8 SOILS AND GEOLOGY

8.1 INTRODUCTION

This chapter assesses the impacts of the Project (**Figure 1.2**) on soils and geology. The Project refers to all elements of the application for the construction of Letter Wind Farm (**Chapter 2: Project Description**). Where negative effects are predicted, the chapter identifies appropriate mitigation strategies therein. The assessment will consider the potential effects during the following phases of the Project:

- Construction of the Project
- Operation of the Project
- Decommissioning of the Project

Common acronyms used throughout this EIAR can be found in **Appendix 1.2.** This chapter of the EIAR is supported by Figures provided in Volume III and by the following Appendix documents provided in Volume IV of this EIAR:

- **Appendix 8.1-Numerical Analysis of Key Indicators to Determine HAZARD for the Purposes of Peat Slide Risk Evaluation**
- **Appendix 8.2-Analytical Analysis**
- **Appendix 8.3-Peat Probing Data**
- **Appendix 8.4 (a)-Vane Data**
- **Appendix 8.4 (b)-Von Post Data**
- **Appendix 8.5-Trial Hole Logs**
- **Appendix 8.6-Trial Pit Photographs**
- **Appendix 8.7-Geotechnical Risk Register**
- **Appendix 8.8-Peat Slide Risk, Preventative Action, Guide for Workers**

A Construction and Environmental Management Plan (CEMP) is appended to the EIAR in **Appendix 2.1**. This document will be developed into a Site-Specific Letter CEMP post consent/pre-construction once a contractor has been appointed and will cover construction of the Project. It will include all of the mitigation recommended within the EIAR. For the purpose of this application, a summary of the mitigation measures is included in **Appendix 17.1**

8.1.1 Assessment Structure

In line with the revised EIA Directive and current EPA guidelines the structure of this chapter will consist of separate considerations of soils and geology effects in the following order:

- Assessment Methodology and Significance Criteria
- Description of baseline conditions at the Site
- Identification and assessment of impacts to soils and geology associated with the Development, during the construction, operational and decommissioning phases of the Development
- Mitigation measures to avoid or reduce the impacts identified
- Identification and assessment of residual impact of the Development considering mitigation measures.
- Identification and assessment of cumulative impacts if and where applicable.

8.1.2 Statement Of Authority

John Whiteford BSc (Hons) Geophys MIOSH MEAGE FGS has more than 20 years of experience in the field of earth sciences, geotechnical engineering, and management. His academic qualifications are a BSc with Honours in Geophysics from Edinburgh University, with memberships of The European Association of Geoscientists and Engineers and The Institute of Safety and Health.

Commencing work with Kirk McClure Morton (Consulting Engineers) in Belfast since then has been engaged in full-time consultancy for the past 15 years and since 1996 trading as Whiteford Geoservices Ltd. The company has a staff of more than 15 professional and technical personnel and has completed in excess 700 contracts for clients within the construction and mineral exploration sectors where they have built up a recognised level of specialist experience, particularly in the field of Wind Energy. Working at home, in Europe and worldwide the company has been involved in more than 80 wind power projects where our services have been sought in relation to foundation design, peat slide risk assessment, geophysics, electrical earthing design and thermal resistivity analysis. Site data collection was assisted by the following members of the project team:

1. Mr Armand Tollas BSc (Hons) Environmental Science – Project Engineer. (15 years' experience).
2. Mr Jaime Stothers – Field Engineer. (8 years' experience).
3. Mr Leon Jain – Assistant Field Engineer. (1 years' experience).

8.1.3 Description of the Proposed Development

Planning Permission is being sought by the Developer for the construction of 4 no. wind turbines, a permanent met mast, installation of battery arrays, an on-site 20kV substation and all ancillary works.

The full description of the development assessed hereunder is contained in Chapter 2 of the EIAR Project Description.

8.1.4 Structure Of This Report

This report contains the following elements:

1. A Study of the Soils and Geology pertaining to the site and surrounding hinterland.
2. An assessment of the risk of peat instability.

This assessment required a phased approach involving preliminary research, site visits, preliminary testing, follow up site investigations, laboratory testing and a detailed analysis of the findings.

Table 8.1: Summary Schedule of Fieldwork

Key Dates	Activity	Turbines	Remarks
February 2021	Peat depth probing / In-situ testing	T1 / T2 / T3 / T4	
May 2021	Peat depth probing / Trial hole excavations	Substations / Access Tracks T1 / T2 / T3 / T4 / Substations	
January 2023	Peat depth probing Trial Hole excavations	Adjustment Access Track Network and Compound. Assessment of proposed Borrow Pit	
May 2023	Additional Peat Probing	Additional probing at Battery Storage, Temporary Compound and T2	
July 2023	Trial hole excavation	Relocation of T2	TP2A, TP2B & TP2C
August 2023	Site Walkover	Assessment of Grid Route	

This report contains the finding of fieldwork undertaken to gather soils and geology data, including that required to determine the risk from peat instability to the surrounding environment. It also details the analytical process undertaken to apportion risk to the various construction elements; namely construction of the turbine bases and new proposed access tracks.

This Chapter 8 – Soils and Geology, together with Peat Stability Risk Assessment (PSRA) is a "stand-alone" document. No data acquired by 3rd parties (at the site) has been used to augment the dataset acquired by Whiteford Geoservices Ltd, which has been used to produce this PSRA report.

Although research has been made into conditions external to this wind farm site, no physical data collected from outside the wind farm planning boundary has been employed for the purpose of determining peat stability risk. Risk to the proposed development lands from natural events originating outside of the development has not been considered.

This assessment solely relates to the determination of the Hazard associated with soils and geology including, specifically peat instability, and the potential for peat slide to occur, as a result of works required during the Construction and Operational Phases of the development.

8.1.5 Relevant Legislation

This chapter is based upon the following guidance:

1. "*Peat Slide Hazard and Risk Assessment – Best Practice Guide for Proposed Electricity Generation Developments*", published as a Second edition April 2017 by the Scottish Executive (referred to as "the Scottish Guidance").
2. Leitrim County Development Plan 2023-2029

8.2 ASSESSMENT METHODOLOGY AND SIGNIFICANCE CRITERIA

8.2.1 Assessment Structure

In line with the revised EIA Directive and current EPA guidelines the structure of this Soils and Geology chapter is as follows:

- Assessment Methodology and Significance Criteria
- Description of baseline conditions at the Site
- Identification and assessment of impacts to soils and geology associated with the Development, during the construction, operational and decommissioning phases of the Development
- Mitigation measures to avoid or reduce the impacts identified
- Identification and assessment of residual impact of the Development considering mitigation measures.
- Identification and assessment of cumulative impacts if and where applicable.

8.2.2 Assessment Methodology

From the desk and field data acquired, the following assessments were undertaken in order to evaluate the stability and type of soils, geology, hydrology and slope aspects of the environment at the proposed development site for Letter Wind Farm.

- Characterisation of the sites topographical, geological, hydrological and geomorphological regime from the data acquired.
- Consideration of ground stability issues as a result of the proposed development, its design and methodology of construction.
- Assessment of the combined data acquired to evaluate any likely impacts on the soils, geology and hydrological aspects of the environment.
- If impacts are identified, consider measures that would mitigate or reduce the identified impact.
- Present and report these findings in a clear and logical format that complies with EIAR reporting requirements.

8.2.3 Relevant Legislation and Guidance

8.2.3.1 Legislation

The EIAR complies with the following legislation:

- Planning and Developments Acts 2010 to 2019 and the Planning and Development Regulations 2001 to 2019
- Directives 2011/92/EU and 2014/52/EU on the assessment of the effects of certain public and private projects on the environment, including Circular Letter PL 1/2017; Implementation of Directive 2014/52/EU on the effects of certain public and private projects on the environment (EIA Directive)
- Planning and Development Act, 2000, as amended
- S.I. No. 296 of 2018: S.I No. 296 of 2018: European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2018 which transposes the provisions of Directive 2014/52/EU into Irish Law
- The Heritage Act 1995, as amended

8.2.3.2 Guidance

- The soils and geology chapter of this EIAR was prepared having regard to relevant guidance contained in the following documents:
- Environmental Protection Agency (2022): Guidelines on the Information to be contained in Environmental Impact Assessment Reports
- Environmental Protection Agency (2003): Advice Notes on Current Practice (in the preparation of Environmental Impact Assessments)

- Environmental Protection Agency (2002): Guidelines on the Information to be contained in Environmental Impact Assessments
- Institute of Geologists Ireland (2013): Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Assessments
- National Road Authority (2009) Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes
- The Scottish Executive (April 2017) Peat Slide Hazard and Risk Assessment – Best Practice Guide for Proposed Electricity Generation Developments, 2nd Edition (referred to as "the Scottish Guidance")
- National Road Authority (2008) Environmental Impact Assessment of National Road Schemes – A Practical Guide
- Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessments (DoHPLG, 2018)
- Guidance on the preparation of the EIA Report (Directive 2011/92/EU as amended by 2014/52/EU), European Union, 2017

8.2.4 Desk Study and Walkover Survey

WGS initially undertook out a desk study assessment of the soils, geology, hydrology and slope aspects of the proposed development site involving the following components:

- Acquire and compile all available maps of the proposed wind farm development.
- Study any geotechnical reporting available within the public domain for the locality (www.gsi.ie *Geological Survey Ireland Spatial Resources*).
- Study and assess the proposed locations of turbines with regard to available data on site topography and slope gradients (www.osi.ie *Ordnance Survey Ireland*).
- Study and assess the proposed locations of turbines with regard to available data on site soils, sub-soils and bedrock geology (www.gsi.ie *Geological Survey Ireland Spatial Resources*).
- Study and assess the proposed locations of turbines relative to aerial photographs.
- Overlay Geological Survey of Ireland (GSI) online data to determine site bedrock geology and the presence of any major faults or other anomalies.
- Use of Geological Survey Ireland (GSI) Quaternary mapping to determine soil classification on the site.
- Review Met Eireann Office meteorological records pertaining to the site.
- Review Water Service of Ireland data to identify water supply sources in the vicinity of the wind farm.
- Conduct peat slide risk assessment to identify any potential hazards at proposed turbine positions and substation control building.

Following completion of the desk study, a preliminary scoping assessment was carried out as follows:

- A site visit and walkover assessment of the main wind farm infrastructure and grid connection route.
- Determination of soil and peat characteristic at each turbine consisting of probing and trial pitting to determine soil / peat thickness, shear vane testing and an assessment of peat decomposition according to Von Post.
- Reconnaissance to identify sensitive receptors with respect to potential peat, soils landslide.
- Identification of potential pre-failure indicators, failure preconditions and potential triggers within the vicinity of the main infrastructure.
- Preliminary determination of superficial soils at the main infrastructure

The equipment and materials used during this part of the study consisted of:

- AutoCAD (Graphics)
- Surfer 13 (Graphics)
- Microsoft Excel (Database)
- Microsoft Word (Report)
- PDF (Report)
- Thales DGPS System
- Peat probing "depthing" rods

8.2.5 Site Investigations

Following on from the desk study and walkover phase of the study, a campaign of detailed site investigation was undertaken at the Development between February and July 2023. Refer to **Section 8.4** for further details.

These site investigation works consisted of:

- Bedrock and sub-soils outcrop logging and characterisation at proposed turbine locations.
- 7 No. machine excavated trial holes at proposed turbine / substations locations to a maximum depth of 4.00m below existing ground level.
- Peat depth probing at 10m x 10m centres within the footprint of the wind turbine foundation and hardstand. Additional peat depth probing was also carried out at the substation, temporary compound and battery compound. The access track network was probed for peat depth at 25m intervals along the centre-line and 10m either side.

- Further gouge core samples of the peat and superficial soils were recovered along with additional shear strength and peat decomposition data.
- A further 2 No. machine excavated trial holes undertaken at a proposed Borrow Pit location within the development boundary.
- Following a review of environmental constraints, the location of Turbine T2 was amended. A further 3 No. trial holes were undertaken to identify the new position.

8.2.6 Evaluation of Potential Effects

8.2.6.1 Sensitivity

Using information from the desk study, and data from the pre-planning site investigations, an assessment of the importance of the soil and geological environment within the study area, the landscape character of the local environment and the development has been assessed using the criteria set out in **Tables 8.2** and **8.3**.

Table 8.2: Criteria for Rating Site Attributes – Soils and Geology Specific

Importance	Criteria
Extremely High	Attribute has a high quality or value on an international scale. Degree or extent of soil contamination is significant on a international scale. Volume of peat and / or soft organic soils underlying the footprint of the Development is significant on a international scale.
Very High	Attribute has a high quality or value on a national or regional scale. Degree or extent of soil contamination is significant on a national or regional scale. Volume of peat and / or soft organic soils underlying the footprint of the Development is significant on a regional or national scale.
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 soils underlying the footprint of the Development is significant on a local scale.
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 soils underlying the footprint of the Development is moderate on a local scale.
Low	Attribute has a low quality, significance or value on a local scale. Degree or extent of soil contamination is low on a local scale. Volume of peat and / or soft organic soils underlying the footprint of the Development is low on a local scale.

Table 8.3: Criteria for Rating Site Sensitivity – Landscape Character Specific

Importance	Criteria
High Sensitivity	Key characteristics and features which contribute significantly to the distinctiveness and character of the landscape character type. Designated landscapes e.g. National

Importance	Criteria
	Parks, Natural Heritage Areas (NHAs) and Special Areas of Conservation (SACs) and landscapes identified as having low capacity to accommodate proposed form of change, that is; sites with attributes of **Very High Importance**.
Medium Sensitivity	Other characteristics or features of the landscape that contribute to the character of the landscape locally. Locally valued landscapes which are not designated. Landscapes identified as having some tolerance of the proposed change subject to design and mitigation etc., that is; sites with attributes of **Medium to High Importance**.
Low Sensitivity	Landscape characteristics and features that do not make a significant contribution to landscape character or distinctiveness locally, or which are untypical or uncharacteristic of the landscape type. Landscapes identified as being generally tolerant of the proposed change subject to design and mitigation etc, that is; sites with attributes of **Low Importance**.

8.2.6.2 Magnitude

The rating criteria for quantifying the magnitude of impacts is outlined in **Table 8.4**, whilst the rating of potential environmental impacts on the soils and geology environment are based on the matrix presented in **Table 8.5.**

Table 8.4: Describing the Magnitude of Impacts

Magnitude of Impact	Description
Imperceptible	An impact capable of measurement but without noticeable consequences.
Slight	An impact that alters the character of the environment without affecting its sensitivities.
Moderate	An impact that alters the character of the environment in a manner that is consistent with the existing or emerging trends.
Significant	An impact, which by its character, magnitude, duration or intensity alters a sensitive aspect of the environment.
Profound	An impact which obliterates all previous sensitive characteristics.

Table 8.5: Qualifying the Magnitude of Impact on Soil and Geological Attributes

Magnitude of Impact	Description	Example	
Large Adverse	Results in a loss of attribute.	Removal of the majority (>50%) of geological heritage feature.	
Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute.	Removal of part (15-50%) of geological heritage feature.	
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute.	Removal of small part (<15%) of geological heritage feature.	
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.	

Magnitude of Impact	Description	Example	
Moderate Beneficial	Results in moderate improvement of attribute quality.	Moderate enhancement of geological heritage feature.	
Major Beneficial	Results in major improvement of attribute quality.	Major enhancement of geological heritage feature.	

8.2.6.3 Significance Criteria

Table 8.6 rates the significance the magnitude of impacts to the importance of the particular attribute.

Table 8.6: Qualifying Significance Criteria

Importance of Attribute	Magniture of Impact			
	Negligible	Small	Moderate	Large
Extremely High	Imperceptible	Significant	Profound	Profound
Very High	Imperceptible	Significant / Moderate	Profound / Significant	Profound
High	Imperceptible	Moderate / Slight	Significant / Moderate	Severe / Significant
Medium	Imperceptible	Slight	Moderate	Significant
Low	Imperceptible	Imperceptible	Slight	Slight / Moderate

8.2.6.4 Scoping Responses and Consultation

Table 8.7: Scoping Responses and Consultation

Consultee	Type and Date	Summary of Response
Geological Survey Ireland	Email dated 08/02/2023	Scoping response received 08/02/2023 and includes the following comments: • Geoheritage: The audit for Co Leitrim was completed in 2020. Our records show that there are no CGSs in the vicinity of the proposed wind farm. • Groundwater: The Groundwater Data Viewer indicates an aquifer classed as a 'Poor Aquifer – Bedrock which is Generally Unproductive' underlies the proposed wind farm development. The Groundwater Vulnerability map indicates the range of groundwater vulnerabilities within the area covered is variable. We would therefore recommend use of the Groundwater Viewer to identify areas of High to Extreme Vulnerability and 'Rock at or near surface' in your assessments, as any groundwater-surface water interactions that might occur would be greatest in these areas. • Geohazards: The Landslide Susceptibility Map indicates there are some areas of Moderately High to High Landside Susceptibility in the wind farm site boundary area. The viewer indicates there is a Shallow Landslide Event in peat within the wind farm site boundary. • Natural Resources (Minerals/Aggregates): We would recommend use of the Aggregate Potential Mapping viewer to identify areas of High to Very High source aggregate potential within the area. In keeping with a sustainable approach we would recommend use of our data and mapping viewers to identify and ensure that natural resources used in

Consultee	Type and Date	Summary of Response
		the proposed wind farm development are sustainably sourced from properly recognised and licensed facilities, and that consideration of future resource sterilization is considered.

8.3 BASELINE DESCRIPTION

8.3.1 Introduction

The study area relates to lands contained within the construction boundary for the proposed Letter Wind Farm, located approximately 2.9km west of Drumkeeran and 7.3km south of Killarga, Co. Leitrim, situated 3km to the west of the R280 regional carriageway.

8.3.2 Site Description

8.3.2.1 Wind Farm

The Development comprises 4 No. wind turbines in the townlands of Letter, Boleybaun, and Stangaun near Drumkeeran in County Leitrim and resides on lands were surface elevation range from 170m to 260m above sea level (O.D. Malin Head).

The Site consists of lands characterised as blanket bog peatland, turbury, mature forestry and isolated areas of semi-improved grassland.

Preliminary ground investigation data records that peat is underlain by a natural sequence of glacial soils overlying shale rock. Intact bedrock was encountered during the intrusive investigations at proposed Turbine T1, approximately 2.80m below existing ground level.

Groundwater was generally not encountered within exploratory trial hole excavations, in any significant volumes.

Ground slopes range from low to moderate across the wind farm locality and exhibits slope gradients of less than 15^0 to the horizontal within the Development.

A detailed description of the Development is provided in **Chapter 2: Project Description.**

8.3.2.2 Grid Route

The substation at Letter Wind Farm will connect via 20kV underground grid cables laid in ducts within public roads, to the Corderry 110kV Substation, a distance of approximately 6.4km.

8.3.2.3 Turbine Delivery Route

It is proposed that the turbine nacelles, tower hubs and rotor blades will be landed at Killybegs Harbour, Co. Donegal. From there they will be to the N56 some 4.0km northeast of the harbour. The Turbine Delivery Route primarily follows the national road network namely the N56, N15, N4, R285 and R280 before turning left onto the local road L-4282 towards the Wind Farm Site entrance.

8.3.3 Bedrock Geology

Land in the vicinity of the proposed Letter Wind Farm site is predominantly underlain by the Dergvone Shale Formation. The Dergvone Shale Formation contains four main shale facies, arranged in rhythmical order; primarily a dark pyritic, sometimes calcareous shale. In the northern portion of the site the forestry roads have been constructed using this shale rock recovered from existing borrow pits located on site.

Not the uppermost sequence, but underlying the Deryvone Formation, is the Carraun Shale Formation. This formation consists of grey black shale with minor limestone. The Bricklieve Limestone Formation, consisting of bioclastic cherty limestone is recorded in GSI online mapping to be the uppermost sequence approximately 3km west of the site. This formation is potentially present at significant depth below Letter Wind Farm.

Consultation with the Geological Survey of Ireland indicates that there are no active quarries within a 5km radius of the proposed site. Kerrigan Quarries, a limestone quarry supplying a range of crushed stone, sand and chippings, ready-mix concrete and concrete blocks, is located approximately 6km north of the proposed site.

The closest recorded shafts or adits pertain to historic coal mining approximately 4km to the south-west of the site.

8.3.4 Seismic Activity

An assessment has been made with regard to seismic activity. However, any movement anticipated can be expected to be negligible with respect to the Development; with the region remaining one of the least seismically active in Europe with Peak Ground Accelerations of 0.02g[1].

[1] Source: British Geological Survey – Search of Earthquake Database centred on existing Tullynamoyle Wind Farm – search radius of 100km; time period 1st Jan 1000 to 23/12/2022.

The most significant recent and nearest event to the proposed wind farm site recorded by the BGS was a low energy earthquake on 7th April 2019. Details held for this incident were as follows:

yyyy-mm-dd	hh:mm:l.ss	Lat	Long	Depth (km)	ML	Nsta	RMS	Intensity	Locality
20/08/1994	04:39:29.3	54.291	-7.883	0.5	1.5				COUNTY LEITRIM, EIRE
30/11/1994	21:59:51.7	54.346	-8.015	9.4	2.1				NORTH LEITRIM, EIRE
29/08/1999	22:59:29.1	55.038	-7.647	6.1	1.3			2	DONEGAL, IRELAND
07/04/2019	22:58:19.4	54.529	-8.609	10	2.2	7	0.4	3	COUNTY DONEGAL, IRELAND
29/04/2019	20:18:24.6	54.588	-7.968	16.5	1.8	11	0.3	3	COUNTY DONEGAL, IRELAND
19/12/2021	20:25:45.4	54.684	-7.689	12.1	0.6	4	0.2		KILLETER, COUNTY TYRONE
21/12/2021	06:13:38.5	54.689	-7.67	11.2	0.3	3	0.4		KILLETER, COUNTY TYRONE

8.3.5 Soils and Subsoils

Superficial soils, consisting of blanket peat are recorded to mantle the majority of Letter Wind Farm and have been confirmed during fieldwork to be the case at all significant infrastructure. Underlying mineral soils are consistent with tills derived from Namurian Shales recorded in the vicinity, where blanket peat is absent.

8.3.5.1 Soils and Subsoils Encountered During Site Investigation

The following table summarises the ground conditions encountered at the proposed Letter Wind Farm site. Refer to **Appendix 8.5** for the Trial Hole engineering logs detailing the ground conditions encountered at wind turbine generators, substations and potential borrow pit.

Table 8.8A: Summary of Ground Conditions at Turbine and Substation Locations

Stratum Encountered	Depth to Stratum (m)
Very soft, fibrous PEAT.	0.00
Very soft to soft, slightly sandy SILT / CLAY.	1.80
Soft to firm, slightly sandy, slightly gravelly SILT / CLAY with occasional cobbles and boulders.	2.45

Stratum Encountered	Depth to Stratum (m)
Loose to medium dense, clayey, sandy GRAVEL with occasional cobbles and boulders.	3.10

Table 8.8B: Summary of Ground Conditions at Potential Borrow Pit

Stratum Encountered	Depth to Stratum (m)
Very soft, blackish brown, fibrous PEAT with rootlets	0.00
Very soft, grey, slightly sandy, slightly gravelly SILT / CLAY	0.20
Loose, becoming medium dense at base, grey, slightly clayey, slightly sandy GRAVEL	0.65 – 1.00
Extremely weak, narrowly laminated, crystalline, fine grained SLATE, distinctly weathered to locally destructured	2.10 – 2.50

The tables below summarise the findings of the peat probing survey and illustrates the peat thickness across the general survey area.

8.3.5.2 Peat Depth

Table 8.9: Peat Depth Distribution by Category

Peat Depth Range (m)	Peat Depth Distribution from analysed data (%)	No. of Points
– - Very Shallow (0 – 0.5m)	19.0	107
B – Shallow (0.5 – 1.0m)	13.9	68
C – Moderately Shallow – (1.0 – 2.0m)	33.7	159
D – Moderately Deep (2.0 – 3.0m)	19.4	92
E – Deep (3.0 – 4.0m)	7.5	36
F – Extremely Deep (> 4.0m)	6.6	31

The mean peat depth encountered across the proposed Letter Wind Farm site was 1.98m, with a corresponding median value of 1.68m, whilst the peat thickness displayed a range from 0.10m to 5.50m within the proposed development area.

The table below shows the range of peat thickness encountered within an area 100m x 100m around each of the proposed turbine locations as well as specifically within the confines of the proposed construction footprint. The 100m x 100m zone is assessed in detail to provide a full understanding of peat stability in the locality immediately surrounding any proposed structure and to allow for the potential for micro-siting. It is, however, within the construction footprint, that direct disturbance will occur and for this reason the peat characteristics from this zone are employed to calculate the peat slide risk.

Table 8.10: Variation of Peat Depth at proposed Turbine / Structural Locations

ID	Coordinates (ITM)		Peat Depth Range (m)	
	Easting	Northing	Within 100m x 100m Survey Area	Within Construction Footprint (30m radius)
T1	587562	824666	1.20 – 2.60	1.20 – 2.60 (ave. = 1.85m)
T2	587446	824203	1.00 – 2.60	0.40 - – 2.60 (Limited peat data due to tree cover. Worst scenario ave.peat depth of 2.50m used)
T3	587716	823982	1.00 – 3.50	1.00 – 3.50 (ave. 2.25m)
T4	587857	823695	0.20 – 3.00	0.70 – 2.10 (ave. = 1.40m)
Substation 1	588014	823424	0.20 – 0.60	0.20 – 0.60 (ave. = 0.40m)
Substation 2	587445	824510	4.40 – 5.00	4.40 – 5.00 (ave. = 4.70m)
Substation 3	587830	823862	1.00 – 3.00	1.00 – 3.00 (ave. = 2.00m)
Temporary Compound	588006	823459	0.10 – 0.70	0.10 – 0.20 (ave. = 0.10m)
Access Track	N/A	N/A	ave. = 1.98m	1.00 – 3.00 (ave. = 1.98m)
Grid Cable Connection	N/A	N/A	Ave. = 0.70m	N/A

Table 8.11: Details of Estimated Peat and Subsoil Excavation at Wind Farm Infrastructure

Element	Peat	Subsoil	Estimated Total Excavation Volume (m3)
4 no. Hardstanding	29,380	4,589	33,968
4no. Turbine Foundation (25m) Diameter	4,393	3,295	7,689
On-site Access Tracks (5m wide)	3,809	497	4,306
Temporary Construction Compound	150	450	600
Grid Connection	980	4,180	5,160
Battery Storage	0	366	366
Substation	22	16	38
Met Mast	29	295	324
Drainage	1,105	681	1,786
Total	**39,867**	**14,369**	**54,236**

Further details on the volumes of peat and subsoil excavations are presented in **Management Plan 4: Peat and Spoil Management Plan** in **Appendix 2.1**.

Refer to **Figure 8.1** for plot depicting discrete peat depth in the vicinity of each turbine location.

Refer to **Figure 8.2** which illustrates the peat depth at the proposed site of Letter Wind Farm in the form of a contoured plot, gridded at 10m centres using a standard Kriging function.

Figure 8.3 and **Figure 8.4** display the variation in ground surface as contoured plots of surface elevation and ground slope gradient respectively. All plots are provided as overlays on top of the proposed wind farm layout.

8.3.6 Geological Resource Importance

8.3.6.1 Regional Hydrogeology

Aquifer Classification

A review was made with the Geological Survey of Ireland's National Draft Bedrock Aquifer database.

The geology of the site comprises peat soils and superficial drift deposits overlying shales and sandstones. The drift deposits generally consist of impermeable glacial till (boulder clay). Isolated zones of semi-permeable to permeable material may be present in the locality.

Essentially, surface water is anticipated to enter the sub-surface where it is permeable (blanket peat) and will continue vertically downwards until it comes into contact with either an impermeable stratum or the water table. At this point the surface water will migrate in the same direction as the groundwater or according to the gradient of the impermeable stratum.

The National Draft Bedrock Aquifer map indicates that the proposed Letter Wind Farm site is underlain by a poor aquifer bedrock which is generally unproductive; neither locally or regionally important.

Groundwater Vulnerability

The groundwater vulnerability, within the boundaries of the proposed development, can be classified generally as moderate, with areas in the high to extreme classification present in the vicinity of the site.

Wind farm drainage should be designed to adequately cope with the groundwater conditions identified.

Well Database

Consultation with the Geological Survey of Ireland's database indicates that there have been no exploratory wells undertaken within the land surrounding the proposed development area.

8.3.6.2 Local Hydrology

Site Drainage

Across the Site there are a number of drains in place. The majority of these occur along the boundaries between forestry and adjacent to existing access tracks. Most are approximately 0.50m – 1.00m in width and 0.50m – 1.00m in depth. Within the peatland areas drains are more prevalent, although it was not possible to determine the full extent of the site drainage network.

Local Watercourses

The Site and the southern part of the and Grid Connection Route are situated within the Upper Shannon Catchment (ID:26; Area: 604.47km^2). The Northern part of the and Grid Connection Route is situated in the Sligo Bay Catchment (ID:35, Area: 1605.94km^2). The Turbine Delivery Route passes through the Donegal Bay North Catchment (ID:37, Area: 807km^2), the Erne Catchment (ID:36, Area: 3440.55km^2) the Sligo Bay Catchment (ID:35, Area: 1605.94km^2), the Upper Shannon Catchment (ID:26B, Area: 674.13km^2), the Upper Shannon Catchment (ID:26; Area: 604.47km^2) near the red line boundary of the Site.

Surface water runoff associated with the Site drains into two sub catchments and/or three river sub basins, or three no. rivers, 1 no. lough:

- Sub Catchment: Owengar (Leitrim)_SC_10, River Sub Basins: Owengar (Leitrim)_SC_010 and Diffagher_10, Rivers: Owengar (Leirtim)_010, Owengar (Leitrim)_020, Diffagher_010
- Sub Catchment: Shannon Upper_SC_020; River Sub Basin: Shannon Upper_040, Lough: Lough Allen

All surface waters draining from the Site eventually combine into Lough Allen, from which waters eventually flow to the Upper Shannon, Lough Corry, Tap North and Lough Boderg, Lough Forbes, Lough Ree, the Lower Shannon, Lough Derg, and Shannon Estuary through to the mouth of the Shannon and into the South Western Atlantic Seaboard.

Please refer to **Chapter 9: Hydrology and Hydrogeology** for further details on the local and regional hydrology.

8.3.7 Features Of Geological or Geotechnical Significance

8.3.7.1 Palaeo-Karstic Features

Karst topography is defined as "An assemblage of topographic forms resulting from dissolution of the bedrock and consisting primarily of closely spaced sinkholes." [2]

Karst topography can form in regions of exceptionally soluble rocks, including Limestone. The proposed site is not located in an area of limestone bedrock. No karst type features were identified during site visits.

[2] (Skinner and Porter, 1987: p259)

8.3.7.2 Mining or Active Quarry Operations

Review of the GSI Online Database data indicates that there is one active quarry within 10km of the site. The closest quarry is as follows:

1. Kerrigan's Quarry (Limestone – Hard rock) approximately 6km north of Letter Wind Farm.

The closest recorded mine workings to the site are approximately 4km to the south east, in the townland of SELTANNASAGGART, where coal was mined during the last century.

8.3.7.3 Peat Disturbance and Soil Removal

At the site of Letter Wind Farm significant evidence of historic peat cutting was recorded within the southern half of the site, during the walk over survey. Moderate peat depths were recorded within this part of site, ranging from 0m to 2.5m in thickness.

The majority of the northern part of the site is covered by forestry and peat depths in excess of 5m were recorded. No evidence of peat cutting was recorded in the northern part of the site.

8.3.7.4 Historic Landslides and Landslide Susceptibility

GSI records indicate a significant number of historic soils movements within the lands surrounding the proposed development site. Refer to **Figure 8.6** for GSI Mapping identifying both known landslide events and mapped extents of historic areas of soil detachment.

In total 59 No. landslide events have been mapped within a 5km radius of the centre of Letter Wind Farm. 29 No. of these are part of a "GSI Pilot Project" and relate to locations where a scar / soil detachment is visible on the hillside. These do not generally have any date of occurrence, whereas the other landslide events record an approximate date of the landslide along with other details.

One mapped area of soil detachment is recorded within the landholding of Letter Wind Farm. The location of this mapped landslide is approximately 75m north-west of Wind Turbine T4 and is highlighted on the **Figures 8.1** to **8.6** in **Section 8.9**. The following details are recorded by GSI for this feature: -

Table 8.12: Details of GSI Record of Landslide Event in the vicinity of Wind Turbine T4

Visibility	
Source	GSI HAZARD PILOT
Geographic Area	1,773
Centroid X	587745
Centroid Y	823726
Reference Name	
General Shape	
Variation to shape	
Scarp and toe shape	
Status	
Comments	
County	
LS_SHAPE	
Quaternary Type	Blanket Peat
Type Code	SLP
Year	0
Name of Mapper	SC
Type of Landslide	Shallow landslide
Material Type	Peat
Activity	
Aspect ratio	0
Length	0
Width	0
GEOMETRY.AREA	
GEOMETRY.LEN	

No actual event marker is included for this mapped feature, neither is a year of occurrence recorded. The author considers it to be of "natural" occurrence, i.e. triggered by heavy rainfall / surface water flow on thin soils in a steep valley. The actual mechanism behind this event does not appear to have been observed.

GSI landslide susceptibility mapping also indicates that this landslide event is within lands designated as Moderately High landslide susceptibility. Comparison of the wind farm layout to GSI mapping indicates that the vast majority of the wind farm infrastructure coincides with low to moderately low landslide susceptibility. Where the Substation, Compound and access track impinge on moderately high susceptibility the risk of instability is offset by low average peat thickness of < 0.5m.

8.3.7.5 Potential Contamination

Land Contamination

The site has not been subject to the action of industrial activities that would have the potential to contaminate the soils at the site, although it is adjacent to established quarrying operations.

Although no regions of filled ground have, as yet, been identified, there remains potential for a negative impact on natural soils as a result of exposure to unknown historic contamination within such filled ground. Any areas of imported fill material should be assessed by a contaminated land specialist.

Contaminated Watercourses

There is no visual or olfactory evidence to suggest that any potential contaminants have significantly affected existing watercourses at the Letter Wind Farm site. An assessment of baseline surface and groundwater should be included within the contaminated land investigations.

8.3.7.6 Significant Features Observed During Walkover Survey

The following is an appraisal of ground conditions at each of the locations where turbine bases and other infrastructure are being considered, for the proposed Letter Wind Farm development. This section contains data, which was originally collected using a previous layout design, but has subsequently been updated for this published version of the report.

Point – - Turbine T1

Nature of Assessment	Observations
Position (IG)	E587562, N824666
Peat Depth	1.00m to 2.00m
Superficial Soils	Peat overlying very soft to soft sandy, gravelly, SILT / CLAY
Solid Geology	Extremely weak SHALE at 2.80m b.g.l.
Presence of peat landforms, evidence of past ground	N/A

Nature of Assessment	Observations
movement, hydrological features, other watercourses or other features of note	
Topography	Up to 5 degrees to the horizontal.
Sensitive Receptors	Not with buffer for sensitive receptor. The turbine is situated within forestry, removal of which can have a detrimental effect of peat stability.
Utilities: Underground or overhead	None evident in vicinity
Any other observations	None

Point – - Turbine T2

Nature of Assessment	Observations
Position (IG)	E587446, N824203
Peat Depth	0.40m to 2.50m (0.4m at turbine centre)
Superficial Soils	Peat overlying very soft to soft sandy, gravelly, SILT / CLAY, overlying loose to medium dense clayey sandy GRAVEL at 3.60m b.g.l.
Solid Geology	Not recorded
Presence of peat landforms, evidence of past ground movement, hydrological features, other watercourses or other features of note	N/A
Topography	Up to 5 degrees to the horizontal,
Sensitive Receptors	The proposed turbine location is approximately 90m north of a receptor of minor environmental sensitivity – i.e. minor watercourse. The turbine is also situated within forestry, removal of which can have a detrimental effect of peat stability.
Utilities: Underground or overhead	None evident in vicinity
Any other observations	None

Point – - Turbine T3

Nature of Assessment	Observations
Position (IG)	E587716, N823982
Peat Depth	1.00m to 3.00m
Superficial Soils	Peat overlying very soft to soft sandy, gravelly, SILT / CLAY, overlying medium dense clayey sandy GRAVEL at 3.60m b.g.l.
Solid Geology	Not recorded
Presence of peat landforms, evidence of past ground movement, hydrological features, other watercourses or other features of note	N/A
Topography	Up to 10 degrees to the horizontal.
Sensitive Receptors	The proposed turbine location is approximately 100m from a receptor of minor environmental sensitivity
Utilities: Underground or overhead	None evident in vicinity
Any other observations	None

Point – - Turbine T4

Nature of Assessment	Observations
Position (IG)	E587857, N823695
Peat Depth	0.90m to 1.80m
Superficial Soils	Peat overlying very soft to soft sandy, gravelly, SILT / CLAY, overlying loose to medium dense clayey sandy GRAVEL at 3.60m b.g.l.
Solid Geology	Not recorded
Presence of peat landforms, evidence of past ground movement, hydrological features, other watercourses or other features of note	N/A
Topography	Up to 10 degrees to horizontal,

Nature of Assessment	Observations
Sensitive Receptors	Geological survey of Ireland (GSI) documented area of landslide <100m from infrastructure.)
Utilities: Underground or overhead	None evident in vicinity
Any other observations	None

Point 5 – Substation 1

Nature of Assessment	Observations
Position (IG)	E588014, N823424
Peat Depth	0.20m to 0.60m
Superficial Soils	Topsoil and soft clay overlying very soft to soft sandy, gravelly, SILT / CLAY, overlying loose to medium dense clayey sandy GRAVEL at 2.60m b.g.l. Stiff to very stiff, sandy, gravelly SILT / CLAY at 3.00m b.g.l.
Solid Geology	Not recorded
Presence of peat landforms, evidence of past ground movement, hydrological features, other watercourses or other features of note	N/A
Topography	Up to 22.5 degrees to horizontal,
Sensitive Receptors	Proposed substation location is < 50m from a minor public road
Utilities: Underground or overhead	None recorded in vicinity
Any other observations	None

8.3.7.7 Existing Mineral Extraction Activities

Review of the GSI online mapping data indicates that the closest active quarry / pit is approximately 6km north of the site, operated by Kerrigan Quarries. The site walkover confirms this observation, although there is evidence of disused borrow pits in the immediate vicinity to the proposed wind farm.

The closest historic mining activity to the site is confirmed to be approximately 4km to the south west and pertains to coal mining adits, dating back to the last century.

8.3.7.8 Existing Services / Utilities

The walkover survey did not yield any further information regarding the position of additional underground utilities within the site.

8.3.7.9 Grid Cable Connection

8.3.7.9.1 Superficial Soils

Analysis of the grid connection route indicates the presence of the following general soils lithology to be applicable:

- MADE GROUND consisting of bituminous macadam (c. 0.10m to 0.30m) overlying, granular road base materials consisting of dense sands and gravels (c. 0.10m to 0.40m thick)
- Peat, averaging 0.70m in thickness
- Mineral soils consisting of both cohesive and granular glacial till soils.

8.3.7.9.2 Rock Formations

Analysis of the grid connection route indicates that the uppermost rock formations are recorded as:

- Upper Carboniferous Yoredale and Pendleside Series, sandstones and shales
- Upper Carboniferous Millstone Grit and Flagstone Series, mudstone, sandstone, shale and greywacke, occasionally with coal
- Upper and Middle Carboniferous Limestone

Minimal rock excavation is anticipated during the construction of the cable trench. Where rock is encountered the upper 0.5m is considered extremely weak to very weak and rippable with a 21T tracked excavator.

8.3.7.9.3 Cable Trench Construction

Where the grid connection passes along public roads the circuits will be installed within ducts emplaced following excavation of a cable trench, within the carriageway of the public road. Soil arisings generated during the construction of the cable trench will be removed for disposal off site by the contractor. The cable trench excavation will then be reinstated using suitable gravel surrounding the ducts, compacted in thin c 150mm layers and finished with a bound surface according to the appropriate specification for highway reinstatement.

8.3.8 Slope Stability

8.3.8.1 Peat Stability Hazard Assessment

8.3.8.1.1 Cumulative Risk

Peat landslides are caused by a combination of factors, triggering factors and preconditioning factors, and thus the potential for peat landslide to occur can be considered to be a cumulative risk scenario.

For the purpose of this assessment, we place most emphasis on the potential for construction of the new development to trigger a peat landslide, although it is also recognised that conditions could be such that this could have occurred naturally during the lifetime of the project.

Reference is made, in this section, to "*Peat Slide Hazard and Risk Assessment Best Practice Guide for Proposed Electricity General Developments*" 2nd Edition, produced by The Scottish Executive & Halcrow Group Ltd (Apr 2017).

According to the Scottish Guidance, "*A number of preparatory factors also operate in peatlands which act to make peat slopes increasingly susceptible to failure without necessarily initiating a landslide. Triggering factors change the state of the slope from marginally stable to unstable and can be considered as the cause' of failure (DoE, 1996). There are also inherent characteristics (or preconditions) of some peat covered slopes which predispose them to failure.*"

Triggering factors have an immediate or rapid effect on the stability of a peat accumulation, whereas preconditioning factors can influence peat stability over a much longer period. Only some of these factors can be addressed by site characterisation.

8.3.8.1.2 Preparatory Factors

The following are some of the ***Preparatory Factors*** which operate to reduce the stability of peat slopes in the short to medium term (tens to hundreds of years):

- Increase in mass of the peat slope through progressive vertical accumulation (deep peat formation).
- Increase in mass of the peat slope through increases in water content.
- Increase in mass of the peat slope through growth of trees planted within the peat deposit (afforestation).

- Reduction in shear strength of peat or substrate from changes in physical structure caused by progressive creep and vertical fracturing (tension cracking or desiccation cracking), chemical or physical weathering or clay dispersal in the substrate.
- Loss of surface vegetation and associated tensile strength (e.g., by dry-out, burning or pollution induced vegetation change);
- Increase in buoyancy of the peat slope through formation of sub-surface pools or water-filled pipe networks or wetting up of desiccated areas; and
- Afforestation of peat areas, reducing water held in the peat body, and increasing potential for formation.

8.3.8.1.3 Preconditions

Preconditions to slope instability in peatlands often act over longer periods of time. See table below for those applicable at the Letter Wind Farm site.

Table 8.12: Preconditions Applicable to the Site as Determined during Walkover Survey

Precondition	Minimum distance to Development (m)	Remarks
Concentrated drainage network / presence of standing water / area of flush / springs, or rises	0m (within site)	Presence of any of the scenarios mentioned causes elevation in the risk of peat instability. No specific banding apportioned.
Significant slopes	0m (within site)	In vicinity of proposed substation and temporary compound. Within river valleys.
Significant peat thickness	Peat depth of >4m encountered along access track between T1 and T2	Peat thicknesses capable of inducing "bog burst" recorded (c. >2.5m). Significance based on probabilistic factor assigned to banding of depth.
Very highly decomposed Peat	Not at assessed infrastructure	Assessed according to Von Post
Very weak Peat and underlying mineral soils	T1	In general peat shear strength recorded at all turbine locations was low
Potential sonic vibration or ground accelerations	Potential for quarry blasting at nearest active quarry, c. 6km to north	Vibrationally induced energy, e.g. from quarry blasting, earthquakes or piling.

Precondition	Minimum distance to Development (m)	Remarks
	Potential impact from piling to construct foundations for turbines. Seismic activity in Ireland is considered to be extremely low and consequent hazard to development negligible.	Where piling is required bored piles are recommended in place of driven piles to reduce magnitude of propagating seismic energy.

8.3.8.1.4 Triggers

Peat landslides may be ***triggered*** by natural events and human activities. The following ***natural triggers*** have been reported in relation to peat instability.

- Intense rainfall causing development of transient high pore-water pressures along pre-existing or potential rupture surfaces (e.g., at the discontinuity between peat and substrate);
- Snow melt causing development of high pore-water pressures, as above.
- Rapid ground accelerations (earthquakes) causing a decrease in shear strength.
- Unloading of the peat mass by fluvial incision of a peat slope at its toe, reducing support to the upslope material; and
- Loading of the peat mass by landslide debris causing an increase in shear stress.

External environmental triggers such as rainfall and snowmelt cannot be mitigated, though they can be managed (e.g., by limiting construction activities during periods of intense rain). Unloading of the peat mass by excavation, loading by plant and focusing of drainage can be managed by careful design, site specific stability analyses, informed working practices and monitoring.

Triggers associated with human activities include:

- *Alteration to natural drainage patterns focussing drainage and generating high pore-water pressures* along pre-existing or potential rupture surfaces (e.g., at the discontinuity between peat and substrate);
- Rapid ground accelerations (blasting or mechanical vibrations) causing an increase in shear stresses.
- Unloading of the peat mass by cutting of peat at the toe of a slope reducing support to the upslope material (e.g., during track construction);

- Loading of the peat mass by heavy plant, structures or overburden causing an increase in shear stress; and
- Digging and tipping, which may be associated with building, engineering, farming or mining (including subsidence).

8.3.8.1.5 Pre-failure Indicators

The influence of ***Preparatory Factors*** or presence of ***Preconditions*** are often highlighted visually by **Pre-Failure Indicators**, i.e., landforms that results from their effects. Where Preparatory factors and Preconditions can often prove difficult to determine, Pre-failure Indicators are generally evident in the landscape as follows:

- Presence of historical and recent failure scars and debris.
- Presence of features indicative of tension.
- Presence of features indicative of compression.
- Evidence of 'peat creep'.
- Presence of subsurface drainage networks or water bodies.
- Presence of seeps and springs.
- Presence of artificial drains or cuts down to substrate.
- Concentration of surface drainage networks.
- Presence of soft clay with organic staining at the peat and (weathered) bedrock interface; and
- Presence of an iron pan within a mineral substrate.

Thus, in order to assess the stability of peatland sites there is a tendency to rely heavily on Pre-Failure Indicators and certain Preconditions (identified as bold italics text) in order to provide the necessary inputs to the algorithm for the purposes of risk determination.

Assessment of the risk of peat instability requires the assessment of the effect of these cumulative risk factors. In the case of ***triggers,*** we assume the "worst-case" external environmental impact attributable over a period equivalent to twice the "normal lifespan[3]" and assume that the trigger will be one of those highlighted in bold italic text above, most likely cumulative and loading / weather related. We caveat certain potential triggers such as "earthquake", "rapid ground accelerations", "alteration to natural drainage", "*loading of peat mass*", "*digging or dumping*" by the following respective practices:

- Review of historic seismicity, in the context that the Ireland is generally considered very low risk in this respect.

[3] 70 years

- Determining whether quarry blasting occurs in the vicinity and assuming that "*driven*" piles will not be used as part of the construction method.
- The drainage that is recommended is as a default "*non-positive*" primarily so that surface water will not develop significant momentum.
- A competent contractor will undertake the works and understand the risks associated with construction of peatlands and will be capable of maintaining ground stability at all times.
- Where ground conditions are particularly sensitive, we advocate risk mitigation by suggesting the use of low-pressure plant, at least until construction works are complete. All mitigation measures are included within the CEMP (**Appendix 2.1)** and will be transposed into task specific construction method statements.

Table 8.13: Pre-Failure Indicators Applicable to the Site as Determined during Walkover Survey

Pre-Failure Indicator	Minimum distance to Structures / Infrastructure (m)	Remarks
Historic peat cutting	0m (within site)	Extensive areas of historic peat cutting in vicinity of T3 & T4.
Evidence historical peat slide	<100m west of T4 and associated access track	GSI has identified one historical soil movement within the wind farm landholding. Culverting works to remove this hazard and improve stability have been proposed.
Evidence of tension cracking or compression features	0m (within site)	Some evident within wind farm landholding.
Evidence of soil creep	N/A	Evident on steep slopes of river valleys
Cracking / desiccation	N/A	Not observed within proposed construction zone

Thus, a mixture of desktop research, visual assessment, topographic analysis, in-situ testing and laboratory testing forms the basis of determining the Hazard Ranking in respect to Peat Stability.

Following an initial scoping assessment of the above factors / indicators, e.g., following the Desk Study and Walkover Survey a coarse assessment of the hazard ranking for Peat Stability was completed and deployed to assist in the design of the amended development and the production of the optimal Wind Farm layout plan.

Following this preliminary analysis, further fieldwork was initiated to analyse and collect soil samples and more comprehensive information on rock composition and on soil stability within the construction footprint for the associated amended infrastructure layout.

Further analysis was then made of available topographic, hydrological and other geological information, in-situ test data and collected peat depth data for each turbine to determine the potential for peat movement, particularly focusing on exposure / proximity to sensitive receptors from sources of potential triggering activities. This information was further augmented by laboratory testing undertaken on recovered soil samples. From this analysis the following table of residual risks was produced, summarising appropriate mitigation.

8.3.8.1.6 Sensitive Receptors

Analysis of desk study resources and follow up walkover surveys identified the following receptors with the potential to be susceptible to peat instability generated by activity related to the proposed wind farm construction and / or operation.

Table 8.14: Analysis of Sensitive Receptors Applicable to the Site

Receptor	Minimum distance to Development	Exposure Factor Assigned (Using Factor Based Probabilistic Analysis)	Remarks
Peatlands / Bog	0m (within site)	1	-
Agricultural Lands	0m (within site)	1	-
Minor Utilities	0m (within or adjacent to wind farm)	2	Overhead electricity cables near site entrance. Possible water and telecom within road verge
Significant Utilities (Overhead) / Underground	c. 300m to west of site at closest approach	3	Overhead Electricity – 110kV Line.

Receptor	Minimum distance to Development	Exposure Factor Assigned (Using Factor Based Probabilistic Analysis)	Remarks
Designated Minor Watercourses / Water Bodies	0m (within site)	2	Owengar, Turpaun and Boleybaun streams
Designated Major Watercourses / Water Bodies	c. 5km	3	Lough Allen, east of site
Undesignated Watercourses / Drainage	0m (within site)	1	e.g. ditches and man-made watercourses, ephemeral run-off channels
Area of Recorded Environmental Significance	<500m south of site entrance	3	Corry Mountain Bog; Natural Heritage Area (EPA)
Minor Public Roads	0m (within site)	3	At site entrance
Moderately to highly trafficked Public Road	c. 2.2km west	4	R280
Dwellings	<500m from site boundary	4	East of site entrance
Commercial Property	1. <1000m from site boundary 2. <50m from access track, near site entrance	3	1. Garvagh Glebe Wind Farm 2. Agricultural shed
Population centre / Urban area	<2km; population c.220	5	Drumkeeran

8.3.8.1.7 Existing Slopes

A preliminary analysis of OSI topographic data was undertaken to identify the variation in gradient applicable to the existing slopes within the vicinity of the proposed wind farm development.

Both Evans and Warburton (2007) and Boylan et al. (2008) found from their analysis of recorded failures in blanket bog, that these were often recorded for slopes of typically 4 – 8 degrees to the horizontal. However, it is not wise to suggest that the slope angle, as represented within the failed area, is of significance in the hierarchy of preconditioning when it comes to bog failure. In such cases the mechanism of failure is by "bog burst" where the cause is a build-up of excessive hydrostatic pressure in the peat mass as a whole.

In this case, the peat failure is often internal and not due to a detaching of the peat soils from the underlying mineral substrate. This probably causes internal rupturing and detachment to occur below the failure point, coupled with lubrication of the basal plane by water. It is unlikely that the peat – mineral soil friction will have been exceeded in the case of "bog-burst".

Friction at the base of the peat is nonetheless important and thus it is important to consider the existing slope gradient as a potential trigger and a precondition for peat instability.

For this reason, this report advocates a banded factor-based approach to apportioning risk. The following bands are used for this purpose, based on our experience with accidently triggered peat slides on over 100 different wind farm sites.

Table 8.15: Risk Factor Assignment – Existing Slope Gradient

Existing Slope Angle (Measured at Surface of Peat, Angle to Horizontal)	Risk Factor Assigned (Using Factor Based Probabilistic Analysis)	Remarks
0 - ≤5	0	Negligible influence
5 - ≤ 10	1	Low
10 - ≤ 22.5	2	Medium
> 22.5	3	High

8.1.1.1 Summary of Peat Stability Analysis

Table 8.16 Summary of Peat Stability Analysis for Letter Wind Farm

Stability Issue	Turbine Base Locations
Existing Slopes	Slopes encountered at the proposed turbine locations are generally low and display magnitudes of 0 – 5 degrees to the horizontal. However, slopes in the region of 5 – 15 degrees to the horizontal are present in the nearby vicinity at proposed turbines T3 and T4, as well as at the Substation and Compound.

Stability Issue	Turbine Base Locations
Landslip / Peat Slide	Analysis of available topographic information and peat depth data gives the following assessment at the proposed turbine positions. *Excavations* At proposed turbine base locations, the combination of moderate to moderately deep peat thickness, peat strength and low slope gradient has been considered. Consequently, these locations can be classified to have **NEGLIGIBLE to LOW RISK.** It is important to stress that the designation NEGLIGIBLE or LOW RISK does not mean that the risks of constructing within environments where PEAT is present can be ignored. Mitigation has not been recommended where the Hazard Ranking calculated exists at the top of this category. These designations all make the assumption that the general procedures outlined in the ***Recommendations*** set out in the Mitigation Measures section will be adopted and implemented fully during the construction period.

8.3.8.2 Analytical Analysis

The following analysis uses an analytical approach to determine factors of safety to quantify the risks of peat slides and local rotational failure or engulfment of excavations occurring.

The Scottish Guidance suggests the application of Infinite Slope Stability Analysis be employed to gauge the stability of peat on slopes and determination of the relevant Factor of Safety (FoS).

As an additional observation, the Stability of Excavations within peat at the site of approved turbine excavations has also been considered. Refer to **Appendix 8.2** - "Analytical Analysis" for detailed analysis in respect to the above.

Results of these analyses are presented in the tables provided following.

Table 8.17: Analytical assessment of Infinite Slope Stability

Location	Max Slope (°)	z (m)	Undrained Condition		Dry Conditions	
			Cu[4] (kPa)	Factor of Safety Sliding	Cu (kPa)	Factor of Safety Sliding[5]
T1	5	3.40	10[6]	**2.25**[7]	5	1.13
T2	5	2.60	18	4.43	5	1.47
T3	10	3.50	16	1.78	5	0.56
T4	10	2.10	12	2.23	5	0.93
Substation 1	22.5	0.70	12	3.23	5	1.35

Table 8.18: Analytical assessment of Stability of Excavations (Undrained)

Location	Cu (kPa)	Maximum Face Height Considered (m)	Factor of Safety Rotational Failure[8]
T1	10	3.40	**> 1.3**
T2	18	2.60	**> 1.3**
T3	16	3.50	**> 1.3**
T4	12	2.10	**> 1.3**
Substation 1	12	0.70	**> 1.3**

8.3.8.3 Quantitative Analysis

The Scottish Guidance originally proposed an assessment of "Degree of Risk", as described by Clayton in the Institution of Civil Engineers' publication, "Managing Geotechnical Risk" (2001).

DEGREE OF RISK = LIKELIHOOD X EFFECT

This original approach was later modified, and the final formulation conceived: -

HAZARD RANKING = HAZARD X EXPOSURE

The Scottish Guidance provides no definitive approach to determination of elements required to determine HAZARD or EXPOSURE although it does provide guidance. Neither does it provide the relative weighting that should be employed to each individual term to determine its severity.

[4] Minimum in-situ test values used
[5] Dry peat immediately followed by saturation – "worst case scenario"
[6] In-situ testing Undrained undertaken by WGS Ltd. in April / May 22
[7] Minimum FoS highlighted
[8] Undrained conditions only

For this purpose, all consultants derive their own weightings for factors they predict to relate to each HAZARD factor and what is considered an EXPOSURE.

The parameters employed in this particular assessment of risk are given in the following sections.

Hazard: *Likelihood of the peat slide event occurring*
(This relates to the potential for a peat slide to be triggered. Factors considered include the topographic slope, peat thickness, strength of peat, type of peat present and method of construction proposed.)

The tables below give the factors used to establish HAZARD RISK.

Table 8.19: Qualitative assessment of Peat Slide Hazard – Peat Depth

Scale of Risk	*Hazard*
0	*Peat depth less than 0.5m*
+1	*Peat depth between 0.5 - 2.5m*
+2	*Peat depth between 2.5 – 4.0m*
+3	*Peat depth greater than 4.0m*

Table 8.20: Qualitative assessment of Peat Slide Hazard – Slope

Scale of Risk	*Hazard*
0	*Slopes < 5 degrees to the horizontal*
+1	*Slopes between 5 and 10 to the horizontal*
+2	*Slopes between 10 and 22.5 degrees to the horizontal*
+3	*Slopes > 22.5 degrees to the horizontal*

Table 8.21: Qualitative assessment of Peat Slide Hazard – Drainage

Scale of Risk	*Hazard*
0	*Drainage issues not significant*
+1	*Drainage issues significant*

Table 8.22: Qualitative assessment of Peat Slide Hazard – Relic Peat Landforms

Scale of Risk	Hazard
0	*Relic Peat Landforms not present locally*
+1	*Relic Peat Landforms present in vicinity of construction zone*

Table 8.23: Qualitative assessment of Peat Slide Hazard – Piling

Scale of Risk	Hazard
0	*No Sonic/Seismic Activity locally (Piling or Blasting within 500m)*
+1	*Sonic/Seismic Activity locally (Piling or Blasting within 500m)*

Table 8.24: Qualitative assessment of Peat Slide Hazard – Humification

Scale of Risk	Hazard
-0.5	*H0 –H2 Von Post Classification of Peat Degradation* [9] *Where very low rates of degradation are present this tends to correspond to a highly organic silty clay soil and as such these soils exhibit a much-reduced risk of instability.*
0	*H3 –H8 Von Post Classification of Peat Degradation*
+1	*H9 –H10 Von Post Classification of Peat Degradation*

Table 8.25: Qualitative assessment of Peat Slide Hazard – Shear Strength

Scale of Risk	Hazard
-0.5	*>60 kPa Vane Test Classification of Shear Strength at 1.5m depth. Refer to Table 11. Applies where very low rates of decomposition are present and the soils are more akin to highly organic silty clays.*
0	*20-60 kPa Vane Test Classification of Shear Strength at 1.5m depth*
+1	*10-20 kPa Vane Test Classification of Shear Strength at 1.5m depth*
+2	*5-10 kPa Vane Test Classification of Shear Strength at 1.5m depth*
+3	*<5 kPa Vane Test Classification of Shear Strength at 1.5m depth*

[9] Negative factors are only employed where the positive sum of all other HAZARD factors >4

Exposure: Impact that such an event might have at this particular location

The Scottish Guidance assesses exposure in terms of impact, e.g. Very Low Impact to Extremely High Impact, but does not state directly what receptors are of concern. The two receptors identified by the Scottish Guidance are potential for "Financial Impact" and / or "Environmental Impact".

The nature of these EXPOSURE receptors is often debated by consultants. The chosen rationale promoted in this report is as follows:

1. The main purpose of this report is to determine the risk to 3rd parties. That is infrastructure, structures and environmentally sensitive receptors, such as watercourses and protected zones.
2. The section titled "Analytical Analysis", within **Appendix 8.2** of this report contains information about the relative stability of peat soils to determine the optimal methodology for undertaking construction works.

That being the case, the individual EXPOSURES employed, and their relative weighting are summarised in **Table 8.26,** below.

Table 8.26: Qualitative Assessment of Peat Slide Exposure

Scale of Exposure	***Examples of Determining Factors***	***Impact upon total project***
1	*Flat agricultural land or blanket bog within 100m of structure or 50m for roads (i.e. Structure >100m or site tracks >50m from an unspecified environmental receptor, such as an undesignated stream,*	*Very low Impact (< 1%)*
2	*Structure <100m from minor water course or other sensitive landform. <50m in the case of site tracks* *Structure <200m from area of special scientific interest, where there is potential of indirect / downslope impact.*	*Low Impact (1% - 4%)*
3	*Structure or site tracks <100m from receptor of high environmental sensitivity – e.g. major designated water course, or uninhabited buildings or site tracks <200m from receptor of strategic importance, e.g. lightly trafficked minor roads, major public utilities*	*High Impact (4% - 10%)*
4	*Structure <200m from moderately to highly trafficked public road or minor rail lines, area of special scientific interest where there is potential for direct / downslope impact, sensitive buildings, water abstraction etc.*	*Very High Impact (10% - 100%)*

Scale of Exposure	*Examples of Determining Factors*	*Impact upon total project*
5	*Structure <300m proximity to temporarily or permanently inhabited buildings, areas of public congregation, primary rail lines and infrastructure or other sensitive facility.*	*Extremely High Impact (> 100%)*

The precise classification of each EXPOSURE is determined by the consultant in consultation with other members of the team. By assessing each peat slide event against the scales given above, it is possible to assess the hazard ranking by multiplying the hazard and exposure of each event.

This results in a Hazard Ranking value as follows:

HAZARD RANKING = HAZARD x EXPOSURE

The following table outlines the suggested action for the different levels of hazard ranking. The rationale employed to determine the relative severity of Hazard Rankings is based upon the Scottish Guidance.

Table 8.27: Hazard Ranking and Suggested Actions

Hazard Ranking	*Hazard Ranking Level*	*Action Suggested*
≥17	**High**	Avoid project development at these locations
11 – 16	**Medium**	Project should not proceed unless risk can be avoided or mitigated at these locations, without significant environmental impact, in order to reduce risk ranking to Low or Negligible
5 – 10	**Low**	Project may proceed through the use of mitigation techniques applied during construction.
0 – 4	**Negligible**	Project should proceed with monitoring and mitigation of peat landslide hazards at these locations as appropriate

The following table summarise the relative Hazard Ranking of each Turbine to be constructed at the Letter Wind Farm site.

Table 8.28: Hazard Ranking for each Major Structure at Letter Wind Farm

ID	**ITM Coordinates**		**Peat Slide Hazard Ranking**
	Easting	**Northing**	
T1	587562	824666	**3**

ID	ITM Coordinates		Peat Slide Hazard Ranking
	Easting	Northing	
T2	587450	824196	**8**
T3	587716	823982	**8**
T4	587857	823695	**6**
Substation 1	588014	823424	**9**
Substation 2	587445	824510	**4**
Substation 3	587830	823862	**3**

Table 8.28A: Hazard Ranking for each new Section of Access Track at Letter Wind Farm

ID	Peat Slide Hazard Ranking
T1 – T2	**4**
T2 – T3	**6**
T3 – T4	**6**
Substation 1 to T4	**9**

Appraisal of the Hazard Rankings for each proposed turbine location provides the following findings. The following discourse offers an appraisal of ground conditions at each of the structural locations.

1. At the proposed turbine **T1** location, the following assessment of HAZARD has been made:

Item	Description of Key Indicator	Factor
A	Maximum gradient is in range of **0º - 5º** to horizontal.	0
B	Maximum peat thickness at the proposed turbine location is **3.40m**	+2
C	Risk of drainage issues from saturated ground – **N/A**	0
D	Relic peat landforms – **N/A**	0
E	No sonic activity within 500m – Negligible seismic activity.	0
F	Peat degradation H**5 – H7**	0
G	Peat strength 10**kPa – 38kPa**	+1
Sum		**+3**

Preliminary Peat Slide Hazard is 3

Potential Exposure Risk is 1. (Not within sensitive receptor buffer)

This equates to a **Hazard Ranking of 3** and places turbine construction at this location in the **NEGLIGIBLE RISK** Category.

2. At the proposed turbine **T2** location, the following assessment of HAZARD has been made:

Item	Description of Key Indicator	Factor
A	Maximum gradient is in range of **0º - 5º** to horizontal.	0
B	Maximum peat thickness in the vicinity of the proposed turbine location is 2.60m (At the turbine centre peat is locally 0.4m thick)	+2
C	Risk of drainage issues from saturated ground – Yes	+1
D	Relic peat landforms – **N/A**	0
E	No sonic activity within 500m – Negligible seismic activity.	0
F	Peat degradation H**4 – H6**	0
G	Peat strength **18kPa – 26kPa**	+1
Sum		**+4**

Preliminary Peat Slide Hazard is 4

Potential Exposure Risk is 2. (The proposed turbine location is approximately 90m from a receptor of minor environmental sensitivity – i.e. minor watercourse).

This equates to a **Hazard Ranking of 8** and places turbine construction at this location in the **LOW RISK** Category.

3. At the proposed turbine **T3** location, the following assessment of HAZARD has been made:

Item	Description of Key Indicator	Factor
A	Maximum gradient is in range of **5º - 10º** to horizontal.	+1
B	Maximum peat thickness at the proposed turbine location is **3.50m**	+2
C	Risk of drainage issues from saturated ground – **N/A**	0
D	Relic peat landforms – **N/A**	0
E	No sonic activity within 500m – Negligible seismic activity.	0
F	Peat degradation H**6**	0
G	Peat strength **16kPa – 20kPa**	+1
Sum		**+4**

Preliminary Peat Slide Hazard is 4

Potential Exposure Risk is 2. (The proposed turbine location is approximately 100m from a receptor of minor environmental sensitivity).

This equates to a **Hazard Ranking of 8** and places turbine construction at this location in the **LOW RISK** Category.

4. At the proposed turbine **T4** location, the following assessment of HAZARD has been made:

Item	Description of Key Indicator	Factor
A	Maximum gradient is in range of **5º - 10º** to horizontal.	+1
B	Maximum peat thickness at the proposed turbine location is **2.10m**	+1
C	Risk of drainage issues from saturated ground – **N/A**	0
D	Relic peat landforms – **N/A**	0
E	No sonic activity within 500m – Negligible seismic activity.	0
F	Peat degradation H**5 – H6**	0
G	Peat strength 12**kPa – 22kPa**	+1
Sum		**+3**

Preliminary Peat Slide Hazard is 3

Potential Exposure Risk is 2. (Geological survey of Ireland (GSI) documented area of landslide <100m from infrastructure.).

This equates to a **Hazard Ranking of 6** and places turbine construction at this location in the **LOW RISK** Category.

5. At the proposed **Substation 1** location, the following assessment of HAZARD has been made:

Item	Description of Key Indicator	Factor
A	Maximum gradient is in range of **10º - 22.5º** to horizontal.	+2
B	Maximum peat thickness at the proposed turbine location is **0.70m**	+1
C	Risk of drainage issues from saturated ground – **N/A**	0
D	Relic peat landforms – **N/A**	0
E	No sonic activity within 500m – Negligible seismic activity.	0
F	Peat degradation	0
G	Peat strength	0

Sum		**+3**

Preliminary Peat Slide Hazard is 3

Potential Exposure Risk is 3. (Proposed substation location is < 50m from a minor public road)

This equates to a **Hazard Ranking of 9** and places substation construction at this location in the **LOW RISK** Category.

6. At the proposed **Substation 2** location, the following assessment of HAZARD has been made:

Item	Description of Key Indicator	Factor
A	Maximum gradient is in range of **0º - 5º** to horizontal.	0
B	Maximum peat thickness at the proposed turbine location is **5.00m**	+3
C	Risk of drainage issues from saturated ground **– N/A**	0
D	Relic peat landforms **– N/A**	0
E	No sonic activity within 500m – Negligible seismic activity.	0
F	Peat degradation	0
G	Peat strength	+1
Sum		**+4**

Preliminary Peat Slide Hazard is 4

Potential Exposure Risk is 1. (Not within sensitive receptor buffer)

This equates to a **Hazard Ranking of 4** and places substation construction at this location in the **NEGLIGIBLE RISK** Category.

7. At the proposed **Substation 3** location, the following assessment of HAZARD has been made:

Item	Description of Key Indicator	Factor
A	Maximum gradient is in range of **0º - 5º** to horizontal.	0
B	Maximum peat thickness at the proposed turbine location is **3.00m**	+2
C	Risk of drainage issues from saturated ground **– N/A**	0
D	Relic peat landforms **– N/A**	0
E	No sonic activity within 500m – Negligible seismic activity.	0
F	Peat degradation	0

G	Peat strength	+1
Sum		**+3**

Preliminary Peat Slide Hazard is 3

Potential Exposure Risk is 1. (Not within sensitive receptor buffer)

This equates to a **Hazard Ranking of 3** and places substation construction at this location in the **NEGLIGIBLE RISK** Category.

An assessment of risk was also carried out for the proposed site access tracks as follows.

8. For site tracks between **T1 – T2**, the following assessment of HAZARD was made:

Item	Description Of Key Indicator	Factor
A	Maximum gradient is in range **0º - 5º** to horizontal	0
B	Maximum peat thickness in vicinity of **1.50m – 5.00m**	+3
C	Risk of drainage issues from saturated ground – **N/A**	0
D	No relic peat landforms – **N/A**	0
E	No sonic activity within 500m. Negligible seismic activity.	0
F	Peat degradation	0
G	Peat strength	+1
Sum		**+4**

Preliminary Peat Slide Hazard is 4

Potential Exposure Risk is 1. (Not within sensitive receptor buffer)

This equates to a Hazard Ranking of 4 and places site track construction at this location in the **NEGLIGIBLE RISK** Category

9. For site tracks between **T2 – T3**, the following assessment of HAZARD was made:

Item	Description Of Key Indicator	Factor
A	Maximum gradient is in range 1**0º - 22.5º** to horizontal	+2
B	Maximum peat thickness in vicinity of **1.80m**	+1
C	Risk of drainage issues from saturated ground – **N/A**	0
D	No relic peat landforms – **N/A**	0
E	No sonic activity within 500m. Negligible seismic activity.	0
F	Peat degradation	0

G	Peat strength	0
Sum		**+3**

Preliminary Peat Slide Hazard is 3

Potential Exposure Risk is 2. (Within buffer for sensitive watercourse)

This equates to a Hazard Ranking of 6 and places site track construction at this location in the **LOW RISK** Category

10. For site tracks between **T3 – T4**, the following assessment of HAZARD was made:

Item	Description Of Key Indicator	Factor
A	Maximum gradient is in range **0º - 5º** to horizontal	0
B	Maximum peat thickness in vicinity of > **2.00m**	+2
C	Risk of drainage issues from saturated ground – **N/A**	0
D	No relic peat landforms – **N/A**	0
E	No sonic activity within 500m. Negligible seismic activity.	0
F	Peat degradation	0
G	Peat strength	+1
Sum		**+3**

Preliminary Peat Slide Hazard is 3

Potential Exposure Risk is 2. (Geological survey of Ireland (GSI) documented area of landslide <100m from infrastructure.)

This equates to a Hazard Ranking of 6 and places site track construction at this location in the **LOW RISK** Category

11. For site tracks between **Substation – T4**, the following assessment of HAZARD was made:

Item	Description Of Key Indicator	Factor
A	Maximum gradient is in range **10º - 22.5º** to horizontal	+2
B	Maximum peat thickness in vicinity of **1.80m**	+1
C	Risk of drainage issues from saturated ground – **N/A**	0
D	No relic peat landforms – **N/A**	0
E	No sonic activity within 500m. Negligible seismic activity.	0
F	Peat degradation	0

G	Peat strength	0
Sum		**+3**

Preliminary Peat Slide Hazard is 3

Potential Exposure Risk is 3. (Minor public road <50m from proposed site track)

This equates to a Hazard Ranking of 9 and places site track construction at this location in the **LOW RISK** Category

The above Hazard Rankings have been determined by analysis of ground conditions at the proposed Letter Wind Farm site in accordance with the guidelines outlined by The Scottish Executive & Halcrow Group Ltd in "*Peat Slide Hazard and Risk Assessment - Best Practice Guide for Proposed Electricity Generation Developments*", April 2017.

8.4 ASSESSMENT OF POTENTIAL EFFECTS

8.4.1 Introduction

A review has been undertaken into the potential effects on soils and geology during the following scenario or stage of the development's lifetime:

A. If the development was not to proceed

B. During the Construction Phase

C. During the Operational Phase

D. Following the Decommissioning Phase

8.4.2 Do Nothing Impact

Where the proposed Wind Energy development not to take place, the soils and geology environment would benefit / not benefit as follows: -

Table 8.29: Do Nothing Impact – Does Construction Have a Net Positive Or Net Negative Impact On The Environment?

Item	Assessed Element	Assessed Condition Pre-Construction	Net Impact Anticipated Post-Construction
1	Water Regime – Response to Storm events	Combination of Mobile and Perched groundwater at site of wind farm infrastructure. Because of lack of effective	Minor positive impact. Installation of an effective drainage network will result in a small net reduction in the

Item	Assessed Element	Assessed Condition Pre-Construction	Net Impact Anticipated Post-Construction
		drainage storm events result in a high risk of soil movement.	risk of soil movement during storm events.
2	Water Regime - Erosion of slopes	GSI has indicated an area of historic landslide within the wind farm boundary. This area of erosion is currently at high risk of further soil movement, because of the slopes present.	Moderate positive impact. During construction works the water course in the vicinity of the historic landslide will be culverted, in order to protect the river environment from further contamination by peat and mineral soils.
3	Stabilisation of Soils	Peat Stability Assessment indicated some locations to be at a medium hazard of landslide.	Construction works, using the mitigation protocols discussed, can be expected to result in a small net improvement in soil stability
4	Land Contamination	Negligible contamination of nature soils and groundwater was encountered at Letter Wind Farm.	There will be small negative impact to groundwater as a result of the construction of the new wind farm that will decrease following completion of construction, but will remain at a minor level throughout the lifetime of the wind farm. The use of imported construction materials will mean that there will be a low to medium long-term impact on the soils and geology environment that will continue for at least the lifetime of the wind farm.

8.4.3 Construction Phase Potential Effects

8.4.3.1 Subsoil and Bedrock Removal

8.4.3.1.1 Earthworks Activities

Implementation of the Development will result in the removal of peat and superficial mineral soils in parts of the site to facilitate excavation for the construction of access roads and platforms for the wind turbines and substation to a competent stratum or bedrock suitable for the emplacement of foundations. Excavations will also be required to construct the site compound, cable trenches and grid route as well as for parts of the haul route that require temporary widening.

8.4.3.1.2 Turbines and Hardstand areas

The material encountered at each turbine and infrastructure location, during construction, is considered to be a combination of Peat and Glacial Till. The underlying Sandstone and Shale rock formation is likely to be exposed in the excavation of turbine foundations, where it is the preferred formation in which to commence construction. For all other infrastructure the overlying peat soils will be removed until glacial till soils of sufficient competence are encountered and construction commenced.

8.4.3.1.3 Site Access Tracks

Site Access Tracks will be needed to accommodate the construction works and to provide access to the turbine locations for the whole life cycle of the wind farm. The tracks will be constructed using unbound crushed aggregates and incorporate drainage to maintain the performance of the pavement during wet weather.

8.4.3.1.4 Turbines Delivery Haul Route

The turbine delivery haul route will generally use the existing public roads. However, some widening will be required at acute turns, within third party lands. Details are presented in **Chapter 15: Traffic and Transportation**. Generally, the impacts associated with this will be as per the Site access track construction but on a very minor scale and reversible. The impacts are considered to be **not significant**, **temporary**, **negative** effects.

8.4.3.1.5 Bedrock Excavations

Excavations of bedrock are anticipated during the construction of turbine foundations and to a lesser amount where this is exposed at a shallower depth elsewhere on-Site during construction. Rock excavated during construction will be reused as construction fill where possible.

8.4.3.1.6 Site Cable Trenches

Cable trenches throughout the Site will be excavated to a maximum depth of 1.2m. Peat and glacial till soils will be stored separately during construction and any excess remaining after reinstatement will be stored permanently on site.

8.4.3.1.7 Grid Connection Cable

Grid connection excavations will also take place along the grid connection route to Corderry Substation for the placement of underground cables.

8.4.3.1.8 Temporary Construction Compound

It is proposed to construct a temporary Site construction compound, north-west to the 20kV Substation.

8.4.3.1.9 Volumes of Material to be Excavated

Estimated total volumes of material to be excavated are presented in **Table 8.11.**

8.4.3.2 Potential for Bog Failure

Consideration has been given to the potential for bog failures at the Site. These mass movements of peat can take the form of either bog burst or bog slide. Historical evidence suggests that raised bogs are more prone to bog bursts while bog slides are more common on blanket bogs.

These peat failures generally occur either during or immediately after periods of heavy rainfall. Failures are especially likely to occur where there is a break of slope at the edge of an upland plateau of peat. Records indicate that bog bursts can naturally occur on shallow slope angles of less than 6 degrees while bog slides appear to occur on slopes that are steeper than 6 degrees.

Following well documented bogslides on the slopes of Dooncarton and Barnachuille mountains, Co. Mayo in September 2003 and at Derrybrien, Co. Galway in October 2003, the potential for bog failure has come to the fore in consideration of planning for wind farm development.

At Derrysallagh Wind Farm located approximately 10km west of Tullynamoyle on the Sligo/ Roscommon border, a suspected peat slide event in December 2016 resulted in a fatality.

Significantly, a peat slide originating on Shass Mountain near Drumkeeran, approximately 3km south-east of Letter occurred in June 2020. A recent, well documented peat slide event was also recorded at Meenbog Wind Farm, Co. Donegal during November 2020. The following potential causal factors for bog failure are identified following research and assessment of recent slides and from historical evidence over the last 200 years in Ireland.

1. Research into the history of bogslide occurrence indicates that the majority of bogslides have occurred on the blanket bogs in the west where rainfall is highest. Here, bogslides tend to be more frequent during the autumn and winter months.
2. The following criteria are considered to be the causal or contributory factors to bogslide occurrence:
   (a) Slope is the single most important factor for blanket bogs. Bog slides are especially likely to occur where there is a break in slope at the edge of an upland plateau of blanket peat, providing a line of weakness. While initial failure is likely to be slippage (translational or rotational faults) semi-fluid to fully fluid behaviour is the main movement mechanism downslope. Slope gradient imparts kinetic energy to the sliding material.
   (b) The depth of peat and its relationship to humification (the degree to which the fibre structure of the peat has decayed), pore water pressure, shear vane strength and other parameters generally indicates that the deeper the peat profile the more unstable it is, if external controls such as slope, drainage, removal of adjoining earth materials are changed. Exact depth thresholds for stability are not applicable due to the variability of peat environments (raised bog, blanket bog or fen habitats) and their site-specific conditions. However, as a rule of thumb peat of depths greater than >1.5m is significantly more vulnerable to instability than shallower peat at <1.5m depth, and in particular the top-layer of acrotelm (living) peat at <0.3m.
   (c) The pattern of recent precipitation at the site over the last c. 30 years such as intense localised rainfall (or melting snow) is an important trigger mechanism.
   (d) Antecedent weather conditions such as drought conditions are identified as a contributing factor. In the case of the landslides at Dooncarton and Barnachuille in September 2003 and at Derrybrien October 2003, short intense periods of heavy rainfall followed an exceptionally dry late summer. Historically, the Owenmore bogslide in Erris, Co. Mayo (1819) was also preceded by two months of drought. Sustained dry conditions leads to high soil moisture deficit (SMD). This dries the blanket peat, causing shrinkage and desiccation cracks.

(e) Some bogslides are caused by excessive interference – e.g. opening of turf banks, opening deep drains on blanket bog. All drains should be perpendicular to slope contour not parallel to it.

Finally, the following items are noted:

1. Geological structural features generally play no part in bogslide occurrence.
2. Bogslides are prone in certain upland locations due to their peculiar topography, ground composition and hydrology. When a slide occurs, it acts as a safety valve to restore equilibrium.
3. The most destructive bogslides involve the combination of slide materials with floodwaters, diluting the peat and mud in waterways and accelerating the velocity of the debris flow.

8.4.3.3 Vehicular Movements

8.4.3.3.1 Overview

Vehicle movement will occur primarily during the construction phase of the wind farm. Construction vehicles will include cranes, excavators, dumper trucks, concrete trucks, private cars (construction personnel). During the operation phase, vehicles will generally be limited to occasional maintenance vehicles only. Additional vehicles including cranes will however be required in the event that any turbine requires replacement.

8.4.3.3.2 Compaction, Erosion and Degradation

Compaction of soils will occur during construction and to a limited extent during operation and decommissioning. In general, compacted soils will be excavated during construction, and access to soils away from hardstanding areas will be prevented. Ongoing compaction of soils will occur in areas of floated road construction, which will continue during operation and decommissioning. Compaction effects are considered to be insignificant, permanent and negative.

Erosion and degradation of exposed soils will also occur, primarily during construction. Erosion and degradation effects are also considered to be **not significant, permanent and negative**.

8.4.3.3.3 Haul Route and Site Tracks

There will be no changes to the existing public roads with the exception of temporary widening at a discrete number of locations on the haul route to allow a temporary load bearing surface to be constructed. Some compaction of the underlying soils may occur, although this will be slight. The impacts associated with vehicle movements along the haul route is considered to be **insignificant, permanent** and **negative**.

Vehicle movement along the Site Access Tracks will again result in a slight compaction of the underlying soils, particularly in areas where floated roads are constructed. The impacts associated with vehicle movements along the Site Access Tracks is considered to be **not significant, permanent** and **negative.**

8.4.3.4 Water Quality

The following impacts both likely and potential are identified:

Suspended solids release during excavations

In a wind farm development, it is the construction phase that poses the highest risk to the site's hydrology, in particular to the quality of surface water due to generally poor aquifer conditions on high elevation terrain. The Letter Wind Farm site is situated on high elevation terrain. Nevertheless, it is likely that during excavation works, storage and re-use of materials, suspended solids will be entrained by sustained rainfall and surface water runoff.

The most vulnerable areas to surface water quality deterioration are (a) access road crossings of man-made drains and (b) turbine hardstand and infrastructure development at moderate gradient slopes proximal to existing waterways.

Some of the man-made drains have moderate gradients cut out, which should be taken into account if constructing new access tracks. This is considered to be short-term and temporary but could have a significant negative impact. With appropriate environmental engineering controls and measures, this impact can be negated and mitigated against.

Risk of pollution from hydrocarbons

The second pollutant of concern during the construction phase of the project is the potential spillage and release of hydrocarbons from plant equipment and associated transfer stations during the construction phase. An accidental hydrocarbon spillage would have a significant negative impact on both vegetation and water quality at the site.

Temporary sanitation

A temporary site office, service area and sanitation will be required for the construction stage of the development. Associated with this facility is the potential risk of water and soil contamination by wastewater release or chemical contamination of water and soil from temporary sanitation facilities. The level of risk posed is dependent on the type and location of facilities that are put in place.

The Water Framework Directive (WFD) highlights that all groundwater has a value irrespective of whether it occurs in a major or minor aquifer. Groundwater also contributes and maintains the surface water network and as a result its contamination should be mitigated against.

8.4.4 Operational Phase Potential Effects

8.4.4.1 Change to Hydrological Regime

The rate and amount of surface water run-off from the site will increase as a function of the replacement of vegetation, peat and sub-soils cover (which absorb rainfall) in parts of the site with a concrete / aggregate hardstand at turbine locations, and aggregate mix for proposed access tracks.

8.4.4.2 Water Quality

A potential impact on water aspects of the environment may arise during the operational phase of the development if regular maintenance, monitoring and auditing of mitigation structures and procedures are not undertaken during the lifetime of the Project.

8.4.5 Decommissioning Phase Potential Effects

8.4.5.1 Change to Hydrological Regime

The rate and amount of surface water run-off from the site will increase as a function of the replacement of vegetation, peat and sub-soils cover (which absorb rainfall) in parts of the site with a concrete / aggregate hardstand at turbine locations, and aggregate mix for proposed access tracks.

8.4.5.2 Water Quality

A potential impact on water aspects of the environment may arise during the operational phase of the development if regular maintenance, monitoring and auditing of mitigation structures and procedures are not undertaken during the lifetime of the project.

8.5 MITIGATION MEASURES AND RESIDUAL EFFECTS

8.5.1 Design Phase

8.5.1.1 Mitigation by Avoidance

The opportunity to mitigate any effect is greatest at the design period. In this respect, a detailed Site selection process was carried out by the Developer. This process identified deep peat and potentially deep bedrock as specific geotechnical constraints. Furthermore, infrastructure design sought to avoid those areas as much as possible.

In order to mitigate against the risk of landslide associated with the construction and operation of floating roads, areas of deep peat have been avoided wherever possible. The floated roads will be laid directly on the existing peat using geogrid and crushed stone. Pipes will be installed at intervals to allow the existing runoff regime on the site to continue.

8.5.1.2 Pre-Construction Phase Confirmatory Ground Investigation Works

Prior to the Construction Phase it will be necessary to undertake confirmatory pre-construction phase ground investigation works to confirm an absence of change to baseline condition that have informed the proposed wind farm design.

The works are required for this ground investigation contain both intrusive and non-invasive elements. The intrusive investigative works will consist of the following main elements:

- Excavation and sampling of trial holes within soils to depths of up to 5m below existing ground level.
- Drilling and sampling of boreholes within soils and bedrock to depths of up to 30m below existing ground level.
- Carrying out of in-situ testing using mechanical and man-portable equipment to depths of up to 20m below existing ground level.

These works, although of lesser significance are similar to the type of activities undertaken during the Construction Phase. As such mitigation as detailed in **Section 8.6.2** will be applied to reduce the effect from these activities to slight impact.

The non-invasive investigative works will consist of the following main elements: -

- Geophysical Surveys
- Topographic Surveys
- Laboratory Testing

These non-invasive activities will have a much lesser effect on soils and geology, based on the lack of requirement for heavy plant and machinery. Where possible the pre-construction Ground Investigation will prioritise the use of non-invasive methods over intrusive methods.

The pre-construction Ground Investigation programme will be designed so as to collect sufficient information on soils and geology across the entire development area in order to mitigate against adverse impact at Construction Phase, as follows:

- Determine ground water table at the location of significant excavations. This will allow appropriate design of excavations and groundwater control ahead of construction.
- Assess soil thickness, type and competence to inform excavation stability, suitable methods for protecting soil structure and permeability and minimise excavation for foundations.
- Test soils and subsoils to determine reusability of soils on site for "cut" and "fill" purposes.
- Assess the suitability of existing roads, footpaths and hardstanding areas for re-use and / or inclusion in the proposed design, without the need for removal and new construction.

8.5.2 Construction Phase

8.5.2.1 Earthworks Activities

The removal of soils will be unavoidable in places, but every effort should be made to ensure that the amount of sub-soils to be removed is kept to a minimum in order to limit the impact on the geotechnical and hydrological balance of the site.

It is noted that the "natural hydrology" of parts of the site may have been significantly altered by land drainage, however measures will be emplaced to minimise any additional changes to the existing site hydrology resulting from the construction of the wind farm.

During the construction works, the excavation, storage and re-use of excavated materials have the potential to, directly or indirectly, negatively impact on water quality. Appropriate engineering controls, such as the installation of a drainage system with settlement / stilling ponds, silt traps, check dams and interceptor drains, will be carried out in tandem with, and where possible, prior to, any excavation work to mitigate potential impacts. In relation to construction works, the most important aspects of these recommendations involve:

1. Deep excavations at turbine base locations in order to construct turbine foundations and hard-standings to support crane loadings.
2. Construction of new site roads, the upgrade of existing site roads and construction on new road surface at locations along the turbine delivery haul route where widening is required.
3. Construction of new sections of "floated road" (where recommended to fulfil a geotechnical requirement) where excess peat depth is present.
4. Removal / transport of "waste" peat and glacial spoil and disposal within designated zones.

5. Construction of a new grid connection between the Letter Wind Farm Substation and Corderry 110kV Substation, approximately 6.4km.

In addition to standard ground investigation works carried out prior to construction additional, supplementary investigations may be undertaken during the construction phase to assess the integrity of the rock formation beneath critical infrastructure.

8.5.2.2 Soils and Bedrock Removal

The following mitigation measures will be implemented to minimise potential impacts on soils and geology during the construction phase:

- Prior to commencement of construction works all-natural organic topsoil will be stripped from the footprint of the proposed development and stored temporary in a series of stockpiles.
- Surface water runoff will be intercepted and diverted away from open excavations towards the nearest gulley (on roadways) or to a temporary holding pond/tank (near river/stream) crossings.
- For off- sections, granular material will be placed over exposed clayey subsoil or made ground, to prevent erosion of fines and/or rutting.
- Minimal bedrock excavations are expected and where these are undertaken will be shallow in penetration. During construction any exposure of bedrock surfaces will be minimised. Following uncovering of the bedrock surface and excavation to the required level, the exposed formation will be quickly covered by a non-permeable barrier material until construction work can be completed in a timely manner and then reinstated.

8.5.2.3 Degradation of Soil and / or Subsoil

The following mitigation measures will be implemented to minimise potential impacts on soils and geology during the construction phase:

- Surface water runoff will be intercepted and diverted away from open excavations towards the nearest gulley (on roadways) or to a temporary holding pond/tank (near river/stream) crossings.
- Within the fields or other off-road areas, granular material will be placed over exposed clayey subsoil or made ground, to prevent erosion of fines and/or rutting and to provide a temporary trafficable surface.
- There will be limited stockpiling of material on-site. Excavated soil / material will be removed directly onto an awaiting truck for removal off site for recovery or re-use at

an appropriate destination within the Site. Any stockpiles will be small in size and covered with appropriate waterproofed material where fine content exceeds 5%.

- Open excavations, where practical, will be covered and sidewalls supported, if these are to remain open for periods in excess of one day.
- Regular site audits will be undertaken to ensure compliance with this mitigation and to provide active management of surface groundwater runoff.

8.5.2.4 Karst

GSI does not record the presence of any karst features within the proposed development site, neither is it located within an area known to be directly underlain by soluble bedrock.

Pre-construction ground investigation undertaken to inform design, will be reviewed to ensure the findings confirm this opinion.

Impact to any unrecorded "karst" landforms that may exist below the footprint of the Development will be limited by the shallowness of the proposed excavations and minimisation of bedrock exposure.

Where bedrock exposure occurs, the mitigation provided in **Section 8.6.2.2** can be expected to ensure the magnitude of this effect will be SLIGHT.

8.5.2.5 Geological Heritage

The site is not located within an area of geological heritage. Should sensitive aspects of the local geology be exposed within the infrastructure footprint during the construction phase these will be documented and recorded by a suitably qualified geologist and a combined factual and interpretative report produced.

8.5.2.6 Contamination of Overburden and Groundwater

Where contaminated material is encountered, it will be left in-situ while testing to determine its characteristics is carried out. This material will be covered to minimise rainfall ingress. The material will be excavated and either retained on site or transported by a permitted waste contractor to an appropriate facility for treatment or disposal.

All contaminated materials encountered within the Site will be excavated, stored, moved, disposed of or recovered in accordance with the requirements of the Waste Management Act 1996 as amended and the Best Practice Guidelines on the Preparation of Waste Management Plans for Construction and Demolition Projects.

To reduce the risk of soil, subsoil, made ground and/or groundwater contamination arising as a result of spills or leakages, a number of measures will be implemented during the construction phase of the Development to control the storage and handling of fuels, lubricants and waste.

These measures include, but are not limited to, the following:

- Storing fuels, chemicals, liquid and solid wastes in appropriately bunded areas within the temporary compound(s)
- Removal of all potentially contaminating materials as well as plant and machinery away from rivers/stream crossings to the temporary compound(s) at the end of each working day
- Undertaking refuelling of plant, equipment and vehicles within the temporary compound(s)
- Provision of spill kits at high risk sites.

8.5.2.7 Potential for Bog Failure

Site investigations and assessment of the proposed Letter Wind Farm site indicate that the site is a low risk for slope failure or mass movements.

Applying the precautionary principle however, the following procedures are recommended as best-practise mitigation measures to avoid / improve slope instability at wind farm sites.

For Letter Wind Farm, these procedures are both management driven and through risk reduction enabling works.

Construction mitigation (specified below), where applied in full, will further reduce the hazard rankings recorded in **Tables 8.28 / 8.28a** to those indicated in **Tables 8.31 / 8.31a.**

Construction Mitigation of Risk

General Constraints and Anecdotal Evidence

Analysis of the historic conditions following peat slides indicates that the following main factors generally trigger slope failures:

1. Excessive quantities of spoil loaded onto sensitive peat covered sloping ground. (In such cases the gradient of the slope should be no more than an average of 5 degrees to the horizontal). Where peat is not of a sensitive nature, it will be possible to load spoil onto slopes up to a maximum of 10 degrees to the horizontal.

2. The angle of repose of the cut face of excavations is all too often found to be too high, sometimes 70 – 80 degrees to the horizontal. Battering back the sides of an excavation to approx. 45 degrees helps to reduce the potential for slippage, which will significantly reduce the potential for peat movement.
3. The consequences of peat slide can be identified as Damage to Machinery, Damage or Loss of Access Track, Damage to Site Drainage, Site Works Damaged, Death or Injury to Personnel or Degradation to the Environment.
4. A contingency plan is to be compiled and will be enacted should peat movement occur.

Prevention of Peat Slide and Bog Burst

Application of the following procedures will have the effect of reducing the Hazard Ranking associated with Peat Instability:

1. Excavated spoil will not be deposited on the down slope or up slope edges of the adjacent peat. This spoil will instead be deposited on the two flanks either side of the excavation (where gradient is least) and spread in such a way as to limit the surcharge pressure on sensitive peat.
2. Bog Burst is recognised to be a difficult condition to mitigate against. Bog Burst tends to occur within deep peat (> 3.00m) after very heavy or prolonged precipitation. To ward against this possibility the design of turbine bases should be engineered to ensure that excavations do not cut into deep peat (>2.50m). It is however considered acceptable, where slopes are less than 5 degrees, that floating roads may be placed within peat cover exceeding 2.50m depth.
3. The hardstanding areas surrounding the turbine bases will be designed in a manner such that crane loadings can be transferred directly onto the competent strata underlying the peat. In order to facilitate these works it will be necessary to undertake limited excavations. To ensure effective sidewall support during these operations the contractor will adopt an approved engineering solution (such as sheet piling) to maintain sidewall stability at all times.
4. Movement can often occur during or following severe rainstorm events, particularly when following a prolonged dry spell. Extra vigilance will be maintained at such times, during construction.
5. All slopes are to be regularly checked for development of tension cracks (caused by desiccation), indicative of slope movement.
6. Extra care will be taken where the peat has previously been tilled. Attention should be paid to any historic turbary nature of a site.

7. Method statements will be followed at all times. Where modification is required, this will be agreed by the supervising engineer.
8. Slopes will not be undercut, or excavations left unsupported for periods in excess of 24 hours. Excavations are to be backfilled as soon as practicable. Excavation and filling operations shall be coordinated to minimise the time an excavation remains opened.
9. Pore water pressure within excavations should be kept low at all times by draining deliberate or intentional sumps at regular intervals. This is to prevent ponding of water within excavations which can in turn increase hydraulic heads locally and potentially lead to instability.
10. The potential for Peat Slide will be monitored regularly during the construction works, by means of regular site visits and assessments, by a suitably qualified and experienced professional.
11. Only experienced and competent contractors will be appointed to carry out the construction works. Low ground bearing pressure machinery shall be used for transport of construction materials in sensitive areas. It is also recommended that the less sensitive areas are completed first to allow suitable construction practices to be established before works commence in the more difficult areas.
12. Site staff will also undergo induction training to learn about the risks associated with working on "upland environments" and procedures aimed at reducing Peat Slide risk.
13. Sufficient time should be allowed to carry out the works in a safe and timely manner.

Spoil Disposal

Spoil will invariably be generated during excavations for foundations at turbines and along new access roads.

Minimisation of the production of this spoil will be treated as a high priority, but it is nevertheless expected that there will be in the region of 54,236m^3 of peat soils and subsoils excavated during site works.

Analysis of peat depths recorded along proposed site tracks and turbine locations indicates a range of 0.10m to 5.50m across the development area with an average peat depth of 1.98m within the construction zone. The volume of peat (or organic soils) to be extracted as part of the Development is estimated to be approximately 54,236m^3.

Spoil types will be treated separately. Glacial soils and peat will be separated during excavation and these two types of spoil will be disposed of generally as follows:

A *Glacial soils will be deposited directly on top of other glacial soils. This will require the removal of peat where present to facilitate the process.*

B *Peat can be disposed of either on top of glacial soils, on top of inactive peat or on top of the "Acrotelm" where the "Top Mat" has been removed.*

1. Glacial spoil disposal will take place within a 100m radius of each structure.

2. It is intended that spoil movements will be minimised by disposing of the material within or immediately adjacent to the construction footprint of the structure from whence it was excavated.

3. Preparation of the Spoil Disposal site will involve the removal of the "Top Mat" which will be transplanted to an area of inactive bog and maintained for re-use during restoration operations.

4. Spoil will be deposited, in layers of 0.50m and will not exceed a total thickness of 1.50m.

5. Spoil will only be deposited on slopes of < 10 degrees to the horizontal and greater than 10m from the top of a cutting. The exact location of such areas will be determined on consultation with the geotechnical specialist.

6. A Peat Stability Register will record the location of each Spoil Disposal Site used and regular weekly assessment will be made by the construction manager or other suitably qualified individual.

7. Once disposal is complete the disposal sites will be re-vegetated with the "Top Mat" removed at the commencement of disposal operations. Upon commencement of the restoration phase guidance from a suitably qualified ecologist will be sought to provide a suitable methodology and programme of maintenance for the restored areas.

Adjustment factors for Hazard due to adoption of Mitigation Measures:

Table 8.30: Hazard Mitigation – Risk Reducing factors

Risk Reduction Factor	***Scale of Risk***	***Hazard***
A	**-0.25**	*Limiting of construction during periods of heavy rainfall*
B	**-0.25**	*Direct support of peat faces at excavation locations*
C	**-0.50**	*Battering back of peat faces within 100m of proposed works*

Risk Reduction Factor	*Scale of Risk*	*Hazard*
D	**-0.50**	*Engineered drainage solution*
E	**-0.25**	*Use of machinery with low ground bearing pressure for the transport of spoil and fill*
F	**-0.50**	*Staff Induction and regular surveillance by geotechnical engineer*

The reduction in risk due to the above measures is discussed below, and the Hazard Rankings are updated for each location; refer to **Tables 8.31 / 8.31A.**

Post-Mitigation

Implementation of the mitigation measures contained within the previous section (**Table 8.30** – Hazard – Risk Reducing Factors) allows the optimal level of risk to be attained at each turbine at the proposed development site of Letter Wind Farm.

Table 8.31: Hazard Ranking for each Turbine Location following Mitigation Measures

ID	Pre-Mitigation			Risk Reduction Factors[10]						Post-Mitigation		
	Hazard	Exposure	HAZARD RANKING	A (-0.25)	B (-0.5)0	C (-0. 50)	D (-0.50)	E (-0.25)	F (-0.50)	Hazard	Exposure	HAZARD RANKING
T1	3	1	3	Y	-	-	-	Y	Y	2	1	2
T2	4	2	8	Y	Y	Y	-	Y	Y	2	2	4
T3	4	2	8	Y	Y	Y	-	Y	Y	2	2	4
T4	3	2	6	Y	-	-	-	Y	Y	2	2	4
Substation 1	3	3	9	Y	Y	Y	-	Y	Y	1	3	3
Substation 2	4	1	4	Y	-	-	-	Y	Y	3	1	3
Substation 3	3	1	3	Y	-	-	-	Y	Y	2	1	2

[10] Refer to Table 8.30 for explanation of the Risk Reduction Factors (A – F)

Table 8.31A Hazard Ranking for each new Section of Access Track following Mitigation Measures

Track Section ID	Pre-Mitigation			Risk Reduction Factors						Post-Mitigation		
	Hazard	Exposure	HAZARD RANKING	A (-0.25)	B (-0.5)0	C (-0. 50)	D (-0.50)	E (-0.25)	F (-0.50)	Hazard	Exposure	HAZARD RANKING
T1 – T2	4	1	4	Y	-	-	-	Y	Y	3	1	3
T2 – T3	3	2	6	Y	Y	Y		Y	Y	1	2	2
T3 – T4	3	2	6	Y	-Y	Y-	-	Y	Y	1	2	2
Substation – T4	3	3	9	Y	Y	Y	-	Y	Y	1	3	3

8.5.2.8 Management Driven Procedures and Protocols

The Contractor's methodology statement should be reviewed and approved by a suitably qualified geotechnical engineer with experience in peat environments prior to site operations.

- Any excavations that may tend to undermine the up-slope component of a peat and / or unstable sub-soils slope should be sufficiently supported by buttress, frame or rampart to resist lateral slippage.
- In areas where peat soils are to be excavated, machinery of a sufficient size to complete the works will be employed. Excessively heavy plant machinery will not be used in these areas. This measure is intended to avoid large vibrations disturbing the peat substrate.
- Drainage management measures will be installed to effectively drain grounds in tandem with access track construction. Such drains should be positioned at an oblique angle to slope contours to ensure ground stability. Drains on areas of the site with minimal risk of bog failure as identified by site investigations can be positioned at a more acute angle to the slope contour in order to reduce the velocity of surface water drainage.
- Due to peat's fluid-like properties, all peat excavated should be immediately removed from sloping sites. If peat is required for reinstatement, then acrotelm peat (<0.3m shallow, living layer) should be moved to a lower elevation part of the site that is characterised by near-horizontal slopes, is >100m away from any significant break of slope and is >50m away from drains and streams.
- If additional materials are required for the construction process, after exhausting excavated materials during road and infrastructure construction, additional materials may be acquired from external sources. Wherever possible any imported aggregates should consist of a similar geo-chemistry to the local geology of the site. It should be

noted that this is dependent on the quality and variety of aggregate supplied by available quarries.

- From evidence (landslides in Mayo and Galway), excessively wet periods should be avoided in terms of scheduling significant excavations in peat substrates.
- Adherence to additional site-specific mitigation detailed in **Table 8.30** and **Table 8.31** and referenced in **Table 8.31A.**

These recommendations will be included in the Contractor's contract of works, who should be experienced in construction within peat environments. In addition, a construction and environmental management plan will be in operation to check equipment, materials storage and transfer areas, drainage structures and their attenuation ability on a regular basis. The purpose of this management control is to ensure that the measures in place are operating effectively, prevent accidental leakages, and identify potential breaches in the protective retention and attenuation network during earthworks operations.

8.5.2.9 Additional Risk Reduction Enabling Works

The zone of historic peat landslide movement to the western side of access track and infrastructure at turbine T4, will be stabilised so as to prevent the continued natural loss of peat and / or mineral soils into the adjacent watercourse.

Such naturally induced migration of organic or mineral soils into watercourses has the effect of diminishing water quality and negatively impacting the associated flora and fauna.

To achieve this the watercourse will be culverted along the entire length of the recorded landslide zone. This will have the effect of stopping any subsequent soil movements from entering the water course and therefore negate further impact on the downstream watercourse.

8.5.2.10 Water Quality

During the construction phase, surface water drainage is generally found to be more at risk to water quality change than groundwater, where the majority of documented pollution events tend to involve suspended solids from sediment flows. The following mitigation measures are recommended to protect surface water and, to a lesser degree, groundwater quality.

8.5.2.11 Groundwater Dewatering

Any water ingress that may be encountered in the upper weathered zone of the bedrock during the construction phase should be intercepted by a toe drain and diverted to an existing artificial drainage channel and attenuation before release.

The design of the drainage takes into account factors of slope stability and where possible should be sealed at the base.

8.5.3 Operational Phase

8.5.3.1 Change to Hydrological Regime

Stilling ponds and interceptors will be kept for attenuation and runoff. Consideration should be given to the engineered design of roadside drains, the hardstanding areas and improved access roads to take the capacity of additional surface run-off arising from the proposed development.

The design must prevent both ***(a) hydraulic loading*** of the existing surface water network and ***(b) provide sufficient attenuation of suspended solids*** prior to outfall to the natural drainage network to maintain the existing environments baseline chemistry. Surface water flows in all existing waterways and drainage should not be impeded in any way by the proposed development.

Access tracks that intercept existing waterways should have suitably designed culverts installed to maintain baseline flows, large enough to accommodate peak flow of a one in 100-year return period.

8.5.3.2 Water Quality

The following measures are recommended to mitigate pollution to surface waters and groundwaters during the lifetime of the Development.

A regular programme of environmental site maintenance for the drainage network and drainage culverts to ensure their performance to standards at the site. Some changes in the drainage network may be required as a result of unanticipated changes in the hydrological regime at the site during the operation phase of the Development.

If fuelling has occurred on site, the fuel tanks and oil interceptor used at the fuel transfer area should be removed by a suitably qualified contractor. An audit of ground and water conditions immediately under and around the transfer area is recommended to investigate whether any leakage has occurred to the hydrological system and whether some clean-up measures are required. Aside from the use of lubricant oils at the substation (low volume), fuels should not be stored on site for the operation phase of the Development.

The substation compound is likely to require substation transformer cooling oil or gas. This should be stored in containers within a safe part of the substation compound, minimising accidental leakage and / or fire hazards. Consideration should also be given to a "bunded" area for the oil. Similarly, any other potentially harmful substances used to service the substation should be stored in an environmentally safe manner to mitigate impact to the soils and water.

8.5.3.3 Monitoring

In order to ensure there are no impacts on soils and geology during the operational phase a schedule of regular maintenance is proposed, as follows:

- Regular inspections and maintenance of surface water drainage to ensure correct functioning and to prevent build-up of blockages
- Regular inspection and maintenance of bunded storage of chemicals and fuels to prevent escape of contaminants and allow early indications of any potential defects in storage facilities
- Regular inspection and maintenance of roads, footpaths and parking areas to monitor settlement and investigation further where recorded.
- Regular monitoring of adjacent watercourses for contamination and comparison to baseline readings.

8.5.4 Decommissioning Phase

There will be a change in ground conditions at the site with the replacement of natural materials such as peat, sub-soils and possibly bedrock by concrete, sub-grade and surfacing materials. This is a direct permanent change to the materials composition at the site.

No new mitigation is anticipated during the decommissioning phase. However, prior to initiating the decommissioning phase a review will be undertaken of the relevant legislation and guidance in force at that time to determine if additional mitigation is required.

Limited temporary decrease in water quality on a local level is likely to arise from the release of suspended solids and sediments during the excavation and construction process, particularly following rainfall events after a sustained dry period. This local deterioration in water quality will subsequently be reduced naturally by dilution and by managed mitigation prior to exiting from the site boundary to main catchments.

8.5.5 Residual Effects

This section describes any residual effects of the Development that continue to exist when the mitigation measures have been put in place. The significance of this effect after mitigation (residual effect) is determined using professional judgement.

Residual impacts that are most likely to occur at the Site during the operational phase would be as follows:

Changes in ground surfacing including areas of new hardstands will impact on the hydrology of the site and may result in increased run-off of rainwater and increased drainage discharge. This will result in increased soil erosion.

The drainage infrastructure that will be emplaced as part of the roads and turbines development will also change the subsurface hydrology by replacing a natural diffuse drainage system with line interceptors and point discharges to buffered outfalls. Careful design of this drainage to mimic natural conditions will help to mitigate negative impacts of artificial drainage and the potential increase in soil erosion.

8.5.5.1 Construction Phase Residual Effects

- Dewatering - implementation of the proposed mitigation measures identified to minimise the effects of dewatering during the construction phase will ensure that the magnitude of resultant impacts on the quality of the existing groundwater and surface water will reduce from low to very low.
- Groundwater Vulnerability - implementation of the proposed mitigation measures identified to minimise the effects on the groundwater during the construction phase will ensure that the magnitude of resultant impacts on the groundwater quality will reduce from low to very low.
- Degradation of soil and /or subsoil - implementation of the proposed mitigation measures identified to reduce soil degradation during the construction phase will ensure that the magnitude of impacts on the quality and function of soil will typically reduce from moderate - low for all soil types.
- Erosion of soil, subsoil and/or made ground - implementation of the proposed mitigation measures identified to reduce erosion during the construction phase will ensure that the magnitude of impacts on the quality of soil, subsoil and made ground will reduce from low to very low.
- Contamination of soil, subsoil and/or made ground - implementation of the proposed mitigation measures identified to minimise ground contamination during the

construction phase will ensure that the magnitude of resultant impacts on the quality of soil, subsoil and/or made ground will typically reduce from low to very low.

- Ground Movement including settlement - provided that the impact mitigation measures outlined are put in place, this will ensure that the magnitude of resultant impacts on the ground during construction will reduce from low to very low.
- Management of excavated materials at off-site locations - any contaminated soil transferred to offsite recovery or disposal facilities presents a low level of environmental risk. Accordingly, the magnitude of any potential impact on soil and subsoil quality at off-site locations is likely to be low.

8.5.5.2 Operational Phase Residual Effects

Once operational mitigation measures are set out, as in **Section 8.6.3,** the residual effects from any operational event will be slight.

8.5.6 Cumulative Effects

The soil and geology impact assessment undertaken in this chapter outlines that significant effects are not expected during the construction, operation or decommissioning of the Letter Wind Development (within the Site boundary) and that impacts on the soil and geological environment of its construction, operation and decommissioning are of a localised nature.

Impacts on soil and geology do not extend beyond the immediate vicinity of the Site. Therefore, no cumulative impacts, between the Letter Wind Farm and other existing or permitted or proposed projects, on soils and geology have been identified.

8.6 SUMMARY OF SIGNIFICANT EFFECTS

Providing the mitigation measures outlined in this report are fully implemented and best practice as described in the IWEA and Scottish Best Practice Guidelines is followed on Site, it is expected that impacts associated with the development of the wind farm will not be significant. The CEMP (**Appendix 2.1**) also includes a suitable monitoring programme which will ensure that there is rigid adherence both to the CEMP and to the mitigation measures outlined here during construction, operation and decommissioning of the wind farm.

Table 8.32: Summary of Effect of the Development on Soils and Geology – Significance before and after Mitigation

Reference	Potential Effect	Prior to Mitigation Magnitude of Impact	Post Mitigation Significance	Remarks
A	Excessive Dewatering	Moderate Adverse	Slight	
B	Groundwater Vulnerability	Small Adverse	Slight	
C	Degradation of Shallow Soils	Moderate Adverse	Slight	
D	Erosion of Shallow Soils	Small Adverse	Slight	
B	Degradation of Bedrock	Small Adverse	Slight	
C	Contamination of Groundwater	Small Adverse	Slight	
D	Presence of Contaminated Soils and Groundwater	Moderate Adverse	Slight	
E	Environmental Liabilities Associated with the Site	Small Adverse	Small	
F	Degradation of Priority Habitats	Small Adverse	Imperceptible	
G	Loss of Geological Heritage	Small Adverse	Imperceptible	
H	Alteration of Hydrogeological Regime	Moderate Adverse	Slight	
I	Loss of Aggregate Resource	Small Adverse	Imperceptible	
J	Organic Soil Stability	Moderate Adverse	Slight	
K	Soil Slope Stability	Moderate Adverse	Slight	
L	Seismic Hazard	Small Adverse	Imperceptible	
M	Underground Utilities	Small Adverse	Slight	

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