ARUP

Reside Investments Limited

SHD Residential at Carrigaline

Flood Risk Assessment

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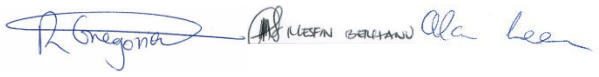
		Signature			
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Executive Summary

Reside Investments Ltd are submitting a Planning Application for a mixed-use development in Carrigaline consisting of 224 no. new dwelling units and small and large commercial units. The development incorporates a 2-storey car park, a creche and double-height retail units.

Arup is commissioned to undertake a Flood Risk Assessment (FRA) for the proposed residential development. The FRA is undertaken in accordance with 'The Planning System and Flood Risk Management' Guidelines for Planning Authorities published in November 2009, jointly by the Office of Public Works (OPW) and the then Department of Environment, Heritage and Local Government (DEHLG).

An assessment of fluvial, tidal, pluvial and groundwater flood risk to the site was carried out. The predominant flood risk to the site is fluvial and tidal from the Owenboy River. The Lee CFRAMS mapping and Cork County Development Plan (January 2022) SFRA mapping indicated that parts of the site near the river are located within Flood Zones A (high risk) and B (medium risk), with areas at the south and higher grounds in Flood Zone C (low risk). A detailed and site-specific hydraulic modelling of the area is undertaken to confirm design flood levels and assess in detail fluvial and tidal flood risk. As a result, the flood zones have been re-calculated and adjusted.

Flood mitigation measures are proposed to prevent inundation of the site. These include dedicating large areas within Flood Zone A for open space amenity uses that are water compatible, raising finished floor levels above the design flood protection level and proposing highly vulnerable uses to higher levels to provide vertical differentiation. Water tanking construction methods are proposed if groundwater proves to be problematic subject to ground investigations. As parts of the development proposals lie within Flood Zone A, level for level flood compensation is proposed within the site to replace any flood storage taken by the development. As such, there are no negative flood impacts from the proposed development to other sites. The measures are designed to adequately protect the site from flooding and allow safe access and egress to the site for up to the 0.5% annual exceedance probability tidal event with allowance for climate change and freeboard.

The proposed drainage system for the development will not increase flood risk to the site or off site. The system proposes to control the rate of run-off from the new development to Greenfield rates, thereby managing any increase in run-off to the Owenboy River. Attenuation storage will be provided underneath the buildings and a petrol interceptor will be installed to capture hydrocarbons before the surface water is discharged to the river.

The potential impacts of the development on flood storage, conveyance and surface water run-off were assessed. The impact of the development on these issues are local to the proposals and negligible at other upstream or downstream receptors. The residual risks to the occupants of the development were assessed as part of the FRA. The residual risk of flooding is considered acceptable.

A Development Management Justification Test was carried out in accordance with the Guidelines. It is demonstrated that the proposed development satisfies all the criteria of the development management Justification Test.

This FRA has demonstrated that the risks relating to flooding can be managed and mitigated to acceptable levels and therefore comply with DoEHLG / OPW and Cork County Council planning guidance.

1. Introduction

1.1 Project Background

Arup was approached by Reside Investments Ltd to undertake a Flood Risk Assessment (FRA) for a proposed mixed-use development comprising residential, retail, childcare space, car parking and public realm works at Carrigaline, Co., Cork. This is a Strategic Housing Development comprising of 224 no. residential units.

The purpose of the FRA is to identify current and potential future risks of flooding to the existing site, as well as outline the flood mitigation measures proposed to ensure the development is safe from flooding in line with the applicable guidelines. This assessment was completed in accordance with 'The Planning System and Flood Risk Management' Guidelines for Planning Authorities published in November 2009, jointly by the Office of Public Works (OPW) and the then Department of Environment, Heritage and Local Government (DEHLG).

1.2 Scope

The scope of the FRA included the following:

- Confirmation of the sources of flooding which may affect the site.
- Review of the availability and adequacy of existing information including but not limited to:
  - The OPW Preliminary Flood Risk Assessment Mapping (PFRA)
  - Lee Catchment Flood Risk Assessment and Management (CFRAM) Study
  - Historic flooding information for the area
  - Groundwater information from OPW's Draft Preliminary FRA
  - Existing drainage records
  - Available topographical information for the site.
- Hydrological assessment and hydraulic modelling of the Owenboy River to assess the risk of flooding to the site and to adjacent sites as a result of construction of the proposed development.
- Identification of possible measures which could mitigate the flood risk to acceptable levels.

1.3 Summary of Data Used

In preparing this report, data regarding flood risk relevant to the proposed development and surrounding area has been obtained from the following sources:

- OPW National Flood Hazard Mapping website (https://www.floodinfo.ie/).
- Lee CFRAM Hydrology and Hydraulics Reports and predictive flood mapping (https://www.floodinfo.ie/).
- Draft Cork County Development Plan 2022-2028 (https://www.corkcoco.ie/en/cork-county-development-plan-2022-2028)
- Cork County Development Plan 2021 Strategic Flood Risk Assessment
- Ballincollig - Carrigaline Municipal District - Local Area Plan 2017, Environmental Reports and Map (http://corklocalareaplans.com/ballincollig-carrigaline-municipal-district/)
- Site Geological and hydrogeological data from the Geological Survey of Ireland website (www.gsi.ie).
- Topographical survey of the site and environs.

- Survey data of Owenboy River.
- Proposed Development Planning Application Drawings.
- Aerial photography and mapping from Bing Maps and Google Maps.

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

2. Site Description

2.1 Site Location

The development site is approximately 3.0ha in area and is located west of Carrigaline town centre, Co. Cork.

An overview of the area is shown in Figure 1 below, with the development boundary outlined in red.

Figure 1: Site location (©2022 Google, Maxar Technologies Map Data ©2021)

The site is bounded to the south by a residential housing and Kilmoney Road Lower, to the east by the Dairygold Co Op superstore, to the north by Owenboy River and west by agricultural land. The Western Relief Road is currently under construction along the western boundary.

The site is currently a greenfield and is zoned for Town Centre uses. It slopes from south to north towards the Owenboy River, which meanders along the northern site boundary from east to west. The topography ranges significantly within the site, with higher levels at the southwest boundary at 11.0m OD and lower levels at the north along the river at 1.8m OD.

A topographic survey of the site was undertaken in December 2020 by Precise Control and an extract is shown in Figure 2. This is also included in Appendix A.

Figure 2: Site topography

2.2 Proposed Development

It is proposed to construct 224 no. new dwelling units on a net developable area of 2.0ha at Kilmoney Rd Lower, Carrigaline. The dwelling units are proposed to be incorporated within two 4 storey apartment blocks with own door units provided.

The proposed development will consist of the following components:

- The construction of 224 no. residential units consisting of 202 no. proposed apartments in 2 no. blocks, ranging in height from 6 to 7 storey and 22 no. townhouse/duplex units:
- A 184 m^2 creche/childcare facility;
- The provision of landscaping and amenity areas to include 1 no. local play area, 1 no. kick about areas, an activity trail/greenway along the river, a gathering area/amphitheatre with tired seating areas, a civic space/promenade and 2 no. courtyard areas;
- The provision of 3 no. retail units, residential amenity and management spaces at ground and first floor level; and
- All associated ancillary development including vehicular access on to the Kilmoney Road Lower, and a cycle/pedestrian connection on to the R611 (via an activity trail/greenway along the river), lighting, drainage, roads boundary treatments, ESB Substation, bicycle & car parking and bin storage.

Figure 3: Proposed development (Henry J Lyons Architects)

3. Methodology

The following planning policy documents were used to assess the proposed development:

- The Planning System and Flood Risk Management Guidelines for Planning Authorities - OPW & Department of the Environment, Heritage and Local Government (November 2009)
- Draft Cork County Development Plan 2022-2028 and SFRA
- Ballincollig - Carrigaline Municipal District - Local Area Plan 2017.

3.1 The Planning System and Flood Risk Management Guidelines

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

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

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

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

The guidelines require the adoption of a Sequential Approach to Flood Risk Management of Avoidance, Reduction, Justification and Mitigation and they require the incorporation of Flood Risk Assessment into the process of making decisions on Planning Applications and Planning Appeals. The assessments are completed in three stages:

i. Stage 1 – Flood risk identification,

ii. Stage 2 - Initial flood risk assessment, and

iii. Stage 3 - Detailed flood risk assessment

Key to the Planning guidelines is the introduction of flood risk zoning and the classifications of different types of development having regard to their vulnerability. The management of flood risk is now a key element of any development proposal in an area of potential flood risk and should therefore be addressed as early as possible in the site master planning stage.

Safe access and egress during a flood event are also a fundamental part of the guidelines.

3.1.1 Definition of Flood Zones

Flood Zones are geographical areas within which the likelihood of flooding is in a particular range.

There are three types of flood zones defined in the Planning guidelines as follows:

Table 3-1: Flood Zone Categories

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

3.1.2 Definition of Vulnerability Classes

The following table summarises the Vulnerability Classes defined in the Planning Guidelines and provides a sample of the most common type of development applicable to each. The proposed development uses in Carrigaline are a) residential, b) retail and c) amenity open space with riverside greenway and are considered *Highly Vulnerable*, *Less Vulnerable* and *Water Compatible* respectively.

Table 3-2: Vulnerability Classes

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

3.1.3 Sequential Approach and Justification Test

The Planning Guidelines outline the sequential approach that is to be applied to all levels of the planning process. This approach should also be used in the design and layout of a development and the broad philosophy is shown in Figure 4. In general, development in areas with a high risk of flooding should be avoided as per the sequential approach.

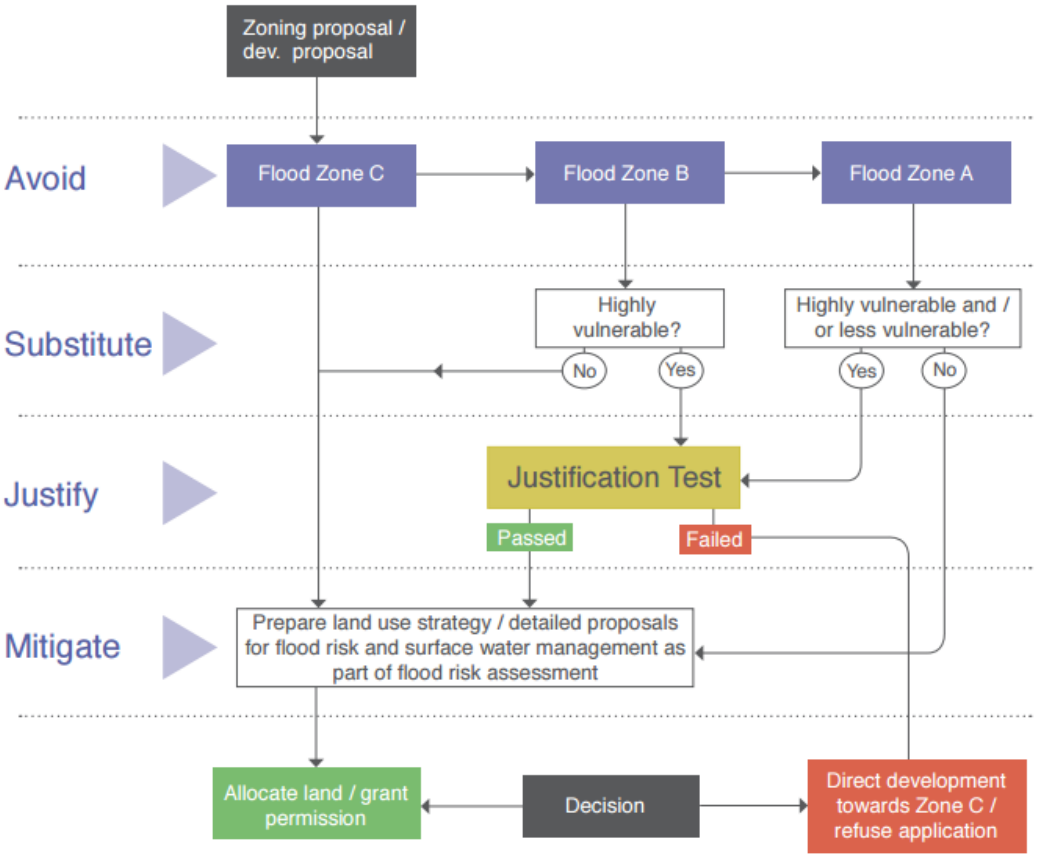

Figure 4: Sequential approach (reproduced from the Planning Guidelines)

The Justification Test has been designed to rigorously assess the appropriateness, or otherwise, of developments that are being considered in areas of moderate or high flood risk. The test comprises the following two processes.

- The first is the Plan-making Justification Test and is used at the plan preparation and adoption stage where it is intended to zone or otherwise designate land which is at moderate or high risk of flooding.

- The second is the Development Management Justification Test and is used at the planning application stage where it is intended to develop land at moderate or high risk of flooding for uses or development vulnerable to flooding that would generally be inappropriate for that land.

Table 3-3 illustrates the different types of Vulnerability Class appropriate to each zone and indicates where the Justification Test is required.

Table 3-3: Vulnerability classes matrix

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

The Planning Guidelines recognise that there is a need to reconcile the desire to avoid development in areas at risk of flooding while also ensuring sequential and compact urban development as several large urban centres are already located in areas that are at risk of flooding.

3.2 Draft Cork County Development Plan 2022-2028

The Draft Cork County Development Plan 2022 (CDP) has become available for public consultation and amendments are being considered (no amendments are proposed for the subject site yet), with the aim that the plan is expected to be adopted on 25th April 2022 and come into effect on 6th June 2022.

The draft Plan includes policies and actions specific to flood risk management which were informed by the Flood Risk Management Guidelines. Chapter 11 – Water management of the Plan details Cork County Council's approach to Flood Protection and Flood Risk. The following summarises sections of particular interest to the proposed development in Carrigaline.

3.2.1 WM 11-13: Floodplains and Wetlands

The plan states that floodplains, wetlands and coastal areas subject to flooding are protected as vital green infrastructure that provide space for storage and conveyance, enabling flood risk to be more effectively managed and reducing the need to provide flood defences in the future.

3.2.2 WM 11-14: Flood Risk – Overall Approach

The Draft Cork County Development Plan states that the following approach is implemented to reduce the risk of new development being affected by possible future flooding:

- Avoid development in areas at risk of flooding; and
- Where development in floodplains cannot be avoided, take a sequential approach to flood risk management based on avoidance, reduction and mitigation of risk;
- Implement the recommendations of the South Western CFRAM study.
- Where a development proposal is in 'Zone A' – an area with a high probability of flooding:

"avoid development other than 'water compatible development' as described in Section 3 of The Planning System and Flood Risk Management Guidelines for Planning Authorities issued in November 2009 by DoEHLG".

- If the development proposal is in 'Zone B' – an area where there is a moderate probability of flooding:

"avoid 'highly vulnerable development' described in Section 3 of 'The Planning System and Flood Risk Management – Guidelines for Planning Authorities' issued in November 2009 by DoEHLG".

3.2.3 WM 11-15: Development in Flood Risk Areas

The Plan states that all proposals for development falling within Flood Zones A & B identified as being at risk from flooding will need to be supported by a site-specific flood risk assessment and are consistent with the Ministerial Guidelines – 'The Planning System and Flood Risk Management".

Cork County Council has developed flood zone maps as part of the Strategic Flood Risk Assessment. The flood zones are based on the flood risk mapping outputs from the CFRAM studies.

In the Draft CDP the site is zoned for town centre uses with the following CL-T-01 objective: "*This area denotes the built existing footprint of the town centre and any proposals for development within this core area should comply with the overall uses acceptable in town centre areas. The western inner relief is due to commence construction in 2021 and the delivery of this road offers opportunities to deliver an updated public realm for the town including the introduction of new public spaces. These should be designed to accommodate a number of community functions including a market space, festival space, meeting place, seating area etc. The desirable location of these future public spaces are:*

- *The site of the existing car park adjoining the Main Street and River;*
- *Within the town centre expansion area west of the Main Street and should form part of a wider public realm strategy for the town.*

Community uses which will be considered appropriate for this site include youth facilities, theatre, cinema, town hall / multi purpose building and town square. Within the site there will be opportunity for regeneration and town centre expansion. The road scheme will give priority to pedestrians and cyclists and will provide permeability to the rest of the town including the open space area directly adjacent to the site (CL-GR-02)"* (* denotes the requirement for a Flood Risk Assessment).

There are no amendments proposed to the CL-T-01 objective and therefore the above zoning objective will be the adopted/operative zoning for the subject site in the forthcoming CDP.

The draft Plan and proposed amendments were subject to a Strategic Flood Risk Assessment (SFRA) in accordance with the "Plan Making Justification Test" in the 'The Planning System and Flood Risk Management' Guidelines for Planning Authorities published in November 2009.

The SFRA highlights the following design considerations relevant to the site:

- Raising finished floor levels can be an effective way of avoiding damage to the interior of a building in times of flood. Levels should be raised at a minimum to the following:
    - Fluvial, undefended: 1% AEP flood + climate change + 300mm freeboard
    - Tidal, undefended: 0.5% AEP flood + climate change + 300mm freeboard (or +500mm freeboard where wave overtopping, and surge is an additional risk).
- The climate change allowances shall be as described in Table 49 of the SFRA, summarised below:
    - Less vulnerable & Highly vulnerable development: 20% increase in flows and 0.5m increase in sea levels (Mid-Range Future Scenario - MRFS).

3.3 Ballincollig - Carrigaline Local Area Plan 2017

The Ballincollig - Carrigaline Local Area Plan (LAP) contains the policies and objectives to guide development and land use in the Municipal District. The area of the development is zoned for Town Centre uses with objectives for community uses, priority to pedestrian and cyclists and expansion and regeneration of the urban centre. The southern part of the site backing into existing residential development on the Kilmoney Road may have a mix of residential development.

All proposals for development within areas identified as being at risk of flooding shall comply with the objective of the objectives under Chapter 11 – Water management of the Cork County Development Plan and with the provisions of the Ministerial Guidelines – 'The Planning System and Flood Risk Management'. A site-specific Flood Risk Assessment will be required.

3.4 Consultations with Cork County Council

A 247 meeting was held with Cork County Council on 11th August 2021. Among other subjects, flood risk and management at the site was presented to the council and discussed.

A follow up meeting with the Drainage division of the council was held on 14th January 2022 to discuss the management of flood risk on site.

The overall flood management strategy for the site was presented and the Council pointed out that the following items are considered and included in the site-specific FRA:

- Climate change factors and associated OPW guidelines on uplift figures are being followed,
- Operation and maintenance of the flood mitigation measures (storage areas, or crates), including access requirements, regularity of maintenance and responsibility, and
- A Flood Awareness Plan and preliminary Flood Emergency Response Plan shall be prepared for developments within either Flood Zones A or B.

The council also noted that Carrigaline was identified as AFA (area for further assessment) under the Lee CFRAMS and that the South Western CFRAM and '*the Carrigaline Flood Relief Scheme is under review to confirm the technical aspects and viability, and, subject to outcomes, will then progress to Outline Design and Planning.'*

The council had expressed no objection to the proposed approach as set out in the presentation other than the comments above are considered.

4. Stage I – Flood Risk Identification

4.1 Potential Flood Sources

In broad terms, the potential sources of flooding at the site and its vicinity can be categorised as:

- Fluvial (River) Flooding – There is a potential risk of fluvial flooding from the Owenboy River at the northern part of the site,
- Coastal / Tidal Flooding – There is a potential risk of tidal flooding from Owenboy estuary at the site,
- Pluvial Flooding/urban drainage - Pluvial flooding occurs when the capacity of the local surface water network is exceeded during periods of intense rainfall. At these times, water can collect at low points in the topography and cause flooding,
- Groundwater Flooding - This can occur during lengthy periods of heavy rainfall, typically during late winter / early spring when the ground water table is already high. If the groundwater level rises above ground level, it can pond at local low points and cause periods of flooding.

4.2 Historic Flood Data

Records of historic fluvial and tidal floods were obtained (accessed in March 2022) from the OPW National Flood Hazard mapping website, http://wwww.floodinfo.ie.

There are no records of fluvial or tidal flooding within the site boundary. There are, however, a number of events recorded at close proximity.

An extract map is shown in Figure 5 below with the site boundary indicated in red and details of the events are included in Table 6-1. A summary report is contained in Appendix B.

Figure 5: Historic Flood Points (source floodinfo.ie)

Table 4-1: Historic Flood Events (source floodinfo.ie)

Point	Flood event	Date	Source
1	Carrigaline Main Street Area	26/10/2004	Coastal/ Estuarine
2	Property (Rosie's Pub) in Carrigaline centre	16-17/10/2012	High tides and pluvial flooding
3	Property (Rosie's Pub) in Carrigaline centre	14/12/2012	High tidal water/surface depression
4	Carrigaline City Centre (Main Street, Strand Road and Crosshaven road)	02/01/2014	High tide driven by high winds
5	Carrigaline bridge	19/10/2009	Heavy rainfall, surface water drainage.

4.3 Fluvial Flood Risk

The Lee CFRAM study was undertaken on behalf of OPW to assess flood risk from rivers and the sea in the Lee catchment between 2009 and 2012. Flood maps were produced and are openly available on floodinfo.ie.

An extract from the Lee CFRAMS fluvial (current) flood extent map is displayed in Figure 6. The predicted fluvial flood extents for three separate return period events are presented on the map: 1 in 10 (10% Annual Exceedance Probability AEP), 1 in 100 (1% AEP) and 1 in 1000-year (0.1% AEP) fluvial flood extents.

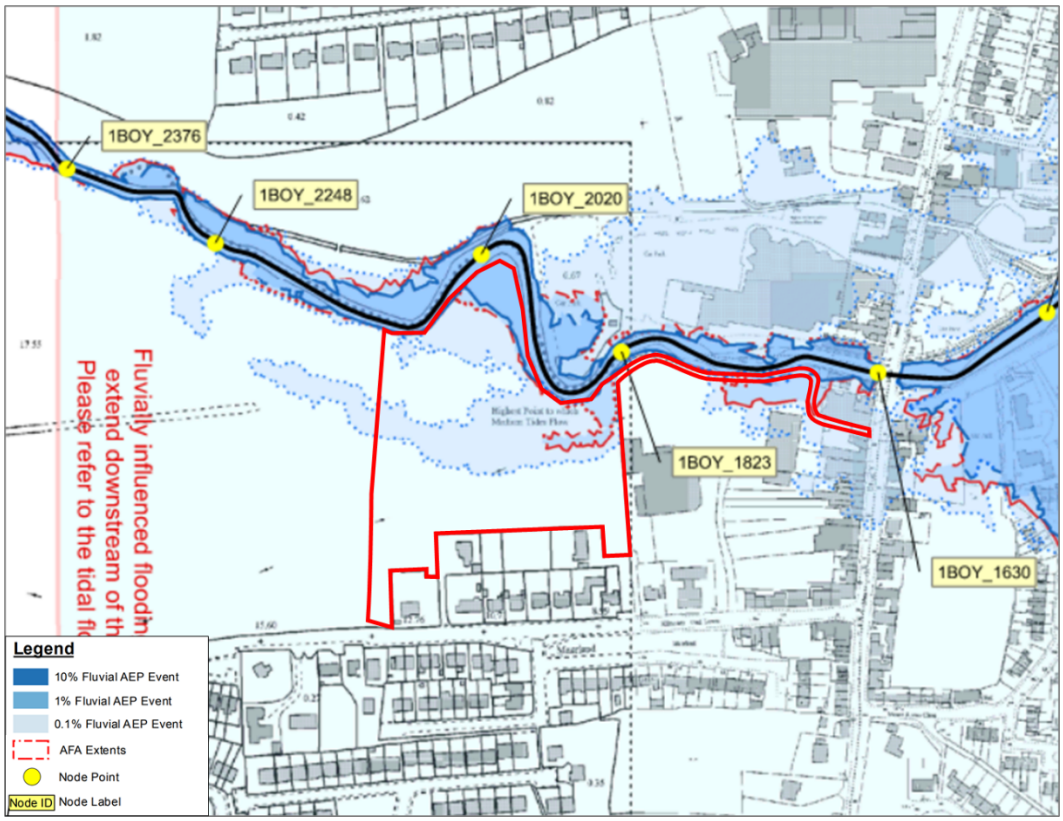

Figure 6: Lee CFRAMS fluvial flood extents (current scenario)

The CFRAM flood mapping indicates that parts of the site on the low-lying north part and riverside greenway lie within the 10%, 1% and 0.1% AEP extents. The 0.1% fluvial event extends to the centre of the site, where some buildings are proposed. The development site therefore partially lies in Flood Zones A, B and C.

The peak fluvial flood level at the site (node 1BOY_2020) during the 1% AEP event is 2.88mOD and during the 0.1% event is 3.13mOD.

The above modelling is based on the hydrological assessment done for Owenboy river as part of the Lee CFRAM studies in 2009 by Halcrow, on behalf of the OPW. The assessment made use of the Flood Estimation Handbook (FEH) method and Flood Studies Report (FSR) techniques for UK and Ireland. Since then, these methods have been superseded by the Flood Studies Update (FSU) methodology for Ireland developed by the OPW. Furthermore, more hydrometric data have been collected since the study was done. As such, a new analysis has been done for the Owenboy River for the purposes of this FRA and updated flood maps have been produced. The updated hydrology and hydraulic modelling for the site are presented in Chapters 5 and 6.2.

4.4 Tidal Flood Risk

As part of the 2009 Lee CFRAM studies, the risk of flooding due to tidal inundation was also assessed.

An extract from the Lee CFRAMS tidal (current) flood extent map is displayed in Figure 7. The predicted fluvial flood extents for three separate return period events are presented on the map: 1 in 10 (10% AEP), 1 in 200 (0.5% AEP) and 1 in 1000-year (0.1% AEP) fluvial flood extents.

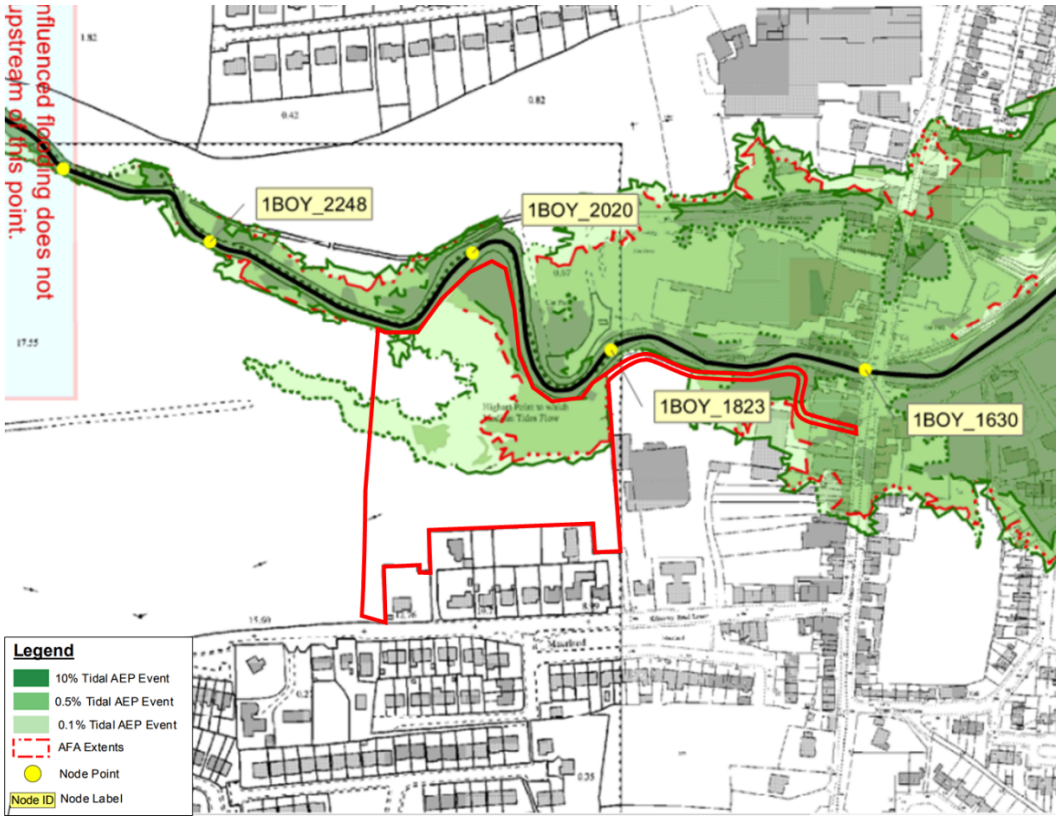

Figure 7: Lee CFRAMS tidal flood extents (current scenario)

The CFRAM flood mapping indicates that parts of the site on the low-lying north part and riverside greenway lie within the 10%, 0.5% and 0.1% AEP extents. The 0.5% and 0.1% AEP tidal event extents further to the centre of the site. The development site therefore partially lies in Flood Zones A, B and C.

The peak fluvial flood level at the site (node 1BOY_2020) during the 0.5% AEP event is 2.98mOD and during the 0.1% AEP event is 3.16mOD.

As with the fluvial modelling, tidal modelling has also been updated with an updated hydrology, following the latest guidance by OPW. Updated flood extents have been produced and are presented in Section 6.2.

4.5 Pluvial Flood Risk

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

The site is greenfield and as such there are no known surface water drainage sewers within the site.

The OPW has prepared Preliminary Flood Risk Assessment (PFRA) mapping for all sources of flooding.

The fluvial maps have been superseded by the CFRAM studies; however, flood risk from pluvial flooding has not yet been assessed in higher accuracy or detail.

An extract from the draft PFRA map is presented in Figure 8. No pockets of pluvial flooding are found at the site or in the vicinity. However, it should be noted that the accuracy of the maps is low and only indicative.

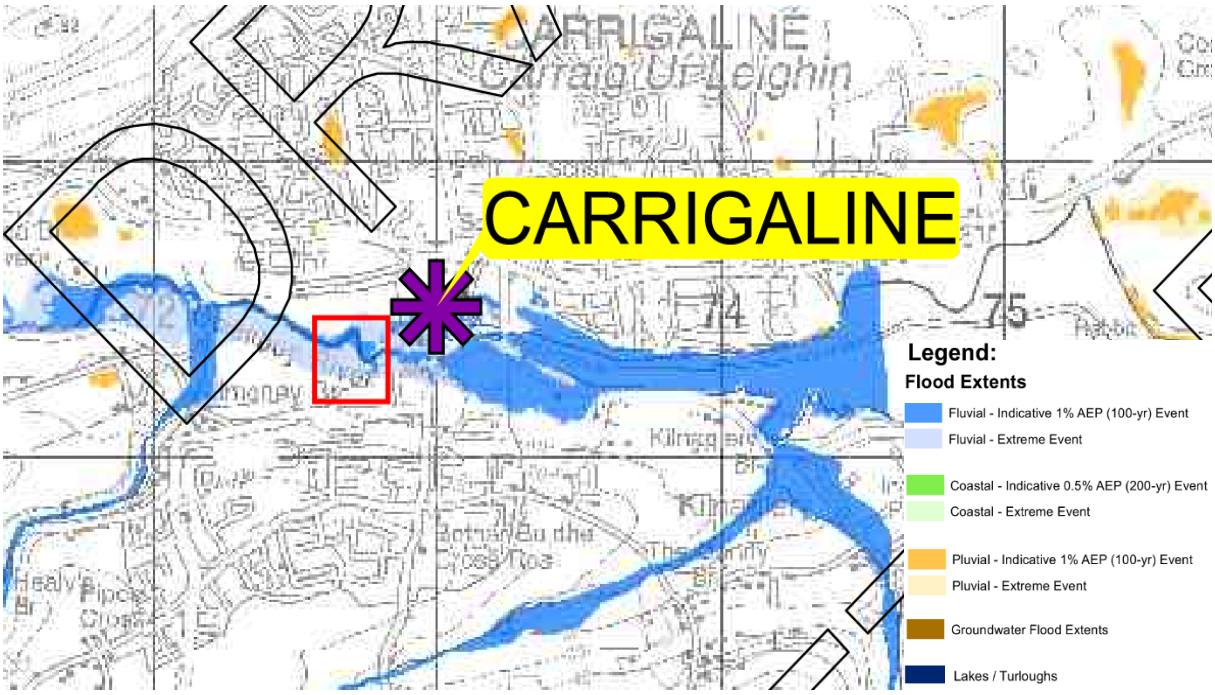

Figure 8: PFRA Draft Pluvial Flood Map

There appears to be little history of pluvial flooding at the site, and the available predictive pluvial flood mapping has not highlighted a particular risk. However, surface water run-off from higher grounds surrounding the site could potentially pose a risk of pluvial flooding to the properties. Appropriate landscaping and regrading to direct any run-off away from the buildings are proposed.

4.6 Groundwater Flood Risk

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

The Geological Survey of Ireland (GSI) "GWFlood" project predictive flood mapping[1] did not indicate a risk of groundwater flooding at the site.

No evidence of historic groundwater flood risk at the site was found.

[1] https://www.gsi.ie/en-ie/programmes-and-projects/groundwater-and-geothermal-unit/activities/groundwater-flooding/gwflood-project-2016-2019/Pages/default.aspx

Figure 9 presents information on the Geological Survey of Ireland (GSI) groundwater vulnerability for the proposed development. It can be seen from the figure that the groundwater vulnerability is indicated as moderate and high for the site, indicating that the groundwater table has a moderate and high level of vulnerability as the overburden soils are likely to be permeable. However, this mapping does not give a clear indication of the potential for groundwater flood risk at the site.

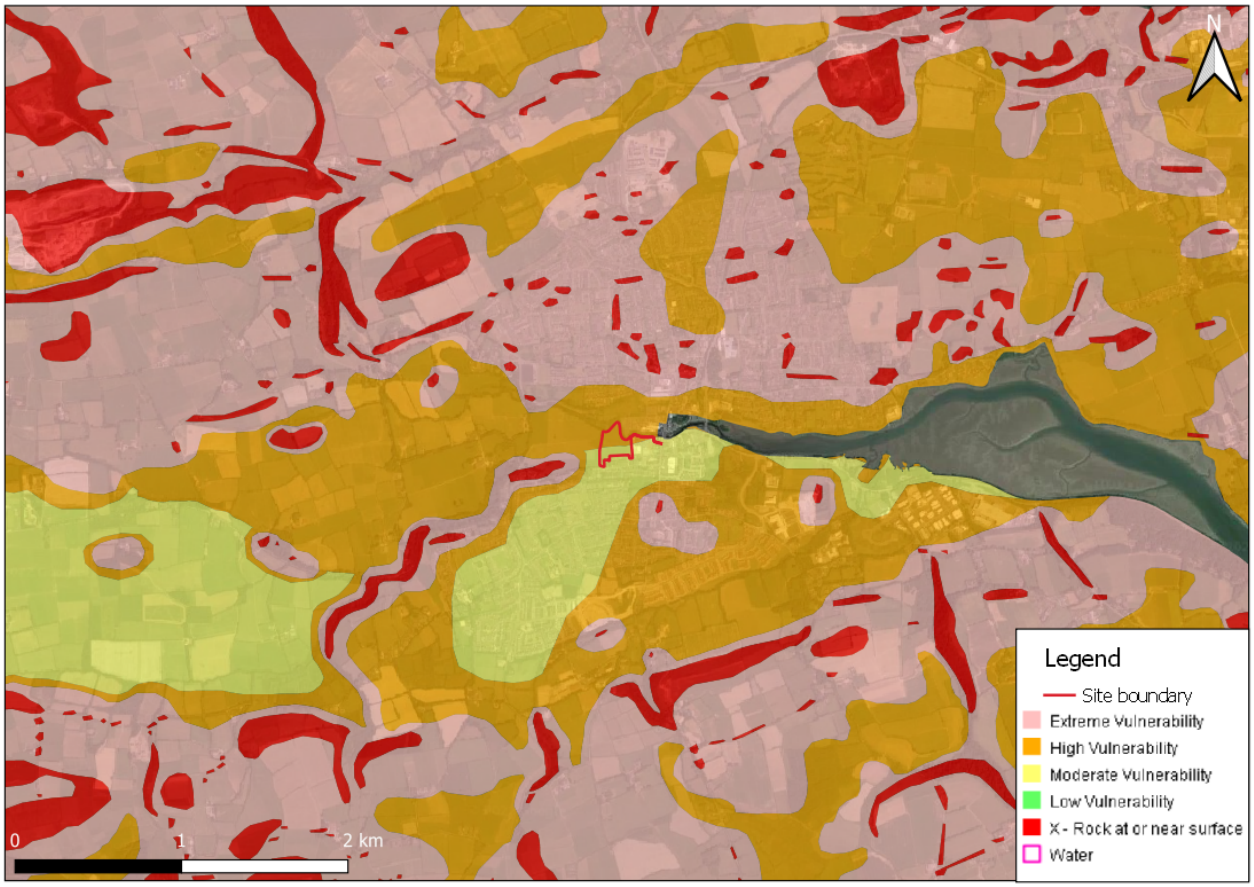

Figure 9: Groundwater Vulnerability Map – Geological Survey of Ireland (www.gsi.ie)

Ground investigations have been undertaken for the purposes of the adjacent Western Relief Road over the period 05/10/2006 to 04/01/2007. The scope of the site investigation was to investigate subsurface ground conditions by means of cable percussion boreholes with rotary follow-on, trial pits and lab testing. The locations of the boreholes and trial pits closer to the site are shown in Figure 10.

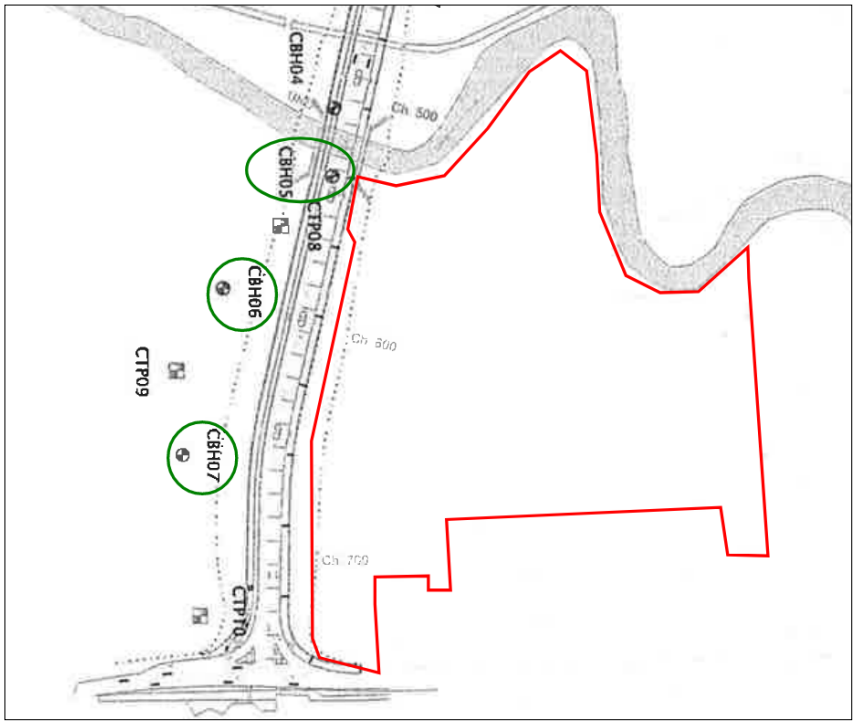

Figure 10: Location of boreholes and trial pits near the site (Western Relief Road site investigation, 2007)

The trial pits closest to the site indicated that the alluvium layers are mainly gravels. Three boreholes are located very close to the site, CBH5, CBH6 and CBH7. Borehole CBH5 located closest to the river shows 8m of clay with a band of sand from 1.6-2.9m b.g.l. (below ground level). CBH06 indicates gravels from 1.3-7.5m b.g.l. CBH07 indicates 8.5m of clay with a band of gravel from 2.7-5.7m b.g.l.

Monitoring of groundwater was undertaken between 23/12/06 to 16/04/07 at CBH05 and CBH06. The monitoring indicates artesian conditions at CBH05 and very shallow groundwater (0.05-0.29m b.g.l) at CBH06. CBH06 is shown at 3.243m AOD, indicating the groundwater levels could be at 3.193m AOD (when groundwater levels is as high as 0.05m b.g.l). This level is higher than the average river level during normal conditions (recorded at 1.2m AOD during river surveys in August 2021).

The above information indicates shallow ground water levels near the site. The risk of groundwater flooding to the site is therefore considered moderate. It is recommended that the groundwater levels are monitored long-term as part of the site investigations and measures are put in place to prevent hydrostatic uplift during construction, construction dewatering as well as measures to prevent water ingress to lower levels and basements.

4.7 Summary of Existing Flood Risk

The risk of flooding to the existing site from fluvial, tidal, pluvial and groundwater sources was assessed. Historical records show that the site is at low risk of flooding. However, the Lee CFRAM study 2009 indicates that the site lies in areas at risk of flooding from fluvial and tidal sources. Therefore, the development site partially lies within Flood Zones A and B.

The risk of pluvial flooding to the site is currently low. However, the drainage system may increase the risk of flooding, if not designed properly

Groundwater information from nearby boreholes indicate shallow groundwater table due to its proximity to the Owenboy River and hence the risk of groundwater flooding to the site is considered moderate.

As a result of the risks identified, the assessment is progressed to Stage II – Flood Risk Assessment.

5. Stage II – Initial Flood Risk Assessment

The purpose of Stage 2-FRA is to confirm flooding sources, appraise the adequacy of existing information and to scope the extent of the risk of flooding and assess possible mitigation measures. Stage 1 flood risk assessment has identified the primary sources of flooding to the site. The Source-Pathway-Receptor model outlined in Section 5.1 below shows the appraisal of these sources.

5.1 Source-Pathway-Receptor Model

A Source-Pathway-Receptor model was developed to assess the risks from the various sources of flooding. The model provides the likelihood of flooding from the specified source and its consequence taking account of the vulnerability classification of the development and mitigation measures in place. The basis of the scores is shown below:

- Likelihood:
  - Remote (1): less the 0.1% AEP
  - Unlikely (2): 0.1% AEP
  - Possible (3): 1% AEP
  - Likely (4):10% AEP
- Consequence:
  - Minimal (1): inconvenience
  - Medium (2): damage to property
  - High (3): damage to property and injury
  - Major (4): loss of life and damage to property
- Risk: Low (<=3), Medium (b/n 3 and 6), High (b/n 8 and 12), Very High (>16)

Table 5-1 Source-Pathway-Receptor Model

Source	Pathway	Receptor	Likelihood	Consequence	Risk
Fluvial	Overbank Flow	People/ Property	Possible (3)	High (3)	High (9)
Tidal	Sea Level Rise	People/ property	Possible (3)	High (3)	High (9)
Surface water	Blockage/ Overflow	People/ Property	Remote (1)	Medium (2)	Low (2)
Groundwater	Rising Water Table	People /Property	Remote (1)	Medium (2)	Low (2)

The risk of fluvial and tidal flooding sources is appraised as “high”. Therefore, it will be necessary to further assess the risk of flooding from these sources. The flood event that would result in the worst flood levels and extents is the tidal source and hence will be used to set the flood protection levels for the development site.

5.2 Conclusion of Stage II – Initial Flood Risk Assessment

The proposed site for redevelopment is classified as within Flood Zones A and B from both fluvial and tidal flood sources. Therefore, the impact of the development on flooding elsewhere and the scope of possible mitigation measures must be assessed using a hydraulic model. The CFRAM 2009 study was based on

hydrological methods that have now been superseded by new data have become available since its completion. As such, the hydrological analysis and hydraulic modelling had to be updated to re-produce flood extents, revised Flood Zones and to:

- Propose the development FFLs,
- Assess the impact, if any, of the development on flood risk elsewhere,
- Assess the adequacy of the proposed mitigation measures, and
- Determine the residual risk, if any.

For this reason, the Flood Risk Assessment was progressed to Stage III – Detailed Flood Risk Assessment.

6. Stage III – Detailed Flood Risk Assessment

6.1 Hydrological Assessment

The following chapter explains the methodologies and hydrological analysis undertaken to derive the design event hydrology for the updated Owenboy model.

A hydrological assessment was carried out for Owenboy River as part of the Lee CFRAM studies in 2009 by Halcrow, on behalf of the OPW. The assessment made use of the Flood Estimation Handbook (FEH) method and Flood Studies Report (FSR) techniques for UK and Ireland. Since then, these methods have been superseded by the Flood Studies Update (FSU) methodology for Ireland developed by the OPW. Furthermore, more hydrometric data have been collected since the study was completed. Therefore, a new analysis is carried out for the Owenboy River for the purposes of this FRA.

The methodology is summarised as follows:

- The Q_{MED} (median flow) was derived at the site location using the FSU 7-variable Physical Catchment Descriptors (PCD) equation.
- The Ballea Bridge Gauging station located upstream of the site was used as a Pivotal site to adjust the Q_{MED}.
- A flood frequency analysis was undertaken to develop a flood growth curve, using a pooling group with a total of 506 years of records. The curve provides growth factors for higher order events, such as the 1 in 100 and 1 in 1000.
- The growth factors and Q_{MED} were multiplied to produce flood flow estimates for a series of events.
- The hydrograph shape from the historic November 2009 flood event has been used to create the design hydrograph. The hydrograph was scaled to the peak flood flow estimates for each flood event.

6.1.1 Q_{MED} Derivation

The OPW FSU method for ungauged catchments as described in Work Package 2.3 was used to estimate the Q_{MED}. The methodology uses 7 PCDs to estimate the Q_{MED} value at the site location. The equation is shown below, and the parameters used are listed in Table 6-1.

$$Q_{MED} = 1.237x10^{-5}\ AREA^{0.937}\ BFIsoils^{-0.922}\ SAAR^{1.306}\ FARL^{2.21\ 7}DRAIND^{0.341}\ S1085^{0.185}\ (1+ARTDRAIN2)^{0.408}$$

An OPW gauging station (19001) is located approximately 3m downstream of Ballea Bridge Upper and 2750m upstream from the site location. The station is a crumped weir of 7.74m width and lower crest elevation of 8.56m AOD. The station has been used as a Pivotal site to adjust the estimated flows at the site location and reduce the inherent error of the 7-variable equation.

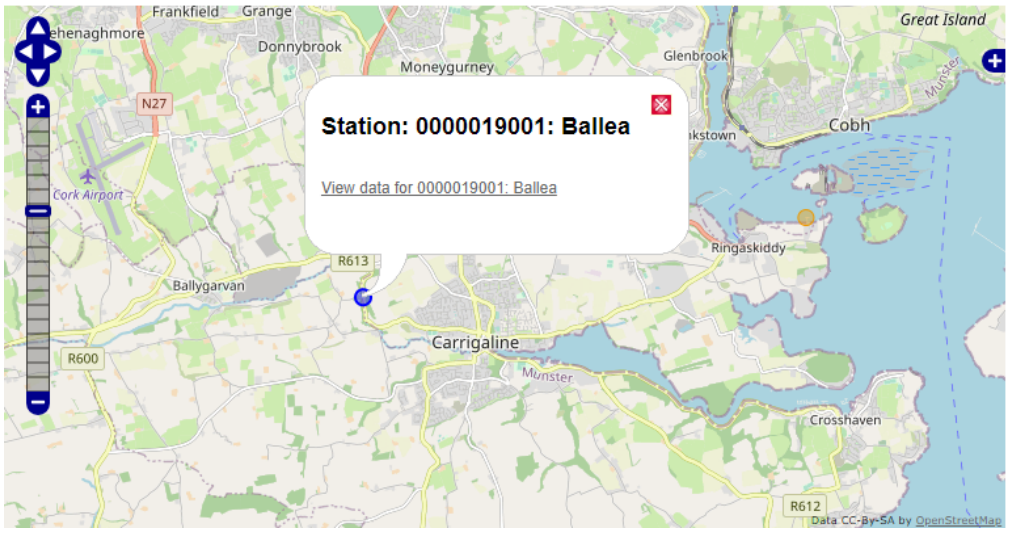

Figure 11: Location of Ballea bridge gauging station in relation to Carrigaline

The 7-variable equation was used to estimate the $Q_{MED(PCD)}$ at the Pivotal site. The PCDs at the site location and the Pivotal site, as well as the estimated $Q_{MED\ (PCD)}$ values are shown in Table 6-1. The catchments at the two locations are shown in Figure 12.

Table 6-1: Flow calculations on Owenboy River

FSU Physical Catchment Descriptors	Owenboy at site	Pivotal site (Ballea bridge upper)
Location number	19_1968_3	19_731_3
Catchment area	115.63 km^2	103.292 km^2
BFISOIL	0.657	0.6399
FARL	1	1
SAAR	1171.05 mm	1175.67 mm
DRAIND	1.064 km/km^2	1.036 km/km^2
S1085	2.7136 m/km^2	3.7507 m/km^2
ARTDRAIN2	0	0
URBEXT	0.0201	0.019
$Q_{MED\ (PCD\ rural)}$	19.5256 m^3/s	19.0341 m^3/s
$Q_{MED\ (PCD\ urban)}$	20.11 m^3/s	19.5725 m^3/s

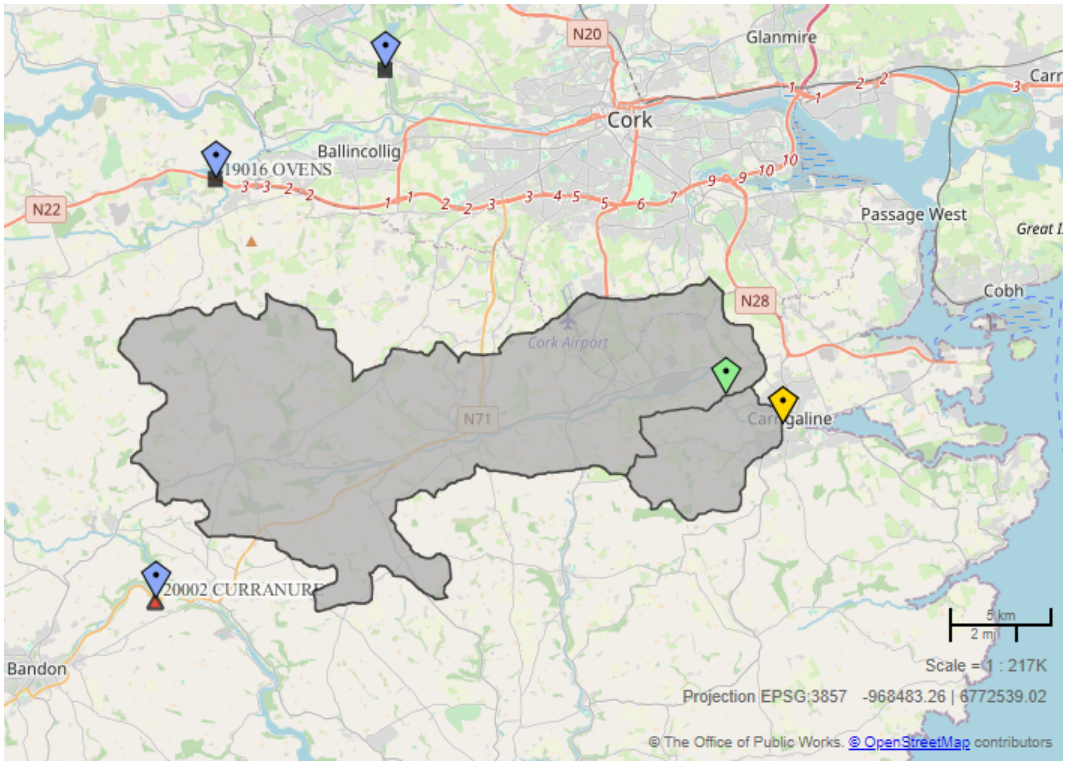

Figure 12: Site location and Pivotal site catchments

Annual Maxima records (AMAX) from Ballea Bridge Gauging station from 1974 were obtained from https://waterlevel.ie/hydro-data and the gauged Q_{MED} was calculated. A table with the AMAX can be found in Appendix C. The adjustment factor between the Q_{MED} as calculated using the 7-variable equation and the gauged Q_{MED} was used to adjust the Site Q_{MED}.

Parameter	Values
Pivotal site $Q_{MED\ (PCD\ urban)}$	19.5725 m^3/s
Pivotal site $Q_{MED\ (gauged)}$	28.9 m^3/s
Adjustment factor	1.4765
Site $Q_{MED\ (PCD\ urban)}$	20.11 m^3/s
Site $Q_{MED\ (adjusted)}$	29.69 m^3/s

6.1.2 Growth Curve Derivation

Although the Ballea Bridge gauging station is suitable for estimation of the QMED, the station does not have sufficient record of data to allow an estimation of the 1 in 100-year flood event. Therefore, a pooling group analysis was undertaken with a dataset of approximately 500 years of recorded data to allow for a better estimate. The online FSU application was used to perform this analysis.

The pooling group analysis was based on Euclidian distance of the stations with the site (the hydrological similarity of the stations to the site based on PCDs). All chosen stations have a Euclidian distance of less than 1, indicating high similarity. A list of the stations used is presented in Table 6-2.

Table 6-2: Pooling group analysis

Station	Euclidean DIST(ij)	Number of years in FSU database	Cumulative number of station-years
19020	0.359	28	28
19016	0.499	11	39
19015	0.542	28	67
25038	0.551	17	84
19046	0.565	9	93
25044	0.579	40	133
16006	0.675	33	166
29001	0.699	40	206
6012	0.723	47	253
34011	0.75	30	283
26014	0.769	16	299
16005	0.777	30	329
26018	0.79	48	377
25027	0.793	42	419
30021	0.817	26	445
26010	0.821	35	480
29071	0.83	26	**506**

Two and three parameter distributions were compared to assess which distribution best fits the pooling group data. The Lee CFRAMs recommended the use of GEV as the best fit curve for return periods less than 50 years based on a pooled group analysis based on the FEH methodology (as the FSU method was not still available) and the FSR method for flows greater than a 50-year return period. The GEV is still considered valid for our pooling group. However, we noted that the GEV is concave downwards slightly underestimating the design flows. Therefore, for conservatism, the EV1 distribution was adopted and used to produce the growth curve for the site.

The resulting growth curve factors and flood frequency curve at the site location for a series of return periods is shown in Table 6-3 and Figure 13 below.

Table 6-3: Growth curve factors and design flows

Return period (years)	Growth Factors	Design Peak Flows (m^3/s)
1.3	0.82	24.48
2	1.00	29.69
5	1.27	37.58
10	1.44	42.80

Return period (years)	Growth Factors	Design Peak Flows (m^3/s)
20	1.61	47.81
30	1.71	50.69
50	1.83	54.30
100	1.99	59.15
200	2.16	64.00
500	2.37	70.38
1000	2.53	75.21

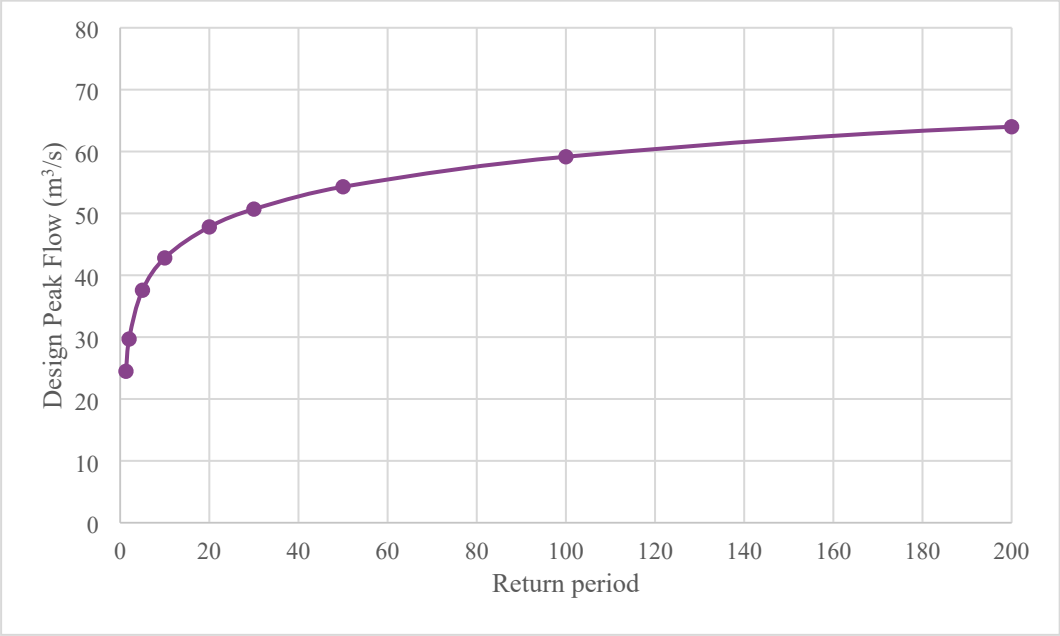

Figure 13: Flood frequency curve for Carrigaline site

6.1.3 Flood Hydrograph

Time varying hydrographs have been produced to represent a realistic flood event. Records from the historic November 2009 event at Ballea gauging station has been used and scaled proportionally to the estimated peak flows for each event.

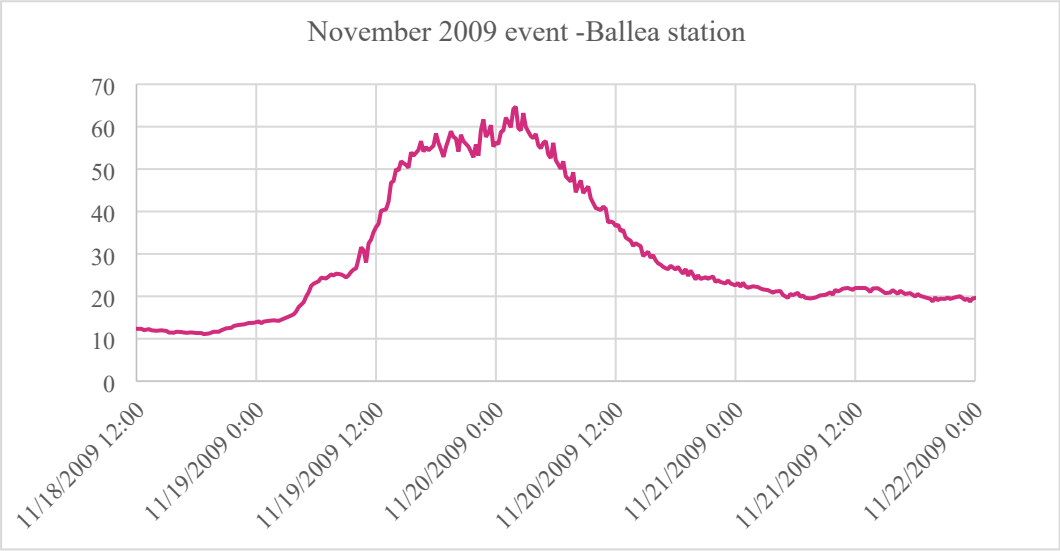

Figure 14: Ballea gauging station records - November 2009 flood event

The hydrographs for each event at the site location are shown in Figure 15.

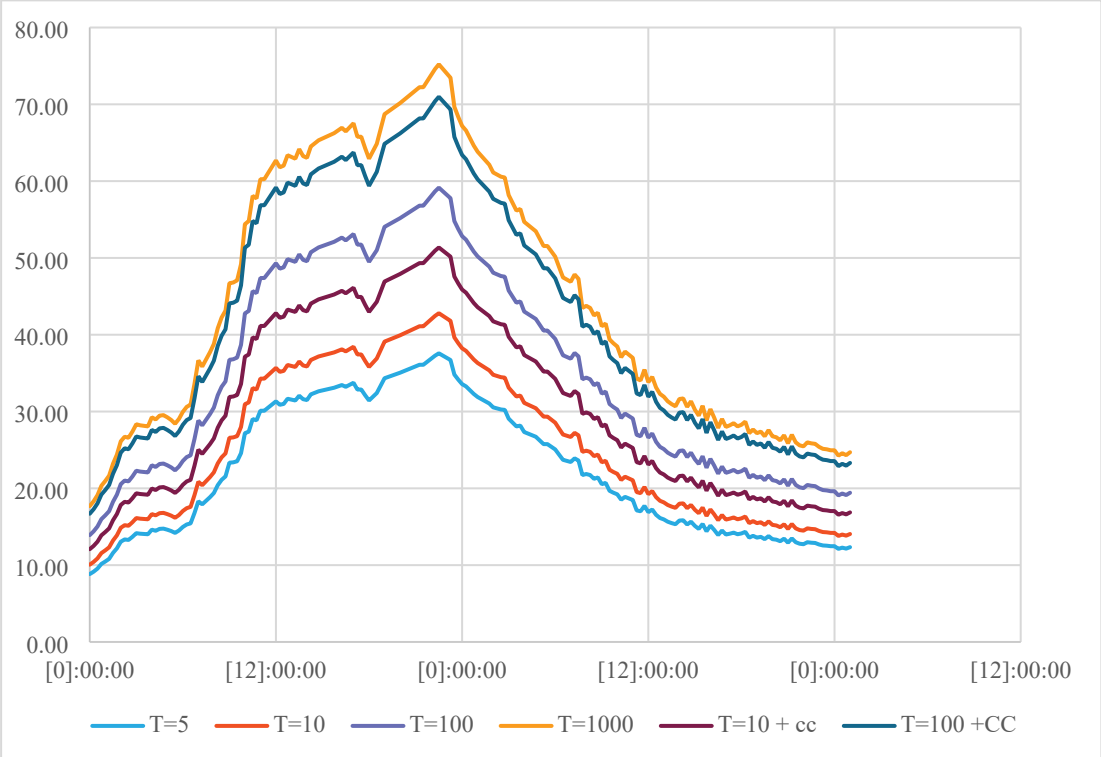

Figure 15: Design hydrographs (return period in years)

6.1.4 Coastal Tidal Boundary

The tidal boundary condition of the hydraulic model for the design runs has been set as a tidal curve within the Owenboy Estuary. The tidal curve has been created using information from the Lee CFRAM Studies and the closest tidal gauging station in Ringaskiddy NMCI (Station number 19069).

The extreme value tidal analysis undertaken as part of the Lee CFRAM Study has been used to set the peak water levels at the downstream boundary in the Owenboy estuary. The values are taken from CFRAM model at node 1BOY_0 and have been applied at the same location in the new model created for the purposes of this FRA. The peak tidal values used are shown in Table 6-4.

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Table 6-4: Peak tidal levels (Lee CFRAM study)

Event (AEP % – return period)	Tidal level (CFRAM node 1BOY_0)
MHWS	1.93m AOD
2% - 1 in 50-year event	2.63m AOD
0.5% - 1 in 200-year event	2.77m AOD
0.1% - 1 in 1000-year event	2.93m AOD
Climate change scenarios	
MHWS CC – MHWS + 0.5m	2.43m AOD
0.5% CC - 1 in 200-year event + 0.5m	3.27m AOD

The closest gauging station is located at Ringaskiddy NMCI, 5km away from the site and outside the Owenboy estuary. Recorded tidal water levels from the station were obtained from waterlevel.ie and were used to define the shape of the tidal curve. Records of data are only available from 2012 to present. The most extreme tidal event was identified as the 03/04 February 2014 tidal event. The curves from that event for the duration of the modelling simulation were extracted, as shown in Figure 16.

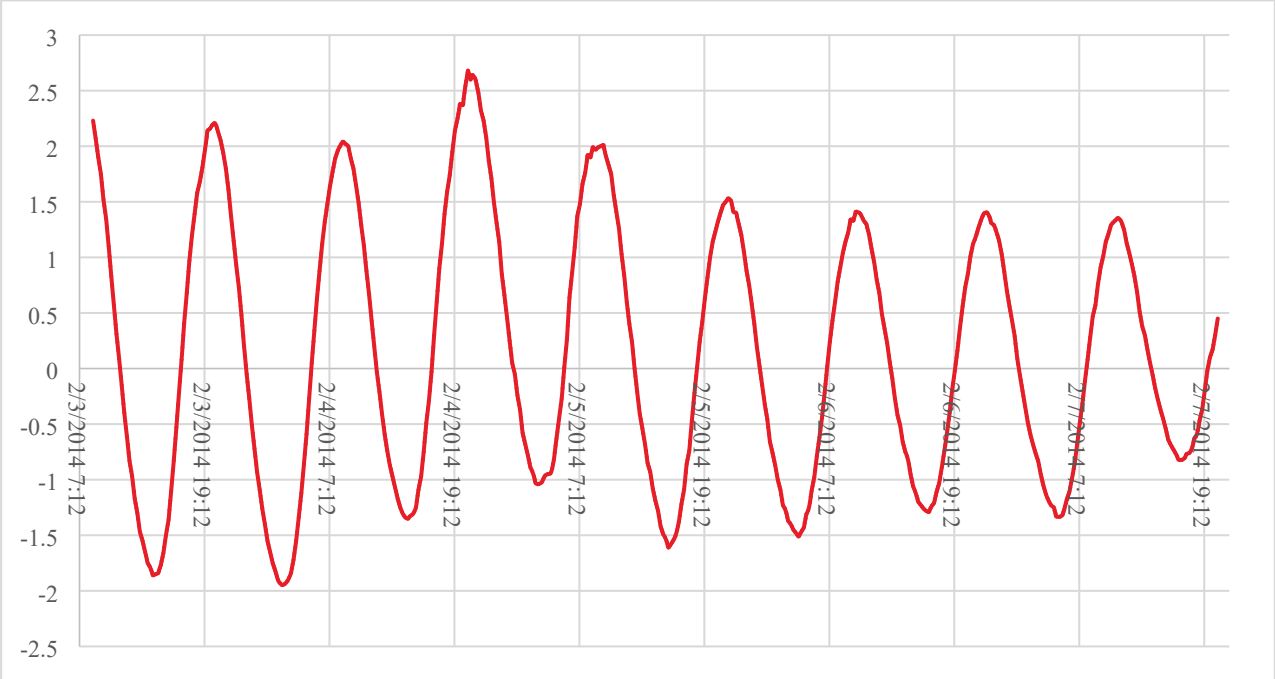


Figure 16: Tidal curve from Ringaskiddy NMCI gauging station (19069) during the February 2014 tidal event

As the design water levels in the outer harbour are different from the levels in the Owenboy Estuary, the tidal curves were adjusted by uplifting the peak levels of the tidal curve to match the Lee CFRAM levels above. The curves are shown in Figure 17.

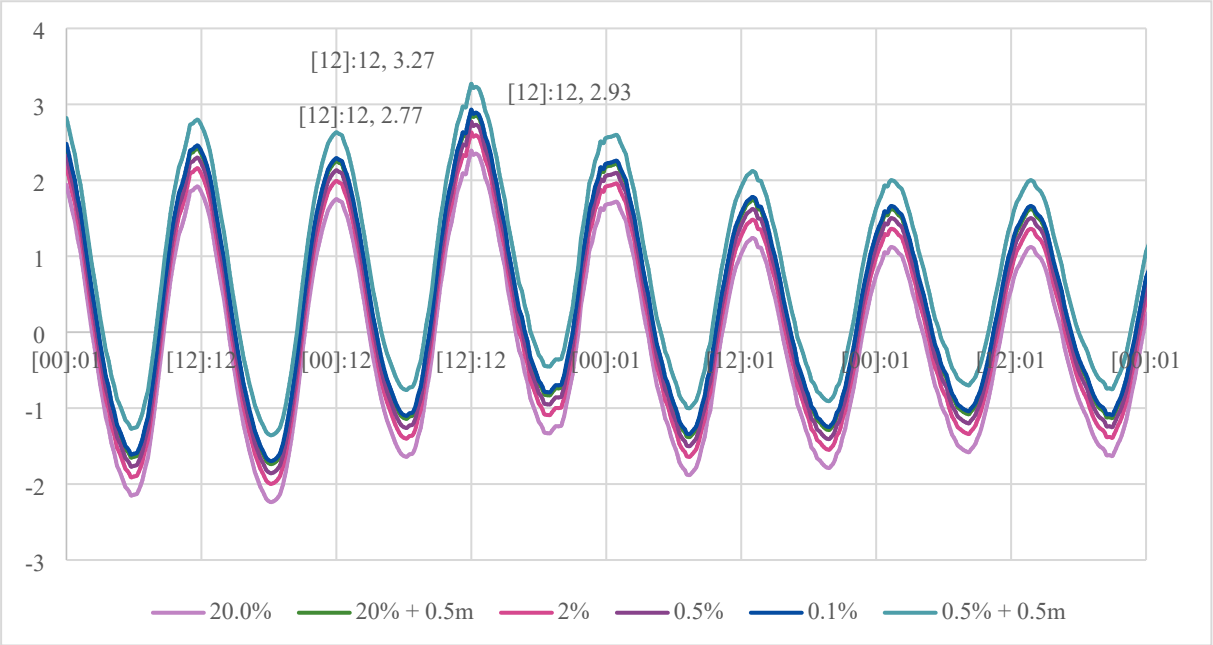


Figure 17: Tidal curves for Owenboy Estuary for the modelled flood events

6.1.5 Climate Change Considerations

Future climate change is predicted to result in several effects, including more extreme rainfall, more severe floods, and an increase in mean sea level.

Current OPW guidance on climate change for flood risk management defines two possible future scenarios of varying severity, with an equivalent allowance for increase in flows:

- Mid-range future scenario (MRFS) – 20% increase in fluvial flows and 0.5m increase in sea level rise
- High-end future scenario (HEFS) – 30% increase in fluvial flows and 1m increase in sea level rise.

In accordance with the Cord County Development Plan SFRA, the allowances for the MRFS apply for less vulnerable and highly vulnerable development. As such, the MRFS scenario has been included in the analysis to estimate appropriate finished floor levels and assess residual risks.

6.1.6 Joint Probability Assessment

A joint probability analysis between the tidal and fluvial events was carried out as part of the Lee CFRAM study. The CFRAM analysis was based on an application of the "Joint Probability – Dependence Mapping and Best Practice (2006)" by UK DEFRA, using assumptions about the dependence of tidal/fluvial floods in the Lee catchment. The combinations were then acknowledged to be conservative and are shown in Figure 18.

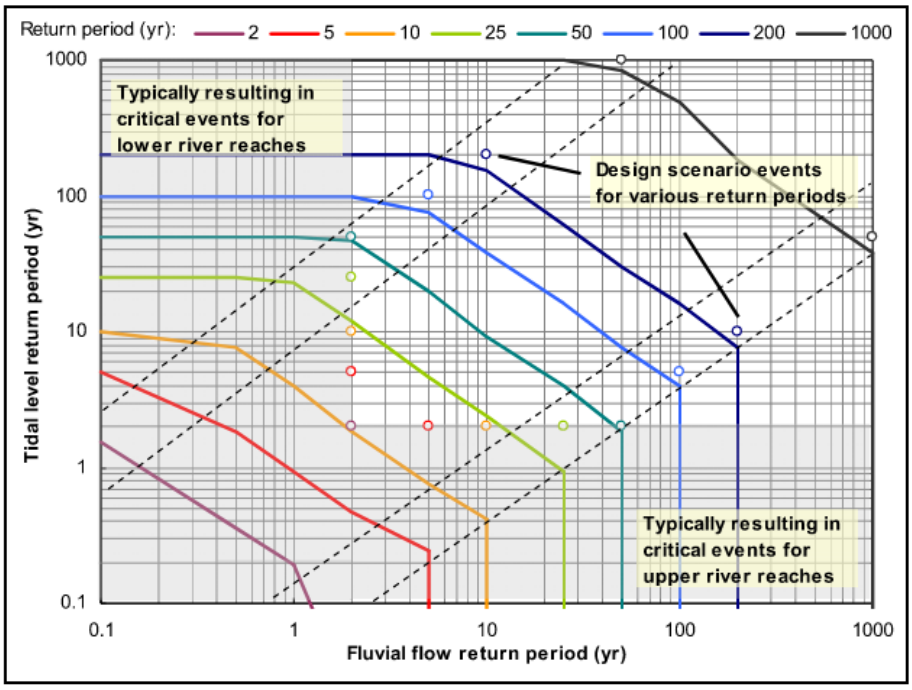


Figure 18: Joint probability combinations explored in the Lee CFRAM study

The proposed joint probability combinations for this FRA are shown below and form six scenarios that modelling has been done for the purposes of the FRA. The peak flows and peak tidal levels applied under each scenario are also included in Table 6-5.

Table 6-5: Design fluvial and tidal joint probability scenarios

Scenario	Design event	Purpose	Fluvial (AEP)	Tidal (AEP)	Upstream flow (m^3/s)	Tidal level boundary (m AOD)
1	1% Fluvial	Flood Zone definition	1%	MHWS	59.15 m3/s	1.93 m AOD
2	1% Fluvial MRFS	Design levels	1% + 20%CC uplift	MHWS +0.5m sea level rise	70.98 m3/s	2.43 m AOD
3	0.5% Tidal	Flood Zone definition	10%	0.5%	42.8 m3/s	2.77 m AOD
4	0.5% Tidal MRFS	Design levels	10% + 20%CC uplift	0.5% +0.5m sea level rise	51.36 m3/s	3.27 m AOD
5	0.1% Fluvial	Flood Zone definition	0.1%	2%	75.21 m3/s	2.63 m AOD
6	0.1% Tidal	Flood Zone definition	2%	0.1%	54.3 m3/s	2.93 m AOD

6.2 Baseline Hydraulic Modelling

A combined 1D-2D model was built using MIKE FLOOD Flexible Mesh (MIKE FLOOD FM) software, by DHI. The 1D domain was represented in MIKE 11 and its hydrodynamic module was used to simulate river flows and water levels in the Owenboy River. A 2D model was created in MIKE21 to model the floodplain.

The domain of the model was chosen to focus on the area of interest, i.e., the proposed development site. The extent of the model domain is presented in Figure 19, shown by the yellow line, including the proposed development site which is outlined in red.

Figure 19: Hydraulic model extent

This section of the report details the model development and presents results from the design model runs.

6.2.1 Available Data

6.2.1.1 River survey

A section of the Owenboy River channel was surveyed by Murphy's Surveys Ltd. in August 2021 and was used to build the 1D part of the model. This survey included 50 cross-sections of the river and floodplain, from the Carrigaline United AFC sports grounds, through Carrigaline town and into the river estuary. The locations of the cross-sections from the survey are shown below in Figure 20 in blue (the extent of the 1D-2D model can be seen in yellow, with the development site outlined in red).

Two road crossing bridges (R611 and R612) in Carrigaline were also surveyed as part of the river channel survey completed by Murphy's Surveys in August 2021 and relevant river channel and bridge geometric information were recorded.

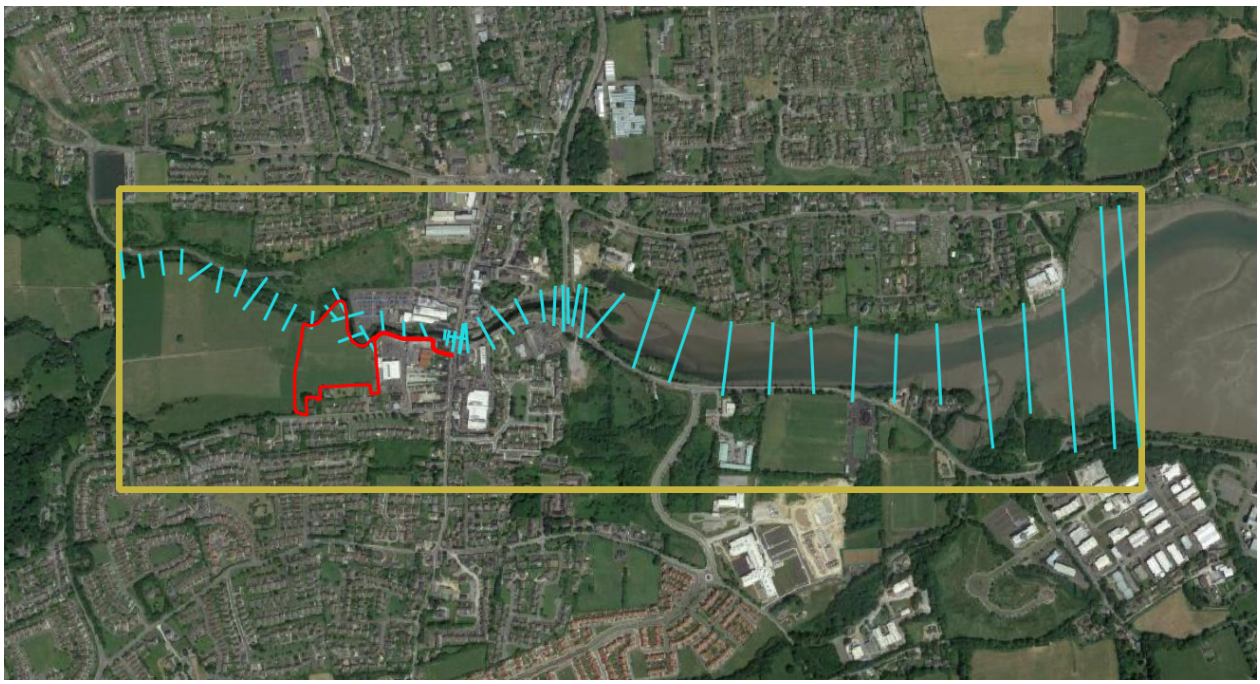


Figure 20: Cross-section location of river channel survey

6.2.1.2 Topographic surveys

A topographic survey of the site was completed in December 2020 by Precise Control. The survey was not directly used in the model build as it only covers a small part of the study area, however it was used to inform the model and calibrate the OSi Lidar data.

A topographic survey undertaken for the purposes of the Western Relief Road was also made available and was used to validate the adjustments required to the Lidar Data.

6.2.1.3 OSi Lidar data

Lidar data were purchased from Ordnance Survey Ireland (OSi). This data was captured in 2006 at a 2m horizontal resolution and 0.25m vertical accuracy. This LiDAR dataset was compared to the site topographic survey and the Western Relief Road survey using point sampling using a GIS software. The ground level values from the LiDAR dataset were found to be approximately 0.5m higher than the levels recorded by the topographic surveys. As such, the LiDAR dataset was reduced by 0.5m to adjust for this difference before being used in the hydraulic model.

6.2.1.4 Western relief road proposals

The Western Relief Road is currently under construction and the construction drawings were made available. The road is planned to finish ahead of the development being constructed and as such the proposals have been represented in the model as part of the Baseline hydraulic model (existing condition).

The works with a potential to impact on the flood mechanism consists of the proposed road elevated on an embankment along the western boundary of the development site, the new road bridge over the river immediately upstream of the site boundary, and a foul pumping station and access road within the development boundary. The proposals are shown in Figure 21

Figure 21: Western Relief Road work extents

6.2.2 Model schematisation

As described above, a combined 1D-2D model was built using MIKE FLOOD Flexible Mesh (MIKE FLOOD FM) software, by DHI. The Baseline model was developed using data sources described below.

The 1D domain was represented in MIKE 11 using the river channel cross-sections obtained through the August 2021 survey completed by Murphy's Surveys Ltd. These sections were interpolated in MIKE11 to generate the river channel in the 1D model.

Three bridges on the river were included in the 1D model, as these bridges were deemed to impact on the hydrodynamics of the watercourse by obstructing the flow and adding head losses. The two existing bridges mentioned above were modelled using the details and cross-sections provided by the August 2021 River channel survey. A third bridge and accompanying roadway immediately upstream of the site were also included in the model. This bridge and roadway were under construction at the time of the river channel survey and were therefore not included in the cross-sections provided. This new bridge was represented in the Baseline model using "For Construction" drawings provided by Mott McDonald, dated March 2021. All three bridges were modelled as culverts, with a weir above to represent the bridge deck and allow flow over the top of the bridge.

A 2D model was created in MIKE21 to model the floodplain. The mesh used in the 2D model was created using the LiDAR dataset obtained from Ordnance Survey Ireland (OSi) and adjusted to the site topographic data, as explained in Section 6.2.1.2.

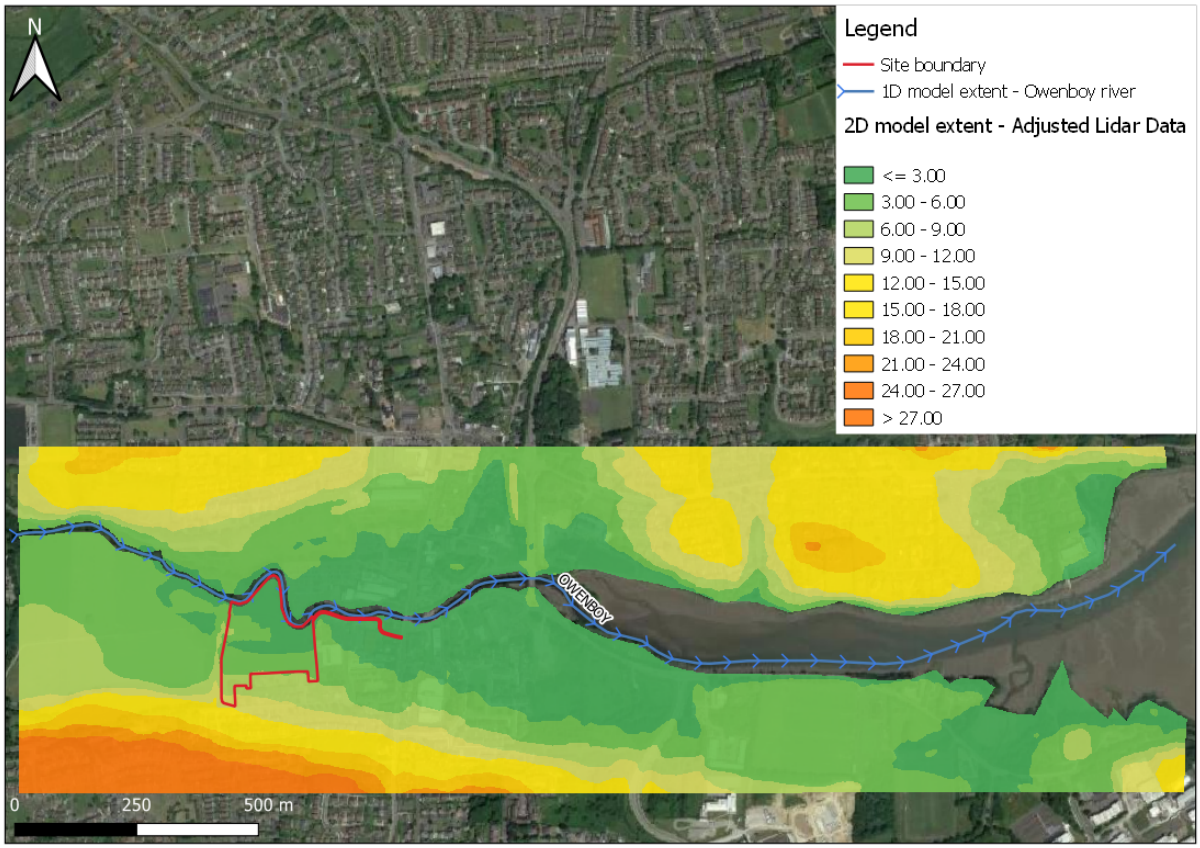


Figure 22: 1D and 2D model extents

The 2D model resolution was set by the area of the triangular mesh elements of the 2D model grid. As the model was a flexible mesh model, the resolution varied throughout the domain. A high resolution was set for the area of interest, while the rest of the model area was set to a slightly lower resolution. The model cell size was typically 30m^2 in open areas and reduced to circa 6m^2 in areas where more detail was required.

The Manning's values used in the model for the floodplain were selected based on standard values in the literature matching as closely as possible the description of the river channel and floodplain and Arup's extensive experience in hydraulic modelling. Buildings were accounted for by applying a low Manning's "M" value (10) to the grid cells which form part of the building footprint. Representing the buildings in this manner allowed for flow paths through the buildings to be simulated and storage volume within the buildings to be accounted for, while simultaneously ensuring that the reduction in flow and velocity caused by the fabric of the building is represented. A higher Manning's "M" value (50) was applied to roads and carparks to allow greater conveyance of water.

The hydrographs calculated as part of this study (shown in Figure 15, Section 6.1.3) were used as the upstream flow boundary conditions for the model. The downstream water level boundary of the model was informed by extreme tidal levels from the Lee CFRAM study and the closest tidal gauging station at Ringaskiddy NMCI. The tidal curves used are shown in Figure 17.

6.2.3 Model Calibration

The model was not calibrated against recorded data due to a lack of a suitable historic flood data at the site. The accuracy of the model however was ensured by following best practice in the model build and adopting standard values of model parameters from literature.

Verification of the model was undertaken. The Arup model was run with the design flows used for the CFRAM studies. The extents produced by the CFRAM studies are compared with the validation run extents in Figure 23 and Figure 24.

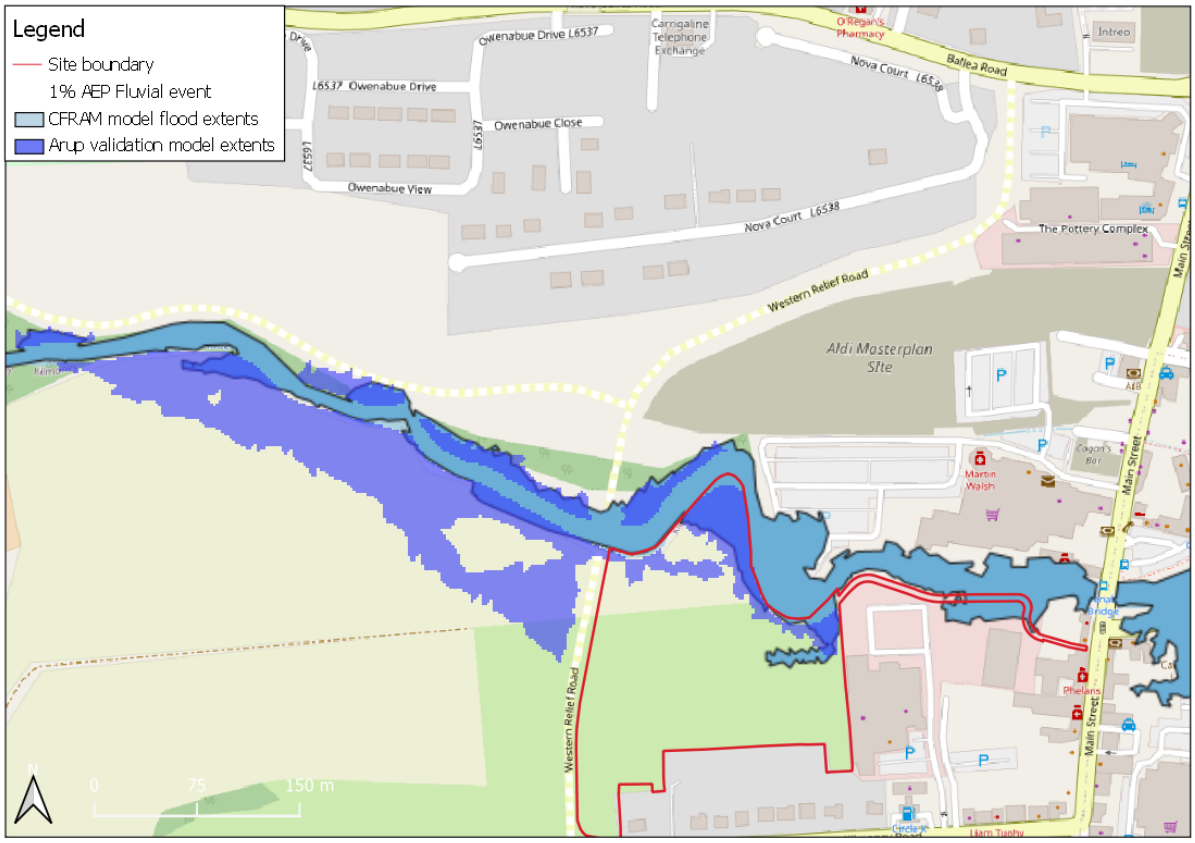


Figure 23: 1% AEP Fluvial event – validation run

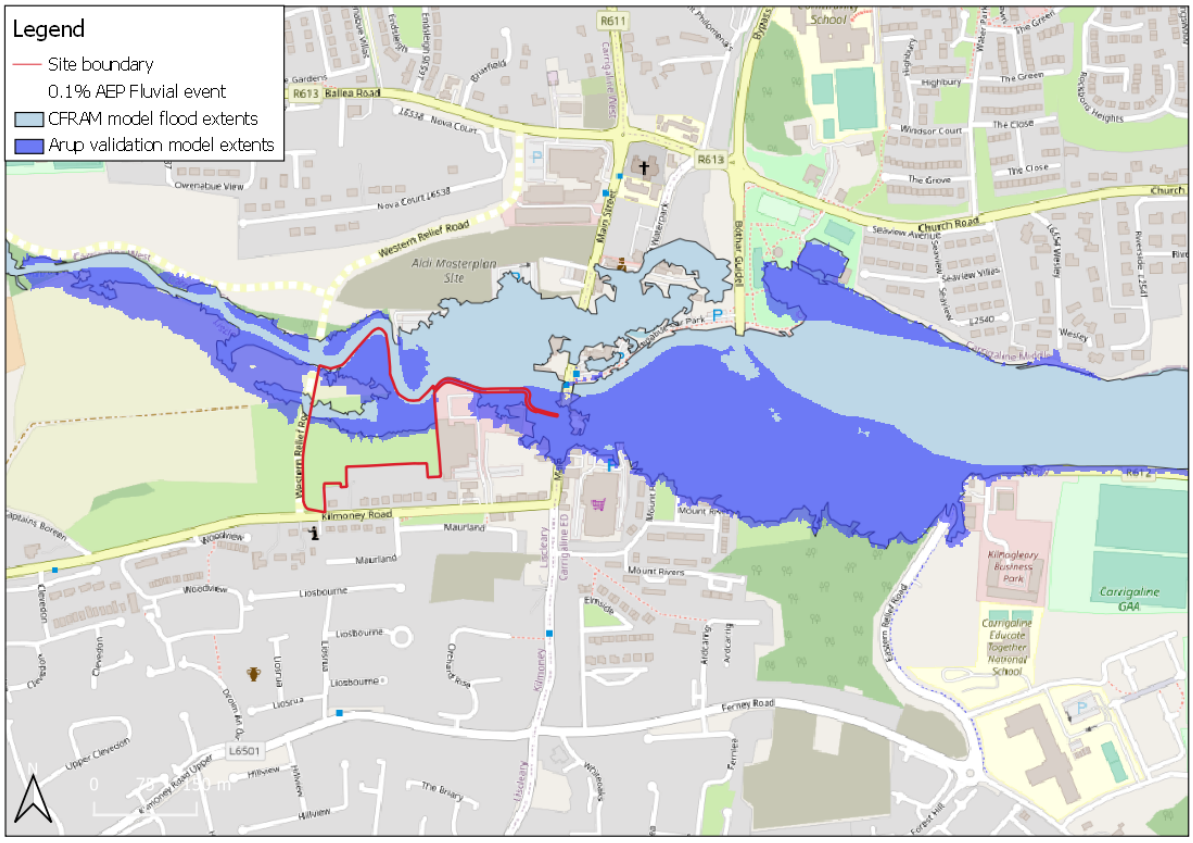


Figure 24: 0.1% AEP Fluvial event - validation run

It is noted that the flood extents at the right bank upstream of the site are larger than estimated by the CFRAM studies. This is believed to be due to the lower ground level used during the CFRAM study at the location. There is very good correlation between the flood extents on the right bank downstream of the site for both the 1% and 0.1% AEP.

The extents of flooding northeast of the site on the left bank are estimated much smaller by the Arup model. More detailed topographic data were available for the SuperValu Car park, which showed the topographic levels to be higher than the Arup modelled flood levels, or the CFRAM flood levels.

The flood levels for the 1% AEP are within 150mm between the CFRAM studies and the Arup validation runs, and up to 200mm for the 0.1% AEP. This generally shows good agreement between the two models.

Comparisons were also made between the Arup final design runs (with update hydrology) and the flood extents derived by the CFRAM studies. These are presented in the following section. The extents were not significantly different outside the site. Within the redline boundary, the differences in flood extents between the CFRAM and the Arup study were as a result of the increase in design flows, updates in the topographic information, the inclusion of the Western Relief Road and pump station. Therefore, the model developed was used for predicting flood levels with the updated design flows and topography.

6.2.4 Baseline Model Results

A series of fluvial and tidal events were modelled for the Baseline scenario. These are described under Table 6-5 and the results from these events are presented below. Flood levels within the site during these events are also shown in Table 6-6.

The 1% AEP and 0.1% AEP fluvial flood events and the 0.5% and 0.1% AEP tidal flood events were simulated to produce flood extents and re-define the flood zones near the site. These are compared with the CFRAM extents in the figures below.

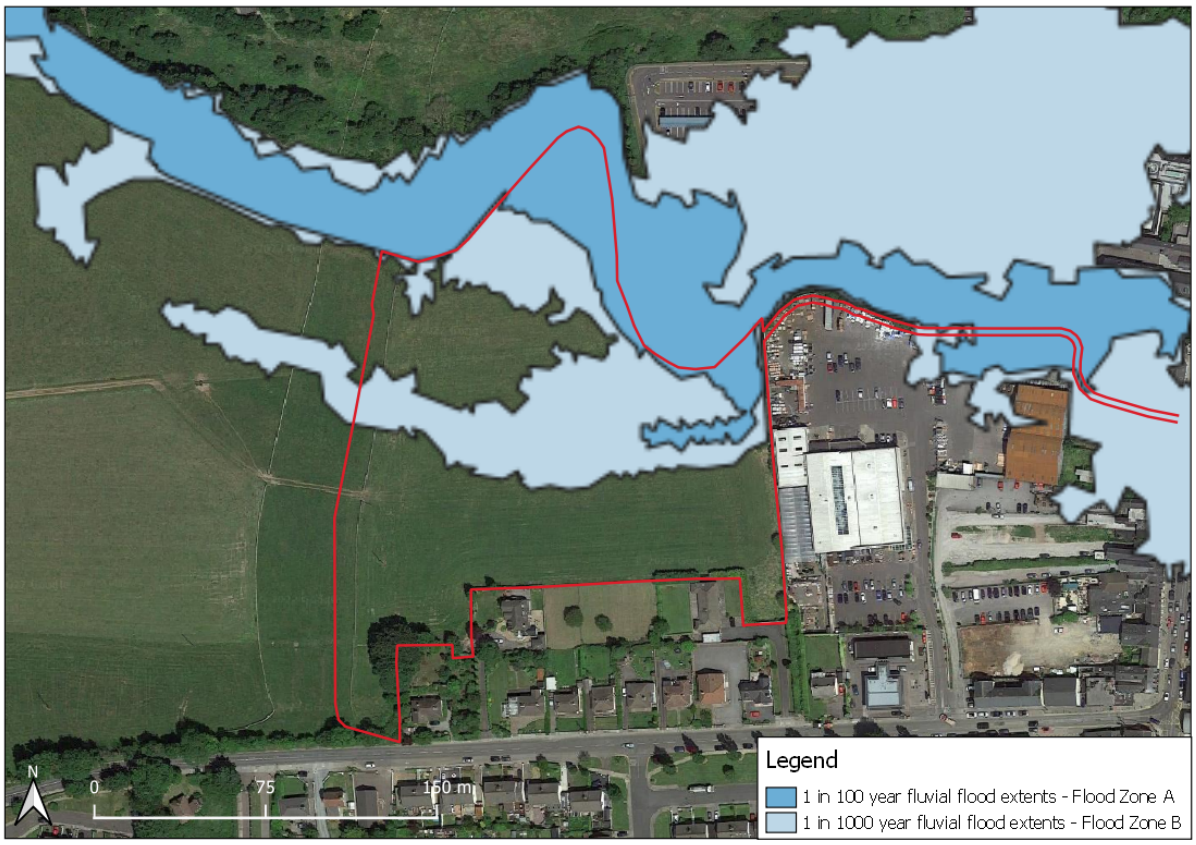


Figure 25: CFRAM fluvial flood extents. 1% AEP (1 in 100 year) and 0.1% AEP (1 in 1000 year) events (Flood Zones A and B)

Figure 26: Arup model Baseline fluvial flood extents. 1% AEP (1 in 100 year) and 0.1% AEP (1 in 1000 year) events (Flood Zones A and B)

The fluvial flood extents for the 1% AEP within the site are significantly larger than the extents shown by the Lee CFRAM study, see Figure 26 and Figure 28. This is due to the revised hydrological analysis resulting in much larger flows for the 1% AEP event (CFRAM flow of 38.4m^3/s compared to the Arup model flow of 59.15m^3/s). The flood levels within the site responded to the increase in flows, with levels near the site increasing from 2.88m AOD under CFRAMS (Node 1BOY_2020), to 3.01m AOD under this study (see Chainage 350,Table 6-6).

For the 0.1% AEP, the flow has increased from 49.04m^3/s in CRFAM to 75.21m^3/s in the Arup analysis and the levels corresponding to this change were from 3.13m AOD to 3.30m AOD, respectively. These levels mostly impacted the central part of the site where the topography is very steep and hence changes in level did not necessarily result in proportional change in extents.

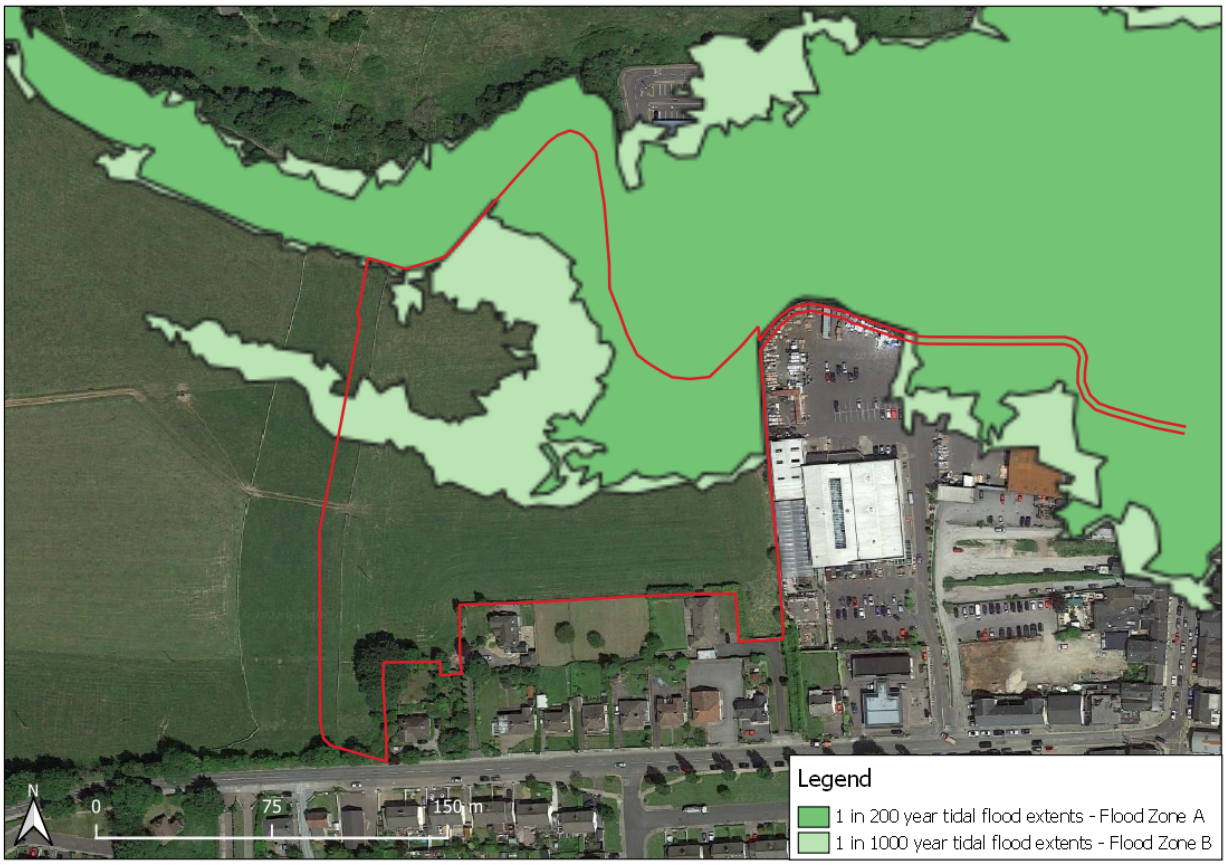


Figure 27: CFRAM tidal flood extents. 0.5% AEP (1 in 200 year) and 0.1% AEP (1 in 1000 year) events (Flood Zones A and B)

Figure 28: Arup model Baseline tidal flood extents. 0.5% AEP (1 in 200 year) and 0.1% AEP (1 in 1000 year) events (Flood Zones A and B)

The tidal flood extent for the 0.5% AEP event is larger than shown in the CFRAM studies, see Figure 27 and Figure 28. The tidal inputs are the same between the CFRAM and the Arup studies and the flood levels near the site for the 0.5% AEP correspond to that (CFRAM: 2.98m AOD, Arup model: 3.02m AOD). The changes in extent are mainly in the northern low-lying area near the river and are attributed to the revised topography of the site, which was calibrated to site specific topographic survey data.

There are no significant changes in the flood extents during the 0.1% AEP tidal event, with the flood levels changing from 3.16m AOD (CFRAM) to 3.20m AOD (Arup model). The flood extents do not change significantly due to the steepness of the site at these levels.

For all the above events, there were significant increases in flood extents in the areas directly west of the site boundary.

The 1% AEP fluvial and 0.5% AEP tidal Mid- Range Future Scenario (MRFS) were also modelled and are plotted for the area around the site in Figure 29.

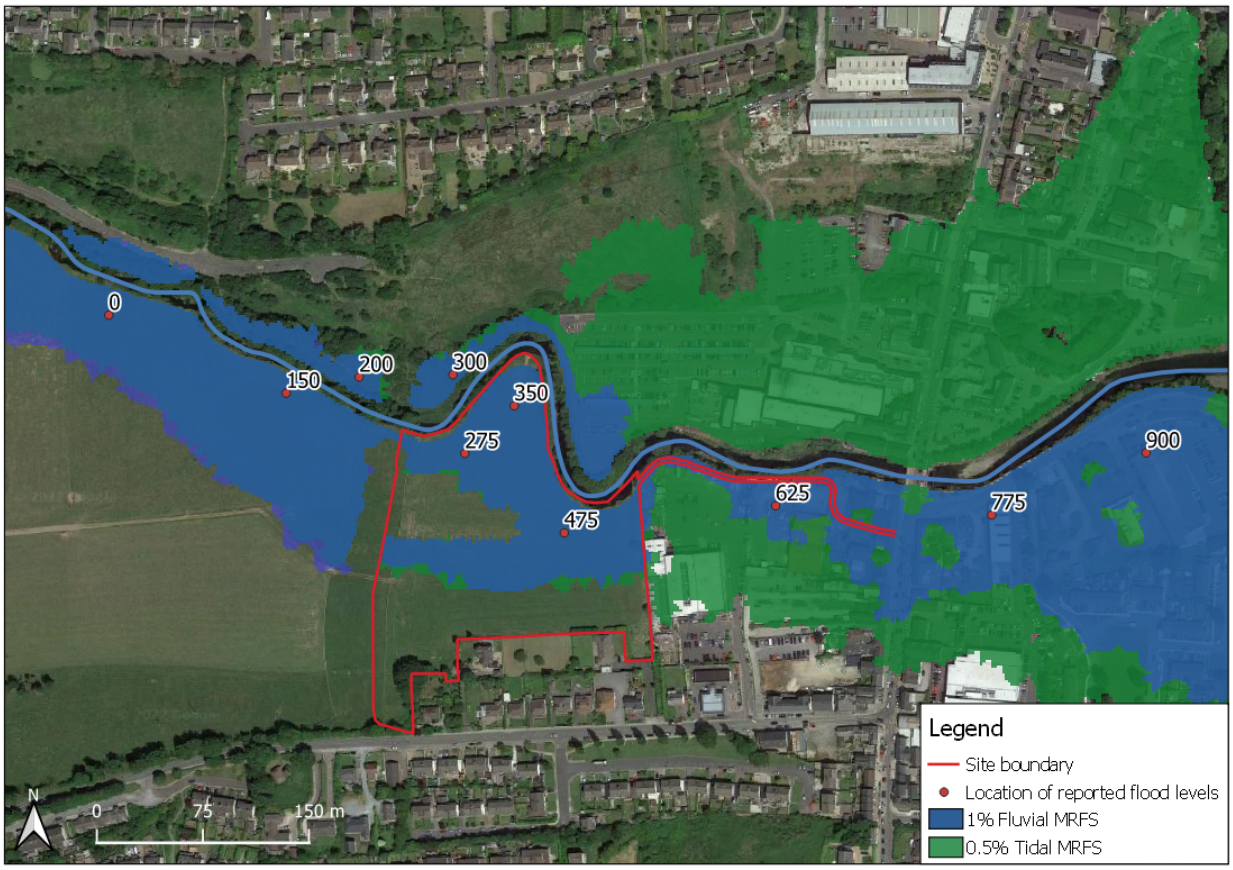


Figure 29:Baseline Mid-Range Future Scenario (MRFS) flood extents. 01% Fluvial MRFS and 0.5% AEP (1 in 200 year). Location of reporting points

Table 6-6: Baseline flood levels near the site for different flood events (maximum levels within site shown in bold)

Chainage (m)	1% Fluvial (m AOD)	1% Fluvial MRFS (m AOD)	0.5% Tidal (m AOD)	0.5% Tidal MRFS (m AOD)	0.1% Fluvial (m AOD)	0.1% Tidal (m AOD)
0	3.80	3.99	3.65	3.81	4.05	3.78
150	3.47	3.80	3.28	3.70	3.88	3.53
200	3.23	3.45	3.11	3.58	3.52	3.32

Chainage (m)	1% Fluvial (m AOD)	1% Fluvial MRFS (m AOD)	0.5% Tidal (m AOD)	0.5% Tidal MRFS (m AOD)	0.1% Fluvial (m AOD)	0.1% Tidal (m AOD)
275	3.01	3.23	3.01	**3.41**	3.29	3.20
300	3.04	3.27	3.04	3.44	3.33	3.23
350	3.01	3.23	3.02	**3.39**	3.30	3.20
475	2.91	3.13	2.97	**3.38**	3.21	3.16
625	2.31	2.46	2.82	3.32	2.79	2.98
775	1.76	2.18	2.80	3.31	2.70	2.96
900	No flooding	2.18	2.80	3.31	2.69	2.96

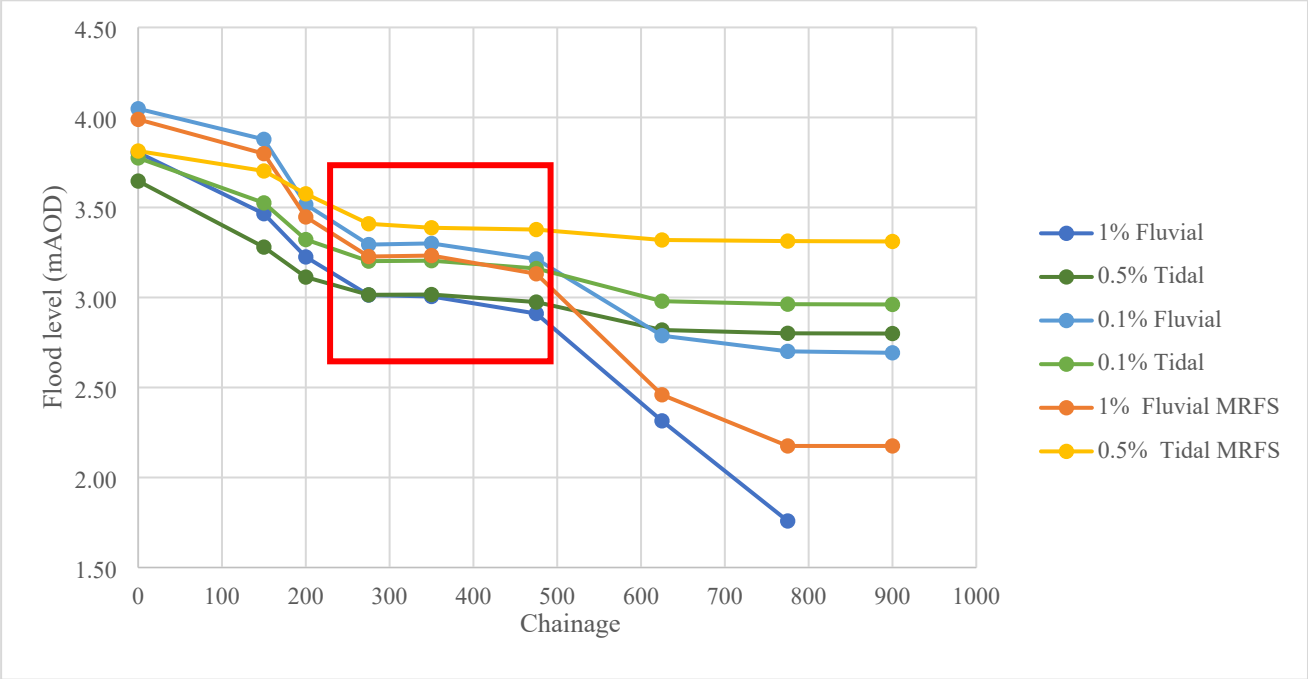


Figure 30: Flood levels upstream, on-site (in red box) and downstream the site for different flood events

Figure 30 demonstrated that the site is located at the point of transition between tidal dominance and fluvial dominance. It is noticeable that the transition between the two happens at different location depending on the event but occurs near the site between chainages 150m to 550m. The event that would result in the highest flood levels on site is the 0.5% MRFS Tidal event shown in yellow. This event will be used to set the flood protection levels for the development.

The two events that define the new Flood Zones for the site are:

- Flood Zone A: 0.5% tidal flood event (as it results in larger extents and higher levels than the 1% fluvial within the site extents)
- Flood Zone B: 0.1% fluvial flood event (as it results in larger extents and higher levels than the 0.1% tidal within the site extents).

6.3 Hydraulic Modelling of Development Proposals

6.3.1 With Scheme Hydraulic Model

The "With Development" model was based on the Baseline model as described in Section 6.2. In addition, the masterplan proposals have been added to assess the impact this could have onsite and offsite to upstream and downstream areas. The proposed road and building development are modelled as a raised ground above the proposed finished floor levels of 4.0m AOD.

The changes in flood extents due to the proposals during the 1% AEP fluvial flood event is shown in Figure 31. The raising of the proposed buildings and road to 4.0m AOD, resulted in a general reduction in flood extents within the site. The area where the buildings and road are proposed are now shown outside the flood extents. There is no increase in flood extents as a result of the development in the entire model domain.

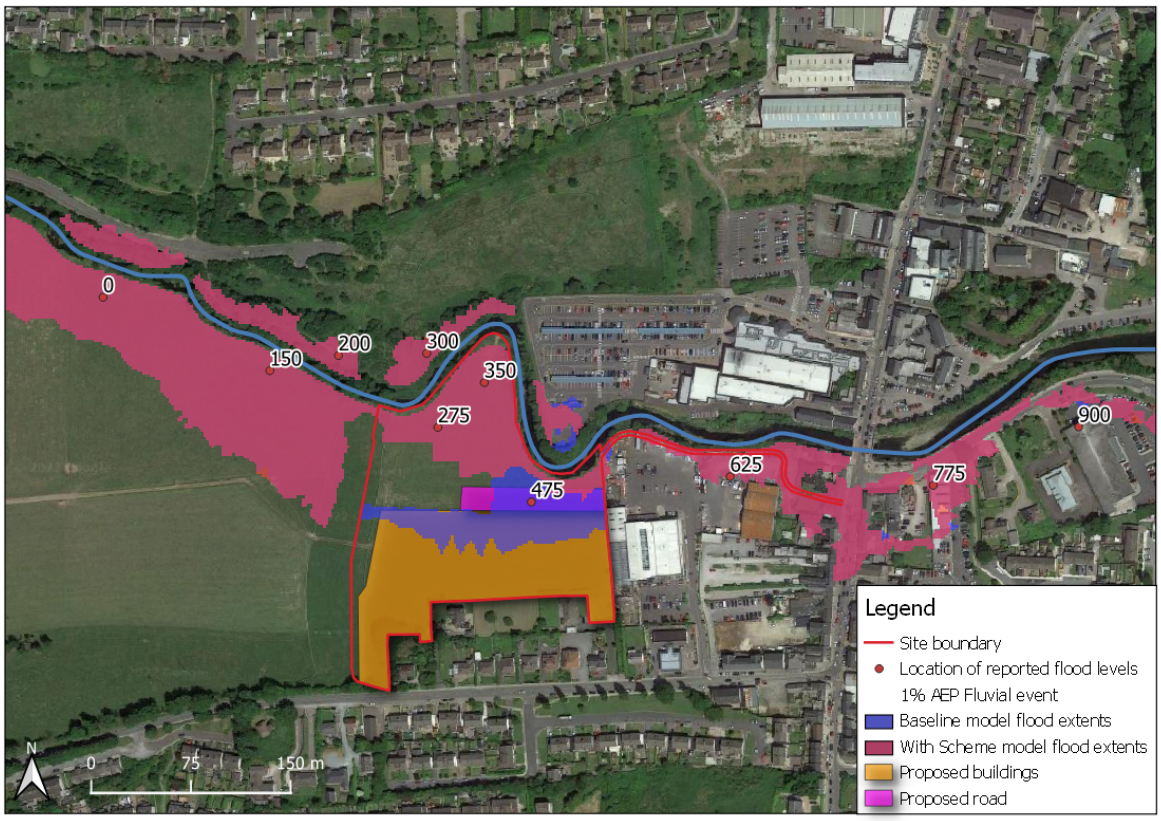


Figure 31: Flood extents during Baseline and With Development scenarios (1%AEP fluvial flood event)

6.3.2 Assessment of Offsite Impacts

A comparison of the changes in flood levels at the site vicinity are illustrated in Figure 32 and reported in Table 6-7.

The "With Development" model shows local increases in levels directly upstream the site of approximately 10-20mm. Across the site, at Ch.300m the increase in levels is up to 30mm. Within the site, flood levels increase by up to 93mm, with some local decreases at the north-eastern parts of up to 50mm. These changes in levels diminish at Chainage 0m (230m upstream of the site). There is no change in levels at downstream locations.

Changes in flood levels within the site are accommodated within the allowances made for the proposed finished floor levels, which have been set 970mm above the estimated "With Development" level for the 1% AEP event.

Figure 32: Changes in flood levels due to proposals 1% AEP (red shows increase, blue decrease)

Table 6-7: Flood level during the 1% AEP, Baseline and With Development

Chainage (m)	Baseline model - 1% Fluvial (m AOD)	With Development model - 1% Fluvial (m AOD)	Increase due to scheme (m)
0	3.80	3.80	0.00
150	3.47	3.48	0.01
200	3.23	3.25	0.02
275	3.01	3.04	0.03
300	3.04	3.06	0.02
350	3.01	3.03	0.02
475	2.91	No flooding	N/A
625	2.31	2.31	0.00
775	1.76	1.76	0.00
900	No flooding	No flooding	N/A

The above changes in flood levels and off-site impact are a result of uptake of flood volume within Flood Zone A (1% AEP fluvial extents) by the proposed development. Level-for-level compensation is proposed to be provided within the site to accommodate the displaced volumes and ensure there is no negative impact from the development to the flood regime off site.

6.3.3 Impact on Flood Storage

The floodplain volumes removed from Flood Zone A due to the proposed development were calculated on a 100mm interval and are presented in Table 6-8.

Table 6-8: Flood volume removed from Flood Zone A due to proposals

Level increment (m AOD)	Flood volumes lost due to development (m^3)
2.8 - 2.9	528
2.7-2.8	482
2.6-2.7	420
2.5-2.6	354
2.4-2.5	174
2.3-2.4	60
2.2-2.3	16
2.1-2.2	0
Total	**2035**

These volumes will be provided as level-for-level compensation in storage crates underneath the new proposed road and car parking areas to ensure all flood compensation is provided for the flood storage removed by the proposals.

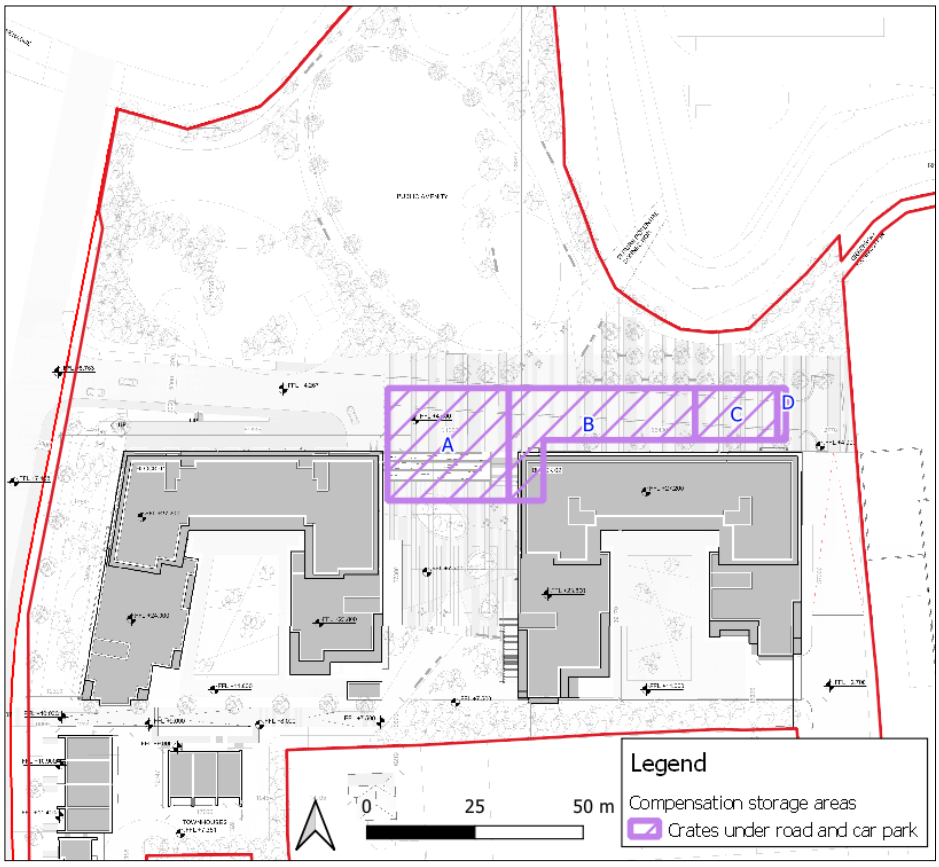


Figure 33: Flood compensation storage areas

The storage crates will be sized to accommodate the above volumes and designed to allow water in, only when the flood levels reach the correct level at which compensation should be provided. The storage crates will utilise a long inlet parallel to the access road and facing the park at the relevant level, at which the water can weir into the crate. An outlet will be provided at 1.2m AOD to discharge the water to the river when the river levels recede. The outlet will be designed to drain down within 12 hours. Figure 34 shows a cross section of the storage crates.

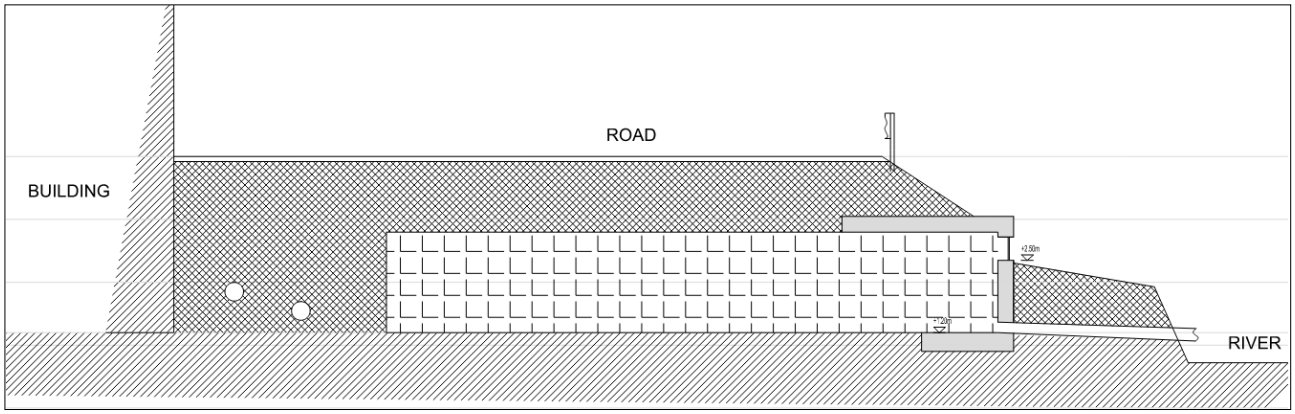


Figure 34: Cross section of the flood compensation storage under the proposed road, showing weir inlet, crates and outlet to river

There are 4no. separate tanks proposed for the purposes of flood compensation, which will provide storage at 200mm increments. It was not considered practical to provide 8 separate tanks to provide storage at 100mm increments. The storage tanks, weir crest levels and volumes are shown in Table 6-9.

Table 6-9: Design of storage crates under proposed road

Compensation increment	Crates under road	Volume (m^3)	Weir level (m AOD)	Effective crate volume (95%, m^3)	Depth of crate to IL of 1.2m (m)	Area (m2)
2.7 - 2.9	Crate A	1010	2.7	1063	1.5	709
2.5-2.7	Crate B	774	2.5	814	1.3	627
2.3-2.5	Crate C	235	2.3	247	1.1	225
2.1-2.3	Crate D	16	2.1	17	0.9	19
Total volume in crates		**2035m^3**				1579m^2

The option of providing flood compensation in the open areas of the park is also considered as an alternative. This would entail lowering the park levels to 2.5m AOD and would accommodate up to 800m^3 of water, thereby reducing the size and extent of the storage crates under the proposed road. The provision of storage at the park area could be compromised in the presence of shallow groundwater levels. The solution will therefore be considered further during design development if groundwater levels are found to be lower, following ground investigations and monitoring of groundwater levels.

6.3.4 Impact on Conveyance

The development occupies an area which is largely cut off from the main flow paths of the river. This is as a result of the construction of the Western Relief Road embankment along the west of the site, the foul pumping station and associated access road, which provide a barrier between the development site and the river. As such, the conveyance of the Owenboy River will not be affected as a result of the proposed development.

6.4 Proposed Flood Mitigation Measures

In order to manage and reduce flood risk to the site, a number of flood mitigation measures are considered during design development. These are summarised in the list below and described in detail in the following sections. The proposals for the development and flood extents are demonstrated in Figure 35.

Summary of proposed mitigation measures:

- Vulnerable uses are moved away from areas at risk of flooding. Areas at highest risk of flooding are limited to water compatible uses, such as open amenity space and riverside greenway.
- The FFL of the buildings partially located within the Flood Zones A and B are set above the 0.5% AEP tidal event with climate change allowances and adequate provision of freeboard.
- Vertical differentiation of uses was applied in areas at flood risk where buildings are proposed. Commercial uses (less vulnerable development) are located at lower levels, with residential uses (highly vulnerable development) at higher levels.
- Flood compensation is provided within the site to prevent any increase in flood risk elsewhere due to encroachment of the development to the floodplain.

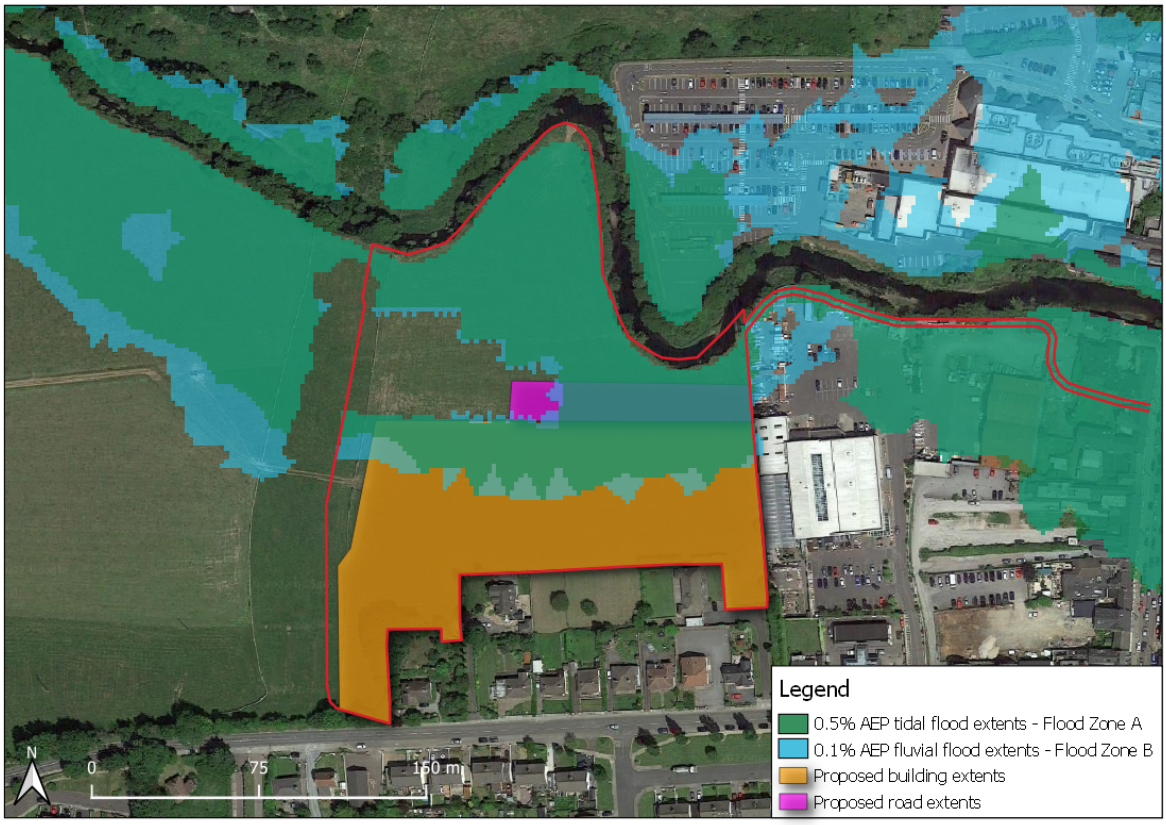


Figure 35: Updated Flood Zone extents with proposed buildings and road

6.4.1 Layout of Development

A large extent of the site is at risk of flooding in the current scenario (Baseline model). Most of the floodplain (as predicted in the Arup model) is designated for water compatible uses under the proposed development, such as recreational green space and amenities. However, some sections of the proposed buildings (marked orange in Figure 35) are at risk of flooding (within Flood Zones A & B). It was therefore necessary to reduce flood risk to these areas by setting appropriate finished floor level (FFL).

6.4.2 Appropriate Finished Floor Levels

The SFRA of the draft Cork County Development Plan recommends that FFLs are set above the design flood level (1% AEP fluvial or 0.5% AEP tidal event, whichever higher) with inclusion for climate change and a freeboard allowance.

The hydraulic modelling results indicated that the maximum flood level for the design scenario (0.5% AEP tidal MRFS event) at the reporting points within the subject site vary from 3.38 – 3.42 m AOD, see Table 6-6. This level rises to 3.6m AOD within the Owenboy River adjacent to the site during this design event. This is considered conservative and was taken forward as the design flood level.

A minimum freeboard of 300mm is provided in line with the recommendations included in the SFRA. Thus, the recommended minimum finished floor level for the development was calculated as:

Recommended FFL = 3.6mOD (0.5% AEP tidal MRFS flood level) + 0.3m (freeboard) **= 3.9mOD**

For the proposed development, buildings and hardstanding areas are set at **4.0mOD**, which is above the minimum recommended.

6.4.3 Vertical Differentiation of Uses

The risk of flooding to the development is further mitigated by vertical differentiation of uses, with the ground floor level being dedicated to less vulnerable development such as car parking and retail uses (4m AOD). Highly vulnerable development such as residential lounges and creche are proposed for the first-floor level (7.5m AOD), while residential sleeping accommodation is proposed for the second-floor level (11.0m AOD) and above.

6.4.4 Mitigation of Groundwater Flood Risk

Groundwater information from nearby boreholes indicate shallow groundwater table due to the site's proximity to the river. The groundwater levels and variation through the seasons need to be better understood to support design development and as such, it is recommended that long-term groundwater monitoring is undertaken during site investigations.

If groundwater levels are found to be shallow within the site, consideration shall be given to waterproofing/watertight 'tanking' techniques for basement structures and underground utilities.

6.4.5 Mitigation of Offsite Impacts

It is proposed to mitigate risk of flooding to the development site by means of appropriate land uses and raised finished floor levels. However, raising of the site above the recommended minimum FFL will remove flood storage volume from the site, sending it offsite and potentially negatively impacting other receptors by increasing flood levels and extents. The hydraulic model developed for the site was used to assess the off-site flood risk impacts associated with the proposed development with the proposed mitigation measures. It was determined that offsite impacts are minimal. Flood compensation is proposed to be provided within the site in the form of storage underneath the access road to reduce offsite impacts. Further details on the findings of the "With Development" modelling and the associated proposed flood compensation measures are described in Section 6.3.2.

6.5 Residual Risks

6.5.1 Operation and Maintenance of Mitigation Measures

It is key that the flood compensation measures proposed are maintained to perform their purpose. This should be detailed in an operation and maintenance plan which the management staff will be able to refer to.

6.5.2 Storage Crates

The storage crates will be positioned underneath the access road. Access to the crates will be provided to inspect and monitor their performance, allow flushing of the system in case of silt accumulation and removal of any debris that might obstruct the inlets or outlets.

The development management will be responsible for the inspection and maintenance of the crates and park area. It is recommended that inspection of both areas is undertaken annually.

6.5.3 Park Area

If during design development is considered feasible to provide flood compensation in the park area following GIs, the levels within the park area should not be raised in the future without providing the designed compensation somewhere else.

The Park area and riverside greenway will be equipped with bollards at entry points. This will be used to close off with chains and signs the area following a flood warning and ahead of a flood event and prevent public from entering the space.

Following a flood event, some silt and debris could settle in the park area or greenway. Jet washing of hardstanding area or litter picking might be required to remove the silt and any solid waste.

6.5.4 Residual Risk from Failure of Mitigation Measures

While the flood mitigation measures such as the storage areas provided would mitigate against any increases in offsite impacts from the development, there is an unlikely risk that the measures could fail, due to blockage of the inlets or other disfunction of the systems. In the case where the storage compensation areas are not available to be utilised during the design event, it is expected that the flood levels would rise in upstream areas (as far as 250m from the site boundary) to up to 30mm during the 1% AEP and 47mm during the 1% AEP MRFS event. There will be no impact to downstream areas.

Currently, the impacted sites are Greenfield and as such the small increase in flood levels during failure of the measures is not anticipated to cause increased damages. If the areas are developed in the future, developments will be constructed setting their floor levels in accordance with the OPW Guidelines and the Cork Council Development Plan SFRA guidelines, incorporating appropriate freeboard, which would prevent any increased damages due to the 30mm increase in levels.

6.5.5 Residual Risk of Rainfall Exceedance Event

Whilst the proposed surface water drainage system and associated storage are designed in accordance with the latest industry standard, including an allowance for climate change, there remains a risk of a rainfall event in excess of the design standard. In practice, this risk is quite small as the design event assumes a conservative joint probability of extreme rainfall event and high tide. It is unlikely that these will coincide and therefore the on-site storage tanks will have sufficient capacity to deal with extreme rainfall events.

6.5.6 Safe Access and Egress

Access and egress from the site will be via an entrance from the proposed development to the new road, currently under construction, to the west of the site. An emergency egress strategy will be implemented for the proposed development which will allow for emergency egress to the higher existing ground levels to the south of the development site, as follows:

- The design will facilitate emergency egress to the south-west of the site to take advantage of the existing higher levels of the site as it rises towards Kilmoney Rd Lower. Access is provided for both vehicles and pedestrians, as shown in Figure 36.

- From Kilmoney Rd Lower, there is flood-free access to areas at higher ground, the local Carrigaline Health Care Centre and other essential facilities.
- As flood risk to the site is predominantly caused by a combination of high river flows and high tides, potential flood events could be predicted. Therefore, advance warnings will be issued to development users to take appropriate action.
- Access and egress procedures will be documented in a detailed emergency response plan.

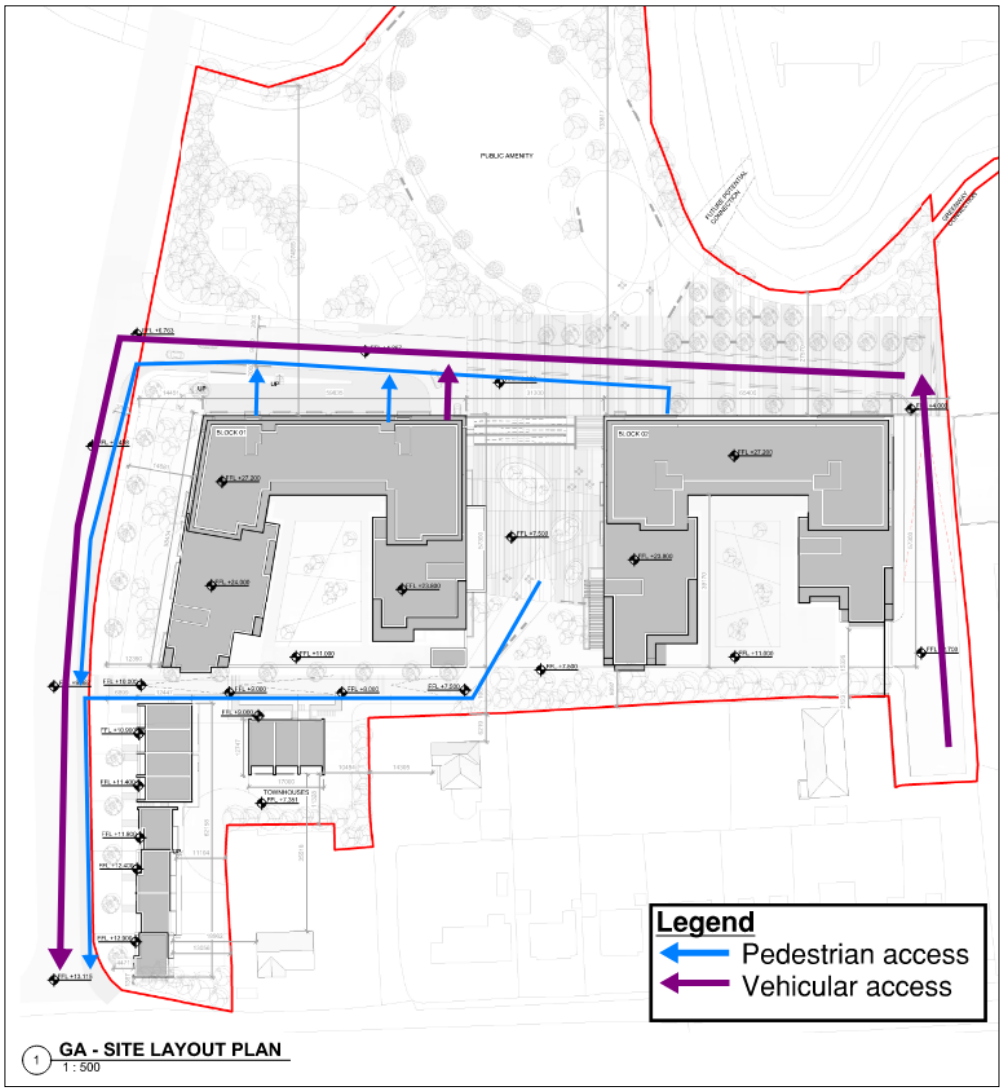


Figure 36: Safe access and egress routes to Kilmoney road

6.5.7 Flood Emergency Plan

The buildings are at very close proximity to areas at risk of flooding and as such, a flood emergency response plan will be developed for the building and park area users. This will be implemented in the event of a significant flood event being forecasted for Carrigaline.

The development management will develop a Flood Emergency Plan in accordance with the OPW Planning Guidelines which will be updated annually to take account of the latest knowledge on flooding, available flood protection for Carrigaline and the latest Cork City Emergency Plan. The Flood Emergency Plan will be informed by the Emergency Response Plans of Cork County Council. The plan will detail triggers for activation, including receipt of a timely flood warning, a staged response and to set out the management and operational roles and responsibilities. The plan will set out arrangements for access and egress, both for pedestrians, vehicles and emergency services.

Met Éireann Forecast services will be used to provide flood warning and trigger activation of the emergency plan. As part of the emergency plan, the management staff of the proposed development and park area will be required to maintain awareness of flood and weather forecasts on an ongoing basis as well as receive warning from Cork County Council and Met Éireann. A text service is available for Cork County Council that the management staff will sign up to.

In the event of an extreme flood being forecast, then it is likely that advisories will be issued by Cork County Council and the Emergency Authorities for the prior evacuation of all vulnerable parts of the County, and that such evacuation will be carried out in a safe and timely manner.

In the event of forecasts of significant or severe flooding, the general response plan will be as follows:

- The Park area will be equipped with bollards at entry points. Following a flood warning for a severe event, the management staff will close off the Park area at the entry points, by securing chains and signs on the bollards to prevent public entry to the park.
- Warnings of the impending flood with details of timings and likely levels of impact will be communicated to all building users.
- Occupants of the buildings will be provided with sufficient notice to either leave in advance of the flood if needed or stay in the building until the flood recedes.
- Where possible, building users will remain inside until any flood recedes.
- People choosing to leave the building during a flood would be responsible for their own safety and would have to exercise appropriate care and caution. They would be advised of the best route to take to get to higher ground. Safe access and egress can be provided via the Western Relief Road or Kilmoney road.
- Where an individual or individuals are required to leave the building due to a medical emergency, depending on the severity of the flooding, they would be evacuated by emergency vehicle as required.
- The development management and management of the individual tenancies will, as part of their Emergency Evacuation Plans, be connected to the medical services at appropriate hospitals and will have a plan to deal with the treatment and evacuation of a medical emergency during a flood.

6.5.8 Surface Water Drainage Strategy

The Surface Water Drainage Strategy (SWDS) for the site is prepared by Horgan Lynch Consultants. A summary is included below.

The SWDS proposes to control the rate of run-off from the new development. The maximum permitted surface water outflow from the new development is proposed to be restricted to Greenfield rates of run-off, thereby managing any increase in run-off to the Owenboy River.

Control of run-off by attenuation methods requires a hydraulic control to restrict the magnitude of flows passing downstream, together with an upstream storage capacity to contain the volume of run-off held back. The flows are proposed to be attenuated in the surface water system by adopting a flood storage detention tank underneath the buildings along with a restricted outlet as the control device.

The network is piped and has been sized to the following standards:

- 1 in 2-year return period events were used to ensure that the system does not surcharge;
- 1 in 100-year return period events were used to ensure that flooding does not occur.

The outfall from the detention tank discharges to River Owenboy.

A petrol interceptor is proposed to capture hydrocarbons prior to discharge to the river.

6.6 Justification Test

6.6.1 Flood Zones

Based on the updated Baseline flood model and mapping of the site, parts of the site are within Flood Zones A, B and C.

6.6.2 Vulnerability Classification

The proposed mixed used development contains residential and creche uses, classed as a 'highly vulnerable development', and retail uses, which are classified as 'less vulnerable development' as per the vulnerability classification of the Planning Guidelines.

6.6.3 Sequential Approach

Figure 4 illustrates the sequential approach to be adopted under the 'Planning System and Flood Risk Management' Guidelines. The proposed development is 'highly or less vulnerable development' and partially lies within Flood Zone A and B. A Justification Test is therefore required to be undertaken.

6.6.4 Development Management Justification Test

The Development Management Justification Test is undertaken when developments vulnerable to flooding are proposed in areas at moderate or high risk of flooding (Flood Zones A and B). Prior to granting permission for the development, the planning authority must be satisfied that the development meets the criteria set out in the Development Management Justification Test described in Section 5 of The Planning Guidelines. These criteria are included in Table 6-10. It is demonstrated that the proposed development satisfies the criteria of the Development Management Justification Test.

Table 6-10: Justification test for Development management

Justification Test Criteria	Response based on findings of FRA
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 current 2014 Cork County Development Plan, Draft Cork County Development Plan for 2022-2028 and the Ballingollic – Carrigaline LAP 2017 have zoned the land for Town Centre Uses with objectives for mixed use development including commercial, community uses, pedestrian/cyclists' facilities and expansion and regeneration of the urban centre. The 2014 CDP specifically stated the southern part of the site backing into existing residential development on the Kilmoney Road could have a mix of residential development The development proposals include creche (community uses), retail and residential uses, which all align with the recommendation of the Development Plans. Therefore, it is considered that the proposed development satisfies the criteria of Part 1 of the development management Justification Test.
2. The proposal has been subject to an appropriate flood risk assessment that demonstrates:	

Justification Test Criteria	Response based on findings of FRA
i. The development proposed will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk;	In terms of assessing whether the development would increase flood risk elsewhere, flood mitigation measures are proposed to reduce flood risk to the development as well as areas outside the site boundary. The buildings are raised above the 0.5% MRFS tidal level with freeboard. A hydraulic model was used to assess the impact of these measures in terms of flood risk to other areas. It was identified that due to raising the ground level within Flood Zone A, flood levels could increase up to 30mm to offsite areas. As such, further mitigation measures are proposed to ensure no increase in flood levels. Flood compensation is proposed to provide the same volume of flood storage taken in a level for level manner. Therefore, it is considered that the proposed development satisfies the criteria of Part 2(i) of the development management Justification Test.
ii. The development proposal includes measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible;	The proposed development and flood mitigation measures are designed to prevent the development from being inundated during and up to at least the 0.5% AEP tidal flood event with an allowance for climate change and freeboard. The defence level provides resilience to climate change and exceedance events such as the 0.1% flood events. As per above, flood compensation is proposed to ensure no negative flood impact to other sites. It is considered that the proposed development satisfies the criteria of Part 2(ii) of the development management Justification Test.
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;	The flood mitigation measures proposed herein have been assessed against climate change and a higher order event (1 in 1000) to evaluate residual risks. The proposed development and access road are safe from flooding for these events and do not increase flood risk elsewhere. Safe dry access and egress is provided to and from the site via Kilmoney Road Lower. It is considered that the proposed development therefore satisfies the criteria of Part 2(iii) of the development management Justification Test.
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 proposed development supports the development of a vibrant and active town centre and objective for increasing housing provision and therefore is in line with wider planning objectives. It is considered that the proposed development satisfies the criteria of Part 2(iv) of the development management Justification Test.

7. Conclusion

The FRA has assessed risks of flooding to the development from fluvial, tidal, pluvial and groundwater flood sources. Part of the site is at risk from fluvial and tidal flooring from the Owenboy River. The Lee CFRAMS mapping indicates that the site is partially located within Flood Zones A and B.

A hydrological analysis and hydraulic modelling were undertaken to assess in detail the risk of fluvial and tidal flooding from the river. The modelling showed increases in the flood zones compared to the CFRAM mapping.

Flood mitigation measures were developed to ensure the development is safe from flooding now and in the future. Measures include raising of development levels above the flood protection level, vertical differentiation of uses, and water tanking construction methods to prevent groundwater ingress to lower levels if needed.

Parts of the development are proposed within Flood Zone A. The impact of building within the flood zone was assessed and found to result in 20-30mm increases in flood levels to upstream greenfield sites. As such, a level-for-level flood compensation is proposed in the form of storage crates underneath the proposed road. The entire volume taken by the development will be compensated by the crates, in line with the DoEHLG / OPW Planning Guidelines for flood risk management. As a result of the provision of flood compensation, there is no anticipated impact from the development to upstream or downstream sites in terms of flood risk. The measures are designed to adequately protect the site from flooding and allow safe access and egress to the site for up to the 0.5% annual exceedance probability tidal event with allowance for climate change and freeboard.

The potential impacts of the development on flood storage, conveyance and surface water run-off were also assessed. No impact was detected on properties upstream and downstream the site.

The residual risks to the occupants of the development were assessed as part of the FRA. It was determined that the residual risk of flooding was considered acceptable.

The proposed development is a ‘highly vulnerable development’, and partially lies within Flood Zone A. Therefore, a Justification Test in accordance with the OPW Guidelines was carried out. It has been demonstrated that the proposed development satisfies all the Development Management Justification Test criteria.

This FRA has demonstrated that the risks relating to flooding can be managed and mitigated to acceptable levels and therefore comply with DoEHLG / OPW and Cork County Council planning guidance.

Appendix A

Topographic Survey – Precise Control

Survey Notes:

GRID:

THIS SURVEY IS RELATED TO ORDNANCE SURVEY GRID. IRISH TRANSVERSE MERCATOR (OSGM15).

DATUM:

LEVELS ARE RELATED TO ORDNANCE SURVEY DATUM. (MALIN HEAD, OSGM15 ADJUSTMENT).

SURVEY ABBREVIATION LIST.

AV : WATER MAIN AIR VALVE
BH : BENCH
BL : BOLLARD
BS : BUS STOP
CL : COVER LEVEL
C/L : CENTRE LINE
DP : DOWN PIPE
EIC : ESB INSPECTION COVER
EM : ESB MARKER
EP : ESB POLE
EPL : ESB PILLAR
ER : EARTH ROD
ESB : ELECTRICITY SUPPLY BOARD
FFL : FINISHED FLOOR LEVEL
FH : FIRE HYDRANT
FHR : FIRE HYDRANT RISER
FP : FLAG POLE
GM : GAS MARKER
GUY : GUY WIRE TO POLE
GV : GAS VALVE
IC : INSPECTION COVER
IL : INVERT LEVEL
LP : LIGHT POST
LS : LIGHT STANDARD
LT : LIGHT TOWER
MH : MANHOLE
O/H : OVERHEAD
OSBM : O.S. BENCH MARK
PB : POST BOX
RG : ROAD GULLY
SAP : TREE SAPLING
SC : WATER MAIN STOP COCK
SH : SHORE
SN : SIGN
STN : SURVEY STATION
SV : WATER MAIN SLUICE VALVE
TBM : TEMPORARY BENCH MARK
TFL : LEVEL AT DOOR THRESHOLD
TIC : TELECOM INSPECTION COVER
TK : TELEPHONE KIOSK
TL : TRAFFIC LIGHT
TM : TELECOM MARKER
TOF : TOP OF FENCE LEVEL
TOT : TOP OF TREE LEVEL
TOW : TOP OF WALL LEVEL
TP : TELECOM POLE
TPL : TELECOM PILLAR
TRIC : TRAFFIC INSPECTION COVER
U/G : UNDERGROUND
UM : UTILITY MARKER
UP : UTILITY PILLAR
VL : VALVE
VP : VENT PIPE
WM : WATER MAIN METER
WV : WATER MAIN VALVE

NOTES:

FURTHER LEVELS ARE SHOWN ON FROZEN LAYERS WITHIN THE AUTOCAD DRAWING. (LAYERS PRECEDED WITH 'Z')

EVERY EFFORT HAS BEEN MADE TO OBTAIN ALL DETAIL. HOWEVER SOME DETAIL MAY HAVE BEEN HIDDEN AT THE TIME OF THE SURVEY DUE TO PARKED CARS OR OTHER OBSTRUCTIONS.

Rev.	Drn.	Date.	Description.

PRECISE CONTROL
LAND AND ENGINEERING SURVEYORS
Unit 11, Eastgate Way, Eastgate, Little Island, T45 TD77, Co. Cork.
t: 021 4351050 - e: info@precisecontrol.com - w: www.precisecontrol.com

Job Title:
Kilmoney Road,
Carrigaline, Co. Cork.

Survey:
3d Topographic Survey

For:
Henry J Lyons (Hallmark Dev.)

Plot Scale: 1:500 (A1)	Surveyed by : md
Date : 18-12-20	Drawn by : md
Job Nr. : 20111	Checked by : hme
Drg. Nr.: 20111d.dwg	Rev.: 0

Appendix B

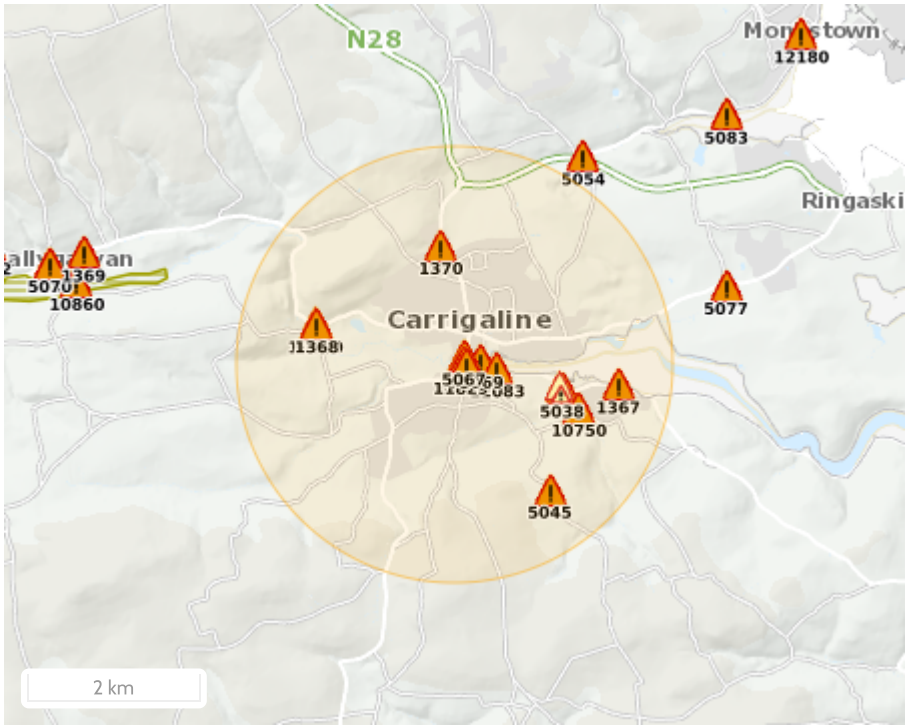
National Flood Hazard Mapping Website Report

Past Flood Event Local Area Summary Report

OPW Oifig na nOibreacha Poiblí Office of Public Works

Report Produced: **29/3/2022 10:29**

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



Map Legend

- Single Flood Event
- Recurring Flood Event
- Past Flood Event Extents
- Drainage Districts Benefited Lands*
- Land Commission Benefited Lands*
- Arterial Drainage Schemes Benefited Lands*

* Important: These maps do not indicate flood hazard or flood extent. Their purpose and scope is explained on Floodinfo.ie

17 Results

	Name (Flood_ID)	Start Date	Event Location
1.	Shannonpark (R611) Carrigaline Nov 2002 (ID-1370)	27/11/2002	Approximate Point
	Additional Information: Reports (3) Press Archive (0)		
2.	Carrigaline walk Owenboy Estuary Cork Nov 1994 (ID-1367)	03/11/1994	Approximate Point
	Additional Information: Reports (3) Press Archive (0)		
3.	Owenboy Ballea Bridge, Carrigaline Recurring (ID-1368)	n/a	Approximate Point
	Additional Information: Reports (5) Press Archive (1)		
4.	Crosshaven Road Carrigaline Oct 2004 (ID-5038)	27/10/2004	Approximate Point
	Additional Information: Reports (2) Press Archive (0)		
5.	Commeen Hill LP2495 Nov 2002 (ID-5045)	27/11/2002	Approximate Point
	Additional Information: Reports (2) Press Archive (0)		
6.	Carrigaline Main Street area Oct 2004 (ID-5067)	27/10/2004	Approximate Point
	Additional Information: Reports (3) Press Archive (0)		

	Name (Flood_ID)	Start Date	Event Location
7.	Carrigaline Strand Road area Oct 2004 (ID-5069) **Additional Information:** Reports (4) Press Archive (0)	27/10/2004	Approximate Point
8.	Ballea Road Nov 2002 (ID-5071) **Additional Information:** Reports (3) Press Archive (0)	27/11/2002	Exact Point
9.	Carrigaline Town Nov 2002 (ID-5074) **Additional Information:** Reports (1) Press Archive (3)	27/11/2002	Approximate Point
10.	Carrigaline Co.Cork 14th.December 2012 (ID-11829) **Additional Information:** Reports (1) Press Archive (0)	14/12/2012	Approximate Point
11.	Flooding at Carrigaline, Co.Cork on 3rd February 2014 (ID-12083) **Additional Information:** Reports (1) Press Archive (0)	03/02/2014	Approximate Point
12.	Carrigaline Co.Cork 2nd January 2014 (ID-12091) **Additional Information:** Reports (2) Press Archive (0)	02/01/2014	Approximate Point
13.	Carrigaline Co.Cork 16th/17th October 2012 (ID-11824) **Additional Information:** Reports (1) Press Archive (0)	16/10/2012	Approximate Point
14.	Kilnaglery Bridge, Carrigaline, Co. Cork Recurring (ID-1575) **Additional Information:** Reports (3) Press Archive (0)	n/a	Approximate Point
15.	Kilnagleary,Carrigaline,Co.Cork (ID-10750) **Additional Information:** Reports (1) Press Archive (0)	11/11/2009	Approximate Point
16.	Ballea Bridge (Lower) Carrigaline,Co.Cork.19th.Nov.2009 (ID-11000) **Additional Information:** Reports (1) Press Archive (0)	19/11/2009	Approximate Point
17.	Carrigaline Bridge,Co.Cork 19th.Nov.2009 (ID-11034) **Additional Information:** Reports (1) Press Archive (0)	19/11/2009	Approximate Point

Appendix C

AMAX data at Ballea Gauging Station

Date recorded	AMAX value (m^3/s)
10-07-1975	23.6
23-10-1975	49
20-02-1977	30.8
22-02-1978	67.2
10-02-1979	49.9
27-12-1979	49.9
01-03-1981	28.9
13-12-1981	48.2
09-11-1982	50
26-01-1984	38.6
08-02-1985	21.5
25-08-1986	27.7
26-10-1988	25.4
17-12-1989	25.4
01-01-1991	14.5
25-11-1991	19
19-09-1993	14.5
22-02-1994	30.3
10-03-1995	36.4
14-03-1996	40.1
25-10-1996	14.9
17-11-1997	31.6
29-12-1998	24.2
20-12-1999	27.1
15-11-2000	48.1
04-02-2002	23.1
21-11-2002	55.3
03-02-2004	24.2
29-10-2004	25.5
19-10-2005	39.1
03-12-2006	53.2

Date recorded	AMAX value (m^3/s)
10-01-2008	25.2
30-01-2009	26.2
20-11-2009	64.7
27-12-2010	18.0
28-06-2012	34.5
25-01-2013	26.1
01-01-2014	22.9
13-11-2014	19.9
06-02-2017	14.3
17-04-2018	45.7
15-04-2019	52.5
14-10-2019	29.8
Q_{MED}	28.9