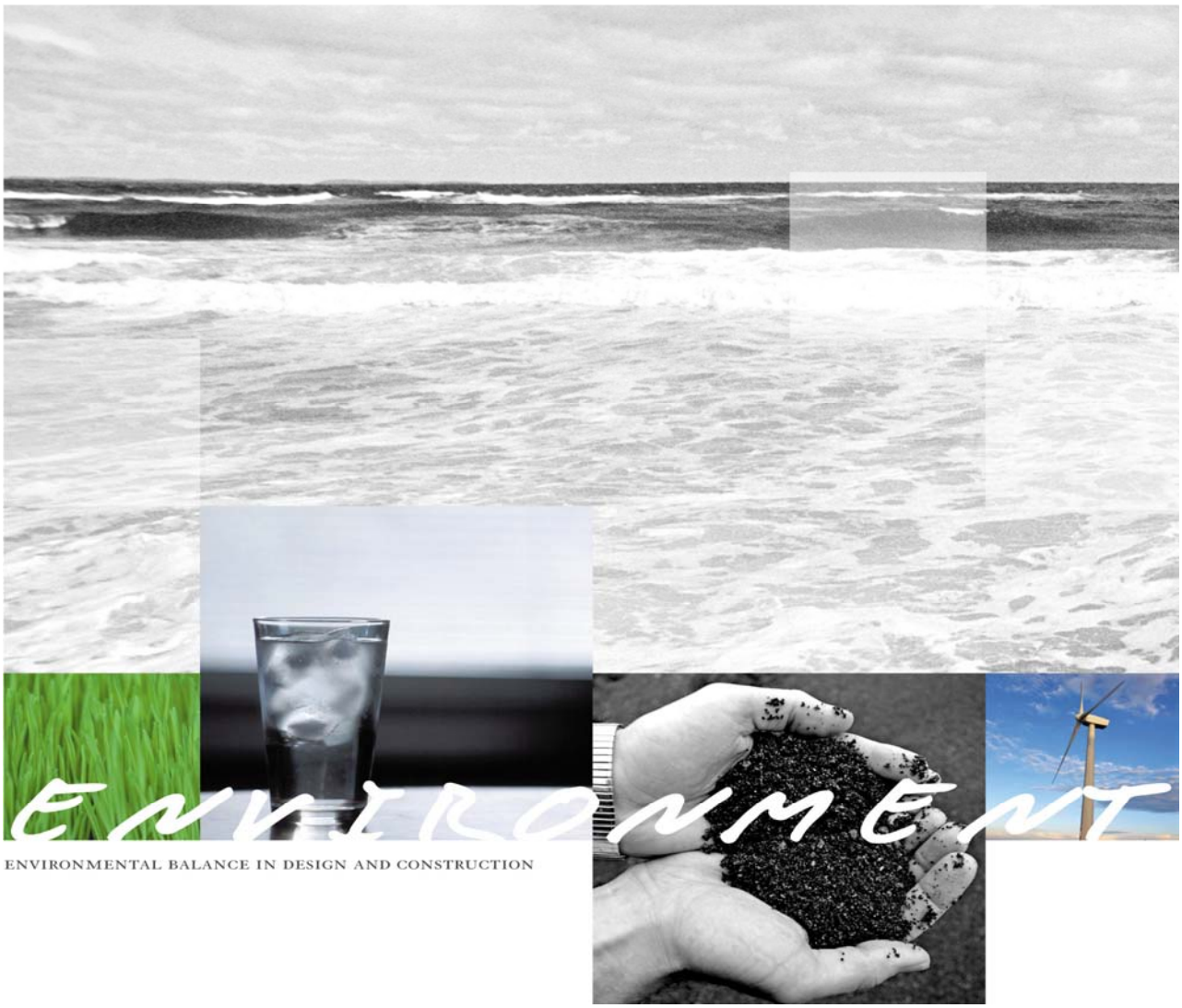
APPENDIX 9-1

FEHILY TIMONEY – GEOTECHNICAL & PEAT STABILITY ASSESSMENT REPORT FOR CAHERMURPHY TWO WIND FARM, CO. CLARE



GEOTECHNICAL & PEAT STABILITY ASSESSMENT REPORT FOR CAHERMURPHY TWO WIND FARM, CO. CLARE

MKO

MAY 2020

FEHILY TIMONEY
30 YEARS

Geotechnical & Peat Stability Assessment Report for Cahermurphy Two Wind Farm, Co. Clare

MKO

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Abstract: Fehily Timoney and Company (FT) formerly Applied Ground Engineering Consultants Ltd (AGEC) was engaged by McCarthy Keville O'Sullivan to undertake an assessment of the Cahermurphy Two Wind Farm site with respect to peat stability. The findings of the geotechnical and peat stability assessment showed that the site has an acceptable margin of safety and is suitable for the proposed wind farm development.

TABLE OF CONTENTS

PAGE

1 NON-TECHNICAL SUMMARY 1

2 INTRODUCTION 2

2.1 Background and Experience 2
2.2 Peat Stability Assessment Methodology 2
2.3 Peat Failure Definition 4
2.4 Main Approaches to Assessing Peat Stability 4
2.5 Peat Stability Assessment – Deterministic Approach 4
2.6 Applicability of the Factor of Safety (Deterministic) Approach for Peat Slopes 5
2.7 Assessment of Intense Rainfall and Extreme Dry Events on the Peat Slopes 5

3 DESK STUDY 7

3.1 Desk Study 7
3.2 Review of Previous Failures 7
3.3 Review of OSI Mapping 7
3.4 Soils, Subsoil & Bedrock 7

4 SITE WALKOVER 9

4.1 Findings of Site Walkover for Wind Farm 9

5 GROUND INVESTIGATION 12

5.1 Summary of In-situ & Laboratory Tests 12
5.2 Interpretation & Summary of Ground Conditions 12
5.3 Overview of Ground Conditions 13
5.4 Summary of Geotechnical Parameters 13

6 PEAT DEPTH, STRENGTH & SLOPE AT PROPOSED INFRASTRUCTURE LOCATIONS 15

7 PEAT STABILITY ASSESSMENT 17

7.1 Methodology for Peat Stability Assessment 17
7.2 Analysis to Determine Factor of Safety (Deterministic Approach) 18
7.3 Results of Analysis 20
7.3.1 Undrained Analysis for the Peat 20
7.3.2 Drained Analysis for the Peat 23

8 PEAT STABILITY RISK ASSESSMENT 24

8.1 Summary of Risk Assessment Results 24

9 INDICATIVE FOUNDATION TYPE FOR TURBINES 26

10 FOUNDING DETAILS FOR OTHER INFRASTRUCTURE ELEMENTS 27

10.1 Access Roads 27
10.2 Crane Hardstands 27
10.3 Substation Foundations & Platform 27
10.4 Temporary Construction Compound Platform 27
10.5 Met Mast Foundation 28
10.6 Potential for Development of Borrow Pits 28
10.7 Grid Connection Route 28

11 SUMMARY AND RECOMMENDATIONS 29

11.1 Summary 29
11.2 Recommendations 29

12 REFERENCES 31

LIST OF APPENDICES

Appendix A: Photos from FT Site Walkover
Appendix B: Ground Investigation (2019) – Exploratory Logs, Laboratory Testing & Photographs
Appendix C: Peat Stability Risk Register
Appendix D: Calculated FOS for Peat Slopes
Appendix E: Methodology for Peat Stability Assessment

LIST OF FIGURES

PAGE

FIGURE 2-1: FLOW DIAGRAM SHOWING GENERAL METHODOLOGY FOR PEAT STABILITY ASSESSMENT 3
FIGURE 2-2: PEAT SLOPE SHOWING BALANCE OF FORCES TO MAINTAIN STABILITY 5
FIGURE 4-1: PEAT DEPTH CONTOUR PLAN 10
FIGURE 5-1: GROUND INVESTIGATION LOCATION PLAN 14
FIGURE 6-1: UNDRAINED SHEAR STRENGTH (CU) PROFILE FOR PEAT WITH DEPTH 16
FIGURE 7-1: FACTOR OF SAFETY PLAN – SHORT TERM CRITICAL CONDITION (UNDRAINED).....22

LIST OF TABLES

TABLE 4-1: SUMMARY OF GEOTECHNICAL PARAMETERS 13
TABLE 6-1: PEAT DEPTH & SLOPE ANGLE AT PROPOSED INFRASTRUCTURE LOCATIONS 15
TABLE 7-1: LIST OF EFFECTIVE COHESION AND FRICTION ANGLE VALUES..... 17
TABLE 7-2: FACTOR OF SAFETY LIMITS FOR SLOPES 19
TABLE 7-3: FACTOR OF SAFETY RESULTS (UNDRAINED CONDITION) 21
TABLE 7-4: FACTOR OF SAFETY RESULTS (DRAINED CONDITION) 23
TABLE 8-1: RISK RATING LEGEND 24
TABLE 8-2: SUMMARY OF PEAT STABILITY RISK REGISTER 24
TABLE 9-1: SUMMARY OF INDICATIVE TURBINE FOUNDATION TYPE 26

1 NON-TECHNICAL SUMMARY

Fehily Timoney and Company (FT), formerly Applied Ground Engineering Consultants (AGEC) Ltd. was engaged by MKO (McCarthy Keville O'Sullivan) to undertake a geotechnical assessment of the proposed Cahermurphy Two wind farm with respect to peat stability. In accordance with planning guidelines compiled by the Department of the Environment, Heritage and Local Government (DoEHLG, Wind Farm Development Guidelines for Planning Authorities, 2006), 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 over 120 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 proposed wind farm comprises 10 no. wind turbines with associated infrastructure including access roads (new and upgrading of existing roads), substation, construction compounds, met mast and borrow pits.

The approximate development area for the site is 137.2 hectares. A number of existing wind farm developments are located in the area of the site.

Peat thicknesses recorded during the site walkovers from approximately 290 no. probes ranged from 0 to 4.5m with an average of 1.05m. Over 95 percent of the peat depth readings are 3m or less. The deepest peat was recorded in a localised area in the west of the site where the topography is typically flatter. No infrastructure is proposed for this area.

Ground conditions comprised mainly of peat overlying locally glacial till overlying bedrock.

A walkover including intrusive peat depth probing, a ground investigation including trial pits, 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 (PLHRA, 2017).

The purpose of the stability analysis is to determine the stability i.e. Factor of Safety (FoS), of the peat slopes. The FoS provides a direct measure of the degree of stability of a peat slope. A FoS of less than 1.0 indicates that a slope is unstable; a FoS of greater than 1.0 indicates a stable slope. An acceptable FoS for slopes is generally taken as a minimum of 1.3.

Based on the stability assessment carried out on the peat slopes the calculated FoS's are acceptable. Localised areas of deeper peat deposits are present which will require specific construction methods, but do not represent a peat slide risk. The risk assessment at each infrastructure location includes mitigation/control measures to ensure the continued stability of the site.

The results of the stability assessment reflect the nature of the terrain and show that the site has an acceptable FoS with respect to peat stability. In addition, the terrain is considered to have a low susceptibility to peat failure due to:

- Limited historical peat failures in the area (nearest located some 25km to the southeast (occurred in 1997) and the next nearest some 29km northwest (occurred in 2011).

2 INTRODUCTION

2.1 Background and Experience

Fehily Timoney and Company (FT) were engaged in July 2019 by McCarthy Keville O'Sullivan (MKO) to undertake a geotechnical assessment of the proposed wind farm site with respect to peat stability.

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

The proposed development site is located in County Clare, approximately 5km north of the village of Kilmihil and 25km southwest of Ennis.

The proposed wind farm comprises 10 no. wind turbines with associated infrastructure including access roads (new and upgrading of existing roads), 1 no. onsite electrical substation which will be constructed in Cahermurphy townland, underground electrical and communications cabling connecting the turbines to the proposed onsite substation, underground cabling connecting the onsite substation to Booltiagh substation, temporary construction compound, met mast and borrow pits.

The approximate development area for the site is 137.2 hectares. A number of existing wind farm developments are located in the area of the site.

A walkover survey of the site was carried out by FT in August 2019. The peat depth data recorded by FT will be used in the assessment of peat stability for the proposed wind farm.

A walkover survey of the site was also carried out by MKO in 2019. The peat depth data recorded by MKO during this walkover survey will also be used in the assessment of peat stability for the proposed wind farm.

2.2 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 (PLHRA, 2017). The Peat Hazard and Risk Assessment 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 assessment of peat stability at the proposed site included the following activities:

(1) Desk study

(2) Site walkover findings including shear strength and peat depth measurements

(3) Interpretation of ground investigation data (trial pits)

(4) Overview of ground conditions at the site

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

(6) Peat contour depth plan – is compiled based on the peat depth probes carried out across the site by FT and MKO

(7) Factor of safety plan – is compiled for the short-term critical condition (undrained) for 128 no. FoS points analysed across the site

(8) A peat stability 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 2-1. The methodology illustrates the optimisation of the wind farm layout based on the findings from a site walkover and subsequent feedback from the peat stability and risk assessment results.

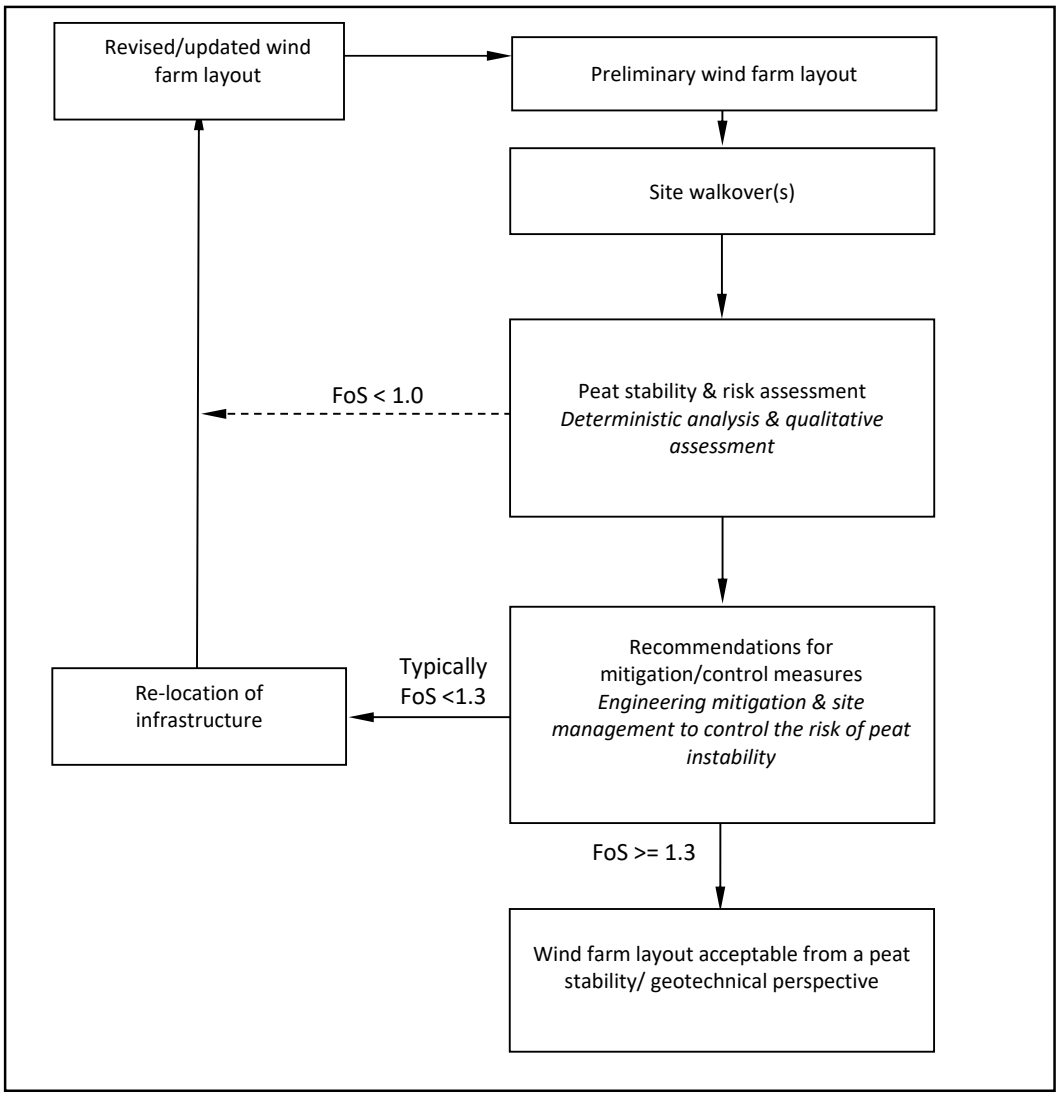

Figure 2-1: Flow Diagram Showing General Methodology for Peat Stability Assessment

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 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 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 2.4).

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 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 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 2-2.

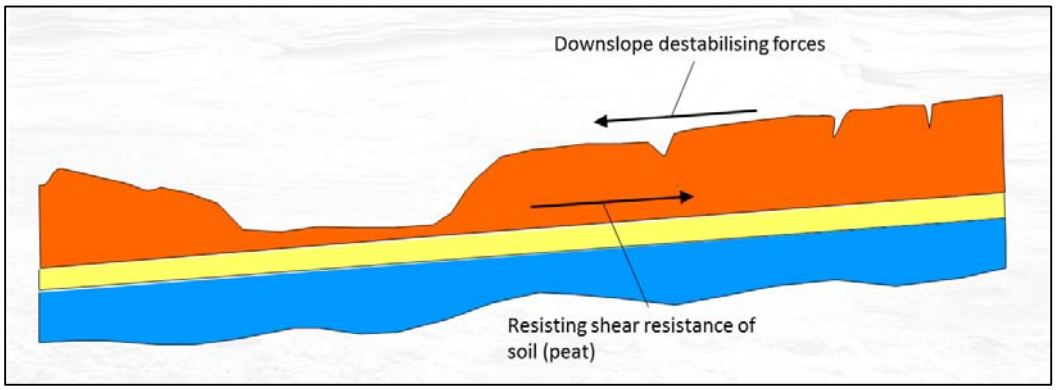

Figure 2-2: Peat Slope Showing Balance of Forces to Maintain Stability

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

2.6 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 (PLHRA, 2017); see Section 5.3.1 of the guide. This guide provides best practice methods to identify, mitigate and manage peat slide hazards and associated risks in respect of consent applications for electricity generation projects.

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

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

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

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

2.7 Assessment of Intense Rainfall and Extreme Dry Events on the Peat Slopes

The deterministic approach carried out by FT examines intense rainfall and extreme dry events. The deterministic approach includes an 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 in particular, 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 between 0 and 100% of the peat depth is conducted, where 0% equates to the peat been completely dry and 100% equates to the peat been 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 8 of this report.

3 DESK STUDY

3.1 Desk Study

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

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

The desk study also included a review of both published literature and GSI online dataset viewer (GSI, 2019) on peat failures/landslides in the vicinity of the site. In addition, this section of text includes commentary on a number of landslides within the proposed development of the wind farm inspected during the site walkover.

The Ordnance Survey Ireland (OSI, 2019) mapping/plans were reviewed to determine if any notable features or areas of particular interest (from a geotechnical or hydrology point of view) are present on the site.

The Geological Survey of Ireland (GSI, 1999) geological plans for the site were used to verify the bedrock conditions. The GSI (2019) database was used to verify soil and subsoil types on site.

3.2 Review of Previous Failures

A desk study review of previous failures in the locality (GSI, 2019) was carried out to assess the susceptibility of the area to slope failures.

Based on the review, there are no previous recorded slope failures within the boundary of the site location. In addition, there are no recorded slope failures within an 20km radius of the study area.

The nearest recorded slope failure is located approximately 25km southeast of the study area. The failure recorded occurred in Ballyhahill, Co. Limerick. The slope failure in this area was an embankment landslide, the mechanism is undefined.

An additional slope failure occurred approximately 29km northwest of the study area. The failure recorded occurred in Doonnagore, Co. Clare. The slope failure in this area was an embankment landslide, the mechanism is undefined.

There are no other failures within a 30km radius of the site boundary.

3.3 Review of OSI Mapping

From a review of the OSI mapping, no notable geotechnical features are recorded in the area. The elevation at the site varies from 88 to 141m OD. A single stream drains the central part of the site. This stream is linear through the site and drains in a westerly direction.

3.4 Soils, Subsoil & Bedrock

A review of the Geological Survey of Ireland online database and published documents from GSI namely sheet 17 Geology of the Shannon Estuary was carried out.

A review of the GSI subsoils maps indicate that the site is mainly overlain by blanket peat, with localised areas of till derived from Sandstone and Shale.

In relation to bedrock, the site location and surrounding area is underlain by 3 different formations. Predominantly the site location is underlain by Gull Island Formation, which is described as grey siltstone and sandstone grey siltstones, with up to 20% sandstones at the base of the succession, decreasing towards the

top. The sandstones are usually graded and exhibit flute casts at their base and ripple marks at the top. The south and east of the site is predominantly underlain by Central Clare Group, which is described as mudstones overlain by laminated to massive grey siltstones followed by thick layer of sandstone. Throughout the site there is a Goniatite marine band ranging across the site location, described as a structural feature.

There are no fault-lines within the bedrock of the site boundary.

No geological heritage sites are noted within the site development. The closest feature is approximately 9km northwest of the proposed site location. The feature is described as coastal section – foreshore exposure, consists of well-bedded sandstones, siltstones and mudstones of the Upper Carboniferous (Namurian) Central Clare Group.

4 SITE WALKOVER

As part of the peat stability assessment at the proposed wind farm, a site walkover was carried out by FT during 2019 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, substation, met mast, construction compounds, existing and proposed new access roads, borrow pits and all associated infrastructure.

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

4.1 Findings of Site Walkover for Wind Farm

The site reconnaissance comprised a walkover inspection of the site on the 7th and 8th August 2019. Weather conditions for the site visit was 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 typically covered in a relatively thin layer of peat and has undulating terrain. Generally deeper peat was encountered in the flatter areas of the site with thinner peat on the surrounding slopes. Young and mature forestry is present across the site.

(2) Peat depths recorded within the proposed infrastructure envelope ranged from 0 to 2.6m with an average of 0.7m. Peat depths recorded across the site ranged from 0 to 4.5m with an average of 0.8m (Figure 4-1). A total of 290 no. peat depth probes were carried out on site. Over 95 percent of peat depth probes recorded peat depths of less than 3.0m.

(3) The peat depths recorded at the turbine locations varied from 0.25 to 2.6m with an average depth of 0.7m. The slope angle at the turbine locations range from 2 to 5 degrees.

(4) The access tracks for the wind farm will comprise upgrading of existing and construction of new tracks. The existing tracks were noted as being in relatively good condition and consist of both excavated/founded and floated tracks. Examples of the existing tracks are shown in Photos 1 and 2.

(5) With respect to the new proposed and existing tracks, peat depths are typically less than 1.5m with localised depths of up to 2.5m recorded.

(6) Localised areas of ponding water were recorded. This is not unexpected given the ground conditions and the flat terrain present in localised areas across the site.

(7) An inspection of the ground conditions at 2 no. existing borrow pits on site was carried out. The findings from the inspection of the proposed borrow pits are included in Section 10.6.

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

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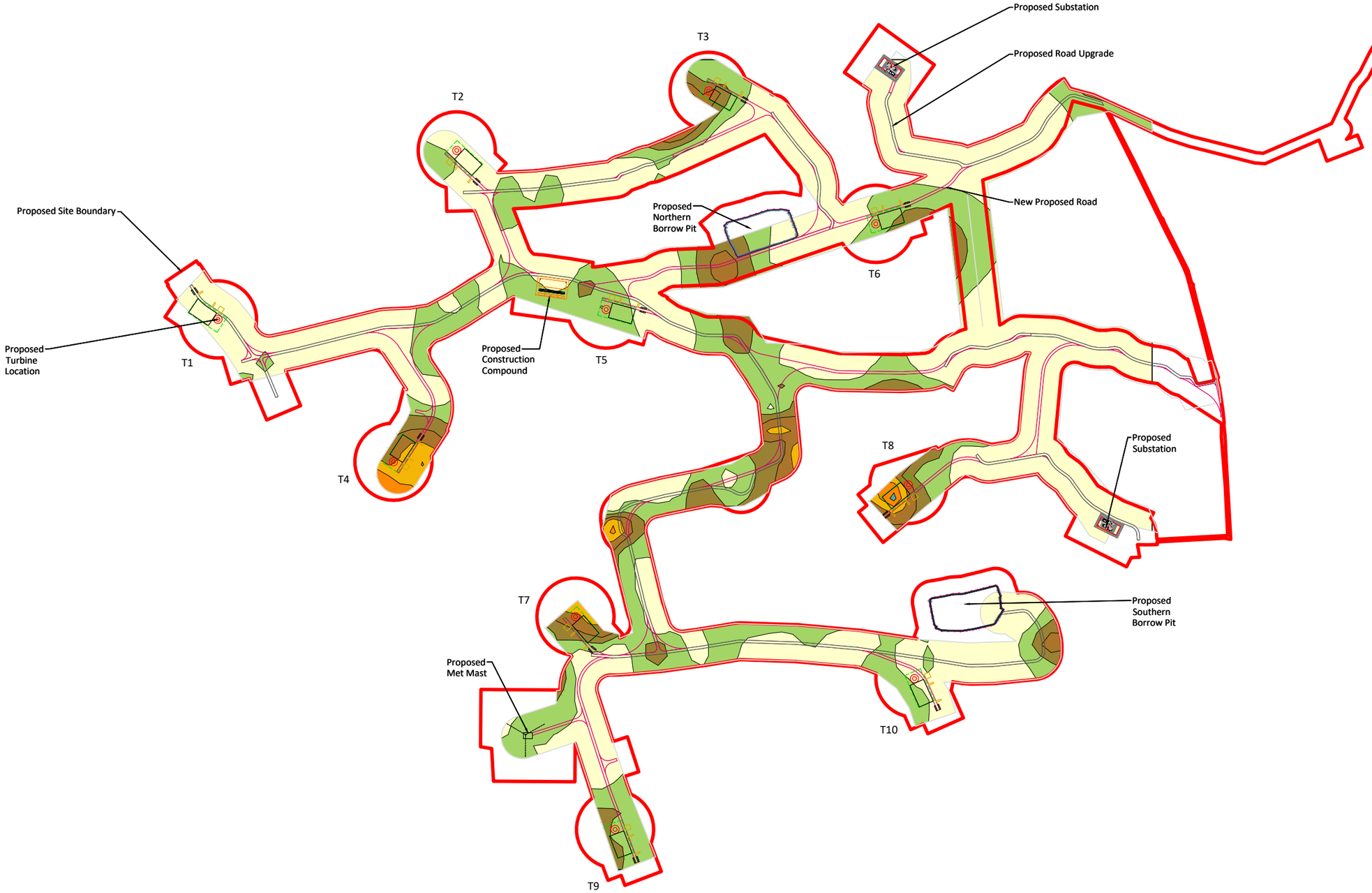

Peat Depth Legend:

- ≥ 0 < 0.5
- ≥ 0.5 < 1
- ≥ 1 < 1.5
- ≥ 1.5 < 2
- ≥ 2 < 2.5
- ≥ 2.5 < 3
- ≥ 3 < 3.5
- ≥ 3.5 < 4
- ≥ 4 < 4.5
- > 4.5

Scale 1:10000

0m 50m 100m 150m 200m 250m 300m 350m 400m 450m 500m

Scale 1:10000

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FIGURE 4-1 : PEAT DEPTH CONTOUR PLAN

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(9) A watercourse crossing is present along the proposed access route between turbine T5 and T7. The existing culvert will require widening at this location, and possibly upgrading.

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

(a) The site is typically covered in a relatively thin layer of peat with undulating terrain and widespread young to mature forestry coverage. Peat depths recorded across the site ranged from 0 to 4.5m with an average of 0.7m.

(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 assessment, see Sections 7 and 8 of this report.

(c) Based on the findings from the walkover survey, the proposed wind farm development is considered to have a low risk of peat failure.

5 GROUND INVESTIGATION

A ground investigation was carried out at the site by Irish Drilling Ltd (IDL) during September 2019.

The ground investigation comprised 14 no. trial pits and was carried out on 18th and 19th September 2019. Laboratory testing of samples was carried out by IDL. A 13-tonne tracked excavator was used for the ground investigation works. The trial pits were carried out at various locations across the site to depths of up to 4.6m bgl. The laboratory testing comprised classification testing of the silt/clay underlying the peat. The trial pit logs, photographs and laboratory test results from the ground investigation are included in Appendix B. Figure 5-1 showing the ground investigation locations. Due to the presence of mature forestry on the site, it was not possible to access the exact locations of T3 and T8.

The purpose of the ground investigations was to assess the ground conditions across the site in particular the extent, characteristics and strength of the soil immediately underlying the peat, to determine the potential founding stratum of various infrastructure elements across the site and to determine the potential to develop borrow pits across the site.

The ground investigation was carried out in accordance with the principles in BS 5930:2015 and Eurocode 7 Part 2. A ground investigation location plan showing all trial pit and borehole locations is included as Figure 5-1 in this report.

5.1 Summary of In-situ & Laboratory Tests

As part of the ground investigation carried out at the site, laboratory testing was carried out as part of the works. The laboratory testing carried out included:

- Soil classification tests

Laboratory testing was scheduled on bulk samples recovered from trial pits.

Particle size distribution (PSD) tests and atterberg limit classification tests were carried out on samples recovered from the trial pits. The PSD tests showed that the majority of the material can be described as a very silty very sandy Gravel, with areas of slightly sandy gravelly Silt also present. The atterberg limit test results show the material as a clay with low plasticity.

5.2 Interpretation & Summary of Ground Conditions

The ground conditions and stratigraphy at the site can be typically categorised into the following sequence:

Peat

Typically described as soft plastic black amorphous peat. Peat thicknesses from the trial pits ranged from 0.35 to 2.7m.

Glacial Till

Typically described as firm and stiff, slightly sandy gravelly Silt/Clay with occasional to frequent cobbles and locally occasional boulders. Cobbles and boulders were typically noted as angular and sub-rounded and rounded. The thickness of the layer is variable across the site depending on topography and depth to bedrock.

Also recorded was a silty sandy Gravel with cobbles, considered to be a granular glacial deposit.

The base of the glacial till was not encountered in most of the trial pits. The till is essentially derived from the underlying Namurian sandstones and shales.

The till is suitable for a founding stratum for some of the infrastructure elements on site e.g. access tracks, hardstands, etc.

Bedrock

Possible weathered bedrock was encountered in 8 of the 14 nos. trial pits. The weathered bedrock was described as angular gravel and cobbles of shale/siltstone.

Other Comments and Observations

Groundwater was noted during the excavation of five of the trial pits. Groundwater was recorded at depth of between 1.9 and 4.5m bgl, with flow ranging from slow to rapid.

The stability of the excavation faces of the trial pits was noted as unstable in five of the trial pits.

5.3 Overview of Ground Conditions

The site is covered with areas of blanket bog, cut away bog, pastures, tracks and exposed rock. Based on a number of probes carried out during walkover surveys the peat depth ranged from 0 to 4.5m with an average peat depth from probes of 0.8m.

Peat depths vary across the site. Generally deeper peat was encountered in the flatter areas of the site with thinner peat on sloping ground. Localised variations in peat depth over short distances were recorded, which reflects the undulations in the underlying surface of the mineral soil/rock topography.

The peat is immediately underlain by a glacial till derived from Namurian sandstones and siltstone. Based on a desk study, bedrock on the site comprises dominantly siltstone with interbedded minor sandstone.

5.4 Summary of Geotechnical Parameters

Table 5-1 below provides proposed geotechnical material parameters for each material type encountered during the site investigation.

Table 5-1: Summary of Geotechnical Parameters

Material Type/Strata	Unit Weight	Geotechnical Parameters				
		Undrained Parameters	Drained Parameters			
	γ (kN/m^3)	c_u (kPa)	φ' (°)	c' (kPa)	E' (MPa)	E_u (MPa)
Peat	10.5		25	4	2	
Glacial Deposits	19	75	28	0	15	20
Bedrock	21		40	0	100	

Note (1) The above parameters are indicative only and have been derived based on experience and from a review of the ground investigation carried out at the site.
Note (2) Where direct measurement of parameters has not been carried out, established correlations with measured properties have been used to derive values.

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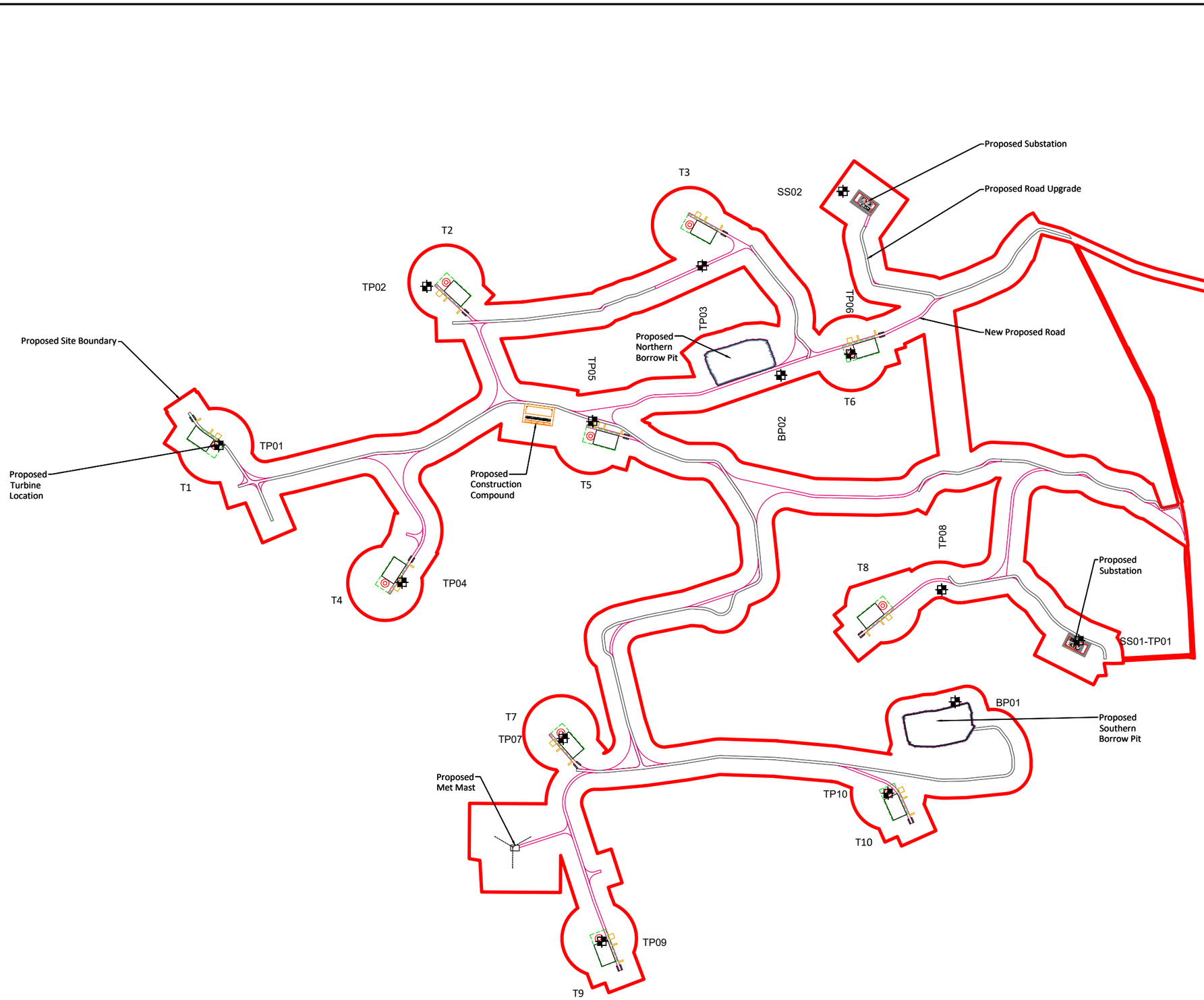

Ground Investigation Legend:

TP01 Location of Trial Pit

Scale 1:10000

0m 50m 100m 150m 200m 250m 300m 350m 400m 450m 500m

Scale 1:10000

Scale (@ A3)
1:10000

Date - 30.04.20

FIGURE 5-1 : GROUND INVESTIGATION LOCATION PLAN

Drawn - POR

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Friday 1 May 2020

6 PEAT DEPTH, STRENGTH & SLOPE AT PROPOSED INFRASTRUCTURE LOCATIONS

Based on the peat depths recorded across the site by FT and MKO the peat varied in depth from 0 to 4.5m with an average of 0.8m. All peat depth probes carried out on site have been utilised to produce a peat depth contour plan for the site (Figure 4-1).

A summary of the peat depths at the proposed infrastructure locations is given in Table 6-1. The data presented in Table 6-1 is used in the peat stability assessment of the site; see Section 7 of this report.

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)
T1	507385	669377	0.2 to 0.3	0.25	3
T2	507942	669772	0.1 to 0.3	0.15	3
T3	508531	669911	0.3 to 0.5	0.4	3
T4	507833	669002	1.0 to 2.3	1.8	2
T5	508291	669400	0.1 to 0.4	0.25	4
T6	508921	669600	0.15 to 0.4	0.25	2
T7	508219	668683	0.25 to 1.7	0.85	4
T8	508965	668990	1.7 to 2.5	1.9	2
T9	508312	668187	0.1 to 0.7	0.35	2
T10	509012	668538	0 to 0.3	0.15	5
Substation 1	508888	669971	0.15	0.15	2
Substation 2	509457	668893	0.8	0.8	3
Construction Compound	508164	669452	0.15	0.15	3
Met Mast	508107	668404	0.4 to 0.7	0.5	7
Borrow Pit 1	507398	669233	0.15	0.15	5
Borrow Pit 2	508725	669570	0.3	0.3	6

Note (1) Based on probe results from the site walkover. The range of peat depths for the infrastructure locations are generally based on a 10m grid carried out around the infrastructure element, where accessible.
Note (2) Slope angle obtained during site survey by FT using handheld equipment or from slope contour survey data. The slope angle quoted reflects the slope immediately around the infrastructure location.
Note (3) The data presented in the Table above is used in the peat stability assessment of the site; see Section 8 of this report.

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 6-1.

The hand vane results indicate undrained shear strengths in the range 8 to 56kPa, with an average value of about 30kPa. The lower bound strengths recorded are typical of deep weak saturated peat and were recorded in the deeper peat deposits in the flatter areas of the 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.

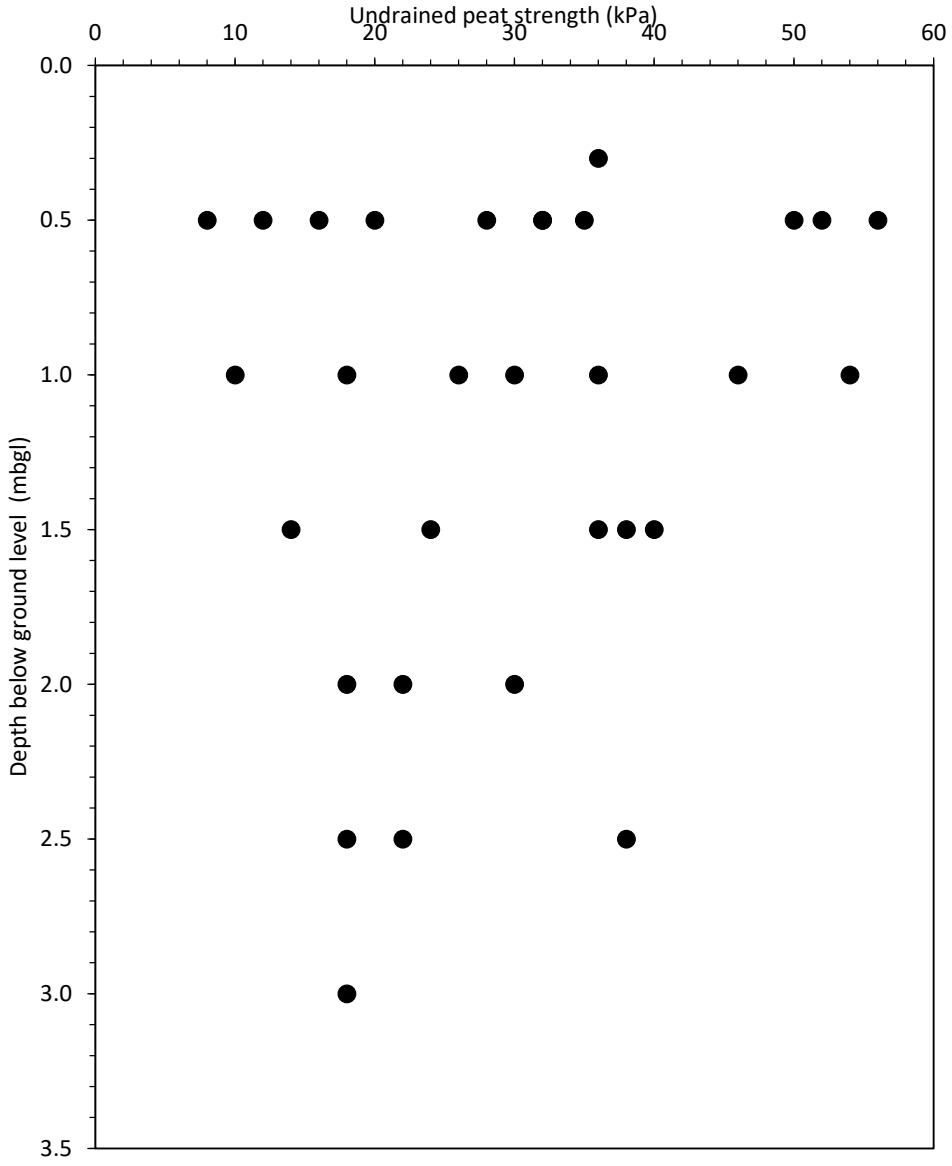

Figure 6-1: Undrained shear strength (Cu) profile for peat with depth

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 7-1 shows a summary of the published information on peat together with drained strength values.

Table 7-1: 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.

Reference	Cohesion, c' (kPa)	Friction Angle, ø' (degs)	Testing Apparatus/ Comments
	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

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 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 including the substation and borrow pits.

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

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

As a general guide the FoS limits for peat slopes in this report are summarised in Table 7-2.

Table 7-2: Factor of Safety Limits for Slopes

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

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

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

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

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

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

Where,

F = Factor of Safety
c_u = Undrained strength
γ = Bulk unit weight of material
z = Depth to failure plane assumed as depth of peat
a = 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
a = 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 8kPa was selected for the assessment based on the c_u values recorded at the site. It should be noted that a cu of 8kPa for the peat is considered a conservative value for the analysis and is not representative of all peat present across the site. In reality the peat generally has a higher undrained 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 D 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 calculated FoS for load condition (1) is in excess of 1.30 for each of the 128 no. locations analysed with a range of FoS of 5.75 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 128 no. locations analysed with a range of FoS of 3.53 to in excess of 10, indicating a low risk of peat instability.

Table 7-3: Factor of Safety Results (Undrained Condition)

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T1	507385	669377	51.02	11.77
T2	507942	669772	51.02	11.77
T3	508531	669911	30.61	10.20
T4	507833	669002	8.82	6.37
T5	508291	669400	45.99	9.20
T6	508921	669600	57.34	16.38
T7	508219	668683	6.76	4.26
T8	508965	668990	9.17	6.55
T9	508312	668187	32.77	13.49
T10	509012	668538	30.71	7.09
Substation 1	508888	669971	152.91	19.95
Substation 2	509457	668893	28.67	12.74
Construction Compound	508164	669452	102.05	13.31
Met Mast	508107	668404	9.45	3.89
Borrow Pit 1	507398	669233	61.43	8.01
Borrow Pit 2	508725	669570	25.65	5.92

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Proposed Site Boundary

Proposed Turbine Location

T1

T2

T3

T4

T5

T6

T7

T8

T9

T10

Proposed Construction Compound

Proposed Northern Borrow Pit

Proposed Substation

Proposed Road Upgrade

New Proposed Road

Proposed Met Mast

Proposed Southern Borrow Pit

Proposed Substation

Factor of Safety Legend:

0 < 1.0

≥ 1.0 < 1.3

≥ 1.3

No Peat Recorded At This Location

Increasing Stability

0m 50m 100m 150m 200m 250m 300m 350m 400m 450m 500m

Scale 1:10000

Scale 1:10000

Scale (@ A3) 1:10000

Date - 30.04.20

FIGURE 7-1 : FACTOR OF SAFETY PLAN - SHORT TERM CRITICAL CONDITION (UNDRAINED)

Drawn - POR

Checked - IH

Rev - B

Friday 1 May 2020

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7.3.2 Drained Analysis for the Peat

The results of the drained analysis for the peat are presented in Appendix D. The results from the main infrastructure locations are summarised in Table 7-4. 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 128 no. locations analysed with a range of FoS of 2.87 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 128 no. locations analysed with a range of FoS of 3.79 to in excess of 10, indicating a low risk of peat instability.

Table 7-4: Factor of Safety Results (Drained Condition)

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T1	507385	669377	25.51	12.73
T2	507942	669772	25.51	12.73
T3	508531	669911	15.31	11.03
T4	507833	669002	4.41	6.89
T5	508291	669400	22.99	9.93
T6	508921	669600	28.67	17.73
T7	508219	668683	3.38	4.60
T8	508965	668990	4.59	7.09
T9	508312	668187	16.38	14.60
T10	509012	668538	15.36	7.64
Substation 1	508888	669971	76.46	21.58
Substation 2	509457	668893	9.57	9.20
Construction Compound	508164	669452	51.02	14.39
Met Mast	508107	668404	4.72	4.18
Borrow Pit 1	507398	669233	38.32	10.80
Borrow Pit 2	508725	669570	30.71	8.64

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 due to the subjective nature of the assessment, 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 E.

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 Peat Stability Risk Register in Appendix C and summarised in Table 8-2.

The risk rating for each infrastructure element at the Cahermurphy Two wind farm is designated negligible and low following some mitigation/control measures being implemented. Sections of access roads to the nearest infrastructure element will be subject to the same mitigation/control measures that apply to the nearest infrastructure element.

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

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	Negligible	1 to 4	No	Negligible	1 to 4
Turbine T2	Negligible	1 to 4	No	Negligible	1 to 4
Turbine T3	Negligible	1 to 4	No	Negligible	1 to 4
Turbine T4	Low	5 to 10	Yes	Negligible	1 to 4
Turbine T5	Negligible	1 to 4	No	Negligible	1 to 4

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 T6	Negligible	1 to 4	No	Negligible	1 to 4
Turbine T7	Negligible	1 to 4	No	Negligible	1 to 4
Turbine T8	Medium	11 to 16	Yes	Low	5 to 10
Turbine T9	Low	5 to 10	Yes	Negligible	1 to 4
Turbine T10	Negligible	1 to 4	No	Negligible	1 to 4
Substation 1	Negligible	1 to 4	No	Negligible	1 to 4
Substation 2	Negligible	1 to 4	No	Negligible	1 to 4
Construction Compound	Negligible	1 to 4	No	Negligible	1 to 4
Met Mast	Negligible	1 to 4	No	Negligible	1 to 4
Borrow Pit 1	Negligible	1 to 4	No	Negligible	1 to 4
Borrow Pit 2	Negligible	1 to 4	No	Negligible	1 to 4

9 INDICATIVE FOUNDATION TYPE FOR TURBINES

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

Table 9-1: Summary of Indicative Turbine Foundation Type

Turbine No.	Indicative Turbine Foundation Type	Relevant GI	Ground Conditions
T1	Gravity type foundation	TP01	Peat to 0.8m overlying very clayey gravelly Sand to 3.9m. TP terminated on boulders (possible weathered bedrock).
T2	Gravity type foundation	TP02	Peat to 0.4m overlying silty sandy Gravel to 3.3m.
T3	Possible piled foundation	TP03 (nearest TP)	Firm slightly gravelly sandy Silt to 3.5m. TP terminated on boulders. (Peat depth at turbine location 0.3-0.5m)
T4	Possible piled foundation	TP04	Peat to 2.7m overlying stiff Silt to 4m.
T5	Gravity type foundation	TP05	Peat to 0.35m overlying stiff, gravelly Clay to 3.9m. TP terminated on boulders (possible weathered bedrock).
T6	Gravity type foundation	TP06	Peat to 0.4m overlying stiff, Silt to 1.6m overlying sandy Gravel and Cobbles to 2.6m. TP terminated on possible rock.
T7	Gravity type foundation	TP07	Peat and soft silt/clay to 0.7m overlying stiff Silt to 2.8m. TP terminated on possible rock.
T8	Possible piled foundation	TP08 (nearest TP)	Peat to 0.25m overlying silty sandy Gravel to 4.3m. Layer of stiff sandy gravelly Clay between 1.9-2.5m bgl. (Peat depth at turbine location is 1.7-2.5m)
T9	Gravity type foundation	TP09	Peat and soft clay to 0.65m overlying stiff Silt to 3.3m overlying sandy Gravel to 4m.
T10	Gravity type foundation	TP10	Peat to 0.6m overlying firm to stiff Silt to 4.6m.

It should be noted that further ground investigation will be carried out at each turbine location in the form of a borehole with in-situ SPT testing at 1.0m intervals in the overburden and follow-on rotary core through bedrock to confirm the foundation types assumed in Table 9-1. The founding depths for each of the turbine foundations will be confirmed following the completion of further ground investigation at detailed design stage.

For gravity type turbine foundations, where the depth of excavation exceeds the minimum 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 FOUNDING DETAILS FOR OTHER INFRASTRUCTURE ELEMENTS

10.1 Access Roads

Up to 6km of existing access tracks requiring upgrade are present across the Cahermurphy Two wind farm site and based on site visits and historical information have been in operation for a significant number of years. The existing access tracks were constructed using both excavate and replace and floated construction techniques.

Up to 5.5km of new proposed access roads will be constructed as part of the wind farm construction. The new proposed access roads will be constructed using an excavate and replace construction technique (see Figure 2-1 of the Peat & Spoil Management Plan).

The typical make-up of the new proposed access roads is a minimum stone thickness of 1000mm. The requirement for a layer of geotextile and geogrid and the necessary stone thickness will be confirmed at detailed design stage.

See the Peat & Spoil Management Plan for Cahermurphy Two wind farm for further details on the proposed access roads on site.

10.2 Crane Hardstands

The crane hardstands will be constructed using the founded technique (i.e. not floated technique).

Crane hardstands are generally constructed using compacted Class 1/6F material on a suitable sub-formation to achieve the required bearing resistance. The hardstands will be designed for the most critical loading combinations from the crane.

The hardstands will require to be founded on material underlying the peat deposits. The founding levels for the hardstands will be variable across the site and will be determined during detailed ground investigation/design stage.

The typical make-up of the hardstands will include up to 1000mm of granular stone fill with possibly a layer of geotextile and/or geogrid to ensure stability.

10.3 Substation Foundations & Platform

The substation platforms will be constructed using the founded technique (i.e. not floated technique). The substation foundations may comprise strip/raft foundations under the main footprint of the building.

Substation platforms are generally constructed using compacted Class 1/6F material on a suitable sub-formation to achieve the required bearing resistance. The substation platform will require to be founded on material underlying the peat deposits.

Given the ground conditions present at the proposed substations, it is envisaged that the foundations will require to be founded on cohesive or granular glacial deposits.

The make-up of the substation platform will include up to 1000mm of granular stone fill with possibly a layer of geotextile and/or geogrid to ensure stability. At the underside of the substation foundations, a layer of structural up-fill (class 6N/6P) material in accordance with Transport Infrastructure Ireland (TII) requirements will be required.

10.4 Temporary Construction Compound Platform

The construction compound platform will be constructed using the founded technique (i.e. not floated technique).

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

The construction compound platform will require to be founded on material underlying the peat deposits.

The founding depth for construction compound platform will require excavations from 0.3m to 0.5m bgl. The make-up of the construction compound platform will include up to 1000mm of granular stone fill with possibly a layer of geotextile and/or geogrid where soft ground is present.

10.5 Met Mast Foundation

The met mast foundation will likely comprise gravity type foundation.

Given the ground conditions present at the proposed met mast, it is envisaged that the foundation will require to be founded on glacial till. The peat is not a suitable founding stratum for the met mast foundation.

10.6 Potential for Development of Borrow Pits

An inspection of the ground conditions at 2 no. proposed borrow pits on site was carried out. The proposed borrow pits are located close to turbines T6 and T10.

The ground conditions at the borrow pits were recorded as up to 0.5m of peat/peaty topsoil overlying 1-2m of till overlying bedrock (see Photo 3). The bedrock was recorded as a slightly weathered medium strong to strong Sandstone and Siltstone.

From a visual inspection only, the reusability of the Sandstone/Siltstone during the construction of the wind farm would be suitable for the construction of access tracks and hardstanding areas. However, a stronger and more durable imported rock may be required for the finished running surface of the access tracks.

Two trial pits were excavated within the proposed borrow pits. These recorded possible bedrock at 4.1m and 0.9m bgl respectively.

Further discussion on the proposed borrow pit is given in the Peat and Spoil Management Plan (FT, 2019) for the site.

10.7 Grid Connection Route

A connection between the proposed development site and the national electricity grid will be necessary to export electricity from the proposed wind farm. This connection will originate at the proposed onsite substation and will travel west along a series of local roads towards the existing ESB Networks Booltiagh substation). It is proposed to make the grid connection by underground cable.

The proposed grid connection construction methodology, including proposals for any water crossings on the underground cabling routes is described in the EIAR.

The cable trench route will encounter peat. It is proposed to excavate the trenches for the underground cable at a uniform depth in peat or non-peat overburden material. The trenches will be approximately 600mm wide and 1250mm deep. No peat stability issues are anticipated with these works.

11 SUMMARY AND RECOMMENDATIONS

11.1 Summary

The following summary is given.

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

The findings of the peat assessment showed that the site has an acceptable margin of safety and is suitable for the proposed wind farm development.

The site is typically covered in blanket peat with undulating terrain and widespread young to mature forestry coverage. Peat depths vary across the site depending on mainly topography.

Peat depths recorded across the site ranged from 0 to 4.5m with an average of 0.8m. A total of over 290 no. peat depth probes were carried out on site. Over 90 percent of the probes recorded peat depths of less than 2.5m. Over 95 percent of peat depth probes recorded peat depths of less than 3.0m. Areas of deeper peat were avoided when siting the wind farm infrastructure.

No peat failures/landslides are recorded on the Cahermurphy Two wind farm site which suggests that site conditions do not pre-dispose themselves to failures/landslides.

An analysis of peat sliding was carried out at the main infrastructure 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.

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 locations analysed, show that all locations have an acceptable FoS of greater than 1.3, indicating a low risk of peat failure. The undrained analysis is considered the most critical condition for the peat slopes. Figure 7-1 shows the results of the factor of safety (FoS) analysis for the peat slopes on site for the most critical load condition.

A drained analysis was carried out, which examines 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, show that all locations have an acceptable FoS of greater than 1.3, again indicating a low risk of peat failure.

The risk assessment at each turbine location identified a number of mitigation/control measures to reduce the potential risk of peat failure (see Appendix C).

In summary, the findings of the site development geotechnical assessment showed that the proposed Cahermurphy Two wind farm has an acceptable margin of safety and is suitable for wind farm development. Notwithstanding the above, and for extra prudence, a number of recommendations are given below which will be taken into account prior to development of the site. Overall, the peat characteristics on the Cahermurphy site are similar to that encountered on many developed wind farm sites.

11.2 Recommendations

The following recommendations are given.

Notwithstanding that the site has an acceptable margin of safety a number of mitigation/control measures are given to ensure that all works adhere to an acceptable standard of safety for work in peatlands. 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 C).

Recommendations and guidelines given in FT's report 'Peat & Spoil Management Plan for Cahermurphy Two Wind Farm, County Clare' (FT 2019) will be taken into consideration during the design and construction stage of the wind farm development.

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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Appendix A

Photos from FT Site Walkover

Photo 1 Example of existing founded track on site

Photo 2 Example of existing founded track on site

Photo 3 Bedrock exposure at Borrow Pit 2 (North)

Appendix B

Ground Investigation (2019) – Exploratory Hole Logs, Laboratory Testing & Photographs




IRISH DRILLING LIMITED

LOUGHREA, CO. GALWAY, IRELAND

CONTRACT DRILLING
SITE INVESTIGATION

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CAHERMURPHY WIND FARM PHASE 2, 2019

FACTUAL REPORT

MKO,
Tuam Road,
Galway,
H91 VW84.

Fehily Timoney& Company,
The Grainstore,
Bagenalstown,
Co. Carlow.

	Prepared by	Approved by	Rev. Issue Date:	Revision No.
	Ronan Killeen	Declan Joyce	18th November 2019	19 CE/103_001
Signature				

FOREWORD

The trial pit records have been compiled from an examination of the samples by a Geotechnical Engineer and from the Drillers' descriptions.

The report presents an opinion on the configuration of the strata within the site based on the trial pit results. The assumptions, though reasonable, are given for guidance only and no liability can be accepted for changes in conditions not revealed by the trial pits.

The fieldwork was carried out in accordance with IS EN 1997-2 and BS5930, 2015 Code of Practice for Site Investigations with precedence given to IS EN 1997-2 where applicable.

Contents:

1.0 Introduction
2.0 The Site & Geology
3.0 Fieldwork
4.0 Laboratory Testing

Book 1 of 1

Appendix 1 Trial Pit Records

Appendix 2 Laboratory Test Results

Appendix 3 Trial Pit Photographs

Appendix 4 AGS Files

Appendix 5 Site Plan

1.0 Introduction.

Irish Drilling Ltd. (IDL) was instructed by Fehily Timoney & Company Consulting Engineers, on behalf of MKO, to carry out a site investigation at the site of the proposed Cahermurphy Wind Farm.

This site investigation was carried out to provide detailed factual geotechnical information of the underlying ground conditions along the proposed substation and borrow pit sites and at proposed turbine locations.

The fieldwork commenced on September 18th 2019 and was completed on September 19th 2019.

2.0 Site & Geology

The site is located near Kilmihil, County Clare.

The fieldwork was carried out predominantly on agricultural and/or forestry lands.

Weather conditions in general were quite variable with the majority of the fieldwork carried out over a typical autumn/winter period in Ireland.

Geological Survey maps of the area indicate that the site is underlain by Carboniferous Limestone Rock Formations.

A Site Plan, prepared by the client's representatives and showing approximate fieldwork locations, is included as an appendix with this report.

3.0 Fieldwork.

The following plant was mobilised to site to carry out fieldwork operations:

Hitachi LCN 12T Tracked Excavator.

Fieldwork carried out to date has included the following:

Fourteen trial pits were excavated on site using a 12T wide-padded tracked excavator. The pits were logged and photographed by an Engineer with observations made on ground conditions, pit stability and water ingress.

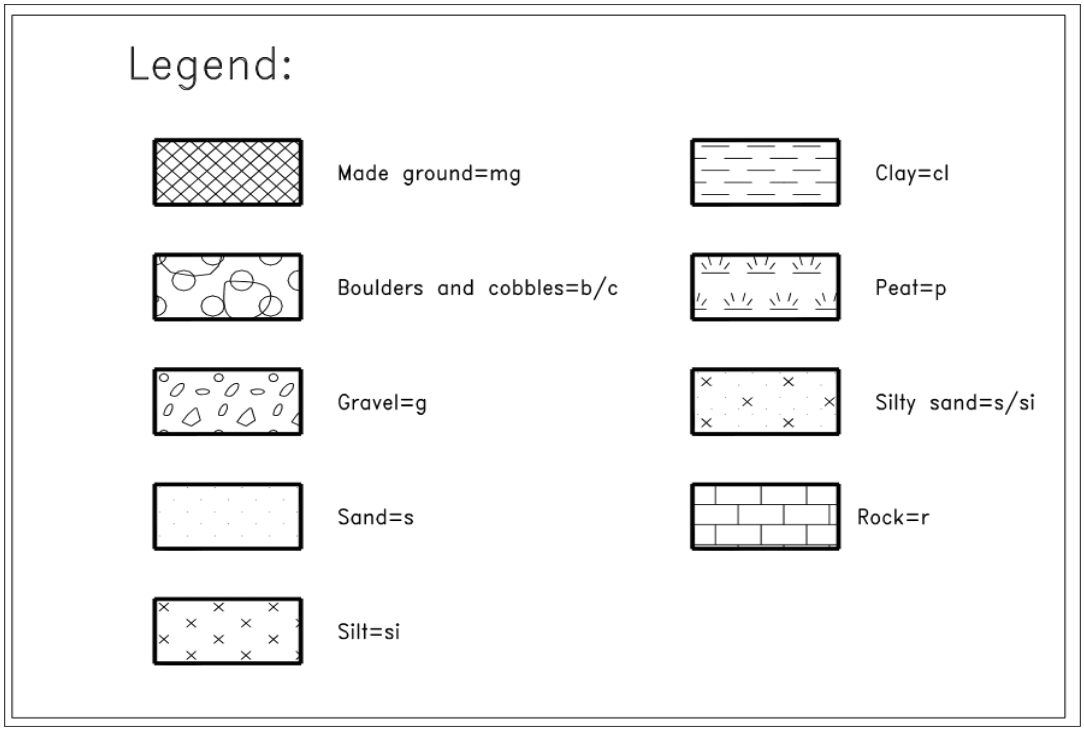
Small and bulk disturbed soil samples were recovered at each change in strata and the samples were returned to the laboratory and presented for testing.

The trial pit locations were set out on site using a Trimble CU Bluetooth GPS Surveying Unit and the co-ordinates are included on the logs presented in the appendices.

All fieldwork co-ordinates are reported to Irish Transverse Mercator (ITM) with Reduced Levels recorded relative to Malin Head Datum and with an accuracy level of + or – 0.10m.

For detailed descriptions of the ground conditions encountered please refer to the engineering logs included in the appendices to this report.

The following Key Legend Table details the symbology used on the engineering logs to describe ground conditions encountered:



The fieldwork was carried out in accordance with IS EN 1997-2 and BS5930, 2015 Code of Practice for Site Investigations with precedence given to IS EN 1997-2 where applicable.

4.0 Laboratory Testing

Representative samples recovered from the trial pits were scheduled for testing in the laboratory.

The test schedules were prepared by the Client's Engineer and included some or all of the following tests on disturbed soil samples:

* Natural Moisture Content.
* Atterberg Limits.
* Particle Size Distribution.
* Sedimentation.

The soil and rock descriptions as noted on the trial pit logs are in general visual descriptions as observed and logged by our Engineers and are described in accordance with IS EN 1997-2 and BS5930, 2015 Code of Practice for Site Investigations.

Soils descriptions (cohesive or otherwise) are also initially assessed based on the texture and 'feel' of the soil materials as witnessed by our Geotechnical Engineers and in accordance with IS EN 1997-2 and BS5930.

Where laboratory classification tests have been carried out on soil or rock samples then these visual descriptions have been amended accordingly to take into account the results of these classification tests.

The records of all fieldwork, laboratory test results and photographs are included in the appendices of this Factual Report.

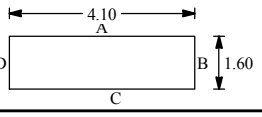
Ronan Killeen
Chartered Engineer
Irish Drilling Limited
November 18th 2019

PROJECT: Cahermurphy Wind Farm 2		**TRIALPIT: BP01**
LOCATION: Co Clare		**Sheet 1 of 1**
CLIENT: MKOS	**Co-ordinates:**	**Rig: Zaxis 130LCN**
ENGINEER: Fehily Timoney & Partners	**E 509,172.9 N 668,757.9**	**Rev: DRAFT**
Ground level: 128.11m O.D.		**DATE: 18.9.19**

GROUNDWATER

Water strikes: Rose to after:
1st: dry
2nd:
3rd:

PIT DIRECTION: 000-180
PIT DIMENSION: 1.60 * 4.10m
LOGGED BY: DF



Shoring/Support: N/A
Stability: Pit stable.

Depth (m)	Date	Water	Samples	Depth (m)	In-situ Vane Tests	LEGEND	Elevation m O.D.	Depth (m)	DESCRIPTION
0							127.71	0.40	Grass and reeds over plastic brown amorphous PEAT with rootlets.
			B 1	0.60-0.80			127.11	1.00	Soft light brown sandy gravelly SILT with medium cobble content. Gravel is subangular fine to coarse. Cobbles are subrounded.
1							126.41	1.70	Light brown silty gravelly fine to coarse SAND with medium cobble content. Gravel is subangular fine. Cobbles are subangular to subrounded.
			B 2	1.70-1.90			125.91	2.20	Greyish brown slightly silty coarse SAND and angular to subrounded fine GRAVEL with medium cobble content. Cobbles are subrounded.
2							125.31	2.80	Greyish brown slightly silty sandy and angular and elongate GRAVEL. Sand is coarse.
			B 3	2.60-2.80					
3			B 4	3.00-3.20			124.01	4.10	Greyish black gravelly elongate angular and flat shale COBBLES. Gravel is angular and flat.
4									**END** TP terminated at 4.10m bgl - obstruction as possible rock.
5									

Remarks: TP dry on excavation. TP backfilled with arisings.

Scale: 1:25

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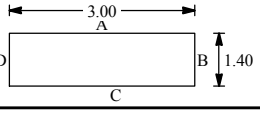
TRIAL PIT VANE & WL RISES CAHERMURPY 2 WF TPS FILE 1 OCT 7 2019.GPJ IRISHDRL.GDT 18/11/19

PROJECT: Cahermurphy Wind Farm 2	**TRIALPIT: BP02**
LOCATION: Co Clare	**Sheet 1 of 1**
CLIENT: MKOS	**Co-ordinates:** **Rig: Zaxis 130LCN**
ENGINEER: Fehily Timoney & Partners	**E 508,751.6 N 669,546.8** **Rev: DRAFT**
Ground level: 134.10m O.D.	**DATE: 18.9.19**

GROUNDWATER

Water strikes: Rose to after:
1st: dry
2nd:
3rd:

PIT DIRECTION: 000-180
PIT DIMENSION: 1.40 * 3.00m
LOGGED BY: DF



Shoring/Support: N/A
Stability: Pit stable.

Depth (m)	Date	Water	Samples	Depth (m)	In-situ Vane Tests	LEGEND	Elevation m O.D.	Depth (m)	DESCRIPTION
0			B 1	0.40-0.60			133.20	0.90	Brown gravelly medium to coarse SAND with high cobble content and high boulder content. Gravel is subangular to rounded fine to coarse. Cobbles are angular. Boulders are angular.
1						END			TP terminated at 0.90m bgl - obstruction as probable rock.
2									
3									
4									
5									

Remarks: TP dry on excavation. TP backfilled with arisings.

Scale: 1:25

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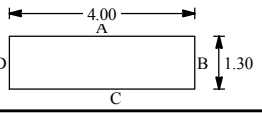
TRIAL PIT VANE & WL RISES CAHERMURPY 2 WF TPS FILE 1 OCT 7 2019.GPJ IRISHDRL.GDT 18/11/19

PROJECT: Cahermurphy Wind Farm 2		**TRIALPIT: SS01-TP01**
LOCATION: Co Clare		**Sheet 1 of 1**
CLIENT: MKOS	**Co-ordinates:**	**Rig: Zaxis 130LCN**
ENGINEER: Fehily Timoney & Partners	**E 509,472.0 N 668,905.9**	**Rev: DRAFT**
Ground level: 140.62m O.D.		**DATE: 18.9.19**

GROUNDWATER
Water strikes: Rose to after:
1st: dry
2nd:
3rd:

PIT DIRECTION: 000-180
PIT DIMENSION: 1.30 * 4.00m
LOGGED BY: DF



Shoring/Support: N/A
Stability: Pit stable.

Depth (m)	Date	Water	Samples	Depth (m)	In-situ Vane Tests	LEGEND	Elevation m O.D.	Depth (m)	DESCRIPTION
0							140.42	0.20	Grass and reeds over plastic blackish brown amorphous PEAT with rootlets.
							140.02	0.60	Firm light brown slightly sandy slightly gravelly SILT. Gravel is subrounded coarse.
			B 1 D 2 VANE	0.65-0.85 0.65-0.85 0.80	19mm vane 121 kN/m²		139.52	1.10	Stiff greyish blue SILT with medium cobble content and rootlets. Cobbles are subrounded.
1									
			B 3	1.60-1.80			138.62	2.00	Stiff greyish blue slightly gravelly SILT with medium cobble content and medium boulder content and rootlets. Gravel is subrounded to rounded fine to coarse. Cobbles are subrounded. Boulders are subrounded.
2			B 4	2.10-2.30			137.62	3.00	Brown clayey subangular to subrounded coarse GRAVEL and subangular COBBLES.
3			B 5	3.30-3.50			136.92	3.70	Brown clayey GRAVEL and elongate and angular shale/siltstone COBBLES. Cobble size increasing with depth. Hard digging.
						END			TP terminated at 3.70m bgl - obstruction as possible weathered rock.
4									
5									

Remarks: TP dry on excavation. TP backfilled with arisings.

Scale: 1:25

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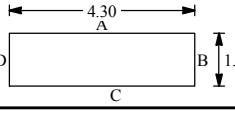
TRIAL PIT VANE & WL RISES CAHERMURPY 2 WF TPS FILE 1 OCT 7 2019.GPJ IRISHDRL.GDT 18/11/19

PROJECT: Cahermurphy Wind Farm 2	**TRIALPIT: SS02**
LOCATION: Co Clare	**Sheet 1 of 1**
CLIENT: MKOS	**Co-ordinates:** E 508,901.6 N 669,991.4
ENGINEER: Fehily Timoney & Partners	**Rig: Zaxis 130LCN**
Ground level: 98.61m O.D.	**Rev: DRAFT**
	DATE: 18.9.19

GROUNDWATER

Water strikes: Rose to after:
1st: 0.40m
2nd:
3rd:

PIT DIRECTION: 090-270
PIT DIMENSION: 1.50 * 4.30m
LOGGED BY: DF



Shoring/Support: N/A
Stability: Pit unstable. Sidewall collapse.

Depth (m)	Date	Water	Samples	Depth (m)	In-situ Vane Tests	LEGEND	Elevation m O.D.	Depth (m)	DESCRIPTION
0									
							98.21	0.40	Grass over soft brown peaty SILT with medium boulder content. Boulders are subangular. Boulders are up to 700mm in length.
			B 1 D 2 VANE	0.60-0.80 0.60-0.80 0.70	19mm vane 129 kN/m²		97.51	1.10	Stiff bluish grey slightly sandy SILT with medium cobble content. Cobbles are subangular.
1									
			B 3	1.60-1.80			96.01	2.60	Stiff bluish grey and brown slightly sandy gravelly SILT with medium cobble content. Gravel is subangular to rounded fine to coarse. Cobbles are subrounded.
2									
			B 4	2.80-3.00			95.41	3.20	Grey slightly sandy silty angular fine to coarse GRAVEL with high cobble content and high boulder content. Cobbles are angular to subrounded. Boulders are angular to subrounded of limestone. Boulders are up to 800mm in length.
3									
			B 5	3.50-3.70			94.61	4.00	Soft damp grey sandy gravelly SILT with high cobble content and low boulder content. Gravel is angular to subangular fine to coarse. Cobbles are subangular to subrounded. Boulders are subangular to subrounded.
4						END			TP terminated at 4.00m bgl. Unable to keep TP open - sidewall collapse.
5									

Remarks: Slight ingress of water at 0.40m bgl. TP backfilled with arisings.

Scale: 1:25

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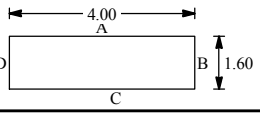
TRIAL PIT VANE & WL RISES CAHERMURPY 2 WF TPS FILE 1 OCT 7 2019.GPJ IRISHDRL.GDT 18/11/19

PROJECT: Cahermurphy Wind Farm 2	**TRIALPIT: TP01**
LOCATION: Co Clare	**Sheet 1 of 1**
CLIENT: MKOS	**Co-ordinates:** E 507,392.3 N 669,378.0 — **Rig: Zaxis 130LCN**
ENGINEER: Fehily Timoney & Partners	**Rev: DRAFT**
Ground level: 104.86m O.D.	**DATE: 19.9.19**

GROUNDWATER

Water strikes: Rose to after:
1st: dry
2nd:
3rd:

PIT DIRECTION: 090-270
PIT DIMENSION: 1.60 * 4.00m
LOGGED BY: DF



Shoring/Support: N/A
Stability: Pit stable.

Depth (m)	Date	Water	Samples	Depth (m)	In-situ Vane Tests	LEGEND	Elevation m O.D.	Depth (m)	DESCRIPTION
0									
									Grass over plastic black amorphous PEAT.
							104.06	0.80	
			VANE	0.80					Very stiff brown sandy SILT.
			B 1	0.80-1.00					0.80m: hand vane - test failed.
1			D 2	0.80-1.00					
							103.66	1.20	
									Brown silty locally very silty very sandy coarse GRAVEL with high cobble content and medium boulder content. Gravel is angular fine. Cobbles are subrounded of limestone. Boulders are subrounded. Boulders are up to 500mm in length. Hard digging.
			B 3	1.60-1.80					
2									
3			B 4	3.00-3.20					
							100.96	3.90	
							END		TP terminated at 3.90m bgl - obstruction as boulders.
4									
5									

Remarks: TP dry on excavation. TP backfilled with arisings.

Scale: 1:25

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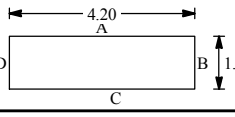
TRIAL PIT VANE & WL RISES CAHERMURPY 2 WF TPS FILE 1 OCT 7 2019.GPJ IRISHDRL.GDT 18/11/19

PROJECT: Cahermurphy Wind Farm 2		**TRIALPIT: TP02**
LOCATION: Co Clare		**Sheet 1 of 1**
CLIENT: MKOS	**Co-ordinates:**	**Rig: Zaxis 130LCN**
ENGINEER: Fehily Timoney & Partners	**E 507,895.2 N 669,761.6**	**Rev: DRAFT**
Ground level: 90.97m O.D.		**DATE: 19.9.19**

GROUNDWATER
Water strikes: Rose to after:
1st: dry
2nd:
3rd:

PIT DIRECTION: 090-270
PIT DIMENSION: 1.70 * 4.20m
LOGGED BY: DF



Shoring/Support: N/A
Stability: Pit unstable. Sidewall collapse.

Depth (m)	Date	Water	Samples	Depth (m)	In-situ Vane Tests	LEGEND	Elevation m O.D.	Depth (m)	DESCRIPTION
0							90.77	0.20	Soft brown silty PEAT.
							90.57	0.40	Stiff orangish brown SILT.
			B 1	0.50-0.70					Dark grey silty sandy subrounded to rounded fine to coarse GRAVEL with high cobble content. Cobbles are angular to subrounded. Cobbles increasing with depth.
1									
			B 2	1.50-1.70					
2									2.00m: with medium boulder content. Boulders are subrounded of limestone.
									2.40m: becoming dark grey.
3			B 3	3.00-3.20			87.67	3.30	
						END			TP terminated at 3.30m bgl. Unable to keep TP open - sidewall collapse.
4									
5									

Remarks: TP damp below 0.80m bgl. TP backfilled with arisings.

Scale: 1:25

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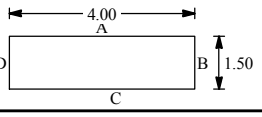
TRIAL PIT VANE & WL RISES CAHERMURPY 2 WF TPS FILE 1 OCT 7 2019.GPJ IRISHDRL.GDT 18/11/19

PROJECT: Cahermurphy Wind Farm 2	**TRIALPIT: TP03**
LOCATION: Co Clare	**Sheet 1 of 1**
CLIENT: MKOS	**Co-ordinates:** **Rig: Zaxis 130LCN**
ENGINEER: Fehily Timoney & Partners	**E 508,561.5 N 669,811.3** **Rev: DRAFT**
Ground level: 101.26m O.D.	**DATE: 19.9.19**

GROUNDWATER

Water strikes: **Rose to after:**
1st: 2.20m
2nd:
3rd:

PIT DIRECTION: 000-180
PIT DIMENSION: 1.50 * 4.00m
LOGGED BY: DF



Shoring/Support: N/A
Stability: Pit stable.

Depth (m)	Date	Water	Samples	Depth (m)	In-situ Vane Tests	LEGEND	Elevation m O.D.	Depth (m)	DESCRIPTION
0							101.01	0.25	TOPSOIL: Grass and reeds over firm brown organic SILT.
			B 1 J 2	0.50-0.70 0.50-0.70			100.41	0.85	Firm brownish grey SILT with rootlets.
1			B 3	1.00-1.20			99.96	1.30	Stiff brown slightly gravelly sandy SILT with high cobble content. Gravel is subangular to subrounded fine to coarse.
							99.46	1.80	Brown silty gravelly medium to coarse SAND with high cobble content. Gravel is subangular to subrounded fine to coarse. Cobbles are subrounded of limestone.
2		▼							Orange brown very sandy very silty coarse GRAVEL with high cobble content and low boulder content. Gravel is subangular to rounded fine to coarse. Cobbles are angular to subrounded. Boulders are angular. Boulders are up to 550mm in length.
			B 4	2.70-2.90					
3							97.76	3.50	
						END			TP terminated at 3.50m bgl - obstruction as boulders.
4									
5									

Remarks: Seepage of water at 2.20m bgl. TP backfilled with arisings.

Scale: 1:25

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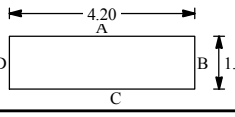
TRIAL PIT VANE & WL RISES CAHERMURPY 2 WF TPS FILE 1 OCT 7 2019.GPJ IRISHDRL.GDT 18/11/19

PROJECT: Cahermurphy Wind Farm 2	**TRIALPIT: TP04**
LOCATION: Co Clare	**Sheet 1 of 1**
CLIENT: MKOS	**Co-ordinates:** E 507,835.3 N 669,046.5
ENGINEER: Fehily Timoney & Partners	**Rig: Zaxis 130LCN**
Ground level: 104.81m O.D.	**Rev: DRAFT**
	DATE: 19.9.19

GROUNDWATER

Water strikes: Rose to after:
1st: 2.70m
2nd:
3rd:

PIT DIRECTION: 090-270
PIT DIMENSION: 1.60 * 4.20m
LOGGED BY: DF



Shoring/Support: N/A
Stability: Pit unstable. Sidewall collapse.

Depth (m)	Date	Water	Samples	Depth (m)	In-situ Vane Tests	LEGEND	Elevation m O.D.	Depth (m)	DESCRIPTION
0									
									Firm brownish black fibrous PEAT.
1			B 1	1.00-1.20					
2									
							102.11	2.70	
			B 2 J 3	2.80-3.00 2.80-3.00					Stiff bluish grey slightly sandy slightly gravelly SILT with medium cobble content. Gravel is angular to subrounded fine to coarse. Cobbles are subrounded. 2.80m: increase in sand content.
3									
							100.81	4.00	
4						END			TP terminated at 4.00m bgl. Unable to keep TP open - sidewall collapse.
5									

Remarks: Rapid ingress of water at 2.70m bgl. TP backfilled with arisings.

Scale: 1:25

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TRIAL PIT VANE & WL RISES CAHERMURPY 2 WF TPS FILE 1 OCT 7 2019.GPJ IRISHDRL.GDT 18/11/19

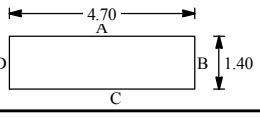
PROJECT: Cahermurphy Wind Farm 2
LOCATION: Co Clare
TRIALPIT: TP05
Sheet 1 of 1

CLIENT: MKOS
ENGINEER: Fehily Timoney & Partners
Co-ordinates: E 508,296.4 N 669,435.4
Rig: Zaxis 130LCN
Rev: DRAFT

Ground level: 125.99m O.D.
DATE: 19.9.19

GROUNDWATER
Water strikes: Rose to after:
1st: dry
2nd:
3rd:

PIT DIRECTION: 000-180
PIT DIMENSION: 1.40 * 4.70m
LOGGED BY: DF



Shoring/Support: N/A
Stability: Pit stable.

Depth (m)	Date	Water	Samples	Depth (m)	In-situ Vane Tests	LEGEND	Elevation m O.D.	Depth (m)	DESCRIPTION
0							125.64	0.35	Plastic black amorphous PEAT.
			B 1 D 2 VANE	0.50-0.70 0.50-0.70 0.70	19mm vane 158 kN/m²		125.14	0.85	Stiff bluish grey and brown SILT with medium cobble content and rootlets. Cobbles are subrounded.
1			B 3 D 4	1.20-1.40 1.20-1.40					Stiff brown and grey slightly sandy gravelly SILT/CLAY with low cobble content and low boulder content. Gravel is subrounded medium to coarse. Cobbles are subrounded. Boulders are subrounded of limestone. Boulders are up to 600mm in length. Hard digging.
2									
			B 5	2.60-2.80					
3							122.09	3.90	
4						END			TP terminated at 3.90m bgl - obstruction as boulders.
5									

Remarks: TP dry on excavation. TP backfilled with arisings.

Scale: 1:25

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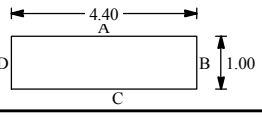
TRIAL PIT VANE & WL RISES CAHERMURPY 2 WF TPS FILE 1 OCT 7 2019.GPJ IRISHDRL.GDT 18/11/19

PROJECT: Cahermurphy Wind Farm 2	**TRIALPIT: TP06**
LOCATION: Co Clare	**Sheet 1 of 1**
CLIENT: MKOS	**Co-ordinates:**
ENGINEER: Fehily Timoney & Partners	**E 508,920.0 N 669,598.2**
Rig: Zaxis 130LCN	
Rev: DRAFT	
Ground level: 133.92m O.D.	**DATE: 18.9.19**

GROUNDWATER

Water strikes: Rose to after:
1st: dry
2nd:
3rd:

PIT DIRECTION: 090-270
PIT DIMENSION: 1.00 * 4.40m
LOGGED BY: DF



Shoring/Support: N/A
Stability: Pit stable.

Depth (m)	Date	Water	Samples	Depth (m)	In-situ Vane Tests	LEGEND	Elevation m O.D.	Depth (m)	DESCRIPTION
0									
							133.52	0.40	Grass and heather over plastic dark brown amorphous PEAT.
							133.22	0.70	Stiff light brown organic SILT.
			B 1 D 2	0.70-0.90 0.70-0.90					Bluish grey very sandy very silty coarse GRAVEL with high cobble content. Gravel is subangular to subrounded medium to coarse. Cobbles are subrounded.
1							132.32	1.60	
			B 3	1.80-2.00					Grey silty sandy angular to subangular fine to coarse GRAVEL and COBBLES with medium boulder content. Boulders are angular to subrounded of limestone. Boulders are up to 550mm in length.
2							131.32	2.60	
									END TP terminated at 2.60m bgl - obstruction as possible rock.
3									
4									
5									

Remarks: TP dry on excavation. TP backfilled with arisings.

Scale: 1:25

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TRIAL PIT VANE & WL RISES CAHERMURPY 2 WF TPS FILE 1 OCT 7 2019.GPJ IRISHDRL.GDT 18/11/19

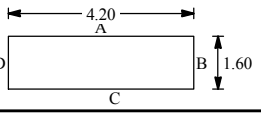
PROJECT: Cahermurphy Wind Farm 2
LOCATION: Co Clare
TRIALPIT: TP07
Sheet 1 of 1

CLIENT: MKOS
ENGINEER: Fehily Timoney & Partners
Co-ordinates: E 508,224.8 N 668,669.4
Rig: Zaxis 130LCN
Rev: DRAFT

Ground level: 112.59m O.D.
DATE: 19.9.19

GROUNDWATER
Water strikes: Rose to after:
1st: dry
2nd:
3rd:

PIT DIRECTION: 000-180
PIT DIMENSION: 1.60 * 4.20m
LOGGED BY: DF



Shoring/Support: N/A
Stability: Pit stable.

Depth (m)	Date	Water	Samples	Depth (m)	In-situ Vane Tests	LEGEND	Elevation m O.D.	Depth (m)	DESCRIPTION
0									
			D 1	0.50-0.70					Firm brown fibrous PEAT.
			VANE	0.60	33mm vane 26 kN/m²		112.14	0.45	
									Soft light brown organic SILT.
							111.89	0.70	
1			B 2	1.10-1.30					Stiff bluish grey gravelly SILT with high cobble content. Gravel is angular to subrounded fine to coarse. Cobbles are subrounded.
			D 3	1.10-1.30					
							111.19	1.40	
									Stiff damp dark grey slightly sandy gravelly SILT with high cobble content and medium boulder content. Gravel is subangular to subrounded fine to coarse. Cobbles are subrounded. Boulders are subangular to subrounded of limestone. Boulders are up to 600mm in length.
2			B 4	1.80-2.00					1.80-2.00m: grey sandy very silty medium and coarse GRAVEL.
							109.79	2.80	
						END			TP terminated at 2.80m bgl - obstruction as possible rock.
3									
4									
5									

Remarks: TP damp below 1.40m bgl. TP backfilled with arisings.

Scale: 1:25

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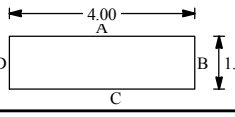
TRIAL PIT VANE & WL RISES CAHERMURPY 2 WF TPS FILE 1 OCT 7 2019.GPJ IRISHDRL.GDT 18/11/19

PROJECT: Cahermurphy Wind Farm 2	**TRIALPIT: TP08**
LOCATION: Co Clare	**Sheet 1 of 1**
CLIENT: MKOS	**Co-ordinates:** **Rig: Zaxis 130LCN**
ENGINEER: Fehily Timoney & Partners	**E 509,140.5 N 669,028.7** **Rev: DRAFT**
Ground level: 121.87m O.D.	**DATE: 18.9.19**

GROUNDWATER

Water strikes: **Rose to after:**
1st: 1.90m
2nd:
3rd:

PIT DIRECTION: 090-270
PIT DIMENSION: 1.20 * 4.00m
LOGGED BY: DF



Shoring/Support: N/A
Stability: Pit unstable. Sidewall collapse from 2.50m bgl.

Depth (m)	Date	Water	Samples	Depth (m)	In-situ Vane Tests	LEGEND	Elevation m O.D.	Depth (m)	DESCRIPTION
0							121.62	0.25	Grass and reeds over light brown silty PEAT.
			VANE	0.50	19mm vane 89 kN/m²		121.32	0.55	Firm light brown organic SILT.
1			B 1	0.70-0.90			119.97	1.90	Bluish grey silty sandy angular to subangular fine to coarse GRAVEL with low cobble content and low boulder content. Cobbles are subrounded. Boulders are subrounded of limestone. Boulders are up to 500mm in length.
2		1	B 2	1.90-2.10			119.37	2.50	Stiff brown sandy gravelly CLAY with high cobble content. Gravel is subangular to subrounded fine to coarse. Cobbles are subrounded.
3			B 3	2.90-3.10			117.57	4.30	Light grey silty sandy angular to subrounded medium to coarse GRAVEL with high cobble content. Cobbles are angular to subrounded. 2.80m to 4.30m: with low boulder content. Boulders are subangular. Boulders are up to 500mm in length.
4						END			TP terminated at 4.30m bgl. Unable to keep TP open - sidewall collapse.
5									

Remarks: Moderate ingress of water at 1.90m bgl. TP backfilled with arisings.

Scale: 1:25

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TRIAL PIT VANE & WL RISES CAHERMURPY 2 WF TPS FILE 1 OCT 7 2019.GPJ IRISHDRL.GDT 18/11/19

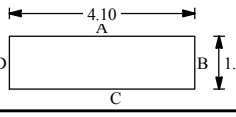
PROJECT: Cahermurphy Wind Farm 2
LOCATION: Co Clare
TRIALPIT: TP09
Sheet 1 of 1

CLIENT: MKOS
ENGINEER: Fehily Timoney & Partners
Co-ordinates: E 508,318.4 N 668,179.3
Rig: Zaxis 130LCN
Rev: DRAFT

Ground level: 90.26m O.D.
DATE: 19.9.19

GROUNDWATER
Water strikes: Rose to after:
1st: 3.70m
2nd:
3rd:

PIT DIRECTION: 000-180
PIT DIMENSION: 1.60 * 4.10m
LOGGED BY: DF



Shoring/Support: N/A
Stability: Pit unstable. Sidewall collapse.

Depth (m)	Date	Water	Samples	Depth (m)	In-situ Vane Tests	LEGEND	Elevation m O.D.	Depth (m)	DESCRIPTION
0							89.96	0.30	Grass and heather over firm brown fibrous PEAT.
							89.61	0.65	Soft light brown fibrous organic SILT.
			B 1 D 2	0.70-0.90 0.70-0.90			88.46	1.80	Stiff bluish grey slightly sandy slightly gravelly SILT with medium cobble content. Cobbles are subrounded.
1									
2			B 3	2.00-2.20					Stiff damp light brown slightly sandy gravelly SILT with medium cobble content and low boulder content. Gravel is subrounded medium to coarse. Cobbles are subangular. Boulders are subangular. Boulders are up to 700mm in length.
3			B 4	3.20-3.40			86.96	3.30	2.90m to 3.00m: becoming firm and wet. 3.00m to 3.30m: becoming locally soft. Gravel is angular.
		▼					86.26	4.00	Wet brown silty sandy angular coarse GRAVEL with medium cobble content. Cobbles are subrounded.
4						END			TP terminated at 4.00m bgl. Unable to keep TP open - sidewall collapse.
5									

Remarks: Slight ingress of water at 3.00m bgl. Rapid ingress of water at 3.70m bgl. TP backfilled with arisings.

Scale: 1:25

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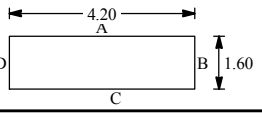
TRIAL PIT VANE & WL RISES CAHERMURPY 2 WF TPS FILE 1 OCT 7 2019.GPJ IRISHDRL.GDT 18/11/19

PROJECT: Cahermurphy Wind Farm 2	**TRIALPIT: TP10**
LOCATION: Co Clare	**Sheet 1 of 1**
CLIENT: MKOS	**Co-ordinates:** E 509,010.5 N 668,537.0 — **Rig: Zaxis 130LCN**
ENGINEER: Fehily Timoney & Partners	**Rev: DRAFT**
Ground level: 109.85m O.D.	**DATE: 18.9.19**

GROUNDWATER

Water strikes: Rose to after:
1st: dry
2nd:
3rd:

PIT DIRECTION: 000-180
PIT DIMENSION: 1.60 * 4.20m
LOGGED BY: DF



Shoring/Support: N/A
Stability: Pit stable.

Depth (m)	Date	Water	Samples	Depth (m)	In-situ Vane Tests	LEGEND	Elevation m O.D.	Depth (m)	DESCRIPTION
0									
							109.25	0.60	Grass and heather over firm brown fibrous PEAT.
			D 1	0.60-0.80					Stiff light brown slightly gravelly SILT with high cobble content and medium boulder content. Gravel is subangular coarse. Cobbles are subangular. Boulders are subangular.
			B 2	0.90-1.10			108.95	0.90	
1									Firm bluish grey organic SILT with rootlets.
							108.25	1.60	
									Firm light grey slightly gravelly sandy SILT with high cobble content and medium boulder content. Gravel is subangular to rounded fine to coarse. Cobbles are subrounded of limestone. Boulders are subrounded. Boulders are up to 450mm in length.
2							107.85	2.00	
									Brownish grey sandy very silty coarse GRAVEL with high cobble and boulder content. Gravel is subangular to rounded fine to coarse. Cobbles are subrounded of limestone. Boulders are subrounded. Boulders are up to 700mm in length.
			B 3	2.40-2.60					
			D 4	2.40-2.60					2.50m to 3.50m: hard digging due to boulders.
3							106.35	3.50	
			B 5	3.60-3.80					Stiff dark bluish grey gravelly SILT with medium cobble content. Gravel is angular coarse. Cobbles are subrounded.
							105.95	3.90	
4									Stiff brown gravelly SILT with high cobble content. Gravel is angular to subrounded fine to coarse. Cobbles are subrounded.
			D 6	4.10-4.30					
							105.25	4.60	
						END			TP terminated at 4.60m bgl on REs instruction.
5									

Remarks: TP damp at 1.60m bgl. Rapid ingress of water at 4.50m bgl. TP backfilled with arisings.

Scale: 1:25

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TRIAL PIT VANE & WL RISES CAHERMURPY 2 WF TPS FILE 1 OCT 7 2019.GPJ IRISHDRL.GDT 18/11/19

Project ID	2019CE103	Client	MKOS	Remarks		Turnaround	
Project Name	Cahermurphy Wind Farm 2	Due Date	24/09/2019 16:05				
Schedule ID	2019CE103_1	Scheduled Date	24/09/2019 16:05				

Sample Details							Classification						Chemical / Concrete								Compaction					Compressibility				Strength (Total)						Shear Stregth (Effective Stress)			Rock		Other								
Location	Depth (m)	Base Depth	Sample Type	Sample Ref	Date Sampled	Storage	Moisture Content	Atterberg 4 Point	Particle Density by Gas Jar	Particle Density by Small Pyknometer	Particle Size Distribution	Hydrometer	Organic Content	Loss On Ignition	Sulphate Total	Sulphate Water Gravimetric	Carbonate Titration	ph	Chloride Content	Chloride Content Acid	Compaction Light	Compaction Heavy	Compaction Vibrating Hammer	Moisture Condition Value	Moisture Condition Relationship	CBR	Consolidation	Pressures	Swelling Pressure Test	Laboratory Vane test	Small Direct Shearbox	Ring shear Test	Triaxial Quick Undrained	(Specify Cell Pressure)	Triaxial UU Multi Stage	Triaxial UU Multi Specimen	Consolidated Drained Triaxial Test	Consolidated Undrained Triaxial Test	Consolidated Undrained Triaxial Multi	Rock Uniaxial compression	Point Load								
BP01	0.60	0.80	B	1	18/09/19																																											
BP01	1.70	1.90	B	2	18/09/19																																											
BP01	2.60	2.80	B	3	18/09/19																																											
BP01	3.00	3.20	B	4	18/09/19																																											
BP02	0.40	0.60	B	1	18/09/19																																											
SS01-TP01	0.65	0.85	B	1	18/09/19																																											
SS01-TP01	0.65	0.85	D	2	18/09/19																																											
SS01-TP01	1.60	1.80	B	3	18/09/19																																											
SS01-TP01	2.10	2.30	B	4	18/09/19																																											
SS01-TP01	3.30	3.50	B	5	18/09/19																																											
SS02	0.60	0.80	B	1	18/09/19																																											
SS02	0.60	0.80	D	2	18/09/19																																											
SS02	1.60	1.80	B	3	18/09/19																																											
SS02	2.80	3.00	B	4	18/09/19																																											
SS02	3.50	3.70	B	5	18/09/19																																											
TP01	0.80	1.00	B	1	19/09/19																																											
TP01	0.80	1.00	D	2	19/09/19																																											
TP01	1.60	1.80	B	3	19/09/19		1				1																																					
TP01	3.00	3.20	B	4	19/09/19																																											
TP02	0.50	0.70	B	1	19/09/19																																											
TP02	1.50	1.70	B	2	19/09/19		1				1																																					
TP02	3.00	3.20	B	3	19/09/19																																											
TP03	0.50	0.70	B	1	19/09/19																																											
TP03	0.50	0.70	J	2	19/09/19																																											
TP03	1.00	1.20	B	3	19/09/19																																											
TP03	2.70	2.90	B	4	19/09/19		1	1			1	1																																					
TP04	1.00	1.20	B	1	19/09/19																																											
TP04	2.80	3.00	B	2	19/09/19																																											
TP04	2.80	3.00	J	3	19/09/19																																											
TP05	0.50	0.70	B	1	19/09/19																																											
TP05	0.50	0.70	D	2	19/09/19																																											
TP05	1.20	1.40	B	3	19/09/19		1	1			1																																					
TP05	1.20	1.40	D	4	19/09/19																																											
TP05	2.60	2.80	B	5	19/09/19																																											
TP06	0.70	0.90	B	1	18/09/19		1	1			1	1																																					
TP06	0.70	0.90	D	2	18/09/19																																											
TP06	1.80	2.00	B	3	18/09/19																																											
TP07	0.50	0.70	D	1	19/09/19																																											
TP07	1.10	1.30	B	2	19/09/19																																											
TP07	1.10	1.30	D	3	19/09/19																																											
TP07	1.80	2.00	B	4	19/09/19		1	1			1	1																																					
TP08	0.70	0.90	B	1	18/09/19																																											
TP08	1.90	2.10	B	2	18/09/19																																											
TP08	2.90	3.10	B	3	18/09/19		1				1																																					
TP09	0.70	0.90	B	1	19/09/19																																											
TP09	0.70	0.90	D	2	19/09/19																																											
TP09	2.00	2.20	B	3	19/09/19		1	1			1	1																																					
TP09	3.20	3.40	B	4	19/09/19																																											
TP10	0.60	0.80	D	1	18/09/19																																											
TP10	0.90	1.10	B	2	18/09/19																																											

Project ID	2019CE103	Client	MKOS	Remarks	Turnaround
Project Name	Cahermurphy Wind Farm 2	Due Date	24/09/2019 16:05		
Schedule ID	2019CE103_1	Scheduled Date	24/09/2019 16:05		

Sample Details							Classification						Chemical / Concrete								Compaction					Compressibility				Strength (Total)						Shear Stregth (Effective Stress)			Rock		Other							
Location	Depth (m)	Base Depth	Sample Type	Sample Ref	Date Sampled	Storage	Moisture Content	Atterberg 4 Point	Particle Density by Gas Jar	Particle Density by Small Pyknometer	Particle Size Distribution	Hydrometer	Organic Content	Loss On Ignition	Sulphate Total	Sulphate Water Gravimetric	Carbonate Titration	ph	Chloride Content	Chloride Content Acid	Compaction Light	Compaction Heavy	Compaction Vibrating Hammer	Moisture Condition Value	Moisture Condition Relationship	CBR	Consolidation	Pressures	Swelling Pressure Test	Laboratory Vane test	Small Direct Shearbox	Ring shear Test	Triaxial Quick Undrained	(Specify Cell Pressure)	Triaxial UU Multi Stage	Triaxial UU Multi Specimen	Consolidated Drained Triaxial Test	Consolidated Undrained Triaxial Test	Consolidated Undrained Triaxial Multis	Rock Uniaxial compression	Point Load							
TP10	2.40	2.60	B	3	18/09/19		1	1			1	1																																			
TP10	2.40	2.60	D	4	18/09/19																																										
TP10	3.60	3.80	B	5	18/09/19																																										
TP10	4.10	4.30	D	6	18/09/19																																										
Scheduled							9	6			9	5																																			
Completed							9	6			9	5																																			

Summary of Classification Test Results

Project No.: 2019CE103

Project Name: Cahermurphy Wind Farm 2

Hole No.	Sample Ref	Top	Base	Type		Soil Description	Density bulk Mg/m3	Density dry Mg/m3	w %	Passing 425µm %	LL %	PL %	PI %	Particle density Mg/m3	Remarks
TP01	3	1.60	1.80	B		Brown very silty very sandy coarse GRAVEL.			9.2	35					
TP02	2	1.50	1.70	B		Grey very silty vert sandy fmc GRAVEL.			8.1	29					
TP03	4	2.70	2.90	B		Orange-brown very sandy very silty coarse GRAVEL.			11.0	44	31	16	15		CL
TP05	3	1.20	1.40	B		Grey and orange-brown slightly sandy gravelly SILT.			11.0	53	28	14	14		CL
TP06	1	0.70	0.90	B		Grey very sandy very silty coarse GRAVEL.			12.0	41	26	NP			NP
TP07	4	1.80	2.00	B		Grey sandy very silty medium and coarse GRAVEL.			7.9	32	26	14	12		CL
TP08	3	2.90	3.10	B		Grey silty sandy fmc GRAVEL.			8.5	24					
TP09	3	2.00	2.20	B		Orange and grey slightly sandy gravelly SILT.			12.0	49	32	16	16		CL
TP10	3	2.40	2.60	B		Brownish-grey sandy very silty coarse GRAVEL.			7.1	29					NP

All tests performed in accordance with BS1377:1990 unless specified otherwise

Key

Density test | Liquid Limit | Particle density

Linear measurement unless : | 4pt cone unless : | sp - small pyknometer

wd - water displacement | 1pt - single point test | gj - gas jar

wi - immersion in water | NP - Non Plastic

Date Printed: 11/01/2019 00:00

QC From No: R1

Approved By:

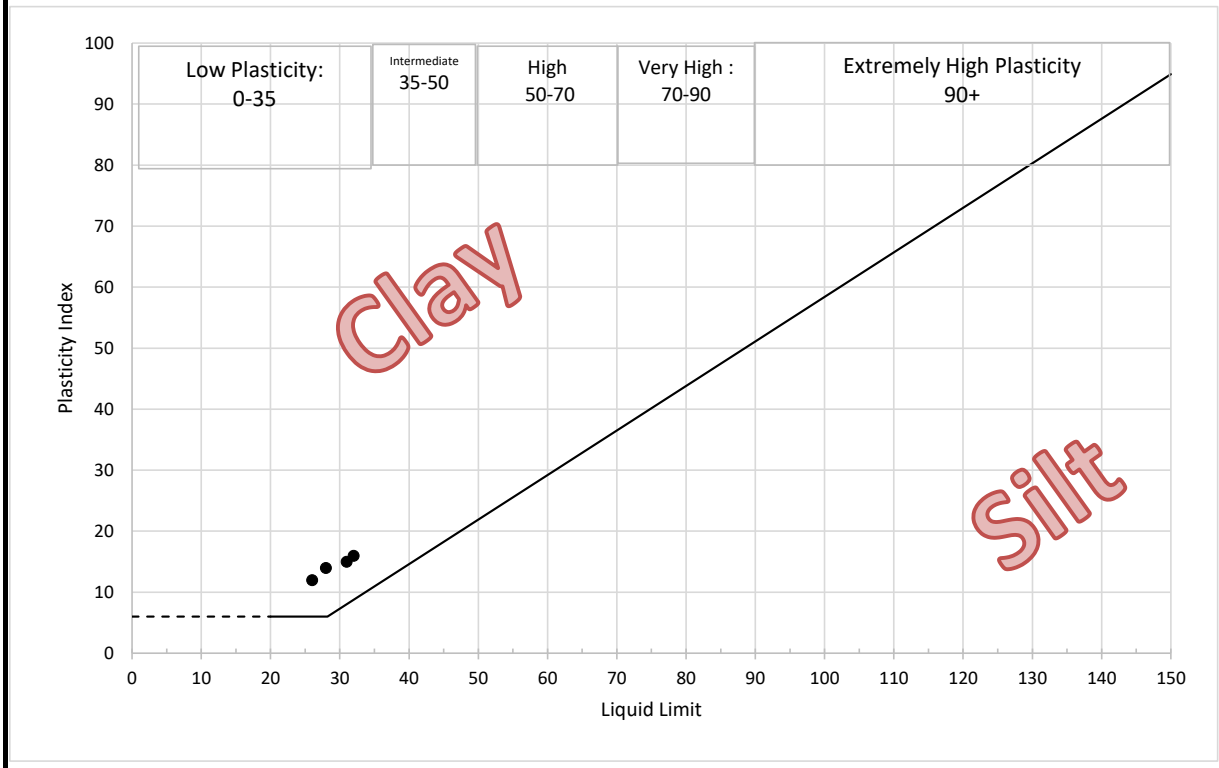
Table 1

sheet 1

Tested in: Irish Drilling Ltd.(IDL), Old Galway Road, Loughrea, Co. Galway, Ireland. H62VX39

Approved Signatures: Dympna Darcy (DCD) Lab Manager, Declan Joyce (DJ) Chartered Geotechnical Engineer, Ronan Killeen (RK) Quality Manager.

	Plasticity (A-Line) Chart	Project Number
Project Name:	**Cahermurphy Wind Farm 2**	
Location:		2019CE103



Abreviations in the remarks column of the Classification Summary Sheet: C = Clay, M = Silt

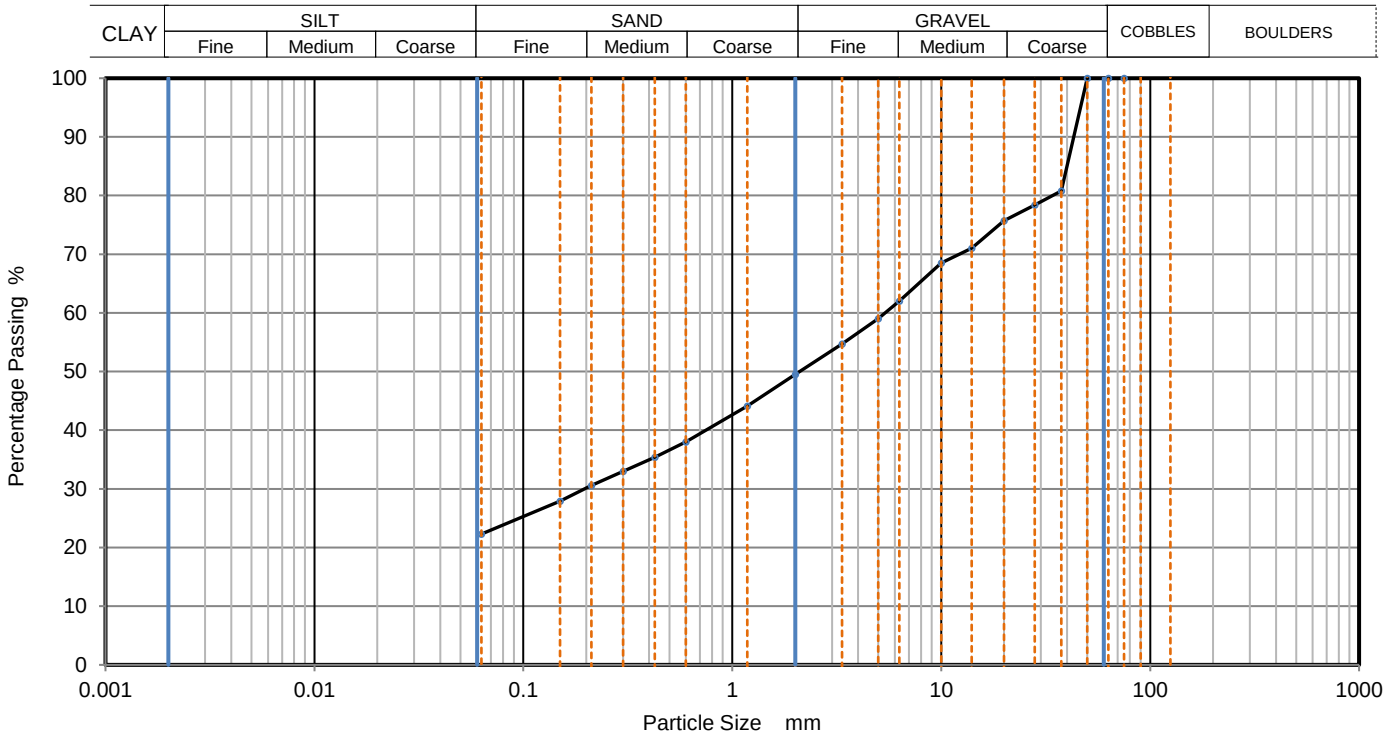
Plasticity abeviations: L = Low, I = Intermediate = H = High, V = Very High, E = Extremely High.

The letter O is added to the symbol of any material containing a significant proportion of organic material.

Chart taken from BS5930: 2010

QC Form: R1

IRISH DRILLING LIMITED	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**2019CE103**
				Borehole/Pit No.	TP01
Site Name	Cahermurphy Wind Farm 2			Sample No.	3
Soil Description	Brown very silty very sandy coarse GRAVEL.			Depth, m	1.60
Specimen Reference		Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2			KeyLAB ID	IDL12019092420



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
75	100		
63	100		
50	100		
37.5	81		
28	78		
20	76		
14	71		
10	69		
6.3	62		
5	59		
3.35	55		
2	50		
1.18	44		
0.6	38		
0.425	35		
0.3	33		
0.212	31		
0.15	28		
0.063	22		

Dry Mass of sample, g	1952

Sample Proportions	% dry mass
Very coarse	0
Gravel	51
Sand	27
Fines <0.063mm	22

Grading Analysis		
D100	mm	
D60	mm	5.4
D30	mm	0.196
D10	mm	
Uniformity Coefficient		
Curvature Coefficient		

Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operator	Checked	Approved	Sheet printed	
		Dympna Darcy B.Sc.	01/11/2019 14:28	**1**
				QC From No:R2

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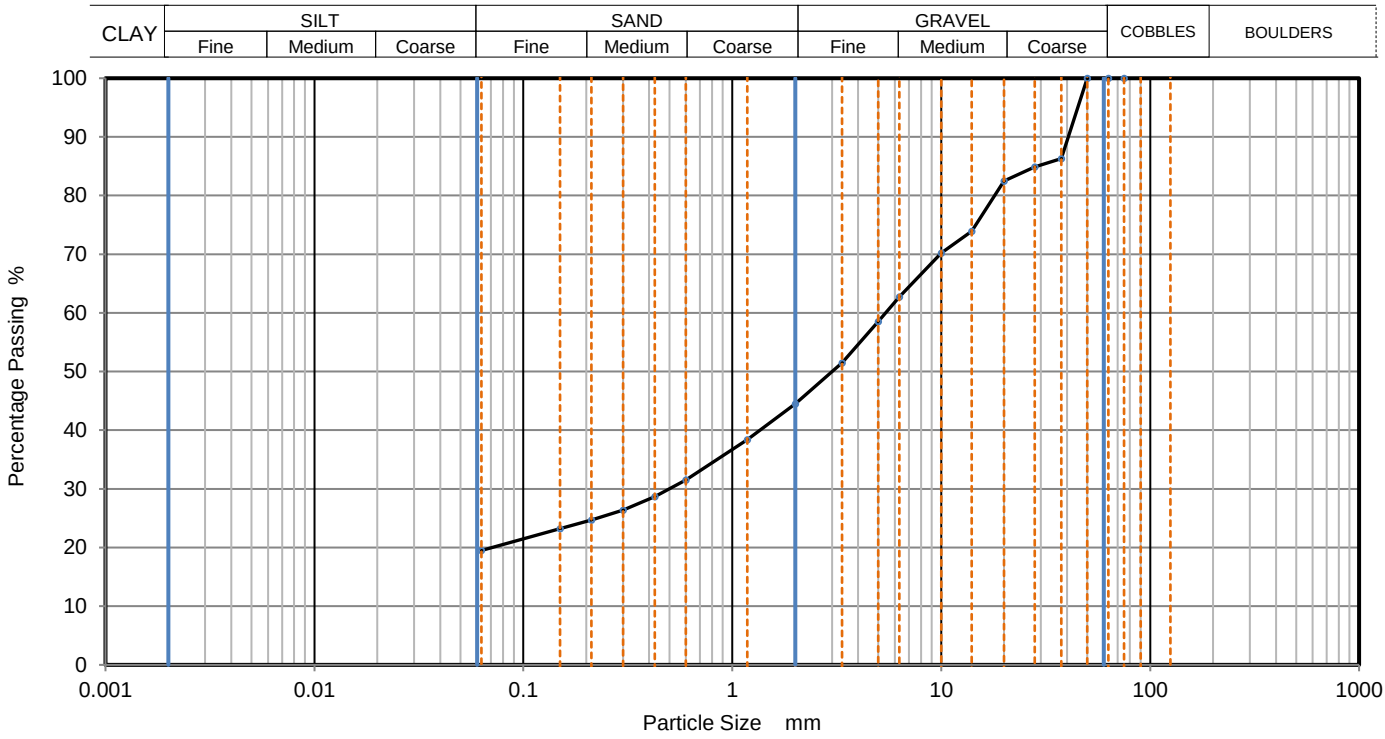
Approved Signatures: Dympna Darcy (DCD) Lab Manager, Declan Joyce (DJ) Chartered Geotechnical Engineer, Ronan Killeen (RK) Quality Manager.

IRISH DRILLING LIMITED	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**2019CE103**
				Borehole/Pit No.	TP02
Site Name	Cahermurphy Wind Farm 2			Sample No.	2
Soil Description	Grey very silty vert sandy fmc GRAVEL.			Depth, m	1.50
Specimen Reference		Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2			KeyLAB ID	IDL12019092423



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
75	100		
63	100		
50	100		
37.5	86		
28	85		
20	83		
14	74		
10	70		
6.3	63		
5	59		
3.35	52		
2	45		
1.18	38		
0.6	32		
0.425	29		
0.3	26		
0.212	25		
0.15	23		
0.063	20		

Dry Mass of sample, g	2529

Sample Proportions	% dry mass
Very coarse	0
Gravel	56
Sand	25
Fines <0.063mm	19

Grading Analysis		
D100	mm	
D60	mm	5.43
D30	mm	0.501
D10	mm	
Uniformity Coefficient		
Curvature Coefficient		

Remarks

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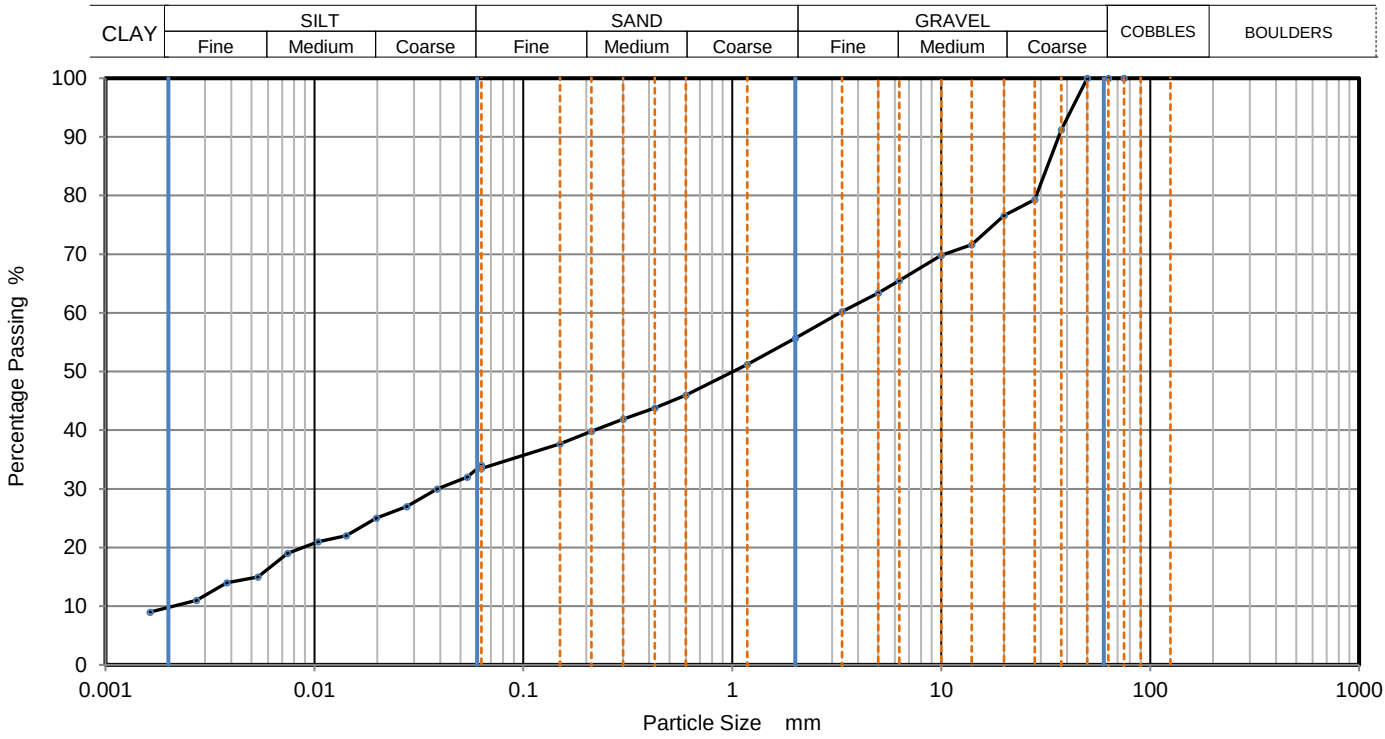
Operator	Checked	Approved	Sheet printed	
		Dympna Darcy B.Sc.	01/11/2019 14:28	**1** QC From No:R2

Tested in: Irish Drilling Ltd.(IDL), Old Galway Road, Loughrea, Co. Galway, Ireland. H62VX39

Approved Signatures: Dympna Darcy (DCD) Lab Manager, Declan Joyce (DJ) Chartered Geotechnical Engineer, Ronan Killeen (RK) Quality Manager.

IRISH DRILLING LIMITED	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**2019CE103**
				Borehole/Pit No.	TP03
Site Name	Cahermurphy Wind Farm 2			Sample No.	4
Soil Description	Orange-brown very sandy very silty coarse GRAVEL.			Depth, m	2.70
Specimen Reference		Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clauses 9.2 and 9.5			KeyLAB ID	IDL12019092428



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
		0.0630	34
		0.0539	32
75	100	0.0386	30
63	100	0.0277	27
50	100	0.0198	25
37.5	91	0.0142	22
28	79	0.0104	21
20	77	0.0075	19
14	72	0.0054	15
10	70	0.0038	14
6.3	66	0.0027	11
5	63	0.0016	9
3.35	60		
2	56		
1.18	51		
0.6	46	Particle density (assumed)	
0.425	44	2.65	Mg/m3
0.3	42		
0.212	40		
0.15	38		
0.063	34		

Dry Mass of sample, g	1594

Sample Proportions	% dry mass
Very coarse	0
Gravel	44
Sand	22
Silt	24
Clay	10

Grading Analysis		
D100	mm	
D60	mm	3.28
D30	mm	0.0398
D10	mm	0.00214
Uniformity Coefficient		1500
Curvature Coefficient		0.23

Remarks

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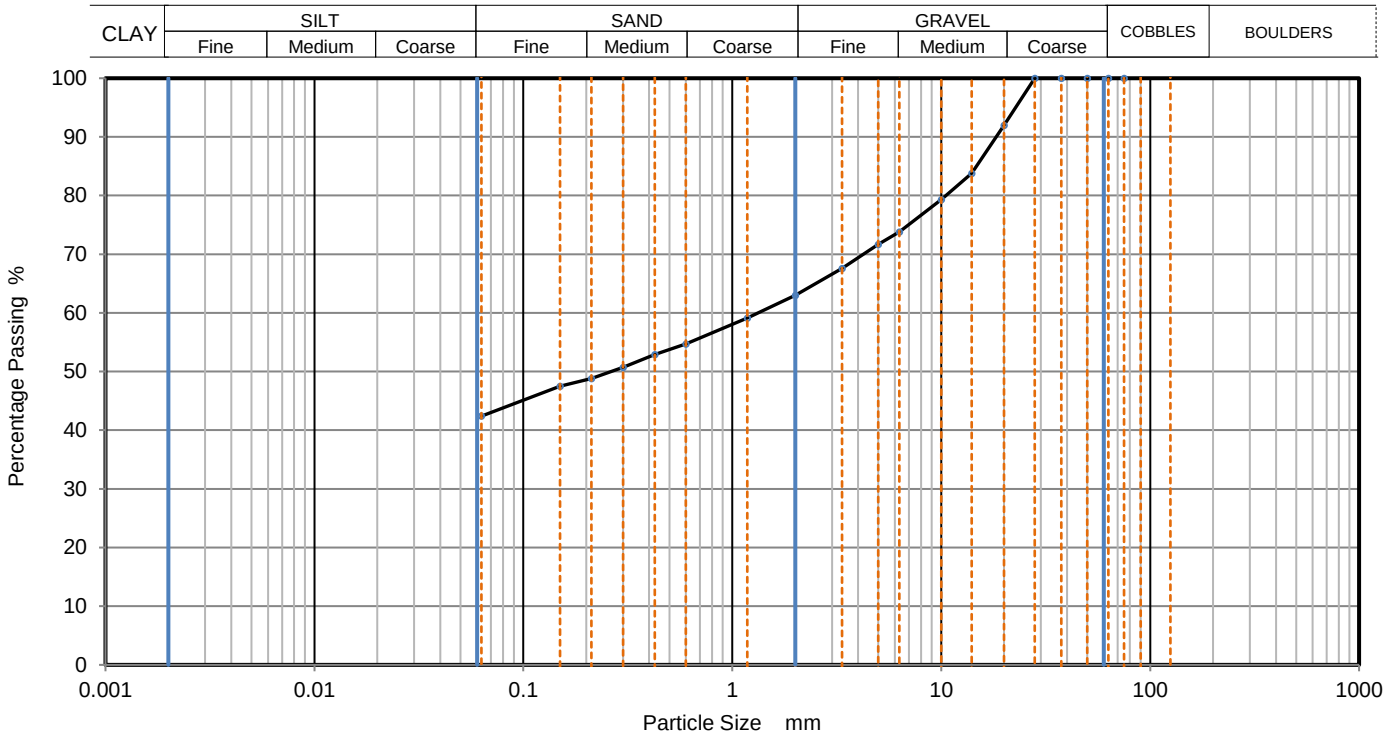
Approved Signatures: Dympna Darcy (DCD) Lab Manager, Declan Joyce (DJ) Chartered Geotechnical Engineer, Ronan Killeen (RK) Quality Manager.

IRISH DRILLING LIMITED	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**2019CE103**
				Borehole/Pit No.	TP05
Site Name	Cahermurphy Wind Farm 2			Sample No.	3
Soil Description	Grey and orange-brown slightly sandy gravelly SILT.			Depth, m	1.20
Specimen Reference		Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2			KeyLAB ID	IDL12019092435



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	92		
14	84		
10	79		
6.3	74		
5	72		
3.35	68		
2	63		
1.18	59		
0.6	55		
0.425	53		
0.3	51		
0.212	49		
0.15	48		
0.063	42		

Dry Mass of sample, g	1043

Sample Proportions	% dry mass
Very coarse	0
Gravel	37
Sand	21
Fines <0.063mm	42

Grading Analysis		
D100	mm	
D60	mm	1.34
D30	mm	
D10	mm	
Uniformity Coefficient		
Curvature Coefficient		

Remarks

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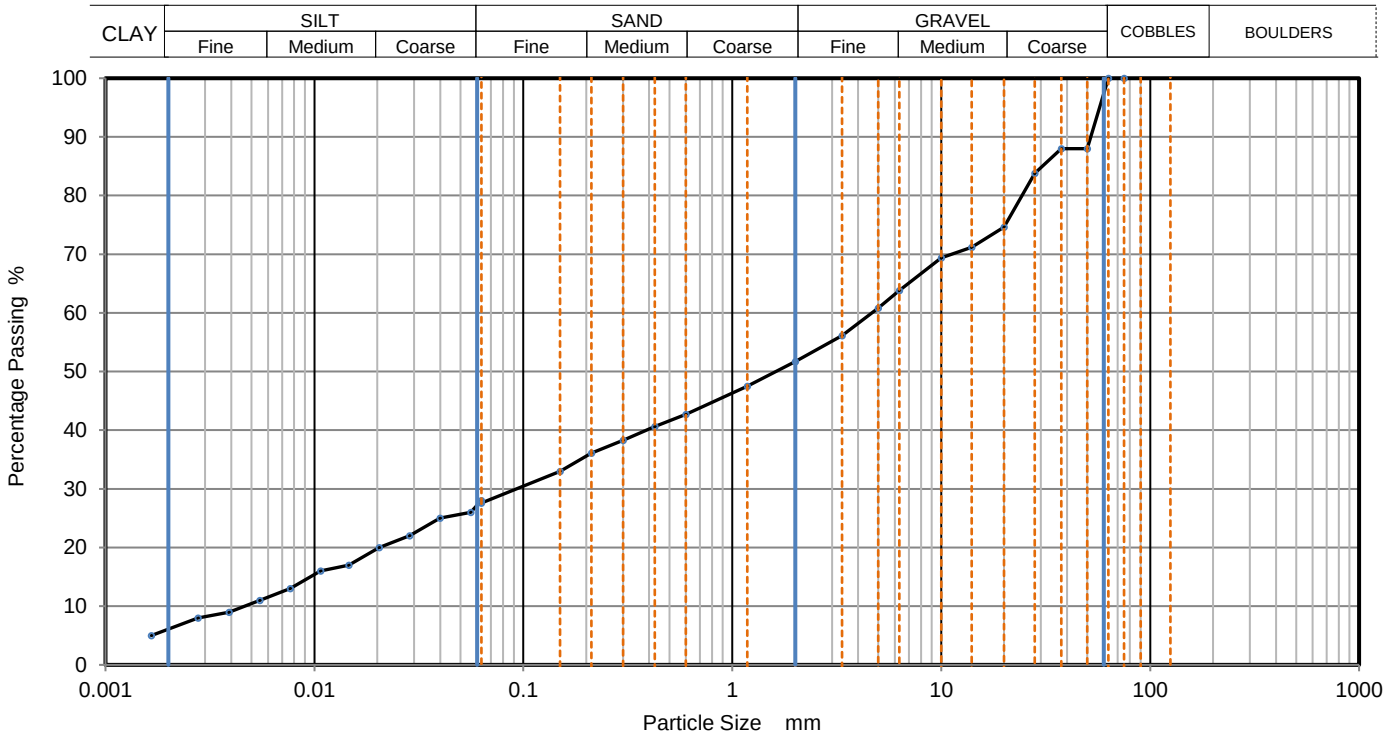
Approved Signatures: Dympna Darcy (DCD) Lab Manager, Declan Joyce (DJ) Chartered Geotechnical Engineer, Ronan Killeen (RK) Quality Manager.

IRISH DRILLING LIMITED	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**2019CE103**
				Borehole/Pit No.	TP06
Site Name	Cahermurphy Wind Farm 2			Sample No.	1
Soil Description	Grey very sandy very silty coarse GRAVEL.			Depth, m	0.70
Specimen Reference		Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clauses 9.2 and 9.5			KeyLAB ID	IDL12019092438



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
		0.0630	28
		0.0560	26
75	100	0.0399	25
63	100	0.0285	22
50	88	0.0204	20
37.5	88	0.0146	17
28	84	0.0107	16
20	75	0.0077	13
14	71	0.0055	11
10	69	0.0039	9
6.3	64	0.0028	8
5	61	0.0017	5
3.35	56		
2	52		
1.18	48		
0.6	43	Particle density (assumed)	
0.425	41	2.65 Mg/m3	
0.3	38		
0.212	36		
0.15	33		
0.063	28		

Dry Mass of sample, g	1655

Sample Proportions	% dry mass
Very coarse	0
Gravel	48
Sand	24
Silt	21
Clay	6

Grading Analysis		
D100	mm	
D60	mm	4.69
D30	mm	0.0925
D10	mm	0.0048
Uniformity Coefficient		980
Curvature Coefficient		0.38

Remarks

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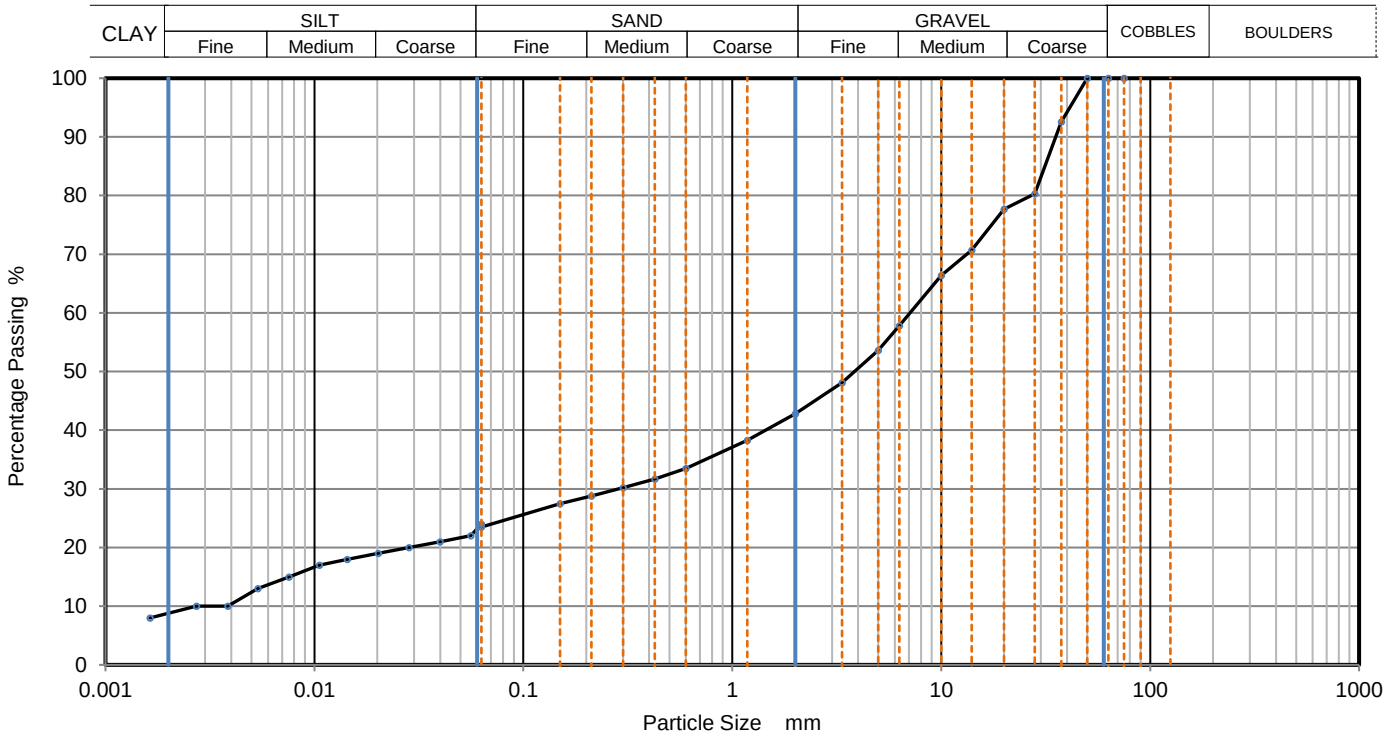
Approved Signatures: Dympna Darcy (DCD) Lab Manager, Declan Joyce (DJ) Chartered Geotechnical Engineer, Ronan Killeen (RK) Quality Manager.

IRISH DRILLING LIMITED	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**2019CE103**
				Borehole/Pit No.	TP07
Site Name	Cahermurphy Wind Farm 2			Sample No.	4
Soil Description	Grey sandy very silty medium and coarse GRAVEL.			Depth, m	1.80
Specimen Reference		Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clauses 9.2 and 9.5			KeyLAB ID	IDL12019092445



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
		0.0630	24
		0.0560	22
75	100	0.0399	21
63	100	0.0284	20
50	100	0.0202	19
37.5	93	0.0143	18
28	80	0.0105	17
20	78	0.0075	15
14	71	0.0054	13
10	66	0.0039	10
6.3	58	0.0027	10
5	54	0.0016	8
3.35	48		
2	43		
1.18	38		
0.6	34	Particle density (assumed)	
0.425	32	2.65	Mg/m3
0.3	30		
0.212	29		
0.15	28		
0.063	24		

Dry Mass of sample, g	1711

Sample Proportions	% dry mass
Very coarse	0
Gravel	57
Sand	19
Silt	15
Clay	9

Grading Analysis		
D100	mm	
D60	mm	7.1
D30	mm	0.288
D10	mm	0.00268
Uniformity Coefficient		2600
Curvature Coefficient		4.3

Remarks

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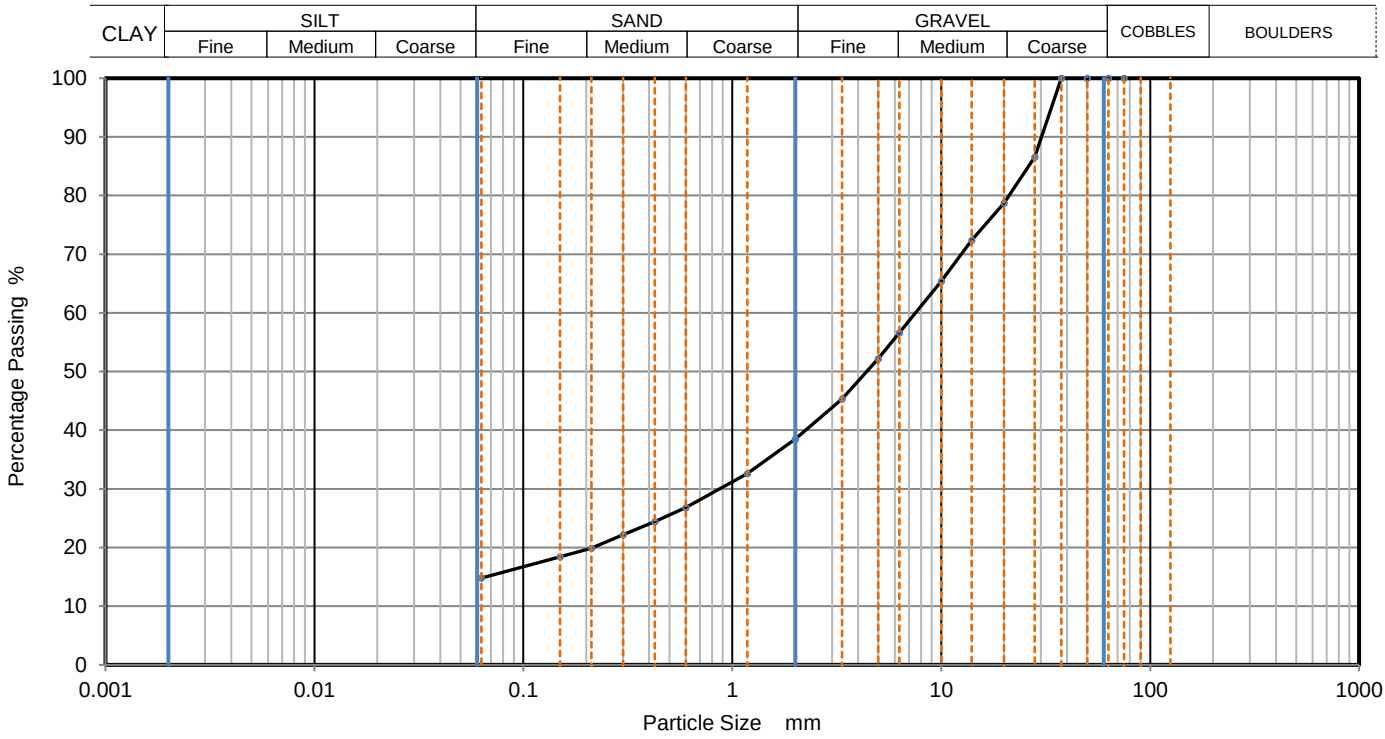
Approved Signatures: Dympna Darcy (DCD) Lab Manager, Declan Joyce (DJ) Chartered Geotechnical Engineer, Ronan Killeen (RK) Quality Manager.

IRISH DRILLING LIMITED	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**2019CE103**
				Borehole/Pit No.	TP08
Site Name	Cahermurphy Wind Farm 2			Sample No.	3
Soil Description	Grey silty sandy fmc GRAVEL.			Depth, m	2.90
Specimen Reference		Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2			KeyLAB ID	IDL12019092449



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
75	100		
63	100		
50	100		
37.5	100		
28	87		
20	79		
14	72		
10	65		
6.3	57		
5	52		
3.35	45		
2	39		
1.18	33		
0.6	27		
0.425	24		
0.3	22		
0.212	20		
0.15	18		
0.063	15		

Dry Mass of sample, g	2198

Sample Proportions	% dry mass
Very coarse	0
Gravel	62
Sand	24
Fines <0.063mm	15

Grading Analysis		
D100	mm	
D60	mm	7.53
D30	mm	0.871
D10	mm	
Uniformity Coefficient		
Curvature Coefficient		

Remarks

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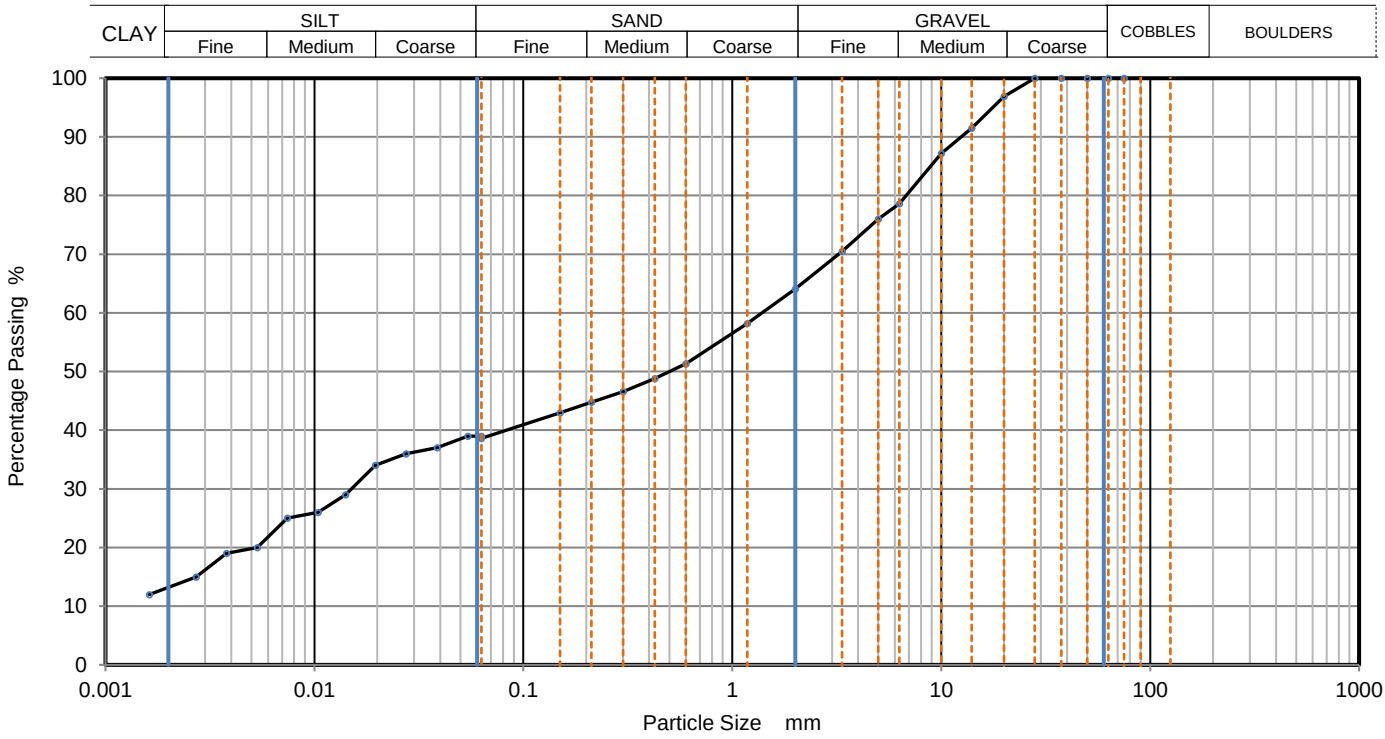
Approved Signatures: Dympna Darcy (DCD) Lab Manager, Declan Joyce (DJ) Chartered Geotechnical Engineer, Ronan Killeen (RK) Quality Manager.

IRISH DRILLING LIMITED	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**2019CE103**
				Borehole/Pit No.	TP09
Site Name	Cahermurphy Wind Farm 2			Sample No.	3
Soil Description	Orange and grey slightly sandy gravelly SILT.			Depth, m	2.00
Specimen Reference		Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clauses 9.2 and 9.5			KeyLAB ID	IDL12019092452



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
		0.0630	39
		0.0542	39
75	100	0.0386	37
63	100	0.0275	36
50	100	0.0196	34
37.5	100	0.0141	29
28	100	0.0104	26
20	97	0.0074	25
14	92	0.0053	20
10	87	0.0038	19
6.3	79	0.0027	15
5	76	0.0016	12
3.35	71		
2	64		
1.18	58		
0.6	51	Particle density (assumed)	
0.425	49	2.65 Mg/m3	
0.3	47		
0.212	45		
0.15	43		
0.063	39		

Dry Mass of sample, g	1493

Sample Proportions	% dry mass
Very coarse	0
Gravel	36
Sand	26
Silt	25
Clay	14

Grading Analysis		
D100	mm	
D60	mm	1.39
D30	mm	0.0148
D10	mm	
Uniformity Coefficient		
Curvature Coefficient		

Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operator	Checked	Approved	Sheet printed	
		Dympna Darcy B.Sc.	01/11/2019 14:28	**1** QC From No:R2

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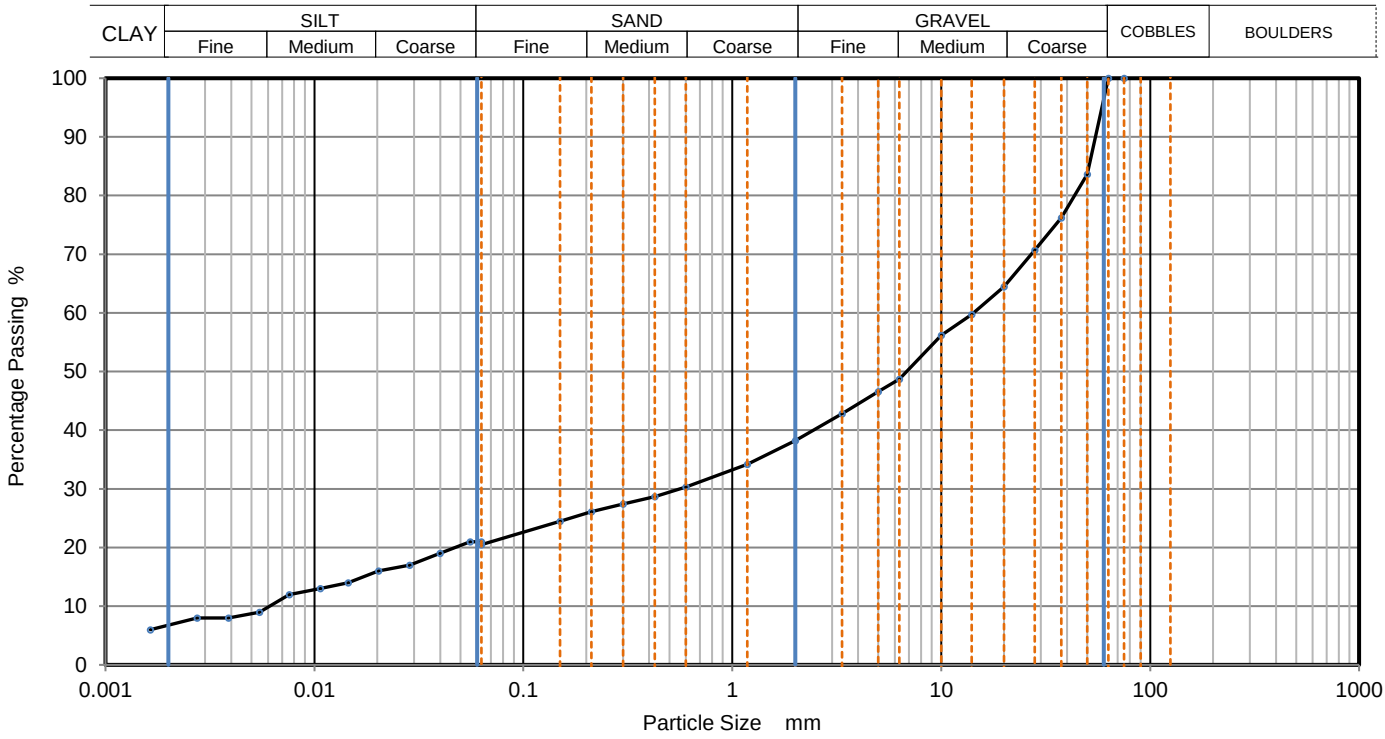
Approved Signatures: Dympna Darcy (DCD) Lab Manager, Declan Joyce (DJ) Chartered Geotechnical Engineer, Ronan Killeen (RK) Quality Manager.

IRISH DRILLING LIMITED	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**2019CE103**
				Borehole/Pit No.	TP10
Site Name	Cahermurphy Wind Farm 2			Sample No.	3
Soil Description	Brownish-grey sandy very silty coarse GRAVEL.			Depth, m	2.40
Specimen Reference		Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clauses 9.2 and 9.5			KeyLAB ID	IDL12019092456



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
		0.0630	21
		0.0557	21
75	100	0.0399	19
63	100	0.0285	17
50	84	0.0203	16
37.5	76	0.0145	14
28	71	0.0107	13
20	65	0.0076	12
14	60	0.0055	9
10	56	0.0039	8
6.3	49	0.0027	8
5	47	0.0016	6
3.35	43		
2	38		
1.18	34		
0.6	30	Particle density (assumed)	
0.425	29	2.65 Mg/m3	
0.3	27		
0.212	26		
0.15	25		
0.063	21		

Dry Mass of sample, g	2302

Sample Proportions	% dry mass
Very coarse	0
Gravel	62
Sand	18
Silt	14
Clay	7

Grading Analysis		
D100	mm	
D60	mm	14.3
D30	mm	0.566
D10	mm	0.00625
Uniformity Coefficient		2300
Curvature Coefficient		3.6

Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operator	Checked	Approved	Sheet printed	
		Dympna Darcy B.Sc.	01/11/2019 14:28	**1** QC From No:R2

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Approved Signatures: Dympna Darcy (DCD) Lab Manager, Declan Joyce (DJ) Chartered Geotechnical Engineer, Ronan Killeen (RK) Quality Manager.

Figure 1 H:\2019CE103_Cahermurphy2\Bp1...jpg

Figure 3 H:\2019CE103_Cahermurphy2\Bp1.jpg

Figure 2 H:\2019CE103_Cahermurphy2\Bp1..jpg

Figure 4 H:\2019CE103_Cahermurphy2\Bp2...jpg

Figure 5 H:\2019CE103_Cahermurphy2\Bp2..jpg

Figure 7 H:\2019CE103_Cahermurphy2\Ss1-tp1...jpg

Figure 6 H:\2019CE103_Cahermurphy2\Bp2.jpg

Figure 8 H:\2019CE103_Cahermurphy2\Ss1-tp1..jpg

Figure 9 H:\2019CE103_Cahermurphy2\Ss1-tp1.jpg

Figure 11 H:\2019CE103_Cahermurphy2\Ss2..jpg

Figure 10 H:\2019CE103_Cahermurphy2\Ss2...jpg

Figure 12 H:\2019CE103_Cahermurphy2\Ss2.jpg

Figure 13 H:\2019CE103_Cahermurphy2\T1...jpg

Figure 15 H:\2019CE103_Cahermurphy2\T1.jpg

Figure 14 H:\2019CE103_Cahermurphy2\T1..jpg

Figure 16 H:\2019CE103_Cahermurphy2\T2...jpg

Figure 17 H:\2019CE103_Cahermurphy2\T2..jpg

Figure 19 H:\2019CE103_Cahermurphy2\T3....jpg

Figure 18 H:\2019CE103_Cahermurphy2\T2.jpg

Figure 20 H:\2019CE103_Cahermurphy2\T3...jpg

Figure 21 H:\2019CE103_Cahermurphy2\T3.jpg

Figure 23 H:\2019CE103_Cahermurphy2\T4..jpg

Figure 22 H:\2019CE103_Cahermurphy2\T4...jpg

Figure 24 H:\2019CE103_Cahermurphy2\T4.jpg

Figure 25 H:\2019CE103_Cahermurphy2\T5...jpg

Figure 27 H:\2019CE103_Cahermurphy2\T5.jpg

Figure 26 H:\2019CE103_Cahermurphy2\T5..jpg

Figure 28 H:\2019CE103_Cahermurphy2\T6...jpg

Figure 29 H:\2019CE103_Cahermurphy2\T6..jpg

Figure 31 H:\2019CE103_Cahermurphy2\T7...jpg

Figure 30 H:\2019CE103_Cahermurphy2\T6.jpg

Figure 32 H:\2019CE103_Cahermurphy2\T7..jpg

Figure 33 H:\2019CE103_Cahermurphy2\T7.jpg

Figure 35 H:\2019CE103_Cahermurphy2\T8..jpg

Figure 34 H:\2019CE103_Cahermurphy2\T8...jpg

Figure 36 H:\2019CE103_Cahermurphy2\T8.jpg

Figure 37 H:\2019CE103_Cahermurphy2\T9...jpg

Figure 39 H:\2019CE103_Cahermurphy2\T9.jpg

Figure 38 H:\2019CE103_Cahermurphy2\T9..jpg

Figure 40 H:\2019CE103_Cahermurphy2\T10...jpg

Figure 41 H:\2019CE103_Cahermurphy2\T10..jpg

Figure 42 H:\2019CE103_Cahermurphy2\T10.jpg

Map Legend

- Site Location
- Proposed Turbine Location (V5)
- Proposed Substation Compound
- Proposed Borrow Pit Location
- Proposed Temporary Construction Compound
- Proposed New Road
- Existing Coillte Forest Roads
- Coillte Properties
- Regional Road
- Local Road
- Access Road for Permitted Cahermurphy Site
- Trial Pit Access Roads
- Trial Pit Representative Locations

Possible access close to T3 at corner of field

Excavate on edge of access track instead

Southern access preferred as it gets much closer to turbine location

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MAP TITLE: Trial Pit Locations	MAP NO.: Figure 1	SCALE: 1:12,000
PROJECT TITLE: Cahermurphy Two Wind Farm		DATE: 26-07-2019
DRAWING BY: Eoin O'Sullivan	CHECKED BY: Michael Watson	ISSUE NO.: 170238-2019.07.26-D4

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Appendix C

Peat Stability Risk Register




Cahermurphy Two Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	**Turbine T1**

Grid Reference (Eastings, Northings):	**507385**	**669377**
Distance to Watercourse (m)	**> 150**	
Min & Max Measured Peat Depth (m):	**0.3**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 11.77 (u), 12.73(d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	1	1	1	Negligible	No		1	1	1	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	2	1	2	Negligible	No		2	1	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	2	1	2	Negligible	No		2	1	2	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Turbine 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.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cahermurphy Two Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	**Turbine T2**

Grid Reference (Eastings, Northings):	**507942**	**669772**
Distance to Watercourse (m)	**> 150**	
Min & Max Measured Peat Depth (m):	**0.3**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 11.77 (u), 12.73 (d)	1	1	1	Negligible	No		1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	1	1	1	Negligible	No		1	1	1	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	2	1	2	Negligible	No		2	1	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	2	1	2	Negligible	No	See Below	2	1	2	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Turbine T2**
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.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cahermurphy Two Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	**Turbine T3**

Grid Reference (Eastings, Northings):	**508531**	**669911**
Distance to Watercourse (m)	**> 150**	
Min & Max Measured Peat Depth (m):	**0.5**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 10.2 (u), 11.03 (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	1	1	1	Negligible	No		1	1	1	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Negligible	No		2	1	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	2	1	2	Negligible	No		2	1	2	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Turbine T3**
i	Maintain hydrology of area as far as possible;
ii	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.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cahermurphy Two Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	**Turbine T4**

Grid Reference (Eastings, Northings):	**507833**	**669002**
Distance to Watercourse (m)	**100 - 150**	
Min & Max Measured Peat Depth (m):	**2.3**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 6.37 (u), 6.89 (d)	1	2	2	Negligible	No	See Below	1	2	2	Negligible
2	Evidence of sub peat water flow	1	2	2	Negligible	No		1	2	2	Negligible
3	Evidence of surface water flow	2	2	4	Negligible	No		1	2	2	Negligible
4	Evidence of previous failures/slips	0	2	0	Not Applicable	No		0	2	0	Not Applicable
5	Type of vegetation	3	2	6	Low	No		2	2	4	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	2	2	4	Negligible	No		2	2	4	Negligible
7	Evidence of very soft/soft clay at base of peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
8	Evidence of mechanically cut peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
10	Evidence of bog pools	0	2	0	Not Applicable	No		0	2	0	Not Applicable
11	Other	0	2	0	Not Applicable	No		0	2	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Turbine T4**
i	Due to poor drainage and deeper peat this location would require additional construction measures such as: - detailed ground investigation to determine peat, mineral soil and bedrock condition and properties. - excavation side slopes to be supports or excavation face battered to shallow angle - potential for greater water inflow into excavation requiring remvoal of water using pumps - daily detailed inspection of excavation faces - increased exclusion zone around excavation to aviod accidental loading of crest of slope
ii	Maintain hydrology of area as far as possible;
iii	Use of experienced geotechnical staff for site investigation;
iv	Use of experienced contractors and trained operators to carry out the work;

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

Cahermurphy Two Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	**Turbine T5**

Grid Reference (Eastings, Northings):	**508291**	**669400**
Distance to Watercourse (m)	**> 150**	
Min & Max 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 (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 9.2 (u), 9.93 (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	1	1	1	Negligible	No		1	1	1	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	2	1	2	Negligible	No		2	1	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	2	1	2	Negligible	No		2	1	2	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Turbine T5**
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.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cahermurphy Two Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	**Turbine T6**

Grid Reference (Eastings, Northings):	**508921**	**669600**
Distance to Watercourse (m)	**> 150**	
Min & Max 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 (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 16.38 (u), 17.73 (d)	1	1	1	Negligible	No		1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	1	1	1	Negligible	No		1	1	1	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	2	1	2	Negligible	No		2	1	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	2	1	2	Negligible	No	See Below	2	1	2	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Turbine 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.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cahermurphy Two Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	**Turbine T7**

Grid Reference (Eastings, Northings):	**508219**	**668683**
Distance to Watercourse (m)	**> 150**	
Min & Max Measured Peat Depth (m):	**1.7**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 4.26 (u), 4.6 (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	1	1	1	Negligible	No		1	1	1	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	2	1	2	Negligible	No		2	1	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	2	1	2	Negligible	No		1	1	1	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Turbine T7**
i	Maintain hydrology of area as far as possible;
ii	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.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cahermurphy Two Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	**Turbine T8**

Grid Reference (Eastings, Northings):	**508965**	**668990**
Distance to Watercourse (m)	**< 50**	
Min & Max Measured Peat Depth (m):	**2.5**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 7.4 (u), 8.01 (d)	1	4	4	Negligible	No	See Below	1	4	4	Negligible
2	Evidence of sub peat water flow	1	4	4	Negligible	No		1	4	4	Negligible
3	Evidence of surface water flow	3	4	12	Medium	No		2	4	8	Low
4	Evidence of previous failures/slips	0	4	0	Not Applicable	No		0	4	0	Not Applicable
5	Type of vegetation	3	4	12	Medium	No		2	4	8	Low
6	General slope characteristics upslope/downslope from infrastructure location	2	4	8	Low	No		1	4	4	Negligible
7	Evidence of very soft/soft clay at base of peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	2	4	8	Low	No		2	4	8	Low
10	Evidence of bog pools	0	4	0	Not Applicable	No		0	4	0	Not Applicable
11	Other	0	4	0	Not Applicable	No		0	4	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Turbine T8**
i	Due to poor drainage, deeper peat and the presence of a watercourse this location would require additional construction measures such as: - detailed ground investigation to determine peat, mineral soil and bedrock condition and properties. - install temporary sheet piling as required to ensure excavation of turbine base is free from water ingress/flooding - excavation side slopes to be supports or excavation face battered to shallow angle - potential for greater water inflow into excavation requiring remvoal of water using pumps - daily detailed inspection of excavation faces - increased exclusion zone around excavation to aviod accidental loading of crest of slope
ii	Maintain hydrology of area as far as possible;
iii	Use of experienced geotechnical staff for site investigation;
iv	Use of experienced contractors and trained operators to carry out the work;

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

Cahermurphy Two Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	**Turbine T9**

Grid Reference (Eastings, Northings):	**508312**	**668187**
Distance to Watercourse (m)	**50 - 100**	
Min & Max 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 (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 13.49 (u), 14.6 (d)	1	3	3	Negligible	No	See Below	1	3	3	Negligible
2	Evidence of sub peat water flow	1	3	3	Negligible	No		1	3	3	Negligible
3	Evidence of surface water flow	2	3	6	Low	No		1	3	3	Negligible
4	Evidence of previous failures/slips	0	3	0	Not Applicable	No		0	3	0	Not Applicable
5	Type of vegetation	2	3	6	Low	No		2	3	6	Low
6	General slope characteristics upslope/downslope from infrastructure location	2	3	6	Low	No		1	3	3	Negligible
7	Evidence of very soft/soft clay at base of peat	0	3	0	Not Applicable	No		0	3	0	Not Applicable
8	Evidence of mechanically cut peat	0	3	0	Not Applicable	No		0	3	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	3	0	Not Applicable	No		0	3	0	Not Applicable
10	Evidence of bog pools	0	3	0	Not Applicable	No		0	3	0	Not Applicable
11	Other	0	3	0	Not Applicable	No		0	3	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **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.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cahermurphy Two Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	**Turbine T10**

Grid Reference (Eastings, Northings):	**509012**	**668538**
Distance to Watercourse (m)	**> 150**	
Min & Max Measured Peat Depth (m):	**0.3**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 7.09 (u), 7.64 (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	1	1	1	Negligible	No		1	1	1	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	1	1	1	Negligible	No		2	1	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	2	1	2	Negligible	No		1	1	1	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	Control Measures to be Implemented Prior to/and During Construction for **Turbine 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.
(2) Probability assessed as per Table A and B of Appendix E.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Appendix D

Calculated FOS For Peat Slopes

Calculated FoS of Natural Peat Slopes for Cahermurphy Two 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	507385	669377	3.0	8	10	0.30	1.3	**51.02**	**11.77**
T2	507942	669772	3.0	8	10	0.30	1.3	**51.02**	**11.77**
T3	508531	669911	3.0	8	10	0.50	1.5	**30.61**	**10.20**
T4	507833	669002	2.0	8	10	2.60	3.6	**8.82**	**6.37**
T5	508291	669400	4.0	8	10	0.25	1.3	**45.99**	**9.20**
T6	508921	669600	2.0	8	10	0.40	1.4	**57.34**	**16.38**
T7	508219	668683	4.0	8	10	1.70	2.7	**6.76**	**4.26**
T8	508965	668990	2.0	8	10	2.50	3.5	**9.17**	**6.55**
T9	508312	668187	2.0	8	10	0.70	1.7	**32.77**	**13.49**
T10	509012	668538	5.0	8	10	0.30	1.3	**30.71**	**7.09**
Substation 1	508888	669971	2.0	8	10	0.15	1.2	**152.91**	**19.95**
Substation 2	509457	668893	2.0	8	10	0.80	1.8	**28.67**	**12.74**
Construction Compound	508164	669452	3.0	8	10	0.15	1.2	**102.05**	**13.31**
Met Mast	508107	668404	7.0	8	10	0.70	1.7	**9.45**	**3.89**
Borrow Pit 1	507398	669233	5.0	8	10	0.15	1.2	**61.43**	**8.01**
Borrow Pit 2	508725	669570	6.0	8	10	0.30	1.3	**25.65**	**5.92**
S19	508551	669875	5.0	8	10	1.20	2.2	**7.68**	**4.19**
S22	507240	669669	2.0	No peat encountered					
S26	507403	669376	4.0	No peat encountered					
S30	507863	669029	2.0	8	10	2.50	3.5	**9.17**	**6.55**
S31	507921	669110	2.0	8	10	1.20	2.2	**19.11**	**10.43**
S32	507883	669199	2.0	No peat encountered					
S33	507826	669282	3.0	8	10	0.30	1.3	**51.02**	**11.77**
S34	507770	669364	5.0	No peat encountered					
S35	507718	669450	2.0	No peat encountered					
S36	507666	669535	5.0	No peat encountered					
S37	507615	669621	5.0	No peat encountered					
S38	507625	669672	1.0	8	10	0.10	1.1	**458.46**	**41.68**
S39	507736	669676	1.0	8	10	0.15	1.2	**305.64**	**39.87**
S40	507826	669679	2.0	No peat encountered					
S41	507924	669680	3.0	No peat encountered					
S42	508024	669685	6.0	8	10	0.10	1.1	**76.96**	**7.00**
S43	508124	669685	7.0	8	10	0.15	1.2	**44.09**	**5.75**
S44	508224	669694	6.0	No peat encountered					
S46	507240	669246	2.0	No peat encountered					
S47	507337	669269	4.0	No peat encountered					
S48	507434	669292	2.0	No peat encountered					
S49	507532	669314	2.0	No peat encountered					
S50	507630	669335	2.0	8	10	0.20	1.2	**114.68**	**19.11**
S51	507728	669355	1.0	8	10	0.30	1.3	**152.82**	**35.27**
S52	507825	669377	3.0	No peat encountered					
S53	507921	669402	4.0	8	10	0.30	1.3	**38.32**	**8.84**
S54	508014	669437	4.0	No peat encountered					
S55	508101	669487	4.0	No peat encountered					
S56	508200	669475	5.0	No peat encountered					
S57	506970	668641	2.0	No peat encountered					
S58	507069	668629	5.0	No peat encountered					
S59	507169	668637	5.0	No peat encountered					
S70	508218	668589	6.0	No peat encountered					
S71	508313	668608	3.0	No peat encountered					
S73	508284	668313	6.0	No peat encountered					
S74	508255	668408	9.0	8	10	0.15	1.2	**34.52**	**4.50**
S75	508226	668504	3.0	8	10	0.30	1.3	**51.02**	**11.77**
S76	509000	668568	5.0	No peat encountered					
S77	508914	668604	8.0	8	10	0.20	1.2	**29.02**	**4.84**
S78	508815	668613	3.0	8	10	0.10	1.1	**153.07**	**13.92**
S79	508715	668620	4.0	8	10	0.10	1.1	**114.96**	**10.45**
S80	508615	668621	2.0	8	10	0.40	1.4	**57.34**	**16.38**
S81	508515	668613	2.0	8	10	0.20	1.2	**114.68**	**19.11**
S84	508405	668646	7.0	8	10	0.30	1.3	**22.05**	**5.09**
S85	508377	668742	7.0	8	10	0.25	1.3	**26.45**	**5.29**
S86	508338	668833	7.0	8	10	0.50	1.5	**13.23**	**4.41**
S87	508302	668925	5.0	No peat encountered					
S88	508384	668960	4.0	8	10	0.40	1.4	**28.74**	**8.21**
S89	508481	668986	2.0	No peat encountered					
S90	508578	668995	2.0	8	10	0.20	1.2	**114.68**	**19.11**
S91	508639	669014	2.0	8	10	1.00	2.0	**22.94**	**11.47**
S92	508706	669074	4.0	8	10	0.50	1.5	**22.99**	**7.66**
S93	508687	669170	2.0	8	10	0.10	1.1	**229.37**	**20.85**
S94	508627	669250	3.0	8	10	0.50	1.5	**30.61**	**10.20**
S95	508561	669318	2.0	8	10	1.00	2.0	**22.94**	**11.47**
S96	508467	669345	1.0	8	10	0.15	1.2	**305.64**	**39.87**
S97	508382	669398	3.0	8	10	0.10	1.1	**153.07**	**13.92**
S98	508830	669941	4.0	8	10	0.30	1.3	**38.32**	**8.84**
S99	508742	669893	3.0	8	10	0.40	1.4	**38.27**	**10.93**
S101	508561	669808	5.0	No peat encountered					
S102	508475	669757	7.0	No peat encountered					
S103	508381	669725	10.0	No peat encountered					
S104	508352	669670	10.0	8	10	0.10	1.1	**46.78**	**4.25**
S105	508382	669575	10.0	No peat encountered					
S106	508369	669469	5.0	8	10	0.10	1.1	**92.14**	**8.38**
S107	508465	669496	2.0	8	10	0.45	1.5	**50.97**	**15.82**
S108	508564	669499	4.0	8	10	2.00	3.0	**5.75**	**3.83**
S109	508663	669510	5.0	8	10	0.50	1.5	**18.43**	**6.14**
S110	508758	669539	5.0	No peat encountered					
S111	508849	669580	3.0	8	10	0.30	1.3	**51.02**	**11.77**
S112	508929	669574	5.0	8	10	0.20	1.2	**46.07**	**7.68**

Calculated FoS of Natural Peat Slopes for Cahermurphy Two 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)
S113	508972	669484	2.0	8	10	1.70	2.7	**13.49**	**8.50**
S114	509035	669409	3.0	8	10	0.60	1.6	**25.51**	**9.57**
S115	509129	669384	3.0	No peat encountered					
S117	509532	668887	2.0	8	10	0.15	1.2	**152.91**	**19.95**
S118	509446	668932	3.0	8	10	0.10	1.1	**153.07**	**13.92**
S119	509375	669001	7.0	8	10	0.10	1.1	**66.14**	**6.01**
S120	509305	669066	5.0	8	10	0.10	1.1	**92.14**	**8.38**
S121	509206	669046	3.0	8	10	0.20	1.2	**76.53**	**12.76**
S122	509108	669059	4.0	8	10	0.20	1.2	**57.48**	**9.58**
S125	509121	669263	3.0	No peat encountered					
S126	509176	669347	5.0	No peat encountered					
S127	509260	669394	5.0	No peat encountered					
WP001	507834	669308	2.0	8	10	0.10	1.1	**229.37**	**20.85**
WP002	507850	669295	2.0	8	10	0.25	1.3	**91.75**	**18.35**
WP003	508659	669168	4.0	8	10	0.60	1.6	**19.16**	**7.19**
WP008	508680	669867	2.0	No peat encountered					
Peat Stability from MKO probes									
MKO_23	508981	668993	0.4	8	10	2.25	3.3	**50.93**	**35.26**
MKO_28	509002	668696	3.3	8	10	0.90	1.9	**15.47**	**7.33**
MKO_31	509032	668576	7.3	8	10	0.80	1.8	**7.93**	**3.53**
P1-CM	509400	669917	5.0	8	10	1.10	2.1	**8.38**	**4.39**
P10-CM	509124	669715	10.0	8	10	0.30	1.3	**15.59**	**3.60**
P11-CM	509060	669683	5.0	8	10	0.50	1.5	**18.43**	**6.14**
P12-CM	508987	669651	5.0	8	10	0.80	1.8	**11.52**	**5.12**
P13-CM1	509005	668588	6.0	8	10	0.70	1.7	**10.99**	**4.53**
P14-CM	509100	668579	6.5	8	10	0.10	1.1	**71.13**	**6.47**
P15-CM	509190	668573	5.5	8	10	0.10	1.1	**83.85**	**7.62**
P16-CM	509290	668585	4.6	8	10	0.70	1.7	**14.30**	**5.89**
P17-CM	509325	668616	1.0	8	10	2.10	3.1		
P18-CM	509282	668681	10.0	8	10	0.10	1.1	**46.78**	**4.25**
P2-CM	509346	669862	6.0	8	10	0.30	1.3	**25.65**	**5.92**
P3-CM	509284	669792	6.0	8	10	0.10	1.1	**76.96**	**7.00**
P4-CM	509191	669754	0.3	8	10	0.10	1.1	**1527.92**	**138.90**
P5-CM	509123	669741	10.0	8	10	0.10	1.1	**46.78**	**4.25**
P6-CM	509047	669777	10.0	8	10	0.10	1.1	**46.78**	**4.25**
P9-CM	508962	669930	4.6	8	10	0.10	1.1	**100.07**	**9.10**
5	508942	669254	2.0	8	10	0.80	1.8	**28.67**	**12.74**
6	508874	669255	2.0	8	10	0.20	1.2	**114.68**	**19.11**
7	508785	669266	2.0	8	10	0.20	1.2	**114.68**	**19.11**
7a	508705	669278	2.0	8	10	0.40	1.4	**57.34**	**16.38**
11	509194	669173	3.0	8	10	1.00	2.0	**15.31**	**7.65**
22	508140	668449	7.0	8	10	0.70	1.7	**9.45**	**3.89**

Minimum =	**5.75**	**3.53**
Maximum =	**1527.92**	**138.90**
Average =	**82.38**	**12.72**

Notes:

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

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

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

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

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

(6) For load conditions see report text.

Calculated FoS of Natural Peat Slopes for Cahermurphy Two 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	3.0	4	10.0	10.0	0.30	25	1.0	1.3	**25.51**	**12.73**
T2	3.0	4	10.0	10.0	0.30	25	1.0	1.3	**25.51**	**12.73**
T3	3.0	4	10.0	10.0	0.50	25	1.0	1.5	**15.31**	**11.03**
T4	2.0	4	10.0	10.0	2.60	25	1.0	3.6	**4.41**	**6.89**
T5	4.0	4	10.0	10.0	0.25	25	1.0	1.3	**22.99**	**9.93**
T6	2.0	4	10.0	10.0	0.40	25	1.0	1.4	**28.67**	**17.73**
T7	4.0	4	10.0	10.0	1.70	25	1.0	2.7	**3.38**	**4.60**
T8	2.0	4	10.0	10.0	2.50	25	1.0	3.5	**4.59**	**7.09**
T9	2.0	4	10.0	10.0	0.70	25	1.0	1.7	**16.38**	**14.60**
T10	5.0	4	10.0	10.0	0.30	25	1.0	1.3	**15.36**	**7.64**
Substation 1	2.0	4	10.0	10.0	0.15	25	1.0	1.2	**76.46**	**21.58**
Substation 2	3.0	4	10.0	10.0	0.80	25	1.0	1.8	**9.57**	**9.20**
Construction Compound	3.0	4	10.0	10.0	0.15	25	1.0	1.2	**51.02**	**14.39**
Met Mast	7.0	4	10.0	10.0	0.70	25	1.0	1.7	**4.72**	**4.18**
Borrow Pit 1	4.0	4	10.0	10.0	0.15	25	1.0	1.2	**38.32**	**10.80**
Borrow Pit 2	5.0	4	10.0	10.0	0.15	25	1.0	1.2	**30.71**	**8.64**
S19	5.0	4	10.0	10.0	1.20	25	1.0	2.2	**3.84**	**4.52**
S22	2.0	4	10.0	10.0	No Peat Encountered					
S26	4.0	4	10.0	10.0	No Peat Encountered					
S30	2.0	4	10.0	10.0	2.50	25	1.0	3.5	**4.59**	**7.09**
S31	2.0	4	10.0	10.0	1.20	25	1.0	2.2	**9.56**	**11.28**
S32	2.0	4	10.0	10.0	No Peat Encountered					
S33	3.0	4	10.0	10.0	0.30	25	1.0	1.3	**25.51**	**12.73**
S34	5.0	4	10.0	10.0	No Peat Encountered					
S35	2.0	4	10.0	10.0	No Peat Encountered					
S36	5.0	4	10.0	10.0	No Peat Encountered					
S37	5.0	4	10.0	10.0	No Peat Encountered					
S38	1.0	4	10.0	10.0	0.10	25	1.0	1.1	**229.23**	**45.13**
S39	1.0	4	10.0	10.0	0.15	25	1.0	1.2	**152.82**	**43.16**
S40	2.0	4	10.0	10.0	No Peat Encountered					
S41	3.0	4	10.0	10.0	No Peat Encountered					
S42	6.0	4	10.0	10.0	0.10	25	1.0	1.1	**38.48**	**7.53**
S43	7.0	4	10.0	10.0	0.15	25	1.0	1.2	**22.05**	**6.18**
S44	6.0	4	10.0	10.0	No Peat Encountered					
S46	2.0	4	10.0	10.0	No Peat Encountered					
S47	4.0	4	10.0	10.0	No Peat Encountered					
S48	2.0	4	10.0	10.0	No Peat Encountered					
S49	2.0	4	10.0	10.0	No Peat Encountered					
S50	2.0	4	10.0	10.0	0.20	25	1.0	1.2	**57.34**	**20.68**
S51	1.0	4	10.0	10.0	0.30	25	1.0	1.3	**76.41**	**38.18**
S52	3.0	4	10.0	10.0	No Peat Encountered					
S53	4.0	4	10.0	10.0	0.30	25	1.0	1.3	**19.16**	**9.55**
S54	4.0	4	10.0	10.0	No Peat Encountered					
S55	4.0	4	10.0	10.0	No Peat Encountered					
S56	5.0	4	10.0	10.0	No Peat Encountered					
S57	2.0	4	10.0	10.0	No Peat Encountered					
S58	5.0	4	10.0	10.0	No Peat Encountered					
S59	5.0	4	10.0	10.0	No Peat Encountered					
S70	6.0	4	10.0	10.0	No Peat Encountered					
S71	3.0	4	10.0	10.0	No Peat Encountered					
S73	6.0	4	10.0	10.0	No Peat Encountered					
S74	9.0	4	10.0	10.0	0.15	25	1.0	1.2	**17.26**	**4.81**
S75	3.0	4	10.0	10.0	0.30	25	1.0	1.3	**25.51**	**12.73**
S76	5.0	4	10.0	10.0	No Peat Encountered					
S77	8.0	4	10.0	10.0	0.20	25	1.0	1.2	**14.51**	**5.18**
S78	3.0	4	10.0	10.0	0.10	25	1.0	1.1	**76.53**	**15.05**
S79	4.0	4	10.0	10.0	0.10	25	1.0	1.1	**57.48**	**11.29**
S80	2.0	4	10.0	10.0	0.40	25	1.0	1.4	**28.67**	**17.73**
S81	2.0	4	10.0	10.0	0.20	25	1.0	1.2	**57.34**	**20.68**
S84	7.0	4	10.0	10.0	0.30	25	1.0	1.3	**11.02**	**5.47**
S85	7.0	4	10.0	10.0	0.25	25	1.0	1.3	**13.23**	**5.68**
S86	7.0	4	10.0	10.0	0.50	25	1.0	1.5	**6.61**	**4.74**
S87	5.0	4	10.0	10.0	No Peat Encountered					
S88	4.0	4	10.0	10.0	0.40	25	1.0	1.4	**14.37**	**8.87**
S89	2.0	4	10.0	10.0	No Peat Encountered					
S90	2.0	4	10.0	10.0	0.20	25	1.0	1.2	**57.34**	**20.68**
S91	2.0	4	10.0	10.0	1.00	25	1.0	2.0	**11.47**	**12.41**
S92	4.0	4	10.0	10.0	0.50	25	1.0	1.5	**11.50**	**8.28**
S93	2.0	4	10.0	10.0	0.10	25	1.0	1.1	**114.68**	**22.57**
S94	3.0	4	10.0	10.0	0.50	25	1.0	1.5	**15.31**	**11.03**
S95	2.0	4	10.0	10.0	1.00	25	1.0	2.0	**11.47**	**12.41**
S96	1.0	4	10.0	10.0	0.15	25	1.0	1.2	**152.82**	**43.16**
S97	3.0	4	10.0	10.0	0.10	25	1.0	1.1	**76.53**	**15.05**
S98	4.0	4	10.0	10.0	0.30	25	1.0	1.3	**19.16**	**9.55**
S99	3.0	4	10.0	10.0	0.40	25	1.0	1.4	**19.13**	**11.82**
S101	5.0	4	10.0	10.0	No Peat Encountered					
S102	7.0	4	10.0	10.0	No Peat Encountered					
S103	10.0	4	10.0	10.0	No Peat Encountered					
S104	10.0	4	10.0	10.0	0.10	25	1.0	1.1	**23.39**	**4.53**
S105	10.0	4	10.0	10.0	No Peat Encountered					
S106	5.0	4	10.0	10.0	0.10	25	1.0	1.1	**46.07**	**9.03**
S107	2.0	4	10.0	10.0	0.45	25	1.0	1.5	**25.49**	**17.12**
S108	4.0	4	10.0	10.0	2.00	25	1.0	3.0	**2.87**	**4.14**
S109	5.0	4	10.0	10.0	0.50	25	1.0	1.5	**9.21**	**6.62**
S110	5.0	4	10.0	10.0	No Peat Encountered					
S111	3.0	4	10.0	10.0	0.30	25	1.0	1.3	**25.51**	**12.73**
S112	5.0	4	10.0	10.0	0.20	25	1.0	1.2	**23.04**	**8.28**
S113	2.0	4	10.0	10.0	1.70	25	1.0	2.7	**6.75**	**9.19**
S114	3.0	4	10.0	10.0	0.60	25	1.0	1.6	**12.76**	**10.34**
S115	3.0	4	10.0	10.0	No Peat Encountered					
S117	2.0	4	10.0	10.0	0.15	25	1.0	1.2	**76.46**	**21.58**

Calculated FoS of Natural Peat Slopes for Cahermurphy Two 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
S118	3.0	4	10.0	10.0	0.10	25	1.0	1.1	**76.53**	**15.05**
S119	7.0	4	10.0	10.0	0.10	25	1.0	1.1	**33.07**	**6.46**
S120	5.0	4	10.0	10.0	0.10	25	1.0	1.1	**46.07**	**9.03**
S121	3.0	4	10.0	10.0	0.20	25	1.0	1.2	**38.27**	**13.79**
S122	4.0	4	10.0	10.0	0.20	25	1.0	1.2	**28.74**	**10.35**
S125	3.0	4	10.0	10.0	No Peat Encountered					
S126	5.0	4	10.0	10.0	No Peat Encountered					
S127	5.0	4	10.0	10.0	No Peat Encountered					
WP001	2.0	4	10.0	10.0	0.10	25	1.0	1.1	**114.68**	**22.57**
WP002	2.0	4	10.0	10.0	0.25	25	1.0	1.3	**45.87**	**19.86**
WP003	4.0	4	10.0	10.0	0.60	25	1.0	1.6	**9.58**	**7.76**
WP008	2.0	4	10.0	10.0	No Peat Encountered					
MKO_23	0.4	4	10.0	10.0	2.25	25	1.0	3.3	**25.47**	**38.18**
MKO_28	3.3	4	10.0	10.0	0.90	25	1.0	1.9	**7.73**	**7.92**
MKO_31	7.3	4	10.0	10.0	0.80	25	1.0	1.8	**3.97**	**3.79**
P1-CM	5.0	4	10.0	10.0	1.10	25	1.0	2.1	**4.19**	**4.73**
P10-CM	10.0	4	10.0	10.0	0.30	25	1.0	1.3	**7.80**	**3.83**
P11-CM	5.0	4	10.0	10.0	0.50	25	1.0	1.5	**9.21**	**6.62**
P12-CM	5.0	4	10.0	10.0	0.80	25	1.0	1.8	**5.76**	**5.52**
P13-CM1	6.0	4	10.0	10.0	0.70	25	1.0	1.7	**5.50**	**4.87**
P14-CM	6.5	4	10.0	10.0	0.10	25	1.0	1.1	**35.56**	**6.95**
P15-CM	5.5	4	10.0	10.0	0.10	25	1.0	1.1	**41.93**	**8.21**
P16-CM	4.6	4	10.0	10.0	0.70	25	1.0	1.7	**7.15**	**6.35**
P17-CM	0.0	4	10.0	10.0	2.10	25	1.0	3.1		
P18-CM	10.0	4	10.0	10.0	0.10	25	1.0	1.1	**23.39**	**4.53**
P2-CM	6.0	4	10.0	10.0	0.30	25	1.0	1.3	**12.83**	**6.37**
P3-CM	6.0	4	10.0	10.0	0.10	25	1.0	1.1	**38.48**	**7.53**
P4-CM	0.3	4	10.0	10.0	0.10	25	1.0	1.1	**763.96**	**150.41**
P5-CM	10.0	4	10.0	10.0	0.10	25	1.0	1.1	**23.39**	**4.53**
P6-CM	10.0	4	10.0	10.0	0.10	25	1.0	1.1	**23.39**	**4.53**
P9-CM	4.6	4	10.0	10.0	0.10	25	1.0	1.1	**50.04**	**9.82**
5	2.0	4	10.0	10.0	0.80	26	1.0	1.8	**28.30**	**20.34**
6	2.0	4	10.0	10.0	0.20	27	1.0	1.2	**71.93**	**24.15**
7	2.0	4	10.0	10.0	0.20	28	1.0	1.2	**72.57**	**24.78**
7a	2.0	4	10.0	10.0	0.40	29	1.0	1.4	**44.54**	**24.07**
11	3.0	4	10.0	10.0	1.00	30	1.0	2.0	**18.67**	**14.84**
22	7.0	4	10.0	10.0	0.70	31	1.0	1.7	**9.62**	**6.84**
								Minimum =	**2.87**	**3.79**
								Maximum =	**763.96**	**150.41**
								Average =	**42.26**	**14.08**

Notes:

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

(2) Assuming a surcharge equivalent to fill depth of 1.0m.

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

(4) FoS is based on slope inclination and shear test results obtained from published data.

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

(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 E

Methodology for Peat Stability Risk Assessment

Methodology for Peat Stability Risk Assessment

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

The main approaches for assessing peat stability include the following:

(a) Geomorphological

(b) Qualitative (judgement)

(c) Index/Probabilistic (probability)

(d) Deterministic (factor of safety)

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

Probability

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

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

Table A Qualitative Factors used to Assess Potential for Peat Failure

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

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

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

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

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

Table B Probability Scale

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

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

Impact

The severity of the risk is also assessed qualitatively in terms of impact. The impact of a peat failure on the environment within and beyond the immediate wind farm site is assessed based on the potential travel distance of a peat failure. Where a peat failure enters a 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
5	Proposed infrastructure element within 50 m of watercourse, in an environmentally sensitive area	Extremely High

Risk Rating

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

The Risk Rating is calculated from: $R = P \times I$

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

Table D Qualitative Risk Rating

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

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

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