Planning and Environmental Consultants

Environmental Impact Assessment Report

Carrig Renewables Wind Farm

Chapter 8 – Land, Soils and Geology

DOCUMENT DETAILS

Client:	**Carrig Renewable Energy Ltd.**
Project Title:	**Carrig Renewables Wind Farm**
Project Number:	**211016**
Document Title:	**Environmental Impact Assessment Report**
Document File Name:	**Ch. 8 Land Soils & Geology F – 2023.08.25 - 211016**
Prepared By:	**MKO** **Tuam Road** **Galway** **Ireland** **H91 VW84**

Planning and Environmental Consultants

Rev	Status	Date	Author(s)	Approved By
00	FINAL	2023.08.25	DB	MG

Table of Contents

8. LAND, SOILS AND GEOLOGY

8.1 Introduction

8.1.1 Background and Objectives

Hydro-Environmental Services (HES) was engaged by MKO to carry out an assessment of the potential likely and significant effects of the proposed Carrig Renewables Wind Farm (Proposed Development) in Co. Tipperary and Co. Offaly on Land, Soils and Geology aspects of the receiving environment.

The Proposed Development is described in full in Chapter 4 of this EIAR.

In summary, the Proposed Development which includes 7 no. turbines, substation, underground grid connection and turbine delivery route (TDR) accommodation works is located at Carrig (and surrounding townlands), situated approximately 9km to the northeast of Borrisokane, Co. Tipperary.

The proposed underground grid connection is to the existing Dallow 110kV substation, situated 2.5km north of Birr in Co. Offaly, and measures a total distance of 13.7km.

The Proposed Development site (as defined by the EIAR Study Area Boundary) includes the wind farm site and grid connection route and the TDR accommodation works.

This report provides a baseline assessment of the environmental setting of the Proposed Development, as described in Chapter 4, in terms of Land, Soils and Geology and discusses the potential likely significant effects that the construction, operation and decommissioning of the Proposed Development may have. Where required, appropriate mitigation measures to avoid any identified significant effects to Land, Soils and Geology (i.e., natural resources) are recommended and the residual effects of the Proposed Development post-mitigation are assessed.

Please note that in this chapter we refer to specific elements of the Proposed Development such as the wind farm site, underground grid connection cable route options and Turbine Delivery Route (TDR).

8.1.2 Statement of Authority

Hydro-Environmental Services (HES) are a specialist geological, 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 areas of expertise and experience includes soils, subsoils and geology. We routinely complete impact assessments for land, soils and geology, hydrology and hydrogeology for a large variety of project types including wind farms and renewable energy projects.

This chapter of the EIAR was prepared by David Broderick and Michael Gill.

David Broderick P.Geo (BSc, H. Dip Env Eng, MSc) is a Hydrogeologist with over 17 years' experience in both the public and private sectors. Having spent two years working in the Geological Survey of Ireland working mainly on groundwater and source protection studies David moved into the private sector. David has a strong background in groundwater resource assessment and geological, hydrogeological/hydrological investigations in relation to developments such as quarries and wind farms. David has completed numerous geology and water sections for input into EIARs for a range of commercial developments. David has worked on the EIS/EIARs for Derrykillew WF, Oweninny WF, Yellow River WF and over 80 other wind farm related projects across the country.

Michael Gill P.Geo (BA, BAI, Dip Geol., MSc, MIEI) is an Environmental Engineer and Hydrogeologist with over 22 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms and renewable projects in Ireland. In addition, he has substantial experience in geological characterisation, peatland morphology, and surface water drainage design and SUDs design and surface water/groundwater interactions. Michael has worked on the EIS/EIAR for Oweninny WF, Cloncreen WF, Derrinlough WF and over 100 other wind farm related projects across the country.

8.1.3 Relevant Legislation

The EIAR is prepared in accordance with the requirements of European Union Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (the 'EIA Directive') as amended by Directive 2014/52/EU. The requirements of the following legislation are complied with:

- Planning and Development Acts, 2000-2021;
- Planning and Development Regulations, 2001 (as amended);
- Directives 2011/92/EU and 2014/52/EU on the assessment of the effects of certain public and private projects on the environment;
- S.I. No. 296/2018 European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2018; and,
- The Heritage Act 1995, as amended.

8.1.4 Relevant Guidance

The Land, Soils and Geology chapter of this EIAR was prepared in accordance with, where relevant, the guidance contained in the following documents:

- Environmental Protection Agency (2022): Guidelines on the Information to be contained in Environmental Impact Assessment Reports;
- Institute of Geologists Ireland (2013): Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements;

- National Roads Authority (2008): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;
- Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment (DoHPLG, 2018); and,
- Guidance on the preparation of the EIA Report (Directive 2011/92/EU as amended by 2014/52/EU), (European Commission 2017).

8.2 Assessment Methodology

8.2.1 Desk Study

A desk study of the Proposed Development site and land, soils and geology receiving environment (described below) was completed in advance of undertaking the walkover survey and site investigation works. This involved collecting all relevant geological data for the Proposed Development site and receiving environment. This included consultation with the following data sources:

- Environmental Protection Agency database (www.epa.ie);
- Geological Survey of Ireland - Groundwater and Geology Databases (www.gsi.ie);
- Geological Survey of Ireland – Geological Heritage site mapping (www.gsi.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 15 (Geology of Galway - Offaly). Geological Survey of Ireland (GSI, 1999);
- Geological Survey of Ireland – 1:25,000 Field Mapping Sheets;
- General Soil Map of Ireland 2nd edition (www.epa.ie); and,
- Aerial Photography, 1:5000 and 6 inch base mapping.

8.2.2 Baseline Monitoring and Site Investigations

A walkover survey, including geological mapping and investigations of the Proposed Development site, were undertaken by David Broderick of HES (refer to Section 8.1.2 above for qualifications and experience) on 24th August 2022, 17th, 24th January, 25th March and 14th April 2023.

Peat probing, to assess peat depths across the site, was undertaken by Jonny Fearon and Karen Mulryan of MKO on the 15th June 2022 and 15th February 2023.

Geotechnical ground investigations and a peat stability assessment were undertaken by Gavin & Doherty Geosolutions (GDG) (refer to Appendix 8-1). The combined geological and hydrogeological dataset collated by HES, MKO and GDG has been used in the preparation of this EIAR Chapter.

The objectives of the intrusive site investigations included mapping the distribution and depth of peat at the wind farm site along with assessing the mineral subsoil / bedrock conditions beneath the peat at key development locations (i.e. proposed turbines, met mast, substation, temporary construction compound, existing and proposed access roads, and walkover survey of the cable route). This data was used to inform the final layout design.

In summary, site investigations to address the Land, Soils and Geology chapter of the EIAR included the following:

- A total of 176 no. investigations points (155 no. were peat probes) were carried out by MKO, GDG, and HES to determine the depth and geomorphology of the peat at the proposed wind farm site;
- A Peat Stability Assessment Report by GDG (Appendix 8-1);
- A total of 10 no. gouge core sample points were undertaken by HES at proposed infrastructure locations to investigate peat and underlying mineral soil lithology;

- Trial pitting (15 no.) to investigate underlying mineral soil lithology and the subsoil/bedrock interface was carried out by GDG (Trial pit logs included in Appendix 3 of Appendix 8-1 of this EIAR);
- Logging of peat and subsoil exposures across the site where mineral soils and peat profiles are exposed; and,
- Mineral subsoils and peat were logged according to BS: 5930 and Von Post Scale respectively.

The Peat Stability Assessment Report and Peat and Spoil Management Plan prepared by GDG are included as Appendix 8-1 and Appendix 4-2 of this EIAR respectively.

8.2.3 Scope and Consultation

The scope for this EIAR has been informed by consultation with statutory consultees, bodies with environmental responsibility and other interested parties. This consultation process is outlined in Section 2.5 of this EIAR.

The Geological Survey of Ireland and Inland Fisheries Ireland were the only consultees to respond with respect to Land, Soils and Geology and their response is summarised in Table 8-1 below.

Table 8-1 Summary of Scoping Responses

Consultee	Description	Addressed in Section
Geological Survey of Ireland (GSI)	*"Arragh More Bog, Co. Tipperary (GR 197387, 201288), under IGH themes: IGH7 Quaternary, IGH16 Hydrogeology. An active raised bog in a low-lying hollow 6 km east of Carrigahorig. The entire Arragh More Bog comprises several interconnecting bogs, with till ridges running between deeper areas of bog. Peat has developed on some of the ridges. A large flush occurs in the northern area of the bog partially forested by conifers. Large areas of the southern part of the bog are characterised by cutover".* *"With the current plan, there may be potential impacts on the integrity of current CGSs* [County Geological Site] *envisaged by the proposed development, should these sites not be assessed as constraints. Ideally, the sites should not be damaged or integrity impacted or reduced in any manner due to the proposed development. However, this is not always possible, and in this situation appropriate mitigation measures should be put in place to minimize or mitigate potential impacts".*	8.3.6
Inland Fisheries Ireland (IFI)	*"We are concerned about soils, their structure and types around all the turbines, turbine pads, associated access roads and site development. In particular we have concerns about the stability of the soils and the impact that works on both the turbines and access roads may have either directly or by vibration on the stability of the soils. IFI are particularly concerned where it is proposed to construct wind turbines on peat soils especially if these peat soils are located on upland*	8.3.8 & 8.5.2.5

Consultee	Description	Addressed in Section
	areas. Extra caution will be required to prevent deleterious discharges to waters". *"IFI strongly recommends that specialist personnel are employed to assess soil strength and suitability of the ground at each site and along any proposed access road. This is particularly important in relation to peat soils. From our experiences we will have serious difficulties with developments on peat soils where there is excessive slope and/or where the peat depth exceeds one metre. Excessive slopes will be an issue with all wind farm proposals regardless of soil type. The potential for soil movement and landslides should be assessed fully within the EIS".*	

8.2.4 Impact Assessment Methodology

Using information from the desk study and data from the site investigations, an assessment of the importance of the land, soil and geological environment within the study area and Proposed Development site is assessed using the criteria set out in Table 8-2 (NRA, 2008).

Table 8-2 Estimation of Importance of Soil and Geology Criteria (NRA, 2008).

Importance	Criteria	Typical Example
Very High	Attribute has a high quality, significance or value on a regional or national scale. Degree or extent of soil contamination is significant on a national or regional scale. Volume of peat and/or soft organic soil underlying route is significant on a national or regional scale.	Geological feature rare on a regional or national scale (NHA). Large existing quarry or pit. Proven economically extractable mineral resource
High	Attribute has a high quality, significance or value on a local scale. Degree or extent of soil contamination is significant on a local scale. Volume of peat and/or soft organic soil underlying site is significant on a local scale.	Contaminated soil on site with previous heavy industrial usage. Large recent landfill site for mixed wastes Geological feature of high value on a local scale (County Geological Site). Well drained and/or highly fertility soils. Moderately sized existing quarry or pit Marginally economic extractable mineral resource.
Medium	Attribute has a medium quality, significance or value on a local scale. Degree or extent of soil contamination is moderate on a local scale.	Contaminated soil on site with previous light industrial usage. Small recent landfill site for mixed Wastes. Moderately drained and/or moderate fertility soils. Small existing quarry or

Importance	Criteria	Typical Example
	Volume of peat and/or soft organic soil underlying site is moderate on a local scale.	pit. Sub-economic extractable mineral Resource.
Low	Attribute has a low quality, significance or value on a local scale. Degree or extent of soil contamination is minor on a local scale. Volume of peat and/or soft organic soil underlying site is small on a local scale.	Large historical and/or recent site for construction and demolition wastes. Small historical and/or recent landfill site for construction and demolition wastes. Poorly drained and/or low fertility soils. Uneconomically extractable mineral Resource.

The guideline criteria (EPA, 2022) for the assessment of likely significant effects require that likely effects are described with respect to their extent, magnitude, type (i.e. negative, positive or neutral) probability, duration, frequency, reversibility, and transfrontier nature (if applicable). The descriptors used in this environmental impact assessment report are those set out in the EPA (2022) Glossary of effects as shown in Chapter 1 of this EIAR. In addition, the two impact characteristics proximity and probability are described for each impact and these are defined in Table 8-3.

In order to provide an understanding of this descriptive system in terms of the geological/hydrological environment, elements of this system of description of effects are related to examples of potential likely significant effects on the geology and morphology of the existing environment, as listed in Table 8-4.

Table 8-1: Additional Impact Characteristics.

Impact Characteristic	Degree/ Nature	Description
Proximity	Direct	An impact which occurs within the area of the proposed project, as a direct result of the proposed project.
	Indirect	An impact which is caused by the interaction of effects, or by off-site developments.
Probability	Unlikely	A low likelihood of occurrence of the impact.
	Likely	A medium likelihood of occurrence of the impact.

Table 8-2: Impact descriptors related to the receiving environment.

Impact Characteristics		Potential Hydrological Impacts
Quality	Significance	
Negative only	Profound	Widespread permanent impact on: › The extent or morphology of a cSAC. › Regionally important aquifers. › Extents of floodplains. Mitigation measures are unlikely to remove such impacts.
Positive or Negative	Significant	Local or widespread time-dependent impacts on: › The extent or morphology of a cSAC / ecologically important area. › A regionally important hydrogeological feature (or widespread effects to minor hydrogeological features). › Extent of floodplains. Widespread permanent impacts on the extent or morphology of an NHA/ecologically important area. Mitigation measures (to design) will reduce but not completely remove the impact – residual impacts will occur.
Positive or Negative	Moderate	Local time-dependent impacts on: › The extent or morphology of a cSAC / NHA / ecologically important area. › A minor hydrogeological feature. › Extent of floodplains. Mitigation measures can mitigate the impact OR residual impacts occur, but these are consistent with existing or emerging trends
Positive, Negative or Neutral	Slight	Local perceptible time-dependent impacts not requiring mitigation.
Neutral	Imperceptible	No impacts, or impacts which are beneath levels of perception, within normal bounds of variation, or within the bounds of measurement or forecasting error.

8.2.5 Limitations and Difficulties Encountered

No limitations or difficulties were encountered during the preparation of the Land, Soils and Geology Chapter of the EIAR.

8.3 Existing Environment

8.3.1 Site Description and Topography

The wind farm site is a low-lying cutaway raised bog setting (basin peat) located 9km to the northeast of Borrisokane, Co. Tipperary. The town of Birr in County Offaly is located 6.5km to the northeast. Access to the wind farm site is from the N52 which is located immediately to the east of the Proposed Development site.

The wind farm site, which has a total area of approximately 314ha, is predominantly cutaway raised bog with areas of agricultural grassland and forestry. The surrounding area is largely agricultural including a piggery development which is located immediately to the northwest of the wind farm site. The wind farm site is accessible via network of public roads which run through the site along with some bog tracks that give access to various turbary plots on the periphery of the bog.

The wind farm site is located in a low-lying area (surrounded by small hills) where the ground is largely flat and sits at approximately 60m OD. The ground level rises to 70m OD on the east and west of the wind farm site where small hills are present. This forms a subdued topographic divide running through the centre of the wind farm site which creates gentle falls towards the north and south of the Proposed Development site.

Most of the wind farm site is exposed cutaway raised bog (with pockets of intact bog towards the centre), however there is tree coverage on the bog particularly on the northeast, northwest and west. There is agricultural land on the southwest.

The proposed grid connection is to the Dallow 110kV substation, situated 2.5km north of Birr (Co. Offaly) and measures a total distance of 13.7km. The proposed route is located entirely along public roads. Approximately 3.5km of route is in County Offaly.

8.3.2 Land and Land Use

Based on Corine (2018) mapping the wind farm site comprises peat bogs and areas of mixed forestry surrounded by agricultural pastures. Corine also map some local pockets of non-irrigated arable land to the north. Corine Land Change maps (www.land.copernicus.eu) do not record any major land use changes within the wind farm site from 1990 to 2018. Turbary plots are extensive across the bog area.

4 no. of the proposed 7 no. turbines are located on open cutaway bog, 2 no. are located within a conifer plantation on the north of the Proposed Development site (also underlain by bog) and 1 no. on grassland at the southwest of the site. The substation, located close to the site entrance on the east of the wind farm site, is in an area of mixed forestry.

Land use along the grid connection option routes is predominantly agricultural with a scattered pattern of rural houses and farmyards.

However, as stated above, the grid connection will be contained within the carriageway of the existing public road network and no change to land use or land cover will occur result from the proposed works.

8.3.3 Soils and Subsoils

The published soil map (www.epa.ie) for the area shows that the wind farm site is dominated by Cut Peat (Basin Peats) with some basic deep well drained mineral soil on the east and southwest. All proposed wind farm site infrastructure is mapped to be underlain Cut Peat.

Similarly, the GSI subsoil mapping (www.gsi.ie) shows that the wind farm site is underlain predominantly by Cutover Raised Peat along with till derived from limestones. A localised pocket of gravels derived from limestones is mapped to the west of proposed turbine location T5. All proposed wind farm site infrastructure is mapped to be underlain by Cutover Raised Peat with the exception of a short section of proposed access road on the southwest of the wind farm which is mapped as limestone tills.

A subsoil geology map for the wind farm site and grid connection is shown as Figure 8-1.

Measured peat depths range from 0 - 4.49m across the wind farm site, with an average depth of 1.6m recorded. Where peat was encountered it was typically described as spongy, dark brown, pseudo-fibrous peat.

Peat depths are greatest in the northeast of the wind farm site (around turbine locations T2 and T6) where peat depths range between approximately 2 and 4.5m, with another area of similar depth peat located more centrally between proposed turbine T5 and the temporary construction compound and also on the east of the site near proposed turbine T1.

Peat depths on the northwest of the wind farm site (around turbine locations T5 and T7) are typically shallower where they range from between 0.5 and 2m and then thin out where bordered by agricultural land. Peat is generally absent or very shallow on the southwest of the wind farm site. (i.e. along the main site entrance road) where there is improved agricultural grassland. Peat is also absent on the far east of the wind farm site at the proposed substation location.

Peat depths at the turbine locations ranged between 0.6 (T4) and 3.7m (T2) with an average peat depth of 2.3m. Refer to Table 8-5 below.

A peat distribution plot for peat probe depths at the wind farm site is shown in Figure 8-2 below. Approximately 32% (49 no.) of the peat depths were less than 0.5m while 81% (126 no.) were less than 2m. Overall the peat depths would be considered shallow for midlands basin peat.

A summary peat depth map for the wind farm site is shown as Figure 8-3.

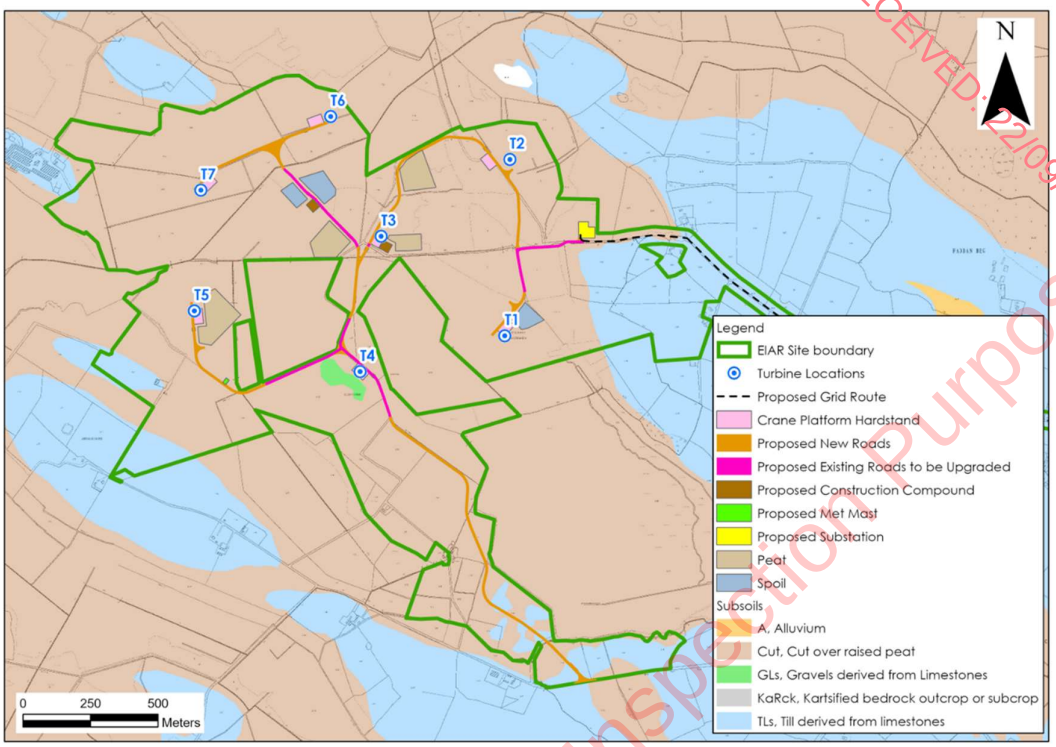

Figure 8-1 Subsoils Geology Map

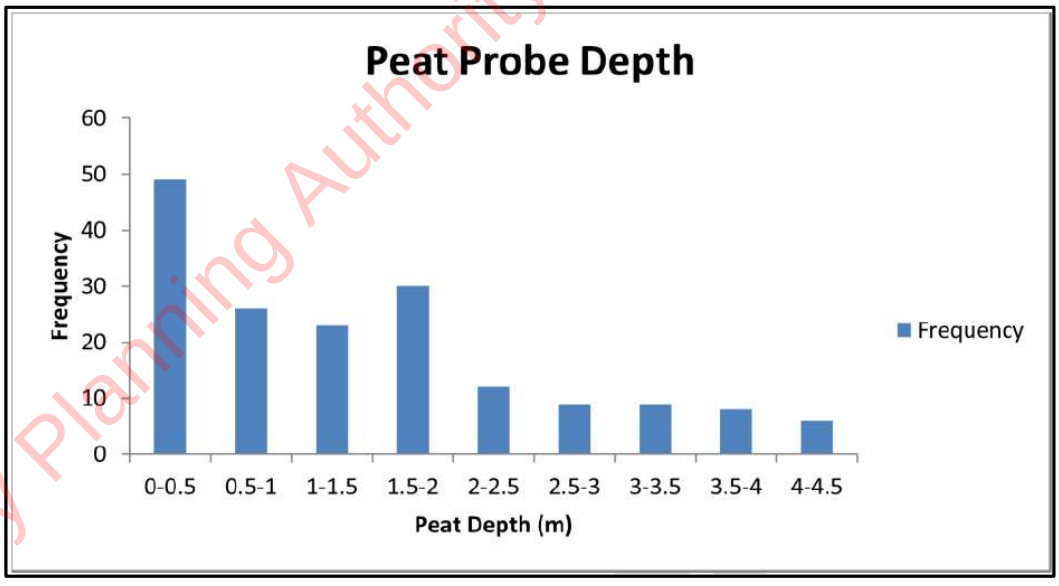

Figure 8-2 Peat Depth Distribution

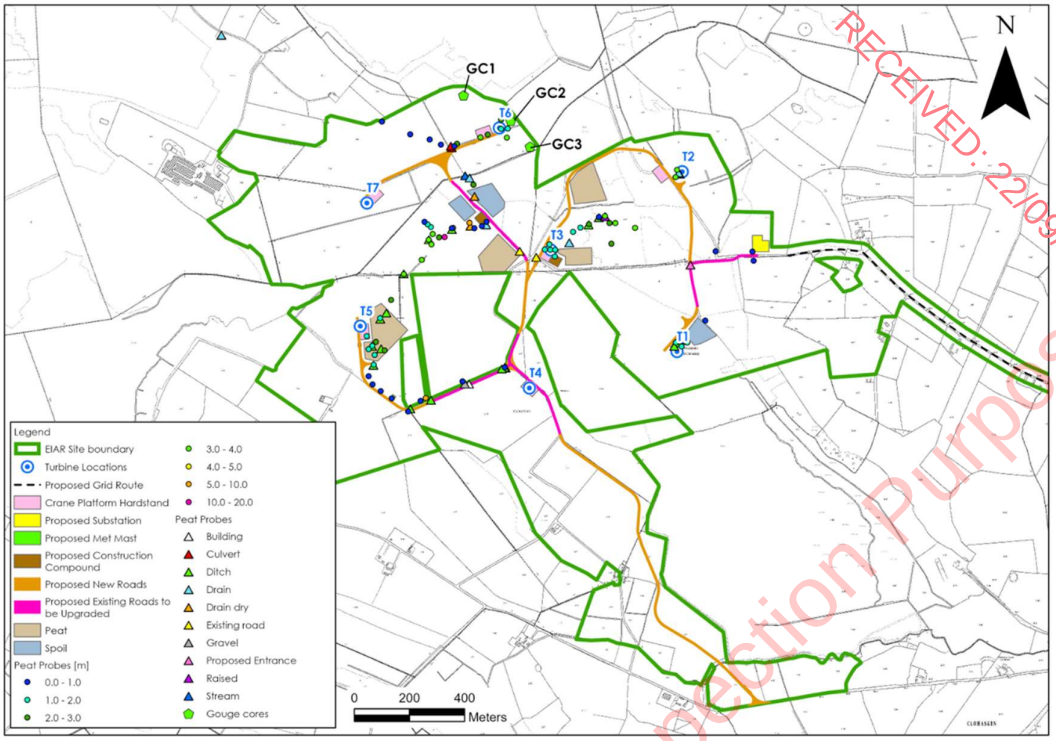

Figure 8-3 Summary Peat Depth Map

Trial pit investigations were carried out at the wind farm site by GDG in November 2022 and March 2023 (refer to Figure 8-4 for locations). 15 no. trial pits were completed across the wind farm site in total.

The trial pits were carried close to each of the turbine locations (with the exception of T2 which is inaccessible due to forestry), at the substation, construction compound, met mast and along sections of proposed access roads (Refer to Table 8-5 below). Gouge cores were carried out at T2 as an alternative to trial pits due to inaccessibility.

The trial pits, which ranged between 1.8m and 4m in depth, encountered mainly CLAY or SILT dominated subsoils which were typically described as gravelly and sandy with cobble and boulder content (glacial tills derived from limestone) below the peat or topsoil layer.

Marl (typically deposited below raised bogs) was only encountered in the trial pit carried out at turbine T5 (TP104). Raised peat bogs in the midlands are often extensively underlain by marl and lacustrine deposits but appear to be largely absent below the peat at the proposed wind farm infrastructure locations.

Gouge coring carried out by HES along the northeastern boundary of the wind farm site, indicate marl deposits thicken in the direction of Ballyduff/Clonfinane Bog which is located less than 0.5km to the northeast (refer to Section 8.3.6 below for more information on Ballyduff/Clonfinane Bog which is a designated SAC). The locations of the gouge cores are shown on Figure 8-3.

The total thickness of mineral subsoils over bedrock (i.e. depth to bedrock) was only confirmed in 2 no. of the 15 no. trial pits. These trials pits were located at proposed turbine T3 (TP03) and at the construction compound (TP04). Limestone bedrock was confirmed at 1.8mbgl at turbine T3 and 2.8mbgl at the primary construction compound. Mineral subsoils below the peat at turbine T3 are absent.

Similarly, bedrock directly below the peat was also presumed at turbine T2 during gouge coring where very hard substrate was encountered.

The trial pit geological logs are included in Appendix 8-1 (Peat Stability Assessment Report).

Table 8-3: Summary of Peat/Subsoil Depths and Mineral Subsoil Lithology at Proposed Development Locations

Infrastructure Location	Total Peat Thickness (m)	Total Mineral Subsoil Thickness (m)	Summary of Underlying Mineral Subsoil Lithology
T1	3.43	>2.3	Firm, grey, slightly sandy, slightly gravelly CLAY
T2	3.7	0	Refusal on very hard substrate (bedrock assumed)
T3	0.9 – 1.8	0	Refusal on weathered LIMESTONE bedrock
T4	0.6	>2.4	Firm, grey, slightly sandy, slightly gravelly CLAY
T5	1.5	>1.9	Sandy CLAY (MARL)
T6	2.54	>1.3	Very soft, slightly sandy SILT
T7	1.8	>1.9	Very gravelly, very sandy CLAY
Substation	0	>1.9	Firm, grey, slightly sandy, slightly gravelly CLAY
Construction Compound No. 1	0.85	1.95	Stiff, gravelly CLAY (refusal on LIMESTONE bedrock)

Infrastructure Location	Total Peat Thickness (m)	Total Mineral Subsoil Thickness (m)	Summary of Underlying Mineral Subsoil Lithology
Met Mast	0.1	>2.1	Soft, grey, slightly sandy, slightly gravelly CLAY

Soils along the grid connection route are mapped largely as basic deep well drained mineral soils and cutover peat (www.epa.ie). The EPA also map the presence of pockets of basic shallow well drained mineral soils.

The published subsoils map (www.gsi.ie) shows that the lands local to the grid connection route are predominantly underlain by cut over raised peat, till derived from limestones and gravels derived from limestones. As stated above the grid connection will be placed within the carriageway of existing public roads and is unlikely to encounter any peat.

8.3.4 Bedrock Geology

Based on the GSI bedrock mapping (www.gsi.ie) 4 no. bedrock geological formations are mapped as underlying the wind farm site.

The north of the wind farm site is mapped as being underlain by Waulsortian Limestones comprising massive-unbedded lime-mudstone (Dinantian Pure Unbedded Limestones). The central and southern section of the wind farm site is mapped as being underlain by the Terryglass Formation comprising calcarenites and oolitic limestones (Dinantian Pure Bedded Limestones). The proposed turbine layout is largely distributed over these two mapped bedrock formations.

The Lismaline Micrite Formation and Slevoir Formation are mapped to underlie parts of the southwest of the wind farm siter and both are described as Dinantian Upper Impure Limestones. The bedrock is not exposed at the wind farm site due to the coverage of peat and glacial deposits.

The GSI map an anticlinal fold axis in the west of the wind farm site. A large southwest-northeast trending fault is also mapped in the south of the site and juxtaposes the Terryglass Formation against the Lismaline Micrite Formation and the Slevoir Formation. The presence of mapped faults will have no effect on the Proposed Development.

Limestone bedrock was confirmed at 1.8mbgl at turbine T3 and 2.8mbgl at the construction compound along with presumed bedrock at turbine T2 at a depth of 3.7mbgl.

The GSI do not map any karst features within the Proposed Development site. The closest mapped karst feature to the wind farm site is an enclosed depression located 0.7km to the north. The large coverage of peat and limestone tills in the area is likely to cover up any potential karstification in the underlying bedrock.

The grid connection route is underlain primarily by Dinantian Pure Bedded Limestones along with Dinantian Pure Unbedded Limestones and Dinantian Lower Impure Limestones towards the north end of the proposed route.

A bedrock geology map of the area is attached as Figure 8-4.

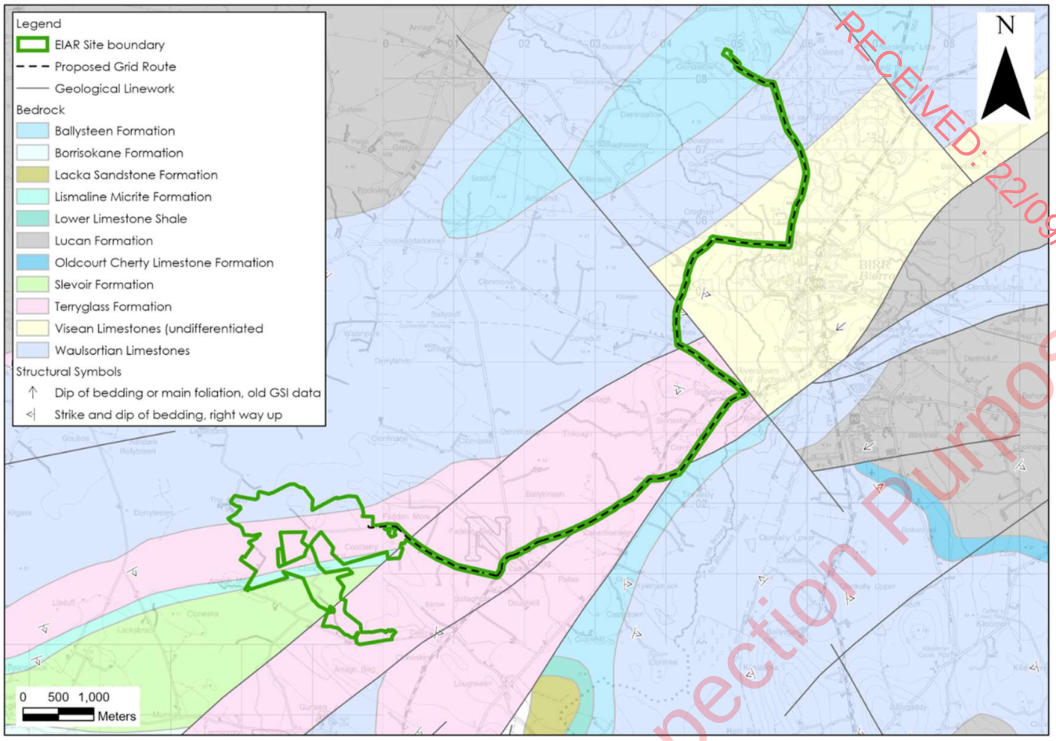

Figure 8-4 Bedrock Geology Map

8.3.5 Geological Resource Importance

The GSI do not record the presence of any mineral extraction within the wind farm site (www.gsi.ie). However, there are several mapped quarries and sand and gravel pits in the wider area. The closest mapped mineral extraction is located approximately 4.2km east of the wind farm site in the townland of Clondallow where the GSI map a sand and gravel pit.

The GSI also map the presence of dimension stone quarry approximately 5.6km southwest of the wind farm site in the townland of Fortmoy where dark grey micrite is exposed in a small quarry. Meanwhile, approximately 5.1km west of the wind farm site the GSI map the presence of limestones quarry with an accompanying note that the site has no potential for commercial block extraction.

The closest mapped active quarries (www.gsi.ie) to the wind farm site are located to the northeast of Birr Town. The closest to the wind farm site is Ballywilliam sand and gravel pit and is located approximately 8.2km to the northeast. Meanwhile, the closest mapped crushed rock quarry is Ballinaguishla Quarry located 9km to the northeast.

The GSI online Crushed Rock Aggregate Potential Database shows that the wind farm site is located within an area of low to moderate crushed rock potential. Meanwhile, the GSI's Granular Aggregate Potential Database shows that the majority of the wind farm site does not have any potential for gravel reserves. However there are very localised and small pockets of high granular aggregate potential corresponding to the mapped extent of the subsoil gravel limestone derived deposits.

Based on NRA (2008) criteria in Table 8-1, bedrock underlying the Proposed Development site can be classified as "Medium" importance. The bedrock could be used on a "sub-economic" local scale for construction purposes.

The glacial subsoils at the wind farm site can be classified as "Low" importance. The glacial subsoils could be used on a "sub-economic" local scale for construction purposes.

The overlying peat deposits at the wind farm site could be classified as "Low" importance as the peat is not designated in this area and is significantly degraded in most places due to peat cutting and coniferous forestry plantations drainage.

The GSI do not map the presence of any mineral localities, active quarries or pits along the grid connection route (www.gsi.ie).

Crushed rock aggregate potential along the grid route is mapped predominantly as low to moderate, with some areas of high. Granular aggregate potential along the grid route is mapped as low to high.

8.3.6 Geological Heritage and Designated Sites

The GSI map two geological heritage sites within 3km of the wind farm site. Arragh More Bog (Site Code: TY004) is located immediately to the west of the site, while Kilcarren-Firville Bog (Site Code: TY037) is located 2km to the west of the site.

These sites are described as active raised bogs located in low-lying hollows that includes areas of high bog and cutover bog. The Proposed Development site does not encroach these geological heritage sites and are therefore scoped out for potential effects. The closest turbine to Arragh More Bog is T5 which sits at a distance of approximately 300m from the mapped heritage site boundary. The potential for hydrological and hydrogeological effects on Arragh More Bog are assessed in the Water Chapter (Chapter 9).

The GSI also map the presence of the Ballyduff-Clonmona Mushroom rocks (Site Code: TY006) approximately 1.2km northeast of the wind farm site. Geological heritage sites within 5km of the wind farm are listed in Table 8-6.

With regard European designated sites, Ballyduff/Clonfinane Bog SAC (Site Code: 000641) is located approximately 110m to the north of the wind farm site at its closest point.

To the west, a section of the Arragh More Bog (Derrybreen) is a designated SAC (Site Code: 002207). The SAC designated section of Arragh More Bog is located approximately 450m to the west of the wind farm site EIAR boundary. Also, Kilcarren-Firville Bog, located 1.5km to the west is also a designated SAC (Site Code: 00647).

From a Land, Soils and Geology perspective, the Proposed Development will have no effect on these local designated sites. Hydrological and hydrogeological effects on local designated are assessed in the Water Chapter (Chapter 9).

Proposed grid route intercepts the mapped geological heritage site Kilcormac Esker (Site Code: OY018) as it passes through Kilcormac Esker via an existing public road. Therefore, the proposed works cannot directly effect Kilcormac Esker.

The locations of nearby Geological Heritage sites and Designated Sites and are shown on Figure 8-6.

Table 8-6: County Geological Heritage Sites within 5km of Wind Farm Site

Site Code	Site Name	IGH Theme	Features	Distance from wind farm site (km)
TY004	Arragh More Bog	IGH7	Raised bog which includes areas of high bog and cutover bog.	0
TY037	Kilcarren-Firville Bog	IGH7	Ridge-basin type raised bog	2
TY006	Ballyduff-Clonmona Mushroom Rocks	IGH1	Mushrooms rocks	1.2
TY029	Fiagh Bog	IGH7	Example of a calcium rich fen	5

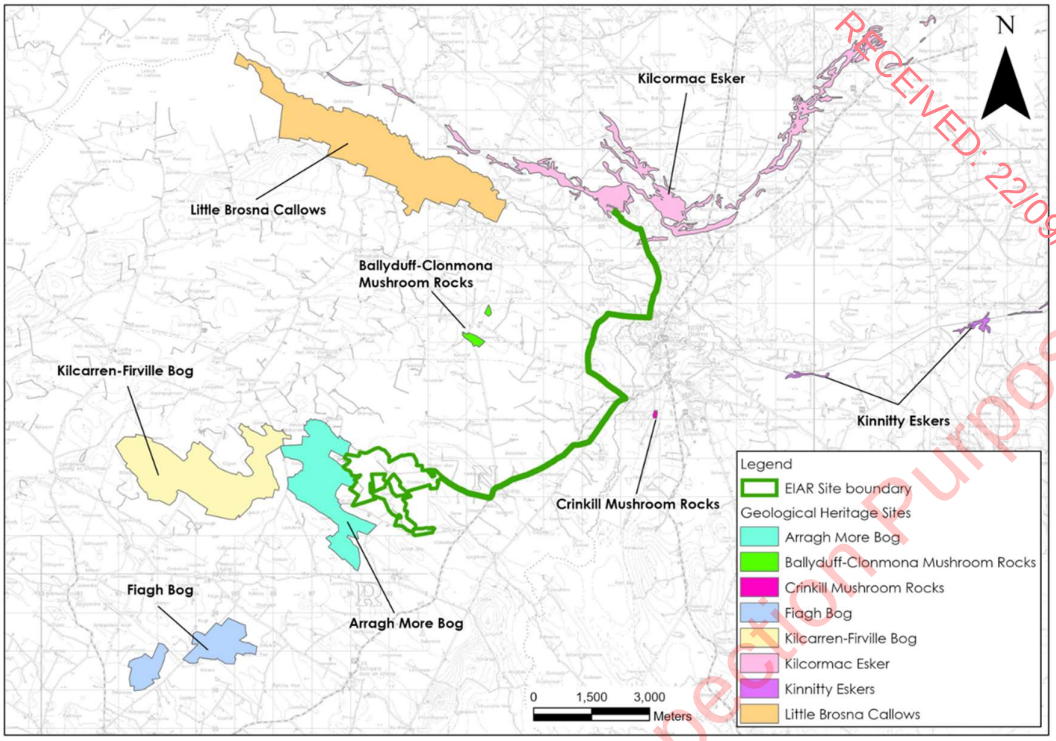

Figure 8-5 Geological Heritage Sites and Designated Sites

8.3.7 Soil Contamination

There are no known areas of soil contamination on the site of the Proposed Development site. During the site walkovers or investigations, no areas of contamination concern were identified.

According to the EPA online mapping (http://gis.epa.ie/Envision), there are no licensed waste facilities on within the wind farm site. However, an IPPC licenced facility exists adjacent the north-western boundary of the wind farm site. This facility is associated with Sharragh Pig Farms and is operating under IPPC Licence No: P0437.

In addition, the GSI do not map the presence of any historic mines at or in the immediate vicinity of the wind farm site that could potentially have contaminated tailings.

8.3.8 Peat Stability Assessment

8.3.8.1 Introduction

Gavin and Doherty Geosolutions (GDG) were engaged to undertake a geotechnical and peat stability assessment of the Proposed Development site. A Peat Stability Assessment Report (GDG, 2023) is attached as Appendix 8-1.

Hydrological, hydrogeological and ecological factors were considered in the Peat Stability Assessment Report, and regular interaction between HES and MKO were undertaken throughout the iterative design process (i.e. hydrological constraints mapping etc). The assessment was done in accordance with Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (PLHRAG, Scottish Government, 2017).

A constraints study was initially undertaken by the Environmental (MKO), Hydrological (HES) and Ecological (MKO) members of the project design team to determine the developable area on the site, prior to the site reconnaissance by engineering geologists/geotechnical engineers from GDG.

8.3.8.2 Hydrological Considerations

The hydrological factors with regard peat stability were assessed using a combination of desk study data, aerial photography (historical and contemporary), topographic lidar data flow path drainage analysis, site walkovers, field drainage mapping and gouge coring. Detailed drainage maps were prepared along with hydrological constraints mapping for on-site drainage features and wet areas.

Many of the Pre-conditions as described by PLHRAG are hydrological in nature and are listed in the guidance as follows:

- Impeded drainage caused by a peat layer overlying an impervious clay or mineral base (hydrological discontinuity, especially an iron pan at the base of the peat deposit);
- A convex slope or a slope with a break of slope at its head (concentration of subsurface flow);
- Proximity to local drainage, either from flushes, pipes or streams (supply of water); and
- Connectivity between surface drainage and the peat/impervious interface (mechanism for generation of excess pore pressures).

Identifying the above Pre-conditions at the wind farm site was a key part of the hydrological constraints assessment carried out in conjunction with project design team.

8.3.8.3 Peat Stability Desk Study

The GSI landslide inventory (GSI, 2022a), the multi-temporal aerial / satellite imagery, the DEM, the landslide susceptibility map (GSI, 2016), and the rainfall information of Met Éireann data 1981-2010 have been used for this part of the desk study.

The GSI landslide inventory depicts the spatial relationship between records of previous landslide events and rainfall across Ireland from the Met Éireann (2018) average annual rainfall dataset. The study area is in a region of high rainfall and relatively flat topography, and there is no record of past landslide events from the national landslide database nor from the desk study and fieldwork for this project. However, there is one landslide event in the database within 10km of the eastern boundary of the site, with the closest landslide according to the GSI database occurring on flat, heavily worked peat bog around 10km from the Proposed Development red line boundary. The likely cause of the landslide instabilities is from the extraction of peat from the raised bog (GDG, 2023).

The GSI Landslide Susceptibility Map (www.gsi.ie) classifies the probability of a landslide occurring. This map was obtained by using an empiric probabilistic method at a regional scale and did provide input into site-specific scale engineering studies. The entirety of the site is mapped as having low susceptibility due to the low slope angles encountered. The field visits of the project team support that the site is stable (GDG, 2023).

8.3.8.4 Peat Stability Investigations

A walkover including intrusive peat depth probing, an intrusive ground investigation comprising trial pit and a stability analysis and risk assessment was carried out by GDG to assess the susceptibility of the Proposed Development site to peat failure following the principles in PLHRAG.

The assessment involved slope stability analysis at 176 locations, including turbine locations, access roads, the substation location and the proposed construction compound.

8.3.8.5 Peat Stability Analysis

GDG have completed an analysis of peat sliding at all the main Proposed Development infrastructure locations (proposed turbines, meteorological mast, substation, temporary construction compound and access roads) across the Proposed Development site for both the undrained and drained conditions.

The purpose of the analysis was to determine the Factor of Safety (FoS) of the peat slopes. The minimum required Factor of Safety (FoS) is 1.3 based on BS6031:1981: Code of Practice for Earthworks (BSI, 2009). The assigned probability of instability associated with a given FoS value is described in Table 8-7 below. Hydrological and hydrogeological factors were also assessed in the Peat Stability Assessment Report.

No peat failures/landslides are recorded on the Proposed Development site which suggests that site conditions do not pre-dispose themselves to failures/landslides.

A walkover survey of the grid connection route identified no peat stability issues and therefore there was no requirement to carry out the detailed analysis as described below for the wind farm site (GDG, 2023).

Table 8-7: Probability Scale for Factor of Safety.

Scale	Factor of Safety	Probability
1	1.30 or greater	Negligible/None
2	1.29 to 1.20	Unlikely
3	1.19 to 1.11	Likely
4	1.01 to 1.10	Probable
5	<1.0	Very Likely

8.3.8.6 Peat Stability Assessment Results

Stability of a peat slope is dependent on several factors working in combination. The main factors that influence peat stability are slope angle, shear strength of peat, depth of peat, pore water pressure and loading conditions.

An adverse combination of factors could potentially result in peat sliding. An adverse condition of one of the above-mentioned factors alone is unlikely to result in peat failure. The infinite slope model (Skempton and DeLory, 1957) is used to combine these factors to determine a factor of safety for peat sliding. This model is based on a translational slide, which is a reasonable representation of the dominant mode of movement for peat failures.

To assess the factor of safety for a peat slide, an undrained[1] (short-term stability) and drained (long-term stability) analysis has been undertaken to determine the stability of the peat slopes on site.

- The undrained loading condition applies in the short-term during construction and until construction induced pore water pressures dissipate.
- The drained loading condition applies in the long-term. The condition examines the effect of in particular, the change in groundwater level as a result of rainfall on the existing stability of the natural peat slopes.

As mentioned above, the Peat Stability Assessment Report (GDG, 2023) is attached in Appendix 8-1.

8.3.8.6.1 *Undrained Analysis*

Undrained analysis results are presented in Table 8-8. As outlined above the undrained loading condition applies in the short-term during construction and until construction induced pore water pressures dissipate.

The calculated FoS for Condition 1 and Condition 2 are in excess of 1.30 for all proposed development locations assessed, indicating a low risk of peat instability.

[1] *For the stability analysis two load conditions were examined, namely*

Condition (1): *no surcharge loading*
Condition (2): *surcharge of 10 kPa, equivalent to 1 m of stockpiled peat assumed as a worst case.*

Table 8-8: Factor of Safety Results (undrained condition)

Turbine No./Waypoint	Factor of Safety for Load Condition	
	Condition (1)	Condition (2)
T1	4.14	3.21
T2	34.39	27.09
T3	13.56	8.48
T4	51.29	20.72
T5	48.7	29.89
T6	44.27	31.77
T7	37.6	24.35
Substation	51,605.94	10.32
Construction Compound	29.32	13.47
Met Mast	561.75	51.07

8.3.8.6.2 *Drained Analysis*

Drained analysis results are presented in Table 8-9. As outlined above, the drained loading condition applies in the long-term. The condition examines the effect of in particular, the change in groundwater level as a result of rainfall on the existing stability of the natural peat slopes.

The calculated FoS for Condition 1 and Condition 2 are in excess of 1.30 for all Proposed Development locations assessed, indicating a low risk of peat instability.

Table 8-9: Factor of Safety Results (drained condition)

Turbine No./Waypoint	Factor of Safety for Load Condition	
	Condition (1)	Condition (2)
T1	3.58	5.76
T2	29.89	11.27
T3	11.27	14.96
T4	41.68	36.16
T5	40.40	52.67
T6	37.51	56.55
T7	31.37	43.02
Substation	41,284.94	17.86

Turbine No./Waypoint	Factor of Safety for Load Condition	
	Condition (1)	Condition (2)
Construction Compound	23.92	23.55
Met Mast	450.45	88.57

8.3.8.6.3 *PSRA Conclusions*

In summary, an analysis of peat stability was carried out each of the proposed infrastructure locations and the purpose of the analysis was to determine the Factor of Safety (FoS) of the peat slopes.

In summary, the findings of the peat assessment showed that the Proposed Development site has an acceptable margin of safety, is suitable for the Proposed Development and is considered to be at low risk of peat failure. The findings include a series of control (mitigation) measures for construction work in peatlands to ensure that all works adhere to an acceptable standard of safety. These are included below at Section 8.5.2.5.

8.4 Characteristics of the Proposed Development

The Proposed Development will involve removal of peat, subsoils and, in places, bedrock for access roads, internal access road networks, internal cable network, hardstanding emplacement, turbine foundations, substation, crane hardstands, construction compounds, drainage works and met mast installation. Rock for construction purposes will be sourced off-site from local quarries.

Generally, for constructing any structure or platform foundation, such as a turbine base, hardstand or substation, removing all soft material is required to a depth where a suitable bearing material is encountered. Rock breaking maybe required at some of the turbines and hard-standing locations to create the reduced foundation level and the levelling required for construction. The material excavated is required to be properly managed and stored and should be re-used in other elements of the proposed wind farm design.

During turbine construction, peat will be permanently excavated to the substrate to make room for the concrete turbine foundation and a small working area surrounding the foundation footprint. Breaking and excavation of bedrock may be required where it is encountered at shallow depths to achieve the reduced foundation level and level surface required by design. Turbine bases in the range of 25m in diameter are proposed. The plan area of the material to be removed will be dictated by the enabling temporary works design, allowable excavation angle and the mean peat and overburden depths across each turbine location. The design of the turbine base foundations is subject to further confirmatory ground investigation.

Similarly, all turbine crane hardstands will be required to be founded on a suitable bearing material requiring the excavation of all peat and other soft ground materials, where present. The platform will be constructed in the excavated area using a suitable specified engineered stone fill. Following the placement of the platform, the excavated peat can be re-used to batter the platform edges and landscape the platform back into the existing topography. The construction grade granular fill will be sourced from the off-site borrow pit.

The total volume of spoil (peat and non-peat superficial deposits) requiring placement/reinstatement on wind farm site is estimated at 99,700m^3 (refer to Table 8-10 below). These volumes assume a gravity base foundation which is worst case in terms of excavation volumes. If piling is carried out, excavations volumes will be significantly less.

A conservative reinstatement volume of 20% of the total peat excavation has been considered available for side casting and re-use across the site, while 10% of the total spoil volumes has been considered as available for re-use in the construction of safety berms across the site. The excess material will be placed in 5 no. dedicated Peat Repository Areas (PRA) and 3 no. Spoil Repository Areas (SRA).

Table 8-4: Estimated Peat and Mineral Soil Excavation Volumes

Infrastructure Element	Average Peat Depth (m)	Excavated peat Volume (m^3)	Excavated Spoil Volume (m^3)
Access Roads	0.3	21,680	0
Turbines Foundations	1.9	13,810	8,500
Crane Hardstands	1.8	33,700	13,160
Substation	0	0	1,410
Construction Compound	0.9	4,660	0
Met Mast	0	0	2,780
Sub-total (m^3)		**73,850**	**25,850**
Total Peat and Spoil volume (m^3)		**99,700**	

8.5 Likely Significant Effects and Associated Mitigation Measures

8.5.1 Do Nothing Scenario

If the Proposed Development were not to proceed, peat cutting and forestry plantation operations will continue and may be extended to occupy a larger portion of the land. Forestry will be felled as forestry compartments reach maturity. Re-planting of these areas is likely to occur.

8.5.2 Construction Phase - Likely Significant Effects and Mitigation Measures

The likely effects of the Proposed Development and mitigation measures that will be put in place during the construction phase to eliminate or reduce them are outlined below.

8.5.2.1 Effects on Land and Land use

The loss of commercial forestry amounts to 9.7ha and the loss of agricultural land amounts only to 4.5ha.

There will be no effects on the lands adjoining the Proposed Development site. Turf cutting and agriculture will continue during the construction and operation of the wind farm.

Pathway: Land take

Receptor: Land and Landuse (i.e. the land upon which the development will occur)

Potential Pre-mitigation Impact: Negative, slight, direct, likely, permanent impact on land and landuse.

Impact Assessment:
The loss of agricultural and forestry land resulting from the Proposed Development on a local or regional scale is minimal and therefore the effects of actual agricultural land loss is imperceptible.

Mitigation Measures:

No mitigation is proposed with regard agricultural or forestry loss of land.

The total amount to be felled (9.7ha) accounts for only approximately 14.9% of the existing forestry coverage at the site which is approximately 64.8ha.

The total loss of agricultural land (4.5ha) accounts for only approximately 6% of the existing agricultural land coverage at the site which is approximately 75ha.

Residual Impact: Due to the small footprint of the Proposed Development on a local scale the residual effect is considered Negative, direct, slight, likely, permanent impact on land and landuse. The land and landuse along the underground electrical cabling route will not change.

Significance of Effects: For the reasons outlined above, no significant effects on land or landuse will occur.

8.5.2.2 Peat and Subsoil Excavation

Excavation of peat, subsoil and bedrock will be required for construction of works for the installation of access roads, foundations for turbine bases, crane hardstands, met masts, substation, construction compounds, grid connection cable, internal cable network and site drainage network. This will result in a permanent removal and relocation of in-situ peat and subsoil at most excavation locations. Estimated volumes of peat, subsoils and bedrock to be relocated are summarised above in Table 8-4. There is no net loss of peat or subsoil, it will just be relocated within the site.

Pathway: Extraction/excavation.

Receptor: Peat, soil and subsoil.

Pre-Mitigation Potential Effect: Negative, slight/moderate, direct, likely, permanent effect on peat, soil, subsoil and bedrock due to relocation within the Proposed Development site.

Proposed Mitigation Measures by Design:

- Placement of turbines and associated infrastructure in areas with shallower peat;
- Use of floating roads, where appropriate, to reduce peat excavation volumes;
- The peat and subsoil which will be removed during the construction phase will be localised to the wind farm infrastructure turbine location, substation and temporary compounds and access roads;
- The proposed development has been designed to avoid, insofar as possible, sensitive habitats within the application area; and,
- Construction of settlement ponds will be volume neutral, and all excess material will be used locally to form pond bunds and surrounding landscaping.

Residual Effect Assessment: The granular soil and peat at the site can be classified as of "Low" importance and the bedrock of "Medium" importance.

The overall site area is extensive while the Proposed Development footprint is approximately 1.9% of the overall EIAR Site Boundary area. The negative effect is the disturbance and relocation of c 99,700m^3 of peat, soil and subsoil during construction. The design measures incorporated into the project as described above in particular the avoidance of deeper peat areas combined with the 'low' importance of the deposits means that the residual effect will be - Negative, slight, direct, likely, permanent effect on peat, soil, subsoils and bedrock due to disturbance and relocation within the site.

Significance of Effects: For the reasons outlined above, no significant effects on peat and subsoils will occur.

8.5.2.3 Contamination of Soils by Leakages and Spillages of Hydrocarbons or Chemicals

Accidental spillage during refuelling of construction plant with petroleum hydrocarbons is a pollution risk at the Proposed Development site. The accumulation of small spills of fuels and lubricants during routine plant use can also be a significant pollution risk. Hydrocarbon has a high toxicity to humans, and all flora and fauna, including fish, and is persistent in the environment. Large spills or leaks have the potential to result in significant effects (i.e. contamination of peat, subsoils and pollution of the underlying aquifer) on the geological and water environment.

Pathway: Peat, soil and subsoil and underlying bedrock pore space.

Receptor: Peat, soil and subsoil, bedrock.

Pre-Mitigation Potential Effect: Negative, slight, direct, short-term, unlikely effect on peat, soil, subsoils and bedrock.

Proposed Mitigation Measures:

- On-site re-fuelling will be undertaken using a double skinned bowser with spill kits kept on site for accidental leakages or spillages;
- Only designated trained operatives will be authorised to refuel plant on-site;
- Taps, nozzles or valves associated with refuelling equipment will be fitted with a lock system;
- All fuel storage areas will be bunded appropriately for the duration of the construction phase. All bunded areas will be fitted with a storm drainage system and an appropriate oil interceptor. Ancillary equipment such as hoses, pipes will be contained within the bunded area;
- Fuel, oil and chemical stores including tanks and drums will be regularly inspected for leaks and signs of damage;
- The electrical control building (at the substation) will be bunded appropriately to the volume of oils likely to be stored and to prevent leakage of any associated chemicals to groundwater or surface water. The bunded area will be fitted with a storm drainage system and an appropriate oil interceptor;
- The plant used during construction will be regularly inspected for leaks and fitness for purpose;
- Safety data sheets for all chemicals used will be kept on-site; and,
- An emergency response plan for the construction phase to deal with accidental spillages is contained within the Construction and Environmental Management Plan (which is contained in Appendix 4-3).

Residual Effect Assessment: The use and storage of hydrocarbons and small volumes of chemicals is a standard risk associated with all construction sites. Proven and effective measures to mitigate the risk of spills and leaks have been proposed above and will break the pathway between the potential source and the receptor. The residual effect will be - Negative, imperceptible, direct, short-term, unlikely effect on peat, soil, subsoils and bedrock.

Significance of Effects: For the reasons outlined above, and with the implementation of the listed mitigation, no significant effects on peat, soil, subsoils and bedrock will occur.

8.5.2.4 Erosion of Exposed Subsoils and Peat During Construction of Infrastructure

There is a high likelihood of erosion of peat and spoil during its excavation and during landscaping works at the Proposed Development site. The main impacts associated with this aspect is to the water environment, and therefore this aspect is further assessed in detail in Chapter 9.

Pathway: Vehicle movement, surface water and wind action.

Receptor: Peat, soil and subsoil.

Pre-Mitigation Potential Effect: Negative, slight, direct, short-term, likely effect on peat, soil and subsoils by erosion and wind action.

Proposed Mitigation Measures:

- The upper vegetative layer (where still present) of excavated peat will be stored with the vegetation part of the sod facing the right way up to encourage growth of plants and vegetation at the surface of the stored peat within the peat storage areas;
- Re-seeding and spreading/planting will also be carried out in these areas;

- Brash/bog mats will be put in place to support vehicles on soft ground, reducing peat and mineral soils erosion and avoiding the formation of rutted areas, in which surface water ponding can occur; and,
- A full Peat and Spoil Management Plan for the development is included as Appendix 4-2 of this EIAR.

Residual Effect Assessment: Peat soils and spoil can be eroded by vehicle movements, wind action and by water movement. To prevent this all excavation works will be completed in accordance with a detailed Peat and Spoil Management Plan, material will remain within the Proposed Development site and reseeding and planting will be completed to bind landscaped peat and spoil together. Following implementation of these measures the residual effects will be - Negative, slight, direct, short-term, likely effect on peat, soils and subsoils by erosion and wind action.

Significance of Effects: For the reasons outlined above, no significant effects on peat, soils, subsoils or bedrock will occur.

8.5.2.5 Peat Instability and Failure

A peat stability risk assessment was carried out for the main infrastructure elements at the wind farm. This approach takes into account guidelines for geotechnical/peat stability risk assessments as given in PLHRA (2017) and MacCulloch (2005).

Peat instability or failure refers to a significant mass movement of a body of peat that would have an adverse impact on the proposed wind farm development and the surrounding environment. The potential significant effects of peat failure at the study area may result in:

- Death or injury to site personnel;
- Damage to machinery;
- Damage or loss of infrastructure;
- Drainage disruption by blockage of drainage pathway by relocated peat and spoil;
- Site works damaged or unstable;
- Contamination of watercourses, water supplies by particulates; and,
- Degradation of the peat environment by relocation of peat and spoil.

However, the findings of the peat assessment, which involved analysis of 176 no. locations, showed that the Proposed Development areas have an acceptable margin of safety and that the site is suitable for the proposed wind farm development. Notwithstanding the above, the management of peat stability and appropriate construction practices will be inherent in the construction phase of the wind farm to ensure peat failures do not occur on site.

Pathway: Vehicle movement and excavations.

Receptor: Peat and subsoils.

Pre-Mitigation Potential Impact: Negative, significant, direct, permanent, likely effect on peat and subsoils. The findings of the peat stability assessment showed that the Proposed Development site has an acceptable margin of safety, is suitable for the Proposed Development and is considered to be at low risk of peat failure. The findings include recommendations and control measures for construction work in peatlands to ensure that all works adhere to an acceptable standard of safety.

Proposed Mitigation Measures:

Firstly, the key mitigation with regard peat stability risk at the Proposed Development site was the carrying out of a robust, multidisciplinary site investigation and peat stability risk assessment carried out in accordance with best practice guidance (PLHRAG, Scottish Government, 2017).

The findings of the peat assessment, which involved analysis of 176 no. locations, showed that the proposed development areas have an acceptable margin of safety and that the site is suitable for the proposed wind farm development.

The peat stability risk assessment report provides a number of mitigation/control measures to reduce the potential risk of peat failure at each infrastructure location. Sections of access roads to the nearest infrastructure element will be subject to the same mitigation/control measures that apply to the nearest infrastructure element. The required mitigation/control measures are shown below:

The following control measures incorporated into the construction phase of the project will ensure the management of the risks for this site:

- Appointment of experienced and competent contractors;
- The site will be supervised by experienced and qualified personnel;
- Allocate sufficient time for the project (be aware that decreasing the construction time has the potential to increase the risk of initiating a localised peat movement);
- Prevent undercutting of slopes and unsupported excavations;
- Maintain a managed robust drainage system;
- Prevent placement of loads/overburden on marginal ground;
- Implementation of safety buffers around deep peat areas;
- Adhere to the spoil and peat storage restriction areas detailed in the Geotechnical and Peat Stability Risk Assessment (GDG, 2023);
- Set up, maintain and report findings from monitoring systems as outlined in the Geotechnical and Peat Stability Assessment (GDG, 2023);
- Ensure construction method statements are developed and agreed before commencement of construction and are followed by the contractor; and,
- Revise and amend the Construction Risk Register as construction progresses to ensure that risks are managed and controlled for the duration of construction.

Please refer to **Appendix 8-1** for details on the safety buffers and stockpile restrictions.

Residual Effect Assessment: A detailed Geotechnical and Peat Stability Assessment (GDG, 2023) (**Appendix 8-1**) has been completed for the development proposal. The findings of that assessment have demonstrated that there is a low risk of peat failure at the site as a result of the Proposed Development. With the implementation of the control measures outlined above the residual effect is considered - negative, imperceptible, direct, permanent, unlikely effect on peat and subsoils.

Significance of Effects: No significant effects on peat, soils and subsoils will occur.

8.5.3 Operational Phase - Likely Significant Effects and Mitigation Measures

Very few potential direct impacts are envisaged during the operational phase of the Proposed Development. These may include:

- Some construction vehicles or plant may be necessary for maintenance of turbines which could result in minor accidental leaks or spills of fuel/oil;
- The transformer in the substation and transformers in each turbine are oil cooled. There is potential for spills / leaks of oils from this equipment resulting in contamination of soils and groundwater; and,
- In relation to indirect impacts a small amount of granular material may be required to maintain access tracks during operation which will place intermittent minor demand on local quarries.

None of these potential impacts will be significant, as they are of such small scale and also of an intermittent nature.

Mitigation measures for land, soils and geology during the operational phase include the use of aggregate from authorised quarries for use in road and hardstand maintenance. Oil used in transformers (at the substation and within each turbine) and storage of oils in tanks at the substation could leak during the operational phase and impact on ground/peat and subsoils and groundwater or surface water quality. The substation transformer will be in a concrete bunded capable of holding 110% of the stored oil volume. Turbine transformers are located within the turbines, so any leaks would be contained within the turbine. These mitigation measures are considered sufficient to eliminate potential risks to ground/peat/soils and subsoils, and groundwater and surface water quality.

8.5.4 Decommissioning Phase - Likely Significant Effects and Mitigation Measures

The potential effects associated with decommissioning of the proposed development will be similar to those associated with construction but of reduced magnitude.

During decommissioning, it will be possible to reverse or at least reduce some of the potential impacts caused during construction by rehabilitating construction areas such as turbine bases, hard standing areas. This will be done by covering with peatland vegetation/scraw or poorly humified peat to encourage vegetation growth and reduce run-off and sedimentation. Other impacts such as possible soil contamination by fuel leaks will remain but will be of reduced magnitude. However, as noted in the Scottish Natural Heritage report (SNH) Research and Guidance on Restoration and Decommissioning of Onshore Wind Farms (SNH, 2013) reinstatement proposals for a wind farm are made approximately 30 years in advance, so within the lifespan of the wind farm, technological advances and preferred approaches to reinstatement are likely to change. According to the SNH guidance, it is therefore:

> *"best practice not to limit options too far in advance of actual decommissioning but to maintain informed flexibility until close to the end-of-life of the wind farm".*

Mitigation measures applied during decommissioning activities will be similar to those applied during construction phase as shown in Section 8.5.2 above.

Some of the impacts will be avoided by leaving elements of the proposed development in place where appropriate. The substation will be retained by EirGrid. The turbine bases will be rehabilitated by covering with local topsoil/peat in order to regenerate vegetation which will reduce runoff and sedimentation effects. Internal roads will remain as amenity pathways and forestry access roads. Mitigation measures to avoid contamination by accidental fuel leakage and compaction of soil by on-site plant will be implemented as per the construction phase mitigation measures.

No significant effects on the land, soils and geological environment will occur during the decommissioning stage of the Proposed Development.

8.5.5 Risk of Major Accidents and Disasters

Due to the nature of the Proposed Development site, *i.e.* soft peat deposits, there is a risk of peat movement occurring. However, due to the flat nature of the site, the risk is low.

A comprehensive Peat Stability Risk Assessment (GDG, 2023) has been undertaken for all Proposed Development infrastructure locations, and it concludes that with the implementation of the proposed control (mitigation) measures. The residual risk of a landslide occurring is determined to be negligible/none.

8.5.6 Human Health Effects

Potential health effects arise mainly through the potential for soil and ground contamination. The Proposed Development is not a recognized source of pollution (e.g. it's not a waste management site, or a chemical plant), and so the potential for effects during the operational phase is very low.

Hydrocarbons will be used onsite during construction; however, the volumes will be small in the context of the scale of the Proposed Development and will be handled and stored in accordance with best practice mitigation measures. The potential residual effects associated with soil or ground contamination and subsequent health effects are imperceptible.

Peat failure has also the potential to affect human health, but this would likely require a catastrophic failure to occur. The residual risk of significant peat slide/failure occurring is determined to be negligible/none following the implementation of the proposed control (mitigation) measures outlined in Section 8.5.2.5.

8.5.7 Cumulative Effects

Due to the localised nature of the proposed construction works which will be kept within the Proposed Development site boundary, there is no potential for significant cumulative effects in-combination with other local developments on the land, soils and geology environment as all effects are direct within the Proposed Development site. Other projects outside the Proposed Development site do not have the potential to reduce or increase the magnitude of effects of the Proposed Development on Land, Soils and Geology.

Imported aggregate and rock materials used during the construction of the wind farm will be from fully authorised quarries. The direct excavation at those external sites are remote from the proposed development site.

The only way the Proposed Development can have cumulative effects with other off site projects and plans is via the drainage and off site surface water network, and this hydrological pathway is assessed in Chapter 9. The construction of the grid connection works will only require relatively localised excavation works within the site boundary and therefore will not contribute to any significant cumulative effects.

8.5.8 Non-Technical Summary

The geology of the site predominately comprises raised bog (peat) overlying glacial subsoil deposits which in turn are underlain by limestone bedrock. Trial pit investigations were undertaken to investigate the subsoil conditions below the peat. Peat depths were determined by probing.

Measured peat depths range from 0 - 4.49m across the wind farm site, with an average depth of 1.6m recorded. Approximately 32% (49 no.) of the peat depths were less than 0.5m while 81% (126 no.) were less than 2m. Overall the peat depths would be considered shallow for basin peat.

Peat depths at the turbine locations ranged between 0.6 (T4) and 3.7m (T2) with an average peat depth of 2.3m. CLAY or SILT dominated glacial tills are present below the peat.

Construction of the wind farm infrastructure will require the removal of peat, soil and rock to competent foundation. Local quarries will provide material for access road, turbine bases and general hard-standing construction. Removal of soil, peat and bedrock represents a permanent direct impact on the geology of the site which is considered to be an acceptable part of economic progression and development.

During the construction phase sources of contaminants (such as oil based substances or other hazardous chemicals) will not be stored at the site except where this is done within safely bunded areas that safely contain all spillages and prevent the migration of contaminants into soil, peat and bedrock. Refuelling will be done with a double skinned bowser with spill kits on the ready in case of accidental spillages. The risk is considered to be low once mitigation measures are implemented.

The peat stability assessment undertaken at the site shows that the site has an acceptable margin of safety for the proposed development. A number of control measures are given in the peat stability assessment to manage all risks associated with peat instability.

A Peat Management Plan has been prepared for the development which details management of peat during construction works and long term storage thereafter. Peat removed during the excavation works will be deposited in the proposed spoil and peat repositories.

The potential residual impacts associated with soil or ground contamination and subsequent health effects are imperceptible.

No significant impacts on land, soil and geological environmental are anticipated during the construction, operation or decommissioning phases of the Proposed Development.

The geological impact assessment undertaken in this chapter outlines that significant effects will not occur due to the localised nature of the construction works and therefore there is no potential for cumulative effects.

FIGURES

BIBLIOGRAPHY

British Standards Institution (BSI). (2015) BS5930 - Code of Practice for Site Investigations.

Department of Housing, Planning and local Government, 2018: Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment.

Environmental Protection Agency (2022): Guidelines on the Information to be contained in Environmental Impact Assessment Reports.

European Union, 2017: Guidance on the preparation of the EIA Report (Directive 2011/92/EU as amended by 2014/52/EU).

Gavin and Doherty Geosolution (GDG) (2023). Peat Stability Assessment Report – Carrig Renewable Wind Farm, County Tipperary, June 2023.

Gavin and Doherty Geosolution (GDG) (2023). Peat & Spoil Management Plan - Carrig Renewable Wind Farm, County Tipperary, June 2023.

Geological Survey of Ireland (GSI). (1999) Geology of Galway - Offaly, 1:100,000 scale Bedrock Geology Series, Sheet 15.

Institute of Geologists Ireland (2013). Guidelines for Preparation of Soils, Geology & Hydrogeology Chapters in Environmental Impact Statements.

National Roads Authority (2008): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes.

Scottish Natural Heritage report (SNH) Research and Guidance on Restoration and Decommissioning of Onshore Wind Farms (SNH, 2013).