Chleansaid Wind Farm 132 kV OHL Connection

Environmental Appraisal (EA) Report

Appendix 10.1 Stage 1 Peat Landslide Hazard Risk Assessment

November 2024

Scottish & Southern Electricity Networks

TRANSMISSION

Scottish Hydro Electric Transmission plc

Inveralmond House

200 Dunkeld Road

Perth PH1 3AQ

Tel: +44 (0)1738 456 000

www.ssen-transmission.co.uk

Scottish & Southern Electricity Networks

TRANSMISSION

CONTENTS

1. INTRODUCTION

1.1 Background

1.1.1 This report forms an Appendix to Environmental Appraisal (EA) Report **Chapter 10: Hydrology, Hydrogeology, Geology and Soils** and should be read with reference to this chapter and associated figures.

1.1.2 The Proposed Development will be located on land approximately 3 km to the north of Lairg, in the Sutherland region of the Highlands and within the Local Authority area of The Highland Council (THC). The Proposed Development consists of the construction of a new 132 kV overhead line (OHL) connection supported on 132 trident wood poles approximately 10.5 km in length running from the consented Chleansaid Wind Farm Substation to the existing Dalchork Substation.

1.1.3 Ancillary works to enable the Proposed Development would include tree felling and vegetation clearance, new access bellmouths from existing roads, construction of a small number of temporary access using bog mats and / or trackway, and temporary measures to protect road and water crossings. Deemed planning permission would be sought for these as part of the application for consent. The Scottish Government's Peat Landslide Hazard and Risk Assessment Guidance[1] provides information on methods for identifying, mitigating and managing peat landslide hazards and their associated risks. This Guidance has been used for this assessment. Section 37 applications under the Electricity Act 1989[2], should also be assessed for detailed peat landslide risk in response to demonstrable requirement following peat landslide hazard risk assessment where infrastructure is proposed in peatland areas, as outlined in Scottish Government guidance for Section 37 applications without an EIA[3].

1.1.4 WSP were commissioned in 2023 to undertake a peat stability assessment for the Proposed Development, in conjunction with the soil and water elements of the EA.

1.1.5 This document presents WSP's method for a Peat Stability Risk Assessment, the analyses undertaken and the findings, which are based on peat depth surveys undertaken by WSP in 2024 and by preceding data gathered by a third party.

1.2 Study Area

1.2.1 The Study Area for the peatland assessment extends 250 m from the proposed OHL route as shown on **Figure 10.1.1**.

1.2.2 Land use within and surrounding the Site is dominated by commercial forestry operations, with forestry blocks located to the north and south, and associated access tracks and openings located throughout the Site. Outside of

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1 Scottish Government (2017). Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (Second Edition). [online] Available at: http://www.gov.scot/Publications/2017/04/8868 [Accessed in April 2024].

2 Department of Energy and Climate Change (2016). Electricity Act 1989. [online] Available at: https://assets.publishing.service.gov.uk/media/5a80c002ed915d74e62303b1/Electricity_Act_1989__Energy_Bill_2015-16_Keeling_Schedule_.pdf [Accessed September 2024]

3 Scottish Government (2019). Applications to the Scottish Ministers under Section 37 of The Electricity Act 1989 Without an EIA Report: Guidance - Processing Applications (August 20129 update). [online] Available at: https://www.gov.scot/binaries/content/documents/govscot/publications/advice-and-guidance/2018/12/energy-consents-overhead-line-applications-without-an-eia-report/documents/s37-applications-without-an-eia-report-guidance/s37-applications-without-an-eia-report-guidance/govscot%3Adocument/Section%2B37%2Bapplications%2Bwithout%2Ban%2BEIA%2Breport%2B-%2Bguidance%2B-%2Bupdated%2BAugust%2B2019.pdf [Accessed September 2024]

the forestry areas, most of the Site and surrounding area is classified as Class 5-3 agricultural land. Artificial drainage is present to a degree across the Site.

1.3 Objectives of this PLHRA

1.3.1 The aims of this assessment were to:

- provide a good level of understanding of site baseline (pre-development) peat stability conditions;
- aid the Proposed Development design in order to reduce development activities that could cause an increased likelihood of peat instability, by careful consideration of infrastructure location and also construction techniques employed;
- identify the receptors that would be subject to adverse consequences, should a peatslide occur; and
- report peat stability risk assessment outcomes of the design following the principles of the Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments.

1.4 Methods

1.4.1 The methods adopted by WSP for the PLHRA of the Proposed Development have involved the following stages:

- desk study review of peat stability literature and available site data;
- aerial imagery review;
- site reconnaissance including peat depth survey to characterise the prevailing ground conditions and identify existing or potential peat instability;
- Ground Investigation (GI) at specific locations of concern to provide additional data;
- stability analysis to identify initial risk using a purposefully cautious factor of safety (FoS) method;
- revised risk assessment based on additional site information and visits to locations of concern, presented as datasheets detailing local characteristics and appropriate mitigation for specific locations of concern; and
- summarising key findings, including appropriate recommendations for further investigations at later stages of the Proposed Development, subject to planning consent.

1.4.2 The assessment applied a phased approach, with findings at each phase feeding into the iterative design process and associated EA. This included gathering further site information as the design progressed and revising stability calculations using the best information available.

1.4.3 Further detail on each of these stages is provided in the following sections, with Geographical Information System (GIS) software employed to manage, analyse, and visualise spatial datasets.

1.4.4 Figures have been provided that demonstrate the data available and analysis undertaken within this assessment, as **Figures 10.1.1** to **10.1.10,** in **Annex D.**

2. DESK STUDY

2.1 Literature Review of Peat Stability

2.1.1 Peat is a soft to very soft, highly compressible, and highly porous organic material which can consist of up to 90% water by volume. Scottish Government guidance[4] defines peat as a soil with a surface organic layer greater than 0.50 metres (m) depth, which has an organic matter content of more than 60%. The Wildlife Management and Muirburn (Scotland) Bill (2024) defines peat as soil which has an organic content of more than 60% and peatland as land where the soil layer of peat has a thickness of greater than 40 cm. For the purpose of this assessment, the Scottish Government guidelines for PLHRA[1&2] are followed. Unmodified peat typically has two layers:

- Acrotelm (surface layer) - often around 0.30 m thick (but can vary widely in depth depending on local conditions), highly permeable and receptive to rainfall. It generally has a high proportion of fibrous material and often forms a crust under dry conditions; and
- Catotelm (base layer) – in deeper peat deposits, this layer lies beneath the acrotelm and forms a stable colloidal substance which is generally impermeable. As a result, the catotelm usually remains saturated with little groundwater flow. A sub-division in catotelmic peat may occur, but is not always present, with fibrous catotelmic peat above amorphous catotelmic peat. Amorphous catotelmic peat is characterised as highly decomposed plant matter, with low structural integrity and may act as a liquid in terms of physical or geotechnical qualities, with associated challenges in terms of excavation, handling and storage.

2.1.2 The peat on the Site, where present, is predominantly characterised as blanket peat and peaty podzols (with associated habitat known blanket bog communities, wet heathland and rough grassland communities). Blanket peat tends to be formed in areas with high rainfall and low temperatures. In the Scottish context, blanket peat can be over 5.00 m in depth, especially in hollows or valleys, but is generally much shallower. Peaty podzols are characteristic of any topographic position where aerobic conditions prevail, and water can percolate freely through the upper part of the profile. Podzols are formed in acid, coarse textured, well drained materials. Blanket peat is the most common form of peat in Scotland, podzols are widespread throughout Scotland.

2.1.3 Peat is thixotropic, meaning that its viscosity decreases under applied stress. This property may be considered less important where the peat has been modified through artificial drainage and is drier but can be an important factor when the peat body is saturated and is an important issue to consider in relation to potential peat stability failures.

2.1.4 Peat movements can be small-scale or large-scale. Small-scale movements include slope terracing, slumps, collapse of peat banks and collapses above peat pipe features. These small-scale events are relatively widespread in peatland environments and have limited consequences to receptors, although they do provide useful indicators of peatland morphology and processes which may influence large-scale peat instability.

2.1.5 A series of large scale (mass movement) peat events in autumn 2003, including at Derrybrien in the Republic of Ireland, and Dooncanton in Channerwick (South Shetland Mainland), Scotland, led to an increased recognition of the mass movement hazard, particularly in relation to development design and construction of windfarm projects on peatland. This led to Scottish Government guidance for energy developments being published in 2006 and updated in 2017[1] to assess development risk of peat landslide. More recently, in November 2020 a mass movement of peat was recorded and widely reported at Meenbog Wind Farm, in County Donegal, Republic of Ireland.

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4 Scottish Government (2017). Guidance on Developments on Peatland - Peatland Survey (2017 Edition). [online] Available at: https://www.gov.scot/publications/peatland-survey-guidance/ [Accessed in January 2024].

2.1.6 Peat mass movement events have been classified by geomorphologists Dykes & Warburton[5], within a Scottish context the primary processes of concern are peat landslides and peaty debris slides, with limited evidence of historic bog bursts and other phenomena. These features are defined below:

- Peat landslide – failure of a blanket bog slope, involving intact peat material shearing and sliding along at, or immediately above, the interface with underlying mineral soil, bedrock or boulder clay substrate[3]. The peat above the shear plane generally initially moves as an intact mass, then breaks into smaller pieces and may then act as a liquid flow and follow drainage routes until material has been deposited[6]; and
- Peaty debris slides - shallow translational failure of a slope, often on very steep gradients, with the failure zone occurring wholly in mineral soil substrate below a shallow organic soil surface layer which may be less than 0.50 m depth. Surface peat is sheared and displaced due to failure of underlying material, rather than inherent peat instability[3].

2.1.7 In comparison with other peat mass movement phenomena described by Dykes & Warburton[3], peat landslides and peaty debris slides typically involve lower volumes of material, estimated as 500 - 50,000 m^3, with estimated velocities of 0.1 - 5.0 m/s for peat landslides and 0.1 - 10.0 m/s for peaty debris slides.

2.1.8 Peatland characteristics that may initially suggest a higher likelihood of peat mass movement, i.e. pre-disposition, include:

- increasing depth of peat;
- increasing slope angle;
- the presence of amorphous peat (well humified/decomposed); with less structural integrity and cohesion to remain on slope;
- convex slopes; instability may occur at or immediately downhill of the 'break of slope', often at the interface of deeper peat on a lower slope angle plateau or ridge; and
- waterlogged peat conditions; providing extra weight upon slope and lubricating transition zone/ basal surface between peat and underlying materials, such as clay, mineral soil or bedrock.

2.1.9 Specific conditions that are generally recognised as triggers for mass movement of peat include:

- Removal of slope support; reduces slope stability by natural or anthropogenic removal of support material below peat body. This could also be caused by decreased strength of slope materials on a temporal basis.
- Additional loading of slope; reduction in slope stability due to increasing of mass of slope above the peat body. This could be a result of development design or ancillary activities such as stockpiling of materials or heavy plant movement.
- Alteration to drainage patterns; increasing the mass of the peat body and lubricating the transition zone, potentially also increasing pore-water pressure at base of peat body. Can be a particular concern when intense rainfall follows a prolonged dry period, as fissures in peat body may enable rapid ingress to the transition zone. Prolonged wet periods in autumn and winter months in Ireland are considered as having a greater probability

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5 Dykes, A.P. & Warburton, J. (2007). Mass movements in peat: A formal classification scheme. Geomorphology, Volume 86, 2007.

6 Boylan, N., Jennings, P. & Long, M (2008). Peat slope failure in Ireland. Quarterly Journal of Engineering Geology and Hydrogeology, Volume 41, 2008.

for peatslide events[4] and seasonal accumulation of snow may also be a factor, in terms of both weight and snowmelt input.

- Vibration; construction activities such as piling, stockpiling of materials or traffic, including heavy plant, movement. Potentially also caused by earth movement at susceptible geological locations.

2.1.10 Examples of mass peat instability can occur involving peat of less than 1.00 m depth and on relatively low gradient slopes (<5°), where appropriate combinations of conditions occur. Where depths are relatively shallow and gradients relatively shallow, events may be expected to be more limited in terms of area, volume of material and run-out distance. Peatslide events often commence on a susceptible slope and then follow drainage pathways downslope, with sediment release into such receptors.

2.1.11 There are a number of geotechnical variables in relation to peat properties. Those applicable to the FoS stability methodology applied by WSP are detailed below. The FoS calculation and method is discussed further in Section 1.4 of this report. These variables include both site data and values based on academic literature. Where using literature values, conservative values are typically applied as a precautionary approach, which can then be potentially refined where there is justification to do so from further site information:

- Depth of peat – measured onsite, to full depth with an accuracy of +/- 0.05 m;
- Slope angle – measured using site Digital Terrain Model (DTM) data at 5 m resolution, for both peat probes and using mean values for grid cells. The slope angles have been assessed as follow:
  - Low slope: 0° – <5°;
  - Gentle slope: 5° – <10°;
  - Moderate slope: 10° - <15°; and
  - Steep slope: >15°.
- Shear strength of peat – Literature values suggest an expected pressure (expressed as force per area) range between 4 - 20 Kilonewton / square metre (kN / m^2)[4], with higher values for less humified/decomposed peat.
- Cohesive strength of peat – back-calculated using site-specific data using a 99th percentile value from the site depth data, this parameter largely dictates the shear strength of the peat in the FoS calculation. As above, literature values of shear strength suggest a range between 4 – 20 kN/m^4.
- Undrained bulk density of peat – values for in situ peat range from 900 – 1300 kg/m^3 quoted in various papers and reports, with a typical value of 1,000 kg/m^3 (1.0 Mg/m^3) referenced in literature[4 & 7].
- Bulk density of water – Standard scientific value of 1,000 kg/m^3.
- Water table depth as ratio of peat depth – a value of 1 represents water level being constantly at surface, this is conservative as the water level will vary temporally and geographically across the Site, often dropping below ground level.

7 Dykes AP, Kirk KJ (2006). Slope instability and mass movements in peat deposits. Peatlands: Evolution and Records of Environmental and Climate Changes. Elsevier, Amsterdam, 377-406

- Angle of internal friction – a number of variables are present in peat (particularly fibre content and water content), a lower angle is more susceptible to movement on a slope. At 'quaking bog' locations, where the peat takes the form of a slurry beneath a surface mat of vegetation, the angle of internal friction will be very low (less than 5°) as the peat will effectively act as a fluid, however peat values of up to 58° are quoted in literature[4].

2.1.12 The Von Post classification system is a field-based method for characterising the level of peat humification/decomposition across 10 classes, with H1 categorised as completely undecomposed peat and H10 categorised as completely decomposed peat. Amorphous catotelmic peat is generally considered to be classified as H6 - H10, i.e. strongly decomposed or greater on this scale[2].

2.1.13 There are a number of recognised indicators that may occur in advance of mass peat instability, with the factors below particularly applicable to low velocity peat slides:

- development of tension fracture cracking across the slope or in semi-circular patterns, particularly if these reach to base of peat;
- boggy ground or new springs appearing at the base of slopes;
- sudden reactivation of spring lines;
- peat creep or compression features, such as bulging of ground;
- displacement and leaning of trees, fence posts, dykes etc.; and
- breaking of underground services.

2.2 Information Sources

2.2.1 A desk study was undertaken, reviewing available information on the ground conditions within the Site; sources included:

- Ordnance Survey (OS) digital raster maps at 1:50,000 and 1:25,000 scale;
- OS Historical mapping, 1:25,000 scale;
- OS Infrastructure digital layers;
- OS Terrain 5 DTM (5 m resolution);
- British Geological Survey maps of bedrock, superficial and linear geology at 1:50,000 scale, available through Geology Digimap;
- British Geological Survey Hydrogeological Map of Scotland, 1:625,000 scale;
- James Hutton Institute Soil Maps of Scotland, digital dataset (1:250 000 scale);
- Bing Aerial Imagery available via QGIS plugin; and
- Nature Scot Designated nature and conservation sites[8]

[8] NatureScot (2024). Scotland's Environment Map. [online] Available at: https://map.environment.gov.scot/sewebmap/ [Accessed in August 2024]

2.3 Baseline Conditions

2.3.1 Baseline conditions at the Site are discussed in detail within **Chapter 10: Hydrology, Hydrogeology, Geology and Soils** of the EA Report.

2.3.2 **Appendix 10.2 Soil and Peat Management Plan** of the EA Report includes details of peat depths at various infrastructure locations and an analysis of the potential locations where the more sensitive amorphous catotelmic peat may be anticipated.

2.4 Topography

2.4.1 The elevation of the Site ranges from about 110 m above Ordnance Datum (AOD) near Dalchork to about 230 m AOD on Cnoc na Fuaralachd in the northern part. In Feith Osdail valley, the Proposed Development largely follows the valley bottom. Here, the Site is hummocky with flat basins infilled with peat. The hummocky terrain exhibits a range of slope angles. South of the confluence of Feith Osdail and the River Tirry, the Proposed Development contours the hill side on land modified commercial forestry.

2.4.2 Further geomorphology information is provided within **Chapter 10: Hydrology, Hydrogeology, Geology and Soils** of the EA.

2.5 Geology & Hydrology

2.5.1 The majority of the Site is located within the catchment of the river Tirry, and a small extent in the north is within the River Brora catchment.

2.5.2 Further baseline information for geology and hydrology is provided in **Chapter 10: Hydrology, Hydrogeology, Geology and Soils** of the EA.

2.5.3 Hydrology features and superficial deposits (superficial geology) are presented on **Figure 10.1 Hydrology Overview** and **Figure 10.2 Superficial Geology** of the EA, respectively.

2.6 National Planning Framework 4

2.6.1 The publication of National Planning Framework 4 (Scottish Government, 2023[9]) provides a national spatial strategy, with Policy 5 seeking to protect valued soils, including peat. This establishes the expectation to firstly avoid and then minimise disturbance to soils on undeveloped land (Policy 5a-i), in a manner that protects soil from damage, including compaction and erosion, whilst minimising soil sealing.

2.6.2 In relation to the Proposed Development, developments on peatland, carbon-rich soils and priority peatland habitat shall only be supported if deemed essential infrastructure with no alternative sites (Policy 5c-i). Specific to the scope of work for this report, it will support addressing the requirements of Policy 5d-i and 5d-ii. Namely, providing a detailed site specific assessment to identify depth, habitat condition, quality and stability of carbon rich soils, to assess the likely effects of the development.

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9 Scottish Government (2023). National Planning Framework 4. [online] Available at: https://www.gov.scot/publications/national-planning-framework-4/carbon [Accessed in January 2024].

2.7 Carbon Rich Soils, Deep Peat and Priority Peatland Habitats

2.7.1 The NatureScot Carbon and Peatland Map[10], a dataset covering Scotland, presents the importance of these environmental interests. It was derived using a matrix of soil carbon categories (derived from Soil Survey of Scotland maps) and peatland habitat types (derived from Land Cover of Scotland 1988 map).

2.7.2 Carbon-rich soils, deep peat and priority peatland habitat importance categories (also referred to as Classes) 1 and 2 are considered as the most sensitive and valuable peatlands, with low levels of disturbance. Desktop study indicates that 44% of Site is within Class 1 and 2 peatland of national importance (NatureScot, 2016). Field surveys confirmed the presence of peat at the Site. The remainder of the Site is covered by Class 5 and a small area of Class 0. These classes are not classified as priority peatland habitat.

2.7.3 The outcomes of the more detailed peat survey, discussed below, provide site-specific peat depth information which supersedes the higher-level characterisation from the NatureScot Carbon and Peatland Map[7]. This more detailed peat information was used to inform the design of the Proposed Development and the subsequent assessment (see **Figure 10.1.2 Peat Depth & Condition**). Further information on peat management is provided in **Appendix 10.2 Soil and Peat Management Plan** of the EA Report.

2.8 Peat stability and Morphology

2.8.1 Aerial imagery was reviewed for evidence of landslides and peat morphology features such as peat landslides, peaty debris slides, gully head failures and collapsing peat banks, with particular attention to features within 100 m of pole locations. No evidence of peat instability was identified from a review of aerial imagery and site observations.

2.9 Historical Information

2.9.1 OS historical mapping was reviewed and identifies moorland or rough pasture land use and forestry as at present.

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[10] NatureScot (2016). *Carbon and Peatland Map*. [online] Available at: https://www.nature.scot/professional-advice/planning-and-development/planning-and-development-advice/soils/carbon-and-peatland-2016-map [Accessed in January 2024].

3. SITE RECONNAISSANCE & FIELD SURVEYS

3.1.1 Phase one peat depth surveys was undertaken by WSP in August 2023, a further concentrated phase two peat depth survey was conducted by third party subcontractor (ERM) in January 2024. Finally, a supplementary peat depth and condition survey (phase three) was conducted by WSP in April 2024. These site visits focussed on gaining a good overall understanding of the Site, collecting representative peat depth data and peat coring. During site visits, surveyors did not observe any evidence of previous peat instability within the Site.

3.1.2 The weather during the site visits was generally good. There were no occasions where frozen conditions prevented peat depth measurements being taken.

3.2 Site Reconnaissance

3.2.1 **Photographs 3.1** to **3.6** provide images and descriptive text of the landscape and vegetation at the Site. It should be noted that these photos provide context and do not necessarily indicate the location of infrastructure, which has been located to avoid the steepest and deeper peat areas, where possible.

Photograph 3.1: *Feith Osdail valley, looking north-east from NGR 260361, 914237 (166 m AOD). Hummocky terrain with flat basins containing peat / organic soil. Peat depths over 4 m in the flat basin on the left hand side of the image. No evidence of peat instability was noted. Heathland vegetation dominated by grasses and heather.*

Photograph 3.2: *Feith Osdail valley, looking north from approximately NGR 260361, 914237 (166 m AOD), same location as Photograph 3.1.*

Photograph 3.3: *Looking east, NGR 260650, 914236 (162 m AOD). Peat in this area is over 3 m. Slope gradient is approximately 1.5°. No evidence of peat instability was noted. Heathland vegetation dominated by grasses with occasional coniferous juvenile trees.*

Photograph 3.4: *Looking north, photograph taken at NGR 257936, 910354 (125 m AOD). Slope gradient is approximately 8°. Peat at this location is 0.74 m. No evidence of peat instability was noted. Felled forestry.*

Photograph 3.5 *Looking south from NGR 262683, 914897 (174 m AOD). Slope gradients approximately 4°. Pocket of peat with a depth of 2.1 m down from the road. Heathland vegetation dominated by grasses.*

Photograph 3.6: *Looking north, photograph taken at NGR 257905, 910277 (136 m AOD). Slope gradient is approximately 7°. Peat at this location is 0.34 m. No evidence of peat instability was noted. Felled forestry and juvenile pine trees.*

3.3 Field Surveys

3.3.1 Peat depth surveys were undertaken to inform this PLHRA as well as **Appendix 10.2 SPMP**.

3.3.2 Peat survey campaigns have generally been conducted with reference to the Scottish Government guidance for peat surveys.

3.3.3 Peat depth survey methods followed good practice guidance. Depths were recorded using utility probes advanced by hand through the soil until refusal. Notations on morphology, condition and a judgement of the likely substrate were also recorded.

3.3.4 The distribution of survey points is shown in **Figure 10.1.2: Peat Depth & Condition**.

3.4 Peat Cores

3.4.1 Peat cores were taken using a Russian auger in April 2024. The following information was recorded during peat core sampling (where possible) with details provided in **Table 3-1**:

- Depth of acrotelm;
- Degree of humification using Von Post classification;
- Water content; and
- Substrate underlying the peat (where possible).

3.4.2 Four peat cores were collected in locations of deeper peat and initial peat stability concern close to the proposed OHL (**Figure 10.1.2 Peat Depth & Condition)**.

3.4.3 Amorphous catotelmic peat has been confirmed by all cores collected, exhibiting a Von Post value of H8 & H9 humification degrees, very strongly decomposed peat.

3.4.4 A threshold depth between fibrous catotelmic and amorphous catotelmic peat is suggested to be 1 m.

3.4.5 The geotechnical input (peat probing and coring surveys) provided to date does not replace geotechnical site investigations that would take place post consent and prior to construction commencing to inform the detailed site design, with the above information intended to provide design advice and the basis for assessment for the purposes of the application submission.

3.4.6 Peat core locations are presented on **Figure 10.1.2 Peat Depth & Condition**, and photographs are provided in **Annex C**.

Table 3-1 - Peat core and additional ground investigation data

Peat Core ID	National Grid Reference (NGR)	Core Depth (m)	Core Description and Results	Core Location Information
C1	NGR 262888, 915305	2	Von Post H9 – Brown very strongly decomposed from 1.7 m depth. Considered amorphous catotelmic peat based on greater than H6 humification score.	No visual evidence of instability, low gradient. Moorland Peat core shown on **Photographs in Annex C**.
C2	NGR 260540, 914214	2.5	Von Post H8/9 – Brown very strongly decomposed from about 2 m depth. From 2.25 m depth it contains wood remnants and fibres, and clay.	No visible evidence of instability. Flat area in otherwise hummocky terrain. Moorland.

Peat Core ID	National Grid Reference (NGR)	Core Depth (m)	Core Description and Results	Core Location Information
			Substrate – grey silty sand Considered amorphous catotelmic peat based on greater than H6 humification score.	Peat core shown on **Photographs in Annex C**.
C3	NGR 257962, 913632	3.23	Von Post H9 – Brown very strongly decomposed from 2.1 m depth. Substrate – silty sand Considered amorphous catotelmic peat based on greater than H6 humification score.	No visible evidence of instability in vicinity to the core. Felled forestry. Peat core shown on **Photographs in Annex C**.
C4	NGR 258217, 911927	5.2	Von Post H9 – Brown strongly decomposed. Substrate – not recovered Considered amorphous catotelmic peat based on greater than H6 humification score.	No visible evidence of instability. Felled forestry. Peat core shown on **Photographs in Annex C**.

4. PEAT DEPTH & DISTRIBUTION

Peat Depth Survey Results

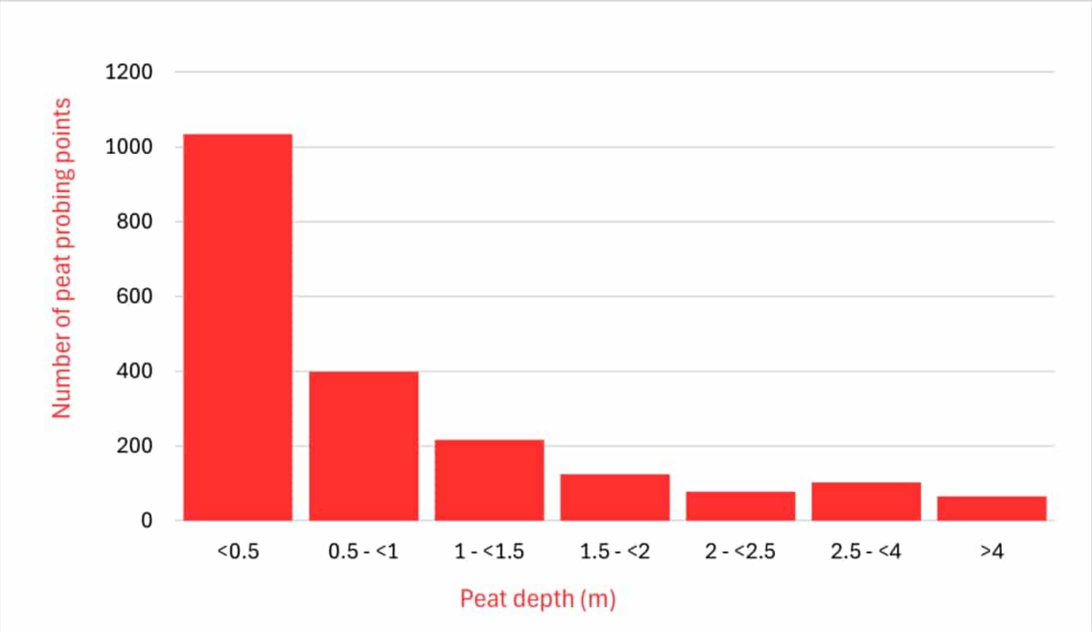
4.1.1 The peat was found to vary across the site in terms of depth and character.

4.1.2 A total of 2,017 peat depth measurements were made, with the results summarised in **Table 4-1** Results of peat depth survey below. 51.3% of the points probed had a peat depth of less than 0.50 m (non-peat), with 71.0% of the results less than 1.00 m and 81.7% less than 1.50 m, the average peat depth was 0.87 m. The peat depth results are presented in **Figure 10.1.2 Peat Depth & Condition.**

Table 4-1 - Results of the peat depth survey

Peat/Soil Depth Range (m)	Number of locations surveyed	Percentage of locations surveyed	Average depth in range (m)
0.0 to <0.5	1,034	51.3%	0.23
≥0.5 to <1.0	398	19.7%	0.69
≥1.0 to <1.5	216	10.7%	1.14
≥1.5 to <2.0	124	6.2%	1.71
≥2.0 to <2.5	77	3.8%	2.18
≥2.5 to <4.0	103	5.1%	3.0
≥4.0	65	3.2%	4.65
Total / Aggregate	**2,017**	**100.0%**	**0.87**

Image 4-1 - Number of peat probing points by peat depth category



4.1.3 Deeper peat (≥2.0 m) represented 9.9 % of the total depths recorded. These areas of deep peat were generally localised to flat areas at the bottom of Feith Osdail valley and between the River Tirry and Cnoc a' Bhreac-leathaid and Dalchork Wood shown in **Figure 10.1.2 Peat Depth & Condition**.

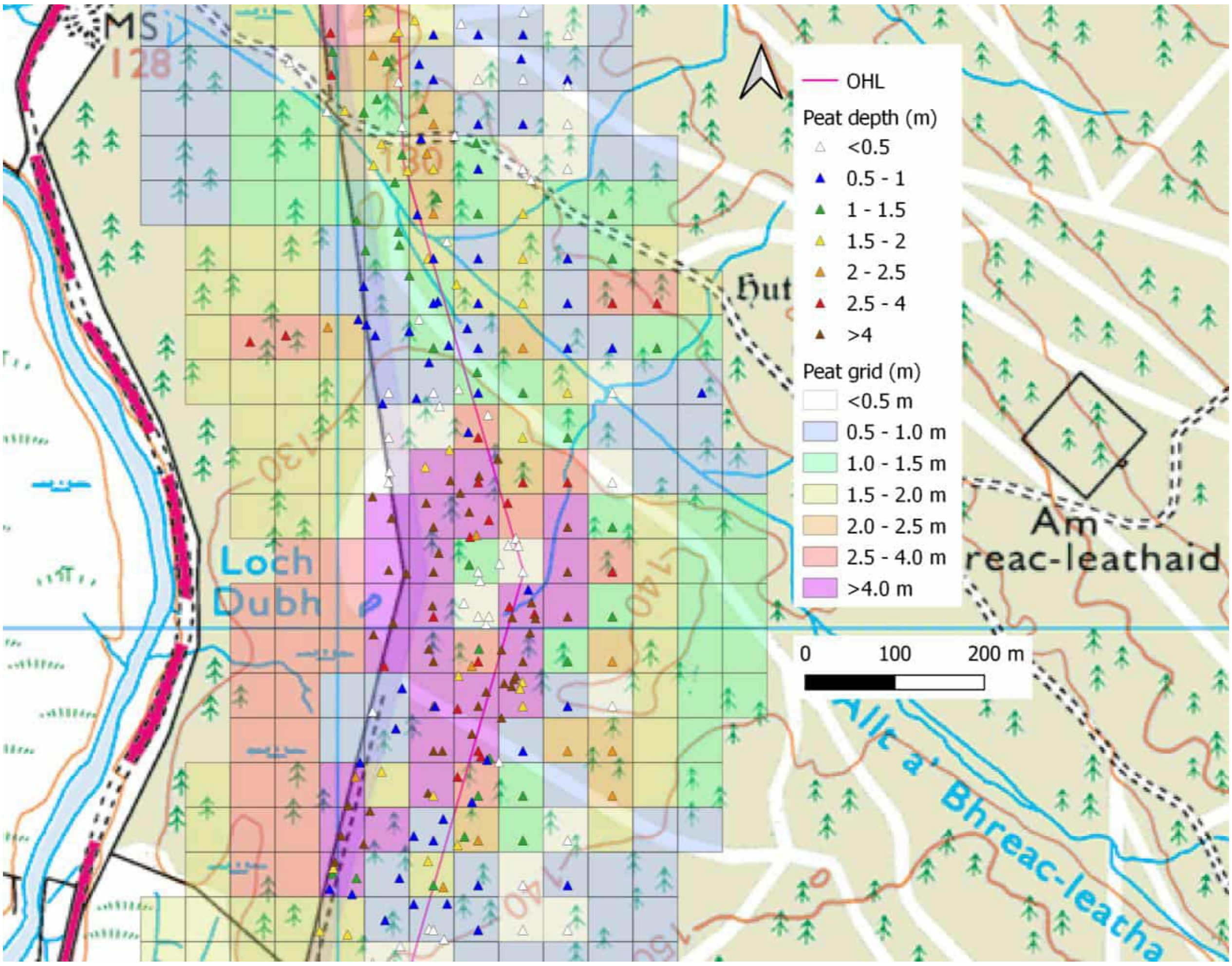
Peat Depth Mapping

4.1.4 To assess peat landslide risk across the Site and to inform the refinement of the infrastructure layout, recorded peat depth data were extrapolated to a 50 x 50 m grid covering the entire Site. The use of a regular grid for terrain analyses of this type is a standard geospatial technique and is widely applied in a range of situations. It allows for a systematic extrapolation of relevant properties across the terrain, including in locations with no measurements. In this analysis, peat depths are extrapolated and mean, maximum and minimum slope angles for each cell derived from a DTM.

4.1.5 The choice of 50 x 50 m grid is determined by the resolution of DTM as using a very fine grid with a resolution identical to or finer than the DTM would return spurious results with a false indication of accuracy. For the Proposed Development, a 50 x 50 m grid was used in line with WSP's established peat stability analysis method as this resolution is fine enough to provide an appropriate level of detail for analysis but also sufficiently large to gain meaningful results from the 5 m DTM and derived slope model.

4.1.6 Each cell within the peat depth grid is assigned a peat depth value either based on a maximum measured peat depth within the given cell or extrapolated. Peat depth extrapolation is done manually using professional judgement, taking into account nearby peat depth measurements and slope angles, and an indicative value assigned to each cell. An enlarged portion of the peat depth grid is shown in **Image 4-2.** In some cases, aerial imagery is also consulted, for instance if it shows bare ground, this is taken as an indication of no peat present. The peat grid is then categorised following the peat depth ranges detailed in **Table 4-1**. The full indicative peat depth map across the Site is included as **Figure 10.1.2 Peat Depth & Condition.**

Image 4-2 - An example of peat grid mapping



4.1.7 Peat depth categories were chosen in the context of energy projects development; for example, the threshold between considering cut-and-fill and floating access track construction is typically around 1.00 m - 1.50 m peat depth. Equally, the practicalities of installing turbines in peat over 2.50 m deep makes this a less attractive option. The minimum threshold for peat of 0.50 m is based on the Scottish Government guidelines[1&2]. Although the Wildlife Management and Muirburn (Scotland) Bill (2024) defines peat as a soil which has an organic content of more than 60% and peatland as land where the soil layer of peat has a thickness of greater than 40 cm, the Scottish Government guidelines for PLHRA[1&2] are followed here, as previously mentioned in Section 2.

4.1.8 From observation, it is clear that both slope and elevation have an influence on the development of peat, although the exact mechanism is not definitive and there is no mathematical growth/ decay model for the Proposed Development and depth of peat. However, slope and elevation factors may be used intuitively when extrapolating from peat sampling data in the creation of an indicative peat depth map. It is often evident that deeper peat is generally found in flatter areas such as valleys, plateaux and hollows. Flat areas on hill summits tend to have relatively little peat; this is possibly due to a combination of exposure and slow growth rate as well as better drainage. Steep slopes also generally have less peat, owing for the most part to the reduced potential for peat to form due to more efficient runoff process.

4.1.9 As can be seen from **Image 4-2** and **Figure 10.1.2 Peat Depth & Condition**, where a cluster of peat probing points is all within the same peat depth category this has been taken as a good indication of the general peat depth in the surrounding area and the indicative peat depth map has been coloured accordingly. However, where clusters of peat probing points have returned depths in a range of depth categories a cautious approach has been taken, with the indicative peat depth map being classified in line with the deepest category of peat found in the area. This leads to a conservative indicative peat depth map.

4.1.10 The peat depth category breakdown for the peat depth grid, for all cells within the grid and cells with measured peat depths, is given in **Table 4-2**.

Table 4-2 - Peat depth category breakdown

Peat Depth Range (m)		<0.50	0.50 - <1.00	1.00 - <1.50	1.50 - <2.00	2.00 - <2.50	2.50 - <4.00	≥4.00	Total
Probing Data	**No. of points**	**1,034**	**398**	**216**	**124**	**77**	**103**	**65**	**2,017**
	% of points	51.3%	19.7%	10.7%	6.2%	3.8%	5.1%	3.2%	100.0%
Indicative Peat Depth Grid	**No. of cells**	**528**	**1,490**	**194**	**149**	**59**	**97**	**45**	**2,562**
	% of cells	20.6%	58.2%	7.6%	5.8%	2.3%	3.8%	1.76%	100.0%
Indicative Peat Depth Grid (with measured peat depths)	**No. of cells**	**524**	**269**	**152**	**82**	**51**	**73**	**45**	**1,196**
	% of cells	43.8%	22.5%	12.7%	6.9%	4.3%	6.1%	3.8%	100.0%

5. FACTOR OF SAFETY ANALYSIS

5.1.1 To establish the stability of peatland and slope areas, WSP applies the 'Factor of Safety' methodology. This procedure involves the application of site data (peat depth and slope angle) alongside values for a number of further variables, with the more sensitive of these being the values allocated for cohesive strength and in situ (undrained) bulk density of peat. The values applied are based on literature review and are generally considered conservative, in accordance with a purposefully precautionary approach.

5.1.2 This PLHRA initially determined areas at greatest risk of slope failure, based on FoS slope stability calculations, which were then considered in greater detail, including site visits to gather further information.

5.1.3 Using the collated data an initial analysis of slope stability can be carried out using the infinite slope model. The stability of a slope can be assessed by calculating the FoS, *F* which is the ratio of the sum of resisting forces (shear strength) and the sum of the destabilising forces (shear stress):

$$F = \frac{c' + (\gamma - m\gamma_w) z \, Cos^2\beta \, Tan\phi}{\gamma \, z \, Sin\beta \, Cos\beta}$$

5.1.4 Where *c′* is the effective cohesion, γ is the unit weight of saturated peat, γ_w is the bulk density of water, *m* is the height of the water table as a fraction of the peat depth, *z* is the peat depth in the direction of normal stress, β is the angle of the slope to the horizontal and ϕ′ is the effective angle of internal friction.

5.1.5 The FoS, *F*, represents the ratio of the forces resisting a slide to the forces causing the material to slide. If $F > 1$ then the slope is stable and normally if $F > 1.4$ then there is a degree of comfort that the slope would not fail. The boundary value of 1.4 is in accordance with the current recommendations of Eurocode 7[11].

5.1.6 To get an indication of the stability of the peat at the proposed pole locations, the FoS can be calculated for each peat probing location. In addition, to gain a better view of peat stability in the areas surrounding the infrastructure, FoS calculations can be carried out for the grid cells of the indicative peat depth map in the vicinity of the infrastructure. To do this, we must know or be able to reasonably infer the parameters for the FoS equation for each probing location and grid cell.

5.1.7 The slope angle, *β*, can be derived from the DTM for the Site. For the peat probing locations, a single slope angle value is generated for each point, whilst for the grid maximum, minimum and mean slope values are calculated for each grid cell. The mean slope angle was used in the grid FoS calculations, although the other statistics provide useful supporting information on the variability of slope within the cells.

5.1.8 The measured peat depth data for each probing location is used in calculating the point FoS values. Measured peat depths are presented as a histogram in **Image 4-1**, with reference to **Table 4-1** and **Table 4-2**; 51.3% of results are less than 0.50 m and 71% are less than 1.00 m. For the grid-based FoS assessment, the peat depth grid is used with indicative values assigned to cells with no measurements (as described in **Section 4**).

5.1.9 The bulk density of water, γ_w, is known to be 1.00 Mg/m^3.

[11] BSI (2004 & 2007). Geotechnical design. Eurocode 7: BS EN 1997-1: 2004 & BS EN 1997-2: 2007, British Standards Institute.

5.1.10 The bulk density of peat is known to vary with the level of decomposition. In situ undrained bulk density of peat reported in literature ranged from 0.50 to 1.40 Mg/m^3. Laboratory analyses undertaken on samples collected by or on behalf of WSP from other projects have returned bulk density values generally ranging between 0.80 and 1.40 Mg/m^3. Based on this experience and also after reviewing externally published values Lindsay[12], Dykes & Warburton[3] and Scottish Government guidance[4] an average wet bulk density value of 1.00 Mg/m^3 has been applied for the FoS calculations.

5.1.11 If it is assumed that the Site is covered with active blanket bog, it follows that the peat must be completely saturated, with a water table at or close to the surface. On site observations indicate that this assumption is only valid on limited areas of this site, as ground conditions were noted to be relatively dry underfoot by survey teams with few evident wetter areas. Consequently, a water table ratio, m, of 1.0 has been chosen, which is considered conservative given most of the Site exhibits drier conditions, but may occur locally during or following heavy rainfall 'trigger' events.

5.1.12 The angle of internal friction in peat also varies, decreasing with increasing decomposition and moisture content. For the FoS calculations, a ϕ' value of 5° has been selected as per WSP's conservative approach.

5.1.13 Finally, a value for the effective cohesion, c', must be derived. Literature values for c' in peat vary widely, generally ranging from 4 – 20 kN/m^2. To provide an indication of the cohesive strength of the peat at this Site, a back-calculation using the FoS equation and measured peat depth data for the Site has been completed. The techniques involved are discussed below.

5.2 Estimation of Cohesive Strength

5.2.1 A range of field and laboratory tests can be carried out to determine the effective cohesion of a material. However, owing to its fibrous and thixotropic nature and the variation in strength with decomposition, peat is a particularly difficult material to analyse both in the field and in the laboratory. An alternative approach to assessing the strength of the peat is to rearrange the FoS equation to calculate a value of c' at actual peat probing locations. Essentially, this approach assumes that if the hillside is stable then the material must have at least a certain minimum strength.

5.2.2 Each peat probing location visited is known to have been stable at the time of the visit and therefore must have a FoS of at least 1. If we assume conservatively that F=1 and use values for the other parameters as discussed above, the FoS equation can be rearranged to allow derivation of a value for c' at each probing location. Slope angles for the probing points are generated from the DTM. It is important to note that the value of c' calculated for each location represents the minimum cohesive strength necessary for the peat to be stable at that location. In fact, the shear strength may be, and in most cases probably is, considerably higher.

5.2.3 In the Study Area, 2,017 locations have been probed during the different phases of fieldwork, c' values for each of these have been calculated and the distribution of these values is shown in **Image 5-1**. For example, reading from the graph, 80% of the probing locations require a theoretical c' value of 0.71 kN/m^2 or less to be stable and retain peat on the slope.

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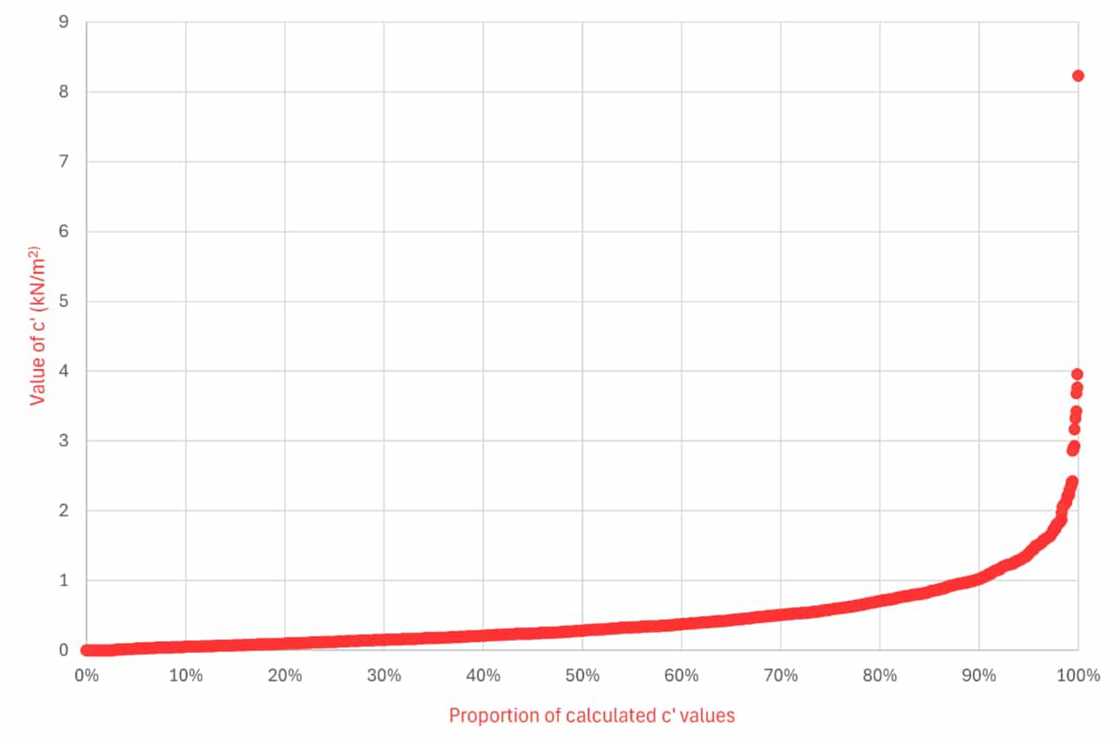
12 Lindsay, R.A (2010). *Peatbogs and Carbon, a critical synthesis to inform policy development in oceanic peat bog conservation and restoration in the context of climate change.. Available at* *https://repository.uel.ac.uk/item/862y6* [Accessed in April 2024].

Image 5-1 - Estimate of minimum cohesive strength, *c'*



5.2.4 From this work it is possible to state, with reasonable confidence, that across the Site as a whole the shear strength of the peat is unlikely to be less than 2.22 kN/m^2 as this is the value of the 99^{th} percentile point on the graph.

5.2.5 Similarly, *c'* values for the grid cells were calculated giving the 99^{th} percentile value of 2.57 kN/m^2, slightly higher than for the point data due to inclusion of indicative depths for a number of cells.

5.2.6 The basis for applying these calculation details depends upon:

- The deliberate choice of conservative values for assumed parameters such as bulk density and water table level, coupled with the assumption of an FoS of 1 when back-calculating c' values.
- Recognition of what the calculations are stating, which is that these are the minimum strengths that would be required, not the actual in situ strengths. Therefore, where slopes are gentle and the peat shallow, very little shear strength is required to ensure stability of the slope. This accounts for the vast majority of the lower values.
- Assuming a reasonable degree of homogeneity for peat properties, particularly strength, across the Site. This seems reasonable, except for very shallow peat where the acrotelm, which is more fibrous, represents a significant proportion of the total depth. Such areas are, in any case, unlikely to be areas of concern.
- Given the above considerations, it is the higher strength values that are relevant. If this were not the case, then one would expect large areas of the Site to be denuded of peat as it would not have the strength to adhere to the hillsides.

5.2.7 For the purposes of the FoS Assessment *c′* values of 2.57 kN/m^2 and 2.22 kN/m^2 have been used for the grid-based and point calculations, respectively. These values are low in comparison with other locations assessed across Scotland, reflecting local characteristics of shallow peat and relatively gentle slopes. Compared with literary values of 4 – 20 kN/m^2, the actual effective cohesion of the peat at the Site may be substantially higher. However, application of these site-derived values ensures a reasonably conservative initial assessment using data from the Site, in tandem with an understanding of literary values.

5.3 FoS Stability Results

5.3.1 Having assigned measured or inferred values to each parameter in the FoS equation, the FoS value was calculated for each probing location and for each cell of the indicative peat depth grid. The results of the FoS assessment for the probing points and site grid are summarised in **Table 5-1.** The FoS assessment maps generated with these values are shown across the Site as series **Figure 10.1.4 Factor of Safety**.

Table 5-1 - Summary of FoS assessment

Factor of Safety	<1.0	1.0 - <1.4	1.4 - <3.0	≥3.0	No Peat (less than 0.5 m depth)	Total
Probing Data (points)	21	48	293	621	1,034	2,017
% of Probing Points	1.0%	2.4%	14.5%	30.8%	51.3%	100%
Grid Cells	25	55	502	1,414	566	2,562
% of Grid Cells	1.0%	2.1%	19.6%	55.2%	22.1%	100%
Grid Cells (with measured peat depths)	10	31	180	452	523	1,196
% of Grid Cells (with measured peat depths)	0.8%	2.6%	15.1%	37.8%	43.7%	100%

5.3.2 Selecting the 99th percentile value of the back-calculated *c′* strengths implies that 1.0 % of the sample locations are subject to slope failure, plus any similar cells across the Site as a whole. As can be seen in **Table 5-1**, only 1.0% of all cells (25) and 1.0% of probing locations have a FoS value of less than 1; in theory these should either have failed or currently be failing. In reality, this is unlikely to be the case and these results are a consequence of the conservative approach adopted. Also, only 2.1% of cells and 2.4% of points have a FoS between 1.0 and 1.4, where stability can be considered marginal. Taken together, only 3.1% of the cells have FoS values of less than 1.4, 3.4% of cells with measured peat depths. As noted previously, indicative depths are conservatively assigned to cells and often overestimate the actual peat depths.

5.3.3 Note that where peat depth is less than 0.50 m, these cells were not considered as peat and are removed from further stability investigation.

5.3.4 To summarise, 96.6% of the peat probing locations have a FoS of 1.4 or greater (including locations with peat less than 0.50 m depth), where stability can be assumed with a degree of comfort. 96.9% of grid cells with measured peat depths have FoS values greater than 1.4 (including cells with peat less than 0.50 m depth), again these are locations where stability can be assumed with a degree of comfort.

5.3.5 The results demonstrate that the majority of the infrastructure would be built in areas where there is a degree of comfort in inferring stability.

5.3.6 Initial risk values were assigned to grid cells based on FoS outcomes as follows and are shown on **Figures 10.1.4**

- High Risk – FoS values <1.0;
- Moderate Risk – FoS values of 1.0 to <1.4;
- Low Risk – FoS values of 1.4 to <3.0; and
- Negligible Risk – FoS values of 3.0 or greater.

5.3.7 Areas considered as ‘Low’ risk or ‘Negligible’ initial risk have not been considered further.

5.3.8 Those cells identified as having marginal stability, i.e. ‘High’ and ‘Moderate’ initial risk cells, are generally clustered into areas where deeper peat and moderate slopes occur, or very steep slopes occur with peat depths of at least 0.5 m. These clusters represent a small proportion of the Site and are discussed further in Section 5.

6. INITIAL RISK ASSESSMENT

6.1.1 Based on the data collated from the desk study, reconnaissance survey, peat probing and FoS stability analysis the peat stability risk across the site can be classified. The Guidelines Guidelines[1] define risk as a function of likelihood and consequence and this has been applied by WSP as:

Risk = Likelihood x Adverse Consequence

6.1.2 The risk level is derived by applying a matrix of likelihood and consequence outcomes to derive a risk value ranging from 'Negligible' to 'High Risk'. Additionally, where peat is not present (such as organic soils with depth less than 0.50 m) these areas were identified as 'N/A – No Peat'.

6.1.3 Central to WSP's analysis is a grid model of the Study Area, using 50 m x 50 m individual cell dimensions. It is therefore essential to have processes that assign likelihood and consequence ratings to the cells and build a map of spatial variability across the Study Area. The rationale for evaluating likelihood and consequence is given in the following sections.

6.2 Likelihood

6.2.1 Although overall the topography is gently undulating, bedrock outcrops exhibit a range of slope gradients. Peat surveys show that deeper peat is generally found in flat basins in between bedrock outcrops. Cells with Likely and Probable Initial Likelihood values generally recorded low to gentle mean slope gradients but exhibited a relatively wide range of slope gradients, some recorded mean cell slopes of up to 10.5°.

6.2.2 In WSP's method, the primary and non-subjective measure of likelihood of slope stability is the FoS calculation. Slopes with FoS values greater than 1.4 are generally regarded as 'safe', with lower FoS value slopes of greater stability concern.

6.2.3 Within FoS analysis, the parameter which may be considered to have the greatest uncertainty is the shear strength of the peat. The derivation of this parameter has been discussed above. The back-calculation approach is more conservative (i.e. gives a safer assumption) than that commonly derived from in situ shear vane tests, which have known limitations when applied to peat. For the initial risk assessment, the likelihood is based solely on FoS, enabling an objective, reasonably cautious initial 'screening' approach to likelihood. The initial likelihood criteria and classification of cells is provided on **Table 6-1** and **Table 6-2**, respectively.

Table 6-1: Criteria relating to initial Likelihood values

Likelihood	Factor of Safety
Almost certain	Not applied at initial likelihood stage, better determined in conjunction with additional data available from a specific peat stability survey of such areas
Probable	FoS <1.0
Likely	FoS is between 1.0 and <1.4
Unlikely	FoS is between 1.4 and <3.0
Negligible	FoS 3.0+
N/A – No Peat	Soil at depth shallower than 0.50 m or confirmed as non-peat material

Table 6-2: Summary of Initial Likelihood classification

Likelihood						
	Probable	Likely	Unlikely	Negligible	No Peat	Total
No. of Grid Cells	26	55	502	1,414	565	2,562
% of Grid Cells	1.0	2.1	19.6	55.2	22.1	100
No. of Grid Cells (with measured peat depths)	10	31	180	452	523	1,196
% of Grid Cells (with measured peat depths)	0.8	2.6	15.1	37.8	43.7	100

6.2.4 The initial likelihood classification of grid cells across the Site is presented as **Figure 10.1.5 Initial Likelihood**.

6.3 Adverse Consequence

6.3.1 The Guidelines[1] identify that 'Consequence' relates to impact upon receptors, this would include property, existing infrastructure and assets, environmental features and/or the Proposed Development infrastructure. These terms need to be taken in their broader context if an itemised list of receptors is to be considered which would include:

- existing public and private infrastructure (roads, bridges, buildings, business facilities, etc.);
- terrestrial ecology;
- aquatic ecology and water quality;
- archaeology; and
- proposed internal infrastructure (access tracks, turbines, cabling, etc.).

6.3.2 In order to include nearby receptors (shown on **Figure 10.1.6 Receptors**), the Site grid extends at least 200 m beyond the Proposed Development. This enables consideration of sensitive features outwith the Proposed Development.

6.3.3 These features have varying dimensions of costs and magnitude caused by an occurrence of mass peat instability, but in addition there may be irretrievable personal, societal or habitat losses:

- Costs: the only quantification provided within the Guidelines is in terms of project costs, which are easier to apply to infrastructure assets than to ecology. If ecology is of relatively minor importance for a particular site, economic impacts or delays in the construction programme may be the main drivers.
- Magnitude: naturally occurring peatslides have been observed to range in size from small-scale, localised slides involving tens of square metres to large-scale slides involving thousands of square metres and with run-out distances of km. Consequently, magnitude may be expressed in terms of area, peat volume and run-out distance and receptor. Provided sufficient peat probing has been undertaken and an indicative peat depth map produced, areas and peat volumes can be derived using professional judgement given local ground conditions. The associated run-out distance is of less significance than the receptor damaged and again should be considered taking account of local conditions to arrive at a realistic outcome.

6.3.4 **Table 6-3** assembles the above considerations to outline the degrees of consequence. Using the table, the three columns are considered, and professional judgement applied, to identify the appropriate 'Consequence' rating. The consequence values were identified and applied using mapping software to escalate the value based on local receptors, with the default (starting) position being that each grid cell was considered of 'Low' consequence, taking a reasonably precautionary approach.

6.3.5 The consequence classification of cells is provided in **Table 6-4**. The consequence classification of grid cells is presented as **Figure 10.1.7 Consequence**.

Table 6-3: Criteria for Consequence values

Consequence	Habitat	Internal Infrastructure	Public / Private Infrastructure
Extremely High	Large loss/damage to valued terrestrial and/or aquatic habitat, i.e. within designated sites. Large loss/damage to archaeological designated sites.	N/A	Damage to property: domestic/public building or business (*within 100 m*). Impact on railways or A class road or bridges, including lower category roads which provide key transport corridors in remote locations (*within 100 m*). Impact on public utilities, water, gas, electricity, telecoms, etc. (*within 100 m*).
High	Medium loss/damage to valued terrestrial and/or aquatic habitat, i.e. designated sites (*within 100 m*). Medium loss/damage to archaeological designated sites (*within 100 m*).	Damage to substation and/or control building *(within 100 m).*	Damage to minor/unclassified public roads or bridges *(within 100 m).* Impact on private utilities, local electrical connection, water and wastewater *(within 100 m).*
Moderate	Small loss/damage to valued terrestrial and/or aquatic habitat. Large loss/damage to common terrestrial and/or hydrology	Damage to planned turbines (*within 100 m*). Damage to section of new access track, construction compound and borrow	Damage to section of existing unclassified access track, or bridge *(within 100 m).*

Consequence	Habitat	Internal Infrastructure	Public / Private Infrastructure
	features shown on 1:10,000 OS mapping (*within 50 m*). Peat grid cells identified with peat depth 1 m+.	pits *(within 50 m)* which would require repair to enable functionality. Damage to car parking (*within 50 m*). Interruption to construction or operation of development.	
Low *Default Position*	Medium loss/damage to common terrestrial and/ or hydrology features shown on 1:10,000 OS mapping.	Minor damage to section of access track which does not necessitate immediate repair for access.	Minor damage to assets.
Very Low *Not Applied*	Small temporary loss/damage to common terrestrial and/or aquatic habitat.	No damage to assets.	No damage to assets.

Table 6-4: Summary of Consequence grid classification

	Consequence				
	Extremely High	High	Moderate	Low	Total
No. of Grid Cells	1,172	21	668	701	2,562
% of Grid Cells	45.7	0.8	26.1	27.4	100
No. of Grid Cells (with measured peat depth)	803	8	326	59	1,196
% of Grid Cells (with measured peat depth)	67.1	0.7	27.3	4.9	100

6.3.6 Grid cells with 'Extremely High' consequence values were identified along Proposed Development. These grid cells coincide with public utilities specifically an existing OHL, and buildings. A cluster of cells with 'High' consequence is identified in the south coinciding with the presence of an existing substation. Multiple 'Moderate' consequence cells are found throughout the Study Area primarily due to the presence of watercourses and access tracks. The remaining 'low' consequence cells coincide with the Proposed Development poles. These Consequence areas are shown in **Figure 10.1.7 Consequence.**

6.4 Initial Risk Assessment Outcomes

6.4.1 The results of the initial likelihood (solely based on FoS) and consequence grid cell categorisations reflect the characteristics of the Site, with the methods and key features of both elements covered in preceding sections.

6.4.2 The Guidelines[1] risk scoring is determined via a matrix table, combining likelihood and consequence. This has been provided as **Table 6-5** and replicates Table 5.3 in the guidance[1]. An initial risk value has been derived for each grid cell through combining the Likelihood and Consequence ratings using the matrix in **Table 6-5**. A summary of the grid cell counts for each risk category is provided in **Table 6-6**.

Table 6-5: Risk matrix based on Likelihood and Consequence values

		Adverse Consequence				
		Extremely High	High	Moderate	Low	Very Low
Peat Landslide Likelihood (over Development Lifetime)	Probable	High	Moderate	Moderate	Low	Negligible
	Likely	Moderate	Moderate	Low	Low	Negligible
	Unlikely	Low	Low	Low	Negligible	Negligible
	Negligible	Low	Negligible	Negligible	Negligible	Negligible

Table 6-6: Summary of Initial Risk assessment outcomes and actions

Initial Risk	Number of Grid Cells	% of Grid Cells	Number of Grid with measured peat depth)	% of Grid Cells (with measured peat depth)	Suggested 'Guideline' Actions (Table 5.4[1])
High	**10**	**0.4**	**5**	**0.4**	*"Avoid project development at these locations".*
Moderate	45	1.8	31	2.6	*"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	888	34.7	479	40.1	*"Project may proceed pending further investigation to refine assessment and mitigate hazard through relocation or re-design at these locations".*
Negligible	1,054	41.1	158	13.2	*"Project should proceed with monitoring and mitigation of peat landslide hazards at these locations as appropriate".*
N/A No Risk (No Peat)	565	22.1	523	43.7	Non-peat material, no peatslide risk.
Total Cells:	**2,562**	**100**	**1,196**	**100**	

6.4.3 As can be seen on **Table 6-6** the majority of the Site has been assessed as having 'No Risk', 'Negligible' or 'Low' risk of peatslide hazard at the initial risk assessment stage (97.9% of all cells and 97.0% of cells with measured peat depth). When considering the grid cells with measured peat depths, five (0.4%) recorded a 'High' initial risk and 31 (2.6%) of cells recorded a 'Moderate' initial risk.

6.4.4 **Figure 10.1.8 Initial Risk** shows the planned infrastructure layout overlaid on the Initial Risk mapping, from which 'High' or 'Moderate' risk of peat instability are identified as red or yellow cells, respectively.

6.4.5 The review of Initial Risk locations has identified six PSA Areas (A-F), further location-specific information has been focused on these in the datasheets provided in **Annex A**.

6.4.6 High initial risk value cells are located within the Study Area within peat stability assessment (PSA) Areas A-C (red cells), with likelihood defined by factor of safety values <1 combined with 'Extremely High' consequence values. High and Moderate initial risk cells are typically located where deeper peat depths were recorded or estimated, coincident with gentle to moderate slope gradients (shown on **Figure 10.1.6 Receptors**).

6.4.7 PSA Areas A-C were initially identified as being at potentially 'High' risk of peat landslide with PSA Areas D-F initially as being at potentially 'Moderate' risk of peat landslide.

6.4.8 Further location-specific information has been focused on these locations in the Revised Risk Assessment and datasheets provided in **Annex A**, to ensure that these outcomes were considered reasonable as part of a sensitivity analysis of the theoretical data. A small number of initial Moderate risk cells also occur outwith PSA Areas A-F with similar characteristics to the PSA Area datasheet locations, which are considered representative.

7. DETAILED ASSESSMENT AND REVISED RISK ASSESSMENT

7.1.1 For each of the PSA Areas, a Detailed Assessment has been undertaken and reported on individual datasheets. This includes description of the peat depths, FoS values, local characteristics including geomorphology and geotechnical information, remote sensing/aerial imagery and available photographs. These datasheets also identify site-specific mitigation, considering the additional information gathered at each of the PSA Areas. The individual datasheets are provided in **Annex A**, with an overview of the locations presented in **Figure 10.1.9: Detailed Assessment Areas**.

7.1.2 Maps in the detailed assessment datasheets display grid cells with High and Moderate Initial Risk values (each cell measuring 50 m x 50 m).

7.1.3 Initial likelihood values assigned to each cell are based solely on FoS values, as discussed for the initial risk assessment, however, regional and local context information may provide additional data that justifies changing the likelihood category at the revised risk assessment stage for locations of concern. These contextual factors are consolidated into **Table 7-1**, which provides rationale to assigning revised likelihood values to refine the assessment process.

7.1.4 In a regional context, some areas have a higher propensity for peatslide events than others and this may be evident from historical records, if reliable. Regional climatic factors influence the development of peat, its coverage and depth; at a site-level peat depths are determined from peat probing fieldwork rather than generalisations. Although the regional context does not provide any spatial differentiation within the Study Area, it may influence the level of caution applied.

7.1.5 In a local context, the variability of local factors material to the development of peatslides may be considered. The primary local factors not already incorporated into the FoS calculations include convex slopes, breaks of slope, drainage patterns, landuse, grazing intensity and incidental events such as fire, which may alter the likelihood of peatslides. These factors may operate across the whole Study Area, in which case they offer no spatial differentiation, but if localised to specific parts of the Site they may be helpful in spatial characterisation. Identification of instability identified from aerial imagery and confirmed by 'ground truthing' as non-peatslide events, such as peaty debris slides, may be relevant as these forms of instability are not caused by peat instability (rather, are due to the slope failure of material underlying the peat layer, or where peat is not present). The Peat Landslide and Hazard Risk Assessment Guidance[1] included suggestions of probability values, these have been included in italics as a contextual reference.

Table 7-1: Criteria relating to Revised Likelihood values

Likelihood/ Hazard	Regional Context	Local Context
Almost Certain	The wider region (if it consists of similar condition units to the Study Area) has several historic peatslides. Study Area has several historic peatslides.	FoS <1.0 (pre-revision) Ancillary considerations: • Locally, indications of incipient mass peat instability such as tension cracks, bulges, misaligned fences or trees etc; • Peat depths on slopes consistently over 1.50 m; • Topography: convex breaks in slope; extensive unconfined slopes; and • Drainage: converging flow paths; large contributing area; peat pipes. *Probability of mass peat instability event occurrence during lifetime of scheme considered greater than 1 in 3.*
Probable	Study Area has evidence of historic peatslide	FoS <1.0 (pre-revision) Ancillary considerations: • Locally, indications of incipient mass peat instability; • Peat depths on slopes consistently over 1.00 m; • Topography: convex breaks in slope; extensive unconfined slopes; and • Drainage: converging flow paths; large contributing area; peat pipes. *Probability of mass peat instability event occurrence during lifetime of scheme considered between 1 in 3 – 1 in 10.*

Likelihood/ Hazard	Regional Context	Local Context
Likely	Study Area has evidence of historic peatslide	FoS is between 1.0 and 1.4 (pre-revision) Ancillary considerations: • Locally, no adjacent indications of incipient mass peat instability but some within 100 m; • Peat depths on slopes consistently over 1.00 m; • Topography: generally rounded/undulating landforms; and • Drainage: suspicious absence of surface channels indications of peat pipes. *Probability of mass peat instability event occurrence during lifetime of scheme considered between 1 in 10 – 1 in 100.*
Unlikely	Study Area has no evidence of past peatslides.	FoS is between 1.4 and 3.0 (pre-revision) Ancillary considerations: • Locally, no indications of incipient mass peat instability • Isolated peat depths over 1.00 m on slopes; • Topography: generally rounded/undulating landforms; and • Drainage: natural well-defined channels; artificial improvements to drainage. *Probability of mass peat instability event occurrence during lifetime of scheme considered between 1 in 100 – 1 in 10,000,000.*

Likelihood/ Hazard	Regional Context	Local Context
Negligible	The wider region (if it consists of similar condition units to the Study Area) has no historic peatslides. Study Area has no evidence of historic peatslides.	FoS > 3.0 (pre-revision) Ancillary considerations: • Locally, no indications of incipient mass peat instability; • Peat depths less than 1.00 m on slopes; • Topography: concave or no break in slope; small confined slopes or pockets; and • Drainage: diverging flow paths; small contributing area; natural well-defined channels; artificial improvements to drainage. *Probability of mass peat instability event occurrence during lifetime of scheme considered less than 1 in 10,000,000.*
N/A – No Peat		Soil at depth shallower than 0.50 m or confirmed as non-peat material.

7.1.6 To aid the revised risk assessment process, focussed on detailed assessment areas, geomorphology data was collated, including grid cells with peat depths greater than 1.0 m, slope angles greater than 8º and convex breaks in slope. These features are displayed with planned infrastructure on **Figure 10.1.1 Geomorphology**.

7.1.7 Supplementary images for each PSA Area are also presented in **Annex B**. These display aerial imagery, slope derived from the DTM data, and OS background mapping.

7.1.8 In addition to good practice and design measures, there are also a number of area-specific mitigation measures that are proposed to be deployed to reduce likelihood at particular locations, with further details in **Section 9**.

7.1.9 The revised risk information on the six individual datasheets (**Annex A**) reflects refinement, following consideration of specific characteristics for each area, using applicable ground investigation information and the identification and application of any appropriate mitigation measures during design, construction and operation.

7.1.10 Potential runout distances and volumes of material for each datasheet have been estimated, factoring-in local conditions, with these estimates recorded within the Detailed Assessment datasheets, alongside identified receptors within and outwith the Site.

7.1.11 Outwith the PSA Areas A-F, there are a small number of additional cells identified as Moderate Initial Risk. These typically occur where an isolated deeper peat depth (or small cluster of depths) were recorded, in areas with similar terrain characteristics and peat conditions to those described in nearby PSA Areas, plus a number of cells on margins of the peat grid that are not close to planned infrastructure. It is recommended that such locations also be considered for micrositing and other mitigation as applicable, with residual risk reduced to low accordingly.

7.2 Revised Risk Assessment Outcomes

7.2.1 Following Detailed Assessment of the PSA Areas, using contextual criteria provided in **Table 7-1**Error! Reference source not found. and assuming application of appropriate good practice and area-specific mitigation measures, likelihood for all cells was reduced to Unlikely. Location-specific rationale and details are provided for each PSA Area in the Datasheets. This revised outcome anticipates slope monitoring and consideration of micrositing to avoid breaks of slope.

7.2.2 Following the risk matrix displayed in **Table 6-5**, the revised risk is reduced to ‘Low’ or ‘Negligible’ for all PSA Areas. The updated risk outcomes are shown in **Table 7.2** and **Figure 10.1.10 Revised Risk**.

Table 7-2: Revised Risk outcomes

Revised Risk	Number of Grid Cells	% of Grid Cells	Number of Grid Cells (with measured peat depth)	% of Grid Cells (with measured peat depth)	Suggested 'Guideline' Actions
High	0	0	0	0	"Avoid project development at these locations".
Moderate	0	0	0	0	"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	577	22.5	218	18.3	"Project may proceed pending further investigation to refine assessment and mitigate hazard through relocation or re-design at these locations".
Negligible	1,420	55.4	455	38.0	"Project should proceed with monitoring and mitigation of peat landslide hazards at these locations as appropriate".
N/A No Risk (No Peat)	565	22.1	523	43.7	Non-peat material, no peatslide risk.
Total Cells:	2,562	100	1,196	100	

8. ASSESSMENT ASSUMPTIONS AND LIMITATIONS

8.1.1 Following previous peat stability report feedback from the Scottish Government Peat Stability Independent Assessor (Ironside Farrar) from similar sites, this section identifies key assumptions which have been applied during the preparation of this deliverable. These assumptions are considered appropriate and proportionate for a development seeking planning consent, with expectation that further data shall be available as the design progresses into construction.

Study Area

8.1.2 A study area considered in this assessment extends 250 m from the Proposed Development. Peat mass movement events are likely to be limited to within this zone, based on local ground conditions and slope angles and taking account of the Proposed Development activities. It is considered unlikely that any peat landslide that occurred outwith this zone would be caused by or cause adverse influence to the Proposed Development.

8.1.3 This is taking into consideration the fact that peatslides in Scotland tend to originate and complete run-out over distances of up to 250 m, with small-scale events a more common occurrence than such larger events.

8.1.4 Longer run-out zones may occur in areas with less constraints, increasingly likely where mass peat movement events meet and then follow watercourse flow paths, as occurred in some well-documented examples such as Meenbog and Derrybrien in the Republic of Ireland. These Irish events may be more likely to represent bog burst phenomena, with higher water content within the peat body involved. Intermittent areas of shallow peaty soils, bedrock exposures, variable gradients, change of slope direction and forestry are local factors that may act individually or collectively to reduce run-out distances in the context of this project.

Peat Survey Constraints and Peat Depth Grid Interpolation

8.1.5 Due to the existing electrical assets present and impassable woodland, there were constraints to the extent of peat depth survey. In addition, the final placement of the Proposed Development occurred subsequently to the latest peat survey. This has reduced the number of peat probe records at Proposed Development locations, with indicative values used where measured depths were not available. To establish indicative peat depths for grid cells without recorded peat depths, WSP applied professional judgement, with determination using the context of local slope angles and regional peat depth records. This manual process adopted the precautionary principle, purposefully registering deeper peat estimates as indicative depths for unsurveyed grid cells where less certainty was available. As this process did not apply automated interpolation procedures, there was much less reliance on peat survey point data than could be the case with software-led determination. WSP have confidence that sufficient data was available (and could be reasonably inferred) to enable a robust assessment at this stage.

8.1.6 This initial (conservative) allocation of indicative peat depths across the grid cells by experienced staff was a critical step for the subsequent analysis that determines factor of safety results, which determined the initial likelihood value, input alongside consequence value to evaluate the initial risk of grid cells, irrespective of collected peat survey data.

8.1.7 The initial risk assessment was refined by undertaking a detailed assessment of locations with ‘High’ initial risk levels closer to the Proposed Development. To ensure representative locations were included and not dependent solely on peat depth records, aerial imagery was reviewed, alongside the factor of safety outcomes. Site surveys included peat probing and coring by experienced personnel.

8.1.8 WSP’s staged approach, with professional judgement applied throughout, results in a high degree of confidence that relevant locations have been identified appropriately and risk assessed by experienced assessment staff. This included noting recommendations for future tasks, including further peat surveys, as the design develops and more GI information may become available.

Factor of Safety

8.1.9 The key variables and most sensitive factors in the FoS analysis are peat depth and slope angle, which are directly applied using a large dataset of site information focussed on planned pole positions, applying a back-calculated specific to site data and conservative lower-bound literature values for other calculation inputs. Thus, the assessment of peat stability at this stage follows an inherently conservative approach. The site visit observations act as a form of sensitivity analysis, as the method bases initial probability directly upon FoS outcomes for the initial risk stage and typically leads to the identification of locations which can be justifiably reduced to a lower probability and potentially lower revised risk, following the collation of ancillary local information.

8.1.10 Reduction in slope stability due to increasing of mass of slope above the peat body is considered as a trigger for mass movement of peat, although peat loading is not a parameter included as part of the Factor of Safety method, specific mitigation measures seek to avoid or reduce this situation occurring at locations of concern. The application of temporary track is part of the design strategy to minimise loading of slopes and removal of slope support. Furthermore, the temporary tracks are of limited duration and will be removed once local construction is completed. This assessment focussed upon in situ (undrained) peat, at the detailed design stage it may be deemed appropriate to also conduct analysis for drained peat for representative locations including the PSA Areas.

Receptors

8.1.11 OS infrastructure digital layers aerial imagery and were primarily used to determine receptors and consequence values alongside some data source listed in section 2.2 of this report. The assessment relies on the completeness and accuracy of these datasets.

Peat Management

8.1.12 Excavated peat would be re-used in as short a timescale as feasible and follow principles provided in **Appendix 10.2 Soil and Peat Management Plan**. Post-consent, the detailed design would include details of plans for temporary storage of peat and associated methodologies for excavation/transfer/storage/reuse. The Geotechnical Risk Register would include peat storage as a specific risk, with applicable controls that would be kept up-to-date with current good practice and lessons learned from site works.

Mapping

8.1.13 Convex breaks of slope were only mapped in areas of 'High' and 'Moderate' Initial Risk in the vicinity of the Proposed Infrastructure based on OS Terrain 5 DTM, and where the break extended horizontally for at least 10 m. However, the hummocky terrain exhibits a variety of slope gradients and orientations across the Site (in a more chaotic pattern), and should additional break of slope mapping be considered appropriate at the detailed design stage, this could be undertaken by the Principal Contractor.

8.1.14 Artificial drainage is present at the Site but these features have not been mapped. These channels are not all shown on OS mapping. Should additional channel mapping be considered appropriate at the detailed design stage, this could be undertaken by the Principal Contractor.

9. MITIGATION AND GOOD PRACTICE MEASURES

9.1.1 The purpose of the PLHRA is to identify areas of the Site which are potentially at most risk of peat instability and thereafter assess potential construction impacts. Where avoidance through design is not possible, mitigation measures require to be implemented to avoid or reduce the risk of peat instability. In addition to specific mitigation measures which may be deployed at particular locations, itemised in the specific detailed assessment datasheets, there are a number of generic construction good practice measures that would be applied, where applicable, as additional data becomes available at the pre-construction stage. A number of these potential actions are set out in **Table 9-1**, including area-specific mitigation measures identified for the Proposed Development PSA Areas.

9.1.2 Good practice guidance documents, such as Floating Roads on Peat[13], Managing Geotechnical Risk[14] (Clayton, 2001) and Peat Landslide Hazard and Risk Assessments: Best Practice[1] would be consulted to inform the design and construction processes. All site investigation work would be undertaken in compliance with relevant British Standards (BS), including BS 5930:1999[15] and BS 6031:2009[16].

9.1.3 Onsite construction staff are often the best placed to provide advance notification of potential problems, provided sufficiently trained and with an appropriate reporting mechanism. There are a number of recognised indicators for slope failures and these may indicate a potential peatslide or the commencement of a peatslide event, as outlined in **Section 1.2** of this report. The suspected identification of any of these indicators should be assessed by specialist peat stability or geotechnical personnel.

9.1.4 Additional items to those identified in **Table 9-1** may be introduced as further site data becomes available at pre-construction and construction stages.

Table 9-1 - Good practice and mitigation measures

Potential Actions	Good Practice	PSA Area-Specific Mitigation Measures, as applicable
1. Geotechnical specialist onsite during the construction phase to undertake advance inspection, carry out regular slope monitoring and provide ongoing advice at locations of concern.	✓	All PSA Areas
2. Maintain and update geotechnical risk register or similar management system.	✓	All PSA Areas
3. Construction staff should be made aware of peatslide indicators and emergency procedures (see below).	✓	
4. Emergency procedures should include steps to be taken on detection of any evidence of potential peat instability.	✓	
5. Microsite the infrastructure in order to avoid the area of concern (subject to non-violation of other constraints).	✓	PSA Areas A, B, C, and E

13 FCE & SNH N (2010). Floating Roads on Peat. Scottish Natural Heritage and Forestry Civil Engineering. [online]. Available at: http://www.roadex.org/wp-content/uploads/2014/01/FCE-SNH-Floating-Roads-on-Peat-report.pdf [Accessed in April 2024].

14 Clayton, C. R. I. (2001). Managing Geotechnical Risk: Improving Productivity in UK Building & Construction. Thomas Telford, London.

15 BSI (1999). Code of practice for site investigations. BS 5930:1999, British Standards Institute.

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

Potential Actions	Good Practice	PSA Area-Specific Mitigation Measures, as applicable
6. Ensure that good groundwater and surface water control, such as moor gripping or drainage ditches, is in place in advance of construction activities.	✓	
7. Installation of stand-pipes / piezometers to monitor ground water levels and pore pressures.	✓	
8. Ensure artificial drainage does not concentrate flows onto slopes, gully heads or into excavations.	✓	
9. Ensure that sediment control measures are incorporated into all artificial drainage measures and including specific scour protection mitigation where steep slopes or high activity erosion processes are identified. Concrete aprons, rip rap, gabion/reno mattress or geotextile mats may be applicable options, depending on watercourse characteristics and sensitivities.	✓	
10. Earthmoving activities should be restricted during and immediately after heavy and/or prolonged rainfall events, including use of weather forecasting and re-programming of construction activities as applicable. Particular care should be taken when heavy rainfall events are predicted following a prolonged dry spell.	✓	
11. The construction plan should minimise the extent and duration of open excavations and bare ground.	✓	
12. Avoid placing excavated material or other forms of loading on or immediately above breaks of slope or any other potentially unstable slopes.	✓	PSA Area B
13. Avoid removing slope support, particularly where slope stability has been highlighted as of concern. Consider temporary or floating access track at appropriate locations to avoid removing slope support.	✓	PSA Areas A, B, C, E, and F
14. Establish / re-establish vegetation as soon as possible to improve slope stability and provide sediment transport control.	✓	
15. Consider limiting loads crossing newly created peat embankments to enable pore water pressure in both embankment and underlying peat to reduce to pre-construction levels and original shear strength.	✓	
16. Modify slope geometry to provide a ‘weighted toe’.	✓	
17. Use of retaining structures, such as gabion terracing to support specific slopes.	✓	
18. In locations where limited opportunity for avoidance or other mitigation to reduce likelihood, the application of debris nets, catch fences, catch ditches and/or deflection systems to protect receptors and reduce adverse consequences. Such installations should be subject to routine inspection and maintenance.	✓	
19. Forestry clearance activities should be undertaken following good practice, including careful positioning of log piles to avoid overloading of slope, sediment control and consideration of retaining tree roots *in situ* for soil stabilisation in appropriate locations.	✓	

Potential Actions	Good Practice	PSA Area-Specific Mitigation Measures, as applicable
20. Borrow pit blasting activities to take account of any peat stability locations of concern in the proximity, including seeking alternative methods that avoid blasting. If sensitive peat stability receptors are identified, there are a number of methods to manage, mitigate and monitor, such as careful placement, charge size, vibration monitoring and pre- and post-blasting slope monitoring.	N/A	

10. SUMMARY AND RECOMMENDATIONS

10.1.1 Peat depth probing in conjunction with slope angle mapping is a cost-effective method to establish peat depth and peat stability profiles across large areas. Combining this with aerial imagery data interpretation enables potential evidence of mass movement events to be efficiently identified. Experienced staff used professional judgement to interpolate and determine indicative peat depths, where measured results were not available.

10.1.2 The Proposed Development is underlain by peat of varying depths and shallower peaty soil, of varying depths from 0.0 m to 6.3 m, with an average depth of 0.87 m across the Study Area. Slope angles and orientation vary greatly reflecting the hummocky terrain of the Site. Convex breaks of slope were also identified in one area near the pole locations. Where deeper peat coincides with steeper slopes, the likelihood of peatslide increases. Higher likelihood for instability was identified primarily in areas with deeper peat deposits (> 0.99 m, measured or inferred) found on gentle to moderate slopes.

10.1.3 Initial risk was determined following a conservative approach based on FoS analysis and the presence of receptors. The potentially least stable areas in any specific locations were initially applied 'Moderate' or 'High' risk, with this risk level relative to the remainder of the Site. In order to review the initial risk, six areas with initial 'High' risk locations close to Proposed Infrastructure were selected for the detailed assessment and revised risk process.

10.1.4 **Annex A** provides datasheets for the six locations identified for 'Detailed Assessment', initially identified as of 'High' or 'Moderate' risk. Further information was collated in the datasheets to discuss initial and revised risk assessment outcomes for these locations.

10.1.5 Following the Detailed Assessment process, 'Low' or 'Negligible' risk was confirmed for all locations. This takes account of local ground conditions, surveyor observations and mitigation measures, including construction of temporary access tracks without excavation and consideration of micrositing to avoid/minimise disturbance of deeper peat. On the basis of applying mitigation recommendations, no areas likely to be impacted by the pole locations are considered to be above 'Low' revised risk (with the vast majority of the Site considered 'Negligible', 'Low' risk or non-peat) in terms of peat stability assessment. Revised risk outcomes for the Site are shown on **Figure 10.1.10: Revised Risk**.

10.1.6 The Guidelines[1] quote the following requirements, of which 'Low' and 'Negligible' risk applies to this Site:

- High risk - 'Avoid project development at these locations';
- Moderate risk - '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 risk - 'Project may proceed pending further investigation to refine assessment and mitigate hazard through relocation or re-design at these locations'; and
- Negligible risk - 'Project may proceed with monitoring and mitigation of peat landslide hazards at these locations as appropriate'.

10.1.7 Further geotechnical investigation is proposed as part of the site investigations, which would take place post-submission and prior to construction. This is standard practice and would inform the final, detailed design of the Proposed Development, along with detailed mitigation to be implemented during construction, undertaken by an appropriately qualified geotechnical engineer. Any additional areas of concern identified by surveys pre-construction, should be added to the areas for further investigation.

10.1.8 Whilst good practice and specific mitigation measures have been identified in this document in order to minimise risk, the suggested techniques are not exhaustive and it is expected that a design consultancy and contractor would use these and other techniques, as appropriate, to effectively manage the peat stability risk.

10.1.9 Management of peat stability risk would remain a consideration throughout the subsequent detailed design processes, including additional site investigation, pre-construction activities and during construction, subject to the development receiving consent. A key issue is that the design remains 'live' and subject to ongoing optimisation, with the iterative design process continuing into construction phase. The contractor shall consider to microsite to reduce peat instability risk, whilst taking account of other local environmental and engineering constraints.

10.1.10 The need for risk management has been emphasised throughout this report. Risk management would include the regular review of the Geotechnical Risk Register, supported by appropriate actions within the contractor's Construction Method Statement (CMS) and Construction Environmental Management Plan (CEMP), in due course.

10.1.11 It is considered that the Proposed Development is in accordance with National Planning Framework 4, specifically Policy 5c-i, given there is a requirement to upgrade the connection between existing electrical assets, with this report providing supporting information in relation to Policy 5d-i and Policy 5d-ii.

11. TECHNICAL AUTHOR EXPERIENCE

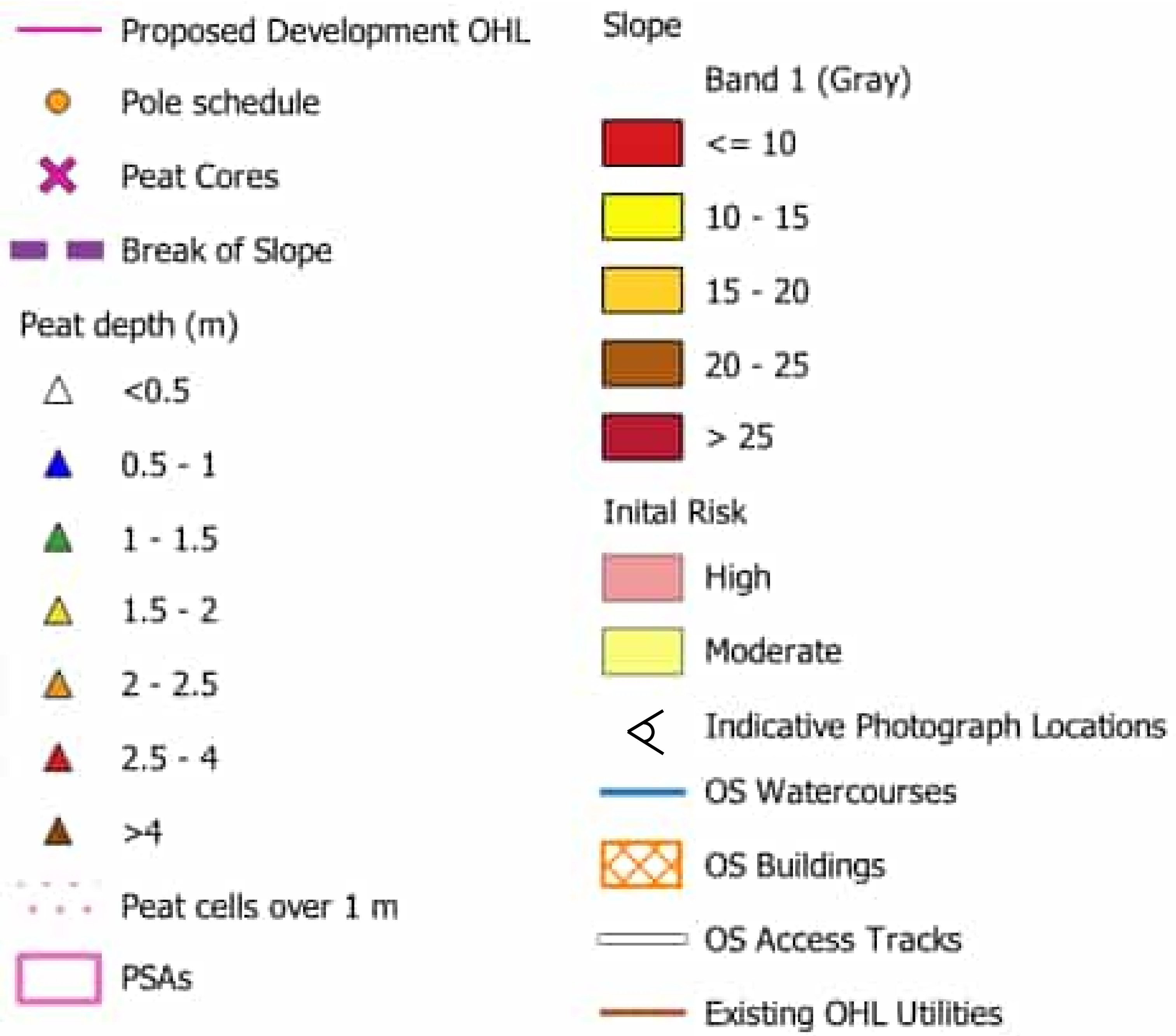
11.1.1 The technical reviewer of this report was Stuart Bone BSc (Hons.) MSc PIEMA CWEM CEnv.

11.1.2 Stuart Bone is a Chartered Environmentalist (CEnv) and Chartered Water and Environmental Manager (CWEM) holding chartered status since 2005 and is also a Practitioner Member of the Institute of Environmental Management & Assessment (PIEMA). Stuart has a BSc (Hons.) in Environmental Geography from the University of Aberdeen and a MSc in Marine Resource Development and Protection from Heriot-Watt University. Stuart has over 20 years environmental experience, since 2006 focused on delivering PLHRA and other soil and water EIA deliverables in the renewable energy sector and highways. He has been involved in the planning of fieldwork and the delivery of PLHRA reports since 2006, following the initial Scottish Government guidance being published, becoming a technical lead on these deliverables in 2012. Stuart has a strong understanding of peat morphology, geomorphological processes, environmental data collection, FoS stability analysis and risk assessment both from project experience and from his academic background. Stuart has a thorough familiarity of the latest guidance and promotes early data collation and stability interpretation to inform the iterative design process in accordance with good risk management and proportionate assessment principles. Stuart has been supported by a range of staff undertaking various field and desk tasks, providing guidance and technical reviews at every stage of this PLHRA process, leading the GIS-based assessment, detailed assessment refinements and acting as report reviewer.

11.1.3 Monika Mendelova undertook a number of the peat surveys, undertook the peat depth data and FoS stability analysis, risk assessment and drafted this report, under supervision and guidance of Stuart Bone. Monika has over 5 years of research experience in geomorphology, holds a PhD from the University of Edinburgh, MSc in Polar and Alpine Change from the University of Sheffield and a MA (Hons.) in Geography from the University of Aberdeen. Monika has a strong understanding of geomorphological processes, landscape and climate change, and extensive experience with field data collection, sedimentological analysis, geomorphological mapping, and remote sensing.

ANNEX A. DETAILED ASSESSMENT DATASHEET DESCRIPTIONS

Legend for Detailed Assessment Datasheets



PSA Area A: **Initial Risk- High**

Revised Risk – Low

Good Practice and Design

Section 1.8 details standard good practice measures.

The Proposed OHL crosses four cells of Moderate Initial Risk. No infrastructure is planned within High Initial Risk cells.

Specific Mitigation, Potential Scale and Receptor

Section 1.8 lists standard mitigation measures.

Micrositing of pole locations to areas of shallower peat. In areas of deep peat, temporary access tracks shall adopt construction techniques to reduce or avoid excavation, e.g. using matting to protect underlying peatland whilst enabling vehicle access. Slope monitoring would be applied, as applicable. This area should be recorded in the Geotechnical Risk Register.

Should peatslide occur: approximated width 20m, length 20 m, at an average depth of 3 m; volume of peat 1200 m^3; Receptor(s) – The Proposed OHL Infrastructure.

No photograph available

Revised Risk

No peat instability evidence was observed during Site visit or identified on aerial imagery. Deeper peat is found in areas with low slope angle (<5 ^{o}). Taking account of the peatland morphology, existing drainage, design and mitigation (construction techniques to avoid excavation, micrositing of pole locations):

The Revised Likelihood is reduced from Likely to Unlikely;

***The Revised Risk is reduced to Low*.**

Area Details

This area is identified due to areas of deep peat and localised moderate (10^{o} - 15^{o}) slopes. The Consequence of this area is Extremely High due to presence of the Proposed Infrastructure, existing 132kV OHL, access track and a watercourse. No evidence of peat instability was identified from satellite imagery, nor any noted during site visits. The area is covered by felled forestry. Breaks of slope have been identified, but these are localised to hummocks.

PSA Area A images with OS background and DTM data are also provided in **Annex B**.

Peat depth measurements within the PSA Area A range from 0.09 to 6.3 m and an average depth of 2.24 m. Peat probing location with the lowest FoS value of 0.67 based on 7.3^{o} slope and 2.7 m peat depth.

All High Initial Risk cells within PSA Area A are based on indicative peat depths 3.99 m. These are all away from the Proposed Development. Four Moderate Initial Risk cells crossed by the Proposed Development with the lowest FoS value out of cells being 1.13 on the northern boundary of PSA Area A. This yielded this FoS values of based on a peat depth of 2.82 m and a 4.7 ^{o} slope. If applying a shear strength value of 4 kN/m2, as literature lower-bound value, to this grid cell, the revised FoS outcome would be 1.76.

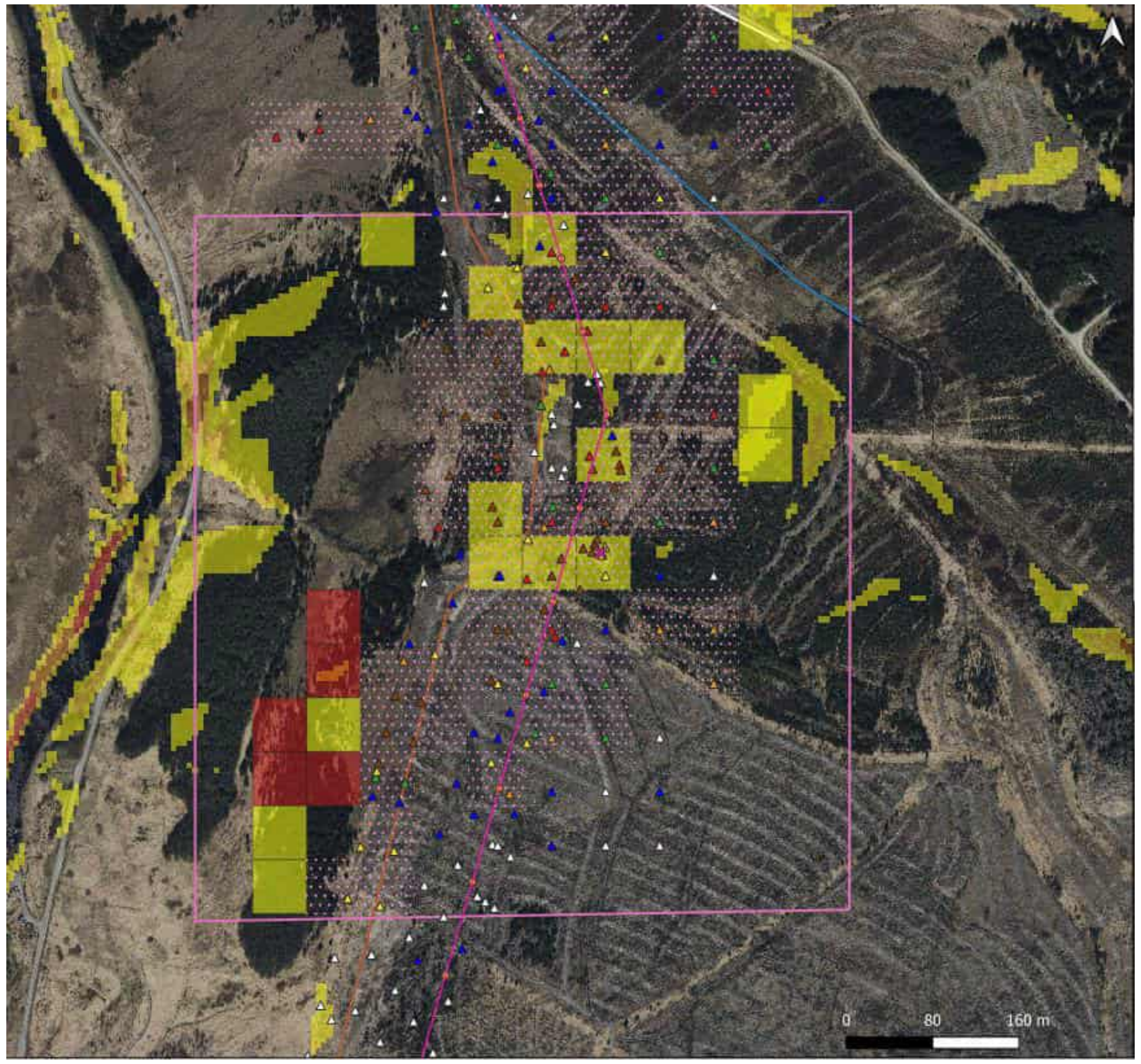


Image A1 - Aerial Image of PSA Area A (grid cells are 50m x 50m)

Microsoft Bing screen shot reprinted with permission from Microsoft Corporation. Contains Ordnance Survey data © Crown copyright and database right 2024.

PSA Area B: Initial Risk - High

Revised Risk – Low

Good Practice and Design

Section 1.8 details standard good practice measures.

The Proposed OHL crosses one cell of Moderate Initial Risk. No infrastructure is planned within High Initial Risk cells.

Specific Mitigation, Potential Scale and Receptor

Section 1.8 lists standard mitigation measures.

In areas of deep peat, temporary access tracks shall adopt construction techniques to reduce or avoid excavation, e.g. using matting to protect underlying peatland whilst enabling vehicle access. Consider micrositing of pole locations to areas of shallower peat.

Should peatslide occur; approximated width 20 m, length 40 m, at an average depth of 2.0 m; volume of peat 1,600 m^3; Receptor(s) – watercourse, existing 132 kV OHL and existing access track.

No photograph available

Revised Risk

Most deep peat areas within PSA B are found on low slope gradients (< 5^o). No peat instability evidence was observed from Site visit or identified on aerial image. Taking account of the peatland morphology, existing drainage, individual peat probe FoS, design and mitigation (construction techniques to avoid excavation, micrositing of pole locations):

The Revised Likelihood is reduced from Likely to Unlikely;

The Revised Risk is reduced to Low.

Area Details

This area is identified due to areas of deep peat and localised moderate (10^o - 15^o) slopes. The Consequence of this area is Extremely High due to presence of the Proposed Infrastructure, existing 132 kV OHL, access track and a watercourse. No evidence of peat instability was identified from satellite imagery, nor any noted during site visits. The area is covered by felled forestry.

PSA Area B images with OS background and DTM data are also provided in Annex B.

Peat depth measurements within the PSA Area B range from 0.1 to 3.0 m and an average depth of 1.4 m. Peat probing location with the lowest FoS value of 1.58 based on 2.7^o slope and 3.0 m peat depth.

The High Initial Risk closer to the Proposed Development has a FoS value of 0.74, based on a 3.0 m peat depth and a mean slope of 6.9^o. If applying a shear strength value of 4 kN/m^2, as literature lower-bound value, to this grid cell, the revised FoS outcomes would be 1.15. The Moderate Initial Risk cell crossed by the Proposed Development has a FoS value of 1.1 based on 2.4 m peat depth and a mean slope of 5.8^o. If applying a shear strength value of 4 kN/m^2, as literature lower-bound value, to this grid cell, the revised FoS outcomes would be 1.7.

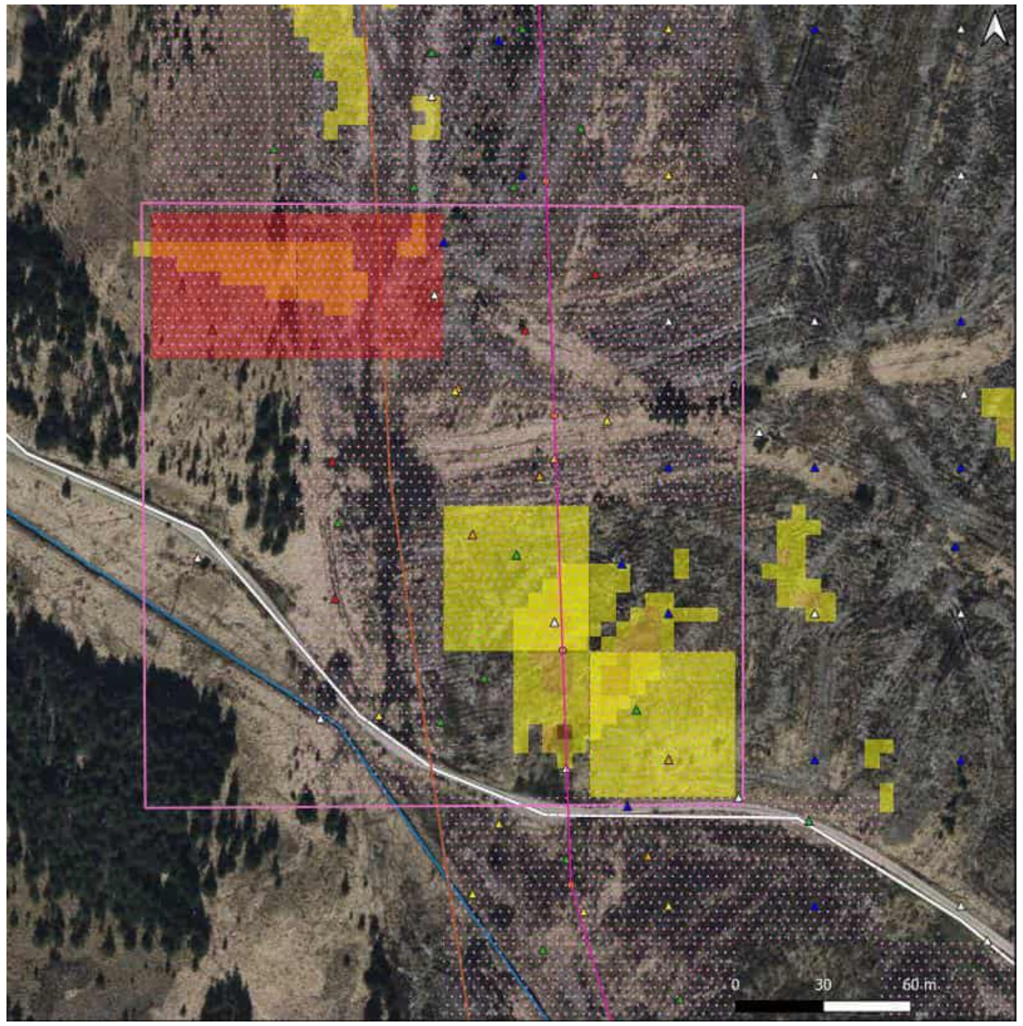


Image A2 - Aerial Image of PSA Area B (grid cells are 50m x 50m)

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PSA Area C: **Initial Risk - High**

Revised Risk – Low

Good Practice and Design

Section 1.8 details standard good practice measures.

The Proposed OHL crosses one cells of Moderate Initial Risk. No infrastructure is planned within High Initial Risk cells.

Specific Mitigation, Potential Scale and Receptor

Section 1.8 lists standard mitigation measures.

In areas of deep peat, temporary access tracks shall adopt construction techniques to reduce or avoid excavation, e.g. using matting to protect underlying peatland whilst enabling vehicle access. Consider micrositing of pole locations to areas of shallower peat.

Should peatslide occur; approximated width 40 m, length 40 m, at an average depth of 4.0 m; volume of peat 6,400 m^3; Receptor(s) – Existing 132 kV OHL and Proposed OHL Infrastructure.

Photograph A1: Looking north-west from core C3 location, NGR 257965, 913632 (144 m AOD).

Photograph A2: Looking south-east from core C3 location.

Revised Risk

Most deep peat areas within PSA C are found on low slope gradients (< 5°). No peat instability evidence was observed from Site visit or identified on aerial image. Taking account of the peatland morphology, existing drainage, individual peat probe FoS, design and mitigation (construction techniques to avoid excavation, micrositing of pole locations):

The Revised Likelihood is reduced from Likely to Unlikely;

The Revised Risk is reduced to Low.

Area Details

This area is identified due to areas of deep peat and small areas with moderate (10° - 15°) slopes. The Consequence of this area is Extremely High due to presence of the Proposed Infrastructure, existing 132kV OHL, and a watercourse. No evidence of peat instability was identified from satellite imagery, nor any noted during site visits. The area is covered by felled forestry.

PSA Area C images with OS background and DTM data are also provided in Annex B.

Peat depth measurements within the PSA Area C range from 0.1 to 6.0 m and an average depth of 1.3 m. Peat probing location with the lowest FoS value of 0.56 based on 5.8° slope and 4.0 m peat depth.

The High Initial Risk cell closest to the Proposed Development has a FoS value of 0.82, based on a 4.0 m peat depth and a mean slope of 4.6°. If applying a shear strength value of 4 kN/m^2, as literature lower-bound value, to this grid cell, the revised FoS outcomes would be 1.27. The Moderate Initial Risk cell crossed by the Proposed Development has a FoS value of 1.38 based on 2.7 m peat depth and a mean slope of 4.1°. If applying a shear strength value of 4 kN/m^2, as literature lower-bound value, to this grid cell, the revised FoS outcomes would be 2.14.

Image A3 - Aerial Image of PSA Area C (grid cells are 50m x 50m)

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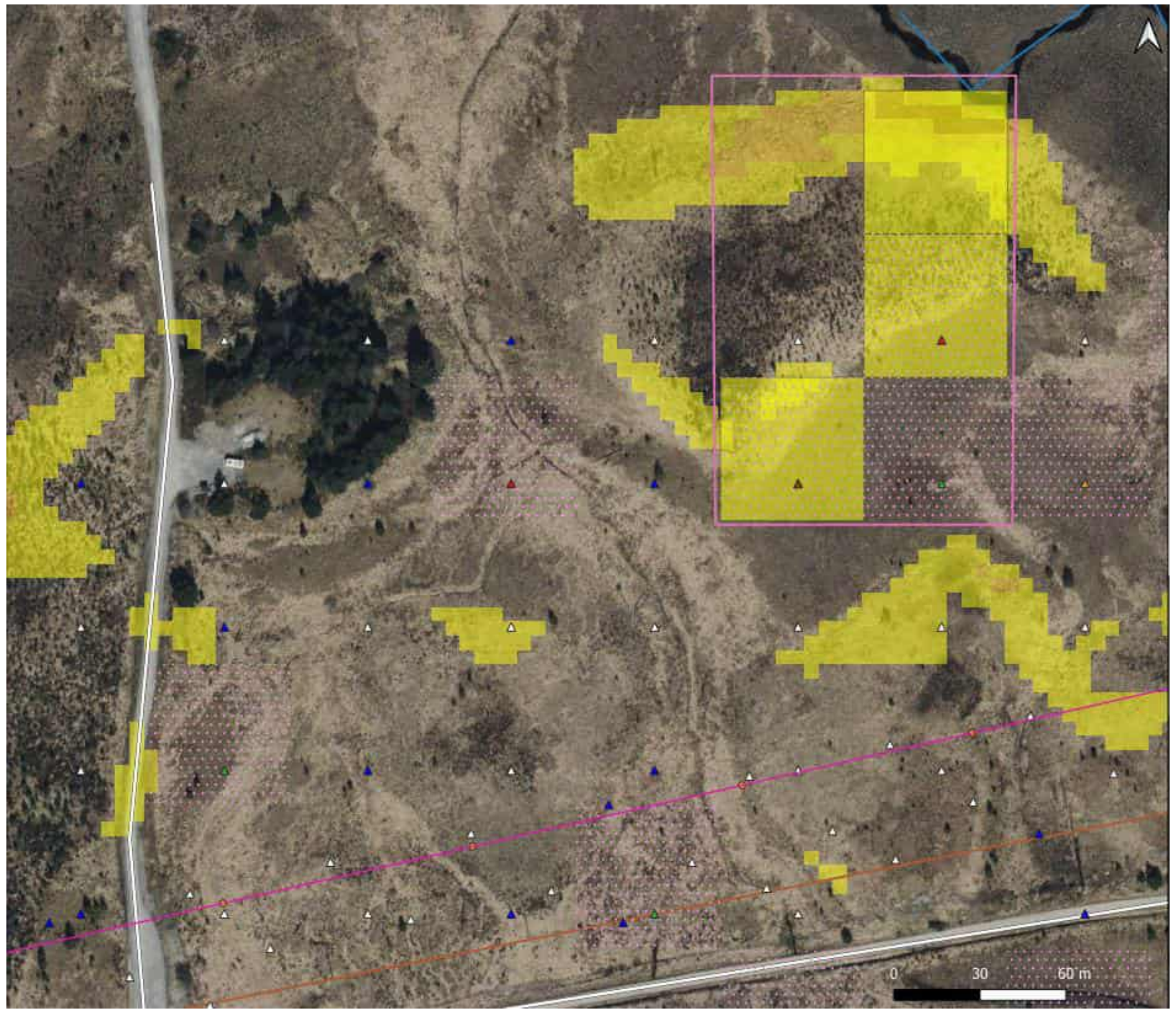
PSA Area D: Initial Risk - Moderate Revised Risk - Negligible	**Area Details**
Good Practice and Design **Section 1.8** details standard good practice measures. There is no proposed infrastructure within cells of High or Moderate Initial Risk, with the nearest part of the OHL alignment 50 m to the south, and upslope.	This area is identified due to areas of deep peat and localised moderate to steep (> 15°) slopes. The Consequence of this area is Moderate due to presence of a watercourse. No evidence of peat instability was identified from satellite imagery, nor any noted during site visits. The terrain is hummocky and covered by heathland. PSA Area D images with OS background and DTM data are also provided in Annex B. Peat depth measurements within the PSA Area D range from 0.44 to 4.0 m and an average depth of 2.2 m. Peat probing location with the lowest FoS value of 0.6 based on 6.9° slope and 3.1 m peat depth. The highest Initial Risk in the south-west corner of PSA Area D has a FoS value of 0.71, based on a 4.0 m peat depth and a mean slope of 5.3°. If applying a shear strength value of 4 kN/m², as literature lower-bound value, to this grid cell, the revised FoS outcomes would be 1.1.
Specific Mitigation, Potential Scale and Receptor **Section 1.8** lists standard mitigation measures. **Should peatslide occur**; approximated width 20 m, length 20 m, at an average depth of 4.0 m; volume of peat 1,600 m³; Receptor(s) – watercourse.	
No photograph available.	 **Image A4 - Aerial Image of PSA Area D (grid cells are 50m x 50m)** *Microsoft Bing screen shot reprinted with permission from Microsoft Corporation. Contains Ordnance Survey data © Crown copyright and database right 2024.*
Revised Risk This area is characterised by hummocky terrain with most deep peat found on low slope gradients (< 5°). No peat instability evidence was observed from Site visit or identified on aerial image. Taking account of the peatland morphology, existing drainage, individual peat probe FoS and the Proposed Development being outwith of High or Moderate Initial Risk: *The Revised Likelihood is reduced from Likely to Unlikely;* ***The Revised Risk is reduced to Negligible*.**	

PSA Area E: **Initial Risk - Moderate**

Revised Risk – Low

Good Practice and Design

Section 1.8 details standard good practice measures.

The Proposed OHL crosses two cells of Moderate Initial Risk.

Specific Mitigation, Potential Scale and Receptor

Section 1.8 lists standard mitigation measures.

In areas of deep peat, temporary access tracks shall adopt construction techniques to reduce or avoid excavation, e.g. using matting to protect underlying peatland whilst enabling vehicle access. Consider micrositing of pole locations to areas of shallower peat.

Should peatslide occur; approximated width 20 m, length 20 m, at an average depth of 2.5 m; volume of peat 1,000 m^3; Receptor(s) – Proposed OHL Infrastructure.

Photograph A3: Looking south-west from core C2 location, NGR 260540, 914214 (163 m AOD). Slope gradient is about 5 º. Heathland with juvenile coniferous trees. No evidence of peat instability was observed.

Photograph A4: Looking north-east from NGR 260361, 914237 (166 m AOD). Hummocky terrain with flat basins containing peat / organic soil. No evidence of peat instability was noted. Same as in Section 3.

Revised Risk

Most deep peat areas within PSA E are found on low slope gradients (< 5º). No peat instability evidence was observed from Site visit or identified on aerial image. Taking account of the peatland morphology, existing drainage, individual peat probe FoS, design and mitigation (construction techniques to avoid excavation, micrositing of pole locations):

The Revised Likelihood is reduced from Likely to Unlikely;

The Revised Risk is reduced to Low.

Area Details

This area is identified due to areas of deep peat and small areas with moderate to steep (>15º) slopes. The Consequence of this area is Extremely High due to presence of the Proposed Infrastructure, existing 132kV OHL, access track, and a watercourse. No evidence of peat instability was identified from satellite imagery, nor any noted during site visits. The terrain is hummocky and covered by heathland.

PSA Area E images with OS background and DTM data are also provided in Annex B.

Peat depth measurements within the PSA Area E range from 0 to 4.9 m and an average depth of 1.9 m. Peat probing location with the lowest FoS value of 0.27 is based on 15.8º slope and 3.2 m peat depth.

Two Moderate Initial Risk cells are crossed by the Proposed Development, the western cell has an FoS value of 1.23 is based on 4.9 m peat depth and a mean slope of 2.5º. If applying a shear strength value of 4 kN/m^2, as literature lower-bound value, to this grid cell, the revised FoS outcomes would be 1.9. The eastern cell cross by the proposed development has an FoS value of 1.09 is based on 3.9 m peat depth and a mean slope of 2.5º. If applying a shear strength value of 4 kN/m2, as literature lower-bound value, to this grid cell, the revised FoS outcomes would be 1.67.

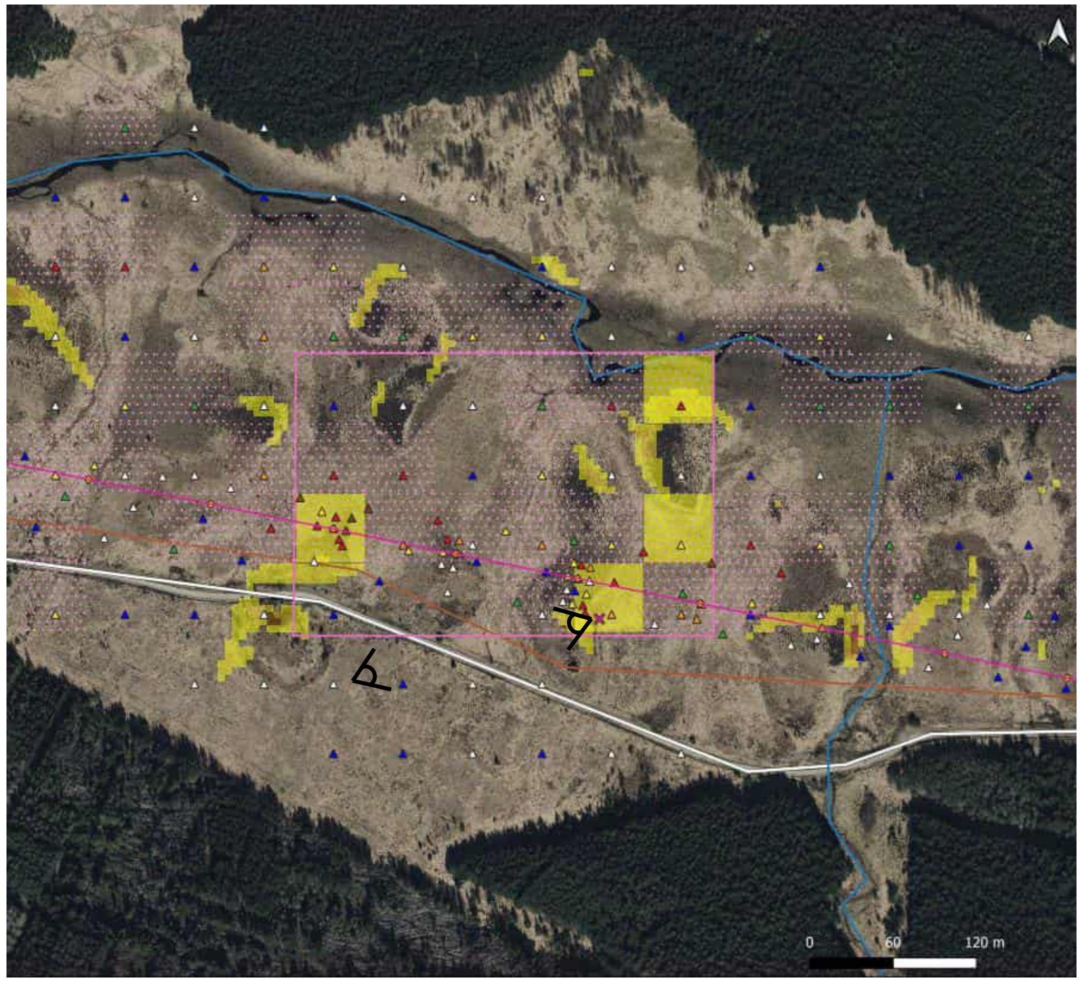


Image A5 - Aerial Image of PSA Area E (grid cells are 50m x 50m)

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PSA Area F: Initial Risk- Moderate

Revised Risk – Low

Good Practice and Design

Section 1.8 details standard good practice measures.

There are two cells of Moderate Initial Risk with no infrastructure planned within.

Specific Mitigation, Potential Scale and Receptor

Section 1.8 lists standard mitigation measures.

In areas of deep peat, temporary access tracks shall adopt construction techniques to reduce or avoid excavation, e.g. using matting to protect underlying peatland whilst enabling vehicle access. This area should be recorded in the Geotechnical Risk Register.

Should peatslide occur: approximated width 20 m, length 60 m, at an average depth of 4 m; volume of peat 4,800 m^3; Receptors – OS Building and the Proposed OHL Infrastructure (the well displayed on OS mapping is confirmed as not in use).

Photograph A5: Looking north-west from core C1 location, NGR 262868, 915308 (185 m AOD). Slope gradient is 3 °.

Photograph A6: Looking south-east from core C1 location.

Revised Risk

No peat instability evidence was observed during Site visit or identified on aerial imagery. Deeper peat is found in areas with low slope angle. Taking account of the peatland morphology, existing drainage, design and mitigation (construction techniques to avoid excavation):

The Revised Likelihood is reduced from Likely to Unlikely;

The Revised Risk is reduced to Low.

Area Details

This area is identified due to areas of deep peat and localised moderate (10º - 15º) slopes. The Consequence of this area is Extremely High due to presence of the Proposed Infrastructure, existing 132kV OHL, access track, and a building. No evidence of peat instability was identified from satellite imagery, nor any noted during site visits. The area is covered by heathland and forestry.

PSA Area F images with OS background and DTM data are also provided in **Annex B**.

Peat depth measurements within the PSA Area F range from 0 to 4.2 m and an average depth of 0.83 m. Peat probing location with the lowest FoS value of 0.77 based on 4º slope and 4.2 m peat depth.

The Moderate Initial Risk cell with the lowest FoS value (northern cell) has an FoS value of 0.86 is based on 4.2 m peat depth and a mean slope of 4.2 °. If applying a shear strength value of 4 kN/m^2, as literature lower-bound value, to this grid cell, the revised FoS outcomes would be 1.33.

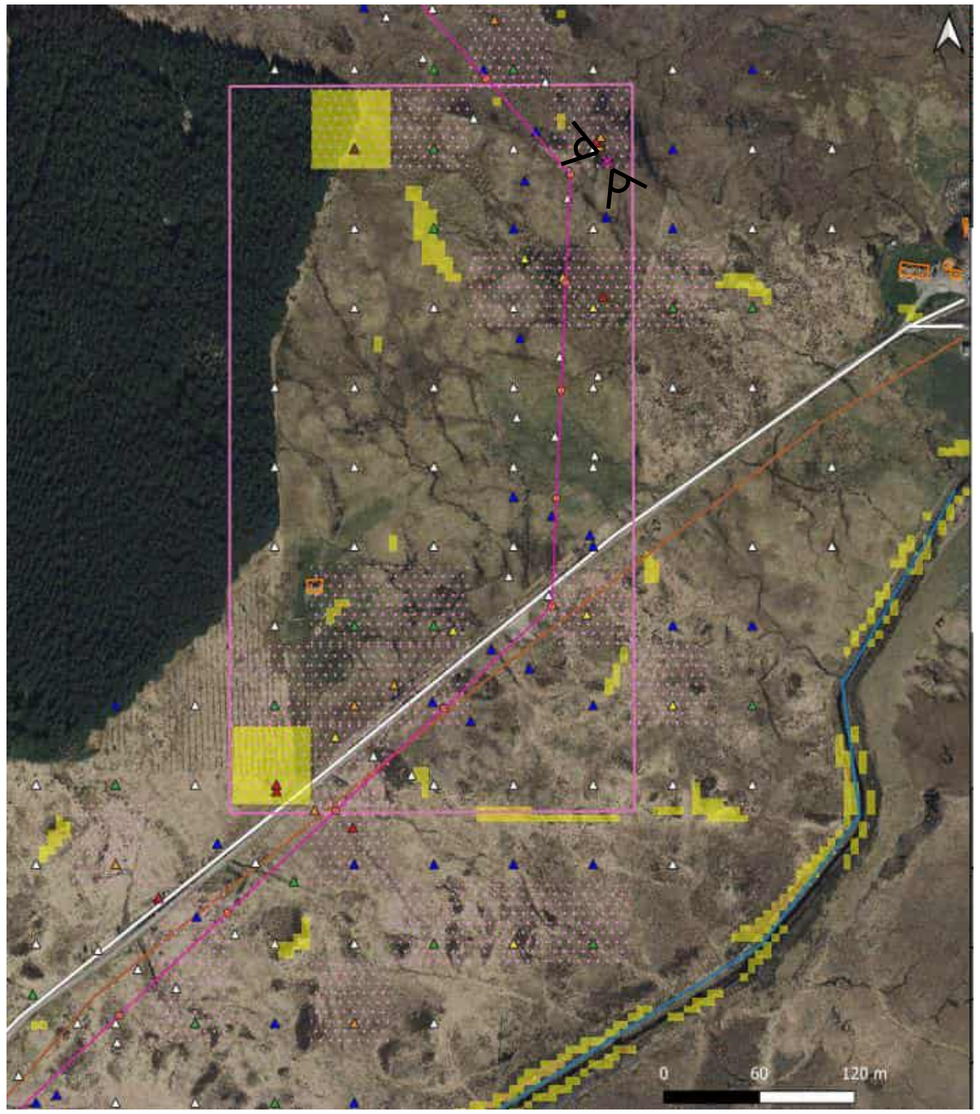

Image A6 - Aerial Image of PSA Area F (grid cells are 50m x 50m)

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ANNEX B. ADDITIONAL IMAGES

Image A7 - Aerial overview of PSA Area A

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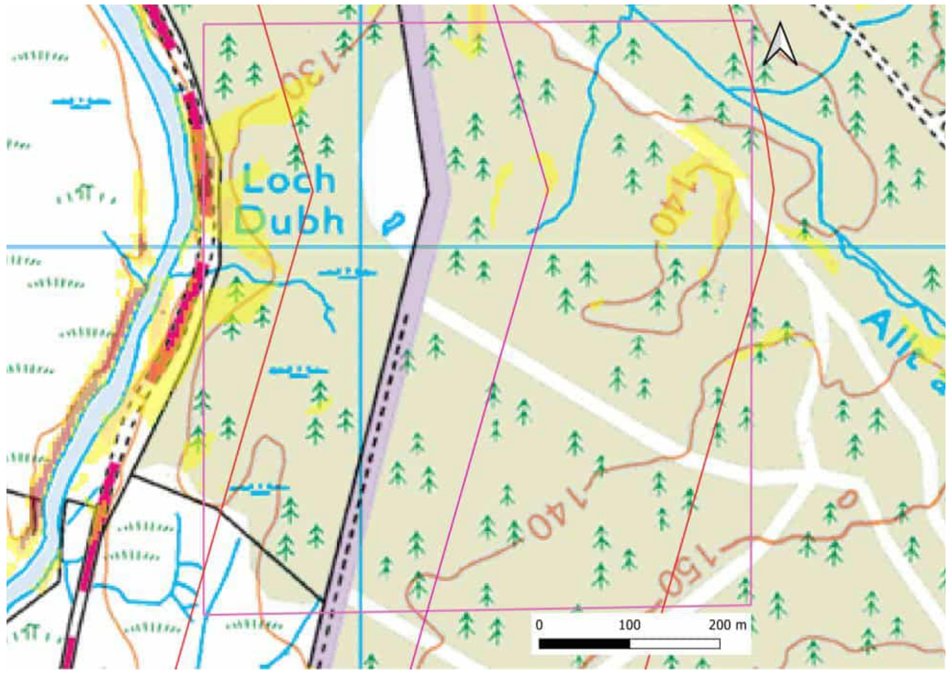

Image A8 - OS overview with DTM slope data of PSA Area A

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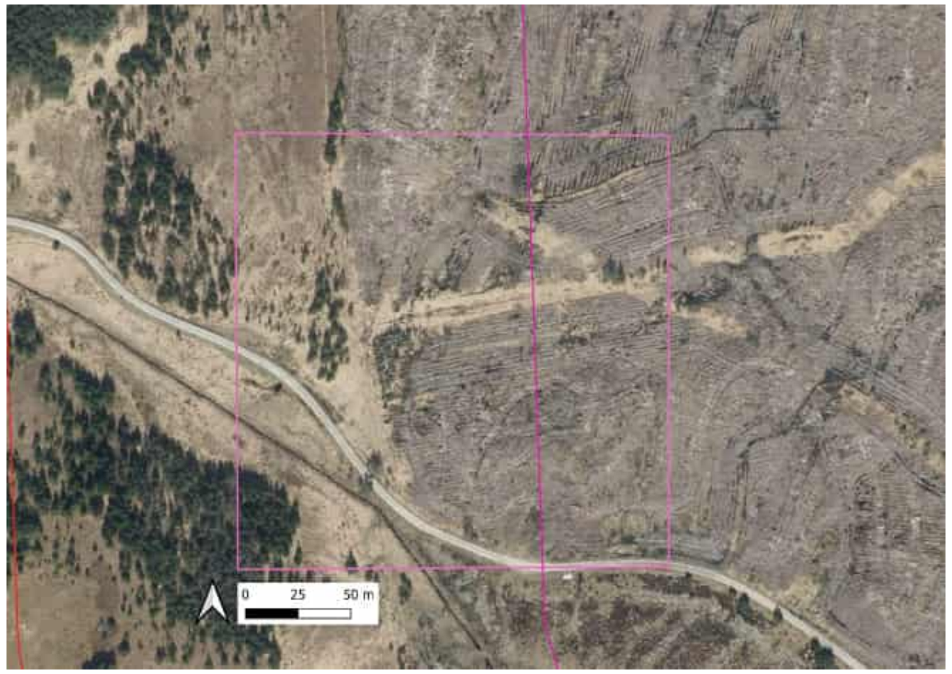

Image A9 - Aerial overview of PSA Area B

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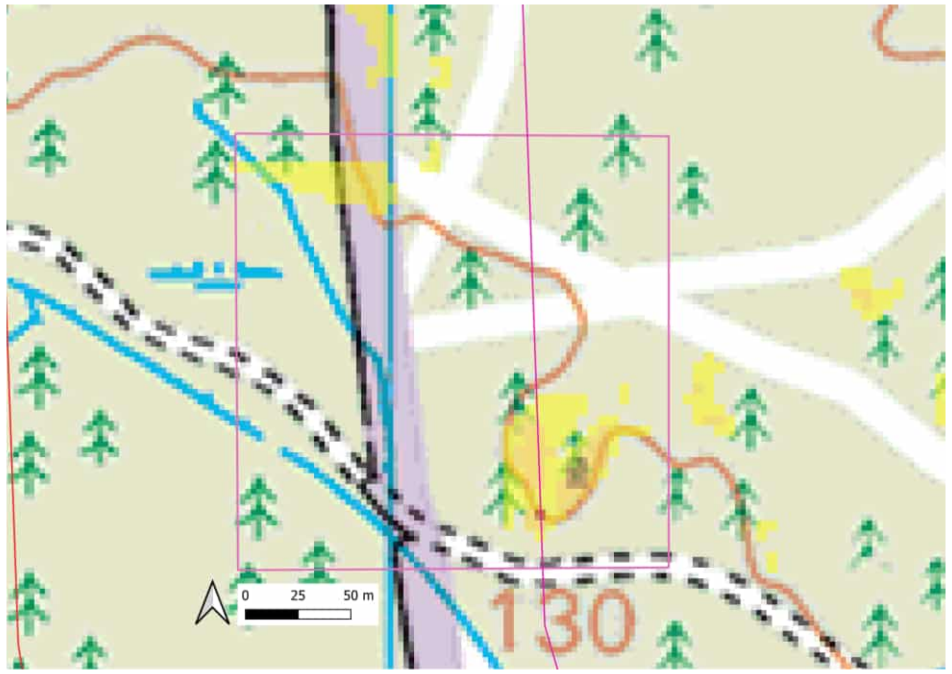

Image A10 - OS overview with DTM slope data of PSA Area B

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Image A11 - Aerial overview of PSA Area C

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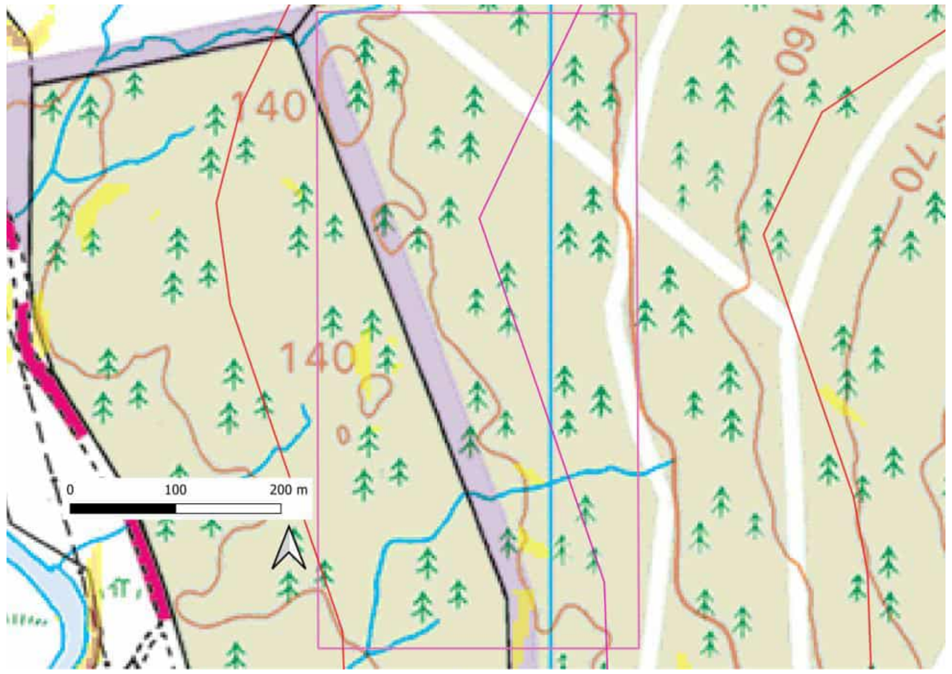

Image A12 - OS overview with DTM slope data of PSA Area C

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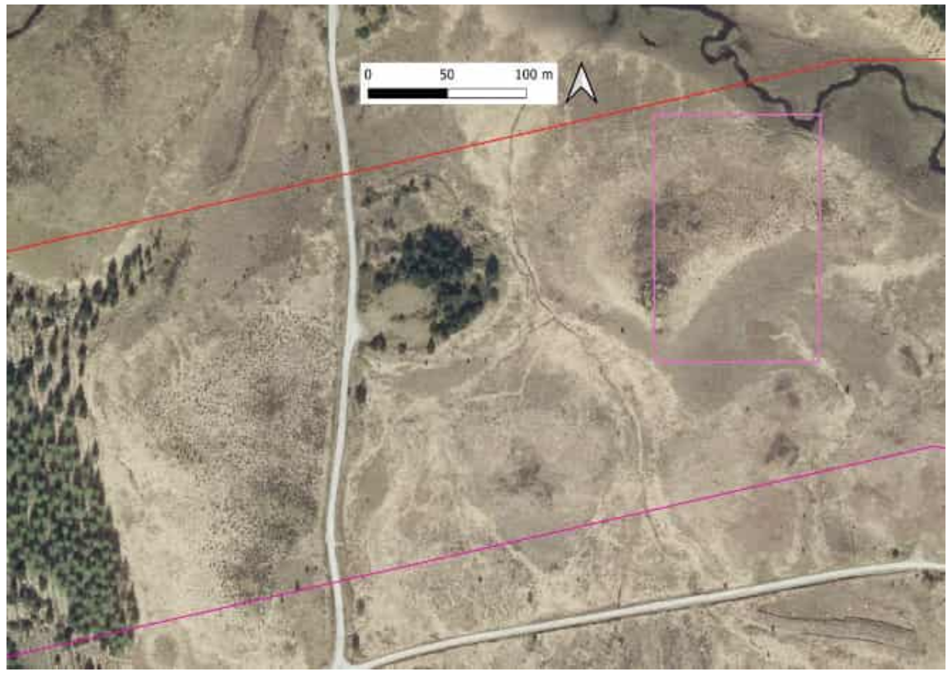

Image A13 - Aerial overview of PSA Area D

Microsoft Bing screen shot reprinted with permission from Microsoft Corporation.

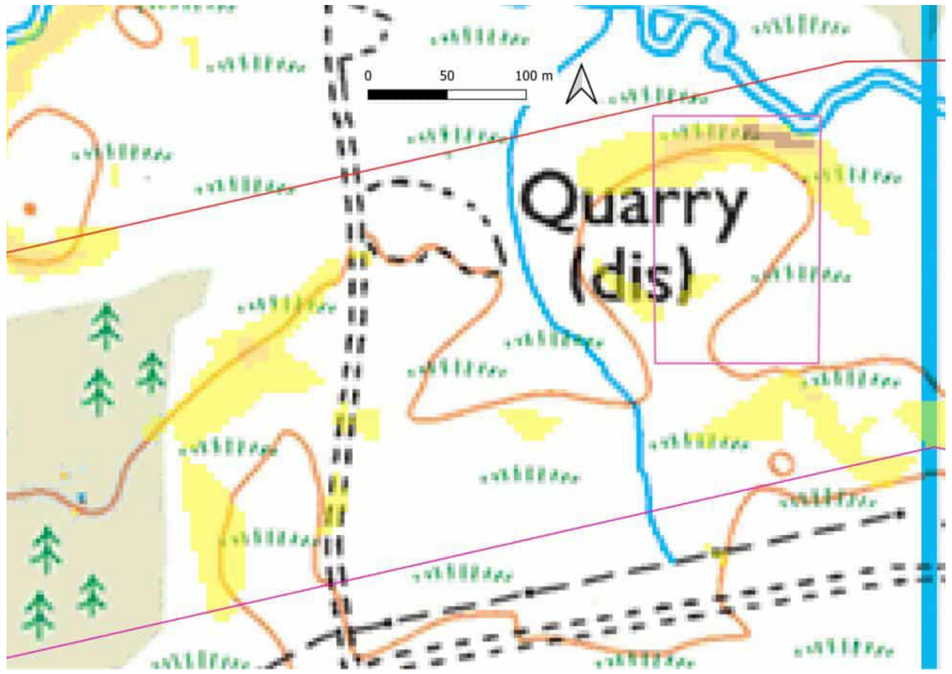

Image A14 - OS overview with DTM slope data of PSA Area D

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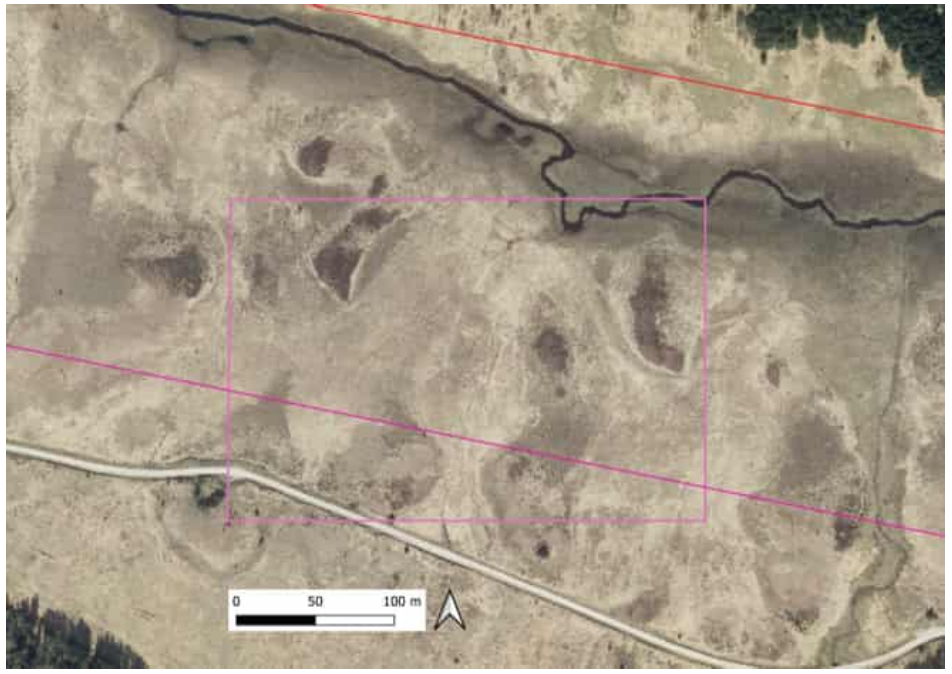

Image A15 - Aerial overview of PSA Area E

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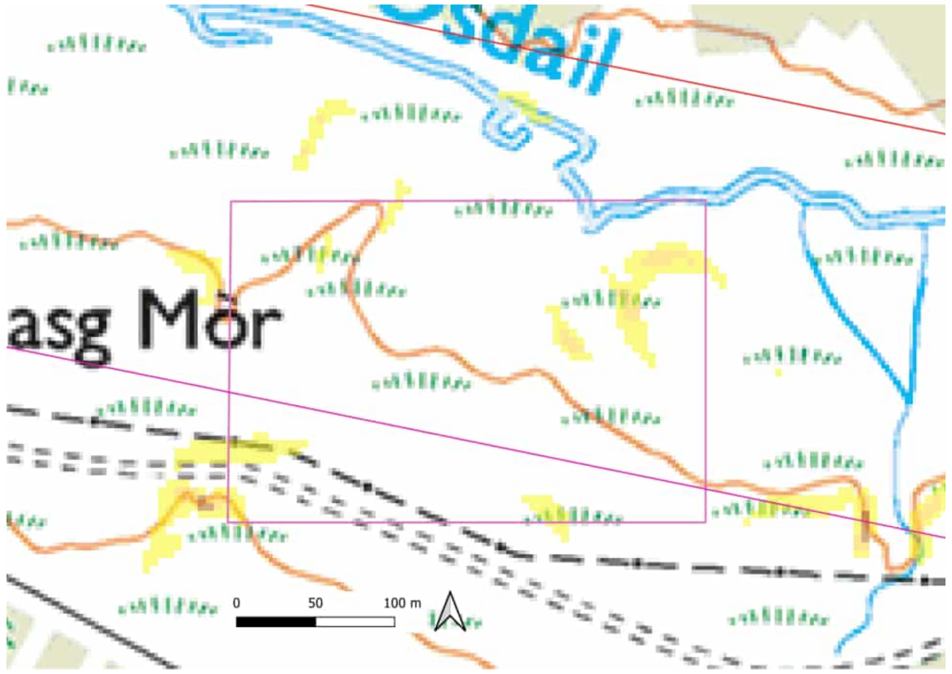

Image A16 - OS overview with DTM slope data of PSA Area E

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Image A17 - Aerial overview of PSA Area F

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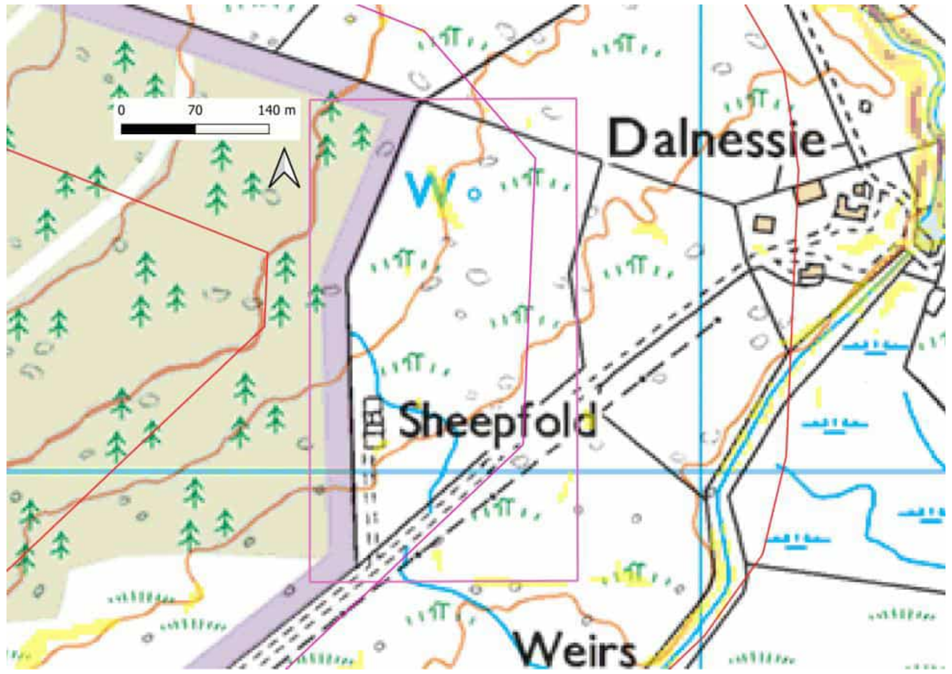

Image A18 - OS overview with DTM slope data of PSA Area F

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ANNEX C. PEAT CORE PHOTOGRAPHS

Core C2

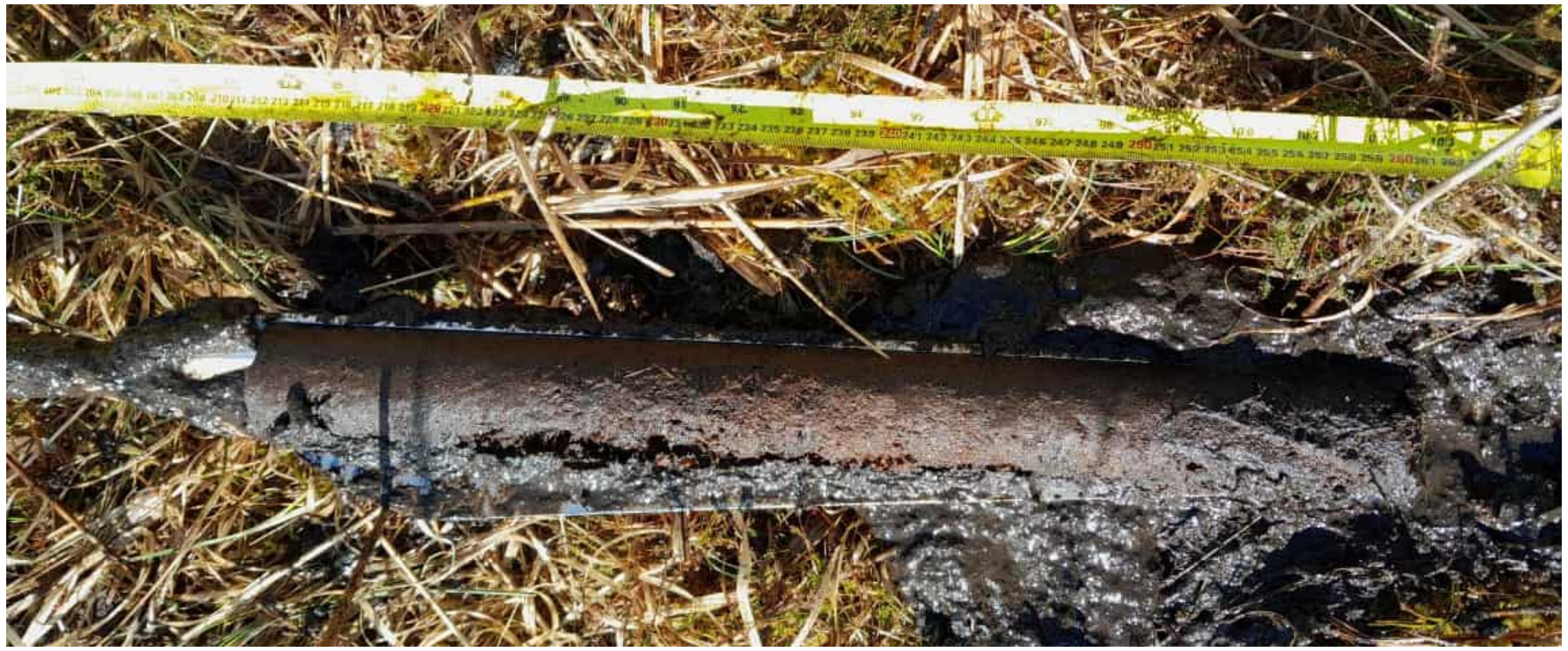
Depth (m)	Von Post Score
0.25	H2/3
0.7	H6
1	H6
1.5	H7
1.64	H7
2.1	H7
2	H8/9
2.25	

Photographs A7: Core C2 images

C3

Depth (m)	Von Post Score
0.2	H5
0.7	H4
0.85	H5
1.35	H5/6
1.45	H5/6
1.95	H5/6
2.1	H9
2.6	H9
2.75	H9
3.05	H9

Photographs A8: Core C3 images



C4

Depth (m)	Score
0.35	H3
0.8	H5
1.35	H8/9
2.3	H5/6
2.6	H9
3.3	H7
3.7	H8
4.8	H5
5.2	H8

Photographs A9: Core C4 images