Site Specific Flood Risk Assessment

Project:

Castle Street, Bray, County Wicklow

Client:

Silverbow Limited

Doc Ref. CHC-00-XX-RP-C-00004

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The information contained herein is current at date of issue in the Details, Control and Issue Log and may be subject to third part approvals for items such as connections, access arrangements and planning approvals.

The report addresses those items outlined only. In the event that there are items not covered within the report, the reader shall not infer that such extraneous items have been considered irrelevant or immaterial. Any items not covered within the report have not been investigated by the Authors and the reader should satisfy themselves that such items have been suitably investigated elsewhere.

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1.0 Introduction

1.1 Background

Corrigan Hodnett Consulting Limited (CHC) have been appointed by their Client to prepare a Site Specific Flood Risk Assessment (SSFRA) to supplement a planning application for a Strategic Housing Development at the Former Heiton-Buckley builders suppliers site, off Putland Road in Bray, County Wicklow. The SSFRA has been prepared in accordance with the relevant guidelines, namely The Planning System and Flood Risk Management Guidelines, 2009, published by the OPW to comply with current planning legislation and forms part of the proposed planning submission for the subject development.

1.2 Purpose of Report

The purpose of the report is to identity and present the flood risks associated with the proposed development and, where necessary, propose appropriate flood risk mitigation and management measures to be implemented into the development to mitigate against any residual flood risk.

The SSFRA assesses the proposed development in accordance with 'The Planning System and Flood Risk Management Guidelines for Planning Authorities', Nov 2009 published by the OPW[1] and then DOEHLG[2], hereinafter the Guidelines.

1.3 Site Specific Flood Risk Assessment Scope

The SSFRA relates solely to the subject site and immediately surrounding areas unless it is determined that a development generated flood risk impacts on extraneous areas, in which case the extents of any such remote impacts will also be assessed as appropriate. The extents of the assessment are as stated, and no extraneous areas are assessed unless expressly stated.

1.4 Existing Site

The subject development site under consideration straddles the townlands of Ravenswell and Little Bray, off, and to the immediate northeast of Castle Street (Regional Road R761), Bray, County Wicklow; to the west of the existing Dwyer Park housing estate; to the east and north of existing Dargle Centre retail park. There are third party development zoned lands to the northwest and west of the site which are designated for the access route into the Former Bray Golf Course lands to the north of the development lands (identified as SLO 3 under the current Bray Local Area Plan).

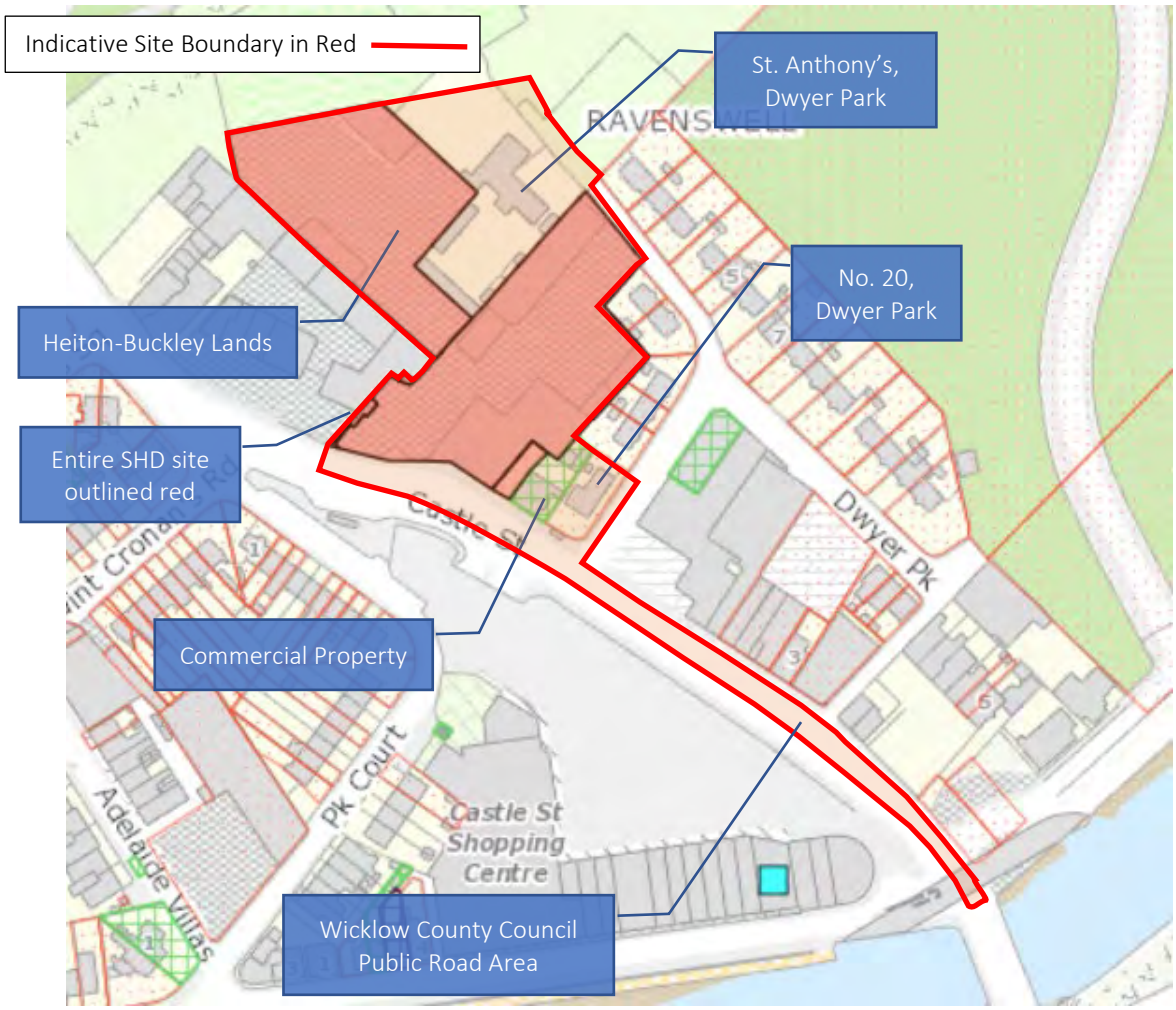
The overall site is accessed off Castle Street via the existing access which previously served the Heiton-Buckley builder's providers on the site with two access points off Dwyer Park which serves the two

[1] Office of Public Works

[2] Department of Environment Health & Local Government, now DECLG (Department of Environment, Community & Local Government)

existing dwellings on the site. The site is comprised of four properties, the actual Heiton-Buckley site, an adjacent commercial building to the south and two dwellings, namely St. Anthony's, Dwyer Park and No. 20 Dwyer Park as detailed in the following figure;

Figure 1-1 Site Extents



The applicant redline boundary also includes areas of public footpath and roadway along Castle Street to accommodate the necessary footpath upgrade works adjacent to the site, water services connections/outfalls and the proposed amended roadmarkings to facilitate a right turn into the site across the existing ghost island.

The lands to the north of the site proper are currently undeveloped greenfield lands which are zoned.

The Dwyer Park housing development to the east of the site is comprised of a mix of terraced, semi-detached, and detached single and two storey houses.

The existing buildings on the site were most recently used as a builder's providers, Heiton-Buckley but have been unoccupied for some time and are in a state of dilapidation. One of the existing dwellings on the site, No. 20 Dwyer Park, has been unoccupied for some time and is in a state of disrepair due to

weathering and vandalism. The other existing dwelling on the site has been occupied until very recently and appears structurally sound. The external walls of a number of the existing commercial buildings also form the rear garden boundaries of the immediately adjacent houses in Dwyer Park and there are proposals to extend these gardens to improve amenities for these residents. Similarly, the rear wall of one of the shed structures within the development forms a common boundary with several of the commercial units in the Dargle Centre retail park.

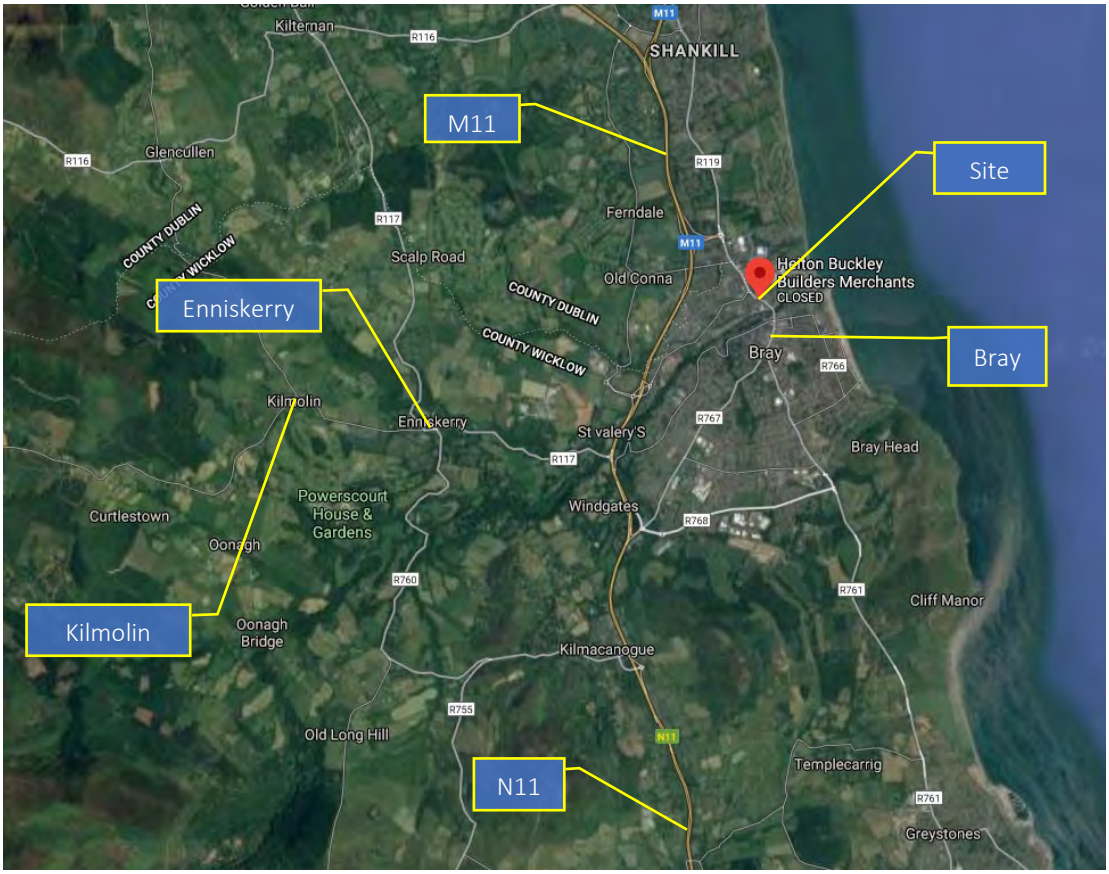
For future reference the terminology 'site' will apply to the subject development lands, i.e. the site under consideration which is identified graphically in the following pages.

The site falls under the authority of Wicklow County Council for planning, road/access and stormwater services purposes. Irish Water are the authority for potable water and wastewater in the area.

The wider surrounding lands is a mix of low/medium density residential and commercial/retail uses.

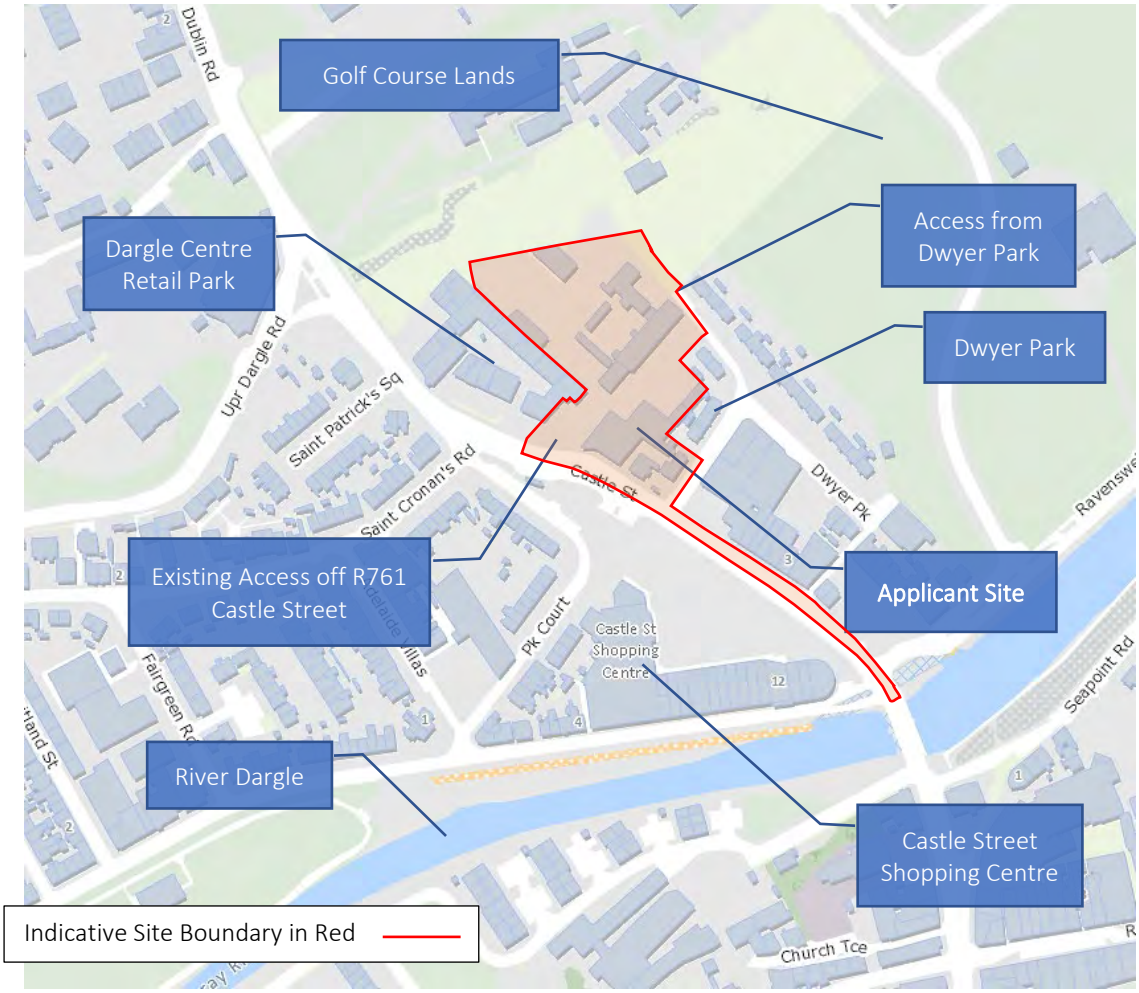
Figure 1-2 and Figure 1-3 following detail the location of the site in a regional and local context respectively.

Figure 1-2 Site Location; Regional Context[3]



[3] Source – Google Maps

Figure 1-3 Site Location; Local Context[4]



From the OS mapping provided and using the topographical survey procured for the site, the overall gross site area (redline area) amounts to approximately 1.0557 Hectares (10,557 square metres/ 2.609 Acres) which is inclusive of the area of public roads and footpaths. The nett area for development calculation purposes amounts to approximately 0.8594 Hectares (8,594 square metres/ 2.124 Acres). The co-ordinates listed in Table 1-1 following fall within the site boundary.

Table 1-1 Site Co-ordinates

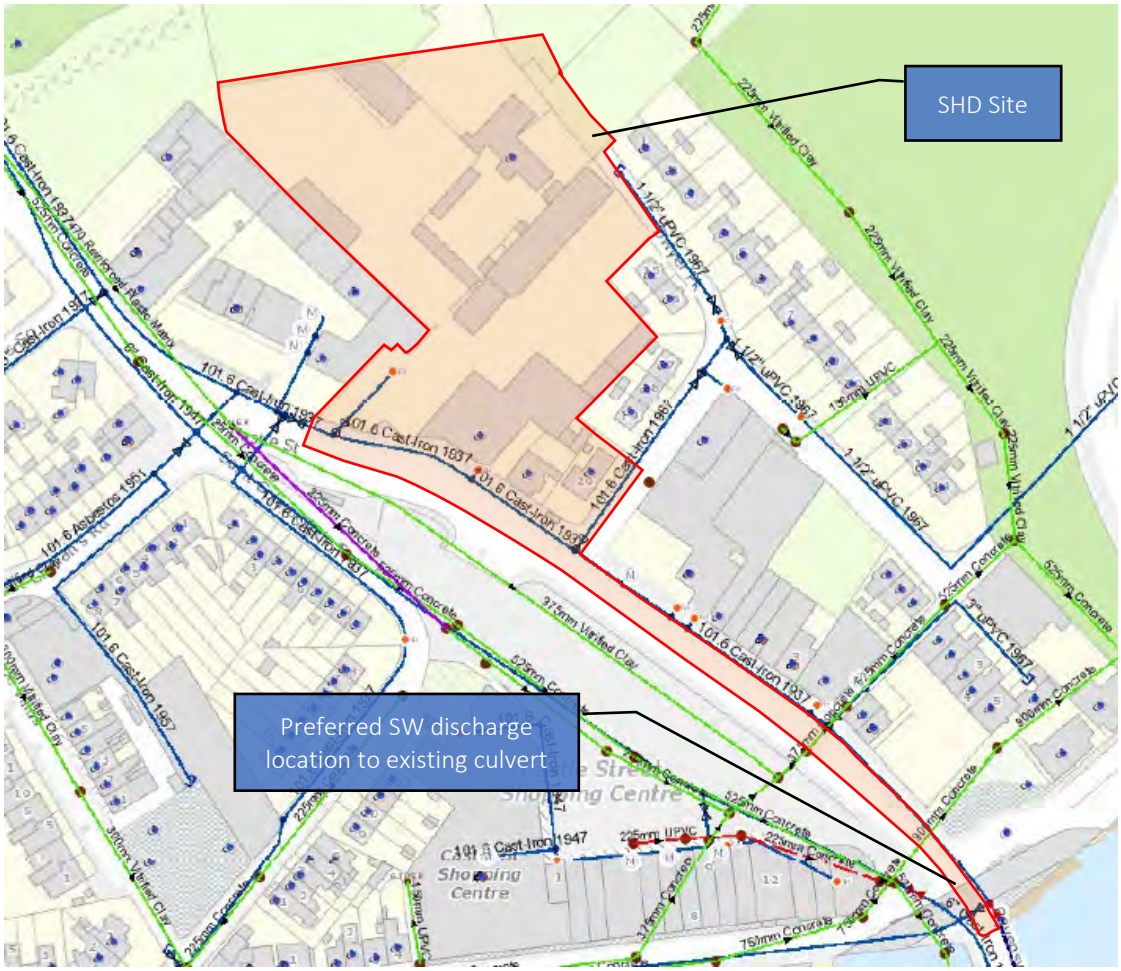
	X/Easting	Y/Northing
ITM co-ordinates	726140	719075
ING co-ordinates	326217	219045

Based on the age of the existing development on the site, the most likely scenario is that the surface water collected from roofs and other areas within the development currently discharges to the existing combined sewer network. It is noted that the site is almost completely impermeable with the exception

[4] Source – Ordnance Survey Ireland, Geohive Mapping

of the garden areas of the two houses. The result is that all rainwater is discharged unattenuated and untreated to the combined sewer network in Castle Street. Furthermore, there is currently no form of treatment or attenuation prior to discharge. An extract from the Irish Water Surface Water network for the area is shown in Figure 1-4 following.

Figure 1-4 Existing Water Services Network and Preferred SW Discharge Location



The site has been previously developed and is therefore considered a 'Brownfield site'.

The topography of the site is generally flat with a maximum level deviation of less than 1.0metres with the Castle Street/Dwyer Park junction being the lowest point.

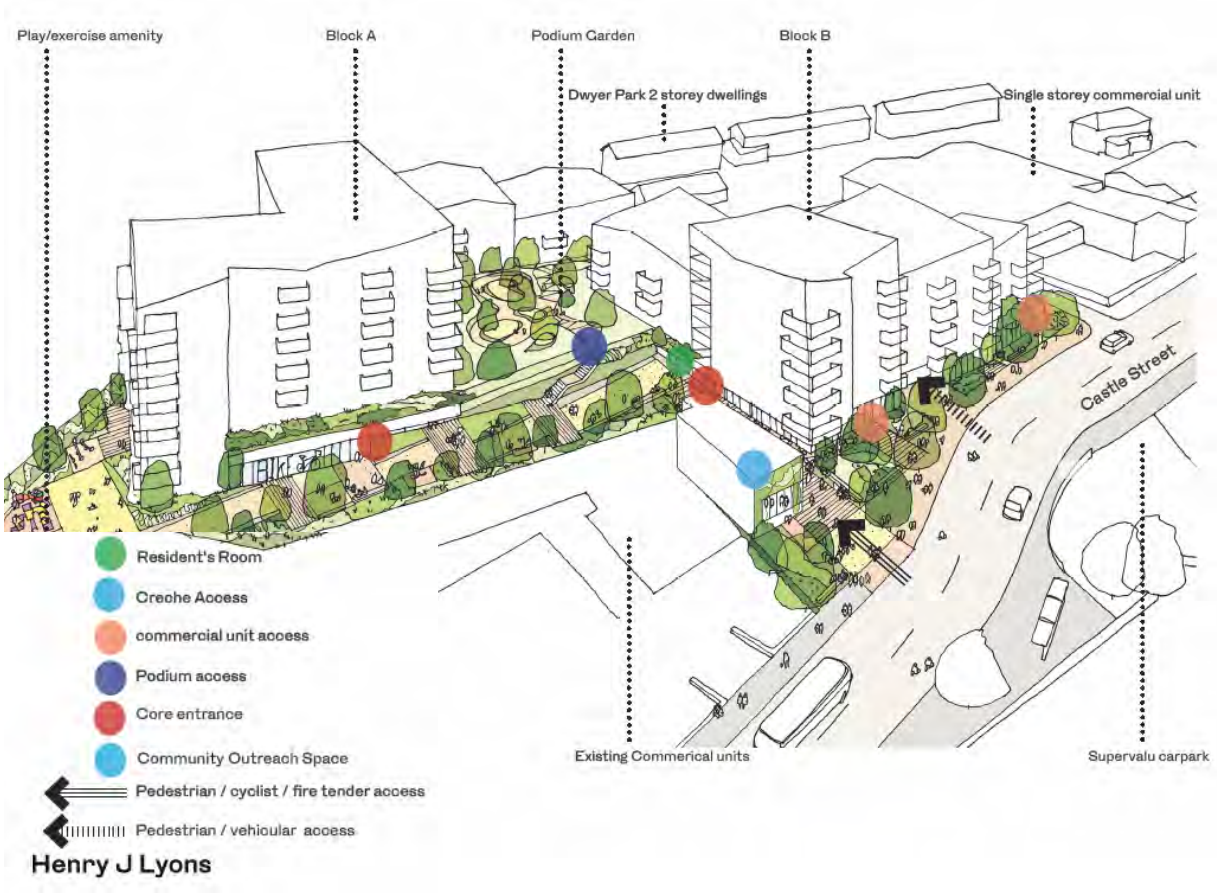
Due to the fact that the site is paved, all surface water is collected in a series of gullies within the Heiton-Buckley area of the site and is discharged to the existing combined sewer in Castle Street. Surface water from roofs and paved areas within the housing plots is similarly discharged to the existing combined sewer in Dwyer Park.

The site is located approximately 700m from the Irish Sea at its closest point at Bray Harbour to the east and c.170m from the River Dargle to the southeast. It is noted that substantial flood defences have been carried out on the Dargle in recent years and the site is now within an area of defended lands.

1.5 Proposed Development

The proposed development is an apartment development based on a density of 162 units per hectare realising a total number of 139 apartments. The scheme will also include a creche (220 square metres) at ground floor of Block A. Block B will include two commercial units at ground floor (combined area of 688 square metres), a residents community meeting room at ground floor (74 square metres) and a separate smaller building housing a community facility (86 square metres). The accommodation is proposed in two blocks, up to seven storeys in height, with undercroft car and motorcycle parking, secure cycle parking and bin storage. There are also a number of visitor cycle parking spaces at surface level. The scheme includes a high level of landscape proposals for the development. For full details of the architectural and landscape proposals please refer to the relevant professional's reports in this regard. Refer Figure 1-5, Figure 1-6 and Figure 1-7 for details of the current proposal.

Figure 1-5 SHD Application, Context Sketch[5]



[5] Source – Henry J. Lyons Architects

Figure 1-6 SHD Application, Proposed Ground Floor Plan[6]

[6] Source – Henry J. Lyons Architects

Figure 1-7 Aerial View of proposal with podium between Block A and Block B visible[7]

Figure 1-8 following details the Schedule of Accommodation for the proposed residential elements of the development.

Figure 1-8 Schedule of Accommodation[8]

RESIDENTIAL GIA	1 BED	2 BED	3 BED	TOTAL	
TOTAL Block A	**28**	**53**	**12**	**93**	**10026**
TOTAL Block B	**5**	**38**	**3**	**46**	**4941**
TOTAL Block A&B	**33**	**91**	**15**	**139**	**14967**
Area of podium Carpark					**1734**
UNIT MIX	24%	65%	11%	100%	

Commerical/Community area (sqm):		Creche:	
Community outreach:	86sqm	**Creche Area:**	**220sqm**
Unit 01:	284sqm	**No. of children:**	**28**
Unit 02:	404sqm	**External Play area:**	**85sqm**
Community meeting:	74sqm	**Creche Drop off spaces:**	3

[7] Source – Henry J. Lyons Architects
[8] Source – Henry J. Lyons Architects

2.0 The Planning System and Flood Risk Management

2.1 Background and Objectives

'The Planning System and Flood Risk Management Guidelines for Planning Authorities', Nov 2009 (hereinafter 'the Guidelines') was published jointly by the OPW and the then DOELG. The primary purpose of the Guidelines is to *'introduce comprehensive mechanisms for the incorporation of flood risk identification, assessment and management into the planning process'*. The Guidelines set out a comprehensive process for identifying flood risk and carrying out flood risk assessment in a consistent manner for all developments nationally.

The Guidelines require specific actions from authorities at national, regional and county/city level to identify potential flood risks to inform the planning process and incorporate sustainable drainage solutions for developments in an effort to reduce future flood risk.

However, this SSFRA is being prepared in compliance with the planning permission application requirements detailed in the Guidelines which state;

> *'In the case of applications for planning permission and development consents to planning authorities and An Bord Pleanála, applicants and their agents are required to:*
>
> *12. Carefully examine their development proposals to ensure consistency with the requirements of these Guidelines including carefully researching whether there have been instances of flooding or there is the potential for flooding, on specific sites and declaring any known flood history in the planning application form as required under the Planning and Development Regulations 2006.*
>
> *13. Engage with planning authorities at an early stage, utilising the arrangements for pre-planning application consultation with regard to any flood risk assessment issues that may arise.*
>
> *14. Carry out a site-specific flood risk assessment, as appropriate, and comply with the terms and conditions of any grant of planning permission with regard to the minimisation of flood risk.'*[9]

[9] The Guidelines, Page v

As set out in the Guidelines, the core objectives of the Guidelines are to:

- Avoid inappropriate development in areas at risk of flooding;
- Avoid new developments increasing flood risk elsewhere, including that which may arise from surface water run-off;
- Ensure effective management of residual risks for development permitted in floodplains;
- Avoid unnecessary restriction of national, regional or local economic and social growth;
- Improve the understanding of flood risk among relevant stakeholders; and
- Ensure that the requirements of EU and national law in relation to the natural environment and nature conservation are complied with at all stages of flood risk management.

2.2 The Sequential Approach

The Guidelines outline methodologies for the transparent consideration of flood risk at all levels of the planning process, ensuring a consistency of approach throughout the country. The Guidelines will contribute to the avoidance or minimisation of potential flood risk through a more systematic approach within a river catchment context.

The key principles of a risk-based sequential approach to managing flood risk in the planning system are;

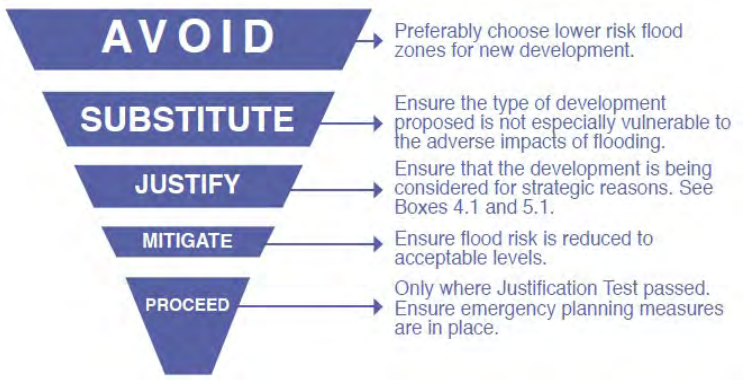
- **Avoid** development in areas at risk of flooding;

If this is not possible, consider substituting a land use that is less vulnerable to flooding.

Only when both avoidance and **substitution** cannot take place should consideration be given to **mitigation and management of risks**.

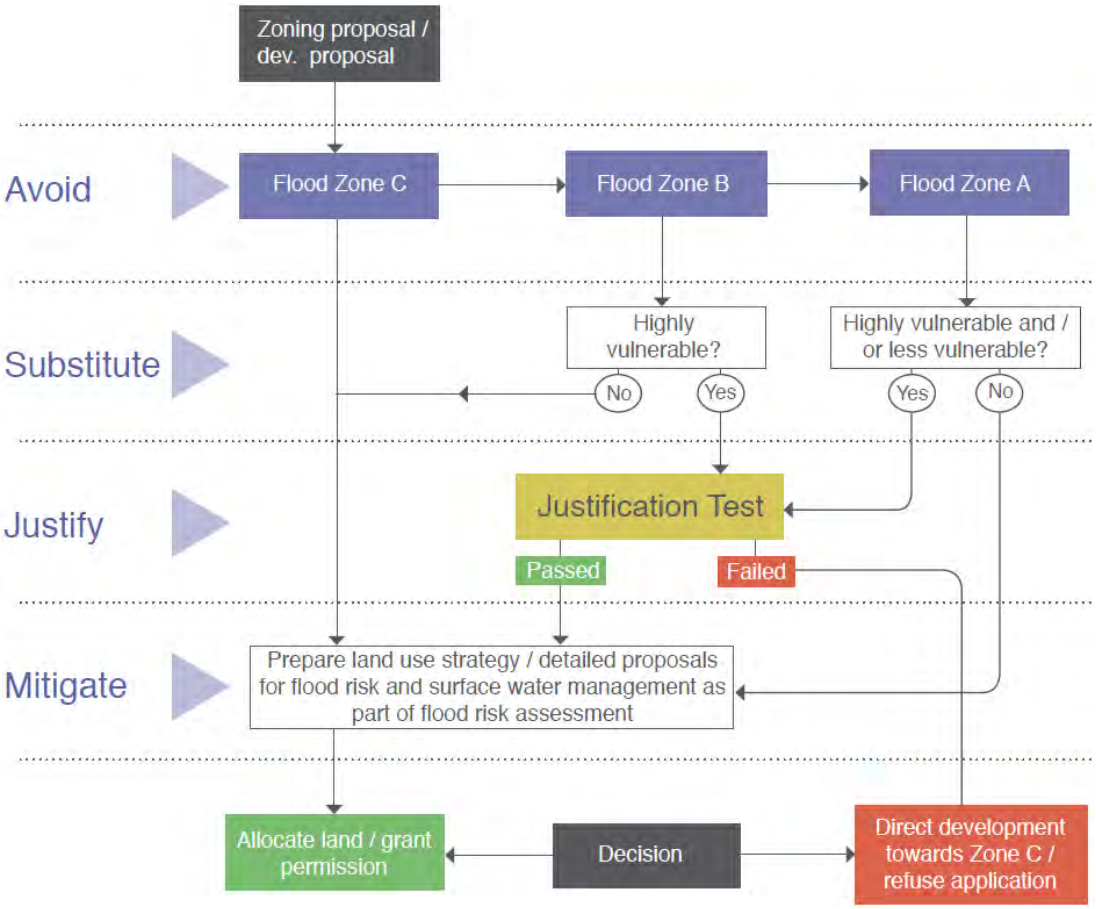
- Inappropriate types of development that would create unacceptable risks from flooding should not be planned for or permitted.
- **Exceptions** to the restriction of development due to potential flood risks are provided for through the use of a **Justification Test**, where the planning need and the sustainable management of flood risk to an acceptable level must be demonstrated.

Figure 2-1 Sequential approach principles in flood risk management[10]



In instances where avoidance or substitution are not possible, the Guidelines require that a Justification Test is carried out and that processes are followed such to minimise flood risks to each development.

Figure 2-2 Sequential approach mechanisms in the planning process[11]



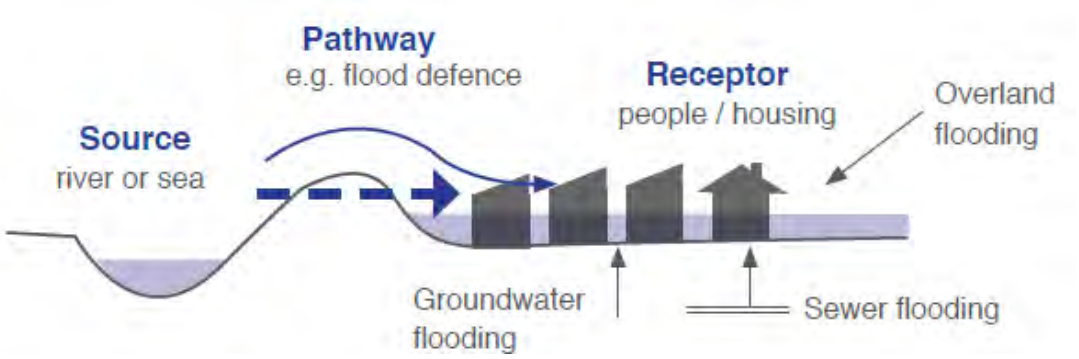
[10] Source – The Guidelines, '*Fig. 3.1: Sequential approach principles in flood risk management*'

[11] Source – The Guidelines, '*Fig. 3.2: Sequential approach mechanisms in the planning process*'

The sequential approach makes use of flood risk assessment and of prior identification of flood zones for river and coastal flooding and classification of the vulnerability to flooding of different types of development. It is essential that the risk potentially arising from other sources of flooding should also be taken into account in all areas and at all stages of the planning process.

The flood zones ignore the presence of defences. Areas that benefit from an existing flood relief scheme or flood defences have a reduced probability of flooding but can be particularly vulnerable due to the speed of flooding when overtopping or a breach or other failure takes place as exemplified in *Figure 2.3* following. Because this residual risk of flooding remains, the sequential approach and the Justification Test apply to such defended locations.

Figure 2-3 Source-Pathway-Receptor (S-P-R Model)[12]



2.3 Types & Causes of Flooding

There are two primary types of flooding, namely **Coastal flooding** and **Inland flooding**.

Coastal flooding is caused by higher sea levels than normal, largely as a result of storm surges, resulting in the sea overflowing onto the land. Coastal flooding is influenced by the following three factors, which often work in combination:

- High tide level;
- Storm surges caused by low barometric pressure exacerbated by high winds (the highest surges can develop from hurricanes); and
- Wave action which is dependent on wind speed and direction, local topography and exposure.

[12] Source – The Guidelines, '*Fig. 2.2: Source-Pathway-receptor Model*'

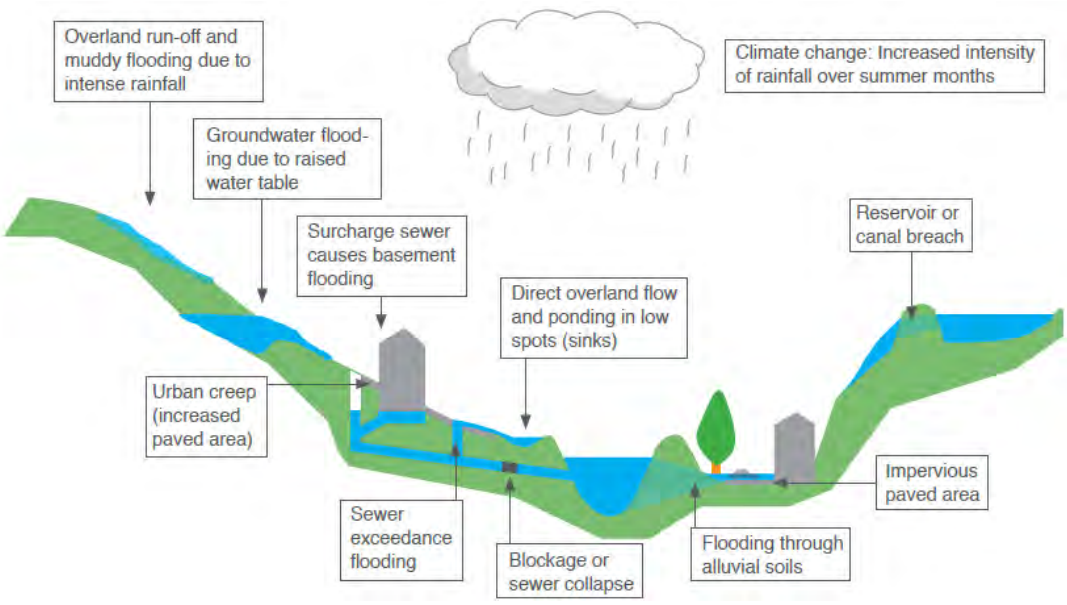
Inland flooding is caused by prolonged and/or intense rainfall. Inland flooding can include a number of different types:

- Overland flow occurs when the amount of rainfall exceeds the infiltration capacity of the ground to absorb it. This excess water flows overland, ponding in natural hollows and low-lying areas or behind obstructions. This occurs as a rapid response to intense rainfall and eventually enters a piped or natural drainage system.

- River flooding occurs when the capacity of a watercourse is exceeded or the channel is blocked or restricted, and excess water spills out from the channel onto adjacent low-lying areas (the floodplain). This can occur rapidly in short steep rivers or after some time and some distance from where the rain fell in rivers with a gentler gradient.

- Flooding from artificial drainage systems results when flow entering a system, such as an urban storm water drainage system, exceeds its discharge capacity and the system becomes blocked, and / or cannot discharge due to a high water level in the receiving watercourse. This mostly occurs as a rapid response to intense rainfall. Together with overland flow, it is often known as pluvial flooding. Flooding arising from a lack of capacity in the urban drainage network has become an important source of flood risk, as evidenced during recent summers.

Figure 2-4 Principal causes and types of flooding[13]



- Groundwater flooding occurs when the level of water stored in the ground rises as a result of prolonged rainfall to meet the ground surface and flows out over it, i.e. when the capacity of this underground reservoir is exceeded. Groundwater flooding tends to be very local and results from

[13] Source – The Guidelines, '*Fig. 2.1: Principal causes and types of flooding*'

interactions of site-specific factors such as tidal variations. While water level may rise slowly, it may be in place for extended periods of time. Hence, such flooding may often result in significant damage to property rather than be a potential risk to life.

- Estuarial flooding may occur due to a combination of tidal and fluvial flows, i.e. interaction between rivers and the sea, with tidal levels being dominant in most cases. A combination of high flow in rivers and a high tide will prevent water flowing out to sea tending to increase water levels inland, which may flood over river banks.

Flooding can also arise from the failure of infrastructure designed to store or carry water (e.g. the breach of a dam, a leaking canal, or a burst water main), or to protect an area against flooding (e.g. breach of a flood defence, failure of a flap valve or pumping station or blockage of a pipe or culvert). Because of the sudden onset, the impacts of this form of flooding can be severe and where appropriate should be assessed.

Increases in flood risk as a result of new development may be caused:

- Upstream by restricting the capacity and conveyance function of the watercourse and floodplain system; or

- Downstream by decreasing the volume available for flood storage on the floodplain, altering flow routes on the floodplain or by changes to the channel which can increase the flow discharged to downstream locations; and by increasing run-off due to changes in land management and introducing surfaces with reduced permeability, such as roads, roofs and car parks.

2.4 Flood Zones & Vulnerability Class

Flood zones are geographical areas within which the likelihood of flooding is in a particular range and they are a key tool in flood risk management within the planning process as well as in flood warning and emergency planning. There are three types or levels of flood zones defined for the purposes of the Guidelines:

- Flood Zone A – where the 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 – where the probability of flooding from rivers and the sea is moderate (between 0.1% or 1 in 1000 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 – where the 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.

The flood zones described above are indicative of river and coastal flooding only. They should not be used to suggest that any areas are free from flood risk, since they do not include the effects of other forms of flooding such as from groundwater, overland flows or artificial drainage systems.

The vulnerability of development to flooding depends on the nature of the development, its occupation and the construction methods used. A broad classification of vulnerability has been developed within the Guidelines. The classification of different land uses and types of development as '*highly vulnerable'*, *'less vulnerable'* and *'water-compatible'* is influenced primarily by the ability to manage the safety of people in flood events and the long-term implications for recovery of the function and structure of buildings.

Table 2-1 on the following page sets out the Vulnerability Class for different land uses and types of development.

In this case, the development under consideration is categorised as follows;

'Dwelling houses, student halls of residence and hostels;'

As such, the proposed development is classified as ***'Highly Vulnerable Development'*** under the Guidelines.

Table 2-1 Classification of vulnerability of different types of development[14]

Vulnerability Class	Land uses and types of development which include: (Uses not listed here should be considered on their own merits)
Highly vulnerable development (including essential infrastructure)	Garda, ambulance and fire stations and command centres required to be operational during flooding; Hospitals; Emergency access and egress points; Schools; Dwelling houses, student halls of residence and hostels; Residential institutions such as residential care homes, children's homes and social services homes; Caravans and mobile home parks; Dwelling houses designed, constructed or adapted for the elderly or, other people with impaired mobility; and Essential infrastructure, such as primary transport and utilities distribution, including electricity generating power stations and sub-stations, water and sewage treatment, and potential significant sources of pollution (SEVESO sites, IPPC sites, etc.) in the event of flooding.
Less vulnerable development	Buildings used for: retail, leisure, warehousing, commercial, industrial and non-residential institutions; Land and buildings used for holiday or short-let caravans and camping, subject to specific warning and evacuation plans; Land and buildings used for agriculture and forestry; Waste treatment (except landfill and hazardous waste); Mineral working and processing; and Local transport infrastructure.
Water compatible development	Flood control infrastructure; Docks, marinas and wharves; Navigation facilities; Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location; Water-based recreation and tourism (excluding sleeping accommodation); Lifeguard and coastguard stations; Amenity open space, outdoor sports and recreation and essential facilities such as changing rooms; and Essential ancillary sleeping or residential accommodation for staff required by uses in this category (subject to a specific warning and evacuation plan).

Each development type is assessed based on the vulnerability of the development type and which flood plain the site is located within. *Table 2-2* following is a matrix of vulnerability versus flood zone and will dictate the requirement, or not, for a justification test dependant on these factors.

[14] Source – The Guidelines, '*Table 3.1 Classification of vulnerability of different types of development*'

Table 2-2 Matrix of vulnerability versus flood zone to illustrate appropriate development and that required to meet the Justification Test[15]

	Flood Zone A	Flood Zone B	Flood Zone C
Highly vulnerable development (including essential infrastructure)	Justification Test	Justification Test	Appropriate
Less Vulnerable Development	Justification Test	Appropriate	Appropriate
Water-compatible Development	Appropriate	Appropriate	Appropriate

2.5 Justification Test

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

- The first is the **Plan-making Justification Test** and used at the development 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** 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.

2.6 Flood Risk Assessment Stages

FRAs are typically undertaken over a number of stages, with the need for progression to a more detailed stage dependent on the outcomes of the former stage until the level of detail of the FRA is appropriate to support the planning matter, be it a zoning proposal or a decision on an individual planning application, or it has been demonstrated that flooding is not a relevant issue for the area or site.

As outlined in chapter 3 of the Guidelines the stages of assessment are:

- **Stage 1 Flood risk identification** – to identify whether there may be any flooding or surface water management issues related to a plan area or proposed development site that may warrant further investigation;

[15] Source – The Guidelines, '*Table 3.2 Matrix of vulnerability versus flood zone to illustrate appropriate development and that required to meet the Justification Test.*'

- Stage 2 Initial flood risk assessment – to confirm sources of flooding that may affect a plan area or proposed development site, to appraise the adequacy of existing information and to determine what surveys and modelling approach is appropriate to match the spatial resolution required and complexity of the flood risk issues. The extent of the risk of flooding should be assessed which may involve preparing indicative flood zone maps. Where existing river or coastal models exist, these should be used broadly to assess the extent of the risk of flooding and potential impact of a development on flooding elsewhere and of the scope of possible mitigation measures; and

- Stage 3 Detailed risk assessment – to assess flood risk issues in sufficient detail and to provide a quantitative appraisal of potential flood risk to a proposed or existing development, of its potential impact on flood risk elsewhere and of the effectiveness of any proposed mitigation measures. This will typically involve use of an existing or construction of a hydraulic model of the river or coastal cell across a wide enough area to appreciate the catchment wide impacts and hydrological processes involved.

3.0 Stage 1 Flood Risk Identification

3.1 Proposed Development Details

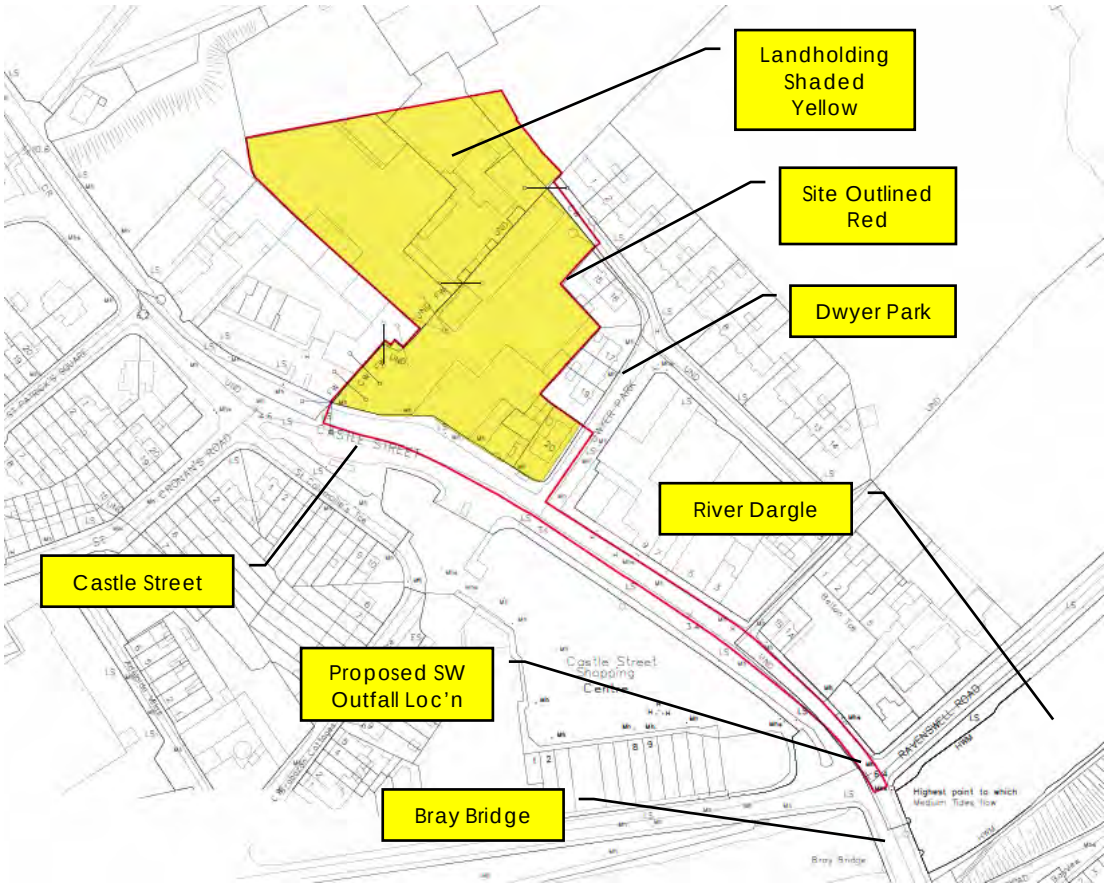
The subject development site under consideration falls within the townlands of Ravenswell and Little Bray, off, and to the immediate northeast of Castle Street (Regional Road R761), Bray, County Wicklow; to the west of the existing Dwyer Park housing estate; to the east and north of existing Dargle Centre retail park. There are third party development zoned lands to the northwest and west of the site which are designated for the access route into the Former Bray Golf Course lands to the north of the development lands (identified as SLO 3 under the current Bray Local Area Plan). The land is currently occupied by several warehouses which served a builder's providers and two dwelling houses and ancillaries. The site is therefore considered a '*Brownfield Site*'.

The site is located approximately 700m from the Irish Sea at its closest point at Bray Harbour to the east and c.170m from the River Dargle to the southeast which is tidal at this location. It is noted that substantial flood defences have been carried out on the Dargle in recent years and the site is now within defended lands. The minimum elevation within the site is 3.4 metres above Malin Head (Ordnance) Datum. There are no watercourses or sewers, culverts, etc. traversing the site which would have a flood potential. Substantial flood defences have been constructed on the River Dargle in recent years and the site is now located within a defended area. The works were carried out under the 'River Dargle (Bray) Flood Relief Scheme'. The River Dargle (Bray) Drainage Scheme commenced construction in May 2012, and was completed in 2017. The Scheme, that comprises widening and deepening of the river channel, the construction of walls, embankments and culverts, underpinning of Bray Bridge, river regrading, soil nailing and erosion protection, provides protection against a 100-Year flood (1% Annual Exceedance Probability) for fluvial flooding and a 200-Year flood (0.5% Annual Exceedance Probability) against tidal flooding for 658 properties including the applicant site.

Figure 3-1 Site Location at Context Scale

The following figure shows the location of the site (outlined red) at a larger scale for clarity, with the River Dargle shown to the south. It is noted that the applicant's land ownership does not include the areas of public road within the redline boundary – these areas are necessary to be included as works are proposed to be carried out in the form of new footpaths, landscaping and roadmarkings and construction of a surface water sewer from the site to a proposed outfall to the River Dargle.

Figure 3-2 Site Location



3.2 Coastal Flood Risk

Coastal flooding results from sea levels which are higher than normal and result in sea water overflowing onto the land. Coastal flooding is influenced by the following three factors which often work in combination; high tide levels, storm surges and; wave action:

Given the existing ground levels in the site, the lowest being less than 4metres above Malin Head Ordnance Datum, and the location of the River Dargle which is tidal relative to the site and records of previous flooding in the area, coastal flood risk must be investigated as part of this initial stage of the SSFRA.

3.3 Fluvial Flood Risk

Fluvial flooding Is the result of a river exceeding its capacity and excess water spilling out onto the adjacent floodplain. Due to the location of the River Dargle relative to the site and historical flooding which has taken place previously fluvial flood risk must be investigated as part of this initial stage of the SSFRA.

3.4 Pluvial Flood Risk

Pluvial flooding is the result of rainfall generated overland flows which arise before runoff can enter a watercourse or sewer. It is usually associated with high intensity rainfall that typically occurs in the summer months.

3.5 Existing Flood Risk Information

The Stage 1 Flood Risk Identification process uses existing available information to assess whether there are potential flooding issues with the site which may require further investigation. If the Stage 1 process identifies potential flooding issues it will be necessary to progress to Stage 2 – Initial Flood Risk Assessment, and so on. *Table 3-1* following details the available information reviewed as part of this Stage 1 assessment.

Table 3-1 Review of available flood risk information

	Information Source	Coverage	Quality	Confidence	Identified Flood Risks/Comments	Identified Flood Risk
Primary Sources for flood risk information	Catchment Flood Risk Assessment & Management Study (CFRAMS);	National	High	High	Mapping confirms that the site is not within the low probability 0.1% AEP flood extents areas for fluvial or coastal flooding.	**No**
	Bray Municipal District Local Area Plan 2017 SFRA	Local/	Moderate	Moderate	Flood extents modelled without River Dargle (Bray) Drainage Scheme for Justification Test purposes. Justification Test passed.	**No**
	Irish Coastal Protection Strategy Study (ICPSS) flood and coastal erosion risk maps;	National	High	Low	Flood extents do not extend to the applicant site.	**No**
	Eastern Catchment Flood Risk Assessment & Management Study (CFRAMS);	National	High	High	Confirms the site is not liable to coastal flooding for the 0.1% Tidal AEP event.	**No**
Secondary Sources for Flood Risk Information	Predictive and historic flood maps, and Benefiting Lands Maps, such as those at http://www.floodmaps.ie;	National	Varies	Varies	Interrogation of the OPW's floodmaps.ie website confirms that there is a single recorded flood event on the site, Hurricane Charlie in 1986. Recent completed flood defence measures have been put in place and the flooded areas are now defended.	**No**
	Topographical survey maps, in particular digital elevation models produced by aerial survey or ground survey techniques;	Local	High	High	Inspection of the topographic maps commissioned for the development and inspection of the proposed design levels confirm that the site is not at risk of flooding from overland flows.	**No**
	Alluvial deposit maps of the Geological Survey of Ireland;	National	Moderate	Low	Inspection of the GSI mapping shows that there is no evidence of historical flooding extending to the area of the site to be developed.	**No**
	'Liable to flood' markings on the old '6 Inch' and '25 Inch' maps;	National	Low	Low	There are no 'Liable to flood' markings on the old 6inch and 25inch maps.	**No**
	Walkover survey to assess potential sources of flooding, likely routes for flood waters and the site's key features, including flood defences, and their condition;	Local	Varies	Varies	The site inspection did not identify any sources of potential flooding to the site.	**No**
	Planning and Development Records.	Local	High	Varies	There has been a previous planning application on the subject site which included a flood risk assessment. The development was not deemed to be at risk of flooding.	**No**
	Proposed Development	Local	High	High	The drainage design for the proposed development is compliant with the GDSDS and the Planning System & Flood Risk Management Guidelines for Planning Authorities. The SuDS measures incorporated into the design are compliant with the CDP and LAP recommendations.	**No**

3.5.1 OPW Catchment Flood Risk Assessment & Management Study

In March 2012, the OPW published the Preliminary Flood Risk Assessment (PFRA) maps covering the entire country. The PFRA was not a detailed assessment of flood risk. It was rather a broad assessment, based on available and readily derivable information to identify areas where there was a genuine cause for concern about a risk and impact of flooding that may require further assessment. As part of the PFRA

study, there were 300 areas designated as Areas for Further Assessment (AFAs) which are covered by the Catchment Flood Risk Assessment and Management Study (CFRAMS) which was carried out at a later stage.

The OPW used three sources of information to designate these 300 areas:

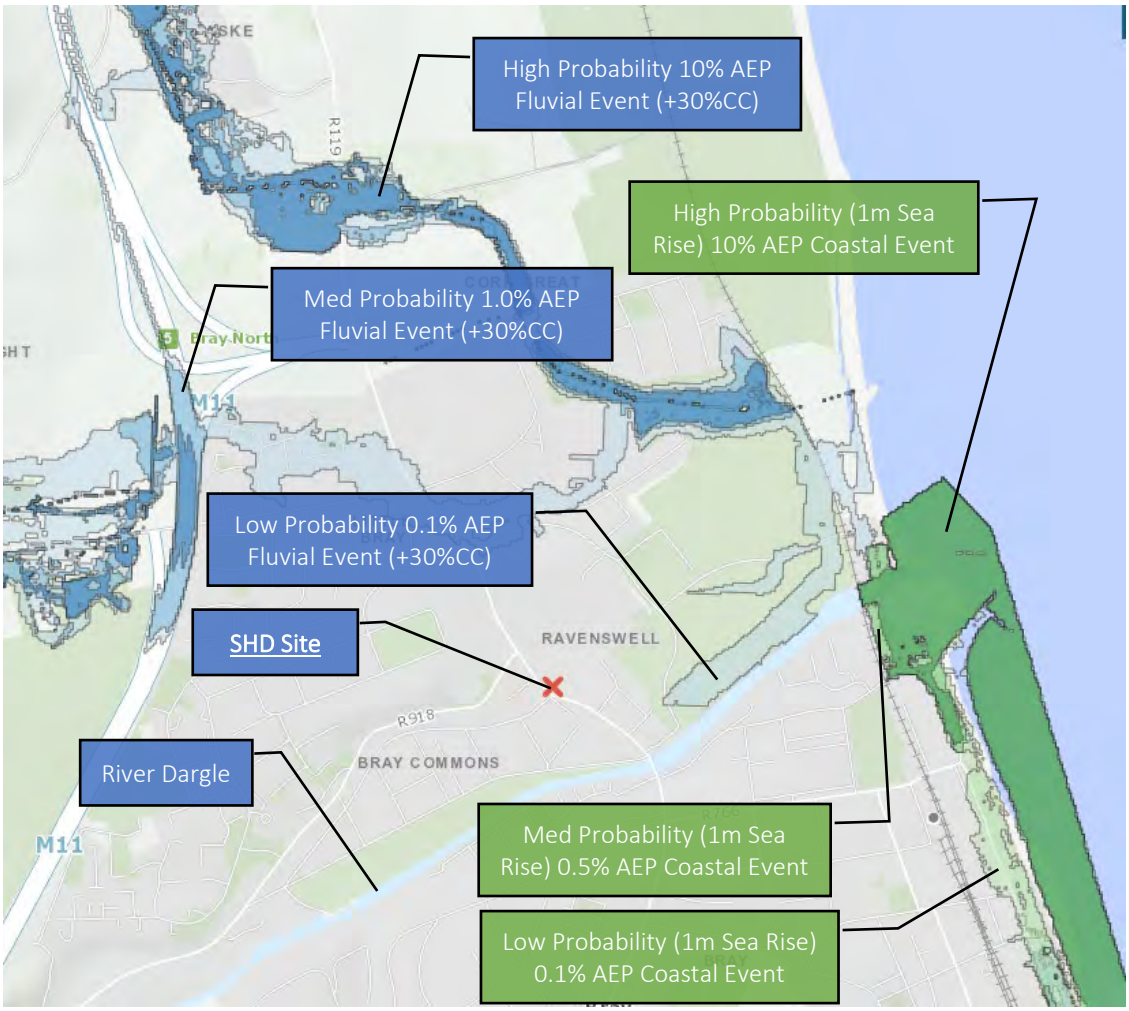
- Historic information on floods that happened in the past.
- Public consultation to gain local and expert knowledge from Local Authorities and other Government departments and agencies to identify areas prone to flooding and the potential consequences.
- Engineering techniques to analyse potential damage that could be caused by flooding.

In preparing the PFRA mapping, the OPW considered all types of flooding, including from rivers, the sea, intense rainfall events and groundwater. The OPW also considered the impacts flooding can have on people, property, businesses, critical infrastructure, the environment and cultural heritage. Bray was one of the areas designated for further assessment and the area within which the site falls was assessed as part of the Bray Fluvial Flood Extents project.

Inspection of the Bray Fluvial Flood Extents project mapping prepared by the OPW shows that the flood extent mapping is currently under review. However, the extents shown clearly show that the site is not close to any of the fluvial flood extents previously identified (on the withdrawn flood extent mapping). Refer Figure 3-3 following which is an extract from the Floodinfo.ie flood extents mapping. The extents of the flooding area for low, medium and high probability fluvial and coastal events are shown. Based on the mapping, the site is not subject to fluvial flooding for the low probability 0.1% AEP Fluvial event (1in1000year fluvial event) and is not subject to coastal flooding for the low probability 0.1% AEP Coastal event (1in1000year coastal event).

Based on the available Bray Fluvial Flood Extents mapping, fluvial flooding is not considered to pose a constraint to development

Figure 3-3 Extract from Floodinfo.ie Fluvial & Coastal High End Future Scenario Flood Maps

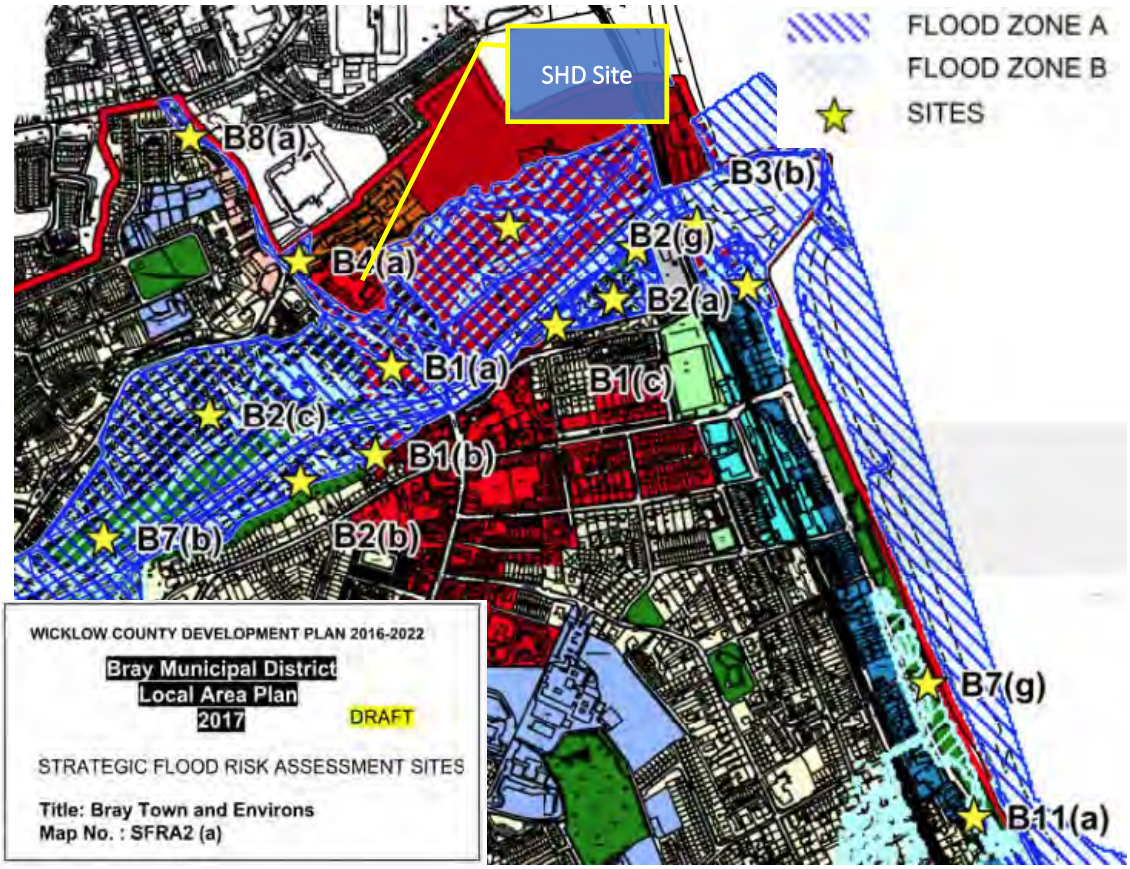


3.5.2 Bray Municipal District LAP SFRA

The Bray Municipal District Local Area Plan 2018 includes a Strategic Flood Risk Assessment (SFRA) under Appendix C, titled *'Appendix C Strategic Flood Risk Assessment'*. The assessment was prepared in accordance with the requirements of The Planning System and Flood Risk Assessment Guidelines for Planning Authorities (2009) and Circular PL02/2014 (OPW, 2014). The SFRA provides an assessment of all types of flood risk within the County and assisted Wicklow County Council to make informed strategic land-use planning decisions and formulate flood risk policies. A review of available flood risk information was undertaken to identify any flooding or surface water management issues related to the County that may warrant further investigation.

The flood risk mapping for the Bray town and environs area is included in the assessment, an extract of which is shown in Figure 3-4 following and the full map is included in *Appendix A.1* to the rear of this report.

Figure 3-4 Extract from Bray Town and Environs SFRA Sites, Map No.: SFRA2(a)



The mapping was prepared in accordance with the OPW Guidelines for a Strategic Flood Risk Assessment (SFRA) for Wicklow County Council. The OPW Guidelines require that defended lands (that have had flood defence works carried out) are included within the assessment including areas which are defended for land use zoning purposes. It is acknowledged within the SFRA that *'As part of the River Dargle Flood Defence Scheme these lands have had flood defence works carried out and are therefore considered to be defended.'* The River Dargle (Bray) Drainage Scheme commenced construction in May 2012, and was completed in 2017. The Scheme, that comprises widening and deepening of the river channel, the construction of walls, embankments and culverts, underpinning of Bray Bridge, river regrading, soil nailing and erosion protection, provides protection against a 100-Year flood (1% Annual Exceedance Probability) for fluvial flooding and a 200-Year flood (0.5% Annual Exceedance Probability) against tidal flooding for 658 properties including areas of the applicant site shown within Flood Zone A for the SFRA Justification Test.

As such, the applicant site is within Flood Zone C for Fluvial Flooding.

3.5.3 Pluvial Flooding

The topography of the immediate surrounding area would suggest that there is little risk of pluvial flooding to the site. In the event that the public network surcharges, the natural topography will direct any flood water away from the site towards the River Dargle along Castle Street to the south/southeast.

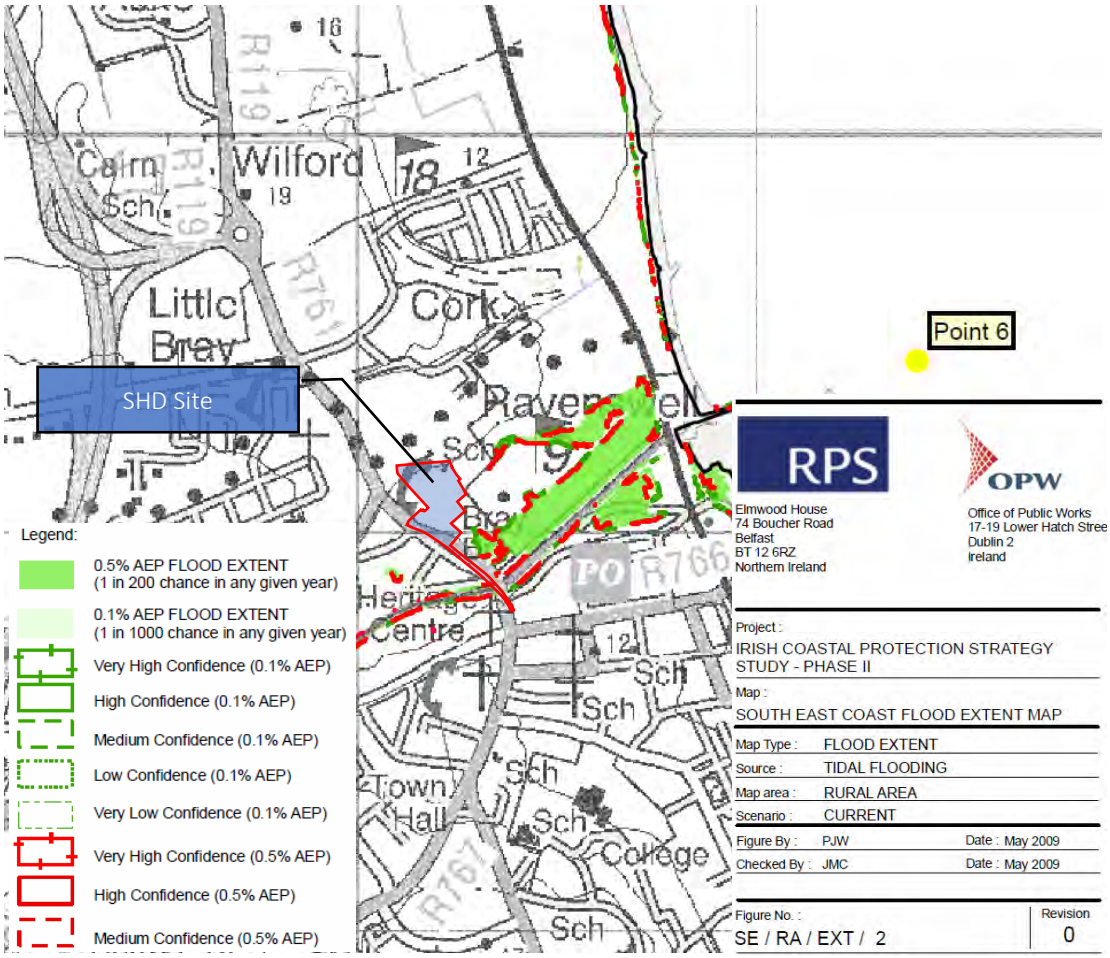
The finished level designs for the development on the site reflects the existing topography and natural surface flow routes. The internal drainage for the scheme has been designed such that there is no risk of internal flooding to the properties in the event of a system failure. In the event of a total system failure within the development, surface water from the development will primarily flow towards Castle Street and on to the River Dargle via Castle Street to the southeast of the site.

As such, pluvial flooding is not considered to pose a constraint to development.

3.5.4 Irish Coastal Protection Strategy Study (ICPSS)

The Irish Coastal Protection Strategy Study was carried out by RPS Consulting Engineers and the OPW. It was carried out to assess the degree of flood hazard and risk to assist in the identification and development of measures for managing the flood risk. They may, however, also be of use to the public, Local Authorities and other parties as indicative maps of flood-prone areas for a range of purposes, including raising awareness of flood hazard and risk, preparedness and response planning for flood events and assisting in planning and development decisions. The mapping was prepared in 2010 and does not identify a flood risk at the site although the 1986 Hurricane Charlie event did exceed the extents identified on the ICPSS mapping. While the mapping is a useful tool, the Eastern CFRAM Study mapping is more appropriate at this time as the River Dargle flood defences were completed in 2017 and their benefit to the defended lands is not reflected in the ICPSS mapping. Figure 3-5 following is an extract from the tidal flooding map which covers the Bray area. The entire sheet, Figure Number SE/RA/EXT/2 is included in *Appendix B.1* to the rear of this report. It can be seen that the applicant site is outside of the 0.5% AEP Flood Extents.

Figure 3-5 Extract from ICPSS South East Coast Flood Extent Map, Fig. No. SE/RA/EXT/2, May 2009

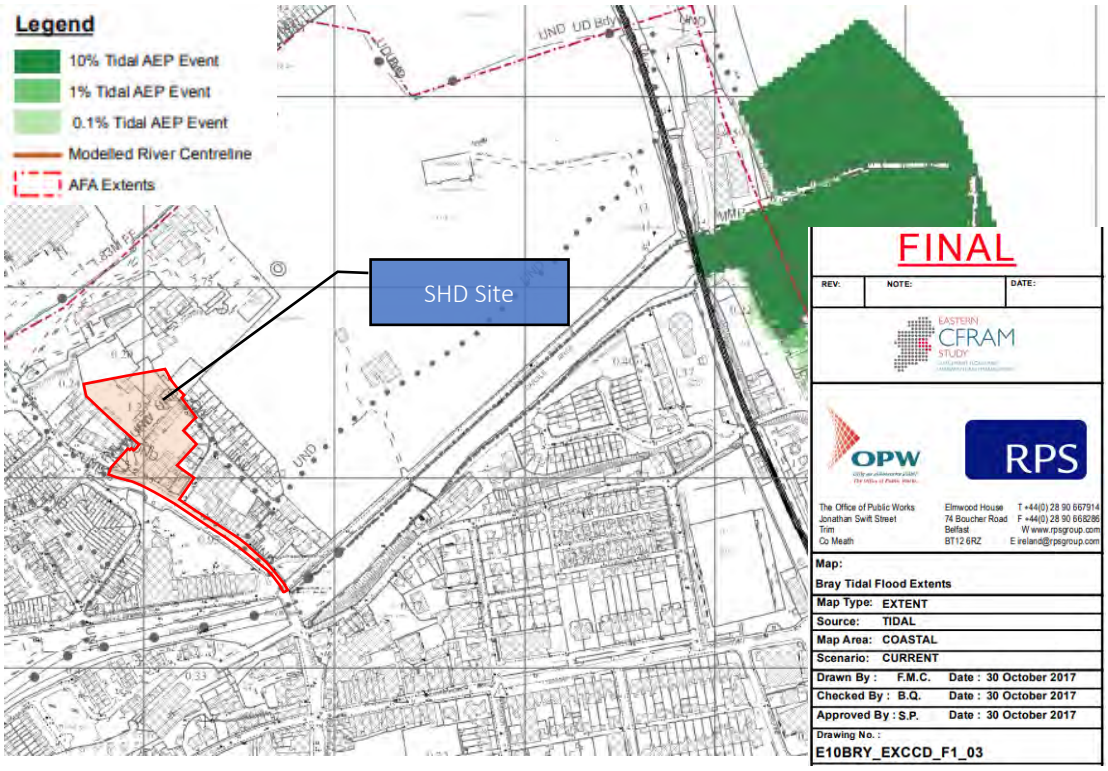


3.5.5 Eastern Catchment Flood Risk and Management Study

Inspection of the Eastern Catchment Flood Risk Assessment and Management Study, 2016 (CFRAMS) prepared by RPS for the OPW confirms that the site is not subject to Coastal Flooding. Refer Figure 3-6 following which is an extract from the ECFRAMS Bray Tidal Flood Extents map (Map No. E10BRY_EXCCD_F1_03, dated October 2017). Based on the mapping, the site is not subject to tidal flooding for the 0.1% AEP Tidal event (1in1000year tidal event). The full map is included in *Appendix B.2* to the rear of this report.

As such, coastal flooding is not considered to pose a constraint to development.

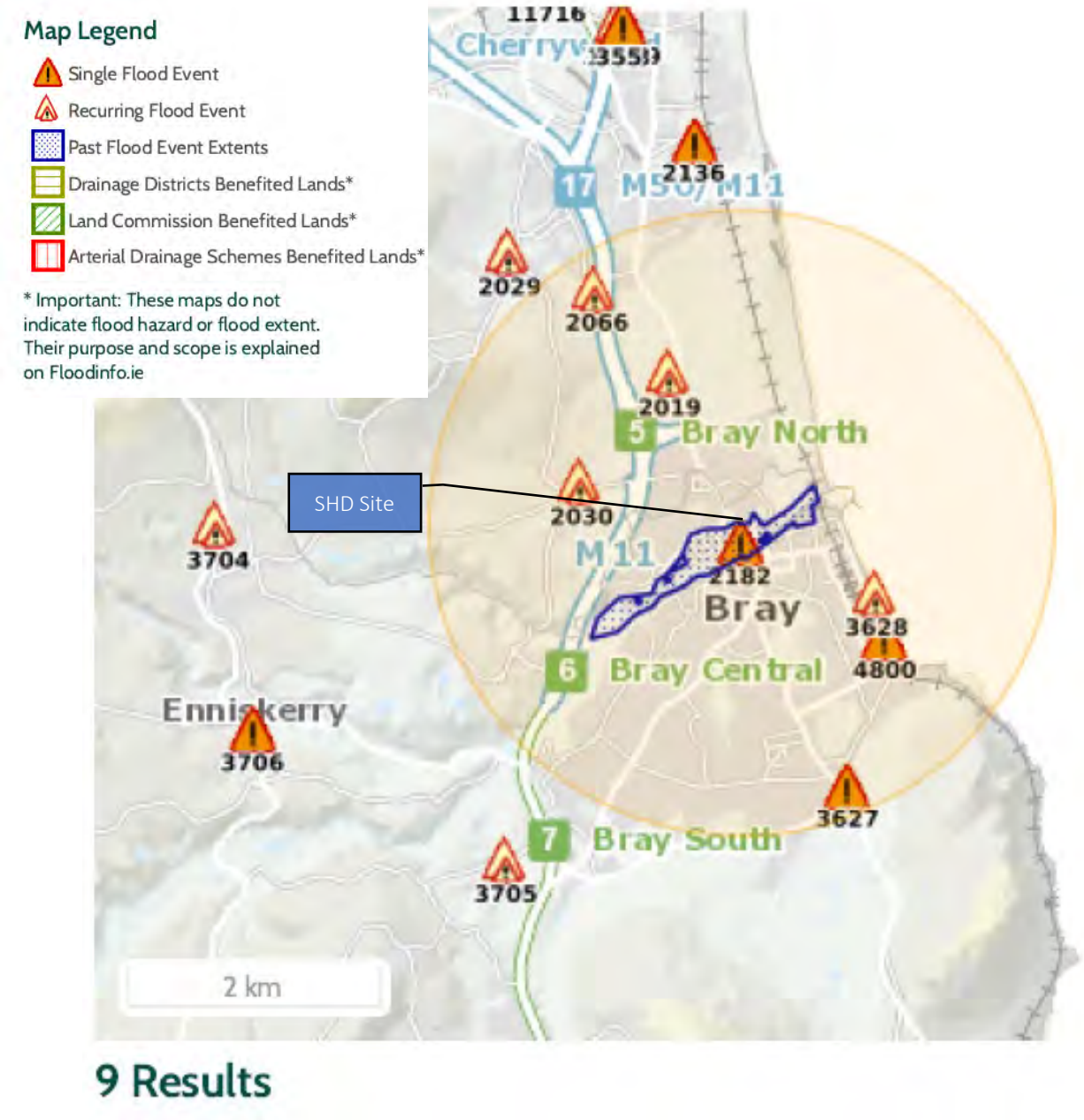
Figure 3-6 Extract from ECFRAMS Mapping, Map No. E10BRY_EXCCD_F1_03, Dated Oct 2017



3.5.6 OPW Flood Records

As part of this assessment the OPW flood event database was interrogated. There are six records of floods within 2.5kilometres of the site. There are a total of nine flood events recorded within the radius – see Figure 3-7 following extracted from the Summary Local Area Report. A copy of the relevant generated Summary Local Area Report is included in *Appendix C.1*.

Figure 3-7 Extract from OPW floodmaps.ie generated Summary Local Area Report



The Past Flood Event Extents area shown in blue is the only event that impacted the site and occurred in August 1985 as a result of Hurricane Charlie. On the 25th and 26th of August 1986 Hurricane Charlie occurred and was deemed exceptional with large rainfall totals accompanied by strong to gale force winds causing flood events in Avoca, Bray, Arklow and Aughrim, and also in the Carrickmines/Shanganagh HPW. On the 26th of August rainfall was in excess of 100mm in the 24-hour period in many areas. The rushing water resulting from Hurricane Charlie did damage in excess of IR£3m to roads and bridges in County Wicklow. In Bray, a total of 520 houses were flooded together with retail, industrial and commercial premises. The River Dargle (Bray) Drainage Scheme was since completed in 2017. The Scheme provides protection against a 100-Year flood (1% Annual Exceedance Probability) for fluvial

flooding and a 200-Year flood (0.5% Annual Exceedance Probability) against tidal flooding for these flooded areas.

3.5.7 Topographic Surveys

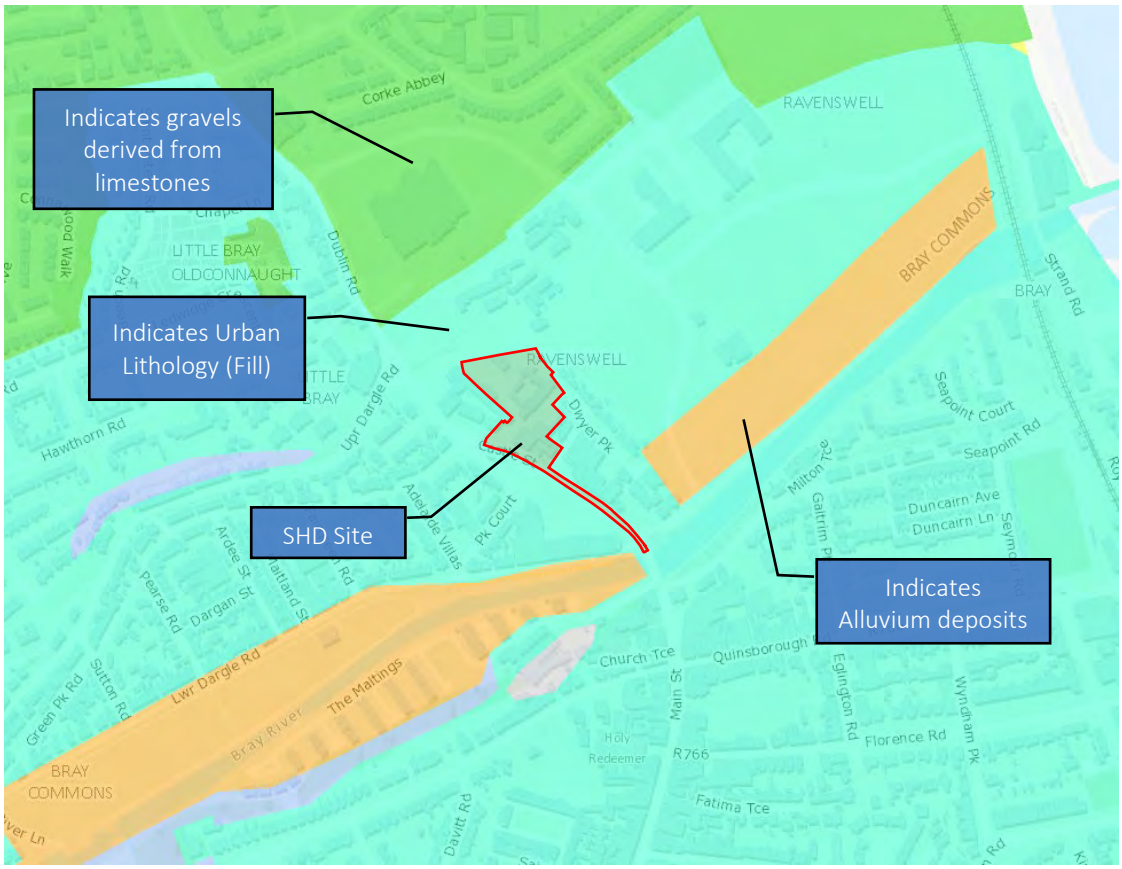
Inspection of the topographic survey commissioned for the site confirms that the site is not at risk of flooding from overland pluvial flows. The proposed scheme includes extensive SuDS measures which will reduce surface water discharge and overland flow routes created within the development will ensure there is only limited risk of flooding as a result of a surface water network failure. Surface water from the development will be collected in green roofs areas, permeable paving surfaced areas and, infiltration storage areas and attenuation tanks throughout the site. The development design mirrors the existing scenario regarding surface levels and existing overland flow routes will remain unchanged with surface flows being directed naturally towards Castle Street which will as a channel for any surface waters reaching them and direct them towards the River Dargle as is currently the case.

3.5.8 Geological Survey of Ireland (GSI) Mapping

The Geological Survey of Ireland provides a national database on a number of different geological characteristics nationally. Inspection of the soil maps can show where there are alluvial mineral deposits which would indicate historical out of channel flows and inspection of the aquifer vulnerability in an area gives a general indication of the infiltration characteristics of the area.

Inspection of the Geological Survey of Ireland database and in particular the quaternary soils shows that the soils beneath the site are categorised as 'Urban' which is typically general urban fill which occurs as a result of continuous urban development. Alluvium deposits would have indicated a prehistoric watercourse where silts would be likely which concludes that the previous flood events extending to the site prior to the completion of the Dargle flood defences are as a result of urban development. An extract from the GSI mapping is shown in Figure 3-8 following and the generated map is included in *Appendix D.1*.

Figure 3-8 GSI Quaternary Soils Maps



3.5.9 Inspection of 6 Inch and 25 Inch Mapping

Inspection of the OSI 6inch and 25inch mapping shows that there are no indications of flooding on the old 6inch and 25inch maps and there are no *'Liable to Flooding'* annotations in the vicinity of the site. Figure 3-9 and Figure 3-10 following are extracts from the old 6inch and 25inch mapping from the OSI.ie website for the area in question.

Figure 3-9 Extract from OSI Historic Map 6 inch B&W (1837-1842)

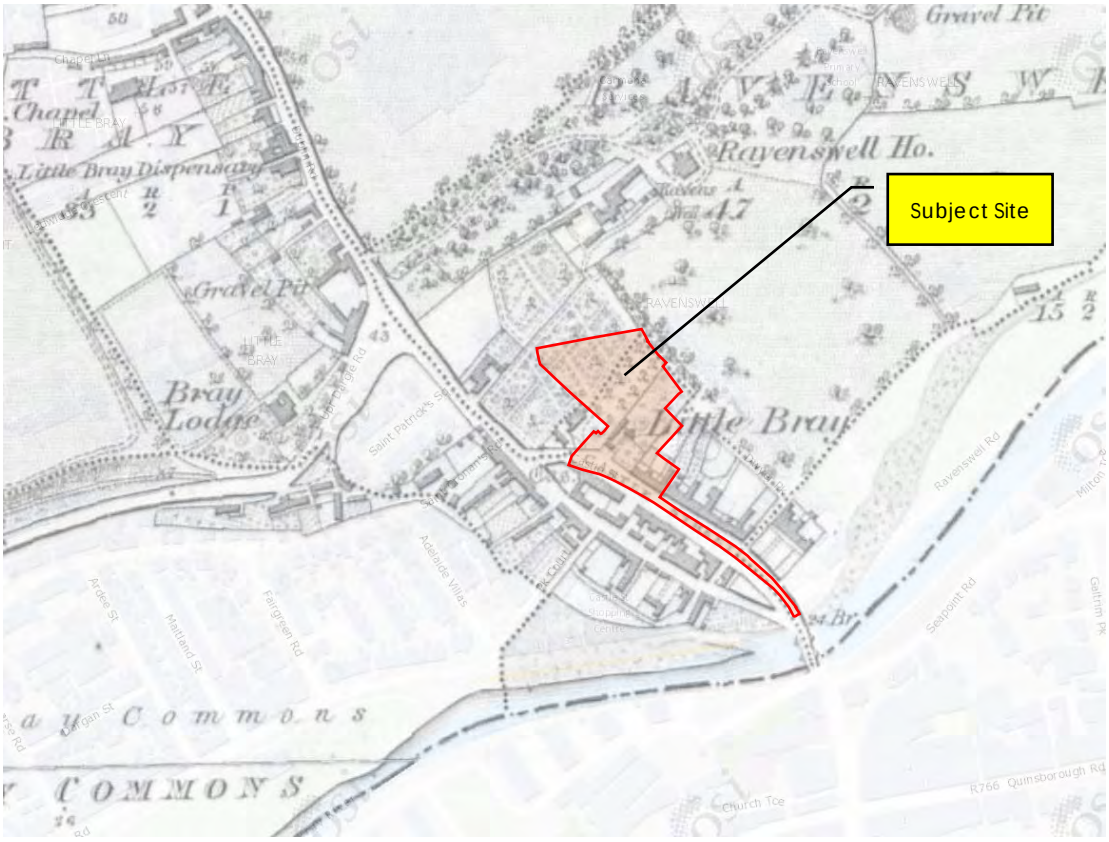
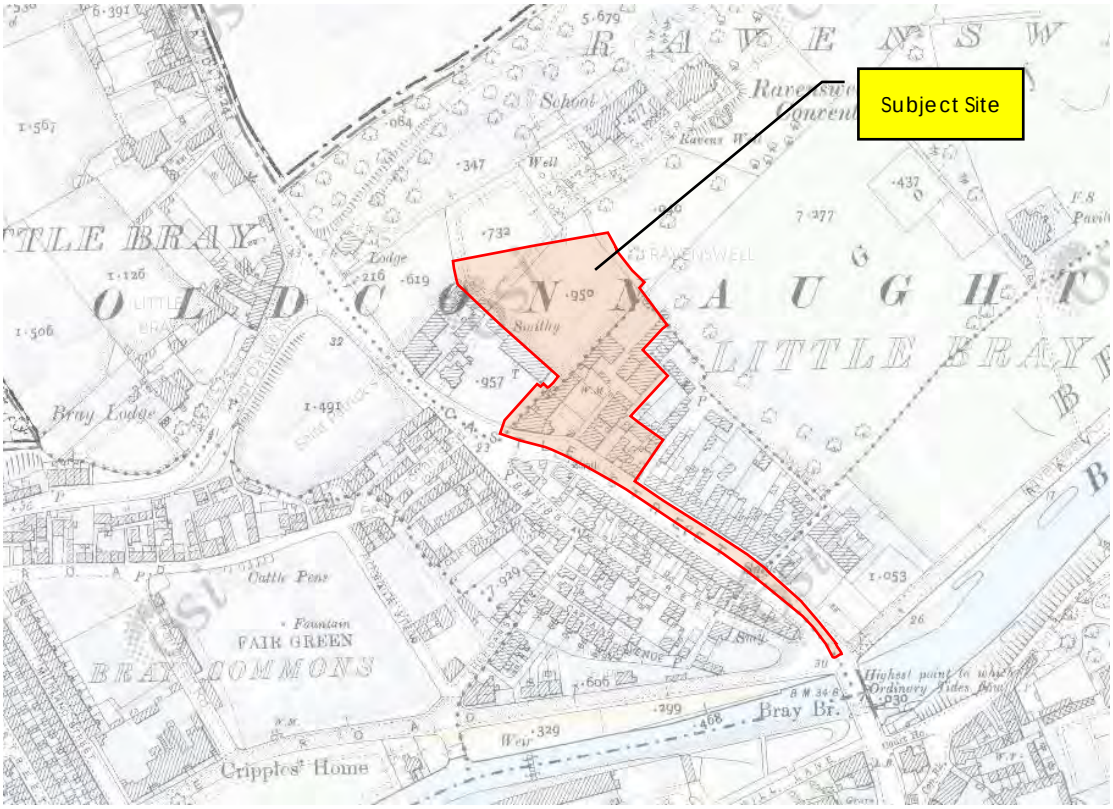


Figure 3-10 Extract from OSI Historic Map 25 inch (1888-1913)



3.5.10 Walkover Survey

A walkover survey of the site was carried out to assess potential sources of flooding and likely overland flow routes. Due to the location of the site, the surrounding developments on the higher west side, and based on the previously discussed topography of the site, the likelihood of flooding from the existing lands to the north or the existing lands to the east or west of the site which are at a lower elevation than the site is considered extremely low.

The initial portion of the entrance road into the site from Castle Street rises from the public road so no overland flows will enter the site from the public road to the south.

Based on the walkover survey of the site, there is no apparent flood mechanisms which would impact on the developed area of the site.

Photographic records of the walkover survey are included in *Appendix E.1* to the rear of this report.

3.5.11 Planning and Development Records

While there are records of a previous planning application on the site (PA Ref. Ref. 14/2174) which includes a flood risk assessment prepared by Waterman Moylan Consulting Engineers, it was prior to the River Dargle (Bray) Drainage Scheme completion in 2017. Despite this fact, the proposed development was not deemed to be at risk of flooding at that time.

3.5.12 Proposed Development Design

The proposed development includes a number of SuDS measures which are designed to minimise flood risk to the subject site and upstream and downstream properties in accordance with the GDSDS. The surface water discharge for the development is limited to the calculated greenfield runoff rate and the necessary attenuation storage is designed allowing for a 20% climate change factor. The addition of green roofs, attenuation storage and extensive areas of permeable paving areas further increases storage throughout the site and also increases the time of entry for discharge into the attenuation area, thereby further flattening the peak flow curves. The floor levels for all units are a minimum of 500mm above the modelled attenuation storage critical storm top water levels.

The proposed drainage layouts, basement drainage layout and the different drainage catchments (Permeable, impermeable, green roof, etc.) for the scheme are shown on CHC drawings CHC-00-GR-DR-C-00200, CHC-00-GR-DR-C-00203, CHC-00-B1-DR-C-00201 and CHC-00-GR-DR-C-00400 respectively. The site specific details are shown on accompanying CHC Drawing CHC-00-GR-DR-C-00121, CHC-00-GR-DR-C-00210, CHC-00-GR-DR-C-00230, CHC-00-GR-DR-C-00240, CHC-00-GR-DR-C-00241 and CHC-00-GR-DR-C-00242.

Details of the surface water model analysis results are included in *Appendix F.1* to the rear of this report. The Greenfield Runoff calculation and calculations for 10mm interception storage for the site is included in *Appendix F.2*. The analysis confirms that the proposed system does not flood in any of the modelled storm events.

3.6 Flood Risk Assessment

The Site Specific Flood Risk Assessment (SSFRA) has been prepared in accordance with the requirements of The Planning System and Flood Risk Assessment Guidelines for Planning Authorities (2009) and Circular PL02/2014 (OPW, 2014). As part of the assessment, potential flooding impacts on adjacent properties resulting from system failure, overland flows, etc. have been evaluated. The assessment has not identified any potential flooding issues and the proposed development is deemed *'Appropriate'*.

In accordance with The Planning System and Flood Risk Management Guidelines for Planning Authorities, there is no requirement to carry out a Stage 2 Flood Risk Assessment on the site.

4.0 Summary, Conclusions and Recommendations

4.1 Summary of Results

A flood risk assessment has been carried out for the proposed development site at the former Heiton-Buckley site at Castle Street, Bray, County Wicklow. The flood risk assessment has been carried out in accordance with *'The Planning System and Flood Risk Management Guidelines for Planning Authorities'*, Nov 2009 and the Wicklow County Development Plan 2016-2022. The following is the summary of the risk assessment:

- The proposed development is an apartment development based on a density of 162 units per hectare realising a total number of 139 apartments. The scheme will also include a creche (220 square metres) at ground floor of Block A. Block B will include two commercial units at ground floor (combined area of 688 square metres), a residents community meeting room at ground floor (74 square metres) and a separate smaller building housing a community facility (86 square metres). The accommodation is proposed in two blocks, up to seven storeys in height, with undercroft car and motorcycle parking, secure cycle parking and bin storage. There are also a number of visitor cycle parking spaces at surface level. The overall gross site area (redline area) amounts to approximately 1.0557 Hectares (10,557 square metres/ 2.609 Acres) which is inclusive of the area of public roads and footpaths. The nett area for development (core area) calculation purposes amounts to approximately 0.8594 Hectares (8,594 square metres/ 2.12 Acres). There are no watercourses, culverts or surface water sewers passing through the site with the exception of the internal drainage network within the site.

- The site is located approximately 700m from the Irish Sea at its closest point at Bray Harbour to the east and c.170m from the River Dargle to the southeast. It is noted that substantial flood defences have been carried out on the Dargle in recent years and the site is now within an area of defended lands.

- The Irish Coastal Protection Strategy Study (ICPSS) mapping confirms that the site is not at risk of coastal flooding, but it is acknowledged that the mapping is aged and does not take into account the River Dargle (Bray) Drainage Scheme which was completed in 2017. Inspection of the Eastern Catchment Flood Risk Assessment and Management Study (CFRAMS) mapping, October 2017 prepared by RPS for the OPW confirms that the site is not subject to Coastal Flooding.

- The OPW Catchment Flood Risk Assessment and Management Study (CFRAMS) fluvial flood extent mapping is currently being revised so full mapping is not currently available. However, on inspection of Floodinfo.ie flood extents mapping it is clear that the site is not subject to fluvial flooding for the low probability 0.1% AEP Fluvial event (1in1000year fluvial event) and is not subject to coastal flooding for the low probability 0.1% AEP Coastal event (1in1000year coastal event).

- The topography of the immediate surrounding area would suggest that there is little risk of pluvial flooding to the site. In the event that the public network surcharges, the natural topography will direct any flood water away from the site towards Castle Street which will channel any surface water flows towards the River Dargle to the southeast. The finished level designs for the development on the site reflects the existing topography and natural surface flow routes and maintain the required freeboard above the attenuation storage for the site.

- On review of the OPW www.floodmaps.ie website the single recorded flood event in the area is the 1986 Hurricane Charlie event which occurred prior to the River Dargle (Bray) Drainage Scheme which was completed in 2017. The result of the scheme is that the previously flooded area is now defended and the recent fluvial and coastal mapping for the area reflects this fact.

- The Bray Municipal District Local Area Plan 2018 Strategic Flood Risk Assessment (SFRA) mapping shows the flood extents without the benefit of the River Dargle (Bray) Drainage Scheme as is required for justification test assessment and the zoning for the site is deemed appropriate.

- The topographic survey of the site shows that there is limited risk of overland flows from adjacent properties, based on the levels of the subject site and surrounding lands and the surrounding land uses. The proposed scheme includes extensive SuDS measures which will reduce surface water discharge and overland flow routes created within the development will ensure there is only limited risk of flooding as a result of a surface water network failure.

- The GSI mapping confirms that there are no alluvial deposits beneath the proposed development area which would be an indicator of historical recurring out of channel flows or flooding.

- Inspection of historical 6inch and 25inch mapping did not return any indications of areas 'liable to flooding' in the vicinity of the site.

- The walkover survey of the site confirms that there are no further sources of flooding which need to be considered and verifies that the overland flow routes of the site and wider area do not pose a concern.

- The proposed development includes a number of SuDS measures which are designed to minimise flood risk to the subject site and upstream and downstream properties. The surface water discharge for the development is limited to the calculated greenfield runoff rate and the necessary attenuation storage is designed allowing for a 20% climate change factor. The addition of significant permeable parking, 10mm interception volume storage for the entirety of the paved areas within the development, including permeable paved areas and green roofs, further increases storage throughout the site and also increases time of entry for discharge into the attenuation area, thereby further flattening the peak flows. The floor levels for the development are a minimum of 500mm

above the modelled attenuation storage critical storm top water levels. The proposed surface water drainage solution for the development has been designed in accordance with the CDP drainage policies and The Greater Dublin Strategic Drainage Study and The Planning System and Flood Risk Management Guidelines for Planning Authorities. The SuDS measures proposed are compliant with the SSFRA recommendations.

The Stage 1 – Flood Risk Identification element of the flood risk assessment has been carried out sequentially in accordance with *'The Planning System and Flood Risk Management Guidelines for Planning Authorities'*, Nov 2009, the Wicklow County Development Plan 2016-2022 and the Draft Bray Municipal District LAP, 2017. Based on the fact that the development site is located wholly within Flood Zone C for all types of flooding and there have been no sources of flooding identified for the site, there is no requirements to progress to a Stage 2 Initial Flood Risk Assessment.

The proposed development is classified as 'Highly Vulnerable' and is located within Flood Zone C. Based on the Guidelines, the proposed development is deemed 'Appropriate' and no justification test is required.

4.2 Recommendations

In order to protect the building against potential flooding as a result of network failure within the site, the FFL have been set a minimum of 500mm above the TWL of the attenuation facility for the critical storm event.

A Climate Change Factor of 20% has been applied to the model simulation for the proposed drainage network which will attenuate and service the development.

SuDS measures in accordance with the CDP and the GDSDS have been incorporated into the surface water management and disposal designs for the development.

4.3 Impact of the proposed development on the existing flood regime of the area

The site area for drainage calculations (excluding wider areas of public road) amounts to 8,594 square metres, of which 4,999 square metres is IMPermeable (including green roof and podium areas). The PIMP (Percentage IMPermeable) value for the site is thus 58%. Based on the High-Density Residential zoning and the resultant site layout, there is no scope to provide any long term or treatment storage. However, given the existing paved nature of the site and the fact that green infrastructure SuDS has been incorporated into the surface water management and disposal designs for the development, it is considered that the development will not have any effect on the existing flood regime of the area.

Flow control devices will be fitted to outfall manholes to achieve an attenuated discharge. The calculated Greenfield Runoff rate $QBAR_{RURAL}$ of 1.9 litres per second has been adopted for the development design. In addition, 10mm interception volume storage will also be provided as well as a number of SuDS measures which provide treatment and storage benefits. It is noted that the delayed time of entry resulting from the green infrastructure (with the exception of the green roof areas) are not assessed as part of the network model analysis and will therefore provide a further factor of safety within the network. In addition, due to limited infiltration rates encountered, an infiltration rate of zero has been adopted for design purposes which will further increase storage capacity and reduce discharge volume. The factor of safety adopted for design purposes is 5.0.

It is considered, based surface water management and disposal arrangements proposed, that the proposal will not adversely impact the existing flood regime of the area.

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Wicklow County Council. (2016-2022). *Wicklow County Development Plan.*
Wicklow County Council. (2017). *Bray Municipal District Local Area Plan 2017.* Wicklow County Council.

Appendix A

A.1 – Bray Town and Environs SFRA Sites, Map No.: SFRA2(a)

B8(a)
B3(b)
B2(g)
B4(a)
B2(a)
B1(a)
B1(c)
B2(c)
B1(b)
B7(b)
B2(b)
B2(d)
B7(g)
B6(a)
B2(f)
B2(e)
B2(l)
B11(a)
B6(b)
B7(d)
B7(e)
B2(k)
B2(h)
B3(c)
B2(i)
B7(f)
E6 (a)
E2(a)
E2(b)
E2(c)
B6(c)
E4(c)
B6(e)
B5(a)
B6(d)
B2(j)
B9(a)
B6(f)

WICKLOW COUNTY DEVELOPMENT PLAN 2016-2022

Bray Municipal District Local Area Plan 2017 DRAFT

STRATEGIC FLOOD RISK ASSESSMENT SITES

Title: Bray Town and Environs
Map No. : SFRA2 (a)

- Municipal District Boundary
- Settlement Boundary
- RE Existing Residential
- R-HD New Residential
- R20 New Residential
- R15 New Residential
- R10 New Residential
- R Special New Residential
- TC Town Centre
- VC Village Centre
- LSS Local Shops & Services
- E Employment
- E Special Employment
- FI Film Industry
- T Tourism
- MU Mixed Use
- AOS Active Open Space
- OS1 Open Space
- OS2 Open Space
- SF Bray Seafront
- GTH Bray Gateway & Transport Hub
- KD Kilruddery Demesne Conservation & Tourism Zone
- PU Public Utility
- CE Community & Education
- FLOOD ZONE A
- FLOOD ZONE B
- SITES
- Conservation Area
- Bray Head SAAO

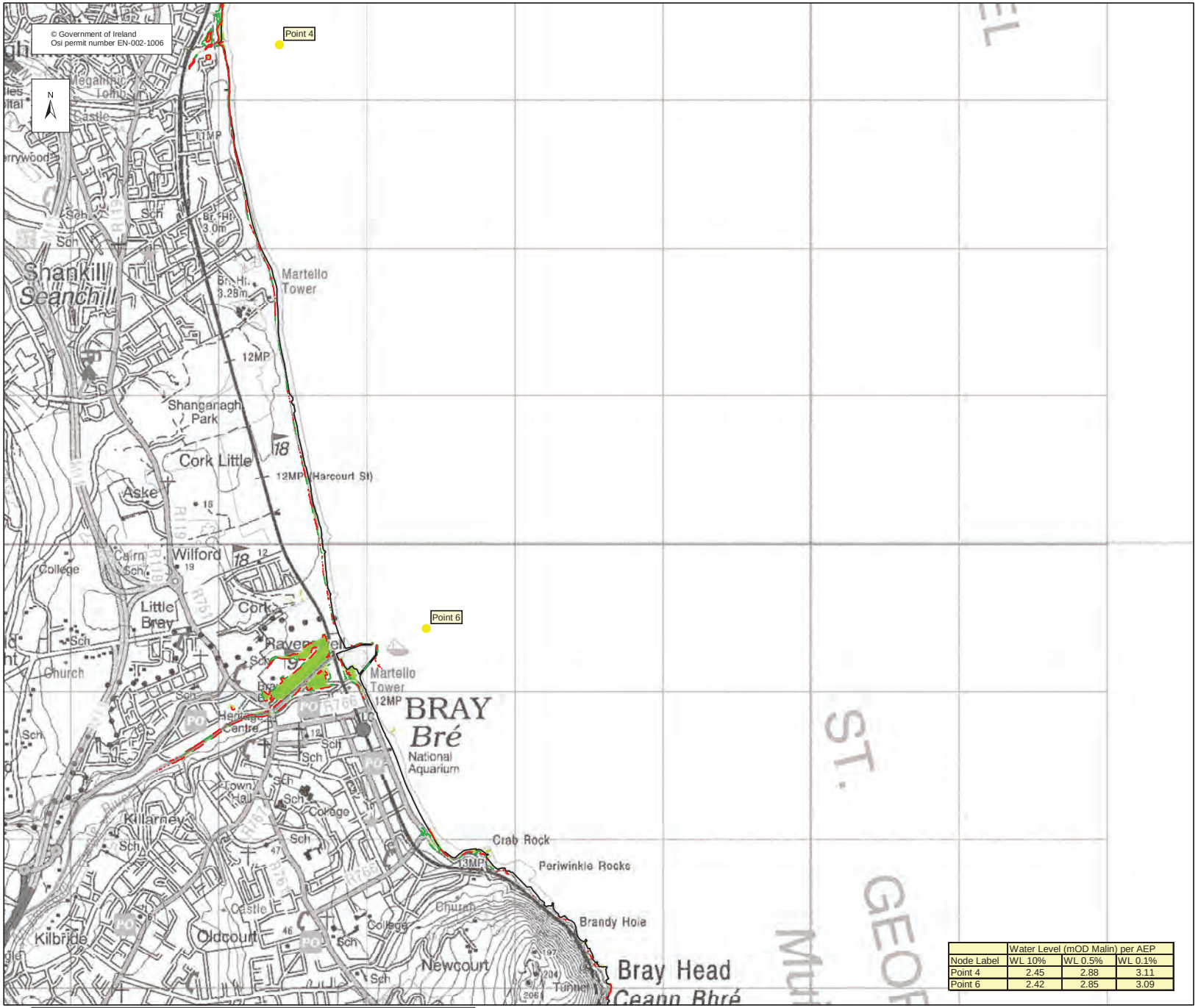
Wicklow County Council
Planning Department

Maps are not to scale

Appendix B

B.1 – Irish Coastal Protection Strategy Study Mapping Fig. SE/RA/EXT/2

B.2 – Eastern CFRAM Study Tidal Mapping Drg. E10BRY_EXCCD_F1_03



	Water Level (mOD Malin) per AEP		
Node Label	WL 10%	WL 0.5%	WL 0.1%
Point 4	2.45	2.88	3.11
Point 6	2.42	2.85	3.09

0.5 0.25 0 0.5 1 1.5 2 Kilometers

Location Plan :

EXTENT MAP

Legend:

- 0.5% AEP FLOOD EXTENT (1 in 200 chance in any given year)
- 0.1% AEP FLOOD EXTENT (1 in 1000 chance in any given year)
- Very High Confidence (0.1% AEP)
- High Confidence (0.1% AEP)
- Medium Confidence (0.1% AEP)
- Low Confidence (0.1% AEP)
- Very Low Confidence (0.1% AEP)
- Very High Confidence (0.5% AEP)
- High Confidence (0.5% AEP)
- Medium Confidence (0.5% AEP)
- Low Confidence (0.5% AEP)
- Very Low Confidence (0.5% AEP)
- High Water Mark (HWM)
- Node Point
- Point 34 — Node Label (refer to table)

USER NOTE :

USERS OF THESE MAPS SHOULD REFER TO THE DETAILED DESCRIPTION OF THEIR DERIVATION, LIMITATIONS IN ACCURACY AND GUIDANCE AND CONDITIONS OF USE PROVIDED AT THE FRONT OF THIS BOUND VOLUME. IF THIS MAP DOES NOT FORM PART OF A BOUND VOLUME, IT SHOULD NOT BE USED FOR ANY PURPOSE.

RPS
Elmwood House
74 Boucher Road
Belfast
BT 12 6RZ
Northern Ireland

OPW
Office of Public Works
17-19 Lower Hatch Street
Dublin 2
Ireland

Project :
IRISH COASTAL PROTECTION STRATEGY STUDY - PHASE II

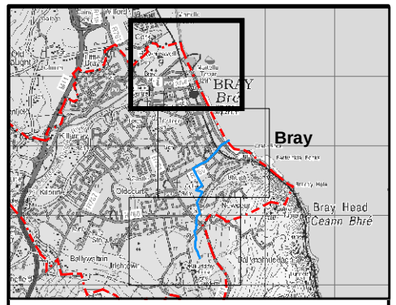
Map :
SOUTH EAST COAST FLOOD EXTENT MAP

Map Type : FLOOD EXTENT
Source : TIDAL FLOODING
Map area : RURAL AREA
Scenario : CURRENT
Figure By : PJW Date : May 2009
Checked By : JMC Date : May 2009

Figure No. : SE / RA / EXT / 2
Revision 0

Drawing Scale : 1:25,000 Plot Scale : 1:1 @ A3

Node Label	Water Level (OD) 10% AEP	Flow (m³/s) 10% AEP	Water Level (OD) 0.5% AEP	Flow (m³/s) 0.5% AEP	Water Level (OD) 0.1% AEP	Flow (m³/s) 0.1% AEP
E1009C0002	2.42	N/A	2.85	N/A	3.09	N/A



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

Legend

- 10% Tidal AEP Event
- 1% Tidal AEP Event
- 0.1% Tidal AEP Event
- Modelled River Centreline
- AFA Extents
- Node Point
- Node ID Node Label

E1009C0002

FINAL

REV:	NOTE:	DATE:

EASTERN CFRAM STUDY

The Office of Public Works
Jonathan Swift Street
Trim
Co Meath

Elmwood House
74 Boucher Road
Belfast
BT12 6RZ

T +44(0) 28 90 667914
F +44(0) 28 90 668286
W www.rpsgroup.com
E ireland@rpsgroup.com

Map:
Bray Tidal Flood Extents

Map Type:	**EXTENT**
Source:	**TIDAL**
Map Area:	**COASTAL**
Scenario:	**CURRENT**
Drawn By :	**F.M.C. Date : 30 October 2017**
Checked By :	**B.Q. Date : 30 October 2017**
Approved By :	**S.P. Date : 30 October 2017**

Drawing No. :
E10BRY_EXCCD_F1_03

Map Series : 3 of 3

Drawing Scale : 1:5,000 @A3

0 50 100 200 300 400 500 Metres

Appendix C

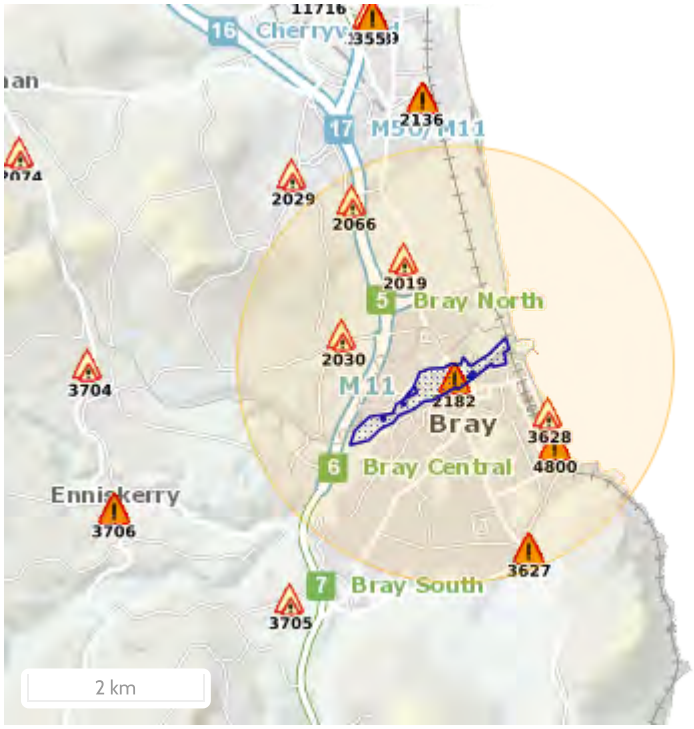
C.1 OPW floodmaps.ie generated Summary Local Area Report

Past Flood Event Local Area Summary Report

Report Produced: **23/6/2021 12:16**

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

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



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

9 Results

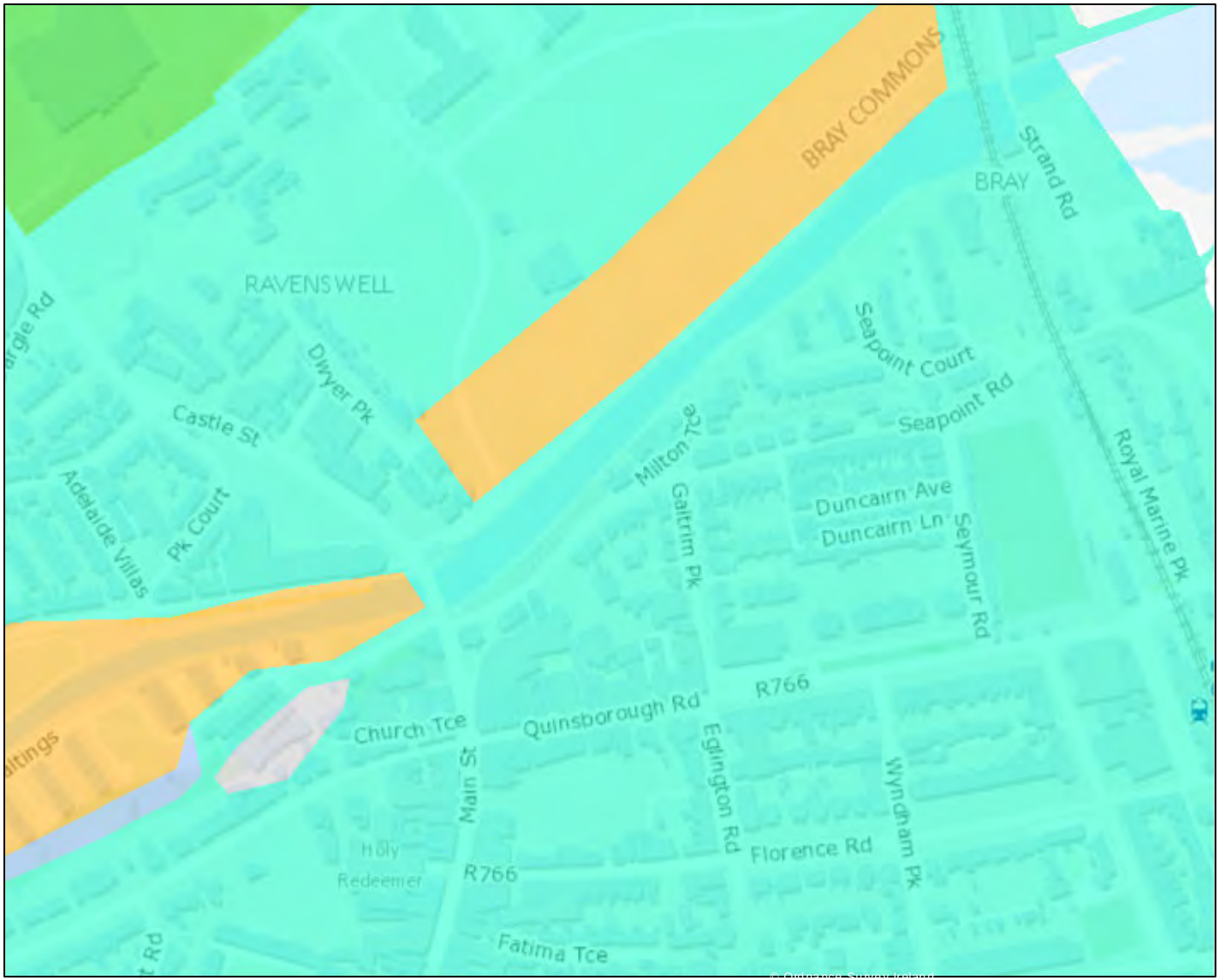
	Name (Flood_ID)	Start Date	Event Location
1.	Dargle Bray August 1986 (ID-235)	25/08/1986	Area
	Additional Information: Reports (9) Press Archive (38)		
2.	Crinken Woodbrook Stream Recurring (ID-2019)	n/a	Exact Point
	Additional Information: Reports (5) Press Archive (0)		
3.	Old Connaught Ave Recurring (ID-2030)	n/a	Exact Point
	Additional Information: Reports (2) Press Archive (0)		
4.	Springmount Shankill Recurring (ID-2066)	n/a	Exact Point
	Additional Information: Reports (2) Press Archive (0)		
5.	Dargle Bray Nov 1965 (ID-2182)	17/11/1965	Approximate Point
	Additional Information: Reports (4) Press Archive (3)		
6.	Dargle Bray 1905 (ID-3344)	24/08/1905	Approximate Point
	Additional Information: Reports (4) Press Archive (54)		

	Name (Flood_ID)	Start Date	Event Location
7.	Briarswood Estate Co. Wicklow November 2003 (ID-3627)	01/11/2003	Approximate Point
	Additional Information: Reports (2) Press Archive (0)		
8.	Bray Seafront Co Wicklow Recurring (ID-3628)	n/a	Approximate Point
	Additional Information: Reports (5) Press Archive (29)		
9.	Bray, Co. Wicklow February 2002 (ID-4800)	01/02/2002	Approximate Point
	Additional Information: Reports (2) Press Archive (7)		

Appendix D

D.1 – Geological Survey of Ireland (GSI) Mapping

Geological Survey Ireland Public Data



Scale: 1:5,000

Geological Survey Ireland

PSI Licence

N W E S

0 0.035 0.07 0.14 mi

0 0.05 0.1 0.2 km

Map Centre Coordinates (ITM) 726,415 718,971

6/23/2021, 4:21:20 PM

Legend

Appendix E

E.1 – Walkover Survey Photographs


SUBARU
HONDA
30


SUBARU
SUBARU


11-WW-494


11-D-49046


uponor
STOCKIST


BRIDGESTONE

Appendix F

F.1 – Microdrainage SW Drainage Design and Simulation Results

F.2 – Greenfield Runoff Rate & Interception/Treatment Volume Calculations

STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for Storm

Pipe Sizes STANDARD Manhole Sizes STANDARD

FSR Rainfall Model - Scotland and Ireland

Return Period (years)	5	PIMP (%)	100
M5-60 (mm)	17.000	Add Flow / Climate Change (%)	0
Ratio R	0.269	Minimum Backdrop Height (m)	0.200
Maximum Rainfall (mm/hr)	150	Maximum Backdrop Height (m)	1.500
Maximum Time of Concentration (mins)	30	Min Design Depth for Optimisation (m)	1.200
Foul Sewage (l/s/ha)	0.000	Min Vel for Auto Design only (m/s)	1.00
Volumetric Runoff Coeff.	0.750	Min Slope for Optimisation (1:X)	500

Designed with Level Soffits

Network Design Table for Storm

« - Indicates pipe capacity < flow

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
S1.000	32.594	0.192	170.0	0.037	4.00	0.0	0.600	o	225	Pipe/Conduit	
S1.001	38.233	0.225	170.0	0.027	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.002	23.838	0.140	170.0	0.008	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.003	21.796	0.128	170.0	0.008	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.004	9.264	0.054	170.0	0.037	0.00	0.0	0.600	o	225	Pipe/Conduit	
S2.000	42.681	0.251	170.0	0.063	4.00	0.0	0.600	o	225	Pipe/Conduit	
S2.001	29.084	0.171	170.0	0.020	0.00	0.0	0.600	o	225	Pipe/Conduit	
S3.000	33.101	0.233	142.0	0.034	4.00	0.0	0.600	o	225	Pipe/Conduit	

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
S1.000	65.16	4.54	3.278	0.037	0.0	0.0	0.0	1.00	39.8	6.5
S1.001	62.17	5.18	3.086	0.064	0.0	0.0	0.0	1.00	39.8	10.7
S1.002	60.47	5.58	2.861	0.071	0.0	0.0	0.0	1.00	39.8	11.7
S1.003	59.02	5.94	2.721	0.080	0.0	0.0	0.0	1.00	39.8	12.7
S1.004	58.43	6.10	2.593	0.117	0.0	0.0	0.0	1.00	39.8	18.5
S2.000	64.34	4.71	3.394	0.063	0.0	0.0	0.0	1.00	39.8	11.0
S2.001	62.10	5.20	3.143	0.083	0.0	0.0	0.0	1.00	39.8	14.0
S3.000	65.36	4.50	3.205	0.034	0.0	0.0	0.0	1.10	43.5	6.1

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
S2.002	11.535	0.147	78.2	0.093	0.00	0.0	0.600	o	225	Pipe/Conduit	
S4.000	33.736	0.198	170.0	0.039	4.00	0.0	0.600	o	225	Pipe/Conduit	
S4.001	25.869	0.152	170.0	0.019	0.00	0.0	0.600	o	225	Pipe/Conduit	
S2.003	22.174	0.130	170.0	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.005	10.595	0.062	170.9	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.006	19.916	0.117	170.0	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.007	30.596	0.180	170.0	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.008	29.385	0.173	170.0	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.009	51.507	0.303	170.0	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.010	35.620	0.210	170.0	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.011	48.580	0.286	170.0	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.012	2.996	0.050	59.9	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
S2.002	61.53	5.33	2.972	0.210	0.0	0.0	0.0	1.48	58.8	35.0
S4.000	65.06	4.56	3.175	0.039	0.0	0.0	0.0	1.00	39.8	6.9
S4.001	63.01	4.99	2.977	0.058	0.0	0.0	0.0	1.00	39.8	9.9
S2.003	59.99	5.70	2.824	0.268	0.0	0.0	0.0	1.00	39.8«	43.6
S1.005	67.05	4.18	2.538	0.000	1.9	0.0	0.0	1.00	39.7	1.9
S1.006	65.33	4.51	2.376	0.000	1.9	0.0	0.0	1.00	39.8	1.9
S1.007	62.89	5.02	2.259	0.000	1.9	0.0	0.0	1.00	39.8	1.9
S1.008	60.76	5.51	2.079	0.000	1.9	0.0	0.0	1.00	39.8	1.9
S1.009	57.42	6.37	1.906	0.000	1.9	0.0	0.0	1.00	39.8	1.9
S1.010	55.37	6.96	1.603	0.000	1.9	0.0	0.0	1.00	39.8	1.9
S1.011	52.85	7.77	1.394	0.000	1.9	0.0	0.0	1.00	39.8	1.9
S1.012	52.76	7.80	1.108	0.000	1.9	0.0	0.0	1.69	67.3	1.9

PIPELINE SCHEDULES for Storm

Upstream Manhole

PN	Hyd Sect	Diam (mm)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
S1.000	o	225	S1	4.003	3.278	0.500	Open Manhole	1200
S1.001	o	225	S2	4.000	3.086	0.689	Open Manhole	1200
S1.002	o	225	S3	4.050	2.861	0.964	Open Manhole	1200
S1.003	o	225	S4	3.900	2.721	0.954	Open Manhole	1200
S1.004	o	225	S5	3.900	2.593	1.082	Open Manhole	1200
S2.000	o	225	S6	4.119	3.394	0.500	Open Manhole	1200
S2.001	o	225	S7	3.950	3.143	0.582	Open Manhole	1200
S3.000	o	225	S8	3.930	3.205	0.500	Open Manhole	1200
S2.002	o	225	S9	3.900	2.972	0.703	Open Manhole	1200
S4.000	o	225	S10	3.900	3.175	0.500	Open Manhole	1200
S4.001	o	225	S11	3.900	2.977	0.698	Open Manhole	1200
S2.003	o	225	S12	3.900	2.824	0.851	Open Manhole	1200
S1.005	o	225	S13	3.900	2.538	1.137	Open Manhole	1200
S1.006	o	225	S14	3.950	2.376	1.249	Open Manhole	1200
S1.007	o	225	S15	3.900	2.259	1.416	Open Manhole	1200

Downstream Manhole

PN	Length (m)	Slope (1:X)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
S1.000	32.594	170.0	S2	4.000	3.086	0.689	Open Manhole	1200
S1.001	38.233	170.0	S3	4.050	2.861	0.964	Open Manhole	1200
S1.002	23.838	170.0	S4	3.900	2.721	0.954	Open Manhole	1200
S1.003	21.796	170.0	S5	3.900	2.593	1.082	Open Manhole	1200
S1.004	9.264	170.0	S13	3.900	2.538	1.137	Open Manhole	1200
S2.000	42.681	170.0	S7	3.950	3.143	0.582	Open Manhole	1200
S2.001	29.084	170.0	S9	3.900	2.972	0.703	Open Manhole	1200
S3.000	33.101	142.0	S9	3.900	2.972	0.703	Open Manhole	1200
S2.002	11.535	78.2	S12	3.900	2.824	0.851	Open Manhole	1200
S4.000	33.736	170.0	S11	3.900	2.977	0.698	Open Manhole	1200
S4.001	25.869	170.0	S12	3.900	2.824	0.851	Open Manhole	1200
S2.003	22.174	170.0	S13	3.900	2.694	0.981	Open Manhole	1200
S1.005	10.595	170.9	S14	3.950	2.476	1.249	Open Manhole	1200
S1.006	19.916	170.0	S15	3.900	2.259	1.316	Open Manhole	1200
S1.007	30.596	170.0	S16	3.459	2.079	1.155	Open Manhole	1200

PIPELINE SCHEDULES for Storm

Upstream Manhole

PN	Hyd Sect	Diam (mm)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
S1.008	o	225	S16	3.459	2.079	1.155	Open Manhole	1200
S1.009	o	225	S17	3.644	1.906	1.513	Open Manhole	1200
S1.010	o	225	S18	3.480	1.603	1.652	Open Manhole	1200
S1.011	o	225	S19	3.705	1.394	2.086	Open Manhole	1200
S1.012	o	225	S20	5.782	1.108	4.449	Open Manhole	1200

Downstream Manhole

PN	Length (m)	Slope (1:X)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
S1.008	29.385	170.0	S17	3.644	1.906	1.513	Open Manhole	1200
S1.009	51.507	170.0	S18	3.480	1.603	1.652	Open Manhole	1200
S1.010	35.620	170.0	S19	3.705	1.394	2.086	Open Manhole	1200
S1.011	48.580	170.0	S20	5.782	1.108	4.449	Open Manhole	1200
S1.012	2.996	59.9	S21	5.913	1.058	4.630	Open Manhole	0

Area Summary for Storm

Pipe Number	PIMP Type	PIMP Name	PIMP (%)	Gross Area (ha)	Imp. Area (ha)	Pipe Total (ha)
1.000	Classification	PER	70	0.031	0.022	0.022
	Classification	PER	70	0.022	0.015	0.037
1.001	Classification	PER	70	0.038	0.027	0.027
1.002	Classification	PER	70	0.011	0.008	0.008
1.003	Classification	PER	70	0.012	0.008	0.008
1.004	Classification	IMP	100	0.037	0.037	0.037
2.000	Classification	IMP	100	0.008	0.008	0.008
	Classification	PER	70	0.078	0.055	0.063
2.001	Classification	PER	70	0.028	0.020	0.020
3.000	Classification	IMP	100	0.004	0.004	0.004
	Classification	PER	70	0.043	0.030	0.034
2.002	Classification	IMP	100	0.093	0.093	0.093
4.000	Classification	PER	70	0.056	0.039	0.039
4.001	Classification	PER	70	0.027	0.019	0.019
2.003	-	-	100	0.000	0.000	0.000
1.005	-	-	100	0.000	0.000	0.000
1.006	-	-	100	0.000	0.000	0.000
1.007	-	-	100	0.000	0.000	0.000
1.008	-	-	100	0.000	0.000	0.000
1.009	-	-	100	0.000	0.000	0.000
1.010	-	-	100	0.000	0.000	0.000
1.011	-	-	100	0.000	0.000	0.000
1.012	-	-	100	0.000	0.000	0.000
				Total	Total	Total
				0.489	0.385	0.385

Network Classifications for Storm

PN	USMH Name	Pipe Dia (mm)	Min Cover Depth (m)	Max Cover Depth (m)	Pipe Type	MH Dia (mm)	MH Width (mm)	MH Ring Depth (m)	MH Type
S1.000	S1	225	0.500	0.689	Unclassified	1200	0	0.500	Unclassified
S1.001	S2	225	0.689	0.964	Unclassified	1200	0	0.689	Unclassified
S1.002	S3	225	0.954	1.170	Unclassified	1200	0	0.964	Unclassified
S1.003	S4	225	0.954	1.551	Unclassified	1200	0	0.954	Unclassified
S1.004	S5	225	1.082	1.477	Unclassified	1200	0	1.082	Unclassified
S2.000	S6	225	0.497	0.884	Unclassified	1200	0	0.500	Unclassified
S2.001	S7	225	0.582	1.052	Unclassified	1200	0	0.582	Unclassified
S3.000	S8	225	0.500	0.982	Unclassified	1200	0	0.500	Unclassified
S2.002	S9	225	0.703	1.348	Unclassified	1200	0	0.703	Unclassified
S4.000	S10	225	0.500	0.844	Unclassified	1200	0	0.500	Unclassified
S4.001	S11	225	0.698	1.303	Unclassified	1200	0	0.698	Unclassified
S2.003	S12	225	0.851	1.295	Unclassified	1200	0	0.851	Unclassified
S1.005	S13	225	1.137	1.382	Unclassified	1200	0	1.137	Unclassified
S1.006	S14	225	1.249	1.384	Unclassified	1200	0	1.249	Unclassified
S1.007	S15	225	1.155	2.187	Unclassified	1200	0	1.416	Unclassified
S1.008	S16	225	1.155	1.513	Unclassified	1200	0	1.155	Unclassified
S1.009	S17	225	1.513	1.652	Unclassified	1200	0	1.513	Unclassified
S1.010	S18	225	1.645	2.086	Unclassified	1200	0	1.652	Unclassified
S1.011	S19	225	2.086	4.449	Unclassified	1200	0	2.086	Unclassified
S1.012	S20	225	4.449	4.630	Unclassified	1200	0	4.449	Unclassified

Free Flowing Outfall Details for Storm

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
S1.012	S21	5.913	1.058	0.000	0	0

Simulation Criteria for Storm

Volumetric Runoff Coeff	0.750	Additional Flow - % of Total Flow	0.000
Areal Reduction Factor	1.000	MADD Factor * 10m³/ha Storage	2.000
Hot Start (mins)	0	Inlet Coeffiecient	0.800
Hot Start Level (mm)	0	Flow per Person per Day (l/per/day)	0.000
Manhole Headloss Coeff (Global)	0.500	Run Time (mins)	60
Foul Sewage per hectare (l/s)	0.000	Output Interval (mins)	1

Number of Input Hydrographs	0	Number of Storage Structures	1
Number of Online Controls	1	Number of Time/Area Diagrams	7
Number of Offline Controls	0	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model		FSR	M5-60 (mm) 17.000
Return Period (years)		5	Ratio R 0.269
Region	Scotland and Ireland	Profile Type	Summer

Synthetic Rainfall Details

Cv (Summer) 0.750 Storm Duration (mins) 30
Cv (Winter) 0.840

Online Controls for Storm

Hydro-Brake® Optimum Manhole: S13, DS/PN: S1.005, Volume (m³): 2.7

Unit Reference	MD-SHE-0070-1900-0650-1900
Design Head (m)	0.650
Design Flow (l/s)	1.9
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	70
Invert Level (m)	2.538
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.650	1.9
Flush-Flo™	0.193	1.9
Kick-Flo®	0.422	1.6
Mean Flow over Head Range	-	1.6

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.8	1.200	2.5	3.000	3.8	7.000	5.7
0.200	1.9	1.400	2.7	3.500	4.1	7.500	5.9
0.300	1.8	1.600	2.9	4.000	4.4	8.000	6.1
0.400	1.7	1.800	3.0	4.500	4.6	8.500	6.3
0.500	1.7	2.000	3.2	5.000	4.9	9.000	6.5
0.600	1.8	2.200	3.3	5.500	5.1	9.500	6.6
0.800	2.1	2.400	3.5	6.000	5.3		
1.000	2.3	2.600	3.6	6.500	5.5		

Storage Structures for Storm

Cellular Storage Manhole: S13, DS/PN: S1.005

Invert Level (m) 2.538 Safety Factor 5.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	545.0	0.0	1.013	0.0	0.0
1.012	545.0	0.0			

Manhole Headloss for Storm

PN	US/MH Name	US/MH Headloss
S1.000	S1	0.500
S1.001	S2	0.500
S1.002	S3	0.500
S1.003	S4	0.500
S1.004	S5	0.500
S2.000	S6	0.500
S2.001	S7	0.500
S3.000	S8	0.500
S2.002	S9	0.500
S4.000	S10	0.500
S4.001	S11	0.500
S2.003	S12	0.500
S1.005	S13	0.500
S1.006	S14	0.500
S1.007	S15	0.500
S1.008	S16	0.500
S1.009	S17	0.500
S1.010	S18	0.500
S1.011	S19	0.500
S1.012	S20	0.500

Summary of Critical Results by Maximum Level (Rank 1) for Storm

Simulation Criteria

Areal Reduction Factor	1.000	Additional Flow - % of Total Flow	0.000
Hot Start (mins)	0	MADD Factor * 10m³/ha Storage	2.000
Hot Start Level (mm)	0	Inlet Coeffiecient	0.800
Manhole Headloss Coeff (Global)	0.500	Flow per Person per Day (l/per/day)	0.000
Foul Sewage per hectare (l/s)	0.000		

Number of Input Hydrographs	0	Number of Storage Structures	1
Number of Online Controls	1	Number of Time/Area Diagrams	7
Number of Offline Controls	0	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model		FSR	Ratio R 0.269
Region	Scotland and Ireland	Cv (Summer)	0.750
M5-60 (mm)	17.000	Cv (Winter)	0.840

Margin for Flood Risk Warning (mm)	300.0	DVD Status	OFF
Analysis Timestep	Fine	Inertia Status	OFF
DTS Status	ON		

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 180, 240, 360, 480, 600, 720, 960, 1440, 2160, 2880, 4320, 5760, 7200, 8640, 10080
Return Period(s) (years)	1, 30, 100
Climate Change (%)	20, 20, 20

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.
S1.000	S1	60 Winter	100	+20%				
S1.001	S2	15 Winter	100	+20%				
S1.002	S3	2880 Winter	100	+20%	100/960 Winter			
S1.003	S4	2880 Winter	100	+20%	30/960 Winter			
S1.004	S5	2880 Winter	100	+20%	30/240 Winter			
S2.000	S6	60 Winter	100	+20%				
S2.001	S7	120 Winter	100	+20%				
S3.000	S8	60 Winter	100	+20%				
S2.002	S9	15 Winter	100	+20%				
S4.000	S10	60 Winter	100	+20%				
S4.001	S11	2880 Winter	100	+20%				
S2.003	S12	2880 Winter	100	+20%	100/15 Summer			
S1.005	S13	2880 Winter	100	+20%	30/180 Winter			
S1.006	S14	120 Summer	30	+20%				
S1.007	S15	120 Summer	30	+20%				
S1.008	S16	120 Summer	30	+20%				
S1.009	S17	120 Summer	30	+20%				
S1.010	S18	7200 Summer	100	+20%				
S1.011	S19	120 Summer	30	+20%				
S1.012	S20	480 Winter	100	+20%				

Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status
S1.000	S1	3.343	-0.160	0.000	0.17			6.5	OK
S1.001	S2	3.170	-0.141	0.000	0.29			11.0	OK
S1.002	S3	3.156	0.070	0.000	0.05			2.0	SURCHARGED
S1.003	S4	3.155	0.209	0.000	0.07			2.5	SURCHARGED
S1.004	S5	3.154	0.336	0.000	0.09			3.0	SURCHARGED
S2.000	S6	3.469	-0.150	0.000	0.23			8.7	OK
S2.001	S7	3.226	-0.142	0.000	0.28			10.6	OK
S3.000	S8	3.260	-0.170	0.000	0.13			5.3	OK
S2.002	S9	3.175	-0.022	0.000	0.85			42.6	OK
S4.000	S10	3.242	-0.158	0.000	0.19			7.0	OK
S4.001	S11	3.157	-0.045	0.000	0.05			1.7	OK
S2.003	S12	3.169	0.120	0.000	0.15			5.5	SURCHARGED
S1.005	S13	3.153	0.390	0.000	0.06		2160	1.9	SURCHARGED
S1.006	S14	2.409	-0.192	0.000	0.05			1.9	OK
S1.007	S15	2.292	-0.193	0.000	0.05			1.9	OK
S1.008	S16	2.112	-0.193	0.000	0.05			1.9	OK
S1.009	S17	1.938	-0.193	0.000	0.05			1.9	OK
S1.010	S18	1.636	-0.193	0.000	0.05			1.9	OK
S1.011	S19	1.426	-0.193	0.000	0.05			1.9	OK
S1.012	S20	1.144	-0.190	0.000	0.06			1.9	OK

PN	US/MH Name	Level Exceeded
S1.000	S1	
S1.001	S2	
S1.002	S3	
S1.003	S4	
S1.004	S5	
S2.000	S6	
S2.001	S7	
S3.000	S8	
S2.002	S9	
S4.000	S10	
S4.001	S11	
S2.003	S12	
S1.005	S13	
S1.006	S14	
S1.007	S15	
S1.008	S16	
S1.009	S17	
S1.010	S18	
S1.011	S19	
S1.012	S20	

Catchment #01 - Entire Development Site

Drainage Site Area (Ha) =	0.8594
IMP Paved Area =	0.4999 (incl. Green Roof Area)
SOIL =	0.3
SAAR (mm) =	825
M5-60 (mm) =	17.0
M5-2day (mm) =	63.2
Jenkinson's 'R' =	0.269

GDSDS E2.1.1 Interception - Criterion 1.1

Table E1 Calculation of Interception Volume

Item	Measurement/ Calculation	Comment/clarification
Paved surfaces connecting to the drainage system	80% x 58% x 8,594sq.m = 3,999.2sq.m	80% of the paved area (Runoff Factor) 58% of the site is paved 0.85694Ha development area in sq.m
Volume of interception storage	3,999.2sq.m x 10mm = 39.992cu.m	Paved area directly drained 10mm rainfall depth

GDSDS E2.2.2 Greenfield Runoff Analysis

AREA	0.5	sq.km (using 50Ha as site area < 50Ha)
SAAR	825	mm
SOIL	0.3	(SOIL Type 2)
$QBAR_{RURAL} = 0.00108 \times (50Ha)^{0.89} \times SAAR^{1.17} \times SOIL^{2.17}$		
$QBAR_{RURAL}$ for 50Ha site =	110	litres per second
Using IH 124 method apply linear scaling factor (Site Area/50Ha)		0.0172
$QBAR_{RURAL}$ =	**1.9**	**litres per second**
Q_1	**1.6**	**litres per second**
Q_{30}	**4.0**	**litres per second**
Q_{100}	**5.5**	**litres per second**

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