APPENDIX 9-1

FLOOD RISK ASSESSMENT

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
web: www.hydroenvironmental.ie

PROPOSED SEVEN HILLS WINDFARM, CO. ROSCOMMON

SITE-SPECIFIC FLOOD RISK ASSESSMENT

FINAL REPORT

Prepared for:
Energia Renewables ROI Ltd.

Prepared by:
Hydro-Environmental Services

DOCUMENT INFORMATION

Document Title:	**Proposed Seven Hills Wind Farm, Co. Roscommon Site-Specific Flood Risk Assessment**
Issue Date:	**19th May 2022**
Project Number:	**P1500**
Project Reporting History:	**None**
Current Revision No:	**P1599_0050 Final_Rev F0**
Author(s):	**Michael Gill** **Conor McGettigan** **Adam Keegan**
Signed:	 _____ **Michael Gill B.A., B.A.I., M.Sc., MIEI** **Managing Director – Hydro-Environmental Services**

Disclaimer:
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.

TABLE OF CONTENTS

FIGURES IN TEXT

TABLES IN TEXT

1. INTRODUCTION

1.1 BACKGROUND

Hydro-Environmental Services (HES) were requested to undertake a site-specific Flood Risk Assessment (FRA) for the proposed Seven Hills Wind Farm development (the Proposed Development), Co. Roscommon. A site location map is shown below as **Figure A.**

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

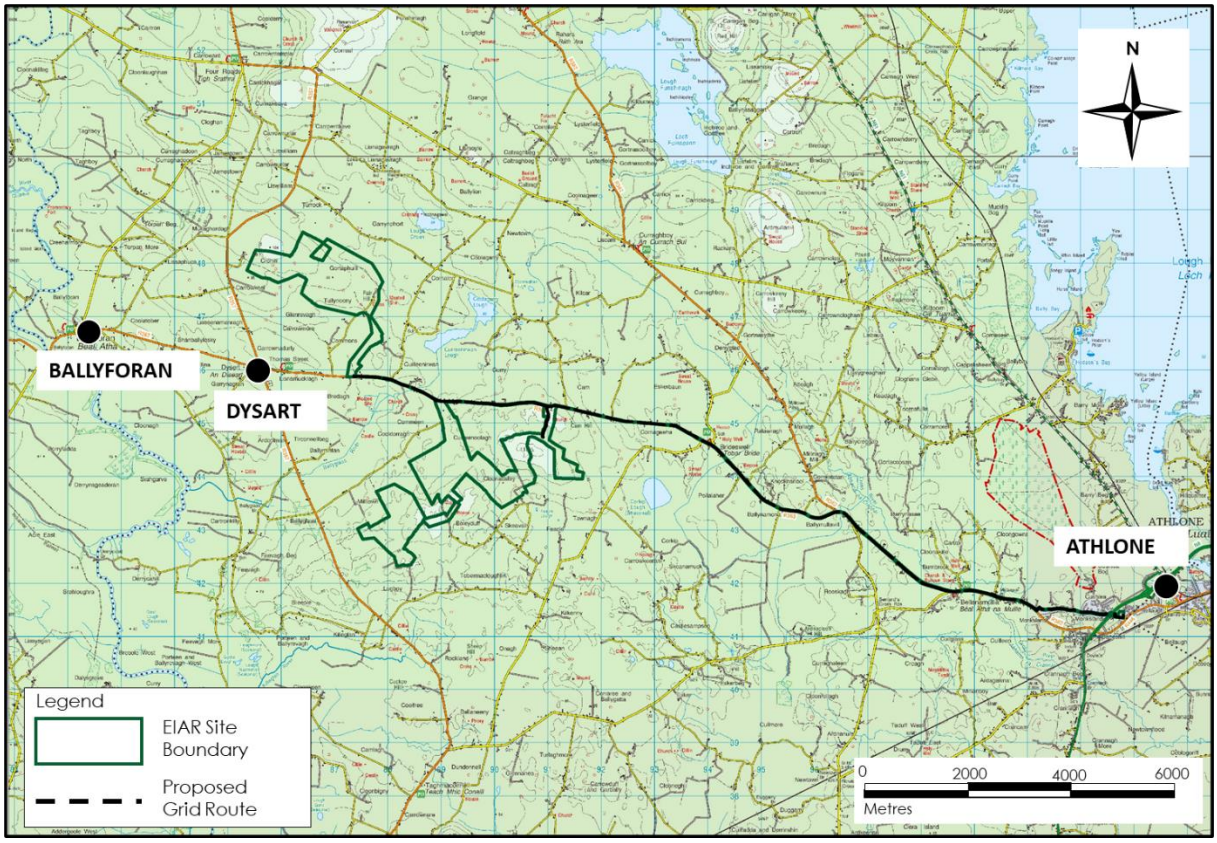

Figure A: Site Location Map

1.2 STATEMENT OF EXPERIENCE

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 PGeo (BA, BAI, MSc, Dip Geol, MIEI) 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 (BSc, MSc) is a hydrogeologist with three years of experience in the environmental sector in Ireland. Adam has been involved in Environmental Impact Assessment Reports (EIARs) for numerous projects including wind farms, grid connections, quarries and small housing developments. Adam holds an MSc in Hydrogeology and Water Resource Management. Adam has worked on several wind farm EIAR projects and associated Flood Risk Assessments, including Derrinlough WF, Lyrenacarriga WF (SID), Cleanrath WF and Carrownagowan WF (SID).

Conor McGettigan (BSc, MSc) is an environmental scientist with one years experiences in the environmental sector in Ireland. In recent times Conor has assisted in the preparation of several Flood Risk Assessments (FRAs) for a range of developments including several wind farms.

1.3 REPORT LAYOUT & METHODOLOGY

This FRA report has the following format:

- Section 2 describes the proposed site setting and details of the proposed development;
- Section 3 outlines the hydrological and geological characteristics of the local surface water catchment in the vicinity of the proposed development site;
- Section 4 deals with a site-specific flood risk assessment (FRA) undertaken for the proposed development which was carried out in accordance with the above-mentioned guidelines. The section determines whether a Justification Test for the development would be required and then options going forward with regard flood risk management are presented;
- Section 5 reviews the flood impact and risks associated with the proposed development; and,
- Section 6 presents the FRA report conclusions.

As stated above this FRA is carried out in accordance with 'The Planning System and Flood Risk Management Guidelines for Planning Authorities' (DoEHLG, 2009). The assessment methodology involves researching and collating flood related information from the following data sources:

- Local Base maps – Ordnance Survey of Ireland;
- Flood Hazard Maps and flooding information for Ireland (www.floodmaps.ie);
- Office of Public Works (OPW);
- Geological Survey of Ireland (GSI) maps on superficial deposits;
- EPA hydrology maps (www.catchments.ie);
- GSI Groundwater Flood Maps (www.gsi.ie)
- CFRAM Mapping; and,
- Site Walkovers, drainage mapping, intrusive geological investigations (trial pits, boreholes, dynamic probes) and seasonal groundwater level monitoring.

2. BACKGROUND INFORMATION

2.1 INTRODUCTION

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

2.2 SITE LOCATION AND TOPOGRAPHY

The proposed development comprises of a proposed 20 no. turbine wind farm, grid connection and all associated siteworks. The Wind Farm site comprises of a Northern Cluster and a Southern Cluster as detailed in Chapter 4 of this EIAR.

The Northern Cluster includes 7 no. turbines and is located ~2.8km northwest of the village of Ballyforan and 1.5km northeast of Dysart village, Co. Roscommon. The Northern Cluster lies within a ~2km^2 area between the townlands of Cronin, Gortaphuill and Cornalee. Elevation ranges between 70-105 mOD, with the proposed turbine locations situated along a northwest-southeast trending ridge. The land is generally agricultural, primarily used for grazing and appears well drained.

The Southern Cluster of the proposed development includes a further 13 no. turbines and is located ~3km southeast of Dysart, Co. Roscommon and 12km west of Athlone, Co. Westmeath. The area consists of 13 no. proposed turbine locations over a ~5km^2 area, from the townland of Lugboy towards Cuilleenoolagh and Cam Hill. Elevation ranges between 70-110 mOD, along a northwest-southeast range of small hills. The land is generally rough agricultural and scrub and appears generally well drained with some forestry on the higher ground near the old Dysart cemetery.

A site location map is shown as **Figure B** above.

2.3 PROPOSED DEVELOPMENT DETAILS

There are 20 no. turbines (7 no. turbines in the Northern Cluster and 13 no. turbines in the Southern Cluster) and associated hardstands included in the proposed development. The proposed development also includes 2 no. construction compounds (1 in the north and 1 in the south), 3 no. spoil storage areas (1 in the north and 2 in the south), 1 no. proposed substation, site access roads and all associated infrastructure. The proposed substation is located within the northeast of the Southern Cluster in the townland of Cam.

The proposed development includes a grid connection route joining the Northern Custer and the Southern Cluster along the R363. The grid route will then continue from the proposed on-site substation within the Southern Cluster of the Wind Farm site to the Athlone 110kV substation, located ~10km southeast of the Southern Cluster. The proposed underground grid connection will be in the carriageway of the existing public road network, travelling along R363 and the R362 as far as the Athlone substation.

Please note, for the purpose of this report, where:

- The Wind Farm site is referred to, this relates to all infrastructure located in both the Northern and Southern Clusters. In some instances, the Northern and Southern Clusters are differentiated.
- The Grid Route is referred to, this relates to all grid infrastructure outside of the Wind Farm site.
- The Proposed Development is referred to, this relates to the all project components, including the Wind Farm site and the grid connection.
- The Site is referred to relates to the primary study area for the development, as delineated by the EIAR site boundary.

3. EXISTING ENVIRONMENT AND CATCHMENT CHARACTERISTICS

3.1 INTRODUCTION

This section gives an overview of the hydrological and geological characteristics in the area of the proposed development.

3.2 BASELINE HYDROLOGY

3.2.1 Regional and Local Hydrology

On a regional scale, the Proposed Development is located in the Upper Shannon (26D) catchment, with a small section to the southeast of the Site within the Upper Shannon (26G) catchment, all within Hydrometric Area 26 (Upper Shannon) of the Irish River Basin District.

On a more local scale the Wind Farm site (Northern and Southern Cluster) is broadly contained within the River Suck sub-catchment (Suck_SC_090), with a small section in the east of the Southern Cluster contained within the Cross River sub-catchment (Shannon[Upper]_SC_100).

The River Suck is located ~3.5km west of the Southern Cluster, and ~3.9km west of the Northern Cluster. The River Suck flows south through the village of Ballyforan, west of Dysart, continuing south through the town of Ballinasloe before turning southeast and discharging to the River Shannon at Shannonbridge, ~20km south of the Southern Cluster.

The Cross River is situated ~3.2km east of the nearest Southern Cluster turbines and drains the broader area east of Lough Croan and Cuilleenirwan Lough. The headwaters of the Cross River is on the western slope of a small hill (~80mOD) in the townland of Kilcar and is mapped as a series of smaller turloughs near Dooloughan Lough. The most southeastern turbines of the Southern Cluster area drain towards this river, although Corkip turlough is situated downslope of these 2 no. turbines before the small tributaries of the Cross River.

The Wind Farm site and the general regional area between Roscommon town and south of Dysart is distinctively void of mapped river channels. This implies that the majority of effective rainfall is infiltrating to the groundwater system, rather than creating runoff which would lead to a larger number of streams/rivers. However, several locations in this area are known to flood temporarily during wet winters creating a turlough type feature (groundwater fed water feature).

The main surface water drainage in the vicinity of the Wind Farm site is provided by the Ballyglass and Cross rivers. The Ballyglass River, which flows southwest from Cuilleenirwan Lough ~ 1.6km southeast of the Northern Cluster and ~ 1.3km north of the Southern Cluster and reaches a confluence with the River Suck in the townland of Srahgarve. There are no other tributaries, aside from very short minor drains, mapped for the Ballyglass River, so it is likely that the majority of the flow is derived from Cuilleenirwan Lough. Cuilleenirwan lough itself is seasonal, and tends to "disappear" during the summer months, therefore flows within the Ballyglass River will vary considerably throughout the year. The Killeglan River is mapped ~1.5 km southwest of the Southern Cluster and ~2-3km south of the Ballyglass River. This river originates at Killeglan Spring and flows west/southwest towards the River Suck.

The Grid Route is situated along an existing road and is generally distant from any hydrological features. There are, however, 5 no. river crossings along the Grid Connection route at existing bridges and culverts. Along the Ballyglass River in the townland of Cuilleenirwan, 2 no. tributaries of the Cross River in the townlands of Brideswell and Ballymullavill and the Cross River in the townland of Bellanamullia. There is also an additional culvert crossing in the townland of Cloonakille.

A local hydrology map is shown as **Figure B**.

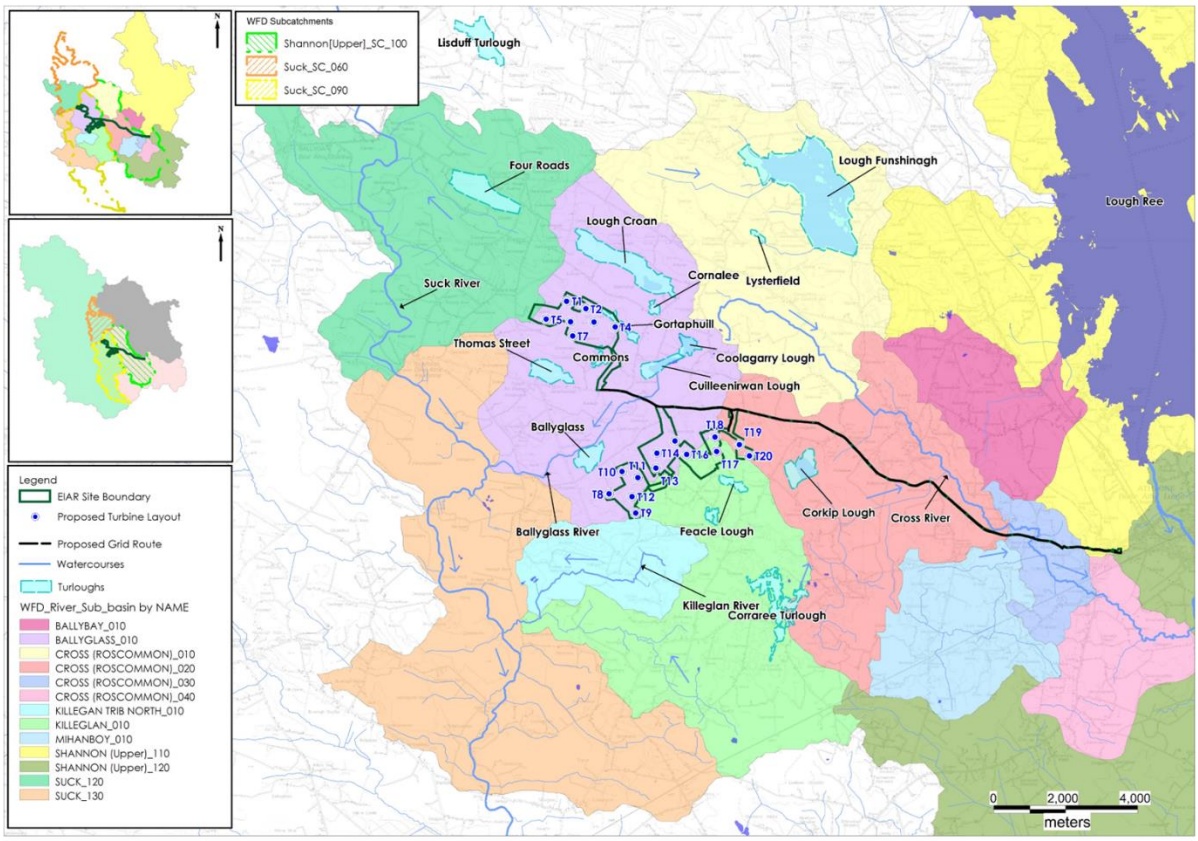

Figure B: Local Hydrology Map

3.3 RAINFALL AND EVAPORATION

The Standard Average Annual Rainfall (SAAR) recorded at Ballyforan, ~4km southeast of the Site, is 9584mm (www.met.ie). The average potential evapotranspiration (PE) at Mullingar, ~60km east of the Wind Farm site, is 446mm/year (www.met.ie). The actual evapotranspiration ("AE") is calculated to be 423mm (95% PE). Using the above figures the effective rainfall ("ER")[1] for the area is calculated to be (ER = SAAR – AE) 562mm.

Based on recharge coefficient estimates from the GSI (www.gsi.ie), an estimate of 60% recharge is taken for the Site as an overall average. This value is for "moderate permeability subsoil overlain by well drained soils". However, in reality, the recharge potential for the site is likely between 80-100%. The distinct lack of surface water features (streams/rivers) near the Site would indicate that all water is infiltrating to ground (i.e. 100% recharge). Site investigations have revealed a variance in the thickness and clay/silt content of subsoils across the site. The depth of subsoil introduces variance in permeability and it is likely that rainfall infiltrates through the sandy/silty/gravelly subsoil, seeps by gravity following the local undulating topography, before recharging to the bedrock aquifer in areas of shallow subsoil downslope. A regional permeability value of 100% is assumed, based on the lack of surface water features, however this will vary locally.

Therefore, annual recharge and runoff rates for the Site (Northern and Southern Cluster) are estimated to be 500-562 mm/yr and 0-62mm/yr respectively.

Table A below presents return period rainfall depths for the area of the Site. These data are taken from https://www.met.ie/climate/services/rainfall-return-periods and they provide

[1] *ER – Effective Rainfall is the excess rainfall after evaporation which produces overland flow and recharge to groundwater.*

rainfall depths for various storm durations and sample return periods (1-year, 5-year, 30-year, 100-year).

Table A: Rainfall return period depths for the Seven Hills Wind Farm site

	Return Period (Years)				
Duration	**1-year**	**5-years**	**10-years**	**50-years**	**100-years**
15 mins	5.7	9.4	11.6	17.9	21.5
1 hour	9.7	14.9	17.9	26.3	30.8
6 hours	19.1	27.2	31.6	43.1	49.0
12 hours	24.9	34.4	39.3	52.2	58.6
24 hours	32.5	43.4	49.0	63.2	70.2
2 days	40.4	52.4	58.5	73.6	81.0

3.4 GEOLOGY

The general area of the Wind Farm site is mapped by the GSI as being overlain by Limestone Tills, with smaller areas of Fen peat mapped west of Dysart (which do not coincide with the Site) and isolated ribbons of Esker deposits which are broadly oriented in a northwest-southeast direction.

According to EPA mapping (www.epa.ie), soils in the Northern Cluster comprise predominantly of deep well drained basic mineral soils (BminDW) with smaller pockets of shallow well drained mineral soil (BminSW) mapped near the townlands of Cronin and Turrock. A small area of fen peat is mapped near the townland of Garrynaphort, close to Lough Croan. The GSI subsoils map (www.gsi.ie) shows the Northern Cluster is underlain by Tills derived from limestone (TLs) with some areas of karstified bedrock outcrop or subcrop (KaRck) mapped on higher ground, particularly near Cronin. The underlying bedrock in the Northern Cluster is mapped by the GSI as Visean Limestones (Undifferentiated). There are no mapped faults in the area.

Within the Northern Cluster a total of 22 no. boreholes have been drilled along with the excavation of 48 no. trial pits, the completion of geophysical surveys and PSD and permeability analysis of subsoils. The subsoils consist of sandy CLAY, gravelly SAND and sandy GRAVEL, with a depth of overburden between 1.3 – 16.3m where the full profile was described (i.e. at boreholes). Average depth to bedrock was 7.41mbgl (metres below ground level). Bedrock was described as typically strong, dark grey bioclastic limestone with discrete weathered zones and intermittent clay infilled fractures. No significant karst features were logged during the drilling of the 22 no. boreholes.

According to EPA mapping (www.epa.ie), soils in the Southern Cluster comprise predominantly of deep well drained basic mineral soils (BminDW) with some basic poorly drained mineral soils (BminPD) mapped on higher ground. The GSI subsoils map (www.gsi.ie) shows the Southern Cluster is underlain by Tills derived from limestone (TLs) with some eskers comprised of gravels of basic reaction (BasEsk) mapped east and southeast of the site near the townlands of Boleyduff and Cloonacaltry. The underlying bedrock in the Southern Cluster is mapped by the GSI as Visean Limestones (Undifferentiated). There are no mapped faults or bedrock outcrop in this area.

Within the Southern Cluster a total of 32 no. boreholes haven been drilled along with the excavation of 61 no. trial pits, the completion of geophysical surveys and PSD and permeability analysis of the subsoils. The subsoils consist of sandy CLAY, clayey gravelly SAND and sandy clayey GRAVEL, with a depth of overburden between 1.3m – 30m where the full profile was described (*i.e* at boreholes). Average depth to bedrock was 7.32mbgl (metres below ground level). Bedrock was described as strong to very strong, dark blueish grey, fine to medium grained Limestone. The bedrock geology in the area was found to be largely competent and does not appear to be characteristic of a karst system.

Soils along the Grid Route are mapped as deep well drained basic mineral soils (BminDW) between Dysart and Brideswell. The soils mapped between Brideswell and the Monksland substation vary between shallow well drained basic mineral soil (BminSW), cutover Peat (Cut), basic shallow, lithosolic or podzolic type soils potentially with peaty topsoil (BminSRPT). A small section of Alluvium occurs along near the Cross River and with made ground between the R362 and R446. Subsoils along the Grid Connection are mapped as Tills derived from Limestone (TLs) between Dysart and the townland of Cornageeha. A small area of Esker is mapped between the townlands of Cam and Cornageeha. Limestone gravels (GLs) are mapped just southeast of the Esker deposit between Cornageeha and Brideswell. Cutover raised Peat is mapped between Brideswell and Ballymulavil. The subsoils between Ballymulavil and the Monkland (Athlone) substation are a mixture of Limestone gravels, Limestone Tills and cutover Peat, with some Alluvium mapped along the Cross River. The bedrock geology mapped along the Grid Route consists of Undifferentiated Visean Limestones between Dysert and Bellanamullia, with Waulsortian Limestone mapped between Bellanamullia and the Monksland substation. There is 1 no. fault mapped within the Waulsortian Limestone near Monksland which trends northwest-southeast.

The soils and subsoils were investigated along the Grid Route by means of Slit trenching, rotary core borehole drilling and down hole hammer borehole drilling. The soils and subsoils were found to consist primarily of GRAVEL/Silty GRAVEL/SAND. No bedrock met within any boreholes which ranged in depth from 4.2m – 16m.

3.5 HYDROGEOLOGY

The Dinantian Pure Bedded Limestones of the Visean Formation are classified by the GSI as a Regionally Important Karstified Aquifer with conduit groundwater flow characteristics. The majority of the proposed Wind Farm site is located within the Suck South GWB (GSI, 2014) with a small area inn he west of the Southern Cluster located within the Funshinagh GWB.

Pure bedded limestones are generally devoid of intergranular permeability. Groundwater flows through fissures, faults, joints and bedding planes. In pure bedded limestones these openings are often enlarged by karstification which significantly enhances the permeability of the rock. Karstification can also be accentuated along structural features such as fold axes and faults (GSI, 2014).

The GSI bedrock mapping is completed at a broad regional scale and should be considered to be indicative of the bedrock type. However, it is superseded by the collection of site investigation data which is site-specific and completed at a much finer scale, for the purposes of the Proposed Development. The bedrock geology encountered during the site investigations comprised of hard to medium hard, medium grey bioclastic Limestone and does not record any significant karst features.

The hydrology of the area between Roscommon town and just south of Dysart is dominated by groundwater hydrology, with a lack of surface water drainage features, but there is a strong connection between surface waters (rivers, streams and lakes) and groundwater flow by means of springs, swallow holes and gaining/losing streams.

Groundwater hydrology is dominant particularly in summer, spring and autumn. However, during winter when groundwater level rise, due to rainfall recharge, the sub-surface groundwater hydrology overflow/spills onto the land surface resulting in increased spring discharge, gaining streams and a karst phenomenon known as turloughs. Turloughs are temporary lakes caused by lowlands flooding with groundwater.

Based on the GSI karst database, there are several karst features, including turloughs, enclosed depressions and springs in the lands surrounding the Site (**Figure C**). Several of these mapped turloughs correspond to the loughs mapped in the local hydrology map above (**Figure B)**.

Extensive groundwater level monitoring has been completed in the area of the Proposed Development and is discussed in detail in Chapter 9 of the EIAR.

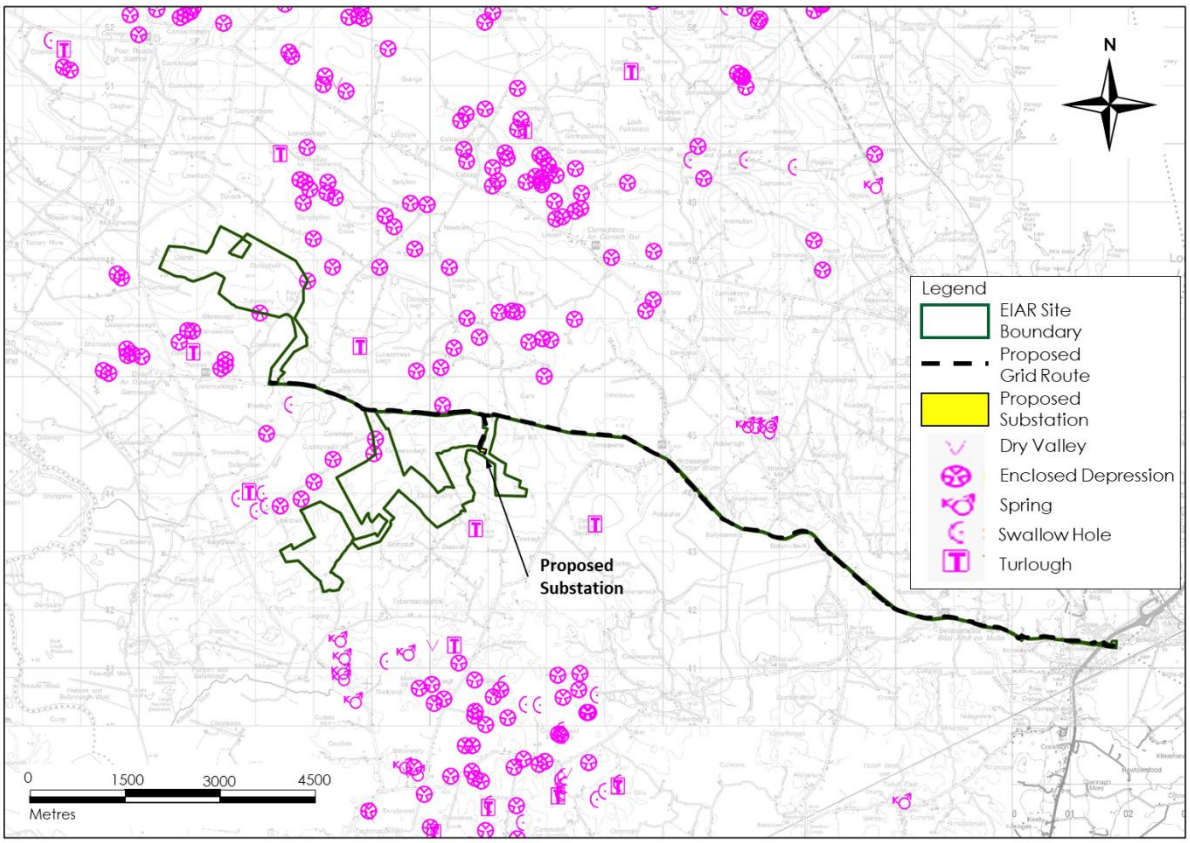

Figure C: GSI Karst Mapping

3.6 DESIGNATED SITES & HABITATS

Within the Republic of Ireland designated sites include National Heritage Areas (NHAs), proposed National Heritage Areas (pNHAs), candidate Special Areas of Conservation (cSAC), Special Areas of Conservation (SAC) and Special Protection Areas (SPAs). No designated sites are mapped within the proposed site boundaries.

The nearest designated site to the Northern Cluster is the Lough Croan Turlough SAC, SPA and pNHA (Site Code: 000610), located ~1.4km to the northeast, at an elevation of ~69 mOD. This is a linear wetland, aligned north-west/south-east, which lies in a relatively flat area of glacial till. It is split into two main parts - the east functions as a typical turlough, with a wet area dominated by Common Reed (Phragmites australis) at the centre; at the west is a fen, with floating vegetation in places, which also floods in winter. In between there is undulating ground. There is little over-ground flow, but both basins retain some water all year round. The SAC is designated under the qualifying interest of Turlough (3180).

The Four Roads Turlough SAC, SPA and pNHA (Site Code: 001637) is situated northwest of Lough Croan, and ~2.8km north/northwest of the Northern Cluster. It lies below a low scarp of limestone hills and is an open, shallow basin without permanent standing water which seems to flood predictably and dry out early. The SAC is designated under the qualifying interest of Turlough (3180).

The nearest designated site to the Southern Cluster is the Killeglan Grassland SAC (Site Code: 002214)[2]. The Killeglan grassland is designated under the qualifying interest of Orchid rich calcareous grassland. The site is undulating and slopes southwest from a height of ~90mOD to ~55 mOD.

The Feacle Turlough pNHA is situated ~0.6km south of the Southern Cluster of the proposed Wind Farm site. Feacle Lough is at an elevation of ~ 67 mOD, while the proposed turbines are mapped at >90 mOD. Feacle turlough lies in an uneven, glacial terrain of kame deposits. The basin runs roughly East- West but the edge is sinuous because of encroaching mounds. An esker-like feature projects from the southern side. The floor of the basin is similarly uneven with a number of discrete hollows: some at the western end show bedrock.

The Ballynamona Bog and Corkip Lough SAC is mapped ~1.0km east of the Southern Cluster area of the proposed Wind Farm site. The site comprises a relatively small portion of what was once a large bog complex, and includes areas of high bog and cutover bog, and also the turlough, Corkip Lough. The site is mapped at an elevation of ~55-58 mOD.

Further west, the River Suck Callows SPA and NHA exist along the banks of the River Suck. This designated site is mapped ~ 2.4km from the western edge of the proposed Site. Further east, Lough Funshinagh SAC and pNHA exists, at a distance of ~5.8km to the eastern edge of the proposed Site. The lake, which is underlain by Carboniferous limestone, is classified as a turlough because it fluctuates to a significant extent every year and occasionally dries out entirely (approximately two to three times every ten years). In most years, however, an extensive area of water persists. This is filled with vegetation, providing excellent breeding habitat for wildfowl, and the site is designated a Wildfowl Sanctuary. The lake is fed by springs and a small catchment to the west. It is mesotrophic in quality, with some marl (calcium carbonate) deposition, and is surrounded by pastures.

[2] *https://www.npws.ie/protected-sites/sac/002214*

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.

A stage 1 assessment of flood risk requires an understanding of where the water comes from (*i.e.* the source), how and where it flows (*i.e.* the pathways) and the people and assets affected by it (*i.e.* the receptors). It is necessary to identify whether there may be any flooding or surface water management issues related to the proposed site that may warrant further detailed investigation.

As per the 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; and,
- *Initial flood risk assessment* - confirm sources of flooding that may affect a proposed development.

Further to this, a stage 2 assessment involves the confirmation of sources of flooding, appraising the adequacy of existing information and determining what surveys and modelling approach may be required for further assessment.

4.2 FLOOD ZONE MAPPING

Flood zones are geographical areas within which the likelihood of flooding is in a particular range. There are three types or levels of flood zones defined according to OPW 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.

4.3 FLOOD RISK IDENTIFICATION

4.3.1 Soils Maps – Fluvial Maps

A review of the soil types in the vicinity of the Proposed Development was undertaken as soils can be a good indicator of past flooding in an area. Due to past flooding of rivers deposits of transported silts/clays referred to as alluvium build up within the floodplain and hence the presence of these soils is a good indicator of potentially flood-prone areas.

Based on the EPA/GSI soil map for the area no regions of river alluvium are mapped within the Wind Farm site (Northern and Southern Clusters). The closest mapped area of river alluvium (fluvial deposits) deposits to the Northern Cluster are found ~3km to the northeast along the Cross River and ~2.7km to the west on the Suck River. The closest mapped area of river alluvium (fluvial deposits) deposits to the Southern Cluster are found ~3km to the west along the Suck River and ~2km to the southeast on a local 1st order stream.

The EPA soils map (www.epa.ie) records an area of lake marl in the southeast of the Southern Cluster in the townland of Feacle and extending westwards into Cloonacaltry. This area corresponds to a known turlough, referred to as Lough Feacle, which does not correspond to the location of any wind farm infrastructure. Lough Feacle is located ~1.8km south of the proposed substation location.

Therefore, there is no significant alluvium deposition that would be associated with a flood plain or a large geographical area prone to flooding.

Along the Grid Route alluvium deposits are mapped on the Cross River in the townland of Bellanamullia. Significant areas of alluvium deposition occur downstream of the grid route along the Cross River.

4.3.2 Historical Mapping

There is no text on local available historical 6" or 25" mapping for the proposed Wind Farm site (Northern and Southern Cluster) or along the proposed grid route that identifies areas that are "*prone to flooding*".

4.3.3 OPW National Flood Hazard Mapping

The OPW National Flood Hazard Maps have no records of recurring flood incidences within the Wind Farm site (www.floodinfo.ie). However, there are several recurring flood incidents locally, which related to the turloughs in the surrounding lands.

A recurring flood event (Flood ID-177) is recorded to the southwest of the Northern Cluster and to the northeast of Dysart village. The Roscommon area engineer's report states that a "*large area floods every 2-3 years. The R357 is liable to flooding approximately every 10 years. The flooding is caused mainly by groundwater and runoff*". This recurring flood event corresponds to the location of the Carrownadurly Turlough.

Additional recurring flood events are reported to the east of the Northern Cluster, in the townlands of Cuilleenirwan (Flood ID: 806) and Ballinteleva (Flood ID: 183). The flooding at Cuilleenirwan is related to Cuilleenirwan Lough/Turlough while at Ballinteleva low-lying areas are reported to be susceptible to flooding every winter. This recurring flood event corresponds to the location of Coolagarry Lough. Further north, a turlough related recurring flood event (Flood ID-802) is mapped at Lough Croan in the townland of Turrock. No recurring or historic flood instances are recorded at Gortaphuill Turlough, located immediately to the north of T4.

Further south, a recurring flood event (Flood ID: 19) is mapped ~500m northwest of the Southern Cluster along the Ballyglass River. Here the Ballyglass River is noted to overflow its banks and flood a large area. A recurring flood event (Flood ID: 807) is also mapped to the southeast of

the Southern Cluster, in the townland of Feacle. This flood event coincides with the location of Lough Feacle. No recurring or historic flood events are located at the proposed substation location. The closest mapped flood incident to the substation location is at Lough Feacle, ~1.2km south of the substation location, with a second flood incident ~2km to the east at Lough Corkip (Flood ID: 808).

No recurring flood incidents are reported along the proposed Grid Route. A map of the locations of recurring and historic flood incidents is included as **Figure D** below.

The OPW (www.floodinfo.ie) do not record the presence of any Arterial Drainage Schemes or Benefited Lands within the proposed Wind Farm site, along the Grid Route or in the surrounding lands. The closest mapped benefited lands are along the Suck River to the west of the Site. This suggests that there has been no requirement to improve these lands for agriculture and/or to mitigate flooding within the Wind Farm site or along the Grid Route.

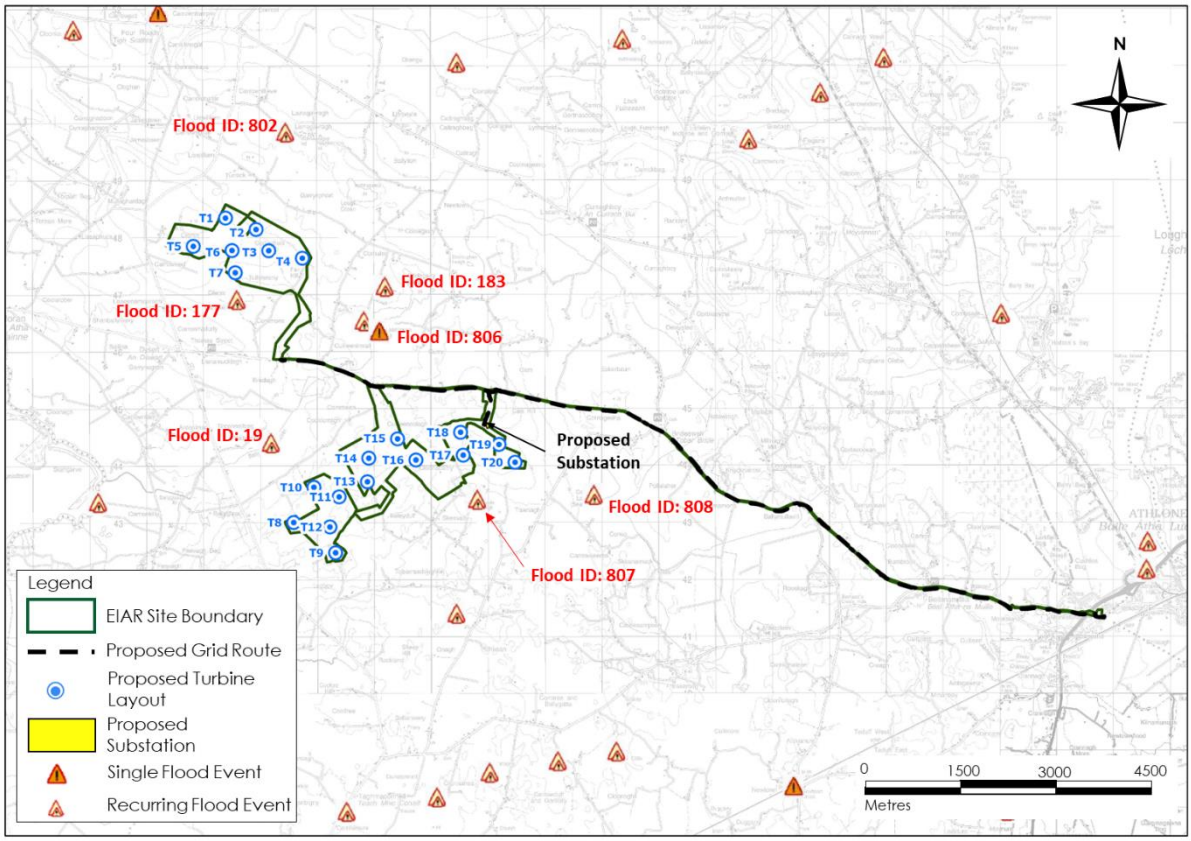

Figure D: OPW Flood Hazard Mapping (www.floods.ie)

4.3.4 OPW Flood Risk Assessment – Fluvial and Pluvial Flooding

Where complete the Catchment Flood Risk Assessment and Management (CFRAM)[3] OPW Flood Risk Assessment Maps are now the primary reference for flood risk planning in Ireland and supersede the Preliminary Flood Risk Assessment Maps (PFRA) maps. However, CFRAM mapping is not currently available for the area of the proposed Wind Farm site and therefore the PFRA maps were reviewed.

Flood maps were queried via the Roscommon Council website and via the OPW Flood Mapping (www.floodmaps) for potential areas prone to flooding (**Figure E**). The maps show that the Wind Farm site (Northern and Southern Clusters) is located outside the 1 in 100-year and the extreme (1 in 1,000-year) fluvial flood event zones (Flood Zones A and B respectively). The Northern and Southern Clusters, including the proposed substation location are therefore located in fluvial Flood Zone C (Low Risk).

The closest mapped fluvial flood zone to the Wind Farm site is located along the Suck River. At the closest point the mapped extreme fluvial flood zone is located more than 1.5km west of the Southern Cluster.

Along the Grid Route, fluvial flood zones are mapped on the Cross River to the west of Athlone town. CFRAM mapping has also been completed in this area. However a road crossing currently exists above the Cross River and the road itself is not mapped within any fluvial flood zones. Therefore the entire grid connection route lies within fluvial Flood Zone C (Low Risk).

There is no OPW pluvial flood mapping available for the Wind Farm site, however due to the hydrogeological regime present at the Wind Farm site characterised by very high groundwater recharge rates, no surface water and/or pluvial flooding is likely after heavy or persistent rainfall.

The GSI Historical 2015/2016 surface water flood map[4] shows fluvial and pluvial flooding, during the winter 2015/2016 flood event, which was the largest flood on record in many areas. This map does not show any surface water flooding within the Wind Farm site (Northern and Southern Clusters). The closest mapped surface water flood zones to the proposed on-site substation are located ~2.3km to the northeast and ~2.7km to the northwest. In terms of the T4 in the northern cluster, the closest mapped flood zone is ~1.1km to the northeast, corresponding to the location of Cornalee Turlough. In terms of the Grid Route, no surface water flooding was recorded along the route during the 2015/2016 flood event. Extensive areas of flooding are recorded ~1.2km southeast of Monkstown substation, associated with flooding of the River Shannon south of Athlone town.

[3] *CFRAM is Catchment Flood Risk Assessment and Management. The national CFRAM programme commenced in Ireland in 2011, and is managed by the OPW. The CFRAM Programme is central to the medium to long-term strategy for the reduction and management of flood risk in Ireland.*

[4] *GSI Historical flood mapping principally developed using Sentinel-1 Satellite Imagery from the European Space Agency Copernicus Programme as well as any available historic records (from winter 2015/2016 or otherwise).*

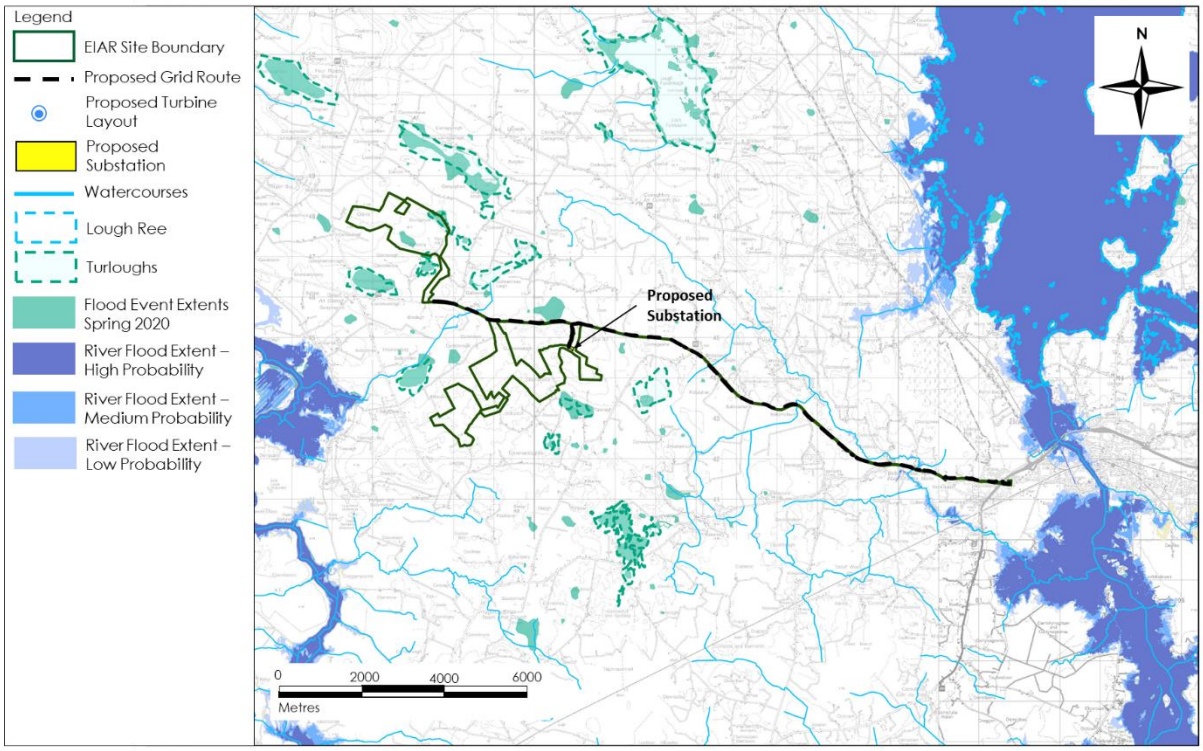

Figure E: Roscommon County Council Flood Mapping (www.rosco.maps.arcgis.com)

4.3.5 Historic Groundwater Flooding

The GSI Historical 2015/2016 groundwater flood map (**Figure F**) shows the observed peak flood extents caused by groundwater flooding in Ireland.

A large area of historic groundwater flooding is recorded in the southeast of the Northern Cluster in the townlands of Glenrevagh and Tulluyneeny. These groundwater flood zones are located ~700m southeast of T7 and ~700m southwest of T4. This area coincides with the Commons Turlough. Historic groundwater flooding is also recorded ~100m to the north of T4, associated with the Gortaphuill Turlough. Additional extensive groundwater flood zones are located to the southeast and northwest of the Northern Cluster, corresponding to the Carrownadurly Turlough and Lough Croan respectively.

A large area of groundwater flooding is mapped to the northwest of the Southern Cluster. This corresponds to the location of the Ballyglass turlough and is ~600m northwest of T10. Some areas of groundwater flooding are also recorded in the vicinity of T16, ~80m north of the proposed turbine location and within the proposed soil storage area. This groundwater flood zone is mapped ~1km southwest of the proposed substation location. Further extensive historic groundwater flood zones are mapped in the southeast of the Southern Cluster, corresponding to the location of Lough Feacle. This flood mapped flood zone is ~500m south of T17.

Some historic groundwater flooding is also mapped along the Grid Route in the townlands of Cam and Cornageeha, ~1.4km northeast of the proposed substation. As stated above, the proposed substation location itself is located ~1km from the closest historic groundwater flood zone.

Historic flood maps queried from Roscommon County Council show groundwater flooding in the Spring of 2020 (**Figure E** above). These flood zones largely coincide with the historic groundwater flood zones mapped by the GSI for the Winter 15/16 flood event and the location of known turloughs.

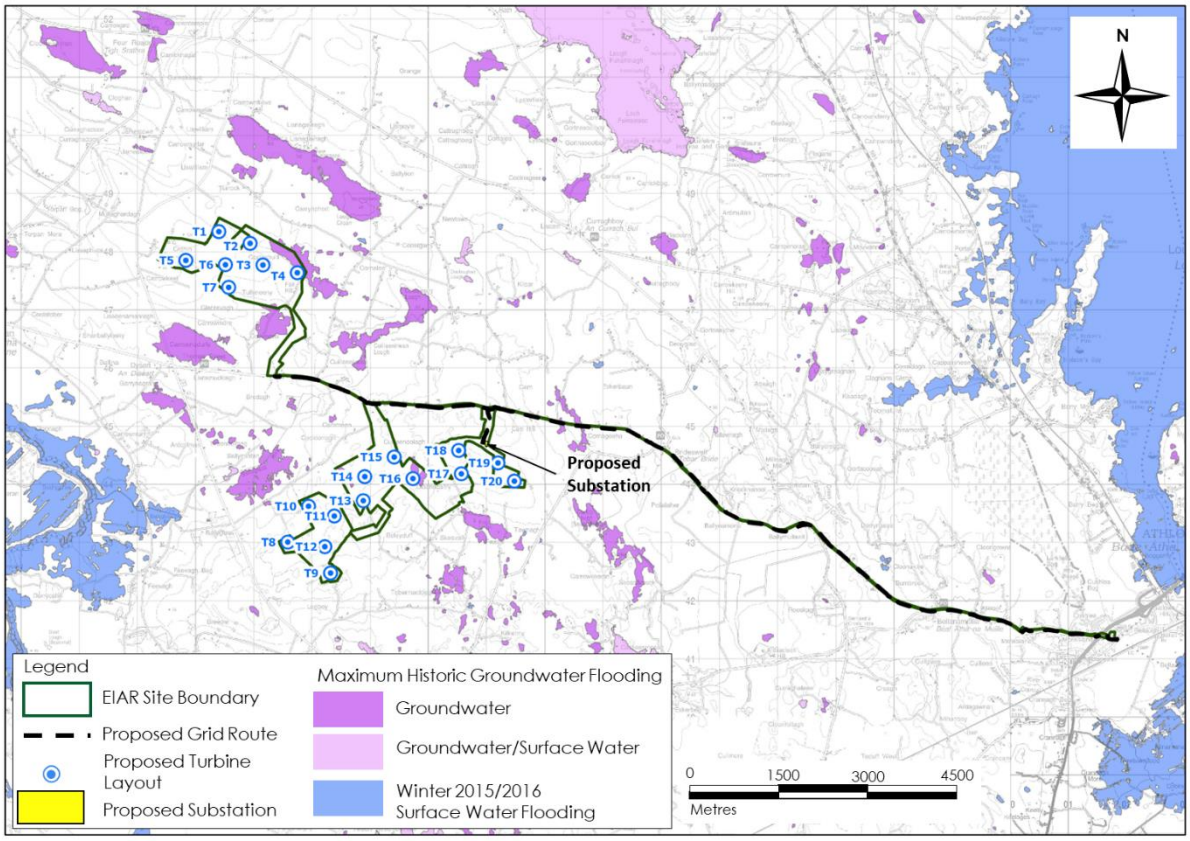

Figure F: GSI Historical Groundwater Flood Zones

4.3.6 Predictive Groundwater Flooding

In addition, the GSI predictive groundwater flood map records groundwater flood zones [high (1 in 10-year,) medium (1 in 100-years) or low (1 in 1,000-years) probability flood zone] in the southeast of the Northern Cluster in the townlands of Glenrevagh and Tulluyneeny. No wind farm infrastructure is proposed in this area of the Wind Farm site. In the northeast of the Northern Cluster, the high probability flood zone associated with the Gortaphuill Turlough is located ~100m northeast of T4, with the low probability flood zone located ~60m from the proposed turbine location. The low probability flood extents associated with the Carrownadurly Turlough to the southwest and Lough Croan to the northeast do not encroach upon the Wind Farm site.

Similarly, within the Southern Cluster no key wind farm infrastructure is located within the high, medium or low probability groundwater flood zones. A small area in the southeast of the Wind Farm site, located ~700m southeast of T18 and ~1km south of the proposed substation location, in the townlands of Feacle and Cloonacaltry, is mapped within these predicted groundwater flood zones. This corresponds to the location of Lough Feacle and is the closest mapped predictive groundwater flood zone to the proposed substation. No other predictive groundwater flood zones are mapped within the Southern Cluster. The area mapped as a historic groundwater flood zone to the north of T16 is not mapped by the GSI as a predicted flood zone. Finally, the Modelled flood zones associated with the Ballyglass Turlough to the northwest of the Southern Cluster do not encroach upon the Wind Farm site.

No areas along the proposed Grid Route are mapped within the GSI predictive groundwater flood zones.

While the local area is dominated by groundwater hydrology and turlough associated groundwater flooding, no proposed Site infrastructure (turbines, hardstands, access roads and/or the proposed substation) is located in a modelled groundwater flood zone.

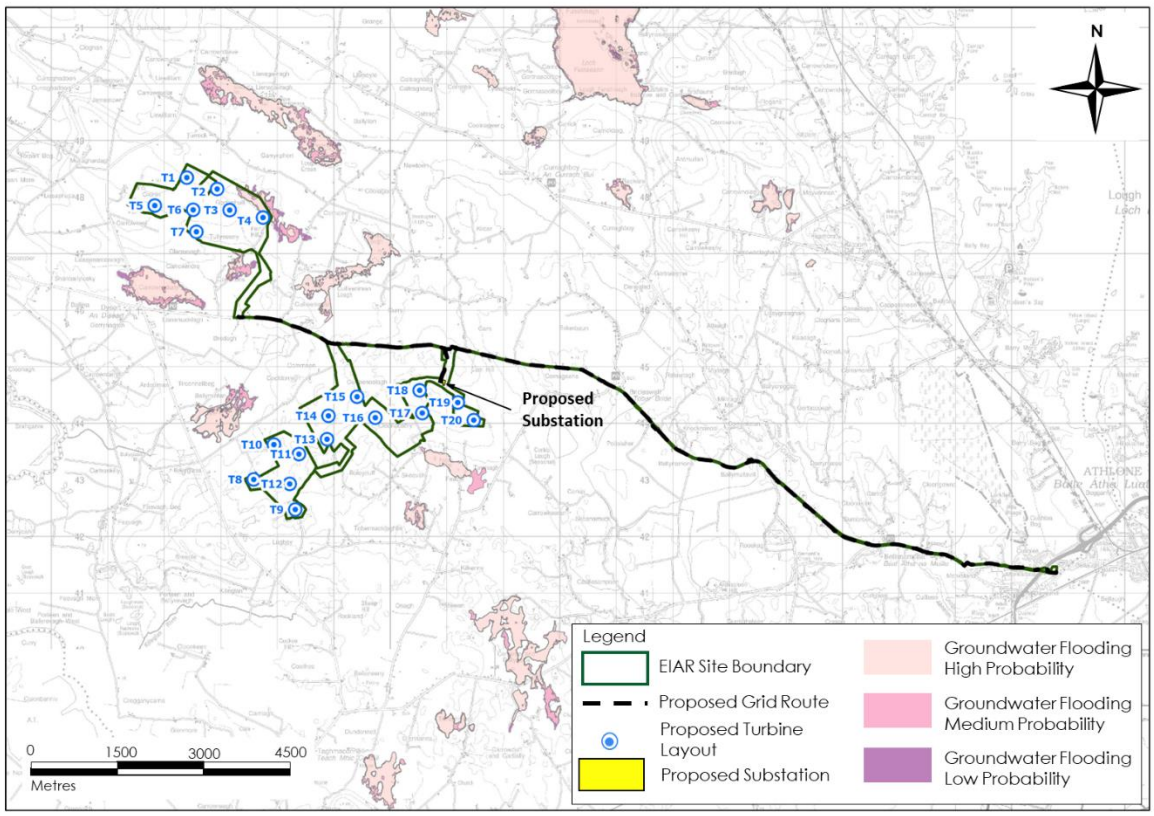

Figure G: GSI Predictive Groundwater Flood Zones

4.3.7 Summary – Flood Risk Identification

Based on the information gained through the flood identification process, it would appear that the Wind Farm site is not susceptible to fluvial or pluvial flooding. While sections of the Wind Farm site are susceptible to groundwater flooding these areas do not include any of the proposed key infrastructure locations. The Wind Farm site, including the proposed substation location and all 20. no turbine locations are therefore mapped as Flood Zone C *i.e.* low risk of flooding with small areas located in Flood Zone A.

In addition, the Grid Route is located in Flood Zone C.

4.4 INITIAL FLOOD RISK ASSESSMENT

4.4.1 Site Survey and Drainage

Detailed walkover surveys of the Site, the proposed Grid Route and the surrounding areas was undertaken by HES on several dates between 2019 and 2021.

The Northern Cluster lies generally on agricultural land, with grass pastures used primarily for sheep grazing. Some areas of scrub were noted to the north of the Northern Cluster. Land use in the Southern Cluster is also largely grassland used for sheep grazing, with some areas of rough scrub which is strewn with boulders. Both the Northern Cluster and the Southern Cluster are easily accessible with access roads situated within the grasslands.

The Wind Farm site (Northern and Southern Clusters) is characterized by a lack of surface water drainage features. The low drainage density of this area implies that the majority of effective rainfall is infiltrating to the groundwater system, rather than surface water runoff which would lead to a larger number of streams and rivers in the area.

The area is characterised by the occurrence of several karst features. A clear relationship exists between the local topography and the mapped karst hydrology with the majority of mapped karst features located on low-lying lands. The hills in the area, which generally stand at 70-100mOD are generally devoid of any karst features. Several turloughs are located in the lands surrounding the Wind Farm site. These are karst wetland ecosystems which flood annually in autumn through springs and fissures in the underlying karst limestone bedrock and drain in the springtime through the same fissures or swallow holes. HES completed groundwater monitoring in several of these turloughs between January 2020 and May 2021, the results of which are discussed in terms of flood risk in **Section 4.4.2** below.

4.4.2 Groundwater Level Monitoring

To further assess the risk of groundwater flooding at the Wind Farm site water level monitoring has been completed at a number of local turloughs over a period of 13 no. months between January 2020 - May 2021. The maximum recorded water level in each turlough is listed in **Table B** along with the distance to the nearest proposed turbine and the turbine elevation.

The turloughs are located between 0.1 – >5km from the nearest proposed turbine. The recorded maximum winter water levels within the turloughs range between 51.5 – 70.5 mOD, with elevation differences between each turlough and its nearest proposed turbine ranging between 4.6 - ~33m. The water levels in these turloughs generally increased from February to March before levelling out and gradually subsiding over the following months.

Table B: Turloughs near the proposed Wind Farm site

Turlough	Distance to nearest turbine (m)	Elevation of Max. Winter Water Level (mOD)	Turbine Elevation (mOD)	Elevation difference (m)
Ballyglass	0.9 km to T8	51.5	~71 mOD	19.4m
Thomas Street/Carrownadurly	1.1km to T7	57.5	~72 mOD	14.4m
Coolagarry/Cuilleenirwan)	1.3km to T4	65.1	~72 mOD	6.9m
Corkip Lough	1.0km to T20	~57	~95 mOD	~38m
Commons	0.9km to T7	66.44	~72 mOD	5.6m
Dooloughan	2.9km to T4	70.5	~72 mOD	1.5m
Feacle Lough	0.7km to T18	62.2	~90 mOD	27.8
Four Roads	2.75km to T1	48.6	~93 mOD	~41m
Gortaphuill	0.1km to T4	67.4	~72 mOD	4.6m
Lough Croan	1.3km to T2	68.2	~76 mOD	7.8m
Lough Funshinagh	>5km	69.04	N/A	N/A

As stated in **Table B** and in **Section 4.2**, T4 is located in close proximity (~100m) to Gortaphuill Turlough. The current ground elevation at the proposed turbine location is 72mOD and the turbine formation level is ~69mOD. The formation level is ~1.6m above the elevation of the maximum winter water level (67.4mOD) recorded during the 13 month monitoring period at Gortaphuill turlough. However as seen in below, the proposed turbine location is located on a local topographic high to the southwest of the turlough and some ground excavations will be required in this area. The topography to the northeast of Gortaphuill turlough is lower-lying with topography less than 68.1mOD. In the event of an extreme groundwater flood event, Gortaphuill turlough will preferentially flood theses areas of lower elevation to the northeast. As the water level in the turlough increases so does the plan area of the turlough. Therefore, greater volumes of groundwater are required to cause an increase in water level across the turlough. Consequently, significant volumes of water would be required for the proposed T4 location to experience flooding. Groundwater flooding at T4 is therefore highly unlikely.

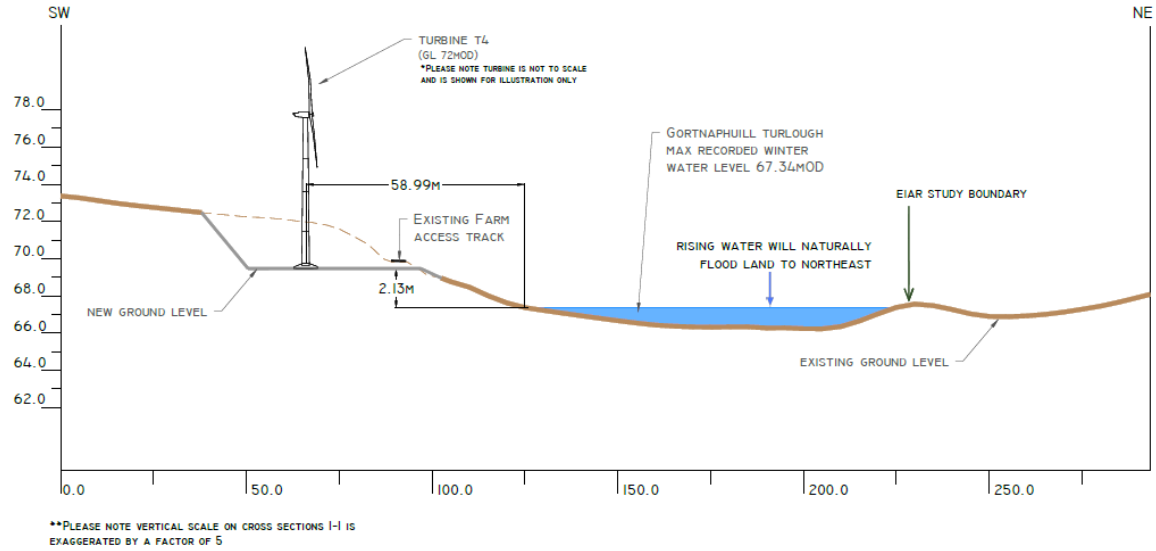

Figure H: Cross-Section of T4 and Gortaphuill Turlough

4.4.3 Hydrological Flood Conceptual Model

Potential flooding in the vicinity of the proposed 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 site, is groundwater flooding.

The primary potential pathways, in the most likely order of significance, would be groundwater flooding during extremely wet winters. The potential receptors in the area are infrastructure and land as outlined below.

4.4.4 Summary – Initial Flood Risk Assessment

Based on the information gained through the flood identification process and Initial Flood Risk Assessment process it would appear that flooding is unlikely to be problematic at the site or downstream of the site. The potential sources of flood risk for the proposed site are outlined and assessed in **Table C**.

Table C: S-P-R Assessment of Flood Sources for the proposed site

Source	Pathway	Receptor	Comment
Tidal	Not applicable	Land and infrastructure.	The proposed site is >55km from the coast and there is no risk of coastal flooding.
Fluvial	No streams/rivers mapped within the Wind Farm site. Overbank flooding along the Ratawragh stream, Barr's Drain and the Cross River along the grid route.	Land and infrastructure.	The area of the Site has a low drainage density with few watercourses. No fluvial flood zones are mapped in the area of the Wind Farm site and no historic flood events have been recorded, with the exception of one event along the Ballyglass River. The Wind Farm site including all key development infrastructures and the proposed substation location is located in Fluvial Flood Zone C (Low Risk). The Grid Route is located in Flood Zone C with no fluvial flood zones encroaching upon the route.
Pluvial	Ponding of rainwater on site	Land and infrastructure.	The Wind Farm site including all key development infrastructures and the proposed substation location is elevated with sloping topography, well drained and permeable soils and subsoils. Therefore, the Wind Farm site is not at risk of pluvial flooding.
Surface water	Surface ponding/ Overflow	Land and infrastructure	Same as above (pluvial).
Groundwater	Rising groundwater levels	Land and infrastructure.	GSI mapping records the occurrence of groundwater flood zones in the lands surrounding the Wind Farm site, some of which encroach upon the site but do not coincide with the location of key infrastructures (turbines or the proposed substation). No flood zones are mapped along the grid connection route. Gortaphuill turlough is located ~100m from T4. Local topography will ensure that lands to the northeast of the turlough will preferentially flood during extreme flood events. Groundwater flooding at T4 is extremely unlikely due to its location on a topographic high. The proposed T4 turbine and hardstand are therefore not susceptible to groundwater flooding, and the proposed construction of these wind farm elements will not impact on flood levels elsewhere.

4.5 REQUIREMENT FOR A JUSTIFICATION TEST

The matrix of vulnerability versus flood zone to illustrate appropriate development and that required to meet the Justification Test[5] is shown in **Table D** below.

It may be considered that the Proposed Development can be categorised as "Highly Vulnerable Development". However, as stated above, all key development infrastructures including turbines, the proposed substation and access roads are located in Flood Zone C. The Grid Route is also mapped as Flood Zone C with all river crossings already in existence and not mapped within flood zones. Consequently, the proposed development is not at risk of flooding and is deemed appropriate (refer to **Table D** below).

Table D: 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	**Appropriate**
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*

[5] *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).*

5. FLOOD RISK ASSOCIATED WITH THE PROPOSED DEVELOPMENT

5.1 INTRODUCTION

This section assesses the flood risk of the proposed development with regard to Section 5.28 of the Flood Risk Management Guidelines. The assessment is made based on the Groundwater flood zone mapping as this is currently the only available published flood mapping for the development site.

5.2 FLOODING IMPACT ASSESSMENT OF PROPOSED INFRASTRUCTURE

This section outlines the potential for flooding to arise elsewhere as a result of the proposed development.

As no proposed wind farm infrastructure is located within mapped low probability groundwater flood zones, no water will be displaced by the proposed development during times of extreme flooding (1 in 1,000-year flood events). Therefore, the proposed development will not increase the flood risk elsewhere in the wider area.

The creation of impermeable areas within a development site has the effect of increasing rates of runoff into the downstream drainage system and this may increase flood risk and flood severity downstream. This applies particularly to urban areas that drain to closed pipe systems which do not have the capacity to cater for increased hydraulic loads. However, the proposed Site is located within a large rural catchment with a low drainage density and in an area of high groundwater recharge rates. The footprint of the impermeable areas (hardstands, turbine bases and access roads) and the associated increase in runoff rate is very small in the context of the catchment size and therefore represents a negligible increase in downstream flood risk. Notwithstanding the low increase in flood risk due to the Proposed Development, the drainage system has been designed to prevent any increase in discharge rates above that which already exist in the undeveloped site. Therefore, runoff from impermeable surface will be directed laterally to soakaways/infiltration trenches where it will recharge to the groundwater system within metres of where it would have naturally done so.

The proposed Grid Connection route does not pose any risk to downstream flooding as the cable trench will be excavated in the carriageway of the existing public road network.

5.3 FLOODING IMPACT ASSESSMENT OF FUTURE CLIMATE CHANGE SCENARIOS

Current climate models project increased winter rainfall in the coming decades, particularly in western Ireland. Lowland karst systems will be particularly vulnerable to these changing climate conditions due to extremely fast recharge. Climate change is therefore predicted to increase the frequency of extreme groundwater flooding events, indicating that more significant flooding events, such as the winter of 2015/2016 flood event, are likely to become more common.

In extreme future groundwater flood events, as highlighted by the medium and low probability flood events, an increasing proportion of the Wind Farm site will be located within groundwater flood zones. However, these flood zones do not coincide with the location of any proposed infrastructure locations (turbines, hardstands, substation). Therefore, the proposed development will not result in the displacement of floodwaters as extreme events become more common in the coming decades.

6. FRA REPORT CONCLUSIONS

- A flood risk identification study was undertaken to identify existing potential flood risks associated with the proposed Seven Hills Wind Farm development in Co. Roscommon. From this study:
    - No instances of historical flooding were identified in historic OS maps within the Site;
    - No instances of recurring flooding were identified on OPW maps within the Site;
    - The Site was not identified as being within the CFRAM Flood Zones; and,
    - The Site is not mapped within any PFRA fluvial flood zones, with all key wind farm infrastructures located at least 50m away from mapped surface watercourses.
- The Site is therefore not susceptible to fluvial flooding;
- Due to the high permeability of the soils and subsoils at the Site there is a limited surface water drainage network. As a result all available rainfall recharges to groundwater;
- Several recurring flood instances have been reported in the lands surrounding the Wind Farm site, which relate to locally mapped turloughs;
- The GSI Historic and Predictive Groundwater Flood Maps shows the extent of local groundwater flood zones which generally coincide with the known mapped turloughs in the area. All key wind farm infrastructures and also the proposed substation site are located outside of the GSI predictive and historic groundwater flood zones;
- Groundwater level monitoring in local turloughs revealed that the proposed turbine locations remained 1.5 – 33m above the maximum winter water level of the nearest turlough;
- T4 is located ~100m from Gortaphuill Turlough and is not mapped within any historic or predictive groundwater flood zone. Local topography ensures that groundwater flooding at Gortaphuill will occur preferentially to the northeast and away from the Wind Farm site, increasing the plan area of the turlough. Flooding at T4 in not likely as significant volumes of groundwater would be required to flood to this elevation;
- The proposed substation location is not mapped within a high, medium or low probability fluvial or groundwater flood zone and is therefore located in Flood Zone C;
- A small section of the Grid Route is mapped in the GSI Historic Groundwater Flood Zone in the townlands of Cam and Cornageeha. However, the public road network already currently exists in this location;
- The Justification Test concluded that the proposed Site, all key infrastructure including turbines and the proposed on-site substation and grid route are located within a low-risk area (Flood Zone C), and as such is appropriate from a flood risk perspective; and,
- Flood risks associated with potential flooding downstream of the Site can be managed by way of avoidance during flooding, standard SuDs drainage measures, scour protection measures and the implementation of surface water attenuation systems.

* *

7. REFERENCES

AGMET	1996	Agroclimatic Atlas of Ireland.
DOEHLG	2009	The Planning System and Flood Risk Management.
GSI	2014	GWB Characterisation Report - Suck South GWB
Met Eireann	1996	Monthly and Annual Averages of Rainfall for Ireland 1961-1990.