APPENDIX 4B

AGL CONSULTING

REVIEW OF PEAT STABILITY RISK ASSESSMENT & DESIGN OF BUNDED PEAT STORAGE AREAS

TECHNICAL NOTE

To: **Kieran O Malley, FuturEnergy Ireland**

From: Conor O'Donnell

Re: **Croagh Wind Farm – Review of Peat Stability Risk Assessment & design of bunded peat storage areas.**

Date: 10/3/2026 **Ref: 24-235-TN001 (Rev.0)**

1.0 INTRODUCTION

I have been requested by FuturEnergy Ireland to review the EIAR and associated reports and drawings for the Croagh Windfarm to carry out a review of the geotechnical and peat stability risk assessment for the site, as well as the design proposals for the bunded peat repository sites and borrow pit cells that will be used to store excavated peat and soft clay from the access roads, turbine foundations and hardstanding areas on the site during construction.

2.0 STATEMENT OF EXPERTISE

My name is Conor O'Donnell. I am a Senior Geotechnical Consultant and Managing Director of AGL Consulting, based in Dublin, Ireland. I have an honours undergraduate degree in Civil, Structural and Environmental Engineering from Trinity College Dublin, and a master's degree in geotechnical engineering and structural mechanics from Cornell University in Ithaca, New York. I am a Chartered Engineer with Engineers Ireland, a Fellow of the Geological Society of London, and a Fellow Consulting Engineer with the Association of Consulting Engineers of Ireland.

I have extensive experience with civil and earthworks design for wind farms and infrastructure works in Ireland and the UK and have developed a particular area of expertise in assessing and managing the risk of peat instability for wind farms on upland blanket bogs at planning, detailed design and construction stage. I was the lead project geotechnical engineer responsible for managing the risk of peat stability for the completion of the civil works on the Derrybrien Wind Farm site after the peat slide in October 2003, which included the design, evaluation and testing of over 17.5km of floating roads across the site as well as geotechnical investigations and stability analyses to design repository sites to store peat excavated from 70 turbines and crane hardstanding areas and the substation site.

Since then I have carried out peat stability risk assessments and provided expert advice on geotechnical risk mitigation and management for several wind farms on upland blanket bogs including the Garvagh Glebe and Tullynahaw Wind Farms in Co. Leitrim and Co. Roscommon, the Grousemount Wind Farm in Co. Kerry, and the Crockagarran, Carrickatane and Crockdun Wind Farms in Co. Tyrone.

I have also provided expert advice and forensic investigation services to the Health and Safety Authority and Liberty Insurance in relation to peat slides that occurred on wind farm sites in Ireland.

In 2020 I prepared the chapter on soils, geology and land for the 2020 remedial Environmental Impact Assessment Report (rEIAR) for the Derrybrien Wind Farm, including the appendices on peat stability risk assessment and on the management of peat stability during construction. Since then, I have also prepared the chapters on soils, geology and land for the 2025 application to decommission the wind farm, which included an EIAR and PSRA for the elements of the windfarm to be decommissioned and taken off site, as well as an rEIAR and PSRA for the elements to be left in place after decommissioning.

I was the geotechnical advisor to An Bord Pleanála on peat stability and ground movement for the Oral Hearing into the 2009 application for the Corrib Onshore Gas Pipeline. I was also the expert geotechnical consultant to Sligo County Council on spoil management for excess peat and mineral soil for the EIS and 2014 Oral Hearing for the N4 Collooney to Castlebaldwin Road Improvement Scheme, which included design proposals for storage of large volumes of excavated peat in borrow pits and bunded peat repository sites.

3.0 DOCUMENTS REVIEWED

I have been provided with a copy of the Environmental Impact Assessment report and associated reports and drawings, which includes the following relevant documents that give details of the earthworks and drainage design for the wind farm in addition to the spoil management proposals, the ground and groundwater conditions on the site, and the peat stability risk assessment for the project:

- EIAR Chapter 4: Description of the Proposed Development
    - EIAR Appendix 4-1: Site Layout Drawings
    - EIAR Appendix 4-2: Peat and Spoil Management Plan
    - EIAR Appendix 4-4: Construction Environmental Management Plan
    - EIAR Appendix 4-5: Drainage Layout Drawings
- EIAR Chapter 8: Land, Soils & Geology
    - EIAR Appendix 8-1: Geotechnical & Peat Stability Risk Assessment Report – (including site investigation information).

I was also provided with the responses to requests for further information from Sligo County Council and Leitrim County Council.

4.0 OPINION

Having reviewed the relevant information on the project details, ground and groundwater conditions, spoil management and peat stability I would make the following observations:

- An appropriate peat stability risk assessment methodology has been adopted for the project in accordance with the 2017 Best Practice Guidelines for Peat and Landslide Hazard and Risk Assessments prepared by the Energy Consents Unit of the Scottish Government, which includes:
    - [Scoping]: A scoping study to identify the extent of peat on the windfarm site as well as records of peat instability in the surrounding area.
    - [Desk Study]: A desk study of relevant information, including:
        - Aerial photography, OS & LiDAR survey data on topography, geomorphology and historic landslides and peat slides.
        - Subsoils and bedrock geology from the Geological Survey of Ireland (GSI)
        - Landslide susceptibility mapping (GSI) – including records of historic landslides and peat slides in and around the study area.
        - Local and regional hydrology (Environmental Protection Agency).
    - [Site Reconnaissance Survey] – extensive site reconnaissance and walkover surveys, including inspection of historic peat slides and zones of similar characteristics on upland blanket bog outside of site boundary.
    - [Ground Conditions Assessment] – a preliminary ground investigation involving trial pits, boreholes, rotary coreholes and extensive peat probing to characterise the peat, subsoil and bedrock conditions across the site, and in-situ hand vane testing to determine profiles of shear strength with depth in the peat.
    - [Stability Analysis] – A deterministic approach has been used to assess the stability of the peat slopes based on an infinite slope factor of safety against sliding in the short-term undrained and long-term drained condition. Reasonably conservative lower-bound shear strength parameters have been assumed for the peat. Sensitivity analyses have been carried out to assess the stability of the slopes under a 10kPa surcharge load in the short-term undrained condition (1.0m of peat), and for a range of groundwater levels up to ground level in the long-term effective stress condition.
    - [Hazard Ranking Assessment] – A qualitative assessment has also been carried out to assess the potential impact of known contributary factors on the likelihood of a peat slide.
    - [Peat Stability Risk Assessment] - The results of the stability analyses and qualitative hazard ranking assessment have been combined into the Peat Stability Risk Assessment to calculate a risk rating for peat instability based on the interpreted likelihood and impact of a peat failure at representative locations for the wind farm infrastructure, which is in accordance with the ICE publication on Managing Geotechnical Risk [Clayton, 2001].

  - [Mitigation] – Mitigation measures have been recommended to ensure that the risk of a peat slide is at an acceptable level for the proposed scope of works.

- The peat stability risk assessment and drainage designs have been carried out by engineering consultants with the appropriate level of professional qualifications and experience for wind farm developments on upland blanket bogs. i.e.:

  - The peat stability risk assessment and ground conditions summary were carried out by Fehily Timoney & Co. (FTC) under the direction of Mr. Ian Higgins – a Principal Geotechnical Engineer with an MSc in Geotechnical Engineering and over 25 years of experience in earthworks and the geotechnical assessment and design of windfarms on upland blanket bogs at various stages of development across Ireland and the UK.

  - The hydrological assessment and drainage design were carried out by Hydro Environmental Services (HES) under the direction of Mr. Michael Gill – a Senior Civil Engineer and Hydrogeologist with an undergraduate degree in Civil, Structural and Environmental Engineering; Master of Science Degrees in Wetlands Hydrology and Applied Hydrogeology; and over 20 years of related experience in drainage design and hydrological and hydrogeological assessment of over 100 wind farms on upland blanket bogs across Ireland.

- FTC and HES have demonstrated a clear understanding of the pertinent ground and groundwater conditions on the site that relate to peat stability as well as contributory factors that could have an impact on peat stability for the wind farm development, including, for example:
  - The depth and extent of peat across the site.
  - Profiles of characteristic undrained shear strength with depth determined by in-situ hand vanes.
  - Zones of elevated or higher construction risk in areas of deep very soft peat ("quaking bog"), or where there is a low infinite slope Factor of Safety.
  - The characteristics and strength of the underlying mineral subsoil, including a thin cover of soft clay over the glacial till at the base of the peat which is locally referred to as the "Leitrim daub" and has been identified as the shear failure plane for the 2016 slide to the west of the site, and on the site of the Garvagh Glebe Windfarm.
  - Zones of disturbed remoulded peat debris from previous or relic peat slides.
  - Topographical features related to previous and relic peat slides along the edge of the upland ridges to the east and west of the site.
  - Zones where the integrity of the peat has been disturbed by mechanical peat harvesting.
  - Site hydrology and hydrogeology – lakes (Lough Nacroa), rivers, streams, evidence concentrated subsurface flow or piping along buried shallow valleys, & existing site drainage.
- This information has informed the layout of the site infrastructure, which is predominately aligned along existing roads and corridors of relatively shallow peat and avoids areas of very deep saturated peat or "quaking bog". A buffer has also been

provided to the disturbed peat at the base of the 2016 slide that originated offsite to the west.

- Aspects of the works have also been designed to address specific geotechnical stability issues – for example supporting the access roads, crane hardstandings and rockfill berms at the borrow pit and repository sites on competent glacial till below the soft "Leitrim daub" clay layer, where encountered.
- Since the original EIAR submission, additional ground investigation works were carried out on the site of the proposed borrow pit and bunded peat repository sites in September & October 2025 to get further site-specific information on the depth and characteristics of the peat, mineral subsoil and bedrock, where encountered. The investigations were comprised of:
    - Peat depth probes
    - In-situ vane shear tests with the Geonor H-70 vane
    - Rotary coreholes
    - 2D resistivity and seismic refraction geophysical profiles.
- Combined with the original site investigation, there is sufficient information in this ground investigation information to address the issue of peat stability for the design of the borrow pit and peat repository sites.
- Overall, although there is a history of peat instability in the region, either naturally or due to contributory anthropogenic factors related to mechanical peat harvesting or due to construction activities on other wind farm sites, I would consider that the overall risk of peat instability for the proposed works on the Croagh Wind Farm is relatively low and manageable with appropriate construction management and supervision. This is primarily because:

    - Approximately 60% (10.9km) of the site access roads will involve upgrading and widening existing roads and forestry tracks that are generally constructed as excavated access tracks founded on the mineral subsoil below the peat and have been in place for several years without any issues of peat stability.

    - The three short sections of the existing roads that need to be upgraded but were originally constructed as floating roads are currently supported on peat that has consolidated and increased in strength under the sustained load from the roads. This significantly reduces the risk of instability in the peat when the roads are upgraded.

    - The majority of the 6.9km of new site access tracks will be constructed by excavating the peat and soft clay layers out from under the alignment of the roads to construct the roads with a suitable thickness of compacted rockfill directly on the underlying competent cohesive glacial till or rock. These roads exert negligible loading on the peat and will also improve overall site stability where they act as a barrage to support peat directly upslope from the roads.

    - Similarly, all the peat and soft clay will be excavated out from under the crane hardstandings, turbine foundations, site compounds and substation sites to support the hardstanding areas and foundations on the underlying competent glacial till and bedrock with negligible loading on the peat.

- Almost all the excavated peat and soft clay will be placed in the designated bunded peat repository and borrow pit storage areas on the site where the peat and clay will be fully contained by granular rockfill berms above existing ground level, or by the glacial till and rock slopes below ground level within deep cells inside the borrow pit. Sidecasting will be limited to minor landscaping around the turbine and crane hardstanding excavations with vegetated acrotelm peat turves for site reinstatement which will generate minimal loading on the peat slopes.

- The drainage design includes comprehensive standard details for upslope interceptor drains and downslope collector drains along the access tracks and crane hardstanding areas, with regular outfalls, check dams, settlement ponds and vegetated swales to effectively manage the collection and controlled discharge of surface runoff and to prevent an accumulation of groundwater in the granular rockfill to prevent downslope peat instability from concentrated groundwater seepage and hydrostatic pressures during periods of heavy rainfall.

- The construction of new floating roads is limited to three short sections of access road on the approach to Turbines T3, T7 and T8. These are areas of relatively deep peat on gently sloping ground which are suited to floating roads as an alternative to the excavate replace design.

- In my opinion storing the excavated peat and soft clay in the bunded repository sites and borrow pit cells is the most reliable method of spoil management to mitigate the risk of peat instability during construction compared to sidecasting or "floating" repository sites that are not contained by perimeter bunds, i.e.

  - It is a proven method of effective containment of weak remoulded excavated peat that has been successfully implemented on windfarm sites on upland blanket bogs in Ireland, including sites where there was a history of peat instability, for example:

    - Photos 1 and 2 show the deep borrow pit cells in cohesive glacial till and mudstone/shale bedrock that were backfilled with excavated peat on the Garvagh Glebe wind farm site in Co. Leitrim, which would have similar geological characteristics to the proposed borrow pit on the Croagh wind farm site. Photo 3 shows an aerial view of the cells in their current condition where they have been stable for over 15 years.

    - Photo 4 shows an example of a stable bunded peat repository on the Crockagarren Wind Farm in Co. Tyrone.

    - Photos 5 and 6 show recent aerial photographs of other examples of bunded peat repository sites that have been in place for over 15 years on the Garvagh Glebe and Tullynahaw Wind Farm sites.

    Similar bunded repository sites and borrow pit cells have routinely been used to safely store large volumes of excavated peat and soft clay on many other wind farm sites on upland blanket bogs across Ireland. Rockfill barrages have also been used to effectively contain large volumes of remoulded displaced peat within the slide area on the Derrybrien Windfarm.

- The design of the rockfill berms proposed for the Croagh Wind Farm incorporates standard earthworks and drainage details to ensure that they will be stable and can effectively contain the excavated peat and soft clay, i.e.:
    - The berms will be constructed on competent firm or stiff cohesive glacial till below the peat and soft clay layers to ensure that there is adequate bearing capacity and resistance to sliding.
    - The size and geometry of the berms will be designed to resist the fluid and earth pressures from the peat and soft clay in sliding, uplift and overturning by self-weight and frictional resistance.
    - The berms will be constructed of coarse well-graded angular rockfill which will be sufficiently permeable to allow water from the peat to drain through the berm and allow the peat to dry out over time.
    - The rockfill will also have a high friction angle to ensure that the side slopes of the berms are stable for the steady state seepage condition that will develop initially after the pits are filled.
    - The depth, geometry and design side slopes of the borrow pit cells will be determined during construction. However, the ground investigation information indicates that bedding in the rock is near horizontal so that it should be possible to achieve steep stable temporary side slopes, as illustrated by the image in Photo 1.
    - Interceptor drains will be constructed upslope from the borrow pit and repository sites to intercept surface runoff, and toe drains will be constructed at the base of the berms to collect seepage through the rockfill. Drains will also be installed through the berms at the top of the backfilled peat to prevent ponding and overtopping of surface water.
- The proposed methodology for backfilling the borrow pits and bunded peat repository sites is consistent with the methodology that was used for the sites shown in Photos 1-6. The surface of the peat and soft clay will be levelled out and shaped to promote surface runoff and the berms will be designed with min. 0.5m freeboard to prevent overtopping.

- Finally, I would consider that the earthworks and drainage design for the wind farm in the EIAR and supporting documents incorporates standard details that can be developed into the detailed design to effectively mitigate the risk of peat instability during construction. It is proposed to carry out supplemental ground investigations on the site to develop the design, which is standard practice, and construction of the wind farm will be supervised by a suitably qualified geotechnical engineer to ensure that peat stability is effectively managed on site.

Document Approval Form			
Document No:	24-235-TN001	**Description:**	Review of peat stability risk assessment and design of bunded peat storage areas.
Revision No:		**Date:**	**Notes**
Rev.0		10/3/2026	**DRAFT for Review**
Rev.1		12/3/2026	**Final**
Made/Checked by		**Signature**	
Made by:	Conor O'Donnell		



Photo 1 – Fully developed borrow pit cell prior to backfilling on the Garvagh Glebe Wind Farm



Photo 2 – Backfilled borrow pit cells on the Garvagh Glebe Wind Farm, Co. Leitrim



Photo 3 – Recent aerial photo of the backfilled borrow pit cells on the Garvagh Glebe Wind Farm



Photo 4 – Bunded peat repository site on the Crockagarran Wind Farm, Co. Tyrone

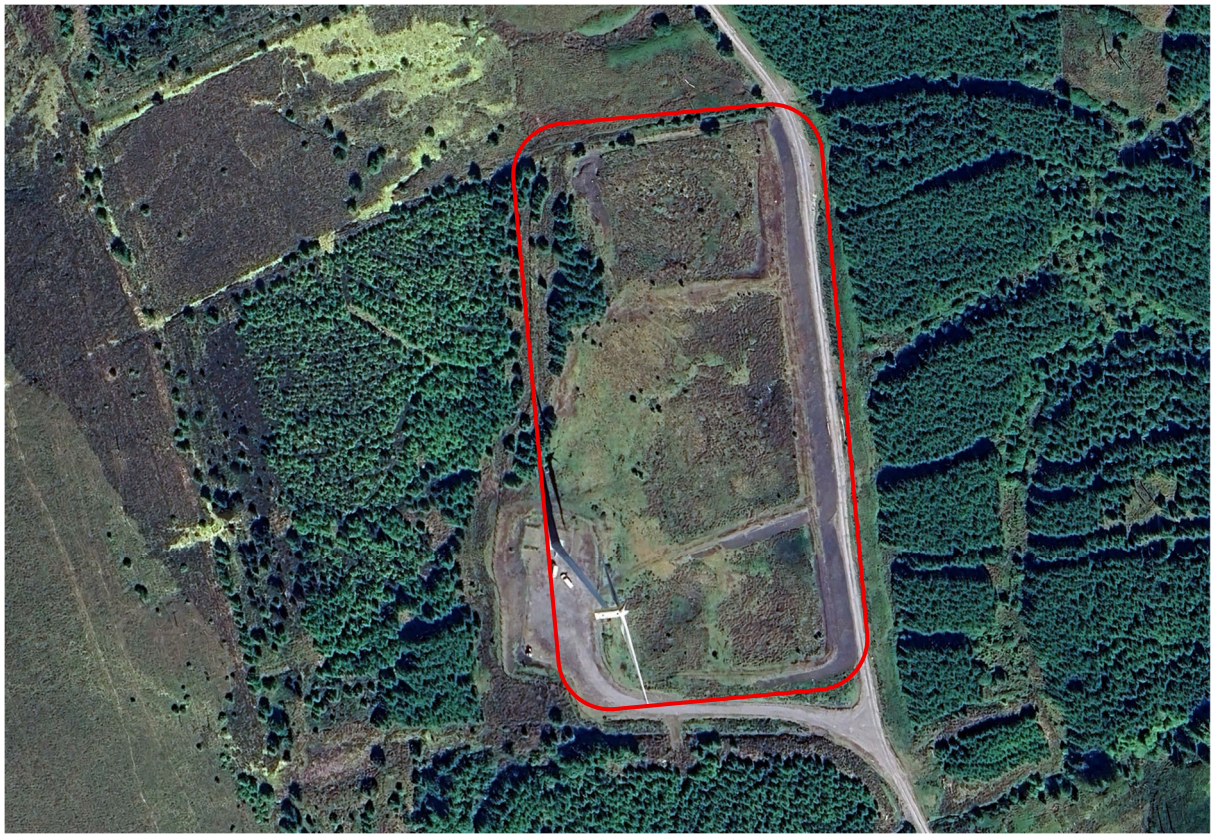


Photo 5 – Recent aerial photo of bunded peat repository cells on the Garvagh Glebel Wind Farm.



Photo 6 – Recent aerial photo of bunded peat repository cells on the Tullynahaw Wind Farm in Co. Roscommon.