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# APPENDIX 6

Geotechnical and Peat Stability Assessment Report

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# ENVIRONMENTAL IMPACT ASSESSMENT REPORT (EIAR) FOR THE PROPOSED BALLINAGREE WIND FARM

## GEOTECHNICAL & PEAT STABILITY ASSESSMENT REPORT

**Prepared for:** Ballinagree Wind DAC

Ballinagree
Wind farm

**Date:** January 2022


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# 1. NON-TECHNCIAL SUMMARY

Fehily Timoney and Company (FT) was engaged by Coillte and Ørsted to undertake a geotechnical and peat stability assessment of the proposed Ballinagree Wind Farm site. 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.

A walkover including intrusive peat depth probing, desk study, stability analysis and risk assessment was carried out to assess the susceptibility of the site to peat failure following the principles in Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (PLHRAG, 2nd Edition, 2017).

The findings show that the proposed development has an acceptable margin of safety and is suitable for the proposed wind farm development. Based on the findings, recommendations and control measures for construction work in peat lands are suggested to ensure that all works adhere to an acceptable standard of safety.

The proposed development comprises 20 no. wind turbines and associated infrastructure. The site comprises flat to steep sloped agricultural land with areas of peat bog in the north.

Slope inclinations at the main infrastructure locations range from 4 to 16 degrees. Ground conditions comprised mainly of peaty topsoil or peat overlying silt overlying bedrock.

Peat depth recorded during the site walkovers from over 124 probes ranged from 0 to 3m with an average peat depth of 0.6m. 86% of the probes recorded peat depths of less than 1.0m with 95% of peat depth probes recorded peat depths of less than 2.0m. A number of localised readings recorded peat depths from 2.0 to 3m. Peat probing was focused on areas of the site where peat was identified during the site walkover and desk study (the northern area of the site). Average peat depth is given for the probes carried out, which may be higher than the actual average peat depth for the site..

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

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

In summary, the proposed development site has an acceptable margin of safety and is considered to be at **low** risk of peat failure.

# 2. INTRODUCTION

## 2.1 Fehily Timoney and Company

Fehily Timoney and Company (FT) is an Irish engineering, environmental science and planning consultancy with offices in Cork, Dublin and Carlow. The practice was established in 1990 and currently has about 70 members of staff, including engineers, scientists, planners and technical support staff. FT deliver projects in Ireland and internationally in our core competency areas of Waste Management, Environment and Energy, Civils Infrastructure, Planning and GIS and Data Management.

## 2.2 Project Description

FT was engaged by Coillte to undertake an Environmental Impact Assessment of the proposed Ballinagree Wind Farm. As part of this assessment a geotechnical & peat stability assessment was required to be carried out.

The proposed Ballinagree Wind Farm is located approximately 10km south-east of Millstreet, Co. Cork.

The Ballinagree Wind Farm site, which comprises agricultural land, forestry and blanket peat which extends to an area of approximately 380 hectares contained to the north and north-east of the site. The site is located in the west of Co. Cork, between Millstreet and Macroom. The surrounding landscape comprises gently undulating to steep topography with land-use comprising forestry, agricultural land and peatland.

The development comprises the following:

(1) 20 no. wind turbines with a maximum overall blade tip height of up to 185m and all associated hard-standing areas
(2) 2 no. permanent meteorological masts up to 100m in height
(3) Provision of new site access tracks and associated drainage
(4) Temporary construction compound
(5) All works associated with the connection of the proposed wind farm to the national electricity grid, including the construction of an electricity substation
(6) New access junctions, improvements and temporary modifications to existing public road infrastructure to facilitate delivery of abnormal loads and construction access
(7) All associated site development works

## 2.3 Ground Investigation

Intrusive investigations were undertaken by Irish Drilling Limited at the proposed borrow pit locations, all proposed turbine locations and along the proposed access tracks. The purpose of the intrusive works was to confirm the geological succession underlying the site. The site investigations comprised the excavation of 64 no. trial pits to a maximum depth of 4.8m BGL and 5 no. rotary boreholes to a maximum depth of 15m BGL. The boreholes were carried out at each of the proposed borrow pit locations to assess the suitability of the material to be used as site-won material during construction.

## 2.4 Peat Stability Assessment Methodology

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

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

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

(1) Desk study

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

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

(4) Factor of safety plan – compiled for the short-term critical condition (undrained) for points analysed along the proposed infrastructure envelope on site

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

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

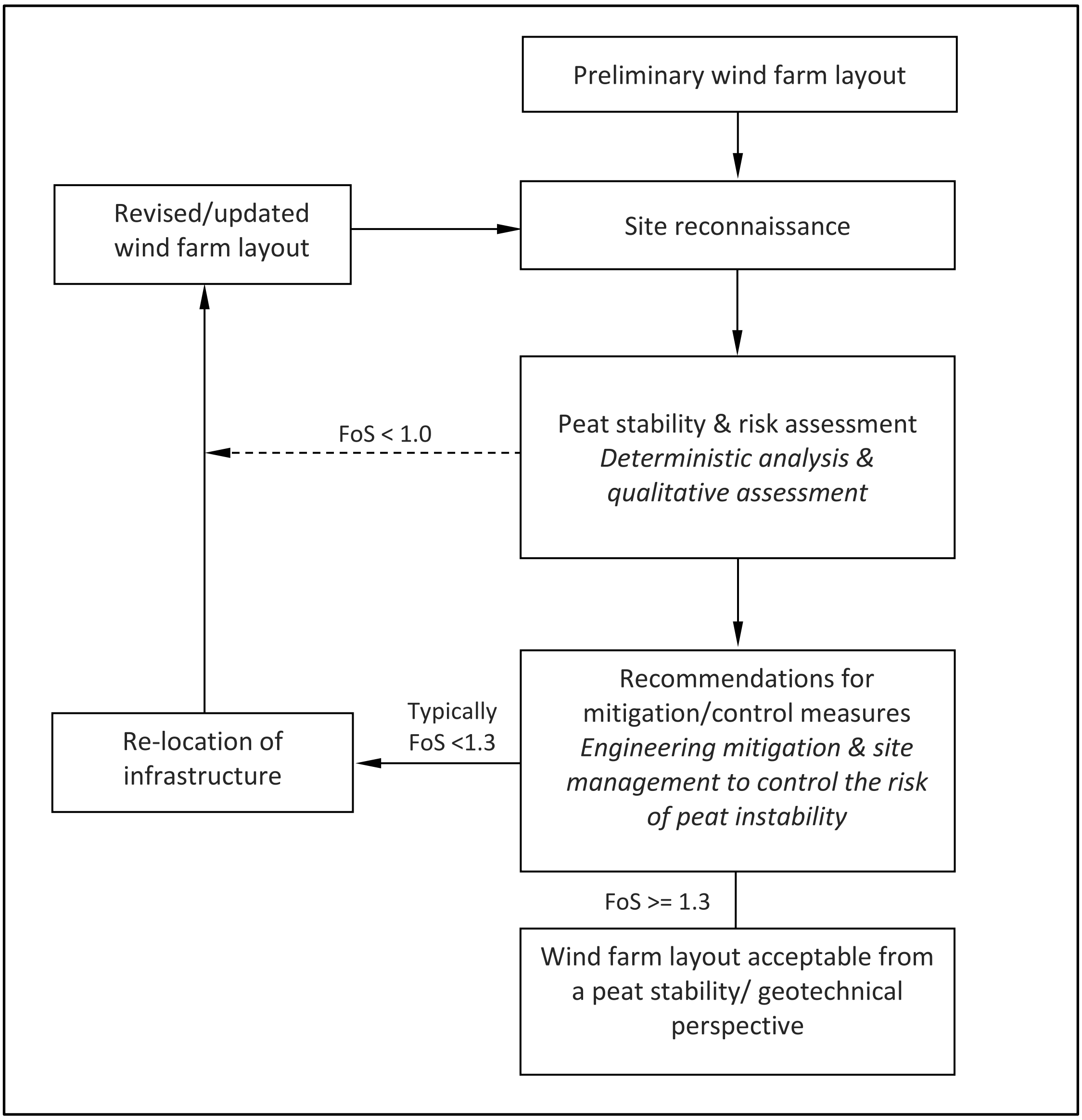



Figure 2-1: Methodology for Peat Stability Assessment

## 2.5 Peat Failure Definition

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

The potential for peat failure at this site is examined with respect to construction works and associated activity, operation works and decommissioning works.

## 2.6 Main Approaches to Assessing Peat Stability

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

(1) Geomorphological

(2) Qualitative (judgement)

(3) Index/Probabilistic (probability)

(4) Deterministic (factor of safety)

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

As part of FT's deterministic approach, a qualitative risk assessment is also carried out taking into account qualitative factors, which cannot necessarily be quantified, such as the presence of mechanically cut peat, quaking peat, bog pools, sub peat water flow, slope characteristics and numerous other factors. The qualitative factors used in the risk assessment are compiled based on FT's experience of assessments and construction in peat land sites and peat failures throughout Ireland and the UK. This approach follows the guidelines for geotechnical risk management as given in Clayton (2001), as referenced in the best practice for Peat Landslide Hazard and Risk Assessment Guide (PLHRAG, 2017), and takes into account the approach of MacCulloch (2005).

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

## 2.7 Peat Stability Assessment – Deterministic Approach

The peat stability assessment is carried out across a wide area 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 7).

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

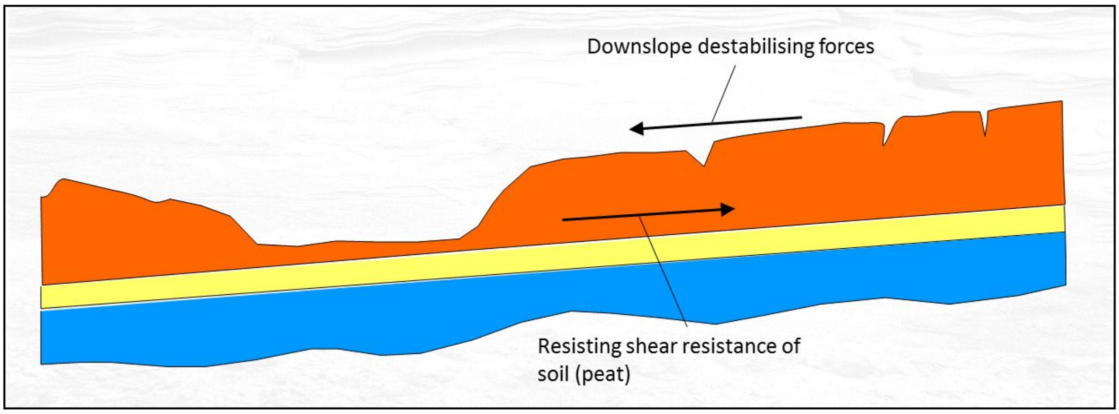



Figure 2-2: Peat Slope Showing Balance of Forces to Maintain Stability

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

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

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

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

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

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

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

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

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

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

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

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

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

# 3. DESK STUDY

## 3.1 Desk Study

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

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

The Geological Survey of Ireland (GSI, 1999) geological plans for the site were used to verify the soil and bedrock conditions.

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

The desk study also includes a review of both published literature and GSI online dataset viewer (GSI, 2021) on peat failures/landslides in the vicinity of the site.

## 3.2 Soils, Subsoil & Bedrock

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

The GSI subsoils maps indicates that the site is underlain by a combination of Till derived from Devonian Sandstones, Bedrock outcrop or sub-crop, Blanket Peat and Alluvium.

In relation to bedrock, the site location and surrounding area is underlain by the Ballytrasna Formation and the Caha Mountain Formation. The Ballytrasna Formation comprises dusky-red mudstone with subordinate pale-red sandstones. The Caha Mountain Formation is described as comprising purple and green siltstones and sandstones.

According to the GSI datasets, there are no karst features recorded within the proposed site. The nearest karst feature is Tubrid Well (526034E 590928N) which is located approximately 20km to the north-west of the proposed site.

The GSI Online Irish Geological Heritage database indicates that the proposed development area is not located in an area of specific geological heritage interest. The nearest site of significant geological heritage features to the study area is located approximately 3km to the east of the proposed development which is the Boggeragh Mountains. The Boggeragh Mountains is a Natural Heritage Area (NHA) that consists of upland blanket bog habitat.

## 3.3 Previous Failures

There are no recorded peat failures within the proposed development site (GSI, 2021). The nearest recorded failure is located some 20km west of the study area just north of Ballyvourney. No information is available on the size of this failure

The landslide susceptibility at the site was classified by the GSI (2021) as ranging from Low to Extreme. This only relates to the topography of the site and does not take any peat specific data into account (i.e. peat depths, etc). This is expected as there are certain areas across the site, predominantly in the west that are quite steep (slopes reaching up to 22 degrees).

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 and the terrain and ground conditions present on site it can be concluded that site conditions in the area of the proposed development have a limited potential of peat failure.

## 3.4 Ground Investigation Findings

As mentioned in Section 2.3 above, intrusive investigations were undertaken by Irish Drilling Limited at the proposed borrow pit locations, at selected proposed turbine locations, along the proposed access tracks to confirm the geological succession underlying the site. A total of 64 no. trial pits to a maximum depth of 4.8m BGL and 6 no. rotary boreholes (at proposed borrow pit locations) to a maximum depth of 15m BGL were carried out. The trial pit and borehole logs and a ground investigation location map are included in Appendix 9.2 of the main EIAR.

Topsoil was encountered in areas across the site during the site walkover and intrusive investigations. The Topsoil was predominantly a peaty *sandy gravelly CLAY* (0.1 to 0.8 mbgl) with areas of MADE GROUND and PEAT also present across the site. Peat deposits of an amorphous peat were found predominantly in the northern area of the site.

Peat deposits were generally noted to be limited to the northern area of the site and typical thicknesses of between 0.1 – 2.7m. Peaty topsoil was present in areas of the southern area of the site.

The Topsoil and Peat deposits described above were found to overlie Glacial Till deposits either cohesive or granular in nature. Cohesive deposits encountered typically comprised *Soft to Stiff sandy gravelly SILT with high cobble and boulder content*. The granular Glacial Till deposits encountered typically comprised *Silty sandy GRAVEL with high cobble content.*

Weathered Bedrock of the Ballytrasna Formation was encountered during site investigations at depths of between 0 to 3.8m BGL where it was typically described as comprising *Weathered SILTSTONE or SANDSTONE*.

# 4. FINDINGS OF SITE RECONNAISSANCE

## 4.1 Site Reconnaissance

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

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 turbine locations and associated infrastructure and proposed access tracks.

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

## 4.2 Findings of Site Reconnaissance

The site reconnaissance comprised a walkover inspection of the site during January and August 2020 and March 2021. Weather conditions for the site visits were mainly dry.

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

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

(1) The site is predominantly agricultural land, forestry and peat. Areas of peat are located predominantly in the north of the site with localised areas of peaty topsoil found in the south.

(2) A series of peat depth probes were carried out on site. Peat depths recorded across the site ranged from 0.2 to 3m. Approximately 95 percent of peat depth probes recorded peat depths of less than 2.0m. A number of localised readings were recorded where peat depths were 2.0 to 3m.

(3) The peat depths recorded at the turbine locations where there was peat present (there was no peat encountered at 7 turbine locations) varied from 0 to 2m with an average depth of 0.63m[1].

(4) With respect to the new proposed access tracks, peat depths are typically less than 1.0m with localised depths of up to 3m recorded.

[1] Peat was recorded at 13 of the proposed turbine locations.

(5) Access tracks for the wind farm comprise the upgrade of existing agricultural/forestry tracks and the construction of new tracks. The construction of new tracks will be carried out using an excavate & replace construction technique which involves the removal and replacement of peat or soft ground where encountered.

(6) Slope angles at the turbine locations ranged from 2 to 16 degrees. These slope angle readings were obtained using a combination of readings taken during the site reconnaissance by FT using handheld equipment, such as the Silva Clino Master which has an accuracy of +/- 0.25 degrees and from contour survey plans for the site.

(7) The slope angle quoted typically reflects the slope within the footprint of each infrastructure location.

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

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

(a) The site comprises relatively flat terrain with localised areas of peat in the north and north-east of the site. Peat depths recorded across the site ranged from 0 to 3m with an average depth of 0.6m. Peat probing was focused on areas of the site where peat was identified during the site walkover and desk study (the northern area of the site). Average peat depth is given for the probes carried out, which may be higher than the actual average peat depth for the site.

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

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

# 5. SITE GROUND CONDITIONS

## 5.1 Soils & Subsoils

A review of the GSI subsoils maps in Section 3 indicates that the site is underlain by a combination of Till derived from Devonian Sandstones, Bedrock outcrop or sub-crop, Blanket Peat and Alluvium.

Based on the site walkover undertaken by FT and trial pits excavated by IDL, the superficial deposits for the site were typically described as peaty topsoil or spongy brown/black fibrous and amorphous Peat overlying typically firm and stiff slightly gravelly Silt/Clay. Where peat was present on site, peat depths ranged from 0 to 3m with an average depth of 0.6m. At turbine locations, peat depth ranged from 0-2.3m.

## 5.2 Bedrock

A review of the GSI bedrock maps in Section 3 indicates that the site location and surrounding area is underlain by the Ballytrasna Formation and the Caha Mountain Formation. The Ballytrasna Formation comprises dusky-red mudstone with subordinate pale-red sandstones. The Caha Mountain Formation is described as comprising purple and green siltstones and sandstones.

No karst features were identified in the survey area. The closest recorded karst feature is a spring noted approximately 10km to the west of the site.

# 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. A map is displayed in Figure 6.1 displaying where the peat probe locations were taken across the site.

## 6.1 Peat Depth

Peat depth probes were carried out at/near to proposed turbine locations and access tracks and other main infrastructure elements. At turbine locations up to 5 probes were carried out around the turbine location, where accessible, and an average peat depth was calculated. This method was used predominantly in the northern area of the site where there was evidence of more extensive peat deposits.

## 6.2 Peat Strength

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

## 6.3 Slope Angle

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

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

## 6.4 Summary of Findings

Based on the peat depths recorded across the site by FT, the peat varied in depth from 0 to 3m with an average depth of 0.6m.

A summary of the peat depths at the proposed turbine and borrow pit locations is given in Table 6.1. The data presented in Table 6.1 is used in the peat stability assessment of the site. Peat depths are based on the data collected from both the trial pitting and peat probing.

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

| Turbine | Easting | Northing | Peat Depth Range (m) (1) | Average Peat Depth (m) | Slope Angle (°) (2) | Factor of Safety (Load Condition 2) | |
|---|---|---|---|---|---|---|---|
| | | | | | | Undrained | Drained |
| T1 | 534501 | 584042 | | | 4 | | |
| T2 | 534621 | 583586 | 0.3-0.8 | 0.6 | 4 | 37.72 | 10.26 |
| T3 | 535181 | 583428 | 0.5-0.6 | 0.6 | 12 | 12.29 | 3.42 |
| T4 | 535989 | 582819 | | | 6 | | |
| T5 | 536420 | 582647 | 0.2-0.3 | 0.3 | 4 | | |
| T6 | 535505 | 583151 | 0.2-0.3 | 0.1 | 10 | | |
| T7 | 536168 | 583308 | | | 12 | | |
| T8 | 536754 | 583185 | | | 4 | | |
| T9 | 536843 | 583683 | | | 6 | | |
| T10 | 536178 | 584279 | | | 6 | | |
| T11 | 535332 | 584249 | | | 6 | | |
| T12 | 535205 | 584703 | 0.2-0.4 | 0.3 | 8 | | |
| T13 | 536298 | 586077 | 0.5-0.6 | 0.5 | 14 | 12.50 | 3.01 |
| T14 | 536707 | 586702 | 0.5-1.5 | 1 | 8 | 9.43 | 4.77 |
| T15 | 537272 | 586528 | 0.4-0.6 | 0.5 | 6 | 20.52 | 7.00 |
| T16 | 537466 | 586089 | 0.2-0.4 | 0.3 | 16 | | |
| T17 | 537125 | 585649 | 0.6-0.7 | 0.6 | 12 | 18.44 | 3.42 |
| T18 | 538431 | 586680 | 1.7-2.3 | 2 | 2 | 26.76 | 17.18 |
| T19 | 538959 | 586490 | 0.2-0.6 | 0.4 | 2 | 126.97 | 21.55 |
| T20 | 539629 | 586861 | 0.8-1.3 | 1 | 4 | 30.18 | 9.54 |
| BP1 | 533661 | 533661 | 0.1-0.4 | 0.3 | 14 | | |
| BP2 | 533478 | 533478 | | | 16 | | |
| BP3 | 537925 | 537925 | 0.8-1 | 0.9 | 4 | 25.72 | 25.72 |

Note (1) Based on probe results from the site walkovers. The range of peat depths for the infrastructure locations are typically 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 using a combination of readings taken during the site reconnaissance by FT using handheld equipment, such as the Silva Clino Master (which has an accuracy of +/- 0.25 degrees) and from contour survey plans for site. The slope angle quoted typically reflects the slope within the footprint of each infrastructure location.

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

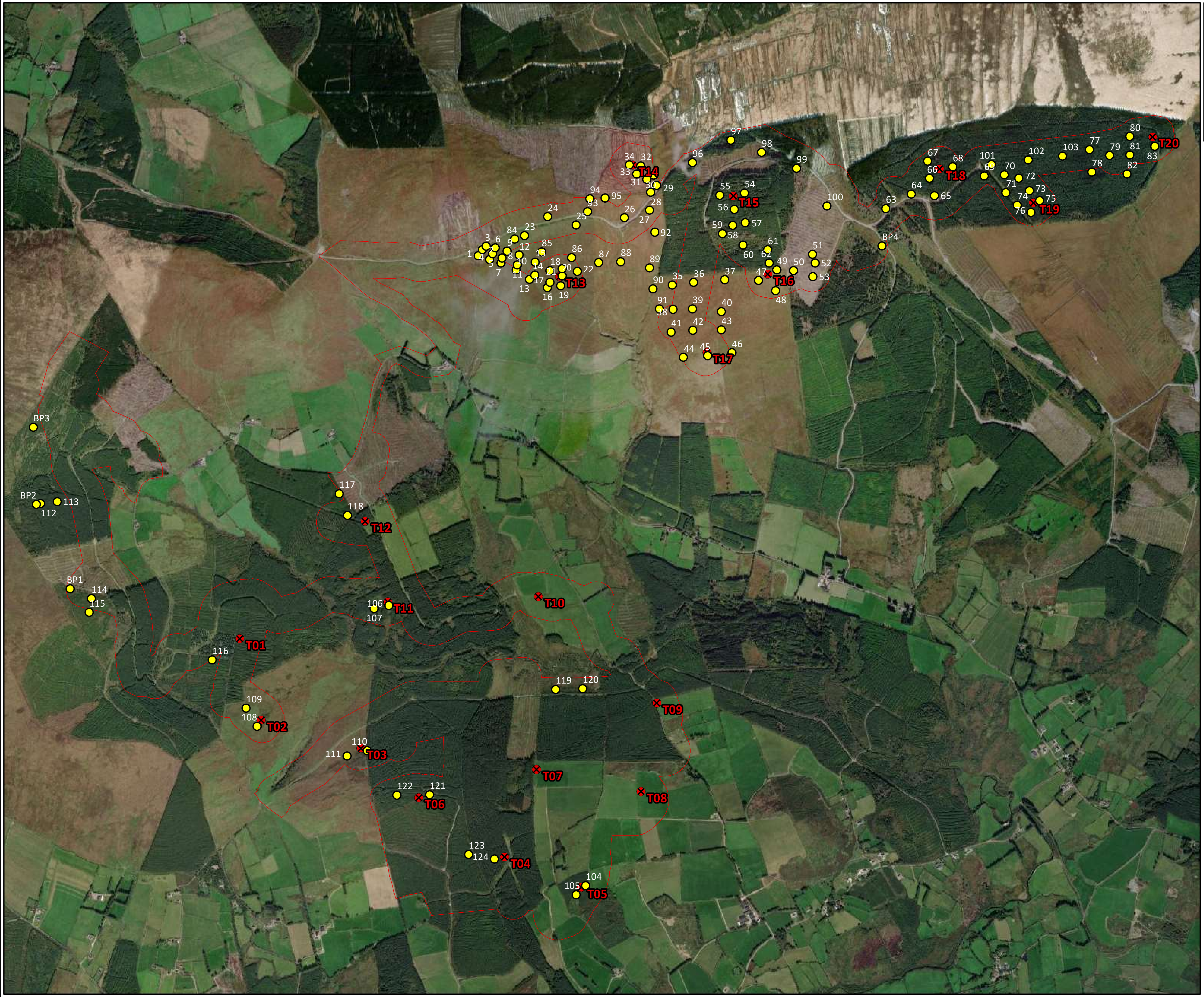
In addition to probing, in-situ shear vane testing was carried out as part of the ground investigation. Strength testing was carried out at selected locations across the site to provide representative coverage of indicative peat strengths. The results of the vane testing with depth taken at the turbine locations are presented in Figure 6.2.

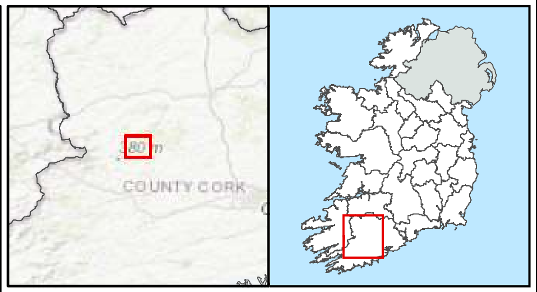
The hand vane results indicate undrained shear strengths in the range 10 to 62kPa across the whole site, with an average value of about 25kPa. The average value at turbine locations was recorded as 41kPA. The ground investigations that was carried out by Irish Drilling Ltd. consisted of a series of trial pits and boreholes. The peat depths encountered during the trial pitting correspond with the peat depths encountered during the peat probing.

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

Path: R:\Map Production\2019\P2114\Workspace\Information Only\P2114_GIS_INFO_PeatProbingLocations_A3.mxd






**Legend**

- Wind Farm Study Area
- Proposed Turbine Layout
- Peat Probe Locations

| | |
|---|---|
| **TITLE:** | Peat Probing Locations |
| **PROJECT:** | Ballinagree Wind Farm |
| **FIGURE NO:** | - |
| **CLIENT:** | Coillte and Ørsted |
| **SCALE:** 1:21000 | **REVISION:** 0 |
| **DATE:** 22/09/2021 | **PAGE SIZE:** A3 |

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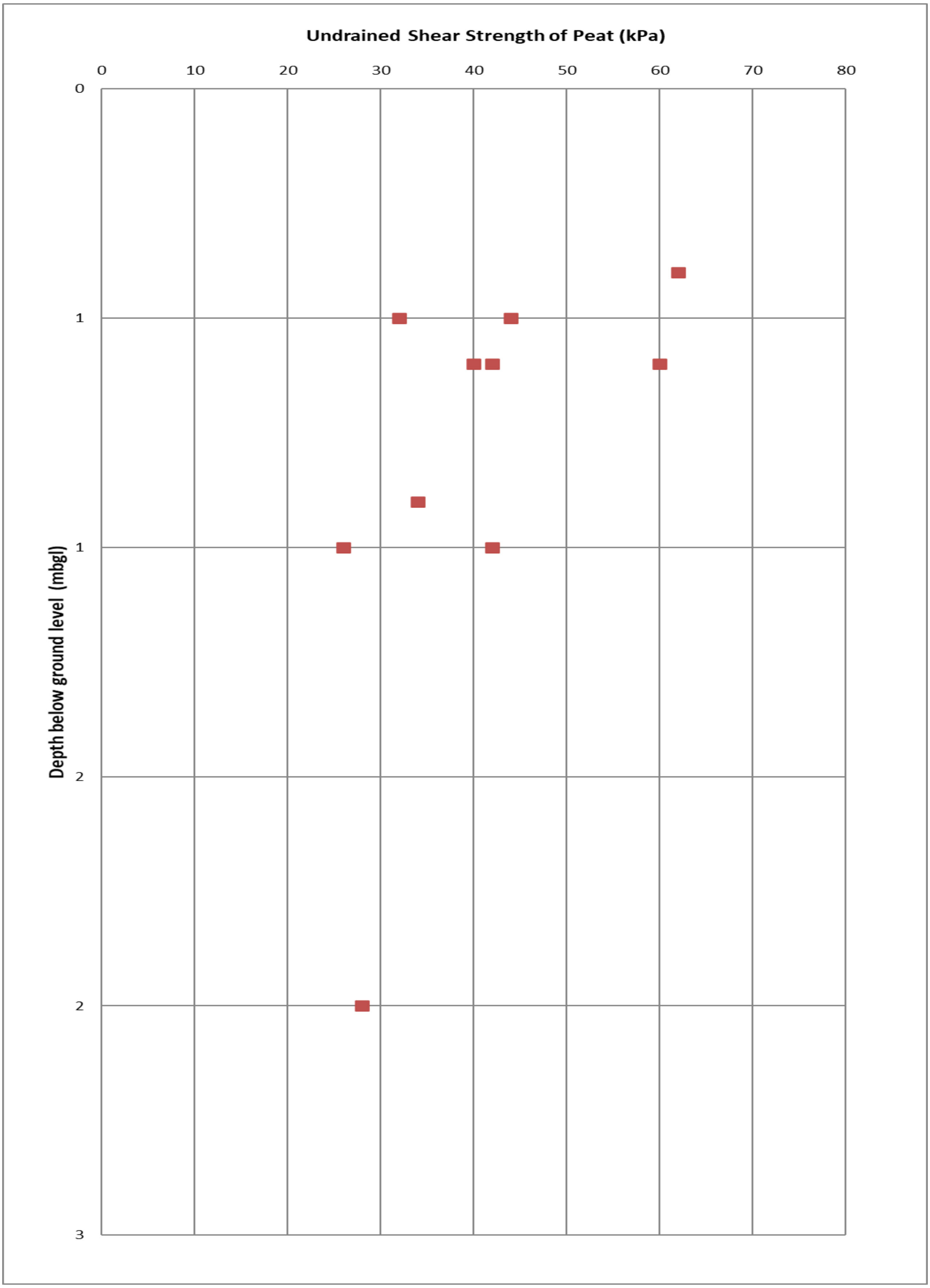


**Figure 6-2: Undrained Shear Strength ($c_u$) Profile for Peat with Depth at Turbine Locations**

# 7. PEAT STABILITY ASSESSMENTS

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

## 7.1 Methodology for Peat Stability Assessment

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

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

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

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

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

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

From Table 7.1 the values for c’ ranged from 1.1 to 8.74kPa and ø’ ranged from 21.6 to 43°. The average c’ and ø’ values are 4.5kPa and 30° respectively. Based on the above, it was considered to adopt a conservative approach and to use design values below the averages. For design the following general drained strength values have been used for the site:

*c’* = 4kPa
*ø’* = 25°

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

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

## 7.2 Analysis to Determine Factor of Safety (Deterministic Approach)

The purpose of the analysis was to determine the Factor of Safety (FoS) of the peat slopes using infinite slope analysis. The analysis was carried out at the turbine locations, along the proposed access tracks 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 is greater than 1.3. The previous code of practice for earthworks BS 6031:1981 (BSI, 1981), provided advice on design of earthworks slopes. It stated that for a first-time failure with a good standard of site investigation the design FoS should be greater than 1.3.

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

**Table 7.2: Factor of Safety Limits for Slopes**

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

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

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

A lower bound undrained shear strength, $c_u$ for the peat of 8kPa was selected for the assessment based on the $c_u$ values recorded at the proposed development site. It should be noted that a $c_u$ of 8kPa for the peat is considered a conservative value for the analysis and is not representative of all peat present across the site. As described in Section 6.4, the hand vane results indicate undrained shear strengths in the range 10 to 62kPa across the whole site, with an average value of about 25kPa. The average value at turbine locations was recorded as 41kPA. In-situ testing of the peat at the site suggests that peat strength is greater than 10 kPa across the site.

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

$\gamma$ = Bulk unit weight of material

$z$ = Depth to failure plane assumed as depth of peat

$\alpha$ = 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

$\gamma$ = Bulk unit weight of material

$z$ = Depth to failure plane assumed as depth of peat

$\gamma_w$ = Unit weight of water

$h_w$ = Height of water table above failure plane

$\alpha$ = Slope angle

$\phi'$ = Effective friction angle

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

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

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

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

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

(4) A lower bound undrained shear strength, $c_u$ for the peat of 8kPa was selected for the assessment. The lowest recorded value at the proposed development site during the walkover was 10kPa. It should be noted that a $c_u$ of 8kPa for the peat is considered a conservative value for the analysis and is not representative of all peat present across the site. In reality, the peat at the proposed development site has a significantly higher undrained strength which is likely as a result of the extensive drainage & extraction works which have been carried out on site.

For the stability analysis two load conditions were examined, namely

Condition (1): no surcharge loading

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

## 7.3 Results of Analysis

### 7.3.1 Undrained Analysis for the Peat

The results of the undrained analysis for the natural peat slopes are presented in Appendix B and the results of the undrained analysis for the most critical load case (load condition 2) are shown on Figure 7.1. The undrained analysis for load condition 2 is considered the most critical load case as most peat failures occur in the short term upon loading of the peat surface. The results from the main infrastructure locations are summarised in Table 7.3. The results from all probe data taken across the site is included in Appendix B.

The calculated FoS for load condition 1 is in excess of 1.30 for each of the locations analysed with a range of FoS of 4.15 to in excess of 400 across the whole of the site (including turbine locations, access tracks, substation and temporary compound locations), indicating a low risk of peat instability across the site. The FoS at turbine locations where peat was present ranged from 18.87 to 444.4, indicating a low risk of peat instability at turbine locations.

The calculated FoS for load condition 2 is in excess of 1.30 for each of the locations analysed with a range of FoS of 3.01 to in excess of 100 across the whole of the site (including turbine locations, access tracks, substation and temporary compound locations, indicating a low risk of peat instability across the site. The FoS at turbine locations where peat was present ranged from 9.43 to 126.97, indicating a low risk of peat instability at turbine locations.

**Table 7.3: Factor of Safety Results (Undrained Condition)**

| Turbine No./Waypoint | Easting | Northing | Factor of Safety for Load Condition | |
|---|---|---|---|---|
| | | | Condition (1) | Condition (2) |
| T1 | 534501 | 584042 | No Peat | |
| T2 | 534621 | 583586 | 100.59 | 37.72 |
| T3 | 535181 | 583428 | 32.78 | 12.29 |
| T4 | 535989 | 582819 | No Peat | |
| T5 | 536420 | 582647 | No Peat | |
| T6 | 535505 | 583151 | No Peat | |
| T7 | 536168 | 583308 | No Peat | |
| T8 | 536754 | 583185 | No Peat | |
| T9 | 536843 | 583683 | No Peat | |

| Turbine No./Waypoint | Easting | Northing | Factor of Safety for Load Condition | |
|---|---|---|---|---|
| | | | Condition (1) | Condition (2) |
| T10 | 536178 | 584279 | No Peat | |
| T11 | 535332 | 584249 | No Peat | |
| T12 | 535205 | 584703 | No Peat | |
| T13 | 536298 | 586077 | 37.49 | 12.50 |
| T14 | 536707 | 586702 | 18.87 | 9.43 |
| T15 | 537272 | 586528 | 61.56 | 20.52 |
| T16 | 537466 | 586089 | No Peat | |
| T17 | 537125 | 585649 | 49.17 | 18.44 |
| T18 | 538431 | 586680 | 40.14 | 26.76 |
| T19 | 538959 | 586490 | 444.40 | 126.97 |
| T20 | 539629 | 586861 | 60.36 | 30.18 |
| BP1 | 533661 | 533661 | No Peat | |
| BP2 | 533503 | 533503 | No Peat | |
| BP3 | 533478 | 533478 | No Peat | |
| BP4 | 537925 | 537925 | 54.29 | 25.72 |

### 7.3.2 Drained Analysis for the Peat

The results of the drained analysis for the peat are presented in Appendix B. The results from the main infrastructure locations are summarised in Table 7.4. As stated previously, the drained loading condition examines the effect of rainfall and water 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 locations analysed with a range of FoS of 1.56 to in excess of 70 across the whole of the site (including turbine locations, access tracks, substation and temporary compound locations, indicating a low risk of peat instability across the site. The FoS at turbine locations where peat was present ranged from 5.28 to 42.02, indicating a low risk of peat instability at turbine locations.

The calculated FoS for load condition 2 is in excess of 1.30 for each of the locations analysed with a range of FoS of 1.99 to in excess of 20 across the whole of the site (including turbine locations, access tracks, substation and temporary compound locations, indicating a low risk of peat instability across the site. The FoS at turbine locations where peat was present ranged from 3.01 to 21.55, indicating a low risk of peat instability at turbine locations.

**Table 7.4: Factor of Safety Results (Drained Conditions)**

| Turbine No./Waypoint | Easting | Northing | Factor of Safety for Load Condition | |
|---|---|---|---|---|
| | | | Condition (1) | Condition (2) |
| T1 | 534501 | 584042 | No Peat | |
| T2 | 534621 | 583586 | 16.25 | 10.26 |
| T3 | 535181 | 583428 | 5.47 | 3.42 |
| T4 | 535989 | 582819 | No Peat | |
| T5 | 536420 | 582647 | No Peat | |
| T6 | 535505 | 583151 | No Peat | |
| T7 | 536168 | 583308 | No Peat | |
| T8 | 536754 | 583185 | No Peat | |
| T9 | 536843 | 583683 | No Peat | |
| T10 | 536178 | 584279 | No Peat | |
| T11 | 535332 | 584249 | No Peat | |
| T12 | 535205 | 584703 | No Peat | |
| T13 | 536298 | 586077 | 5.28 | 3.01 |
| T14 | 536707 | 586702 | 6.22 | 4.77 |
| T15 | 537272 | 586528 | 12.13 | 7.00 |
| T16 | 537466 | 586089 | No Peat | |
| T17 | 537125 | 585649 | 5.47 | 3.42 |
| T18 | 538431 | 586680 | 19.09 | 17.18 |
| T19 | 538959 | 586490 | 42.02 | 21.55 |
| T20 | 539629 | 586861 | 12.42 | 9.54 |
| BP1 | 533661 | 533661 | No Peat | |
| BP2 | 533503 | 533503 | No Peat | |
| BP3 | 533478 | 533478 | No Peat | |
| BP4 | 537925 | 537925 | 13.06 | 9.69 |

### 7.3.3 Summary of Results

The results above state that the FoS for both drained and undrained conditions at all infrastructure locations and along proposed access tracks are in excess of 1.30. This indicates that the site has a low risk of peat instability. There are areas located in the north where the FoS ranges from 1.56 to 3.63. These values are above the 1.30 allowance and there is no proposed infrastructure at these locations, therefore these areas with lower factors of safety also indicate a low risk of instability.

# 8. PEAT STABILITY RISK ASSESSMENT

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

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

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

**Table 8.1: Risk Rating Legend**

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

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

## 8.1 Summary of Risk Assessment Results

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

The risk rating for each infrastructure element at the proposed development is designated negligible with some mitigation/control measures being implemented on a precautionary basis. Sections of access tracks to the nearest infrastructure element will be subject to the same mitigation/control measures that apply to the nearest infrastructure element.

Details of the required mitigation/control measures can be found in the Geotechnical Risk Register for each infrastructure element (Appendix A).

## Table 8.2: Summary of Peat Stability Risk Register

| Infrastructure | Pre-Control Measure Implementation Risk Rating | Pre-Control Measure Implementation Risk Rating Category | Notable Control Measures Required | Post-Control Measure Implementation Risk Rating | Post-Control Measure Implementation Risk Rating Category |
|---|---|---|---|---|---|
| Turbine T1 | No peat recorded at location | | | | |
| Turbine T2 | Negligible | 1 to 4 | No | Negligible | 1 to 4 |
| Turbine T3 | Negligible | 1 to 4 | No | Negligible | 1 to 4 |
| Turbine T4 | No peat recorded at location | | | | |
| Turbine T5 | No peat recorded at location | | | | |
| Turbine T6 | No peat recorded at location | | | | |
| Turbine T7 | No peat recorded at location | | | | |
| Turbine T10 | No peat recorded at location | | | | |
| Turbine T11 | No peat recorded at location | | | | |
| Turbine T12 | No peat recorded at location | | | | |
| Turbine T13 | Negligible | 1 to 4 | No | Negligible | 1 to 4 |
| Turbine T14 | Negligible | 1 to 4 | No | Negligible | 1 to 4 |
| Turbine T15 | Negligible | 1 to 4 | No | Negligible | 1 to 4 |
| Turbine T16 | No peat recorded at location | | | | |
| Turbine T17 | Negligible | 1 to 4 | No | Negligible | 1 to 4 |
| Turbine T18 | Negligible | 1 to 4 | No | Negligible | 1 to 4 |
| Turbine T19 | Negligible | 1 to 4 | No | Negligible | 1 to 4 |
| Turbine T20 | Negligible | 1 to 4 | No | Negligible | 1 to 4 |
| BP1 | No peat recorded at location | | | | |
| BP2 | No peat recorded at location | | | | |
| BP3 | No peat recorded at location | | | | |
| BP4 | Negligible | 1 to 4 | No | Negligible | 1 to 4 |

# 9. INDICATIVE FOUNDATION TYPE AND FOUNDATION DEPTH FOR TURBINES

## 9.1 Summary

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

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

| Turbine No. | Relevant GI | Geology Encountered | Turbine Foundation Type | Comment |
|---|---|---|---|---|
| T1 | T-01 | 0-0.5m: Topsoil<br>0.5-4.3m: Glacial Till | Gravity foundation | The site investigation works carried out indicate that a gravity foundation may be required. |
| T2 | T-02 | 0-0.8m: Peat<br>0.8-1.7m: Glacial Till | Gravity foundation | The site investigation works carried out indicate that a gravity foundation may be required. |
| T3 | T-03 | 0-0.8m: Peat<br>0.8-1.3m: Bedrock | Gravity foundation | The site investigation works carried out indicate that a gravity foundation may be required. |
| T4 | T-04 | 0-0.1m: Peat<br>0.1-1.4m: Bedrock | Gravity foundation | The site investigation works carried out indicate that a gravity foundation may be required. |
| T5 | T-05 | 0-2.1m: Made Ground<br>2.1-3.6m: Bedrock | Gravity foundation | The site investigation works carried out indicate that a gravity foundation may be required. |
| T6 | T-06 | 0-0.3m: Peat<br>0.3-3m: Glacial Till | Gravity foundation | The site investigation works carried out indicate that a gravity foundation may be required. |
| T7 | T-07 | 0-0.2m: Topsoil<br>0.2-2.5m: Glacial Till | Gravity foundation | The site investigation works carried out indicate that a gravity foundation may be required. |
| T8 | T-08 | 0-0.3m: Topsoil<br>0.3-2.5m: Glacial Till | Gravity foundation | The site investigation works carried out indicate that a gravity foundation may be required. |

| Turbine No. | Relevant GI | Geology Encountered | Turbine Foundation Type | Comment |
|---|---|---|---|---|
| T9 | T-09 | 0-0.1m: Topsoil<br>0.1- 4.8m: Glacial Till | Gravity foundation | The site investigation works carried out indicate that a gravity foundation may be required. |
| T10 | T-10 | 0-0.2m: Topsoil<br>0.2-3.6m: Glacial Till | Gravity foundation | The site investigation works carried out indicate that a gravity foundation may be required. |
| T11 | T-11 | 0-0.3m: Peat<br>0.3-4.6m: Glacial Till | Gravity foundation | The site investigation works carried out indicate that a gravity foundation may be required. |
| T12 | T-12 | 0-0.2m: Topsoil<br>0.2-1.6m: Glacial Till | Gravity foundation | The site investigation works carried out indicate that a gravity foundation may be required. |
| T13 | T-13 | 0-0.3m: Peat<br>0.3-4.5m: Glacial Till | Gravity foundation | The site investigation works carried out indicate that a gravity foundation may be required. |
| T14 | T-14 | 0-1m: Peat<br>1-3.8m: Glacial Till | Gravity foundation | The site investigation works carried out indicate that a gravity foundation may be required. |
| T15 | T-15 | 0-0.5m: Peat<br>0.5-2.1m: Glacial Till | Gravity foundation | The site investigation works carried out indicate that a gravity foundation may be required. |
| T16 | T-16 | 0-0.3m: Peat<br>0.3-1m: Glacial Till | Gravity foundation | The site investigation works carried out indicate that a gravity foundation may be required. |
| T17 | T-17 | 0-0.6m: Peat<br>0.6-2m: Glacial Till | Gravity foundation | The site investigation works carried out indicate that a gravity foundation may be required. |
| T18 | T-18 | 0-2m: Peat<br>2-4.3m: Glacial Till | Gravity foundation | The site investigation works carried out indicate that a gravity foundation may be required. |
| T19 | T-19 | 0-0.4m: Peat<br>0.4-1.4m: Glacial Till | Gravity foundation | The site investigation works carried out indicate that a gravity foundation may be required. |
| T20 | T-20 | 0-0.7m: Peat<br>0.7-3.5m: Glacial Till | Gravity foundation | The site investigation works carried out indicate that a gravity foundation may be required. |

It should be noted that further ground investigation will be carried out prior to construction at each turbine location in the form of a borehole with in-situ SPT testing at 1m intervals in the overburden and follow-on rotary core through bedrock to confirm the foundation types and founding stratums assumed in Table 10-1.

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

# 10. SUMMARY AND RECOMMENDATIONS

## 10.1 Summary

FT was engaged by Coillte and Ørsted to undertake a geotechnical and peat stability assessment of the proposed Ballinagree Wind Farm site.

The findings of the peat stability and general stability assessment displayed that the proposed development site has an acceptable margin of safety and is suitable for the proposed 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 comprises relatively flat/gently undulating terrain consisting predominantly of agricultural land with peat present in the north and north-east of the site.

Peat thicknesses recorded during the site walkover ranged from 0 to 3m with an average depth of 0.6m. 85% of the probes recorded peat depths of less than 1.0m. 95% of peat depth probes recorded peat depths of less than 2.0m. A number of localised readings were recorded where peat depths range from 2.0 to 3m.

Slope inclinations at the main infrastructure locations range from 4 to 16 degrees.

An analysis of peat sliding was carried out at the main infrastructure and borrow pit locations across the 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.

For the undrained condition, the calculated FoS for load conditions 1 and 2 for the locations analysed, showed that all locations have an acceptable FoS of greater than 1.3, indicating a low risk of peat failure. The undrained analysis would be considered the most critical condition for the peat slopes.

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

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

In summary, the findings of the peat assessment showed that the Ballinagree Wind Farm site has an acceptable margin of safety, is suitable for the proposed wind farm development and is considered to be at **low** risk of peat failure. 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.

## 10.2 Recommendations

The following recommendations are given.

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

The proposed construction method for most of the new proposed access tracks at the wind farm is excavate and replace type construction and floating roads where there is deeper peat located in the north of the site. The FoS along all of the proposed access tracks is above the 1.30 recommendation. The access tracks follow the slopes of the existing topography as much as possible therefore there should be no stability issues.

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

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