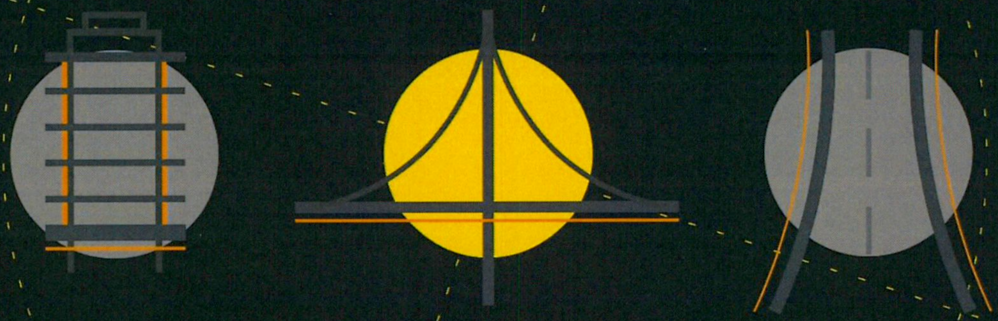
Cúil Dúin & Parklands, Creche & Community Facility, Citywest

Infrastructure Design Report

132071-DBFL-XX-SP-RP-C-001

INFRASTRUCTURE



October 2022

DBFL CONSULTING ENGINEERS

Project Title:	**Cúil Dúin & Parklands, Creche & Community Facility, Citywest**		
Document Title:	**Infrastructure Design Report**		
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	S4 Suitable for Stage Approval		

Rev.	Date	Description	Prepared	Reviewed	Approved
P01	07/10/22	First Issue	Kabelo Mokoka	Kevin Sturgeon	Dan Reilly
P02	14/10/222	Planning Approval	Kabelo Mokoka	Kevin Sturgeon	Dan Reilly

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1 INTRODUCTION

1.1 Background

DBFL Consulting Engineers were commissioned by the applicant to provide engineering design services in support of a proposed Cúil Dúin & Parklands Creche and Community facility at 1 Cúil Dúin Ave Fortunestown, Citywest, Dublin 24.

It is proposed to apply for planning permission to amend the scheme previously permitted under Reg. Ref. SD14A/0121 (ABP-300555-18, ABP-300563-19) which included a creche building and associated parking/services.

1.2 Development Proposals

The proposed development/amendments are summarised as follows:

- Extension of the building southwards increases the building imprint and capacity; to house the new Cúil Dúin and Parklands crèche and the ground floor entrance to the proposed community facility, increasing the roof area collected from 469 sqm to *782sqm*.
- Additional floor space and sectioning of the building, to house the new community facility and creche, therefore increasing the gross floor area from 520sqm to 1725 sqm.
- Inclusion of additional land, to make provision for a play park area for the proposed creche, increasing the overall area of the site by 0.075Ha.
- A reduction of paving area in favour of additional bike storage and bin storage. The addition of both the bike and bin store increases the total roof area by 18.8 sqm.
- A reduction of the green area west of the building, in favour of an additional footpath to allow access to the creche entrance from the bike store and parking area.
- Provision of an additional pedestrian access/egress route to the west of the permitted creche development through the proposed creche play park area.
- An addition of 4 parallel parking spaces along Cúil Dúin avenue adjacent to the proposed building to facilitate a drop-off zone for the creche.
- Provision of shared path that transitions to a footpath and cycle path that runs adjacent to the proposed site, along Cúil Dúin avenue.

The proposed amendments result in an increase of the total gross floor area (GFA) of the building from 520 sqm to 2223 sqm(613sq for the creche and 1610 sqm for the community centre), an increase in permeable pavement area from 215 sqm to 383 sqm, an increase in total green/grass area from 342 sqm to 1119 sqm, an increase in roof area from 469 sqm to 782 sqm and a decrease in impermeable pavement area from 772 sqm to 227 sqm.

The amendments have resulted in an increase in the site extent. However, the location of the main entrance remains unchanged as per the previously permitted scheme.

1.3 Report Objectives

This report considers the impact of the proposed amendments to the subject site on the previously approved engineering details including the following;

- Preliminary flood risk assessment.
- Road Layout/Site access.
- Surface water strategy and servicing.
- Foul sewer strategy and servicing.
- Water supply and servicing.

1.4 Existing Site

The site is located at 1 Cúil Dúin Ave, Fortunestown, Citywest, Dublin 24. Cúil Dúin Avenue is directly to the south, Citywest & Saggart Community National school to the north-west and TLC Healthcare Centre to the east. The Corbally/ Vershoyles Stream runs through the site splitting the western creche play park from the proposed creche and community facility building, refer to Figure 1-1.

The site currently comprises disturbed ground / open space from previous development works. The topography of the site generally slopes from south to north and towards the watercourse from a level of approximately 112.0m OD to 110.2m OD.

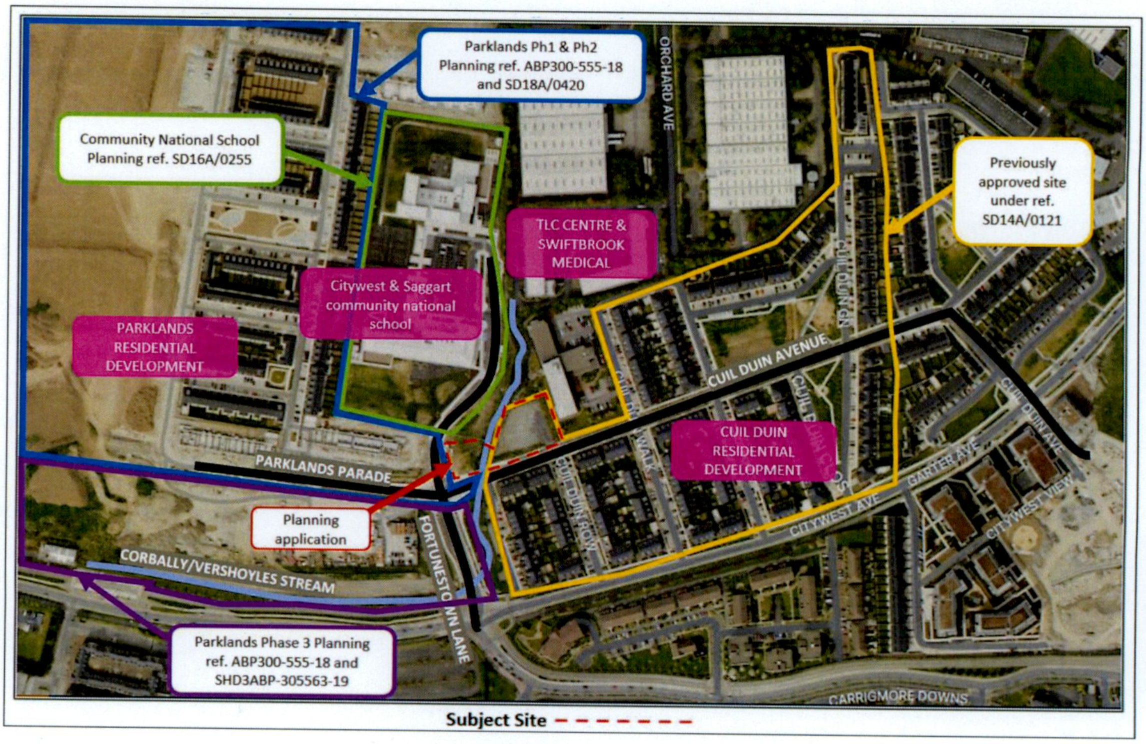

Figure 1-1: Site location (indicative red line) [Source Bing maps]

2 Flood Risk

2.1 Existing Flood Risk

The "Flood Risk Assessment" undertaken by JBA Consulting in 2019 for Parklands Phase 3 (refer to Appendix A :JBA "Strategic Housing Development at Fortunestown Lane Flood Risk Assessment" under separate cover (September 2019) is submitted again with this application as it covers the site, it details the flood risk mitigation measures adopted and summaries the existing and future flood risk to the site.

It determined that the subject site was originally located in flood zones A and B (Figure 2-1), indicating a high flood risk. The fluvial flood levels for 10%, 1% and 0.1% AEP events for the site were 111.46m, 111.53m and 111.64m respectively. The flood depths occurring onsite for both the 1% and 0.1% AEP events were shallow and generally less than 0.25m. As per the OPW Eastern Catchment Flooding Risk Assessment and Management (CFRAM) mapping, the main cause of flooding was from overland flows from the Corbally/ Vershoyles Stream south of the site, crossing the Luas line and passing along existing roads and open space in a northerly direction.

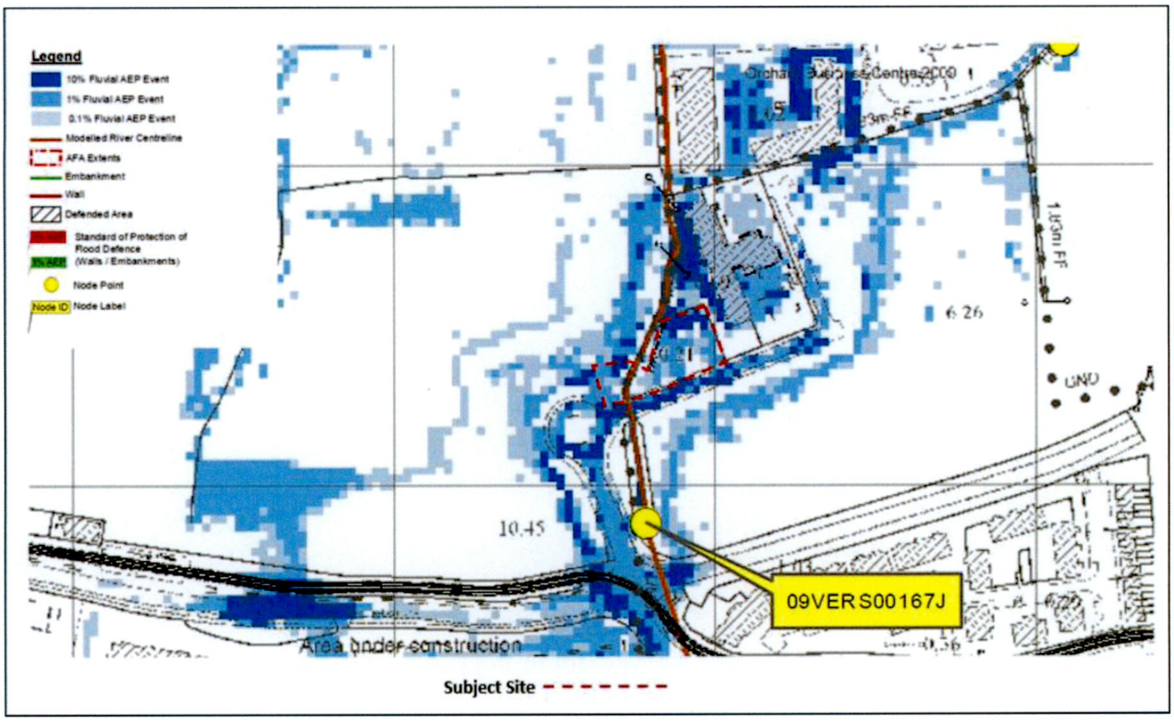

Figure 2-1: CFRAM Fluvial Flood Extents [Source OPW]

2.2 Proposed Mitigation

The proposed flood mitigation works as part of the Parklands development included modification to the existing link road to Fortunestown Lane to channel overland flow back into the Corbally/ Vershoyles Stream and the construction of a flood conveyance channel along the southern boundary of Parklands residential development to intercept existing overland flows and redirect them into the Corbally/ Vershoyles Stream via the western part of the site (through the open space play area) ensuring that 1% & 0.1% AEP flood events were conveyed in a controlled manner while protecting vulnerable development.

A hydraulic model was developed by JBA to test the effectiveness of the channel during both the 1% & 0.1% AEP flood events. The results are depicted in Figure 2-2, which confirms the 1% and 0.1% AEP flood events are conveyed through the channel and back to the Corbally/ Vershoyles Stream. It is clear that the subject site, specifically the creche and community facility building, will not be affected by the predicted peak flood flow levels for 100 years and 1000 years i.e. it is in Flood Zone C. Also that the proposed open space play area is water compatible and suitable within Flood Zone A/B.

Figure 2-2:Post development 1% AEP and 0.1% AEP MRFS Peak Flood levels (indicative Subject site red line) [Source CityWest Flood Risk Assessment by JBA consulting 2019]

The peak flood level for the 1% AEP event at the subject site was determined to be 111.57m OD. The proposed creche and community facility building floor level is 112.4m OD. This represents a freeboard of 0.83 m above the 1% AEP flood level, which is in excess of the 0.5m minimum freeboard to protect against flooding recommended by Greater Dublin Strategic Drainage Strategy (GDSDS) and Office of Public Works (OPW).

2.3 Overland Flow paths

Overland flows from the Corbally/ Vershoyles Stream are indicated from the hydraulic modelling as following Fortunestown Lane, across Parklands Parade and Cúil Dúin Avenue, and into the open space play area within the western part of the subject site. A proposed fence/railing along the boundary to the open space play area has been selected to facilitate overland flood flows to pass freely back into channel without blockage. The open space is designed so as not to alter ground levels to facilitate the free flow through the open space of any overland flows. The proposed amendments to the site as such will not affect the previously approved planning permission.

2.4 Flood Risk & Planning Guidelines

The Planning System and Flood Risk Management Guidelines for Planning Authorities", November 2009 classifies the proposed creche and community building as commercial development which is "Less vulnerable development" (Table 3.1 of the Guidelines). Table 3.2 of the Guidelines indicates that it is appropriate in Flood zone C i.e. outside the 100 year flood extents. (The sequential approach mechanism for planning has been met, refer to Figure 2-3 below.)

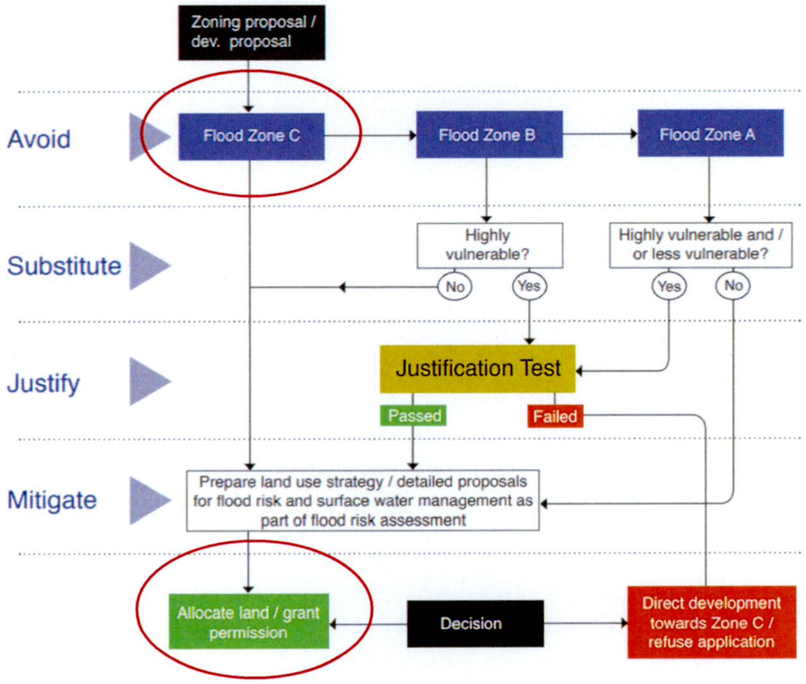

Figure 2-3: Sequential Approach mechanism in the Planning Process

It is concluded that the;

- The Corbally/ Vershoyles Stream passes through the site.
- The Site and immediate area was studied by JBA in detail as part of the adjacent Parklands development in the context of existing and proposed flood risk and in the context of now constructed flood mitigation works and climate change allowance.
- The current site is within Flood Zones A, B and C.
- The proposed development comprises highly vulnerable/ less vulnerable and water compatible development types.
- All proposed development types are suitable for the existing flood risk zones on the site.
- Flood Zones A and B associated with the Corbally/ Vershoyles Stream are contained within proposed open space i.e. water compatible area and existing overland flood flows are not impacted by the development proposals.
- The freeboard to the proposed buildings is 0.83m above the 1% AEP event and exceeds the minimum recommended freeboard detailed in the GDSDS.
- The Planning System and Flood Risk Management Guidelines Sequential Approach is met and the 'Avoid' principal achieved.

3 Roads and Access

3.1 Overall Road and Access Layout

The subject site will be accessed via Cúil Dúin Avenue to the south, which was built as part of the adjacent Parklands Development (Planning Ref. SD14A/0121). Refer to DBFL drawing 132071-DBFL-CS-SP-DR-C-1000 for location of vehicular access and pedestrian connection points. The main entrance to the creche building will be on the south-western corner of the building while the community centre will have a separate pedestrian entrance on the south-eastern corner of the building.

To provide for 4 new set down spaces to serve the creche it is proposed to modify the existing footpath and cycle path along Cúil Dúin Avenue, A new segregated cycle lane (1.5m wide) and footpath (1.8m wide) is proposed which will improve pedestrian / cyclist and set down facilities along this section. The new off-road cycle path will transition to the on-road cycle lane to the east of the new vehicular entrance.

3.2 Sightlines & Speed Limit

It is proposed to introduce a new speed limit of 30km/hr along Cúil Dúin Avenue which is more in keeping with the residential nature of the development, the proposed new creche and proximity to schools.

Sightlines for the new vehicular entrance are 2.4m x 24m as per the Design Manual for Urban Roads and Streets (DMURS) for a 30kmph speed limit.

3.3 Internal Layout

The proposed internal parking area is designed as a shared surface with a 6m wide aisle to allow access to perpendicular vehicular parking spaces. It is designed to have a minor turning head for small vehicles/cars, refer to DBFL drawing 132071-DBFL-CS-SP-DR-C-1001. The road layout is designed in accordance with the recommendations of the Design Manual for Urban Roads and Streets (DMURS) and the entrance detail is as per the NTA cycle Manual for an entrance.

3.4 Pavement Design Standards

Proposed footpaths and cycle paths on Cúil Dúin Avenue are designed in accordance with the Department of the Environment Recommendations for Site Development Works, the Design Manual for Urban Roads and Streets (DMURS), NTA Cycle Manual and Local Authority requirements for taking in charge.

The private internal shared surface / parking area is designed as a permeable pavement which is a change to the previously approved planning application.

3.5 Vehicle Tracking

The proposed layout has been tracked to ensure all carpark spaces are compliant for vehicle turning for a standard car, refer DBFL drawing 132071-DBFL-CS-SP-DR-C-1001.

3.6 Parking Management

A total of 11 car parking spaces plus 4 set down spaces (including1 disabled parking space, 2 electric vehicle charging spaces) are proposed which is a decrease of 6 from the previously approved application. The parking bay sizes are 5m x 2.5m.

A total of 58 cycle spaces are provided around the site including 48 short term Sheffield stands and 10 long term secure spaces.

3.7 Traffic & Transportation

A separate Transport Statement (TS) report prepared by DBFL Consulting Engineers is included in the overall planning application pack which includes all relevant Transport data relating to the project, including background information on:

- Current Access to the Local Area
- Pedestrian and Cycling facilities along roads leading to the subject site
- Public Transport Provision in Citywest and near the site
- Proposed Roads, Cycling and Public Transport Infrastructure

The TS also outlines relevant policy documents which guide the design of the traffic and transportation network of the proposed development. There has been a progression from encouraging car-based infrastructure to active travel measures in the years after the previously approved planning application. This has seen stricter guidelines on car parking requirements, carriageway widths, and speed limits. There are also new minimum standards to ensure priority, and a friendlier environment, is given to pedestrians and cyclists alike. These new changes are reflected in the new proposed site design, with less car parking provision and higher cycle parking provision in the new planning application.

4 Surface Water Management

4.1 General

The previously approved surface water drainage for the creche site (planning reference SD14A/012), consisted mainly of traditional pipework and manholes collecting run-off from impermeable road surfaces and roofs and directing it to the main Cúil Dúin drainage network where is was attenuated and discharged to an existing stream / drainage ditch at the northern boundary. Attenuated runoff was then stored within the main open space area and consisted of a part underground / part overground storage system.

As per the previously granted development, runoff from the creche site will not be discharged into the adjacent Corbally/ Vershoyles Stream, but instead it will be connected to the main Cúil Dúin drainage system via a spur located at the entrance. Although the total area of development is increased, it is proposed by incorporating the following SUDS measures that stormwater run-off will not exceed previously permitted drainage design flows;

- Green roof and part flat roof / terrace draining to underground drainage pipe network;
- Permeable paving for the private car-parking / shared surface also collecting run-off from adjacent bike parking and storage areas.
- Open space area and riverside / riparian strips are not drained.

The various catchment areas on the site can be seen below in Figure 4-1.

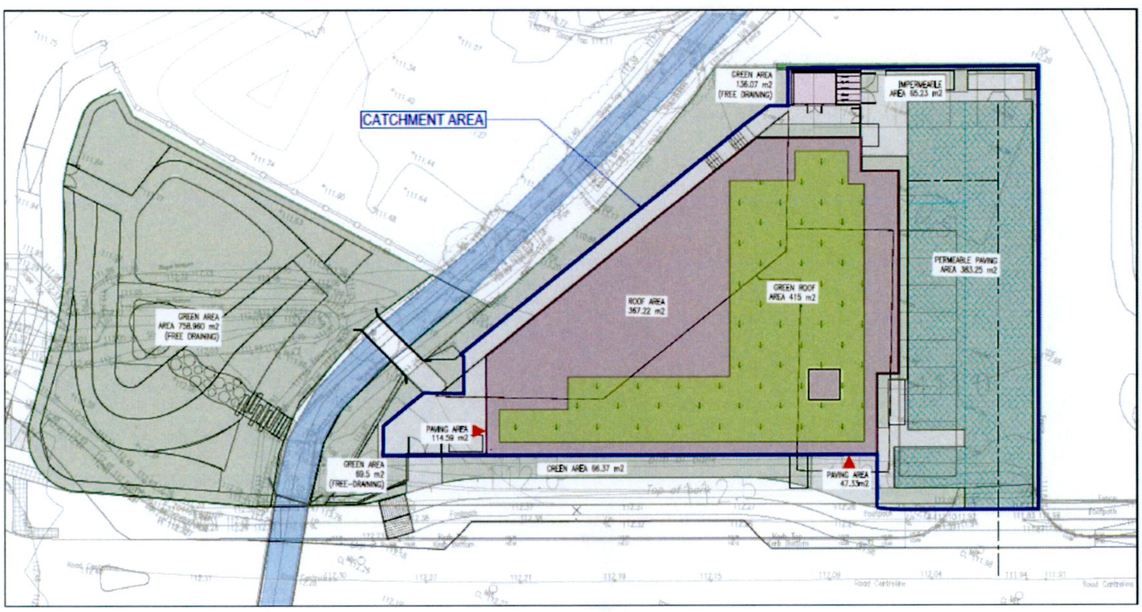

Figure 4-1: The proposed development catchment area

4.2 Surface Water Drainage Areas

The new drainage strategy and SUDS features will result in the total drained run-off area reducing to 0.119ha when compared to the previously permitted drainage design (0.147ha), refer to Appendix B :Stormwater calculations. The amendments have resulted in a reduction in effective run off coefficient from 0.82 to 0.81, that coupled with a reduction in impermeable area has from 0.146 to 0.115 ha positively affects the runoff generated by the site. This resulted in the interception volume reducing from 5.8m^3 to 4.6m^3 . See table below for a summary.

	PROPOSED	PREVIOUSLY PERMITTED	Runoff Coeff.
Roofs - Type 1 (Draining to gullies) (m²)	550.2	469	1
Roofs - Type 2 (Draining to SUDS features) (m²)	0	0	0.7
Green Roofs (m²)	232	0	0.85
Roads and Footpaths - Type 1 (Draining to gullies) (m²)	0	305	0.95
Roads and Footpaths - Type 2 (Draining to Suds features) (m²)	0	0	0.7
Paved Areas (m²)	214	467	0.95
Permeable Paving (m²)	383	215	0.5
Bioretention Areas (m²)	0	0	0.7
Grassed Areas (m²)	91	342	0.47
Public Open Space (non-contributary) (m²)	1036	0	0.47
Total Effective catchment area (ha)	0.119	0.147	
Effective catchment runoff coeff.	0.81	0.82	
Total Impermeable area (ha)	0.115	0.146	
Interception Volume required (m³)	4.6	5.8	

Table 4-1: Summary of Runoff areas and Interception [Proposed vs previously permitted]

(The open space play area is considered as free draining and does not contribute to the effective catchment area of the subject site.)

4.3 Surface Water Drainage Design Standards

The mean annual catchment runoff from the site (Q_{bar}) was calculated using the Institute of Hydrology equation, refer to Appendix B for details. It is unchanged from the previous approved planning application Reg. Ref. SD14A/0121.

Storm water drainage for the proposed development is designed using the recommendations of the GDSDS, EN752 and BS8301:1985, with the following parameters applied:

- Return period for pipe network 2 years,
    - check 30-year 15 minute, no flooding;
    - check 100-year flooding in designated areas;

- Time of entry — 4 minutes
- Pipe Friction (Ks) (concrete) — 0.6 mm
- Minimum Velocity — 1.0 m/s
- Standard Average Annual Rainfall — 824mm
- M5-60 — 18.5mm
- Ratio r (M5-60/M5-2D) — 0.263
- Storage System Storm Return Event GDSDS Volume 2, p61, Criterion 3
  - 10-year no flooding on site
  - 30-year no flooding on site
  - 100-year check no internal property flooding. Flood routing plan. FFL + 500mm freeboard above 100-year flood level. No flooding to adjacent areas.
- Climate Change — 20%
- C_v winter — 0.84
- C_v summer — 0.75

(Note on C_v Factors; value of 0.84 for Winter and 0.75 for Summer is standard practice and is appropriate for this site.)

The Network Module of Microdrainage has been used to assess the performance of the proposed surface water network. This analysis indicated that the pipe sizes and grades are adequate for storm events up to the 1% AEP refer to Appendix C : Stormwater Network analysis and applicable Met Eireann Rainfall data.

It should be noted that the FFL of the proposed building is at 112.4m OD and the top of water level of the attenuation tanks constructed under the previously permitted scheme is 109.0m OD.

4.4 Interception Volume

To prevent pollutants or sediments from discharging into water courses the GDSDS requires "interception storage" to be incorporated into the development. The minimum volume of interception required for the application is 4.6m^3 based on 5mm of rainfall depth from 80% of the runoff from impermeable areas, refer to Appendix B :Interception volume calculations.

This volume is accommodated in the drainage board of the green roof, (see Appendix D :Bauder product data sheet) and within the permeable pavement voids (see Appendix C :Appendix B :Permeable paving model analysis results).

- Green Roofs: Area of Green Roof: 232 sqm:
    - Filter layer depth = 10 litres per sqm
    - Interception volume = $23.2m^3$

- Permeable paving: Area of paving : 383 sqm
    - Subbase depth = 0.5m, Void Ratio = 30%
    - Infiltration Rate 0 m/hr
    - Interception volume = $19.2m^3$

Total interception volume provided is $42.9m^3$.

4.5 SUDs

In accordance with the GDSDS it is proposed to use Sustainable Urban Drainage systems (SUDS) for managing storm-water for the proposed development. As an improvement to the previously approved development it is proposed to provide at least 30% of roofs as green roofs and permeable paving, refer to Figure 4-2. For a comparison of the proposed and the previously permitted suds features. The aim of the SUDS strategy for the site will be to;

- Reduce storm-water runoff.
- Reduce pollution impact.
- Replicate the natural characteristics of rainfall runoff for the site.

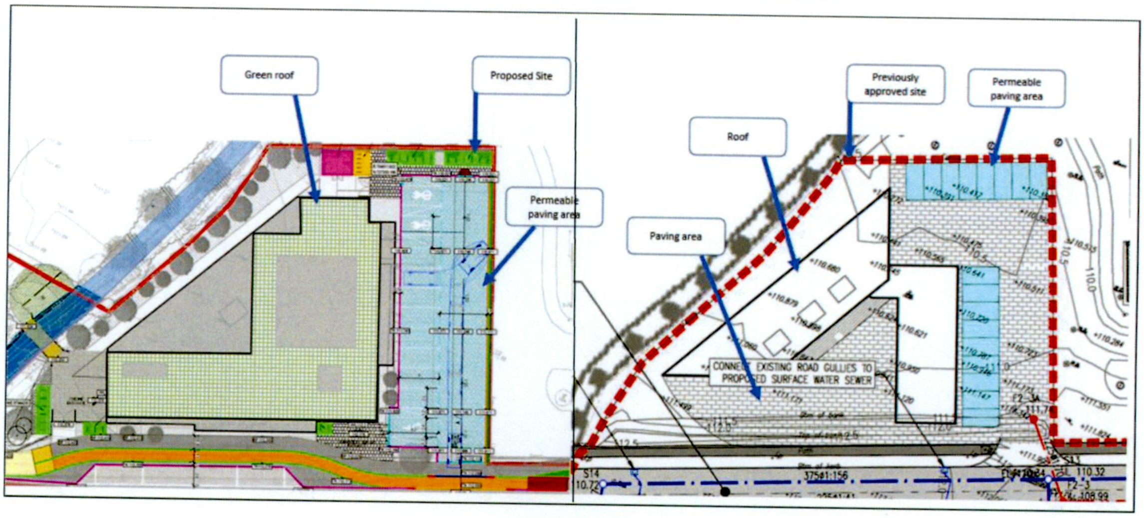

Figure 4-2: Proposed and Permitted roof area and pavement finishes

The proposed surface water drainage and SUDs layout is detailed on DBFL drawing 132071-DBFL-CS-SP-DR-C-1001.

5 Foul Sewerage

5.1 Existing Foul Sewer Network

The foul sewerage strategy for the previously permitted planning application Ref. SD14A/0121 discharged the 224 residential units and creche through an existing 225mm diameter foul sewer to the north of the subject site which in turn discharges to the Saggart / Rathcoole and Newcastle drainage system (constructed under planning reference SD06A/0993).

Two existing 225mm foul sewers pass through the subject site from south to north, refer to DBFL drawing 132071-DBFL-CS-SP-DR-C-1001. The eastern sewer is at a depth of approximately 5.5m below ground level and the building has been positioned to provide the required Irish Water minimum separation distance of 7.5m (total 15m wide).

5.2 Proposed Foul Drains and Sewers

It is proposed that the new creche and community centre will drain by gravity via initial private building drainage and connect to the Irish Water 225mm diameter foul sewer within the site via a backdrop manhole detail, refer to DBFL drawing 132071-DBFL-CS-SP-DR-C-1001.

Private foul drains for the development are designed in accordance with the Building Regulations. The foul connection to the Irish water sewer is designed in accordance with the Irish Water code of practice and standard details.

5.3 Foul Loading

The proposed amendments will result in an equivalent increase in total average daily foul flow loading from 0.08l/s to 0.12l/s, or approximately 50%. Total predicted Development Peak foul flows are estimated to increase from 0.37l/s to 0.52l/s, refer to table below Table 5-1.

The increased foul loading generated by the subject site, will increase the total Cúil Dúin development foul loading from 10.5l/s to 10.65l/s. This additional loading/flow is easily accommodated by the existing 225mm diameter foul sewer (capacity 32.3l/s) and the 450mm diameter Irish Water foul sewer (capacity 121l/s) into which the wider Cúil Dúin development discharges.

NON-RESIDENTIAL - PREDICTED DEVELOPMENT FOUL FLOWS							Previous Daily loading l/s
Unit Type	Floor Area m²	Occupancy Load m² /person	Occupancy	Loading l/Person/day	Daily Loading l/day	Daily Loading l/s	
Creche	613	4	153	50	7,663	0.09	**0.08**
Community Facility	1,610	55	29	50	1,464	0.02	**0.0**
					Non - Residential Daily Loading	**0.11**	**0.08**
					Growth Factor	1	**1**
					Infiltration @ 10% (as CoP App B 2.2.4)	0.01	**0.01**
					Dry Weather Flow l/s	**0.12**	**0.08**
					Commercial Peak Factor (as CoP App B 2.2.7)	4.5	**4.5**
					Design Foul Flow l/s	**0.52**	**0.37**
					TOTAL PREDICTED DEVELOPMENT AVERAGE FOUL FLOWS l/s	**0.12**	**0.08**
					TOTAL PREDICTED DEVELOPMENT PEAK FOUL FLOWS l/s	**0.52**	**0.37**
					24 Hour Emergency Storage Requirement (if required) = DWF x 24 x 60 x 60 m³	n/a	n/a
					***Flow rates calculated using IW CoP for Wastewater Infrastructure Appendix D**		

Table 5-1: Estimated foul loading comparison (Proposed v Permitted)

6 Water Supply

6.1 Existing Water Network

There is an existing Irish Water 160mm diameter PE watermain on Cúil Dúin Avenue opposite the proposed site, constructed under Reg. Ref. SD14A/0121.

6.2 Proposed Water Connection

It is proposed to connect the development to the existing Irish Water 160mm diameter PE watermain on Cúil Dúin Avenue via standard service connections as per Irish Water standard detail STD-W-01 with boundary boxes provided at the rear of the new public footpath, refer to DBFL drawing 132071-DBFL-CS-SP-DR-C-1001.

6.3 Water Demand

The development proposals will result in a minor increase in water demand compared to the previously approved scheme (Reg Ref: SD14A/0121). The daily average demand has increased from 0.08l/s to 0.11l/s, the average day peak week water demand is estimated to increase from 0.09l/s to 0.13 l/s and peak hour water demand increased from 0.47l/s to 0.66l/s as seen in Table 6-1 The total estimated daily water demand volume for the proposed development is approximately 9.5m^3/day from the previously estimated 6.91m^3/day.

NON-RESIDENTIAL WATER DEMAND							Previous Daily Demand l/s
Unit Type	Floor Area m^2	Occupancy Rate m^2/person	Occupancy	Per Capita Consumption l/Person/day	Average Daily Demand l/day	Average Daily Demand l/s	
Creche	613	4	153	50	7,663	0.09	0.08
Community Facility	1,610	55	29	50	1,464	0.02	0.00
Total Average Daily DEMAND l/s						**0.11**	**0.08**
Average Day/Week Demand						1.25	1.25
Average Day/Peak Week Demand l/s						**0.13**	**0.09**
Peak Demand Factor						5	5
Peak Hour Water Demand l/s						**0.66**	**0.47**
*Flow rates calculated using IW CoP for Water Infrastructure							

TOTAL AVERAGE DAILY DEMAND l/s	**0.11**	**0.08**
AVERAGE DAY/PEAK WEEK DEMAND l/s	**0.13**	**0.09**
PEAK HOUR WATER DEMAND	**0.66**	**0.47**
*Flow rates calculated using IW CoP for Wastewater Infrastructure Appendix D		

Table 6-1:Estimated water demand comparison (Proposed v Permitted)

The creche and community centre will utilize water-saving fittings to reduce water consumption.

6.4 Fire Fighting

It is envisaged that the existing watermain network and fire hydrants on Cúil Dúin Avenue will be utilised for fire-fighting purposes.

7 CONCLUSIONS

- Flooding onsite results from the ingress of overland flows along the southern boundary of the site. Flows are shallow during both flood events with depths predominantly less than 250mm. The proposed channel has sufficient capacity to channel both the 1% and 0.1% AEP flood events around the site and back to the Corbally/ Vershoyles stream. The subject site, specifically the creche and community facility building, will not be affected by the predicted peak flood flow levels for 100 years and 1000 years i.e. it is in Flood Zone C. The peak flood level for the 1% AEP event at the subject site was determined to be 111.57m OD which is 0.83m below the 112.4m proposed finish floor level. It is concluded that the proposed amendments to this site will not affect the previously approved planning permission.
- There has been a progression from encouraging car-based infrastructure to active travel measures in the years after the previously approved planning application. These new changes are reflected in the new proposed site design, with less car parking provision and higher cycle parking provision in the new planning application.
- The effective catchment area, effective catchment runoff coefficient and impermeable area of the subject site have decreased as a result of the revisions, from 0.147ha to 0.119ha, 0.82 to 0.81 and ,0.146 to 0.115ha respectively. This result in a reduction of run off generated by the site. The proposed surface water network analysis indicated that the pipe sizes and grades are adequate for storm events up to the 1% AE. Both the interception and treatment volumes requirements for the site are comfortably met by the proposed network. Furthermore, runoff will not be released into the stream, which will continue to be an open feature, and will instead be channelled through a spur at the site's entry into the larger drainage system as per the previously issued permit,.
- The total 6 x Dry weather Foul Loading generated by the Cúil Dúin development will increase from 10.5 l/s to 10.64l/s, which is easily accommodated by the developments discharge point at the existing 450mm diameter , which was determined to have a capacity of 121 l/s. The subject site discharges to an on-site pipe of 225mm diameter with a gradient of 1 in 232. The pipe has a capacity of 32.3l/S, which is sufficient to accommodate the proposed design foul flow of 0.51l/s generated by the site.

- The estimated water demand for the proposed development is approximately 8.64m3/day from the previously estimated 6.91m3/day. The creche and community centre will utilize water-saving fittings to reduce water consumption. It is envisaged that the existing watermain network and fire hydrants on Cúil Dúin Avenue will be utilised for fire-fighting purposes.

The proposed changes to the previously permitted scheme mainly involve the inclusion of additional land (creche play park), changes to the building imprint and improvements to the transportation infrastructure. These amendments do not affect engineering services or infrastructure to the already permitted development.

Appendix A : JBA FLOOD RISK

JBA consulting

Strategic Housing Development at Fortunestown Lane, Saggart Co. Dublin - Flood Risk Assessment

2019s0507

Final Report

September 2019

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Revision History

Revision Ref/Date	Amendments	Issued to
V1.0 27/06/2019	Draft Report	Dermot Grogan (DBFL)
V2.0 05/07/2019	Draft Report, adjustments made following client feedback	Dermot Grogan (DBFL)
V3.0 16/07/2019	Final Report	Dermot Grogan (DBFL)
V4.0 19/09/2019	Amended Final Report	Dermot Grogan (DBFL)

Contract

This report describes work commissioned by Dermot Grogan, on behalf of DBFL Consulting Engineers. Hannah Moore and Tim Cooke of JBA Consulting carried out this work.

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Reviewed by .... Tim Cooke BE BSc MIEAUST

Senior Engineer

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
DTM	Digital Terrain Model
EPA	Environmental Protection Agency
GSI	Geological Survey of Ireland
HEP	Hydrological Estimation Point
LiDAR	Light Detection And Ranging
mOD	Meters above Ordnance Datum
MRFS	Medium Range Future Scenario
OD	Ordnance Datum
OPW	Office of Public Works
PFRA	Preliminary Flood Risk Assessment
SDCC	South Dublin County Council

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 Greenacre Residential DAC to prepare a Flood Risk Assessment (FRA) for a proposed development site in City West, Dublin.

1.2 Flood Risk Assessment Aims and Objectives

This study is being completed to inform the future development of this 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 the land, property and people and the measures that would be recommended to manage the risk.

The primary objective is to work with the design team to progress a site design that can manage the impacts of flooding to the site without negatively impacting areas off the site. Additional objectives are to:

- Identify potential sources of flood risk,
- Confirm the level of flood risk and identify key hydraulic features,
- Assess the impact the proposed development has on flood risk,
- Develop appropriate flood risk mitigation and management measures.

Recommendations for development have been provided in the context of the OPW / DoEHLG 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 the greenfield site which is zoned for residential development. It is proposed to build five residential apartment blocks (A, B,C,D and E)and surrounding landscaped areas adjacent to the existing Saggart Luas stop (Figure 1-1). There is a basement carpark proposed under Block 'A' at the western end of the site and a second larger basement proposed under blocks 'C', 'D', and 'E.' The proposal is part of phase two of a wider residential development. Phase one of the development has previously been granted planning permission in March 2018 via the SHD planning process, under planning reference ABP 300555-18 (refer to Figure 1-2).

The approved scheme included a flood conveyance channel through the phase 2 development site (subject site) and surface water attenuation and storage measures (in the district park within Phase 1) addressing the phase 1 development and future development of phase 2 lands. The proposed development includes modifications to the flood conveyance channel previously approved. The proposed amendments will refine the channel design in keeping with the proposed development and specifically in keeping with the landscape proposals. This FRA includes hydraulic modelling of the refined flood conveyance channel.

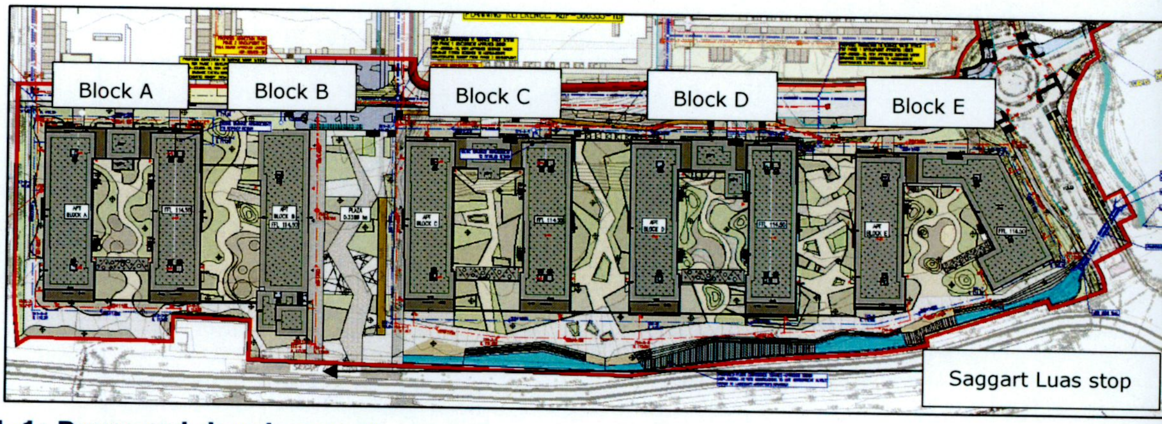


Figure 1-1: Proposed development

Figure 1-2: Proposed development site in relation to the approved Phase 1 development

2 Site Background

This section describes the proposed development site in City West, including the local watercourses and the wider geographical area.

2.1 Site Description

The site is located within City West, Co Dublin, as shown in Figure 2-1. The site is currently a greenfield site and is approximately 3.3ha. The site is to be bounded by residential dwellings from the phase 1 development that are currently under construction to the north and by the Luas Red line and Saggart Luas stop to the south. The site generally slopes in a south to north direction between approximately 116 and 114 mOD.

There are two tributaries of the Camac River which flow near to the east and west (culverted) boundaries of the site, as provided by the EPA database. The most significant tributary of the Camac River is along the east boundary referred to as Vershoyles Stream within the Eastern CFRAM. There is known historical flooding across the site resulting from over bank flows within the former golf course to the south and overland flow at the roundabout adjacent to the south east corner of the site. The flows coming from the former golf course are sufficient enough to cross over Fortunestown road and the Luas line situated across the southern boundary of the site.

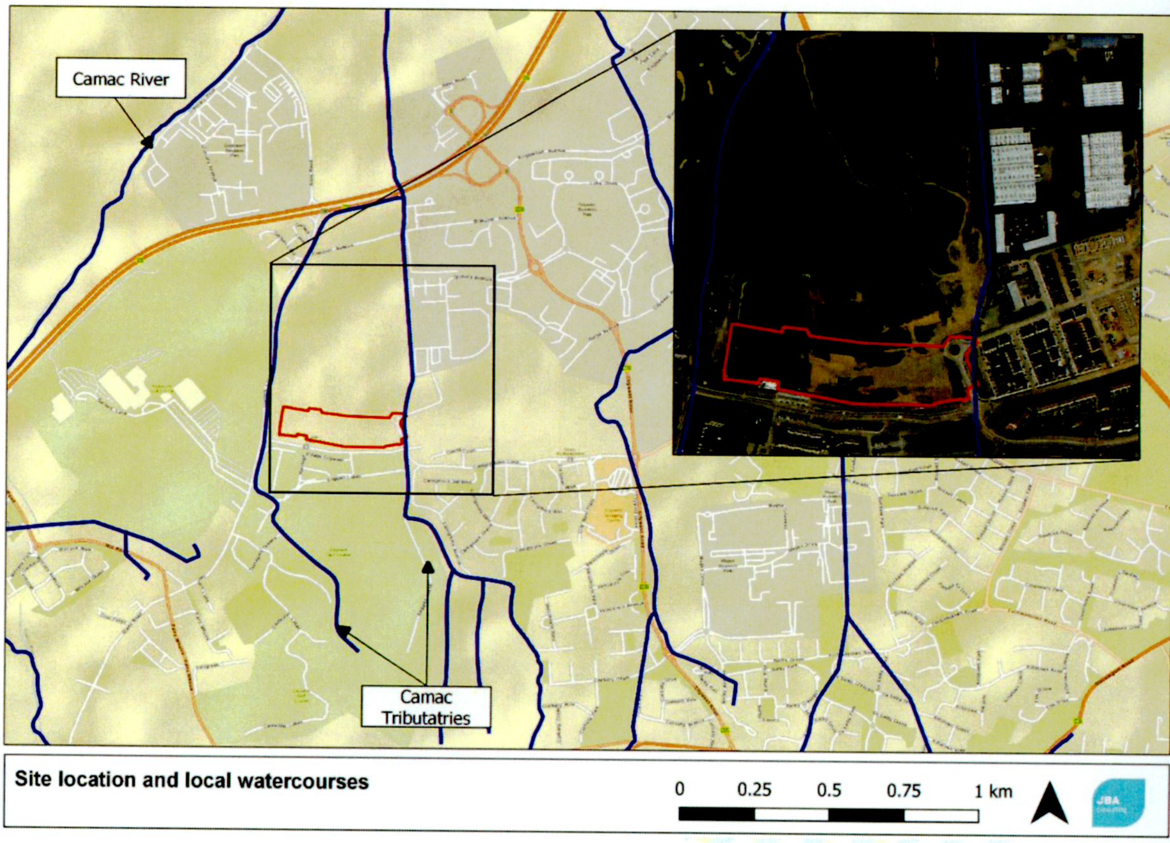


Figure 2-1: Site location and watercourses

2.2 Site Geology

The Geological Survey of Ireland (GSI) groundwater and geological maps of the site were reviewed. The subsoil within the site is made up of till derived chiefly from limestone, refer to Figure 2-2. The surrounding areas to the east and west of the site are made up of made ground with till derived from Palaeozoic rock to the south.

The underlying bedrock is classified as Dinaritian Upper Impure Limestones. There are no karst features located within the site of the immediate surrounding area. The associated groundwater vulnerability which indicated the risk of the underlying waterbody for the site is classified as low at this location.

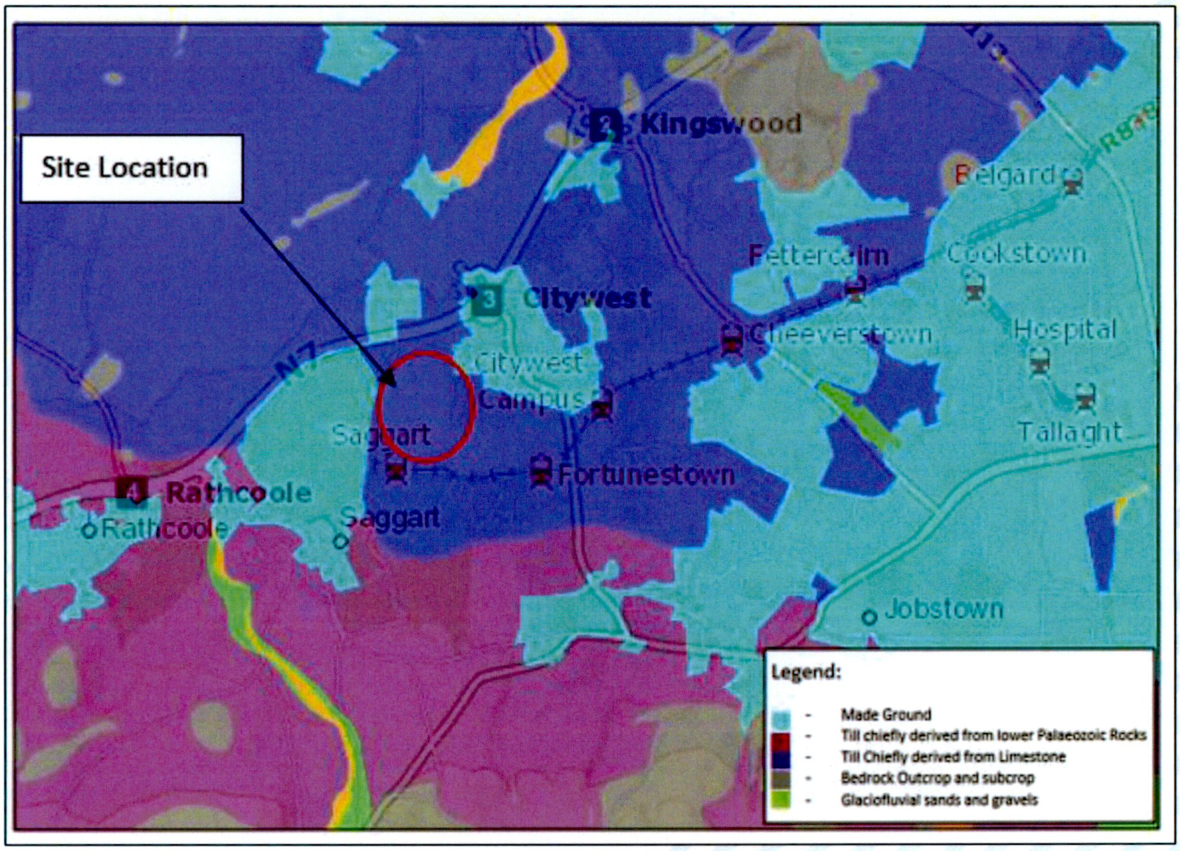


Figure 2-2: Subsoils (GSI)

3 Flood Risk Assessment

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 flood information. The findings from the flood risk identification stage of the assessment are provided in the following sections. Further detail on the Planning Guidelines and technical concepts 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. 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 instances of historic flooding directly on the site however there have been several recorded flooding events across the south boundary of the site at Fortunestown Road.

- 24th October 2011 - Heavy rainfall resulted in major flooding along the Camac watercourse and its tributaries. The run-off from the golf course spilled onto City West Carpark and Carrigmore Glen. The water pressure between the car park and Fortunestown Lane caused the wall to collapse and water and flooding also occurred further downstream at a new development.
- 5th-6th November 2000 - Heavy rainfalls caused flooding of the Carmac river effecting Fortunestown Lane.
- There is re-occurring flooding identified north of the site in Baldonnel, Barney's Lane. This does not appear to have an effect on the proposed site.

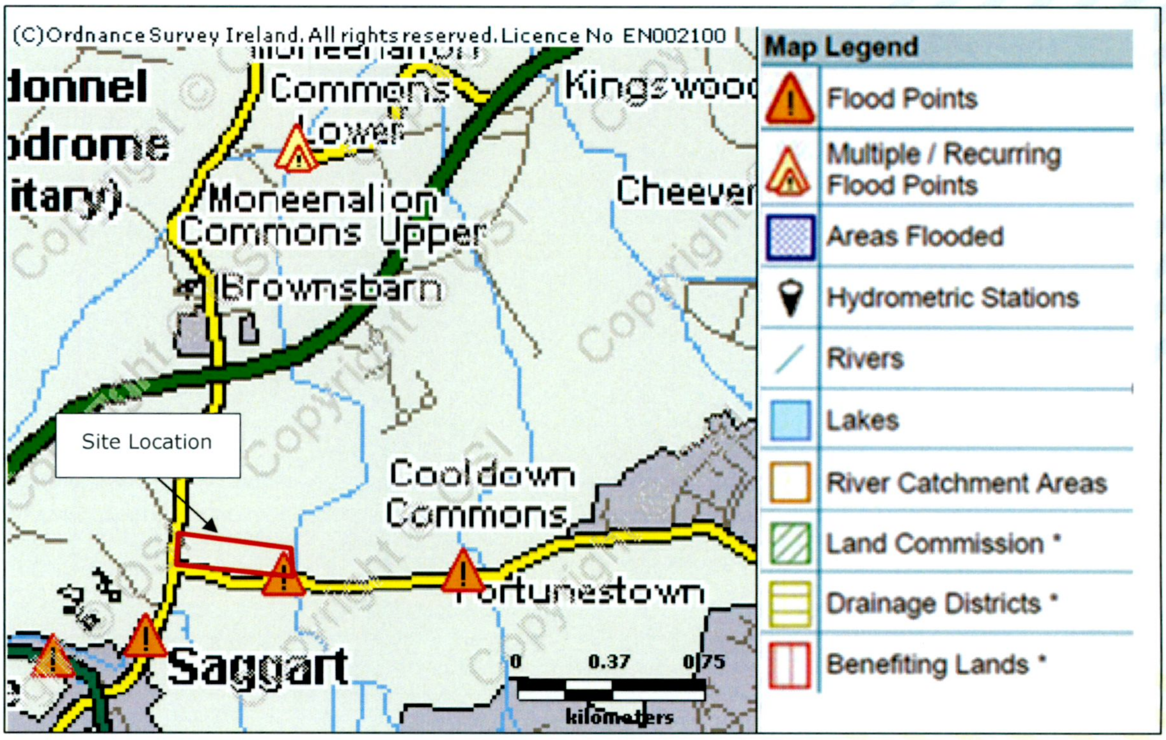


Figure 3-1: Floodmaps.ie

3.1.2 Internet searches

An internet search was conducted to gather information about whether or not the site was affected by flooding previously. There were no search results found for historic flooding at this site other than those mentioned above.

3.2 Predictive Flooding

City West has been subject to predicative flood mapping and modelling.

- OPW Preliminary Flood Risk Assessment (PFRA),
- Eastern Catchment Flood Risk Assessment and Management Study (CFRAM)

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

3.2.1 OPW Preliminary Flood Risk Assessment (PRFA)

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 OPW PFRA study has largely been superseded by the CFRAM programme for fluvial and tidal sources, however, it remains valuable information particularly regarding pluvial and groundwater flood mapping. The PFRA fluvial flood extents for the site are superseded by the CFRAM fluvial flood mapping programme. See Figure 3-2 for OPW PFRA flood extents at the site and surrounding area.

The PFRA does not identify any pluvial flooding across the site. Pluvial flooding is known to occur on the low-lying areas of the former golf course to the south of the development site.

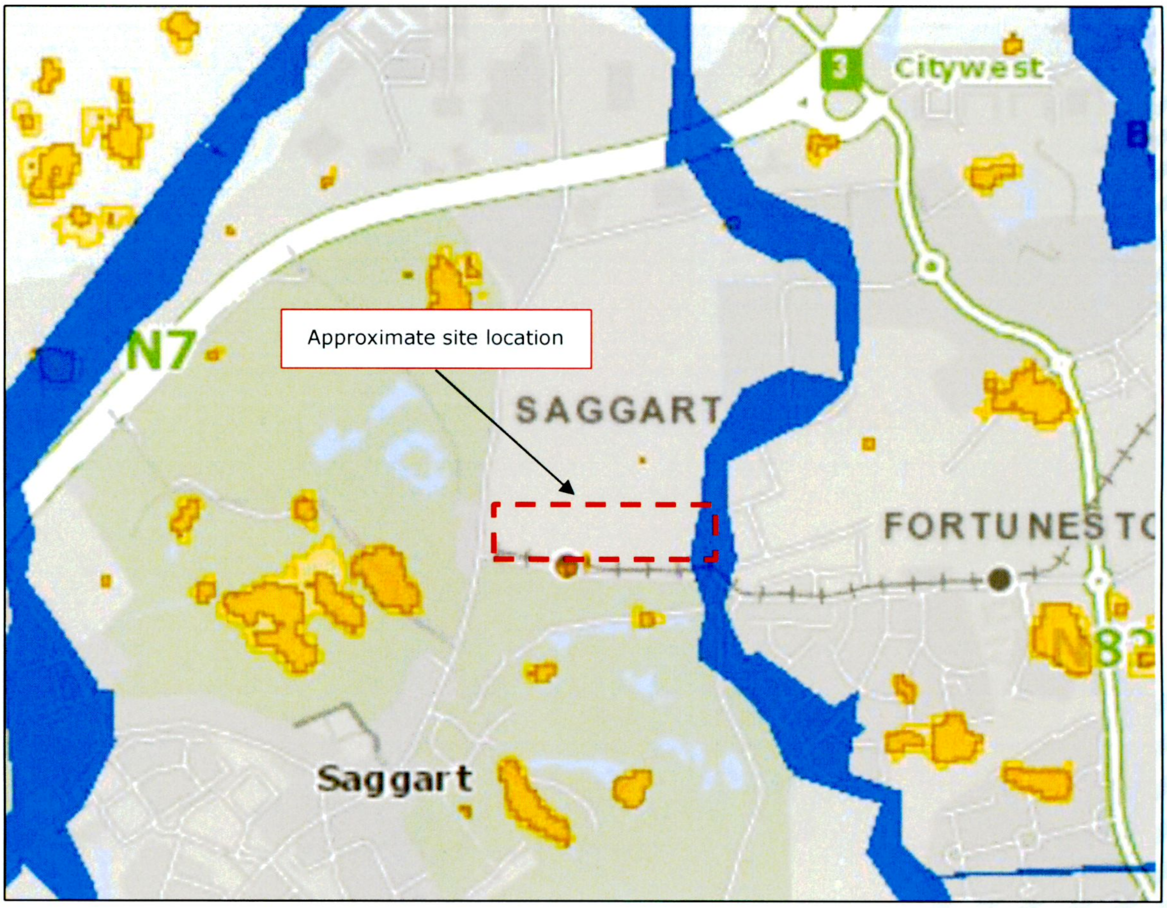


Figure 3-2: PFRA Flood Maps (myplan.ie)

3.2.2 Catchment Flood Risk Assessment and Management Study (ECFRAM)

The Eastern CFRAM study is the most comprehensive flood mapping undertaken in the Dublin region. It commenced in June 2011 with final flood maps issued during 2016. The study involved detailed hydraulic modelling of rivers and their tributaries.

The Eastern CFRAM highlighted the Camac catchment as an Area of Further Assessment (AFA) and a high priority watercourse due to historical flooding and the PFRA flood extents.

3.2.2.1 ECFRAM Hydrology Report

The Camac River is a tributary of the River Liffey and has a total catchment area of $58km^2$, with several small steep sub-catchments originating in the foothills of the Wicklow Mountains. The site location, adjacent to Vershoyles Stream, is located within one of these sub-catchments.

The specific model provided for the study area, identified as Model 2D, within the CFRAM Hydrology Report HA09 outlines the various methods used in calculating flow rates for Hydrologic Estimation Points (HEPs). Qmed for all HEPs with the Vershoyles Stream sub-catchment has been determined using IH124 methodology.

The CFRAM hydrology report details the calibration of flows to the Killeen Road Flow Gauge (09035) approximately 7km downstream from the site. As a result, all flows derived from the IH124 methodology on the upper reaches were adjusted downwards in line with the ratio of Qmed at the Killeen Road gauging station to the Qmed derived from the IH124 method at the gauging station location.

The hydraulic estimation points (HEPs), gauging station and subject site location of this FRA are shown in Figure 3-3.

This calibration process takes a catchment wide approach, incorporating a catchment size considerably larger than the site location. The adjustments made within the CFRAM approach may be valid at the total catchment scale but may not be appropriate for a single sub-catchment considered in isolation. Additionally, CFRAM Qmed flows for HEPs within Vershoyles Stream sub-catchment could not be validated through IH124 methodology for either the adjusted or unadjusted values.

To translate Qmed values to peak flows for standard return periods at HEP locations, the ECFRAMS hydrology method assessed 54 catchments under $10km^2$ in area and developed a median growth curve to be applied to all small catchments of this size. The pooling of similar catchments where appropriate, provides greater information to develop, and therefore better represent, estimation of growth curves. This is a significant improvement on the one national growth curve developed in the FSR over 40 years ago which only included a limited number of small catchments in its development. The adopted growth curve factors with ECFRAMs for catchments under $10km^2$ are provided in Table 3-1.

Table 3-1: ECFRAM Growth Factors for catchments <$10km^2$

Annual exceedance probability	50%	20%	10%	5%	4%	2%	1%	0.5%	0.2%	0.1%
Growth Factor	1.00	1.45	1.80	2.18	2.32	2.78	3.32	3.96	4.99	5.93

3.2.2.2 Hydraulic Report – Camac Catchment

A 1D-2D hydraulic model was developed incorporating flows determined at each HEP.

HEP flow comparison within the ECFRAM Camac Hydraulic Report notes a significant reduction in flow determined within the hydraulic model when compared directly to the HEP for the Vershoyles Stream Sub-catchment.

At HEP 09_586_3 (Vershoyles Stream catchment) the difference of -38% is due to significant flooding along this tributary with comparatively large areas of ponding. The downstream hydrograph at this check HEP is significantly wider than input hydrographs indicating attenuation of peak flows.

Table 3-2 presents the comparison for hydraulic model peak flows to HEP values for Vershoyles catchment (HEP point 09_586_3).

Table 3-2: Validation of CFRAM Model to HEP calculation point

AEP event	Model 10% AEP	HEP 10% AEP	Model 1% AEP	HEP 1% AEP	Percentage difference in 1% AEP values	Model 0.1% AEP	HEP 0.1% AEP
Flow (m^3/s)	1.43	2.59	2.97	4.79	-38	5.63	8.55

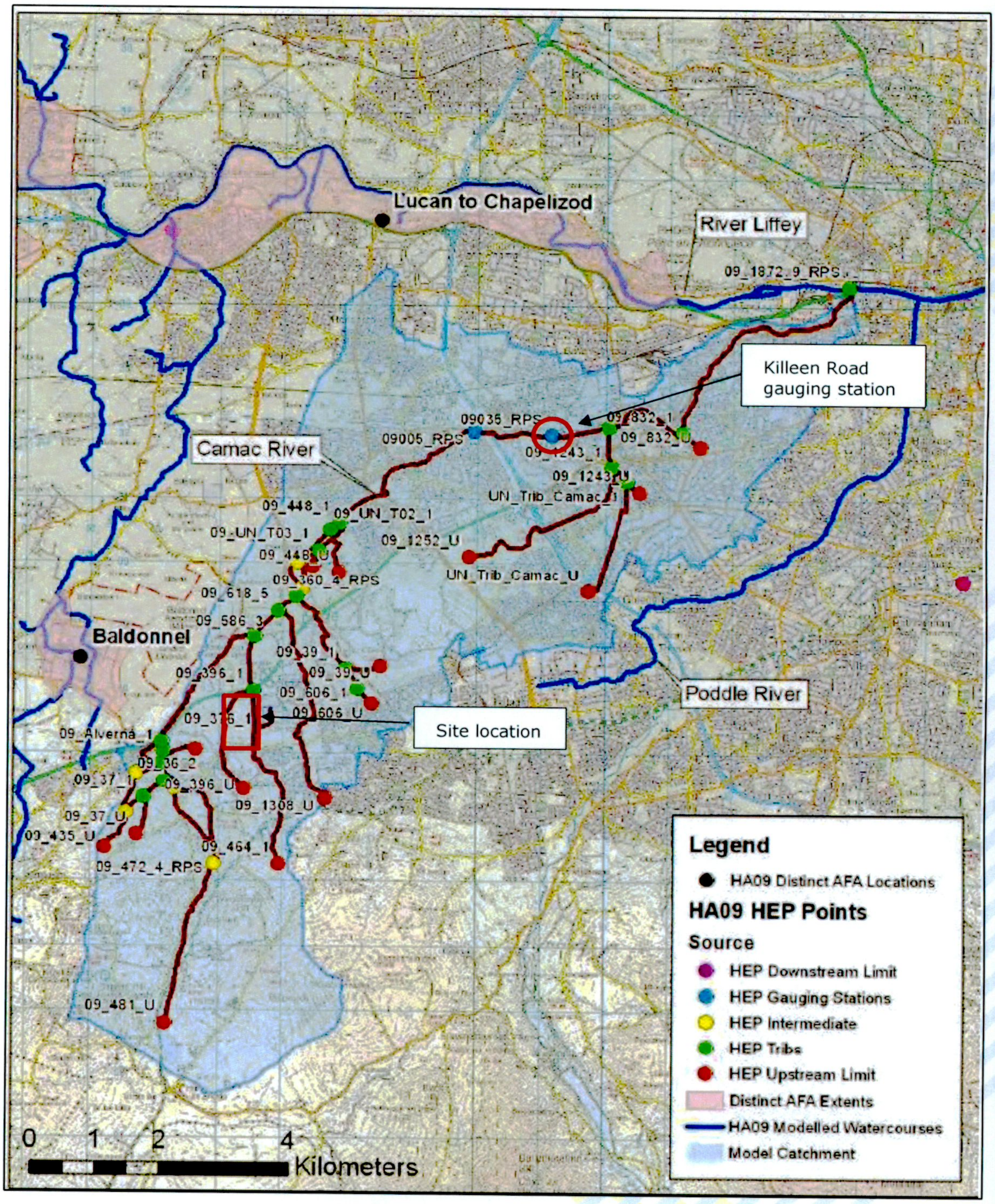


Figure 3-3: Model 2D HEPs and Catchment Boundary (ECFRAM Hydrology Report HA09)

3.2.2.3 ECFRAM Mapping Extents

CFRAM mapping of the 0.1% AEP,1% AEP and 10% AEP flood extents are shown in Figure 3-4. Table 3-3 provides details of the water levels for 10% ,1% and 0.1% AEP at nodes relevant to the site location.

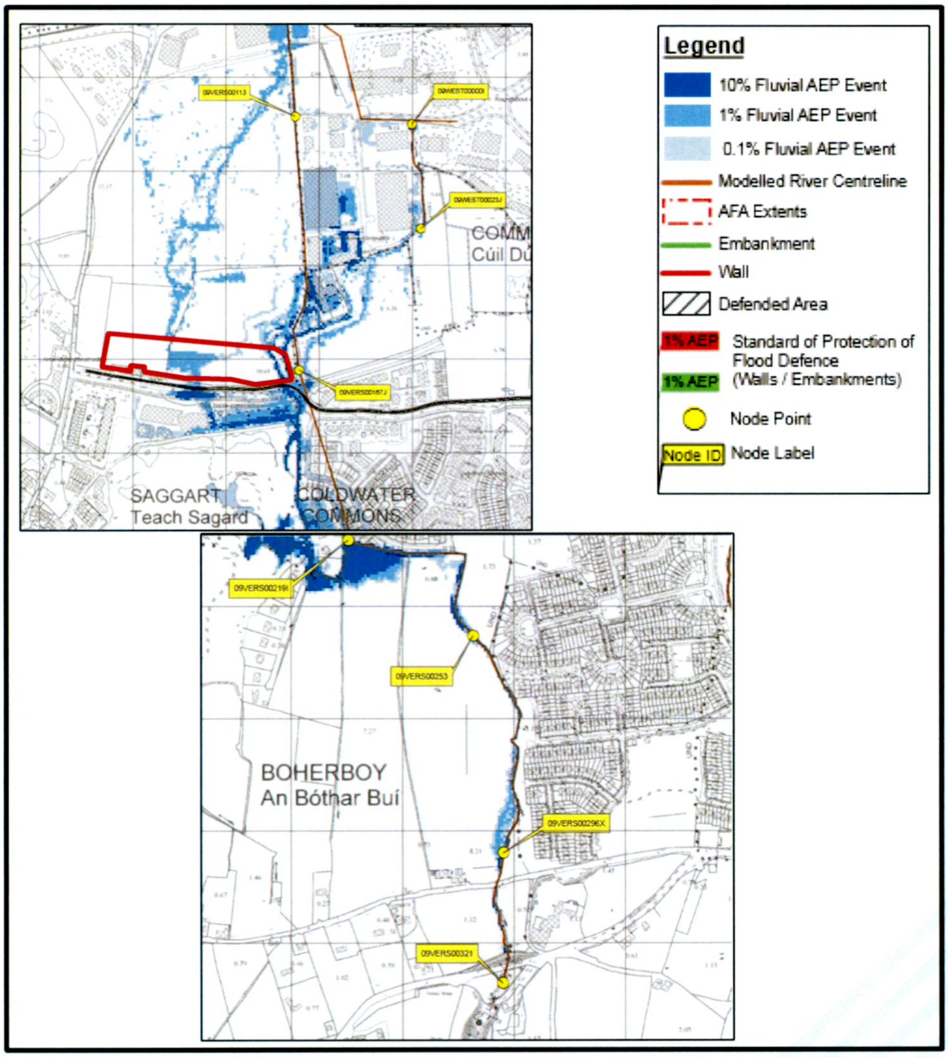


Figure 3-4: CFRAM Fluvial Flood Extents

Table 3-3: Water levels for node points at and around site location

Node	Water Level 10% AEP (mOD)	Water Level 1% AEP (mOD)	Water Level 0.1% AEP (mOD)
09VERS00219I	117.84	118.01	118.13
09VERS00167J	111.46	n/a	111.64
09VERS00113	102.63	n/a	103.01

It is clear in the flood extents in Figure 3-4 that the exceedance of capacity at the entrance to culvert VERS00219 is primarily responsible for all out of bank flooding from Vershoyles Stream upstream of the N7 Naas Road. Substantial ponding occurs at the culvert entrance with floodwaters spilling to the west between residential blocks. The overland flow path then runs north along the eastern boundary of the former golf course. Significant attenuation and ponding appears to occur within this former golf course. The flow path splits at the carpark to the south of Fortunestown Road.

The main flowpath continues across Fortunestown Road where the flow further separates. Some flow continues along the road, some enters the south-east corner of the site, and some returns to the open channel of Vershoyles Stream. The secondary flowpath from the carpark heads west, where it then turns northwards across Fortunetown Road and the Luas Line. This flowpath enters the site from the southern boundary east of the Saggart Luas sto in the 0.1% and 1% AEP events. Flows in the 0.1% and 1% AEP event are predicted to cros the centre of the site and travel from the southern boundary to the north-east corner of the site where it returns to Vershoyles Stream at Bianconi Avenue.

There is no flooding across the site in the 10%AEP event, indicating that overland flow path only occur in large events, with no fluvial flooding occurring in more frequent events.

Flood depths occurring onsite for both the 1% and 0.1% AEP events are shallow and generally shown to be less than 0.25m. Isolated locations of deeper ponding are a result of ponding behind temporary soil stockpiles onsite. These areas are not representative of actual flood depths for natural ground levels of the site.

Downstream of the subject site and the Phase 1 development site overland flow paths acros the site return to Vershoyles Stream between Binaconi Avenue and the N7 Naas Road.

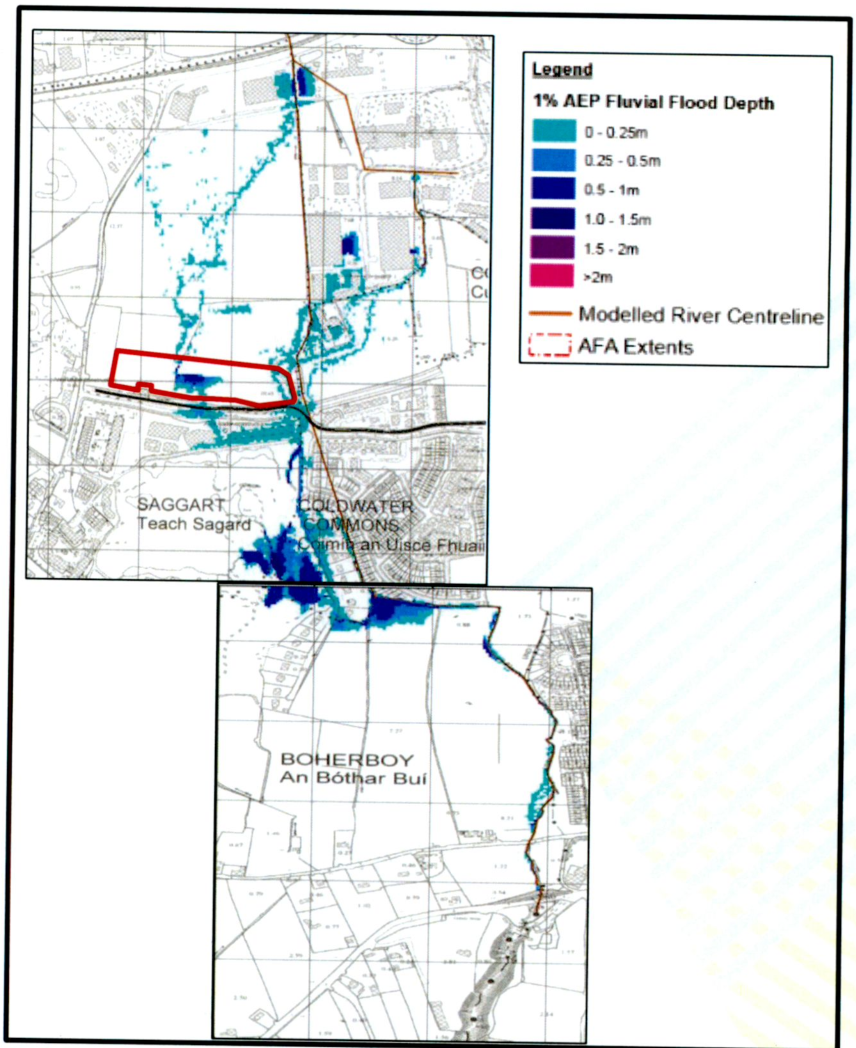


Figure 3-5: 1% AEP Fluvial Flood Depths

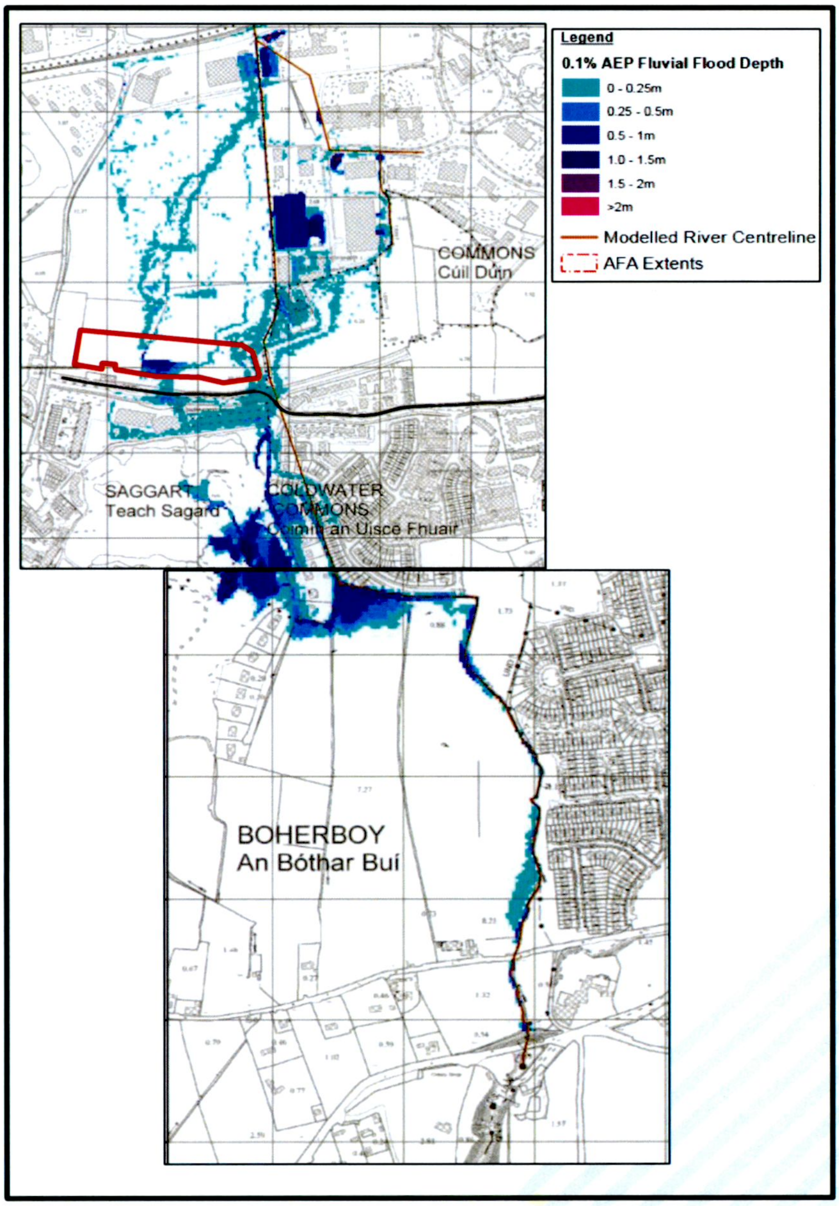


Figure 3-6: 0.1% AEP Fluvial Flood Depths

3.2.2.4 CFRAM Preliminary Options Report (POR)

The preliminary options report outlines defence options for the Camac Catchment. Figure 3-7 identifies properties at risk to flooding. It is noted that the flood extents within Figure 3-7 do not correspond with the flood extents provided in the final CFRAM flood mapping. It is not understood how or why the flood extents are different between the 2 CFRAM reports, though it is presumed that the POR mapping is based on outdated draft mapping.

Figure 3-8 shows two mitigation options relevant to the site location. Walls were proposed upstream from the site where 1% AEP residential flooding was identified. The proposed wall would benefit an area of residential properties south of the site. A second smaller wall was proposed on the east boundary of the site. If these mitigation measures were applied to the final CFRAM flood mapping, all flow paths across the site would be contained within the area benefitting from defences. This shows that a relatively low cost solution could provide significant benefit to flood affected areas.

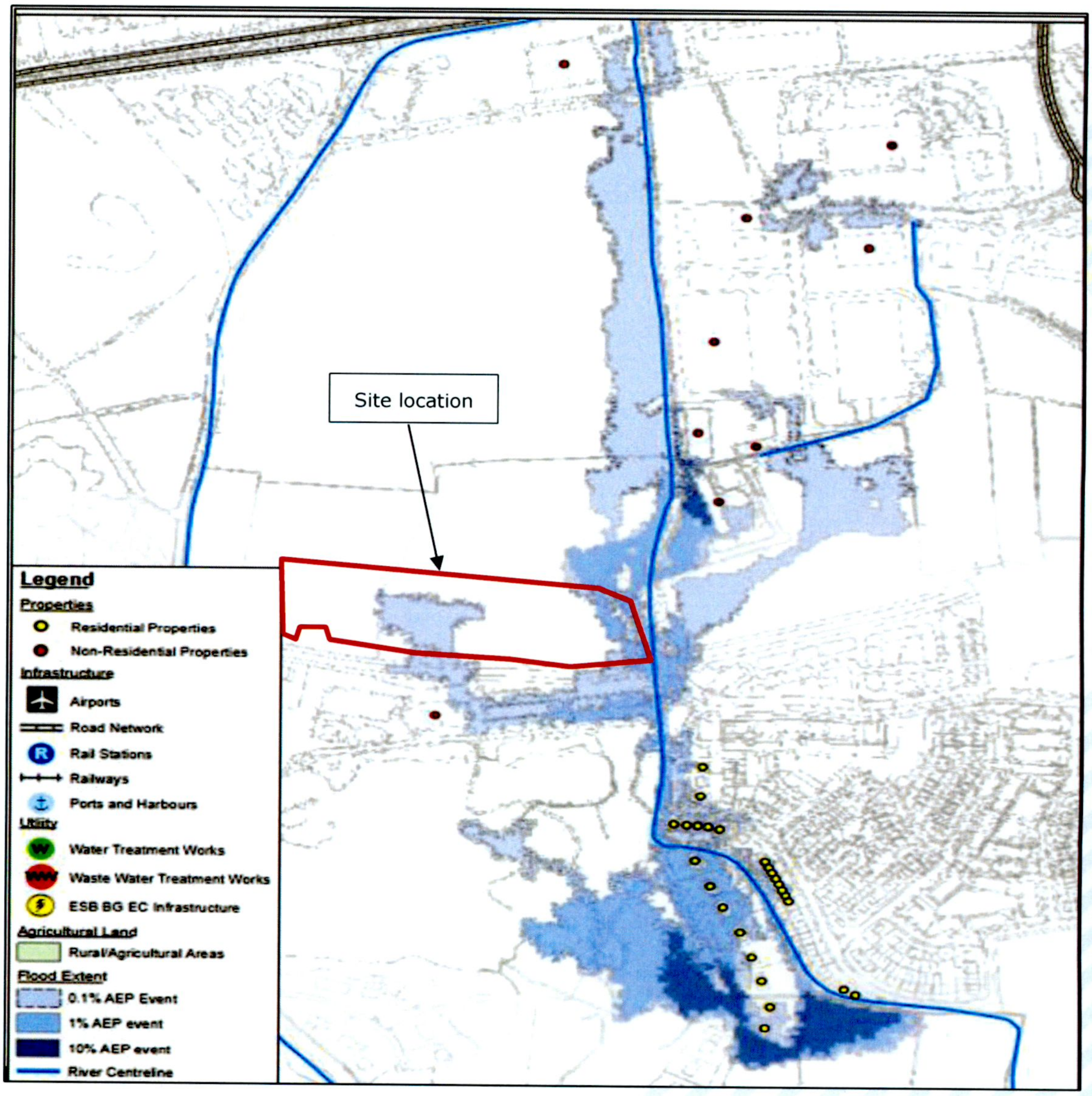


Figure 3-7: Flood Risk Mapping

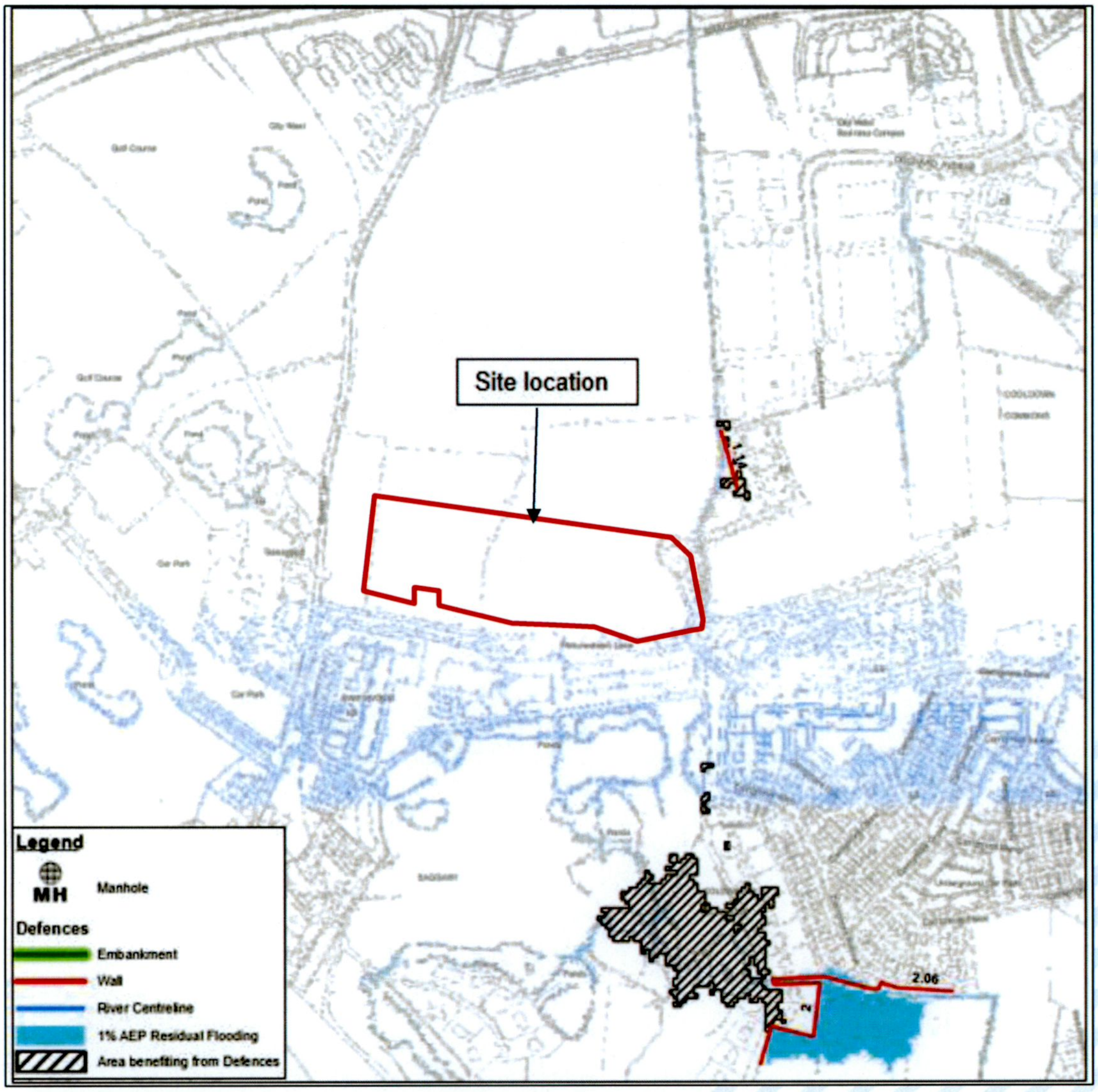


Figure 3-8: Proposed Defence options and benefitting areas

3.2.3 Predictive Flooding Summary

- Qmed estimations were adjusted based on a total catchment-scale analysis, which may not be appropriate for an isolated sub-catchment assessment.
- CFRAM IH124 values could not be replicated with or without the calibration adjustment
- A revised growth curve was adopted for catchments less than 10km² based on the assessment of 54 such catchments.
- There is significant storage and attenuation occurring in the former golf course upstream of the site
- Several temporary soil stockpiles are located on site resulting in unrepresentative deeper ponding locations
- CFRAM mapping has filtered very shallow depths across the site resulting in isolated puddles (sometimes a single pixel). It is reasonable to assume that these puddle spots are not a realistic representation of flood risk on the site. These would be considered ponding of surface water, rather than a floodplain.
- The site would benefit from relatively low cost mitigation measures upstream.

3.3 Sources of Flooding

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

3.3.1 Fluvial

The Eastern CFRAM flood maps, hydraulic and hydrology reports predict shallow fluvial flooding across the site. The predicted flooding is primarily a result in the exceedance of capacity of a culvert much further upstream from the site. Historical observations acknowledge the occurrence of flooding at Fortunestown Road resulting from this overland flow path. As such, the site is not a natural floodplain and is only subjected to fluvial flooding because of undersized drainage infrastructure upstream of the site. Resulting sheet flow across the site remains shallow and disjointed.

3.3.2 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 does not indicate any potential pluvial flood risk on the site. The surface water for the site will be connected to the surface water system designed for phase one of the development that has already been granted planning permission with surface water attenuation and storage for up to the 1% AEP event for phase one and future development of phase two (the subject site). This surface water storage system has been designed to store water up to the 1% AEP event plus an allowance of 10% for climate change. The surface water drainage network approved for phase one is designed to accommodate unattenuated surface flows from the phase two site (subject site). Surface water storage for both phases has been designed in the form of two detention basins and the provision of a controlled discharge to a watercourse. Refer to Figure 3-9 for the drainage design for the proposed development site.

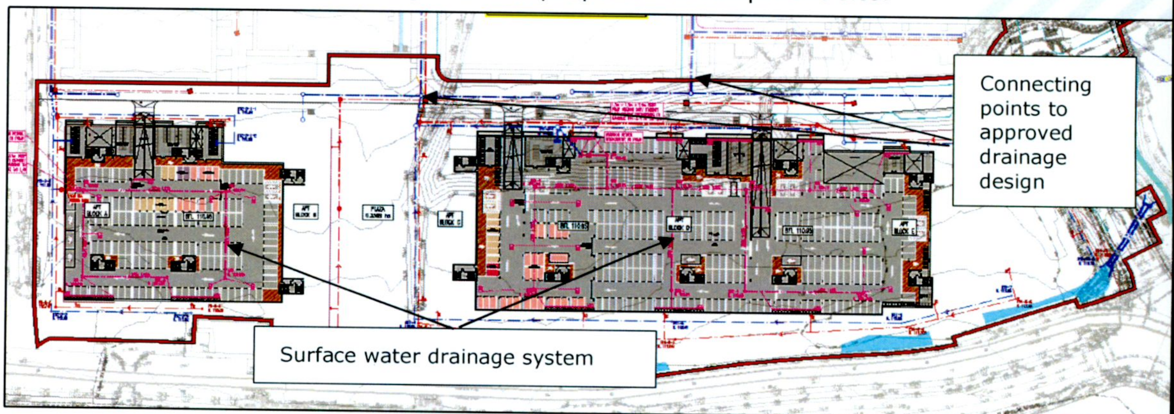


Figure 3-9: Proposed drainage design

3.3.3 Coastal

The site is located near the foothills of the Wicklow Mountains. Coastal flooding is not considered a source of flood risk to the site.

3.3.4 Groundwater

The OPW PFRA mapping does not indicate any groundwater flooding at the site or surrounding area. The GSI groundwater vulnerability for the site is classified as low. Furthermore, there are no karst features in the area which would indicate areas at risk of groundwater flooding. There is no known risk of groundwater flooding in this area, therefore groundwater should not be considered as a likely source of flood risk to the site.

4 Flood Risk Assessment

The CFRAM flood mapping of the Camac catchment provides the most recent assessment of flood risk to the site, with draft mapping incorporated into the SDCC SFRA to inform development of flood zones and appropriate development.

As the estimation of hydrologic flows for the site location could not be verified from the CFRAM report, a hydrologic analysis was undertaken using all available hydrologic methods to appropriately determine flow at the site.

Due to the substantial volume of overland flow resulting from the exceedance in capacity of a culvert far upstream of the site, it appears from the CFRAM flood mapping that Vershoyles Stream downstream of Fortunestown Road is not flowing bankfull during flood events and that due to existing topography, the overland flow paths are not able to return to the stream downstream of Fortunestown Road, resulting in shallow sheet flow across the site and flooding of adjacent properties.

Hydraulic modelling was undertaken to assess under the phase 1 approved application the channel capacity of the existing condition of Vershoyles Stream adjacent to the site.

The following sections will detail the process of flow estimation, hydraulic modelling and present results.

4.1 Hydrology

The hydrologic inflows in terms of annual exceedance probability were derived for the site. This allowed the calculation of flow rates that were used within the hydraulic model. Figure 4-1 shows the catchment area for the site location and identifies the flood estimation point used to estimate flows.

Flow estimation for the catchment was completing using the following methods:

- Flood Studies Update (FSU)
- Flood Studies Report (FSR)
- Flood Studies Report Rainfall-Runoff (FSR RR)
- Institute of Hydrology Report no. 124 (IH124)

All approaches required the input of various hydrological variables specific to the site which were calculated using a digitised version of the original FSU portal and the FSR maps.

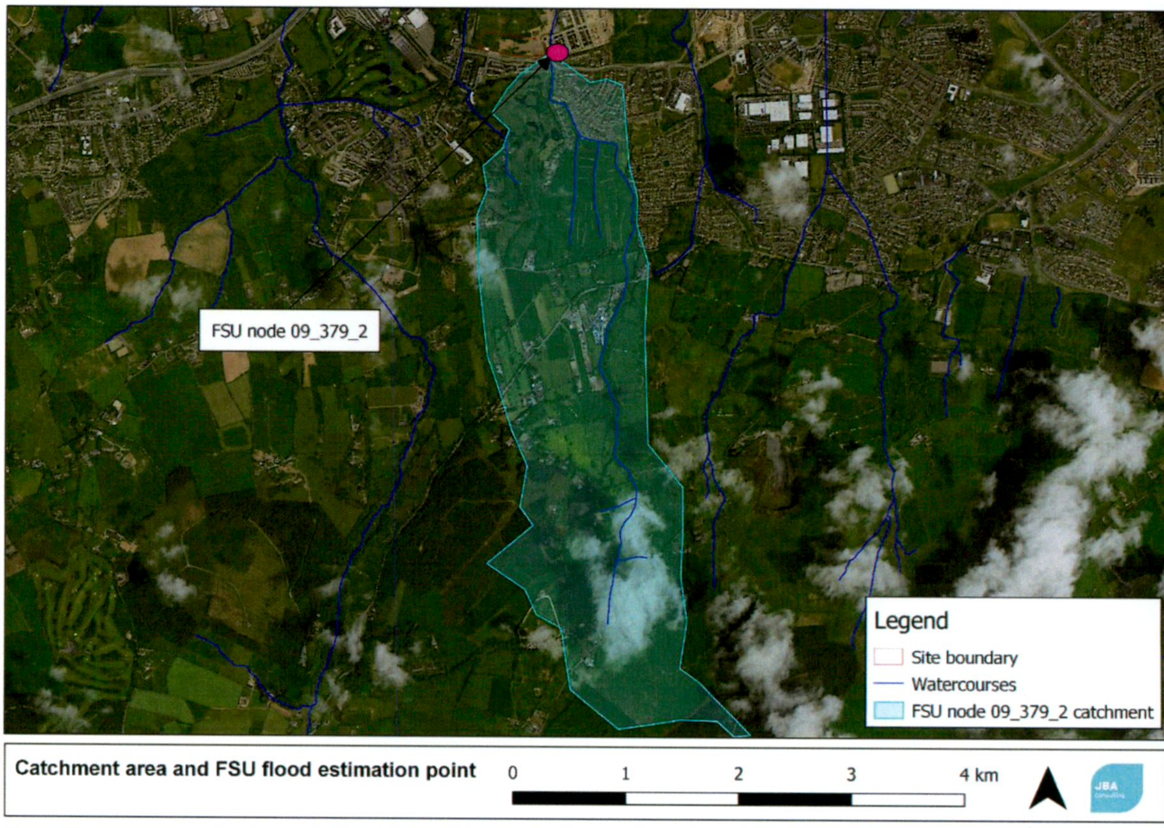


Figure 4-1: Catchment area and FSU flood estimation point

Each hydrology method was assessed independently to determine the best available estimate of peak flows, though all methods remain subject to uncertainty. The FSU estimation points used are reflective of the catchment as a whole and allowed for a conservative assessment of the hydrology as they do not include for any storage or attenuation within the catchment.

The IH124 method was chosen as the preferred method for the purposes of this assessment as it is the best method to represent smaller catchment areas. This is consistent with the ECFRAM approach. The values derived for the IH124 method were found to be higher than those represented in the ECFRAM values. Whilst the methodology was consistent, the IH124 flows calculations reported within the CFRAM study were unable to be validated either before, or after the adjustments made through calibration at the Killeen Road gauge. Therefore, the CFRAM determined flows have not been used in this assessment. However, the growth curve produced from the CFRAM study is preferred as the IH124 method uses a derived generalised curve for the entire country, whereas the ECFRAM assessment derived a growth curve for all node points within the ECFRAM area with a catchment area less than $10km^2$. The growth curve determined within ECFRAM is applied to the IH124 Qmed determined in this assessment to provide the best estimate of flows for the study site catchment.

Table 4-1 outlines the derived flows for the FSU estimation point at the site location.

Table 4-1: Estimated Peak Flows

Annual Exceedance Probability (AEP)	CRFAM Growth Factor	09_376_2 Flow (m3/s)
50%	1	1.32
20%	1.45	1.92
10%	1.80	2.37
5%	2.18	2.89
2%	2.78	3.67
1%	3.32	4.39
0.1%	5.93	7.82

4.2 Hydraulic Modelling

A hydraulic model was developed to appropriately assess conveyance within Vershoyles Stream downstream of Fortunestown Road. The CFRAM mapping indicates fluvial flooding at the site location is the result of a culvert far upstream of the site and that no overtopping of Vershoyles Stream occurs downstream of Fortunestown Road. Predicted overland flow paths do not currently return to Vershoyles Stream. The hydraulic model was used to inform the mitigation measures required if the total unattenuated catchment flow is contained within the drainage network upstream of the site.

4.2.1 Hydraulic Modelling Overview

The hydraulic model was completed using TUFLOW-ESTRY software. TUFLOW is a comparable commercial product to Infoworks ICM and Mike Flood.

TUFLOW is specifically oriented towards establishing flow and inundation patterns in floodplains and urban areas where the flow behaviour is essentially two-dimensional in nature and cannot appropriately be represented within a one-dimensional model. TUFLOW can dynamically link to 1D networks using the hydrodynamic solutions of ESTRY or ISIS. This model has been refined by modelling the open stream and inline structures using ESTRY.

The hydraulic model was carried out in the following stages:

- A new 1D-2D ESTRY-TUFLOW model of the site location and Vershoyles Stream running along the east boundary of the site was created using river data surveyed and on-site observations.
- Design simulations were run to simulate the ECFRAM 1% AEP and 0.1% AEP flood events.

Figure 4-2 represents the river channel on the east boundary of the site. The arrows represent the open channel flow, weirs and culverts running parallel to the study site.

This assessment applies the full hydrologically ECFRAM determined flows at the downstream outlet of the Fortunestown Road culvert, producing a highly conservative application of the flow in the stream. This approach does not incorporate any of the attenuation or storage upstream of the site in the former golf course. The ECFRAMS hydraulic report estimates that storage and attenuation in the Vershoyles Stream catchment results in a decrease in peak flow of 38% in the 1% AEP flow event.

Assessment of residual risk including blockage at key structures and allowance for climate change have also been considered.

Bianconi Avenue forms the downstream boundary of the model where overland flow leaves the model under normal flow conditions and the rectangular culvert under Bianconi Avenue has been assigned a flow-stage relationship based on the conveyance properties of the culvert.

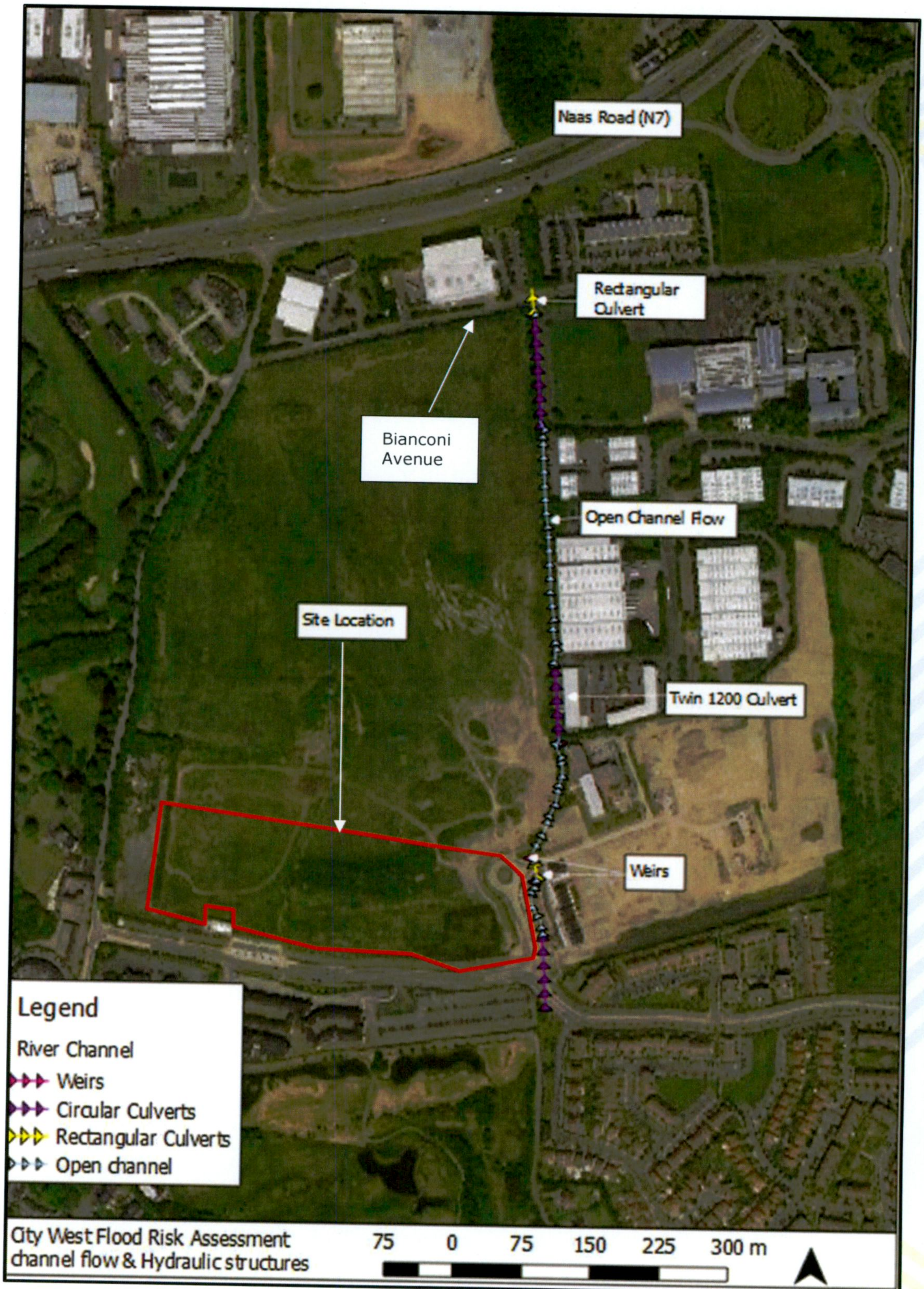


Figure 4-2: Existing channel conditions

4.2.2 Results

The results from the hydraulic modelling for the 1% and 0.1% AEP flood events are presented in Figure 4-3 and Figure 4-4. Inundation occurs onsite during both flood events. The flood flow pathways and extents are similar to the ECFRAM flood outlines which are presented in Figure 4-3.

As per the ECFRAM mapping, the main cause of inundation onsite results from the ingress of overland flows along the southern boundary of the site. The main flow pathway traverses the site from the site centre at the southern boundary, through the site to the north-eastern corner. Flows are shallow during both flood events with depths predominantly less than 250mm. Greater flood extents are recorded during the 0.1% AEP flood event.

The mapping shows flooding on the east boundary along Vershoyles Stream at the Fortunestown Road culvert system and at the twin 1200mm circular culverts where out of channel spill occurs. The hydraulic model boundary does not include the adjacent industrial buildings; therefore, depth mapping is intended to be considered at this location. There is also shallow overland flow across Bianconi Avenue.

Figure 4-3: Existing 1% AEP flood risk

Figure 4-4: Existing 0.1% AEP flood risk

4.3 Diversion Channel / Flood Conveyance Channel

To manage inundation of the site, it is proposed that an open channel drain is placed across part of the southern boundary of the site running parallel to Fortunestown Road. This swale will redirect shallow flows across the site back into Vershoyles Stream. This uniform channel of 4m width was modelled and approved under the Phase 1 development. This application proposes modifications to the approved channel in keeping with the proposed development of the site and the associated landscape proposals. The modifications include providing a channel of varying widths which are demonstrated in dwg 162073-3200. The hydraulic model created for the Phase 1 development has been updated to reflect the changes proposed to the flood conveyance channel.

Additional measures that have already been approved as part of the phase one planning application for the development area included modification to the existing link road to Fortunestown Lane to channel overland flow back into the Vershoyles Stream. Some re-grading of the Vershoyles Stream has been carried out between the Fortunestown Road junction and the Twin culvert system. The purpose of the outlined mitigation measures is to ensure that no overtopping occurs onto the proposed development during the 1% & 0.1% AEP flood events.

A hydraulic model was developed to test the effectiveness of the channel during both the 1% & 0.1% AEP flood events. The results are depicted in Figure 4-5, which confirms that the proposed channel has sufficient capacity to channel both the 1% and 0.1% AEP flood events around the site and back to the Vershoyles Stream.

Figure 4-6 over page, provides the peak flood levels for the 1% AEP MRFS along the proposed swale and confirm that the development is not at risk of inundation following implantation of the mitigation measures.

The proposed mitigation measures achieve the objective of intercepting all overland flows onto the site. No overland flows are recorded as all flows remain instream. Inundation occurs surrounding the access roadway as per the pre-development scenario. The source of overland flow originating from the south which is intercepted by the modified link road from Fortunestown Lane and channelled instream.

Figure 4-5: Post Development- 1% AEP & 0.1% AEP Flood Extent

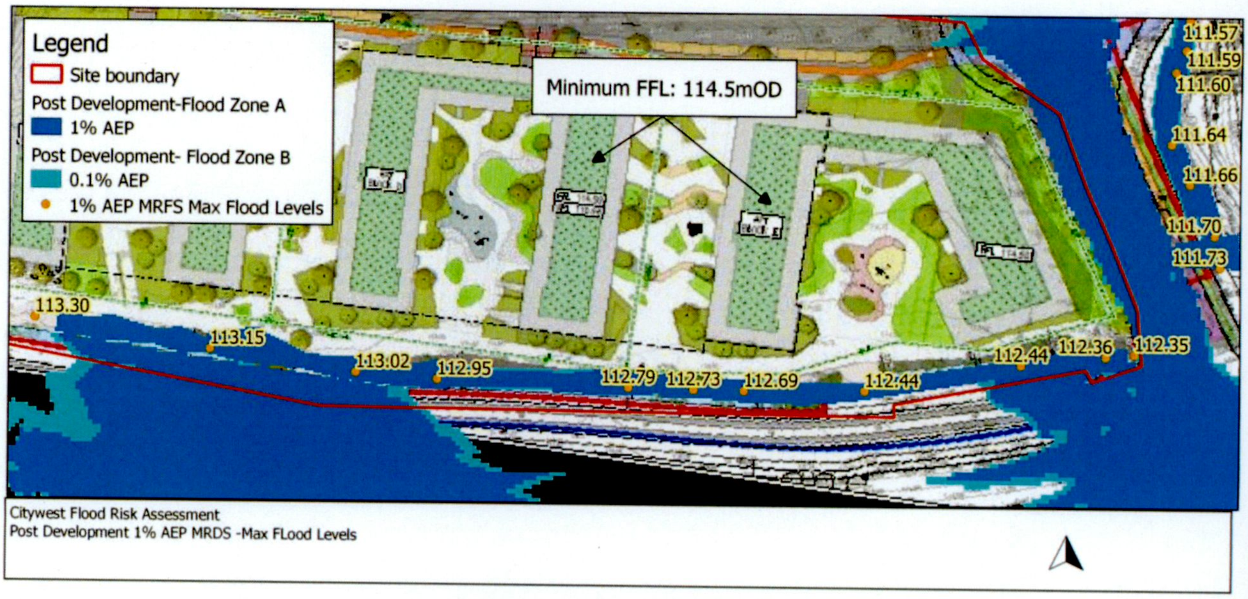


Figure 4-6: Post Development- 1% AEP MRFS Peak Flood Levels

5 Flood Risk Mitigation

5.1 Overland flow swale

Mitigation measures have been developed in response to the risks previously discussed. As outlined in Section 4.3, it is proposed that an open channel drain is placed across the top of the site running parallel to Fortunestown Road. This channel will redirect shallow flows across the site back into Vershoyles Stream. A landscaped channel of variable width (1.7-4m) with sloped sides which has the capacity to intercept shallow flows across the site for events up to and including the 0.1% AEP event and includes a 300mm freeboard within the channel.

5.2 Site layout, landscaping and finished floor levels

Assessment of channel capacity within Vershoyles Stream concludes the stream has the capacity to contain the 1% AEP flow with an allowance for climate change. The urban storm water drainage will discharge to the stream, and will form an important constraint for flood levels within this flat site. The minimum finished floor level proposed is 114.5mOD, the peak water level for within the overland flow swale in the 1% AEP plus climate change scenario is 113.30mOD, refer to Figure 4-6. Therefore, there is freeboard of 1.2m provided in the design scenario.

5.3 Access and Egress

Access and Egress to the site will be provided via the existing roundabout off Fortunestown Road and there are additional two access points from Garter Lane (approved and currently under construction) which are not at risk of flooding. CFRAM mapping identifies shallow flow over the road in the 1% AEP and 0.1% AEP events from overland flow crossing Fortunestown Road. Re-design of road levels and inclusion of the on-site open channel will reduce the risk of shallow flows over the road. The entrance to the development from Fortunestown Lane at the south east corner of the site is at risk from the 1% AEP and 0.1% AEP flood events. Flood depths are shallow at <0.1m. Therefore, access and egress will not be impeded during these flood events.

5.4 Drainage Design

The drainage system has been assessed for 30 and 100-year return period events for a full range of storm events with no out of system flooding, i.e. designed to surcharge within the system up to 100% AEP event. A climate change factor of 10% has been incorporated into the stormwater calculations. Refer to Figure 3-9 for the proposed stormwater system.

5.5 Residual Risk

Increasing 1% AEP flows by 20% to include an allowance for climate change Medium Range Future Scenario (MRFS) would increase the peak 1% AEP flow to 5.26m^3/s. The channel capacity assessment identifies the twin 1200mm culvert north of the site's eastern boundary as the hydraulic control within the existing drainage network with a flow capacity of approximately 6.1m^3/s. The culvert can convey both the 1% & 0.1% AEP flood events without surcharging. The peak flow rate thought the culvert during the 1% AEP event is 2.15m^3/s, therefore the culvert has sufficient capacity to convey the 1% AEP flood event during a 50% blockage scenario.

To minimise the risk of blockage, it is recommended that a management plan be devised as part of the overall development's maintenance programme to visually check for blockage and clear any debris within the flood conveyance channel and connecting culverts if required.

It is suggested that raised entry treatments are located at ramp access to the basements to prevent overland flow. It is also recommended that vent locations for the basements on the southern faces of the proposed buildings are placed at a level above the 0.1% AEP peak water level within the channel (113.53mOD) and an additional 300mm freeboard applied. The recommended vent minimum vent height for the southern face is therefore 113.83mOD.

The proposed vents located on the northern faces are not at risk of inundation and therefore can be set at a lower level, there are no vents proposed on the east or west faces.

5.6 Impacts on flood risk through the development

As shown in the hydraulic modelling, there is no impact to flood risk in the 1% AEP as the existing channel and structures have the capacity to contain the 1% AEP flow including allowance for climate change.

5.7 Justification Test

The proposed buildings lie within A/B. As the development encroaches into Flood Zone A/B, the Justification Test for Development Management has been applied and passed:

• The Fortunestown Local Area Plan 2012-2017 (as a constituent of the South Dublin County Development Plan 2016-2022) has provided a zoning for this site as an area ' to provide for new residential communities in accordance with approved Area Plan. The zoning and designation of the overall site demonstrates that the development complies with Section 1 of the Justification Test.

• The Proposal has been subject to an appropriate flood risk assessment which shows:

i. The Development will not significantly increase flood risk elsewhere
ii. The development (building FFL) is raised above the 1% AEP event including climate change and freeboard to minimise the risk to people and property as far as is possible. Flood flows are managed by an open channel drain diversion which routes any overland flows around the site in channel.
iii. Residual risk is managed by the setting of appropriate finished floor levels, building placement and landscaping on site. Improvements to the culvert entrance will improve the hydraulics and reduce the residual risk.
iv. The development meets the standards of typical residential development design.

The mitigation strategy comprises of the construction of a flood conveyance channel through the subject site. This application proposes modifications to the channel to ensure that it is in keeping with the development strategy for the site.

6 Conclusion

This Flood Risk Assessment has comprehensively reviewed existing flood risk to the site and predictive flood studies, specifically the ECFRAM study. This assessment has shown that overland flow paths affecting the site in the 1% and 0.1% AEP events are caused by the exceedance in capacity of a culvert approximately upstream of the site.

These overland flow paths have limited ability to return to Vershoyles Stream due to the existing topography. However, as part of this Flood Risk Assessment a review of the capacity downstream of Fortunestown Road has shown Vershoyles Stream can convey the full un-attenuated flow in the 1% AEP event including an allowance for climate change, should the culvert restrictions be removed in the future.

Capacity of a twin 1200mm culvert on the upstream of the eastern boundary of the site is exceeded in the 0.1% AEP event for the existing scenario. Mitigation measures to re-grade the channel upstream from the culvert and provide a new trash screen have been approved as part of the phase one planning application. The existing flood risk with flows are contained in the proposed design scenario contained in channel for the 1% and 0.1% AEP flood event post-development.

The proposed mitigation strategy relates to the subject site and the Phase 1 development site under construction (approved under the ABP 300555-18). The mitigation strategy would remove flood risk from the site by returning overland flow paths to Vershoyles Stream via an open channel drain (flood conveyance channel). The channel capacity assessment shows that flow for the 1% AEP MRFS and 0.1% AEP events remains in channel without increasing flood risk to the site or adjacent properties. The proposed mitigation measures also shows that the Vershoyles Stream downstream of Fortunestown Road has the capacity to convey the full 1% AEP MRFS flow without the inclusion for any attenuation upstream. Management of flood risk of the site up to the 0.1% AEP event would be addressed by the open channel drain and any changes upstream would not impact on the development flood risk as the channel has a flexible capacity.

The minimum Finish Floor Level (FFL) proposed for the development is 114.5mOD. Review of the post-development flood levels provide a maximum 1% AEP MRFS of 113.3mOD which confirms that a minimum freeboard of 1.20mOD is provided for in the proposed design over the 1% plus climate change event and a freeboard of 0.97m over the 0.1% AEP event.

Residual risks to the site have been identified to occur from a potential blockage of the twin culvert system downstream of the subject site and the potential increase in stream flow due to climate change. The 1% AEP MFRS confirms that the proposed flood conveyance channel and existing twin culvert system downstream have sufficient capacity to contain this flood event. Although the twin culvert system can convey flood waters during a 50% blockage event, a blockage greater than 50% could result in overtopping of the culvert system. Overtopping of the culverts could lead to localised flooding directly upstream of the culvert system, but the extents would be reduced from those seen in Figure 4-4 due to the proposed design features. A blockage of greater than 50% is a worst-case scenario event and unlikely to occur as the culverts are within a maintained system. To protect against this residual risk it is recommended that frequent visual inspections of the culvert be undertaken and debris removed as required as part of the wider maintenance programme.

A stormwater system is included as part of the development to manage surface water runoff. The proposals for the site limits the discharge rate to its greenfield equivalent. Stormwater attenuation is provided which is designed to contain the capacity for a 1% (1 in 100 year) storm event plus an allowance for climate change.

The proposed mitigation measures do not result in an increased flood risk to surrounding properties but will reduce flood risk. The post-development residential area is outside of Flood Zone A/B. The development has passed the Justification test for residential development.

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:

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.

Table: Conversion between return periods and annual exceedance probabilities

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

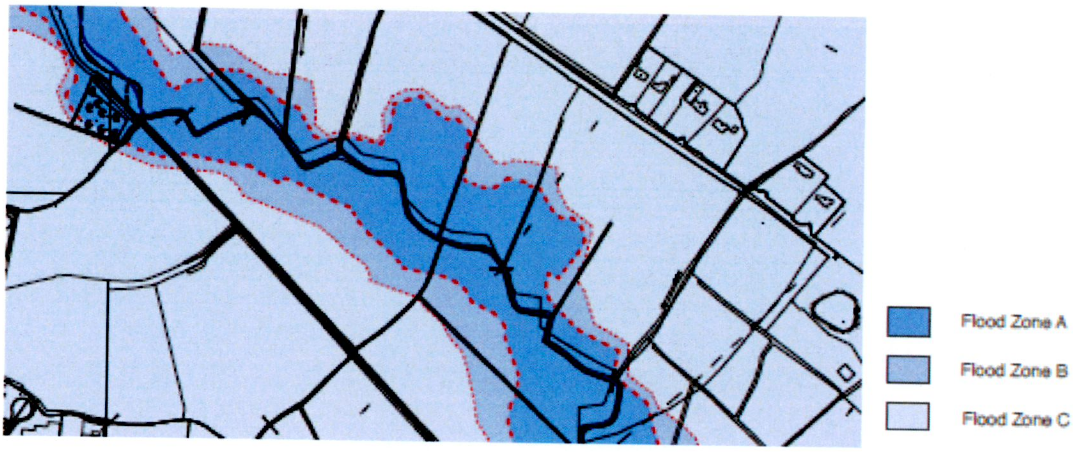
A.2 Flood Zones

Flood Zones are geographical areas illustrating the probability of flooding. For the 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% from coastal/tidal.
Flood Zone C	Lowest probability of flooding; less than 0.1% from both rivers and coastal/tidal.

It is important to note that the definition of the flood zones is based on an undefended scenario and does not take into account the presence of flood protection structures such as flood walls or embankments. This is to allow for the fact that there is a residual risk of flooding behind the defences due to overtopping or breach and that there may be no guarantee that the defences will be maintained in perpetuity.

Indicative Flood Zones (OPW & DoEHLG 2009)



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.

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Appendix B : SURFACE WATER CALCULATIONS AND RAINFALL DATA

Met Eireann

Return Period Rainfall Depths for sliding Durations

Irish Grid: Easting: 304573, Northing: 227288,

	Interval		Years													
DURATION	6months,	1year,	2,	3,	4,	5,	10,	20,	30,	50,	75,	100,	150,	200,	250,	500,
5 mins	2.5,	3.7,	4.4,	5.5,	6.2,	6.8,	8.7,	10.9,	12.4,	14.6,	16.6,	18.1,	20.6,	22.5,	24.1,	N/A ,
10 mins	3.5,	5.2,	6.2,	7.6,	8.6,	9.4,	12.1,	15.2,	17.3,	20.4,	23.1,	25.3,	28.7,	31.3,	33.5,	N/A ,
15 mins	4.1,	6.1,	7.2,	9.0,	10.2,	11.1,	14.2,	17.9,	20.4,	24.0,	27.2,	29.7,	33.7,	36.8,	39.5,	N/A ,
30 mins	5.4,	8.0,	9.4,	11.6,	13.1,	14.3,	18.3,	22.9,	26.0,	30.5,	34.5,	37.6,	42.6,	46.4,	49.7,	N/A ,
1 hours	7.2,	10.5,	12.3,	15.1,	17.0,	18.5,	23.5,	29.3,	33.2,	38.7,	43.7,	47.7,	53.8,	58.6,	62.6,	N/A ,
2 hours	9.4,	13.7,	16.0,	19.6,	22.0,	23.9,	30.2,	37.5,	42.3,	49.3,	55.5,	60.4,	67.9,	73.8,	78.8,	N/A ,
3 hours	11.1,	16.0,	18.7,	22.8,	25.6,	27.8,	35.0,	43.3,	48.8,	56.7,	63.8,	69.3,	77.9,	84.6,	90.2,	N/A ,
4 hours	12.4,	17.9,	20.9,	25.4,	28.5,	30.9,	38.8,	48.0,	54.0,	62.7,	70.4,	76.5,	85.8,	93.1,	99.2,	N/A ,
6 hours	14.6,	20.9,	24.4,	29.6,	33.1,	35.9,	45.0,	55.4,	62.3,	72.2,	81.0,	87.8,	98.4,	106.7,	113.6,	N/A ,
9 hours	17.2,	24.5,	28.4,	34.4,	38.5,	41.7,	52.1,	64.0,	71.9,	83.1,	93.1,	100.8,	112.9,	122.2,	130.0,	N/A ,
12 hours	19.3,	27.4,	31.8,	38.4,	42.9,	46.4,	57.8,	70.9,	79.6,	91.8,	102.8,	111.3,	124.4,	134.6,	143.1,	N/A ,
18 hours	22.6,	32.0,	37.1,	44.7,	49.8,	53.9,	67.0,	81.9,	91.8,	105.7,	118.1,	127.8,	142.6,	154.2,	163.8,	N/A ,
24 hours	25.4,	35.8,	41.4,	49.8,	55.5,	59.9,	74.4,	90.8,	101.6,	116.9,	130.4,	141.0,	157.2,	169.8,	180.3,	217.0,
2 days	32.1,	43.9,	50.2,	59.4,	65.6,	70.3,	85.7,	102.8,	113.9,	129.4,	143.1,	153.6,	169.7,	182.1,	192.3,	227.8,
3 days	37.5,	50.5,	57.2,	67.1,	73.7,	78.7,	94.9,	112.6,	124.2,	140.1,	154.0,	164.7,	180.9,	193.3,	203.6,	238.9,
4 days	42.3,	56.2,	63.4,	73.8,	80.7,	86.0,	102.9,	121.3,	133.1,	149.4,	163.6,	174.5,	190.9,	203.5,	213.8,	249.2,
6 days	50.7,	66.2,	74.1,	85.5,	93.0,	98.7,	116.7,	136.2,	148.7,	165.7,	180.4,	191.6,	208.5,	221.4,	231.9,	267.7,
8 days	58.2,	75.0,	83.5,	95.7,	103.7,	109.7,	128.8,	149.2,	162.2,	179.8,	195.1,	206.6,	223.9,	237.1,	247.8,	284.2,
10 days	65.0,	83.0,	92.0,	105.0,	113.4,	119.7,	139.6,	160.9,	174.3,	192.6,	208.2,	220.1,	237.8,	251.2,	262.1,	299.1,
12 days	71.4,	90.5,	100.0,	113.6,	122.3,	129.0,	149.7,	171.7,	185.5,	204.3,	220.4,	232.5,	250.6,	264.3,	275.4,	312.9,
16 days	83.3,	104.3,	114.6,	129.3,	138.8,	145.9,	168.0,	191.3,	205.9,	225.6,	242.4,	255.0,	273.8,	287.9,	299.4,	337.8,
20 days	94.4,	117.0,	128.1,	143.7,	153.8,	161.3,	184.6,	209.1,	224.4,	244.8,	262.2,	275.3,	294.7,	309.2,	321.0,	360.4,
25 days	107.4,	131.8,	143.7,	160.4,	171.1,	179.1,	203.8,	229.5,	245.5,	266.9,	285.0,	298.5,	318.5,	333.5,	345.6,	386.0,

NOTES:

N/A Data not available

These values are derived from a Depth Duration Frequency (DDF) Model

For details refer to:

'Fitzgerald D. L. (2007), Estimates of Point Rainfall Frequencies, Technical Note No. 61, Met Eireann, Dublin',
Available for download at www.met.ie/climate/dataproducts/Estimation-of-Point-Rainfall-Frequencies_TN61.pdf

Appendix C : MICRODRAINAGE CALCULATIONS

STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for Storm

Pipe Sizes STANDARD Manhole Sizes STANDARD

FSR Rainfall Model - Scotland and Ireland

Return Period (years)	100	PIMP (%)	100
M5-60 (mm)	18.500	Add Flow / Climate Change (%)	0
Ratio R	0.263	Minimum Backdrop Height (m)	0.200
Maximum Rainfall (mm/hr)	50	Maximum Backdrop Height (m)	1.500
Maximum Time of Concentration (mins)	30	Min Design Depth for Optimisation (m)	0.600
Foul Sewage (l/s/ha)	0.000	Min Vel for Auto Design only (m/s)	1.00
Volumetric Runoff Coeff.	0.750	Min Slope for Optimisation (1:X)	500

Designed with Level Soffits

Time Area Diagram for Storm

Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.096	4-8	0.023

Total Area Contributing (ha) = 0.119

Total Pipe Volume (m³) = 1.722

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
S1.000	10.279	0.069	149.0	0.119	4.00	0.0	0.600	o	225	Pipe/Conduit	🔓
S1.001	26.738	0.134	200.0	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	🔓
S1.002	6.294	0.031	200.0	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	🔓

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
S1.000	50.00	4.16	109.934	0.119	0.0	0.0	0.0	1.07	42.5	16.1
S1.001	50.00	4.64	109.865	0.119	0.0	0.0	0.0	0.92	36.6	16.1
S1.002	50.00	4.76	109.731	0.119	0.0	0.0	0.0	0.92	36.6	16.1

Manhole Schedules for Storm

MH Name	MH CL (m)	MH Depth (m)	MH Connection	MH Diam.,L*W (mm)	PN	Pipe Out Invert Level (m)	Diameter (mm)	PN	Pipes In Invert Level (m)	Diameter (mm)	Backdro (mm)
S3	110.843	0.909	Open Manhole	1200	S1.000	109.934	225				
S2	110.863	0.998	Open Manhole	1200	S1.001	109.865	225	S1.000	109.865	225	
S1	112.065	2.334	Open Manhole	1200	S1.002	109.731	225	S1.001	109.731	225	
S	112.000	2.300	Open Manhole	0		OUTFALL		S1.002	109.700	225	

MH Name	Manhole Easting (m)	Manhole Northing (m)	Intersection Easting (m)	Intersection Northing (m)	Manhole Access	Layout (North)
S3	704508.821	727331.813	704508.821	727331.813	Required	
S2	704519.041	727330.713	704519.041	727330.713	Required	
S1	704528.660	727305.765	704528.660	727305.765	Required	
S	704531.248	727300.027			No Entry	

PIPELINE SCHEDULES for Storm

Upstream Manhole

PN	Hyd Sect	Diam (mm)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
S1.000	o	225	S3	110.843	109.934	0.684	Open Manhole	1200
S1.001	o	225	S2	110.863	109.865	0.773	Open Manhole	1200
S1.002	o	225	S1	112.065	109.731	2.109	Open Manhole	1200

Downstream Manhole

PN	Length (m)	Slope (1:X)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
S1.000	10.279	149.0	S2	110.863	109.865	0.773	Open Manhole	1200
S1.001	26.738	200.0	S1	112.065	109.731	2.109	Open Manhole	1200
S1.002	6.294	200.0	S	112.000	109.700	2.075	Open Manhole	0

Area Summary for Storm

Pipe Number	PIMP Type	PIMP Name	PIMP (%)	Gross Area (ha)	Imp. Area (ha)	Pipe Total (ha)
1.000	-	-	100	0.119	0.119	0.119
1.001	-	-	100	0.000	0.000	0.000
1.002	-	-	100	0.000	0.000	0.000
				Total	Total	Total
				0.119	0.119	0.119

Free Flowing Outfall Details for Storm

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
S1.002	S	112.000	109.700	109.700	0	0

Simulation Criteria for Storm

Volumetric Runoff Coeff	0.750	Additional Flow - % of Total Flow	0.000
Areal Reduction Factor	1.000	MADD Factor * 10m³/ha Storage	2.000
Hot Start (mins)	0	Inlet Coeffiecient	0.800
Hot Start Level (mm)	0	Flow per Person per Day (l/per/day)	0.000
Manhole Headloss Coeff (Global)	0.500	Run Time (mins)	60
Foul Sewage per hectare (l/s)	0.000	Output Interval (mins)	1

Number of Input Hydrographs	0	Number of Offline Controls	0	Number of Time/Area Diagrams	0
Number of Online Controls	0	Number of Storage Structures	0	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model	FSR	Profile Type	Summer
Return Period (years)	30	Cv (Summer)	0.750
Region	Scotland and Ireland	Cv (Winter)	0.840
M5-60 (mm)	18.500	Storm Duration (mins)	30
Ratio R	0.263		

Summary of Critical Results by Maximum Level (Rank 1) for Storm

Simulation Criteria

Areal Reduction Factor	1.000	Additional Flow - % of Total Flow	0.000
Hot Start (mins)	0	MADD Factor * 10m³/ha Storage	2.000
Hot Start Level (mm)	0	Inlet Coeffiecient	0.800
Manhole Headloss Coeff (Global)	0.500	Flow per Person per Day (l/per/day)	0.000
Foul Sewage per hectare (l/s)	0.000		

Number of Input Hydrographs 0 Number of Offline Controls 0 Number of Time/Area Diagrams 0
Number of Online Controls 0 Number of Storage Structures 0 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model	FSR	Ratio R	0.263
Region	Scotland and Ireland	Cv (Summer)	0.750
M5-60 (mm)	18.500	Cv (Winter)	0.840

Margin for Flood Risk Warning (mm)	300.0	DVD Status	OFF
Analysis Timestep	Fine	Inertia Status	OFF
DTS Status	ON		

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 180, 240, 360, 480, 600, 720, 960, 1440, 2160, 2880, 4320, 5760, 7200, 8640, 10080
Return Period(s) (years)	10, 30, 100
Climate Change (%)	20, 20, 20

PN	US/MH Name	Event	US/CL (m)	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.
S1.000	S3	15 minute 100 year Winter I+20%	110.843	110.438	0.279	0.000	1.37
S1.001	S2	15 minute 100 year Winter I+20%	110.863	110.299	0.209	0.000	1.42
S1.002	S1	15 minute 100 year Winter I+20%	112.065	110.032	0.075	0.000	1.71

PN	US/MH Name	Overflow (l/s)	Pipe Flow (l/s)	Status
S1.000	S3		48.7	SURCHARGED
S1.001	S2		48.2	SURCHARGED
S1.002	S1		48.1	SURCHARGED

DBFL Consulting Engineers		Page 1
Ormond House Upper Ormond Quay Dublin 7	132071 Cuil Duin & Parklands Creche and Community Facility	Micro Drainage
Date 10/10/2022 File 132071 - Permeable Pavin...	Designed by KMM Checked by KJS	
Innovyze	Source Control 2020.1	

Summary of Results for 100 year Return Period (+20%)

Half Drain Time : 23 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	109.865	0.138	0.0	9.0	0.0	9.0	15.8	O K
30 min Summer	109.895	0.168	0.0	12.4	0.0	12.4	19.3	O K
60 min Summer	109.912	0.185	0.0	14.2	0.0	14.2	21.2	O K
120 min Summer	109.909	0.182	0.0	13.9	0.0	13.9	20.9	O K
180 min Summer	109.899	0.172	0.0	12.7	0.0	12.7	19.7	O K
240 min Summer	109.888	0.161	0.0	11.6	0.0	11.6	18.5	O K
360 min Summer	109.872	0.145	0.0	9.8	0.0	9.8	16.7	O K
480 min Summer	109.860	0.133	0.0	8.5	0.0	8.5	15.3	O K
600 min Summer	109.851	0.124	0.0	7.5	0.0	7.5	14.2	O K
720 min Summer	109.843	0.116	0.0	6.7	0.0	6.7	13.3	O K
960 min Summer	109.830	0.103	0.0	5.8	0.0	5.8	11.9	O K
1440 min Summer	109.816	0.089	0.0	4.6	0.0	4.6	10.2	O K
15 min Winter	109.882	0.155	0.0	10.9	0.0	10.9	17.8	O K
30 min Winter	109.913	0.186	0.0	14.3	0.0	14.3	21.3	O K
60 min Winter	109.922	0.195	0.0	15.3	0.0	15.3	22.3	O K
120 min Winter	109.907	0.180	0.0	13.7	0.0	13.7	20.7	O K
180 min Winter	109.891	0.164	0.0	11.9	0.0	11.9	18.8	O K
240 min Winter	109.877	0.150	0.0	10.3	0.0	10.3	17.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	96.276	0.0	19.4	0.0	15
30 min Summer	66.495	0.0	27.5	0.0	23
60 min Summer	43.245	0.0	36.5	0.0	40
120 min Summer	27.402	0.0	46.8	0.0	72
180 min Summer	20.832	0.0	53.6	0.0	102
240 min Summer	17.110	0.0	58.9	0.0	132
360 min Summer	12.934	0.0	66.9	0.0	194
480 min Summer	10.593	0.0	73.2	0.0	254
600 min Summer	9.070	0.0	78.4	0.0	316
720 min Summer	7.987	0.0	82.9	0.0	376
960 min Summer	6.536	0.0	90.5	0.0	498
1440 min Summer	4.922	0.0	102.2	0.0	736
15 min Winter	96.276	0.0	21.9	0.0	15
30 min Winter	66.495	0.0	31.1	0.0	24
60 min Winter	43.245	0.0	41.2	0.0	42
120 min Winter	27.402	0.0	52.7	0.0	74
180 min Winter	20.832	0.0	60.3	0.0	106
240 min Winter	17.110	0.0	66.2	0.0	136

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
360 min Winter	109.858	0.131	0.0	8.3	0.0	8.3	15.1	O K
480 min Winter	109.845	0.118	0.0	6.9	0.0	6.9	13.5	O K
600 min Winter	109.834	0.107	0.0	6.0	0.0	6.0	12.3	O K
720 min Winter	109.826	0.099	0.0	5.4	0.0	5.4	11.3	O K
960 min Winter	109.814	0.087	0.0	4.5	0.0	4.5	10.0	O K
1440 min Winter	109.804	0.077	0.0	3.4	0.0	3.4	8.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
360 min Winter	12.934	0.0	75.3	0.0	198
480 min Winter	10.593	0.0	82.3	0.0	262
600 min Winter	9.070	0.0	88.1	0.0	322
720 min Winter	7.987	0.0	93.2	0.0	382
960 min Winter	6.536	0.0	101.7	0.0	500
1440 min Winter	4.922	0.0	114.8	0.0	736

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	Scotland and Ireland	Cv (Winter)	0.840
M5-60 (mm)	18.500	Shortest Storm (mins)	15
Ratio R	0.263	Longest Storm (mins)	1440
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 0.119

Time From:	**(mins) To:**	**Area (ha)**
0	4	0.119

Time Area Diagram

Total Area (ha) 0.000

Time From:	**(mins) To:**	**Area (ha)**
0	4	0.000

Model Details

Storage is Online Cover Level (m) 110.307

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	11.0
Membrane Percolation (mm/hr)	1000	Length (m)	34.8
Max Percolation (l/s)	106.3	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	109.727	Membrane Depth (m)	0

Pipe Outflow Control

Diameter (m)	0.150	Entry Loss Coefficient	0.500
Slope (1:X)	100.0	Coefficient of Contraction	0.600
Length (m)	7.200	Upstream Invert Level (m)	109.727
Roughness k (mm)	0.600		

Pipe Overflow Control

Diameter (m)	0.100	Entry Loss Coefficient	0.500
Slope (1:X)	33.0	Coefficient of Contraction	0.600
Length (m)	7.300	Upstream Invert Level (m)	110.227
Roughness k (mm)	0.600		

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Appendix D : BAUDER PRODUCT DATA SHEET

BAUDER

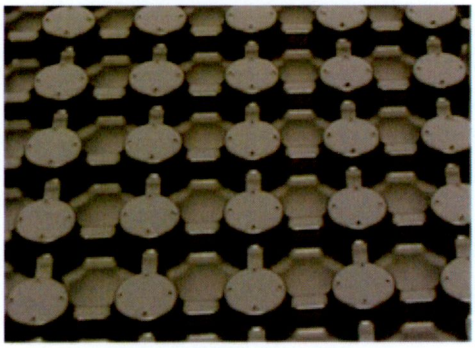
PRODUCT DATASHEET

Bauder DSE60 Drainage and Water Storage Layer

Water storage and multi-directional drainage layer. Used on roofs below 5° pitch.

Intended Use

Provides a pressure resistant stable base for high loads or support for roof mounted equipment without compression to the drainage capacity. If DSE60 is filled with Bauder Mineral Drain, it provides a robust temporary finish able to accept site traffic, including vehicles.



PRODUCT INFORMATION AND TECHNICAL PERFORMANCE			
Characteristic	**Test method**	**Unit**	**Value**
Weight (dry)	DIN EN 1848-1	Kg/m²	2
Weight (filled with mineral drain)		Kg/m²	51.9
Water Storage (when filled with mineral drain)		Ltr	10-12
Depth		mm	60
Size		m	1 x 2
Coverage		m²	2

CERTIFICATION AND ENVIRONMENTAL INFORMATION	
International Standards Organisation (ISO)	ISO 9001:2015 Quality Management Certificates EN1271 (UK) and 70499/03-15_e (Germany). ISO 14001:2015 Environmental Management Certificates A10552 (UK) and 70499/03-15_d (Germany). ISO 50001: 2011 Energy Management Certificate 70499/03-15_c
Recycled content	100% recycled high density polyethylene

INSTALLATION GUIDANCE
Normally installed over a protection layer, sheets are laid open cels down (as above) over entire areas. Butt up each sheet and overlap the lips. See Bauder's Green Roof Installation Guide for full details.

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