REPORT ON

ASSESSMENT OF PEAT STABILITY

FOR

CLEANRATH WIND FARM, CO. CORK

Prepared for:

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TABLE OF CONTENTS

TABLES (within text)

FIGURES (within text)

APPENDICES

ACRONYMS AND SYMBOLS

AGEC	Applied Ground Engineering Consultants Ltd
BS	British Standard
c’	Effective cohesion
CMS	Construction Method Statement
c_u	Undrained strength
EC7	Eurocode 7
FoS	Factor of Safety
GSI	Geological Survey of Ireland
kPa	Kilopascals
m bgl	Metres below ground level
m	Metres
mm	Millimetres
mOD	Metres ordnance datum
ø’	Effective angle of shearing resistance
PHRAG	Peat Hazard and Risk Assessment Guide

1 NON-TECHNICAL SUMMARY

Applied Ground Engineering Consultants Ltd (AGEC) was engaged by McCarthy Keville O'Sullivan to undertake an assessment of the proposed Cleanrath wind farm site with respect to peat stability. In accordance with planning guidelines compiled by the Department of the Environment, Heritage and Local Government (DoEHLG), where peat is present on a proposed wind farm development, a peat stability assessment is required.

The findings of the peat assessment, which involved analysis of 171 no. locations, showed that the site has very shallow peat depths and low risk of peat instability associated with the proposed works.

The geotechnical assessment showed that the site has an acceptable margin of safety and is suitable for the proposed wind farm development. 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. These need only apply at this site to localised areas of the site.

The proposed wind farm comprises 11 no. wind turbines with associated infrastructure including access roads (new and upgrading of existing roads), construction compound, substation, met mast and borrow pits.

The site which is undulating consists predominantly of shallow blanket peat/peaty topsoil with some forested, deforested and pasture areas across the site. Over 2.0km of existing access tracks which have been in operation for a number of years are proposed to be incorporated into the access road network for the wind farm.

Peat depths recorded during the site walkover vary from 0 to 0.6m with localised deeper peat deposits of up to 3.4m. A total of over 220 no. peat depth probes were carried out on site.

A walkover including peat probing, desk study and stability analysis was carried out to assess the susceptibility of the site to peat failure.

The purpose of the peat stability assessment was to determine the stability i.e. Factor of Safety (FoS), of the peat slopes where construction is proposed during the development of the wind farm.

Based on the stability assessment carried out on the peat slopes the calculated FoS's with respect to peat instability are acceptable. The risk assessment at each infrastructure location includes a number of routine mitigation/control measures to ensure the continued stability of the site.

2 INTRODUCTION

2.1 Background and Experience

Applied Ground Engineering Consultants Ltd (AGEC) was engaged in December 2015 by McCarthy Keville O'Sullivan to undertake an assessment of the proposed wind farm site with respect to peat stability.

AGEC have been involved in over 80 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.

The proposed Cleanrath site is located approximately 4km northeast of Ballingeary, Co. Cork.

The proposed wind farm comprises 11 no. wind turbines with associated infrastructure including access roads (new and upgrading of existing roads), construction compound, substation, met mast and borrow pits.

A walk-over inspection of the site was carried out by AGEC between the 9th and the 11th December 2015. The peat depth data recorded by AGEC was used in the assessment of peat stability for the proposed wind farm site.

2.2 Peat Stability Assessment Methodology

AGEC undertook the assessment following the principles in Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (Scottish Executive, 2007). The Peat Hazard and Risk Assessment Guide (PHRAG) 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.

The assessment of peat stability at the proposed site included the following activities:

(1) Site reconnaissance including shear strength and peat depth measurements

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

(3) Peat contour depth plan – is compiled based on the peat depth probes carried out across the site by AGEC

(4) Factor of safety plan – is compiled for the short term critical condition (undrained) for the 171 no. FoS points analysed across the site

(5) Construction buffer zone plan – identifies areas with an elevated or higher construction risk where mitigation/control measures will need to be implemented

during construction to minimise the potential risks and ensure they are kept within an acceptable range

(6) A risk register is 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

A flow diagram showing the general methodology for peat stability assessment is shown in Figure 1. The methodology illustrates the optimisation of the wind farm layout based on the findings from a site reconnaissance and subsequent feedback from the peat stability and risk assessment results.

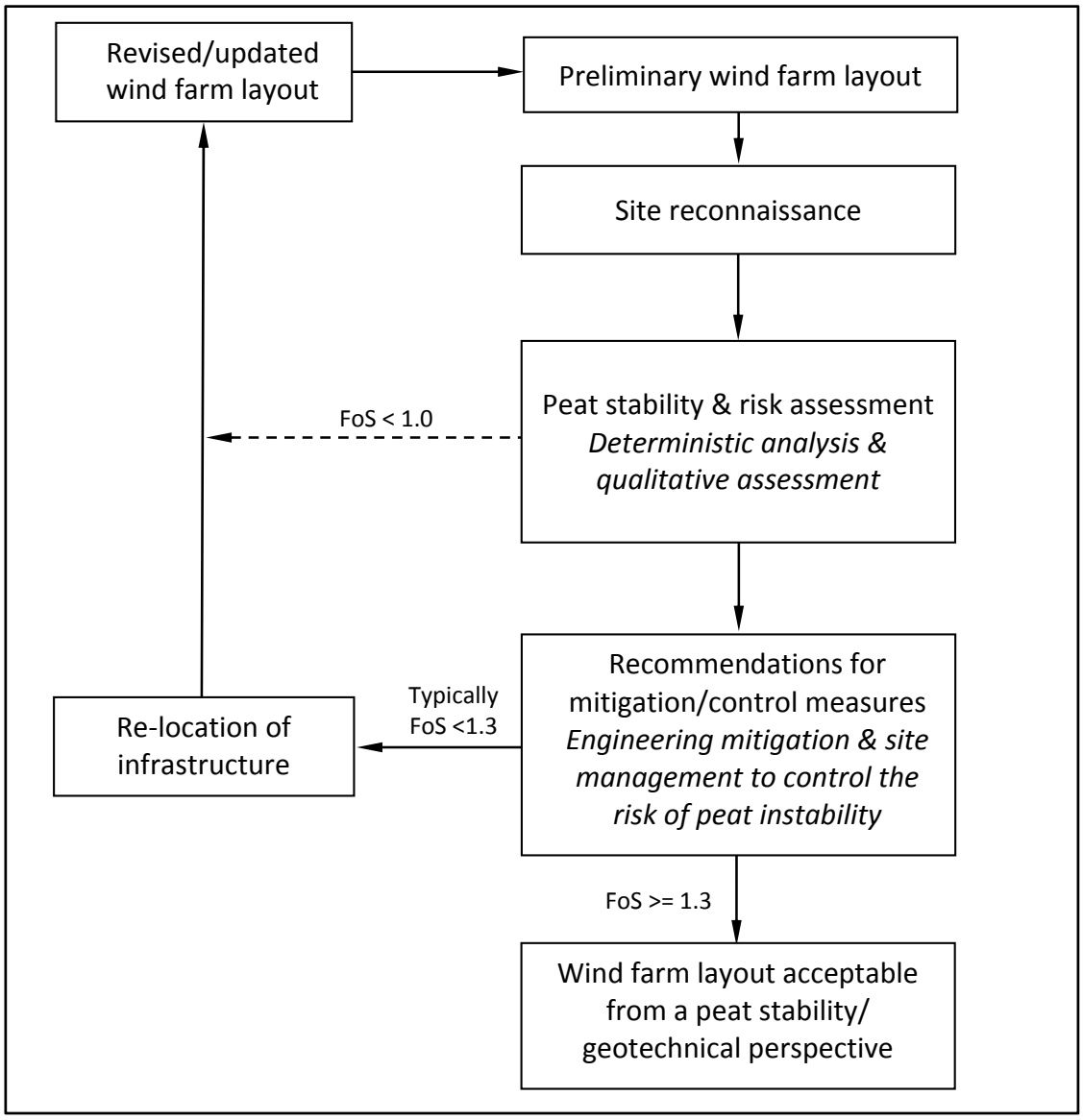

Figure 1 Flow Diagram Showing General Methodology for Peat Stability Assessment

2.3 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 proposed wind farm development and the surrounding environment. Peat failure excludes localised movement of peat that would occur (say) below an access road, 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.

2.4 Main Approaches to Assessing Peat Stability

The main approaches for assessing peat stability for wind farm developments 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. AGEC apply a more objective approach, the deterministic approach (as discussed in section 2.4).

As part of AGEC'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 AGEC's experience of assessments and construction in peat land sites and peat failures throughout Ireland and the UK. This approach follows the guidelines for geotechnical risk management as given in Clayton (2001), as referenced in the best practice for Peat Hazard and Risk Assessment Guide (Scottish Executive, 2007), 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.

2.5 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 roads 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 8).

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.

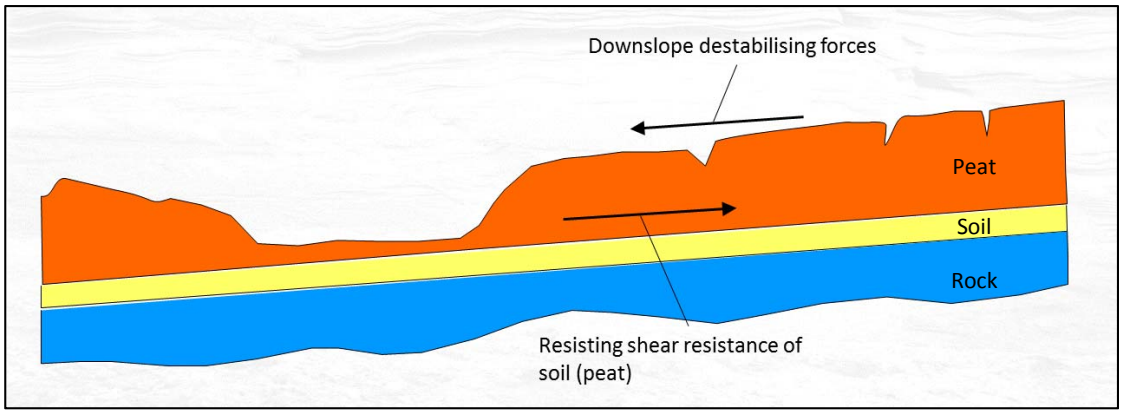

Figure 2 Peat Slope Showing Balance of Forces to Maintain Stability

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.

3 DESK STUDY AND SITE RECONNAISSANCE

3.1 Desk Study

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

- Geological plans
- Ordnance Survey plans
- Literature review of peat failures

The Geological Survey of Ireland (GSI, 1997 & 2015) geological plans for the site were used to verify the bedrock conditions.

The ordnance surveys 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 included a review of both published literature and GSI online dataset viewer (GSI, 2015) on peat failures/landslides in the vicinity of the site.

3.2 Site Reconnaissance

As part of the assessment of potential peat failure at the proposed site, AGEC carried out a site reconnaissance. This comprised walk-over inspections of the site with recording of salient geomorphological features with respect to the wind farm development and to provide peat thickness and preliminary assessment of peat strength.

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

4 FINDINGS OF SITE RECONNAISSANCE

4.1 Previous Failures

The investigation works carried out at the study area have been used in conjunction with a desk study review to assess the susceptibility of the study area to peat failure.

There are no recorded peat failures at the Cleanrath wind farm site (GSI, 2006 & GSI, 2015).

The nearest recorded peat failure is located some 6km west of the study area. The failure occurred at Fuhiry in 1997, the failure mechanism is not specified.

Another peat failure occurred some 20km northwest of the study area at Kilgarvan in October 2012 and was described as a peat slide. The likely triggering event of the peat slide was heavy rainfall. Insufficient drainage at the head of the failure also likely contributed to the peat failure (AGEC, 2012).

Based on the Geological Survey of Ireland's dataset viewer (GSI, 2015) no other peat failures occurred within a 30km radius of the site.

The nearest recorded landslide (non-peat) failure is located some 16km to the southwest of the study area within an area called Gortacreenteen. The failure is reported to have occurred in 2004, the failure mechanism is described as an unspecified slide and the material type was described as debris.

The presence, or otherwise, of relict peat failures or clustering of relict failures within an area is an indicator that particular site conditions exist that pre-dispose a site to failure or not as the case may be. Hence based on the historical data reviewed above it can be concluded that site conditions in the area of the Cleanrath site have low potential for peat failure.

4.2 Findings of Site Reconnaissance

The site reconnaissance comprised walk-over inspection of the site between the 9th & 11th December 2015. Weather conditions for the site visit were very wet with heavy showers on the 9th, while mainly dry with scattered showers on the 10th and 11th December.

The walkover was carried out by geotechnical engineers experienced in peat failure assessment.

The findings from the site reconnaissance have been used to optimise the layout of the infrastructure on site.

The main findings of the site reconnaissance are as follows:

(1) The site which is undulating consists predominantly of shallow blanket peat/peaty topsoil with forested areas across the site, predominantly in the northern half. There are also de-forested areas with juvenile trees in the north and a localised pasture area around turbine T4. The blanket peat areas contain shallow

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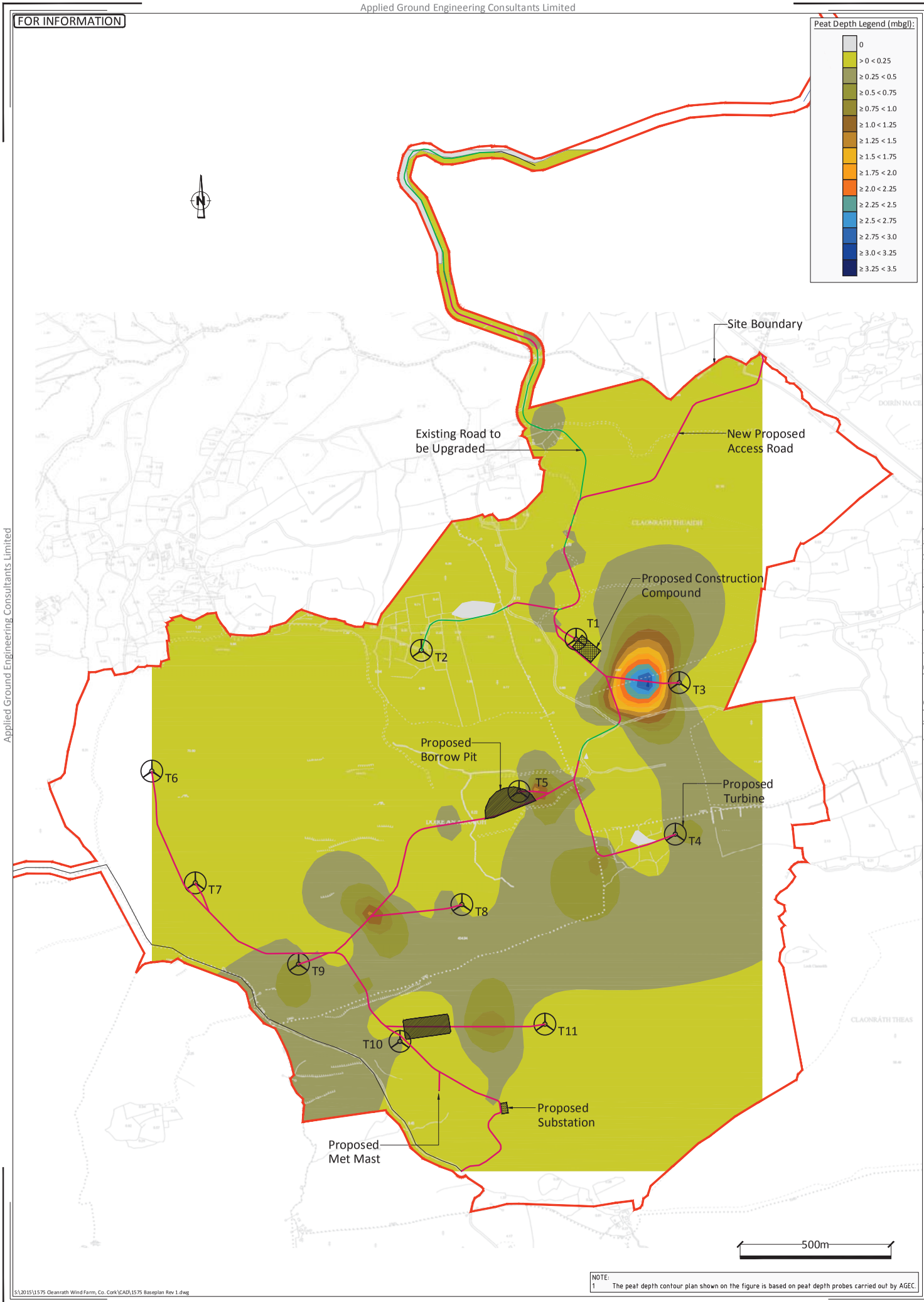

NOTE:
1 The peat depth contour plan shown on the figure is based on peat depth probes carried out by AGEC.

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Figure 3 Peat Depth Contour Plan

peat with some localised deeper peat deposits in the south and the east of the site (See Appendix A – Photos 1 and 2).

(2) Peat depths recorded during the site reconnaissance vary from 0 to 1.6m with an average of 0.2m, locally peat depths of up to 3.4m were recorded along a section of access road to turbine T3 (Figure 3). A total of over 220 no. peat depth probes were carried out on site.

(3) The peat depths recorded at the 11 no. proposed turbine locations varied from 0.0 to 0.7m with an average depth of 0.2m.

(4) The slope angles recorded at the turbine locations range from 1.0 to 4.0 degrees, locally a slope angle of 14 degrees was recorded at turbine T6. It should be noted that minimal/no peat is present at the proposed location for turbine T6. These slope angle readings are based on site recordings and were obtained during site reconnaissance by AGEC using handheld equipment, namely Silva Clino Master which has an accuracy of +/- 0.25 degrees. The slope angle quoted reflects the slope within the footprint of each turbine location.

(5) The deepest peat was recorded in the east of the site where the topography is typically flatter. There are also some localised pockets of deep peat adjacent to the proposed access roads in the southern area of the site. The deepest peat deposits on site have been identified and are highlighted on the construction buffer zone plan (Figure 4).

(6) The access roads for the wind farm comprise upgrading of existing access roads and construction of new proposed access roads. The existing access roads appear to have been constructed using an excavate and replace construction technique (Photo 3). The upgrading works and construction of new proposed access roads will be carried out using both excavate and replace and floated construction techniques.

(7) With respect to the existing access roads, peat depths are typically less than 0.3m. The existing access roads are located in the northern half of the site and are in close proximity to turbines T1 to T5. Over 2.0km of existing access tracks which have been in operation for a number of years are proposed to be incorporated into the access road network for the wind farm.

(8) The peat situated on the raised areas particularly in the north of the site, has a notable vegetation cover, which is generally indicative of relatively well-drained peat.

(9) Localised areas of waterlogged peat and surface water are present at numerous areas across the site. This is not unexpected given the type of terrain present within the site.

(10) A number of deeper peat areas were identified during the site walkover (Figure 4). These areas are typically located outside the footprint of the proposed infrastructure. These areas are typically infilled basins i.e. flat areas infilled with peat sometimes surrounded by relatively steep slopes and hence do not represent a peat slide risk but a safety risk during construction.

(11) Two borrow areas are proposed for the south and central area of the site. The peat depth in both these areas are typically shallow i.e. less than 0.5m. Rock outcrops were also recorded in the vicinity of the borrow areas. The proposed borrow areas are deemed suitable for the storage of excavated peat.

(12) No evidence of past failures or any significant signs of peat instability were noted on site.

(13) The findings of the site reconnaissance are as follows:

(a) The site which is undulating consists predominantly of shallow blanket peat/peaty topsoil with some forestry areas across the site particularly in the north of the site.

(b) The turbines are located in areas of shallow peat where peat depths of less than 0.8m were recorded, and as such are not considered to be at risk from peat failure.

(c) Along a section of the access road to turbine T3 localised peat depths of up to 3.4m were recorded. This localised section is located within a flat area of the site where slopes of less than 3 degrees were recorded and does not represent a peat slide risk but a safety risk during construction.

(a) A construction buffer zone plan has been produced for the site (Figure 4). This Figure shows areas which have an elevated or higher construction risk due to the terrain and features encountered during the site reconnaissance. Additional mitigation/control measures will be implemented in these areas, as required (see Appendix B).

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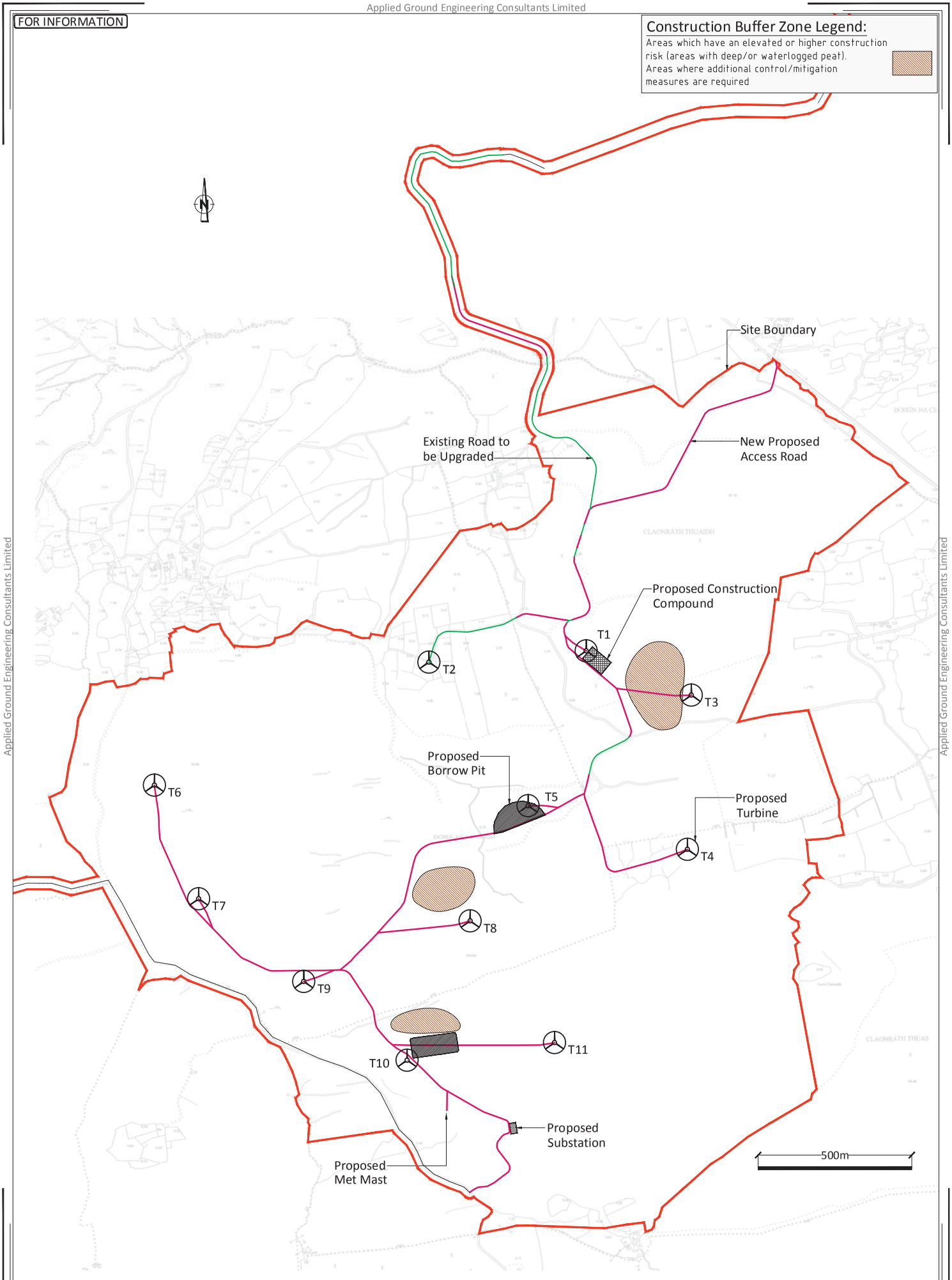
Construction Buffer Zone Legend:

Areas which have an elevated or higher construction risk (areas with deep/or waterlogged peat). Areas where additional control/mitigation measures are required



NOTES:
1. The watercourses/streams on the drawing are based on OSI data. It should be noted that further watercourses/streams may be present on site.
2. It should be noted that the areas highlighted on this drawing are indicative only.

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Figure 4 Construction Buffer Zone Plan

5 SITE GROUND CONDITIONS

5.1 Soils & Subsoils

The site which is undulating consists predominantly of shallow blanket peat/peaty topsoil with some forested, deforested and pasture areas across the site. Peat depths recorded during the site walkover vary from 0 to 0.6m with a localised maximum peat depths of up to 3.4m.

Based on the site walkover and the minimal exposures present at the site the superficial deposits were typically described as peaty topsoil/ brown firm fibrous Peat overlying sandy gravelly Clay with cobbles and boulders and/or overlying weathered bedrock (Photos 4 & 5).

A review of the GSI subsoils maps indicate that the site is underlain by predominantly blanket peat with outcrops of rock at the surface and occasionally some till derived from Devonian Sandstone.

5.2 Bedrock

The underlying bedrock was described by the Geological Survey of Ireland (GSI, 1997) and shown on Sheet 21 (Geology of Kerry-Cork). In the area of the Cleanrath site, Sheet 21 shows three bedrock formation and localised bedrock formations across the site.

The northern portion of the site consists of the Bird Hill formation which is described as purple siltstone and fine grained sandstone. Fine grained lithologies are found dominating the formation.

The bedrock formation spanning the centre of the site is the Gortanimill Formation and is comprised of green medium to fine grained sandstone, interbedded with green and red to purple siltstones and fine sandstones.

Across the southern portion of the site the dominant formation is the Caha Mountain. This formation is comprised of purple siltstones and fine grained parallel and cross laminated sandstones.

There are a number of mapped faults shown within the proposed boundary of the site. Two of these mapped faults are situated centrally within the site and are orientated in a north-west to south-east trend. There are also faults bordering the site to the east and to the west. There are also shallow faults or thrusts running centrally along the site from east to west.

No karst features were identified on the site following a review of the GSI database (GSI, 2015) or during the site walkover.

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 the proposed turbine locations and access roads. At turbine locations up to 5 probes were carried out around the turbine location, where accessible, and an average peat depth was calculated.

6.2 Peat Strength

The strength testing was carried out in-situ using a Geonor H-60 Hand-Field Vane Tester. From AGEC'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 generally obtained during the site reconnaissance by AGEC using handheld equipment, such as Silva Clino Master which has an accuracy of +/- 0.25 degrees. The slope angles quoted reflect the slope within the footprint of each infrastructure location. 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.

The slope angles used in the peat stability assessment and associated report for the main infrastructure locations were generally recorded during the site reconnaissance by AGEC using handheld equipment and would be deemed more accurate and representative of local topography than slope angles derived from contour plans.

6.4 Summary of Findings

Based on the peat depths recorded across the site by AGEC the peat varied from 0 to 1.6m with an average of 0.2m, locally peat depths of up to 3.4m were recorded along a section of access road to turbine T3. All peat depth probes carried out on site have been utilised to produce a peat depth contour plan for the site (Figure 3).

A summary of the peat depths at the proposed infrastructure locations is given in Table 1. The data presented in Table 1 is used in the peat stability assessment of the site; see Section 7 of this report.

Table 1 Peat Depth & Slope Angle at Proposed Infrastructure Locations

Turbine	Easting	Northing	Peat Depth Range (m) (1)	Average Peat Depth (m)	Slope Angle (°) (2)
T1	120871	70057	0 to 0.2	0.15	2.0
T2	120359	70020	0 to 0.1	0.0	1.0
T3	121213	69913	0 to 0.1	0.1	3.0
T4	121200	69411	0 to 0.6	0.15	3.0
T5	120682	69553	0 to 0.1	0.05	2.0
T6	119466	69620	0 to 0.1	0.05	14.0
T7	119610	69250	0 to 0.1	0.1	3.0
T8	120493	69178	0 to 0.1	0.05	4.0
T9	119952	68981	0.1 to 0.7	0.5	3.0
T10	120288	68725	0 to 0.4	0.2	3.0
T11	120768	68782	0 to 0.1	0.1	2.0
Substation	120634	68504	0 to 0.1	0.1	4.0
Construction Compound	120907	70023	0.1 to 0.2	0.1	3.0
Met Mast	120418	68563	0.2	0.2	4.0

Note (1) Based on probe results from the site walkovers. The range of peat depths for the infrastructure locations are based on a 10m grid carried out around the infrastructure element, where accessible.
Note (2) The slope angles at each of the main infrastructure locations were obtained during site reconnaissance by AGEC using handheld equipment, such as the Silva Clino Master which has an accuracy of +/- 0.25 degrees. The slope angle quoted reflects the slope within the footprint of each infrastructure location.

In addition to probing, in-situ shear vane testing was carried out as part of the ground investigation. 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 are presented in Figure 5.

The hand vane results indicate undrained shear strengths in the range 8 to 39kPa, with an average value of about 20kPa. The lower bound strengths were recorded locally in the deeper peat deposits in the flatter areas of the site. Typically the peat strengths recorded are representative of shallow well drained peat as is present on the Cleanrath 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 essentially back-analysis, though some testing was carried out, was estimated at 2.5kPa.

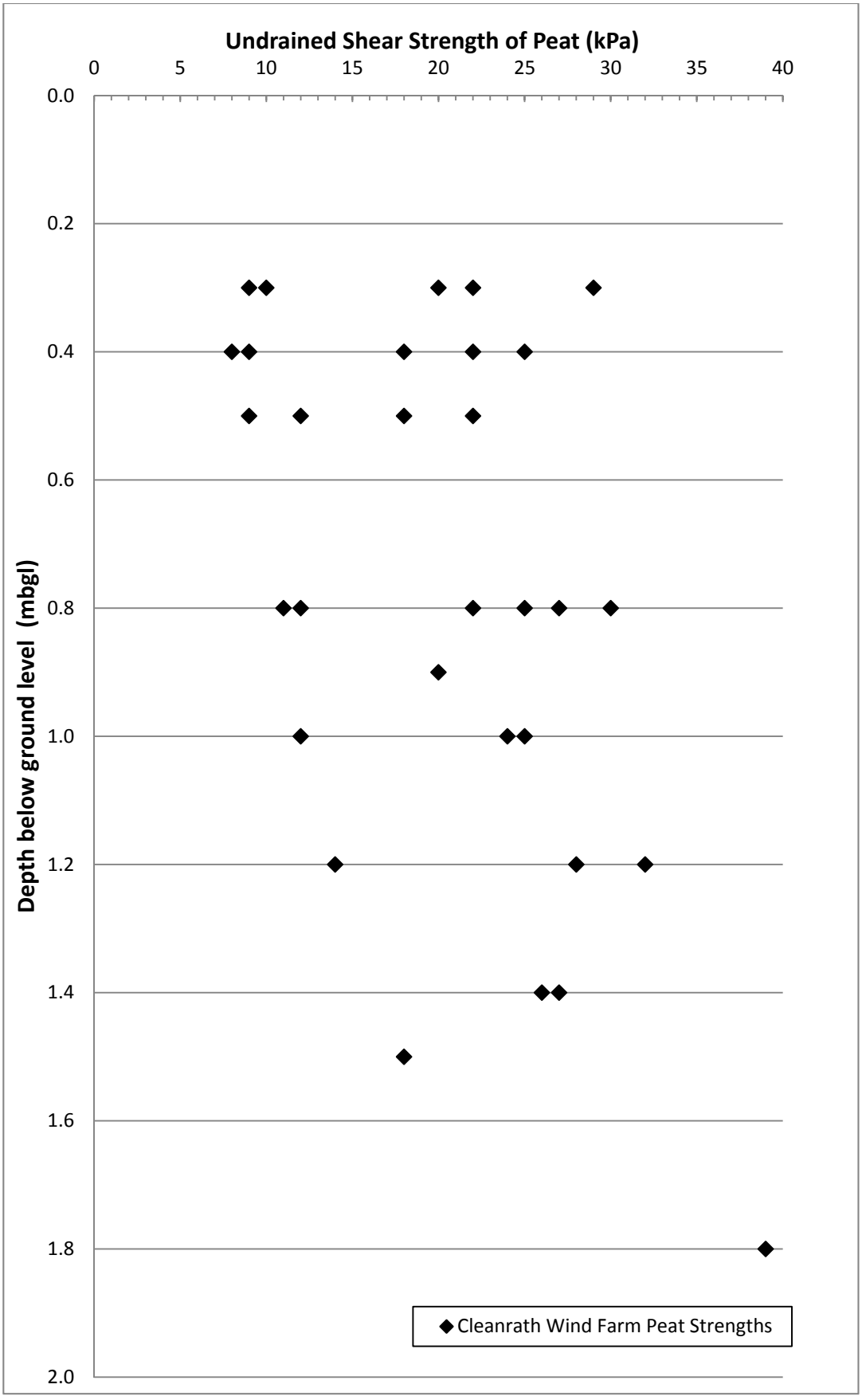

Figure 5 Undrained Shear Strength (C_u) Profile for Peat with Depth

7 PEAT STABILITY ASSESSMENT

The peat stability assessment analyses the stability of the natural peat slopes for individual parcels across the site including at the turbine locations and along the proposed access roads. 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 in particular, 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 Derrybrien failure, 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 2 shows a summary of the published information on peat together with drained strength values.

Table 2 List of Effective Cohesion and Friction Angle Values

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
Sandorini et al (1984)	4.5	28	From triaxial 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
Madison et al (1996)	10	23	-
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
Entec (2008)	3.8	36.8	Generalised values derived from various peat tests (shear box and triaxial)

From Table 2 the values for c' ranged from 1.1 to 10kPa and ø' ranged from 21.6 to 43°. The average c' and ø' values are 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 degrees

7.2 Analysis to Determine Factor of Safety (Deterministic Approach)

The purpose of the analysis was to determine the Factor of Safety (FoS) of the peat slopes using infinite slope analysis. The analysis was carried out at the turbine locations, along the proposed access roads and at various 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 3.

Table 3 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 6kPa was selected for the assessment. It should be noted that a c_u of 6kPa 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 minimum shear strength recorded for the peat on site was 8kPa which is a significantly higher 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 been 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 survey.

(2) A lower bound undrained shear strength, c_u for the peat of 6kPa was selected for the assessment. It should be noted that a c_u of 6kPa 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 minimum shear strength recorded for the peat on site was 8kPa which is a significantly higher strength.

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

For the stability analysis two load conditions were examined, namely

Condition (1): no surcharge loading

Condition (2): surcharge of 10 kPa, equivalent to 1 m of stockpiled peat assumed as a worst case.

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 6. 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 4.

The calculated FoS for load condition (1) is in excess of 1.30 for each of the 171 no. locations analysed with a range of FoS of 2.23 to in excess of 10, indicating a low risk of peat instability.

The calculated FoS for load condition (2) is in excess of 1.30 for each of the 171 no. locations analysed with a range of FoS of 1.34 to in excess of 10, indicating a low risk of peat instability.

Table 4 Factor of Safety Results (undrained condition)

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T1	120871	70057	86.01	14.34
T2	120359	70020	343.84	31.26
T3	121213	69913	114.80	10.44
T4	121200	69411	19.13	7.18
T5	120682	69553	172.03	15.64
T6	119466	69620	25.56	2.32
T7	119610	69250	114.8	10.44
T8	120493	69178	86.22	7.84
T9	119952	68981	16.40	6.75
T10	120288	68725	28.70	8.20
T11	120768	68782	172.03	15.64
Substation	120634	68504	86.22	7.84
Construction Compound	120907	70023	114.80	10.44
Met Mast	120418	68563	43.11	7.19

FOR INFORMATION

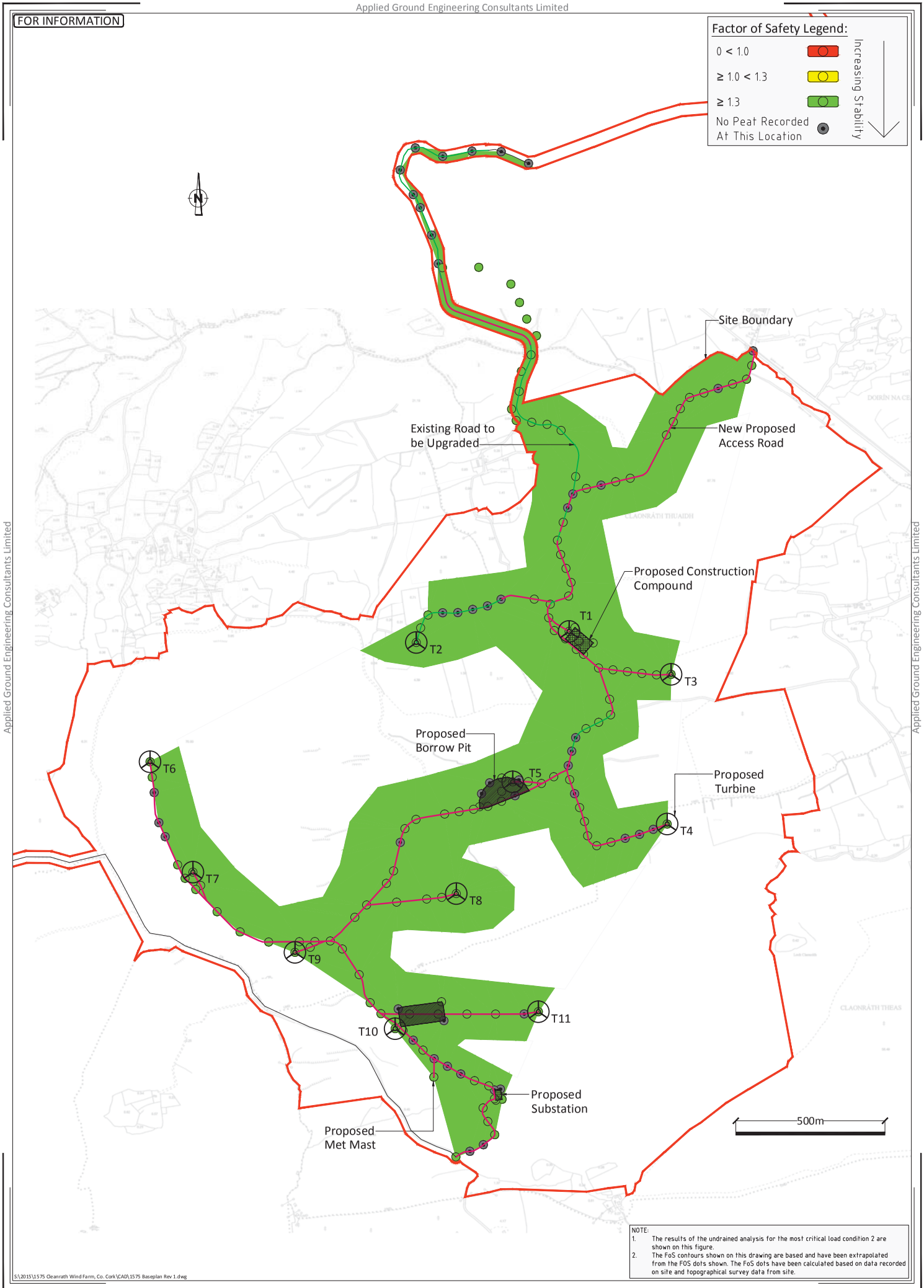

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Figure 6 Factor of Safety Plan - Short Term Critical Condition (Undrained)

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 5. As stated previously, the drained loading condition examines the effect of in particular, rainfall on the existing stability of the natural peat slopes.

The calculated FoS for load condition (1) is in excess of 1.30 for each of the 171 no. locations analysed with a range of FoS of 1.49 to in excess of 10, indicating a low risk of peat instability.

The calculated FoS for load condition (2) is in excess of 1.30 for each of the 171 no. locations analysed with a range of FoS of 1.90 to in excess of 10, indicating a low risk of peat instability.

Table 5 Factor of Safety Results (drained condition)

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T1	120871	70057	57.34	20.68
T2	120359	70020	229.23	45.13
T3	121213	69913	76.53	15.05
T4	121200	69411	12.76	10.34
T5	120682	69553	114.68	22.57
T6	119466	69620	17.04	3.25
T7	119610	69250	76.53	15.05
T8	120493	69178	57.48	11.29
T9	119952	68981	10.93	9.74
T10	120288	68725	19.13	11.82
T11	120768	68782	114.68	22.57
Substation	120634	68504	64.15	11.89
Construction Compound	120907	70023	76.53	15.05
Met Mast	120418	68563	28.74	10.35

8 RISK ASSESSMENT

A risk assessment was carried out for the main infrastructure elements at the proposed wind farm development. This approach follows the guidelines for geotechnical risk management as given in Clayton (2001), as referenced in PHRAG, and takes into account the approach of 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 infrastructure element, a risk rating (product of probability and impact) is calculated and rated as shown in Table 6. Where an infrastructure element is rated 'Substantial' or 'Unacceptable', control measures are required to reduce the risk to at least a 'Tolerable' risk rating. Where an infrastructure element is rated 'Trivial' or 'Tolerable', only routine control measures are required.

Table 6 Risk Rating Legend

10 to 20	Unacceptable: re-location or significant control measures required
5 to 9	Substantial: notable control measures required
3 to 4	Tolerable: only routine control measures required
1 to 2	Trivial: none or only routine control measures required

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

8.1 Summary of Risk Assessment Results

The results of the 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 7.

The risk rating for each infrastructure element at the Cleanrath wind farm is designated trivial following some mitigation/control measures being implemented. Sections of access roads to the nearest infrastructure element should 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).

Table 7 Summary of Geotechnical 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
Turbine T1	Trivial	1 to 2	No	Trivial	1 to 2
Turbine T2	Trivial	1 to 2	No	Trivial	1 to 2
Turbine T3	Trivial	1 to 2	No	Trivial	1 to 2
Turbine T4	Trivial	1 to 2	No	Trivial	1 to 2
Turbine T5	Trivial	1 to 2	No	Trivial	1 to 2
Turbine T6	Trivial	1 to 2	No	Trivial	1 to 2
Turbine T7	Trivial	1 to 2	No	Trivial	1 to 2
Turbine T8	Trivial	1 to 2	No	Trivial	1 to 2
Turbine T9	Trivial	1 to 2	No	Trivial	1 to 2
Turbine T10	Trivial	1 to 2	No	Trivial	1 to 2
Turbine T11	Trivial	1 to 2	No	Trivial	1 to 2
Substation	Trivial	1 to 2	No	Trivial	1 to 2
Construction Compound	Trivial	1 to 2	No	Trivial	1 to 2
Met Mast	Trivial	1 to 2	No	Trivial	1 to 2

9 SUMMARY AND RECOMMENDATIONS

9.1 Summary

The following summary is given.

AGEC was engaged by McCarthy Keville O'Sullivan to undertake an assessment of the proposed wind farm site with respect to peat stability.

The findings of the peat assessment, which involved analysis of 171 no. locations, showed that the site has an acceptable margin of safety and is suitable for the proposed wind farm development. 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.

The site which is undulating consists predominantly of shallow blanket peat/peaty topsoil with some forested, deforested and pasture areas across the site. Over 2.0km of existing access tracks which have been in operation for a number of years are proposed to be incorporated into the access road network for the wind farm.

Peat depths recorded during the site walkover vary from 0 to 0.6m with localised deeper peat deposits of up to 3.4m.

An analysis of peat sliding 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) & (2) for the 171 no. locations analysed, shows that at all locations an acceptable FoS of greater than 1.3 was calculated, indicating a low risk of peat instability.

A drained analysis was carried out, which applies in the long-term. For the undrained condition, the calculated FoS for load conditions (1) & (2) for the 171 no. locations analysed, shows an acceptable FoS of greater than 1.3 was calculated, indicating a low risk of peat instability.

The risk assessment at each infrastructure location identified a number of mitigation/control measures to reduce the potential risk of peat failure. Sections of access roads 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 peat assessment, which involved analysis of 171 no. locations, showed that the proposed Cleanrath wind farm site has an acceptable margin of safety and is suitable for the proposed wind farm development. 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. These need only apply at this site to localised areas of the site.

9.2 Recommendations

The following general 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 in peatlands. Mitigation/control measures identified for each of the infrastructure elements in the risk assessment should be taken into account and implemented throughout design and construction works (Appendix B).

A construction buffer zone plan has been produced for the site (Figure 4). This Figure shows areas which have an elevated or higher construction risk due to the terrain and features encountered during the site reconnaissance and are areas where additional mitigation/control measures will be required (Appendix B).

To minimise the risk of construction activity causing potential peat instability it is recommended that the Construction Method Statements (CMSs) for the project 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.

10 REFERENCES

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APPENDIX A

PHOTOS FROM SITE VISIT

Photo 1 Overview of site conditions

Photo 2 Overview of site conditions

Photo 3 Example of an existing access road on site

Photo 4 Example of ground conditions on site

Photo 5 Example of ground conditions on site

APPENDIX B

GEOTECHNICAL RISK REGISTER

Cleanrath Wind Farm - Geotechnical Risk Register (Rev 0)

Location:	Turbine T1

Grid Reference (Eastings, Northings):	**120871**	**70057**
Distance to Watercourse (m)	**> 150**	
Maximum Measured Peat Depth (m):	**0.2**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob	Impact	Risk	Risk Rating
1	FOS = 14.34 (u), 20.68 (d)	1	1	1	Trival	No	See Below	1	1	1	Trival
2	Evidence of sub peat water flow	1	1	1	Trival	No		1	1	1	Trival
3	Evidence of surface water flow	1	1	1	Trival	No		1	1	1	Trival
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Trival	No		1	1	1	Trival
6	General slope characteristics upslope/downslope from infrastructure location	1	1	1	Trival	No		1	1	1	Trival
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 T1**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	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.

Cleanrath Wind Farm - Geotechnical Risk Register (Rev 0)

Location:	Turbine T2

Grid Reference (Eastings, Northings):	**120359**	**70020**
Distance to Watercourse (m)	**> 150**	
Maximum 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	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob	Impact	Risk	Risk Rating
1	FOS = 31.26 (u), 45.13 (d)	1	1	1	Trival	No		1	1	1	Trival
2	Evidence of sub peat water flow	1	1	1	Trival	No		1	1	1	Trival
3	Evidence of surface water flow	1	1	1	Trival	No		1	1	1	Trival
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Trival	No		1	1	1	Trival
6	General slope characteristics upslope/downslope from infrastructure location	1	1	1	Trival	No	See Below	1	1	1	Trival
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**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	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.

Cleanrath Wind Farm - Geotechnical Risk Register (Rev 0)

Location:	Turbine T3

Grid Reference (Eastings, Northings):	**121213**	**69913**
Distance to Watercourse (m)	**> 150**	
Maximum 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	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob	Impact	Risk	Risk Rating
1	FOS = 10.44 (u), 15.05 (d)	1	1	1	Trival	No		1	1	1	Trival
2	Evidence of sub peat water flow	1	1	1	Trival	No		1	1	1	Trival
3	Evidence of surface water flow	1	1	1	Trival	No		1	1	1	Trival
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Trival	No		1	1	1	Trival
6	General slope characteristics upslope/downslope from infrastructure location	1	1	1	Trival	No	See Below	1	1	1	Trival
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	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	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.

Cleanrath Wind Farm - Geotechnical Risk Register (Rev 0)

Location:	Turbine T4

Grid Reference (Eastings, Northings):	**121200**	**69411**
Distance to Watercourse (m)	**> 150**	
Maximum 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	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob	Impact	Risk	Risk Rating
1	FOS = 7.18 (u), 10.34 (d)	1	1	1	Trival	No	See Below	1	1	1	Trival
2	Evidence of sub peat water flow	1	1	1	Trival	No		1	1	1	Trival
3	Evidence of surface water flow	1	1	1	Trival	No		1	1	1	Trival
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Trival	No		1	1	1	Trival
6	General slope characteristics upslope/downslope from infrastructure location	1	1	1	Trival	No		1	1	1	Trival
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 T4**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	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.

Cleanrath Wind Farm - Geotechnical Risk Register (Rev 0)

Location:	Turbine T5

Grid Reference (Eastings, Northings):	**120682**	**69553**
Distance to Watercourse (m)	**> 150**	
Maximum 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	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob	Impact	Risk	Risk Rating
1	FOS = 15.64 (u), 22.57 (d)	1	1	1	Trival	No	See Below	1	1	1	Trival
2	Evidence of sub peat water flow	1	1	1	Trival	No		1	1	1	Trival
3	Evidence of surface water flow	2	1	2	Trival	No		1	1	1	Trival
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Trival	No		1	1	1	Trival
6	General slope characteristics upslope/downslope from infrastructure location	1	1	1	Trival	No		1	1	1	Trival
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		1	1	1	Trival

	Control Measures to be Implemented Prior to/and During Construction for **Turbine T5**
i	Maintain hydrology of area as far as possible;
ii	Installation of interceptor drains upslope of works to divert any surface water away from turbine construction area;
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.

Cleanrath Wind Farm - Geotechnical Risk Register (Rev 0)

Location:	Turbine T6

Grid Reference (Eastings, Northings):	**119466**	**69620**
Distance to Watercourse (m)	**> 150**	
Maximum 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	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob	Impact	Risk	Risk Rating
1	FOS = 2.32 (u), 3.25 (d)	1	1	1	Trival	No	See Below	1	1	1	Trival
2	Evidence of sub peat water flow	1	1	1	Trival	No		1	1	1	Trival
3	Evidence of surface water flow	1	1	1	Trival	No		1	1	1	Trival
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Trival	No		1	1	1	Trival
6	General slope characteristics upslope/downslope from infrastructure location	2	1	2	Trival	No		1	1	1	Trival
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 T6**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	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.

Cleanrath Wind Farm - Geotechnical Risk Register (Rev 0)

Location:	Turbine T7

Grid Reference (Eastings, Northings):	**119610**	**69250**
Distance to Watercourse (m)	**> 150**	
Maximum 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	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob	Impact	Risk	Risk Rating
1	FOS = 10.44 (u), 15.05 (d)	1	1	1	Trival	No	See Below	1	1	1	Trival
2	Evidence of sub peat water flow	1	1	1	Trival	No		1	1	1	Trival
3	Evidence of surface water flow	1	1	1	Trival	No		1	1	1	Trival
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Trival	No		1	1	1	Trival
6	General slope characteristics upslope/downslope from infrastructure location	1	1	1	Trival	No		1	1	1	Trival
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	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	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.

Cleanrath Wind Farm - Geotechnical Risk Register (Rev 0)

Location:	Turbine T8

Grid Reference (Eastings, Northings):	**120493**	**69178**
Distance to Watercourse (m)	**100 - 150**	
Maximum 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	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob	Impact	Risk	Risk Rating
1	FOS = 7.84 (u), 11.29 (d)	1	2	2	Trival	No		1	2	2	Trival
2	Evidence of sub peat water flow	1	2	2	Trival	No		1	2	2	Trival
3	Evidence of surface water flow	1	2	2	Trival	No		1	2	2	Trival
4	Evidence of previous failures/slips	0	2	0	Not Applicable	No		0	2	0	Not Applicable
5	Type of vegetation	1	2	2	Trival	No		1	2	2	Trival
6	General slope characteristics upslope/downslope from infrastructure location	1	2	2	Trival	No	See Below	1	2	2	Trival
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 T8**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	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.

Cleanrath Wind Farm - Geotechnical Risk Register (Rev 0)

Location:	Turbine T9

Grid Reference (Eastings, Northings):	**119952**	**68981**
Distance to Watercourse (m)	**> 150**	
Maximum Measured Peat Depth (m):	**0.7**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob	Impact	Risk	Risk Rating
1	FOS = 6.75 (u), 9.74 (d)	1	1	1	Trival	No		1	1	1	Trival
2	Evidence of sub peat water flow	1	1	1	Trival	No		1	1	1	Trival
3	Evidence of surface water flow	1	1	1	Trival	No		1	1	1	Trival
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Trival	No		1	1	1	Trival
6	General slope characteristics upslope/downslope from infrastructure location	1	1	1	Trival	No	See Below	1	1	1	Trival
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	
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Other	0	1	0	Not Applicable	No		1	1	1	Trival

	Control Measures to be Implemented Prior to/and During Construction for **Turbine T9**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	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.

Cleanrath Wind Farm - Geotechnical Risk Register (Rev 0)

Location:	Turbine T10

Grid Reference (Eastings, Northings):	**120288**	**68725**
Distance to Watercourse (m)	**> 150**	
Maximum Measured Peat Depth (m):	**0.4**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob	Impact	Risk	Risk Rating
1	FOS = 8.20 (u), 11.82 (d)	1	1	1	Trival	No	See Below	1	1	1	Trival
2	Evidence of sub peat water flow	1	1	1	Trival	No		1	1	1	Trival
3	Evidence of surface water flow	1	1	1	Trival	No		1	1	1	Trival
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Trival	No		1	1	1	Trival
6	General slope characteristics upslope/downslope from infrastructure location	1	1	1	Trival	No		1	1	1	Trival
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 T10**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	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.

Cleanrath Wind Farm - Geotechnical Risk Register (Rev 0)

Location:	Turbine T11

Grid Reference (Eastings, Northings):	**120768**	**68782**
Distance to Watercourse (m)	**> 150**	
Maximum 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	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob	Impact	Risk	Risk Rating
1	FOS = 15.64 (u), 22.57 (d)	1	1	1	Trival	No		1	1	1	Trival
2	Evidence of sub peat water flow	1	1	1	Trival	No		1	1	1	Trival
3	Evidence of surface water flow	1	1	1	Trival	No		1	1	1	Trival
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Trival	No		1	1	1	Trival
6	General slope characteristics upslope/downslope from infrastructure location	1	1	1	Trival	No	See Below	1	1	1	Trival
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 T11**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	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.

Cleanrath Wind Farm - Geotechnical Risk Register (Rev 0)

Location:	Substation

Grid Reference (Eastings, Northings):	**120634**	**68504**
Distance to Watercourse (m)	**> 150**	
Maximum 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	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob	Impact	Risk	Risk Rating
1	FOS = 7.84 (u), 11.89 (d)	1	1	1	Trival	No		1	1	1	Trival
2	Evidence of sub peat water flow	1	1	1	Trival	No		1	1	1	Trival
3	Evidence of surface water flow	1	1	1	Trival	No		1	1	1	Trival
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Trival	No		1	1	1	Trival
6	General slope characteristics upslope/downslope from infrastructure location	1	1	1	Trival	No	See Below	1	1	1	Trival
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 **Substation**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	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.

Cleanrath Wind Farm - Geotechnical Risk Register (Rev 0)

Location:	Const. Compound

Grid Reference (Eastings, Northings):	120907	70023
Distance to Watercourse (m)	> 150	
Maximum Measured Peat Depth (m):	0.2	
Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob	Impact	Risk	Risk Rating
1	FOS = 9.57 (u), 13.79 (d)	1	1	1	Trival	No	See Below	1	1	1	Trival
2	Evidence of sub peat water flow	1	1	1	Trival	No		1	1	1	Trival
3	Evidence of surface water flow	1	1	1	Trival	No		1	1	1	Trival
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Trival	No		1	1	1	Trival
6	General slope characteristics upslope/downslope from infrastructure location	1	1	1	Trival	No		1	1	1	Trival
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 **Construction Compound**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	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.

Cleanrath Wind Farm - Geotechnical Risk Register (Rev 0)

Location:	Met Mast

Grid Reference (Eastings, Northings):	**120418**	**68563**
Distance to Watercourse (m)	**> 150**	
Maximum Measured Peat Depth (m):	**0.2**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob	Impact	Risk	Risk Rating
1	FOS = 7.19 (u), 10.35 (d)	1	1	1	Trival	No		1	1	1	Trival
2	Evidence of sub peat water flow	1	1	1	Trival	No		1	1	1	Trival
3	Evidence of surface water flow	1	1	1	Trival	No		1	1	1	Trival
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Trival	No		1	1	1	Trival
6	General slope characteristics upslope/downslope from infrastructure location	1	1	1	Trival	No	See Below	1	1	1	Trival
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 **Met Mast**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	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.

APPENDIX C

CALCULATED FOS FOR PEAT SLOPES ON SITE

Calculated FoS of Natural Peat Slopes for Cleanrath 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	120871	70057	2.0	6	10	0.2	1.2	**86.01**	**14.34**
T2	120359	70020	1.0	6	10	0.1	1.1	**343.84**	**31.26**
T3	121213	69913	3.0	6	10	0.1	1.1	**114.80**	**10.44**
T4	121200	69411	3.0	6	10	0.6	1.6	**19.13**	**7.18**
T5	120682	69553	2.0	6	10	0.1	1.1	**172.03**	**15.64**
T6	119466	69620	14.0	6	10	0.1	1.1	**25.56**	**2.32**
T7	119610	69250	3.0	6	10	0.1	1.1	**114.80**	**10.44**
T8	120493	69178	4.0	6	10	0.1	1.1	**86.22**	**7.84**
T9	119952	68981	3.0	6	10	0.7	1.7	**16.40**	**6.75**
T10	120288	68725	3.0	6	10	0.4	1.4	**28.70**	**8.20**
T11	120768	68782	2.0	6	10	0.1	1.1	**172.03**	**15.64**
MET	120418	68563	4.0	6	10	0.2	1.2	**43.11**	**7.19**
CC1	120891	70070	3.0	6	10	0.1	1.1	**114.80**	**10.44**
CC2	120952	70019	3.0	6	10	0.1	1.1	**114.80**	**10.44**
CC3	120920	69980	3.0	6	10	0.1	1.1	**114.80**	**10.44**
CC4	120859	70032	3.0	6	10	0.2	1.2	**57.40**	**9.57**
CC5	120907	70023	3.0	6	10	0.1	1.1	**114.80**	**10.44**
S1	120641	68522	No peat recorded at this location						
S2	120646	68488	4.0	6	10	0.1	1.1	**86.22**	**7.84**
S3	120626	68485	4.0	6	10	0.1	1.1	**86.22**	**7.84**
S4	120620	68519	No peat recorded at this location						
S5	120634	68504	4.0	6	10	0.1	1.1	**86.22**	**7.84**
CC	122750	61934	5.0	6	10	0.1	1.1	**69.11**	**6.28**
MM	120902	61562	6.0	6	10	0.4	1.4	**14.43**	**4.12**
BS1	120298	68791	No peat recorded at this location						
BS2	120444	68815	2.4	6	10	0.1	1.1	**143.41**	**13.04**
BS3	120451	68752	No peat recorded at this location						
BS4	120309	68732	4.8	6	10	0.1	1.1	**71.96**	**6.54**
BN1	120571	69469	0.2	6	10	0.1	1.1	**1718.89**	**156.26**
BN2	120578	69513	No peat recorded at this location						
BN3	120605	69550	No peat recorded at this location						
BN4	120646	69565	3.8	6	10	0.2	1.2	**45.37**	**7.56**
BN5	120703	69559	No peat recorded at this location						
BN6	120645	69521	3.0	6	10	0.1	1.1	**114.80**	**10.44**
1	120735	71626	No peat recorded at this location						
3	120644	71666	No peat recorded at this location						
5	120545	71668	No peat recorded at this location						
7	120447	71650	No peat recorded at this location						
9	120356	71678	No peat recorded at this location						
11	120305	71604	No peat recorded at this location						
13	120349	71522	No peat recorded at this location						
14	120372	71478	No peat recorded at this location						
16	120410	71386	No peat recorded at this location						
18	120433	71290	No peat recorded at this location						
30	120694	70765	14.0	6	10	0.1	1.1	**25.56**	**2.32**
31	120746	70758	12.9	6	10	0.4	1.4	**6.89**	**1.97**
32	120797	70751	9.2	6	10	0.3	1.3	**12.67**	**2.92**
33	120844	70731	10.5	6	10	0.2	1.2	**16.74**	**2.79**
36	120893	70576	2.0	6	10	0.2	1.2	**86.01**	**14.34**
37	120884	70518	No peat recorded at this location						
38	120930	70536	3.0	6	10	0.1	1.1	**114.80**	**10.44**
39	120978	70548	No peat recorded at this location						
40	121027	70559	3.0	6	10	0.1	1.1	**114.80**	**10.44**
41	121076	70571	5.3	6	10	0.1	1.1	**65.23**	**5.93**
45	121197	70715	3.0	6	10	0.1	1.1	**114.80**	**10.44**
46	121221	70760	7.9	6	10	0.1	1.1	**44.07**	**4.01**
47	121244	70804	2.0	6	10	0.2	1.2	**86.01**	**14.34**
48	121275	70842	2.3	6	10	0.1	1.1	**149.63**	**13.60**
49	121323	70857	2.0	6	10	0.2	1.2	**86.01**	**14.34**
50	121371	70872	No peat recorded at this location						
51	121419	70886	3.0	6	10	0.1	1.1	**114.80**	**10.44**
52	121466	70903	1.0	6	10	0.2	1.2	**171.92**	**28.65**
53	121484	70949	2.0	6	10	0.2	1.2	**86.01**	**14.34**
54	121488	70998	No peat recorded at this location						
55	120866	70472	No peat recorded at this location						
56	120851	70423	3.0	6	10	0.3	1.3	**38.27**	**8.83**
57	120832	70363	6.0	6	10	0.2	1.2	**28.86**	**4.81**
58	120843	70315	4.0	6	10	0.4	1.4	**21.56**	**6.16**
59	120861	70268	4.4	6	10	0.1	1.1	**78.44**	**7.13**
60	120878	70221	4.0	6	10	0.2	1.2	**43.11**	**7.19**
61	120870	70176	8.0	6	10	0.2	1.2	**21.77**	**3.63**
62	120755	70165	4.0	6	10	0.4	1.4	**21.56**	**6.16**
64	120643	70165	No peat recorded at this location						
65	120597	70142	No peat recorded at this location						
66	120548	70131	No peat recorded at this location						
67	120498	70120	No peat recorded at this location						
68	120447	70120	No peat recorded at this location						
69	120398	70112	4.7	6	10	0.1	1.1	**73.47**	**6.68**
70	120373	70069	2.0	6	10	0.3	1.3	**57.34**	**13.23**
71	120808	70148	8.8	6	10	0.2	1.2	**19.84**	**3.31**
72	120803	70103	3.0	6	10	0.3	1.3	**38.27**	**8.83**
73	120822	70060	3.0	6	10	0.2	1.2	**57.40**	**9.57**
75	120896	69997	3.0	6	10	0.1	1.1	**114.80**	**10.44**
77	120970	69934	0.2	6	10	0.5	1.5	**343.78**	**114.59**
78	121018	69928	2.0	6	10	2.2	3.2	**7.82**	**5.38**
79	121067	69922	2.0	6	10	2.7	3.7	**6.37**	**4.65**
80	121115	69916	1.0	6	10	3.4	4.4	**10.11**	**7.81**
81	121164	69911	6.0	6	10	1.7	2.7	**3.40**	**2.14**
83	121007	69829	2.0	6	10	1.6	2.6	**10.75**	**6.62**
84	121010	69777	2.0	6	10	0.1	1.1	**172.03**	**15.64**
85	120971	69752	5.1	6	10	0.1	1.1	**67.76**	**6.16**
86	120928	69731	3.0	6	10	0.1	1.1	**114.80**	**10.44**
87	120893	69701	No peat recorded at this location						
88	120880	69655	No peat recorded at this location						
89	120868	69607	No peat recorded at this location						
90	120873	69560	2.0	6	10	1.1	2.1	**15.64**	**8.19**
91	120890	69513	No peat recorded at this location						

Calculated FoS of Natural Peat Slopes for Cleanrath 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)
92	120906	69466	2.3	6	10	0.1	1.1	**149.63**	**13.60**
93	120923	69420	2.0	6	10	0.1	1.1	**172.03**	**15.64**
94	120933	69371	2.6	6	10	0.5	1.5	**26.48**	**8.83**
95	120964	69338	1.0	6	10	1.0	2.0	**34.38**	**17.19**
96	121012	69350	1.0	6	10	0.1	1.1	**343.84**	**31.26**
97	121059	69363	No peat recorded at this location						
98	121107	69376	No peat recorded at this location						
99	121154	69393	No peat recorded at this location						
100	120820	69570	1.6	6	10	0.5	1.5	**42.99**	**14.33**
101	120778	69547	2.0	6	10	1.0	2.0	**17.20**	**8.60**
102	120734	69553	2.0	6	10	1.6	2.6	**10.75**	**6.62**
104	120690	69506	No peat recorded at this location						
105	120645	69487	7.5	6	10	0.2	1.2	**23.18**	**3.86**
106	120599	69471	2.3	6	10	0.2	1.2	**74.81**	**12.47**
107	120551	69460	3.0	6	10	0.1	1.1	**114.80**	**10.44**
108	120502	69453	2.0	6	10	0.2	1.2	**86.01**	**14.34**
109	120454	69445	2.0	6	10	0.4	1.4	**43.01**	**12.29**
111	120358	69427	3.0	6	10	0.1	1.1	**114.80**	**10.44**
112	120321	69396	8.1	6	10	0.1	1.1	**43.01**	**3.91**
113	120305	69350	No peat recorded at this location						
115	120283	69254	6.2	6	10	0.1	1.1	**55.88**	**5.08**
116	120259	69212	11.6	6	10	0.2	1.2	**15.23**	**2.54**
118	120193	69140	10.5	6	10	1.5	2.5	**2.23**	**1.34**
120	120293	69149	12.6	6	10	0.5	1.5	**5.64**	**1.88**
122	120394	69160	3.0	6	10	0.1	1.1	**114.80**	**10.44**
123	120444	69165	9.5	6	10	0.7	1.7	**5.27**	**2.17**
124	120153	69098	3.0	6	10	0.3	1.3	**38.27**	**8.83**
126	120070	69019	4.4	6	10	0.1	1.1	**78.44**	**7.13**
127	120111	68992	5.2	6	10	0.2	1.2	**33.24**	**5.54**
129	120167	68906	3.0	6	10	0.6	1.6	**19.13**	**7.18**
131	120204	68812	7.2	6	10	0.2	1.2	**24.13**	**4.02**
132	120240	68775	2.0	6	10	0.1	1.1	**172.03**	**15.64**
134	120336	68774	3.0	6	10	0.2	1.2	**57.40**	**9.57**
136	120432	68774	2.0	6	10	0.3	1.3	**57.34**	**13.23**
138	120528	68774	2.0	6	10	0.8	1.8	**21.50**	**9.56**
140	120624	68774	3.0	6	10	0.9	1.9	**12.76**	**6.04**
142	120720	68774	No peat recorded at this location						
144	120315	68719	6.0	6	10	0.1	1.1	**57.72**	**5.25**
145	120348	68686	No peat recorded at this location						
146	120381	68653	15.0	6	10	0.1	1.1	**24.00**	**2.18**
148	120419	68624	No peat recorded at this location						
149	120463	68599	No peat recorded at this location						
150	120508	68573	No peat recorded at this location						
151	120554	68551	8.1	6	10	0.1	1.1	**43.01**	**3.91**
152	120602	68533	9.0	6	10	0.5	1.5	**7.77**	**2.59**
153	120621	68490	9.3	6	10	0.0	1.0	**376.22**	**3.72**
154	120583	68459	10.0	6	10	0.1	1.1	**35.09**	**3.19**
155	120599	68414	17.2	6	10	0.1	1.1	**21.24**	**1.93**
156	120622	68369	3.0	6	10	0.1	1.1	**114.80**	**10.44**
157	120584	68336	No peat recorded at this location						
158	120538	68314	No peat recorded at this location						
159	120492	68295	4.9	6	10	0.1	1.1	**70.50**	**6.41**
160	120003	68998	1.2	6	10	0.2	1.2	**143.28**	**23.88**
162	120019	69017	6.8	6	10	0.3	1.3	**17.01**	**3.93**
163	119967	69017	1.0	6	10	0.2	1.2	**171.92**	**28.65**
165	119864	69016	2.0	6	10	0.3	1.3	**57.34**	**13.23**
167	119768	69050	2.0	6	10	0.2	1.2	**86.01**	**14.34**
169	119691	69117	2.0	6	10	0.1	1.1	**172.03**	**15.64**
171	119636	69205	1.0	6	10	0.1	1.1	**343.84**	**31.26**
172	119619	69192	5.3	6	10	0.1	1.1	**65.23**	**5.93**
173	119584	69229	3.0	6	10	0.1	1.1	**114.80**	**10.44**
174	119559	69274	13.7	6	10	0.1	1.1	**26.08**	**2.37**
176	119517	69369	No peat recorded at this location						
177	119496	69416	No peat recorded at this location						
179	119480	69517	No peat recorded at this location						
180	119473	69568	14.0	6	10	0.1	1.1	**25.56**	**2.32**
WP014	120447	71277	2.0	6	10	0.3	1.3	**57.34**	**13.23**
WP016	120568	71278	2.0	6	10	0.2	1.2	**86.01**	**14.34**
WP018	120676	71222	1.0	6	10	0.1	1.1	**343.84**	**31.26**
WP019	120705	71160	1.0	6	10	0.1	1.1	**343.84**	**31.26**
WP020	120729	71105	1.0	6	10	0.3	1.3	**114.61**	**26.45**
WP021	120762	71049	3.4	6	10	0.4	1.4	**25.34**	**7.24**
WP022	120744	70985	2.0	6	10	0.1	1.1	**172.03**	**15.64**
WP023	120711	70929	5.4	6	10	0.1	1.1	**64.04**	**5.82**
WP024	120704	70862	1.0	6	10	0.2	1.2	**171.92**	**28.65**
WP025	120678	70802	4.2	6	10	0.1	1.1	**82.15**	**7.47**

Minimum =	**2.23**	**1.34**
Maximum =	**1718.89**	**156.26**
Average =	**96.72**	**11.99**

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 6kPa was selected for the assessment. It should be noted that a cu of 6kPa 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 minimum shear strength recorded for the peat on site was 8kPa which is a higher strength.

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

(6) For load conditions see report text.

Calculated FoS of Natural Peat Slopes for Cleanrath 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	2.0	4	10.0	10.0	0.2	25	1.0	1.2	**57.34**	**20.68**
T2	1.0	4	10.0	10.0	0.1	25	1.0	1.1	**229.23**	**45.13**
T3	3.0	4	10.0	10.0	0.1	25	1.0	1.1	**76.53**	**15.05**
T4	3.0	4	10.0	10.0	0.6	25	1.0	1.6	**12.76**	**10.34**
T5	2.0	4	10.0	10.0	0.1	25	1.0	1.1	**114.68**	**22.57**
T6	14.0	4	10.0	10.0	0.1	25	1.0	1.1	**17.04**	**3.25**
T7	3.0	4	10.0	10.0	0.1	25	1.0	1.1	**76.53**	**15.05**
T8	4.0	4	10.0	10.0	0.1	25	1.0	1.1	**57.48**	**11.29**
T9	3.0	4	10.0	10.0	0.7	25	1.0	1.7	**10.93**	**9.74**
T10	3.0	4	10.0	10.0	0.4	25	1.0	1.4	**19.13**	**11.82**
T11	2.0	4	10.0	10.0	0.1	25	1.0	1.1	**114.68**	**22.57**
MET	4.0	4	10.0	10.0	0.2	25	1.0	1.2	**28.74**	**10.35**
CC1	3.0	4	10.0	10.0	0.1	25	1.0	1.1	**76.53**	**15.05**
CC2	3.0	4	10.0	10.0	0.1	25	1.0	1.1	**76.53**	**15.05**
CC3	3.0	4	10.0	10.0	0.1	25	1.0	1.1	**76.53**	**15.05**
CC4	3.0	4	10.0	10.0	0.2	25	1.0	1.2	**38.27**	**13.79**
CC5	3.0	4	10.0	10.0	0.1	25	1.0	1.1	**76.53**	**15.05**
S1	No peat recorded at this location									
S2	4.0	4	10.0	10.0	0.1	25	1.0	1.1	**64.15**	**11.89**
S3	4.0	4	10.0	10.0	0.1	25	1.0	1.1	**64.15**	**11.89**
S4	No peat recorded at this location									
S5	4.0	4	10.0	10.0	0.1	25	1.0	1.1	**64.15**	**11.89**
CC	5.0	4	10.0	10.0	0.1	25	1.0	1.1	**51.40**	**9.52**
MM	6.0	4	10.0	10.0	0.4	25	1.0	1.4	**14.06**	**7.19**
BS1	No peat recorded at this location									
BS2	2.4	4	10.0	10.0	0.1	25	1.0	1.1	**106.73**	**19.82**
BS3	No peat recorded at this location									
BS4	4.8	4	10.0	10.0	0.1	25	1.0	1.1	**53.52**	**9.91**
BN1	0.2	4	10.0	10.0	0.1	25	1.0	1.1	**1279.51**	**237.76**
BN2	No peat recorded at this location									
BN3	No peat recorded at this location									
BN4	3.8	4	10.0	10.0	0.2	25	1.0	1.2	**30.24**	**10.89**
BN5	No peat recorded at this location									
BN6	3.0	4	10.0	10.0	0.1	25	1.0	1.1	**76.53**	**15.05**
1	No peat recorded at this location									
3	No peat recorded at this location									
5	No peat recorded at this location									
7	No peat recorded at this location									
9	No peat recorded at this location									
11	No peat recorded at this location									
13	No peat recorded at this location									
14	No peat recorded at this location									
16	No peat recorded at this location									
18	No peat recorded at this location									
30	14.0	4	10.0	10.0	0.1	25	1.0	1.1	**18.91**	**3.42**
31	12.9	4	10.0	10.0	0.4	25	1.0	1.4	**6.63**	**3.35**
32	9.2	4	10.0	10.0	0.3	25	1.0	1.3	**11.33**	**4.83**
33	10.5	4	10.0	10.0	0.2	25	1.0	1.2	**13.68**	**4.38**
36	2.0	4	10.0	10.0	0.2	25	1.0	1.2	**70.70**	**22.91**
37	No peat recorded at this location									
38	3.0	4	10.0	10.0	0.1	25	1.0	1.1	**85.43**	**15.86**
39	No peat recorded at this location									
40	3.0	4	10.0	10.0	0.1	25	1.0	1.1	**85.43**	**15.86**
41	5.3	4	10.0	10.0	0.1	25	1.0	1.1	**48.52**	**8.98**
45	3.0	4	10.0	10.0	0.1	25	1.0	1.1	**85.43**	**15.86**
46	7.9	4	10.0	10.0	0.1	25	1.0	1.1	**32.74**	**6.03**
47	2.0	4	10.0	10.0	0.2	25	1.0	1.2	**70.70**	**22.91**
48	2.3	4	10.0	10.0	0.1	25	1.0	1.1	**111.36**	**20.68**
49	2.0	4	10.0	10.0	0.2	25	1.0	1.2	**70.70**	**22.91**
50	No peat recorded at this location									
51	3.0	4	10.0	10.0	0.1	25	1.0	1.1	**85.43**	**15.86**
52	1.0	4	10.0	10.0	0.2	25	1.0	1.2	**141.33**	**45.82**
53	2.0	4	10.0	10.0	0.2	25	1.0	1.2	**70.70**	**22.91**
54	No peat recorded at this location									
55	No peat recorded at this location									
56	3.0	4	10.0	10.0	0.3	25	1.0	1.3	**34.41**	**14.78**
57	6.0	4	10.0	10.0	0.2	25	1.0	1.2	**23.68**	**7.64**
58	4.0	4	10.0	10.0	0.4	25	1.0	1.4	**21.04**	**10.77**
59	4.4	4	10.0	10.0	0.1	25	1.0	1.1	**58.35**	**10.81**
60	4.0	4	10.0	10.0	0.2	25	1.0	1.2	**35.41**	**11.46**
61	8.0	4	10.0	10.0	0.2	25	1.0	1.2	**17.83**	**5.74**
62	4.0	4	10.0	10.0	0.4	25	1.0	1.4	**21.04**	**10.77**
64	No peat recorded at this location									
65	No peat recorded at this location									
66	No peat recorded at this location									
67	No peat recorded at this location									
68	No peat recorded at this location									
69	4.7	4	10.0	10.0	0.1	25	1.0	1.1	**54.65**	**10.12**
70	2.0	4	10.0	10.0	0.3	25	1.0	1.3	**51.58**	**22.18**
71	8.8	4	10.0	10.0	0.2	25	1.0	1.2	**16.24**	**5.22**
72	3.0	4	10.0	10.0	0.3	25	1.0	1.3	**34.41**	**14.78**
73	3.0	4	10.0	10.0	0.2	25	1.0	1.2	**47.16**	**15.28**
75	3.0	4	10.0	10.0	0.1	25	1.0	1.1	**85.43**	**15.86**
77	0.2	4	10.0	10.0	0.5	25	1.0	1.5	**362.77**	**209.98**
78	2.0	4	10.0	10.0	2.2	25	1.0	3.2	**18.57**	**16.94**
79	2.0	4	10.0	10.0	2.7	25	1.0	3.7	**17.60**	**16.45**
80	1.0	4	10.0	10.0	3.4	25	1.0	4.4	**33.46**	**31.92**
81	6.0	4	10.0	10.0	1.7	25	1.0	2.7	**6.70**	**5.86**
83	2.0	4	10.0	10.0	1.6	25	1.0	2.6	**20.52**	**17.76**
84	2.0	4	10.0	10.0	0.1	25	1.0	1.1	**128.04**	**23.78**
85	5.1	4	10.0	10.0	0.1	25	1.0	1.1	**50.40**	**9.33**
86	3.0	4	10.0	10.0	0.1	25	1.0	1.1	**85.43**	**15.86**
87	No peat recorded at this location									
88	No peat recorded at this location									
89	No peat recorded at this location									
90	2.0	4	10.0	10.0	1.1	25	1.0	2.1	**23.78**	**18.81**
91	No peat recorded at this location									
92	2.3	4	10.0	10.0	0.1	25	1.0	1.1	**111.36**	**20.68**
93	2.0	4	10.0	10.0	0.1	25	1.0	1.1	**128.04**	**23.78**
94	2.6	4	10.0	10.0	0.5	25	1.0	1.5	**27.92**	**16.15**
95	1.0	4	10.0	10.0	1.0	25	1.0	2.0	**49.64**	**38.18**
96	1.0	4	10.0	10.0	0.1	25	1.0	1.1	**255.94**	**47.55**
97	No peat recorded at this location									
98	No peat recorded at this location									
99	No peat recorded at this location									
100	1.6	4	10.0	10.0	0.5	25	1.0	1.5	**28.66**	**20.68**
101	2.0	4	10.0	10.0	1.0	25	1.0	2.0	**11.47**	**12.41**
102	2.0	4	10.0	10.0	1.6	25	1.0	2.6	**7.17**	**9.55**
104	No peat recorded at this location									
105	7.5	4	10.0	10.0	0.2	25	1.0	1.2	**15.45**	**5.53**

Calculated FoS of Natural Peat Slopes for Cleanrath 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
106	2.3	4	10.0	10.0	0.2	25	1.0	1.2	**49.88**	**17.99**
107	3.0	4	10.0	10.0	0.1	25	1.0	1.1	**76.53**	**15.05**
108	2.0	4	10.0	10.0	0.2	25	1.0	1.2	**57.34**	**20.68**
109	2.0	4	10.0	10.0	0.4	25	1.0	1.4	**28.67**	**17.73**
111	3.0	4	10.0	10.0	0.1	25	1.0	1.1	**76.53**	**15.05**
112	8.1	4	10.0	10.0	0.1	25	1.0	1.1	**28.67**	**5.59**
113	No peat recorded at this location									
115	6.2	4	10.0	10.0	0.1	25	1.0	1.1	**37.26**	**7.29**
116	11.6	4	10.0	10.0	0.2	25	1.0	1.2	**10.15**	**3.59**
118	10.5	4	10.0	10.0	1.5	25	1.0	2.5	**1.49**	**1.90**
120	12.6	4	10.0	10.0	0.5	25	1.0	1.5	**3.76**	**2.64**
122	3.0	4	10.0	10.0	0.1	25	1.0	1.1	**76.53**	**15.05**
123	9.5	4	10.0	10.0	0.7	25	1.0	1.7	**3.51**	**3.08**
124	3.0	4	10.0	10.0	0.3	25	1.0	1.3	**25.51**	**12.73**
126	4.4	4	10.0	10.0	0.1	25	1.0	1.1	**52.29**	**10.26**
127	5.2	4	10.0	10.0	0.2	25	1.0	1.2	**22.16**	**7.96**
129	3.0	4	10.0	10.0	0.6	25	1.0	1.6	**12.76**	**10.34**
131	7.2	4	10.0	10.0	0.2	25	1.0	1.2	**16.08**	**5.76**
132	2.0	4	10.0	10.0	0.1	25	1.0	1.1	**114.68**	**22.57**
134	3.0	4	10.0	10.0	0.2	25	1.0	1.2	**38.27**	**13.79**
136	2.0	4	10.0	10.0	0.3	25	1.0	1.3	**38.23**	**19.09**
138	2.0	4	10.0	10.0	0.8	25	1.0	1.8	**14.34**	**13.79**
140	3.0	4	10.0	10.0	0.9	25	1.0	1.9	**8.50**	**8.71**
142	No peat recorded at this location									
144	6.0	4	10.0	10.0	0.1	25	1.0	1.1	**38.48**	**7.53**
145	No peat recorded at this location									
146	15.0	4	10.0	10.0	0.1	25	1.0	1.1	**16.00**	**3.04**
148	No peat recorded at this location									
149	No peat recorded at this location									
150	No peat recorded at this location									
151	8.1	4	10.0	10.0	0.1	25	1.0	1.1	**31.95**	**5.88**
152	9.0	4	10.0	10.0	0.5	25	1.0	1.5	**8.12**	**4.67**
153	9.3	4	10.0	10.0	0.0	25	1.0	1.0	**253.66**	**5.33**
154	10.0	4	10.0	10.0	0.1	25	1.0	1.1	**23.39**	**4.53**
155	17.2	4	10.0	10.0	0.1	25	1.0	1.1	**14.16**	**2.66**
156	3.0	4	10.0	10.0	0.1	25	1.0	1.1	**76.53**	**15.05**
157	No peat recorded at this location									
158	No peat recorded at this location									
159	4.9	4	10.0	10.0	0.1	25	1.0	1.1	**47.00**	**9.22**
160	1.2	4	10.0	10.0	0.2	25	1.0	1.2	**95.52**	**34.47**
162	6.8	4	10.0	10.0	0.3	25	1.0	1.3	**11.34**	**5.63**
163	1.0	4	10.0	10.0	0.2	25	1.0	1.2	**114.61**	**41.36**
165	2.0	4	10.0	10.0	0.3	25	1.0	1.3	**38.23**	**19.09**
167	2.0	4	10.0	10.0	0.2	25	1.0	1.2	**57.34**	**20.68**
169	2.0	4	10.0	10.0	0.1	25	1.0	1.1	**114.68**	**22.57**
171	1.0	4	10.0	10.0	0.1	25	1.0	1.1	**229.23**	**45.13**
172	5.3	4	10.0	10.0	0.1	25	1.0	1.1	**43.49**	**8.52**
173	3.0	4	10.0	10.0	0.1	25	1.0	1.1	**76.53**	**15.05**
174	13.7	4	10.0	10.0	0.1	25	1.0	1.1	**17.38**	**3.32**
176	No peat recorded at this location									
177	No peat recorded at this location									
179	No peat recorded at this location									
180	14.0	4	10.0	10.0	0.1	25	1.0	1.1	**17.04**	**3.25**
WP014	2.0	4	10.0	10.0	0.3	25	1.0	1.3	**38.23**	**19.09**
WP016	2.0	4	10.0	10.0	0.2	25	1.0	1.2	**57.34**	**20.68**
WP018	1.0	4	10.0	10.0	0.1	25	1.0	1.1	**229.23**	**45.13**
WP019	1.0	4	10.0	10.0	0.1	25	1.0	1.1	**229.23**	**45.13**
WP020	1.0	4	10.0	10.0	0.3	25	1.0	1.3	**76.41**	**38.18**
WP021	3.4	4	10.0	10.0	0.4	25	1.0	1.4	**16.89**	**10.43**
WP022	2.0	4	10.0	10.0	0.1	25	1.0	1.1	**114.68**	**22.57**
WP023	5.4	4	10.0	10.0	0.1	25	1.0	1.1	**42.69**	**8.37**
WP024	1.0	4	10.0	10.0	0.2	25	1.0	1.2	**114.61**	**41.36**
WP025	4.2	4	10.0	10.0	0.1	25	1.0	1.1	**54.76**	**10.75**
								Minimum =	**1.49**	**1.90**
								Maximum =	**1279.51**	**237.76**
								Average =	**70.47**	**18.71**

Notes:

(1) Assuming a bulk unit weight of peat of 10 (kN/m^3)
(2) Assuming a surcharge equivalent to fill depth of 1.0 (m)
(3) Slope inclination (β) based on site readings and topo survey plans of site.
(4) FoS is based on slope inclination and shear test results obtained from published data.
(5) Peat depths based on peat depth probes carried out by AGEC.
(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.

APPENDIX D

METHODOLOGY FOR RISK ASSESSMENT

Methodology for Risk Assessment

A risk assessment is carried out for the main infrastructure elements at the proposed wind farm development. This approach follows the guidelines for geotechnical risk management as given in Clayton (2001), as referenced in PHRAG, and takes into account the approach of MacCulloch (2005).

The risk assessment uses the results of the stability analysis (deterministic approach) in combination with qualitative factors (Table A), 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.

The stability analysis takes into account the peat depth, slope angle and shear strength properties of the peat (see section 7 of report). The qualitative factors used in the risk assessment have been compiled based on AGEC's experience of assessments and construction in peat land sites and peat failures throughout Ireland and the UK.

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 a particular location.

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	
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	

Qualitative Factor	Type of Feature/Indicator for each Qualitative Factor (1)	Explanation/Description of Qualitative Factor
	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 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.
	Yes	
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	

Qualitative Factor	Type of Feature/Indicator for each Qualitative Factor (1)	Explanation/Description of Qualitative Factor
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.

Probability

The likelihood of a hazard (peat failure) occurring has been based on the results of the stability calculation FoS and qualitative factors from Table B, where present.

The probability assigned to the FoS and qualitative factors is judged on a qualitative scale (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 water course 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

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

The Risk Rating can range from 1 to 20 as shown in Table D.

Table D Qualitative Risk Rating

Impact \ Probability	1	2	3	4	5
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	
10 to 20	Unacceptable: re-location or significant control measures required
5 to 9	Substantial: notable control measures required
3 to 4	Tolerable: only routine control measures required
1 to 2	Trivial: none or only routine control measures required

Note. Where any individual contributory factor is given a probability of 5 then this defaults to an 'Unacceptable' risk rating irrespective of the impact.

In many cases a simple 4- to 5-level scale is considered sufficient (Clayton, 2001); in this case a 4-level scale is used. The control measures in response to the qualitative risk ratings are included in the Geotechnical Risk Register for each turbine 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.