Carrigtwohill URDF Initiative - Public Realm Infrastructure Bundle
Flood Risk Assessment

Technical Report

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Cork County Council

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This report describes work commissioned by Atkins, on behalf of Cork County Council, by a letter correspondence dated 14 December 2020. Cork County Council's representative for the contract was John O'Callaghan of Atkins. Ben Murphy of JBA Consulting carried out this work.

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Purpose

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Contents

1 Introduction 1

1.1 Terms of Reference and Scope 1
1.2 Flood Risk Assessment; Aims and Objectives 1
1.3 Development Proposal 1
1.4 Report Structure 3

2 Site Background 4

2.1 Location 4
2.2 Site Topography 5
2.3 Local Watercourses 5
2.4 Site Geology 9

3 Flood Risk Identification 11

3.1 Flood History 11
3.2 Predictive Flooding 15
3.3 Flood Sources 16

4 Flood Model Assessment 18

4.1 Hydrology 18
4.2 Hydraulic Model Set-Up 19
4.3 Model Results 19

5 Flood Risk Assessment 22

5.1 Flood Risk 22
5.2 Mitigation 22

6 The Justification Test for Development Management 26

6.1 Strategy 26
6.2 Justification Test: Part 1 26
6.3 Justification Test: Part 2 26

7 Conclusion 28

Appendices I

A Appendix - Understanding Flood Risk I

List of Figures

Figure 1-1: Carrigtwohill URDF Initiative Public Realm Infrastructure Bundle 3
Figure 2-1: Site Location 4
Figure 2-2: Carrigtwohill Topography 5
Figure 2-3: Woodstock Stream - Upper Reach (left) & Middle Reach (right) 6
Figure 2-4: Poulaniska Stream - Upper Reach (left) & Lower Reach (right) 6
Figure 2-5: Tibbotstown Upper Reach 8
Figure 2-6: Slatty Pond 9
Figure 2-7: Quaternary Sediments 10
Figure 3-1: Summary of Anecdotal Evidence (Source: Cork County Council) 12
Figure 3-2: Video showing Woodstock Flooding 13
Figure 3-3: Carrigtwohill LAP land zoning 14
Figure 3-4: LAP Flood Zones 15
Figure 3-5: Pre & Post Scheme Flood Maps 16
Figure 4-1: Catchments and HEPs 18
Figure 4-2: Fluvial Flood - Existing Scenario 19
Figure 4-3: Woodstock Fluvial Flood Extents 20
Figure 4-4: Pluvial Flood Extents 21
Figure 4-5: Pluvial Flood Extents - South of railway station (zoom A) 21

Abbreviations

1D	One Dimensional (modelling)
2D	Two Dimensional (modelling)
AEP	Annual Exceedance Probability
CFRAM	Catchment Flood Risk Assessment and Management
FB	Freeboard
FFL	Finish Floor Levels
FRA	Flood Risk Assessment
FSR	Flood Studies Report
FSU	Flood Studies Update
GSI	Geological Survey of Ireland
OPW	Office of Public Works
PFRA	Preliminary Flood Risk Assessment
RR	Rainfall-Runoff
SAAR	Standard Average Annual Rainfall (mm)
SFRA	Strategic Flood Risk Assessment
WL	Water Level

1 Introduction

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

1.1 Terms of Reference and Scope

JBA Consulting was appointed by Atkins on behalf of Cork County Council to prepare a Flood Risk Assessment (FRA) for an upgrade to the Carrigtwohill URDF Initiative - Public Realm Infrastructure Bundle in Carrigtwohill, Co. Cork.

1.2 Flood Risk Assessment; Aims and Objectives

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

The objectives are to:

- Identify potential sources of flood risk,
- Confirm the level of flood risk at and adjacent to the proposed development and identify key hydraulic features,
- Assess the impact the proposed development has on flood risk,
- Develop appropriate flood risk mitigation and management measures which will reduce flood risk and allow for safe and sustainable development of the proposed infrastructure.

In 2013, JBA completed a study to investigate flood risk for the wider Carrigtwohill area; the reports and associated flood mapping published under this study are available publicly for download on the Cork County Council website. This has been used as the base data for this assessment, supported and updated where necessary by updated survey and site specific data.

Recommendations for development have been provided in the context of the OPW / DoEHLG planning guidance, "The Planning System and Flood Risk Management[1]".

1.3 Development Proposal

With reference to Figure 1-1 the proposed development comprises of the following infrastructure projects:

1. Main Street and Station Road Public Realm Works comprising of the following:
    a. Upgrade of Main Street and Station Road junction including footpath widening, road re-alignment and widening, re-surfacing, signalisation, provision of pedestrian crossings and removal of existing structures/buildings;

    b. Provision of three new public spaces as follows:
        i. At junction of Station Road and Main Street;
        ii. At and north of the Community Centre on Main Street;
        iii. At and west of St. Mary's Church on Station Road.

    c. Public realm upgrade of Station Road from the junction with Main Street to the junction at Carrigtwohill Train Station including:
        i. Road widening with footpaths / off-road cycle tracks on both sides of the road, raising of existing roads levels where required, and re-location of the existing Grotto;

1 The Planning System and Flood Risk Management: Guidelines for Planning Authorities, (2009) OPW/DoEHLG

ii. Removal of existing boundary walls, re-building of boundary walls, re-location of entrances and local realignment of the stream channel;
iii. Two number 'Biodiversity Areas';
iv. New street lighting, undergrounding of overhead lines, new underground services and drainage, and diversion of existing services where required;
v. Traffic calming measures including re-surfacing, road narrowing, tree planting and raised tables, signalised and unsignalised raised pedestrian crossings;
vi. Removal of on-street carparking and provision of a new car park (46 no. spaces);
vii. Upgrade of existing car park at Patrick Pearse Place;
viii. New shared use pedestrian and cyclist path between Station Road and recreation areas south of Main Street via Patrick Pearse Place and the existing Centra car park;
ix. New footpaths connecting the following housing developments:
- Cluain Cairn and An Fána;
- Cluain Cairn and Castle Close/Castle Avenue

d. Public realm upgrade of Main Street from the junction with Castlelake Avenue to the junction with Carrigane Road including:
i. Footpath widening on both sides of the road with varying surface treatments;
ii. Shared cycle/pedestrian path on north side of the road from junction with Castlelake Avenue to Bán Na Gréine;
iii. Removal of existing boundary walls, re-building of boundary walls, and re-location of entrances;
iv. Street lighting, undergrounding of overhead lines and diversion of existing services as required;
v. Traffic calming measures including re-surfacing, road narrowing, tree planting, raised tables, signalised and unsignalised raised pedestrian crossings;
vi. Re-location of on-street car parking to three new car parks (45 no. spaces);
vii. New road running south from Main Street including underground services, and public lighting;
viii. New school drop off area accessed from Carrigane Road and ambulant accessible parking.

2. Wises Road Junction Upgrades comprising of the following:
a. Upgrade of junction of Wises Road and Main Street including provision of traffic signals, pedestrian crossings, road re-alignment and footpath widening;
b. Upgrade of junction of Wises Road and Oakbrook Link Road/ IDA Industrial Estate Access Road including provision of traffic signals, road re-alignment and footpath widening.

3. N25 Junction 3 (Cobh Cross) Additional Capacity Interim Measures to include an increase in the size of the existing northern roundabout, widening and re-alignment of approach roads to the roundabout.

Full details of the proposed infrastructure are shown in the Part 8 drawings which are appended to this report.

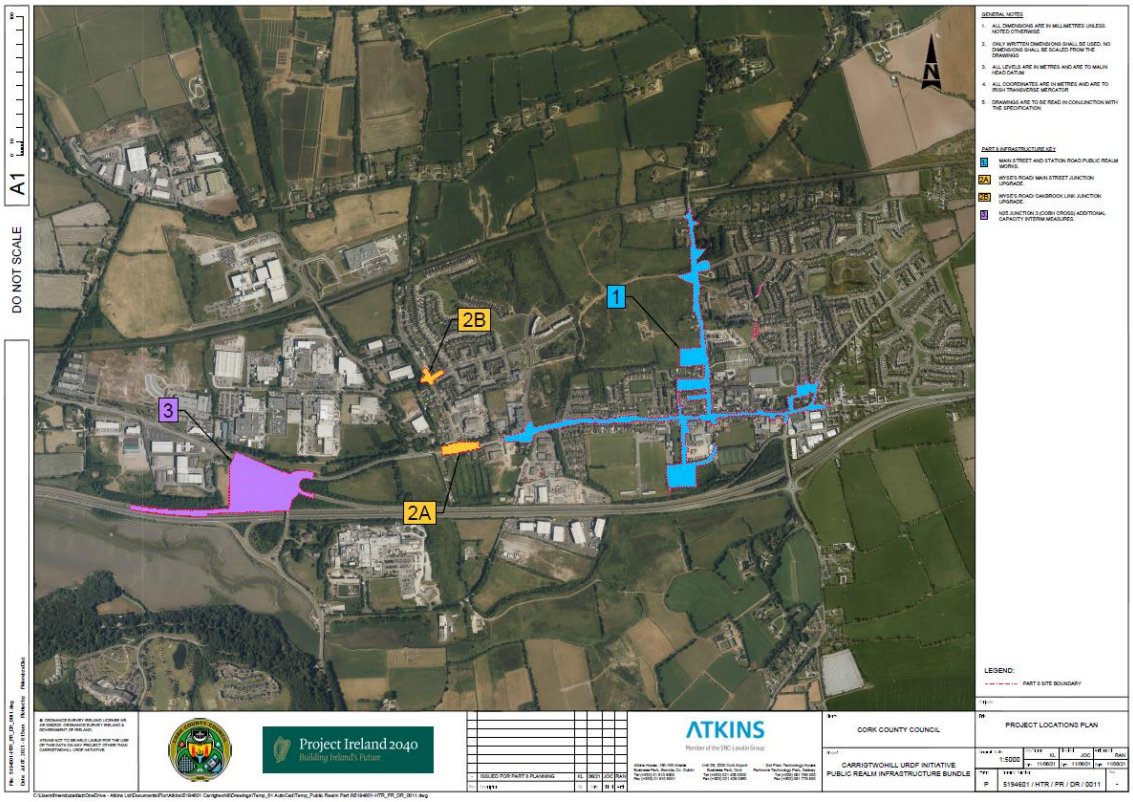


Figure 1-1: Carrigtwohill URDF Initiative Public Realm Infrastructure Bundle

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 initial assessment of flood risk. The hydraulic model is covered in Section 4. Site-specific mitigation measures are outlined in Section 5, while conclusions are provided in Section 6.

2 Site Background

This section of the report describes the site, including the relevant water courses and key hydraulic features.

2.1 Location

Carrigtwohill is a commuter town located 11km east of Cork City on the main Cork to Rosslare Europort N25 national route. The town has experienced extensive development in recent years, in part supported by the re-opening of the rail line with a new station in Carrigtwohill.

The proposed upgrade to the Public Realm Infrastructure covers Station Road, Main Street, Carrigane Road, Wises Road and the N25 junction 3 (Cobh Cross) and adjoining lands. The proposed upgrades to the public realm are shown in Figure 2-1 below.

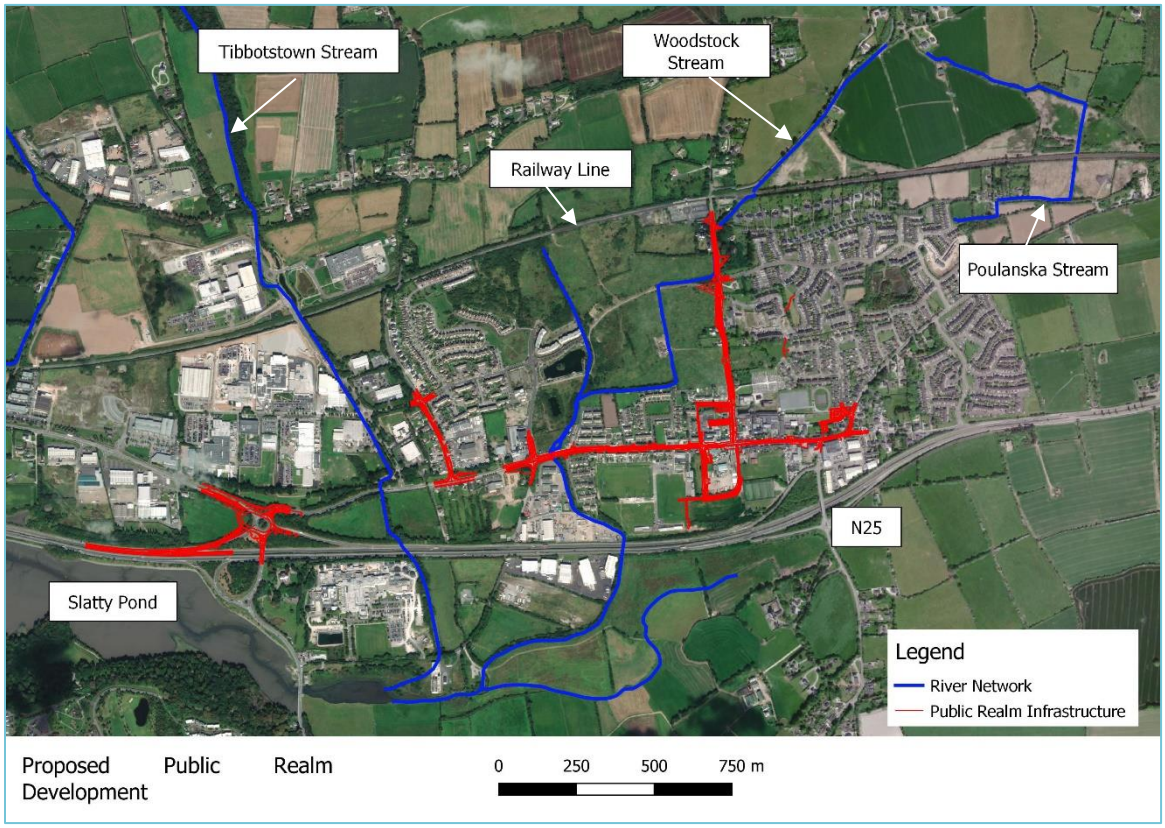


Figure 2-1: Site Location

2.2 Site Topography

The overall slope of the land is to the south west towards the Slatty Pond. At a more local level, there are areas of higher ground to the east where the main town of Carrigtwohill is located. The Woodstock stream flows along the lowest topographical area north of the N25 (natural flow path). The topography south of the N25 is much lower giving a north-south slope within the area of the development.

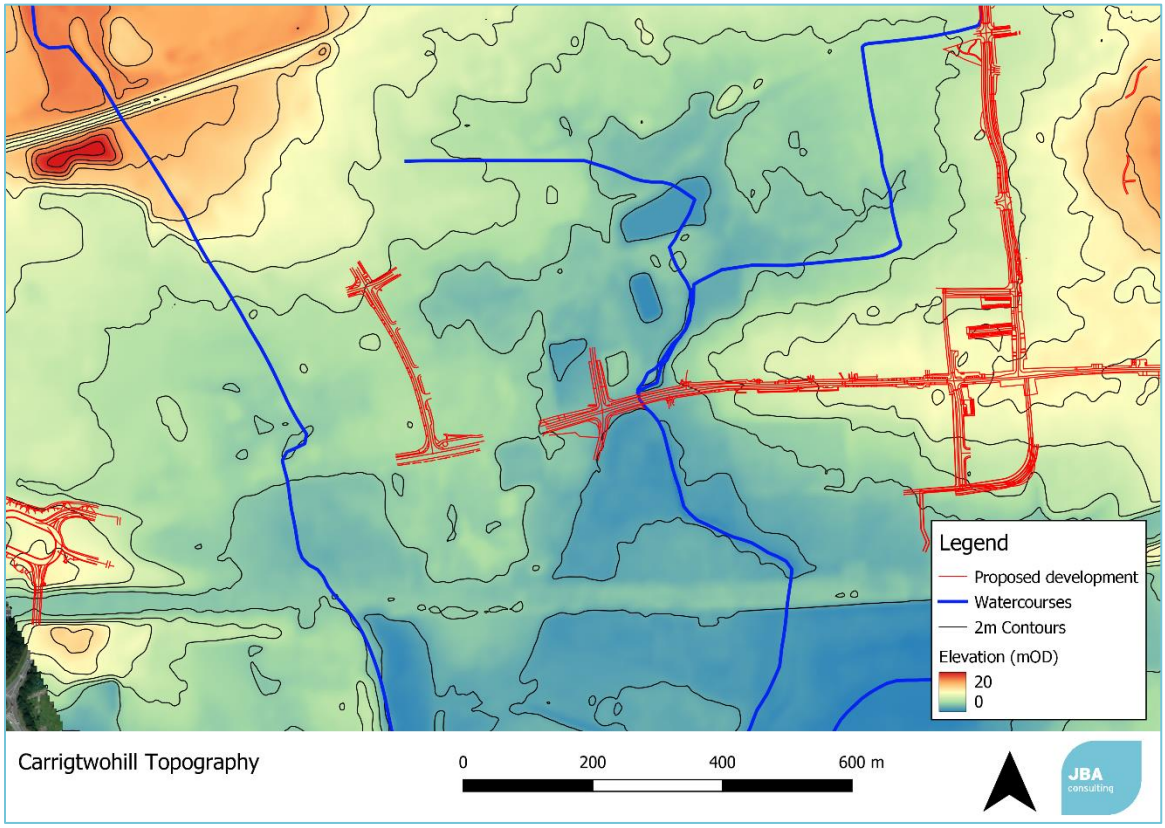


Figure 2-2: Carrigtwohill Topography

2.3 Local Watercourses

2.3.1 Woodstock Stream

The course of the Woodstock Stream is shown in Figure 2-1. The stream flows in a south westerly direction along the Leamlara road, under the rail line, through private residential land, into a long culvert at the junction near the railway station and the Bog Road, through private land and the proposed development site to Carrigtwohill Bridge and on further downstream under the N25 road embankment and into Slatty Pond.

The following photos give an indication of the general size and nature of the Woodstock Stream through Carrigtwohill.

Figure 2-3: Woodstock Stream - Upper Reach (left) & Middle Reach (right)

2.3.2 Poulaniska Stream

The Poulaniska Stream discharges into a network of underground caves at Cúl Ard housing estate. From its upstream extent the Poulaniska Stream flows in a north south direction to the Bog Road, then flows in a westerly direction along the Bog Road, before turning southward and discharging into the underground caves.

Based on the hydrogeological study, it is assumed that this flow re-emerges further downstream, near Slatty Pond.

The following photos give an indication of the general size and nature of the Poulaniska Stream.

Figure 2-4: Poulaniska Stream - Upper Reach (left) & Lower Reach (right)

2.3.3 Tibbotstown

The Tibbotstown Stream flows through IDA lands to the west of Carrigtwohill centre. It is located beyond the extent of the proposed public realm upgrades, to the west. To facilitate on-going development in the area this stream has been subject to modifications i.e. inclusion of weirs, realignment.

The stream flows from North to South crossing under a local third class road upstream of Gilead. From here the stream flows over 2 stone weirs, under an IDA culvert into a localised deep pond section before discharge into a 3 way flow split structure at the rail line. The flow is directed to a siphon under the rail line to continue downstream in an open channel, to a cascade leading into the

rail diversion channel and the remainder enters the IDA surface water drainage network and then re-emerges in the open channel further downstream.

Additional works undertaken in 2019 as part of the IDA Land Minor Works Scheme, involved the construction of new embankments, enlarged attenuation pond and associated control structures. This includes a 1.5m dia. overflow pipe from the Tibbotstown Stream to attenuation pond constructed as part of the flood alleviation works, a storm water manhole, pipework and outfall to intercept the previous network downstream of the railway line, and replacement of the trash screen on the Tibbotstown Stream.

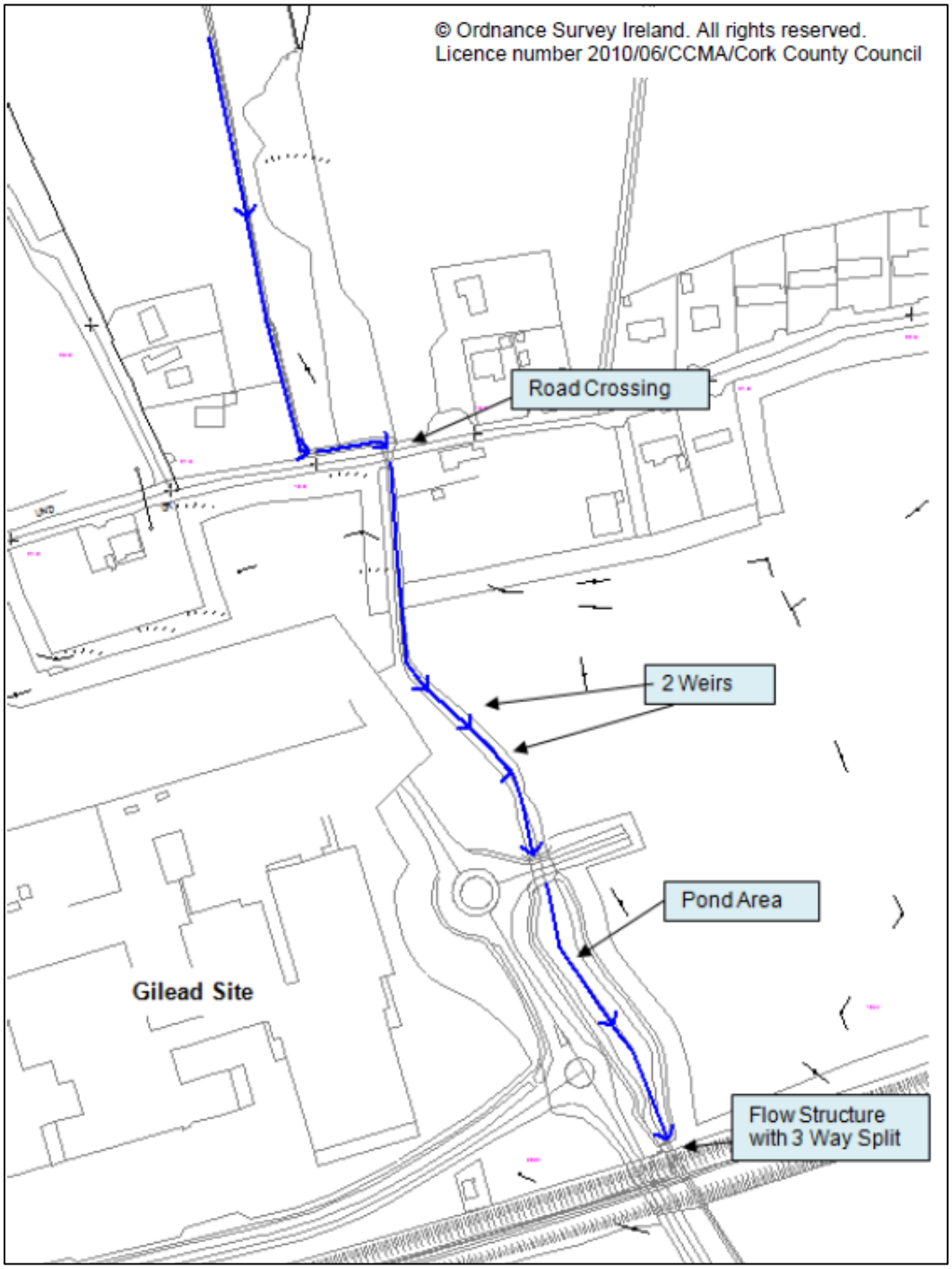


Figure 2-5: Tibbotstown Upper Reach[2]

2.3.4 Slatty Pond

Slatty Pond is located at the southern end of the catchment, as shown in Figure 2-6, being supplied by the Woodstock Stream and other watercourses before draining into Slatty Water. This pond was once part of the larger estuary but since the construction of Slatty Bridge, a large portion of land in the vicinity has been reclaimed for agricultural purposes.

Slatty Pump Station was constructed in recent years to address local concerns about rising water levels in the pond. This pump station pumps water from Slatty Pond to Slatty Water, the tidal estuary downstream of Slatty Bridge. Water also drains by gravity through 5 non-return valves at Slatty Bridge.

2 Source: Carrigtwohill Flood Risk Assessment, 2013

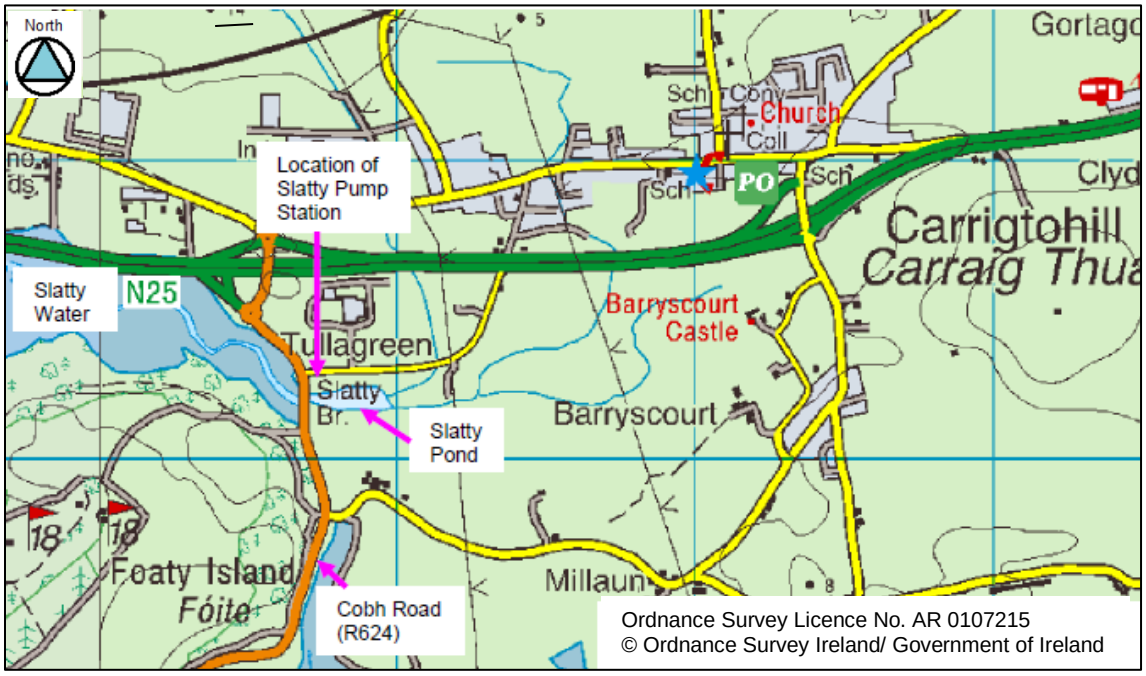


Figure 2-6: Slatty Pond[3]

2.4 Site Geology

The Geological Survey of Ireland (GSI) groundwater and geological data viewer was consulted to review the site and local area. The bedrock predominant in the area of the proposed public realm infrastructure bundle is identified as Waulsortian Limestone and the Ballysteen Formation intersects at the most northern point on Station Road. The subsoils (as identified by the GSI) along the area of the proposed development are identified predominantly as deep well drained mineral soils. In relation to Quaternary sediments, an area of made ground intersects the public realm along Main Street, refer to Figure 2-7. Alluvium sediments border the proposed development on the eastern boundary which would indicate historic flooding in the absence of other records.

The groundwater vulnerability across the proposed development ranges from 'Medium' to 'Bedrock at surface.' This classification is due to the proximity of the bedrock to the surface. At the site location itself the bedrock is not exposed; it is covered by predominantly hardstanding area which has a low permeability. The GSI data viewer identifies three caves and a swallow hole within the Carrigtwohill area.

3 Source: Carrigtwohill Flood Risk Assessment, 2013

Figure 2-7: Quaternary Sediments

3 Flood Risk Identification

To begin the process, an assessment of the potential and scale of flood risk at the site is conducted using existing and historical information. This identifies 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. Further detail on the Planning Guidelines and technical concepts is provided in Appendix A.

3.1 Flood History

A number of sources of flood information were reviewed to establish any recorded flood history at, or near the site. This includes the OPW's website, www.floodinfo.ie and anecdotal evidence collated during a previous FRA study in Carrigtwohill in 2013.

3.1.1 Floodinfo.ie

The OPW host a national flood hazard mapping database that is now incorporated into www.floodinfo.ie, which highlights areas at risk of flooding through the collection of recorded data and observed flood events. There are two recurring flood events identified in the vicinity of Carrigtwohill. Both of these relate to the Turlough located in Ballyadam, 2km northeast of the proposed development area. This is related to groundwater flooding and links in with the findings of the hydrogeological assessment undertaken as part of the Carrigtohill FRA 2013. It is important to note however that other instances of flooding may have occurred in the past in the locality as the website depends on information being supplied to the OPW for inclusion.

3.1.2 Anecdotal Evidence

3.1.2.1 Carrigtwohill FRA, 2013

As part of an FRA carried out in Carrigtwohill in 2013, anecdotal evidence was collated from a number of local stakeholders including the community council, local landowners, IDA, Irish Rail and local authority personnel. A public consultation day was also held, to allow the general public highlight particular areas of concern in relation to flooding. Information collated from this process that is relevant to the proposed site is summarised in Figure 3-1. This indicates that there is a history of flooding in Carrigtwohill. Flooding has been reported to occur in the past as a result of blockage at culverts i.e. on Bog Road and N25.

The Community Council highlighted concerns regarding flooding at Castlelake. Castlelake lies to the north of the proposed upgrades on west Main Street and this area suffered severe flooding in 2009. This flooding was thought to have been exacerbated due to the installation of a temporary small culvert during construction.

The anecdotal evidence was found to correlate well with the predictive flood mapping produced as part of the Carrigtwohill FRA 2013.

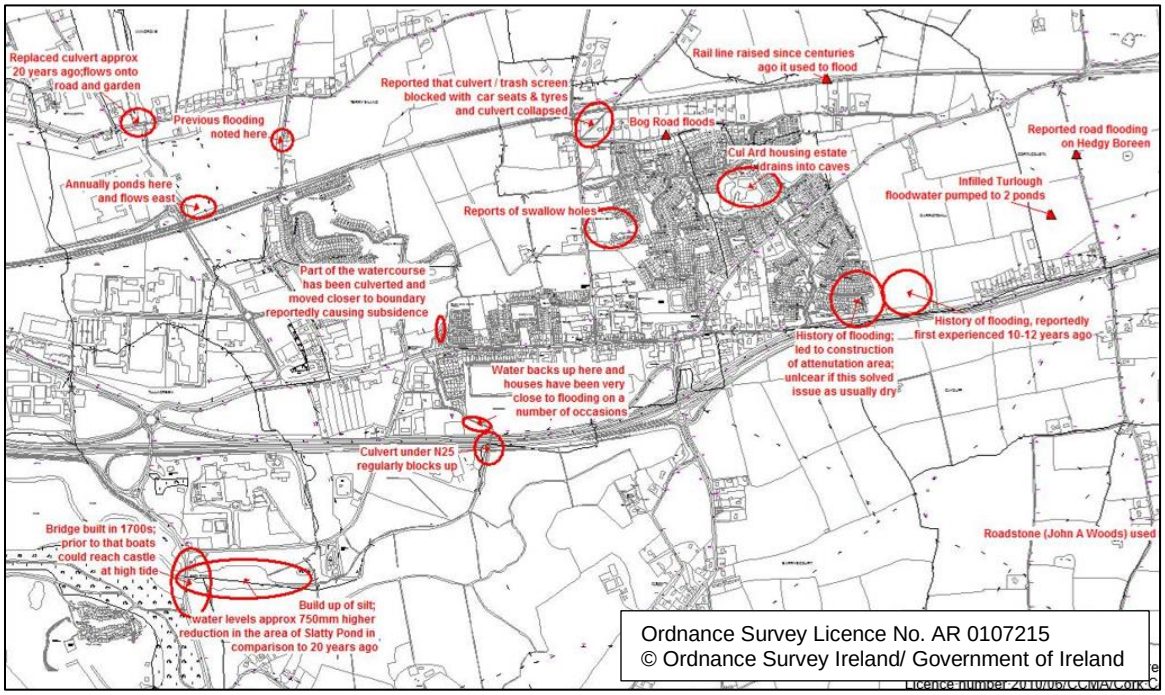


Figure 3-1: Summary of Anecdotal Evidence (Source: Cork County Council)

3.1.2.2 Local Residents

A video was provided by local residents, whose property is traversed by the Woodstock Stream, north of the railway line. The video shows flood waters flowing along the Leamlara road after the Woodstock burst its banks. The video was taken in October 2019 and they indicated that this was not the first time this has occurred. Figure 3-2 below shows the location of where the video was taken and also a screenshot of the flooding shown in the video.

Figure 3-2: Video showing Woodstock Flooding

3.1.3 Internet Searches

An internet search was conducted to gather information about whether the area had been flooded previously. There were no explicit mentions of properties within Carrigtwohill being flooded however there were records of road closures around the Carrigtwohill area found for various events.

3.1.4 Cobh Municipal District Local Area Plan

The Carrigtwohill area is encompassed by the Cobh Municipal District Local Area Plan (LAP) that was adopted in July 2017. It is noted that this LAP remained 'in force until December 2020', but an updated version has not yet been released. The aim of the LAP is to inform development within the municipal district. As part of the LAP process flood mapping was produced to highlight areas at risk of inundation to help determine land zoning. The Carrigtwohill Local Area Plan map is show in Figure 3-3 below. The proposed development transverses a number of zones; Town Centre, Enterprise, Utility, Business and Community.

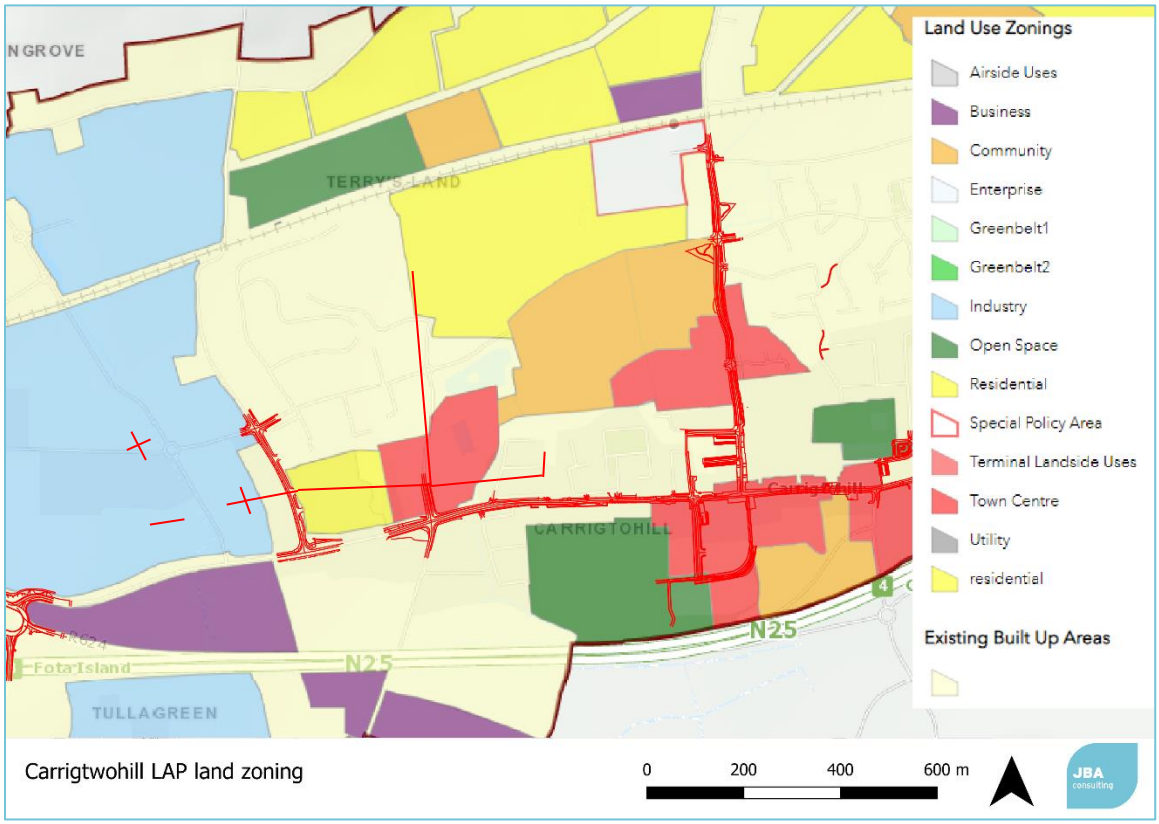


Figure 3-3: Carrigtwohill LAP land zoning

3.2 Predictive Flooding

The area has been subject to one predictive flood mapping/modelling study.

3.2.1 Cobh Municipal District Local Area Plan (2017)

Cork County Council appointed JBA Consulting to undertake a flood risk assessment study at Carrigtwohill, Co. Cork, in January 2012. The results of that study were used in the Cobh Municipal District LAP (2017). The JBA study follows on from the recommendations in the Lee Catchment Flood Risk Assessment and Management Study (CFRAMS) that a more detailed assessment of flood risk in Carrigtwohill is warranted "due to the nature of the watercourses, on-going development and work recently undertaken by Cork County Council.'' The following watercourses were modelled as part of the 2012 study;

- Killacloyne Stream
- Tibbotstown Stream
- Woodstock Stream
- Poulaniska Stream

Figure 3-4 identifies the areas at risk of flooding. The proposed development area is shown to traverse Flood Zone A north on Station Road and Flood Zone B west on Main Street.

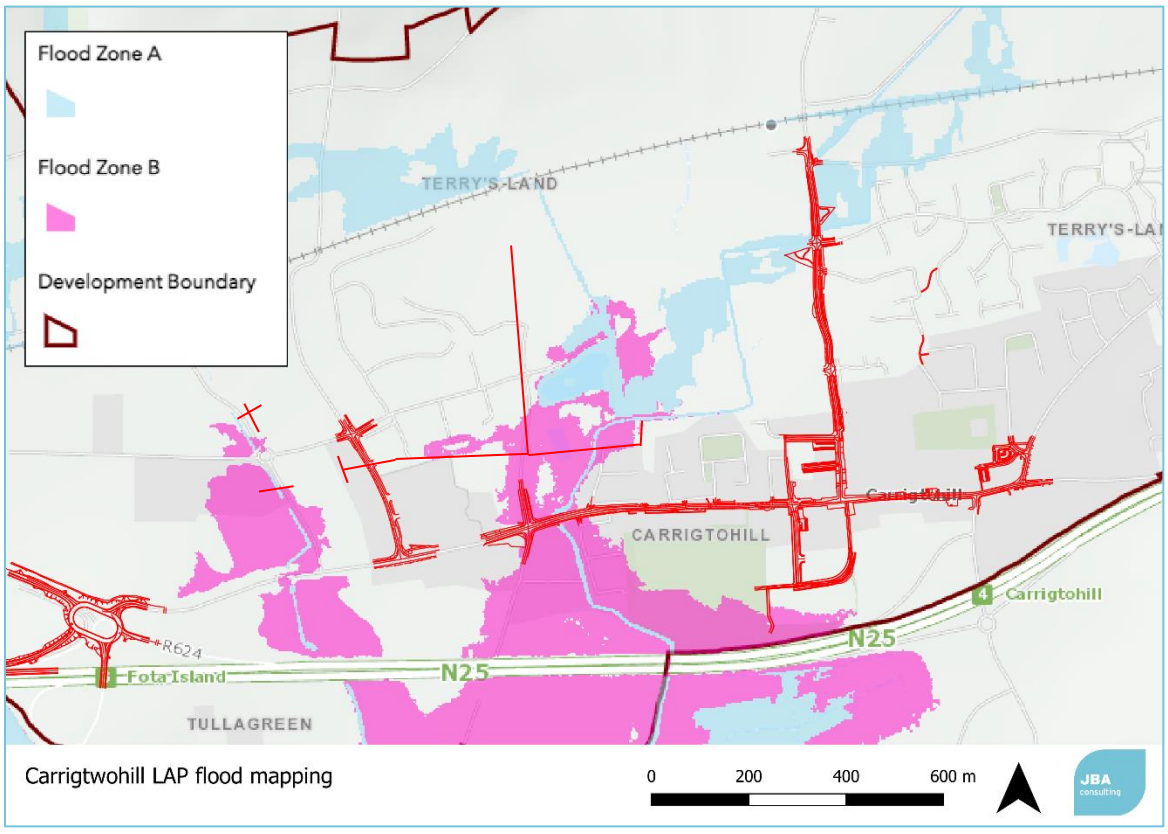


Figure 3-4: LAP Flood Zones

3.2.2 Carrigtwohill Flood Relief Scheme

The preparatory work was originally commissioned in 2010 and the Carrigtwohill Flood Mitigation Scheme was completed in Autumn 2019. The works were undertaken at the IDA business park lands in Carrigtwohill.

The scheme involved the construction of new embankments on the Tibbotstown Stream north of the railway line, an enlarged attenuation pond and associated control structures, a 1.5m diameter overflow pipe from the Tibbotstown Stream to new attenuation pond, a storm water manhole, pipework and outfall to intercept the previous network downstream of railway line, and replacement of the trash screen on the Tibbotstown Stream.

JBA Consulting was appointed to undertaken hydraulic modelling of the scheme. The resulting flood map is presented in Figure 3-5.

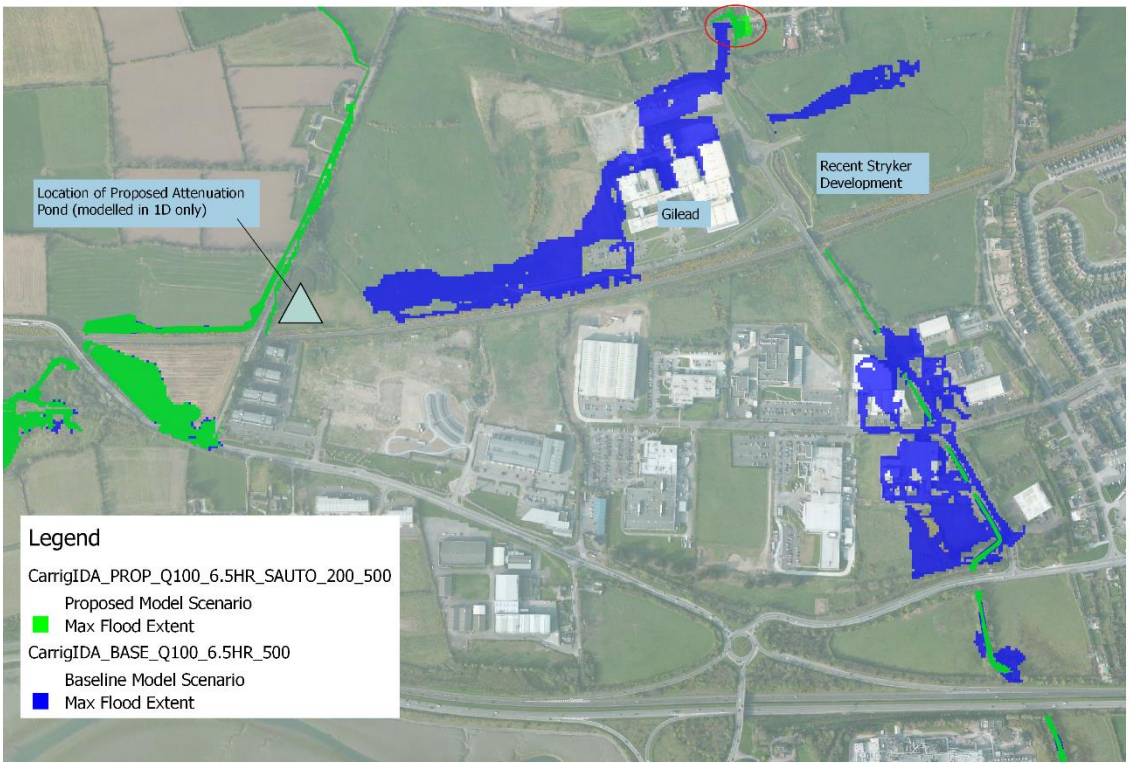


Figure 3-5: Pre & Post Scheme Flood Maps

3.2.3 Carrigtwohill Local Area Plan FRA 2012

JBA undertook a Flood Risk Assessment for the Carrigtwohill area in 2012. The aim of the study was to confirm the flood risk from the main watercourses in Carrigtwohill. Extensive hydraulic modelling was undertaken as part of the study and the resulting flood maps have been utilised in the Cobh Municipal District Local Area Plan (2017).

3.3 Flood Sources

The potential flood sources in the wider Carrigtwohill area include fluvial, tidal, pluvial (surface water), and groundwater flooding.

3.3.1 Fluvial

A number of sources were investigated to identify the occurrence of historic flooding within the site and surrounding area. No specific flood incidence was noted within the site boundary, however some anecdotal evidence regarding flood risk was provided in the surrounding area.

The main source of flood risk is provided from the Carrigtwohill Flood Risk Assessment completed by JBA in 2013 as part of the Carrigtwohill LAP. The Carrigtwohill FRA involved a detailed assessment of the watercourses that flow through Carrigtwohill including Slatty Pond and its pump station at the downstream extent.

Review of the flood maps produced as part of the Carrigtwohill FRA confirm that sections of the public realm are located in Flood Zone A north on Station Road and in Flood Zone B west on Main Street. The source of the flooding is the Woodstock Stream.

To fully assess the fluvial risk in the region of the upgrades work, a hydraulic model was developed. This is discussed in detail in Section 4.

3.3.2 Tidal

The area of interest is a sufficient distance from the tidal downstream boundary. Therefore, tidal flooding has been screened out at this stage.

3.3.3 Pluvial/ Surface Water

Pluvial, or surface water, flooding is the result of rainfall-generated flows that arise before run-off can enter a watercourse or sewer. It is usually associated with high intensity rainfall. Flood risk from pluvial sources exists in all areas.

To fully assess the pluvial risk in the region of the proposed development, a rain on grid model was developed. This model was developed to provide indicative flow paths in the area but can also be used to highlight areas of potential pluvial flooding and also provide indicative flood depths. This is discussed in detail in Section 4.

3.3.4 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 vulnerability in the area of the proposed development is classified as 'Medium' to 'Bedrock at surface'. Mitigation measures to reduce the groundwater risk are discussed in Section 5.2 below.

4 Flood Model Assessment

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 Poulinska 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. Table 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.

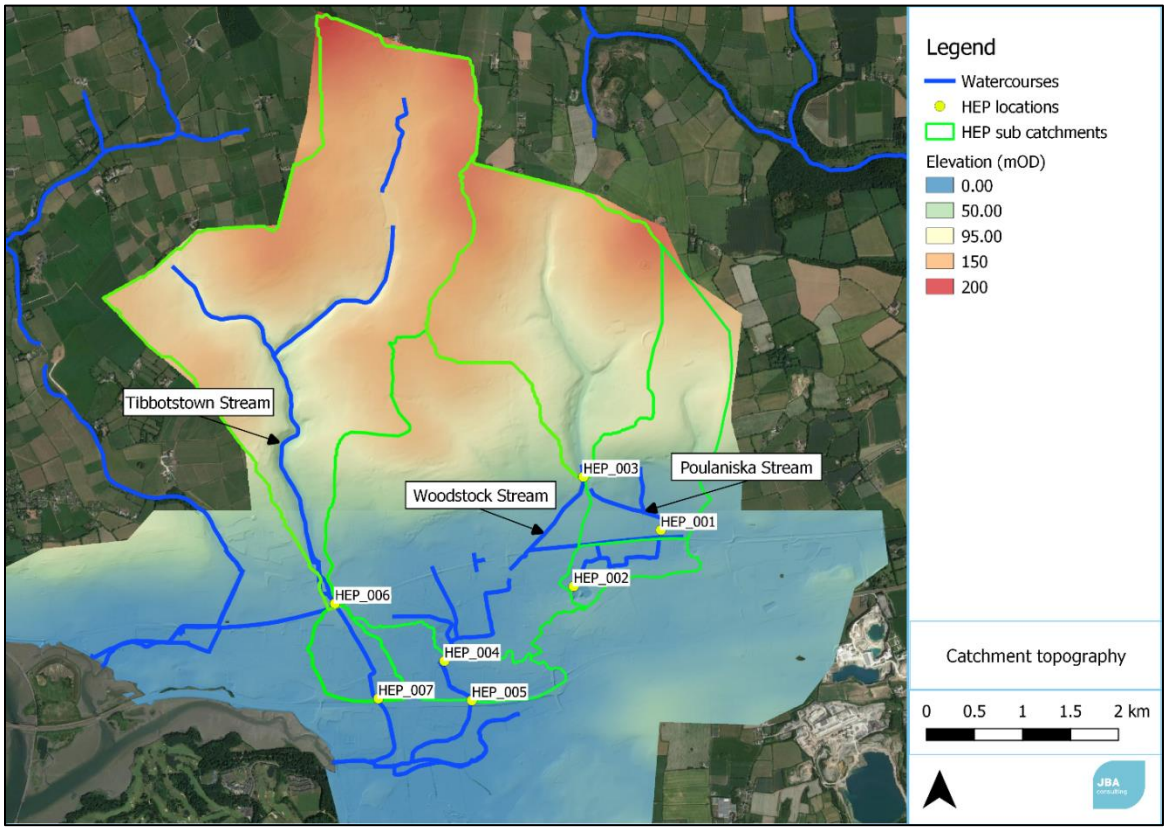


Figure 4-1: Catchments and HEPs

Table 4-1: Peak 1%AEP inflows for the three watercourse

Method	1%AEP flow (m^3/s)
Tibbotstown (HEP_006+HEP_007)	2.56
Woodstock (HEP_003+HEP_004+HEP_005)	5.07
Poulinska (HEP_001+HEP_002)	1.21

4.2 Hydraulic Model Set-Up

Due to the identified flood risk within the area, it was necessary to develop a hydraulic model to further define the fluvial flood risk to the proposed development. The model used to appraise the flood risk has been developed from the Carrigtwohill Flood Risk Assessment completed by JBA in 2013 on behalf of Cork County Council and OPW.

The hydraulic model was developed in Tuflow-Estry and used topographic river survey data acquired as part of the study. A rain-on-grid model was used to provide indicative flow routes in the area. The results of this model are also used to highlight low-lying areas along the public realm upgrade area which would be prone to pluvial flooding and also provide indicative pluvial flood depths in these areas.

4.3 Model Results

4.3.1 Fluvial Results

The results from the fluvial scenario are shown in Figure 4-2. It shows the fluvial flood extents from both the 1% and 0.1% AEP events. Figure 4-3 shows a more detailed view of the Woodstock flood extents, respectively (as outlined in Figure 4-2).

The northern section of the proposed development, south of the railway station, is identified as traversing both Flood Zone A and B. This is an overland flow route from the Woodstock Stream. Flows overtop the left bank of the stream in a field centre northeast of the proposed development (Point A in Figure 4-3). A second overtopping point occurs further downstream in the same field (Point B). The overland flows from this field overtop the railway line, where they flow southwest towards Station Road. The section south of the railway line is identified as being at risk from the 1% and 0.1% AEP events (Point C).

It should be noted that the presented flood extents represent the 'existing' scenario within Carrigtwohill and the flood extents are not the result of the proposed Public Realm Instructure works.

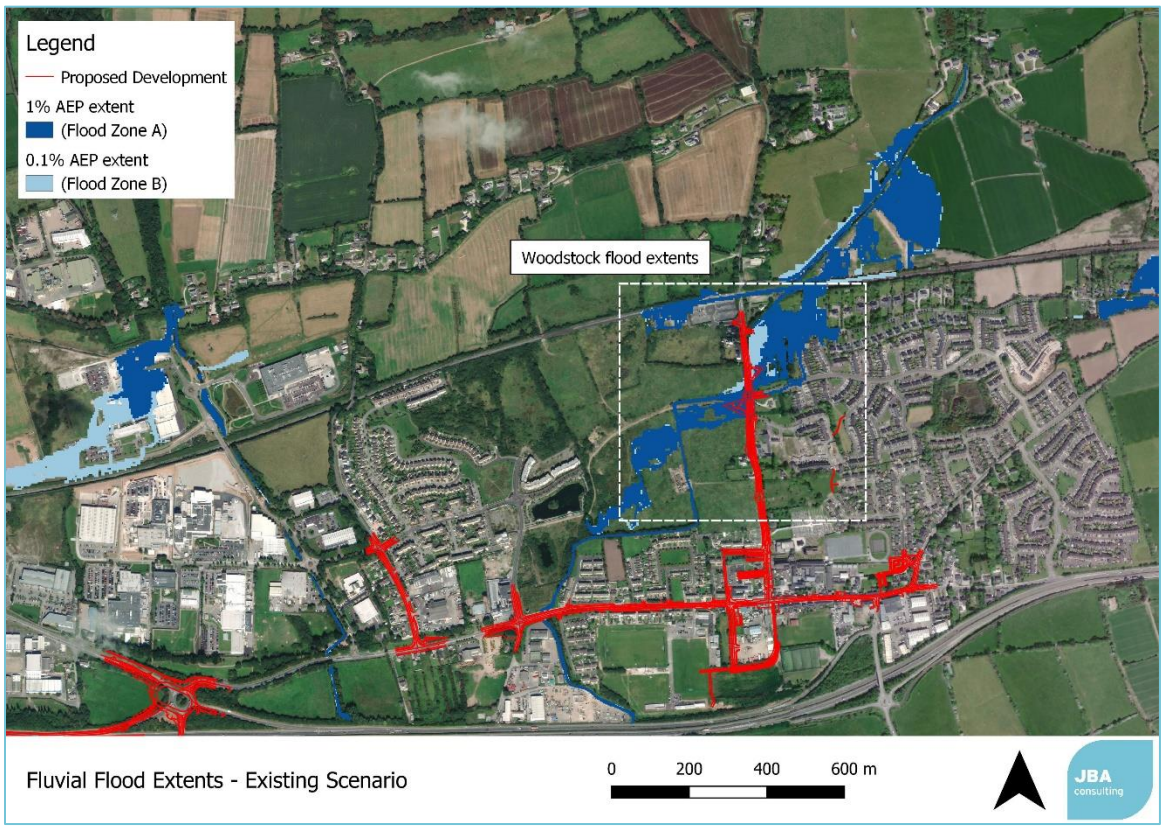


Figure 4-2: Fluvial Flood - Existing Scenario

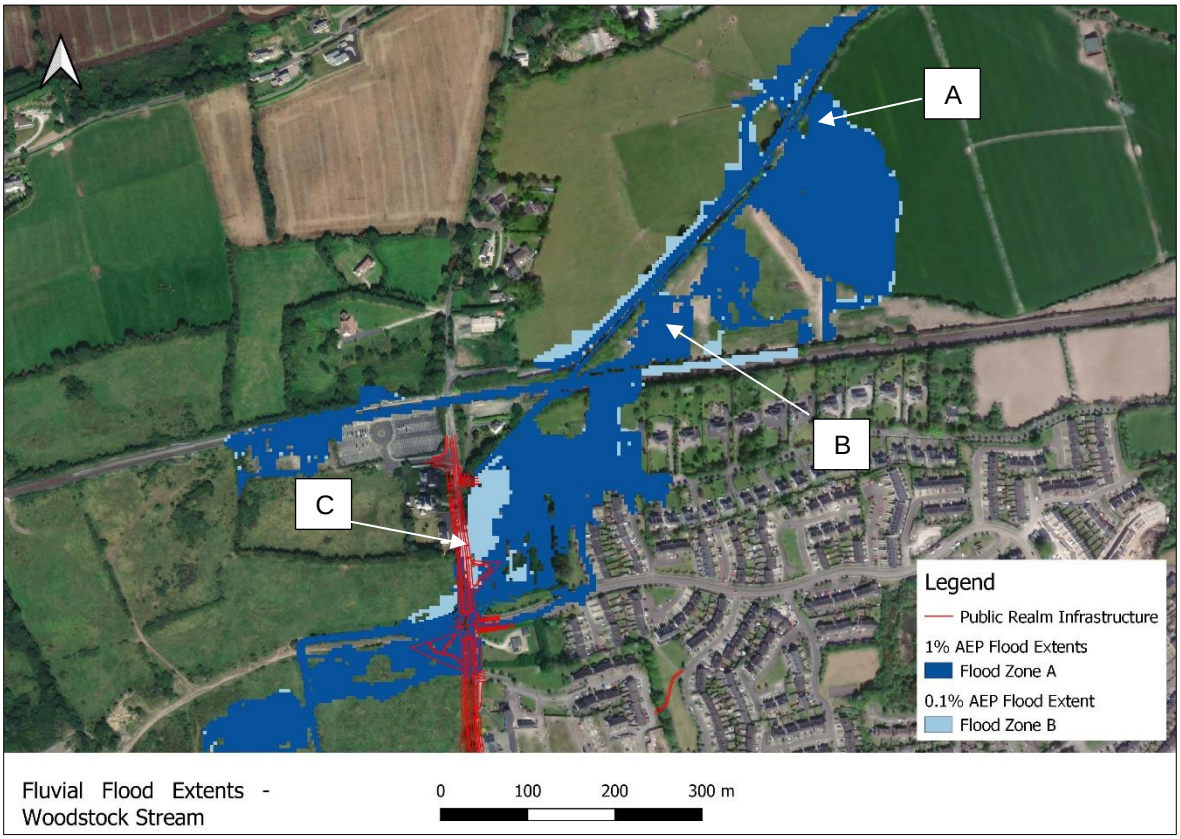


Figure 4-3: Woodstock Fluvial Flood Extents

4.3.2 Pluvial Flood Extents

The results from the pluvial scenario are shown in Figure 4-4. It shows the pluvial flood extents from the 1% AEP event. Peak flood depths occur along the section of Station Road included in the proposed development south of the railway station (Point A). Figure 4-5 provides greater detail of the pluvial flood extents south of the railway station section. Peak depths here are indicated as reaching approx. 500mm.

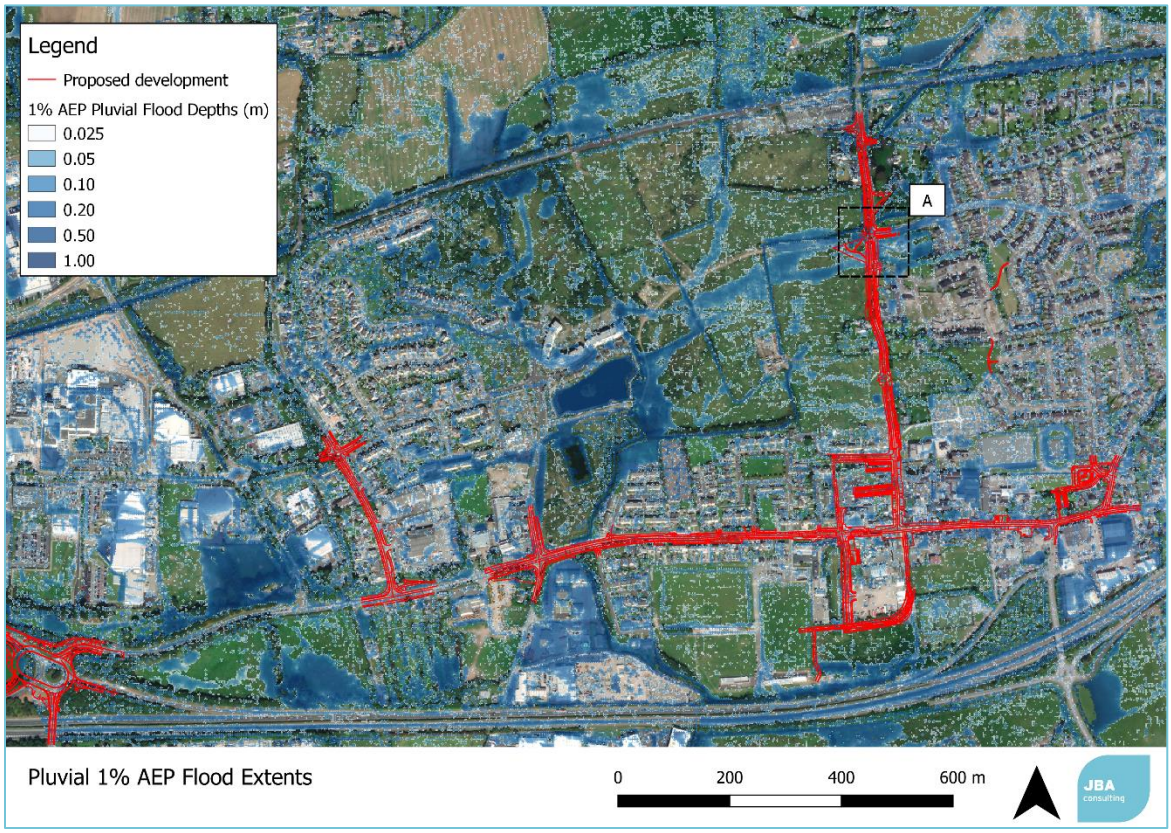


Figure 4-4: Pluvial Flood Extents

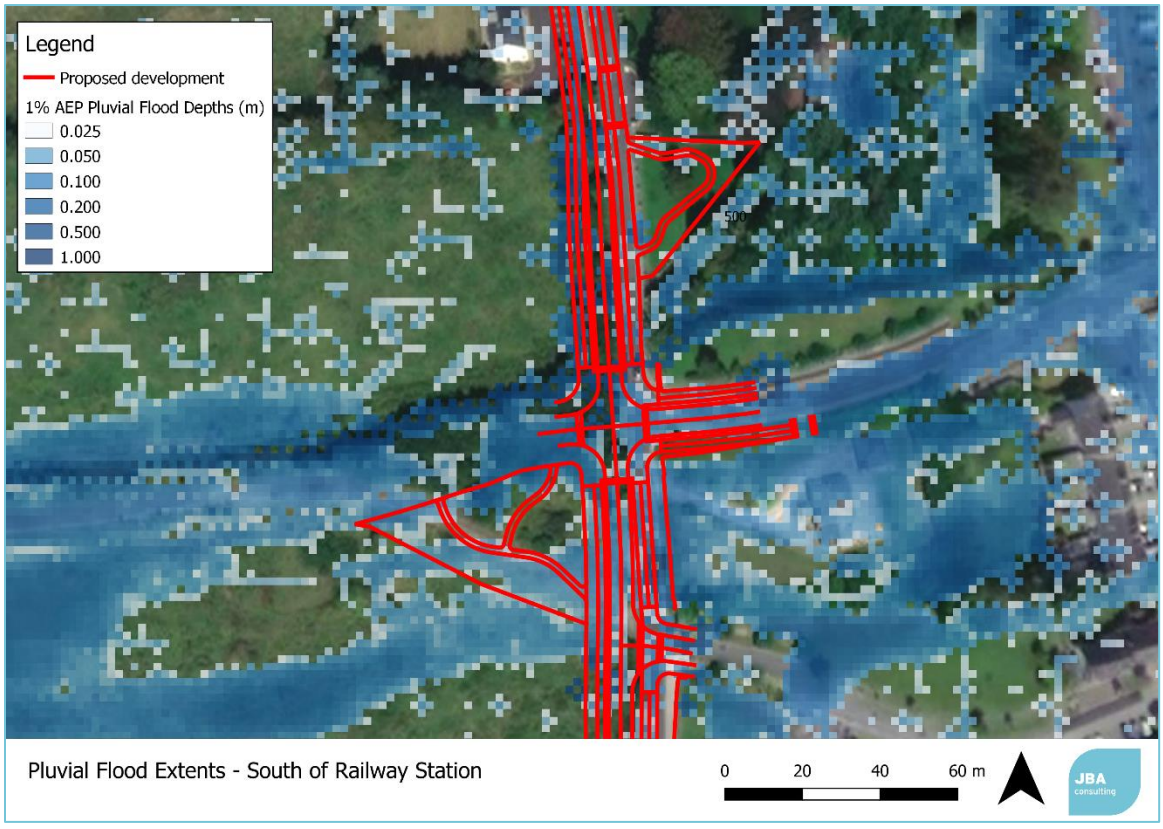


Figure 4-5: Pluvial Flood Extents - South of railway station (zoom A)

5 Flood Risk Assessment

5.1 Flood Risk

A section of Station Road, south of Carrigtwohill Train Station, which is to be upgraded as part of the proposed development is identified as being at risk of flooding from both fluvial and pluvial sources. The proposed upgrade in this area traverses Flood Zone A of the Woodstock Stream along the northern part of Station Road. There is also a risk of pluvial flooding in this area.

With reference to the Flood Risk Management Guidelines (2009) and particularly Table 3.1, the proposed development is considered less vulnerable development. However, as Flood Zone A does traverse a section of the upgrade works along Station Road, a Justification Test will need to be applied (refer to Section 6).

5.2 Mitigation

Following review of the predictive flood maps, Station Road has been identified as the only area of the proposed development at risk of inundation. Specific mitigation measures have been outlined in Section 5.2.1.

5.2.1 Station Road

Station Road has been identified as an area at risk of flooding from the 1% AEP and 0.1% AEP events. Various measures have been investigated to manage the flood risk along Station Road, and are as follows:

- Do Nothing
- Flood Relief Culverts
- Upgrade of Existing Woodstock Culvert
- Raising of Station Road

5.2.1.1 Do Nothing Approach

A section of Station Road to the south of Carrigtwohill Railway Station has been identified at being at risk of inundation due to the undersized culvert along the Woodstock Stream. Given the significant investment in undertaking the proposed development, it would be advantageous to use the Public Realm Infrastructure development to minimise the flood risk to this section of Station Road and where possible remove the road from the 1% AEP flood event. This can be achieved by increasing the flow capacity of the Woodstock Stream by various measures outlined in the following sections.

The possible impact is an increase in flows downstream of Station Road and resulting increase in flood risk. Consideration also needs to be given the proposed school development downstream of Station Road and the associated mitigation measures. Retaining the existing culvert setup presents an ongoing flood risk to Station Road from extreme flows, blockage and collapse.

The ideal approach is to remove the flood risk to Station Road while also to minimise the impact downstream. This is the aim of the measures outlined in the following sections.

5.2.1.2 Option 1: Flood Relief Culverts

Under this scenario the existing culvert along the Woodstock will be retained. It is proposed that the overland flows will be captured by drainage channels on the eastern side of Station Road that will convey the floodwaters to new culverts under the road and back into the Woodstock Stream, refer to Figure 5-1. This option also involves raising of a section of Station Road by approximately 700mm. Additional drainage channels may be required on the western side of Station Road to divert the flood waters back in channel.

The works will significantly reduce the 1% AEP and the 0.1% AEP flood extent along Station Road. Some flows during the flood events flow along the Parochial house access road and will discharge directly onto Station Road and by-passes the mitigation measures.

The proposals are cost-effective but long-term maintenance measures will be required to minimise the risk of blockage.

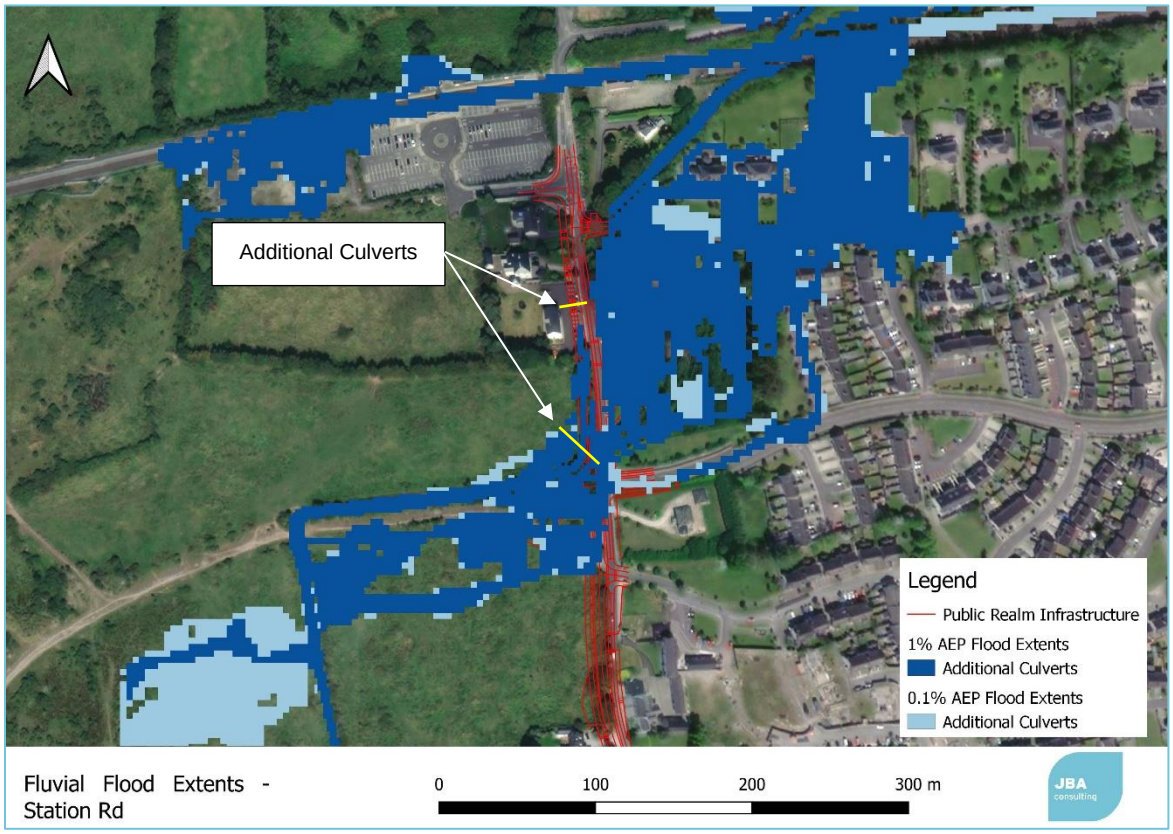


Figure 5-1: Option 1 -Additional Culverts

5.2.1.3 Option 2: Woodstock Culvert Replacement

A direct and long-term measure would be the construction of a replacement Woodstock culvert under Station Road. There have been historic issues with this culvert system which has collapsed and repair works were undertaken. A section of the culvert was replaced. Therefore, the current setup comprises difference culvert types and dimensions,

A proposal to upgrade this culvert to convey flows up to the 1% AEP event is the most direct method to manage the flood risk along Station Road. This will also significantly reduce the risk of collapse when compared to the existing culvert construction.

The proposals also included the widening of the Woodbrook Stream downstream of station road and slight lowering of the bed at the culvert outlet.

As a completely new culvert will be required, it may be necessary to submit a Section 50 application to the OPW. A Section 50 application is required for all new culvert/bridge structures across an existing watercourse. To meet the Section 50 specifications, a culvert with the approx. dimensions of 3.3m*1m would be required. It would be very difficult if not impossible to install a culvert of this size due to the physical site constraints along the route. Further analysis confirms that a 1.2m*0.75m or 1.5m*0.75m culvert can convey the predicted 0.1% AEP event. The larger sized culvert is preferred, however it is acknowledged that it may not be feasible to install a 1.5m wide culvert at this location. The results presented in in the FRA are based on the 1.5m*0.75m culvert, however the 1.2m*0.75m culvert can be installed without any significant impact on flood risk/ levels along Station Road.

The proposed upgrade of the Woodstock culvert will completely remove Station Road and lands directly upstream from the 1% AEP flood event. As with the flood relief culverts, the 0.1% AEP flood extents are significantly reduced with only minor inundation during the 0.1% AEP event via the pathway from the Parodical house.

The upgrade of the Woodstock culvert is the preferred option to manage the flood risk to Station Road. Additional assessment has been undertaken on the potential impact downstream. This assessment includes the current condition downstream and with the proposed school development (Planning Ref:19/05707) mitigation measures just downstream of Station Road.

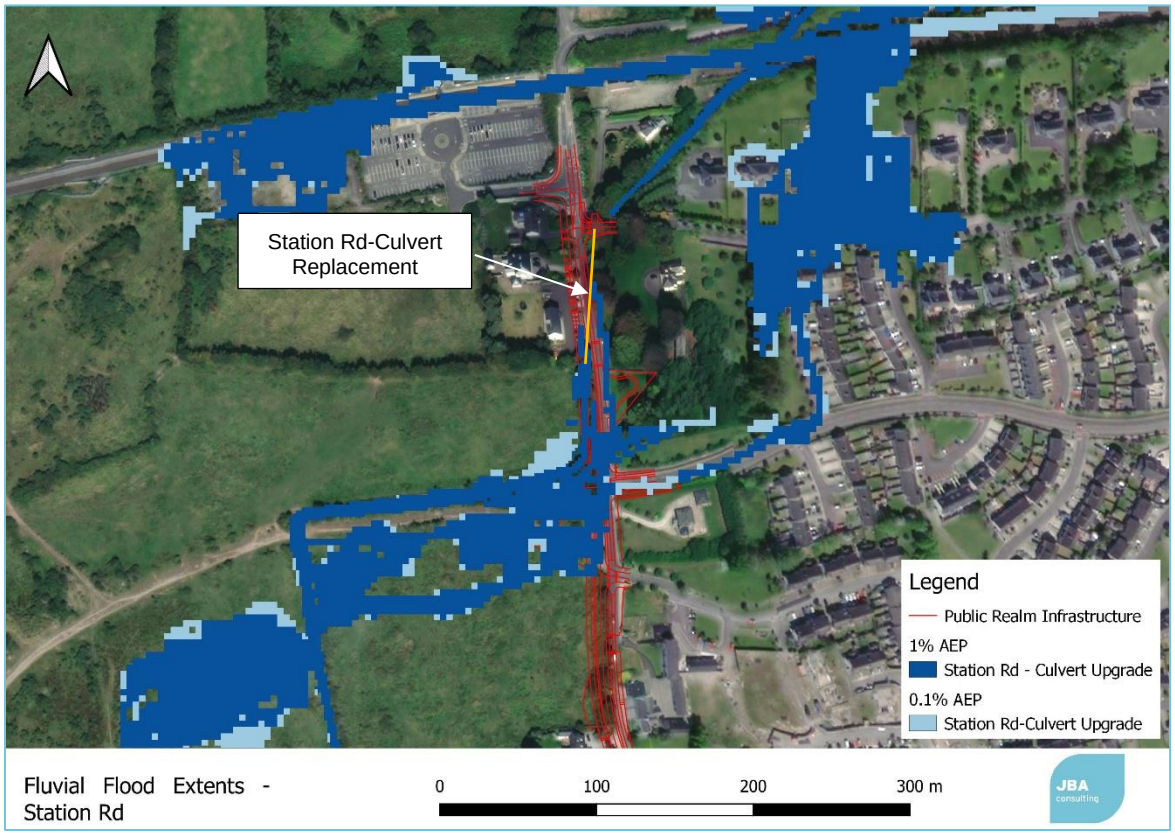


Figure 5-2: Option 2 -Station Rd-Culvert Upgrade

5.2.1.4 Impacts

A number of nodes downstream of the site have been selected to assess the potential impact of the mitigation measures, Option 1 and Option 2. The impact on levels during the 1% AEP event is presented in Table 5-2 and the 0.1% AEP impacts are presented in Table 5-2. The monitoring point locations are presented in Figure 5-3.

With reference to Option 1, the additional overflow culverts, there is a reduction at all monitoring points for the 1% and 0.1% AEP flood events. This is likely due to the attenuation effects of the land drains and culverts east of Station Road.

With reference to Option 2, there is an increase in levels downstream during both the 1% AEP and 0.1% AEP events. The impact/increase varies from 0.01-0.02m for the 1% AEP event and 0.1% AEP events. It should be noted that no bank overtopping occurs downstream of the site.

An additional assessment has been undertaken taking into consideration of the proposed school mitigation measures. The results confirm that there is no impact on the effectiveness of the school mitigation measure. The school will remain protected from both the 1% AEP and 0.1% AEP flood events. All floodwaters will remain in bank.

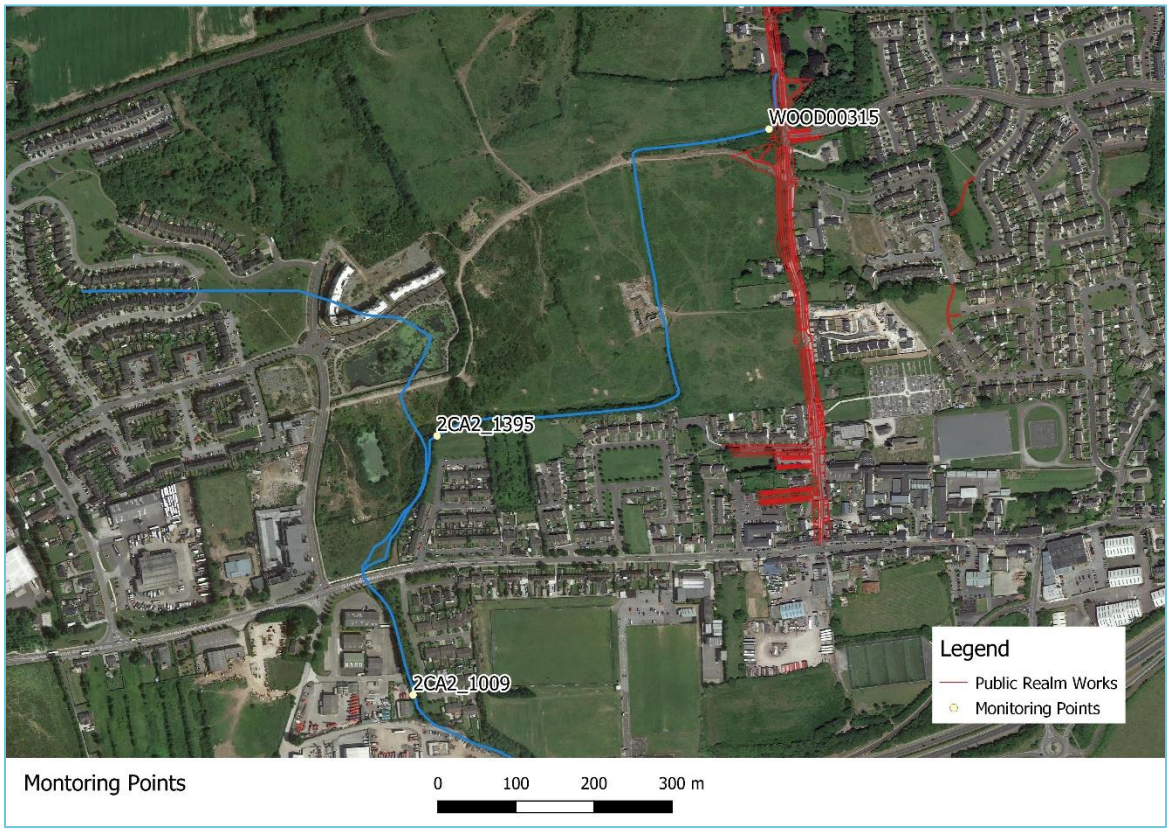


Figure 5-3: Monitoring Points

Table 5-1: 1% AEP-Flood Level Impact

Node	Q100 Existing (mOD)	Q100 Option 1 (mOD)	Option 1 Impact (m)	Q100 Option 2 (mOD)	Option 2 Impact (m)
WOOD00315	6.11	6.10	-0.01	6.12	0.01
2CA2_1395	1.35	1.29	-0.06	1.33	-0.02
2CA2_1009	0.86	0.80	-0.06	0.83	-0.03

Table 5-2: 0.1% AEP-Flood Level Impact

	Q1000 Existing (mOD)	Q1000 Option 1	Option1 Impact (m)	Q1000 Option 2	Option 2 Impact (m)
WOOD00315	6.12	6.12	0.00	6.13	0.01
2CA2_1395	1.36	1.36	0.00	1.38	0.02
2CA2_1009	0.89	0.88	-0.01	0.90	0.01

5.2.2 Wider Public Realm Area

As displayed in Figure 1-1, the scale of the works encompasses areas in Main Street, Carrigane Road, Wises Road and the N25 junction 3 and lands adjoining these locations. It is recommended that the existing levels be maintained where possible to preserve the existing flow pathways during a flood event.

5.2.3 Stormwater Design

As part of the Public Realm Infrastructure Bundle, the existing stormwater system will be upgraded to connect the road infrastructure to the public stormwater system in Carrigtwohill. The aim of the scheme is to improve on the existing stormwater system and reduce the risk of pluvial flooding.

6 The Justification Test for Development Management

6.1 Strategy

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 Justification Test for the development has been undertaken to demonstrate the development satisfies the planning Guidelines. The lands within Flood Zone A/B are classified as local transport infrastructure and is considered less vulnerable as indicated in Table 3.1 of "The Planning System and Flood Risk Management".

Under the Local Area Plan, the site traverses a number of land's zoned such as Town Centre, Enterprise, Utility, Business and Community. The Town Centre has an objective "To Expand a town centre in line with overall uses acceptable in town centre areas and providing for improved connectivity and public realm spaces".

The specific aim of the development design is to place less vulnerable development outside of Flood Zone A. 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 Cobh Municipal District Local Area Plan 2017, the upgrade traverses the zone 'Town Centre and Community'. As stated above it is considered that the proposed upgrade complies with the landuse zoning. The works will primarily be undertaken on existing road infrastructure.

Conclusion: It has been outlined that the proposed development which comprises an upgrade to the public realm complies with the Town Centre land use zoning.

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;

A detailed hydraulic model has been undertaken as part of the assessment of flood risk. The majority of the works involve resurfacing/widening of existing road infrastructure. Where possible, a stormwater system will be included to manage surface water flows. At Station Road, an existing culvert along the Woodstock Stream is undersized and results in flooding at the inlet that subsequently inundates Station Road. It is proposed to upgrade this culvert to convey flows up to the 0.1% AEP event. This will lower the flood risk to Station Road and reduce the risk of blockage/collapse of the culvert system.

The upgrade results in a minor increase in flood levels downstream but flows remain in bank and therefore it does not present a flood risk to lands downstream of the Station Road. Further assessment has been undertaken on the school development and associated mitigation measures downstream of Station Road. The results confirm that the school remains protected from inundation for all modelled flood events.

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

The aim of the works is to remain neutral regarding flood risk. Where possible a stormwater system will be incorporated to manage surface water. Furthermore, the proposed upgrade of the culvert at Station Road, along the Woodstock Stream will minimise the flood risk to Station Road.

(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 upgrade works for the Station Road culvert system will minimise the risk of blockage and collapse in comparison to the existing system.

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

Refer to the supporting planning application documents for the wider planning objectives.

7 Conclusion

JBA Consulting has undertaken a detailed Flood Risk Assessment for the Carrigtwohill URDF Initiative - Public Realm Infrastructure Bundle at Carrigtwohill, Co. Cork.

The Flood Risk Assessment was undertaken in accordance with 'The Planning System and Flood Risk Management' guidelines and confirms that the development is in agreement with the core principles contained within.

Based on historic data and predictive mapping, areas within Carrigtwohill have been identified as at risk of flooding during a 1% AEP and 0.1% AEP flood event.

From reviewing the available sources of flooding, a section of the proposed development is located in Flood Zone A & B along Station Road. Ideally, road infrastructure would be located in Flood Zone B or C. Therefore, an aim of the Public Realm Works is to remove sections of the road network from Flood Zone A. Various mitigation measures have been reviewed and assessed to alleviate the flood risk to Station Road post development. The existing flood risk is caused by an undersized culvert along the Woodstock Stream.

Two mitigation options have been assessed, Option 1 involves the installation of overflow culverts to intercept the overland flood flows across Station Road. Land drains will intercept the floodwaters and divert flows to two proposed culverts under Station Road. The culverts will discharge the flood waters directly or via lands on the western side back into the Woodstock Stream. Review of the results show a significant reduction in flood extents across Station Road for the 1% and 0.1% AEP flood events. Long-term, the operation effectiveness of Option 1 is dependent on maintenance measures to minimise the risk of blockage during a flood event.

Downstream of the site, there is a reduction of flood levels within the Woodstock due to the attenuation effects of the land drains and culverts.

Option 2, is the complete removal and replacement of the Woodstock culvert to ensure it has the capacity to convey flows up to the 0.1% AEP flood event. The works will also minimise the risk of blockage and collapse of the culvert in the long term. Review of the results confirm that the upgrade works will completely remove the risk of bank overtopping upstream of the culvert upstream of Station Road. The flood risk from the 1% AEP event and 0.1% AEP event are significantly reduced.

Downstream of the site, due to the increased conveyance of the culvert flood levels do show a minor increase but remain in bank. Furthermore, an assessment has been undertaken on the proposed school development (Ref: 19/05707) and mitigation measures to ensure that they are not negatively impacted. Review of the results confirm that the mitigation within the school development will continue to prevent inundation during a 1% and 0.1% AEP event.

Based on the analysis, Option 2 is the preferred method to manage flood risk along Station Road.

Considering the wider Public Realm development, the proposed works are within Flood Zone C. To ensure no increased risk of pluvial flooding, it is recommended that all existing levels are maintained where possible so as not to impact on potential flow pathways.

A stormwater system will be incorporated within the proposed development to manage surface water flows. This will ensure that the works will not negatively impact on potential pluvial flooding across the scheme area.

The Flood Risk Assessment was undertaken in accordance with 'The Planning System and Flood Risk Management' guidelines and confirms that the development is in agreement 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:

Flood Risk = Probability of Flooding x 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 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

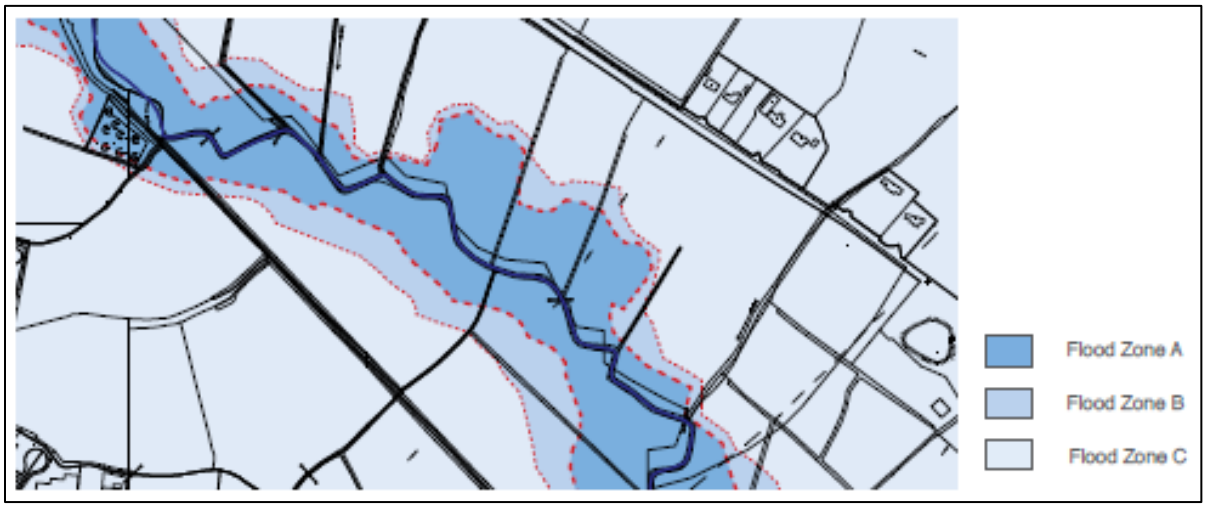
Return period (years)	Annual exceedance probability (%)
2	50
10	10
50	2
100	1
200	0.5
1000	0.1

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

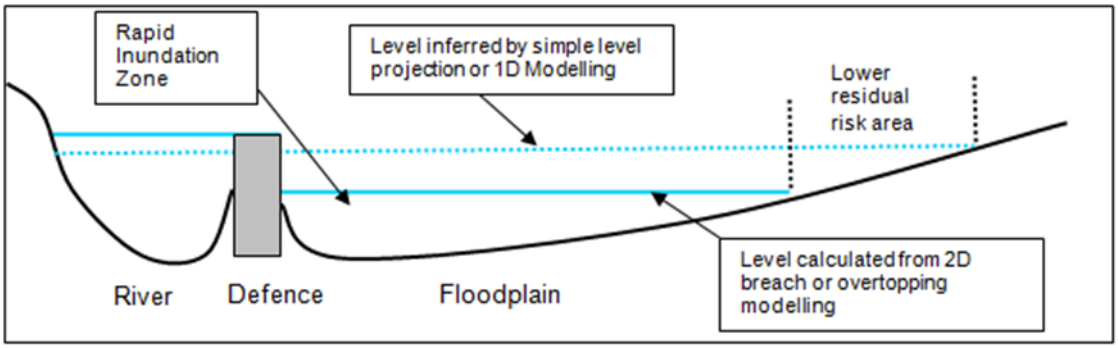
Consequences of flooding depend on the Hazards caused by flooding (depth of water, speed of flow. Rate of onset, duration, wave-action effects, water quality) and the vulnerability of receptors (type of development, nature, e.g. age-structure of the population, presence and reliability of mitigation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

The 'Planning System and Flood Risk Management' provides three vulnerability categories, based on type of development, nature, which are detailed in 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.

A.4 Residual Risk

The presence of flood defences, by their very nature, hinder the movement of flood water across the floodplain and prevent flooding unless river levels rise above the defence crest level or a breach occurs. This known as residual risk:



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