

Castlelake SHD,
Carrigtwohill
Co. Cork
Flood Risk Assessment

Technical Report

May 22

2021s1374

BAM Property Limited

Euro Business Park

Little Island

Co. Cork

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Revision History

Revision Ref / Date Issued	Amendments	Issued to
S3.P01/ 27 October 2021	Daft Issue	BAM Property
A3.C01/ 28 October 2021	Final Issue	BAM Property
A3.C02/ 04 May 2022	Updated Site Layout	BAM Property

Contract

This report describes work commissioned by BAM Property, on behalf of BAM Property, by a letter dated 22 September 2021. BAM Property’s representative for the contract was Paul Kenneally. Paul Browne, David Casey and Ross Bryant of JBA Consulting carried out this work.

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Purpose

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Abbreviations

AEP	Annual Exceedance Probability
CCC	Cork County Council
CFRAM	Catchment Flood Risk Assessment and Management
DoEHLG.....	Department of the Environment, Heritage and Local Government
EU	European Union
FFL.....	Finished Floor Level
FRA.....	Flood Risk Assessment
GSDSDS	Greater Dublin Strategic Drainage Strategy
GSI.....	Geological Survey of Ireland
HEFS	High-End Future Scenario
ICPSS	Irish Coastal Protection Strategy Study
LAP	Local Area Plan
MD	Municipal District
MRFS.....	Mid-Range Future Scenario
NCFHM	National Coastal Flood Hazard Mapping
NIFM.....	National Indicative Fluvial Mapping
OPW	Office of Public Works
PFRA	Preliminary Flood Risk Assessment
SFRA	Strategic Flood Risk Assessment
SHD	Strategic Housing Development
SPA.....	Special Protection Area

1 Introduction

Under "The Planning System and Flood Risk Management - Guidelines for Planning Authorities" (DoEHLG & OPW, 2009) proposed development must undergo a Flood Risk Assessment to ensure sustainability and effective management of flood risk.

1.1 Terms of Reference and Scope

JBA Consulting was appointed by BAM Property to prepare a Flood Risk Assessment (FRA) for a proposed residential development located in Carrigtwohill, Co. Cork.

1.2 Flood Risk Assessment; Aims and Objectives

This study is being completed to inform the future development of the site as it relates to flood risk. It aims to identify, quantify and communicate to Planning Authority officials and other stakeholders the risk of flooding to land, property and people and the measures that would be recommended to manage the risk.

The objectives of this FRA are to:

- Identify potential sources of flood risk;
- Confirm the level of flood risk and identify key hydraulic features;
- Assess the impact that the proposed development has on flood risk;
- Develop appropriate flood risk mitigation and management measures which will allow for the long-term development of the site.

Recommendations for development have been provided in the context of the OPW / DoEHLG planning guidance, "The Planning System and Flood Risk Management - Guidelines for Planning Authorities". A review of the likely effects of climate change, and the long-term impacts this may have on any development has also been undertaken.

For general information on flooding, the definition of flood risk, flood zones and other terms see 'Understanding Flood Risk' in Appendix A.

1.3 Development Proposal

The proposed site is extensive and covers an area of c.18.2ha, of which c.15.5ha is stated to be developable and 2.748ha to be undevelopable. It is proposed to construct the following as part of a Strategic Housing Development (SHD) within a greenfield site:

- 224no. house units of varying type;
- 284no. duplex units of varying type;
- 208no. apartment units of varying type in 7no. apartment blocks.

The layout of the proposed development is provided in Figure 1-1.

The proposed development consists of 8no. sites, which are as follows:

- Castl lake North Site
- Blandcrest Site
- Castl lake West Site
- Castl lake South Site 01
- Castl lake South Site 02
- Station Road North Site
- Station Road South Site

The overall site is located to the south of the Cork-Midleton railway line, west of Station Road, east of several housing estates (Maple Crescent, Line Court, Oakbrook) and north of the existing Aldi shopping complex. 2no. proposed access roads will link the development to Station Road (north and south of the proposed post primary school) and connect with the existing roundabout at Maple Crescent. Areas of soft landscaping are proposed throughout the development.

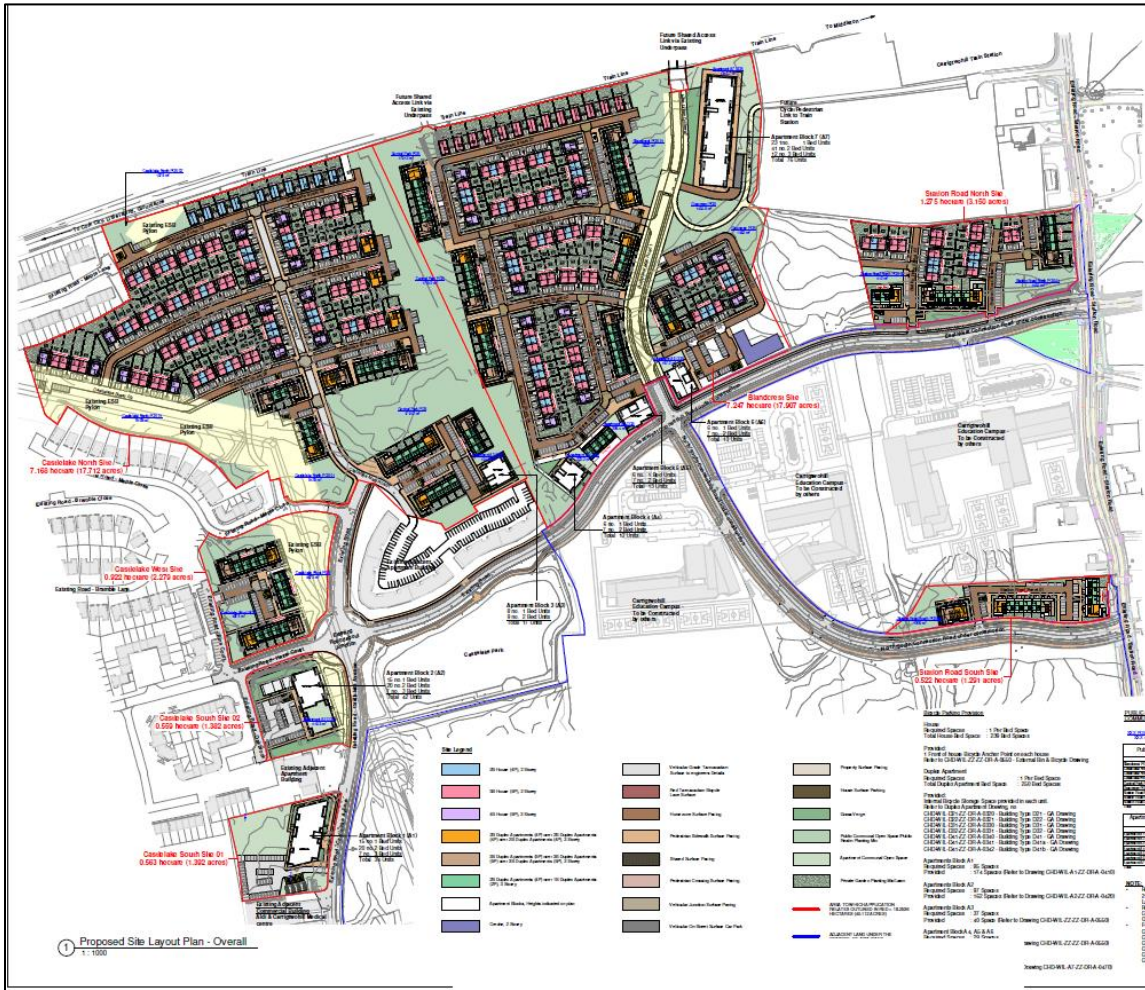


Figure 1-1: Proposed Site Layout

As part of this development and other development adjacent to the site, it is proposed to partly culvert the existing field drain running north to south through the Castlelake North Site. The existing drainage ditch will be predominantly maintained. This culvert will convey surface water entering the site via culverts under the railway line safely through the site before discharging to the Woodstock River further downstream.

1.4 Report Structure

Section 2 of this report gives an overview of the study location and associated watercourses. Section 3 contains background information and identification of sources of flood risk. An assessment of flood risk and site-specific mitigation measures are outlined in Section 5, while conclusions are provided in Section 7.

2 Site Background

This section describes the watercourses, geology and wider geographical area of Carrigtwohill, Co. Cork.

2.1 Location

The proposed site is located in Carrigtwohill, Co. Cork to the west of Station Road and south of the Cork-Midleton railway line. The overall site is split into 7no. individual sites. Several residential estates are located to the west. To the south of the proposed site, there are open fields and residential estates. Much of the existing site contains open fields and areas of dense vegetation overgrowth. Refer to Figure 2-1 for the existing site overview.

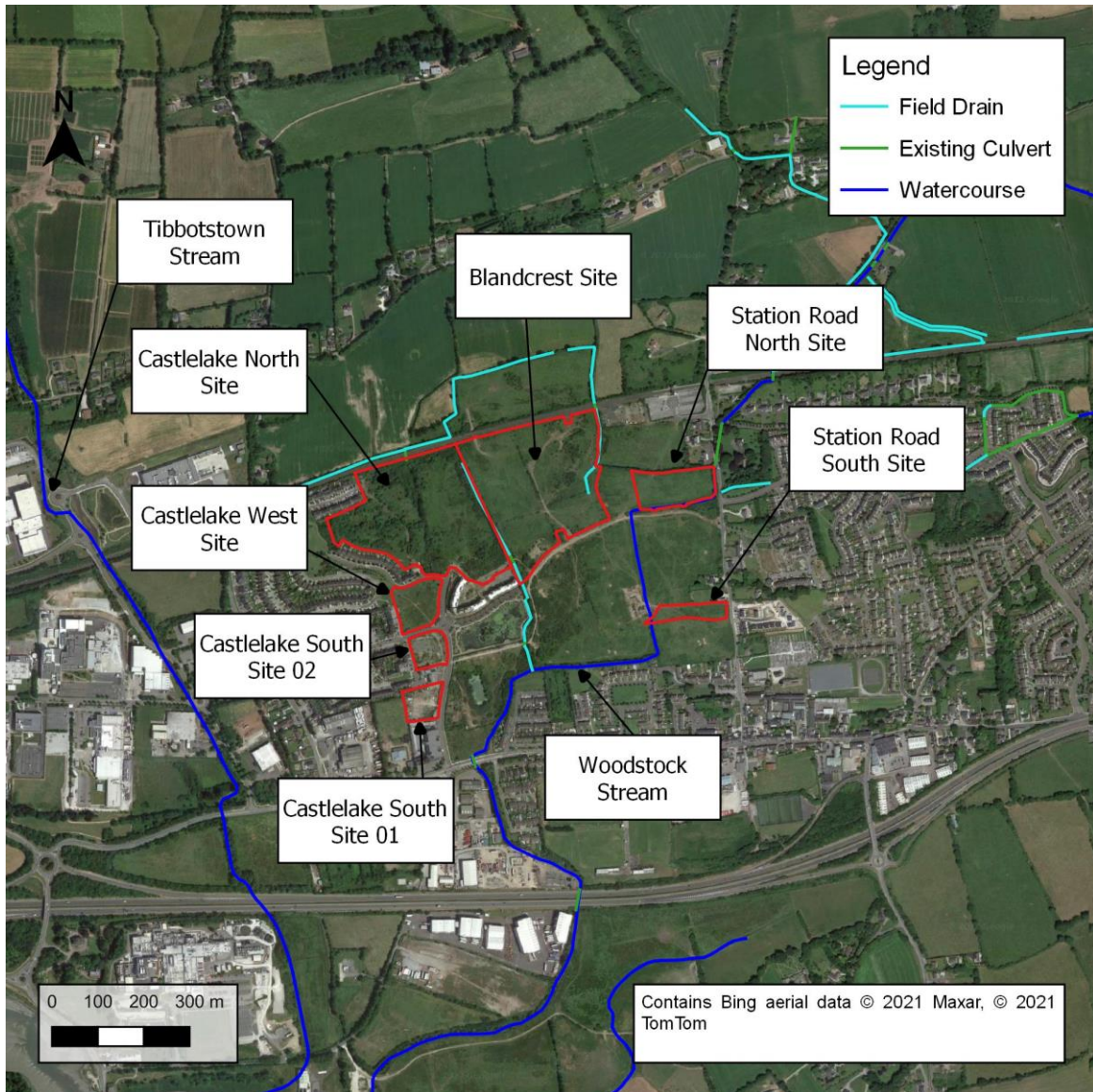


Figure 2-1: Site Overview

2.2 Watercourses

The main hydrological feature in vicinity to the site is the Woodstock Stream. The Woodstock Stream flows into the Slatty Pond c.1.32km southwest of the main site. Slatty Pond ultimately discharges to the Slatty Water in the River Lee estuary / Cork harbour. Slatty Pond is located upstream of Slatty Bridge, which links Fota Island to the townland of Tullagreen. The Cork Harbour area is designated as a Special Protection Area (SPA). There are several field drains within the proposed site confines, including one at the northeast corner of the Blandcrest Site. This flows in a northern direction before passing under the railway line as a culvert. The field drain continues to fall outside of the proposed site before re-entering the Castl lake North Site as a culvert near the northwest corner. This area is severely overgrown, and it is not clear at the time of writing this report whether this culvert ultimately discharges to the existing field drain which runs north to south towards the Cascade apartment complex. However, it is proposed to culvert this section of field drain to connect to the existing culvert near the northwest corner of the Castl lake North Site. The proposed culvert will ultimately discharge to the existing field drain before entering the Woodstock Stream to the north of Ryan and Aherne Place. An existing farm underpass is located c. halfway along the northern boundary and passes under the railway. This has been identified as a potential flow path, which will need to be managed within the proposed design. As part of future developments in the area, it is proposed to culvert the Woodstock Stream to the south of the Station Road South Site, before turning south to pass under the proposed access road. Refer to Figure 2-1 for a record of existing watercourses and culverts in the area.

2.3 Site Topography

The site covers an area of c.18.2ha, of which c.15.5ha is stated to be developable.

The topographical survey for the proposed site was available for review, and summarised as follows:

- Blandcrest Site: North to south fall from 9.00mOD to 2.75mOD;
- Castlelake North Site: North to south fall from 7.25mOD to 3.75mOD;
- Castlelake West Site: West to east fall from 5.50mOD to 4.00mOD;
- Castlelake South Site 02: North to south fall from 5.00mOD to 3.50mOD;
- Castlelake South Site 01: North to south fall from 3.75mOD to 2.75mOD;
- Station Road North Site: North to south fall from 7.50mOD to 5.25mOD, with localised fall to 4.75mOD at the Woodstock Stream at the southeast corner;
- Station Road South Site: East to west fall from 7.25mOD to 5.25mOD.

Refer to Figure 2-2 for the site topographical survey.

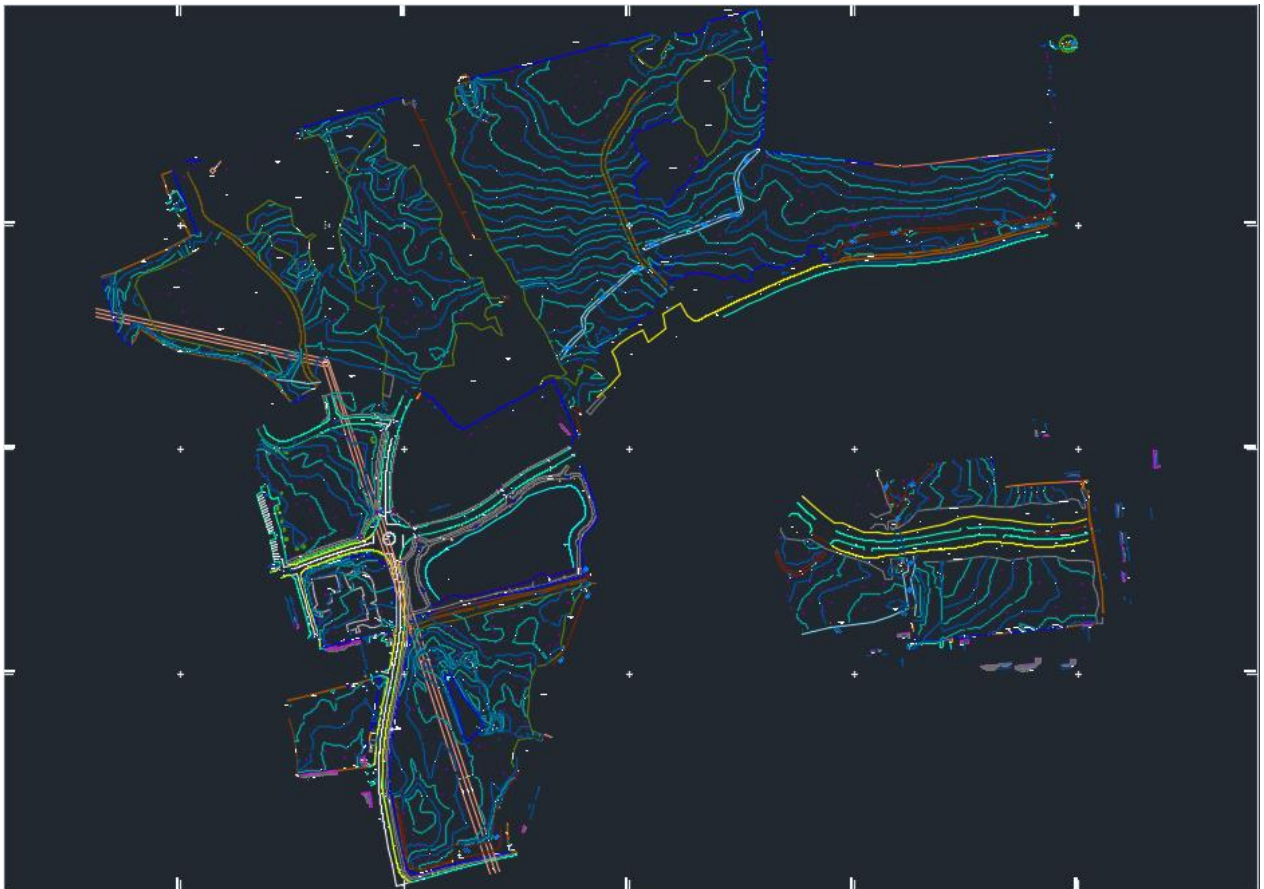


Figure 2-2: Topographical Survey

2.4 Site Geology

The Geological Survey of Ireland (GSI) groundwater and geological maps of the site were reviewed. The subsoil present under the proposed site is primarily tills derived from mainly non-calcareous sandstones belonging to the Acid Brown Earths / Brown Podzolics group. There is a pocket of pocket of the same type of tills material to the west of the proposed site but from the Surface Water Gleys / Ground Water Gleys group. An area of alluvial mineral soils exists c.500m south of the Blandcrest Site, which may be an indicator of previous flooding in the past. Refer to Figure 2-3.

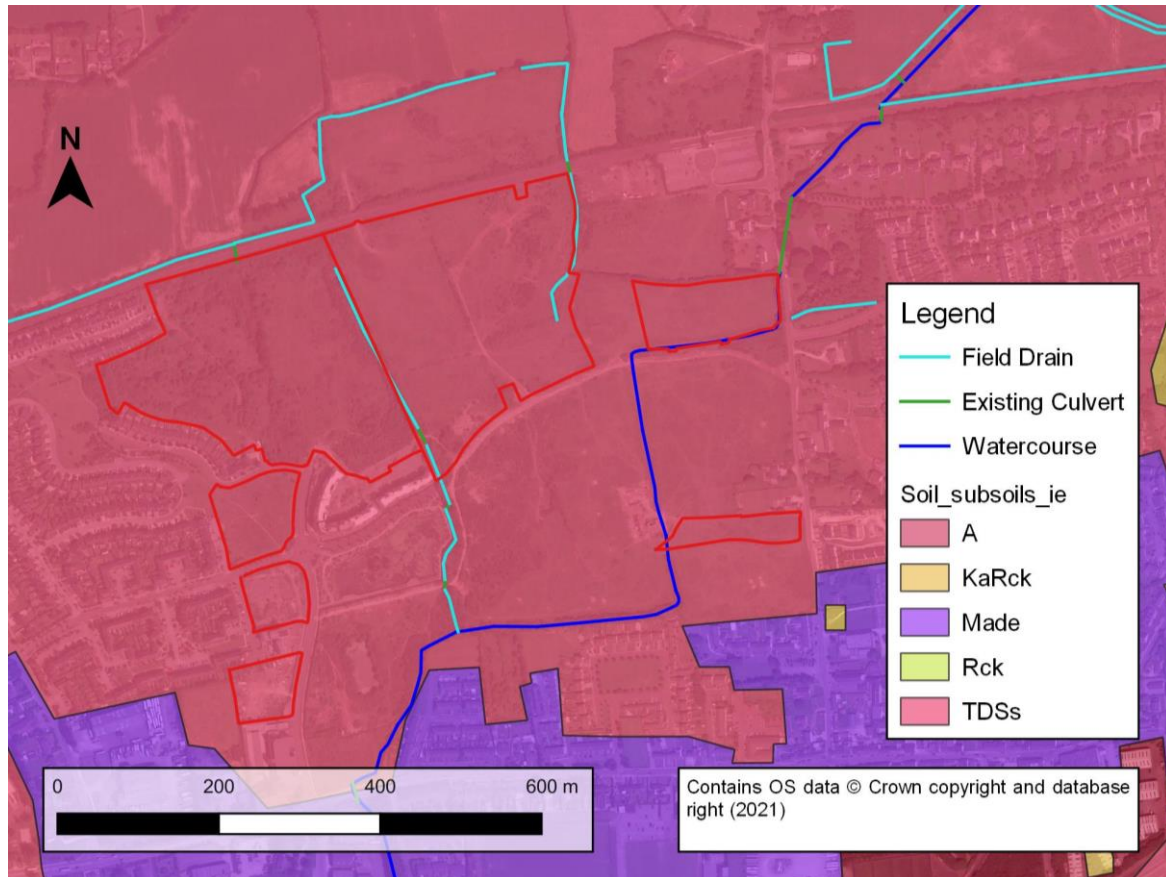


Figure 2-3: Site Subsoils

There are two primary bedrock types present within the proposed site. To the north, the underlying bedrock is classified as the Ballysteen Formation, which is described as dark muddy limestone and shale. To the south, the underlying bedrock is classified as Waulsortian Limestones, which is described as massive unbedded lime-mudstone.

The associated groundwater vulnerability is classified as 'Moderate' to 'High' for the site which indicates that there is a moderate to high risk to the groundwater under the site. This classification is based on relevant hydrogeological characteristics of the underlying geological materials.

A record of historic groundwater and surface water flooding in the Carrigtwohill area by the GSI was also available for review. There were no identified historic groundwater or surface water flood events within the proposed site confines. Groundwater flooding probability extents were available for review on www.floodinfo.ie. There were no identified predictive groundwater flooding extents on-site or nearby.

A review of karstic features in the area shows that there are a number of caves and a swallow hole identified within a c.600-1000m radius from the Blandcrest Site. One cave is identified within the grounds of St. Aloysius College to the southeast. Two caves and a swallow hole are identified within the Cúl Árd housing estate to the east. The accuracies of these karstic features vary to within 20-50m for the caves and 20m for the swallow hole. The underground extents of these karstic features were not available for review at the time of writing this report. It is not unexpected to find these karstic features in the Carrigtwohill area as the local bedrock is predominantly composed of limestone. There are no karstic features identified within the proposed site confines. A well / spring was previously identified at the location of the proposed post primary school, which was not picked up on in the GSI map viewer. Refer to Figure 2-4 for historic groundwater flooding, groundwater vulnerability and karstic features in the area.

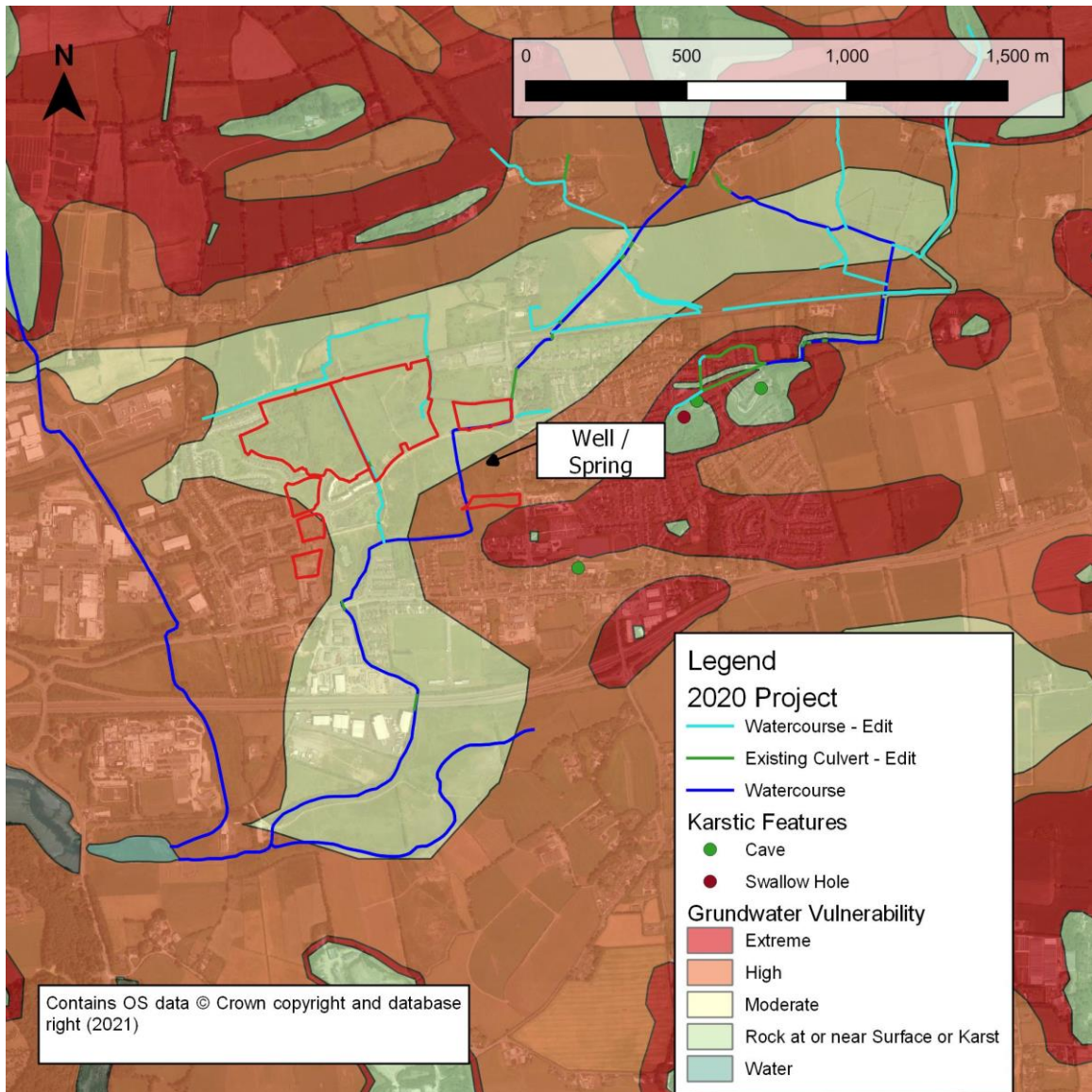


Figure 2-4: GSI Datasets

3 Flood Risk Identification

An assessment of the potential for and scale of flood risk at the site is conducted using historical and predictive information. This identifies any sources of potential flood risk to the site and reviews historic flood information. The findings from the flood risk identification stage of the assessment are provided in the following sections.

3.1 Flood History

Several sources of flood information were reviewed to establish any recorded flood history at, or near the site. This includes the OPW's National Flood Information Portal, www.floodinfo.ie and general internet searches.

3.1.1 Floodinfo.ie

The OPW host a National Flood Information Portal, www.floodinfo.ie, which highlights areas at risk of flooding through the collection of recorded data and observed flood events. Refer to Figure 3-1 for historic / recurring flood events in the Carrigtwohill area.

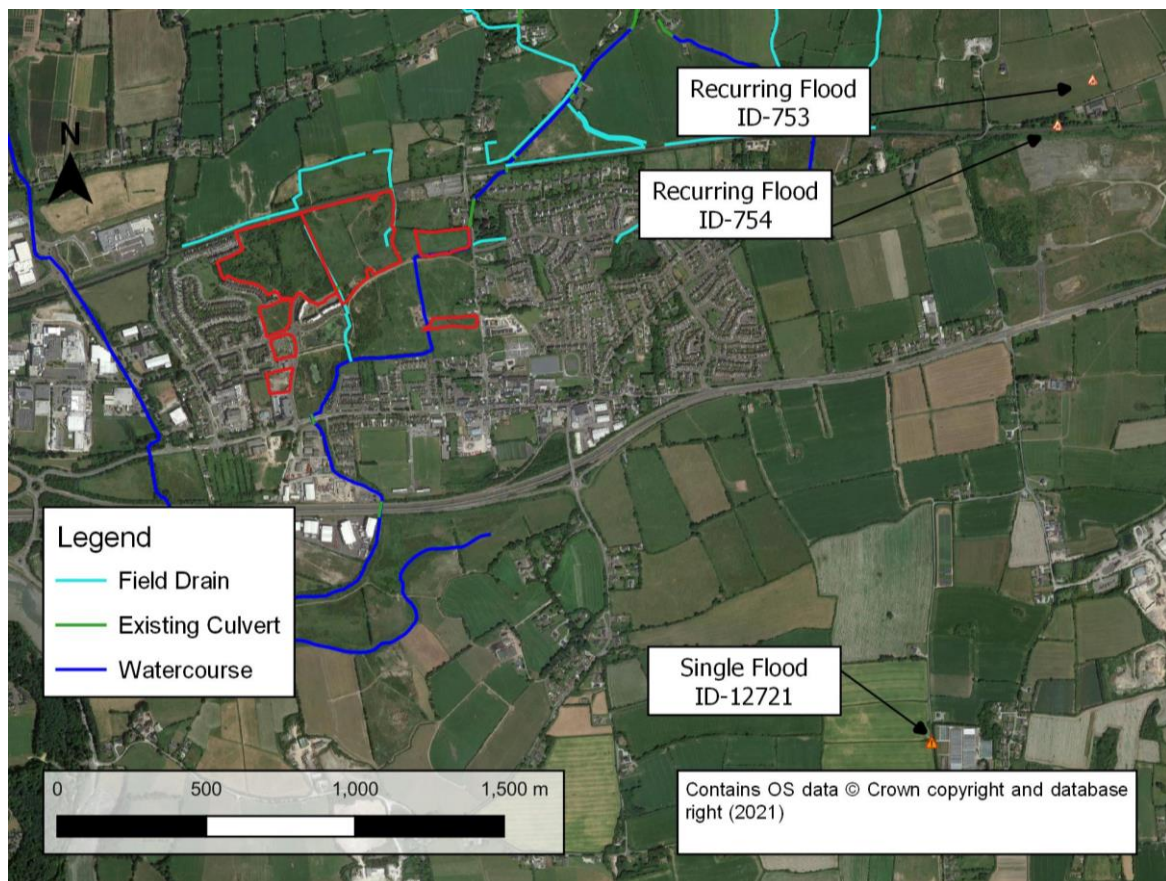


Figure 3-1: Floodinfo.ie Historic / Recurring Flood Events in the Carrigtwohill Area

A review of Figure 3-1 shows several recurring and historic flood events within a 2.5km radius of the proposed site. No flood events have been identified as having occurred within the proposed site confines. A summary of single and recurring flood events is presented below:

- 16 September 2016 - Flooding at Ballintubbrid West, Carrigtohill, Co.Cork. Winter 2016 to 2016 (ID-12721). The floodinfo.ie website states the following:
"Report by an OPW Engineer based on information extracted from a Minor Flood Relief Works Funding Application submitted to OPW by Cork Co.Co. Contains information on properties affected and mapped extents."
 (www.floodinfo.ie/map/pf_addinfo_report/12721)

It appears that this location aligns with an area of maximum historic groundwater flooding as presented in Figure 3-1. No further information relating to this flood event was available for review.

- 14 April 2005 - Two recurring turlough flood events with ID-753 and ID-754 at Ballyadam, Carrigane, Cork. The floodinfo.ie website states the following for both records:
"GSI Turlough Data - List of Turloughs with locations (some townlands and a few coordinates in this report for the turlough locations required modification, these have been corrected in the GIS and flood events in conjunction with the GSI and/or other flood reports."
 (www.floodinfo.ie/map/pf_addinfo_report/754)
 (www.floodinfo.ie/map/pf_addinfo_report/753)

No further information was available at the time of writing this report.

3.1.2 Internet Searches

An internet search was conducted to gather information about whether the site and surrounding area was affected by flooding previously. The search returned three results:

- 30 December 2015 - "Yellow weather warning remains in place as 4,600 homes still without power". The Journal.ie website reported this article, in which one site user left a comment on the article, which stated the following:
"homes and business flooded in ... Carrigtwohill,..."
 It was unclear at the time of writing this report where this flooding occurred, nor whether the user's comment was authentic.
 (www.thejournal.ie/storm-frank-weather-power-roads-2523798-Dec2015/)

- 1 February 2016 - "Floods sink council's master plan for thousands of homes in county Cork". The Irish Examiner website reported this article, which stated the following:
"Council officials have reported they have yet to complete a list of lands flooded during Storm Frank. However, the council acknowledged problems occurred in Carrigtwohill... councillor Anthony Barry, who lives in Carrigtwohill, previously told council officials he was concerned about flooding on most of the 160 acres of lands in the town for the master plan development".
 It was unclear at the time of writing this report where the lands mentioned in the above article extract referred to.
 (www.irishexaminer.com/news/arid-20379213.html)

- 14 October 2019 - "LIVE: Here are all the parts of Cork that you should avoid due to spot flooding". The Cork Beo website reported this article, which stated the following:
"The main road between Carrigtwohill and Midleton is experiencing large amounts of surface water."
 It was unclear at the time of writing this report where this flooding occurred. The Carrigtwohill to Midleton road is located away to the east of the proposed site.
 (www.corkbeo.ie/news/local-news/live-here-parts-cork-you-17082969)

No flooding incidents were reported to have occurred within the proposed site confines.

3.2 Predictive Flooding

The area has been a subject of several predictive flood mapping or modelling studies and other related studies and plans:

- Office of Public Works (OPW) National Indicative Fluvial Mapping (NIFM);
- Lee Catchment Flood Risk Assessment and Management Study (CFRAM);
- National Coastal Flood Hazard Mapping (NCFHM) 2021;
- Cobh Municipal District (MD) Local Area Plan (LAP) 2017 Strategic Flood Risk Assessment (SFRA);
- Cork County Development Plan 2022-2028 Strategic Flood Risk Assessment (SFRA);

The level of detail presented by each method varies according to the quality of the information used and the approaches involved.

3.2.1 Office of Public Works (OPW) National Indicative Fluvial Mapping (NIFM)

The OPWs National Indicative Fluvial Mapping (NIFM) flood extents have recently been uploaded to the www.floodinfo.ie website. These replace the OPW PFRA mapping. The current available extents highlight the probabilities of fluvial flooding for the 0.1% (low probability) and 1% (medium probability) AEP fluvial flood events. At the time of writing this report, the high probability flood extents for the area were not available for review. A review of the NIFM mapping shows the Castlelake North Site, Castlelake West Site and Castlelake South Site 02 are subject to flooding during the 1% AEP fluvial event, refer to Figure 3-2.

This fluvial flow path emanates from the Tibbotstown Stream to the west and does not account for remedial works which have recently taken place on the stream, including culverting and re-routing of sections. It also does not consider the Cork-Midleton railway line, which traverses across this flow path. The railway line will ultimately impede any potential fluvial flow path from the Tibbotstown Stream. Further discussion on the flood map is undertaken in Section 4.2.1.

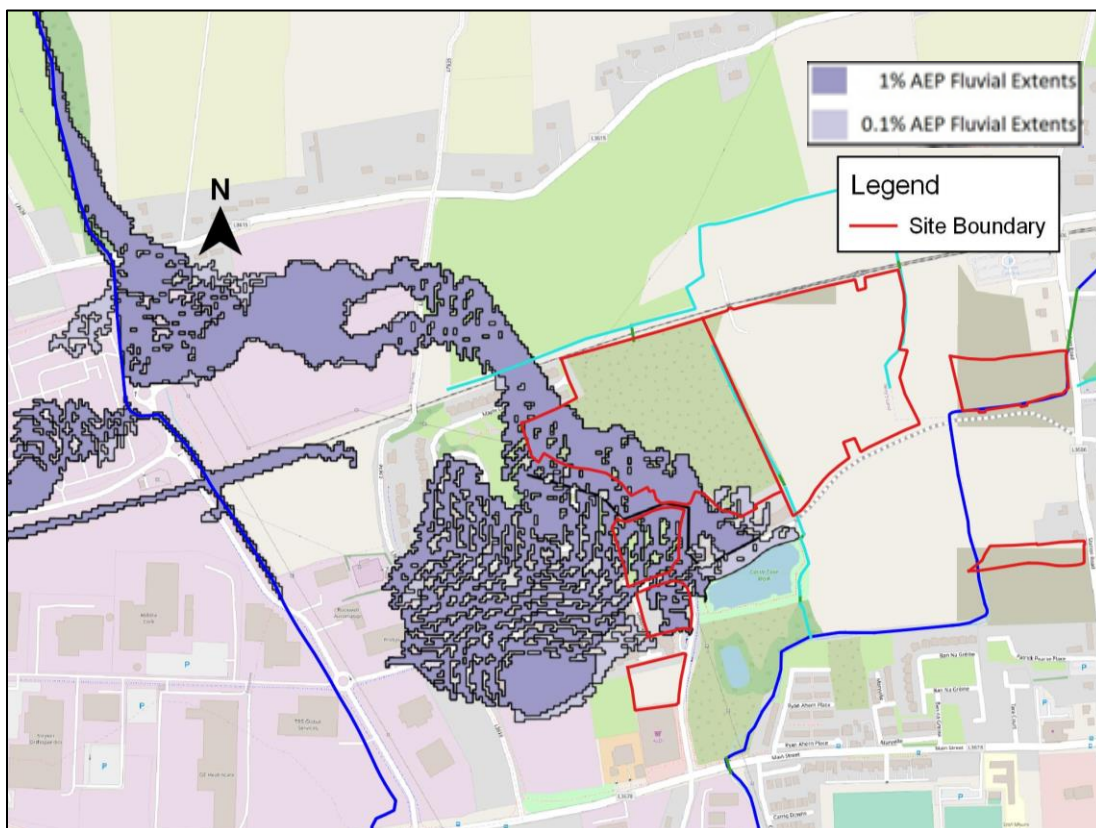


Figure 3-2: OPW NIFM Fluvial Extents - Present Day

3.2.2 Lee Catchment Flood Risk Assessment and Management Study (CFRAM)

The primary source of data with which to identify flood risk to the site is the Lee CFRAM study. Predictive fluvial and coastal flood extents for the local area are available on floodinfo.ie. A review of the fluvial flood extents shows that the northeast corner of the Castlelake South Site 01 is subject to flooding during the 0.1% AEP fluvial flood event. However, JBA carried out detailed modelling of the Woodstock Stream under Planning Application Reference 19/5707, which indicates that this site is not at risk of flooding from the 1% AEP and 0.1% AEP flood events. This is outlined in detail in Section 4. The nearest CFRAM coastal flood extents are located to the south, and do not extend north of the N25 Carrigtwohill bypass. Therefore, they do not impact upon the proposed site. Refer to Figure 3-3 for the CFRAM flood extents.

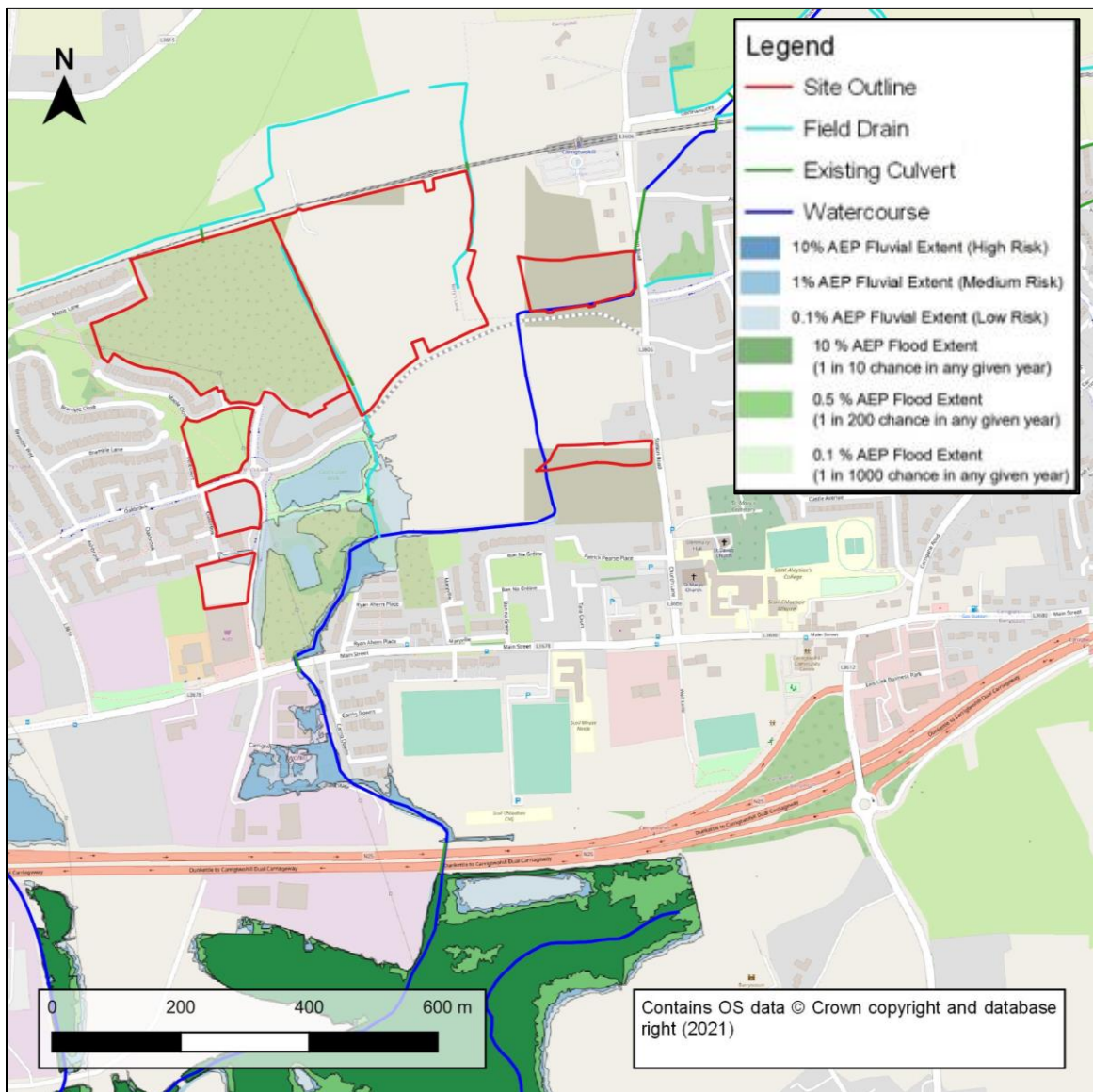


Figure 3-3: Lee CFRAM Flood Extents

3.2.3 National Coastal Flood Hazard Mapping (NCFHM) 2021

The NCFHM 2021 study is an improvement on the ICPSS and contains predictive coastal flood extents and depths. The predictive coastal flood extents and flood depths for the area are available on floodinfo.ie. A review of the predictive coastal flood extents shows that the southeast corner of the Castlelake North Site, the southwest corner of the Blandcrest Site, and a significant portion of the Castlelake South Site 01 are subject to flooding during the 0.5% AEP coastal flood event. Extended areas at these locations are also subject to flooding during the 0.1% AEP coastal flood event, as well as a small portion of the Castlelake South Site 02. Refer to Figure 3-4 for the NCFHM predictive coastal flood extents. Corresponding flood depth maps for the area are also available.

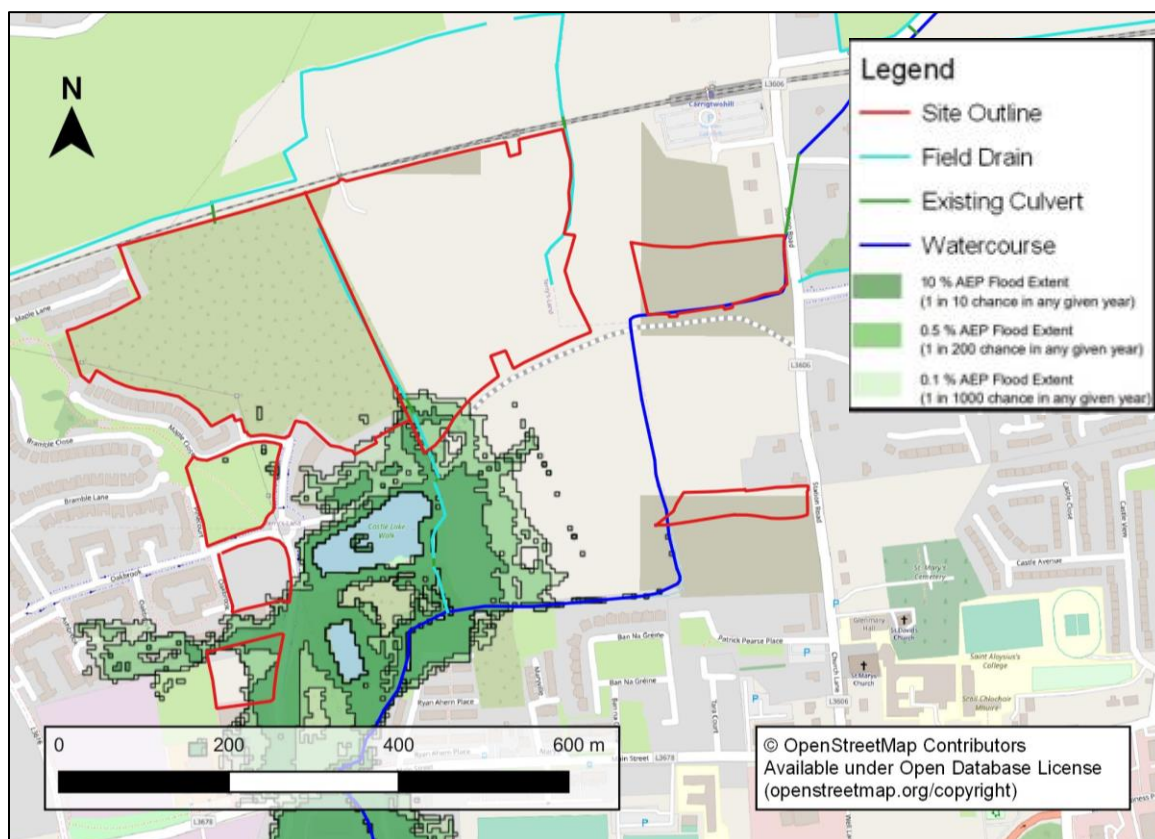


Figure 3-4: NCFHM Coastal Flood Extents - Present Day

The NCFHM maps were produced using estimated extreme water levels from Phase 1 of the Irish Coastal Wave and Water Level Modelling Study (ICWWS 2018) node points. The nearest node point to the proposed site with modelled levels to accurately reflect on-site condition is South Point C3, located c.7.9km away in the Lee estuary, near Rochestown. The predicted water levels at this node were available for review on floodinfo.ie, and are presented in Table 3-1.

AEP (%)	Present Day (mOD)	MRFS (mOD)
10%	2.76	3.26
0.5%	3.12	3.62
0.1%	3.31	3.81

Table 3-1: ICWWS 2018 Water (Joint Probability Tide and Surge) Levels (South Point C3)

3.2.4 Cobh Municipal District (MD) Local Area Plan (LAP) 2017 Strategic Flood Risk Assessment (SFRA)

The Cobh Municipal District Local Area Plan was released in 2017 and sets out the detailed planning strategy and land use zoning for the towns and villages of the Cobh MD, with the exception of Cobh town itself. As part of the LAP SFRA, flood zone and land use zoning maps were prepared. The maps were uploaded to the Cobh LAP 2017 online map viewer and were available for review. In preparation for the LAP, CCC updated their indicative flood zone mapping (from the 2011 LAP) to include information which became available under the National CFRAM programme. The flood zones were created using predictive fluvial and tidal flooding only. The flood zones are based on an undefended scenario and do not consider the presence of flood defences. A review of the flood zones map shows the southeast corner and along the field drain in the Castlflake North Site, the southwest corner of the Blandcrest Site, and a portion of the Station Road North Site are located within Flood Zone A. An extended portion of the southeast corner of the Castlflake North Site, the southwest corner of the Blandcrest Site, and a significant portion of the Castlflake South Site 01 are located within Flood Zone B. Refer to Figure 3-5.

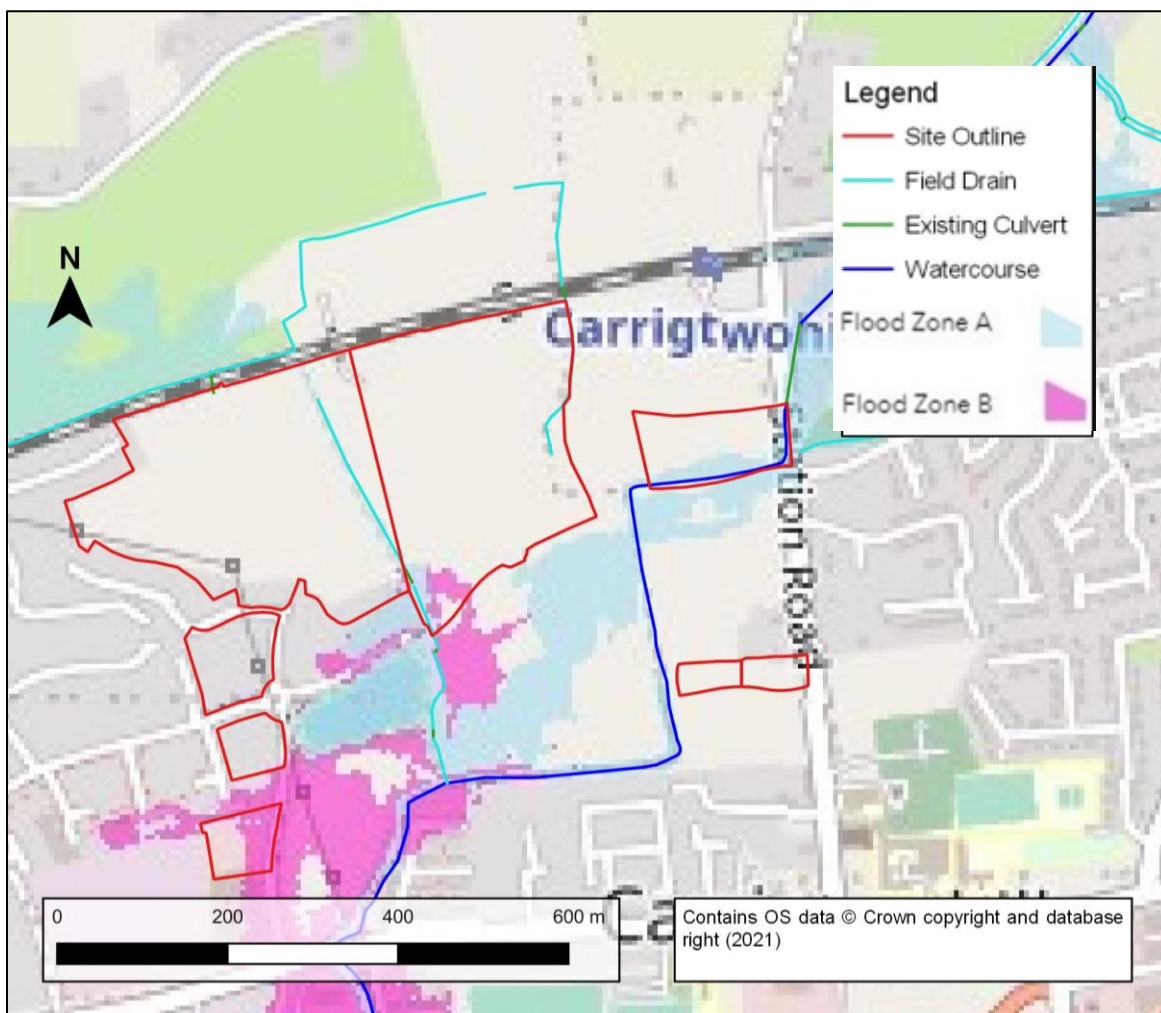


Figure 3-5: Cobh MD LAP 2017 Flood Zones

A review of the land use zoning map shows that the Castlflake North Site, Blandcrest Site and Station Road North Site are zoned as "Residential". The Castlflake South Site 01, Station Road South Site 01 and Station Road South Site 02 are zoned as "Town Centre". The Castlflake West Site and Castlflake South Site 02 have not been zoned under the LAP.

It is noted that the Cobh Municipal District (MD) Local Area Plan (LAP) 2017 has been superseded

3.2.5 The Cork County Development Plan 2022-2028 & Strategic Flood Risk Assessment (SFRA)

The Cork County Development Plan 2022-2028 has been adopted and will come into effect on the 6th June 2022. The SFRA for the County Development Plan 2022-2028 was prepared in accordance with the requirements of 'The Planning System and Flood Risk Management - Guidelines for Planning Authorities' (2009) and Circular PL02/2014 (August 2014). The SFRA provides an assessment of all types of flood risk within the County and assisted CCC to make informed strategic land-use planning decisions and formulate flood risk policies. This flood risk information has enabled CCC to apply 'The Guidelines' sequential approach, and where necessary the Justification Test, to appraise sites for suitable land zonings and identify how flood risk can be managed as part of the development plan. As part of the County Development Plan, flood zone and land use zoning maps were prepared. The maps were uploaded to the County Development Plan 2022-2028 online map viewer and were available for review.

The LEE CFRAM study identified areas in the south of Carrigtwohill and recommended a more detailed flood risk assessment (FRA) for Carrigtwohill take place. CCC carried out this FRA and identified a number of areas in Carrigtwohill at risk of flooding. This is reflected in the land use zoning maps for the development plan. The flood zones were created using predictive fluvial and tidal flooding only. The flood zones are the same as those outlined in the Cobh MD LAP 2017 and shown in Figure 3-5. The CCC development plan 2022-2028 flood zones map is available in Appendix B.

The land use zoning map for the CCC Development Plan 2022-2028 is the same as that produced for the Cobh MD LAP 2017, with the only difference being the zoning category "Town Centre" is renamed as "Town Centres/Neighbourhood Centres". The map is available for review in Appendix B.

4 Hydraulic Modelling

4.1 Hydrology

To assist in the estimation of potential flood risk to the proposed development area, this section provides flow estimates for the 1% and 0.1% AEP flood event flows expected along the watercourses that flow through the area of interest.

The flows for the model were calculated for a number of hydrological estimation points (HEPs), refer to Figure 4-1. HEPs were calculated along the Tibbotstown, Woodstock and Poulaniska Streams. Flows were calculated using a range of flow estimation methods, but the FSU method was used for the design flows.

The flows were applied to the model by summing each of the lateral sub-catchments together for each watercourse and applying this to the point inflow flows at the upstream extent of each watercourse. Figure 4-1 shows the 1% AEP flows to be applied to each watercourse based on this approach. This method ensures the lateral catchment areas are accounted for in the flows without the complication of deriving the lateral flows applying them along the watercourse.

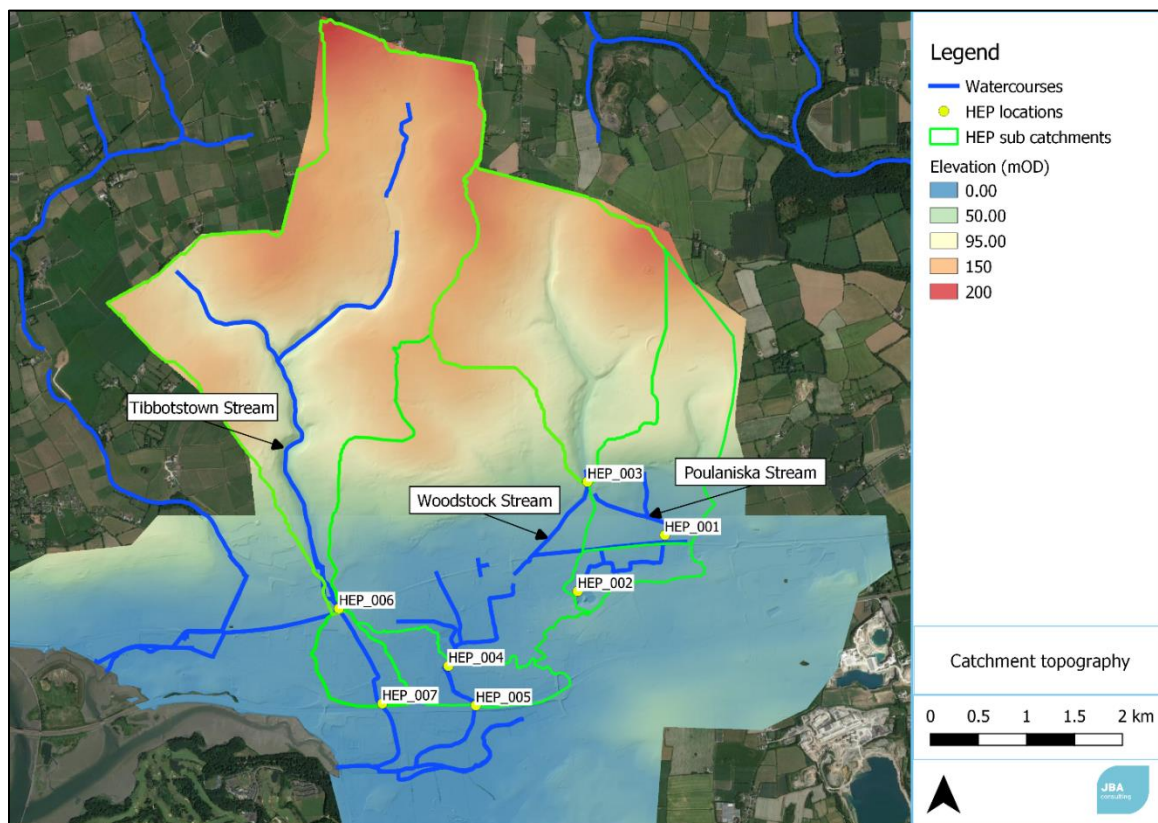


Figure 4-1: Catchment Area

4.1.1 Model Set-up

To assess flood risk at the site, a 1D/2D Flood Modeller/TUFLOW hydraulic model was constructed, allowing for the modelling of river channels, streams, floodplains and hydraulic structures to predict water levels for a range of scenarios. The hydraulic model was developed in the following stages:

- A 1D/2D TUFLOW model of the Tibbotstown and Woodstock Rivers was created based on a detailed survey data which has been supplemented by DTM data,
- Inclusion of constructed culvert along the Woodstock Stream west of Station Road,
- Inclusions of flood mitigation measures undertaken along the Tibbotstown Stream,
- Hydraulic simulations were run to derive the existing flood extent to determine Flood Zones A and B (the 1% and 0.1% AEP flood events),
- The model was then updated to account for road embankments and features not captured by the LIDAR data,

- The scenario examining the effect of climate change (+20% flow under the MRFS scenario) was also assessed.

The fluvial results from the hydraulic modelling are presented in Figure 4-2, while the tidal flood extents are presented in Appendix C. Review of the tidal flood maps confirm that the development is not at risk from the tidal flood events.

The hydraulic model includes a completed culvert along the Woodstock Stream (refer to Figure 4-2) but excludes the works included as part of the school development. The works undertaken as part of the school development has no impact on the site. Refer to planning application 19/5707 for the mitigation measures and resulting flood extents.

Review of Figure 4-2 highlights areas within the development that are at risk of inundation during a 0.1% AEP flood event. The area is located at the junction between the Woodstock Stream and Station Road. Floodwaters ovetop onto Station Road and ultimately the site before discharging back into the Woodstock Stream.

The inundation within the development's redline boundary and associated mitigation measures will be discussed further in Section 5.

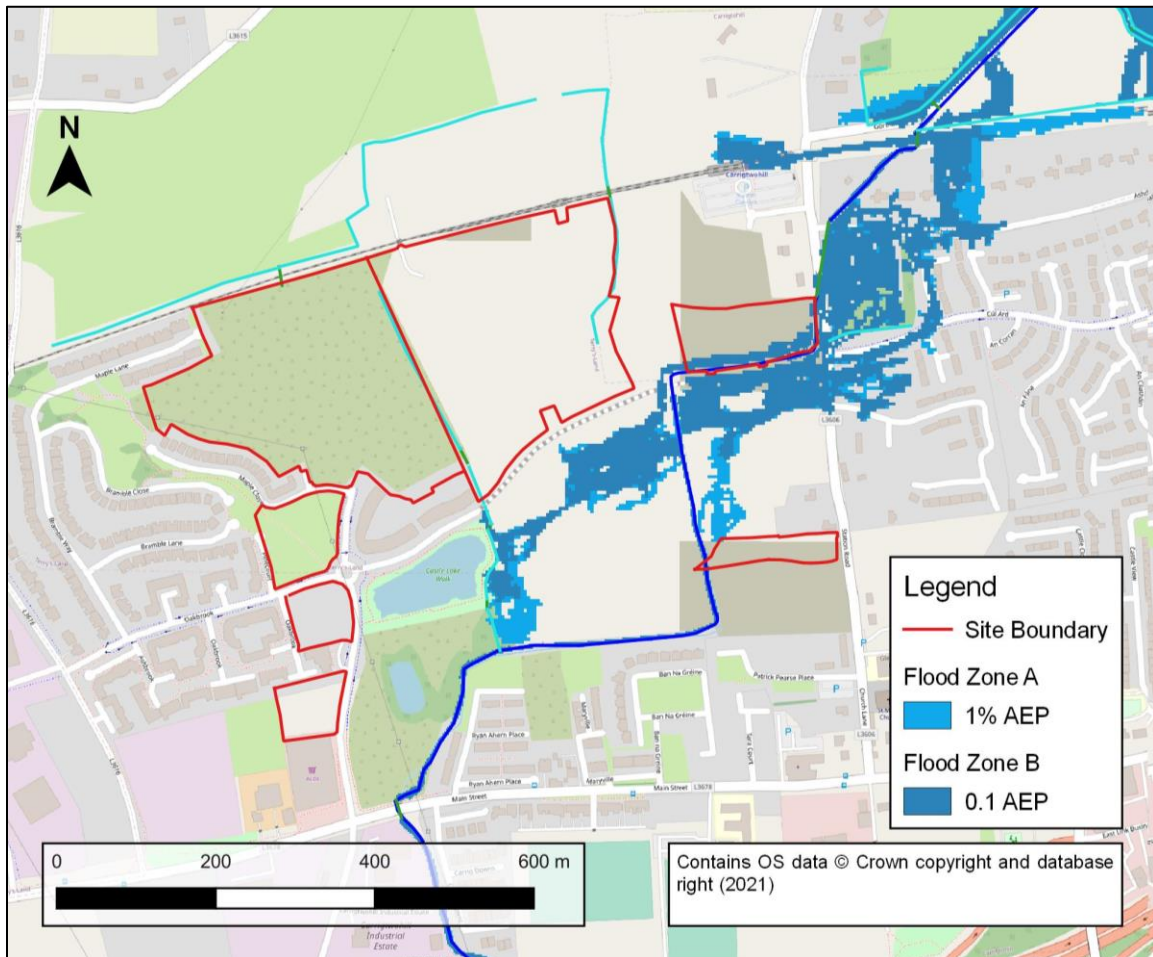


Figure 4-2: Pre-Development Flood Extents (No Mitigation Measures)

4.2 Flood Sources

The initial stage of a Flood Risk Assessment requires the identification and consideration of probable sources of flooding. Following the initial phase of this Flood Risk Assessment, it is possible to summarise the level of potential risk posed by each source of flooding, and are described below.

4.2.1 Fluvial / River

The main watercourses in the area are the Woodstock Stream and the Tibbotstown Stream. The fluvial sources are summarised as follows:

- There is no record of historic fluvial flooding having occurred within the proposed site confines;
- As per the Cork County Development Plan 2022-2028 SFRA, areas of the proposed site are located within Flood Zones A and B, meaning there is a "High" and "Medium" probability of flooding occurring, respectively. The majority of the site is located within Flood Zone C, indicating there is a "Low" probability of flooding occurring;
- The OPW NIFM study indicated flooding on-site for the 1% AEP flood event ("Medium" probability), however, it is concluded that this fluvial flow path does not take account of modifications to the Tibbotstown Stream and the presence of the Cork-Midleton railway line, which acts as a physical barrier. Therefore, the site is deemed not to be impacted by the NIFM predicted flood extents;
- The CFRAM study indicated flooding in the Castlelake South Site 01 for the 0.1% AEP flood event ("Low" probability).

To account for recently completed works along the Tibbotstown Stream and a culvert along the Woodstock, a hydraulic model has been developed by JBA to confirm the pluvial flood risk to the site. The model is presented in Section 4

The fluvial risk is addressed and further presented in detail in the mitigation measures section of this report.

4.2.2 Tidal / Coastal

The proposed site is located upstream of the Lee estuary / Cork Harbour area. It is located in close proximity to the coastline and there is a potential for floodwaters to surge up the Woodstock Stream. The coastal sources are summarised as follows:

- There is no record of historic tidal flooding having occurred within the proposed site confines;
- As per the Cork County Development Plan 2022-2028 SFRA, areas of the proposed site are located within Flood Zones A and B, meaning there is a "High" and "Medium" probability of flooding occurring, respectively. The majority of the site is located within Flood Zone C, indicating there is a "Low" probability of flooding occurring;
- The CFRAM study indicated no flooding on-site for the 0.1% AEP flood event;
- The NCFHM study indicated that the southeast corner of the Castlelake North Site, the southwest corner of the Blandcrest Site, and a significant portion of the Castlelake South Site 01 are subject to flooding during the 0.5% AEP coastal flood event. Extended areas at these locations, as well as a small portion of the Castlelake South Site 02, are also subject to flooding during the 0.1% AEP coastal flood event.

To date the Lower Lee/ CFRAM study is the most detailed study undertaken of the study area. The study does not indicate any tidal flooding of the study area. The NCFHM does indicate flooding but may not incorporate sufficiently detailed LIDAR data.

To confirm the flood risk to the site a hydraulic model has been developed to confirm the tidal flood risk to the development. This is presented in Section 4.

The tidal risk is addressed and further presented in detail in the mitigation measures section of this report.

4.2.3 Pluvial / Surface Water

Pluvial / surface water flooding is the result of rainfall-generated overland flows that arise before run-off can enter a watercourse or sewer. It is particularly sensitive to increases in hard-standing ground / urbanised areas and is usually associated with rainfall events of high intensity. There is no

record of historic pluvial flooding in the area, nor any relevant predictive pluvial flood mapping studies. However, the risk from pluvial inundation is always present. The pluvial risk is addressed and further presented in detail in the mitigation measures section of this report.

4.2.4 Groundwater

Groundwater flooding results from high sub-surface water levels that impact upper levels of the soil strata and overland areas that are usually dry. The groundwater risk is summarised as follows:

- The groundwater vulnerability has been classified as "Moderate" to "High" by the GSI groundwater vulnerability maps.
- There are no predictive groundwater flood extents located on-site or nearby,
- There is no record of any historical groundwater or surface water flooding within the proposed site confines.
- Review of the GSI Groundwater Flood Map does not indicate any groundwater water flooding within or adjacent to the development boundary.

In summary, there is no known risk of groundwater flooding in this area. In addition, the site will be developed and much of it is proposed to be fully covered in hardstanding, thus it has been screened out at this stage.

5 Flood Risk Assessment

5.1 Flood Risk

The flood risk to the 7no. proposed sites which make up the development is summarised in the following sections.

Proposed culvert works as part of this development to capture pluvial/surface water flows along the existing drainage channel along the northeastern boundary of the Blandcrest stie. The flood extents presented in Figure 5-1 take into account specific measures discussed below.

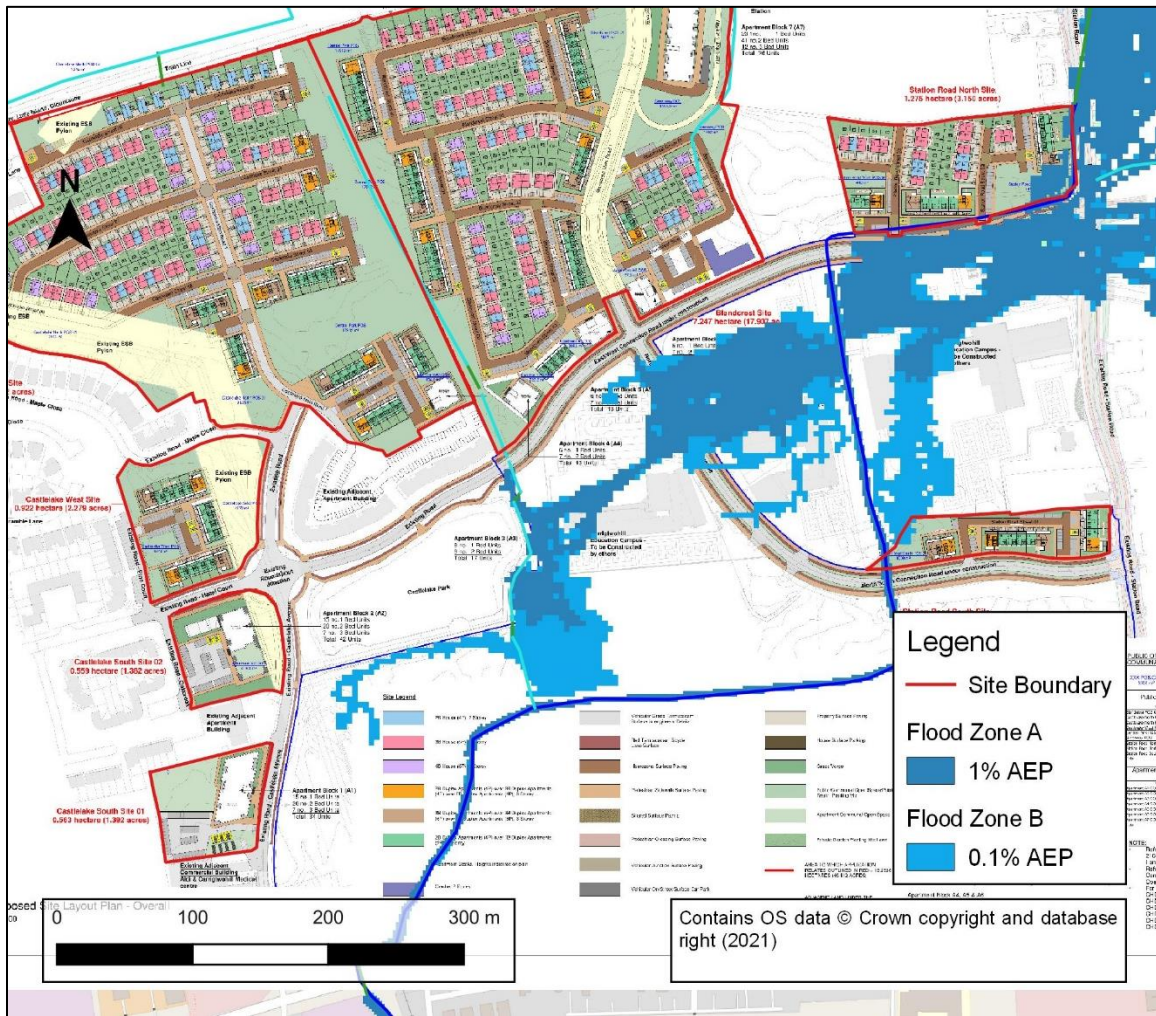


Figure 5-1: Post-Development Flood Map

5.1.1 Blandcrest Site

Review of Figure 5-1 confirms that the site is completely located within Flood Zone C. The main flood risk to the is presented by an existing drainage ditch that collects local surface water from lands north of the railway line. There are two culverts located along the railway line that convey surface water onto the site via the local drainage network.

The existing culverts will be maintained and extended where necessary, refer to Figure 5-2 for the proposed culvert location though the site. The culvert/drain system will discharge this to an existing drainage ditch at the southern end of the site.

No specific mitigation measures are required to manage fluvial flood risks to the site.

To minimise the pluvial flood risk it is recommended that a threshold of 150mm between the ground floor and surrounding hardstanding areas.

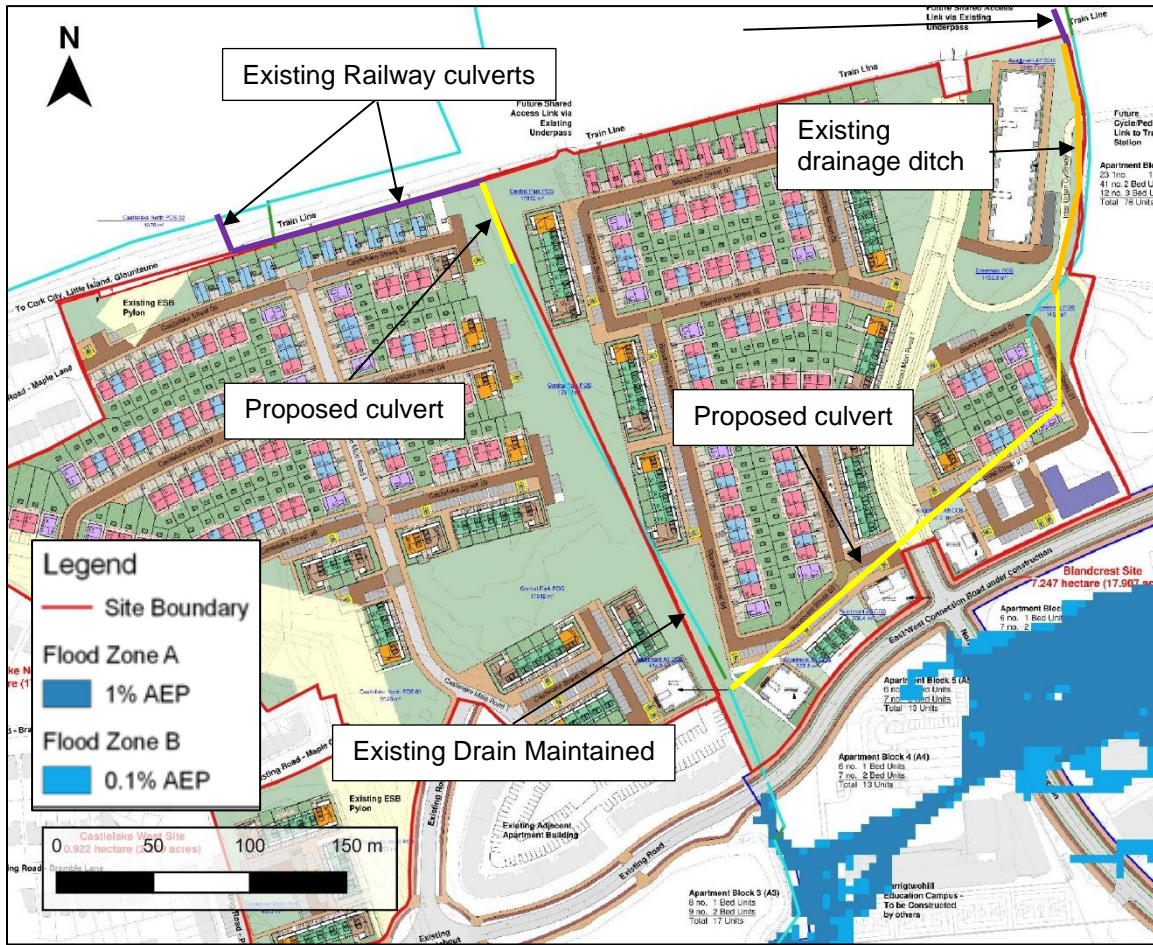


Figure 5-2: Blandcrest Site / Castlelake North Site

5.1.2 Castlelake North Site/ Castlelake South Site 01/ Castlelake South Site 02

The remaining areas of the development identified as Castlelake North, Castlelake South 01 and Castlelake South 02 are all located in Flood Zone C. The flood extents are based on the JBA hydraulic model and validated against the CFRAM/Lower Lee model results.

No specific mitigations are required to manage the fluvial flood risk to these areas. Typical measures will be provided in Sections 5.2 and Section 5.3.

To minimise the pluvial flood risk it is recommended that a threshold of 150mm between the ground floor and surrounding hardstanding areas.

5.1.3 Castlelake West & Station Road South

Regarding the Castlelake West & Station Road South development sites, there has been no identified fluvial or pluvial flood risks. Therefore, no specific mitigations are required to manage the fluvial flood risk to these areas. Typical measures will be provided in Sections 5.2 and Section 5.3.

To minimise the pluvial flood risk it is recommended that a threshold of 150mm between the ground floor and surrounding hardstanding areas.

5.1.4 Station Road North Site

Areas of this site along the southern boundary are located in Flood Zones A and B, meaning there is a "High" and "Moderate" risk of flooding in these areas, refer to Figure 5-3. As it is proposed to include residential development in these areas, it is necessary to include mitigation measures to counter the fluvial risk. Mitigation measures are discussed in Section 5.1.4. It is noted that the minimum FFL provided at the Station Road North Site is 6.6mOD

It is noted that the majority of the flood extents are located within the public green space at the south-eastern corner of the site. To manage the existing 1% AEP and 0.1% AEP flood events it is necessary to profile the landscaping in the greenspace to divert overland flows back in channel. This will remove the flood risk to the site, refer to Figure 5-3.

The post-development flood extents are presented in Figure 5-3, which confirms that all residential properties are appropriately mitigated, post development.

To minimise the pluvial flood risk it is recommended that a threshold of 150mm between the ground floor and surrounding hardstanding areas.

The flood levels for the modelled flood events are presented in Table 5-1. Review of Table 5-1 confirms that the adjacent apartment block to node WOOD00315 has a freeboard of 500mm above the 1% AEP MRFS flood event.

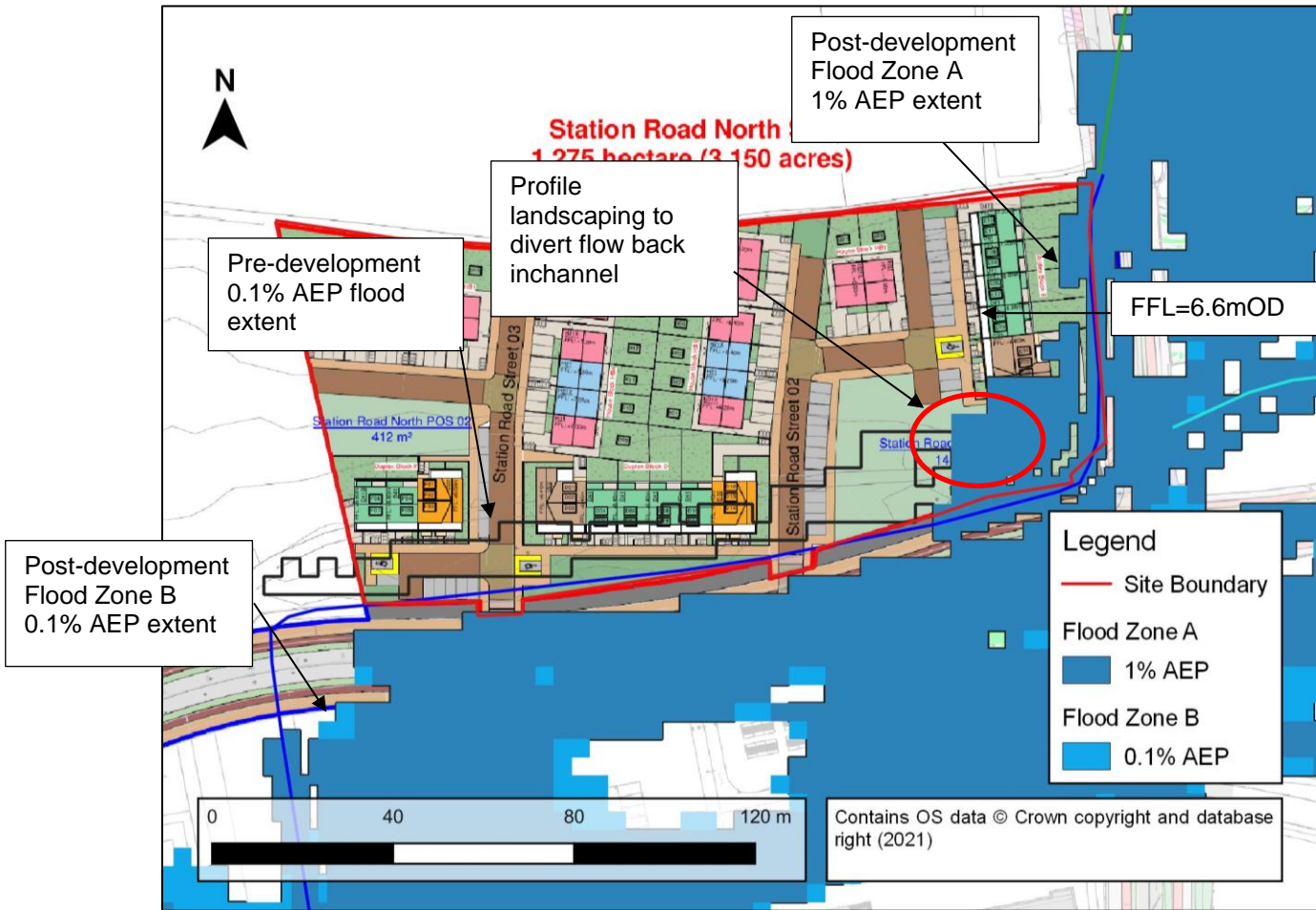


Figure 5-3: Station Road North Site

Key Node	1% AEP (mOD)	1% AEP MRFS (mOD)	0.1% AEP (mOD)
WOOD00315	6.1	6.1	6.13
WOOD00307	5.56	5.57	5.63

Table 5-1: Modelled Flood Levels Summary (Fluvial)

5.2 Finished Floor Levels

The majority of the development is located in Flood Zone C and therefore is at a low risk of flooding. However, to minimise the flood risk particularly from pluvial flooding it is recommended that a threshold of 150mm is provided to the external hardstanding areas.

Specific FFL's for segment Station Road North, a minimum FFL of 6.6mOD is provided to minimise the flood risk. This provides a freeboard of 0.5m above the 1% AEP MRFS flood event.

5.2.1 Areas at Risk from Fluvial Inundation

1no. site has been identified as being at risk from fluvial flooding; the Station Road North Site. It is necessary to set a minimum FFL to mitigate against the fluvial risk. This is done by identifying the predicted flood level for the 1% AEP MRFS fluvial event, and then incorporating allowances for climate change and freeboard, and is outlined as follows:

- As per Table 5-1 the predicted water level for the 1% AEP MRFS fluvial event is 6.1mOD, for the Present Day scenario. This is the level taken from the 'WOOD00315' node, as this is located adjacent to proposed development within the site;
- Finally, a freeboard of 500mm is provided to account for any residual risk to the development, bringing the minimum FFL to 6.6mOD for the apartment block adjacent to the Woodstock Stream.

5.2.2 Areas at risk from Coastal Inundation

None of the 7no. proposed sites has been shown to be at risk from coastal flooding during the 0.5% and 0.1% AEP events for the Present Day scenario. However, Castl lake Site 01 has been identified as being at risk of inundation during the 0.2% AEP HEFS (High End Future Scenario) flood event. The proposed FFL of 3.55mOD is sufficient to protect the development from this event. Therefore, it is not necessary to include mitigation measures to deal with coastal flood risk.

5.3 Drainage Design (Pluvial Flooding)

There is a potential risk of pluvial flooding to the Blandcrest Site via stormwater flow through the railway culverts. These culverts are connected to local drains on the northern side of the railway line. If not mitigated against, pluvial flood waters would be discharged into the site.

The proposed culvert system provided in Figure 5-2. This culvert will capture stormwater from the railway culverts and convey the stormwater through the site. The proposed culvert will discharge the stormwater to a local drain at the southern end of the site which connects to the Woodbrook Stream.

Regarding direct rainfall onsite, the existing site is greenfield in nature and has not been subject to any previous development. The proposed surface water drainage systems should be designed in accordance with the requirements of the Greater Dublin Strategic Drainage Strategy (GSDSDS) guidance documents and incorporating Sustainable Urban Drainage Systems (SuDS) to reduce runoff and improve receiving water quality. The SuDS elements of the proposed drainage systems should be designed in accordance with The SuDS Manual, CIRIA Report C753. The main provisions of the GSDSDS and SuDS guidance documents are as follows:

- Reduce runoff by providing interception of the first 5mm of rainfall;
- Provide temporary / permanent water storage;
- Treat runoff before entering receiving watercourses / networks;
- Attenuate for the 30-year design storm, with no on-site flooding;
- Attenuate for the 100-year design storm, with limited on-site flooding permitted;
- Limit discharge to the equivalent greenfield runoff rate for the development;
- Mitigate the effects of climate change by incorporating a minimum allowance for climate change of 10%.

As previously stated, to minimise the pluvial flood risk it is recommended that a threshold of 150mm between the ground floor and surrounding hardstanding areas.

5.4 Climate Change

5.4.1 Fluvial Climate Change Risk

Fluvial modelling was undertaken for the Mid-Range Future Scenario (MRFS). The MRFS extents showed on-site flooding within the Station Road North Site for the 1% and 0.1% AEP events. The results from the MRFS flood model confirm that the site is not at risk of inundation from the predicted MRFS flood event. Refer to Appendix C.1 for the pluvial MRFS floodmap.

Regarding the development at Station Road North, a minimum FFL of 6.6mOD is provided to minimise the flood risk. This provides a freeboard of 0.5m above the 1% AEP MRFS flood event.

5.4.2 Coastal Climate Change Risk

Coastal modelling was undertaken for the Mid-Range and High-End Future Scenarios (MRFS and HEFS, respectively). The MRFS extents showed no on-site flooding in any of the 8no. proposed sites for the 0.5% and 0.1% AEP events. The HEFS showed flooding in the Castlflake South Site 01 for the 0.5% and 0.1% AEP events. Refer to Appendix C.2 for the coastal flood maps

The FFL's for the apartment block within Castlflake South has been set at 3.55mOD which provides a freeboard of 0.34m and 0.2m above the 0.1% HEFS predicated tidal flood levels.

The 0.2% AEP HEFS tidal flood event has been selected as the design event for the site regarding FFL's to minimise flood risk.

The HEFS coastal modelling extents are available for review in Appendix C.

5.4.3 Pluvial Flooding Climate Change

Regarding pluvial flooding and climate change, the potential increase in rainfall can lead to an increased flood risk. To mitigate against climate change, a minimum climate change allowance of 10% should be incorporated into the design of the surface water drainage / attenuation systems as

per GSDSD requirements. This, along with setting the minimum FFL of 150mm above external hardstanding areas, will mitigate the ongoing risk of pluvial flooding.

5.5 Residual Risk

Residual risks are defined as risks that remain after all risk avoidance, substitution and mitigation measures have been taken. This flood risk assessment identifies the following as the main sources of residual risk to the proposed development;

- Failure of the on-site surface water drainage / attenuation systems (pluvial risk);

Failure of the surface water systems could include exceedance of the attenuation tank capacities, or blockage of the surface water gullies. To mitigate against failure of the drainage / attenuation systems, it is recommended to set a minimum Finished Flood Level (FFL) of 150mm above any external hardstanding areas.

6 The Justification Test for Development Management

6.1 Strategy

As it is proposed to locate a residential development within Flood Zone A/B, it is necessary to undertake a Justification Test as part of the development.

The source of the inundation during the 0.1% AEP event is an overland flow path following overtopping of the Woodstock Stream east of the Station Road North site

The existing land use is agricultural within the site and a minor section of the site is located within Flood Zone A/B.

The planning guidance appropriate to this development is, "The Planning System and Flood Risk Management" and sets out a framework within which the planning authority should consider proposals for new development in areas of flood risk. This framework is called the Justification Test for Development Management.

The specific aim of the development design is to place all highly vulnerable development outside of Flood Zone A and B. A Justification Test (JT) will be applied and passed in order to satisfy the Guidelines.

In the following text, each of the criteria within the JT is responded to as they relate to the proposed development. For ease of reading, where the responses are supported by technical detail which is contained in this report, an appropriate chapter has been referenced.

6.2 Justification Test: Part 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 the planning guidelines.

Under the CCC Development Plan 2022-2028 the site is zoned as residential. The map is available for review in Appendix B.

Conclusion: It has been outlined that the proposed development which comprises residential development is compatible with the current zoning. All residential developments will be raised above the relevant 1% AEP and 0.1% AEP flood levels.

6.3 Justification Test: Part 2

The proposal has been subject to an appropriate flood risk assessment that demonstrates:

(i) the development proposed will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk;

All development will be placed above the 1% AEP and 0.1% AEP flood levels. Mitigation measures have been outlined in Section 5.2 which ensures that the proposed development will not increase the risk of flooding downstream.

Conclusion: All development within Flood Zone A or B will be raised above the 1% AEP and 0.1% AEP flood levels. The proposed mitigation measures will ensure that there is no increase in runoff from the site.

(ii) the development proposal includes measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible;

All residential areas are located in Flood Zone C and the residential dwellings will be raised above the 1% and 0.1% AEP events and will not be impacted by the predicted flood events.

Conclusion: All residential areas will be located above the 1% and 0.1% AEP flood levels plus appropriate freeboard.

(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 proposed development has been designed with sufficient freeboard to account for any uncertainty in the modelling process. Residual risks have been accounted for as outlined in Section 5.5, relating to modelling uncertainty, climate change and surface water system-related residual risk.

Climate change has also been considered in the development of the mitigation measures.

(iv) The development proposed will address 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.

To address Part (iv) of the Justification Test, please refer to supplementary HW planning statement report provided as part of the application.

7 Conclusion

JBA Consulting has undertaken a Flood Risk Assessment for the proposed residential development at Carrigtwohill, Co. Cork. The existing 7no. sites are greenfield in nature and have not been subject to any previous development. A review of the available sources of flooding indicates there are no instances of historic flooding on-site, but there may be a risk from moderate-probability fluvial and pluvial events.

The majority of the development is located in Flood Zone C, however the FRA has determined that a minor section of the Station Road North Site resides within Flood Zone A/B. Mitigation measures have been proposed to manage the flood risks to the Station Road North Site which ensures that the residential areas are located above the 1% AEP and 0.1% AEP flood levels including climate change.

To address the risk of pluvial flooding, surface water drainage / attenuation systems will be incorporated into the development to manage surface water flows on site. It is recommended to set a minimum Finished Floor Level of 150mm above any external hardstanding areas to mitigate against potential failure of the surface water systems. It is also recommended to include climate change allowance into the design of the surface water systems to mitigate against the effects of climate change. These measures will mitigate the ongoing risk of pluvial flooding.

Within the Blandcrest Site, culverts are located along the railway line which will divert surface water flows to the existing drainage ditch that runs through the site. This system will be maintained in the post development scenario and retains the existing surface water drainage mechanisms in the area.

Climate Change has been assessed for the site for the fluvial and coastal events. Where necessary, mitigation measures have been provided to minimise flood risks from the climate change events. Post-development all residential areas are located above the predicted fluvial and coastal climate change flood levels.

In summary, the majority of proposed development on-site is located within Flood Zone C. The proposed development within Flood Zone C is deemed appropriate. For development within Flood Zones A and B, mitigation measures have been proposed to manage the ongoing risk of inundation from coastal and fluvial sources. The Justification Test has been undertaken and passed for the development.

This Flood Risk Assessment was undertaken in accordance with 'The Planning System and Flood Risk Management - Guidelines for Planning Authorities' and agrees with the core principles contained within.

Appendices

A Appendix - Understanding Flood Risk

Flood Risk is generally accepted to be a combination of the likelihood (or probability) of flooding and the potential consequences arising. Flood Risk can be expressed in terms of the following relationship:

$$\text{Flood Risk} = \text{Probability of Flooding} \times \text{Consequences of Flooding}$$

A.1 Probability of Flooding

The likelihood or probability of a flood event (whether tidal or fluvial) is classified by its Annual Exceedance Probability (AEP) or return period years, a 1% AEP flood 1 in 100 chance of occurring in any given year. In this report, flood frequency will primarily be expressed in terms of AEP, which is the inverse of the return period, as shown in the table below and explained above. This can be helpful when presenting results to members of the public who may associate the concept of return period with a regular occurrence rather than an average recurrence interval and is the terminology which will be used throughout this report.

Table: Conversion between return periods and annual exceedance probabilities

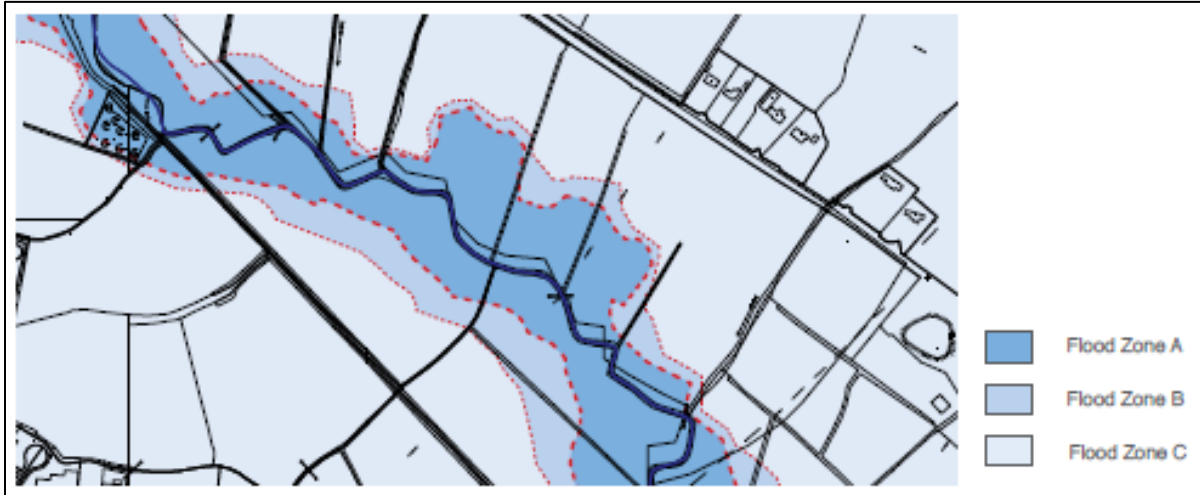
• Return period (years)	• Annual exceedance probability (%)
2	50
10	10
50	2
100	1
200	0.5
1000	0.1

A.2 Flood Zones

Flood Zones are geographical areas illustrating the probability of flooding. For the purpose of the Planning Guidelines, there are 3 types of levels of flood zones, A, B and C.

Zone	Description
Flood Zone A	Where the probability of flooding is highest, greater than 1% (1 in 100) from river flooding or 0.5% (1 in 200) for coastal/ tidal Flooding
Flood Zone B	Moderate probability of flooding, between 1% and 0.1% from rivers and between 0.5% and 0.1% from coastal/ tidal.
Flood Zone C	Lowest probability of flooding, less than 0.1% from both rivers and coastal/ tidal.

It is important to note that the definition of the flood zones is based on an undefended scenario and does not take into account the presence of flood protection structures such as flood walls or embankments. This is to allow for the fact that there is a residual risk of flooding behind the defences will be maintained in perpetuity.



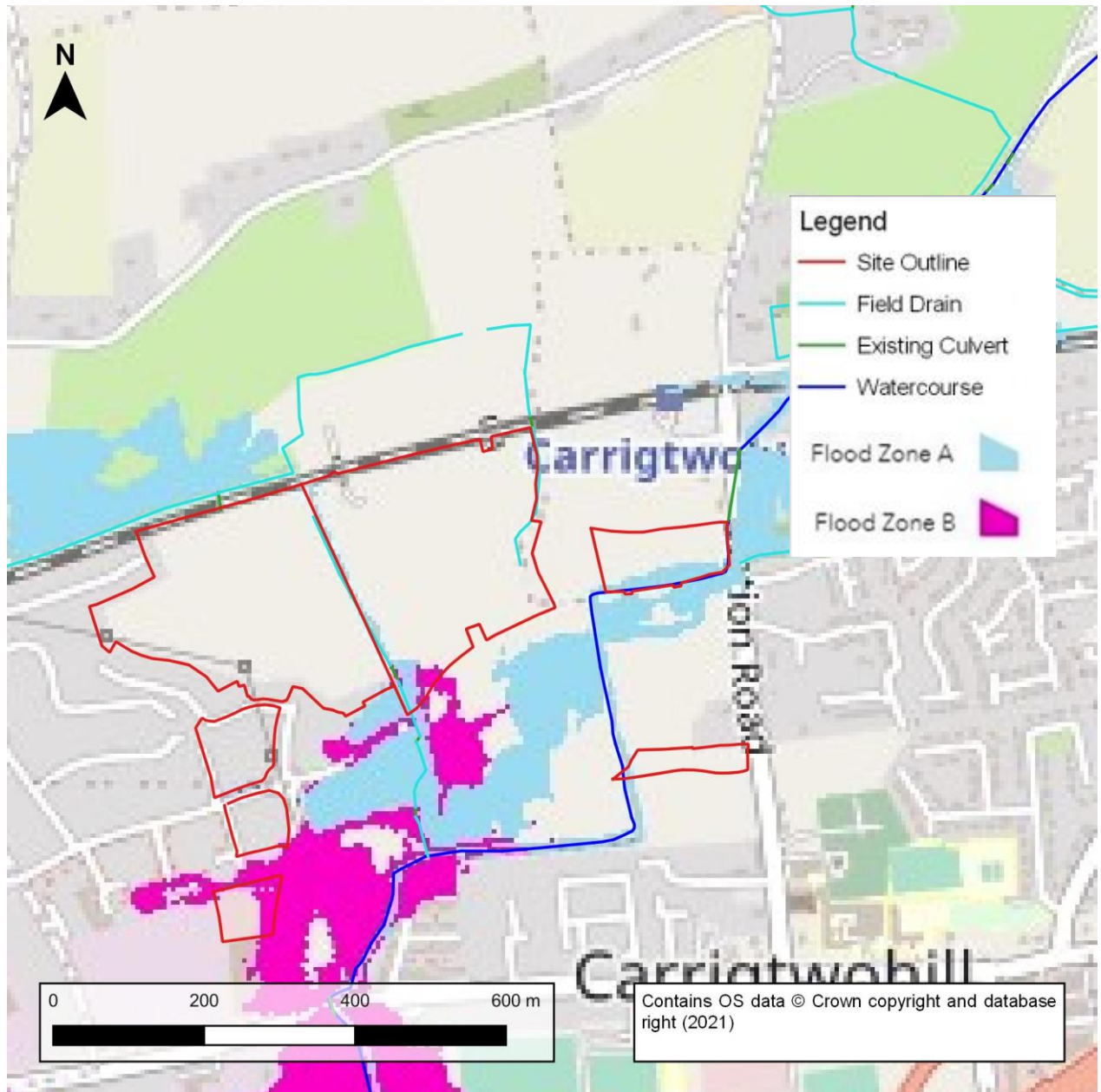
A.3 Consequences of Flooding

Consequences of flooding depend on the Hazards caused by flooding (depth of water, speed of flow. Rate of onset, duration, wave-action effects, water quality) and the vulnerability of receptors (type of development, nature, e.g. age-structure of the population, presence and reliability of mitigation measures etc.)

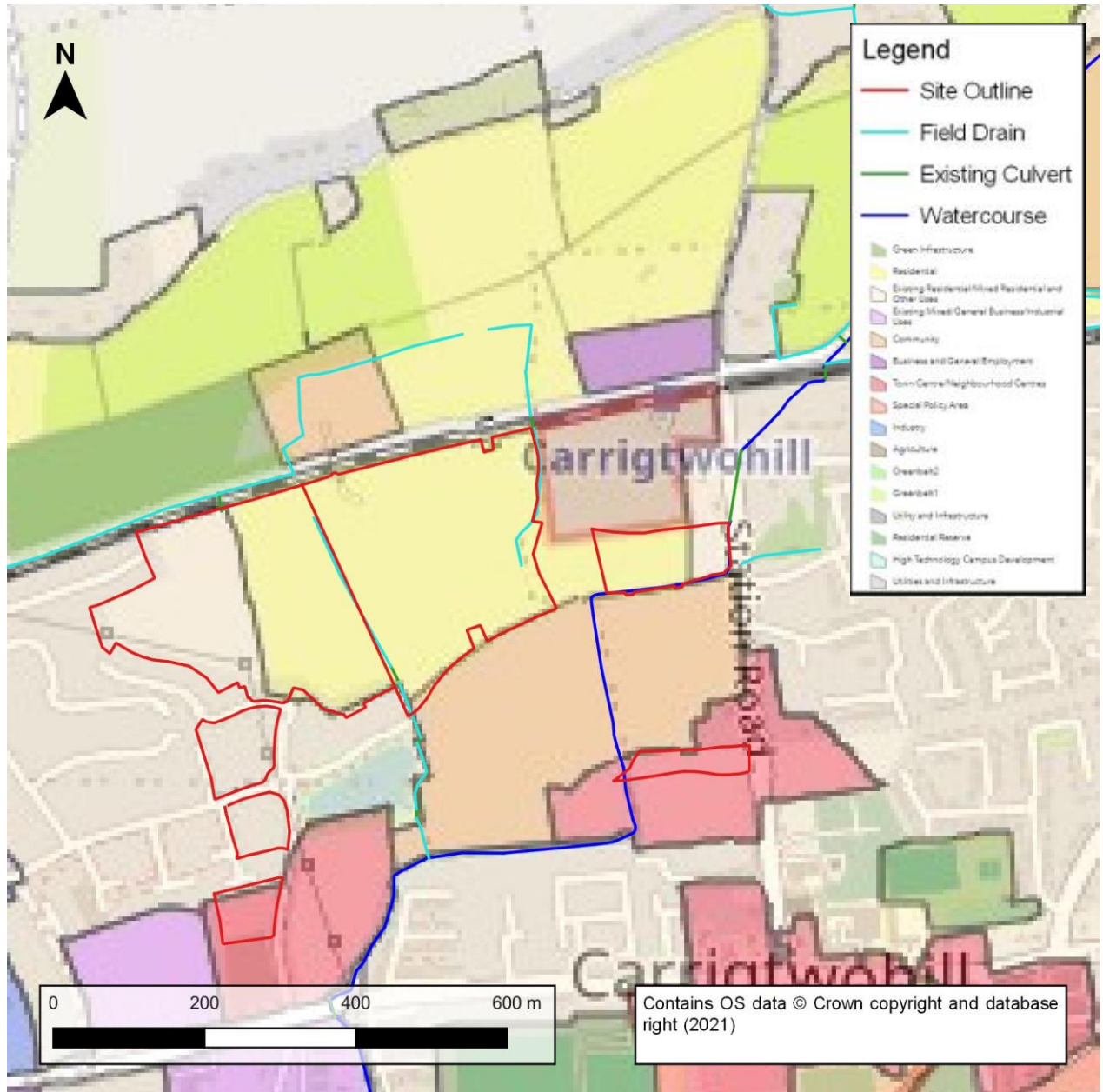
The 'Planning System and Flood Risk Management' provides three vulnerability categories, based on type of development, nature, which are detailed in Table 3.1 of the Guidelines, and are summarised as:

- **Highly vulnerable**, including residential properties, essential infrastructure and emergency service facilities
- **Less vulnerable**, such as retail and commercial and local transport infrastructure, such as changing rooms.
- **Water compatible**, including open space, outdoor recreation and associated essential infrastructure, such as changing rooms.

B Appendix - Additional Maps



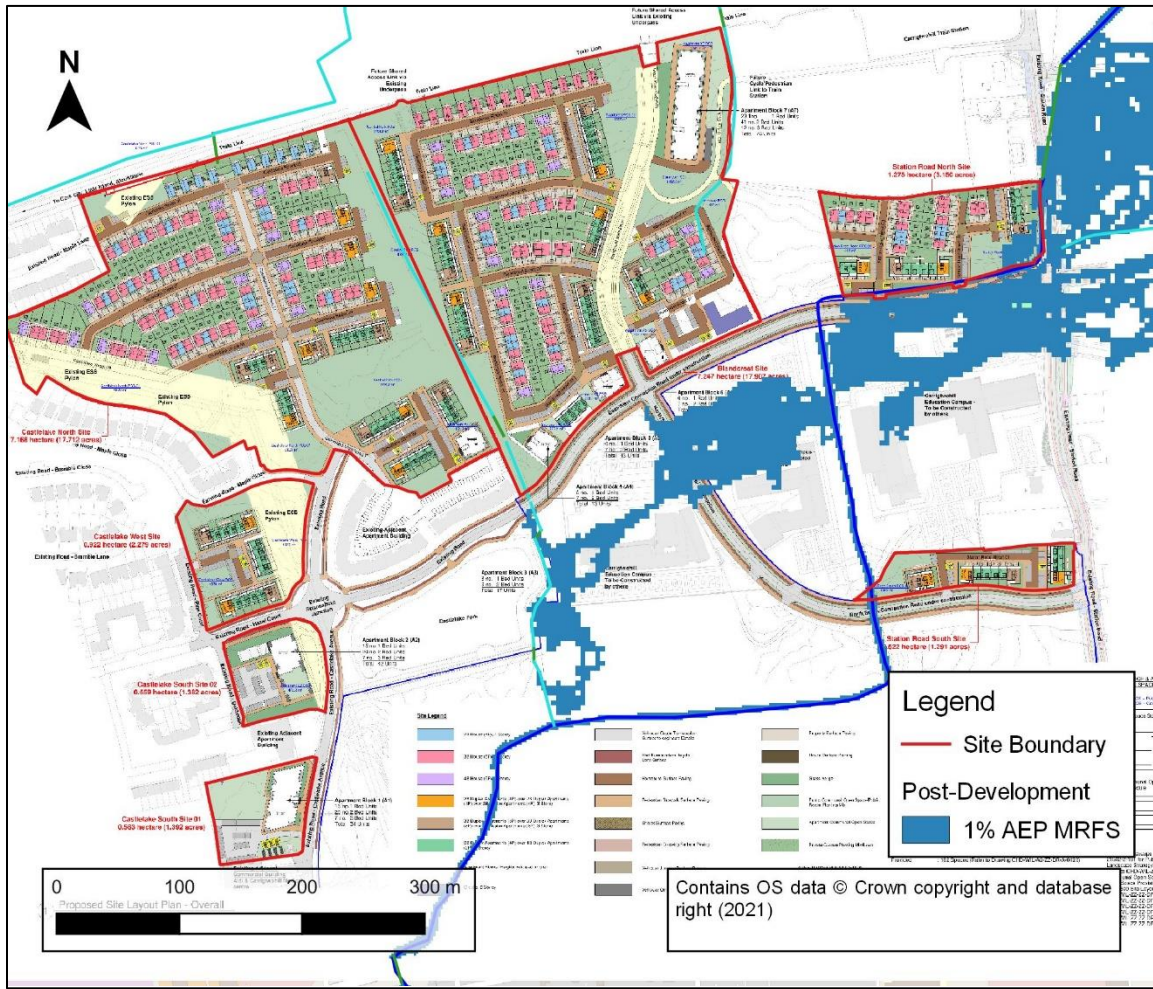
CCC Development Plan (2022-2028) Flood Zones



CCC Development Plan (2022-2028) Land Use Zoning

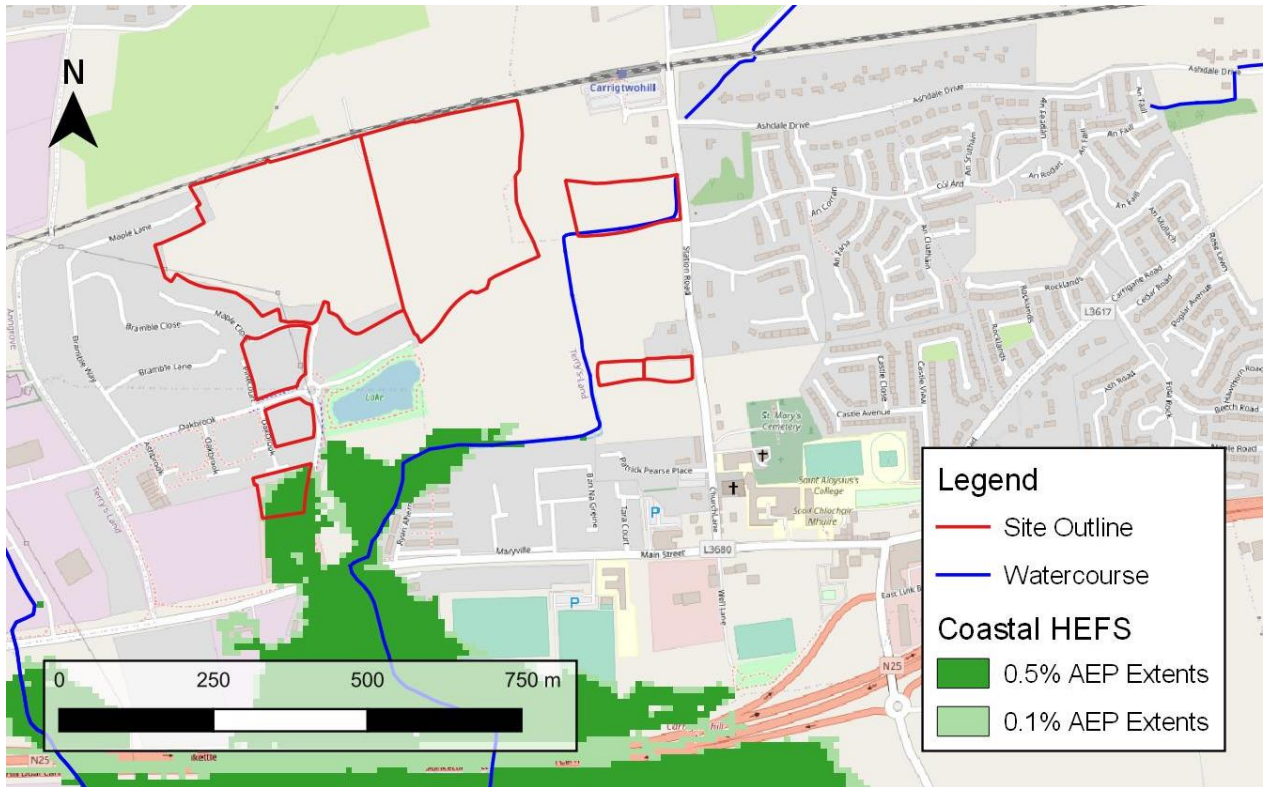
C Climate Change

C.1 Fluvial



Post-Development Fluvial Flood Extents - Mid-Range Future Scenario (MRFS)

C.2 Coastal



Coastal Flood Extents - High-End Future Scenario (HEFS)

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