White Hill Wind Farm

Environmental Impact Assessment Report

Annex 6.1: Geotechnical & Peat Stability Report

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GEOTECHNICAL & PEAT STABILITY REPORT

WHITE HILL WIND FARM

Prepared for: White Hill Wind Limited

Date: July 2022

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GEOTECHNICAL & PEAT STABILITY ASSESSMENT REPORT
WHITE HILL WIND FARM

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Abstract: Fehily Timoney and Company (FT) were engaged by White Hill Wind Limited to undertake a geotechnical assessment of the proposed White Hill Wind Farm site with respect to peat stability. As part of the geotechnical assessment of the wind farm site, FT completed a walkover survey at the site. The findings of the geotechnical and peat stability assessment showed that the site has an acceptable margin of safety and is suitable for the proposed wind farm development.

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1. NON-TECHNCIAL SUMMARY

Fehily Timoney and Company (FT) was engaged by White Hill Wind Limited to undertake a geotechnical and peat stability assessment of the proposed White Hill Wind Farm site. In accordance with planning guidelines compiled by the Department of the Environment, Heritage and Local Government (Draft Revised Wind Energy Development Guidelines, DoHPLG, 2019), where peat >0.5m thickness is present on a proposed wind farm development, a peat stability assessment is required.

The proposed wind farm comprises 7 no. wind turbines and associated infrastructure. The topography of the wind farm site is 'hilly-to-undulating' with the overall site elevation ranging between approximately 220m and 290m OD (Ordnance Datum). The land use within the proposed development site comprises commercial forestry and agricultural pastures, with small pockets of transitional woodland scrub within the wider landscape.

A walkover including intrusive peat depth probing, desk study, stability analysis and risk assessment was carried out to assess the susceptibility of the site to peat failure following the principles in Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (PLHRAG, Scottish Government, 2017).

Peat deposits were only recorded in localised/isolated areas across the site. Peat depths recorded during the site walkovers and from the ground investigation ranged from 0.0 to 0.8m with an average peat depth of 0.12m. 70% of the probes recorded no peat, confirming the localised nature of the peat deposits across the site.

Slope inclinations at the main infrastructure locations range from 2 to 9 degrees. The relatively flat topography/nature of the terrain on site reflects the low risk of peat failure. Ground conditions comprised localised pockets of peat and peaty topsoil overlying glacial till comprising SILT/CLAY overlying bedrock which is recorded as being weathered.

The purpose of the stability analysis was to determine the stability i.e. Factor of Safety (FoS), of the peat slopes. The FoS provides a direct measure of the degree of stability of a peat slope. A FoS of less than 1.0 indicates that a slope is unstable; a FoS of greater than 1.0 indicates a stable slope. An acceptable FoS for slopes is generally taken as a minimum of 1.3. The stability analysis for this project, which analysed the turbine locations, access tracks and related infrastructure, resulted in FoS above the minimum acceptable value of 1.3 and hence the site has a satisfactory margin of safety.

From the stability analysis for both the undrained and drained conditions, which analysed the turbine locations and other proposed infrastructure locations, the calculated values were above the minimum acceptable FoS of 1.3.

The peat stability risk assessment uses the results of the stability analysis in combination with qualitative factors, which cannot be reasonably included in a stability calculation but nevertheless may affect the occurrence of peat instability, to assess the risk of peat failure at the site. The results of the risk assessment are given in Appendix B.

The findings of the stability analysis, which involved analysis of approximately 40 probe locations, show that the site has an acceptable margin of safety and is suitable for the proposed wind farm project. The findings include recommendations and control measures for construction work in peat lands to ensure that all works adhere to an acceptable standard of safety.

In summary, the White Hill Wind Farm site has an acceptable margin of safety and is considered to be at **Low** risk of peat failure.

2. INTRODUCTION

2.1 Fehily Timoney and Company

Fehily Timoney and Company (FT) is an Irish engineering, environmental science and planning consultancy with offices in Cork, Dublin and Carlow. The practice was established in 1990 and currently has about 90 members of staff, including engineers, scientists, planners and technical support staff. FT deliver projects in Ireland and internationally in our core competency areas of Waste Management, Environment and Energy, Civils Infrastructure, Planning and GIS and Data Management.

FT have been involved in over 100 wind farm developments in both Ireland and the UK at various stages of development i.e., preliminary feasibility, planning, design, construction, and operational stage and have established themselves as one of the leading engineering consultancies in peat stability assessment, geohazard mapping in peat land areas, investigation of peat failures and site assessment of peat.

2.2 Project Description

FT was engaged in June 2022 by White Hill Wind Limited to undertake a geotechnical & peat stability assessment of the proposed White Hill Wind Farm.

The proposed White Hill Wind Farm is located approximately 4km west of Old Leighlin, Co. Carlow, approximately 14km southwest of Carlow and approximately 13km northeast of Kilkenny.

The White Hill wind farm site comprises an area of approximately 2.55km^2. The surrounding landscape to the east and north is 'hilly-to-undulating' with land use comprising forestry, agricultural pastures, with small pockets of transitional woodland scrub within the wider landscape.

The development comprises the following:

- 7 no. wind turbines with an overall tip height of 185m, and all associated ancillary infrastructure;
- Upgrades to the turbine component haul route;
- Construction of an electricity substation and installation of c. 15km of underground grid connection cable between the White Hill wind farm and the existing Kilkenny 110kV electricity substation; and
- All associated and ancillary site development, excavation, construction, landscaping, and reinstatement works, including provision of site drainage infrastructure

The peat depth data was recorded by FT during the site walkover undertaken on the 21st of June 2022.

Ground investigation in the form of trial pits (9 no.) was carried out by Hydro-Environmental Services Ltd. (HES) on the 6th of October 2021.

2.3 Peat Stability Assessment Methodology

FT undertook the assessment following the principles in Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (2nd Edition, PLHRAG, 2017). The Peat Landslide Hazard and Risk Assessment Guide (PLHRAG) is used in this report as it provides best practice methods to identify, mitigate and manage peat slide hazards and associated risks in respect of consent applications for electricity generation projects.

The best practice guide was produced following peat failures in the Shetland Islands, Scotland in September 2003 but more pertinently following the peat failure in October 2003, during the construction of a wind farm at Derrybrien, County Galway, Ireland.

This peat stability assessment has been undertaken taking into account peat failures that have occurred on peatland sites (such as recent failures at Meenbog 2020, Co. Donegal and Shass Mountain 2020, Co. Leitrim). The lessons learned from both peat slide events have been incorporated into the design of this project, where relevant, and the construction methodologies to be implemented. The Meenbog failure occurred during the construction of a section of floating road on sidelong ground in an area of weak peat. This construction technique is not proposed on the White Hill wind farm site. It is important that the existing site drainage is maintained during construction to avoid a similar failure to that on Shass Mountain, which occurred following heavy rainfall, and this is referenced, where relevant, in the Risk Assessments for the turbines/access tracks. The limited extent and shallow depth of peat/peaty topsoil recorded on the White Hill site make a failure similar to Shass Mountain highly unlikely.

The extent of the peat stability analysis by FT has been undertaken in accordance with guidance within Eurocode 7 and PLHRAG (2nd Edition, 2017) to investigate peat slopes that have the potential to impact on the proposed development, as applicable. The peat stability assessment is undertaken to identify peat slopes at risk from the proposed development, and to identify peat slopes that may pose a risk to the proposed development.

The geotechnical and peat stability assessment at the site included the following activities:

(1) Desk study, involving the review of publicly available soils and geology maps, records of historical peat failures, aerial photography.

(2) Site reconnaissance including shear strength and peat depth measurements undertaken following initial multidisciplinary constraints study (by the design team) to determine the proposed construction envelope within the site i.e. the area within the overall site where development is possible following multidisciplinary review and assessment of constraints.

(3) Peat stability assessment of the peat slopes on site using a deterministic and qualitative approach.

(4) Peat contour depth plan – compiled based on the peat depth probes carried out across the site by FT (2022).

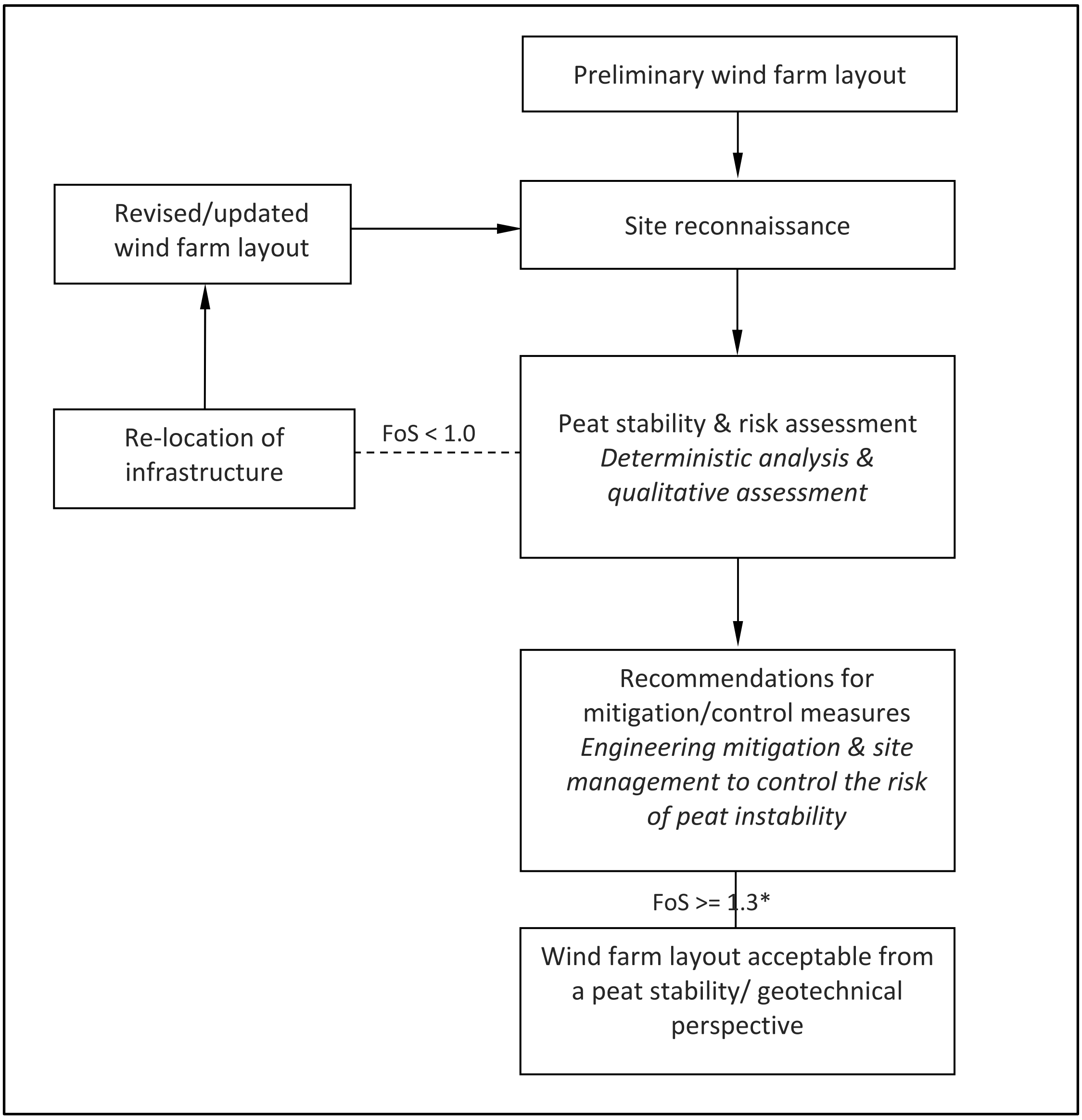
(5) Factor of safety plan – compiled for the short-term critical condition (undrained) for 13 no. FoS points analysed along the proposed infrastructure envelope on site.

(6) A peat stability risk register was compiled to assess the potential design/construction risks at the infrastructure locations and determine adequate mitigation/control measures for each location to minimise the potential risks and ensure they are kept within an acceptable range, where necessary.

(7) Review of ground investigation carried out at the site by HES.

A flow diagram showing the general methodology for peat stability assessment is shown in Figure 2.1. The methodology illustrates the optimisation of the wind farm layout based on the findings from the site reconnaissance and stability analysis and subsequent feedback.

Figure 2.1: Methodology for Peat Stability Assessment



*An FoS of between 1.0 and 1.3 does not mean that a failure will occur, but that the area requires attention. Mitigation measures can be provided for areas with an FoS of between 1.0 and 1.3 to reduce the risk of failure.

As for all construction projects, a detailed engineering construction design must be carried out by the appointed construction stage designer prior to any construction work commencing on site. This must take account of the consented project details and any conditions imposed by that consent. This must include a confirmatory peat stability assessment to account for any changes in the environment which may have occurred in the time leading up to the commencement of construction.

2.4 Peat Failure Definition

Peat failure in this report refers to a significant mass movement of a body of peat that would have an adverse impact on the proposed wind farm development and the surrounding environment. Peat failure excludes localised movement of peat that would occur below an access track, creep movement or erosion type events.

The potential for peat failure at this site is examined with respect to wind farm construction and associated activity.

2.5 Main Approaches to Assessing Peat Stability

The main approaches for assessing peat stability for wind farm developments include the following:

(1) Geomorphological

(2) Qualitative (judgement)

(3) Index/Probabilistic (probability)

(4) Deterministic (factor of safety)

Approaches (1) to (3) listed above are considered subjective and do not provide a definitive indication of stability; in addition, a high level of judgement/experience is required which makes it difficult to relate the findings to real conditions. FT apply a more objective approach, the deterministic approach (as discussed in Section 2.6).

As part of FT's deterministic approach, a qualitative risk assessment is also carried out taking into account qualitative factors, which cannot necessarily be quantified, such as the presence of mechanically cut peat, quaking peat, bog pools, sub peat water flow, slope characteristics and numerous other factors. The qualitative factors used in the risk assessment are compiled based on FT's experience of assessments and construction in peat land sites and peat failures throughout Ireland and the UK. FT have been involved with in excess of 100 wind farm developments across Ireland and the UK at various stages of development, from preliminary feasibility stage through planning and from scheme development at tender design and detailed design stage, through to the construction and operational stages. This approach follows the guidelines for geotechnical risk management as given in Clayton (2001), as referenced in the best practice for Peat Landslide Hazard and Risk Assessment Guide (PLHRAG, 2017), and takes into account the approach of MacCulloch (2005).

The risk assessment uses the results of the deterministic approach in combination with qualitative factors, which cannot be reasonably included in a stability calculation but nevertheless may affect the occurrence of peat instability to assess the risk of instability on a peat land site.

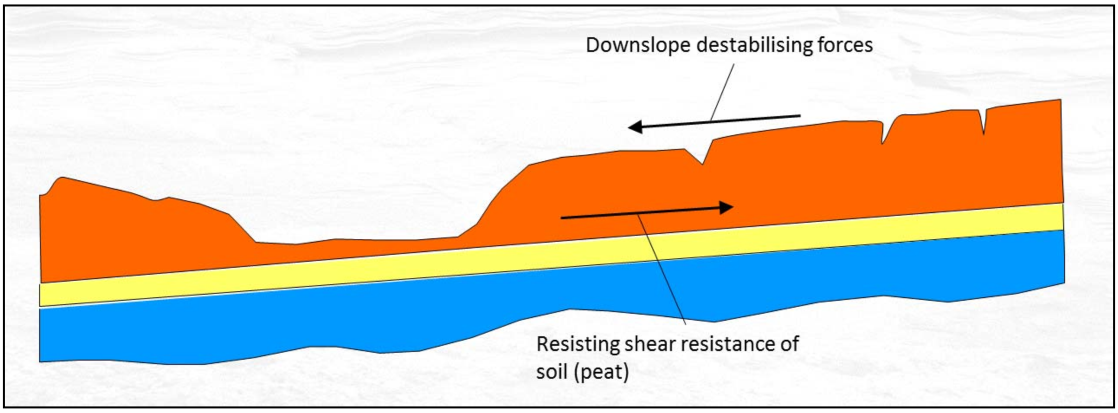
2.6 Peat Stability Assessment – Deterministic Approach

The peat stability assessment is carried out across a wide area of peatland to determine the stability of peat slopes and to identify areas of peatland that are suitable for development; this allows the layout of infrastructure on a particular wind farm site to be optimised. The assessment provides a numerical value (factor of safety) of the stability of individual parcels of peatland. The findings of the assessment discriminate between areas of stable and unstable peat, and areas of marginal stability where restrictions may apply. This allows for the identification of the most suitable locations for turbines, access tracks and infrastructure.

A deterministic assessment requires geotechnical information and site characteristics which are obtained from desk study and site walkover, e.g. properties of peat/soil/rock, slope geometry, depth of peat, underlying strata, groundwater, etc. An adverse combination of the factors listed above could potentially result in instability. Using the information above, a factor of safety is calculated for the stability of individual parcels of peatland on a site (as discussed in Section 7).

The factor of safety is a measure of the stability of a particular slope. For any slope, the degree of stability depends on the balance of forces between the weight of the soil/peat working downslope (destabilising force) and the inherent strength of the peat/soil (shear resistance) to resist the downslope weight, see Figure 2.2.

Figure 2.2: Peat Slope Showing Balance of Forces to Maintain Stability



The factor of safety provides a direct measure of the degree of stability of a slope and is the ratio of the shear resistance over the downslope destabilising force. Provided the available shear resistance is greater than the downslope destabilising force then the factor of safety will be greater than 1.0 and the slope will remain stable. If the factor of safety is less than 1.0 the slope is unstable and liable to fail. The acceptable range for factor of safety is typically from 1.3 to 1.4.

2.7 Applicability of the Factor of Safety (Deterministic) Approach for Peat Slopes

The factor of safety approach is a standard engineering approach in assessing slopes which is applied to many engineering materials, such as peat, soil, rock, etc.

The factor of safety approach is included in the Peat Landslide Hazard and Risk Assessments Best Practice Guide for Proposed Electricity Generation Developments (PLHRAG, 2017); see Section 5.3.1 of the guide. This guide provides best practice methods to identify, mitigate and manage peat slide hazards and associated risks in respect of consent applications for electricity generation projects.

Furthermore, the best practice guide notes that the results from the factor of safety approach 'has provided the most informative results' with respect to analysing peat stability (Section 5.3.1 of the guide).

The factor of safety approach in this report includes undrained (short-term stability) and drained (long-term stability) analyses. The undrained condition is the critical condition for the development. The purpose of the drained analysis is to identify the relative susceptibility of rainfall-induced failures at the site.

Notwithstanding the above, the stability analysis used by FT in this report also includes qualitative factors to determine the potential for peat stability i.e. the analysis used does not solely rely on the factor of safety approach.

The deterministic analysis is considered an acceptable engineering design approach. This concurs with the best practice guide referenced above.

2.8 Assessment of Intense Rainfall and Extreme Dry Events on the Peat Slope

The deterministic approach carried out by FT examines intense rainfall and extreme dry events. The deterministic approach includes and undrained (short-term stability) and drained (long-term stability) analysis to assess the factor of safety for the peat slopes against a peat failure.

The drained loading condition applies in the long-term. This condition examines the effect of the change in groundwater level as a result of rainfall on the existing stability of the natural peat slopes. For the drained analysis the level of the water table above the failure surface is required to calculate the factor of safety for the peat slope.

In order to represent varying water levels within the peat slopes, a sensitivity analysis is carried out which assesses varying water level in the peat slopes i.e. water levels ranging from 0 to 100% of the peat depth is conducted, where 0% equates to the peat been completely dry and 100% equates to the peat being fully saturated.

By carrying out such a sensitivity analysis with varying water level in the peat slopes, the effects of intense rainfall and extreme dry events are considered and analysed. The results of which are presented in Section 7 of this report.

3. DESK STUDY

3.1 Desk Study

The main relevant sources of interest with respect to the site include:

- Geological plans and Geological Survey of Ireland database
- Ordnance Survey plans
- Literature review of peat failures

The Geological Survey of Ireland online dataset viewer (GSI, 2022) for the site were used to verify the soil and bedrock conditions.

The Ordnance Survey plans were reviewed to determine if any notable features or areas of particular interest (from a geotechnical point of view) are present on the site.

The desk study also includes a review of both published literature and GSI online dataset viewer (GSI, 2022) on peat failures/landslides in the vicinity of the site.

3.2 Soils, Subsoil & Bedrock

A review of the Geological Survey of Ireland online database and published documents from GSI was carried out.

The GSI subsoils maps indicates that the site is underlain predominantly by Till derived from Namurian sandstones and shales. Bedrock outcrop or subcrop is mapped on the more elevated central and eastern sections of the wind farm site. There are some localised areas of blanket peat identified in the northern section of the site, close to T7. Two areas have been identified as alluvium within the GSI subsoils maps. These locations correspond with two streams running through the site.

In relation to bedrock, the site location and surrounding area is underlain by the following formations:

- Coolbaun Formation, described as consisting of shales and sandstone with thin coals
- Swan Sandstone Member, described as laminated dark-grey siliceous sandstone

There are no fault lines identified through the wind farm site . However, 2 no. fault lines have been identified 0.8km east and 1.4km west.

The nearest quarry is located approximately 5km south-east from the development site and has a rock type as limestone. Another quarry was identified approximately 7.5km north-east of the site boundary, again described as limestone. The final quarry identified within a 10km radius of the project is located approximately 8km south of the site boundary and is described as flagstone. There are no other quarries located within a 10km radius of the site.

No karst features were identified within 5km of the wind farm.

No geological heritage sites are noted within the vicinity of the site boundary. The closest geological heritage site is located approximately 5km south-east of the proposed development and is described as a very large deep working quarry.

According to GSI data, no previous failures have been recorded within 15km of the wind farm. The landslide susceptibility of the site was classified by the GSI (2022) as predominantly low, but ranges from low to moderately high susceptibility, which is expected given the undulating terrain present.

4. FINDINGS OF SITE RECONNAISSANCE

4.1 Site Reconnaissance

As part of the assessment of potential peat failure at the proposed site, FT carried out a site reconnaissance in conjunction with the desk study review described in Section 3. This comprised a walkover inspection of the site with recording of salient geomorphological features with respect to the wind farm development which included peat depth and preliminary assessment of peat strength. General photographs of the site are included at the end of the main text.

The following salient geomorphological features were considered:

- Active, incipient or relict instability (where present) within the peat deposits
- Presence of shallow valley or drainage line
- Wet areas
- Any change in vegetation
- Peat depth
- Slope inclination and break in slope

The survey covered the proposed locations for the turbine bases and associated infrastructure.

The site reconnaissance adopted for carrying out the site reconnaissance relied on experienced practitioners carrying out a visual assessment of the site supplemented with measurement of slope inclinations.

4.2 Findings of Site Reconnaissance

The site reconnaissance undertaken by FT comprised a walkover inspection of the site on 21st June. Weather conditions for the site visit was dry. Subsoil maps indicates that the site is underlain predominantly of Till derived from Namurian sandstones and shales. Bedrock outcrop or subcrop is mapped on the more elevated central and eastern sections of the wind farm site. There are some localised areas of blanket peat identified in the northern section of the site, close to T7. Two areas have been identified as alluvium within the GSI subsoils maps. These locations correspond with two streams running through the site.

The main findings of the site walkover of the wind farm site are as follows:

(1) A total of approximately 40 no. peat depth probes were carried out on site during the various site visits. Peat/peaty topsoil depths recorded across the site ranged from 0.0m (no peat) to 0.8m with an average depth of 0.12m (Figure 4-1). 70 percent of peat depth probes recorded no peat. A number of localised readings were recorded where peat/peaty topsoil depths were between 0.5 and 0.8m.

(2) Peat/peaty topsoil, where recorded, is shallow and localised/isolated in nature. Peat is described as firm with intact fibres visible. This is not an intact blanket bog deposit but is more likely to be a remnant of a more localised peat deposit.

(3) The peat/peaty topsoil depths recorded at the turbine locations varied from 0.0 to 0.6m with an average depth of 0.23m.

(4) With respect to the new access tracks, peat/peaty topsoil depths are typically less than 0.2 (average 0.12m) with localised depths of up to 0.6m recorded.

(5) Slope angles at the turbine locations ranged from 2 to 9 degrees. These slope angle readings were obtained using a combination of readings taken during the site reconnaissance by FT using handheld equipment, such as the Silva Clino Master which has an accuracy of +/- 0.25 degrees and from contour survey plans for the site.

(6) The slope angle quoted typically reflects the slope within the footprint of each infrastructure location. The relatively flat topography/nature of the terrain on site highlights the low risk of peat failure.

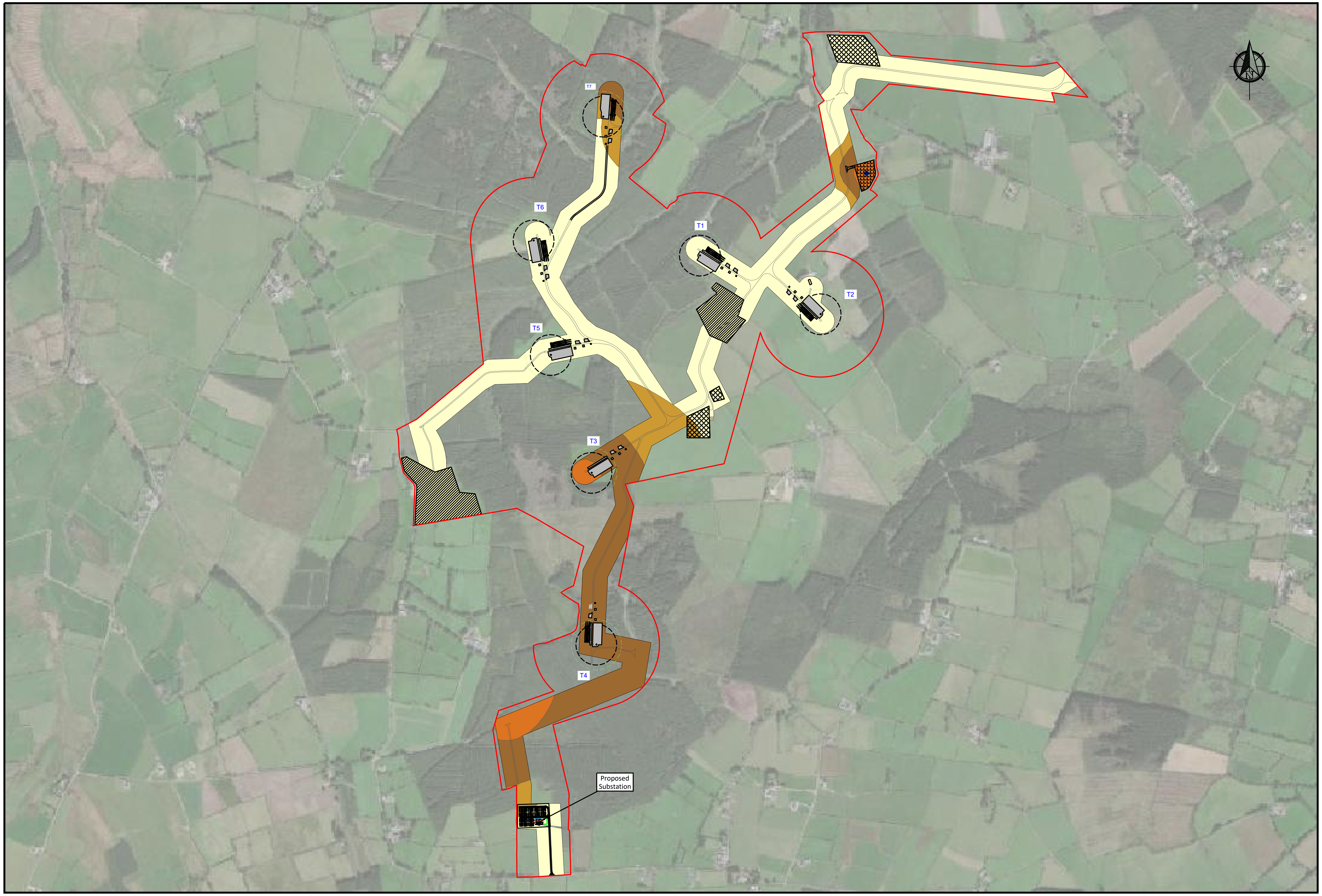
(7) A summary of the site walkover findings for the wind farm are as follows:

(a) The site is typically covered by a layer of cohesive overburden (glacial till) with localised/isolated pockets of shallow peat/peaty topsoil present across the site. Peat/peaty topsoil depths recorded across the site ranged from 0.0m (no peat) to 0.8m with an average depth of 0.12m.

(b) The results of the peat depth probing, shear strength testing of the peat and qualitative factors identified on site have been used in the stability and risk assessments, see Sections 6, 7 and 8 of this report for details.

(c) Based on the findings from the walkover survey, the proposed wind farm development is considered to have a **low** risk of peat failure or ground instability, due to the limited and shallow nature of the peat/peaty topsoil present across the site.

In summary, based on the findings from the site reconnaissance, the wind farm site would be considered to have a **low** risk of peat instability.



Legend:

- Proposed Turbine Location
- Proposed Access Track
- Proposed Met Mast Location
- Proposed Site Compound
- Proposed Soil Deposition Area
- Proposed Borrow Pit & Soil Deposition Area
- Application Boundary

Peat Depth Legend:

- No peat
- > 0 < 0.1
- ≥ 0.1 < 0.5
- ≥ 0.5 < 0.75
- < 0.75

PLAN

Scale 1:15000

0m 75m 150m 225m 300m 375m 450m 525m 600m 675m 750m

Scale 1:15000

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Rev.	Description	App By	Date
A	FOR INFORMATION	BDH	27.06.22

PROJECT: WHITE HILL WIND FARM

CLIENT: WHITE HILL WIND LIMITED

SHEET: FIGURE 4.1 - PEAT DEPTH CONTOUR PLAN

Date	Project number	Scale (@ A3)	
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Thursday 7 July 2022

5. GROUND INVESTIGATION

A ground investigation in the form of trial pits was carried out by Hydro Environmental Services (HES) on the 6th of October 2021. The ground investigations comprised 9 no. trial pits and 2 no. gouge cores. The trial pits were carried out at all turbine locations with the exception of turbine locations T4 and T7, which are located in dense coniferous forestry and are not currently accessible by track machine. Soil gouge cores were carried out a turbines T4 and T7 as an alternative.

The trial pits logs and photographs are included within Appendix E of this report. A ground investigation location plan is included within the EIAR Soils & Geology chapter (Chapter 6).

5.1 Summary of Ground Conditions

The ground conditions at the site from the trial pit logs can be typically categorised into the following deposits:

Peaty Topsoil – up to 0.15m in thickness in trial pits. Deeper peat/peaty topsoil was recorded from peat probes undertaken across the site, which is to be expected due to natural variability in the ground conditions.
Glacial Till – Firm to very firm gravelly SILT or SILT/CLAY. The thickness of the layer is variable across the site.
Weathered Bedrock – described as extremely weak to weak weathered Shale.

7 of the 9 no. trial pits encountered bedrock at depths varying between 0.5m and 1.9m. Weathered bedrock was recorded at 4 no. of the 5 no. turbine locations (T1, T2, T3 & T5) where trial pits were carried out.

No groundwater strikes were recorded in the trial pits.

5.2 Summary of Geotechnical Parameters

Table 5-1 contains characteristic geotechnical parameters for the main material types likely to be encountered on the White Hill wind farm site. Where direct measurement of parameters has not been carried out, established correlations with measured properties have been used to derive values. Characteristic values are defined as a cautious estimate of the value affecting the occurrence of limit state based on clause 2.4.5.2 from Eurocode 7.

Table 5-1: Summary of Geotechnical Parameters

Material Type/Strata	Unit Weight	Geotechnical Parameters		
		Undrained Parameters	Drained Parameters	
	γ (kN/m^3)	c_u (kPa)	φ' (°)	c' (kPa)
Peat/Peaty Topsoil	10	8 (3)	25	4
Glacial Till	19	30	30	0
Weathered Bedrock	21	-	30	100

Notes
Note (1) The above parameters are indicative only and have been derived based on experience and from a review of the ground investigation carried out at the site.

Note (2) Where direct measurement of parameters has not been carried out, established correlations with measured properties have been used to derive values.

Note (3) A lower bound undrained shear strength, c_u for the peat of 8kPa was selected. The lowest recorded value on the White Hill wind farm site was 21kPa, recorded in one location, hence a value of 8kPa is a conservative value.

6. PEAT DEPTHS, STRENGTH & SLOPE AT PROPOSED INFRASTRUCTURE LOCATIONS

As part of the site walkover, peat depth, in-situ peat strength and slope angles were recorded at various locations across the site.

6.1 Peat Depth

Peat depth probes were carried out at/near to turbine locations and access tracks and other main infrastructure elements.

6.2 Peat Strength

The strength testing was carried out in-situ using a Geonor H-60 Hand-Field Vane Tester. From FT's experience hand vanes give indicative results for in-situ strength of peat and would be considered best practice for the field assessment of peat strength.

6.3 Slope Angle

The slope angles at each of the main infrastructure locations were obtained using a combination of readings taken during the site reconnaissance by FT using handheld equipment, such as the Silva Clino Master

The slope angle quoted typically reflects the slope within the footprint of each infrastructure location. It should be noted that slope angles derived from contour survey plans would be considered approximate, as such surveys are dependent on the density of survey data and do not always reflect local variations in ground topography. Slope angles recorded during the site reconnaissance by FT using handheld equipment would generally be deemed more accurate and representative of local topography.

6.4 Summary of Findings

Based on the depths recorded across the site by FT, peat/peaty topsoil was only recorded in localised/isolated areas across the site, varying in depth from 0.0 to 0.8m with an average depth of 0.12m. All peat depth probes carried out on site have been utilised to produce a peat depth contour plan for the site (Figure 4.1).

A summary of the peat/peaty topsoil depths at infrastructure locations is given in Table 6.1. The data presented in Table 6.1 is used in the peat stability assessment of the site.

Table 6.1: Peat Depth & Slope Angle at Proposed Infrastructure Locations

Turbine	Easting	Northing	Peat Depth (m)(2)	Slope Angle (°)(1)
T1	661462	667051		4
T2	661941	666818		6
T3	661032	666188	0.15-0.6	2
T4	661051	665506	0-0.5	3
T5	660870	666656		5
T6	660802	667111		3
T7	661078	667603	0-0.5	4
Met Mast	661509	666404		4
Site Compound (1)	662119	667377	0-0.8	5
Substation	660863	664820		2
Borrow Pit (1)	662069	667870		8
Borrow Pit (2)	661529	666498	0.1	5
Borrow Pit (3)	661460	666377	0-0.1	5
Soil Deposition Area (1)	661542	666826		3
Soil Deposition Area (2)	660416	666104		3

Note (1) The slope angles at each of the main infrastructure locations were obtained using a combination of readings taken during the site reconnaissance by FT using handheld equipment, such as the Silva Clino Master (which has an accuracy of +/- 0.25 degrees). The slope angle quoted typically reflects the slope within the footprint of each infrastructure location.

Note (2) Deeper peat/peaty topsoil was recorded from peat probes when compared to trial pits undertaken across the site, which is to be expected due to natural variability in the ground conditions. Peat depths are not consistent across the site or, indeed, at infrastructure locations which serves to demonstrate the isolated and localised nature of areas of peat/peaty topsoil

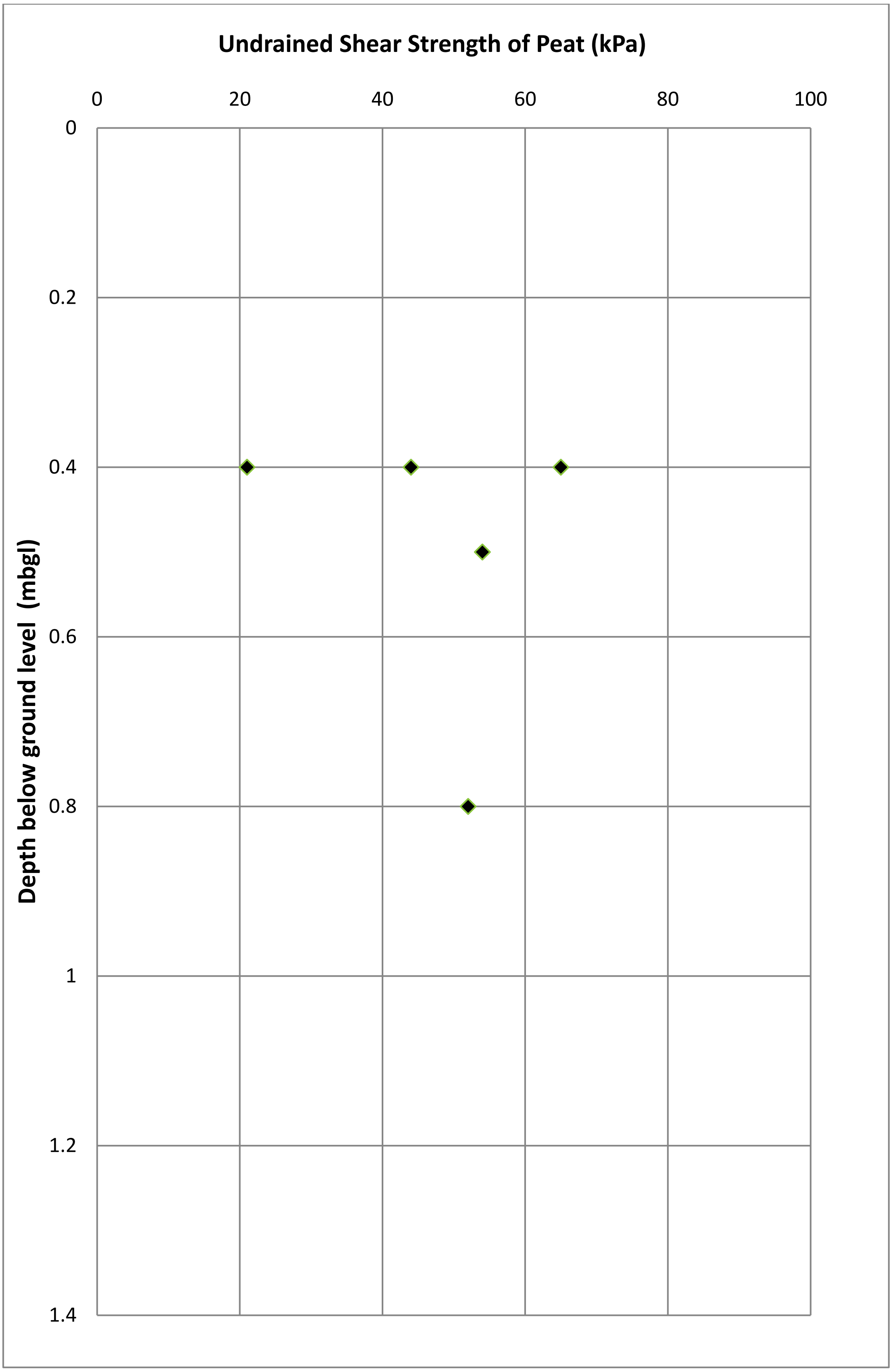
Note (3) The data presented in the Table above is used in the peat stability assessment of the site.

In addition to probing, in-situ shear vane testing was carried out as part of the site walkover. Strength testing was carried out at selected locations across the site to provide representative coverage of indicative peat strengths. The results of the vane testing with depth are presented in Figure 6.1.

The hand vane results indicate undrained shear strengths in the range 21 to 54kPa, an average value of about 40kPa. This strength range is to be expected due to the shallow and localised peat deposits on the proposed wind farm site.

Peat strength at sites of known peat failures (assuming undrained loading failure) are generally very low, for example the undrained shear strength at the Derrybrien failure (AGEC, 2004) as derived from back-analysis, was estimated at 2.5kPa. The recorded undrained strength at the White Hill Wind Farm site is significantly greater than the lower bound values for Derrybrien indicating that there is no close correlation to the peat conditions at the Derrybrien site and that there is significantly less likelihood of failure on the White Hill Wind Farm site.

Figure 6.1: Undrained Shear Strength (c_u) Profile for Peat with Depth



7. PEAT STABILITY ASSESSMENTS

The peat stability assessment includes an assessment of the stability of the natural peat slopes for individual parcels across the site including at the turbine locations and along the proposed access tracks. The assessment also analyses the stability of the natural peat slopes with a surcharge loading of 10kPa, equivalent to placing 1m of stockpiled peat on the surface of the peat slope.

7.1 Methodology for Peat Stability Assessment

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

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

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

1. The undrained loading condition applies in the short-term during construction and until construction induced pore water pressures dissipate.

2. The drained loading condition applies in the long-term. The condition examines the effect of the change in groundwater level as a result of rainfall on the existing stability of the natural peat slopes.

Undrained shear strength values (c_u) for peat are used for the total stress analysis. Based on the findings of the 2003 Derrybrien failure and other failures in peat, undrained loading during construction was found to be the critical failure mechanism.

A drained analysis requires effective cohesion (c') and effective friction angle (ø') values for the calculations. These values can be difficult to obtain because of disturbance experienced when sampling peat and the difficulties in interpreting test results due to the excessive strain induced within the peat. To determine suitable drained strength values a review of published information on peat was carried out. Table 7.1 shows a summary of the published information on peat together with drained strength values.

From Table 8.1 the values for c' ranged from 1.1 to 8.74kPa and ø' ranged from 21.6 to 43°. The average c' and ø' values are 4.5kPa and 30° respectively. Based on the above, it was considered to adopt a conservative approach and to use design values below the averages. For design the following general drained strength values have been used for the site:

c' = 4kPa
ø' = 25°

Table 7.1: List of Effective Cohesion and Friction Angle Values for Peat

Reference	Cohesion, c' (kPa)	Friction Angle, ø' (degs)	Testing Apparatus/ Comments
Hanrahan et al (1967)	5 to 7	36 to 43	From triaxial apparatus
Rowe and Mylleville (1996)	2.5	28	From simple shear apparatus
Landva (1980)	2 to 4	27.1 to 32.5	Mainly ring shear apparatus for normal stress greater than 13kPa
	5 to 6	-	At zero normal stress
Carling (1986)	6.5	0	-
Farrell and Hebib (1998)	0	38	From ring shear and shear box apparatus. Results are not considered representative.
	0.61	31	From direct simple shear (DSS) apparatus. Result considered too low therefore DSS not considered appropriate
Rowe, Maclean and Soderman (1984)	1.1	26	From simple shear apparatus
	3	27	From DSS apparatus
McGreever and Farrell (1988)	6	38	From triaxial apparatus using soil with 20% organic content
	6	31	From shear box apparatus using soil with 20% organic content
Hungr and Evans (1985)	3.3	-	Back-analysed from failure
Dykes and Kirk (2006)	3.2	30.4	Test within acrotelm
Dykes and Kirk (2006)	4	28.8	Test within catotelm
Warburton et al (2003)	5	23.9	Test in basal peat
Warburton et al (2003)	8.74	21.6	Test using fibrous peat
Hendry et al (2012)	0	31	Remoulded test specimen
Komatsu et al (2011)	8	34	Remoulded test specimen
Zwanenburg et al (2012)	2.3	32.3	From DSS apparatus
Den Haan & Grognet (2014)	-	37.4	From large DSS apparatus
O'Kelly & Zhang (2013)	0	28.9 to 30.3	Tests carried out on reconstituted, undisturbed and blended peat samples

7.2 Analysis to Determine Factor of Safety (Deterministic Approach)

The purpose of the analysis was to determine the Factor of Safety (FoS) of peat slopes using infinite slope analysis. The analysis was carried out at the turbine locations, along the access tracks and at various other infrastructure locations across the site.

The FoS provides a direct measure of the degree of stability of the slope. A FoS of less than unity indicates that a slope is unstable, a FoS of greater than unity indicates a stable slope.

The acceptable safe range for FoS typically ranges from 1.3 to 1.4. The previous code of practice for earthworks BS 6031:1981 (BSI, 1981), provided advice on design of earthworks slopes. It stated that for a first-time failure with a good standard of site investigation the design FoS should be greater than 1.3.

As a general guide the FoS limits for peat slopes in this report are summarised in Table 7.2.

Table 7.2: Factor of Safety Limits for Slopes

Factor of Safety (FoS)	Degree of Stability
Less than 1.0	Unstable (red)
Between 1.0 and 1.3	Marginally stable (yellow)
1.3 or greater	Acceptable (green)

Eurocode 7 (EC7) (IS EN 1997-1:2005) now serves as the reference document and the basis for design geotechnical engineering works. The design philosophy used in EC7 applies partial factors to soil parameters, actions and resistances. Unlike the traditional approach, EC7 does not provide a direct measure of stability, since global Factors of Safety are not used.

As such, and in order to provide a direct measure of the level of safety on a site, EC7 partial factors have not been used in this stability assessment. The results are given in terms of FoS.

A lower bound undrained shear strength, c_u for the peat of 8kPa was selected for the assessment based on the c_u values recorded at the site. It should be noted that a c_u of 8kPa for the peat is considered a conservative value for the analysis and is not representative of all peat present across the site. In reality the peat generally has a higher undrained strength.

The formula used to determine the factor of safety for the undrained condition in the peat (Bromhead, 1986) is as follows:

$$F = \frac{c_u}{\gamma z \sin\alpha \cos\alpha}$$

Where:

F = Factor of Safety

c_u = Undrained strength

γ = Bulk unit weight of material

z = Depth to failure plane assumed as depth of peat

α = Slope angle

The formula used to determine the factor of safety for the drained condition in the peat (Bromhead, 1986) is as follows:

$$F = \frac{c' + (\gamma z - \gamma_w h_w)\cos^2\alpha \tan\phi'}{\gamma z \sin\alpha \cos\alpha}$$

Where:

F = Factor of Safety

c' = Effective cohesion

γ = Bulk unit weight of material

z = Depth to failure plane assumed as depth of peat

γ_w = Unit weight of water

h_w = Height of water table above failure plane

α = Slope angle

ø' = Effective friction angle

For the drained analysis the level of the water table above the failure surface is required to calculate the factor of safety for the slope. Since the water level in blanket peat can be variable and can be recharged by rainfall, it is not feasible to establish its precise location throughout the site. Therefore, a sensitivity analysis using water level ranging between 0% and 100% of the peat depth was conducted, where 0% equates to the peat being completely dry and 100% equates to the peat been fully saturated.

The following general assumptions were used in the analysis of peat slopes at each location:

(1) Peat depths are based on the maximum peat depth recorded at each location from the walkover surveys.

(2) The slope angles used in the peat stability assessment were obtained using readings taken during the site reconnaissance by FT using handheld equipment.

(3) Slope angle at base of sliding assumed to be parallel to ground surface.

(4) A lower bound undrained shear strength, c_u for the peat of 8kPa was selected for the assessment. The lowest recorded value on the White Hill wind farm site during the site walkover was 21kPa. It should be noted that a c_u of 8kPa for the peat is considered a conservative value for the analysis and is not representative of all peat present across the site. In reality, the majority of the peat has a significantly higher undrained strength as a result of the shallow nature of the peat across the site.

For the stability analysis two load conditions were examined, namely

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

7.3 Results of Analysis

7.3.1 Undrained Analysis for the Peat

The results of the undrained analysis for the natural peat slopes are presented in Appendix C and the results of the undrained analysis for the most critical load case (load condition 2) are shown on Figure 7.1. The undrained analysis for load condition 2 is considered the most critical load case as most peat failures occur in the short term upon loading of the peat surface. The results from the main infrastructure locations are summarised in Table 7.3. The remainder of the locations where an analysis has been undertaken are along access tracks, and these results are included in Appendix C. The range of FoS results at all locations across the site is summarised below.

The calculated FoS for load condition 1 is in excess of 1.30 for each of the locations (13 no. locations in total where peat was recorded across the site) analysed with a range of FoS of 11.52 to 114.68, indicating a low risk of peat instability.

The calculated FoS for load condition 2 is in excess of 1.30 for each of the locations (13 no. locations in total where peat was recorded across the site) analysed with a range of FoS of 5.12 to 19.11, indicating a low risk of peat instability.

Table 7.3: Factor of Safety Results (Undrained Condition)

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T1	661462	667051	No peat encountered	
T2	661941	666818	No peat encountered	
T3	661032	666188	**38.23**	**14.34**
T4	661051	665506	**30.61**	**10.20**
T5	660870	666656	No peat encountered	
T6	660802	667111	No peat encountered	
T7	661078	667603	**22.99**	**7.66**
Met Mast	661509	666404	No peat encountered	
Site Compound	662119	667377	**11.52**	**5.12**
Substation	660863	664820	No peat encountered	
Borrow Pit (1)	662069	667870	No peat encountered	
Borrow Pit (3)	661529	666498	**92.14**	**8.38**
Borrow Pit (4)	661460	666377	**92.14**	**8.38**
Soil Deposition Area (1)	661542	666826	No peat encountered	
Soil Deposition Area (2)	660416	666104	No peat encountered	

Legend:

- Proposed Turbine Location
- Proposed Access Track
- Proposed Met Mast Location
- Proposed Site Compound
- Proposed Soil Deposition Area
- Proposed Borrow Pit & Soil Deposition Area
- Application Boundary

Factor of Safety Legend:

- 0 < 1.0
- ≥ 1.0 < 1.3
- ≥ 1.3

Increasing Stability

No Peat Recorded At This Location

0m 75m 150m 225m 300m 375m 450m 525m 600m 675m 750m

Scale 1:15000

PLAN

Scale 1:15000

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Rev.	Description	App By	Date
A	FOR INFORMATION	BDH	27.06.22

PROJECT: WHITEHILL WIND FARM

CLIENT: GALETECH ENERGY SERVICES

SHEET: FACTOR OF SAFETY - SHORT TERM CRITICAL CONDITION (UNDRAINED)

Date	Project number	Scale (@ A3)
27.06.22	P22-148	1:15000

Drawn by	Drawing Number	Rev
POR	P22-148-0600-0001	A

Checked by: IH

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Monday 27 June 2022

7.3.2 Drained Analysis for the Peat

The results of the drained analysis for the peat are presented in Appendix C. The results from the main infrastructure locations are summarised in Table 7.6. As stated previously, the drained loading condition examines the effect of in particular, rainfall on the existing stability of the natural peat slopes and represents the post construction phase of the development. The results from the main infrastructure locations are summarised in Table 7.4. The remainder of the locations where an analysis has been undertaken are along access tracks, and these results are included in Appendix C. The range of FoS results at all locations across the site is summarised below.

The calculated FoS for load condition 1 is in excess of 1.30 for each of the locations (13 no. locations in total where peat was recorded across the site) analysed with a range of FoS of 5.76 to 57.34, indicating a low risk of peat instability.

The calculated FoS for load condition 2 is in excess of 1.30 for each of the locations (13 no. locations in total where peat was recorded across the site) analysed with a range of FoS of 5.52 to 20.68, indicating a low risk of peat instability.

Table 7.4: Factor of Safety Results (Drained Conditions)

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T1	661462	667051	No peat encountered	
T2	661941	666818	No peat encountered	
T3	661032	666188	**19.11**	**15.51**
T4	661051	665506	**15.31**	**11.03**
T5	660870	666656	No peat encountered	
T6	660802	667111	No peat encountered	
T7	661078	667603	**11.50**	**8.28**
Met Mast	661509	666404	No peat encountered	
Site Compound	662119	667377	**5.76**	**5.52**
Substation	660863	664820	No peat encountered	
Borrow Pit (1)	662069	667870	No peat encountered	
Borrow Pit (2)	661529	666498	**46.07**	**9.03**
Borrow Pit (3)	661460	666377	**46.07**	**9.03**
Soil Deposition Area (1)	661542	666826	No peat encountered	
Soil Deposition Area (2)	660416	666104	No peat encountered	

8. PEAT STABILITY RISK ASSESSMENT

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

The risk assessment uses the results of the stability analysis (deterministic approach) in combination with qualitative factors, which cannot be reasonably included in a stability calculation but nevertheless may affect the occurrence of peat instability, to assess the risk for each infrastructure element.

For each of the main infrastructure elements, a risk rating (product of probability and impact) is calculated and rated as shown in Table 8.1. Where a subsection is rated 'Medium' or 'High', control measures are required to reduce the risk to at least a 'Low' risk rating. Where a subsection is rated 'Low' or 'Negligible', only routine control measures are required.

Table 8.1: Risk Rating Legend

17 to 25	High: avoid works in area or significant control measures required
11 to 16	Medium: notable control measures required
5 to 10	Low: only routine control measures required
1 to 4	Negligible: none or only routine control measures required

A full methodology for the peat stability risk assessment is given in Appendix D.

8.1 Summary of Risk Assessment Results

The results of the peat stability risk assessment for potential peat failure at the main infrastructure elements is presented as a Geotechnical Risk Register in Appendix B and summarised in Table 8.2.

The risk rating for each infrastructure element at the White Hill Wind Farm is designated low following some mitigation/control measures being implemented. Sections of access tracks to the nearest infrastructure element will be subject to the same mitigation/control measures that apply to the nearest infrastructure element.

Details of the required mitigation/control measures can be found in the Geotechnical Risk Register for each infrastructure element (Appendix B) and are summarised below:

- Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.
- Use of experienced geotechnical staff for site investigation.
- Maintain hydrology of area as far as possible by maintaining existing drains to prevent the build-up of water pressures in the peat, leading to the peat becoming "buoyant".
- Use of experienced contractors and trained operators to carry out the work.

Table 8.2: Summary of Peat Stability Risk Register

Infrastructure	Pre-Control Measure Implementation Risk Rating	Pre-Control Measure Implementation Risk Rating Category	Notable Control Measures Required	Post-Control Measure Implementation Risk Rating	Post-Control Measure Implementation Risk Rating Category
T1	No peat recorded at location				
T2	No peat recorded at location				
T3	Negligible	1 to 4	No	Negligible	1 to 4
T4	Negligible	1 to 4	No	Negligible	1 to 4
T5	No peat recorded at location				
T6	No peat recorded at location				
T7	Negligible	1 to 4	No	Negligible	1 to 4
Met Mast	No peat recorded a location				
Site Compound	Low	5 to 10	No	Low	5 to 10
Substation	No peat recorded at location				
Borrow Pit (1)	No peat recorded at location				
Borrow Pit (2)	Negligible	1 to 4	No	Negligible	1 to 4
Borrow Pit (3)	Negligible	1 to 4	No	Negligible	1 to 4
Soil Deposition Area (1)	No peat recorded at location				
Soil Deposition Area (2)	No peat recorded at location				

9. INDICTATIVE FOUNDATION TYPE AND FOUNDATION DEPTH FOR TURBINES

9.1 Summary

Based on a review of the ground investigation and walkover information for the wind farm site, a preliminary assessment of the likely foundation type and founding depths for each turbine location was carried out, where possible. A summary of this assessment is provided in Table 9-1.

Table 9-1: Summary of Indicative Turbine Foundation Type and Founding Depths

Turbine No.	Turbine Foundation Type	Relevant GI	Indicative founding depth (m bgl)	Comment
T01	Gravity foundation	TP_T1	2m	Weathered bedrock indicated at 1.9m bgl.
T02	Gravity foundation	TP_T2	2m	Weathered bedrock indicated at 1.0m bgl.
T03	Gravity foundation	TP_T3	2m	Weathered bedrock indicated at 1.4m bgl.
T04	Gravity foundation	GC_T4_1 & GC_T4_2	-	
T05	Gravity foundation	TP_T5	2m	Weathered bedrock indicated at 0.6m bgl.
T06	Gravity foundation	TP_T6	3m	Stiff grey Silt to 2.9m bgl.
T07	Gravity foundation	GC_T7_1 & GC_T7_2	-	
Substation	Gravity foundation	TP_SUB	1m	Weathered bedrock indicated at 1.0m bgl.
Met Mast	Gravity foundation	TP_BP3	1m	Weathered bedrock indicated at 0.7m bgl.

It should be noted that further ground investigation will be carried out prior to construction at each turbine location to confirm the foundation types and founding stratums assumed in Table 9-1. It is likely that following the completion of further ground investigation prior to construction that the turbine bases will be deemed suitable for gravity type foundations.

For gravity type turbine foundations, where the depth of excavation exceeds the required founding depth for the turbine base, up-fill material consisting of granular fill (6N) shall be used to backfill the excavation to the required founding depth.

Excavation slopes for turbine bases will be stable at 1(v):2(h) in overburden materials and 1(v):1(h) in weathered and intact rock. No groundwater was recorded in any of the trial pits and as such no stability issues are anticipated with any turbine excavations.

10. FOUNDING DETAILS FOR INFRASTRUCTURE ELEMENTS (EXCEPT TURBINES)

This section provides a summary of the founding details for various elements of the proposed infrastructure across the wind farm site. The detailed methodologies for the construction of these elements of the proposed development are included in Chapter 3 of the EIAR.

10.1 Access Tracks

The access tracks on site will be constructed as excavate and replace (founded) type construction, which, given the ground conditions and type of terrain present, is deemed an appropriate construction approach.

The total length of new access tracks to be constructed on site is c. 7km. Excavation slopes for access tracks will be stable at 1(v):2(h) in overburden materials. No stability issues are anticipated for excavation side slopes for access tracks.

The proposed make-up of the founded access tracks is a minimum stone thickness of 500mm. The requirement for a layer of geotextile and geogrid and the necessary stone thickness will be confirmed at pre-construction stage.

10.2 Crane Hardstands

The crane hardstands will be constructed using the founded technique (i.e. not floated) technique. The hardstands will require to be founded on competent material underlying any peat/peaty topsoil or soft soils. The founding levels for the hardstands will be variable across the site and will be confirmed at pre-construction stage.

Crane hardstands are constructed using compacted Class 1/6F material on a suitable sub-formation to achieve the required bearing resistance. The hardstands will be designed for the most critical loading combinations from the crane. Any excavation slopes required for hardstands will be constructed at a 1(v):2(h) slope in overburden materials and 1(v):1(h) slope in weathered rock.

The typical make-up of the hardstands may include up to 1000mm of granular stone fill with possibly a layer of geotextile and/or geogrid. Hardstand fill will be typically constructed to 1(v)1.5(h) side slopes. No stability issues are anticipated at hardstand locations.

10.3 Substation Foundations & Platforms

The substation platform will be constructed using the founded technique (i.e. not floated technique). The substation foundations will comprise strip/raft foundations under the main footprint of the building with a basement/pit for cable connections. The substation platform will require to be founded on competent material underlying any peat/peaty topsoil or soft soils.

The substation platform is constructed using compacted Class 1/6F material on a suitable sub-formation to achieve the required bearing resistance. The typical founding depth for the substation platform is to be 1.0m bgl.

The typical make-up of the substation platform may include up to 1000mm of granular stone fill with possibly a layer of geotextile and/or geogrid. At the underside of the substation foundations, a layer of structural up-fill (class 6N) will be required.

10.4 Construction Compound Platform

The temporary construction compound platform will be constructed using the founded technique (i.e. not floated technique). The construction compound platform will require to be founded on competent material underlying any peat/peaty topsoil or soft soils.

The construction compound platforms are generally constructed using compacted Class 1/6F material on a suitable sub-formation to achieve the required bearing resistance.

Typical founding depth for the construction compound platform may require excavation to 1.0m bgl.

The typical make-up of the construction compound platform may include up to 750mm of granular stone fill with possibly a layer of geotextile and/or geogrid.

10.5 Spoil Deposition Areas

A number of spoil deposition areas were reviewed as part of the assessment of the site. The locations of these are shown on Figure 4.1. Material in the spoil deposition areas will be placed to a maximum height of 1m. Given the ground conditions recorded in the spoil deposition areas, and the shallow slope angles within the spoil deposition areas, no stability issues are anticipated in these areas. Should any peaty topsoil or localised peat be encountered within the deposition areas, this material should be removed prior to placing spoil and stored within the spoil deposition area or used to topsoil the deposition area once completed.

Where practical, it should be ensured that the surface of the placed material is shaped to allow efficient run-off of surface water. Where possible, shaping of the surface of the placed material should be carried out as placement within the placement area progresses. This will reduce the likelihood of debris run-off and ensure stability of the placed material.

Finished/shaped side slopes of the placed material shall not exceed 1(v):3(h). This slope inclination will be reviewed during construction, as appropriate.

Suitable drainage will be installed around the perimeter of the spoil deposition area in order to control any run-off.

11. CONSTRUCTION OF ACCESS TRACKS

Approximately 7km of new proposed access tracks will be constructed as part of the wind farm . Due to the ground conditions, the access tracks on site will be founded. The typical make-up of the founded access tracks is a minimum stone thickness of 500mm. The requirement for a layer of geotextile and geogrid and the necessary stone thickness will be confirmed prior to construction.

11.1 Construction of New Access Tracks

The excavation of topsoil & soil/peaty soil and founding of access roads on competent stratum for new access tracks will be carried out at various locations on the site.

This methodology includes procedures that are to be included in the construction to minimise any adverse impact on soil stability. The methodology is not intended to cover all aspects of construction such as drainage and environmental considerations.

(1) Interceptor drains will be installed upslope of the access track alignment to divert any surface water away from the construction area.

(2) Excavation will take place to a competent stratum beneath the topsoil/peaty soil (as agreed with the site designer and resident engineer).

(3) The surface of the excavated access track will be overlaid with up to 500mm of selected granular fill. Granular fill to be placed in layers in accordance with the designer’s specification.

(4) Access track to be finished with a layer of capping across the full width of the track.

(5) A layer of geogrid/geotextile may be required at the surface of the competent stratum (to be confirmed by the Site Engineer).

(6) A final surface layer shall be placed over the excavated track, as per design requirements, to provide a suitable profile and graded to accommodate wind turbine construction and delivery traffic.

12. SUMMARY AND RECOMMENDATIONS

12.1 Summary

The following summary is given.

FT was engaged by White Hill Wind Limited to undertake a geotechnical and peat stability assessment of the proposed wind farm site.

The findings of the peat assessment showed that the site has an acceptable margin of safety and is suitable for the wind farm development. While the findings do not indicate any risk of ground instability, recommendations and control measures for construction work are provided to ensure that all works adhere to an acceptable standard of safety.

The site is typically covered in a layer of Glacial Till derived from Namurian sandstones and shales with undulating terrain. Some localised areas of shallow peat/peaty topsoil were identified across the site.

Peat/peaty topsoil was only recorded in isolated areas across the site. Peat/peaty topsoil depths recorded during the site walkovers from approximately 40 probes ranged from 0.0m (no peat) to 0.8m with an average depth of 0.12m. 70% of the peat depth probes recorded no peat.

Slope inclinations at the main infrastructure locations range from 2 to 9 degrees.

An analysis of peat stability was carried out at the main infrastructure locations across site for both the undrained and drained conditions. The purpose of the analysis was to determine the Factor of Safety (FoS) of the peat slopes.

An undrained analysis was carried out, which applies in the short-term during construction. For the undrained condition, the calculated FoS for load conditions 1 and 2 for the locations analysed, showed that all locations have an acceptable FoS of greater than 1.3, indicating a low risk of peat failure. The undrained analysis would be considered the most critical condition for the peat slopes.

A drained analysis was also carried out, which examined the effect of in particular, rainfall on the existing stability of the natural peat slopes on site. For the drained condition, the calculated FoS for load conditions (1) & (2) for the locations analysed, showed that all locations have an acceptable FoS of greater than 1.3.

The peat stability risk assessment undertaken for each infrastructure location identified a number of mitigation/control measures to reduce the potential risk of peat failure, where peat is present. Sections of access tracks to the nearest infrastructure element should be subject to the same mitigation/control measures that apply to the nearest infrastructure element. See Appendix B for details of the required mitigation/control measures for each infrastructure element.

In summary, the findings of the geotechnical and peat assessment showed that the White Hill Wind Farm site has an acceptable margin of safety, is suitable for the wind farm development and is considered to be at **low** risk of peat failure or ground instability. The findings include recommendations and control measures for construction work in peat lands to ensure that all works adhere to an acceptable standard of safety.

12.2 Recommendations

The following recommendations are given.

Notwithstanding that the site has an acceptable margin of safety a number of mitigation/control measures are given to ensure that all works adhere to an acceptable standard of safety for work where peat is present. Mitigation/control measures identified for each of the infrastructure elements in the risk assessment will be taken into account and implemented throughout design and construction works (Appendix B).

The proposed construction method for all the new proposed access tracks at the wind farm is excavate and replace type construction.

To minimise the risk of construction activity causing potential peat instability the Construction Method Statements (CMSs) for the project will take into account, but not be limited, to the recommendations above. This will ensure that best practice guidance regarding the management of peat stability will be inherent in the construction phase.

13. REFERENCES

Applied Ground Engineering Consultants (AGEC) (2004). Derrybrien Wind Farm Final Report on Landslide of October 2003.

British Standards Institute (1981). BS 6031:1981 Code of practice for earthworks.

Bromhead, E.N. (1986). The Stability of Slopes.

Carling, P.A. (1986). Peat slides in Teesdale and Weardale, northern Pennines, July 1983: Description and failure mechanisms. Earth Surface Processes and Landforms, 11.

Clayton, C.R.I. (2001). Managing Geotechnical Risk. Institution of Civil Engineers, London.

Den Haan EJ and Grognet M (2014). A large direct simple shear device for the testing of peat at low stresses. Géotechnique Letters 4(4): 283–288, http://dx.doi.org/10.1680/geolett. 14.00033.

Dykes, A.P. and Kirk, K.J. (2006). Slope instability and mass movements in peat deposits. In Martini, I.P., Martinez Cortizas, A. and Chesworth, W. (Eds.) Peatlands: Evolution and Records of Environmental and Climatic Changes. Elsevier, Amsterdam.

Farrell, E.R. & Hebib, S. (1998). The determination of the geotechnical parameters of organic soils. Proceedings of International Symposium on problematic soils, IS-TOHOKU 98, Sendai, Japan.

Geological Survey of Ireland (1992). Sheet 6 Geology of North Mayo.

Geological Survey of Ireland (2006). Landslides in Ireland. Geological Survey of Ireland -Irish Landslides Group. July 2006.

Geological Survey of Ireland (2022). Online dataset public viewer, June 2022 https://dcenr.maps.arcgis.com/apps/MapSeries/index.html?appid=a30af518e87a4c0ab2fbde2aaac3c228,

Hanrahan, E.T., Dunne, J.M. and Sodha, V.G. (1967). Shear strength of peat. Proc. Geot. Conf., Oslo, Vol. 1.

Hendrick, E. (1990). A Bog Flow at Bellacorrick Forest, Co. Mayo. Irish Forestry, Volume 47 (1): pp 32-44.

Hendry MT, Sharma JS, Martin CD and Barbour SL (2012). Effect of fibre content and structure on anisotropic elastic stiffness and shear strength of peat. Canadian Geotechnical Journal 49(4): 403–415, http://dx.doi.org/10.1139/t2012-003.

Hungr, O. and Evans, S.G. (1985). An example of a peat flow near Prince Rupert, British Columbia. Canadian Geotechnical Journal, 22.

Komatsu J, Oikawa H, Tsushima M and Igarashi M (2011). Ring shear test on peat. In Proceedings of the 21st International Offshore and Polar Engineering Conference, Maui, Hawaii, USA (Chung JS, Hong SY, Langen I and Prinsenberg SJ (eds)). International Society of Offshore and Polar Engineers, Cupertino, CA, USA, vol. 2, pp. 393–396.

Landva, A.O. (1980). Vane testing in peat. Canadian Geotechnical Journal, 17(1).

MacCulloch, F. (2005). Guidelines for the Risk Management of Peat Slips on the Construction of Low Volume/Low Cost Roads over Peat. RoadEx 11 Northern Periphery.

McGeever J. and Farrell E. (1988). The shear strength of an organic silt. Proc. 2nd Baltic Conf., 1, Tallin USSR.

O'Kelly BC and Zhang L (2013). Consolidated-drained triaxial compression testing of peat. Geotechnical Testing Journal 36(3): 310–321, http://dx.doi.org/10.1520/ GTJ20120053.

PLHRAG (2017). Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments. Prepared for Energy Consents Unit Scottish Government, 2nd Edition. Dated April 2017.

Skempton, A. W. and DeLory, F. A. (1957). Stability of natural slopes in London Clay. Proc 4th Int. Conf. On Soil Mechanics and Foundation Engineering, Rotterdam, vol. 2, pp.72-78.

Warburton, J., Higgett, D. and Mills, A. (2003). Anatomy of a Pennine Peat Slide. Earth Surface Processes and Landforms.

Warburton, J., Holden, J. and Mills, A. J. (2003). Hydrological controls of surficial mass movements in peat. Earth-Science Reviews 67 (2004), pp. 139-156.

Zwanenburg C, Den Haan EJ, Kruse GAM and Koelewijn AR (2012). Failure of a trial embankment on peat in Booneschans, the Netherlands. Géotechnique 62(6): 479–490, http://dx.doi.org/10.1680/geot.9.P.094.

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APPENDIX A

Photos from Site Walkover

Photo 1: Existing access track

Photo 2: Route of proposed access track

Photo 3: Route of proposed access track

Photo 4: Proposed Substation location

Photo 5: Proposed Turbine 3 location

Photo 6: Proposed Site Compound location

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APPENDIX B

Peat Stability Risk Registers

White Hill Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Turbine T1

Grid Reference (Eastings, Northings):	**661462**	**667051**
Distance to Watercourse (m)	**100 - 150**	
Min & Max Measured Peat Depth (m):	**0.0**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = n/a (u), n/a (d)	1	2	2	Negligible	No	See Below	1	2	2	Negligible
2	Evidence of sub peat water flow	1	2	2	Negligible	No		1	2	2	Negligible
3	Evidence of surface water flow	1	2	2	Negligible	No		1	2	2	Negligible
4	Evidence of previous failures/slips	0	2	0	Not Applicable	No		0	2	0	Not Applicable
5	Type of vegetation	1	2	2	Negligible	No		1	2	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	1	2	2	Negligible	No		1	2	2	Negligible
7	Evidence of very soft/soft clay at base of peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
8	Evidence of mechanically cut peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
10	Evidence of bog pools	0	2	0	Not Applicable	No		0	2	0	Not Applicable
11	Other	0	2	0	Not Applicable	No		0	2	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Turbine T1**
	Not applicable - No peat recorded at proposed turbine location

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

White Hill Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Turbine T2	
Grid Reference (Eastings, Northings):	661941	666818
Distance to Watercourse (m)	> 150	
Min & Max Measured Peat Depth (m):	0.0	
Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = n/a (u), n/a (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	1	1	1	Negligible	No		1	1	1	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Negligible	No		1	1	1	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	1	1	1	Negligible	No		1	1	1	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Turbine T2**
	Not applicable - No peat recorded at proposed turbine location

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

White Hill Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Turbine T3	
Grid Reference (Eastings, Northings):	661032	666188
Distance to Watercourse (m)	> 150	
Min & Max Measured Peat Depth (m):	0.6	
Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 14.34 (u), 15.51 (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	1	1	1	Negligible	No		2	1	2	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	2	1	2	Negligible	No		2	1	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	1	1	1	Negligible	No		1	1	1	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Turbine T3**
i	Maintain hydrology of area as far as possible;
ii	Installation of appropriate drainage measures to alleviate ingress of surface water into excavations
iii	Use of experienced geotechnical staff for site investigation;
iv	Use of experienced contractors and trained operators to carry out the work;
v	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

White Hill Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Turbine T4	
Grid Reference (Eastings, Northings):	661051	665506
Distance to Watercourse (m)	100 - 150	
Min & Max Measured Peat Depth (m):	0.5	
Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 10.20 (u), 11.03 (d)	1	2	2	Negligible	No	See Below	1	2	2	Negligible
2	Evidence of sub peat water flow	1	2	2	Negligible	No		1	2	2	Negligible
3	Evidence of surface water flow	1	2	2	Negligible	No		1	2	2	Negligible
4	Evidence of previous failures/slips	0	2	0	Not Applicable	No		0	2	0	Not Applicable
5	Type of vegetation	1	2	2	Negligible	No		1	2	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	1	2	2	Negligible	No		1	2	2	Negligible
7	Evidence of very soft/soft clay at base of peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
8	Evidence of mechanically cut peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
10	Evidence of bog pools	0	2	0	Not Applicable	No		0	2	0	Not Applicable
11	Other	0	2	0	Not Applicable	No		0	2	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Turbine T4**
i	Maintain hydrology of area as far as possible;
ii	Installation of appropriate drainage measures to alleviate ingress of surface water into excavations
iii	Use of experienced geotechnical staff for site investigation;
iv	Use of experienced contractors and trained operators to carry out the work;
v	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

White Hill Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Turbine T5	
Grid Reference (Eastings, Northings):	660870	666656
Distance to Watercourse (m)	> 150	
Min & Max Measured Peat Depth (m):	0.0	
Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = n/a (u), n/a (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	2	1	2	Negligible	No		2	1	2	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Negligible	No		1	1	1	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	1	1	1	Negligible	No		1	1	1	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Turbine T5**
	Not applicable - No peat recorded at proposed turbine location

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

White Hill Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	**Turbine T6**

Grid Reference (Eastings, Northings):	**660802**	**667111**
Distance to Watercourse (m)	**100 - 150**	
Min & Max Measured Peat Depth (m):	**0.0**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = n/a (u), n/a (d)	1	2	2	Negligible	No	See Below	1	2	2	Negligible
2	Evidence of sub peat water flow	1	2	2	Negligible	No		1	2	2	Negligible
3	Evidence of surface water flow	1	2	2	Negligible	No		1	2	2	Negligible
4	Evidence of previous failures/slips	0	2	0	Not Applicable	No		0	2	0	Not Applicable
5	Type of vegetation	1	2	2	Negligible	No		1	2	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	1	2	2	Negligible	No		1	2	2	Negligible
7	Evidence of very soft/soft clay at base of peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
8	Evidence of mechanically cut peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
10	Evidence of bog pools	0	2	0	Not Applicable	No		0	2	0	Not Applicable
11	Other	0	2	0	Not Applicable	No		0	2	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Turbine T6**
	Not applicable - No peat recorded at proposed turbine location

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

White Hill Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Turbine T7	
Grid Reference (Eastings, Northings):	661078	667603
Distance to Watercourse (m)	> 150	
Min & Max Measured Peat Depth (m):	0.1 - 0.5	
Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 7.66 (u), 8.28 (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	1	1	1	Negligible	No		1	1	1	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Negligible	No		1	1	1	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	1	1	1	Negligible	No		1	1	1	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Turbine T7**
i	Maintain hydrology of area as far as possible;
ii	Installation of appropriate drainage measures to alleviate ingress of surface water into excavations
iii	Use of experienced geotechnical staff for site investigation;
iv	Use of experienced contractors and trained operators to carry out the work;
v	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

White Hill Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Met. Mast

Grid Reference (Eastings, Northings):	661509	666404
Distance to Watercourse (m)	> 150	
Min & Max Measured Peat Depth (m):	0.0	
Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = n/a (u), n/a (d)	1	3	3	Negligible	No	See Below	1	3	3	Negligible
2	Evidence of sub peat water flow	1	3	3	Negligible	No		1	3	3	Negligible
3	Evidence of surface water flow	1	3	3	Negligible	No		1	3	3	Negligible
4	Evidence of previous failures/slips	0	3	0	Not Applicable	No		0	3	0	Not Applicable
5	Type of vegetation	1	3	3	Negligible	No		1	3	3	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	1	3	3	Negligible	No		1	3	3	Negligible
7	Evidence of very soft/soft clay at base of peat	0	3	0	Not Applicable	No		0	3	0	Not Applicable
8	Evidence of mechanically cut peat	0	3	0	Not Applicable	No		0	3	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	3	0	Not Applicable	No		0	3	0	Not Applicable
10	Evidence of bog pools	0	3	0	Not Applicable	No		0	3	0	Not Applicable
11	Other	0	3	0	Not Applicable	No		0	3	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Met. Mast**
	Not applicable - No peat recorded at proposed infrastructure location

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

White Hill Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Site Compound

Grid Reference (Eastings, Northings):	**662119**	**667377**
Distance to Watercourse (m)	**50 - 100**	
Min & Max Measured Peat Depth (m):	**0.8**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 5.12 (u), 5.52 (d)	1	3	3	Negligible	No	See Below	1	3	3	Negligible
2	Evidence of sub peat water flow	1	3	3	Negligible	No		1	3	3	Negligible
3	Evidence of surface water flow	1	3	3	Negligible	No		1	3	3	Negligible
4	Evidence of previous failures/slips	0	3	0	Not Applicable	No		0	3	0	Not Applicable
5	Type of vegetation	1	3	3	Negligible	No		1	3	3	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	2	3	6	Low	No		2	3	6	Low
7	Evidence of very soft/soft clay at base of peat	0	3	0	Not Applicable	No		0	3	0	Not Applicable
8	Evidence of mechanically cut peat	0	3	0	Not Applicable	No		0	3	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	3	0	Not Applicable	No		0	3	0	Not Applicable
10	Evidence of bog pools	0	3	0	Not Applicable	No		0	3	0	Not Applicable
11	Other	0	3	0	Not Applicable	No		0	3	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Site Compound**
i	Maintain hydrology of area as far as possible;
ii	Installation of appropriate drainage measures to alleviate ingress of surface water into excavations
iii	Use of experienced geotechnical staff for site investigation;
iv	Use of experienced contractors and trained operators to carry out the work;
v	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

White Hill Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Substation

Grid Reference (Eastings, Northings):	660863	664820
Distance to Watercourse (m)	> 150	
Min & Max Measured Peat Depth (m):	0.0	
Control Required:	No	

Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Pre-Control Measure Implementation: Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Post-Control Measure Implementation: Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = n/a (u), n/a (d)	1	2	2	Negligible	No	See Below	1	2	2	Negligible
2	Evidence of sub peat water flow	1	2	2	Negligible	No		1	2	2	Negligible
3	Evidence of surface water flow	1	2	2	Negligible	No		1	2	2	Negligible
4	Evidence of previous failures/slips	0	2	0	Not Applicable	No		0	2	0	Not Applicable
5	Type of vegetation	2	2	4	Negligible	No		2	2	4	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	1	2	2	Negligible	No		1	2	2	Negligible
7	Evidence of very soft/soft clay at base of peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
8	Evidence of mechanically cut peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
10	Evidence of bog pools	0	2	0	Not Applicable	No		0	2	0	Not Applicable
11	Other	0	2	0	Not Applicable	No		0	2	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Substation**
	Not applicable - No peat recorded at proposed infrastructure location

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

White Hill Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Borrow Pit (1)

Grid Reference (Eastings, Northings):	**662069**	**667870**
Distance to Watercourse (m)	**100 - 150**	
Min & Max Measured Peat Depth (m):	**0.0**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = n/a (u), n/a (d)	1	2	2	Negligible	No	See Below	1	2	2	Negligible
2	Evidence of sub peat water flow	1	2	2	Negligible	No		1	2	2	Negligible
3	Evidence of surface water flow	1	2	2	Negligible	No		1	2	2	Negligible
4	Evidence of previous failures/slips	0	2	0	Not Applicable	No		0	2	0	Not Applicable
5	Type of vegetation	1	2	2	Negligible	No		1	2	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	1	2	2	Negligible	No		1	2	2	Negligible
7	Evidence of very soft/soft clay at base of peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
8	Evidence of mechanically cut peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
10	Evidence of bog pools	0	2	0	Not Applicable	No		0	2	0	Not Applicable
11	Other	0	2	0	Not Applicable	No		0	2	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Borrow Pit (1)**
	Not applicable - No peat recorded at proposed infrastructure location

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

White Hill Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Borrow Pit (2)

Grid Reference (Eastings, Northings):	**661529**	**666498**
Distance to Watercourse (m)	**> 150**	
Min & Max Measured Peat Depth (m):	**0.1**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 8.38 (u), 9.03 (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	1	1	1	Negligible	No		1	1	1	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Negligible	No		1	1	1	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	1	1	1	Negligible	No		1	1	1	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Borrow Pit (2)**
i	Maintain hydrology of area as far as possible;
ii	Installation of appropriate drainage measures to alleviate ingress of surface water into excavations
iii	Use of experienced geotechnical staff for site investigation;
iv	Use of experienced contractors and trained operators to carry out the work;
v	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

White Hill Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	**Borrow Pit (3)**

Grid Reference (Eastings, Northings):	**661460**	**666377**
Distance to Watercourse (m)	**> 150**	
Min & Max Measured Peat Depth (m):	**0.1**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 8.38 (u), 9.03 (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	1	1	1	Negligible	No		1	1	1	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Negligible	No		1	1	1	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	1	1	1	Negligible	No		1	1	1	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Borrow Pit (3)**
i	Maintain hydrology of area as far as possible;
ii	Installation of appropriate drainage measures to alleviate ingress of surface water into excavations
iii	Use of experienced geotechnical staff for site investigation;
iv	Use of experienced contractors and trained operators to carry out the work;
v	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

White Hill Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	**Soil Deposition Area (1)**

Grid Reference (Eastings, Northings):	**661542**	**666826**
Distance to Watercourse (m)	**> 150**	
Min & Max Measured Peat Depth (m):	**0.0**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = n/a (u), n/a (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	1	1	1	Negligible	No		1	1	1	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Negligible	No		1	1	1	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	1	1	1	Negligible	No		1	1	1	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Soil Deposition Area (1)**
	Not applicable - No peat recorded at proposed infrastructure location

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

White Hill Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Soil Deposition Area (2)

Grid Reference (Eastings, Northings):	660416	666104
Distance to Watercourse (m)	> 150	
Min & Max Measured Peat Depth (m):	0.0	
Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = n/a (u), n/a (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	1	1	1	Negligible	No		1	1	1	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Negligible	No		1	1	1	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	1	1	1	Negligible	No		1	1	1	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Soil Deposition Area (2)**
	Not applicable - No peat recorded at proposed infrastructure location

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

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APPENDIX C

Calculated FOS for Peat Slopes on Site

Calculated FoS of Natural Peat Slopes for White Hill Wind Farm - Undrained Analysis

Turbine No./Waypoint	Easting	Northing	Slope	Undrained shear strength	Bulk unit weight of Peat	Peat Depth	Surcharge Equivalent Placed Fill Depth (m)	Factor of Safety for Load Condition	
			β (deg)	c_u (kPa)	γ (kN/m^3)	(m)	Condition (2)	Condition (1)	Condition (2)
T1	661462	667051	4	NO PEAT RECORDED AT THIS LOCATION					
T2	661941	666818	6	NO PEAT RECORDED AT THIS LOCATION					
T3	661032	666188	2	8	10	0.60	1.60	**38.23**	**14.34**
T4	661051	665506	3	8	10	0.50	1.50	**30.61**	**10.20**
T5	660870	666656	5	NO PEAT RECORDED AT THIS LOCATION					
T6	660802	667111	3	NO PEAT RECORDED AT THIS LOCATION					
T7	661078	667603	4	8	10	0.50	1.50	**22.99**	**7.66**
Borrow Pit (1)	662069	667870	8	NO PEAT RECORDED AT THIS LOCATION					
Borrow Pit (2)	661529	666498	5	8	10	0.10	1.10	**92.14**	**8.38**
Borrow Pit (3)	661460	666377	5	8	10	0.10	1.10	**92.14**	**8.38**
Soil Deposition Area (1)	661542	666826	3	NO PEAT RECORDED AT THIS LOCATION					
Soil Depsoition Area (2)	660595	666024	3	NO PEAT RECORDED AT THIS LOCATION					
	660416	666104	2	NO PEAT RECORDED AT THIS LOCATION					
Site Compound	662119	667377	5	8	10	0.80	1.80	**11.52**	**5.12**
Met Mast	661509	666404	4	NO PEAT RECORDED AT THIS LOCATION					
Substation	660863	664820	2	NO PEAT RECORDED AT THIS LOCATION					
R2	662736	667722	4	NO PEAT RECORDED AT THIS LOCATION					
R3	662487	667753	5	NO PEAT RECORDED AT THIS LOCATION					
R4	662240	667785	4	NO PEAT RECORDED AT THIS LOCATION					
R5	662033	667738	9	NO PEAT RECORDED AT THIS LOCATION					
R6	662011	667515	8	NO PEAT RECORDED AT THIS LOCATION					
R7	662033	667274	9	NO PEAT RECORDED AT THIS LOCATION					
R9	661725	666985	3	NO PEAT RECORDED AT THIS LOCATION					
R10	661675	666937	3	NO PEAT RECORDED AT THIS LOCATION					
R11	661464	667071	4	NO PEAT RECORDED AT THIS LOCATION					
R12	661454	667077	4	NO PEAT RECORDED AT THIS LOCATION					
R13	661943	666791	6	NO PEAT RECORDED AT THIS LOCATION					
R14	661763	666964	3	NO PEAT RECORDED AT THIS LOCATION					
R16	661464	666623	3	NO PEAT RECORDED AT THIS LOCATION					
R22	661083	666240	3	8	10	0.30	1.30	**51.02**	**11.77**
R23	661006	666192	2	8	10	0.60	1.60	**38.23**	**14.34**
R24	661232	666331	2	8	10	0.20	1.20	**114.68**	**19.11**
R25	661170	666096	4	8	10	0.30	1.30	**38.32**	**8.84**
R27	661037	665627	3	8	10	0.30	1.30	**51.02**	**11.77**
R29	660699	665196	2	8	10	0.60	1.60	**38.23**	**14.34**
R38	660815	667134	3	NO PEAT RECORDED AT THIS LOCATION					
R40	660808	666641	5	NO PEAT RECORDED AT THIS LOCATION					
R42	660395	666401	3	NO PEAT RECORDED AT THIS LOCATION					
WP01	661874	667125	9	NO PEAT RECORDED AT THIS LOCATION					
WP02	661062	667060	4	NO PEAT RECORDED AT THIS LOCATION					
WP03	661181	667676	4	8	10	0.50	1.50	**22.99**	**7.66**

Minimum =	**11.52**	**5.12**
Maximum =	**114.68**	**19.11**
Average =	**49.39**	**10.92**

Notes:

(1) Assuming a bulk unit weight for peat of 10kN/m^3

(2) Assuming a surcharge equivalent to fill depth of 1m of peat i.e. 10kPa.

(3) Slope inclination (β) based on site readings and site contour plans.

(4) A lower bound undrained shear strength, cu for the peat of 8kPa was selected for the assessment. It should be noted that a cu of 8kPa for the peat is considered a conservative value for the analysis and is not representative of all peat present across the site. In reality the peat has a significantly higher undrained strength.

(5) Peat depths based on probes carried out by FT.

(6) For load conditions see report text.

Calculated FoS of Natural Peat Slopes for White Hill Wind Farm - Drained Analysis

Turbine No./Waypoint	Slope	Design c'	Bulk unit weight of Peat	Unit weight of Water	Depth of In situ Peat	Friction Angle	Surcharge Equivalent Placed Fill	Equivalent Total Depth of Peat (m)	Factor of Safety for Load Condition	
	α (deg)	c' (kPa)	γ (kN/m^3)	$γ_w$ (kN/m^3)	(m)	ø' (deg)	Condition (2)	Condition (2)	Condition (1)	Condition (2)
									100% Water	100% Water
T1	4	NO PEAT RECORDED AT THIS LOCATION								
T2	6	NO PEAT RECORDED AT THIS LOCATION								
T3	2	4	10.0	10.0	0.60	25	1.0	1.6	**19.11**	**15.51**
T4	3	4	10.0	10.0	0.50	25	1.0	1.5	**15.31**	**11.03**
T5	5	NO PEAT RECORDED AT THIS LOCATION								
T6	3	NO PEAT RECORDED AT THIS LOCATION								
T7	4	4	10.0	10.0	0.50	25	1.0	1.5	**11.50**	**8.28**
Borrow Pit (1)	8	NO PEAT RECORDED AT THIS LOCATION								
Borrow Pit (2)	5	4	10.0	10.0	0.10	25	1.0	1.1	**46.07**	**9.03**
Borrow Pit (3)	5	4	10.0	10.0	0.10	25	1.0	1.1	**46.07**	**9.03**
Soil Deposition Area (1)	3	NO PEAT RECORDED AT THIS LOCATION								
Soil Depsoition Area (2)	3	NO PEAT RECORDED AT THIS LOCATION								
	2	NO PEAT RECORDED AT THIS LOCATION								
Site Compound	5	4	10.0	10.0	0.80	25	1.0	1.8	**5.76**	**5.52**
Met Mast	4	NO PEAT RECORDED AT THIS LOCATION								
Substation	2	NO PEAT RECORDED AT THIS LOCATION								
R2	4	NO PEAT RECORDED AT THIS LOCATION								
R3	5	NO PEAT RECORDED AT THIS LOCATION								
R4	4	NO PEAT RECORDED AT THIS LOCATION								
R5	9	NO PEAT RECORDED AT THIS LOCATION								
R6	8	NO PEAT RECORDED AT THIS LOCATION								
R7	9	NO PEAT RECORDED AT THIS LOCATION								
R9	3	NO PEAT RECORDED AT THIS LOCATION								
R10	3	NO PEAT RECORDED AT THIS LOCATION								
R11	4	NO PEAT RECORDED AT THIS LOCATION								
R12	4	NO PEAT RECORDED AT THIS LOCATION								
R13	6	NO PEAT RECORDED AT THIS LOCATION								
R14	3	NO PEAT RECORDED AT THIS LOCATION								
R16	3	NO PEAT RECORDED AT THIS LOCATION								
R22	3	4	10.0	10.0	0.30	25	1.0	1.3	**25.51**	**12.73**
R23	2	4	10.0	10.0	0.60	25	1.0	1.6	**19.11**	**15.51**
R24	2	4	10.0	10.0	0.20	25	1.0	1.2	**57.34**	**20.68**
R25	4	4	10.0	10.0	0.30	25	1.0	1.3	**19.16**	**9.55**
R27	3	4	10.0	10.0	0.30	25	1.0	1.3	**25.51**	**12.73**
R29	2	4	10.0	10.0	0.60	25	1.0	1.6	**19.11**	**15.51**
R38	3	NO PEAT RECORDED AT THIS LOCATION								
R40	5	NO PEAT RECORDED AT THIS LOCATION								
R42	3	NO PEAT RECORDED AT THIS LOCATION								
WP01	9	NO PEAT RECORDED AT THIS LOCATION								
WP02	4	NO PEAT RECORDED AT THIS LOCATION								
WP03	4	4	10.0	10.0	0.50	25	1.0	1.5	**11.50**	**8.28**

Minimum =	**5.76**	**5.52**
Maximum =	**57.34**	**20.68**
Average =	**24.70**	**11.80**

Notes:

(1) Assuming a bulk unit weight of peat of 10 (kN/m^3)
(2) Assuming a surcharge equivalent to fill depth of 1.0m.
(3) Slope inclination (β) based on site readings and contour survey plans of site.
(4) FoS is based on slope inclination and shear test results obtained from published data.
(5) Peat depths based on probes carried out by FT.
(6) For load conditions see Report text.
(7) Minimum acceptable factor of safety required of 1.3 for first-time failures based on BS: 6031:1981 Code of practice for Earthworks.

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APPENDIX D

Methodology for Peat Stability Risk Assessment

Methodology for Peat Stability Risk Assessment

A peat stability risk assessment was carried out for each of the main infrastructure elements at the proposed wind farm development. This approach takes into account guidelines for geotechnical/peat stability risk assessments as given in PLHRAG (2017) and MacCulloch (2005). The degree of risk is determined as a Risk Rating (R), which is the product of probability (P) and impact (I). How these factors are determined and applied in the analysis is described below.

The main approaches for assessing peat stability include the following:

(a) Geomorphological

(b) Qualitative (judgement)

(c) Index/Probabilistic (probability)

(d) Deterministic (factor of safety)

Approaches (a) to (c) listed above would be considered subjective and do not provide a definitive indication of stability; in addition, a high level of judgement/experience is required which makes it difficult to relate the findings to real conditions. FT apply a more objective approach, the deterministic approach. As part of FT's deterministic approach, a qualitative risk assessment is also carried out taking into account qualitative factors, which cannot necessarily be quantified.

Probability

The likelihood of a peat failure occurring was assessed based on the results of both the quantitative results of stability calculations (deterministic approach using factors of safety) and the assessment of the severity of several qualitative factors which cannot be reasonably included in a stability calculation but nevertheless may affect the occurrence of peat instability.

The qualitative factors used in the risk assessment are outlined in Table A and have been compiled based on FT's experience of assessments and construction in peat land sites and peat failures throughout Ireland and the UK.

Table A: Qualitative Factors used to Assess Potential for Peat Failure

Qualitative Factor	Type of Feature/Indicator for each Qualitative Factor (1)	Explanation/Description of Qualitative Factor
Evidence of sub peat water flow	No	Based on site walkover observations. Sub peat water flow generally occurs in the form of natural piping at the base of peat. Where there is a constriction or blockage in natural pipes a build-up of water can occur at the base of the peat causing a reduction in effective stress at the base of the peat resulting in failure; this is particularly critical during periods of intense rainfall.
	Possibly	
	Probably	
	Yes	

Qualitative Factor	Type of Feature/Indicator for each Qualitative Factor [1]	Explanation/Description of Qualitative Factor
Evidence of surface water flow	Dry	Based on site walkover observations. The presence of surface water flow indicates if peat in an area is well drained or saturated and if any additional loading from the ponding of surface water onto the peat is likely.
	Localised/Flowing in drains	
	Ponded in drains	
	Springs/surface water	
Evidence of previous failures/slips	No	Based on site walkover observations. The presence of clustering of relict failures may indicate that particular pre-existing site conditions predispose a site to failure.
	In general area	
	On site	
	Within 500m of location	
Type of vegetation	Grass/Crops	Based on site walkover observations. The type of vegetation present indicates if peat in an area is well drained, saturated, etc. Vegetation that indicates wetter ground may also indicate softer underlying peat deposits.
	Improved Grass/Dry Heather	
	Wet Grassland/Juncus (Rushes)	
	Wetlands Sphagnum (Peat moss)	
General slope characteristics upslope/downslope from infrastructure location	Concave	Based on site walkover observations. Slope morphology in the area of the infrastructure location is an important factor. A number of recorded peat failures have occurred in close proximity to a convex break in slope.
	Planar to concave	
	Planar to convex	
	Convex	
Evidence of very soft/soft clay at base of peat	No	Based on inspection of exposures in general area from site walkover. Several reported peat failures identify the presence of a weak layer at the base of the peat along which shear failure has occurred.
	Yes	
Evidence of mechanically cut peat	No	Based on site walkover observations. Mechanically cut peat typically cut using a 'sausage' machine to extract

Qualitative Factor	Type of Feature/Indicator for each Qualitative Factor (1)	Explanation/Description of Qualitative Factor
	Yes	peat for harvesting. Areas which have been cut in this manner have been linked to peat instability. The mechanical cuts can notably reduce the intrinsic strength of the peat and also allow ingress of rainfall/surface water.
Evidence of quaking or buoyant peat	No	Based on site walkover observations. Quaking/buoyant peat is indicative of highly saturated peat, which would generally be considered to have a low strength. Quaking peat is a feature on sites that have been previously linked with peat instability.
	Yes	
Evidence of bog pools	No	Based on site walkover observations. Bog pools are generally an indicator of areas of weak, saturated peat. Commonly where there are open areas of water within peat these can be interconnected, with the result that there may be sub-surface bodies of water. The presence of bog pools have been previously linked with peat instability.
	Yes	
Other	Varies	In addition to the above features/ indicators and based on site recordings the following are some of the features which may be identified: Excessively deep peat, weak peat, overly steep slope angles, etc.

Note (1) The list of features/indicators for each qualitative factor are given in increasing order of probability of leading to peat instability/failure.

It should be noted that the presence of one of the qualitative factors alone from Table A is unlikely to lead to peat instability/failure. Peat instability/failure at a site is generally the combination of a number of these factors occurring at the same time at a particular location. The probability rating assigned to the quantitative and qualitative factors is judged on a 5-point scale from 1 (indicating negligible or no probability of failure) to 5 (indicating a very likely failure), as outlined in Table B.

Table B: Probability Scale

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

Scale	Likelihood of Qualitative Factor leading to Peat Failure	Probability of Failure
1	Negligible/None	Least
2	Unlikely	
3	Probable	
4	Likely	
5	Very Likely	Greatest

Impact

The severity of the risk is also assessed qualitatively in terms of impact. The impact of a peat failure on the environment within and beyond the immediate wind farm site is assessed based on the potential travel distance of a peat failure. Where a peat failure enters a watercourse, it can travel a considerable distance downstream. Therefore, the proximity of a potential peat failure to a drainage course is a significant indicator of the likely potential impact.

The risk is determined based on the combination of hazard and impact. A qualitative scale has been derived for the impact of the hazard based on distance of infrastructure element to a watercourse (Table C).

The location of watercourses is based on topographic maps and supplemented by site observations from walkover survey. Note that not all watercourses are shown on maps.

Table C: Impact Scale

Scale	Criteria	Impact
1	Proposed infrastructure element greater than 150m of watercourse	Negligible/None
2	Proposed infrastructure element within 150 to 101m of watercourse	Low
3	Proposed infrastructure element within 100 to 51m of watercourse	Medium

4	Proposed infrastructure element within 50 m of watercourse	High
5	Proposed infrastructure element within 50 m of watercourse, in an environmentally sensitive area	Extremely High

Risk Rating

The degree of risk is determined as the product of probability (P) and impact (I), which gives the Risk Rating (R) as follows:

The Risk Rating is calculated from: R = P x I

Due to the 5-point scales used to assess Probability and Impact, the Risk Rating can range from 1 to 25 as shown in Table D.

Table D: Qualitative Risk Rating

		Probability				
		1	**2**	**3**	**4**	**5**
Impact	**5**	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5

Risk Rating & Control Measures	
17 to 25	High: avoid working in area or significant control measures required
11 to 16	Medium: notable control measures required
5 to 10	Low: only routine control measures required
1 to 4	Negligible: none or only routine control measures required

The risk rating is calculated individually for each contributory factor. Control measures are required to reduce the risk to at least a 'Low' risk rating. The control measures in response to the qualitative risk ratings are included in the peat stability risk registers for each main infrastructure element in Appendix B.

The risk rating is calculated individually for each contributory factor. Control measures are required to reduce the risk to at least a 'Tolerable' risk rating

FEHILY TIMONEY

CONSULTANTS IN ENGINEERING, ENVIRONMENTAL SCIENCE & PLANNING

APPENDIX E

Ground Investigation (HES, 2021)

Trial Pit Log

Project No: P1547-0
Site: White Hill WF, Co. Carlow
Client: Galetech Energy Services

Date started: 6/10/2021
Date finished: 6/10/2021

Trial Pit No: TP-TA
Easting: 661467
Northing: 667060
Elevation: .

SUBSURFACE PROFILE

Depth	Symbol	Depth/Elev.	Description	Water Strikes	Sample Type	Comments
		0.00	Ground Surface			
0.00		0.00 / 0.00	Slightly peaty topsoil			
			Firm, organgy brown SILT			
1.00		-1.00 / 1.00	Very firm, organgy brown, gravelly SILT/CLAY			
2.00		-1.90 / 1.90	Soft, grey, weathered SHALE			
3.00		-3.30 / 3.30				

Remarks:

Contractor:
Excavator type:
Logged by: DB

Scale as shown
Sheet: 1 of 1

Trial Pit Log

Trial Pit No: TP-TB

Project No: P1547-0
Site: White Hill WF, Co. Carlow
Client: Galetech Energy Services

Date started: 6/10/2021
Date finished: 6/10/2021

Easting: 661941
Northing: 666818
Elevation: .

SUBSURFACE PROFILE

Depth	Symbol	Depth/Elev.	Description	Water Strikes	Sample Type	Comments
		0.00	Ground Surface			
0.00		0.00 -0.15	Topsoil			
		0.15 -1.00	Firm, reddish brown, slightly gravelly SILT with angular cobbles			
1.00		1.00 -2.30	Soft, loose and weathered bedrock			
2.00		2.30				

Remarks:

Contractor:
Excavator type:
Logged by: DB

Scale as shown
Sheet: 1 of 1

Trial Pit Log

Trial Pit No: TP-TC

Project No: P1547-0
Site: White Hill WF, Co. Carlow
Client: Galetech Energy Services

Date started: 6/10/2021
Date finished: 6/10/2021

Easting: 661027
Northing: 666207
Elevation: .

SUBSURFACE PROFILE

Depth	Symbol	Depth/Elev.	Description	Water Strikes	Sample Type	Comments
		0.00	Ground Surface			
0.00		0.00 / -0.15	Dark brown, peaty Topsoil			
		0.15 / -0.60	Soft, browish grey CLAY			
1.00		0.60 / -1.70	Firm grey CLAY with abundant angular cobbles			
		1.70				

Remarks:

Refusal on weathered/broken (blocky) bedrock

Contractor:
Excavator type:
Logged by: DB

Scale as shown
Sheet: 1 of 1

Trial Pit Log

Project No: P1547-0
Site: White Hill WF, Co. Carlow
Client: Galetech Energy Services

Date started: 6/10/2021
Date finished: 6/10/2021

Trial Pit No: TP-TE
Easting: 660872
Northing: 666649
Elevation: .

SUBSURFACE PROFILE

Depth	Symbol	Depth/Elev.	Description	Water Strikes	Sample Type	Comments
		0.00	Ground Surface			
0.00		0.00 -0.10	Topsoil			
		0.10 -1.40	Very firm, brown, gravelly SILT			
1.00						
		1.40 -1.50	Soft, weathered SHALE			
		1.50				

Remarks:

Contractor:
Excavator type:
Logged by: DB

Scale as shown
Sheet: 1 of 1

HYDRO-ENVIRONMENTAL SERVICES 22 Lower Main Street Dungarvan Co. Waterford Tel: 058-44122 Email: info@hydroenvironmental.ie

Trial Pit Log

Project No: P1547-0
Site: White Hill WF, Co. Carlow
Client: Galetech Energy Services

Date started: 6/10/2021
Date finished: 6/10/2021

Trial Pit No: TP-TF
Easting: 660803
Northing: 667128
Elevation: .

SUBSURFACE PROFILE

Depth	Symbol	Depth/Elev.	Description	Water Strikes	Sample Type	Comments
0.00		0.00	Ground Surface			
		0.00	Peaty Topsoil			
1.00		-1.90	Very firm to stiff grey SILT with occasional cobbles			
2.00		-2.90 1.90	Very firm, sandy, gravelly SILT			
3.00		2.90				

Remarks:

Contractor:
Excavator type:
Logged by: DB

Scale as shown
Sheet: 1 of 1

Trial Pit Log

Trial Pit No: TP-BP3

Project No: P1547-0
Site: White Hill WF, Co. Carlow
Client: Galetech Energy Services

Date started: 6/10/2021
Date finished: 6/10/2021

Easting: 661530
Northing: 666946
Elevation: .

SUBSURFACE PROFILE

Depth	Symbol	Depth/Elev.	Description	Water Strikes	Sample Type	Comments
		0.00	Ground Surface			
0.00		0.00 / -0.10	Topsoil			
		0.10 / -0.70	Firm, orangy grey SILT			
		0.70 / -1.00	Soft, grey, weathered SHALE			
1.00		1.00				

Remarks:

Contractor:
Excavator type:
Logged by: DB

Scale as shown
Sheet: 1 of 1

HYDRO-ENVIRONMENTAL SERVICES 22 Lower Main Street Dungarvan Co. Waterford Tel: 058-44122 Email: info@hydroenvironmental.ie

Trial Pit Log

Project No: P1547-0
Site: White Hill WF, Co. Carlow
Client: Galetech Energy Services

Date started: 6/10/2021
Date finished: 6/10/2021

Trial Pit No: TP-Substation
Easting: 660831
Northing: 664804
Elevation: .

SUBSURFACE PROFILE

Depth	Symbol	Depth/Elev.	Description	Water Strikes	Sample Type	Comments
		0.00	Ground Surface			
0.00		0.00 -0.15	Peaty Topsoil			
		0.15 -1.00	Firm, organgy grey SILT getting more gravelly with depth			
1.00		1.00 -1.10	Soft, weathered SHALE			
		1.10				

Remarks:

Contractor:
Excavator type:
Logged by: DB

Scale as shown
Sheet: 1 of 1

Trial Pit Log

Project No: P1547-0
Site: White Hill WF, Co. Carlow
Client: Galetech Energy Services

Date started: 6/10/2021
Date finished: 6/10/2021

Trial Pit No: TP_Compound
Easting: 662093
Northing: 667653
Elevation: .

SUBSURFACE PROFILE

Depth	Symbol	Depth/Elev.	Description	Water Strikes	Sample Type	Comments
0.00		0.00	Ground Surface			
		0.00	Topsoil			
		-0.90 0.90	Firm, grey slightly sandy SILT			
1.00			Brown, very firm SILT/CLAY with numersous angular clasts and frequesnt cobbles (Boulder Clay)			
2.00		-2.60 2.60				

Remarks:

Contractor:
Excavator type:
Logged by: DB

Scale as shown
Sheet: 1 of 1

Trial Pit Log

Project No: P1547-0
Site: White Hill WF, Co. Carlow
Client: Galetech Energy Services

Date started: 6/10/2021
Date finished: 6/10/2021

Trial Pit No: TP-BattSt
Easting: 660813
Northing: 664857
Elevation: .

SUBSURFACE PROFILE

Depth	Symbol	Depth/Elev.	Description	Water Strikes	Sample Type	Comments
		0.00	Ground Surface			
0.00		0.00 / -0.15	Peaty topsoil			
		0.15 / -0.50	Firm, organgy grey SILT getting more gravelly with depth			
1.00		0.50 / -1.10	Soft, weathered SHALE			
		1.10				

Remarks:

Contractor:
Excavator type:
Logged by: DB

Scale as shown
Sheet: 1 of 1

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