Flood Risk Assessment Report

Cherrywood, Co. Dublin

Dún Laoghaire Rathdown County Council

February 2022

Quality information

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Revision History

Revision	Revision date	Details	Authorized	Name	Position
V1.0	20/11/2020	First Draft	RSR	Richard Reid	Principal Engineer
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1. Introduction

Dún Laoghaire-Rathdown County Council is seeking to commence the Part 8 Planning process for the Green (Greenway, Cycle and Pedestrian) Routes Network for the Cherrywood Strategic Development Zone (SDZ).

The proposed Green Network footprint extends from the Luas tram/ light rail system near Carrickmines Luas Park & Ride to Páirc Choill Na Silíní, Coill na Silíní, Dublin running parallel to the N11 National Road. The footprint extent is shown below in Figure 1.

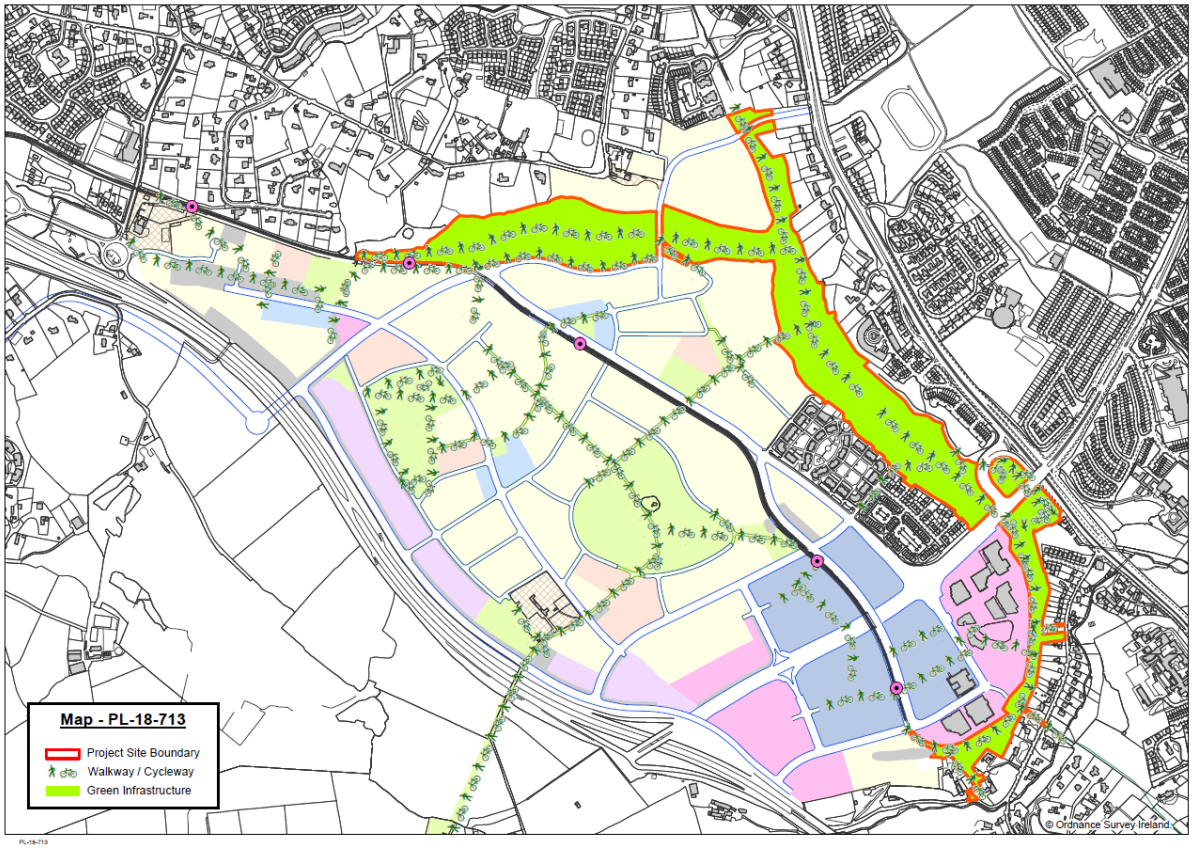


Figure 1. Green (Greenway, Cycle and Pedestrian) Routes Network

In accordance with the *'The Planning System and Flood Risk Management – Guidelines for Planning Authorities'* there is a requirement to undertake a Flood Risk Assessment Report, which will accompany the planning application.

AECOM has been appointed to conduct a Flood Risk Assessment in support of the planning application.

The objectives of this Flood Risk Assessment (FRA) are the following:

- Stage 1 – Flood Risk Identification
- Stage 2 – Initial Flood Risk Assessment
- Stage 3 – Detailed Flood Risk Assessment

1.1 Scope of Services

AECOM is required to undertake an FRA for the proposed Green (Greenway, Cycle and Pedestrian) Routes Network.

This FRA study has been undertaken in consideration of the following guidance document:

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

The assessment will demonstrate that the proposed infrastructure development will:

1. Not increase flood risk elsewhere and, if practicable, will reduce overall flood risk;
2. Include measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible;
3. Include 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 and implementation of any future flood risk management measures and provisions for emergency services access.

2. Site Information

This chapter sets the context for the proposed development by giving an overview of existing conditions within the SDZ and surrounding areas.

The Cherrywood SDZ is located near Loughlinstown and Carrickmines, Co. Dublin. Cherrywood is 8km south of Dún Laoghaire Town Centre and is situated between the N11 national road and the M50 motorway. The multiple watercourses that flow through the site are within the Carrickmines/ Shanganagh Catchment.

The proposed greenway, and the associated infrastructure, is located within the Cherrywood SDZ. The site location is shown in Figure 2.

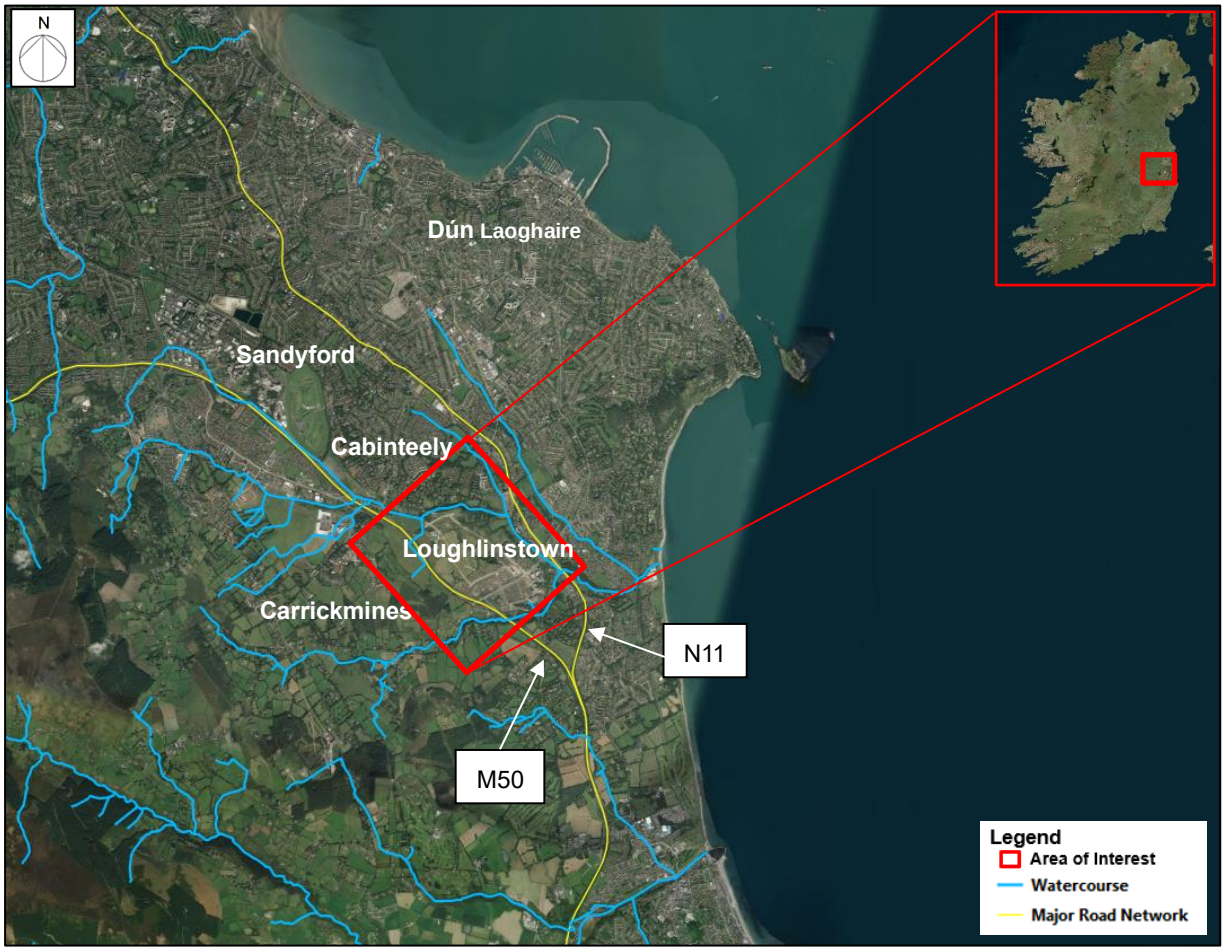


Figure 2. Site Location

2.1 Existing Site Conditions

Cherrywood is a new developing suburb in South East Dublin. The proposed greenway is part of the Cherrywood Planning Scheme masterplan. The area of interest, along the Carrickmines River and Loughlinstown River, is within an area designated for open space. There are several existing parks and walkways (e.g. Cabinteely Park, Druid Valley) in this area but they do not all connect which is therefore separating communities.

There are several existing structures (e.g. bridges, culverts etc.) along the primary and secondary watercourses. The existing hydrology is discussed more detail in Section 2.3.

2.1.1 Cherrywood Strategic Development Zone (SDZ) Planning Scheme

In 2010, Cherrywood was designated as an SDZ following a Government Order. The SDZ lands cover approximately 360 hectares and is one of the most sizable undeveloped tranches of land in the Dublin Metropolitan Area. Cherrywood is located approximately 16km to the south of Dublin City Centre, 8km south of Dún Laoghaire, and 3km west of the coast. Following the Cherrywood SDZ designation, the Development Agency was required to prepare a Planning Scheme.

The Cherrywood Masterplan proposes retail units, residential properties and open space to facilitate the growth of South Dublin. The Cherrywood Planning Scheme (CDS) is accompanied by a Strategic Environmental Assessment Environmental Report, an Appropriate Assessment Screening Report and The Cherrywood Biodiversity Plan.

As shown in Figure 3 the SDZ and the CPS boundaries differ. The CPS extent is reduced to only include areas of land which could benefit from investment. The Green (Greenway, Cycle and Pedestrian) Routes Network extent is within both the SDZ and CPS boundaries.

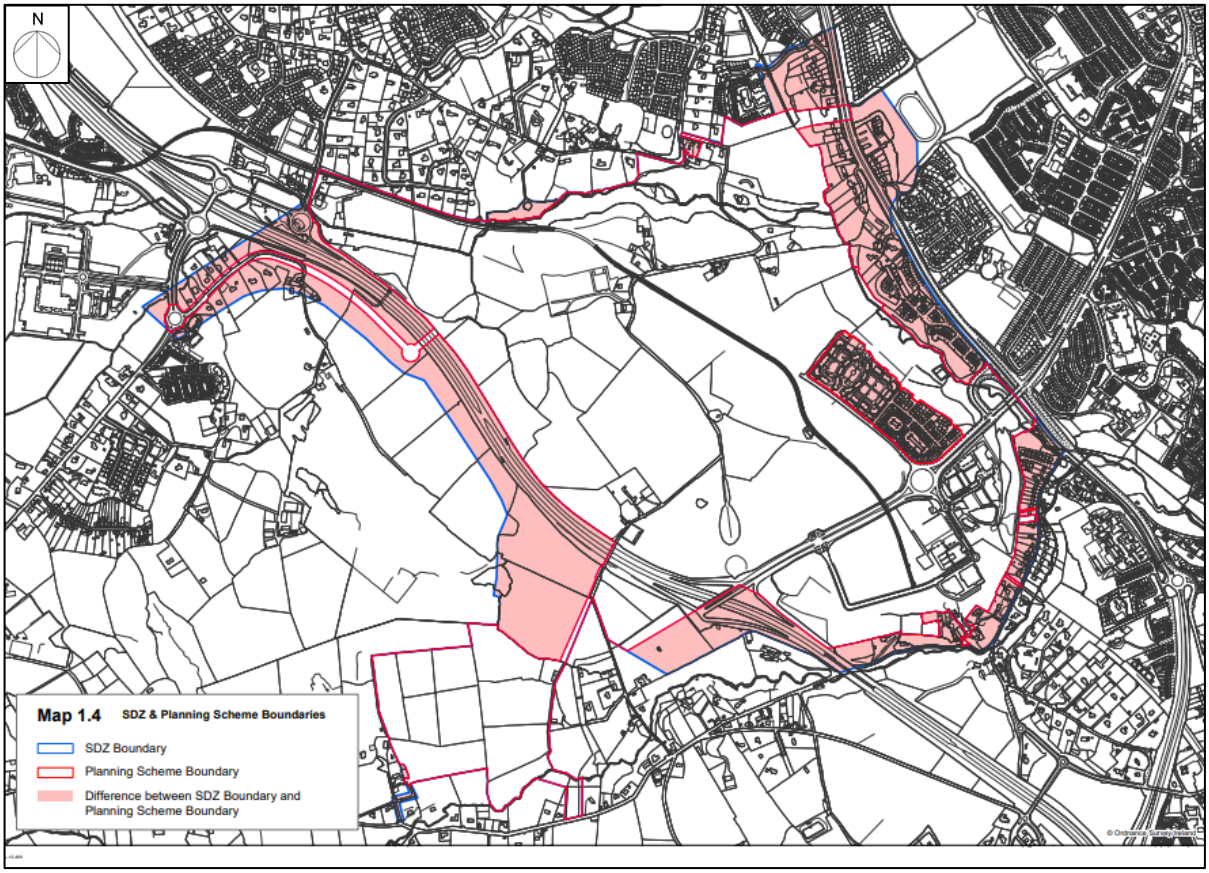


Figure 3. SDZ and CPS Boundaries

In order to ensure future development within Cherrywood adheres to the overarching vision for the Planning Scheme main principles have been developed. These include:

- To promote balanced sustainable growth within the Greater Dublin Region;
- To set the standards for future development and create the framework for the development of a sustainable town, supporting a range of services and uses;
- To develop an area and community which reflects its hinterland through restoring sustainable green connectivity networks;
- To integrate the landscape into the design process, and developing places which respond to the hinterland in a form unique to Cherrywood;
- To balance the employment, commercial and retail utilisation of Cherrywood in respect of future residential growth;
- To facilitate the movement to smarter travel with a focus on pedestrian and cycle facilities.

For more information about the Cherrywood Strategic Development Zone (SDZ) Planning Scheme, all documents can be accessed at the following link (https://www.dlrcoco.ie/en/planning/cherrywood-sdz).

2.2 Proposed Development

The proposed Cherrywood Green Routes Network development aims to improve the landscaping, sustainable design, and aesthetic nature of the existing open space along the floodplain of the Carrickmines and Loughlinstown River

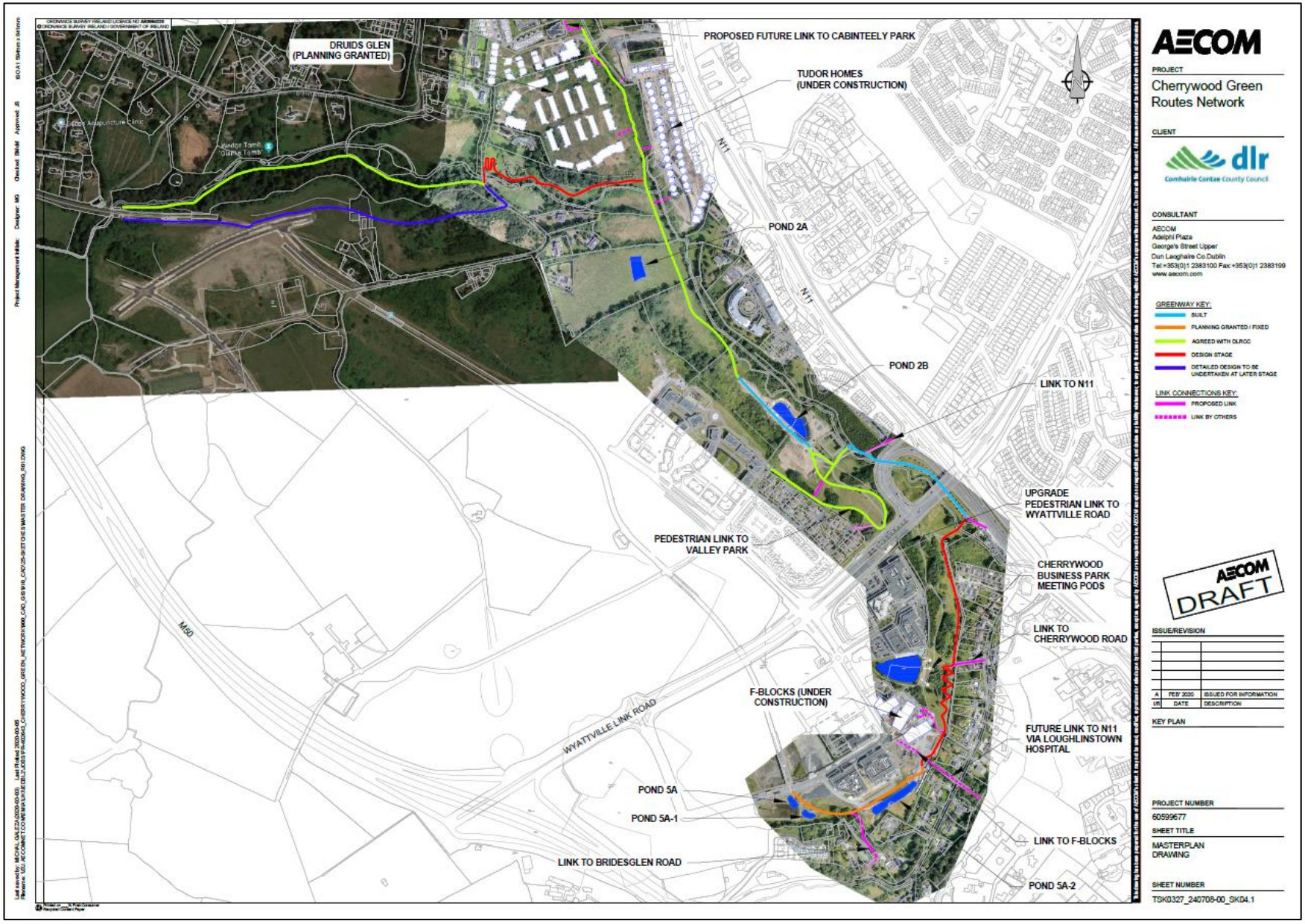


Figure 4. Proposed Developments (Draft)

The future development as shown in Figure 4 will have the means to facilitate the growth in population which is expected following the adoption of the Cherrywood Planning Scheme via connectivity. The development supports the Cherrywood masterplan objective to allow the new community to set down roots, to provide more recreational amenities for the community to explore and enjoy.

2.3 Local Hydrology

Cherrywood is located within the Carrickmines/ Shanganagh catchment which outfalls into Irish Sea, approximately 8km southeast of Dublin Bay. There are several waterbodies which flow through the site and wider area. These include the Cabinteely Stream, Carrickmines River, Loughlinstown River, and the Shanganagh River.

The waterbodies referenced in Figure 5 flow in an east to west direction and lie within the Carrickmines/ Shanganagh catchments. The Shanganagh River discharges into the sea near Ballybrack. The Carrickmines River and Cabinteely Stream discharges to the Loughlinstown River which flows parallel to the N11 National Road. The Carrickmines River flows through the M50 motorway in a west to east direction. The Loughlinstown River flows in a northwest to southeast direction before discharging into the Shanganagh River. The Shanganagh/ Loughlinstown confluence flows under the N11 National Road.

Figure 5. Watercourses in vicinity of the Site

2.4 Topography

The topography is an important factor in terms of assessing and understanding the flood risk associated with the site. Online sources can provide a baseline of information which can assist the flood risk identification process.

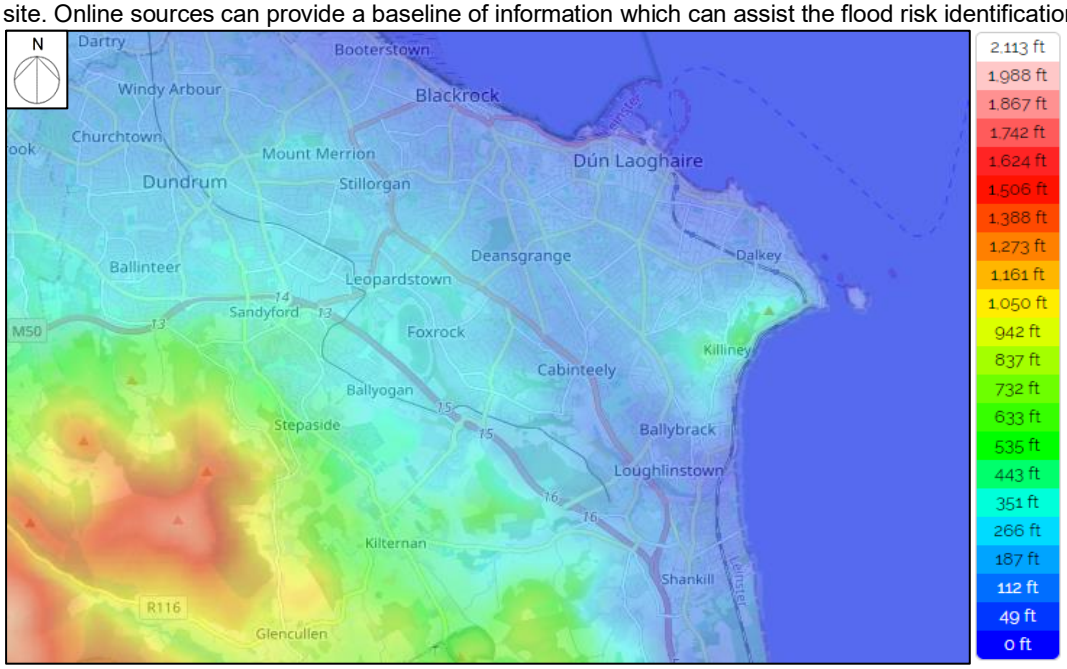


Figure 6. Site Topography (https://en-ie.topographic-map.com/maps/5h/Ireland/)

Figure 6 suggests a gradual increase in elevation from the southeast to northwest across the site. The site elevation appears to vary between 351ft-144ft. The metric equivalent is approximately 10.67m-43.89m.

A Drone Survey was carried out in August 2019. The survey information was converted to an ascii file format and viewed using Geographic Information Systems (GIS). The drone survey does not cover the entire proposed Greenway location. As expected, the data suggests the watercourse flows through an area of low elevation, in this case a valley called Druid Valley.

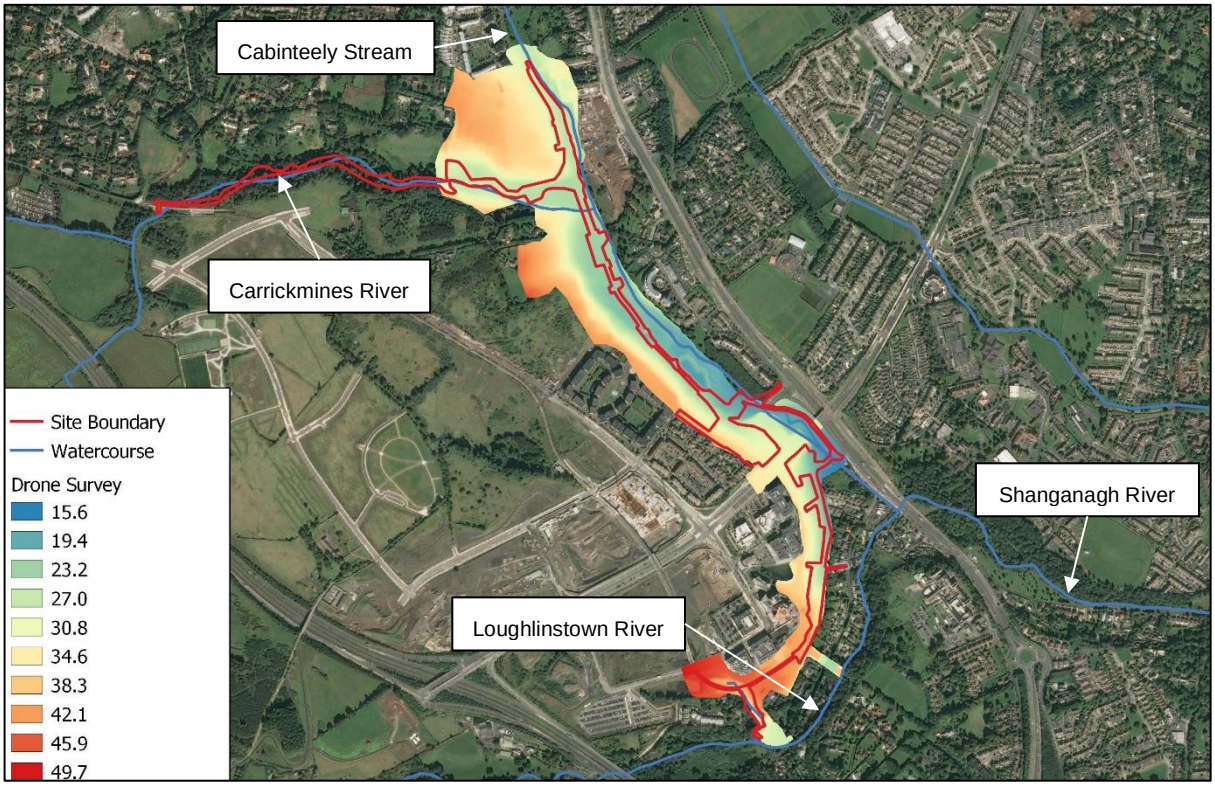


Figure 7. Drone Survey

3. Stage 1 – Flood Risk Identification

The purpose of Stage 1 is to establish whether a flood-risk issue exists or may exist in the future. If there is a potential flood risk issue then, in accordance with 'The Planning System and Flood Risk Management – Guidelines for Planning Authorities (DOEHLG 2009)', the FRA procedure should move to 'Stage 2 – Initial flood risk assessment'. If no potential flood risk is identified during Stage 1 then the overall FRA can be concluded.

The following information and data were collated as part of the screening assessment for the proposed Green (Greenway, Cycle and Pedestrian) Routes Network for the Cherrywood SDZ.

3.1 Hydrometric Data

Existing sources of hydrometric data from the OPW (www.waterlevel.ie) were investigated, This investigation has determined that the closest active permanent hydrometric gauging stations is located at Cherry Wood (10048) which is within the site, along the watercourse of interest, as illustrated below Figure 8. This station records surface water only and the first recording was the 11th of October 2019. A second station at Glenavon Park (10047) is located approximately 0.7km southeast of the Cherry Wood gauging station but it not located on the watercourse of interest.

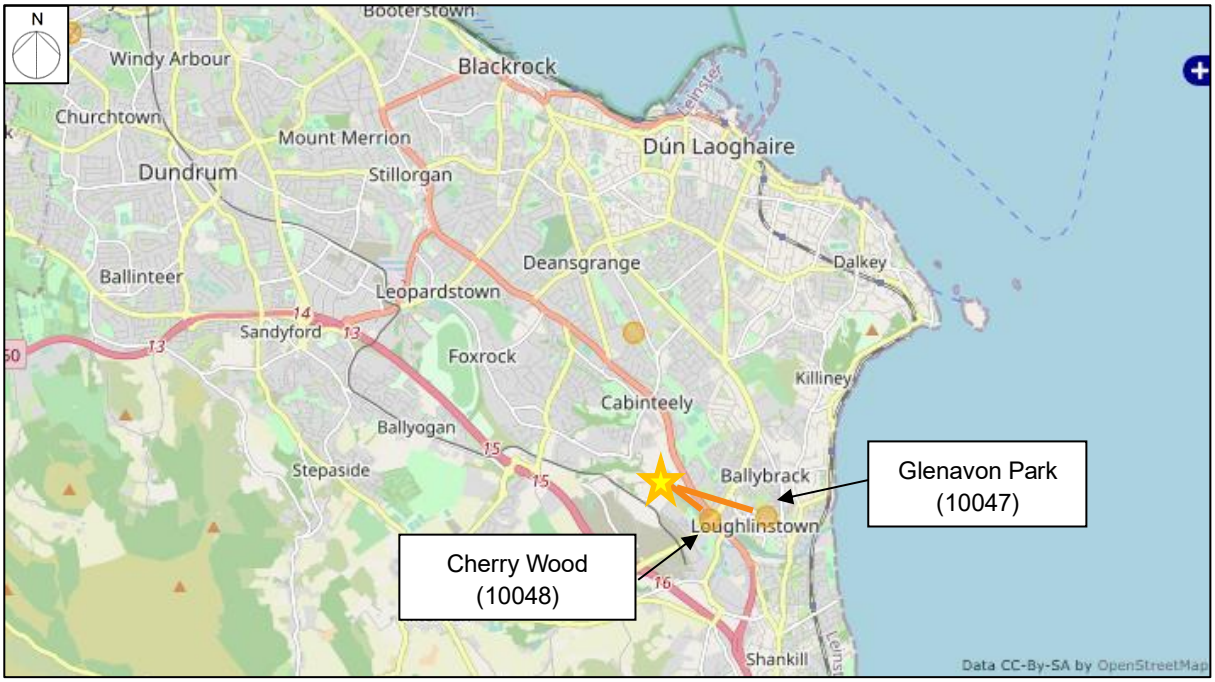


Figure 8. Gauge Stations in the vicinity of the site

3.2 OPW Land Benefitting Maps

The area in the vicinity of the site is not located within a “Drainage District”. Figure 9 below is a map extracted from the OPW Arterial Drainage viewer (https://maps.opw.ie/drainage/map/).

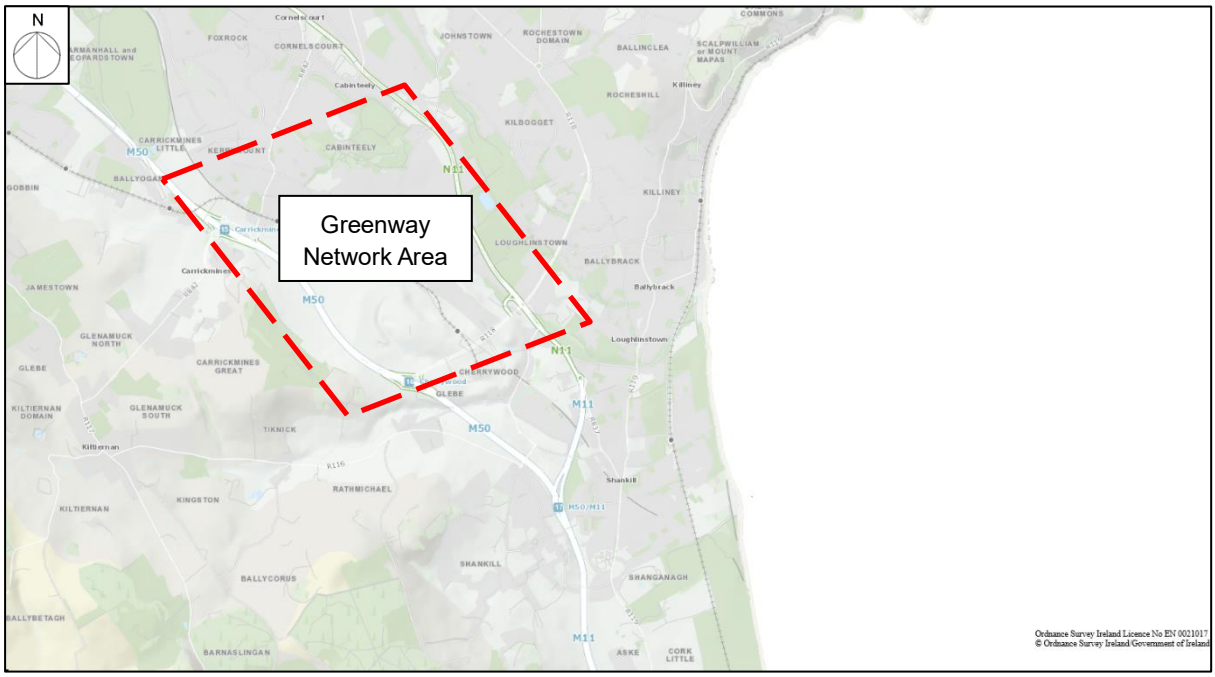


Figure 9. OPW Benefitting Lands

The structure conveying flow through the N11 National Road was part of the Carrickmines – Shanganagh Main Drainage Scheme. The DR-N11-003.00 Bridge was officially opened on the 5th of December 1996. No further information was provided. The Environmental Services Report commissioned by Dún Laoghaire-Rathdown County Council suggests a continuation of the Carrickmines/Shanganagh Main Drainage Scheme (https://www.dlrcoco.ie/sites/default/files/atoms/files/chapter12.pdf).

3.3 Groundwater Wells and Springs

An investigation into the rise and abstraction of water from underground wells and springs around the site was taken from the Department of Communications, Climate Change and Environment (https://dcenr.maps.arcgis.com/apps/MapSeries/index.html?appid=a30af518e87a4c0ab2fbde2aaac3c228). This was to identify if there are any areas of rising groundwater that could contribute to flooding.

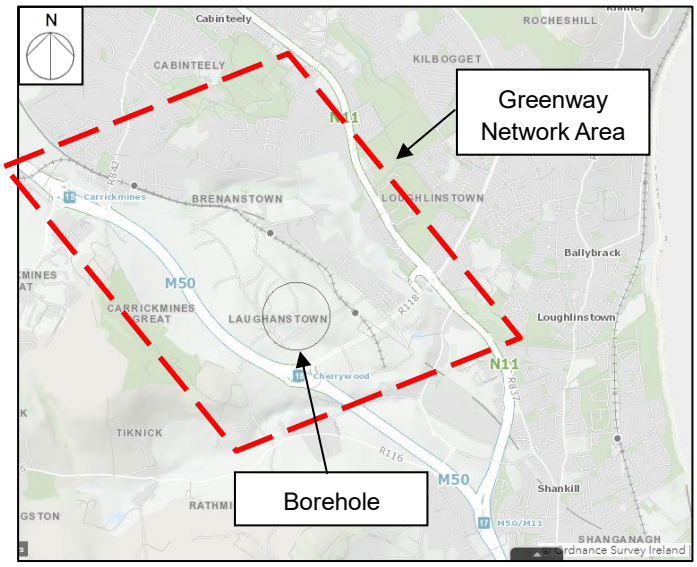


Figure 10. Wells or Springs

Figure 10 is an extract from the information available.

3.4 OPW Flood Hazard Maps

The OPW Flood Hazard Maps website (https://www.floodinfo.ie/map/floodmaps/) was consulted in relation to available historical or anecdotal information on any flooding incidences or occurrence in the vicinity of the Green, (Greenway, Cycle and Pedestrian), Routes Network. Figure 11 below shows mapping from the website.

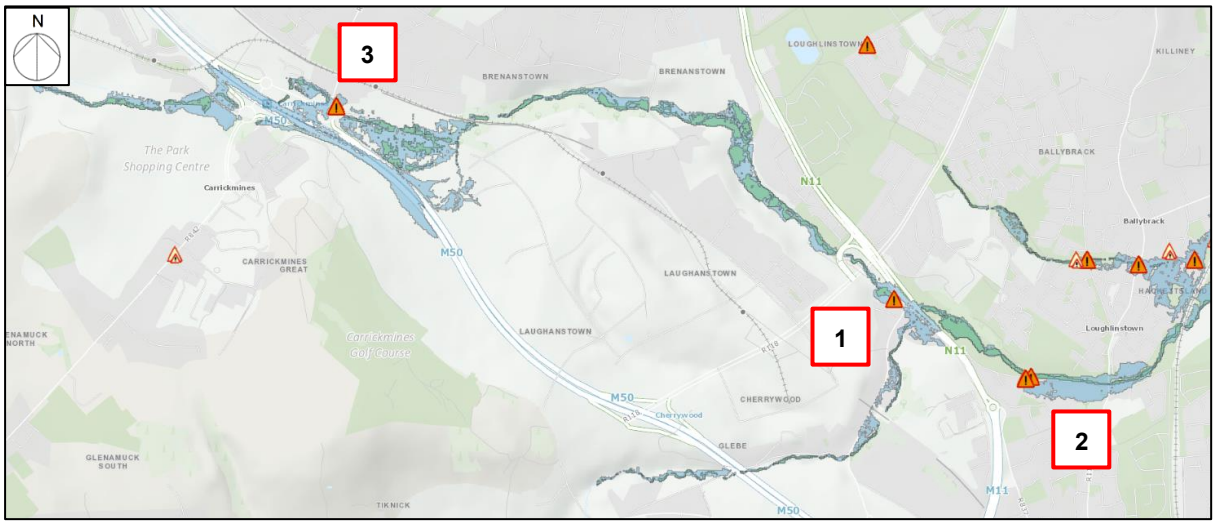


Figure 11. Flood Hazard Maps (www.floodmaps.ie)

Historic flood records indicate several locations in the proximity of the site which are both flagged as "flood event"; These are listed as "Flooding at N11, Loughlinstown, Co. Dublin on 24th Oct 2011", labelled as '1', "Shanganagh January 1980" labelled as '2', and "Shanganagh Carrickmines Nov 2002" , labelled as '3'.

Reports for Flooding at N11, Loughlinstown, Co. Dublin on 24th Oct 2011 was caused by the overtopping of the Carrickmines River, a tributary of the Shanganagh River. The peak flood occurred at 11pm on the 24th of October. A blockage due to overgrowth at a pedestrian river crossing may increase the flood levels which flooded properties in this area.

Reports for Flooding at Shanganagh January 1980 caused road and gardens to flood. No further information is available.

There are reports of Flooding at the Shanganagh Carrickmines Common's Road Station on the 27th of November 2002. The water level peaked at 1.59m. The Cabinteely Stream flooded the Shanganagh Commons Road on May 1993. The flood level recorded was 1.38m on a staff gauge.

3.5 National Catchment Flood Risk Assessment and Management (CFRAM) Programme

The National Irish CFRAM Programme was developed by the OPW in 2004 to meet the requirements set out in the EU Floods Directive (2007/60/EC). The CFRAM programme studied and assessed flood risk in Ireland and focused on a total of 300 communities and areas that were considered at significant risk of flooding.

For the 300 communities which were investigated flood plans and flood maps have since been published (www.floodinfo.ie). A range of flood event scenarios were modelled, and flood maps were produced.

As a result of the potential risk of fluvial flooding in the Carrickmines/ Shanganagh Catchment the Carrickmines River, Loughlinstown River and Shanganagh River were modelled in the CFRAM Programme and the results are shown below in Figure 13 and Figure 14. The Loughlinstown watercourse to the North of the site was classed as an Area for Further Assessment (AFA) during the CFRAM Programme.

The Flood Risk Management Plan (FRMP) for the Avoca - Vartry River Basin (Unit of Management 10) described the Loughlinstown area as an Area for Further Assessment (AFA). The FRMP Flood Extents suggest the Loughlinstown area is vulnerable and sensitive to climate change scenarios. The Flood Extents produced by the CFRAM suggest that the Green, (Greenway, Cycle and Pedestrian), Routes Network extent is within Flood Zone

A and Flood Zone B, refer to Figure 12. The . No pluvial flood maps are available for the Green, (Greenway, Cycle and Pedestrian), Routes Network site.

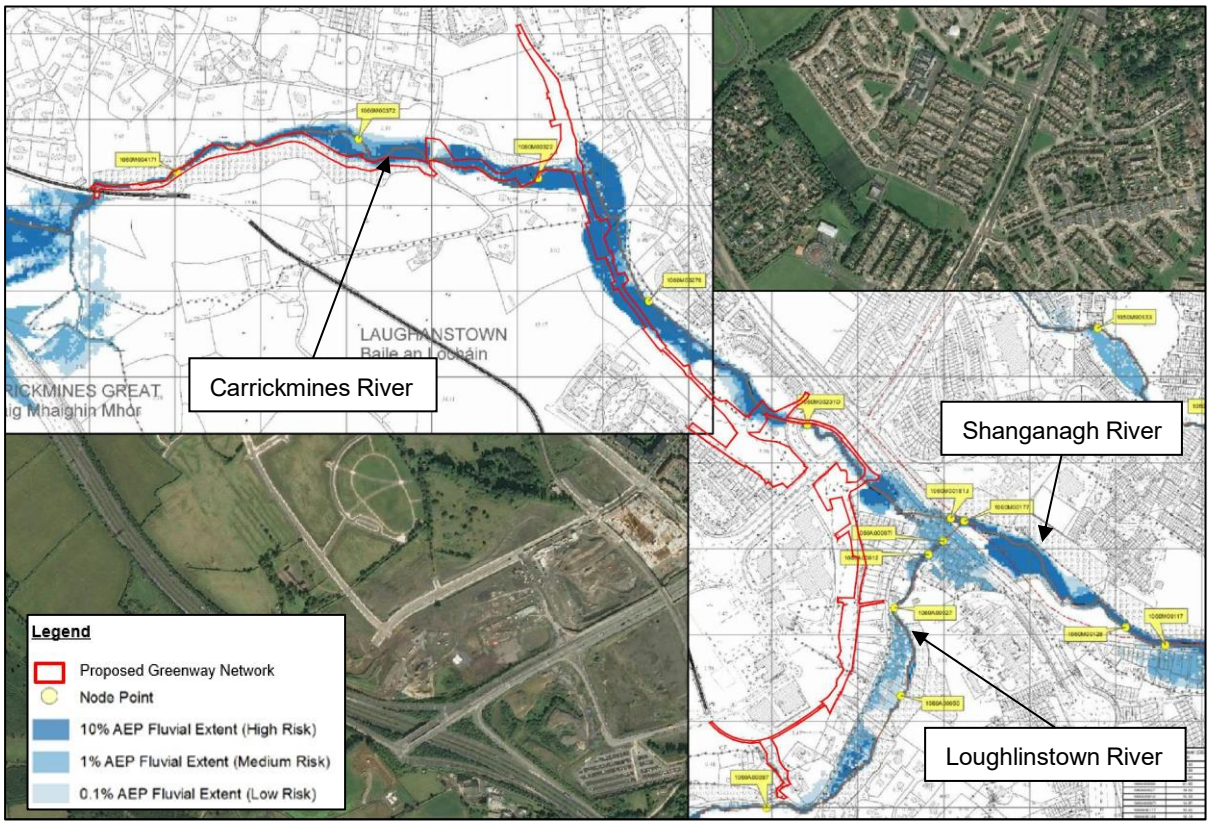


Figure 12. CFRAM Flood Map – Proposed Network

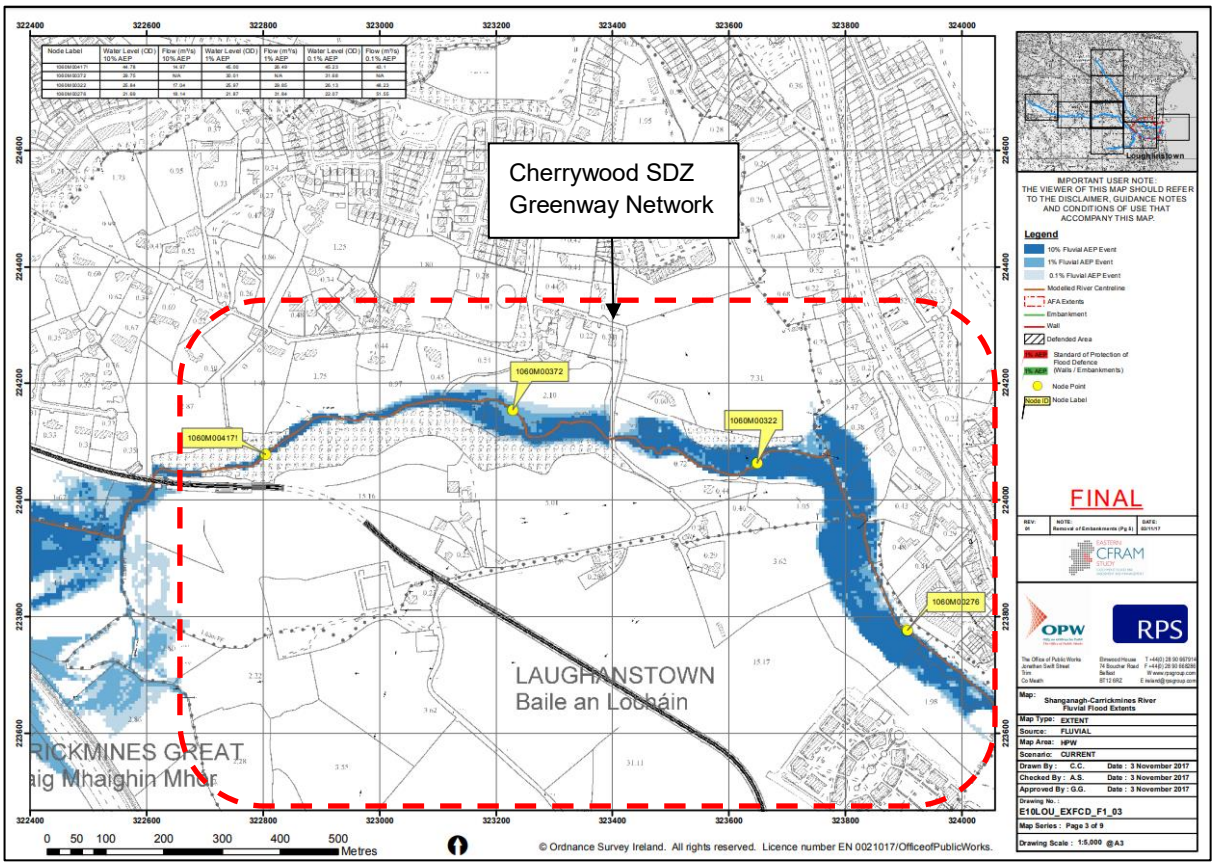


Figure 13. CFRAM Flood Map Shanganagh-Carrickmines River

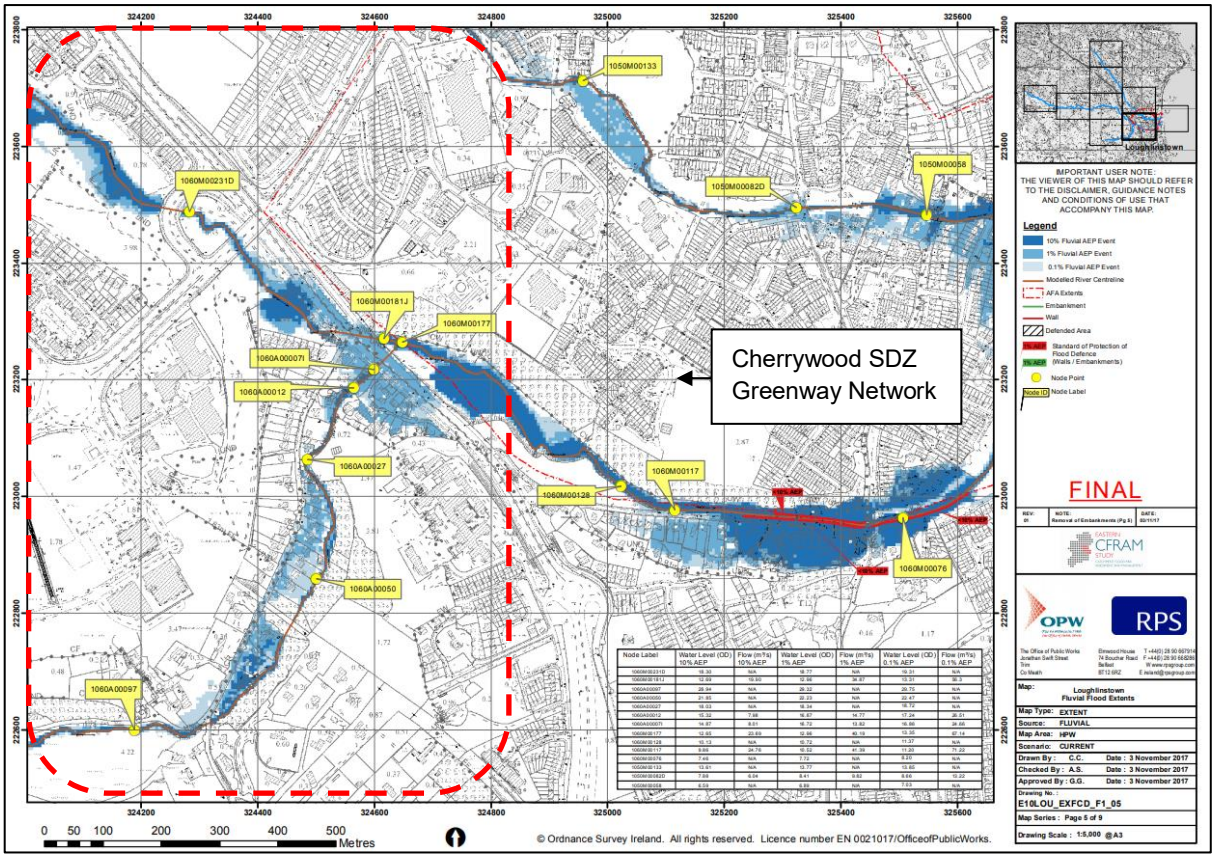


Figure 14. CFRAM Flood Map Loughlinstown

3.6 Dún Laoghaire-Rathdown County Development Plan

The Dún Laoghaire-Rathdown County Development Plan 2016-2022 outlines flooding objectives to be applied in the preparation of future town development plans and in the assessment of planning applications, referring to 'The Planning System and Flood Risk Management – Guidelines for Planning Authorities (DOEHLG 2009)'. The approach to managing flood risk in Ireland shifted from a structurally engineered solution to taking a catchment-based approach. Dún Laoghaire-Rathdown County Development Plan 2016-2022 has taken this approach to Flood Risk Management. Flood Risk management should be consulted at pre-planning stage and has provided recommendations for both small development and large development applications. Recommendation for the larger scale developments include compliance with the GDSDS and the inclusion of SuDS.

Dún Laoghaire-Rathdown County highlights the strategic importance of the Development Plan 2016-2022 and has thus provided a Strategic Flood Risk Assessment (SFRA) which is in compliance with the Strategic Environmental Assessment. The SFRA excludes the Cherrywood Planning Scheme. The site proposed for the Green, (Greenway, Cycle and Pedestrian), Routes Network is included in the SFRA.

3.6.1 Dún Laoghaire-Rathdown Strategic Flood Risk Assessment

An SFRA was carried out to inform strategic land use planning. The main objectives of the Dún Laoghaire-Rathdown County Development Plan in terms of flooding include but are not limited to:

- To liaise with neighbouring Local Authorities (e.g. Fingal, Dublin County Council etc.) regarding the development of cross-boundary flood risk management and measures;
- To provide for an improved understanding of flood risk issues within the development plan;
- To detail the appropriate scope or level of detail necessary for a strategic FRA of a county development plan;
- To carry out an FRA based on existing datasets and survey work, as appropriate, leading to a suite of flood risk maps that support the application of the sequential approach, in areas within the development envelope, where there may be tension between development pressures and avoidance of flood risk;
- To inform, where necessary, the application of the Justification Test;
- To produce guidance on where surface water should be managed and appropriate criteria to be used in the consideration of site-specific FRA.

For more information about the Dún Laoghaire-Rathdown County Development Plan, all documents can be accessed at the following link (https://www.dlrcoco.ie/en/planning/county-development-plan/county-development-plan-2016-2022). It should be noted that these flood extents have been taken from the Dún Laoghaire-Rathdown County Development Plan SFRA.

The SFRA stated that the exceedance of channel capacity during high flows was the primary cause of flooding within Dún Laoghaire-Rathdown County. The SFRA highlights the importance of a Green Corridor adjacent to the river. The Green, (Greenway, Cycle and Pedestrian), Routes Network development adheres to such recommendations through the connecting riverside walks with communities and offering more public open space.

The SFRA states that much of the land within Flood Zone A and B are lands zoned for water compatible development but suggests this land is located near point No. 5 shown in Figure 15 below. The SFRA also states that no new developments can be justified in a Flood Zone A or Flood Zone B, and recommends this land be utilised as open space.

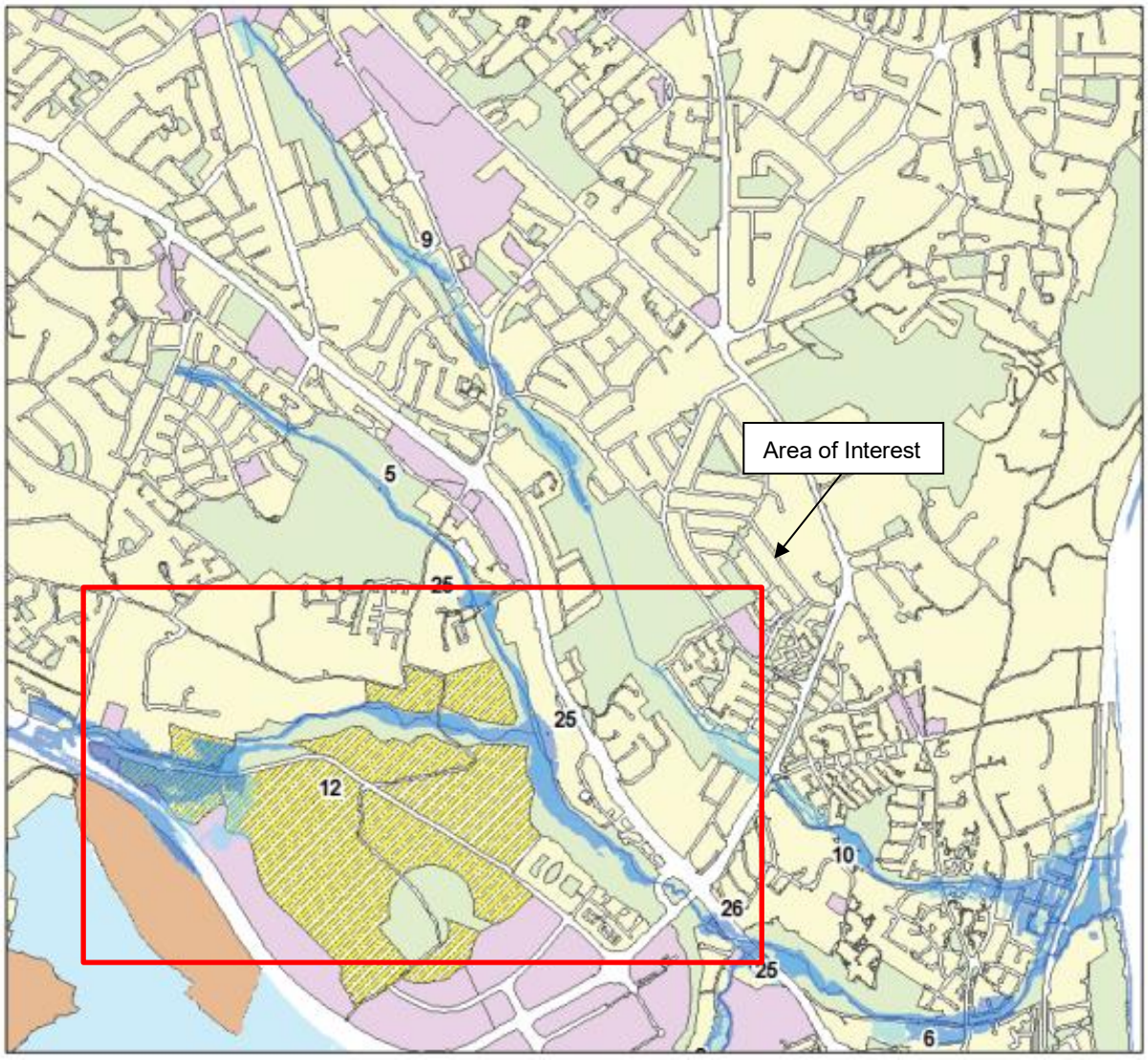


Figure 15. Dún Laoghaire-Rathdown County Development Plan 2016-2022 - Strategic Flood Risk Assessment Shanganagh and Deansgrange Rivers Flood Map

3.7 Greater Dublin Strategic Drainage Strategy (GDSDS)

The GDSDS Report was commissioned in June 2011 following the significant growth of Dublin City and the expansion of the Irish economy. As a result, Ireland experienced increased development which inevitably put pressure on existing infrastructure and key infrastructure.

The purpose of this Report was to outline the services required to facilitate the increased demand on foul and stormwater drainage infrastructure. The significant economic success of the Greater Dublin City and surrounding areas prompted the GDSDS which developed a strategic analysis of the existing foul and surface water systems by Local Authorities. The Local Authorities included Dublin City, Fingal, South Dublin, Dún Laoghaire-Rathdown and the adjacent catchments in counties Meath, Kildare and Wicklow.

The proposed Green, (Greenway, Cycle and Pedestrian), Routes Network is located within the S1008 Carrickmines River Catchment as shown in Figure 16. The catchment is part of the Shanganagh-Bray foul system (F012). There are several overflows within the system but the impact on the storm network is small. The GSDS also states that the storm sewerage system does not regularly flood. A future scenario was modelled as part of the GDSDS to facilitate a growth in population, which included growth of Cherrywood, Carrickmines and Lauganstown, and suggests allowances for future surface water connections has the potential to cause flooding on the Carrickmines Sewer. Improving the drainage and network planning could resolve this issue but no further work was carried out as part of the GDSDS to confirm this.

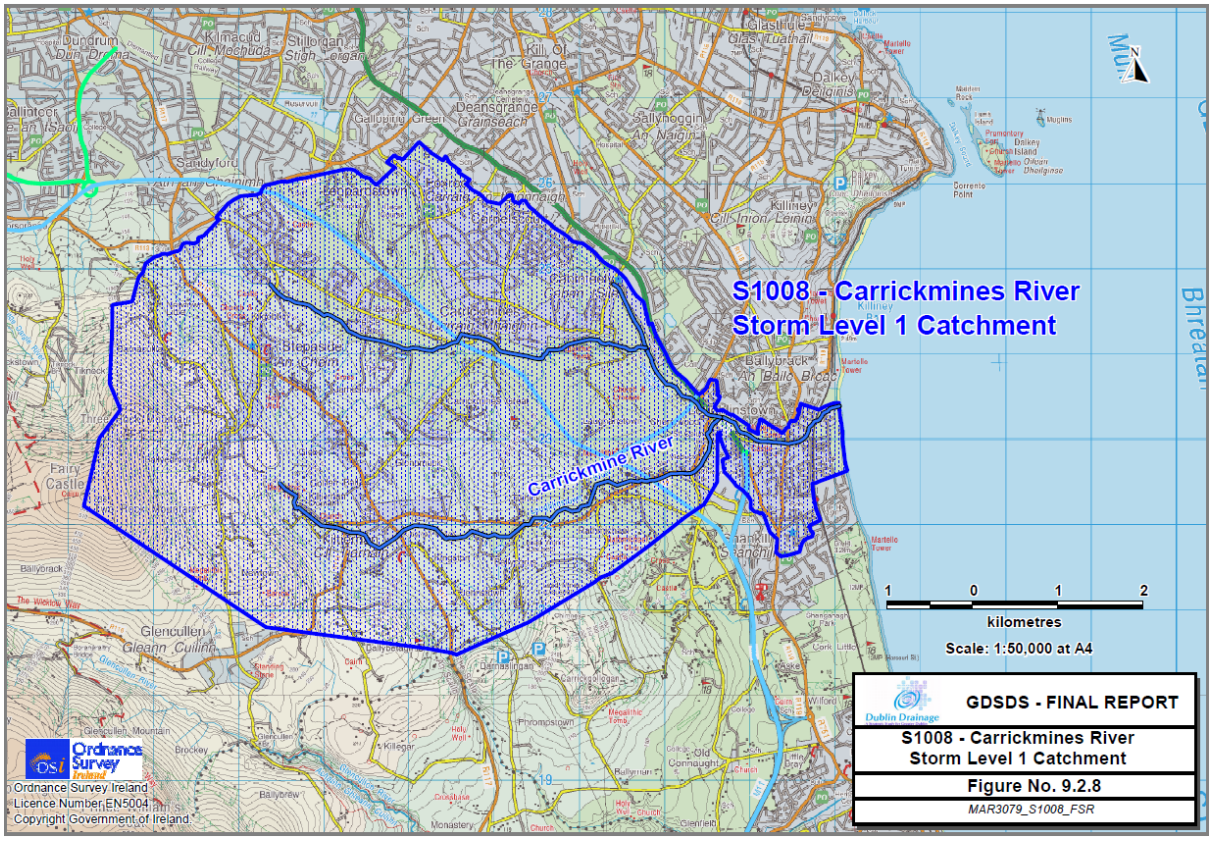


Figure 16. GDSDS Storm Level Catchment Boundary

The objectives of this study are summarised below:

- To develop an environmentally sustainable strategy that meets the increased demand in the Greater Dublin Region in the context of current Development Plans, the Regional Planning Guidelines and the longer-term development potential of the region;
- To provide overarching policy framework and set standards which will apply throughout the Greater Dublin Region, and continue to promote the requirements of environmental legislation and GDSDS recommendations;
- To develop tools for the effective management of the drainage systems including Geographical Information Systems (GIS), network models and digital mapping; and

- To develop the optimum drainage solution from a range of alternative scenarios. The solutions will consider the whole-life cost and environmental performance.

For more information about the GDSDS Report, all documents can be accessed at the following link (http://www.greaterdublindrainage.com/gdsds/

3.8 Beech Park Planning Application (D15A_0385): Flood Risk Assessment Stage 3

A Stage 3 FRA formed part of the D15A_0385 Beech Park Planning Application which was made available by Dún Laoghaire-Rathdown County Council. This Assessment was accompanied by the Cabinteely Hydraulic Analysis. The Planning Application proposed a new residential development located partially within Flood Zone A and Flood Zone B. The development proposed mitigating the flood risk within the site through providing additional flood storage to the south west of the site, focusing primarily on the left bank of the Cabinteely watercourse upstream of the Carrickmines/ Shanganagh confluence. The proposed design included lowering the ground level of the floodplain between the proposed development and the watercourse to compensate for the loss of storage. The proposed development also includes approximately 475m of sheet pile wall the ensure the development is raised significantly above the watercourse.

The hydraulic modelling carried out for this FRA consisted of two scenarios; Existing and Proposed. The flow hydrograph was derived from CFRAM flows and incorporated into a 1D/2D Infoworks model. The existing scenario suggests the Cabinteely watercourse received low flows when compared with the Carrickmines/ Shanganagh

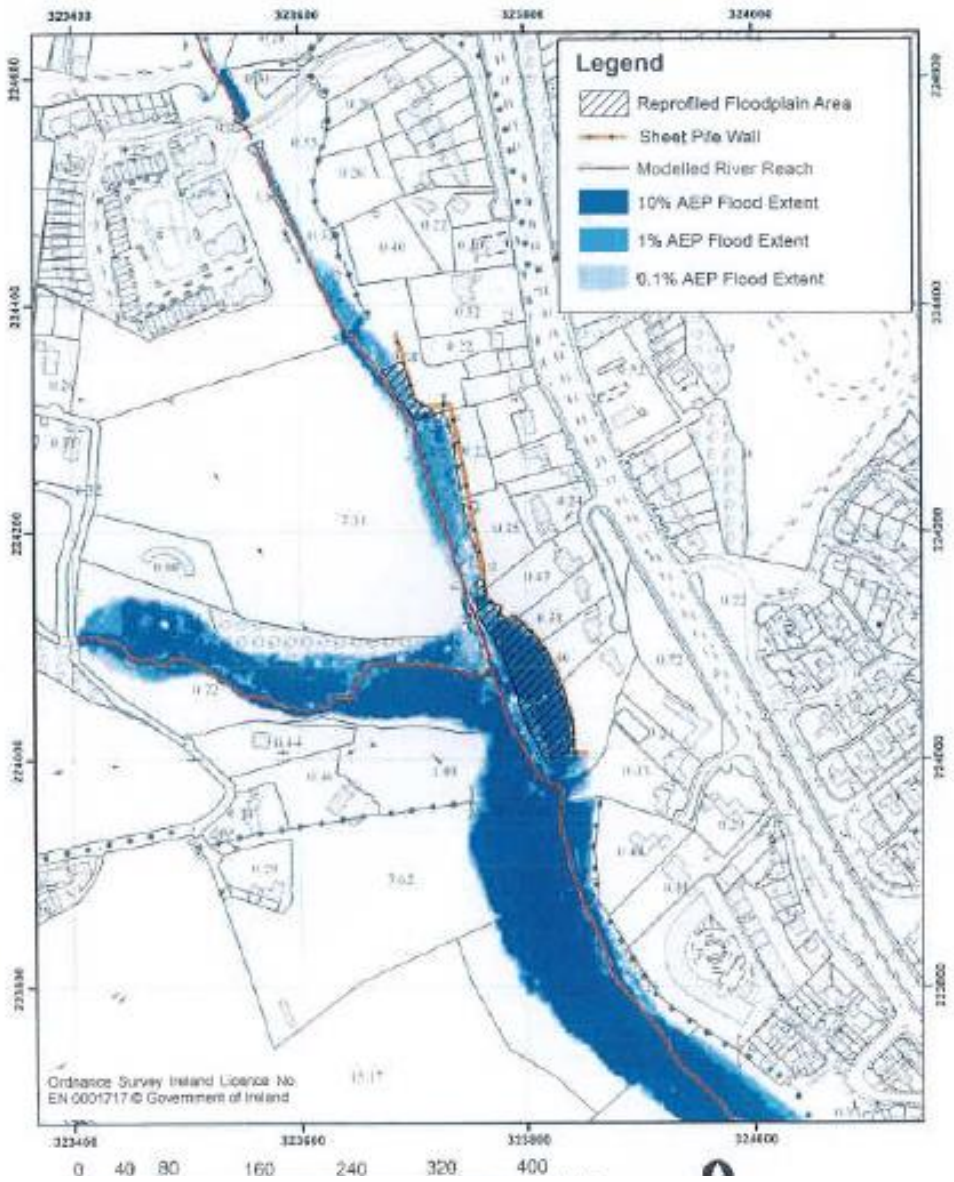


Figure 17. Flood Extents following the Proposed Development

watercourse. Figure 17 outlines the proposed 10%, 1% and 0.1% Annual Exceedance Probabilities (AEP) flood extents. The results indicate a reduced water level at 7 cross sections and an increase at 3 cross section locations.

The largest increase of 31mm, in the 1% AEP, occurs upstream of the compensation lands along the Cabinteely watercourse. The flood risk does not increase for local receptors as a result of this development. This development does not cause an increase in level or flood extent along the Carrickmines/ Shanganagh watercourse and the impact to the Cabinteely watercourse is negligible in terms of flood risk.

3.9 Screening Assessment Conclusion

The possible flooding mechanisms in consideration of the proposed Green, (Greenway, Cycle and Pedestrian), Routes Network are summarised in Table 1 below.

The purpose of this screening assessment was to identify whether a potential risk of flooding exists and to what extent for the proposed works. The assessment was based on the collation and assessment of existing current information, historical information and data which may indicate the level or extent of any flood risk.

In consideration of the flood risk identified in the CFRAM Flood Mapping, the Dún Laoghaire-Rathdown County Development Plan, the associated Dún Laoghaire-Rathdown County SFRA, and the Beech Park Planning Application this FRA is required to proceed to 'Stage 2 - Initial Flood Risk Assessment'. The screening assessment shows that there is significant flooding risk to the proposed site.

Table 1 Possible Flood Mechanisms

Source of Flooding	Significant?	Comment / Reason
Tidal / Coastal	No	The site is not located in a tidal/coastal flood risk zone.
Fluvial	Yes	Flooding is likely to occur from fluvial flow.
Pluvial (Urban Drainage)	No	The existing site does have adequate surface water drainage provisions. An updated system (e.g. improvements) has been proposed for future scenarios.
Pluvial (Overland Flow)	No	No flooding is likely to occur from overland flow
Groundwater	No	There are no significant springs or groundwater discharges recorded in within the site.

4. Stage 2 – Initial Flood Assessment

In order to undertake the initial flood assessment a determination of the flood zone in which the site is located along with a determination of the vulnerability of the proposed works is required.

4.1 Determination of Vulnerability

The vulnerability of the proposed works is classified into three classes as given below in Table 2.

Table 2 Classification of Vulnerability

Vulnerability class	Land uses and types of development*
Highly vulnerable development (including essential infrastructure)	Garda, ambulance and fire stations and command centres required to be operational during flooding; Hospitals; Emergency access and egress points; Schools; Dwelling houses, student halls of residence and hostels; Residential institutions such as residential care homes, children's homes and social services homes; Caravans and mobile home parks; Dwelling houses designed, constructed or adapted for the elderly or, other people with impaired mobility; and Essential infrastructure, such as primary transport and utilities distribution, including electricity generating power stations and sub-stations, water and sewage treatment, and potential significant sources of pollution (SEVESO sites, IPPC sites, etc.) in the event of flooding.
Less vulnerable development	Buildings used for: retail, leisure, warehousing, commercial, industrial and non-residential institutions; Land and buildings used for holiday or short-let caravans and camping (subject to specific warning and evacuation plans); Land and buildings used for agriculture and forestry; Waste treatment (except landfill and hazardous waste); Mineral working and processing; and Local transport infrastructure.
Water-compatible development	Flood control infrastructure; Docks, marinas and wharves; Navigation facilities; Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location; Water-based recreation and tourism (excluding sleeping accommodation); Lifeguard and coastguard stations; Amenity open space, outdoor sports and recreation and essential facilities such as changing rooms; and Essential ancillary sleeping or residential accommodation for staff required by uses in this category (subject to a specific warning and evacuation plan).

* Uses not listed here should be considered on their own merits

Source: The Planning System and Flood Risk Management - Guidelines for Planning Authorities

The guidelines would initially indicate that the site, as it is amenity open space, should considered to be water-compatible development.

4.2 Determination of Flood Zone

In accordance with 'The Planning System and Flood Risk Management – Guidelines for Planning Authorities (DOEHLG 2009)', there are three flood zones designated in the consideration of flood risk to a particular site. The three flood zones are described in Table 3 below.

Table 3 Flood Zone Description

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

Source: The Planning System and Flood Risk Management - Guidelines for Planning Authorities

The planning implications for each of the flood zones are:

Zone A - High probability of flooding. Most types of development would be considered inappropriate in this zone. Development in this zone should be avoided and/or only considered in exceptional circumstances, such as in city and town centres, or in the case of essential infrastructure that cannot be located elsewhere, and where the Justification Test has been applied. Only water-compatible development, such as docks and marinas, dockside activities that require a waterside location, amenity open space, outdoor sports and recreation, would be considered appropriate in this zone.

Zone B - Moderate probability of flooding. Highly vulnerable development, such as hospitals, residential care homes, Garda, fire and ambulance stations, dwelling houses and primary strategic transport and utilities infrastructure, would generally be considered inappropriate in this zone, unless the requirements of the Justification Test can be met. Less vulnerable development, such as retail, commercial and industrial uses, sites used for short-let for caravans and camping and secondary strategic transport and utilities infrastructure, and water-compatible development might be considered appropriate in this zone. In general, however, less vulnerable development should only be considered in this zone if adequate lands or sites are not available in Zone C and subject to an FRA to the appropriate level of detail to demonstrate that flood risk to and from the development can or will adequately be managed.

Zone C - Low probability of flooding. Development in this zone is appropriate from a flood risk perspective (subject to assessment of flood hazard from sources other than rivers and the coast) but would need to meet the normal range of other proper planning and sustainable development considerations.

In consideration of the above guidelines, the 1% AEP and 0.1% AEP fluvial event is to be taken into account in order to assess whether the site is located within Flood Zone 'A' or Flood Zone 'B'.

4.2.1 Coastal Flooding

The site is not at risk of coastal flooding as the waterbodies within the site and surrounding the site are not tidally influenced, thus no further assessment will be carried out. The site is within Flood Zone 'C' from a coastal flood risk perspective.

4.2.2 Fluvial Flooding

The CFRAM confirms out of bank flooding along the Carrickmines River, Loughlinstown River, and Shanganagh River.

The Carrickmines River experiences significant flooding upstream and downstream of the M50 motorway (Junction 15) but this particular extent does not appear to impact the proposed greenway network. The Carrickmines River becomes inundated further downstream near the confluence with the Loughlinstown River which causes widespread flooding in the floodplain. This widespread flooding continues downstream along the Loughlinstown River towards the N11 National Road. The risk of flooding from the Carrickmines and Loughlinstown watercourse is high and the site is within '**Flood Zone A'**. The flood extents are localised and currently impact the open space and fields.

4.2.3 Pluvial flooding (Urban Drainage)

The current surface water management practices are fit for purpose. However, the area is developing and a growth in population is expected. Further expansion will increase the need for improved sustainable methods to manage surface water. Historical event data such as the reports from Shanganagh Nov 2002 suggest rainfall has significantly impacted the levels within the surrounding watercourses. Due to nature of the proposed development no further action is required to determine the impact associated with the development.

4.3 Justification Test Requirement

The requirement for a justification test was reviewed for this study to determine whether the proposed works would be considered acceptable in terms of flood risk. The conclusion of 'Stage 1 – Flood Risk Identification' noted that it is not clear if the proposed Greenway is impacted by fluvial flooding.

The requirement for a Justification Test is determined based on the type of development and flood zone designation as indicated in Table 4 below.

Table 4. Justification Test Matrix – Green, (Greenway, Cycle and Pedestrian), Routes Network

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

Source: The Planning System and Flood Risk Management - Guidelines for Planning Authorities

Given the determination of the flood zone as 'Flood Zone A' for the *Green, (Greenway, Cycle and Pedestrian), Routes Network* and the determination of the development as 'Water compatible Development' a justification test is not required to be passed as the development is appropriate.

4.4 Stage 2 Flood Assessment Conclusion

In order to fulfil the Justification Test there is a requirement to quantify the flood risk at the proposed site, and where necessary mitigate the flood risk.

The purpose of the scoping stage is to identify possible flood risks and to implement the necessary level of detail required to assess these possible flood risks, and to ensure these can be adequately addressed in the FRA. The scoping exercise should also identify that sufficient quantitative information is already available to complete an FRA appropriate to the scale and nature of the development.

The CFRAM flood map extents indicate that there is a flood risk to the proposed *Green, (Greenway, Cycle and Pedestrian), Routes Network* development. The primary source of flood risk to the site is fluvial flooding.

Access and egress during flood events are of critical importance and this needs to be a key consideration going forward. It is therefore recommended that flood forecasting is used to ensure Health and Safety remains a key priority in terms of Management of the Greenway. To reduce the impact of man-made foot paths it is recommended that semi permeable sustainable materials are used.

The information available was deemed to be sufficient to assess the potential fluvial flood risk to the proposed open space development.

While the development can be classed as "water-compatible" and its construction within 'Flood Zone A' is appropriate without the need for further justification, a new bridge structure is proposed on the Carrickmines River just upstream of the confluence with the Cabinteely Stream. A hydraulic modelling exercise has been subsequently undertaken to determine the flood levels at this location and the impact of the new bridge structure to satisfy the requirements of OPW as part of the Section 50 Application process.

5. Stage 3 – Detailed Flood Risk Assessment

Section 4 of this report has concluded that while a detailed flood risk assessment is not required for the greenway, the flood levels and potential impact need to be determined at the proposed new crossing location of the Carrickmines River. This has been achieved through the development of a linked 1D-2D flood model. The following section will outline the process undertaken in the development of the hydraulic model.

5.1 Assessment of Flow

AECOM have undertaken a river flood flow assessment employing best practice techniques. Given the catchment area at the downstream of the model of circa 20km^2, AECOM have utilised the FSSR 16 method and subsequently a unit hydrograph approach to estimate the flows for the model input. A peak flow of 30.36m^3/s was estimated for the 1% AEP event. The calculation is presented in Appendix A.

This flow has been split up based on the contributing catchment areas of the Carrickmines River and Cabinteely Stream respectively with the hydrograph applied to the model as an unsteady flow input.

5.1.1 Comparison with CFRAM Flows

The flow estimated by AECOM is slightly lower than the corresponding peak flow derived by CFRAM of 34.87m^3/s. Given the substantial hydrological process undertaken by the CFRAM study and also for conservatism, AECOM have decided to scale up the peak of the flow from the unit hydrograph to match that derived by CFRAM.

5.1.2 Downstream Conditions

Downstream conditions are fluvial only and are derived from slope and from modelled flow in the downstream section of the model.

5.1.3 Climate Change Considerations

The Flood Policy Review Report (2004) produced by OPW states that climate change considerations should be taken into consideration when undertaking flood risk assessments. Two possible scenarios are proposed in this report:

- The 'Mid-Range Future Scenario' (MRFS) considers the more likely estimates of climate change to the future scenario drivers by 2100. This includes extreme rainfall depths increase by 20%, a resulting 20% increase in flood flow, 0.500m sea level rise and decrease in time to peak by 1/6 (Tp) due to deforestation. This is supported by the Defra FCDPAG3 (2006) guidance policy, where 20% is used as a sensitivity range to be adopted for peak river flow.
- The 'High End Future Scenario' (HEFS) considers the less likely estimates of climate change to the future scenario drivers by 2100. This includes extreme rainfall depths increase by 30%, a resulting 30% increase in flood flow, 1m sea level rise and decrease in time to peak by 1/3 (Tp) and addition of 10% to the Standard Percentage Runoff (SPR) rate due to deforestation.

Given the low sensitivity of the proposals to flooding, sensitivity testing will only be undertaken using the MRFS by increasing the flood flow estimates by 20%.

5.2 Model Geometry, Build and Parameters

5.2.1 Topographic Data

A Drone Survey was carried out in August 2019. The survey information was converted to an ascii file format and viewed using Geographic Information Systems (GIS). The drone survey does not cover the entire proposed Greenway location. Figure 18 below shoes the extent of the drone survey.

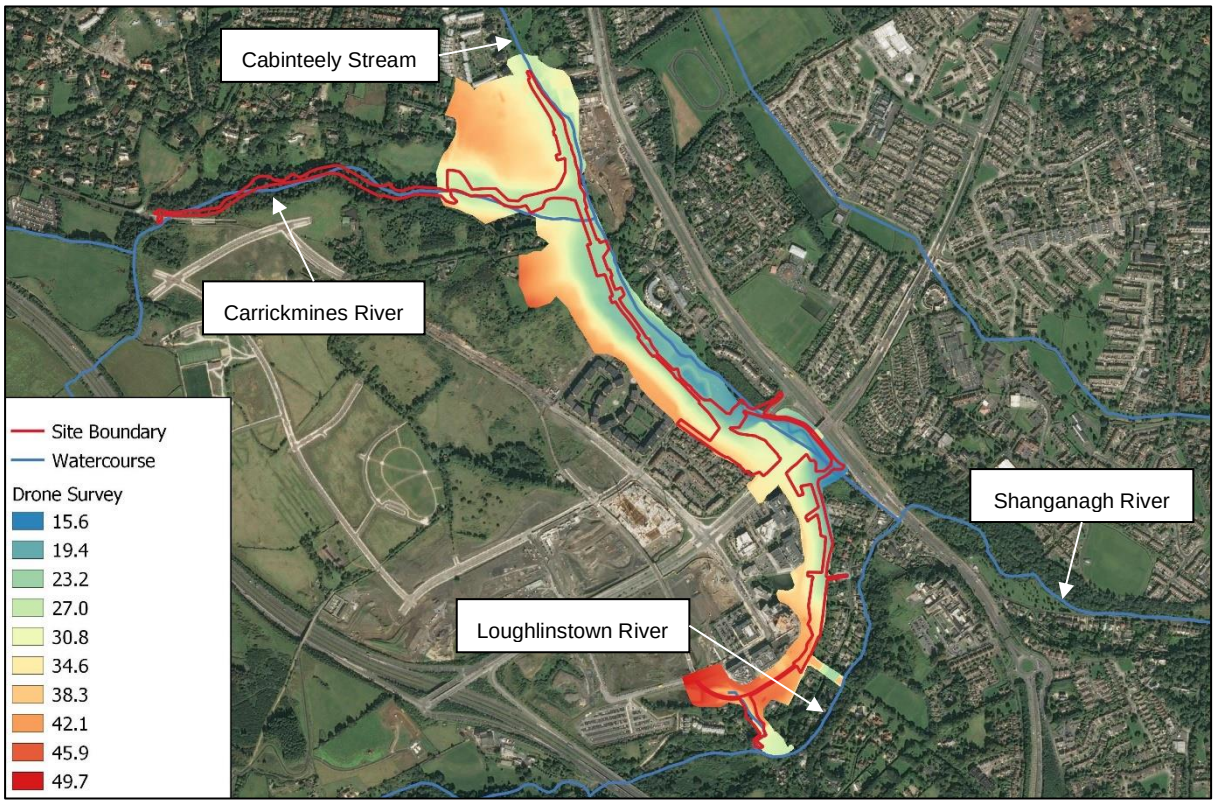


Figure 18. Drone Survey

Additional survey information was used to supplement the above coverage to ensure adequate DTM extents where developed for entirety of the model.

5.2.2 River Channel Survey

In order to construct a hydraulic model representative of the current river channel conditions it is necessary to have detailed survey information of the channel of interest. River channel surveys were undertaken as part of the CFRAM model development in November 2012 which were deemed to be of adequate detail and within a recent time period to still be utilised. This survey information was obtained from OPW via DLRCC for AECOM.

These surveys included details of the watercourse bank and bed levels. It also includes details of hydraulic structures such as bridges and culverts.

5.2.3 Hydraulic Structures

There are five hydraulic structures within the extent of the constructed baseline model as summarised in Table 5 below:

Table 5. Hydraulic Structures

Structure Location	Information	Image
1060M00386D	Footbridge over 1060M00386 Dimensions Length: 13.9m Opening: 3.1m x 1.9m U/S Invert:28.857mOD D/S Invert: 29.353mOD Road Level:31.2mOD	

Structure Location	Information	Image
1060M00351I	Culvert Dimensions Length: 9.9m Opening: 3.97m x 2m U/S Invert: 26.915mOD D/S Invert: 25.862mOD Road Level:32.13mOD	
1060M00285D	Foot Bridge Dimensions Length: 15.8m Opening: 6.64mx1.89m (WxH) U/S Invert: 16.825mOD D/S Invert: 16.918mOD Road Level:19.18mOD	
1606M00205D	Foot Bridge Dimensions Length: 16.2m Opening: 4.26mx2.3m (WxH) U/S Invert: 14.977mOD D/S Invert: 15.031mOD Road Level:17.7mOD	
1060M00195D	Foot Bridge Dimensions Length: 11.29m Opening: 3.92mx1.4m (WxH) U/S Invert: 14.805mOD D/S Invert: 14.515mOD Road Level:16.54mOD	

5.2.4 Model Build

A linked 1D-2D model of the watercourse was constructed using ESTRY/TUFLOW. The model geometry consists of river cross sections, bank lines, culverts, bridges and floodplain. The main river channel and tributaries have been constructed as a 1D channel which is then linked to the 2D floodplain. Over-bank flow allows flood waters to escape from the 1D channel into the 2D floodplain. Figure 19 below is a screenshot of the baseline model constructed.

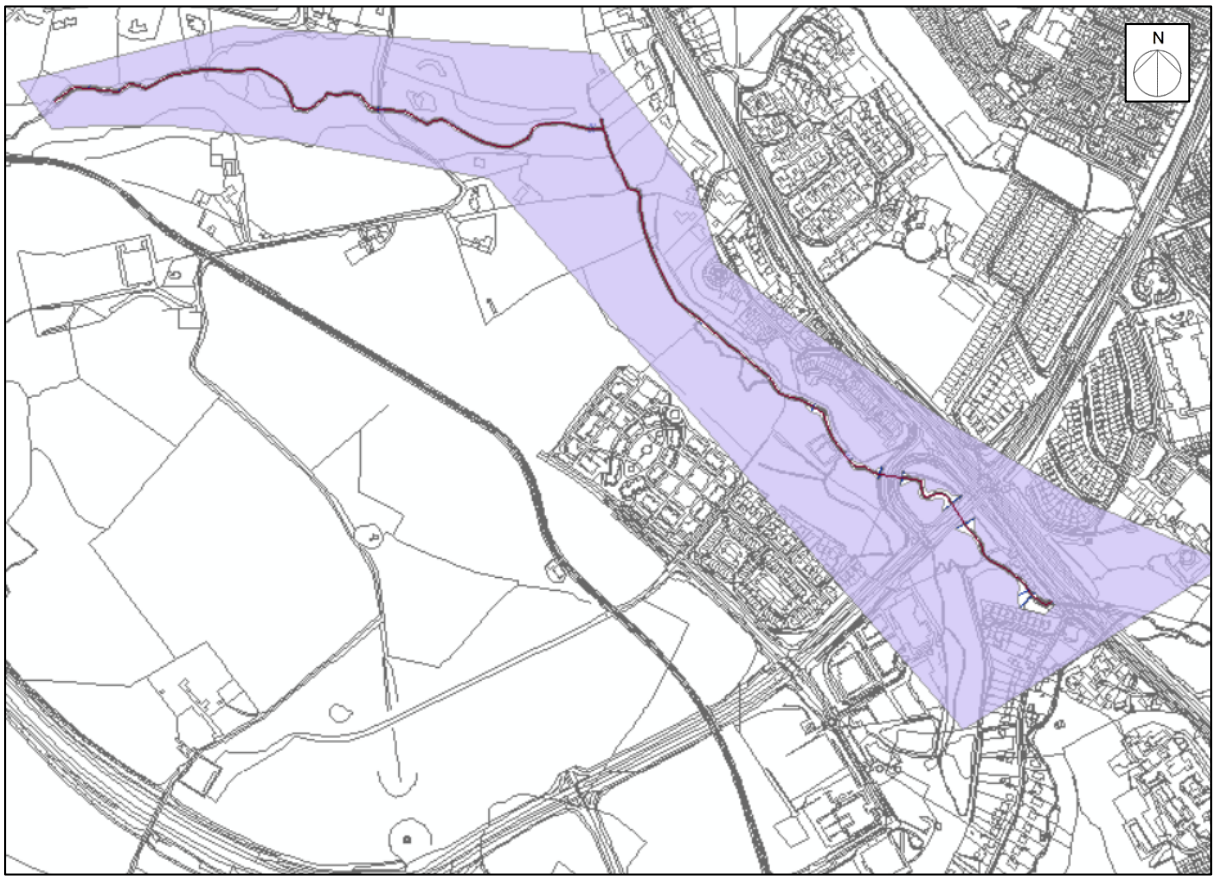


Figure 19. Baseline Model Screenshot

5.2.5 Model Parameters

ESTRY/TUFLOW operates by representing the modelled hydraulic network using a system of cross-sections and links to represent hydraulically significant features. Where cross sections represent the 1D structure of the channel from the banks to the bed, where links represent the length of the channel and channel properties.

5.2.5.1 Roughness Coefficients

Manning's 'n' values were used as a measure of the roughness of the bed and side slopes of the watercourse. Evidence from the photographic information provided as part of the survey was used to provide a best estimate of Manning's 'n' values for the terrain for use in the hydraulic model. Table 6 summarises the Manning's 'n' values used within the model

Table 6. 1D Manning's 'n' Values

Location	Manning's 'n'	Location	Manning's 'n'
Channel Bed	0.040 – 0.065	Roads tracks and paths manmade	0.02
Channel Banks	0.060 – 0.080	Roads tracks and paths tarmac or dirt tracks	0.025
Building	0.30	Rail	0.05
General surface residential yards	0.04	Water	0.035
General surface step	0.025	Land (unclassified) industrial yards, car parks	0.035
General surface grass, parkland	0.05	Slope	0.04
Water	0.035	Land, assume grass	0.04

5.3 Model Scenarios

5.3.1 Baseline Model

An existing model is constructed which is representative of the current site conditions. This is then used for simulations for 1% AEP, 1% AEP+CC and 0.1% AEP flood events to produce a baseline set of results.

5.3.2 Proposed Model

The proposed model will show the impact that the new design bridge will have on the water levels and flood extents and will be used in comparison with the baseline model to show where there is betterment or worsening caused by the structure.

A summary and commentary on the results of these are presented in the following sections.

5.4 Baseline Model Results

Figure 20 below illustrates extent of flooding for the 1% AEP flood event across the site. A breakdown of the level at each cross section is provided in Appendix B with a cross section reference plan in Appendix C.

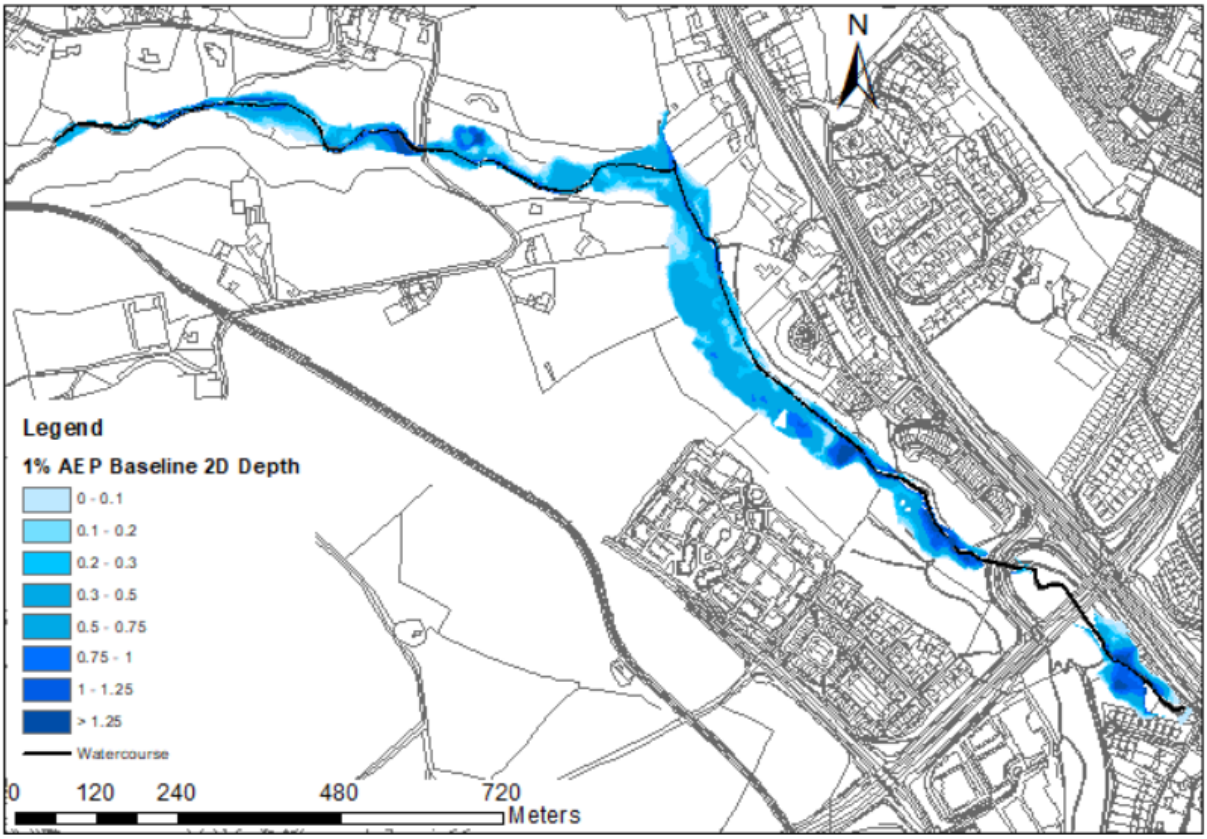


Figure 20. Existing 1% AEP Flood Extent

The existing modelled flood level upstream and downstream of the proposed bridge structure are as given in Table 7 below:

Table 7. Existing Flood Levels at Proposed Bridge Location

Cross Section	1% AEP Level (mAOD)	1%+CC AEP Level (mAOD)	Comment
1060M00317.1	25.325	25.391	Upstream of Proposed Structure
1060M00312	25.150	25.215	Upstream Face, Proposed Structure
1060M00309	24.838	24.911	Downstream of Proposed Structure

5.4.1 Flood Mechanism

Flooding would appear to occur due to a number of mechanisms in this area including:

- Lack of existing channel capacity
- Gradient surrounding the channel

Existing out of bank flooding is observed over the majority of the study area. This is attributable to a lack of capacity within the watercourse channel which spills out into a low flat lying area. The locations where there is depth of greater than 1.25m is located at low points in the ground level and at areas surrounding structures whereby flow is

constrained until channel capacity is reached, leading to flooding. It should be noted that no properties are located within the flood extents inside the study boundary.

5.5 Proposed Model Results

5.5.1 Model Development

The development of the proposed scenario was used to address the impact that an additional structure would have on river levels located on the Carrickmines River upstream of the confluence with the Cabinteely Stream. The bridge deck and channel structure were modelled in 1D with the embankments leading up to the deck modelled in the 2D.

The structure design is provided in Appendix D however it is a single span structure with a clear opening of 12.1mOD between the bridge abutments and a 4m crossing width to accommodate pedestrians and cyclists. The soffit level, and hence deck level, have been determined based on the proposed model runs to ensure 300mm freeboard is provided to the 1% AEP event. The bridge will have a 1.4m high guardrail on both the upstream and downstream sides.

Figure 21 shows the 1% AEP water level differences as a result of the placement of the new structure with the 1% AEP water levels given in Table 8.

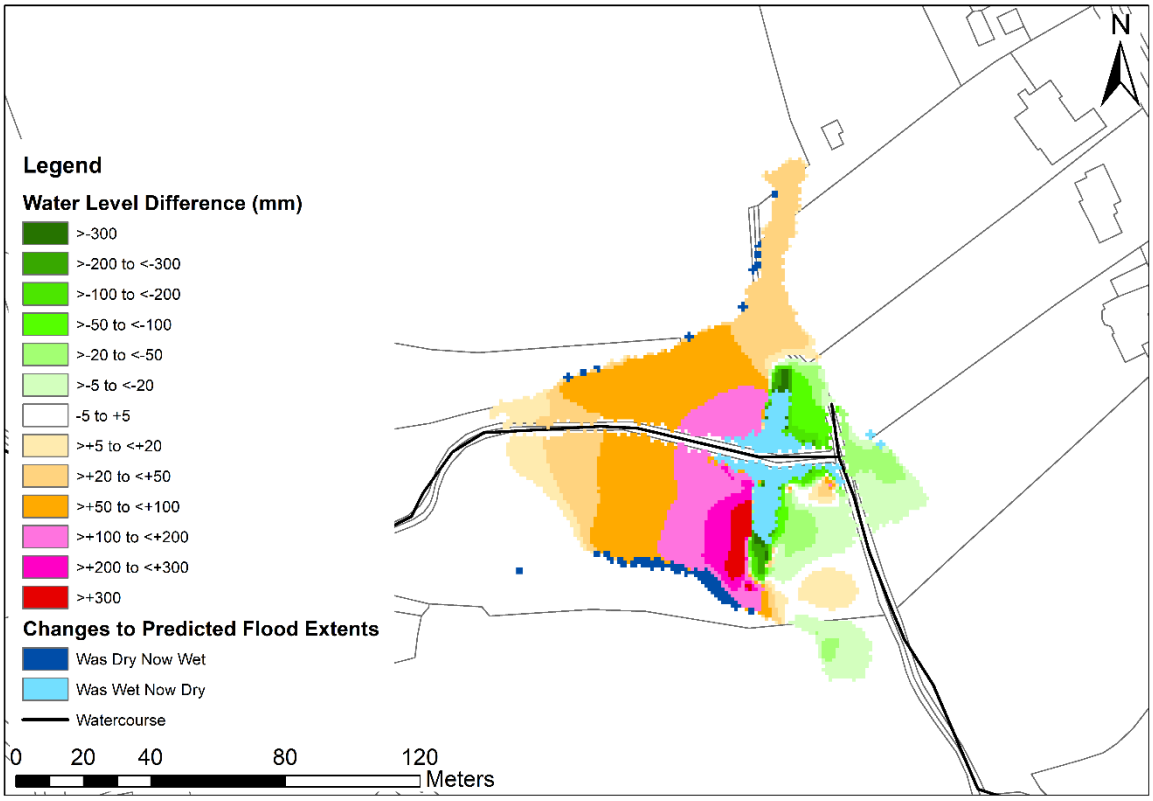


Figure 21. Proposed 1% AEP Water Level Difference at Proposed Structure

Table 8. Flood Level Difference at Proposed Bridge

Cross Section	Existing 1% AEP Level (mAOD)	Proposed 1% AEP Level (mAOD)	Difference (mm)	Comment
1060M00317	25.325	25.373	48	Upstream of Proposed Structure
1060M00312 *(Baseline)* 1060M00317.2 *(Proposed)*	25.150	25.330	180	Upstream Face, Proposed Structure
1060M00312.1	N/A	25.034	N/A	Downstream Face, Proposed Structure
1060M00309	24.838	24.827	-11	Downstream of Proposed Structure

The results from Figure 21 show that there is an increase in water level upstream of the structure as a result of the constriction of flow for the structure and the embankments altering overland flow routes. This causes any overland flow to pool against the embankment thereby increasing the water level in comparison to the baseline scenario, by between 100mm and 200mm. As a result of a higher water level upstream of the structure, there is a reduction in the water level directly downstream of the proposed structure. This can be attributed to the bridge causing overland flow to pool against the upstream side, reducing the amount that pools at the downstream side of the embankment, by up to 76mm.

Following on from the initial testing of the bridge, alterations were made to the structure to allow for 300mm freeboard between predicted flood levels and the soffit level of the bridge.

It should be noted however that the increases in the flood level are very localised to the upstream side of the structure and the changes to the flood extents are negligible and cause no impact to properties. The bridge soffit has been kept at the minimum freeboard level to reduce the extent of the approach embankments. It is acknowledged that the construction of the approach embankments will slightly reduce the floodplain volume, but this reduction is negligible in comparison to the total volume of the floodplain.

5.6 Sensitivity Analysis – Climate Change

As part of the impact testing of the proposed structure, the model was tested in for the 1%+CC AEP to assess the impact that climate change would have in the area surrounding the structure. Figure 22 below shows the 1%+CC AEP modelled water level differences and the impact it has on the proposed structure.

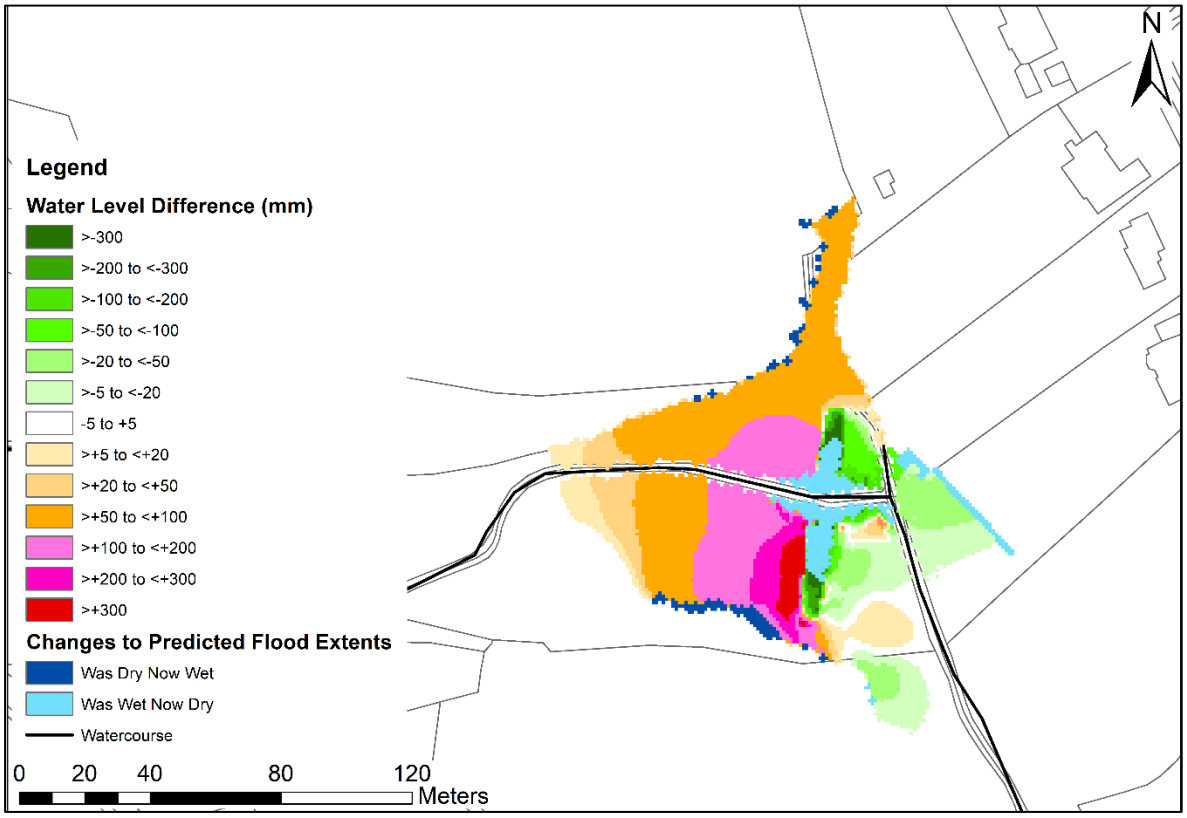


Figure 22. Proposed 1% AEP Water Level Difference at Proposed Structure 'Bridge No.1'

The water level differences between the proposed and baseline scenario in the 1%+CC AEP show similar results to that of Figure 21. There is an increase in water levels upstream of the structure primarily due to the constriction that a structure has on flow through a channel and overland flow routes. There is an increase upstream of the between 15mm and 347mm, with a decrease downstream of the structure between 73mm and 127mm. There is a negligible modelled difference throughout the rest of the model, highlighting that the impact the structure has on modelled water levels is localised. The 1%+CC AEP level at the upstream side of structure is 25.392mOD resulting in a freeboard of 238mm.

5.7 Sensitivity Analysis - Blockage

Sensitivity analysis was undertaken using the proposed model to ascertain the impact of blockages at three existing structures separately, with 20% and 80% blockage utilised, to analyse the impact that a blockage would have on water levels, shown as water level difference maps below. The locations of the existing structures where blockages were applied is given in Figure 23.

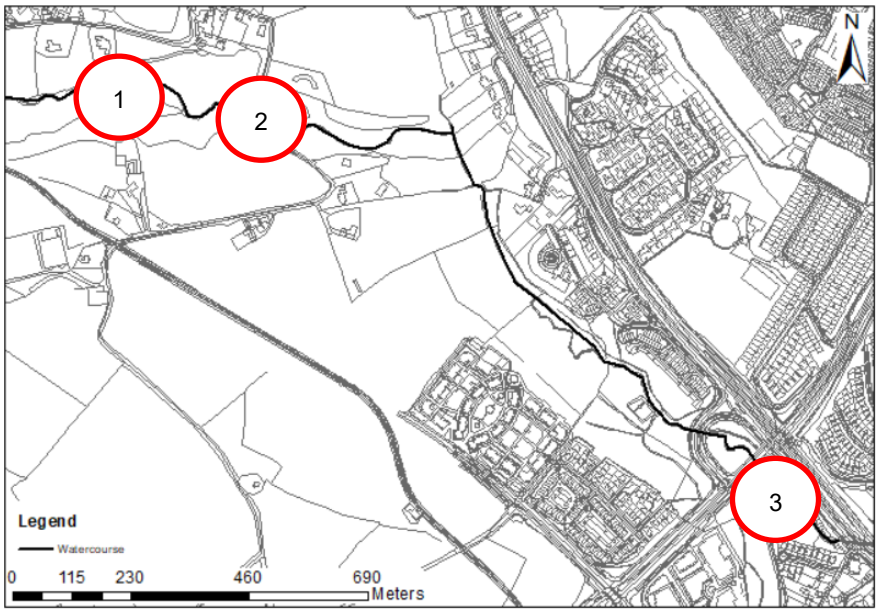


Figure 23. Blockage Sensitivity Testing Location

5.7.1 Blockage Location 1

Blockage location 1 was developed at structure 1060M00386D, to test the impact that blockages would have on the proposed scenario. Structure 1060M00386D is circa 740m upstream of the proposed structure and is an arch bridge, of span 3.1m and height 2.0m.

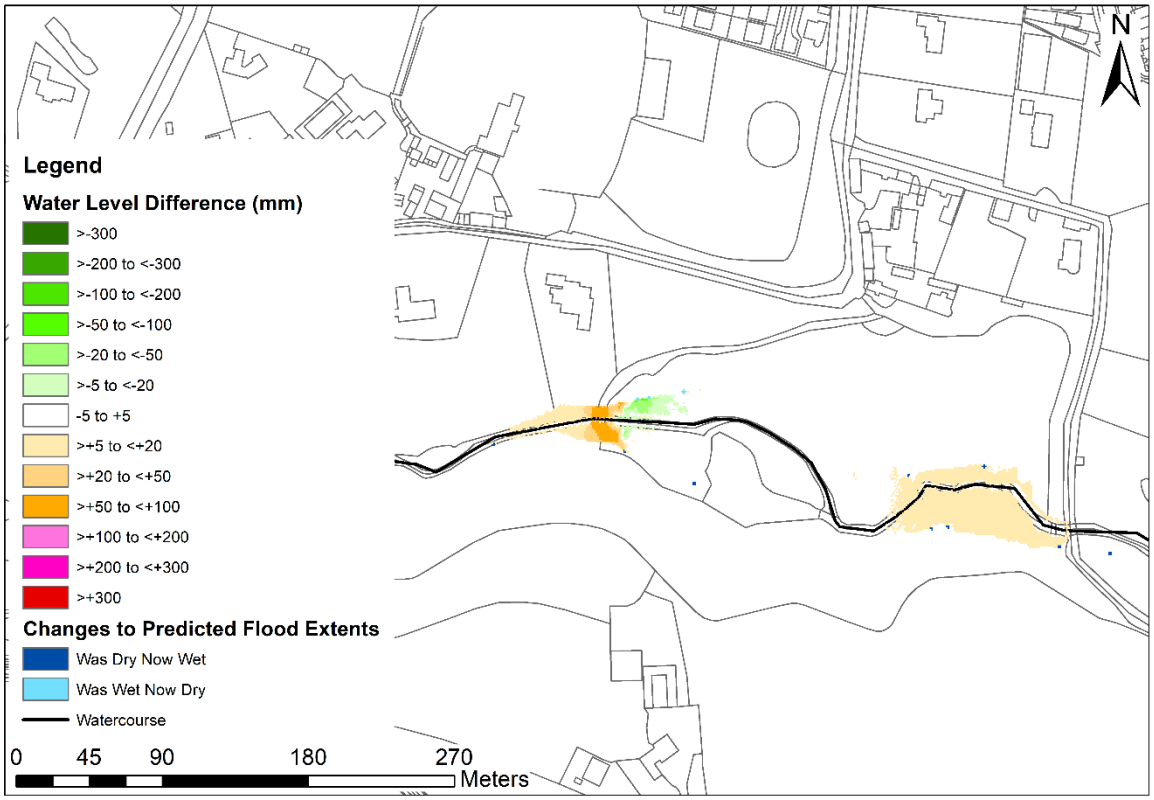


Figure 24. Proposed 1% AEP Water Level Difference (80% Blockage at Blockage Location 1)

The results of an 80% blockage at blockage location 1 shows a localised impact, as the sections of the model outside of Figure 24 show a negligible modelled change in water level and flood extents. The increase in water levels at the structure itself is up to 87mm, with small decreases in water level downstream of the structure (of up to 43mm). This shows that a blockage at this structure in the model shows a small impact in the 1% AEP event. This means that the model is not very sensitive to a blockage at structure 1060M00386D and has a negligible modelled impact on the proposed structure.

5.7.2 Blockage Location 2

Blockage location 2 is located at 1060M00351I, an arch bridge of width circa 4.0m and height 2.0m which is circa 390m upstream of the proposed structure. The impact that this has on the model is negligible as the water level differences found no change.

5.7.3 Blockage Location 3

Blockage location 3 is located at structure 1060M00205D, towards the downstream end of the model and circa 1070m downstream of the proposed structure. The existing structure is a clear span bridge of span circa 4.3m and clearance of circa 2.4m above the channel bed. Figure 25 shows the water level difference between the Blockage Location 3 scenario and the Proposed Scenario in the 1% AEP event.

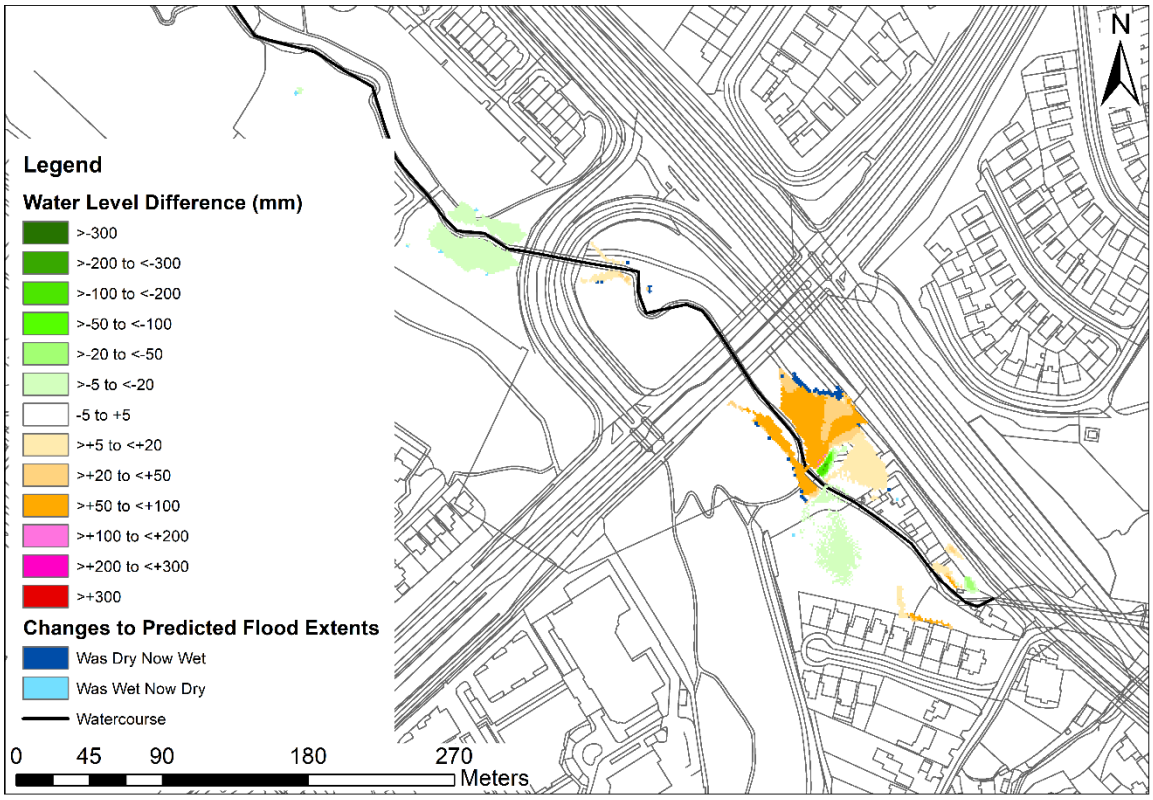


Figure 25. Proposed 1% AEP Water Level Difference (80% Blockage at Blockage Location 3)

The results of the water level difference map show a similar impact to that of the Blockage Location 1 scenario. The impact of an 80% blockage at location 3 is localised to the area around the structure and has a negligible modelled impact on the proposed structure. This is likely due to the distance between the Blockage Location 3 structure and the proposed structure. The impact at the location of 1060M00205D shows an increase upstream of the structure of between 62mm and 97mm, with a localised decrease in water level located directly downstream on the left bank of the structure of between 43mm and 127mm.

In conclusion, the impacts arising from the blockages are localised and have a negligible impact on the proposed modelled structure, primarily due to the distance between the structures.

5.8 Sensitivity Analysis – 1D Manning's 'n'

Sensitivity analysis was undertaken using the baseline model to ascertain the impact of an increase of 20% and a decrease of 20% in Manning's 'n' roughness coefficient, of the channel in 1D, on flooding in the 1% AEP event.

5.8.1 Manning's 'n' 20% Increase

Figure 26 below shows a water level difference between the 1D Manning's 'n' increase of 20% and the proposed scenario, to assess the impact that an increase in 1D Manning's 'n' values would have on the proposed 'Bridge No.1' structure and to test how sensitive the model as a whole would be to an increase in Manning's 'n' roughness.

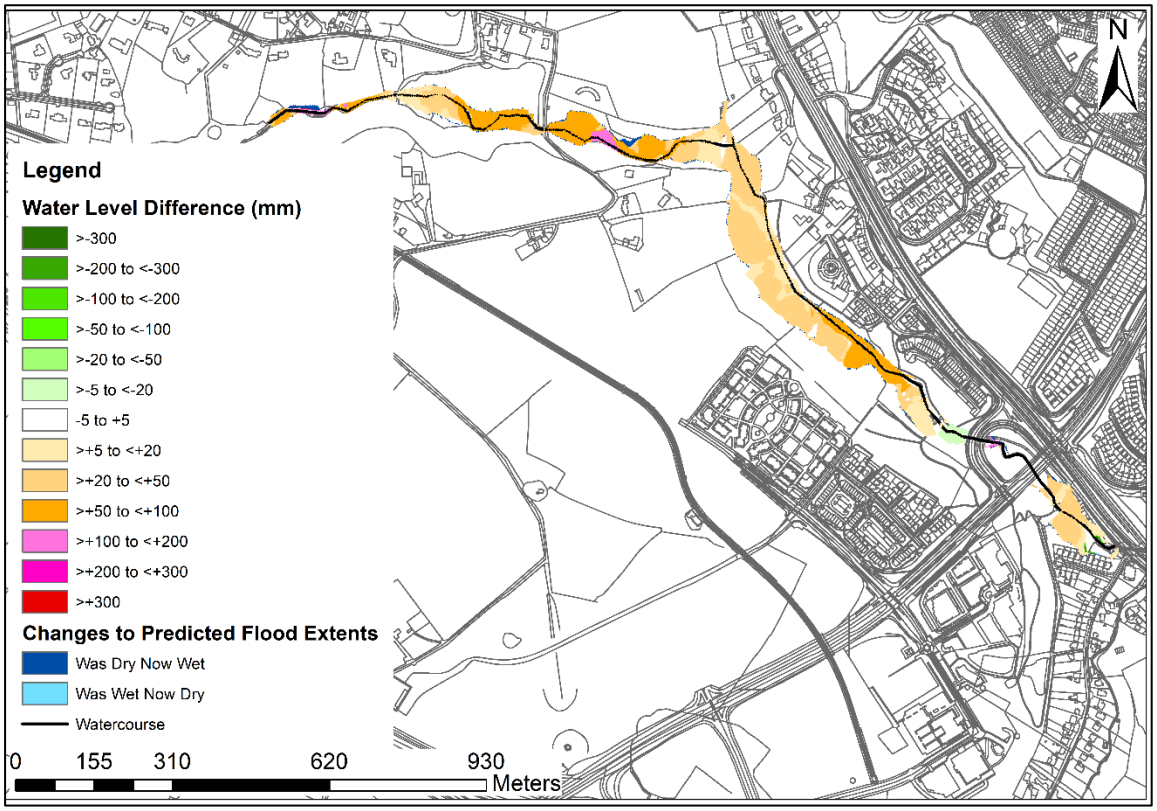


Figure 26. Proposed 1% AEP Water Level Difference (Manning's 'n' 20% Increase)

The results of an increase in 1D Manning's 'n' roughness of 20%, shows an increase in water levels throughout the majority of the model of between 17mm and 110mm. This can be due to the increased channel and bank roughness slowing down the flow of water though the channel, resulting in an increased build-up of flow in the channel, causing more out of bank flooding and thereby an increase in water levels throughout the model. With specific reference to water level difference at the proposed structure, there is an increase in water level present but only at an increase of between 17mm and 48mm. This shows that the proposed structure is sensitive to an increase in 1D Manning's 'n' roughness however it is less sensitive than the rest of the model.

5.8.2 Manning's 'n' 20% Decrease

Figure 27 shows a water level difference map compared between the Manning's 'n' decrease of 20% and the proposed scenario.

The results of the water level difference map show that in the majority of the model, there is a decrease in water levels between 14mm and 145mm. This can be due to the 1D channel being smoother which can result in increased 1D velocity, allowing flows to pass downstream faster than it would in the proposed scenario. As a result of this there is an increase in water levels further downstream, ranging between 34mm and 225mm. This comparison shows that the proposed scenario is sensitive to a decrease of 1D Manning's 'n' roughness by 20%.

To conclude, the proposed scenario is sensitive to a change in Manning's 'n' roughness by +/- 20%. The water level difference around the proposed structure is also sensitive to the change in Manning's, but not as sensitive as the change in water level at the overall model.

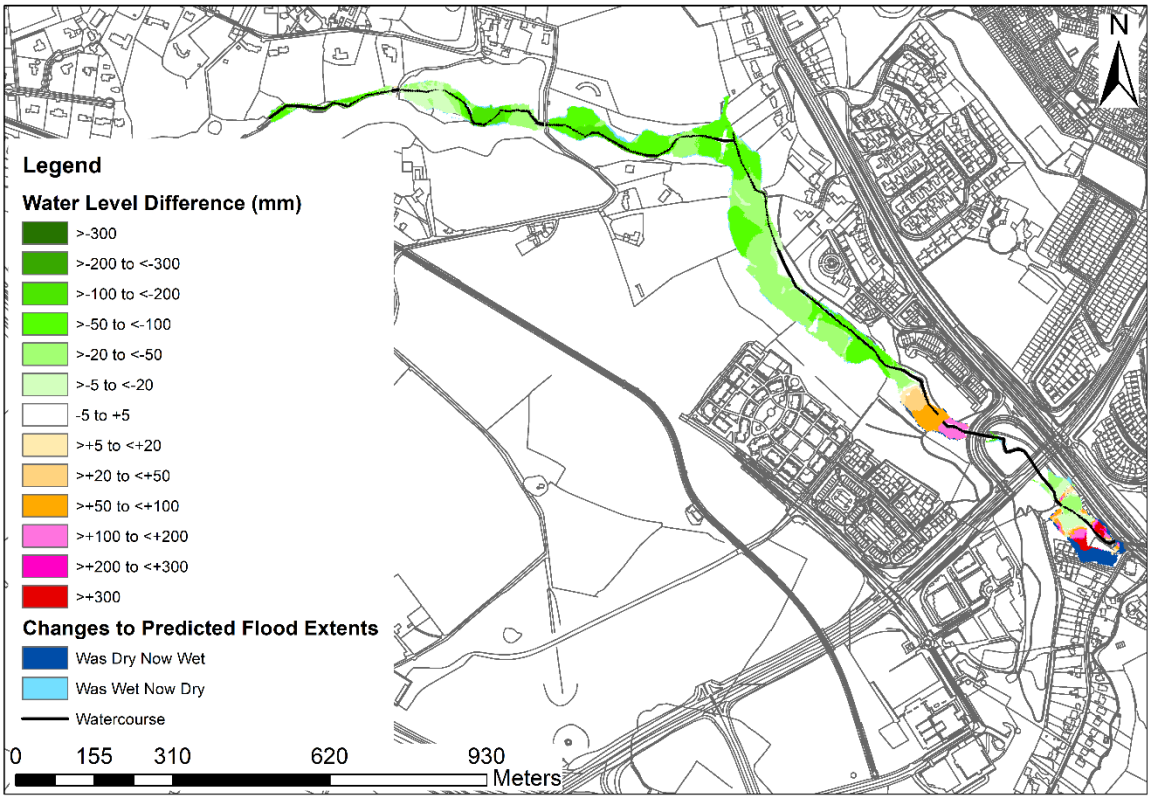


Figure 27. Proposed 1% AEP Water Level Difference (Manning's 'n' 20% Decrease)

5.9 Detailed Flood Risk Assessment Conclusion

A hydraulic model was developed to assess the flood risk associated within the Cherrywood area. One proposed structure is to be constructed along the watercourse. The model has also included Cabinteely Stream as the structure is to be constructed close of the confluence of the Carrickmines River and Cabinteely Stream.

A hydrological assessment was undertaken of the watercourses in the study area with flows generated for the 1% AEP and 1%+CC AEP (MRFS). These were then run through the baseline and proposed model to assess impacts at a greater exceedance.

This assessment included the development of a linked ESTRY/TUFLOW hydraulic model from surveyed information including cross sections. A baseline and proposed scenario were developed.

The analysis of the baseline model showed flooding attributed to the low gradient around the banks of the channel and channel capacity, resulting in out of channel flooding throughout most of the model.

The proposed model, implementing the proposed bridge, showed a localised impact around the structure itself, viewing an increase in water levels directly upstream of it, whilst reducing water level directly downstream of the structure, adjustments have been made to the structure to allow an acceptable 300mm freeboard on the structure.

Sensitivity testing was undertaken to assess how sensitive the model would be based on a change in Manning's 'n' roughness and the impact that blockages at three existing structures would have on the model, with reference to the proposed structure. The conclusion found that the model was sensitive to a change in Manning's 'n' values. The impact that the blockages have on the model are localised and have a negligible impact on the proposed structure. Sensitivity testing was also undertaken for Climate Change with an increase in level at the proposed bridge for the MRFS Climate Change run of 62mm in comparison with the present day flows.

6. Conclusion

AECOM have been commissioned by Dún Laoghaire-Rathdown County Council to undertake a Flood Risk Assessment as part of the Part 8 Planning process for the Green (Greenway, Cycle and Pedestrian) Routes Network for the Cherrywood SDZ.

The Stage 1 – Flood Risk Identification identified that the site is likely to be impacted by fluvial flooding with flooding identified in the CFRAM study, DLRCC SFRA and County Development Plan and a planning application for a development at 'Beech Park'.

The Stage 2 – Initial Flood Assessment determined that the proposed project would be classified as "water-compatible" development as it is "amenity/open space". The construction of the scheme within 'Flood Zone A' is appropriate without the need for further justification.

A new bridge structure is proposed on the Carrickmines River just upstream of the confluence with the Cabinteely Stream. A hydraulic modelling exercise has been subsequently undertaken to determine the flood levels at this location and the impact of the new bridge structure to satisfy the requirements of OPW as part of the Section 50 Application process. This modelling exercise found that the bridge would have a very limited impact in a localised area in the vicinity of the structure.

Appendix A Flood Flow Estimation

Input Data

S1085	11.9397	m/km	*from FSU*
URBAN	0.3693		*from FSU*
SAAR	950	mm	*from FSR Maps*
MSL	9.086	km	*from FSU*
S1	0.40		*from FSR Maps*
S2	0.36		*from FSR Maps*
S3	0.00		*from FSR Maps*
S4	0.00		*from FSR Maps*
S5	0.24		*from FSR Maps*
CWI	123.5	mm	*from chart*
P	70.3	mm	*from FSU*
Area	20.039	km^2	*from FSU*
ARF	0.932		*from FSU*

$Tp(0) = 283.0\ S1085^{-0.33}\ (1+URBAN)^{-2.2}\ SAAR^{-0.54}\ MSL^{0.23}$ — Tp(0) 2.56 hrs

$T = Tp(0)/5$ — T 0.50 hrs

$Tp(T) = Tp(0) + T/2$ — Tp(T) 2.81 hrs

$D = (1.0+SAAR/1000)T_p$ — Dcalc 5.48 hrs

D 5.50 hrs

$SPR = 10\ S1 + 30\ S2\ \ 37\ S3 + 47\ S4 + 53\ S5$ — SPR 27.56

$DPR_{CWI} = 0.25\ (CWI - 125)$ — DPRcwi -0.38

$DPR_{RAIN} = 0.45\ (P - 40)^{0.7}$ for $P > 40$ mm; $= 0$ for $P \leq 40$ mm — DPRrain 4.90

$PR_{RURAL} = SPR + DPR_{CWI} + DPR_{RAIN}$ — PRrural 32.08

$PR_{TOTAL} = PR_{RURAL}\ (1.0 - 0.3\ URBAN) + 70\ (0.3\ URBAN)$ — PRtotal 36.28

$ANSF = [33\ (CWI - 125) + 3.0\ SAAR + 5.5] \times 10^{-5}$ — ANSF 0.03

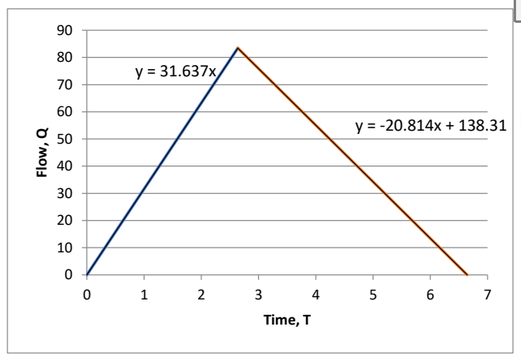
Unit Hydrograph

$Qp = 220/Tp(T)$ — Qp 78.24

$Tb = 2.52Tp(T)$ — Tb 7.09

0	0
2.81	78.24
7.09	0

Rise, x	27.827
Fall, x	-18.307
Fall, intercept	129.719



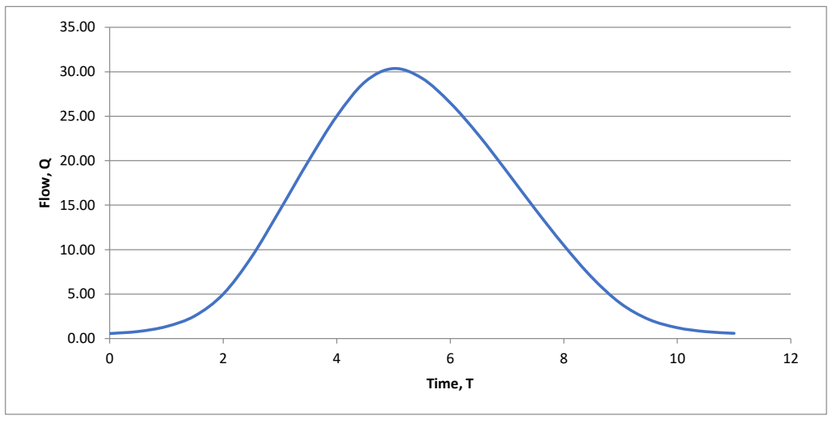
Rainfall Distribution

% Duration	% Rain	Increment %	Increment (mm)
11.11	26	26	17.04
33.33	64	38	24.90
55.56	83	19	12.45
77.78	93	10	6.55
100.00	100	7	4.59

Interval	Total Rain (mm)	Net Rain (mm)
1	2.29	0.83
2	3.28	1.19
3	6.22	2.26
4	12.45	4.52
5	17.04	6.18
6	12.45	4.52
7	6.22	2.26
8	3.28	1.19
9	2.29	0.83

Convolution of Unit Hydrograph and Net Rain Profile

	Unit Hydrograph (cumecs)																					
Net Rain (cm)	0	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50	11.00
	0.00	2.79	5.58	8.36	11.15	13.94	14.99	13.15	11.32	9.49	7.65	5.82	3.98	2.15	0.31								
0.08	0.00	0.23	0.46	0.70	0.93	1.16	1.25	1.09	0.94	0.79	0.64	0.48	0.33	0.18	0.03								
0.12		0.00	0.33	0.66	0.99	1.33	1.66	1.78	1.56	1.35	1.13	0.91	0.69	0.47	0.26	0.04							
0.23			0.00	0.63	1.26	1.89	2.52	3.15	3.38	2.97	2.56	2.14	1.73	1.31	0.90	0.49	0.07						
0.45				0.00	1.26	2.52	3.78	5.04	6.30	6.77	5.94	5.11	4.28	3.46	2.63	1.80	0.97	0.14					
0.23					0.00	0.63	1.26	1.89	2.52	3.15	3.38	2.97	2.56	2.14	1.73	1.31	0.90	0.49	0.07				
0.12						0.00	0.33	0.66	0.99	1.33	1.66	1.78	1.56	1.35	1.13	0.91	0.69	0.47	0.26	0.04			
0.08							0.00	0.23	0.46	0.70	0.93	1.16	1.25	1.09	0.94	0.79	0.64	0.48	0.33	0.18	0.03		
Total	*0.00*	*0.23*	*0.80*	*1.99*	*4.44*	*8.62*	*13.91*	*19.38*	*24.45*	*28.31*	*29.80*	*28.72*	*25.94*	*22.31*	*18.19*	*13.95*	*9.93*	*6.28*	*3.39*	*1.58*	*0.66*	*0.22*	*0.03*
Base Flow	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56
Total Q	**0.56**	**0.79**	**1.36**	**2.55**	**5.00**	**9.18**	**14.47**	**19.94**	**25.01**	**28.87**	**30.36**	**29.28**	**26.50**	**22.87**	**18.75**	**14.52**	**10.49**	**6.84**	**3.95**	**2.15**	**1.22**	**0.78**	**0.59**



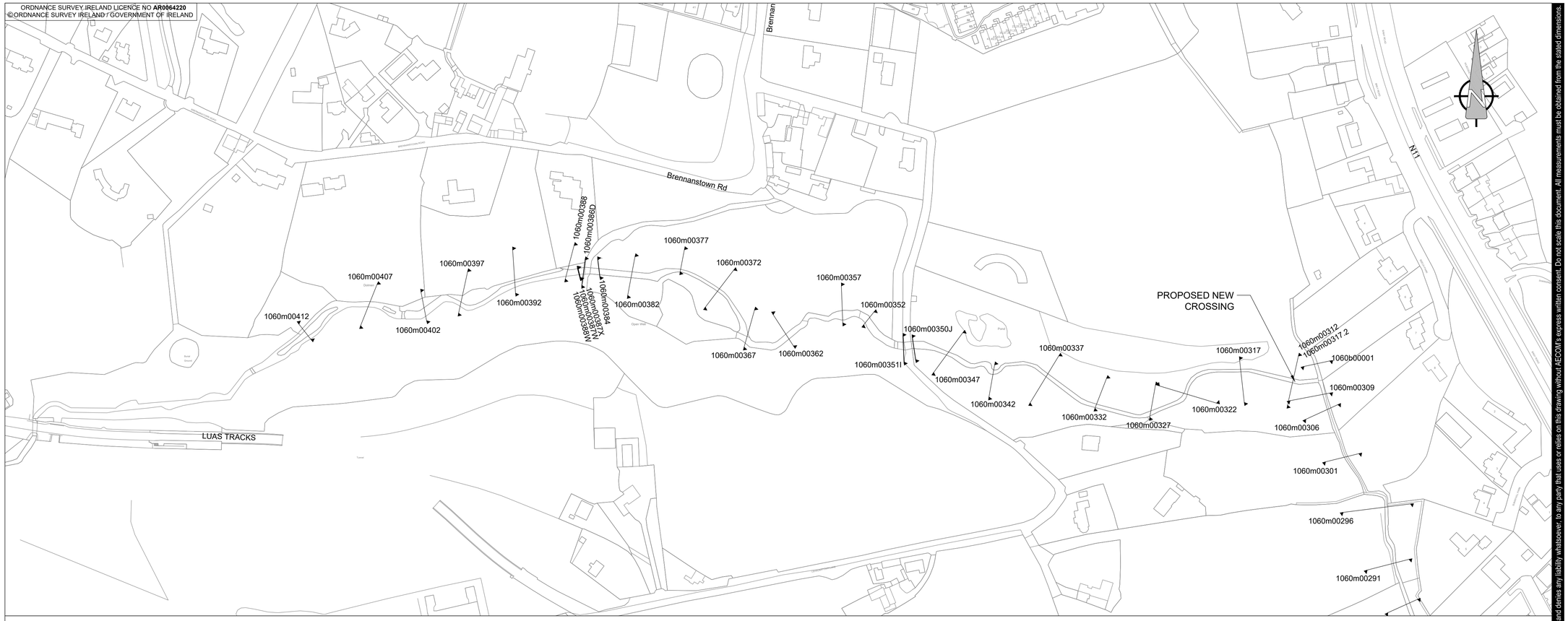
Appendix B Model Results

Note: ESTRY/TUFLOW outputs water levels at node points; any node ID with a ".1" suffix is at the cross section location indicated. Node IDs with a ".2" suffix is the downstream computational node associated with that reach. Not all reaches will report the ".2" node.

Node ID	Flood Level; 1% AEP Baseline mAOD		Node ID	Flood Level; 1% AEP Proposed mAOD	Difference (mm)
1060B00001.1	25.236		1060B00001.1	25.181	-55
1060B00001.2	25.236		1060B00001.2	25.172	-64
1060M00191.1	17.980		1060M00191.1	17.976	-4
1060M00191.2	16.411		1060M00191.2	16.411	0
1060M00195.1	17.979		1060M00195.1	17.977	-2
1060M00203.1	18.013		1060M00203.1	18.011	-2
1060M00203.2	17.989		1060M00203.2	17.988	-2
1060M00205.1	18.266		1060M00205.1	18.265	-1
1060M00211.1	18.431		1060M00211.1	18.429	-2
1060M00216.1	18.440		1060M00216.1	18.438	-2
1060M00226.1	19.081		1060M00226.1	19.079	-2
1060M00226.2	18.726		1060M00226.2	18.724	-2
1060M00231.1	19.686		1060M00231.1	19.692	6
1060M00236.1	19.723		1060M00236.1	19.723	0
1060M00238.1	19.825		1060M00238.1	19.859	34
1060M00246.1	20.269		1060M00246.1	20.278	9
1060M00246.2	20.059		1050M00246.2	20.082	23
1060M00257.1	20.511		1060M00257.1	20.516	5
1060M00257.2	20.325		1060M00257.2	20.333	8
1060M00266.2	20.641		1060M00266.2	20.644	3
1060M00272.1	21.623		1060M00272.1	21.623	0
1060M00276.1	21.933		1060M00276.1	21.933	0
1060M00281.1	22.805		1060M00281.1	22.806	0
1060M00281.2	22.341		1060M00281.2	22.341	0
1060M00286.1	23.245		1060M00286.1	23.245	0
1060M00291.1	23.499		1060M00291.1	23.499	0
1060M00296.1	23.902		1060M00296.1	23.902	0
1060M00301.1	24.393		1060M00301.1	24.393	0
1060M00301.2	24.025		1060M00301.2	24.025	0
1060M00309.1	24.838		1060M00309.1	24.827	-11
1060M00309.2	24.539		1060M00309.2	24.544	5
No Section			1060M00312.1	25.034	N/A
1060M00312.1	25.150		1060M00317.2	25.330	180
1060M00317.1	25.325		1060M00317.1	25.373	48
1060M00322.1	26.070		1060M00322.1	26.071	1
1060M00322.2	25.618		1060M00322.2	25.615	-3
1060M00327.1	26.302		1060M00327.1	26.303	1
1060M00332.1	26.587		1060M00332.1	26.587	1
1060M00337.1	27.093		1060M00337.1	27.094	1
1060M00342.1	27.434		1060M00342.1	27.435	1
1060M00347.1	27.520		1060M00347.1	27.521	1
1060M00350.1	27.750		1060M00350.1	27.751	1
1060M00351.1	29.086		1060M00351.1	29.090	4
1060M00352.1	29.160		1060M00352.1	29.164	3
1060M00352.2	29.139		1060M00352.2	29.143	3
1060M00357.1	29.179		1060M00357.1	29.182	3
1060M00362.1	29.412		1060M00362.1	29.414	2
1060M00367.1	29.542		1060M00367.1	29.543	1
1060M00372.1	30.052		1060M00372.1	30.053	1
1060M00377.1	30.584		1060M00377.1	30.585	1
1060M00382.1	30.695		1060M00382.1	30.695	0
1060M00384.1	30.718		1060M00384.1	30.720	2
1060M00386.1	31.210		1060M00386.1	31.212	2
1060M00388.1	31.456		1060M00388.1	31.457	1
1060M00392.1	31.969		1060M00392.1	31.970	1
1060M00397.1	32.735		1060M00397.1	32.735	0
1060M00402.1	33.739		1060M00402.1	33.739	0
1060M00407.1	35.557		1060M00407.1	35.557	0
1060M00412.1	38.671		1060M00412.1	38.671	0
1060M00412.2	36.956		1060M00412.2	36.956	0

Node ID	Flood Level; 1%+CC AEP Baseline mAOD		Node ID	Flood Level; 1%+CC AEP Proposed mAOD	Difference (mm)
1060B00001.1	25.315		1060B00001.1	25.241	-74
1060B00001.2	25.315		1060B00001.2	25.241	-74
1060M00191.1	17.811		1060M00191.1	17.849	38
1060M00191.2	16.411		1060M00191.2	16.411	0
1060M00195.1	18.102		1060M00195.1	18.100	-2
1060M00203.1	18.133		1060M00203.1	18.131	-2
1060M00203.2	18.112		1060M00203.2	18.110	-2
1060M00205.1	18.345		1060M00205.1	18.344	-1
1060M00211.1	18.536		1060M00211.1	18.535	-2
1060M00216.1	18.551		1060M00216.1	18.549	-2
1060M00226.1	19.245		1060M00226.1	19.242	-2
1060M00226.2	18.889		1060M00226.2	18.886	-3
1060M00231.1	19.875		1060M00231.1	19.881	7
1060M00236.1	19.903		1060M00236.1	19.905	1
1060M00238.1	19.991		1060M00238.1	20.022	31
1060M00246.1	20.402		1060M00246.1	20.412	10
1060M00246.2	20.221		1060M00246.2	20.243	22
1060M00257.1	20.656		1060M00257.1	20.661	5
1060M00257.2	20.461		1060M00257.2	20.470	9
1060M00266.2	20.780		1060M00266.2	20.783	3
1060M00272.1	21.717		1060M00272.1	21.716	0
1060M00276.1	22.013		1060M00276.1	22.013	0
1060M00281.1	22.846		1060M00281.1	22.845	0
1060M00281.2	22.381		1060M00281.2	22.381	0
1060M00286.1	23.303		1060M00286.1	23.303	0
1060M00291.1	23.547		1060M00291.1	23.546	0
1060M00296.1	23.964		1060M00296.1	23.964	0
1060M00301.1	24.467		1060M00301.1	24.467	0
1060M00301.2	24.090		1060M00301.2	24.089	0
1060M00309.1	24.911		1060M00309.1	24.899	-12
1060M00309.2	24.614		1060M00309.2	24.619	5
No Section			1060M00312.1	25.101	N/A
1060M00312.1	25.215		1060M00317.2	25.392	177
1060M00317.1	25.391		1060M00317.1	25.454	63
1060M00322.1	26.146		1060M00322.1	26.146	0
1060M00322.2	25.682		1060M00322.2	25.679	-3
1060M00327.1	26.383		1060M00327.1	26.382	0
1060M00332.1	26.690		1060M00332.1	26.689	-1
1060M00337.1	27.228		1060M00337.1	27.227	-1
1060M00342.1	27.549		1060M00342.1	27.549	-1
1060M00347.1	27.605		1060M00347.1	27.604	-1
1060M00350.1	27.844		1060M00350.1	27.844	-1
1060M00351.1	29.645		1060M00351.1	29.640	-5
1060M00352.1	29.687		1060M00352.1	29.682	-5
1060M00352.2	29.675		1060M00352.2	29.670	-5
1060M00357.1	29.693		1060M00357.1	29.687	-5
1060M00362.1	29.783		1060M00362.1	29.779	-4
1060M00367.1	29.809		1060M00367.1	29.805	-3
1060M00372.1	30.125		1060M00372.1	30.125	0
1060M00377.1	30.655		1060M00377.1	30.653	-1
1060M00382.1	30.764		1060M00382.1	30.762	-2
1060M00384.1	30.774		1060M00384.1	30.772	-1
1060M00386.1	31.326		1060M00386.1	31.325	-1
1060M00388.1	31.560		1060M00388.1	31.560	-1
1060M00392.1	32.117		1060M00392.1	32.116	-1
1060M00397.1	32.811		1060M00397.1	32.811	-1
1060M00402.1	33.889		1060M00402.1	33.888	-1
1060M00407.1	35.671		1060M00407.1	35.669	-2
1060M00412.1	38.734		1060M00412.1	38.734	0
1060M00412.2	37.042		1060M00412.2	37.040	-1

Appendix C Modelled Cross Sections



AECOM

PROJECT

Cherrywood Green Routes Network

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NOTES

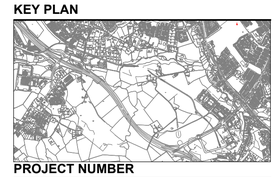
1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT ENGINEERING DRAWINGS. ANY DISCREPANCIES, ERRORS OR OMISSIONS TO BE BROUGHT TO THE ATTENTION OF THE DESIGNER.
2. THE LOCATION AND DEPTH OF SERVICES TO BE CHECKED ON SITE PRIOR TO COMMENCING ANY WORKS. NO WARRANTY GIVEN AS TO THE ACCURACY OF THE INFORMATION PROVIDED.
3. THE EMPLOYERS REPRESENTATIVE IS TO BE INFORMED BY THE CONTRACTOR OF ANY DISCREPANCIES PRIOR TO COMMENCEMENT OF WORKS ON SITE.
4. DO NOT SCALE. ALL MEASUREMENTS AND COORDINATES TO BE CHECKED ON SITE.
5. LOCATIONS OF EXISTING SERVICES ARE INDICATIVE ONLY, THE CONTRACTOR MUST LIAISE WITH EACH UTILITY PROVIDER THROUGHOUT THE WORKS.
6. THE CONTRACTOR IS TO ENSURE THAT DISTURBANCE TO LOCAL WATER, POWER OR TELEPHONE SUPPLY MUST BE AVOIDED WHERE POSSIBLE, WHERE UNAVOIDABLE. IT MUST BE KEPT TO A MINIMUM AND PROPERTY OWNERS NOTIFIED IN ADVANCE OF PROPOSED WORKS.
7. THE CONTRACTOR IS TO PRESUME THAT ALL EIRCOM, VIRGIN AND BT DUCTS CONTAIN FIBRE OPTIC CABLES.
8. NO LIABILITY IS ACCEPTED FOR ANY DISCREPANCY, OMISSION OR DEVIATION BETWEEN THE ACTUAL LOCATION OF MAINS AND SERVICES AND THE LOCATIONS SHOWN ON THE DRAWINGS. THE ACTUAL LOCATION MUST BE BE VERIFIED AND ESTABLISHED BY THE CONTRACTOR ON SITE BEFORE ANY MECHANICAL EXCAVATING PLANT IS USED.
9. THE INFORMATION IS SUPPLIED WITHOUT PREJUDICE AND DOES NOT RELIEVE THE CONTRACTOR OF HIS RESPONSIBILITY TO CONTACT EACH OF THE RELEVANT UTILITY COMPANIES DIRECTLY TO SATISFY HIMSELF OF THE LOCATIONS OF ALL SERVICES PRIOR TO EXCAVATION WORKS.
10. ALL EXISTING SERVICES TO BE PROTECTED IN PLACE UNDER NEW CARRIAGEWAY, FOOTPATH AND CYCLE TRACKS WITH 150mm ST2 CONCRETE AS SHOWN ON CC-SCD-00561 UNLESS STATED OTHERWISE.
11. ALL EXISTING SERVICES WITHIN 750mm OF THE NEW ROAD SURFACE SHALL BE SURROUNDED WITH 150mm ST2 CONCRETE AS SHOWN ON CC-SCD-00561.

ISSUE/REVISION

AECOM DRAFT

I/R	DATE	DESCRIPTION
A	NOV 2020	ISSUED FOR INFORMATION

KEY PLAN



PROJECT NUMBER

60599677

SHEET TITLE

FLOOD RISK ASSESSMENT
MODELLED CROSS SECTIONS

SHEET NUMBER

60599677_FRA_SHT_001

Project Management Initials: Designer: TM Checked: BMcM Approved: JS ISO A1 594mm x 841mm

Last saved by: RICHARD REID(2020-11-20) Last Plotted: 2020-11-20
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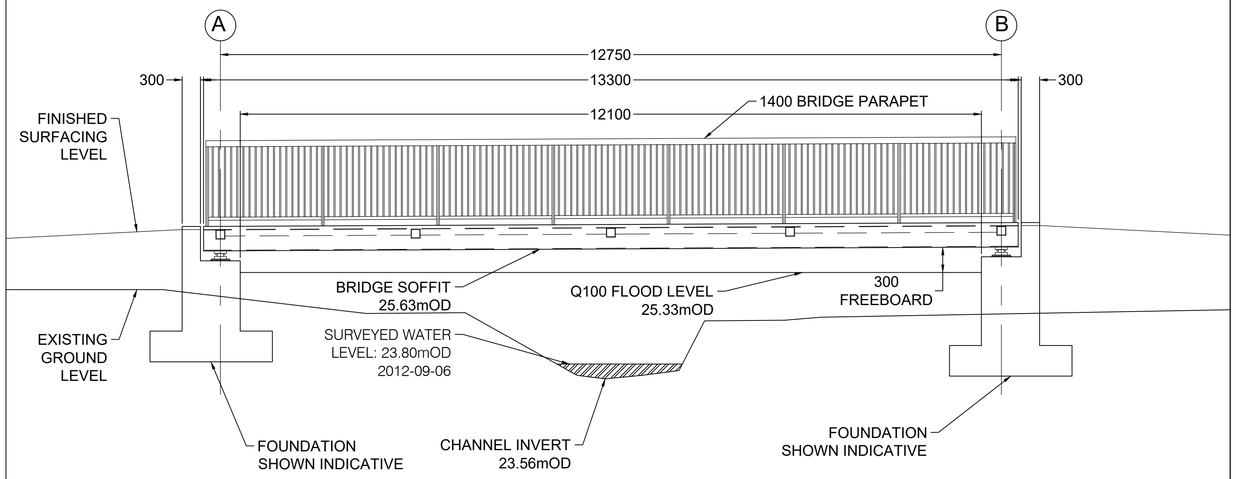
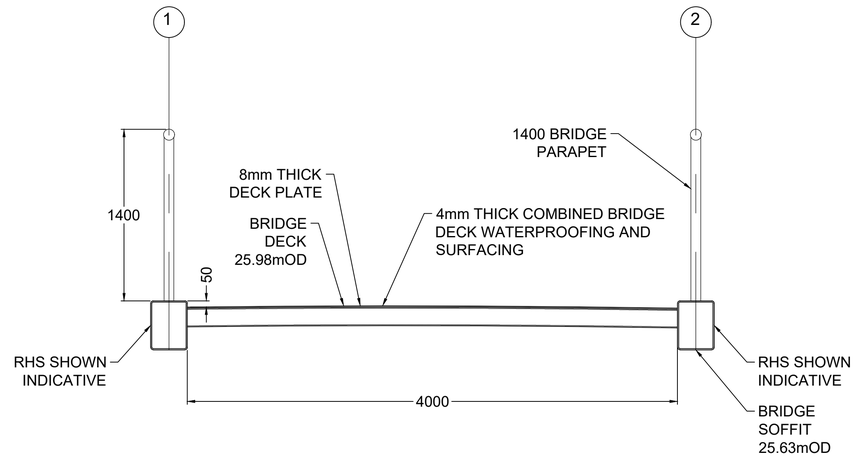
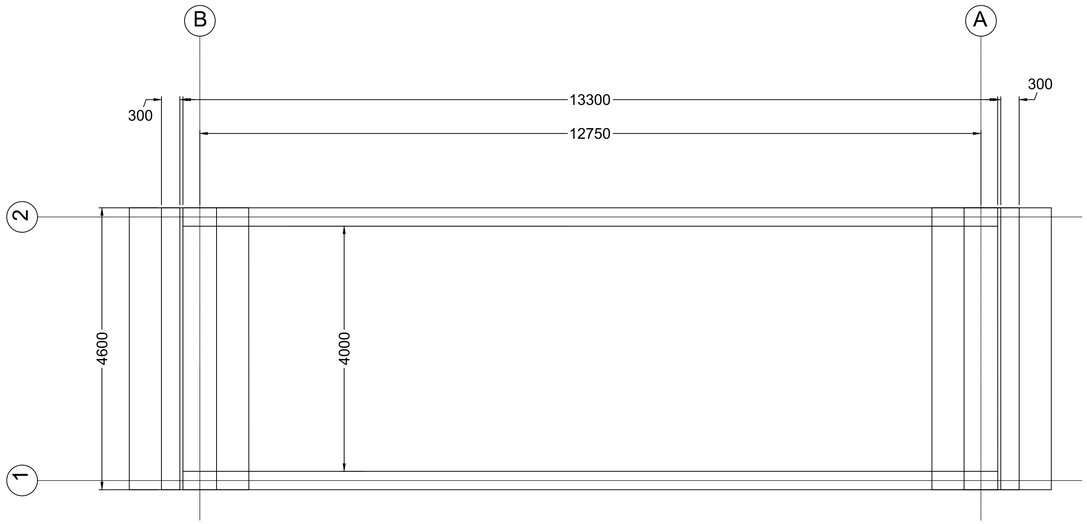
Appendix D Structure Proposals



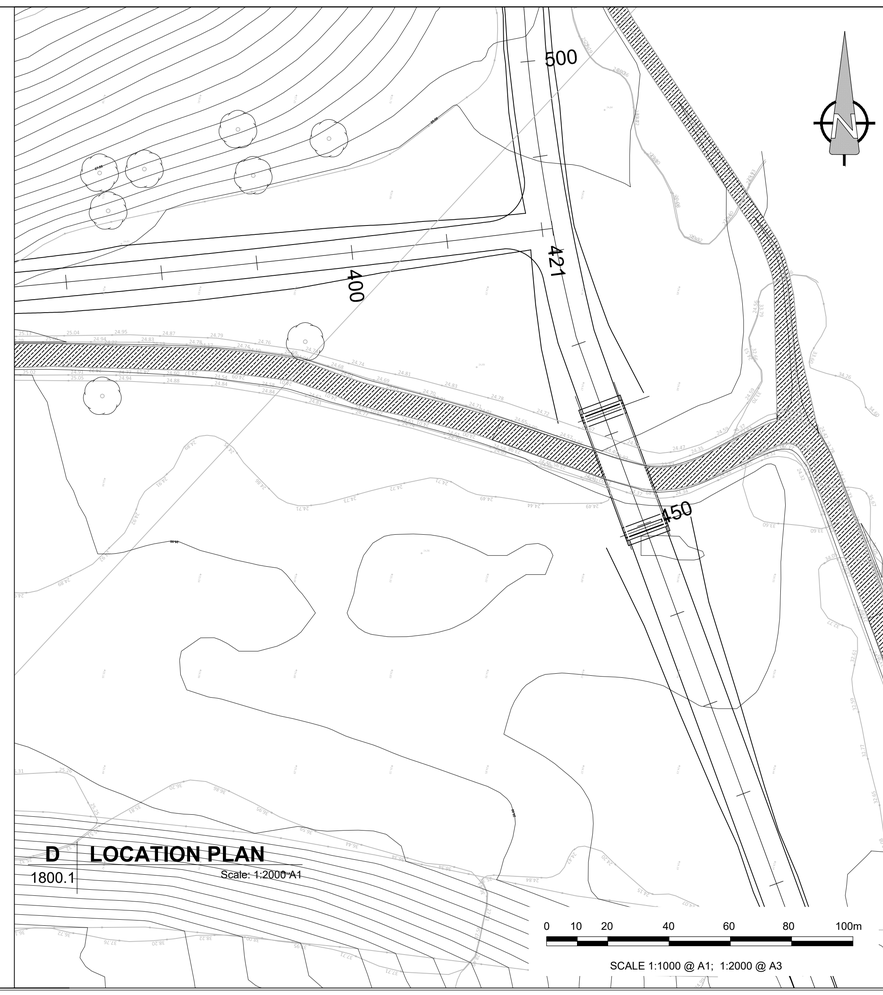
B | **ELEVATION A-A**
1800.1 Scale: 1:50 A1



C | **SECTION 1-1**
1800.1 Scale: 1:25 A1



A | **PLAN**
1800.1 Scale: 1:50 A1



D | **LOCATION PLAN**
1800.1 Scale: 1:2000 A1

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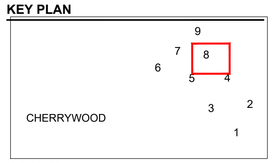
2. DO NOT SCALE. ALL MEASUREMENTS AND COORDINATES TO BE CHECKED ON SITE.

ISSUE/REVISION

AECOM DRAFT

I/R	DATE	DESCRIPTION
B	NOV 2020	SECTION 50 APPLICATION
A	FEB 2020	ISSUED FOR INFORMATION

KEY PLAN



PROJECT NUMBER

60599677

SHEET TITLE

CARRICKMINES RIVER BRIDGE NO.1
GENERAL ARRANGEMENT

SHEET NUMBER

SHT_1800.1

Project Management Initials: Designer: CM Checked: AC Approved: BMcM ISO A1 594mm x 841mm
Last saved by: RICHARD.REID(2020-11-19) Last Plotted: 2020-11-19
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