

**HYDRO  
ENVIRONMENTAL  
SERVICES**

22 Lower Main St  
Dungarvan  
Co. Waterford  
Ireland

tel: +353 (0)58 44122  
fax: +353 (0)58 44244  
email: [info@hydroenvironmental.ie](mailto:info@hydroenvironmental.ie)  
web: [www.hydroenvironmental.ie](http://www.hydroenvironmental.ie)

**PROPOSED DERRINLOUGH WIND FARM,  
CO. OFFALY**

**FLOOD RISK ASSESSMENT**

**FINAL REPORT**


Prepared for:

**BORD NA MÓNA POWERGEN LTD.**

Prepared by:

**HYDRO-ENVIRONMENTAL SERVICES**

## DOCUMENT INFORMATION

<b>DOCUMENT TITLE:</b>	<b>PROPOSED DERRINLOUGH WIND FARM, CO. OFFALY – FLOOD RISK ASSESSMENT</b>
<b>ISSUE DATE:</b>	<b>12<sup>TH</sup> FEBRUARY 2020</b>
<b>PROJECT NUMBER:</b>	<b>P1463</b>
<b>PROJECT REPORTING HISTORY:</b>	-
<b>CURRENT REVISION NO:</b>	<b>P1463-FRA APP 9.1_FINAL REV F0</b>
<b>AUTHOR(S):</b>	<b>MICHAEL GILL ADAM KEEGAN</b>
<b>SIGNED:</b>	  <b>Michael Gill B.A., B.A.I., M.Sc., MIEI</b> <b>Managing Director – Hydro-Environmental Services</b>
<p><i>Disclaimer:</i>  This report has been prepared by HES with all reasonable skill, care and diligence within the terms of the contract with the client, incorporating our terms and conditions and taking account of the resources devoted to it by agreement with the client. We disclaim any responsibility to the client and others in respect of any matters outside the scope of the above. The flood risk assessment undertaken as part of this study is site specific and the report findings cannot be applied to other sites outside of the survey area which is defined by the site boundary. This report is confidential to the client and we accept no responsibility of whatsoever nature to third parties to whom this report, or any part thereof, is made known. Any such party relies upon the report at their own risk.</p>	

## TABLE OF CONTENTS

<b>1. INTRODUCTION .....</b>	<b>4</b>
1.1 BACKGROUND .....	4
1.2 STATEMENT OF QUALIFICATIONS.....	4
1.3 REPORT LAYOUT .....	4
<b>2. BACKGROUND INFORMATION.....</b>	<b>5</b>
2.1 INTRODUCTION .....	5
2.2 SITE LOCATION AND TOPOGRAPHY .....	5
2.3 PROPOSED DEVELOPMENT DETAILS.....	6
<b>3. EXISTING ENVIRONMENT AND CATCHMENT CHARACTERISTICS .....</b>	<b>8</b>
3.1 INTRODUCTION .....	8
3.2 HYDROLOGY .....	8
3.2.1 Regional and Local Hydrology.....	8
3.2.2 Rainfall and Evaporation.....	9
3.3 GEOLOGY.....	9
3.4 SITE DRAINAGE .....	10
3.4.1 Existing Site Drainage.....	10
3.4.2 Proposed Site Drainage.....	12
3.5 DEVELOPMENT WATER BALANCE .....	12
<b>4. SITE SPECIFIC FLOOD RISK ASSESSMENT .....</b>	<b>14</b>
4.1 INTRODUCTION .....	14
4.2 FLOOD RISK ASSESSMENT PROCEDURE .....	14
4.3 FLOOD RISK IDENTIFICATION .....	16
4.3.1 OPW National Flood Hazard Mapping .....	16
4.3.2 Soils Maps - Fluvial Maps.....	17
4.3.3 Historical Mapping .....	17
4.3.4 Preliminary Flood Risk Maps .....	17
4.3.5 CFRAM Mapping.....	18
4.3.6 Summary – Flood Risk Identification .....	19
4.4 INITIAL FLOOD RISK ASSESSMENT.....	19
4.4.1 Site Walkover Survey.....	19
4.4.2 Hydrological Flood Conceptual Model.....	20
4.5 REQUIREMENT FOR A JUSTIFICATION TEST .....	21
4.6 DETAILED FLOOD RISK ASSESSMENT FOR PROPOSED SUBSTATION.....	22
<b>5. PLANNING POLICY AND JUSTIFICATION TEST .....</b>	<b>25</b>
<b>6. REPORT CONCLUSIONS .....</b>	<b>28</b>
<b>7. REFERENCES.....</b>	<b>29</b>

### FIGURES IN TEXT

Figure A: Site Location Map .....	6
Figure B: Proposed turbine layout at Derrinlough Wind Farm Site .....	7
Figure C: Regional Hydrology at the proposed site with river sub-catchments.....	8
Figure D: Existing generalised surface water drainage route within Drinagh and Clongawny bogs .....	11
Figure E: Existing drainage within Clongawny bog (west side of proposed site) .....	11
Figure F: Existing drainage at Drinagh bog (east side of proposed site) .....	12
Figure G: OPW Indicative Flood Map ( <a href="http://www.floods.ie">www.floods.ie</a> ) .....	17
Figure H: PFRA Flood Zone Mapping (Flood Zones obtained from PFRA Map no. 317, 318, 334 and 335) ..	18
Figure I: Local CFRAMS Fluvial Flood Zone Mapping .....	19

### TABLES IN TEXT

Table A. Derrinlough – Return Period Rainfall Depths (mm) .....	9
Table B. Derrinlough – Water Balance Assessment .....	13
Table C: Surface Water Flow Monitoring.....	20
Table D. S-P-R Assessment of Flood Sources for the Proposed Site.....	21
Table E: Matrix of Vulnerability versus Flood Zone .....	21
Table F: Drinagh north-east - Storage Volume Relationship.....	23
Table G: Drinagh north-east - Storage Volumes in T <sub>100</sub> and T <sub>1000</sub> rainfall events.....	23
Table H: Drinagh north-east – Estimated Flood Levels for T <sub>100</sub> and T <sub>1000</sub> rainfall events .....	23
Table I: CDP Policy on flooding and reference to relevant sections of this FRA report .....	25
Table J: Format of Justification Test for Development Management .....	26

# 1. INTRODUCTION

## 1.1 BACKGROUND

Hydro-Environmental Services (HES) were requested by MKO Ireland (MKO), on behalf of Bord Na Móna Powergen Ltd. to undertake a Flood Risk Assessment (FRA) for a proposed wind farm and associated works in Co. Offaly. The site is located approximately 2km to the south of the village of Cloghan and 7km north east of Birr in County Offaly. A site location map is attached as **Figure A**. The development site is a Bord na Móna peat bog, and as such the site is extensively modified, cutover and drained.

The proposed development at the site is a 21 no. turbine wind farm and associated access tracks, construction compounds, sub-station, cable trench route, grid connection, amenity pathways, carpark and other ancillary works.

The following assessment is carried out in accordance with 'The Planning System and Flood Risk Management Guidelines for Planning Authorities' (DoEHLG, 2009).

## 1.2 STATEMENT OF QUALIFICATIONS

Hydro-Environmental Services ("HES") are a specialist hydrological, hydrogeological and environmental practice which delivers a range of water and environmental management consultancy services to the private and public sectors across Ireland and Northern Ireland. HES was established in 2005, and our office is located in Dungarvan, County Waterford.

Our core area of expertise and experience is hydrology and hydrogeology, including flooding assessment and surface water modelling. We routinely work on surface water monitoring and modelling and prepare flood risk assessment reports.

Michael Gill is an Environmental Engineer with 18 years environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological assessments for various developments across Ireland. Michael has significant experience in surface water drainage issues, SUDs design, and flood risk assessment.

Adam Keegan is a junior hydrogeologist with 2 years' experience in the environmental/engineering sector.

## 1.3 REPORT LAYOUT

This FRA report has the following format:

- Section 2 describes the site setting and details of the proposed development;
- Section 3 outlines the hydrological and geological characteristics of the site and downstream surface water catchments, and the existing and proposed site drainage;
- Section 4 presents a site-specific flood risk assessment (FRA) undertaken for the proposed development which was carried out in accordance with the above-mentioned guidelines; and,
- Section 5 presents the FRA report conclusions.

## 2. BACKGROUND INFORMATION

### 2.1 INTRODUCTION

This section provides details on the topographical setting of the site along with a description of the proposed development site.

### 2.2 SITE LOCATION AND TOPOGRAPHY

The proposed Derrinlough Wind Farm site ("the site") which is a Bord na Móna peat bog is a combination of two bogs, Clongawny to the west and Drinagh to the east, split by the N62 which runs north-south between the two bogs. The site is located approximately 2km to the south of the village of Cloghan and 7km northeast of Birr in County Offaly. The total site area is approximately 2,400ha (24km<sup>2</sup>). A site location map is shown below as **Figure A**.

The Bord na Móna Derrinlough Peat Briquette Factory is located between the two bogs, along the N62 on the eastern side of the road. This plant processes the peat from a number of bogs in the midlands into briquettes and consists of the factory and a number of ancillary buildings. A site compound (known as Clongawny Tea Centre) relating to the currently ceased peat harvesting works exists close to the main site entrance on the western bog site (Clongawny). The majority of the overall site comprises heavily drained cutover raised bog. A number of active industrial rail lines intersect Clongawny and Drinagh bogs and these railways service the adjacent bogs and the Bord na Móna Derrinlough Peat Briquette Factory.

The topography of the development site is relatively flat with an elevation range of between approximately 53 and 62mOD (metres above Ordnance Datum). Along the majority of the site boundaries, a ~1-2m high peat headland exists which is a remnant of the original bog. These headlands and in some areas remnant peat banks create a boundary berm, forming a basin effect within the extraction areas of the overall bogs. There are some areas of higher ground at the centre and southwest of Clongawny bogs and these are covered with conifer forestry.

The surface of Clongawny bog is drained by a network of northeast / southwest orientated drains that are typically spaced every 15 to 20m. Larger arterial drains run northwest-southeast which connect the smaller field drains. On the western Clongawny bog, these drains typically slope gently towards perimeter settlement ponds and surface water outfalls. Surface water outflows from Clongawny bog are located at the north and north-eastern edges, and also at the south and southwestern boundaries of the bog.

The surface of Drinagh bog is drained by a network of north / south orientated drains that are typically spaced every 15 to 20m. Larger arterial drains run north-south also, and these connect the smaller field drains. Surface water outflows from Drinagh bog are located at the north, northwest and southeast boundaries of the bog.

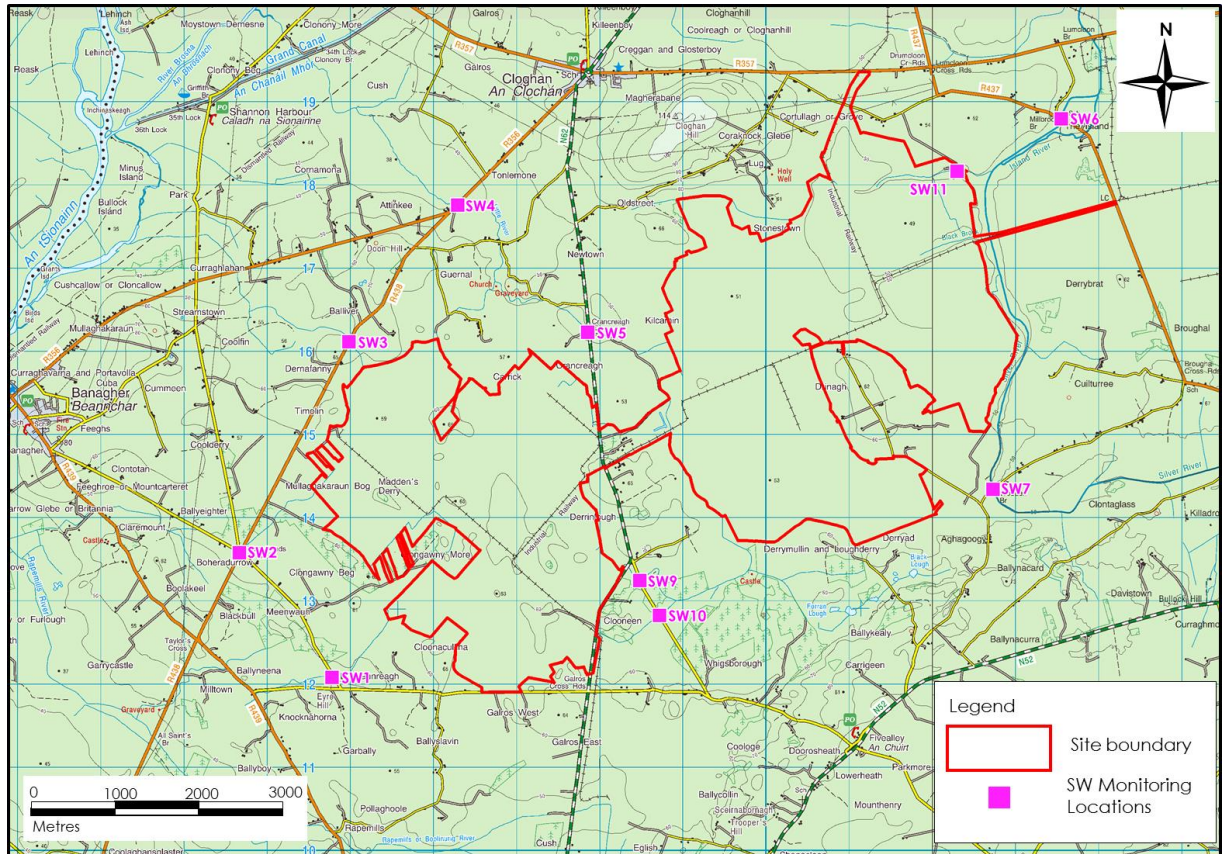


Figure A: Site Location Map

## 2.3 PROPOSED DEVELOPMENT DETAILS

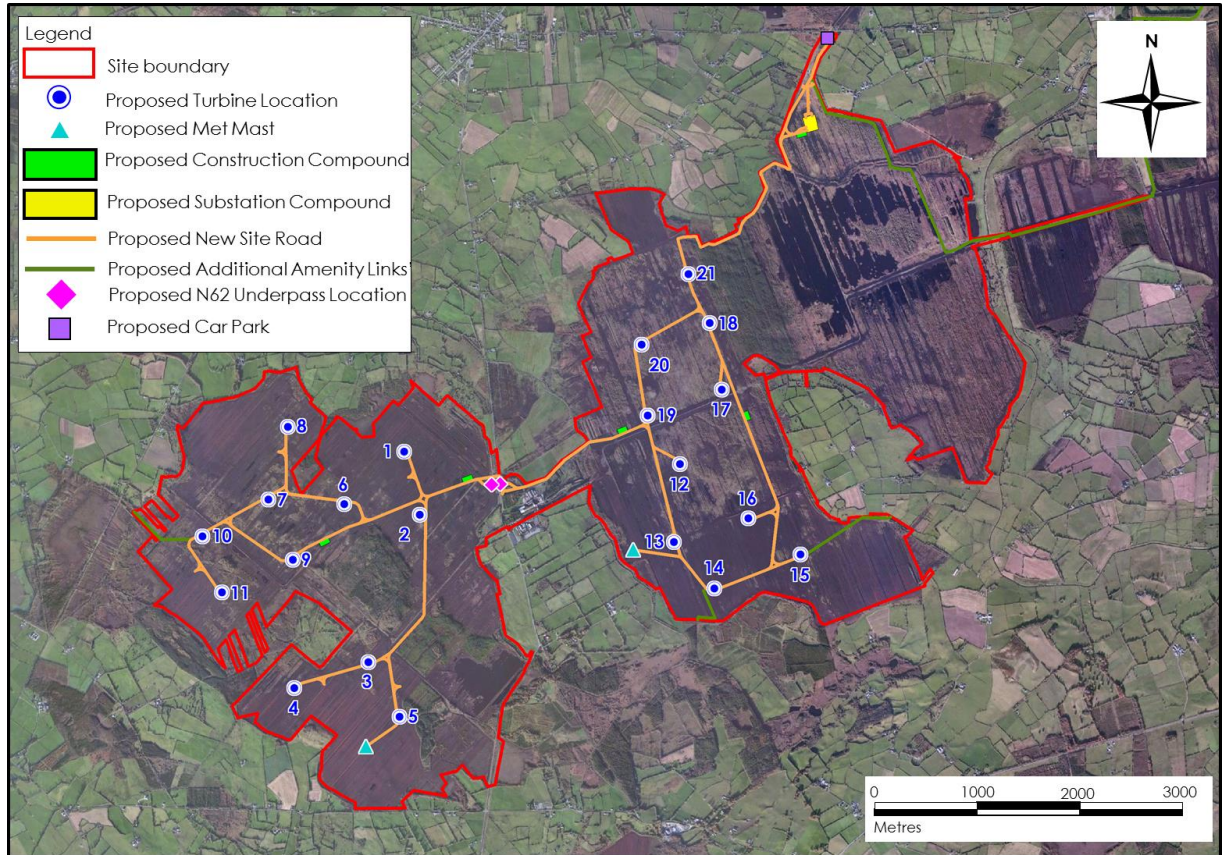
The development comprises of the following:

- 21 No. wind turbines with an overall blade tip height of up to 185 metres and all associated hard-standing areas.
- 2 No. permanent Anemometry Masts up to a height of 120 metres.
- Provision of new and upgraded internal site access roads, passing bays, amenity pathways, amenity carpark and associated drainage.
- 2 No. permanent underpasses in the townland of Derrinlough. One underpass will be located beneath the N62 and one will be located beneath an existing Bord na Móna rail line.
- 1 No. 110 kV electrical substation, which will be constructed in the townland of Cortullagh or Grove. The electrical substation will have 2 No. control buildings, associated electrical plant and equipment and a wastewater holding tank.
- 5 No. temporary construction compounds, in the townlands of Clongawny More, Derrinlough, Derrinlough/Crancreagh, Drinagh and Cortullagh or Grove.
- All associated underground electrical and communications cabling connecting the turbines to the proposed electrical substation.
- 2 No. temporary security cabins at the main construction site entrances in the townland of Derrinlough.
- All works associated with the connection of the proposed wind farm to the national electricity grid, which will be to the existing Dallow/Portlaoise/Shannonbridge 110 kV line.
- Removal of existing meteorological mast.
- Upgrade of existing access and temporary improvements and modifications to existing public road infrastructure to facilitate delivery of abnormal loads including locations on the N52 and N62; construction access for delivery of construction

materials at locations on the N62 and R357; operational access onto L7009 in the townland of Cortullagh or Grove and amenity access off R357 and L7005.

- All associated site works and ancillary development including signage.
- A 10-year planning permission and 30-year operational life from the date of commissioning of the entire wind farm.

The proposed wind farm layout is shown as **Figure B**.



**Figure B: Proposed turbine layout at Derrinlough Wind Farm Site**

### 3. EXISTING ENVIRONMENT AND CATCHMENT CHARACTERISTICS

#### 3.1 INTRODUCTION

This section gives an overview of the hydrological and geological characteristics of the region and the proposed development site.

#### 3.2 HYDROLOGY

##### 3.2.1 Regional and Local Hydrology

Regionally the proposed wind farm development site is located in the River Shannon surface water catchment (IE25\_01) within Hydrometric Area 25 of the Shannon River Basin District. A regional hydrology map is shown as **Figure C**.

On a more local scale, the majority of the site is located in the Brosna river sub-catchment (Brosna\_SC\_080). The Little River flows in a northwesterly direction through the centre of the site and crosses the N62 ~1.5km north of the Derrinlough Briquette Factory. The Little river discharges to the Brosna river at the confluence in the townland of Moytown Demense, ~5.5km northwest of the site. The Brosna then flows west, where it meets the River Shannon near Shannon Harbour.

The eastern side of the Drinagh bog is mapped within the Brosna\_SC\_070 sub-catchment. The Silver River flows north through this catchment, along the eastern boundary of the site. It flows north before joining the Brosna river ~3km southeast of Ferbane.

The western edge of the site, within the Clongawny bog, is drained by the Shannon lower sub-catchment (Shannon [Lower]\_SC\_040). A number of small tributaries flow west/southwest before joining the Rapemills river, which drains the sub-catchment. The Rapemills river then flows north for ~5.5km before entering the Shannon river just west of Banagher.

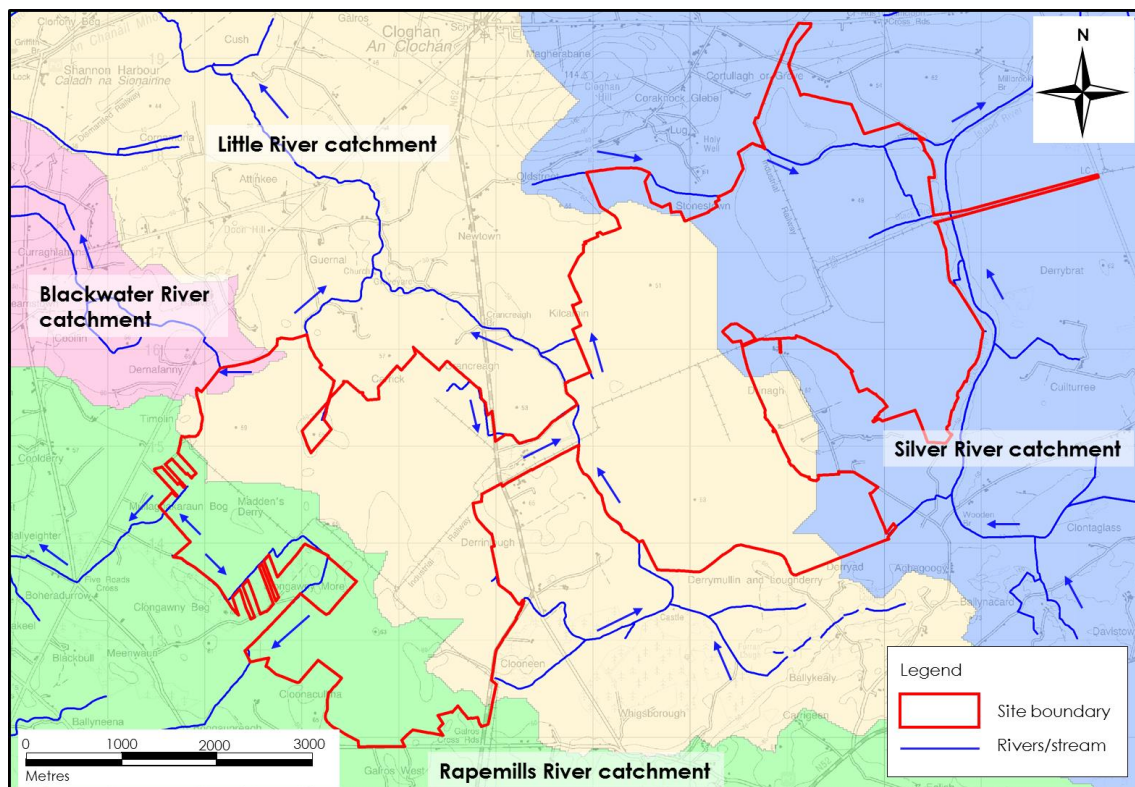


Figure C: Regional Hydrology at the proposed site with river sub-catchments



### 3.2.2 Rainfall and Evaporation

The SAAR (Standard Average Annual Rainfall) recorded at Banagher, the closest rainfall station to the site with long term SAAR data, is 842mm ([www.met.ie](http://www.met.ie)).

The average potential evapotranspiration (PE) at Birr is taken to be 445mm ([www.met.ie](http://www.met.ie)). The actual evapotranspiration (AE) is calculated to be 422mm (95% PE). Using the above values the effective rainfall (ER)<sup>1</sup> for the area is calculated to be (ER = SAAR – AE) ~420mm/yr.

In addition to average rainfall data, extreme value rainfall depths are available from Met Éireann. A summary of rainfall depths for various return periods and durations for the Derrinlough site are presented in **Table A**.

**Table A. Derrinlough – Return Period Rainfall Depths (mm)**

Duration	Return Period (Years)					
	1	5	30	100	500	1000*
<b>5 mins</b>	3.8	6.6	13.9	17.1	-	-
<b>15 mins</b>	6.2	10.9	19.5	28.0	-	-
<b>30 mins</b>	7.8	12.3	22.9	32.0	-	-
<b>1 hours</b>	10	16.2	26.8	36.5	-	-
<b>12 hours</b>	23.6	33.3	47.3	58.9	-	-
<b>24 hours</b>	30	40.6	55.5	67.3	86.8	124
<b>2 days</b>	37.1	48.6	63.9	75.8	94.9	137
<b>3 days</b>	43.1	55.3	71.2	83.4	102.6	150
<b>4 days</b>	48.6	61.3	77.9	90.3	109.7	162
<b>6 days</b>	58.4	72.2	89.7	102.7	122.6	188
<b>8 days</b>	67.3	82	100.4	113.8	134.2	210
<b>10 days</b>	75.7	91.1	110.3	124.1	144.9	226
<b>12 days</b>	83.7	99.8	119.5	133.7	155	242
<b>16 days</b>	98.7	116	136.9	151.7	173.6	268
<b>20 days</b>	113	131.2	153.1	168.4	190.9	294
<b>25 days</b>	130	149.4	172.1	188	211.1	327

\*Estimated using growth factors as data not available from ([www.met.ie](http://www.met.ie))

### 3.3 GEOLOGY

The published soils map for the site ([www.gsi.ie](http://www.gsi.ie)) show that Raised Cutaway Bog (Cut) is exclusively mapped in the proposed development site.

The mapped subsoil type ([www.gsi.ie](http://www.gsi.ie)) underlying the site is cutover peat. Overall peat depths recorded during the peat probing investigation ranged from 0 to 4.7m with an average of 1.1m. Peat depths at the site are shallow within the cutover areas but are deeper on headlands where less peat extraction has occurred.

Peat is underlain by intermittent shell marl deposits, and lacustrine clay deposits. Lacustrine clays are underlain by variable glacial fills, and these overly limestone bedrock.

The bedrock geology below the site is mapped as Dinantian Pure Unbedded Limestones (DPUL). There are 2 no. mapped faults intersecting the site, which trend in a northwest-southeast direction. The easternmost of these faults has displaced the DPUL ~ 0.5km north. These types of rocks are classified a Locally Important Aquifer - bedrock which is Moderately Productive only in Local Zones - by the GSI ([www.gsi.ie](http://www.gsi.ie)).

<sup>1</sup> ER – Effective Rainfall is the excess rainfall after evaporation which produces overland flow and recharge to groundwater.

### 3.4 SITE DRAINAGE

#### 3.4.1 Existing Site Drainage

In general, the overall site area comprising the two bogs is relatively flat. The topography ranges from ~53 – 62 mOD, with gentle slopes in some locations.

The surface of Clongawny bog is drained by a network of northeast / southwest orientated drains that are typically spaced every 15 to 20m. Larger arterial drains run northwest-southeast which connect the smaller field drains. On the western Clongawny bog, these drains typically slope gently towards perimeter settlement ponds and surface water outfalls. Surface water outflows from Clongawny bog are located at the north and north-eastern edges, and also at the south and southwestern boundaries of the site. All bar the northern outfall are drained by gravity. There is a single pumped outfall (P15/006) at the northern side of Clongawny bog.

The surface of Drinagh bog is drained by a network of north / south orientated drains that are typically spaced every 15 to 20m. Larger arterial drains run north-south also, and these connect the smaller field drains. Surface water outflows from Drinagh bog are located at the northwest and southeast. Both outfalls are drained by gravity. There is a single pumped outfall (P15/007) at the northern side of Drinagh bog. There is also a single internal pumping station (P15/008) within the bog that raises water from a low area.

There are 3 no. pumping stations across the two bogs (P15/006, P15/007, and P15/008). Max discharge from the pumping stations are designed to be below greenfield runoff rates and are rated for removal of rainfall events equivalent to 15mm in 1 hour (approx. -5yr return period).

Surface water draining/pumped from the site is routed via large settlement ponds prior to discharge to off-site drainage channels which flow into the local rivers (i.e. Little River and Silver River).

A flow diagram of the existing drainage system is shown as **Figure D**, and layout drawing of the existing drainage system is attached as **Figure E** and **Figure F**.

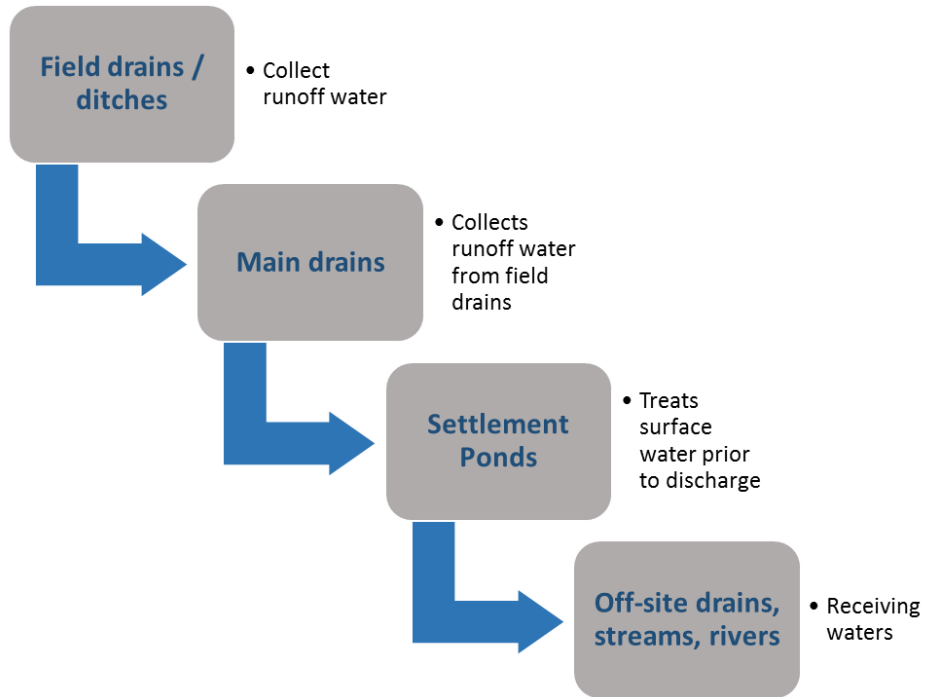


Figure D: Existing generalised surface water drainage route within Drinagh and Clongawny bogs

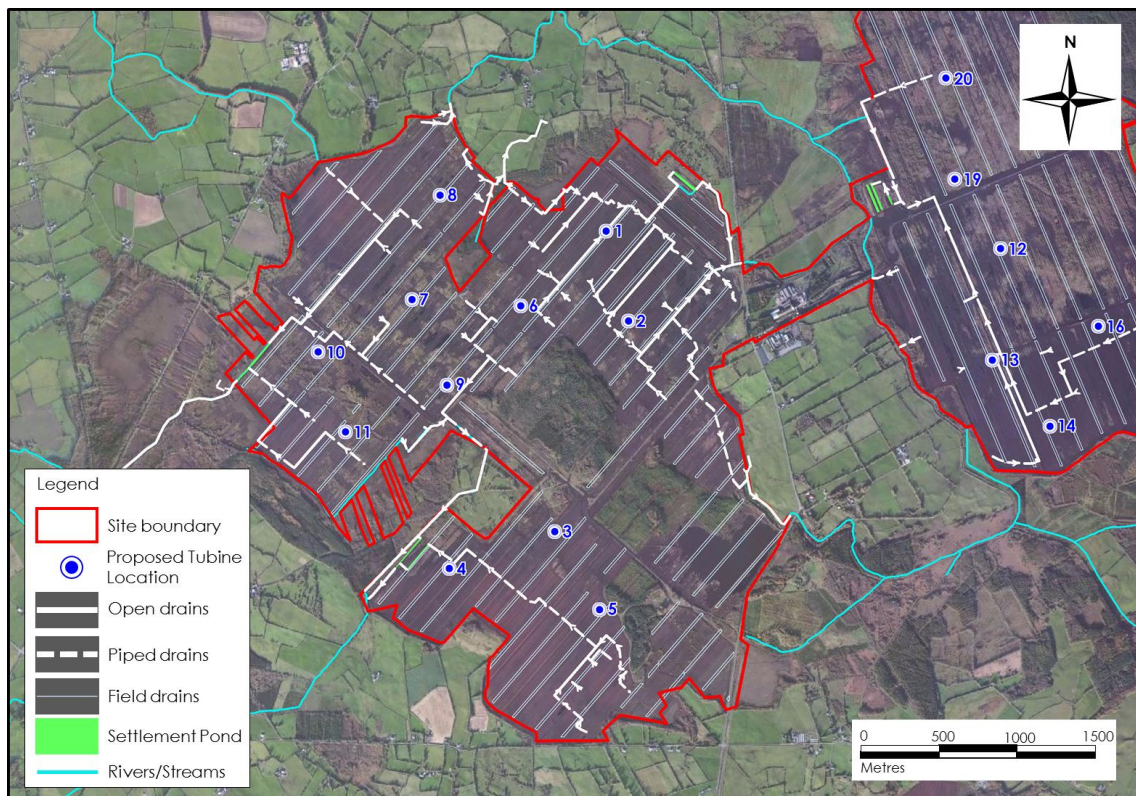


Figure E: Existing drainage within Clongawny bog (west side of proposed site)

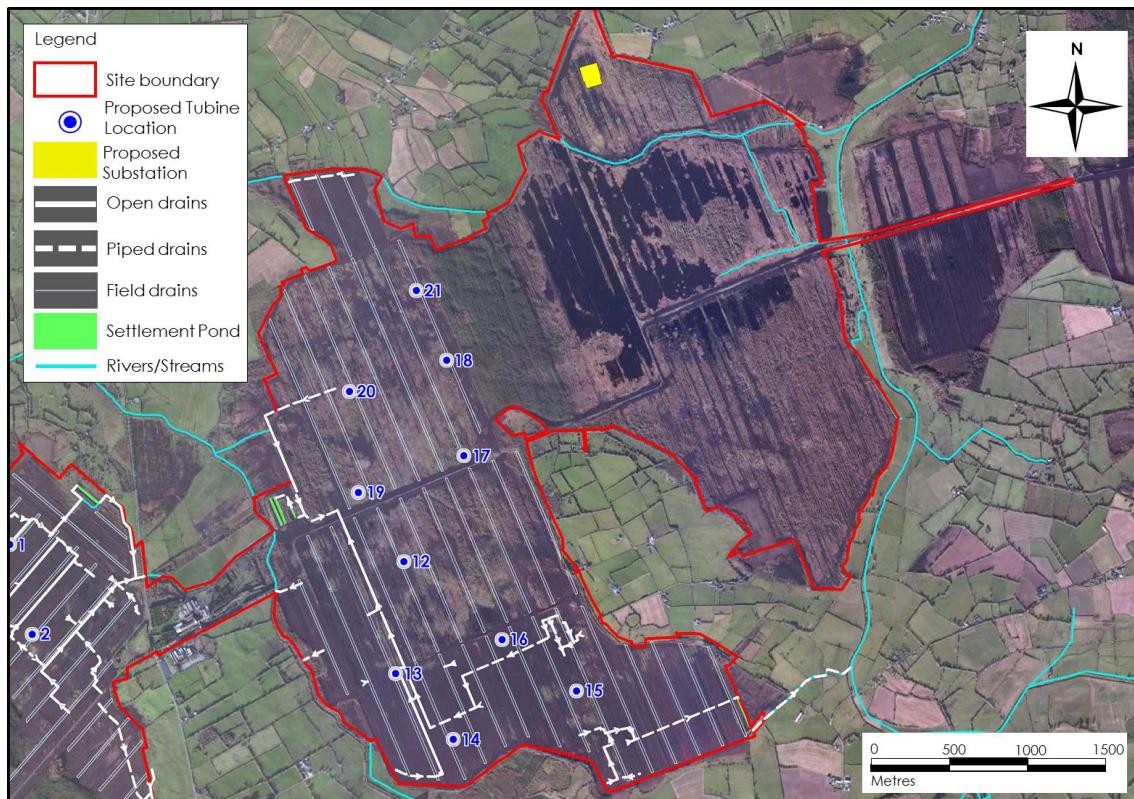


Figure F: Existing drainage at Drinagh bog (east side of proposed site)

### 3.4.2 Proposed Site Drainage

The proposed wind farm drainage will not significantly alter the existing drainage regime at the site. Moreover, the proposed drainage system will be fully integrated into the existing bog drainage systems.

Existing field drains and main drains will be routed under/around access tracks using culverts as required.

Runoff from access tracks, turbine bases, and developed areas (construction compounds, sub-station, met masts etc) will be collected and treated in local (proposed) silt traps and then discharged to existing peat field drains. From there this water will flow towards the site boundaries in field drains and main drains) and be treated further in the existing main settlement ponds prior to discharge from the site.

One of the proposed ecological aspects of the drainage design is to re-wet the site in small areas, where possible, to create wet areas as such wetland features which are good for overall site biodiversity. Ponding would occur in these areas to a very shallow depth, and only intermittently following heavy rainfall. It is not intended to create large open bodies of water, and where intermittent ponding occurs this will be broken up into small areas using peat berms.

### 3.5 DEVELOPMENT WATER BALANCE

There are existing surface water control measures at the bog which comprise high level bog surface drains, low level main drains and settlement ponds. All these existing drainage measures offer some surface water attenuation during rainfall events. However, as the part of the proposed wind farm drainage, it is proposed that runoff from the proposed infrastructure will be collected locally in new proposed silt traps and settlement ponds prior to release into the existing drainage network. The new proposed drainage measures will then in effect

create significant additional attenuation to what is already present at the site. The net effect of this will be a reduction in the overall runoff coefficient of the bog as demonstrated by the use of the Rational Method in **Table B** below. Based on a conservative reduction in the runoff coefficient from 0.96 to 0.85 for the overall site, there would a potential 11.4% reduction in runoff volumes from the site. This assessment demonstrates that there will be no risk of exacerbated flooding down-gradient of the site as a result of the proposed wind farm development. The proposed development will in effect retain water within the bog for longer periods.

**Table B. Derrinlough – Water Balance Assessment**

Site Area	C <sup>1</sup>	Area (m <sup>2</sup> )	Rc <sup>2</sup>	Rainfall Intensity (mm/hr)	Runoff Rate (m <sup>3</sup> /s)	Total Site Runoff Rate (m <sup>3</sup> /s)
Without Wind Farm Drainage Control						
Undeveloped Area	2.78	23,258,000	0.96	0.0515	1,149,876	1,167,489
Development Footprint	2.78	342,000	1.00	0.0515	17,613	
With Wind Farm Drainage Control						
Undeveloped Area	2.78	23,258,000	0.85	0.0515	1,018,119	1,034,851
Development Footprint	2.78	342,000	0.95	0.0515	16,732	
<b>Estimated Potential Reduction in Site Runoff Rate</b>						<b>11.4%</b>

Notes: 1 – Constant, 2- Runoff Coefficient

## 4. SITE SPECIFIC FLOOD RISK ASSESSMENT

### 4.1 INTRODUCTION

The following assessment is carried out in accordance with 'The Planning System and Flood Risk Management Guidelines for Planning Authorities' (DoEHLG, 2009). The basic objectives of these guidelines are to:

- Avoid inappropriate development in areas at risk of flooding;
- Avoid new developments increasing flood risk elsewhere, including that which may arise from surface water run-off;
- Ensure effective management of residual risks for development permitted in floodplains;
- Avoid unnecessary restriction of national, regional or local economic and social growth;
- Improve the understanding of flood risk among relevant stakeholders; and,
- Ensure that the requirements of EU and national law in relation to the natural environment and nature conservation are complied with at all stages of flood risk management.

### 4.2 FLOOD RISK ASSESSMENT PROCEDURE

This section of the report details the site-specific flood risk assessment carried out for the site and surrounding area. The primary aim of the assessment is to consider all types of flood risks and the potential impact on the development. As per the relevant guidance (DOEHLG, 2009), the stages of a flood risk assessment are:

- *Flood risk identification* – identify whether there are surface water flooding issues at a site;
- *Initial flood risk assessment* - confirm sources of flooding that may affect a proposed development; and,
- *Detailed flood risk assessment* – quantitative appraisal of potential risk to a proposed development.

As per the Guidelines, there are essentially two major causes of flooding:

**Coastal flooding** which is caused by higher sea levels than normal, largely as a result of storm surges, resulting in the sea overflowing onto the land. Coastal flooding is influenced by the following three factors, which often work in combination:

- High tide level;
- Storm surges caused by low barometric pressure exacerbated by high winds (the highest surges can develop from hurricanes); and,
- Wave action, which is dependent on wind speed and direction, local topography and exposure.

Coastal Flooding is not applicable to the Derrinlough wind farm site.

**Inland flooding** which is caused by prolonged and/or intense rainfall. Inland flooding can include a number of different types:

- Overland flow occurs when the amount of rainfall exceeds the infiltration capacity of the ground to absorb it. This excess water flows overland, ponding in natural hollows and low-lying areas or behind obstructions. This occurs as a rapid response to intense rainfall and eventually enters a piped or natural drainage system.

- River flooding occurs when the capacity of a watercourse is exceeded or the channel is blocked or restricted, and excess water spills out from the channel onto adjacent low-lying areas (the floodplain). This can occur rapidly in short steep rivers or after some time and some distance from where the rain fell in rivers with a gentler gradient.
- Flooding from artificial drainage systems results when flow entering a system, such as an urban storm water drainage system, exceeds its discharge capacity and the system becomes blocked, and / or cannot discharge due to a high-water level in the receiving watercourse. This mostly occurs as a rapid response to intense rainfall. Together with overland flow, it is often known as pluvial flooding. Flooding arising from a lack of capacity in the urban drainage network has become an important source of flood risk, as evidenced during recent summers.
- Groundwater flooding occurs when the level of water stored in the ground rises as a result of prolonged rainfall to meet the ground surface and flows out over it, i.e. when the capacity of this underground reservoir is exceeded. 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.
- Estuarial flooding may occur due to a combination of tidal and fluvial flows, i.e. interaction between rivers and the sea, with tidal levels being dominant in most cases. A combination of high flow in rivers and a high tide will prevent water flowing out to sea tending to increase water levels inland, which may flood over river banks.

The Flood Risk Management Guidelines provide direction on flood risk and development. The guidelines recommend a precautionary approach when considering flood risk management and the core principle of the guidelines is to adopt a risk based sequential approach to managing flood risk and to avoid development in areas that are at risk. The sequential approach is based on the identification of flood zones for inland and coastal flooding.

Flood zones are geographical areas within which the likelihood of flooding is in a particular range and they are a key tool in flood risk management within the planning process as well as in flood warning and emergency planning.

There are three types or levels of flood zones defined within the guidelines:

- Flood Zone A** – where the probability of flooding from rivers and the sea is highest (greater than 1% or 1 in 100 for river flooding or 0.5% or 1 in 200 for coastal flooding);
- Flood Zone B** – where the probability of flooding from rivers and the sea is moderate (between 0.1% or 1 in 1000 and 1% or 1 in 100 for river flooding and between 0.1% or 1 in 1000 year and 0.5% or 1 in 200 for coastal flooding); and,
- Flood Zone C** – where the probability of flooding from rivers and the sea is low (less than 0.1% or 1 in 1000 for both river and coastal flooding). Flood Zone C covers all areas of the plan which are not in zones A or B.

Once a flood zone has been identified for a site, the guidelines set out the different types of development appropriate to each identified zone (pg 25, Table 3.1 of the Guidelines). Exceptions to the restriction of development due to potential flood risks are provided for through the application of a Justification Test, where the planning need and the sustainable management of flood risk to an acceptable level must be demonstrated by the applicant.

The Justification Test has been designed to rigorously assess the appropriateness, or otherwise, of particular developments that, for the reasons outlined above, are being considered in areas of moderate or high flood risk. The test is comprised of two processes.

- The first is the **Plan-making Justification Test** described in chapter 4 of the Guidelines and used at the plan preparation and adoption stage where it is intended to zone or otherwise designate land which is at moderate or high risk of flooding. Plan making Justification Tests are made at Plan/Policy development stage such as County Development Plans, or Local Area Plans.
- The second is the **Development Management Justification Test** described in chapter 5 of the Guidelines and used at the planning application stage where it is intended to develop land at moderate or high risk of flooding for uses or development vulnerable to flooding that would generally be inappropriate for that land. For example, application of Development Management Justification Test would be required at a site specific level, such as for this FRA assessment, if a Justification Test is required.

### 4.3 FLOOD RISK IDENTIFICATION

#### 4.3.1 OPW National Flood Hazard Mapping

To identify those areas as being at risk of flooding, OPW's indicative river and coastal flood map ([www.floodmaps.ie](http://www.floodmaps.ie)) were consulted. No recurring flood incidents within the site boundary were identified from OPW's indicative river and coastal flood map. Several recurring flooding incidences are mapped to the northwest of the site, near Banagher near the confluence of the Rapemills and Shannon River and near Kilcormac, southeast of the site along the Little River. Refer to **Figure G**.

According to the OPW ([www.floodmaps.ie](http://www.floodmaps.ie)), the eastern half of Clongawny bog (Little River catchment) and all of Drinagh bog (Little River and Sliver River catchments) are "Benefiting Lands". Benefiting lands are defined as a dataset prepared by the Office of Public Works identifying land that might benefit from the implementation of Arterial (Major) Drainage Schemes (under the Arterial Drainage Act 1945) and indicating areas of land subject to flooding or poor drainage.



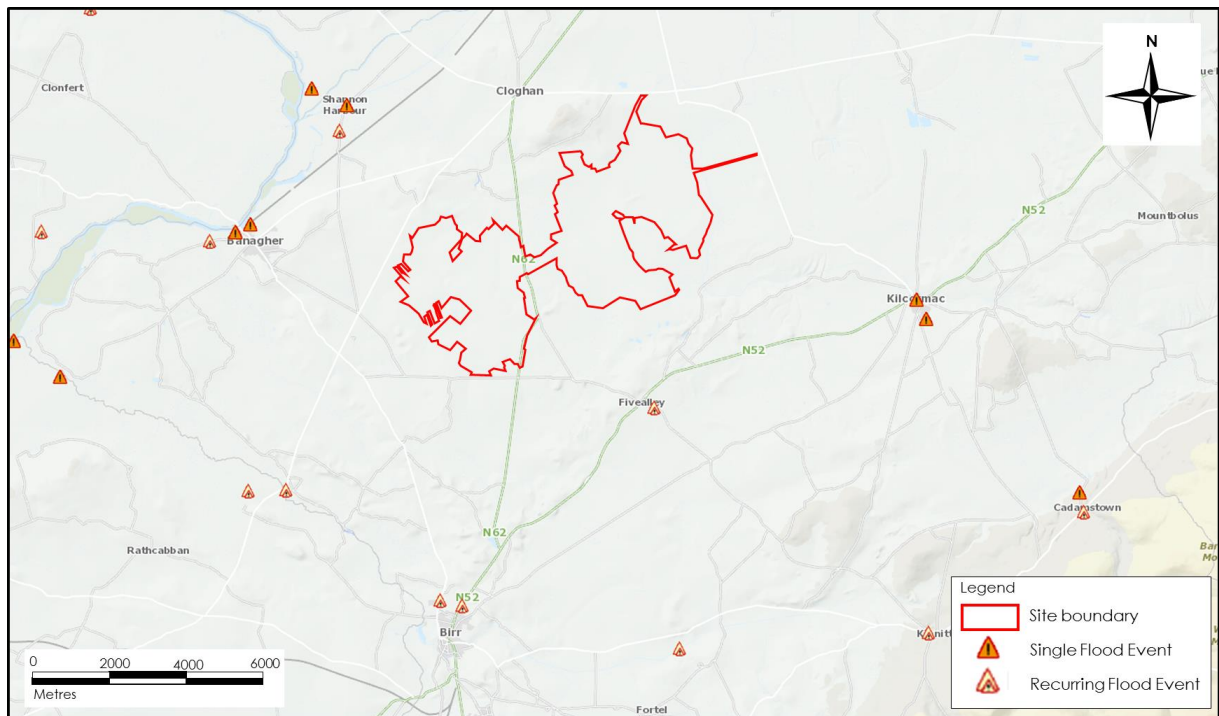


Figure G: OPW Indicative Flood Map ([www.floods.ie](http://www.floods.ie))

#### 4.3.2 Soils Maps - Fluvial Maps

A review of the soil types in the vicinity of the site was undertaken as soils can be a good indicator of past flooding in an area. Based on the EPA/GSI soil map for the area it appears that the site is predominately underlain by poorly draining, waterlogged peaty soils. This would indicate that the area is historically prone to high water table levels. However, extensive drainage has occurred in the area for peat production and extraction.

#### 4.3.3 Historical Mapping

To identify those areas as being at risk of flooding, historical mapping (*i.e.* 6" and 25" base maps) were consulted. No such areas are recorded at the development site, or on the local rivers around the development site. Areas of flooding are only recorded along larger rivers such as the Shannon and the Brosna River, but these areas are remote from the proposed development site.

#### 4.3.4 Preliminary Flood Risk Maps

To identify those areas as being at risk of flooding, OPW's indicative river and coastal flood map ([www.myplan.ie](http://www.myplan.ie)), Preliminary Flood Risk Assessment (PFRA) maps were also consulted.

The PFRA mapping ([www.cfram.ie](http://www.cfram.ie)) shows the extents of the indicative 1 in 100-year flood zone which relates to fluvial (*i.e.* river) and pluvial (*i.e.* rainfall) flood events. The vast majority of the proposed development site is located outside of the 1 in 100-year flood zone with the exception of a section on the north-eastern corner of the Drinagh bog site and an area on the margins of the site boundary, particularly along the Silver River towards the east of the proposed development site (refer to **Figure H**). All proposed turbine locations, substation and the access roads are outside of the fluvial indicative 1 in 100-year flood zone.

Also shown on the PFRA mapping is the indicative extent of pluvial flooding (*i.e.* flooding from rainfall ponding). As seen from **Figure H**, pluvial flooding appears to occur along the main drainage channels within the site and this is as result of surface water runoff backing up in the drainage routes when the capacity of the outfalls are exceeded.

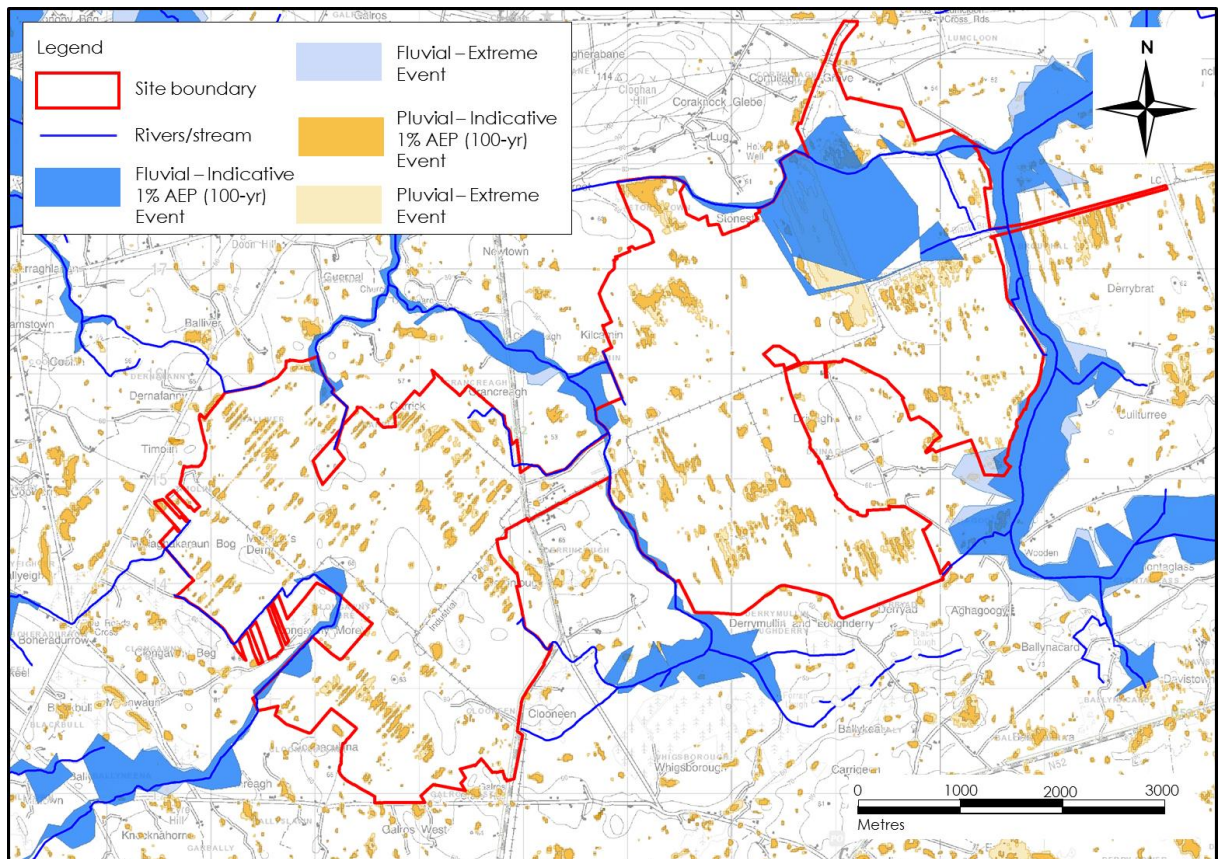


Figure H: PFRA Flood Zone Mapping (Flood Zones obtained from PFRA Map no. 317, 318, 334 and 335)

### 4.3.5 CFRAM Mapping

Where complete the CFRAMS OPW Flood Risk Assessment Maps are now the primary reference for flood risk planning in Ireland and supersede the PFRAM maps. CFRAM fluvial mapping has been completed in the proposed wind farm development area.

The proposed development site is not identified on the CFRAM flooding fluvial extent mapping, dated February 2015 as either in Flood Zone A or B. Therefore, according to CFRAMs the majority of the proposed development is located in Zone C, where the probability of fluvial flooding is low. The fluvial flood zones areas indicated on the CFRAM mapping are shown on **Figure I** below.

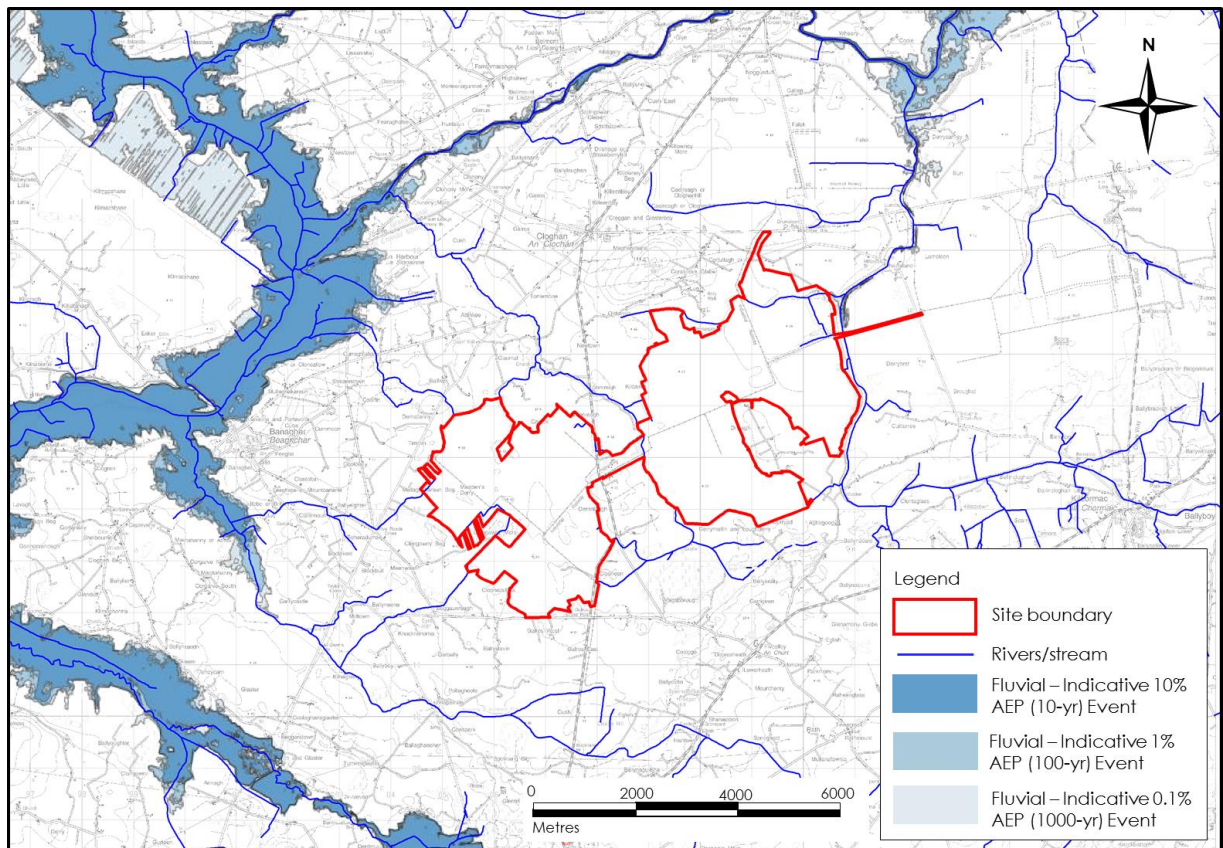


Figure I: Local CFRAMS Fluvial Flood Zone Mapping

#### 4.3.6 Summary – Flood Risk Identification

Based on the information gained through the flood identification process the available data indicates that the proposed development site is not within a fluvial flood zone (*i.e.* <100-Year Flood Zone). Therefore, according to CFRAMs the proposed development is located in Zone C, where the probability of fluvial flooding is low.

However, because of the pluvial flooding recorded at the site, a site-specific flood risk assessment was carried out below to further assess the risk of flooding at the development site, and downstream of the site as a result of the proposed development.

The main flood risk associated with the site is pluvial flooding within the development site.

### 4.4 INITIAL FLOOD RISK ASSESSMENT

#### 4.4.1 Site Walkover Survey

A hydrological walkover survey, including detailed drainage mapping and baseline monitoring/sampling, was undertaken by HES between the 5<sup>th</sup> – 9<sup>th</sup> April 2019, and again between 9<sup>th</sup> and 11<sup>th</sup> September 2019. HES staff have undertaken ~60-man hours of site work and have observed all areas of the proposed development on the ground.

The field drains and main drains within Clongawny and Drinagh bogs are the primary drainage routes towards the bog boundaries. At the boundaries of the bogs surface water draining/pumped from the site is routed via large settlement ponds prior to discharge to off-site drainage channels which flow into the local rivers (*i.e.* Little River and Silver River).

Low lying areas within Clongawny and Drinagh Bogs were observed to hold surface water following heavy rainfall, but ponding only occurs to very shallow depths, (<0.2m) and only in certain areas does ponded water persist in drier periods.

Monitoring of stream discharge in the main streams downstream of the site was undertaken on several occasions at 10 no. monitoring locations (SW1 – SW7, and SW9-SW11) on 3<sup>rd</sup> March 2019 and 09<sup>th</sup> April 2019. These data are presented in **Table C** below. The monitoring locations are shown on **Figure A** above.

**Table C: Surface Water Flow Monitoring**

Location/Date	03/04/2019	09/04/2019
	Flow(L/sec)	Flow (L/sec)
SW1	200	150
SW2	20	20
SW3	-	10
SW4	240	200
SW5	400	400
SW6	1800	1500
SW7	450	500
SW9	20	25
SW10	20	20
SW11	120	100

#### 4.4.2 Hydrological Flood Conceptual Model

Potential flooding in the vicinity of the site can be described using the Source – Pathway – Receptor Model (S-P-R). The primary potential source of flooding in this area, and the one with most consequence for the proposed development site, is pluvial flooding from rainfall. The site is isolated by boundary high banks and intermediate land from all local rivers.

#### 4.4.3 Summary – Initial Flood Risk Assessment

During winter conditions the proposed wind farm site holds/retains rainwater following heavy rain. The depth of intermittent ponding is shallow (<0.2m). This retention of water on the bogs during such events will reduce downstream flooding risk.

Potential receptors in the area are infrastructure, people, land and other private property and the River Shannon Callows SAC.

Based on the information gained through the flood identification process and Initial Flood Risk Assessment process the sources of flood risk for the site are outlined and assessed in Table D.

**Table D. S-P-R Assessment of Flood Sources for the Proposed Site.**

Source	Pathway	Receptor	Comment
Fluvial	Overbank flooding of the Little, Silver and Rapemills Rivers	Land, People, property, infrastructure, River Shannon Callows SAC	No direct flooding of development site from rivers adjacent to site.
Pluvial	Ponding of rainwater on site	Land, People, property.	Site evidence of localised infrequent pluvial flooding/ponding.
Surface water	Surface ponding/ Overflow	Land, People, property.	OPW mapping shows incidences of pluvial flooding in the proposed development area.
Groundwater	Rising groundwater levels	Land, People, property	Based on local hydrogeological regime and CFRAM mapping, no apparent risk from groundwater flooding
Coastal/tidal	Overbank flooding	Land, People, property	Not applicable.
Human/mechanical	Ponding of rainwater on site	Site land	Mechanical error at pumping stations will increase depth of pluvial flooding but will not impact upon downstream fluvial flooding risks.

#### 4.5 REQUIREMENT FOR A JUSTIFICATION TEST

A matrix of vulnerability versus flood zone is shown in **Table E**. This table is used to illustrate appropriate development types or indicate when a Justification Test<sup>2</sup> is required.

The majority of the proposed development infrastructure is located in fluvial Flood Zone C. Based on this a Justification Test is not required. However, in order to be conservative, and given the pluvial risk at the site, and the location of turbine bases and substations within the development, we have completed a Justification test below in Section 5.2.

**Table E: Matrix of Vulnerability versus Flood Zone**

	Flood Zone A	Flood Zone B	Flood Zone C
Highly vulnerable development (including essential infrastructure)	Justification test	Justification test	<b>Appropriate</b>
Less vulnerable development	Justification test	Appropriate	Appropriate
Water Compatible development	Appropriate	Appropriate	Appropriate

**Note:** Taken from Table 3.2 (DoEHLG, 2009)

**Bold:** Applies to this project.

<sup>2</sup> A 'Justification Test' is an assessment process designed to rigorously assess the appropriateness, or otherwise, of particular developments that are being considered in areas of moderate or high flood risk, (DoEHLG, 2009).

## 4.6 DETAILED FLOOD RISK ASSESSMENT FOR PROPOSED SUBSTATION

### 4.6.1 Introduction

Due to the sensitivity of the proposed substation location we have completed a detailed assessment to determine a proposed floor level (or formation level) that is above the predicted 1-1000yr pluvial flood level.

The existing ground levels at the proposed substation location vary between 49.45 to 52mOD.

The PFRA mapping (refer to **Figure H**), which is the only public available mapping, suggests that the southern portion of the proposed substation site lies within the 100-year flood zone (Flood Zone A). The remainder is mapped as being in Flood Zone B/Flood Zone C.

In order to determine if the proposed substation location is above the 1-1000yr flood level we modelled flood levels by applying 1000-yr rainfall depths to the north-eastern surface water catchment within Drinagh Bog, and to be very conservative we included the catchment to the west of the substation site outside of the bog (in the townlands of Lug and Oldstreet). These townlands drain to the east and cross the north-eastern corner of Drinagh Bog in a stream that flows to the east and discharges into the Silver River. Part of this stream is culverted as it crosses Drinagh bog. The north-eastern corner of Drinagh bog also drains via this tributary to the Silver River. The total area of the drainage catchment is 5.3 km<sup>2</sup>, and 2.25km<sup>2</sup> of this north-eastern catchment lies within the Derrinlough Wind Farm application area.

This outfall from the north-eastern Drinagh bog catchment is ungauged in respect to flood flow estimation and requires Flood Studies Update (FSU) ungauged flood estimation methods to determine the greenfield runoff rate and the return period design flows. The FSU method for estimating flood flow magnitudes based on physical catchment descriptors estimates a median flood flow ( $Q_{med}$ ) magnitude of 0.157m<sup>3</sup>/km<sup>2</sup> for a SAAR = 848mm, BFISOIL = 0.4275, FARL = 1, DRAININD = 0.66km/km<sup>2</sup> and S1085 = 2.14m/km.

For a catchment area of 5.3km<sup>2</sup> the annual flood discharge from the Drinagh northeast catchment is 0.83m<sup>3</sup>/sec. The estimated 100-yr and 1000-yr flood flows (using growth factors and climate change factor of 1.2) from the north-eastern catchment are ( $Q_{100}$ ) 2.66m<sup>3</sup>/sec and ( $Q_{1000}$ ) 3.56m<sup>3</sup>/sec respectively.

Extreme rainfall depths for the Derrinlough site were determined using the Met Éireann 20 km by 20 km model of rainfall depth-duration-frequency model ([www.met.ie](http://www.met.ie)). The rainfall totals at different durations and return periods are presented below in **Table A**.

A lidar survey at 2m grid interval of the entire Derrinlough Wind Farm site was used to determine the flood volume available in the north-eastern catchment of the bog (2.25km<sup>2</sup> catchment) at a particular water elevation. This information is presented in **Table F**.

**Table F** shows that significant storage is available within the bog, and this is due to the expanse of the bog (2.25km<sup>2</sup>), the flat nature of the ground (small increases in water level requires large volumes of water), and the shallow bowl that has been created by previous peat extraction works.

As a preliminary assessment a conservative volumetric (catchment area × rainfall depth for each return period and storm duration) and flood storage calculation with  $Q_{100}$  and  $Q_{1000}$  discharges (multiplied by a reduction factor (30%) to estimate average outflow, rather than using the peak flow as presented above) from the catchment was undertaken for various rainfall durations. Under this scenario the peak storage occurs for a 1-day duration rainfall events in both return periods ( $T_{100}$  and  $T_{1000}$ ), with the storage required for longer duration

events being exceeded by the discharge from the catchment. A summary of these volumetric calculations is provided in **Table G**.

Using the stage-volume relationship presented in **Table F**, it is possible to calculate the flood level for each return period. These are shown in **Table H**.

**Table F: Drinagh north-east - Storage Volume Relationship**

Stage mOD (Malin)	Volume (m <sup>3</sup> )
48.75	83,318
49	197,973
49.1	289,402
49.2	394,529
49.25	451,823
49.5	771,861
49.55	840,734
49.6	910,974
49.75	1,129,751
50	1,517,881
50.25	1,928,183

**Table G: Drinagh north-east - Storage Volumes in T<sub>100</sub> and T<sub>1000</sub> rainfall events**

Rainfall Event Duration	T <sub>100</sub> Residual Storage Volume (m <sup>3</sup> )	T <sub>1000</sub> Residual Storage Volume (m <sup>3</sup> )
24hrs (1 day)	358,331	694,309
2 days	343,259	687,302
3 days	322,471	678,124
4 days	297,238	661,480
6 days	237,881	638,811
8 days	170,268	597,269
10 days	97,576	513,506
12 days	20,438	426,504
16 days	Discharge > Storage	226,838
20 days	Discharge > Storage	19,943
25 days	Discharge > Storage	Discharge > Storage

**Table H: Drinagh north-east – Estimated Flood Levels for T<sub>100</sub> and T<sub>1000</sub> rainfall events**

Rainfall Event	Estimated Peak Flood Level (mOD Malin)
T <sub>100</sub>	49.15
T <sub>1000</sub>	49.41

#### 4.6.2 Summary – Detailed Flood Risk Assessment for Proposed Substation

As outlined above a very conservative volumetric analysis has determined the peak flood levels at the proposed substation site for 100-yr and 1000-yr rainfall events.

The over-riding factor in the analysis is the expanse of the bog to the south of the substation which needs to fill with pluvial flood water before the substation site can flood. In addition to the above analysis a freeboard of 1m is added to the determined flood levels to define the required floor/formation level for the substation. Applying this to the T<sub>1000</sub> flood level gives a required substation floor/formation level of **>50.41mOD**. At this elevation the risk of flooding at the substation site is very low.



## 5. PLANNING POLICY AND JUSTIFICATION TEST

### 5.1 PLANNING POLICY AND CDP

The following policies (Table I) are defined in Offaly County Council CDP 2014-2020 in respect of flooding, and we have outlined in the column to the right how these policies are provided for within the proposed development design:

**Table I: CDP Policy on flooding and reference to relevant sections of this FRA report**

No.	Policy	Development Design Response
<b>EnvP-18</b>	It is Council policy to have due regard to the CFRAM plans in assessing development proposals.	As outlined in this FRA. CFRAM mapping outlined within <b>Section 4.3</b> .
<b>EnvP-19</b>	It is Council policy to implement the Flood Risk Management Guidelines at both Plan and development management levels	As outlined in this FRA.
<b>EnvP-20</b>	It is Council policy to apply the Sequential Test and Approach within development sites located within Flood Zoned A and B to inform site layout by locating the most vulnerable elements of a development in the lowest risk areas. Flood Zone A & B shall be promoted for less vulnerable uses such as for recreation, amenity and environmental purposes thus providing for an effective means of flood risk management as well as providing connected green spaces with consequent social and environmental benefits.	As outlined within this FRA. Flood zone types defined within <b>Section 4.3</b> .
<b>EnvP-21</b>	It is Council policy to require development proposals locating in Flood Zones A and B to be accompanied by a detailed explanation of how the Development Management Justification Test has been met where proposals for development may be vulnerable to flooding i.e. Box. 5.1: The Planning System and Flood Risk Management Guidelines, 2009.	As outlined in this FRA, and <b>Section 4.5 and 5.2</b> .
<b>EnvP-22</b>	It is Council policy to require more detailed assessment frameworks (Site Specific Flood Risk Assessments) for planning applications where flooding is an issue, including the assessment of flooding from other sources at the site-specific level and offer mitigating options for the management of the risk, without increasing flood risk elsewhere.	As outlined in this FRA.
<b>EnvP-23</b>	It is Council policy to preserve riparian zones along rivers free from development and of adequate width to permit access to rivers for maintenance.	No natural watercourse will be altered, neither will there be changes in flows or water levels.

## 5.2 JUSTIFICATION TEST

Box 5.1 (**Table J** below) of “The Planning System and Flood Risk Management Guidelines” (PSFRM Guidelines) outlines the criteria required to complete the “Justification Test”.

**Table J: Format of Justification Test for Development Management**

Box 5.1 Justification Test for Development Management (to be submitted by the applicant)
<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"> <li>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.</li> <li>2. The proposal has been subject to an appropriate flood risk assessment that demonstrates: <ol style="list-style-type: none"> <li>i. The development proposed will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk;</li> <li>ii. The development proposal includes measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible;</li> <li>iii. The development proposed includes measures to ensure that residual risks to the area and/or development can be managed to an acceptable level as regards the adequacy of existing flood protection measures or the design, implementation and funding of any future flood risk management measures and provisions for emergency services access; and</li> <li>iv. 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.</li> </ol> </li> </ol> <p>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>

*Note: this table has been adapted from Box 5.1 of “The Planning System and Flood Risk Management Guidelines”, (2009).*

Referring to Point 1 and Points 2 (i) to (iv) inclusive in Figure 20 [of PSFRMG guideline document]:

1. The proposed development is currently in the planning process and has been deemed suitable for development by the applicant.
2. The proposal for 21 no. turbine wind farm and associated access tracks, construction compounds, sub-station, cable trench route, grid connection, amenity pathways, carpark and other ancillary works has been the subject of a Stage II and Stage III flood risk assessment (this report) and this assessment has shown that:
  - i. The development has been assessed to have no impact on flood risk elsewhere in the locality.
  - ii. The proposed development will not impede the flow of surface water during extreme flood events. Drainage designs for the proposed development follows SuDS principles and will restrict discharge to greenfield runoff rates. It is therefore estimated that the development presents minimal risk to people, property, the economy and the environment. In addition, volumetric modelling has demonstrated that the proposed substation site is above the 1000-yr flood level. There will be no increase in flood risk on lands upstream of downstream of the application site;
  - iii. The assessment has shown that there will be no residual risks to the proposed development or local area; and,
  - iv. With respect to the above (flood risk management proposals) the proposed development is therefore compatible with the wider planning objectives of the area. It does not alter the flood risk upstream or downstream of the proposed application site.

With regards to the proposed development site, it will for the large part remain flood free, but on very rare occasions there is a risk of shallow inundation from pluvial flooding. Surface water discharges from the site are attenuated and will be slowed down below greenfield runoff rates. Where pumping is used, pumping stations are rated for low discharge volumes in the order of 15mm per hour from the catchment drained.

Surface water will be held on site, behind access tracks, in shallow wet areas (as described in Section 3.4.2), in low lying areas, in silt traps, in settlement ponds, and upstream of pumping stations.

Given the large area of the site (~2,360Ha), the two bogs areas have an enormous capacity to store water following rainfall events, even if storage is only a couple of centimetres in depth, the volume of stored water will be very large.

Overall, during the wind farm operation phase of development for the site, water is more likely to be held on site, and this will have a positive impact on downstream flooding events.

No part of the proposed wind farm infrastructure will flood, and all access roads, and turbine bases will be designed to be above known pluvial flood levels.

The proposed substation will be raised to be above the 1 in 1000-year flood level as outlined above.

## 6. REPORT CONCLUSIONS

- The Preliminary Flood Risk Assessment (PFRA) mapping indicates the vast majority of the proposed site is located outside a Fluvial flood zone (>100-year flood zone) with the exception of a section on the north-eastern corner of the site and smaller regions on the peripheries of the site boundary. No proposed turbine locations are within these areas. There is an access road in this area, but it will be raised above the 100-year flood level;
- The Preliminary Flood Risk Assessment (PFRA) mapping indicates that pluvial flooding appears to occur along the main drainage channels within the site and this is as a result of surface water runoff backing up in the drainage routes when the capacity of the outfalls are exceeded;
- The more recent fluvial CFRAM mapping, indicates that the proposed development site area, is not within Flood Zone A or Flood Zone B, and that the majority of the proposed development site is located within Flood Zone C for fluvial flood events;
- OPW records indicate there is no history of recurring fluvial flood incidents within the site boundary. Several recurring flooding incidences are mapped to the northwest and east of the site on the Shannon/Rapemills River and the Silver River;
- The main risk of flooding at the proposed development site is via pluvial flooding;
- Site walkover indicates the surface of the cutover bog contains an extensive network of peat drains with surface water outflows from the two bogs (Clongawny bog and Drinagh bog);
- The overall increase in hardstanding area from the proposed development site is relatively small due to the nature of the construction and operation, therefore no downstream flooding from storm water runoff is anticipated;
- The overall risk of flooding posed at the development site is estimated to be low, and all proposed infrastructure will be located in Flood Zone C, and the proposed substation location will be located above the predicted 1000-year flood level; and
- In addition, the risk of the wind farm contributing to downstream flooding is also very low, as the long-term plan for the site is to retain and slow down drainage from the bogs, and this will result in sections of the site being wetter for longer and therefore promoting more Fen like conditions.

\*\*\*\*\*

## 7. REFERENCES

DOEHLG	2009	The Planning System and Flood Risk Management.
Natural Environment Research Council	1975	Flood Studies Report (& maps).
Cunnane & Lynn	1975	Flood Estimated Following the Flood Studies Report
CIRIA	2004	Development and Flood Risk – Guidance for the Construction Industry.
OPW	Not Dated	Construction, Replacement or Alteration of Bridges and Culverts. A Guide to Applying for Consent under Section 50 of the Arterial Act, 1945.
Institute of Hydrology	1994	Flood Estimation in Small Catchments (IH 124).
Fitzgerald & Forrestal	1996	Month and Annual Averages of Rainfall for Ireland 1961 – 1990.
Met Eireann	1996	Monthly and Annual Averages of Rainfall for Ireland 1961-1990.

© **HYDRO-ENVIRONMENTAL SERVICES**

22 Lower Main Street, Dungarvan, Co. Waterford, X35 HK11  
T: +353-(0)58-441 22 F: +353-(0)58-442 44 E: info@hydroenvironmental.ie

[www.hydroenvironmental.ie](http://www.hydroenvironmental.ie)