Peat Stability Risk Assessment
Cummeennabuddoge Wind Farm

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Acronyms and symbols

FoS. Factor of Safety
GDG. Gavin & Doherty Geosolutions

GI. Geo-Investigation
IDW. Inverse Distance Weighted
masl. meters above sea level
NIR. Near Infrared
OSi. Ordnance Survey Ireland
OTF. Orthophoto
PSR. peat and spoil stockpile restrictions
PSRA. Peat Stability Risk Assessment
SWIR. Short Wave Infrared

Executive Summary

Atmos Consulting commissioned Gavin and Doherty Geosolutions Limited (GDG) to undertake a Peat Stability Risk Assessment (PSRA) for the proposed Cummeennabuddoge Wind Farm site. A peat stability assessment is required in accordance with planning guidelines compiled by the Department of the Environment, Heritage and Local Government (DoEHLG), where peat is present on a proposed wind farm development.

The findings of the peat assessment showed that the site has an acceptable margin of safety and is suitable for the proposed renewable energy development, based on select conditions and the assurance that best practice peat management shall be undertaken during development.

The average peat depth recorded across the site is 1.3m. A localised section of deeper peat up to a depth of 5.4m was recorded within the proposed access track. Where possible, the deeper peat areas have been avoided by optimising the proposed layout for the site.

A desk study, site walkovers, ground investigation campaigns, stability analyses and a risk assessment were carried out to assess the risks posed by peat failures. The risks were assessed following the principles in Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (Scottish Executive, 2017).

The stability analysis aims to determine the stability of the peat slopes, i.e., the Factor of Safety (FoS). The FoS provides a direct measure of the degree of stability of a peat slope. A FoS of less than 1.0 indicates that a slope is unstable; an acceptable FoS for slopes is 1.3 or greater. During the layout design stage of the Proposed Development the Factor of Safety Analysis along with observations from site walkovers and desk study review were used to develop *Safety Buffer Areas*. These areas of identified potential instability were avoided where possible during the siting of the Proposed layout. *Safety buffer areas* are presented in Appendix L, Figure L- 1 and Figure L- 2. A risk assessment was carried out considering the FoS value calculated in the stability analysis along with other factors that could influence the stability of peat, as a peat slide would be potentially very damaging to this particular site's environment, given the presence of sensitive water receptors downstream of the site, including Lough Leane and a Special Area of Conservation.

The site, in association with the Proposed Development layout, was found to have both acceptable factors of safety and levels of risk against peat instability. Outside of the footprint of the Proposed Development some limited potential instability areas have been highlighted throughout the layout design of the Proposed Development and will have no construction activities. In addition, peat and spoil stockpile restriction (PSR) areas are proposed at the limited locations where the proposed development overlaps or is adjacent to *safety buffer areas.* PSRs are presented in Appendix L, Figure L- 3 and Figure L- 4, and occur in isolated localised areas of the Proposed Development where total avoidance was not possible as some *safety buffer areas* extend across large extents of the site, particularly on steep slopes along watercourses.

A separate bearing capacity, sliding check, and local and global stability assessment for the peat repository areas was carried to examine the constructability and stability of the berms and peat

stored within. The assessment outlines a criteria for the proposed areas and detail that the area will be suitable for the proposed temporary and permanent storage of peat.

Outside of the peat and spoil stockpile restriction areas, the Proposed Development is considered to have a negligible to low landslide risk and is safe for construction provided all works comply with the methodologies and mitigations outlined in the associated Peat Management Plan (PMP), included as Appendix 10-3 of the EIAR.

1. Introduction

1.1. Background

Gavin and Doherty Geosolutions (GDG) was commissioned by Atmos Consulting to undertake a Peat Stability Risk Assessment (PSRA) for the proposed Cummeennabuddoge Wind Farm site located in Co.Kerry, adjacent to the county boundary with Co. Cork, close to the village of Ballyvourney.

GDG has been involved in many wind farm developments in both Ireland and the UK at various stages of development, i.e. preliminary feasibility, planning, peat stability assessment, design and construction. In addition to this, the GDG team made up of engineering geologists, geomorphologists, geotechnical engineers and environmental scientists, has developed expertise in landslide hazard mapping, including leading a recent national landslide hazard mapping pilot study, which included extensive landslide runout and hazard mapping and calculation in Irish blanket peat.

1.2. Statement of Authority

This document was prepared by Gavin & Doherty Geosolutions (GDG). GDG is a specialist engineering consultancy with a foundation in geoscience, environmental services and geotechnical engineering.

The company was founded in 2011 and is committed to supporting projects that contribute to the global sustainability agenda, such as enhancing infrastructure, supporting onshore and offshore wind farm developments, and general civil infrastructure design.

The members of the GDG team involved in this assessment include:

- Stephen Curtis is the primary author of this report. Stephen was involved throughout the development of the proposed design including several visits to the site and has carried out the stability analysis and interpretation of the ground model, reviewed peat stability and influence of peat handling practice at the site relating to the infrastructure design. Stephen is a Senior Engineering Geologist on the onshore renewable team. He has over seven years of experience in both site investigation contracting and geotechnical consultancy environments. He is Chartered with the Institute of Geologist of Ireland (IGI) and the European Association of Geographers. Stephen has worked on multiple renewable energy projects, primarily solar and wind farm projects in Ireland and the UK, for over four years. He has been involved in the feasibility study, planning, design and construction stages of wind and solar farm developments with a particular focus on geotechnical risk management and mitigation for construction in upland peat areas and Irish glacial ground conditions.
- Ruadh McIntosh is the project manager and has been involved in the design of the proposed development. Ruadh is a Senior Engineering Geologist working in the Environment team. She has eight years' experience working within the consultancy sector, and has been responsible for the project management and delivery of a number of renewable energy project components in the UK and the Republic of Ireland, largely relating to peat and

borrow pit assessments. She is a Chartered Geologist with the Royal Geological Society of London.

- Paul Quigley is the project director and has provided guidance and review approval for the analysis and reporting. Paul is a Chartered Engineer with over 25 years of experience in geotechnical engineering and a UK Registered Engineering (RoGEP) Advisor. He has worked on a wide variety of projects for employers, contractors and third parties, gaining a range of experience including earthworks for major infrastructure schemes in Ireland and overseas, roads, tunnelling projects, flood protection schemes, retaining wall and basement projects, ground investigations and forensic reviews of failures. Paul is adept at designing creative solutions for difficult problems and has published numerous peer-reviewed technical papers. He has also acted as an independent expert for several legal disputes centred on ground-related issues. He is a reviewer for the ICE Geotechnical Engineering Journal, a member of the Eurocode 7 review panel at NSAI and a former Chairman of the Geotechnical Society of Ireland.
- Alastair Lewis has been involved in the oversight and review of the engineering design of the Proposed Development. Alastair is a Civil Engineer with over twenty-five years' experience in civil and ground engineering. He oversees the delivery of multi-disciplinary development infrastructure projects including, brownfield development, ground engineering, earthworks platforming, mining remediation, SUDS, sewerage, flooding, bridges, windfarms, and roads. As head of infrastructure, he developed engineering strategies in the property and energy sectors with particular reference to planning and environmental requirements. He has design experience of major earthworks and mine stabilisation schemes and extensive experience in assessment of abandoned mine workings.
- Chris Engleman has carried out the ground model development, stability analysis, GIS mapping and constaints mapping analysis for the project. Chris is a Geologist with four years of industry experience within the onshore renewables sector and the field of geological mapping; predominantly working on projects for peat stability and management in advance of wind farm construction, ground investigation, rock and soil logging, GIS mapping and geotechnical design. He has strong experience within peat stability, soil logging to BS5930, geological mapping, site investigation and GIS mapping.
- Daniel Murphy carried out several site visits to the site for ground investigations and engineering design. Daniel is a Graduate Engineer working in both the GDG Infrastructure team and the Structures team. He has a Masters' degree in Civil Structural and Environmental Engineering from University College Cork and has been working with GDG since graduating in 2022. Daniel has worked on a variety of Temporary Works and Permanent Works design projects in Ireland and the UK, and is experienced at peat probing.
- Brian McCarthy carried out several site visits to the site for ground investigations and engineering design. Brian is a Civil Engineer within the infrastructure team in GDG with two years of post-graduate experience. Brian holds a Masters degree in Civil, Structural and Environmental Engineering from University College Cork and is a member of the Institution of Engineers of Ireland. Brian has worked on various renewable energy and infrastructural projects in Ireland and the UK and has carried out peat probing on a number of projects throughout Ireland.

1.3. Proposed Development

The proposed Cummeennabuddoge Wind Farm is located approximately 8km north of Ballymakeera town, in the Derrynasaggart Mountains, Co. Kerry. It encompasses the townlands of Cummeennabuddoge and Clydaghroe and is 709 ha in size. The proposed access route passes through the townlands of Cummeenavrick and Glashacormick, Co. Kerry.

A detailed map of the proposed site's administrative locations is provided in Appendix A.

A full description of the development is provided in Chapter 4 of the environmental impact assessment report (EIAR), however the Proposed Development infrastructure will comprise of the following:

- Construction of 17 wind turbines and associated hardstand areas;
- One 110kV permanent electrical substation including a control building with welfare facilities, all associated electrical plant and equipment, security fencing, all associated underground cabling, wastewater holding tank and all ancillary structures and works;
- All works associated with the permanent 110kV connection from the proposed substation to the national electricity grid via underground cabling to the existing 220/110kV Ballyvouskil Substation;
- All associated underground electrical and communications cabling connecting the turbines to the proposed substation;
- One permanent Meteorological Mast of 110 metres in height and associated hardstand area;
- New and upgraded tracks, roads and site access;
- Four borrow pits;
- Six permanent peat repository areas;
- Permanent placement of peat along sections of site access roads and hardstands (side casting) where appropriate as part of the peat management plan for the site;
- Three temporary construction compounds;
- All temporary works associated with the facilitation of turbine components and abnormal load delivery;
- Site drainage;
- Site signage;
- Ancillary forestry felling to facilitate construction and operation of the proposed development; and
- All associated site development works.

The Proposed Development has been designed with an operational life of 35 years, at the end of which the wind farm can be decommissioned.

This report examines the conditions at the Proposed Development Site, located within the red line boundary as defined in Chapter 4 of the EIAR. The turbine transport delivery route along public roads is not included in this assessment because minimal ground excavation is required for this and where required, no peat is present. As very little peat or soft ground has been identified on the grid connection route and no peat stability risk is thought to be present, this has also not been included in the report.

The “Proposed Development Site” or “Site” as referred to in this report is in reference to the access road and main Development Area within the red line boundary as defined in Chapter 4 of the EIAR.

1.4. Overview of peat landslides

1.4.1. Peat landslides types

Two general groups of peat landslides are typically referred to in the literature: peat slides and bog bursts. Some descriptions of each type are provided in Table 1-1.

Table 1-1: Peat landslide types.

Characteristics	Peat slide	Bog burst
Outstanding characteristic	Shallow translational failures	Particularly fluid failures without necessarily a clear scar margin. The liquefied basal material is expelled through surface tears followed by settlement of the overlying mass.
Mechanism	Shear failure along discrete shear surfaces, typically at the peat-substrate interface	Subsurface creep, swelling
Peat depth	≤ 2 m	≥ 1.5 m
Slope angle	5 – 15° (moderate)	2 – 10° (gentle), where deeper peat is more likely

A study of historical landslides, regional landslides identified within a 5km buffer of the site boundary and a study of a landslide event at a neighbouring renewable energy development are outlined in Section 2.6.

1.4.2. Controls of peat instability

The spatial and temporal occurrence of landslides, including peat landslides, is controlled by a combination of *conditioning* and *triggering factors*.

The conditioning factors are responsible for the location of a landslide event, and are related to the inherent properties of the terrain, such as:

- soil type,
- slope angle,
- curvature (convex/concave) of the slopes, and
- drainage.

The triggering factors explain the frequency of landslides. They can be distinguished between fast and slow triggers:

- Fast triggers:
    - Intense rainfall (the most frequent trigger);
    - Snowmelt (very frequent trigger);
    - Rapid ground accelerations (e.g. from blasting rock);
    - Undercutting of peat by natural processes (e.g. fluvial) or man-made; or

  - Loading the peat.
- Slow triggers:
  - Low intensity but constant rainfall;
  - Afforestation / Deforestation (wildfires, pollution-induced vegetation change); or
  - Weathering (physical, chemical, biological).

Slow triggers can start landslides by themselves and can also act as *preparatory factors* for fast triggers by lowering their threshold to start landslides.

1.4.3. Failure indicators

The presence of conditioning factors and low-pace triggers before failure is often indicated by ground conditions, features and morphologies that can be identified remotely or during the fieldwork by the geomorphologist or through basic monitoring techniques.

According to the updated guidelines provided by the Scottish-Executive (2017), the following critical features are indicative of the susceptibility or proneness to failure in peat environments:

- Presence of historical and recent failure scars and debris;
- Presence of features indicative of tension (e.g. cracks);
- Presence of features indicative of compression (e.g. ridges, thrusts, extrusion features);
- Evidence of peat creep (typically associated with tension and compression features);
- Presence of subsurface drainage networks or water bodies;
- Presence of seeps and springs;
- Presence of artificial drains or cuts down to substrate;
- Presence of drying and cracking features;
- The concentration of surface drainage networks;
- Presence of soft clay with organic staining at the peat and (weathered) bedrock interface; and
- Presence of iron pans or similar hardened layers in the upper part of the mineral substrate.

Other evidence of peat instability not related to landslides has been considered, namely quaking peat in horizontal areas with very low bearing capacity.

1.5. Peat Stability Risk Assessment workflow

GDG has carried out the PSRA for the Proposed Development Site following the principles set out in the *Proposed electricity generation developments: peat landslide hazard best practice guide* (Scottish Executive, 2017). This guide has been used in this report as it provides best practice methods to identify, mitigate, and manage peat slide hazards and associated risks with respect to consent applications for electricity generation projects.

Figure 1-1 shows a workflow diagram showing the general methodology for the PSRA. The methodology can be summarised into the following steps:

1. Completion of the desk study.
2. Undertaking a walkover and fieldwork to:
    - Carry out geo-investigations, especially concentrated at the proposed infrastructure areas, including peat probing and hand shear vane testing, Russian core sampling and trial pitting;
    - Record geological and geomorphological features, including exposures of the soil profile and evidence of peat instability; and
    - Record hydrologic and vegetation features.
3. Risk assessment, including:
    - Interpolation of the peat probe values and generation of the peat depth map;
    - Creation of the Factor of Safety (FoS) maps using a deterministic approach (Bromhead, 1986) for drained and undrained conditions;
    - Qualitative hazard assessment by combining the FoS with observations of the peat condition identified both on aerial imagery and during fieldwork.
    - Qualitative consequences assessment;
    - Calculation of the peat landslide risk by multiplying hazards and consequences;
    - Reclassification of the risk values into four classes:
        - Negligible;
        - Low;
        - Medium; and
        - Serious.
4. Proposal of actions required for each infrastructure element.

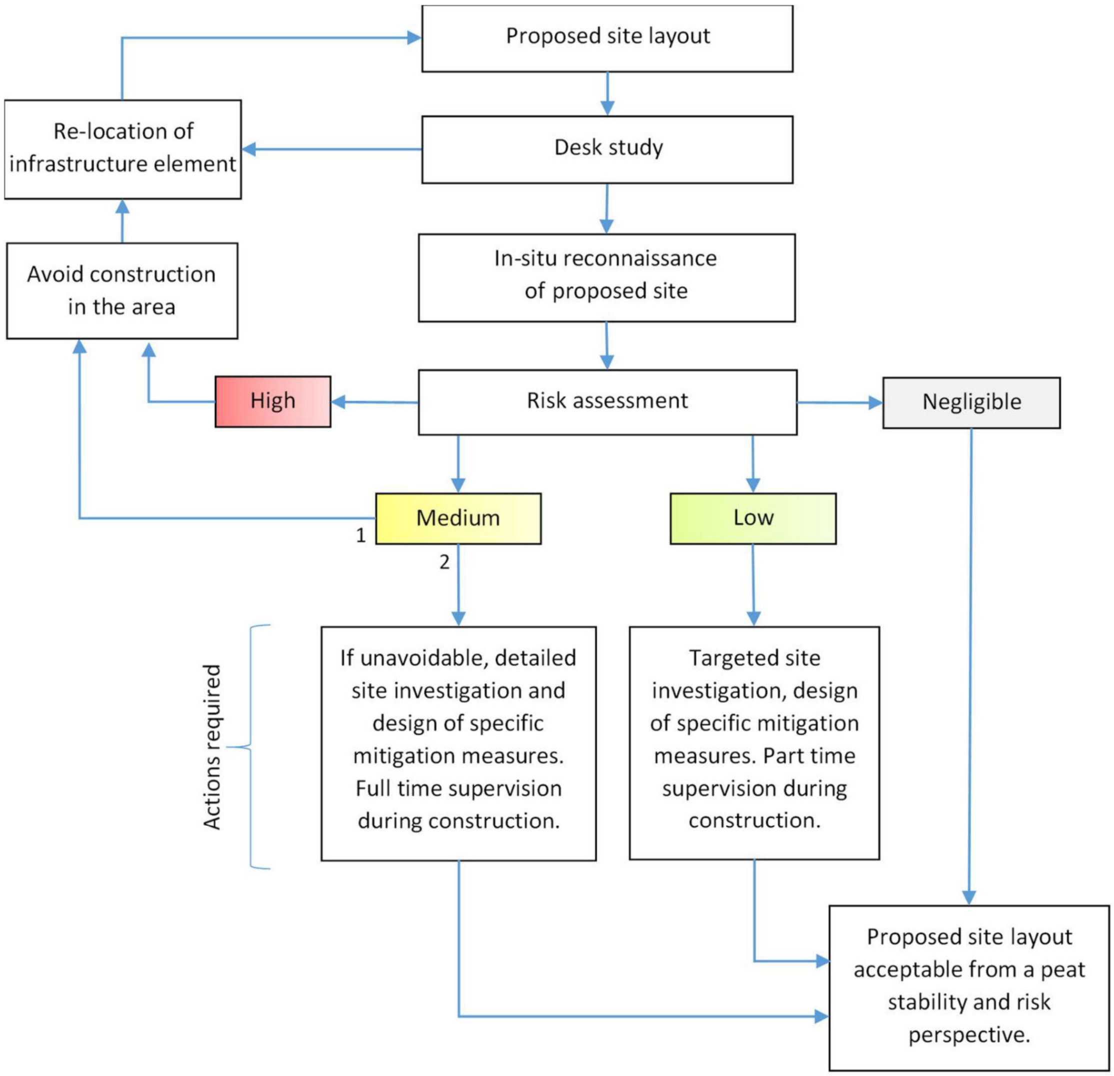


Figure 1-1: Workflow of the PSRA methodology for the acceptability of the proposed site layout

2. Desk study

A desk study is conducted to carry out a preliminary assessment of the ground conditions at the site and the local peat conditions. The following information have been assessed as part of the desk study:

1. Geology and Quaternary sediments (subsoils);
2. Soils;
3. Moisture;
4. Hydrogeology;
5. Multi-temporal aerial / Satellite imagery;
6. Topography;
7. Landslide inventories and landslide susceptibility;
8. Hydrology;
9. Land cover and land use;
10. Relevant academic literature and publications.

2.1. Geology and Quaternary sediments

According to the GSI bedrock geological map of Ireland at 1:100,000 scale (Figure B-1 in Appendix B) (GSI, 2018a), the bedrock under the proposed site is green sandstone and purple siltstone from the Glenflesk Chloritic Sandstone Formation. The Glenflesk Chloritic Sandstone Formation is an Upper Devonian (Frasnian) age sandstone & siltstone. The lithology is characterised by green, mostly medium-grained sandstone, conglomerate and pebbly sandstone, together with green and purple siltstone.

South of the southern site boundary, the Gun Point Formation, which is also Upper Devonian (Famennian) in age but older than the Glenfesk sandstone, is mapped. The Gun Point Formation consists of green-grey to purple, medium to fine-grained sandstones (locally pebbly), interbedded with green and red to purple siltstones and fine sandstones. This rock may be present on site; however, based on mapping, it would not be expected to be extensive.

The bedrock is encountered as outcrop or subcrop in the south-east corner of the Proposed Development, with more prolific bedrock outcropping in the area to the south and southeast of the development boundary. Rock is mapped as outcropping south of the majority of the eastern cable route. The thickness of superficial soil along the cable route is therefore predicted to be minimal.

The map of Quaternary sediments at 1:500,000 scale shown in Figure B-2 (GSI, 2022) shows that the main Proposed Development wind farm area is located on blanket peat. The south of the Proposed Development contains some soils classified as Podzols (Peaty), Lithosols, and Peats.

Alluvium is mapped along some of the hillside streams that runs off the eastern Proposed Development slopes. It is expected that some form of alluvium would be present adjacent to most of the watercourses that cross the site. Alluvium follows the River Clydagh, which runs westwards adjacent to the northern site boundary.

Two pockets of Till, derived from Devonian sandstones, are mapped along the northern boundary within the Proposed Development, whilst Till and bedrock outcrop are mapped along the final 500m of the proposed cable route to the east and along the majority of the first 1.6km of the proposed site access track route. Till typically comprises a heterogeneous mix of sand, gravel, cobbles, and boulders, often held in an overconsolidated clay matrix.

2.2. Soils

The Irish soil map at 1:250,000 scale is shown in Figure C-1 (EPA, Teagasc, & Cranfield University, n.d.) The proposed site is covered by peat. It is noted that the presence or absence of peat cover in the regional scale maps (Figure C-1) must not be taken as exact. The depth and extent of peat deposits may vary over short distances as a function of local underlying geology, past and ongoing geomorphological activity and management history. Therefore, these maps have been complemented by peat probes and field observations, which are described in Section 3.

2.3. Moisture

Water reaching a slope can produce the following processes:

- Lubrication. It reduces the friction along discontinuities (joints or stratification) in rock or soil (Wu, 2003). In clay soils, lubrication is due to the presence of water that produces a repulsion or separation between the clay particles.
- Softening. It mainly affects the physical properties of filler materials in fractures and fault planes in rocks.
- Pore pressure. Water in soil pores exerts pressure on soil particles, changing the effective pressure and the shear strength. The negative impact of pore pressure changes is particularly evident in partially saturated or unsaturated soils, where the increase in moisture content causes the development of a wetting front that converts beneficial negative suction stresses within the capillary structure of the soil to a fully saturated positive pore pressure. When soil is saturated, capillary stresses and adhesion between particles diminish, and, as a result, soil shear strength decreases.
- Confined water pressures. The confined underground water acts as an uplifting pressure on the impermeable layers, decreasing the shear strength and producing hydrostatic pressures on the layers where permeability changes. These lifting stresses can cause material deformation or failure, and pore pressure decreases soil resistance.
- Fatigue failure due to fluctuations in the water table. Some landslides occur in episodes of rain with lower intensity than previous ones. This phenomenon is explained by Santos et al. (1997) as a case of soil fatigue due to cyclical pore pressures. In temperate climates, seasonal temperature variations can lead to slight variations in the water table. These changes are much more significant in tropical climates (Xue & Gavin, 2008).

- Washing away of cement material. The groundwater flow can remove the soluble cement (e.g. calcium carbonate) from the soil and thus, decreases the cohesion and the friction angle. This process is usually progressive.
- Density increase. The presence of water in soil pores increases the bulk density and weight of the materials in the slope. Therefore, shear stress increases and the slope safety factor decreases.
- Internal hydraulic forces. The movement of groundwater currents creates hydrodynamic pressure on the ground in the direction of flow. This force acts as a destabilizing element on the groundmass and can appreciably decrease the safety factor of the slope. The hydrodynamic or seepage/flow force can also cause the movement of the particles and the destruction of the soil mass (piping).
- Collapse. Collapsible soils (alluvial soils deposited very rapidly and wind soils or loess) are very sensitive to changes in humidity. When water content increases, their volume decreases, and the microstructure collapses.
- Desiccation cracks. Changes in humidity can cause cracking, and these cracks can determine the extension and location of the surface of failure and have a significant effect on the safety factor or possibility of sliding.
- Piping in clays. Some clayey soils disperse and lose their cohesion when saturated. The result can be the soil structure's total collapse and landslide activation.
- Chemical weathering: Processes of ion exchange, dissolution, hydration, hydrolysis, corrosion, oxidation, reduction and precipitation (Wu, 2003).
- Erosion. The detachment, dragging, and deposition of soil particles by water flows modifies the relief and the stresses on slopes and can activate a landslide, especially when erosion undercuts slopes.

The *Normalized Difference Moisture Index Colorized* GIS service from the United States Geological Survey (USGS) has been used to estimate moisture levels in the soil across the Proposed Development site. This service is based on the analysis of multispectral Landsat 8[1] OLI images. Using on-the-fly processing, the raw digital number (DN) values for each Landsat band are transformed to scaled (0 - 10000) apparent reflectance values and then, the Normalised Difference Moisture Index is obtained using Equation 2-1 (Gao, 1996):

NDMI = (Band 5[2] – Band 6[3]) / (Band 5 + Band 6) **Equation 2-1**

[1] Landsat 8 includes 8-band multispectral scenes at 30-meter resolution which are typically used for mapping and change detection of agriculture, soils, moisture, vegetation health, water-land features and boundary studies.
[2] Near Infrared (NIR)
[3] Short Wave Infrared 1 (SWIR1)

Figure D-1 in Appendix D illustrates the levels of estimated soil moisture across the proposed wind farm site. Much of the site is covered in wetlands and other heavily vegetated areas with high levels of moisture appearing as dark blue. Some isolated areas of lower moisture are identified within the site and in areas surrounding the site. Regions of high elevation (e.g. south of the site boundary) and some isolated slope areas that face east exhibit lower values of moisture and are represented as light blue through green, yellow, and red. These results should only be considered indicative as much of the site is covered in forestry, which will augment the results. It is noted that satellite RADAR and aerial LiDAR images also provide estimates of terrain moisture. However, these have not been used in this report due to their high cost and the time frame for this project.

2.3.1. Consideration of the effects of climate change

As the planning application is being sought for a relatively short period, ten years for construction and an operational and decommissioning period of 35 years, the effects of climate change on the development are not considered to be severe. However, they have been considered in the assessment of the environmental conditions at the site.

The annual rainfall considered in Ireland is outlined in Figure 2-1 (Noone et al., 2015) with an average annual rainfall of between 1050 and 1150mm/year. Consideration needs to be given to the geographical location of the site, with areas of Kerry and the west of Ireland experiencing higher periods of rainfall than the rest of the country. Studies indicate an average rainfall in the region of the site of approximately 1200 to 1400mm/yr. The weighted factor considerations used in the risk assessment exercise for this site assumes the worst case (highest factor) for annual rainfall >1400mm/yr.

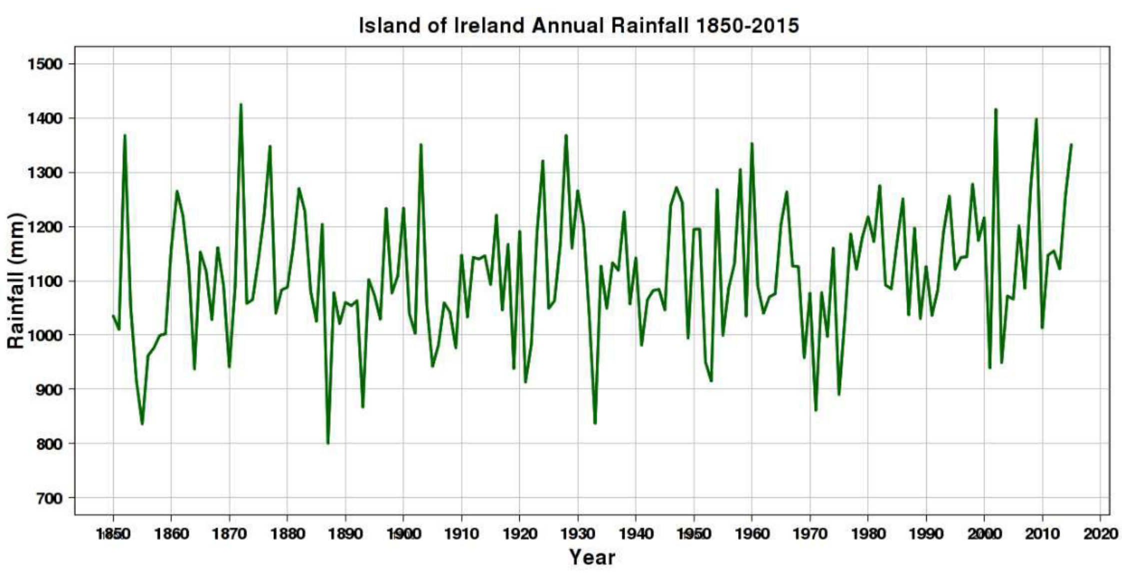


Figure 2-1: Average annual rainfall in Ireland (Noone et al., 2015)

Although sleet and snow are common on upland areas in the region, it has been noted that in the past a prolonged period of snow cover would not be expected. This stability assessment considered vertical loading of the site as per the Scottish Executive Guidelines (2017) for a vertical surchange of

10kPa. This would be the equivalent of a minimum 3.5m of snowfall (approx. density of snow = 200kg/m^3 + 1kg per day on ground). This should be more than adequate for considering any applied loading due to an increase in the frequency or duration of snow and sleet cover events due to climate change.

2.4. Multi-temporal aerial / satellite imagery

The aerial / satellite imagery used for this report is the ESRI orthophoto (OTF), Bing Maps Aerial Imagery and the Google Earth multi-temporal imagery (2010 onwards). This imagery has been used to:

- Identify any evidence of peat failures;
- Identify pre-conditioning factors for failure (where visible at the resolution of the imagery);
- Observe, where possible, vegetation cover, drainage regime and dominant drainage pathways; and
- Identify evidence for land management practices with the potential to influence ground conditions (e.g. burning, artificial drainage, peat cutting and forestry).

It is noted that the time-lapse of the available imagery is too short to identify old peat instability evidence that may have been eroded or re-vegetated with time or changes in land management.

2.5. Topography

Four different data sources were used to analyse the topography:

1. Aerial survey Sintegra, 2020.
2. Bluesky orthophoto, 2018.
3. Transport Infrastructure Ireland LiDAR 2m, 2022.
4. Copernicus 10m digital elevation model (DEM) (EEA, 2022).

Sintegra (2020) and Bluesky (2018) data were used for most of the analysis.

The site's topography is dominated by the northern valley formed by the River Clydagh (E-W). Twelve watercourses run perpendicular (S-N) to River Clydagh, which generates small depressions in the topography within the slope. The site's topography can be described as undulating hills, consistent with typical dendritic drainage patterns incising into the hillsides. The elevation varies between 298 m to 522 mOD (meters above ordnance datum).

A topographic map of the site is shown in Figure F-1 in Appendix F, generated using the digital elevation model (DEM).

The LiDAR dataset has collected slope angles at the site ranging between 0° and 89°. The terrain at the site predominantly ranges between 0° and 10°, with some areas outside of the footprint of Proposed Development with terrain slopes of up to 30°. Some limited isolated areas display slopes over 60°; these areas are typically adjacent to watercourses and are considered to be locally eroded slopes and riverbank areas. The vast majority of the area within the Proposed Development footprint indicates slopes ranging between 0° and 5°.

The curvature of the terrain can also influence the soil stability in the following ways:

- Plan curvature (across slope): This variable influences the capacity of the slope to retain surface water. Regions of higher concavity allow greater funnelling of surface water, while regions of higher convexity allow greater surface water dispersion.

- Profile curvature (downslope): This affects the speed of surface water runoff along the terrain, influencing the infiltration rate and erosion capacity of surface waters. Convex profile slopes are more prone to landslides.

An assessment of the terrain profile and curvature is carried out in the stability Risk assessment, as outlined in Section 4.

2.6. Landslide mapping

A desk study of landslides case studied in similar landscapes in Ireland and the UK was carried out, as well as identifying any local historical landslide events, to aid in assessing landslide probability and potential trigger mechanisms at the Proposed Development site.

2.6.1. Historical peat slide case studies

Numerous peat slippages and failures have been recorded in Ireland and the UK over the past 20 to 30 years, some of which have been high profile, resulting in environmental and asset damages. These landslides have varied failure and deformation types, resulting from natural and man-made trigger mechanisms.

The type and nature of the failures depend on inherent factors such as slope and soil type and independent factors such as intense rainfall events, the development of tension cracks due to dry weather, loading due to construction, excavation or peat cutting and historical land uses.

Table 2-1 outlines examples of peat failures in Ireland in recent decades. Examples where published assessments have been carried out have been included and, where known, the published cause for the landslide has been included.

As outlined in the case studies in Table 2-1, the most common trigger mechanisms for peat landslides in Ireland include:

- **Weather:** prolonged or intense periods of rainfall or dry weather,
- **Terrain and slope:** Peat slides were recorded occurring at slope angles of 3° up to 60°, with steeper slopes being more susceptible to slippages.
- **Human interaction:** Construction, industrial or agricultural activities influence on the environment, triggering a peat slide event.

Many of the events outlined in Table 2-1 are recorded as slide events. However, in most cases, they developed into a peat or debris flow as they propagated downslope, with water-suspended material flowing downslope over the in-situ terrain.

Table 2-1: Notable past landslide events in Ireland

Event Location	Date	Failure type	Slope (deg)	Contributing factor
Meenbog, Co. Donegal	13/09/2020	Slide	1-3.8	Over surcharging deep peat areas during access track construction for a wind farm development. The failure triggered a preceding failure at the site.
Slieveanorra, Co. Antrim	25/08/2020	Slide	Unknown	Intense rainfall triggered an area of repeated historical slides.
Shass Mountain, Co. Leitrim	28/06/2020	Slide	3-6	Period of dry weather followed by heavy rainfall.
Ballincollig, Co. Kerry	22/08/2008	Flow	3	Long periods of extended rainfall triggered areas of intense peat harvesting.
Clare Island, Co. Mayo	14/12/2006	Unknown	Unknown	Extended period of very heavy rainfall.
Derrybrien, Co. Galway	16/10/2003	Slide	8 - 10	Inappropriate construction practices lead to over surcharging of in situ peat at a hardstand excavation for a wind farm development.
Pollatomish, Co. Mayo	19/09/2003	Slide	30-60	A prolonged period of warm and dry weather was followed by an intense rainfall over a short period. Highly impermeable rock enables sub-peat flow of water. Triggered over 40nr. peat slides.

Where available, the undrained shear strength of the local peat at the landslide locations has been noted to compare the characteristics of the peat body. Landslide events with available peat undrained shear strength values are outlined below:

- Maghera Mountain (35,000m^3 bog flow) – range in the acrotelm (upper peat) 2.9kPa -7.6kPa
- Croaghan peat slide - <5kPa
- Garvagh Glebe peat failure – 2kPa to 4kPa
- Derrybrien peat slide – 2.5kPa
- Ballincollig Hill peat slide – 2.5kPa to 6kPa (catotelm) and 5kPa to 40kPa (acrotelm)

In some cases, these are extreme examples of weakened peat, with these results often outlined following the forensic investigation of the peat landslide event. These values outline the variation in the local peat strength characteristics experienced in failure events and capture a variety of event trigger mechanisms.

The findings of the ground investigations at this site, including peat characteristics and undrained shear strength testing in the peat, are outlined in Section 3.

2.6.2. Geological Survey landslide database

The GSI landslide inventory (GSI, 2022), the multi-temporal aerial / satellite imagery, the DEM, the landslide susceptibility map (GSI, 2016b), and rainfall information of Met Éireann data 1981-2010 have been used for this part of the desk study.

Figure G-1 depicts the spatial relationship between records of previous landslide events (GSI, 2016a, 2018b) and rainfall across Ireland from the Met Éireann (2018) average annual rainfall dataset. While the study area is in a region of high rainfall and relatively steep topography, there is no record of past landslide events from the national landslide database or the desk study directly within the Proposed Development area. Although there is no evidence of landslides within the Proposed Development Site, this does not necessarily mean that landslides have never occurred at the proposed site location. It is noted that the geomorphological features associated to peat landslides (peat slides and bog bursts) are softened with time through erosion, drying and re-vegetation (Feldmeyer-Christe & Küchler, 2002; Mills, 2003). Additionally, the frequent forest harvesting activities across the proposed site obscure the identification of possible historical landslides.

There are, however, several landslide events within 5km of the northern boundary of the site are recorded in the GSI database (GSI, 2016a), with the closest landslide occurring on steep ground on the opposite side of the Clydagh River, approximately 100m north of the Proposed Development red line boundary and 350m from the nearest Proposed turbine T13. The landslides shown are grouped together and no information is provided for the date of occurrence or if these occurred together or separately over time. The area of the landslides varies between 200m^2 to 1400m^2. Figure 2-2 shows the landslide event closest to the site boundary. The locations of the past landslide events identified in the GSI landslide archive are shown in Figure G-1 in Appendix G. The elongated morphology of the closest landslide to the site boundary is shown in Figure 2-2. The landslide geometry suggests that the base of the slide is shallow (less than a metre deep) and satellite imagery suggests that the displaced material is suggestive of a debris fall or slide more-so than a peat displacement feature. The landslide is located at the maximum erosive face of the river (external side of the river's curvature). Due to the elongated landslide morphology and its location relative to the river, the soil at the toe of the slope was likely eroded by the river, causing the instability of the slope and, hence, the landslide.

All the landslides within a 5km buffer from the site are located beside rivers at the maximum erosive face (external side of the river's curvature). The likely cause of the landslide instabilities is the undermining of the steep riverbanks by fluvial erosion. No human interference has triggered these landslides and rather the natural erosion of the steep hillside.

Figure G-2 illustrates the landslide susceptibility (GSI, 2016b) across the Proposed Development Site. This map was obtained using an empiric probabilistic method at a regional scale and provided input into site-specific scale engineering studies. For instance, turbines T10, T12, and T15 are located in a sector of *moderately high* susceptibility (orange colour) due to the high slope angle in this sector. Further assessment carried out as part of the project-specific fieldwork and site assessment is outlined in Section 3, where the stability of these areas is found to be acceptable.

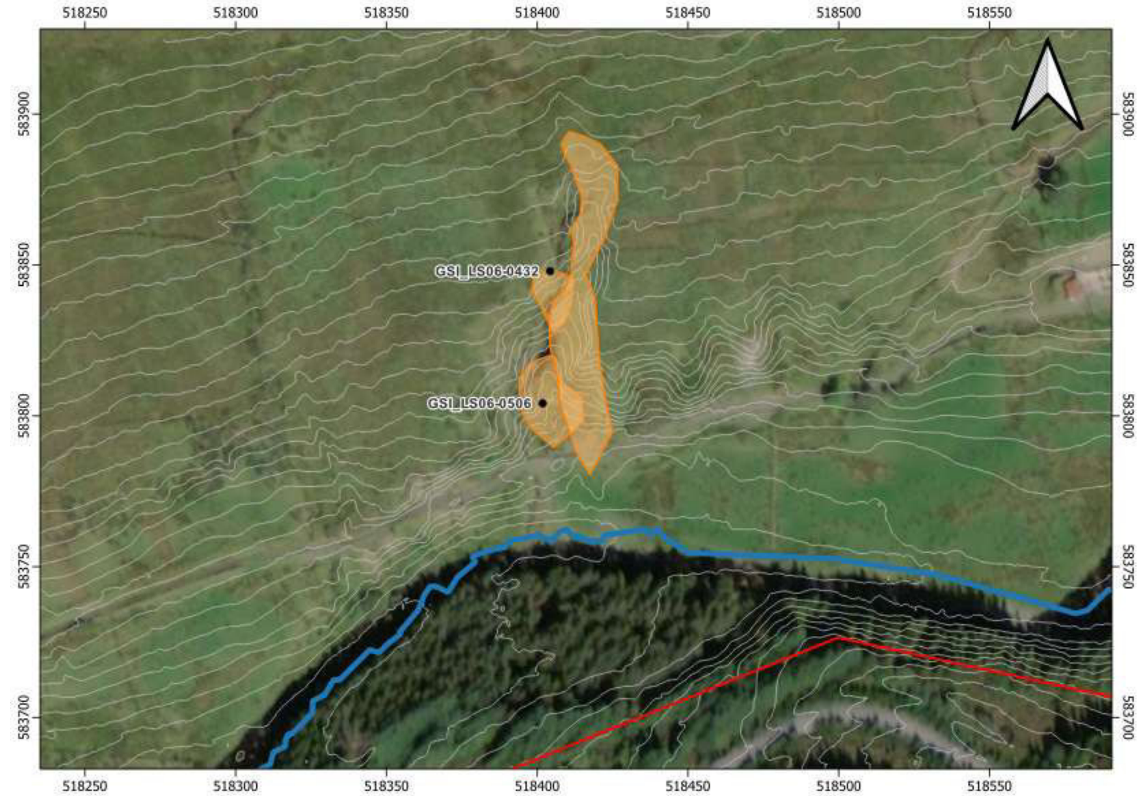


Figure 2-2: Nearby landslide from GSI landslide inventory (2022)

2.6.3. Comparison of Proposed Development and past landslide events

Throughout the industry, lessons have been learned from past landslide events such as those outlined in Section 2.6.1 including Derrybrien and Meenbog Wind Farms. Over the past decade a comprehensive set of best practice guidelines (Scottish Executive, 2017) have been developed to aid in a more robust and accurate assessment of the on-site conditions and characterisation of peat stability.

Advances in technology and assessment methodologies have allowed for better quality data to be fed into the stability assessment, such as:

- LiDAR topographic data, as has been used in the Proposed Development Site (Sintegra, 2020), capturing areas where ground-based surveys would have been limited due to terrain and tree cover,
- The use of geospatial analysis through ArcGIS enables a semi-automated site-wide stability assessment with the application of vertical loading surcharges and sensitivity checks.

These digital and geospatial analyses, in combination with the site-based assessment, create a more robust assessment than would have been available previously.

The engineering characteristics of the peat material encountered at the Proposed Development are outlined in Appendix 10-1 Geotechnical Interpretive Report and in Section 3 of this report. The undrained shear strength recorded during the assessments of the site are higher than the critical parameters recorded at case study failure slip surfaces outlined in Section 2.6.1. However, a conservative undrained shear strength value in line with the case study values has been used for the stability Factor of safety (FoS) assessments at the Proposed Development as outlined in Section 4 of this report.

Examination of past forensic reports and landslide case studies have been considered to inform the assessment in this report and to highlight potential landslide hazards at the site. The findings of the case studies suggest a broad range of causes for these landslides, both natural and manmade. Key triggering mechanisms in the landslides outlined in Table 2-1, include extreme weather (particularly rainfall), slope gradient, peat strength and over surcharging of peat material. The following considerations were used to assess similar landslide triggering mechanisms at the Proposed Development area:

- During the layout design of the Proposed Development layout areas of similar characteristics to the past landslides were avoided as best as possible, such as steep areas of hillside, convex slopes, and areas of deep peat directly on shoulders adjacent to steep slopes. Areas of risk highlighted during the design of the Proposed Development are highlighted as safety buffer and peat and spoil stockpile restriction areas, as outlined in Section 4.5.
- As outlined in Appendix 10-1: Geotechnical Interpretive Report, peat strength was assessed using shear vane testing, assessing changes in peat vertically with depth to identify areas of low strength peat and investigate areas of potential reduced strength at the interface at the base of the peat,
- The use of floated roads has been avoided by the development, using all founded road construction, limiting the risk of triggering a bearing failure in the underlying peat body by over-surcharging,
- Over-surcharge of peat material and disturbance of the peat body by over-harvesting of upland peat appear to be the key manmade triggering mechanisms, often occurring alongside other natural contributary factors. The methodologies for management of peat excavation, peat movement operations and mitigation requirements are outlined in Appendix 10-3 Peat Management Plan.

The associated Peat Management Plan (PMP) (GDG, 2023) has been developed to ensure that a similar peat slip event does not occur at the Proposed Development Site. The PMP outlines a stringent set of guidelines related to the construction methodologies, monitoring, supervision of construction activities and the required continuous monitoring of environmental factors onsite during construction and operation of the Proposed Wind Farm Development. It will be critical that the requirements outlined in the PMP are followed to ensure the safe construction of the Proposed Development.

2.7. Hydrology

According to the Ordnance Survey Ireland (Osi) shapefile of rivers, lakes and catchments/basins (Figure H-1), watercourses from the site flow into the River Clydagh, which flows into the River Flesk.

Further details are outlined in Chapter 11: Hydrology of the EIAR.

2.8. Land cover and land use

According to the Corine Land cover map shown in Figure I-1 in Appendix I, the surrounding landscape of the proposed site comprises forest and blanket peat wetlands. Land use within the site is predominantly commercial forestry.

The Proposed Cummeennabuddoge Wind Farm site is planned adjacent to operational wind farms: Clydaghroe Wind Farm, Curragh Wind Farm, Coomacheo Wind Farm, Gneeves Wind Farm and Caherdowney Wind Farms.

3. Site reconnaissance and ground investigation

As part of the assessment, the project team carried out site reconnaissance. This comprised seven site visits (March 2021, June 2021, March 2022, June 2022 and October 2022) to record geomorphological features concerning the Proposed Development, peat depths and peat strength. An indication of the site conditions (forested and recently felled areas) and undulating topography are shown in Figure 3-1 and Figure 3-2.

Seven ground investigations (GI) were carried out on the site:

1. QMEC consulting (2009): extracted from Kerry County Council.
2. GDG (March 2021): 33 peat probes.
3. GDG (June 2021): three peat probes at the substation location.
4. GDG (March 2022): 132 peat probes and 17 shear vanes.
5. GII (May 2022): 16 trial pits, 25 Russian core samples and geotechnical & environmental Laboratory testing (see EIAR Appendix 10-1).
6. GDG (June 2022): 49 peat probes.
7. GDG (October 2022): 49 peat probes.

Figure 3-1: Forestry on site

Figure 3-2: General site terrain and conditions in recently felled areas.

In summary, intrusive ground investigations were carried out at a total of 415 locations.

The investigation locations (Figure J-1 to Figure J-2 in Appendix J) considered the following criteria:

- Spatial distribution of the proposed infrastructure;
- Distance between probe points to avoid interpolation of peat depths across large distances;
- Changes in slope angle, as peat depths are likely to be shallower on steeper slopes;
- Changes in vegetation, which can reflect changes in peat condition;
- Changes in hydrological conditions; and
- Changes in land use.

No evidence of any previous landslides or peat instability was identified during the walkovers. Table J-1 to Table J-17 in Appendix J presents the observations made at the proposed infrastructure.

3.1. Interpretation of Ground Investigations

The findings of the ground investigations and an interpretative ground model are summarised in Technical Appendix 10-1 Geotechnical Interpretive Report (GIR) of this EIAR.

In general, the ground investigations across the site identified a ground model consisting of varying thicknesses of peat material overlying grey sandy gravelly SILT/CLAY and/ or dark brown angular sandy GRAVEL and weathered sandstone bedrock. The site area is generally covered with a peat body, with some areas of glacial till outcrop and bedrock outcrop identified through the site naturally at the higher areas and at eroded watercourse faces, as well as at the existing road cutting and drainage excavations.

The peat thickness varies across the site from 0m to a maximum of 5.4m. An extensive peat depth model is outlined in Figure J-3 to Figure J-4 in Appendix J. The highest peat thickness was found between T07 and T08, adjacent to T17, and in one localised area on the main site access road. A large variation in the level of decomposition and humification was observed throughout the peat body; however, this generally appeared to increase with depth. Most of the peat material identified at the site is logged as fibrous and pseudo-fibrous, indicating that is of a higher strength material and shall be suitable for use in landscaping and reinstatement adjacent to proposed infrastructure locations.

Examination of the identified peat depth, in correlation with the site contours would suggest that the peat material exists in relatively thin thicknesses on the higher angle slopes angles (>5°). The higher elevation regions at the site, which are isolated from the footprint of the Proposed Development, would indicate high slope angles, but glacial till and bedrock outcrops were identified in these areas. The larger peat thicknesses (>2.5m) are generally topographically constrained, identified in isolated areas where lower topographic slopes have enabled peat to remain and form, developing into larger thicknesses.

It is important to consider this varied stratigraphy and peat thicknesses when using the interpolated peat thickness analysis outlined in Figure J-3 to Figure J-4 in Appendix J as this will extend these larger thicknesses across slopes, creating a very conservative ground model.

The associated Technical Appendix 10-1 Geotechnical Interpretive Report (GIR) of this EIAR outlined the testing carried out on the site and a review of existing literature for the assessment of the engineering parameters of peat material. The characteristic geotechnical parameters for the peat body used in the special factor of safety stability modelling at the Proposed Development site are outlined in Table 3-1.

Table 3-1: Characteristic geotechnical parameters of the peat strata

Strata	Unit Weight (kN/m^3)	Undrained shear strength, cu, (kPa)	Effective friction angle Ø' (degrees)	Cohesion, c' (kPa)
Peat	10	5	25	5

4. Peat stability assessment

The peat stability assessment is one of the inputs required for the peat hazard assessment and risk calculation. This section presents:

- A review of the general approaches to assess peat stability;
- The concept of Factor of Safety;
- The methodology adopted for this report and the parameters required; and
- The resulting FoS, which is used to delineate safety buffer areas and, peat and spoil stockpile restriction areas as outlined in Section 4.5.

The eastern cable route is not included in this analysis. It was noticed that the bedrock is very shallow at this location, and the peat thickness varies from 0 m to 0.63 m, with an average value of 0.2 m. Topography and slope angles are relatively shallow along much of the cable route, for this reason it is not expected to be a peat instability risk.

A slope stability assessment examining the local and global stability of the proposed berms at the peat repository areas has been outlined in Section 4.6 and a separate technical note in Appendix N.

4.1. Main approaches to assess peat stability

The main approaches for assessing peat stability for wind farm developments include the following:

1. Qualitative geomorphological judgement; and
2. Quantitative assessment:
    a. Empirical probabilistic approach.
    b. Physically-based deterministic approach (Factor of Safety - FoS).

Approach 1 is subjective and thus not adopted for this study. Approach 2a is objective and quantitative but is more appropriate for land planning and decisions making studies at a regional scale. Additionally, the method does not provide an engineering indication of physical stability as Approach 2b does.

In this report, the peat stability assessment uses the Approach 2b: deterministic (FoS) approach (Bromhead, 1986).

4.2. Factor of Safety (FoS) Analysis

The factor of safety is a measure of the stability of a slope. For any slope, the degree of stability depends on the balance between the landslide driving forces (weight of the slope) and its inherent shear strength, illustrated in Figure 4-1.

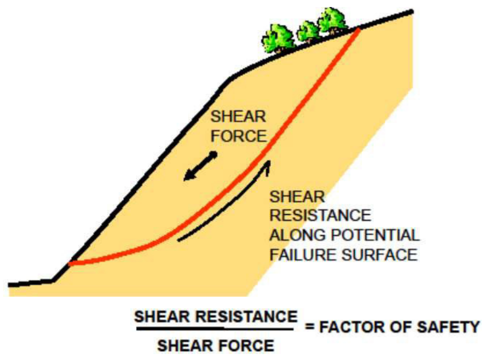


Figure 4-1: Balance of forces in a slope (Scottish Executive, 2017).

Therefore, the factor of safety provides a direct measure of the degree of stability of a slope by the ratio of the shear resistance along a potential surface of failure and the landslide driving forces acting on such surface. Multiple potential surfaces of failure are possible, but the FoS assigned to a slope is that of the surface of failure with the lowest value of FoS.

- FoS < 1 indicates a slope is unstable and prone to fail.
- FoS = 1 indicates a slope is theoretically stable but not safe.
- FoS ≥ 1.3 indicates the acceptable safety threshold. The previous code of practice for earthworks BS 6031:1981 (British Standards Institution, 1981). The older standard is used as it does not account for the use of partial factors, which cannot be applied to this assessment. It stated that for a first-time failure with a good standard of site investigation, the design FoS should be greater than 1.3. This way, the slope is stable and safe.

As a general guide, the FoS limits for peat slopes assumed in this report are summarised in Table 4-1.

Table 4-1: Factor of Safety limits assumed in this report.

Factor of Safety limits	Slope stability
FoS < 1	Unstable
1 ≤ FoS <1.3	Stable but not safe
FoS ≥ 1.3	Stable and safe

The spatial distribution of the FoS values discriminates between areas of stable and unstable peat and areas of marginal stability where restrictions may apply. This approach enables the identification of the most suitable locations for turbines, access roads and infrastructure.

4.3. Methodology adopted and parameters

The stability of a peat slope depends on several factors working in combination, namely the slope angle, the peat's shear strength, the depth of the peat, the pore water pressure and the loading conditions. An adverse combination of these factors could potentially result in peat failure. An adverse value of one of the factors mentioned above alone is unlikely to result in peat failure. The infinite slope model (Skempton and DeLory, 1957) combines these factors to determine a safety factor for peat sliding in the study area. This model is based on a translational slide, which reasonably represents the dominant mode of movement for peat failures.

A raster map was created in GIS software presenting the interpolated peat depth across a site from the peat probe points using the Inverse Distance Weighted (IDW) method. The produced peat interpolated map outlines a planar base of peat surface based on the ground investigation point data across the Proposed Development area. The interpolated raster of peat depth is represented in Figure J-3 to Figure J-4 in Appendix J.

The produced interpreted peat depth raster is used in conjunction with a slope angle raster of a matching pixel sizing created from the topographic survey information and the peat characteristics observed on site to create a spatial stability analysis. The spatial stability analysis methodology is outlined in Sections 4.3.1 and 4.3.2.

Undrained (short-term stability during construction) and drained (long-term stability during operation) analyses have been carried out to determine the stability of the peat slopes in the study area.

4.3.1. Undrained conditions

The undrained loading condition applies in the short-term during construction, and until construction, induced pore water pressures dissipate.

The total stress analysis uses undrained shear strength values (cu) for peat. Based on the findings of the Derrybrien failure, undrained loading during construction was found to be the critical failure mechanism.

Among the shear strength values obtained by GDG using the hand shear vane tests in the proposed site, the lowest registered value was 9 kPa. However, based on GDG's experience in the assessment of similar blanket peats, consideration of values observed from the past landslide events outlined in Section 2.6.1 and Table 2-1, and values reviewed in the literature, a more conservative value of 5 kPa has been adopted for the undrained calculation. Further details are outlined in Appendix 11-1 of the Environmental impact Assessment Report (Atmos, 2022).

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

$$F = \frac{c_u}{\gamma * z * sin\alpha * cos\alpha}$$ **Equation 4-1**

Where:

F = Factor of Safety;
c_u = Undrained strength 5 kPa in the study area as outlined in Section 3.1;
γ = Bulk unit weight of the material (assumed 10 kN/m^3);
z = Depth to failure plane assumed as the depth of peat (this is the interpolated raster of peat depth); and
α = Slope angle (in each pixel of 1 m. This is obtained from the 1m DEM outlined in Section 2.5).

4.3.2. Drained conditions

The drained loading condition applies in the long-term. The condition examines the effect of the change in groundwater level due to rainfall on the existing stability of the natural peat slopes.

A drained analysis requires effective cohesion (c') and effective friction angle (ø') values for the calculations. These values can be difficult to obtain because of the disturbance experienced when sampling peat and the difficulties in interpreting test results due to the excessive strain induced within the peat. A review of published information on peat was undertaken to determine suitable drained strength values. The characteristic drain parameters for peat are outlined in Table 3-1. These characteristic parameters are based on GDG's experience in assessing similar blanket peats and the values reviewed in the literature. It was considered appropriately conservative to use design. Further details are outlined in Appendix 10-1: Geotechnical Interpretive Report of the EIAR.

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

$$F = \frac{c' + (\gamma z - \gamma_w h_w)\cos^2\alpha \tan\phi'}{\gamma z \sin\alpha \cos\alpha}$$

Equation 4-2

Where,

F = Factor of Safety;

c' = Effective cohesion (5 kPa);

γ = Bulk unit weight of the material (10 kN/m^3);

z = Depth to failure plane assumed as the depth of peat (this is the interpolated peat depth);

γ_w = Unit weight of water (9.81 kN/m^3);

h_w = Height of the water table above the failure plane (= *z*, i.e. surface level);

α = Slope angle (in each pixel of 1 m. This is obtained from the 1m DEM as outlined in Section 2.5); and

ø' = Effective friction angle (25°).

Several general assumptions were made as part of the analysis:

1. Peat depths are based on the maximum peat depths recorded in each probe from the walkover surveys.
2. The slope angles derived from the combined DEM, as outlined in Section 2.5, are accurate and have not been obstructed by the forestry canopy.
3. The surface of failure is assumed to be parallel to the ground surface.
4. The peat stability is calculated in pixels of 1 m across the fringe containing information of peat depth and the proposed infrastructure.

Two surcharging conditions are considered for the stability analysis:

- No surcharging load; and
- Surcharging load of 10 kPa, equivalent to 1 m of stockpiled or side-cast peat. This is the maximum allowable depth of stockpiling/side-cast of peat.

4.4. FoS results

The safety factors obtained for the two different conditions (undrained and drained) and for the two surcharge scenarios (no surcharge and 1 m of peat surcharge) are presented in table format and map format.

Table K-1 and Table K-2 in Appendix K show the FoS calculation process in the proposed turbine sites only for undrained and drained conditions, respectively. The FoS calculation for the rest of the sites, i.e. the proposed substation, temporary construction compound, existing and upgraded access roads, borrow pits and met mast (more than 5000 pixels of 5 m), has been carried out semi-automatically in GIS by implementing Equation 4-1 and Equation 4-2 in the GIS raster calculator.

4.4.1. FoS for undrained conditions

The spatial distribution of the FoS values calculated for undrained conditions (no surcharge) is shown in Figure K-1 in Appendix K. At each turbine location and construction compound, the pixels exhibit a FoS > 1.3 (green: stable and safe).

4.4.2. FoS for undrained condition and a surcharge of 10 kPa

Figure K-4 in Appendix K depicts the spatial distribution of the FoS values calculated for undrained conditions with a 10 kPa surcharge.

Almost all of the pixels are shown to be stable and safe (FoS > 1.3, green), but there are some small areas along access roads and, within or beside the hardstands of T8, T9, T10, T12, and T17 which show FoS values between 1 and 1.3 (yellow: stable but not safe).

These risk areas are caused by localised factors, which have been examined in more detail in Section 4.5. Where required, additional mitigation, including exclusion zones and peat storage restriction areas, have been scheduled, which the designer and contractor must adhere to at the construction stage.

4.4.3. FoS for drained conditions

The spatial distribution of the FoS values calculated for undrained conditions (no surcharge) is shown in Figure K-7 in Appendix K. Each of the pixels exhibits a FoS > 1.3 (green: stable and safe).

4.4.4. FoS for drained condition and a surcharge of 10 kPa

The spatial distribution of the FoS values calculated for undrained conditions (no surcharge) is shown in Figure K-10 in Appendix K. At each turbine and hardstand location, the pixels exhibit a FoS > 1.3 (green: stable and safe).

4.5. Safety Buffer Areas and Peat and Spoil Stockpile Restriction Areas

From the site reconnaissance and the calculations of the FoS for the peat slopes, safety buffer areas are presented in Figure L- 1 and Figure L- 2 in Appendix L, and peat and spoil stockpile restriction (PSR) areas are proposed and presented in Figure L- 3 Figure L- 4 in Appendix L.

4.5.1. Safety Buffer Areas

Safety buffer areas are areas identified during the development phase of the wind farm layout that are highlighted as possessing a potential instability risk. The development of the safety buffer areas is a semi-automated approach that combines the developed polygon areas of the FoS results, areas of stability hazard identified during the site walkovers, and potential risk areas identified from examining peat depths and site topography. It is noted that the results from all FoS analyses (drained/undrained, with and without surcharge) are used, highlighting areas indicative as having a FoS < 1.3 in the worst-case surcharged condition with 10kPa. This analysis was used throughout the development process to aid in the siting and design of the proposed development layout and ensure that turbines, hardstands, and other key infrastructure locations are only developed in stable and safe locations.

In addition to the semi-automated FoS-derived safety buffer areas, some features were highlighted during site visits and site reconnaissance, which were added to the buffer areas. These features are outlined in the Geotechnical Interpretive Report in Appendix 10-1 and include:

- North of Turbine Four an area of saturated deep peat was identified during a site walkover. The area was located at the crest of a steep slope above a nearby watercourse. The area will not be used for material/spoil storage or side casting, and plant movement will be restricted.
- An area of very soft peat with a depth of up to 5.4m was identified on the western access track (situated at 515107, 581873). The area is not to be used for peat placement or storage or side casting.
- The large safety buffer area identified between T11 and T12 is based on the results of the peat FoS obtained for undrained conditions with surcharge. The slope south and southwest of T12 is overlaid by a 2.5 m thick blanket peat, which can be unstable in the presence of higher loads and pose a propagation landslide risk. As a result, peat storage is prohibited in this area.

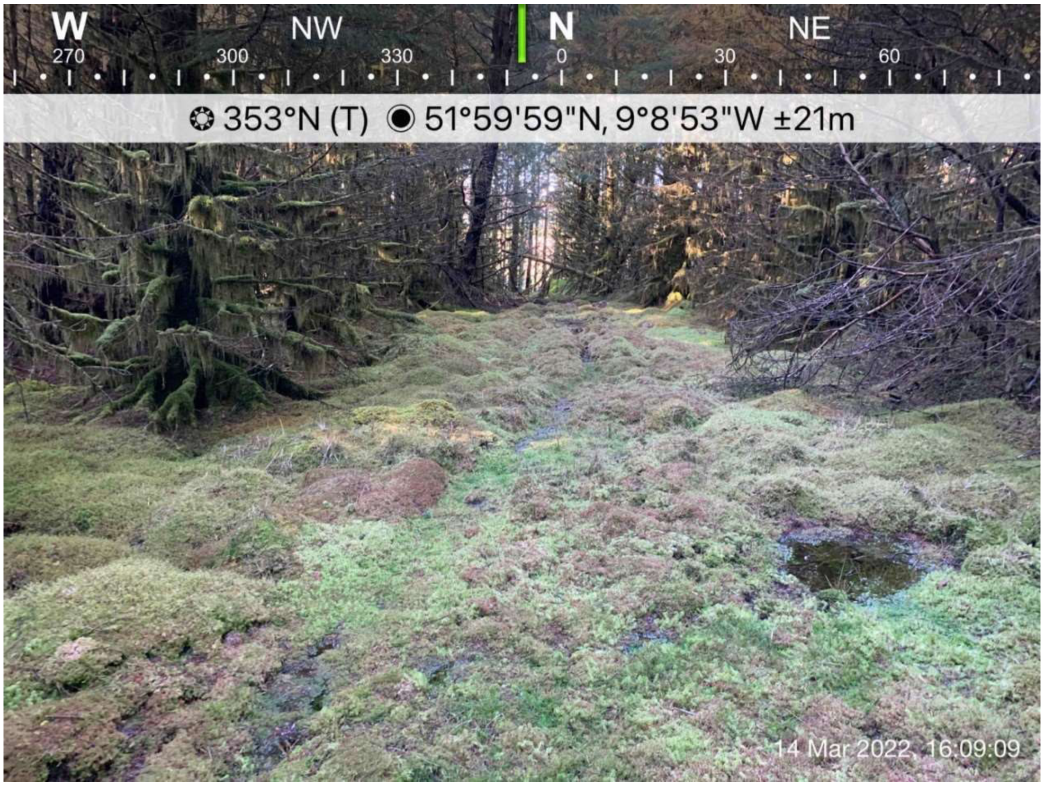
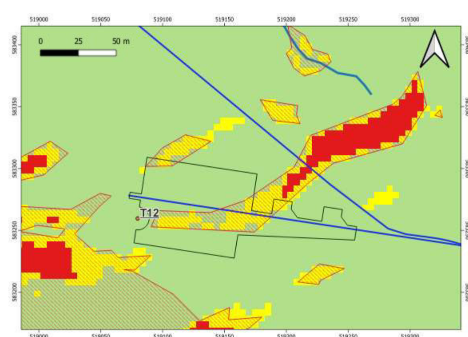
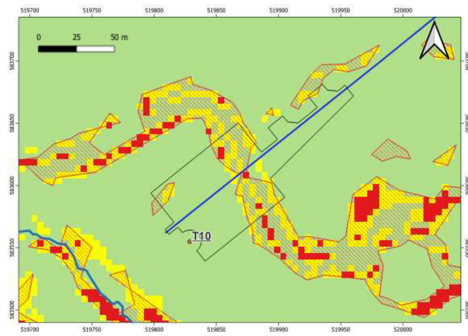
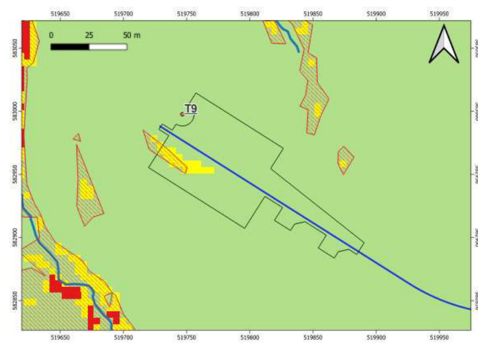
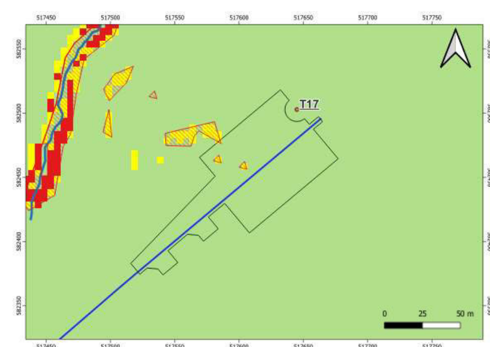


Figure 4-2: Area of deep soft peat north of T04

Areas where key infrastructure proposed earthworks encounter areas of FoS <1.3 where the analysis was carried out with a surcharge loading are outlined in :

Table 4-2: Safety buffer areas at key locations

Risk and mitigation	Undrained surcharged FoS analysis
The area at the hardstand for T12 suggests a FoS <1.3 with the application of a surcharge. Without the application of the surcharge indicate a FoS>1.3, indicating the natural, undisturbed slope is stable. This instability is caused by local variation in the slope angle. All the intersection area is proposed for excavate and replace, and so will be be stabilised by excavating to a bearing strata. **We recommend that peat the placement of peat material shall not be carried out at the northern, downslope side of the T12 turbine and hardstand area.**	

Risk and mitigation	Undrained surcharged FoS analysis
The area at the hardstand for T10 suggests a FoS <1.3 with the application of a surcharge. Without the application of the surcharge indicate a FoS>1.3, indicating the natural, undisturbed slope is stable All of the low FoS results here are caused by existing the existing cut and side cast material at the existing forestry road currently at the hardstand area. Having inspected the site during a site walkover, this is not all considered to be a true risk area. **However, we recommend that the placement of peat material shall not be carried out at the northern, downslope side of the T10 turbine and hardstand area.**	
The area at the hardstand for T09 suggests a FoS <1.3 in the undrained with surcharge case. The lower FoS results at this location are caused by an existing localised steep slope face and 0.45m to 0.65m of peat in the vicinity of the proposed floated blade finger area. This area will be levelled off for the construction stage. The area is also uphill of the proposed excavation area for the turbine and hardstand so any instability hazard will be mitigated out by the detail design and temporary works designer in their design of the cutting at the levelled off blade finger area.	
The area at the hardstand for T17 suggests a FoS <1.3 in the undrained condition with the application of a surcharge. The lower FoS results here are caused by localised cutting on the peat surface due to peat harvesting or drainage of the forestry area. The peat in these areas will be excavated to a competent stratum to construct the hardstand platform, thus eliminating the hazard. The detail and temporary works design must consider these cuttings in their method statements.	
The area to the north of T08 is highly sensitive, indicating instability with and without the surcharge. The area of instability is indicated by a relatively thick peat coverage and steep northernly slopes. This area is located directly upslope of the River Clydagh and is considered to be of a particularly high sensitivity. Although the proposed construction footprint is not directly within these safety buffer area, **the Contractor will ensure complete avoidance of plant movements and peat storage to the areas north of the T08 location.**	

4.5.2. Peat and Spoil Stockpile Restriction Areas

During the layout design phase of the Proposed Development, access roads, turbines and wind farm infrastructure were designed avoiding these potentially unstable areas as much as was possible. However, total avoidance of these areas was not possible as some safety buffer areas extend across large extents of the site, particularly on steep slopes along watercourses. At the limited locations where the Proposed Development layout and the safety buffer areas have overlapped or are in close proximity, further assessment of the localised risk has been carried out as outlined in Table 4 2, and where required, further mitigation measures have been scheduled, such as peat storage restriction areas.

The stability assessment results at these locations suggest FoS values <1.3 in the surcharged scenario only and have FoS results >1.0 in the analysis without the surcharge (natural state). These results suggest that the areas have a negligible to low instability risk in their natural state and are unsuitable for storing peat or other materials.

Peat and spoil stockpile restriction (PSR) areas are identified at some access roads and in areas at or adjacent to some turbine hardstands. Peat and spoil stockpile restriction (PSR) areas are outlined in Appendix L, Figure L- 3 to Figure L- 4.

Locations where PSR areas are identified are as follows:

- Areas identifying a stable but unsafe FoS (FoS>1 but <1.3) when a surcharge is applied,
- The steep eroded stream banks adjacent to watercourses. These areas are already subject to reinstatement restrictions as they are within the 60m watercourse development buffer area. The watercourse reinstatement restriction buffer areas are shown in Appendix L, Figure L- 3 to Figure L- 4,
- Areas of peat side casting on existing forestry roads,
- Areas of deep peat adjacent to steep slopes where there is a risk of propagated peat slide,
- An area of deep saturated peat north of T4, adjacent to a steep drop in elevation and a watercourse, was identified during the walkover.

The risk at these locations can be examined by looking at the geometry of the local slope and the proposed construction methodology, and the hazards can be mitigated with restricted peat placement and limiting plant operations within the area.

Peat and spoil stockpile restriction (PSR) areas are outlined in Appendix L, Figure L- 3 to Figure L- 4.

Certain mitigations must be adhered to within the PSR areas in future stages of the proposed development:

- No peat, spoil or other materials shall be temporarily or permanently placed in the areas within the PSR areas,
- Any peat excavated in the area shall be immediately removed and placed/ stored in an appropriate storage location as outlined in Technical Appendix 10-3: Peat Management Plan,
- Plant used within these areas shall be low ground bearing, and only the necessary plant shall be used here. No excessive quantity or size of plant will be stored in these areas.

All areas outside of the footprint of the Proposed Development layout, where construction is not required, shall be treated as peat storage and plant restriction areas, and construction activities will not be carried out in these areas.

4.6. Peat repository stability assessment

A slope stability assessment examining the stability of the proposed berms at the peat repository areas has been outlined in a separate technical note in Appendix N.

The report outlines that the design proposed for the designated areas for the temporary and permanent storage of peat can be safely constructed. This assessment examines the constructability and the berm geometries for the proposed six peat repository areas. As part of this assessment a bearing capacity check for the proposed berm, a sliding check, and the local and global stability of the berm and stored peat has been carried out.

The berm geometries will be subject to confirmatory ground investigations at the construction stage and the design team's independent assessment.

5. Peat Stability Risk Assessment (PSRA)

A peat stability risk assessment (PSRA) is carried out at each proposed structure, considering each location's landslide hazard probability and potential consequences. The production of a PSRA for the access road is not possible as it is a linear structure, but the same considerations were used in the design and assessment of the stability of the access road alignment.

5.1. Risk definition

Risk is the potential or probability of adverse consequences, including economic losses, environmental or social harm or detriment. Risk is expressed as the product of a hazard (e.g. peat landslide) and its adverse consequences (Lee & Jones, 2004; Corominas et al., 2014) (Equation 5-1). Some use approximate synonyms and refer to risk as the product of the likelihood and the impact or the product of susceptibility and the exposure.

Risk = (Hazard) x (Adverse Consequences) **Equation 5-1**

5.2. General methods for risk assessment

There are various levels of risk assessment, ranging between:

- Detailed quantitative risk assessments (QRA) where the objective is to generate more precise measures of the risks (e.g. expressing risk as a specific probability of loss). These require a large amount of quantitative input and time; and
- High-level qualitative assessments where the objective is to develop an approximate estimate of the risks, particularly in relative terms (e.g. low, medium and high levels of risk).

Qualitative risk assessments are typically used for PSRA reports, given the availability of information and the time frame. To apply Equation 5-1, the quantitative information (e.g. FoS) and the qualitative information (e.g. geomorphic observations relevant to peat stability) that determine the hazard and the consequences need to be transformed into subjective ratings. The following sections address the calculation of the two risk components: hazard and consequence.

5.3. Hazard assessment

Landslide hazard is the likelihood or probability of landslide occurrence in each location and a given period. The likelihood or hazard of peat landslides has been determined according to the guidelines for geotechnical risk management provided by Clayton (2001), taking into account the approach of MacCulloch (2005) and using the available data from the desk study, site reconnaissance and site investigations.

The hazard is calculated from various weighted factors, including the FoS and thirteen secondary factors related to geomorphic observations, topography, hydrology, vegetation, peat workings, existing loads and slide history (Appendix M). These secondary factors are challenging to quantify in a stability calculation but may contribute to peat instability.

Each hazard factor has been reclassified into one of four classes with rating values ranging from 0 to 3 (Appendix M). A rating of 0 indicates that the hazard factor is irrelevant; ratings 1, 2 and 3 indicate low, moderate and high correlation to peat slide hazard, respectively.

These factors have been assigned weighting values to reflect their relative importance in peat stability. Both the rating and the weighting values have been assigned according to the expert criteria of the project team and are presented in Appendix M. The hazard score of each factor is the multiplication of its rating value and weight value. These factors and their corresponding weightings are shown in Table 5-1.

The hazard values for a given wind farm element are the sum of the scores of all the hazard factors divided by the maximum hazard value possible to obtain a normalised hazard value ranging from 0 to 1 (see tables in Appendix M). Hazard is grouped into four categories: Negligible, low, medium and high.

Table 5-1: Factors affecting peat stability and hazard.

Hazard factors			Role in peat stability	Weight
Factor of Safety			This is the most critical factor, including the slope angle, the peat depth, the peat density, the peat cohesion in the drained and undrained conditions, as well as the effective friction angle. This is the complete factor. See Section 4 for further details.	10
Secondary factors	Topography	Curvature Plan (across the slope)	This represents the curvature across the slope and the funnelling/dispersion of the runoff.	
		Curvature Profile (downslope)	This represents the curvature down-slope and, therefore, the capacity of water retention and infiltration. Convex slopes are typically more prone to landslides.	
	Hydrology	Distance from watercourse (m)	This tends to affect the likelihood of landslides, especially in sectors where this distance is short.	
		Moisture index (NDMI)	This Landsat-derived factor indicates the water content or moisture of the vegetation, which can be considered a proxy of the terrain moisture.	
		Evidence of piping	The presence of piping is clear evidence of potential peat instability.	1
		The direction of existing drainage ditches	Drainage ditches that are aligned cross slope can affect the overall stability of a slope face.	
	Vegetation	Bush	This indicates the type of peat at the site and the hydrological nature of the site.	
		Forestry	The tree's vigour is another indicator of peat stability, with stunted trees more frequent in unstable sectors.	
	Peat workings	Peat cuts presence	This factor evaluates the effect of various peat workings on the stability of the peat.	
		Peat cuts vs contour lines	Where the peat cuts parallel the contour lines, the potential instability increases.	
	Existing loads	Roads	Side-cast of solid roads and floating roads pose a load to the peat blanket.	1

Hazard factors			Role in peat stability	Weight
	Slide history	Distance to previous slides (km)	This suggests that landslides at the site are likely if a peat slide has occurred at the site or within a 10-kilometre radius. The weight assigned doubles the weights for the other secondary factors	2
		Evidence of peat movement (e.g. tension cracks, compression features).	This factor evaluates the effect of any existing peat movement indicators on-site, such as tension cracks. The weight assigned doubles the weights for the other secondary factors.	

5.4. Adverse consequences assessment

The impacts of peat landslides on the wind farm elements, surrounding environment, and existing assets may typically generate a variety of adverse consequences. This report qualitatively assessed these consequences following the *Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments* (Scottish-Executive, 2017).

Table 5-2 summarises the consequences considered for the PSRA of the development.

Table 5-2: Consequences considered for the PSRA

Consequence factors	Description	Weight
The volume of potential peat flow (function of distance from the nearest watercourse and peat depth in the area)	This is the second most heavily weighted factor. It is estimated based on the distance from the nearest defined watercourse and the depth of peat in the area—the longer the distance and the deepest the peat depth, the larger the landslide.	3
Downslope features	This factor accounts for the type/shape of downslope features that may hamper or favour the propagation downhill of the peat flow.	1
Proximity from the defined valley (m)	This is the distance from the site to the nearest defined river valley. Rivers close to potential landslide sectors are more vulnerable to a landslide event.	
Downhill slope angle	This factor accounts for the runout distance as a matter of slope angle.	
Downstream aquatic environment	Reflects the severity of a peat slide event's impact on the receiving aquatic environment.	
Public roads in the potential peat flow path	Rates the impact of a peat slide striking a public road.	1
Overhead lines in the potential peat flow path	Rates the impact of a peat slide striking a service line.	
Buildings in the potential peat flow path	Rates the impact of a peat slide striking a habitable structure.	
Capability to respond (access and resources)	Rates the capability of the site staff to respond to a peat instability event.	

The nine consequence factors considered have been reclassified similarly to the hazard factors (Appendix M). A rating of 0 indicates that the consequence factor is irrelevant, and a rating of 3 indicates high consequences.

'Volume of potential landslide' has been assigned a weight of 3 to reflect its relative importance in the potential consequences. The rest of the factors have been assigned a weight of 1. Both the rating and the weighting values have been assigned according to the expert criteria of the project team. The score of each consequence factor is the multiplication of its rating value and weight value (Appendix M).

The consequences value for a given wind farm element is the sum of the nine consequences scores. This total value is then divided by the maximum consequence value possible to obtain a normalised consequence value ranging from 0 to 1 (see tables in Appendix M). Consequences are grouped into four categories: Negligible, low, medium and high.

5.5. Risk calculation

Risk in each wind farm infrastructure element is calculated with Equation 5-1, i.e. multiplying the hazard scores and the consequences scores. The risk rating ranges between 0 and 1, and the following risk rating levels have been distinguished in Figure 5-1 and Figure 5-2.

- High (0.6 to 1): Avoid project development at these locations. Mitigation is generally not feasible.
- Medium (0.4 to 0.6): The project should not proceed unless risk can be avoided or mitigated at these locations without significant environmental impact to reduce risk ranking to low or negligible.
- Low (0.2 to 0.4): Project may proceed pending further investigation to refine assessment and mitigate hazard through relocation or re-design at these locations.
- Negligible (0 to 0.2): The project should proceed with monitoring and mitigating peat landslide hazards at these locations as appropriate.

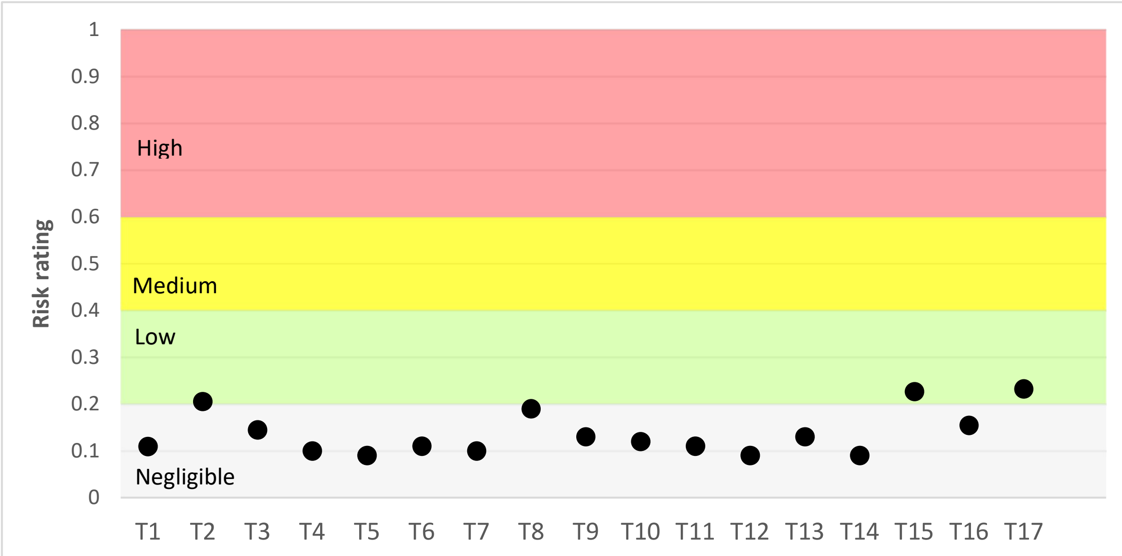


Figure 5-1: Risk ratings at the proposed turbine locations.

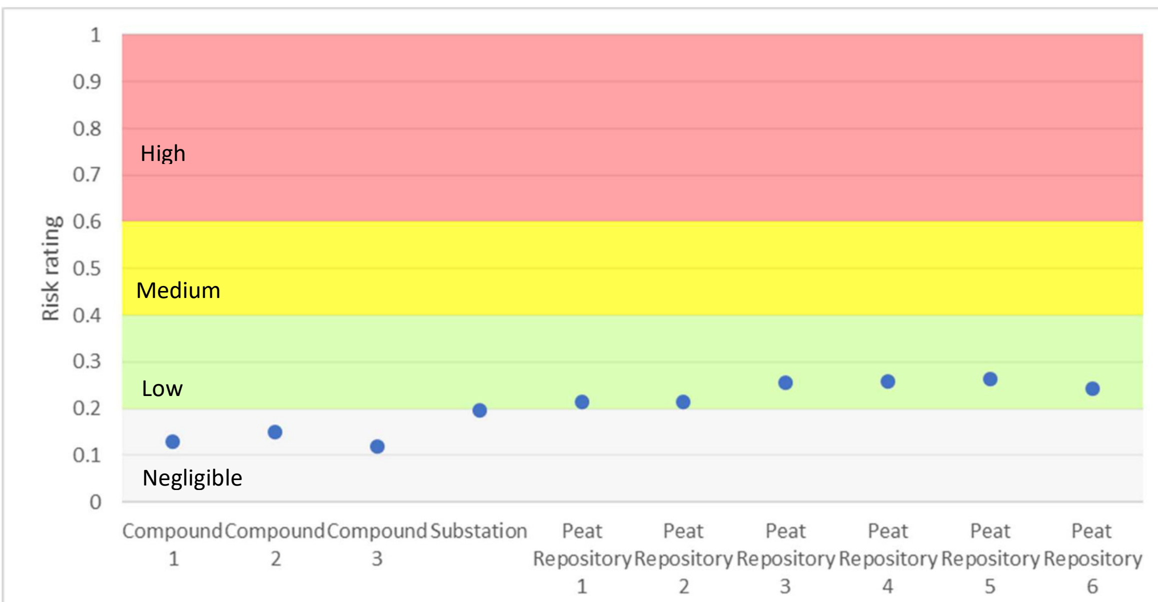


Figure 5-2: Risk ratings at the proposed infrastructure element sites.

Appendix M gathers the risk calculation process at each turbine considering the four scenarios of hazard: Undrained; undrained with a surcharge of 1 m; drained; and drained with a surcharge of 1 m. Figure 5-1 and Figure 5-2 summarise the risk rating obtained at the turbines, substation, compound and peat repository area locations. All the turbines and infrastructure locations are indicative of negligible to low risk.

It is stressed that the resulting risk rating does not indicate a probability of losses due to landslides; it simply expresses a rating.

6. Geotechnical Risk register

Table 6-1: Geotechnical risk register

Ref.	Risk	Contributing factor	Management and Mitigation of Risk
1	The collapse of the dried peat berm/ peat slippage	Overestimation of soil strength parameters	The soil parameters are based on the hand shear vane test carried out by GDG at each turbine location. Shear vane testing was carried out at 0.5m intervals through the peat to assess variation within the peat body. The interpreted undrained shear strength values consider a conservative reduction factor for the influence of the fibres within the peat. Extensive sampling ground investigation at infrastructure location, including trial pitting and Russian coring, to assess the composition and strength of the peat and collect samples for testing. The derived values were compared with a literature review of the most common general drained and undrained parameters for each soil type and on the descriptions. Further testing and assessment of the peat during further ground investigation campaigns is expected to be required before construction. This will allow for a robust understanding of the ground conditions and the detailed design of access roads and structures. An extensive testing protocol shall be developed by the Construction stage contractor and the design team. These tests shall be observed by a suitably qualified engineer and reported to the owner's engineer. It would be expected that an observational approach will be required when constructing on peat due to the limitations associated with testing and verifying its strength, and the contractor is required to frequently inspect the peat material and providing proof of inspection.
2	The collapse of berm/peat slippage	Underestimation of peat depth	Extensive ground investigation, including trial pitting, Russian coring and peat probing, has been carried out across the site. GI locations have been carried out at locations where access was possible. Access was limited to some areas of the site, with restrictions on forestry and terrain limiting coverage. Further GI will be required at these locations during the detail and construction stage to assess peat depths. The detailed designer and contractor team will carry this out. The design team shall develop their own testing criteria to satisfy and derisk the possibility of larger peat depths occurring at these locations.
3	Failure of peat slope due to loading or agitation of existing instability	Failure to identify existing instability/ peat deformation at the site	Assessment of satellite imagery and topographical data for evidence of past landslide events was carried out as part of the desk study, finding no evidence of past instabilities or landslide events within the site area. The Geological Survey of Ireland (GSI) landslide database was examined, identifying several landslide events in the local region within 5km of the site, the closest approx. 100m from the site boundary and 3km from the nearest turbine, turbine 13.

Ref.	Risk	Contributing factor	Management and Mitigation of Risk
			The client provided a report investigating a landslide event at a neighbouring windfarm site. The findings of this are outlined in the report and are considered in the assessment at this site. During the site walkovers the site GDG engineers examined the landscape and the areas surrounding the proposed infrastructure for evidence of instability or past landslide events. No past landslide or instability events was identified. Although there is no evidence of landslides within the Proposed Development Site, this does not necessarily mean that landslides have never occurred at the proposed site location. It is noted that the geomorphological features associated to peat landslides (peat slides and bog bursts) are softened with time through erosion, drying and re-vegetation, particularly given the forestry and harvesting activities which have taken place at this site. Access was limited to some areas of the site with restriction relating to dense forestry and terrain limiting visibility and inspection areas. Further inspection will be required during the detail design and construction stage to inspect for peat instabilities. This will be carried out by the detail designer and Contractors team. The design team shall develop their own inspection and testing criteria to satisfy and de-risk the possibility of larger peat depth occurring at these locations.
4	The collapse of peat berm/peat slippage	Failure due to excessive loading of peat	The peat stability analysis factor of safety exercise examines the peat in the drained and undrained condition both without and with the addition of a surcharge equating to 1m of peat loading. Areas indicative of a low or moderate FoS result with the 1m peat surcharge within or adjacent to the proposed site infrastructure have been designated as peat storage restriction (PSR) areas, as outlined in Section 4.5. Requirements for the safe and sustainable storage of peat material are outlined in the associated Peat Management Plan (PMP) document, Technical Appendix 11-3 (GDG,2022). The requirements and restrictions for peat storage outlined in this document must be adhered to during the constriction stage.
5	Instability of peat slippage	Variations in the groundwater conditions at the site	The groundwater conditions were examined during the walkovers and within the trial pit locations. Areas of saturated surface peat were identified during the walkovers as outlined in Section 4, and these have been considered in the risk assessment and findings of the report. Water strikes, peat water content and groundwater conditions are noted in the trail pit locations (GII, 2022) and outlined in Technical Appendix 11-1 GIR (GDG,2022). The groundwater conditions and peat moisture content way vary seasonally and/or more frequently with the immediate weather conditions. Long term groundwater monitoring across shall be carried out in further design stage ground investigations and further lab testing of the peat in its insitu condition will need to be assessed for the construction design.

7. Conclusions and recommendations

Following the guidance of the Scottish Executive (2017), a review of the published thematic and geographic information (e.g. geology, soils, protected areas) and relevant background literature was undertaken for the proposed development. Site reconnaissance and site investigations were conducted to validate and enhance the desk study information. Based on the revision of the available data, the fieldwork and GDG's professional judgement, it is concluded that peat slides are unlikely on the site. However, the developer will require diligent peat management and careful consideration of the peat conditions at the site throughout the detailed design and construction stage.

A deterministic Factor of Safety was calculated across the proposed element locations, and from this, a robust peat stability risk assessment (PSRA) was performed. The findings of the peat assessment showed that the site has an acceptable margin of safety and is suitable for the proposed turbine locations.

The peat stability risk for the proposed infrastructure is negligible to low. However, the results of the factor of safety deterministic calculation and the site walkover allowed for identifying safety buffers and peat and spoil stockpile restriction (PSR) areas outlined in Section 4.5 and shown in Appendix L. These must be adhered to in future stages of the Proposed Development. Outside of the areas defined by the safety buffers and peat and spoil stockpile restriction (PSR) areas, the construction of the Proposed Development is considered to be safe and stable for construction following the methodologies and safe working practices outlined in the associated in Appendix 10-3 Peat and Soil Management Plan (PMP) and Appendix 4-1: Construction Environmental Management Plan (CEMP) of the EIAR.

All earthworks shall be designed by a competent geotechnical designer, informed by a detailed ground investigation.

All on-site construction activities shall follow the peat management and monitoring requirements outlined in the peat and overburden management plan, included in Appendix 10-3 of the EIAR.

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Appendix A Location and administrative limits

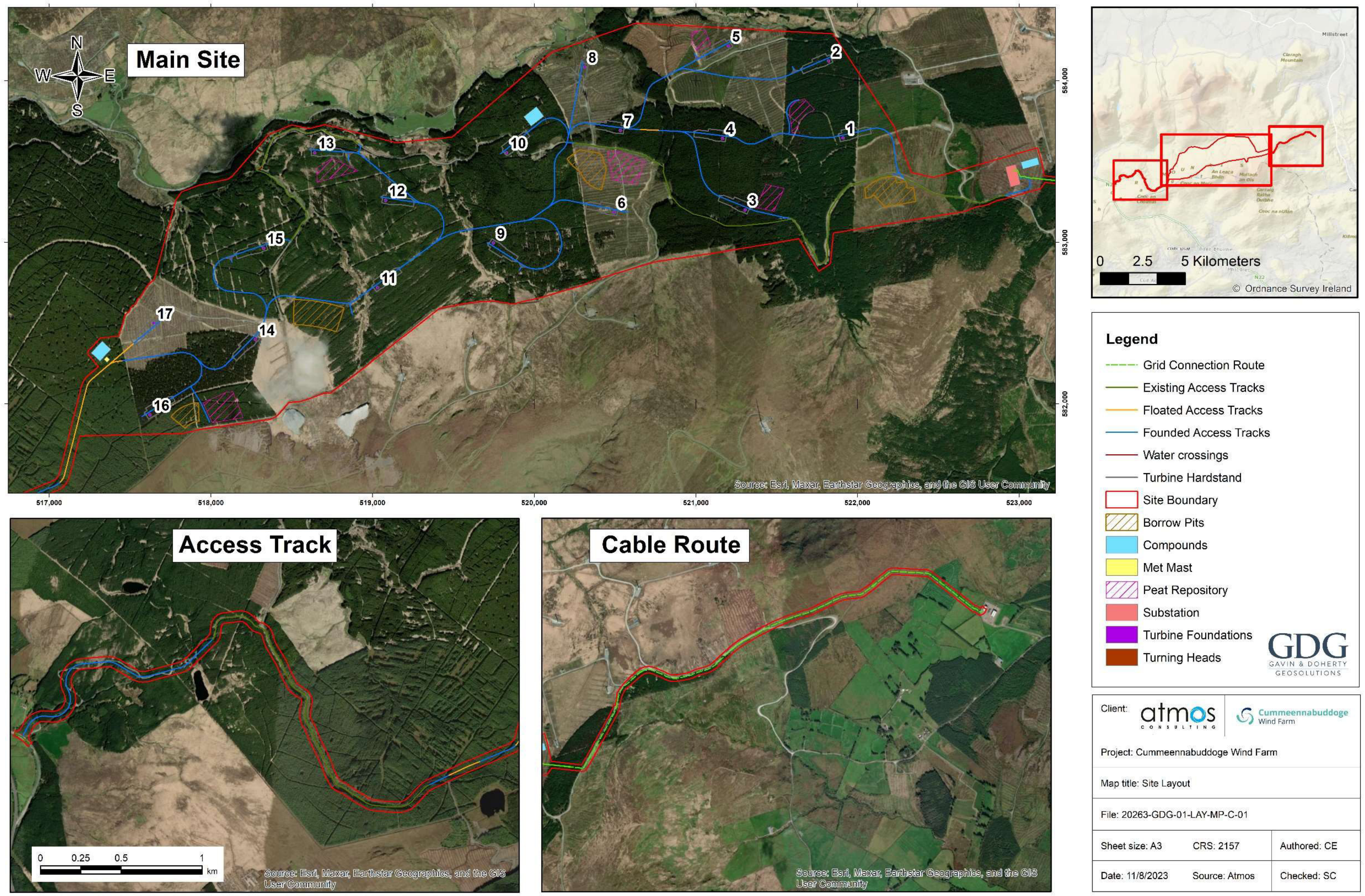


Figure A-1 Location of the proposed site and administrative limits.

Appendix B Geology

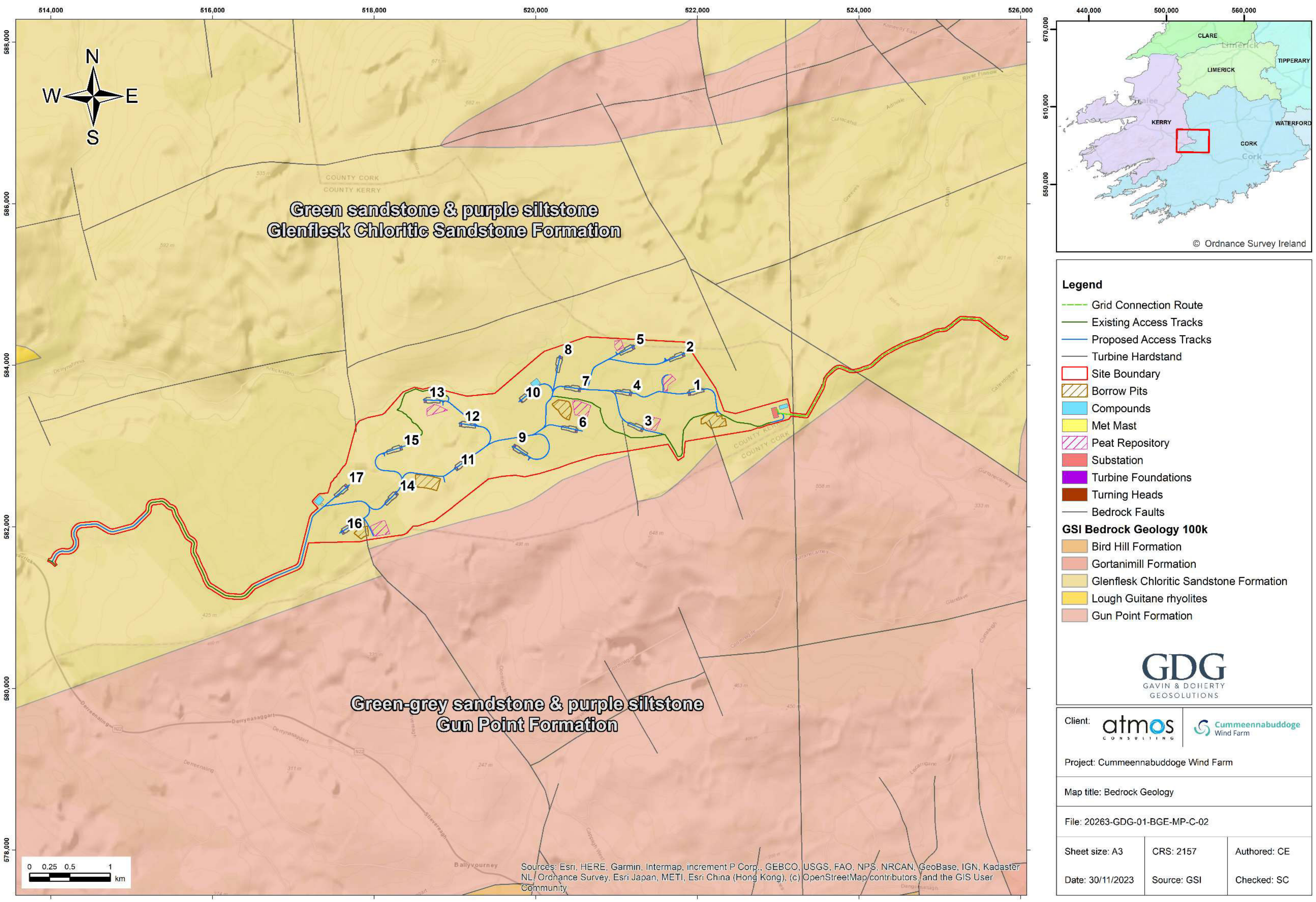


Figure B-1: Bedrock geology 100k (GSI).

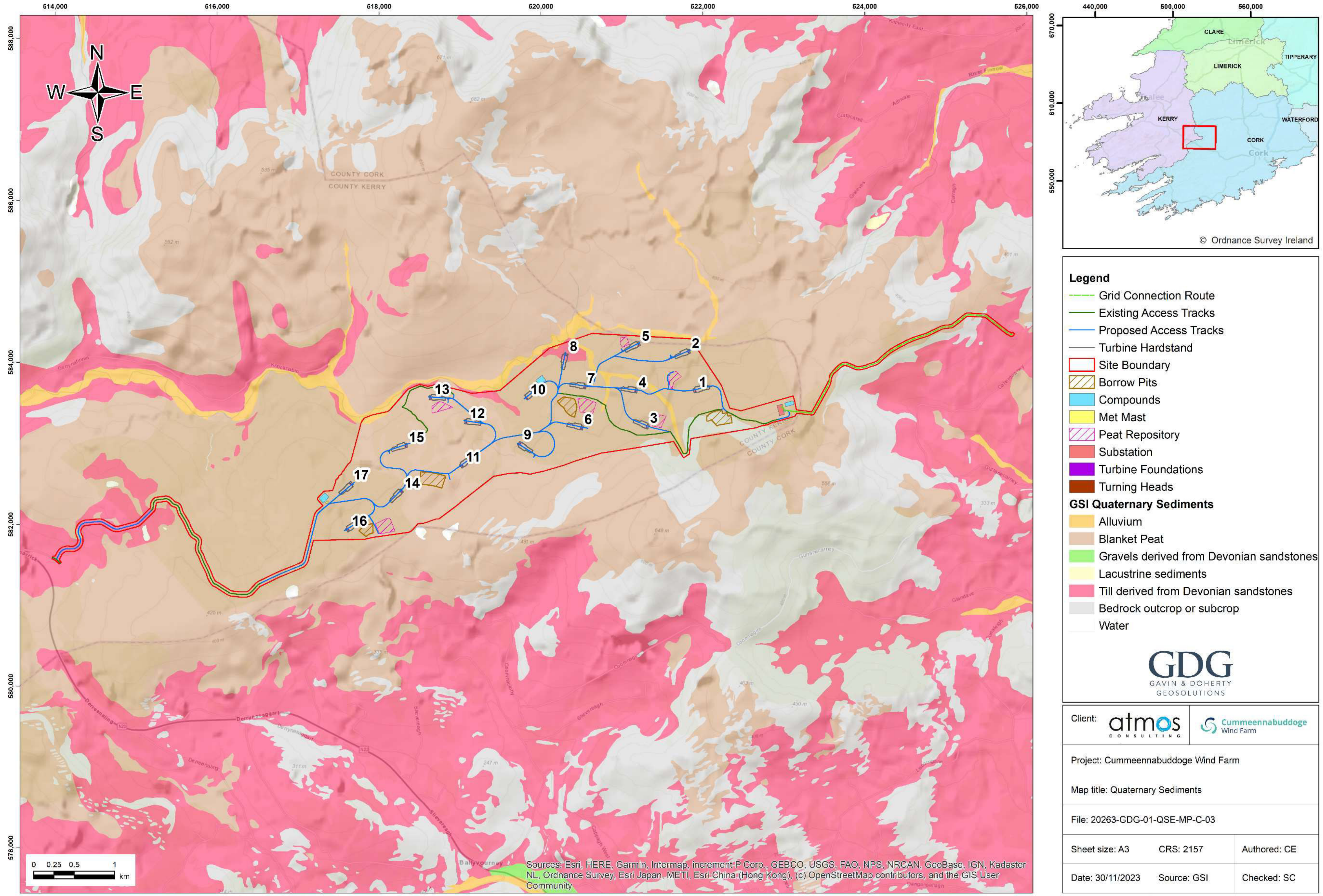


Figure B-2: Quaternary sediments (GSI).

Note: The quaternary sediments in the proposed site have been labelled in the map. This is a regional scale map that does not represent the local details of the peat spatial distribution, which was enhanced for this project through fieldwork peat probes.

Appendix C Soils

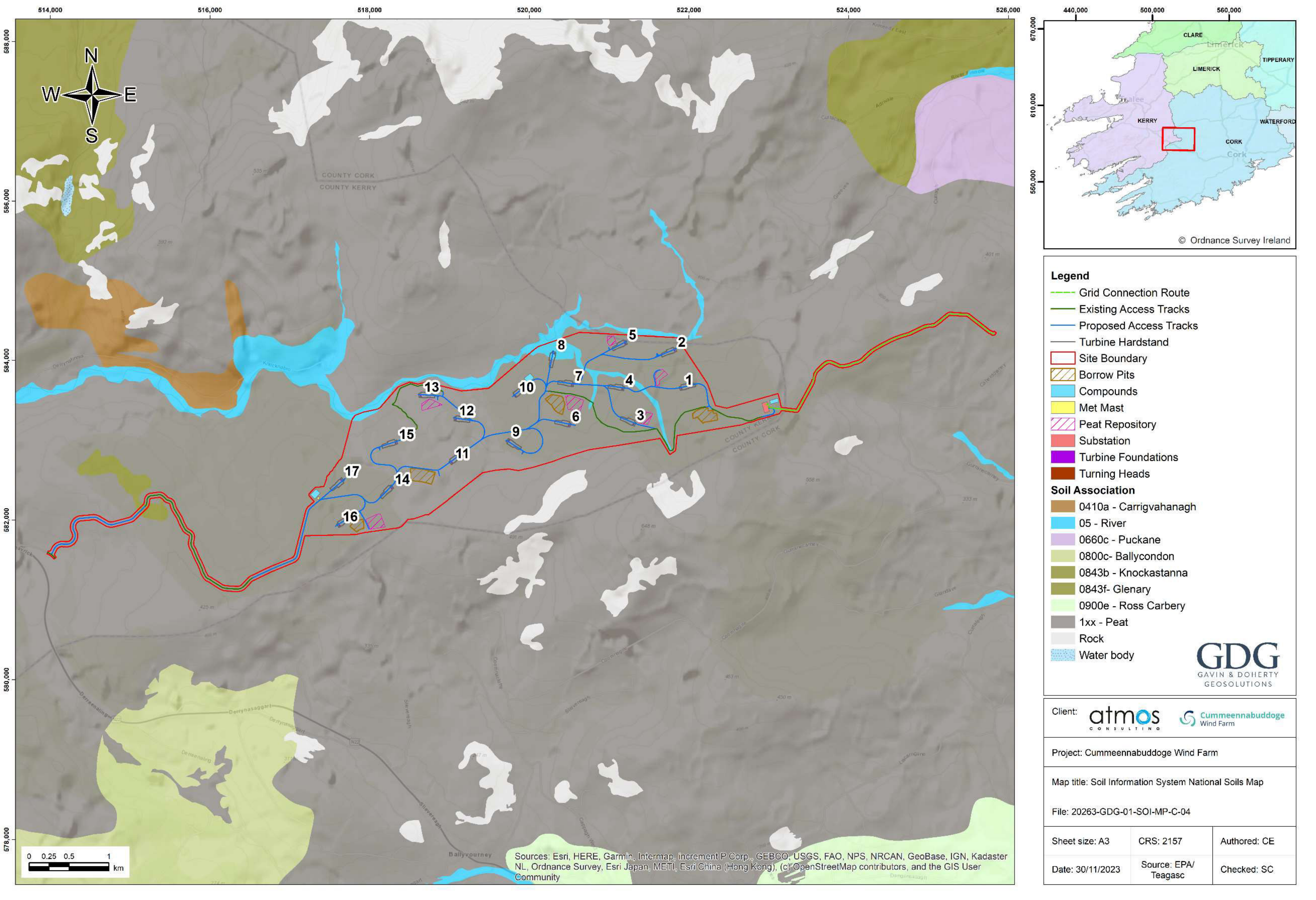


Figure C-1: Soils.

Note: The soils in the proposed site have been labelled in the map. This is a regional scale map that does not represent the local details of the peat spatial distribution, which was enhanced for this project through fieldwork and peat probes.

Appendix D Moisture

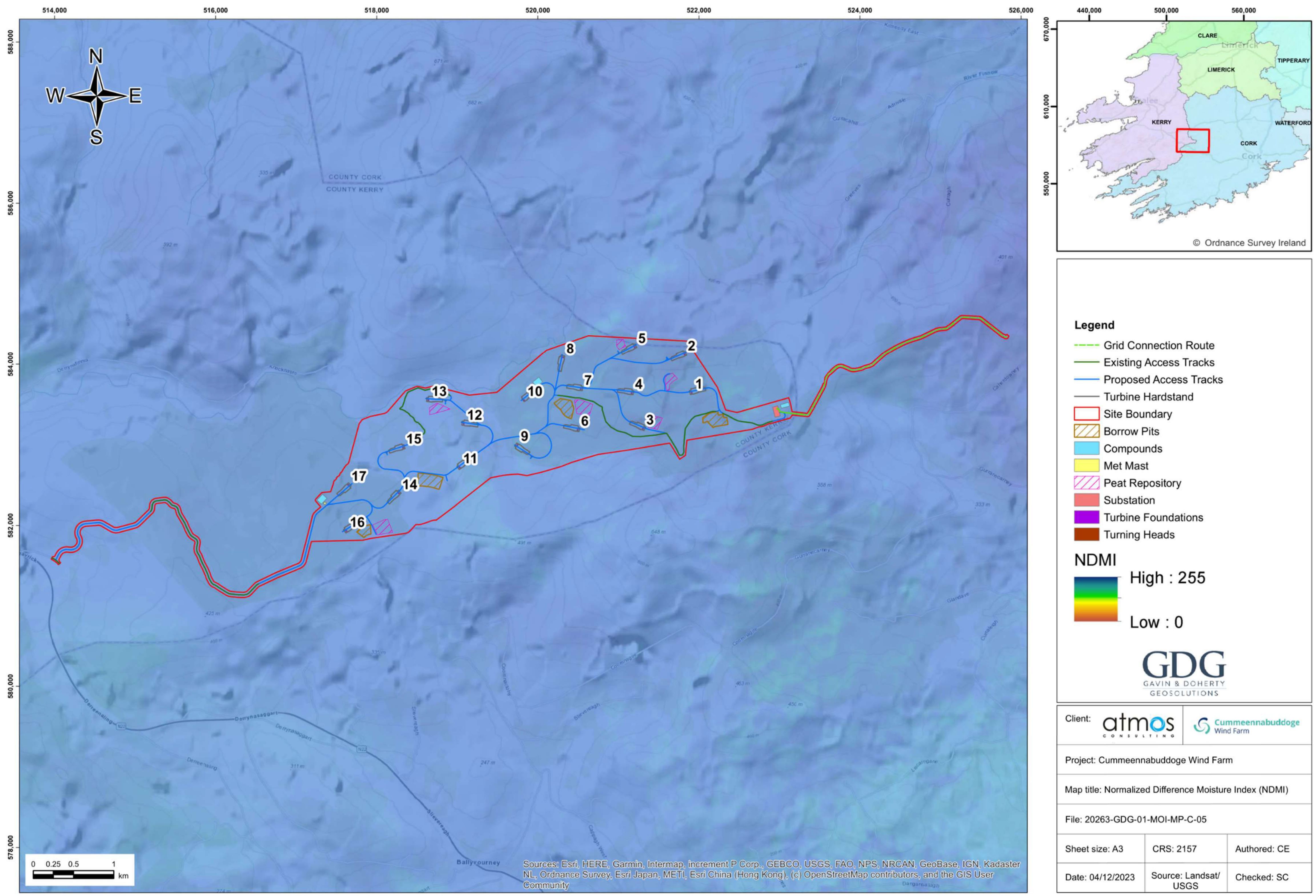


Figure D-1: Moisture Index developed from Landsat 8 and the USGS.

Appendix E Hydrogeology

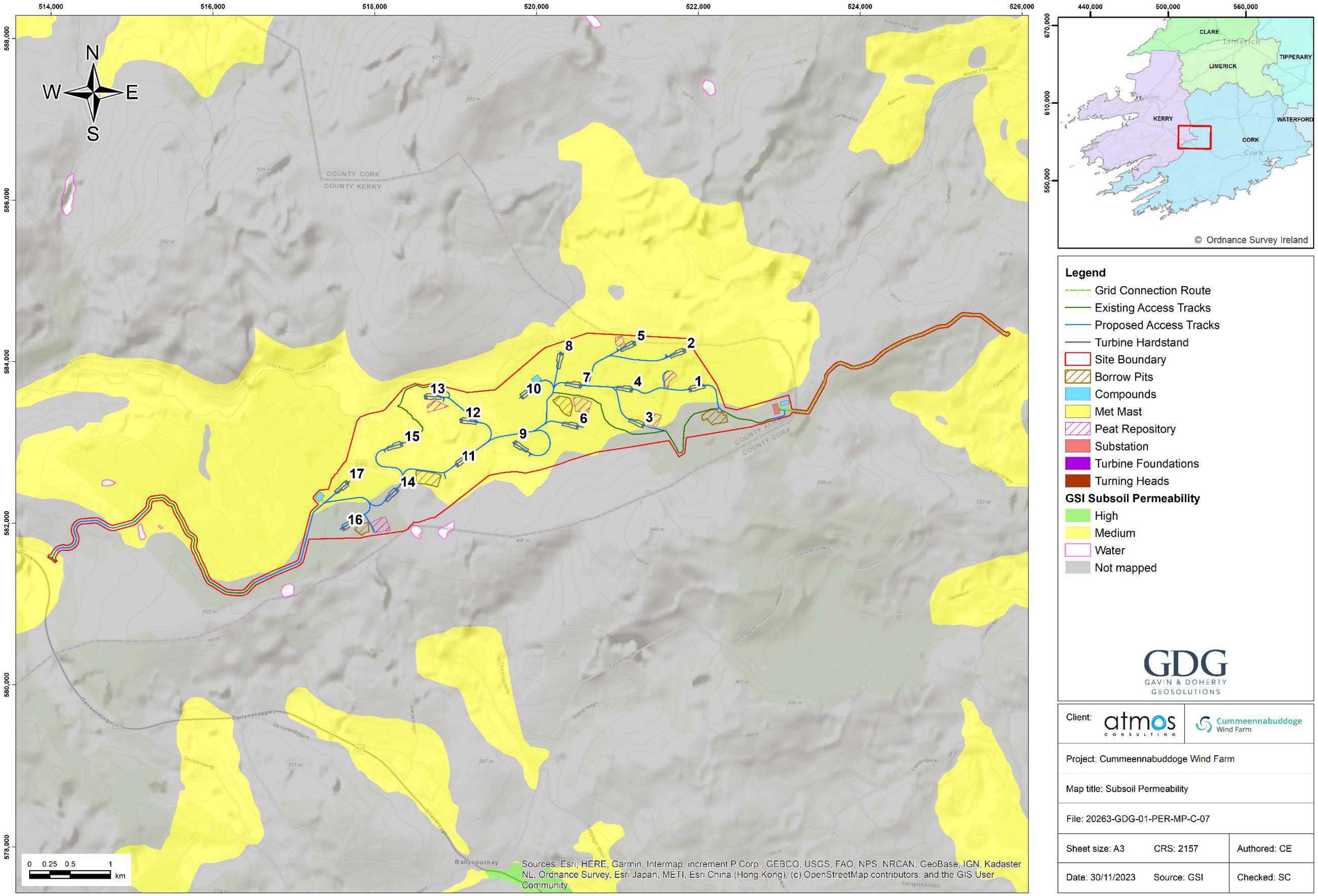


Figure E-1: Subsoil permeability (GSI).

Note: There are no wells shown in the map extent. The closest well to the study area is located ~5 km southwest.

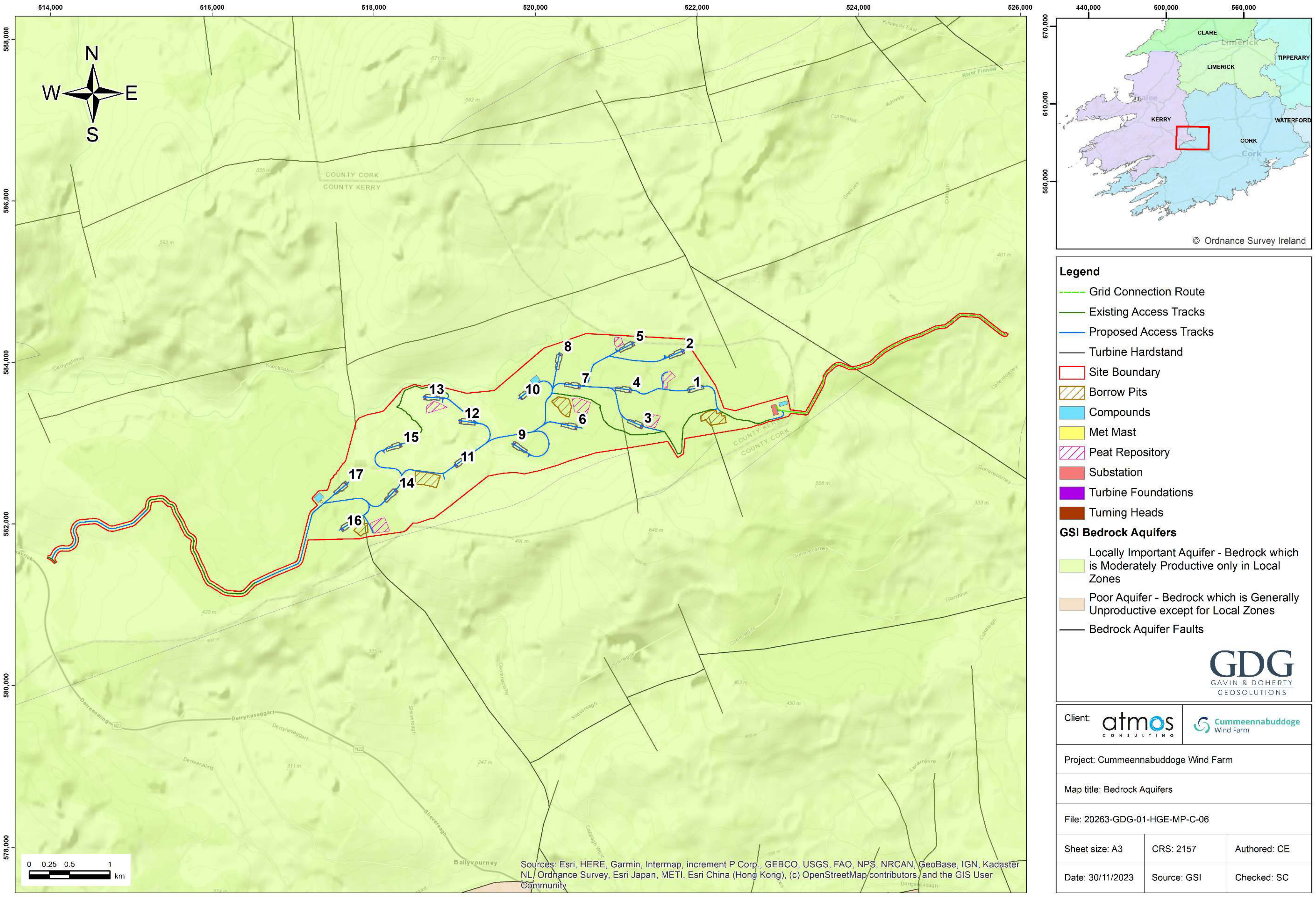


Figure E- 2: bedrock Aquifers (GSI).

Appendix F Topography

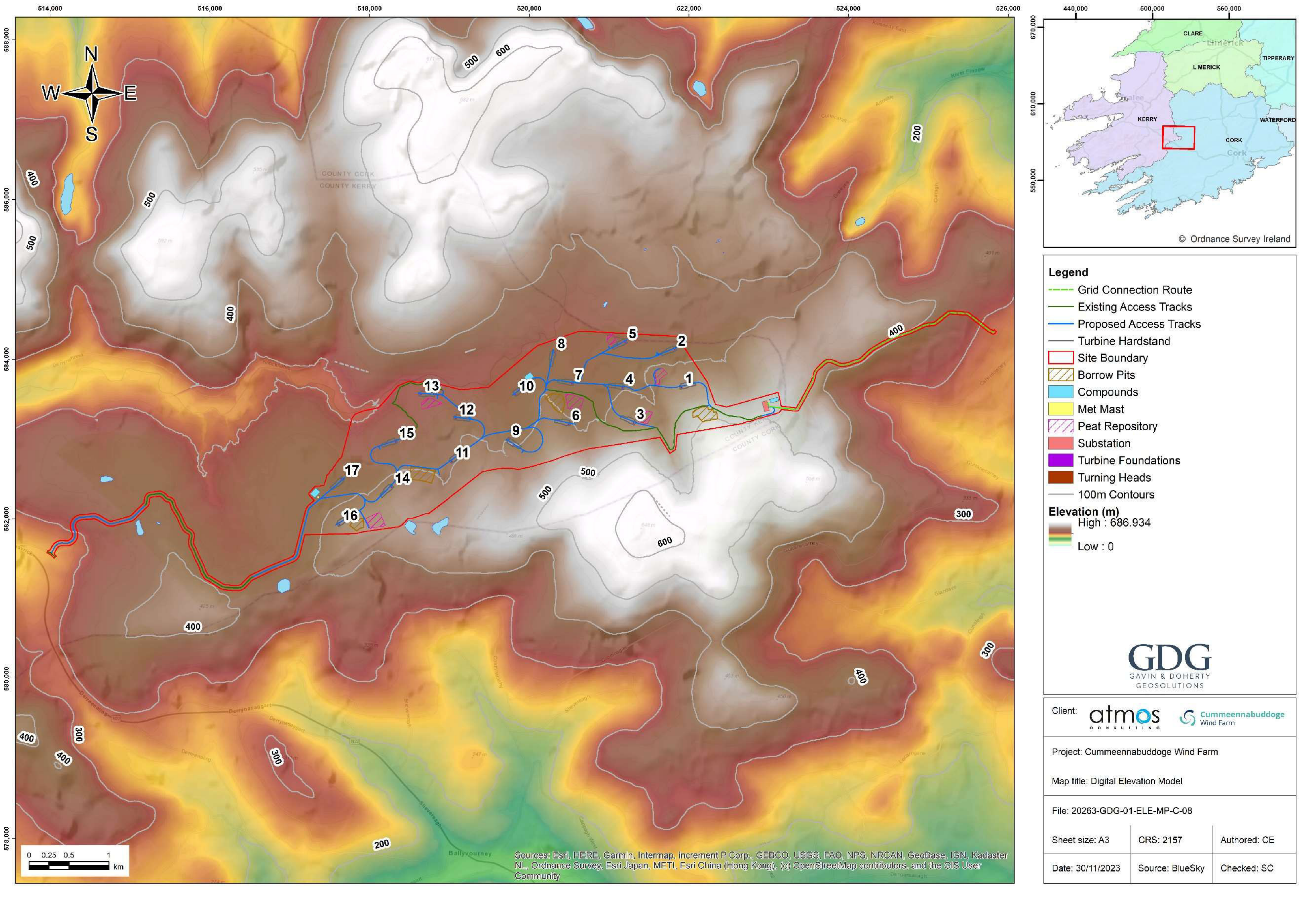


Figure F-1: DEM sourced from Sintegra (2020) and EEA (2022).

Appendix G Slope instability mapping

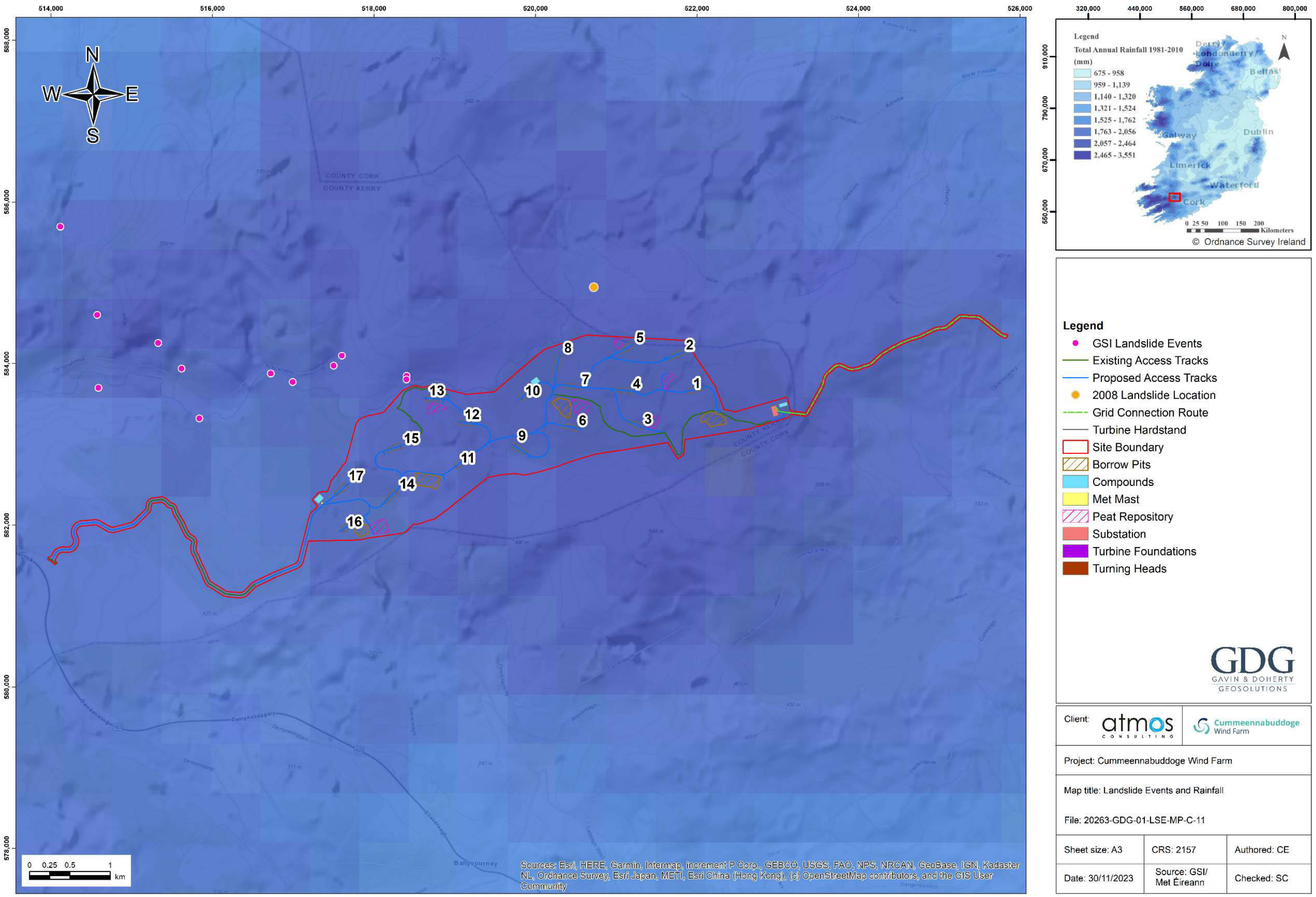


Figure G-1: Landslide from national database (GSI) and rainfall (Met Éireann, 2018)

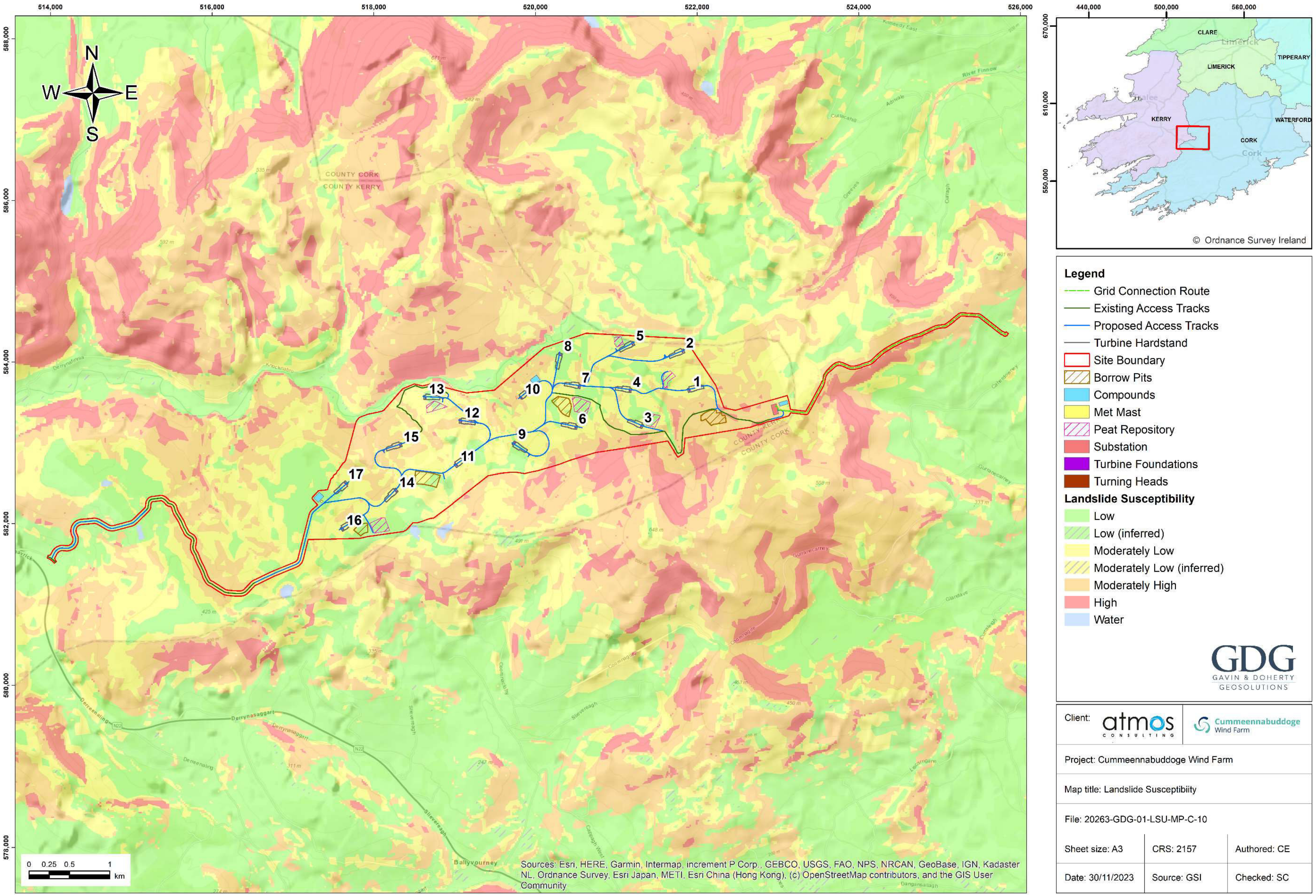


Figure G-2: Landslide Susceptibility (GSI).

Appendix H Hydrology

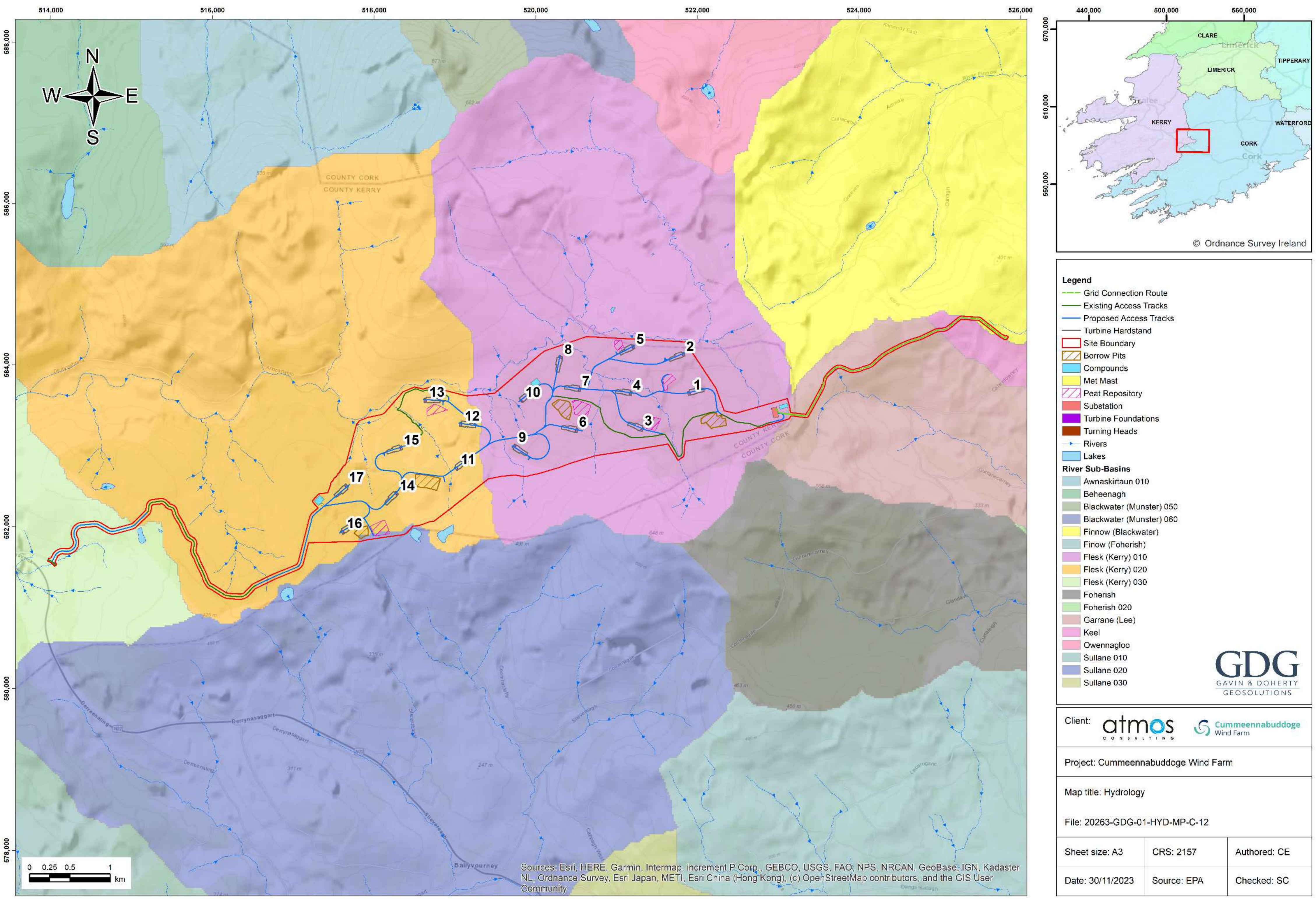


Figure H-1: Rivers and lakes.

Appendix I Land cover and land use

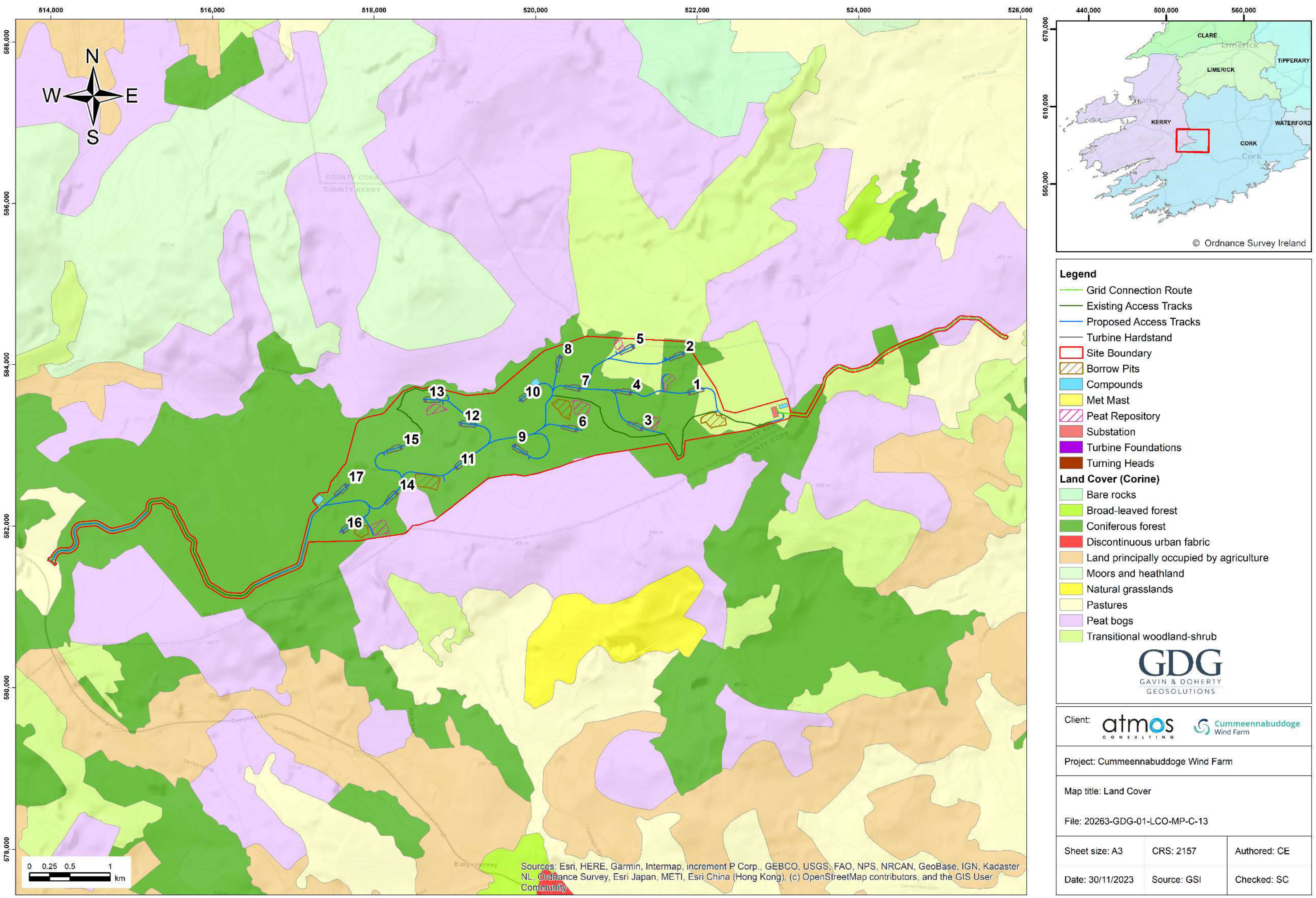


Figure I-1: Corine land cover map (2018).

Appendix J Geo-Investigations

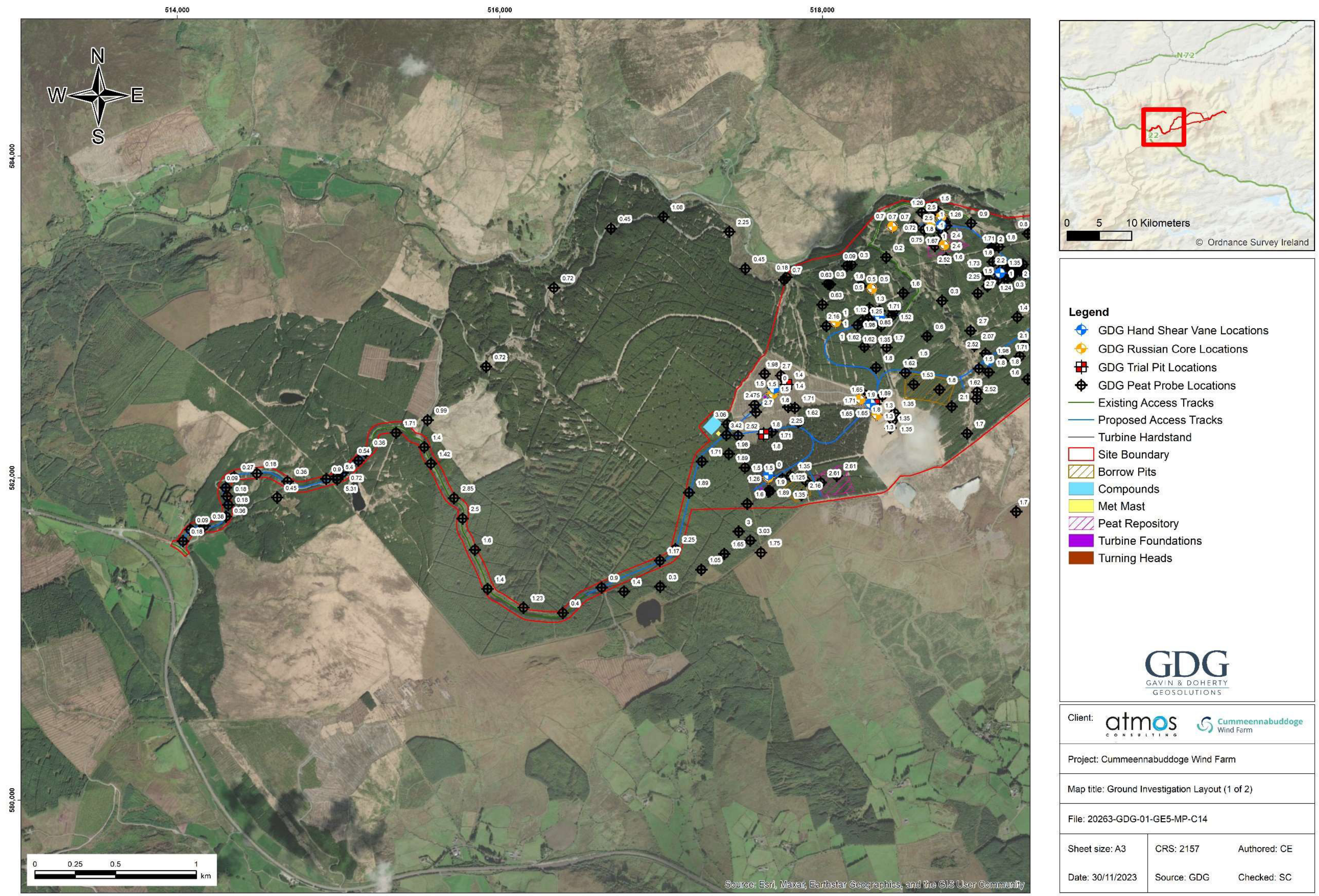


Figure J-1: Geo-investigation map (1 of 3).

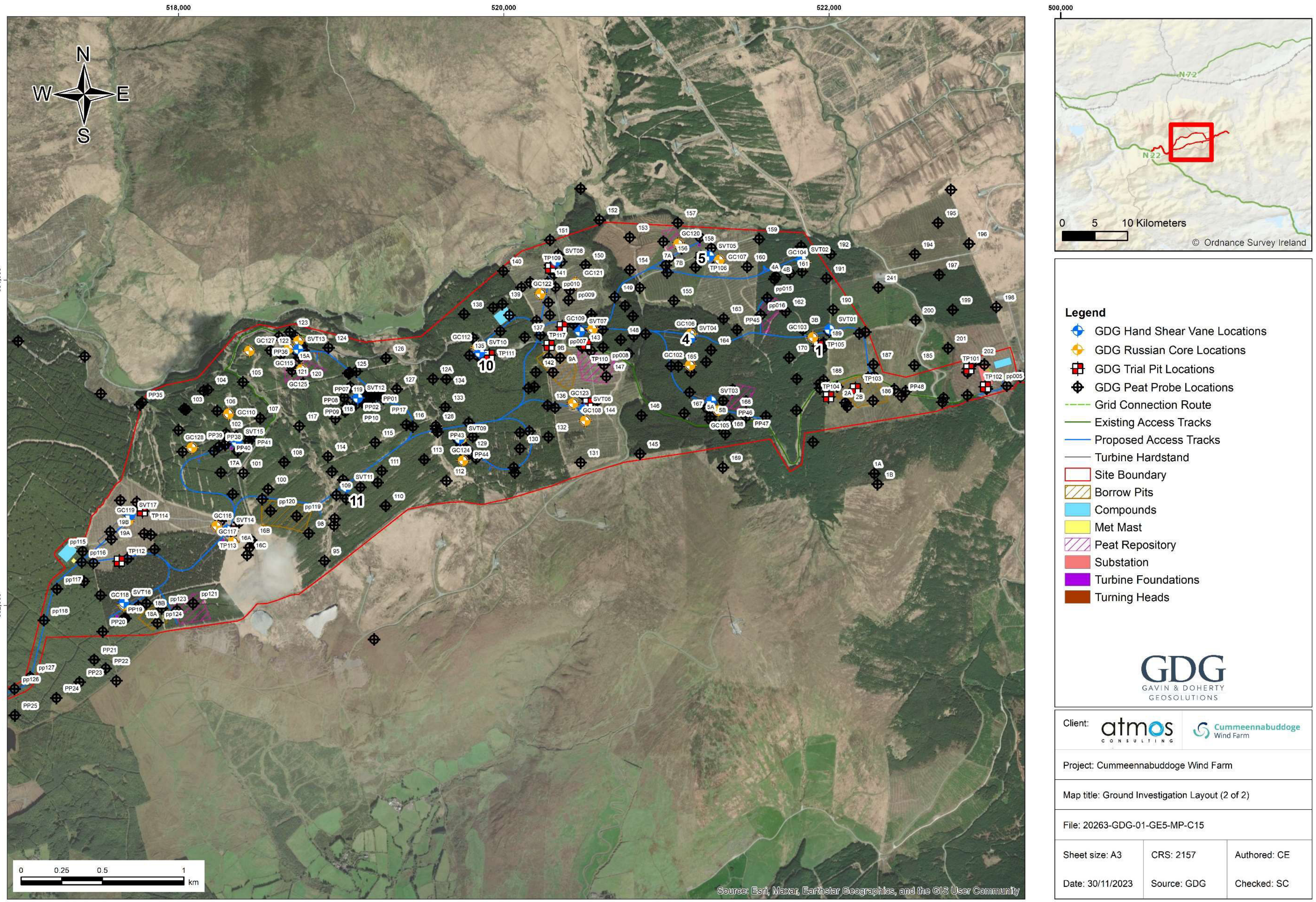


Figure J-2: : Geo-investigation map (2 of 2)

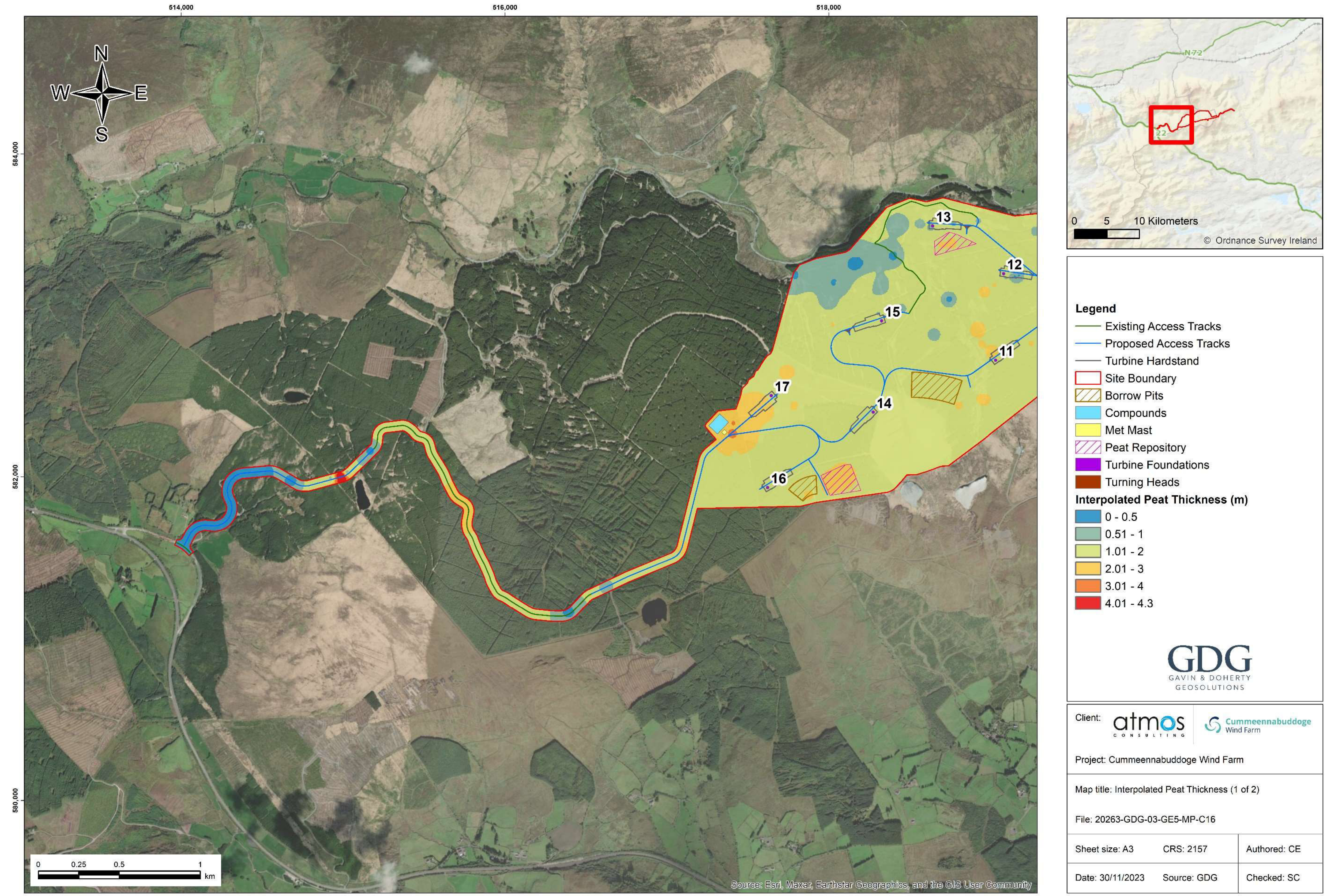


Figure J-3: Interpolated peat depth map. (1 of 3)

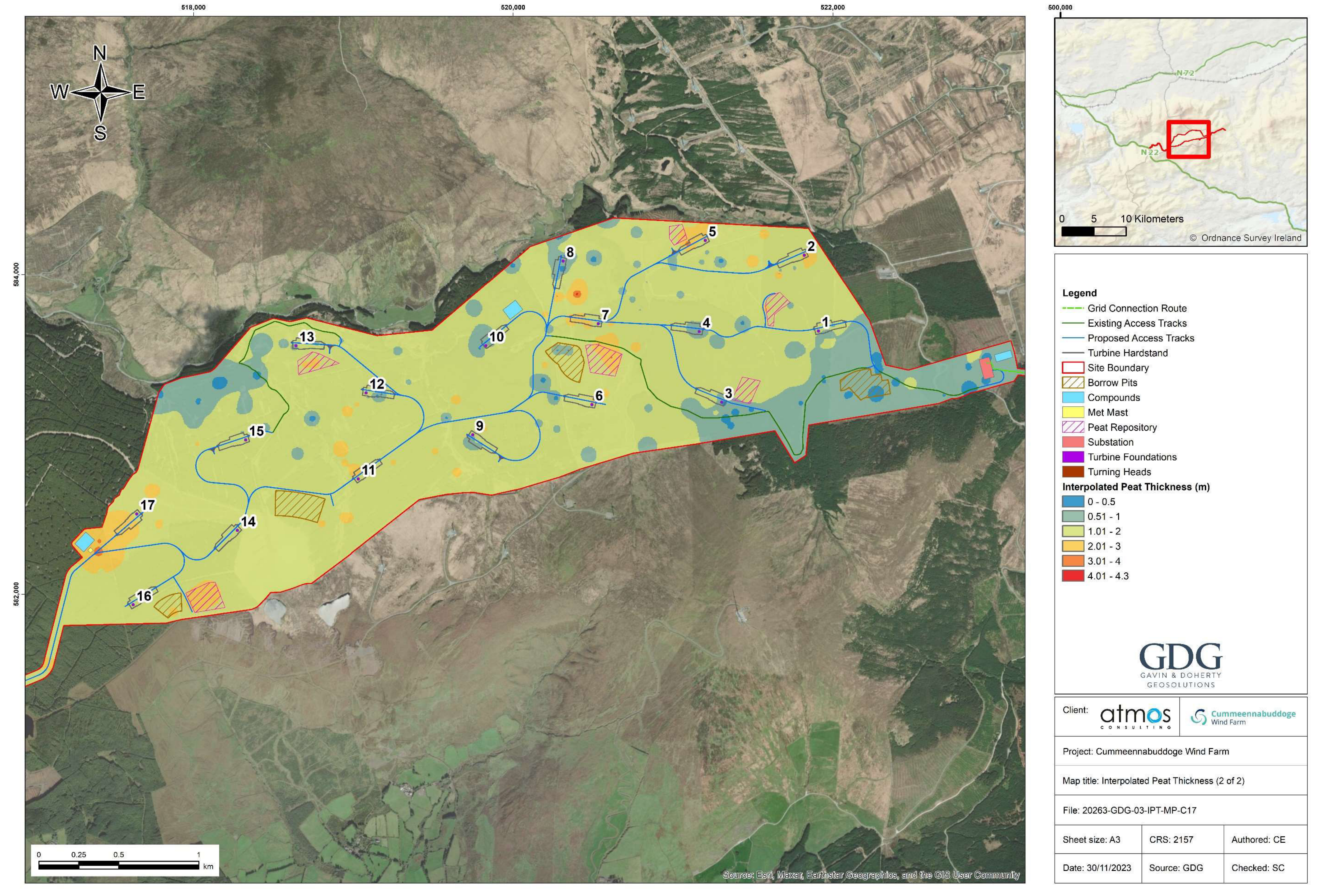
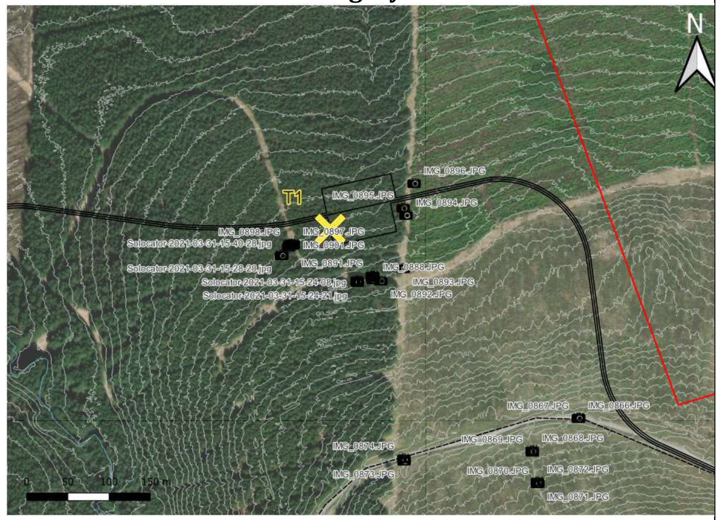


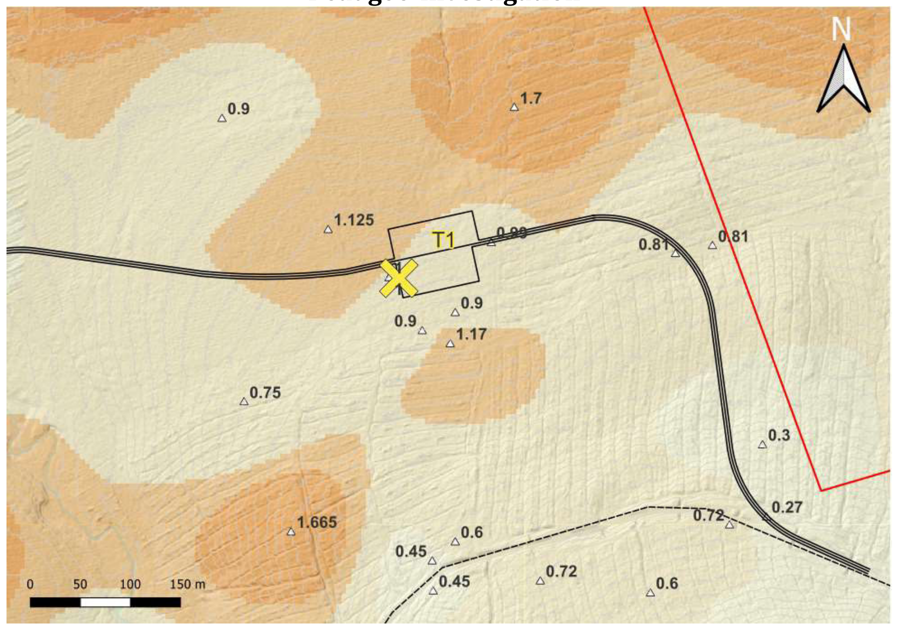
Figure J-4: Interpolated peat depth map. (2 of 2)

Table J-1: Site reconnaissance of the Turbine 1 site.

Imagery



Peat geo-investigation



IMG_0899.JPG

Shared legend

Geotagged photos
Turbine Locations
Site Boundary
Contour Lines (2 m)
Peat Probe Locations
Water Courses

ROADS
Internal track
Upgrade of existing roads 22-08-18
Upgrade of existing roads
Access tracks
New Roads
Upgrade of existing roads

Peat Depth (m)
<= 0.50
0.50 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 2.50
2.50 - 3.00
3.00 - 3.50
> 3.50

Description

Date of the satellite images: April 2020. [Centre National d'Études Spaciales (CNES) / Airbus].

Date of the ground-based pictures: 14th of March, 2022 [GDG].

Geomorphology: T1 is located within a forest. Slope towards the north of the site.

Peat: The peat depth at T1 is 1 m and slope angle of 8.9 degrees.

Instability evidences: No.

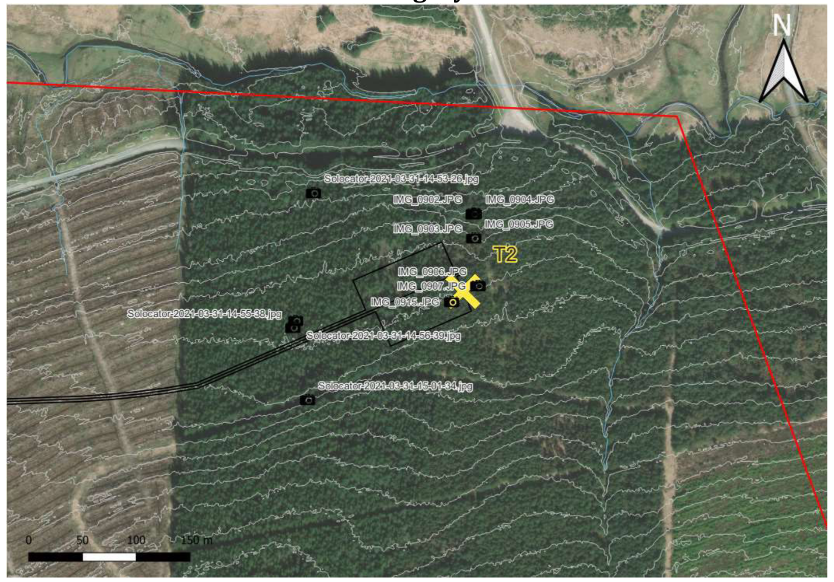
IMG_0895.JPG

IMG_0891.JPG

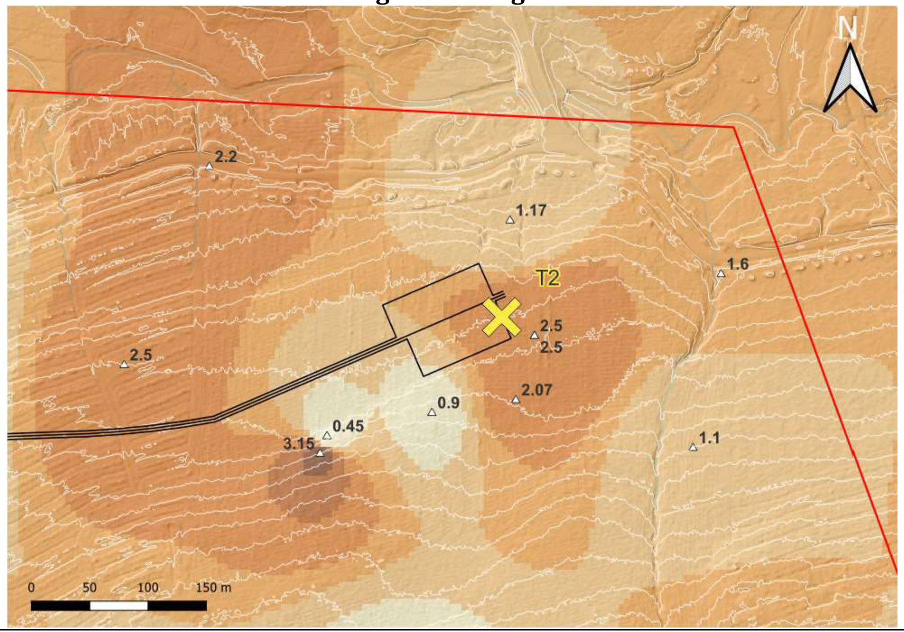
IMG_0890.JPG

Table J-2: Site reconnaissance of the Turbine 2 site.

Imagery

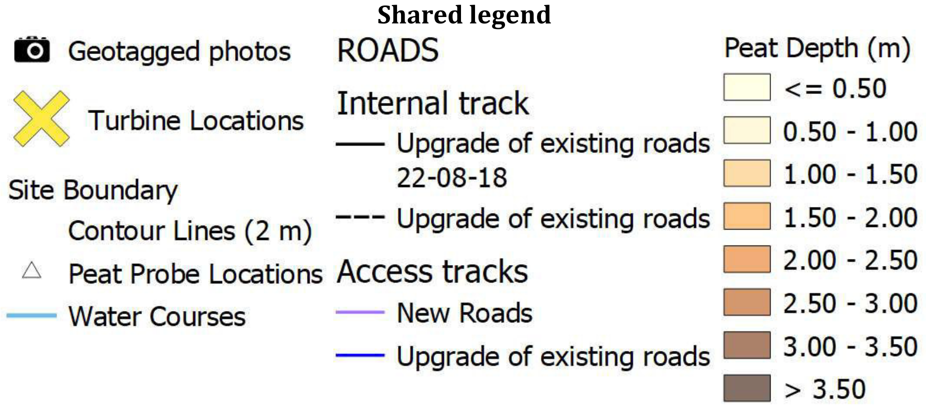


Peat geo-investigation



IMG_0904.JPG

Shared legend



Description

Date of the satellite images: April 2020. [Centre National d'Études Spaciales (CNES) / Airbus].

Date of the ground-based pictures: 14th of March, 2022 [GDG].

Geomorphology: The topography is partially flat.

Peat: The interfered peat depth at T2 and across its hardstanding varies from 1 m to 2.4 m with a slope angle of 3 degrees

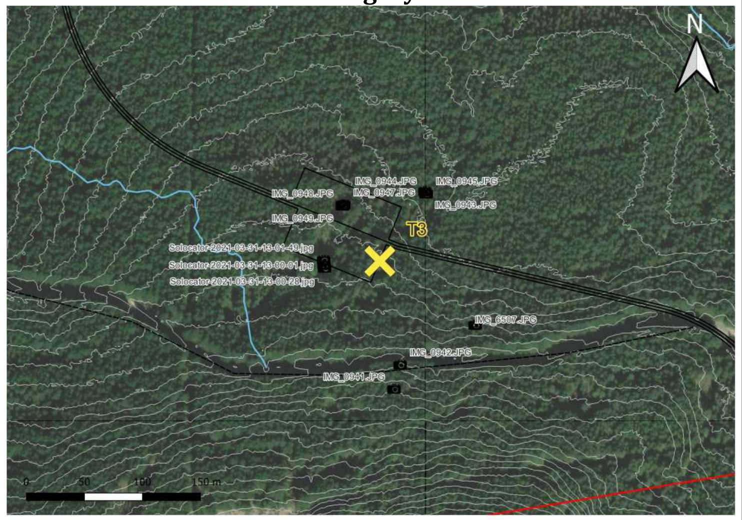
Instability evidences: No.

IMG_0907.JPG

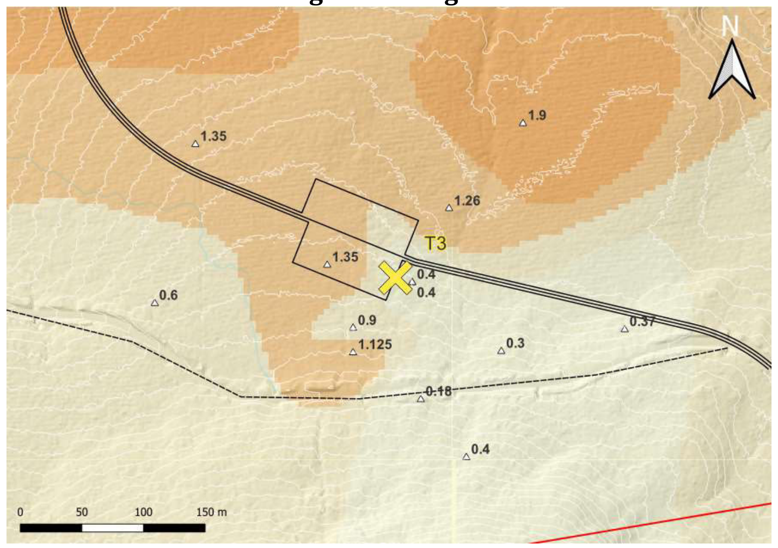
IMG_0910.JPG

Table J-3: Site reconnaissance of the Turbine 3 site.

Imagery

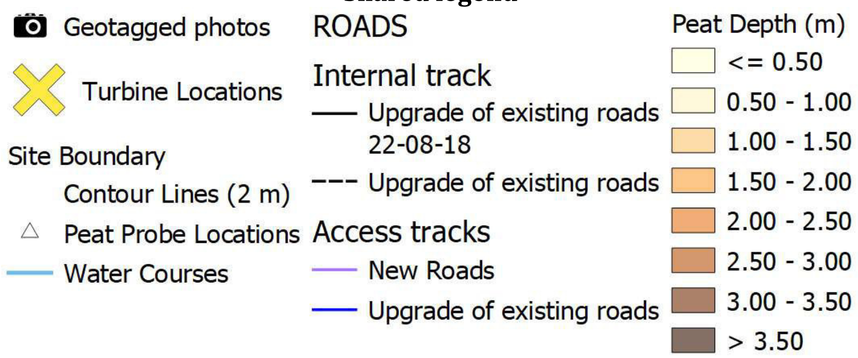


Peat geo-investigation



IMG_0944.JPG

Shared legend



Description

Date of the satellite images: April 2020. [Centre National d'Études Spaciales (CNES) / Airbus].

Date of the ground-based pictures: 14th of March, 2022 [GDG].

Geomorphology: the topography is mostly flat.

Peat: The peat depth is 0.4 m at T3 location which increase along the hardstanding up to 1.35 m with a slope angle of 4.6 degrees.

Instability evidences: No.

IMG_0947.JPG

IMG_0945.JPG

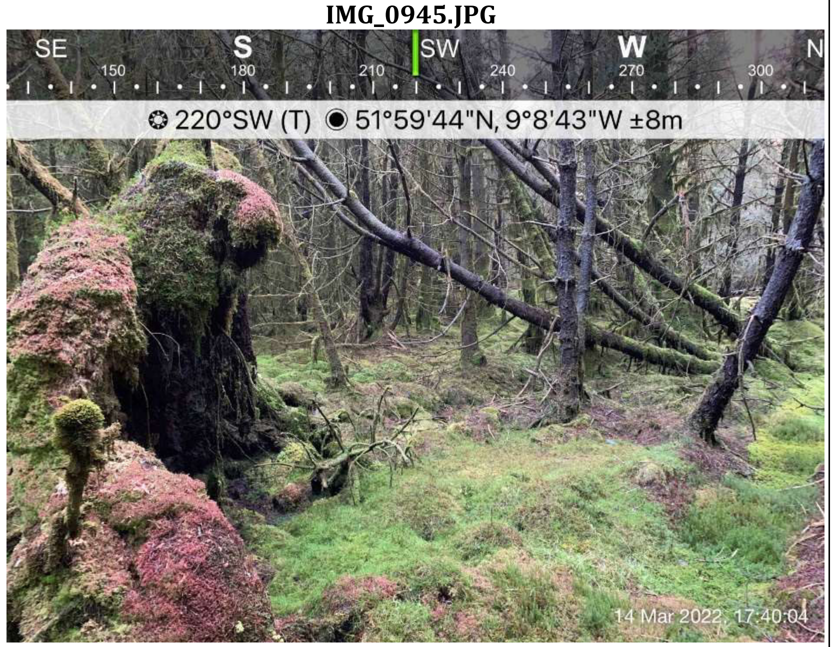
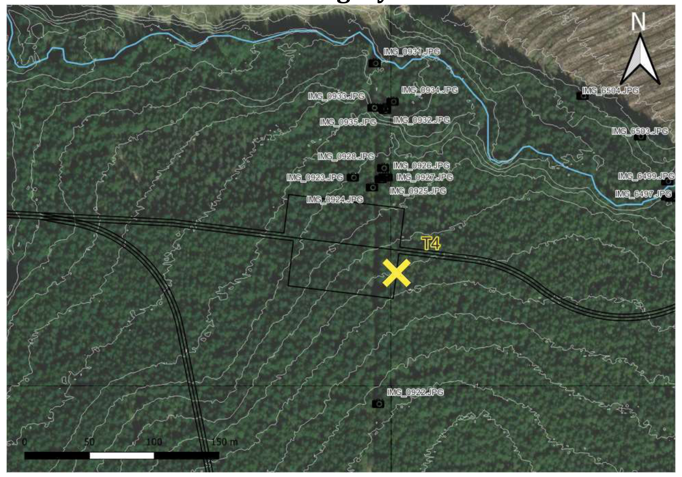
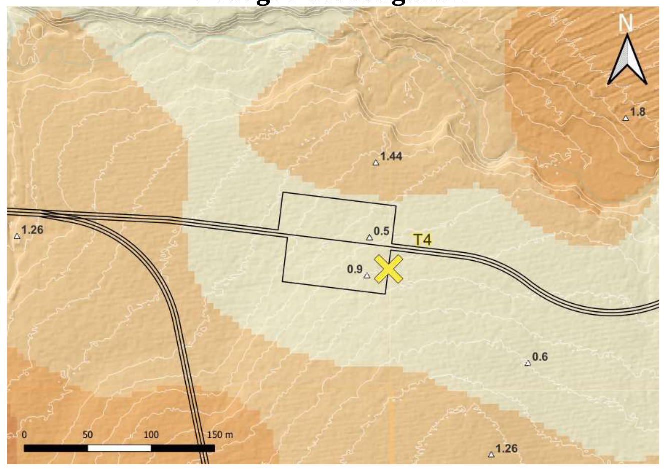


Table J-4: Site reconnaissance of the Turbine 4 site.

Imagery



Peat geo-investigation



IMG_0920.JPG

Shared legend

Geotagged photos
Turbine Locations
Site Boundary
Contour Lines (2 m)
Peat Probe Locations
Water Courses

ROADS
Internal track
Upgrade of existing roads 22-08-18
Upgrade of existing roads
Access tracks
New Roads
Upgrade of existing roads

Peat Depth (m)
<= 0.50
0.50 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 2.50
2.50 - 3.00
3.00 - 3.50
> 3.50

Description

Date of the satellite images: April 2020. [Centre National d'Études Spaciales (CNES) / Airbus].

Date of the ground-based pictures: 14th of March, 2022 [GDG].

Geomorphology: The topography is slightly hilly.

Peat: The peat depth in this sector is 0.5 – 0.9 m.

Instability evidences: No.

IMG_0925.JGP

IMG_0929.JPG

IMG_0934.JPG

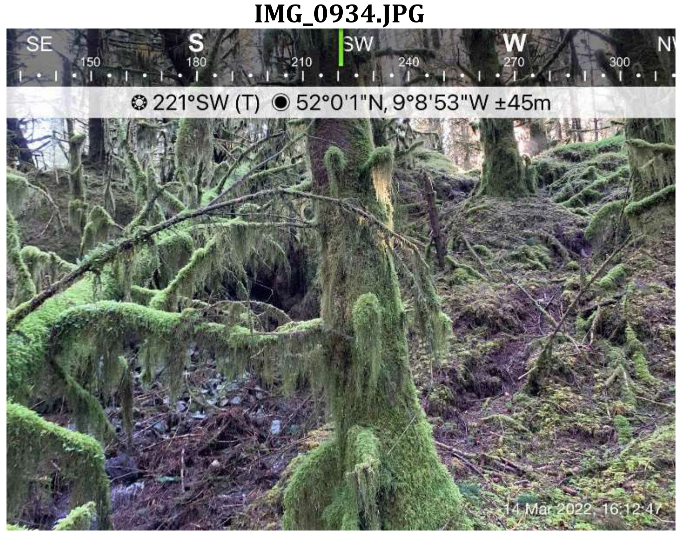
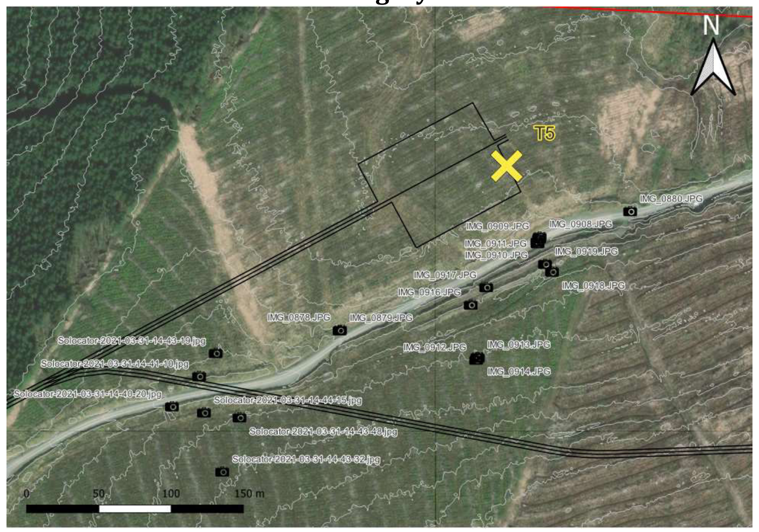
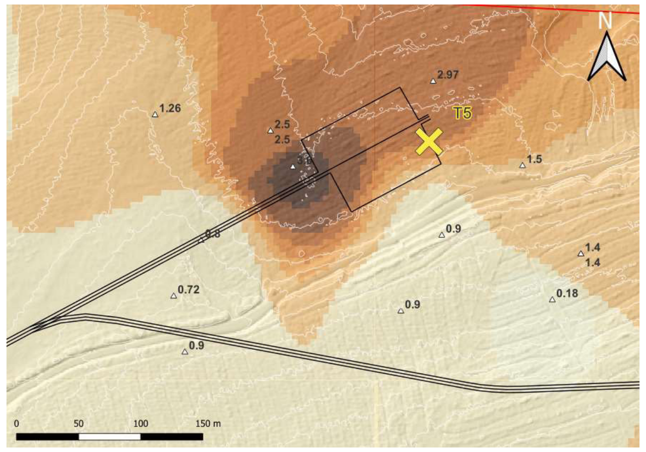


Table J-5: Site reconnaissance of the Turbine 5 site.

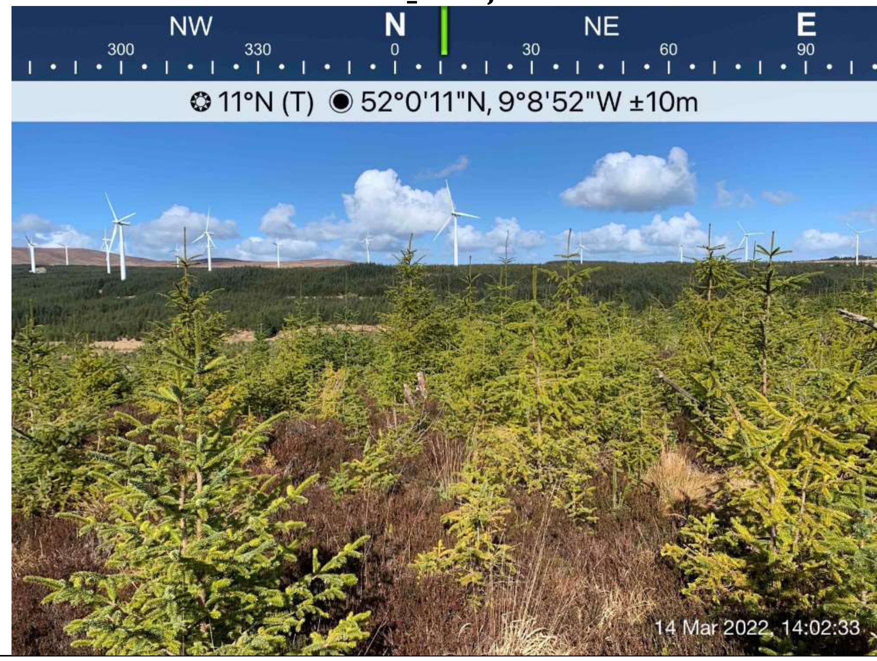
Imagery



Peat geo-investigation



IMG_0912.JPG



Shared legend

- Geotagged photos
- Turbine Locations
- Site Boundary
- Contour Lines (2 m)
- △ Peat Probe Locations
- Water Courses

ROADS

Internal track

- Upgrade of existing roads 22-08-18
- Upgrade of existing roads

Access tracks

- New Roads
- Upgrade of existing roads

Peat Depth (m)

- <= 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- 3.00 - 3.50
- > 3.50

Description

Date of the satellite images: April 2020. [Centre National d'Études Spaciales (CNES) / Airbus].

Date of the ground-based pictures14th of March, 2022 [GDG].

Geomorphology: Moderated slope facing SE (right side of the road).

Peat: Depths of 2.6 m along the hardstand a turbine location.

Instability evidences: No.

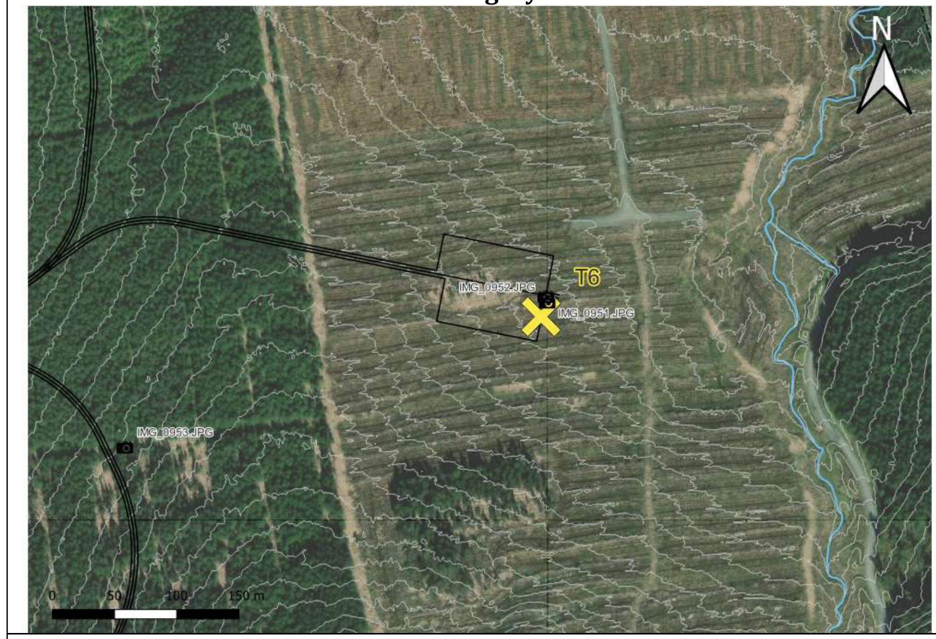
IMG_0916.JPG

IMG_0917.JPG

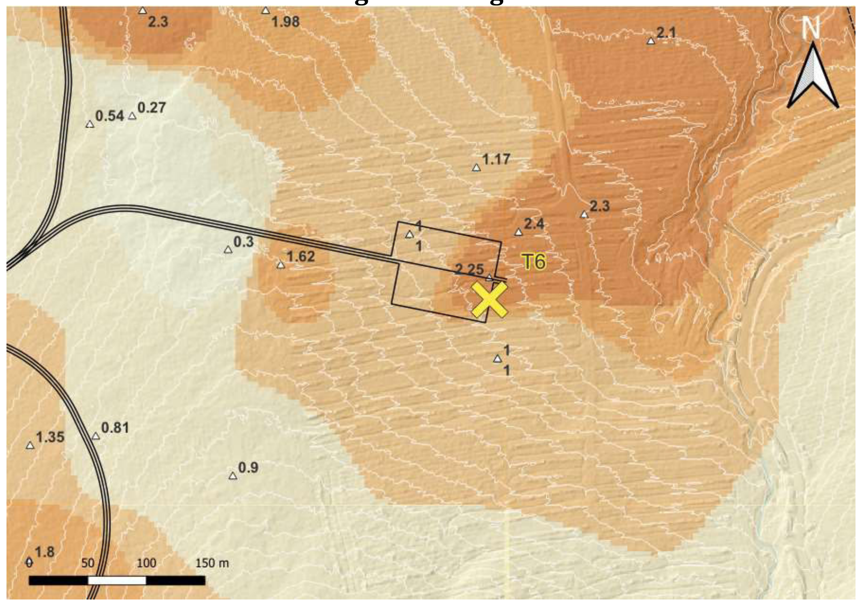
IMG_0918.JPG

Table J-6: Site reconnaissance of the Turbine 6 site.

Imagery

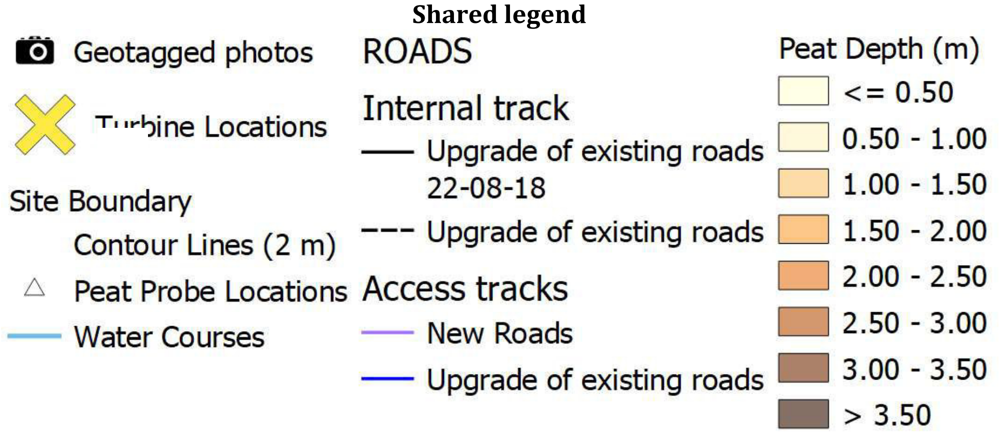


Peat geo-investigation



IMG_0951.JPG

Shared legend



Description

Date of the satellite images: April 2020. [Centre National d'Études Spaciales (CNES) / Airbus].

Date of the ground-based pictures: 15th of March, 2022 [GDG]

Geomorphology: mostly flat.

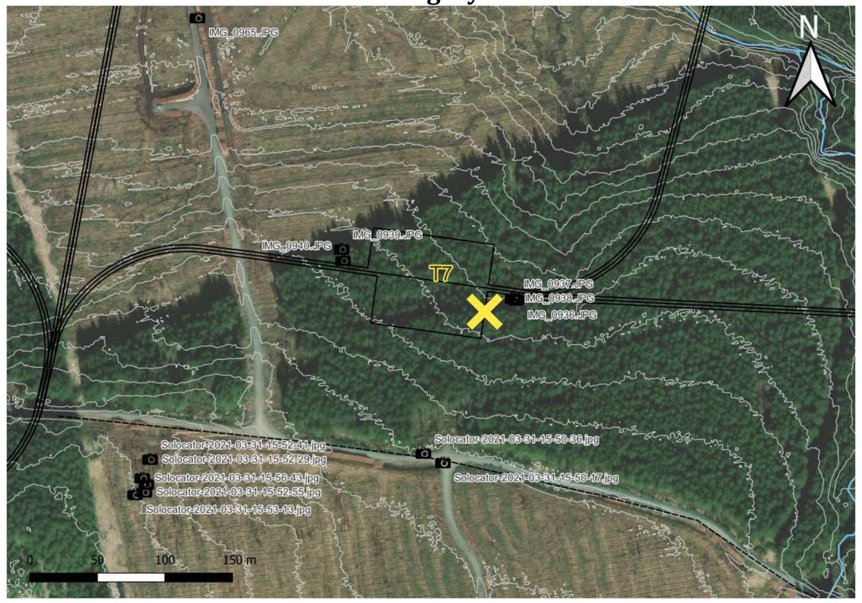
Peat: Depths of 1 m at the middle of the hardstanding and 2.6 at T6 site.

Instability evidences: No.

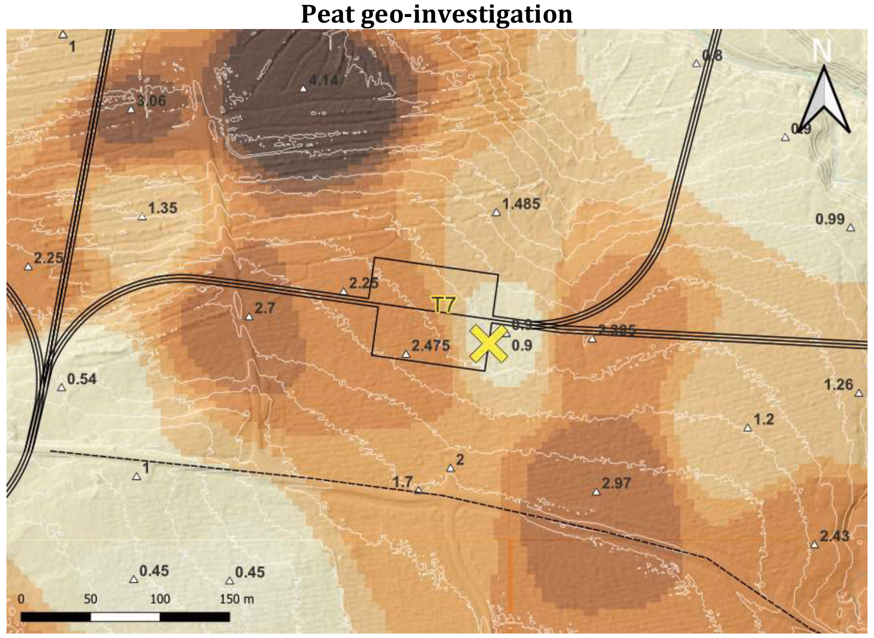
IMG_0952.JPG

Table J-7: Site reconnaissance of the Turbine 7 site.

Imagery



Peat geo-investigation



IMG_0937.JPG

Shared legend

Geotagged photos
Turbine Locations
Site Boundary
Contour Lines (2 m)
Peat Probe Locations
Water Courses

ROADS
Internal track
Upgrade of existing roads 22-08-18
Upgrade of existing roads
Access tracks
New Roads
Upgrade of existing roads

Peat Depth (m)
<= 0.50
0.50 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 2.50
2.50 - 3.00
3.00 - 3.50
> 3.50

Description

Date of the satellite images: April 2020. Source: Centre National d'Études Spaciales (CNES) / Airbus.

Date of the ground-based pictures14th of March, 2022 [GDG].

Geomorphology: mostly flat.

Peat: Peat depth varies from 2.4 m to 1 m along the hardtands and turbine location respectively.

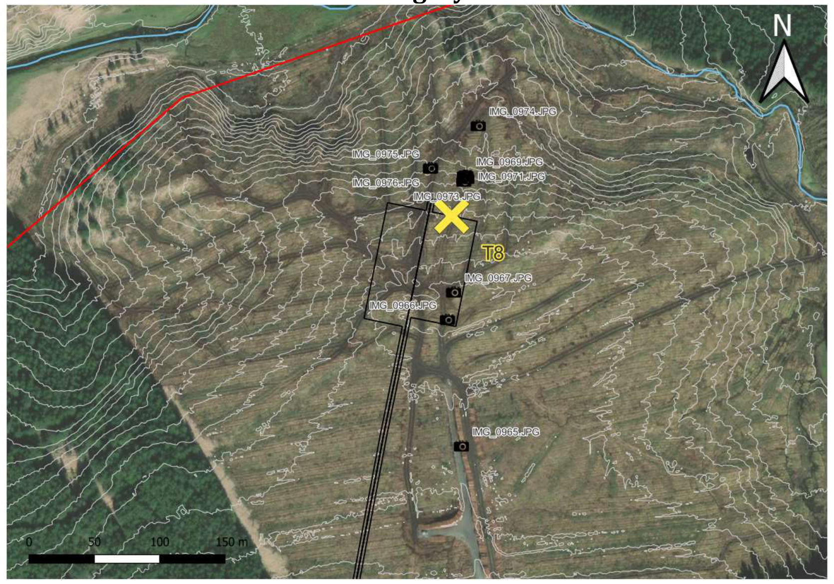
Instability evidences: No.

IMG_0939.JPG

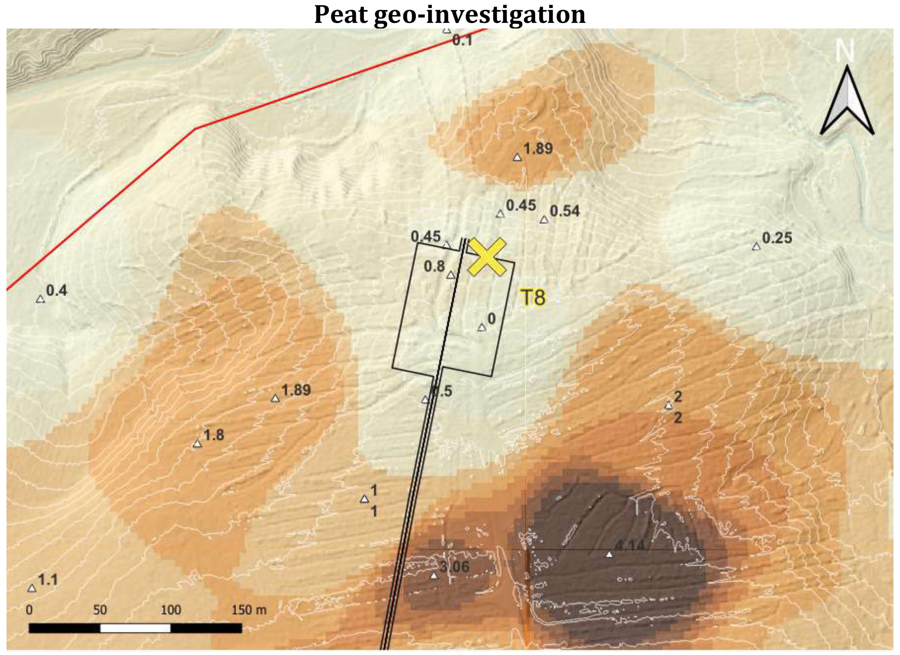
IMG_0942.JPG

Table J-8: Site reconnaissance of Turbine 8 site.

Imagery



Peat geo-investigation



IMG_0968.JPG

Shared legend

Geotagged photos

Turbine Locations

Site Boundary

Contour Lines (2 m)

Peat Probe Locations

Water Courses

ROADS

Internal track

Upgrade of existing roads 22-08-18

Upgrade of existing roads

Access tracks

New Roads

Upgrade of existing roads

Peat Depth (m)

- <= 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- 3.00 - 3.50
- > 3.50

Description

Date of the satellite images: April 2020. [Centre National d'Études Spaciales (CNES) / Airbus].

Date of the ground-based pictures: February 2020 [GDG].

Geomorphology: Slope facing NW.

Peat: Depth ranges between 0 and 0.6 m at the turbine location.

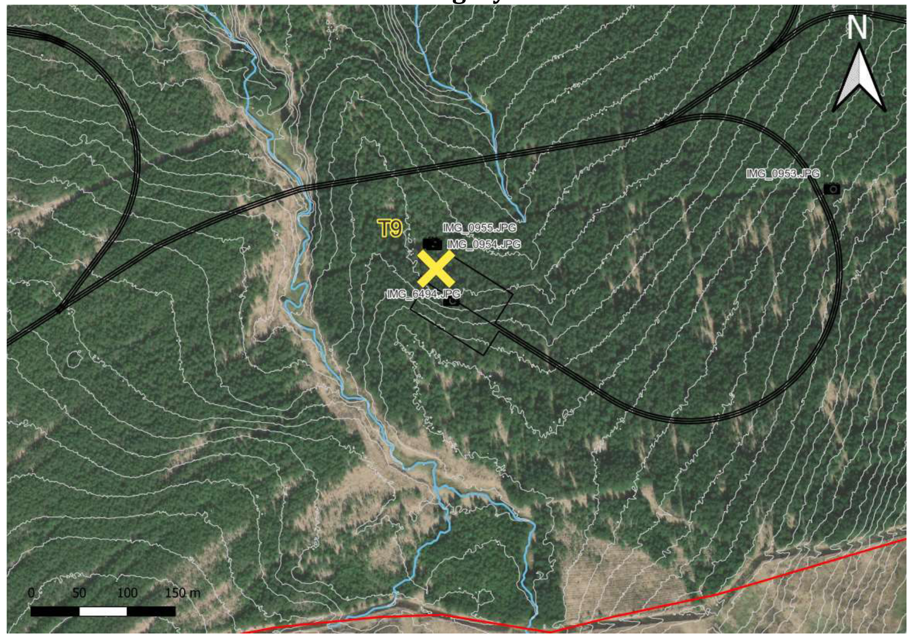
Instability evidences: No.

IMG_0970.JPG

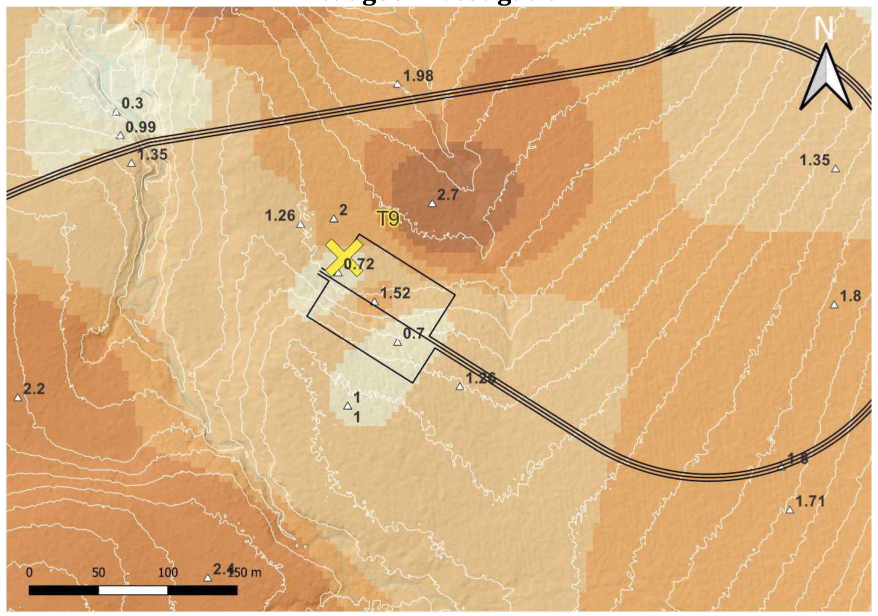
IMG_0975.JPG

Table J-9: Site reconnaissance of Turbine 9 site.

Imagery



Peat geo-investigation



IMG_6494.JPG

Shared legend

Geotagged photos
Turbine Locations
Site Boundary
Contour Lines (2 m)
Peat Probe Locations
Water Courses

ROADS
Internal track
Upgrade of existing roads 22-08-18
Upgrade of existing roads
Access tracks
New Roads
Upgrade of existing roads

Peat Depth (m)
<= 0.50
0.50 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 2.50
2.50 - 3.00
3.00 - 3.50
> 3.50

Description

Date of the satellite images: April 2020. [Centre National d'Études Spaciales (CNES) / Airbus].

Date of the ground-based pictures: February 2020 [GDG].

Geomorphology: Slope facing North.

Peat: Depth ranges between 0.7 and 1.52 m with a value of 0.8 at the turbine location.

Instability evidences: No.

IMG_0954.JPG

Table J-10: Site reconnaissance of Turbine 10 site.

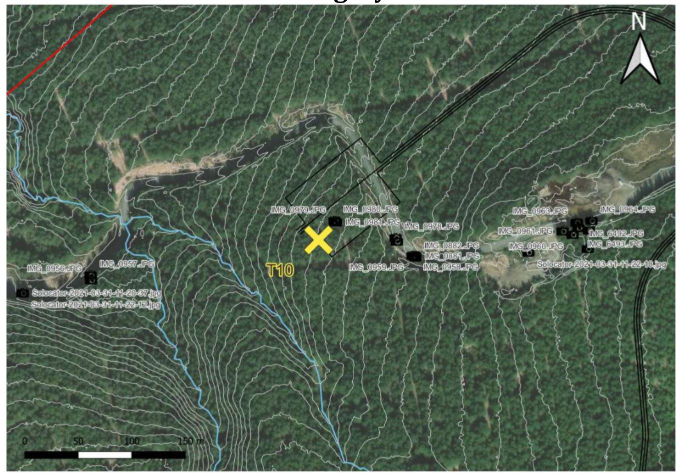
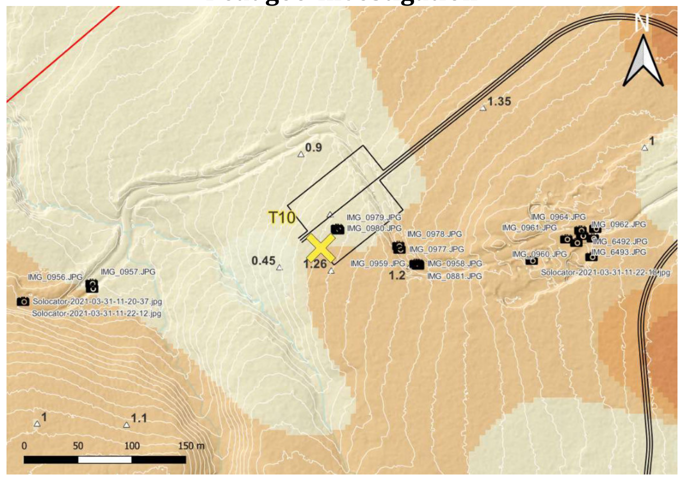
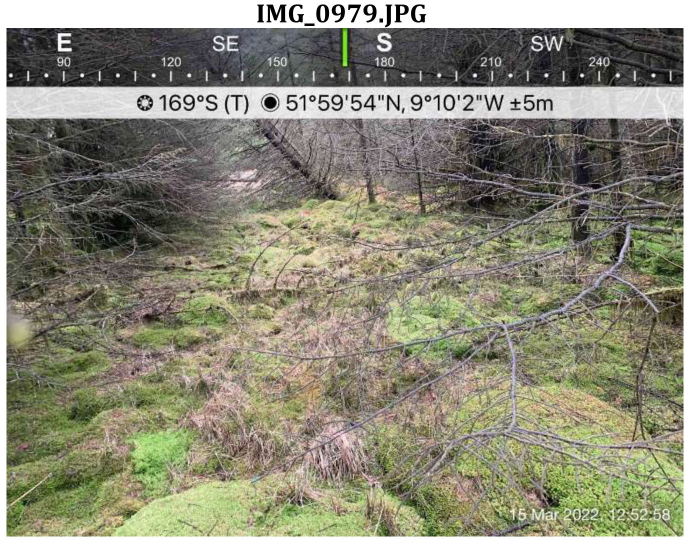
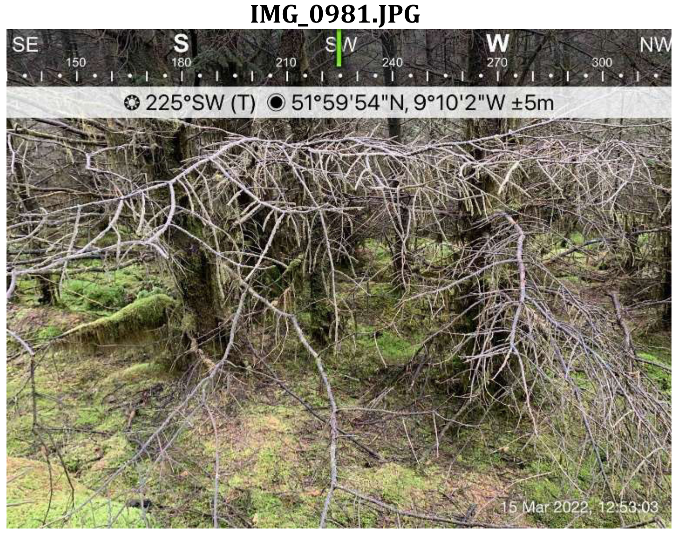
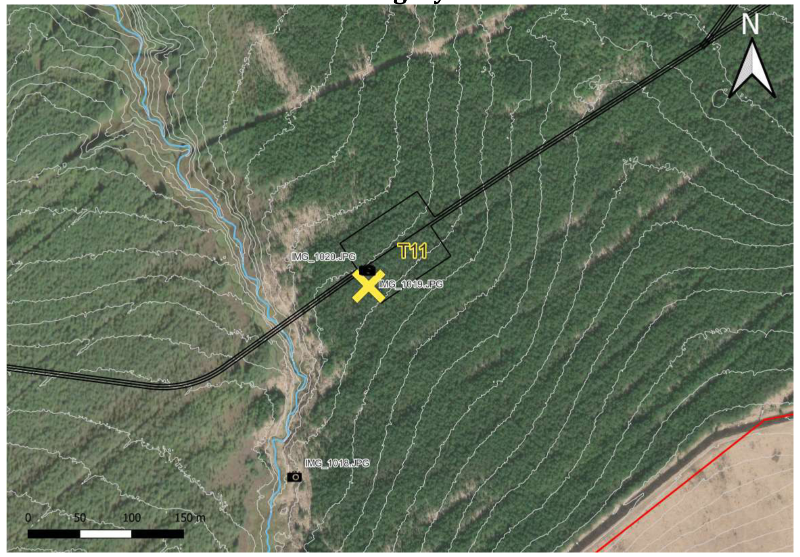
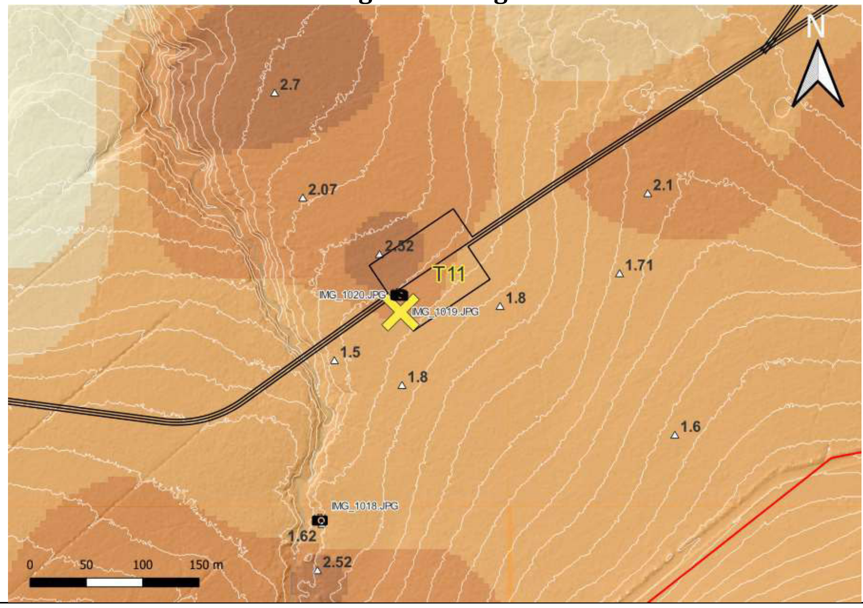
Imagery 	**Peat geo-investigation** 	**IMG_0978.JPG** 	
Shared legend Geotagged photos Turbine Locations Site Boundary Contour Lines (2 m) Peat Probe Locations Water Courses ROADS Internal track Upgrade of existing roads 22-08-18 Upgrade of existing roads Access tracks New Roads Upgrade of existing roads Peat Depth (m) <= 0.50 0.50 - 1.00 1.00 - 1.50 1.50 - 2.00 2.00 - 2.50 2.50 - 3.00 3.00 - 3.50 > 3.50			
Description **Date of the satellite images:** April 2020. [Centre National d'Études Spaciales (CNES) / Airbus]. **Date of the ground-based pictures**14th of March, 2022 [GDG] . **Geomorphology**: Slope facing NW. Superfical water running towards NE to the closets watercourse. **Peat**: Depth of 1 m at the turbine location. **Instability evidences**: No.	**IMG_0979.JPG** 	**IMG_0980.JPG** 	**IMG_0981.JPG** 

Table J-11: Site reconnaissance of Turbine 11 site.

Imagery



Peat geo-investigation



IMG_1018.JPG

Shared legend

Geotagged photos
Turbine Locations
Site Boundary
Contour Lines (2 m)
Peat Probe Locations
Water Courses

ROADS
Internal track
Upgrade of existing roads 22-08-18
Upgrade of existing roads
Access tracks
New Roads
Upgrade of existing roads

Peat Depth (m)
- <= 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- 3.00 - 3.50
- > 3.50

Description

Date of the satellite images: April 2020. [Centre National d'Études Spaciales (CNES) / Airbus].

Date of the ground-based pictures: 16th of March, 2022 [GDG].

Geomorphology: The topography is mostly flat.

Peat: The peat depth at the turbine location is over 2 m.

Instability evidences: No.

IMG_1019.JPG

IMG_1020.JPG

Table J-12: Site reconnaissance of Turbine 12 site.

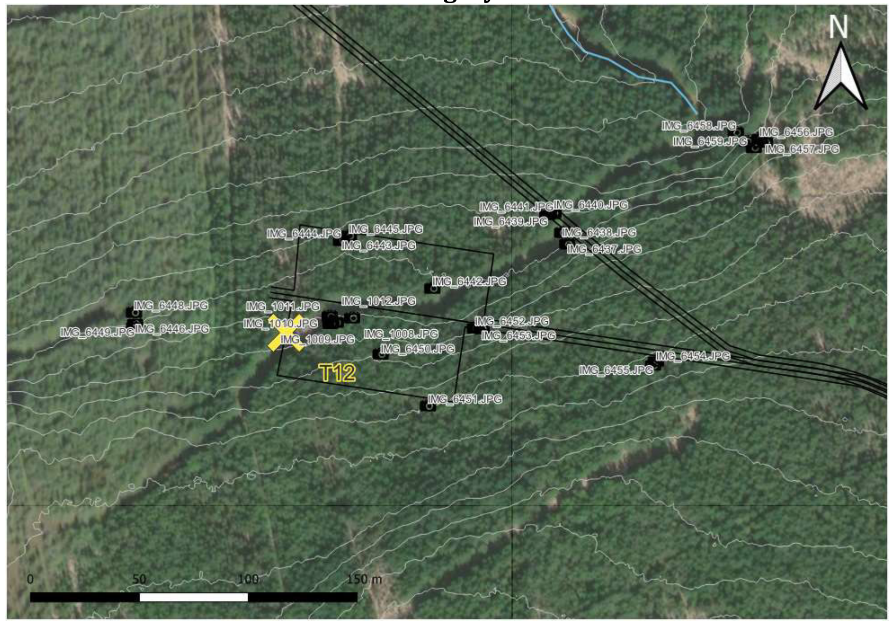
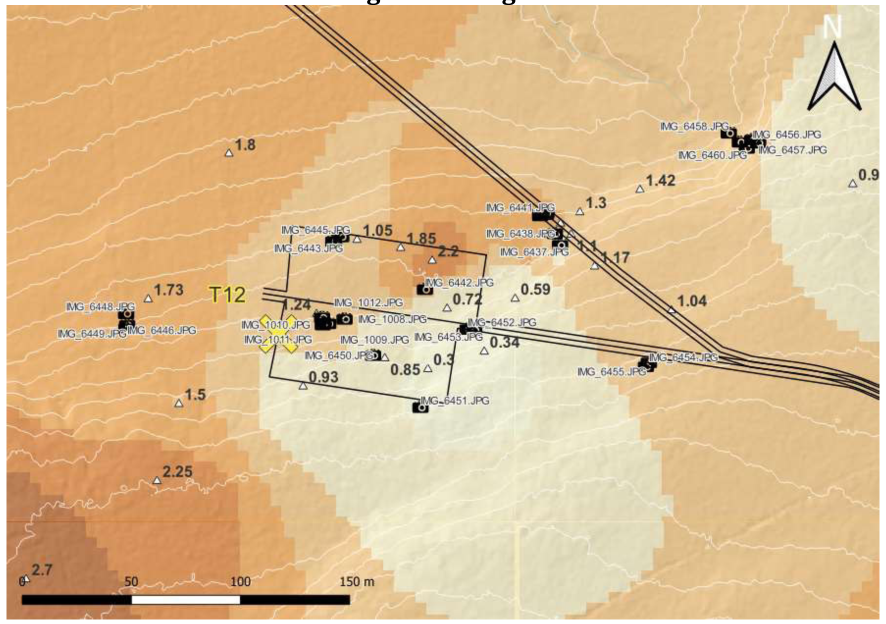
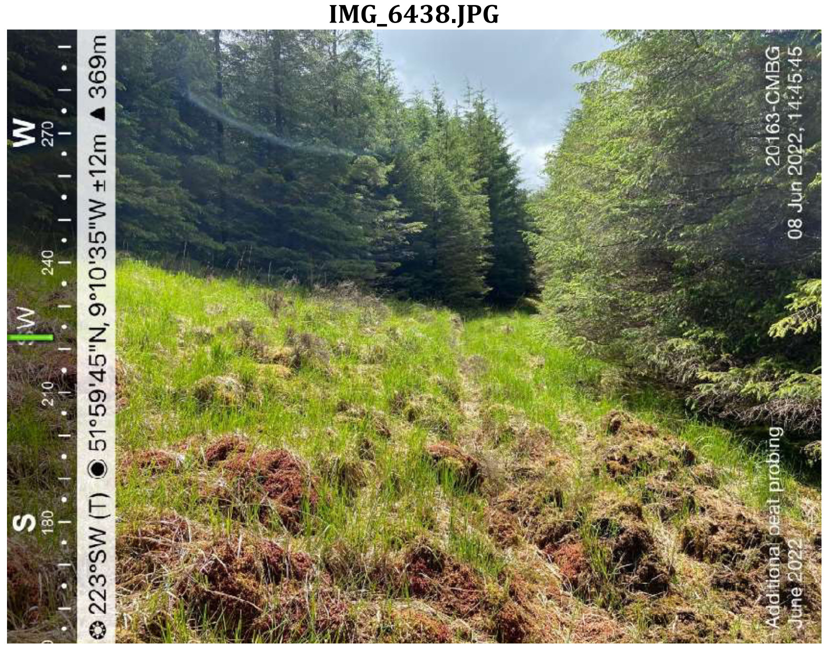
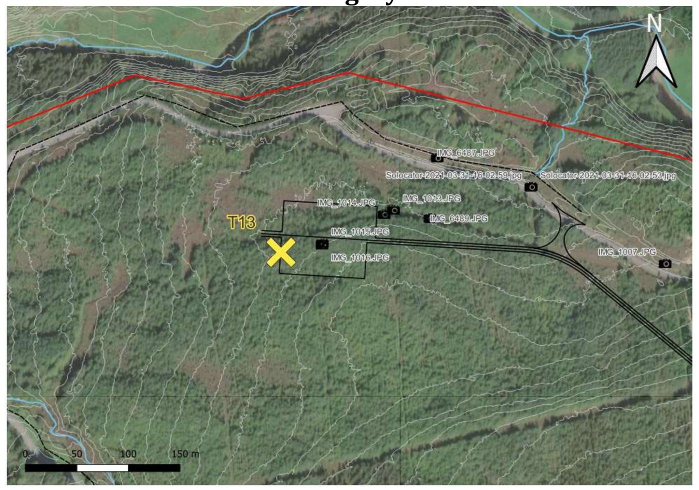
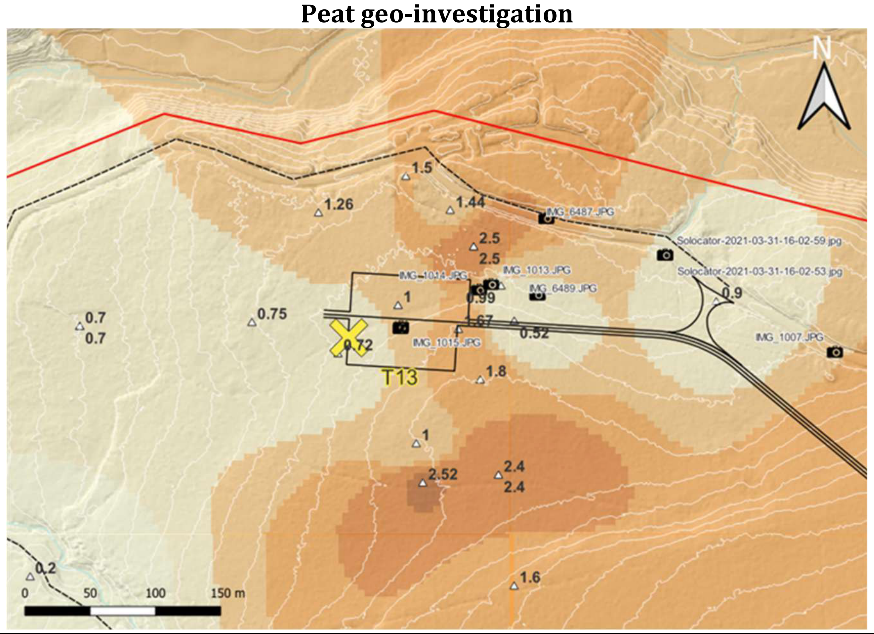
Imagery	Peat geo-investigation	IMG_6450.JPG
		
Shared legend Geotagged photos Turbine Locations Site Boundary Contour Lines (2 m) Peat Probe Locations Water Courses ROADS Internal track Upgrade of existing roads 22-08-18 Upgrade of existing roads Access tracks New Roads Upgrade of existing roads Peat Depth (m) <= 0.50 0.50 - 1.00 1.00 - 1.50 1.50 - 2.00 2.00 - 2.50 2.50 - 3.00 3.00 - 3.50 > 3.50		
Description **Date of the satellite images:** April 2020. [Centre National d'Études Spaciales (CNES) / Airbus]. **Date of the ground-based pictures:** 8th of June, 2022 [GDG]. **Geomorphology**: Slope facing Noth. **Peat**: the peat depth ranges from 0.3 to 1.24 m along the hardstand with a value of 1.15 m at the turbine location. **Instability evidences**: at the cut of the road only.	**IMG_6455.JPG** 	**IMG_6438.JPG** 

Table J-13: Site reconnaissance of Turbine 13 site.

Imagery



Peat geo-investigation



IMG_1013.JPG

Shared legend

Geotagged photos
Turbine cations
Site Boundary
Contour Lines (2 m)
Peat Probe Locations
Water Courses

ROADS
Internal track
Upgrade of existing roads 22-08-18
Upgrade of existing roads
Access tracks
New Roads
Upgrade of existing roads

Peat Depth (m)
<= 0.50
0.50 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 2.50
2.50 - 3.00
3.00 - 3.50
> 3.50

Description

Date of the satellite images: April 2020. [Centre National d'Études Spaciales (CNES) / Airbus].

Date of the ground-based pictures: 16th of March, 2022 [GDG].

Geomorphology: Mostly lfat.

Peat: The peat thickness ranging between 1.67 m a long the hardstand to 0.72m at the turbine location.

Instability evidences: No.

IMG_1016.JPG

IMG_6487.JPG

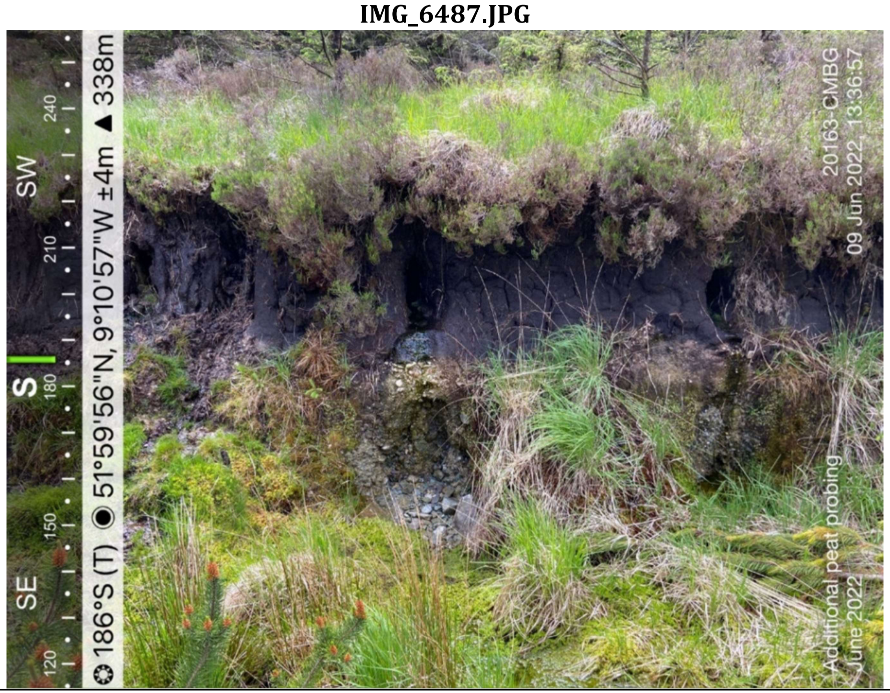
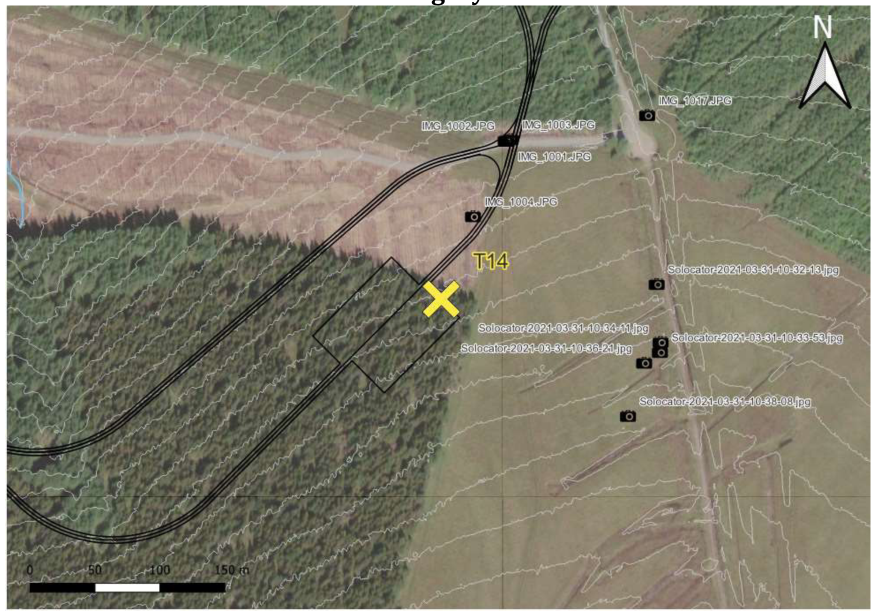
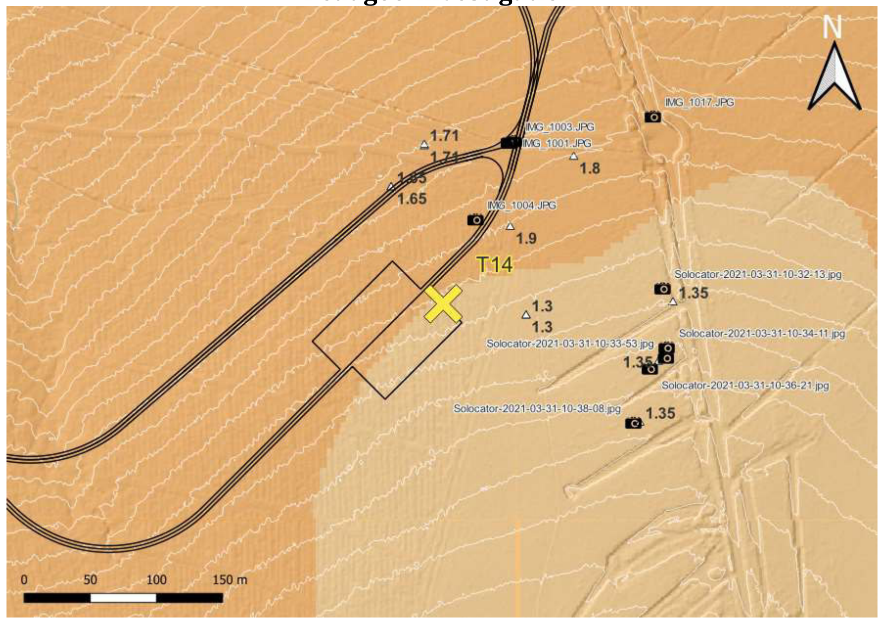


Table J-14: Site reconnaissance of Turbine 14 site.

Imagery



Peat geo-investigation



IMG_1001.JPG

Shared legend

Geotagged photos

Turbine Locations

Site Boundary

Contour Lines (2 m)

Peat Probe Locations

Water Courses

ROADS

Internal track

Upgrade of existing roads 22-08-18

Upgrade of existing roads

Access tracks

New Roads

Upgrade of existing roads

Peat Depth (m)

- <= 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- 3.00 - 3.50
- > 3.50

Description

Date of the satellite images: April 2020. [Centre National d'Études Spaciales (CNES) / Airbus].

Date of the ground-based pictures: 16th of March, 2022 [GDG].

Geomorphology: Slope facing north. A drainage channel is running S-N.

Peat: peat depth is 1.4 m at the turbine location. Excavation and fill will required.

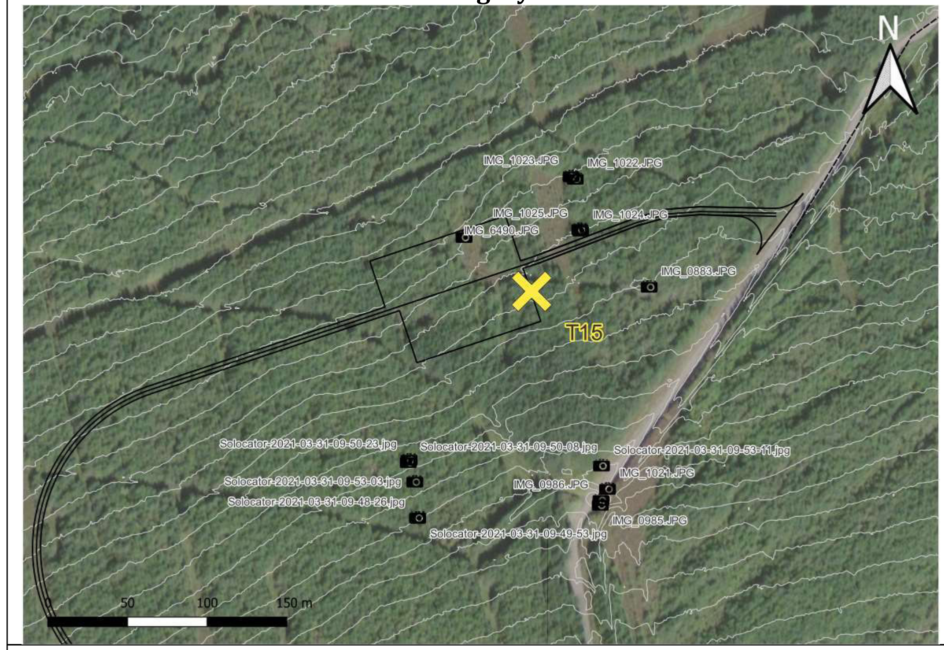
Instability evidences: No.

IMG_1003.JPG

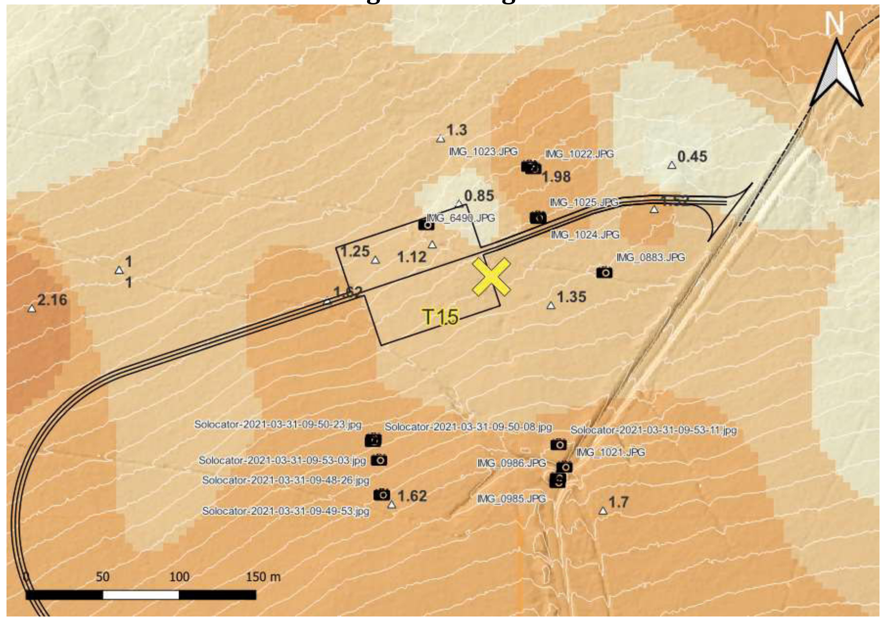
IMG_1004.JPG

Table J-15: Site reconnaissance of Turbine 15 site.

Imagery



Peat geo-investigation



IMG_6490.JPG

Shared legend

- Geotagged photos
- Turbine Locations
- Site Boundary
- Contour Lines (2 m)
- Peat Probe Locations
- Water Courses

ROADS

Internal track
- Upgrade of existing roads 22-08-18
- Upgrade of existing roads

Access tracks
- New Roads
- Upgrade of existing roads

Peat Depth (m)
- <= 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- 3.00 - 3.50
- > 3.50

Description

Date of the satellite images: April 2020. [Centre National d'Études Spaciales (CNES) / Airbus].

Date of the ground-based pictures: 16th of March, 2022 [GDG].

Geomorphology: Slope facing NW.

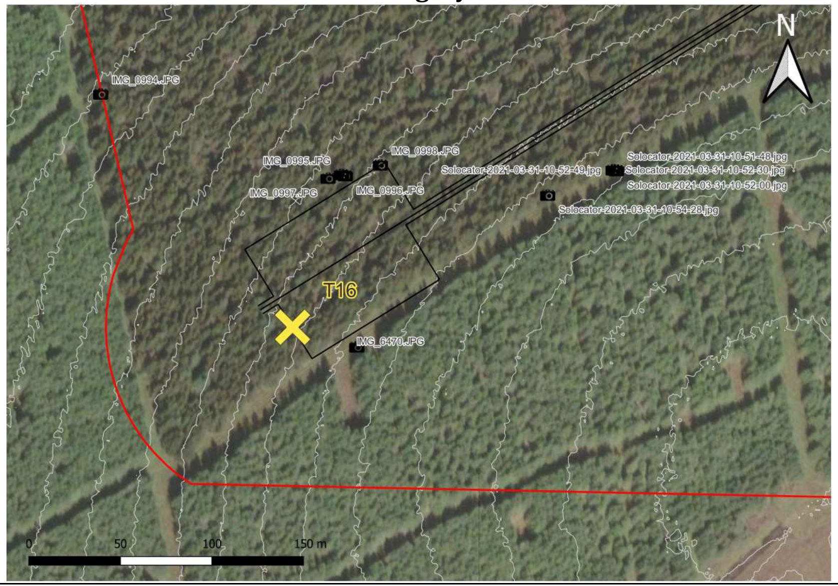
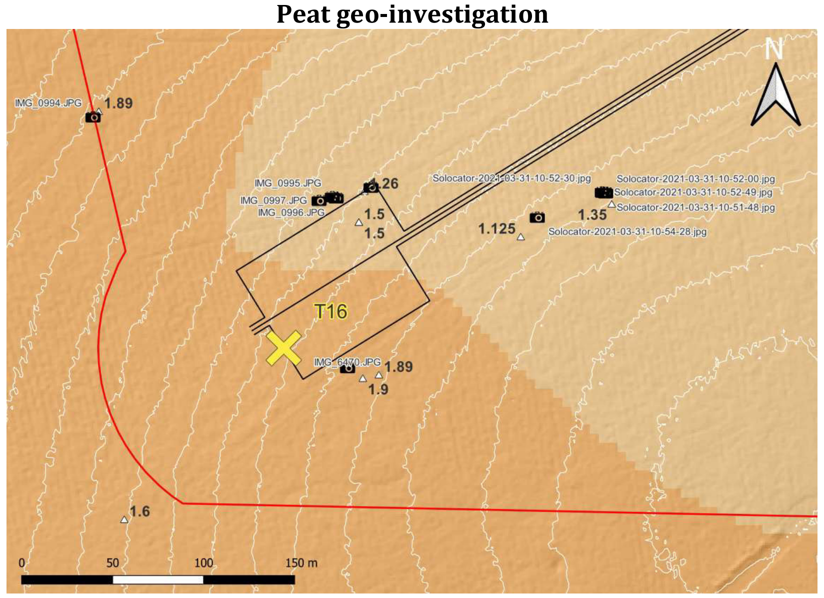
Peat: peat depth is 1.2 m at the turbine location. Excavation and fill will required.

Instability evidences: No.

IMG_1022.JPG

IMG_1026.JPG

Table J-16: Site reconnaissance of Turbine 16 site.

Imagery	Peat geo-investigation	IMG_0998.JPG
		

Shared legend

- Geotagged photos
- Turbine Locations
- Site Boundary
- Contour Lines (2 m)
- Peat Probe Locations
- Water Courses

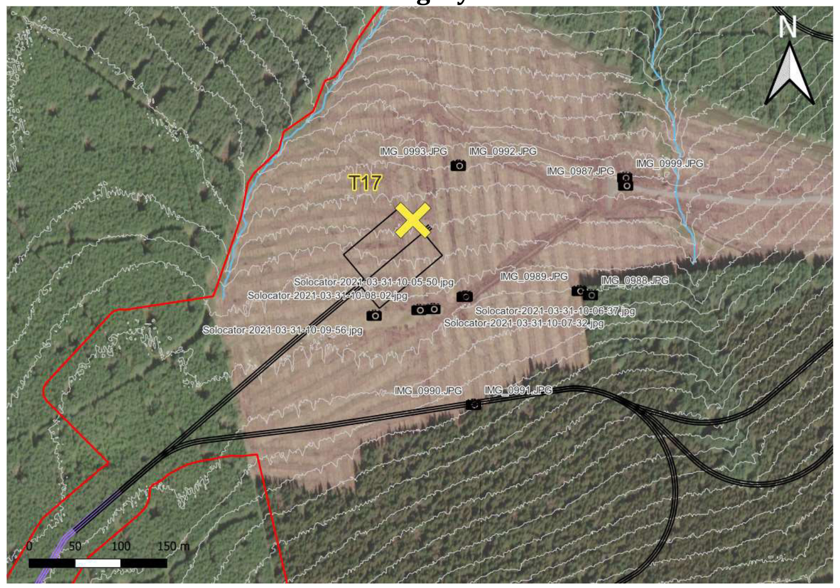
ROADS
- Internal track
  - Upgrade of existing roads 22-08-18
  - Upgrade of existing roads
- Access tracks
  - New Roads
  - Upgrade of existing roads

Peat Depth (m)
- <= 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- 3.00 - 3.50
- > 3.50

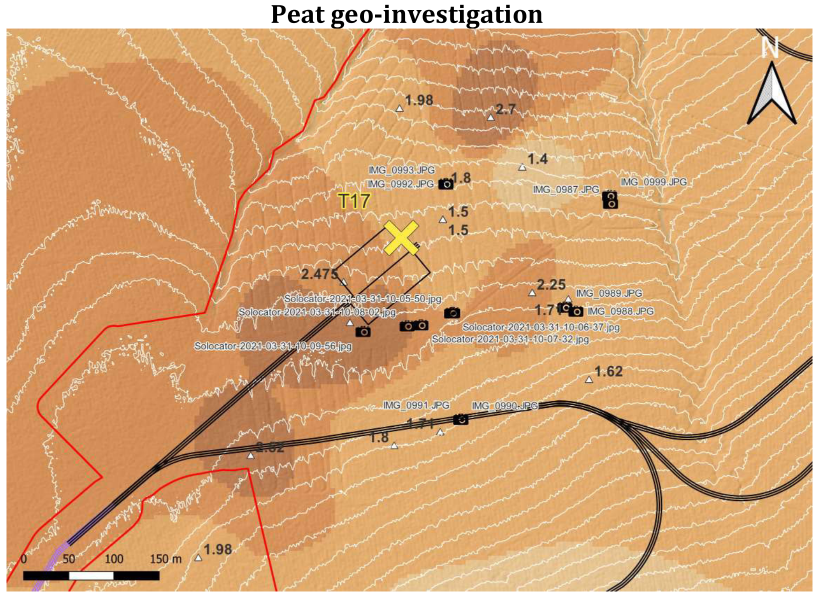
Description	IMG_6470.JPG	IMG_0997.JPG
Date of the satellite images: April 2020. [Centre National d'Études Spaciales (CNES) / Airbus]. **Date of the ground-based pictures:** 16th of March, 2022 [GDG]. **Geomorphology**: Slope facing NW. **Peat**: Peat depth ranges between1.2 m to 1.8 m at the turbine location. **Instability evidences**: No		

Table J-17: Site reconnaissance of Turbine 17 site.

Imagery



Peat geo-investigation



IMG_0989.JPG

Shared legend

Geotagged photos
Turbine Locations
Site Boundary
Contour Lines (2 m)
Peat Probe Locations
Water Courses

ROADS
Internal track
Upgrade of existing roads 22-08-18
Upgrade of existing roads
Access tracks
New Roads
Upgrade of existing roads

Peat Depth (m)
<= 0.50
0.50 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 2.50
2.50 - 3.00
3.00 - 3.50
> 3.50

Description

Date of the satellite images: April 2020. [Centre National d'Études Spaciales (CNES) / Airbus].

Date of the ground-based pictures: 16th of March, 2022 [GDG].

Geomorphology: Mostly flat.

Peat: depth ranges between 1.5 m to 2.7 m with a value of 1.6 m at the turbine location.

Instability evidences: No

IMG_0990.JPG

IMG_0992.JPG

Appendix K Factor of Safety

Table K-1: Example of calculation of Factor of Safety for undrained conditions (with and without surcharge).

Turbine No.	Slope	Cos Slope	Sin Slope	Undrained shear strength	Bulk unit weight of Peat	Peat depth	Factor of Safety	Surcharge	FoS surcharge
	(º)			Cu (kPa)	Y (kN/m^3)	(m)		(m)	
T1	5.5122	0.995	0.096	5	10	0.999995	**5.23**	1	**2.61**
T2	3.3564	0.998	0.059	5	10	2.481092	**3.45**	1	**2.46**
T3	4.629	0.997	0.081	5	10	0.401344	**15.49**	1	**4.44**
T4	7.1325	0.992	0.124	5	10	0.82851	**4.90**	1	**2.22**
T5	3.3913	0.998	0.059	5	10	2.606751	**3.25**	1	**2.35**
T6	2.7573	0.999	0.048	5	10	2.24474	**4.64**	1	**3.21**
T7	4.5468	0.997	0.079	5	10	0.900492	**7.03**	1	**3.33**
T8	5.9756	0.995	0.104	5	10	0.590142	**8.18**	1	**3.04**
T9	1.5549	1.000	0.027	5	10	0.799915	**23.04**	1	**10.24**
T10	4.7771	0.997	0.083	5	10	1.056415	**5.70**	1	**2.93**
T11	3.2458	0.998	0.057	5	10	2.247583	**3.94**	1	**2.72**
T12	8.9635	0.988	0.156	5	10	1.148773	**2.83**	1	**1.51**
T13	3.7853	0.998	0.066	5	10	0.720964	**10.53**	1	**4.41**
T14	4.9573	0.996	0.086	5	10	1.424948	**4.08**	1	**2.40**
T15	4.3304	0.997	0.076	5	10	1.234268	**5.38**	1	**2.97**
T16	6.3583	0.994	0.111	5	10	1.852289	**2.45**	1	**1.59**
T17	3.1559	0.998	0.055	5	10	1.577746	**5.77**	1	**3.53**

Undrained conditions

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

Where,

F = Factor of Safety
c_u = Undrained strength
γ = Bulk unit weight of material
z = Depth to failure plane assumed as depth of peat
α = Slope angle

Table K-2: Example of calculation of Factor of Safety for drained conditions (with and without surcharge).

Turbine No.	Drained shear strength	Bulk unit weight of Peat	Peat depth	Bulk unit weight of water	Height of water table above failure surface	Slope	Cos Slope	Cos^2 Slope	Sin Slope	ϕ'	Tan ϕ'	**FoS**	Surcharge (m)	**FoS Surcharge**
	Cu (kPa)	Y (kN/m³)	(m)	Y (kN/m³)	(m)	(º)								
T1	5	10	0.999995	9.8	0.999995	5.512242	0.995	0.991	0.096	25	0.466	**5.33**	1	**5.08**
T2	5	10	2.481092	9.8	2.481092	3.356378	0.998	0.997	0.059	25	0.466	**3.61**	1	**4.85**
T3	5	10	0.401344	9.8	0.401344	4.628984	0.997	0.993	0.081	25	0.466	**15.60**	1	**8.58**
T4	5	10	0.82851	9.8	0.82851	7.132485	0.992	0.985	0.124	25	0.466	**4.97**	1	**4.29**
T5	5	10	2.606751	9.8	2.606751	3.391298	0.998	0.997	0.059	25	0.466	**3.41**	1	**4.64**
T6	5	10	2.24474	9.8	2.24474	2.757271	0.999	0.998	0.048	25	0.466	**4.83**	1	**6.33**
T7	5	10	0.900492	9.8	0.900492	4.546793	0.997	0.994	0.079	25	0.466	**7.14**	1	**6.47**
T8	5	10	0.590142	9.8	0.590142	5.9756	0.995	0.989	0.104	25	0.466	**8.27**	1	**5.87**
T9	5	10	0.799915	9.8	0.799915	1.55487	1.000	0.999	0.027	25	0.466	**23.39**	1	**19.94**
T10	5	10	1.056415	9.8	1.056415	4.777083	0.997	0.993	0.083	25	0.466	**5.81**	1	**5.70**
T11	5	10	2.247583	9.8	2.247583	3.245785	0.998	0.997	0.057	25	0.466	**4.10**	1	**5.37**
T12	5	10	1.148773	9.8	1.148773	8.963456	0.988	0.976	0.156	25	0.466	**2.89**	1	**2.92**
T13	5	10	0.720964	9.8	0.720964	3.785343	0.998	0.996	0.066	25	0.466	**10.67**	1	**8.56**
T14	5	10	1.424948	9.8	1.424948	4.957313	0.996	0.993	0.086	25	0.466	**4.18**	1	**4.68**
T15	5	10	1.234268	9.8	1.234268	4.330383	0.997	0.994	0.076	25	0.466	**5.50**	1	**5.80**
T16	5	10	1.852289	9.8	1.852289	6.358307	0.994	0.988	0.111	25	0.466	**2.54**	1	**3.11**
T17	5	10	1.577746	9.8	1.577746	3.155932	0.998	0.997	0.055	25	0.466	**5.93**	1	**6.91**

Drained conditions

$$F = \frac{c' + (\gamma z - \gamma_w h_w)\cos^2\alpha \tan\phi'}{\gamma z \sin\alpha \cos\alpha}$$

Where,

F = Factor of Safety
c' = Effective cohesion
γ = Bulk unit weight of material
z = Depth to failure plane assumed as depth of peat
γ_w = Unit weight of water
h_w = Height of water table above failure plane
α = Slope angle
ø' = Effective friction angle

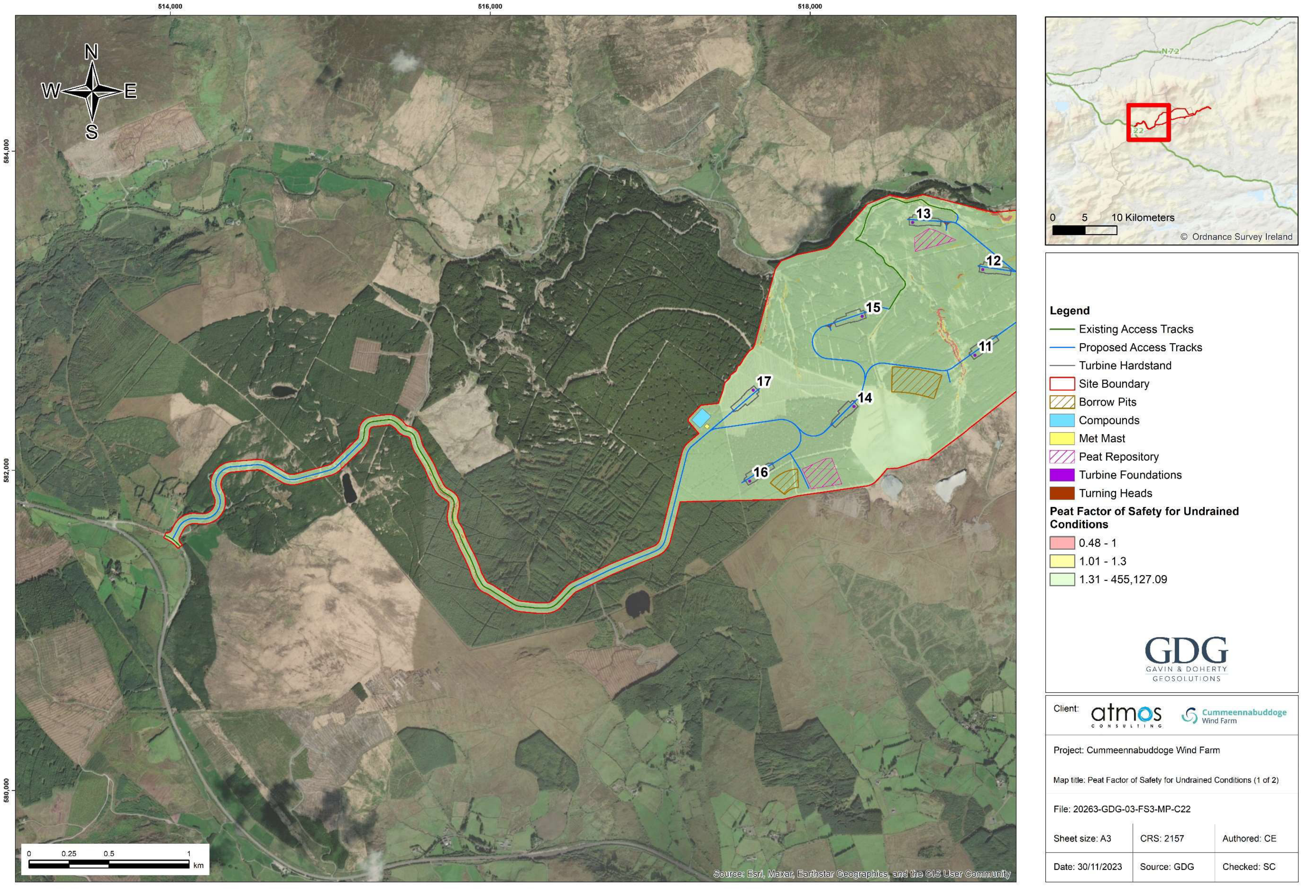


Figure K-1: FoS for undrained conditions (1 of 2)

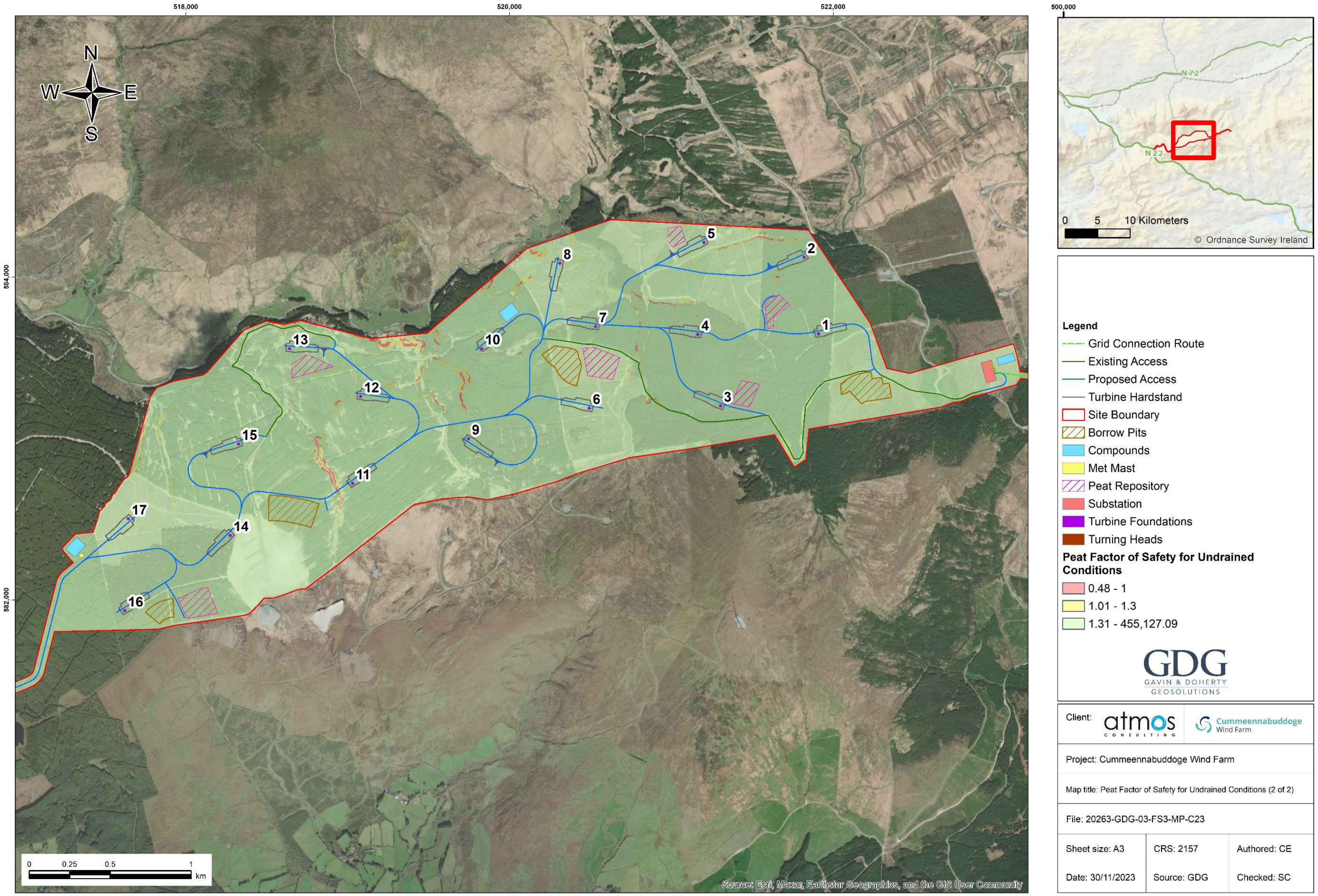


Figure K- 2: FoS for undrained conditions (2 of 2).

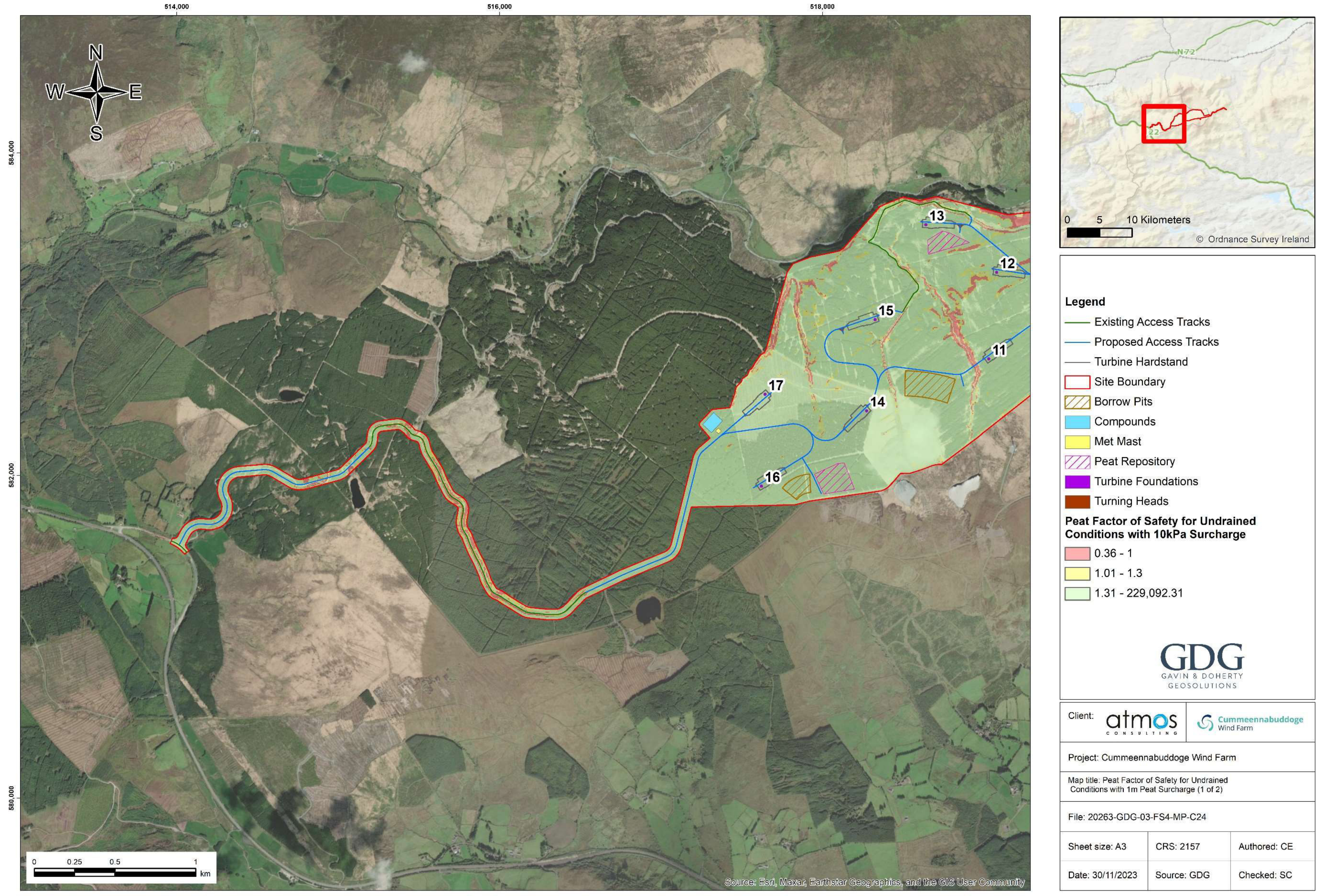


Figure K- 3: FoS for undrained conditions and surcharge of 1 m (i.e. 10 kPa) (1 of 2).

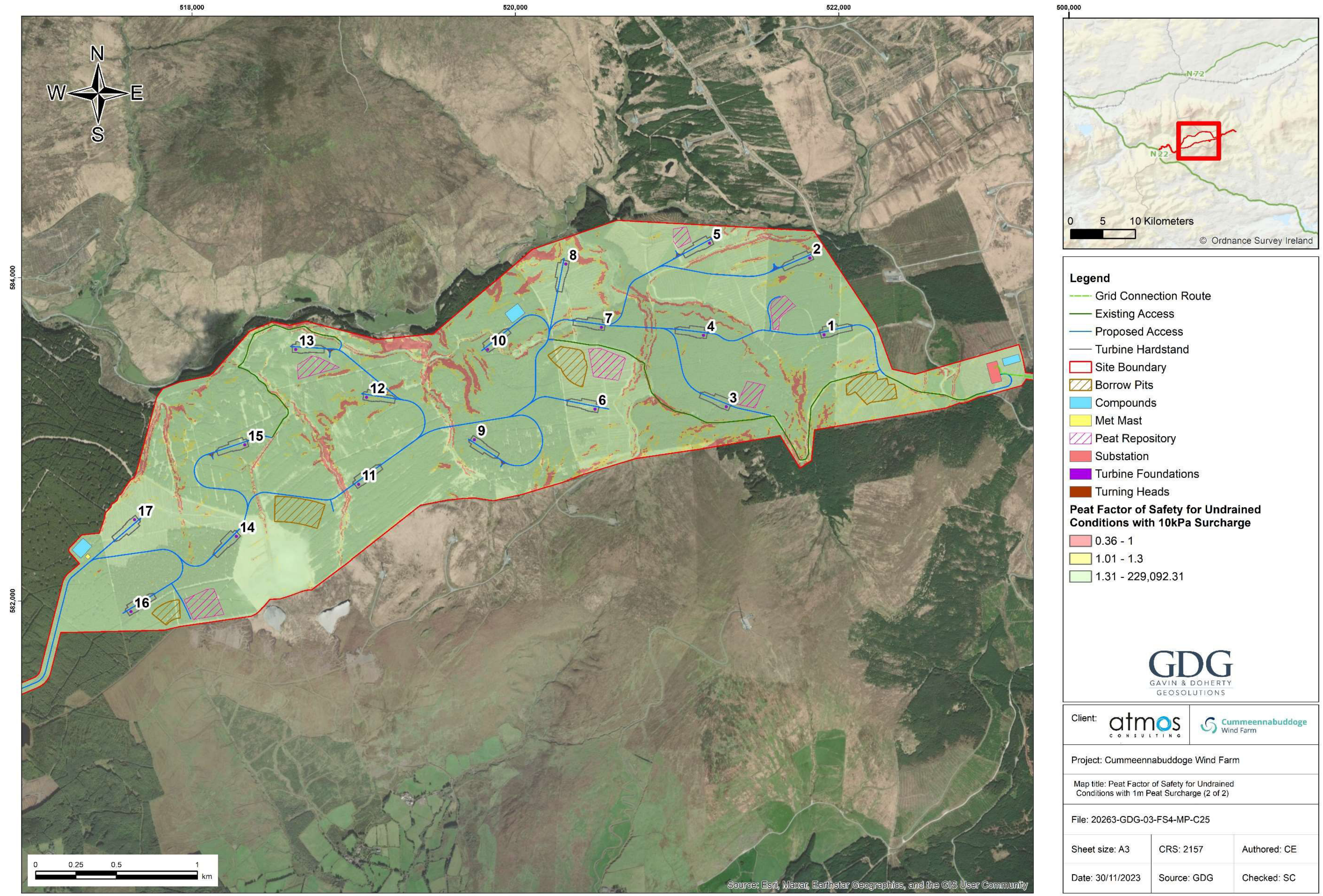


Figure K- 4: FoS for undrained conditions and surcharge of 1 m (i.e. 10 kPa) (2 of 2)

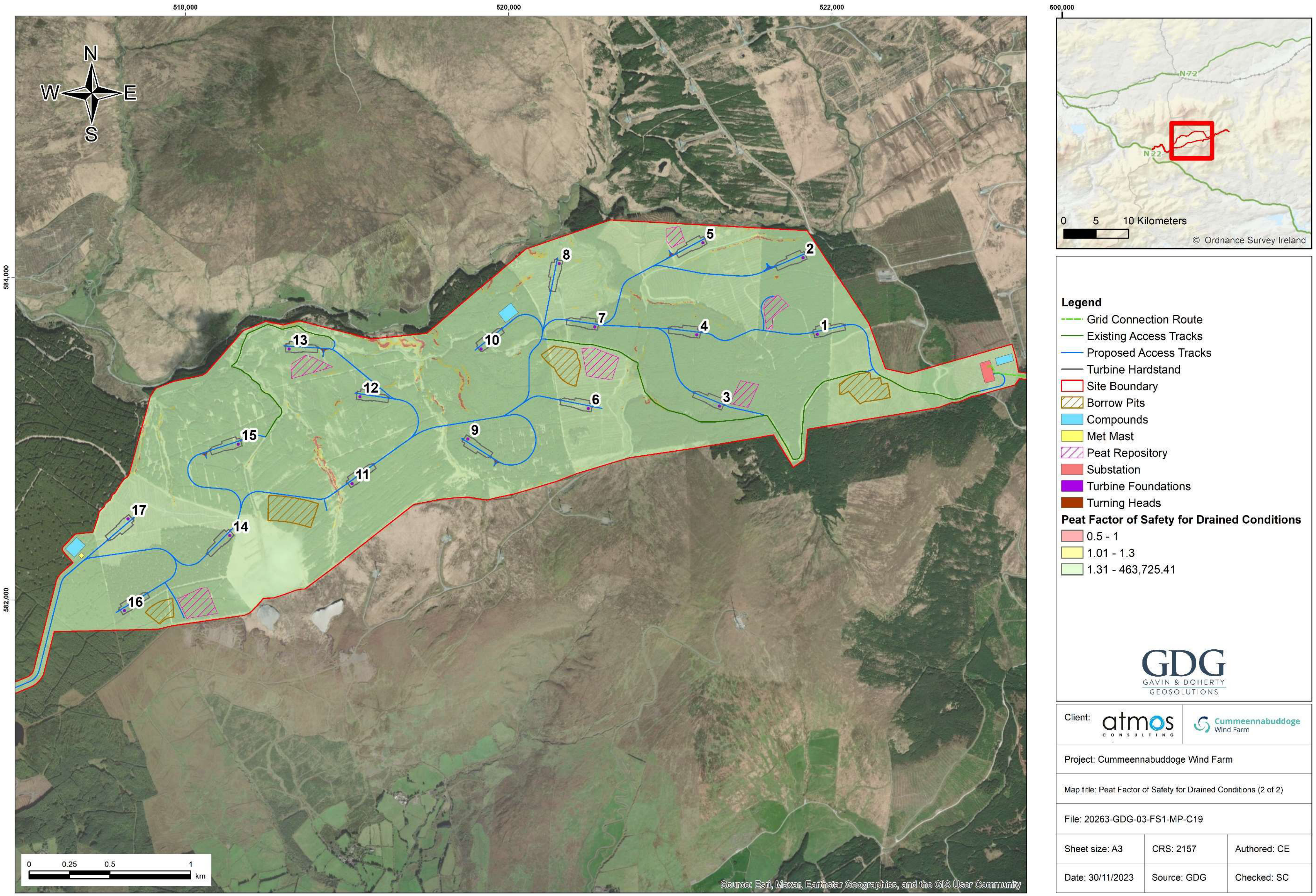


Figure K- 5: FoS for drained conditions (1 of 2).

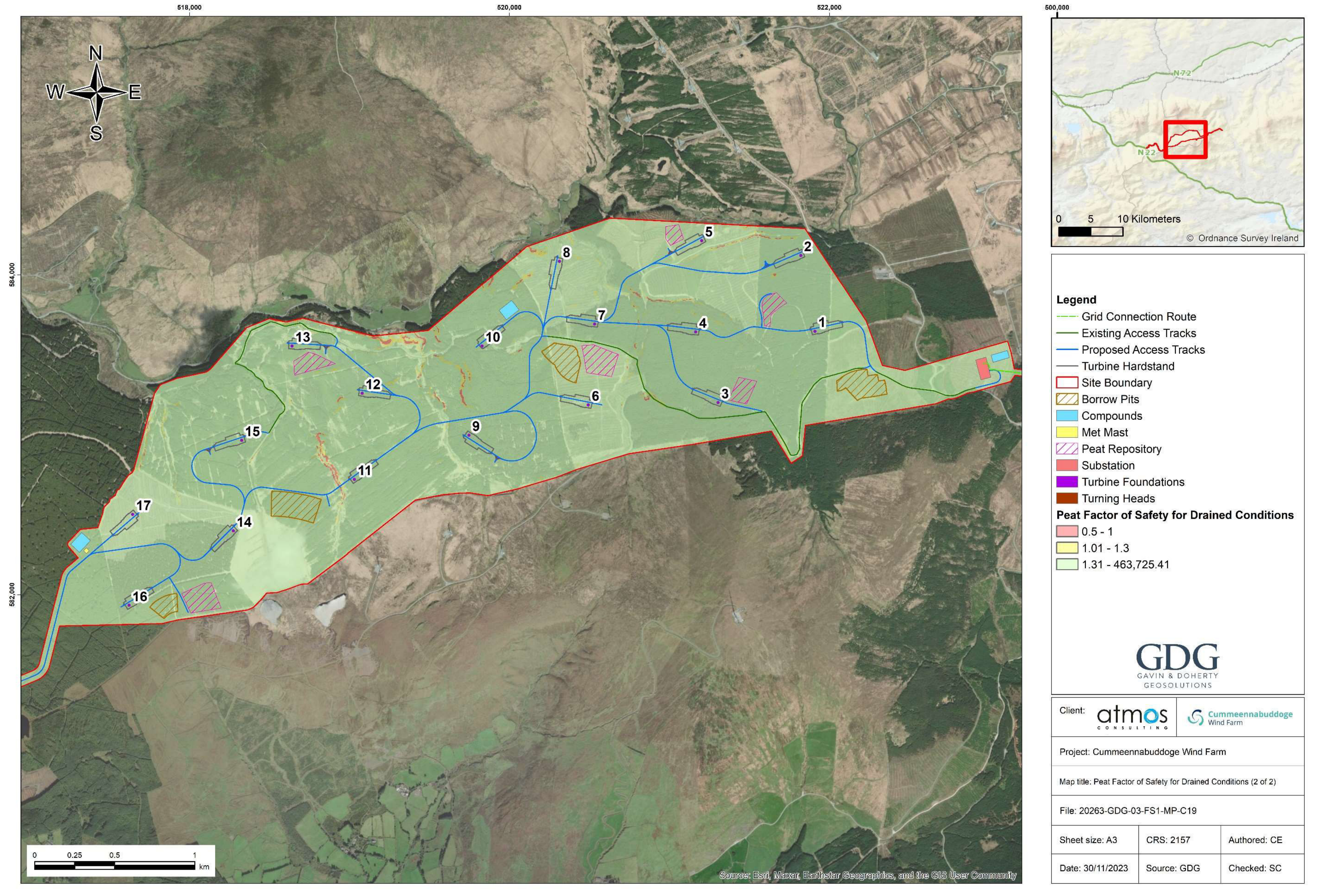


Figure K- 6: FoS for drained conditions (2 of 2).

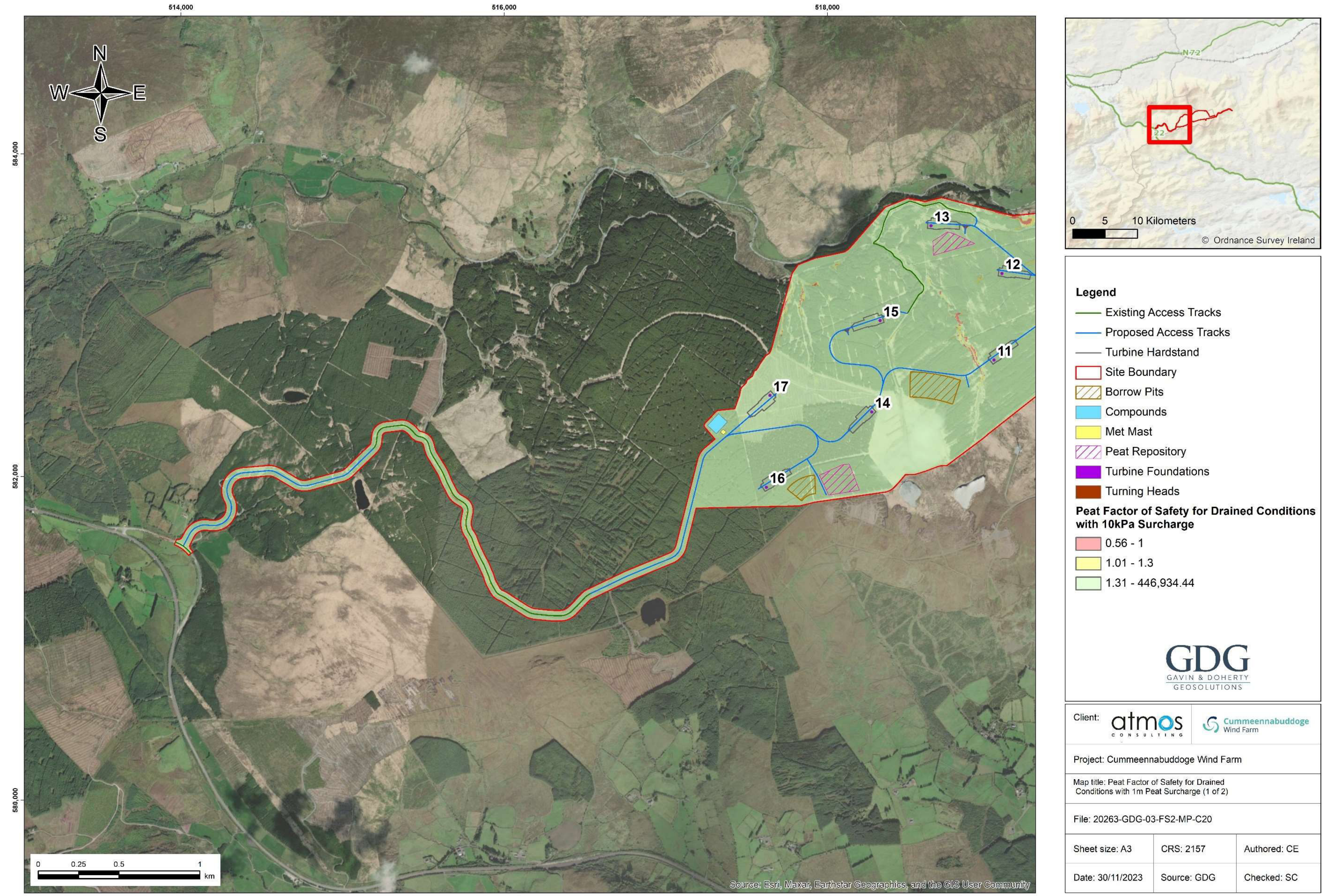


Figure K- 7: FoS for drained conditions and surcharge of 1 m (i.e. 10 kPa) (1 of 2).

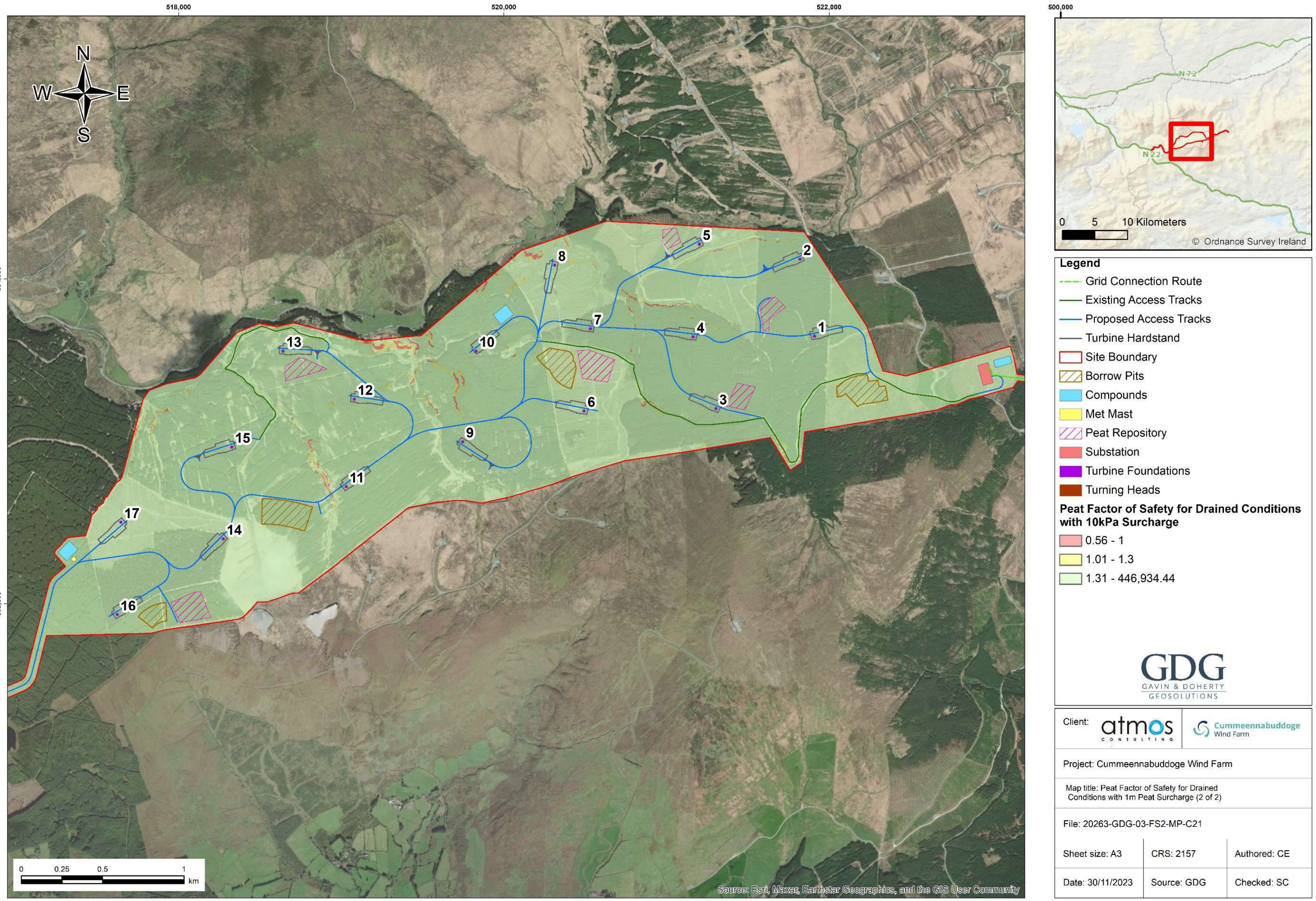


Figure K- 8: FoS for drained conditions and surcharge of 1 m (i.e. 10 kPa) (2 of 2).

Appendix L Safety buffers

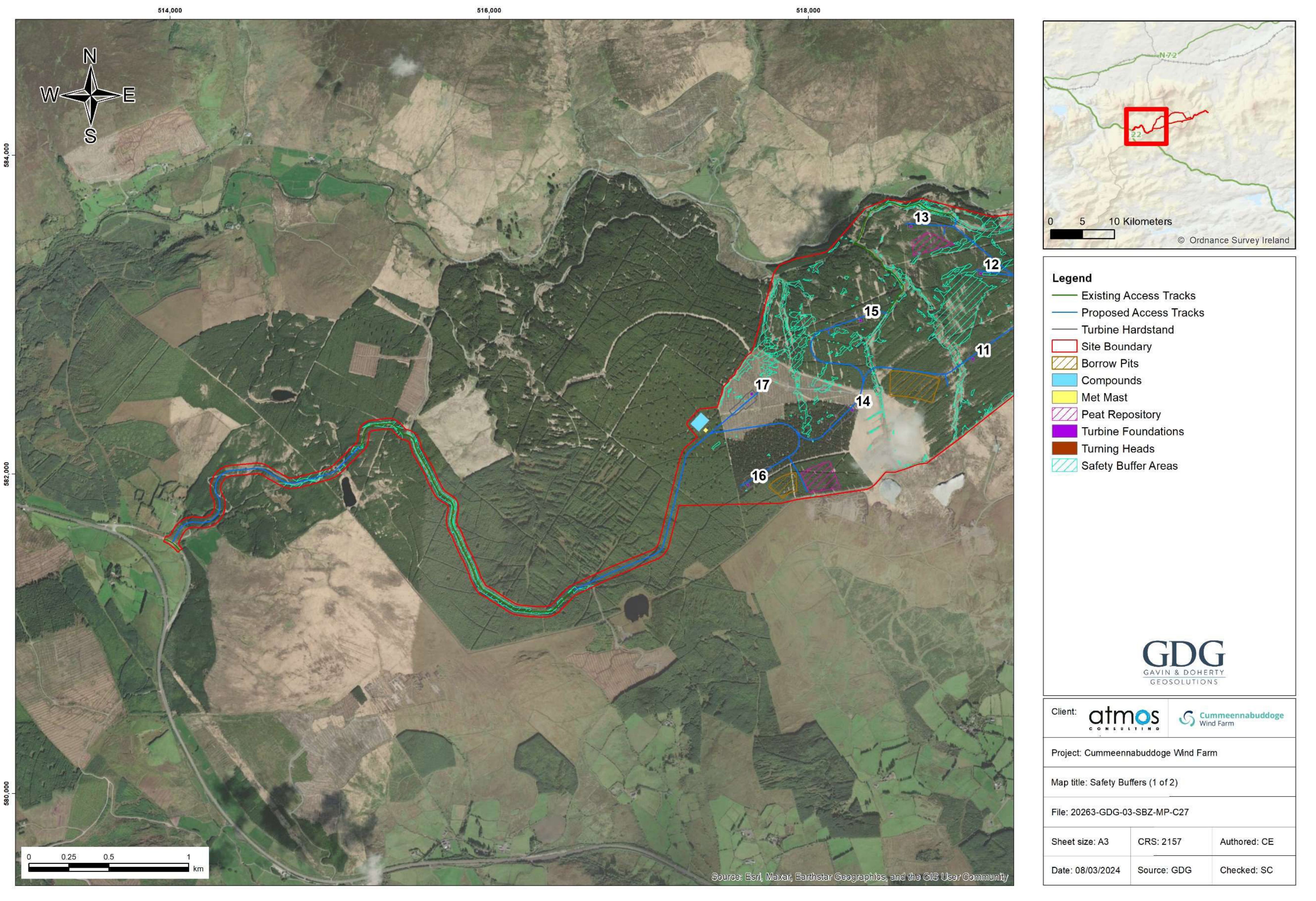


Figure L- 1: Safety buffer areas. (1 of 2)

Note: The delineation of Safety Buffers is based on the semi automated approach derived from the results of the FoS calculation, with the addition of areas identified during site walkovers and site reconnaissance outlined in Sect 4.5.

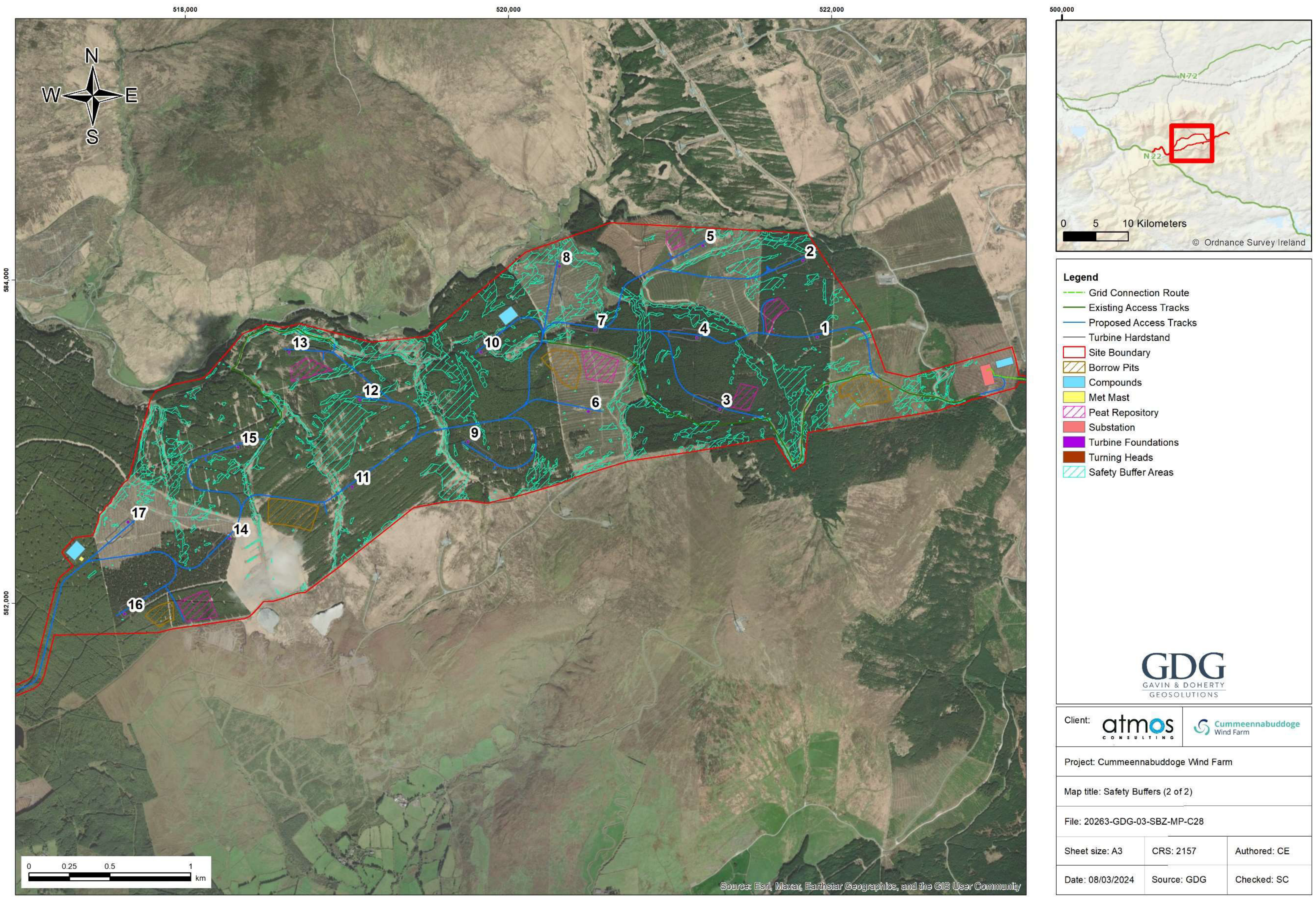


Figure L- 2: Safety buffer areas. (2 of 2)

Note: The delineation of Safety Buffers is based on the semi automated approach derived from the results of the FoS calculation, with the addition of areas identified during site walkovers and site reconnaissance outlined in Sect 4.5.

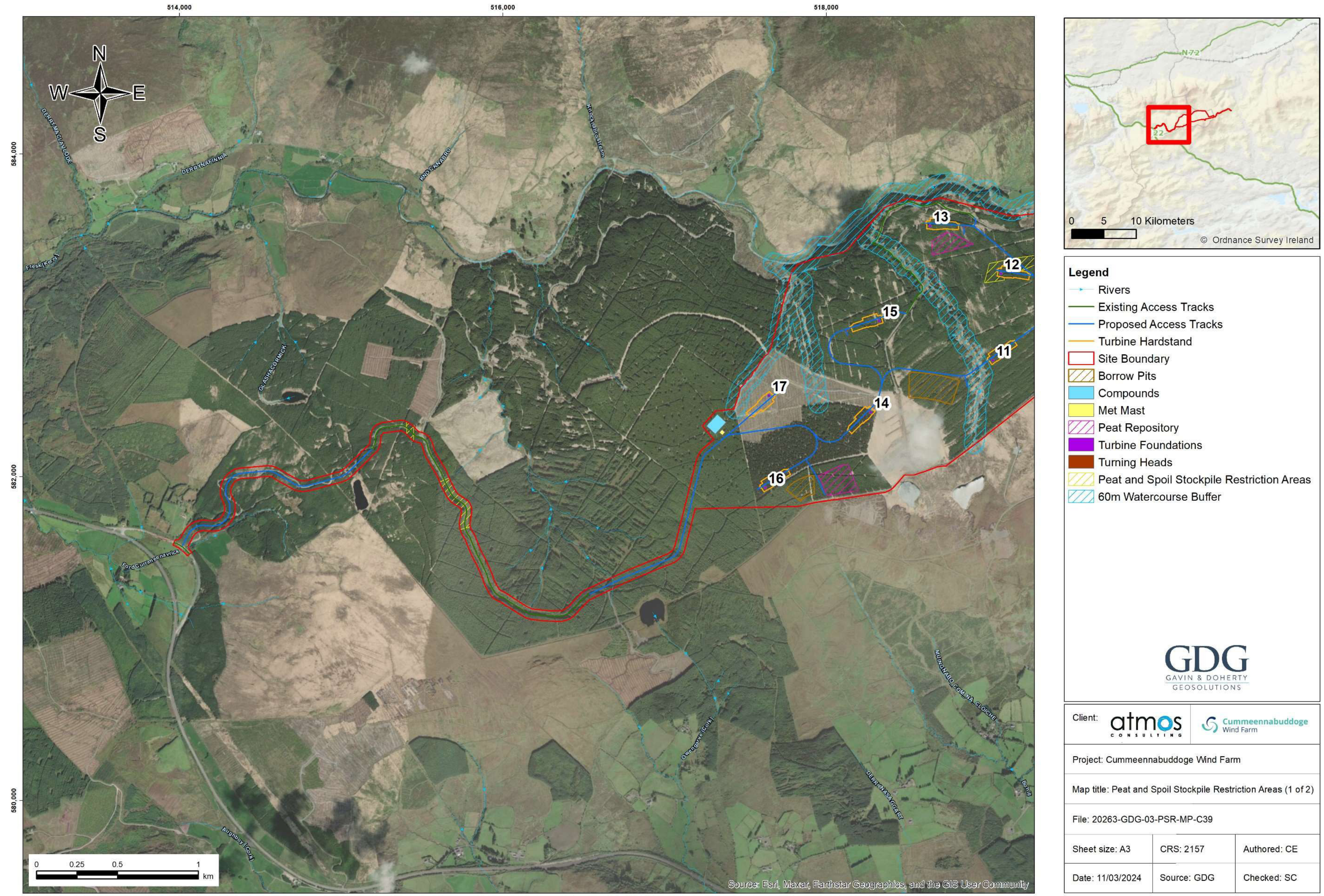


Figure L- 3: Peat and Spoil Stockpile Restriction Areas (1 of 2).

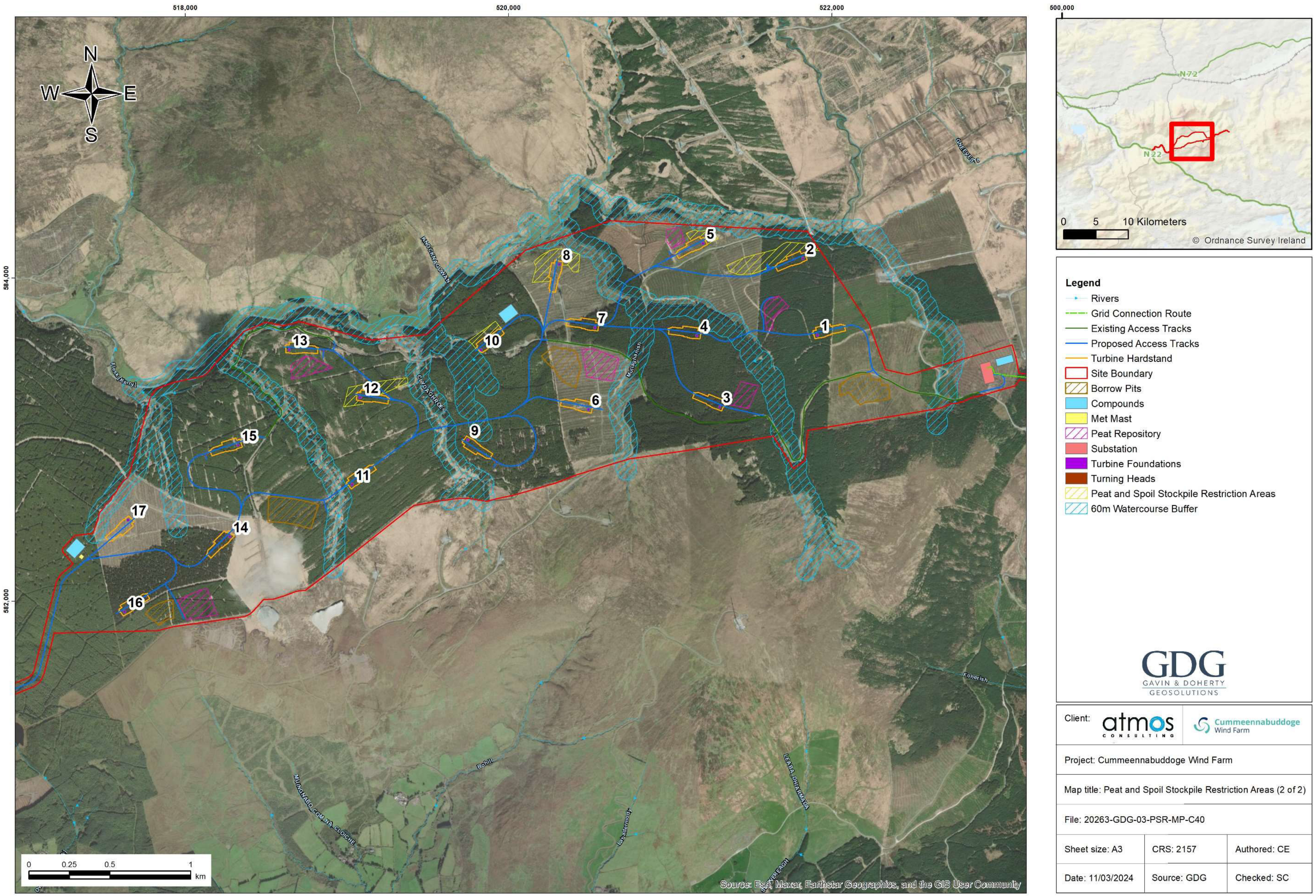


Figure L- 4: Peat and Spoil Stockpile Restriction Areas (2 of 2).

Appendix M Peat stability risk calculation

Table M-1: Peat risk assessment in turbine 1.

GDG GAVIN & DOHERTY GEOSOLUTIONS — **Peat Stability Risk Assessment (PSRA)**

atmos CONSULTING — **Clydaghroe wind farm**

Location:	Turbine 1
Conditions:	Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)
Inspected on:	Mar-22
Inspected by:	SC
Completed by:	IPP
Date:	Oct-22

Hazard factors			Value	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Factor of Safety			U: 5.23, US: 2.61, D: 5.33, DS: 5.08	-	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: ~1 m. Slope angle: 8.903513º.
Secondary factors	Slide history	Distance to previous slides (km)	< 5	NA	5 - 10	< 5	On site	2	2	4	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	NA	NA	-	-	Yes	0	2	0	
	Subsoil conditions (visible in trial pits)	Subsoil type	Gravel / Firm glacial till	NA	Gravel / Firm glacial till	Smooth rock	Soft sensitive clay	1	1	1	Stiff orangeish brown slightly gravelly silty sandy CLAY with rare cobbles.
		Peat fibres across transition to subsoil	Yes	NA	Yes	Partially	No	1	1	1	F3 high content
		Peat wetness		NA	Dry / Stands well	Slowly squeezing	Extremely wet / Undiggable	2	1	2	B2 less than 500%
	Topography	General curvature downslope	Planar	NA	-	Planar	Convex	2	1	2	
		Distance to the convexity break (only if previous factor is Convex)	NA	NA	> 100 m	50 - 100 m	< 50 m	0	1	0	
		Slope aspect (for high latitudes in northern hemisphere)	NW, N, NE	NA	SW, S, SE	W, E	NW, N, NE	3	1	3	
	Hydrology	Distance from watercourse (m)	> 300	NA	> 300	200 - 300	< 200	1	1	1	
		Surface moisture index (NDMI)	0 - 96	NA	0 - 96	96 -135	135 - 174	1	1	1	
		Surface water (water table level indicator)	Localised	NA	Localised	Ponded in drains	Springs	1	1	1	
		Evidence of piping (subsurface flow)	NA	NA	-	-	Yes	0	1	0	
		Significant surface desiccation (previous summer was dry?)	NA	NA	-	-	Yes	0	1.5	0	
		Existing drainage ditches	NA	NA	Down slope	Varied / Oblique	Across slope	0	1	0	
		Annual rainfall	> 1400 mm/yr	NA	< 1000 mm/yr	1000 - 1400 mm/yr	> 1400 mm/yr	3	1	3	
	Vegetation	Bush	Wetlands	NA	Dry heather	Grassland	Wetlands	3	1	3	
		Forestry (if applicable)	Good growth	NA	Good growth	Fair	Stunted growth	1	1.5	1.5	
	Peat workings	Peat cuts presence	NA	NA	-	Cutaway / Turbary	Machine cut	0	1	0	
		Peat cuts vs contour lines	NA	NA	Perpendicular	Oblique	Parallel	0	1	0	
	Existing loads	Roads	NA	NA	Solid	-	Floating	0	1	0	
	Time of year for construction		Late Summer, Autumn	NA	Spring	Winter, Early Summer	Late Summer, Autumn	3	1	0	Worse case estimated

Hazard	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

$Hazard_{total}$	33.5
Max. possible	102
$Hazard_{0\text{-}1}$	0.33

Consequence factors	Value	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Small	NA	Small	Medium	Large	1	3	3	
Downslope hydrology features	Minor undefined watercourse	NA	Bowl / contained	Minor undefined watercourse	Valley	2	1	2	
Proximity from defined valley (m)	> 500	NA	> 500	200 - 500	< 200	1	1	1	
Downhill slope angle	Horizontal	NA	Horizontal	Intermediate	Steep	1	1	1	
Downstream aquatic environment	Sensitive	NA	Non-sensitive	Sensitive	Drinking water supply	2	1	2	
Public roads in potential peat flow path	NA	NA	Minor road	Local road	Regional road	0	1	0	
Overhead lines in potential peat flow path	NA	NA	Phone lines	Electricity (LV)	Electricity (MV, HV)	0	1	0	
Buildings in potential peat flow path	NA	NA	Farm out-houses	-	Dwelling	0	1	0	
Capability to respond (access and resources)	Fair	NA	Good	Fair	Poor	2	1	2	

Consequences	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

$Consequences_{total}$	11
Max. possible	33
$Consequences_{0\text{-}1}$	0.33

Risk rating

Risk		Action required
0.00 - 0.20	Negligible	Normal site investigation
0.20 - 0.40	Low	Targeted site investigation, design of specific mitigation measures. Part time supervision during construction.
0.40 - 0.60	Medium	Avoid construction in the area if possible. If unavoidable, detailed site investigation and design of specific mitigation measures. Full time supervision during construction.
0.60 - 1.00	High	Avoid construction in this area.

Risk rating = Hazard * Consequences

Risk rating = 0.33 × 0.33 = **0.11**

Table M-2: Peat risk assessment in turbine 2.

GDG GAVIN & DOHERTY GEOSOLUTIONS

Peat Stability Risk Assessment (PSRA)

atmos CONSULTING

Clydaghroe wind farm

Location:	**Turbine 2**
Conditions:	**Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)**
Inspected on:	Mar-22
Inspected by:	SC
Completed by:	IPP
Date:	Oct-22

Hazard factors			Value	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Factor of Safety			U: 3.45; US: 2.46; D: 4; DS: 4.85	-	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: ~2.5 m. Slope angle: 3.35º.
Secondary factors	Slide history	Distance to previous slides (km)	< 5	NA	5 - 10	< 5	On site	2	2	4	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	NA	NA	-	-	Yes	0	2	0	
	Subsoil conditions (visible in trial pits)	Subsoil type	Gravel / Firm glacial till	NA	Gravel / Firm glacial till	Smooth rock	Soft sensitive clay	1	1	1	
		Peat fibres across transition to subsoil	Yes	NA	Yes	Partially	No	1	1	1	
		Peat wetness	Slowly squeezing	NA	Dry / Stands well	Slowly squeezing	Extremely wet / Undiggable	2	2	4	
	Topography	General curvature downslope	Convex	NA	-	Planar	Convex	3	1	3	
		Distance to the convexity break (only if previous factor is Convex)	> 100 m	NA	> 100 m	50 - 100 m	< 50 m	1	1	1	
		Slope aspect (for high latitudes in northern hemisphere)	NW, N, NE	NA	SW, S, SE	W, E	NW, N, NE	3	1	3	
	Hydrology	Distance from watercourse (m)	< 200	NA	> 300	200 - 300	< 200	3	1	3	
		Surface moisture index (NDMI)	0 - 96	NA	0 - 96	96 -135	135 - 174	1	1	1	
		Surface water (water table level indicator)	NA	NA	Localised	Ponded in drains	Springs	0	1	0	
		Evidence of piping (subsurface flow)	NA	NA	-	-	Yes	0	1	0	
		Significant surface desiccation (previous summer was dry?)	NA	NA	-	-	Yes	0	1.5	0	
		Existing drainage ditches	Varied / Oblique	NA	Down slope	Varied / Oblique	Across slope	2	1	2	
		Annual rainfall	> 1400 mm/yr	NA	< 1000 mm/yr	1000 - 1400 mm/yr	> 1400 mm/yr	3	1	3	
	Vegetation	Bush	Wetlands	NA	Dry heather	Grassland	Wetlands	3	1	3	
		Forestry (if applicable)	Stunted growth	NA	Good growth	Fair	Stunted growth	3	1.5	4.5	
	Peat workings	Peat cuts presence	NA	NA	-	Cutaway / Turbary	Machine cut	0	1	0	
		Peat cuts vs contour lines	NA	NA	Perpendicular	Oblique	Parallel	0	1	0	
	Existing loads	Roads	Solid	NA	Solid	-	Floating	1	1	1	
	Time of year for construction		Late Summer, Autumn	NA	Spring	Winter, Early Summer	Late Summer, Autumn	3	1	3	Worse case estimated

Hazard	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

$Hazard_{total}$	47.5
Max. possible	105
$Hazard_{0-1}$	**0.45**

Consequence factors	Value	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Medium	NA	Small	Medium	Large	2	3	6	
Downslope hydrology features	Minor undefined watercourse	NA	Bowl / contained	Minor undefined watercourse	Valley	2	1	2	
Proximity from defined valley (m)	> 500	NA	> 500	200 - 500	< 200	1	1	1	
Downhill slope angle	Horizontal	NA	Horizontal	Intermediate	Steep	1	1	1	
Downstream aquatic environment	Sensitive	NA	Non-sensitive	Sensitive	Drinking water supply	2	1	2	
Public roads in potential peat flow path	Minor road	NA	Minor road	Local road	Regional road	1	1	1	
Overhead lines in potential peat flow path	NA	NA	Phone lines	Electricity (LV)	Electricity (MV, HV)	0	1	0	
Buildings in potential peat flow path	NA	NA	Farm out-houses	-	Dwelling	0	1	0	
Capability to respond (access and resources)	Fair	NA	Good	Fair	Poor	2	1	2	

Consequences	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

$Consequences_{total}$	15
Max. possible	33
$Consequences_{0-1}$	**0.45**

Risk rating

Risk		Action required
0.00 - 0.20	Negligible	Normal site investigation
0.20 - 0.40	Low	Targeted site investigation, design of specific mitigation measures. Part time supervision during construction.
0.40 - 0.60	Medium	Avoid construction in the area if possible. If unavoidable, detailed site investigation and design of specific mitigation measures. Full time supervision during construction.
0.60 - 1.00	High	Avoid construction in this area.

Risk rating = Hazard * Consequences

Risk rating = 0.45 | 0.45 = **0.21**

Table M-3: Peat risk assessment in turbine 3.

GDG GAVIN & DOHERTY GEOSOLUTIONS — **Peat Stability Risk Assessment (PSRA)**

atmos CONSULTING — **Clydaghroe wind farm**

Location:	**Turbine 3**
Conditions:	**Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)**
Inspected on:	Mar-22
Inspected by:	SC
Completed by:	IPP
Date:	Oct-22

Hazard factors			Value U	Value US	Value D	Value DS	Rating criteria 0	Rating criteria 1	Rating criteria 2	Rating criteria 3	Rating value	Weighting	Score	Comment
Factor of Safety			15.49	4.44	15.60	8.58	-	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: ~0.4 m. Slope angle: 4.6º.
Secondary factors	Slide history	Distance to previous slides (km)	< 5				NA	5 - 10	< 5	On site	2	2	4	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	NA				NA	-	-	Yes	0	2	0	
	Subsoil conditions (visible in trial pits)	Subsoil type	Gravel / Firm glacial till				NA	Gravel / Firm glacial till	Smooth rock	Soft sensitive clay	1	1	1	Conservative estimate as no GI at location
		Peat fibres across transition to subsoil	Partially				NA	Yes	Partially	No	2	1	2	Conservative estimate as no GI at location
		Peat wetness					NA	Dry / Stands well	Slowly squeezing	Extremely wet / Undiggable	2	2	4	Conservative estimate as no GI at location
	Topography	General curvature downslope	Planar				NA	-	Planar	Convex	2	1	2	
		Distance to the convexity break (only if previous factor is Convex)	NA				NA	> 100 m	50 - 100 m	< 50 m	0	1	0	
		Slope aspect (for high latitudes in northern hemisphere)	NW, N, NE				NA	SW, S, SE	W, E	NW, N, NE	3	1	3	
	Hydrology	Distance from watercourse (m)	< 200				NA	> 300	200 - 300	< 200	3	1	3	
		Surface moisture index (NDMI)	0 - 96				NA	0 - 96	96 -135	135 - 174	1	1	1	
		Surface water (water table level indicator)	NA				NA	Localised	Ponded in drains	Springs	0	1	0	
		Evidence of piping (subsurface flow)	NA				NA	-	-	Yes	0	1	0	
		Significant surface desiccation (previous summer was dry?)	NA				NA	-	-	Yes	0	1.5	0	
		Existing drainage ditches	NA				NA	Down slope	Varied / Oblique	Across slope	0	1	0	
		Annual rainfall	> 1400 mm/yr				NA	< 1000 mm/yr	1000 - 1400 mm/yr	> 1400 mm/yr	3	1	3	
	Vegetation	Bush	Wetlands				NA	Dry heather	Grassland	Wetlands	3	1	3	
		Forestry (if applicable)	Good growth				NA	Good growth	Fair	Stunted growth	1	1.5	1.5	
	Peat workings	Peat cuts presence	NA				NA	-	Cutaway / Turbary	Machine cut	0	1	0	
		Peat cuts vs contour lines	NA				NA	Perpendicular	Oblique	Parallel	0	1	0	
	Existing loads	Roads	NA				NA	Solid	-	Floating	0	1	0	
	Time of year for construction		Late Summer, Autumn				NA	Spring	Winter, Early Summer	Late Summer, Autumn	3	1	3	Worse case estimated

Hazard	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

$Hazard_{total}$	40.5
Max. possible	105
$Hazard_{0-1}$	**0.39**

Consequence factors	Value	Rating criteria 0	Rating criteria 1	Rating criteria 2	Rating criteria 3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Small	NA	Small	Medium	Large	1	3	3	
Downslope hydrology features	Minor undefined watercourse	NA	Bowl / contained	Minor undefined watercourse	Valley	2	1	2	
Proximity from defined valley (m)	> 500	NA	> 500	200 - 500	< 200	1	1	1	
Downhill slope angle	Horizontal	NA	Horizontal	Intermediate	Steep	1	1	1	
Downstream aquatic environment	Sensitive	NA	Non-sensitive	Sensitive	Drinking water supply	2	1	2	
Public roads in potential peat flow path	NA	NA	Minor road	Local road	Regional road	0	1	0	
Overhead lines in potential peat flow path	NA	NA	Phone lines	Electricity (LV)	Electricity (MV, HV)	0	1	0	
Buildings in potential peat flow path	NA	NA	Farm out-houses	-	Dwelling	0	1	0	
Capability to respond (access and resources)	Fair	NA	Good	Fair	Poor	2	1	2	

Consequences	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

$Consequences_{total}$	11
Max. possible	33
$Consequences_{0-1}$	**0.33**

Risk rating

Risk		Action required
0.00 - 0.20	Negligible	Normal site investigation
0.20 - 0.40	Low	Targeted site investigation, design of specific mitigation measures. Part time supervision during construction.
0.40 - 0.60	Medium	Avoid construction in the area if possible. If unavoidable, detailed site investigation and design of specific mitigation measures. Full time supervision during construction.
0.60 - 1.00	High	Avoid construction in this area.

Risk rating =	Hazard *	Consequences		
Risk rating =	0.39	0.33	=	**0.13**

Table M-4: Peat risk assessment in turbine 4.

GDG GAVIN & DOHERTY GEOSOLUTIONS — **Peat Stability Risk Assessment (PSRA)**

atmos CONSULTING — **Clydaghroe wind farm**

Location:	**Turbine 4**
Conditions:	**Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)**
Inspected on:	Mar-22
Inspected by:	SC
Completed by:	IPP
Date:	Oct-22

Hazard factors			Value (U / US / D / DS)	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Factor of Safety				-	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: ~0.8 m. Slope angle: 7.14º.
Secondary factors	Slide history	Distance to previous slides (km)	< 5	NA	5 - 10	< 5	On site	2	2	4	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	NA	NA	-	-	Yes	0	2	0	
	Subsoil conditions (visible in trial pits)	Subsoil type	Gravel / Firm glacial till	NA	Gravel / Firm glacial till	Smooth rock	Soft sensitive clay	1	1	1	Conservative estimate as no GI at location
		Peat fibres across transition to subsoil	Partially	NA	Yes	Partially	No	2	1	2	Conservative estimate as no GI at location
		Peat wetness		NA	Dry / Stands well	Slowly squeezing	Extremely wet / Undiggable	2	2	4	Conservative estimate as no GI at location
	Topography	General curvature downslope	NA	NA	-	Planar	Convex	0	1	0	
		Distance to the convexity break (only if previous factor is Convex)	NA	NA	> 100 m	50 - 100 m	< 50 m	0	1	0	
		Slope aspect (for high latitudes in northern hemisphere)	NW, N, NE	NA	SW, S, SE	W, E	NW, N, NE	3	1	3	
	Hydrology	Distance from watercourse (m)	200 - 300	NA	> 300	200 - 300	< 200	2	1	2	
		Surface moisture index (NDMI)	135 - 174	NA	0 - 96	96 -135	135 - 174	3	1	3	
		Surface water (water table level indicator)	Localised	NA	Localised	Ponded in drains	Springs	1	1	1	
		Evidence of piping (subsurface flow)	NA	NA	-	-	Yes	0	1	0	
		Significant surface desiccation (previous summer was dry?)	NA	NA	-	-	Yes	0	1.5	0	
		Existing drainage ditches	NA	NA	Down slope	Varied / Oblique	Across slope	0	1	0	
		Annual rainfall	> 1400 mm/yr	NA	< 1000 mm/yr	1000 - 1400 mm/yr	> 1400 mm/yr	3	1	3	
	Vegetation	Bush	Wetlands	NA	Dry heather	Grassland	Wetlands	3	1	3	
		Forestry (if applicable)	Good growth	NA	Good growth	Fair	Stunted growth	1	1.5	1.5	
	Peat workings	Peat cuts presence	NA	NA	-	Cutaway / Turbary	Machine cut	0	1	0	
		Peat cuts vs contour lines	NA	NA	Perpendicular	Oblique	Parallel	0	1	0	
	Existing loads	Roads	NA	NA	Solid	-	Floating	0	1	0	
	Time of year for construction		Late Summer, Autumn	NA	Spring	Winter, Early Summer	Late Summer, Autumn	3	1	3	Worse case estimated

Hazard	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

$Hazard_{total}$	40.5
Max. possible	105
$Hazard_{0-1}$	**0.39**

Consequence factors	Value	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Small	NA	Small	Medium	Large	1	3	3	
Downslope hydrology features	Valley	NA	Bowl / contained	Minor undefined watercourse	Valley	3	1	3	
Proximity from defined valley (m)	< 200	NA	> 500	200 - 500	< 200	3	1	3	
Downhill slope angle	Horizontal	NA	Horizontal	Intermediate	Steep	1	1	1	
Downstream aquatic environment	Sensitive	NA	Non-sensitive	Sensitive	Drinking water supply	2	1	2	
Public roads in potential peat flow path	NA	NA	Minor road	Local road	Regional road	0	1	0	
Overhead lines in potential peat flow path	NA	NA	Phone lines	Electricity (LV)	Electricity (MV, HV)	0	1	0	
Buildings in potential peat flow path	NA	NA	Farm out-houses	-	Dwelling	0	1	0	
Capability to respond (access and resources)	Fair	NA	Good	Fair	Poor	2	1	2	

Consequences	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

$Consequences_{total}$	14
Max. possible	33
$Consequences_{0-1}$	**0.42**

Risk rating

Risk		Action required
0.00 - 0.20	Negligible	Normal site investigation
0.20 - 0.40	Low	Targeted site investigation, design of specific mitigation measures. Part time supervision during construction.
0.40 - 0.60	Medium	Avoid construction in the area if possible. If unavoidable, detailed site investigation and design of specific mitigation measures. Full time supervision during construction.
0.60 - 1.00	High	Avoid construction in this area.

Risk rating = Hazard * Consequences

Risk rating = 0.39 0.42 = **0.16**

Table M-5: Peat risk assessment in turbine 5.

GDG GAVIN & DOHERTY GEOSOLUTIONS — **Peat Stability Risk Assessment (PSRA)**

atmos CONSULTING — **Clydaghroe wind farm**

Location:	**Turbine 5**
Conditions:	**Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)**
Inspected on:	Mar-22
Inspected by:	SC
Completed by:	IPP
Date:	Oct-22

Hazard factors			Value	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Factor of Safety			U 3.25; US 2.35; D 3.41; DS 4.64	-	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: ~ 2.6m. Slope angle: 3.4º.
Secondary factors	Slide history	Distance to previous slides (km)	NA	NA	5 - 10	< 5	On site	0	2	0	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	NA	NA	-	-	Yes	0	2	0	
	Subsoil conditions (visible in trial pits)	Subsoil type	Gravel / Firm glacial till	NA	Gravel / Firm glacial till	Smooth rock	Soft sensitive clay	1	1	1	Firm orangeish brown slightly sandy slightly gravelly silty CLAY with occasional
		Peat fibres across transition to subsoil	Partially	NA	Yes	Partially	No	2	1	2	F1 low content
		Peat wetness	Slowly squeezing	NA	Dry / Stands well	Slowly squeezing	Extremely wet / Undiggable	2	2	4	B2 less than 500%;
	Topography	General curvature downslope	Planar	NA	-	Planar	Convex	2	1	2	
		Distance to the convexity break (only if previous factor is Convex)	NA	NA	> 100 m	50 - 100 m	< 50 m	0	1	0	
		Slope aspect (for high latitudes in northern hemisphere)	NW, N, NE	NA	SW, S, SE	W, E	NW, N, NE	3	1	3	
	Hydrology	Distance from watercourse (m)	> 300	NA	> 300	200 - 300	< 200	1	1	1	
		Surface moisture index (NDMI)	96 -135	NA	0 - 96	96 -135	135 - 174	2	1	2	
		Surface water (water table level indicator)	Ponded in drains	NA	Localised	Ponded in drains	Springs	2	1	2	
		Evidence of piping (subsurface flow)	NA	NA	-	-	Yes	0	1	0	
		Significant surface desiccation (previous summer was dry?)	NA	NA	-	-	Yes	0	1.5	0	
		Existing drainage ditches	Varied / Oblique	NA	Down slope	Varied / Oblique	Across slope	2	1	2	
		Annual rainfall	> 1400 mm/yr	NA	< 1000 mm/yr	1000 - 1400 mm/yr	> 1400 mm/yr	3	1	3	
	Vegetation	Bush	Wetlands	NA	Dry heather	Grassland	Wetlands	3	1	3	
		Forestry (if applicable)	Fair	NA	Good growth	Fair	Stunted growth	2	1.5	3	
	Peat workings	Peat cuts presence	NA	NA	-	Cutaway / Turbary	Machine cut	0	1	0	
		Peat cuts vs contour lines	NA	NA	Perpendicular	Oblique	Parallel	0	1	0	
	Existing loads	Roads	Solid	NA	Solid	-	Floating	1	1	1	
	Time of year for construction		Late Summer, Autumn	NA	Spring	Winter, Early Summer	Late Summer, Autumn	3	1	3	Worst case estimate

Hazard	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

$Hazard_{total}$	42
Max. possible	105
$Hazard_{0-1}$	**0.40**

Consequence factors	Value	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Medium	NA	Small	Medium	Large	2	3	6	
Downslope hydrology features	Valley	NA	Bowl / contained	Minor undefined watercourse	Valley	3	1	3	
Proximity from defined valley (m)	> 500	NA	> 500	200 - 500	< 200	1	1	1	
Downhill slope angle	Horizontal	NA	Horizontal	Intermediate	Steep	1	1	1	
Downstream aquatic environment	Sensitive	NA	Non-sensitive	Sensitive	Drinking water supply	2	1	2	
Public roads in potential peat flow path	NA	NA	Minor road	Local road	Regional road	0	1	0	
Overhead lines in potential peat flow path	NA	NA	Phone lines	Electricity (LV)	Electricity (MV, HV)	0	1	0	
Buildings in potential peat flow path	NA	NA	Farm out-houses	-	Dwelling	0	1	0	
Capability to respond (access and resources)	Fair	NA	Good	Fair	Poor	2	1	2	

Consequences	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

$Consequences_{total}$	15
Max. possible	33
$Consequences_{0-1}$	**0.45**

Risk rating

Risk		Action required
0.00 - 0.20	Negligible	Normal site investigation
0.20 - 0.40	Low	Targeted site investigation, design of specific mitigation measures. Part time supervision during construction.
0.40 - 0.60	Medium	Avoid construction in the area if possible. If unavoidable, detailed site investigation and design of specific mitigation measures. Full time supervision during construction.
0.60 - 1.00	High	Avoid construction in this area.

Risk rating = Hazard * Consequences

Risk rating = 0.40 | 0.45 = **0.18**

Table M-6: Peat risk assessment in turbine 6.

GDG GAVIN & DOHERTY GEOSOLUTIONS — **Peat Stability Risk Assessment (PSRA)**

atmos CONSULTING — **Clydaghroe wind farm**

Location:	**Turbine 6**
Conditions:	**Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)**
Inspected on:	Mar-22
Inspected by:	SC
Completed by:	IPP
Date:	Oct-22

Hazard factors			Value	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Factor of Safety			U 4.64 / US 3.21 / D 4.83 / DS 6.33	-	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: ~2.25 m. Slope angle: 2.75º.
Secondary factors	Slide history	Distance to previous slides (km)	< 5	NA	5 - 10	< 5	On site	2	2	4	
Secondary factors	Slide history	Evidence of peat movement (e.g. tension cracks, step features, compression features).	NA	NA	-	-	Yes	0	2	0	
Secondary factors	Subsoil conditions (visible in trial pits)	Subsoil type	Gravel / Firm glacial till	NA	Gravel / Firm glacial till	Smooth rock	Soft sensitive clay	1	1	1	Stiff light greenish grey slightly sandy gravelly CLAY/SILT with rare angular to subangular cobbles and boulders.
Secondary factors	Subsoil conditions (visible in trial pits)	Peat fibres across transition to subsoil	Yes	NA	Yes	Partially	No	1	1	1	F2 moderate content
Secondary factors	Subsoil conditions (visible in trial pits)	Peat wetness	Slowly squeezing	NA	Dry / Stands well	Slowly squeezing	Extremely wet / Undiggable	2	2	4	B2 less than 500%
Secondary factors	Topography	General curvature downslope	Planar	NA	-	Planar	Convex	2	1	2	
Secondary factors	Topography	Distance to the convexity break (only if previous factor is Convex)	NA	NA	> 100 m	50 - 100 m	< 50 m	0	1	0	
Secondary factors	Topography	Slope aspect (for high latitudes in northern hemisphere)	NW, N, NE	NA	SW, S, SE	W, E	NW, N, NE	3	1	3	
Secondary factors	Hydrology	Distance from watercourse (m)	< 200	NA	> 300	200 - 300	< 200	3	1	3	
Secondary factors	Hydrology	Surface moisture index (NDMI)	96 -135	NA	0 - 96	96 -135	135 - 174	2	1	2	
Secondary factors	Hydrology	Surface water (water table level indicator)	NA	NA	Localised	Ponded in drains	Springs	0	1	0	
Secondary factors	Hydrology	Evidence of piping (subsurface flow)	NA	NA	-	-	Yes	0	1	0	
Secondary factors	Hydrology	Significant surface desiccation (previous summer was dry?)	NA	NA	-	-	Yes	0	1.5	0	
Secondary factors	Hydrology	Existing drainage ditches	NA	NA	Down slope	Varied / Oblique	Across slope	0	1	0	
Secondary factors	Hydrology	Annual rainfall	> 1400 mm/yr	NA	< 1000 mm/yr	1000 - 1400 mm/yr	> 1400 mm/yr	3	1	3	
Secondary factors	Vegetation	Bush	Wetlands	NA	Dry heather	Grassland	Wetlands	3	1	3	
Secondary factors	Vegetation	Forestry (if applicable)	Stunted growth	NA	Good growth	Fair	Stunted growth	3	1.5	4.5	
Secondary factors	Peat workings	Peat cuts presence	NA	NA	-	Cutaway / Turbary	Machine cut	0	1	0	
Secondary factors	Peat workings	Peat cuts vs contour lines	NA	NA	Perpendicular	Oblique	Parallel	0	1	0	
Secondary factors	Existing loads	Roads	NA	NA	Solid	-	Floating	0	1	0	
Secondary factors	Time of year for construction		Late Summer, Autumn	NA	Spring	Winter, Early Summer	Late Summer, Autumn	3	1	3	Worst case estimate
									Hazard $_{total}$	43.5	
									Max. possible	105	
									Hazard $_{0-1}$	**0.41**	

Hazard	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

Consequence factors	Value	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Medium	NA	Small	Medium	Large	2	3	6	
Downslope hydrology features	Minor undefined watercourse	NA	Bowl / contained	Minor undefined watercourse	Valley	2	1	2	
Proximity from defined valley (m)	> 500	NA	> 500	200 - 500	< 200	1	1	1	
Downhill slope angle	Intermediate	NA	Horizontal	Intermediate	Steep	2	1	2	
Downstream aquatic environment	Sensitive	NA	Non-sensitive	Sensitive	Drinking water supply	2	1	2	
Public roads in potential peat flow path	NA	NA	Minor road	Local road	Regional road	0	1	0	
Overhead lines in potential peat flow path	NA	NA	Phone lines	Electricity (LV)	Electricity (MV, HV)	0	1	0	
Buildings in potential peat flow path	NA	NA	Farm out-houses	-	Dwelling	0	1	0	
Capability to respond (access and resources)	Fair	NA	Good	Fair	Poor	2	1	2	
							Consequences $_{total}$	15	
							Max. possible	33	
							Consequences $_{0-1}$	**0.45**	

Consequences	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

Risk rating

Risk		**Action required**
0.00 - 0.20	Negligible	Normal site investigation
0.20 - 0.40	Low	Targeted site investigation, design of specific mitigation measures. Part time supervision during construction.
0.40 - 0.60	Medium	Avoid construction in the area if possible. If unavoidable, detailed site investigation and design of specific mitigation measures. Full time supervision during construction.
0.60 - 1.00	High	Avoid construction in this area.

Risk rating =	Hazard *	Consequences		
Risk rating =	0.41	0.45	=	**0.19**

Table M-7: Peat risk assessment in turbine 7.

GDG GAVIN & DOHERTY GEOSOLUTIONS — **Peat Stability Risk Assessment (PSRA)**

atmos CONSULTING — **Clydaghroe wind farm**

Location:	**Turbine 7**
Conditions:	**Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)**
Inspected on:	Mar-22
Inspected by:	SC
Completed by:	IPP
Date:	Oct-22

Hazard factors			Value U	Value US	Value D	Value DS	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Factor of Safety			7.03	3.33	7.14	6.47	-	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: ~1 m. Slope angle: 4.5º.
Secondary factors	Slide history	Distance to previous slides (km)	< 5				NA	5 - 10	< 5	On site	2	2	4	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	NA				NA	-	-	Yes	0	2	0	
	Subsoil conditions (visible in trial pits)	Subsoil type	Gravel / Firm glacial till				NA	Gravel / Firm glacial till	Smooth rock	Soft sensitive clay	1	1	1	Possible Weathered Rock: Recovered as light greyish brown mottled orange slightly sandy very clayey/silty fine to coarse angular to subangular GRAVEL with occasional angular to subrounded cobbles.
		Peat fibres across transition to subsoil	Yes				NA	Yes	Partially	No	1	1	1	F2 moderate content
		Peat wetness	Slowly squeezing				NA	Dry / Stands well	Slowly squeezing	Extremely wet / Undiggable	2	2	4	B2 less than 500%
	Topography	General curvature downslope	Planar				NA	-	Planar	Convex	2	1	2	
		Distance to the convexity break (only if previous factor is Convex)	NA				NA	> 100 m	50 - 100 m	< 50 m	0	1	0	
		Slope aspect (for high latitudes in northern hemisphere)	NW, N, NE				NA	SW, S, SE	W, E	NW, N, NE	3	1	3	
	Hydrology	Distance from watercourse (m)	> 300				NA	> 300	200 - 300	< 200	1	1	1	
		Surface moisture index (NDMI)	0 - 96				NA	0 - 96	96 -135	135 - 174	1	1	1	
		Surface water (water table level indicator)	NA				NA	Localised	Ponded in drains	Springs	0	1	0	
		Evidence of piping (subsurface flow)	NA				NA	-	-	Yes	0	1	0	
		Significant surface desiccation (previous summer was dry?)	NA				NA	-	-	Yes	0	1.5	0	
		Existing drainage ditches	NA				NA	Down slope	Varied / Oblique	Across slope	0	1	0	
		Annual rainfall	> 1400 mm/yr				NA	< 1000 mm/yr	1000 - 1400 mm/yr	> 1400 mm/yr	3	1	3	
	Vegetation	Bush	Wetlands				NA	Dry heather	Grassland	Wetlands	3	1	3	
		Forestry (if applicable)	Good growth				NA	Good growth	Fair	Stunted growth	1	1.5	1.5	
	Peat workings	Peat cuts presence	NA				NA	-	Cutaway / Turbary	Machine cut	0	1	0	
		Peat cuts vs contour lines	NA				NA	Perpendicular	Oblique	Parallel	0	1	0	
	Existing loads	Roads	NA				NA	Solid	-	Floating	0	1	0	
	Time of year for construction		Late Summer, Autumn				NA	Spring	Winter, Early Summer	Late Summer, Autumn	3	1	3	Worst case estimate

Hazard	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

$Hazard_{total}$	37.5
Max. possible	105
$Hazard_{0\text{-}1}$	**0.36**

Consequence factors	Value	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Medium	NA	Small	Medium	Large	2	3	6	
Downslope hydrology features	Valley	NA	Bowl / contained	Minor undefined watercourse	Valley	3	1	3	
Proximity from defined valley (m)	> 500	NA	> 500	200 - 500	< 200	1	1	1	
Downhill slope angle	Intermediate	NA	Horizontal	Intermediate	Steep	2	1	2	
Downstream aquatic environment	Sensitive	NA	Non-sensitive	Sensitive	Drinking water supply	2	1	2	
Public roads in potential peat flow path	NA	NA	Minor road	Local road	Regional road	0	1	0	
Overhead lines in potential peat flow path	NA	NA	Phone lines	Electricity (LV)	Electricity (MV, HV)	0	1	0	
Buildings in potential peat flow path	NA	NA	Farm out-houses	-	Dwelling	0	1	0	
Capability to respond (access and resources)	Fair	NA	Good	Fair	Poor	2	1	2	

Consequences	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

$Consequences_{total}$	16
Max. possible	33
$Consequences_{0\text{-}1}$	**0.48**

Risk rating

Risk		Action required
0.00 - 0.20	Negligible	Normal site investigation
0.20 - 0.40	Low	Targeted site investigation, design of specific mitigation measures. Part time supervision during construction.
0.40 - 0.60	Medium	Avoid construction in the area if possible. If unavoidable, detailed site investigation and design of specific mitigation measures. Full time supervision during construction.
0.60 - 1.00	High	Avoid construction in this area.

	Hazard *	Consequences		
Risk rating =	Hazard *	Consequences		
Risk rating =	0.36	0.48	=	**0.17**

Table M-8: Peat risk assessment in turbine 8.

GDG	Peat Stability Risk Assessment (PSRA)	Location:	Turbine 8
		Conditions:	Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)
		Inspected on:	Mar-22
		Inspected by:	SC
atmos	Clydaghroe wind farm	Completed by:	IPP
		Date:	Oct-22

Hazard factors			Value				Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
			U	US	D	DS	0	1	2	3				
Factor of Safety			8.18	3.04	8.27	5.87	-	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: ~0.6m. Slope angle: 6º.
Secondary factors	Slide history	Distance to previous slides (km)	< 5				NA	5 - 10	< 5	On site	2	2	4	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	NA				NA	-	-	Yes	0	2	0	
	Subsoil conditions (visible in trial pits)	Subsoil type	Gravel / Firm glacial till				NA	Gravel / Firm glacial till	Smooth rock	Soft sensitive clay	1	1	1	Firm light greyish brown slightly sandy gravelly CLAY/SILT with many angula rto subangular cobbles and occasional boulders.
		Peat fibres across transition to subsoil	Partially				NA	Yes	Partially	No	2	1	2	F2 moderate content
		Peat wetness	Slowly squeezing				NA	Dry / Stands well	Slowly squeezing	Extremely wet / Undiggable	2	2	4	B2 less than 500%
	Topography	General curvature downslope	Planar				NA	-	Planar	Convex	2	1	2	
		Distance to the convexity break (only if previous factor is Convex)	NA				NA	> 100 m	50 - 100 m	< 50 m	0	1	0	
		Slope aspect (for high latitudes in northern hemisphere)	NW, N, NE				NA	SW, S, SE	W, E	NW, N, NE	3	1	3	
	Hydrology	Distance from watercourse (m)	< 200				NA	> 300	200 - 300	< 200	3	1	3	
		Surface moisture index (NDMI)	96 -135				NA	0 - 96	96 -135	135 - 174	2	1	2	
		Surface water (water table level indicator)	NA				NA	Localised	Ponded in drains	Springs	0	1	0	
		Evidence of piping (subsurface flow)	NA				NA	-	-	Yes	0	1	0	
		Significant surface desiccation (previous summer was dry?)	NA				NA	-	-	Yes	0	1.5	0	
		Existing drainage ditches	Across slope				NA	Down slope	Varied / Oblique	Across slope	3	1	3	
		Annual rainfall	> 1400 mm/yr				NA	< 1000 mm/yr	1000 - 1400 mm/yr	> 1400 mm/yr	3	1	3	
	Vegetation	Bush	Wetlands				NA	Dry heather	Grassland	Wetlands	3	1	3	
		Forestry (if applicable)	Stunted growth				NA	Good growth	Fair	Stunted growth	3	1.5	4.5	
	Peat workings	Peat cuts presence	NA				NA	-	Cutaway / Turbary	Machine cut	0	1	0	
		Peat cuts vs contour lines	NA				NA	Perpendicular	Oblique	Parallel	0	1	0	
	Existing loads	Roads	NA				NA	Solid	-	Floating	0	1	0	
	Time of year for construction		Late Summer, Autumn				NA	Spring	Winter, Early Summer	Late Summer, Autumn	3	1	3	Worst case estimate

Hazard	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

$Hazard_{total}$	47.5
Max. possible	105
$Hazard_{0-1}$	0.45

Consequence factors	Value	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Small	NA	Small	Medium	Large	1	3	3	
Downslope hydrology features	Valley	NA	Bowl / contained	Minor undefined watercourse	Valley	3	1	3	
Proximity from defined valley (m)	< 200	NA	> 500	200 - 500	< 200	3	1	3	
Downhill slope angle	Steep	NA	Horizontal	Intermediate	Steep	3	1	3	
Downstream aquatic environment	Sensitive	NA	Non-sensitive	Sensitive	Drinking water supply	2	1	2	
Public roads in potential peat flow path	NA	NA	Minor road	Local road	Regional road	0	1	0	
Overhead lines in potential peat flow path	NA	NA	Phone lines	Electricity (LV)	Electricity (MV, HV)	0	1	0	
Buildings in potential peat flow path	NA	NA	Farm out-houses	-	Dwelling	0	1	0	
Capability to respond (access and resources)	Fair	NA	Good	Fair	Poor	2	1	2	

Consequences	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

$Consequences_{total}$	16
Max. possible	33
$Consequences_{0-1}$	0.48

Risk rating

Risk		Action required
0.00 - 0.20	Negligible	Normal site investigation
0.20 - 0.40	Low	Targeted site investigation, design of specific mitigation measures. Part time supervision during construction.
0.40 - 0.60	Medium	Avoid construction in the area if possible. If unavoidable, detailed site investigation and design of specific mitigation measures. Full time supervision during construction.
0.60 - 1.00	High	Avoid construction in this area.

Risk rating =	Hazard *	Consequences		
Risk rating =	0.45	0.48	=	0.22

Table M-9: Peat risk assessment in turbine 9.

GDG GAVIN & DOHERTY GEOSOLUTIONS — **Peat Stability Risk Assessment (PSRA)**

atmos CONSULTING — **Clydaghroe wind farm**

Location:	**Turbine 9**
Conditions:	**Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)**
Inspected on:	Mar-22
Inspected by:	SC
Completed by:	IPP
Date:	Oct-22

Hazard factors			Value (U / US / D / DS)	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Factor of Safety			23.04 / 10.24 / 23.39 / 19.94	-	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: ~0.8 m. Slope angle: 5.9º.
Secondary factors	Slide history	Distance to previous slides (km)	< 5	NA	5 - 10	< 5	On site	2	2	4	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	NA	NA	-	-	Yes	0	2	0	
	Subsoil conditions (visible in trial pits)	Subsoil type	Gravel / Firm glacial till	NA	Gravel / Firm glacial till	Smooth rock	Soft sensitive clay	1	1	1	Conservative estimate as no GI at location
		Peat fibres across transition to subsoil	Partially	NA	Yes	Partially	No	2	1	2	Conservative estimate as no GI at location
		Peat wetness		NA	Dry / Stands well	Slowly squeezing	Extremely wet / Undiggable	2	2	4	Conservative estimate as no GI at location
	Topography	General curvature downslope	Convex	NA	-	Planar	Convex	3	1	3	
		Distance to the convexity break (only if previous factor is Convex)	> 100 m	NA	> 100 m	50 - 100 m	< 50 m	1	1	1	
		Slope aspect (for high latitudes in northern hemisphere)	NW, N, NE	NA	SW, S, SE	W, E	NW, N, NE	3	1	3	
	Hydrology	Distance from watercourse (m)	< 200	NA	> 300	200 - 300	< 200	3	1	3	
		Surface moisture index (NDMI)	135 - 174	NA	0 - 96	96 -135	135 - 174	3	1	3	
		Surface water (water table level indicator)	Ponded in drains	NA	Localised	Ponded in drains	Springs	2	1	2	
		Evidence of piping (subsurface flow)	-	NA	-	-	Yes	1	1	1	
		Significant surface desiccation (previous summer was dry?)	NA	NA	-	-	Yes	0	1.5	0	
		Existing drainage ditches	Varied / Oblique	NA	Down slope	Varied / Oblique	Across slope	2	1	2	
		Annual rainfall	> 1400 mm/yr	NA	< 1000 mm/yr	1000 - 1400 mm/yr	> 1400 mm/yr	3	1	3	
	Vegetation	Bush	Wetlands	NA	Dry heather	Grassland	Wetlands	3	1	3	
		Forestry (if applicable)	Good growth	NA	Good growth	Fair	Stunted growth	1	1.5	1.5	
	Peat workings	Peat cuts presence	NA	NA	-	Cutaway / Turbary	Machine cut	0	1	0	
		Peat cuts vs contour lines	NA	NA	Perpendicular	Oblique	Parallel	0	1	0	
	Existing loads	Roads	NA	NA	Solid	-	Floating	0	1	0	
	Time of year for construction		Late Summer, Autumn	NA	Spring	Winter, Early Summer	Late Summer, Autumn	3	1	3	Worse case estimated

Hazard	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

Hazard $_{total}$	49.5
Max. possible	105
Hazard $_{0-1}$	**0.47**

Consequence factors	Value	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Small	NA	Small	Medium	Large	1	3	3	
Downslope hydrology features	Valley	NA	Bowl / contained	Minor undefined watercourse	Valley	3	1	3	
Proximity from defined valley (m)	< 200	NA	> 500	200 - 500	< 200	3	1	3	
Downhill slope angle	Horizontal	NA	Horizontal	Intermediate	Steep	1	1	1	
Downstream aquatic environment	Sensitive	NA	Non-sensitive	Sensitive	Drinking water supply	2	1	2	
Public roads in potential peat flow path	NA	NA	Minor road	Local road	Regional road	0	1	0	
Overhead lines in potential peat flow path	NA	NA	Phone lines	Electricity (LV)	Electricity (MV, HV)	0	1	0	
Buildings in potential peat flow path	NA	NA	Farm out-houses	-	Dwelling	0	1	0	
Capability to respond (access and resources)	Fair	NA	Good	Fair	Poor	2	1	2	

Consequences	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

Consequences $_{total}$	14
Max. possible	33
Consequences $_{0-1}$	**0.42**

Risk rating

Risk		Action required
0.00 - 0.20	Negligible	Normal site investigation
0.20 - 0.40	Low	Targeted site investigation, design of specific mitigation measures. Part time supervision during construction.
0.40 - 0.60	Medium	Avoid construction in the area if possible. If unavoidable, detailed site investigation and design of specific mitigation measures. Full time supervision during construction.
0.60 - 1.00	High	Avoid construction in this area.

Risk rating =	Hazard *	Consequences		
Risk rating =	0.47	0.42	=	**0.20**

Table M-10: Peat risk assessment in turbine 10.

GDG GAVIN & DOHERTY GEOSOLUTIONS	**Peat Stability Risk Assessment (PSRA)**	**Location:**	**Turbine 10**
atmos CONSULTING	**Clydaghroe wind farm**	**Conditions:**	**Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)**
		Inspected on:	Mar-22
		Inspected by:	SC
		Completed by:	IPP
		Date:	Oct-22

Hazard factors			Value	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Factor of Safety			U 5.70, US 2.93, D 5.81, DS 5.70	-	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: 1.05 m. Slope angle: 4.7º.
Secondary factors	Slide history	Distance to previous slides (km)	< 5	NA	5 - 10	< 5	On site	2	2	4	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	NA	NA	-	-	Yes	0	2	0	
	Subsoil conditions (visible in trial pits)	Subsoil type	Gravel / Firm glacial till	NA	Gravel / Firm glacial till	Smooth rock	Soft sensitive clay	1	1	1	Firm orangeish brown slightly sandy gravelly CLAY/SILT with occasional angular to subangular cobbles
		Peat fibres across transition to subsoil	Partially	NA	Yes	Partially	No	2	1	2	F2 moderate content
		Peat wetness	Slowly squeezing	NA	Dry / Stands well	Slowly squeezing	Extremely wet / Undiggable	2	2	4	B2 less than 500%
	Topography	General curvature downslope	Convex	NA	-	Planar	Convex	3	1	3	
		Distance to the convexity break (only if previous factor is Convex)	> 100 m	NA	> 100 m	50 - 100 m	< 50 m	1	1	1	
		Slope aspect (for high latitudes in northern hemisphere)	NW, N, NE	NA	SW, S, SE	W, E	NW, N, NE	3	1	3	
	Hydrology	Distance from watercourse (m)	< 200	NA	> 300	200 - 300	< 200	3	1	3	
		Surface moisture index (NDMI)	135 - 174	NA	0 - 96	96 -135	135 - 174	3	1	3	
		Surface water (water table level indicator)	Ponded in drains	NA	Localised	Ponded in drains	Springs	2	1	2	
		Evidence of piping (subsurface flow)	NA	NA	-	-	Yes	0	1	0	
		Significant surface desiccation (previous summer was dry?)	NA	NA	-	-	Yes	0	1.5	0	
		Existing drainage ditches	Varied / Oblique	NA	Down slope	Varied / Oblique	Across slope	2	1	2	
		Annual rainfall	> 1400 mm/yr	NA	< 1000 mm/yr	1000 - 1400 mm/yr	> 1400 mm/yr	3	1	3	
	Vegetation	Bush	Wetlands	NA	Dry heather	Grassland	Wetlands	3	1	3	
		Forestry (if applicable)	Good growth	NA	Good growth	Fair	Stunted growth	1	1.5	1.5	
	Peat workings	Peat cuts presence	NA	NA	-	Cutaway / Turbary	Machine cut	0	1	0	
		Peat cuts vs contour lines	NA	NA	Perpendicular	Oblique	Parallel	0	1	0	
	Existing loads	Roads	NA	NA	Solid	-	Floating	0	1	0	
	Time of year for construction		Late Summer, Autumn	NA	Spring	Winter, Early Summer	Late Summer, Autumn	3	1	3	Worst case estimate

Hazard	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

Hazard $_{total}$	48.5
Max. possible	105
Hazard $_{0-1}$	**0.46**

Consequence factors	Value	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Small	NA	Small	Medium	Large	1	3	3	
Downslope hydrology features	Minor undefined watercourse	NA	Bowl / contained	Minor undefined watercourse	Valley	2	1	2	
Proximity from defined valley (m)	200 - 500	NA	> 500	200 - 500	< 200	2	1	2	
Downhill slope angle	Intermediate	NA	Horizontal	Intermediate	Steep	2	1	2	
Downstream aquatic environment	Sensitive	NA	Non-sensitive	Sensitive	Drinking water supply	2	1	2	
Public roads in potential peat flow path	Minor road	NA	Minor road	Local road	Regional road	1	1	1	
Overhead lines in potential peat flow path	NA	NA	Phone lines	Electricity (LV)	Electricity (MV, HV)	0	1	0	
Buildings in potential peat flow path	NA	NA	Farm out-houses	-	Dwelling	0	1	0	
Capability to respond (access and resources)	Fair	NA	Good	Fair	Poor	2	1	2	

Consequences	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

Consequences $_{total}$	14
Max. possible	33
Consequences $_{0-1}$	**0.42**

Risk rating

Risk		Action required
0.00 - 0.20	Negligible	Normal site investigation
0.20 - 0.40	Low	Targeted site investigation, design of specific mitigation measures. Part time supervision during construction.
0.40 - 0.60	Medium	Avoid construction in the area if possible. If unavoidable, detailed site investigation and design of specific mitigation measures. Full time supervision during construction.
0.60 - 1.00	High	Avoid construction in this area.

Risk rating =	Hazard *	Consequences		
Risk rating =	0.46	0.42	=	**0.20**

Table M-11: Peat risk assessment in turbine 11.

GDG / atmos

Peat Stability Risk Assessment (PSRA)

Clydaghroe wind farm

Location:	**Turbine 11**
Conditions:	**Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)**
Inspected on:	Mar-22
Inspected by:	SC
Completed by:	IPP
Date:	Oct-22

Hazard factors			Value	Rating criteria 0	Rating criteria 1	Rating criteria 2	Rating criteria 3	Rating value	Weighting	Score	Comment
Factor of Safety			U 3.94, US 2.72, D ###, DS 5.37	-	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: ~2.25 m. Slope angle: 3.25º.
Secondary factors	Slide history	Distance to previous slides (km)	< 5	NA	5 - 10	< 5	On site	2	2	4	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	NA	NA	-	-	Yes	0	2	0	
	Subsoil conditions (visible in trial pits)	Subsoil type	Gravel / Firm glacial till	NA	Gravel / Firm glacial till	Smooth rock	Soft sensitive clay	1	1	1	Conservative estimate as no GI at location
		Peat fibres across transition to subsoil	Partially	NA	Yes	Partially	No	2	1	2	Conservative estimate as no GI at location
		Peat wetness		NA	Dry / Stands well	Slowly squeezing	Extremely wet / Undiggable	2	2	4	Conservative estimate as no GI at location
	Topography	General curvature downslope	Convex	NA	-	Planar	Convex	3	1	3	
		Distance to the convexity break (only if previous factor is Convex)	> 100 m	NA	> 100 m	50 - 100 m	< 50 m	1	1	1	
		Slope aspect (for high latitudes in northern hemisphere)	NW, N, NE	NA	SW, S, SE	W, E	NW, N, NE	3	1	3	
	Hydrology	Distance from watercourse (m)	< 200	NA	> 300	200 - 300	< 200	3	1	3	
		Surface moisture index (NDMI)	135 - 174	NA	0 - 96	96 -135	135 - 174	3	1	3	
		Surface water (water table level indicator)	Ponded in drains	NA	Localised	Ponded in drains	Springs	2	1	2	
		Evidence of piping (subsurface flow)	NA	NA	-	-	Yes	0	1	0	
		Significant surface desiccation (previous summer was dry?)	NA	NA	-	-	Yes	0	1.5	0	
		Existing drainage ditches	NA	NA	Down slope	Varied / Oblique	Across slope	0	1	0	
		Annual rainfall	> 1400 mm/yr	NA	< 1000 mm/yr	1000 - 1400 mm/yr	> 1400 mm/yr	3	1	3	
	Vegetation	Bush	Grassland	NA	Dry heather	Grassland	Wetlands	2	1	2	
		Forestry (if applicable)	Good growth	NA	Good growth	Fair	Stunted growth	1	1.5	1.5	
	Peat workings	Peat cuts presence	NA	NA	-	Cutaway / Turbary	Machine cut	0	1	0	
		Peat cuts vs contour lines	NA	NA	Perpendicular	Oblique	Parallel	0	1	0	
	Existing loads	Roads	NA	NA	Solid	-	Floating	0	1	0	
	Time of year for construction		Late Summer, Autumn	NA	Spring	Winter, Early Summer	Late Summer, Autumn	3	1	3	Worse case estimate

Hazard	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

Hazard $_{total}$	45.5
Max. possible	105
Hazard $_{0-1}$	**0.43**

Consequence factors	Value	Rating criteria 0	Rating criteria 1	Rating criteria 2	Rating criteria 3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Medium	NA	Small	Medium	Large	2	3	6	
Downslope hydrology features	Minor undefined watercourse	NA	Bowl / contained	Minor undefined watercourse	Valley	2	1	2	
Proximity from defined valley (m)	< 200	NA	> 500	200 - 500	< 200	3	1	3	
Downhill slope angle	Horizontal	NA	Horizontal	Intermediate	Steep	1	1	1	
Downstream aquatic environment	Sensitive	NA	Non-sensitive	Sensitive	Drinking water supply	2	1	2	
Public roads in potential peat flow path	NA	NA	Minor road	Local road	Regional road	0	1	0	
Overhead lines in potential peat flow path	NA	NA	Phone lines	Electricity (LV)	Electricity (MV, HV)	0	1	0	
Buildings in potential peat flow path	NA	NA	Farm out-houses	-	Dwelling	0	1	0	
Capability to respond (access and resources)	Fair	NA	Good	Fair	Poor	2	1	2	

Consequences	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

Consequences $_{total}$	16
Max. possible	33
Consequences $_{0-1}$	**0.48**

Risk rating

Risk		Action required
0.00 - 0.20	Negligible	Normal site investigation
0.20 - 0.40	Low	Targeted site investigation, design of specific mitigation measures. Part time supervision during construction.
0.40 - 0.60	Medium	Avoid construction in the area if possible. If unavoidable, detailed site investigation and design of specific mitigation measures. Full time supervision during construction.
0.60 - 1.00	High	Avoid construction in this area.

Risk rating = Hazard * Consequences

Risk rating = 0.43 0.48 = **0.21**

Table M-12: Peat risk assessment in turbine 12.

GDG GAVIN & DOHERTY GEOSOLUTIONS
atmos CONSULTING

Peat Stability Risk Assessment (PSRA)

Clydaghroe wind farm

Location:	**Turbine 12**
Conditions:	**Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)**
Inspected on:	Mar-22
Inspected by:	SC
Completed by:	IPP
Date:	Oct-22

Hazard factors			Value				Rating criteria				Rating value	Weighting	Score	Comment
			U	US	D	DS	0	1	2	3				
Factor of Safety			2.83	1.51	2.89	2.92	-	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: ~1.15 m. Slope angle: 9º.
Secondary factors	Slide history	Distance to previous slides (km)	< 5				NA	5 - 10	< 5	On site	2	2	4	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	NA				NA	-	-	Yes	0	2	0	
	Subsoil conditions (visible in trial pits)	Subsoil type	Gravel / Firm glacial till				NA	Gravel / Firm glacial till	Smooth rock	Soft sensitive clay	1	1	1	Conservative estimate as no GI at location
		Peat fibres across transition to subsoil	Partially				NA	Yes	Partially	No	2	1	2	Conservative estimate as no GI at location
		Peat wetness					NA	Dry / Stands well	Slowly squeezing	Extremely wet / Undiggable	2	2	4	Conservative estimate as no GI at location
	Topography	General curvature downslope	-				NA	-	Planar	Convex	1	1	1	
		Distance to the convexity break (only if previous factor is Convex)	NA				NA	> 100 m	50 - 100 m	< 50 m	0	1	0	
		Slope aspect (for high latitudes in northern hemisphere)	NW, N, NE				NA	SW, S, SE	W, E	NW, N, NE	3	1	3	
	Hydrology	Distance from watercourse (m)	< 200				NA	> 300	200 - 300	< 200	3	1	3	
		Surface moisture index (NDMI)	135 - 174				NA	0 - 96	96 -135	135 - 174	3	1	3	
		Surface water (water table level indicator)	NA				NA	Localised	Ponded in drains	Springs	0	1	0	
		Evidence of piping (subsurface flow)	Yes				NA	-	-	Yes	3	1	3	
		Significant surface desiccation (previous summer was dry?)	NA				NA	-	-	Yes	0	1.5	0	
		Existing drainage ditches	NA				NA	Down slope	Varied / Oblique	Across slope	0	1	0	
		Annual rainfall	> 1400 mm/yr				NA	< 1000 mm/yr	1000 - 1400 mm/yr	> 1400 mm/yr	3	1	3	
	Vegetation	Bush	Wetlands				NA	Dry heather	Grassland	Wetlands	3	1	3	
		Forestry (if applicable)	Good growth				NA	Good growth	Fair	Stunted growth	1	1.5	1.5	
	Peat workings	Peat cuts presence	NA				NA	-	Cutaway / Turbary	Machine cut	0	1	0	
		Peat cuts vs contour lines	NA				NA	Perpendicular	Oblique	Parallel	0	1	0	
	Existing loads	Roads	NA				NA	Solid	-	Floating	0	1	0	
	Time of year for construction		Late Summer, Autumn				NA	Spring	Winter, Early Summer	Late Summer, Autumn	3	1	3	Worse case estimate

Hazard $_{total}$	44.5
Max. possible	105
Hazard $_{0-1}$	**0.42**

Hazard	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

Consequence factors	**Value**	**Rating criteria**				**Rating value**	**Weighting**	**Score**	**Comment**
		0	1	2	3				
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Medium	NA	Small	Medium	Large	2	3	6	
Downslope hydrology features	Minor undefined watercourse	NA	Bowl / contained	Minor undefined watercourse	Valley	2	1	2	
Proximity from defined valley (m)	200 - 500	NA	> 500	200 - 500	< 200	2	1	2	
Downhill slope angle	Horizontal	NA	Horizontal	Intermediate	Steep	1	1	1	
Downstream aquatic environment	Sensitive	NA	Non-sensitive	Sensitive	Drinking water supply	2	1	2	
Public roads in potential peat flow path	NA	NA	Minor road	Local road	Regional road	0	1	0	
Overhead lines in potential peat flow path	NA	NA	Phone lines	Electricity (LV)	Electricity (MV, HV)	0	1	0	
Buildings in potential peat flow path	NA	NA	Farm out-houses	-	Dwelling	0	1	0	
Capability to respond (access and resources)	Fair	NA	Good	Fair	Poor	2	1	2	

Consequences $_{total}$	15
Max. possible	33
Consequences $_{0-1}$	**0.45**

Consequences	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

Risk rating

Risk		**Action required**
0.00 - 0.20	Negligible	Normal site investigation
0.20 - 0.40	Low	Targeted site investigation, design of specific mitigation measures. Part time supervision during construction.
0.40 - 0.60	Medium	Avoid construction in the area if possible. If unavoidable, detailed site investigation and design of specific mitigation measures. Full time supervision during construction.
0.60 - 1.00	High	Avoid construction in this area.

Risk rating =	Hazard *	Consequences		
Risk rating =	0.42	0.45	=	**0.19**

Table M-13: Peat risk assessment in turbine 13.

GDG GAVIN & DOHERTY GEOSOLUTIONS
atmos CONSULTING

Peat Stability Risk Assessment (PSRA)

Clydaghroe wind farm

Location:	**Turbine 13**
Conditions:	**Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)**
Inspected on:	Mar-22
Inspected by:	SC
Completed by:	IPP
Date:	Oct-22

Hazard factors			Value	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Factor of Safety			U 10.53, US 4.41, D 10.67, DS 8.56	-	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: ~0.72 m. Slope angle: 3.8º.
Secondary factors	Slide history	Distance to previous slides (km)	< 5	NA	5 - 10	< 5	On site	2	2	4	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	NA	NA	-	-	Yes	0	2	0	
	Subsoil conditions (visible in trial pits)	Subsoil type	Gravel / Firm glacial till	NA	Gravel / Firm glacial till	Smooth rock	Soft sensitive clay	1	1	1	Conservative estimate as no GI at location
		Peat fibres across transition to subsoil	Partially	NA	Yes	Partially	No	2	1	2	Conservative estimate as no GI at location
		Peat wetness		NA	Dry / Stands well	Slowly squeezing	Extremely wet / Undiggable	2	2	4	Conservative estimate as no GI at location
	Topography	General curvature downslope	-	NA	-	Planar	Convex	1	1	1	
		Distance to the convexity break (only if previous factor is Convex)	NA	NA	> 100 m	50 - 100 m	< 50 m	0	1	0	
		Slope aspect (for high latitudes in northern hemisphere)	NW, N, NE	NA	SW, S, SE	W, E	NW, N, NE	3	1	3	
	Hydrology	Distance from watercourse (m)	< 200	NA	> 300	200 - 300	< 200	3	1	3	
		Surface moisture index (NDMI)	96 -135	NA	0 - 96	96 -135	135 - 174	2	1	2	
		Surface water (water table level indicator)	Ponded in drains	NA	Localised	Ponded in drains	Springs	2	1	2	
		Evidence of piping (subsurface flow)	NA	NA	-	-	Yes	0	1	0	
		Significant surface desiccation (previous summer was dry?)	NA	NA	-	-	Yes	0	1.5	0	
		Existing drainage ditches	Varied / Oblique	NA	Down slope	Varied / Oblique	Across slope	2	1	2	
		Annual rainfall	> 1400 mm/yr	NA	< 1000 mm/yr	1000 - 1400 mm/yr	> 1400 mm/yr	3	1	3	
	Vegetation	Bush	Wetlands	NA	Dry heather	Grassland	Wetlands	3	1	3	
		Forestry (if applicable)	Good growth	NA	Good growth	Fair	Stunted growth	1	1.5	1.5	
	Peat workings	Peat cuts presence	NA	NA	-	Cutaway / Turbary	Machine cut	0	1	0	
		Peat cuts vs contour lines	NA	NA	Perpendicular	Oblique	Parallel	0	1	0	
	Existing loads	Roads	Solid	NA	Solid	-	Floating	1	1	1	
	Time of year for construction		Late Summer, Autumn	NA	Spring	Winter, Early Summer	Late Summer, Autumn	3	1	3	Worse case estimate

Hazard	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

$Hazard_{total}$	45.5
Max. possible	105
$Hazard_{0-1}$	**0.43**

Consequence factors	Value	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Small	NA	Small	Medium	Large	1	3	3	
Downslope hydrology features	Valley	NA	Bowl / contained	Minor undefined watercourse	Valley	3	1	3	
Proximity from defined valley (m)	< 200	NA	> 500	200 - 500	< 200	3	1	3	
Downhill slope angle	Intermediate	NA	Horizontal	Intermediate	Steep	2	1	2	
Downstream aquatic environment	Sensitive	NA	Non-sensitive	Sensitive	Drinking water supply	2	1	2	
Public roads in potential peat flow path	NA	NA	Minor road	Local road	Regional road	0	1	0	
Overhead lines in potential peat flow path	NA	NA	Phone lines	Electricity (LV)	Electricity (MV, HV)	0	1	0	
Buildings in potential peat flow path	NA	NA	Farm out-houses	-	Dwelling	0	1	0	
Capability to respond (access and resources)	Fair	NA	Good	Fair	Poor	2	1	2	

Consequences	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

$Consequences_{total}$	15
Max. possible	33
$Consequences_{0-1}$	**0.45**

Risk rating

Risk		Action required
0.00 - 0.20	Negligible	Normal site investigation
0.20 - 0.40	Low	Targeted site investigation, design of specific mitigation measures. Part time supervision during construction.
0.40 - 0.60	Medium	Avoid construction in the area if possible. If unavoidable, detailed site investigation and design of specific mitigation measures. Full time supervision during construction.
0.60 - 1.00	High	Avoid construction in this area.

Risk rating = Hazard * Consequences

Risk rating = 0.43 0.45 = **0.20**

Table M-14: Peat risk assessment in turbine 14.

GDG / atmos

Peat Stability Risk Assessment (PSRA)

Clydaghroe wind farm

Location:	Turbine 14
Conditions:	Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)
Inspected on:	Mar-22
Inspected by:	SC
Completed by:	IPP
Date:	Oct-22

		Hazard factors	Value	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Factor of Safety			U 4.08 / US 2.40 / D 4.18 / DS 4.68	-	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: ~1.4 m. Slope angle: 4.9º.
Secondary factors	Slide history	Distance to previous slides (km)	< 5	NA	5 - 10	< 5	On site	2	2	4	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	NA	NA	-	-	Yes	0	2	0	
	Subsoil conditions (visible in trial pits)	Subsoil type	Gravel / Firm glacial till	NA	Gravel / Firm glacial till	Smooth rock	Soft sensitive clay	1	1	1	Recovered as light grey/brown slightly sandy very clayey/silty fine to coarse angular to subrounded Gravel with many angular to subrounded cobbles and boulders.
		Peat fibres across transition to subsoil	Partially	NA	Yes	Partially	No	2	1	2	F2 moderate content
		Peat wetness	Slowly squeezing	NA	Dry / Stands well	Slowly squeezing	Extremely wet / Undiggable	2	2	4	B2 less than 500%
	Topography	General curvature downslope	Planar	NA	-	Planar	Convex	2	1	2	
		Distance to the convexity break (only if previous factor is Convex)	NA	NA	> 100 m	50 - 100 m	< 50 m	0	1	0	
		Slope aspect (for high latitudes in northern hemisphere)	NA	NA	SW, S, SE	W, E	NW, N, NE	0	1	0	
	Hydrology	Distance from watercourse (m)	< 200	NA	> 300	200 - 300	< 200	3	1	3	
		Surface moisture index (NDMI)	96 -135	NA	0 - 96	96 -135	135 - 174	2	1	2	
		Surface water (water table level indicator)	Ponded in drains	NA	Localised	Ponded in drains	Springs	2	1	2	
		Evidence of piping (subsurface flow)	NA	NA	-	-	Yes	0	1	0	
		Significant surface desiccation (previous summer was dry?)	NA	NA	-	-	Yes	0	1.5	0	
		Existing drainage ditches	Varied / Oblique	NA	Down slope	Varied / Oblique	Across slope	2	1	2	
		Annual rainfall	> 1400 mm/yr	NA	< 1000 mm/yr	1000 - 1400 mm/yr	> 1400 mm/yr	3	1	3	
	Vegetation	Bush	Grassland	NA	Dry heather	Grassland	Wetlands	2	1	2	
		Forestry (if applicable)	NA	NA	Good growth	Fair	Stunted growth	0	1.5	0	
	Peat workings	Peat cuts presence	NA	NA	-	Cutaway / Turbary	Machine cut	0	1	0	
		Peat cuts vs contour lines	NA	NA	Perpendicular	Oblique	Parallel	0	1	0	
	Existing loads	Roads	NA	NA	Solid	-	Floating	0	1	0	
	Time of year for construction		Late Summer, Autumn	NA	Spring	Winter, Early Summer	Late Summer, Autumn	3	1	3	Worst case estimate

Hazard	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

Hazard total: 40
Max. possible: 105
Hazard 0-1: 0.38

Consequence factors	Value	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Medium	NA	Small	Medium	Large	2	3	6	
Downslope hydrology features	Valley	NA	Bowl / contained	Minor undefined watercourse	Valley	3	1	3	
Proximity from defined valley (m)	200 - 500	NA	> 500	200 - 500	< 200	2	1	2	
Downhill slope angle	Horizontal	NA	Horizontal	Intermediate	Steep	1	1	1	
Downstream aquatic environment	Sensitive	NA	Non-sensitive	Sensitive	Drinking water supply	2	1	2	
Public roads in potential peat flow path	NA	NA	Minor road	Local road	Regional road	0	1	0	
Overhead lines in potential peat flow path	NA	NA	Phone lines	Electricity (LV)	Electricity (MV, HV)	0	1	0	
Buildings in potential peat flow path	NA	NA	Farm out-houses	-	Dwelling	0	1	0	
Capability to respond (access and resources)	Fair	NA	Good	Fair	Poor	2	1	2	

Consequences	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

Consequences total: 16
Max. possible: 33
Consequences 0-1: 0.48

Risk rating

Risk		Action required
0.00 - 0.20	Negligible	Normal site investigation
0.20 - 0.40	Low	Targeted site investigation, design of specific mitigation measures. Part time supervision during construction.
0.40 - 0.60	Medium	Avoid construction in the area if possible. If unavoidable, detailed site investigation and design of specific mitigation measures. Full time supervision during construction.
0.60 - 1.00	High	Avoid construction in this area.

Risk rating = Hazard * Consequences

Risk rating = 0.38 × 0.48 = **0.18**

Table M-15: Peat risk assessment in turbine 15.

GDG GAVIN & DOHERTY GEOSOLUTIONS — **Peat Stability Risk Assessment (PSRA)**

atmos CONSULTING — **Clydaghroe wind farm**

Location:	**Turbine 15**
Conditions:	**Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)**
Inspected on:	Mar-22
Inspected by:	SC
Completed by:	IPP
Date:	Oct-22

Hazard factors			Value U	Value US	Value D	Value DS	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Factor of Safety					6	5.8	-	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: ~1.2 m. Slope angle: 4.33º.
Secondary factors	Slide history	Distance to previous slides (km)	< 5				NA	5 - 10	< 5	On site	2	2	4	
Secondary factors	Slide history	Evidence of peat movement (e.g. tension cracks, step features, compression features).	NA				NA	-	-	Yes	0	2	0	
Secondary factors	Subsoil conditions (visible in trial pits)	Subsoil type	Gravel / Firm glacial till				NA	Gravel / Firm glacial till	Smooth rock	Soft sensitive clay	1	1	1	Conservative estimate as no GI at location
Secondary factors	Subsoil conditions (visible in trial pits)	Peat fibres across transition to subsoil	Partially				NA	Yes	Partially	No	2	1	2	Conservative estimate as no GI at location
Secondary factors	Subsoil conditions (visible in trial pits)	Peat wetness					NA	Dry / Stands well	Slowly squeezing	Extremely wet / Undiggable	2	1	2	Conservative estimate as no GI at location
Secondary factors	Topography	General curvature downslope	Convex				NA	-	Planar	Convex	3	1	3	
Secondary factors	Topography	Distance to the convexity break (only if previous factor is Convex)	NA				NA	> 100 m	50 - 100 m	< 50 m	0	1	0	
Secondary factors	Topography	Slope aspect (for high latitudes in northern hemisphere)	NW, N, NE				NA	SW, S, SE	W, E	NW, N, NE	3	1	3	
Secondary factors	Hydrology	Distance from watercourse (m)	< 200				NA	> 300	200 - 300	< 200	3	1	3	
Secondary factors	Hydrology	Surface moisture index (NDMI)	96 -135				NA	0 - 96	96 -135	135 - 174	2	1	2	
Secondary factors	Hydrology	Surface water (water table level indicator)	NA				NA	Localised	Ponded in drains	Springs	0	1	0	
Secondary factors	Hydrology	Evidence of piping (subsurface flow)	Yes				NA	-	-	Yes	3	1	3	
Secondary factors	Hydrology	Significant surface desiccation (previous summer was dry?)	NA				NA	-	-	Yes	0	1.5	0	
Secondary factors	Hydrology	Existing drainage ditches	NA				NA	Down slope	Varied / Oblique	Across slope	0	1	0	
Secondary factors	Hydrology	Annual rainfall	> 1400 mm/yr				NA	< 1000 mm/yr	1000 - 1400 mm/yr	> 1400 mm/yr	3	1	3	
Secondary factors	Vegetation	Bush	Wetlands				NA	Dry heather	Grassland	Wetlands	3	1	3	
Secondary factors	Vegetation	Forestry (if applicable)	Good growth				NA	Good growth	Fair	Stunted growth	1	1.5	1.5	
Secondary factors	Peat workings	Peat cuts presence	NA				NA	-	Cutaway / Turbary	Machine cut	0	1	0	
Secondary factors	Peat workings	Peat cuts vs contour lines	NA				NA	Perpendicular	Oblique	Parallel	0	1	0	
Secondary factors	Existing loads	Roads	NA				NA	Solid	-	Floating	0	1	0	
Secondary factors	Time of year for construction		Late Summer, Autumn				NA	Spring	Winter, Early Summer	Late Summer, Autumn	3	1	3	Worst case estimate

Hazard	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

$Hazard_{total}$	43.5
Max. possible	102
$Hazard_{0-1}$	**0.43**

Consequence factors	Value	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Medium	NA	Small	Medium	Large	2	3	6	
Downslope hydrology features	Valley	NA	Bowl / contained	Minor undefined watercourse	Valley	3	1	3	
Proximity from defined valley (m)	200 - 500	NA	> 500	200 - 500	< 200	2	1	2	
Downhill slope angle	Horizontal	NA	Horizontal	Intermediate	Steep	1	1	1	
Downstream aquatic environment	Sensitive	NA	Non-sensitive	Sensitive	Drinking water supply	2	1	2	
Public roads in potential peat flow path	NA	NA	Minor road	Local road	Regional road	0	1	0	
Overhead lines in potential peat flow path	NA	NA	Phone lines	Electricity (LV)	Electricity (MV, HV)	0	1	0	
Buildings in potential peat flow path	NA	NA	Farm out-houses	-	Dwelling	0	1	0	
Capability to respond (access and resources)	Fair	NA	Good	Fair	Poor	2	1	2	

Consequences	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

$Consequences_{total}$	16
Max. possible	33
$Consequences_{0-1}$	**0.48**

Risk rating

Risk		Action required
0.00 - 0.20	Negligible	Normal site investigation
0.20 - 0.40	Low	Targeted site investigation, design of specific mitigation measures. Part time supervision during construction.
0.40 - 0.60	Medium	Avoid construction in the area if possible. If unavoidable, detailed site investigation and design of specific mitigation measures. Full time supervision during construction.
0.60 - 1.00	High	Avoid construction in this area.

Risk rating = Hazard * Consequences

Risk rating = 0.43 × 0.48 = **0.21**

Table M-16: Peat risk assessment in turbine 16.

GDG GAVIN & DOHERTY GEOSOLUTIONS

atmos CONSULTING

Peat Stability Risk Assessment (PSRA)

Clydaghroe wind farm

Location:	**Turbine 16**
Conditions:	**Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)**
Inspected on:	Mar-22
Inspected by:	SC
Completed by:	IPP
Date:	Oct-22

Hazard factors			Value (U / US / D / DS)	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Factor of Safety			2.45 / 1.59 / 2.54 / 3.11	-	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: ~1.8 m. Slope angle: 6.9º.
Secondary factors	Slide history	Distance to previous slides (km)	< 5	NA	5 - 10	< 5	On site	2	2	4	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	NA	NA	-	-	Yes	0	2	0	
	Subsoil conditions (visible in trial pits)	Subsoil type	Gravel / Firm glacial till	NA	Gravel / Firm glacial till	Smooth rock	Soft sensitive clay	1	1	1	Conservative estimate as no GI at location
		Peat fibres across transition to subsoil	Partially	NA	Yes	Partially	No	2	1	2	Conservative estimate as no GI at location
		Peat wetness	Slowly squeezing	NA	Dry / Stands well	Slowly squeezing	Extremely wet / Undiggable	2	1	2	Conservative estimate as no GI at location
	Topography	General curvature downslope	Planar	NA	-	Planar	Convex	2	1	2	
		Distance to the convexity break (only if previous factor is Convex)	NA	NA	> 100 m	50 - 100 m	< 50 m	0	1	0	
		Slope aspect (for high latitudes in northern hemisphere)	NW, N, NE	NA	SW, S, SE	W, E	NW, N, NE	3	1	3	
	Hydrology	Distance from watercourse (m)	> 300	NA	> 300	200 - 300	< 200	1	1	1	
		Surface moisture index (NDMI)	135 - 174	NA	0 - 96	96 -135	135 - 174	3	1	3	
		Surface water (water table level indicator)	Localised	NA	Localised	Ponded in drains	Springs	1	1	1	
		Evidence of piping (subsurface flow)	NA	NA	-	-	Yes	0	1	0	
		Significant surface desiccation (previous summer was dry?)	NA	NA	-	-	Yes	0	1.5	0	
		Existing drainage ditches	NA	NA	Down slope	Varied / Oblique	Across slope	0	1	0	
		Annual rainfall	> 1400 mm/yr	NA	< 1000 mm/yr	1000 - 1400 mm/yr	> 1400 mm/yr	3	1	3	
	Vegetation	Bush	Wetlands	NA	Dry heather	Grassland	Wetlands	3	1	3	
		Forestry (if applicable)	Good growth	NA	Good growth	Fair	Stunted growth	1	1.5	1.5	
	Peat workings	Peat cuts presence	NA	NA	-	Cutaway / Turbary	Machine cut	0	1	0	
		Peat cuts vs contour lines	NA	NA	Perpendicular	Oblique	Parallel	0	1	0	
	Existing loads	Roads	NA	NA	Solid	-	Floating	0	1	0	
	Time of year for construction		Late Summer, Autumn	NA	Spring	Winter, Early Summer	Late Summer, Autumn	3	1	3	Worst case estimate

Hazard	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

Hazard $_{total}$	39.5
Max. possible	102
Hazard $_{0-1}$	**0.39**

Consequence factors	Value	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Small	NA	Small	Medium	Large	1	3	3	
Downslope hydrology features	Valley	NA	Bowl / contained	Minor undefined watercourse	Valley	3	1	3	
Proximity from defined valley (m)	> 500	NA	> 500	200 - 500	< 200	1	1	1	
Downhill slope angle	Horizontal	NA	Horizontal	Intermediate	Steep	1	1	1	
Downstream aquatic environment	Sensitive	NA	Non-sensitive	Sensitive	Drinking water supply	2	1	2	
Public roads in potential peat flow path	NA	NA	Minor road	Local road	Regional road	0	1	0	
Overhead lines in potential peat flow path	NA	NA	Phone lines	Electricity (LV)	Electricity (MV, HV)	0	1	0	
Buildings in potential peat flow path	NA	NA	Farm out-houses	-	Dwelling	0	1	0	
Capability to respond (access and resources)	Fair	NA	Good	Fair	Poor	2	1	2	

Consequences	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

Consequences $_{total}$	12
Max. possible	33
Consequences $_{0-1}$	**0.36**

Risk rating

Risk		Action required
0.00 - 0.20	Negligible	Normal site investigation
0.20 - 0.40	Low	Targeted site investigation, design of specific mitigation measures. Part time supervision during construction.
0.40 - 0.60	Medium	Avoid construction in the area if possible. If unavoidable, detailed site investigation and design of specific mitigation measures. Full time supervision during construction.
0.60 - 1.00	High	Avoid construction in this area.

Risk rating = Hazard * Consequences

Risk rating = 0.39 × 0.36 = **0.14**

Table M-16: Peat risk assessment in turbine 17.

GDG GAVIN & DOHERTY GEOSOLUTIONS — **Peat Stability Risk Assessment (PSRA)**

atmos CONSULTING — **Clydaghroe wind farm**

Location:	**Turbine 17**
Conditions:	**Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)**
Inspected on:	Mar-22
Inspected by:	SC
Completed by:	IPP
Date:	Oct-22

Hazard factors			Value (U / US / D / DS)	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Factor of Safety				-	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: ~1.6 m. Slope angle: 3.2º.
Secondary factors	Slide history	Distance to previous slides (km)	< 5	NA	5 - 10	< 5	On site	2	2	4	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	NA	NA	-	-	Yes	0	2	0	
	Subsoil conditions (visible in trial pits)	Subsoil type	Gravel / Firm glacial till	NA	Gravel / Firm glacial till	Smooth rock	Soft sensitive clay	1	1	1	Soft greenish grey slightly sandy slightly gravelly CLAY/SILT
		Peat fibres across transition to subsoil	Partially	NA	Yes	Partially	No	2	1	2	F2 moderate content
		Peat wetness	Slowly squeezing	NA	Dry / Stands well	Slowly squeezing	Extremely wet / Undiggable	2	1	2	B2 less than 500%
	Topography	General curvature downslope	Planar	NA	-	Planar	Convex	2	1	2	
		Distance to the convexity break (only if previous factor is Convex)	NA	NA	> 100 m	50 - 100 m	< 50 m	0	1	0	
		Slope aspect (for high latitudes in northern hemisphere)	NA	NA	SW, S, SE	W, E	NW, N, NE	0	1	0	
	Hydrology	Distance from watercourse (m)	< 200	NA	> 300	200 - 300	< 200	3	1	3	
		Surface moisture index (NDMI)	96 -135	NA	0 - 96	96 -135	135 - 174	2	1	2	
		Surface water (water table level indicator)	NA	NA	Localised	Ponded in drains	Springs	0	1	0	
		Evidence of piping (subsurface flow)	NA	NA	-	-	Yes	0	1	0	
		Significant surface desiccation (previous summer was dry?)	-	NA	-	-	Yes	1	1.5	1.5	
		Existing drainage ditches	Varied / Oblique	NA	Down slope	Varied / Oblique	Across slope	2	1	2	
		Annual rainfall	> 1400 mm/yr	NA	< 1000 mm/yr	1000 - 1400 mm/yr	> 1400 mm/yr	3	1	3	
	Vegetation	Bush	Wetlands	NA	Dry heather	Grassland	Wetlands	3	1	3	
		Forestry (if applicable)	Good growth	NA	Good growth	Fair	Stunted growth	1	1.5	1.5	
	Peat workings	Peat cuts presence	Cutaway / Turbary	NA	-	Cutaway / Turbary	Machine cut	2	1	2	
		Peat cuts vs contour lines	Perpendicular	NA	Perpendicular	Oblique	Parallel	1	1	1	
	Existing loads	Roads	Floating	NA	Solid	-	Floating	3	1	3	
	Time of year for construction		Late Summer, Autumn	NA	Spring	Winter, Early Summer	Late Summer, Autumn	3	1	3	Worst case estmate

Hazard	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

Hazard $_{total}$	46
Max. possible	102
Hazard $_{0-1}$	**0.45**

Consequence factors	Value	Rating criteria 0	1	2	3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Medium	NA	Small	Medium	Large	2	3	6	
Downslope hydrology features	Minor undefined watercourse	NA	Bowl / contained	Minor undefined watercourse	Valley	2	1	2	
Proximity from defined valley (m)	< 200	NA	> 500	200 - 500	< 200	3	1	3	
Downhill slope angle	Intermediate	NA	Horizontal	Intermediate	Steep	2	1	2	
Downstream aquatic environment	Sensitive	NA	Non-sensitive	Sensitive	Drinking water supply	2	1	2	
Public roads in potential peat flow path	NA	NA	Minor road	Local road	Regional road	0	1	0	
Overhead lines in potential peat flow path	NA	NA	Phone lines	Electricity (LV)	Electricity (MV, HV)	0	1	0	
Buildings in potential peat flow path	NA	NA	Farm out-houses	-	Dwelling	0	1	0	
Capability to respond (access and resources)	Fair	NA	Good	Fair	Poor	2	1	2	

Consequences	
0.0 - 0.3	Negligible
0.3 - 0.5	Low
0.5 - 0.7	Medium
0.7 - 1.0	High

Consequences $_{total}$	17
Max. possible	33
Consequences $_{0-1}$	**0.52**

Risk rating

Risk		Action required
0.00 - 0.20	Negligible	Normal site investigation
0.20 - 0.40	Low	Targeted site investigation, design of specific mitigation measures. Part time supervision during construction.
0.40 - 0.60	Medium	Avoid construction in the area if possible. If unavoidable, detailed site investigation and design of specific mitigation measures. Full time supervision during construction.
0.60 - 1.00	High	Avoid construction in this area.

Risk rating = Hazard * Consequences

Risk rating = 0.45 0.52 = **0.23**

Appendix N Peat Repository and Borrow Pit Stability Analysis

TECHNICAL NOTE

Project title:	Cummeennabuddoge Wind Farm		
Subject:	Peat Repository and Borrow Pit Stability		
To:	Atmos Consulting Ltd.		
Project number:	20263	Document ref.:	20263-TN-006
Prepared by: Checked by: Approved by:	Kelly Griffin Tomas McGrath Stephen Curtis	Revision: Date of issue:	01 20/03/2024

Table of Contents

1 INTRODUCTION

Gavin and Doherty Geosolutions Ltd. (GDG) was requested by Atmos Consulting Ltd. to prepare a Peat Stability Risk Assessment (PSRA) for the proposed Cummeennabuddoge Wind Farm site located in Co. Kerry, adjacent to the county boundary with Co. Cork, close to the village of Ballyvourney.

This technical note details the planning stage assessment of the proposed structures:

- Peat repository areas where retaining structures (berms) are proposed to retain approximately 1m of peat, and
- Borrow pit areas where intermediate retaining (berm) structures are proposed within the borrow pit levels to retain the peat and spoil material used in the borrow pit reinstatement.

This technical note is considered to be supplementary to the PSRA (GDG Doc. Ref. 20263-PSRA-001-02and Appendix 10-1 of this EIAR). It should be noted that this technical note contains a preliminary review only and is considered to provide high level insight into geotechnical design consideration at planning stage. This is not to be used for design or construction purposes and is advised to be revisited following a detailed review and interpretation of the geotechnical parameters following verification by in-situ testing for use in design, specific to the final design solution.

1.1 SCOPE

The scope of this technical note is as follows:

- Carry out a bearing capacity assessment of the subgrade (peat) underlying the proposed peat repository area cell berms, considering a range of undrained shear strengths including 9kPa, 14kPa and 20kPa which are considered representative of the geotechnical parameters for the in-situ peat based on limited field testing.
- Conduct a sliding check for the proposed berms at the borrow pit and peat repository areas.
- Conduct a stability analysis for 6 no. design cross sections through the proposed peat repository areas likely representative of the conditions on site, considering a range of slopes at the toe of the berm including 0%, 5%, 10%, 15% ,20% and 25%. (Corresponding to slope angles of 0^{o}, 2.9^{o}, 5.7^{o}, 8.6^{o}, 11.3^{o} and 14.2^{o} respectively).

Bearing capacity assessment and slope stability assessment was not required at the borrow pit areas these structures will be constructed directly on or embedded within competent bedrock material. At the construction stage, inspection and assessment of the bedrock and the exposed rock cutting will need to be conducted by a suitable qualified engineer and structural assessments such as rock mass rating will be carried out.

1.2 DESIGN ASSUMPTIONS

To prevent uncertainty, the following design assumptions have been made in this analysis.

- Peat Repository Areas
    - The cell berm is assumed to be 1.25m in height, with a width at the top equal to 1m, side slopes with a gradient of 1:2 (v:h), resulting in a base width of 6m as illustrated in Figure 1-1.

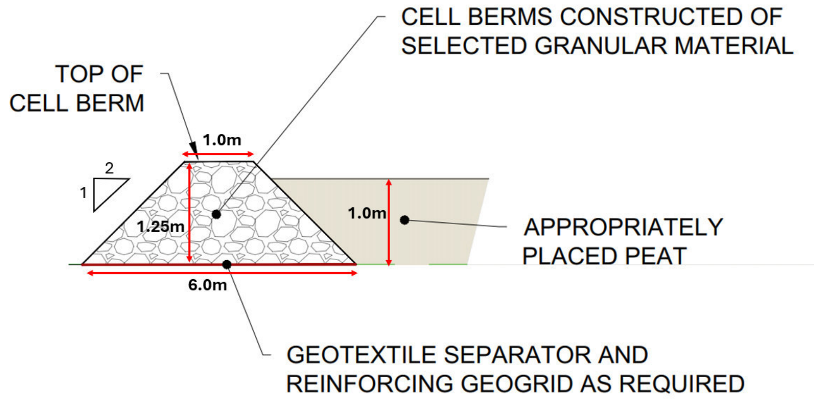


Figure 1-1: Assumed dimensions of proposed peat repository berm

- It is assumed that the cell berm shall be constructed with selected granular materials assumed have the following geotechnical characteristics: Friction angle = 35^{o}, Unit weight = $19kN/m^3$ and cohesion intercept = 0kPa. The party responsible for the selection of this material shall ensure compliance with the geotechnical characteristics described in this technical note.
- The design of the drainage measures and restraint systems are outside the scope of this technical note.
- The characteristic geotechnical parameters assumed in this technical note are based on limited in-situ field testing. It is recommended that prior to the detailed design stage, the geotechnical parameters are verified by in-situ testing.
- The characteristic undrained shear strength of the peat deposits is based in-situ hand shear vane tests at 17 no. locations with results ranging from 9kPa to 32kPa with an average value of 18.5kPa. For the purpose of this preliminary assessment, the undrained shear strength of peat was modelled based on a lower bound estimate of 9kPa, a best estimate of 14kPa and upper bound of 20kPa.
- The ground conditions assumed at each peat repository area are described in Table 1-1.

Table 1-1: Ground conditions at each peat repository area

Peat Repository	Peat Thickness (m)	Minimum Gradient (^{o})	Maximum Gradient (%)	Undrained Shear Strength (kPa)
PR1	2.6	3.9	6.8	11-22
PR2	2.5	7.4	13.0	20-22
PR3	3.0	7.1	12.5	15-33
PR4	2.5	5.5	9.6	15-17
PR5	2.3	8.4	14.8	13-19
PR6	2.0	3.8	6.7	17-19

- Borrow Pit Areas
  - The borrow pit cell berm is assumed to be 2.5m in height, with a width at the top equal to 1m, side slopes with a gradient of 1:1 (V:H), resulting in a base width of 6m as illustrated in Figure 1-2.

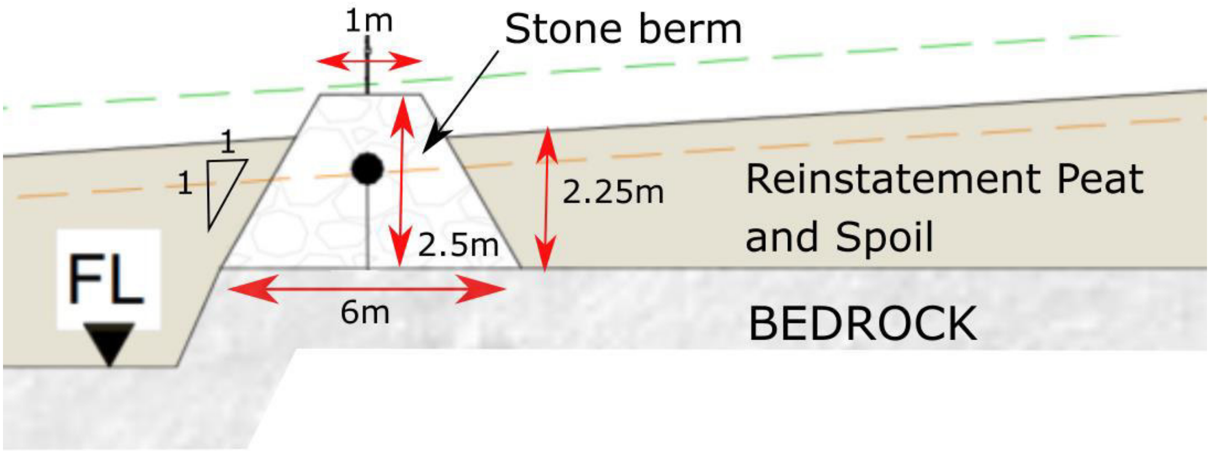


Figure 1-2: Assumed dimensions of proposed borrow pit berm

- It is assumed that the cell berm shall be constructed with selected granular materials assumed have the following geotechnical characteristics: Friction angle = 35^o, Unit weight = 19kN/m^3 and cohesion intercept = 0kPa. The party responsible for the selection of this material shall ensure compliance with the geotechnical characteristics described in this technical note.
- The design of the drainage measures and restraint systems are outside the scope of this technical note.
- The characteristic geotechnical parameters assumed in this technical note are based on limited in-situ field testing. It is recommended that prior to the detailed design stage, the geotechnical parameters are verified by in-situ testing.
- The basal or bearing material for the borrow pit berms is proposed to be the local sandstone or siltstone bedrock. The conservative characteristic geotechnical parameters assumed for this include: Friction angle = 30^o, Unit weight = 25kN/m^3 and cohesion intercept = 55kPa.

1.3 INTERPRETATION OF GROUND CONDITIONS

The ground model for this assessment has been derived based on the information provided in the Geotechnical Interpretive Report (GIR) (Document Reference Technical Appendix 10-1 issued February 2024) and the PSRA (Document Reference: 20263-PRSA-001-02 issued 20/12/2023).

In general, the ground investigations across the site identified a ground model consisting of varying thicknesses of peat material overlying grey sandy gravely SILT/CLAY and/or dark brown angular sandy GRAVEL and weathered sandstone bedrock. The site area is generally covered with a peat body, with some areas of glacial till outcrop and bedrock outcrop identified through the site naturally at the higher areas and at eroded watercourses faces, as well as at the existing road cutting and drainage excavations.

The peat thickness varied across the site from 0m to a maximum of 5.4m. Examination of the identified peat depth, in correlation with the site contours would suggest that the peat material exists in relatively thin thicknesses on the higher angle slopes (>5^o). The larger peat thickness (>2.5m) are generally topographically constrained, identified in isolated areas where lower topographic slopes have enabled peat to remain and form developing into larger thicknesses.

2 Bearing resistance to I.S. EN 1997-1:2005

The bearing resistance was carried out in accordance with I.S. EN 1997-1:2005 (EC7). The bearing resistance assessment was completed following EC7 Design approach 1 Combination 1 (DA1-C1) and Combination 2 (DA1-C2), using the appropriate factors.

The anticipated characteristic actions applied to the subgrade is assumed to be the self-weight of the proposed cell berm conservatively assumed to be 25kPa (i.e., 1.25m x 19kN/m^3). As a result, the bearing resistance at the top of the in-situ peat has been assessed in the undrained condition only as described in the following sections. The bearing resistance was calculated for each of the 3 no. shear strength options presented in Table 2-1

The bearing resistance assessment was completed at the interface between the in-situ peat material and the proposed granular cell berm. As the design groundwater level has been taken to be 0.0m bgl, the subformation material has been assumed to be fully saturated for all design cases with the effective unit weight taken to be the difference between the bulk unit weight of the soil (typically 12 kN/m^3) and the unit weight of water (10 kN/m^3).

Table 2-1: Summary of design bearing resistance results for in-situ peat

Embedment depth beneath existing ground level (m)	Undrained Shear Strength	Design Approach	Ultimate Bearing Resistance (kPa)	Over Design Factor
0.00	9	DA1 C1	46	1.37
0.00	9	DA1 C2	33	1.32
0.00	14	DA1 C1	72	2.13
0.00	14	DA1 C2	51	2.06
0.00	20	DA1 C1	103	3.05
0.00	20	DA1 C2	73	2.94

3 Sliding resistance to I.S. EN 1997-1:2005

3.1 Peat repository areas

The sliding resistance check was carried out in accordance with I.S. EN 1997-1:2005 (EC7). The sliding resistance assessment was completed following EC7 Design approach 1 Combination 1 (DA1-C1) and Combination 2 (DA1-C2), using the appropriate factors, and considered both the undrained (total stress) and drained (effective stress) conditions. The retained material was therefore modelled with a c_u of 5kPa and a remoulded angle of internal friction of 15°. The intact peat beneath the bund was modelled with a c_u of 9kPa and a remoulded angle of internal friction of 20°.

For compliance with the I.S. EN 1997-1:2005 sliding resistance requirements, the following inequality shall be satisfied:

$$H_d \leq R_d$$

The design horizontal (H_d) action is given by:

$$H_d = P'_{ad} + U'_{ad} \text{ for the drained condition, and}$$

$$H_d = 0.5*(\sigma_{vd} - K_{ac}\ .c_{ud})h \text{ for the undrained condition.}$$

Where:

- P'_{ad} is the effective earth thrust.
- U'_{ad} is the effective groundwater thrust.
- σ_{vd} is the total vertical stress of the retained material.
- K_{acd} is the design coefficient of active earth pressure.
- c_{ud} is the undrained shear strength of the retained material.
- h is the height of the retained material.

The design horizontal resistance (R_d) is given by:

$$R_d = (V'_d \cdot \tan \delta_d) / \gamma_{R;h} \text{ for the drained condition, and}$$

$$R_d = (A_c \cdot c_{ud}) / \gamma_{R;h} \text{ for the undrained condition.}$$

Where:

- V'_d is the design value of the effective vertical action or component of the total action acting normal to the foundation base, and
- δ_k is the critical interface shear angle between the base of the bund, including the interface between the geotextile and confining soils, and the natural soils (i.e. intact peat). δ_k was taken as 15° (or 75% of the angle of internal friction of the peat) assuming the most critical interface is between the geotextile and the intact peat.
- $\gamma_{R;h}$ is the partial factor for sliding resistance taken as per I.S. EN 1997-1:2005.
- A_c is the total base area of the bund in compression.

The resulting ratio of the estimated horizontal resisting forces at the proposed berm structure compared with the horizontal loading of the reinstated peat and/or spoil material, expressed as an over design factor (ODF). The resulting ODF values for all proposed peat repository area berms exceeded 1.0 and therefore are deemed acceptable.

3.2 Borrow Pit Areas

A similar sliding check was carried out at the borrow pit area berms in accordance with I.S. EN 1997-1:2005 (EC7) and the same calculations were applied, considering EC7 Design approach 1 Combination 1 (DA1-C1) and Combination 2 (DA1-C2).

However, the follow differences were considered:

- δ_k is the critical interface shear angle between the base of the bund, including the interface between the geotextile and confining soils, and the natural soils (i.e. bedrock). δ_k was taken as 0° (horizontal) as this area will have been previously broken out for bedrock extraction.

The ODF for each design case exceeded 1.0 and therefore was deemed acceptable.

4 Cell Berm Stability Assessment

4.1 Design Assumptions and Model Set Up

The stability analyses of the peat repository cell berms for the proposed Cummeennabuddoge Wind Farm have been completed using the GeoStudio 2021 software package SLOPE/W. SLOPE/W uses limit equilibrium calculations to establish a factor of safety, over design factor or degree of utilisation for a two-dimensional plain-strain cross-section of the peat repository areas. As a result, the SLOPE/W analysis does not account for the three-dimensional effects associated with rectangular, square, or circular loading footprints. The method of analysis adopted was that of

Morgenstern-Price in combination with a grid and radius slip-surface definition to determine the critical circular and near-circular slip planes beneath the proposed structure.

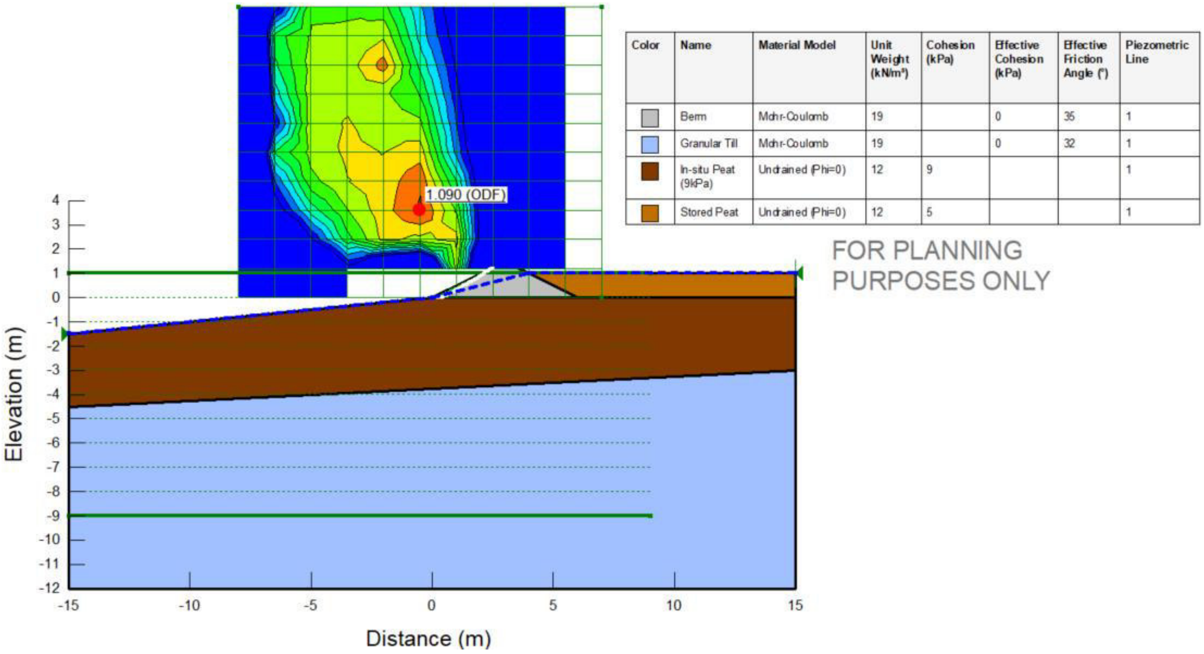
- For the stability analysis of the peat repository cell berms the EC7 design approaches DA1 C2 condition only were used within the SLOPE/W analysis.
- The following design assumptions apply to the Slope/W modelling:
- The subgrade underlying all cell berms was anticipated to consist of peat overlying granular glacial till. The peat was modelled as an undrained material and the granular deposits (glacial till and proposed cell berm) were modelled as Mohr-Coulomb materials in the design software.
- 6 no. models were assessed whereby the ground surface was modelled with a 0%, 5%, 10%, 15%, 20% and 25% gradient beyond the toe of the proposed berm.
- The groundwater level was conservatively modelled to be at 0mbgl.
- It is assumed sufficient site drainage shall be installed and maintained throughout the design life of the wind farm.
- The undrained shear strength of the peat varied depending on the gradient of the slope at the toe of the berm. An undrained shear strength of 9kPa was assumed for the models with a 0%, 5% and 10% gradient, while an undrained shear strength of 14kPa was assumed when the slope was modelled as 15% and 20% while and undrained shear strength of 20kPa was modelled with a toe slope of 25%.

4.2 SLOPE STABILITY ASSESSMENT RESULTS

Table 4-1 presents a summary of the critical failure planes analysed in SLOPE/W with the models demonstrating ODF values greater than or equal to 1.0 for the slope stability as required under EC7. An example of the critical failure plane for a berm installed on a low strength peat deposits with a slope angle of 10% at the toe is presented in Figure 4-1 . The other SLOPE/W model outputs have been appended to this document.

Table 4-1: Summary of SLOPE/W models

Gradient at toe of berm (%)	Subgrade shear strength parameters (kPa)	Minimum embedment depth (m)	ODF (DA1C2 only)
0	9	0	1.11
5	9	0	1.13
10	9	0	1.09
15	14	0	1.27
20	14	0	1.05
25	20	0	1.14



Color	Name	Material Model	Unit Weight (kN/m³)	Cohesion (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Line
	Berm	Mohr-Coulomb	19		0	35	1
	Granular Till	Mohr-Coulomb	19		0	32	1
	In-situ Peat (9kPa)	Undrained (Phi=0)	12	9			1
	Stored Peat	Undrained (Phi=0)	12	5			1

Figure 4-1: Critical failure plane for a berm installed on low strength peat with c_u of 9kPa and gradient at the toe of 10%

- The results from this analysis indicate that the berm is expected to maintain sufficient stability across all scenarios, provided that the geotechnical parameters of the in-situ materials comply with the assumptions stated in this technical note.
- The SLOPE/W models, based on worst-case scenarios, assume a uniform peat thickness of 3m with conservative undrained shear strength parameters. When considering the anticipated conditions at each proposed repository area (Table 1-1), it is unlikely that the subgrade will consist of peat with a uniform thickness. In general peat is likely to be in the range of 2.5m, and undulating in nature, including pockets of shallower peat and occasional obstructions like boulders, potentially enhancing stability.
- Furthermore, given the site's topography, it is unlikely that the slope angle at the berm's toe will exceed 15%. It is also possible that the shear strength parameters of the in-situ peat may be more favourable than assumed, given the results obtained from the hand shear vane testing.
- It should be noted that these results are preliminary and are intended provide high level insight into geotechnical design consideration at planning stage. This is not to be used for design or construction purposes and is advised to be revisited following a detailed review and interpretation of the geotechnical parameters following verification by in-situ testing for use in design, specific to the final design solution.

5 Conclusions

GDG has completed a preliminary bearing capacity assessment and stability analysis for the cell berms proposed to be installed at each of the six peat repository areas at the Cummeendabuddoge Wind Farm site. A sliding resistance check was carried out for the proposed berms at the peat repository and borrow pit areas. The resistance check examines the resistance of the proposed berm to the estimated horizontal forces from the reinstated peat and spoil material. The assessments have been carried out in accordance with I.S. EN 1997-1:2005 and the results of each assessment are detailed in Sections 2 and 4.

The findings are as follows:

- Results of the bearing capacity assessment at the peat repository areas indicate that in-situ peat has sufficient bearing capacity to support the cell berm, assuming the in-situ peat with characteristic undrained shear strengths of 9kPa, 14kpa and 20kPa and provided the geometry of the berm is as described in this technical note.
- The results of the sliding assessments at the peat repository area and borrow pit berms suggest that the proposed berms provide sufficient sliding resistance to the estimated horizontal loading caused by the proposed reinstated materials.
- The results from the slope stability analysis indicate that the berm at the peat repository areas is expected to maintain sufficient stability across all scenarios examined in this technical note, provided that the geotechnical parameters of the in-situ materials comply with the assumptions stated in this assessment.
- The results detailed in this technical note are considered preliminary only and are intended provide high level insight into geotechnical design consideration at planning stage. This is not to be used for design or construction purposes and is advised to be revisited following a detailed review and interpretation of the geotechnical parameters following verification by in-situ testing for use in design, specific to the final design solution.
- A Designer's risk assessment (DRA) has been carried out with respect to the above elements and is included in Appendix A. This is considered to provide preliminary insight into the design risks identified at planning stage and it is recommended that these are incorporated into risk assessments at detailed design stage.

Appendix A DESIGNER'S RISK ASSESSMENT

DESIGNER'S ASSESSMENT OF SAFETY AND HEALTH HAZARDS/RISKS			
Designer Company Gavin & Doherty Geosolutions	Project: Cummeenabuddoge Wind Farm	**Designer:** K. Griffin	Date: 01/03/2024
	Project No: 20263	Checker: TMcG	Sheet No: 1
Design Stage: Peat Repository Stability Assessment (Planning Stage)			

No.	Key construction hazards (or risks) identified	Evaluations, Design decisions made (or alternative actions)
1	Unforeseen ground conditions or adoption of inadequate design parameters.	The ground investigation data is limited to the locations and depths tested; hence many parameters have been derived from empirical methods. Parameters have been derived based on the available information and literature review, and as such conservative parameters have been assumed to account for the limitation in the data for certain materials. The Contractor should be aware of the ground model derived from site investigation phases and ensure that ground conditions assumed, comply with those on site when undertaking any intrusive works. All works will need to be confirmed by the project design team at the construction stage and the geometries of the design reevaluated alongside the confirmatory GI and the onsite assessments following felling. The results of the confirmatory GI , including peat depths, derived results of insitu and groundwater conditions, will need to be assessed by the project team so that implications can be assessed.
2	Design loads	The assessment is only valid for the loads as stated in this design report. The design loading considered for the bearing capacity assessment of the in-situ subgrade underlying the proposed cell berm has been assumed to be as a result of the berms self-weight. Hence, the assessment is only valid if the geometry of the berm complies with dimensions detailed in this technical note. Any variances in the geometry as described in this technical should be communicated with the design team to assess.
3	Collapse of berm/peat slippage	Underestimation of peat depth could contribute to an increased risk of berm collapse/peat slippage. Planning stage ground investigation, including trial pitting, Russian coring and peat probing, has been carried out across the site. GI has been carried out at locations where access was possible. Access was limited to some areas of the site, with restrictions on forestry and terrain limiting coverage. Further GI will be required at these locations during the detailed design and construction stage to assess peat depths and confirm engineering parameters. The design team shall develop their own testing criteria

		to satisfy and derisk the possibility of larger peat depths occurring at these locations.
4	Collapse of borrow pit cut wall	The assessment carried out as part of this technical note examines the suitability of the proposed berms for the containment of the reinstated materials at the borrow pit locations. The assessment assumes that the berms at the borrow pit areas will be bearing on competent bedrock. Assessment of the bedrock and insitu materials will be required during the construction stage verification ground investigations and inspection of any excavated/ cut faces must be carried out an appropriately qualified geotechnical engineer.
5	Engulfment	The loose granular berms may pose an engulfment hazard if they shift or slide. Workers shall not stand, climb, or walk on the berms without appropriate safety equipment.

Other parties please take note: These are designer's risk evaluations of the design options carried out in-house for the purpose of our complying with designers' duties under the Safety, Health and Welfare at Work (Construction) Regulations 2013.The evaluations relate only to those aspects/elements of the project which we are responsible for designing under the terms of our appointment by our client.
Other parties should not rely on these evaluations for their own purposes; in particular, contractors, who must deal with and control all risks arising during construction, must carry out their own definitive risk assessments ab initio for that purpose.

Appendix B SLOPE/W OUTPUTS

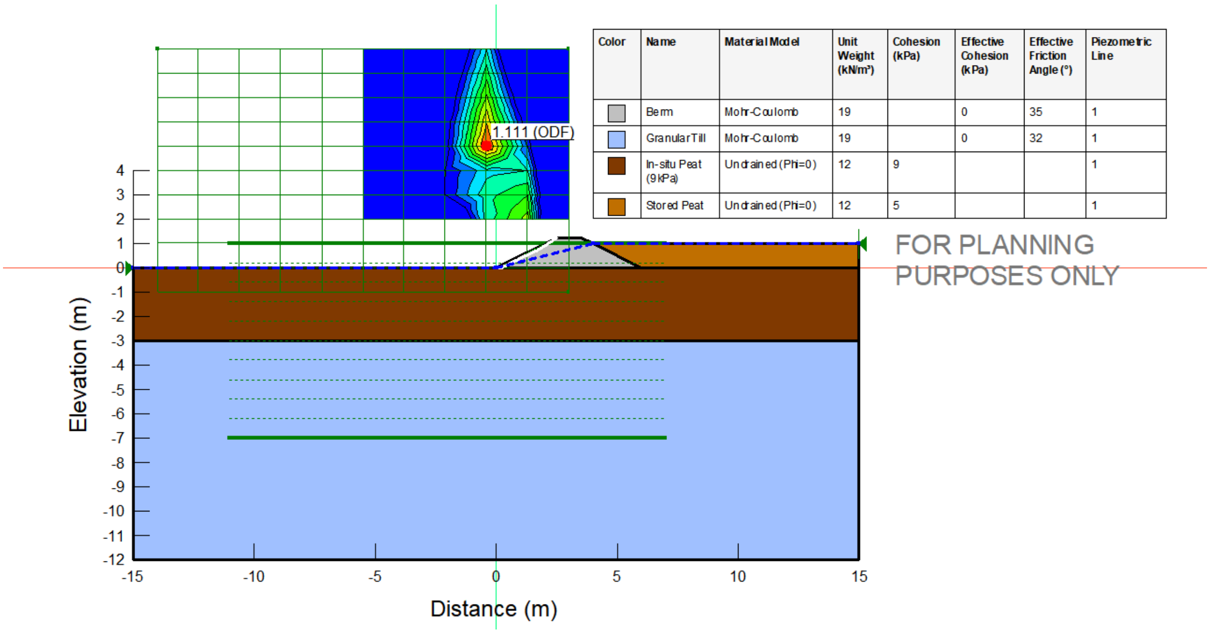


Figure 5-1: Critical failure pane developed from Slope/W model of peat repository area with on low strength peat with c_u of 9kPa and gradient at the toe of 0% (Undrained , DA1C2)

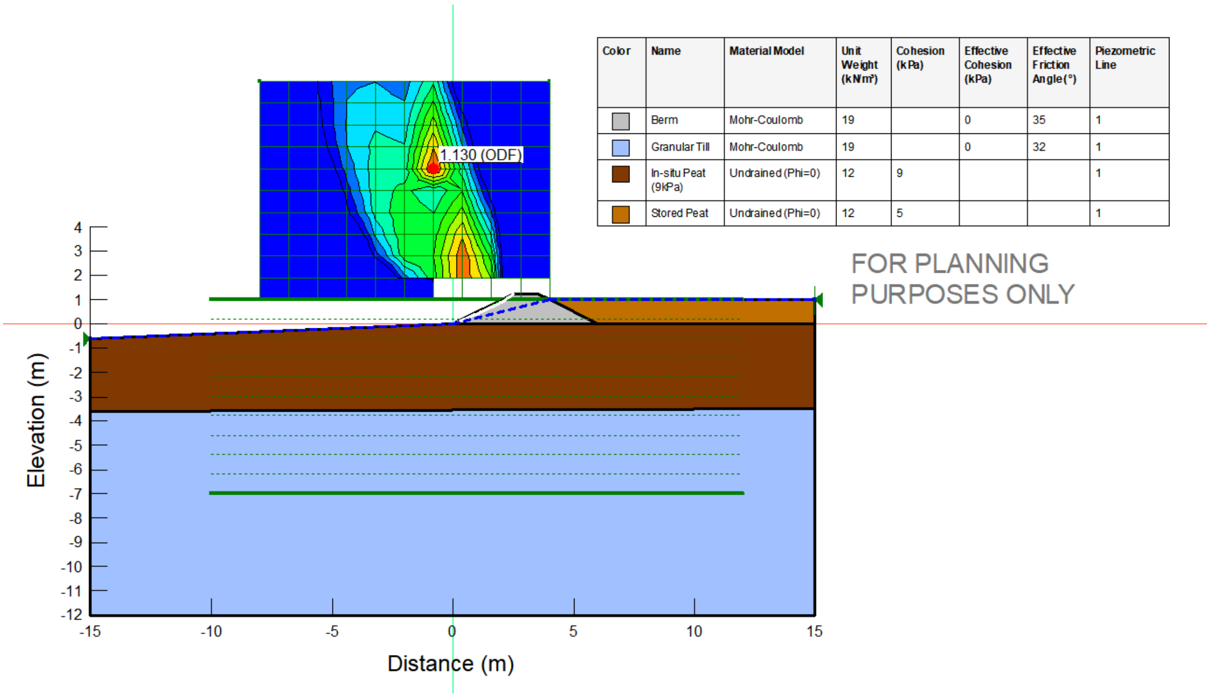


Figure 5-2: Critical failure pane developed from Slope/W model of peat repository area with on low strength peat with c_u of 9kPa and gradient at the toe of 5% (Undrained , DA1C2)

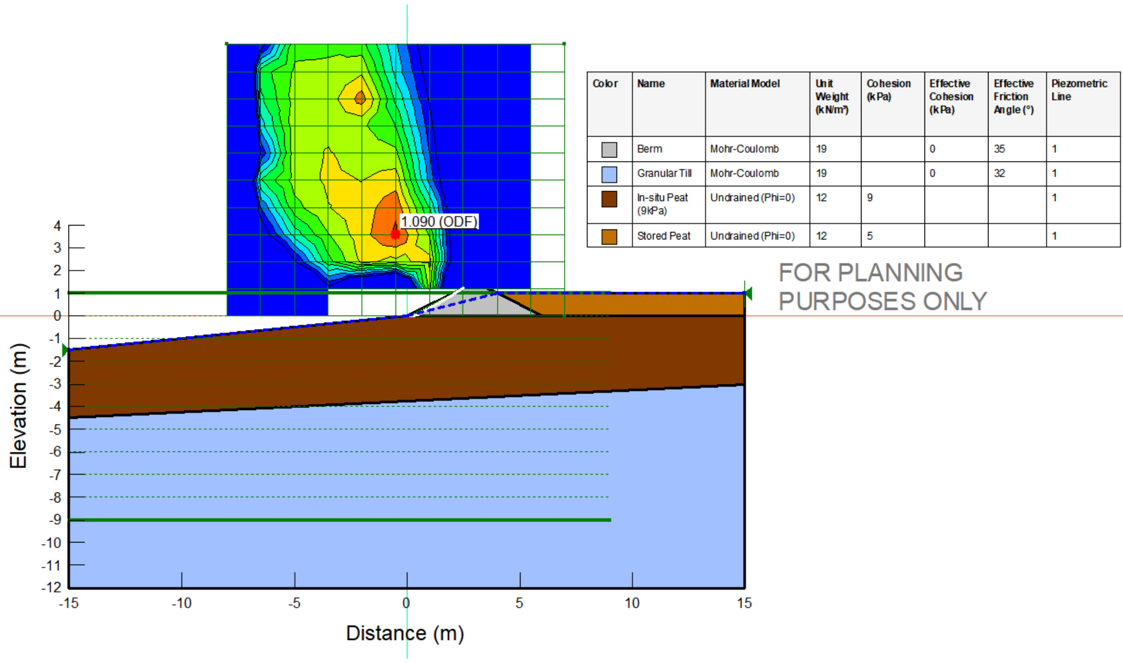


Figure 5-3: Critical failure pane developed from Slope/W model of peat repository area with on low strength peat with c_u of 9kPa and gradient at the toe of 10% (Undrained , DA1C2)

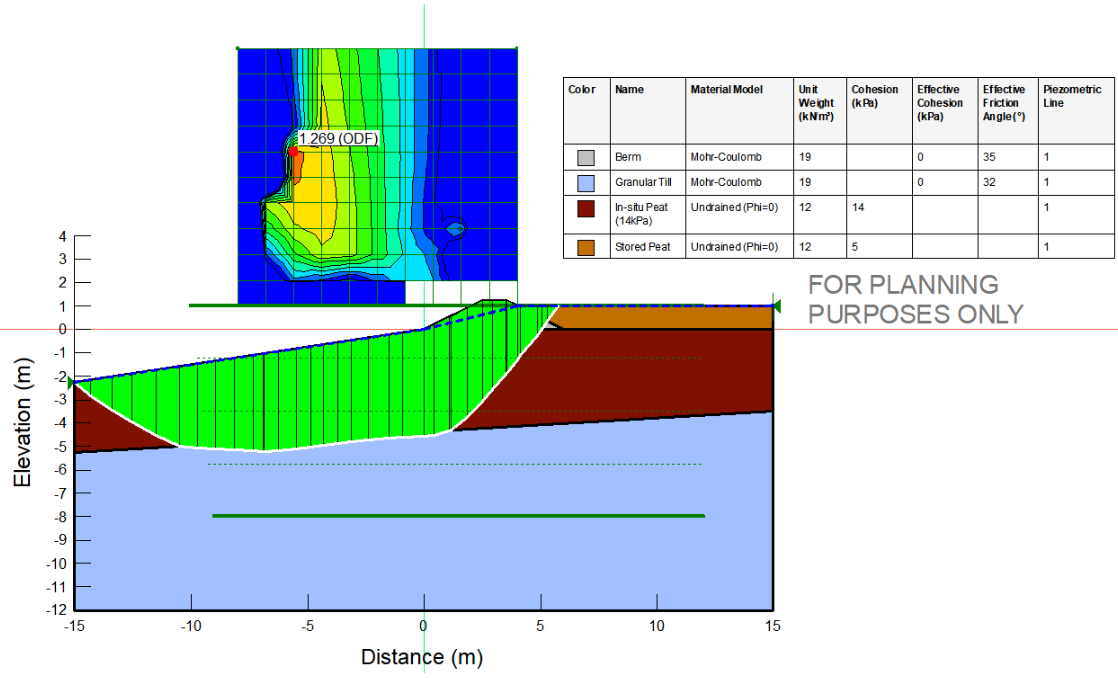


Figure 5-4: Critical failure pane developed from Slope/W model of peat repository area with peat with c_u of 14kPa and gradient at the toe of 15% (Undrained , DA1C2)

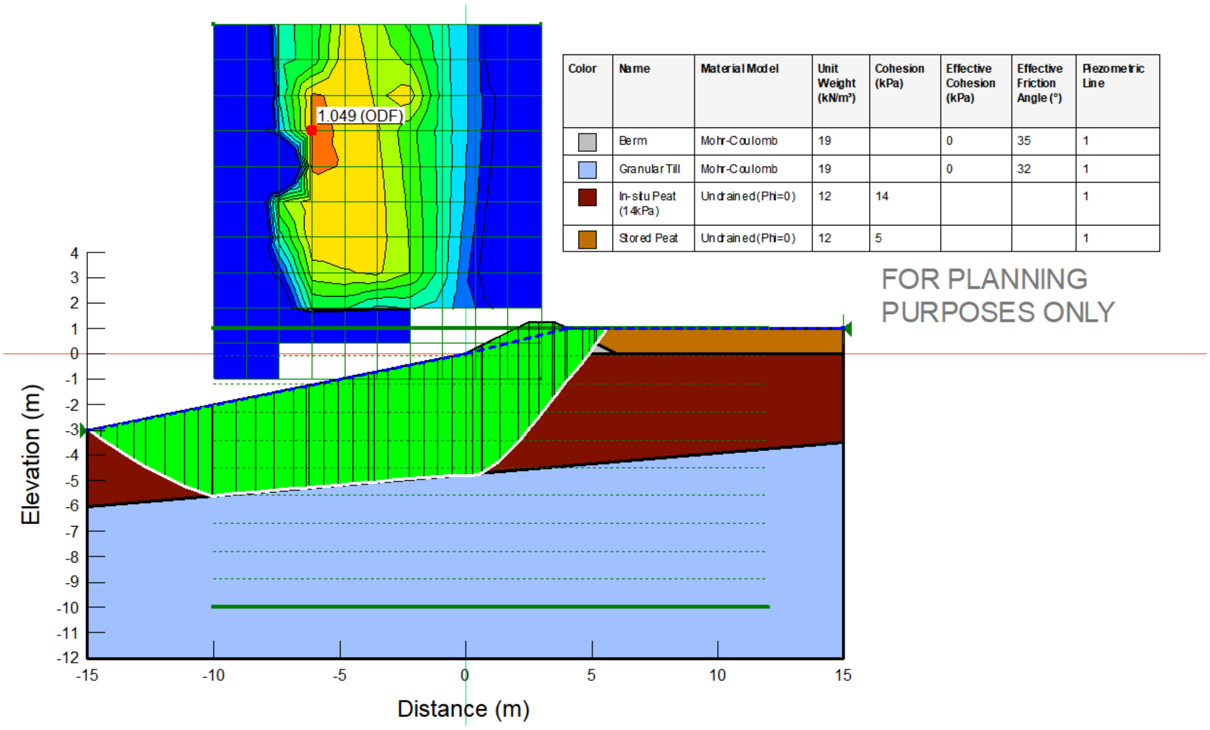


Figure 5-5: Critical failure pane developed from Slope/W model of peat repository area with peat with c_u of 14kPa and gradient at the toe of 20% (Undrained , DA1C2)

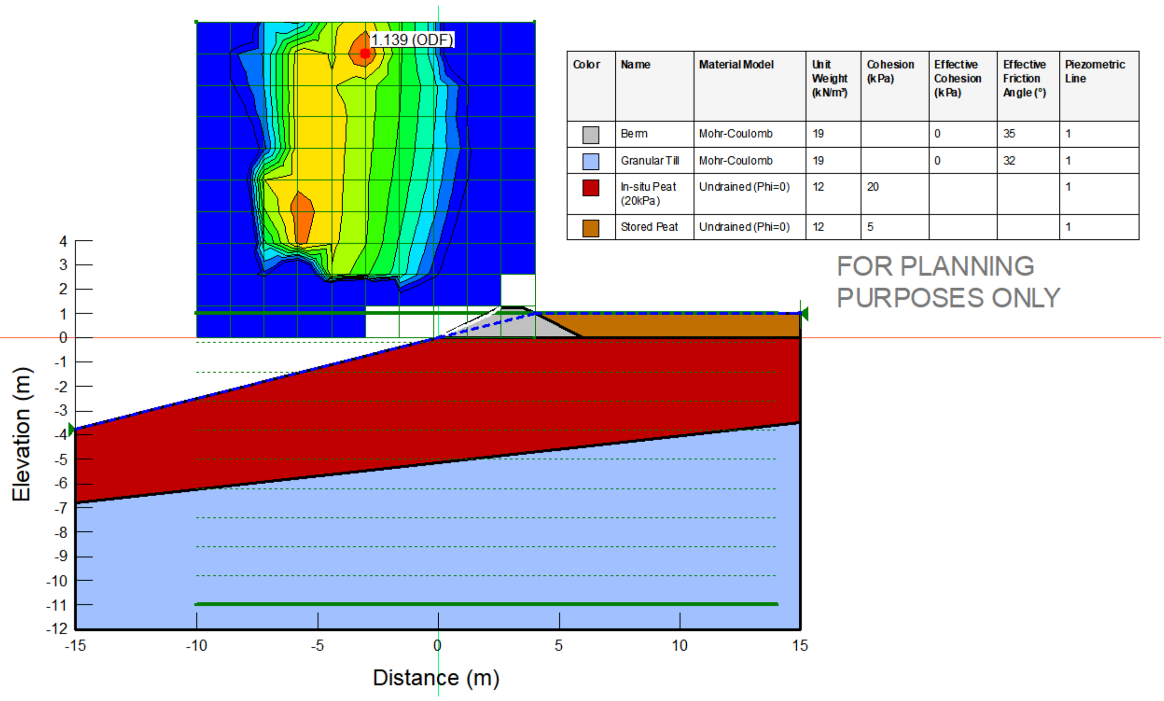


Figure 5-6: Critical failure pane developed from Slope/W model of peat repository area with peat with c_u of 20kPa and gradient at the toe of 25% (Undrained , DA1C2)

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