MWP

PEAT STABILITY RISK ASSESSMENT

Dernacart 110kV Substation and Grid Connection
Co. Laois and Co. Offaly

Statkraft Ireland

October 2024

MWP

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Project No.	Doc. No.	Rev.	Date	Prepared By	Checked By	Approved By	Status
23268	23268-MWP-XX-XX-RP-C-6010	P02	07/10/2024	MP	PC	PC	Information
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ENGINEERS IRELAND CPD ACCREDITED EMPLOYER

Executive Summary

Dernacart Wind Farm Ltd. engaged Malachy Walsh and Partners (MWP) to complete a Peat Stability Risk Assessment as part of the EIAR for the proposed Dernacart 110kV Substation and Grid Connection in Co. Laois and Co. Offaly.

The location of the Dernacart 110kV Substation and Grid Connection infrastructure was designed from the outset with a constraint driven approach. This approached placed substation in area of low risk for peat slides and avoided environmentally sensitive areas.

MWP completed walkovers and surveys of the site. 75 peat probes were completed across the site with peat depths ranging from 0.25m to 3.68m. Shear strengths were recorded ranging from 10kPa to 78kPa.

MWP used LiDAR data to create a Digital Elevation Model (DEM) of the site. Slope analysis from the DEM was used to identify areas of the site with low ground slope. On this site, the ground slope was found to be low across the entire site.

MWP completed a two-stage peat stability risk assessment approach. Stage 1 was based on desk study information, site reconnaissance and assessment of contour data. Stage 1 concluded that further quantitative stability risk assessment was required for this site. Stage 2 involved quantitative risk assessment factor of safety analysis (Infinite Slope Stability Analysis), and application of the Peat Slide Hazard Rating System (PHRS) (Nichol, 2006). Both stages were completed for this project. This approach is in line with industry best practice guidance, as published by the Scottish Government PLHRA (Energy Consents Unit, Scottish Government, 2017).

The findings of the PHRS, carried out as part of the Stage 2 assessment, were that the risk level is Negligible.

Following on from the PHRS, MWP completed an Infinite Slope Stability Analysis (ISSA) for the site using the peat probe data and slope data from the LiDAR DEM to calculate the Factor of Safety (FoS) against peat slide for each location probed. The ISSA output found that FoS ranged from 9 to 1796.

MWP completed assessments of the risk presented using the industry best practice guidance of the Scottish Executive and Scottish Government guidelines for Peat Landslide Hazard and Risk Assessments. The outcome of the risk assessment was that the risk level is Negligible.

Design measures in the form of a peat stability monitoring programme during construction has been proposed in order to further mitigate and manage risk.

1. Introduction

1.1 Overview

The proposed Dernacart 110kV Substation and Grid Connection comprises of a substation, access roads, material storage areas, grid connection and drainage infrastructure. The site of the proposed substation is located c.1.8km north of Mountmellick, Co.Laois. The site is within both Co. Laois and Co. Offaly. The site predominantly consists of greenfields used for pastural farming and coniferous forest. A map of the area within which the Peat Stability Risk Assessment has been completed is shown in Figure 1-1.

Dernacart Wind Farm Ltd. has requested Malachy Walsh and Partners (MWP) to complete a Peat Stability Risk Assessment (PSRA) as part of the Environmental Impact Assessment Report (EIAR) for the project. MWP has extensive experience in completing PSRAs, having completed PSRAs on over 20 planning applications and the construction of in excess of 30 substations located in peatland throughout Ireland.

The PSRA presented in this report has been carried out within the area of the proposed substation infrastructure and grid connection.

MWP adhere to the latest industry standards when completing PSRAs. The guidance of the Scottish Government publication "Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments, Energy Consents Unit Scottish Government, Second Edition, April 2017" and the "Draft Revised Wind Energy Development Guidelines December 2019" have been used for this PSRA.

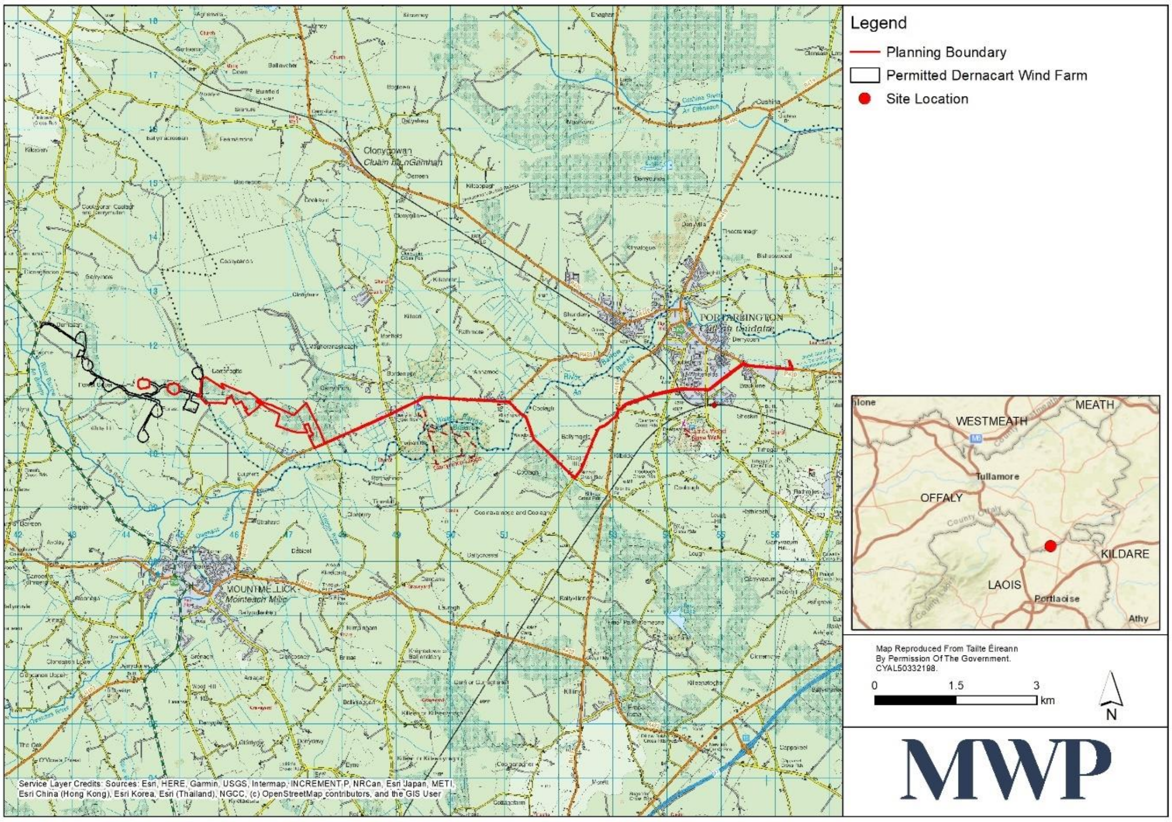

Figure 1-1 Site Location Plan

1.2 Peat Stability Risk Assessment Methodology

The methodology used to complete the Peat Stability Risk Assessment for this site is set out in the following subsections of this report.

1.2.1 Relevant Guidelines

The following guidance documents were used in completing the assessment presented in this report:

- Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments, Energy Consents Unit Scottish Government, Second Edition 2017.
- British Standards Institute (2009). BS 6031:2009 Code of practice for earthworks.
- Draft Revised Wind Energy Development Guidelines December 2019.
- OPW Flood Risk Management Climate Change Sectoral Adaptation Plan, September 2019.

1.2.2 Approach

The approach to peat stability risk assessment taken in this report involves the below listed steps. These steps are in accordance with *“Draft Revised Wind Energy Development Guidelines December 2019”* and *“Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments, Energy Consents Unit Scottish Government, Second Edition 2017*”.

- A **scoping** exercise was carried out to determine whether a detailed Peat Landslide Hazard and Risk Assessment is required for this site.
- A **desk study** to gain an understanding of the quaternary geology, bedrock geology, hydrology, hydrogeology, landslide history, land use and topography of the site.
- **Site reconnaissance** to verify the findings of the desk study and further assess the geology, hydrology, topography and search for signs of past landslides or incipient instability.
- A thorough **ground investigation** to determine the extents and nature of the peat. This includes peat probes, shear strength readings and von post humification characteristics.
- An **assessment of ground conditions** across the site including the peat information, substrate information, topography and land use.
- A **quantitative analysis of peat stability** across the site using infinite slope stability analysis.
- A **risk assessment** which identifies the risk levels for various parts of the site based on the probability of a peat slide and the adverse consequence of the slide.
- Suggested **mitigation measures** depending on the level of risk for various parts of the site.

2. Scoping

A scoping exercise was carried out to determine whether a detailed Peat Landslide Hazard and Risk Assessment is required for this site. This scoping exercise reviewed whether peat was present onsite and reviewed the topography and slope angles within the site. A summary of the scoping process is provided in Figure 2-1 and a commentary on each of the scoping items reviewed is provided in Sections 2.1 to 2.3.

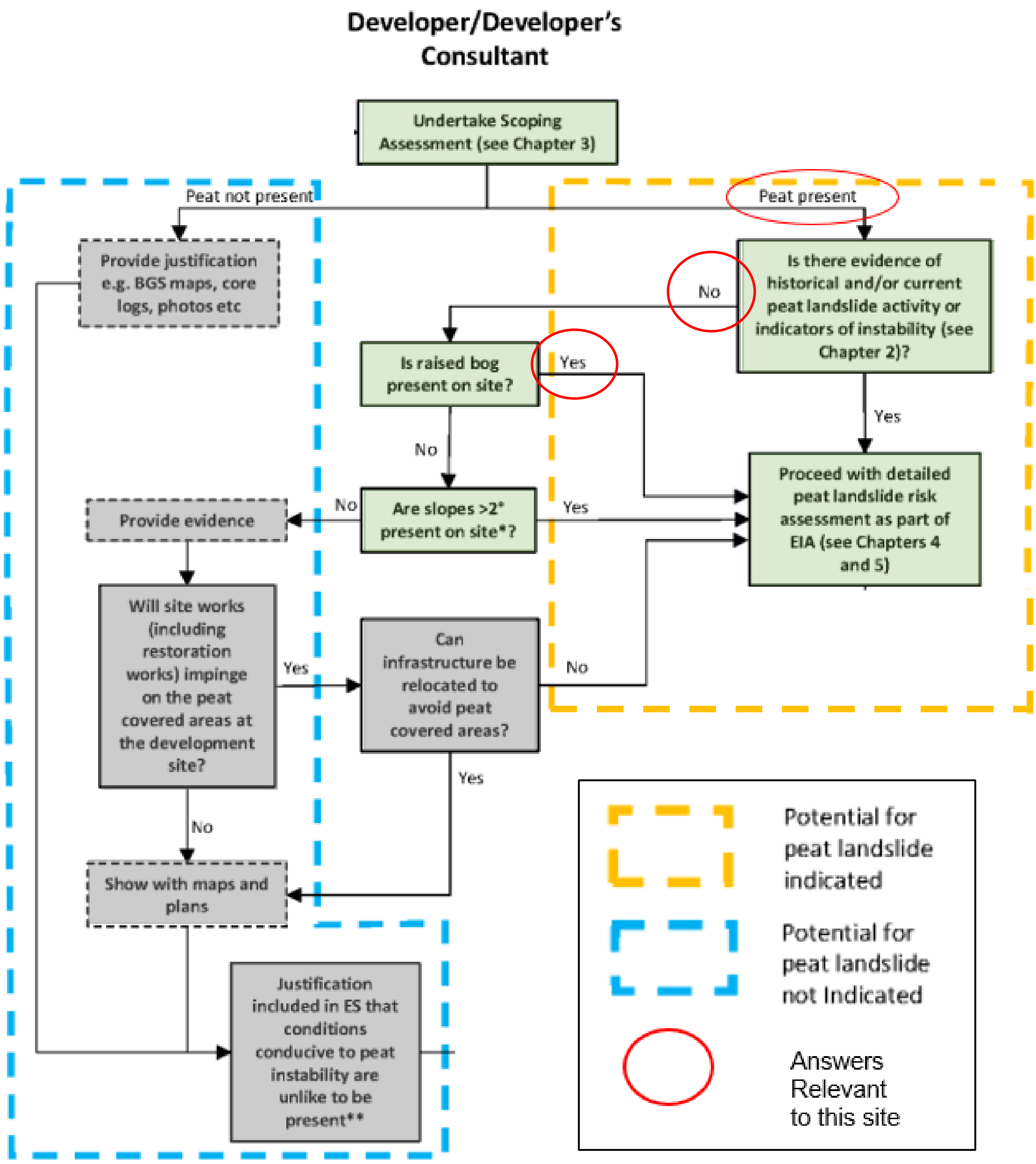

Figure 2-1 Summary Flow Chart of Scoping for Requirement for Detailed Peat Stability Risk Assessment

2.1 Presence of Peat

A review of the digital geological maps on the Geological Survey of Ireland website showed the presence of Cut-Over Raised Peat within the site. This was confirmed on the ground via initial site reconnaissance and subsequent peat probing. No evidence of peat instability was noted during the scoping exercise. Further detail on the geological maps, site reconnaissance findings and peat probing are provided in Section 3 of this report.

2.2 Slope

The Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments states that "*In raised bogs (which typically occur on very gentle terrain), PLHRAs should be undertaken, reflecting published data (Boylan et al., 2008) which indicates the occurrence of peat landslides on very low gradients in raised bog environments.".* (PLHRA = Peat Landslide Hazard Risk Assessment).

A review of topographical maps and Lidar indicated the presence of slope angles greater than 2° within this site. Further details of slopes within the site are provided in Section 3 of this report.

2.3 Outcome of Scoping Exercise

Raised Peat and slope angles greater than 2° have been identified within this site, therefore a detailed Peat landslide hazard and risk assessment is required for this site.

3. Detailed Site Assessment

3.1 Desk Study

The proposed route of the collector cable and the proposed 110kV substation are underlain predominantly by Cutover/cutaway peat according to Teagasc soil data. A review of the digital geological maps on the GSI website and the quaternary sediment map, bothshowed the presence of Cut-Over Raised Peat within the site. This was confirmed on the ground via initial site reconnaissance and subsequent peat probing.

The proposed grid connection route is also underlain by a mosaic of soil and subsoil with an area of Cut-Over Raised Peat in the southern most part of the route at Sleigh Hill, along with strains of BminSRPT - shallow, rocky, peaty/non-peaty mineral complexes, BminPDPT - peaty poorly drained mineral, BminPD - mineral poorly drained, BminSP - Shallow poorly drained mineral and AlluvMIN - Alluvial. The presence of Alluvium soils can be an initial indicator of an area which has been subject to flooding in the geological past but cannot be used to determine flood risk to an area (see Figure 3-1).

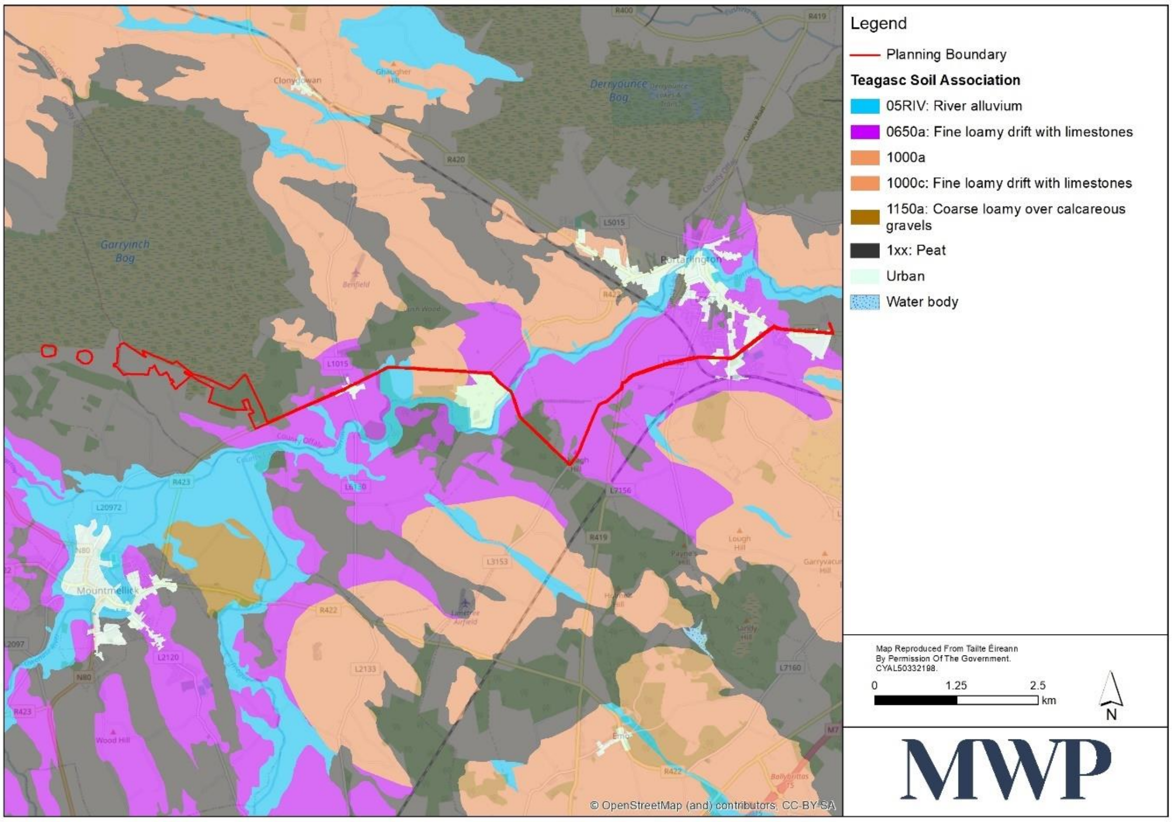

Figure 3-1 Teagasc Soil Map

The quaternary sediment map also indicates the presence of Cut over raised peat, Gravels derived from Limestones, Till derived from limestones and Alluvium (See Figure 3-2).

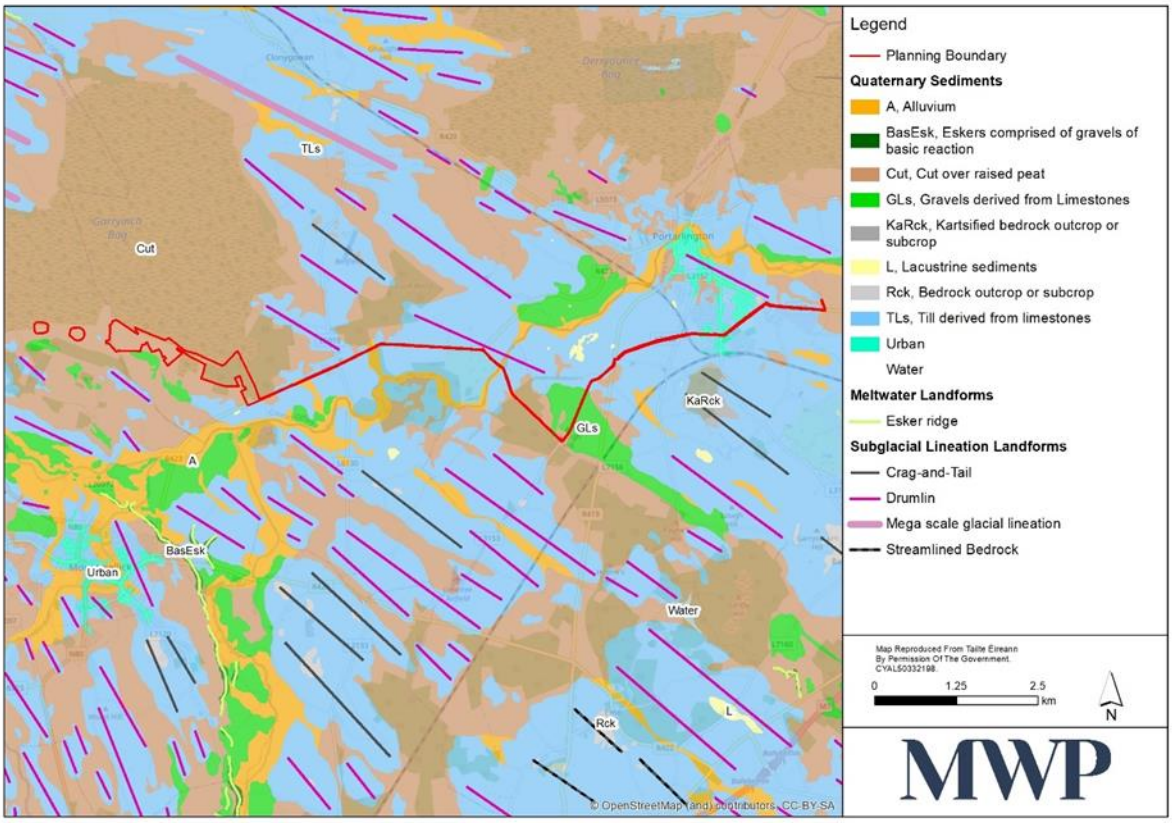

Figure 3-2 Quaternary Sediment Map

The GSI Map Viewer shows the proposed development site to be underlain by a combination of limestone and shale. Commencing in the west, where the underground collector cable and 110kV substation are proposed, with the dark muddy limestone and shale of the Ballysteen Formation. The 10.5km long underground 110kV cable connection is then underlain by the massive un-bedded lime mudstone of the Waulsortian Limestones, the thick bedded limestone of the Allenwood Formation and, at the far eastern end of the proposed route, the dark limestone and shale of the Lucan Formation.

There is a fault underlying the route of the proposed grid connection, trending northeast –southwest, separating the Waulsortian and the Allenwood Formations. These faults are no longer active and do not present a hazard for construction of the proposed development

The bedrock geology in this area is dominated by Ballysteen Formation which is described as *Dark muddy limestone, shale*. The bedrock geology of the site and surrounding area is presented in Figure 3-3.

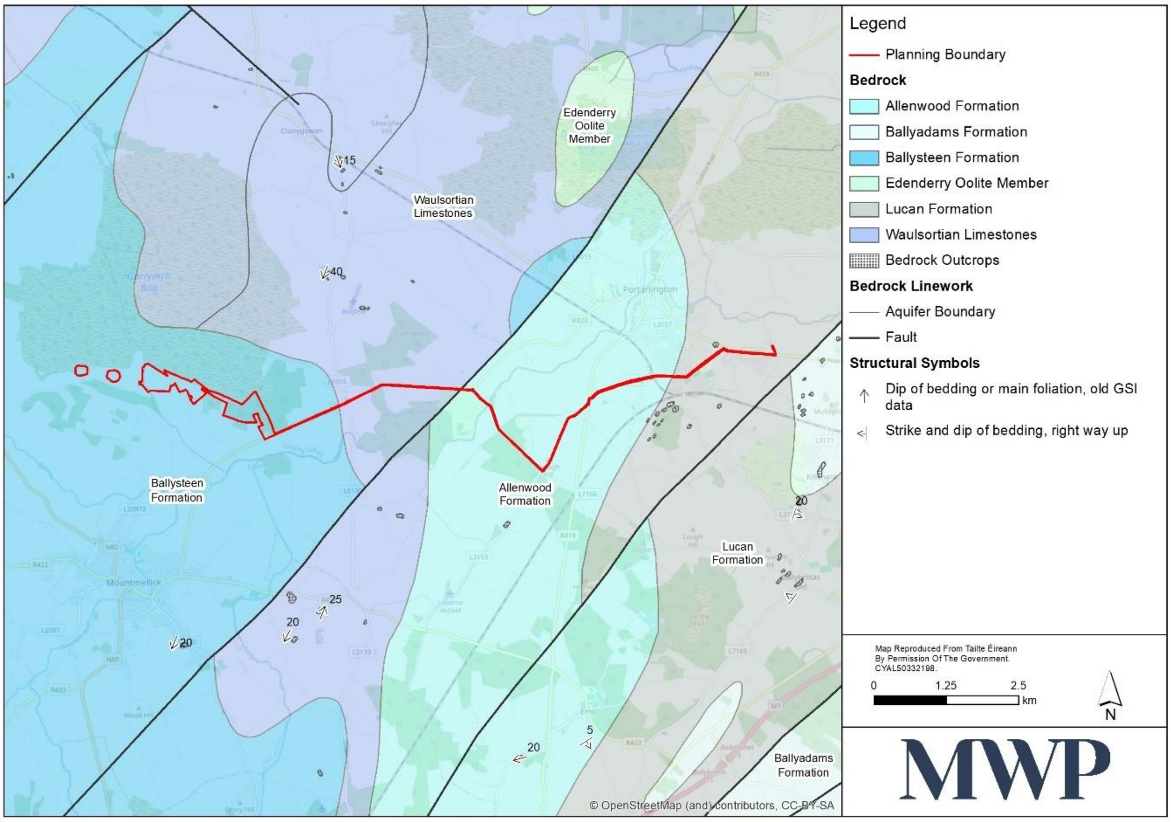

Figure 3-3 Bedrock Geology

3.2 Site Reconnaissance Survey

Site reconnaissance surveys were carried out to verify the features identified during the desk study and to enable an interpretation of the site in the context of the surrounding environment.

Peat probing was carried out by Ground Investigations Ireland to verify the presence of peat and gain an initial understanding of the depth and extents of the peat. Dates of the site visits are provided in Table 3-1.

The following observations were made during the site reconnaissance:

- No evidence of historical landslides or incipient instability were noted during the site visits.
- The hydrology of the site was reviewed. Watercourses within the site were observed to flow towards the site.
- The watercourses were relatively moderate in size.
- Land drains have been installed throughout areas of the site.
- The proposed peat and spoil deposition areas were noted as being in flat areas of the site.
- Existing access tracks were noted in a number of areas of the site and were noted as being in relatively good condition.
- Areas of the site were heavily forested.

Table 3-1: Summary of Site Visits

Date	Personnel	Purpose of Site Visit
08/06/2023	Ben Murphy (Hydrologist)	Review of the Site from a Hydrological Perspective
12/07/2023	Paddy Curran (Geotechnical Engineer)	Initial Review of the Site from a Geotechnical Perspective
03/08/2023	Ger Hayes	Aquatica Ecological Review
18/07/2023	Fiona McKenna (Ecologist)	Terrestrial Ecological Review
10/10/2023	Fiona McKenna (Ecologist)	Terrestrial Ecological Review
30/11/2023	Fiona McKenna (Ecologist)	Terrestrial Ecological Review
13/02/2024	Paddy Curran (Geotechnical Engineer)	Review of the Site from a Geotechnical Perspective based on a Finalised Layout
11/04/2024	Fiona McKenna (Ecologist)	Terrestrial Ecological Review

3.3 Ground Conditions Assessment

An assessment of ground conditions was carried out to gain a thorough understanding of the site in terms of peat stability. This assessment included the following reviews:

- Review of any site evidence of past landslides or incipient instability.
- Site hydrology and the impact of land-use on natural hydrology and peat thickness.
- Collection of peat depth data.
- Collection of peat characterisation data (geotechnical properties, humification, substrate, wetness etc).

3.3.1 Review of any Site Evidence for Past Landslides or Incipient Instability

No evidence of past landslides or incipient instability was noted in the desk study or during any of the site visits.

A number of positive observations in term of stability of the site were noted as follows:

- No existing landslides are noted on the Geological Survey of Ireland landslide database.
- No evidence of historical landslides or incipient instability were noted during the site visits.
- The drainage appears to be functioning well and having the effect of drying the peat. This is positive in terms of peat stability as deposits of very wet peat have been identified as a contributory factor to previous peat landslide.

3.3.2 Site Hydrology

The Proposed Development site is located within Hydrometric Area No. 14, also known as the Barrow catchment. Refer to Figure 3-4 for an overview of the catchment extents.

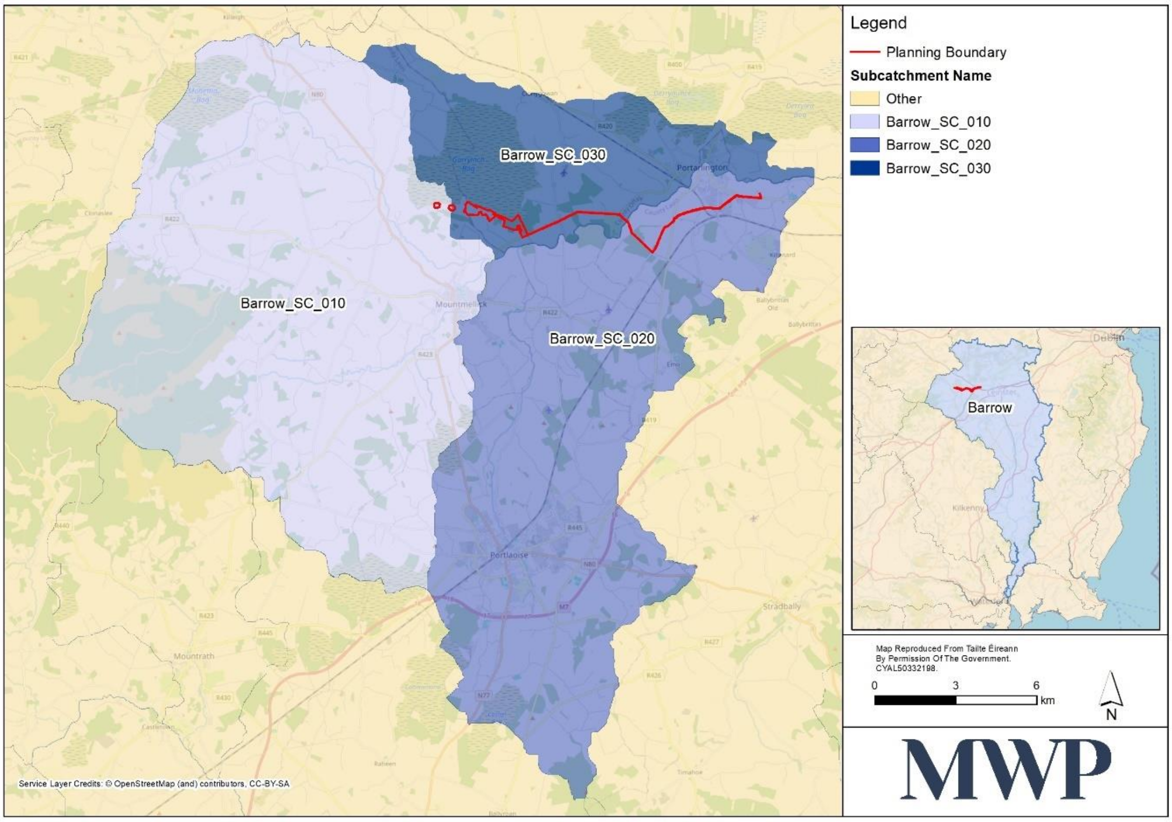

Figure 3-4 Catchment Areas

Windfarm Collector Cable

The windfarm collector cable is located within sub catchment 14_1 (Barrow_SC_030) within the following river sub basins:

- Cottoners Brook_010; and
- Barrow_050.

Proposed 110kV Substation

The proposed substation is located within sub catchment 14_1 (Barrow_SC_030) within the following river sub basins:

- Barrow_050.

110kV Grid Connection

The start of the 110kV Grid Connection is located within sub catchment 14_1 (Barrow_SC_030) with the remainder falling within sub-catchment 14_11 (Barrow_SC_020). The grid connections passes through the following river sub basins:

- Barrow_060;
- Clonygowan_010;
- Barrow_070; and
- Barrow_080.

3.3.2.1 EPA Mapped Surface Water Features

The River Barrow is the main surface water feature flowing in an easterly direction within close proximity to the proposed development. Refer to Figure 3-5 for the location of the surface water features applicable to the assessment in relation to the proposed development.

The River Barrow is a designated Special Area of Conservation (SAC) named the River Barrow And River Nore SAC (002162).

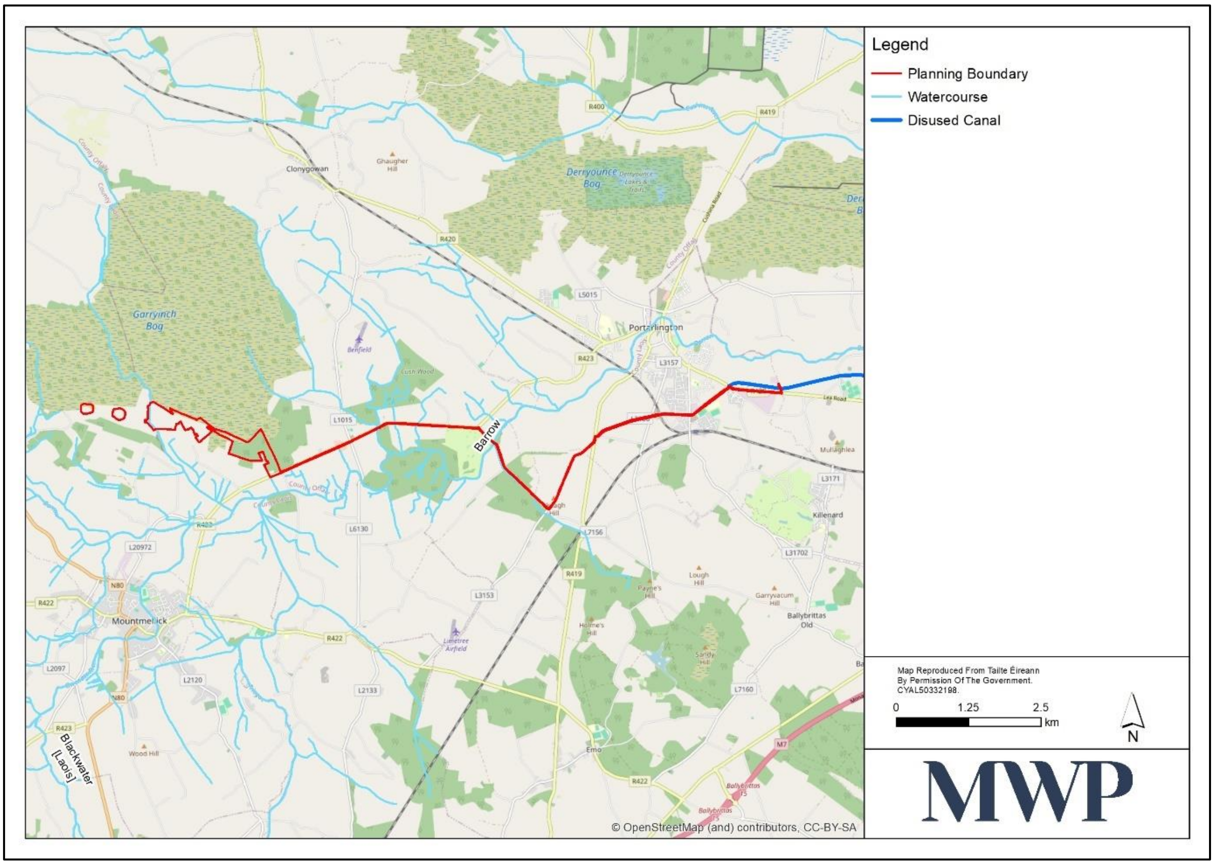

Figure 3-5 Hydrology Features within Proximity to the Proposed Development

Windfarm Collector Cable

The wind farm collector cable starts from the permitted Dernacart wind farm and crosses Cottoner's brook (IE_SE_14C150500) EPA mapped water course. The crossing will be a new clear span bridge structure for both the collector cable and the access road. The Cottoners brook stream flows in a southerly direction for approximately 1.8km before the confluence with the River Barrow (IE_SE_14B010550). There are several deep drainage ditches and minor shallow ditches along the collector cable route.

<u>Proposed Substation</u>

There are no EPA mapped surface water features traversing the proposed substation site. The River Barrow (IE_SE_14B010550) flows in an easterly direction approximately 350m south of the proposed substation site on the opposite side of the R423 road.

<u>110kV Grid Connection</u>

The 100kV grid connection will be underground from the proposed substation until it connects into the existing Bracklone substation southeast of Portarlington. The total length of the underground cable will follow existing road routes and will installed under the following mapped water courses:

- Clonygowan (IE_SE_14C510940) – this water course flows in a southerly direction under the R423 for approximately 500m before the confluence with the River Barrow (IE_SE_14B010550);
- Unnamed tributary of the River Barrow (IE_SE_14B010700) – this tributary flows under the R423 in a southerly direct for approximately 550m before the confluence with the River Barrow (IE_SE_14B010550);
- Rathmore 14 (IE_SE_14B010700) – this stream flows in a southerly direction under the R423 for approximately 420m before the confluence with the River Barrow (IE_SE_14B010550); and
- River Barrow (IE_SE_14B010700) – this river flows in an easterly direction through Portarlington before changing to a southerly direction after Monastervin. This river is the second longest river in Ireland at 192km. It is joined by the River Nore downstream and then by the River Suir before entering the Atlantic Ocean.

<u>River Crossings</u>

There are a total of 16 watercourse crossings related to the proposed development. Refer to Figure 3-6 and Figure 3-7 for the location of these crossings.

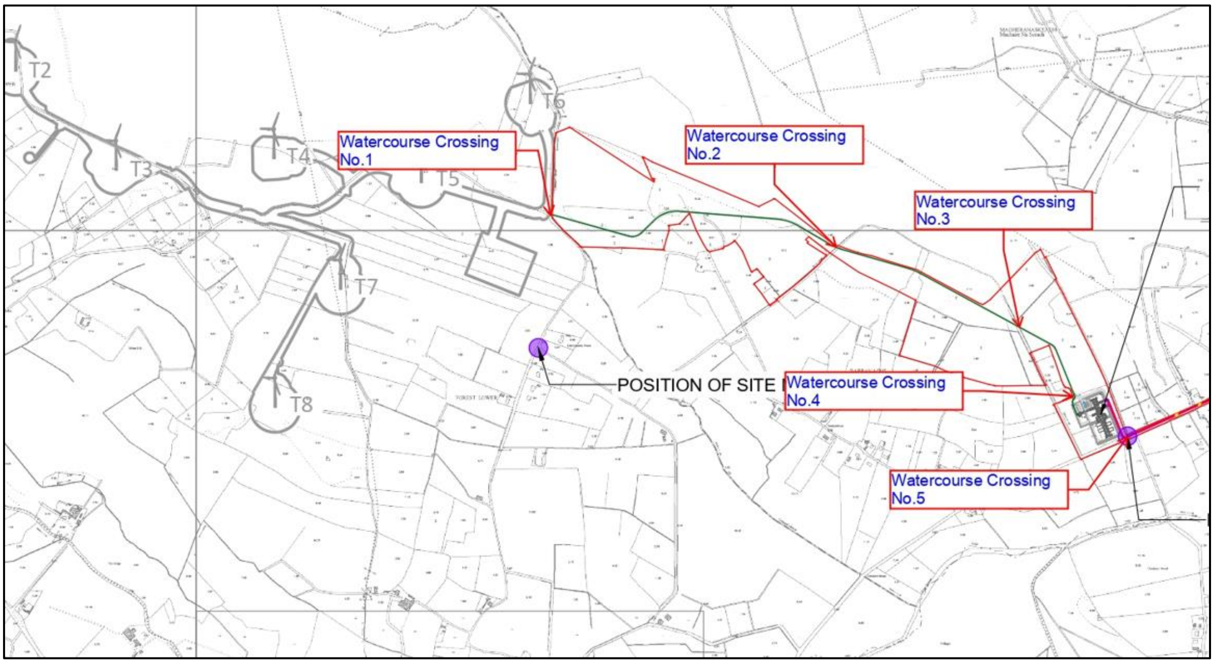

Figure 3-6 Watercourse Crossings (Wind Farm Connector Cable and Proposed Sub-station)

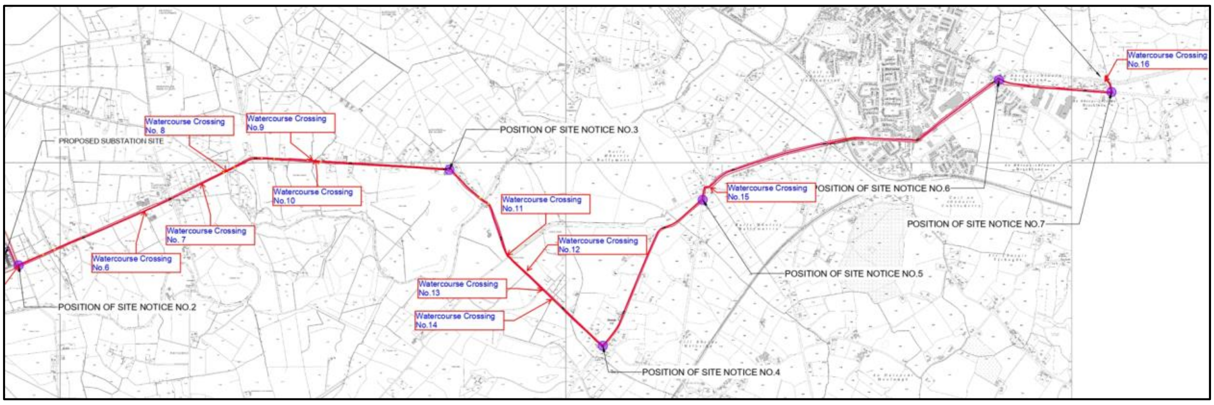

Figure 3-7 Watercourse Crossings (110kV Grid Connection)

Figure 3-8 Aerial photograph showing drainage network

3.3.3 Impact of Land Use on Natural Hydrology and Peat Thickness

The land use at the site was reviewed during site visits and by reviewing the Corine Land Cover 2018 maps on the EPA website. The following land uses were mapped within the study area:

Coniferous Forestry

- Agricultural Areas
- Peat Bog

The above land uses were verified during site visits. In terms of hydrology and peat thickness, the following was noted:

- Localised turf cutting.
- Manmade drains were noted near the perimeter of fields in the agricultural areas.
- Manmade drains were noted in the forestry areas of the site.

3.3.4 Collection of Peat Depth and Characterisation Data

The following peat depth and characterisation data was collected for this report:

- 75 peat probes were carried out as part of the assessment (See data summary in Figure 3-10 and peat depth distribution map in Figure 3-9).
- 75 Hand Shear Vane Readings (See data summary in Figure 3-11)
- All of the above investigation data is included in Appendix C of this document. It should be noted that Infinite Slope Stability Analysis was also carried out at all locations where peat depths were established.
- All peat probe locations are shown on the map included in Figure 3-9.
- The Material/Peat Storage Area is proposed in the area between T4 and T5 for the Dernacart Wind Farm. The PSRA in this area was carried out as part of the Dernacart Wind Farm Planning Pack. The assessment has shown that the peat depth in this area ranges from 0.6m to 1.2m and that the shear strength in this location varied from 3.2 kPa to 7.2 kPa.

Figure 3-9 Peat Depth Map

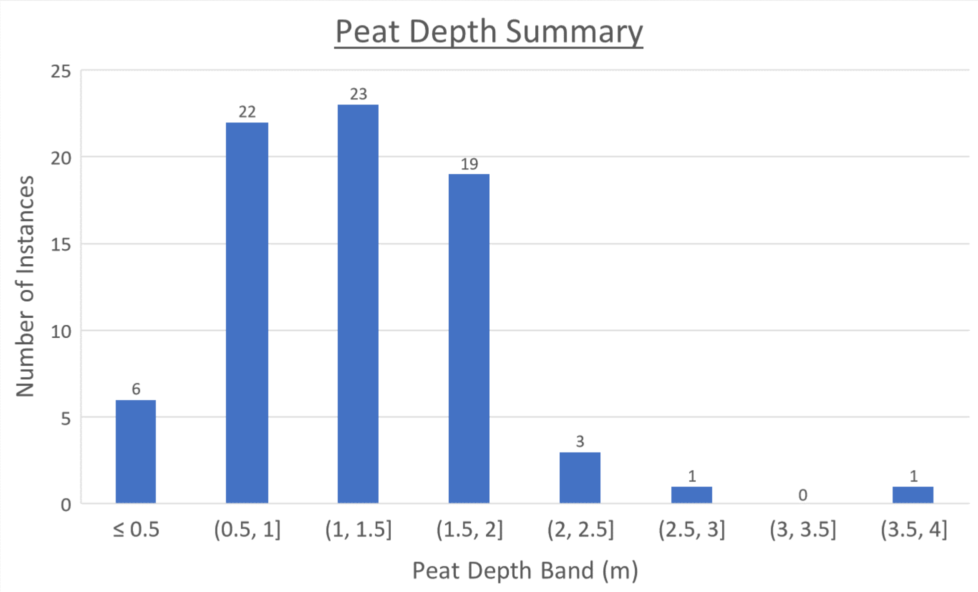

Figure 3-10 Peat Depth Data Summary

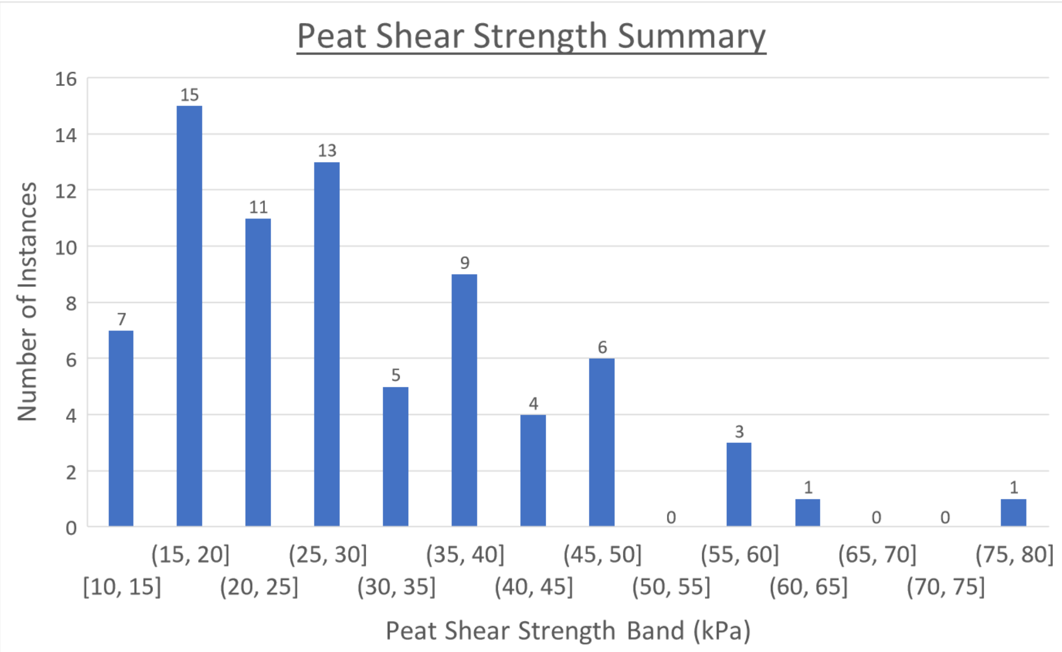

Figure 3-11 Peat Shear Strength Data Summary

4. Peat Stability Hazard and Risk Assessment

The information obtained from the desk study, site reconnaissance, ground investigation and LiDAR data was used to complete a peat stability hazard and risk assessment.

Risk can be expressed as the product of the probability of a [peat] landslide event and its adverse consequences (Scottish Government "peat-landslide-hazard-risk-assessments-best-practice-guide-proposed-electricity" April 2017), i.e.:

Risk = Probability of Landslide × Adverse Consequences *Eq. 1*

Estimation of the probability of a landslide was carried out through stability analysis, i.e. by providing a quantitative measure of slope stability incorporating consideration of slope form (slope angle), materials (shear strength) and loadings (overburden). This involved a quantitative analysis (infinite slope stability analysis) to determine the factor of safety against peat slide at each investigation point. The output from the infinite slope stability analysis was used as a quantification of the probability of a peat stability hazard.

Adverse consequences may include accidents, loss of life, environmental impacts or damage to site infrastructure and associated financial losses. The potential for adverse consequences reflects the exposure to peat landslide hazard of elements at risk within a specific area.

4.1 Assessment of Probability of Peat Slide – Infinite Slope Stability Analysis

The Scottish Executive Guidelines for Peat Landslide Hazard and Risk Assessments recommends the use of Infinite Slope Stability Analysis as a quantitative method to calculate a Factor of Safety (FoS) for each study area of a site.

Factors of safety were calculated for the un-drained condition using the equation below. This formula was applied across the area of proposed infrastructure within the substation site and results are displayed in the colour coded map in Appendix A.

$$FoS = \frac{S_u}{\gamma z Sin\theta Cos\theta}$$

where S_u= Shear Strength, γ = Density, z = depth, θ = Slope Angle

4.1.1 Peat Depth

The peat depths from the peat probes were used in the analysis. Details of the peat depths throughout the site are provided in Appendix C. A summary map of the peat depths is provided in the map in Appendix B.

4.1.2 Slope Angle

For the purpose of calculating slope angle for each data point of the peat probe dataset, MWP used the Digital Elevation Model (DEM) created using the LiDAR data. For each peat probe point the AutoCAD software was used to interrogate the DEM at 3 points on a 5m radius around the peat probe (identified in red circles in the screenshot below). The software uses the elevation of those three points to create an inclined plane centred on the peat probe. The geometric slope of that inclined plane is then calculated mathematically to give the ground slope for each peat probe in the data set.

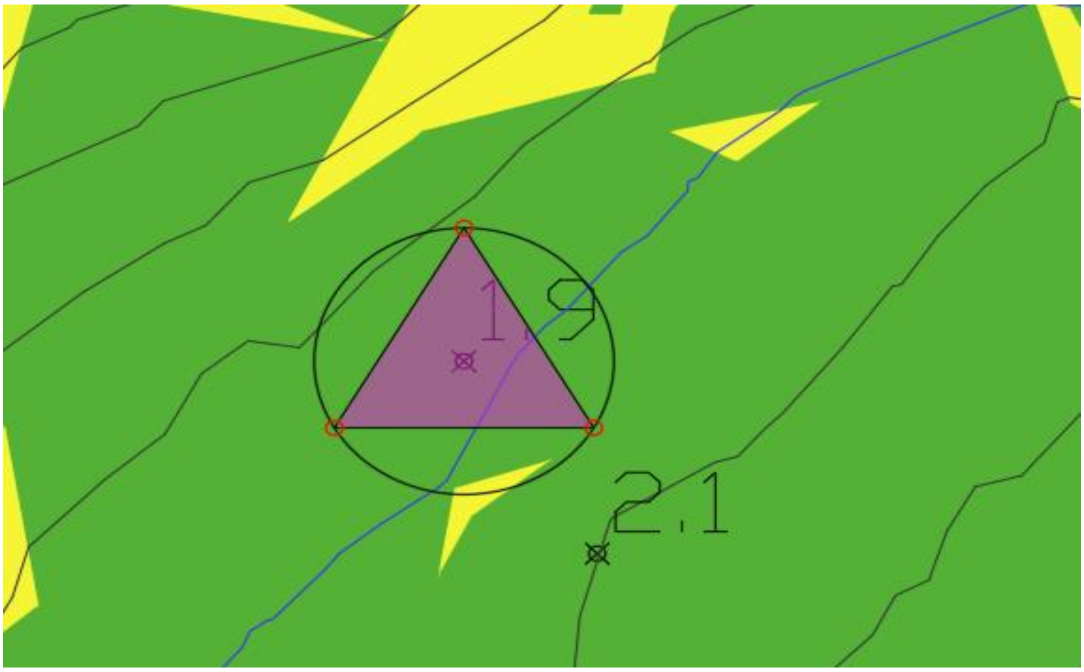

Figure 4-1 Example of DEM interrogation for slope dataset calculation

4.1.3 Shear Strength of Peat

The peat shear strengths from the hand shear vane testing conducted onsite were used in the analysis. Details of the peat shear strengths throughout the site are provided in Appendix C.

4.1.4 Bulk Density of Peat

For the purpose of calculating FoS a peat bulk density of $10kN/m^3$ was adopted. This value has been adopted based on information from “Peat slope failure in Ireland, Article in Quarterly Journal of Engineering Geology and Hydrogeology”, February 2008, N. Boylan, P. Jennings and M. Long. This paper states that the “bulk density of peat is typically similar to or less than that of water.”

4.1.5 Surcharge

A surcharge of 10kPa which represents placement of an additional 1m of peat on the existing ground surface was used in the analysis.

4.1.6 Future Climate Change

Future climate change has been taken into account in the analysis and assessment by using a surcharge loading in the analysis and by placing infrastructure in areas with a Factor of Safety against slope instability greater than 1.6 (20% higher than the minimum required by BS6031).

The surcharge can mimic additional load (during construction), or it can represent additional water (i.e. a future climate change scenario) on the slopes during construction or operational phase of the substation, or it can represent a combination of both scenarios. In either scenario, the analyses completed indicate that the slope stability risks at the Dernacart substation site poses a negligible risk (See Section 4.3).

OPW Flood Risk Management Climate Change Sectoral Adaptation Plan, September 2019, was reviewed when considering climate change in the peat stability assessment. The following is noted from this document:

"Met Éireann has predicted that in Ireland the autumns and winters may become wetter, with a possible increase in heavy precipitation events of approximately 20%, and that summers may become drier, with a projected 12-40% increase in the number of extended dry periods (Nolan, 2015)."

A FOS of 1.3 is the minimum FOS design required by "BS 6031:2009 Code of practice for earthworks". In order to account for future climate change and increase in precipitation, the minimum factor of safety used in the assessment presented in this report has been increased by 20% to 1.6 (ie 1.3 x 1.2 = 1.56 ≈ 1.6).

4.1.7 Operational and Decommissioning Phases of Project

During the operation and maintenance phase of a substation, movement of machinery is confined to the roads therefore there will be no surcharging of peat during these stages of the project life cycle. No large excavations will be required during operation and maintenance phase of the project. Therefore, surcharging of the peat is not envisaged during this phase of the project and the assessment presented in this report is more onerous than the operational and maintenance phase (i.e. the site has negligible risk for the Construction phase, therefore it has negligible risk for Operational Phase).

During the decommissioning phase, it is envisaged that the roadways will be left in place. Cables will be removed by pulling them out from the ducts as opposed to excavating them (the ducts themselves will remain in the ground). Therefore, no significant excavations or surcharging of the peat will occur during this phase of the project and the assessment presented in this report is more onerous than the decommissioning phase (i.e. the site has negligible risk for the Construction phase, therefore it has negligible risk for the Decommissioning Phase).

4.1.8 Factor of Safety Analysis Output

The output of the Factor of Safety (FOS) analysis for each peat probe location is detailed in Appendix C and shown in map format in Appendix A. A summary of the distribution of the calculated FOS is presented in Figure 4-2 and Figure 4-3.

A summary of the calculated factor of safety at the centre of each of the proposed Substation and Infrastructure Locations is provided in Table 4-1.

A FOS of 1.3 is the minimum FOS design required by "BS 6031:2009 Code of practice for earthworks". No infrastructure has been placed in areas with FOS<1.6 (allowing for future climate change as discussed in Section 4.1.6.

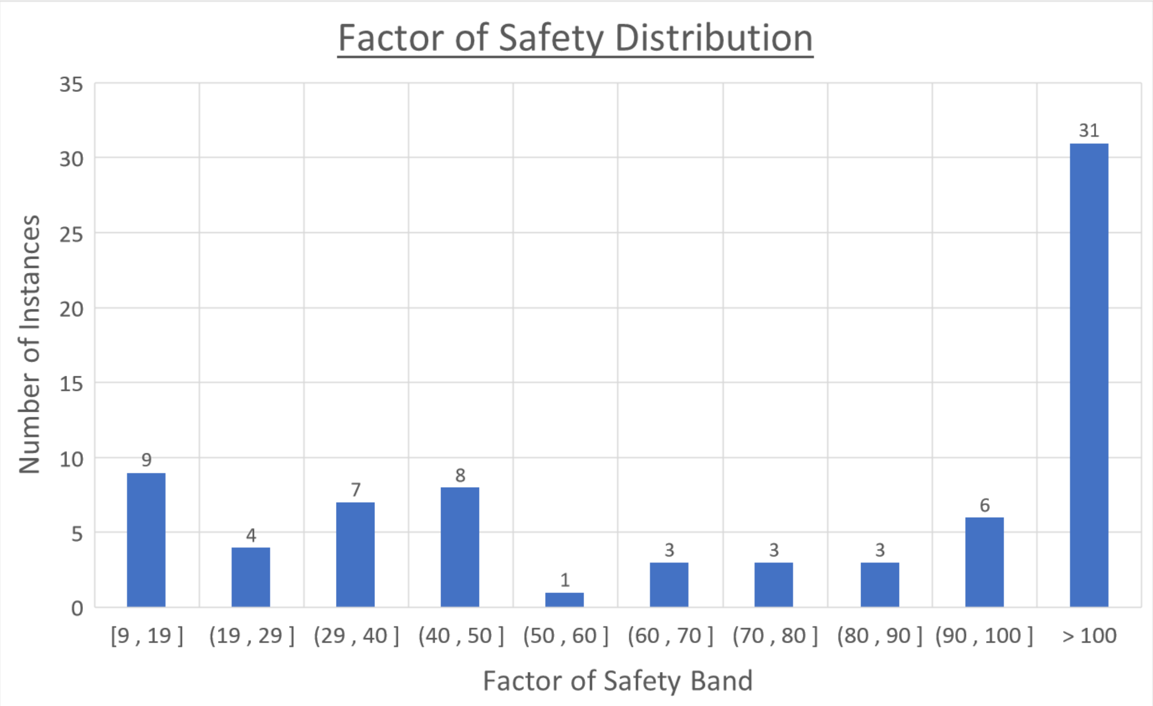

Figure 4-2 Factor of Safety Distribution

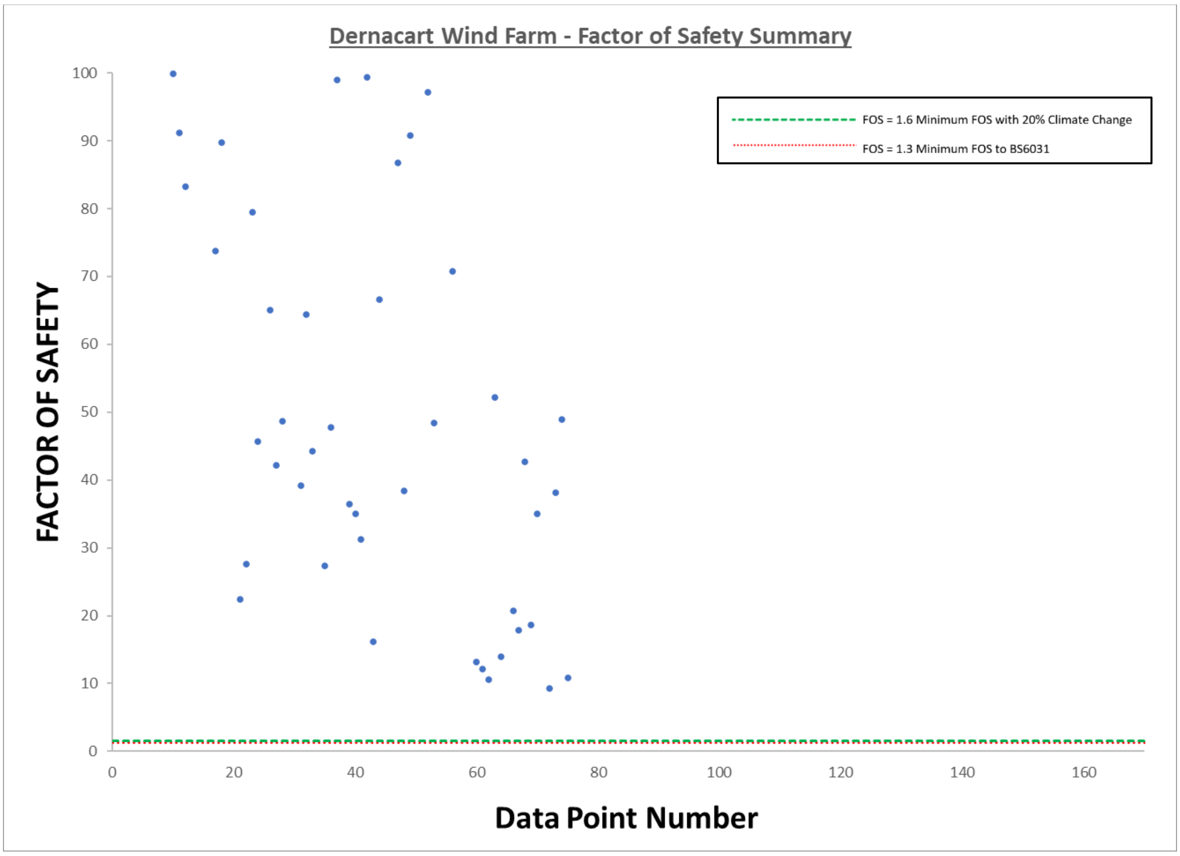

Figure 4-3 Factor of Safety Summary

Table 4-1: Summary of Factor of Safety at Proposed Infrastructure Locations

Location	Land use category	Slope (^{0})	Approx. Peat Depth (m)	Shear Strength (kPa)	Factor of Safety
Substation / Water Crossing No. 4	Coniferous Forest	0.11 to 3.5	0.6 to 2.8	16 to 33	27 to 786
Material/Peat Storage Area	Agricultural Area - Pastures	0.2 to 0.3*	0.6 to 1.2*	3.2 to 7.2*	13 to 43*
Access Road at Water Crossing No. 1	Coniferous Forest	0.28 to 2.68	0.3 to 1.0	28 to 50	74 to 427
Access Road at Water Crossing No. 2	Coniferous Forest	0.31 to 1.13	0.8 to 1.8	24 to 39	46 to 396
Access Road at Water Crossing No. 3	Coniferous Forest	0.08 to 1.18	1.0 to 1.8	10 to 25	38 to 607
Access Road at Water Crossing No. 5	Coniferous Forest	0.82 to 2.73	1.1 to 1.2	11 to 16	11 to 52
* As per PSRA carried out by Fehily Timoney for Dernacart Wind Farm in December 2019.					

4.1.9 Assessment of Probability of Occurrence Based on Factor of Safety Analysis

The probability of occurrence of a landslide for use in the risk assessment has been quantified below based on the factor of safety analysis completed for this site.

Table 4-2: Probability of Landslide based on Factor of Safety Analysis

Scale	Probability of Occurrence	FOS	Comment
5	Almost Certain	< 1	Factors of safety less than 1 indicate that a landslide is almost certain to occur
4	Likely	1 to 1.3	Above 1 indicates it is stable but below 1.3 is not acceptable in BS 6031:2009 standard
3	Unlikely	1.3 to 1.6	Slightly higher FOS than that required by BS 6031:2009 however a larger value is desirable to account for future climate change
2	Very Unlikely	1.6 to 2.0	Values above 1.6 are higher than what is required by BS 6031:2009 and have an additional 20% buffer for future climate change
1	Negligible	> 2.0	Values above 2 are considered to have a negligible probability of occurrence of landslide.

4.2 Assessment of Adverse Consequences

Potential adverse consequences, in the event that a peat landslide does occur, have been estimated. The intention was to represent consequences as a range that can be applied to specific areas of the development site. For example, the consequences of a landslide occurring for a watercourse depend on how far the landslide is from it, or on the importance of a watercourse from a habitat perspective, e.g. it may be designated as a Special Area of Conservation (SAC). A review was completed to identify potential receptors in the event of a peat slide.

Consequences and receptors considered include the following elements:

- The potential for harm to life during construction;
- The potential economic costs associated with lost infrastructure, or delay in programme;
- The potential for permanent, irreparable damage to the peat resource (both carbon stock and habitat) associated with mobilisation (and ultimately loss) of peat in a landslide; and
- The potential for ecological damage to watercourses, NHA, SAC or SPA subject to inundation by peat debris.

4.2.1 Potential Harm to Life During Construction

Peat slides have a potential to cause harm to life during construction if construction activities are not managed properly. For the purpose of assessing the adverse consequences associated with harm to life during construction, the peat depth has been used as the criteria for quantitatively assessing the potential for harm to life. Deeper deposits of peat increase the potential for inundation in peat and hence the potential for harm to life. The impact scale is shown below in Table 4-3. A score of 1 is considered a low rating and a score of 5 is considered a high rating.

Table 4-3: Impact Score - Potential Harm to Life Adverse Consequence

Impact Scale	**Criteria Peat Depth (m)**
1	0-1
2	1-2
3	2-3
4	3-4
5	4+

4.2.2 Potential Economic Costs Associated with Loss of Infrastructure

The economic costs associated with loss of Infrastructure has considered the distance of the proposed substation infrastructure from public roads, power lines, gas lines, houses, railway lines etc. The following pieces of infrastructure have been identified and considered in this assessment:

- The existing high voltage electrical lines running through the site
- The existing houses in the area
- The existing public road to the south of the site
- No railway line has been identified within 5 km of the site
- No gas line has been identified within 5 km of the site

Table 4-4: Impact Scale - Potential Economic Costs Associated with Loss of Infrastructure

Impact Scale	**Criteria** **Distance from Proposed Infrastructure (m)**
1	Proposed infrastructure element greater than 150m from existing infrastructure
2	Proposed infrastructure element within 101 to 150m of existing infrastructure
3	Proposed infrastructure element within 51 to 100m of existing infrastructure
4	Proposed infrastructure element within 21 to 50m of existing infrastructure
5	Proposed infrastructure element within 20m of existing infrastructure

4.2.3 Potential Permanent Damage/Loss of Peat Resource

The assessment of potential Damage/Loss of Peat Resource has been based on the peat depth at each proposed piece of infrastructure. Deeper deposits of peat increase the potential volume of peat within a landslide and hence the potential damage / loss of the peat resource. The impact scale is shown below in Table 4-3.

Table 4-5: Impact Score - Potential Harm to Life Adverse Consequence

Impact Score	Criteria Peat Depth (m)
1	0-1
2	1-2
3	2-3
4	3-4
5	4+

4.2.4 The Potential for Ecological Damage to EPA Mapped Watercourses/SACs/NHAs/SPAs

The potential for ecological damage to EPA mapped watercourses has been assessed based on the distance of proposed infrastructure to the watercourse. There are no Special Areas of Conservation or Special Protection Areas in the vicinity of the site. A constraints map, including the location of the NHA and watercourses, is shown in Figure 4-4.

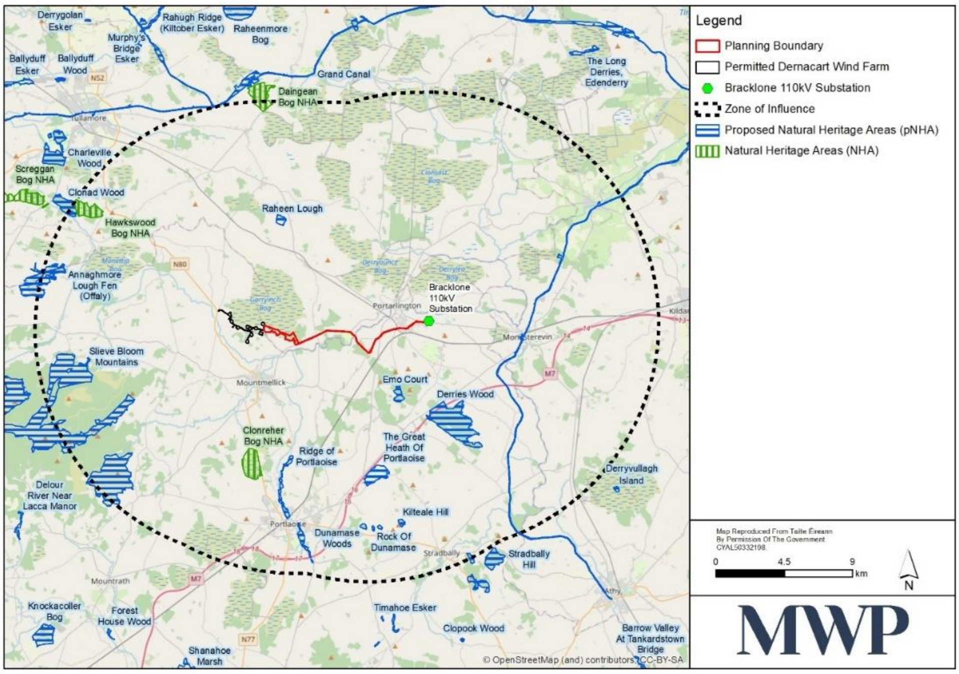

Figure 4-4 Constraints Map

Table 4-6: Impact Score - Potential for Ecological damage to Watercourse

Impact Score	Criteria Distance from Proposed Infrastructure to watercourse (m)
1	Proposed infrastructure element greater than 150m from watercourse or NHA/SPA/SAC
2	Proposed infrastructure element within 101 to 150m of watercourse or NHA/SPA/SAC
3	Proposed infrastructure element within 51 to 100m of watercourse or NHA/SPA/SAC
4	Proposed infrastructure element within 21 to 50m of watercourse or NHA/SPA/SAC
5	Proposed infrastructure element within 20m of watercourse or NHA/SPA/SAC

4.2.5 Summary Table of Potential Adverse Consequences and Associated Impact Rating

In order to assess the overall risk based on the impact scores for each of the consequences discussed in previous sections, an adverse consequence rating is applied to the impact scores discussed in previous sections of this report. Table 4-7 summarises the Adverse Consequence Rating for each impact score band.

A summary of the impact criteria and associated impact scores for each of the proposed infrastructure locations is provided in Table 4-9.

Table 4-7: Impact Score - Adverse Consequence Rating for use in Risk Assessment

Adverse Consequence Rating	Total Impact Score	Description
1	0 to 4	Negligible
2	5 to 8	Low
3	9 to 12	Moderate
4	13 to 16	High
5	16 to 20	Extremely High

Table 4-8: Impact Criteria Summary

	Substation / Water Crossing No.4	Peat and Spoil Deposition Area	Access Road at Water Crossing No.1	Access Road at Water Crossing No.2	Access Road at Water Crossing No.3	Access Road at Water Crossing No.5
The potential for harm to life during construction (Peat depth in m)	2.8	1.2	1	1.8	1.8	1.2
The potential economic costs associated with lost infrastructure, or delay in programme (Distance to infrastructure in m)	100m to Public Road 320m from house 80m from pylon line	No Public Road, houses or pylon lines within 1000m	No Public Road, houses or pylon lines within 1000m	No Public Road, houses or pylon lines within 1000m	550m to Public Road 570m from house 430m from pylon line	At the Public Road 320m from house 30m from pylon line
The potential for permanent, irreparable damage to the peat resource (Peat depth in m)	2.8	1.2	1	1.8	1.8	1.2
The potential for ecological damage to watercourses subject to inundation by peat debris. (Distance to watercourse/NHA/SAC/SPA in m)	30m from watercourse. No NHA, SAC or SPA within 1000m	670m from watercourse. No NHA, SAC or SPA within 1000m	At the watercourse. No NHA, SAC or SPA within 1000m	At the watercourse. No NHA, SAC or SPA within 1000m	At the watercourse. No NHA, SAC or SPA within 1000m	At the watercourse. No NHA, SAC or SPA within 1000m

Table 4-9: Impact Score Summary

Impact Score

	Substation / Water Crossing No.4	Peat and Spoil Deposition Area	Access Road at Water Crossing No.1	Access Road at Water Crossing No.2	Access Road at Water Crossing No.3	Access Road at Water Crossing No.5
The potential for harm to life during construction	3	2	1	2	2	2
The potential economic costs associated with lost infrastructure, or delay in programme	3	1	1	1	1	5
The potential for permanent, irreparable damage to the peat resource (both carbon stock and habitat) associated with mobilisation (and ultimately loss) of peat in a landslide	3	2	1	2	2	2
The potential for ecological damage to watercourses subject to inundation by peat debris	5	5	5	5	5	5
Sum of Scores	**14**	**10**	**8**	**10**	**10**	**14**
Adverse Consequence Rating	**4**	**3**	**2**	**3**	**3**	**4**
Adverse Consequence Description For Risk Assessment	**High**	**Moderate**	**Low**	**Moderate**	**Moderate**	**High**

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4.3 Determination of Risk

The risk associated with peat landslides at this site was calculated using the below formula and the scores from Table 4-2 and Table 4-9.

Risk = Probability of Landslide (From Table 4-2*) × Adverse Consequences (From* Table 4-9*)* *Eq. 2*

The risk associated with the site was quantified based on Table 4-10 from "Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments", Energy Consents Unit Scottish Government, Second Edition 2017.

A summary of the results of the risk assessment is provided in Table 4-11. It should be noted that proposed infrastructure has been location in areas of negligible risk within the site.

Table 4-10: Risk Score and Description Summary

			Adverse Consequence				
			Extremely High	**High**	**Moderate**	**Low**	**Very Low**
			5	**4**	**3**	**2**	**1**
Peat Slide Probability or Likelihood	**Almost Certain**	**5**	25 (High)	20 (High)	15 (Moderate)	10 (Moderate)	5 (Low)
	Likely	**4**	20 (High)	16 (Moderate)	12 (Moderate)	8 (Low)	4 (Negligible)
	Likely	**3**	15 (Moderate)	12 (Moderate)	9 (Low)	6 (Low)	3 (Negligible)
	Unlikely	**2**	10 (Moderate)	8 (Low)	6 (Low)	4 (Negligible)	2 (Negligible)
	Negligible	**1**	5 (Low)	4 (Negligible)	3 (Negligible)	2 (Negligible)	1 (Negligible)

Table 4-11: Risk Summary at Substation Infrastructure

Location	Probability / Likelihood Score (A)	Adverse Consequence Score (B)	Risk Rating Score (A x B)	Risk Description
Substation / Water Crossing No.4	1	4	4	Negligible
Material / Peat Storage Area	1	3	3	Negligible
Access Road at Water Crossing No.1	1	2	2	Negligible
Access Road at Water Crossing No.2	1	3	3	Negligible
Access Road at Water Crossing No.3	1	3	3	Negligible
Access Road at Water Crossing No.5	1	4	4	Negligible

4.4 Cumulative Impact

The cumulative impact of the development on the on peat stability has been reviewed.

Peat stability is local to the point of construction, and this has been assessed at 75 locations within the proposed Wind Farm site. Other local wind farms (e.g Mount Lucas Wind Farm, Moanvane Wind Farm and Derrinlough Wind Farm have no potential to impact on peat stability at the Dernacart site and vice versa due to the topography of the area and distance between the wind farms.

Another important observation is the fact that the wind farms local to Dernacart, which have similar ground conditions, have been successful completed without occurrence of peat instability.

5. Mitigation Measures

The peat stability risk assessment described above has yielded a negligible risk rating for this site. The engineering response for areas with negligible risk level is that the "project should proceed with monitoring and mitigation of peat landslide hazards at these locations as appropriate". This is in accordance with Table 5.4 of Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments, Energy Consents Unit Scottish Government, Second Edition 2017 (Scottish Guidelines).

Table 5-1: Suggested Actions for Peat Slide Risk Level

Risk Level	Action suggested for each zone
High	Avoid project development at these locations
Medium	Project should not proceed unless risk can be avoided or mitigated at these locations, without significant environmental impact, in order to reduce risk ranking to low or negligible
Low	Project may proceed pending further investigation to refine assessment and mitigate hazard through relocation or re-design at these locations
Negligible	Project should proceed with monitoring and mitigation of peat landslide hazards at these locations as appropriate

Source: Table 5.4 of Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments, Energy Consents Unit Scottish Government, Second Edition 2017 (Scottish Guidelines)

Mitigation measures are presented in 5.1 to 5.3. All of these mitigation measures shall be implemented at Dernacart Substation. While peat movement is unlikely to occur, if onsite mitigation measures are not adhered to and peat movement is noted, a series of emergency responses and procedures that would be implemented are also listed below. Experience and vigilance are fundamental requirements when working on peat where inappropriate construction methodology can cause instability in otherwise stable conditions. Therefore, the appointed contractor shall review all of their methodologies, equipment, construction vehicle loads and safety procedures against the information in this report and produce temporary works designs appropriate to their procedures which take into account peat stability.

5.1 Design Mitigations (Avoidance of Hazards)

The design mitigation used on this project has avoided high risk areas. An iterative design process was followed where the layout was adjusted based on information from peat probe surveys and topographical surveys.

5.2 Engineered Mitigations

5.2.1 Construction Management

The appointed contractor and detailed designer will be required to produce a detailed Construction Stage Peat Management Plan which aligns with their detailed design and construction methodologies. This shall include details of site specific monitoring plans. Any residual stability risks that remain at the end of the construction phase shall be detailed in the Safety File.

The Construction Manager for the project should impart the philosophy that everyone on the site is aware of peat stability and report any sign of misalignment in monitoring posts. The methodology of all civil works should be reviewed by the Geotechnical Engineer.

The following general measures incorporated into the construction phase of the project will assist in the management of the risks for this site:

- Appointment of experienced and competent contractors and detailed designers;
- The construction works on site should be supervised by experienced and qualified personnel;
- Ensure construction method statements are followed or where agreed modified/ developed.
- Allocate sufficient time for the project to be constructed safely with all peat stability mitigation measures included in the programme;
- Set up, maintain and report findings from monitoring systems, including sightline monitoring;
- Maintain vigilance and awareness through Tool-Box-Talks (TBTs) on peat stability;
- Prevent undercutting of slopes and unsupported excavations;
- Prevent placement of loads/overburden on marginal ground; and,
- Manage and maintain a robust drainage system. This will be the responsibility of the appointed contractor and their designer.

Vigilance is a fundamental requirement when working on peat where inappropriate construction methodology can cause instability in otherwise stable conditions. Only competent and experienced contractors will be employed for this project.

5.2.1.1 Rainfall Mitigations

It is notable the previous peat slide in Ireland have generally occurred after prolonged periods of heavy rain (eg landslides at Meenbog, Derrybrien and Ballincollig Hill). Therefore, it is important to have precautions in place regardless of the negligible risk level of peat slide risk at the site. For the duration of the construction work the contractor will use weather forecasting (e.g. using Met Éireann website) to plan works their work and suspense /cease the works during periods of prolonged rainfall.

5.2.2 Monitoring

The precautionary principle dictates that monitoring should be carried out in areas where peat is present. The level of peat monitoring recommended for the site reflects the strategy of placing infrastructure in low risk areas of the site. With the siting of infrastructure using mitigation by avoidance higher risk parts of the site have been avoided as described in Section 5.1, sightline monitoring is considered appropriate for the Dernacart site.

Monitoring by sightlines entails driving a series of posts at approximately 5m centres, exactly aligned, across the section of bog being monitored. An illustration of this approach is given below in Figure 5-1. Any signs of distress or deformation in the bog will quickly manifest itself by some of the posts moving out of alignment. Early discovery of stress in the peat will give the developer an opportunity to implement emergency procedures to prevent the onset of a bog burst or localised peat slide. While the risk of such occurrence is low in this instance, the precautionary principle dictates that monitoring posts should be installed in work areas where peat is present.

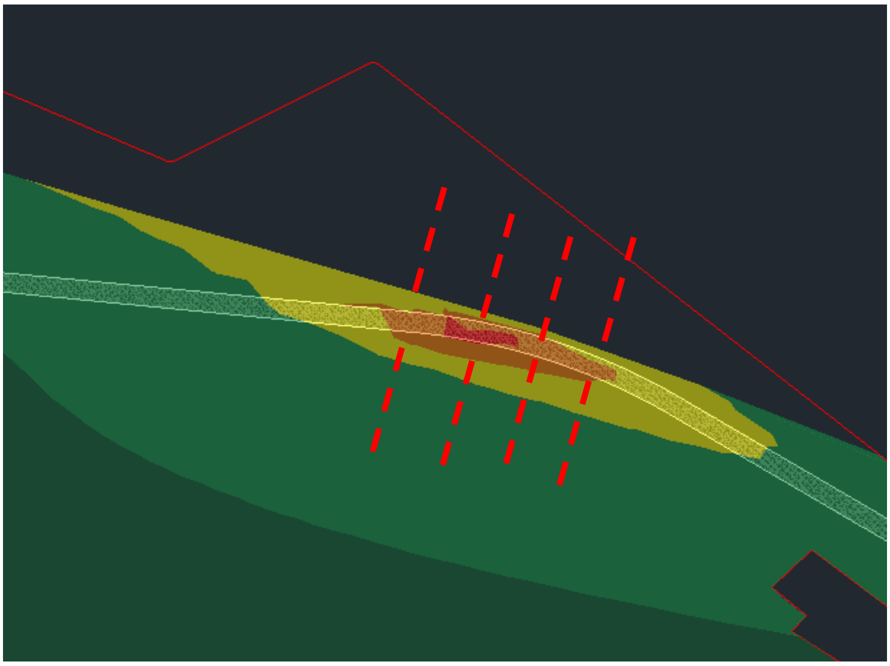


Figure 5-1 Example of Typical Sightline Post Layout

5.3 Control Slide

Despite the negligible risk on this site, it is good practice to have a slide control plan in place in any case. Emergency procedures are the responsibility of the appointed contractor and are to be included in the appointed contractor's method statements. These typically include the following:

- Emergency response procedures to protect the health and safety of workers and to implement containment procedures for remoulded peat slurry on or off site.
- Identification of potential flow paths of peat slides to determine accessible intervention points on or off site to construct barrages, settlement ponds and silt traps to contain the peat slurry and to prevent downstream contamination of watercourses.
- Stockpiling of rockfill on or off site to use in the construction of emergency containment barrages in the event of a slide.

6. Conclusion

Statkraft Ireland engaged Malachy Walsh and Partners (MWP) to complete a Peat Stability Risk Assessment as part of the EIAR for the proposed Dernacart 110kV Substation and Grid Connection in Co. Laois and Co. Offaly.

The location of the Dernacart 110kV Substation and Grid Connection infrastructure was designed from the outset with a constraint driven approach. This approached placed substation in area of low risk for peat slides and avoided environmentally sensitive areas.

MWP completed walkovers and surveys of the site. 75 peat probes were completed across the site with peat depths ranging from 0.25m to 3.68m. Shear strengths were recorded ranging from 10kPa to 78kPa.

MWP used LiDAR data to create a Digital Elevation Model (DEM) of the site. Slope analysis from the DEM was used to identify areas of the site with low ground slope. On this site, the ground slope was found to be low across the entire site.

MWP completed a two-stage peat stability risk assessment approach. Stage 1 was based on desk study information, site reconnaissance and assessment of contour data. Stage 1 concluded that further quantitative stability risk assessment was required for this site. Stage 2 involved quantitative risk assessment factor of safety analysis (Infinite Slope Stability Analysis), and application of the Peat Slide Hazard Rating System (PHRS) (Nichol, 2006). Both stages were completed for this project. This approach is in line with industry best practice guidance, as published by the Scottish Government PLHRA (Energy Consents Unit, Scottish Government, 2017).

The findings of the PHRS, carried out as part of the Stage 2 assessment, were that the risk level is Negligible.

Following on from the PHRS, MWP completed an Infinite Slope Stability Analysis (ISSA) for the site using the peat probe data and slope data from the LiDAR DEM to calculate the Factor of Safety (FoS) against peat slide for each location probed. The ISSA output found that FoS ranged from 9 to 1796.

MWP completed assessments of the risk presented using the industry best practice guidance of the Scottish Executive and Scottish Government guidelines for Peat Landslide Hazard and Risk Assessments. The outcome of the risk assessment was that the risk level is Negligible.

Design measures in the form of a peat stability monitoring programme during construction has been proposed in order to further mitigate and manage risk.

7. References

British Standards Institute (2009). BS 6031:2009 Code of practice for earthworks

Nichol, D., 2006. Peatslide hazard rating system for wind farm development purposes. Proceedings of the 28th Annual Conference of the British Wind Energy Association (BWEA28, Glasgow), 00-00

OPW Flood Risk Management Climate Change Sectoral Adaptation Plan, September 2019.

Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments, Energy Consents Unit Scottish Government, Second Edition 2017.

Draft Revised Wind Energy Development Guidelines December 2019

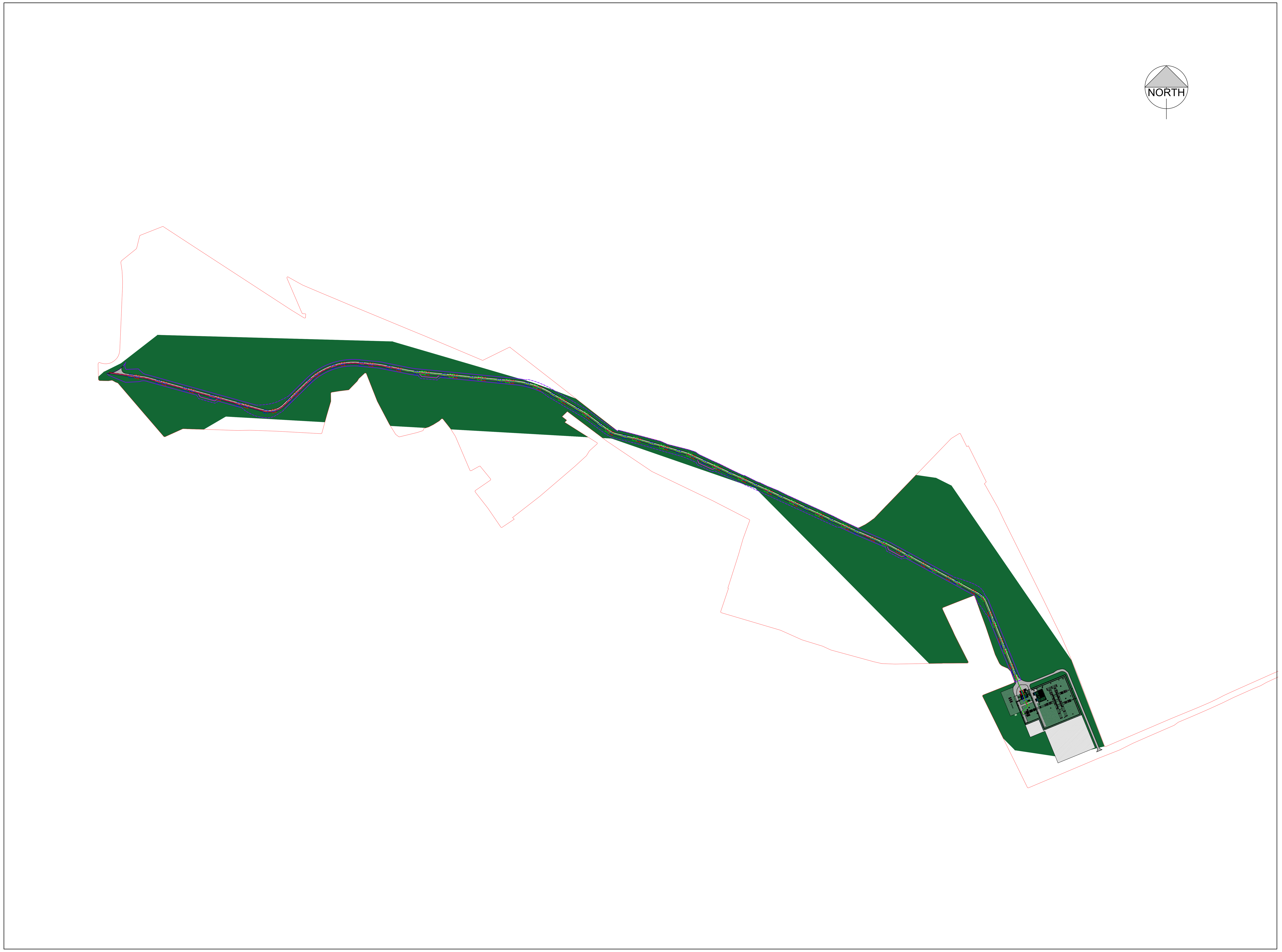
Geological Survey of Ireland, Online Mapping System, https://www.gsi.ie/en-ie/Pages/default.aspx [Accessed on 22/06/2022]

EPA Maps, https://gis.epa.ie/EPAMaps/, Accessed on 29/07/2022

Peat Stability Report, Fehily Timoney, December 2019

Appendix A

Factor of Safety Map



FoS WITH SURCHARGE INCLUDED	RISK LEVEL	RISK CATEGORY	MITIGATION MEASURE
>2	1	NOMINAL	Values above 2 are considered to have a negligible probability of occurrence of landslide.
1.6 - 2	2	LOW	Values above 1.6 are higher than what is required by BS 6031:2009 and have an additional 20% buffer for future climate change
1.3 - 1.6	3	MEDIUM	Slightly higher FOS than that required by BS 6031:2009 however a larger value is desirable to account for future climate change
1 - 1.3	4	SIGNIFICANT	Above 1 indicates it is stable but below 1.3 is not acceptable in BS 6031:2009 standard
<1	5	HIGH	Factors of safety less than 1 indicate that a landslide is almost certain to occur

NOTES:

1. ALL DRAWINGS ARE TO BE READ IN CONJUNCTION WITH ALL RELEVANT SPECIFICATIONS, BILLS OF QUANTITIES, ARCHITECTURAL, SERVICES AND ENGINEERING DRAWINGS.
2. ALL LEVELS ARE IN **METRES** RELATED TO ORDNANCE DATUM MALIN HEAD, OSGM15.
3. ALL CO-ORDINATES ARE TO IRISH TRANSVERSE MERCATOR (ITM) AND IN **METRES**.
4. ANY DISCREPANCIES BETWEEN THESE DOCUMENTS SHALL BE BROUGHT TO THE ATTENTION OF THE ENGINEER.
5. DRAWINGS ARE NOT TO BE SCALED.
6. ALL DIMENSIONS ARE IN **METRES**, UNLESS NOTED OTHERWISE.

REV	DATE	DESCRIPTION	BY	APP
P02	07.10.24	ISSUED FOR INFORMATION	MP	PC
P01	02.05.24	ISSUED FOR INFORMATION	MP	BS

PROJECT:
DERNACART 110kV SUBSTATION AND GRID CONNECTION

TITLE:
FACTOR OF SAFETY MAP

CLIENT:
DERNACART WIND FARM LTD.

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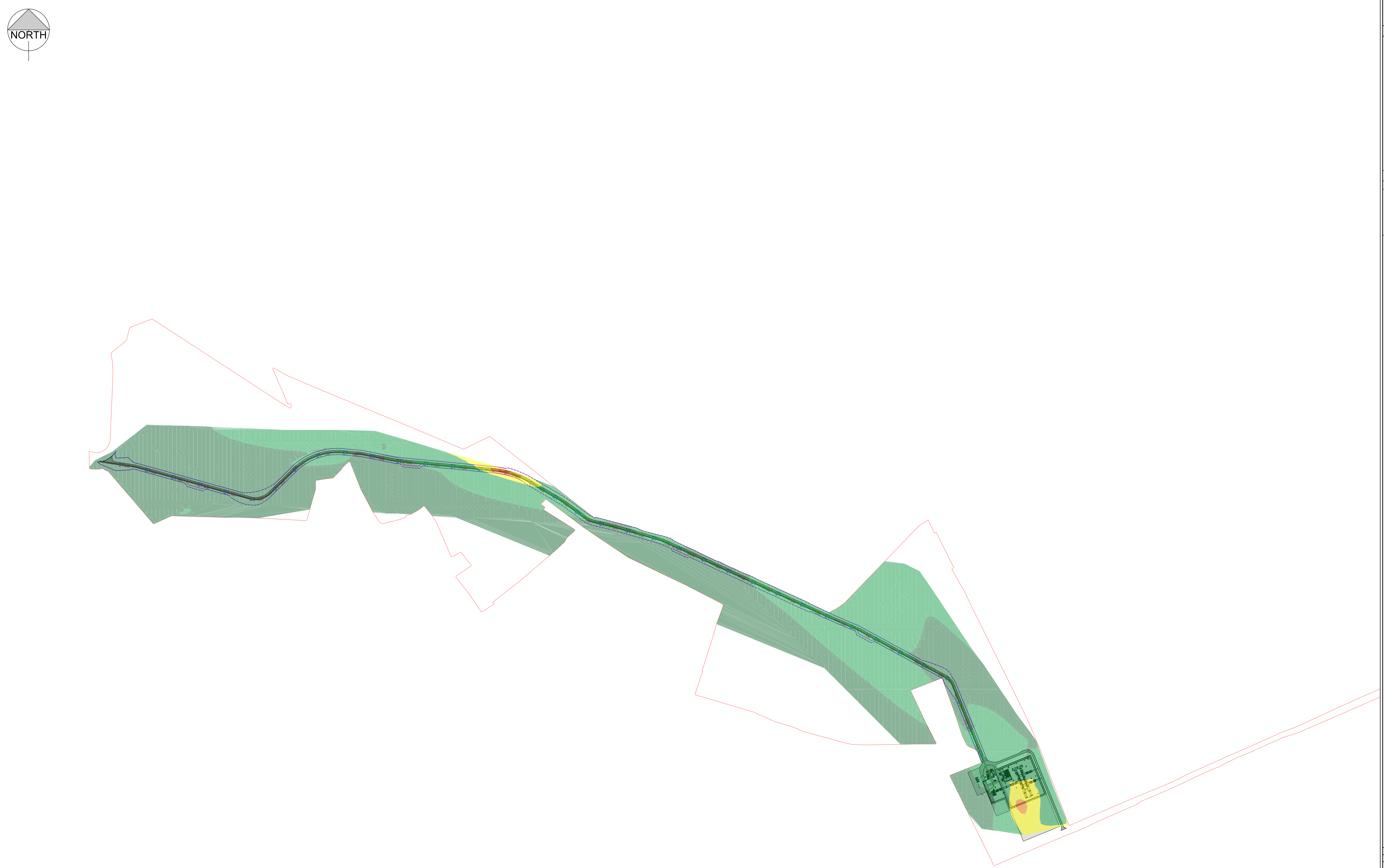
DRAWN:	CHECKED:	APPROVED:
M.P.	P.C.	P.C.
PROJECT NUMBER: 23268	DATE: MAY/24	SCALE @ A1: 1:5000

STATUS DESCRIPTION: FOR INFORMATION | STATUS: S2

DRAWING NUMBER: 23268 - MWP - ST - 00 - SK - C - 0014 | REV: P02

Appendix B

Peat Depth Map



NOTES:

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5. DRAWINGS ARE NOT TO BE SCALED.
6. ALL DIMENSIONS ARE IN **METRES**, UNLESS NOTED OTHERWISE.

PEAT DEPTH LEGEND

COLOUR CODING	PEAT DEPTH RANGE
(dark green)	0.0m -1.0m
(green)	1.0m-2.0m
(yellow)	2.0m-2.5m
(orange)	2.5m-3.0m
(red)	>3.0m

REV	DATE	DESCRIPTION	BY	APP
P02	07.10.24	ISSUED FOR INFORMATION	MP	PC
P01	02.05.24	ISSUED FOR INFORMATION	MP	PC

PROJECT:
DERNACART 110kV SUBSTATION AND GRID CONNECTION

TITLE:
PEAT DEPTH MAP

CLIENT:
DERNACART WIND FARM LTD.

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DRAWN:	CHECKED:	APPROVED:
M.P.	P.C.	P.C.
PROJECT NUMBER: 23268	DATE: MAY/2024	SCALE @ A1: 1:5000

STATUS DESCRIPTION:	STATUS:
FOR INFORMATION	S2

DRAWING NUMBER:	REV:
23268 - MWP - ST - 00 - SK - C - 0015	P02

Appendix C

Results of Infinite Slope Stability Analysis

Easting	Northing	PeatDepth(m)	Shear(kPa)	Slope(deg)	FoS	Risk
645076	710921	0.8	78	0.141	1795.846	0
645143	710902	1.2	24	0.325	196.185	0
645197	710898	1.5	65	0.655	231.079	0
645266	710875	1.9	58	0.329	354.564	0
645319	710856	1	46	0.294	443.529	0
645062	710852	0.8	50	0.356	451.644	0
645129	710833	0.8	48	0.33	450.622	0
645171	710833	1.2	50	0.622	213.292	0
645240	710808	1.1	44	0.677	179.059	0
645239	710808	1.1	26	0.697	99.938	0
645371	711133	0.3	50	2.365	91.185	0
645401	711186	0.7	42	1.711	83.285	0
645424	711125	0.7	28	0.324	300.348	0
645425	711069	0.6	60	0.516	406.609	0
645488	711116	1	38	0.288	385.762	0
645515	711075	0.9	40	0.28	427.014	0
645465	711030	0.5	50	2.684	73.727	0
645568	711043	0.5	32	1.353	89.778	0
645501	710978	1.1	60	1.008	166.471	0
645560	710996	0.3	45	1.135	181.847	0
646271	711076	2.2	30	2.416	22.466	0
646322	711058	2	26	1.801	27.595	0
646363	711035	1.8	26	0.682	79.489	0
646414	710999	1.7	24	1.133	45.653	0
646529	710943	0.8	39	0.312	396.287	0
646607	710920	1.2	24	0.949	64.998	0
646687	710890	1	29	1.974	42.119	0
646747	710860	0.7	36	2.496	48.677	0
646794	710829	0.7	43	1.259	113.783	0
646857	710808	1.1	33	0.366	243.989	0
646911	710776	1.4	40	2.428	39.22	0
646986	710748	1.2	30	1.23	64.437	0
647396	710333	1.1	28	1.771	44.228	0
647452	710351	2	20	0.113	343.469	0
647507	710387	0.9	33	3.548	27.4	0
647466	710320	2	16	0.639	47.791	0
647519	710347	2	21	0.405	98.917	0
647420	710279	0.6	38	0.173	785.827	0
647488	710275	2.8	30	1.232	36.431	0
647534	710300	2.1	25	1.302	35.039	0
647531	710227	2.1	29	1.713	31.216	0
647577	710252	1.3	28	0.708	99.384	0
646245	711077	3.7	12	0.908	16.175	0
647016	710742	1.6	15	0.49	66.666	0
647079	710707	1.1	16	0.159	277.872	0
647138	710677	1.8	16	0.243	133.53	0
647169	710757	1.8	20	0.48	86.807	0
647181	710789	1.7	10	0.558	38.345	0
647193	710816	1.8	16	0.364	90.812	0
647214	710853	1.4	21	0.082	606.585	0
647250	710835	1.1	18	0.32	153.554	0
647229	710798	1.1	18	0.51	97.212	0

647221	710779	1.1	21	1.177	48.474	0
647204	710748	1.3	20	0.275	180.149	0
647176	710720	1.6	25	0.501	107.985	0
647182	710687	1.4	21	0.696	70.812	0
647215	710638	1	25	0.482	150.193	0
647310	710598	0.8	18	0.286	202.335	0
647352	710534	0.9	20	0.602	101.749	0
647387	710467	1.8	21	3.329	13.127	0
647386	710467	0.9	14	3.401	12.188	0
646086	711090	1.2	11	2.725	10.529	0
646166	711083	1.1	16	0.817	52.177	0
645907.98	711159.73	2	15	2.037	13.936	0
645947.55	711170.66	1.8	36	0.507	145.238	0
645982.87	711135.7	1.4	18	2.103	20.71	0
645962.16	711132.25	1.7	30	3.564	17.841	0
645939.33	711128.73	1.9	18	0.83	42.73	0
645903.9	711125.07	1	30	4.684	18.618	0
645965.55	711133.62	0.3	31	3.828	34.993	0
645829.3	711127.3	0.9	38	0.253	454.505	0
645847.58	711108.28	1.7	36	8.479	9.28	0
645927.29	711102.21	0.4	34	3.685	38.135	0
646006.91	711095.92	0.8	20	1.267	48.904	0
646086.33	711089.66	1.2	11	2.658	10.792	0