PEAT LANDSLIDE HAZARD RISK ASSESSMENT

TOM NA CLACH WINDFARM EXTENSION

STAGE 1 CHECKING REPORT

Scottish Government
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ENERGY CONSENTS UNIT

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Contents

History/ Stage

This document has been prepared to audit Peat Landslide and Hazard Risk Assessments on behalf of the Scottish Government Energy Consents Units.

The Stage of the Checking Point and history of the document is as follows:

Stage	Date	Description	Author	Checked/ Approved
1	26.08.22	Stage 1 Checking Report	Christian Partridge BSc,	Nick Matheson BSc, CGeol, FGS

1.0 INTRODUCTION

1.1 Context to Report

The Scottish Government Energy Consents Unit is responsible for processing applications under sections 36 and 37 of the Electricity Act 1989 to develop electricity generation projects and overhead electric lines. In addition, under the Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017, Scottish Ministers are required to consider the environmental impacts of the proposal. EIA Development applications are therefore required to be supported by EIA Reports, which include site-specific information and survey details in respect of the risk of peat landslide events for elements of the proposal and its infrastructure (i.e. construction of roads, access, tracks, wind turbine foundations etc).

The Energy Consents Unit commissioned Ironside Farrar Ltd to technically assess the Peat Landslide Hazard and Risk Assessment(s) (PLHRAs) submitted by developers. This checking report will consider whether or not adequate and appropriate field survey, peat sampling and analytical methods have been employed to provide a sound basis for assessing peat stability and the risk from peat landslides within the development envelope. The checking report will provide a summary of findings and recommendations and the Energy Consents Unit will issue a copy to the developer in accordance with the requirements of the Best Practice Guide (Scottish Government, 2017).

1.2 Audit Methodology

This audit primarily reviews the information submitted by the developer against the guidance provided in:

- Peat Landslide Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments, Energy Consents Unit Scottish Government, Second Edition, April 2017 (ECUBPG)
- Scottish Government, Scottish Natural Heritage, SEPA (2017) Peatland Survey. Guidance on Developments on Peatland, on-line version only.

1.3 Documents Reviews

The documents reviewed as part of this audit were:

Stage 1 Audit:

- Peat Landslide Hazard and Risk Assessment Appendix 13.D - Tom na Clach Extension Wind Farm, 20-FEC-012-D-001v01, 24/02/2022.
- Various Figures from EIAR to support the PLHRA.
- Tom na Clach Wind Farm Extension Appendix 13.B: Peat Depth Survey Report
- Tom na Clach Wind Farm Extension Appendix 13.C: Outline Peat Management Plan
- Vol 1 Chapter 3 Description of the Proposed Development
- Vol 1 Chapter 13 Hydrology, Hydrgeology, Geology & Peat

2.0 REVIEW OF DATA SUPPORTING PLHRA

2.1 Background on Proposed Development

The site is located approximately 25 miles to the south-east of Inverness in the Scottish Highlands and is approximately 398 hectares in size. It comprises open upland areas and hillside. It includes the tributaries of the Allt Carn an t-Sean-Liathanaic. The site is bordered to the south-west by extensive conifer plantations and to the north and east by moderately steep open fells. The existing Tom nan Clach Wind Farm lies immediately north of the site.

The Proposed Development will include the following elements:

- 7 turbines of up to 149.9 m tip height, with associated hardstandings.
- Up to 4 km of new access track, of which 1.5 km will be floating and 2.5 km of cut and fill construction.
- A new substation/control building/battery energy storage system (adjacent to the existing Tom na Clach wind farm substation).
- A new borrow pit.
- A construction compound.

2.2 Is a PLHRA Necessary?

Section 1.1 of the report states that peat is present on the site on slopes of greater than 2 degrees and therefore in accordance with the guidance ECUBPG, a PLHRA is required.

2.3 Team Competencies and Spatial Scope of Study

Competencies of the team undertaking the PLHRA have not been stated. The ECUBPG states these team members should be led by a Competent Person who will be chartered through an appropriate professional institution (CEng, CGeol, CIWEM, MICE or equivalent) with a minimum of 5 years demonstrable experience in managing geotechnical risk and undertaking upland geohazard assessments and/or surveys, specifically in peatland environments. Given the complexity of peatlands, the qualifications and experience of the team should be clearly stated early in the developers' reports.

However, competencies of the team are stated within Section 3.6, which identifies that the site walkover was undertaken by a Chartered Geologist / peatland geomorphologist with over 20 years' experience of assessing peat landslides.

Whilst the extent of the survey covers the majority of the site, there is an area along the western boundary, west of the existing access track, that has not been subject to desk study analysis and geomorphological mapping. Although the interpolated peat depth map includes this area of the site, it is not clear on what data this is based on. This is discussed on later sections.

2.4 Structure of PLHRA Reporting

The PLHRA reports is structured as follows:

- Section 1 presents an introduction, background and summarises the structure, scope and approach of the PLHRA.
- Section 2 gives context and background to peat instability and peat slides within the UK and Ireland based on literature review. It also details the types and mechanisms associated with peat slides.

- Section 3 provides a site description based on desk study and site observations, including consideration of aerial imagery, digital elevation data, geology and peat depth and character and peatland geomorphology.
- Section 4 describes the approach, methodology and results of an assessment of peat landslide likelihood.
- Section 5 describes the approach, methodology and results of a consequence assessment and calculated overall risk for the site.
- Section 6 provides mitigation and control measures to reduce or minimise peat slide risks prior during and after construction.

The reporting is supported by a number of Figures in the Appendix.

The scope of the PLHRA is generally considered satisfactory and it is well structured. There are appropriate supporting Figures presenting a variety of information that is required to support the risk assessment. Each of these plans shows the development layout and the site boundary.

2.5 Review of Desk Study

Sections 2.1 and 2.2 discuss a background to peat instability in the UK and Ireland, types of instability and factors that contribute to this. The section is thorough and well researched and conveys a good level of understanding on peat slide. It includes information on failure mechanisms, contributory factors to both peat slide and bog burst. It also details peat slides that have historically been recorded in the UK and Ireland. The research references both the ECBPG and a range of other sources. It would have been useful to include local knowledge from landowners, farmers and local residents which are not stated.

The desk study is presented in Section 3 and assesses both a relevant and appropriate range of data sets. There is discussion on the topography and slope character of the site in relation to the proposed infrastructure. Published ground conditions are described from appropriate published mapping and includes BGS information as well as SNH Carbon and Peatland Mapping. This mapping shows areas of Class 1,2, 4 and 5 peat on the site.

Section 3.3 describes the hydrology of the site and supported by Figure 4 showing drains and minor water courses. Land use is discussed in Section 3.4, and identifies that in places, there is evidence of managed burning for grouse and artificial drainage, with limited localised informal tracks for site access. Otherwise there is little active land use.

Section 3.5 describes peatland geomorphology. This has been assessed by a site walkover. There are also photographs within the reporting that show features identified during the walkovers. The site exhibits complex peatland geomorphology with extensive patterning associated with a range of linear, dendritic and anastomosing gullies, local areas of bare ground and isolated diffuse drainage pathways. These areas enable relatively efficient transport of water from the slopes to major gullies or watercourses and, given their eroded state in many cases, transfer of fine particulate peat with associated carbon losses.

A geomorphological map has been provided (Figure 4) that conveys a suitable amount of information including peat and slope characteristic, drainage and water courses. The western part of the site (west of the main access track) doesn't appear to have had any features added to the mapping. Therefore the plan should be updated to provide information for this area, or suitable justification given as to why this area is not included in the assessment.

Additional information identifying any major slope breaks would have been a useful addition to the mapping which feeds into the likelihood assessment.

Within this section it would have been useful to include reference to historical mapping data and meteorological data which were not stated. Furthermore, it would be useful to include the resolution of the digital terrain model (DTM) illustrated in Figure 1.

2.6 Review of Field Surveys

Field surveys including a site walkover and peat probing have been completed. Section 3.5 describes the method of peat probing and is generally in accordance with the ECUBPG. In all, 3,733 probes were collected, with 19 cores taken at infrastructure locations to characterise the peat deposits. The peat probing was completed in two phases. An initial Phase I survey comprising a 100m grid was reported to have been completed across all site areas in November 2020. However, the probing plan (Figure 5) suggests the peat depths west of the existing Tom na Clach access track have been interpolated from probes previously completed for the existing Tom na Clach windfarm. However, the probing locations, layout and density in this area have not been provided so it is unclear if the interpolation is based on reasonable and adequate peat depth data (e.g. so that over interpolation has not occurred). Please provide further information including peat probe layouts for this area of the site.

A second more detailed phase concentrating on infrastructure was completed in June, August and October 2021. The density of probing within the detailed Phase 2 probing is reported as 50m intervals along tracks with 10m offsets, and a 10m probing grid over other infrastructure locations. Figure 5 of the Peat Survey report presents the locations of the peat probes overlain with the infrastructure layout. In total 3,733 probes were completed. It appears that suitable probing layouts and frequencies have been adopted at the infrastructure locations and along proposed tracks. There is no probing along the main access track from the north and also along existing track that will be used to access T3,T4, T5 and the proposed substation. Comment is required as to whether any construction activity will be carried out on the existing track. Suitable justification is also required for omitting detailed probing in these areas.

The results of the peat probing are summarised in both Section 3.5 of the PLHRA and also the Peat Survey Report which includes a table summarising peat depth across the site. It reports that a peat depth of <0.5m (peaty soil) was reported for approximately 46% of the probes. 24% of probes measures a depth of 0.5-1.0m and approximately 30% were >1.0m.

Figure 5 of the PLHRA present interpolated peat depth across the site with peat bands split into 0.5m bands. Interpolation of peat depths was undertaken in the ArcMap GIS environment using a natural neighbour approach. This approach was selected because it preserves recorded depths at each probe location, unlike some other approaches (e.g. kriging), is computationally simple, and minimises 'bullseye' effects. The approach was selected after comparison of outputs with three other methods (inverse distance weighted, kriging and TIN).

The probing has identified the peat is relatively deep across much of the site, thinning eastwards to organic soil in the vicinity of turbines 2, 3 and 6 and around the proposed borrow pit. The deepest peat is concentrated in pockets in the south and west of the site, and has been avoided by proposed infrastructure, which has generally been sited into the shallowest peat in any particular locality (within the limits imposed by other constraints such as watercourse buffers, turbine spacings and highest value habitats). While careful siting of turbines has minimised impacts on deep peat so far as is possible, tracks are required to connect each turbine location, and these necessarily cross deep peat areas; where gradients permit floating track has been specified in order to reduce excavation, e.g. over an area of very deep peat between turbines 5 and 6, over moderately deep peat between turbines 2 and 1 and on the link track from turbine 5 to the Operation Scheme access track

Probing has also been supported by 19 peat cores which is discussed on the peat survey report and referenced on the PLHRA. Von Post logging undertaken during probing indicate acrotelm thicknesses of between 0.06 and 0.12 m, with H values of H2-H5 in the acrotelm and values of H6-H8 in the underlying catotelm. Correspondence between probe depth and the depth of the peat-substrate contact (as determined from coring) indicate a very good correlation, indicative of an absence of soft substrate beneath the peat. Rock, grit or sand is reported at all core locations. Photographs of the cores are included in the Peat Survey Report which contains a summary of ground conditions at every probe location.

2.7 Integration of Desk Study and Field Surveys

The data from desk study, site walkover and site investigations has been complied to produce a series of figures including peat depth, geomorphology and slope. The site walkover has been used to verify the desk study data and geomorphological map interpretation.

3.0 REVIEW OF HAZARD & RISK ASSESSMENT AND PROPOSED MITIGATION

3.1 Assessment of Likelihood

Assessment of likelihood has been carried out via both a semi-quantitative contributory factor- based approach and also a Factor of Safety (FoS) analysis.

The assessment does consider peat slides and bog bursts. Due to the combination of moderate slopes, moderate depth peat and extensive gullying at this site, the most likely mode of failure is smaller scale peat slides, and this is the failure mechanism considered in this report. This is in keeping with the most likely mode of failure for the peat depths and slope angles present at the site.

The stability analysis has been undertaken using the infinite slope model with both a baseline stability (drained) analysis, and a modified (loaded) analysis completed. The equation utilised for this assessment is considered appropriate and in accordance with ECUBPG. The input values used from published literature (unit weight, cohesion, shear strength and angle of internal friction etc.), are suitably referenced and considered credible and representative for site conditions.

The stability analysis was undertaken in ArcMap GIS software. A 25 m x 25 m grid was superimposed on the full site extent and key input parameters derived for each grid cell. In total, c. 4,475 grid cells were analysed. A 25 m x 25 m cell size was chosen because it is sufficiently small to define a credible landslide size and avoid 'smoothing' of important topographic irregularities. Both a baseline analysis and a modified analysis (including vehicle loads) has been undertaken.

The results of the FoS analysis are resented on Figure 6The outputs of the undrained analysis incorporating crane loads on floating track indicate lower factors of safety in the following locations:

- For 100 m of track leaving the Operational Scheme access track towards turbine 5 (FoS: 1.0- 1.4);
- For 75 m of track at the western end of the section between turbines 5 and 7 (FoS: 1.0-1.4);
- For 125 m of track at the southern end of the access to turbine 4 (FoS: 1.0 -1.4).

All other areas are presented as stable (>1.4).

Likelihood has also been assessed using a factor based approach that considers Landslide Susceptibility. The assessment has considered 8 No. contributory factors that include slope, peat depth, slope angle, substrate geology, peat geomorphology, drainage, forestry, slope/ profile curvature and land use. The methodology is based on the layering of the contributory factors to produce unique 'slope facets' that define areas of similar susceptibility to failure. 2,665 facets were considered in the analysis, with an average area of c. 1,000 m2 (or an average footprint of c. 30 m x 30 m, consistent with smaller to medium scale peaty soil or peat slides reported in the published literature.

An appropriate range of input factors have been used and the rationale for class factor scoring also seems both logical and credible and are discussed through Section 4.3.1 to 4.3.9 with a series of tables. It is good to see that both bog burst and peat slide have been considered. Figures showing the scoring of each class across the site is presented on Figure 7. Please justify why landslide susceptibility has not been calculated for the area west of the access track. Comment is required as to whether this affects the robustness of the assessment, in particular calculating risks on slopes downslope of the track.

The contributory factor layers were summed to provide a Landslide Likelihood Score. Figure 8 shows the outputs of the landslide susceptibility approach for peat slides. The results indicate that the majority of the site has a 'Low' likelihood and the remainder a 'Moderate' likelihood of a peat slide under natural conditions. The score bandings adopted appears to be reasonable and also fits with the ECUBPG.

3.2 Assessment of Consequence

A consequence assessment has been undertaken for the areas of moderate (or higher) likelihood that intersect with infrastructure. The assessment considers runout and identifies environmental and infrastructure receptors. The receptors on and off site the site are identified as watercourses and habitat, as well as the windfarm development itself.

Table 5-1 in the PLHRA outlines the scoring for each receptor type with justification. This appears to be logical and appropriate. Figure 8 presents overall risks and shows a number of areas where infrastructure intersects with moderate landslide susceptibility.

Six locations are considered to have the potential for runout to reach watercourses. However, in 5 out of 6 cases, the source volumes are sufficiently small that runout thickness will likely have reduced to < 0.2 m within the runout zone adjoining the watercourses and the surface roughness of vegetation may arrest debris movement and cause it to stall prior to entry. Only Source Zone 4 is assessed to have peat of sufficient depth to be conveyed further downstream. However, the debris would have to travel over 0.6 km downstream of the source zone before entering the Allt Carn an t-Sean-liathanaich watercourse, and it is considered unlikely that any significant volume of material would travel this distance. Run out is shown on Figure 9.

Figure 9 shows the location of source zones selected from the risk mapping where run out has been assessed. It is noted that not all moderate areas have been included and comments is required as to why some locations have been omitted, e.g. a section of track to T6. It is also noted that a number of areas designated as marginally unstable (FoS<1.4) that intersect with infrastructure have also been omitted. It would be anticipated that these areas would also warrant consideration so as to provide a robust assessment. Again comment is required and mapping and assessment needs to be updated accordingly.

3.3 Calculation of Risk

Calculation of risk is discussed in Section 5.4. The methodology for the calculation of risk is considered appropriate. Table 5.2 details the risk at the six areas identified as moderate likelihood with calculates a low risk. There is also accompanying discussion on each area and reasons are presented to explain/ justify the risk output. Overall the calculation of risk appears to be appropriate, however it may need to be updated as a result of the forgoing comments made in relation to the consequence assessment.

3.4 Proposed Mitigation

Mitigation is discussed within Section 6. Based on the analysis presented in this report, risks are calculated to be "Low" or "Negligible" across the site, and site-specific mitigation is not required to reduce risks pre-consent. It is considered a range of site-wide good practice measures should be sufficient to manage and mitigate any construction induced instability risks for the site.

Mitigation and good practise covering track construction, peat storage and for excavations are discussed. Other control measures include preparation of a geotechnical risk register,

site walkovers and on site monitoring. The section also considers a range of control measures and best practise post construction.

Overall the mitigation is considered adequate and proportionate to the PLHRA findings. Mitigation may require to be updated based on the foregoing comments.

4.0 SUMMARY AND RECOMMENDATIONS

4.1 Summary of Developers PLHRA

The following provides a summary of the developer's PLHRA making reference to whether or not adequate and appropriate field survey, peat sampling and analytical methods have been employed to assess peat stability and associated landslide risks including mitigation.

Desk Study

The desk study carried out for this review is thorough and is considered to be in line with the guidance. A good range of datasets have been reviewed and there is good detail on the site characteristics, hydrology, terrain and slope and peat morphology supported by mapping and photographs.

A useful addition to the desk study would have been local knowledge from landowners, and also any relevant information from the adjacent operational windfarm such as findings of the PLHRA for this development or any instability experienced during and post construction. In addition, identifying any major slope breaks would have been a useful addition to the geomorphological mapping.

Within this section it would have been useful to include reference to historical mapping data and meteorological data which were not stated.

Given the complexity of peatlands, the qualifications and experience of the team should be clearly stated early in the developers' reports.

Field Surveys

Field surveys including a site walkover and peat probing have been completed in accordance with the guidance (ECUBPG). The level of probing undertaken at the site is generally appropriate, however, peat probing west of the existing access track (undertaken as part of an earlier investigation linked to the existing windfarm) has not been shown on the mapping and therefore it is not clear as to what the level/ frequency of probing the interpolated peat depth map is based upon for this area of the site.

The peat probing has been supported by coring and good characterisation of the peat morphology and the substrate.

Integration of Desk Study and Field Surveys

The data from desk study, site walkover and site investigations has been compiled to produce a series of figures including peat depth, geomorphology and slope. The site walkover has been used to verify the desk study data and geomorphological map interpretation.

Hazard Assessment – Likelihood

Two separate methodologies consisting of a factor based approach and Factor of Safety analysis using the infinite slope model have been completed. Both methodologies are considered suitable and in line with ECU guidance. Landslide susceptibility has not been provided for the areas west of the access track.

Hazard Assessment – Consequence

A consequence assessment has been undertaken as part of the assessment of risk and has considered runout and as well as identifying appropriate environmental and infrastructure receptors.

Not all moderate areas have been included within the assessment and therefore these areas need to be considered or comment is required as to why these have been omitted. In addition, it is also noted that a number of areas designated as marginally unstable (FoS<1.4) that intersect with infrastructure have also been omitted. These should warrant consideration so as to provide a robust assessment with mapping and risk assessment updated accordingly.

Calculation of Risk

The methodology for the calculation of risk is considered appropriate and in general accordance with ECUBPG. Comments in relation to likelihood and consequence may mean that overall risk requires to be updated.

Proposed Mitigation

A reasonable range of mitigation is discussed on the PLHRA that is credible and covers a number of construction aspects. It is considered proportionate to the findings of the PLHRA.

4.2 Summary Outcome of Checking Report

The following comprises the summary outcome of the checking report:

- The PLHRA **requires minor revisions:** although much of the PLSRA is sound, there are some key elements that are considered to be insufficiently robust to support the PLSRA conclusions and minor revisions are required. Areas of attention will be advised in the review of the findings and may be progressed by the developer through either an appendix to the original submission or by clarification letter.

Recommendations

The following recommendations are made:

Recommendations requiring response from Developer:

- In line with ECUVPG, please provide competencies of the team including the competent chartered person.
- The western part of the site (west of the main access track) doesn't appear to have had any features added to the mapping. Please update mapping as appropriate.
- The probing plan suggests the peat depths west of the existing Tom na Clach access track have been interpolated from probes from investigations. However, the probing locations, layout and density in this area have not been provided so it is unclear if the interpolation is based on reasonable and adequate peat depth data Please provide further information including peat probe layouts for this area of the site.

- There is no detailed probing along the main access track from the north and also along existing track that will be used to access T3,T4, T5 and the proposed substation. Suitable justification for omitting detailed probing in these areas is required and comments as to whether any construction activity will be carried out on the existing track.

- Landslide susceptibility has not been calculated for the area west of the access track. The assessment should be updated to include this area or suitable justification given as to why it has not been included. Comment is required as to whether this affects the robustness of the assessment, in particular calculating risk on slopes downslope of the track.

- It is noted that not all moderate areas have been included in the consequence assessment e.g. a section of track to T6. It is also noted that a number of areas designated as marginally unstable (FoS<1.4) that intersect with infrastructure have also been omitted. It would be anticipated that these areas would also warrant consideration, so that there is robust assessment, with mapping and risk updated accordingly.

Recommendations made for information only – no response required:

- A useful addition to the desk study would have been local knowledge from landowners, farmers and local residents and additional information identifying any major slope breaks would have been a useful addition to the mapping.

- Historical mapping data and meteorological data would have been other useful baseline data for the desk study.