Celbridge, Co Kildare

Flood Risk Assessment

December 2018

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Celbridge,
Co. Kildare.
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Revision History

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Contract
This report describes work commissioned by Donnachadh O’Brien and Associates on behalf of O’Flynn Construction Co Unlimited Company. David Casey and Holly O’Keeffe of JBA Consulting carried out this work.

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Purpose
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Abbreviations

AEP ............................................. Annual Exceedance Probability
CFRAM ..................................... Catchment Flood Risk Assessment and Management
DoEHLG ................................ Department of the Environment, Heritage and Local Government
EPA ........................................ Environmental Protection Agency
FEM FRAM .............................. Fingal East Meath Flood Risk Assessment and Management
FFL .......................................... Finished Floor Level
FRA .......................................... Flood Risk Assessment
GDSDS ................................ Greater Dublin Strategic Drainage Strategy
GSI .......................................... Geological Survey of Ireland
OPW ........................................ Office of Public Works
PFRA ...................................... Preliminary Flood Risk Assessment
SFRA ...................................... Strategic Flood Risk Assessment
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

JBA Consulting was appointed by O’Flynn Construction Co. Ltd. to prepare a Flood Risk Assessment (FRA) for a proposed residential development located along Shackleton Road, Celbridge, Co. Kildare. The report was prepared in response to a request by Donnachadh O’Brien on behalf of O’Flynn Construction Co. Ltd for an FRA.

A flood risk assessment for the site was requested by Kildare CoCo during initial correspondence regarding the development. The main points requested by Kildare CoCo are outlined as follows:

- Finish Floor Levels (FFL) are to be placed a minimum of 500mm above the 1% AEP flood levels.
- Flooding during the 1% and 0.1% AEP events are noted along the southern bank of the Crippaun / Toni River.
- Potential blockage, failure of the culvert system along the Crippaun / Toni River and resulting impact upon the site will need to be assessed.

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 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.

Recommendation for development have been provided in context of the OPW / DoECLG 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

The client has proposed to develop a residential estate including access roadway, landscaping and ancillary works at the site located in Celbridge, Co. Kildare. The site is currently a greenfield site which is used for agricultural purposes. The total area of the site is 9.3 ha. The proposed design consists of 251 residential properties. In addition to the site works, a stormwater system will be incorporated within the design. The stormwater system is divided into two main areas. The northern section of the development is serviced by a dedicated stormwater system, which discharges to the existing public system at the north-eastern corner of the site. The southern half of the site is serviced by a dedicated stormwater system that discharges to the existing culvert located at the developments south-eastern corner.

The proposed design and proposed stormwater system layout are outlined in Figure 1-1 and Figure 1-2.
Figure 1-1: Design and Stormwater Layout
Figure 1-2 Design and Stormwater Layout

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. Section 4 outlines the hydrology and hydraulic model results and Section 5 provides mitigation measures for the site. Conclusions are outlined in Section 6.
2 Site Background

This section describes the proposed residential development site at Shackleton Road, Celbridge, Co. Kildare.

2.1 Location

The site is located to the west of Celbridge town, Co. Kildare. The site will be accessible from Shackleton Road to the east and Oldtown Road to the north of the site. Figure 2-1 details the site location and watercourses in the area. The site is located on the fringe of Celbridge town, with the predominant surrounding land use to the northwest and west classified as agricultural land. It is bound to the north by residential properties, to the south and west by agricultural lands, and to the east by Scoil na Mainistreach.

A site visit was carried out on 15th May 2018 to appraise the flood risk to the site. The site slopes gently in a northwest to southeast direction. Figure 2-2 outlines the development site, access road and the River Liffey and its tributaries.

Figure 2-1: Site location & Hydrological Environment
Drainage (north of Site)

Drainage Culvert Through Site

Stone Wall Structure along Crippoun River

Development site (view to West boundary)

Figure 2-2: Site Photographs
2.2 Watercourses

The River Liffey is the main watercourse in the Celbridge area and is located 1.2km to the east of the site. The Toni River/Crippaun River (hereafter referred to as the Crippaun River) and the Posseckstown Stream are two tributaries of the River Liffey which are in close proximity to the site. The Crippaun River runs along the site’s southern boundary and is culverted at the site’s southernmost corner. The river is culverted as it passes through Celbridge before ultimately discharging to the River Liffey, 1.2km east of the site as shown in Figure 2-1.

The Posseckstown stream flows in a southerly direction and joins the River Liffey 3.4km to the southwest of the site. Topographic analysis shows the site is not located within the sub-catchment of the Posseckstown stream, and thus is screened out from further analysis.

Figure 2-3 displays the existing drainage network onsite. This system drains the agricultural lands located directly west of the site. Refer to Figure 2-2 for photographs taken of the drainage channels and culvert outlet system.

2.3 Site Geology

The Geological Survey of Ireland (GSI) groundwater and geological data viewer of the site and local area were reviewed. The subsoil within the site consists of till derived chiefly from limestone. No alluvium type soils were noted along the Crippaun River system, the presence of alluvium could indicate historic flooding.

The underlying bedrock is classified as Dark Limestone and Shale, there are no karst features located within the site or surrounding area.

The associated groundwater vulnerability, which indicates the risk to the underlying groundwater body for the site is classified as 'High'. This indicates a high risk of flooding from groundwater. Figure 2-4 details the underlying subsoil, and Figure 2-5 details the groundwater vulnerability at the site location.
Figure 2-4: Subsoils at the site location (Source: EPA)

Figure 2-5: Groundwater vulnerability at the site location (Source: EPA)
3 Flood Risk Identification

An assessment of the potential 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 flooding information. The findings from the flood risk identification stage of the assessment are provided in the following sections. Further detail on the Planning Guidelines and technical concepts are provided in Appendix A.

3.1 Flood History

A number of sources of flood information were reviewed to establish any recorded flood history at or near the site location. This includes the OPW’s website, www.floodmaps.ie and general internet searches.

3.1.1 Floodmaps.ie

The OPW host a national flood hazard mapping website, www.floodmaps.ie, which highlights areas at risk of flooding through the collection of recorded data and observed flood events. See Figure 3-1 for historic flood events in the area.

Review of Figure 3-1 does not show any instances of flooding at the site of along the Crippaun River. Several incidents of flooding are noted along the River Liffey to the east of the site. The incidents of flooding surrounding the site have all been caused by extreme rainfall.

![Figure 3-1: Historical flooding (Source: Floodmaps.ie)](image)

3.1.2 Internet search

An internet search was conducted to gather information about whether or not the site was affected by flooding previously. No flooding incidents were recorded at the site.

It is worthy to note a flood event occurred 0.4km east of the site in Vanessa Close Estate: 8 properties were flooded during this event. The Crippaun River flows through a culvert in St. Raphaels Manor, the ditch adjacent to Shackleton flows towards Vanessa Close. The CFRAM study Hydraulics Report provides details of this flood event. This event was due to a blockage of a culvert system downstream of Vanessa Close.
3.2 Predictive flooding

The site has been subject to two predictive flood mapping / modelling studies:

- OPW's Preliminary Flood Risk Assessment (PFRA);
- Eastern Catchment Flood Risk Assessment and Management Study.

3.2.1 OPW Preliminary Flood Risk Assessment (PFRA)

The Preliminary Flood Risk Assessment (PFRA) is a requirement of the EU Flood Directive (2007/60/EC). One of the PFRA deliverables is flood probability mapping for various sources: pluvial (surface water), groundwater, fluvial and tidal. The PFRA is a preliminary or 'indicative' assessment and analysis which has been undertaken to identify areas potentially prone to flooding. The OPW PFRA study has largely been superseded by the CFRAM programme, however, it does provide valuable information regarding pluvial and groundwater flooding. The PFRA flood maps are also the main source of flood risk information in this area as it was not covered by the CFRAM programme. See Figure 3-2 for OPW PFRA flood extents at the site and surrounding area.

Review of the PFRA mapping indicates localised pluvial flooding within the site boundary and a cell located at the site’s western boundary. Review the PFRA mapping also confirms that no groundwater flooding is noted at the site.

Figure 3-2: OPW PFRA flood map (source: myplan.ie)
3.2.2 Eastern Catchment Flood Risk Assessment and Management Study (CFRAM).

The primary source of data utilised to identify flood risk to this site is the Eastern CFRAM. Flood maps have been finalised for Celbridge and surrounding area.

The CFRAM consists of detailed hydraulic modelling of rivers and their tributaries. The Crippaun River has been modelled under the Eastern CFRAM and flood extent maps for the fluvial scenario have been completed. The relevant flood maps are available through the CFRAM website.

Review of the Eastern CFRAM flood maps for the Crippaun River confirms that the proposed development is in Flood Zone C, refer to Figure 3-3 for an extract of the flood maps. The extents of Flood Zones A and B border the southern length of the site but do not encroach within the site boundary. The relevant flood levels for the 1% AEP and 0.1% AEP along the Crippaun River are 65.24mOD and 65.43mOD at node 09CRIP00214.

Figure 3-3: CFRAM Flood Map

3.3 Development Plans

3.3.1 Kildare County Development Plan 2017-2023

The overarching guidance document governing the development at the site is the Kildare County Development Plan (DP) 2017-2023. The document sets out the overall strategy for proper planning and sustainable development across County Kildare.

The Kildare County DP sets out a number of policies relating to flood risk and stormwater management, which are used to guide development. Refer to Appendix C for stated policies and objectives relating to flood risk.

3.3.2 Celbridge Local Area Plan (LAP) 2017-2023

The Celbridge LAP guides the development within Celbridge and the surrounding hinterland. Specific policies and objectives area provided in Appendix B. As part of the LAP, a Strategic Flood Risk Assessment (SFRA) was carried out for Celbridge to assess flood risk in the town and inform
strategic land-use decisions. The purpose of the SFRA ensuring that flood risk management is fully integrated into the LAP. It should be noted that the SFRA is based on the Eastern CFRAM flood maps. The flood maps confirm the flood extents presented in CFRAM flood map presented in Figure 3-3.

The Celbridge SFRA identifies 5 No. Key Development Areas (KDA) to promote strategic development. The proposed development site occupies KDS No 3 (Shackleton) for residential use. As part of the objectives of the SFRA, areas outlined in the Flood Risk Map are subject to a site specific flood risk assessment.

3.4 Sources of flooding

The initial stage of Flood Risk Assessment requires the identification and consideration of probable sources of flooding. These sources are described in the following section:

3.4.1 Fluvial

The principal source of flooding to the site is the Crippaun River which flows along the southern boundary of the site and is a tributary of the River Liffey. The flood maps produced as part of the Eastern CFRAM study confirm that the site is not at risk from the 1% AEP or 0.1% AEP flood events. Some overtopping of the Crippaun River’s right hand bank (RHB) is noted upstream and adjacent to the site. Criticality, the CFRAM study confirms that the Crippaun River has mostly sufficient capacity to convey both the 1% and 0.1% AEP flood events, however some overtopping is noted along the RHB in localised depressions.

It should be noted that, based on the area topography, the flood outlines provided in Figure 3-3 may not be attenable due to the prevailing flow pathways. This assertion is based on the latest LIDAR data and site survey information. The purpose of this FRA is to confirm the findings of the CFRAM study and further test residual flood risks to the development such as blockage of the Crippaun River culvert system downstream of the site.

As outlined in Section 1.1, an FRA is required to confirm the 1% AEP flood level and corresponding FFL and to assess residual risks such as potential blockage of inline structures. To appraise the flood risk, a hydraulic model was developed for the site, which is outlined in Section 4. Mitigation measures relating to the identified fluvial flood risks are discussed further in Section 5.1.

3.4.2 Pluvial

Pluvial or surface water flooding is the result of rainfall-generated flows that arise before run-off can enter a watercourse or sewer. The OPW PFRA mapping suggests potential localised pluvial flooding on the site and along the western boundary.

Based on the review of the site survey information, a fall is noted towards the centre of the site with depressions located towards the eastern boundary of the site that could cause ponding of surface water. An extensive drainage system is currently located across the site and the lands west of the site. This drainage network will convey surface water from the agricultural lands to an outlet located at the site’s eastern boundary.

There is always the risk that change in land cover could result in an increase in speed of runoff and therefore an increase in flood risk to neighbouring lands. Therefore, it is important to consider all aspects of the site as well as existing drainage works. Adequate finished floor levels, a surface water management strategy and maintenance plan for the drains are important for the management of surface water flood risk at the site. The stormwater management measures proposed to mitigate this risk have been reviewed and will be discussed further in Section 5.1.3.

3.4.3 Groundwater

Groundwater flooding results from high sub-surface water levels that impact upper levels of the soil strata and overland areas that are usually dry. The OPW PFRA maps were reviewed and do not indicate groundwater flooding at the site or surrounding area. The GSI groundwater vulnerability for the site is classified as ‘High’ and there were no karst features located in or around the site location. Based on this information, there is a low risk of groundwater flooding at the site.
4 Hydrology

To assist in the estimation of potential flood risk to the proposed development from the Crippaun River, this section provides flow estimates for the 100 year (1% flood event) and 1000 year (0.1% flood event) flows expected along the Crippaun River to the south and east of the proposed development.

4.1.1 Catchment characteristics

The physical characteristics of the catchment influence the hydrology, this includes catchment size, soil type, steepness and also the average rainfall. Table 4-1 outlines the parameters calculated for the site catchment. Figure 4-1 over page details the catchment area.

Table 4-1: Catchment Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Note</th>
</tr>
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<tr>
<td>AREA (km²)</td>
<td>2.7km²</td>
<td>The area of the catchment in km²</td>
</tr>
<tr>
<td>MSL (km)</td>
<td>2.50</td>
<td>Main Stream length</td>
</tr>
<tr>
<td>S1085 (m/km)</td>
<td>5.18</td>
<td>Slope based on the stream elevation at 10% and 85% along MSL</td>
</tr>
<tr>
<td>SAAR (mm)</td>
<td>729.72</td>
<td>Standard Average Annual Rainfall</td>
</tr>
<tr>
<td>SOIL</td>
<td>0.2</td>
<td>Soil index, which is a composite index determined from soil survey maps that accompany the Flood Studies Report.</td>
</tr>
<tr>
<td>M5-2day (mm)</td>
<td>55</td>
<td>5 year return period rainfall for 2 day duration</td>
</tr>
<tr>
<td>r</td>
<td>0.35</td>
<td>1hr M5 expressed as a percentage of 2day M5</td>
</tr>
<tr>
<td>ArtDra2</td>
<td>0</td>
<td>Arterial Drainage</td>
</tr>
</tbody>
</table>

Figure 4-1: Site Catchment Area
4.1.2 Flow Estimation

Two flood estimation methods were used to compare under hydrological analysis. These are:

- The Flood Studies Report Method (FSR Statistical)
- Institute of Hydrology Report No. 124 (IH124)
- FSR Rainfall Runoff (RR)
- Flood Studies Update (FSU)

Table 4-2 outlines the calculations for each method. Climate change was accounted for by increasing the relevant peak flows by 20%, which is based on the Medium Range Forecast Scenario (MRFS) OPW guidance.

<table>
<thead>
<tr>
<th>Peak flow methods</th>
<th>Qmed (m³/s)</th>
<th>1% AEP (m³/s)</th>
<th>1% AEP + MRFS (m³/s)</th>
<th>0.1% AEP (m³/s)</th>
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<tr>
<td>FSR Statistical Method</td>
<td>0.41</td>
<td>0.86</td>
<td>1.03</td>
<td>1.14</td>
</tr>
<tr>
<td>IH124</td>
<td>0.40</td>
<td>0.84</td>
<td>1.01</td>
<td>1.11</td>
</tr>
<tr>
<td>FSR Rainfall Runoff (RR)</td>
<td>0.56</td>
<td>1.58</td>
<td>1.90</td>
<td>2.48</td>
</tr>
<tr>
<td>FSU</td>
<td>0.40</td>
<td>1.03</td>
<td>1.24</td>
<td>1.38</td>
</tr>
<tr>
<td>CFRAM</td>
<td>-</td>
<td>1.35</td>
<td>-</td>
<td>2.71</td>
</tr>
</tbody>
</table>

The IH124, FSU and the FSR Statistical methods all produce a similar Qmed value of approximately 0.04m³/s. As higher growth curves were obtained from the FSU methodology, the final peak flood rates are considered the most appropriate for the catchment.

It is noted that the FSR Rainfall Runoff (RR) method overall, provides the highest flow estimates, however this methodology can overestimate the peak flood flows and would usually be restricted to small hilly catchment areas.

For comparison, the CFRAM hydrology was based on the downstream Hydrological Estimation Point (HEP) ‘09_1245_6_RPS’. This HEP is located at the outlet point between the Crippaun River and the River Liffey. The CFRAM calculated flow rates of 3.45m³/s 1% AEP and 6.15m³/s (0.1% AEP). The flows were subsequently linearly applied across the model. A number of HEPs have been provided along the river reach including the downstream boundary of the site i.e. JBA estimation point HEP. The corresponding 1% and 0.1% AEP flows are 1.35m³/s and 2.71m³/s. It was noted that the QMed (2-year flow) was increased to match historic flooding on the downstream section of the Crippaun River. Furthermore, the downstream section of the Crippaun catchment is largely classified as urban which results in higher overall flow rates.

4.2 Hydraulic Model

This study was modelled using a 1D-2D ESTRY-TUFLOW hydraulic model. It allows for the modelling of river channels, streams, floodplains and hydraulic structures to predict water levels for a range of scenarios. The hydraulic model was carried out in the following stages:

- A 1D Estry model of the Crippaun River was created using a DTM and available surveyed data.
- Two upstream culverts were included in the model. The wall structure displayed in Figure 2-2, was also incorporated into the model.
- Hydraulic simulations were run to derive the existing flood extent to determine Flood Zones A, B and C at the site,
- Hydraulic simulation was run to determine the 1% AEP flood extent with a 20% allowance included for climate change, under the MRFS scenario,
A hydraulic simulation was run to derive the flood extent to determine flow paths caused by a blockage to the Stone Wall and downstream culvert.

4.2.1 TUFLOW Model Build & Set-up

The focus of the model is to examine the risk of overtopping of the Crippaun River across the southern boundary of the site. Potential overland flow pathways from the west of site also need to be assessed.

Overtopping of the Crippaun River could pose a flood risk to the proposed development.

Figure 4-2 over page, outlines the model set-up. The model was built to represent the Crippaun River through the study area as displayed in Figure 2-2. All structures have been incorporated into the model. The 2D model boundary has been extended upstream of the site to ensure that any potential overland flow pathways have been captured.

Figure 4-2: Hydraulic Model Build

4.3 Model Results and Flood Mechanism

Figure 4-3, provides an outline of Flood Zone A (1% AEP) and Flood Zone B (0.1% AEP) flood event. Based on the results the Crippaun River predominantly remains in bank during the 1% AEP flood event with only some localised overtopping noted. All overtopping of the river bank is limited to the RHB (right hand bank) (southern). No inundation is recorded of the proposed development.
Table 4-3 below provides the relevant flood levels for the 1% AEP, and the 0.1% AEP flood levels across the site boundary, from chainages 13-17. For comparison the Left Hand Bank (LHB) elevation along the site boundary is provided for each cross section.

Table 4-3: Hydraulic Model Results

<table>
<thead>
<tr>
<th>Cross Section</th>
<th>Water Levels (mOD)</th>
<th>Left Hand Bank (LHB) Levels (mOD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1% AEP</td>
<td>1% MRFS</td>
</tr>
<tr>
<td>CH 13</td>
<td>64.23</td>
<td>64.30</td>
</tr>
<tr>
<td>CH 14</td>
<td>64.00</td>
<td>64.07</td>
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<td>CH 15</td>
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<td>63.68</td>
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<td>CH 16</td>
<td>62.89</td>
<td>62.96</td>
</tr>
<tr>
<td>CH 17</td>
<td>62.48</td>
<td>62.59</td>
</tr>
</tbody>
</table>

4.4 Comparison with CFRAM

The final model results produce a flood outline that significantly differs from the Eastern CFRAM flood map presented in Figure 3-3. Based on review of the topography, the latest Lidar and site survey data, the flow pathways displayed in the CFRAM flood maps are not considered to be accurate.

Figure 4-4 shows the topography of the upstream, section of the Crippaun River. The CFRAM flood map shows an overland flow pathway to the south of the stream along the RHB. However, based on the topography, this area is higher than the lands along the LHB, to the north of the river. In reality, flood waters will find an overland flow pathway on lower lands to the north and any multiple of flows would not generate the overland flow path depicted in Figure 3-3.

It was not possible to replicate the flood outlines provided in the CFRAM flood map. Increasing flows results in surcharging of the Crippaun Culvert system and subsequently inundation of the...
Shackleton Road. Further increases in flood flows will only result in increased inundation of the Shackleton Road without replicating the CFRAM model results.

Figure 4-4: Topography

4.5 Residual Risks

Further to the estimation of the baseline 1% and 0.1% AEP flood events, a number of residual risk scenarios were developed. These are outlined as follows:

- SCEN-1 - Blockage of the Crippaun River Culvert,
- SCEN-2 - Failure of the Block Structure,
- SCEN-3 - Blockage of the Block Structure Culvert

The Crippaun River culvert is located at the south-eastern corner (downstream) of the site, while the block structure is located upstream. Refer to Figure 4-2 for the location of the relevant culvert structures. The results from the model scenarios confirm that no overtopping of the LHB or inundation of the proposed development occurs during the 1% AEP flood event. The results are discussed further in the following sections.

SCEN-1 - Blockage of the Crippaun River Culvert,

Due to the heavy vegetation along the Crippaun River, there is an associated high risk of blockage. To appraise the potential impact on the development from a potential blockage of the Crippaun River Culvert, a scenario was developed to model a 66% blockage of the culvert system. The results are depicted in Figure 4-5.

Review of Figure 4-5 confirms that overtopping onto the Shackleton road will occur following blockage of the culvert system. During the standard residual risk scenario of 66%, flood extents are restricted to the Shackleton Road and Oakley Park. There is no inundation to the site during this scenario, however the final floor levels will reflect the flood risk posed from this scenario.
SCEN-2 - Failure of the Block Structure,

Failure of the block wall upstream of the site could result in increased stream flows across the site, refer to Figure 2-1 and Figure 2-2. A model scenario was run to appraise this scenario and the results are depicted in Figure 4-6 over page. The results from the modelling that there is no increase in flood risk to the site follow the complete failure of this instream block structure.
SCEN-3 - Blockage of Block Structure Culvert

Further to Scenario 2, blockage of the block structure could increase the risk of bank overtopping upstream of the site and therefore, pose a flood risk to site via an upstream overland flow pathway.

A model scenario was run to appraise this scenario and the results are depicted in Figure 4-7. The results from the modelling that there is no increase in flood risk to the site from this scenario.

Figure 4-7: Block Structure Culvert Blockage Scenario
5 Flood Risk Assessment and Mitigation

Having reviewed the available sources of flooding outlined in Section 3, there is no identified historic flooding at the site. Review of the Eastern CFRAM flood map for the area indicates that the site is located within Flood Zone C, and therefore at a low risk of inundation. Some overtopping of the right hand bank is noted but this does not impact upon the development.

Hydraulic modelling was undertaken to confirm the findings of the CFRAM study and provide a FFL of the development that is 500mm above the 1% AEP flood level. Further assessment was to be undertaken on the identified residual risks, such as culvert blockage.

To enable assessment of the residual risk at the site, it was necessary to develop a hydraulic model of the Crippaun waterbody. The analysis on the residual risks is undertaken in Section 5.2. As part of the assessment, flood maps were developed for the 1% and 0.1% flood events which confirm that the site is located within Flood Zone C, refer to Figure 4-3.

5.1 Mitigation

In response to the risks identified from pluvial and fluvial flooding, mitigation measures are required to minimise the flooding onsite, which are outlined in the following section.

5.1.1 Finished floor levels

The development proposed for the site is classified as residential development and the proposed site layout is provided in Figure 1-1. The minimum FFL should be set c. 500mm above the 1% AEP flood level and 300mm above the 66% blockage of the Crippaun culvert scenario flood levels, refer to Section 4.5. Based on the model results, this ranges from 64.25 - 62.48mOD adjacent to the site.

Based on the above, the required minimum FFL across the site are provided in Figure 5-1 over page. The FFL’s along the Crippaun River are primarily based on the 1% AEP (+500mm) event, while the flood levels along the Shackleton Road are based on the 66% blockage scenario (+300mm).

Furthermore, to protect against potential pluvial flooding, a freeboard of 150mm from the FFL to the external hardstanding areas should be provided. This will protect the properties from any increased overland flows conveyed on the site due to residual risk or surface water run-off.

Figure 5-1: Required Minimum FFLs
5.1.2 Access

An entrance way will be constructed at the east boundary of the site from Shackleton Road and at the north boundary of the site also from Shackleton Road. The north and east entrances are located in Flood Zone C and will not be impacted by a 1% AEP flood event.

Access to the development during a flood event is not considered to be an issue.

5.1.3 Stormwater design

As this is currently a greenfield site, the development works will increase the hardstanding area at the site. This increase will result in the corresponding increase in surface water runoff post development, if not mitigated against. The stormwater system is made up of three underground attenuation tanks; one will store the 1 in 30 year storm event and two will store the 1 in 100 year storm event. There are two overground retention ponds to store a 1 in 100 year event. The tanks are positioned along the south, north, and east site boundary. It will be discharged away from the site via existing storm water sewer at the northeast corner, and an existing storm water sewer at the southeast corner to the of the site in St. Raphael’s Manor.

The proposed attenuation volume for the over-ground retention ponds for a 1 in 100 year event are 110m³ and 550m³. The volume for the underground attenuation tanks range between 1,300m³ and 120m³. The allowable discharge run-off rate from the attenuation tanks is calculated as 22.5l/s to the southeast and 4.0 l/s to the northeast (total 26.5l/s) for the site, refer to Figure 1-1 for the locations. A hydrobrake system has been designed in order to restrict flows to this value to avoid inundation of the stormwater system and reduce flood risk to areas downstream of the site.

With the stormwater system in place the function of the field drainage network on the site will change considerably. All direct inputs will be dealt with by the new system and the smaller drains will all be backfilled. The drain traversing the site from the north west to south east corner will be culverted to retain conveyance (with no direct input from the site stormwater). The drain adjacent to the Shackleton Road along the north east boundary of the site will also be culverted to retain conveyance (again with no direct input from the site stormwater).

In summary, the stormwater system has been designed to contain a 100yr event including a 20% climate change factor. This is designed to ensure there is no increased flood risk to the surrounding area. Some of the existing land drains are backfilled, their function is replaced by the stormwater system, field drains with the potential to convey flow through the site are retained in culvert through the site, with no stormwater input from the new development.

5.2 Residual Risk

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

- Blockage of Crippaun River culvert south of the site
- Blockage of the Block Structure Culvert
- Failure of the Block Structure.
- Failure of stormwater system onsite

5.2.1 Crippaun River Culvert Blockage

The Crippaun / Toni River flows via the southwest boundary of the site and is culverted when it crosses Shackleton Road after which it flows via the public SW network through St. Raphael’s Manor. If this stream / culvert blocked the majority of the flows would be conveyed overland which can increase flows travelling towards the site. A model simulation was created by blocking the stream / culvert by the 66% event during a 1% AEP flood event.

The result confirms that overtopping onto Shackleton Road will occur under the 66% blockage scenario. No overtopping of the Crippaun River occurs upstream of the culvert. There is however, an overland flow pathway present along the Shackleton Road. This requires the setting of a minimum FFL of 300mm above the modelled flood levels.

The hydraulic model confirms that no overtopping of the river’s left hand bank (the proposed development site) occurs during this scenario, upstream of the culvert system. Refer to Figure 4-5.
5.2.2 Failure/Blockage of the Block Structure Culvert

Failure of the block structure, located upstream of the site could result in increased flood flows past the site boundary. Refer to Figure 2-2 for the location of the structure. A model scenario was developed to appraise the impact that removal of the block structure would have on the 1% AEP flood event at the site. The results confirm that there is no change in flood levels across the site or increased risk of inundation at the development.

Blockage of the culvert could increase the risk of bank overtopping upstream of the site, that could pose a flood risk to the development via potential overland flow. A model scenario was developed to appraise the potential blockage (66%) of this culvert. The results confirm that the flood levels across the site are reduced due to the restricted flow. No overtopping occurs upstream of the site.

5.2.3 Stormwater system failure

The proposed layout for the site will increase the hardstanding area and result in an associated increase in surface water runoff. The proposed drainage system will be designed according to the relevant standards to limit the discharge rate to the greenfield equivalent and ensure no increased risk of flooding from the stormwater proposal.

Failure of the system could result in an increased water levels within the site along the lower lying areas across the east boundary. Designing minimum finished floor levels with a freeboard of 150mm above the external hardstanding area is recommended. This will protect the residential properties during a possible failure of the stormwater system.

5.3 Future Development

As displayed in Figure 4-3, some overtopping of the RHB of the Crippau River is noted adjacent to the site boundary. Inundation occurs in low lying areas of the neighbouring lands.

To prevent the future inundation of these lands, it is feasible to widen the stream by c. 2m and subsequently raise the RHB in the affected areas. Specific model scenario was developed to determine the impact in flood levels along the Crippau River following the widening works. This was tested against the 1000-year flood event.

The result of the widening scenario is presented in Figure 5-2, which confirms that following the implementation of the potential stream widening, that all flood waters remain in bank including previous out of bank flows along the lands to the south (RHB). Furthermore, widening of the stream channel will result in a slight reduction in flows through the Crippau River culvert, and subsequently downstream of the site. This measure could reduce the associated flood risk to the adjacent lands directly to the south of the site and correspondingly, reduce the impact to lands east of the site following blockage of the culvert system.

Figure 5-2: Scenario-Stream Widening (0.1% AEP)
6 Conclusion

JBA consulting has undertaken a detailed Flood Risk Assessment for the proposed site development along the Shackleton Rd, Celbridge, Co. Kildare. The proposed works involve the development of a residential development on a greenfield site.

From reviewing the available sources of flooding on the site, there is no historic flooding on floodmaps.ie found at the site location. Review of the Eastern CFRAM flood maps places the development within Flood Zone C and at a low risk of inundation. To further appraise the residual risk to the site, a hydraulic model was developed for the Crippaun / Toni River. Flood maps were produced for the 1% AEP and 0.1% AEP flood event which further confirms that the site is located in Flood Zone C.

Although, the site is shown to lie within Flood C, there is a residual risk to the site from blockage of the culvert system and higher flows. Blockage (66%) of the Crippaun / Toni River will result in inundation of the Shackleton Road and Oakley Park, however there is no inundation of the proposed development during this flood event.

To sufficiently protect the site from the identified residual risk, a minimum FFL of 500mm is required above the 1% AEP flood level, and 300mm above the overland flow along the Shackleton Road following blockage of the culvert system. The final FFL’s range from 62.10mOD to 64.50mOD.

Two localised areas have been identified in the area that are at risk of pluvial flooding. One cell is located within the site boundary and one located adjacent to the site’s western boundary. Based on the site visit and site survey data, a comprehensive drainage network is present to the east of the site which will manage off site surface water flows.

Potential pluvial flooding within the site will be managed via the proposed stormwater system. This stormwater system has been designed to contain a 100yr 6hour rainfall event including the 20% climate change requirement. Three separate stormwater attenuation tanks have been incorporated into the stormwater system. Furthermore, two hydrobrakes have been incorporated to maintain the stormwater discharge from the site to its greenfield equivalent. The allowable discharge run-off rate from the attenuation tanks was calculated as 22.5/s and 4.0/l/s for the site This will ensure that the site will not increase the risk of inundation elsewhere in the catchment.

To minimise the pluvial flood risk to the development, a minimum freeboard of 150mm is recommended from the FFLs to the external hardstanding area.

Residual risks have been assessed for the development, which include the impact of climate change, blockage of the culvert system located along the Crippaun / Toni River and failure of the block wall structure. A model scenario was developed for each of the identified residual risks. The results confirm that the development is not at risk of inundation from any of the identified residual sources.

The 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 Understanding Flood Risk

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

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

A.1 Probability of Flooding

The likelihood or probability of a flood event (whether tidal or fluvial) is classified by its Annual Exceedance Probability (AEP) or return period (in years). A 1% AEP flood has a 1 in 100 chance of occurring in any given year.

In this report, flood frequency will primarily be expressed in terms of AEP, which is the inverse of the return period, as shown in the table below and explained above. This can be helpful when presenting results to members of the public who may associate the concept of return period with a regular occurrence rather than an average recurrence interval, and is the terminology which will be used throughout this report.

Table: Conversion between return periods and annual exceedance probabilities

<table>
<thead>
<tr>
<th>Return period (years)</th>
<th>Annual exceedance probability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>200</td>
<td>0.5</td>
</tr>
<tr>
<td>1000</td>
<td>0.1</td>
</tr>
</tbody>
</table>

A.2 Flood Zones

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

<table>
<thead>
<tr>
<th>Zone</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood Zone A</td>
<td>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.</td>
</tr>
<tr>
<td>Flood Zone B</td>
<td>Moderate probability of flooding; between 1% and 0.1% from rivers and between 0.5% and 0.1% from coastal/tidal.</td>
</tr>
<tr>
<td>Flood Zone C</td>
<td>Lowest probability of flooding; less than 0.1% from both rivers and coastal/tidal.</td>
</tr>
</tbody>
</table>

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 due to overtopping or breach and that there may be no guarantee that the defences will be maintained in perpetuity.
A.3 Consequence 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 the type of development, 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;
- 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 is known as residual risk.
B Development Plan Policies & Objectives

B.1 Kildare County Development Plan 2017-2023

B.1.1 Surface Water and Flood Alleviation

The control of surface water and appropriate measures for eliminating flood risk are part of the Council's sustainable water services policy.

The Office of Public Works (OPW) is the lead agency for flood risk management in Ireland. The coordination of Government Policy in terms of flood risk identification, assessment and management is the responsibility of the OPW, and as such it is primarily charged with ensuring Ireland’s compliance with its legal obligations in relation to flood risk.

The Council is required to implement and comply with the Planning System and Flood Risk Management Guidelines, DEHLG (2009). Kildare County Council has carried out a Strategic Flood Risk Assessment (SFRA) for this plan as required by these guidelines. The SFRA is a countywide assessment of flood risk to inform strategic land-use decisions with the purpose of ensuring that flood risk management is fully integrated into the Development Plan. The SFRA of this Plan is a live document and any updates to it including the identification of flood zones will inform future planning decisions throughout the count.

B.1.2 Policies: Surface Water and Flooding

It is the policy of the Council to:

SW 1 Manage, protect and enhance surface water quality to meet the requirements of the EU Water Framework Directive.

SW 2 Incorporate Flood Risk Management into the spatial planning of the county, to meet the requirements of the EU Floods Directive and the EU Water Framework Directive.

SW 3 Support and co-operate with the Office of Public Works in delivering the Catchment Based Flood Risk Assessment and Management Programme in particular the Eastern and South Eastern CFRAM studies and associated Flood Management Plans. The recommendations and outputs arising from these studies shall be incorporated in preparing plans and assessing development proposals.

SW 4 Support the implementation of the EU Flood Risk Directive (2007/60/EC) on the assessment and management of flood risks and the Flood Risk Regulations (SI No 122 of 2010).

SW 5 Manage flood risk in the county in accordance with the requirements of the Planning System and Flood Risk Management Guidelines for Planning Authorities, DECLG and OPW (2009) and circular PL02/2014 (August 2014), in particular when preparing plans and programmes and assessing development proposals. For lands identified in the Strategic Flood Risk Assessment a site-specific Flood Risk Assessment to an appropriate level of detail, addressing all potential sources of flood risk, is required, demonstrating compliance with the aforementioned Guidelines or any updated version of these guidelines, paying particular attention to residual flood risks and any proposed site-specific flood management measures.

SW 6 Ensure effective management of residual risks for development permitted on floodplains.

SW 7 Maintain and enhance the existing surface water drainage systems in the county and promote and facilitate the development of Sustainable Urban Drainage Systems including integrated constructed wetlands and to promote and support the retrofitting of SuDS in established urban areas.

SW 8 Incorporate Sustainable Urban Drainage Systems as part of all plans to address the potential for sustainable urban drainage at district or site level.

SW 9 Limit the surface water runoff from new developments through the use of Sustainable Urban Drainage Systems (SuDS). These systems should not adversely impact on open space provision in residential areas.
SW 10 Liaise with the Office of Public Works in delivering on flood management works and schemes, as may arise, through the OPW Non-Coastal Minor Works Programme and through the OPW’s Capital Programme.

SW 11 Ensure that all towns, villages and settlements are provided with adequate flood alleviation measures within the limits of cost effectiveness and the availability of finance.

SW 12 Ensure that flood risk management is incorporated into the preparation of Local Area Plans in accordance with The Planning System and Flood Risk Management - Guidelines for Planning Authorities, DECLG and OPW (2009).

SW 13 Ensure that the Justification Test for Development Management is applied to proposals for development in areas at a high or moderate risk of flooding where the development proposed is vulnerable to flooding and would generally be inappropriate as set out in Table 3.2 of The Planning System and Flood Risk Management - Guidelines for Planning Authorities (2009).

SW 14 Seek to ensure that development will not interfere with or interrupt existing surface water drainage systems.

SW 15 Ensure that the reasonable requirements of Inland Fisheries Ireland are adhered to in the construction of flood alleviation measures in the county.

SW 16 Recognise the important role of bogland and other wetland areas in flooding patterns. Development in these areas shall therefore be subject to a Flood Risk Assessment in accordance with the relevant guidance.

SW 17 Require development proposals which may affect canals and their associated infrastructure to prepare a Flood Risk Assessment in accordance with the relevant guidance.

SW 18 Ensure development proposals in rural areas (excluding one-off rural housing) demonstrate compliance with the following:

- The ability of a site in an unserviced area to accommodate an on-site waste water disposal system in accordance with the County Kildare Groundwater Protection Scheme, and any other relevant documents and legislation as may be introduced during the Plan period.
- The ability of a site in an unserviced area to accommodate an appropriate onsite surface water management system in accordance with the policies of the Greater Dublin Strategic Drainage Study (2005), in particular those of Sustainable Urban Drainage Systems (SuDS).
- The need to comply with the requirements of The Planning System and Flood Risk Management Guidelines for Planning Authorities, published by the Minister for the Environment, Heritage and Local Government (2009).

SW 19 Liaise with the Office of Public Works in delivering flood management and alleviation programmes to include, but not limited to, the following:

- South Eastern CFRAMS and the recommendations therein.
- Eastern CFRAMS and the recommendations therein.
- Newbridge Surface Water Improvement Schemes.
- Morrell River Flood Management Scheme.
- Hazelhatch Flood Management Scheme.

SW 20 Develop and resource a multi-annual programme for the maintenance of river channels under the responsibility of Kildare County Council, to include but not limited to:

- Barrow Drainage District.
- Greese Drainage District.
- Lerr Drainage district.

SW 21 Ensure that rural one-off residential developments maintain existing drainage systems, particularly at access points to the property.
B.2 Celbridge Local Area Plan

B.2.3 Surface Water Drainage
Policy INF2 – Surface Water

It is the policy of the Council to maintain and enhance the existing surface water drainage systems in Celbridge and to protect surface and ground water quality in accordance with the Water Framework Directive.

Objectives

It is an objective of the Council:

INFO2.1 To carry out surface water infrastructure improvement works as required, subject to relevant environmental assessments.
INFO2.2 To require Sustainable Urban Drainage Systems (SUDS) as part of all plans and development proposals in Celbridge. Proposals for KDAs should address the potential for SUDS at a local and district level to control surface water outfall and protect water quality.
INFO2.3 To maintain, improve and enhance the environmental and ecological quality of surface waters and groundwater in Celbridge in accordance with the Eastern River Basin District River Basin Management Plan and in conjunction with the EPA.
INFO2.4 To require applicants to demonstrate that proposals will not negatively impact on the status of a water body, in accordance with the requirements of the Water Framework Directive and associated River Basin Management Plans.
INFO2.5 To ensure that planning applications have regard to any existing groundwater protection schemes and/or the likely impacts that the development may have on groundwater, groundwater dependent terrestrial ecosystems (GWDTEs) and soils.

Actions

To ensure that the surface water drains are regularly maintained to minimise the risk of flooding.

B.2.4 Flood Risk Management
Policy INF3 – Flood Risk Management

It is the policy of the Council to manage flood risk in Celbridge in conjunction with the OPW and in accordance with the requirements of the Planning System and Flood Risk Management Guidelines for Planning Authorities (2009) and Circular PL02/2014 (August 2014).

Objectives

It is an objective of the Council:

INFO3.1 To manage flood risk in Celbridge in accordance with the requirements of the Planning System and Flood Risk Management Guidelines for Planning Authorities, DECLG and OPW (2009) and Circular PL02/2014 (August 2014).
INFO3.2 To ensure development proposals the subject of Site-Specific Flood Risk Assessment, appropriate to the nature and scale of the development being proposed.
INFO3.3 To support and co-operate with the OPW in delivering flood alleviation work under the Eastern CFRAM Programme.
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