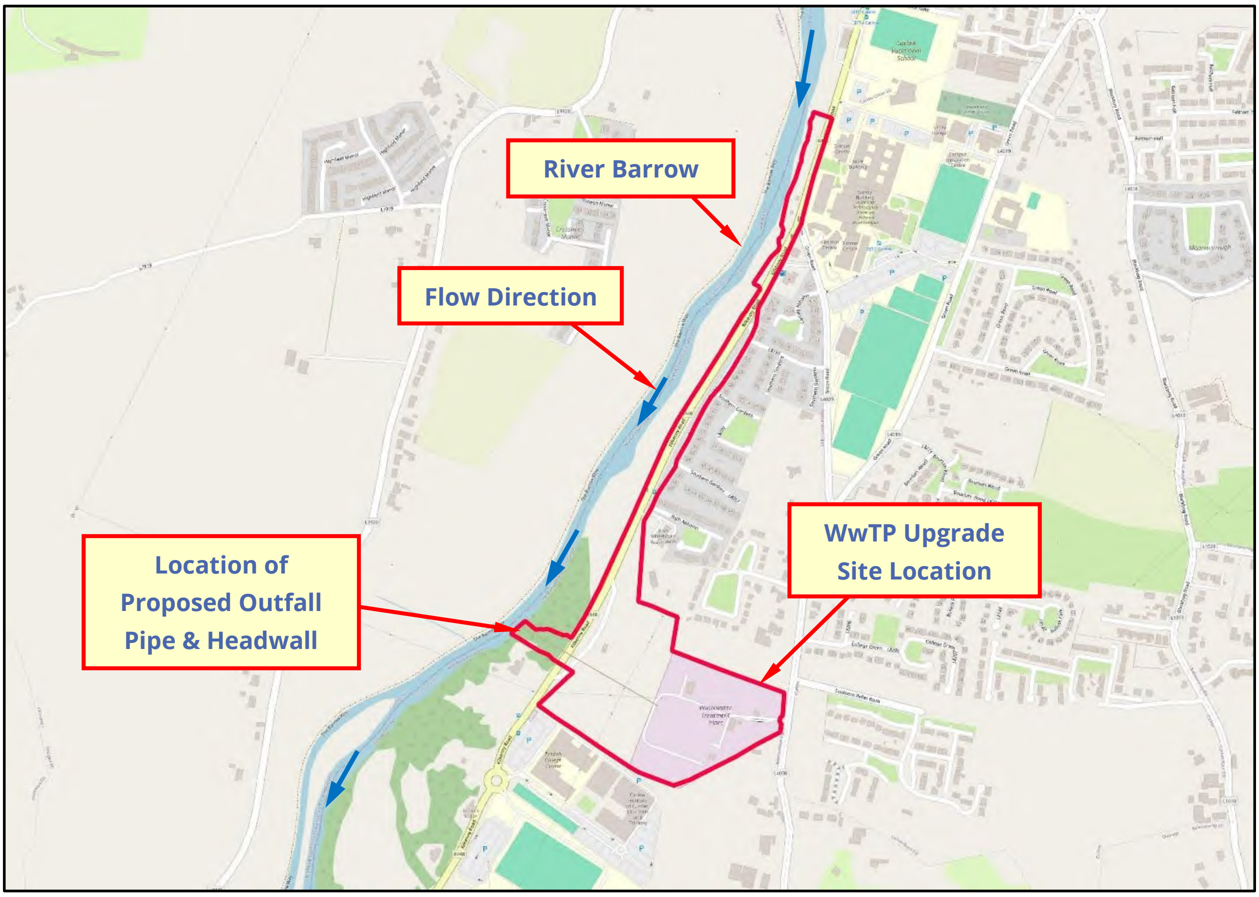


Figure 1 – Site Location

2.2. Existing Topography Levels at Site

Existing ground elevations at the location of the proposed outfall pipe and associated headwall range from approximately 43.3m – 41.9m OD (Malin) within the vicinity of the proposed structure.

2.3. Local Hydrology, Landuse & Existing Drainage

As illustrated in *Figure 1* above, the most immediate and significant hydrological feature at and in the vicinity of the location of the proposed outfall pipe and associated headwall is the River Barrow.

At this location the River Barrow generally flows in a northeast to southwest direction. The catchment area of the River Barrow was delineated and was found to be approximately 2275.88km^2 to a point located immediately downstream of the location of the proposed outfall pipe and headwall. An assessment of the upstream catchment area indicates that the catchment is predominantly rural in nature with the urban fraction accounting for approximately 1.8% of the upstream catchment area.

3. Initial Flood Risk Assessment

The flood risk assessment for the location of the proposed outfall pipe and associated headwall is undertaken in three principal stages, these being 'Step 1 – Screening', 'Step 2 – Scoping' and 'Step 3 – Assessing'.

3.1. Possible Flooding Mechanisms

Table 1 below summarises the possible flooding mechanisms in consideration of the location of the proposed outfall pipe and associated headwall:

Source/Pathway	Significant?	Comment/Reason
Tidal/Coastal	No	The location of the proposed outfall pipe and associated headwall is not located within a coastal or tidally influenced region.
Fluvial	Yes	The River Barrow is located at and adjacent to the location of the proposed outfall pipe and associated headwall.
Pluvial (urban drainage)	No	Note applicable in consideration of this development proposal (outfall pipe and associated headwall)
Pluvial (overland flow)	No	The location of the proposed outfall pipe and associated headwall is not surrounded by significantly elevated lands and does not provide an important surface water discharge point to adjacent lands.
Blockage	No	There are no significant or restrictive hydraulic structures located on the River Barrow immediately vicinity of the location of the proposed outfall pipe and associated headwall.
Groundwater	No	There are no significant springs or groundwater discharges mapped or recorded in the immediate vicinity of the location of the proposed outfall pipe and associated headwall.

Table 1- Flooding Mechanisms

The primary potential flood risk to the location of the proposed outfall pipe and associated headwall can be attributed to an extreme fluvial flood event in the River Barrow. In accordance with 'The Planning System and Flood Risk Management – Guidelines for Planning Authorities - DOEHLG 2009' the potential flood risk to the location of the proposed outfall pipe and associated headwall is analysed in the subsequent 'Screening Assessment' and "Scoping Assessment" section of this study report.

4. Screening Assessment

The purpose of the screening assessment is to establish the level of flooding risk that may or may not exist for a particular location and to collate and assess existing current or historical information and data which may indicate the level or extent of any flood risk. If there is a potential flood risk issue, then the flood risk assessment procedure should move to 'Step 2 – Scoping Assessment' or if no potential flood risk is identified from the screening stage, then the overall flood risk assessment can end at 'Step 1'. The following information and data were collated as part of the flood risk screening assessment for the location of the proposed outfall pipe and associated headwall.

4.1. OPW/EPA/Local Authority Hydrometric Data

Existing sources of OPW, EPA and local authority hydrometric data were investigated. As illustrated in *Figure 2* below, this assessment has determined that there two hydrometric gauging stations located on the River Barrow in the general vicinity of the location of the proposed outfall pipe and associated headwall.

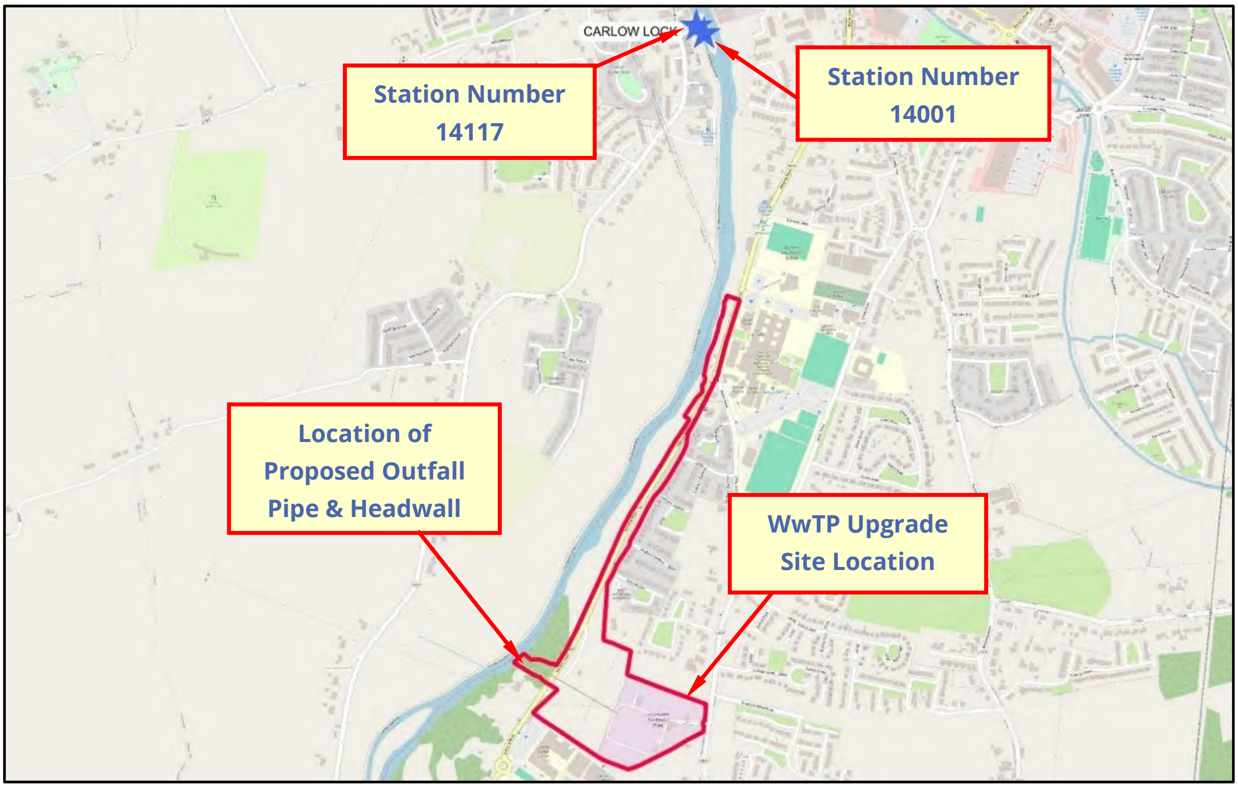


Figure 2 - Hydrometric Gauging Station

Station 14001 and Station 14117 are entered into the Register of Hydrometric Stations of Ireland as active hydrometric gauges that only record water level data.

4.2. OPW PFRA Indicative Flood Mapping

Preliminary Flood Risk Assessment (PFRA) Mapping for Ireland was produced by the OPW in 2011. OPW PFRA flood map number 2019/MAP/169/A illustrates indicative flood zones within this area of County Carlow.

Figure 3 below illustrates an extract from the above indicative flood map in the vicinity of the location of the proposed outfall pipe and associated headwall.

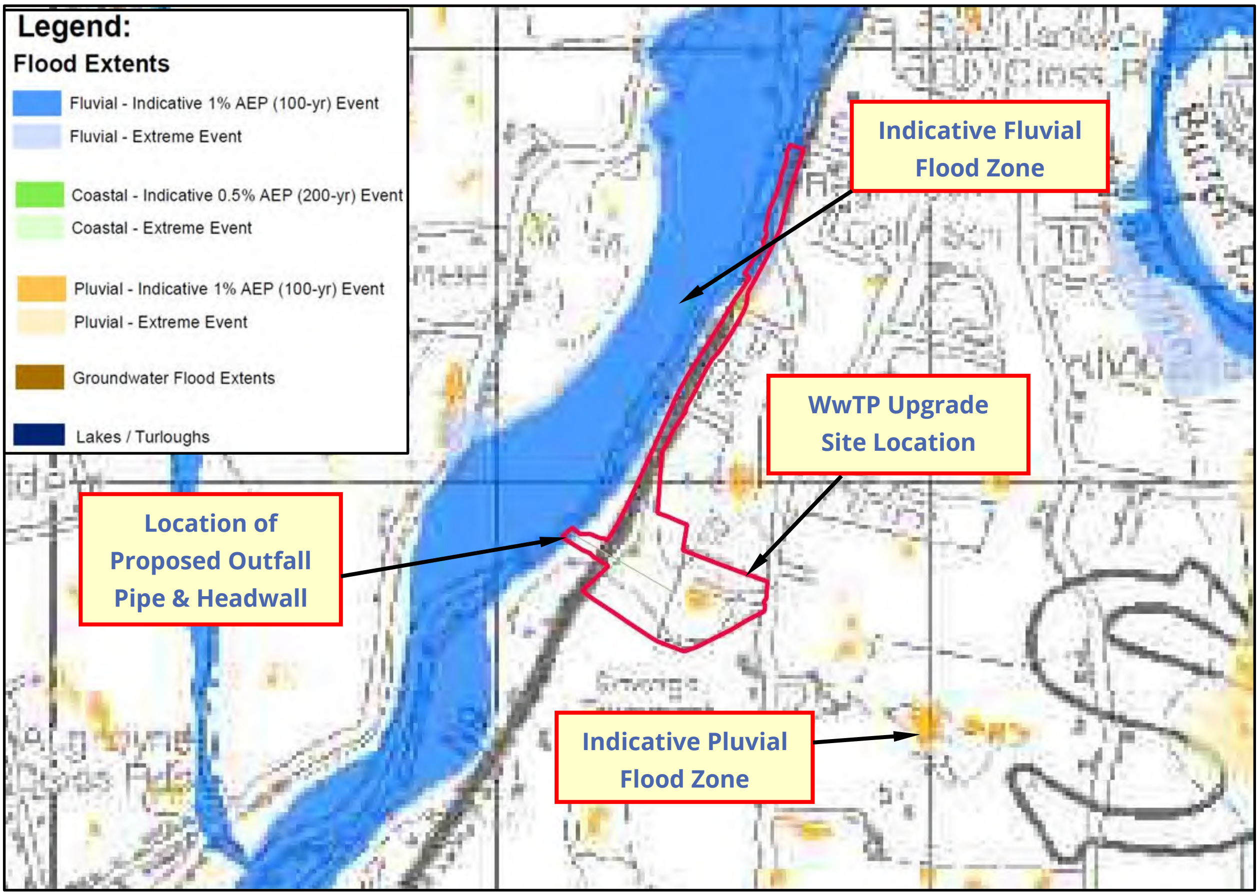


Figure 3 - OPW PFRA Mapping

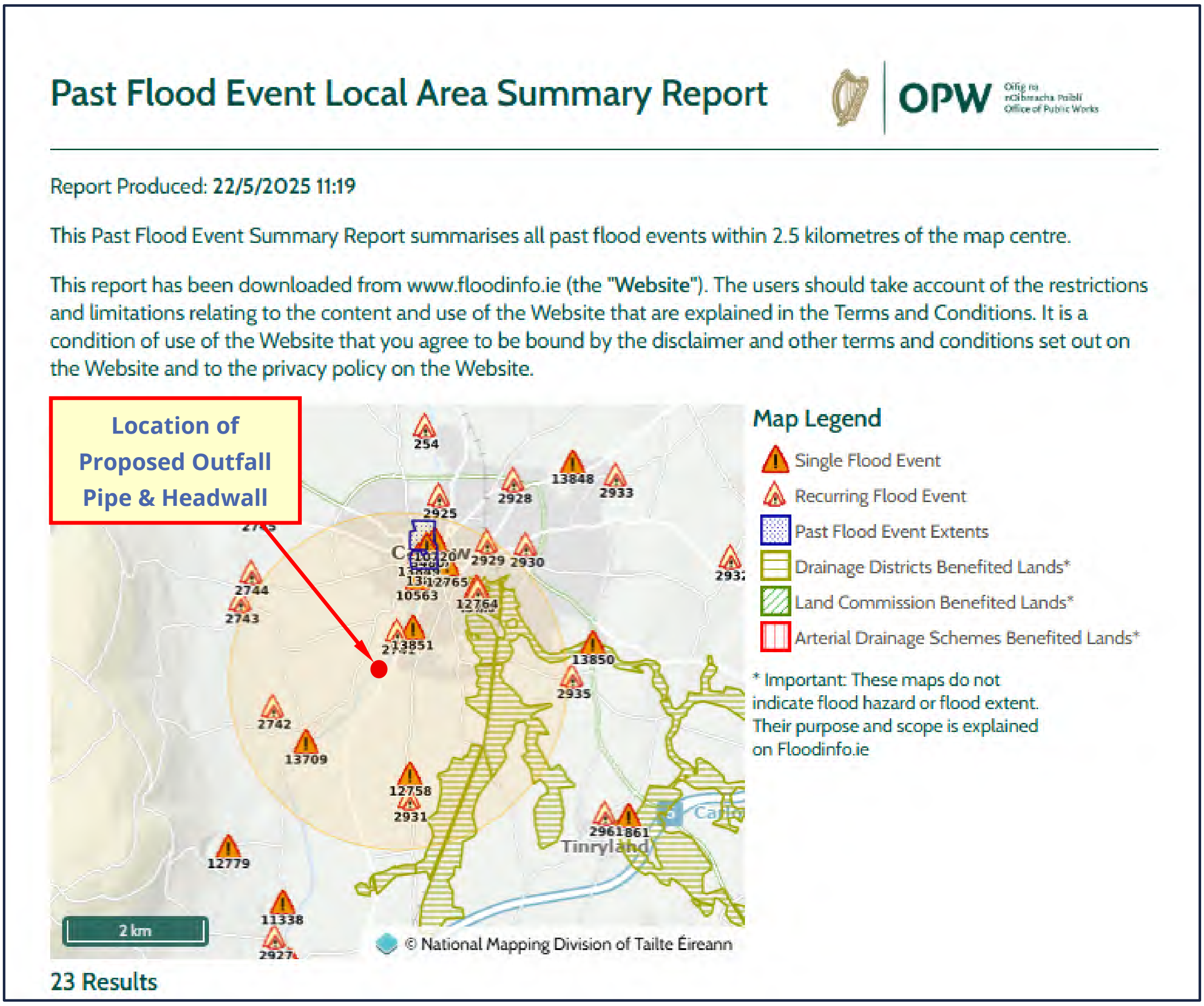
The OPW PFRA flood mapping indicates that the location of the proposed outfall pipe and associated headwall falls within an indicative fluvial flood zone. The location of the proposed outfall pipe and associated headwall does not fall within an indicative pluvial or groundwater flood zone.

It should be noted that the indicated extent of flooding illustrated on these maps was developed using a low-resolution digital terrain model (DTM) and illustrated flood extents are intended to be indicative only. The flood extents mapped on the PFRA maps are not intended to be used on a site-specific basis.

4.3. OPW Flood Maps Website

The OPW Flood Maps Website (www.floods.ie) was consulted in relation to available historical or anecdotal information on any flooding incidences or occurrences at or in the vicinity of the location of the proposed outfall pipe and associated headwall.

Figure 4 below illustrates mapping from the Flood Maps website in the vicinity of the location of the proposed outfall pipe and associated headwall.


Past Flood Event Local Area Summary Report

Report Produced: **22/5/2025 11:19**

This Past Flood Event Summary Report summarises all past flood events within 2.5 kilometres of the map centre.

This report has been downloaded from www.floodinfo.ie (the "**Website**"). The users should take account of the restrictions and limitations relating to the content and use of the Website that are explained in the Terms and Conditions. It is a condition of use of the Website that you agree to be bound by the disclaimer and other terms and conditions set out on the Website and to the privacy policy on the Website.

23 Results

Figure 4 - OPW Flood Maps

Figure 4 above indicates that there is a total of twenty-three historical or recurring flooding events recorded within a 2.5km radius of the location of the proposed outfall pipe and associated headwall. However, 12 of these flood events are located far from the location of the proposed outfall pipe and associated headwall (over a kilometre away) (south of the site Flood ID-2742, Flood ID-13709, Flood ID2931, Flood ID-12758 and north of the site Flood ID-10720, Flood ID-3480, Flood ID-13849, Flood ID-13847 and Flood ID-12765).

Due to the distance of these flood events from the subject site these events are deemed unsuitable to assess flood history at the proposed outfall pipe and associated headwall.

There are 8 past flood events within a 1km radius of the site boundary the location of which are illustrated below in *Figure 5.*

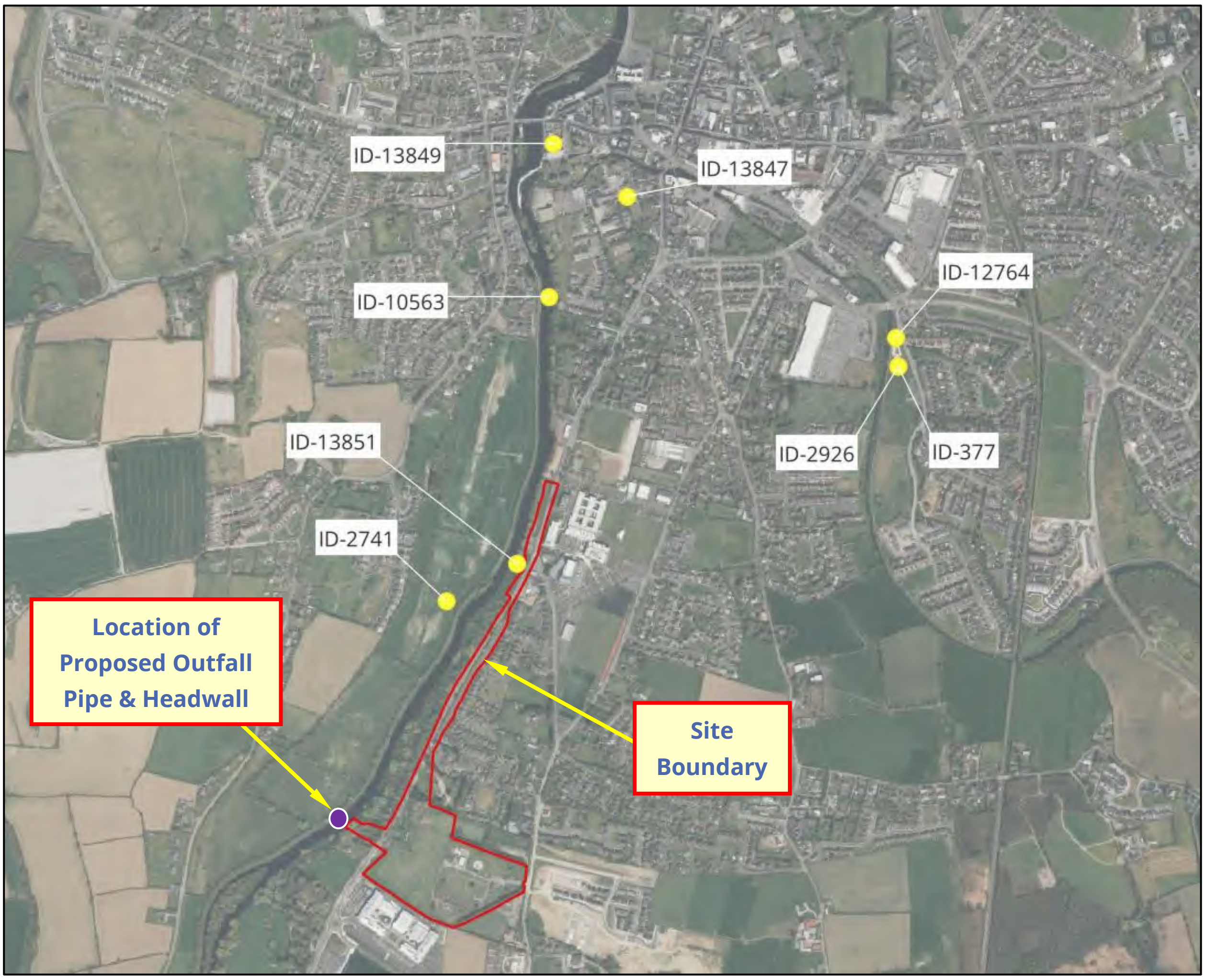


Figure 5 - Past Flood Events with 1km of Site Boundary

The nearest flood event to the location of the proposed outfall pipe and associated headwall is an undated flood event (ID-13851) caused by flooding of the River Barrow. The next nearest flood event is a recurring event (ID-2741) caused by flooding of the River Barrow. There are no details on the flood extents or depths due to these recurring event. The next nearest flood event is a single event (ID-10563) at Barrow Carlow Town 18th August 2008. Hydrometric records are available including flood level comparisons and peak water levels.

ID-12764 refers to a flood event which occurred in 2015. This is an undated flood cause by river source. There are no details on the flood extents or depths due to this recurring event.

ID-2926 and ID-377 refer to the recurring flood event at Burren Paupish Lane Hanover Crest Carlow where the River Burren breaks it banks and flood waters travel in northerly direction to inundate the Lane.

There is no information or data to indicate that any of the above single or recurring flood events has impacted the location of the proposed outfall pipe and associated headwall.

4.4. Ordnance Survey Historic Mapping

Available historic mapping for the area was consulted, as this can provide evidence of historical flooding incidences or occurrences. The maps that were consulted were the historical 6-inch maps (pre-1900), and the historic 25-inch map series. *Figure 6* and *Figure 7* below illustrates the historic mapping for the location of the proposed outfall pipe and associated headwall.

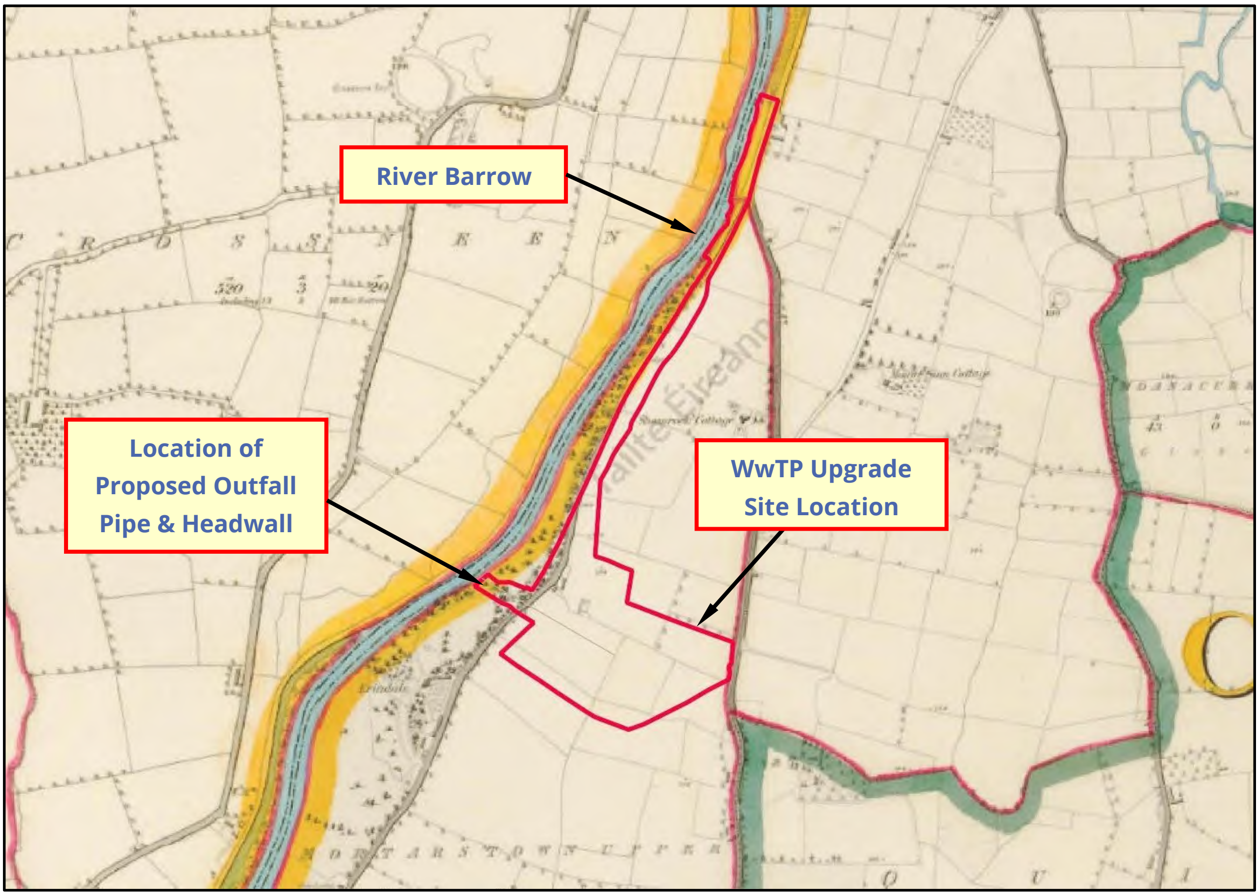


Figure 6 - Historic 6-Inch Mapping

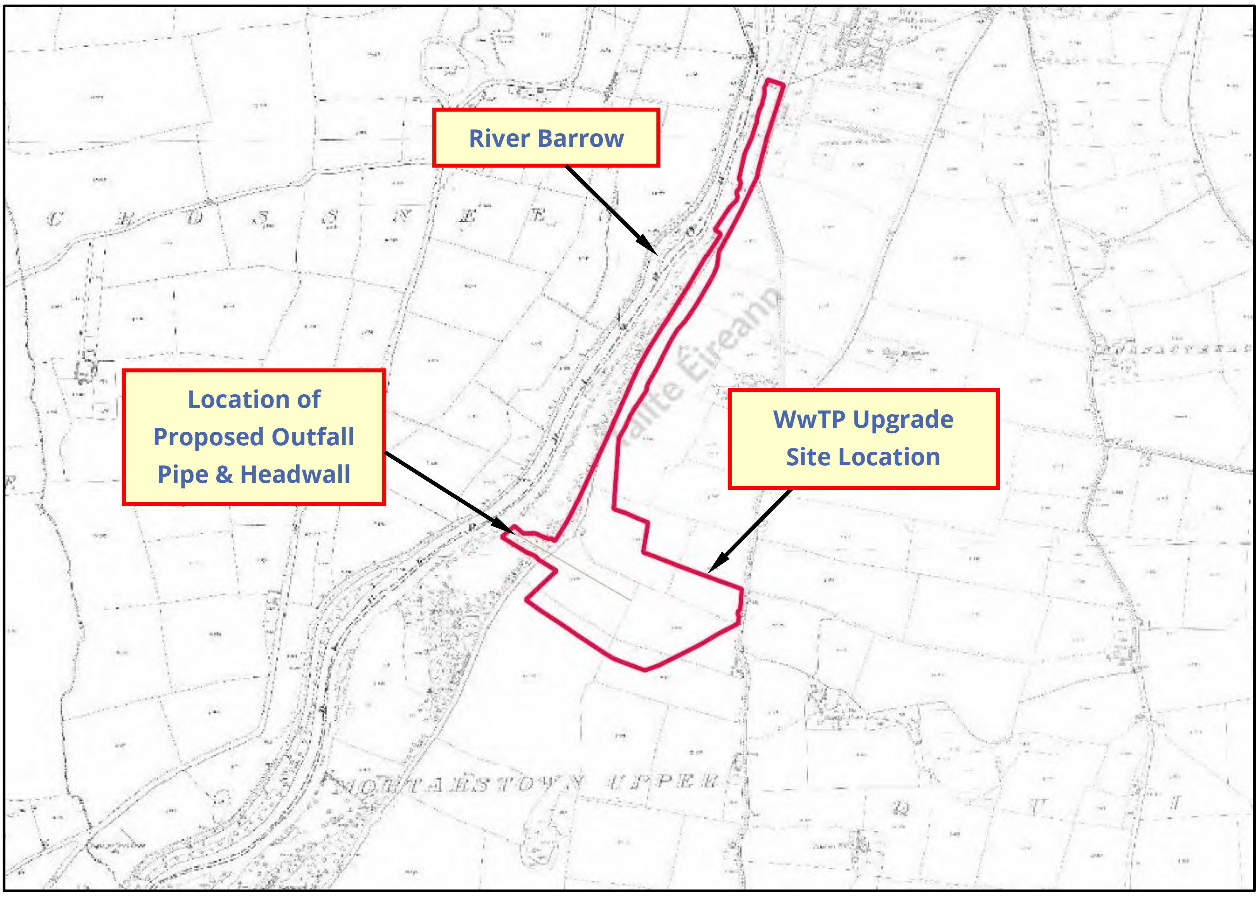


Figure 7 - Historic 25-Inch Mapping

The historic 6-inch and 25-inch mapping does not indicate any historical or anecdotal instances of flooding at the location of the proposed outfall pipe and associated headwall.

4.5. Geological Survey of Ireland Mapping

The alluvial deposit maps from the Geological Survey of Ireland (GSI) were consulted to assess the extent of any alluvial deposits at the location of the proposed outfall pipe and associated headwall. Alluvial deposits can be an indicator of areas that have been subject to flooding in the recent geological past.

Figure 8 below illustrates the sub-soils mapping for the general area of the proposed outfall pipe and associated headwall.

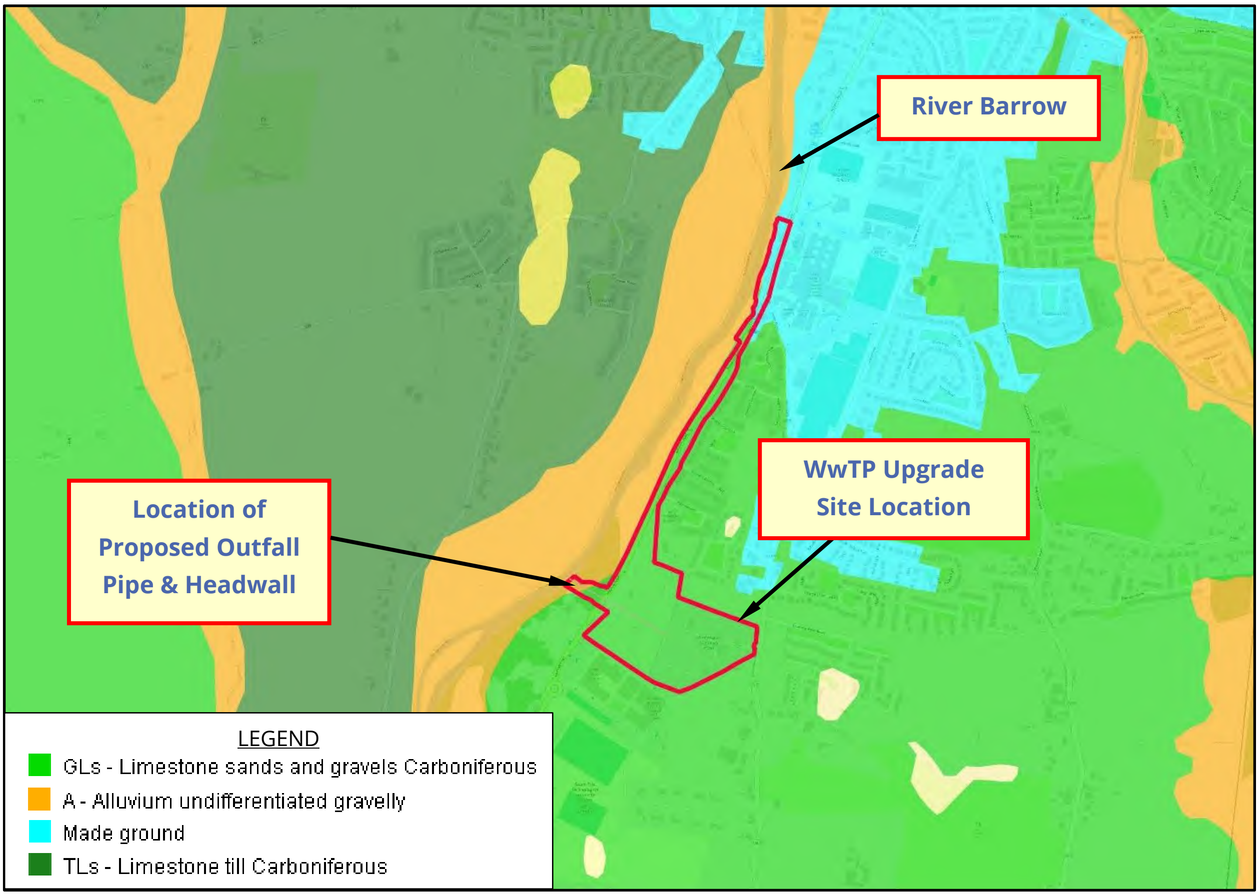


Figure 8 - GSI Subsoil Mapping

Figure 8 above indicates that the location of the proposed outfall pipe and associated headwall is underlain by alluvium deposits.

4.6. Geological Survey of Ireland Groundwater Flood Mapping

Historic and Predictive Groundwater Mapping for Ireland was prepared by the GSI Department of Communication, Climate Action, and Environment in collaboration with Trinity College Dublin and the Institute of Technology Carlow.

Figure 9 below illustrates an extract from the above groundwater flood mapping in the vicinity of the proposed outfall pipe and associated headwall.

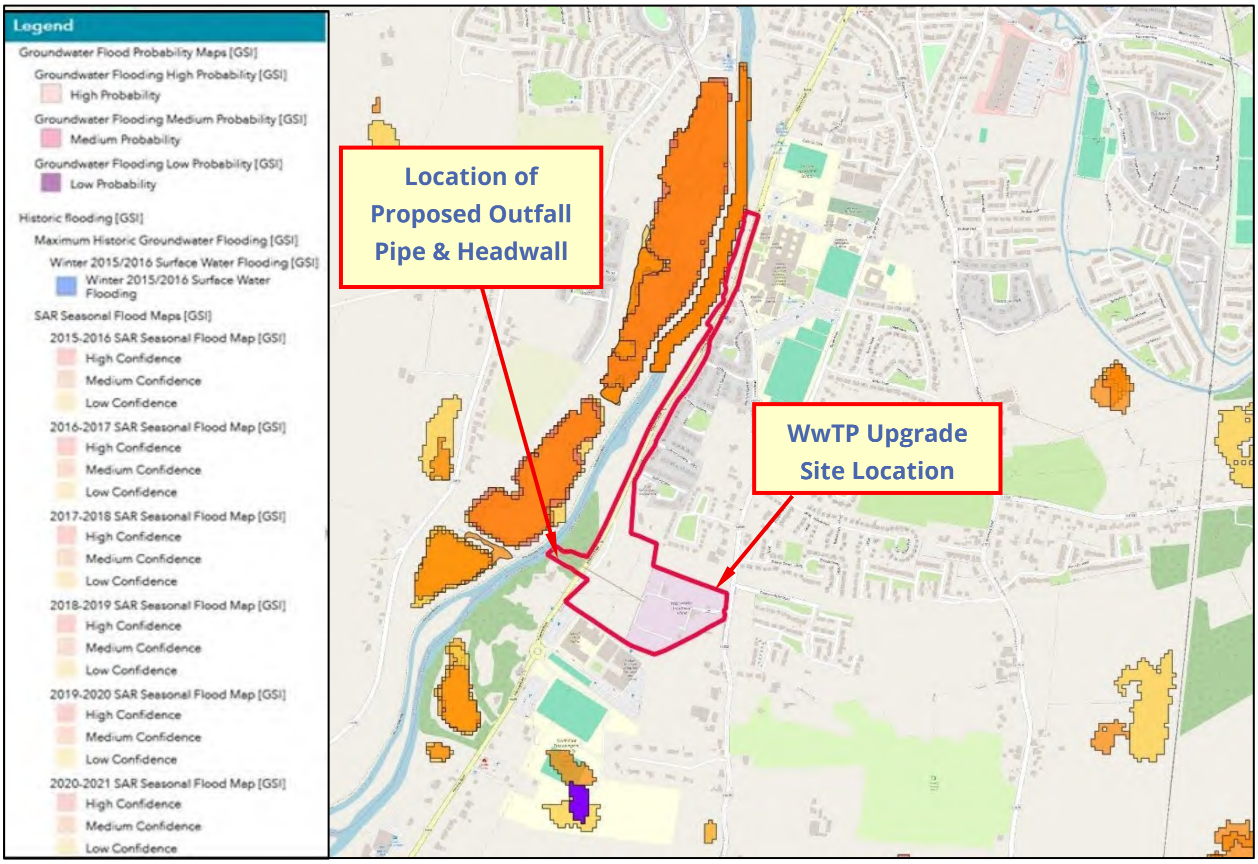


Figure 9 - GSI Groundwater Flood Mapping

The above GSI Groundwater Mapping indicates areas of seasonal groundwater flooding to the west of the location of the proposed outfall pipe and associated headwall, and historic groundwater flooding to the south of the site. The seasonal groundwater flooding delineation in *Figure 9* above was collected through Synthetic Aperture Radar (SAR) imagery (satellite imagery) and is not capable of delineating between surface water flooding (from the River Barrow) and ground water flooding. Therefore the seasonal flooding seen in *Figure 9* can likely be more accurately attributed to fluvial flooding from the River Barrow. The location of the proposed outfall pipe and associated headwall do not fall within an area of historic groundwater flooding.

4.7. OPW South Eastern CFRAM Study

The South Eastern Catchment Flood Risk & Management Study (CFRAMS) has been undertaken by the OPW and the final version of the flood maps were issued in May 2017. Flood risk extent and depth maps for further assessment areas within the Carlow Environs have also been produced.

OPW Eastern CFRAMS predictive flood map number *O14CAR_EXFCD_F0_15* illustrates predictive extreme fluvial flood extents in the vicinity of the location of the proposed outfall pipe and associated headwall. A copy of the map in full is presented in *Appendix B*.

Figure 10 below (extracted from the OPW South Eastern CFRAMS flood map *O14CAR_EXFCD_F0_15)*, illustrates the predictive extreme 10% AEP (1 in 10 year), 1% AEP (1 in 100 year), and 0.1% AEP (1 in 1000 year) flood extents in the vicinity of the location of the proposed outfall pipe and associated headwall.

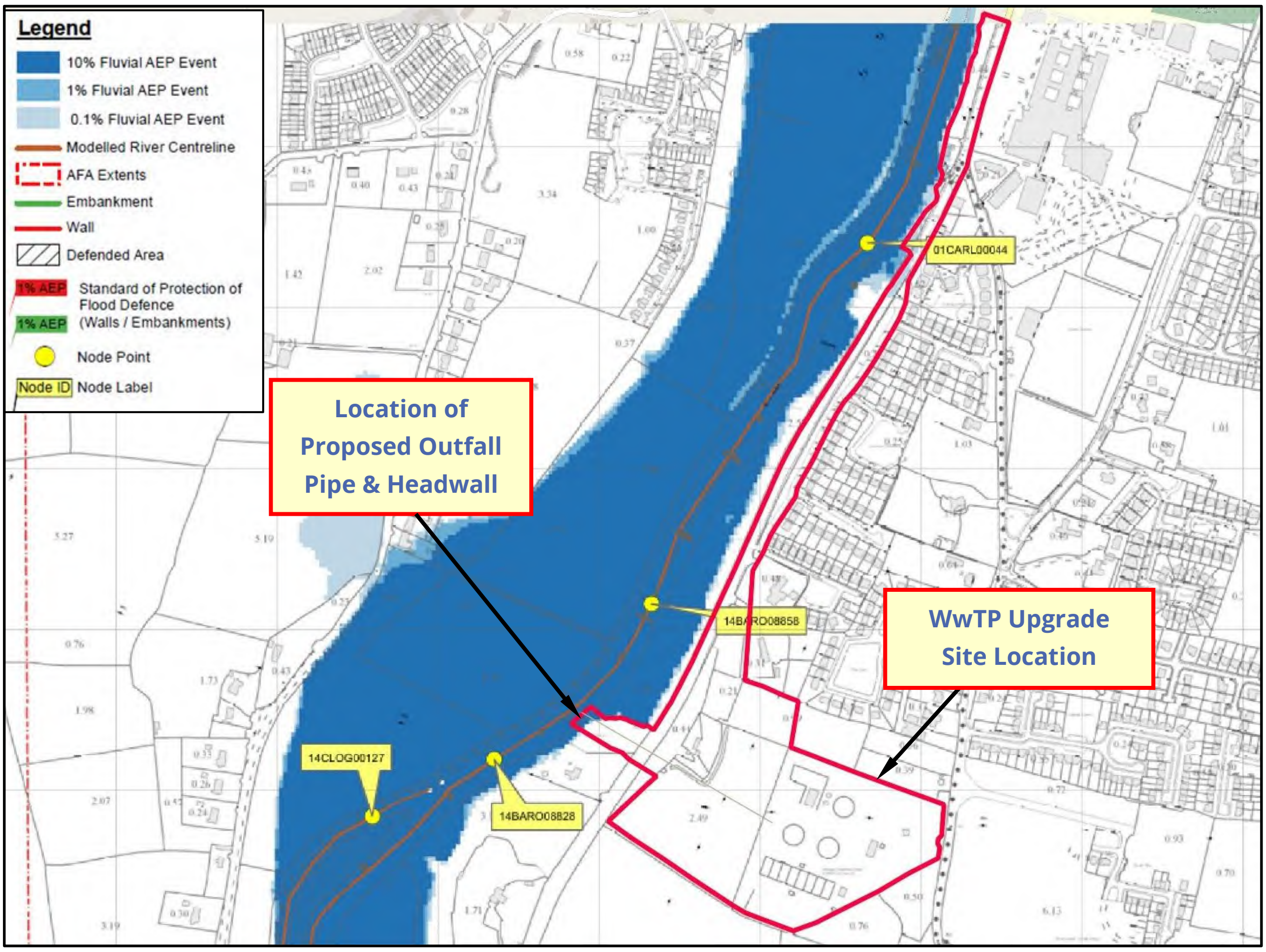


Figure 10 – OPW South Eastern CFRAMS Fluvial Flood Extents Map

Figure 10 above indicates that the location of the proposed outfall pipe and associated headwall falls within a predictive 10% AEP (1 in 10 year, 1% AEP (1 in 100 year) & 0.1% AEP (1 in 1000 year) fluvial flood zone.

The OPW South Eastern CFRAMS flood maps also provide information on predictive water levels and flows for the 10% AEP (1 in 10 year), 1% AEP (1 in 100 year), and 0.1% AEP (1 in 1000 year) fluvial flood events at various hydrological estimate points, or node points. The node points closest to the location of the proposed outfall pipe and associated headwall are referenced as node points 14BARO08828, 14BARO08858 and 01CARL00044 as illustrated in *Figure 10* above.

Details of the predictive fluvial flood levels and flows for the OPW CFRAMS node points in the general vicinity of the location of the proposed outfall pipe and associated headwall are listed in *Table 2* below, which has been extracted from the OPW South Eastern CFRAMS flood map *O14CAR_EXFCD_F0_15.*

Node Label	Water Level (m OD) 10% AEP	Flow (m^3/s) 10% AEP	Water Level (m OD) 1% AEP	Flow (m^3/s) 1% AEP	Water Level (m OD) 0.1% AEP	Flow (m^3/s) 0.1% AEP
14BARO08828	45.62	195.94	46	276.86	46.42	387.05
14BARO08858	45.67	N/A	46.06	N/A	46.48	N/A
01CARL00044	45.82	N/A	46.17	N/A	46.60	N/A

Table 2- OPW South Eastern CFRAMS Predicted Fluvial Flood Levels

The OPW South Eastern CFRAMS maps also provide information on predictive flood water depths. *Figure 11*, *Figure 12,* and *Figure 13* below, duplicated from OPW CFRAMS flood map numbers *O14CAR_DPFCD100_F0_15*, *O14CAR_DPFCD010_F0_15,* and *O14CAR_DPFCD001_F0_15,* illustrates the predictive flood depths for the location of the proposed outfall pipe and associated headwall in consideration of the 10% AEP (1 in 10 year), 1% AEP (1 in 100 year) and 0.1% AEP (1 in 1000 year) fluvial flood events, respectively.

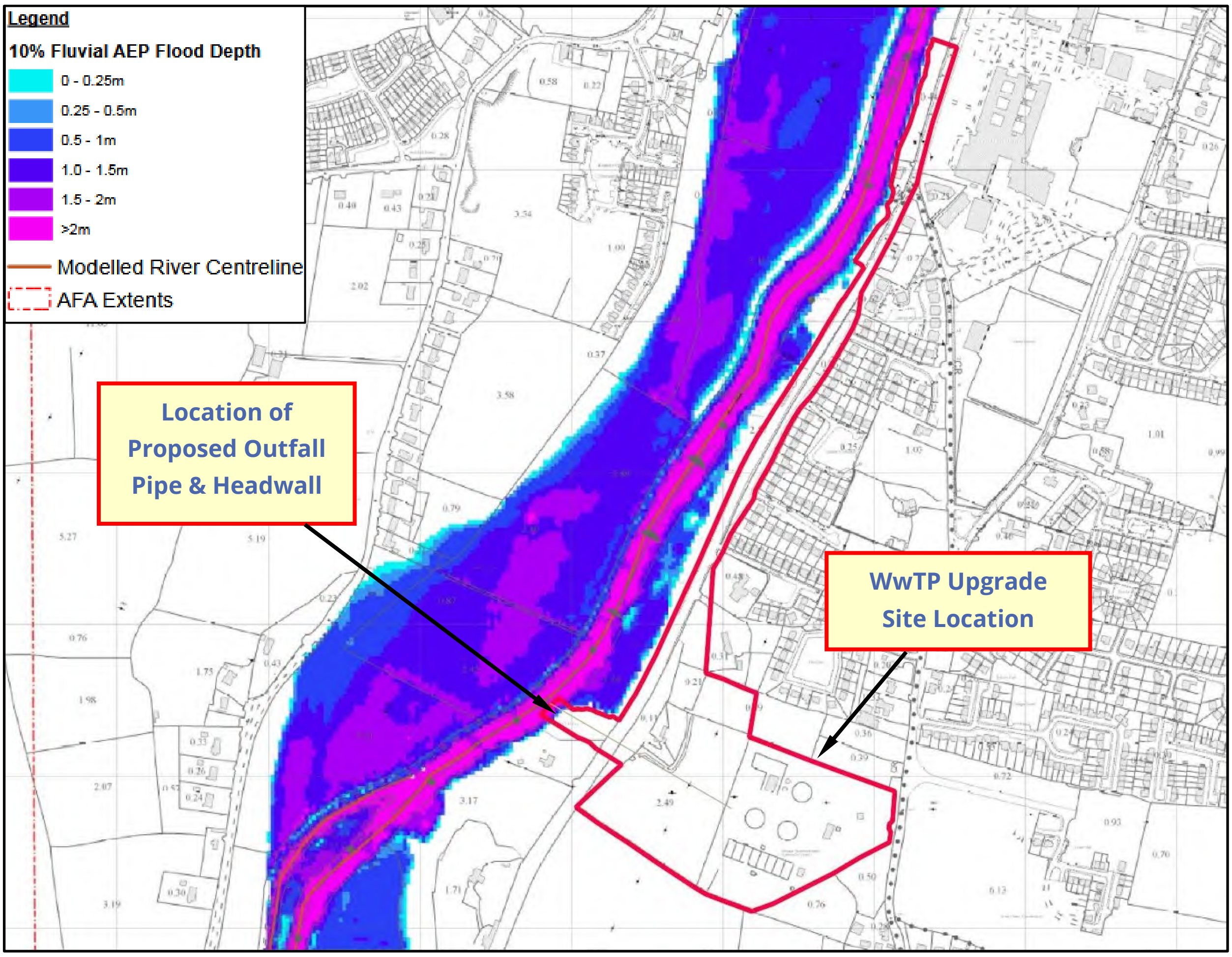


Figure 11 – OPW South Eastern CFRAMS 10% AEP Fluvial Flood Depth Mapping

Figure 11 above indicates that the location of the proposed outfall pipe and associated headwall falls within a predictive 10% AEP (1 in 10 year) fluvial flood zone, with predictive flood depths in the range of 0.25m - >2m at this location.

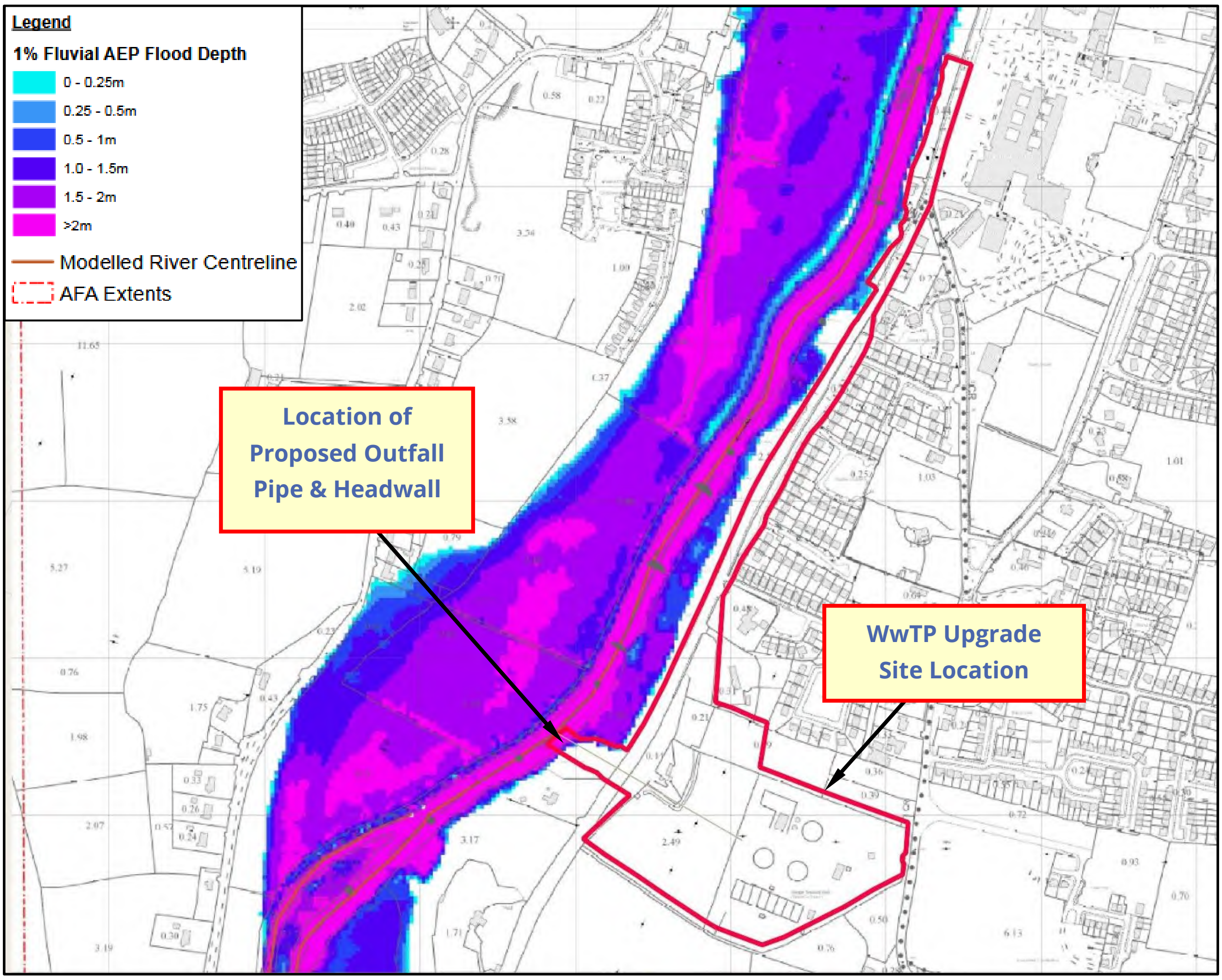


Figure 12 – OPW South Eastern CFRAMS 1% AEP Fluvial Flood Depth Mapping

Figure 12 above indicates that the location of the proposed outfall pipe and associated headwall falls within a predictive 1% AEP (1 in 100 year) fluvial flood zone, with predictive flood depths in the range of 0.5m - >2m at this location

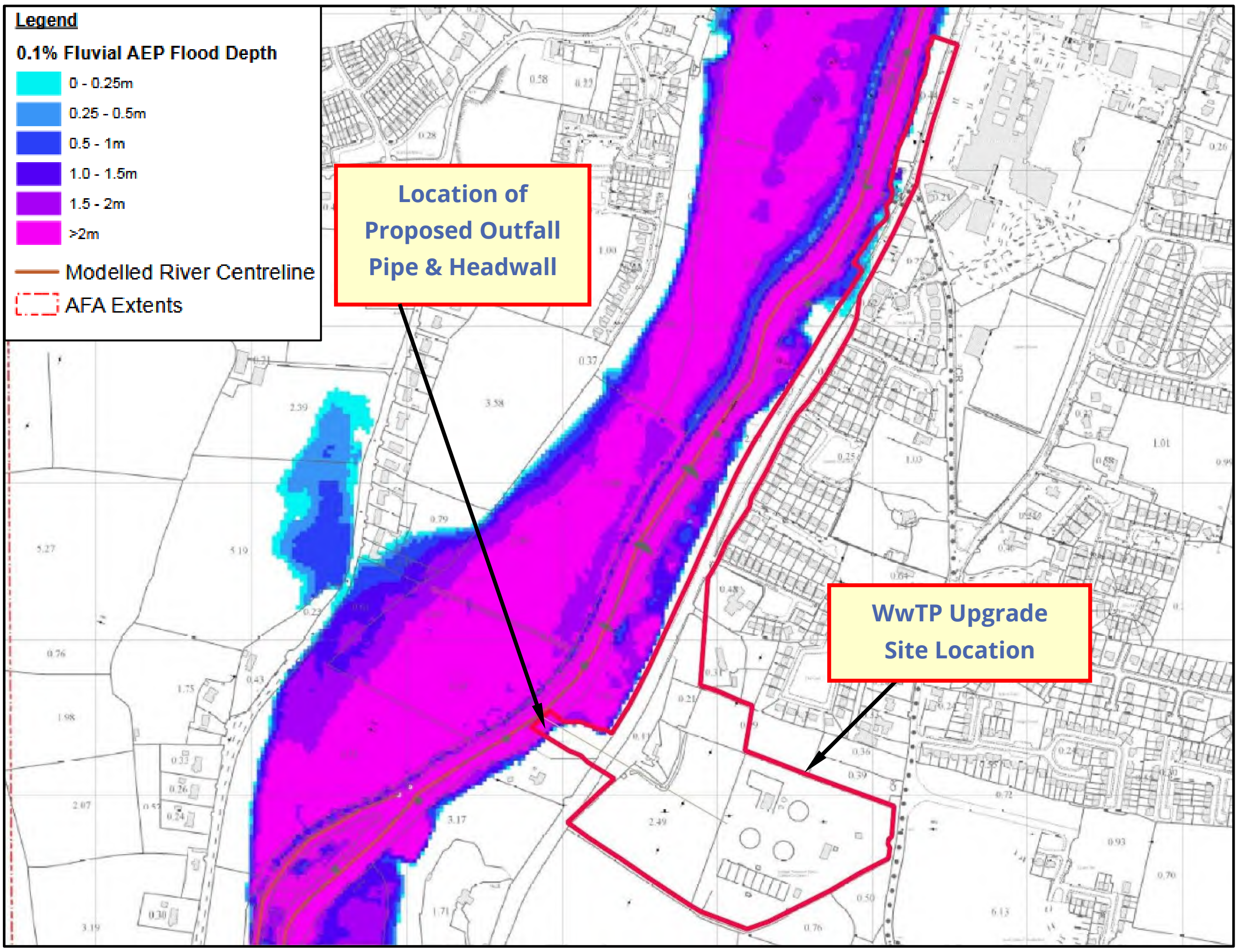


Figure 13 – OPW South Eastern CFRAMS 0.1% AEP Fluvial Flood Depth Mapping

Figure 13 above indicates that the location of the proposed outfall pipe and associated headwall falls within a predictive 0.1% AEP (1 in 1000 year) fluvial flood zone, with predictive flood depths in the range of 0.5m - >2m at this location.

The OPW South Eastern CFRAM flood maps are predictive flood maps, in that they provide predicted flood extent and depth information for a 'design' flood event that has an estimated probability of occurrence (e.g., the 1% AEP event), rather than information for floods that have occurred in the past.

4.7.1. OPW South Eastern CFRAMS – Climate Change

The OPW South Eastern CFRAMS fluvial flood extents maps are based on the present-day scenario and do not provide information or data in relation to potential climate change fluvial flood extents or flood levels. The OPW WMS resource was therefore utilised to assess the potential mid-range future climate change scenario fluvial flood extents and flood levels at and in the general location of the proposed outfall pipe and associated headwall.

Figure 14 below illustrates the predictive mid-range future climate change scenario 1% AEP + CC (1 in 100 year + climate change) fluvial flood extents in the vicinity of the location of the proposed outfall pipe and associated headwall as acquired from the OPW WMS resource.

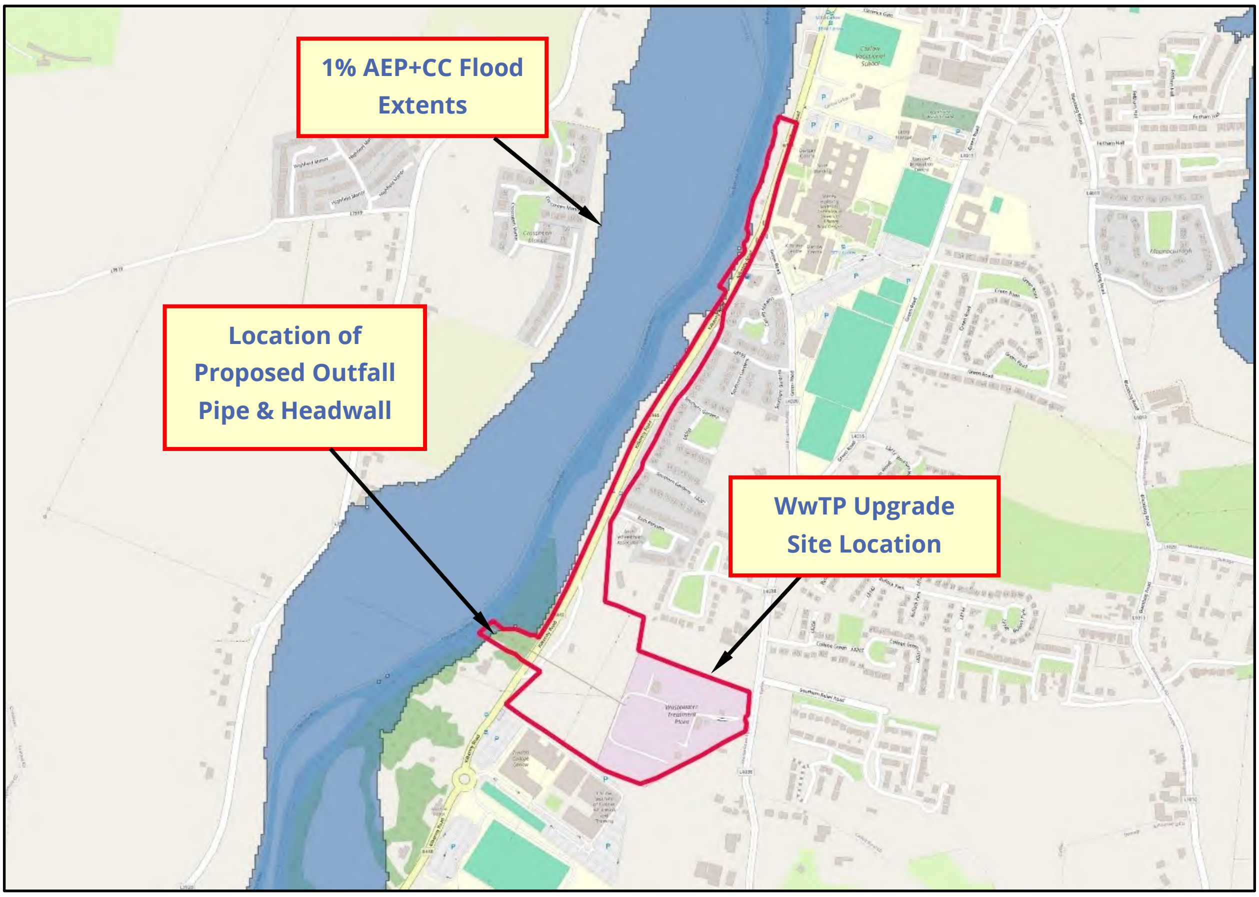


Figure 14 – Mid-Range Future Climate Change Scenario Flood Extent Mapping

Figure 14 above indicates that the location of the proposed outfall pipe and associated headwall falls within a mid-range future climate change scenario 1% AEP + CC (1 in 100 year + climate change) fluvial flood zone.

4.8. Carlow County Development Plan (2022 – 2028) – Draft Strategic Flood Risk Assessment (SFRA)

Figure 15 below, was extracted from the Carlow County Development Plan (2022– 2028) and illustrates the draft strategic flood risk assessment map in the vicinity of the location of the proposed outfall pipe and associated headwall.

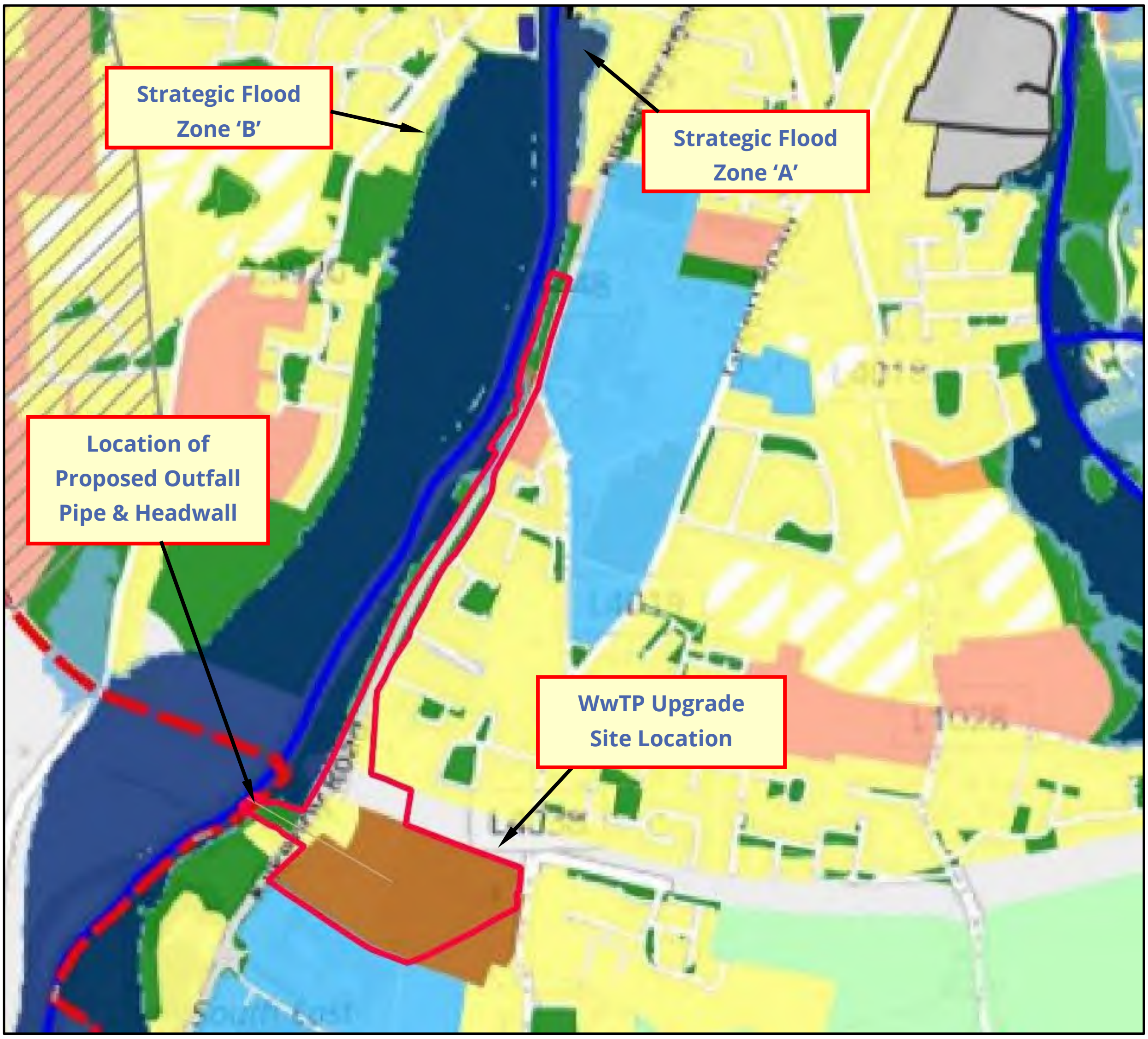


Figure 15 – Carlow County Development Plan - Draft Strategic Flood Risk Assessment Map

Figure 15 above indicates that the location of the proposed outfall pipe and associated headwall falls within a Strategic Flood Zone 'A' and Flood Zone 'B'. It is noted that flood zone delineation illustrated on this map is a duplication of the OPW CFRAMS 1% AEP (1 in 100 year) and 0.1% AEP (1 in 1000 year) fluvial flood extents at this location (*Figure 9* above).

5. Scoping Assessment

The purpose of the scoping stage is to identify possible flood risks and to implement the necessary level of detail and assessment to assess these possible risks, and to ensure these can be adequately addressed in the flood risk assessment. The scoping exercise should also identify that sufficient quantitative information is already available to complete a flood risk assessment appropriate to the scale and nature of the development proposed.

In specific consideration of the OPW South Eastern CFRAMS predictive flood mapping for the area, the above screening assessment indicates that the location of the proposed outfall pipe and associated headwall falls within an predictive extreme 10% AEP (1 10 year), 1% AEP (1 in 100 Year), and 0.1% AEP (1 in 1000 Year) fluvial flood extent. The screening assessment indicates that the location of the proposed outfall pipe and associated headwall is not at risk of groundwater flooding or pluvial flooding.

In consideration of the information collated as part of the screening exercise, and the availability of other information and data specific to the proposed outfall pipe and associated headwall it is considered that sufficient quantitative information to complete an appropriate flood risk assessment cannot be derived from the information collated as part of the screening exercise alone.

In particular, the potential impact of the proposed outfall pipe and associated headwall to the existing hydrological regime of the area needs to be analysed, quantified, and assessed in greater detail. In this regard it is required to undertake a more detailed and robust comparative analysis of the fluvial flood regime at and in the vicinity of the location of the proposed outfall pipe and associated headwall in consideration of the existing undeveloped scenario and the proposed development scenario.

The specific flood risk to and from the proposed outfall pipe and associated headwall is assessed in the subsequent 'Assessing Flood Risk' stage of this study report.

6. Assessing Flood Risk

Flood risk from a particular watercourse is normally assessed for a 1% AEP (1 in 100 year) and 0.1% AEP (1 in 1000 year) flood event, in accordance with most county development plans and in accordance with the DoEHLG guidelines 'The Planning System and Flood Risk Management Guidelines'.

The following sections present an analysis and assessment of the predictive 1% AEP (1 in 100 year) and 0.1% AEP (1 in 1000 year) fluvial flood event in the River Barrow at and in the vicinity of the location of the proposed outfall pipe and associated headwall.

6.1. Peak Flow Estimation

6.1.1. Selection of Hydrological Estimation Point (HEP)

In order to provide an estimation of extreme fluvial flood flows in the River Barrow at the location of the proposed outfall pipe and headwall, a suitable hydrological estimation point (HEP) must be selected. To best represent the hydrological flows in the River Barrow, an HEP was selected close to the location of the proposed outfall pipe and associated headwall. The location of the selected HEP was obtained from the OPW Flood Estimation Package and is illustrated below in *Figure 16.*

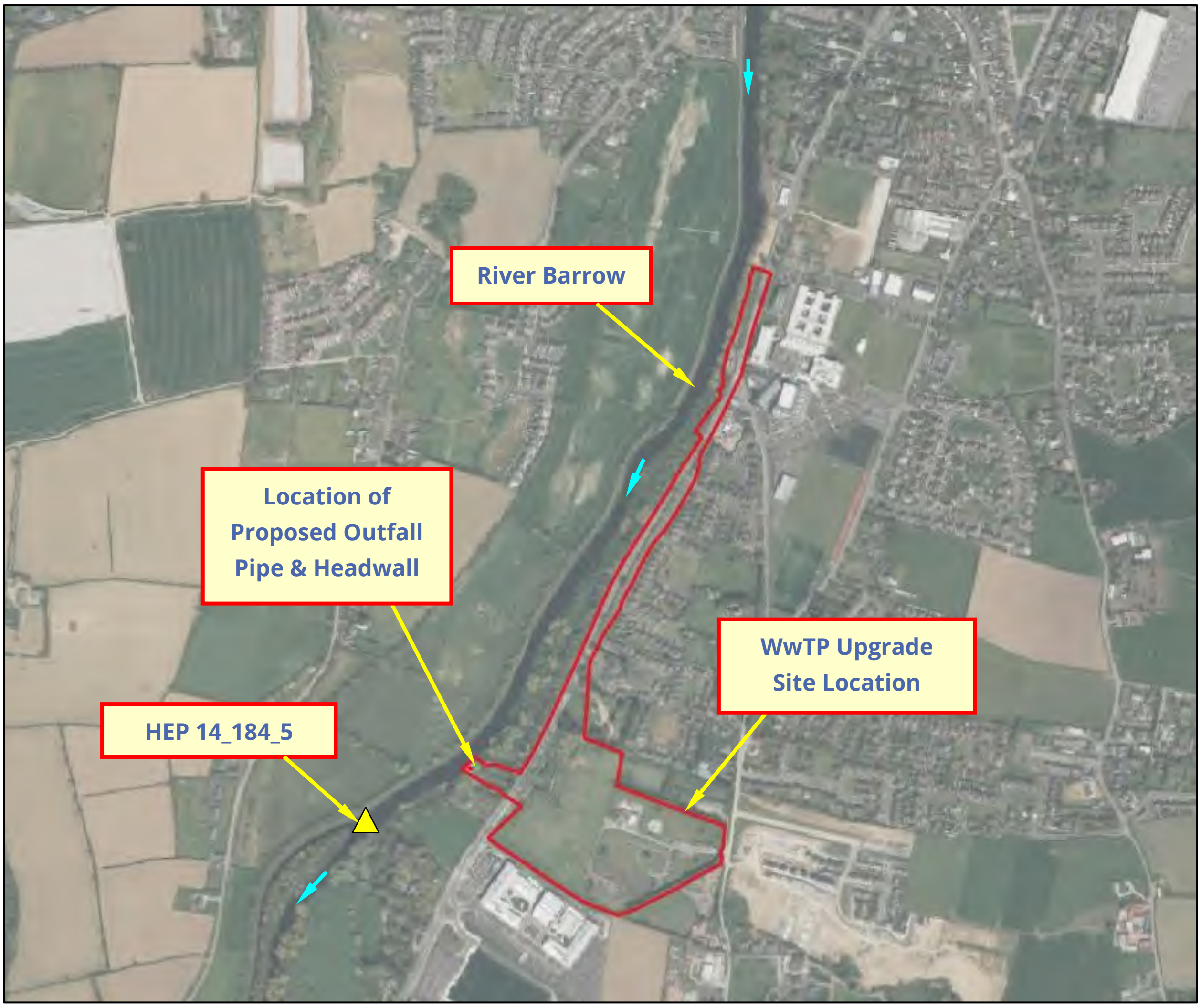


Figure 16 – Hydrological Estimation Point

6.1.1. Catchment Descriptors

Catchment descriptors for the HEP (14_184_5) illustrated in *Figure 5* above were acquired from the OPW Flood Estimation Package and were then reviewed. The catchment descriptors for the selected HEP are listed below in *Table 3.*

Catchment Descriptor	HEP 14_184_5
Area (km^2)	2275.88
FARL	0.999
S1085 (m/km)	0.56446
DRAIND (km/km^2)	0.666

Catchment Descriptor	HEP 14_184_5
ARTDRAIN2	0
BFISOIL	0.66
SAAR (mm)	857.44
URBEXT	0.0181

Table 3 - Catchment Descriptors at HEP 14_184_5

6.1.2. Estimation of Rural Q_{MED}

The OPW South Eastern CFRAMS Hydrology Report was examined to determine the methodology used to derive the 1% AEP (1 in 100 year) and 0.1% AEP (1 in 1000 year) flow rates associated with the River Barrow at this location.

The report states that the OPW Flood Studies Update (FSU) methodology was utilised to determine the peak flow within ungauged catchments. From this review the hydrological methods applied in the OPW South Eastern CFRAMS were deemed suitable for this SSFRA. No suitable hydrometric gauges are located in close proximity to the location of the proposed outfall pipe and associated headwall and from which an estimate of flood flows can be extrapolated. Therefore the 7-parameter QMED equation was applied to the HEP. This equation is listed below (*Equation 1*).

$$QMED_{rural} = 1.237x10^{-5}\ AREA^{0.937}\ BFIsoils^{-0.922}\ SAAR^{1.306}\ FARL^{2.217}\ DRAIND^{0.341}\ S1085^{0.185}\ (1+ARTDRAIN2)^{0.408}$$

Equation 1 - QMED Equation

The catchment descriptors for the HEP selected are listed above in *Table 3*. The resultant QMED value is listed in *Table 4* below:

	The River Barrow Flow (m³/s) at HEP 14_184_5
Rural QMED (m³/s)	130.517

Table 4 - QMED values at HEP

6.1.3. Pivotal Site Selection

No suitable hydrologically similar pivotal sites lie immediately upstream or downstream of the selected HEP. Therefore, the River Barrow is treated as an ungauged catchment at this location. A pivotal site is selected from a donor catchment based on hydrological similarity utilising the OPW FSU Flood Estimation Package. Of the possible donor pivotal sites, OPW FSU Station 14022 –Barrow New Bridge gauge was chosen as the most suitable pivotal sites due to the geographical and hydrological closeness to the subject site. OPW FSU station 14022 Barrow New Bridge gauge was also selected in the OPW South Eastern CFRAM study to calculate the relevant adjustment factor. The OPW South Eastern CFRAM Study developed a catchment run-off model (NAM) to develop an updated gauged QMED value as the original gauged QMED value was deemed to have a high level of uncertainty. The NAM model (Nedbor-Afstromings Model) is a module of the modelling software MIKE 11, which is capable of simulating river flow data based on input rainfall data. As a part of the OPW South Eastern CFRAM study the NAM model simulated flow at OPW FSU Station 14022 – Barrow New Bridge gauge based on the surrounding historic rainfall data from gauges and calculated an updated gauged QMED value of 126.8m^3/s. The calculated QMED value based on catchment descriptors (Equation 1) was calculated at the OPW FSU station 14022 Barrow New Bridge gauge and was then divided by the updated gauged QMED value to determine the adjustment factor. Finally the adjustment factor was applied to the subject site QMED value at HEP 14_184_5 to determine the adjusted rural QMED. The adjusted rural QMED value is listed below in *Table 5*.

	The River Barrow Flow (m^3/s) at HEP 14_184_5
Unadjusted QMED (m^3/s)	130.517
Adjustment Factor	1.029
Adjusted QMED (m^3/s)	134.33

Table 5 - Adjusted Rural QMED

6.1.4. Urbanisation

The effects of urbanisation can have a major impact on flood events. An increase in urbanisation normally results in a corresponding increase in surface runoff volumes due to more impervious surfaces and an increase in the speed of response. To account for this urbanisation an Urban Adjustment Factor (UAF) was calculated using the equation listed below as *Equation 2* and which is sourced from the OPW FSU Work Package 2.2 report (OPW 2009).

$$UAF = (1 + URBEXT)^{1.482}$$

Equation 2 - Urban Adjustment Factor Equation

The UAF and the corresponding urbanised QMED is listed below in *Table 6*.

	River Barrow Flow (m³/s) at HEP 14_184_5
Rural QMED (m³/s)	134.33
UAF	1.027
Urban QMED (m³/s)	137.95

Table 6 - Urban QMED Values

6.1.5. Growth Factors

In order to estimate the 1% AEP (1 in 100 year) and 0.1% AEP (1 in 1000 year) peak flows in the River Barrow at this location, growth factors were derived using the same values applied to the OPW South Eastern CFRAM study. The growth factors from the OPW South Eastern CFRAMS study were calculated utilising a regional pooling group method and applying the Generalised Extreme Value (GEV) statistical distribution method. The resultant growth factors for the River Barrow are listed below in *Table 7*.

Annual Exceedance Probability / AEP (%)	Growth Factors
1% (1 in 100 year)	2.005
0.1% (1 in 1000 year)	2.758

Table 7 - River Barrow Growth Factors

The final peak model flows for this assessment are listed below in *Table 8.* These flows were derived by multiplying the growth factors illustrated above in *Table 7* for the River Barrow with the adjusted QMED values as listed in *Table 6* above.

HEP	Final Peak Model Flows (m^3/s)	
	AEP 1% (1 in 100 year)	AEP 0.1% (1 in 1000 year)
HEP 14_184_4	276.59	380.466

Table 8 - River Barrow 1% AEP & 0.1% AEP Peak Flows

6.1.6. Climate Change

Flooding is a natural process that can occur from a range of sources at any time in a wide variety of locations. Flooding can impact on people, communities, property, infrastructure, economy, environment, and our cultural heritage. It is likely that severe weather events and sea level rise due to climate change will have a considerable impact on flooding and flood risk in Ireland.

To assess the impacts of climate change on the proposed development the Climate Change Sectoral Adaptation Plan was inspected. This Plan considers the impacts of climate change on flooding and flood risk, as well as on flood risk management and what adaptation actions are required to ensure effective and sustainable management of flood risk into the future.

There are a variety of projections which quantify the impacts of climate change in the future. For this assessment the Mid-Range Future Scenario (MRFS) was applied to the predictive 1% AEP (1 in 100 year) fluvial flow. The MRFS was selected as it represents the typical or near to the general average future climate projections. It is also the typical climate change scenario which is used in most flood risk assessments throughout Ireland.

The guidelines recommend that based on the MRFS projection a 20% increase should be applied to the peak fluvial flood flow. These are listed below in *Table 9.*

HEP	1% AEP (1 in 100 year) Flow (m^3/s)	1% AEP + CC (1 in 100 year + Climate change) Flow (m^3/s)
River Barrow - HEP 14_184_4	276.59	331.91

Table 9 - Climate Change Flood Flows

6.1.7. Characteristic Hydrograph Transfer to Subject Site

The 1% AEP (1 in 100 year), 1% AEP + CC (1 in 100 Year + climate change) and 0.1% AEP (1 in 1000 year) peak flow hydrographs for the River Barrow at the HEP were derived utilising the OPW Flood Estimation Package.

The peak flows listed in *Table 10* below have subsequently been fitted onto the created hydrographs, as illustrated in *Figure 17* below.

Watercourse	1% AEP (1 in 100 Year) Flow (m^3/s)	1% AEP + CC (1 in 100 Year + Climate change) Flow (m^3/s)	0.1% AEP (1 in 1000 Year) Flow (m^3/s)
River Barrow - HEP 14_184_4	276.59	331.91	380.466

Table 10 - River Barrow 1% AEP, 1% AEP + CC, & 0.1% AEP Peak Flows

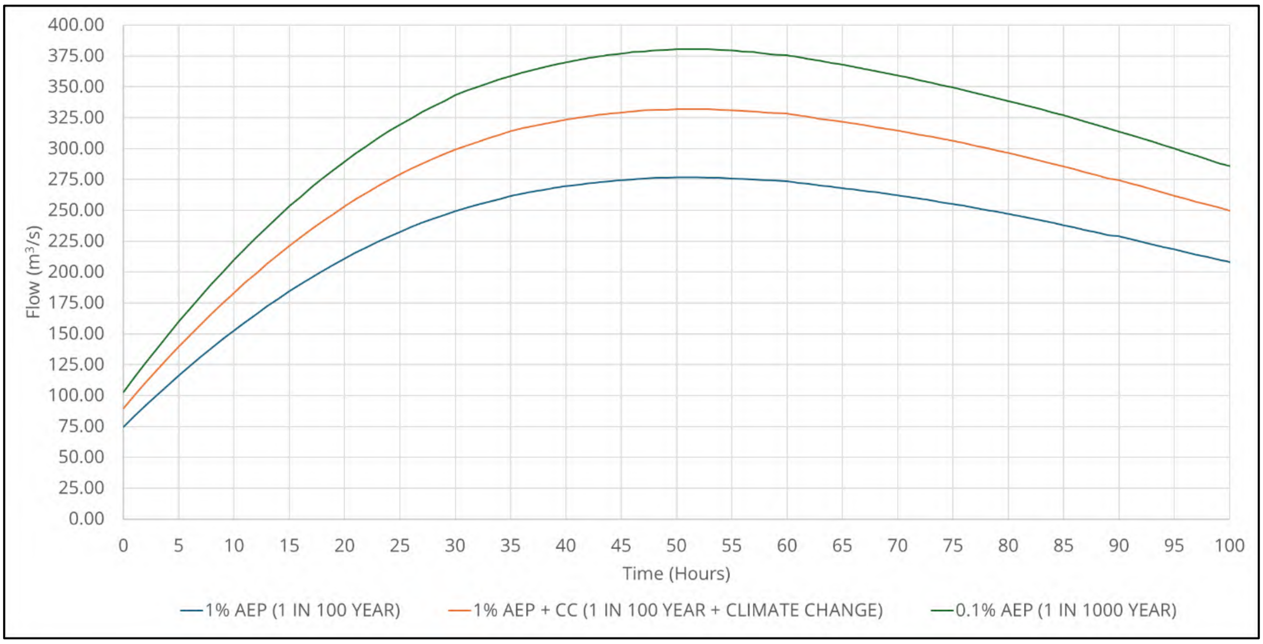


Figure 17 - River Barrow Flood Hydrographs

7. Hydraulic Modelling & Analysis

7.1. Introduction

A two dimensional (2D) hydraulic model was developed for the model reach length of the River Barrow at and in the general location of the proposed outfall pipe and associated headwall.

The purpose of developing a hydraulic model is to estimate flood water levels at specific locations along the modelled reach representing the existing river channel on the River Barrow. The hydraulic model developed is based on an appropriate computer software package that utilises topographical information about the river and flood plain geometry, the hydraulic resistance characteristics (Manning's 'n') of the river and flood plain and appropriate boundary conditions at the upstream and downstream extent of the proposed outfall pipe and associated headwall.

The extent of modelled watercourse reach length is illustrated in *Figure 18* below: -

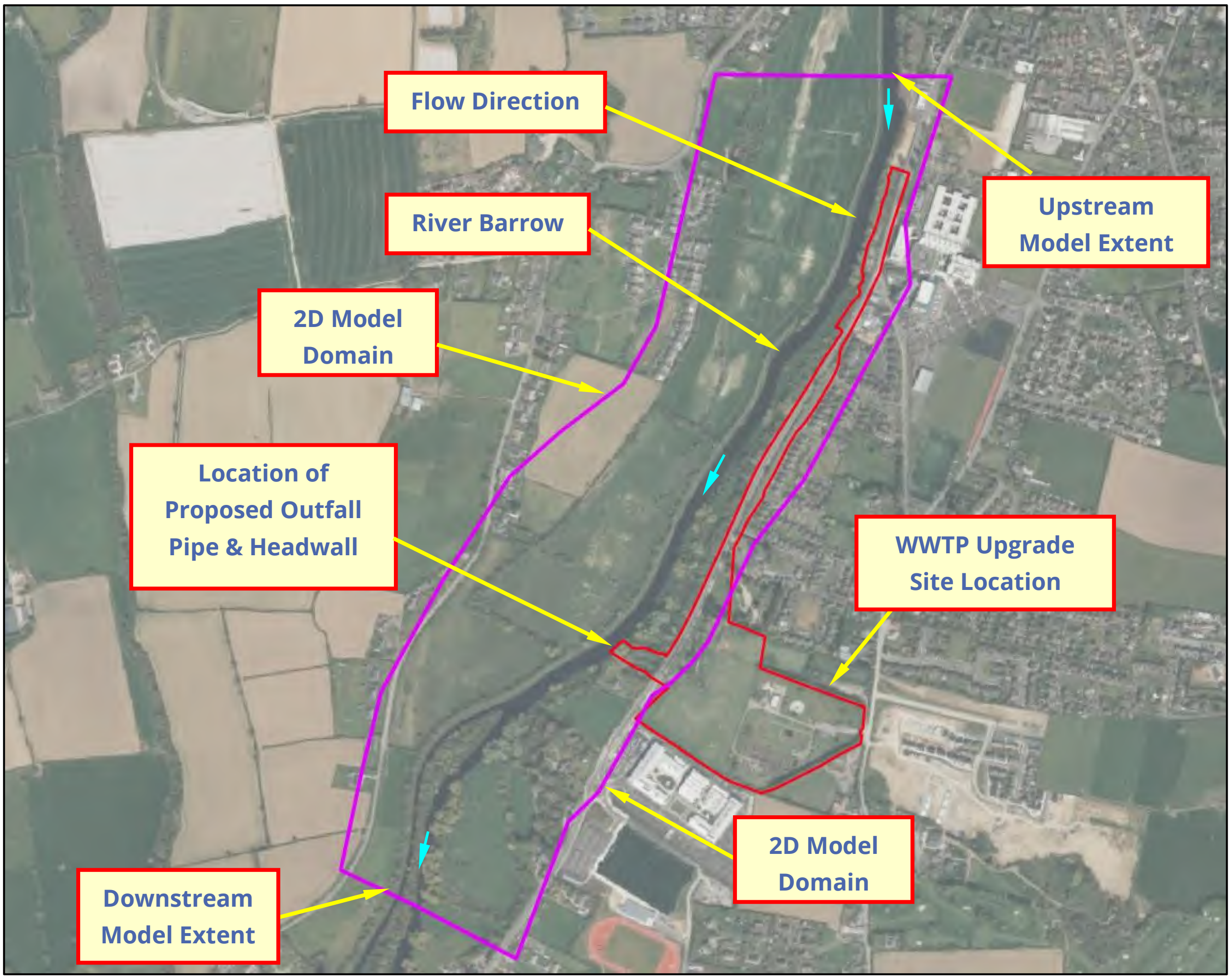


Figure 18 –River Barrow - Hydraulic Model Domain Extent

7.2. Hydraulic Model Selection

A number of hydraulic models are available which will predict flood levels for a given design flow. For this assessment the HEC-RAS hydraulic modelling package was employed. The HEC-RAS modelling package was selected for this assessment as it allows for two-dimensional (2D) modelling of steady and unsteady state flow profiles and thematic mapping of flood plains and overland flow paths when required. It is well regarded for use in the application of river and flood plain modelling in both Ireland and the UK. The model type utilised is a 2D model where the main channel of River Barrow and the left and right overbank lands is represented in the 2D domain.

7.3. Bathymetric Survey Data

High-resolution site-specific survey data was acquired of the River Barrow within the vicinity of the location of the proposed outfall pipe and associated headwall. The survey was gathered by Murphy Geospatial and consisted of detailed bed level data of the River Barrow, 130m upstream and downstream of the proposed outfall pipe and associated headwall. The survey was completed in accordance with a survey specification written by IE Consulting and provided to Murphy Geospatial. A copy of the survey is presented in *Appendix C*.

The DTM and contour mapping developed for the modelled area is illustrated in *Figure 19* below. The highly detailed bathymetric survey provided an extremely accurate representation of the River Barrow bed channel within the vicinity of the location of the proposed outfall pipe and associated headwall.

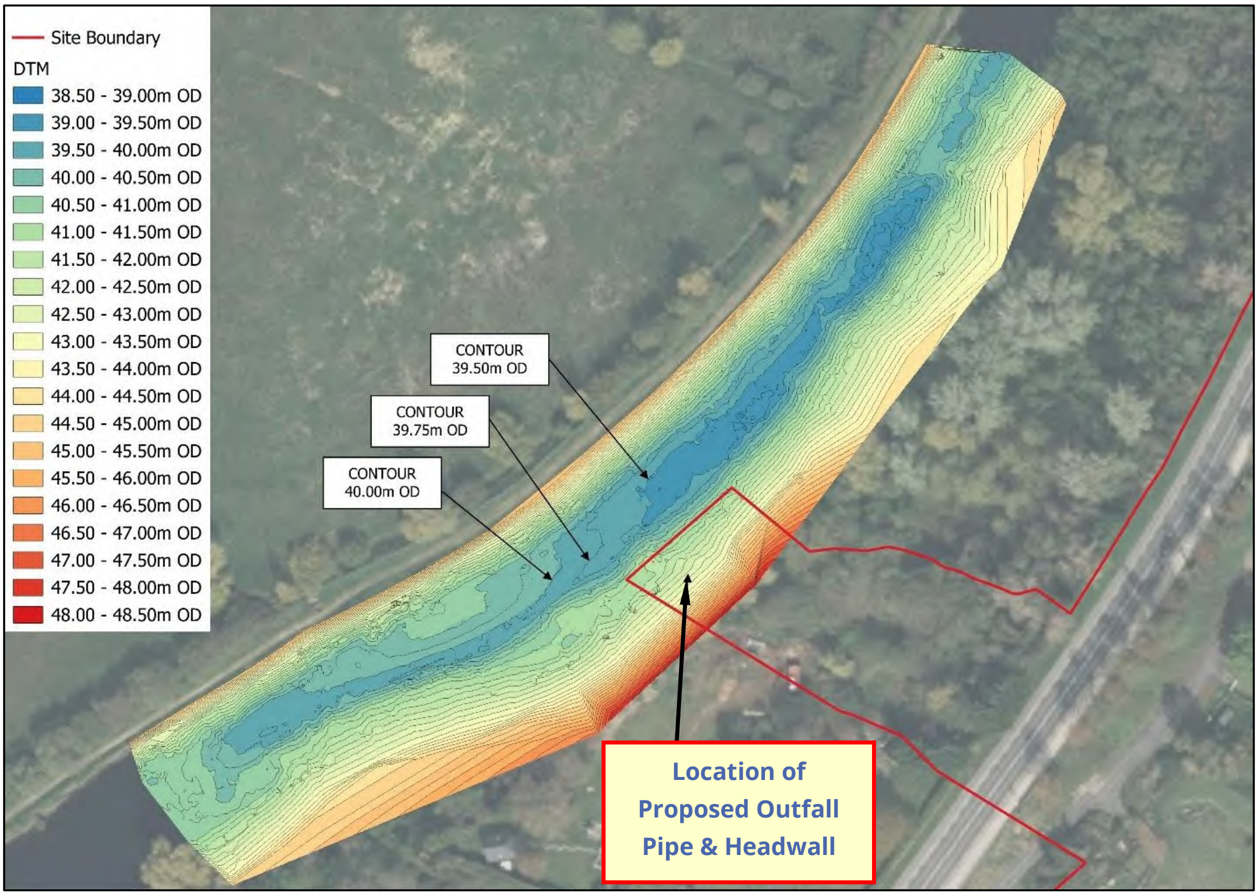


Figure 19 – River Topographic Survey - DTM and Contour Data

7.4. LiDAR Derived Digital Terrain Model & Contour Mapping

In order to assist the hydraulic modelling and analysis in the general area of the location of the proposed outfall pipe and headwall, and to enable an accurate representation of flood zone mapping and delineation to be developed, a detailed Digital Terrain Model (DTM) was developed for this location. From this data a detailed contour map was developed to encompass the area of the hydraulic model domain, including the area of the proposed outfall pipe and headwall, and surrounding lands.

The DTM and contour mapping was developed using aerial flown Light Detection & Ranging Data (LiDAR) which was commissioned by the OPW and acquired by Fugro in 2011. The LiDAR data was supplied in Irish Transverse Mercator (ITM) in TIF file format, at 2m resolution.

The DTM and contour mapping developed for the modelled area is illustrated in *Figure 20* below. The high-resolution river topographical survey discussed above in *Section 7.3* was also incorporated within this DTM.

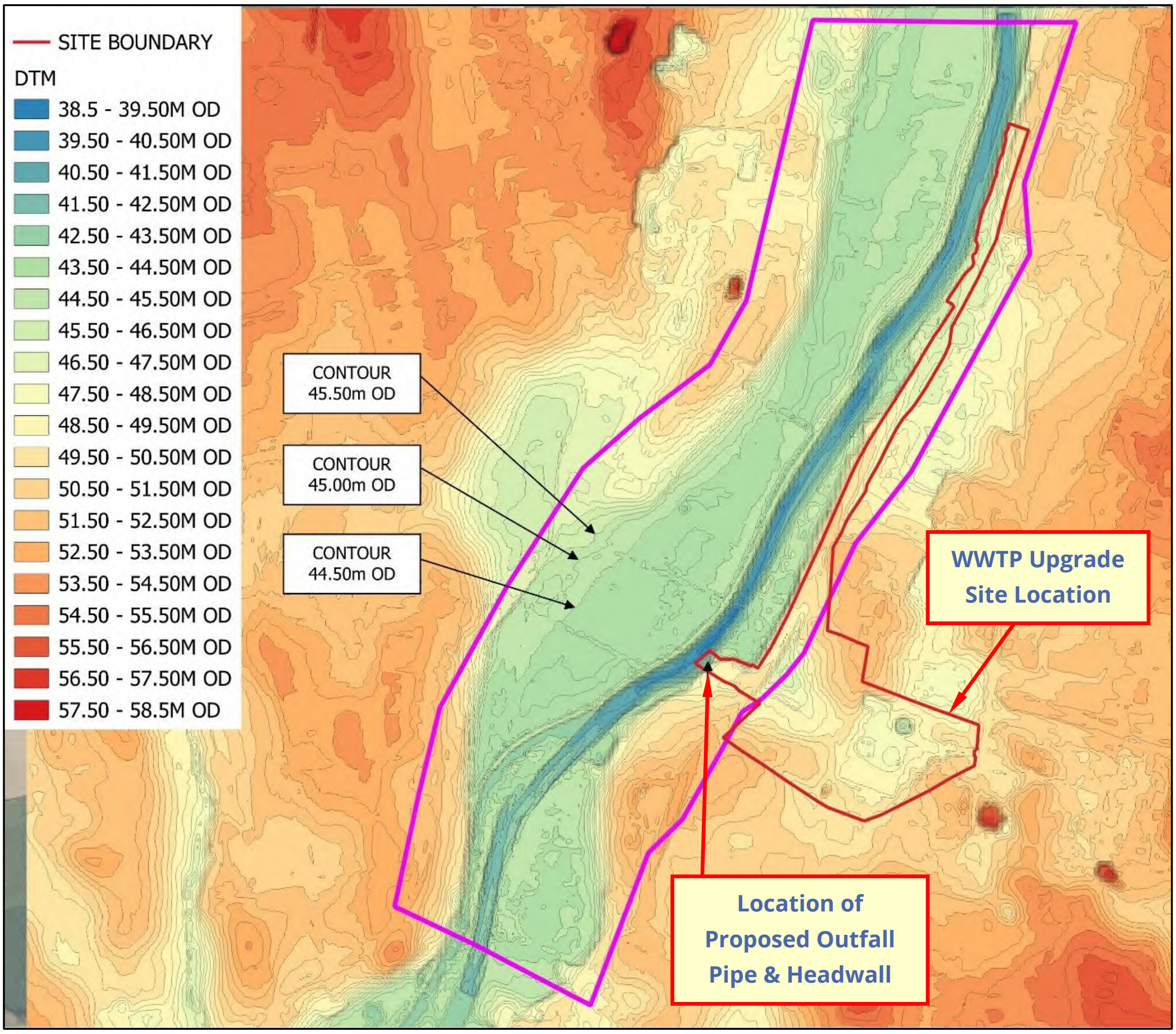


Figure 20 - DTM and Contour Data

7.5. River Channel & Flood Plain Roughness Co-Efficients

The Manning's 'n' coefficient represents the hydraulic resistance to flow of the river channel or flood plain. The Manning's 'n' coefficients chosen are estimated from a visual inspection of the river channel and associated flood plain lands. Guidance is available on selecting appropriate Manning's 'n' values (from Chow 1959, French 1986); however, the Manning's 'n' coefficients are usually subsequently refined upon the development of the model by calibrating with any historical flooding data in the area, if available.

Table 11 below lists recommended river channel overbank land roughness co-efficients for various vegetation types.

Type of Channel and Description	Minimum	Normal	Maximum
A. *Natural Streams*			
1. **Main Channels**			
a. Clean, straight, full, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. Same as "d" but more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy. deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stands of timber and brush	0.070	0.100	0.150
2. **Flood Plains**			
a. Pasture no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
2. Same as above, but heavy sprouts	0.050	0.060	0.080
3. Heavy stand of timber, few down trees, little undergrowth, flow below branches	0.080	0.100	0.120
4. Same as above, but with flow into branches	0.100	0.120	0.160
5. Dense willows, summer, straight	0.110	0.150	0.200

Table 11 - Manning's 'n' Values

With reference to *Table 11* above, varying roughness co-efficients were applied to the hydraulic model to reflect the type and form of vegetation observed during the survey of the River Barrow undertaken by a hydrological engineer from IE Consulting.

In respect of the main channel of the River Barrow an applied roughness co-efficient of 0.040 was utilised, reflecting a channel that is generally clean and straight with some limited areas of stones and weeds. An applied flood plain roughness co-efficient of 0.060 (light brush) were utilised along the left bank of the River Barrow. A roughness co-efficient of 0.045 (open fields of grass) was applied to the remainder of the model domain.

Figure 21 below illustrates the observed conditions along the modelled reach of the River Barrow.

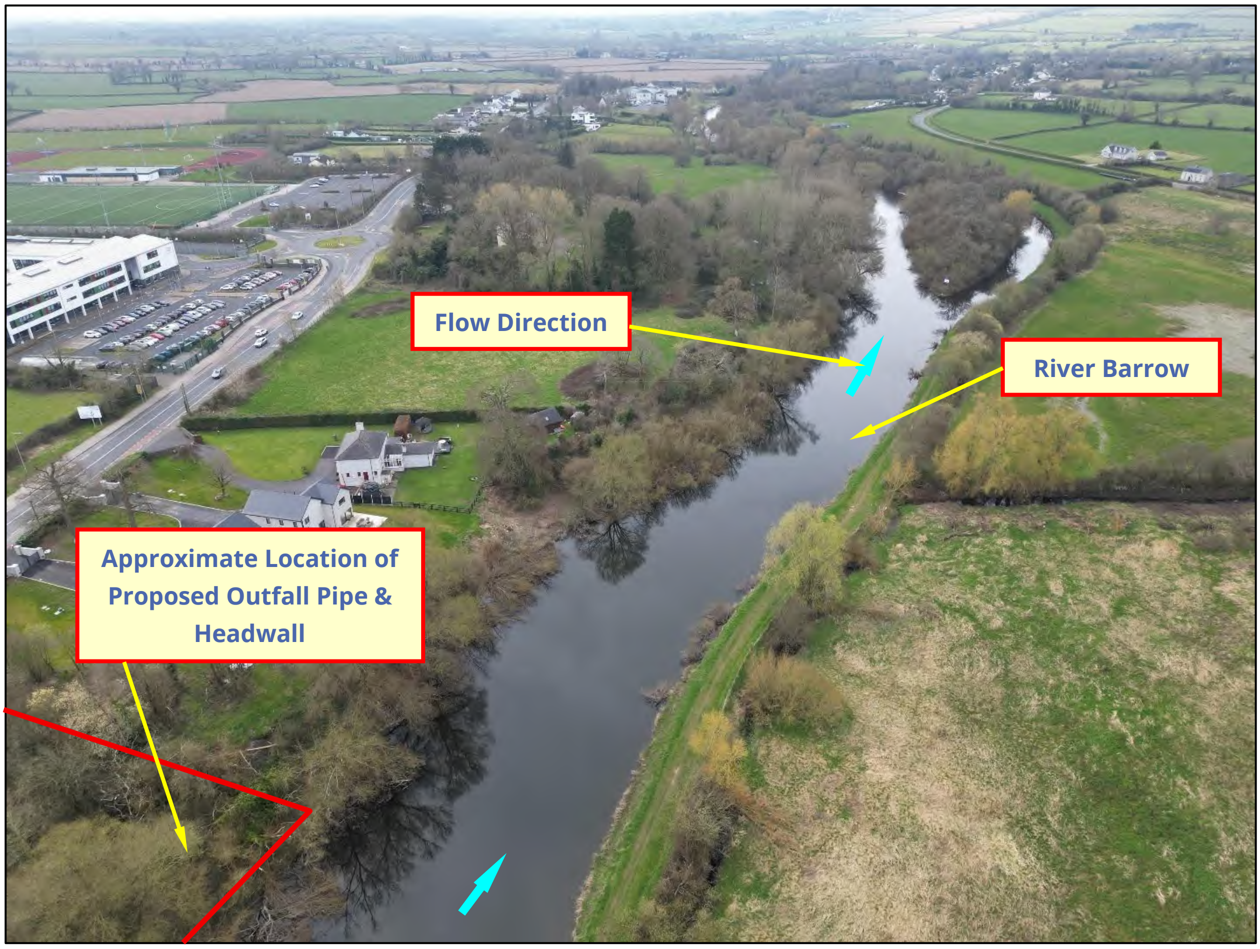


Figure 21 –River Barrow - Looking Downstream

As illustrated in *Figure 22* below, the roughness values in the 2D model domain was represented utilising a GIS shapefile. Different areas within the model domain have different roughness values based on the land use characteristic. The Geological Survey of Ireland CORINE dataset was utilised to confirm the underlying land use.

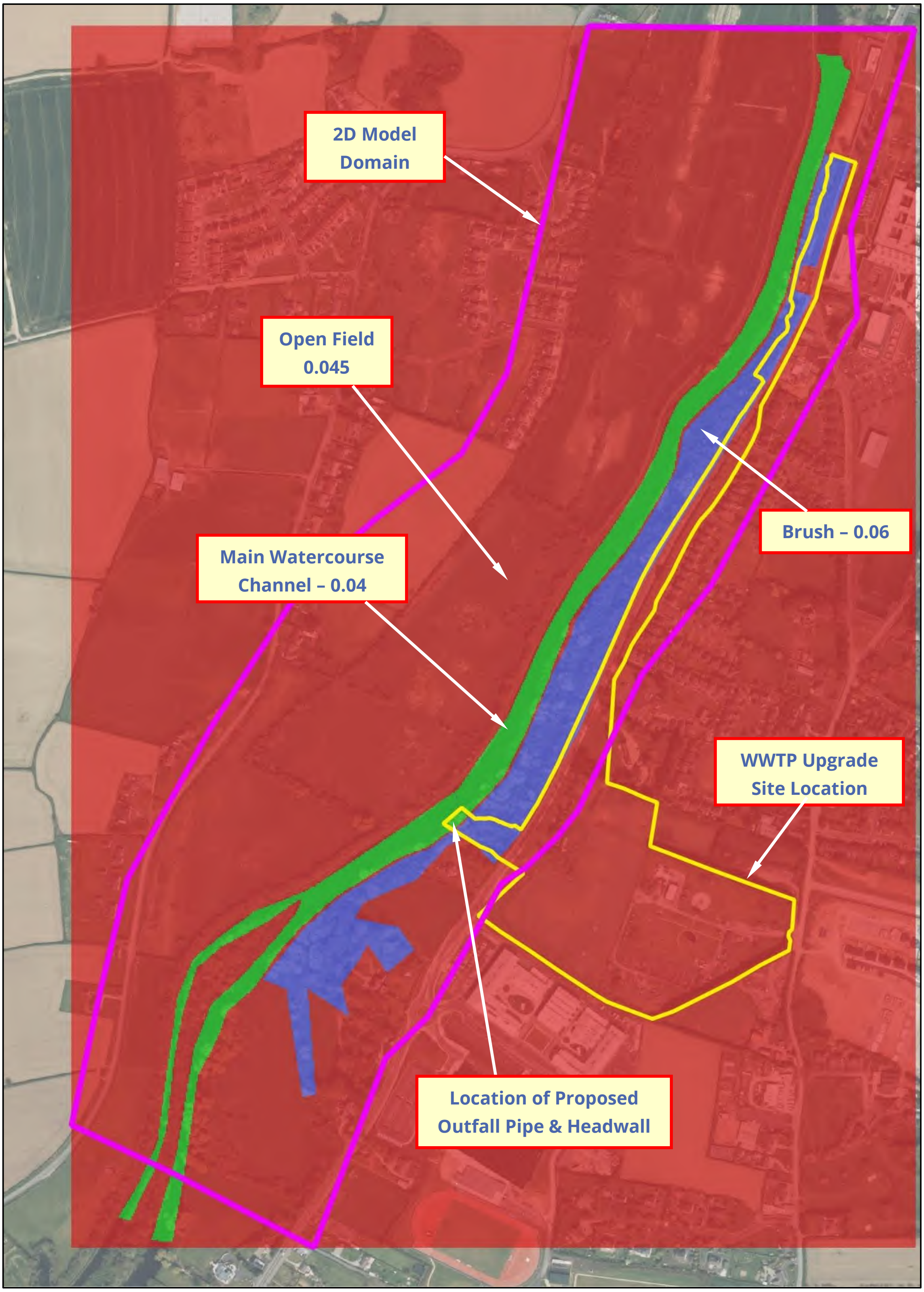


Figure 22 – 2D Roughness Values

7.6. Boundary Conditions

The model flows illustrated above in *Figure 17* were applied to the upstream model extents as a flow time boundary. The location of the upstream model boundary is illustrated below in *Figure 23.* The upstream model boundary is located approximately 1100m upstream of the location of the proposed outfall pipe and headwall.

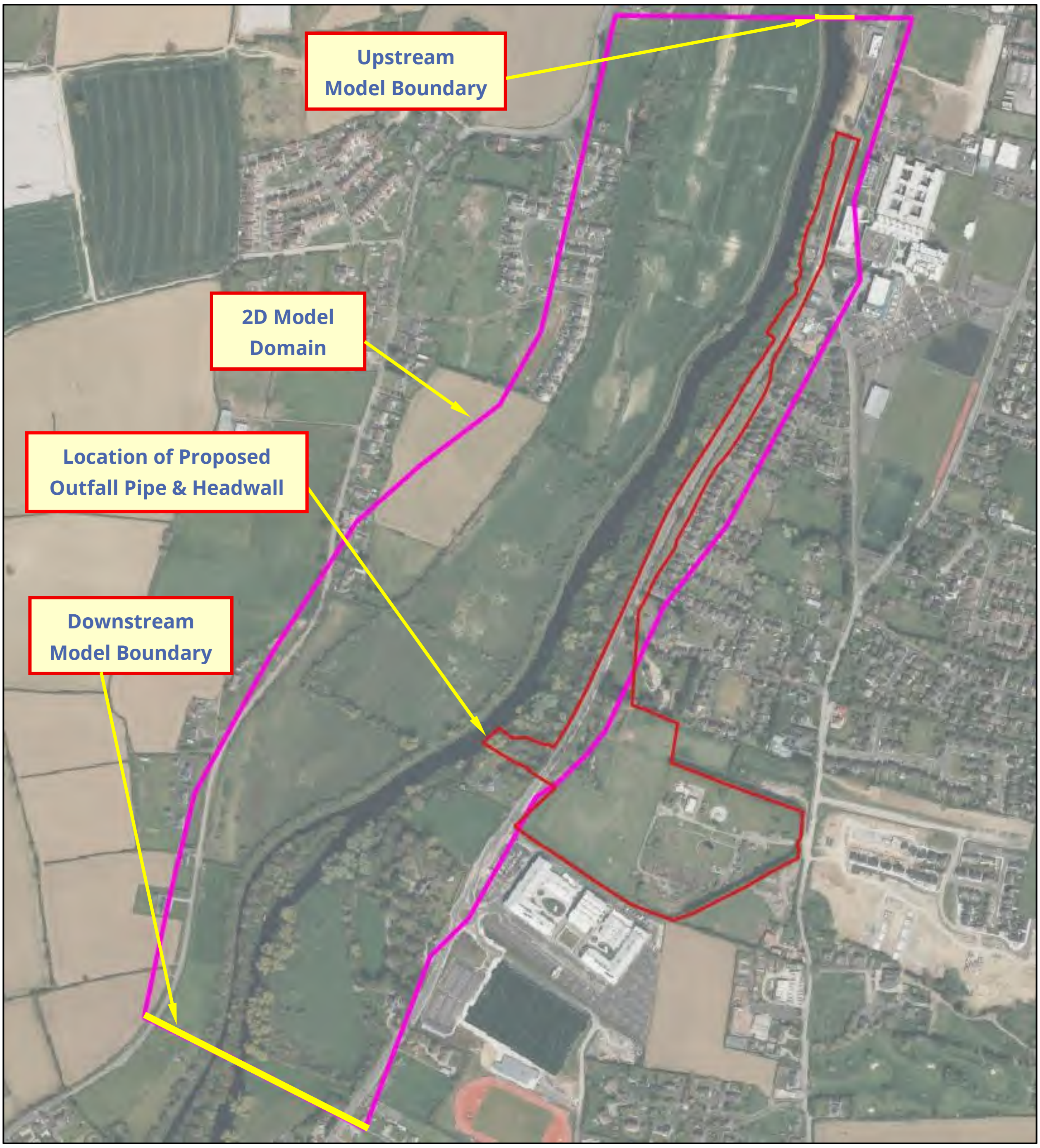


Figure 23 - Model Boundary Conditions

A normal depth boundary condition requiring a friction slope value (approximated to the downstream channel bed slope value) was used as the downstream boundary condition of the hydraulic model. This value was 0.000136 for the River Barrow and is located 680m downstream of the proposed outfall pipe and headwall. The location of both the upstream and downstream boundary conditions were selected to ensure they did not influence flood levels within the vicinity of the proposed outfall pipe and headwall. The model is also run for 1 hour before the main run to further reduce the potential influence of the boundary conditions.

7.7. Model Roughness Sensitivity Test

To assess the uncertainty related to the model roughness values selected above in *Section 7.5*, a sensitivity test was applied to the hydraulic model.

In order to determine the sensitivity of the hydraulic model to different roughness values, the roughness values illustrated above in *Figure 22* have been tested for two scenarios, a 20% increase to all roughness values and a 20% decrease to all roughness values in consideration of the baseline scenario 1% AEP (1 in 100 Year) fluvial flood event.

The output of the hydraulic simulation model indicates that a 20% reduction in roughness values results in a 0.21m decrease in 1% AEP (1 in 100 year) flood levels near to the location of the proposed outfall pipe & headwall, in comparison to the initial roughness values utilised, and as illustrated in *Figure 22* above. This 20% reduction in roughness values also results in a slight reduction in flood extents on the right overbank of the River Barrow, but had no significant or quantifiable notable impact on flood extents on the left overbank in the immediate area of the proposed outfall pipe and headwall.

Conversely, the output of the hydraulic simulation model indicates that a 20% increase in roughness values results in a 0.20 m increase in 1% AEP (1 in 100 year) flood levels near to the location of the proposed outfall pipe & headwall, in comparison to the initial roughness values utilised, and as illustrated in *Figure 22* above. This 20% increase in roughness values also results a minor increase in flood extents on the right overbank, but again, but have no significant or quantifiable notable impact on flood extents on the left overbank in the immediate area of the proposed outfall pipe and headwall. The output sensitivity testing and analysis indicates that the hydraulic model and resultant flood extents are not highly sensitive to changes or alterations in roughness values within the model domain. Therefore, the hydraulic model is considered to be robust and suitable for assessing the potential impact of the proposed outfall pipe and headwall.

8. Baseline Hydraulic Model Simulation Results

The hydraulic model was run in consideration of the predictive existing undeveloped baseline scenario 1% AEP (1 in 100 Year), 1% AEP + CC (1 in 100 Year + climate change) and 0.1% AEP (1 in 1000 Year) flood flows as presented in *Section 6.1* above.

Table 12 below summarises the predictive existing undeveloped baseline scenario 1% AEP (1 in 100 year), 1% AEP + CC (1 in 100 year + climate change) and 0.1% AEP (1 in 1000 year) fluvial flood levels at cross section locations D - G as outputted by the hydraulic simulation model.

The locations of these cross sections is illustrated below in *Figure 24.*

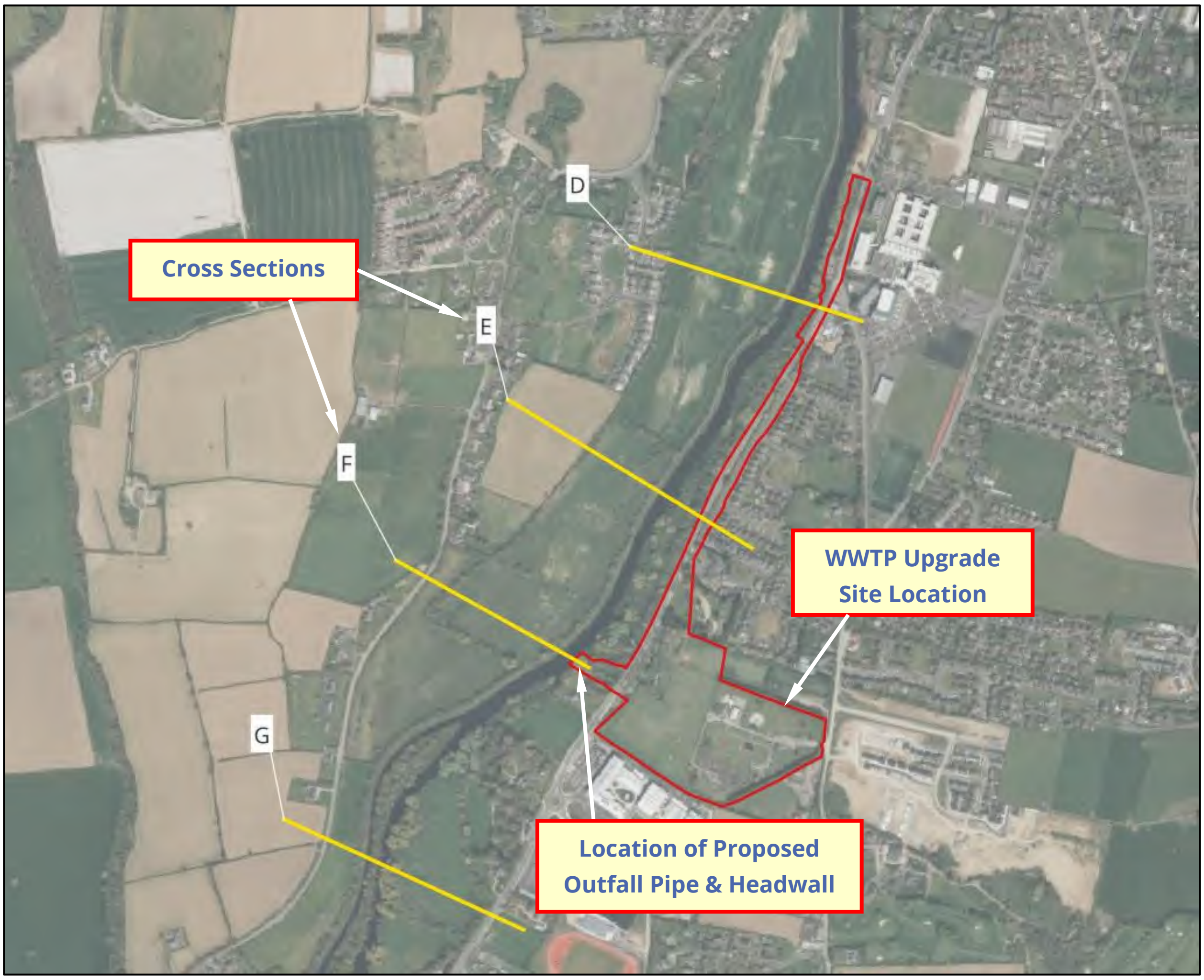


Figure 24 – Hydraulic Model Cross Section Locations

Cross Section Label	1% AEP Peak Flood Level (m OD)	1% AEP + CC Peak Flood Level (m OD)	0.1% AEP Peak Flood Level (m OD)
D	46.22	46.41	46.60
E	46.10	46.31	46.48
F	46.04	46.25	46.41
G	45.88	46.07	46.23

Table 12 – Predictive 1% AEP, 1% AEP+CC, and 0.1% AEP Peak Flood Levels- Baseline Scenario

Figure 25 below illustrates the longitudinal hydraulic model profile of the predictive existing undeveloped baseline scenario 1% AEP (1 in 100 year), 1% AEP + CC (1 in 100 year + climate change) and 0.1% AEP (1 in 1000 year) flood levels along the modelled reach of the River Barrow.

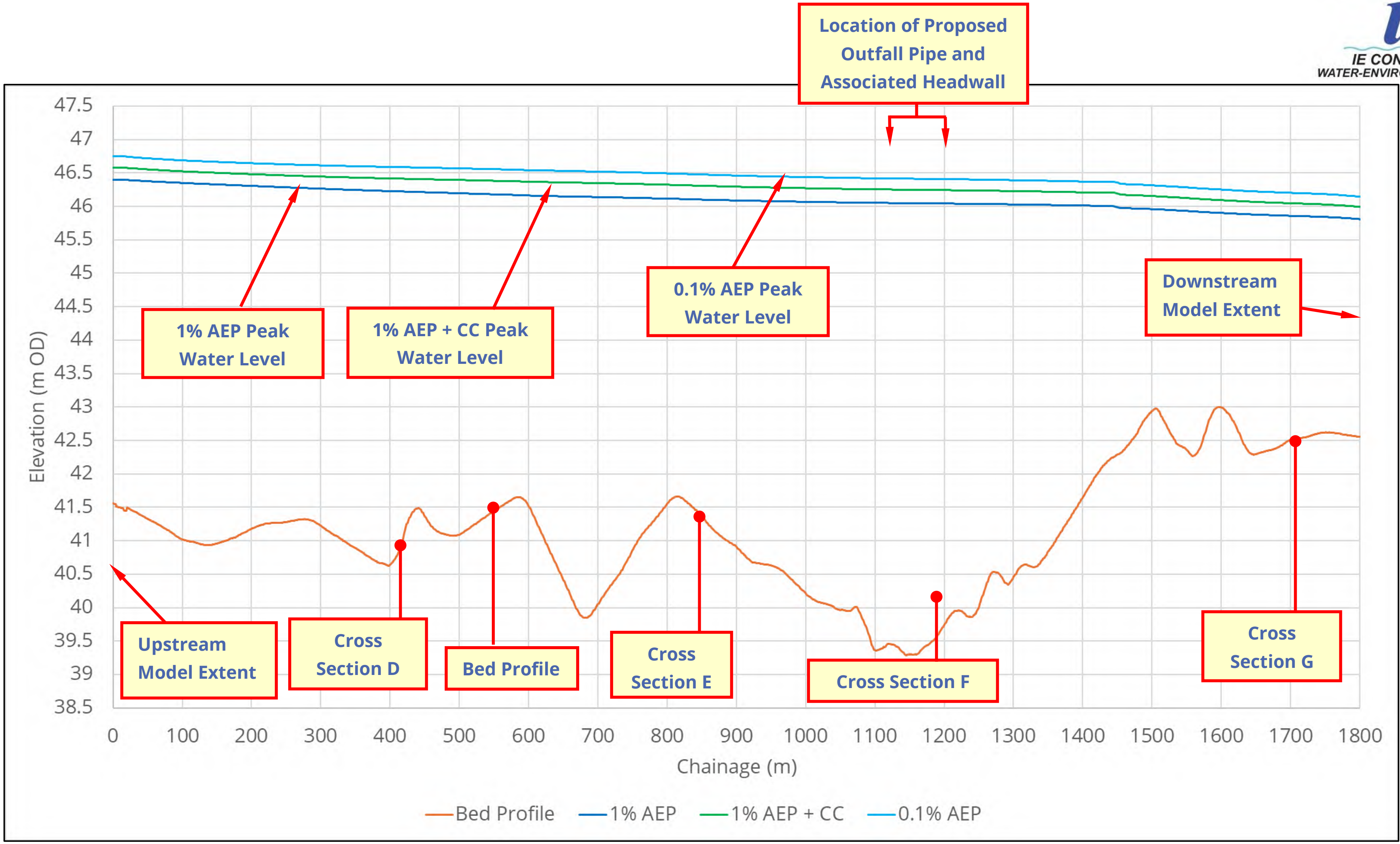


Figure 25 – River Barrow – Longitudinal Hydraulic Profile – Existing Undeveloped Baseline Scenario

Figure 24 below illustrates the predictive existing undeveloped baseline scenario 1% AEP (1 in 100 year) and 0.1% AEP (1 in 1000 year) fluvial flood extents along the modelled reach of the River Barrow as outputted by the hydraulic simulation model.

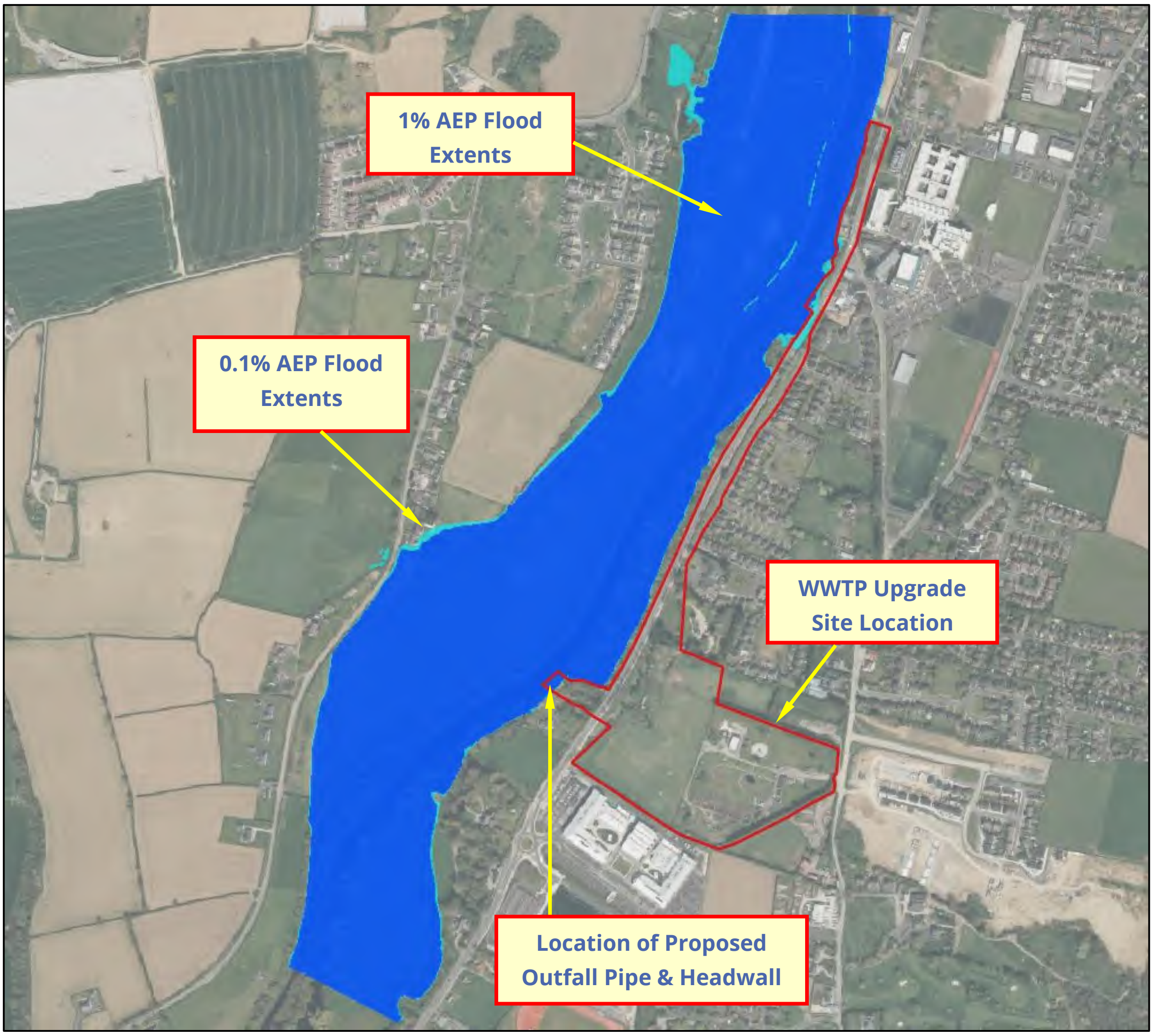


Figure 26 - 1% AEP & 0.1% AEP Fluvial Flood Extents – Existing Undeveloped - Baseline Scenario

Figure 25 below illustrates the predictive existing undeveloped baseline scenario 1% AEP + CC (1 in 100 year + climate change) fluvial flood extents along the modelled reach of the River Barrow as outputted by the hydraulic simulation model.

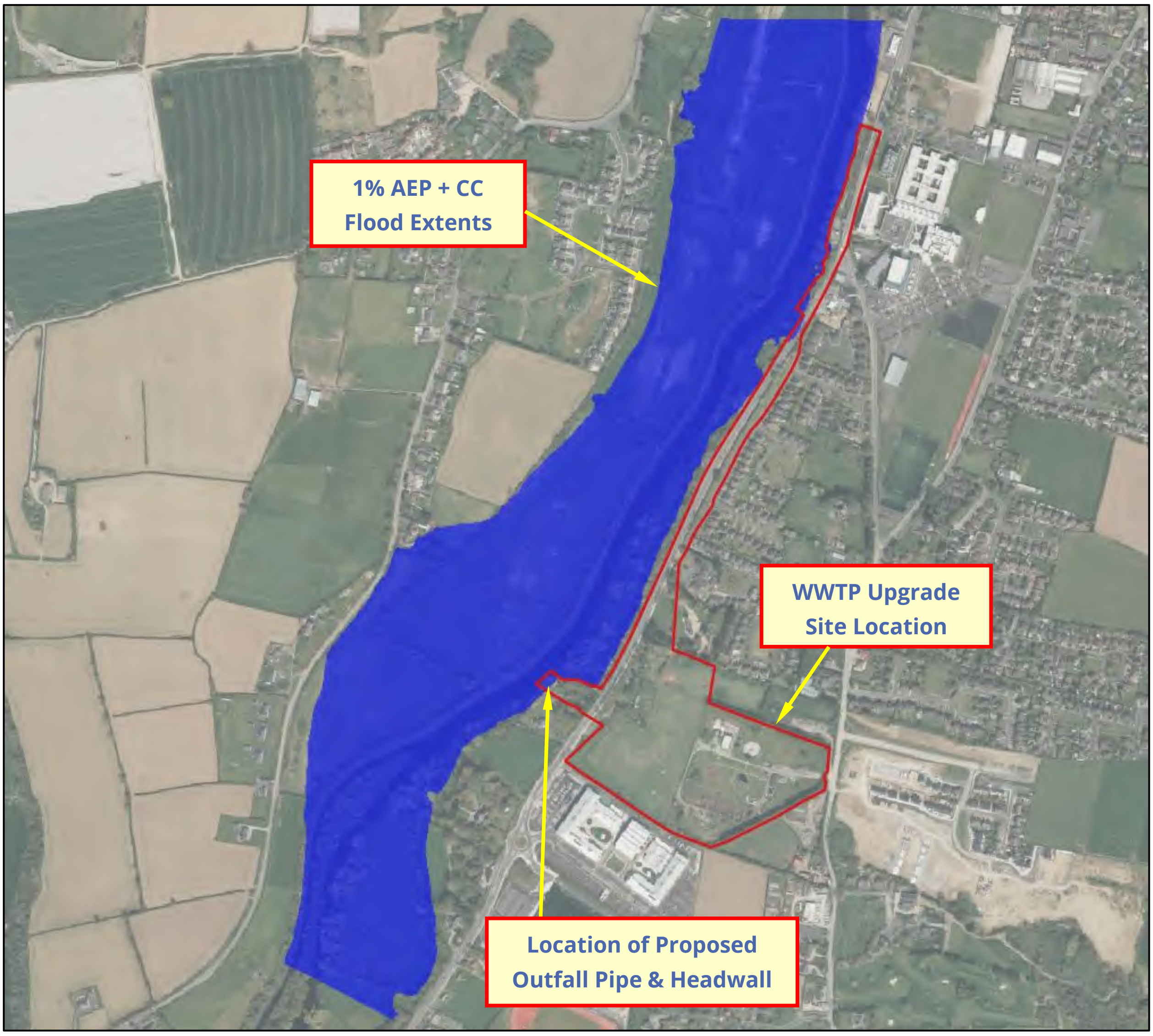


Figure 27 - 1% AEP+CC Fluvial Flood Extents – Existing Undeveloped Baseline Scenario

The delineated predictive existing undeveloped baseline scenario 1% AEP (1 in 100 year) and 0.1% AEP (1 in 1000 Year) fluvial flood extents are also illustrated on *Drawing Number IE3120-006-A*, in *Appendix A.*

The delineated predictive existing undeveloped baseline scenario 1% AEP + CC (1 in 100 year + climate change) fluvial flood extents are also illustrated on *Drawing Number IE3120-007-A* in *Appendix A.*

9. Proposed Development in the Context of the Guidelines

In the context of the 'Planning System and Flood Risk Management Guidelines, DOEHLG, 2009' three flood zones are designated in consideration of flood risk to a particular development site.

Flood Zone 'A' – where the probability of flooding from rivers and watercourses is the highest (greater than 1% or 1 in 100 year for river and watercourse flooding and 0.5% or 1 on 200 for coastal or tidal flooding).

Flood Zone 'B' – where the probability of flooding from rivers and watercourses is moderate (between 0.1% or 1 in 1000 year for river and watercourse flooding and 0.5% or 1 on 200 for coastal or tidal flooding).

Flood Zone 'C' – where the probability of flooding from rivers and watercourses is low or negligible (less than 0.1% or 1 in 1000 year for both river and watercourse and coastal flooding). Flood Zone 'C' covers all areas that are not in Zones 'A' or 'B.'

The 'Planning System and Flood Risk Management Guidelines' list the planning implications for each flood zone, as summarised below: -

Zone A – High Probability of Flooding. Most types of development would not be considered in this zone. Development in this zone should be only be considered in exceptional circumstances, such as in city and town centres, or in the case of essential infrastructure that cannot be located elsewhere, and where the 'Planning System and Flood Risk Management Guidelines' justification test has been applied. Only water-compatible development, such as docks and marinas, dockside activities that require a waterside location, amenity open space and outdoor sports and recreation would be considered appropriate in this zone.

Zone B – Moderate Probability of Flooding. Highly vulnerable development such as hospitals, residential care homes, Garda, fire and ambulance stations, dwelling houses, strategic transport and essential utilities infrastructure would generally be considered inappropriate in this zone, unless the requirements of the justification test can be met. Less vulnerable development such as retail, commercial and industrial uses and recreational facilities might be considered appropriate in this zone. In general however, less vulnerable development should only be considered in this zone if adequate lands or sites are not available in Zone 'C' and subject to a flood risk assessment to the appropriate level of detail to demonstrate that flood risk to the development can be adequately managed and that development in this zone will not adversely affect adjacent lands and properties.

Zone C – Low to Negligible Probability of Flooding. Development in this zone is appropriate from a flood risk perspective. Developments in this zone are generally not considered at risk of fluvial flooding and would not adversely affect adjacent lands and properties from a flood risk perspective.

In the context of the 'Planning System and Flood Risk Management Guidelines, DOEHLG, 2009' the assessment and analysis undertaken as part of this Site Specific Flood Risk Assessment indicates that the location of the proposed outfall pipe and associated headwall falls within a delineated predictive fluvial Flood Zone 'A' and Flood Zone 'B'.

In accordance with the 'Planning System & Flood Risk Management Guidelines, DOEGLG, 2009' the development as proposed may be subject to the requirements of the Justification Test.

10. Discussion

As illustrated in *Figure 26* below, the analysis and flood zone delineation undertaken as part of this hydrological and hydraulic assessment indicates that the location of the proposed outfall pipe and associated headwall falls within a predictive 1% AEP (1 in 100 year – Flood Zone 'A'), 1% +CC AEP (1 in 100 year + climate change) and 0.1% AEP (1 in 1000 Year – Flood Zone 'B') fluvial flood zone associated with the River Barrow (see *Drawing Number IE2999-006-A and IE2999-007-A*, *Appendix A*).

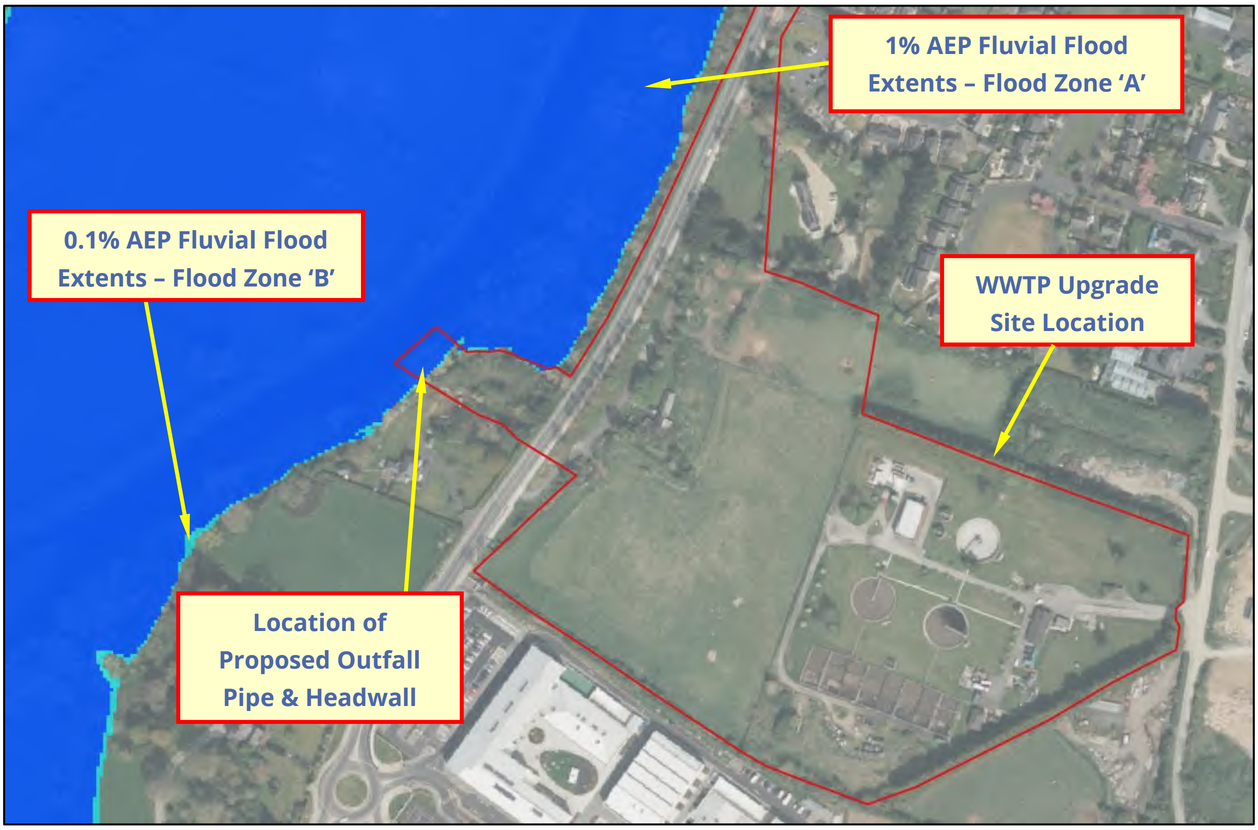


Figure 28 – Existing Undeveloped Baseline Scenario Fluvial Flood Extents

10.1. Potential Hydrological Impact of Proposed Development

In order to assess and quantify the potential impact on the existing hydrological regime of the area, if any, due to the proposed outfall pipe and associated headwall, additional hydraulic modelling incorporating the proposed outfall pipe and associated headwall structure.

Figure 29 below illustrates an example of the typical geometric profile of the proposed outfall pipe and associated headwall to be constructed at this location. The final design and specification for the structure shall be provided by the Works Contractor.

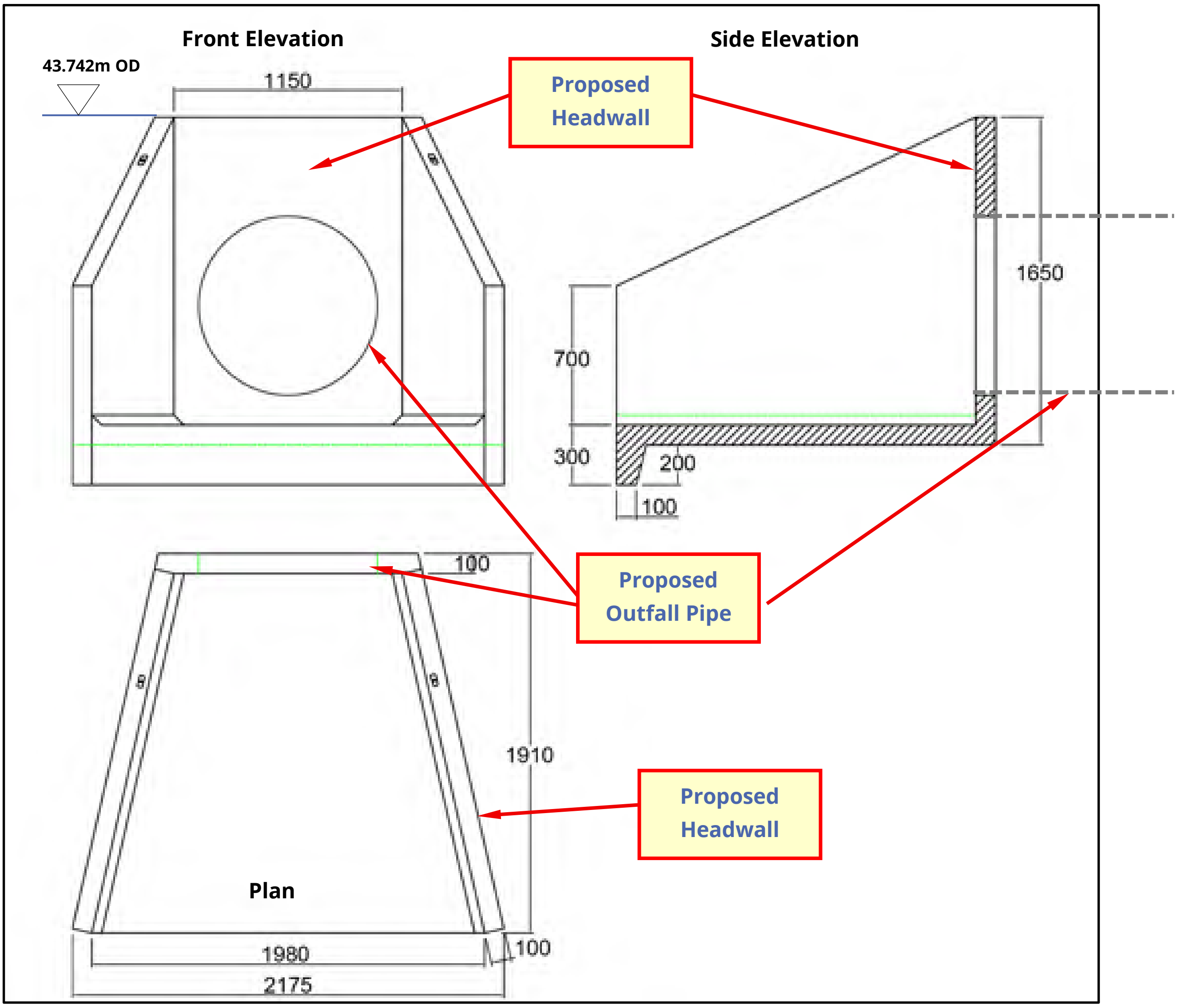


Figure 29 – Proposed Outfall Pipe and Associated Headwall – Typical Layout

The hydraulic simulation model was therefore updated and re-run to incorporate the proposed outfall pipe and associated headwall structure as illustrated above in *Figure 29* and the output results were assessed and evaluated. The total footprint area associated with the proposed outfall pipe and associated headwall has been set to an elevation level of 43.742m OD.

Table 13 below summarises the predictive 1% AEP (1 in 100 year), 1% AEP + CC (1 in 100 year + climate change) and the 0.1% AEP (1 in 1000 year) fluvial flood levels at cross sectional location D – G as outputted by the hydraulic simulation model in consideration of the proposed outfall pipe and associated headwall development scenario.

Cross Section Label	1% AEP Peak Flood Level (m OD)	1% AEP + CC Peak Flood Level (m OD)	0.1% AEP Peak Flood Level (m OD)
D	46.22	46.41	46.60
E	46.10	46.31	46.48
F	46.04	46.25	46.41
G	45.88	46.07	46.23

Table 13 - Predictive 1% AEP, 1% AEP+CC, & 0.1% AEP Flood Levels – Proposed Development Scenario

The delineated predictive proposed development scenario 1% AEP (1 in 100 year – Flood Zone 'A') and 0.1% AEP (1 in 1000 year – Flood Zone 'B') fluvial flood zones as outputted by the hydraulic simulation model are illustrated in *Figure 30* below.

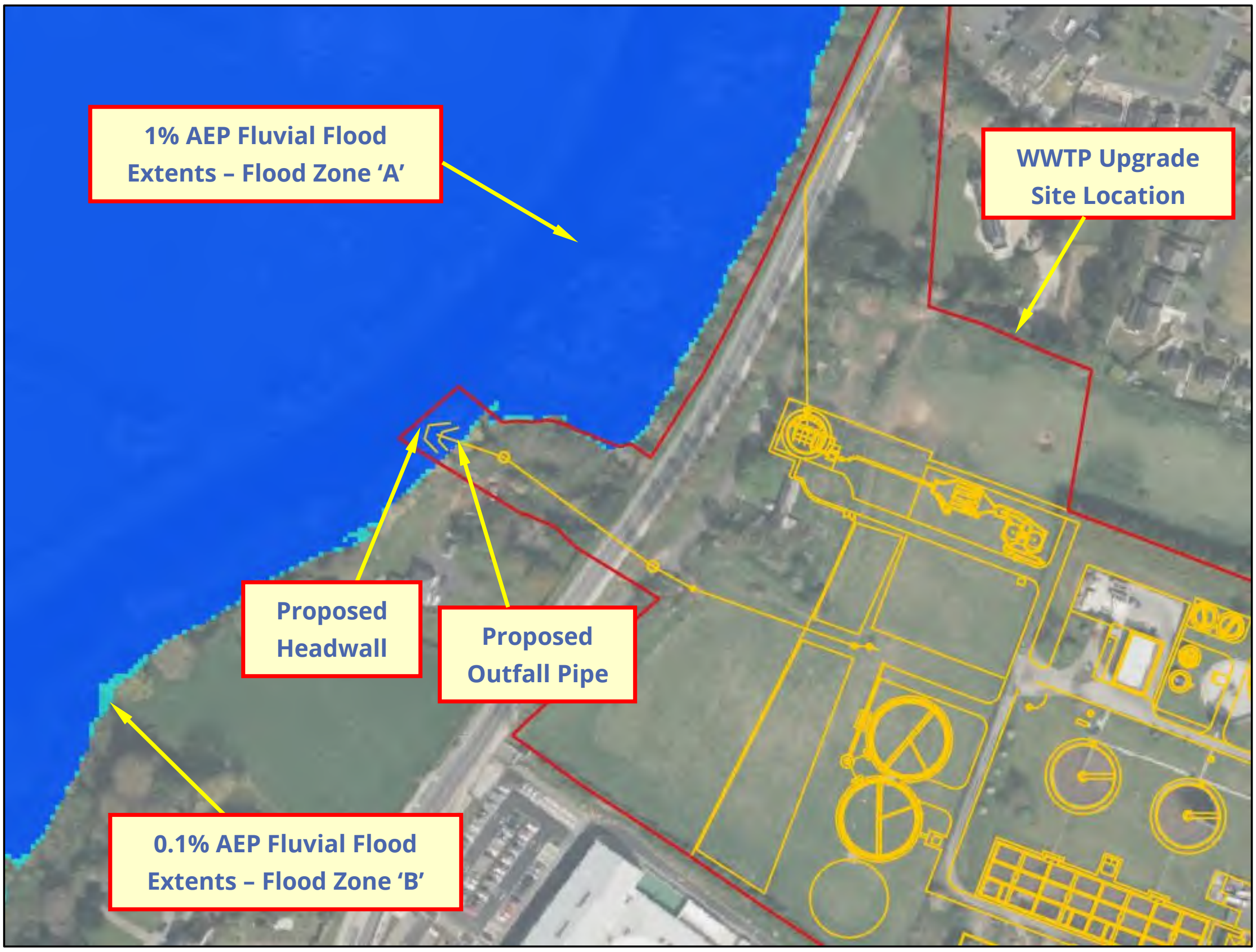


Figure 30 – Proposed Development Scenario 1% AEP & 0.1% AEP Fluvial Flood Extents

As illustrated in *Figure 30* above, in consideration of the proposed development scenario, a partial length of the proposed outfall pipe and the associated headwall structure falls within a predictive 1% AEP (1 in 100 year – Flood Zone 'A') and 0.1% AEP (1 in 1000 year – Flood Zone 'B') fluvial flood zone.

The delineated predictive proposed development scenario 1% AEP (1 in 100 year) and 0.1% AEP (1 in 1000 year) fluvial flood zones are also presented on *Drawing Number IE3120-008-A, Appendix A*.

The delineated predictive proposed development scenario 1% AEP + CC (1 in 100 year + climate change) fluvial flood zone as outputted by the hydraulic simulation model is illustrated in *Figure 31* below.

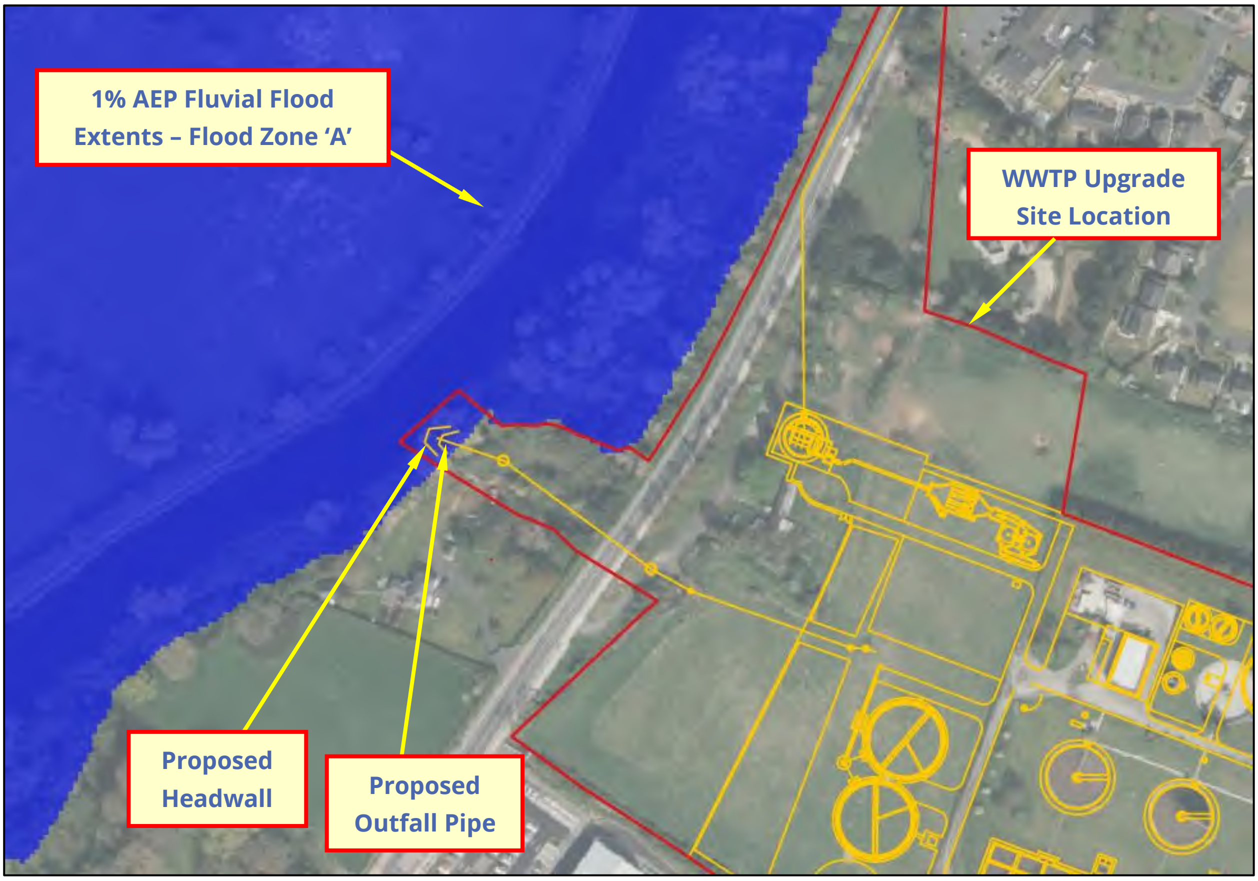


Figure 31 – Proposed Development Scenario 1% AEP+CC Fluvial Flood Extents

As illustrated in *Figure 31* above, in consideration of the proposed development scenario, a partial length of the proposed outfall pipe and the associated headwall structure falls within a predictive 1% AEP + CC (1 in 100 year + climate change) fluvial flood zone.

The delineated predictive proposed development scenario 1% AEP + CC (1 in 100 year + climate change) fluvial flood zone is also presented on *Drawing Number IE3120-009-A, Appendix A.*

10.2. Flood Level & Flood Extents Comparative Analysis

In consideration of the proposed development scenario predictive flood levels and predictive flood extents presented in *Section 10.1* above, an comparative assessment and analysis has been undertaken in order to compare the existing undeveloped baseline scenario versus the proposed development scenario flood regime at the location of the proposed outfall pipe and associated headwall.

Table 14 below lists the output of the comparative analysis of the predictive flood levels in consideration of the existing undeveloped baseline scenario and the proposed development scenario in consideration of the predictive 1% AEP (1 in 100 year), 1% AEP + CC (1 in 100 year + climate change), and the 0.1% AEP (1 in 1000 year) fluvial flood events.

Figure 24 above illustrates the location of the modelled cross section locations.

Node Label	1% AEP Peak Flood Level (m OD) Existing	1% AEP + CC Peak Flood Level (m OD) Existing	0.1% AEP Peak Flood Level (m OD) Existing	1% AEP Peak Flood Level (m OD) Proposed	1% AEP + CC Peak Flood Level (m OD) Proposed	0.1% AEP Peak Flood Level (m OD) Proposed	1% AEP Peak Flood Level (m) Difference	1% AEP + CC Peak Flood Level (m) Difference	0.1% AEP Peak Flood Level (m) Difference
D	46.22	46.41	46.60	46.22	46.41	46.60	0	0	0
E	46.10	46.31	46.48	46.10	46.31	46.48	0	0	0
F	46.04	46.25	46.41	46.04	46.25	46.41	0	0	0
G	45.88	46.07	46.23	45.88	46.07	46.23	0	0	0

Table 14 –Existing Undeveloped Baseline Scenario versus Proposed Development Scenario Flood Levels

As listed in *Table 14* above, during the occurrence of a predictive 1% AEP (1 in 100 year), 1% AEP + CC (1 in 100 year + climate change) or 0.1% AEP (1 in 1000 year) fluvial flood event, there is no predictive increase in flood levels within the River Barrow when comparing the existing undeveloped baseline scenario versus the proposed development scenario.

Figure 32 below illustrates the predictive existing undeveloped baseline scenario 1% AEP (1 in 100 year) fluvial flood extents in comparison to the predictive proposed development scenario 1% AEP (1 in 100 year) fluvial flood extents at and upstream and downstream of the location of the proposed outfall pipe and associated headwall.

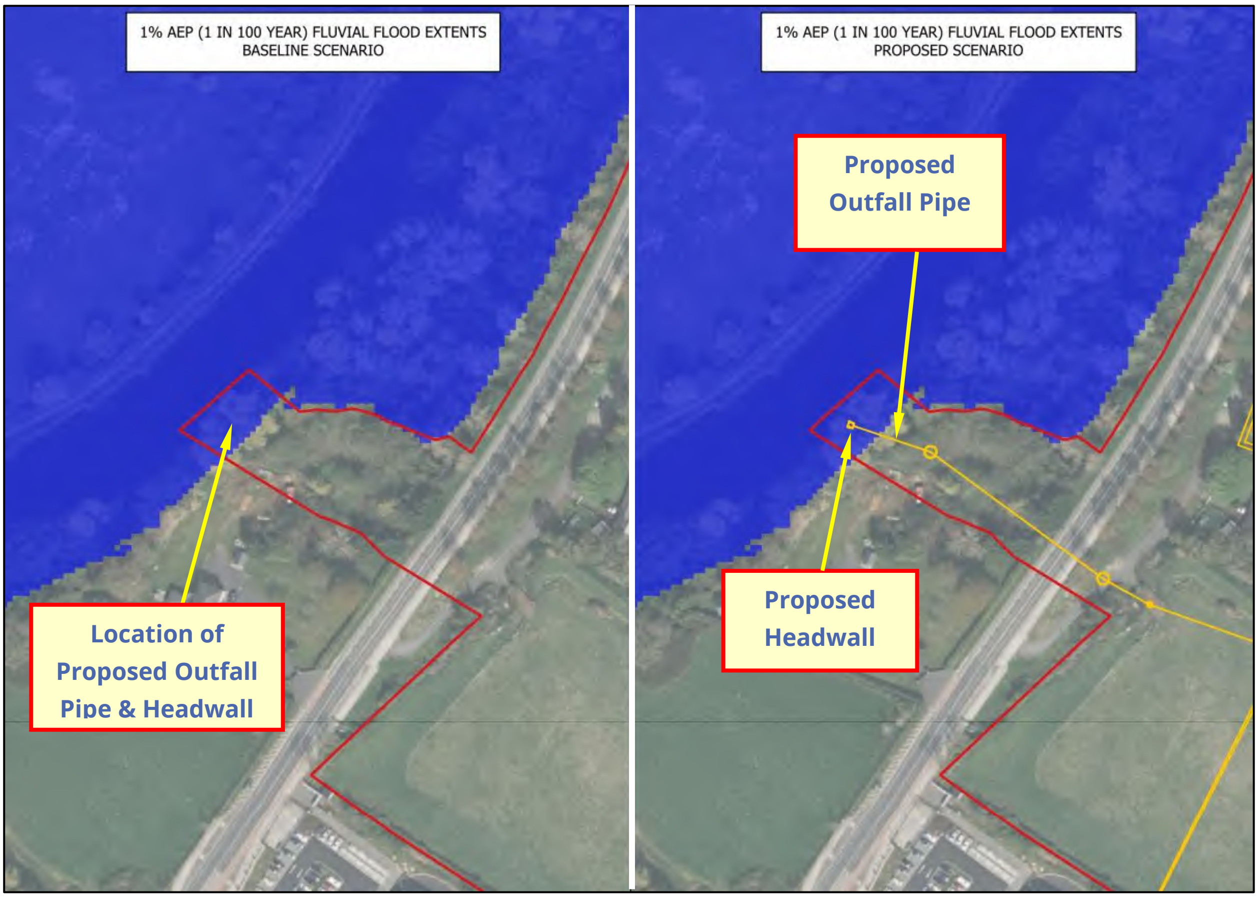


Figure 32 – 1% AEP Fluvial Flood Extents –Existing Undeveloped Baseline Scenario Versus Proposed Development Scenario

As illustrated in *Figure 32* above, during the occurrence of a predictive 1% AEP (1 in 100 year) fluvial flood event, there is no predictive increase in flood extents when comparing the existing undeveloped baseline scenario versus the proposed development scenario.

Figure 33 below illustrates the predictive existing undeveloped baseline scenario 1% AEP+CC (1 in 100 year + climate change) fluvial flood extents in comparison to the predictive proposed development scenario 1% AEP+CC (1 in 100 year + climate change) fluvial flood extents at and upstream and downstream of the location of the proposed outfall pipe and associated headwall.

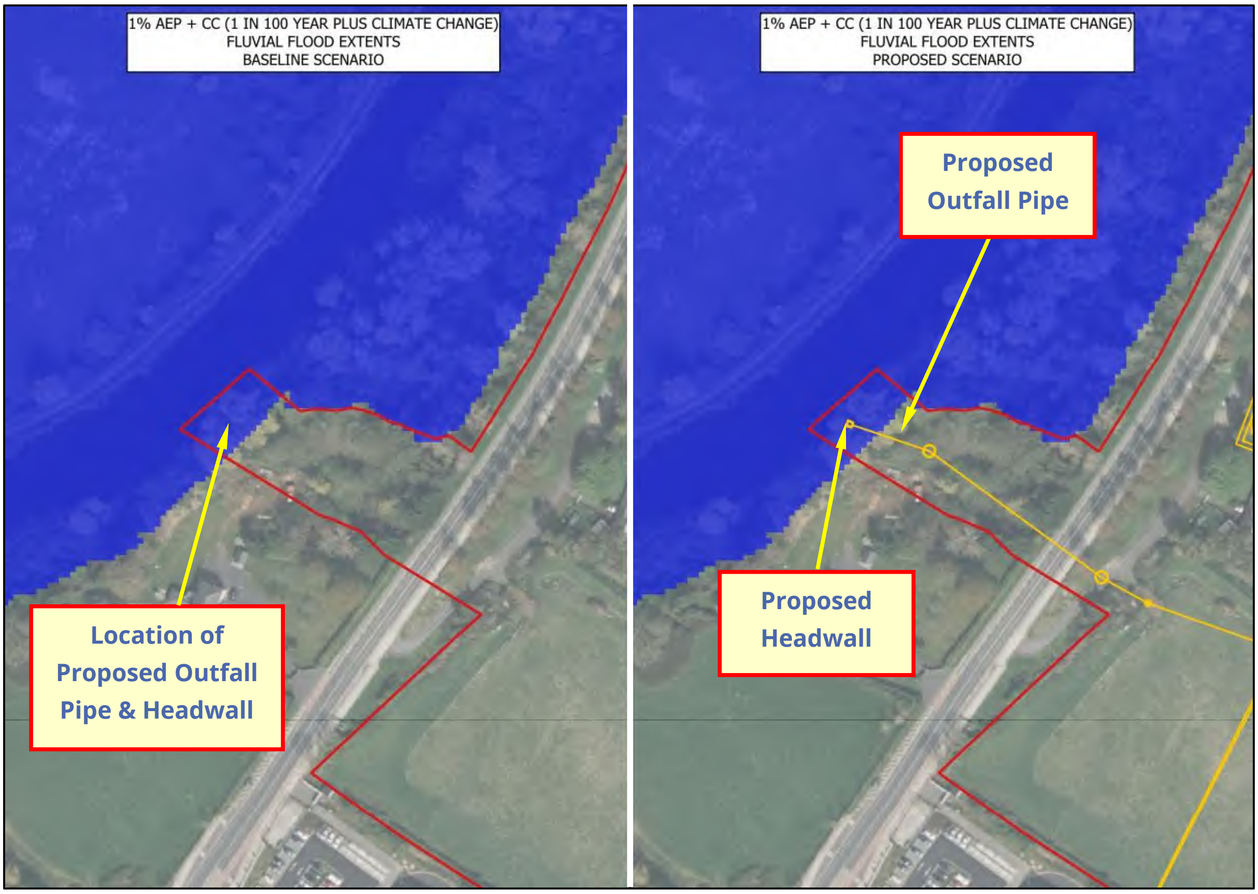


Figure 33 - 1% AEP+CC Fluvial Flood Extents – Existing Undeveloped Baseline Scenario Versus Proposed Development Scenario

As illustrated in *Figure 33* above, during the occurrence of a predictive 1% AEP+CC (1 in 100 year + climate change) fluvial flood event, there is no predictive increase in flood extents when comparing the existing undeveloped baseline scenario versus the proposed development scenario.

Figure 34 below illustrates the predictive existing undeveloped baseline scenario 1% AEP+CC (1 in 100 year + climate change) fluvial flood extents in comparison to the predictive proposed development scenario 1% AEP+CC (1 in 100 year + climate change) fluvial flood extents at and upstream and downstream of the location of the proposed outfall pipe and associated headwall.

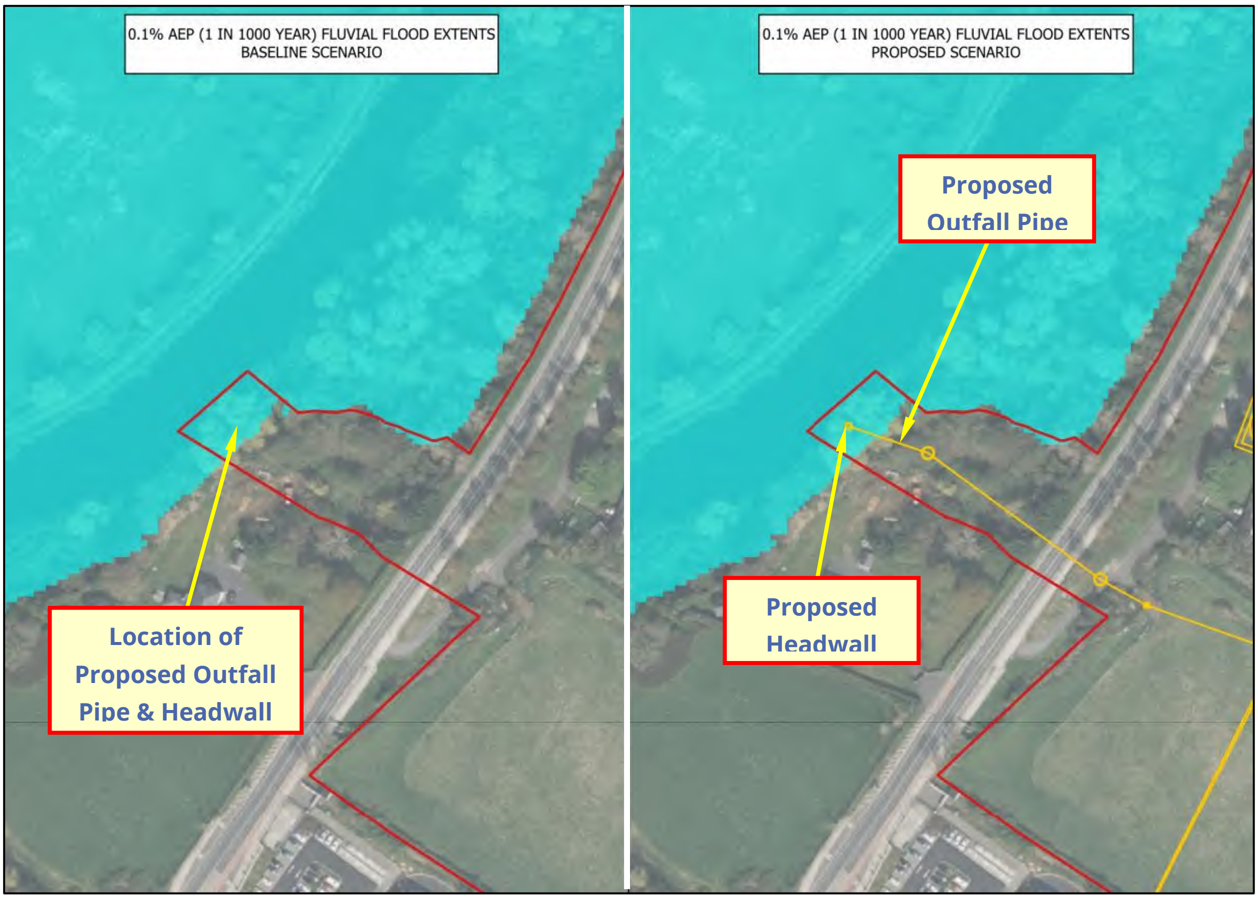


Figure 34 – 0.1% AEP Fluvial Flood Extents – Existing Undeveloped Baseline Scenario Versus Proposed Development Scenario

As illustrated in *Figure 34* above, during the occurrence of a predictive 0.1% AEP (1 in 1000 year) fluvial flood event, there is no predictive increase in flood extents when comparing the existing undeveloped baseline scenario versus the proposed development scenario.

In summary, the comparative assessment and analysis presented above demonstrates that, in consideration of the proposed outfall pipe and associated headwall development scenario, the development as proposed will not result in an adverse impact to the existing hydrological regime of the area, and will not increase flood risk to any surrounding lands or properties, or elsewhere.

11. Justification Test for Development Management

In the context of the 'Planning System and Flood Risk Management Guidelines, DoEHLG, 2009' and in consideration of the scenario that the development as proposed is undefended, the analysis and flood zone delineation undertaken as part of this Site Specific Flood Risk Assessment (SSFRA) indicates that the location of the proposed outfall pipe and associated headwall falls within a predictive Fluvial Flood Zone 'A' and Flood Zone 'B'.

Table 3.1 of the guidelines lists the vulnerability class of various types of development. In the context of the guidelines, the proposed outfall pipe and associated headwall is classified as 'Water-Compatible Development' – i.e. ' a compatible activity that required a waterside location'.

Table 3.2 of the guidelines (duplicated below) provides a matrix of different vulnerability classes of development in relation to Flood Zones A, B and C, and lists if development is appropriate in each Zone and where the Justification Test should be applied.

	Flood Zone A	**Flood Zone B**	**Flood Zone C**
Highly Vulnerable Development (including essential infrastructure	Justification Test	Justification Test	Appropriate
Less Vulnerable Development	Justification Test	Appropriate	Appropriate
Water-Compatible Development	Appropriate	Appropriate	Appropriate

Table 3.2: Matrix of vulnerability versus flood zone to illustrate appropriate development and that required to meet the Justification Test

With reference to the table above, the location of the development as proposed (proposed outfall pipe and associated headwall) falls within Flood Zone 'A' and Flood Zone 'B' and the development as proposed is classified as 'Water-Compatible Development' , therefore the development is 'Appropriate' and is not subject to the Justification Test.

12. Summary Conclusions

In consideration of the findings of this Site Specific Flood Risk Assessment and analysis the following conclusions are made in respect of the proposed outfall pipe and associated headwall:

- A Site Specific Flood Risk (SSFRA) assessment, appropriate to the type and scale of development proposed, and in accordance with 'The Planning System and Flood Risk Management Guidelines – DoEHLG-2009' has been undertaken.
- The location of the proposed outfall pipe and associated headwall has been screened, scoped, and assessed for flood risk in accordance with the above guidelines.
- The primary flood risk to the location of the proposed outfall pipe and associated headwall can be attributed to a fluvial flood event in the River Barrow.
- The screening assessment undertaken as part of this SSFRA indicates that the location of the proposed outfall pipe and headwall is not at risk of pluvial, or groundwater flooding.
- A detailed Digital Terrain Model (DTM) has been developed for the area of the proposed outfall pipe and associated headwall.
- The predictive 1% AEP (1 in 100 year – Flood Zone 'A'), 1% AEP + CC (1 in 100 year + climate change), and 0.1% AEP (1 in 1000 year – Flood Zone 'B') fluvial flood event peak flood flows at the location of the location of the proposed outfall pipe and associated headwall have been derived as part of this assessment.
- A 2D hydraulic simulation model was developed in HEC-RAS in order to provide a site specific delineation of the predictive 1% AEP (1 in 100 year – Flood Zone 'A'), 1% AEP + CC (1 in 100 year + climate change), and 0.1% AEP (1 in 1000 year – Flood Zone 'B') fluvial flood zones at the location of the proposed outfall pipe and associated headwall.
- The location of the proposed outfall pipe and associated headwall falls within a predictive Fluvial Flood Zone 'A' and Flood Zone 'B'.
- The proposed outfall pipe and associated headwall are deemed to be Water-Compatible Development and therefore not subject to the requirements of the Justification Test for development management.
- The 2D hydraulic simulation model was utilised in order to provide a quantitative comparative analysis in consideration of the existing undeveloped baseline scenario and the proposed development scenario.

- The results of the hydraulic modelling exercise undertaken in consideration of the proposed development scenario demonstrates that the proposed outfall pipe and associated headwall will not result in an adverse impact to the existing hydrological regime of the area or increase fluvial flood risk to adjacent lands or properties or elsewhere.
- In consideration of findings and output of this Site Specific Flood Risk Assessment, the potential flood risk to and from the proposed outfall pipe and headwall is considered to be LOW. The development as proposed is not predicted to result in an adverse impact to the existing hydrological regime of the area or increase flood risk elsewhere and is therefore considered to be appropriate from a flood risk perspective.

Appendices

Appendix A. Drawings

Drawing Number IE3120-001-A Site Location Map

Drawing Number IE3120-006-A Baseline Scenario Flood Extents (1% AEP & 0.1% AEP Fluvial Flood Extents)

Drawing Number IE3120-007-A Baseline Scenario Flood Extents (1% AEP + CC Fluvial Flood Extents)

Drawing Number IE3120-008-A Proposed Scenario Flood Extents (1% AEP & 0.1% AEP Fluvial Flood Extents)

Drawing Number IE3120-009-A Proposed Scenario Flood Extents (1% AEP + CC Fluvial Flood Extents)

LEGEND

rev.	date	amendment	drn	ckd
A	26.08.25	ISSUE	MOF	PMS

PROPOSED MORTARSTOWN WWTP UPGRADE PROJECT, CARLOW

HYDRODYNAMIC ASSESSMENT

LOCATION MAP

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

CARLOW OFFICE:
INNOVATION CENTRE
GREEN ROAD
CARLOW R95 W248

NEWRY OFFICE:
1 RDC HOUSE
WIN BUSINESS PARK
NEWRY BT35 6PH

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		drawn: MOF	
drawing no.	rev:	checked: PMS	
IE3120-001	A	approved: PMS	
		date: 26/08/2025	

LEGEND

WWTP UPGRADE SITE LOCATION

1% AEP (1 IN 100 YEAR) FLUVIAL FLOOD EXTENTS BASELINE SCENARIO

0.1% AEP (1 IN 1000 YEAR) FLUVIAL FLOOD EXTENTS BASELINE SCENARIO

rev.	date	amendment	drn	ckd
A	05.09.25	ISSUE	MOF	PMS

PROPOSED MORTARSTOWN WWTP UPGRADE PROJECT, CARLOW

HYDRODYNAMIC ASSESSMENT

1% AEP (1 IN 100 YEAR) & 0.1% AEP (1 IN 1000 YEAR) FLUVIAL FLOOD EXTENTS BASELINE SCENARIO

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

CARLOW OFFICE:
INNOVATION CENTRE
GREEN ROAD
CARLOW R95 W248

NEWRY OFFICE:
1 RDC HOUSE
WIN BUSINESS PARK
NEWRY BT35 6PH

file location: N:\IE3120\DRAWINGS

scale: 1:7,000 | A3

drawing status: PLANNING

datum: MALIN

drawn: MOF

checked: PMS

approved: PMS

drawing no. IE3120-006

rev. A

date: 05/09/2025

LEGEND

- WWTP UPGRADE SITE LOCATION
- 1% AEP (1 IN 100 YEAR + CLIMATE CHANGE) FLUVIAL FLOOD EXTENTS BASELINE SCENARIO

rev.	date	amendment	drn	ckd
A	05.09.25	ISSUE	MOF	PMS

PROPOSED MORTARSTOWN WWTP UPGRADE PROJECT, CARLOW

HYDRODYNAMIC ASSESSMENT

1% AEP + CC (1 IN 100 YEAR + CLIMATE CHANGE) FLUVIAL FLOOD EXTENTS BASELINE SCENARIO

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

CARLOW OFFICE:
INNOVATION CENTRE
GREEN ROAD
CARLOW R95 W248

NEWRY OFFICE:
1 RDC HOUSE
WIN BUSINESS PARK
NEWRY BT35 6PH

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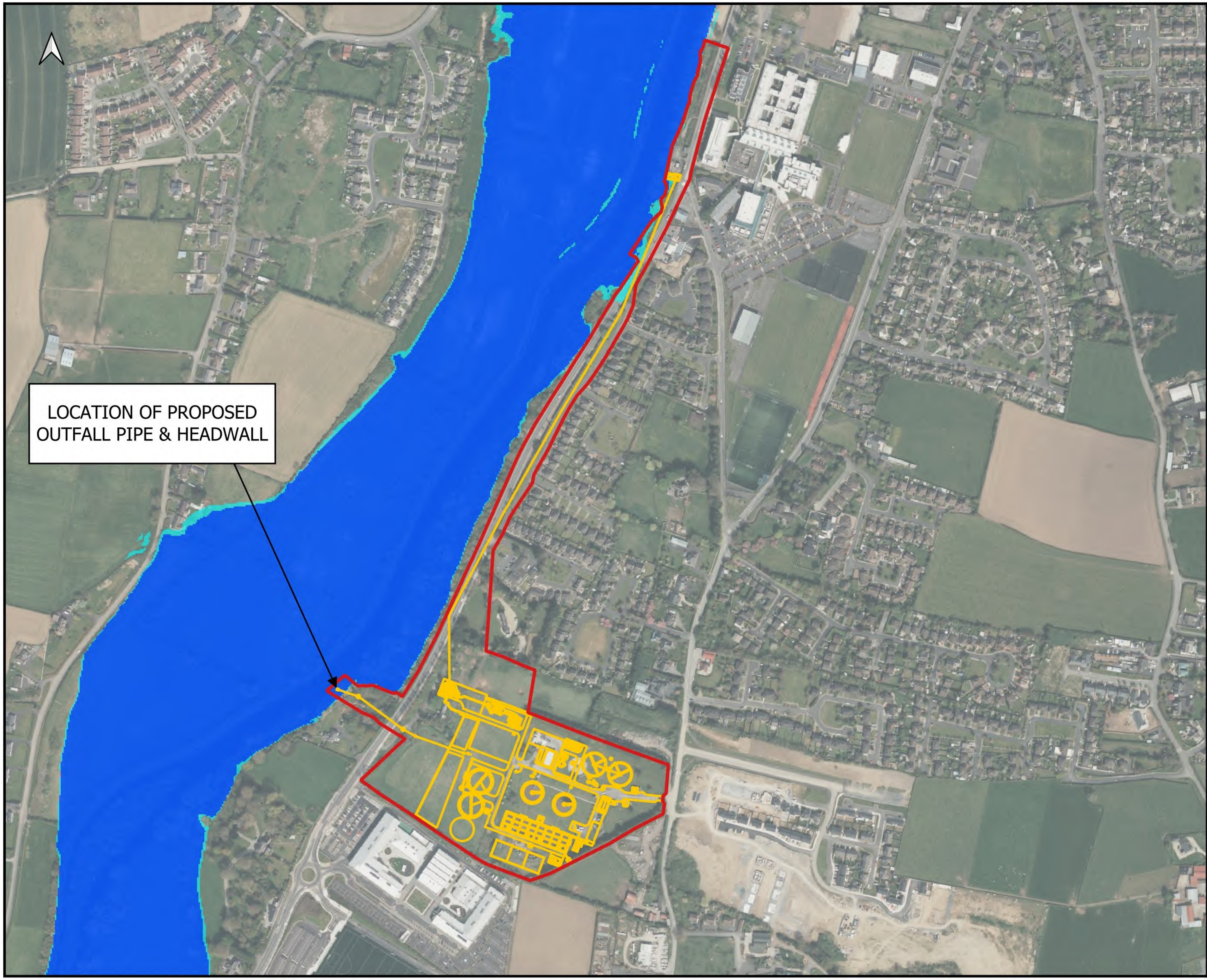

LEGEND

- WWTP UPGRADE SITE LOCATION
- 1% AEP (1 IN 100 YEAR) FLUVIAL FLOOD EXTENTS PROPOSED SCENARIO
- 0.1% AEP (1 IN 1000 YEAR) FLUVIAL FLOOD EXTENTS PROPOSED SCENARIO

rev.	date	amendment	drn	ckd
A	05.09.25	ISSUE	MOF	PMS

PROPOSED MORTARSTOWN WWTP UPGRADE PROJECT, CARLOW

HYDRODYNAMIC ASSESSMENT

1% AEP (1 IN 100 YEAR) & 0.1% AEP (1 IN 1000 YEAR) FLUVIAL FLOOD EXTENTS PROPOSED SCENARIO

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

CARLOW OFFICE:
INNOVATION CENTRE
GREEN ROAD
CARLOW R95 W248

NEWRY OFFICE:
1 RDC HOUSE
WIN BUSINESS PARK
NEWRY BT35 6PH

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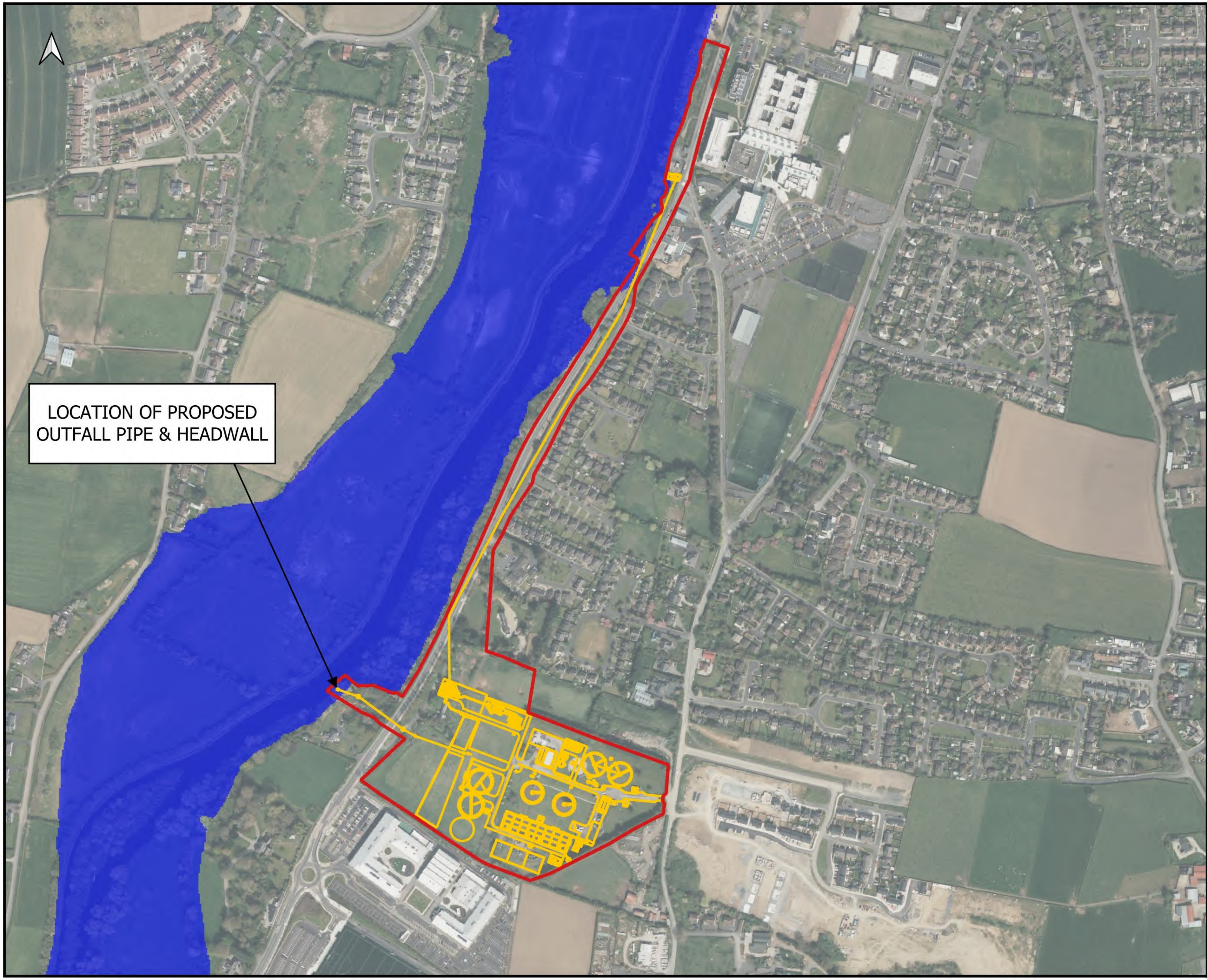

LEGEND

- WWTP UPGRADE SITE LOCATION
- 1% AEP (1 IN 100 YEAR + CLIMATE CHANGE) FLUVIAL FLOOD EXTENTS PROPOSED SCENARIO

rev.	date	amendment	drn	ckd
A	05.09.25	ISSUE	MOF	PMS

PROPOSED MORTARSTOWN WWTP UPGRADE PROJECT, CARLOW

HYDRODYNAMIC ASSESSMENT

1% AEP + CC (1 IN 100 YEAR + CLIMATE CHANGE)
FLUVIAL FLOOD EXTENTS
PROPOSED SCENARIO

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

CARLOW OFFICE:
INNOVATION CENTRE
GREEN ROAD
CARLOW R95 W248

NEWRY OFFICE:
1 RDC HOUSE
WIN BUSINESS PARK
NEWRY BT35 6PH

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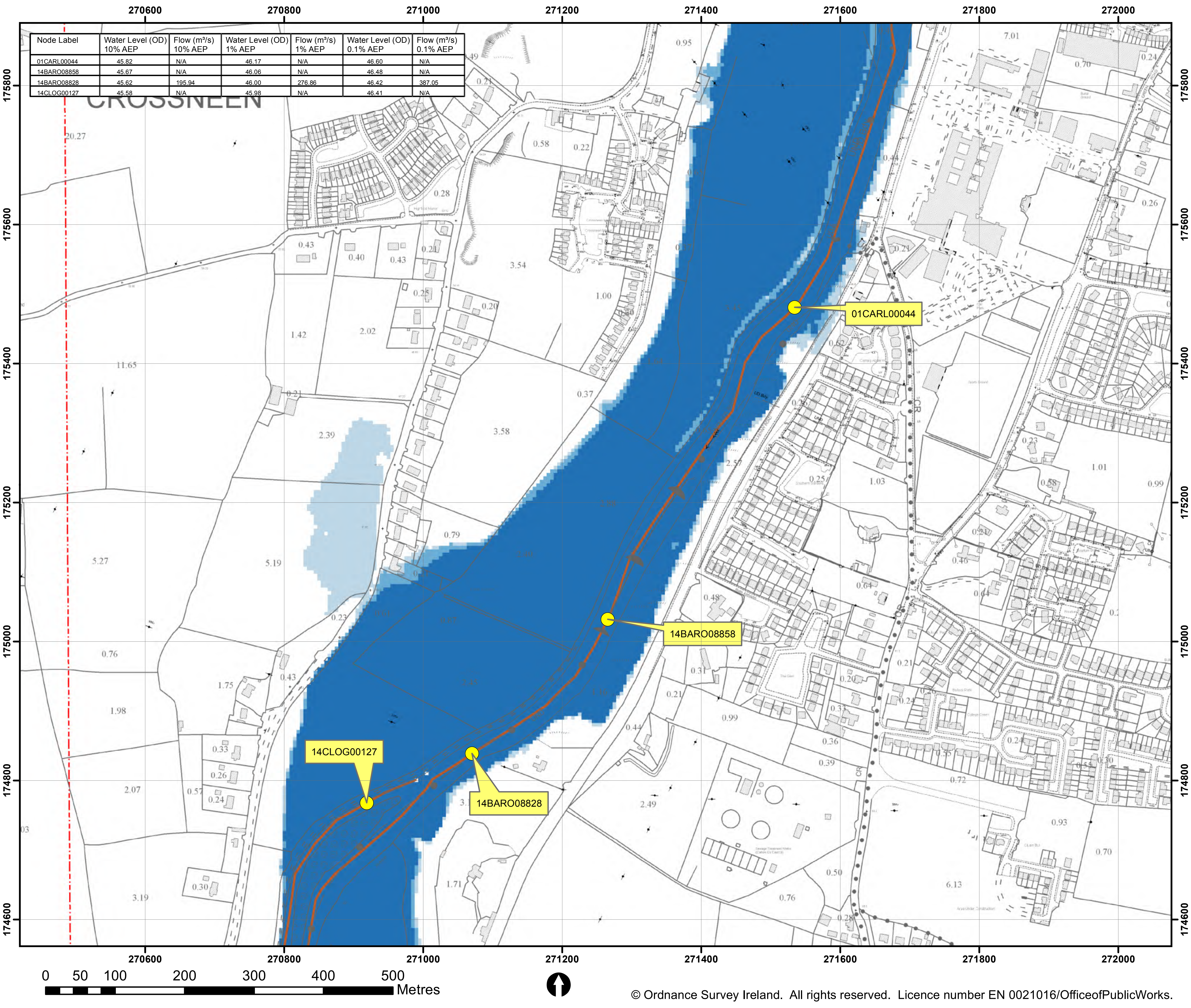
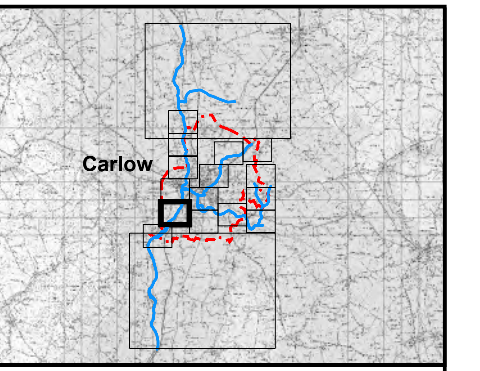
drawing no. IE3120-009	rev: A	checked: PMS
		approved: PMS
		date: 05/09/2025

Appendix B. CFRAMS Map

Fluvial Extents Map O14CAR_EXFCD_F0_15

Node Label	Water Level (OD) 10% AEP	Flow (m³/s) 10% AEP	Water Level (OD) 1% AEP	Flow (m³/s) 1% AEP	Water Level (OD) 0.1% AEP	Flow (m³/s) 0.1% AEP
01CARL00044	45.82	N/A	46.17	N/A	46.60	N/A
14BARO08858	45.67	N/A	46.06	N/A	46.48	N/A
14BARO08828	45.62	195.94	46.00	276.86	46.42	387.05
14CLOG00127	45.58	N/A	45.98	N/A	46.41	N/A





IMPORTANT USER NOTE:
THE VIEWER OF THIS MAP SHOULD REFER TO THE DISCLAIMER, GUIDANCE NOTES AND CONDITIONS OF USE THAT ACCOMPANY THIS MAP.

Legend

- 10% Fluvial AEP Event
- 1% Fluvial AEP Event
- 0.1% Fluvial AEP Event
- Modelled River Centreline
- AFA Extents
- Embankment
- Wall
- Defended Area
- 1% AEP / 1% AEP — Standard of Protection of Flood Defence (Walls / Embankments)
- Node Point
- Node ID — Node Label

FINAL

REV:	NOTE:	DATE:
01	Amendments to flood extents - Bridge Clipping	24/11/2016

SOUTH EASTERN CFRAM STUDY
CATCHMENT FLOOD RISK ASSESSMENT AND MANAGEMENT

The Office of Public Works
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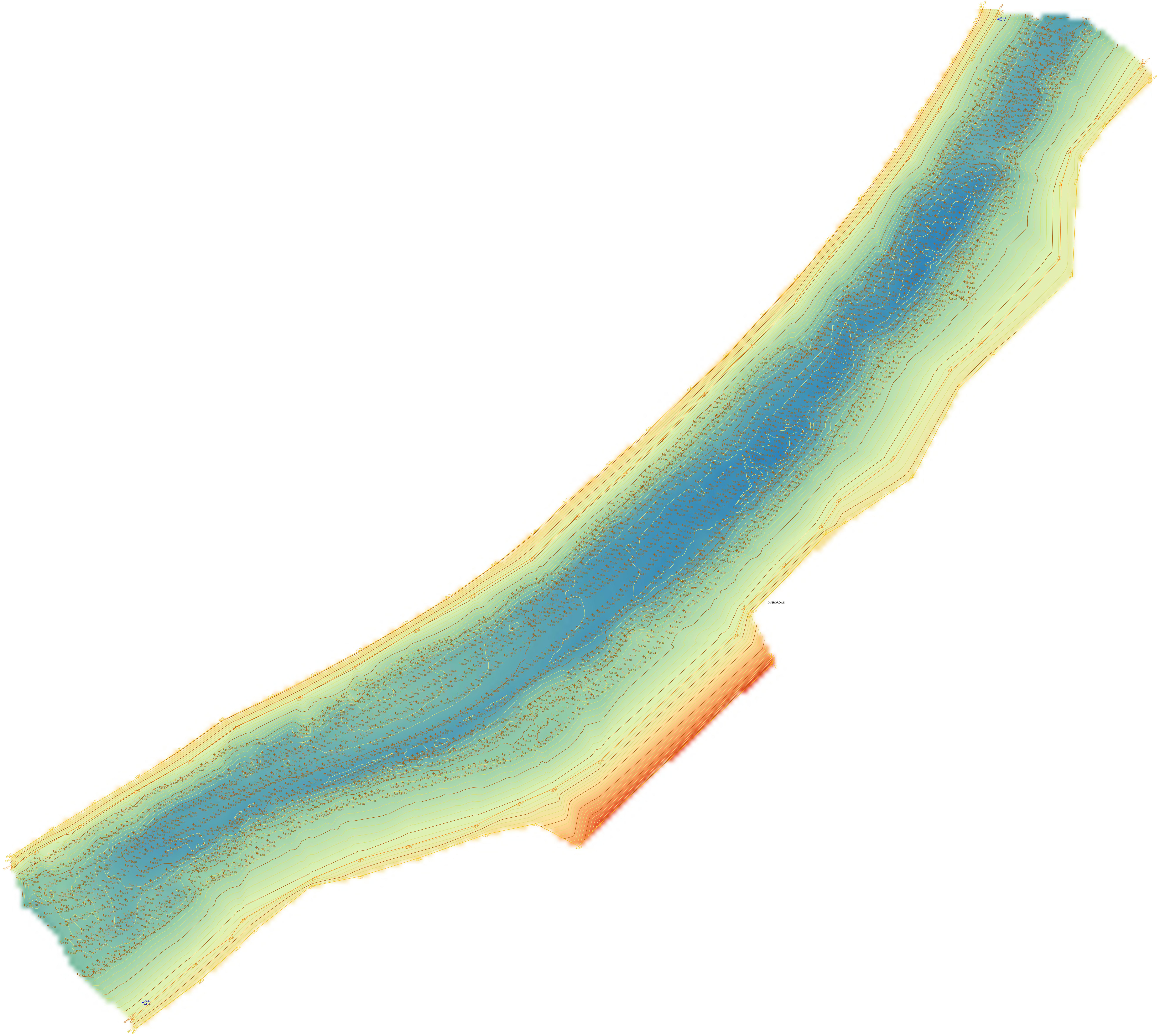
E ireland@rpsgroup.com

Map:
Carlow Fluvial Flood Extents

Map Type: EXTENT
Source: FLUVIAL
Map Area: HPW
Scenario: CURRENT
Drawn By : C.C. **Date :** 24 November 2016
Checked By : J.M. **Date :** 24 November 2016
Approved By : S.P. **Date :** 24 November 2016
Drawing No. :
O14CAR_EXFCD_F0_15
Map Series : Page 15 of 17
Drawing Scale : 1:5,000 @A3

Appendix C. River Topographic Survey



DEM LEGEND

- 39
- 41
- 43
- 45
- 47
- 49

LEGEND

Street furniture & Services

5.12	Over Head Wires (LUAS) - Pylon ESB	Sign RS	Road Sign	PBOX	Phone Box
5.12	Flowerbed		Bus Stop		Bench Seat
					Duct
5.12	Pipe		Bollard		Kiosk
				GAS	Gas Cover
5.12	Lift	BEA	Beacon	GY	Gully
				CPBox	C P Box
5.12	Barrier	CH	Coalhole Cover	U/G Vent	U/G Car Park Vent
5.12	Pump	BH	Bore Hole	BIN	Waste Bin
5.12	Trial Pit	EP	Electricity Pole	HY	Hydrant
5.12	Bus/Tram Shelter	TP	Telegraph pole	FH	Fire Hydrant
5.12	Postbox	OCS	OCS Pole	EBOX	ESB Box
V	Valve - General	CP	CCTV Camera Pole	ICE	ESB Inspection Cover
WV	Water Valve	LP	Lamp Post	TFB	Traffic Control Box
GV	Gas Valve	FMH or	Foul Manhole	LUAS	LUAS Technical Cubicle
SV	Sluice Valve	SMH or	Surface Water MH		Ticket Vending Machine
AV	Air Valve	MH or	Manholes	WM	Water Meter Cover
SC	Stop Cock	AC	Air Conditioning Vents	ICT	Telecom Inspection Cover
CPP	C P Post	ICU	Services Inspection Cover		Monument / Toilets
MK	Marker Post	ICTC	Traffic Inspection Cover		Tank Storage
TL	Traffic light	ICTV	Cable TV Inspection Cover		Basement: MH, Cover & Pipe
PM	Parking Meter	ICES	ESAT Inspection Cover	DAM	Dished Aerial Mark
PAM	Plane Aerial Mark	ICNC	NTL Inspection Cover	STAY	Stay for pole
SCV	Smart Card Validator	ICEM	Eircom Inspection Cover	PP	Pipe Protection
UV	Unknown Valve	RE	Rodding Eye	WO	Washout

Natural Features

5.12	Surface Change	WLVL	Water Level
5.12	Land Drain	CRWN	Crown Level
5.12	Bottom of Slope	IL	Invert level
5.12	Top of Slope	BL	Bed Level
5.12	Ditch	S	Spotheight
5.12	Water Edge / Lake / Pond		
	Hedge / Trees Drip Line / Vegetation		
	Tree Coniferous		Tree Deciduous

Top of Tree

Golf

FWAY	Fair Way
GREE	Green
TBOX	Tee Box

Other

S1 E: 1000.000 N: 1000.000 H: 100.00	Survey Station
	Photo point

Built Features
Roads & Road Markings

5.12	Building	5.12	Fence	FL 0.00	Floor Level
5.12	Edge of Road	Gate	Gate	APX 0.00	Apex Height
5.12	Kerb Bottom	5.12	Road Centreline	EV 0.00	Eaves Height
5.12	Kerb Top	5.12	Top of Wall	PAR 0.00	Parapet Height
5.12	Bridge Abutment	5.12	Hoarding	SOFF 0.00	Soffit Elevation
5.12	Bridge Deck	5.12	Property Line	STPL 5.12	Step Level
5.12	Bridge Parapet	5.12	Road Scar	CONC	Concrete Pad
5.12	Building Façade	5.12	Top of Fence	5.12	Track
5.12	Footpath / Platform Train & Tram	5.12	Wall / Retaining Wall		
5.12	Damp Proof Course / Verge	5.12	Railway / Tram Rail / Grating / Ramp		
5.12	Bridge Pier / Wall & Gate Pillar / LUAS Trackbed	5.12	Building Canopy / Roof / Overhang		
5.12	Cycleway / Private Landing Area				

Murphy Geospatial Ltd. Disclaimer

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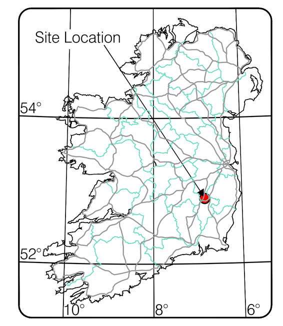
North

Site Location



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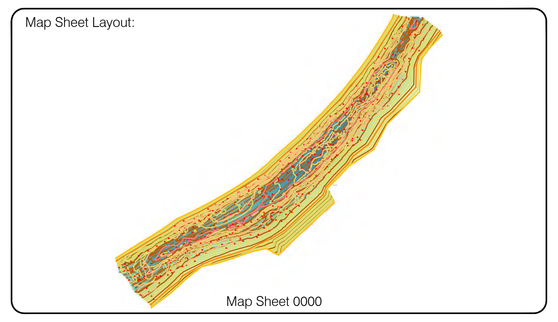

Map Sheet 0000

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Drawn by : CE	Date: May 2025	Grid System:
Checked by : NR	Date: 13.05.2025	Irish National Grid ☐ ITM ■

Revisions

No.	Date	Description
0	13.05.2025	First Drawing

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Kildare Cork Dublin Belfast Glasgow Manchester London

Head Office
Global House
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Kilcullen Co. Kildare, Ireland
Phone: (+353) 045 484040
Fax: (+353) 045 484004
Email: info@murphygs.ie

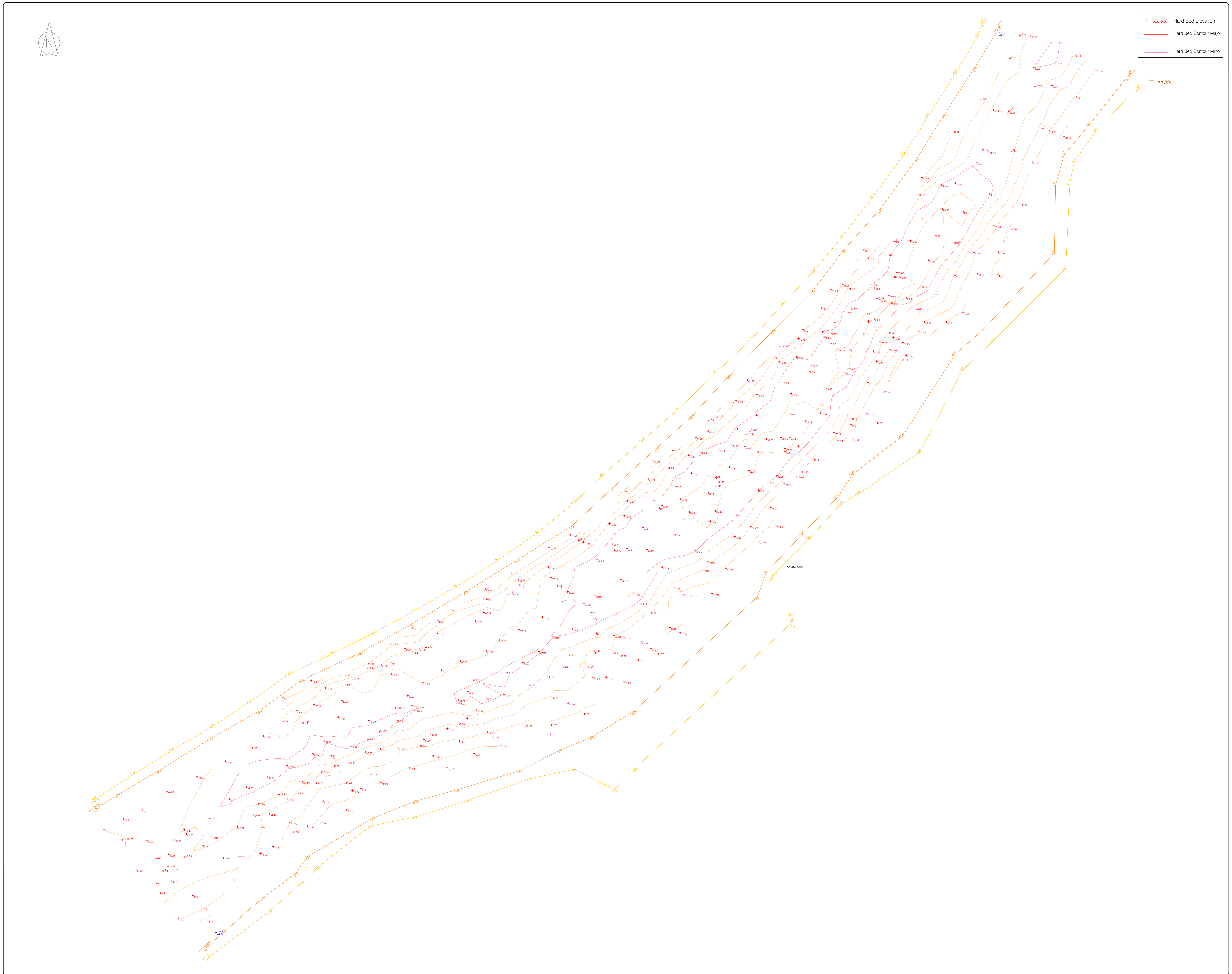
Client : IE Consulting Engineers

Project : 63112 Bathymetric Survey and Soil Sampling of River Barrow

Date : 13.05.2025 **Scale :** 1:250@A0

Description : Topographical Survey

Drawing Number : MGS63112_Barrow_Bathy_01



LEGEND

Street furniture & Services

5.12 Over Head Wires (LUAS) - Pylon ESB
5.12 Flowerbed
5.12 Pipe
5.12 Lift
5.12 Barrier
5.12 Pump
5.12 Trial Pit
5.12 Bus/Tram Shelter
5.12 Postbox
V Valve - General
WV Water Valve
GV Gas Valve
SV Sluice Valve
AV Air Valve
SC Stop Cock
CPP C P Post
MK Marker Post
TL Traffic light
PM Parking Meter
PAM Plane Aerial Mark
SCV Smart Card Validator
UV Unknown Valve
Sign RS Road Sign
Bus Stop
Bollard
BEA Beacon
CH Coalhole Cover
BH Bore Hole
EP Electricity Pole
TP Telegraph pole
OCS OCS Pole
CP CCTV Camera Pole
LP Lamp Post
FMH or Foul Manhole
SMH or Surface Water MH
MH or Manholes
AC Air Conditioning Vents
ICU Services Inspection Cover
ICTC Traffic Inspection Cover
ICTV Cable TV Inspection Cover
ICES ESAT Inspection Cover
ICNC NTL Inspection Cover
ICEM Eircom Inspection Cover
RE Rodding Eye
PBOX Phone Box
Bench Seat
Duct
Kiosk
GAS Gas Cover
GY Gully
CPBox C P Box
U/G Vent U/G Car Park Vent
BIN Waste Bin
HY Hydrant
FH Fire Hydrant
EBOX ESB Box
ICE ESB Inspection Cover
TFB Traffic Control Box
LUAS LUAS Technical Cubicle
Ticket Vending Machine
WM Water Meter Cover
ICT Telecom Inspection Cover
Monument / Toilets
Tank Storage
Basement: MH, Cover & Pipe
DAM Dished Aerial Mark
STAY Stay for pole
PP Pipe Protection
WO Washout

Natural Features

5.12 Surface Change
5.12 Land Drain
5.12 Bottom of Slope
5.12 Top of Slope
5.12 Ditch
5.12 Water Edge / Lake / Pond
Hedge / Trees Drip Line / Vegetation
Tree Coniferous
Tree Deciduous
Top of Tree
WLVL Water Level
CRWN Crown Level
IL Invert level
BL Bed Level
S Spotheight

Golf

FWAY Fair Way
GREE Green
TBOX Tee Box

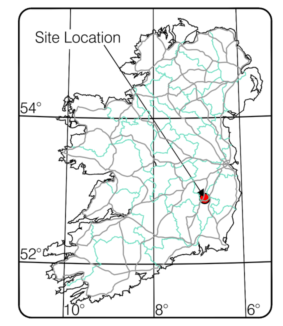
Other

S1 E: 1000.000 N: 1000.000 H: 100.00 Survey Station
Photo point

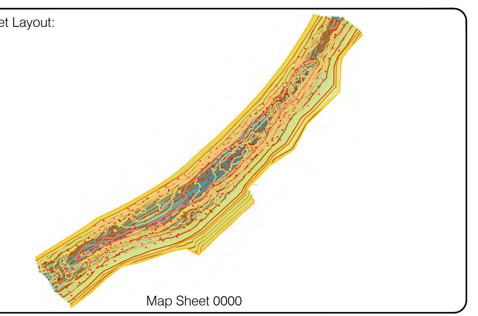
Built Features
Roads & Road Markings

5.12 Building
5.12 Edge of Road
5.12 Kerb Bottom
5.12 Kerb Top
5.12 Bridge Abutment
5.12 Bridge Deck
5.12 Bridge Parapet
5.12 Building Façade
5.12 Footpath / Platform Train & Tram
5.12 Damp Proof Course / Verge
5.12 Bridge Pier / Wall & Gate Pillar / LUAS Trackbed
5.12 Cycleway / Private Landing Area
5.12 Fence
Gate Gate
5.12 Road Centreline
5.12 Top of Wall
5.12 Hoarding
5.12 Property Line
5.12 Road Scar
5.12 Top of Fence
5.12 Wall / Retaining Wall
5.12 Railway / Tram Rail / Grating / Ramp
5.12 Building Canopy / Roof / Overhang
FL 0.00 Floor Level
APX 0.00 Apex Height
EV 0.00 Eaves Height
PAR 0.00 Parapet Height
SOFF 0.00 Soffit Elevation
STPL 5.12 Step Level
CONC Concrete Pad
5.12 Track

North



Map Sheet Layout:



Map Sheet 0000

Surveyed by : MGS Date: May 2025 Datum : Malin Hd. 15
Drawn by : CE Date: May 2025 Grid System:
Checked by : NR Date: 13.05.2025 Irish National Grid ☐ ITM ■

Revisions

No.	Date	Description
0	13.05.2025	First Drawing

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Client : IE Consulting Engineers

Project : 63112 Bathymetric Survey and Soil Sampling of River Barrow

Date : 13.05.2025 **Scale :** 1:250@A0

Description : Topographical Survey

Drawing Number : MGS63112_Barrow_Bathy_Hard Bed_02