Coastal Quarter SHD 2

Flood Risk Assessment

Shankill Property Investments Limited

Sept 22

Notice

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This document has 45 pages including the cover.

Document history

Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
Rev 1	Issued for Planning	A. Corrigan	A. Corrigan	G. Hanratty	K. Boyle	06/09/2022

Client signoff

Client	Shankill Property Investments Limited
Project	Coastal Quarter SHD 2
Job number	5214419
Client signature / date	

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1. Introduction

This Flood Risk Assessment (FRA) has been prepared by Atkins on behalf of Shankill Property Investments Ltd. as part of the supporting assessments required for a planning application for the proposed Coastal Quarter Development in Bray, Co. Wicklow and Co. Dublin.

1.1. Planning Application Description

The applicant intends to apply to An Bord Pleanála for permission for a Strategic Housing Development (SHD) comprising 586 no. residential units in a mix of apartments, duplexes and houses. In addition, a childcare facility, café, retail unit and 1 no. commercial unit (incorporating a gym and a juice bar) are proposed along with all associated and ancillary development and infrastructural works, hard and soft landscaping, open spaces, boundary treatment works, ancillary car and bicycle parking spaces at surface, undercroft and basement levels. The proposed houses and duplexes range in height from 2 – 3 storeys with the proposed 4 no. apartment blocks ranging in height from 3 – 12 storeys. Block A will accommodate 162 no. Build-to-Rent (BTR) units. It is proposed that 274 no. units will be located within the administrative area of Dun Laoghaire-Rathdown County Council and 312 no. units will be located within the administrative area of Wicklow County Council. The childcare facility, retail, café and commercial unit will all be located in the administrative area of Wicklow County Council.

Planning permission was granted on part of the subject site for 234 no. residential units, a childcare facility, café and retail unit subject to compliance with the terms of conditions attached to reference ABP-311181-21. The current proposed development includes the development as previously permitted under ABP-311181-21 including minor revisions chiefly addressing conditions and new proposals for Blocks A and B which were previously refused.

1.2. Overview of the Existing Site

The existing site is part of the former Bray Golf Course Lands. The site is bounded to the North by the Corke Abbey and Corke Abbey Valley Park, to the West by the Ravenswell School Complex, to the South by the old Golf Club Lands and the Dargle River, and to the East by an active Railway line. The site is currently accessed via the Ravenswell Primary School access road.

The existing site topography generally slopes moderately from North to South with a steeper gradient on the southern portion of the site falling from North West to South East to a low point in the South East. The existing site elevations range from 11.50mOD to 1.50mOD.

The site location is indicated on drawings BRA-GHA-SW-XX-DR-A-05001, BRA-GHA-SW-ZZ-DR-A-05002 & 05003.

1.3. Scope of Flood Risk Assessment

The scope of this flood risk assessment was to assess flood risk to and resultant from the proposed Coastal Quarter Development as defined by the planning extents line (redline), refer to drawings BRA-GHA-SW-ZZ-DR-A-05002 & 05003.

The proposed Wicklow County Council Sustainable Transport Bridge (Planning Ref. PRR 21/869) has not been considered in this assessment, however this has been considered as part of the Harbour Point Masterplan Flood Risk Review (IE Consulting Report 4979 September 2022) and the Cumulative Impact Assessment Chapter of the Environmental Impact Assessment Report (Atkins Report 5214419DG0002 September 2022).

Figure 1-1 – Approximate location of the proposed site

2. Flood Risk Assessment Methodology

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 'The Planning System and Flood Risk Management - Guidelines for Planning Authorities together with Technical Appendices'. Circular PL2/2014 was issued by the Department of Environment, Community and Local Government in 2014.

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

2.1.2. Flood Risk

Flood risk can be quantified by relating the probability of the flood event occurring to the consequence of the flood. Probability, in flood event terms, is gauged by potential annual occurrence/return period and flood consequence is dependent on the nature of the flood hazard and the vulnerability of the inundated area. The source-pathway-receptor model considers the components of flood risk.

The source is the hazard with the potential to cause harm through flooding (e.g. rainfall, high sea levels). The pathway is the mechanism by which the source can affect the receptor (e.g. inadequate drainage, overtopping of coastal defences) and finally, the receptor is anything that is affected by the flood event (e.g. people, infrastructure, property).

2.1.3. Definition of Flood Zones

In the context of the 'Planning System and Flood Risk Management Guidelines, DOEHLG 2009', three flood zones are designated in the consideration of flood risk to a site. The three flood zones are described in Table 2-1 below.

Table 2-1 - Flood Zone Description

Flood Zone	Description
Flood 'Zone A'	Where the probability of flooding from watercourses is the highest (greater than 1% or 1 in 100 year for watercourse flooding or 0.5% or 1 in 200 for coastal flooding).
Flood 'Zone B'	Where the probability of flooding from watercourses is moderate (between 0.1% or 1 in 1000 year and 1% or 1 in 100 year for watercourse flooding, and
Flood 'Zone C'	Where the probability of flooding from watercourses and the sea is low or negligible (less than 0.1% or 1 in 1000 year for both watercourse and coastal flooding). Flood Zone 'C' covers all areas which are not in Zones 'A' or 'B'.

2.1.4. Definition of Vulnerability Classes

Table 2-2 summarises the Vulnerability Classes defined in the Guidelines and provides a sample of the most common type of development applicable to each.

Table 2-2 - Definition of Vulnerability Classes

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

2.1.5. Types of Vulnerability Classes appropriate to each zone

Table 2-3 illustrates the types of development that would be appropriate to each flood zone and those that would be required to meet the Justification Test.

Table 2-3 - Matrix - Development Vulnerability and Flood Zone

	Flood Zone A	Flood Zone B	Flood Zone C
Highly vulnerable development	Justification Test	Justification Test	Appropriate
Less vulnerable development	Justification Test	Appropriate	Appropriate
Water-compatible development	Appropriate	Appropriate	Appropriate

2.2. Classification of the proposed development

The Guidelines categorise land uses and development into separate levels of vulnerability as set out in Figure 2-1 below.

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 vulnerable development	Buildings used for: retail, leisure, warehousing, commercial, industrial and non-residential institutions; Land and buildings used for holiday or short-let caravans and camping, subject to specific warning and evacuation plans; Land and buildings used for agriculture and forestry; Waste treatment (except landfill and hazardous waste); Mineral working and processing; and Local transport infrastructure.
Water-compatible development	Flood control infrastructure; Docks, marinas and wharves; Navigation facilities; Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location; Water-based recreation and tourism (excluding sleeping accommodation); Lifeguard and coastguard stations; Amenity open space, outdoor sports and recreation and essential facilities such as changing rooms; and Essential ancillary sleeping or residential accommodation for staff required by uses in this category (subject to a specific warning and evacuation plan).
*Uses not listed here should be considered on their own merits	

Figure 2-1 - Vulnerability Classification

2.3. Sequential Approach

Figure 2-2 below illustrates the sequential approach to be adopted under the 'Planning System and Flood Risk Management' Guidelines' depending on the Flood Zone classification for a proposed development site.

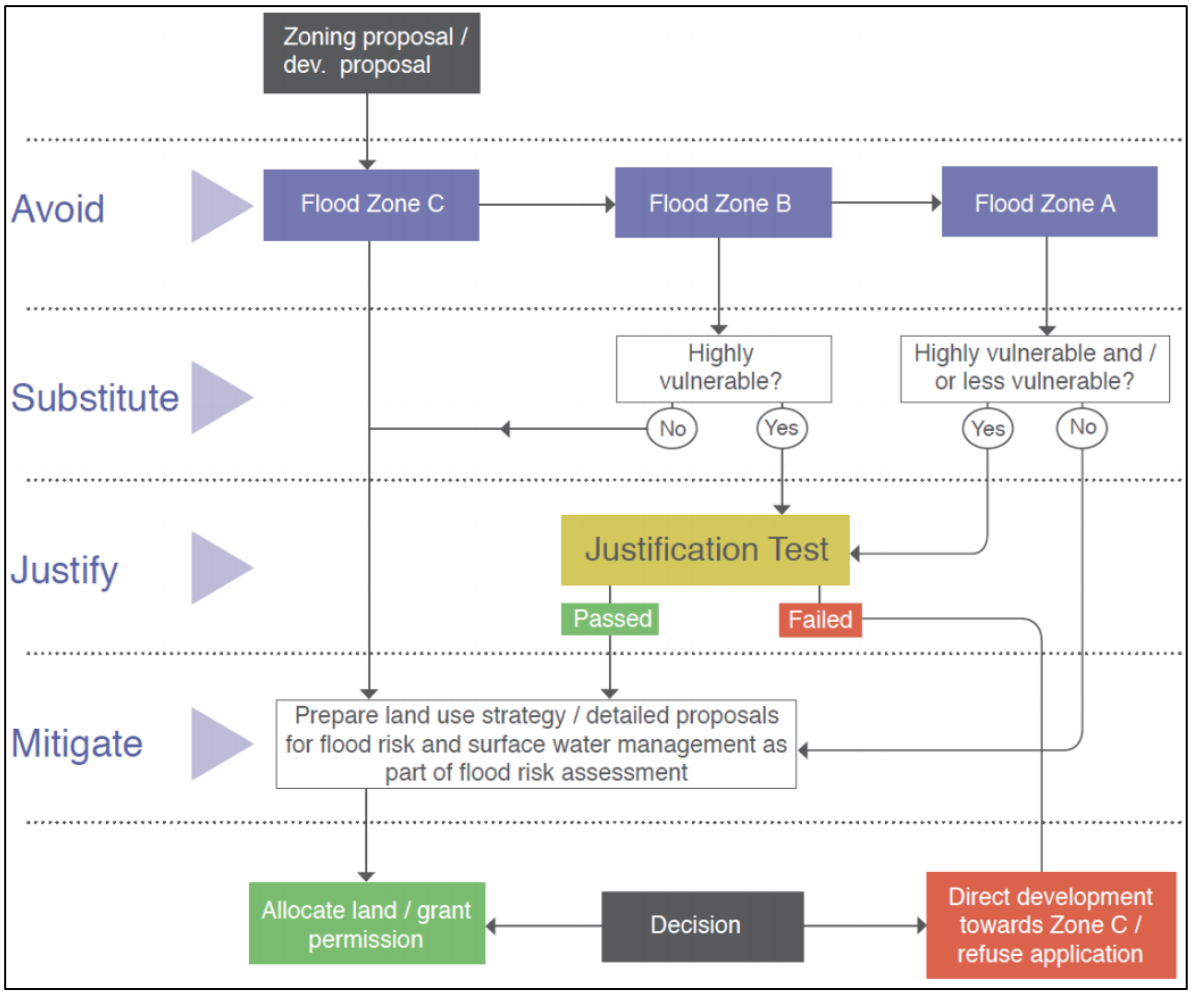


Figure 2-2 - Sequential approach mechanism in the planning process

2.4. Justification Test Criteria

The Justification Test must satisfy the two criteria set out in Figure 2-3 below;

Box 5.1 Justification Test for development management (to be submitted by the applicant)

When considering proposals for development, which may be vulnerable to flooding, and that would generally be inappropriate as set out in Table 3.2, the following criteria must be satisfied:

1. The subject lands have been zoned or otherwise designated for the particular use or form of development in an operative development plan, which has been adopted or varied taking account of these Guidelines.
2. The proposal has been subject to an appropriate flood risk assessment that demonstrates:
   - (i) The development proposed will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk;
   - (ii) The development proposal includes measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible;
   - (iii) The development proposed includes measures to ensure that residual risks to the area and/or development can be managed to an acceptable level as regards the adequacy of existing flood protection measures or the design, implementation and funding of any future flood risk management measures and provisions for emergency services access; and
   - (iv) The development proposed addresses the above in a manner that is also compatible with the achievement of wider planning objectives in relation to development of good urban design and vibrant and active streetscapes.

The acceptability or otherwise of levels of residual risk should be made with consideration of the type and foreseen use of the development and the local development context.

Note: See section 5.27 in relation to major development on zoned lands where sequential approach has not been applied in the operative development plan.

Refer to section 5.28 in relation to minor and infill developments.

Figure 2-3 – Justification Test Criteria

3. Consultations

The responses to the comments received from An Bord Pleanála (ABP), Dun Laoghaire Rathdown County Council (DLRCC) and Wicklow County Council (WCC) outlined in the tables below are in respect to the pre-application consultation ref ABP-308291-20 on part of the subject site for the permitted development for 234 no. residential units, a childcare facility, café and retail unit ref ABP-311181-21. These responses in respect to this new planning application remain relevant and have been fully addressed as part of this planning submission comprising of 586 no. residential units in a mix of apartments, duplexes and houses within the same site boundary.

An initial FRA and a Statement of Consistency (Flood Risk Guidelines) was submitted in September 2020 as part of the pre-application submission to ABP for the previous application ref ABP-308291-20. As part of this process comments where received from ABP and WCC both prior to and following the tripartite meeting on the 15th of December 2020 as outlined in the table below. Each of the comments received has been fully addressed throughout this assessment.

Table 3-1 – Responses to comments during from Opinion ABP-308291-20

Opinion ABP-308291-20

Ref	Issue	Atkins Response
Water Services 5	Further consideration / amendment or justification of the design of the storm water management proposals, including the location of attenuation tanks, having regard to existing underground infrastructure within the site and to all available flood maps / information regarding the potential for pluvial, fluvial and coastal / tidal flood risk within the site. A site-specific Flood Risk Assessment should be submitted. Further consideration of the concerns raised in the report of Dun Laoghaire Rathdown County Councils Drainage Planning Section dated 12th October 2020 and concerns raised under the Drainage section of Wicklow County Councils written opinion dated 28th October 2020.	As detailed in Section 4.12 - Proposed Storm Drainage Network of this report, it was agreed during discussions with WCC that the proposed underground attenuation system in catchment B (refer to Atkins Drawing 5214419-ATK-01-ZZ-DR-CE-0503) will be a sealed concrete tank to ensure that in the unlikely event of flooding there will be no impact on the availability of attenuation volume within the proposed tank. An additional meeting took place with WCC on the 28th January 2021 to discuss and agree both the approach to this Flooding Risk Assessment and the design of the Storm Water Drainage Network including attenuation requirements and storm water outfall to the Dargle River. A full Screening Assessment of each potential flood risk has been carried out as part of this FRA. Refer to Section 4.9 of this report for the Fluvial Flood Risk Screening Assessment. Refer to Section 4.104.9 of this report for the Tidal/Coastal Flood Risk Screening Assessment Refer to Section 4.114.104.9 of this report for the Pluvial Flood Risk Screening Assessment Following the screening assessments Table 4-1 - Possible Flooding Mechanisms provides a summary of potential flooding situations to be further assessed .

		Section 6 - Detailed Flood Risk Assessment of this report provides further assessment of both the Pluvial and Tidal/Coastal Flood Risk along with identification of Flood Zones A and B within the proposed site. Consideration of the concerns raised in the report of Dun Laoghaire Rathdown County Councils Drainage Planning Section dated 12th October 2020 and concerns raised under the Drainage section of Wicklow County Councils written opinion dated 28th October 2020 have been address within the Inspectors Report Section below.

Table 3-2 – Responses to comments during from Inspector's Report on Recommended Opinion ABP-308291-20

Inspector's Report on Recommended Opinion ABP-308291-20

Ref	Issue	Atkins Response
5.2	Clarification of the flood defence works along the River Dargle, to the south of the development site and the impact of these works on the development potential of the site.	A review of the existing Flood Defence works has been carried out as indicated in section 4.4 with further detailed assessment carried out as part of the Technical Note in Appendix A. It is noted that the modelling carried out for the River Dargle as part of this Flood Risk Assessment does not consider the existing Flood Defence scheme which is a requirement of the 'Planning System and Flood Risk Management Guidelines'. There will be no impact from the proposed development on the existing River Dargle Flood defence.
5.3	Clarification of potential pluvial, fluvial and tidal flooding and the location of flood zones within the site.	A full Screening Assessment of each potential flood risk has been carried out as part of this FRA. Refer to Section 4.9 of this report for the Fluvial Flood Risk Screening Assessment. Refer to Section 4.104.9 of this report for the Tidal/Coastal Flood Risk Screening Assessment Refer to Section 4.114.104.9 of this report for the Pluvial Flood Risk Screening Assessment Following the screening assessments Table 4-1 - Possible Flooding Mechanisms provides a summary of potential flooding situations to be further assessed . Section 6 - Detailed Flood Risk Assessment of this report provides further assessment of both the Pluvial and Tidal/Coastal Flood Risk along with

		identification of Flood Zones A and B within the proposed site.
5.4	Justification of the location of attenuation tanks within flood zones	As detailed in Section 4.12 - Proposed Storm Drainage Network of this report, it was agreed during discussions with WCC that the proposed underground attenuation system in catchment B (refer to Atkins Drawing 5214419-ATK-01-ZZ-DR-CE-0503) will be a sealed concrete tank to ensure that in the unlikely event of flooding there will be no impact on the availability of attenuation volume within the proposed tank.
5.5	Consideration of the need for attenuation within the site and further discussion of the proposed drainage network within the site and its impact on potential flooding.	An additional meeting took place with WCC on the 28th January 2021 to discuss and agree both the approach to this Flooding Risk Assessment and the design of the Storm Water Drainage Network including attenuation requirements and storm water outfall to the Dargle River.
WCC Report		
WCC 3	A portion of the southern site boundary is within Flood Zone A. Due to the River Dargle Flood Defence Scheme was completed in 2017 the applicant has considered the southern portion of the site to be classified as Flood Zone B. this requires consideration. Lands located in Flood Zone A require that a justification test be carried out.	Section 6 - Detailed Flood Risk Assessment of this report provides further assessment of both the Pluvial and Tidal/Coastal Flood Risk along with identification of Flood Zones A and B within the proposed site.
WCC 11	Consideration should be given to the location of attenuation tanks within flood zone areas and close proximity to a river.	From discussions with WCC in January 2021, it was agreed that the proposed underground attenuation system in catchment B (refer to Atkins Drawing 5214419-ATK-01-ZZ-DR-CE-0503) will be a sealed concrete tank to ensure that in the unlikely event of flooding there will be no impact on the availability of attenuation volume within the proposed tank. Refer to Section 4.12 - Proposed Storm Drainage Network for further information on the proposed storm drainage design.
DLR Report		
DLR 11	Insufficient details have been submitted to full assess the application. A number of issues relating to site investigation details, green roof areas, attenuation storage and run-off, details pertaining to interception and treatment volumes and calculations, plans and particulars and site-specific flood risk assessment are outstanding. The applicant is revised to review the contents of the Drainage Planning Report.	Refer to Atkins Stormwater Impact Assessment Report 5214419DG0012 and associated drawings for a full design report in relation to site investigation details, green roof areas, attenuation storage and run-off, details pertaining to interception and treatment volumes and calculations, plans and particulars

		As required by DLRCC Development Plan a Stage 1 Stormwater Audit has been completed by a 3rd party reviewer and issued to both DLRCC and WCC prior to this planning application. Refer to Atkins Stormwater Impact Assessment Report 5214419DG0012 for further information. This report and its conclusions completes the requirements for a site-specific flood risk assessment including addressing all comments received from ABP, WCC and DLRCC.

Table 3-3 – Responses to comments during from Record of Meeting ABP-308291-20

Record of Meeting ABP-308291-20

Ref	Issue	Atkins Response
5	***Water Services – flooding and drainage***	
ABP 5.1	Clarification of the flood defence works along the River Dargle, to the south of the development site and the impact of these works on the development potential of the site.	A review of the existing Flood Defence works has been carried out as indicated in section 4.4 with further detailed assessment carried out as part of the Technical Note in Appendix A. It is noted that the modelling carried out for the River Dargle as part of this Flood Risk Assessment does not consider the existing Flood Defence scheme which is a requirement of the 'Planning System and Flood Risk Management Guidelines'. There will be no impact from the proposed development on the existing River Dargle Flood defence.
ABP 5.2	Clarification of potential pluvial, fluvial and tidal flooding and the location of flood zones within the site.	A full Screening Assessment of each potential flood risk has been carried out as part of this FRA. Refer to Section 4.9 of this report for the Fluvial Flood Risk Screening Assessment. Refer to Section 4.104.9 of this report for the Tidal/Coastal Flood Risk Screening Assessment Refer to Section 4.114.104.9 of this report for the Pluvial Flood Risk Screening Assessment Following the screening assessments Table 4-1 - Possible Flooding Mechanisms provides a summary of potential flooding situations to be further assessed . Section 6 - Detailed Flood Risk Assessment of this report provides further assessment of both the Pluvial and Tidal/Coastal Flood Risk along with identification of Flood Zones A and B within the proposed site.
ABP 5.3	Details regarding the proposed location of attenuation tanks within the site and the proximity to flood zones.	As detailed in Section 4.12 - Proposed Storm Drainage Network of this report, it was agreed during discussions with WCC that the proposed underground attenuation system in catchment B (refer to Atkins Drawing 5214419-ATK-01-ZZ-DR-CE-0503) will be a sealed concrete tank to

		ensure that in the unlikely event of flooding there will be no impact on the availability of attenuation volume within the proposed tank.
WCC 5.1	The railway access is at risk of flooding in a 200-year event and this should be included in any FRA • The area between the arch and the river needs to be modelled • Flood scheme needs to have regard to 3 types of flood events • Show if attenuation is needed for surface water. It would be preferable to omit attenuation and to allow surface water entre the River Dargle. • The PA are happy to facilitate further detailed discussions with the applicant.	The railway access has been modelled as part of the IE Technical Note in Appendix A and concludes that there is no increased risk of flooding through the existing railway access as outlined in Section 7.1 of this report. The area between the railway underpass arch and the river has been modelled in IE's Technical Note in Appendix A. As noted in response to ABP 5.2 above, Pluvial, Fluvial and Tidal/Coastal flooding along with ground water flooding have been fully considered as part of this FRA. As detailed in Section 4.12 - Proposed Storm Drainage Network of this report, it was agreed during discussions with WCC that the proposed underground attenuation system in catchment B (refer to Atkins Drawing 5214419-ATK-01-ZZ-DR-CE-0503) will be a sealed concrete tank to ensure that in the unlikely event of flooding there will be no impact on the availability of attenuation volume within the proposed tank. An additional meeting took place with WCC on the 28th January 2021 to discuss and agree both the approach to this Flooding Risk Assessment and the design of the Storm Water Drainage Network including attenuation requirements and storm water outfall to the Dargle River.

Table 3-4 – Conditions of Planning set by ABP (311181: Former Bray Golf Club Lands, Off Ravenswell Road and Dublin Road, Bray, Co. Dublin and Co. Wicklow)

Conditions of planning

Ref	Issue	Atkins Response
	Water Services – flooding and drainage	
ABP 32(c)	location of all construction compounds with no compound or construction equipment permitted to be placed on lands within Flood Zone A or Flood Zone B;	The red line has been adjusted to remove the contractor compound located to the South of the access road. The contractors compound will now be located within the main site and moved and the site progresses.

4. Flood Risk Identification

4.1. Data Collection

As part of the Flood Risk Identification process, the following data and information has been reviewed.

- Planning Context including;
  - Bray Municipal District Local Area Plan 2018-2024
  - Dún Laoghaire-Rathdown County Development Plan 2022-2028
  - Wicklow County Development Plan 2016-2022
  - Wicklow County Draft Development Plan 2022-2028
  - Wicklow County Council Part 8 Planning Application – Bray Sustainable Transport Bridge (Planning Ref. PRR 21/869)

- Bray Municipal District Local Area Plan 2018 – Appendix C, Strategic Flood Risk Assessment (SFRA)
- Existing Topographical Survey
- Local Hydrological features and existing drainage
- Historical Flood Maps
- River Dargle Flood Defence Scheme EIS
- Fluvial Flood Risk
- Tidal Flood Risk
- Pluvial Flood Risk
- Ground Water Flood Risk
- Refer to Section 4.9.2 of this report for further information in relation to OPW CFRAM Mapping.

In addition to the above, a number of site walk-overs were carried out between May 2020 and November 2020 to identify key site features, potential flood sources, extents of surveys required and existing flood defences.

4.2. Planning Context

4.2.1. Dún Laoghaire-Rathdown County Development Plan 2022-2028

The Northern portion of the proposed development site is located within in the county boundary of Dún Laoghaire-Rathdown. Figure 4-1 below indicates that the zoning objective for the proposed site area is to protect and-or improve residential amenity. A strip of land at the northern and eastern boundary of this site is intended for use to preserve and provide for open space with ancillary active recreational amenities.

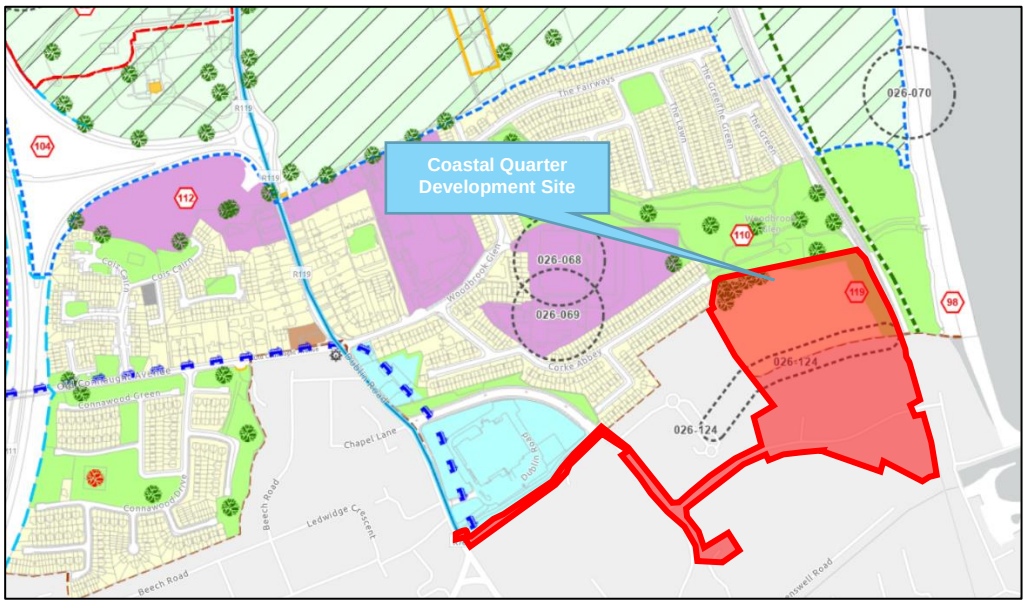


Figure 4-1 - Dún Laoghaire-Rathdown County Development Plan Zoning Objective Use - Map 14 (Red hatched area represents approximate location of the proposed site)

The Dún Laoghaire-Rathdown County Development Plan 2022-2028 sets out policies and objectives for the sustainable development of the County. The following extracts summarise the relevant areas contained within the plan which focus on Flood Risk Management;

> *Section 10.7 of the plan presents the policies on Flooding:*
>
> *Policy EI21: It is a Policy Objective to assist the Office of Public Works (OPW) in the design and construction of flood relief schemes approved in the ten-year Programme of Investment in Flood Relief Measures following from the recommendations and outputs of the CFRAM for the Eastern District that are relevant for DLR.*
>
> *Policy EI22: It is a Policy Objective to support, in cooperation with the OPW, the implementation of the EU Flood Risk Directive (20010/60/EC) on the assessment and management of flood risks, the Flood Risk Regulations (SI No 122 of 2010) and the Department of the Environment, Heritage and Local Government and the Office of Public Works Guidelines on 'The Planning System and Flood Risk Management' (2009) and relevant outputs of the Eastern District Catchment and Flood Risk Assessment and Management Study (ECFRAMS Study). Implementation of the above shall be via the policies and objectives, and all measures to mitigate identified flood risk, including those recommended under part 3 (flood risk considerations) of the Justification Tests, in the Strategic Flood Risk Assessment set out in Appendix 15 of this Plan.*
>
> *Policy EI23: It is a Policy Objective to work with neighbouring Local Authorities when developing cross boundary flood management work programmes and when considering cross boundary development.*
>
> *Policy EI24: It is a Policy Objective to implement and have regard to the recommendations of the Coastal Defence Strategy (2010) for the County where feasible. The Council will endeavour to (i) obtain funding from the OPW in order to undertake defence measures for specific areas as prioritised in the Strategy (ii) become part of any future national OPW Coastal Monitoring Survey Programme. Where feasible and appropriate the Council will endeavour to incorporate leisure and transport objectives with coastal protection.*

Dún Laoghaire-Rathdown County Council are implementing the OPW Guidelines to ensure development that would be subject to an inappropriate risk of flooding or that would cause or exacerbate such a risk at other locations will not be permitted by Dún Laoghaire-Rathdown County Council. Dún Laoghaire-Rathdown County Council have also incorporated Flood Risk Management and Strategic Flood Risk Assessments into the preparation of all Local Area Plans and any other lower tier plans.

4.3. Wicklow County Development Plan 2016-2022

Land Zoning for the Bray area including the proposed Coastal Quarter Development is outlined in the Bray Municipal District Local Area Plan 2018, refer to Section 4.3.1 of this report for further information.

The Wicklow County Development Plan 2016-2022 sets out policies and objectives for the sustainable development of the County. The following extracts summarise the relevant objectives contained within the plan which focus on Flood Risk Management;

FL1 To prepare new or update existing flood risk assessments and flood zone maps for all zoned lands within the County as part of the review process for Local Area Plans, zoning variations and Town Plans, where considered necessary.

FL2 To implement the 'Guidelines on the Planning System and Flood Risk Management' (DoEHLG/OPW, 2009).

FL3 The zoning of land that has been identified as being at a high or moderate flood risk (flood zone A or B) shall be in accordance with the requirements of the Flood Risk Guidelines and in particular the 'justification test for development plans' (as set out in Section 4.23 and Box 4.1 of the guidelines).

FL4 Applications for new developments or significant alterations/extension to existing developments in a flood risk area shall comply with the following:

- *Follow the 'sequential approach' as set out in the Flood Risk Guidelines.*
- *Flood risk assessments will be required with all planning applications proposed in areas identified as having a flood risk, to ensure that the development itself is not at risk of flooding and the development does not increase the flood risk in the relevant catchment (both up and down stream of the application site).*
- *Where a development is proposed in an area identified as being at low or no risk of flooding, where the planning authority is of the opinion that flood risk may arise or new information has come to light that may alter the flood designation of the land, an appropriate flood risk assessment may be required to be submitted by an applicant for planning permission.*
- *Restrict the types of development permitted in Flood Zone A and Flood Zone B to that are 'appropriate' to each flood zone, as set out in Table 3.2 of the guidelines for Flood Risk Management (DoEHLG/OPW, 2009).*
- *Developments that are an 'inappropriate' use for a flood zone area, as set out in Table 3.2 of the guidelines, will not be permitted, except where a proposal complies with the 'Justification Test for Development Management', as set out in Box 5.1 of the Guidelines.*
- *Flood Risk Assessments shall be in accordance with the requirements set out in the Guidelines.*
- *Generally a Flood Impact Assessment will be required with all significant developments and a certificate (from a competent person stating that the development will not contribute to flooding within the relevant catchment) will be required with all small developments of areas of 1 hectare or less.*

FL5 To prohibit development in river flood plains or other areas known to provide natural attenuation for floodwaters except where the development can clearly be justified with the Flood Risk Guidelines 'Justification test'.

FL6 To limit or break up large areas of hard surfacing in new developments and to require all surface car parks to integrate permeability measures such as permeable paving.

FL7 Excessive hard surfacing shall not be permitted for new, or extensions to, residential or commercial developments and all applications will be required to show that sustainable drainage techniques have been employed in the design of the development.

FL8 To require all new developments to include proposals to deal with rain and surface water collected on site and where deemed necessary, to integrate attenuation and SUDS measures.

FL9 For developments adjacent to all watercourses of a significant conveyance capacity or where it is necessary to maintain the ecological or environmental quality of the watercourse, any structures (including hard landscaping) must be set back from the edge of the watercourse to allow access for channel clearing/ maintenance / vegetation. A minimum setback of up to 10m (or other width, as determined by the Council) will be required either side depending on the width of the watercourse.

It is the intention that the application of these policies and objectives will mitigate flooding as much as is reasonably practicable.

4.3.1. Bray Municipal District Local Area Plan 2018

The proposed development is located in the north-east region of Bray Town Centre. Figure 4-2 below from the Bray Municipal District Local Area Plan 2018 indicates that the zoning objective for the proposed development site area is for Mixed Use development within the county boundary of Wicklow.

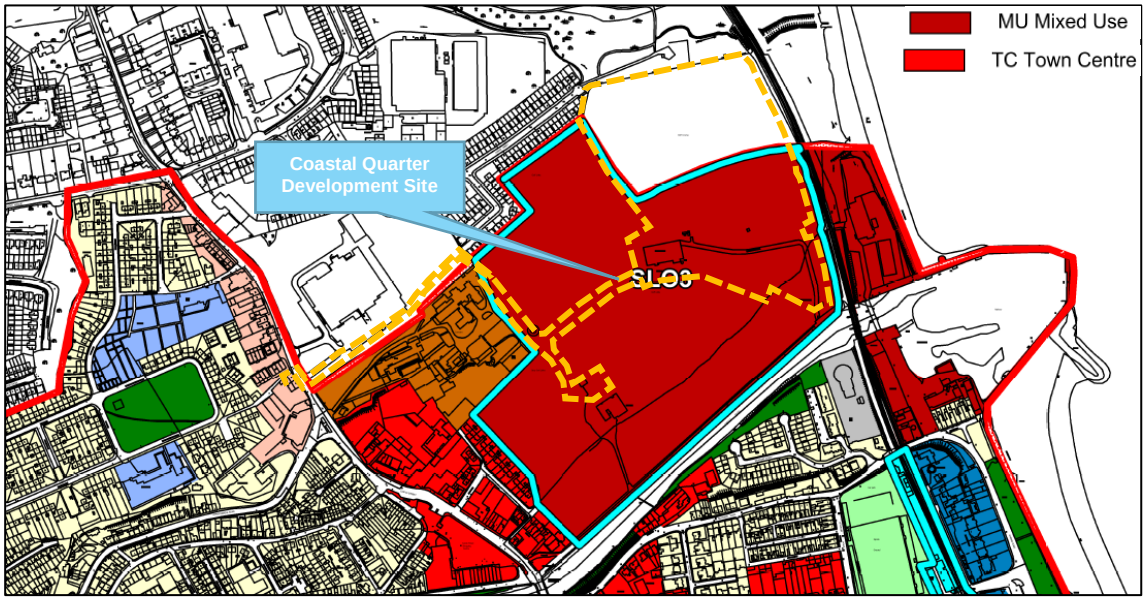


Figure 4-2 - Extract from Bray Municipal District Local Area Plan 2018 (Dashed orange line represents approximate location of the proposed site)

4.4. Bray Municipal District Local Area Plan 2018 – Strategic Flood Risk Assessment

A Strategic Flood Risk Assessment (SFRA) was prepared as part of the Bray Municipal District Local Area Plan 2018 - 2024 and informed by 'The Planning System and Flood Risk Management – Guidelines for Planning Authorities' (2009). The assessment for the SFRA for the draft LAP was carried out in mid-2017 in order to prepare the objectives and land use zonings of the LAP.

Section 1.5 of the SRFA notes that in relation to the River Dargle (Bray) Flood Defence Scheme, Bray has experienced severe historical fluvial flooding from the River Dargle. As a result of this historical flooding, a flood defence study was carried out of the river between Route N11 and the sea. Mathematical and physical modelling was carried out to Office of Public Works specifications using various combinations of return periods for river flooding up to one in a hundred years and tidal events up to one in 200 years. Based on this modelling results the (Bray) Flood Defence Scheme commenced construction in 2012 and was completed in 2017. It is acknowledged that a residual risk of flooding may remain at such defended locations and thus the sequential approach and the 'Justification Test' are to be applied as set out in the The Planning System and Flood Risk Management – Guidelines for

Planning Authorities' (2009). Refer to Figure 4-6 and

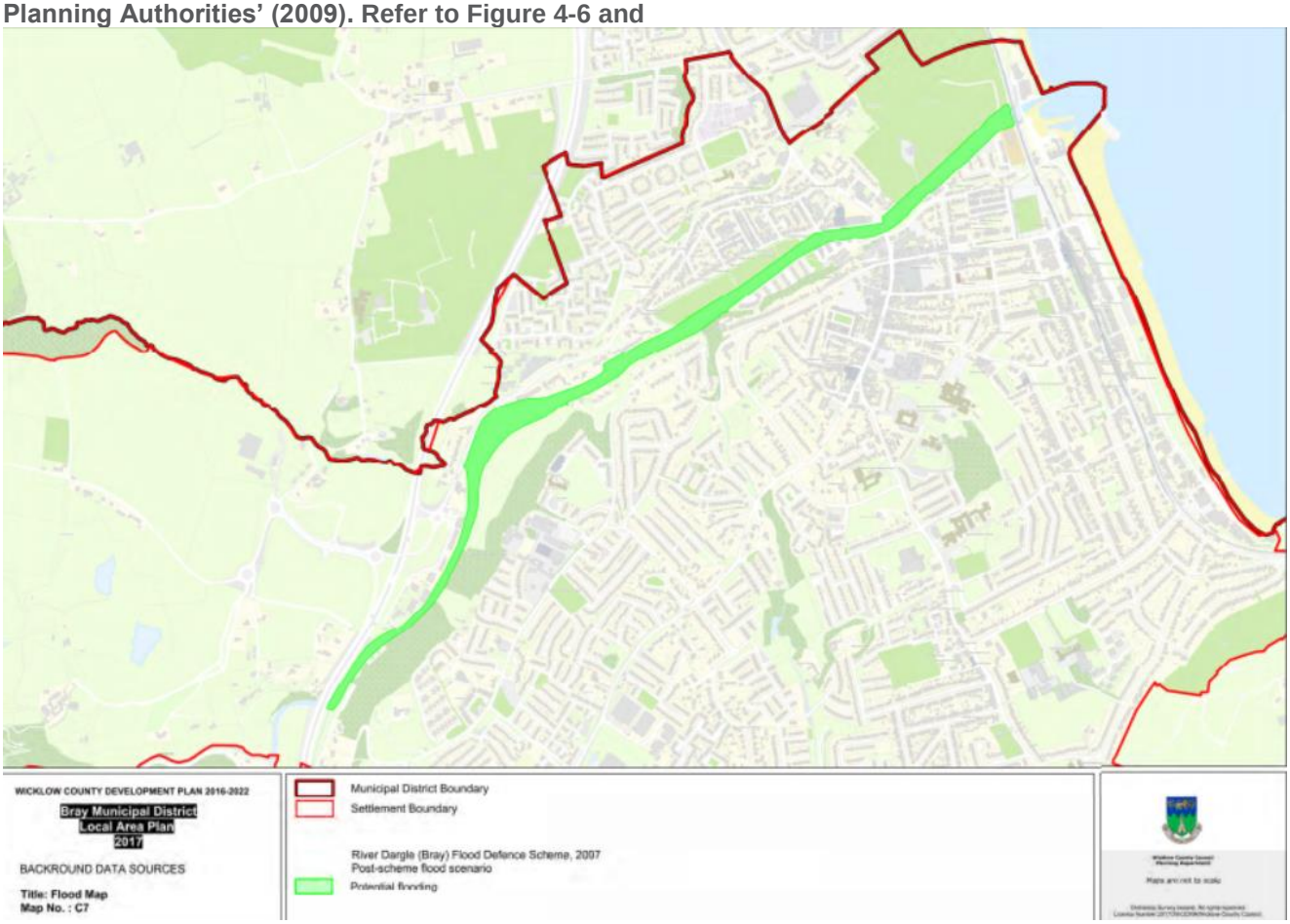


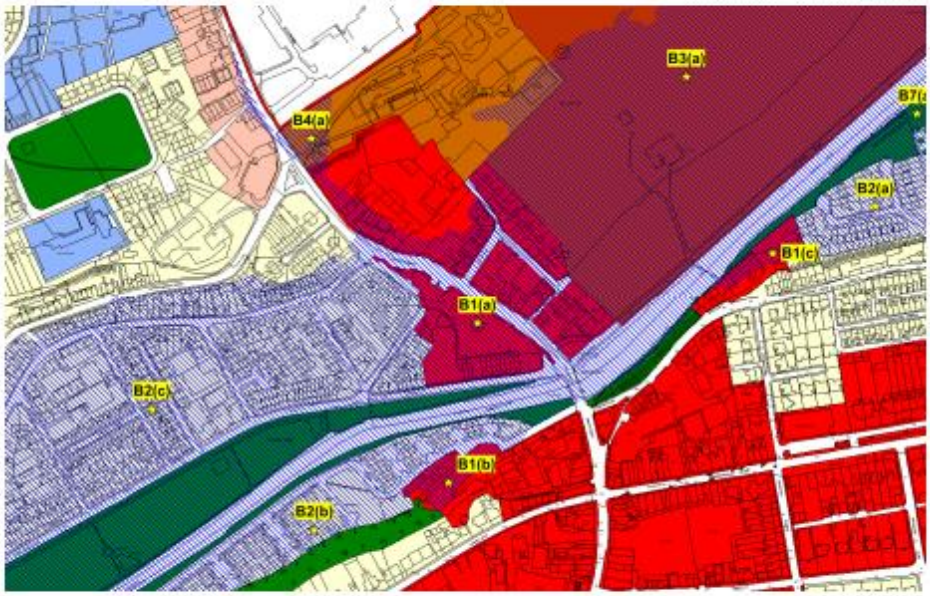
Figure 4-7 of this report for associated maps indicating the extents of flood pre and post the flood defence scheme.

In accordance with flood risk management principles, and in order to ensure the continued development of Bray in line with its designation as a 'Metropolitan Consolidation Town', the Flood Defence scheme gives protection to all vulnerable properties adjacent to the Dargle River and facilitates the expansion of the town centre thereby ensuring its future economic and social prosperity.

Section 3.2 of the SFRA – A Flood Risk Zones and Justification Test for Bray Town and Environs Settlement has carried out as part of the Bray LAP and analysis the vulnerability of the lands uses on the sites that fall within the Flood Zone A and B, refer to extracts of the Bray LAP below;

LAND USE ZONE: Town Centre (TC)

Site no. B1 (a), (b) and (c) Bray



Land zoning	Town Centre
Flood Zone	A and B
Vulnerability of land use vs. Flood Zone	Land use zoning not appropriate
Requirement for Justification Test	Yes

Justification Test			
1	The urban settlement is targeted for growth under the National Spatial Strategy, regional planning guidelines, statutory plans as defined above or under the Planning Guidelines or Planning Directives provisions of the Planning and Development Act 2000, (as amended.)	Under the Wicklow County Development Plan 2010-2016, Bray is designated a 'Level 1 –Consolidation Town' within the metropolitan area of Dublin. Under the 'core strategy' of the CDP, the population of Bray town and environs is targeted to grow to 40,000. It is prioritised to accommodate a significant amount of population growth, to be a strong active town that is economically vibrant with high quality transport links to larger towns/cities.	
2	The zoning or designation of the lands for the particular use or development type is required to achieve the proper and sustainable planning of the urban settlement and in particular:		
	(i) Is essential to facilitate regeneration and/or expansion of the centre of the urban settlement;		Yes
	(ii) Comprises significant previously developed and/or under-utilised lands;		Yes
	(iii) Is within or adjoining the core of an established or designated urban settlement;		Yes
	(iv) Will be essential in achieving compact or sustainable urban growth;		Yes
	(v) There are no suitable alternative lands for the particular use or development type, in areas at lower risk of flooding within or adjoining the core of the urban settlement.		N/A - these lands are developed.
3	A flood risk assessment to an appropriate level of detail has been carried out as part of the Strategic Environmental Assessment as part of the development plan preparation process, which demonstrates that flood risk to the development can be adequately managed and the use or development of the lands will not cause unacceptable adverse impacts elsewhere.		Assessment of flood risk has been incorporated into the Plan SEA process.
Conclusion			
Justification test satisfied.			
Recommendation			
No further action required.			

LAND USE ZONE: Mixed Use (MU)

Site no. B3 (a) and (b) Bray

Site no. B3 (c) Bray

Land zoning	Mixed Use
Flood Zone	A and B
Vulnerability of land use vs. Flood Zone	Land use zoning not appropriate
Requirement for Justification Test	Yes

Justification Test		
1	The urban settlement is targeted for growth under the National Spatial Strategy, regional planning guidelines, statutory plans as defined above or under the Planning Guidelines or Planning Directives provisions of the Planning and Development Act 2000, (as amended)	Under the Wicklow County Development Plan 2010-2016, Bray is designated a 'Level 1 –Consolidation Town' within the metropolitan area of Dublin. Under the 'core strategy' of the CDP, the population of Bray town and environs is targeted to grow to 40,000. It is prioritised to accommodate a significant amount of population growth, to be a strong active town that is economically vibrant with high quality transport links to larger towns/cities.

2	The zoning or designation of the lands for the particular use or development type is required to achieve the proper and sustainable planning of the urban settlement and in particular:	
	(i) Is essential to facilitate regeneration and/or expansion of the centre of the urban settlement;	Site B3 (a) - Yes Site B3 (b) - Yes Site B3 (c) - No
	(ii) Comprises significant previously developed and/or under-utilised lands;	Yes
	(iii) Is within or adjoining the core of an established or designated urban settlement;	Site B3 (a) - Yes Site B3 (b) - Yes Site B3 (c) - No
	(iv) Will be essential in achieving compact or sustainable urban growth;	Site B3 (a) - Yes Site B3 (b) - Yes Site B3 (c) - No
	(v) There are no suitable alternative lands for the particular use or development type, in areas at lower risk of flooding within or adjoining the core of the urban settlement.	Site B3 (a) - Yes Site B3 (b) and (c) - N/A - these lands are developed.
3	A flood risk assessment to an appropriate level of detail has been carried out as part of the Strategic Environmental Assessment as part of the development plan preparation process, which demonstrates that flood risk to the development can be adequately managed and the use or development of the lands will not cause unacceptable adverse impacts elsewhere.	Assessment of flood risk has been incorporated into the Plan SEA process.
Conclusion		
Site B3 (a) - Justification test satisfied. Site B3 (b) - Justification test satisfied. Site B3 (c) - Justification test failed.		
Recommendation		
Site B3 (a) and (b) - No further action required. Site B3 (c) - These lands are currently developed for permitted mixed use. As such, it is considered appropriate to retain the MU zoning objective. Applications for minor development (e.g. extensions) are unlikely to raise significant flooding issues. Should expansion of existing uses be proposed, flood mitigation measures are required (see Section Mitigation Objectives below).		

4.5. Existing Topography

A topographical survey of the development area was carried out by Murphy Surveys in February 2020. An overview of the existing site levels is provided in Figure 4-3. All levels stated in Figure 4-3 are relative to Malin Head Ordnance Datum (OD).

Figure 4-3 - Existing Site Levels (Area bound in red represents approximate location of the proposed site)

The existing Ground Levels along the proposed development range from approximately 1.50mOD to 11.50mOD.

4.6. Local Hydrology and Existing Drainage

There are two watercourses within the vicinity of the scheme area:

- The Crinkeen Stream (known as the Wilford-Old Connaught Stream in Eastern CFRAMS) to the North of the proposed development
- The River Dargle to the South of the proposed development

The majority of the site surface water drains in a south-easterly direction to the River Dargle. A small portion of the site in the north-east sheds surface water directly to the Crinkeen Stream (known as the Wilford-Old Connaught Stream in Eastern CFRAMS). To the north-west, the site is drained to the Crinkeen Stream via public surface water sewerage running through Corke Abbey. Figure 4-4 has been extracted from *catchments.ie*; which provides maps of water features in Ireland based on the Water Framework Directive (WFD). Figure 4-4 indicates the location of the two respective watercourses.

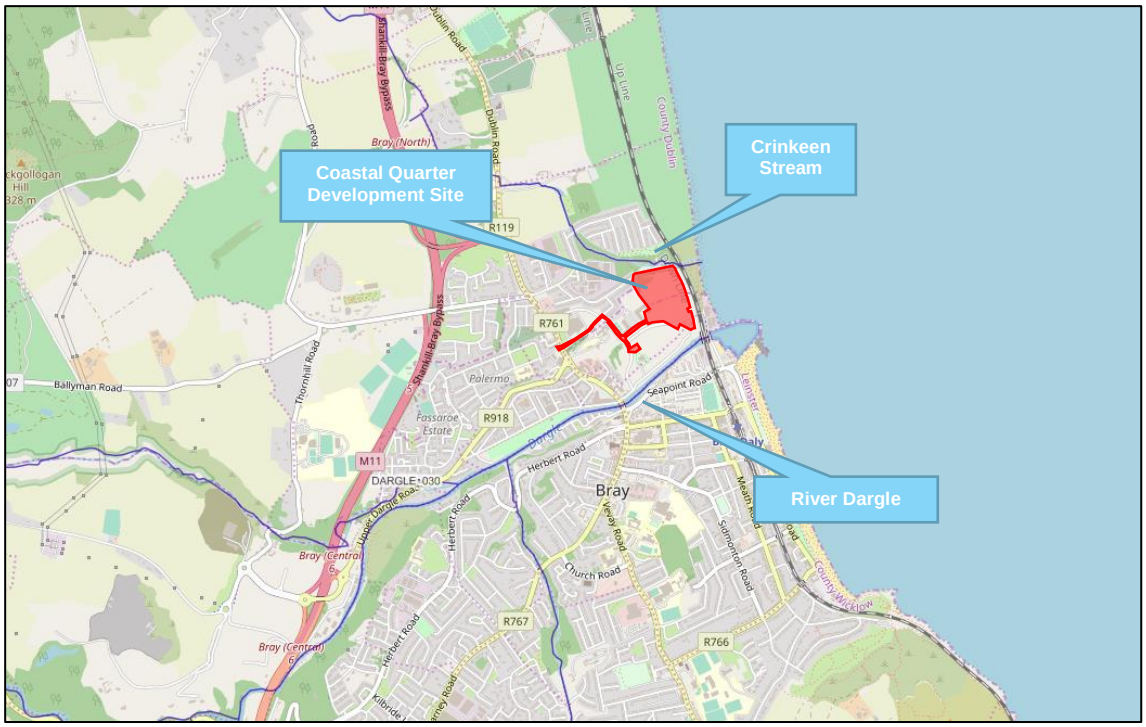


Figure 4-4 - Local River Network (Red hatched area represents approximate location of the proposed site)

4.7. Historical flooding maps

Reports and maps from the OPW National Flood Mapping website (www.floodmaps.ie) have been examined to understand the historic record of flooding at the site.

Figure 4-5 presents an overview of the recorded flood events in the vicinity of the proposed site. It can be seen from the figure that there has been three flood events south-west of the site which occurred in 1986, 1965, and 1905.

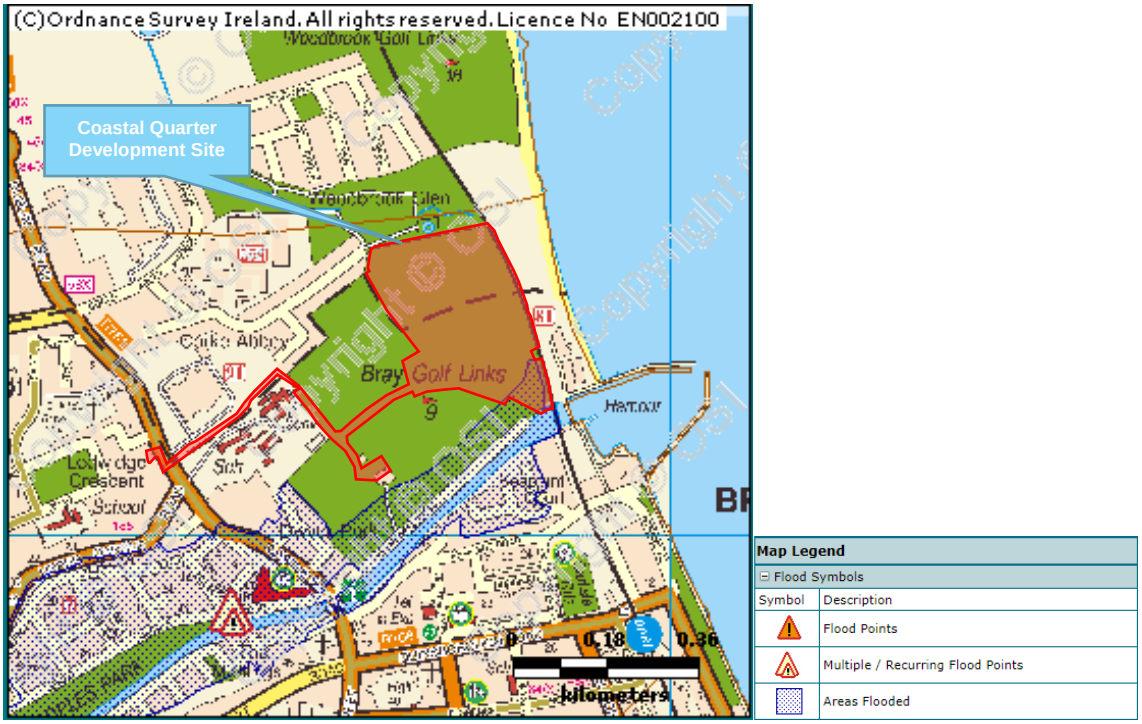


Figure 4-5 - Historical flooding location of proposed development - www.floodmaps.ie (Red hatched area represents approximate location of the proposed site)

4.8. River Dargle Flood Defence Scheme

The River Dargle Flood Defence Scheme comprised of flood defences and channel improvements for 3.1 km of the River Dargle. The flood defences included 2 km of structural walls and 2 km of embankments. Almost one kilometre of new sewers were required to divert existing sewers affected by the works.

A critical element of the works was the provision of a new culvert to allow for an increase of flow capacity of the existing Bray Bridge on Main Street (R761 Regional Road). A culvert to the north of the existing bridge was constructed. The culvert is 7.4m wide x 4.0m high and 6m deep, located immediately behind the abutment of the existing stone arch bridge. This project was one of the key capital investment projects by Wicklow County Council and the Office of Public Works (OPW) with an investment of €46 million. The completed scheme has provided Bray Town with protection from the 100-year return period fluvial flooding and the 200-year return period tidal/coastal flooding.

As part of this FRA, Wicklow County Council has confirmed that there have been no recorded flood events since the completion of the River Dargle Flood Defence Scheme in October 2017.

Extracts of the Bray LAP (Figures 4-6 and 4-7) below indicate the pre-scheme flood scenario extents and post scheme flood extents scenario.

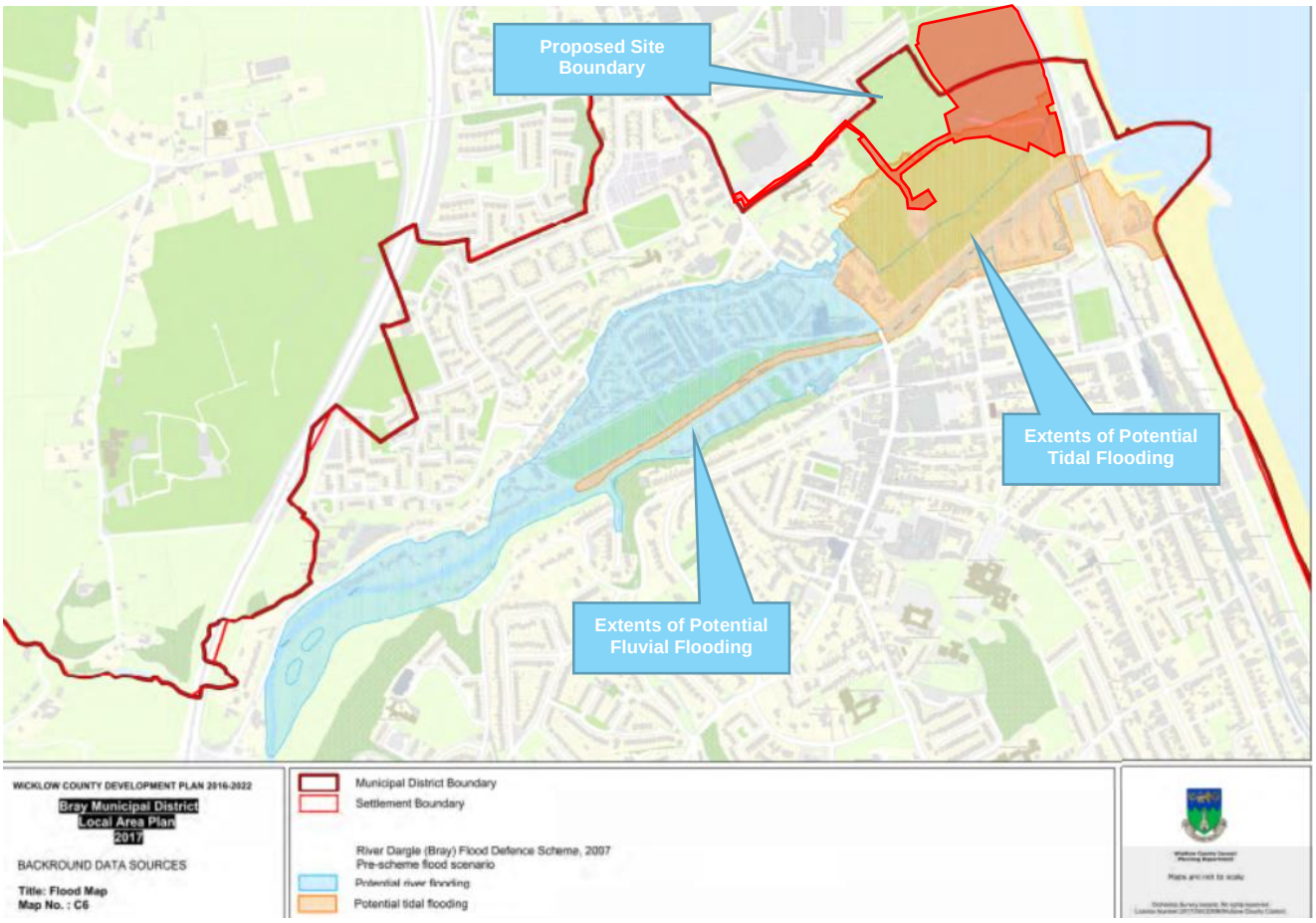


Figure 4-6 – Bray Municipal District LAP 2018 – Strategic Flood Risk Assessment - Potential Flooding – Pre-scheme flood scenario (Red hatched area represents approximate location of the proposed site)

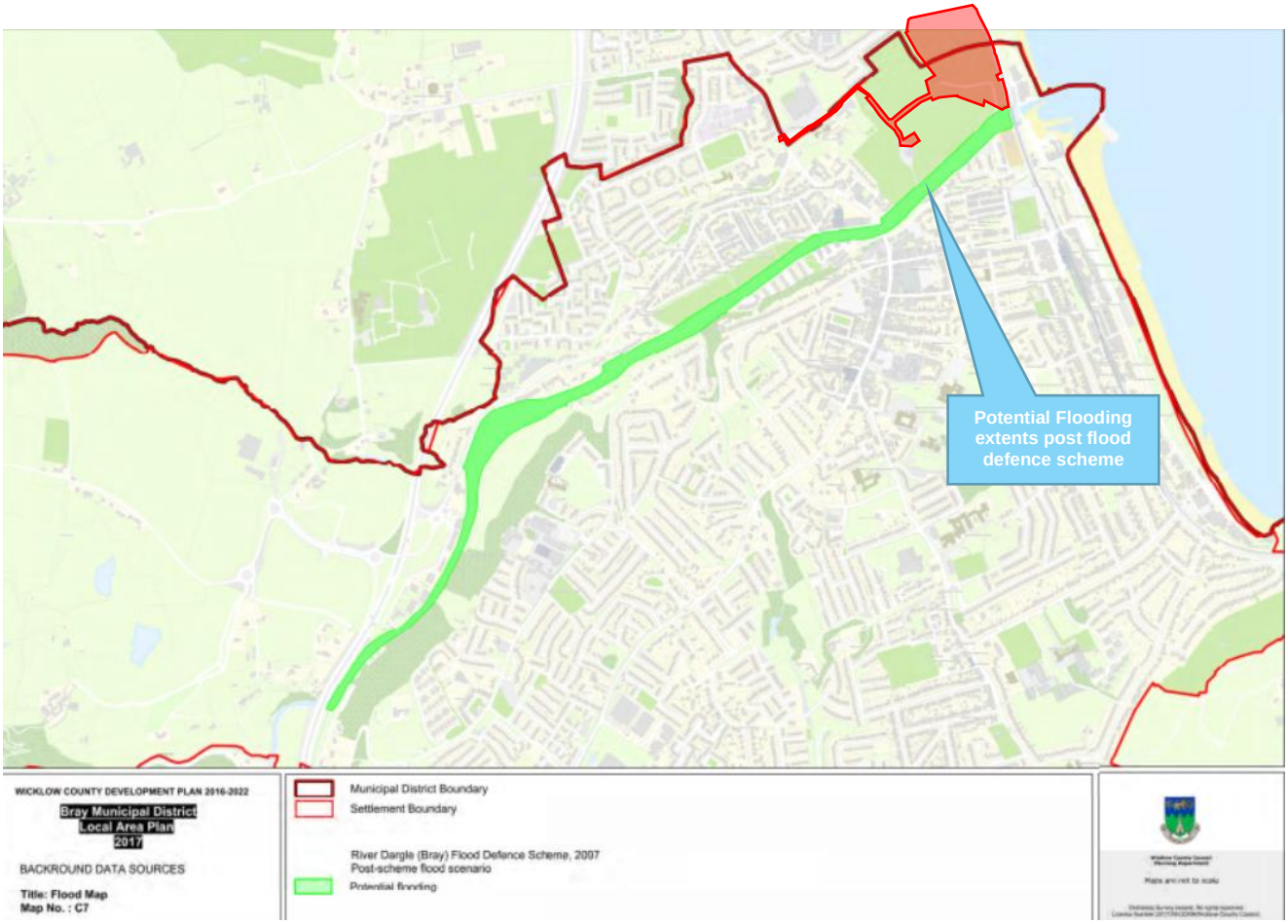


Figure 4-7 – Bray Municipal District LAP 2018 – Strategic Flood Risk Assessment -Potential Flooding – Post Flood Defence Scheme (Red hatched area represents approximate location of the proposed site)

4.9. Fluvial Flood Risk

Fluvial flooding occurs when the runoff from rainfall events exceed the capacity of the stream / river channels. At times flooding can also be impacted by blockages or tide levels.

4.9.1. Crinkeen Stream

The fluvial flood risk has been assessed using maps from the Eastern CFRAM Study published in July 2016. Figure 4-8 below indicates the flood extents extracted from the OPW Old Connaught & Wilford Fluvial Flood Extents map No. E10OLD_EXFCD_F0_02 dated 27th July 2016.

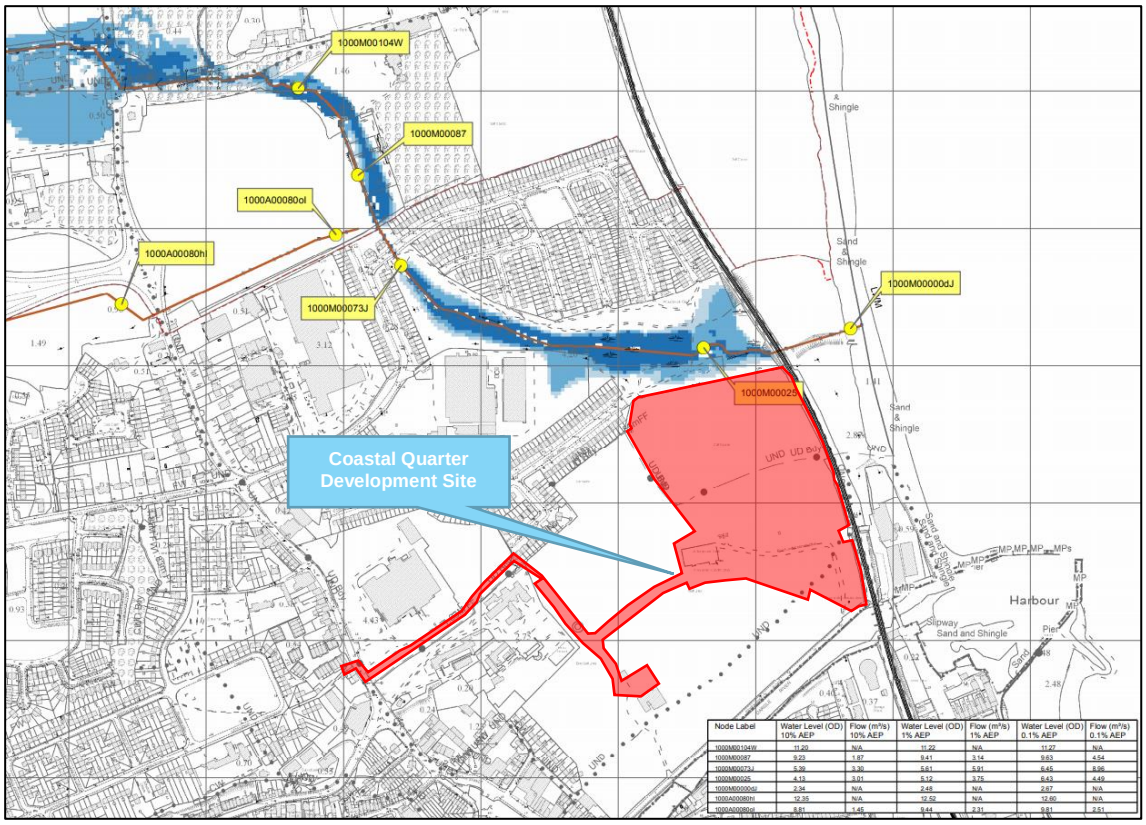


Figure 4-8 - Fluvial Flood Map (Red hatched area represents approximate location of the proposed site)

The water level for the 0.1% Annual Exceedance Probability (AEP) event at node 1000M00025 is indicated as 6.43mOD. The water level for the 1% AEP event at node 1000M00025 is indicated as 5.12mOD. Based on the existing ground levels of circa 9.5mOD at the North Boundary of the proposed site, there is no risk of flood to the proposed development site from the Crinkeen Stream.

4.9.2. River Dargle (Maps Under Review)

The CFRAM flood maps at the southern boundary (River Dargle) of the site are currently under review by the OPW and are therefore not available on *floodinfo.ie* at the time of writing this report.

In absence of flood mapping on the current River Dargle Flood extents, the applicant commissioned Atkins to carry out hydraulic modelling of the River Dargle consisting of a linked 1D-2D hydraulic model using Flood Modeller Pro of the River Dargle and the adjacent lands. Section 6 - Detailed Flood Risk Assessment of this report provides detailed information and associated results of modelling carried out as part of this Flood Risk Assessment.

4.10. Tidal/Coastal Flood Risk

Tidal or Coastal flooding occurs when sea levels along the coast or in estuaries exceed neighbouring land levels or overcome coastal defences where these exist, or when waves overtop the coast.

4.10.1. Tidal/Coastal Flood risk at the proposed site

The tidal/coastal flood risk has been assessed using maps from the Eastern CFRAM Study published in July 2016. The coastal waterbody Southwestern Irish Sea - Killiney Bay is within the vicinity of the proposed site. Figure 4-9 indicates indicative flood zones in the vicinity of the site.

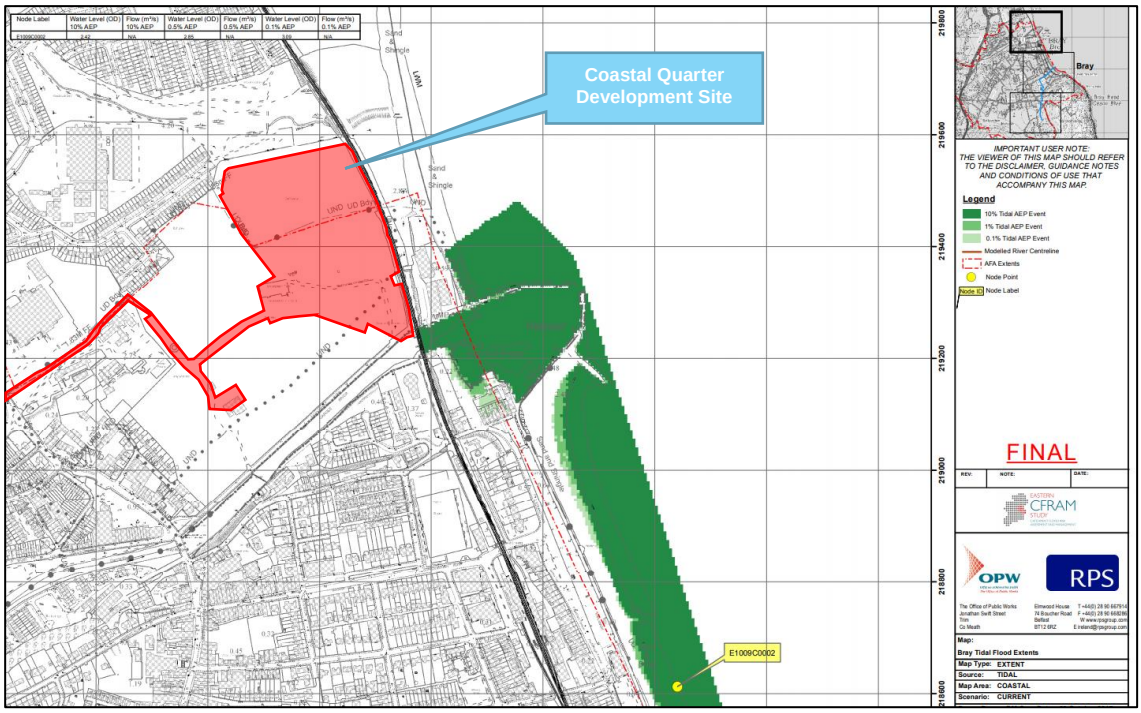


Figure 4-9 - Tidal / Coastal Flood Map (Red hatched area represents approximate location of the proposed site)

The water level for the 0.1% Annual Exceedance Probability (AEP) event at node E1009C0002 is indicated as 3.09mOD. The water level for the 0.5% AEP event at node E1009C0002 is indicated as 2.85mOD. A topographical survey was carried out by Murphy Surveys in February 2020. The existing Ground Levels along the proposed development range from approximately 1.50mOD to 11.50mOD. The area of land which may be susceptible to flooding from the 0.1% AEP event will be assessed further in Section 6 of this report.

4.11. Pluvial Flood Risk

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.

4.11.1. Existing Drainage Networks

Drainage networks have been established and are within proximity to the site as indicated in Figure 4-10 below. Following a review of the existing site topography, in the unlikely event of pluvial flooding from storm or foul existing networks, there would no impact on ‘highly vulnerable’ and ‘less vulnerable’ elements of the proposed development.

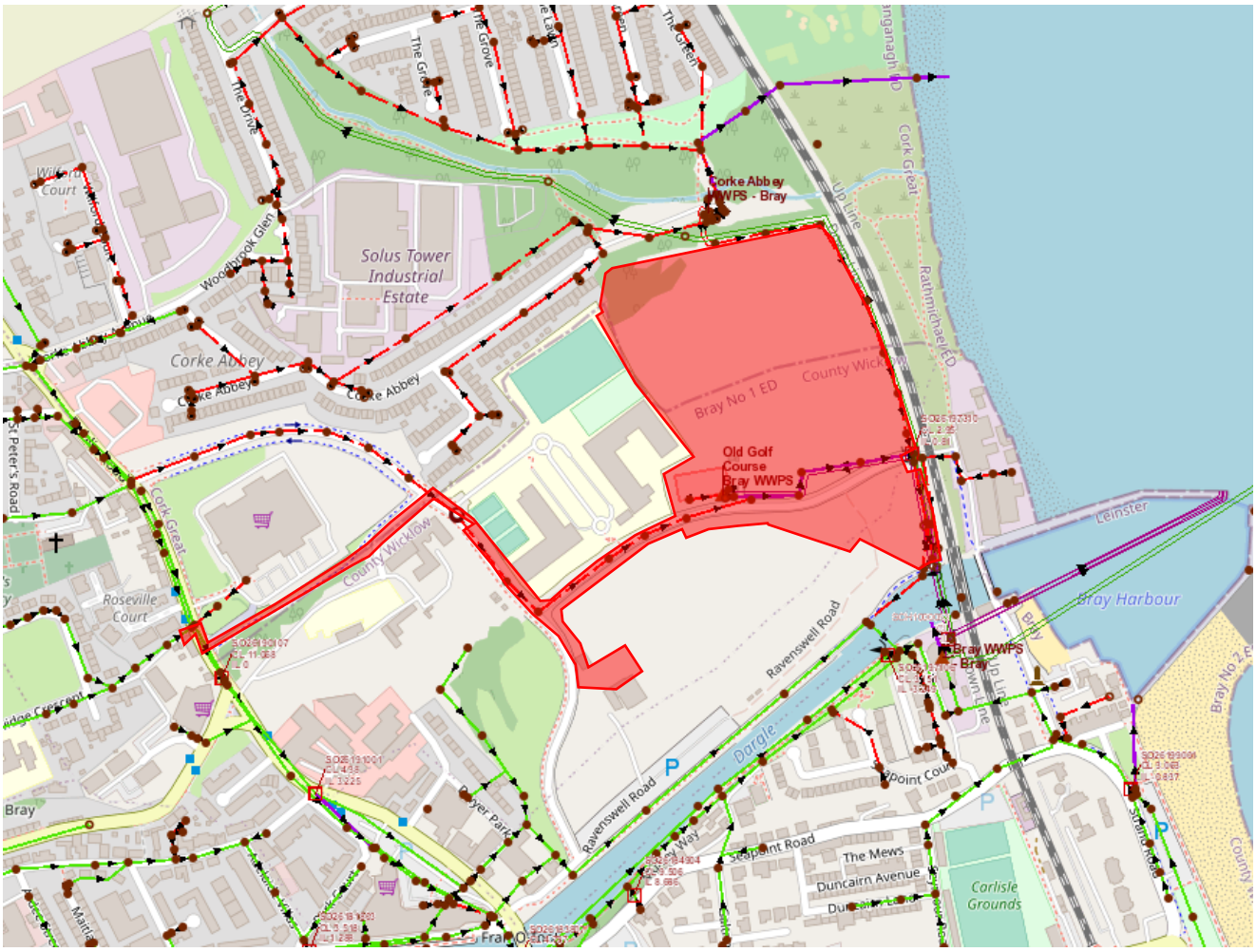


Figure 4-10 – Existing Drainage Networks - GSI mapping (Red hatched area represents approximate location of the proposed site)

4.12. Proposed Storm Drainage Network

An assessment of possible pluvial flood risk from the proposed storm drainage network has been carried out as part of the design process.

In consultation with DLRCC, Surface Water exceedance flows from the site have been considered as part of the drainage design. A modelling exercise was carried out with a 50% blockage within vortex flow control units at 1 location in catchment A ((refer to Atkins Drawing 5214419-ATK-01-ZZ-DR-CE-0503)). The location selected is based on importance / likelihood of blockage to occur. Refer to Atkins Stormwater Impact Assessment Report 5214419DG0012 – Exceedance flow for further information. Based on the current storm drainage design including mitigation measure, no flooding from the proposed surface water network is predicted at this location.

From discussions with WCC in January 2021, it was agreed that the proposed underground attenuation system in catchment B (refer to Atkins Drawing 5214419-ATK-01-ZZ-DR-CE-0503) will be a sealed concrete tank to ensure that in the unlikely event of flooding there will be no impact on the availability of attenuation volume within the proposed tank. The outfall from the proposed storm drainage network to the Dargle River will be fitted with a non-return flap valve and high level overflow to ensure that in the event of high water levels in the Dargle river, the storm water outfall from the proposed development will not be impacted by external water from the Dargle river. Refer to Atkins Stormwater Impact Assessment Report 5214419DG0012 and drawings 5214419-ATK-01-ZZ-DR-CE-0501 – 502 for further information on the proposed storm drainage system.

4.13. Groundwater Flood Risk

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.

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 4-11 indicates the groundwater vulnerability of the site and the surrounding areas.

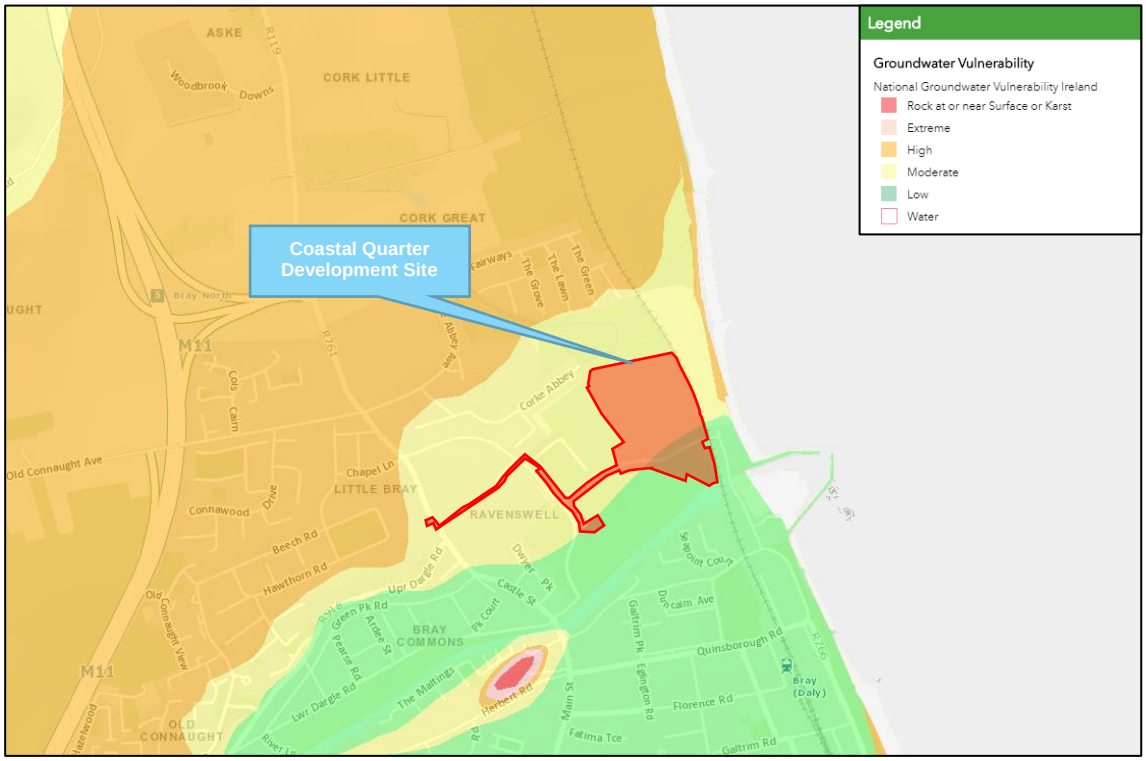


Figure 4-11 - Groundwater Vulnerability - GSI mapping (Red hatched area represents approximate location of the proposed site)

A further review was undertaken of the site investigations that were carried out by IGSL in September 2020. The purpose of the site investigation was to investigate subsurface conditions utilising a variety of methods. Based on the information contained within the IGSL report, it is noted that ground water is shallow at the southern end of the site (circa < 1m below ground level) however, there will be no negative impact from groundwater levels on the 'highly vulnerable' and 'less vulnerable' elements of the proposed development. Full details of the ground investigation are presented in the 'Harbour Point Bray Ground Investigation Report – Factual' prepared by IGSL (2021) and presented in Appendix 9.1, Volume 3 of the EIAR (Atkins, 2022).

4.14. Conclusion - Flood Risk Identification

In accordance with the planning guidelines, flood risk identification has been carried out as required to identify if there are any flooding or surface water management issues related to the proposed development site that may warrant further investigation. As indicated below in Table 4-1 - Possible Flooding Mechanisms, possible flood mechanisms for the proposed development site have been identified.

Table 4-1 - Possible Flooding Mechanisms

Source/Pathway	Significant?	Comment/Reason
Tidal/Coastal	Possible	The coastal waterbody *Southwestern Irish Sea - Killiney Bay* is within the vicinity of the proposed site. Coastal Flood Mapping to be reviewed.
Fluvial	Possible (from the Dargle River)	The Crinkeen Stream and Dargle River are located within the vicinity of the proposed site. Fluvial Flood maps to be reviewed.
Pluvial (urban drainage)	No	Existing drainage networks are within close proximity to the proposed site. Following an assessment of the existing ground topography at the proposed site there is no risk of Flooding from existing storm drainage networks.
Pluvial (overland flow)	No	The surrounding land falls in a south-easterly direction towards the watercourse. Consideration has been taken as part of the proposed storm drainage design, including a review of overland flows. There is no risk to 'highly vulnerable' elements of the proposed development.
Blockage	No	Consideration has been taken as part of the proposed storm drainage design including modelling of a 50% blockage scenario (where the flow control discharge is considered to be blocked by 50% of its outlet flow). Refer to the exceedance flow section of this report and the Atkins Storm Water Report. There is no risk to 'highly vulnerable' elements of the proposed development.
Groundwater	No	There are no significant springs or groundwater discharges recorded in the immediate vicinity of the site. Groundwater levels determined during geotechnical investigations to be reviewed as part of the storm drainage network design.

Therefore, based on the above possible flood mechanisms table the primary flood risks identified for the proposed development site are both Fluvial and Coastal flooding.

4.14.1. Conclusion of Flood Risk Identification

The purpose of the *Flood risk identification* process above was to establish whether a flood risk issue currently exists or may exist in the future on the proposed site. If a potential flood risk issue is identified the risk will be investigated in further detail by undertaking an *Initial Flood Risk Assessment.* However, if no potential flood risk is identified then the overall assessment can conclude at this point.

In relation to this assessment for proposed Coastal Quarter development, a Flood Risk Study is required to continue to *the Initial Flood Risk Assessment*. The potential source identified at the initial flood risk stage is Fluvial flooding from the River Dargle and Tidal/Coastal flooding from the Irish Sea located to the South East of the site.

5. Initial Flood Risk Assessment

5.1. Review of Coastal Quarter Flooding from River Dargle

The above Flood Risk Identification indicates that the southern area of the proposed development site is potentially susceptible to both tidal/coastal flood events and fluvial flood events from the river River Dargle. It is considered that insufficient quantitative information, collated as part of the screening exercise, is available to complete a sufficient appropriate assessment of the fluvial and tidal/coastal flood risk to the site. In this regard, it is required to undertake a more detailed and robust analysis of the fluvial flooding and Coastal/Tidal regime at and in the vicinity of the proposed development site.

6. Detailed Flood Risk Assessment

IE Consulting have completed an overview, on behalf of Atkins, of the fluvial and tidal/coastal flood risk from the River Dargle on the Coastal Quarter Development. A hydraulic model has been developed of the River Dargle in the context of both the Coastal Quarter Development and the wider Masterplan development. In relation to the subject site, the model has been built to assess the fluvial and coastal/tidal flood risk based on the proposed scheme design included in the wider planning pack. We note that pluvial flooding has been assessed and screened / designed out earlier in this report. In relation to the wider Masterplan site, the model has been built using existing site conditions only as detailed design information for these Lands outside the subject is not yet available. The source of the images in this Chapter are taken from the hydraulic model.

Refer to Appendix A for IE Consulting Technical Note on the Detailed Flood Risk Assessment and Hydraulic modelling.

6.1. Hydrology

The peak fluvial flow estimation in the River Dargle included utilising the OPW Flood Studies Update web portal to determine the predicted 1 in 100-year (1% AEP) and the 1 in 1000 year (0.1% AEP) flow rates. These were predicted to be 78.89 m^3/s and 93.39 m^3/s for the 1% AEP and 0.1% AEP events, respectively. The EIS prepared as part of the Bray Flood Defence Scheme was also reviewed in the context of the design flows utilised to design the flood defence walls and embankments. The 1 in 100-year fluvial flow rate was estimated to be 300 m^3/s at Bray Harbour. This was based on a historical flood event in 1986. The EIS did not include an estimation of the 1 in 1000-year fluvial flow rate.

The flows estimated using the Flood Studies Update (FSU) methodology significantly lower flows compared to those utilised in the River Dargle Flood Defence Scheme as described in the EIS. In consideration that the 1 in 100-year EIS flow rate is based on a historical flood event, it is considered more appropriate to use this rather that the flows derived from the FSU method. The extreme fluvial inflows utilised in the hydraulic model are 300 m^3/s and 396.46 m^3/s for the 1% AEP and 0.1% AEP events, respectively.

The tidal flood levels were determined utilising the OPW Eastern CFRAMS mapping and the Irish Coastal Protection Strategy Study mapping for the Bray Harbour area. The extreme tidal flood levels utilised in the hydraulic model are 2.85m OD and 3.09m OD for the 1 in 200-year (0.5% AEP) and 1 in 1000 year (0.1% AEP) events, respectively.

6.2. Hydraulic Model

A Hydraulic model was carried out for the River Dargle which consists of a linked 1D-2D hydraulic model using Flood Modeller Pro of the River Dargle and the adjacent lands. The length of the river model is circa 820m extending from 200m upstream of the existing stone arch bridge on Main Street to immediately downstream of the Strand Road Bridge at Bray Harbour. Refer to Figure 6-1 below for extents of the river model.

Figure 6-1 – Extents of River Model (Red line represents approximate location of the proposed site)

The model was developed utilising river cross section information following a survey completed by Murphy surveys in 2020. This survey included the changes to the riverbed, walkway on the northern bank, flood defence walls/embankment and the additional bridge opening that were constructed as part of the Bray Flood Defence Scheme Works. A topographical survey of the site and surrounding lands together with LiDAR data obtained from Ordnance Survey Ireland was used to represent the 2D flood plain surface on either side of the riverbank. Note that, in accordance with 'The Planning System and Flood Risk Management – Guidelines for Planning Authorities' DOEHLG' 2009, the hydraulic model excludes the presence of the flood defences.

A joint probability assessment has been utilised in the model for the upstream and downstream boundaries (inflows and tidal levels) for the extreme fluvial and tidal events in line with methodology used in the OPW CFRAMS programme. This includes a 1 in 2 year tide level as the downstream boundary for the extreme 1 in 100 year (1% AEP) and the 1 in 1000 year (0.1%) fluvial events. Similarly, a 1 in 2 year fluvial flow rate has been specified as the upstream boundary (inflow) for the extreme 1 in 200 year (0.5% AEP) and the 1 in 1000 year (0.1%) tidal events.

6.3. River Dargle Modelling Results

The topographical levels of the proposed site layout were assessed for the 1% and 0.1% Annual Exceedance Probability (AEP) events. The hydraulic modelling results show the majority of the Coastal Quarter site is located within fluvial and tidal Flood Zone 'C'. The southern area of the site is mapped within both a fluvial and tidal Flood Zone 'A' (1% AEP fluvial event or 0.5% AEP tidal event) and Flood Zone 'B' (0.1% AEP fluvial or tidal event) as in Figure 6-2 below.

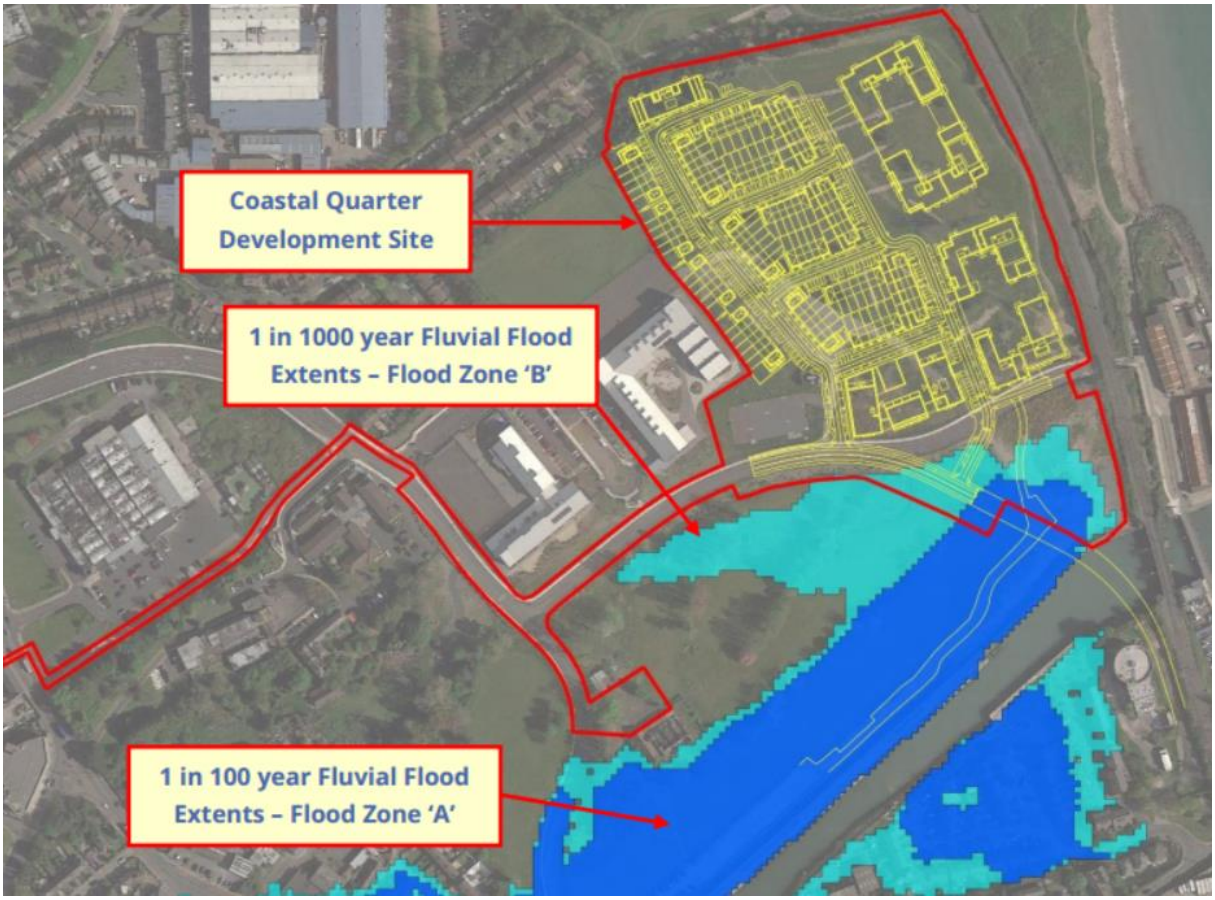


Figure 6-2 – 1 in 100 and 1 in 1000 year Fluvial Flood Extents – modelled without flood defence scheme in place (Red line represents approximate location of the proposed site)

It is necessary to ensure that the intended use for this area which is at risk of flooding from a 0.1% AEP event is for water-compatible use.

As part of the flood modelling process, a number of iterations of the proposed site layout and design levels were carried out in coordination with the wider design team to ensure the least amount of impact on the existing flood zone. All 'highly vulnerable' elements of the proposed development have been located outside of the existing flood Zones A and B. The proposed access road and the market square which are 'less vulnerable' elements are partially located within Flood Zone B. Refer to Section 7 of this report for further investigation of the potential impact of the proposed access road and the market square within Flood Zone B.

Apart from the proposed access road and the Market Square, the proposed development within the existing Flood zones A and B have been designed as 'Water Compatible' elements including amenity open spaces and recreation facilities.

7. Potential Impact of the Proposed Development

The impact of constructing the proposed southern access road and Market Square at their proposed levels in Flood Zone B area shall not impact on Flood level or Flood extents outside of the subject site. However, their provision will create some flood water displacement which shall be catered for via designed compensatory storage within the extents of the subject site. This compensation storage has been provided by designing ground levels within the proposed open space area to the South East of the site to ensure that the existing volume for fluvial flood water displaced due to the proposed access road and Market Square Area during a 1 in 1000 year fluvial flood event is contained within the proposed subject site.

7.1. Comparison of existing and proposed fluvial flood extents

The hydraulic model was used to assess the impact of the proposed subject site on the existing Flood Zones A and B areas and maximum flood levels. The results of the modelling indicate;

- A minor displacement of water as indicated in Figure 6-1 below. The displaced water is contained within the proposed open space area of the subject site.
- No change in either the extents of flooding or flood levels outside of the Wider Masterplan area (Applicant's landholding)
- No change to existing ground levels or increase of flood risk at the existing railway underpass.

Refer to Figure 7-1 below for existing and proposed flood extents.

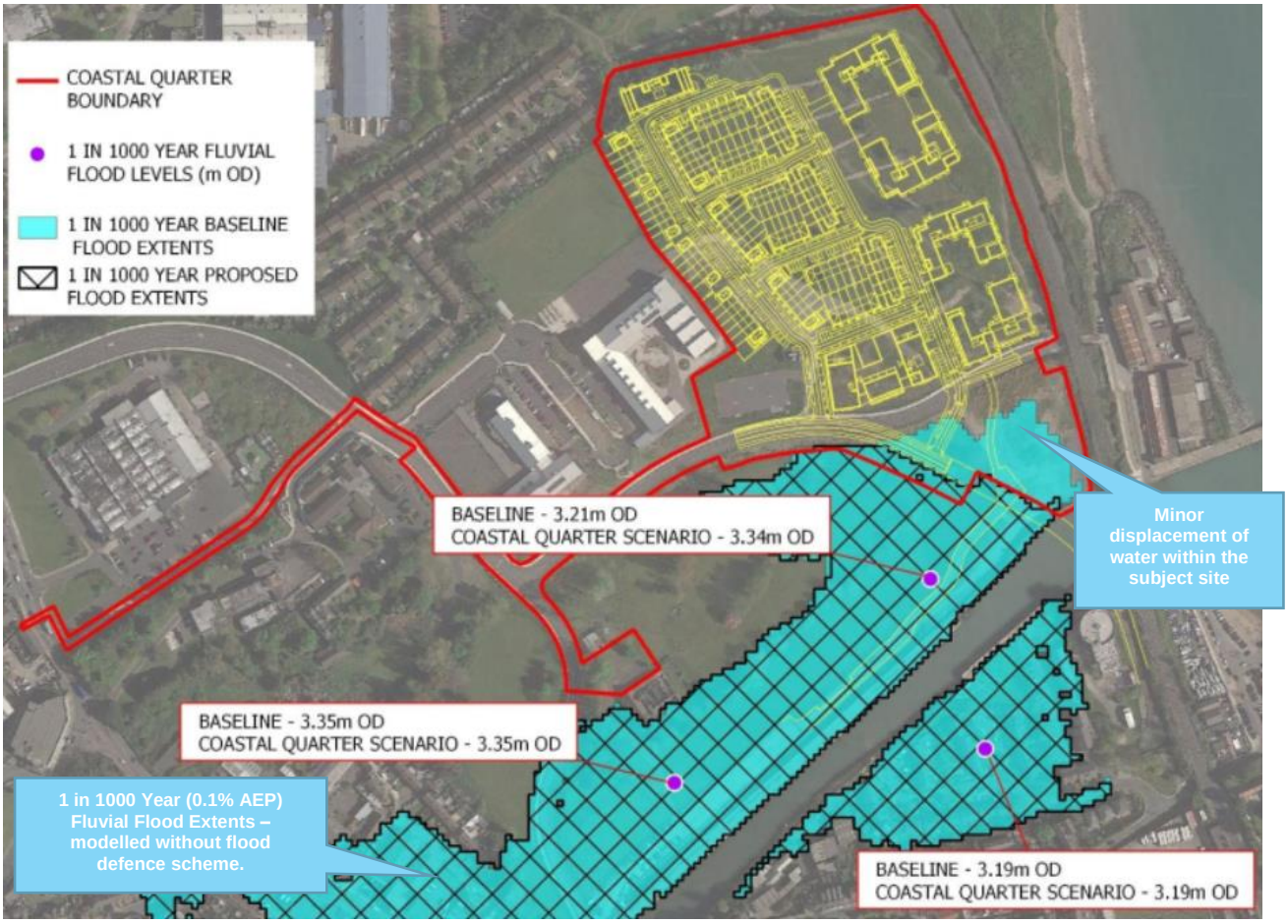


Figure 7-1 - Existing & Proposed 1 in 1000 year fluvial Flood Extents modelled without flood defence scheme in place (Red line represents approximate location of the proposed site)

7.1.1. Conclusion

It is concluded that there is no 'highly vulnerable' development proposed within the delineated Flood Zone 'B' shown in Figure 6-2 above. The access road and Market Square area are proposed to be located in Flood Zone B but are deemed 'less vulnerable' developments. As a mitigating measure for the proposed 'less vulnerable' access road and Market Square being located within Flood Zone B, where some flood water shall be displaced, compensatory storage has been provided within the proposed open space (park) area of the subject site. The proposed development does not pose an increased flood risk to surrounding people or property outside of the applicant's landholding.

8. Justification Test

8.1. Justification Test Criteria

Based on the findings discussed in Section 6 – Detailed Flood Risk Assessment, a Justification Test has been carried out to satisfy the two criteria outlined in Box 5.1 of The Planning System and Flood Risk Management - Guidelines for Planning Authorities (refer to Section 2.4 - Justification Test Criteria of this report).

8.1.1. Criteria 1

The subject lands have been zoned or otherwise designated for the particular use or form of development in an operative development plan, which has been adopted or varied taking account of these Guidelines.

The proposed development site is located in the north-east region of Bray town centre. The zoning objective for the site is for 'Mixed Use development' within the county boundary of Wicklow. The remainder of the site in the northern region of the proposed development is located in the county boundary of Dún Laoghaire-Rathdown. The zoning objective for the majority of this region is to protect and-or improve residential amenity. A strip of land at the eastern boundary of this site is intended for use to preserve and provide for open space with ancillary active recreational amenities. It is concluded that the zoning objective is appropriate for the proposed development as this clearly identifies that the subject land has been designated for this particular use in the County Development Plans and Bray Local Area Plan.

8.1.2. Criteria 2 – Part 1

The development proposed will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk.

The River Dargle Flood Relief Scheme will not be altered as part of the proposed development and therefore the current conveyance of the River will be maintained. These flood defences provide protection against a 1-in-100-year fluvial flood and 1-in-200-year tidal flood.

As outlined in section 7 of this report, an element of compensatory storage has been provided within the boundary of the Coastal Quarter site area to facilitate a small volume of flood water displaced by the proposed road and Market Square. This considered the proposed development does not pose any increased flood risk or flood levels from the River Dargle to surrounding people or property outside of the Wider Masterplan area (applicant's landholding).

8.1.3. Criteria 2 – Part 2

The development proposal includes measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible.

The Finished Floor Levels (FFL) of the proposed development are set at a minimum freeboard level of 500mm above the 0.1% AEP fluvial flood level. The peak 0.1% AEP modelled flood level is 3.969mOD. Block C is the lowest proposed FFL of 6.10mOD which is 2.131m above the peak 0.1% AEP flood level. The level of flood protection provided by the recently constructed River Dargle Flood Defence Scheme will also mitigate the level of flood risk to people, property and the urban environment.

8.1.4. Criteria 2 – Part 3

The development proposed includes measures to ensure that residual risks to the area and/or development can be managed to an acceptable level as regards the adequacy of existing flood protection measures or the design, implementation and funding of any future flood risk management measures and provisions for emergency services access.

The proposed development will have no impact on the existing flood protection measures. The proposed access road leading into the proposed Coastal Quarter Development as indicated in Figure **8-1** below is located above the maximum flood level and therefore, in the unlikely event of flooding it will have no impact on the primary

emergency access route as indicated in both chapter 7 of the Traffic and Transport Assessment (TTA) and Chapter 8 of the Environmental Impact Assessment Report (EIAR).

A proposed secondary emergency access route has also been indicated within both the TTA and EIAR. This secondary emergency access route road would comprise of an unsealed road and has been identified as a route to be used by emergency vehicles to access the development in a rare event when the primary access route may be potentially impassable. This secondary emergency access route is located within the extents of the existing 1 in 1000-year (0.1% AEP) fluvial flood extents, it is noted that this flood event is a very low frequency event. The probability that the secondary emergency access route would be required due to the primary emergency access being impassable at the same time as a 1 in 1000-year (0.1% AEP) flood event is considered to be a very low probability event and therefore highly unlikely. Therefore, based on this, the secondary emergency access route is deemed acceptable from a flood risk perspective.

Refer to Figure **8-1** below for locations of both the Primary and Secondary Emergency Access Routes.

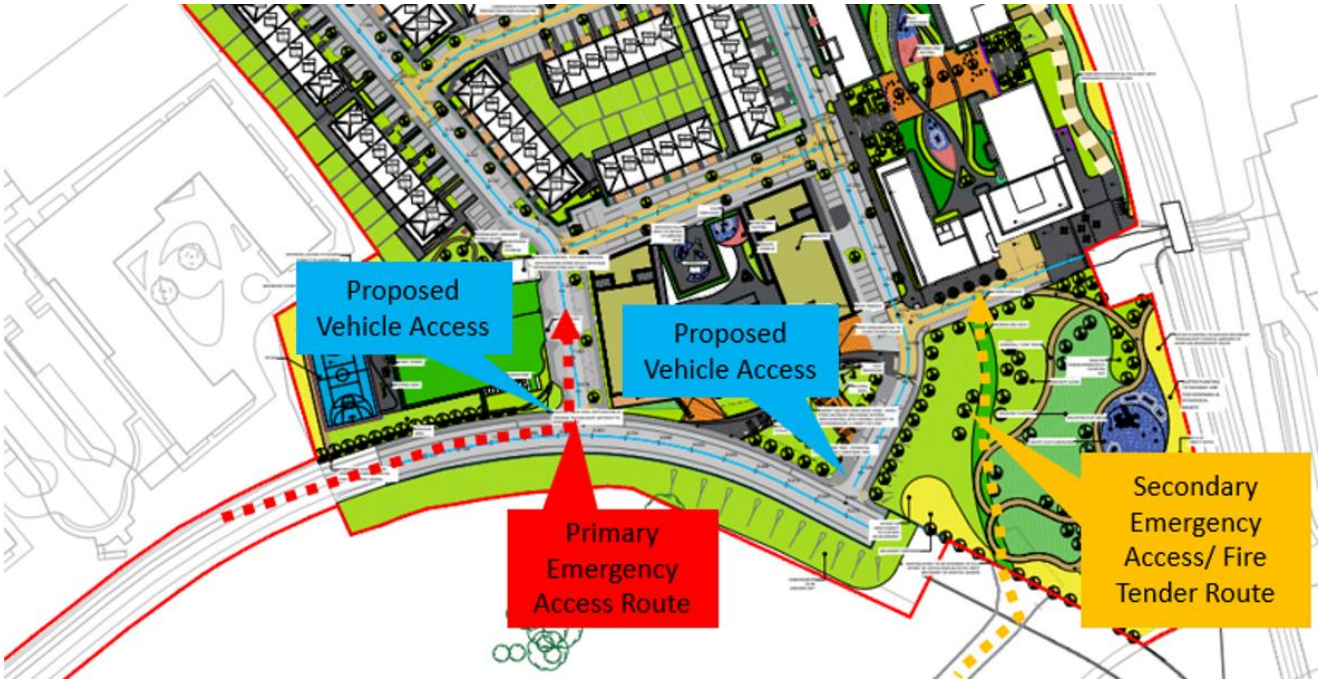


Figure 8-1 **– Emergency Access Routes (Red line represents approximate location of the boundary of the proposed site)**

8.1.5. Criteria 2 – Part 4

The development proposed addresses the above in a manner that is also compatible with the achievement of wider planning objectives in relation to development of good urban design and vibrant and active streetscapes.

The proposed residential development will facilitate sustainable urban growth and the proposed development will assist in achieving strategic planning objectives in the immediate vicinity of Bray. The proposed development is in keeping with the surrounding areas visuals and uses within Bray. The design is suitable for the surrounding area visually and has been designed for the purpose of appropriate residential dwellings and infrastructure in Bray.

8.2. Justification Test - Conclusion

It is deemed that all of the criteria set out in the Justification Test Criteria (as outlined in Section 2.4 of this report) have been addressed and satisfied. There is no residual risk to the proposed Coastal Quarter Development.

9. Flood related design considerations incorporated in the proposed development

As noted throughout the previous sections of this report the proposed development has been designed in compliance with the Departments of the Environments guidelines for planning authorities 'The Planning System and Flood Risk Management'. No highly vulnerable developments are proposed within Flood Zone A or B, less vulnerable elements of the development are compliant and the southern open space park area which may flood on occasion is water compatible. Other specific flood related design considerations incorporated into the development design are;

- Finish Floor Levels (FFL) for proposed Buildings have been designed to be a minimum of 0.5m above the peak 0.1% AEP flood level of 3.969mOD. Block C is the lowest proposed FFL of 6.10mOD which is 2.131m above the peak 0.1% AEP flood level, therefore significantly above the minimum limit. A full assessment of all Flood Levels including the impact of all proposed development levels has been fully detailed within the Appendix A – IE Consulting Technical Note of this report.
- The potential for the development to add to flooding risk locally via the development of a greenfield site with potential significant runoff is controlled using Sustainable Drainage Systems (SuDS) as part of the storm network design. Refer to Atkins Stormwater Impact Assessment Report 5214419DG0012 for further information.
- The proposed discharge for the storm-water drainage network to the receiving watercourse has been designed so it does not exceed greenfield runoff rates as agreed with Wicklow County Council and as per the '*Greater Dublin Strategic Drainage Study Volume 2 – New Developments*' guidelines. Refer to Atkins Stormwater Impact Assessment Report 5214419DG0012 for further information.

Construction stage considerations;

The Contractor will be required to prepare an emergency plan for managing flood risk during construction, which will include monitoring of weather conditions and other considerations or requirements as determined by the local authority. The Contractor is to ensure early warning systems are in place to reduce any potential inundation within the contractor compound and park area due to potential flooding during the works.

10. Conclusion

In accordance with the planning guidelines, flood risk identification was carried out as required to identify if there are any flooding or surface water management issues related to the proposed development site that may warrant further investigation. Following the flood risk identification, it was determined that the primary flood risks identified for the proposed development site are both fluvial and tidal/coastal flooding. It was considered that insufficient quantitative information was available as part of the screening exercise and therefore a detailed and robust analysis of the fluvial flooding and tidal/coastal regime at and in the vicinity of the proposed development site was required.

A detailed hydrological analysis was undertaken of the River Dargle in order to identify the predicted 1 in 100 year (1% AEP) and 1 in 1000 year (0.1% AEP) flood events in the vicinity of the proposed development site. In addition, the predicted 1 in 200 year (0.5% AEP) and 1 in 1000 year (0.1% AEP) tidal flood levels have been analysed in the vicinity of the site.

This detailed analysis of the Fluvial and Tidal/Coastal flooding was carried out as outlined above and it was determined that no 'highly vulnerable' development is proposed within the delineated Flood Zone 'B'. The proposed open space (park) area within the south of the Coastal Quarter Development site shall flood during the fluvial 1 in 100 year and 1 in 1000 year event along with the tidal 1 in 200 year and 1 in 1000 year flood events. This open space area is however deemed 'water compatible' in line with the guidance outlined by the Dept. of the Environments guidelines for planning authorities 'The Planning System and Flood Risk Management' and therefore may flood in these low frequency storm events.

The proposed 'less vulnerable' main access road and Market Square area are proposed to be located within the footprint of Flood Zone B however, the limited volume of displaced flood water resultant from this will be catered for within the proposed southern open space (park) area within the Coastal Quarter Development.

Due to the location of the proposed development adjacent to and partially within a flood zone a Justification Test was carried out in line with the criteria outlined by the Dept. of the Environments guidelines for planning authorities 'The Planning System and Flood Risk Management'. This Justification Test satisfied the required criteria and therefore determined that there is no residual risk of flooding to the proposed Coastal Quarter Development except for that which is planned (during the fluvial 1 in 100 year and 1 in 1000 year event along with the tidal 1 in 200 year and 1 in 1000 year flood events) within the south of the subject site in the open space area. In addition, the proposed development does not pose an increased flood risk to people or the surrounding property outside of the applicant's landholding.

The Finished Floor Levels (FFL) of the proposed units within the Coastal Quarter development have been set at a minimum level of 6.10mOD. A freeboard of 2.131m above the peak 0.1% AEP flood level has been provided which is significantly higher than the minimum freeboard requirement of 500mm. The level of flood protection also provided by the recently constructed River Dargle Flood Defence Scheme mitigates the level of flood risk to people, property and the urban environment

In summary, the development as proposed shall not result in an adverse impact to the existing hydrological regime of the area nor increase flood risk to areas outside of the landowners' holdings, nor create unacceptable levels of flood risk within the proposed development and is therefore considered to be appropriate from a flood risk perspective.

11. References

Dún Laoghaire Rathdown County Council Planning Dept. https://viewer.myplan.ie/

Dún Laoghaire Rathdown County Council. County Development Plan 2022-2028.

Wicklow County Council Planning Dept. https://viewer.myplan.ie/

Wicklow County Council. Wicklow County Development Plan 2016 – 2022

Bray Municipal District Local Area Plan 2018-2024

Department of the Environment, Heritage and Local Government (2020), *The Planning System and Flood Risk Management - Guidelines for Planning Authorities together with Technical Appendices.*

Department of the Environment, Heritage and Local Government (2009), *Planning System and Flood Risk Management Guidelines.*

OPW National Flood Mapping website (www.floodmaps.ie)

OPW (2017), Eastern CFRAM Study

GSI Mapping website (www.gsi.ie)

GDSDS (2005), *Regional Drainage Studies Technical Document – Volume 2 – New Developments*

Appendix A. IE Consulting Technical Note

Technical Note

Coastal Quarter Planning Application, Bray, Co. Wicklow

August 2022

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

Technical Note

Client: Shankill Property Investments Ltd.

Location: Bray Golf Club Lands, Bray, Co. Wicklow

Date: 25th August 2022

Document Control

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Contents

1. Introduction

IE Consulting was requested by Atkins, on behalf of Shankill Property Investments Limited, to prepare a Technical Note for a proposed Strategic Housing Development at the former Bray Golf Club lands in Bray, Co. Wicklow.

The applicant intends to apply to An Bord Pleanála for permission for a Strategic Housing Development (SHD) comprising 586 no. residential units in a mix of apartments, duplexes and houses. In addition, a childcare facility, café, retail unit and 1 no. mixed use commercial unit are proposed along with all associated and ancillary development and infrastructural works, hard and soft landscaping, open spaces, boundary treatment works, ancillary car and bicycle parking spaces at surface, undercroft and basement levels. The proposed houses and duplexes range in height from 2 – 3 storeys with the proposed 4 no. apartment blocks ranging in height from 3 – 12 storeys. Block A will accommodate 162 no. Build-to-Rent (BTR) units. It is proposed that 274 no. units will be located within the administrative area of Dun Laoghaire-Rathdown County Council and 312 no. units will be located within the administrative area of Wicklow County Council. The childcare facility, retail, café and commercial unit will all be located in the administrative area of Wicklow County Council.

The purpose of this Technical Note is to summarise the hydrological and hydraulic assessment undertaken by IE Consulting in relation to the River Dargle. This Technical Note also presents the potential fluvial and tidal flood risk from the River Dargle to the proposed development site and presents and assessment of the impact that development of the site will have on the hydrological regime of the area.

A hydrological engineer from IE Consulting undertook a survey of the site area and surrounding catchment on the 21st of May 2020.

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

This Technical Note has been undertaken in consideration of the following guidance document:

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

2. Proposed Site Description

2.1. General

The proposed Coastal Quarter development site is located on the former Bray Golf Course lands, Bray, Co. Wicklow. The total site area is circa 8.8ha. The proposed residential site is bound to the north by existing public open space at Woodbrook Glen, to the West by Ravenswell Primary School, to the South by the former golf course lands and the River Dargle, and to the East by the Irish Rail Dublin-Rosslare main rail line.

The location of the proposed development site is illustrated on *Figure 1* below.

Figure 1 - Site Location (Red line represents approximate location of the proposed site)

1.1 Existing Topography Levels at Site

The proposed development site slopes moderately from the north-western area of the site towards the southern boundary at an average gradient of approximately 4.2% (1 in 24).

Existing ground elevations within the site boundary range from approximately 11.50m OD (Malin) in the north-western area of the site to 2.12m OD (Malin) in the southern area of the site.

1.2 Local Hydrology, Landuse & Existing Drainage

The River Dargle is located adjacent to the southern boundary of the site. At this location, it generally flows in a south-west to north-east direction. The catchment area of the River Dargle was delineated to be approximately 121.85km^2 to a point located at the downstream boundary of the proposed development site as illustrated in *Figure 2* below. Assessment of the upstream catchment area indicates that the catchment is predominantly rural in nature urban development accounting for 4.1% of the upstream catchment area.

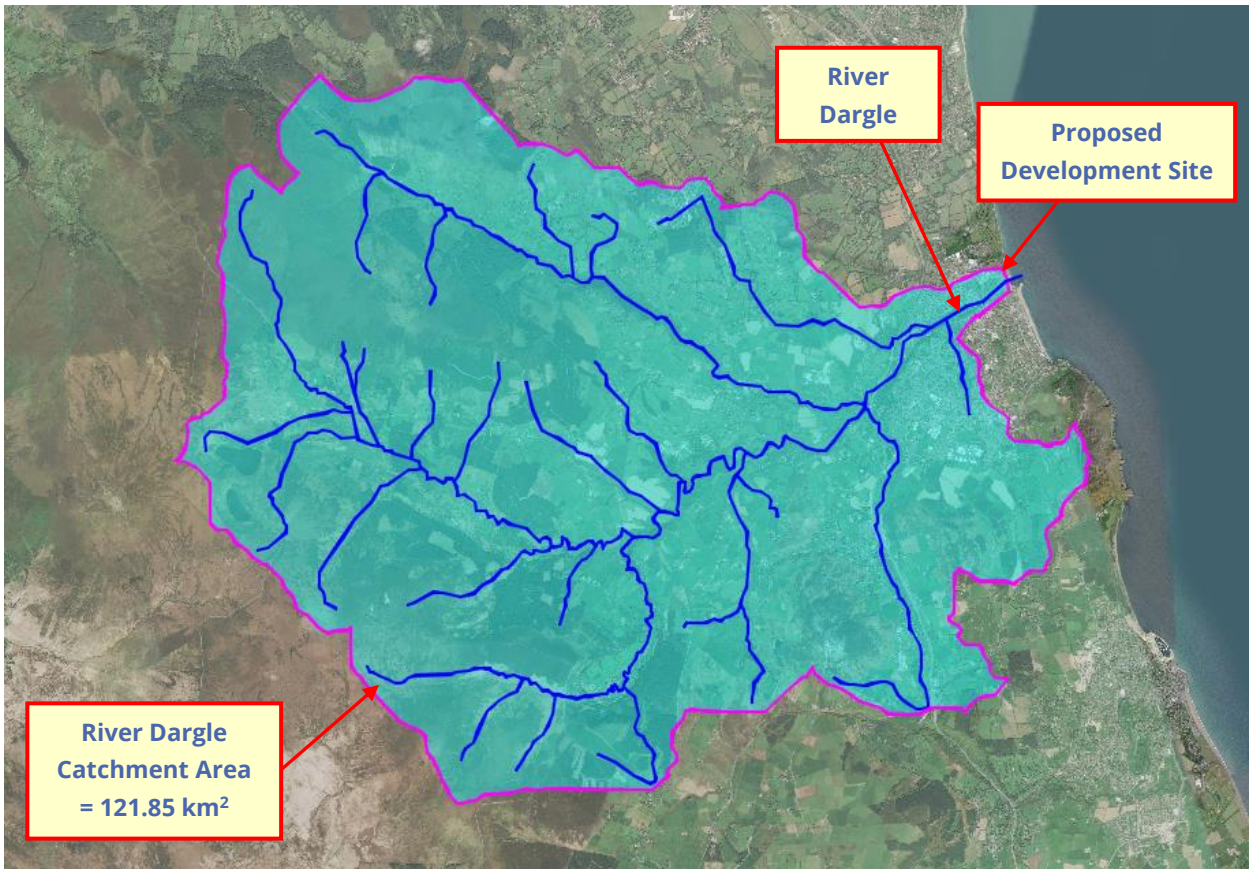

Figure 2 - River Dargle Catchment Delineation

3. Hydrological Analysis of River Dargle

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

Tidal flood risk is normally assessed for a 0.5% AEP (1 in 200 year) and a 0.1% AEP (1 in 1000 year) flood event, which is also in accordance with most county development plans and in accordance with the DOEHLG guidelines '*The Planning System and Flood Risk Management Guidelines'.*

The following sections present an analysis and assessment of the estimated extreme fluvial (1 in 100 year and 1 in 1000 year) and extreme tidal (1 in 200 year and 1in 1000 year) events in the River Dargle in the vicinity of the site.

3.1. River Dargle Peak Flow Estimation – Flood Studies Update

Fluvial peak flood flows in the River Dargle were predicted using the OPW Flood Studies Update (FSU) portal software. The FSU portal allows for the estimation of peak flows through three stages of calculations:

- *Estimation of index flood*
- *Estimation of appropriate growth curve*
- *Flood frequency curve derivation*

These stages vary depending on whether the catchment is gauged or ungauged. In the case of ungauged catchments, the Index Flood, or QMED, is first calculated based on the chosen catchment's characteristics. This value is then correlated using flow data recorded on a catchment with similar characteristics. This second catchment is called the pivotal site.

A pivotal site must be selected when the catchment being analysed is ungauged. This allows the FSU software to incorporate data from the gauged pivotal site into the ungauged selected site where necessary. All pivotal sites are hydrometric gauging stations that were used in the supporting analysis for the FSU methodology and the annual maximum (AMAX) series data at these stations has been quality checked and classified. The chosen pivotal site should ideally lie a short distance either upstream or downstream of the selected site, although any site within the country can be deemed suitable if hydrologically similar enough to the selected site.

Once the value of QMED has been established, an appropriate growth curve is constructed. Where the site in question is ungauged, this is accomplished within the FSU software by tabulating gauging stations on catchments with similar hydrological characteristics and creating a pooled flood frequency analysis curve. Pooling is required to avoid reliance on a single flood frequency curve when extrapolating long return period events.

3.1.1. Subject Site Selection

The subject site catchment selected (10_1274_2) within the FSU portal software is illustrated in *Figure 3* below. The point taken for the calculation of the catchment is located upstream of the proposed development site. The reason this point was chosen is because the route of the Wilford River is shown to discharge to the River Dargle in the FSU portal immediately downstream of this point, which is incorrect. The Wilford River discharges directly to the sea and is not hydrologically linked to the River Dargle catchment in any way. It is proposed to estimate the extreme flows using the FSU web portal at the upstream node location (10_1274_2) and then adjust the flows for the entire catchment area.

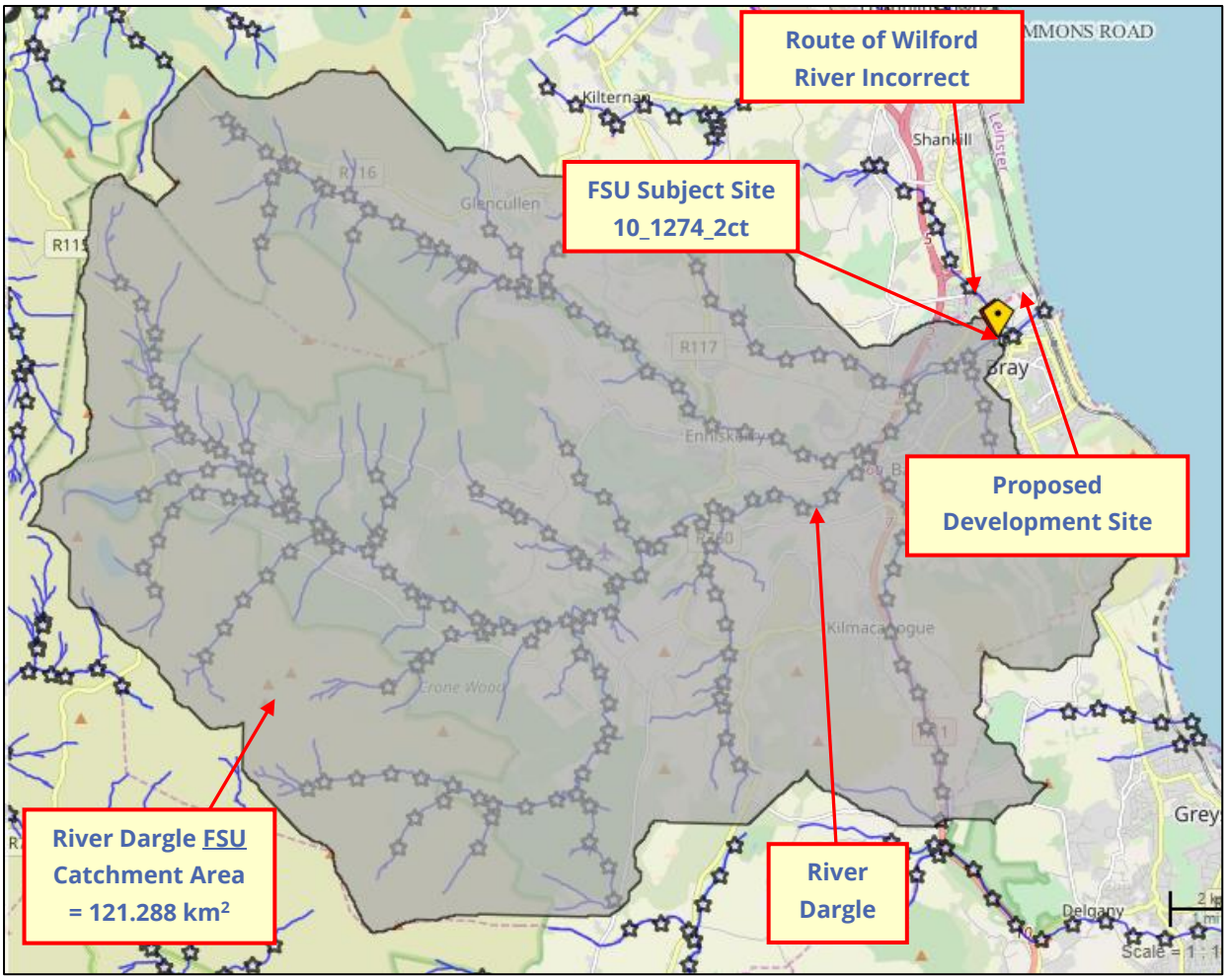

Figure 3 - River Dargle FSU Catchment Area

3.1.2. Pivotal Site Selection

Five possible pivotal sites were available for the selected site. The suitability of a pivotal site is gauged by the level of hydrological similarity to the subject site with values < 1 being considered similar with lower values indicating closer similarity. The FSU Station 26020 Argar located in County Longford was chosen as the most suitable pivotal site as it has the closest hydrological similarity value of 0.2404.

3.1.3. Index Flood Estimation

The QMED or index flood value was calculated by the FSU software for the River Dargle based on the catchment characteristics and the annual maximum flow series data from the pivotal site. The FSU software applies an adjustment factor to the calculated QMED value derived from a ratio of the

pivotal site QMED and the selected site estimated QMED. *Table 1* below lists the calculated QMED flows for the River Dargle and pivotal site.

River Dargle QMED (m^3/s)	31.110
Pivotal Site QMED (m^3/s)	11.120
Pivotal Adjustment Factor	1.399
River Dargle Adjusted QMED (m^3/s)	43.500

Table 1 - River Dargle Predicted QMED Flow

3.1.4. Pooled Flood Frequency Analysis

The flood frequency curve for the River Dargle was constructed within the FSU software using a pool of 28 hydrologically similar sites. For the full list of hydrometric stations used in the analysis, refer to Appendix C. *Figure 4* and *Table 2* below shows the final output from the FSU software, giving details of return period growth factors and return period flows for the River Dargle.

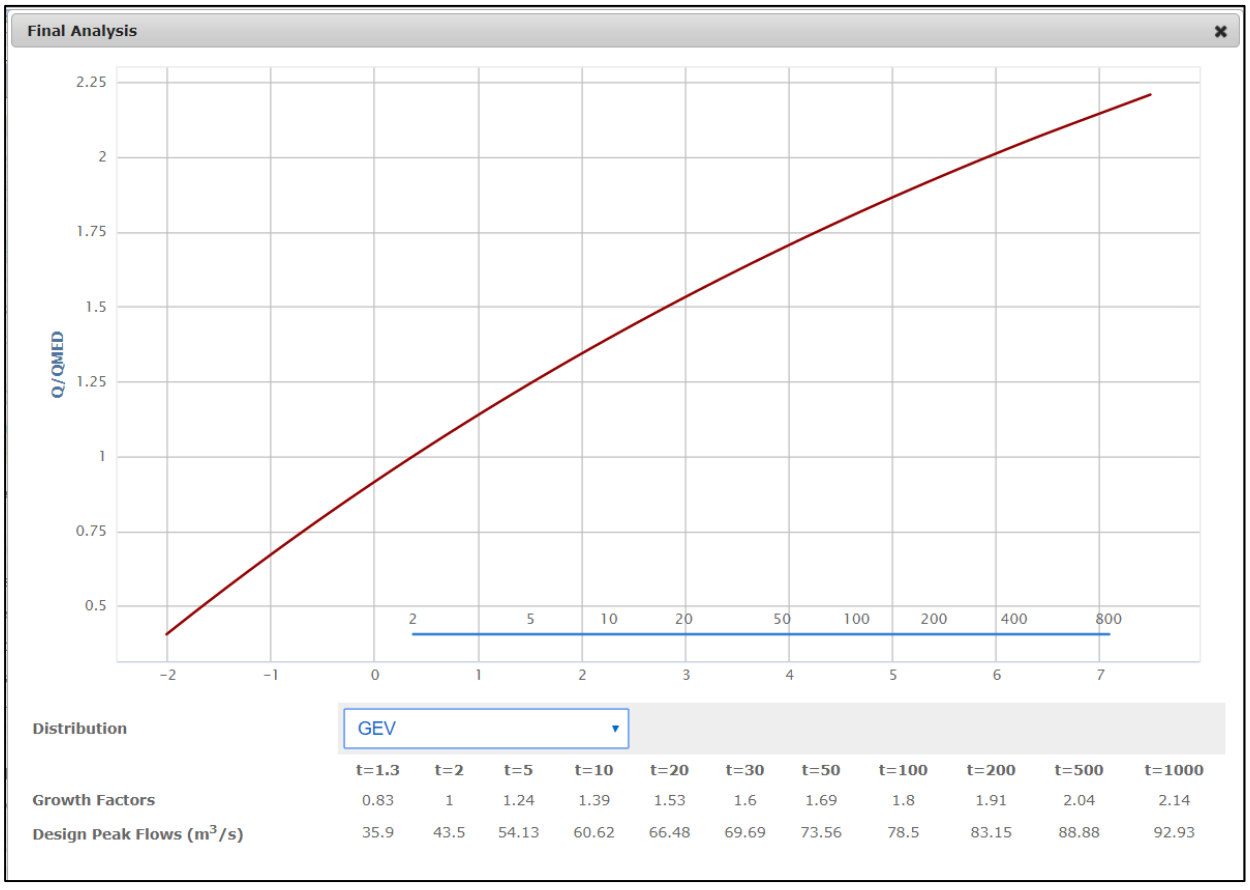

Figure 4 - Predicted Flow Growth Factors & Calculated Return Period Flows

Flood Return Period (Years)	2	5	10	20	30	50	100	1000*
Growth Curve Factor (QT/QBAR)	1	1.24	1.39	1.53	1.6	1.69	1.8	2.14

Table 2 - Growth Factors Estimated for River Dargle Discharge Prediction

Table 3 below lists the estimated peak flood flow in the River Dargle at the point of interest for the various return period events:

Flood Return Period (Years)	2	5	10	20	30	50	100	1000*
Estimated Peak Flow (m^3/s)	43.5	54.13	60.62	66.48	69.69	73.56	78.5	92.93

Table 3 - FSU Estimated Peak Flows in the River Dargle for Various Return Periods

The FSU estimated flows in the River Dargle are for a catchment area of 121.288km^2 as shown in *Figure 3* above. The catchment area delineated as part of this assessment is 121.85 km^2 as shown in *Figure 2*. The FSU flows in *Table 3* above have been adjusted for the River Dargle delineated catchment area using an adjustment factor as follows:

Catchment Area Adjustment Factor = 121.85/121.288 = 1.005

The adjusted flows are shown in *Table 4* below:

Flood Return Period (Years)	2	5	10	20	30	50	100	1000*
Estimated Peak Flow (m^3/s)	43.72	54.40	60.92	66.81	70.04	73.93	78.89	93.39

Table 4 - Adjusted Estimated Peak Flows in the River Dargle for Various Return Periods

The 1% AEP (1 in 100-year) and 0.1% AEP (1 in 1000-year) flood flows for the River Dargle along the reach under consideration is therefore:

Q100 = 78.89 m^3/s

Q1000 = 93.39 m^3/s

*(*Note – The Q100 value is a design flow. The Q1000 value is estimated and is presented only to assess the 1000 year Average Recurrence Interval (ARI) in the context of the 'Planning System and Flood Risk Management Guidelines')*

3.2. River Dargle Flood Defence Scheme Flow Estimation

As part of the River Dargle Flood Defence Scheme (FDS) an Environmental Impact Statement (EIS) was completed in 2007. Chapter 5 of this report includes a summary of the hydrological and hydraulic assessment carried out on the River Dargle where the river discharges to the sea. This report includes a number of methods for determining extreme flows from the Flood Studies Report methodologies including catchment characteristics using regional growth curves, the unit hydrograph method and use of a nearby gauged catchment in the River Dodder with an applied correction to the subject site. The calculated design flows are summarised in *Table 5* (Table 5.5.3 in EIS) below:

Return Period (Yrs)	$\overline{Q}$ Method (m^3/s)	UH Method Original FSR (m^3/s)	UH Method Supplementary Report No. 16 (m^3/s)	Adjustment from Dodder Catchment (m^3/s)
1	74	98	92	139
5	94	132	115	176
50	138	212	204	258
100	153	230	220	288

Table 5 – River Dargle FDS EIS derived flows

The report also references 'Hurricane Charlie' which was a significant flood event that occurred on August 25th and 26th in 1986. The report states:

"Over a 24 hour duration of the storm from 9:00am on the 25th of August to 9:00am on the 26th of August, recorded rainfall in the Dargle catchment ranged from values in excess of 80mm in low lying areas to at least 250mm in the highest areas. Recorded rainfall in the middle catchment, which comprises a significant proportion of the total catchment area, varied from 150mm to 200mm. At Bray Garda Station and at Glenasmole, which is just outside the Dargle catchment, rainfalls of 8 mm and 165mm respectively were recorded during this 24-hour period. Rainfalls of this magnitude in Bray have an estimated return period approaching one hundred years and the recorded Glenasmole rainfall has an estimated return period in excess of 100-years. If it is considered, which is generally the case, that the 'Hurricane Charlie' flow of 285m^3/s represented the total 100-year flow in the River Dargle catchment, then, direct applications of the FSR methodologies underestimate the design flow to varying degrees. Correlation does

exist however, between the estimated 'Hurricane Charlie' flow and that determined using the catchment characteristic methodology when modified from observed data from the River Dodder.

For the purposes of this EIS, a flow of 285m^3/s was taken to represent the 1986 100-year flow to an outfall at the upstream end of the river reach under investigation. The 1-year, 5-year and 50-year design flows used in this report were those determined using the catchment characteristic methodology when modified from observed data from the River Dodder."

The design flows utilised in the hydraulic modelling are summarised in *Table 6* (Table 5.5.4 in EIS) below:

Description	1-Yr Flow (m^3/s)	5-Yr Flow (m^3/s)	50-Yr Flow (m^3/s)	100-Yr Flow (m^3/s)
Flow in River Dargle	139.0	177	258.0	285.0
Flow in County Brook	2.2	2.8	4.1	4.5
Flow in Swan Stream	3.0	3.9	5.5	6.1
Runoff from non-attenuated development since 1986	0.5	0.7	1.0	1.2
Total flow reaching Bray Harbour (*approx*)	**145.0**	**185.0**	**270.0**	**300.0**

Table 6 - EIS final Design Flows

The flows estimated using the FSU methodology significantly underestimates the flows compared to those utilised in the River Dargle Flood Defence Scheme as described in the River Dargle FDS EIS report. In consideration that the EIS flows are based on a historical flood event it is considered more appropriate to utilise these flow rates.

3.3. Estimated Flows for Different Return Periods Using EIS Flows

The Greater Dublin Strategic Drainage Study includes return period growth factor that for the Dublin region for up to the 1 in 200 year event. However, there is no growth factor for the 1 in 1000 year event. In lieu of this the national growth curve for Ireland has been utilised to estimate the 1 in 1000 year flow in the River Dargle.

The return period flows 'Q_T' are estimated using the index flood method and multiplying the annual maximum flow by the appropriate growth factor 'X_T' using the FSR (1975) national growth curve for Ireland, as shown in *Figure 5* below:

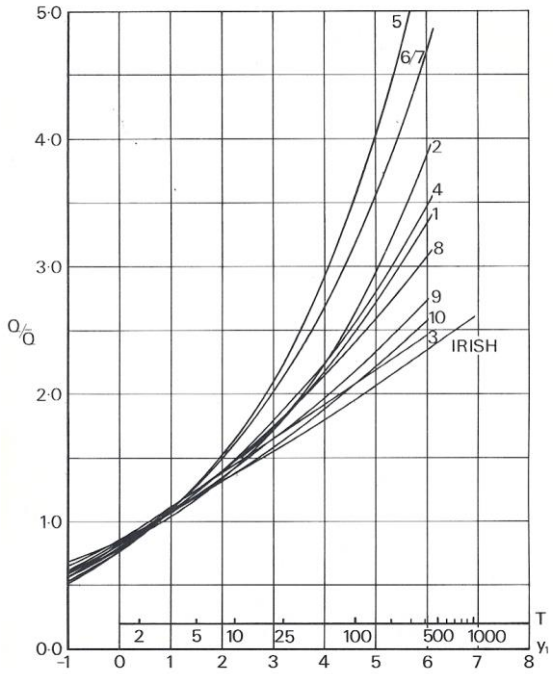

Figure 5 - Regional Growth Factors

For flood return periods 2, 5, 10, 20, 50, 100 and 1000 years the growth factors determined from *Figure 5* are listed in *Table 7* below:

Flood Return Period (Years)	2	5	10	20	50	100	1000*
Growth Curve Factor (QT/QBAR)	0.95	1.20	1.37	1.54	1.77	1.96	2.59

Table 7 - Growth Factors Applied to Irish Catchments for QBAR Discharge Prediction

From *Table 6* and *Table 7* above the Q_{BAR} can be calculated as follows:

Q_{BAR} = 300/1.96 = 153.06 m³/s

Table 8 below shows the estimated peak flood flow in the River Dargle at the point of interest for different return periods:

Flood Return Period (Years)	2	5	10	20	50	100	1000*
Estimated Peak Flow (m³/s)	145.41	185	209.69	235.71	270	300	396.43

Table 8 - Estimated Peak Flows in the River Dargle for Different Return Periods

The estimated 100-year (1% AEP) and 1000-year (0.1% AEP) flood flows for the watercourse along the reach under consideration is therefore:

Q_{100} = 300 m³/s

Q_{1000} = 396.43 m³/s

*(*Note – The Q_{100} value is a design flow. The Q_{1000} value is estimated and is presented only to assess the 1000 year Average Recurrence Interval (ARI) in the context of the 'Planning System and Flood Risk Management Guidelines')*

3.4. Peak Flow Hydrograph

To simulate an unsteady flow in the River Dargle flow rates, a hydrograph corresponding to the peak 1% AEP (1 in 100 year) and the 0.1% AEP (1 in 1000 year) flood events is required. The FSU Web Portal has a tool to generate hydrograph shapes at a subject site.

The FSU methodology employs typical shapes for the hydrograph beneath a given peak value at pivotal sites which are semi-dimensionless with ordinates expressed as a percentage of the peak value at intervals along a time axis defined in hours. The stages of hydrograph estimation are as follows:

- Estimation of Hydrograph Shape from Pivotal Site
- Adjustment of Hydrograph Shape at Pivotal Site
- Transfer of Characteristics to Subject Site

A subject site must be selected where the hydrograph is required, which is usually taken as the same location chosen in the peak flow estimation (Subject site - 10_1274_2).

A hydrograph pivotal site must then be chosen from a selection of hydrologically closest sites as defined by Euclidean Distance (geometrically closest) measure applied to catchment descriptors such as mainstream slope (S1085), flood attenuation because of catchment reservoirs and lakes (FARL) and base flow (BFI) identified by the FSU Web Portal.

Euclidean distance is a measure of hydrological similarity and as a rule-of thumb a value of 2.0 or greater indicates low similarity, however these values can vary depending on the characteristics of the subject catchment. The pivotal site is selected by reviewing the hydrograph shape for the largest peak of the candidate hydrograph pivotal stations and the subject site.

The preferred pivotal site is selected based on the shape most like the subject site and preferably with a hydrological similarity of <1.

Once a pivotal site has been selected the hydrograph shape is adjusted by altering the hours before and after the peak. The FSU Portal will identify and display hydrographs for up to ten (pre-loaded) large events at the hydrograph pivotal site. The hydrographs are displayed according to the rank of their flood magnitude with largest first and only hydrographs with a peak greater than QMED are displayed. The hours displayed before and after the peak can then be altered for a better fit with the recorded events at the pivotal site. A deformation factor and shape parameter (n) can also be edited to adjust the extent and shape of the pivotal site hydrograph.

Once the pivotal hydrograph shape is accepted characteristics of the hydrograph can be transferred to the subject site in the Characteristic Hydrograph Transfer section of the portal. There are three options available including:

- Use adjusted estimate
- Use unadjusted catchment descriptor estimate
- Use user specified value

The last option allows the user to enter a deformation factor somewhere between 1.0 and the value indicated at the hydrograph pivotal site and to enter a justification for adopting a user specified value.

3.4.1. Pivotal Site Selection

A pivotal site was selected from a donor catchment based on the similarity of the hydrograph shape with the River Dargle (10_1274_2) and a hydrological similarity of <1. Of the 30 possible donor pivotal sites highlighted by the FSU software, FSU Station 22009 White Bridge, Dreenagh, Co. Kerry was chosen as the most suitable pivotal site based on the closest hydrological similarity value of 0.6446.

3.4.2. Pivotal Site Hydrograph Display and Adjustment

The pivotal site hydrograph shape was reviewed and the hours before and after the peak was selected as 30 and 20 hours based on shape of the ten large events identified at the pivotal site. The deformation factor and shape parameter were then adjusted to gain a better fit of the hydrograph.

A deformation factor of 1 and a shape parameter n value of 35 is specified for the pivotal site hydrograph. The adjustment applied to the pivotal site hydrograph is shown in *Figure 6* below.

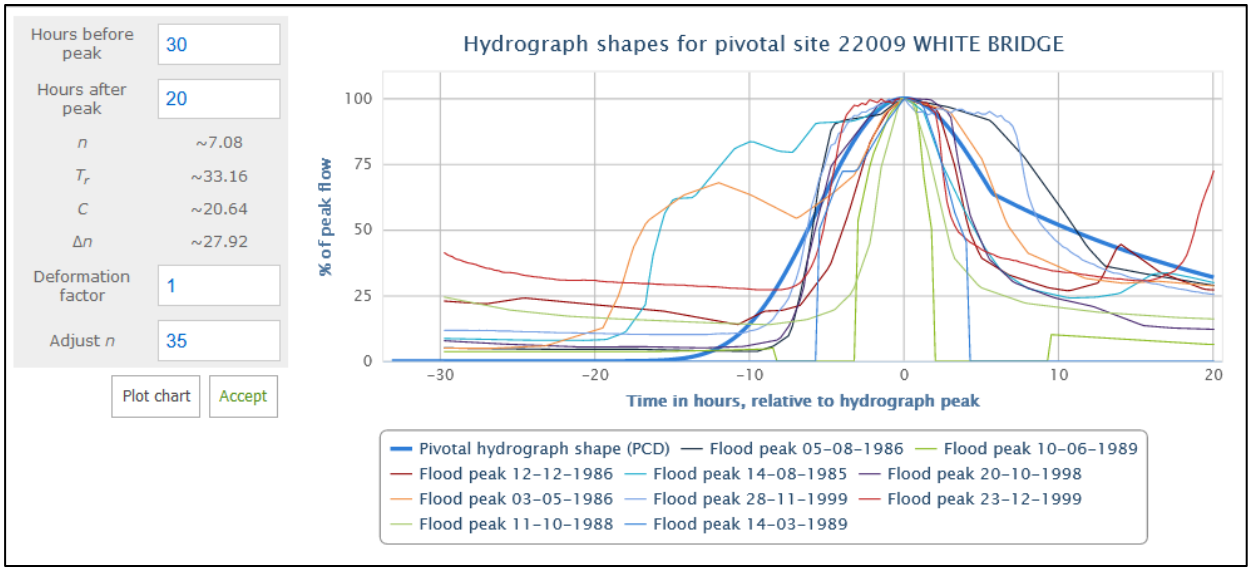

Figure 6 - Pivotal Site Hydrograph Adjustments

3.4.3. Characteristic Hydrograph Transfer to Subject Site

The adjusted estimate was selected to be applied to the subject sites and the hydrographs were generated. The 1% AEP (1 in 100 year) peak flow hydrograph for the River Dargle is illustrated in *Figure 7* below. The FSU Hydrograph Width application does not however generate a hydrograph for the 0.1% AEP (1 in 1000 year) peak flow rate. It is unclear from the FSU Technical Reports why it does not allow this to be generated when the Flood Frequencies application allows the 0.1% AEP peak flow to be estimated. The peak flows listed in *Table 8* above have subsequently been fitted onto the created hydrographs.

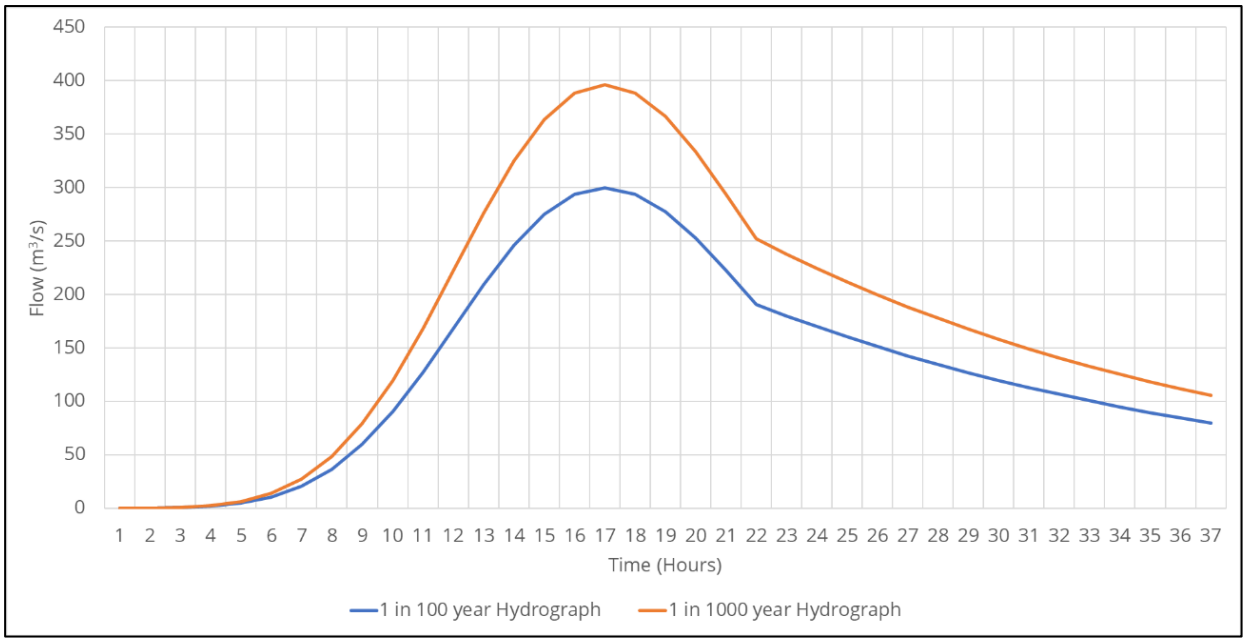

Figure 7 - Model Hydrographs

3.5. Tidal Flood Levels

The Irish Coastal Protection Strategy Study (ICPSS), which was undertaken by the OPW, was completed in 2013 and modelled a combination of tide levels and storm surges in order to estimate extreme event water levels and to map potential coastal flood extents for various return period events along the Irish coastline.

According to the ICPSS mapping a portion of the southern area of the site is located within a tidal flood risk zone. In order to assess the extreme tidal event in the River Dargle the 1 in 200 year tide event (T0200) and 1 in 1000-year tide event (T1000) were modelled using Flood Modeller Pro.

The ICPSS study used numerical modelling of combined storm surges and tide levels to obtain extreme water levels along the coastline. The application of extreme value analysis and joint probability analysis to both historic recorded tide gauge data and data generated by the numerical model allowed an estimation of the extreme water levels of defined exceedance probability to be established along the coastline.

Coastal / tidal flood extent mapping was produced for the 0.5% and 0.1% return periods. *Figure 8* below (extracted from ICPSS flood maps SE/RA/EXT/2) illustrates the predicted extreme 0.5% AEP (1 in 200 year) and 0.1% AEP (1 in 1000 year) flood extents in the vicinity of the proposed development site for the current scenario.

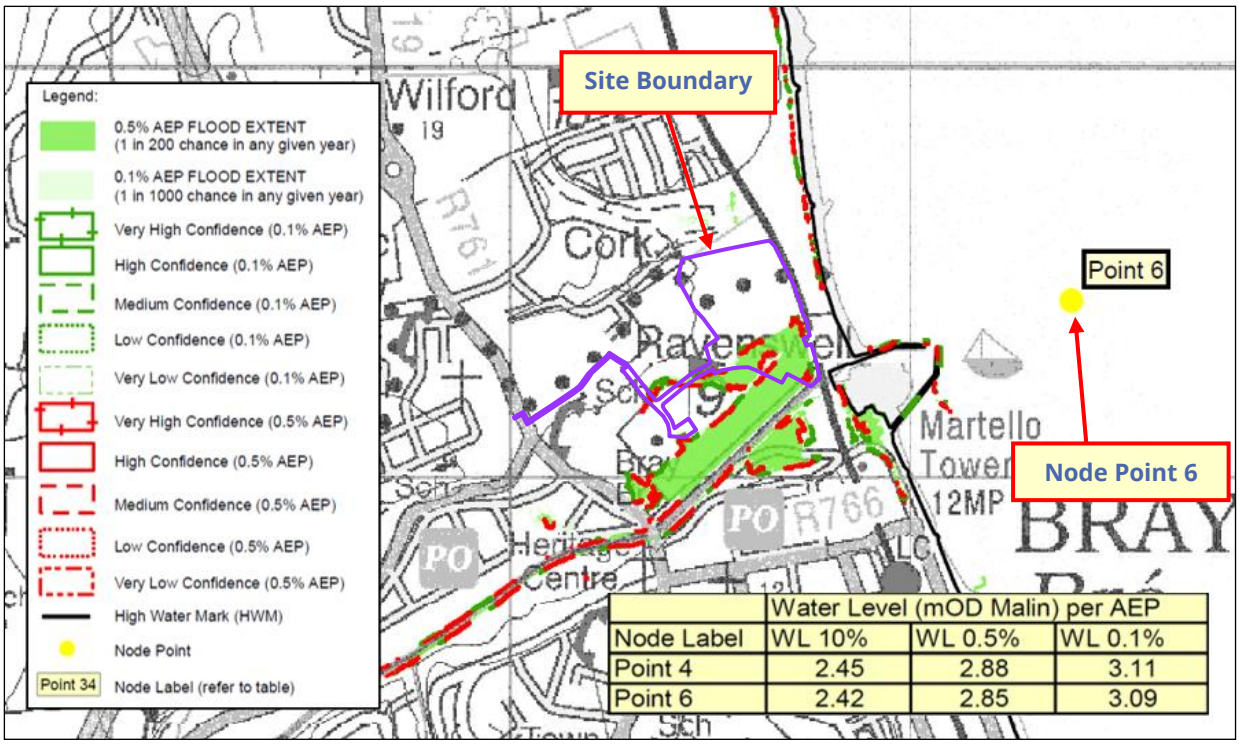

Figure 8 - ICPSS Current Scenario Tidal Flood Extent Map (Red line represents approximate location of the proposed site)

The ICPSS mapping for the area also provides information on predicted tidal flood levels. The closest node point to the proposed development site is Node Point 6 located approximately 650m east of the proposed site. Predicted extreme flood levels at this node point are applicable for the purposes of estimation of extreme tidal flood levels at the location of the proposed development site. The peak tide levels for this study were extracted from Node point 6 and are listed below in *Table 9.*

Return level	Flood Level (m OD)
T0002	2.18
T0200	2.85
T1000	3.09

Table 9 - Tidal flood levels

A static tide water level has been applied to the hydraulic model for both the tidally dominant and fluvially dominant scenarios, which is a more conservative approach.

3.6. Joint Probability

In order to assess an extreme fluvial or tidal event in the River Dargle a joint probability approach has been utilised. The approach taken as part of this assessment is in line with that of the OPW Eastern CFRAM Study. The probability of a joint occurrence of extreme fluvial and extreme coastal events was not considered likely in the Eastern CFRAMS report. A precautionary approach was taken in the Eastern CFRAM Study and so the fluvial dominated events were run in conjunction with the 1 in 2 year tide level (T0002), while the tidally dominated events were run in conjunction with the 1 in 2 year fluvial flows (Q0002). This same approach was deemed suitable for this study. The combinations of tide levels and fluvial flows for the critical events are presented in *Table 10* below.

Scenario	Fluvial Return Period	Tidal Return Period
Fluvial Dominant	Q0100	T0002
Fluvial Dominant	Q1000	T0002
Tidal Dominant	Q0002	T0200
Tidal Dominant	Q0002	T1000

Table 10 - Joint Probability Pairings

4. Hydraulic Assessment of the River Dargle

A hydraulic model was developed of the River Dargle along a channel reach length of approximately 793m. The purpose of developing a hydraulic model is to estimate flood water levels at specific locations along the modelled reach representing the existing river channel and hydraulic structures (bridges) on the River Dargle. The hydraulic model developed is based on an appropriate computer software package that utilises topographical information about the river and flood plain geometry, the hydraulic resistance characteristics (Manning's 'n') of the river and flood plain and appropriate boundary conditions at the upstream and downstream extent of the study area. The extent of modelled reach length is illustrated in *Figure 9* below:

Figure 9 - River Dangle Modelled Reach (Red line represents approximate location of the proposed site)

4.1. Hydraulic Model Selection

Several hydraulic models are available which will predict flood levels for a given design flow. For this assessment Flood Modeller Pro software package was employed. This software suite was preceded

by ISIS, which was developed and progressed by Jacobs over the past 30 years. The Flood Modeller software package allows for one-dimensional and two-dimensional modelling of steady and unsteady state flow profiles and thematic mapping of flood plains and overland flow paths when required. It also supports modelling of structures such as bridges, culverts, and weirs along with storage ponds. It is well regarded for use in the application of river and flood plain modelling.

The model type utilised is a linked 1D-2D model where the 1D model defines the main river channel flow and the 2D model defines the flood plain. The two domains are linked together at the point where the flow spills from the channel bank onto the flood plain. This allows the overland flow paths within the flood plain to be accurately mapped, which is particularly useful in urbanised areas.

4.2. Hydraulic Modelling Assumptions

The following are the main assumptions used in the development of the Flood Modeller hydraulic model:

- Cross-section information between successive surveyed cross-sections was obtained by interpolation, where required to provide stability to the model.
- The openings of all hydraulic structures (bridges, culverts, etc.) and the reach modelled were assumed to be free from blockages or debris in all events.

4.3. Topographical Survey Data

The topographical survey of the site of proposed development was undertaken by Murphy Surveys and was completed on the 25th of February 2020. River section survey was also collected by Murphy Surveys on the 24th of March 2020. The survey also included the walkway underpass levels where it goes underneath the railway line adjacent to the eastern site boundary. For this project 20 cross sections were extracted from the Murphy's survey dataset. This included the details of three hydraulic structures along the modelled reach. The locations of the surveyed cross-sectional elevations are illustrated above in *Figure 9*.

4.4. LiDAR Derived Digital Terrain Model & Contour Mapping

To assist in the assessment of any potential flooding in the general area of the proposed development and to enable an accurate representation of flood zone mapping to be developed, a detailed Digital Terrain Model (DTM) was obtained from the Ordnance Survey of Ireland (OSI). From

this data a detailed contour map was developed to encompass the area of the hydraulic model 2D domain. The DTM and contour mapping was developed using aerial flown Light Detection & Ranging Data (LiDAR). The LiDAR data was supplied in Irish Grid (IG) in ASCll file format, at 2m postings. The topographical survey prepared by Murphy Surveys was utilised where available instead of LiDAR in the development of the DTM. This ensures the ground levels on the site are the most accurate. The DTM and contour mapping developed for the modelled area is illustrated below in *Figure 10* below:

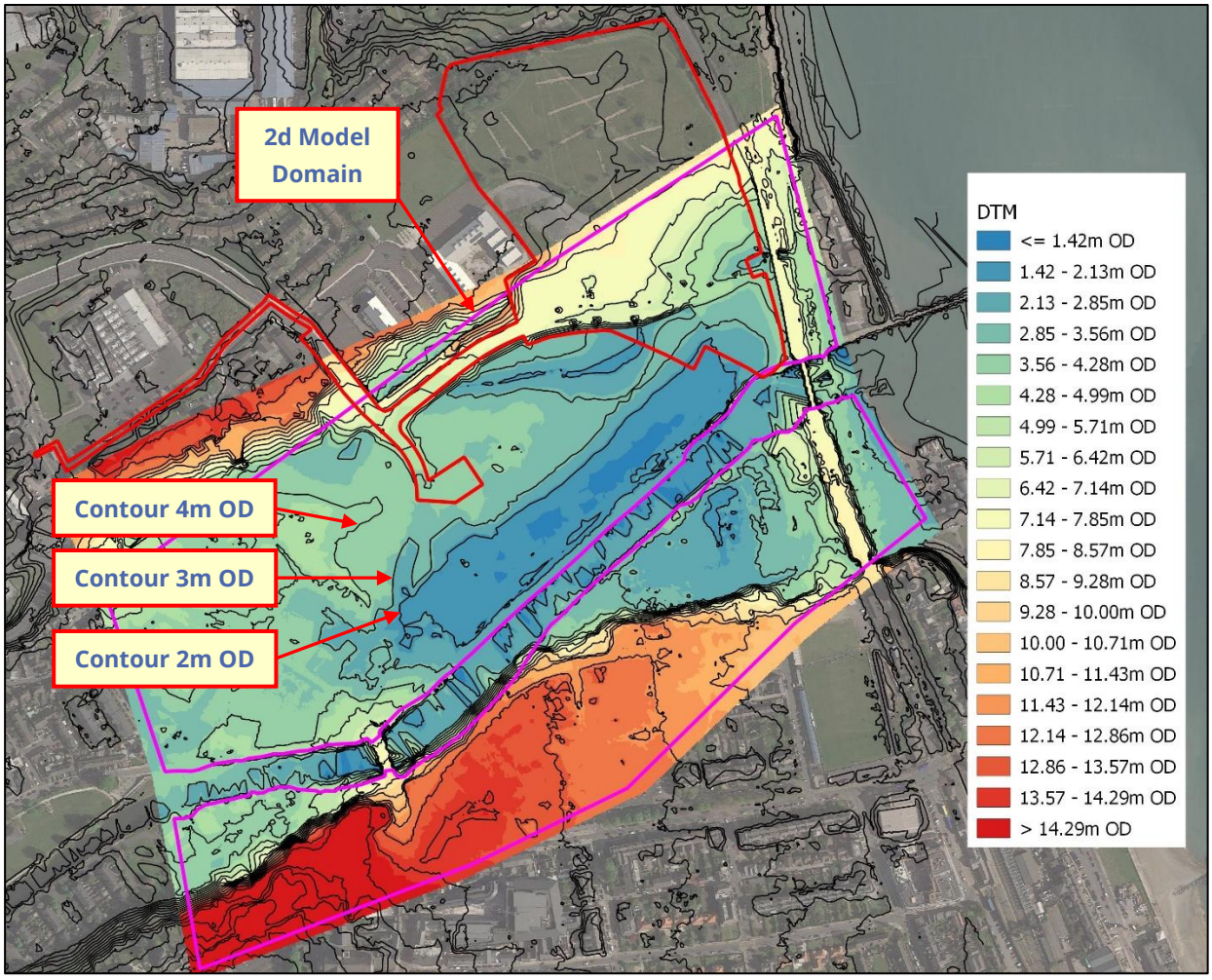

Figure 10 - LiDAR Derived DTM

4.5. River Channel & Flood Plain Roughness Co-Efficients

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

data in the area, if available. *Table 11* below lists recommended river channel overbank land roughness co-efficients for various vegetation types.

Type of Channel and Description	Minimum	Normal	Maximum
A. *Natural Streams*			
1. **Main Channels**			
a. Clean, straight, full, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. Same as "d" but more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy. deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stands of timber and brush	0.070	0.100	0.150
2. **Flood Plains**			
a. Pasture no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
2. Same as above, but heavy sprouts	0.050	0.060	0.080
3. Heavy stand of timber, few down trees, little undergrowth, flow below branches	0.080	0.100	0.120
4. Same as above, but with flow into branches	0.100	0.120	0.160
5. Dense willows, summer, straight	0.110	0.150	0.200
B. *Lined or Built-Up Channels*			
1. **Concrete**			
a. Trowel finish	0.011	0.013	0.015
b. Float Finish	0.013	0.015	0.016
c. Finished, with gravel bottom	0.015	0.017	0.020
d. Unfinished	0.014	0.017	0.020
e. Gunite, good section	0.016	0.019	0.023
f. Gunite, wavy section	0.018	0.022	0.025
g. On good excavated rock	0.017	0.020	
h. On irregular excavated rock	0.022	0.027	
2. **Concrete bottom float finished with sides of:**			
a. Dressed stone in mortar	0.015	0.017	0.020
b. Random stone in mortar	0.017	0.020	0.024
c. Cement rubble masonry, plastered	0.016	0.020	0.024
d. Cement rubble masonry	0.020	0.025	0.030
e. Dry rubble on riprap	0.020	0.030	0.035
3. **Gravel bottom with sides of:**			
a. Formed concrete	0.017	0.020	0.025
b. Random stone in mortar	0.020	0.023	0.026
c. Dry rubble or riprap	0.023	0.033	0.036

Table 11 - Manning's 'n' Values

With reference to *Table 11* above, varying roughness co-efficients were applied to the hydraulic model to reflect the type and form of vegetation observed during the survey of the River Dargle undertaken by a hydrological engineer from IE Consulting. In respect of the main channel of the River Dargle an applied roughness co-efficients of 0.030 was utilised, reflecting a channel that is generally clean and straight with no rifts or pools. Applied flood plain roughness co-efficients of 0.02 (dressed stone in mortar) were utilised. Manning's values have been determined based on the river characteristics as shown in *Figure 11* below.

Figure 11 - River Dargle at Cross Section S-6 Looking Downstream

The Eastern CFRAMS Hydraulic Report describes applying the roughness values in the 2d domain based on land type areas defined in the Corine Land Cover Map with representative roughness values associated with each of the land cover classes in the dataset. This same approach was used for this study to determine the roughness values in the 2d domain. *Figure 12* below illustrates the roughness polygons values applied to the 2d domain in this model. The impact of buildings in the 2d domain was represented using a high roughness value of 0.3.

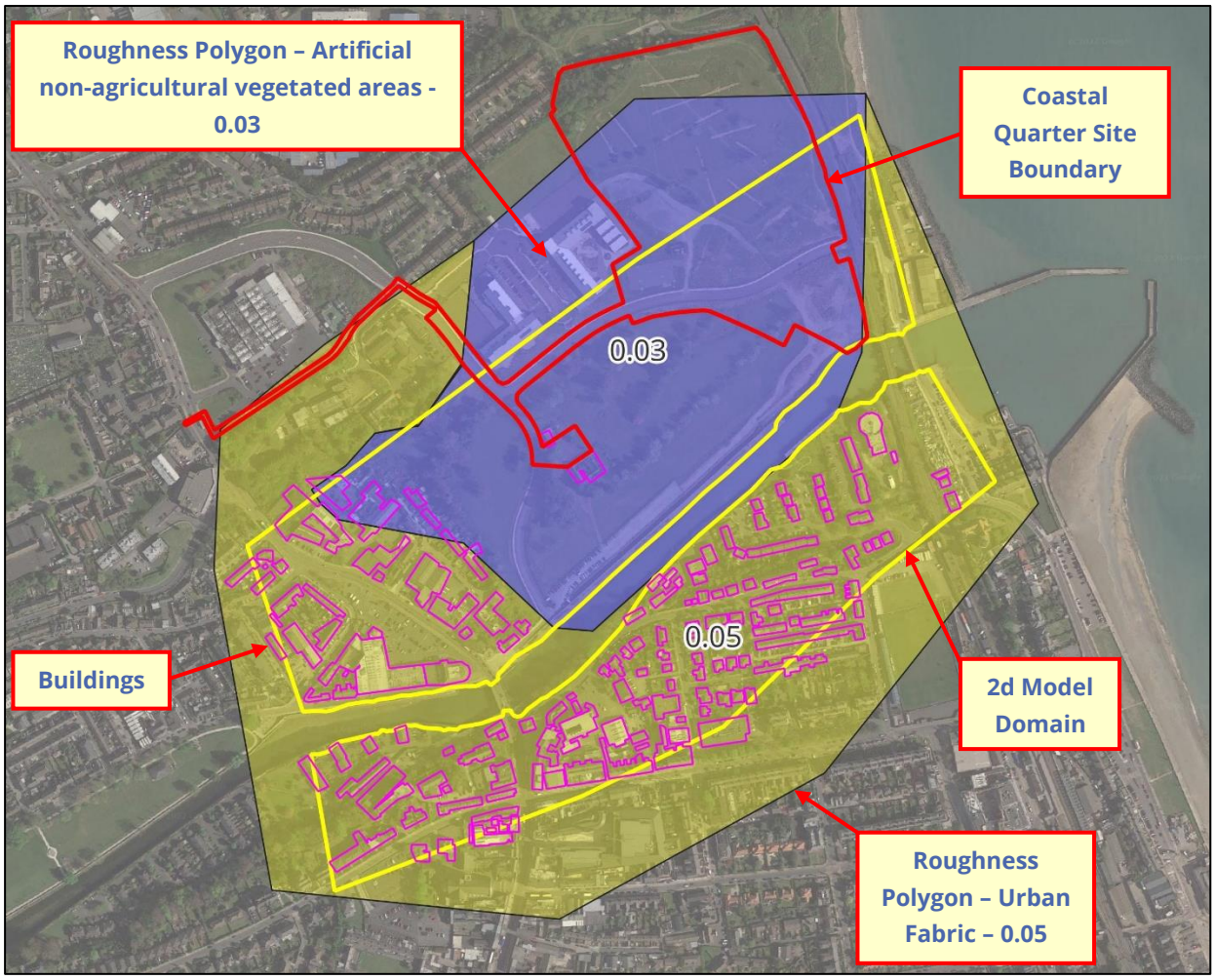

Figure 12 - 2d Roughness Value (Red line represents approximate location of the proposed site)

4.6. Initial Hydraulic Model Development

A total channel length of approximately 793m between Sections S-19 and S-01 along the River Dargle channel was modelled as illustrated in *Figure 9* above. The cross-sections surveyed were geo-referenced and incorporated into the model together with the following existing hydraulic structures as illustrated in *Figure 13*, *Figure 14* and *Figure 15* below:

Figure 13 - 3 Arch Road Bridge and Rectangular Culvert at Section 2 and Section 3 Looking Downstream

Figure 14 - Railway Bridge at Section 12 Looking Downstream

Figure 15 - Road Bridge at Section 16 Looking Upstream

The Three Arch Road Bridge with Rectangular Culvert is located between sections S-2 and S-5. It has been represented in Flood Modeller with an Arch Bridge unit. Any overtopping of the bridge is represented in the 1D domain with a spill unit. There is also a rectangular culvert on the left-hand bank of the river channel. This has been represented in the model using an orifice unit.

The Railway Bridge is situated between sections S-12 and S-15. It has been modelled in Flood Modeller with a USBPR Bridge. Any overtopping of the bridge is represented in the 1D domain with a spill unit.

The Road Bridge is situated between sections S-15 and S-16. It has been modelled in Flood Modeller with a USBPR Bridge. Any overtopping of the bridge is represented in the 1D domain with a spill unit.

4.7. Undefended Scenario

The River Dargle Flood Defence Scheme was completed in October 2017. The scheme comprised a variety of flood defences, including construction of new sections of earth embankments, demolition and rebuilding of river walls with extensive stone facing, channel excavation, regrading and riverbank strengthening.

To fully understand the fluvial and tidal flood risk to the proposed development site the presence of all flood defence walls have been ignored in the hydraulic assessment of the River Dargle. This is in accordance with The Planning System and Flood Risk Management guidance, which states *"the presence of flood protection structures should be ignored in determining flood zones*" (Section 2.25).

4.8. Boundary Conditions

As discussed in *Section 3.5* above a Joint Probability approach has been utilised to assess both the fluvial and tidal dominant scenario. A tidal boundary (stage versus time graph) was applied at the downstream extent of the model. As discussed above in *Section 3.66* when a fluvially dominated event is occurring a 1 in 2 year tide is applied at the downstream extent of the model. When a tidally dominated event is occurring a 1 in 2 year fluvial flow rate is applied at the upstream extent of the model.

5. Baseline Hydraulic Model Simulation Results

5.1. Baseline Scenario - Fluvial Results

The results of the hydraulic model show that during the fluvially dominated flood events the majority of the Coastal Quarter development site is situated within Flood Zone 'C'. As illustrated below in *Figure 16* a limited area located in the southern corner of the site is located within both the 1 in 100 year (1% AEP event - Flood Zone 'A') and 1 in 1000 year (0.1% AEP - Flood Zone 'B') fluvial flood zones.

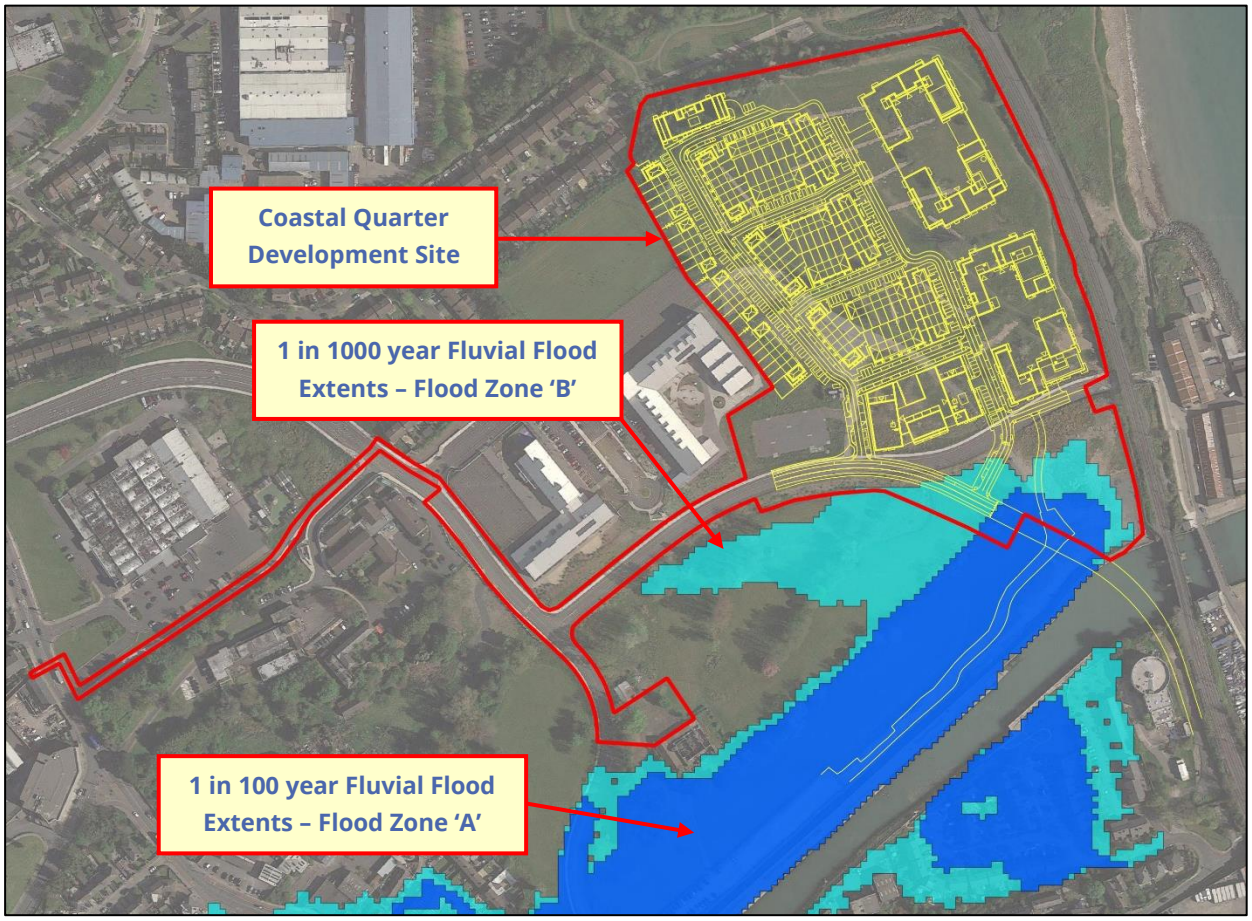

Figure 16 - Baseline 1% AEP & 0.1% AEP Fluvial Flood Extents (Red line represents approximate location of the proposed site)

5.2. Baseline Scenario - Tidal Results

During a tidally dominated flood event, the majority of the Coastal Quarter development site is also situated within Flood Zone 'C'. As illustrated below in *Figure 16* a limited area located in the southern

corner of the site is located within both the 1 in 200 year (0.5% AEP event - Flood Zone 'A') and 1 in 1000 year tidal flood zones (0.1% AEP - Flood Zone 'B').

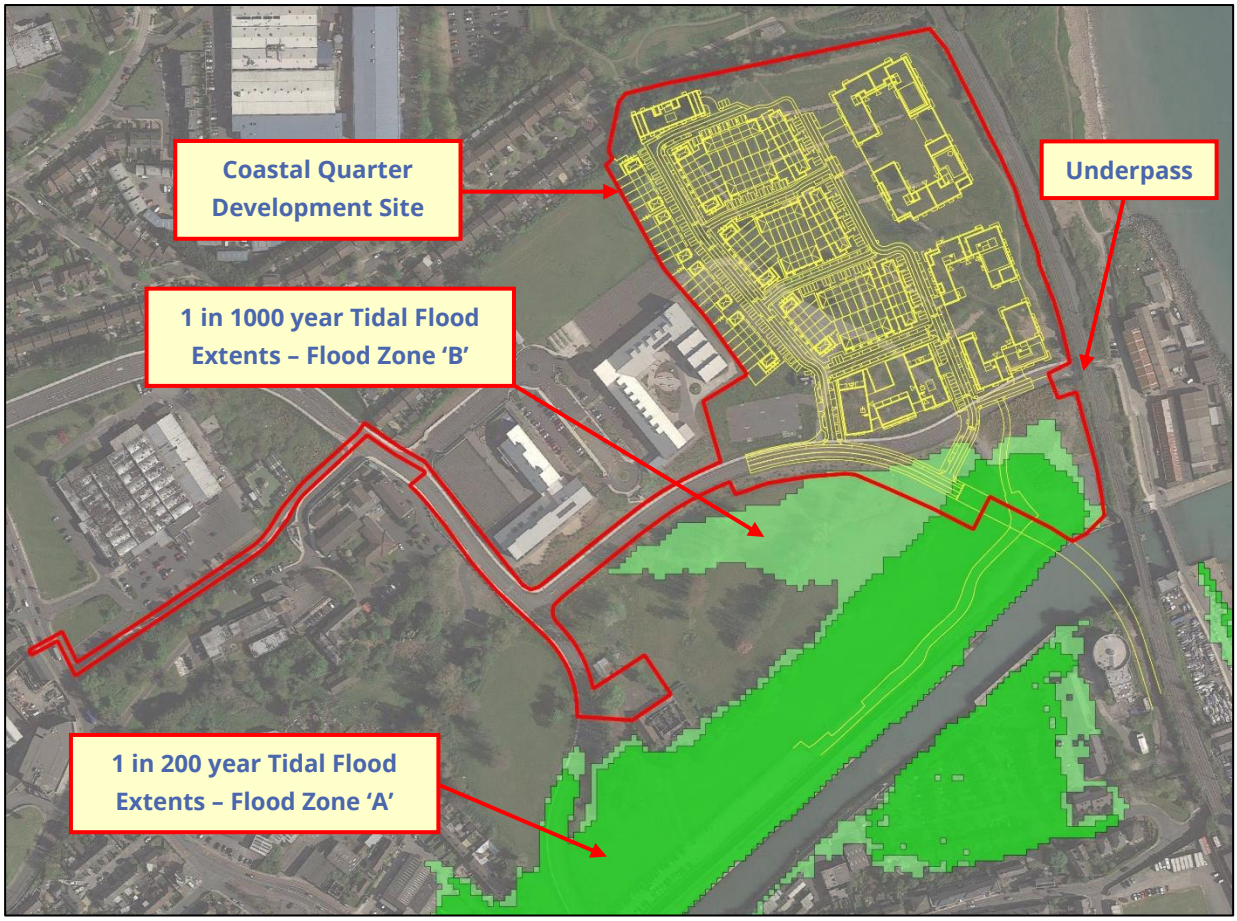

Figure 17 - Baseline 0.5% AEP & 0.1% AEP Tidal Flood Extents (Red line represents approximate location of the proposed site)

An underpass is located along the eastern boundary of the coastal quarter development site under the railway line, which connects the site to the sea front. The hydraulic model was modified to include this location to determine if this could provide a conveyance route for tidal flooding from the east. The results of the analysis showed that ground levels on the eastern side of the underpass (beyond the coastal quarter boundary) are much higher (~4m OD) than the 1 in 1000 year tide level (3.09m OD). Therefore the ground levels around the underpass are deemed to be too high to provide a flow route for tidal flood waters from the east.

6. Proposed Scenario Hydraulic Model Simulation Results

The proposed development comprising 591 no. residential units in a mix of apartments, duplex, and houses, all associated and ancillary development and infrastructural works, hard and soft landscaping and boundary treatment works, associated car and bicycle parking spaces at surface and under croft levels on the former Bray Golf Club lands in the administrative areas of Dun Laoghaire Rathdown and Wicklow County Councils.

As illustrated above in *Figure 16* and *Figure 17* the majority of the Coastal Quarter development site is located within Flood Zone 'C' during both a fluvial dominated flood event and a tidal dominated flood event. A limited portion within the southern corner of the site is located within a Flood Zone 'A' and Flood Zone 'B' during both the fluvial and tidal flood events.

6.1. Hydraulic Model Modifications

In order to enable a sustainable development of the site and to reduce the risk of flood inundation to the site it is proposed to raise ground levels within the southern area of the site. It is also proposed to include a proposed road along the southern boundary within the model. The modifications for the proposed scenario are shown below in *Figure 18* and summarised as follows:

- Raised ground levels in southern area of the site.
- Proposed Road along southern boundary

The impact of raising the ground levels in this location has been assessed using the hydraulic model by adjusting the topography in this location to that of the proposed scenario. Additional model simulations were carried out for the proposed scenario and the results have been compared below.

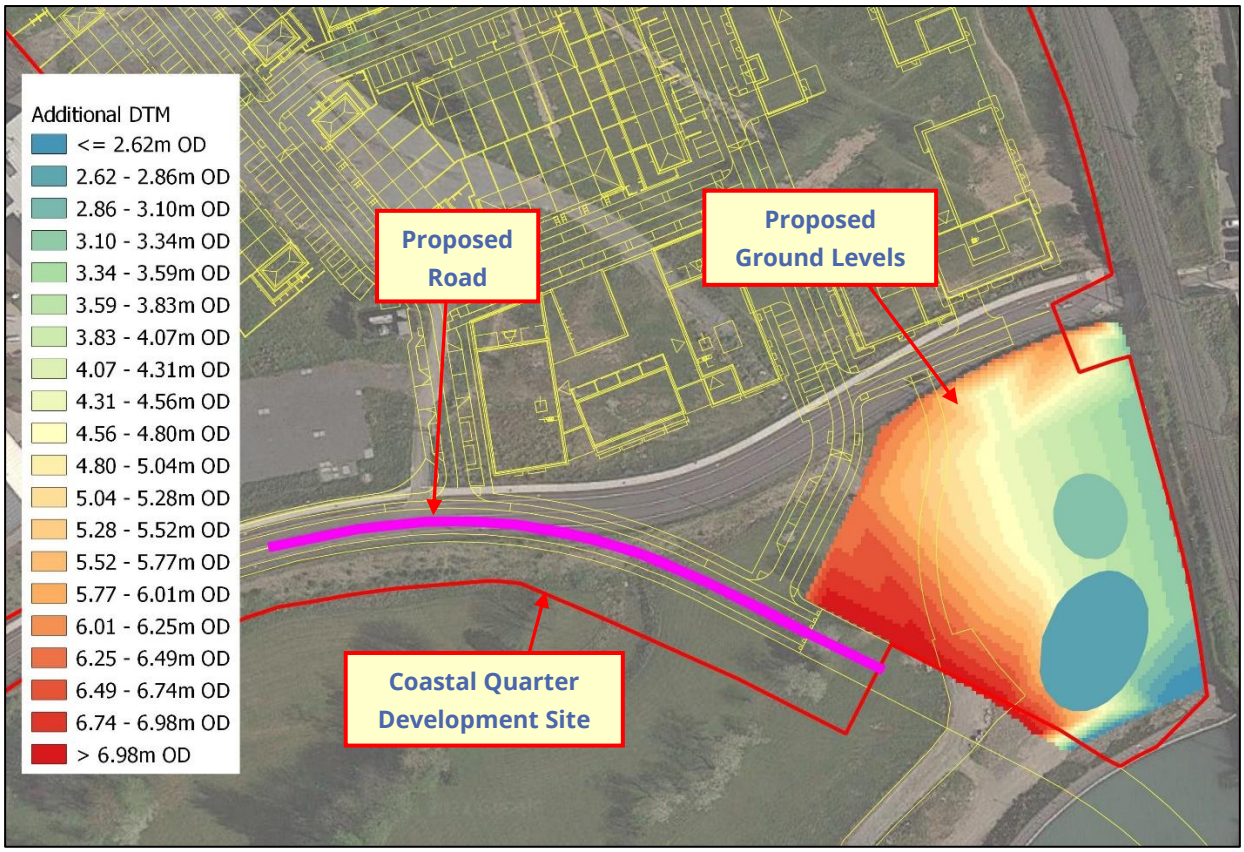

Figure 18 - Topographic Modifications (Red line represents approximate location of the proposed site)

6.2. Proposed Scenario - Fluvial Results

The proposed fluvially dominated flood event was run for the 1 in 100 year and 1 in 1000 year events. The results of the proposed 1 in 100 year fluvial flood event have been compared to the 1 in 100 year baseline scenario, which is illustrated below in *Figure 19*. Although the impact of raising the access ground levels within the southern area of the site is not predicted to have a significant impact on flooding regime in the area, it is proposed to provide flood storage compensation within the proposed development site boundary to compensate for the volume of flood water displaced by the proposed development.

There is a small local increase in water levels immediately adjacent to the Coastal Quarter development site. However this increase is limited to the Applicant's Landholding. There is no increase in flood extents or water levels to surrounding third party lands.

The results of the proposed 1 in 1000 year fluvial flood event were also compared to the baseline 1 in 1000 year fluvial flood event, which is illustrated below in Figure *20*. There is a small local increase

in water levels immediately adjacent to the Coastal Quarter development site. However, this increase is limited to the Applicant's Landholding. There is no increase in flood extents or water levels to surrounding third party lands.

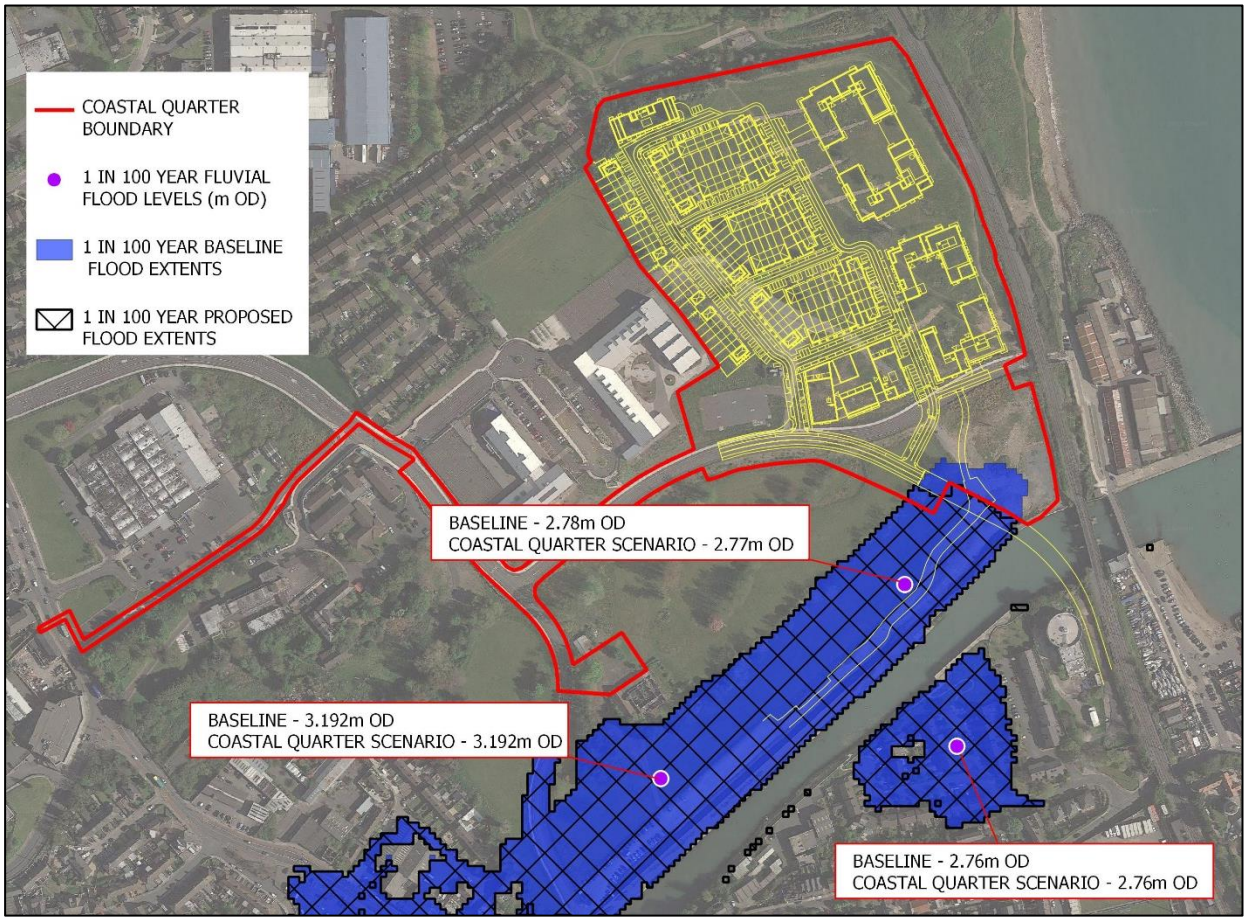

Figure 19 - 1 in 100 year Fluvial Flood Extent- Baseline versus Proposed (Red line represents approximate location of the proposed site)

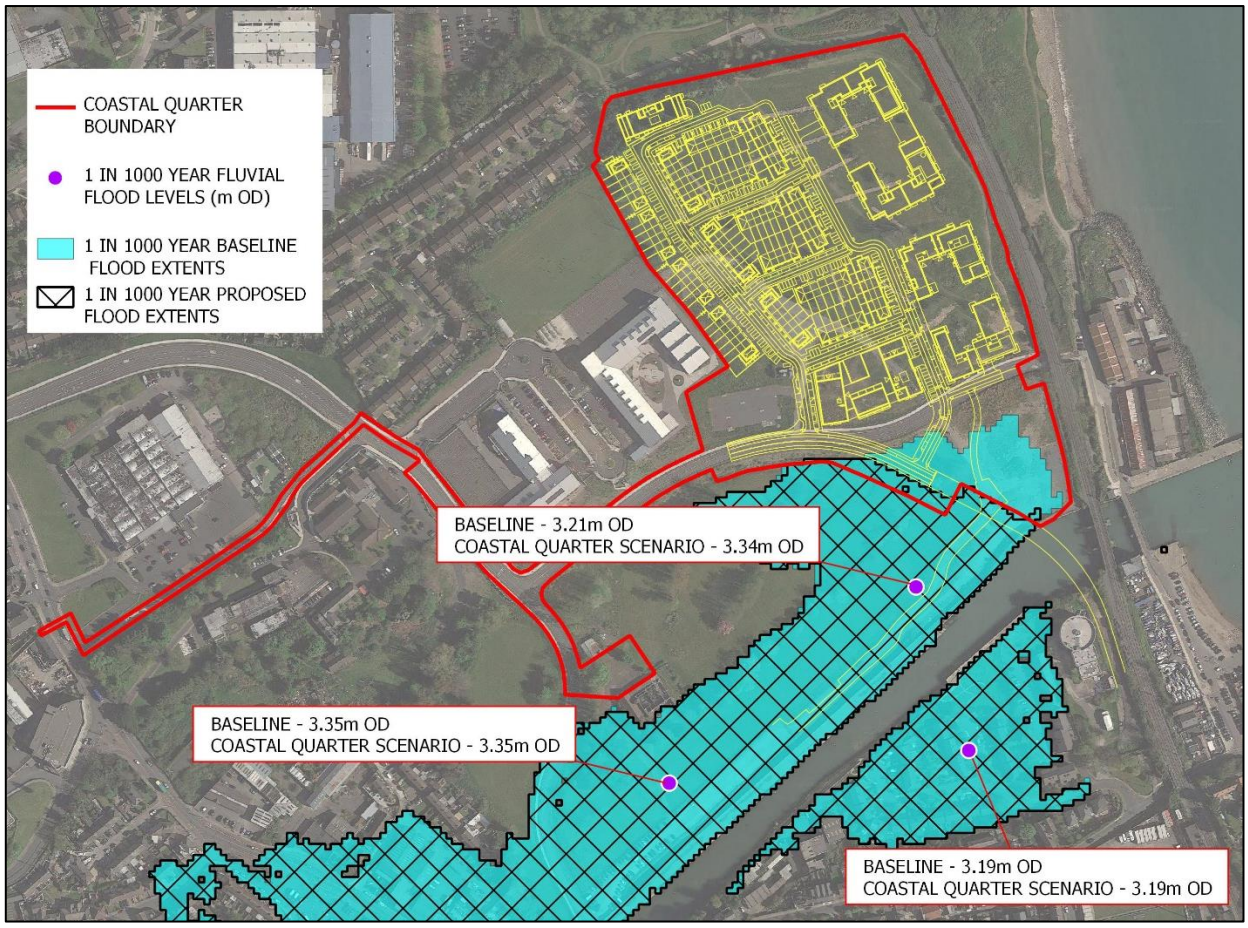

Figure 20 - 1 in 1000 year Fluvial Flood Extent- Baseline versus Proposed (Red line represents approximate location of the proposed site)

6.3. Tidal Proposed Results

The proposed tidally dominated flood event was run for the 1in 200 year and 1 in 1000 year events. The results of the proposed 1 in 200 year tidal flood event has been compared to the 1 in 200 year baseline scenario, which is illustrated below in *Figure 21*. There is a small local increase in water levels immediately next to the coastal quarter development site, which is located within the Applicant's landholding. However there has been no increase in flood extents or water levels to surrounding third party lands.

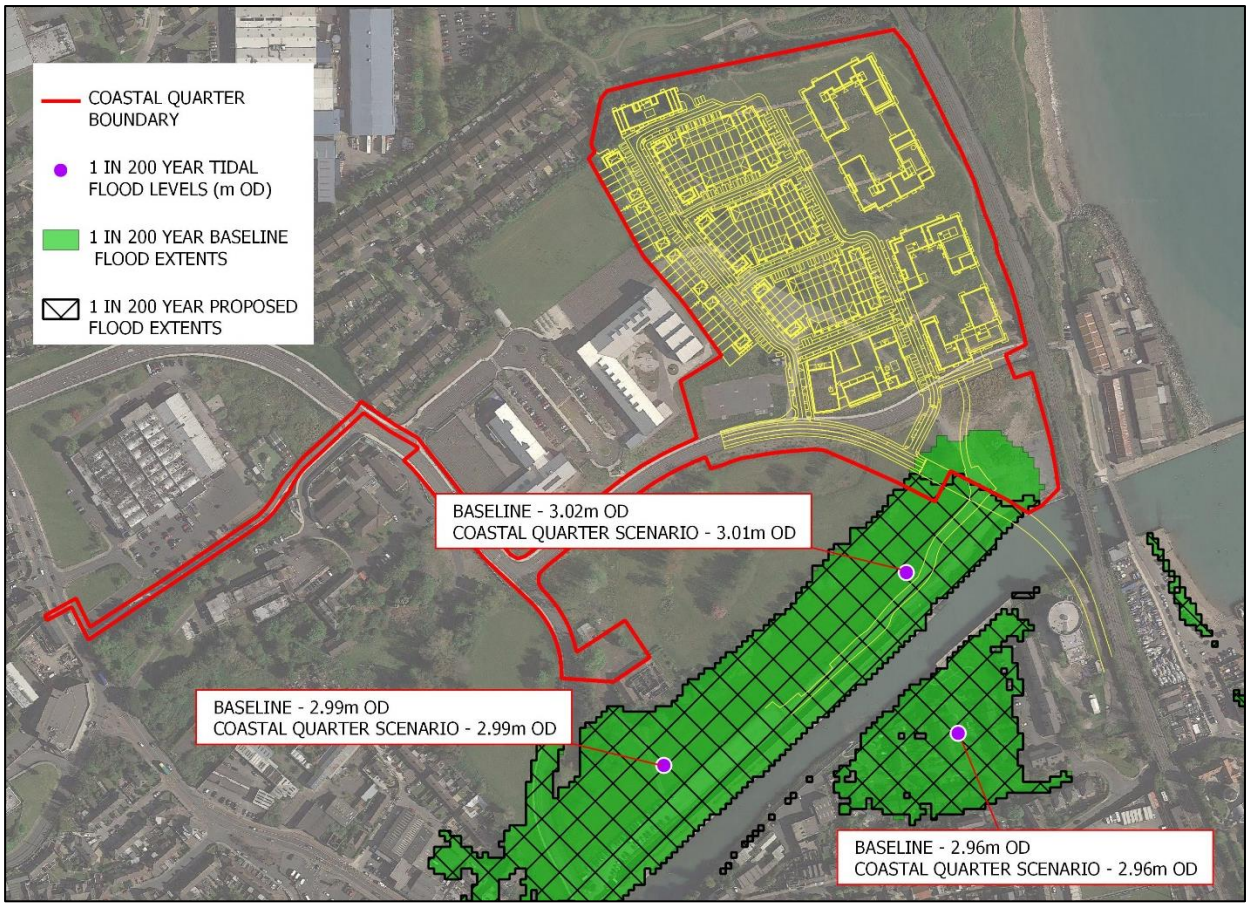

Figure 21 - 1 in 200 year Tidal Flood Extent- Baseline versus Proposed (Red line represents approximate location of the proposed site)

The results of the proposed 1 in 1000 year tidal flood event were also compared to the baseline 1 in 1000 year tidal flood event, as shown in *Figure 22* below. As was seen in the 1 in 200 year event there is a small local increase in water levels immediately adjacent to the coastal development site, however there is no significant increase in water levels or extents outside of the Applicant's landholding.

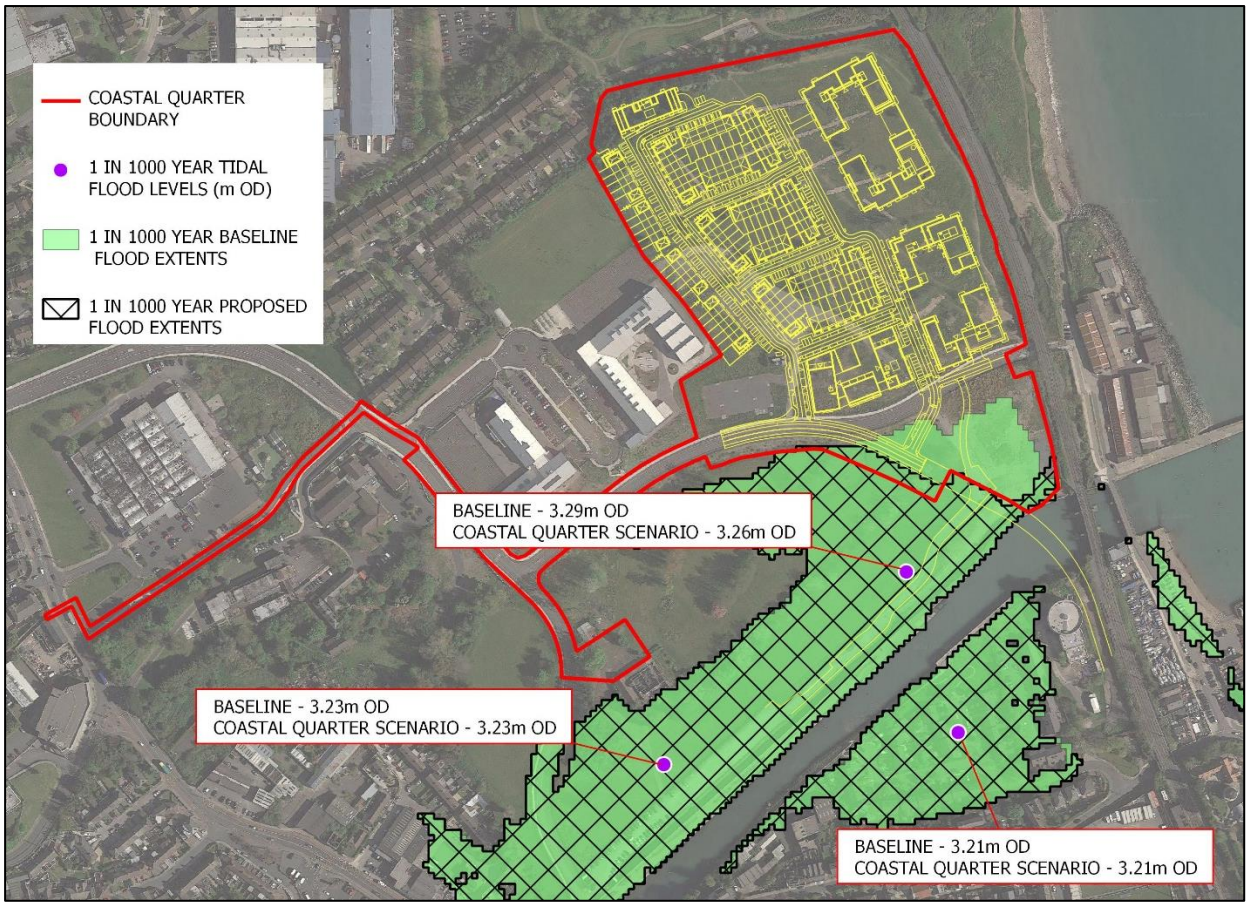

Figure 22 - 1 in 1000 year Tidal Flood Extent- Baseline versus Proposed (Red line represents approximate location of the proposed site)

7. Summary Conclusions

In consideration of the findings of this assessment and analysis the following conclusions are made in respect of the proposed development site:

- *A detailed hydrological analysis has been undertaken of the River Dargle in order to provide an estimate of predicted 1 in 100 year (1% AEP) and 1 in 1000 year (0.1% AEP) in the vicinity of the proposed development site. The predicted 1 in 200 year (0.5% AEP) and 1 in 1000 year (0.1% AEP) tidal flood levels have been analysed in the vicinity of the site.*
- *A linked 1D-2D hydraulic model has been developed of the River Dargle using Flood Modeller Pro over a reach length of approximately 793m. The model has been developed utilising the surveyed river cross sectional data, surveyed geometric data of hydraulic structures and LiDAR data for the area.*
- *A Digital Terrain Model (DTM) has been developed for the general area using the LiDAR data. Utilising the DTM, the predicted 1 in 100 year (1% AEP) and 1 in 1000 year (0.1% AEP) existing scenario fluvial flood extents have been delineated and thematically mapped over the full extent of the DTM. The 1 in 200 year (0.5% AEP) and 1 in 1000 year (0.1% AEP) existing scenario tidal flood extents have also been delineated and thematically mapped over the full extent of the DTM.*
- *A small, limited portion of the southern corner site of the coastal quarter site floods during the fluvial 1 in 100 year and 1 in 1000 year event along with the tidal 1 in 200 year and 1 in 1000 year flood events. No residential development is proposed within this area.*
- *The hydraulic model was modified to include the eastern underpass under the railway line as requested by Wicklow County Council in order to determine if it could provide a conveyance route for tidal flooding from the east. The results of the analysis showed that ground levels on the eastern side of the underpass are much higher than the 1 in 1000 year tide level. Therefore the ground levels around the underpass are deemed to be too high to provide a flow route for tidal flood waters from the east.*
- *In order to enable a sustainable development of the site and to reduce the risk of flood inundation to the site, ground levels have been raised within Flood Zone B for the proposed access road and market square causing minor displacement of flood waters.*
- *Flood storage compensation has been provided within the south eastern portion of the coastal quarter to compensate for the volume of flood water displaced by the proposed development.*

However this increase is limited to the Applicant's Landholding. There is no increase in flood extents or water levels to surrounding third party lands outside of the applicant's landholding.

- *In consideration of the proposed developed scenario, the hydraulic model simulation results indicate that while there is a small local increase in flood levels immediately next to the coastal quarter site boundary, there is no increase in flood extents or water levels outside of the landowners' holdings.*
- *Overall, the development as proposed will not result in an adverse impact to the existing hydrological regime of the area or to increase flood risk to areas outside of the landowners' holdings and is therefore considered to be appropriate from a flood risk perspective.*

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