Holybank, Swords Co. Dublin FRA

Final Report

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www.jbaconsulting.ie

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Revision History

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Contract

This report describes work commissioned by Aidan Mc Lernon, on behalf of Carin homes. Hannah Moore and David Casey of JBA Consulting carried out this work.

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Purpose

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Abbreviations

AEP .... Annual Exceedance Probability

CDP .... County Development Plan

CFRAM .... Catchment Flood Risk Assessment and Management

DoEHLG .... Department of the Environment, Heritage and Local Government

FFL .... Finished Floor Levels

FRA .... Flood Risk Assessment

FRAM .... Flood Risk Assessment and Management

GSI .... Geological Survey of Ireland

OPW .... Office of Public Works

PFRA .... Preliminary Flood Risk Assessment

SFRA .... Strategic Flood Risk Assessment

TUFLOW .... Two-Dimensional Unsteady Flow

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 Carin Homes to prepare a Flood Risk Assessment (FRA) for a proposed residential site located in Holybank, Swords, Co. Dublin. The report was prepared in response to a request by Carin Homes for an FRA.

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.

Recommendations 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 proposed development will consist of a residential scheme of 621 no. units (145 no. 1-bed units, 278 no. 2-bed units, 187 no. 3-bed units and 11 no. 4-bed units) comprising 349 no. apartments, 118 no. houses and 154 no. duplex units. Building heights range from 1 no. to 7 no. storeys (over basement level). The scheme provides for public open space, communal open space areas, a crèche, residential amenities (including concierge, multi-purpose room, meeting room and gym), a new public park to the north of the site as an extension to Broadmeadow Riverside Park and services / bin store areas. The development provides for a total of 705 no. car park spaces (including houses), 856 no. secure bike parking spaces and 21 no. motorbike spaces at basement, under-croft, and surface level.

As part of the proposed development, temporary permission (3 no. years) is sought for a single-storey Marketing Suite and associated signage (including hoarding) during the development construction stage.

Principal vehicular access to the site is from Glen Ellan Road, with an additional new secondary site entrance provided from Jugback Lane/Terrace. Pedestrian connections are provided to the site from Jugback Lane/Terrace, Glen Ellan Road and the proposed Broadmeadow Riverside Park extension. The development also includes infrastructure upgrade works to peripheral roads junctions, and existing Irish Water infrastructure. All associated site development works above and below ground including hard and soft landscaping, boundary treatments, lighting, SuDs, pumping station, ESB substations and services to facilitate the development.

Junction and road improvement works are proposed to the Glen Ellan / Balheary Road junction and R132/R125 Seatown West Roundabout. This will include widening of Balheary Road (South), upgrade works to cycle/pedestrian facilities and for the partial signalisation of

R132/R125 junction. The application also contains proposals to upgrade existing Irish Water infrastructure including the construction of a stormwater storage tank and overflow outfall gravity sewer to the Broadmeadow River.

The proposed development plan for the subject site in presented in Figure **1-1**.

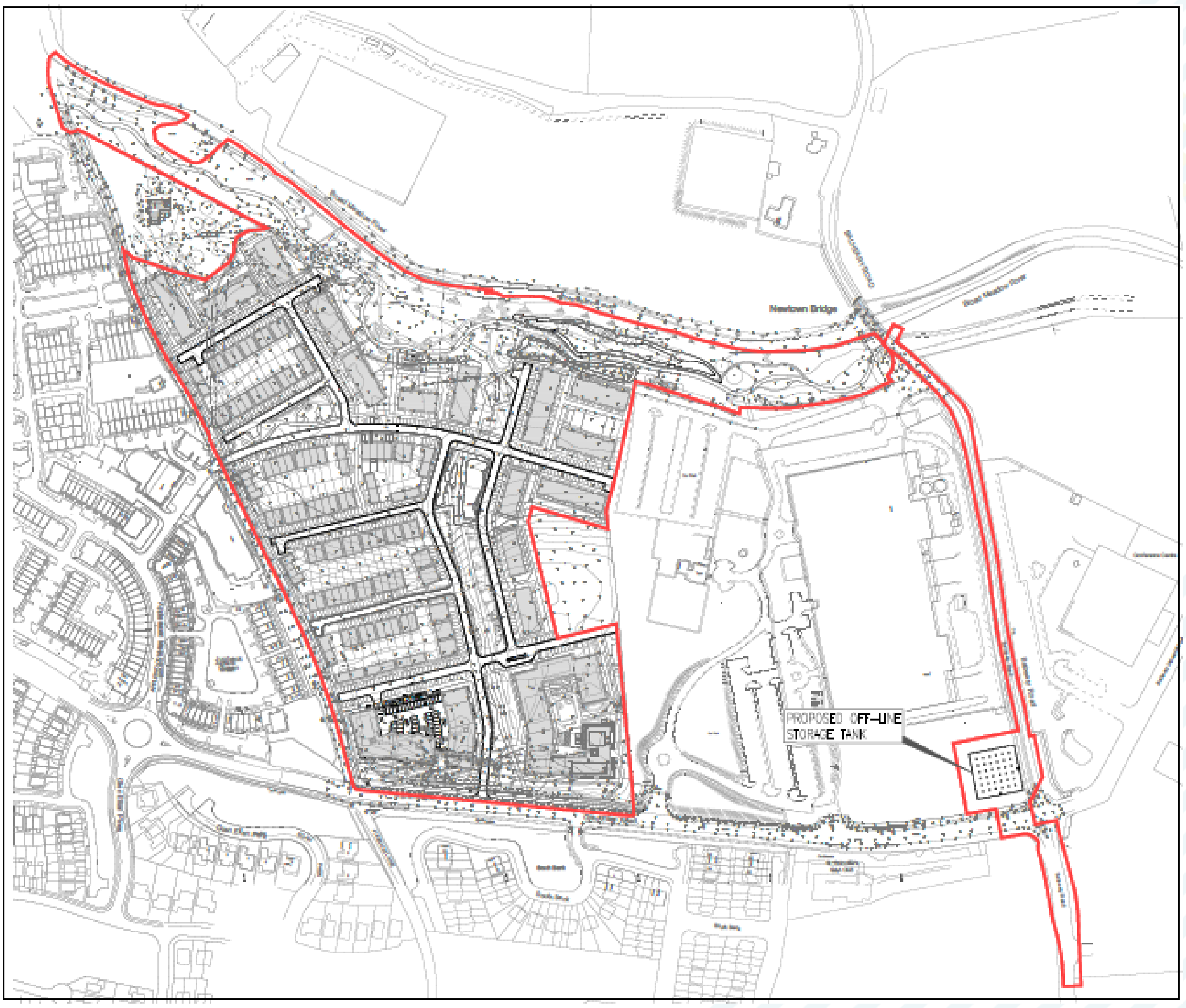


Figure 1-1: Proposed site development plan

2 Site Background

This section describes the proposed site location including nearby watercourses and its wider geographical area.

2.1 Site Location and topography

The site is located approximately 2km north of Swords town centre and 1.5km west of the M1 motorway. It is currently a green field site bounded by the Broadmeadow River to the north and residential areas to the south and west and an industrial park to the east. Proposed access routes into the site are along the Glen Ellen Road and Jugback Terrace (See Figure 2-1).

The site topography is variable, but the land slopes north towards the Broadmeadow River from an elevation of approximately 15.50mOD to 5.00mOD. A section of steeper slope runs though the centre of the site with elevation decreasing by 4.50mOD over 50.0m (Figure 2-2).

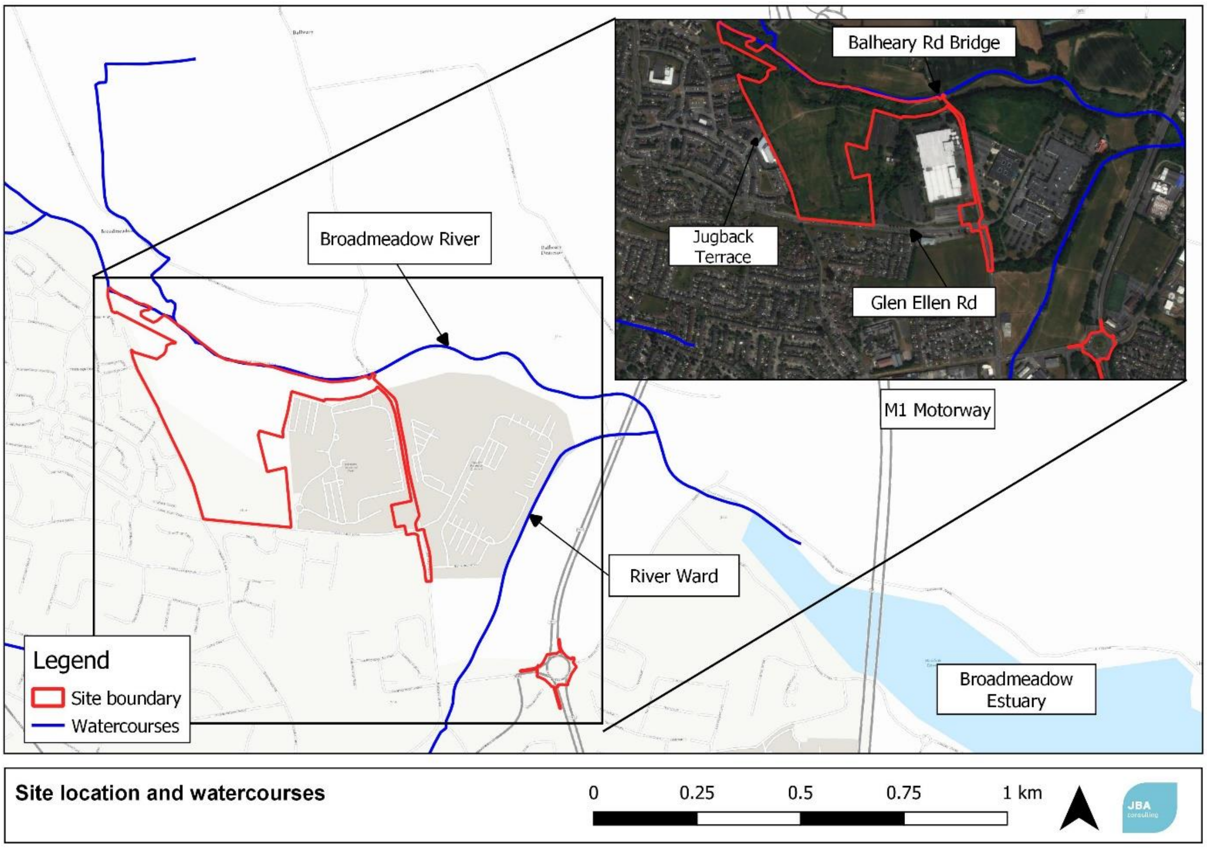


Figure 2-1: Site location and watercourses

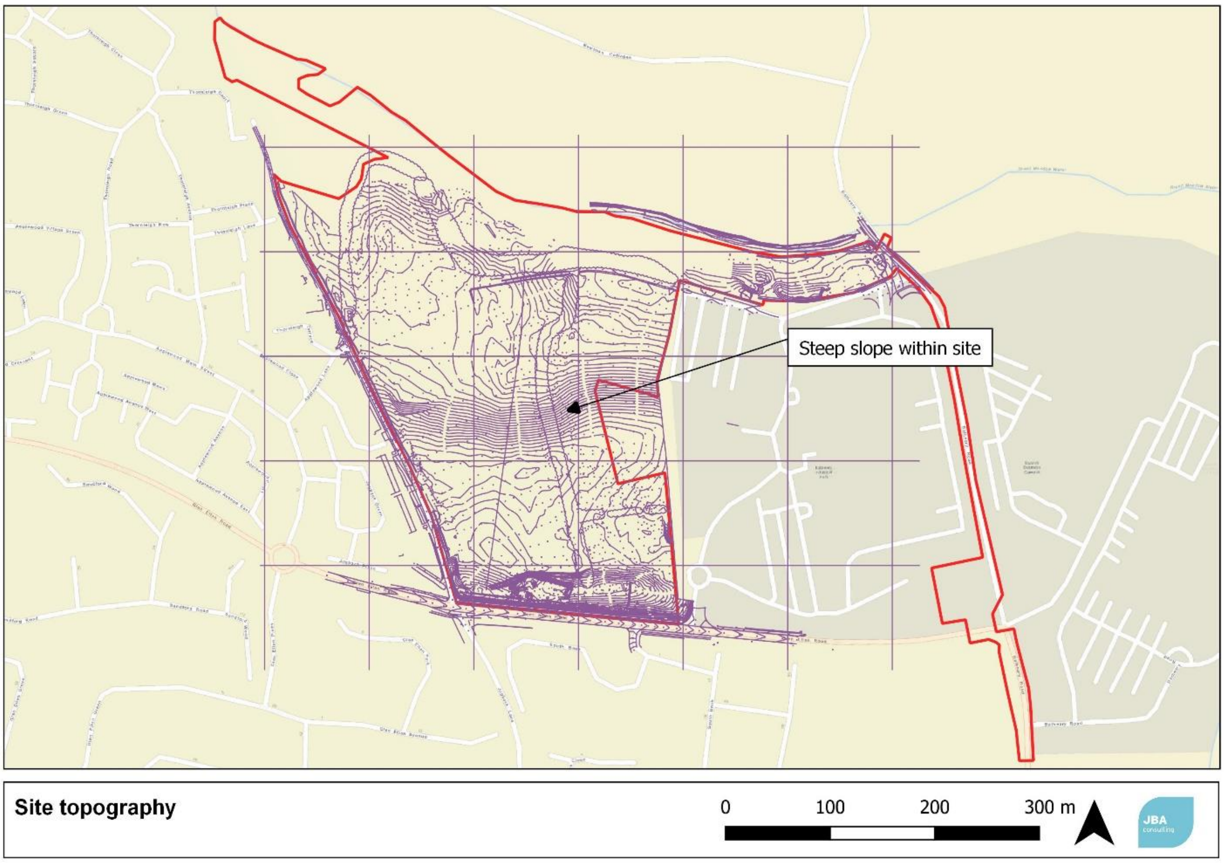


Figure 2-2: Site topography

2.2 Watercourses

There are two main watercourses proximal to the site – the River Ward and the Broadmeadow River (see Figure 2-1).

The River Ward rises in Co. Meath and flows generally in an easterly direction but flows north near the site location. It joins the Broadmeadow River 0.70km downstream of the site.

The Broadmeadow River rises near Dunshaughlin Co Meath and flows in an easterly direction. The river flows along the northern boundary of the site and discharges into the sea at the Broadmeadow Estuary 1.70km downstream of the site location.

2.3 Site Geology

The Geological Survey of Ireland (GSI) groundwater and geological data viewer was consulted to review the site and local area. The subsoil materials at the site location and surrounding area are shown in Figure 2-3. The subsoils at the site are identified as alluvium, limestone gravels and limestone till. The underlying bedrock is classified as the Malahide formation which consists of limestone and shale.

The groundwater vulnerability at the site is classified as 'Moderate' indicating that the depth to bed rock at the site is between 5 and 10m. In terms of groundwater flood risk there are no karst features located in the area.

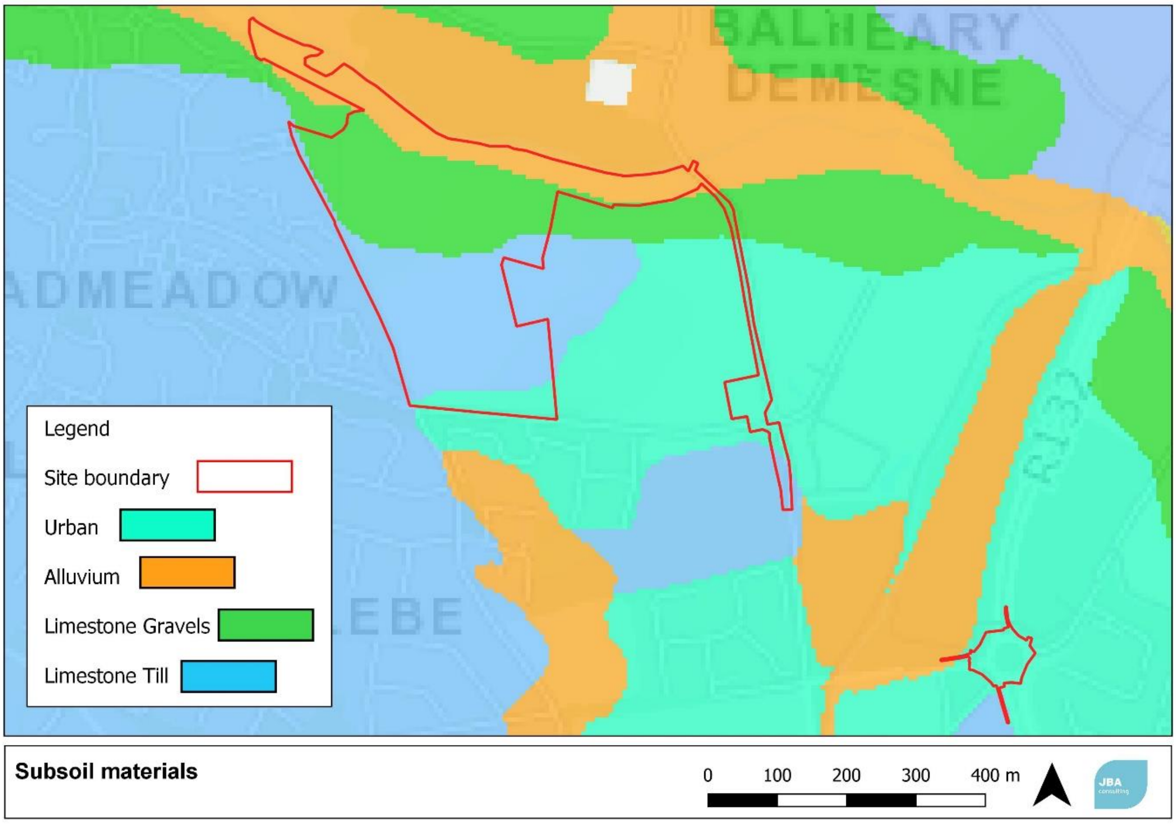


Figure 2-3: Subsoil materials

2.4 Site Visit

A site visit was carried out on the 16th July 2019 to assess the site visually. The generally comprises overgrown grassland, with some pathways through the area. Closer to the Broadmeadow river, there is a treeline which is heavily overgrown. There is a continuous fall to the north towards the Broadmeadow River. Refer to Figure 2-4 for photographs taken during the site visit.

Site View-W-E

Site View-Centre

Site View-West

Site View-Broadmeadow River

Figure 2-4: Site Photographs

3 Flood Risk Identification

An assessment of the potential and scale of flood risk at the site was 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 whether there was 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. The following flood events have been recorded at, or proximal to the site:

- August 1986 - Flooding of the Broadmeadow River during Hurricane Charlie (widespread hydrological event)
- Recurring flooding at Balheary Road (Along Broadmeadow River)

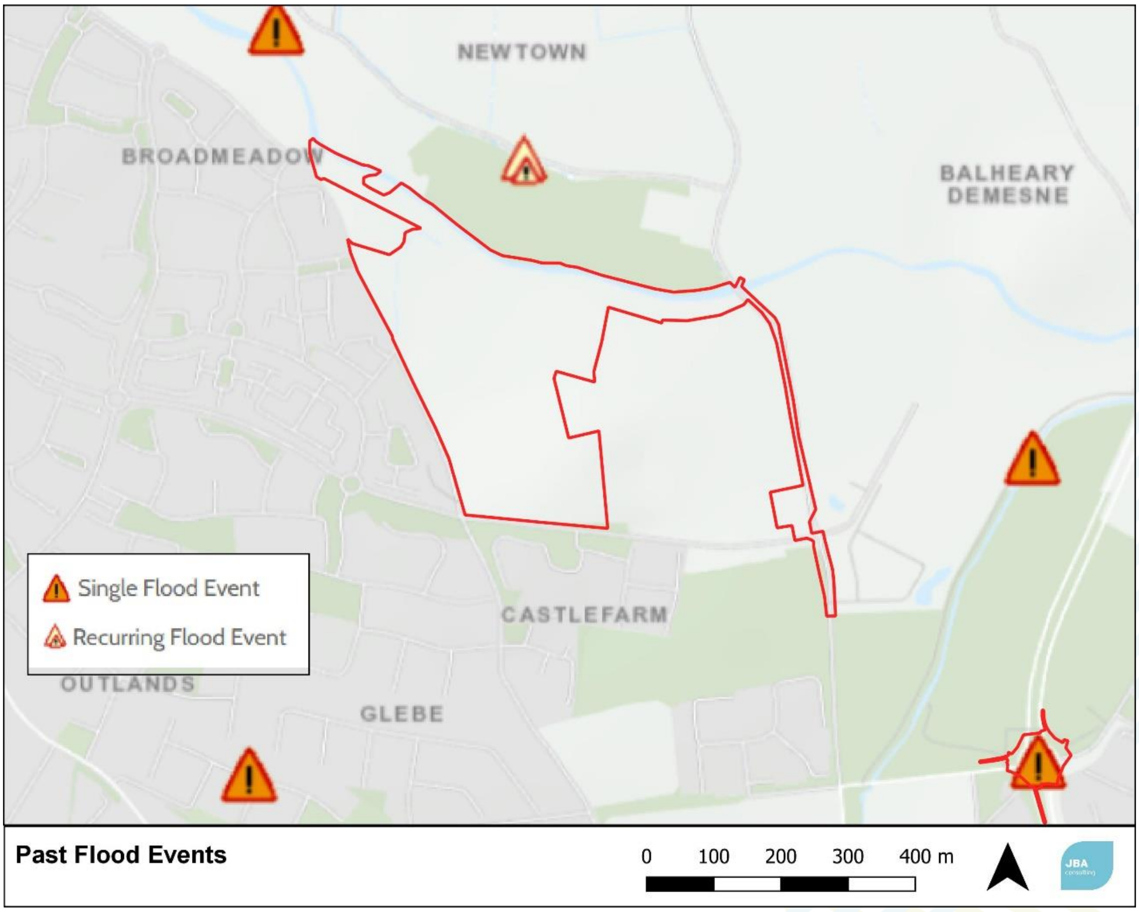


Figure 3-1: Floodmap.ie

3.1.2 Internet Search

An internet search was conducted to gather information about whether the site was affected by flooding previously. No further information was encountered regarding the flood risk specifically to the site, but further information was gathered regarding flood events occurring in the local area. A summary of the findings is provided:

- Following a major flood event in 2002 the Balyheary road (east of the site) was described as impassable (Final Independent online article)
- Balheary Road closed due to flooding in 2017 (Fingal County Council Twitter)

3.2 Predictive Flooding

The site and surrounding area have been subject to three predicative flood mapping or modelling studies:

- The OPW Preliminary Flood Risk Analysis (PFRA);
- The Fingal County Council Strategic Flood Risk Assessment and Management Plan (SFRA);
- Fingal-East Meath Flood Risk Assessment and Management Study (FEM FRAMS).

3.2.1 OPW Preliminary Flood Risk Analysis (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 has been undertaken to identify areas potentially prone to flooding. The fluvial has largely been superseded by the FEM FRAMS flood mapping. The PFRA flood map, however, still provides valuable information regarding pluvial, and groundwater flooding. FEM FRAMs coastal flood mapping was not carried out in this area and therefore the PFRA mapping also provides information about coastal flood risk.

The PFRA flood map for pluvial and groundwater flooding shows the south west corner of the site to be at risk from localised pluvial flooding for the 1% and 0.1% AEP event

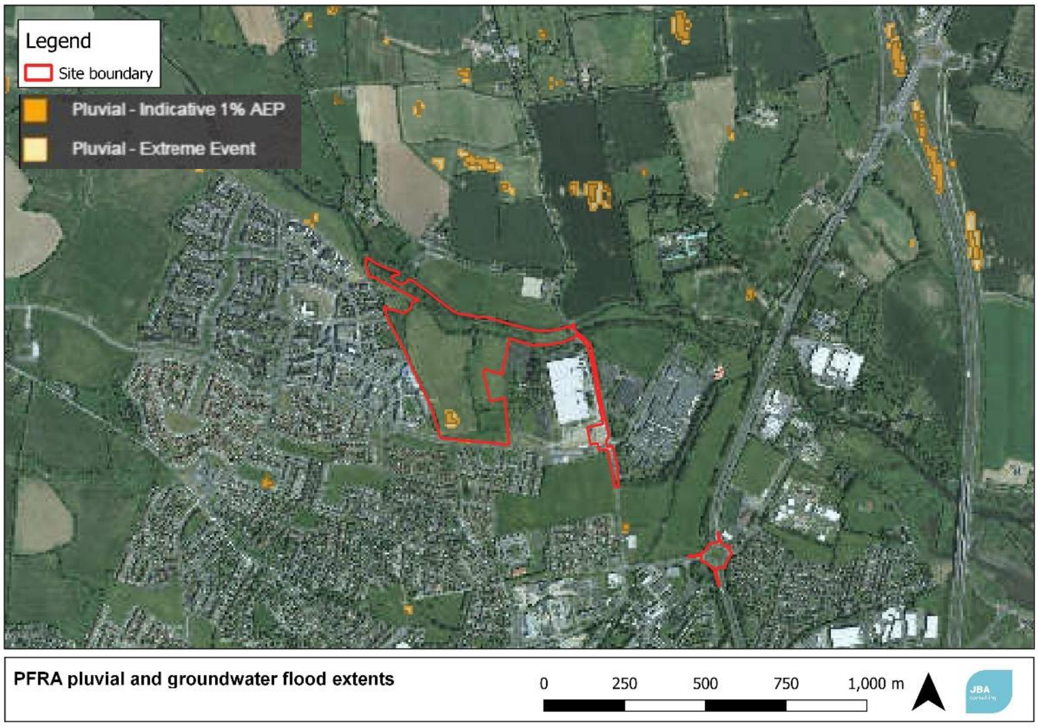


Figure 3-2: PFRA pluvial and groundwater flood extents (source: myplans.ie)

3.2.2 Fingal County Council Strategic Flood Risk Assessment and Management Plan (SFRA)

The Fingal County Council Development Plan 2017-2023 is the governing document for development in the county. It aims to set out the priorities and goals of the council over the lifetime of the plan for spatial and sectoral development.

As part of the Development Plan, a Strategic Flood Risk Assessment (SFRA) was commissioned to inform development based on flood risk. The SFRA informs the strategic land use planning decisions by providing an assessment of flood risk within the region and enables the application of the sequential approach, including Justification Test. A range of flood sources have been investigated as part of the SFRA (OPW PFRA, FEM FRAM, Eastern CFRAM etc.), however the final flood maps are based on FEM FRAM mapping. . An extract of the SFRA flood map for the site and surrounding area is shown in Figure 3-3, as expected, the flood outlines match the FEM FRAM study. From the map the north east corner of the site is shown to be within Flood Zone A/B.

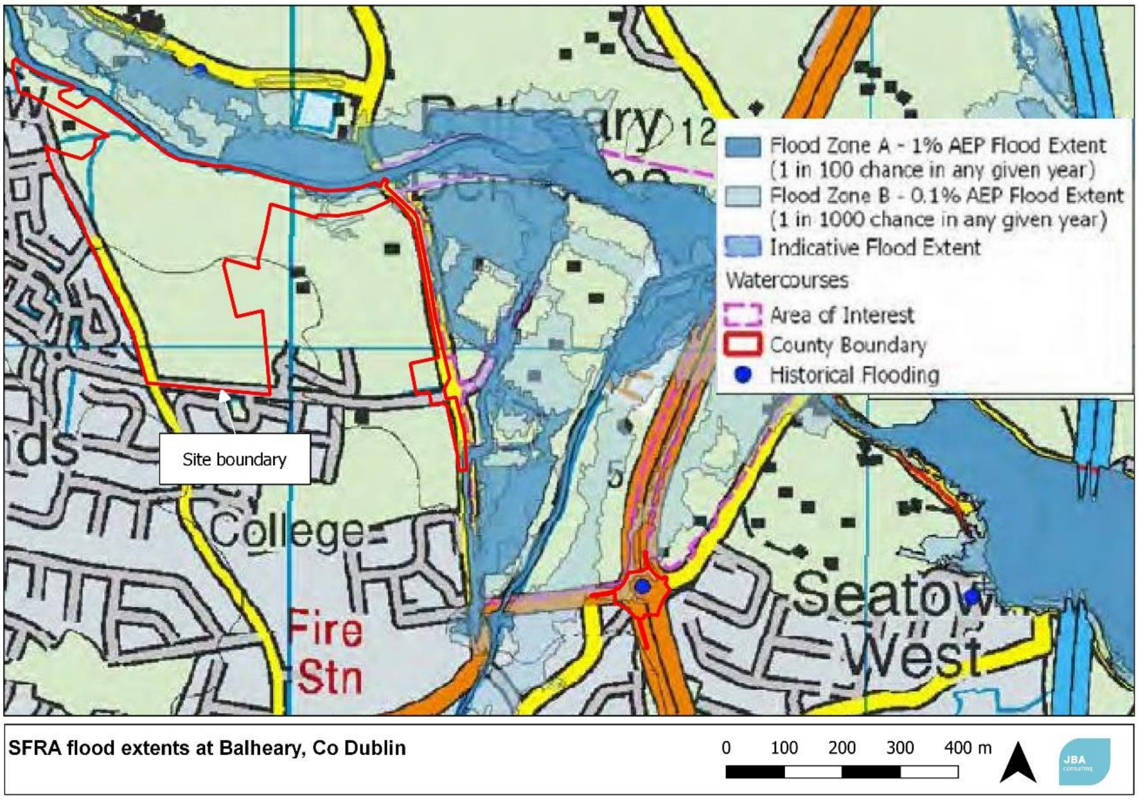


Figure 3-3: Fingal County Council SFRA flood map of Balheary Co Dublin (source: Strategic Flood Risk Assessment for the Draft Fingal Development Plan 2017-2023)

3.2.3 Fingal-East Meath Flood Risk Assessment and Management Study (FEM FRAMS)

The FEM FRAM study is the most detailed mapping undertaken in the north Dublin region. The resulting flood map extents and reports have been incorporated into the Eastern CFRAM study. Following the detailed hydraulic modelling, flood maps were produced for the 10%, 1%, and 0.1% AEP fluvial flood events. The modelled flood extents for the site and surrounding area are shown in Figure 3-4. The FEM FRAM flood mapping shows the north eastern portion is within Flood Zone A/B and therefore at risk from fluvial flooding during the 1% and 0.1% AEP fluvial event.

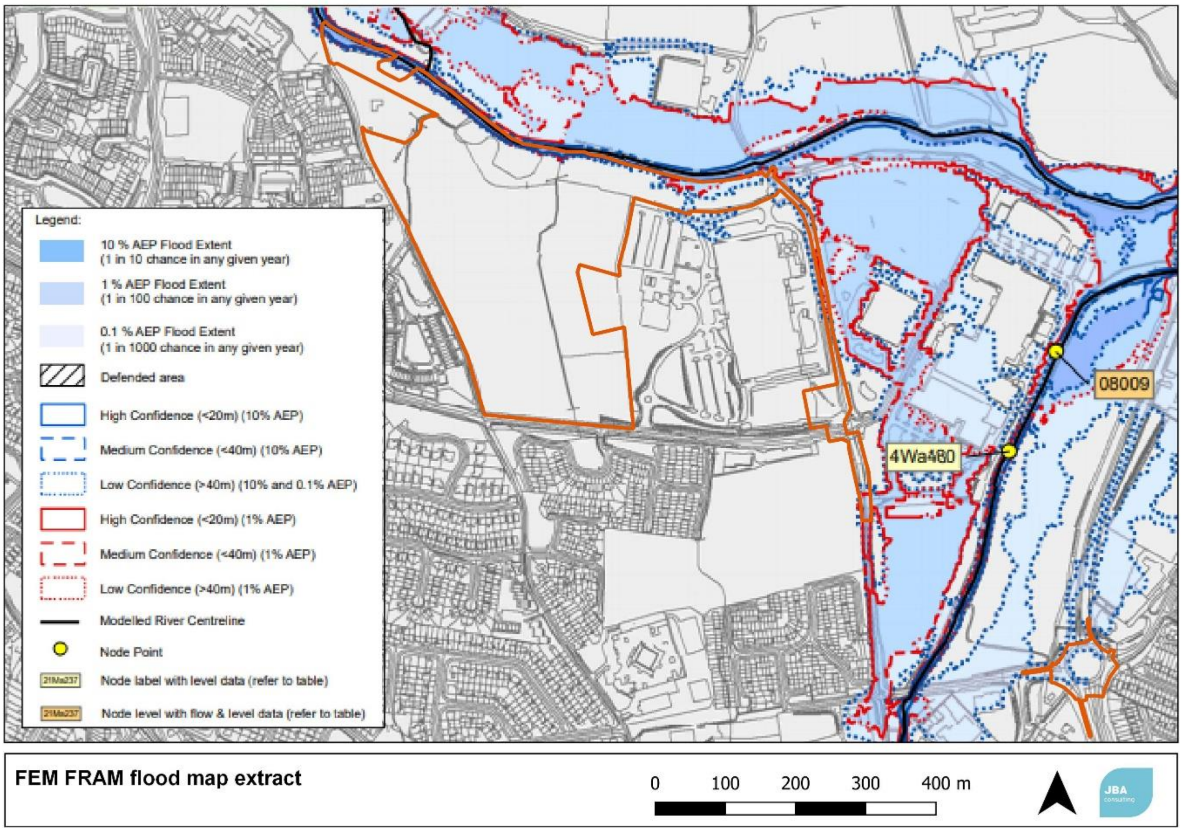


Figure 3-4: FEM FRAM flood map extract (source: floodinfo.ie)

3.3 Development Plan

3.3.1 Fingal County Council Development Plans

The overarching document governing development in Swords is the Fingal County Development Plan 2017-2023. The development plan provides specific guidelines and policies in relation to stormwater and flooding. A Strategic Flood Risk Assessment (SFRA) has been undertaken as part development plan to guide development and highlight areas at risk of flooding from the 1% AEP and 0.1% AEP flood events. Both the development plan and SFRA have been reviewed, however detailed and specific polices for the site area are contained in the Sword Masterplan development document.

3.3.2 Swords Masterplan/ Estuary West

The Swords Masterplan provide a framework for development for three development areas within the Swords that also contains the site, which is identified as Estuary West. The site is identified as a future residential area. The Estuary West Masterplan provides detailed guidance on the designed development within the site, and critically detailed flood mapping is also provided. The baseline 1% AEP and 0.1% AEP flood extents are provided in Figure 3-5. Review of Figure 3-5 highlights two areas of the proposed development that are at risk of inundation during the 0.1% AEP flood event. The potential impacts of climate change have also been assessed under the Mid-range Future Scenario (MRFS) and High-End Future Scenario (HEFS) which involve an increase in flood flows of 20% and 30% respectively. The climate change scenarios result in a larger flood extent onsite during the 0.1% AEP event, but it is noted that the there is no inundation onsite during the 1% AEP event climate change assessment. The Estuary West HEFS flood map is provided in Appendix B.

Tidal and fluvial flood maps have also been provided which confirm that the site is not at risk of tidal flooding. Review of the pluvial food map indicates that localised areas within the site are at risk of pluvial flooding.

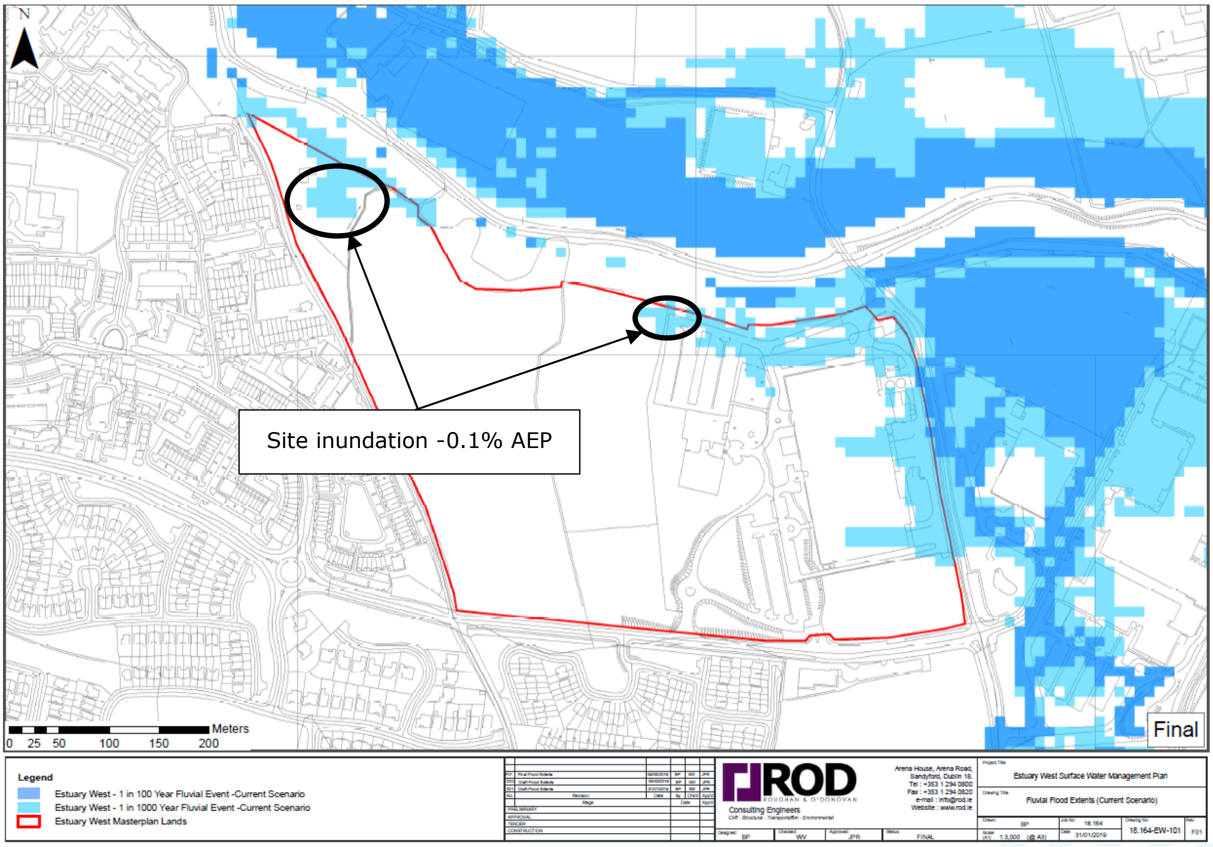


Figure 3-5: Estuary West Flood Map

3.4 Sources of flooding

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

3.4.1 Fluvial

Review of the Fingal County Council Estuary West flood and FEM FRAM flood maps show that the north eastern corner to be within Flood Zone A/B and therefore at risk from fluvial flooding in the 1% and 0.1% AEP event. The rest of the site is in Flood Zone C and therefore not at risk from flooding.

Further analysis of the Estuary West flood maps confirm that increased inundation is noted on the site during the MRFS and HEFS flood events.

Given the flood risk to the proposed development and inundation along the site’s northern boundary with the Broadmeadow River, it is necessary to undertake a detailed hydraulic model of the watercourse to inform the development of appropriate mitigation measures at the site. The flood model is detailed in Section 4 and mitigations are provided in Section 5.

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 pluvial mapping shows that there is a localised area in the south west corner of the site that is at risk from pluvial flooding. To manage the potential generation of surface water runoff by the proposed development careful consideration has been given the surface water drainage design.

As part of the development, it is proposed to upgrade an existing Irish Water stormwater storage tank to the east of the site.

The above measures and mitigation are discussed further in Section 5.2.3.3. With the implementation of appropriate measures, pluvial flooding should not be considered as a likely source of flood risk to the site.

3.4.3 Coastal

Although proximal to the Broadmeadow Estuary the OPW PFRA flood mapping shows there is no perceived flood risk to the site from coastal sources.

3.4.4 Groundwater

The OPW PFRA flood maps do not indicate any risk of groundwater flooding to the site. The groundwater vulnerability at the site location is classified as 'Moderate' signifying that bed rock is 5-10m below ground. Furthermore, there are no karst features in the area which would indicate areas at risk of groundwater flooding.

3.4.5 Summary

Based on the available information the main source of flood risk to the site has been identified as fluvial flooding from the Broadmeadow River. The FEM FRAMs mapping of the site and surrounding area show the north eastern edge of the site to be at risk during the 1% and 0.1% AEP fluvial flood event. To further investigate fluvial flood risk to the site a detailed investigation using hydraulic modelling has been carried out and is discussed further in the following report chapters.

4 Detailed Flood Risk Assessment

As discussed in Section 3 a portion of the site is located within Flood Zone A/B. To further investigate fluvial flood risk to the site a detailed investigation using hydraulic modelling has been carried out. The construction and application of the hydraulic model used is discussed in this chapter.

4.1 Hydrology

4.1.1 Peak flow estimation

Two watercourses are considered for the inflows for this site - the Broadmeadow River and the River Ward. Figure **4-1** shows the site location and the catchments of the watercourses considered. The characteristics for each catchment were sourced from the FSU ungauged node database (see Figure 4-2 for node locations and numbers used). The FSU method was used to calculate the flows for both watercourses. The FSU method is the most up to date flow calculation method in Ireland for catchments greater than 25km^2. Table 4-1 and Table 4-2 show the peak flow estimates for each of the watercourses. Further information about the calculation of these flows can be found in Appendix C of this report.

Following review of the initial model results, it was observed that there was relatively minor bank overtopping during the 1% AEP event. To increase the confidence in the model and ensure that a conservative approach is being applied, a 95%ile Factorial Standard of Error (FSE) of 1.85 has been applied to the baseline flows. All the design flow used to delineate Flood Zone A & B, including the climate change/residual risk analysis have been based on the 95%ile design flows. The final design flows are presented in Table 4-1 and Table 4-2.

Note: The conservative approach undertaken is applicable to this site only i.e. the application of the 95%ile, as the standard approach is to base the design flows on the FSU methodology and application of pooling groups. The above approach and results should not be considered applicable to historic or future Flood Risk Assessments in the surrounding catchments.

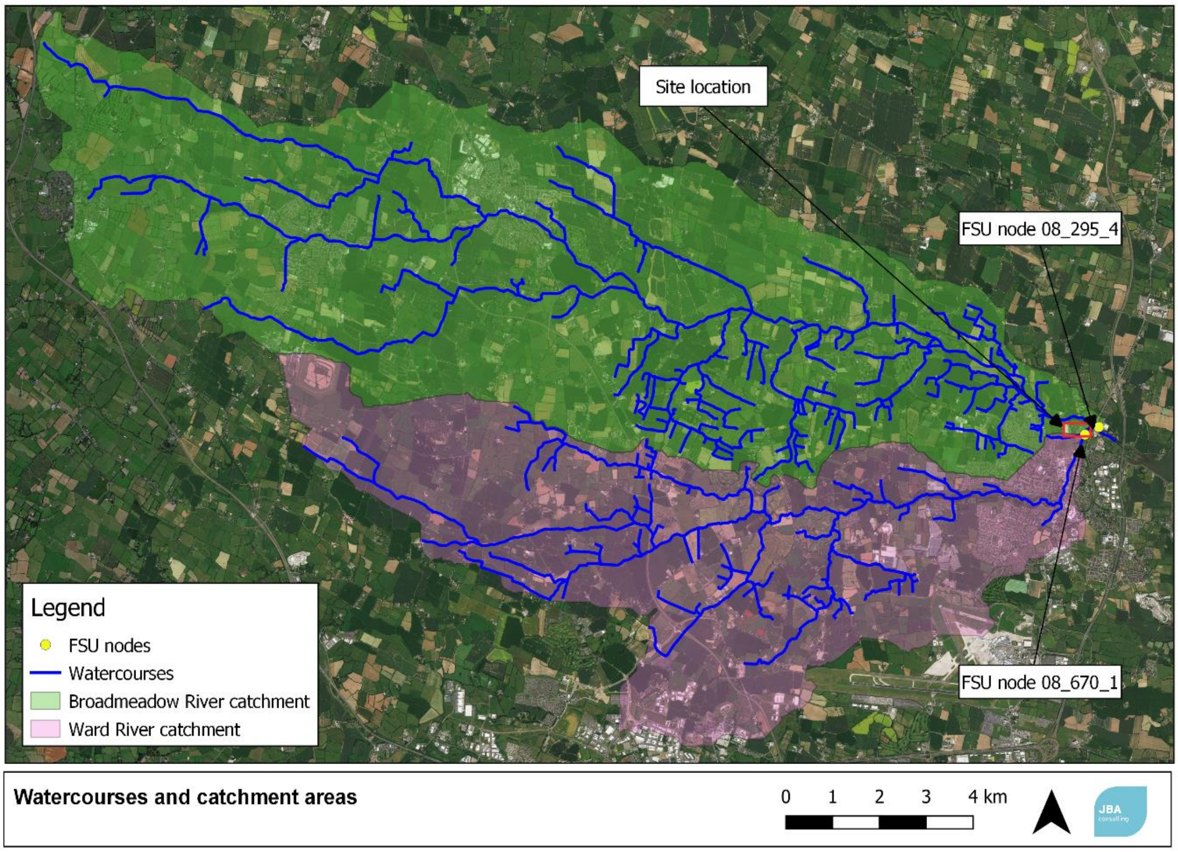


Figure 4-1: Watercourses and catchment areas

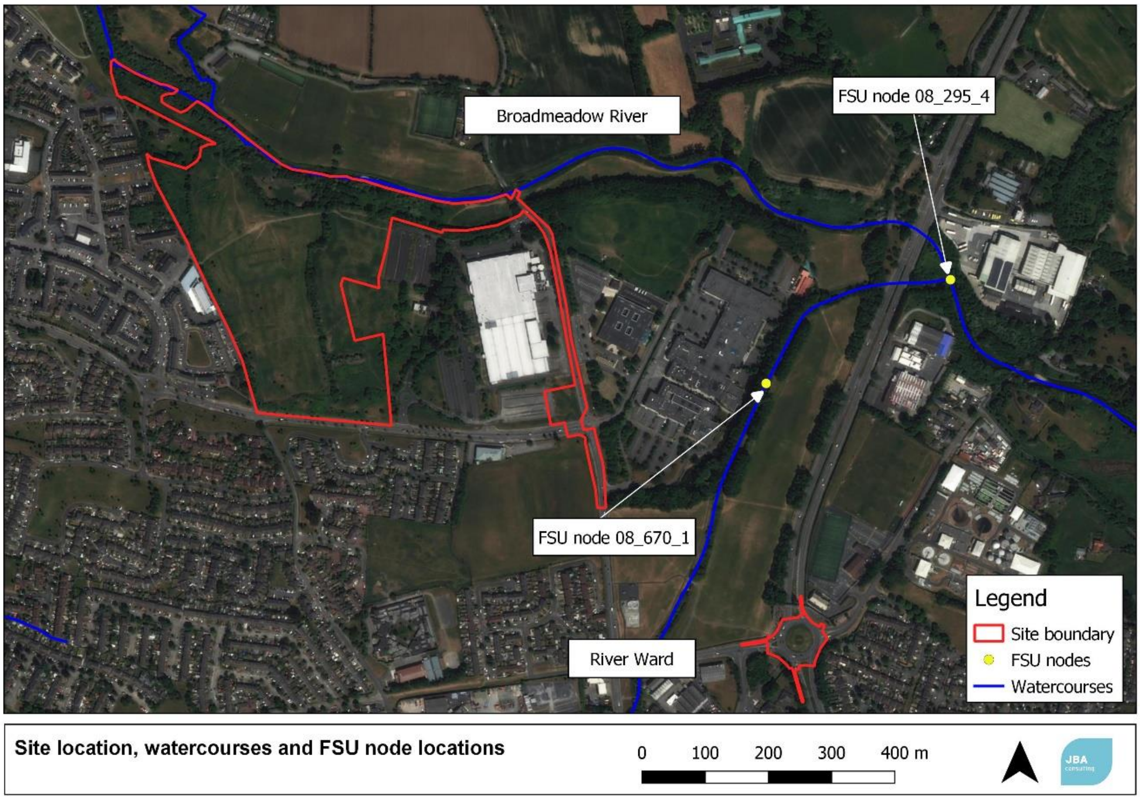


Figure 4-2: Site location, watercourses and FSU node locations

Table 4-1: FSU Peak flow estimates – Broadmeadow River

Annual Exceedance Probability (%)	FSU Adjusted (m^3/s)	FSU Adjusted*FSE (m^3/s)	Growth Factor
50%	21.30	**39.41**	1.00
20%	29.82	**55.17**	1.40
10%	35.36	**65.42**	1.66
5%	40.90	**75.67**	1.92
2%	48.14	**89.06**	2.26
1%	53.68	**99.31**	2.52
0.1%	72.21	**133.59**	3.39

Table 4-2: FSU Peak flow estimates – River Ward

Annual Exceedance Probability (%)	FSU Adjusted (m^3/s)	FSU Adjusted*FSE (m^3/s)	Growth Factor
50%	4.99	**9.23**	1.00
20%	7.06	**13.06**	1.42
10%	8.50	**15.73**	1.70
5%	9.94	**18.39**	1.99
2%	11.90	**22.02**	2.39
1%	13.43	**24.85**	2.69
0.1%	18.93	**35.02**	3.80

4.1.2 Downstream boundary

The Broadmeadow River flows east and enters the Irish sea via the Broadmeadow Estuary. To represent this a head time boundary that replicates the tidal cycle recorded at the Broadmeadow estuary has been used in the hydraulic model. The tidal hydrograph was obtained from the Dublin Port tidal gauge sourced from marine.ie, while the peak flood levels have been sourced from the ICPSS flood maps closest to the site.

4.1.3 FEM FRAM Hydrology Comparison

The corresponding 1% AEP and 0.1% AEP peak flows from the FEM FRAM study are similar to the final JBA design flows, once the 95%ile FSE factor has been applied. There is some disparity in the baseline flows and growth curves provided in Section 4.1.1. The disparity is discussed here.

Within the FEM FRAM study, the rating curve used at the Broadmeadow gauge was reviewed and a new rating curve developed. This new rating curve generated a Qmed (mean flow value) of 21.06m^3/s which is significantly less than the previous OPW rating curve which had a Qmed value of 39.10m^3/s. Based on the updated rating curve, JBA have obtained a Qmed of 21.30m^3/s, which is similar to the modified rating curve within the FEM FRAM study.

Although the Qmed value calculated for this report is similar to that of FEM FRAMS the higher peak flows are different due to the use of different growth curves. The FEM FRAMS growth curve applied to the Qmed values was an area growth curve designed for the entire study region. For this study a site-specific growth curve was developed with the pooling group being tailored to the site area. As a result, it was decided that the site-specific growth curve be applied for this study as it is more representative of the site compared to the area growth curve applied by FEM FRAMS.

A full discussion of the comparison between the FEM FRAMS hydrology and this assessment's hydrology can be found in the Hydrology Check file at the end of this report (Appendix C).

4.2 Hydraulic Modelling

4.2.1 Hydraulic model set-up

To assess flood risk at the site a 1D-2D ESTRY-TUFLOW hydraulic model was constructed. It allows for the modelling of river channels, streams, floodplains and hydraulic structures to predict water levels for a range of scenarios (see Figure 4-3 for hydraulic model schematisation). The hydraulic model was developed in the following stages:

- A 1D-2D ESTRY-TUFLOW model of the Broadmeadow and Ward Rivers and surrounding area including the proposed site was created using a DTM and available survey data.
- The existing structures were inserted into the model based on the available survey information and a baseline condition established.
- Hydraulic simulations of the baseline condition were run to derive the existing flood extents and Flood Zones.
- A number of residual risks were also assessed for the site. Scenarios examining the effect of climate change, and a partial blockage of the Balheary road bridge were run.

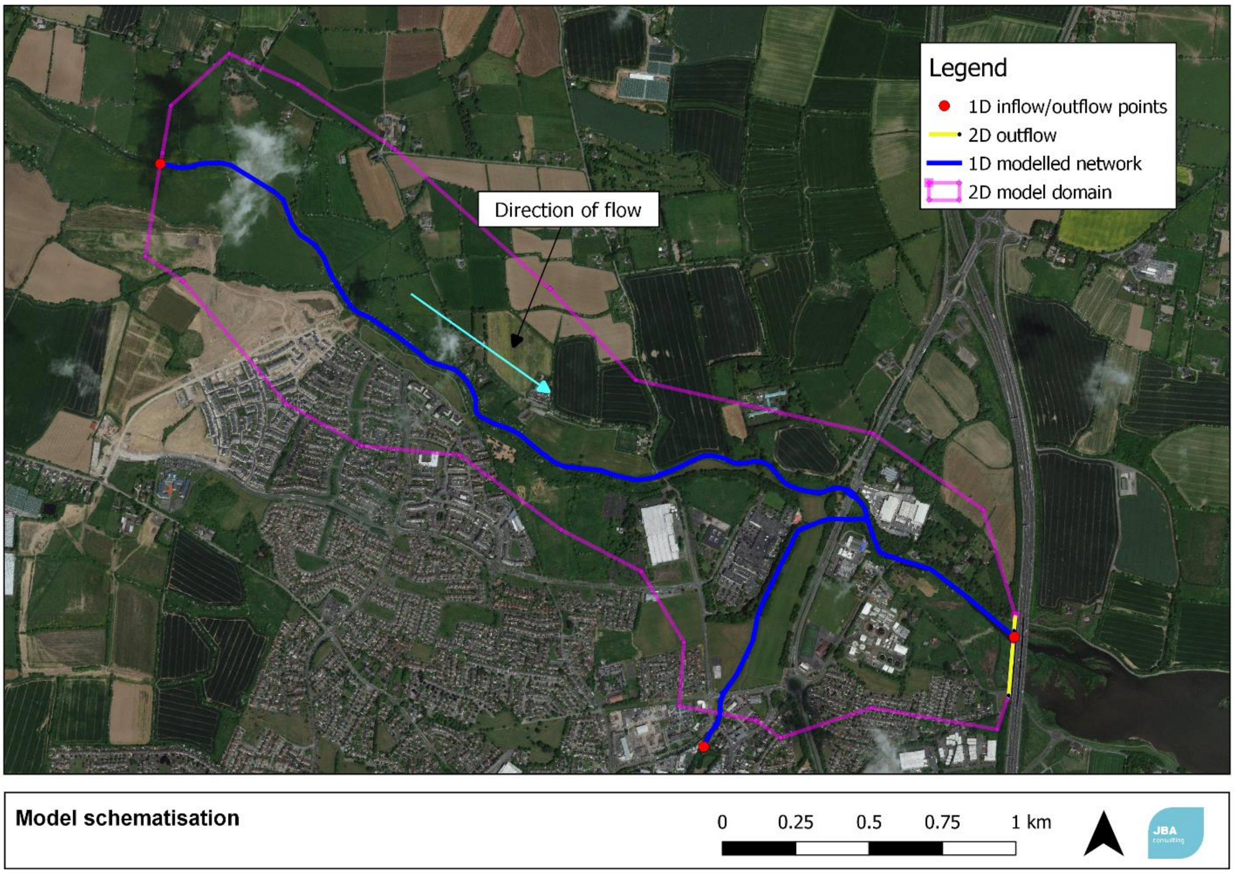


Figure 4-3: Model schematisation

4.2.2 Model results – baseline condition

Figure 4-4 and Figure 4-5 show the modelled flood extents for the 1% AEP and 0.1% AEP events (Flood Zone A and B). The results show that the north east edge of the site along the bank of the Broadmeadow River is affected. This is to be expected due to the location along the riverbank and will not affect the proposed development as the area will be left as open green space with no risk receptors as part of the development plan (refer to Figure 4-5 and Figure 4-6). The key areas of residential and commercial buildings within the site are within Flood Zone C and not at risk from fluvial flooding.

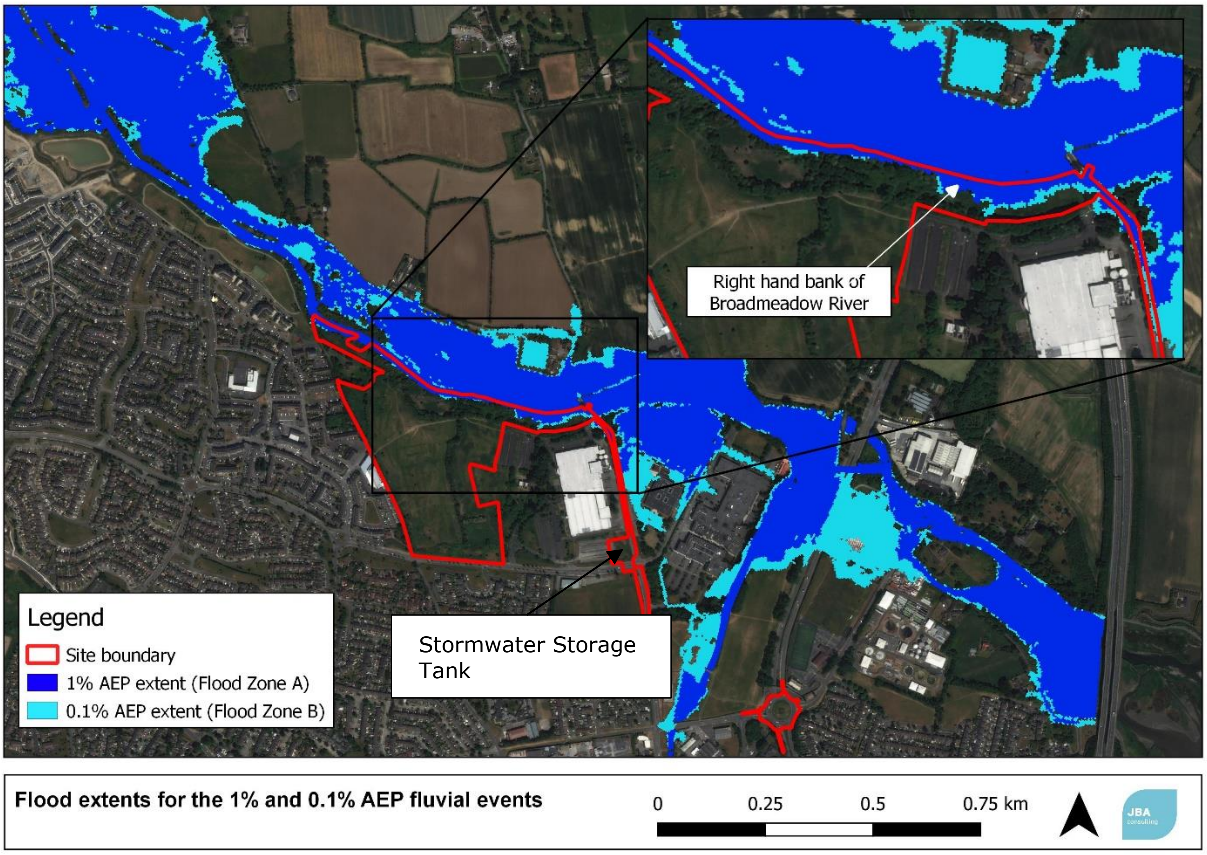


Figure 4-4: Flood extents for the 1% and 0.1% AEP fluvial events

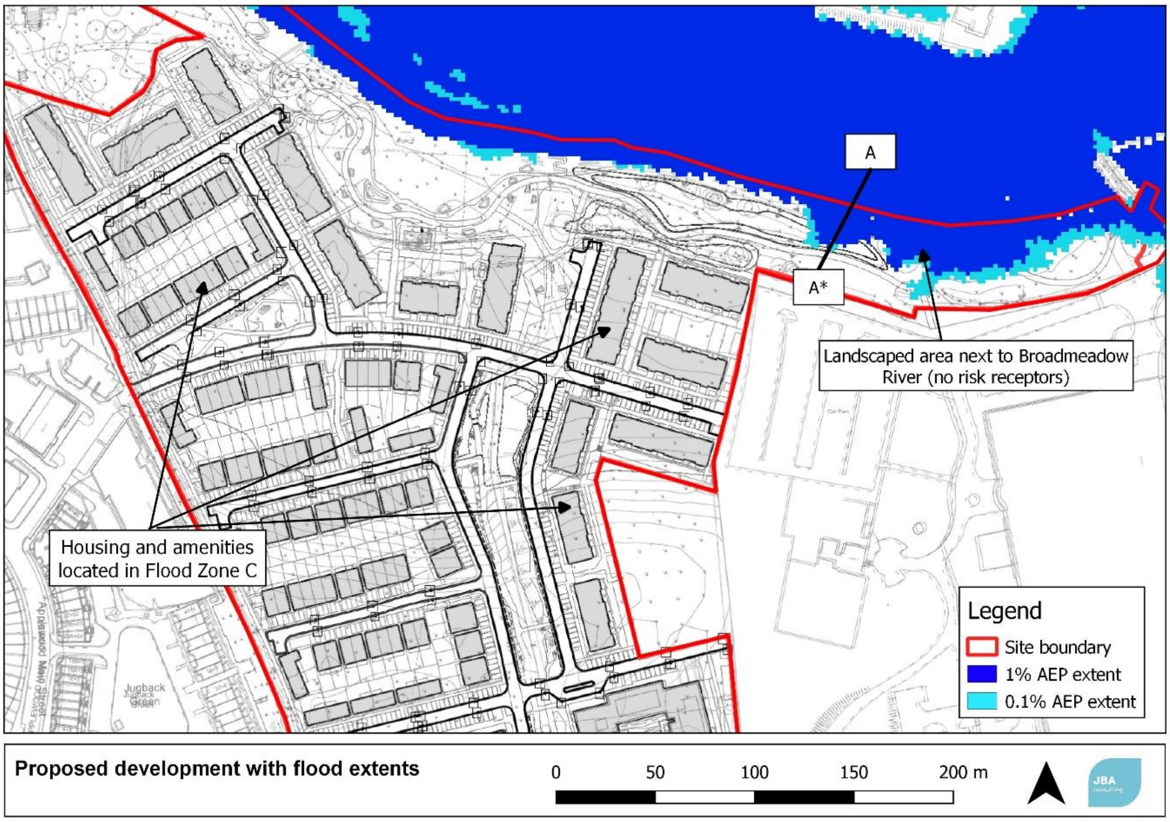


Figure 4-5: Proposed development with flood extents

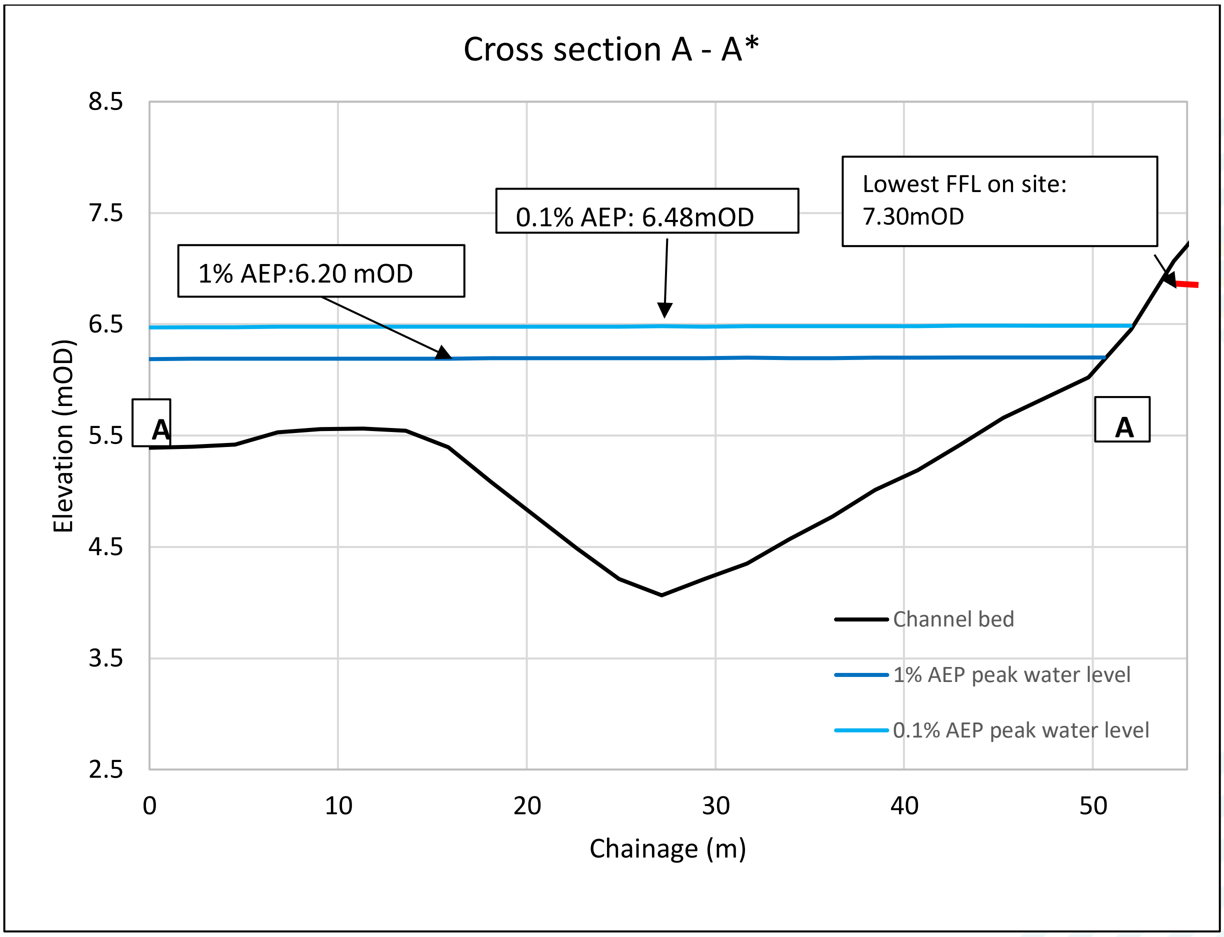


Figure 4-6: Cross Section A – A*

4.2.3 Modelling results – residual risk

4.2.3.1 Climate change

Climate change has been assessed for the site under the High Event Forecast Scenarios (1% AEP +30% flows), although the standard approach would be to base climate change on the Medium Range Forecast (1% +20% flows). Figure 4-7 shows that there is a minor increase flood risk to the site in during the HEFS climate change event. The inundation during the HEFS event is contained within the proposed open green space area proximal to the riverbank at a distance from any of the potential risk receptors.

All the proposed residential development is located in areas not of flooding from the both the 1% AEP and 0.1% AEP HEFS climate change events.

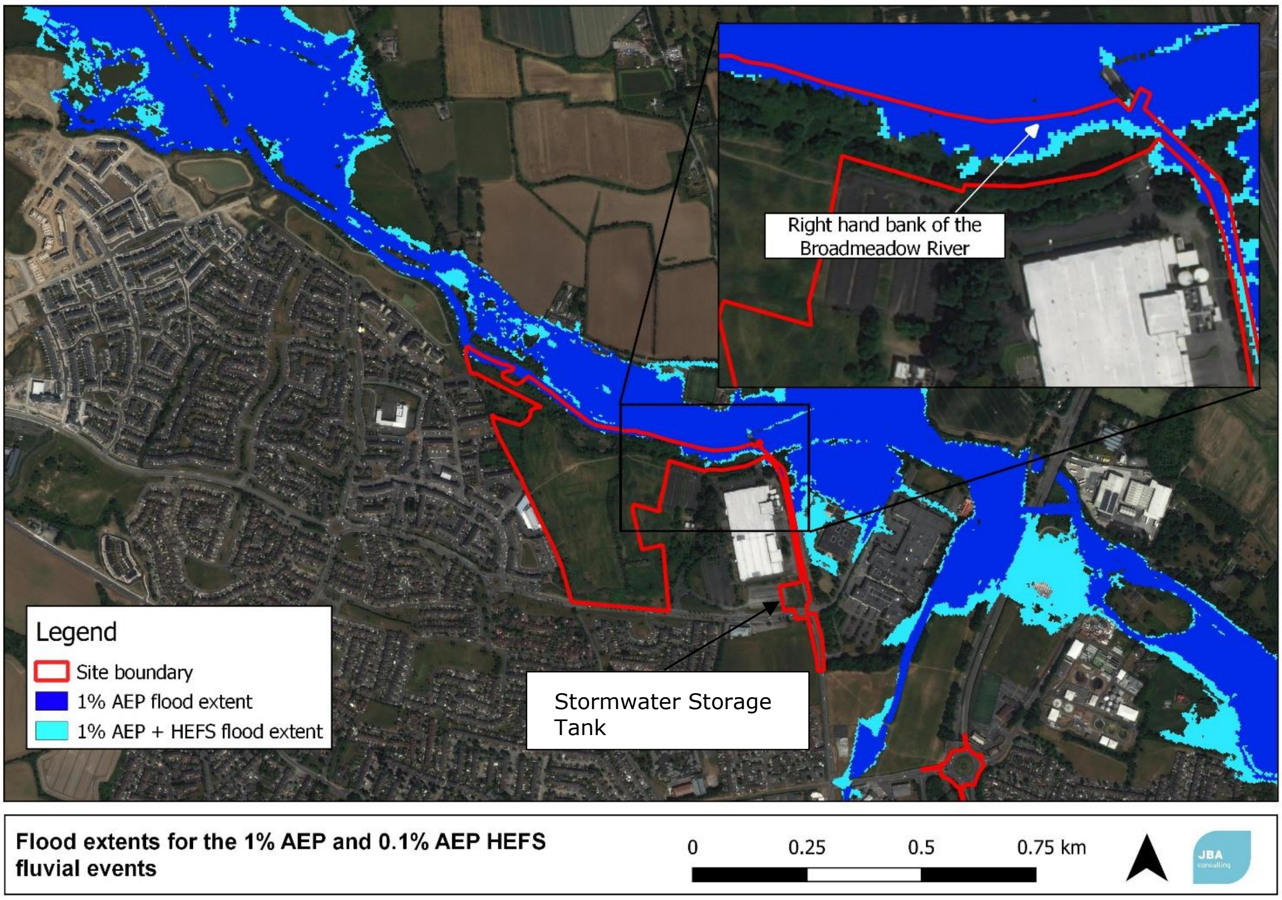


Figure 4-7: Flood extents for the 1% AEP and 1% AEP+HEFS fluvial events

4.2.3.2 Blockage of the Balheary Road bridge

The Balheary Road bridge lies directly downstream of the site. To examine the potential increase in flood risk the blockage of the bridge may have on site the 1% AEP fluvial event was run with a 66% blockage applied to the bridge. From Figure 4-8 the blockage of the bridge does not increase flood risk to the proposed buildings, an increased portion of the proposed open green space along the riverbank is inundated but there are no key risk receptors in this area.

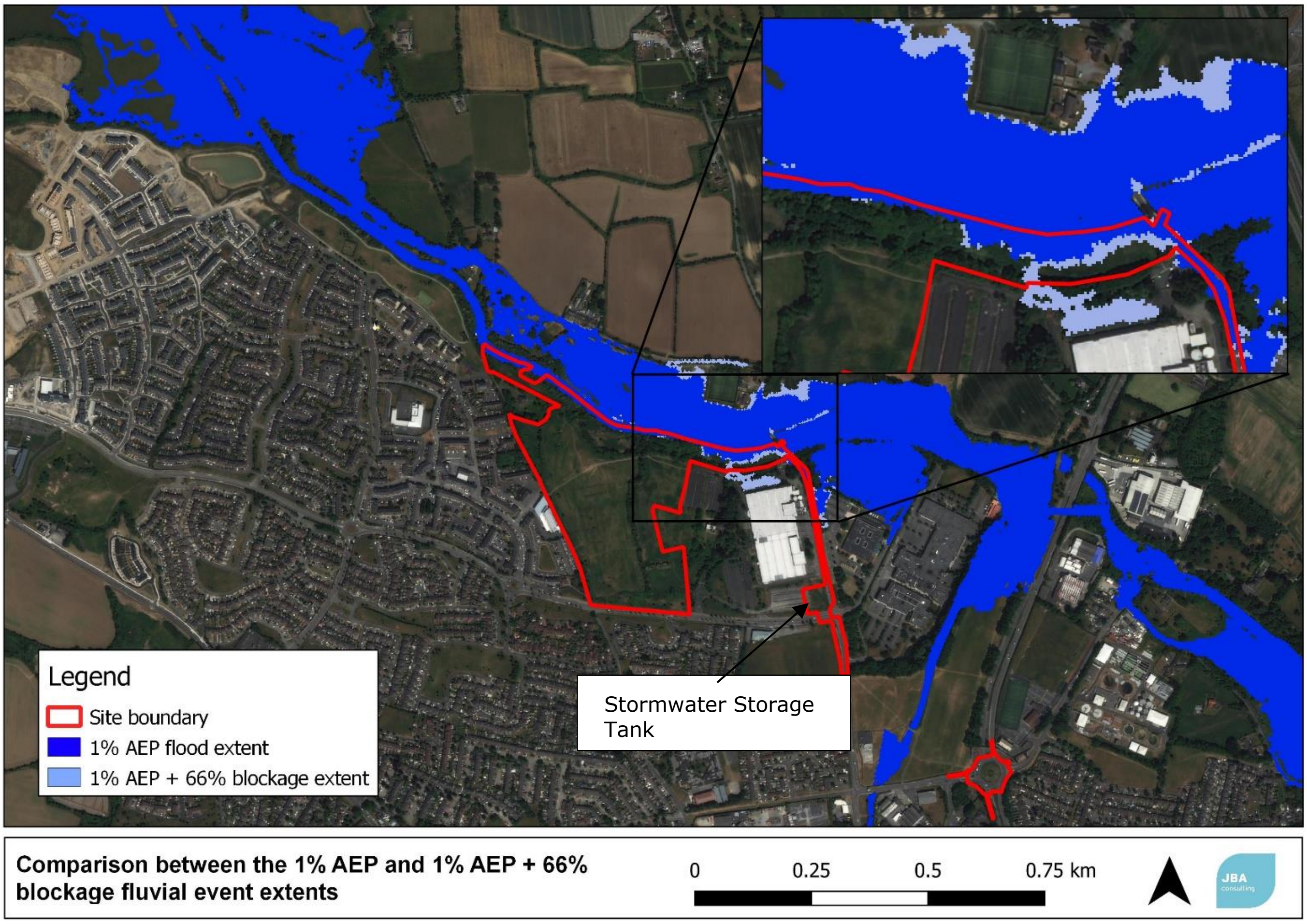


Figure 4-8: Comparison between the 1% AEP and 1% AEP+66% blockage fluvial event extents

4.2.4 Hydraulic modelling results summary

Examination of the modelled flood extents for various fluvial events and residual risk has shown that:

- The proposed residential housing and the amenities on site are located in Flood Zone C for all modelled events.
- A portion of the site along the right-hand bank of the Broadmeadow River which is to be open green space is affected during high flow events. This is to be expected due to the close proximity to the river's edge. There are no risk receptors within this area and therefore no increased flood risk.
- Residual risks have been assessed and the site is not at risk of flooding during the HEFS climate change scenarios or in the event of blockage of the Balheary Road bridge.
- This detailed flood risk assessment has therefore shown that the proposed development is not at risk from fluvial flooding and does not increase flood risk elsewhere. The site is therefore in Flood Zone C.

5 Flood Risk Assessment and Mitigation

5.1 Flood Risk

Review of the available flood data showed that main source of flood risk to the site was fluvial flooding in the north eastern portion of the site. To investigate this further a detailed assessment of fluvial flood risk at the site was carried out using a 1D-2D hydraulic model. The modelling study found that the portion of the site along the right-hand bank of the Broadmeadow to be affected which is expected. This area is to be an open green space with no risk receptors, the areas of residential and commercial buildings are located away from the riverbank and in Flood Zone C. As a result, there is no increased flood risk to the site from fluvial flooding in the 1% AEP or 0.1% AEP flood events.

5.2 Mitigation

5.2.1 Finished floor levels

All residential dwellings are located in Flood Zone C, and therefore are not at risk of inundation up the 0.1% AEP event. Based on the FRA guidelines, it is appropriate to locate residential dwellings in Flood Zone C, as long as the levels are demonstrated to be suitably raised above climate change with freeboard.

The proposed minimum Finish Floor Level (FFL) for the site is 7.30mOD which provides a freeboard of 0.83mOD above the 0.1% AEP flood event (6.48mOD).

The residual risk of failure or exceedance of the stormwater system (discussed further in Section 5.2.3) could result in potential inundation of the site. To protect against this a minimum of 150mm freeboard is recommended between the finished floor level (FFL) of any building and the site/external hardstanding areas.

5.2.2 Access

Access to the development will be via Jugback Terrace and Glen Ellen Road located along the western and southern boundaries of the site. The site access is located in Flood Zone C and therefore, at low risk of flooding. It is concluded that access to the site during a 1% AEP flood event can be maintained without presenting a flood risk to commercial traffic.

5.2.3 Residual risks

5.2.3.1 Climate change

In accordance with the OPW guidelines, it is necessary to assess the risk associated with climate change. The site has been assessed in accordance to the High Event Future Scenario (HEFS 1% AEP event +30% flow). The results confirm that the site is not at risk of inundation following the application of climate change allowances.

The proposed minimum FFL of 7.3mOD provides a freeboard of 0.78mOD above the 1% AEP HEFS event (6.52).

5.2.3.2 Blockage of the Balheary Road bridge

The potential impact blockage of the Balheary Road bridge may have on the site the 1% AEP event with 66% blockage of the bridge was modelled. The results showed the residential and commercial building on site are unaffected in the event of the bridge being blocked.

The proposed minimum FFL of 7.3mOD provides a freeboard of 0.75m above the 1% AEP blockage scenario (6.55mOD).

5.2.3.3 Pluvial flooding and storm water design

Review of the OPW PRFA flood map showed part of the site to be at risk of pluvial flooding. To address this and any increased pluvial flood risk generated by the site a detailed stormwater system has been developed. Figure 5-1 shows the proposed stormwater drainage design. To minimise ponding onsite permeable paving car park spaces are proposed. All surface water from paved surfaces is directed to detention bases from which excess surface water will be discharged at the calculated greenfield runoff rate.

Refer to the accompanying surface water engineering report which confirms that the system has been designed to meet the Fingal County Council/GDSDS requirements. The design ensures there is no increased to the site or surrounding area.

A stormwater storage tank (2,250m^3) will be supplied as part of the proposed development with an outfall to the Broadmeadow River that will alleviate capacity issues within foul network in the area. An overflow pipe is set at 6.25mOD. Review of the Figure 4-4, Figure 4-7 and Figure 4-8 confirms that the storage tank is not at risk from any of the modelled flood events and therefore is located in Flood Zone C.

The recommended ground floor threshold of 150mm to the surrounding area will provide protection from potential fluvial flooding within the site.

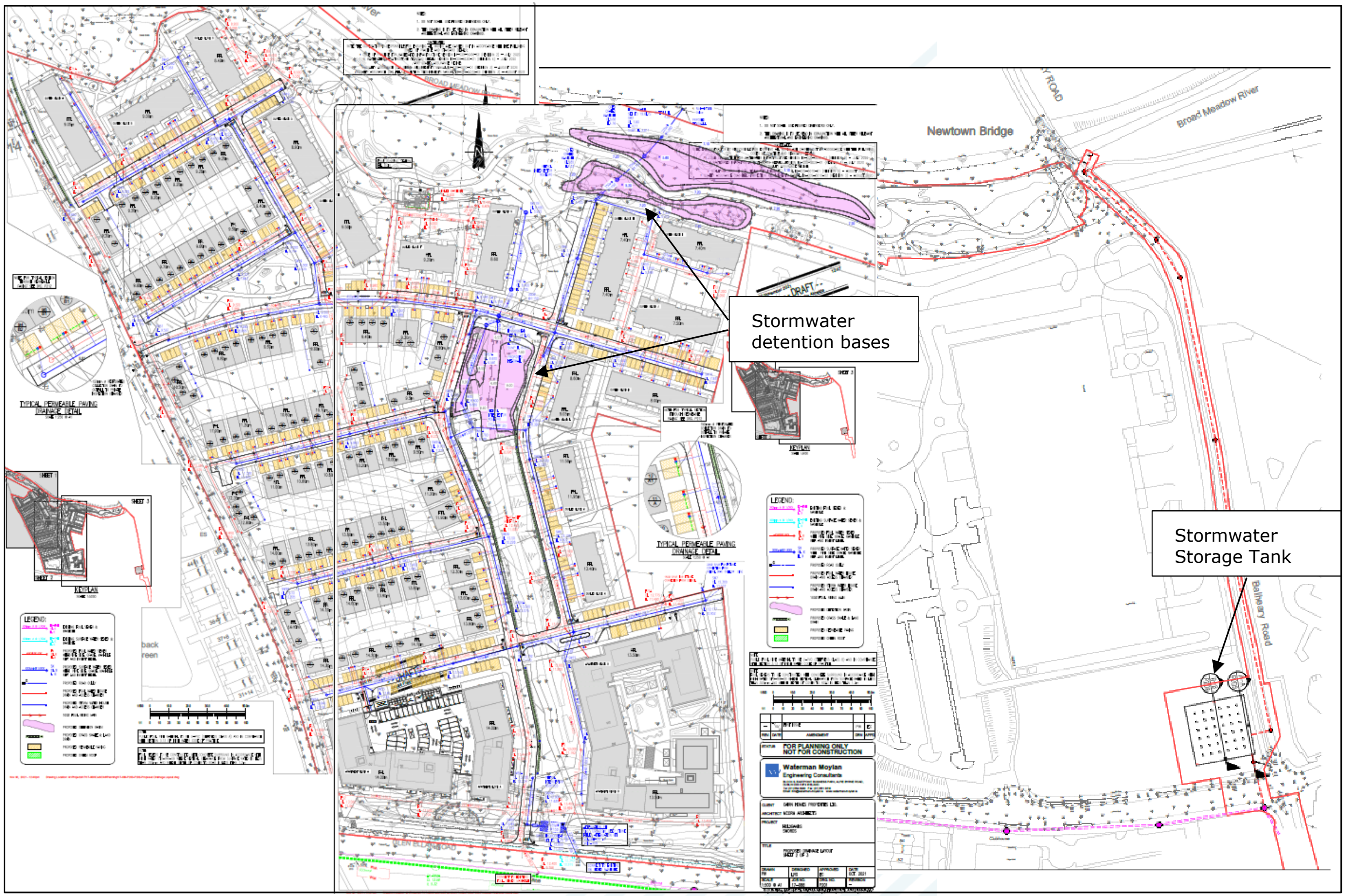


Figure 5-1: Proposed stormwater design (source: Waterman Moylan Consulting Engineers)

6 Conclusion

JBA Consulting has undertaken a detailed Flood Risk Assessment for a proposed mixed-use development in Holybank, Swords, Co Dublin. The nearest watercourse to the site is identified as the Broadmeadow River which runs in a west-east direction past the northern boundary of the site.

Review of the available historic information, confirms that areas to the north and west of the site have experienced historic flooding. Further to the historic flood information, the area has been subject to predictive flood modelling under the FEM FRAM study. The resulting flood maps confirms that minor inundation of the site along the Broadmeadow river occurs during the 1% AEP (Flood Zone A) and the 0.1% AEP (Flood Zone B) events.

Based on the historic and predicted flood risk, a site-specific hydraulic model has been developed to investigate further the flood risk to the site and includes the assessment of climate change and residual risks. The model has been based on up to date site survey and LIDAR data. A conservative approach has been undertaken for the site -specific FRA and a 95%ile FSE (1.85) has been applied to the peak flow (1%/0.1% AEP) hydrology values.

The resulting flood maps from the modelling study confirm that all the proposed residential dwellings are located in Flood Zone C. Minor inundation occurs during the 1% and 0.1% AEP event along the boundary with the Broadmeadow River, however this area of the site will be utilised as greenspace only.

The proposed minimum FFL for the site is 7.3mOD, which provides a freeboard of 0.82m above the 0.1% AEP flood event (6.48mOD).

Residual risks and climate change (HEFS scenario) have also been assessed for the site. The residual risk has included the potential blockage of the Balheary Road bridge downstream of the site. The freeboard available to the site from the residual risk (blockage) and climate change (HEFS) are 0.78m and 0.75m respectively. Review of the hydraulic model results show there is no increased flood risk to the site in any of the fluvial residual risk events assessed.

Pluvial flood risk has also been reviewed for the site. A detailed stormwater system has been designed for the site to minimise increased pluvial flood risk generated by the increase in hardstanding are, refer to the supporting stormwater engineering report. In the event the storm water system failing the minimum FFL on site of 7.30mOD provides over 150mm freeboard above the external hardstanding areas.

The proposed stormwater storage tank that will alleviate capacity constraints of the foul system is located in Flood Zone C and is not at risk of inundation from any of the modelled flood events.

In summary the key areas of the proposed site are located within Flood Zone C and therefore suitable for the development of residential and commercial building.

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 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 (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.

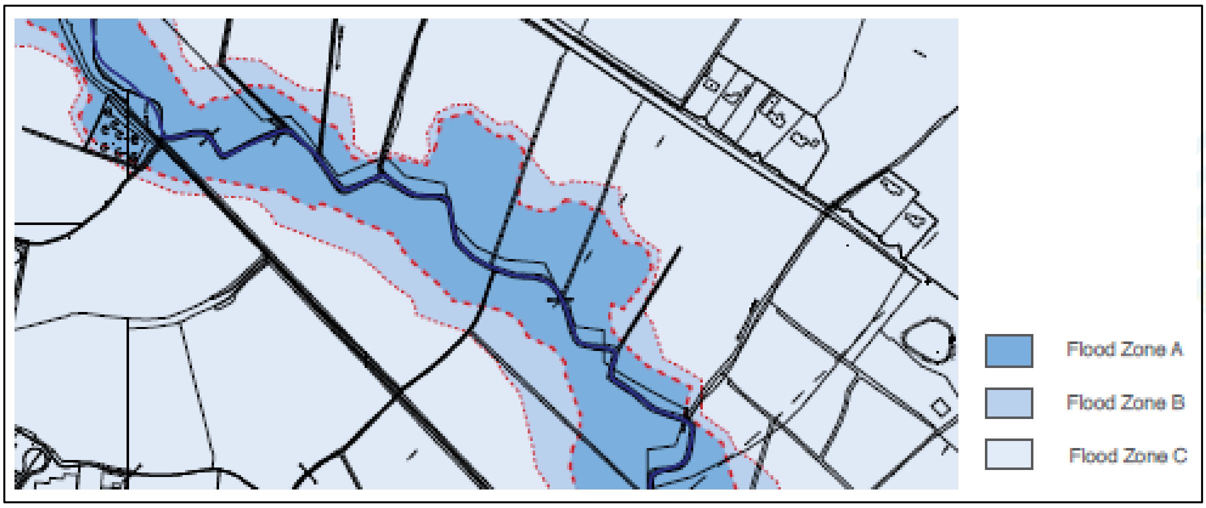
Return Period (years)	Annual Exceedance Probability (%)
2	50
10	10
50	2
100	1
200	0.5
1000	0.1

A.2 Flood Zones

Flood Zones are geographical areas illustrating the probability of flooding. For the purposes of the Planning Guidelines, there are 3 types or 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% 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 due to overtopping or breach and that there may be no guarantee that the defences will be maintained in perpetuity.



A.3 Consequences of Flooding

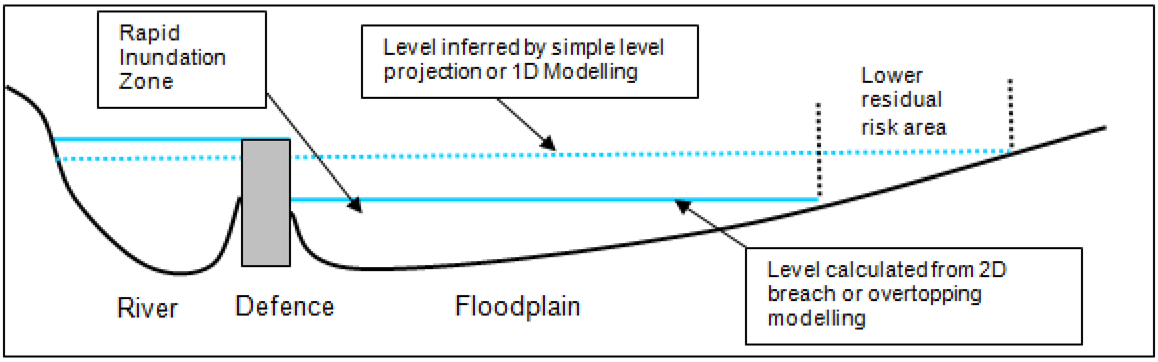
Consequences of flooding depend on the hazards caused by flooding (depth of water, speed of flow, rate of onset, duration, wave-action effects, water quality) and the vulnerability of receptors (type of development, nature, e.g. age-structure, of the population, presence and reliability of mitigation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

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

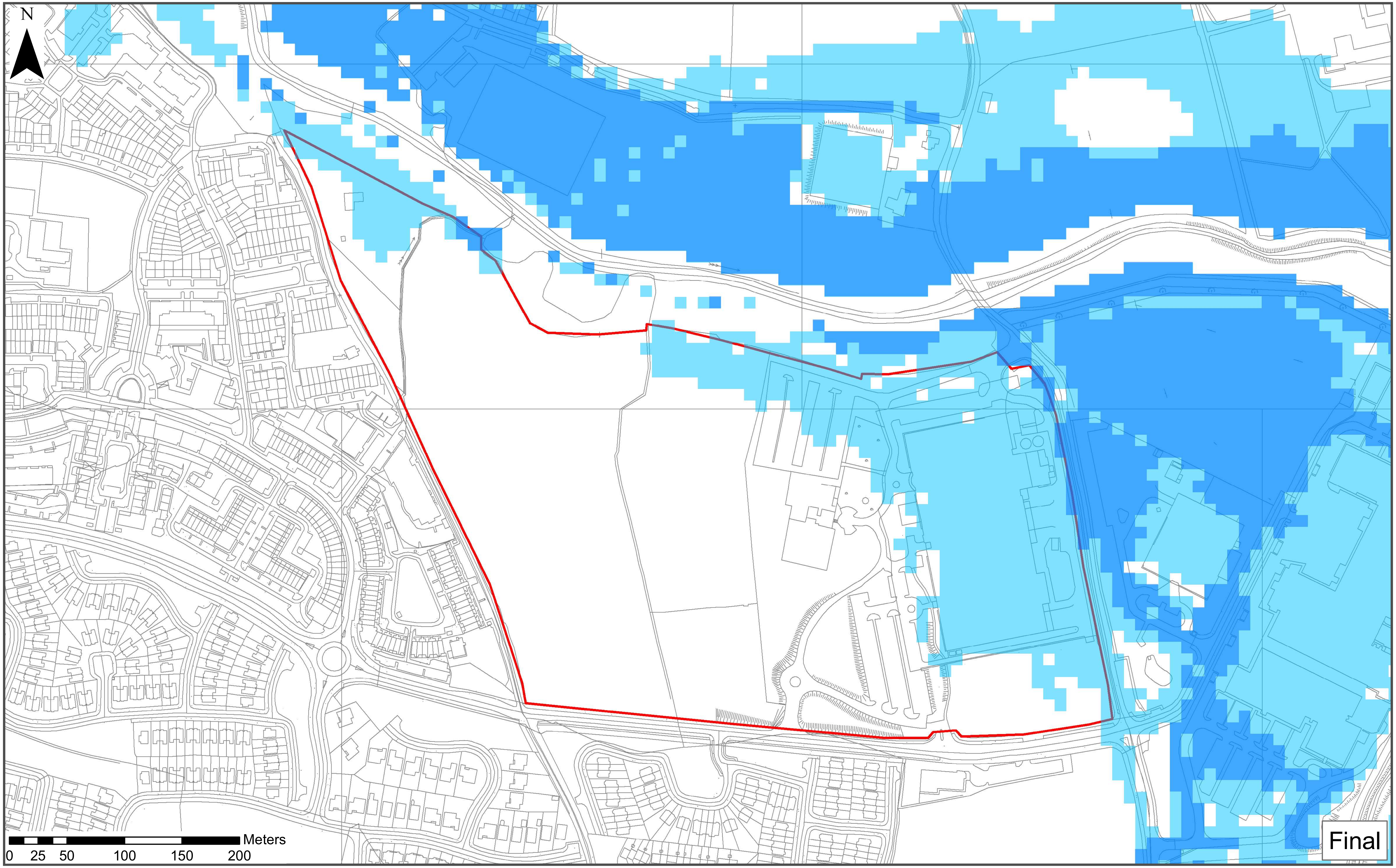
- **Highly vulnerable**, including residential properties, essential infrastructure and emergency service facilities;
- **Less vulnerable**, such as retail and commercial and local transport infrastructure;
- **Water compatible**, including open space, outdoor recreation and associated essential infrastructure, 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 Estuary West -Flood Maps



Legend

- Estuary West - 1 in 100 Year Fluvial Event - High End Future Scenario
- Estuary West - 1 in 1000 Year Fluvial Event - High End Future Scenario
- Estuary West Masterplan Lands

No.	Revision	Date	By	Chk'd	App'd
F01	Final Flood Extents	09/05/2019	BP	WV	JPR
D03	Draft Flood Extents	04/03/2019	BP	WV	JPR
D02	Draft Flood Extents	31/01/2019	BP	WV	JPR
D01	Draft Flood Extents	25/01/2019	BP	WV	JPR

Stage	Date	App'd
PRELIMINARY		
APPROVAL		
TENDER		
CONSTRUCTION		

ROD ROUGHAN & O'DONOVAN
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Website : www.rod.ie

Project Title: Estuary West Surface Water Management Plan

Drawing Title: Fluvial Flood Extents (High End Future Scenario)

Designed: BP | Checked: WV | Approved: JPR | Status: FINAL

Drawn: BP | Job No: 18.164 | Drawing No: 18.164-EW-107 | Rev: F01

Scale: (A1) 1:3,000 (@ A3) | Date: 31/01/2019

09 May 2019 18:21:31 Drawing Location: J:\2018\18164\18164-02_WIP\08 MODELS\05 GIS\01 MXD\Flood Extents\Final\Fluvial\18.164-EW-107 Fluvial Flood Extents HEFS F01.mxd

DO NOT SCALE USE FIGURED DIMENSIONS ONLY

C Hydrology Check File

NOTE TO FILE

JBA Project Code	2019s0831
Contract	Holybank, Swords
Client	Carin Homes
Author	Hannah Moore
Subject	Hydrology check file

1 Introduction

This check file is to assess the hydrology applied to the hydraulic model for a residential site in Holybank, Swords, Co Dublin.

2 Site Details

Site Name	Holybank, Swords, Co Dublin
Site Description	Greenfield site with plans to build residential dwellings
Watercourse Catchment	Broadmeadow and Ward catchments
Watercourse Name	Broadmeadow and Ward Rivers

2.1 Inflow catchments overview

Two watercourses are considered for the inflows for this site - the Broadmeadow River and the River Ward. Figure 2-1 shows the site location and the catchments of the watercourses considered. Table 2-1 shows the catchment characteristics used in the flow estimations for the watercourses. The values are obtained from the FSU ungauged node database (see Figure 2-2). The nodes used are:

- Node 08_295_4 (used to get Broadmeadow River characteristics)
- Node 08_670_1 (used to get River Ward characteristics)

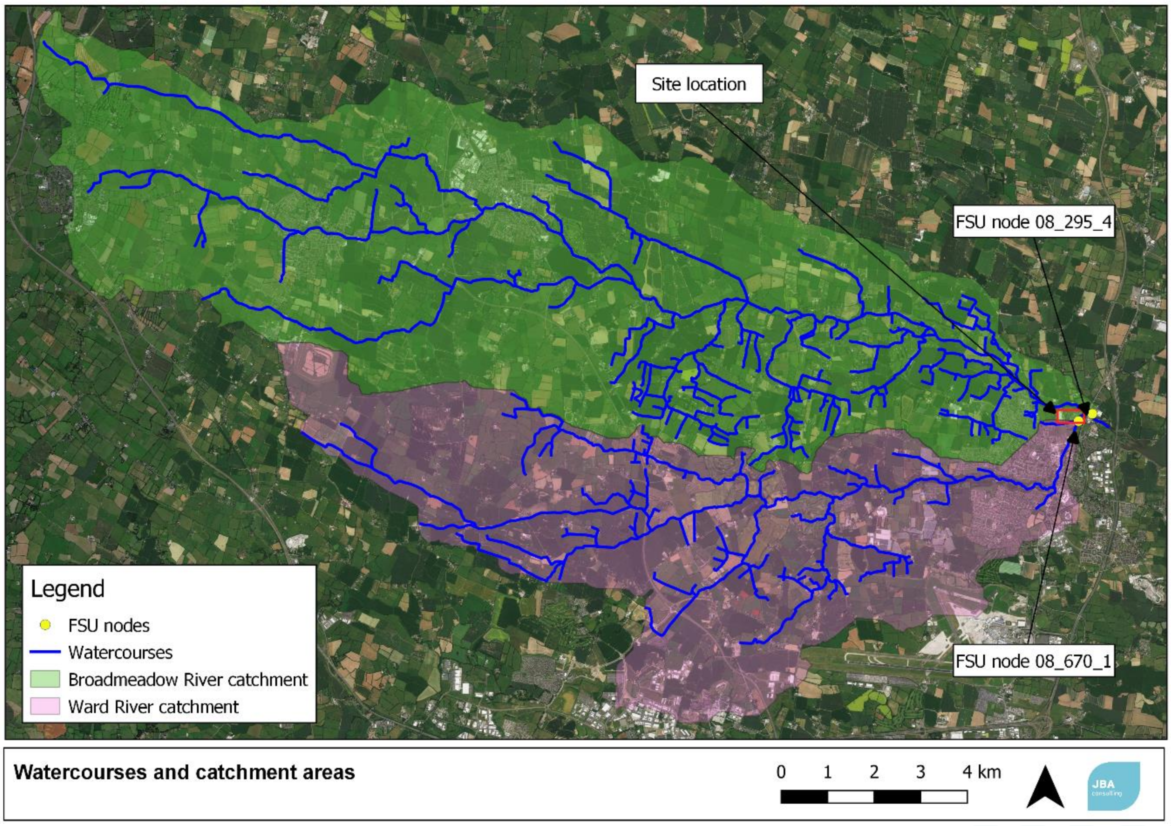

Figure 2-1: Catchment areas and watercourses

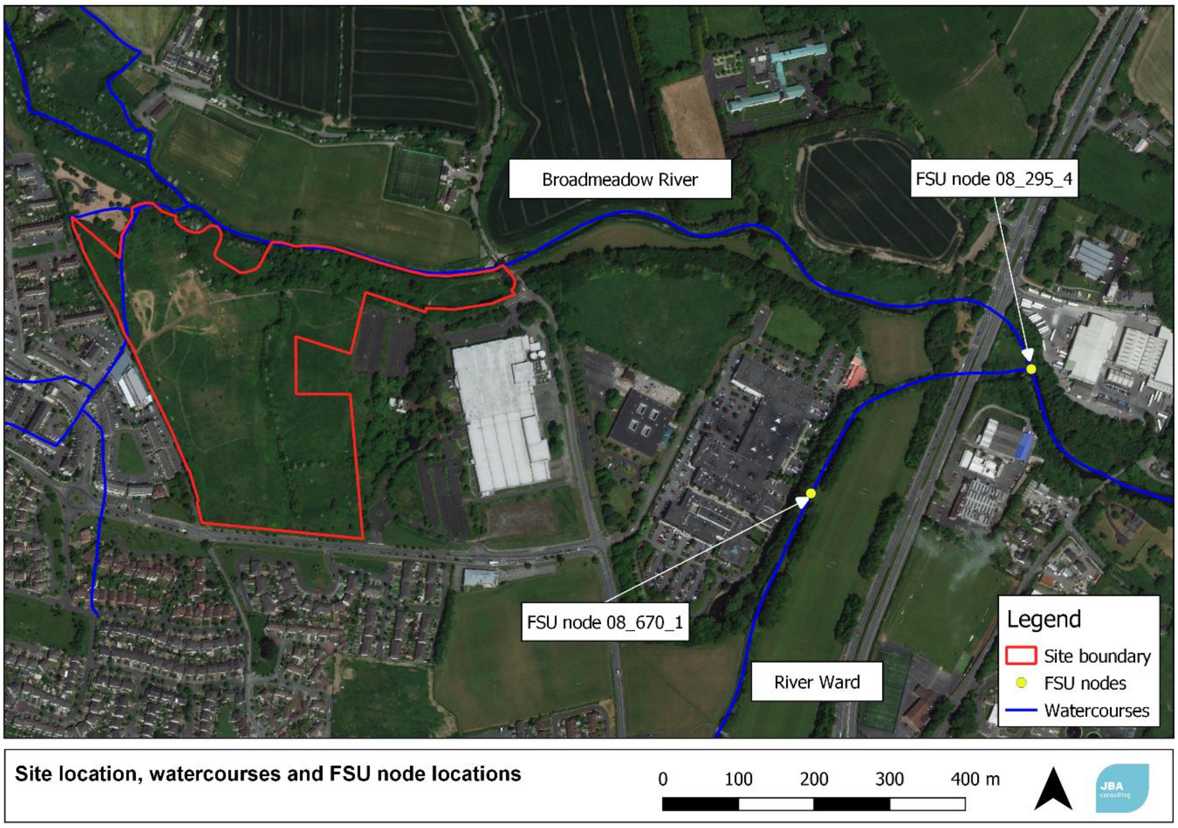

Figure 2-2: Location of site and FSU ungauged nodes used

Table 2-1: Catchment characteristics for ungauged locations

Descriptor	Node 08_295_4	Node 08_670_1
Area	109.68	61.642
SAAR	809.46	767.09
FARL	1	1
BFI Soil	0.49	0.55
URBEXT	0.05	0.07
MSL	27.44	20.50
S1085	3.99	4.09
Stream Frequency	247	142
DrainD	1.32	1.31
ArtDrain2	0.44	0.55
Soil (number)	2	2
SMDBAR	7	7
M5-2day	55.5	55.5
M5-1day	46.7	46.7
r	0.27	0.27

3 Flow Estimation Methods

As both catchments are greater than 25km2 the FSU method is considered the most appropriate method to estimate flows for both watercourses. Peak flows for the 50%, 20%, 5%, 2%, 1% and 0.1% AEP events have been estimated.

Background theory and descriptions for the FSU method can be found in Appendix **Error! Reference source not found.** of this check file.

4 Flow estimation - FSU method pivotal site selection

To allow comparison and adjustment to the flows estimated in the FSU method a pivotal (or donor) site is selected. The pivotal site is a gauged catchment location with records of sufficient quality that has similar characteristics to the ungauged catchment in question.

4.1 Broadmeadow River - Pivotal site review

Table 4-1 shows the details of the short list of gauges considered for the Broadmeadow River pivotal site.

Table 4-1: Pivotal site short list for the Broadmeadow River watercourse

	Broadmeadow	**Fieldstown**	**Ashbourne**
Number	08008	08003	08007
FSU gauge quality ranking	A2	B	B
Catchment area (km2)	107.92	83.59	37.94
Qmed gauged m3/s	40.90	22.55	8.24
Qmed(rural) m3/s	19.97	16.23	9.38
Hydrological similarity to ungauged location	0.015	0.318	1.27
Gauge type	Staff gauge	Staff gauge	Staff gauge
Operator	OPW	OPW	OPW

All gauges in the pivotal site shortlist are located along the Broadmeadow River upstream of the FSU node 08_295_4. From the short list is was decided that the Broadmeadow gauge be used as the pivotal site for the Broadmeadow River. The Ashbourne and Fieldstown gauges are both B ranked gauges which indicates that they have poor quality data and were therefore discounted.

The Broadmeadow gauge is an A2 ranked gauge indicating it has records of reasonable quality for use in analysis and the gauge is located 1.5km upstream of the FSU node.

Table 4-2 shows the key characteristics for the gauge catchment and suitability.

A review of the Broadmeadow gauge data record was carried out. AMAX data for the Broadmeadow gauge was obtained from the OPW. The OPW Qmed was 39.1m3/s. The

OPW rating curve is based on the extrapolation of joining the largest and third largest spot flows, ignoring the 2nd largest, which resulted in exceptionally high flow values. The FEM FRAMS hydrology report carried out a review of the rating curve using an ISIS model. The Qmed from the Halcrow Barry (HB) suggest rating curve is 21.06m3/s. This Qmed value was deemed appropriate as a model was used to produce it and it is very similar to the catchment descriptors Qmed (19.97m3/s).

The FEM FRAMS only used AMAX data up to 2007. The AMAX data provided by the OPW up to present day was compared to the OPW Qmed which showed that the updated Qmed would have an increase of 0.9m3/s. Therefore, the Qmed value produced from HB does not need to be adjusted.

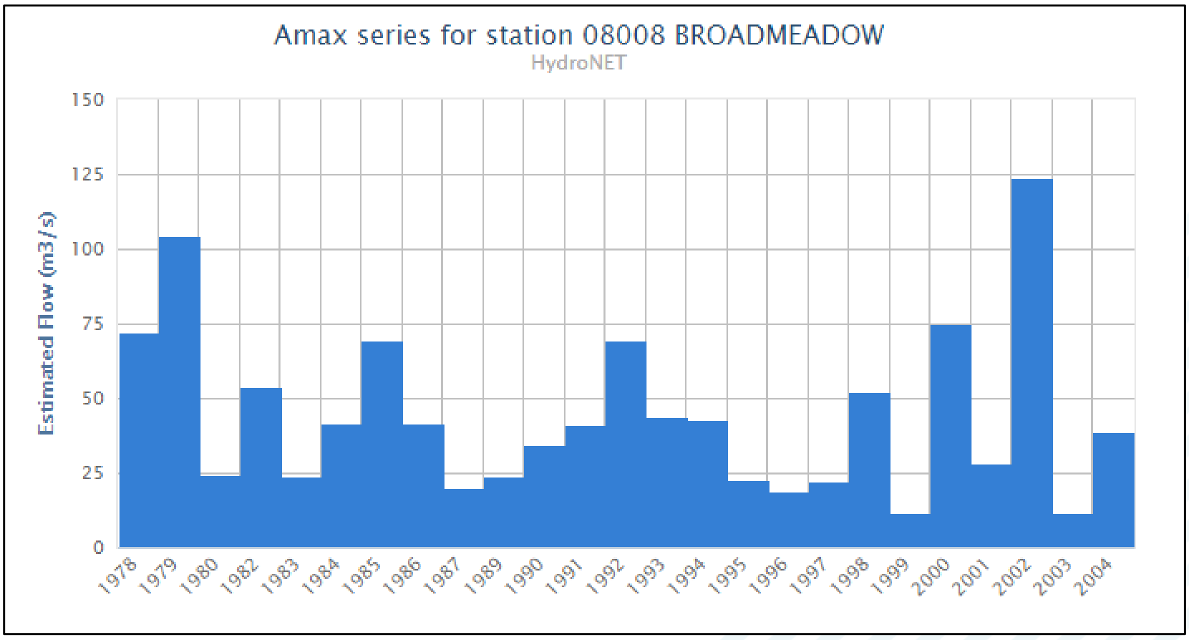

Figure 4-1: AMAX series for the Broadmeadow gauge (Data from 1979 - 2004 sourced from FSU website)

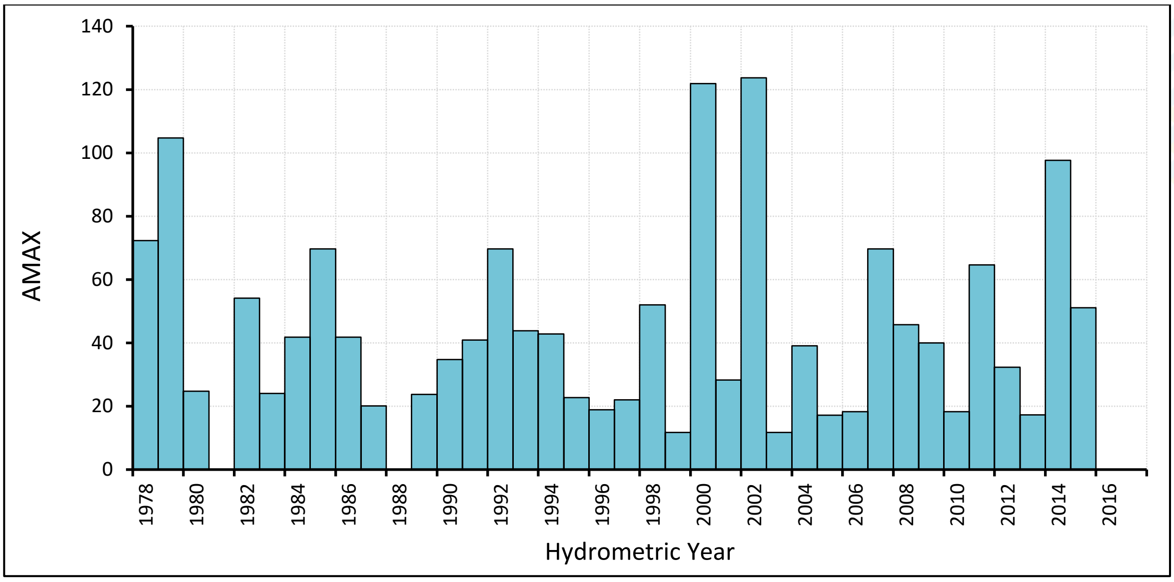

Figure 4-2 AMAX series for the Broadmeadow gauge (OPW Data 1978 - 2015, plot from Jspeed)

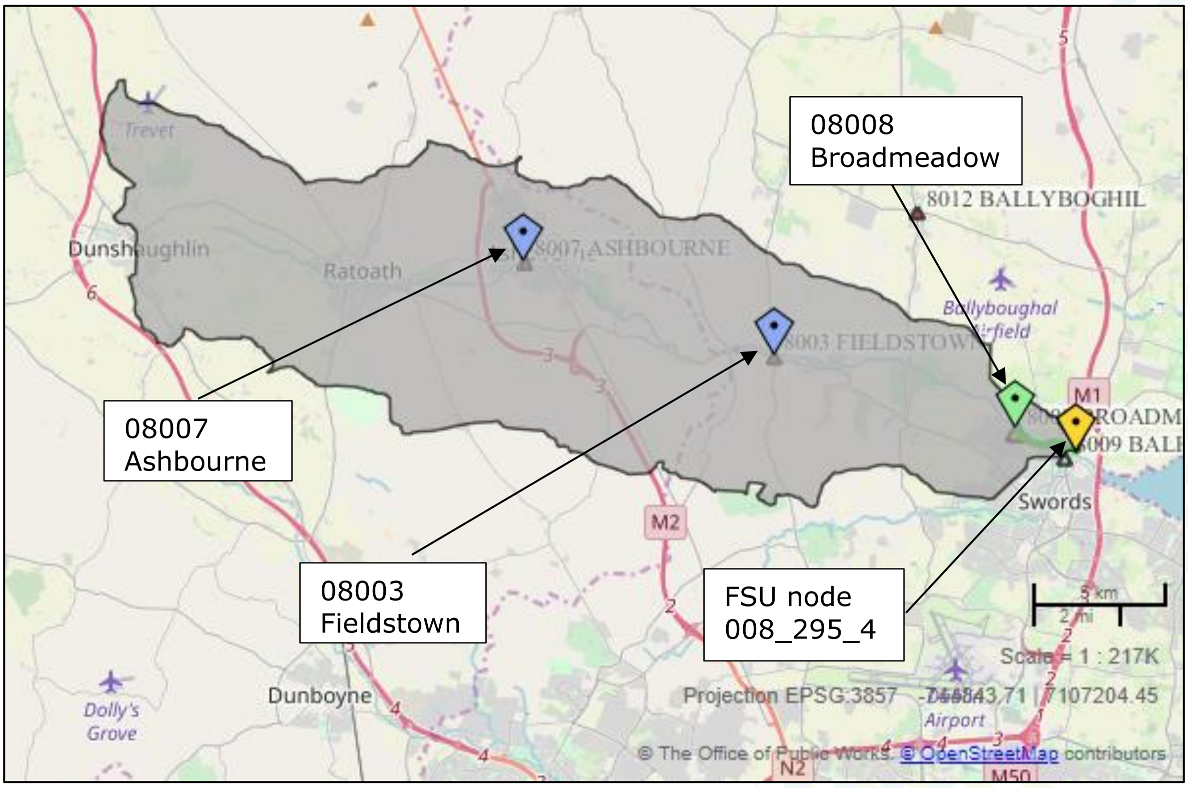

Figure 4-3: The Broadmeadow gauge in reference to the ungauged location and catchment area (Broadmeadow River)

Table 4-2: Comparison of Pivotal gauge and ungauged catchment characteristics

Descriptor	Node 08_2954	08008 - Broadmeadow gauge
Area	109.68	107.92
SAAR	809.46	810.61
FARL	1	1
BFI Soil	0.49	0.49
URBEXT	0.05	0.04
MSL	27.44	26.69
S1085	3.99	3.97
DrainD	1.32	1.31
ArtDrain2	0.44	0.44
Soil (number)	2	2 (100%)
SMDBAR	7	7
M5-2day	55.5	55.5
M5-1day	46.7	46.7
r	0.27	0.27
FSU Gauge ranking	-	A2
Hydrological similarity	-	0.015
FSU record	-	1978 - 2015
Qmed(rural) m3/s	20.29	19.97
Qmed (URBEXT) m3/s	21.59	21.19
Qmed(gauged) m3/s	-	21.06 (FEM FRAMS Qmed)
Qmed stat	-	45.4 (OPW data)
Adjustment factor	-	1.05 (using FEM FRAMS Qmed)
Adjusted Qmed m3/s	21.30	-

4.2 River Ward - Pivotal site review

Table 4-1 shows the details of the gauge considered for the River Ward pivotal site. Only one gauge is suggested by the FSU website - the Balheary guage (08009).

The Balheary is considered a suitable pivotal site as it is located less that 100m downstream of the FSU node 08_670_1 on the same watercourse. There are only 13 years of suitable gauge data, but it is an A1 ranked gauge indicating that the gauge data is of high quality. The minimum recommended record length for pivotal gauges is 10 years therefore there is sufficient data for use in pivotal site analysis.

A rating review was carried out on the Balheary gauge by FEM FRAMs which calculated Qmed as 4.97m^3/s. When calculating Qmed for the subject site, the adjustment factor based on the pivotal site was 0.44, which would almost half the Qmed. Caution should be taken when the adjustment factor is less than 1 however given that the rating review is consistent with the OPW FSU Qmed gauged data the adjusted Qmed is being applied in this case.

Table 4-3: Pivotal site summary - River Ward

	Balheary
Number	08009
FSU gauge quality ranking	A1
Catchment area (km2)	61.64
Qmed gauged m3/s	5.00

Qmed(rural) m3/s	10.29
Hydrological similarity to ungauged location	0.0036
Gauge type	Staff gauge
Operator	EPA

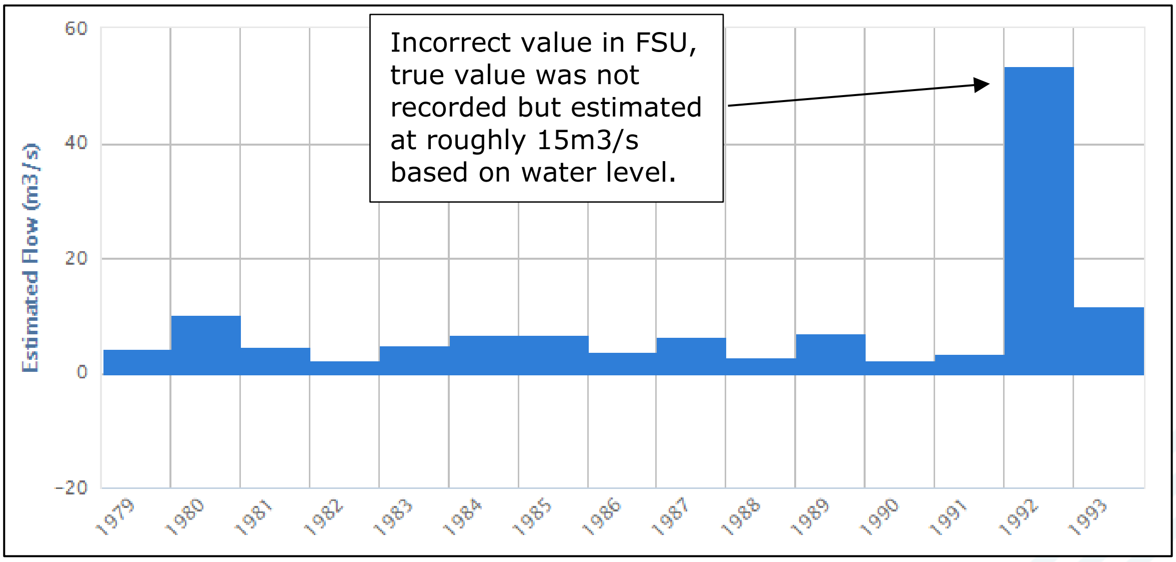

Figure 4-4: AMAX series for the Balheary gauge (Data from 1979 - 1993)

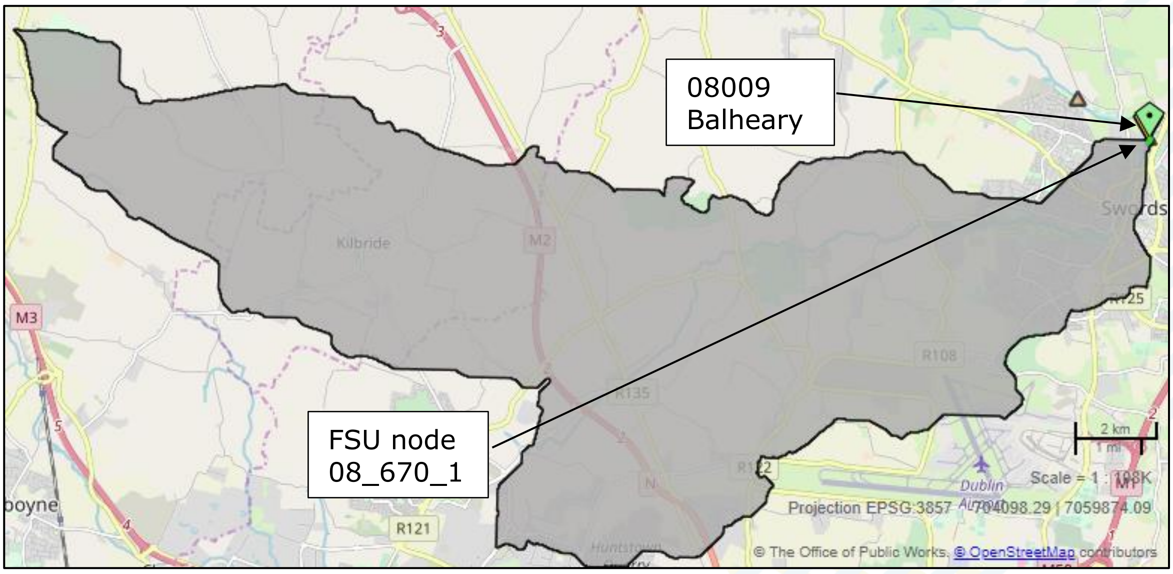

Figure 4-5: The Balheary gauge in reference to the ungauged location and catchment

Table 4-4: Comparison of Pivotal gauge and ungauged catchment characteristics

Descriptor	Node 08_670_1	08009 - Balyheary gauge
Area	61.642	61.64
SAAR	767.09	767.09
FARL	1	1
BFI Soil	0.55	0.55
URBEXT	0.07	0.07
MSL	20.50	20.49
S1085	4.09	4.08
DrainD	1.31	1.32
ArtDrain2	0.55	0.55
Soil (number)	2	2 (100%)
SMDBAR	7	7
M5-2day	55.5	55.5
M5-1day	46.7	46.7
r	0.27	0.27
FSU Gauge ranking	-	A1
Hydrological similarity	-	0.0036
FSU record	-	1979 - 1993
Qmed(rural) m3/s	10.26	10.29
Qmed (URBEXT) m3/s	11.43	11.46
Qmed(gauged) m3/s	-	5.00
Qmed stat	-	4.35
Adjustment factor	-	0.44
Adjusted Qmed m3/s	4.99	-

5 FSU method

For a full description of the FSU method and the pooling group used see Appendix A.1. Table 5-1 and Table 5-2 show the estimated peak flows watercourses. See Figure 5-1 and Figure 5-2 for the corresponding growth curves. a generalised extreme value (GEV) distribution has been fitted for the pooled analysis.

Table 5-1: Estimated peak flow FSU - Broadmeadow River

Annual Exceedance Probability (%)	FSU Adjusted (m3/s)	Growth Factor
50%	21.30	1.00
20%	29.82	1.40
10%	35.36	1.66
5%	40.90	1.92
2%	48.14	2.26
1%	53.68	2.52
0.1%	72.21	3.39

Table 5-2: Estimated peak flow FSU - Ward River

Annual Exceedance Probability (%)	FSU Adjusted (m3/s)	Growth Factor
50%	4.99	1.00
20%	7.06	1.42
10%	8.50	1.70
5%	9.94	1.99
2%	11.90	2.39
1%	13.43	2.69
0.1%	18.93	3.80

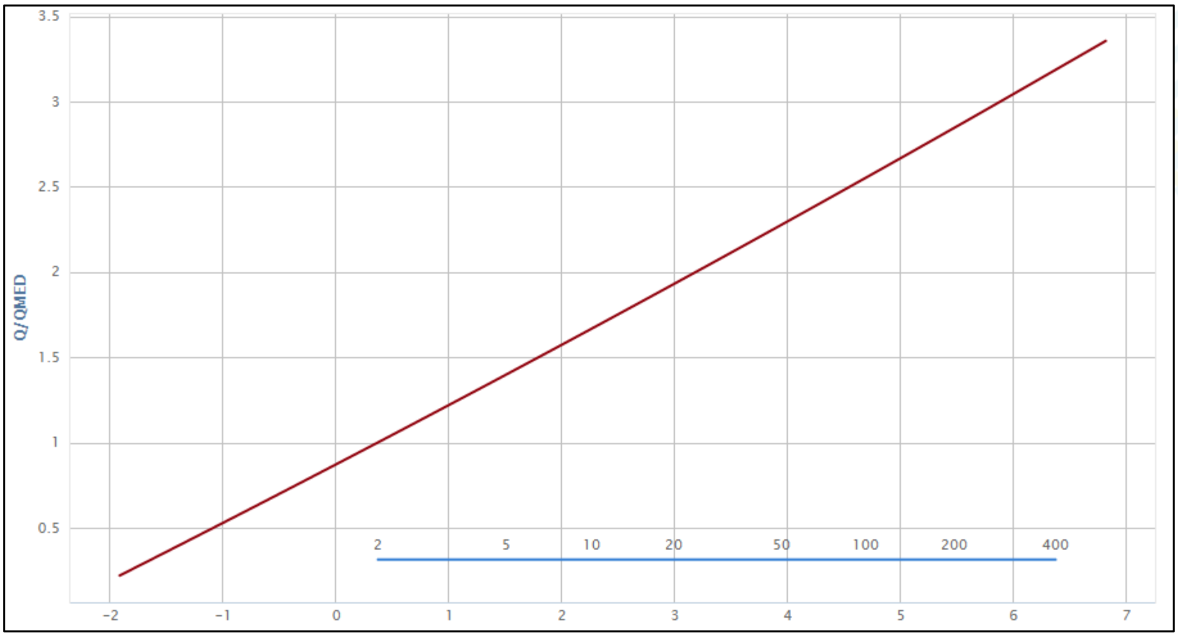

Figure 5-1: FSU growth curve - Broadmeadow River

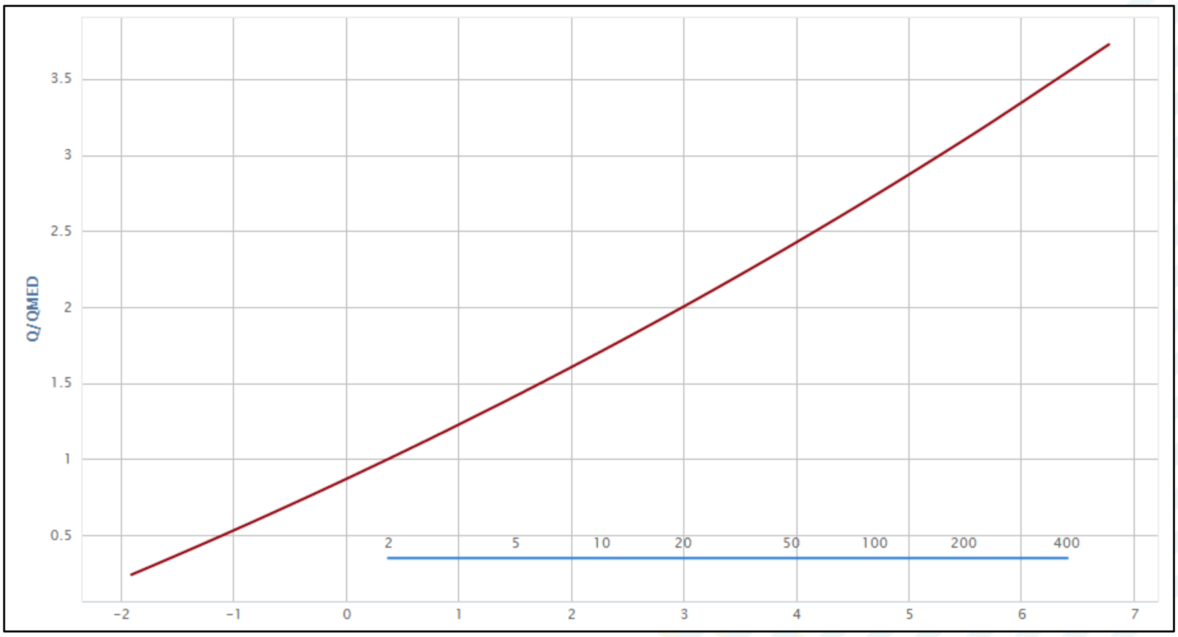

Figure 5-2: FSU growth curve - River Ward

6 Downstream boundary

The Broadmeadow River flows east and enters the Irish sea via the Broadmeadow Estuary. To represent this it is recommended that the hydraulic model use a head time boundary that replicates the tidal cycle recorded at the Broadmeadow estuary.

Table 6-1 shows the peak water levels for the different tidal AEP events estimated by the Irish Coastal Protection Strategy study of the North East coast. Point 16 is the closest estimation point to the study site (Figure 6-1). Tidal cycles can also be sourced using the Irish Coastal Protection Strategy study data for the Dublin tidal cycles.

Table 6-1: Irish Coastal Protection Strategy study estimated peak tidal levels for Point 16

AEP Event	Height to mean sea level
50%	2.61
10%	2.84
1%	3.15
0.5%	3.25
0.1%	3.47

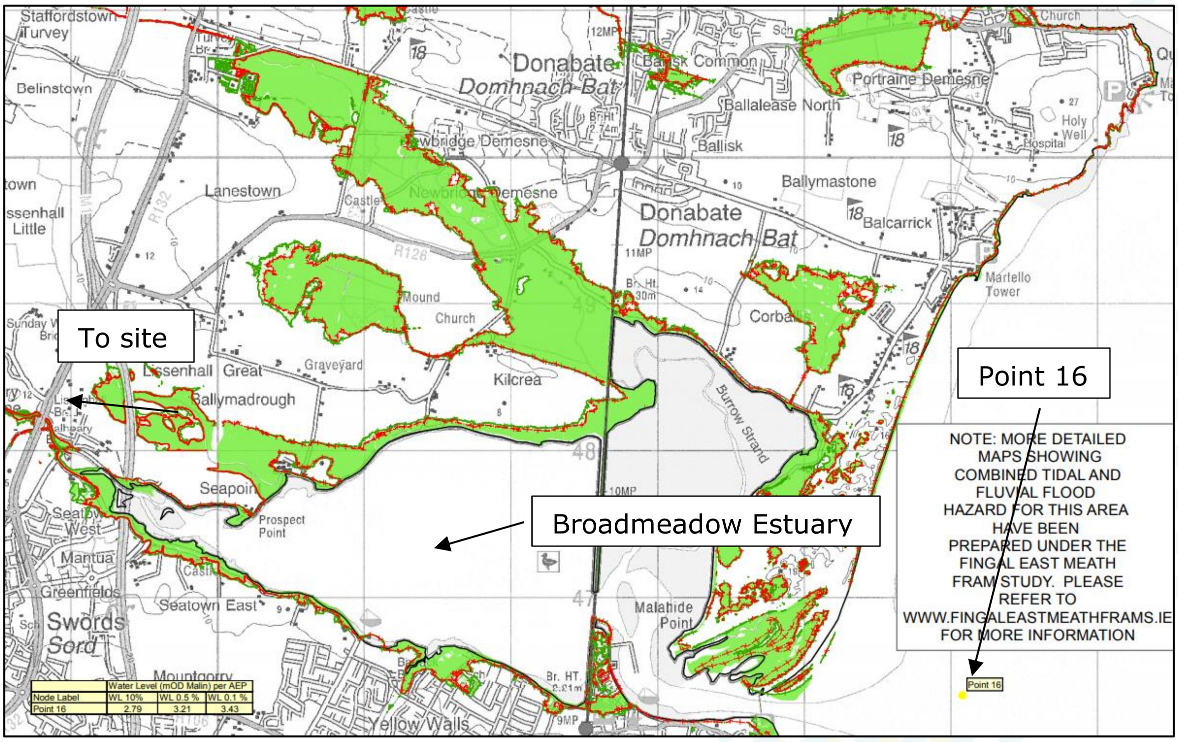

Figure 6-1: Irish Coastal Protection Strategy Tidal flood map of the Broadmeadow estuary

7 Storm Hydrograph shape and storm duration

As there are no lakes or reservoirs upstream of the site that would have an effect on the storm hydrograph shape it is recommended that the hydrograph shape recorded in the FSU for the gauges be used for the watercourses in this study as this allows the actual hydrographs of the systems be tested. The Broadmeadow gauge was used as the hydrograph pivotal site for both watercourses as the Balheary gauge could not be used in the analysis for the River Ward. Figure 7-1 and Figure 7-2 show the final hydrograph shapes applied.

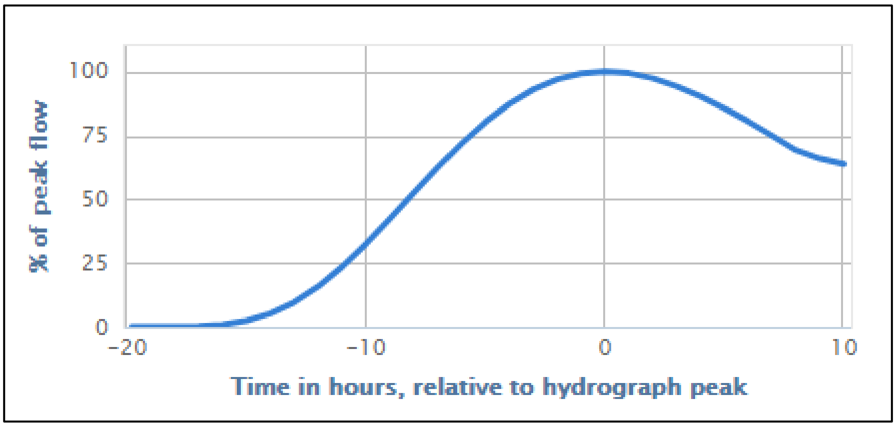

Figure 7-1: Hydrograph shape for the Broadmeadow River

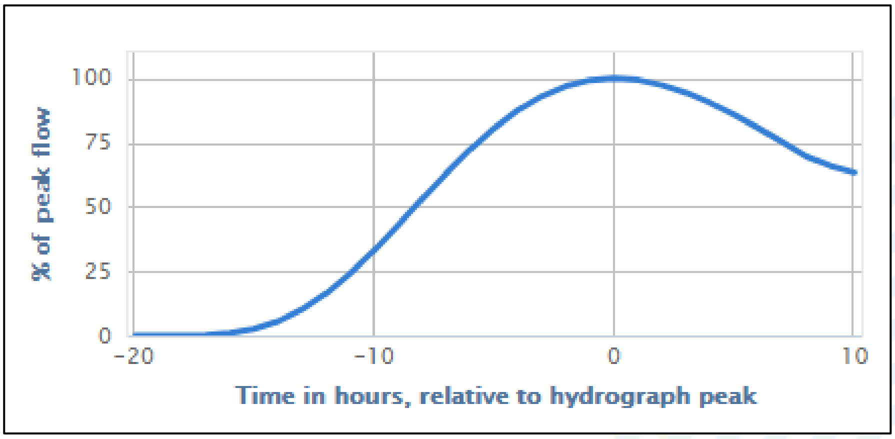

Figure 7-2: Hydrograph shape for the River Ward

7.1 Broadmeadow River

The FSR RR method was used to find the suggested storm duration for the Broadmeadow River. A storm of 8.75 hours was found to be the critical storm duration. It is recommended that storms with a duration of 7, 8 and 9 hours also be tested to see whether the flow or volume of water is the critical factor for the river system and site.

7.2 River Ward

The FSR RR method was also used to find the suggested storm duration for the River Ward. A storm of 4.75 hours was found to be the critical storm duration. It is recommended that storms with a duration of 4, 5 and 6 hours also be tested to see whether the flow or volume of water is the critical factor for the river system and site.

8 Joint Probability

8.1 Joint probability - Fluvial-fluvial combined events

As there are two watercourses within the hydraulic model that are connected the timing of their peak events must be considered.

Due to the nature of the weather systems that generally affect the East coast of Ireland (frontal systems from the Atlantic) the same AEP event will most likely occur over both the Broadmeadow and Ward catchments even though they are large. Therefore, it is recommended that the same AEP event storm be used on both watercourses.

In terms of the coinciding of peak flows for both watercourses to ensure the most conservative approach is taken it is recommended that the two peaks are set to coincide. This will result in the most conservative flows being put through the model. Sensitivity testing should also be carried out with one watercourse experiencing high flows at a time to examine whether flooding is dependent on the combined high flows or is more dependent on a single watercourse.

8.2 Joint probability - Fluvial-tidal combined events

The Broadmeadow River flows east and enters the Irish sea via the Broadmeadow Estuary. A tidal head time boundary is recommended for the downstream boundary of the model. To assess the fluvial flood risk in isolation it is recommended that initial model runs be performed with using a normal 50% AEP tidal boundary in combination with the Fluvial AEP events. Following further sensitivity testing can be carried out with a 0.5% AEP tidal boundary to assess the combined fluvial-tidal flood risk to the site.

9 CFRAM Comparison

Both the Broadmeadow River and River Ward were modelled as part of the FEM FRAM study. Table 9-1 compares the flows within the FEM FRAM model and those estimated in this check file. Refer to Figure 9-1 and Figure 9-2 for the location of the comparison points within the FEM FRAM model.

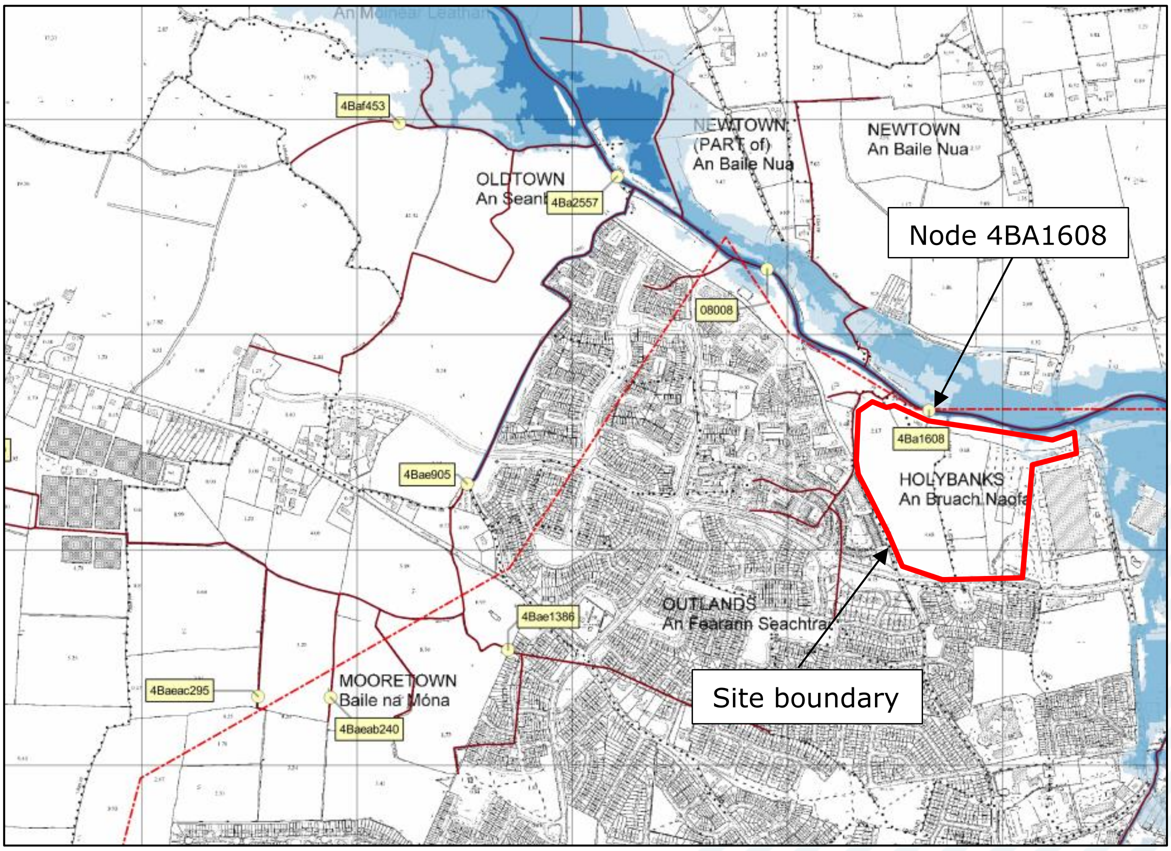

Figure 9-1: An extract from the FEM FRAM map of the Broadmeadow River

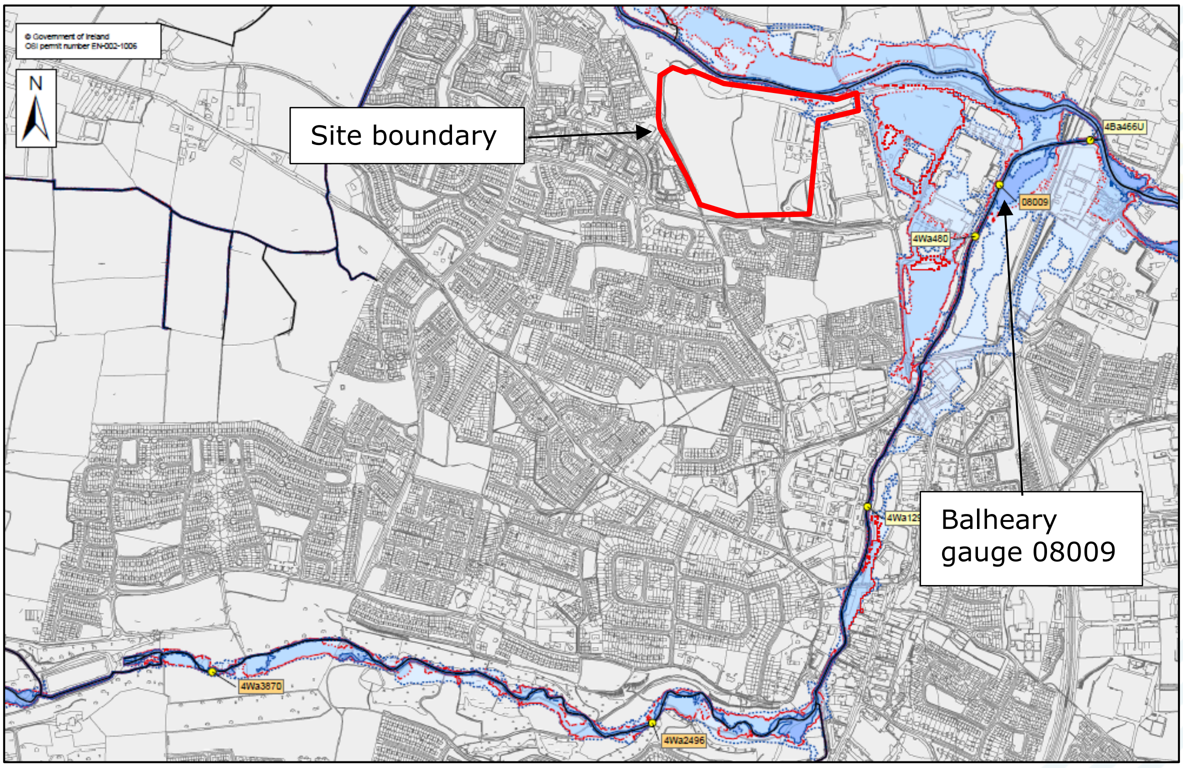

Figure 9-2: An extract from the FEM FRAM map of the River Ward

Table 9-1: Comparison of FEM FRAM and estimated flows

AEP	**FEM FRAM 4Ba1608**	**FSU node 08_295_4**	**FEM FRAM 08009 - Balheary gauge**	**FEM FRAM 08009- Balheary gauge adjusted Qmed**	**FSU node 08_670_1**
10%	36.09	35.36	21.28	9.39	8.50
1%	64.46	53.68	39.08	15.71	13.43
0.1%	129.69	72.21	54.21	22.86	18.93

Table 9-2: Comparison of FEM FRAM regional growth curve and those applied in this check file

Annual Exceedance Event (AEP)	**FEM FRAMS Growth Curve**	**FSU Growth curve (FSU node 08_295_4)**	**FSU Growth Curve (FSU node 08_670_1)**
50%	1.00	1.00	1.00
20%	1.52	1.40	1.42
10%	1.89	1.66	1.70
2%	2.76	2.26	2.39
1%	3.16	2.52	2.69
0.1%	4.60	3.39	3.80

Comparing the FEM FRAM flows and those calculated for the Broadmeadow River in this check file the 10% AEP flows are in reasonable agreement, but the flows diverge as the return period increases. This is due to the different growth curves applied to the Qmed value. A regional growth curve was used to estimate peak flows for the FEM FRAMS study while a site-specific pooling group has been used in this study. Table 9-2 compares the two growth curves; the FEM FRAMS regional growth curve is significantly steeper resulting in higher flow estimates for the larger events. As the pooling group used to generate the growth curve for this study is more tailored to the specific catchment it is considered to generate flows that are more representative to the catchment. Based on this the flows estimated for the FSU node 08_295_4 in this study are recommended for use rather than the FEM FRAM flows estimated.

The difference between the FEM FRAM flows for the Balheary gauge and those estimated for FSU node 08_670_1 in this check file is much larger. The difference is in part due to the growth curves applied (refer to Table 9-2). As well as the differing growth curves the FEM FRAMS study adopted a different Qmed value to the Balheary gauge to the one used in this check file.

The median flow Qmed at Station 080090 Balheary on the Ward River is 5.77m3/s from the EPA rating. Rating review carried out by FEM FRAMS indicated a Qmed of 4.97m3/s (HB rating). The Specific Qmed value, Qmed/$A^{0.77}$, at the station was calculated to be 0.207m3/s from the HB rating. When the FEM FRAM compared this Specific Qmed value to other stations it was found to be much lower. The Specific Qmed of the Broadmeadow Station is 0.564m3/s and the regional area median value is 0.545m3/s. The CFRAM adopted the regional area median value for the Balheary Station to give a Qmed of 13.07m3/s. This process completely ignores the unique catchment characteristics at the gauge which would cause the variation in the Specific Qmed values. It also ignores the recorded gauge data at the location and results in an increased Qmed value which is not reflective of the catchment and hence overestimates flow. When the FEM FRAM regional growth curve is applied to the initial Qmed estimate of 4.97m3/s the difference between the FEM FRAM and the flows estimated in this check file is reduced (See Table 9-1). Based on this it is recommended that the flows calculated in this check file be applied in the hydraulic model as they better represent the catchment and the flows occurring along the River Ward.

10 Summary

Peak flows have been estimated for two watercourses - the Broadmeadow River and the River Ward. These flows are to be used as inflows to a hydraulic model to assess flood risk as part of an FRA.

The FSU method was used to estimate the flows of both watercourses as it is recommended method for the catchment sizes considered. Pivotal gauges were reviewed and applied as part of the FSU method to generate peak flows.

A tidal head time boundary is recommended for the downstream model boundary to replicate the Broadmeadow estuary.

Although the two catchments considered are large it is assumed that the same AEP storm would occur over both therefore the same AEP storm should be applied to both watercourses. The critical storm duration for the Broadmeadow River and River Ward are 8.75 and 4.75 hours respectively although testing of different storm duration through the hydraulic model is recommended to confirm. To ensure the most conservative scenario is used in the assessment it is recommended that the peaks of the two watercourses coincide. A 50% AEP tidal boundary is suggested to assess the fluvial flood risk to the site but sensitivity testing with a 0.5% AEP tidal boundary should be carried out to assess the fluvial-tidal combined flood risk to the site.

When the peak flows estimated were compared with the FEM FRAM hydrology and flow outputs it was found that the FEM FRAM values were higher than those calculated. This is due to the use of a different growth curve and a different Qmed value in the case of the River Ward. After review of the FEM FRAM hydrology it is recommended that the flows estimated in this check file be used within the hydraulic model.

In summary this check file has assessed flow estimates for two watercourses for use in an FRA and examined the application of these flows through the use of combined events and storm hydrograph shapes.

Note: following initial model runs the model review process, it was noted that very minor bank overtopping during the 1% AEP flows, which doesn't match the visual flood plain in the area. Although not specifically stated, it appears that the 95%ile FSE factor has been applied to the FEM FRAM study which results in a significant divergence in the flood extents between the JBA and FEM FRAM flood extents.

It has therefore decided, based on the modelled flood extents, that the 95%ile FSE factor (1.85) has been applied to the JBA baseline flow estimates for use in the final FRA design flows. This is considered the most conservative approach, while sensitivity analysis has also been undertaken such as increasing manning's by 20%.

Table 10-1: Final design flows

AEP% Event	Broadmeadow River (m3/s)	River Ward (m3/s)
50%	39.41	9.23
20%	55.17	13.06
10%	65.42	15.73
5%	75.67	18.39
2%	89.06	22.02
1%	99.31	24.85
0.1%	133.59	35.02

A Appendices

A.1 The FSU method

The Flood Studies Update (FSU) method to estimate Qmed as described in research reports produced from FSU work packages 2.2 and 2.3, has been used. Qmed can be estimated using a regression equation based on seven different physical catchment descriptors, in conjunction with an urban adjustment, developed in FSU work package 2.3.

The multivariate regression equation was developed on the basis of data from 199 gauged catchments, linking Qmed to a set of catchment descriptors.

QMEDrural=1.237x10-5AREA0.937BFIsoils-0.922SAAR1.306FARL2.21DRAIND0.341S10850.185 (1+ARTDRAIN2)0.408

Where:
AREA is the catchment area (km2).
BFIsoils is the base flow index derived from soils data
SAAR is long-term mean annual rainfall amount in mm
FARL is the flood attenuation by reservoir and lake
DRAIND is the drainage density
S1085 is the slope of the main channel between 10% and 85% of its length measured from the catchment outlet (m/km).
ARTDRAIN2 is the percentage of the catchment river network included in the Drainage

The catchment descriptors can be used to determine Qmed. The growth factors for this site are also calculated from the FSU using pooling groups. In order to improve on this initial estimate of QMED, the data transfer process is used from Broadmeadow gauging station for the Broadmeadow river (Station number 08008) and the Balheary gauging station for the River Ward (Station number 08009). In the terminology of the FSU research reports, the gauging station where the adjustment factor is calculated is referred to as a donor site.

The Broadmeadow gauge is located 1.5km upstream of the site on the Broadmeadow river. south east and downstream of the subject site. The Broadmeadow gauge was selected from those provided in the FSU portal as it was the highest standard gauge and most hydrologically similar to the site in question. An adjustment factor for QMED is calculated as the ratio of the gauged to the ungauged estimate of QMED at the gauging station. Refer to Section 4.2 for further discussion on the Qmed of the Broadmeadow gauge. This adjustment factor was found to be 1.05. This factor is then used to adjust the initial estimate of QMED at the hydrological estimation point 08_295_4 downstream of the proposed site.

The Balheary gauge is located less than 100m downstream of the FSU ungauged node location on the River Ward. The Balheary gauge was selected from those provided in the FSU portal as it was the highest standard gauge and most hydrologically similar to the site in question. An adjustment factor for QMED is calculated as the ratio of the gauged to the ungauged estimate of QMED at the gauging station. This adjustment factor was found to be 0.44. This factor is then used to adjust the initial estimate of QMED at the hydrological estimation point 08_670_1 downstream of the proposed site. It is noted that the adjustment factor is less than one but as the adjusted Qmed matches the gauge data it is thought that in this case it is reasonable to accept the adjustment factor calculated.

For pooled analysis within the FSU, gauges are chosen on the basis of their similarity with the subject catchment according to three catchment descriptors, i.e. AREA, SAAR and BFIsoil. The report on FSU WP 2.2 presents two alternative equations for calculating the similarity of catchments according to these three descriptors. For this study, equal weight was given to each of these variables, applying the similarity distance formula given as Equation 10.2 in the report on FSU WP 2.2.

Not all gauges in Ireland were considered for use in pooling, because the analysis required to fit a flood growth curve makes use of the magnitude of each annual maximum flow, and thus it is necessary that even the highest flows are reliably measured. This excludes gauges where there is significant uncertainty in the high flow rating.

The final pooling groups used are shown in Table A-1 and A-2. No alterations were made to the pooling groups defined using the process defined above as it was deemed appropriate for the analysis. Gauging stations had already been screened according to the quality of their flood peak data, as described above. Although there is some evidence from research on UK data1 that flood growth curves are affected by additional catchment descriptors such as FARL, the FSU research found that FARL was not a useful variable for selection of pooling groups (uncertainty was greater when FARL was included than when it was excluded) and therefore no attempt was made to allow for the presence of lakes in the composition of pooling groups. Similarly, no allowance was made for arterial drainage in selecting pooling groups.

For pooled growth curves, WP 2.2 recommends considering 3-parameter distributions, because the extra data provided by the pooling group ensures that the standard error is lower than it would be for single-site analysis. The report states that either the generalised extreme value (GEV) or generalised logistic (GL) distributions are worth considering. For this study, GEV has been fitted for the pooled analysis.

Table A-1: Pooling Group used in Broadmeadow River FSU analysis

Station No.	Name	Watercourse	Years	Cumulative years
08008	Broadmeadow	Broadmeadow	25	25
08003	Fieldstown	Broadmeadow	18	43
08011	Duleek	Nanny	23	66
09001	Leixlip	Ryewater	25	91
06033	Coneyburrow Br	White (Dee)	25	116
08009	NA	NA	15	131
36031	Lisdarn	Cavan	30	161
11001	Boleany	Owenavorragh	33	194
14004	Clobbulloge	Figile	7	241
14011	Rathangan	Slate	25	266
07006	Fyanstown	Moynalty	19	285
26022	Kilmore	Fallan	33	318

1 Kjeldsen, T.R., Jones, D.A. and B06031ayliss, A.C. (2008) Improving the FEH statistical procedu19re32s for flood frequency estimation. Science Report SC050050, Environment Agency.3020

09010	Waldron's Br	Dodder	19	337
08012	NA	NA	19	356
06031	NA	NA	18	374
16001	Athlummon	Drish	33	407
24002	Gray's Br	Camoge	32	439
24022	Hospital	Mahore	20	459
24004	Bruree	Maigue	52	511

Table A-2: Pooling Group used in River Ward FSU analysis

Station No.	Name	Watercourse	Years	Cumulative years
08009	NA	NA	15	15
08002	Naul	Delvin	21	36
08012	NA	NA	19	55
08008	Broadmeadow	Broadmeadow	25	80
06033	Coneyburrow Br	White (Dee)	25	105
08003	Fieldstown	Broadmeadow	18	123
14011	Rathangan	Slate	25	148
08011	Duleek	Nanny	23	171
14007	DerryBrock	Stradbally	24	195
10021	Commons Road	Shanganagh	24	219
09001	Leixlip	Ryewater	25	244
14009	Cushina	Cushina	25	269
26022	Kilmore	Fallan	33	302
09002	Lucan	Girffeen	25	327
36031	Lisdarn	Cavan	30	357
06031	NA	NA	18	375
07003	Castlerickard	Blackwater	46	421
24022	Hospital	Mahore	20	441
14004	Clobbulloge	Figile	47	488

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