Appendix 15.6

Wastewater Treatment Plant
Flood Risk Assessment

Irish Water

Arklow Wastewater Treatment Plant

Flood Risk Assessment

247825-00/FRA

Final | 31 August 2018

Job number 247825-00

Ove Arup & Partners Ireland Ltd

Arup
50 Ringsend Road
Dublin 4
D04 T6X0
Ireland
www.arup.com

ARUP

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1 Introduction and Background

1.1 Project Background

Arup has been commissioned to undertake a Flood Risk Assessment (FRA) for the proposed Wastewater Treatment Plant (WwTP) at the Old Wallboard site at Ferrybank, Arklow. The FRA is to accompany the statutory consent application for the overall Arklow Wastewater Treatment Plant project.

The FRA has been undertaken in accordance with 'The Planning System and Flood Risk Management' Guidelines for Planning Authorities published in November 2009, jointly by the Office of Public Works (OPW) and the then Department of Environment, Heritage and Local Government (DEHLG).

The purpose of the FRA is to identify and quantify the risk of flooding of the proposed development and, if necessary, identify measures to mitigate the risk.

1.2 Scope of Study

The scope of study includes the following:

- Review of all relevant information and data from:
    - The Office of Public Works (OPW) Preliminary Flood Risk Assessment Mapping (PFRA);
    - The Irish Coastal Protection Strategy Study (ICPSS);
    - Historic flooding information for the area;
    - Available topographical information for the site;
    - Eastern Catchment Flood Risk Assessment and Management (CFRAM) Study;
- Review of the risk of coastal, fluvial, pluvial and groundwater flooding;
- Review of available site investigation data;
- Review of the layout of the Wastewater Treatment Plant;
- Preparation of a flood risk assessment report.

1.3 Summary of Data Used

In preparing this report, the following data was collated and reviewed:

- Flood history of the site from the OPW National Flood Hazard Mapping website (www.floodmaps.ie);
- Preliminary Flood Risk Assessment (PFRA) Mapping produced by the OPW (www.cfram.ie/pfra);
- Predicted extreme water levels and flood extent maps from the ICPSS;

- Flood maps and reports from the South Western CFRAM;
- Site Geological and hydrogeological data from the Geological Survey of Ireland website (www.gsi.ie);
- Guidelines for Planning Authorities on 'The Planning System and Flood Risk Management' published in November 2009, jointly by the Office of Public Works (OPW) and the then Department of Environment, Heritage and Local Government (DEHLG);
- Topographical data from the site;
- Architectural drawings of the proposed development;
- Aerial photography and mapping from Bing Maps and Google Maps.

All Ordnance Datum (OD) levels referred to in this report are to Malin Head Ordnance Datum unless otherwise stated.

1.4 Proposed WwTP Development

Wastewater in Arklow is currently collected and discharged without any treatment through 19 existing discrete CSOs and/or outfalls to the Avoca River. To ensure compliance with the Urban Waste Water Treatment Directive, it is necessary to appropriately treat wastewater from agglomerations such as Arklow, prior to discharge to water bodies. The proposed development is designed to address this deficiency and provide appropriate wastewater treatment for Arklow town.

The proposed development will improve water quality in the Avoca River and provide adequate treatment capacity to support further development in Arklow town. All existing outfalls that currently discharge to the Avoca River will be intercepted by a new interceptor sewer network constructed along the north and south of the river channel. This sewer will convey foul flows to the WwTP for treatment and thereby eliminate, in so far as possible, the current practice of discharging raw wastewater to the Avoca River.

The site of the proposed WwTP is the Old Wallboard site, at Ferrybank, located on the north side of the Avoca River at the east of the town. The site is bounded by North Quay, Mill Road and the coastline (Figure 1 and Figure 2).

Figure 1: Location of the site of the proposed WwTP

Figure 2: Aerial view of the site of proposed WwTP (outline indicated in red)

Figure 3 presents an outline of the layout of the WwTP.

Figure 3: WwTP – Proposed Layout

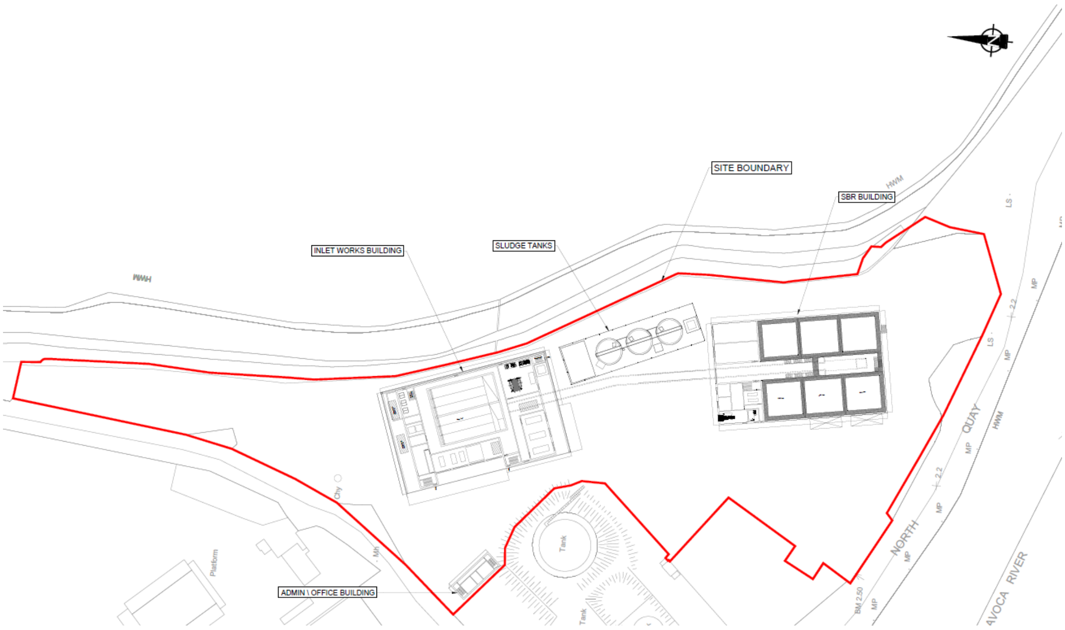
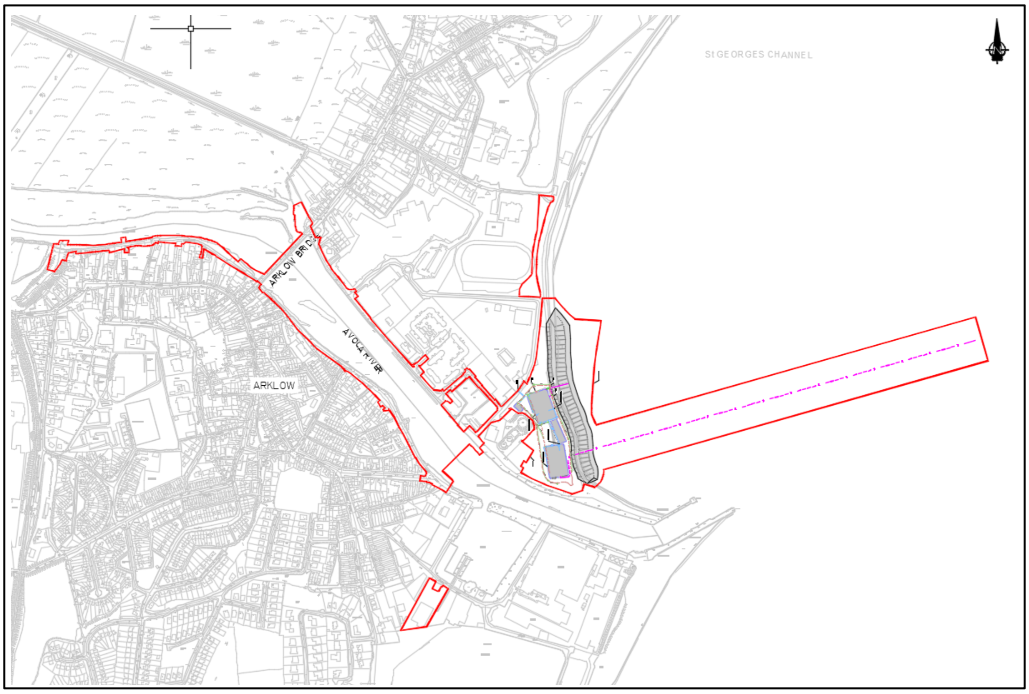


Figure 4 presents an outline of the Planning Boundary which includes the routes of the interceptor sewers within Arklow town and to the Southeast of the site as well as a Storm Water Overflow (SWO) and stormwater tank (to the northwest) at the Alps site. Flood risk associated with the Interceptor Sewers, has also been considered as part of the study and relevant reports are presented in Appendix A.

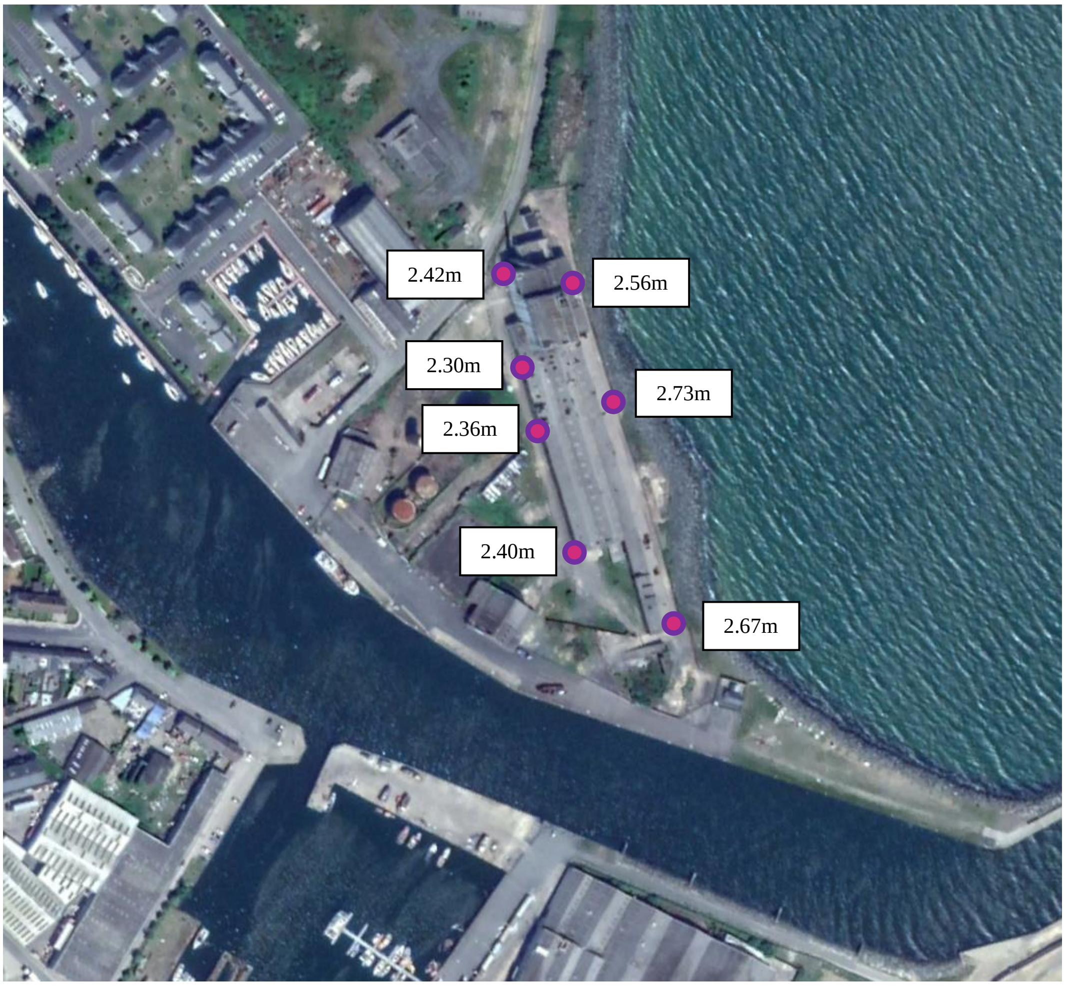
Figure 4: Planning Boundary including routes of interceptor sewers (highlighted in red)



1.4.1 Ground Elevations at the Site of the proposed WwTP

A topographical survey of the site of the proposed WwTP was undertaken by Murphy Surveys in April 2016. As indicated in Figure 5, ground levels in the vicinity of the site range from circa 2.30mOD to 2.73mOD.

Figure 5: Extract from topographical survey



1.5 Proposed Arklow Flood Relief Scheme

Wicklow County Council, on behalf of the Office of Public Works intends to proceed with the proposed Arklow Flood Relief Scheme in the immediate future. When completed the scheme will protect Arklow to a very high standard of protection against flooding – the 1 in 100-year fluvial/200-year tidal flood event.

The scheme will consist of the construction of flood defence walls and flood embankments, dredging of the Avoca River as well as additional conveyance improvement works in the study area.

It is noted that works proposed as part of the flood relief scheme will overlap in terms of location and possibly construction programme with the proposed WwTP.

2 Planning Context

The following planning policy documents are relevant to the assessment of the proposed development:

- The National Planning Guidelines published by the OPW and the Department of the Environment, Heritage and Local Government in November 2009 entitled 'The Planning System and Flood Risk Management Guidelines for Planning Authorities'
- Wicklow County Development Plan 2016 - 2022
- Arklow and Environs Local Area Plan 2018 - 2024

2.1 The Planning System and Flood Risk Management Guidelines

2.1.1 Introduction

In November 2009, the Department of Environment, Heritage and Local Government and the Office of Public Works jointly published a Guidance Document for Planning Authorities entitled "the Planning System and Flood Risk Management".

The Guidelines are issued under Section 28 of the Planning and Development Act 2000, as amended. Planning Authorities and An Bord Pleanála are therefore required to implement these Guidelines in carrying out their functions under the Planning Acts.

The aim of the Guidelines is to ensure that flood risk is neither created nor increased by inappropriate development.

The Guidelines require the Planning system to avoid development in areas at risk of flooding, unless the development can be justified on wider sustainability grounds and the risk can be reduced or managed to an acceptable level.

The Guidelines require the adoption of a Sequential Approach (to Flood Risk Management) of Avoidance, Reduction, Justification and Mitigation and they require the incorporation of Flood Risk Assessment into the process of making decisions on Planning Applications and Planning Appeals.

Fundamental to the Guidelines is the introduction of flood risk zoning and the classifications of different types of development having regard to their vulnerability.

The management of flood risk is now a key element of any development proposal in an area of potential flood risk and should therefore be addressed as early as possible in the site master planning stage.

2.1.2 Definition of Flood Zones

Flood Zones are geographical areas within which the likelihood of flooding is in a particular range. There are three types of flood zones defined in the Guidelines as follows:

Flood Zone	Probability
Flood Zone A	Probability of flooding from rivers and the sea is highest (greater than 1% or 1 in 100 for river flooding or 0.5% or 1 in 200 for coastal flooding).
Flood Zone B	Probability of flooding from rivers and the sea is moderate (between 0.1% or 1 in 1000 year and 1% or 1 in 100 for river flooding and between 0.1% or 1 in 1000 year and 0.5% or 1 in 200 for coastal flooding); and
Flood Zone C	Probability of flooding from rivers and the sea is low (less than 0.1% or 1 in 1000 for both river and coastal flooding). Flood Zone C covers all areas of the plan which are not in zones A or B.

2.1.3 Definition of Vulnerability Classes

The following table summarises the Vulnerability Classes defined in the Guidelines and provides a sample of the most common type of development applicable to each.

Vulnerability	Type of Development
Highly Vulnerable Development	Includes Garda, ambulance and fire stations, hospitals, schools, residential dwellings, residential institutions, essential infrastructure, such as primary transport and utilities distribution and SEVESO and IPPC sites, etc.
Less Vulnerable Development	Includes retail, leisure, warehousing, commercial, industrial and non-residential institutions, etc.
Water Compatible Development	Includes Flood Control Infrastructure, docks, marinas, wharves, navigation facilities, water based recreation facilities, amenity open spaces and outdoor sport and recreation facilities

2.1.4 Types of Vulnerability Classes appropriate to each Zone

The following table illustrates the different types of Vulnerability Class appropriate to each Zone and indicates where a Justification Test will be required.

	Flood Zone A	Flood Zone B	Flood Zone C
Highly Vulnerable	Justification Test	Justification Test	Appropriate
Less Vulnerable	Justification Test	Appropriate	Appropriate

	Flood Zone A	Flood Zone B	Flood Zone C
Water Compatible	Appropriate	Appropriate	Appropriate

2.2 Wicklow County Development Plan 2016 - 2022

The Strategic Flood Risk Assessment (SFRA) for the Wicklow County Development Plan 2016 - 2022 (CDP), was prepared using 'The Planning System and Flood Risk Management – Guidelines for Planning Authorities' (2009).

The purpose of the SFRA primarily was to provide an assessment of all types of flood risk to inform land-use planning decisions in the draft CDP.

2.2.1 Regional Level

The Regional Planning Guidelines 2010 (RPGs) put forward a number of recommendations and best practice to support its Regional Flood Risk Appraisal (RFRA). They are as follows:

Strategic Policy

FP1 Flood risk should be managed proactively at all stages in the planning process avoiding development in flood risk areas where possible and by reducing the risks of flooding to and from existing and future development.

Strategic Recommendations

FR1 New development should be avoided in areas at risk of flooding. Alongside this, the Regional Flood Risk Appraisal recognises the need for continuing investment and development within the urban centres of flood vulnerable designated growth towns and the city and for this to take place in tandem with the completion of CFRAM Studies and investment in comprehensive flood protection and management.

FR2 Development and Local Area Plans should include a Strategic Flood Risk assessment and all future zoning of land for development in areas at risk of flooding should follow the sequential approach set out in the Departmental Guidance on Flood Risk Management. All Flood Risk Assessments and CFRAM studies should take place in coordination and consultation with adjoining local authorities and regions and in coordination with the relevant River Basin Management Plans.

FR3 Local authorities should take the opportunities presented to optimise improvements in biodiversity and amenity when including policies and actions in development plans/local area plans (such as flood plain protection and SUDS) for existing and future developments.

FR4 Plans and projects associated with flood risk management that have the potential to negatively impact on Natura 2000 sites will be subject to a Habitats Directive Assessment (HDA) according to Article 6 of the habitats directive and in accordance with best practice and guidance.

The RPGs seek to emphasise to Local Authorities the need to protect across the Greater Dublin Area the natural flood plains and riparian corridors of all rivers that have not already been built on, and seek that this is explicitly stated and spatially designated in all future Development Plans and Local Area Plans following the completion of the CFRAM programme for the area in question. Land required for current and future flood management should be safeguarded from development. Allocation of future areas for development as extensions to existing built up areas, villages or towns should follow a sequential approach; be within the lowest risk sites appropriate for the development; and should include adequate provision for adaptation to, or protection against, the projected impacts of climate change.

2.2.2 County and Local Level

The CDP states that Local Authorities must undertake a Strategic Flood Risk Assessment for future plans in line with the EU, National and Regional legislative and policy framework. The Department's Guidance on the Planning System and Flood Risk is the key tool in undertaking SFRA. Local Authorities should ensure that they adhere to the principles of avoiding risk where possible in preparing future Plans.

In the preparation of a Development Plan, Local Authorities are advised to:

- Identify and consider at the earliest stage in the planning process flood hazard and potential risk.
- Identify flood risk areas on the Plan maps.
- Review existing plan zonings to ensure that issues of Flood Risk have been addressed in a manner consistent with the Flood Risk Guidelines. Where lands are already zoned for housing or other vulnerable development in flood risk areas, the Council should undertake a re-examination of the zoning in accordance with the sequential approach.
- Include policies which ensure that flood risk areas targeted for development following the sequential approach should be planned, designed and constructed to reduce and manage flood risk and be adaptable to changes in climate.
- Include policies to ensure that flood risk and impact is considered as a key element in the assessment of future waste and mineral planning strategies and developments.
- Include policies that ensure that the location of key infrastructure will be subject to FRA.
- Include policies on the importance of the inclusion of Sustainable Drainage Systems (SUDS) in future developments, in accordance with the recommendations of the Greater Dublin Strategic Drainage Study Guidelines and Appendix B of the Flooding Risk Guidelines published by the Department and the OPW.

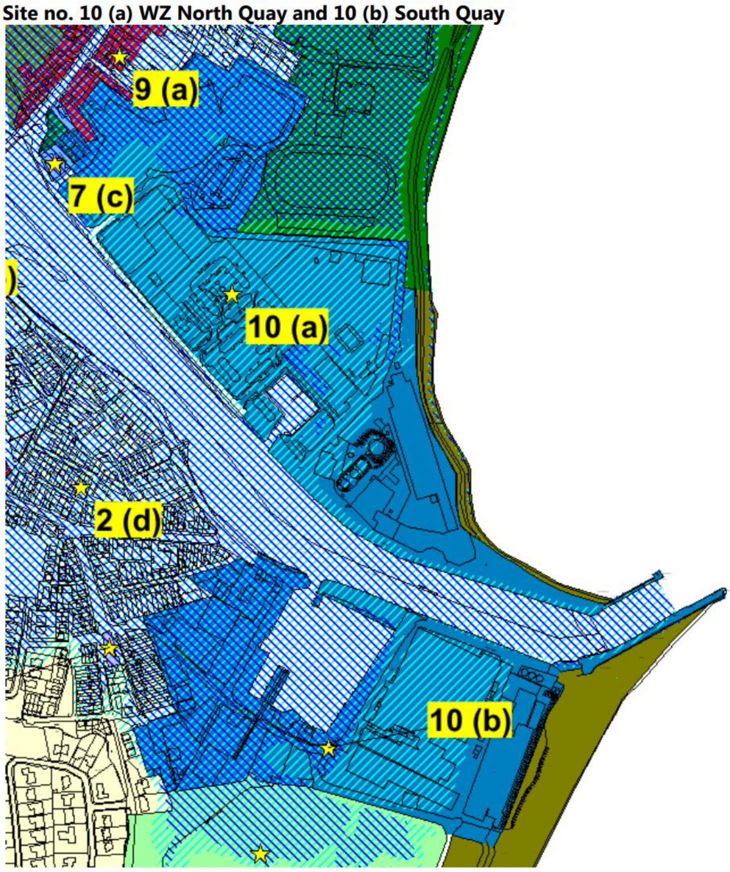
2.3 Arklow and Environs Local Area Plan 2018 - 2024

The Strategic Flood Risk Assessment (SFRA) for the Arklow and Environs Local Area Plan 2018 - 2024 (LAP) was prepared using 'The Planning System and Flood Risk Management – Guidelines for Planning Authorities' (2009).

The SFRA presents the zoning objectives of the plan and their typical permitted uses. In accordance with the guidelines an assessment was undertaken to determine the appropriateness of land uses to each flood zone. The assessment is undertaken in accordance with Tables 3.1 and 3.2 of the guidelines and measures vulnerability to flooding of different types of development in order to illustrate appropriate development that is required to meet the Development Plan Justification Test.

We note that the site of the proposed WwTP as well as the North and South quays in Arklow were deemed to have passed the development plan Justification test in the SFRA. These areas are highlighted in the figure below.

Figure 6: Site no 10 considered as part of the SFRA



3 Overview of Flood Mechanisms and Historical Flooding at the Site

3.1 Flood Mechanisms

In broad terms, the potential sources of flooding to the site of the WwTP can be categorised as:

- Fluvial (River) Flooding – The main risk of fluvial flooding is from the Avoca River, which runs parallel to the southern boundary of the proposed development.
- Tidal/Coastal Flooding – The risk from coastal flooding is from surge events in the Irish Sea.
- Pluvial Flooding - Pluvial flooding occurs when the capacity of the local urban drainage network is exceeded during periods of intense rainfall. At these times, water can collect at low points in the topography and cause flooding.
- Groundwater Flooding - Groundwater Flooding can occur during lengthy periods of heavy rainfall, typically during late winter/early spring when the groundwater table is already high. If the groundwater level rises above ground level, it can pond at local low points and cause periods of flooding.
- Embankment breach assessment – The area north of the site of the proposed WwTP is protected by an embankment which in the event of breach may introduce a flood risk to the site.

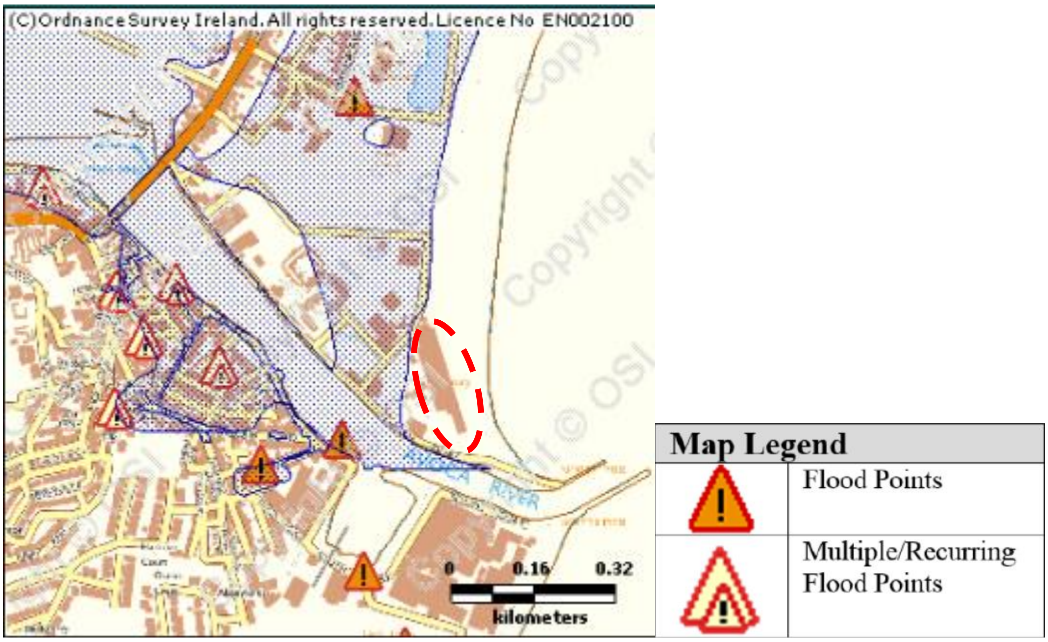
Each of these sources of flood risk are considered in this FRA.

3.2 Historic Flooding

Reports and maps from the OPW’s National Flood Hazard Mapping Website (www.floodmaps.ie) have been examined as part of this Flood Risk Assessment to understand the historic record of flooding at the site of the WwTP and the additional areas.

Figure 7 presents an outline of the recorded historic flood extent in Arklow. It can be seen from the figure that large areas of the town are indicated as being within the historic floodplain. The site of the proposed WwTP however is not located in the historic floodplain.

Figure 7: Historic flood extent - extract from floodmaps.ie (site of proposed WwTP indicated with red dashed outline)



The Flood Hazard Mapping website notes that Arklow was flooded in November 2000 due to heavy rainfall and also in August 1986 during hurricane Charlie.

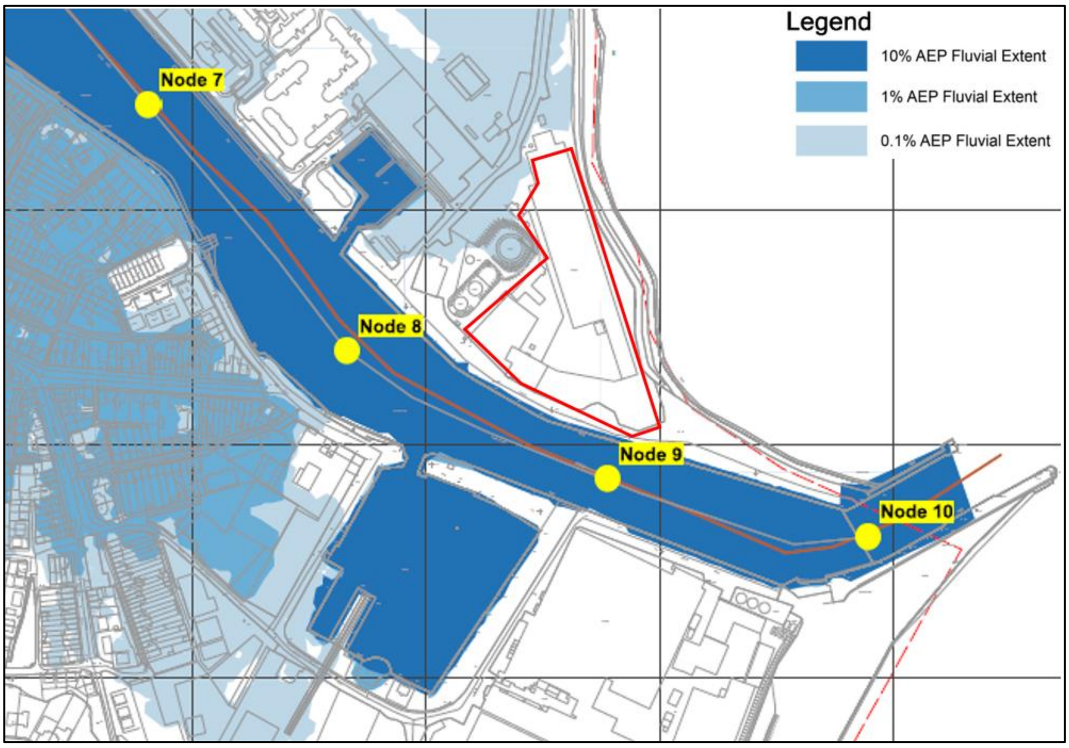
4 Fluvial Flood Risk

4.1 Site of the WwTP

Floodmaps and reports from the Eastern CFRAM study have been used to assess the risk of fluvial flooding to the site of the proposed WwTP.

Figure 8 presents an extract from the Eastern CFRAM showing the predicted fluvial flood extents for the 10%, 1% and 0.1% Annual Exceedance Probability (AEP) events. It can be seen from the figure that the site of the WwTP is not indicated as being within the predicted fluvial flood extents for any of the three return periods considered.

Figure 8: Fluvial Flood Map (WwTP site indicated in red)

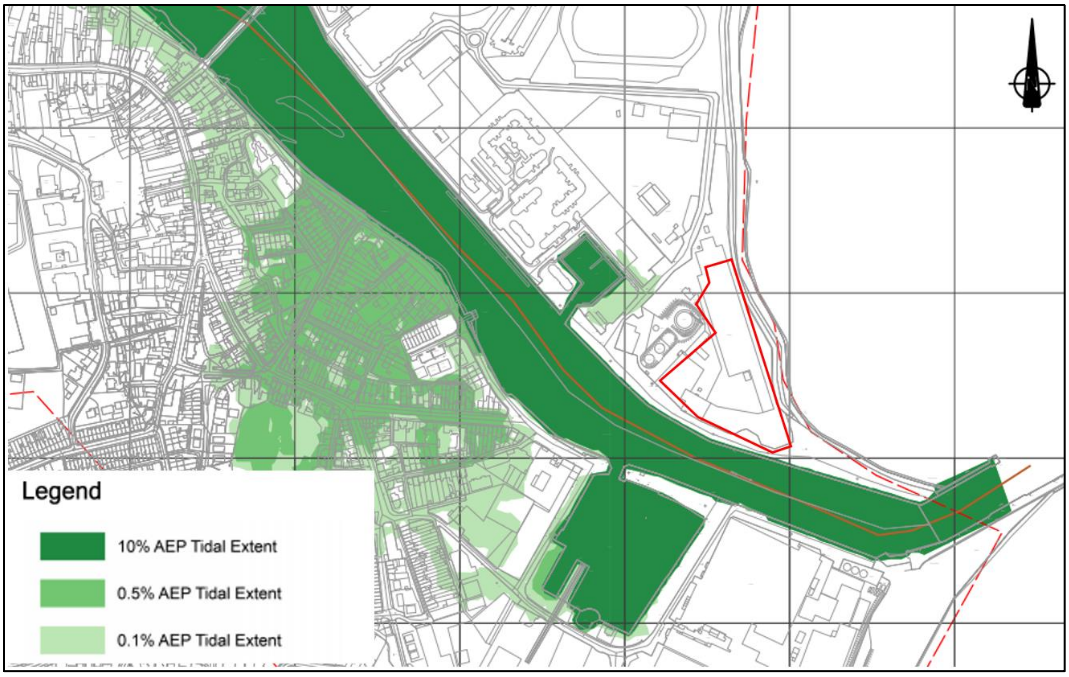


5 Coastal/Tidal Flood Risk

5.1 Site of Proposed WwTP

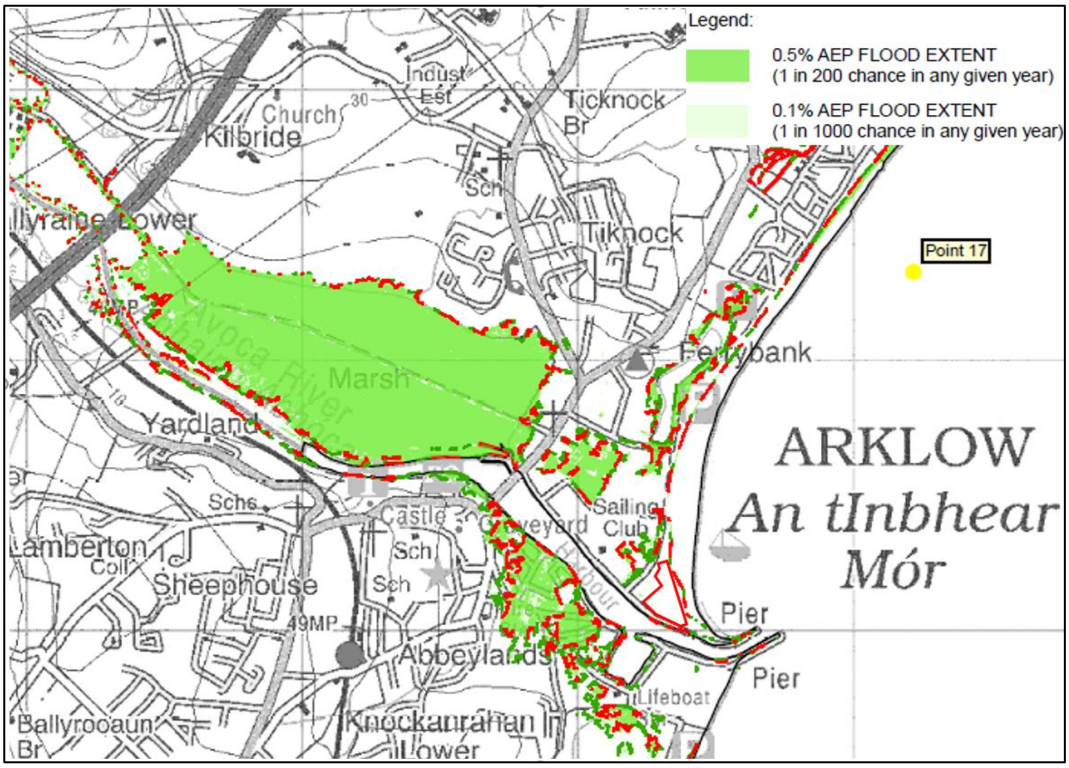
Figure 9 presents the predicted coastal flood extent maps from the Eastern CFRAM Study. It can be seen from the figure that the site of the proposed WwTP is located outside of the predicted flood extent for each of the three events.

Figure 9: Coastal Flood Map – CFRAM (site indicated in red)



As part of the identification of coastal flood risk, we have reviewed output from the Irish Coastal Protection Strategy Study (ICPSS) which was produced by OPW. Figure 10 presents the predicted 0.5% AEP flood extent from the ICPSS. It can be seen that the site of the proposed WwTP is indicated as being outside the predicted flood extent.

Figure 10: ICPSS – Coastal Flood Map



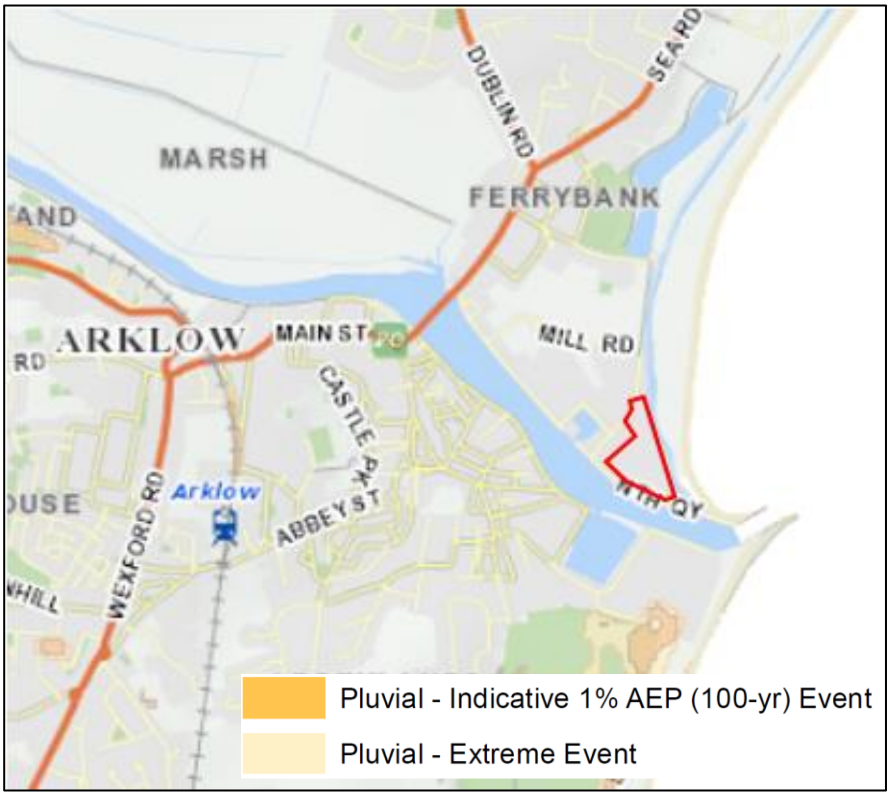
6 Pluvial and Groundwater Flood Risk

6.1 Pluvial Flood Risk

Pluvial flooding occurs when extreme rainfall overwhelms drainage systems or soil infiltration capacity, causing excess rainwater to pond above ground at low points in the topography.

Figure 11 presents the PFRA pluvial flood risk map for Arklow. It can be seen from the figure that the risk of pluvial flooding to the site of the proposed WwTP and the additional areas considered is low.

Figure 11: Pluvial Flood map for Arklow (site indicated in red)



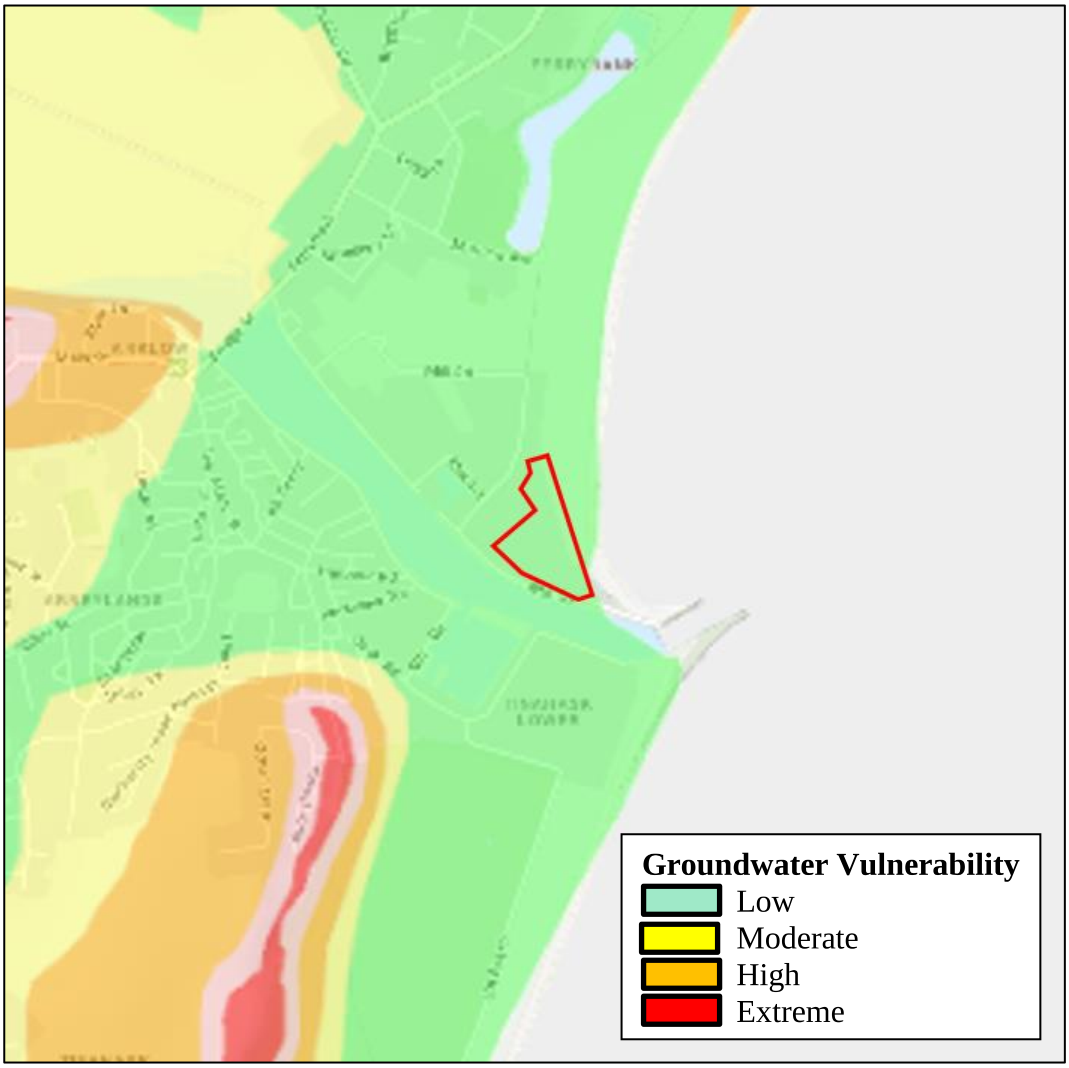
6.2 Groundwater Flood Risk

Groundwater flooding can occur during lengthy periods of heavy rainfall, typically during later winter/early spring when the groundwater table is already high. If the groundwater level rises above surface level, it can pond at local points and cause periods of flooding.

The groundwater vulnerability assessment is based on assembling information on the most relevant factors affecting aquifer vulnerability. These factors include soil type, geologic formation type, recharge, etc, which is then interpreted to produce a class of vulnerability.

Figure 12 indicates the groundwater vulnerability of the site and the surrounding areas. The groundwater vulnerability is indicated as low in the figure.

Figure 12: GSI map – Groundwater Vulnerability (site indicated in red)



The Groundwater vulnerability maps indicate that the groundwater table may be high and/or the overburden may be reasonably permeable. This dataset however is only indicative and does not reflect the risk of groundwater flooding of the site.

A Site Investigation of the site has been undertaken as part of the proposed development. Groundwater levels were monitored at a number of boreholes in the site as part of the investigations and suggest that the groundwater table is circa 2m below ground level.

The risk of groundwater flooding is therefore considered to be low.

7 Embankment Breach Assessment

The area north of the site of the proposed WwTP is protected from coastal inundation by an embankment as indicated in Figure 13. In the event of a breach of the embankment coastal water may inundate the area north of the site. It is considered however that the flood risk to the site of the proposed WwTP in this scenario is low for two key reasons:

- There are embankments along both sides of the section of Mill Road that is orientated in an East West direction as highlighted in Figure 14. These embankments are elevated above the floodplain and will prevent any floodwater from North of Mill Road travelling in the direction of the site. We note that the risk of these embankments being overtopped is very low.
- Existing ground elevations rise towards the site along the section of Mill Road that is orientated in a North South direction (Figure 15). This will also ensure that flood water from north of the site cannot reach the site. We note that should the embankment be breached along the section of Mill Road indicated in Figure 15, ground levels will ensure that any flood water getting through the embankment in the scenario will be conveyed away from the site.

Figure 13: Overview

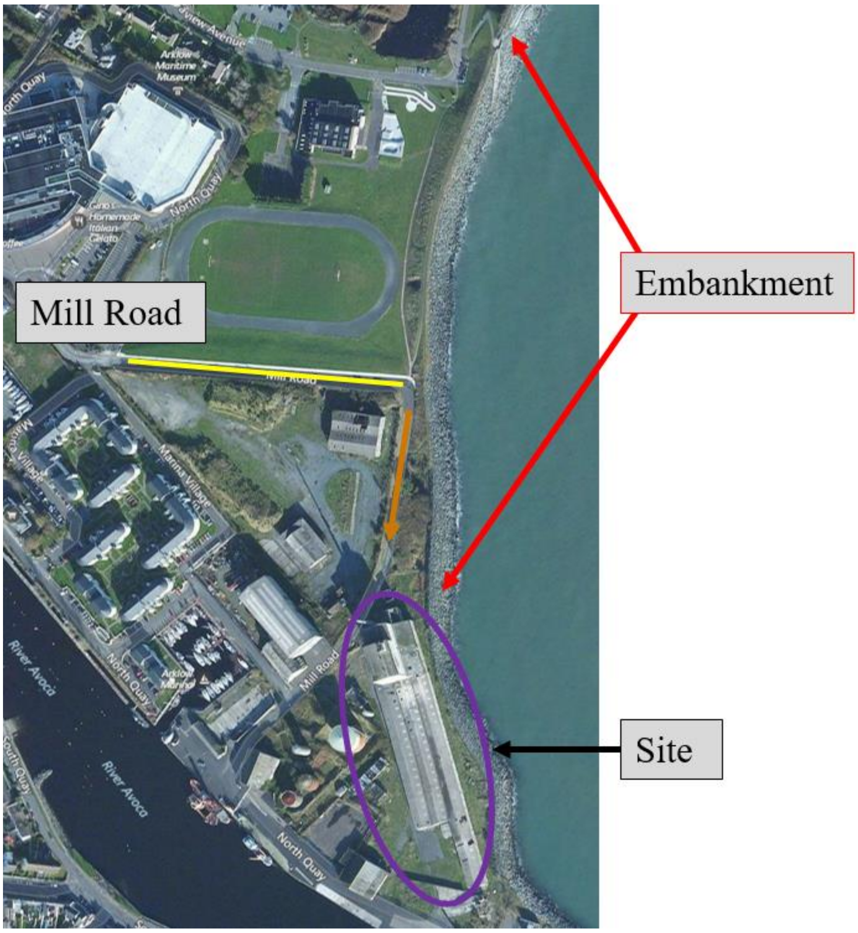


Figure 14: View along Mill Road (looking West)

Figure 15: Looking towards the site from Mill Road

8 Flood Risk associated with the Proposed Interceptor Sewers

The proposed development will improve water quality in the Avoca River. All existing outfalls that currently discharge to the Avoca River will be intercepted by a new interceptor sewer network constructed along the north and south of the river channel. Flood risk associated with the construction and operation of the proposed interceptor sewer is discussed in this section. Please refer to Appendix A1 and Appendix A2 for more detail.

8.1 Encroachment of River Avoca Channel

As part of this development, a route for the interceptor sewer Pipe is proposed along the south quay, as presented in Figure 1 of Appendix A and Figure 4 of Section 1.4.

This route would result in an encroachment into the Avoca River channel for a distance of approximately 270m and reduce the existing channel width by c. 6 m or an average reduction of 4.3%. The proposal avoids direct obstruction of the Arklow Bridge.

To inform the proposed development, Hydro Environmental Ltd carried out detailed hydraulic modelling to assess and quantify the hydraulic impact of the proposed encroachment. Appendix A presents details of the analysis carried out.

Results demonstrate that without mitigation there would be a localised and small potential increase in flood levels of up to 3.3cm immediately downstream of the Arklow Bridge. There would also be a small increase of 1.9cm upstream of the Arklow Bridge. These increases in the context of the overall flood depths are very minor and unlikely to impact significantly on flood risk in Arklow.

A temporary haul road is proposed that would facilitate construction of the interceptor sewer. A worst-case scenario was examined whereby the haul road was extended the full length of the works from downstream to upstream and through the first and second Arch.

A proposed local mitigation measure which assists both construction and operational phases is the localised lowering of the bed in Arch 2 of Arklow Bridge by c. 1m. The flood simulation shows that this measure achieves a slight reduction in upstream flood levels and no worsening of the existing Flood Risk areas in Arklow. The simulation shows that downstream of the bridge flood elevation increases by c. 1.9 and c. 5.5cm due to the causeway encroachment. However, these increases are shown not to be critical to the floodplain inundation and flood risk at Arklow with the computed flood extents presenting a slightly reduced flood area as a result of the slight reduction in upstream Flood level.

8.2 Sewer Network Flooding Assessment

Flood risk associated with the proposed interceptor sewer was assessed as part of this FRA.

This is based on hydraulic modelling carried by Byrne Looby for the proposed development and this section summarises findings. Please refer to Appendix A2 for further details.

The proposed works intercepts the existing 225mm diameter combined sewer and a 1200mm diameter storm sewer, which conveys some foul connections and pass the flows through the existing SWO. The Pass Forward Flow will be conveyed to the proposed Southern Interceptor sewer and the storm flows stored in an underground on-line storage tank. An overflow from this on-line storage tank was connected to the existing storm outfall discharging to Avoca River. All screenings will be passed onto the interceptor sewer. The proposed interceptor sewer will significantly reduce the number of spills into the Avoca River and thereby improve its water quality.

Hydraulic modelling consists of assessing a range of design storm conditions according to the Greater Dublin Strategic Drainage Study and taking account of the joint occurrence of tidal and fluvial risk as well as climate change. 10 years of rainfall data has also been applied to the catchment to assess the proposed condition.

Modelling results show that there is significant risk in terms of network flooding in the current condition, with an estimated 8,104m^3 flood volume throughout the catchment at 106 locations. This risk reduces slightly once the proposed interceptor sewer is provided, with an estimated flood volume of 7,562m^3 at 100 locations.

However, the risk from network flooding remains significant as a number of network upgrades are required to be provided as part of future phases as detailed in the GDSDS Phase 3 implementation. Once all upgrades are implemented, only very minor flooding is predicted within the catchment at only three locations with a marginally flood volume of circa 25 m^3.

Provision of the interceptor sewer is an important requirement for the implementation of the recommendations under the GDSDS and addressing sewer flood risk.

9 Establishment of Suitable Finished Floor Levels

9.1 Proposed WwTP

Given the low flood risk to the site, the finished floor level of the proposed WwTP needs to be considered in the context of the existing ground levels for the site, the process design of the plant and in minimising the low risk of pluvial flooding to the site.

Existing ground levels at the site vary from circa 2.30mOD to circa 2.73mOD. It is recommended that the Finished Floor Level of the main buildings of the WwTP is set at **2.5mOD**.

In the event of an extreme high-intensity rainfall event, the capacity of the drainage system for the proposed development could be exceeded leading to localised surface runoff ponding on the site. This is discussed further in the following section of the report.

10 Management of Residual Flood Risk at the Subject Site

10.1 Access and Egress Routes to the Site

Given the absence of a significant risk of flooding of the site, access and egress routes are unlikely to be compromised during flood events.

10.2 Storage and Conveyance

The proposed development will have no impact on floodplain storage and conveyance as it is located outside of the 1 in 1000-year flood plain.

10.3 Site Drainage System

The drainage system for the site will be designed following best practice and it will be ensured that the proposed development does not increase the surface water runoff from the site.

The reader is referred to the Site drainage report for further information.

10.4 Surface Water Design Exceedance Event

The risk of surface water entering the buildings of the WwTP in a drainage design exceedance event is low as it will be ensured that ground levels external to the entrances to the buildings slope away from the buildings ensuring any surface water is diverted away. Additionally, we note that there is a very limited catchment area around the buildings that can generate surface water and any volume which be generated during a design exceedance event is likely to be low.

11 Application of 'Flood Risk Management Guidelines'

11.1 Classification of Arklow WwTP

The WwTP is classified as 'highly vulnerable development' as per the Vulnerability classification in the planning guidelines (Figure 16).

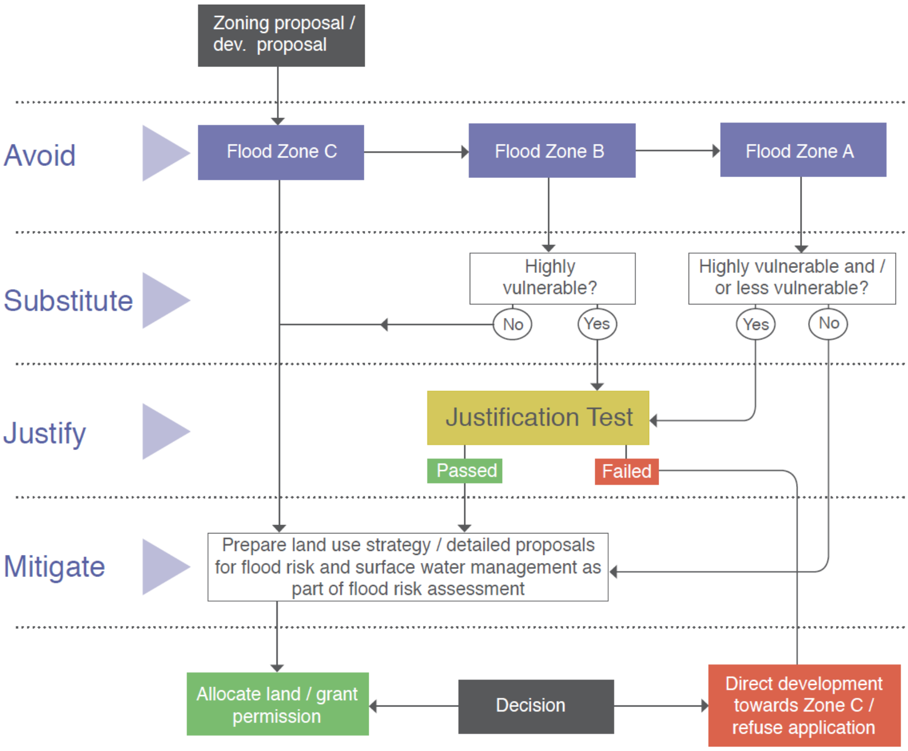
Figure 16: Vulnerability classification

Vulnerability class	Land uses and types of development which include*:
Highly vulnerable development (including essential infrastructure)	Garda, ambulance and fire stations and command centres required to be operational during flooding; Hospitals; Emergency access and egress points; Schools; Dwelling houses, student halls of residence and hostels; Residential institutions such as residential care homes, children's homes and social services homes; Caravans and mobile home parks; Dwelling houses designed, constructed or adapted for the elderly or, other people with impaired mobility; and Essential infrastructure, such as primary transport and utilities distribution, including electricity generating power stations and sub-stations, water and sewage treatment, and potential significant sources of pollution (SEVESO sites, IPPC sites, etc.) in the event of flooding.
Less	Buildings used for: retail, leisure, warehousing, commercial, industrial and

11.2 Sequential Approach

Figure 17 illustrates the sequential approach to be adopted under the 'Planning System and Flood Risk Management' Guidelines. Given the low flood risk to the site of the proposed Arklow WwTP, it is classified as Flood Zone C. Following the sequential approach, a Justification test for the WwTP is therefore not required.

Figure 17: Sequential approach mechanism in the planning process



12 Conclusion

Arup has been commissioned to undertake a Flood Risk Assessment (FRA) for the proposed Wastewater Treatment Plant (WwTP) at the Old Wallboard site at Ferrybank, Arklow. The FRA is to accompany the statutory consent application for the overall Arklow Wastewater Treatment Plant project.

The FRA has been undertaken in accordance with 'The Planning System and Flood Risk Management' Guidelines for Planning Authorities published in November 2009, jointly by the Office of Public Works (OPW) and the then Department of Environment, Heritage and Local Government (DEHLG).

While areas of Arklow have flooded in the past, the site of the proposed WwTP is not within the historic floodplain.

The risk of fluvial flooding to the site of the WwTP is low. The risk of coastal flooding to the site is also low. The risk of groundwater and pluvial flooding is considered to be low.

The area north of the site of the proposed WwTP is protected from coastal inundation by an embankment. In the event of a breach however the flood risk to the site is considered to be low.

Existing ground levels at the site vary from circa 2.30mOD to circa 2.73mOD. It is recommended that the Finished Floor Level of the main buildings of the WwTP is set at 2.5mOD.

Given the absence of a significant risk of flooding of the site, access and egress routes are unlikely to be compromised during flood events. The proposed development will have no impact on floodplain storage and conveyance as it is located outside of the 1 in 1000-year flood plain.

The drainage system for the site will be designed following best practice and it will be ensured that the proposed development does not increase the surface water runoff from the site. The risk of surface water entering the buildings of the WwTP in a drainage design exceedance event is low as it will be ensured that ground levels external to the entrances to the buildings slope away from the buildings ensuring any surface water is diverted away. Additionally, we note that there is a very limited catchment area around the buildings that can generate surface water and any volume which will be generated during a design exceedance event is likely to be low.

The site of the proposed WwTP is classified as Flood Zone C and a Justification Test for the development is therefore not required.

We note that flood risk to areas in which it is proposed to construct interceptor sewers has also been considered as part of the study as well as flood risk of the sewer network and details are presented in Appendix A1 and A2.

Appendix A

Flood Risk Assessment for Interceptor Sewers

A1 Hydraulic Assessment of Proposed Interceptor Sewer Pipe Encroachment of the River Avoca Channel at Arklow

Report No. HEL215601 v1.1

Arklow Sewerage Scheme

Hydraulic Assessment of Proposed Interceptor Sewer Pipe Encroachment of the River Avoca Channel at Arklow

On behalf of

Byrne Looby

August 2018

Hydro Environmental Ltd

No. 4 Caiseal Riada,
Clarinbridge,
Galway, Ireland,
H91 X81W.
Tel No: 091 796734

Hydraulic Impact Assessment of proposed Interceptor Sewer Encroachment of the River Avoca Channel at Arklow

Job No.:	**0215601**
Report No.:	**HEL0215601 v1.1**
Prepared by:	**Anthony Cawley BE, M.EngSc, CEng MIEI**
Date:	**24th August 2018**

DISCLAIMER

This report has been prepared solely as a Hydraulic Report for the proposed Arklow Sewerage Scheme in respect to proposed Sewer Encroachment into the Avoca River Channel at Arklow. Hydro Environmental Ltd. accept no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned.

Table of Contents

1. Introduction

Hydro Environmental Ltd have been engaged as sub-consultants by Byrne Looby to undertake a hydraulic impact assessment of the proposed Interceptor Sewer encroachment of the River Avoca as part of the Arklow Wastewater Treatment Plant Project. One proposed route for the Interceptor sewer pipe is along the south quay and an option being considered is the encroachment of the sewer pipe into the Avoca estuarine channel for a distance of 270m downstream of Arklow Bridge.

The proposed scheme is to run the proposed Interconnector Sewer under the existing bed of the first Arch at Arklow Bridge. The encroachment width from the existing quay walls downstream of the bridge is approximately 6m reducing the channel width from 96m to 90m at the downstream end of the encroachment, 117m to 111m at the mid-section and 132m to 126m towards the upstream section. This represents a reduction in channel area/width downstream of the bridge of 4.3% within the 270m reach section. The existing quay wall will be removed and replaced at a similar wall height along the edge of the encroachment both upstream and downstream of the bridge.

The proposal avoids direct obstruction of the Arklow Bridge arch at the existing bed levels but requires an upstream channel encroachment a short distance upstream of the arch for a manhole and access which potentially will interfere with the river flow entering the first bridge arch. The proposed alignment and channel encroachment is presented in Figure 1.

Figure 1: Proposed encroachment and new position of Quay Wall shown in Red

2. Methodology

2.1 Hydraulic modelling

A 2-D hydraulic model developed by Hydro Environmental Ltd. for the feasibility and engineering design of the Arklow Flood Relief Scheme was used to assess and quantify the hydraulic impact of the proposed Interceptor Sewer encroachment on flows and flood levels in the Avoca River at Arklow. This model uses the TELEMAC hydraulic software package, which is considered to be one of the leading hydraulic software packages internationally for such assessments.

The Telemac-2D model was revised to include a more recent river channel bathymetric survey carried out by Murphy Survey's Ltd. in March 2017 as part of this project. This new bathymetry data covered a reach distance of 575m upstream and 650m downstream of Arklow Bridge, including Arklow Bridge itself (refer to Figure 2) and replaces older survey data in the flood model.

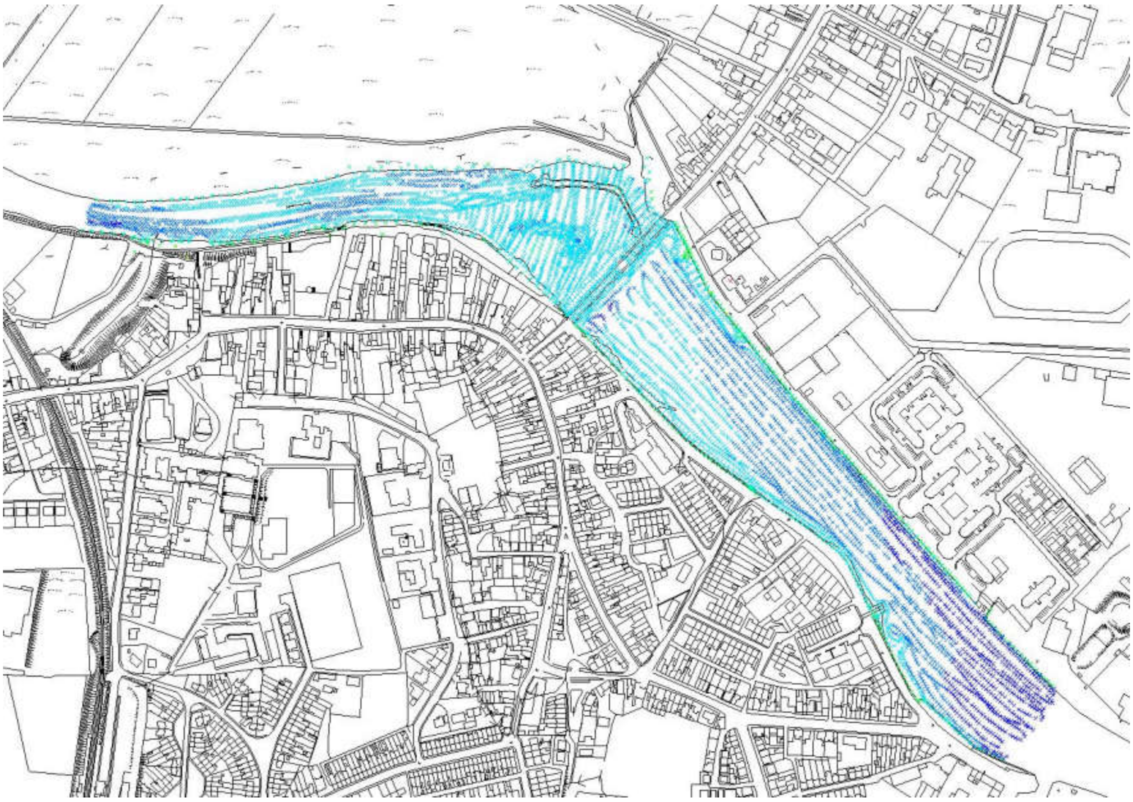


Figure 2: Extent of the March 2017 Murphy Survey of the Avoca near Arklow Br.

2.2 Design Flood Event

The design flood event for the impact assessment is the combined 200year event represented by the 100year river flood and the 0.35year tide (which is the critical combination of fluvial and tidal event). The design flow includes the OPW factors of safety in respect to factorial errors of the flood Study estimation method.

The design flood flows in the Avoca River at Arklow used in the Arklow Flood Relief Scheme Study were estimated using the FSR (Flood Study Report) ungauged catchment characteristic Index Flood Method. The catchment characteristics method gave a QBAR (mean annual maximum Flood Flow) of 247 m^3/s and 363 m^3/s, when multiplied by the Standard Factorial Error (SFE) of 1.47, i.e. a runoff rate of 0.557cumec/km^2. In designing bridges and flood relief schemes it is normal to include the statistical standard error of the estimation method as a safety factor against under predicting. The inclusion of the statistical standard error represents the upper 67-percentile confidence range and including twice the standard error represents the upper 95-percentile confidence interval.

The return period flood flows were derived by multiplying the QBAR estimate by a representative flood growth curve for the catchment. The lack of suitable recorded flood data from similar catchments located in the East / South East region of Ireland in respect to size and runoff, soil type precluded a detailed Pooled Group analysis for the Avoca River. As such, the growth curve for the Avoca River was approximated from combining the growth curves for the Slaney, Owenavorragh, Avonmore and Aughrim Rivers and the growth curve derived by Bruen et al. (2005) for the smaller gauged catchments in the Dublin area. This led to a proposed 100-year Growth Factor of 2.30. Including the SFE, the 100year flood flow estimate for the Avoca River at Arklow is 835m^3/s.

Table 1: Summary of design flood flows with and without climate change

Return Period	Design Flow m^3/s (no climate change allowance)	Design Flow m^3/s (with climate change allowance**)	Design Flow with SFE* m^3/s (no climate change allowance)
2	231	277	340
5	322	386	473
10	381	457	560
25	457	548	672
50	512	614	753
100	568	682	835
200	627	752	922
500	698	838	1026

*SFE is the standard factorial error of the regression equation used (SFE = 1.47)
** Climate Change Allowance – 20% increase in Flow Rate

The design flood hydrograph shape was derived using the Flood Study Report (FSR) hydrograph method and is specified at the upstream flow boundary of the model domain and the 0.35year design tidal curve of period 12.4hours with a highwater

0.83m OD at the downstream harbour open sea boundary. The design return period tidal levels were obtained from the Irish Costal Protection Strategy Study (ICPSS) Phase II Study (DCMNR, 2006) that was funded by the (then) Department of the Communications, Marine and Natural Resources.

Table 2: Combined 200year Fluvial Flow and Storm Tide Events

Fluvial Event (yrs)	***100***	***50***	***10***	***1.5***	***1***	***0.75***	***0.5***
Q_T (cumec)	835	753	560	307	255	217	164
Tide (highwater) event (yrs)	***0.35***	***0.75***	***3.5***	***10***	***50***	***100***	***200***
H_T (m OD Malin)	0.83	0.92	1.107	1.23	1.4	1.48	1.56

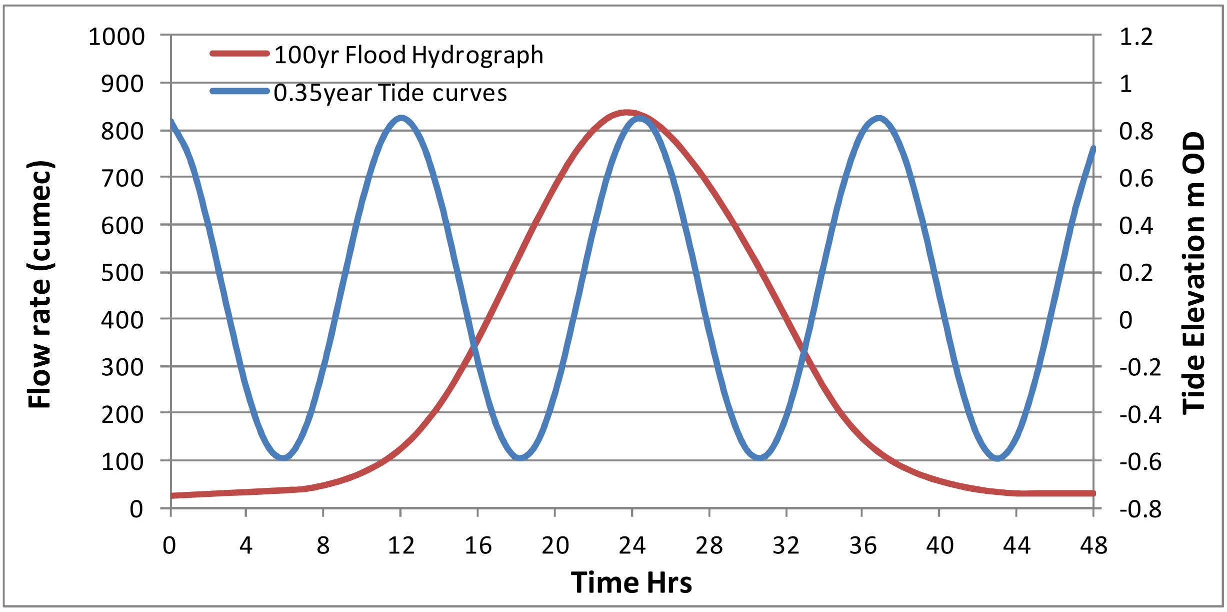


Figure 3: Combined 200year Flood Event (100year Fluvial Flood and 0.35year Tide)

3. Hydraulic Model simulations

3.1 Proposed Sewer Pipe Encroachment

The TELEMAC-2D Hydraulic model of the Avoca was run with and without the proposed Interceptor Sewer quay wall encroachment for the design flood event design flood of 835cumec and a corresponding tide with a highwater level of 0.83m. the shape and timing of the flood and tidal hydrographs were combined to ensure that the flood peaks coincided, refer to Figure 3. Six output locations identified as locations 1 to 6 in Figure 4 are used to compare computed river flood levels between the existing and the proposed encroachment case. The computed maximum flood levels at these reference points are presented in Table 3 for existing and proposed Interceptor Sewer case.

The effect of a c. 6m narrowing of a 270m length of Avoca estuarine channel immediately downstream of Arklow Bridge and the local encroachment immediately upstream of the Bridge produces a 0.033m rise in flood level immediately downstream of the bridge (location 3). The combined impact upstream of the encroachment including the upstream manhole encroachment produces a small rise of 0.017 to 0.019m at locations 4 to 6 respectively.

Table 3: Predicted peak flood elevations for existing case and the proposed Interceptor Sewer encroachment

Reference location Refer to Figure 4	Existing mOD	Proposed With Interceptor Encroachment m OD	Difference (m)
1	1.629	1.622	-0.007
2	1.977	1.970	-0.007
3	2.270	2.303	+0.033
4	3.236	3.253	+0.017
5	3.361	3.380	+0.019
6	3.409	3.427	+0.018

A rise of 3.3cm in predicted flood level caused by the Interceptor Sewer encroachment applies to a localised section of channel located immediately downstream of the bridge. The simulation shows that for much of the encroachment reach, the flow velocity increases which in turn limits or slightly reduces the peak flood levels in the narrowed channel section.

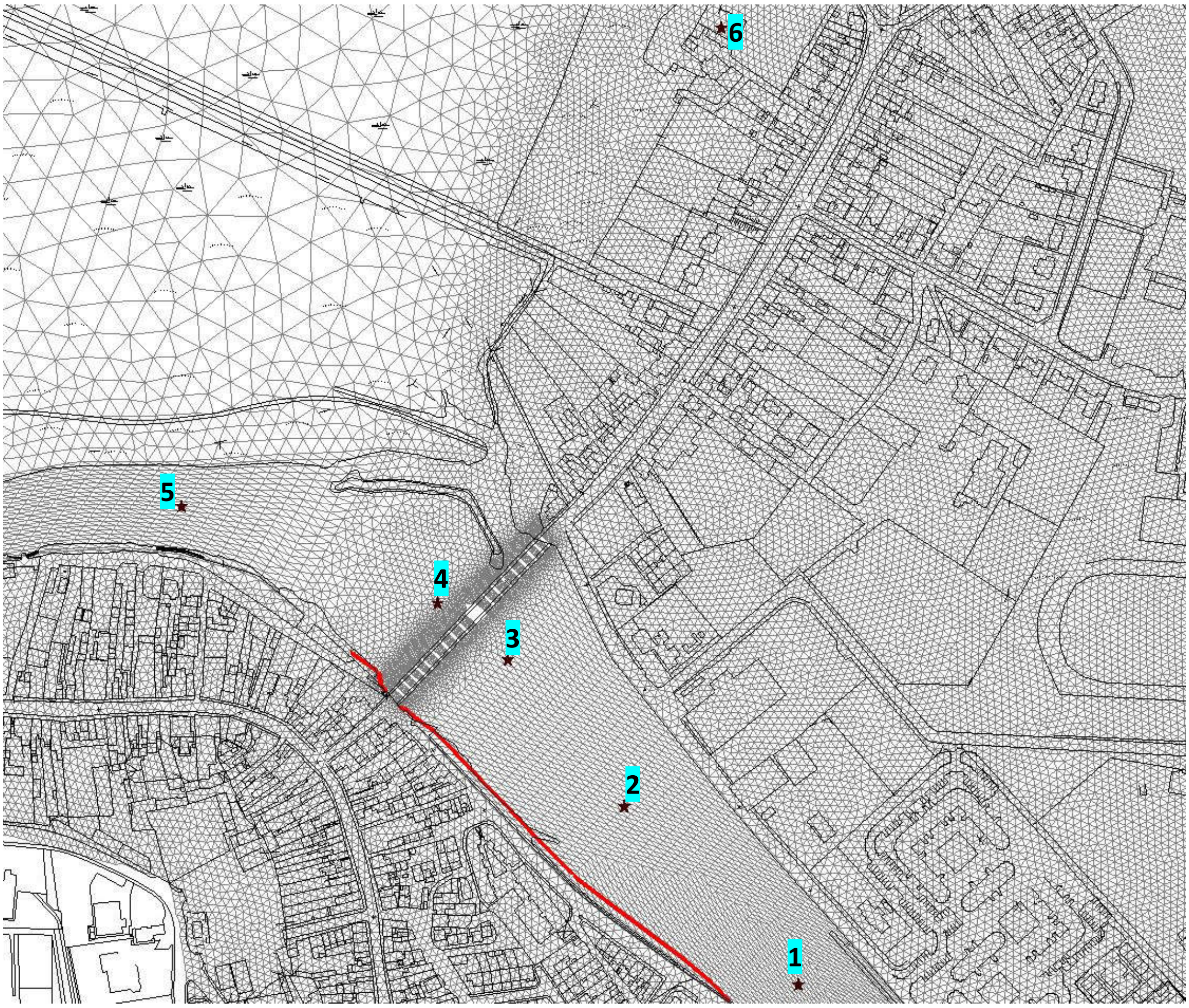


Figure 4: Reference Site locations within the Avoca River Channel for flood level impact prediction between existing and proposed Interceptor

A 1.9cm rise in upstream flood level is relatively minor and will not result in any significant impact on spill volumes discharging overbank on the north and south banks. The minor scale of impact of the encroachment on the design flood level in the river is represented in Figure 5 showing the predicted longitudinal Flood Profile for existing and proposed cases and also in Figure 8 showing the computed flood extent.

The computed flood flow velocities in the river channel for the existing and proposed cases are presented in Figures 6 and 7. The flow field plot shows increased velocities in the vicinity of the encroachment due to a reduction in flow width and area, refer to Figure 8 which presents change in flood velocity magnitude.

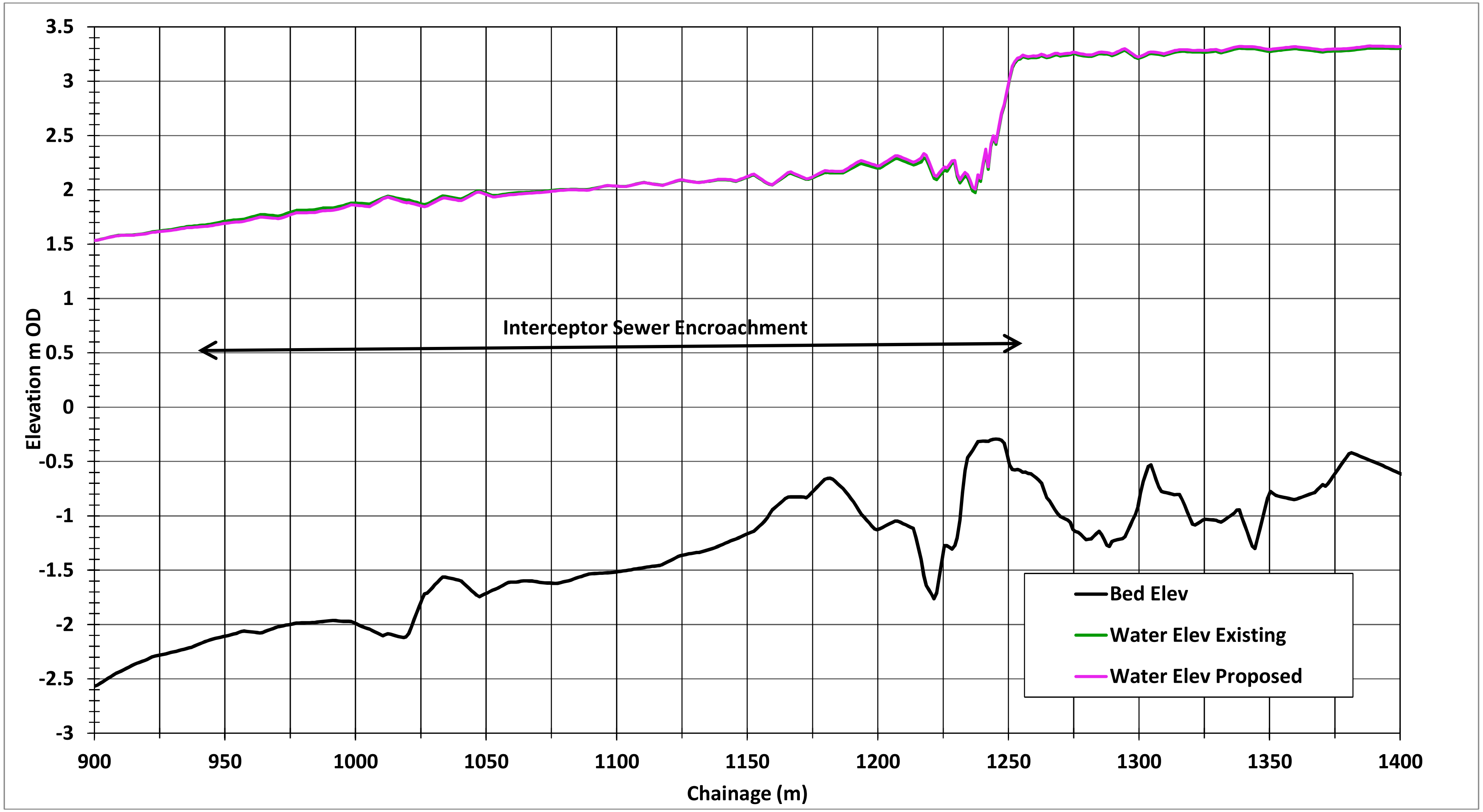


Figure 5: Computed Design Flood Profiles for the existing Case and proposed Sewer Encroachment Case

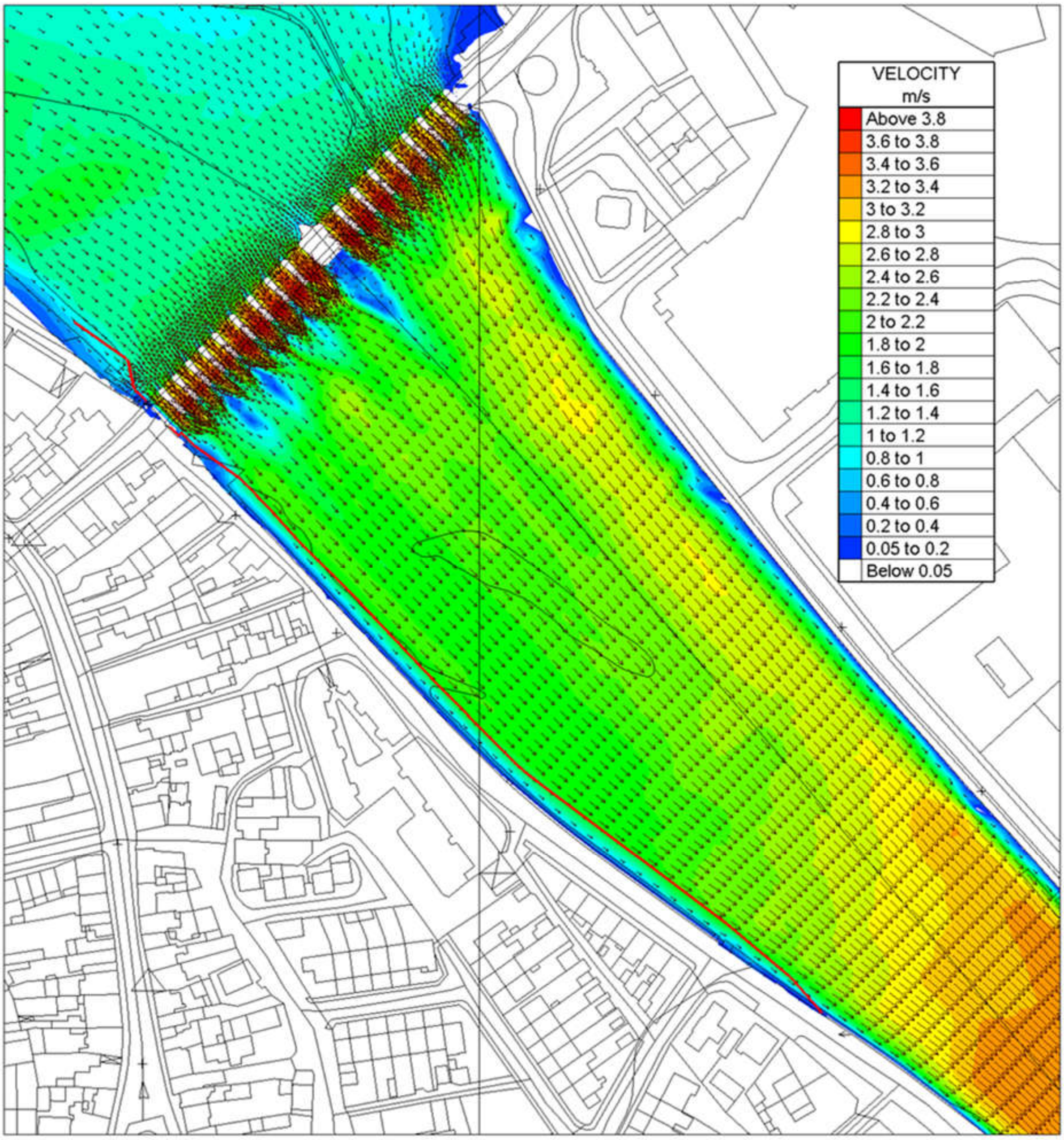


Figure 6: Flood flow velocities in river channel for Existing Case

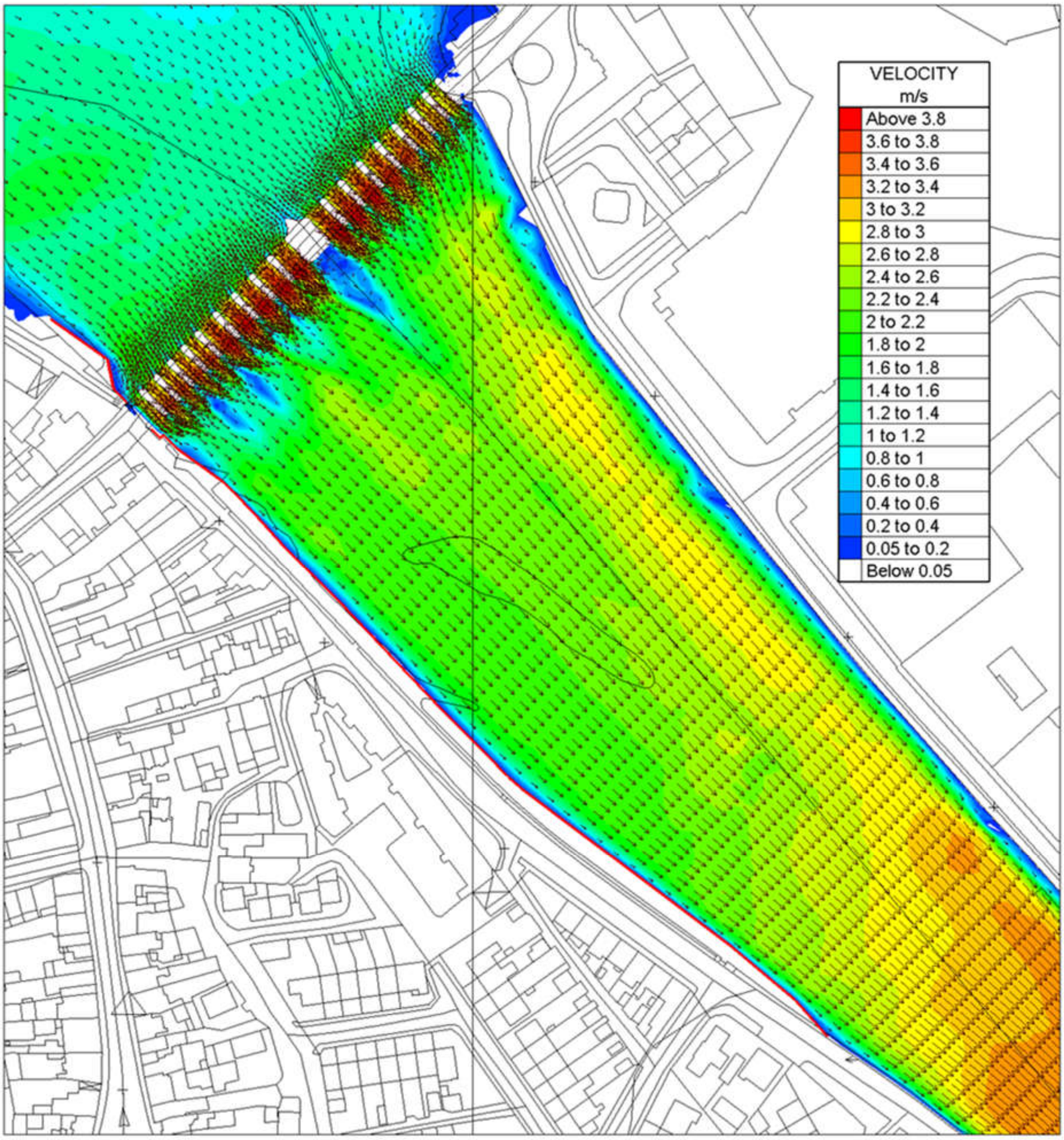


Figure 7: Flood flow velocities in river channel for proposed Interceptor Sewer encroachment

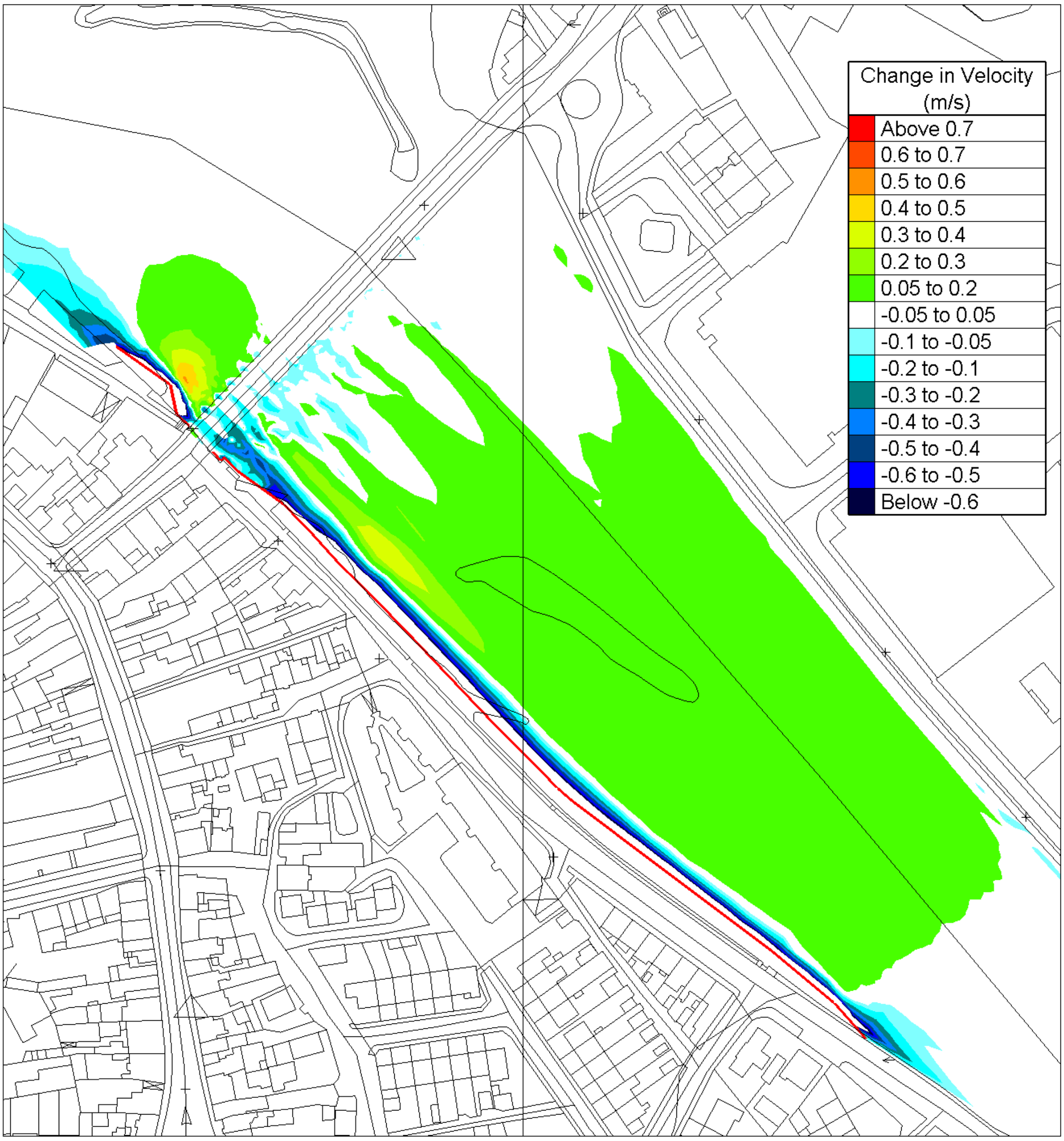


Figure 8: Change in flood flow velocity magnitude as a result of the proposed Interceptor Sewer encroachment

3.2 Flood Impact

The flooding of Arklow is principally caused by Arklow Bridge which under a design flood of 835cumec produces a significant bridge afflux of almost 1.2m (refer to Flood Profile presented in Figure 5). Such upstream flood levels cause flood waters to spill out of channel upstream of the Bridge on both north and south banks and flow as overbank flow downstream and returning to the downstream estuarine channel downstream of the Arklow Bridge. Therefore, increases in flood levels upstream of the bridge are critical as these could potentially worsen flooding in Arklow and where possible such impacts should be avoided or mitigated for.

The proposed Interceptor Sewer encroachment results in a small increase in the design flood level upstream of the Bridge of 0.019m, which in the context of the upstream flood level of c. 3.25 to 3.4m OD that produces overbank flood depths of 1 to 1.5m, is very minor and unlikely to impact significantly the flood risk in Arklow. The flood extents map presented in Figure 9 demonstrates limited effect that a 1.9cm upstream river level rise has on flooding in Arklow.

The development Management justification test in the Flood Risk Management Planning Guidelines (2009)[1] for developments that are located in floodplains or in moderate and high flood risk zones (A and B) require that such developments do not increase flood risk elsewhere and, if practicable, will reduce the overall flood risk, refer to Box 5.1 2. (i) in the flood risk management planning guidelines.

The local increase in downstream flood level of 3.3cm by the proposed Interceptor Sewer encroachment will not increase flooding as adjacent overbanks behind the quay walls will already have been flooded from floodwaters spilling out of bank upstream of the bridge and such flood waters returning to the estuarine reach further downstream. The predicted flood extents under the existing and proposed cases for the 100year design flood are presented in Figure 9, showing very slight expansion of the flood extents on the North side and no discernible change on the southside.

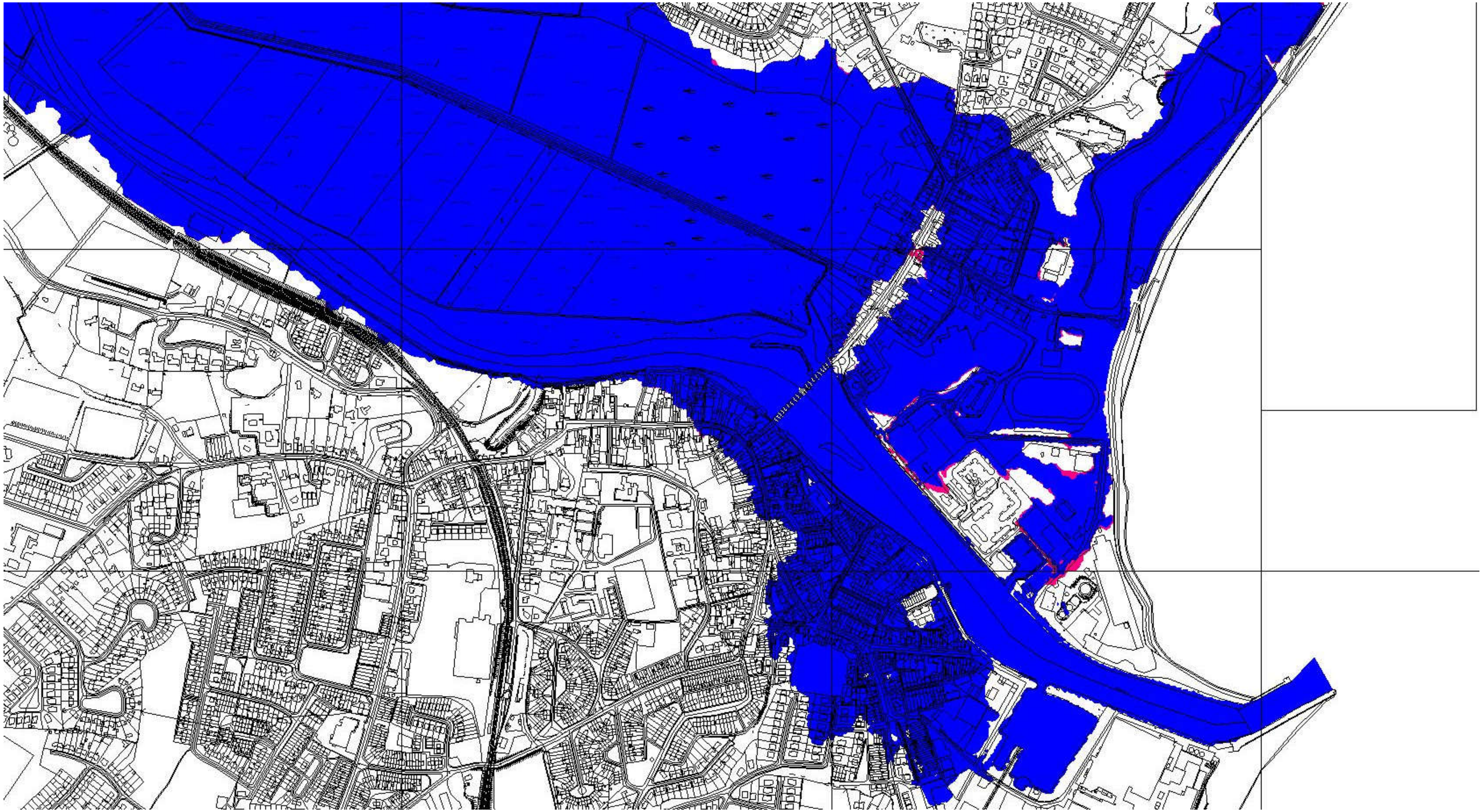


Figure 9: Predicted Flood Extents with and without Interceptor (Blue existing without interceptor and Magenta with interceptor)

3.3 Flood Mitigation

A proposed local mitigation measure that would mitigate and provide a small positive impact on upstream flood levels is the localised lowering of the bed in Arch 2 of Arklow Bridge. Arch 2 is the adjacent arch to the sewer pipe which is to be buried under the existing bed of Arch 1). The proposed lowering of the invert level is by 1m from c. -0.3m OD to -1.3mOD. To facilitate this lowering, dredging would extend 10m upstream and downstream of the arch to provide a suitable transition and met equivalent bed levels downstream. For scour protection the new bed at the bridge would have to be concrete lined or suitably sized rip-rap armour stone protection.

A simulation was carried out of this localised lowering which extended 10m upstream of the arch and 10m downstream. The predicted flood levels at the selected reference points for the proposed case and the mitigation measure are presented in Table 5 below.

This simulation shows that a slight reduction in upstream flood level can be achieved through this local mitigation measure, refer to Table 4 below.

Table 4: Predicted peak flood elevations under design flood conditions for existing baseline case and with proposed mitigation

Reference location Refer to Figure 4	Existing mOD	Proposed Interceptor Sewer and lowering of Arch 2 m OD	Difference (m)
1	1.629	1.623	-0.006
2	1.977	1.970	-0.007
3	2.270	2.303	+0.033
4	3.236	3.228	-0.008
5	3.361	3.356	-0.005
6	3.409	3.404	-0.005

The results of the simulation show a local increase in flood elevation of 3.3cm downstream of the bridge at locations 3 within the channel due to the Interceptor Sewer encroachment during the operation of the proposed sewer i.e. with underpinning of the arches and lowering of the 2nd Arch and temporary causeway fully removed. This 3.3cm increase in downstream flood level is shown not to be critical to the floodplain inundation and flood risk at Arklow for both north and south banks with an overall minor reduction in the flood extents which would be a slight beneficial impact.

The computed flood flow velocities in the river channel for the existing and proposed Interceptor Sewer with underpinning of first 2 arches and lowering of the 2nd Arch by 1m are presented in Figures 10 and 11. The flow field and plot shows increases in flow velocity upstream of 2nd Arch, reduction in the dredged area and increases in velocity in the downstream channel, particularly on the southern side. The higher velocities still remain on the northern side of the channel.

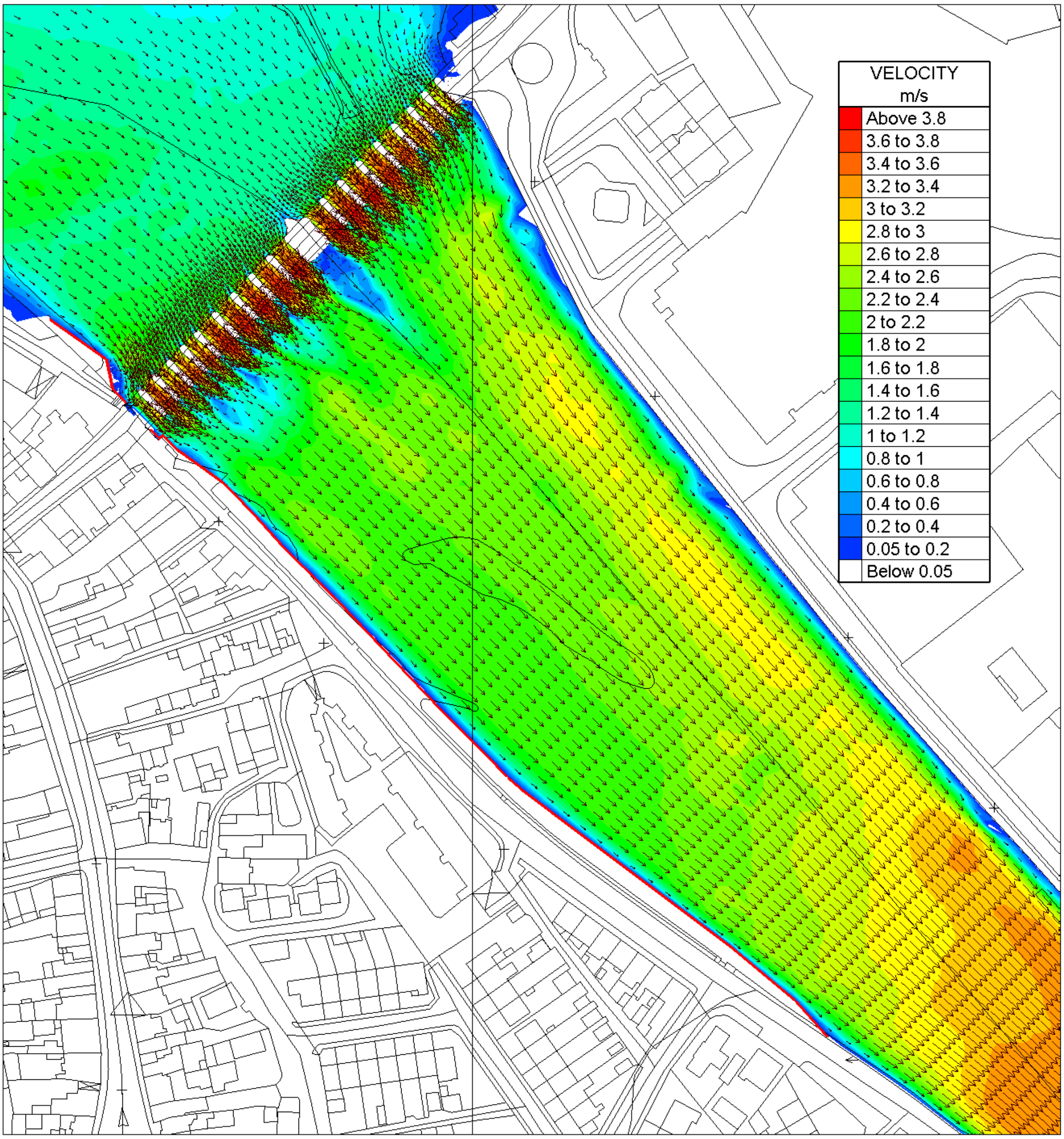


Figure 10 Computed Flood flow velocities for Interceptor sewer and localised deepening of Arch 2

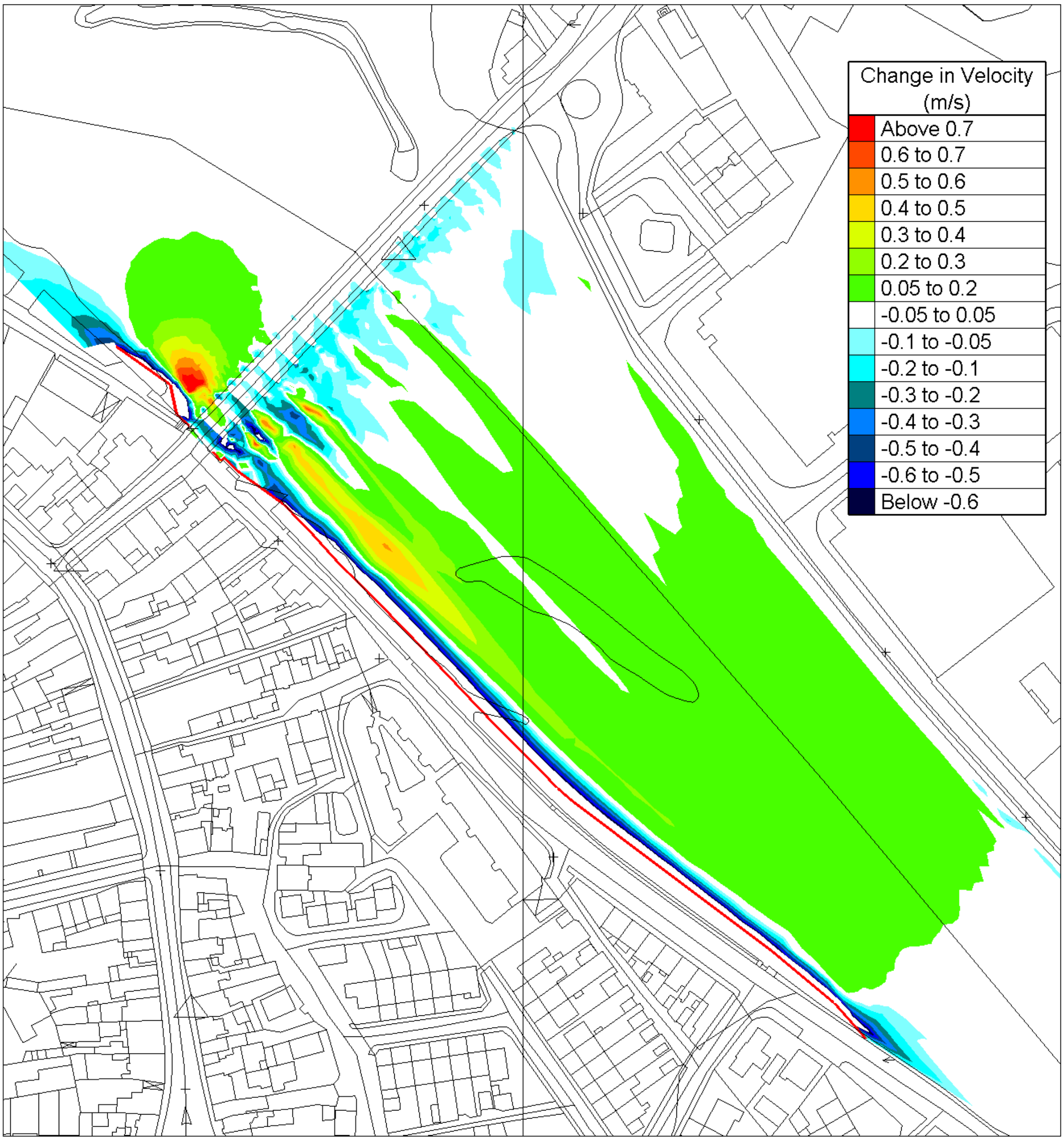


Figure 11 Computed change in Flood Flow Velocity magnitude as a result of Proposed Interceptor sewer and localised deepening of Arch 2

3.4 Proposed Construction Temporary Causeway Encroachment

A temporary causeway is required to facilitate construction of the Interceptor Sewer in the river channel. The temporary causeway would include a sufficient working area for installing manholes, the Interceptor Sewer and sheet pile walls. The causeway would also include provision for a c. 10m wide haul road for HGVs and larger construction plant required to allow excavated material to be removed from the working area, refer to Figure 13. This 10m width is inclusive of the 6m wide permanent encroachment required for the Interceptor Sewer.

The temporary causeway would be constructed from clean, suitable engineered fill granular material free from fines. The causeway would be contained on the river side to mitigate against siltation migration into the Avoca River. The two most likely methods to achieve this containment would either be an additional row of sheet piles on the river side of the causeway or alternatively a row of stone gabions wrapped in a geotextile membrane. Either method would require that the containing material (i.e. the sheet piles or the gabion walls) are extended (i.e. to a height above the surface of the causeway) to be effective.

The proposed elevation of the downstream causeway / haul road is 0.8m OD which includes for highwater mean spring tide of 0.5m OD plus 0.3m Freeboard.

To mitigate and minimise the potential flood impact caused by the construction causeway encroachment of the river channel the following sequence of works is proposed prior to construction of the approximately 270m long causeway downstream of the bridge:

- Proposed underpinning of the first 2 arches and lowering of the 2nd Arch by 1m at the bridge is completed
- Proposed in-stream works at and upstream of the bridge (i.e. the upstream Interceptor Sewer Manhole and the laying of the Interceptor Sewer beneath the bed of Bridge Arch 1).
- Installation of the proposed temporary causeway from downstream to upstream (i.e. from east to west direction).
- Following completion of construction of the Interceptor Sewer in the Avoca River (i.e. when the causeway is no longer required), the causeway would be removed in a similar sequential manner.
- Timely removal of sections of causeway should be a priority once works have been completed

The extent of this causeway is shown in Figure 12 and a cross-section through the causeway is presented in Figure 13.

Figure 12 Construction Infill Area that includes for the Temporary haul road

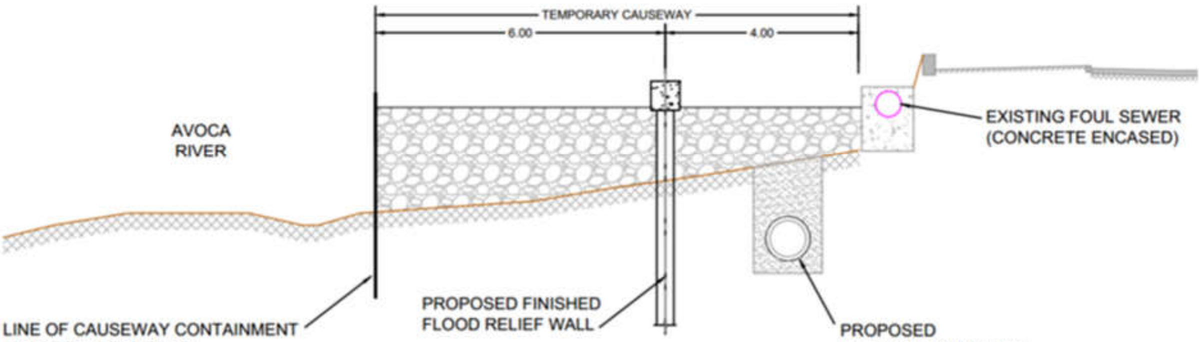


Figure 13 Cross Section through proposed temporary causeway

A flood simulation modelling the 100year design flood event was carried out to investigate the impact of the proposed temporary downstream causeway on design flood levels and flood risk. The simulation assumes that the upstream in-channel works have been completed and include the mitigation measure of deepening and underpinning bridge arch 2, the construction of the Interceptor Sewer manhole upstream of the bridge and all the in-stream works at the bridge (i.e. interceptor sewer through Arch 1 completed and arch reopened).

The computed maximum flood levels at the selected reference points (refer to Figure 4 for locations) are presented in Table 5 for existing and proposed construction causeway case. The simulation shows an overall very slight beneficial impact upstream of the bridge which is critical to mitigating flood impact of the downstream encroachment.

Table 5: Predicted peak flood elevations under design flood conditions for existing baseline case and with the infill for the construction haul road

Reference location Refer to Figure 4	Existing mOD	Proposed Construction Infill haul road m OD	Difference (m)
1	1.629	1.601	-0.028
2	1.977	1.996	+0.019
3	2.270	2.325	+0.055
4	3.236	3.234	-0.002
5	3.361	3.360	-0.001
6	3.409	3.408	-0.001

The simulation shows downstream of the bridge at locations 2 and 3 within the channel, an increase in flood elevation of 1.9 and 5.5cm respectively due to the causeway encroachment. These increases are shown not to be critical to the floodplain inundation and flood risk at Arklow for both north and south banks, which are flooded from upstream of the bridge, refer to Figure 16 showing an overall minor reduction in the flood extents- very slight beneficial impact.

The computed flood flow velocities and change in velocity magnitude for this simulation are presented in Figures 14 and 15.

Without the proposed mitigation of underpinning and phasing the in-stream bridge and upstream works first, the potential increase in upstream Flood Level under the design flood scenario is estimated to be c. 6 to 6.5cm.

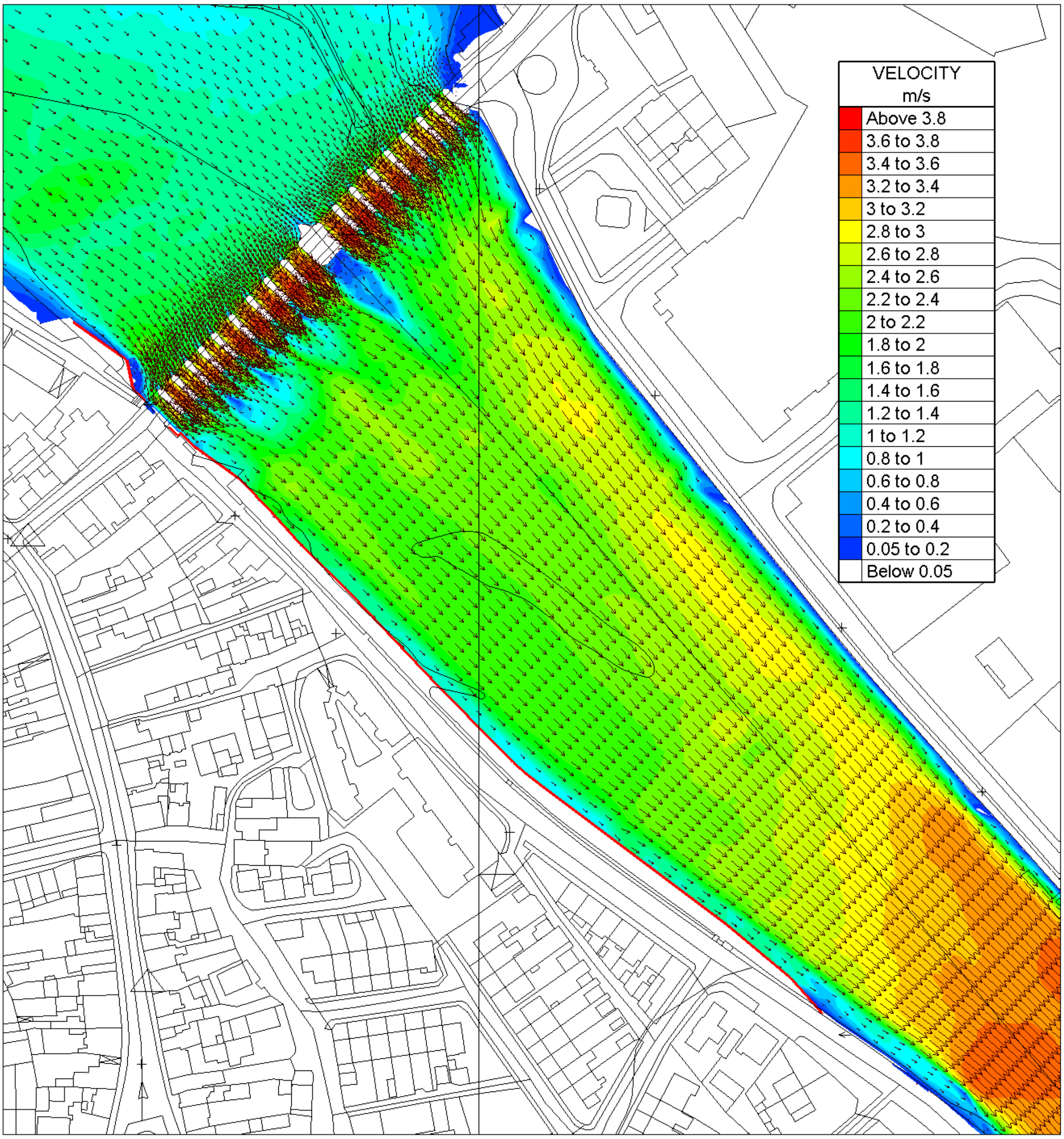


Figure 14: Flood flow velocities in river channel for construction infill and Haul Road

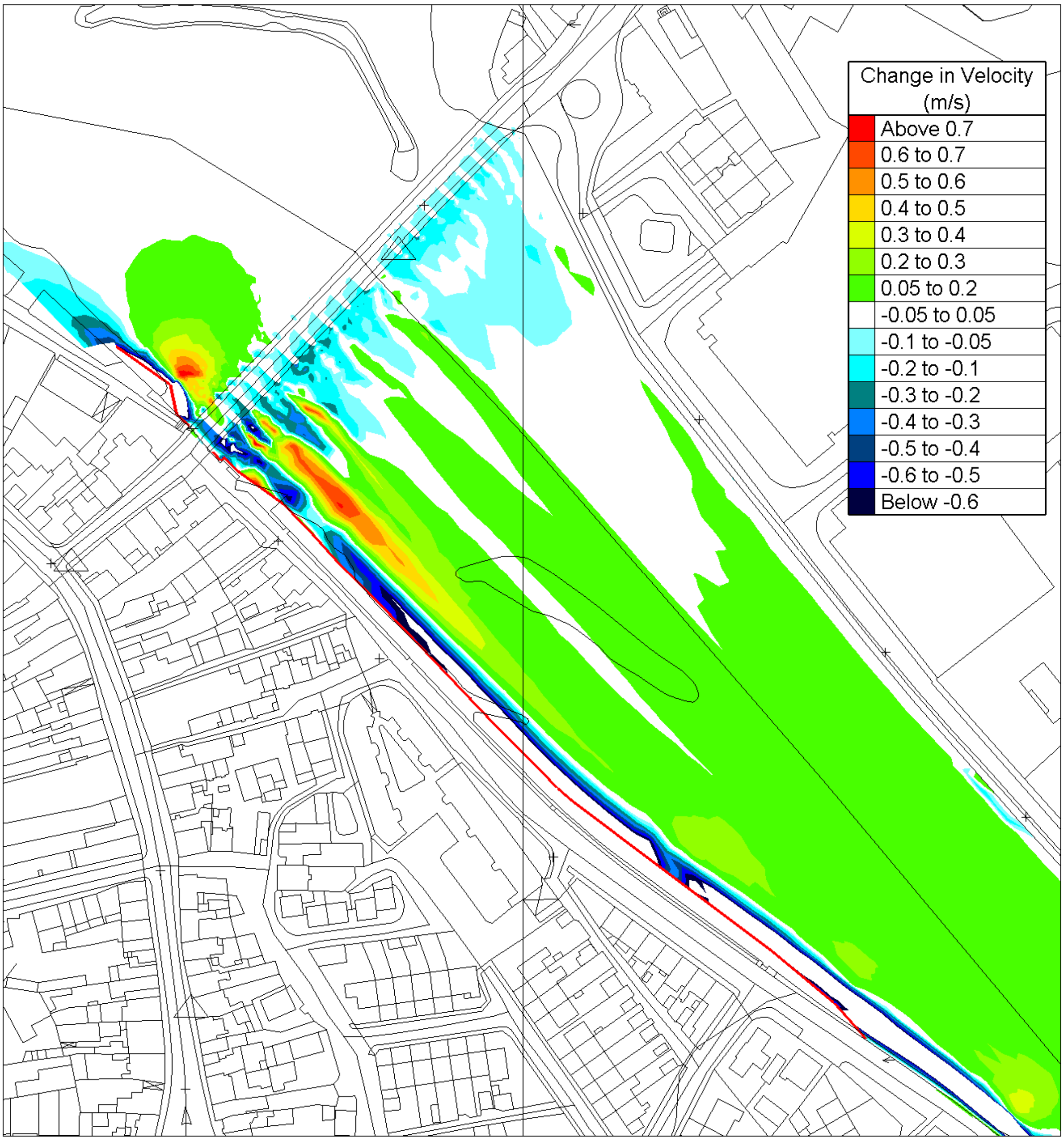


Figure 15: Change in flood flow velocity magnitude as a result of the proposed Construction Infill and Haul Road

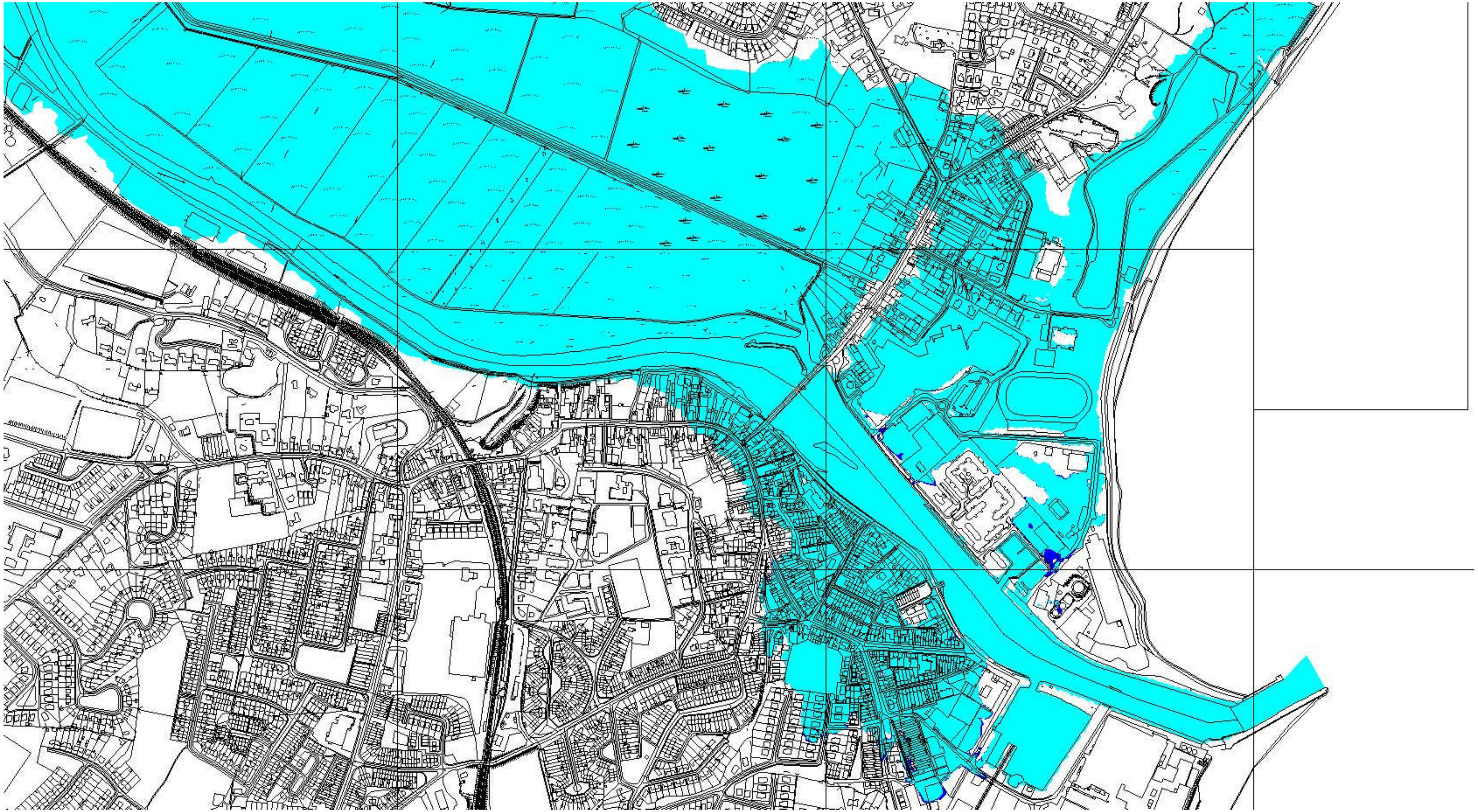


Figure 16: Predicted Flood Extents for existing and proposed temporary haul road downstream and Bridge arch underpinned and in-channel works completed at the bridge including upstream manhole encroachment. (Blue existing baseline and Cyan proposed construction) (overall minor reduction in the flood extents- very slight beneficial impact)

4. Conclusions

The flooding of Arklow is principally caused by Arklow Bridge which under a design flood of 835cumec produces a significant bridge afflux of almost 1.2m. Such upstream flood levels cause flood waters to spill out of channel upstream of the Bridge on both north and south banks and flow as overbank flow downstream causing significant flooding of Arklow before returning to the downstream estuarine channel reach downstream of the Arklow Bridge.

Any increase in flood level upstream of the bridge could potentially worsen flooding by generating a greater overbank spill volume in Arklow. Where possible such impacts should be avoided or mitigated against.

The hydraulic flood modelling, using detailed 2-D modelling of the proposed Interceptor Sewer encroachment shows a small increase in the design flood level of 0.019m upstream and 0.033m downstream of the Bridge. These increases in the context of the overall flood depths and overbank levels are very minor and unlikely to impact significantly the flood risk in Arklow. The computed flood extents indicate a very limited impact by the Proposed Interceptor Sewer encroachment.

The development Management justification test in the Flood Risk Management Planning Guidelines (2009)[1] for developments that are located in floodplains or in moderate and high flood risk zones (A and B) require that such developments do not increase flood risk elsewhere and, if practicable, will reduce the overall flood risk, refer to Box 5.1 2. (i) in the flood risk management planning guidelines.

A proposed local mitigation measure which assists both construction and operational phases is the localised lowering of the bed in Arch 2 of Arklow Bridge by 1m. The flood simulation shows that this measure achieves a slight reduction in upstream flood levels and no worsening of the existing Flood Risk areas in Arklow.

Flood simulations show an overall slight beneficial impact upstream of the bridge which is critical to mitigating flood impact in Arklow. The simulation shows downstream of the bridge flood elevation increases of 1.9 and 5.5cm respectively due to the causeway encroachment. These increases are shown not to be critical to the floodplain inundation and flood risk at Arklow with the computed flood extents presenting a slightly reduced flood area as a result of the slight reduction in upstream Flood level.

Key to the mitigating construction stage impacts on flooding is the phasing of works with the requirement for the bridge underpinning and upstream works to be fully completed before commencing construction of the 270m long causeway downstream of the bridge.

In conclusion the proposed 6m wide Interceptor Sewer pipe encroachment results in a small increase in out of channel flooding which can be fully mitigated by the proposed deepening and underpinning of Arch 2 at Arklow Bridge. The construction requirement of a 10m wide temporary causeway (inclusive of the permanent encroachment 6m width) can be phased and managed not to impact flood risk in Arklow.

Anthony Cawley

Anthony Cawley B.E. M.Eng.SC. (Hydrology), C.Eng M.I.E.I. 24th August 2018
Consulting Hydrologist
Hydro Environmental Ltd.

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A2 Sewer Network Flooding Assessment

BYRNELOOBY

Irish Water

Arklow Sewerage Scheme

Sewer Network Flooding Assessment

Report No. W3136-02

August 2018

Revision 0

BAHRAIN • IRELAND • QATAR • SAUDI ARABIA • UAE • UK

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BYRNELOOBY

H5 Centrepoint Business Park, Oak Road, Dublin 12, Ireland.

Tel: +353 (0)1 456 4370, Fax: +353 (0)1 456 4306, e-mail: Dublin@ByrneLooby.com

www.ByrneLooby.com

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Contents

1 Introduction

Arup in association with Byrne Looby was appointed by Irish Water in November 2015 to provide Engineering and Technical Consultancy Services for the Arklow Sewerage Scheme. The objective of this project is to provide a Wastewater Treatment facility that will comply with all relevant legislative requirements and will service the Arklow agglomeration over the next 20 years.

Existing hydraulic models of Arklow Sewerage Scheme built as part of Greater Dublin Strategic Drainage Study (GDSDS) were updated in accordance with Irish Water's Wastewater Network Hydraulic Model Build and Verification Standard (Document No IW-TEC-800-06, March 2018) and used as a design tool for the development of the Interceptor Sewer Scheme.

This report presents the results of various modelling scenarios undertaken for carrying out joint probabilistic flooding assessment of Arklow Sewer Network.

1.1 Background

Under the proposed Arklow Sewerage Scheme, the existing foul/combined discharges into Avoca River are to be collected by proposed interceptor sewers constructed along both banks of the Avoca River with flows conveyed to the proposed WwTW located at Ferrybank. Flows from the south of the river are to be conveyed via a proposed gravity sewer tunnel under the river bed to the proposed WwTW located at Ferrybank.

Part of the Sewerage Scheme requires the upgrade of existing sewers and a SWO located within the Alps development upstream of Arklow Bridge and adjacent the Avoca River. This overflow was found to be unsatisfactory under existing conditions, with frequent discharges into the Avoca River which was originally considered to be Contact/Recreational Waters. Hence, it was proposed to limit the number of spills via the Alps SWO to 7 per bathing season, in accordance with.

The proposed works intercepts the existing 225mm diameter combined sewer and a 1200mm diameter storm sewer, which conveys some foul connections and pass the flows through the existing SWO. The Pass Forward Flow will be conveyed to the proposed Southern Interceptor sewer and the storm flows stored in an underground on-line storage tank. An overflow from this on-line storage tank was connected to the existing storm outfall discharging to Avoca River. All screenings will be passed onto the interceptor sewer.

2 Existing Sewerage System

The existing sewerage system in Arklow town is a mixture of separate, partially separate and combined sewers. The combined sewers account for the majority of the network within the town. Partially separate systems are on the periphery of the sewer network draining into the combined sewer. More recent new developments have separate storm systems draining to the streams and foul network connecting into the existing combined sewer. New developments, which have been built close to the Avoca River, include both foul and storm systems discharging directly into the river.

The network is primarily a gravity system, with some outlying areas pumped into the main gravity system. There are four sewage pumping stations, viz. Servier, Croghan, Ballyduff and Porters Bridge.

The entire sewer network discharges directly to the Avoca River via outfalls, with no screening of the discharges. It is understood that some outfalls were constructed with flap valves but no outfalls have functioning valves at present. As the river is tidal in nature in the vicinity of all the outfalls, periods of rainfall and / or high tides can result in the backing up of flows in the sewers which results in operational deficiencies (i.e. silting) and hydraulic deficiencies where the sewers surcharge and flood due to the downstream conditions.

The sewerage catchment in Arklow is divided into following five distinct sub catchments shown below in Figure 1:

- Northern
- Southside - Western
- Southside - Central
- Southside - Southern
- Southside - Eastern

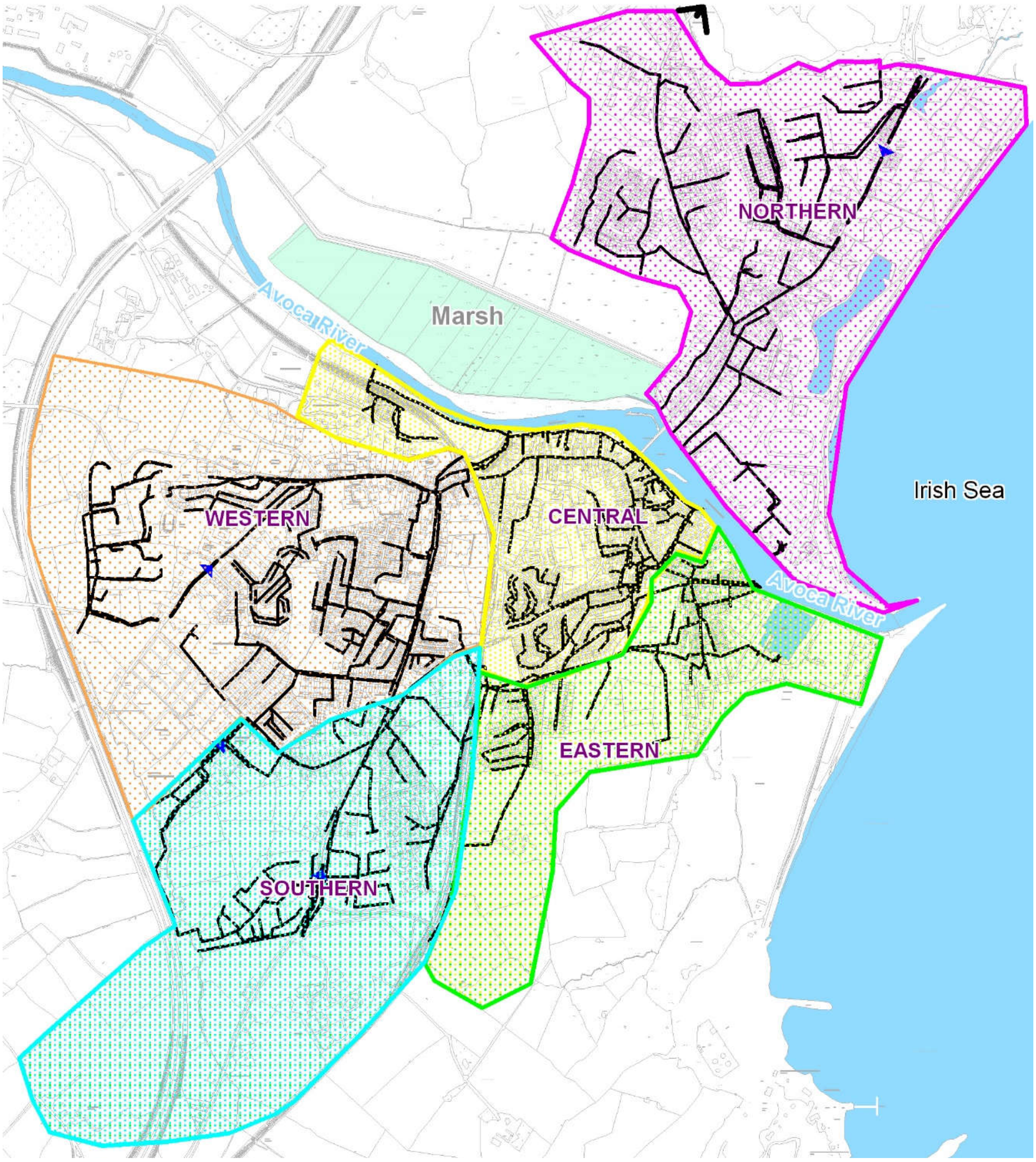

Figure 1 Arklow Sewerage Catchments

3 Hydraulic Modelling

The hydraulic modelling of the Arklow Sewerage Scheme has been undertaken in three Phases which was later updated and analysed for a 50-year design horizon in 2013 as part of the Arklow Sewerage Scheme DBO Works.

The hydraulic model of the Arklow drainage system was originally constructed using InfoWorks CS. This model was imported into InfoWorks ICM SE Version 6.5 for hydraulic assessment of the proposed Interceptor Sewers under this study.

Arklow Sewer Modelling Study (ASMS) was carried out by WYG / PH McCarthy Consulting Engineers in three Phases during GDSDS study as given in Table 1 below. Further, a hydraulic review of the model with amendments to be incorporated into the Arklow Sewerage Scheme DBO contract (2013) was carried out by Lyons Engineering Ltd.

The existing hydraulic models were used as basis for the assessment of the performance of the existing and future sewer system following a detailed review of the models to determine its suitability for use on the Arklow Sewage Scheme. The future system model was updated with proposed interceptor sewers, WwTP and proposed SWOs for the assessment of hydraulic performance of the system with regard to surcharge and flooding.

Table 1 Arklow Sewer Modelling Study Reports

Modelling Study	General Comments
Phase 1 - Data Collection and Review & Initial Planning Report, June 2004	This study involved the surveying of the manholes and sewers, carrying out of a flow and impermeable area survey and detailed loading assessment, for domestic and non-domestic loadings
Phase 2 - Model Preparation, Verification and System Performance Assessment Report, April 2007	The existing hydraulic models of Arklow Sewer System were built and verified against 3 rainfall and 2 dry weather events.
Phase 3 - Development of Needs & Identification of proposed Drainage System Development Report, October 2010	Under this phase, the verified hydraulic models were analysed against 1 in 30 year rainfall return period to identify hydraulic deficiencies in the network under existing and future loading conditions.
Wastewater Flow, Load, Tide and Rainfall Survey Report, November 2012	6 week sampling, flow, tide & rainfall monitoring programme was carried out as part of the preliminary works prior to the design of the proposed Arklow sewerage scheme.

Hydraulic Modelling Review Report, April 2013	Two hydraulic models based on the stages of construction were analysed. - Stage 1 model includes all of the DBO works and a domestic PE of 18,000, - Stage 2 model includes the DBO works, a domestic population of 36,000, as well as the Phase 3 upgrading works.

4 Methodology to assess sewer system flooding

Arklow Sewer system flooding assessment has been carried out in accordance with Greater Dublin Strategic Drainage Study's Final Strategy Report which provides the rainfall event and tide level combinations to be used for design of drainage system.

Section 3.6.2, Specific Recommendation of GDSDS Final Strategy Report provides the following combination that provides a combined return period greater than 30 years for flooding from sewerage systems affected by river or tidal levels.

- MHWS with 30-year Drainage
- 1-year tide with 1-year Drainage
- 5-year tide with 0.25-year Drainage

For the purposes of the design runs simulated for the hydraulic analysis the following tide level were used at the outfalls draining to the Avoca River. A climate change allowance of 0.5m was used in accordance with the recommendations given in Irish Coastal Protection Strategy Study - Work Package 9A Strategic Assessment of Coastal Flooding Extents – Future Scenario, South East Coast – Dalkey Island to Carnsore Point, November 2013.

- Mean High Water Spring Tide (MHWS) level of 0.49m OD Malin
- 5-year tide level of 1.15 m OD Malin
- 1-year tide level of 0.96m OD Malin

5 Existing System Hydraulic Assessment

5.1 Existing System Hydraulic Assessment (without the Interceptor Sewer & SWOs)

The hydraulic model of the existing sewer system in Arklow was run for a 30 year 60 minute critical duration event, with an allowance for climate change.

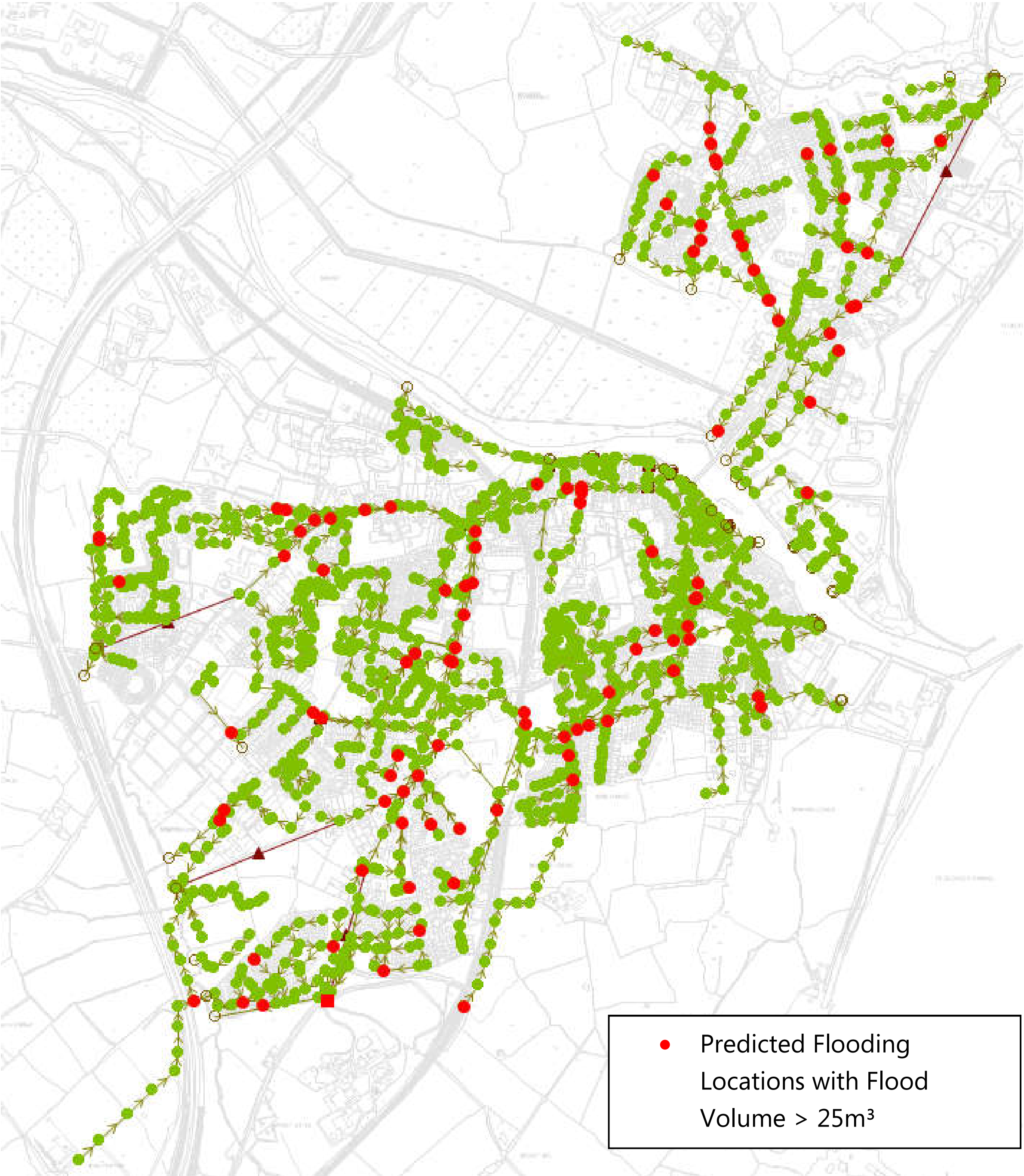

Figure 2: Existing System **-** Predicted flooding location > 25m3 for M30_60 & MHWS with CC

Figure 2 above shows the extent of predicted flooding of the existing system for a 30 year 60-minute critical duration storm which indicates that the existing drainage system is already under capacity in design storm conditions. A total of 106 location are predicted to flood with a flood volume greater than 25 m^3 (refer to Appendix 1). Significant flooding is predicted to occur in both Arklow north and south catchments with total flood volume of 8,104 m^3.

The assessment of the spill volumes shows that 7,566m^3 of raw sewage is predicted to spill via the existing outfalls into Avoca River during Dry Weather Flow (DWF). Further, the sewer system is predicted to spill 15,100m^3 & 21,484m^3 through outfalls into Avoca River for 5 year and 30 year critical duration storm events, respectively.

5.2 Existing System Hydraulic Assessment (with Interceptor Sewers & SWOs)

The hydraulic model of the existing sewer system with the proposed interceptor sewer and the SWOs in Arklow was also run for a 30-year 60 minute critical duration event, with an allowance for climate change to assess the flooding within the catchment.

Figure 3 below shows the extent of predicted flooding of the existing system with the proposed interceptor sewer which indicates that the existing drainage system still floods significantly under design storm conditions without the implementation of all other upgrades proposed in Phase 3 GDSDS Study.

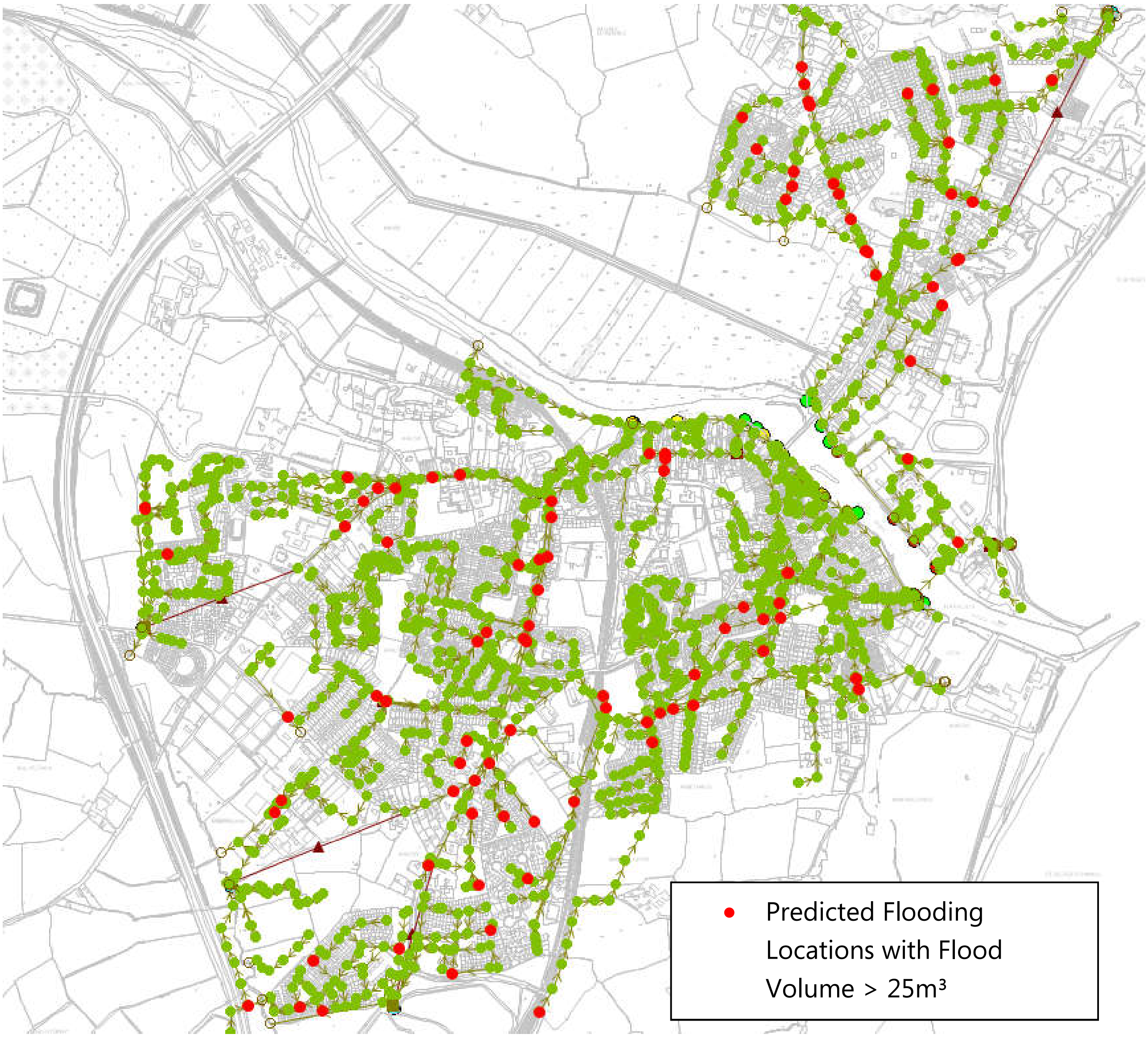

Figure 2: Existing System with Interceptor Sewer - Predicted flooding location > 25m3 for M30_60 & MHWS with CC

Appendix 2 shows a total of 100 location that are predicted to flood with a total flood volume of 7562 m^3.

6 Future System Hydraulic Assessment with Interceptor Sewers and SWOs without

The hydraulic model of the future sewer system incorporating all developments up to a 50 year design horizon including all proposed GDSDS Phase 3 upgrades, proposed interceptor sewers and the SWOs was run for various modelling scenarios as described in Section 4 for carrying out joint probabilistic flooding assessment of Arklow Sewer Network.

6.1 Scenario 1 – M30_60 Storm & MWHS with Climate Change (0.99 mOD)

The hydraulic model of the future system was run for a 30-year 60minute critical duration storm event and MWHS tide level of 0.99m OD Malin (with climate change). Figure 3 below shows 3 predicted flooding locations with flood volume greater than 25 m³ for this scenario.

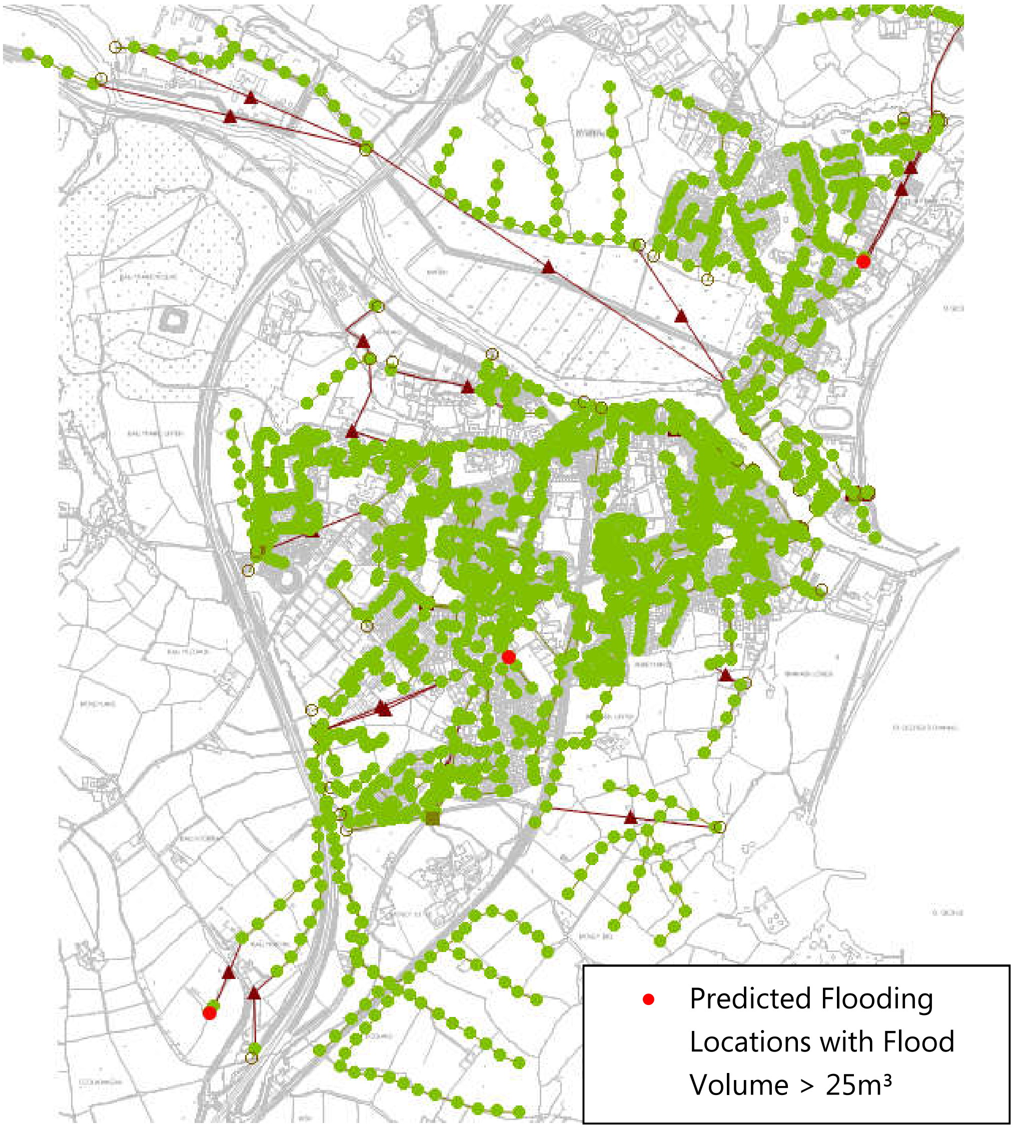

Figure 3 Scenario 1 - Predicted flooding locations with flood volume > 25 m³

Table 4 and 5 below shows the predicted flood volumes and overflow spill volumes on the overflows discharging directly into Avoca River/Irish Sea. The total volume of flooding from 3 predicted flooding locations within the catchment was found to be 134 m³. It was noted that only Alps SWO spills into Avoca River in Scenario 1.

Table 2 Scenario 1 - Predicted Flooding Volume > 25m3

Node ID	System Type	Location	GL mOD	Flood Volume > 25m3
Leis_Bal	Combined	Assumed Golf Course	51.3	81.2
ST25743102	Combined	Junction of Woodbine Rd/Sea Road	15.722	27.1
ST23728502	Foul	Knockenrahan	38.349	25.9
Total				**134.2**

Table 3 Scenario 1 - Predicted Overflow Spill Volumes

SWO Location	Ground Level (mOD)	Invert Level (mOD)	Pipe Diameter (mm)	Spill Volume (m3)
The Alps	4.0	3.0	900mm	1,289
Shaft TSS3 - u/s of River Crossing	1.746	0.0	1200mm	0
WWTP Inlet PS	1.788	-0.3	1200mm	0

6.2 Scenario 2 – M1_60 Storm & 1 Year Tide level with Climate Change (1.4585 mOD - Interpolated)

For Scenario 2, the hydraulic model of the future system was run for a 1-year 60minute critical duration storm event and 1-year tide level of 1.4585 m OD Malin (with climate change). Figure 4 below shows 4 predicted flooding locations with flood volume greater than 25 m³ for this Scenario.

Figure 4 Scenario 2 - Predicted flooding locations with flood volume > 25 m³

Table 6 below shows the predicted flood volumes greater than 25 m³. The total volume of flooding from 4 predicted storm water flooding locations along Harbour Road was found to be 139 m³. The flooding was primarily due to surcharge caused by high tide levels in the Avoca River that prevents storm water discharge into the river. It was noted that for Scenario 2, none of the existing and proposed SWO spills into Avoca River/Irish Sea .

Table 4 Scenario 2 - Predicted Flooding Volume > 25m³

Node ID	System Type	Location	GL mOD	Flood Volume > 25m3
MHS34	Storm	Harbour Road	1.167	49.7
MHS30	Storm	Harbour Road	1.285	28.1
ST24739005	Storm	Harbour Road	1.118	35.8
ST24739004	Storm	Harbour Road	1.21	25.7
	Total			**139.3**

6.3 Scenario 3 – 0.25 Year Storm & 5 Year Tide level with Climate Change (1.65 mOD)

In Scenario 3, the hydraulic model of the future system was run for a 0.25 Year 60minute critical duration storm event and 5-year tide level of 1.65 m OD Malin (with climate change). Figure 5 below shows 10 predicted flooding locations with flood volume greater than 25 m³.

Figure 5 Scenario 3 - Predicted flooding locations with flood volume > 25 m³

Table 7 below shows the predicted flood volumes greater than 25 m³. The total volume of flooding from 10 predicted storm water flooding locations with Arklow South found to be 580 m³. The flooding at these locations were also primarily due to surcharging caused by high tide levels in Avoca River that prevents storm water discharge into the river. Again for Scenario 2, none of the existing and proposed SWO spills into Avoca River/Irish.

Table 5 Scenario 3 - Predicted Flooding Volume > 25m³

Node ID	System Type	Location	GL mOD	Flood Volume > 25m3
MHS34	Storm	Harbour Road	1.167	122.9
MHS30	Storm	Harbour Road	1.285	88
ST24739005	Storm	Harbour Road	1.118	84.3
ST24739004	Storm	Harbour Road	1.21	73.8
ST24739003	Storm	Harbour Road	1.31	44.8
ST25730003	Storm	Harbour Road	1.284	36.3
ST24737325	Storm	Off Doyle's Lane, S Quay	1.351	36.2
ST24738004	Storm	Harbour Road	1.403	36
ST24737395	Storm	The Brook, S Quay	1.373	30
ST24737313	Storm	Off Doyle's Lane, S Quay	1.338	27.7
Total				**580**

7 Future System Hydraulic Assessment with all Pumps down at WWTP

7.1 30-year 60minute storm event and MWHS tide level (with CC) and all pumps down

The hydraulic model of the future system was run for a 30-year 60minute critical duration storm event and MWHS tide level of 0.99m OD Malin (with climate change) with all the pumps shut down at the WwTP to assess catchment flooding due to the pumping station failure. Figure 6 below shows 3 predicted flooding locations with flood volume greater than 25 m³.

Figure 6 Predicted flooding locations with flood volume > 25 m³ with all pumps down for M30_60 & MHWS with CC

Table 8 below shows the predicted flood volumes greater than 25 m³. A total of 37 locations are predicted to flood with a flood volume greater than 25 m³. The total volume of flooding from predicted flooding locations within Arklow was found to be 2,358 m³ with majority of the flooding locations observed in Arklow South particularly along Southgreen Road.

Table 6 Predicted Flooding Volume > 25m³ (all pumps down)

Node ID	Flood Volume > 25m3
ST25730703	192.9
ST25730702	183.7
MHS08	181.7
ST24739601	178.4
ST24738106	108.8
ST24737301	94.7
ST24737410	81.4
Leis_Bal	81.3
MHS10A	75.8
ST25730704	74.8
ST24739906	66.7
ST25720901	63.9
ST24738267	60.4
ST24736337	59.9
ST24736424	58.3
ST24738702	53.7
ST24737335	51.3
ST25731903	47.8
MHS06	43.5
MHS07	43.2
ST24739901	42.3
ST24729902	41.6
ST24729950	41.3
ST24738101	39.6
ST25731901	38.2
ST24729901	38
ST24729904	34.5
ST24737105	33.4
ST24738204	31.6
ST24738601	30
ST25720902	29.2
ST25731803	27.4
ST25743102	27.1
ST24736020	25.7
ST24729704	25.5

Node ID	Flood Volume > 25m3
ST23728502	25.3
ST24737002	25
Total	**2357.9**

7.2 30-year 60minute storm event (with CC) but no tide and all pumps down

The hydraulic model of the future system was also run for a 30-year 60minute critical duration storm event without tide levels applied at the outfalls that discharge into Avoca River with all the pumps shut down at the WwTP to assess flooding due to pumping station failure during low tide conditions. Figure 7 below shows 3 predicted flooding locations with flood volume greater than 25 m³ for this scenario.

Figure 7 Predicted flooding locations with flood volume > 25 m³ with all pumps down for M30_60 & No tide

Table 9 below shows the predicted flood volumes greater than 25 m³. Nine locations are predicted to flood with a flood volume greater than 25 m³. The total volume of flooding from predicted flooding locations within Arklow catchment was found to be 435 m³ with majority of the flooding locations observed in Arklow North.

Table 7 Predicted Flooding Volume > 25m³ (all pumps down without tide)

Node ID	Flood Volume > 25m3
Leis_Bal	81.3
ST25730702	74.2
ST24739601	68.7
ST25730703	54
ST24739906	43.3
ST24736424	33.5
ST25743102	27
ST25731903	27
ST23728502	25.9
Total	**434.9**

It should be noted that no significant flooding was predicted for a 1 in 5 year event with all pumps down and the SWOs that discharge into Avoca River did not spill for a 1 in 5 year critical duration event.

8 Future System - SWO Assessment

SWO performance assessment was carried out to assess its impact on Avoca River in accordance with the requirements given in IW Storm Water Overflow Technical Standard Document (IW-TEC-800-03). Avoca River has been categorised as contact/recreational use waters. Therefore, in accordance with Section 8.3.2 of the above IW Technical Standard all discharges to contact/recreational waters via SWOs are limited to 7 spills/bathing season.

The hydraulic model of the future system incorporating the proposed interceptor sewers, SWOs and the WwTP was run with Time Series Rainfall (TSR) event for assessment of spill frequency and volume of discharge via the proposed SWOs at the WwTP, Shaft TSS3 on Southern Interceptor Sewer, and existing SWO at the Alps. The results of spill frequency analysis of the future system as shown in Tables 10, 11 and 12 indicates that proposed SWOs spill on average less than once during bathing season which is well below the permitted 7 spills/bathing season.

Table 8 Spill Frequency Analysis – Alps SWO

SWO Ref	**ST24732508.2 - The Alps**		
	Total No of Spills	**Total Volume of Spills (m^3)**	**Total No of Spills/Bathing Season**
Year 1	2	451.07	2
Year 2	2	2,988.42	0
Year 3	3	66,708.30	1
Year 4	0	0.00	0
Year 5	0	0.00	0
Year 6	1	334.90	1
Year 7	1	1,018.82	1
Year 8	0	0	0
Year 9	0	0	0
Year 10	0	0	0
Average No of Spills	**0.90**		**0.50**

Table 9 Spill Frequency Analysis – WwTP SWO

SWO Ref	**ST25733201.2 - WwTP SWO**		
	Total No of Spills	**Total Volume of Spills (m^3)**	**Total No of Spills/Bathing Season**
Year 1	0	0.00	0
Year 2	0	0.00	0
Year 3	2	5,690.72	0
Year 4	0	0.00	0
Year 5	0	0.00	0
Year 6	1	63.66	1
Year 7	0	0.00	0
Year 8	0	0.00	0
Year 9	0	0.00	0
Year 10	0	0.00	0
Average No of Spills	**0.30**		**0.10**

Table 10 Spill Frequency Analysis – SI SWO

SWO Ref	**TSS3.2 - Southern Interceptor SWO**		
	Total No of Spills	**Total Volume of Spills (m^3)**	**Total No of Spills/Bathing Season**
Year 1	0	0.00	0
Year 2	0	0.00	0
Year 3	2	52,407.60	0
Year 4	0	0.00	0
Year 5	0	0.00	0
Year 6	1	313.47	1
Year 7	2	0.00	0
Year 8	0	0.00	0
Year 9	0	0.00	0
Year 10	0	0.00	0
Average No of Spills	**0.50**		**0.10**

9 Summary of Modelled Scenarios

Scenario	Combined Sewer Overflow Locations	Total No. of Flooding Locations with Flood Volume > 25m3	Total Flood Volume (m^3) > 25m3	Spill Volumes at Alps (m^3)	Comments
Existing System Hydraulic Assessment without Interceptor Sewers and SWOs					
M30_60 min storm event & MWHS tide level with Climate Change (0.99 mOD)	➢ Ø900mm overflow at The Alps, IL – 3.0m OD ➢ Ø1200mm overflow at TSS3 on Southern Interceptor Sewer to Avoca River, IL – 0.0m OD ➢ Ø1200mm overflow at WWTP Inlet PS to Arklow Bay, IL – 0.3m OD	106	8,103.7	The Alps SWO – 859m^3	➢ Significant flooding predicted within the catchment without implementation of upgrades proposed in Phase 3 GDSDS Study ➢ Northern and Southern Interceptor sewers surcharged under peak flow conditions

Scenario	Combined Sewer Overflow Locations	Total No. of Flooding Locations with Flood Volume > 25m3	Total Flood Volume (m^3) > 25m3	Spill Volumes at Alps (m^3)	Comments
Existing System Hydraulic Assessment with Interceptor Sewers and SWOs					
M30_60 min storm event & MWHS tide level with Climate Change (0.99 mOD)	➢ Ø900mm overflow at The Alps, IL – 3.0m OD ➢ Ø1200mm overflow at TSS3 on Southern Interceptor Sewer to Avoca River, IL – 0.0m OD ➢ Ø1200mm overflow at WWTP Inlet PS to Arklow Bay, IL – 0.3m OD	100	7,562	The Alps SWO – 1,458m^3 Southern Interceptor SWO – 0 m^3 WWTP SWO – 0m^3	➢ Significant flooding predicted within the catchment without implementation of upgrades proposed in Phase 3 GDSDS Study

Scenario	Combined Sewer Overflow Locations	Total No. of Flooding Locations with Flood Volume > 25m3	Total Flood Volume (m³) > 25m3	Spill Volumes (m³)	Comments
Future System Hydraulic Assessment with Interceptor Sewers and SWOs					
M30_60 min storm event & MWHS tide level with Climate Change (0.99 mOD)	Ø900mm overflow at The Alps, IL – 3.0m OD Ø1200mm overflow at TSS3 on Southern Interceptor Sewer to Avoca River, IL – 0.0m OD Ø1200mm overflow at WWTP Inlet PS to Arklow Bay, IL – 0.3m OD	3 (2Foul/Combined, 1 Storm)	134.2	The Alps SWO - 1,289m³ Southern Interceptor SWO - 0³ WWTP SWO - 0m³	3 no location of foul flooding Northern and Southern Interceptor sewer remains surcharged for no of days
M1_60 min storm event & 1-year tide level with Climate Change (Tide Level – 1.4585 mOD)	➢ Ø900mm overflow at The Alps, IL – 3.0m OD ➢ Ø1200mm overflow at TSS3 on Southern Interceptor Sewer to Avoca River, IL – 0.0m OD ➢ Ø1200mm overflow at	4 (Storm)	139.3	No Spills predicted at any SWO	➢ No foul/combined sewer flooding predicted ➢ Increase in tide levels predicts storm flooding at Harbour Road

Scenario	Combined Sewer Overflow Locations	Total No. of Flooding Locations with Flood Volume > 25m3	Total Flood Volume (m^3) > 25m3	Spill Volumes (m^3)	Comments
Future System Hydraulic Assessment with Interceptor Sewers and SWOs					
	WWTP Inlet PS to Arklow Bay, IL – 0.3m OD				
4M_60 min storm event & 5-year tide level with Climate Change (Tide Level – 1.65 mOD)	➢ Ø900mm overflow at The Alps, IL – 3.0m OD ➢ Ø1200mm overflow at TSS3 on Southern Interceptor Sewer to Avoca River, IL – 0.0m OD ➢ Ø1200mm overflow at WWTP Inlet PS to Arklow Bay, IL – 0.3m OD	10 (Storm)	580	No Spills predicted at any SWO	➢ No foul/combined sewer flooding predicted ➢ Increase in tide levels predicts storm flooding particularly at Harbour Road

Scenario	Combined Sewer Overflow Locations	Total No. of Flooding Locations with Flood Volume > 25m3	Total Flood Volume (m³) > 25m3	Spill Volumes (m³)	Comments
Future System Hydraulic Assessment with all Pumps down at WWTP					
M30_60 min storm event & MWHS tide level with Climate Change (0.99 mOD)	➢ Ø900mm overflow at The Alps, IL – 3.0m OD ➢ Ø1200mm overflow at TSS3 on Southern Interceptor Sewer to Avoca River, IL – 0.0m OD ➢ Ø1200mm overflow at WWTP Inlet PS to Arklow Bay, IL – 0.3m OD	37	2,358	The Alps SWO - 1,803m³ Southern Interceptor SWO - 10,935m³ WWTP SWO – 7,416m³	➢ 37 locations predicted to flood despite significant spills at the SWO
M30_60 min storm event with Climate Change & No tide	➢ Ø900mm overflow at The Alps, IL – 3.0m OD ➢ Ø1200mm overflow at TSS3 on Southern Interceptor Sewer to Avoca River, IL – 0.0m OD ➢ Ø1200mm overflow at	9	435	The Alps SWO - 1,533m³ Southern Interceptor SWO – 8,007m³ WWTP SWO – 10,581m³	➢ 9 locations predicted to flood despite significant spills at the SWO

Scenario	Combined Sewer Overflow Locations	Total No. of Flooding Locations with Flood Volume > 25m3	Total Flood Volume (m³) > 25m3	Spill Volumes (m³)	Comments
Future System Hydraulic Assessment with all Pumps down at WWTP					
	WWTP Inlet PS to Arklow Bay, IL – 0.3m OD				
M5_60 min storm event & No tide	➢ Ø900mm overflow at The Alps, IL – 3.0m OD ➢ Ø1200mm overflow at TSS3 on Southern Interceptor Sewer to Avoca River, IL – 0.0m OD ➢ Ø1200mm overflow at WWTP Inlet PS to Arklow Bay, IL – 0.3m OD	-	-	The Alps SWO - 578m³ Southern Interceptor SWO - 5,147m³ WWTP SWO – 9,419m³	➢ No flooding predicted

10 Conclusions

The hydraulic assessment of the existing and future sewer system of Arklow was carried out to assess risk of flooding from the sewers. The hydraulic model of the future sewer was run for various modelling scenarios as per specific recommendations given in GDSDS Final Strategy Report for carrying out joint probabilistic flooding assessment of Arklow Sewer Network.

The hydraulic assessment results indicate that the existing sewerage system in Arklow is significantly under capacity and is predicted to flood at more than 100 locations with flood volume greater than 25m³ for a 1 in 30-year storm event. The assessment of the spill volumes shows that 7,566m³ of raw sewage is predicted to spill via the existing outfalls into Avoca River during Dry Weather Flow (DWF). Further, the sewer system is predicted to spill 15,100m³ and 21,484m³ of combined sewage into Avoca River for a 5 year and 30-year return period critical duration events.

Hydraulic assessment of the existing system incorporating the proposed interceptor sewer, and SWOs shows that the total flooding within Arklow sewerage catchment is only marginally reduced without implementation of all other upgrades proposed in Phase 3 of the GDSDS Study. Further, all the flows from the Arklow catchment will be conveyed to the proposed WwTP at Ferrybank. Hence, there will not be any discharge of raw sewage into Avoca River following the construction of the Interceptor Sewers and the WwTP which will the improve the existing water quality in the Avoca River/Estuary.

The result of the hydraulic assessment of the future sewer system which incorporates all upgrades proposed in Phase 3 of the GDSDS, the proposed interceptor sewer, proposed SWOs and WwTP indicates very minor flooding within the catchment for a 1 in 30-year critical duration storm event with MHWS including allowance of climate change. In total just 3 locations are predicted to flood marginally above 25 m³ in a 30-year return period event.

It should be noted that storm water flooding is predicted in Arklow South particularly along the Harbour Road and South Green Road Areas for both 1 year drainage with 1 year tide level and 0.25 year drainage with 5 year tide level combination events due to surcharging of Storm water sewers caused by high tide conditions in Avoca River.

The results of spill frequency analysis of the future system indicate that proposed SWOs spill on average less than once during bathing season which is well below the permitted 7 spills/bathing season. Therefore, the proposed development would remove the need to discharge untreated wastewater into the Avoca River excluding discharges via SWOs which are compliant with IW standards.

Appendix

1. Existing System - Predicted Flooding Locations
2. Existing System with Interceptor Sewers - Predicted Flooding Volumes

1. Existing System - Predicted Flooding Locations

Node ID	Flood Volume > 25m3
ST24747202	457.7
ST24736020	409.5
ST24730101	335.5
ST23727407	295.8
ST25744501	250.3
ST23729699	216.4
ST25742003	202
ST25742202	192.1
ST23739003	182.6
ST23728911	160.7
ST23729909	142.6
ST25741303	141.2
ST24722601	133
ST24721797	128.4
ST23729903	123.2
ST24733498	120.6
ST24737003	105.5
ST24748104	103
ST23735310	100.6
ST24720401	98
ST24729802	98
ST24749004	97.8
ST24730201	97.1
ST23728503	87.8
ST24721796	84.6
ST24724704	84
ST23735202	78.4
ST24733499	78
ST23725002	76.1
ST25741202	75.5
ST24724804	73.6
ST24747201	72.1
ST24737103	71
ST25731902	69.6
ST23717901	67.5
ST24747402	66.9

Node ID	Flood Volume > 25m3
ST24747501	66.1
ST23737401	65.3
ST23711805	64.4
ST24737101	63.6
ST24733405	62.7
ST24748203	61.8
ST24748208	61.3
ST25743502	60.6
ST25730704	60.1
ST23739107	59
ST23734204	57.2
ST24749003	56.3
ST25742001	55.8
ST23729202	55.3
ST24723701	54.7
ST22738109	54.6
ST23712801	54.3
ST23727602	54
ST23727502	50.1
ST23729302	50.1
ST25740502	49.3
ST23713804	49.1
ST24723702	47.8
ST23719801	47.8
ST24745403	47.2
ST24737602	47.1
ST24747502	46.6
ST24747601	44.6
ST25741510	43.4
ST24749001	42.9
ST23729908	42.1
ST24726899	41.9
ST24735005	41.4
ST25730404	41
ST23727504	40.6
ST24746303	40
ST23722401	38.6
ST24730303	37.4
ST24733406	36.8
ST24729704	36.4

Node ID	Flood Volume > 25m3
ST23713902	35.8
ST23728906	34.6
ST25731901	34.6
ST24732402	33.3
ST24723601	33
ST23728403	32.9
ST23725705	32.7
ST23726203	32.4
ST24747203	32
ST24731101	31.5
ST237353D1	31.4
ST24725901	31.3
ST24726901	30.1
ST23722701	29.8
ST23734402	29.5
ST24737114	29.4
ST23736401	29.1
ST23728201	28.8
ST22738303	28.6
ST23734306	28.4
ST23728003	27.9
ST23725709	27.8
ST23722407	27.8
ST23727401	27.5
ST22738301	27.3
ST24733497	26.6
ST23715805	26.3
ST24735203	26.1
ST23733402	26
ST24723505	25.2
Total	**8103.7**

2. Existing System with Interceptor Sewers - Predicted Flooding Volumes

Node ID	Flood Volume > 25m3
ST24747202	451
ST24736020	381
ST24730101	327.5
ST23727407	288.9
ST25744501	245.7
ST23729699	210.3
ST25742003	193.8
ST25742202	187.3
ST23739003	178
ST23728911	155
ST23729909	138
ST25741303	137.5
ST24722601	130.2
ST24721797	125.2
ST24737003	122.7
ST23729903	120.3
ST24733498	116.2
ST23735310	97.5
ST24730201	95.1
ST24720401	94.9
ST24748104	94.5
ST24729802	94
ST23728503	86.3
ST24724704	83.4
ST24721796	82.1
ST24733499	75.8
ST23735202	75.2
ST25741202	73.5
ST23725002	73.4
ST24724804	71.3
ST24747201	69.1
ST24749004	67.3
ST24747402	64.8
ST23717901	64
ST24747501	64
ST23737401	63
ST24733405	60.8
ST23711805	59.8

Node ID	Flood Volume > 25m3
ST24748208	59.7
ST24748203	59.5
ST25743502	58.5
ST23739107	56.7
ST23734204	54.6
ST24723701	53.2
ST22738109	53
ST23727602	52.7
ST25742001	52.6
ST23729202	52.5
ST23712801	52
ST24737103	51.4
ST25731902	51.4
ST24737101	49.7
ST23727502	48.4
ST23729302	48.1
ST25730704	47.7
ST23713804	47.1
ST25740502	46.7
ST24723702	46.6
ST24745403	45.5
ST24747502	44.8
ST25730404	44.3
ST23719801	44.1
ST24747601	42.3
ST24749003	41.8
ST25741510	41.7
ST24726899	40.4
ST23727504	39.6
ST23729908	39.5
ST24735005	38.4
ST24746303	37.9
ST23722401	37.6
ST24730303	36.5
ST24733406	35
ST24729704	34.2
ST23713902	34
ST24749001	33.2
ST23728906	33.1
ST24723601	31.9
ST23726203	31.7

Node ID	Flood Volume > 25m3
ST23728403	31.5
ST23725705	31
ST24747203	30.9
ST24731101	30.7
ST237353D1	30.2
ST24725901	29.6
ST25731901	29.5
ST23722701	28.8
ST23734402	28.5
ST24726901	28.4
ST23736401	27.8
ST23728201	27.8
ST22738303	27.4
ST23722407	27.1
ST23725709	27.1
ST23734306	27
ST23728003	26.5
ST23727401	26.4
ST22738301	26.2
ST25732201	25.9
ST24733497	25.5
Total	**7561.8**