Great Connell SHD, Newbridge Flood Risk Assessment

Technical Report

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Aston Limited

Great Connell

Newbridge

Co. Kildare

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Contract

This report describes work commissioned by Sinead Fenton, on behalf of Aston Limited , by email dated 19/12/2019. Orla Hannon and Ross Bryant of JBA Consulting carried out this work.

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Abbreviations

1D ..... One Dimensional (modelling)
2D ..... Two Dimensional (modelling)
AEP ..... Annual Exceedance Probability
CFRAM ..... Catchment Flood Risk Assessment and Management
DoEHLG ..... Department of the Environment, Heritage and Local Government
FARL ..... FEH index of flood attenuation due to reservoirs and lakes
FB ..... Freeboard
FFL ..... Finish Floor Levels
FRA ..... Flood Risk Assessment
FSR ..... Flood Studies Report
FSU ..... Flood Studies Update
GSI ..... Geological Survey of Ireland
LHB ..... Left Hand Bank
OPW ..... Office of Public Works
PFRA ..... Preliminary Flood Risk Assessment
RFI ..... Request for Further Information
RHB ..... Right Hand Bank
RR ..... Rainfall-Runoff
SAAR ..... Standard Average Annual Rainfall (mm)
SFRA ..... Strategic Flood Risk Assessment
URBEXT ..... FEH index of fractional urban extent
WL ..... Water Level

Executive Summary

Aston Limited intend to apply to An Bord Pleanála for permission for a Strategic Housing Development (SHD) in Great Connell, Newbridge, County Kildare. The subject site comprises the lands surrounding and including the dwellings of 'Greatconnell' and 'Valencia Lodge', Great Connell, Newbridge, Co. Kildare. The development is partly located within lands shown to be at risk of flooding in the OPW CFRAM mapping (floodinfo.ie). As such, a site-specific flood risk assessment (SSFRA) was carried out for the site to confirm the flood risk to the site and ensure the development would not increase the flood risk elsewhere.

The results of this detailed study have demonstrated that the baseline assessment of flooding on the Great Connell lands differ from what was portrayed in the CFRAM mapping. There are additional overland flow routes across the Great Connell lands than what is shown in the CFRAM mapping. The changes in the flood extents relates to a more detailed representation of the site levels using topographic survey as well as acknowledgment of the sensitivity of the water levels/additional overland paths to the roughness assigned to the watercourse and floodplain. For this reason, the model results in this report are more conservative that the CFRAM results.

Two post-development scenarios were tested. The first includes the proposed SHD development and the proposed bridge and the second represents the proposed SHD development without the bridge. Aston Limited are progressing with a separate planning application for the Road and Bridge Ref:4559, which is included as part of this scenario. The second design scenario is the less likely condition where the SHD development is constructed without the bridge. When the land is raised for the proposed development the overland flow routes through the site are removed. Compensatory storage is included as part of the post-development design to account for the loss of the overland flow routes through the site in Flood Zone A. This is done in accordance with the Planning System and Flood Risk Management Guidelines and the Kildare County Development Plan.

The first post-development scenario which included the SHD development and the proposed bridge confirms that the developments do not increase the flood risk to the surrounding area in the 1% AEP event and has minimal impacts in the 0.1% AEP event. There is an additional overland flow path, but this is constrained to the blue lined boundary, which is lands owned by the applicant. Any future change of use to this land from greenfield/open space will be preceded by a flood risk assessment. Outside of the blue line boundary, there are some increases in flood depths in the 0.1% AEP event downstream of the proposed bridge. These increases do not pose an increased flood risk to any properties downstream.

In the second post-development scenario, which does not include the proposed bridge and is the less likely condition to occur, there are some localised increases in flood extents and depths in addition to those noted in Scenario 1. In areas where there is an increase in extent (green fields), there are no receptors, so in both cases the risk has not increased at the 0.1% AEP standard.

The groundwater risk to the site is confirmed to be low from GSI datasets as well as supplementary data such as the site investigation and the groundwater monitoring carried out at the site.

The proposed minimum floor level for the site places the developments above the 0.1% AEP event plus an additional 500mm freeboard. This FFL also protects the development from the 1% plus climate change event.

The Justification Test was applied and passed as the hydraulic modelling confirms the impact on surrounding water levels is not significant and the development can manage the risk to itself in accordance with the Planning Guidelines.

This report was subject to a peer review carried out by ARUP, dated the 05/04/2022, which confirms this FRA was completed "in accordance with requirements of The Planning System and Flood Risk Management Guidelines and in compliance with the Strategic Flood Risk Assessment (SFRA) of the Kildare County Development Plan 2017-2023". As per the review, ARUP "are satisfied that the proposed development will not result in any material increase in flood risk both on and off site and that the residual risk has been managed to acceptable levels". They are also satisfied that the Justification Test for the proposed development passed all criteria.

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 to ensure sustainability and effective management of flood risk.

1.1 Terms of Reference and Scope

JBA Consulting was appointed by Aston Limited to prepare a Flood Risk Assessment (FRA) for the proposed development of a site located at Great Connell, Newbridge. The report was prepared as an output from An Bord Pleanála response to the proposed development.

1.2 Flood Risk Assessment; Aims and Objectives

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

The objectives of this FRA are to:

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

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

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

1.3 Development Proposal

Aston Limited intend to apply to An Bord Pleanála for permission for a Strategic Housing Development (SHD) at this site at Great Connell, Newbridge, County Kildare. This subject site comprises the lands surrounding and including the dwellings of 'Greatconnell' and 'Valencia Lodge', Great Connell, Newbridge, Co. Kildare. The proposed site layout is shown in Figure 1-1.

The development will consist of the demolition of existing site structures (2,622.3 sqm) and the construction of 569 no. residential units, a neighbourhood centre with 11 no. units (commercial floor area 2,141 sqm) and a childcare facility (886 sqm), a circa 350 metre section of distributor road, and all ancillary and associated works on a site of 27.64 ha. The proposed development comprises:

1. Demolition of existing site structures (total 2,622.3 sqm) comprising; 'Great Connell' a two-storey dwelling of 331.9 sqm with detached single storey garage and outhouses of 48 sqm; 'Valencia Lodge' a single storey dwelling of 135.6 sqm with a single storey garage of 17.8 sqm; two no. single storey sheds of 1,440 sqm and 595 sqm, and a three-sided shed of 54 sqm.
2. Construction of 569 no. new residential dwellings (325 no. houses and 244 no. apartments) comprising:
    a. 64 no. two-bed houses; 173 no. three-bed houses; and 88 no. four-bed houses (ranging in height from 2 to 3 storeys).
    b. Apartment Block A (Part 3 and 4 Storeys): 5 no. one-bed apartments; 14 no. two-bed apartments; and 3 no. three-bed apartments. These proposed units have private balconies or terraces, and access to a community roof terrace of 112.4 sqm.
    c. Apartment Block B (Part 3 and 4 Storeys): 5 no. one-bed apartments; 14 no. two-bed apartments; and 3 no. three-bed apartments. These proposed units have private balconies or terraces, and access to a community roof terrace of 112.4 sqm.

d. Apartment Block C (Part 3 and 4 Storeys): 4 no. one-bed apartments; 19 no. two-bed apartments and 4 no. three-bed apartments. These proposed units have private balconies or terraces, and access to a community roof terrace of 87 sqm.

e. 13 no. apartments above the proposed Neighbourhood Centre comprising; 4 no. own-door two-bed apartments; 3 no. shared-access one-bed apartments; and 6 no. shared-access two-bed apartments. These proposed units have private balconies or terraces.

f. 160 no. own-door apartments in 2- and 3- storey buildings comprising; 16 no. one-bed apartments; 78 no. two-bed apartments, 66 no. three-bed duplex apartments. These units will have private amenity areas in the form of terraces, balconies and/or rear gardens.

3. Provision of Neighbourhood Centre (ranging in height between 2 and 4 storeys) with 11 no. commercial units comprising: a convenience shop of 909 sqm (unit 1); 3 no. doctor/dentist/physio units of 120 sqm, 120 sqm and 90 sqm (units 6, 7, and 8, respectively); a café of 125 sqm (unit 4); a restaurant of 213 sqm (unit 9); and 5 no. shop/convenience services units of 112 sqm, 49 sqm, 171 sqm, 100sqm and 100 sqm (units 2, 3, 5,10 and 11, respectively). The proposed Neighbourhood Centre includes an external roof terrace of 176 sqm.
4. Provision of a childcare facility (886 sqm) within the Neighbourhood Centre with capacity for in the order of 154 no. children.
5. Provision of 1,008 no. car parking spaces comprising 650 no. spaces for the proposed houses; 312 no. spaces for the proposed apartments; and 46 no. spaces to serve the Neighbourhood Centre.
6. Provision of 732 bicycle parking spaces comprising 536 no. secure residential spaces, 134 no. residential visitor spaces, and 62 no. spaces to serve the Neighbourhood Centre.
7. A series of 18 no. public open spaces and pocket parks are proposed throughout the residential development (2.613 ha net area).
8. Provision of a 8.31 ha amenity area adjoining the River Liffey.
9. Vehicular access to the proposed development from Great Connell road via a circa 350 metre section of the Newbridge South Orbital Relief Road (NSOOR), including footpaths and cycle paths. It is proposed to upgrade the existing Great Connell Roundabout to a signalised junction, and provide footpaths and cycle paths within the subject site along the Great Connell Road.
10. Proposed development facilitates future potential pedestrian, cycle and vehicular links to adjoining residential development and undeveloped lands.
11. All enabling and site development works, landscaping, boundary treatments, lighting, services and connections, including connection to permitted wastewater pumping station, waste management, ESB substations, compensatory flood storage and all other ancillary works above and below ground on a site of 27.64 ha.
12. A 7 year permission is sought.

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. An overview of the technical approaches to Flood Risk Assessment (FRA) are included in Section 4 while site-specific mitigation measures are explained in Section 5. Conclusions are provided in Section 6.

Figure 1-1: Proposed Site Layout

2 Site Background

This section describes the proposed development site in Great Connell, including watercourses, geology and wider geographical area.

2.1 Location

The proposed site is a green field site in Newbridge, Co. Kildare. It is located on the right bank of the River Liffey. There are existing buildings within the site boundary which will be demolished as part of the development. The site is bordered to the north and north east by residential estates and green fields to the south. The Murphy International Ltd offices are located to the east of the site. The blue line boundary in the figure below defines the area under the ownership and control of the applicant. A wide, open drain flows through and around the north western section of the site which follows the alignment of a historical meander of the River Liffey. Figure 2-1 below shows the site location and local features.

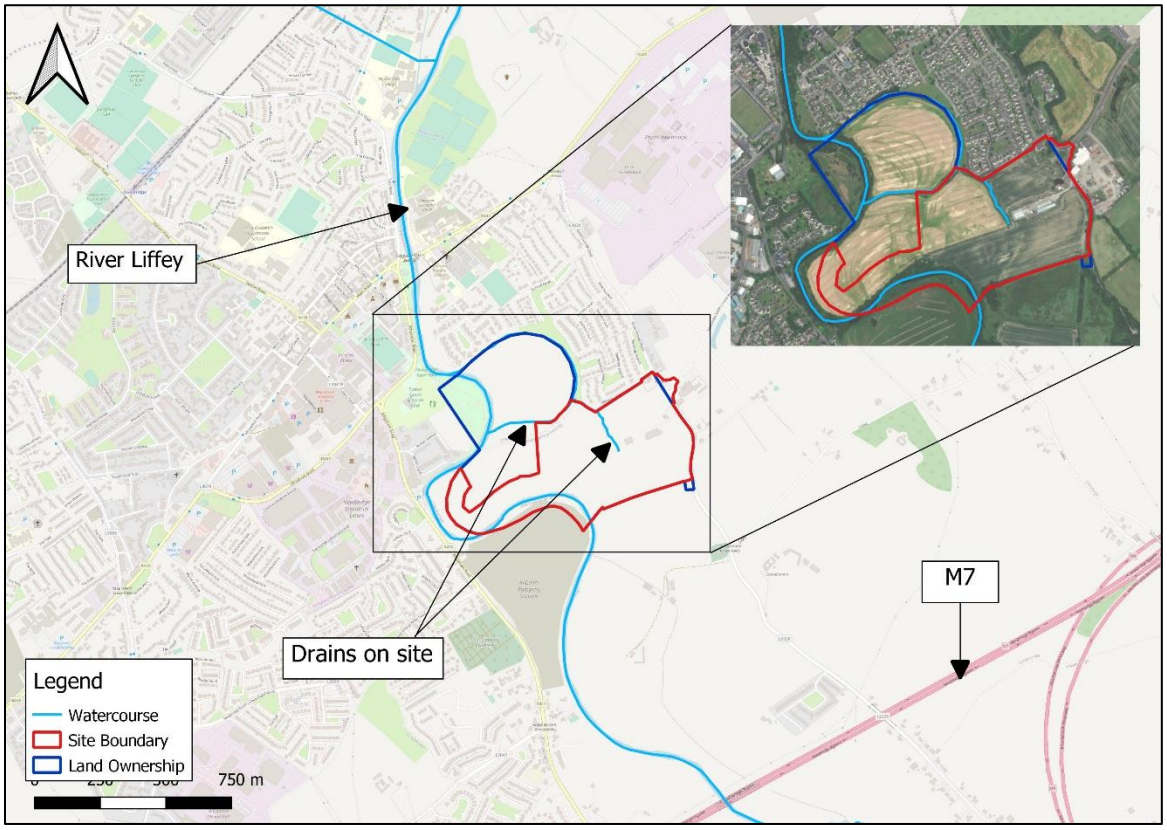


Figure 2-1: Site Location in Newbridge

2.2 Watercourses

The main watercourse in the area is the River Liffey which flows in a northerly direction along the western boundary of the site. It has a total catchment area of 480km². Golden Falls dam is located upstream of Newbridge. The outflow from the dam is controlled and accounts of approx. two thirds of the total catchment area (refer to Figure 2-2).

There are two drains flowing through the Great Connell site which follow the original alignment of the historic meanders on the River Liffey. These drains have a very small catchment area consisting of the green fields in the area and a section of Wellsley Manor housing estate to the north (Figure 2-3).

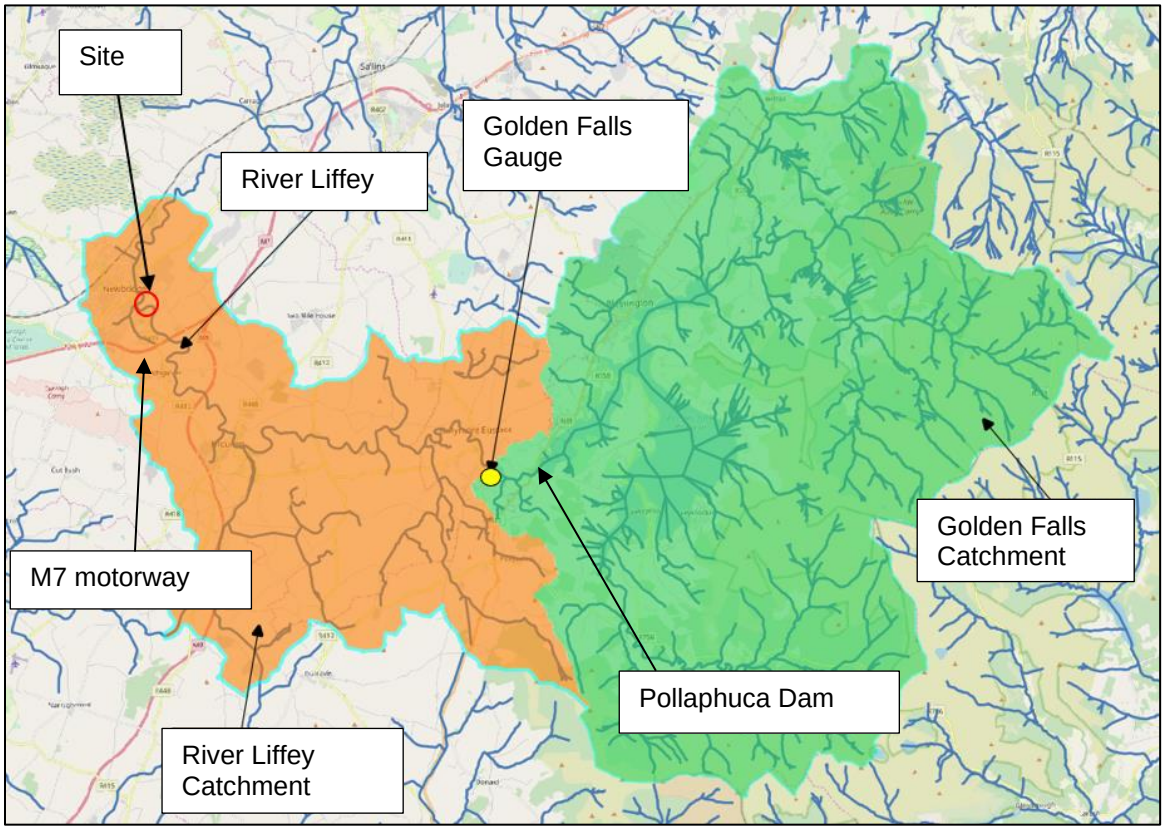


Figure 2-2: River Liffey Catchment Overview

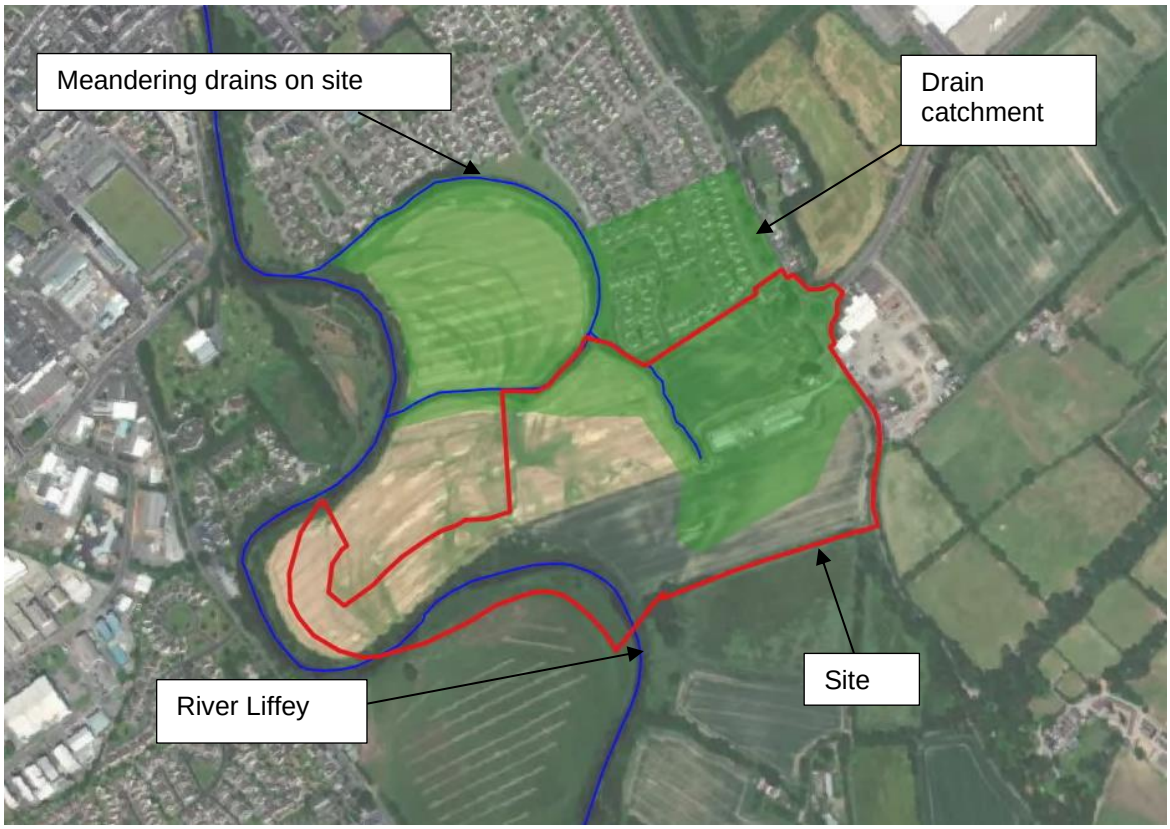


Figure 2-3: Drain Catchment Overview

2.3 Site Geology

The groundwater and geological maps of the site, provided by the Geological Survey of Ireland (GSI), have been studied and an extract of the geological map is presented in Figure 2-4. The subsoil is primarily Alluvium sediments to the western half with Gravels derived from Limestone (GLs) along the eastern half.

Alluvium is river sediment and indicative of previous flooding. This is most likely a historic river terrace, indicative of a period where the position of the meandering river was migrating through the general area. The loop drain to the north is a clear remnant of a historic river meander. Since the construction of the upstream dam the peak flows are controlled, and maximum flood extents reduced. The extent of alluvial soils is no longer likely to correspond with the predicted flood extent. The underlying bedrock is part of the Rickardstown Formation which is described as cherty often dolomitised limestone.

The boreholes completed as part of the groundwater monitoring indicate a groundwater depth of 1m - 2.92m depth across 10No. borehole locations (Appendix B). This was completed over a period of 10 months (April 2021 - January 2022), with an average groundwater depth of 2m. The Site Investigation works carried out for the site indicate a groundwater depth of 2.3m - 2.7m (Appendix C).

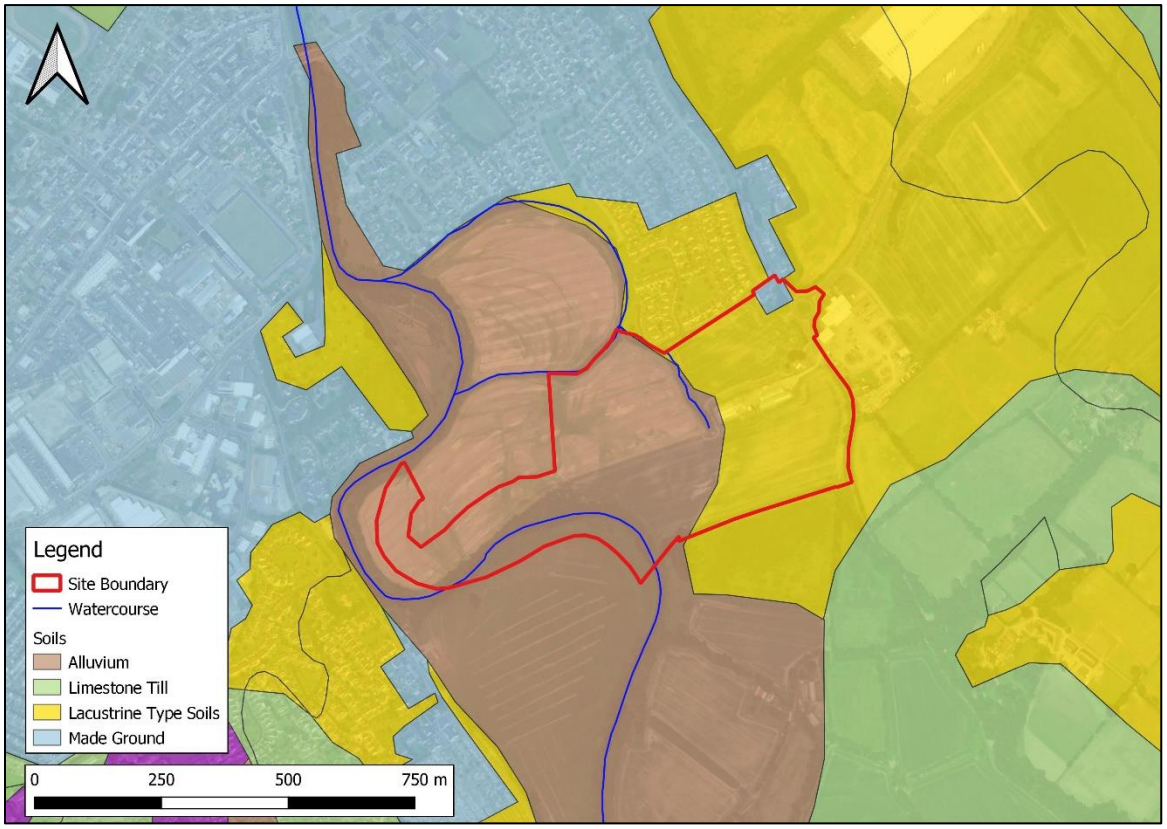


Figure 2-4: Site Subsoils

2.4 Site Topography

The site covers an area of 27.64 ha. The general slope of the site is towards the north west. The highest point of the site is to the south east, 88.6mOD, while the lowest point is in the north west corner, 85.8mOD.

2.5 Newbridge Local Area Plan 2013-2019

The Newbridge LAP shows that the site is in the C zoning (New Residential) and also the F zoning (Open Space and Amenity), Figure 2-5. As indicated in the LAP;

"{The C} zoning provides for new residential development and associated ancillary services. Permission may also be granted for home based economic activity within this zone subject to the preservation of residential amenity and traffic considerations. New residential areas should be

developed in accordance with a comprehensive plan detailing the layout of services, roads, pedestrian and cycle routes and the landscaping of open space.

The aim of {the F} land use zoning objective is to protect recreation, open space and amenity areas, to maintain and improve amenity lands, to preserve private open space and to provide recreational facilities. Existing agricultural uses in open spaces area will continue to be permitted and reasonable development proposals in relation to this issue will be considered on their merits."

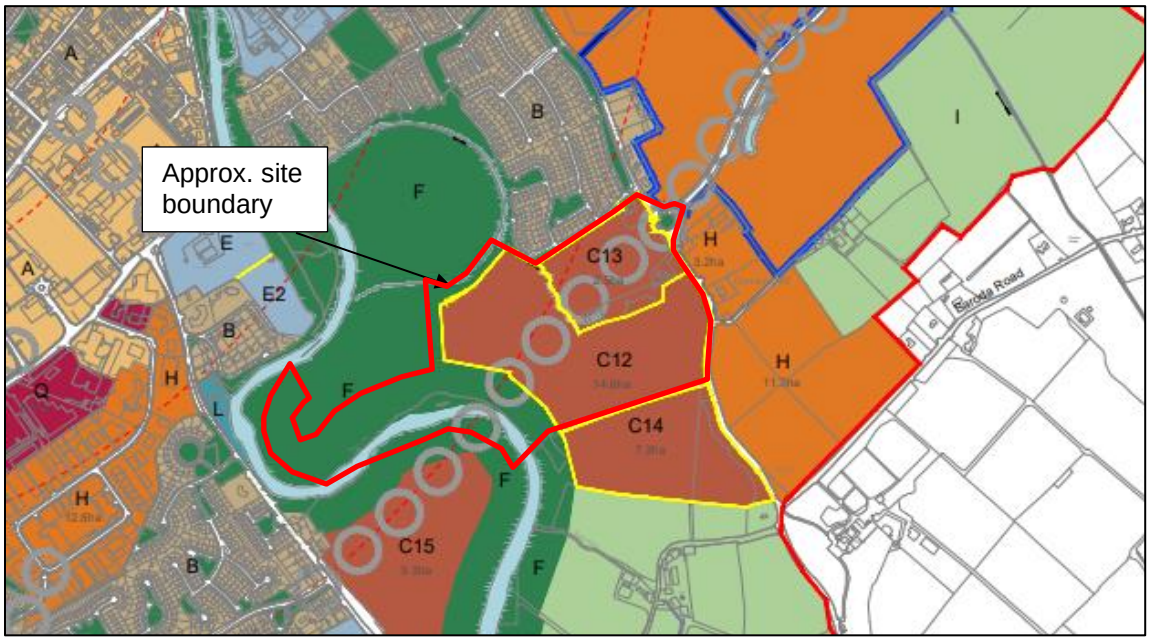


Figure 2-5: Newbridge LAP Zoning

3 Flood Risk Identification

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

3.1 Flood History

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.floodmaps.ie and general internet searches.

3.1.1 Floodmaps.ie

The OPW host a National Flood Information website, www.floodinfo.ie, which highlights areas at risk of flooding through the collection of recorded data and observed flood events. As can be seen in Figure 3-1 below, two historic flood events have been recorded in the area but none have been recorded at the site. Details of the two recurring flood events, both documented in 2005, are provided below.

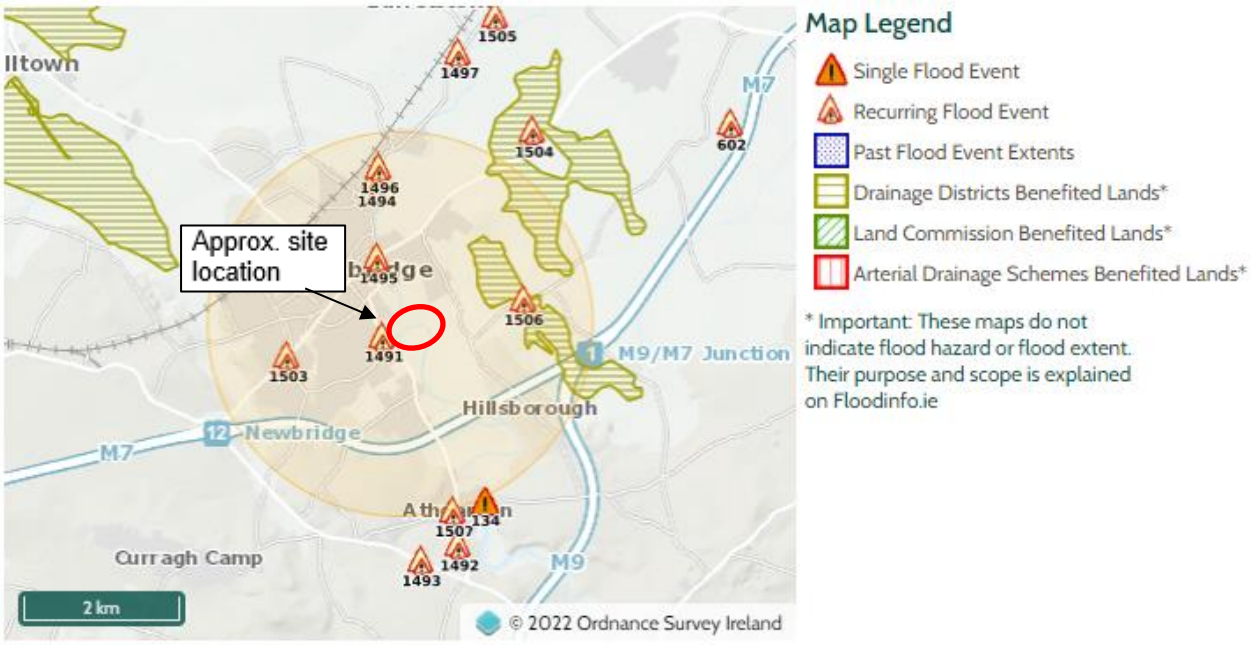


Figure 3-1: Floodinfo.ie

- Ref: 1491 Kilbelin, Newbridge – Area floods after heavy rain. The surface water system not able to cope. Occurs 1 or 2 times per year. This occurs approx. 500m west of the proposed development footprint and the opposite bank of the River Liffey.
- Ref: 1495 Recurring flooding at Newbridge College: Flooding occurs at the junction of the stream in 47 and the Liffey after heavy rain.

3.1.2 Previous FRA for the site

A flood risk assessment review report was carried out for a site within the Great Connell lands in November 2013. It was carried out by Byrne Looby Partners Water Services Ltd to review the KCC SFRA. The study relates to the site directly north of the proposed site, which is surrounded by the historic Liffey meander. According to the study:

'Aston own the land for 42 years and it has never flooded even through Hurricane Charlie rainfalls of the mid-1980's and other serious downpours. Before that the Brennan Family owned the land for many decades and in their time the land never flooded. The Brennan family owned the land before and after the Hydroelectric Scheme of the Liffey in the 1930's.'

3.1.3 GSi Groundwater and Surface Water Flood Mapping

The GSi datasets have been checked and do not indicate any historic surface water or ground water flooding. The GSI dataset indicates a moderate to high groundwater vulnerability.

3.1.4 Internet Searches

An internet search was conducted to gather information about whether the site was previously affected but flooding but no relevant information was found.

3.2 Predicative Flooding

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

- Newbridge SFRA;
- Eastern Catchment Flood Risk Assessment and Management Study;

The level of detail presented by each method varies according to the quality of the information used and the approaches involved. The Eastern CFRAM is the most detailed assessment of flood extent and supersedes the fluvial flood outlines presented by the Newbridge SFRA.

3.2.1 Newbridge SFRA

The Newbridge SFRA, completed as part of the LAP, was completed in 2013 prior to the publication of the CFRAM maps. Flood maps produced as part of the SFRA are shown in Figure 3-2 below. The site is also identified as being partially within the lands subject to a site-specific Flood Risk Assessment appropriate to the scale of the development being proposed. The SFRA states that such development proposals shall also:

- Indicate and quantify loss of floodplain storage arising from the development proposal;
- Provide compensatory storage within or adjacent to the proposed development;
- Indicate measures to ensure that water-vulnerable elements of the development would not be flooded during the 1000year flood;
- Ensure that existing flow paths for flood water will not be compromised.

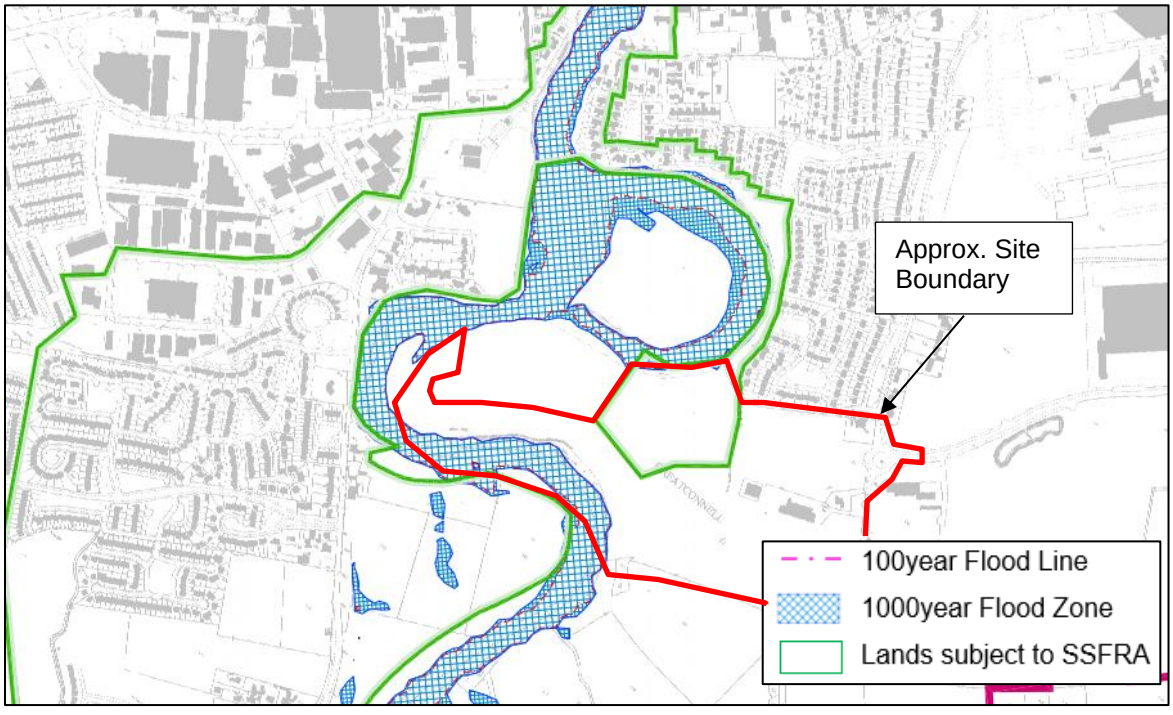


Figure 3-2: SFRA Flood Zones

3.2.2 Eastern CFRAM

The primary source of data with which to identify flood risk to the site is the Eastern CFRAM. The Eastern CFRAM covers approximately 6,300km² and involves detailed hydraulic modelling of rivers and their tributaries along with coastal flooding.

Flood maps are publicly available for 10%, 1% and 0.1% AEP and covers the River Liffey adjacent to the site. Flood maps have been finalised for Newbridge Town and an extract of the flood map covering the site is presented in Figure 3-3. The CFRAM map suggests that there is a potential fluvial overland flow through the centre of the site where the River Liffey overtops its banks and spills across into the drain within the site boundary.

Flood levels for the modelled events are also provided as part of the CFRAM study. Water levels at the nearest nodes to the site are provided in Table 3-1 below.

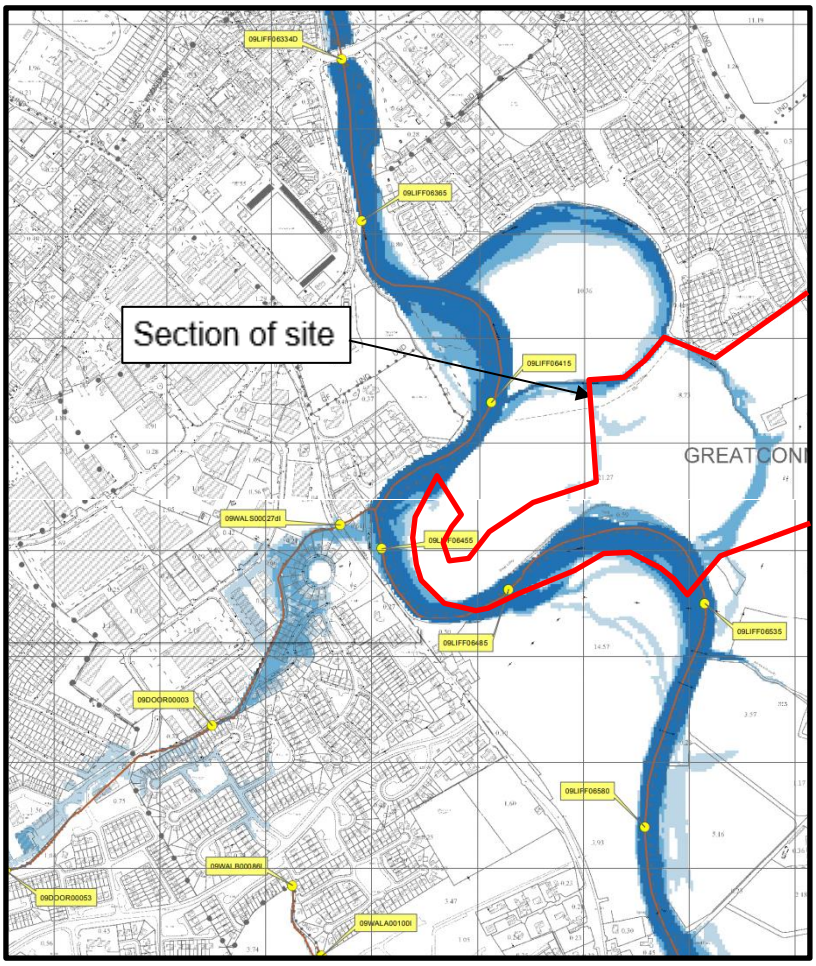


Figure 3-3: CFRAM flood extents

Table 3-1: CFRAM Fluvial Flood Levels

CFRAM Node	1% AEP Water Level (m)	0.1% AEP Water Level (m)
09LIFF06535	87.90	88.06
09LIFF06485	86.90	87.09
09LIFF06415	85.74	85.86

3.3 Sources of Flooding

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

3.3.1 Fluvial

Under the CFRAM flood mapping the proposed development is located primarily in Flood Zone C. However, there is an overland flow path from the River Liffey across the south of the site into the drain as part of the 1% and 0.1% AEP event (Flood Zone A & B). This flow path follows the path of the historic meander of the Liffey. As it is proposed to develop within the site boundary, a more detailed model will be required to clarify the baseline flood extents and support the proposed design of the site. This is discussed in detail in Section 4 below.

3.3.2 Tidal

The development site is located inland so tidal flood risk has therefore been screened out at this stage.

3.3.3 Pluvial

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.

A number of drainage channels are located both through and adjacent to the site, as well as the River Liffey meandering around the site, as discussed in Section 2.2. The site slopes towards the drainage channels to the north and the River Liffey to the south and west. As such surface water entering / falling on the site would flow into these watercourses.

Adequate storm water drainage systems will minimise the pluvial flood risk to the site from these drains. It is also important that increases in surface water runoff as a result of the development, including changes from greenfield to paved area, are managed. Pluvial mitigation is discussed further in Section 6.4.

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. Review of the GSi information on groundwater flood risk does not highlight any historic groundwater flooding on or near the site. The groundwater vulnerability is indicated as moderate to high. However, as mentioned in Section 2.3, the Site Investigation works indicate a groundwater depth of 2.3m - 2.7m. The groundwater monitoring completed over a 10-month period indicates a groundwater depth of 1m - 2.92m depth, with an average depth of 2m across the 10No. borehole locations. This indicates the groundwater flood risk is generally low.

4 Flood Risk Assessment

As outlined in Section 3.3, there is fluvial risk to the site, as indicated by the Eastern CFRAM Study. In order to assess the impacts of the proposed site layout and implement mitigation measures that ensure flood risk to the site is effectively managed, it is necessary to re-model this area. This will also provide clarification of the Flood Zone extents at a site-specific level and allow development scenarios to be tested. The following sections will detail the process of flow estimation, hydraulic modelling and present the results of the flood risk to the site.

A peer review was carried out by ARUP which confirmed the FRA was completed in accordance with The Planning System and Flood Risk Management Guidelines and in compliance with the Strategic Flood Risk Assessment (SFRA) of the Kildare County Development Plan 2017-2023. This involved a review of the proposals, hydrology/modelling approach and mitigation recommendations provided under the FRA. Any comments made by ARUP throughout the review processes were taken on board by JBA and updated according in the model and mitigation process. Refer to Appendix E for the Peer Review.

4.1 Hydrology Estimation

4.1.1 Flow Estimation

Flows and hydrographs have been estimated based on a hydrological analysis of the River Liffey using appropriate methods, such as the FSU method and the FSR Rainfall Runoff method. These have been prepared to check the Final CFRAM flows to ensure the CFRAM flows are suitable for use in the JBA model.

As discussed in Section 2.3 the catchment is sub-divided into the controlled Golden Falls catchment and the natural River Liffey. Using the available information for both catchments, flows were calculated to check and verify the CFRAM flows. The River Liffey flows were calculated using the physical catchment descriptors while the Golden Falls flows were estimated from the gauged flows at the dam. The ESB was contacted in attempt to update the AMAX series from when it was carried out for the CFRAM (Final CFRAM Hydrology Report issued April 2016). Only the average AMAX series was available rather than the peak AMAX series which could not be used as part of the calculations. The calculated flow estimates for both catchments were similar to those used in the CFRAM and so the CFRAM flows were deemed suitable for use in the model.

The 1% AEP and 0.1% AEP fluvial events were modelled using CFRAM calculated flows from node 09LIFF06678E which is at the upstream extent of the model. These estimated flows are outlined in Table 4-1 below.

The CFRAM flow for the Doorfield watercourse, which enters the River Liffey west of the site, were also adopted, Node 09WALS00027dl. This watercourse was not modelled so the flows were applied directly to the River Liffey.

As mentioned in Section 2.2, the local drains on site also had a small catchment area (approx. 0.3km^2), draining local fields and a housing estate. Inflows for this drain were calculated using the IH124 Method plus the 95% Confidence Interval. This method gave a flow of 0.6m3/s for the 1% AEP event and 0.8m^3/s for the 0.1% AEP event. To allow for uncertainties with the inflows of such a small drain, a constant inflow of 1m^3/s was applied in the model for all return periods.

Table 4-1: Fluvial Flows (m^3/s)

Inflow for model	Source	1% AEP (m^3/s)	0.1% AEP (m^3/s)
Upstream Inflow	CFRAM Node 09LIFF06678E	134.15	156.53
Doorfield	CFRAM Node 09WALS00027dl	2.84	4.57
Drain	JBA Estimation	1	1

4.1.2 Inflow Hydrographs

The hydrograph shape was based on the CFRAM hydrograph, where the River Liffey peak flow passes through the site at approx. 30hours and then the Golden Falls Dam peak flow is released at

approx. 96hrs for 24hrs (Figure 4-1). As the River Liffey Peak flow is considerably smaller than the Golden Falls Dam peak, the peak flows in the CFRAM model represent the Dam releases through the site.

For the Doorfield and the Drain inflows, a constant inflow of the flows shown in Table 4-1 were applied to the model.

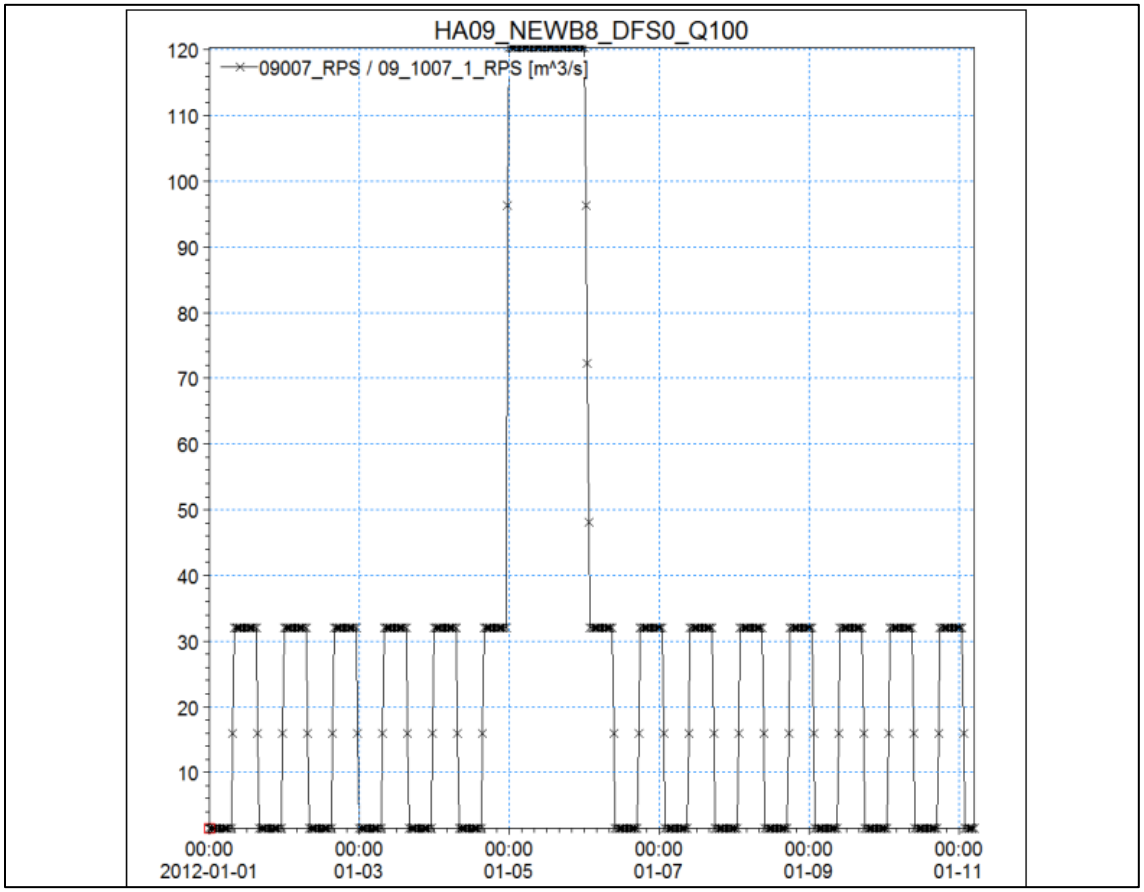


Figure 4-1: Eastern CFRAM Inflow Hydrograph at Model Upstream during 1% AEP Design Run

4.2 Hydraulic Model

The hydraulic modelling for this study was completed using a combination of two software packages: Estry and TUFLOW by BMT-WBM. When both software packages are used in conjunction with each other, they form what is termed a 'linked-model'. A linked-model allows flow in the river channel and structures to be represented using 1D modelling equations (Estry) and allows any out-of-bank volumes to be represented by 2D routing equations (TUFLOW).

The hydraulic modelling was carried out in the following stages:

- A new 1D model of the River Liffey was created using the CFRAM survey data provided by the OPW. A 1D model of the on-site drains was created using topographic survey carried out by Murphy Surveys in January 2020.
- A 2D (TUFLOW) model grid enclosing the study area was created. This was done using LiDAR data covering the area supplemented with site specific ground survey.
- 1D and 2D components were linked along the bank crest lines along with the deactivation of the floodplains from the 1D domain and of the channels from the 2D domain.
- Design simulations were run to derive the existing risk flood extents.

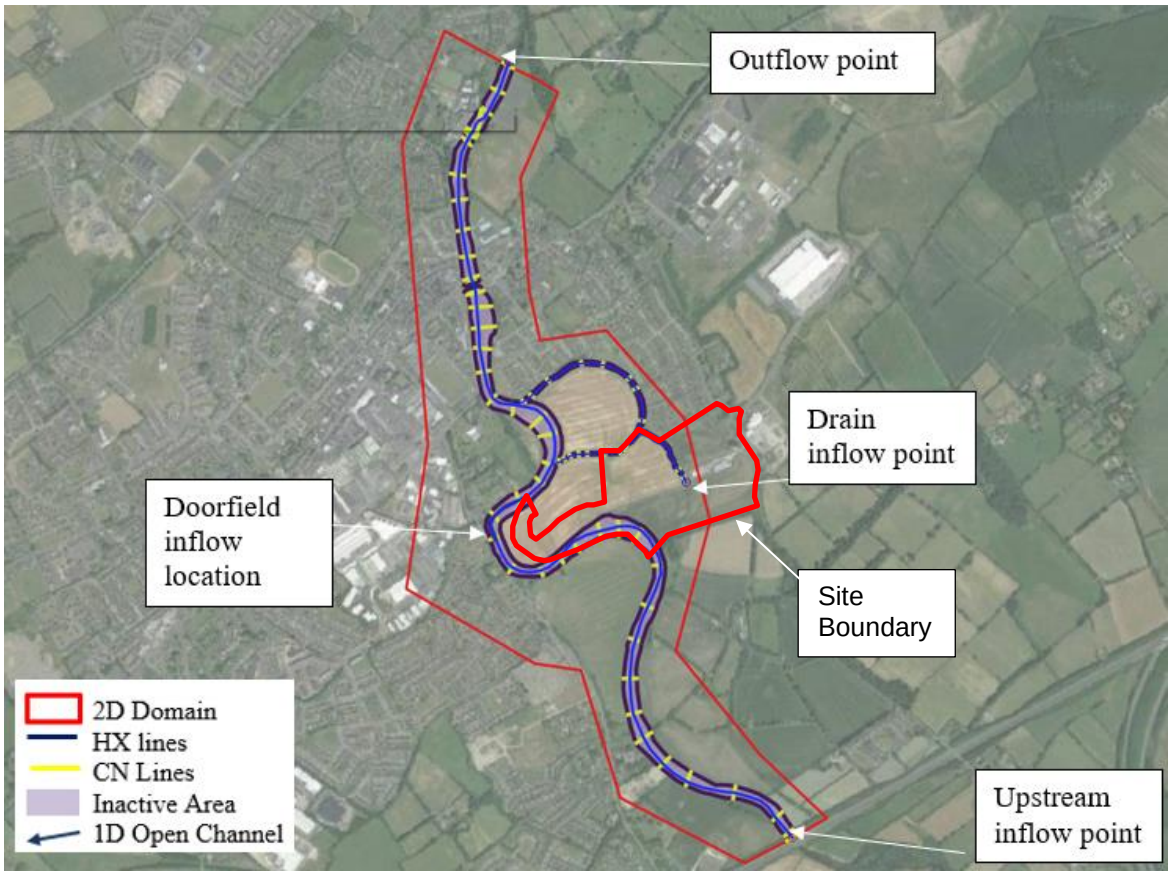


Figure 4-2: JBA Model Schematisation

4.3 Model Results - Baseline Scenario

Model results for the 1% and 0.1% AEP events (Flood Zone A & B) are shown in Figure 4-3 below. The figure also shows the climate change scenario which is a 20% increase in the 1% AEP flows. The site is indicated as being primarily within Flood Zone C. This means the probability of flooding from rivers and the sea is low (less than 0.1% or 1 in 1000 for both rivers and coastal floods). There are two overland flow paths across the site which are within Flood Zone B meaning there is a risk of flooding in this section during the 0.1% AEP event. One of these flow paths is also within Flood Zone A so there is a risk during the 1% AEP event.

The results of the JBA model are shown in Table 4-2. The JBA modelled water levels and flows are compared against the CFRAM modelled water levels and flows at two locations. As seen in the table below JBA water levels results are higher than the CFRAM and so are more conservative. The modelled flows in these locations are lower in the JBA model, despite the inflows for the model being the same (Section 4.1.1). The reason for the increase in water levels and flows moving downstream in the model is discussed below.

JBA carried out a range of sensitivity tests in the model, including roughness sensitivity. The model was shown to be particularly sensitive to a 20% increase in roughness as it gives rise to an additional overland flow path through the site in the 1% AEP event. This flow path is similar to that seen in the CFRAM study. It was therefore decided to adopt the increased roughness values in the model for the final results due to the sensitive nature of the site and this flow path needs to be acknowledged. While the increase in roughness values has increased the water levels across the model, it has also caused a decrease in flow in the model, as evident in the comparison with the CFRAM flows in Table 4-2 below. Without an increase in roughness values the flows and water levels between the two models correlate well, but the increased roughness has changed the flow regime in the model. The increased roughness has slowed the flow through the model which increased water levels and flattens the peak flow curve.

It is also noted that the development on the left bank has been included in the baseline scenario. On 31 October 2018, An Bord Pleanála granted planning permission to Ardstone Homes Limited (An Bord Pleanála Reference 302141-18) for 343 no. units on a site to the west of the current subject

site, identified in yellow on Figure 4.3. This development is currently in the construction phase. It is also a request of Kildare County Council and An Bord Pleanála that this development is included in the baseline scenario.

Figure 4-3: JBA Flood Extents

Table 4-2: JBA vs CFRAM Modelled Results

Node	**CFRAM**		**Model**	
	Water Level	Flow	Water Level	Flow
		Q100		
09LIFF06580	88.50	-	88.82	126.97
09LIFF06535	87.90	-	88.12	130.46
09LIFF06455	86.46	131.97	86.92	130.92
09LIFF06415	85.74	135.10	86.02	121.48
		Q1000		
09LIFF06580	88.69	-	89.00	142.09
09LIFF06535	88.06	-	88.27	149.27
09LIFF06455	86.61	157.76	87.07	144.97
09LIFF06415	85.86	166.03	86.20	132.41

5 Site Design / Masterplanning

Following on from updating the existing flood extents in Section 4, indicative post-development scenarios were modelled. The first scenario involved raising ground levels within the proposed site to represent the proposed residential development and also representing the proposed bridge across the River Liffey. The second scenario included the SHD development only without the proposed bridge. These scenarios are discussed in detail in the sections below.

As discussed in Section 4.3 the site is predominantly in Flood Zone C with an overland flow route through the site in Flood Zone A and B.

Figure 5-1 below identifies the appropriate development types for each flood zone, as per the Planning Guidelines. All development types are appropriate for Flood Zone C. Developments within Flood Zone A are recommended to be water compatible, i.e. car parking and green spaces, while less vulnerable developments such as retail or commercial uses are appropriate within Flood Zone B. Any other developments in these zoning types must apply and pass the Justification Test (JT).

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

Figure 5-1: Matrix of vulnerability versus flood zone to illustrate appropriate development and that required to meet the Justification Test (Table 3:2 of the Planning Guidelines)

When the ground levels at the site are raised, the overland flow routes of Flood Zone A/B are cut off, this is discussed in detail in Section 5.1 below. This development strategy means that the JT must be applied and passed. To pass the JT, it must be shown that the impact on surrounding water levels is not significant, and that the development can manage the risk to itself (refer to Section 7 for the JT).

5.1 Design Scenario 1 - Aston SHD Application & Kildare Co. Co. Road and Bridge Application

The post-development scenario which represents the proposed SHD development and the proposed bridge was modelled to assess the impacts of both developments on the surrounding land. Compensatory storage to account for the loss of the overland flow route through the site in Flood Zone A was included in the design (refer to Section 6.2 for more details on the compensatory storage). This was provided at two locations: along the meander of the River Liffey along the site's western boundary and approx. 80m upstream. Figure 5-2 below shows the post-development flood extent map for the 1% and 0.1% AEP events. Ground levels were also lowered between the development footprint and the River Liffey to reinstate an overland flow route within the floodplain, which re-enters the channel approx. 180m downstream. A depth difference map for the 1% AEP event is shown in Figure 5-3. Table 5-1 below compares the pre- and post-development water level at a number of locations (identified in Figure 5-3). As seen in the table, the impacts of removing the overland flow routes are negligible in the 1% AEP event. There is a decrease in flood depths of up to 20mm upstream of the proposed bridge. There is an additional overland flow path on the right bank as a result of the development but this is within the Blue Line boundary, being the area defined as under the ownership and control of the applicant.

A depth difference map for the 0.1% AEP event is shown in Figure 5-4 below. Table 5-1 below compares the pre- and post-development water level at a number of locations (identified in Figure 5-4). The impacts on water levels and extents upstream of the bridge are negligible as a result of the SHD development and the proposed bridge. Downstream of the proposed bridge there is a slight increase in water levels (approx. 16mm). There is no increase in flood extents on the left bank. As the area adjacent to the river is designated green space, there is no increase to flood risk here. Water level increases of up to 10mm are noted in the River Liffey channel directly downstream

of the compensatory storage areas. This increase is as a result of the additional flow passing through the compensatory storage area and entering back in the channel. Properties are located on the left bank of the River Liffey in this location but ground levels are approx. 5m above water levels so there is no increase to risk. As with the 1% AEP event, there is an additional overland flow path through the site as a result of the development, but this is confined to lands owned by the applicant. Any future change of use to this land from greenfield/open space will be preceded by a flood risk assessment.

It must be noted that the bridge design is in accordance with OPW Section 50 design requirements in terms of water level increases/increases in risk elsewhere. The bridge will be subject to an OPW Section 50 consent application. Aston Limited are progressing with a separate application for the extended road and new bridge crossing.

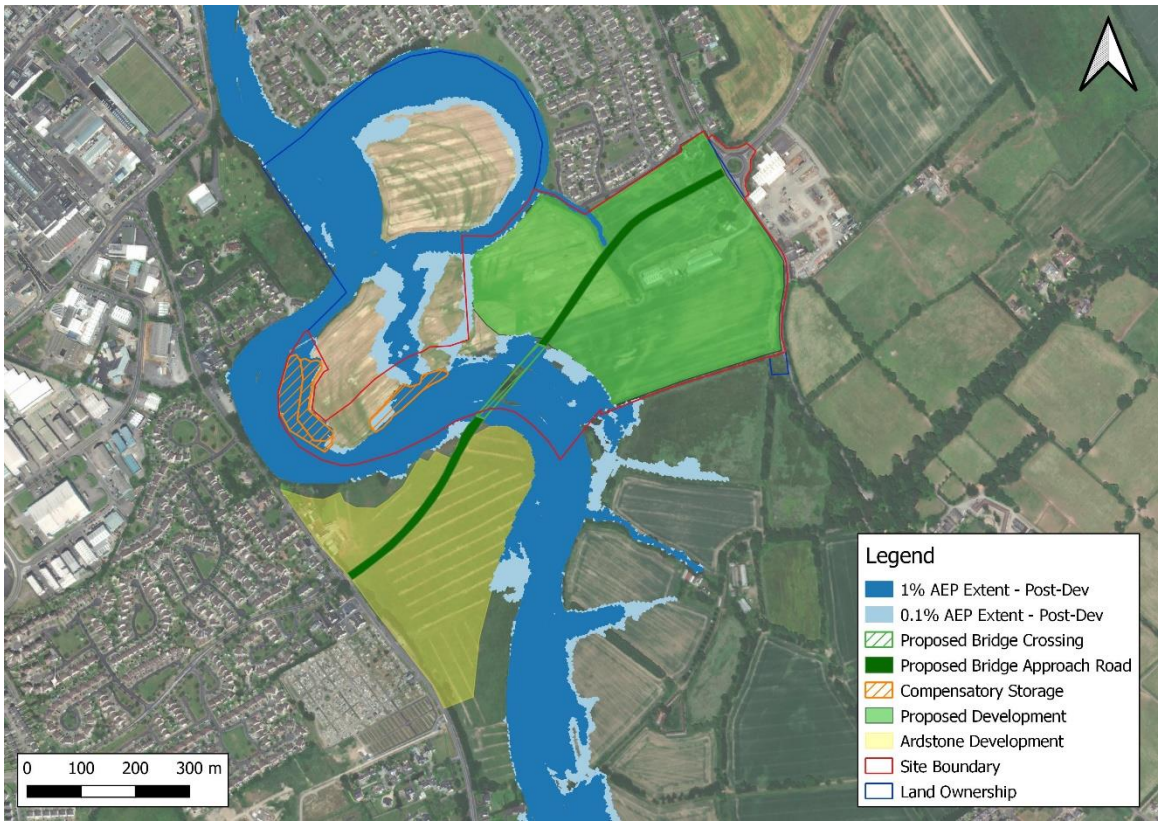


Figure 5-2: Post-Development Flood Extents - Scenario 1 SHD & Bridge Development

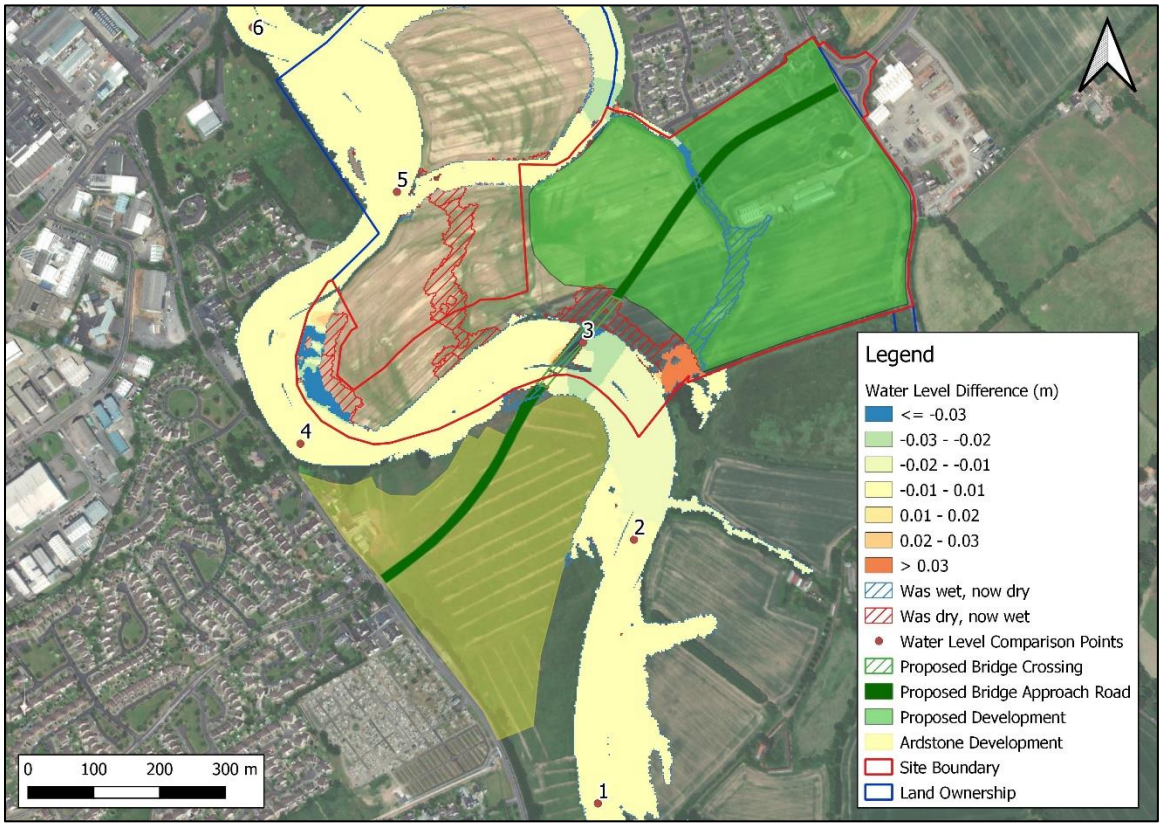


Figure 5-3: 1% AEP Depth Difference Map - Scenario 1 SHD & Bridge Development

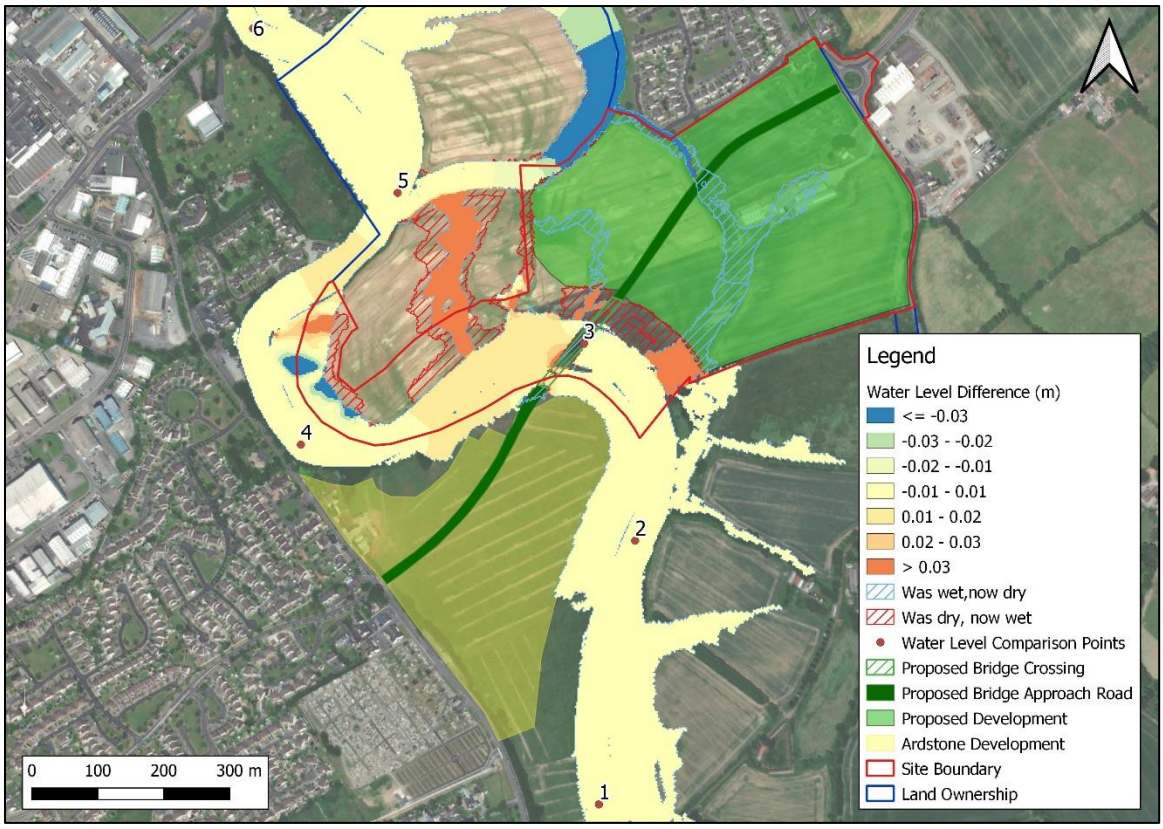


Figure 5-4: 0.1% AEP Depth Difference Map - Scenario 1 SHD & Bridge Development

Table 5-1: Pre- and Post-SHD & Bridge Development Water Levels

Location	1% AEP		0.1% AEP	
	Pre	Post	Pre	Post
1	88.97	88.97	89.15	89.15
2	88.38	88.38	88.55	88.56
3	87.80	87.80	87.93	87.96
4	86.92	86.92	87.07	87.07
5	86.02	86.02	86.20	86.20
6	85.61	85.61	85.86	85.86

5.2 Design Scenario 2 - Aston SHD Application

The post-development scenario which represents the proposed SHD development without the proposed bridge was modelled to assess the impacts of the SHD development alone. **It is noted that this scenario; where the SHD site is constructed without the bridge, is the less likely of the two scenarios as the applicant and Kildare County Council are actively progressing the consenting and funding for the bridge.** Aston Limited are also progressing with the planning application for the Road and Bridge (Ref:4559). As with Design Scenario 1 in the section above, compensatory storage to account for the loss of the overland flow route In Flood Zone A as a result of the SHD development was included in the model as well as the overland flow route in the 1% AEP event being reinstated. Figure 5-2 below shows the post-development flood extent map for the 1% and 0.1% AEP events.

A depth difference map for the 1% AEP event is shown in Figure 5-6 below and compares the pre- and post-development water level at a number of locations (identified in the figure). As seen in the table, the impacts of removing the overland flow routes are negligible in the 1% AEP event. There is an additional overland flow path on the right bank, which is a result of the compensatory storage in this area allowing more flow to enter this area. This additional overland flow path is outside of the development footprint and contained within the Blue Line boundary, being the area defined as under the ownership and control of the applicant.

A depth difference map for the 0.1% AEP event is shown in Figure 5-7 below which compares the pre- and post-development water level at a number of locations (identified in the figure). Similar to the 1% AEP event, there is an additional overland flow path within the blue line boundary as a result of the compensatory storage but this is located away from the development footprint. As with Scenario 1, there is an increase of up to 10mm in the River Liffey channel directly downstream of the compensatory storage areas. Properties are approx. 5m above water levels so there is no increase to risk. There is also an increase in water levels of approx. 15mm adjacent to the proposed development and the northern boundary of the Ardstone development, but there is no increase in flood extents and/or risk as there is still over 1m freeboard between the 0.1% AEP water levels and the finished floor levels of the Ardstone development and all buildings are in Flood Zone C. To the south of the site on the right bank there is an isolated increase in depth and a minor increase in extent, where the water is ponding in a low-lying area. These areas are greenfields within the existing floodplain so again the flood risk is not increased.

While the 0.1% AEP depth difference map does indicate an increase in water levels and extents in the vicinity of the site, there is no increase to flood risk as detailed in the section above and the design scenario with the SHD in place and the bridge unconstructed is the less likely of the two scenarios.

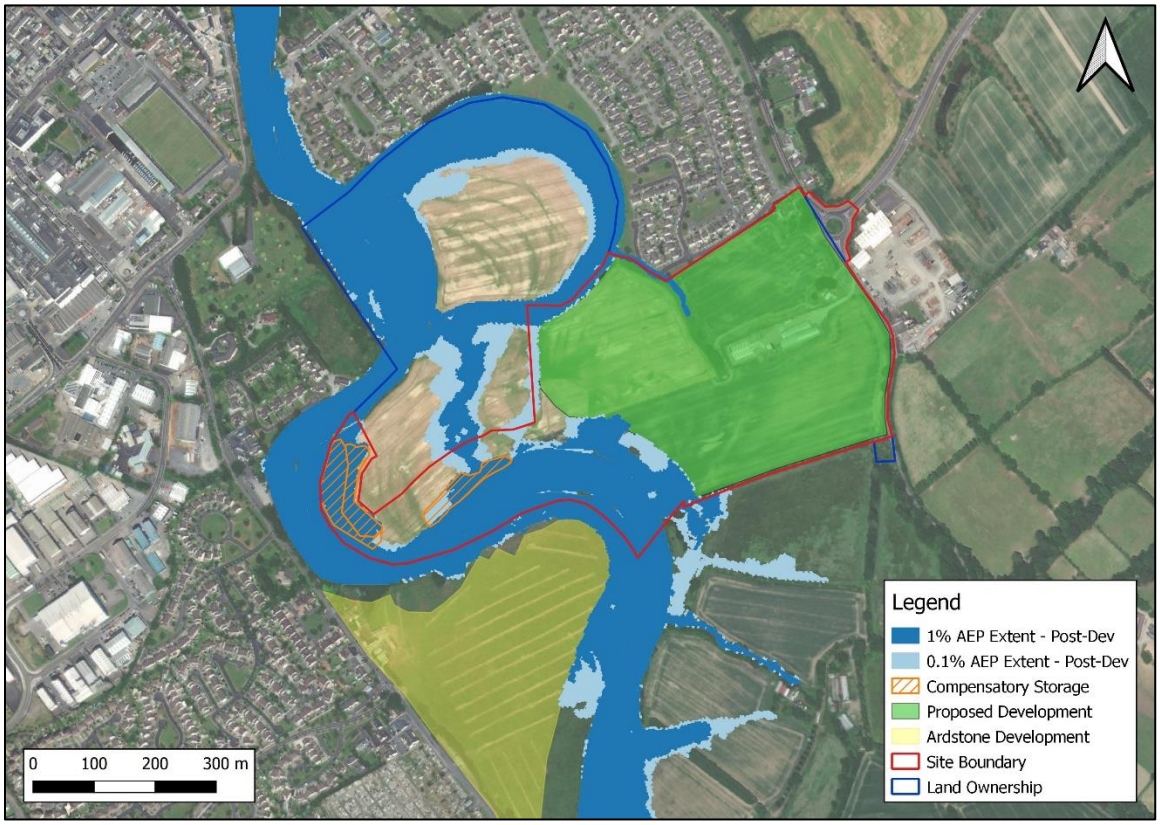


Figure 5-5: Post-Development Flood Extents - Scenario 2 SHD Development

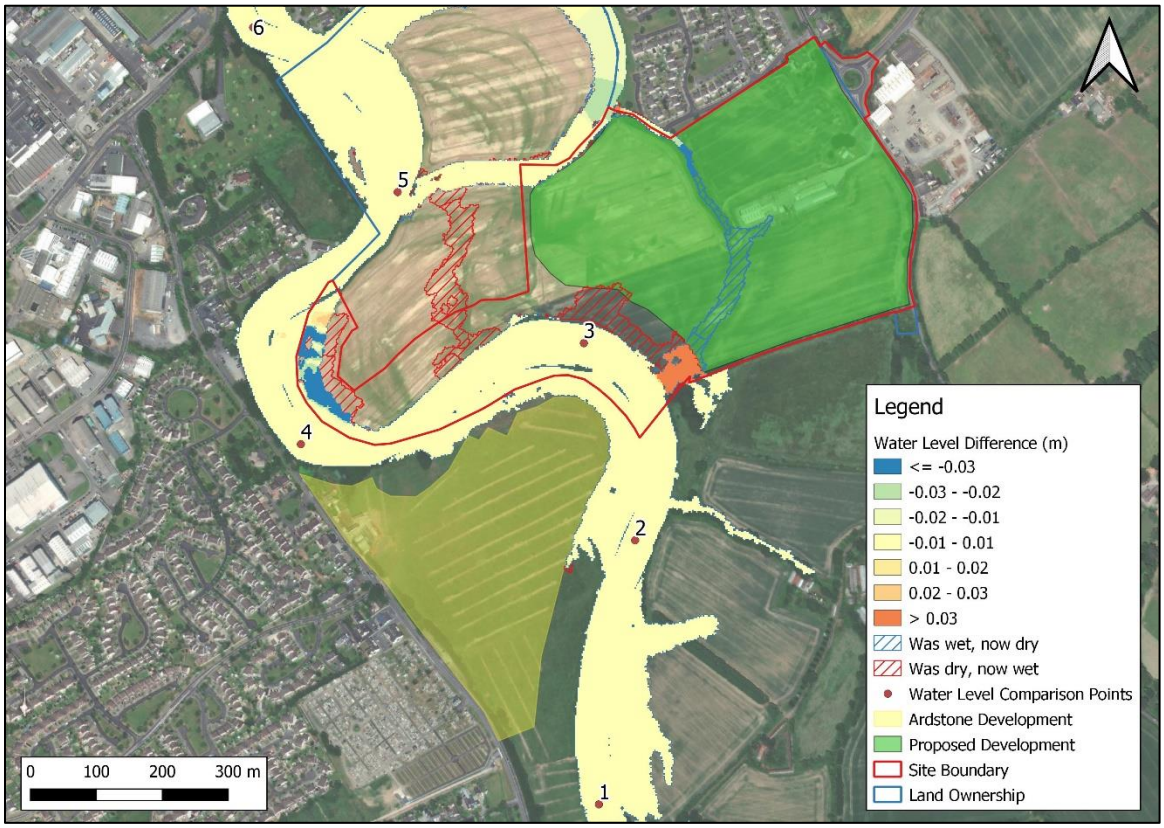


Figure 5-6: 1% AEP Depth Difference Map - Scenario 2 SHD Development

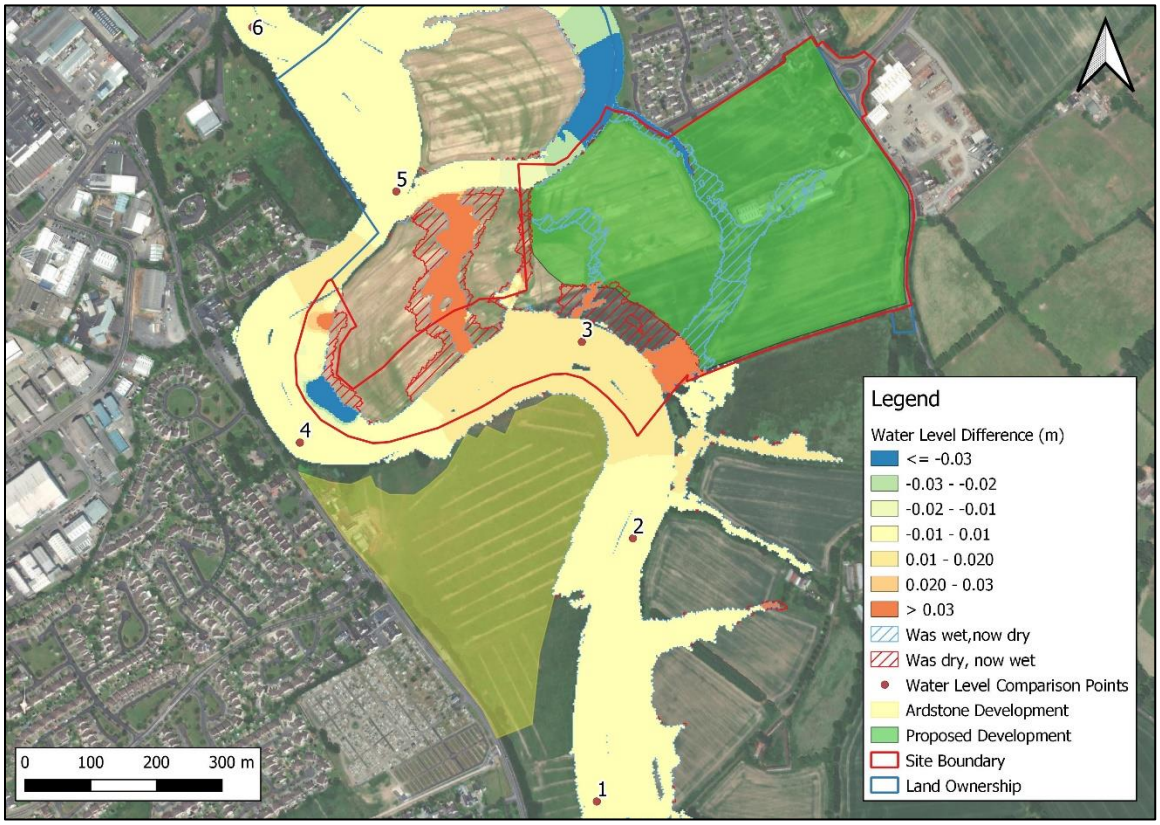


Figure 5-7: 0.1% AEP Depth Difference Map - Scenario 2 SHD Development

Table 5-2: Pre- and Post-SHD Development Water Levels

Location	1% AEP		0.1% AEP	
	Pre	Post	Pre	Post
1	88.97	88.97	89.15	89.15
2	88.38	88.38	88.55	88.56
3	87.80	87.80	87.94	87.95
4	86.92	86.92	87.07	87.07
5	86.02	86.02	86.20	86.20
6	85.61	85.61	85.86	85.86

6 Mitigation Measures

The following section details the necessary mitigation measures required to progress the development strategy.

6.1 Finished Floor Levels

Based on the indicative post-development scenario it is recommended to set the Finished Floor Levels (FFL) above the 0.1% flood level with an additional 500mm freeboard. This is in line with the County Development Plan SFRA[1] recommendations. Refer to Figure 6-1 below for the range of recommended FFL at each block of houses adjacent to the watercourses. Note, these FFL are the recommended FFL, not the proposed FFL. The FFL varies across the length of the site, in accordance with the general downstream slope of the water levels in River Liffey and the drains on site.

The minimum recommended FFL for each block refers to the outer line of each housing block (i.e. adjacent to the river). Once the outer rows are raised to the minimum recommended levels, they will act as a barrier for the inner housing and prevent inundation in the extreme events.

The proposed finished floor level for the site places the developments above the 0.1% AEP event plus a minimum additional freeboard of 500mm. Along the River Liffey the FFL ranges from 89.10mOD at the upstream end to 88.45mOD at the downstream. Similarly, the proposed FFL along the drain to the north ranges from 87.70mOD to 87.05mOD. These proposed FFL are above the minimum recommended FFL as shown in Figure 6-1. These FFL also place the development above the 1% AEP plus climate change event.

It is also recommended to place the FFL 150mm above nearby road levels to prevent surface water inundation during an exceedance event.

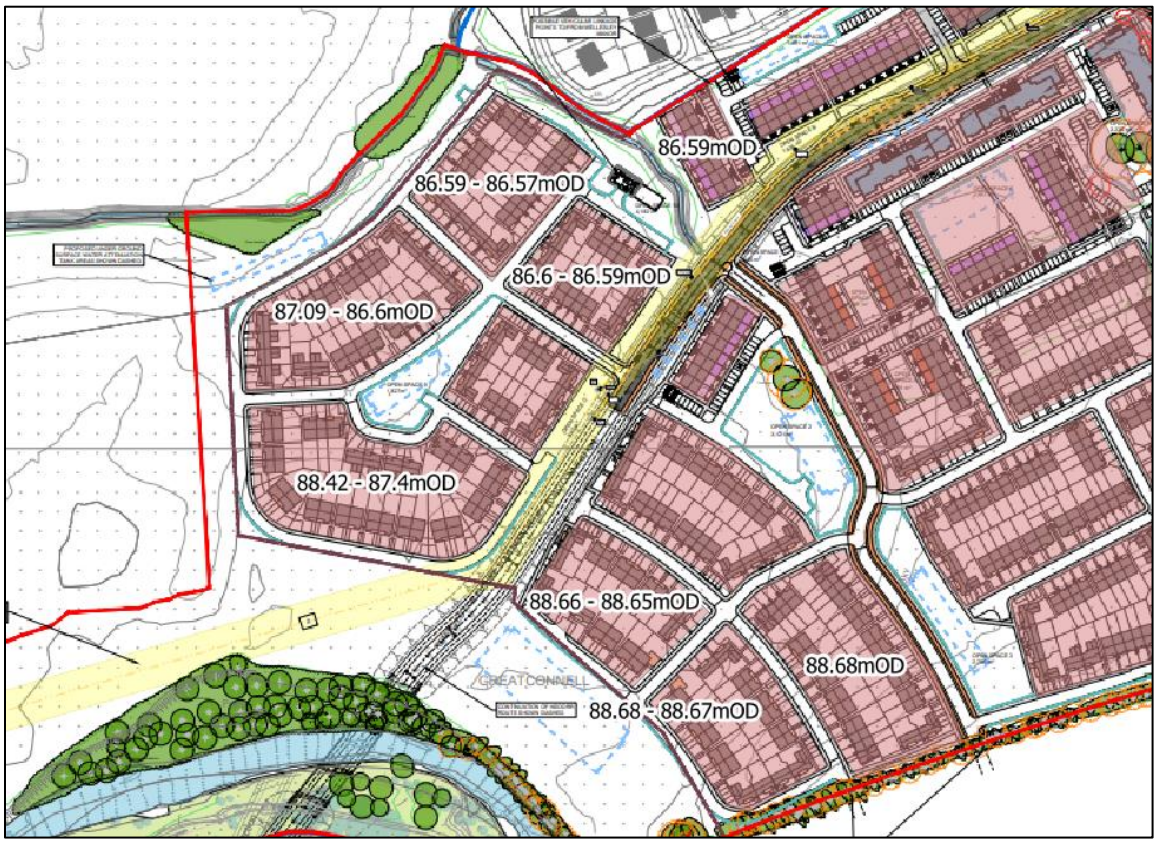


Figure 6-1: Minimum Recommended FFL

1 https://kildare.ie/CountyCouncil/AllServices/Planning/DevelopmentPlans/KildareCountyDevelopmentPlan2017-2023/EnviromentalReports/SFRA%20Report.pdf

6.2 Compensatory Storage

Compensatory storage for the site has been designed in line with the Kildare County Development Plan SFRA whereby compensatory storage is designed for the loss of floodplain within Flood Zone A and is also provided for in lands which do not flood in the 1% AEP event. As per the Planning Guidelines (Appendix A, Section 3.3.1), level for level compensation provides the same surface area at the same elevation before and after development. It is noted that the open space which will be landscaped and used as an amenity area will not be raised. Only the compensatory storage areas will be lowered and the impacts on levels are modelled and discussed below.

Compensatory storage is provided in the pre-development Flood Zone C area. It has been included in the design scenarios in Section 5.1 and 5.2 above. Figure 6-2 below shows the compensatory storage area utilised for the loss volume of Flood Zone A along the western boundary, overlaying the existing flood extents. In addition to this area of compensatory storage for the 1% AEP event, another area of compensatory storage has been provided to reduce impacts in an event exceeding the 1% AEP. This area of compensatory storage has been provided on the right bank of the River Liffey between the proposed bridge crossing and the 1% AEP storage area at the western boundary.

Figure 6-2 confirms the compensatory storage areas are outside of Flood Zone A. The figure also identifies the area of ground requiring regrading to link the flood plain and the compensatory storage. Note the area for regrading is not included in the volumetric calculations for the loss of Flood Zone A. Refer to Figure 5-4 for the post-development flood extents including the compensatory storage area.

Figure 6-3 provides a table of the pre- and post-development volumes for each of the height ranges. The table confirms that, despite a volume shortfall in 5 of the height ranges due to the topography, the overall volume has over 1,200m³ of a gain in the post-development scenario.

For further information on the compensatory storage design refer to the PUNCH engineering drawings submitted as part of the wider planning application (Drawing ref: 192229-Punch-XX-XX-DR-C-0811 - 192229-Punch-XX-XX-DR-C-0815).

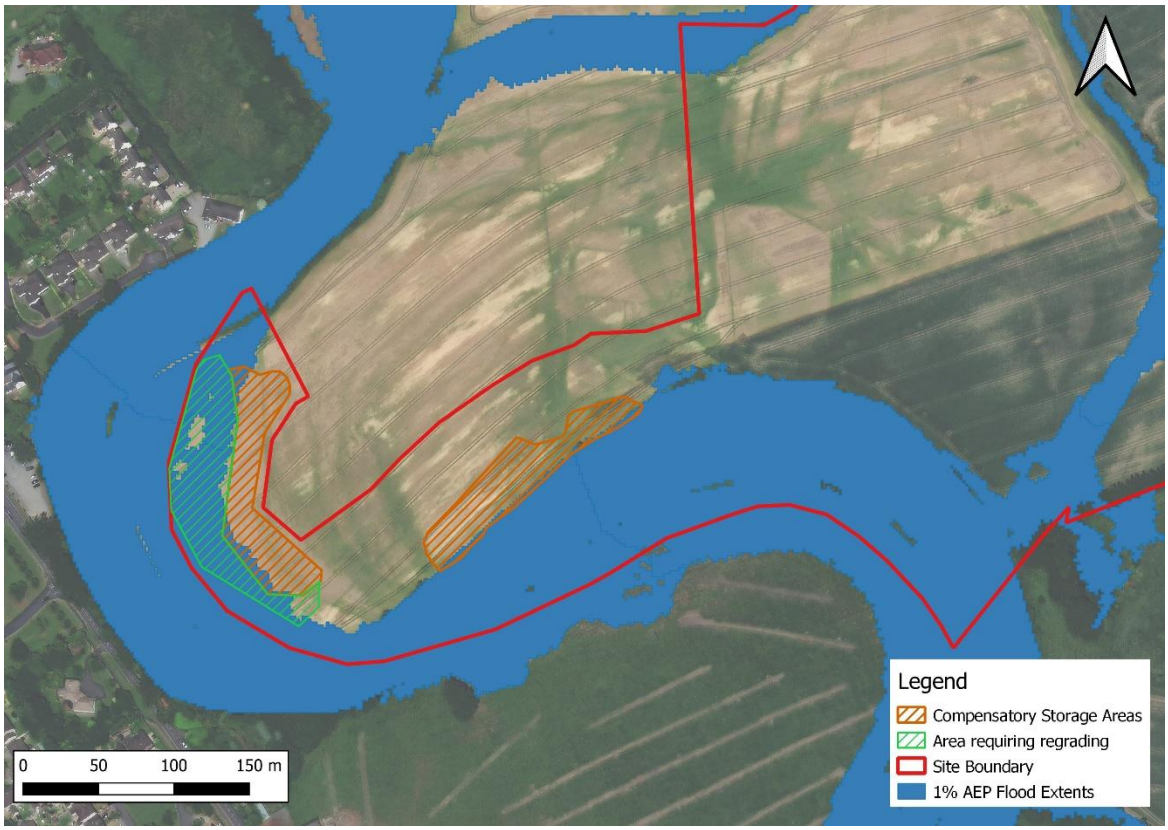


Figure 6-2: Compensatory Storage

FLOOD STORAGE					
Height Range (Below flood plain)		Preworks (Refer to drawing 192229-PUNCH-XX-XX-DR-C-0811)	Post-Works (Refer to drawing 192229-PUNCH-XX-XX-DR-C-0813)	Shortfall	Additional
(m)	(m)	(m3)	(m3)	(m3)	(m3)
0.00	0.20	29127.881	29925.037		797.156
0.20	0.40	23317.669	23922.799		605.130
0.40	0.60	18712.786	18667.366	-45.420	
0.60	0.80	14693.045	14647.683	-45.362	
0.80	1.00	10923.473	10894.683	-28.790	
1.00	1.20	8702.552	8697.846	-4.706	
1.20	1.40	7339.686	7339.677	-0.009	
1.40	1.60	6338.635	6338.635	0.000	
1.60	1.80	5545.515	5545.515	0.000	
1.80	2.00	4841.687	4841.687	0.000	
2.00	2.20	4101.458	4101.458	0.000	
2.20	2.40	2765.708	2765.708	0.000	
2.40	2.60	1452.496	1452.496	0.000	
2.60	2.80	778.381	778.381	0.000	
2.80	3.00	321.364	321.364	0.000	
3.00	3.20	118.410	118.410	0.000	
3.20	3.40	43.792	43.792	0.000	
3.40	3.60	16.866	16.866	0.000	
3.60	3.80	2.391	2.391	0.000	
3.80	4.00	0.133	0.133	0.000	
		139143.928	140421.927	-124.287	1402.286

Figure 6-3: Punch Post-Development with Flood Compensation

In addition to the compensatory storage provided above, additional excavations were introduced to reinstate overland flow paths across the site, as discussed in Section 5.1 as part of the design scenario, refer to Figure 6-4. Figure 6-5 below compares the pre- and post-development floodplain surfaces; with the additional flow path included this time.

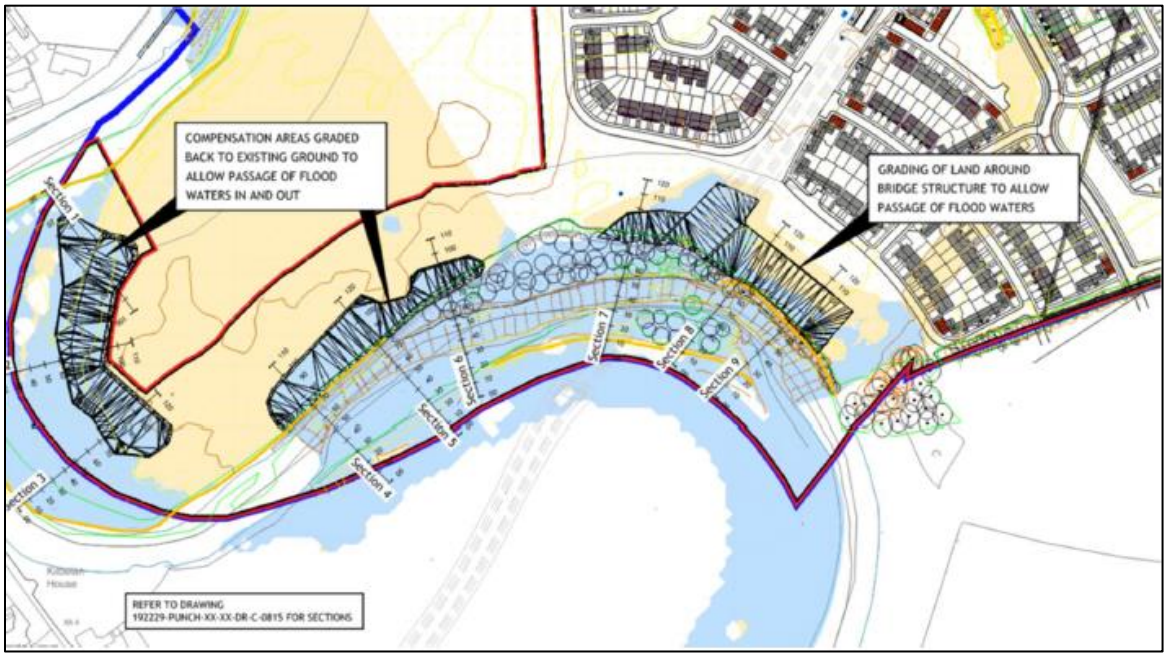


Figure 6-4: Flood Compensation Areas (Extract From 192229-PUNCH-XX-XX-DR-C-0814)

Post-Development (Final) includes flow paths in and out of flood compensation area and around the bridge structure

FLOOD STORAGE

Height Range (Below flood plain)		Preworks (Refer to drawing 192229-PUNCH-XX-XX-DR-C-0811)	Post-Works (Refer to drawing 192229-PUNCH-XX-XX-DR-C-0814)	Shortfall	Additional
(m)	(m)	(m3)	(m3)	(m3)	(m3)
0.00	0.20	29127.881	30657.397		1529.516
0.20	0.40	23317.669	24284.356		966.69
0.40	0.60	18712.786	18670.793	-41.99	
0.60	0.80	14693.045	14647.667	-45.38	
0.80	1.00	10923.473	10894.616	-28.86	
1.00	1.20	8702.552	8697.744	-4.81	
1.20	1.40	7339.686	7339.560	-0.13	
1.40	1.60	6338.635	6338.524	-0.11	
1.60	1.80	5545.515	5545.428	-0.09	
1.80	2.00	4841.687	4841.642	-0.05	
2.00	2.20	4101.458	4101.476		0.02
2.20	2.40	2765.708	2765.720		0.01
2.40	2.60	1452.496	1452.496	0.00	
2.60	2.80	778.381	778.381	0.00	
2.80	3.00	321.364	321.364	0.00	
3.00	3.20	118.410	118.410	0.00	
3.20	3.40	43.792	43.792	0.00	
3.40	3.60	16.866	16.866	0.00	
3.60	3.80	2.391	2.391	0.00	
3.80	4.00	0.133	0.133	0.00	
		139143.928	141518.756	-121.40	2496.23

Figure 6-5: Punch Post-Development - Including overland flow path

Refer to PUNCH drawing 19229-PUNCH-XX-XX-DR-C-0815 for sections indicating the excavations for the flood compensation storage areas and the including flow paths and regrading of the lands back towards the River Liffey.

6.3 Access and Egress

Access and Egress to the site though the main access road is in Flood Zone C.

6.4 Stormwater Design

The attenuation system should be designed to relevant standards, to mitigate against pluvial flooding on the site and the risk of increase due to the changes at the site to a hardstanding area. This should be prepared in accordance with the Kildare County Development Plan, GDSDS and should also include the comprehensive use of a Sustainable Drainage System.

For further information on the stormwater design refer to the PUNCH engineering drawings submitted as part of the wider planning application (Drawing ref: 192229-Punch-XX-XX-DR-C-0101 - 192229-Punch-XX-XX-DR-C-0104, 192229-Punch-XX-XX-DR-C-0160).

Flood risk associated with pre-existing surface water overland flow routes from adjacent lands will not be increased as a result of proposed development. At the Wellesley Manor housing estate to the north of the development, the overland flow route follows the access road within the estate (Figure 6-6). Ground levels suggest overland flow reaches the access road along the southern boundary of the estate and then flows south west along the road into the local drain within the proposed site boundary. No works are proposed for the drain at this location so this overland flow route will not be affected.

Surface water falling on the Great Connell Road along the extent of the site road frontage would enter the existing site along sections of the road. The proposed design will consist of a 2m grass verge/planting along the road and green space within the site adjacent to the road which will allow the surface water from the road to continue drain away and will not impact the flow route.

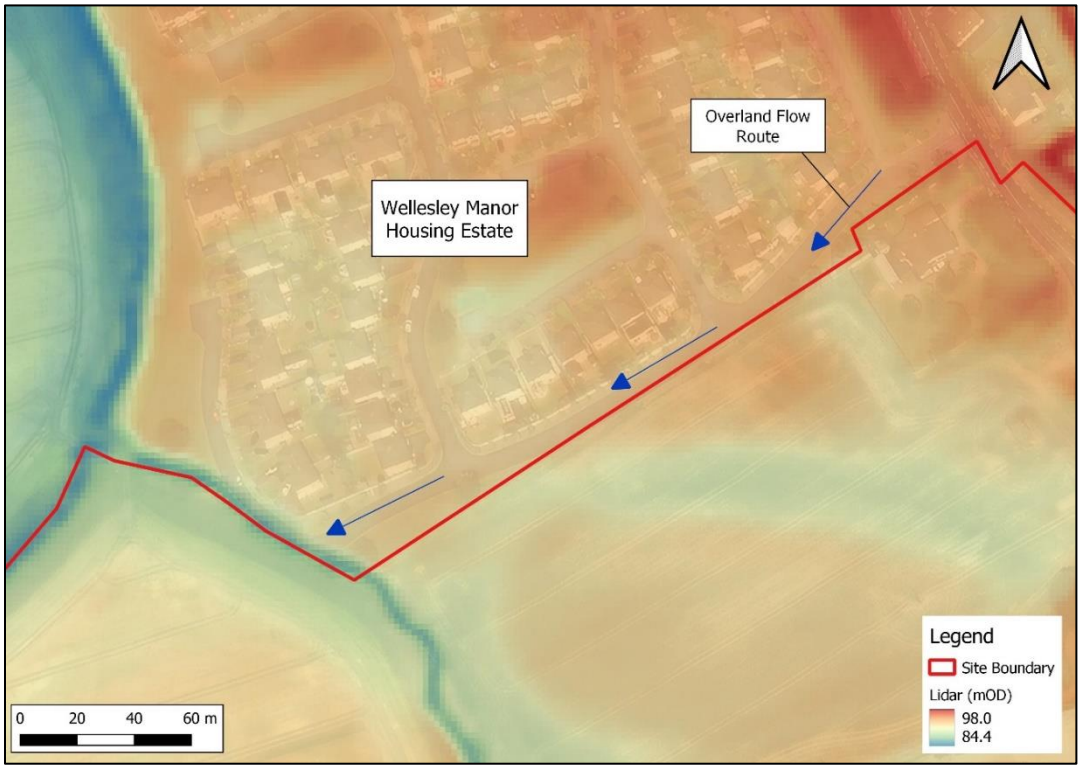


Figure 6-6: Overland surface water flow route

6.5 Bridge Design

As discussed in Section 5.1 it is proposed to construct a bridge across the River Liffey adjacent to the site. Aston Limited are progressing with a separate planning application to construct the extended bridge and bridge crossing. The bridge design has been assessed and is in line with the Section 50 requirements and within the tolerance limits of afflux. The proposed bridge design is therefore appropriate, and it has negligible impacts on water levels and extents at the site and there is no increase in risk to surrounding receptors.

6.6 Residual Risk

Residual risk is defined as risks that remain after all avoidance, substitution and mitigation measures have been taken. The flood risk assessment identified the main sources of residual risk to the development as Structure Blockage and Dam Failure of the ESB infrastructure upstream.

The potential risk of blockage for the proposed bridge adjacent to the site has been considered. The bridge abutments and piers have a minimum span of 24m, which are located outside of the riverbed. These wide spans greatly reduce the potential for blockage and therefore the risk of blockage is considered low.

Failure of the Golden Falls and/or Pollaphuca ESB Dams is identified as the second residual risk. A high flow scenario was tested where the 1% flows were increased by over 60m³/s, this high flow scenario is also above both the 0.1% AEP event and the climate change event. Even with this increase there is still a minimum of 170mm freeboard above the proposed FFL.

7 The Justification Test for Development Management

7.1 Strategy

As the development is partially located in Flood Zone A and B the Justification Test has been undertaken to confirm the site is appropriate for development. The development is a high vulnerability development type and so the JT is required, as indicated in Table 3.1 of The Planning System and Flood Risk Management.

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.

Under the County Development Plan, the part of the site on which residential development is proposed is zoned 'C - New Residential ', with an objective to "*provide for new residential development and associated ancillary services."*

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.

7.2 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.

In line with "The Planning System and Flood Risk Management Guidelines for Planning Authorities (2009)" a Strategic Flood Risk Assessment (SFRA) has been conducted as part of the preparation of the Newbridge Local Area Plan. Under the Newbridge Local Area Plan and the SFRA, the site is zoned 'C - New residential'. As stated above it is considered that the proposed development complies with the land use zoning at the site.

Conclusion: It has been outlined that the proposed residential development complies with the C land use zoning onsite and that the LAP was adopted taking into account The Planning System and Flood Risk Management Guidelines .

7.3 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

As part of the FRA, the site is identified as being located within Flood Zone A, B and C. A hydraulic model has been constructed to confirm the existing flood risk to the site. Following on from this, the post-development scenario was tested which confirmed the development does not increase the flood risk elsewhere. The 1% AEP flood levels and extents remained unchanged, and in some locations, there is a decrease in flood levels and extents of approx. 20mm. An additional overland flow path is noted within the Blue Line boundary, being the area defined as under the ownership and control of the applicant. As such, the increased overland flows and associated extents are on land owned by the applicant, and no impact on third party lands arises. The 0.1% AEP extent (a residual risk/exceedance event) had minor increases in levels, and extent (only in the condition where the bridge is not constructed in combination with the housing). Risk is defined as the likelihood of flooding multiplied by the consequence of flooding at a receptor (Appendix A). As the likelihood is low and the consequence is low (there is no receptor; such as an existing building), then there is no increase in risk.

Compensatory storage has been designed for the site which compensates for the loss of Flood Zone A and ensures existing water levels and extents are managed appropriately in the area.

Conclusion: A hydraulic model constructed for the site compared pre- and post-development scenarios which confirmed there is no increase in flood risk as a result of the development.

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

The FFL of the development will be located above the 0.1% AEP flood level plus an additional 500mm freeboard. All access routes are also placed above the 0.1% AEP event.

Conclusion: All developments onsite will be located above the 0.1% AEP flood level with a 500mm freeboard. Therefore, the flood risk to people and property onsite has been minimised.

(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 FFL levels of the proposed developments are placed above the 1% plus climate change event, therefore they are at low risk of flooding from future climate change. The proposed bridge crossing has a minimum span of 24m between the abutments, which are located outside of the riverbed. These wide spans greatly reduce the potential for blockage and therefore the risk of blockage is considered low. As there is also approx. 170mm freeboard above a high flow scenario which exceeds the 0.1% AEP and climate change event, the risk of inundation as a result of dam failure at the ESB Dams is reduced.

Conclusion: The impacts of climate change have been assessed in the hydraulic model and they were confirmed to be low as the FFL are above the 1% AEP+CC level. The wide span of the bridge will also reduce the risk of blockage from debris. Therefore, residual risks have been accounted for within the design.

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

To address Part iv of the JT, please refer to supplementary Planning Report and Statement of Consistency provided as part of the application.

8 Conclusion

JBA Consulting has undertaken a detailed Flood Risk Assessment for the proposed site development located at Great Connell, Newbridge, Co. Kildare. The site is greenfield and it is proposed to construct a residential development within the site boundary.

The site is identified as being partially within Flood Zone A and B in the CFRAM mapping. In order to assess the impacts of the proposed site layout and implement mitigation measures the site and surrounding area has been re-modelled.

The updated baseline model confirms that the site is partially within Flood Zone A and B from overland flow routes of the River Liffey. The model was tested with two design scenarios. The first included the proposed SHD development and the proposed bridge and the second had proposed SHD development without the bridge. The second design scenario is the less likely condition where the SHD development is constructed without the bridge. When the land is raised for the proposed development the overland flow routes through the site are removed.

Compensatory storage is provided to compensate for the loss of Flood Zone A, a standard which is in accordance with the Planning System and Flood Risk Management Guidelines and the Kildare County Development Plan. This has been designed and modelled as part of the post-development scenario and confirms the proposed development does not increase flood levels or extents in the 1% AEP event for which it has been designed.

The resulting flood maps for the post-development Scenario 1 confirms that the proposed SHD development and the bridge do not increase the flood risk to the surrounding area in the 1% AEP event and has minimal impacts in the 0.1% AEP event. There is an additional overland flow path within the Blue Line boundary, being the area defined as under the ownership and control of the applicant. As such, the increased overland flows and associated extents are on land owned by the applicant. Any future change of use to this land from greenfield/open space will be preceded by a flood risk assessment. Outside of the blue line boundary, there are some increases in flood depths in the 0.1% AEP event downstream of the proposed bridge. In areas where the increases in depths are adjacent to properties there is still sufficient freeboard between the water levels and FFL. Aston Limited are progressing with a separate planning application through Kildare Co Co PP Reference 4559. In Scenario 2, which does not include the proposed bridge and is the less likely condition to occur, there are some localised increases in flood extents and depths in addition to the increases noted in Scenario 1. In areas where there is an increase in extent (green fields), there are no receptors, so in both cases the risk has not increased at the 0.1% AEP standard.

The groundwater risk to the site is confirmed to be low from the site investigation and the groundwater monitoring carried out at the site.

The Justification Test was applied and passed as the hydraulic modelling confirms the impact on surrounding water levels is not significant and the development can manage the risk to itself.

The proposed finished floor level for the site places the developments above the 0.1% AEP event plus a minimum additional freeboard of 500mm. The FFL varies across the site, as the water levels slope downstream. Along the River Liffey the FFL ranges from 89.10mOD at the upstream end to 88.45mOD at the downstream. Similarly, the proposed FFL along the drain to the north ranges from 87.70mOD to 87.05mOD. This level also protects the development from the 1% AEP plus climate change event.

In summary the proposed development will be at low risk of flooding and will not increase the flood risk to the surrounding areas.

This report was subject to a peer review carried out by ARUP which confirms this FRA was completed "in accordance with requirements of The Planning System and Flood Risk Management Guidelines and in compliance with the Strategic Flood Risk Assessment (SFRA) of the Kildare County Development Plan 2017-2023". As per the review, ARUP "are satisfied that the proposed development will not result in any material increase in flood risk both on and off site and that the residual risk has been managed to acceptable levels". They are also satisfied that the Justification Test for the proposed development passed all criteria.

This Flood Risk Assessment was undertaken in accordance with 'The Planning System and Flood Risk Management' guidelines and 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

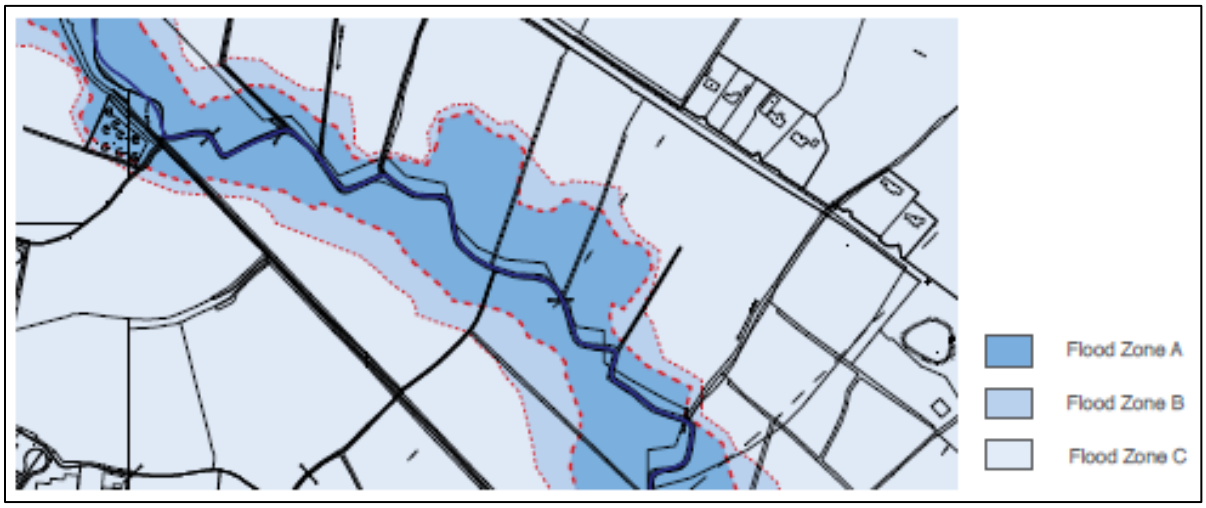
Return period (years)	Annual exceedance probability (%)
2	50
10	10
50	2
100	1
200	0.5
1000	0.1

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

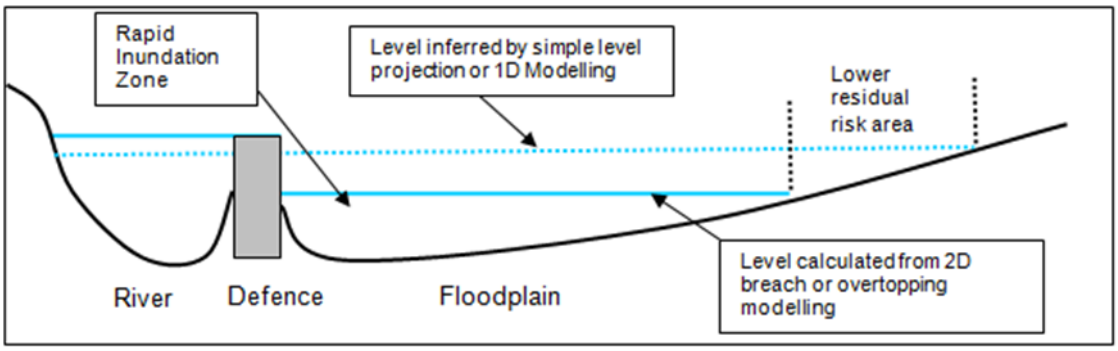
Consequences of flooding depend on the Hazards caused by flooding (depth of water, speed of flow. Rate of onset, duration, wave-action effects, water quality) and the vulnerability of receptors (type of development, nature, e.g. age-structure of the population, presence and reliability of mitigation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

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

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

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:

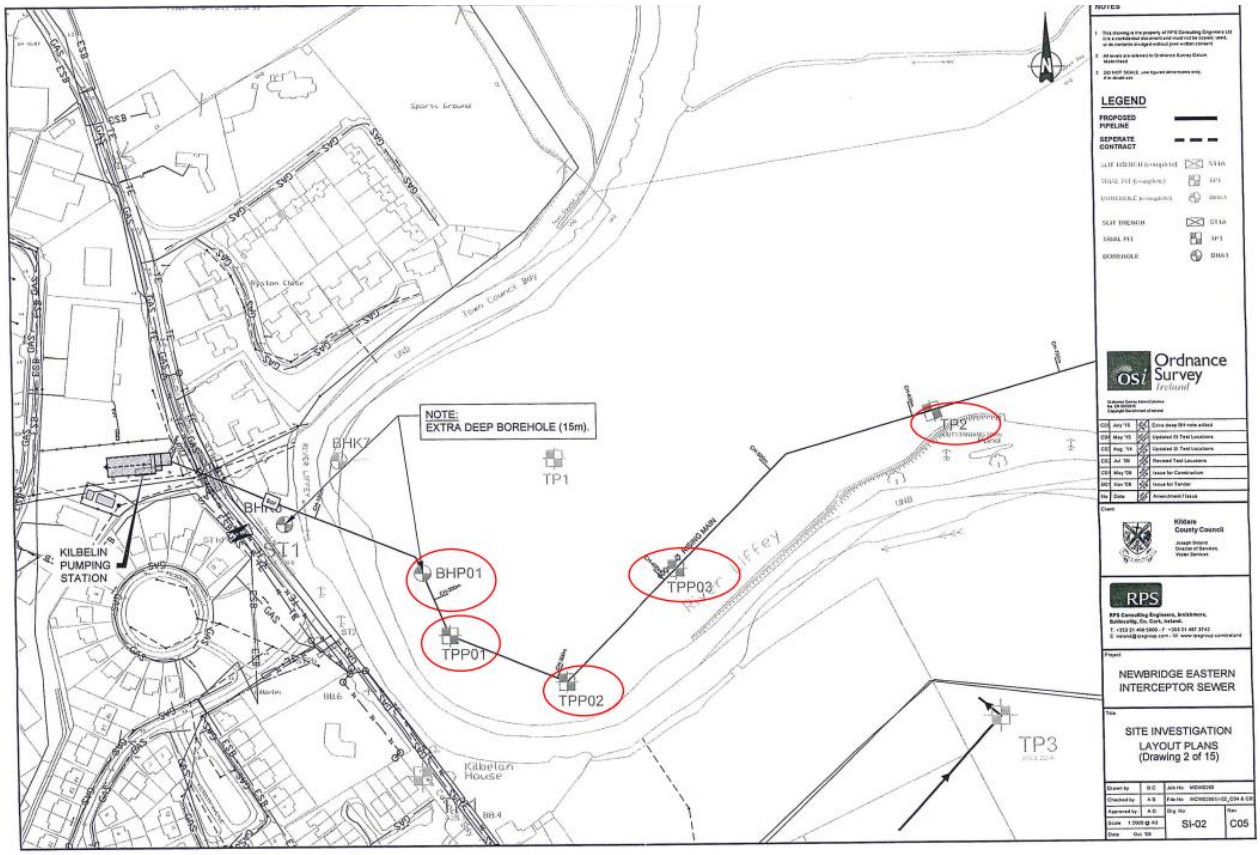


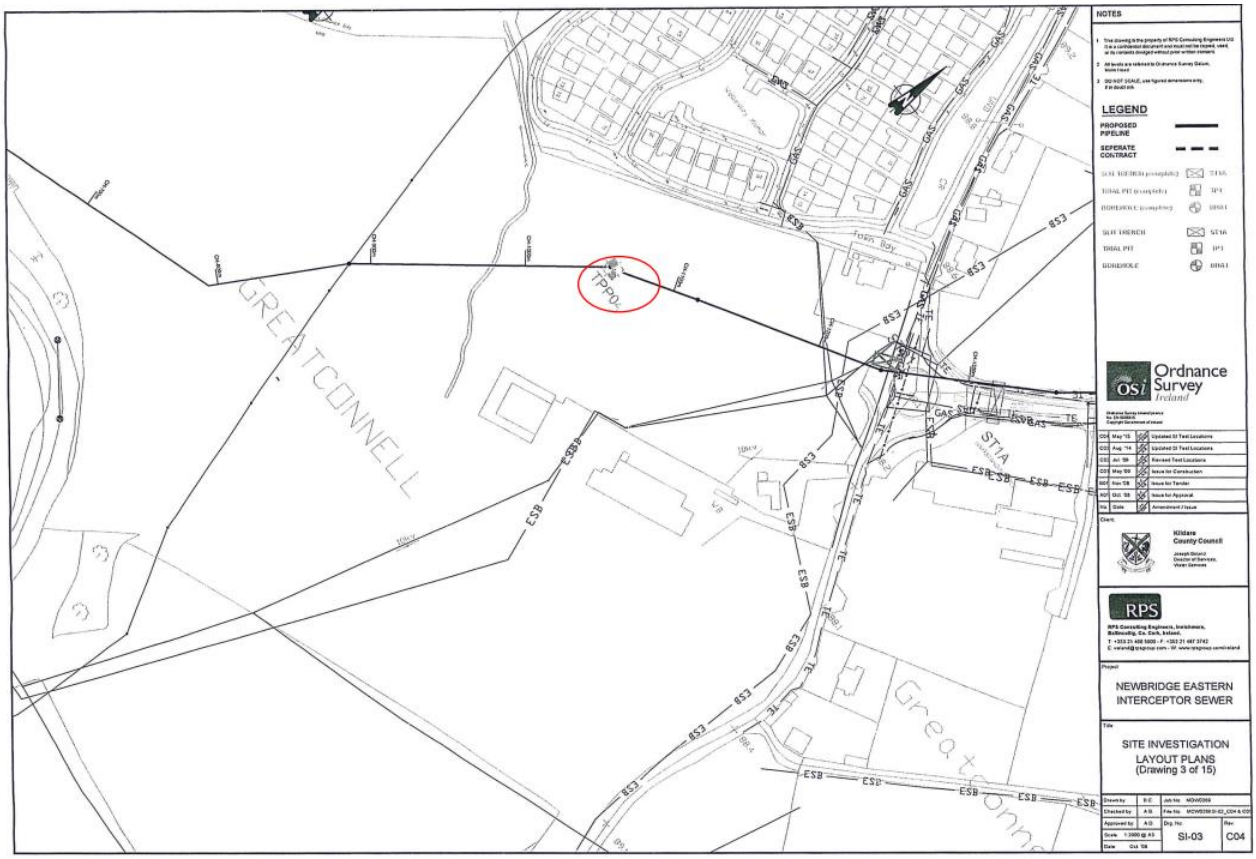
B Groundwater Monitoring

Borehole ID	Date Standpipe Installed	Ground Level (mAOD)	Total Depth of Standpipe (mBGL)	Bottom of Response Zone (mBGL)	Top of Response Zone (mBGL)	Response Strata (Shallow to deep)	Date	Time	Water Level (mBGL)	Water Level (m AOD)	Comment
BH02	16/03/2021	86.31	5.7	5.7	1	GRAVEL, CLAY, GRAVEL, CLAY	22/04/2021	10:04:00	1.15	**85.16**	Top of steel casing is 0.25m above ground level
							18/05/2021	10:31:00	1.17	**85.14**	
							24/06/2021	11:33	1.25	**85.06**	
							20/07/2021	09:23	1.22	**85.09**	
							03/11/2021	10:40	1.01	**85.3**	
							26/11/2021	10:07	1.15	**85.16**	
							11/01/2022	12:19	0.93	**85.38**	
BH5A	15/02/2021	87.58	5.14	5.14	1	GRAVEL, SAND	22/04/2021	09:48:00	2.175	**85.405**	Top of steel casing is 0.36m above ground level
							18/05/2021	10:25:00	2.33	**85.25**	
							24/06/2021	10:32	2.32	**85.26**	
							20/07/2021	10:28	2.39	**85.19**	
							03/11/2021	10:10	2.28	**85.3**	
							26/11/2021	09:23	2.39	**85.19**	
							11/01/2022	11:40	2.18	**85.4**	
BH7	26/03/2021	87.7	7.98	7.98	4	GRAVEL	22/04/2021	10:13:00	2.24	**85.46**	
							18/05/2021	10:53:00	2.28	**85.42**	
							24/06/2021	NM	NM	**NM**	
							20/07/2021	09:48	2.3	**85.4**	
							03/11/2021	10:47	2.08	**85.62**	
							26/11/2021	09:49	2.23	**85.47**	
							11/01/2022	12:02	2.06	**85.64**	
BH12	12/02/2021	87.38	5.81	5.81	1	GRAVEL, SILT/CLAY, SAND, GRAVEL	22/04/2021	09:54:00	1.84	**85.54**	Top of steel casing is 0.19m above ground level
							18/05/2021	10:22:00	1.92	**85.46**	
							24/06/2021	10:28	1.91	**85.47**	
							20/07/2021	11:04	2.03	**85.35**	
							03/11/2021	10:15	1.945	**85.425**	
							26/11/2021	09:27	2.02	**85.36**	
							11/01/2022	12:24	1.69	**85.69**	
BH15	02/03/2021	87.57	5.82	5.82	1	GRAVEL, SILT/CLAY, GRAVEL	22/04/2021	10:46:00	1.77	**85.8**	Top of steel casing is 0.26m above ground level
							18/05/2021	10:57:00	1.82	**85.75**	
							24/06/2021	11:41	1.84	**85.73**	
							20/07/2021	09:58	1.88	**85.69**	
							03/11/2021	10:33	1.68	**85.89**	
							26/11/2021	09:43	1.81	**85.76**	
							11/01/2022	11:57	1.54	**86.03**	
BH17	25/02/2021	88.54	9.41	9.41	1	GRAVEL, SAND, CLAY	22/04/2021	10:54:00	2.64	**85.9**	Top of steel casing is 0.3m above ground level
							18/05/2021	11:00:00	2.745	**85.795**	
							24/06/2021	10:53	2.73	**85.81**	
							20/07/2021	10:06	2.86	**85.68**	
							03/11/2021	10:23	2.92	**85.62**	
							26/11/2021	09:35	2.89	**85.65**	
							11/01/2022	11:50	2.53	**86.01**	
BH19	09/03/2021	NM	NM	NM	NM	GRAVEL	22/04/2021	NM	NM	**NM**	
							18/05/2021	NM	NM	**NM**	
							24/06/2021	13:02	1.6		
							03/11/2021	NM	NM	**NM**	
							26/11/2021	NM	NM	**NM**	
							11/01/2022	NM	NM	**NM**	
BH23	23/02/2021	87.8	7.32	7.32	1	GRAVEL, CLAY, GRAVEL, CLAY	22/04/2021	10:57:00	1.63	**86.17**	Top of steel casing is 0.28m above ground level
							18/05/2021	11:03:00	1.755	**86.045**	
							24/06/2021	10:57	1.81	**85.99**	
							20/07/2021	10:13	1.88	**85.92**	
							03/11/2021	10:27	1.94	**85.86**	
							26/11/2021	09:39	1.92	**85.88**	
							11/01/2022	11:53	1.54	**86.26**	
BH29	25/03/2021	-	13.77	13.77	1	GRAVEL, SILT/CLAY, GRAVEL	22/04/2021	10:24:00	2.38		Top of steel casing is 0.26m above ground level
							18/05/2021	NM	NM	**NM**	
							24/06/2021	NM	NM	**NM**	
							03/11/2021	11:02	2.15		
							26/11/2021	10:00	2.35		
							11/01/2022	12:10	2.12		
BH30	19/03/2021	87.01	9.15	9.15	1	GRAVEL	22/04/2021	10:20	1.77	**85.24**	Top of steel casing is 0.39m above ground level
							18/05/2021	10:34	1.815	**85.195**	
							24/06/2021	NM	NM	**NM**	
							20/07/2021	09:33	1.84	**85.17**	
							03/11/2021	10:52	1.66	**85.35**	
							26/11/2021	09:52	1.81	**85.2**	
							11/01/2022	12:07	1.63	**85.38**	

C Site Investigation

C.1 Locations





C.2 Trial Hole Logs

REPORT NO. 9377	TRIAL PIT RECORD	IGSL Ltd.

CONTRACT:	Newbridge Eastern Interceptor Sewer	Trial Pit No.:	TP2
		Sheet:	Sheet 1 of 1
CLIENT:	Kildare County Council	Excavation Method:	JCB
ENGINEER:	RPS MCOS	Date Started:	14/01/2004
CO-ORDINATES:	E - N -	Date Completed:	14/01/2004
		Ground Level (mOD):	-

Depth (m)	Geotechnical Description	Legend	Depth (m)	Elevation (mOD)	Water Strike (m)	Samples: Ref. No.	Samples: Type	Samples: Depth (m)	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0	TOPSOIL									
	Medium dense grey/brown coarse gravelly SAND with occasional cobbles		0.25							
1.0						K8378	B	1.00		
	Medium dense grey/brown coarse very gravelly SAND with cobbles		1.50							
2.0	End of Trial Pit at 2.00 m		2.00			K8379	B	2.00		
3.0										
4.0										

Groundwater Conditions: No water encountered

Stability: Pit sides very unstable during excavation

Remarks: Trial pit stopped at 2.0m due to sides collapsing.

TRIAL PIT RECORD

REPORT NUMBER 18590

CONTRACT	Newbridge Eastern Interceptor Sewer	TRIAL PIT NO.	TPP01
		SHEET	Sheet 1 of 1
LOGGED BY	I.Reder	CO-ORDINATES	680,818.08 E 714,391.69 N
		DATE STARTED	31/08/2015
		DATE COMPLETED	31/08/2015
CLIENT	Kildare County Council	GROUND LEVEL (m)	86.57
ENGINEER	RPS	EXCAVATION METHOD	JCB

Geotechnical Description	Legend	Depth (m)	Elevation	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0 Gravelly TOPSOIL		0.30	86.27						
Medium dense to dense, brown becoming brownish grey, very sandy fine to coarse GRAVEL with some subrounded to rounded cobbles					AA38353	B	1.00-1.00		
1.0									
Firm, grey, sandy gravelly CLAY with many subrounded cobbles and occasional boulders (<0.3m diameter)		1.80	84.77		AA38354	B	2.00-2.00		
2.0									
Dense, brown/grey, clayey/silty very sandy GRAVEL with many rubrounded to rounded cobbles		2.70	83.87	(Rapid)	AA38355	B	3.00-3.00		
3.0									
End of Trial Pit at 3.50m		3.50	83.07						
4.0									

Groundwater Conditions
Rapid water flow at 2.7m

Stability
TP slightly unstable from G.L. up to 1.8m and from 2.7m to 3.5m

General Remarks

TRIAL PIT RECORD

REPORT NUMBER 18590

CONTRACT	Newbridge Eastern Interceptor Sewer	**TRIAL PIT NO.**	**TPP03**
		SHEET	Sheet 1 of 1
LOGGED BY	I.Reder	**CO-ORDINATES**	680,979.18 E 714,391.21 N
		DATE STARTED	31/08/2015
		DATE COMPLETED	31/08/2015
CLIENT	Kildare County Council	**GROUND LEVEL (m)**	87.60
ENGINEER	RPS	**EXCAVATION METHOD**	JCB

Geotechnical Description	Legend	Depth (m)	Elevation	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0 TOPSOIL									
Soft to firm, brown, very sandy slightly gravelly SILT/CLAY		0.35	87.25		AA38359	B	0.80-0.80		
1.0									
Dense, brown, clayey/silty very sandy fine to coarse GRAVEL with many subrounded to rounded cobbles and occasional boulders		1.70	85.90	1 (Rapid)	AA38360	B	1.80-1.80		
2.0									
					AA38361	B	2.80-2.80		
3.0 End of Trial Pit at 3.00m		3.00	84.60						
4.0									

Groundwater Conditions
Rapid water flow at 2.7m

Stability
TP unstable from 1.7m

General Remarks

TRIAL PIT RECORD

REPORT NUMBER 18590

CONTRACT	Newbridge Eastern Interceptor Sewer	TRIAL PIT NO.	TPP04
		SHEET	Sheet 1 of 1
LOGGED BY	I.Reder	CO-ORDINATES	681,474.97 E 714,765.59 N
		DATE STARTED	31/08/2015
		DATE COMPLETED	31/08/2015
CLIENT	Kildare County Council	GROUND LEVEL (m)	87.28
ENGINEER	RPS	EXCAVATION METHOD	JCB

Geotechnical Description	Legend	Depth (m)	Elevation	Water Strike	Samples: Sample Ref	Samples: Type	Samples: Depth	Vane Test (KPa)	Hand Penetrometer (KPa)
0.0 TOPSOIL									
		0.40	86.88						
Loose, brown, slightly clayey fine SAND					AA38365	B	0.50-0.50		
		0.70	86.58						
Loose to medium dense, brown, clayey/silty very gravelly fine to coarse SAND									
1.0					AA38366	B	1.10-1.10		
		1.30	85.98						
Dense, brown/grey, sandy fine to coarse GRAVEL with many subrounded to rounded cobbles									
2.0					AA38367	B	1.90-1.90		
		2.30	84.98	1 (Rapid)					
Dense, brown/grey, clayey/silty sandy fine to coarse GRAVEL with many subrounded to rounded cobbles									
					AA38368	B	2.70-2.70		
		2.90	84.38						
TP terminated due to major instability - collapsed End of Trial Pit at 2.90m									
3.0									
4.0									

Groundwater Conditions
Rapid water flow at 2.3m

Stability
TP very unstable - collapsed

General Remarks

D JBA Response the KCC Comments

#	KCC Comment	JBA Response
Pg 14	A revised Site Specific Flood Risk Assessment is required to take account of additional information as well as third party expert scrutiny. The current proposal contravenes the Planning System Flood Risk Management Guidelines as it appears to suggest a relocation of flood water to adjoining property outside the site. It should also be revised following a revised SuDS strategy as recommended.	The Site Specific Flood Risk Assessment (SSFRA) has been revised in light of the comments received from KCC and the OPW, referenced below. The SSFRA has also been updated with new information regarding the updated proposed site development. A third party review of the SSFRA was carried out ARUP, dated the 05/04/2022, which confirms this FRA was completed "in accordance with requirements of The Planning System and Flood Risk Management Guidelines and in compliance with the Strategic Flood Risk Assessment (SFRA) of the Kildare County Development Plan 2017-2023". As per the review, ARUP "are satisfied that the proposed development will not result in any material increase in flood risk both on and off site and that the residual risk has been managed to acceptable levels". They are also satisfied that the Justification Test for the proposed development passed all criteria.
#	Water Services (D Hall comments)	JBA Response
2.32 2.32.1	Site Specific Flood Risk Assessment was submitted with any planning application shall be revised as follows: The historic flood adjacent to the subject site as per submitted SSFRA fig 3.1 shall be assessed and	 The historic flood adjacent to the site at Kilbelin, Newbridge (Ref: 1491) has been assessed. It related to the surface water system in the area not being able to cope after heavy rainfall. This occurs 1 or 2 times a year. It is approx. 500m west of the proposed development footprint and so is not considered a risk to the site. Refer to Section 3.1.1 of the SSFRA.
2.32.2	New fluvial flood mapping on OPW floodinfo website including indicative and CFRAMS fluvial flood extents shall be assessed – see item 2.33 below	The CFRAM fluvial flood extents as shown on the OPW floodinfo website have been assessed as part of the SSFRA. They are discussed in Section 3.2.2 of the report. The National Indicative Fluvial Mapping on the OPW floodinfo website did not have any flood extent mapping available in the Newbridge area. Item 2.33 discussed in relevant section below
2.32.3	The site specific hydrological analysis (river Liffey peak flow estimates) appear to correspond to the OPW CFRAMS values and the new 1D-2D linked hydraulic model (SSFRA sections 3.3.1, 4.1 and 4.2) which was development with additional topographic survey details and its results should be subject to third party independent expert scrutiny including:	A third party review of the SSFRA was carried out ARUP, dated the 05/04/2022, which confirms this FRA was completed "in accordance with requirements of The Planning System and Flood Risk Management Guidelines and in compliance with the Strategic Flood Risk Assessment (SFRA) of the Kildare County Development Plan 2017-2023". As per the review, ARUP "are satisfied that the proposed development will not result in any material increase in flood risk both on and off site and that the residual risk has been managed to acceptable levels". They are also satisfied that the Justification Test for the proposed development passed all criteria.

2.32.3.1	Predicted Q100 and Q1000 flows are lower than OPW CFRAMS values due to increased model roughness values to acknowledge the CFRAMS fluvial overland flow path through the subject site (SSFRA 4.3 and Table 4.2) and	The JBA models used the same flow inputs as the CFRAM model, localised changes in modelled flows along the length of the 1D channel are a result of changes in model parameters (e.g. Mannings roughness) and additional flow routes across the site in the JBA model. Refer to FRA Section 4.1.1 and 4.3.
2.32.3.2	The increase Q100 and Q1000 flood levels compared with OPW CFRAMS fluvial flood mapping for present day scenario <Table 4.2> must lead to increased flood extents which is apparent in figure 4.2 and which contravenes Planning System Flood Risk Management Guidelines (PSFRMG) Justification Test criterion 2i as per submitted SSFRA section 6.3 and	The increase in Q100 and Q1000 flood levels compared with the OPW CFRAMS fluvial flood mapping for present day scenario (Table 4.2) relates to the baseline scenario. This is the pre-development scenario as modelled by JBA. This baseline scenario was used as the compassion for the post-development model to assess impacts. Therefore, Justification Test criterion 2i does not apply to this as the baseline scenario is pre-development. Refer to Section 4.3
2.32.3.3	Minimal increase in Liffey flood water levels for 1% and 0.1% AEP events for the post-development scenario ie raised site ground levels thus removing the predicted overland fluvial flow paths through the subject site and representing the proposed Liffey bridge crossing and should include any bridge embankments and NSORR to be constructed under the proposed development (agreement regarding the proposed bridge constructed as per item 2.2 above shall be reflected in SSFRA to be submitted with any planning application including both SSFRA section 5.3) with the existing site watercourse-drainage channel to the north of the subject site retained and	The design scenario 1 which was modelled represents the raised site ground levels (which remove the predicted overland fluvial flow paths through the subject site), the proposed Liffey bridge crossing, embankments and the NSORR, and includes the drainage channel to the north. The model results confirm that there are no negative impacts as a result of this design in the 1% AEP event and in the 0.1% AEP event any increases in extents are confirmed to within the blue line boundary (land owned by the applicant). Increases in water levels are limited to downstream of the bridge and site, and within the river channel. There is no increase in extents or risk in these areas as the adjacent ground levels are sufficiently above the flood levels. Refer to Section 5.1 of the SSFRA for more information on the post-development model results.
2.32.3.4	The claims at SSFRA section 5.1 that changes to the 0.1% event fluvial flood extents post-development are also minimal and outside the Great Connell lands (ie subject site), there is only a minor increase to extents in the green field across the river (ie ongoing Glenveagh SHD?, see item 2.32.3.8 below) in contravention of PSFRMG Justification Test criterion 2i as per submitted SSFRA section 6.3 These changes are not readily distinguishable from a cursory examination of SSFRA figure 5.2 and in fact, it appears that other flood extents outside the subject site have actually increased which would also be in contravention of the PSFRMG Justification Test criterion 2i as per submitted SSFRA section 6.3 and require mitigation and	The post-development scenario and mitigation measures have since been updated and are reflected in the SSFRA. The Glenveagh SHD is also included in the baseline and post-development scenario. Section 5 of the SSFRA discusses the impacts of the proposed development in detail (depth difference maps and comparison of pre- and post-development water levels). Section 7.3 – Justification Test: Part 2 has been amended in light of the updated proposed development design and it confirms the development will not increase the flood risk elsewhere, amongst the other points in the JT.

2.32.3.5	The recommended finished floor levels (FFLs) as per SSFRA section 5.2.1 shall be justified with additional information and SSFRA figure 5.3 minimum recommended FFLs is at odds with the submitted OFS Master Site Layout Plan drawings no PR-002 Rev. O in terms of scheme layout and sub-minimum recommended FFLS e.g. at house numbers 494-499 etc and	The FFL are justified in Section 6.1 of the report – the minimum recommended FFLs of the development are placed above the 0.1% AEP post-development flood level with an additional 500mm freeboard, which is in line with the County Development Plan SFRA recommendations. Figure 6-1 shows the minimum recommended FFL for each block of houses, which have been calculated as discussed in the paragraph above (0.1% AEP + 500mm FB). The proposed FFLs, which have been designed taking into account the recommended minimum levels, will differ from the recommended levels as shown in Figure 6-1 as in some instance the proposed FFL exceeds the minimum recommended FFL. It is noted that this minimum recommended freeboard refers to the outer row of each housing block (i.e. the housing row closest to the watercourse). Once these housing rows are raised above the minimum recommended FFLs, they will act as a barrier preventing inundation to those houses in the inner sections of each housing block. For that reason, there may be some FFL within a block below the recommended level.
2.32.3.6	SSFRA figure 5.4 appears to indicate that the proposed compensatory storage is located in the post-development predicated 1% AEP event fluvial flood extents in contravention of PSFRMG and	The compensatory storage areas have been updated along with the relevant figures and are in accordance with Section 3.3.1 of Appendix B of the Planning Guidelines. The compensatory storage is located outside of the predicted 1% AEP extent, refer to figure 6-2 for areas of compensatory storage overlaying the baseline predicted 1% AEP extent. The areas of compensation in the figures in Section 5 are shown to be inundated as these are the post-development scenarios when the compensatory storage is being utilised.
2.32.3.7	Submitted Punch CE flood compensation area drawing no C-0804-C01 appears to indicate a provided compensatory storage volume of 71m3 but the required compensatory storage volume shall be calculated with appropriate plan and cross-section drawings through the subject site across the existing fluvial floodplain with 1% AEP plus 20% climate change factor fluvial flood levels, existing and proposed ground levels as per SSFRA section 3.2.1 Newbridge LAP SFRA and	The Newbridge LAP SFRA or Written Statement do not outline the compensatory storage standard with regard to AEP or climate change. The Kildare County Development Plan 2017-2023 only points to compensatory storage for loss of Flood Zone A, it does not mention climate change. The Planning Guidelines Appendix B 3.3.1 does not state a requirement for climate change allowance in the design of compensatory storage, only the 1% AEP event. Compensatory storage has been designed in line with the requirements of both the Planning Guidelines and the KCDP 2017-2023, whereby compensatory storage is provided for the loss of Flood Zone A. However, the provision of compensatory storage goes beyond the required 1% AEP storage volume, with an additional 1,200m³ of storage provided for.

2.32.3.8	If the Ardstone-Glenveagh SHD which is ongoing at present has raised ground level on their site, the SSFRA submitted with any planning application shall clearly demonstrate that the proposed development when constructed does not create a new flood risk or increase an existing flood risk on other properties and roads, upstream and downstream of the subject site which would contravene Planning System Flood Risk Management Guidelines (PSFRMG) Justification Test criterion 2i as per submitted SSFRA section 6.3 and	The hydraulic model has been updated to include the Ardstone-Glenveagh SHD in the baseline model (refer to Section 4.3 of the SSFRA). The design scenarios have demonstrated that the proposed development does not create a new flood risk or increase an existing flood risk on other properties and roads, upstream and downstream of the subject site (refer to Section 5 of the SSFRA).
2.32.3.9	Compliance with PSFRMG JT Part 2 – see SSFRA section 6.3.	The Justification Test was applied and passed as the hydraulic modelling confirms the impact on surrounding water levels is not significant and the development can manage the risk to itself (section 7.3).
2.32.4	Pluvial flood risk assessment in submitted SSFRA section 3.3.3 and 5.2.4, EPR Appendix E shall assess both the drainage and surface water overland flow elements as follows:	Section 3.3.3 and 5.2.4 have been updated to assess the pluvial risk from both the drainage and the surface water overland flows; see below.
2.32.4.1	Assess existing drainage systems including the site watercourses and any existing site open drainage channels-ditches that will be retained and any existing pipework that will be de-culverted.	The pluvial flood risk associated with the existing drains on site is discussed in Section 3.3.3 of the SSFRA. The overall slope of the land was reviewed to confirm that any surface water entering/falling on the site would flow into these channels and away from the subject site.
2.32.4.2	Compliance with GDSDS Stormwater Drainage Criterion 3 Site Flooding Level of Service for the proposed drainage systems based on the revised drainage and SuDS strategies and designs that emerge from the review to be carried out as outlined at section 2 above shall be demonstrated by submission of separate 30 year and 100 ear event plus 20% climate change factor pipe network simulations covering event durations up to 10,080 minutes and FFLs shall have a minimum freeboard of 500mm above the top water level in the drainage systems including pipe network and attenuation storage for the 100 year event plus 20% event.	Punch
2.32.4.3	Where planned overspills occur from the drainage system for storm events greater than the climate change adjusted 30 year event, the flow routing shall be directed towards safe areas eg surface water outfalls and open spaces and away from other adjacent properties and road and the flow outing shall not be obstructed.	Punch

	Where the planned overspills are of such a quantum that minimum FFL freeboard requirement shall be achieved at the open spaces where relevant, and at low points of the completed site where they might congregate and the recommended mitigation measure at SSFRA section 5.2.1 ie to place FFLs at least 150mm above ground levels shall be reviewed and	Punch
2.32.4.4	The pluvial risks from 'additional storage' as item 2.27 above.	Punch
2.32.4.5	The effect of the proposed development on pre-existing surface water overland flows into the subject site shall be assessed particularly the effect of raising site levels at boundaries and replacing permeable boundary treatments with impermeable ones. Where these overland flows are deemed to be of such a quantum so as to constitute a potential pluvial flood risk on adjacent properties and roads where they are obstructed, impeded or otherwise diverted by construction of the proposed development and which would contravene Planning System Flood Risk Management Guidelines (PSFRMG) Justification Test criteria 2i as per submitted SSFRA section 6.3 they shall be addressed and mitigated.	Section 6.4 of the SSFRA responds to this query and confirms the flood risk associated with pre-existing surface water overland flow routes from adjacent lands will not be increased as a result of proposed development. At the Wellesley Manor housing estate, ground levels suggest overland flows route flow towards the south west along the road and into the local drain within the proposed site boundary. No works are proposed for the drain at this location so this overland flow route will not be affected. Surface water falling on the Great Connell Road along the extent of the site road frontage would enter the existing site along sections of the road. The proposed design will consist of a grass verge/planting along the road which will allow the surface water from the road to continue drain away and will not impact the flow route. Refer to Section 6.4 of the SSFRA for more information.
2.32.5	Climate change is not a residual risk as per submitted SSFRA section 5.5 and its future effects on all flood risk types shall be assessed including OPW floodinfo website fluvial flood mapping for medium range future scenario for indicative and CFRAMS fluvial flood extents.	Climate change is no longer classed as a 'residual risk'. Section 4.3 discusses the climate change flood extents in the baseline scenario and the Climate Change flood levels are considered as part of the FFLs, where the FFL are placed above the climate change level (refer to Section 6.1)
2.32.6 2.32.6.1	The pluvial residual risk associated with: Failure or design exceedance events of existing and new drainage systems and any structures thereon including culverts, weirs, bridges and crossings. Flow routing, any potential flood risk and its proper mitigation as item 2.32.4.5 above, the achievement of the minimum FFL freeboard at completed site low points as item 2.32.4.3 above and the drainage maintenance regime to be implemented by the prospective application shall be addressed and	 Failure of the existing Golden Falls and/or Pollaphuca ESB Dams have now been considered as part of the residual risk, whereby a high flow scenario was tested to assess the impacts of additional flow from the Dam(s) being released. This high flow scenario estimated a minimum freeboard of 170mm above the proposed FFL. Refer to Section 6.6 for further information. Punch to confirm detail of surface water and any exceedance within the site.

2.32.6.2	high water levels in the receiving drainage networks including site watercourses and river Liffey with the associated network simulations as per EPR section 2.2.4 included and	Punch to confirm detail of surface water and any exceedance within the site.
2.32.6.3	compliance with PSFRMG JT criterion 2ii shall also be reviewed in light of the above.	Punch to confirm detail of surface water and any exceedance within the site.
2.33	Ground water flood risk as submitted SSFRA section 2.3 and 3.3.4 shall be assessed with respect to GSI groundwater vulnerability mapping, OPW PFRA flood mapping, new OPW floodinfo website groundwater flood mapping and the results of the site groundwater monitoring programme. The claim at SSFRA section 2.3 that the high GSI groundwater vulnerability classification for the subject site indicated a groundwater depth of greater than 3m is both counterintuitive and dispelled by the site investigation and groundwater monitoring results to date and shall be reviewed. As SSFRA section 3.3.4 it is further claimed that lower level of the subject site could potentially be impacted by groundwater flooding ie northwest corner and after periods of heavy rainfall, groundwater levels and levels in the 'drain'? could both rise and impact adjacent lands. The contravention of PSFRMG Justification Test criterion 2i as per submitted SSFRA section 6.3 shall be addressed and mitigated.	The ground water flood risk has now been assessed with respect to GSI groundwater vulnerability mapping (moderate to low). No historic surface water or groundwater flooding is identified in either the GSI datasets or the OPW PFRA or maps on the floodinfo website. Section 2.3 of the report discusses the groundwater monitoring carried out for the site which indicated an average groundwater depth of 2m. Site investigation works were also carried out on the site which indicated a groundwater depth of 2.3-2.7m. As concluded in Section 3.3.4, this information concludes that the groundwater risk to the site is low.
2.34	It is hoped that the minimum setbacks from the IFI guidance on planning for watercourses in the urban environment (ie for watercourses greater than 10m width, no development within 35m; less than 10m width, no development within 20m) which was launched in November 2020 will be included in all of the LAPs and the CDP in the future as this will also help with flood risk management. It is noted that the LAP for Newbridge has been extended to the end of the year, but SSFRA submitted within any planning application should address this issue.	This has been addressed in Section 7.8.2 of the EIAR and also in the Natura Impact Statement.
	Other	

2.35	The prospective application should have regard to pre-planning meeting details, previous planning decisions and Irish Water and KCC WSD reports and conditions on the subject and adjacent sites, including the adjacent Ardstone-Glenveagh SHD.	Noted
2.36	WSD remain available for further technical consultation with the applicant-agent.	Noted

E ARUP Peer Review

ARUP

Aston Limited

Aston SHD, Newbridge, Co. Kildare

Peer Review of Flood Risk Assessment

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1. Introduction

Ove Arup & Partners Ireland Ltd. was commissioned by Aston Limited to complete a peer review of the Flood Risk Assessment (FRA) report prepared by JBA Consulting Engineers for a Strategic Housing Development (SHD) at Great Connell, Newbridge Co. Kildare. The development proposal will consist of the demolition of existing site structures (2,622.3 sqm) and the construction of 569 no. residential units, a neighbourhood centre with 11 no. units (commercial floor area 2,141 sqm) and a childcare facility (886 sqm), a circa 350 metre section of distributor road, and all ancillary and associated works on a site of 27.64 ha (see Drawing 1).

More details of the proposed development are provided in the elsewhere in the Planning Documents.

Kildare Co. Co. made comments on an earlier version of the FRA at a pre-planning meeting in October 2021. JBA subsequently amended the report in consideration of same and upon request by Aston Ltd., issued the report to Arup for peer review on 22/02/2022. Arising from this review, Arup made several recommendations as to how the development proposals could be augmented to further reduce the residual flood risk post the development. Of these, the increase in flood level at the proposed bridge adjacent to Ardstone Development was reduced from 100mm to just 15mm which can be seen as a significant improvement. Other revisions were made accordingly, and JBA amended the FRA which was re-issued to Arup for a final review.

This report sets out the findings and recommendations of our peer review of the flood risk assessment for the development site. The review was based solely on the information presented in the FRA and did not include any independent hydraulic modelling to verify the hydraulic model results contained in the report.

2. Objective

The objective of Arup's review was to confirm if the FRA prepared for the proposed development site at Great Connell, Newbridge, Co. Kildare was in accordance with The Planning System and Flood Risk Management Guidelines, Guidelines for Planning Authorities (DOEHLG & OPW, 2009) (hereafter referred to as "the Guidelines") as well as in compliance with the requirements of the Strategic Flood Risk Assessment (SFRA) prepared for the Kildare County Development Plan 2017-2023.

3. Document Reviewed

The FRA report reviewed is titled, "Great Connell SHD, Newbridge Flood Risk Assessment Revision Ref. A3-C03," as prepared by JBA and issued to Arup on 22 March 2022. This is a later revision of the February 2022 FRA report incorporating updates following on comments given by Arup on review of the earlier revision.

4. Reviewer

The review was completed by Mesfin Desta, PhD FIEI. Mesfin Desta is a Principal Hydrologist with Arup and has over 16 years of experience as a hydrologist. He holds a PhD in Civil Engineering (thesis in hydrology) from UCD and MSc in Engineering Hydrology from NUI Galway. He is a chartered member and Fellow of Engineers Ireland since 2006. He has been responsible for the preparation of Flood Risk Assessment reports for various projects including Strategic Housing Developments, transport infrastructures, wind farms, pumping stations, etc.

The report was reviewed by Ken Leahy, Associate Director at Arup

5. Methodology

The Guidelines require that a site-specific FRA be completed which considers all possible flood risk sources and which incorporates appropriate mitigation measures that will reduce the flood risk to acceptable levels both at the development site itself and off site, both upstream and downstream. The Guidelines recommend a three-staged approach that covers both the likelihood of flooding and the potential consequences. This report outlines the findings at each of these stages:

- Stage I - Flood Risk Identification,
- Stage II – Initial Flood Risk Assessment, and
- Stage III – Detailed Flood Risk Assessment.

Our peer review is completed following the three-staged approach as recommended in the Guidelines.

6. Stage I – Flood Risk Identification

The FRA identified the main source of flooding at the Development Site to be the River Liffey as seen on the relevant CFRAM maps and confirmed in JBA's hydraulic modelling work. The development site is not tidally influenced due to its distance and elevation from the sea and hence the risk of coastal flooding was considered extremely low.

The risk of groundwater flooding was also deemed low. Groundwater monitoring completed for the site indicated that the water table varied between 1.0m and 2.9m below ground. Although the risk of groundwater flooding to the site is low, the relatively shallow water table, likely due to the site's proximity to the River Liffey may require management during construction.

The risk of pluvial flooding was also indicated to be generally low. There had been some historical surface water flooding on the R416 at Kilbelin as seen in the OPW historical flood maps, which was indicated to have been caused by a lack of capacity of the drainage system. This event was recorded in 2005 and has little or no relevance to the proposed development as it is at the opposite side of the river, and no flooding has since been reported.

There is also a risk of flooding due to a breach or mechanical failure of the two upstream reservoirs on the River Liffey (Poulaphouca Reservoir and Golden Falls Dam). This was assessed in the FRA prepared by JBA and was considered low.

6.1 Stage II - Initial Flood Risk Assessment

The proposed development site is situated mainly in Flood Zone C, i.e., at low risk from all identified sources of flooding. However, based on the CFRAMS mapping, it was evident that a portion of the development site lies within Flood Zone A and B because of the overland flow path across the site which becomes active in the 1% AEP event and above.

The SHD is considered "highly vulnerable" development, and hence a Justification Test must be undertaken for any such development located within Flood Zones A and/or B. To address the flood risk aspect of the Justification Test, it was established that a detailed Stage III flood risk assessment was required, including the development of a site-specific hydraulic model.

6.2 Stage III - Detailed Flood Risk Assessment

6.2.1 Hydrology - Design Flows

JBA estimated design flows based on gauged flows (Golden Falls) and physical catchment descriptors (River Liffey Flows) and compared the outputs with the CFRAM flows at the same Hydraulic Estimation Points (HEP). The results compared well with the CFRAM and hence the CFRAM flows were brought forward as inputs to the hydraulic model.

Additional flows were added from two small watercourses (Doorfield - southwest of the site) and a field drain east of the site. The 1% AEP flow from Doorfield was calculated to be 2.84m^3/sec while the field drain contribution was approximated to 1.0m^3/sec. These small watercourses were not included in the original CFRAM analysis.

We are satisfied that the methodologies adopted, and flows utilised were appropriate.

The resulting design flows are listed in Table 6-1 below:

Table 6-1 Design Flows

Source	HEP@	1% AEP (m3/sec)	0.1% AEP (m3/sec)
Upstream inflow (Liffey)	CFRAM Node: 09LIFF06678E	134.15	156.53
Doorfield	CFRAM Node: 09WALS00027dl	2.84	4.57
Field Drain	within the site	1	1

6.2.2 Hydrograph Shape

The hydrograph shape developed as part of the CFRAM Study was adopted for the FRA with the release from Golden Falls Dam generating the peak flow in the model over and above the River Liffey peak. Flows from the two small watercourses were added to the CFRAM flows at their respective locations.

6.2.3 Hydraulic Model

A linked 1D(Estry) and 2D (TUFLOW) model was built to estimate existing flood levels and extents within the proposed site. Table 6-2 below shows a comparison of the CFRAM and JBA Model water levels and flows for the 1% and 0.1% AEP at two selected HEPs

Table 6-2 Comparison of CFRAM and JBA Design Flows and Levels

	CFRAM				JBA Model			
	1% AEP		0.1% AEP		1% AEP		0.1% AEP	
HEP	Level, m OD	Flow, m^3/sec	Level, m OD	Flow, m^3/sec	Level, m OD	Flow, m^3/sec	Level, m OD	Flow, m^3/sec
09LIFF06455	86.46	131.97	86.61	157.76	86.92	130.92	87.07	144.97
09LIFF06415	85.74	135.10	85.86	166.03	86.02	121.48	86.20	132.41

The initial JBA model run calibrated well against the CFRAM model. However, having carried out a sensitivity test on roughness, it became apparent that the overland flow route and river levels were sensitive to roughness,

and therefore, to be conservative, JBA adopted the higher roughness values. Accordingly, as seen in Table 6-2 above, the in-channel flows reduce slightly as a result of greater flow escaping to the floodplain, but levels are higher due to the increased roughness.

We consider this to be a conservative approach given the sensitivity of the model to increase roughness values, and the fact that these higher flood levels will be used to set the FFL for the development. The model developed was, therefore, used to compare the pre- and post-development scenarios.

6.2.4 Design Scenarios

The development proposal has two primary constituent parts, namely, the residential element and a proposed bridge and roadway. It is likely that these elements may be delivered separately, and so it was necessary to consider two design scenarios as follows:

- Scenario 1 – Aston SHD Development plus Bridge over River Liffey, and
- Scenario 2 – Aston SHD Development only.

Both Scenarios involve raising the ground levels at the development site, to remove the overland flow path across the site in the 1% AEP event.

The removal of this conveyance route and storage volume would otherwise result in a localised increase in river levels. To offset the loss of this flow path, improved conveyance and two compensatory storage areas are proposed along the inner meander of the River Liffey to the south and southwest of the site. These elements have been further optimised following recommendations from Arup's review of the earlier version of the FRA report.

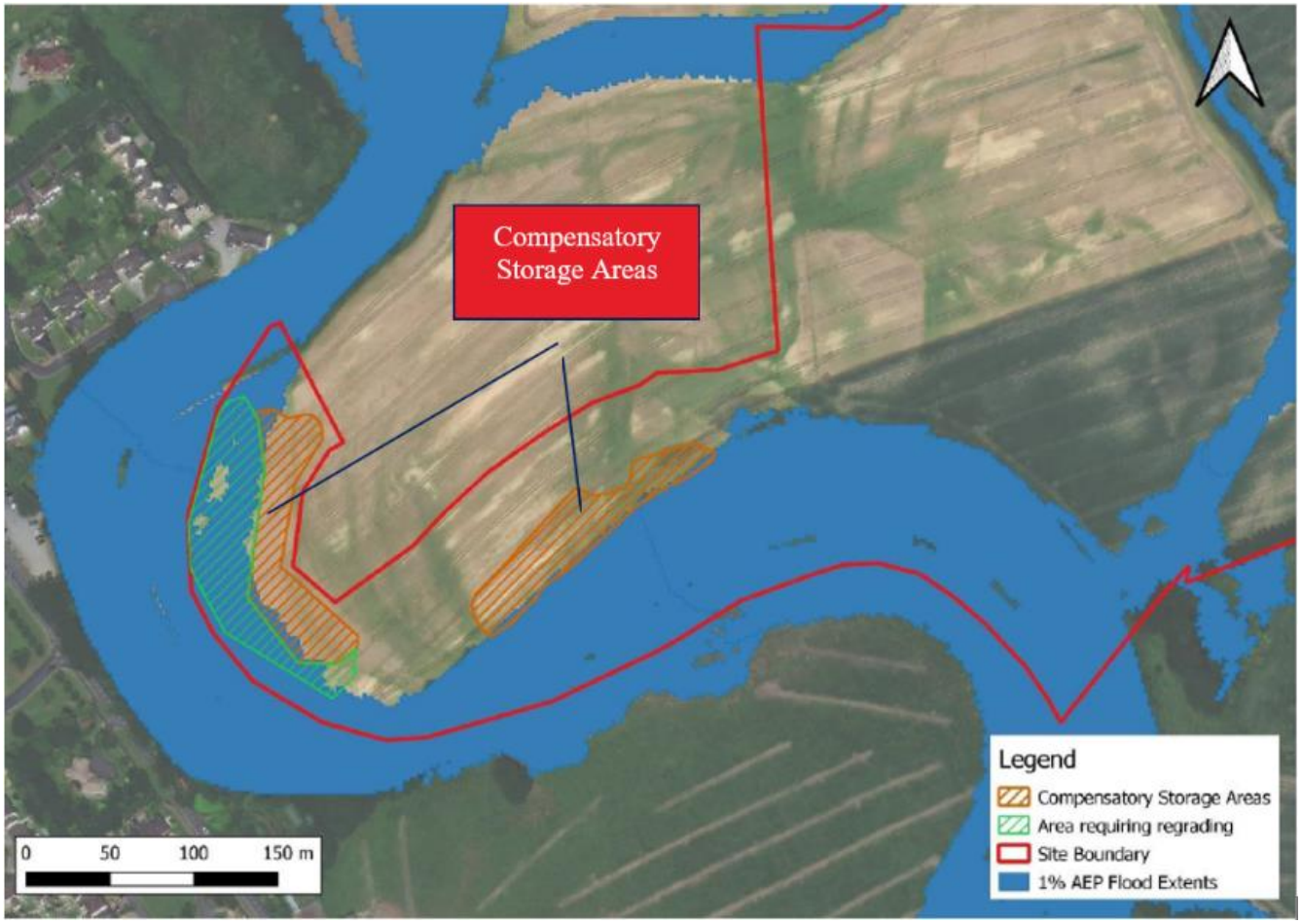

Figure 6-1 Proposed Compensatory Storage Areas

As would be expected, Scenario 1 (i.e., both the SHD and Bridge in place) gives rise to the highest river levels and hence the focus of the peer review was on changes in flood levels pre- and post-development assuming both elements of infrastructure are constructed.

The resulting changes in flood depths/extents for the pre- and post-development conditions under the 1% AEP and 0.1% AEP events for Scenario 1 are presented in Table 6-3 below. Locations 1 to 5 are instream locations shown in Figure 6-2 as used in the FRA Report.

Table 6-3 Pre- and Post-Development Scenario Flood Levels

Location	1% AEP m OD		0.1 AEP m OD	
	Pre	Post	Pre	Post
1	88.97	88.97	89.15	89.15
2	88.38	88.38	88.55	88.56
3	87.80	87.80	87.93	87.96
4	86.92	86.92	87.07	87.07
5	86.02	86.02	86.20	86.20
6	85.61	85.61	85.86	85.86

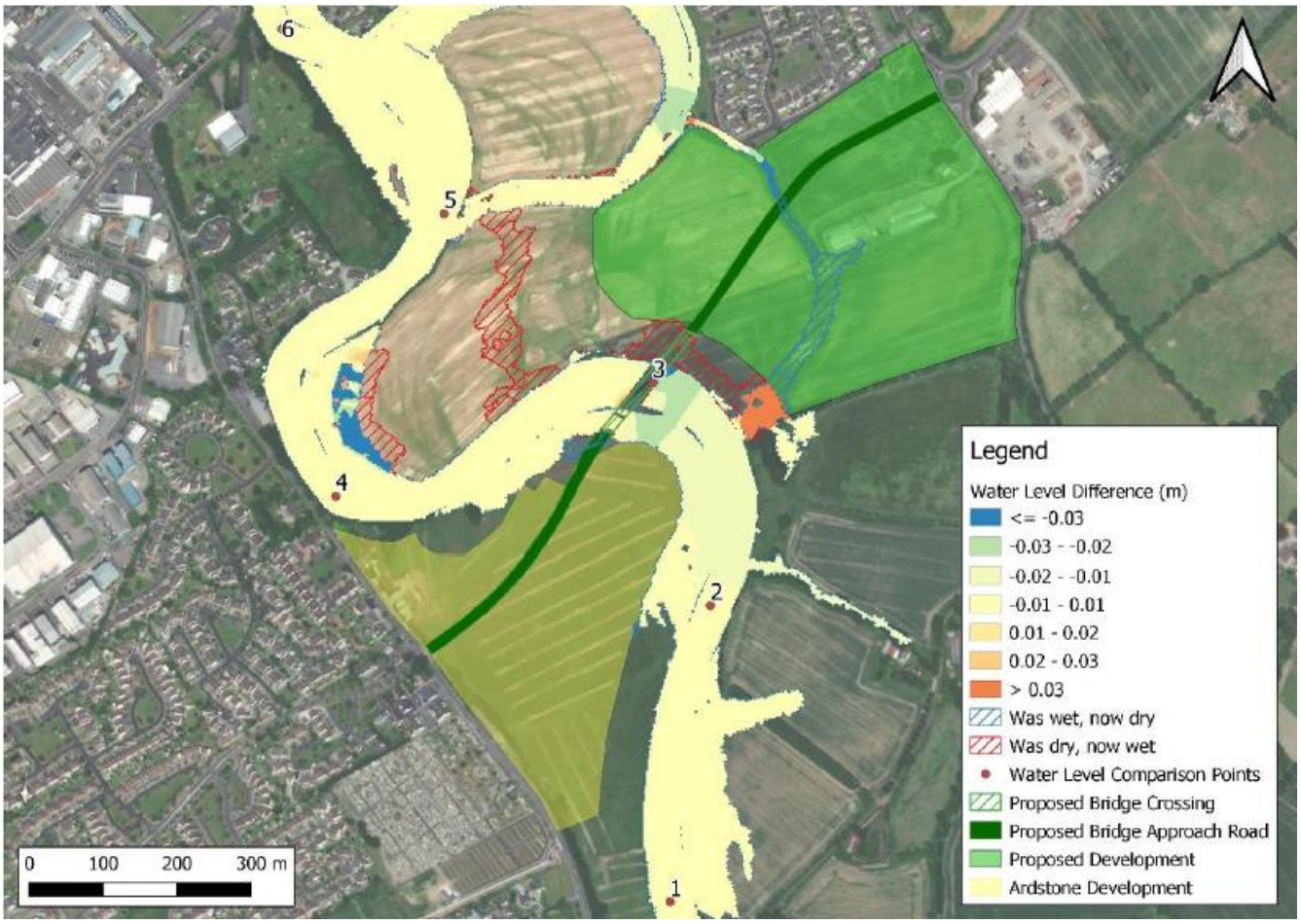

Figure 6-2 Depth Difference Map at Key Instream Locations

The following are the key findings of our review of the pre- and post-development scenarios.

- There is no increase in instream water levels from the pre-development scenario for the 1% AEP event. The 0.1% AEP does show some small-localised increases in instream levels in the order of 0.01m to 0.03m but these are considered negligible in the context of flood risk.
- There were some slight increases in flood levels within the redline boundary (shown in maps), but these are outside of the primary development footprint areas where water compatible development is proposed.
- The main post development change is a small change in flood extents under the 0.1% AEP event (see Figure 6-3 – shown circled). Lands south and southwest of the site are flooded in both the 1% and 0.1% AEP events. Some of these lands are outside the red line boundary. However, these lands are entirely owned by the applicant (Aston Limited) and hence no third party will be impacted by

this.

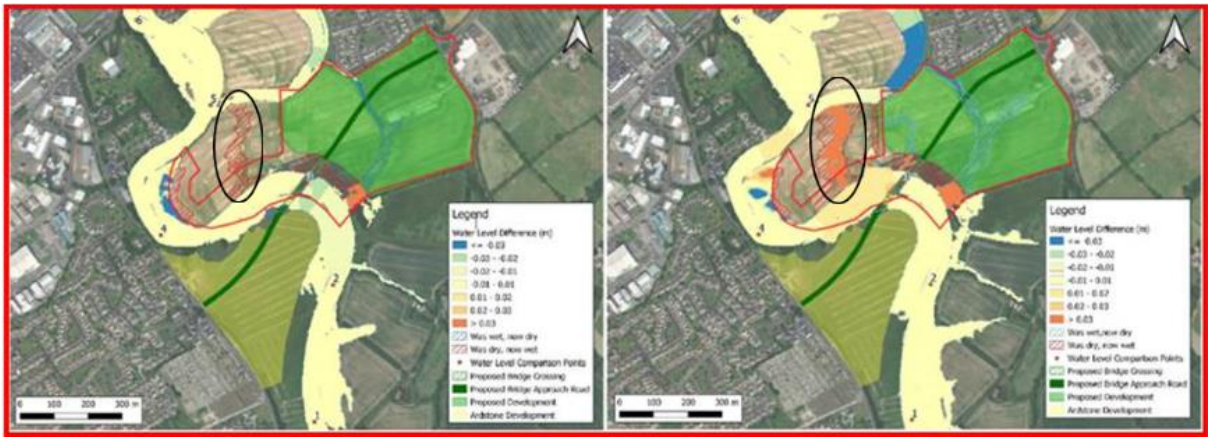

Figure 6-3 Predicted Flood Level Differences for the 1% and 0.1% AEP Events

- The bridge abutments and piers have a minimum span of 24m, which are located outside of the riverbed' to confirm the risk of blockage is low. The span between the centre pier is 40 meters. The 0.1% AEP depth difference map shows a slight local increase in water levels within the channel at the bridge location. It is noted that a separate Section 50 consent will also be required for this bridge.

- On lands not owned by the applicant, no increase in level is observed in the 1% AEP event. A small increase of 15mm depth is reported at the adjacent Ardstone Development. The increase was 100mm in the previous assessment before Arup's recommendations regarding storage and conveyance improvement measure were implemented. The latest run is not expected to result in any discernible increase in the flood extent and over 1m of freeboard is reported to exist between the 0.1% AEP level and the FFL of the Ardstone Development.

7. Justification Test

A Justification Test was prepared by the applicant, and each criterion was deemed to be passed as outlined below:

- Part 1: The Land is zoned for residential development within the LAP for Newbridge.

- Part 2(i): Through the preparation of a detailed FRA including the development of pre- and post-development hydraulic models, it has been shown that the development proposal will not materially alter the risk of flooding either on or off site.

- Part 2(ii): The FFL of the proposed development have been set above the 0.1% AEP fluvial level, plus a minimum freeboard of 500mm to minimise the risk to people, property, and the economy,

- Part 2(iii): The proposal includes compensatory conveyance improvement measures and compensatory storages to mitigate residual risks to acceptable level (i.e., to within the applicant's own land).

- Part 2(iv): The response regarding achievement of the wider planning objectives is addressed elsewhere in the SHD application.

We are satisfied that the Justification Test for the proposed development passed all these criteria.

8. Conclusion and Recommendations

1. Arup completed a peer review of the Flood Risk Assessment (FRA) for Aston SHD as prepared by JBA.

2. The main source of flooding on the proposed Development Site was identified to be the River Liffey. The Development Site is mainly in Flood Zone C. However, the CFRAM flood maps and JBA modelling results showed that there is an overland flow path across the Site for the 1% AEP event, which means that part of the site lies within Flood Zone A and B. Therefore, a detailed flood risk assessment, including a Justification Test, by means of a hydraulic modelling was completed to satisfy the requirements of the Guidelines. We are satisfied that the Justification Test for the proposed development passed all the criteria.

3. The FFL of the proposed development is set above the 0.1% AEP level plus a freeboard of 500mm which we consider appropriate for the class of proposed development.

4. To reduce the residual risk further, a mitigation measure in the form of compensatory conveyance improvements and compensatory storage is proposed on the south and southwestern boundary of the Site. The hydraulic model was used to demonstrate the benefit of these compensatory measures. The compensatory storage areas enabled removal of the flow path from the development footprint without increasing river levels in the 1% AEP event and limiting localised increases to less than 30mm in the 0.1% AEP event. The minor increase in levels results in some minor increase in flood extents in the 0.1%AEP event, but this is generally limited to agricultural lands both within and outside of the redline boundary which are owned by the applicant (Aston Limited) and hence no third party will be impacted.

5. On lands not owned by the applicant, there is a minor increase in flood depth of 15mm in the 0.1%AEP event at an adjacent development (Ardstone Development) but due to the steep bank, there is no discernible increase in flood extent, and it is understood that the FFL of that development provide over 1m of freeboard above the 0.1 % AEP flood level. This is a significant improvement at Ardstone Development (i.e., reduction from 100mm to15mm) in flood levels which was achieved by implementing Arup's comments on the earlier version of the FRA.

6. In addition, by further amending the details of the compensatory measures, to take on board the recommendations from our initial review, we are satisfied that the proposed development will not result in any material increase in flood risk both on and off site and that the residual risk has been managed to acceptable levels.

7. Therefore, following our peer review, Arup considers that the FRA was completed in accordance with the requirements of The Planning System and Flood Risk Management Guidelines, Guidelines for Planning Authorities (DOEHLG & OPW, 2009) and in compliance with the Strategic Flood Risk Assessment (SFRA) of the Kildare County Development Plan 2017-2023.

Drawing 1 - Project Site Map

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