



The Tecpro Building,
Clonsaugh Business & Technology Park,
Dublin 17, Ireland.

T: + 353 1 847 4220
F: + 353 1 847 4257
E: info@awnconsulting.com
W: www.awnconsulting.com

SITE SPECIFIC FLOOD RISK ASSESSMENT

for

LOUGHMACASK MASTERPLAN. KILKENNY, CO. KILKENNY

Technical Report Prepared For

Kilkenny County Council

Technical Report Prepared By

Marcelo Allende

BSc, BEng, Senior Environmental Specialist
(Hydrologist)

Teri Hayes

BSc MSc PGeo, Director

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Cork Office

Unit 5, ATS Building,
Carrigaline Industrial Estate,
Carrigaline, Co. Cork.
T: + 353 21 438 7400
F: + 353 21 483 4606

AWN Consulting Limited

Registered in Ireland No. 319812
Directors: F Callaghan, C Dilworth,
T Donnelly, T Hayes, D Kelly, E Porter

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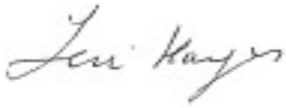
Details	Written by	Approved by
Signature		
Name	Marcelo Allende	Teri Hayes
Title	Senior Environmental Scientist	Director
Date	22 July 2022	22 July 2022

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1.0 INTRODUCTION

1.1 Background

AWN have been requested by Kilkenny County Council to undertake a Site Specific Flood Risk Assessment (SSFRA) for the Masterplan for the Loughmacask development lands in Kilkenny City (as identified in the Kilkenny City & County Development Plan 2021 – 2027).

The circa 150 hectare lands at Loughmacask are located to the northwest of Kilkenny City, immediately north of the River Breagh and either side of the Tullaroan Road. The lands are substantially undeveloped and are within 300m of Irishtown at the north end of the city that leads directly to Parliament Street and High Street in the city centre.

This report has been prepared in accordance with ‘*The Planning System and Flood Risk Management Guidelines for Planning Authorities*’ (2009)¹, published by the Department of Environment, Heritage and Local Government (DoEHLG) of the Masterplan for the Loughmacask development lands.

These Guidelines were issued under Section 28 of the Planning and Development Act 2000 as amended, and require Planning Authorities to introduce flood risk assessment as an integral and leading element of their development planning functions. This is achieved by ensuring that the various steps in the process of making a development plan, together with the associated Strategic Environmental Assessment (SEA), are supported by an appropriate Site Specific Flood Risk Assessment (SSFRA).

The *Kilkenny City and County Development Plan 2021-2027* already provides for land use, zoning and objectives for the Loughmacask area. The development plan also includes a specific objective (Z8 – City Zoning Objectives) to prepare a masterplan for the Loughmacask area. It is noted that during its preparation the Kilkenny City and County Development Plan 2021-2027, including the Loughmacask area, was subject to SEA, Appropriate Assessment (AA) and (SFRA)².

This report should be read in conjunction with the Loughmacask Masterplan, the SEA Environmental Report and the AA Natura Impact Report (NIR).

1.2 Purpose of Site Specific Flood Risk Assessment

In line with the Guidelines, SSFRAs should be undertaken for a scale of master plans and individual site planning applications. The purpose of this SSFRA is to assess all types of flood risk for a new development. A SSFRA identifies the sources of flood risk, the effects of climate change on this, the impact of the development, the effectiveness of flood mitigation and management measures and the residual risks that remain after those measures are put in place.

Note: The SSFRA is a live document that is designed to be updated as further flood risk information becomes available and changes to the development plan are proposed under any variations. Accordingly, all information in relation to flood risk is provided for general

¹ <https://www.gov.ie/en/publication/7db50-the-planning-system-and-flood-risk-management-guidelines-for-planning-authorities-nov-09/>

² <https://www.kilkennycoco.ie/eng/services/planning/development-plans/city-and-county-development-plan/adopted-city-and-county-development-plan.html>

policy guidance only. It may be altered in light of future data and analysis. As a result, all landowners and developers are advised to take all reasonable measures to assess the vulnerability to flooding of lands in which they have an interest prior to making planning or development decisions.

2.0 THE LOUGHMACASK MASTERPLAN

Land use objectives have been established for the Loughmacask area of Kilkenny City in the *Kilkenny City and County Development Plan 2021-2027*, refer to Figure 2.1 below. However, the development plan also includes a specific objective (Z8 – City Zoning Objectives) to prepare a masterplan for the Loughmacask area.

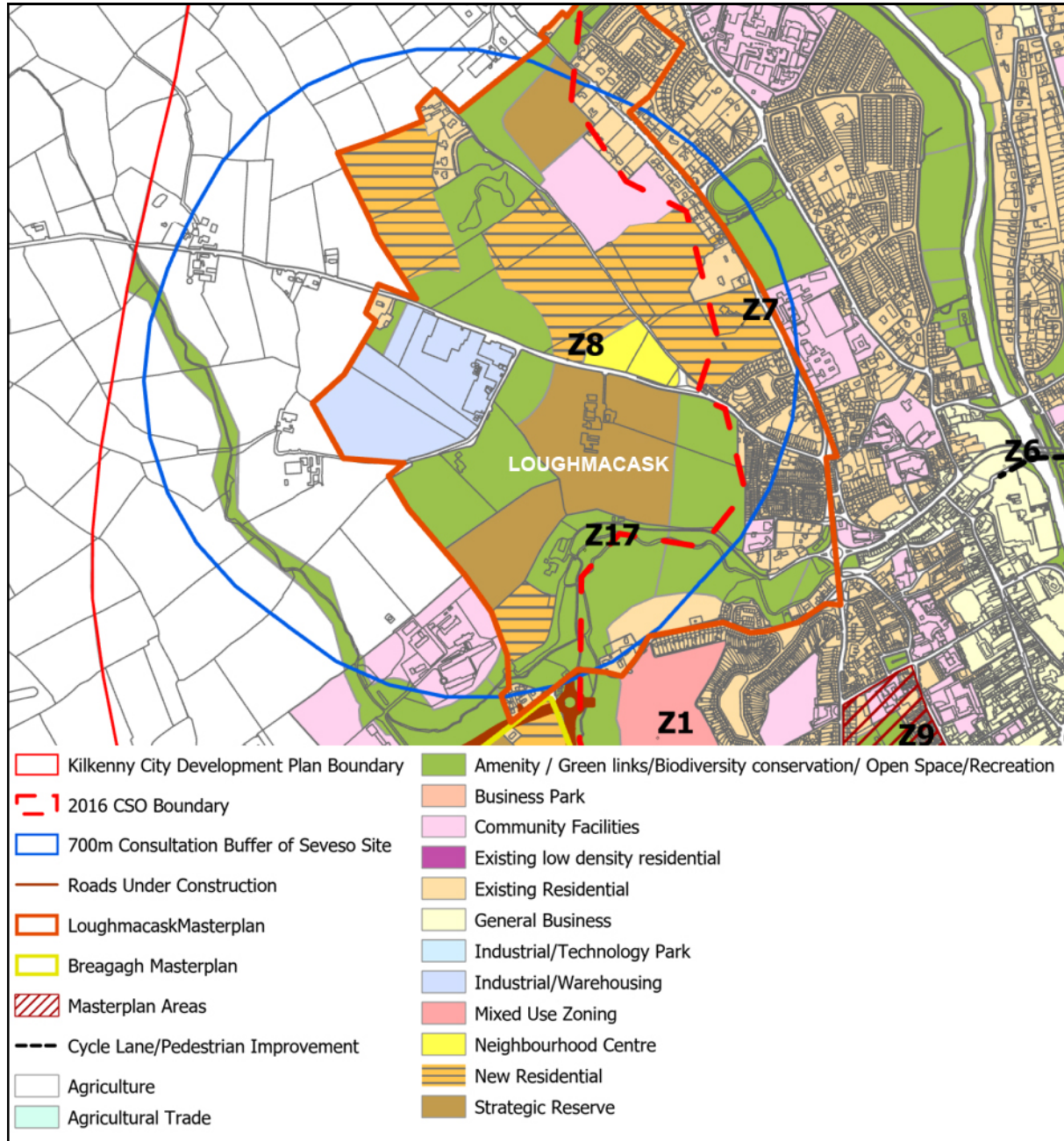


Figure 2.1 Land Use Zoning (Kilkenny City and County Development Plan 2021-2027)

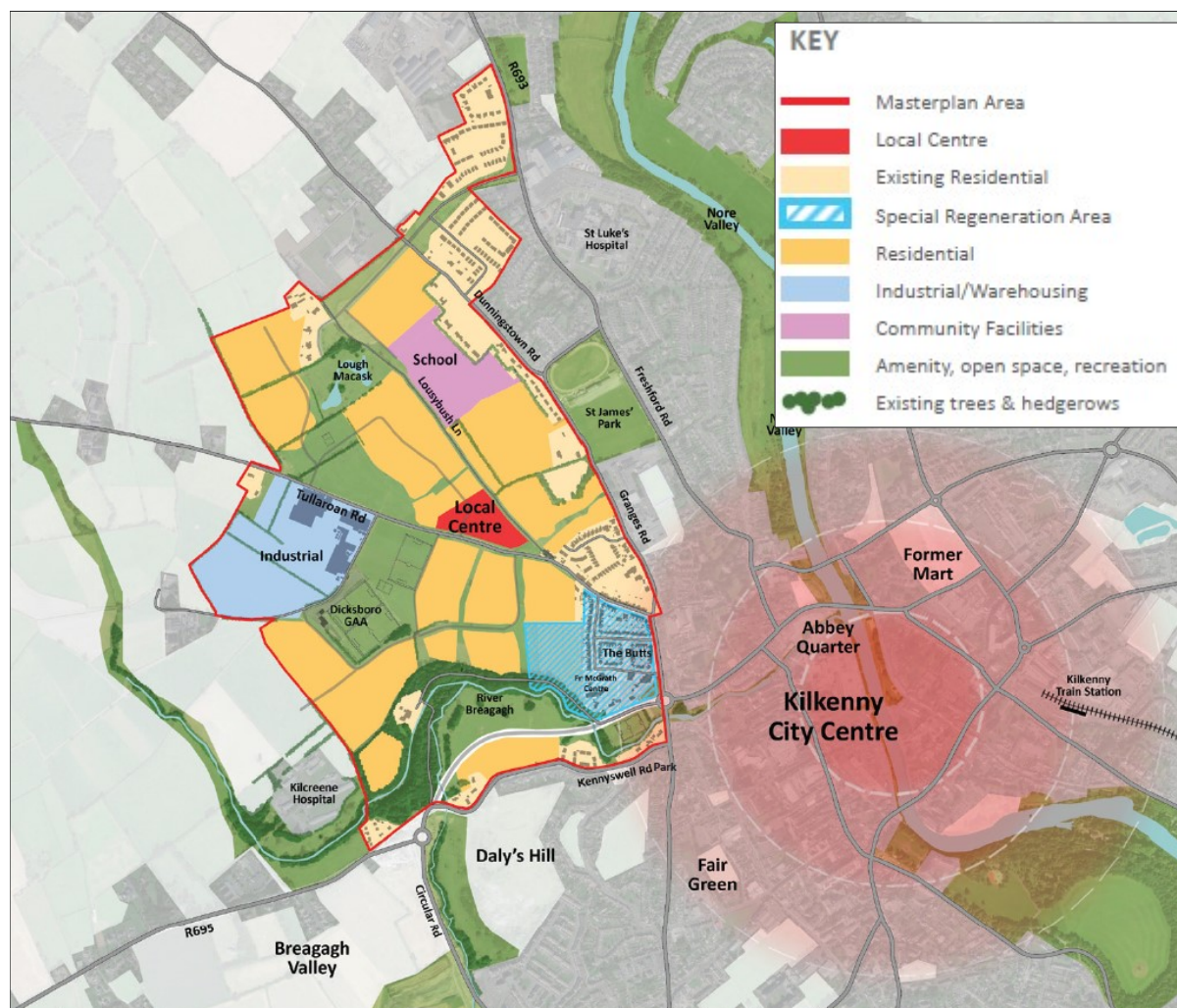
The Loughmacask Masterplan seeks to provide:

- Distinctive and vibrant neighbourhood, building on the existing locality and communities and providing an excellent quality of life with urban and rural amenities.

-
- A walkable urban quarter with day-to-day facilities and amenities within a 10 minute walk or cycle of homes - reducing private transport dependency and strengthening local communities.
 - A new urban quarter that expands on and is integrated with the historic city centre as well as the natural landscape of the Nore and Breagagh river corridors.
 - Excellent provision of open space, green networks and local facilities that cater for local need, foster community growth and support health and well-being.
 - Responds to climate change, through sustainable transport, energy efficient building technologies, and a strong green infrastructure network including sustainable drainage (SuDS) utilising soakaways, swales, infiltration trenches, ponds and wetlands where feasible, to assist with flood management.

In order to achieve the above-stated vision, the Masterplan has set out the following key principles, which have been informed the proposed land use approach (refer to Figure 2.2 below):

- Compact growth and integration;
- Land use;
- 10-minute city quarter;
- Access and movement.

Figure 2.2 Proposed Land Use Zoning (Loughmacask Masterplan)

In terms of residential development, it is estimated that the Loughmacask development lands have the potential to deliver 904 residential units. The Development Plan requires (under Objective C6B) that 10% of land zoned for residential use, or for mixed residential and other uses, be made available for the provision of social housing. It is also required that all new private residential developments on lands zoned in excess of 20 units provide for a minimum of 10% units that can be converted to universal design standards.

The Masterplan has defined distinct residential areas, as follows:

- Loughmacask Village, immediately south and north-west of the local centre;
- Ayersfield, immediately north and south-east of the school and adjoining the existing Ayrfield residential development;
- Kilcreen, between Dicksboro GAA / industrial area and the Breagagh corridor;
- Crokers Hill, immediately south of the Central Access Scheme and Breagagh corridor;
- Lousybush, north-west of Lough Macask; and
- Kilcreen Woods, between Kilcreen and the Breagagh corridor.

The Breaghagh Valley Park, will be developed within the existing green area between the Breaghagh River and the Central Access Scheme to the south, with pedestrian and cycle links provided to connect the residential areas of Loughmacask with the park.

3.0 FLOOD RISK PRINCIPLES

The Flood Risk Guidelines describe flooding as a natural process that can occur at any time and in a wide variety of locations. Flooding can often be beneficial, and many habitats rely on periodic inundation. However, when flooding interacts with human development, it can threaten people, their property and the environment. This Section will firstly outline the definitions of flood risk and the Flood Zones used as a planning tool; a discussion of the principles of the Guidelines and the management of flood risk in the planning system will follow.

3.1 Definition of Flood Risk

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

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

The assessment of flood risk requires an understanding of the sources, the flow path of floodwater and the people and property that can be affected. This Source-Pathway-Receptor model is shown below in Figure 3.1 and is a widely used environmental model to assess and inform the management of risk.

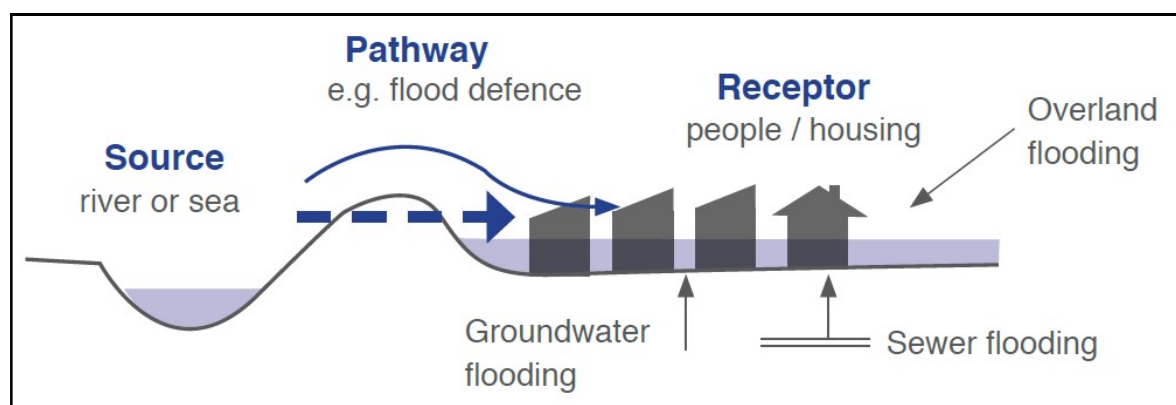


Figure 3.1 Source-Pathway-Receptor Model (OPW, 2009)

The principal sources of flooding are rainfall or higher than normal sea levels while the most common pathways are rivers, drains, sewers, overland flow and river and coastal floodplains and their defence assets. Receptors can include people, their property and the environment. All three elements must be present for flood risk to arise.

Mitigation measures, such as defences or flood resilient construction, have little or no effect on sources of flooding but they can block or impede pathways or remove receptors.

3.2 Likelihood of Flooding

Likelihood or probability of flooding of a particular flood event is classified by its annual exceedance probability (AEP) or return period (in years). A 1% AEP flood indicates the flood event that will occur or be exceeded on average once every 100 years and has a 1 in 100 chance of occurring in any given year. Annual exceedance probability is the inverse of return period as shown in Table 3.1 below.

Table 3.1 Probability of Flooding (OPW, 2009)

Return Period (Years)	Annual Exceedance Probability (%)
2	50
100	1
200	0.5
1,000	0.1

Considered over the lifetime of development, an apparently low-frequency or rare flood has a significant probability of occurring. For example:

- A 1% flood has a 22% (1 in 5) chance of occurring at least once in a 25-year period - the period of a typical residential mortgage;
- And a 53% (1 in 2) chance of occurring in a 75-year period - a typical human lifetime.

3.3 Consequences of Flooding

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

In case of groundwater flooding, it should be noted that groundwater flooding tends to be very local and results from interactions of site-specific factors such as tidal variations. While water level may rise slowly, it may be in place for extended periods of time. Hence, such flooding may often result in significant damage to property rather than be a potential risk to life.

The Flood Risk Guidelines have categorised land uses into three vulnerability classes and have also specified which vulnerability class would be appropriate in each flood zone, or where the Justification Test would be required, refer to Table 3.2 below.

Table 3.2 Classification of Vulnerability of different Types of Development (OPW, 2009)

Vulnerability Class	Land Uses and Types of Development which include:
Highly vulnerable development (including essential infrastructure)	<ul style="list-style-type: none"> • Garda, ambulance and fire stations and command centres required to be operational during flooding; • Hospitals; • Emergency access and egress points; • Schools; • Dwelling houses, student halls of residence and hostels; • Residential institutions such as residential care homes, children's homes and social services homes; • Caravans and mobile home parks; • Dwelling houses designed, constructed or adapted for the elderly or, other people with impaired mobility; and • Essential infrastructure, such as primary transport and utilities distribution, including electricity generating power stations and sub-stations, water and sewage treatment, and potential significant sources of pollution (SEVESO sites, IPPC sites, etc.) in the event of flooding.
Less vulnerable development	<ul style="list-style-type: none"> • Buildings used for: retail, leisure, warehousing, commercial, industrial and non-residential institutions; • Land and buildings used for holiday or short-let caravans and camping, subject to specific warning and evacuation plans; • Land and buildings used for agriculture and forestry; • Waste treatment (except landfill and hazardous waste); • Mineral working and processing; and • Local transport infrastructure.

<p>Water-compatible development</p>	<ul style="list-style-type: none"> • Flood control infrastructure; • Docks, marinas and wharves; • Navigation facilities; • Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location; Water-based recreation and tourism (excluding sleeping accommodation); • Lifeguard and coastguard stations; • Amenity open space, outdoor sports and recreation and essential facilities such as changing rooms; and • Essential ancillary sleeping or residential accommodation for staff required by uses in this category (subject to a specific warning and evacuation plan).
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With regard to the Masterplan, its residential zones are considered to be ‘Highly Vulnerable’. On the other hand, the zone adjacent to the River Breagagh (River Breagagh Park) is considered to be a ‘Water-Compatible Development’ as it is an amenity open space.

3.4 Definition of Flood Zones

In the Guidelines, the likelihood of a flood occurring is established through the identification of Flood Zones which indicate a high, moderate, or low risk of flooding from fluvial or tidal sources, as defined as follows:

- *Flood Zone A* - Where the probability of flooding is highest (greater than 1% AEP or 1 in 100 for river flooding and 0.5% AEP or 1 in 200 for coastal flooding) and where a wide range of receptors would be vulnerable.
- *Flood Zone B* - Where the probability of flooding is moderate (between 0.1% AEP or 1 in 1000 and 1% AEP or 1 in 100 for river flooding and between 0.1% AEP or 1 in 1000 year and 0.5% AEP or 1 in 200 for coastal flooding); and
- *Flood Zone C* - Where the probability of flooding is low (less than 0.1% AEP or 1 in 1000 for both river and coastal flooding).



Figure 3.2 Indicative Flood Zone Map (OPW, 2009)

The flood zones described above are indicative of river and coastal flooding only. They should not be used to suggest that any areas are free from flood risk, since they do not

include the effects of other forms of flooding such as from groundwater or artificial drainage systems.

3.5 The Sequential Approach

The sequential approach in terms of flood risk management is based on the following principles: AVOID - SUBSTITUTE - JUSTIFY - MITIGATE – PROCEED (refer to Figure 3.3 below).

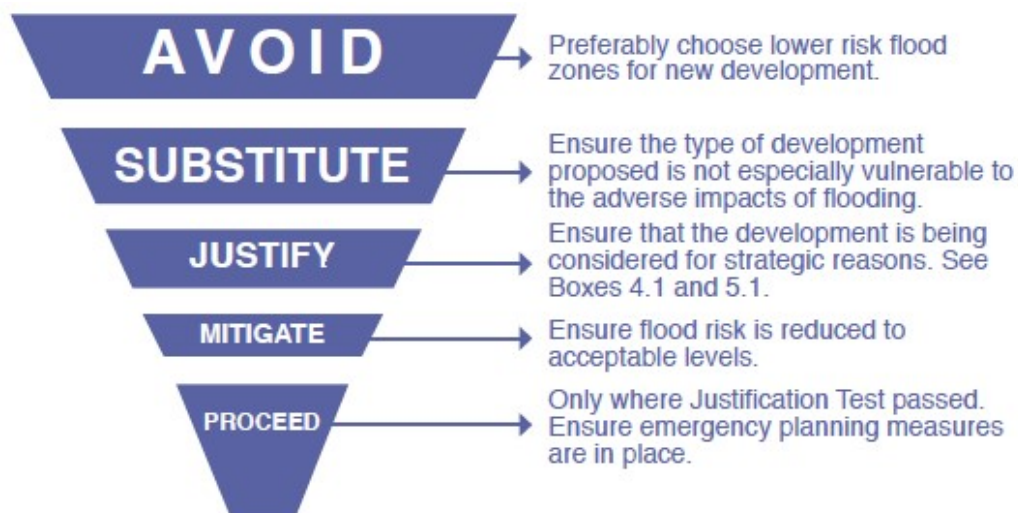


Figure 3.3 Sequential approach principles in flood risk management (OPW, 2009)

The primary objective of the sequential approach is that development is primarily directed towards land that is at low risk of flooding (Avoid). The next stage, and only where avoidance is not possible, is to ensure that the type of development proposed is not especially vulnerable to the adverse impacts of flooding (Substitution).

Where possible, development in areas identified as being at flood risk should be avoided; this may necessitate de-zoning lands within the development plan. If de-zoning is not possible, then rezoning from a higher vulnerability land use, such as residential, to a less vulnerable use, such as open space may be required.

Where rezoning is not possible, exceptions to the development restrictions are provided for through the application of the Justification Test. Many towns have central areas that are affected by existing flood risk and have been targeted for growth. To allow the sustainable and compact development of these urban centres, development in areas of flood risk may be considered necessary. For development in such areas to be allowed, the Justification Test must be passed.

The Justification Test has been designed to rigorously assess the appropriateness, or otherwise, of such developments. The test is comprised of two processes; the Plan-making Justification Test, and the Development Management Justification Test. The latter is used at the planning application stage where it is intended to develop land that is at moderate or high risk of flooding for uses or development vulnerable to flooding that would generally be considered inappropriate for that land, and where the Plan-making Justification Test has already been applied and passed as part of this SSFRA process.

Table 3.3 below shows which types of development, based on vulnerability to flood risk, are appropriate land uses for each of the Flood Zones. The aim of the SSFRA is to guide development zonings to those which are 'appropriate' and thereby avoid the need to apply the Justification Test.

Table 3.3 Matrix of Vulnerability Classes and Flood Zones

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

3.6 Development Management Justification Test

Only the Development Management Justification Test is relevant to the SSFRA for the Loughmacask Masterplan. The process is described in Table 3.4 below.

Table 3.4 Justification Test for Development Management (OPW, 2009)

Justification Test for Development Management
<p>“When considering proposals for development, which may be vulnerable to flooding, and that would generally be inappropriate as set out in Table 3.2, the following criteria must be satisfied:</p> <ol style="list-style-type: none"> 1) The subject lands have been zoned or otherwise designated for the particular use or form of development in an operative development plan, which has been adopted or varied taking account of these Guidelines. 2) The proposal has been subject to an appropriate flood risk assessment that demonstrates: <ol style="list-style-type: none"> a. The development proposed will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk; b. The development proposal includes measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible; c. The development proposed includes measures to ensure that residual risks to the area and/or development can be managed to an acceptable level as regards the adequacy of existing flood protection measures or the design, implementation and funding of any future flood risk management measures and provisions for emergency services access; d. The development proposed addresses the above in a manner that is also compatible with the achievement of wider planning objectives in relation to development of good urban design and vibrant and active streetscapes; e. There are no suitable alternative lands for the particular use or development type, in areas at lower risk of flooding within or adjoining the core of the urban settlement. <p>N.B. The acceptability or otherwise of levels of residual risk should be made with consideration of the type and foreseen use of the development and the local development context.”</p>

The decision to *PROCEED* should only be taken after the Justification Test has been passed.

3.7 Stages of a Flood Risk Assessment (FRA)

The OPW Guidelines recommend that a staged approach is adopted when undertaking a Flood Risk Assessment (FRA). The recommended stages are:

- **Stage 1 – Flood Risk Identification:** To identify whether there may be any flooding or surface water management issues that will require further investigation. This stage comprised a comprehensive desk study of available information to establish whether a flood risk issue exists or whether one may exist in the future. The sources consulted are described in detail in Section 5 below.
- **Stage 2 – Initial Flood Risk Assessment:** If a flood risk issue is deemed to exist arising from the Stage 1 Flood Risk Identification process, the assessment proceeds to Stage 2 which confirms the sources of flooding, appraises the adequacy of existing information and determines the extent of additional surveys and the degree of modelling that will be required. Stage 2 must be sufficiently detailed to allow the application of the sequential approach (as described in Section 2.6) within the flood risk zone. For the purposes of this SFRA, Stage 2 was carried out for the proposed Masterplan as described in Section 5 below.
- **Stage 3 – Detailed Flood Risk Assessment:** A detailed FRA is carried out where necessary to assess flood risk issues in sufficient detail and to provide a quantitative appraisal of potential flood risk. No flood risk issues, which were significant enough to warrant Stage 3, were identified in the Loughmacask area. The CFRAM study covered the area in detail.

4.0 CURRENT STATE OF THE RECEIVING ENVIRONMENT

4.1 The Study Area

The circa 150 hectare lands at Loughmacask are located to the northwest of Kilkenny City, immediately north of the River Breagagh and on either side of the Tullaroan Road. The lands are substantially undeveloped and are within 300m of Irishtown at the north end of the city that leads directly to Parliament Street and High Street in the city centre, refer to Figure 4.1 below.

The lands are bound by the Dunningstown and Granges Road to the north, to the east and southeast by Kilkenny city, and by the River Breagagh Valley and Kennyswell Road to the south. The western and northern extents adjoin rural agricultural lands. Loughmacask derives its name from Lough Macask which is a small wetland at the northern end of Lousybush Lane between the Tullaroan and Dunningstown roads. Lough Macask is a proposed Natural Heritage Area (pNHA) which is located within the more elevated northern part of the lands and is a localised shallow wetland area that fluctuates depending on rainfall and groundwater.

The lands at Loughmacask generally rise in a north westerly direction from the city and River Breagagh Valley. The sloping terrain is further characterised by localised hillocks, hollows and wetland areas. The lands are mostly in agricultural use. The River Breagagh Valley is lined by substantial mature mixed woodland planting.



Figure 4.1 Loughmacask Masterplan Study Area

4.2 Likely Evolution of the Environment in the Absence of the Masterplan

The preparation of a Masterplan for the Loughmacask area is an objective (Z8 – City Zoning Objectives) of the *Kilkenny City and County Development Plan 2021-2027*. However, the Development Plan incorporates land use, zoning (including for permitted development) and objectives for the area, which if the Masterplan is not progressed outlines a sustainable planning and development strategy for the area. The Development Plan also notes that no significant development has taken place in Loughmacask due to the lack of waste water infrastructure in the area and accessibility issues.

Therefore, while higher level environmental protection objectives – such as those of Kilkenny City and County Development Plan and various EU Directives and transposing Irish Regulations – would still apply, the absence of the Masterplan would mean that new development would be less coordinated and controlled. Less coordinated and controlled development would be less certain to result in the positive effects provided for by the Masterplan.

4.3 Description of Environmental Baseline

The Loughmacask Masterplan area is situated on the western periphery of Kilkenny City, the largest urban centre in the County and the seat of local government. As detailed above,

it has been earmarked by the Local Authority, Kilkenny County Council, to be developed as a new residential neighbourhood delivering c. 904 residential units. The development lands are predominantly comprised of intensive agricultural land, but also contain existing residential areas along the eastern margin, an existing industrial facility (Grassland Fertilisers, a SEVESO III site), sports grounds (including Dicksboro GAA), and two distinct pockets of semi-natural habitats / 'green infrastructure' at Lough Macask and in the riparian corridor of the River Breagagh. 'The Butts', a 20th century residential development and early example of Local Authority housing, is situated in the south-eastern portion of the Masterplan area, at its interface with the city centre. Other existing residential developments are situated on Lord Edward Street and Lousybush Lane; and at Ayrfield, Talbot's Court and Talbot's Gate.

The landbank is bordered by Kilkenny City immediately to the east, by the River Breagagh corridor to the south, and by rural hinterland to the west and north. The lands generally rise in a north-westerly direction, affording vistas of Kilkenny City, with localised undulations. Kilkenny Airfield or aerodrome is situated c. 1 km south-west of the Masterplan lands. There is a limestone quarry c. 900 m to the west.

Kilkenny City is served by rail, being situated on the Dublin – Waterford and Waterford – Limerick Junction lines. The station, Kilkenny (MacDonagh), is situated on the Dublin Road, approx. 1.3 km south-east of the nearest point in the Masterplan area. At present, the Masterplan lands are served by the existing road infrastructure, principally the Granges Road, Dunningstown Road, Lord Edward Street, Tullaroan Road (which bisects the lands), Lousybush Lane, Water Barrack and Kenny's Well Road.

4.4 Hydrology and Hydrogeology

The Water Framework Directive (WFD) Directive 2000/60/EC was adopted in 2000 as a single piece of legislation covering rivers, lakes, groundwater and transitional (estuarine) and coastal waters. In addition to protecting said waters, its objectives include the attainment of 'Good Status' in water bodies that are of lesser status at present and retaining 'Good Status' or better where such status exists at present.

The WFD requires 'Good Water Status' for all European waters to be achieved through a system of river basin management planning and extensive monitoring by 2015 or, at the least, by 2027. 'Good status' means both 'Good Ecological Status' and 'Good Chemical Status'. In 2009 the ERBD River Basin Management Plan (RBMP) 2009-2015 was published. In the ERBD RBMP, the impacts of a range of pressures were assessed including diffuse and point pollution, water abstraction and morphological pressures (e.g., water regulation structures). The purpose of this exercise was to identify water bodies at risk of failing to meet the objectives of the WFD by 2015 and include a programme of measures to address and alleviate these pressures by 2015. This was the first River Basin Management planning cycle (2010-2015). The second cycle river basin management plan for Ireland is currently in place and will run between 2018-2021 with the previous management districts now merged into one Ireland River Basin District (Ireland RBD).

The primary aim of the plan is that Water bodies identified as being '*At Risk*' of not achieving their environmental objectives need to have targeted measures implemented to achieve objectives under this Plan. 190 Areas for Action were identified across the 5 Local Authority regions. Within these 190 areas, a total of 726 water bodies were selected for initial actions during this RBMP cycle. There are 832 water bodies identified as being '*At Risk*' of not achieving their environmental objectives under this Plan that have not been included in the Areas for Action. For most of these water bodies, targeted actions will be undertaken in the third cycle RBMP from 2022-2027. The draft third cycle RBMP has been reviewed in the context of ensuring mitigation measures comply with current and expected

future measures required to be implemented for protection of water body status within the context of the proposed development. Areas for Action have proposed for inclusion in the third-cycle draft River Basin Management Plan (RBMP) which includes the River Breagagh for restoration which will be managed by the Local Authority Waters Programme (LAWPRO).

The strategies and objectives of the WFD in Ireland have influenced a range of national legislation and regulations. These include the following:

- European Communities (Water Policy) Regulations, 2003 (S.I. No. 722 of 2003, amended by S.I. No. 350 of 2014);
- European Communities (Drinking Water) Regulations 2014 (S.I. 122 of 2014, amended by S.I. No. 464 of 2017);
- European Communities Environmental Objectives (Surface Waters) Regulations, 2009 (S.I. No. 272 of 2009, amended by SI No. 77 of 2019)
- European Communities Environmental Objectives (Groundwater) Regulations, 2010 (S.I. No. 9 of 2010, amended by S.I. No. 366 of 2016);
- European Union (Good Agricultural Practice for Protection of Waters) Regulations 2022 (S.I. No. 113 of 2022);
- European Communities (Technical Specifications for the Chemical Analysis and Monitoring of Water Status) Regulations, 2011 (S.I. No. 489 of 2011)
- European Communities (Quality of Salmonid Waters) Regulations 1988 (S.I. No. 293 of 1988);
- Local Government (Water Pollution) Act, 1977 (Water Quality Standards For Phosphorus) Regulations, 1998 (S.I. No. 258 of 1988).

The Masterplan area is located within the former South-Eastern RBD. River Basin Management Plans have been prepared for each RBD which are being implemented in order to help protect and improve all waters. The Management Plans provides specific policies for individual river basins in order to implement the requirements of the WFD.

The Masterplan area is situated in the Nore_SC_090 Water Framework Directive (WFD) subcatchment, within the greater Nore WFD catchment.

In terms of groundwater, the Masterplan area is predominantly underlain by a regionally important, karstified, gravel aquifer, the Killkenny-Ballynakill Gravels (WFD code IE_SE_G_163). This groundwater body has been consistently rated as having 'good' status for all parameters, and is 'not at risk' of failing to achieve its WFD objectives / good status by 2027. The groundwater vulnerability is predominantly rated as being 'high' across the Masterplan area.

The River Nore within and in the vicinity of Kilkenny City is listed on the Register of Protected Areas for the following:

- SAC and SPA designations;
- Salmonid River;
- Nutrient Sensitive River (downstream of the City only); and
- Groundwater for Drinking Water.

The River Breagagh (WFD code BREGAGH (KILKENNY) 030) traverses the southern portion of the Masterplan area before entering the River Nore (WFD code NORE_170) a distance of c. 650 m east of the Masterplan area boundary. Where it passes through the Masterplan area, the River Breagagh is of 'poor' status (WFD 2013 – 2018) and 'at risk' of failing to achieve its WFD objectives / good status by 2027. The associated identified

significant pressures are industry, hydromorphology (channelisation and embankments) and pastoral agriculture. The River Nore is of consistently 'good' status, with its level of risk is 'not at risk' at present.

Article 5 of the Surface Water Regulations (S.I. 272 of 2009 and SI No. 77 of 2019 amendment) requires that a public authority shall not knowingly cause or allow deterioration in the chemical or ecological status of a body of surface water. Article 28(2) states that a surface water body whose status is determined to be less than good shall be restored to at least good status. Construction works adjacent to the river should have regard to Inland Fisheries Ireland's Guidelines on Protection of Fisheries during construction works in and adjacent to Waters (2016).

The protection of the River Breagagh as an angling resource, as well as being important for the water environment, is also of significance for its recreational, cultural and landscape value.

Aquifer vulnerability is a term used to represent the intrinsic geological and hydrological characteristics that determine the ease with which groundwater may be contaminated generally by human activities. The GSI (2022) guidance presently classifies the bedrock aquifer in the region of the Masterplan Area as having mainly 'High' vulnerability possibly due to the presence of a gravel aquifer underlying the zone.

5.0 SITE SPECIFIC FLOOD RISK ASSESSMENT OF THE LOUGHMACASK MASTERPLAN

5.1 Stage 1 – Identification of Flood Risk

As mentioned above, the objective of this stage is to undertake a desk-based exercise based on existing information. Flood risk identification uses existing and recorded information to identify whether there may be any flooding or surface water management issues related to the site. The potential sources of flooding to any site are varied and can include one or more of the following:

- Flooding from rivers (fluvial);
- Flooding from the sea or tidal (coastal);
- Flooding from land (pluvial);
- Flooding from groundwater and karst;
- Flooding from sewers; and
- Flooding from manmade impoundments (reservoirs, canals, and other artificial sources).

5.1.1 OPW Publications

The Office of Public Works (OPW) is the lead Authority on flooding in the Country. The OPW commissioned a South Eastern Catchment Flood Risk Assessment and Management (CFRAM) Study, which included Kilkenny City. The study was finalised in 2016, with flood maps and supporting reports available on-line (www.floodinfo.ie). A Strategic Flood Risk Assessment (SFRA) has been carried out for the purposes for the Kilkenny City & County Development Plan 2021 – 2027. These studies have been used to provide the majority of the baseline data for this Site Specific Flood Risk Assessment (SSFRA).

To comply with the 'Floods' Directive³, the OPW commenced a CFRAM (Catchment Flood Risk Assessment and Management) programme in Ireland in 2011. The first cycle of the CFRAM Programme comprised three phases:

- The Preliminary Flood Risk Assessment (PFRA): 2011.
- The CFRAM Studies and parallel activities: 2011-2015.
- Implementation and Review: 2016 onwards.

The Programme provides for three main consultative stages:

- 2011 Preliminary Flood Risk Assessments.
- 2013 Flood Hazard Mapping.
- 2015 Flood Risk Management Plans.

The OPW are now into cycle two of the CFRAM, which includes detailed design of specific flood relief schemes in various towns and cities. The settlements earmarked for flood relief schemes in Kilkenny are: Ballyhale, Freshford, Graiguenamanagh, Inistioge, Piltown and Thomastown. An update to the PFRA mapping, known as the National Indicative Flood Maps, or NIFM, was carried to produce higher resolution broadscale mapping across the whole country. These indicative maps were published recently and were taken into account in this assessment.

³ Directive 2007/ 60/ EC of the European Parliament and of the Council of 23rd October 2007 on the assessment and management of flood risk: Official Journal L288/ 27-34.

Advice on the expected impacts of climate change and the allowances to be provided for future flood risk management in Ireland is given in the OPW draft guidance. Two climate change scenarios are considered; these are the Mid-Range Future Scenario (MRFS) and the High-End Future Scenario (HEFS). The MRFS is intended to represent a "likely" future scenario based on the wide range of future predictions available. The HEFS represents a more "extreme" future scenario at the upper boundaries of future projections. Both MRFS and HEFS model runs have been completed on all study watercourses, providing flood extent and depth maps. However, the River Breagagh has not yet been included in this programme. For watercourses that are not part of the CFRAM programme, fluvial flood extents were qualitatively assessed by using the Flood Zone B outline as a surrogate for 'Flood Zone A with allowance for the possible impacts of climate change', as suggested in the 'Planning System and Flood Risk Management' Guidelines.

As part of the National Flood Risk Management Policy, the OPW developed the www.floodinfo.ie web-based data set, which contains information concerning historical flood data, displays related mapped information and provides tools to search for and display information about selected flood events.

5.1.2 SFRA for Kilkenny City and County Development Plan 2021

The Kilkenny City & County Development Plan SFRA Flood Zone maps have been developed using the most appropriate data available at the time of preparing the Development Plan. The Flood Zone maps have been created specifically to inform the application of the Justification Test and to guide development policy within the County and have been through several iterations of review and are now considered to be fit for purpose. However, it should be borne in mind that the input data was developed at a point in time and there may be changes within the catchment that mean a future study, or more localised assessment of risk may result in a change in either flood extent or depth. This means a site-specific flood risk assessment may result in locally appropriate information which could show a greater or lesser level of risk than is included in the Flood Zone maps.

It is important to note that the Flood Zones do not take into account the benefits of flood defences. The sequential approach and Justification Test should be applied using the undefended outlines, but the benefits of the defences can be used to inform the requirements for detailed flood risk assessment and development design, if the Justification Test for plan making has been passed.

The SFRA for Kilkenny Development Plan considered a flood relief scheme which was completed in Kilkenny city in 2005 to provide defence against the 100 year flood from the Nore. A report entitled Kilkenny City Flooding Study was published in 1986 by M.C. O'Sullivan. A subsequent report was published by the OPW in 1999, entitled Kilkenny City Flood Relief Scheme Engineering Report – Protecting against the 100 year flood. The benefiting lands map for the Kilkenny Scheme Design was obtained from the OPW. The benefiting land outline generally equates to the 100 year flood outline or Flood Zone A. This map covers the centre of Kilkenny City, mainly around the Nore, but also with some coverage of the Breagagh.

Figures 5.1 provides an excerpt from Figure 23B of the SFRA, showing Flood Zones A and B overlain on the Development Plan land use zoning, as adopted. As mentioned above, Flood Zone A refers to areas where the probability of flooding from rivers is greater than 1% AEP or 1 in 100 year for river flooding, or 0.5% AEP or 1 in 200 for coastal flooding. Flood Zone B refers to areas where the probability of flooding from rivers and seas is up to 0.1% AEP or 1 in 1000. The rest of the map shows Flood Zone C, where there is less than a 0.1% AEP or 1 in 1000 chance of flooding.

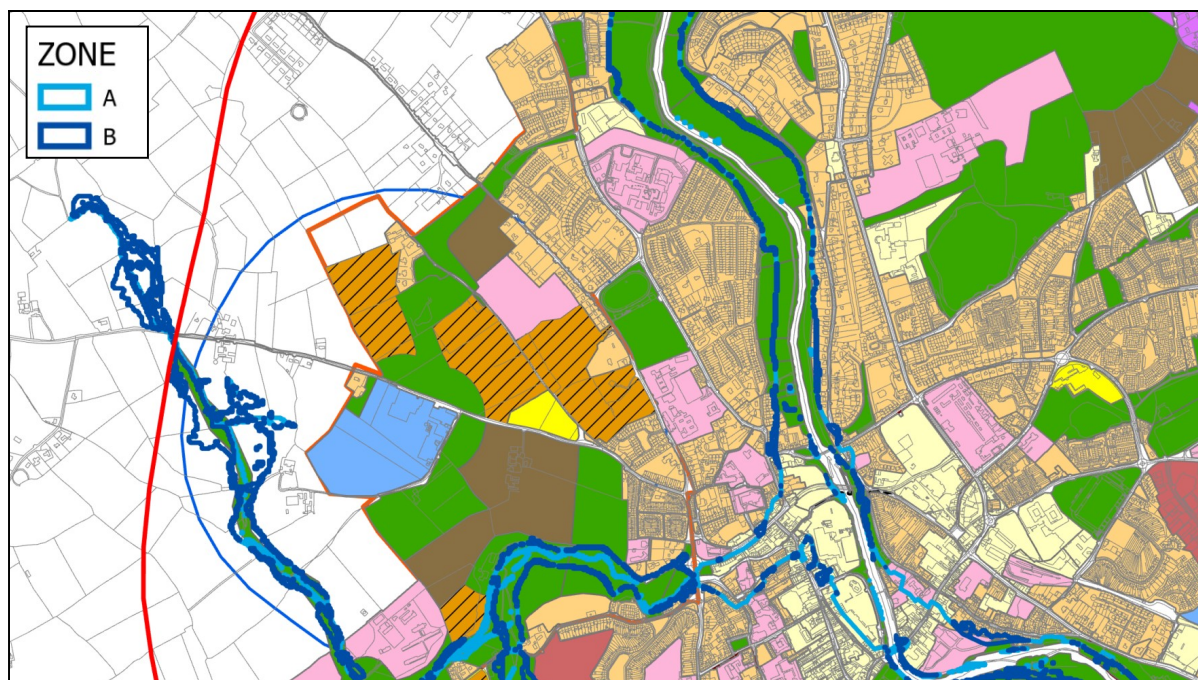


Figure 5.1 Flood Zones A and B in relation to the Masterplan area (Kilkenny County Council, 2021)

5.1.3 GSI Groundwater Flooding Probability Maps

The Geological Survey Ireland (GSI) have developed Groundwater Flood Maps for the Republic of Ireland. The maps were developed in as part of the 2016-2019 GW Flood project in collaboration with Trinity College Dublin and the Institute of Technology Carlow⁴.

The remit of this project was to advance understanding of karst groundwater flooding in Ireland, address the deficit of data available, and enable local and national authorities to make scientifically informed decisions regarding groundwater flood risk management in karst areas.

The Groundwater Flood Probability Maps show the probabilistic flood extent of groundwater flooding in limestone and karstic regions. These maps are focussed primarily (but not entirely) on flooding at seasonally flooded wetlands known as turloughs. It should be noted that the predictive maps are limited to locations where the flood pattern was detectable and capable of being hydrologically modelled to a sufficient level of confidence.

The Groundwater Flooding Probability map shows the expected flood extent of groundwater flooding for annual exceedance probabilities (AEP's) of 0.1% 1% and 10%, which correspond with a return period of every 1000, 100 and 10 years, respectively. The map was created using groundwater levels measured in the field, satellite images and hydrological models.

With regard to the Masterplan Area, it is known that localised groundwater flooding is known to occur at Loughmacask within the area, producing the fluctuating waterbody at this location, which has been designated as a proposed Natural Heritage Area (pNHA).

⁴ GW Flood Project: Monitoring, Modelling and Mapping Karst Groundwater Flooding in Ireland. Geological Survey Ireland. Version 1.2. August 2020.

Figure 5.2 and 5.3 below show the extension of the groundwater flooding for different AEP (0.1% and 1%) and with the context of local geology. It should be noted that while water level may rise slowly, it may be in place for extended periods of time. Hence, such flooding may often result in significant damage to property rather than be a potential risk to life.



Figure 5.2 GSI Groundwater Flooding Zones for 1% and 0.1% AEP

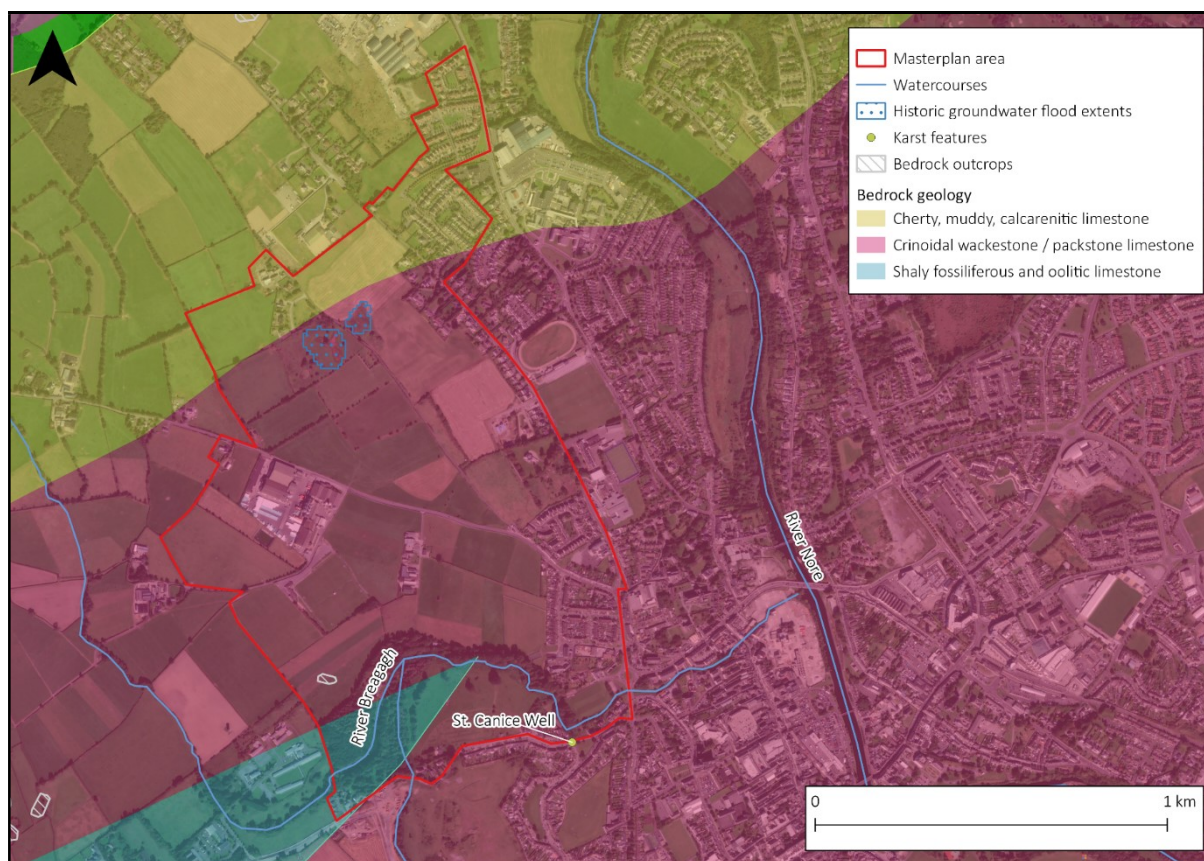


Figure 5.3 Historic Groundwater Flooding Zones and Geological context

5.1.4 Pluvial Flooding

Flooding of land from surface water runoff is usually caused by intense rainfall that may only last a few hours. The resulting water follows along natural valley lines, creating flow paths along roads and through and around developments and ponding in low spots, which often coincide with fluvial floodplains. Any areas at risk from fluvial flooding will almost certainly be at risk from surface water flooding.

The PFRA study considered pluvial flood risk and produced a national set of pluvial flood maps. This dataset was reviewed and used to identify development areas at particular risk of surface water and pluvial flooding. However, the level of detail contained in the PFRA map, and the widespread distribution of areas at risk did not allow a commentary relating to pluvial flood risk to be developed, or for particularly high risk areas to be identified.

Nevertheless, an overall strategy for the management of pluvial risk is presented for the Masterplan. Development of the Masterplan lands will incorporate a network of Sustainable Urban Drainage System (SUDS) measures, including bio-retention swales, reducing flood risk and safeguarding water quality.

It is proposed to use a SUDS approach to storm-water management throughout the masterplan lands. SUDS implementation aims to provide an effective system to mitigate the adverse effects of urban stormwater runoff on the environment by reducing runoff rates, volumes and frequency, reducing pollutant concentrations in stormwater, contributing to amenity, aesthetics and biodiversity enhancement and allowing for the maximum collection of rainwater for re-use where possible.

SUDS features will aim to replicate the natural characteristics of rainfall runoff by providing control of run-off at source.

5.1.5 Other Sources of Flooding

There are no reservoirs, canals or other significant artificial sources in the vicinity of the Masterplan area. The Masterplan area is located circa 60km away from the coast and River Breaghagh and River Nore do not have any tidal influences. As such flooding from this source is not considered a risk to the Masterplan and therefore is not discussed further within this SFRA.

5.1.3 Summary of Identified Flood Zones in the context of the Masterplan Site

As mentioned above, the CFRAM maps indicates that part of the site is located within Flood Zones A and B due to potential flooding from the River Breaghagh. The GSI Flooding Probability map also shows a localised groundwater flooding zone at Loughmacask.

Figures 5.4 and 5.5 below presents the extension of these zones in the context of the projected land zone uses within the Masterplan Area.

According to the Loughmacask Land Use map, it can be observed that parts of the River Breaghagh Park are flood prone. However, it should be noted that this area is a '*Water-Compatible Zone*' and therefore is regarded as being '*Appropriate*'. Furthermore, all of the lands marked for residential development within the Masterplan area under the Development Plan are situated in Flood Zone C, where there is a low probability of flooding, and where development of this nature is also regarded as being '*Appropriate*', as per the OPW flood risk management guidelines.

With regard to the groundwater sources, the Groundwater Flooding Zone for Medium Probability is located within the Lough Macask open space/ amenity area. However, part of the zone associated with Low Probability (0.1% AEP) traverses the Lousybush Lane and partially enters into residential and community areas (School). As mentioned above, groundwater flooding should be considered as a potential risk of damage to property rather than be a potential risk to life. Therefore, the risk of groundwater flooding is not considered significant, as it is a secondary source of flooding in the Masterplan area and will be addressed by its proposed drainage system. For developments in this area, flood risk mitigation and manegement measures are presented in Section 5.1.7 below.

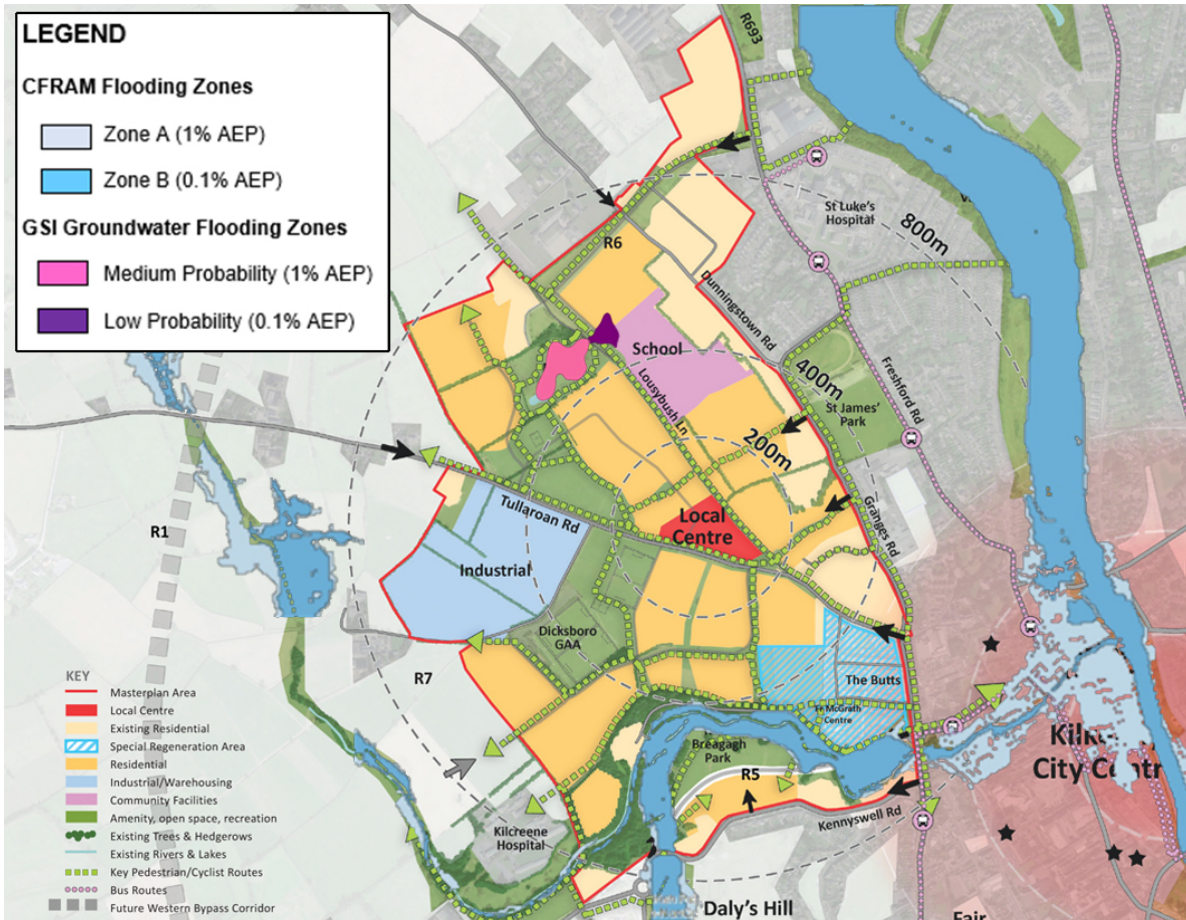


Figure 5.4 Fluvial and Groundwater Flooding Zones and Projected Land Use

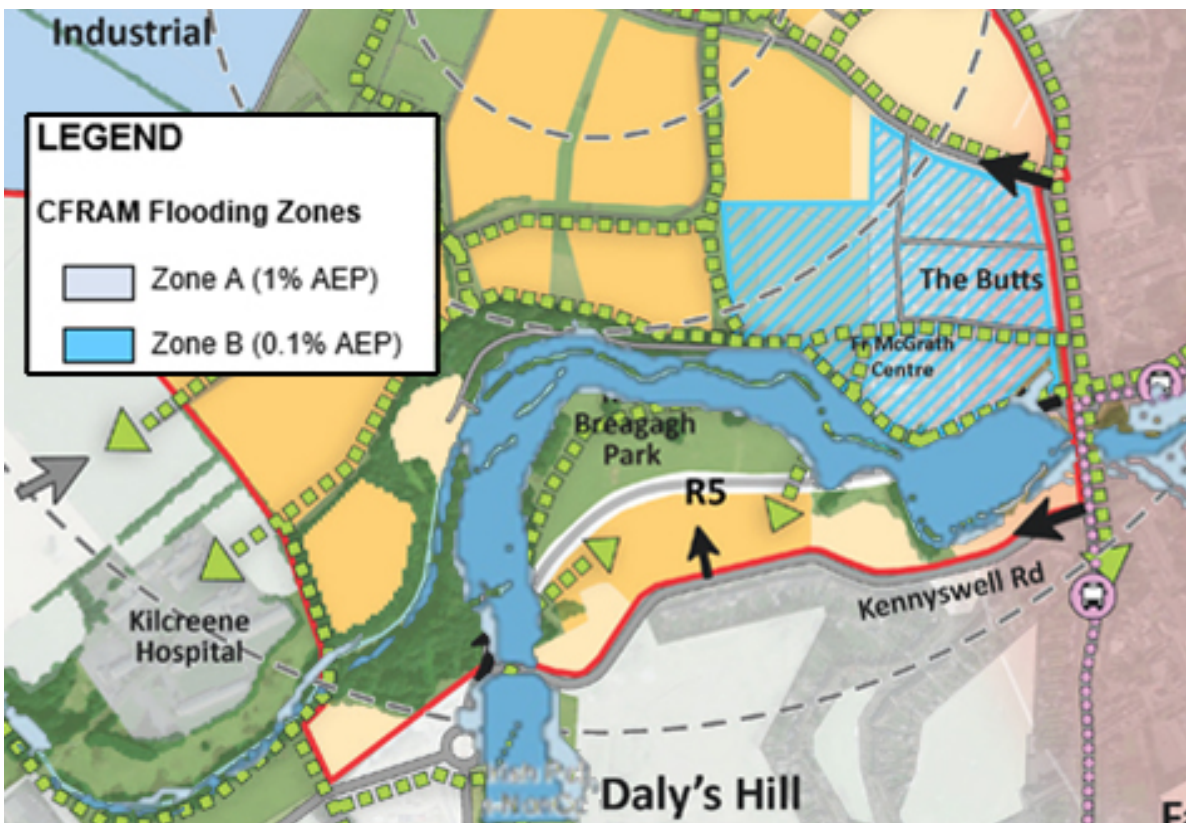


Figure 5.5 CFRAM Flooding Zones in the River Breagh Park

5.1.6 Conclusion of Stage 1

Having regard to all of the information sources as outlined above, it is concluded that the Masterplan will not require a Justification Test. The Flooding Zones A and B associated to flooding from the River Breaghagh are confined within the River Breaghagh Park which is an Amenity Open Area located comprising Water-Compatible development. Therefore, as can be seen in Table 3.3 above, this area does not require a Justification Test.

All of the lands marked for residential development within the Masterplan area under the Development Plan are situated in Flood Zone C, where there is a low probability of flooding, and where development of this nature is also regarded as being 'Appropriate', as per the OPW flood risk management guidelines.

The GSI Flooding Probability map indicates a localised groundwater flooding zone at Loughmacask. Groundwater flooding should be considered as a potential risk of damage to property rather than be a potential risk to life. Therefore, the risk of groundwater flooding is not considered significant, as it is a secondary source of flooding in the Masterplan area and will be addressed by the projected drainage system (refer to Section 5.2 below).

Therefore no further stages of flood risk assessment are considered necessary as part of this SSFRA.

5.2 Flood Risk Management Measures (SUDS)

Where a site is within Flood Zone C, but adjoining or in close proximity to Flood Zone A or B (in the case residential developments adjacent to River Breaghagh Park) there could be a risk of flooding associated with factors such as future scenarios (climate change) or in the event of failure of a defence, blocking of a bridge or culvert.

Development of the Masterplan lands will incorporate a network of Sustainable Drainage Systems (SUDS) measures, which include bio-retention and swales, and will reduce flood risk and safeguarding water quality.

It is proposed to use a SUDS approach to storm-water management throughout the masterplan lands. SUDS implementation aims to provide an effective system to mitigate the adverse effects of urban stormwater runoff on the environment by reducing runoff rates, volumes and frequency, reducing pollutant concentrations in stormwater, contributing to amenity, aesthetics and biodiversity enhancement and allowing for the maximum collection of rainwater for re-use where possible.

SUDS features will aim to replicate the natural characteristics of rainfall runoff by providing control of run-off at source.

Risk from sources other than fluvial (in the case of the identified groundwater flooding zones) must also be addressed through SUDS measures (bio-retention and swales) for all development in Flood Zone C.

The masterplan will set finished floor levels to a height that is above the 1 in 100 year fluvial flood level, with an allowance for climate change and freeboard (refer to Section 5.3 below), or to ensure a step up from road level to prevent surface water ingress. Evacuation routes in the event of inundation of surrounding land should also be included.

5.3 Climate Change

Flood risk is anticipated to increase as a result of climate change. Projected impacts for Ireland include:

- Sea level rise of between 18cm and 59cm this century;
- More intense storms and rainfall events;
- Increased likelihood and magnitude of river and coastal flooding; and
- Increased storm surges.

With respect to this assessment and the Masterplan area only changes in the intensity of rainfall events and the magnitude of river flooding are of direct relevance.

In all developments, climate change should be considered when assessing flood risk and in particular residual flood risk. Consideration of climate change is particularly important where flood alleviation measures are proposed, as the design standard of the proposal may reduce significantly in future years due to increased rainfall, river flows and sea levels.

The Guidelines recommend that a precautionary approach to climate change is adopted due to the level of uncertainty involved in the potential effects. A significant amount of research into climate change has been undertaken on both a national and international front, and updates are ongoing.

Based on these two scenarios the OPW recommended allowances for climate change are given in Table 5.1 below. These climate change allowances are particularly important at the development management stage of planning and will ensure that proposed development is designed and constructed to take into account best current knowledge.

Table 5.1 Allowances in Flood Parameters for the Mid-Range and High-End Future Scenarios for Fluvial and Tidal Sources

Parameter	MRFS	HEFS
Extreme Rainfall Depths	+20%	+30%
Peak Flood Flows	+20%	+30%
Mean Sea Level Rise	+500 mm	+1,000 mm
Land Movement	-0.5 mm/year ¹	-0.5 mm/year ¹
Urbanisation	No General Allowance – Review on a Case by Case Basis	No General Allowance – Review on a Case by Case Basis
Forestation	-1/6 Tp ²	-1/3 Tp ² +10% SPR ³

Note 1: Applicable to the southern part of the country only (Dublin – Galway and south of this)

Note 2: Reduction in the time to peak (Tp) to allow for potential accelerated runoff that may arise as a result of drainage of afforested land

Note 3: Add 10% to the Standard Percentage Runoff (SPR) rate: This allows for temporary increased runoff rates that may arise following felling of forestry.

As set out in 5.1.1 above, through the CFRAM Studies, both MRFS and HEFS model runs have been completed on all study watercourses, providing flood extent and depth maps. This information can be used to support flood risk assessments where the current CFRAM scenario has been deemed appropriate to the location.

For watercourses that are not part of the CFRAM programme, fluvial flood extents can be qualitatively assessed by using the Flood Zone B outline as a surrogate for 'Flood Zone A with allowance for the possible impacts of climate change', as suggested in the 'Planning

System and Flood Risk Management'. Quantitative assessment of risks may require an additional model run to fully understand risks.

For most development, including residential, nursing homes, shops and offices, the medium-range future scenario (20% increase in flows) is an appropriate consideration. This should be applied in all areas that are at risk of flooding (i.e. within Flood Zone A and B) and will be considered for sites which are in Flood Zone C but are adjacent to Flood Zone A or B (e.g., the vicinity of the River Breagagh). This is because land which is currently not at risk may become vulnerable to flooding when climate change is taken into account. There are no defined allowances for groundwater sources that may apply to the Lough Macask area.

Where the risk associated with inundation of a development is low and the design life of the development is short (typically less than 30 years) the allowance provided for climate change may be less than the 20% / 0.5m level.

In general, climate change will be accounted for by the setting of finished floor levels to a height which includes an allowance for climate change. However, climate change may also reveal additional flow paths which need to be protected or give rise to flows which exceed culvert capacity or overtop defences. These outcomes will need to be specifically investigated for each site, and an appropriate response provided.

6.0 CONCLUSIONS

This report has been produced in line with The Planning System and Flood Risk Management Guidelines for Planning Authorities and follows the recommended staged approach to flood risk appraisal and assessment. Potential changes to the risk of flooding within the Masterplan area as a result of climate change have also been assessed in line with national guidance in the Climate Change Sectoral Adaptation Plan.

A broad range of potential sources of flooding have been considered as part of the Stage 1 – Flood Identification of the Flood Risk Assessment. Where this high level review concludes that a source is potentially present in the area this has been carried through for a more detailed Stage 2 – Initial Flood Risk Assessment. Stage 3 would comprise of additional detailed qualification of risk. In this instance Stage 2 and Stage 3 assessments have not been undertaken as a Justification Test for the Masterplan is not required since the identified Flooding Zones A and B from the River Breaghagh are confined within the River Breaghagh Park which is an Amenity Open Area comprising Water-Compatible development.

All of the lands are marked for residential development within the Masterplan area under the Development Plan are situated in Flood Zone C, where there is a low probability of flooding, and where development of this nature is regarded as being appropriate, as per the OPW flood risk management guidelines.

Nevertheless, for development units located within Flood Zone C, but adjoining or in close proximity to Flood Zone A or B (i.e., River Breaghagh Park) there could be a risk of flooding associated with factors such as future scenarios (climate change). Development of the Masterplan lands will incorporate a network of SuDS measures to storm-water management throughout the masterplan lands. SUDS features will aim to replicate the natural characteristics of rainfall runoff by providing control of run-off at source and will involve setting finished floor levels to a height that is above the 1 in 100 year fluvial flood level, with an allowance for climate change and freeboard, or to ensure a step up from road level to prevent surface water ingress.

The GSI Flooding Probability map indicates a localised groundwater flooding zone at Loughmacask. The Groundwater Flooding Zone for Medium Probability is located within the Loughmacask open space/ amenity area. However, part of the zone associated with Low Probability (0.1% AEP) traverses the Lousybush Lane and partially enters into residential and community areas (School). Groundwater flooding should be considered as a potential risk of damage to property rather than be a potential risk to life. Therefore, the risk of groundwater flooding is not considered significant, as it is a secondary source of flooding in the Masterplan area and will be addressed by the projected drainage system and SUDS measures.

All other sources of flooding including pluvial, tidal, and artificial sources, and infrastructure failure have been assessed and scoped out of this SSFRA.

This SSFRA is based on currently available data and in accordance with its status as a “living document” will be subject to modification with the publication of new maps and plans.

7.0 REFERENCES

The Planning System and Flood Risk Management Guidelines for Planning Authorities, DoEHLG, 2009.

Kilkenny City and County Development Plan 2021-2027.

Kilkenny City and County Development Plan Consolidated Strategic Flood Risk Assessment 2021-2027.

GWflood Project: Monitoring, Modelling and Mapping Karst Groundwater Flooding in Ireland. Geological Survey Ireland. Version 1.2. August 2020.

Groundwater Flooding Data Viewer, available in <https://www.gsi.ie/en-ie/programmes-and-projects/groundwater/activities/groundwater-flooding/gwflood-project-2016-2019/Pages/default.aspx>

Flood Hazard Maps and flooding information for Ireland, www.floodinfo.ie

The National Development Plan 2018 – 2027