FEHILY TIMONEY

DESIGNING AND DELIVERING A SUSTAINABLE FUTURE

ENVIRONMENTAL IMPACT ASSESSMENT REPORT (EIAR) FOR THE PROPOSED SHANCLOON WIND FARM, CO. GALWAY

Volume 2 – Main EIAR

Chapter 11 – Soils, Geology and Hydrogeology

Prepared for:

RWE Renewables Ireland Ltd.

RWE

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Core House, Pouladuff Road, Cork, T12 D773, Ireland

T: +353 21 496 4133 | E: info@ftco.ie

CORK | DUBLIN | CARLOW

www.fehilytimoney.ie

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11. SOILS, GEOLOGY AND HYDROGEOLOGY

11.1 Introduction

This chapter has been prepared to examine the potential impacts of the proposed Shancloon Wind Farm, associated grid connection and turbine delivery route on existing geological conditions within the study area. The study area is defined as the 'Site', as shown in Figure 2.2a-c, Volume IVand includes the HDD crossing along the GCR, which has the most potential to impact the underlying geological and hydrogeological receptors. The effects of the Project are assessed, taking account of mitigation measures to reduce or eliminate any residual impacts on Soils, Geology and Hydrogeology. The assessment also considers the cumulative impacts associated with other nearby developments.

The Proposed Development assessed in this EIAR comprises the following elements:

- The wind farm site (referred to in this EIAR as the 'Site') which includes the turbine array and associated civil and electrical infrastructure and the on-site 110 kV substation and loop-in connection to the existing Cashla-Dalton overhead line;
- The turbine delivery route (referred to in this EIAR as the 'TDR').

The location of the Proposed Development is shown in Figure 2.1. An overview of the Site Layout is shown in Figure 2.2a Figure 2.2b and Figure 2.2c. The layout of the TDR is presented in Figure 2.3.

A detailed description of the project assessed in this EIAR is provided in Chapter 2.

The Site includes wind turbines, internal access tracks, watercourse crossings, hard standings, a permanent meteorological mast, on-site substation, internal electrical and communications cabling, temporary construction compounds, drainage infrastructure and all associated works related to the construction of the wind farm. The GCR will consist of underground 33kV cables and will connect via a loop-in 110 kV underground cable connection approximately 650 m in length to the existing Cashla-Dalton 110 kV overhead line. The soils, geology and hydrogeology assessment for the GCR, given the proximity to the site is included as part of the site assessment. There will be one watercourse crossing along the GCR, which will require Horizontal Directional Drilling (HDD). The turbine delivery route includes all aspects of the route from Galway Port to the Site entrance including proposed temporary accommodation works to facilitate the delivery of wind turbine components.

11.2 Statement of Authority

This Chapter has been prepared by EurGeol Aaron T. Clarke PGeo of Fehily Timoney and Company.

Aaron is a Chartered Principal Geologist with a BSc in Earth Sciences from University of Galway and a MSc in Applied Geotechnics from Camborne School of Mines (University of Exeter). He is a professional member of the Institute of Geologists of Ireland (PGeo) and the European Federation of Geologists (EurGeol). Aaron has 20 years of post-graduate experience working in the fields of geoscience and ground engineering. He has experience working on renewable energy projects within the Irish market, preparing Soils, Geology and Hydrogeology EIAR chapters for wind farms sites.

Contributors to this chapter and supporting appendices are as follows:

Gnanasai Chandramoorthy, Bachelor of Engineering in Civil Engineering, Master of Engineering in Soil Mechanics & Foundation Engineering – is a Principal geotechnical Engineer with over 12 years of international experience in the design and planning of major projects, Buildings, Transportation, Infrastructure, Railways and Metros, Oil field industries and Reclamation projects along with 2 years of research experience in tailings. He is fully proficient in geotechnical design in Bridges, deep excavation systems, shallow and pile foundations, combined piled raft foundation systems, slope stability and ground improvement techniques and analysis by using various geotechnical engineering software, onshore and offshore geotechnical investigation works, construction material testing and earthworks supervision.

Doireann Tarrant, MSc Structural and Geotechnical Engineering, BEng Civil, Structural and Environmental Engineering - is a senior project engineer with experience in ground Investigations, slope stability solutions, design of working platforms, design of piled foundations and BIM. She has contributed to peat stability risk assessments and geotechnical assessments to inform wind farm design.

Julian Borlado, Master of Science Degree, Geological Engineering - Julian has experience in civil track works, ground improvement, tunnels, roads and dewatering systems. He has 12 years' experience working in Ireland, Saudi Arabia, United Kingdom and Spain. Besides that, he has experience in geotechnical design for bridges, windfarms, photovoltaic plants, drinking water pipelines and edification. He has contributed to EIAR for multiple wind farms in Ireland.

Technical review of this chapter and supporting appendices has been completed by the following:

Tom Clayton MEng. (Distinction) Civil Engineering - a Chartered Engineer with 15 years of experience within the geotechnical sector with excellent skills in analytical design (including finite element analysis).Tom has expertise in transport geotechnics (for road, rail, underground rail schemes, active travel and greenway schemes), deep excavations and shafts (primarily in the Middle East and London) and Energy Geotechnics (both for solar and wind farms). Tom also specialises in earthwork stabilisation and has worked in asset management and design consultancy roles for both highways and rail projects.

Ian Higgins BSC. Engineering Geology, MSc. Geotechnical Engineering – a geotechnical engineer with 25 years' experience in the design and supervision of construction of bulk earthworks, soft ground engineering, geotechnical foundation design, geotechnical monitoring and reviewing, reinforced earth design and 3rd party checking of piling and ground improvement designs. Ian's experience also includes the design, supervision and interpretation of ground investigations, including desk studies, walkover surveys, hazard mapping of rock excavations and slopes. Ian has acted as reviewer for multiple wind energy EIARs.

11.3 Methodology

In summary the methodology adopted for this assessment includes:

- Review of appropriate guidance and legislation;
- Characterisation of the receiving environment;
- Review of the proposed project;
- Assessment of potential effects;
- Identification of mitigation measures;
- Assessment of cumulative impacts; and
- Assessment of residual impacts.

The assessment methodology and criteria are outlined in Section 11.3.4.

11.3.1 Relevant Guidance and Legislation

The general EIA guidelines are listed in Chapter 1, other topic specific reference documents used in the preparation of this section include the following:

- NRA (2009), Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;
- IGI (2013), Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements;
- Scottish Executive (2017) Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments, 2nd Edition;[1]
- European Union (2000/60/EC) Water Framework Directive (as amended);
- European Union (2006/188/EC) Groundwater Directive (as amended);
- Government of Ireland (2010) European Communities Environmental Objectives (Groundwater) Regulations (S.I. No. 9 of 2010) as amended;
- Government of Ireland (2003) European Communities (Water Policy) Regulations (S.I. No. 722 of 2003) as amended;
- EPA (2003), Towards Setting Guideline Values for the Protection of Groundwater in Ireland.
- EPA (2022), Guidelines on the Information to be Contained in Environmental Impact Assessment Reports;
- Department of Environment, Heritage and Local Government (DoEHLG) (2006), Wind Farm Planning Guidelines;
- Draft Revised Wind Energy Development Guidelines (DHPLG, December 2019)
- Irish Wind Energy Association (IWEA) (2012), Best Practice Guidelines for the Irish Wind Energy Industry.
- River Basin Management Plan 2022-2027

11.3.2 Consultation

The scope for this assessment has been informed by consultation with statutory consultees, bodies with environmental responsibility and other interested parties as summarised in Chapter 5 – Scoping and Consultation. Responses from the consultees have been taken into consideration in the preparation of the respective chapters of this EIAR. Specific issues raised during the scoping process with respect to Soils, Geology and Hydrogeology are presented in Table 11-1:

[1] This guidance document represents the current standard used in Ireland for peatland sites.

Table 11-1: Consultation Responses

Consultee	Response Date	Points Raised	Response
Geological Survey Ireland (GSI)	May 2023	Geological heritage is not a concern, but groundwater vulnerability potentially is. Consider all appropriate guidelines, and data sources.	Extensive ground investigation for the Proposed Development has been carried out and peat slippage risk assessment for the Site, as well as peat and spoil management plan (Appendix 11.4 of this EIAR).
Inland Fisheries Ireland (IFI)	17.08.2023	• 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 • It is important that natural flow paths are not interrupted or diverted in such a manner as to give rise to erosion or instability of soils caused by an alteration in water movement either above or below ground.	Extensive ground investigation for the Proposed Development has been carried out and peat slippage risk assessment for the Site, as well as peat and spoil management plan.

Sections 11.4.6.3 outlines groundwater vulnerability and 11.4.7 outlines text on geological heritage.

11.3.3 Desk Study

An understanding of the baseline geological and hydrogeological conditions within the study area was informed by a desktop review of publicly available information. This review was undertaken initially in January 2022 and intermittently thereafter until final desktop assessment in January 2025. The desk top study involved an examination of the following sources of information:

- Geology of South Mayo [Ref i]
- Galway County Development Plan 2022-2028 [Ref ii]
- Aerial imagery from Google, Bing and OSi (Geohive) [Ref iii]
- Current and historical (6 inch and 25 inch) Ordnance Survey maps [Ref iii]
- Mapping data of the area produced by the Geological Survey of Ireland (GSI) [Ref iv]
    - *Quaternary subsoil geology*
    - *100k bedrock geology*
    - *Karst features*
    - *Geological heritage features*
    - *Aggregate potential*
    - *Landslide susceptibility*
    - *Catchment & Management Units*

- *Groundwater Bodies Status and Risk*
- *Drinking Water Protection Areas*
- *Groundwater Resources (Aquifers)*
- *Groundwater Wells and Springs*
- *Groundwater Vulnerability*

- Datasets from the EPA [Ref v]

11.3.4 Site Investigations and Field Assessments

A site reconnaissance survey was undertaken by FT Chartered Principal Geologist Aaron Clarke (BSc, MSc, MCSM, EurGeol, PGeo) over two separate events: between 18th and 21st January 2022 (when vegetation cover was low allowing better assessment of topography) and again from 4th to 5th April 2023. In addition, peat probe survey was undertaken by FT Senior Project Engineer Julian Borlado (BSc) between 31st October and 2nd November 2023. The purpose of these surveys was to determine the baseline characteristics of the Site with particular emphasis on karst characterisation. The resulting data from these surveys are discussed in Section 11.4.9 of this Chapter. The assessment works undertaken comprised the following:

- Walkover inspections of the Site with recording of salient geomorphological features at proposed infrastructure locations.
- Peat depth probing and slope stability assessment at proposed infrastructure locations and where peat deposits were encountered.
- Recording of GPS co-ordinates of site investigation locations using a hand-held GPS.

In addition to the site walkover and peat probing surveys, a project specific non-intrusive and intrusive ground investigation was carried out to inform the soils, geology and hydrogeology assessment of the Site. The investigation was undertaken by Apex Geophysics between 26th May and 1st June 2022. The investigation comprised:

- 26 no. Electrical Resistivity Tomography (ERT) profiles
- Accompanying soft ground (peat) probing along each ERT profile

Intrusive ground investigation was undertaken by Ground Investigations Ireland (GII) between March 2023 and June 2023. The investigation comprised:

- 22 no. trial pits
- 22 no. rotary cored boreholes with groundwater monitoring well installations
- Geotechnical and geo-environmental testing

The intrusive ground investigation works were supervised by FT's Chartered Principal Geologists Aaron Clarke (BSc, MSc, MCSM, EurGeol, PGeo) and GII's Chartered Senior Engineering Geologist, James Cashen (BSc, EurGeol, PGeo).

Ground investigation findings are presented in the Geotechnical Assessment Report (GAR) in Appendix 11-1. GII's Factual Report, including exploratory hole logs, is included as an appendix within the GAR.

11.3.5 Evaluation Criteria

During each phase (construction, operation and decommissioning) of the Project, several activities will take place on site, some of which will have the potential to cause impacts on the geological regime at the proposed Site and the associated Soils, Geology and Hydrogeology. These potential impacts are discussed throughout this chapter. Mitigation measures where required are presented in Section 11.7.

11.3.5.1 Assessment of Magnitude and Significance of Effects on Soils, Geology and Hydrogeology

An impact rating has been developed for each of the phases of the Project based on the Institute for Geologists Ireland (IGI) "Guidance for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements". In line with the IGI Guidance, the receiving environment (Geological Features) was first identified.

Using the NRA rating criteria in Appendix C of the IGI Guidance, the importance of the geological and hydrogeological features are rated (Table 11-2 and Table 11-3) followed by an estimation of the magnitude of the impacts on geological and hydrogeological features (Table 11-4 and Table 11-5).

This determines the significance of the impact prior to application of mitigation measures as set out in Table 11-6.

Table 11-2: Criteria for Rating Site Importance of Geological Features (NRA, 2009)

Magnitude	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 the site is significant on a national or regional scale.	• Geological feature 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 the 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 high 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. Volume of peat and/or soft organic soil underlying the site 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 pit; • Sub- economic extractable mineral resource.

Magnitude	Criteria	Typical Example
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 the 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; • Uneconomic extractable mineral resource.

Table 11-3: Criteria for Rating Site Importance of Hydrogeological Features (NRA, 2009)

Importance	Criteria	Typical Example
Extremely High	Attribute has a high quality or value on an international scale.	Groundwater supports river, wetland or surface water body ecosystem protected by EU legislation e.g. SAC or SPA status
Very High	Attribute has a high quality or value on a regional or national scale.	Regionally Important Aquifer with multiple wellfields. Groundwater supports river, wetland or surface water body ecosystem protected by national legislation – e.g. NHA status. Regionally important potable water source supplying >2500 homes Inner source protection area for regionally important water source.
High	Attribute has a high quality or value on a local scale.	Regionally Important Aquifer. Groundwater provides large proportion of baseflow to local rivers. Locally important potable water source supplying >1000 homes. Outer source protection area for regionally important water source. Inner source protection area for locally important water source.
Medium	Attribute has a medium quality or value on a local scale.	Locally Important Aquifer Potable water source supplying >50 homes. Outer source protection area for locally important water source.
Low	Attribute has a low quality or value on a local scale.	Poor Bedrock Aquifer. Potable water source supplying <50 homes.

Table 11-4: Estimation of Magnitude of Impact on Geological Features (NRA, 2009)

Magnitude	Criteria	Typical Example
Large Adverse	Results in loss of attribute	• Loss of high proportion of future quarry or pit reserves • Irreversible loss of high proportion of local high fertility soils • Removal of entirety of geological heritage feature • Requirement to excavate / remediate entire waste site • Requirement to excavate and replace high proportion of peat, organic soils and/or soft mineral soils beneath alignment
Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute	• Loss of moderate proportion of future quarry or pit reserves • Removal of part of geological heritage feature • Irreversible loss of moderate proportion of local high fertility soils • Requirement to excavate / remediate significant proportion of waste site • Requirement to excavate and replace moderate proportion of peat, organic soils and/or soft mineral soils beneath alignment
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute	• Loss of small proportion of future quarry or pit reserves • Removal of small part of geological heritage feature • Irreversible loss of small proportion of local high fertility soils and/or • high proportion of local low fertility soils • Requirement to excavate / remediate small proportion of waste site • Requirement to excavate and replace small proportion of peat, organic soils and/or soft mineral soils beneath alignment
Negligible	Results in an impact on attribute but of insufficient magnitude to affect either use or integrity	No measurable changes in attributes
Minor Beneficial	Results in minor improvement of attribute quality	Minor enhancement of geological heritage feature
Moderate Beneficial	Results in moderate improvement of attribute quality	Moderate enhancement of geological heritage feature

Magnitude	Criteria	Typical Example
Major Beneficial	Results in major improvement of attribute quality	Major enhancement of geological heritage feature

Table 11-5: Estimation of Magnitude of Impact on Hydrogeological Features (NRA, 2009)

Magnitude	Criteria	Typical Example
Large Adverse	Results in loss of attribute and /or quality and integrity of attribute	Removal of large proportion of aquifer. Changes to aquifer or unsaturated zone resulting in extensive change to existing water supply springs and wells, river baseflow or ecosystems. Potential high risk of pollution to groundwater from routine run-off. Calculated risk of serious pollution incident >2% annually.
Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute	Removal of moderate proportion of aquifer. Changes to aquifer or unsaturated zone resulting in moderate change to existing water supply springs and wells, river baseflow or ecosystems. Potential medium risk of pollution to groundwater from routine run-off. Calculated risk of serious pollution incident >1% annually.
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute	Removal of small proportion of aquifer. Changes to aquifer or unsaturated zone resulting in minor change to water supply springs and wells, river baseflow or ecosystems. Potential low risk of pollution to groundwater from routine run-off. Calculated risk of serious pollution incident >0.5% annually.
Negligible	Results in an impact on attribute but of insufficient magnitude to affect either use or integrity	Calculated risk of serious pollution incident <0.5% annually.

The matrix in Table 11-6 determines the significance of the impacts based on the importance and magnitude of the impacts as determined by Table 11-2 to Table 11-5 .

Table 11-6: Ratings of Significance of Impacts for Geology/Hydrogeology (NRA, 2009)

Importance of Attribute	Magnitude of Impact			
	Negligible	Small Adverse	Moderate Adverse	Large Adverse
Very High	Imperceptible	Significant/Moderate	Profound/Significant	Profound
High	Imperceptible	Moderate/Slight	Significant/Moderate	Profound/Significant
Medium	Imperceptible	Slight	Moderate	Significant
Low	Imperceptible	Imperceptible	Slight	Slight/Moderate

The determination of the significance of each impact for the Site, GCR and TDR are discussed in Section 11.6.

11.4 Baseline Environment

11.4.1 General

The existing environment is described hereunder. This includes descriptions of the underlying quaternary and bedrock geology, areas of geological heritage, areas of economic interest with respect to geological resources, potential for soil contamination, aquifer classification, groundwater vulnerability and groundwater wells and springs. This section also includes a summary of site-specific information obtained during walkover surveys and intrusive investigations undertaken as part of the baseline assessment works.

The following sections form the basis of the **Conceptual Site Model (CSM)** for the Site, detailing the interactions between the different receiving geological and hydrogeological receptors. Particular emphasis is given to karst processes which are discussed in relevant sections within this report.

11.4.2 Type of Geological/Hydrogeological Environment

Based on regional and site-specific information available, the type of geological/hydrogeological environment as per Figure 2 of the IGI Guidelines [(xiii)] is **Type D – Sensitive Geological / Hydrogeological Environments**.

11.4.3 Quaternary Deposits

The GSI Quaternary mapping [Ref iv] indicates the Site is predominantly underlain by a mantle of cut over raised peat (peat). The remaining areas of the Site are underlain by till derived from limestones (till). In general, the peat deposits are in areas of slightly lower elevation when compared to the till. Subordinate linear deposits of Alluvium are mapped to the west of the site, underlying a portion of the proposed substation and approximately 800m of the proposed internal access track. In general, the Quaternary deposits across the Site can be categorised as being poorly drained.

The Quaternary geology of the proposed project and surrounding area is presented in Figure 11.1. Mapping shows the turbines and hardstands are underlain by the following Quaternary deposits:

- Cut over raised peat at turbines **1, 2, 5, 7, 10** and **11**
- Till derived from limestone at turbines **3, 4, 6, 8** and **9**

11.4.4 Bedrock Geology

The GSI 1:100,000 scale bedrock mapping [Ref iv] (Figure 11.2) indicates the Site is entirely underlain by mid Carboniferous limestone. The Site is predominantly underlain by the Ardnasillagh Formation comprising dark cherty calcarenites (limestone) and thin shales. The northern extent of the Site, at the location of turbine T10, is underlain by the thick bedded pure limestone of the Cong Limestone Formation. The Cong Canal Limestone, comprising medium to thick bedded pure limestone, is mapped to the immediate north of turbine T2; however, this formation is not mapped as being present beneath the Site.

11.4.5 Structural Geology

GSI 1:100,000 structural mapping [Ref iv] (Figure 11.2) indicates the presence of a single northeast-southwest trending regional fault. This fault, which is the result of mountain building (orogenic) processes that occurred during the late Carboniferous (Variscan) period, juxtaposes younger Cong Canal and Cong Limestone Formations against older Ardnasillagh Formation. This fault spurs into two separate faults to the west of the Site, just north of the proposed substation. Total vertical displacements along these faults are unknown.

There are no GSI regional cross-sections available for the Site. The closest cross-section is the Benwee Head to Carnsore Point section, located approximately 27km to the northwest.

Structural mapping [Ref iv] indicate bedding dips range from 2 to 20°. Dip directions are varied.

11.4.6 Hydrogeology

11.4.6.1 Bedrock Aquifer

Groundwater mapping [Ref iv] (Figure 11.6) indicates that the entire Site is underlain by a Regionally Important Aquifer – Karstified (conduit). This is important in the context of the Site as the bedrock aquifer indicates the potential for karst processes.

Groundwater monitoring was undertaken by FT as part of the intrusive ground investigation. Monitoring results are discussed in Section 11.4.11.

11.4.6.2 Anticipated Groundwater Regime

The overburden deposits of till and peat have generally low to moderate permeability and may therefore act as a confining layer (where present), preventing the free movement of surface water to the underlying Regionally Important Karstified Aquifer.

The geomorphology of the Site comprises a series of broadly northwest-southeast trending streamlined hills shown on the GSI's physiographic mapping [Ref iv] as drumlin formations. The drumlins are flanked by areas of low lying and flat topography, typically characterised by peatland deposits. Overall, there is a subtle topographic gradient which gradually slopes down towards the southwest.

Groundwater at the Site flows in the general direction of the topography and surface watercourses, which again flow towards the southwest.

Given the geology of the Site, most groundwater flow will occur along steeply angled fissures and faults within the Ardnasillagh Formation. Due to the argillaceous nature of the limestone beneath the Site, conduit flow is not anticipated. Discharge will likely follow the surface water drainage system flowing southwest towards Lough Corrib.

The composition of the Ardnasillagh Formation indicates a low permeable bedrock. This is important in relation to potential groundwater pathways from the Site to sensitive habitat areas such as nearby Special Areas of Conservation (SAC) and proposed Natural Heritage Areas (pNHA)[Ref v]. Given an anticipated groundwater flow path to the southwest, the closest designated areas are three pNHAs to the south of the Site (Killower Turlough, Turlough O'Gall and Lough Hacket). The closest of which is Lough Hacket, which lies 2.6km south of the proposed on-site substation.

11.4.6.3 Although these sensitive habitats are down gradient of the Site, the nature of the bedrock geology (ie. the Ardnasillagh Formation) indicates that there is limited connectively between the Site and the pNHAs. Groundwater Vulnerability

Groundwater vulnerability, as defined by the GSI, is the term used to represent the intrinsic and hydrogeological characteristics that determine the ease of which groundwater could be contaminated by human activities. The vulnerability of an aquifer to contamination is influenced by the leaching characteristics of the topsoil, the permeability and thickness of the subsoil, the presence of an unsaturated zone, the type of aquifer, and the amount and form of recharge (the hydraulic process where water moved downward from surface water to groundwater).

Groundwater vulnerability is determined mainly according to the thickness and permeability of the subsoil that underlies the topsoil, as both properties strongly influence the travel times and attenuation process of contaminants that could be released into the subsurface from below the topsoil.

The GSI's Groundwater Vulnerability mapping [Ref iv] within the Site ranges from 'Low' to 'High' with localised areas mapped as having 'Extreme' to 'X – Rock at or near Surface'. It should be noted however, that shallow rock was not encountered on Site. The eastern half of the Site is predominantly mapped as having a 'Low' to 'Moderate' groundwater vulnerability. The GSI's Groundwater Vulnerability distribution is presented in Figure 11.3.

Based on GSI's Groundwater Vulnerability mapping[Ref iv], Site walkovers and intrusive ground investigation, overburden deposits are generally >10m deep across the majority of the Site. The expected permeability for the subsoil is 'Low' to 'Moderate', but it may be locally 'High' within 'X' areas, due to the possible presence of shallow or outcropping weathered bedrock.

A summary of the groundwater vulnerability for the Site is presented in Table 11-7 This table outlines the standard ratings of vulnerability used by the GSI, with the existing Site conditions highlighted in green based on the findings of the Site investigations.

Table 11-7: Groundwater Vulnerability

Vulnerability Rating	Hydrogeological Conditions		
	Subsoil Permeability (Type) and Thickness		
	High Permeability (sand/gravel)	Moderate Permeability (sandy soil)	Low Permeability (clayey subsoil, clay, peat)
Extreme (E)	0 - 3.0 m	0 - 3.0 m	0 - 3.0 m
High (H)	> 3.0 m	3.0 -10.0 m	3.0 - 5.0 m
Moderate (M)	N/A	>10.0 m (Note 1)	5.0 - 10.0 m
Low (L)	N/A	N/A	>10 m (Note 1)
Note 1 – mean rock depth from boreholes is 11.15m bgl.			

11.4.6.4 Groundwater Bodies Description

The GSI's Groundwater Body (GWB) data sets (Ref iv) indicate the Site lies within the Clare-Corrib GWB, which covers an area of approx. 1,422 km^2. The main aquifer lithologies of this GWB are pure bedded limestone (such as the Cong Limestone Formation). Karstification within the rock units of the Clare-Corrib GWB is described as being widespread. However, this is not the case for the Site, which is predominantly underlain by muddy limestone lithologies containing shale interbeds (Ardnasillagh Formation), which is less prone to dissolution due to its low Calcium Carbonate ($CaCO_3$) content.

There is no transmissivity data available for the Clare-Corrib GWB. However, the adjacent Cong Robe GWB, which shares similar geological properties, has a reported transmissivity range of 1-250m^2/day. Given the nature of the underlying bedrock geology (i.e. a predominantly muddy impermeable limestone with no karst features mapped), it is anticipated that the transmissivity values within the Site are similarly relatively low.

The descriptions of the GWBs within the study area have been taken from the 'Summary of Initial Characterisation' draft reports for each defined GWB published by the GSI in accordance with the Groundwater Working Group Publication: Guidance Document GW2 (2003). The GWB Characterisation Reports are available from the GSI Public Data Viewer. Site specific data including outcrop rock encountered in walkovers and groundwater observations recorded on Site have been used to supplement and validate the published information.

According to interim classification work carried out as part of the Water Framework Directive and published by the EPA (2016-2021), the Clare-Corrib GWB is classified as having *'Good'* status in terms of quality and quantity. The overall risk result of '*Not At Risk'* is applied to the Clare-Corrib GWB.

Groundwater recharge rates within the Clare-Corrib GWB are not currently available.

A summary of the aquifer classifications is presented in Table 11-8. The GSI's Ground Water Bodies mapping is presented in Figure 11.4.

Table 11-8: Summary of Aquifer Classifications & Characteristics

GWB	European Code	Aquifer Category	Flow Regime	Transmissivity (m^2/day)
Clare-Corrib	E_WE_G_0020	Regionally Important Aquifer – Karstified (conduit)	These rocks are generally devoid of intergranular permeability. Groundwater flows through fissures, faults, joints and bedding planes	There is no available transmissivity data available for the Clare-Corrib. However, the adjacent Cong Robe GWB, which shares similar geological properties, has a reported transmissivity range of 1-250m^2/day.

11.4.6.5 Groundwater Supply Sources

A review of published information on groundwater supply sources within the study area was undertaken to identify potential groundwater dependant receptors at potential risk from the Project. These include group water schemes (GWS), source protection zones and private supply wells with information on these features obtained from the GSI Groundwater database.

11.4.6.6 Public Water Supplies and Source Protection Zones

The GSI maintains a database of Public Supply Source Protection Areas. From a review of the database there are no Public Water Supplies (PWS's) or Public Supply Source Protection Areas within the Site boundary.

There are however 2 No. Public Supply Source Protection Areas for public water supply schemes within 20km of the wind farm Site, and these are:

- Kilmaine Public Water Supply Scheme, 6km to the northwest;
- Dunmore Glenamaddy Public Water Supply Scheme, 19km to the east

These Public Supply Source Protection Areas are presented in Figure 11.5.

11.4.6.7 Group Water Schemes and Source Protection Zones

Based on a review of the current EPA and GSI groundwater databases, there are no Group Water Schemes (GWS) within the boundary of the Site. There are no GWS in the groundwater sub-catchment area in which the wind farm Site is located either. However, there are 11 GWS's within 20km of the Site. These are:

- Cluide–Cahermorris GWS, 7km to the south
- Rusheens GWS, 8km to the southeast
- Caherlea GWS, 10km to the southeast
- Anbally GWS, 13km to the southeast
- Cahermorris Glenreevagh GWS, 11km to the south
- Balrobuckbeg GWS 11km to the south
- Kilcoona Caherlistrane GWS 9.5km to the south
- Feigh East and West GWS, 18km to the southeast

- Gallagh GWS, 12km to the east
- Irishtown GWS, 12km to the northeast
- Gurteen Cloonmore GWS, 16km to the east

Group Water Schemes Protection Areas are presented in Figure 11.5.

11.4.6.8 Groundwater Wells and Springs

Based on a review of the GSI Groundwater Wells and Springs database [Ref iv] there are 4 no. groundwater wells recorded within 1 km of the Site. The locations of these groundwater wells are presented in Figure 11.6.

Table 11-9 and Table 11-10 outline the details of groundwater wells and springs held within the GSI dataset.

Table 11-9: Summary of Wells with 1km of the Project

Location ID	Easting	Northing	Type	Total Depth (m bgl)	Current Use	Yield Class (yield m^3/day)	GSI Location Accuracy (m)	Approx. Distance to Nearest Infrastructure Element (m) Note 1
1125SEW006	535682	754913	Borehole	12.80	Agri & domestic use	Moderate (50.1)	50	T11 (765m)
1125SEW014	535695	754911	Borehole	9.10	Unknown	Good (328)	50	T11 (775m)
1125SEW011	528747	752044	Borehole	18.90	Agri & domestic use	Moderate (98)	100	Substation access road (927m)
1125SEW113	529308	754077	Borehole	15.20	Agri & domestic use	Good (109)	109	Substation (300m)

Note 1 – measured from the edge of the well boundary.

Table 11-10: Summary of spring locations

Location ID	Easting	Northing	Yield Class	Yield (m^3/day)	GSI Location Accuracy (m)	Distance to Nearest Infrastructure Element (m)
1125SEW004	532265	757092	Low Spring	327	20	T10 (1500m)

Yield within the wells range from moderate to good (50.10 to 328m^3 per day). The yield recorded at the spring location is 327m^3 per day. These yields suggest that the underlying bedrock is productive.

11.4.6.9 Karst Features

The GSI groundwater karst mapping [Ref iv] (Figure 11.7) indicates there are no karst features located within 1km of the Site. However, there are several karst features located within an approximate 5km distance of the Site. Table 11-11summarises these mapped karst features:

Table 11-11: Summary of mapped karst features within 5km of the Site

Mapped Karst Feature	Easting	Northing	Underlying Bedrock Geology	Approx. Distance to Nearest Infrastructure Element (m)
Enclosed Depression	525017	753852	Oakport Limestone Formation	Substation (4,930m)
Enclosed Depression	525277	753734	Oakport Limestone Formation	Substation (4,650m)
Enclosed Depression	525440	753919	Oakport Limestone Formation	Substation (4,530m)
Enclosed Depression	525490	753903	Oakport Limestone Formation	Substation (4,480m)
Enclosed Depression	525509	753772	Oakport Limestone Formation	Substation (4,430m)
Enclosed Depression	525408	753537	Oakport Limestone Formation	Substation (4,477m)
Turlough	526287	754291	Ardnasillagh Formation	Substation (3,841m)
Swallow Hole	526521	754051	Illaunagappul Formation	Substation (3,540m)
Swallow Hole	526342	753800	Illaunagappul Formation	Substation (3,630m)
Enclosed Depression	527564	752602	Ardnasillagh Formation	Substation (2,300m)
Turlough	526729	752241	Illaunagappul Formation	Substation (3,200m)
Turlough	526775	752182	Illaunagappul Formation	Substation (3,150m)
Swallow Hole	527076	752032	Illaunagappul Formation	Substation (2,860m)
Swallow Hole	525969	750974	Illaunagappul Formation	Substation (4,300m)
Enclosed Depression	530563	750203	Ardnasillagh Formation	Substation (2,750m)
Swallow Hole	530363	748555	Ardnasillagh Formation	Substation (4,300m)
Turlough	534024	751912	Ardnasillagh Formation	T5 (2,350m)
Turlough	534533	750872	Coranellistrum Formation	T5 (3,500m)
Turlough	537514	752152	Coranellistrum Formation	T7 (3,900m)
Spring Note 1	529787	758613	Cong Canal Formation	T10 (4,330m)
Spring Note 1	532037	759053	Cong Canal Formation	T10 (3,370m)
Spring Note 1	532699	758580	Cong Limestone Formation	T10 (2,750m)
Enclosed Depression	532389	759726	Cong Canal Formation	T10 (3,930m)
Enclosed Depression	532493	759746	Cong Canal Formation	T10 (3,940m)
Enclosed Depression	532584	759835	Cong Canal Formation	T10 (4,010m)
Enclosed Depression	533337	760520	Cong Canal Formation	T10 (4,660m)
Enclosed Depression	533412	760494	Cong Canal Formation	T10 (4,640m)

Mapped Karst Feature	Easting	Northing	Underlying Bedrock Geology	Approx. Distance to Nearest Infrastructure Element (m)
Enclosed Depression	533401	760408	Cong Canal Formation	T10 (4,550m)
Turlough	534605	759780	Cong Limestone Formation	T10 (4,180m)
Turlough	534344	759172	Cong Limestone Formation	T10 (3,520m)
Enclosed Depression	534484	758971	Cong Limestone Formation	T10 (3,390m)
Turlough	536376	759137	Cong Limestone Formation	T10 (4,600m)

Note 1 – these springs are not included in the GSI's Wells and Springs data set.

As part of this EAIR, an extensive karst assessment was undertaken across the Site. The resulting Karst Assessment Report is included as Appendix 11-2. Findings from this assessment are discussed further in Section 11.4.12 and take into consideration results from the desk study, site walkover (Section 11.4.9) non-intrusive geophysical survey (Section 11.4.10) and intrusive ground investigation (Section 11.4.11).

11.4.7 Geological Heritage

The GSI's Geological Heritage (Geo-heritage) division, have undertaken a programme to identify and select important geological and geomorphological Sites throughout the country for designation as NHAs (Natural Heritage Areas). This is being addressed under 16 different geological themes. For each theme, a larger number of sites (from which to make the NHA selection) are being examined, to identify the most scientifically significant. The criterion of designating the minimum number of sites to exemplify the theme means that many sites of national importance are not selected as the very best examples. However, a second tier of County Geological Sites (CGS) (as per the National Heritage Plan) means that many of these can be included in County Development Plans and receive a measure of recognition and protection through inclusion in the planning system.

The GSI's online Geological Heritage database [Ref iv] indicates there are no audited or unaudited Geological Heritage Sites (GHSs) within the Site or wider study area. The closest GHSs are located approximately 4.4km to the east (Dunmore Esker - A number of high, sinuous ridge segments, which all form part of the same, extensive esker system) and 5km to the south (Knockmaa - A large area of landscape with glacial deposits which have slightly modified a much older landscape)

The distribution of Geological Heritage Sites is shown on Figure 11.8.

11.4.8 Economic Geology

The GSI Online Minerals Database [Ref iv] accessed via the Public Data Viewer shows no quarries (active or historic) within 5km of the Site. Two mineral occurrences occur within 5km of the Site and are summarised in Table 11-12. The distribution of these sites are presented in Figure 11.9.

Table 11-12: Mineral Occurrences

Mineral Occurrence	Easting	Northing	Mineral Location Reference	Approximate Distance to Site (km)
Dimension stone	534565	752127	4712	2.2
Dimension stone	534965	758822	4711	2.4

The GSI Aggregates database [Ref iv] indicates that there is a very low to high potential for crushed rock aggregate across the Site (Figure 11.10). There is generally a low potential for granular aggregate but only in localised areas to the far west of the Site (Figure 11.11).

No bedrock outcrops are mapped by the GSI within the Site. Similarly no bedrock outcrops were observed during the site surveys.

11.4.9 Walkover Survey Findings

Karst Assessment Walkover Survey

A site reconnaissance survey was undertaken from 18th to 21st January 2022 and the 4th and 5th April 2023. The survey work was completed by FT Principal Geologist Aaron Clarke (BSc, MSc, MCSM, PGeo, EurGeol) who has over 20 years' professional experience. The purpose of the survey was to:

- verify the presence of potential surface karst features identified as part of the aerial photography and DTM review; and
- where possible, to identify additional karst features not visible on aerial photography or DTM.

In total 26 no. out of the 56 no. features identified during the desk study were visited. An additional 9 no. potential surface karst features that weren't identified during the desk study stage were also recorded during the survey. The remaining 30 no. locations were not accessible during the time of the survey. However, it should be noted that evidence from the DTM strongly suggest that these unvisited locations are enclosed depressions (dolines). No surface features were identified in the area of the proposed substation.

Findings from the Site visit are summarised in Table 11-13 and presented in Figure 11.7.

Table 11-13: Karst features identified during the Site reconnaissance

Karst type	Loc. ID	ITM Coordinate		Visible on aerial photos or DTM (Y/N)	Approx. Distance (m) to Nearest Infrastructure Element	Comments
		E	N			
Possible Enclosed Depression	001	531412	754499	Y	15 (T2)	Subtle shallow oval shaped depression. This may also be a result of non-karst related processes.

Karst type	Loc. ID	ITM Coordinate		Visible on aerial photos or DTM (Y/N)	Approx. Distance (m) to Nearest Infrastructure Element	Comments
		E	N			
Enclosed Depression	002	531581	754047	Y	70 (T3)	Well defined approx. 12m diameter circular depression (approx. 0.5m deep) containing abundant hydrophilic vegetation (rush). The sides of this feature display a stepped vertical drop of approximately 0.3 to 0.5m.
Enclosed Depression	003	531616	753964	Y	20 (T3)	Well defined approx. 12m diameter circular depression (approx. 0.7m deep) containing hydrophilic vegetation (rush).
Enclosed Depression	004	531756	754015	Y	165 (T3)	Obvious broadly semi-circular depression (1-1.5m deep). Limited hydrophilic vegetation. Abundant tree/shrub vegetation.
Possible Enclosed Depression	005	531634	753770	Y	210 (T3)	Subtle circular depression. Potential doline or other geomorphological feature.
Possible Turlough	006	531520	753463	Y	370 (T4)	Subtle linear feature that shows signed of previous flooding. Dry at time of visit.
Karstified Limestone Boulder	007	531578	753473	N	315 (T4)	1.8m high fossiliferous dark grey limestone boulder displaying dissolution weathering features. Does not appear to be glacially transported i.e. not an erratic.
Possible Turlough	008	531485	753303	Y	410 (T4)	Subtle egg shaped depression. Partially filled with water. Contains hydrophilic vegetation.
Enclosed Depression	009	531484	753268	N	420 (T4)	Cluster of 3 no. circular depressions (early development dolines) approx. 1-1.5m diameter and 0.3m deep.
Enclosed Depression	010	531488	753266	N	420 (T4)	Cluster of 3 no. circular depressions (early development dolines) approx. 1-1.5m diameter and 0.3m deep.
Enclosed Depression	011	531491	753253	N	420 (T4)	Cluster of 3 no. circular depressions (early development dolines) approx. 1-1.5m diameter and 0.3m deep.
Enclosed Depression	012	531519	753260	Y	390 (T4)	Water filled well defined circular depression with hydrophilic vegetation. Depth unknown.
Enclosed Depression	013	531717	753383	Y	170 (T4)	Well defined circular bowl shaped depression about (approx. 1m deep).
Possible Enclosed Depression	014	531911	753375	Y	30 (T4)	Circular depression at the base of a shallow valley feature. Possible karst or glacial erosional feature. Pronounced hydrophilic vegetation within circular feature.

Karst type	Loc. ID	ITM Coordinate		Visible on aerial photos or DTM (Y/N)	Approx. Distance (m) to Nearest Infrastructure Element	Comments
		E	N			
Possible Enclosed Depression	015	531911	753287	Y	110 (T4)	Heavy gorse and bramble vegetation over a circular depression. Depth of depression unknown.
Possible Turlough	016	533293	753362	N	800 (T5)	Irregularly shaped water filled depression. No vegetation beneath water. Sharp waterline against adjacent planted grass.
Possible Turlough	017	533299	753339	N	800 (T5)	Broadly circular shaped water filled depression. No vegetation beneath water. Sharp waterline against adjacent planted grass.
Possible Turlough	018	533370	753393	N	800 (T5)	Broadly oval shaped water filled depression. Water level in depression displays a sharp edge and no vegetation growing within depression
Possible Turlough	019	533392	753422	N	800 (T5)	Broadly circular shaped water filled depression. No vegetation beneath water.
Enclosed Depression	020	533892	754308	Y	345 (T6)	Could not access field but circular depression clearly visible from roadside/adjacent fields.
Enclosed Depression	021	533779	754430	Y	280 (T6)	Could not access field but circular depression clearly visible from roadside/adjacent fields.
Enclosed Depression	022	533636	754503	Y	340 (T6)	Could not access field but circular depression clearly visible from roadside/adjacent fields.
Enclosed Depression	023	533649	754549	Y	315 (T6)	Could not access field but circular depression clearly visible from roadside/adjacent fields.
Enclosed Depression	024	533996	754496	Y	165 (T6)	Could not access field but circular depression clearly visible from roadside/adjacent fields.
Enclosed Depression	025	534058	754575	Y	130 (T6)	Could not access field but circular depression clearly visible from roadside/adjacent fields.
Enclosed Depression	026	533952	754593	Y	55 (T6)	Could not access field but circular depression clearly visible from roadside/adjacent fields.
Enclosed Depression	027	533895	754591	Y	80 (T6)	Could not access field but circular depression clearly visible from roadside/adjacent fields.
Enclosed Depression	028	533830	754629	Y	125 (T6)	Could not access field but circular depression clearly visible from roadside/adjacent fields.
Enclosed Depression	029	533755	755181	Y	30 (T8)	Subtle circular depression (0.5-0.7m deep and 22m across) with borehole drilled near centre. More obvious on orthophotograph.
Possible Enclosed Depression	030	533706	755195	Y	30 (T8)	Subtle circular depression (0.3-0.5m deep) with borehole at centre.

Karst type	Loc. ID	ITM Coordinate		Visible on aerial photos or DTM (Y/N)	Approx. Distance (m) to Nearest Infrastructure Element	Comments
		E	N			
Possible Enclosed Depression	031	533527	755165	N	210 (T8)	Subtle circular depression (0.4m deep) - possible early stage doline.
Possible Enclosed Depression	032	533529	755188	Y	205(T8)	Obvious roughly oval depression (1.5-2m deep). Partially vegetated with deciduous trees with brambles and nettles at base. Possible doline or historic excavation.
Enclosed Depression	033	533502	755328	Y	260 (T9)	Circular depression (0.5m deep) with deciduous tree growing within.
Enclosed Depression	034	533612	755383	Y	220 (T8)	Well defined circular depression (0.3m deep) with dock leaves growing within.
Enclosed Depression	035	533428	755523	Y	50 (T9)	Well defined circular depression (0.7m deep).

Of the 35 no. locations visited:

- 28 no. were recorded as enclosed depressions (8 no. of which are located within 100m of a turbine location)
- 6 no. were recorded as turloughs and
- 1 no. was recorded as a boulder displaying karst weathering (however, this is a possible erratic)

Representative photos of these features are presented in Appendix A of the Karst Assessment Report (presented in Appendix 11-2 of this EIAR).

Peat Probe Survey

A peat probe survey was undertaken between 31st October 2023 and 2nd November 2023. The survey work was completed by FT Senior Project Engineer Julian Borlado (MSc) who has over 12 years' professional experience. Findings from the peat probe survey indicates that peat occurs within localised low lying areas of the Site. The minimum, maximum and mean peat depth recorded out of 169 peat probe locations were 0.0, 8.0 and 2.29m respectively. In general, thinner peat layers were encountered on the flanks of the mapped peat deposits, becoming deeper towards the centre of these deposits. Approximately 34% of peat depths recorded as part of the peat probe survey were less than 0.5m.

A summary of the peat probe depths at the key infrastructure locations is presented in Table 11-14.

Table 11-14: Summary of site walkover findings at key infrastructure locations.

Infrastructure Element	Easting	Northing	Peat Depth (m)	Slope (°) Note 1
T01	532133	754079	8	2
T02	No peat – tested by ground investigation exploratory holes			2
T03	No peat – tested by ground investigation exploratory holes			5
T04	No peat – tested by ground investigation exploratory holes			5
T05	533307	754159	1.7	2
T06	No peat – tested by ground investigation exploratory holes			2
T07	534433	754560	6.3	2
T08	No peat – tested by ground investigation exploratory holes			4
T09	No peat – tested by ground investigation exploratory holes			2
T10	533136	755861	2.8	2
T11	534947	755115	4.9	2
On-Site Substation	No peat – tested by ground investigation exploratory holes			4
Note 1 – slope angles measured using a Suunto PM-5/360PC clinometer.				

Photographs taken during the site walkover survey are presented in Appendix 11-2.

11.4.10 Geophysical Survey Findings

Based on the findings of the desk study a geophysical survey was undertaken by Apex Geophysics to identify and delineate potential sub-surface karst features at 13 no. turbine locations (T01 to T13) across the Site (which were identified as part of Design Iteration 1 – See Chapter 3 Alternative for further details). The investigation was undertaken between the 26th May and 1st June 2022 and comprised the following survey methods:

- 26 no. Electrical Resistivity Tomography (ERT) profiles (two orthogonal ERT profiles at each of the proposed 13 no. turbine locations)
- Accompanying soft ground (peat) probing along each ERT profile to determine the thickness of soft peat deposits (to a maximum probe depth of 5m bgl)

The objectives of the survey was to:

- assess the depth to bedrock
- identify the type of bedrock
- identify any potential karst features faults/fissure zones within the bedrock
- propose follow-up borehole locations

Based on the findings of the geophysical survey an intrusive ground investigation was undertaken to target geophysical anomalies associated with potential sub-surface karst features within the underlying limestone bedrock formations. The scope and findings of this intrusive investigation is discussed in Section 11.4.11. The data captured during the geophysical survey was subsequently reprocessed using the intrusive ground investigation findings. The updated geophysical survey report is presented in Appendix 11-1.

Report Findings

Of the 13 no. locations that were surveyed, anomalies within the limestone bedrock were recorded at 3 no. locations (named as follows in Design Iteration1: T08, T10 and T11 (renamed to T12 post-date of geophys and later descoped)). These anomalies are described in the geophysical survey report as MUDSTONE/SHALE or possible weathered/karstified LIMESTONE.

It is important to note the since this survey, the following changes have been made to the turbine locations where potential anomalies were identified:

- T08 – relocated approximately 20m southwest of its initial proposed location. ERT survey line T8-R1 still transects the updated turbine base location.
- T10 – relocated approximately 70m to the south of its initial proposed location. A borehole (PBH-015 was subsequently drilled at the relocated turbine position to test for possible karst features).
- T11 (renamed to T12 post-date of geophys) – descoped.

The anomalies identified at T8 (R1/R2), T10 (R1/R2) and T11 (R1/R2) (renamed to T12 post-date of geophys) present as sub-vertical columnar features which propagate down through interpreted limestone bedrock. The widths of these anomalies range from approximately 5 to 20m across. It is not known from the survey results whether these anomalies represent a circular or linear feature in plan.

11.4.11 Intrusive Ground Investigation Findings

The detailed findings and conclusions of the intrusive ground investigation is provided in Appendix 11-1 – Peat Stability and Geotechnical Assessment Report and generally confirm the anticipated geology described in the Desk Study.

Trial pits were excavated at the turbine and substation locations. Boreholes were advanced at the proposed turbine and substation locations. A summary of ground and groundwater conditions encountered during the intrusive ground investigation are presented in Table 11-15 to Table 11-17.

Table 11-15: Summary of ground and groundwater conditions within the trial pits

Hole ID	Peat		Soft to firm Clay [A] / Very soft Marl [B]		Coarse-Grained Till		Firm to very stiff Fine-Grained Till		Groundwater Strike (mbgl)	Infrastructure Element Tested
	From (mbgl)	To (mbgl)	From (mbgl)	To (mbgl)	From (mbgl)	To (mbgl)	From (mbgl)	To (mbgl)		
PTP-01					0.00	3.70			0.50	T02
PTP-02			0.00 [A]	0.80 [A]	0.80	3.00	3.00	4.50		T02
PTP-03			0.00 [A]	0.50 [A]			0.50	5.10		T04
PTP-04			0.00 [A]	0.70 [A]			0.70	3.10 [Note 1]	3.10	T04
PTP-05	Exploratory hole location was descoped									

Hole ID	Peat		Soft to firm Clay [A] / Very soft Marl [B]		Coarse-Grained Till		Firm to very stiff Fine-Grained Till		Groundwater Strike (mbgl)	Infrastructure Element Tested
	From (mbgl)	To (mbgl)	From (mbgl)	To (mbgl)	From (mbgl)	To (mbgl)	From (mbgl)	To (mbgl)		
PTP-06			0.00 [A]	0.60 [A]	0.60	1.20	1.20	3.30 [Note 1]		T06
PTP-07					0.00	1.00	1.00	4.20 [Note 1]	3.20 & 4.20	T08
PTP-08			0.00 [A]	0.60 [A]			0.60	3.80 [Note 1]	1.50 & 1.80	T09
PTP-09			0.00 [A]	0.90 [A]			0.90	4.00 [Note 1]	1.30 & 2.60	T09
PTP-10	0.00	3.10	3.10 [B]	4.50 [B] [Note 1]					4.50	T10
PTP-11	0.00	0.70	0.70 [B]	3.80 [B]					2.70	Substation A (descoped)
PTP-12			0.00 [A]	2.30 [A] [Note 1]					2.00	Substation A (descoped)
PTP-13							0.00	3.00 [Note 1]	1.80 & 2.30	Substation A (descoped)
PTP-14							0.00	3.00 [Note 1]	1.90	Substation A (descoped)
PTP-15	0.00	0.60					0.60	3.30 [Note 1]	2.10	Substation B
PTP-16			0.00 [A]	1.90 [A]			1.90	3.20	1.90	Substation B
PTP-17							0.00	3.50 [Note 1]	1.70	Substation B
PTP-18			0.00 [A]	1.20 [A]	1.20	2.40	2.40	3.70 [Note 1]	1.80	Substation B
PTP-19	0.00	1.60	1.60 [B]	2.30 [B]			2.30	3.00 [Note 1]	0.70 & 2.30	Substation B
PTP-20			0.00 [A]	1.20 [A]			1.20	4.00 [Note 1]	2.70	Substation B
PTP-21	0.00	1.30	1.30 [B]	2.90 [B]	2.90	3.80			3.20	Substation B
PTP-22			0.00 [A]	1.30 [A]	1.30	3.50 [Note 1]			2.30	Substation B
PTP-23							0.00	3.00 [Note 1]		Black River Crossing (South)

Note 1 – possible boulders/bedrock encountered at base of trial pit.

Key findings from the trail pitting are presented below:

- No evidence of karst features (such as voiding or piping within the superficial deposits) were recorded within the trial pits.
- Peat depth of 3.10m bgl was encountered at turbine T10.
- The most dominant strata type recorded was fine-grained (cohesive) till, which was encountered in 15 no. trial pits.
- Coarse-grained till was encountered in 7 no. trial pits, these deposits were typically underlain by fine-grained till.
- Possible boulders/bedrock was recorded at the base of 16 no. trial pits at depths ranging from 2.30 to 4.00m bgl.

- Groundwater strikes (typically described as seepages) were recorded in 18 no. trial pits at depths ranging from 0.50 to 4.50m bgl. These seepages are likely the result of a perched water table[2].

Table 11-16: Summary of ground conditions within the rotary boreholes

Hole ID	Peat		Soft to firm Clay [A] / Very soft Marl [B]		Medium dense to dense Coarse-Grained Till		Firm to very stiff Fine-Grained Till		Bedrock		Possible karst feature recorded (Y/N)	Element Tested
	From (mbgl)	To (mbgl)	From (mbgl)	To (mbgl)	From (mbgl)	To (mbgl)	From (mbgl)	To (mbgl)	From (mbgl)	To (mbgl)		
PBH-01	0.00	3.50	3.50 [B]	6.50 [B]	6.50	14.60			14.60	18.50	N	T01
PBH-02	0.00	0.20	0.20 [A]	2.00 [A]	2.00	6.50	6.50	10.60	10.60	15.30	N	T02
PBH-03			0.00 [A]	0.90 [A]	0.90	4.10	4.10	10.10	10.10	14.70	N	T03
PBH-03A					0.00	3.50	3.50 Note 1	9.50 Note 1	9.50	16.00	Y	Near T03, investigating potential karst
PBH-04							0.00	5.90	5.90	10.70	N	T04
PBH-05	0.00	5.50	5.50 [B]	6.75 [B]	6.75	8.90			8.90	14.50	N	T05
PBH-06							0.00	12.90	12.90	20.00	N	T06
PBH-07	0.00	3.50	3.50 [B]	7.50 [B]			7.50	8.10	8.10	14.00	N	T07
PBH-08							0.00	14.00	14.00	19.10	N	Near T08 investigating potential karst
PBH-09							0.00	15.50	15.50	21.50	N	Near T08 investigating potential karst
PBH-10							0.00	14.50	14.50	22.00	N	T08
PBH-11							0.00	15.95	15.95	23.00	N	Near T08 investigating potential karst
PBH-12					13.80	14.80	0.00	13.80	14.80	18.50	N	Near T08 investigating potential karst
PBH-13							0.00	13.20	13.20 Note 2	23.00 Note 2	N	T09
PBH-14	0.00	1.00			1.00	3.40	3.40	7.90	7.90	13.00	N	T11 (renamed to T12 post GI) (descoped)
PBH-15	0.00	2.80	2.80 [B]	6.50 [B]	12.30	13.00	6.50	12.30	13.00	17.00	N	T10

[2] A perched water table (or perched aquifer) is an aquifer that occurs above the regional water table. This occurs when there is an impermeable layer of rock or sediment (aquiclude) or relatively impermeable layer (aquitard) above the main water table/aquifer but below the land surface.

Hole ID	Peat		Soft to firm Clay [A] / Very soft Marl [B]		Medium dense to dense Coarse-Grained Till		Firm to very stiff Fine-Grained Till		Bedrock		Possible karst feature recorded (Y/N)	Element Tested
	From (mbgl)	To (mbgl)	From (mbgl)	To (mbgl)	From (mbgl)	To (mbgl)	From (mbgl)	To (mbgl)	From (mbgl)	To (mbgl)		
PBH-16	0.00	5.50			5.50	7.40	7.40	10.50	10.50 Note 3	22.00 Note 3	N	T12 (renamed to T11 post SI)
PBH-17	0.00	3.50	3.50 [B]	11.0 [B]	11.00	12.85			12.85	17.00	N	T13 (descoped)
PBH-18					7.00	8.50	0.00	7.00	8.50 Note 4	20.50 Note 4	Y	Substation A (descoped)
PBH-19			0.00	0.90	0.90	3.50	3.50	6.05	6.05	11.50	N	120m west of Substation
PBH-20	0.00	2.30			2.30	6.10			6.10	12.50	N	Substation
PBH-21	0.00	0.15					0.15	5.20	5.20	10.00	N	Black River Crossing (North)

Note 1 – Loss of flush and reduction in core recovery recorded within the fine-grained till in PBH-03A. Possible void within superficial deposits.
Note 2 – Possible fault rock recorded between 16.60 and 17.00m (0.40m thick) in PBH-13.
Note 3 – Possible fault rock recorded between 14.40 and 16.20m (1.80m thick) in PBH-16.
Note 4 – Possible weathered limestone bedrock / Karst Zone recorded between 8.50 and 14.80m bgl (6.30m thick) in PHB-18.

Table 11-17: Summary of Groundwater Monitoring Findings

BH No.	Elevation (mAOD)	Location	Groundwater Levels (mbgl)											
			30/10/23	28/11/23	19/12/23	30/01/24	27/02/24	20/03/24	17/04/24	29/05/24	25/06/24	30/07/24	27/08/24	24/09/24
PBH01	28.07	T1	0.74	1.02	0.86	1.07	1.04	0.94	1.02	1.46	1.73	1.84	0.96	1.67
PBH02	29.92	T2	1.38	1.84	1.38	1.61	1.57	1.5	1.55	2.38	3.63	2.8	2.19	2.54
PBH03	37.15	T3	3.28	9.02	8.21	6.21	8.56	8.42	8.59	9.77	Note 1	Note 1	Note 1	Note 1
PBH04	33.39	T4	3.92	4.24	3.61	3.92	4.04	4.25	4.16	5.03	Note 1	Note 1	5.54	Note 1
PBH06	30.58	T5	4.1	2.975	2.74	3.03	2.99	2.91	2.97	3.53	4.02	4.45	n/a	3.82
PBH07	37.04	T6	2.56	0.15	0.05	0.1	0.07	0.06	0.08	0.19	0.46	0.59	0.3	0.44
PBH09	30.64	T7	0.1	3.12	2.88	3.14	3.1	3.01	3.05	4.08	4.85	5.35	3.66	4.38
PBH12	37.19	T8	2.76	1.08	0.79	0.99	0.96	0.71	0.91	1.69	3.38	3.17	0.86	2.02
PBH13	37.99	T9	0.67	2.1	1.82	1.82	2.04	1.94	1.96	Note 1	Note 1	4.26	2.56	Note 1
PBH14	34.43	120m east of Black River.	1.5	0.31	Note 1	0.31	0.25	0.13	0.25	0.31	0.66	0.89	0.07	0.55
PBH15	35.37	T10	0	1.27	1.52	0.52	1.57	1.55	1.56	Note 1	Note 1	1.81	1.59	Note 1
PBH16	35.57	T11	1.85	0.25	0.14	0.32	0.25	0.15	0.18	0.46	0.49	0.52	0.02	Note 1
PBH17	30.22	150m SE of Black River.	0	0.32	0.07	0.21	0.2	0.09	0.21	0.41	0.68	0.83	0.26	0.7
PBH18	27.28	Outside RLB.	0	Note 1	0.07	0.24	0.19	0.11	0.18	0.97	Note 1	Note 1	Note 1	1.27
PBH19	29.44	120m west of substation.	0.7	0.81	0.74	0.89	0.83	0.78	0.83	1.22	1.5	1.66	0.75	1.31
PBH20	28.28	Substation.	Artesian	0.04	Artesian	Artesian	Artesian	Artesian	Artesian	Note 2	Note 2	Note 2	Note 2	Note 2
PBH21	25.68	North of Black River.	0.3	0.53	0.36	0.53	0.48	0.44	0.45	0.96	Note 1	1.52	Note 1	Note 1

Note 1 – No access to field due to livestock.

Note 2 – Standpipe cover rusted shut. Could not access.

Key findings from the rotary boreholes are presented below:

- The most dominant soil type recorded was fine-grained (cohesive) till, which was encountered in 18 no. boreholes.
- Bedrock is typically described as medium strong to very strong, thin to medium bedded, dark grey to black, fine grained argillaceous limestone. Fresh to slightly weathered to occasionally moderately weathered. This stratum is dominated by two main joint sets which run sub-horizontally and sub-vertically through the core. These descriptions broadly correspond to the mapped geology and suggest that the limestone encountered within the boreholes belongs to the Ardnasillagh Formation. The only exception to this is within PBH-18, which encountered a thin to medium bedded dark bluish-grey fine grained fossiliferous limestone which is recorded as being slightly to moderately weathered. The lithological description of this unit suggests it does not belong Ardnasillagh Formation but rather a purer limestone such as the Cong Canal Formation. This location was scoped out for infrastructure development (originally considered as a potential substation location).
- The abundance of shaley/argillaceous material within the encountered bedrock suggests low levels of calcium carbonate ($CaCO_3$) within the limestone. This is significant with respect to its susceptibility to karstification. Limestone with a lower percentage of $CaCO_3$ is less prone to dissolution by karst processes and is significantly less likely to host features such as large interconnected sub-surface cavities (i.e. cave systems).
- Possible fault rock [3] was recorded in two boreholes (PBH-13 from 16.60-17.00m bgl and PBH-16 from 14.40-16.20m bgl). According to GSI fault mapping [Ref iv]:
    - **PBH-13** is located approximately 240m southeast of the nearest mapped fault
    - **PBH-16** is located approximately 1.4km southeast of the nearest mapped fault (turbine at this location was subsequently descoped)
- No evidence of karst was recorded within the rotary boreholes with the exception of boreholes PBH-3A and PBH-18:
    - **PBH-3A** – the driller recorded a loss of flush returns between 7.10 and 8.00m bgl within the Quaternary deposits. In addition, the engineers' logs record 17% total core recovery (TCR) between 8.00m and 9.50m bgl. Both loss of flush returns and lack of core recovery indicate the presence of a void within the fine-grained till deposits. It should be noted that borehole PBH-3A was drilled within an existing circular depression, thought to be a doline.
    - **PBH-18** – a 6.30m thick possible weathered limestone / karst zone has been recorded. This is located between 8.50 and 14.80m bgl and directly overlies slightly to moderately weathered limestone. PBH-18 represents one of the substation locations initially under consideration for the Proposed Development, which was subsequently descoped.

[3] a rock that consists of fragments produced by the crushing and grinding which accompany a dislocation and is often found along the fault plane

- Groundwater monitoring wells were installed in 17 no. boreholes (Table 11-17). Readings were taken at monthly intervals over a period of 12 months between October 2023 and September 2024. In general, groundwater levels across the Site are shallow with a mean value of 1.81m bgl. The predominant Quaternary deposits across the Site comprise low permeability fine grained till which attain a minimum, maximum and mean depth of 5.20, 15.95 and 10.79m bgl. This suggests that the groundwater encountered in the monitoring wells lies within a confined aquifer (i.e. the limestone bedrock), which is subject to sub-artesian [4] conditions.
- Artesian groundwater was encountered in borehole PBH-20 (proposed substation). At this location, a slow but continuous flow of water was observed coming out of the top of the installation well (approximately 0.2m above the existing ground level).

11.4.12 Summary of Karst Assessment Findings

A summary of the Site's potential for karst is presented below. The full Karst Assessment Report is presented in Appendix 11-2 and should be read in conjunction with this Chapter.

The Site is entirely underlain by mid-Carboniferous Limestone, predominantly of the Ardnasillagh Formation. However, peripheral areas of the Site are underlain to the north and northwest by the Cong Limestone Formation and Cong Canal Formation respectively. Several potential surface karst features were identified throughout the Site as part of a desktop study. A site reconnaissance was undertaken to ground truth these features. The site reconnaissance also identified potential surface karst features not recorded as part of the desktop study.

To aid in the karst assessment, a combined non-intrusive (ERT survey) and intrusive (boreholes and trial pits) ground investigation was carried out. Findings from the geophysical investigation identified a number of interpreted sub-surface anomalies within the underlying limestone bedrock. The follow-on intrusive ground investigation did not identify karst within the Ardnasillagh Formation. However, potential karst weathering was recorded in borehole PBH-18, which is believed to have tested the limestone of the Cong Canal Formation.

Results from the combined desktop study, site reconnaissance and ground investigations suggest that, with the exception of PBH-18, karst is confined to the overlying Quaternary deposits.

Surface karst features (predominantly collapse dolines) are present throughout the Site. These features are believed to form along unmapped fault lines that create zones of weakened and fractured rock beneath the overlying Quaternary deposits (predominantly Glacial Till). The fault zones allow for piping of the fine-grained portion of the Glacial Till, through fractured rock, resulting in voiding and eventual collapse of the soils overlying the limestone bedrock. The result is a broadly circular bowl-shaped depression of varying widths and depths.

The formation of these collapse dolines is actively occurring across the site with newly forming depression observed during the site reconnaissance. Their formation is due to the washing out of material within the overlying Quaternary deposits through underlying fractured fault rock.

[4] (of water) rising naturally in a well to a height appreciably above that of the surrounding water table but not flowing out of the well

11.4.13 Existing Slope Stability

During the Site walkovers a series of hand-held probes were undertaken to determine the presence/depth of peat and/or soft soils within the Site. From a desktop review of the proposed GCR, most of the route is situated within existing public highway. As such and given the limited extent of lateral and vertical excavations it was not considered a risk was posed to slope stability along the grid connection route.

A summary of the general topography and slopes at the Site are presented below.

11.4.13.1 Topography of the Site

The topography across the Site is defined by a series of ice sculpted broadly north-south trending streamlined mounds (drumlins). Between these drumlins are relatively flat areas of lowland ground, dominated by cut over raised peat deposits. GSI's physiographic mapping describes the site as being within an area of flat to undulating sediments.

Elevations range from approximately 28 to 40m AOD [Ref iii]. In general, the proposed Site can be described as having very gentle to gentle slopes.

Slopes as measured during the walkover survey, at the proposed turbine locations range from 2 to 5°. The slopes at the proposed turbine locations within areas of peat display a slope of 2°.

Slopes at the proposed substation location range from 2 to 4°.

11.4.13.2 Slope Stability Assessment

From a review of the GSI Landslide Susceptibility database, the Project and proposed infrastructure locations are almost exclusively within an area mapped as having a 'Low' landslide susceptibility, with only localised areas classified as having a 'Moderately Low' landslide susceptibility. In addition, desktop review of available aerial photography and site reconnaissance findings did not identify evidence of slope instability and there are no historical records of landslide activity within 5km of the Site on the GSI database. A summary of the GSI landslide susceptibility with respect to the Project is provided in Figure 11.12.

Considering the above, it is therefore considered that the risk of landslide within the Site is negligible.

11.4.13.3 Peat Stability Assessment

Following the Site walkover and given the presence of peat deposits within the Site, a review of the published checklist for peat landslide hazard and risk assessment was carried out. This was undertaken in accordance with the following best practice guidance: Scottish Executive – Peat Landslide Hazard and Risk Assessments (2017).

The potential for a landslide risk is defined in the Scottish Executive "Peat Landslide Hazard and Risk Assessments, Best Practice Guide for Proposed Electricity Generation Developments" (2017) as the following:

- *Peat is present at the development Site in excess of 0.5 m depth, and;*
- *There is evidence of current or historical landslide activity at the Site, or;*
- *Slopes > 2° are present on-Site, or;*
- *The works will impinge on the peat covered areas and cannot be relocated to avoid peat covered areas.*

A peat survey was carried out by an FT Senior Project Engineer (Julian Borlado MSc.) between October and November 2023. Peat depths were taken using a hand held Van Walt peat probe at proposed turbine and associated infrastructure locations. In general, thinner peat layers were encountered on the flanks of the mapped peat deposits, becoming deeper towards the centre of these deposits. The minimum, maximum and mean peat depth recorded out of 169 peat probe locations were 0.0m, 8.0m and 2.29m respectively.

As such and in accordance with the Scottish Executive Best Practice Guide for Proposed Electricity Generation Developments (2017), as the works will impinge on the peat covered areas and cannot be relocated to avoid peat covered areas, and peat depth are in excess of 0.5m bgl, a peat stability assessment was warranted.

A geotechnical assessment has been undertaken using findings from the site walkover surveys and intrusive ground investigations and is presented in Appendix 11-1 – Peat Stability and Geotechnical Assessment Report. Results from the drained and undrained stability analysis are summarised in Table 11-18 and Table 11-19. The analyses returned Factor of Safety Results of >1.3 for all infrastructure elements assessed, indicating the risk of peat landslide is negligible.

Table 11-18: Factor of Safety Results (Undrained Condition)

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T01	532133	754079	2.87	2.55
T02	531396	754501	57.34	16.38
T03	531596	753976	No Peat	
T04	531886	753395	No Peat	
T05	533286	754179	13.49	8.5
T06	533953	754649	No Peat	
T07	534433	754560	3.64	3.14
T08	533733	755199	No Peat	
T09	533408	755568	No Peat	
T10	533136	755861	8.19	6.04
T11	534947	755115	4.68	3.89
Met Mast	531555	753596	No Peat	
Substation	529932	752825	No Peat	
Construction Compound 1 (West)	531869	753881	No Peat	
Construction Compound 2 (East)	538249	755792	No Peat	

Table 11-19: Factor of Safety Results (Drained Condition)

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T01	532133	754079	14.79	14.63
T02	531396	754501	42.02	21.55
T03	531596	753976	No Peat	
T04	531886	753395	No Peat	
T05	533286	754179	17.94	16.63
T06	533953	754649	No Peat	
T07	534433	754560	15.17	14.92
T08	533733	755199	No Peat	
T09	533408	755568	No Peat	
T10	533136	755861	17.76	16.54
T11	534947	755115	10.53	10.24
Met Mast	531555	753596	No Peat	
Substation	529932	752825	No Peat	
Construction Compound 1 (West)	531869	753881	No Peat	
Construction Compound 2 (East)	538249	755792	No Peat	

The results of the peat stability risk assessment for potential peat failure at the main infrastructure elements is presented in Appendix 11-1: Geotechnical & Peat Stability Assessment of the EIAR and summarised in Table 11-20.

The risk rating for each infrastructure element at the Proposed Development is designated Negligible to Low following some mitigation/control measures being implemented. 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.

Details of the required mitigation/control measures can be found in the Geotechnical Risk Register for each infrastructure element (Appendix A to Appendix 11-1: Geotechnical & Peat Stability Assessment).

Table 11-20: Summary of Peat Stability Risk Register

Infrastructure	Pre-Control Measure Implementation Risk Rating	Pre-Control Measure Implementation Risk Rating Category	Notable Control Measures Required	Post-Control Measure Implementation Risk Rating	Post-Control Measure Implementation Risk Rating Category
T01	Low	5 to 10	No	Negligible	1 to 4
T02	Negligible	1 to 4	No	Negligible	1 to 4
T03	N/A – No Peat recorded at location				
T04	N/A – No Peat recorded at location				
T05	Medium	11 to 16	Yes	Low	5 to 10
T06	N/A – No Peat recorded at location				
T07	Low	5 to 10	No	Negligible	1 to 4
T08	N/A – No Peat recorded at location				
T09	N/A – No Peat recorded at location				
T10	Negligible	1 to 4	No	Negligible	1 to 4
T11	Low	5 to 10	No	Negligible	1 to 4
Met Mast	N/A – No Peat recorded at location				
Substation	N/A – No Peat recorded at location				
Construction Compound 1 (West)	N/A – No Peat recorded at location				
Construction Compound 2 (East)	N/A – No Peat recorded at location				

11.4.14 Soil Contamination

There are no known areas of soil contamination on the Site. No evidence of soil contamination was noted during Site walkovers or during the intrusive ground investigation. A review of existing aerial photography and historic ordnance mapping [ref iii] show no indication of potential contamination from historic land use. Mapping indicates that the Site (to include the GCR) all lie within agricultural lands with associated small clusters of agricultural buildings and residential properties. No historic industrial land uses were observed.

The nearest active EPA Licenced Waste Facility is Organic Compost Ltd, Cloonfad (EPA Licence W0159-01), located approximately 19km to the east of the Site (E552753, N768711).

11.5 Characteristics of the Proposed Project

The proposed project will involve the removal of topsoil, peat, overburden and bedrock (where present) for the construction of turbine foundations, hardstands, met mast, substation, temporary construction compounds, river crossing, cable route and access roads.

Aggregate for construction of these access roads and hardstands will be imported to the Site.

Estimated volumes of overburden (topsoil and spoil) and bedrock to be removed are shown in Table 11-20 and Table 11-21 respectively. Excavated soil will be placed in designated spoil deposition areas, be used for reinstatement and landscaping works around the Site, as well as being side cast alongside the access roads.

Settlement ponds (within the wind farm Site) where constructed will be volume neutral, i.e. all material excavated will be used to form side bunds and landscaping around the ponds. There will be no excess material from settlement pond construction. The material will also be reinstated during decommissioning where appropriate.

Table 11-21: Estimated excavation volumes

Infrastructure Element	Typical Dimensions	Peat Volume (m3)	Spoil (non-peat) Volume (m3)	Comment
11 no. Turbines and Hardstands	27m diameter excavation footprint for turbine foundation with 55 x 35m hardstand area.	97,731	39,470	Hardstanding area and foundation footprint
Access Roads	Assumed 5m running surface with 6m wide development footprint.	2,443	19,726	
Temporary Construction Compound 1 (East)	1 no. Hardstanding areas (total area 12,400m^2).	0	13,640	
Temporary Construction Compound 2 (West)	1 no. Hardstanding areas (total area 3,600m^2).	0	3960	
Substation	Total area 14,725m^2	0	9,094	
Met Mast	Total area 900m^2	0	990	
Doline	Surface karst Feature approx. 4 no. 20m diameter.	0	4,147	
Total Volumes		**100,174m^3**	**91,027m^3**	**Total = 191,201m^3 (peat and spoil volume)**

Note 1 – A bulking factor of 15 and 10% has been applied to the excavated peat and non-peat soils respectively. This allows for expected increase in volume upon excavation and to allow for a variation in ground conditions across the Site.
Note 2 – Soil volumes given in this table are indicative and for information purposes only, and subject to detailed estimates.

Table 11-22: Anticipated stone volumes necessary for construction

Infrastructure Element	Typical Dimensions	Stone Volume (m^3)	Average Stone Depth (m)
11 no. Turbines	27m diameter excavation footprint for turbine foundation	3,108	0.50m
11 no. Turbine Hardstands	6,488m2 hardstand area.	131,413	1.00m
Substation	Footprint of 14,725m2.	9,866	1.00m
Access Roads, turning bays and earthworks	Assumed 5m running surface with 6m wide development footprint for the access roads.	47,316	1.00m
Temporary Construction Compound 1 (East)	Footprint of 12,400m2.	15,500	0.30m
Temporary Construction Compound 2 (West)	Footprint of 3,600m2.	4,500	0.30m
Met Mast Foundation and Hardstand	12 x 12m foundation footprint and 40 x 40m hardstanding area (met mast).	1,125	1.0m foundation / 0.3m hardstand area.
Backfill to Dolines where dig and replace is required.	Surface karst Feature approx. 4 no. 20m diameter.	4,712	3.00m
Total Volume		**217,541**	**Fill to be sourced from local aggregate quarries.**

Note 1 – A contingency factor of 25% stone volumes to allow for a variation in ground conditions across the Site.
Note 2 – Stone volumes given in this table are indicative and for information purposes only, and subject to detailed estimates.

11.6 Potential Effects

The potential effects on the underlying soils, geology and hydrogeology at the Site are assessed in the following sections for the activities associated within each phase (Construction, Operation and Decommissioning) for the Project as described in Chapter 2.

The potential impacts are assessed in accordance with the evaluation criteria outlined in Section 11.3. The unmitigated potential impacts are summarised in Table 11-25 and Table 11-26. The proposed mitigation measures are then considered to reduce or eliminate potential impacts.

The importance of the soils, geology and groundwater receptors are summarised in Table 11-22.

Table 11-23: Receptor Importance

Receptors	Activity	Importance	Rational
Geological - Peat deposits/organic soils, glacial till deposits, and bedrock.	Construction, Operational & Decommissioning Phases	Low	Site comprises poorly drained / low fertility soils.
Local quarries (crushed rock and granular aggregate)	Cumulative	Medium	Supply of imported stone to the Site from local quarries. Depleting off-site resources.
Hydrogeological - Regionally Important Bedrock Aquifer – Karstified (Conduit), groundwater wells and springs, and surface water bodies.	All activities	High	Underlying bedrock is a Regionally Important Aquifer.

11.6.1 Do Nothing Impact

If the proposed Wind Farm were not constructed, it is likely that the current land uses will continue for the foreseeable future. The impact on the Soils, Geology and Hydrogeology would remain largely unaltered as a result.

11.6.2 Construction Phase

The following on-Site activities have been identified as the sources of potential impacts on the existing geological and hydrogeological conditions during the construction phase of the Project:

11.6.2.1 Site Clearance

Topsoil and vegetation clearance will be undertaken at the turbine and all ancillary infrastructure locations across the Site. In addition to the permanent infrastructure, 3 no. temporary construction compounds are proposed within the Site (Figure 2.2a-c). These will also require removal of vegetation and topsoil prior to construction.

Permanent felling of approximately 0.54 ha of conifer plantation forestry is required. Felling of 0.40 ha of coniferous forestry is required at the turn off onto the L-6483 from the R332 road to accommodate turbine delivery. An additional 0.14 ha of coniferous forestry will be clear-felled to accommodate the construction of the on-site electrical caballing between the wind farm and 110 kV substation. The proposed areas to be felled are described further in Chapter 2, Description of the Project.

It should be noted that the clear-felling of trees in the State requires a felling licence. The Forest Service of the Department of Agriculture, Food & the Marine is Ireland's national forest authority and is responsible for all forest licensing which is governed by the Forestry Act 2014 as amended and the Forestry Regulations 2017 (S.I. No. 191 of 2017). A felling licence will include the provision of relevant replant lands (afforestation area) to be planted in lieu of the proposed tree felling on the site. The associated afforestation of alternative lands equivalent in area to those lands being permanently clear-felled is also subject to licensing ('afforestation licensing').

It should be noted that the forestry to be felled within the Site and along the TDR were originally planted as commercial crops and will be felled and replanted in the coming years should the project not proceed.

Proposed tree felling will involve the use of heavy felling machinery and exposure of underlying soils to surface water runoff, which could result in soil erosion. This also could lead to an increase in sediment and nutrient concentrations in the surface water run-off which may in turn impact groundwater in the Regionally Important Aquifer – Karstified (conduit) beneath the Site.

The use of plant and machinery during tree felling works will require the storage and use of fuels and oils. Their storage and use present potential for spills and leaks which could contaminate underlying exposed soils and groundwater.

Further assessment of potential impacts to surface water discharges from felling activities are discussed in Chapter 12 Hydrology and Water Quality of the EIAR.

The Magnitude of the impact from these works on the soils and geology receptors is considered to be '**Small Adverse**' in nature. The importance is considered to be '**Low**'. The rating of these potential impacts, prior to mitigation, is considered to be of '**Imperceptible**' significance. The Impact Classification is negative, permanent, direct and will have likely effects.

The Magnitude of the impact from these works on groundwater receptors is considered to be '**Small Adverse**' in nature. The importance is considered to be '**High**'. The rating of these potential impacts, prior to mitigation, is considered to be of '**Moderate to Slight**' significance. The Impact Classification is negative, medium-term, direct and will have likely effects.

11.6.2.2 Earthworks

The Site will require construction phase earthworks associated with the excavation of turbine bases, removal of overburden deposits for the construction of turbine foundations, temporary site compounds, substation, turbine hard standings, internal access roads and permanent met mast.

As such there is the potential for impact to Soils, Geology and Hydrogeology from the excavation and movement of existing superficial Peat deposits, Glacial Till deposits and bedrock during the construction phase of the Site.

The following earthworks excavations will be required:

- Excavation of Topsoil
- Excavation of Peat deposits
- Excavation of Glacial Till
- Excavation of bedrock at Turbine and Met Mast bases, and at the On-Site Substation is not anticipated. Borehole logs indicate that bedrock was not encountered at depths <5.2m bgl.

- Construction of a 245m long floating road running parallel to the Black (Shrule) River, requiring a double sheet pile wall with reinforced ties.

The following filling and material deposition operations will be required:

- Deposition of surplus topsoil/peat and spoil in berms for reinstatement purposes around turbine bases hardstands, and along access roads. Material placed alongside access roads will generally not exceed 1m in height and will be shaped and sealed to prevent the ingress of water.
- Importation and filling of site won and imported General Fill and Engineering Aggregates.

Based on information derived from the preliminary site investigation, site reconnaissance and karst assessment and taking into consideration wind turbine manufacturer specifications, it is expected that wind turbine foundations shall be piled. A minimum of 3m of peat/spoil shall be removed to allow for construction of the piled turbine bases. The piles shall be constructed will be large diameter reinforced concrete and will range in diameter from 600 to 1200mm. Between 14 and 16 piles will be used at each piled turbine foundation. For the piled foundations it will be necessary to embed the piles directly into the bedrock using rock sockets.

Design options for a 245m long section of floating road along the Black (Shrule) River are discussed in a technical note presented in Appendix 11-3. The technical note examined five potential design solutions; the preferred design solution is a double sheet pile wall with reinforced ties. One of the main advantages of this type of retaining structure is that it significantly reduces the volume of in-situ peat needed to be removed. The impact of this design solution on the Site's ecology is discussed further in Chapter 9 Biodiversity.

The design also gives the option of either allowing or preventing the flow of shallow groundwater through the structure between the peatland to the west of the floating road and the Black River. The decision on the best approach will be made after consultation with the NPWS and will consider the potential hydrogeological and hydrological impacts of both options.

Surplus Topsoil and Glacial Till recovered from excavations will be used for the reinstatement proposed around turbine bases, hardstands, temporary construction compounds and peat deposition areas. All associated quantities have been calculated in Section 11.5 and no excavated material will leave the proposed Wind Farm site.

It is proposed that all on-site materials excavated shall be retained on Site and re-used where suitable as part of the construction phase to minimise the import materials requirements.

Direct impacts to the existing geological regime associated with the construction phase of the Site are:

- Soil compaction may occur due to movement of construction traffic. This will occur particularly within areas of highly compressible soft deposits which are left in-situ during the construction phase. This could lead to an increase in surface water runoff due to reduced infiltration of rainfall and subsequently to an increase in erosion of overburden deposits left in-situ.
- The use of plant and machinery during construction will require the storage and use of fuels and oils. Their storage and use present potential for spills and leaks which could contaminate underlying exposed soils.
- The extraction of rock from off-site quarries will represent a reduction in the availability of an exhaustible resource. Imported crushed rock will be required for material such as Class 1 (general fill) 6F2 (capping), 6N1 (Fill to structures) and 6N2 (fill below structures).

The Magnitude of the impact from these works on the soils and geology receptors is considered to be '**Moderate Adverse**' in nature. The importance is considered to be '**Low**'. The rating of these potential impacts, prior to mitigation, is considered to be of '**Slight**' significance. The Impact Classification is negative, permanent, direct and will have likely effects.

Direct impacts to the existing hydrogeological regime associated with earthworks with respect to the construction phase of the Site are:

- Potential for groundwater pollution from the removal of overburden deposits. The aquifer underlying the Site is classified by the GSI as having 'Low' to 'X – Rock at or near surface or Karst'. However, findings from the site investigation and reconnaissance surveys recorded no outcropping or shallow rock in the vicinity of the proposed turbine, substation, met mast or construction compound locations. It is proposed to remove the overlying soft ground and Glacial Till deposits as outlined in the proposed design.
- The vulnerability of the aquifer to groundwater pollution particularly during construction stage will be increased as overburden is removed thus reducing the level of protection from potential pollution sources.
- Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer. Soil erosion as a result of exposure of soils in open excavations and temporary storage of excavated materials represents a potential impact to the underlying groundwater aquifer.
- Reduction in groundwater levels from dewatering of excavations as required during the construction stage if high groundwater is encountered. Groundwater levels within the boreholes recorded during the 2023 ground investigation (Table 11-17) range from 0.0 (PBH-14, 16, 17, 20) to 9.84 mbgl (PBH-3). All exploratory boreholes encountered groundwater. It is anticipated that any drawdown of groundwater levels would be localised to the proposed areas of excavation. This impact is most likely during the excavation of the turbine and substation foundations. There are no groundwater supply wells recorded in the immediate vicinity of the Site. It is considered that other excavations associated with temporary construction compound and grid connection trenches will not extend into the underlying bedrock aquifers. It is possible however that perched groundwater may exist locally within overburden deposits or weathered bedrock. Upon completion of the construction phase, it is considered that groundwater levels will revert to the pre-construction situation when there is no longer a requirement to control groundwater levels.

In relation to groundwater it is worth noting that the overlying glacial till was typically recorded as fine grained and is therefore considered to have a relatively low permeability. In addition, all groundwater well response zones were constructed within the bedrock. It is therefore considered that the groundwater monitoring results presented in Table 11-17 relate groundwater within the underlying bedrock rather than perched groundwater within the overlying superficial deposits.

The Magnitude of the impact from these works on groundwater receptors is considered to be '**Small Adverse'** in nature. The importance is considered to be '**High**'. The rating of these potential impacts, prior to mitigation, is considered to be of '**Moderate to Slight**' significance. The Impact Classification is negative, permanent, direct and will have likely effects.

11.6.2.3 Slope Stability

The Project and proposed infrastructure locations are generally located within areas predominantly mapped as having a 'Low' landslide susceptibility. Results from the site reconnaissance surveys show no evidence of recent or historic landslides. No failures within the underlying till deposits were recorded.

Due to the presence of deep peat on Site and in accordance with guidance in the Scottish Executive – Peat Landslide Hazard and Risk Assessments (2017), a peat stability analysis was undertaken as part of the Peat Stability and Geotechnical Assessment Report (Appendix 11-1). Results from this assessment show no signs of instability within peat deposits across the Site.

Direct impacts to the existing environment associated with potential slope instability and failure include:

- Slope failures have the potential to impact the existing geological conditions from the removal and deposition of landslide/slope failure material and the exposure of underlying overburden deposits and bedrock to an increase in surface water runoff and subsequent increase in erosion. Slope failure also has the potential to have an impact on the safety of construction workers that could be in the vicinity of a landslide/slope failure event, existing infrastructure (roads, access tracks, turbines) and nearby residents / properties.
- The impact of a slope failure could potentially result in the influx of acidic and/or peat laden waters into downgradient surface water features resulting in a decrease in the receiving water's pH values. This may impact groundwater quality in the underlying Locally Important Aquifer and in any groundwater abstractions in the vicinity of a landslide event.

The Magnitude of the impact from these works on the soils and geology receptors is considered to be '**Moderate Adverse**' in nature. The importance is considered to be '**Low**'. The rating of these potential impacts, prior to mitigation, is considered to be of '**Slight**' significance. The Impact Classification is negative, short term, direct and will have unlikely effects.

The Magnitude of the impact from these works on groundwater receptors is considered to be '**Small Adverse**' in nature. The importance is considered to be '**High**'. The rating of these potential impacts, prior to mitigation, is considered to be of '**Moderate/Slight**' significance. The Impact Classification is negative, short-term, direct and will have unlikely effects.

11.6.2.4 Internal Access Roads and Hardstands

There will be approximately 9,748m (approx. 3,567m of this to be floated) of new internal access tracks associated with the Site and approximately 1,845m of existing track upgrade.

All access tracks will be approximately 5m wide along straight sections and wider at bends and as required. The tracks will be finished with a well graded aggregate. The drainage system will be installed adjacent to the internal access tracks. Existing drainage infrastructure will be maintained and upgraded where necessary.

The following filling and material deposition operations will be required:

- Deposition of surplus topsoil, peat and Glacial Till deposits in berms for reinstatement purposes around, hardstands, temporary construction compound and substation compound.
- Importation and Filling of imported General Fill and Engineering Aggregates.

It is anticipated that the stone required for the construction of the internal access roads, hardstands, temporary construction compounds and the substation will be imported from quarries in the vicinity.

The likely off-site, source quarries for the supply of imported crushed rock aggregate during the construction phase of the Project are presented in Table 11-23:.

Table 11-24: Nearest Supplier of TII Series 600 Stone Products.

Quarry	Approx. Distance from Site (km)	Products	Rock Type
Mortimer Quarry Ltd, Belclare, Tuam, Co. Galway	7.6 (S)	Crushed Rock (TII Series 600 and 800 materials)	Knockmaa Formation (thick-bedded pure limestone)
McGraths Limestone Cong, Cong Co. Mayo	21 (W)	Crushed Rock (TII Series 600 and 800 materials)	Cong Limestone Formation (thick-bedded pure limestone)

Typically, access track formation will consist of a minimum 500mm hardcore on a geotextile membrane. The likely construction methodology for newly constructed tracks will be as follows:

- The formation will be prepared to receive the geotextile membrane.
- Stone will be placed and compacted in layers to minimum 500mm depth.
- A drainage ditch will be formed, within the excavated width and along the sides of the track.
- Surplus excavated material will be placed along the side of sections of the tracks and dressed to blend in with surrounding landscaping and partially obscure sight of the track.

Direct impacts to the existing geological regime associated with the construction of proposed access tracks and hardstands are:

- Soil compaction may occur due to movement of construction traffic. This will occur particularly within areas of highly compressible soft deposits which are left in-situ during the construction phase. This could lead to an increase in surface water runoff due to reduced infiltration of rainfall and subsequently to an increase in erosion of overburden deposits left in-situ.
- The use of plant and machinery during construction will require the storage and use of fuels and oils. Their storage and use present potential for spills and leaks which could contaminate underlying exposed soils.
- During construction, imported engineering fill and excavated soils will be exposed in excavations and in temporary stockpiles. These soils will be subject to erosion by wind and rain which could deposit silt in streams with an indirect impact on surface water quality.

The Magnitude of the impact from these works on the soils and geology receptors is considered to be '**Moderate Adverse**' in nature. The importance is considered to be '**Low**'. The rating of these potential impacts, prior to mitigation, is considered to be of '**Slight**' significance. The Impact Classification is negative, permanent, direct and will have likely effects.

Direct impacts to the existing hydrogeological regime associated with the construction of proposed access tracks and hardstands are:

- Potential for groundwater pollution from the removal of overburden deposits. It is proposed to remove the overlying soft ground and Glacial Till deposits as outlined in the proposed design.
- The vulnerability of the aquifer to groundwater pollution particularly during construction stage will be increased as overburden is removed thus reducing the level of protection from potential pollution sources.

- Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer. Soil erosion as a result of exposure of soils in open excavations and temporary storage of excavated materials represents a potential impact to the underlying groundwater aquifer.
- Potential for groundwater pollution from the use of cement-based compounds during the construction phase.

The Magnitude of the impact from these works on the groundwater receptors is considered to be '**Small Adverse**' in nature. The importance is considered to be '**High**'. The rating of these potential impacts, prior to mitigation, is considered to be of '**Moderate/Slight**' significance. The Impact Classification is negative, permanent, direct and will have likely effects.

11.6.2.5 Internal Cabling

As outlined in Chapter 2 of this EIAR, electricity generated from wind turbines shall be collected at medium voltage by an internal circuit of buried cables which will follow on-site access tracks. This circuit shall be terminated at a proposed on-site substation. This will provide a connection point between the wind farm and the proposed loop-in grid connection point to the existing Cashla-Dalton 110 kV overhead line.

Connection works will involve the installation of ducting, joint bays, drainage and ancillary infrastructure and the subsequent running of cables within existing agricultural fields to the proposed loop-in grid connection point. For cable trenches crossing public roads, the contractor shall excavate cable trenches and then lay high density polyethylene (HDPE) ducting in the trench in a surround of cement bound material (CBM). Back-filling and reinstatement in public roads will be to a specification to be agreed with the road authority.

A similar construction methodology will apply for cable trenches laid within the Site's access tracks. In this case the cable-ducts will generally be laid when the track is being constructed and will follow the edge of the Site access tracks. The trenches within these locations will generally be backfilled using the excavated material.

Direct impacts to the existing environment associated with the proposed internal cabling and grid connection works include:

- The proposed grid connection, associated excavations and ducting may present a preferential pathway for the movement of groundwater and/or contamination in the subsurface. However, the subsoil is predominantly Glacial Till which has a low to medium permeability.
- The excavations for the grid connection trenches and joint bays can have a direct impact on the exposed soils and rock in the form of increased erosion from surface water ingress.
- Where the material excavated from the proposed grid connection excavations are not suitable for reuse as backfill or deposition on Site, this material shall be disposed of at a facility licenced (subject to environmental testing and classification) to accept this waste type.

The Magnitude of the impact from these works on the soils and geology receptors is considered to be '**Small Adverse'** in nature. The importance is considered to be '**Low**'. The rating of these potential impacts, prior to mitigation, is considered to be of '**Imperceptible**' significance. The Impact Classification is negative, permanent, direct and will have likely effects.

The Magnitude of the impact from these works on the groundwater receptors is considered to be '**Small Adverse**' in nature. The importance is considered to be '**High**'. The rating of these potential impacts, prior to mitigation, is considered to be of '**Moderate/Slight**' significance. The Impact Classification is negative, permanent, direct and will have likely effects.

11.6.2.6 Turbine Delivery Route (TDR)

The proposed turbine delivery route (TDR) will be from Galway Port as described in more detail in Chapter 14 (Traffic and Transportation) of this EIAR.

Accommodation works required along the TDR are presented in Table 11-23 .

Table 11-25: Proposed Accommodation Works along the TDR

TDR Node Reference Number	Location	TDR Report Description
1	Exit from Galway Harbour	Loads will need to travel through the car park where parking should be suspended and the fences removed. Confirmation should be made that the surface is suitable for the proposed load weights. Lighting columns should be removed from the swept path area. Loads will over-sail the right-hand verge of Lough Atalia Road where one lighting column should be removed. Existing utilities to be protected.
2	Lough Atalia Road Railway Overbridge	The bridge clearance is 5.46m and loads should be set on a lower suspension to provide additional clearances to the structure. Recent studies have been completed by the port authority which confirmed that a blade of similar dimensions is able to exit the port via this route.
3	Lough Atalia Road / College Road Junction	Loads will merge onto the R339 northbound by undertaking a contraflow manoeuvre. Loads will over-sail both verges through the section. One traffic signal head should be removed from the right-hand verge and one traffic signal head, one road sign, and two bollards should be removed from the left-hand verge.
4	R339 / R338 Junction	Blade tip will over-sail the left-hand verge on entry where one traffic signal should be removed. Loads will over-sail the exit splitter island where one traffic signal, one crossing signal and pedestrian guardrails should be removed.

TDR Node Reference Number	Location	TDR Report Description
5	R339 / Connolly Avenue Junction	Blade will over-sail the right-hand verge on turning where vegetation should be trimmed. Two lighting columns, two utility poles and one traffic signal should be removed. Third party land is required. Loads will over-sail the inside verge of the turn where one traffic signal and one lighting column should be removed. Loads will over-run and over-sail the right-hand verge on joining Connolly Avenue where a load bearing surface should be laid and one traffic signal should be removed.
6	Connolly Avenue / R336 Junction	Blade will over-sail the left-hand verge on the entry arm of the junction, though no physical mitigation measures will be required. Loads will over-run and over-sail the inside verge of the turn where a load bearing surface should be laid and two lighting columns should be removed. Loads will also over-sail the left-hand verge on joining the R336, though no physical mitigation measures will be required.
7	R336 / N6 Junction	Loads will turn right at the junction to join the N6 eastbound, undertaking a contraflow manoeuvre. The blade will over-sail the left-hand verge on entry where one road sign should be removed and vegetation should be trimmed. Loads will over-sail the inside verge of the turn where one traffic signal head, one lighting column, the pedestrian guardrail and one junction box should be removed. Trees should be cleared.
8	N6 / R865 Junction	The blade will over-sail the pedestrian guardrail and one bollard on the entry splitter island. One over-head traffic signal head, two traffic signal heads and one crossing signal should be removed.
9	N6 / R339 Junction	The blade will over-sail the left-hand verge on entry, though no physical mitigation measures will be required. Loads will over-sail the central reservation on the exit arm where two traffic signal heads, one road sign, the pedestrian guardrail and one bollard should be removed.
10	N6 Coolagh Roundabout	The blade will over-sail the outside verge of the bend where four road signs should be removed. Loads will over-sail the inside verge where four lighting columns and two road signs should be removed.
11	M6 Junction 18 Slip Road	Loads would leave the M6 and join the slip road for the M17. Escorts to ensure that the convoy can safely complete the manoeuvre.

TDR Node Reference Number	Location	TDR Report Description
12	M17 / N83 Roundabout	The loads will overrun and oversail the western edge of the roundabout island where a load bearing surface should be laid.
13	N17 / R332 Junction	The loads will oversail both the inside and the outside of the left bend where six road signs and two lighting columns should be removed. The blade tip will oversail the traffic bollards. Loads will overrun and oversail the approach, exit and roundabout island where load bearing surfaces should be laid and one bollard and six road signs should be removed
14	R332 Kilconly Left Bend	Loads will oversail the verge on the inside of the bend where one road sign should be removed.
15	R332 Right Bend Castlegrove	Loads will continue through the right bend. Loads will oversail the verge on the inside of the right bend. Vegetation should be cleared.
16	R332 / L6483 Junction	Loads will oversail and overrun into third party land on the inside of the left bend where a load bearing surface should be laid and the drainage ditch culverted. Trees and vegetation should be removed and one utility pole, one road sign and one bollard should be removed.
17	L6483 Right Bend	Loads will continue west on the L6483. The road will need to be widened to a minimum of 4.5m along its length to the proposed site entrance. Loads will oversail both verges through the section.

The accommodation works associated with the TDR route will include the localised excavation of existing overburden deposits. The potential impact would be from the exposure of the overburden and underlying bedrock to erosion via surface water ingress during the works.

The Magnitude of the impact from these works is considered to be '**Small Adverse**' in nature. The importance of the soils and geology receptors (peat, subsoils, bedrock) is considered to be '**Low**'. The magnitude of these potential impacts, prior to mitigation, is considered to be of '**Imperceptible**' significance. The impact classification is negative, short term, direct and will have unlikely effects.

The Magnitude of the impact from these works on groundwater receptors is considered to be '**Negligible**' in nature. The importance is considered to be '**High**'. The rating of these potential impacts, prior to mitigation, is considered to be of '**Imperceptible**' significance. The Impact Classification is negative, short term, direct and will have unlikely effects.

Following the identification of the potential direct impacts during the construction phase, as outlined above, mitigation measures to reduce the risk to an acceptable level are discussed in Section 11.7.2 of this Chapter.

11.6.3 Operational Phase Impacts

The potential impacts on soils, geology & hydrogeology from the operation of the Project are outlined below.

11.6.3.1 Potential Direct Impacts

Very few potential direct impacts are envisaged during the operational phase of the Project. These are:

- Some construction traffic may be necessary for maintenance of turbines, hardstands and access tracks which could result in minor accidental leaks or spills of fuel/oil.
- The grid transformer in the Proposed Substation and transformers in each proposed wind turbine will be oil cooled. There is potential for spills / leaks of oils/battery fluids from this equipment resulting in contamination of soils and groundwater.

The Magnitude of the impact from these works on the soils and geology receptors is considered to be '**Small Adverse'** in nature. The importance is considered to be '**Low**'. The rating of these potential impacts, prior to mitigation, is considered to be of '**Imperceptible**' significance. The Impact Classification is negative, short-term, direct and has unlikely effects.

The Magnitude of the impact from these works on the groundwater receptors is considered to be '**Negligible**' in nature. The importance is considered to be '**High**'. The rating of these potential impacts, prior to mitigation, is considered to be of '**Imperceptible**' significance. The Impact Classification is negative, short-term, direct and has unlikely effects.

11.6.3.2 Potential 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 listed in Section 11.5.2.4.

The Magnitude of the impact from these works on the soils and geology receptors is considered to be '**Small Adverse'** in nature. The importance is considered to be '**Medium**'. The rating of these potential impacts, prior to mitigation, is considered to be of '**Slight**' significance. The Impact Classification is negative, short-term, direct and has unlikely effects.

The Magnitude of the impact from these works on the groundwater receptors is considered to be '**Negligible**' in nature. The importance is considered to be '**High**'. The rating of these potential impacts, prior to mitigation, is considered to be of '**Imperceptible**' significance. The Impact Classification is negative, short-term, direct and has unlikely effects.

11.6.4 Decommissioning Phase Impacts

The potential impacts associated with decommissioning will be similar to those associated with construction but of reduced magnitude.

During decommissioning, it may be possible to reverse or at least reduce some of the impacts caused during construction by rehabilitating construction areas such as turbine bases and hardstanding areas. This will be done by covering with topsoil to encourage vegetation growth and reduce run-off and sedimentation.

Other impacts such as possible soil compaction and contamination by fuel leaks will remain but will be of reduced magnitude. Nevertheless, as noted in the Scottish Natural Heritage 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.

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*'.

Ducts and cables will be left in the ground, therefore no potential impacts during decommissioning stage are likely to occur.

The Magnitude of the impact from these works on the soils and geology receptors is considered to be '**Small Adverse**' in nature. The importance is considered to be '**Low**'. The rating of these potential impacts, prior to mitigation, is considered to be of '**Imperceptible**' significance. The Impact Classification is negative, short-term, direct and has unlikely effects.

The Magnitude of the impact from these works on the groundwater receptors is considered to be 'Small Adverse' in nature. The importance is considered to be '**High**'. The rating of these potential impacts, prior to mitigation, is considered to be of '**Moderate/Slight**' significance. The Impact Classification is negative, short-term, direct and has unlikely effects.

11.6.5 Cumulative Impacts

As part of the assessment of cumulative impacts, planning searches were undertaken using the following online planning enquiry portals to search for large scale developments within 20km of the Site:

- Galway County Council (GCC);
- Mayo County Council (MCC); and
- An Bord Pleanála (ABP).

Relevant projects, that are likely to have an impact on the Soils, Geology and Hydrogeology, in proximity to the Site, GCR and the enabling TDR works are listed in Table 11-24:

Table 11-26: Potential Cumulative Impact from other Developments

Development (Application No.)	Distance from the Site (km)	Status	Interface
Clonberne Wind Farm (ABP ref. 320089)	18.0	Lodged in July 2024	Groundwater, subsoils and bedrock.
Laurclavagh Wind Farm (ABP ref. 319307)	14.0	Lodged in March 2024	Groundwater, subsoils and bedrock.
Western Hygiene Supplies Ltd. (GCC ref. 212138)	12.5	Granted	Groundwater, subsoils and bedrock.
Omaum River Restoration (GCC ref. 2435)	17.0	Granted	Groundwater, subsoils and bedrock.
Nanny River Restoration (GCC ref. 2460226)	14.0	Granted	Groundwater, subsoils and bedrock.
Lislaughera, Cong, County Mayo. (MCC ref. 2460297)	16.5	Further information	Groundwater, subsoils and bedrock.

Development (Application No.)	Distance from the Site (km)	Status	Interface
Restoration of a gravel pit at Brackloon (GCC ref. 221204)	17.5	Granted	Groundwater, subsoils and bedrock.
Development of a warehouse and infrastructure at Farrannamartin (GCC ref. 2360887)	10.0	Granted	Groundwater, subsoils and bedrock.
Development of a factory extension and substation (GCC ref. 19302)	11.5	Granted	Groundwater, subsoils and bedrock.
Quary development at Cloonascragh (GCC ref. 2260819)	13	Granted	Groundwater, subsoils and bedrock.
Development of a care centre at Glebe (GCC ref. 19920)	11	Granted	Groundwater, subsoils and bedrock.
Development of a concrete batching plant at Cartron (GCC ref. 20419)	7	Granted	Groundwater, subsoils and bedrock.
Development of a quarry at Tuam (GCC ref. 2460013)	19	New Application	Groundwater, subsoils and bedrock.
Commercial and residential development at Oughterard (GCC ref. 2460466)	20	Further information	Groundwater, subsoils and bedrock.

The proposed large-scale developments summarised in Table 11-24 have been considered. If construction for these projects overlap or run concurrently with the development of the Site there may be a supply issue with local quarries providing imported aggregate. For example, Clonberne Wind Farm (ABP ref. 320089) may use Mortimer Quarry Ltd. if insufficient site-won material is available. Mortimer Quarry Ltd. is also a potential source of crushed rock aggregate for the Site.

The magnitude of the impact from these works on the soils and geology receptors is considered to be '**Small Adverse**' in nature. The importance is considered to be '**Medium**'. The rating of this potential cumulative impact is considered to be of '**Slight**' significance. The Impact Classification is negative, short-term, indirect and has unlikely effects.

There is the potential for groundwater pollution from run-off impacting on the groundwater receptor from the development sites. The Magnitude of the impact from these works on the groundwater receptors is considered to be '**Negligible**' in nature. The importance is considered to be '**High**'. The rating of this potential cumulative impact is considered to be of '**Imperceptible**' significance. The Impact Classification is negative, short-term, indirect and has unlikely effects.

11.6.6 Summary of Potential Impacts

A summary of unmitigated potential impacts on soils and geology attributes from the Site is provided in Table 11-25 with the potential impacts on hydrogeological attributes provided in Table 11-26.

Table 11-27: Summary of Potential Unmitigated Impact Significance on Soils & Geology

Activity	Potential Impact	Receptor	Importance	Prior to Mitigation	
				Magnitude	Significance
Construction Phase					
Site Clearance	Exposure of underlying overburden leading to increased erosion. Felling machinery resulting soil compaction of soft deposits and an increase in surface water runoff resulting in increased erosion of exposed soils.	Peat deposits/organic soils, Glacial Till deposits and bedrock.	Low	Small Adverse	Imperceptible
Earthworks associated with the construction of the proposed turbines and associated infrastructure.	Removal of overburden material, open excavations and subsequent exposure underlying overburden and bedrock leading to increased erosion. Construction traffic resulting in soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils. Importation of engineering fill and concrete.	Peat deposits/organic soils Glacial Till deposits and bedrock.	Low	Moderate Adverse	Slight
Earthworks associated with the construction of the proposed turbines and associated infrastructure.	Slope Failure.	Peat deposits/organic soils Glacial Till deposits and bedrock. Site Operatives. Existing Infrastructure and nearby residential areas.	Low	Moderate Adverse	Slight
Construction of Turbine and Substation Foundations	Open excavations, increased runoff causing erosion of underlying overburden and bedrock. Construction traffic resulting in soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils. Importation of engineering fill and concrete products	Peat deposits/organic soils Glacial Till deposits and bedrock. Local quarries.	Low	Moderate Adverse	Slight

Activity	Potential Impact	Receptor	Importance	Prior to Mitigation	
				Magnitude	Significance
Construction of Internal Site Access Roads, Hardstands and Temporary Compound	Open excavations, increased runoff causing erosion of underlying overburden and bedrock. Construction traffic resulting in soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils. Importation of engineering fill	Peat deposits/organic soils Glacial Till deposits and bedrock. Local quarries	Low	Moderate Adverse	Slight
Construction of the Grid Connection and Internal Cabling	Removal of overburden material and exposure underlying Clay and Bedrock to erosion. Construction traffic resulting in soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils. Importation of engineering fill and concrete products Disposal of surplus excavated material to licenced facility	Peat deposits/organic soils Glacial Till deposits and bedrock. Local quarries. Licensed waste facilities	Low	Small Adverse	Imperceptible
Accommodation works along TDR	Removal of overburden material and exposure of underlying superficial deposits and bedrock to erosion. Construction traffic resulting soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils. Importation of engineering fill. Disposal of surplus excavated material to licenced facility.	Peat deposits/organic soils Glacial Till deposits and bedrock. Local quarries. Licenced waste facilities	Low	Small Adverse	Imperceptible
Operational Phase					
Construction traffic for maintenance purposes.	Minor accidental leaks or spills of fuel/oil	Peat deposits/organic soils Glacial Till deposits and bedrock.	Low	Small Adverse	Imperceptible

Activity	Potential Impact	Receptor	Importance	Prior to Mitigation	
				Magnitude	Significance
Operation of substation	Spills, leaks of oils/battery fluids.	Peat deposits/organic soils Glacial Till deposits and bedrock.	Low	Small Adverse	Imperceptible
Maintenance of access tracks	Importation of engineering fill from local quarries	Local quarries	Low	Small Adverse	Imperceptible
Decommissioning Phase					
Removal of Turbines and Hardstands.	Construction traffic resulting soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils.	Peat deposits/organic soils Glacial Till deposits and bedrock.	Low	Small Adverse	Imperceptible
Cumulative Impacts					
Large-scale developments within 20km of the Project Site occurring concurrently with construction of the Site.	Strain on supply and reduction of a finite aggregate resource.	Local quarries (crushed rock and granular aggregate)	Medium	Small Adverse	Slight

Table 11-28: Summary of Potential Unmitigated Impact Significance on Hydrogeology

Activity	Potential Impact	Receptor	Importance	Prior to Mitigation	
				Magnitude	Significance
Construction Phase					
Felling Activities	Exposure of soils and bedrock to surface water runoff. An increase in sediment and nutrient concentrations within the surface water impacting the underlying aquifer. Spills, leaks of fuels and oils from forestry machinery which could contaminate the groundwater.	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Small Adverse	Moderate/Slight
Earthworks associated with the construction of the proposed turbines and associated infrastructure.	Potential for groundwater pollution from the removal of overburden deposits. Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer. Potential for contamination to groundwater from spills/leakages during construction phase earthworks. Reduction in groundwater levels from dewatering of excavation as required during the construction phase.	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Small Adverse	Moderate/Slight
Earthworks associated with the construction of the proposed turbines and associated infrastructure.	Slope Failure.	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Small Adverse	Moderate/Slight

Activity	Potential Impact	Receptor	Importance	Prior to Mitigation	
				Magnitude	Significance
Construction of Turbine and Substation Foundations	Potential for groundwater pollution from the removal of overburden deposits. Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer. Potential for contamination to groundwater from spills/leakages during construction phase earthworks. Reduction in groundwater levels from dewatering of excavation as required during the construction phase.	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Small Adverse	Moderate/Slight
Construction of Internal Site Access Roads, Hardstands and Temporary Compound	Potential for groundwater pollution from the removal of overburden deposits. Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer. Potential for contamination to groundwater from spills/leakages during construction phase earthworks. Potential for ground water pollution from the use of cement-based compounds during the construction phase.	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Small Adverse	Moderate/Slight
Construction of the Grid Connection and Internal Cabling	Potential for ground water pollution from the removal of overburden deposits. Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer. Potential for contamination to groundwater from spills/leakages during construction phase earthworks.	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Small Adverse	Moderate/Slight

Activity	Potential Impact	Receptor	Importance	Prior to Mitigation	
				Magnitude	Significance
Accommodation works along TDR	Potential for ground water pollution from the removal of overburden deposits. Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer. Potential for contamination to groundwater from spills/leakages during construction phase accommodation works.	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Negligible	Imperceptible
Operational Phase					
Construction traffic for maintenance purposes.	Minor accidental leaks or spills of fuel/oil	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Negligible	Imperceptible
Operation of substation	Spills, leaks of oils/battery fluids.	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Negligible	Imperceptible

Activity	Potential Impact	Receptor	Importance	Prior to Mitigation	
				Magnitude	Significance
Decommissioning Phase					
Removal of Turbines and Hardstands.	Potential for groundwater pollution from the disturbance of overburden deposits Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer. Potential for contamination to groundwater from spills/leakages during decommissioning phase earthworks.	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Small Adverse	Moderate/Slight
Cumulative Impacts					
Large-scale developments within 20km of the Project Site occurring concurrently with construction of the Site.	Potential for groundwater pollution from runoff.	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Small Adverse	Moderate/Slight

11.7 Mitigation Measures

The following section outlines appropriate mitigation measures by design and best practice to avoid or reduce the potential impact of the Project. Further details are given in the CEMP which is contained in Appendix 2.1 of Volume III.

11.7.1 Mitigation by Design and Best Practice

With regard to the Project, detailed design and best practice has been implemented as follows:

In order to reduce the impacts on soils, geology, hydrogeology and slope stability, infrastructure has been primarily located within areas of thinner peat/soft ground and lower slope gradients. Extensive work has been undertaken at the preliminary design stage to apply risk avoidance by design which included:

- Peat probing, site walkover surveys intrusive and non-intrusive ground investigations to identify geotechnical constraints (e.g. peat deposits and evidence of historic landslip, karst) likely to adversely affect the design of the Site.
- Relocation and micro-siting of turbines, hardstanding's and access roads based on the site assessments and geotechnical assessments (including a detailed karst assessment) in order to reduce ground risk associated with the Site.
- The works have been designed and checked by geotechnical and civil engineers, who are suitably qualified and experienced in excavation and earthworks design and construction methodologies. Details of experience and competence is included in Chapter 1.

The following will also be implemented:

- The Project has been designed in accordance with best practice methodologies to include (but not limited to) guidance documents from the EPA, IGI and the Scottish Executive.
- Any excavation and construction related works will be subject to a design risk assessment at detailed design stage to determine risk levels for the construction, operation and maintenance and decommissioning of the works. Identified impacts will be minimised by the application of principles of avoidance, prevention and protection. Information on residual impacts will be recorded.
- Given that the works comprise a significant proportion of excavation and earthworks, suitably qualified and experienced geotechnical personnel will be required on Site to supervise the works.
- A detailed method statement for each element of the works will be prepared by the Contractor prior to any element of the work being carried out. These method statements shall be reviewed and approved by a qualified geotechnical engineer.
- The Contract will require programming of the works such that earthworks are not scheduled during severe weather conditions. Where such weather is forecast, suitable measures will be taken to secure the works.

11.7.2 Construction Phase

The following sections outline appropriate mitigation measures to avoid or reduce the potential impact of the Project.

11.7.2.1 Construction Environmental Management Plan

A Construction Environmental Management Plan (CEMP) has been prepared for the proposed project and is included in Volume III, Appendix 2.1. The CEMP defines the work practices, environmental management procedures and management responsibilities relating to the construction phase of the proposed project.

The CEMP sets out the key environmental management measures associated with the construction, operation and decommissioning of the Project, to ensure that during these phases of the development, the environment is protected, and any potential impacts are minimized. The final CEMP will be developed further at the construction stage, on the appointment of the main Contractor to the project to address the requirements of any relevant planning conditions, including any additional mitigation measures that are conditioned and shall be submitted to the planning authority.

Reference to relevant sections of the CEMP with respect to the mitigation of potential impacts to Soils, Geology and Hydrogeology from the proposed project are outlined below.

Site Clearance

As outlined in Section 11.5.2.1, potential impacts to the existing environment from the proposed site clearance works have been identified. The works will lead to the exposure of underlying soils to surface water runoff, which could result in soil erosion. This also could lead to an increase in sediment and nutrient concentrations in the surface water run-off which may in turn impact groundwater in the Regionally Important Aquifer – Karstified (conduit) beneath the Site. It should be noted that the amount of vegetation clearance in relation to commercial forestry is small (0.78 ha) and its impact on the underlying soils, geology and hydrogeology receptors is considered to be negligible.

One of the primary mitigation measures to be employed at the construction phase of the development is the management of silt laden runoff. The potential impact from silt laden surface water runoff from increased erosion of exposed overburden deposits has been assessed, particularly at new and existing drainage locations and where vegetation clearance works are proposed and is included in Chapter 12 – Hydrology and Water Quality.

Details of the proposed Surface Water Management System and associated mitigation measures are summarised in Chapter 12 and are also outlined in the Surface Water Management Plan - Appendix 12.2 of Volume III.

Best practices will be employed in the prevention of silt laden run-off from entering watercourses as discussed in Chapter 12. Best practice measures included in the design include sediment control in the form of swales, interceptor ditches and settlement ponds. Additional standard construction management will be employed such as CIRIA C648 (Control of water pollution from linear construction projects), CIRIA C532 (Control of water pollution from construction sites) and CIRIA C753 (SuDS Manual).

The use of plant and machinery during worksite clearance works and throughout the construction will require the storage and use of fuels and oils, which will only be stored at the construction compound areas in designated bunded areas. Details of oil spill protection measures adjacent to sensitive receptors and emergency spill response procedures are outlined in the CEMP, which is contained in Appendix 2.1 of Volume III.

Storage tanks, used to store fuel for the various items of machinery, will be self-contained and double-walled.

Refuelling will be carried out using fuel trucks, which will bring fuel to the felling plant and equipment. Specific mitigation measures relating to the management of hydrocarbons are as follows:

- Any diesel, fuel or hydraulic oils stored on Site will be stored in bunded storage tanks – the bund area will have a volume of at least 110 % of the volume of such materials stored.
- Appropriately sized plant nappies will be used for all mobile equipment e.g. generators and pumps.
- Emergency drip trays and spill kits will be kept available on Site, to ensure that any spills from vehicles are contained and removed off Site. The emergency response procedure is provided in the CEMP
- Only designated trained operators will be authorised to refuel plant on Site
- Taps, nozzles and valves will be fitted with locking systems.

11.7.2.2 Earthworks

Peat and spoil within the Site will be managed in accordance with the Peat and spoil Management Plan – Appendix 11.4, Volume III.

The Site will be constructed in a phased manner to reduce the potential impacts of the Project on the Soils, Geology and Hydrogeology. Phased construction reduces the amount of open, exposed excavations at any one time. Given that the works comprises a significant proportion of excavation and earthworks, suitably qualified and experienced geotechnical personnel will be required on site to supervise the works.

Details of the proposed methodology and mitigation measures are summarised below and are also outlined in the Peat and spoil Management Plan – Appendix 11.4 of Volume III.

One of the primary mitigation measures employed at the preliminary design stage was the minimisation of volumes of excavated overburden deposits to be exported off-site. All excavated overburden will be retained on-site.

This will include:

- Use of suitable Site won material (crushed rock) as general fill in the construction of access tracks, hardstands and in reinstatement around turbine foundations.
- Surplus overburden will be re-used on Site in the form of landscaping and for reinstatement purposes.

Surplus overburden deposits excavated during the course of the works will be temporarily stored adjacent to the construction phase excavations prior to reuse.

Some temporary stockpiles (not exceeding 2m in height) of material will be necessary adjacent to the excavation areas prior to reinstatement, however no long-term stockpiles of material will remain after construction and no surplus/waste soil or rock will be removed from Site. Temporary stockpiles will be shaped and sealed to prevent the ingress of water from rainfall.

To mitigate against the compaction of soil at the Site, prior to the commencement of any earthworks, the work corridor will be pegged, and machinery will stay within this corridor so that soils outside the work area are not damaged. Excavations will then be carried out from access tracks as they are constructed in order to reduce the compaction of soft ground.

To mitigate against erosion of the exposed soil or rock, all excavations will be constructed and backfilled as quickly as possible. Excavations will stop during or prior to heavy rainfall events (>10mm/hour). To mitigate against possible contamination of the exposed soils, bedrock and groundwater.

Soil excavated from trenches where the internal cabling crosses existing paved roads will be taken to a licenced facility for disposal or recycling where required. If feasible, the upper layers of tarmac and asphalt will be excavated separately to the lower engineered fill layers. The lower engineered fill layers will be reused. The tarmac/asphalt layers will be taken to a licenced facility for disposal or recycling.

All temporary cuts/excavations will be carried out such that they are stable or adequately supported. Gravel fill will be used to provide additional support to temporary cuts/excavations where appropriate. Unstable temporary cuts/excavations will not be left unsupported. Where appropriate and necessary, temporary cuts and excavations will be protected against the ingress of water or erosion.

As dolines are considered to be actively occurring within the site, the design of the wind farm infrastructure has accounted for this potential risk. Foundations for the larger infrastructure elements such as the turbine bases will be piled into the underlying bedrock (see Chapter 2 – Development Description for further detail) and not founded on the overlying Glacial Till deposits as there is potential for unrecorded voids within these soils.

Any surface depressions or suspected doline features within the footprint of the hardstands, construction compounds, met mast foundations or access roads will be removed by excavation of the existing soils and replacement with engineered fill.

The construction of the wind farm main infrastructural elements shall be overseen by either a geotechnical engineer or engineering geologist with experience in identifying surface karst features.

It was initially proposed to construct the substation at the location of PBH-18. However, on the basis of the ground investigation results and karst assessment findings, this location was not deemed suitable due to the potential for karst. An alternative substation location was chosen in an area of low karst risk.

11.7.2.3 Control of Sediment Laden Runoff

The potential impacts from silt laden surface water runoff from increased erosion of exposed overburden deposits has been assessed where earthworks and site clearance are proposed and are described in Chapter 12.

Details of the proposed Surface Water Management System and mitigation measures are summarised in Chapter 12 and are also outlined in the Surface Water Management Plan, in Appendix 12.2 of Volume III.

Specific mitigation measures for the proposed HDD location are summarised in Chapter 12 and include:

- The depth of the bore should be at least 3m below the level of the stream bed so as not to conflict with the watercourse;
- Inert, biodegradable drilling fluid will be used;
- There will be no refuelling within 50m of the watercourse.

Best practices will be employed in the prevention of silt laden run-off from entering watercourses as discussed in Chapter 12.

To minimise the impact to surface water quality, existing drainage (including forestry drainage) will be maintained outside the immediate Site area, and where appropriate, additional Site drainage and settlement ponds will be installed as required prior to construction activities. Silt fencing will be installed in new drainage and monitoring of water quality undertaken during the construction phase.

Final drainage will be constructed following the completion of these activities with silt fencing maintained until such time as a vegetation cover has become established. Chapter 12 of this EIAR discusses surface water issues in more detail.

11.7.2.4 Measures for Spills

Details of oil spill protection measures and emergency spill response procedures are outlined in the CEMP which is contained in Appendix 2.1 of Volume III.

Storage tanks, used to store fuel for the various items of machinery, will be self-contained and double-walled. Refuelling of construction vehicles will be carried out from these tanks or from delivery vehicles at designated refuelling areas. Specific mitigation measures relating to the management of hydrocarbons are as follows:

- Fuels, lubricants and hydraulic fluids for equipment used on the Site shall be carefully handled to avoid spillage.
- Any spillage of fuels, lubricants or hydraulic oils shall be immediately contained, and the contaminated soil removed from the Site and properly disposed of;
- Waste oils and hydraulic fluids shall be collected in leak-proof containers and removed from the Site for disposal or re-cycling; and
- Appropriate spill control equipment, such as oil soakage pads, shall be kept within the construction area and in each item of plant to deal with any accidental spillage.

11.7.2.5 Slope Stability

With regard to slope stability and having regard to the Geotechnical & Peat Stability Assessment – Appendix 11.1, the following detailed design and construction phase best practice will be implemented:

- The works will be designed and supervised by a suitably qualified and experienced geotechnical engineer or engineering geologist, and hydrologist or drainage engineer.
- Drainage infrastructure will be put in place in advance of turbine excavations. Drains will divert surface water and groundwater away from excavations into the proposed surface drainage network. Uncontrolled, direct and concentrated discharges of water onto the ground surface will be avoided.
- Loading or stockpiling on the surface of soft ground will be avoided. Loading or stockpiling on other deposits will not be undertaken without first establishing the adequacy of the ground to support loads by an appropriately qualified geotechnical engineer experienced in construction within upland conditions.
- Turbines located in areas adjacent to peat deposits will incorporate drainage measures such that surface water will be drained away from the peat and will not be allowed to collect adjacent to the peat mass.
- Excavation will be carried out from access roads or hardstanding areas to avoid tracking of construction plant across areas of soft ground/peat.

- A detailed assessment of the stability of conditions at proposed infrastructure locations will be undertaken by a suitably qualified and experienced geotechnical engineer prior to the commencement of all excavations to ensure these activities do not result in or contribute to slope failure.
- Blasting of rock will not be permitted.
- Excavations which could have the potential to undermine the up-slope component of an existing slope will be sufficiently supported to resist lateral slippage and careful attention will be given to the existing drainage.
- Earthworks will not be commenced when heavy or sustained rainfall (status orange or higher) is forecast by Met Eireann. A rainfall gauge will be installed on Site to provide a record of rainfall intensity. An inspection of Site stability and drainage by the Geotechnical Engineer will be carried out on Site when a daily rainfall of over 25mm is recorded on Site, works will only recommence after heavy rain with the prior approval of the Geotechnical Engineer following their inspection.

Further details will be given in the CEMP included in Appendix 2.1 of Volume III of this EIAR.

Prior to the progression of the project to detailed design and to inform the detailed design of the Project, the developer shall also ensure that:

- Confirmatory ground investigation works are undertaken, and these should be tailored to the engineering requirements of the Project.
- The Project will be developed to full detailed design prior to construction to minimise the risk of ground instability.
- Adequate time is afforded to any designers or contractors involved in the execution of the confirmatory ground investigation works; detailed design and construction works.

11.7.2.6 Groundwater

To mitigate against the increased vulnerability of the underlying aquifer to groundwater pollution, all excavations will be constructed and backfilled as quickly as possible. Excavations will stop during or prior to heavy rainfall events (status orange or higher). Details of mitigation measures related to spills and fuel storage are outlined in Chapter 12 - Hydrology and Water Quality.

The dewatering of the foundation excavations is not expected to cause interference with domestic wells in the area, due to large offset distances to known wells, relatively shallow depths of excavation and temporary short-term nature of dewatering, if required. To monitor groundwater during the construction phase groundwater monitoring wells will be installed between areas of deeper excavations and sensitive groundwater receptors, such as areas of shallow bedrock. The wells will be used to monitor groundwater levels and quality to assess any potential impacts during the construction works.

The presence of sub-artesian and artesian groundwater will also have to be considered during the construction phase. Ground investigation findings indicate that the underlying bedrock aquifer is confined. Bedrock depths taken from boreholes range from 5.20 to 17.0m bgl with a mean depth of 11.15m bgl. With the exception of piling, it is not anticipated that excavation depths during the construction phase will be in excess of 5m bgl. It is therefore considered that there will be a sufficient cover of low permeability Quaternary deposits to prevent groundwater within the underlying confined aquifer from entering open excavations. However, should groundwater be encountered, appropriate mitigation shall be employed to include sump-pumps and appropriate siltation prevention measures as per the Surface Water Management Plan – Appendix 12.2.

The GSI Wells and Springs database is not complete; it is therefore probable that there are other wells in addition to those in the GSI databases, but are generally associated with houses, the offset to which from the turbines is a minimum of 750m. Given the limited depth of the excavations during the construction phase and the distance to sensitive groundwater receptors the potential risk posed to groundwater supply wells is considered to be **Imperceptible** following the implementation of mitigation measures discussed above.

Grid connection and internal cable trenches could provide preferential pathways for groundwater and contaminant movement. Trenches will be excavated during dry periods where possible in short sections and left open for minimal periods, to avoid acting as a conduit for surface water flows. To further mitigate the risk of cable trenches becoming preferential pathways, clay plugs (or other low permeability material) will be installed at intervals along the trench to stop/inhibit water movement.

11.7.3 Mitigation Measures during Operation

It is not envisaged that the operation of the Project will result in significant impacts on the geological and hydrogeological regimes within the study area, as there will be no further disturbance of overburden post-construction.

There is a low risk to the geology receptors from compaction of soils due to the movement of HGVs and maintenance vehicles. All site traffic will be limited to access tracks, thereby reducing the area over which compaction of the underlying natural soils can occur.

The main potential impact during the operation phase would be the risk to groundwater from contamination from spills. Storage tanks, used to store fuel for the various items of machinery, will be self-contained and double-walled. Refuelling of maintenance vehicles will be carried out from these tanks or from delivery vehicles. Specific mitigation measures relating to the management of hydrocarbons are as follows:

- Fuels, lubricants and hydraulic fluids for equipment used on the Site shall be carefully handled to avoid spillage.
- Any spillage of fuels, lubricants or hydraulic oils shall be immediately contained, and the contaminated soil removed from the Site and properly disposed of;
- Waste oils and hydraulic fluids shall be collected in leak-proof containers and removed from the Site for disposal or re-cycling; and
- Appropriate spill control equipment, such as oil soakage pads, will be kept within the storage areas and in each item of plant / vehicle to deal with any accidental spillage.

Due to the reduced magnitude of the impacts, no additional mitigation measures are required for the maintenance and operation of the wind farm, over and above those incorporated into the design of the substation transformer, which will be bunded to protect soils against accidental leakages of oils and battery fluids.

11.7.4 Mitigation Measures during Decommissioning

Mitigation measures applied during decommissioning activities will be similar to those applied during construction where relevant.

Some of the impacts associated with reinstatement of the Site (excavation of turbine bases, access tracks etc.) will be avoided by leaving these in place where possible. The Irish Wind Energy Association (IWEA) (11) states that when decommissioning a wind farm "*the concrete bases could be removed, but it may be better to leave them under the ground, as this causes less disturbance*". It is proposed to leave the access tracks in-situ at the decommissioning stage. IWEA also state that "*it may be best*" to leave site tracks in-situ depending on the size and geography of the development.

It is considered that leaving the turbine foundations, access tracks and hardstanding areas in-situ will cause less environmental damage than removing and recycling them. It is proposed to retain these elements of the construction and cover with overburden material (which will have been placed at the sides of roads and hardstanding to turbines) to allow for re-vegetation of the development Site.

However, if removal is deemed to be required by the respective Planning Authority all infrastructure will be removed with mitigation measures similar to those during construction being employed.

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 outlined above.

11.7.5 Cumulative

During the construction of the Project there will be the requirement for the importation of engineered fill from source quarries and potential for disposal of materials unsuitable for reuse at licensed facilities. Should these coincide with demand for imported aggregate for maintenance works at the proposed Clonberne Wind Farm (ABP ref. 320089) Laurclavagh Wind Farm (ABP ref. 319307) there would be a cumulative impact in terms of demands placed on local quarries for aggregate.

There is potential for the construction of both the Site and Clonberne Wind Farm and Laurclavagh Wind Farm to coincide. This may put undue strain on the crushed rock aggregate resources at Mortimer Quarry Ltd and McGraths Limestone Cong during the construction phase. As such, it is considered there will be an '**Slight**' cumulative impact during the construction phase of the development.

No significant, direct negative cumulative impacts are envisaged during the operation or decommissioning phase of the Project. As such no mitigation measures are required with respect to potential cumulative impacts of the Project.

11.8 Residual Impacts

It can be observed from Table 11-28 and Table 11-29 that, following the implementation of mitigation measures, the residual impact significance to the receiving environment would be imperceptible during the construction period and imperceptible during the operation of the Project. Mitigation measures shall be monitored throughout the construction and operational phases.

The Project is not expected to contribute to any significant, negative cumulative impacts of other existing or known developments in the vicinity. Slight residual cumulative impacts from the excavation of fill material from local quarries and disposal of material deemed unsuitable for reuse are considered to result from the Project by placing demand on existing quarries and available void space at licensed facilities during the construction phase of the development.

Table 11-29: Summary of Residual Impact Significance on Geological Receptors

Activity	Potential Impact	Receptor	Importanc	Pre-Mitigation		Post-Mitigation	
				Magnitude	Significance	Magnitude	Significance
Construction Phase							
Site Clearance	Exposure of underlying overburden leading to increased erosion. Felling machinery resulting soil compaction of soft deposits and an increase in surface water runoff resulting in increased erosion of exposed soils.	Peat deposits/organic soils Glacial Till deposits and bedrock.	Low	Small Adverse	Imperceptible	Negligible	Imperceptible
Earthworks associated with the construction of the proposed turbines and associated infrastructure.	Removal of overburden material, open excavations and subsequent exposure underlying overburden and bedrock leading to increased erosion. Construction traffic resulting in soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils. Importation of engineering fill and concrete.	Peat deposits/organic soils Glacial Till deposits and bedrock.	Low	Moderate Adverse	Slight	Small Adverse	Imperceptible
Earthworks associated with the construction of the proposed turbines and associated infrastructure.	Slope Failure.	Peat deposits/organic soils Glacial Till deposits and bedrock. Site Operatives. Existing Infrastructure and nearby residential areas.	Low	Moderate Adverse	Slight	Small Adverse	Imperceptible

Activity	Potential Impact	Receptor	Importanc	Pre-Mitigation		Post-Mitigation	
				Magnitude	Significance	Magnitude	Significance
Construction of Turbine and Substation Foundations	Open excavations, increased runoff causing erosion of underlying overburden and bedrock. Construction traffic resulting in soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils. Importation of engineering fill and concrete products	Peat deposits/organic soils Glacial Till deposits and bedrock. Local quarries.	Low	Moderate Adverse	Slight	Small Adverse	Imperceptible
Construction of Internal Site Access Roads, Hardstands and Temporary Compound	Open excavations, increased runoff causing erosion of underlying overburden and bedrock. Construction traffic resulting in soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils. Importation of engineering fill	Peat deposits/organic soils Glacial Till deposits and bedrock. Local quarries	Low	Moderate Adverse	Slight	Small Adverse	Imperceptible
Construction of the Grid Connection and Internal Cabling	Removal of overburden material and exposure underlying Clay and Bedrock to erosion. Construction traffic resulting in soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils. Importation of engineering fill and concrete products Disposal of surplus excavated material to licenced facility	Peat deposits/organic soils Glacial Till deposits and bedrock. Local quarries. Licenced waste facilities	Low	Small Adverse	Imperceptible	Negligible	Imperceptible

Activity	Potential Impact	Receptor	Importanc	Pre-Mitigation		Post-Mitigation	
				Magnitude	Significance	Magnitude	Significance
Accommodation works along TDR	Removal of overburden material and exposure of underlying superficial deposits and bedrock to erosion. Construction traffic resulting soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils. Importation of engineering fill. Disposal of surplus excavated material to licenced facility.	Peat deposits/organic soils Glacial Till deposits and bedrock. Local quarries. Licenced waste facilities.	Low	Small Adverse	Imperceptible	Negligible	Imperceptible
Operational Phase							
Construction traffic for maintenance purposes.	Minor accidental leaks or spills of fuel/oil	Peat deposits/organic soils Glacial Till deposits and bedrock.	Low	Small Adverse	Imperceptible	Negligible	Imperceptible
Operation of substation	Spills, leaks of oils/battery fluids.	Peat deposits/organic soils Glacial Till deposits and bedrock.	Low	Small Adverse	Imperceptible	Negligible	Imperceptible
Maintenance of access tracks	Importation of engineering fill from local quarries	Local quarries	Low	Small Adverse	Imperceptible	Negligible	Imperceptible

Activity	Potential Impact	Receptor	Importanc	Pre-Mitigation		Post-Mitigation	
				Magnitude	Significance	Magnitude	Significance
Decommissioning Phase							
Removal of Turbines and Hardstands.	Construction traffic resulting soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils.	Peat deposits/organic soils Glacial Till deposits and bedrock.	Low	Small Adverse	Imperceptible	Negligible	Imperceptible
Cumulative Impacts							
Large-scale developments within 20km of the Project Site occurring concurrently with construction of the Site.	Strain on supply and reduction of a finite aggregate resource.	Local quarries (crushed rock and granular aggregate)	Medium	Small Adverse	Slight	Negligible	Imperceptible

Table 11-30: Summary of Residual Impact Significance on Hydrogeological Receptors

Activity	Potential Impact	Receptor	Importance	Prior to Mitigation		Post Mitigation	
				Magnitude	Significance	Magnitude	Significance
Construction Phase							
Felling Activities	Exposure of soils and bedrock to surface water runoff. An increase in sediment and nutrient concentrations within the surface water impacting the underlying aquifer. Spills, leaks of fuels and oils from forestry machinery which could contaminate the groundwater.	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Small Adverse	Moderate/Slight	Negligible	Imperceptible
Earthworks associated with the construction of the proposed turbines and associated infrastructure.	Potential for groundwater pollution from the removal of overburden deposits. Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer. Potential for contamination to groundwater from spills/leakages during construction phase earthworks. Reduction in groundwater levels from dewatering of excavation as required during the construction phase.	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Small Adverse	Moderate/Slight	Negligible	Imperceptible
Earthworks associated with the construction of the proposed turbines and associated infrastructure.	Slope Failure.	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Small Adverse	Moderate/Slight	Negligible	Imperceptible

Activity	Potential Impact	Receptor	Importance	Prior to Mitigation		Post Mitigation	
				Magnitude	Significance	Magnitude	Significance
Construction of Turbine and Substation Foundations	Potential for groundwater pollution from the removal of overburden deposits. Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer. Potential for contamination to groundwater from spills/leakages during construction phase earthworks. Reduction in groundwater levels from dewatering of excavation as required during the construction phase.	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Small Adverse	Moderate/Slight	Negligible	Imperceptible
Construction of Internal Site Access Roads, Hardstands and Temporary Compound	Potential for groundwater pollution from the removal of overburden deposits. Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer. Potential for contamination to groundwater from spills/leakages during construction phase earthworks. Potential for ground water pollution from the use of cement-based compounds during the construction phase.	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Small Adverse	Moderate/Slight	Negligible	Imperceptible

Activity	Potential Impact	Receptor	Importance	Prior to Mitigation		Post Mitigation	
				Magnitude	Significance	Magnitude	Significance
Construction of the Grid Connection and Internal Cabling	Potential for ground water pollution from the removal of overburden deposits. Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer. Potential for contamination to groundwater from spills/leakages during construction phase earthworks.	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Small Adverse	Moderate/Slight	Negligible	Imperceptible
Accommodation works along TDR	Potential for ground water pollution from the removal of overburden deposits. Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer. Potential for contamination to groundwater from spills/leakages during construction phase accommodation works.	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Negligible	Imperceptible	Negligible	Imperceptible
Operational Phase							
Construction traffic for maintenance purposes.	Minor accidental leaks or spills of fuel/oil	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Negligible	Imperceptible	Negligible	Imperceptible

Activity	Potential Impact	Receptor	Importance	Prior to Mitigation		Post Mitigation	
				Magnitude	Significance	Magnitude	Significance
Operation of substation	Spills, leaks of oils/battery fluids.	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Negligible	Imperceptible	Negligible	Imperceptible
Decommissioning Phase							
Removal of Turbines and Hardstands.	Potential for groundwater pollution from the disturbance of overburden deposits Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer. Potential for contamination to groundwater from spills/leakages during decommissioning phase earthworks.	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Small Adverse	Moderate/Slight	Negligible	Imperceptible
Cumulative Impacts							
Large-scale developments within 20km of the Project Site occurring concurrently with construction of the Site.	Potential for groundwater pollution from runoff.	Regionally Important Bedrock Aquifer – Karstified (Conduit). Groundwater Wells and Springs. Surface water bodies.	High	Small Adverse	Moderate/Slight	Negligible	Imperceptible

11.9 Conclusions

A study has been undertaken which has identified the principal impacts of the construction of the proposed project in relation to the Soils, Geology and Hydrogeology.

The assessment of Soils, Geology and Hydrogeology has established a baseline for the receiving environment for the impact assessment. Potential impacts were considered for the construction, operational and decommissioning phases of the Project as well as potential residual and cumulative impacts. Mitigation measures have been proposed where relevant.

The Project site is not a sensitive site in terms of soil, geology and hydrogeology, and poses a low risk for landslide. The occurrence of karst formations occurs exclusively within the overlying superficial deposits in the form of cover collapse dolines. The formation of these dolines are thought to be a direct result of faulting within the underlying bedrock and are not a result of cavities or interconnected conduits within the bedrock. Importantly, the underlying bedrock would not be characterised as karstic limestone but rather an argillaceous shaley limestone with a low susceptibility to karstification.

Findings from the site walkover surveys indicates no visual evidence of historic or contemporary landslides or ground instability at or adjacent to the proposed infrastructure locations.

A number of potential impacts have been identified associated with the excavation of soil and rock on the site. The significance of these potential impacts is assessed as being '**imperceptible**' to '**moderate/slight**' significance prior to mitigation.

The Project is not expected to result in any significant, negative cumulative impacts with other existing, permitted or proposed developments in the vicinity.

With mitigation measures, outlined in Section 11.7, put in place during construction, operational and decommissioning stage the Project will have an '**imperceptible**' impact on the Site's geological and hydrogeological receptors.

11.10 References

i. MCCONNELL, B., MACDERMOT, C.V. AND LONG, C.B. 2002 Geology of South Mayo: A geological description of South Mayo, and adjacent parts of Galway and Roscommon to accompany the Bedrock Geology 1:100,000 Scale Map Series, Sheet 11

ii. Galway County Council. *Galway County Development Plant 2022-2028.* https://consult.galway.ie/en/consultation/adopted-galway-county-development-plan-2022-2028

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iv. GSI. Online Data Viewer. Geological Survey of Ireland. https://dcenr.maps.arcgis.com/apps/MapSeries/index.html?appid=a30af518e87a4c0ab2fbde2aaac3c228

v. EPA. Online Database Viewer. Environmental Protection Agency Ireland. https://gis.epa.ie/EPAMaps/

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