APPENDIX 8-1

PEAT STABILITY RISK ASSESSMENT

Peat Stability Risk Assessment (PSRA) for Curraglass Renewable Energy Development

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Acronyms and symbols

DEM. Digital Elevation Model
FoS. Factor of Safety
GDG. Gavin & Doherty Geosolutions
GI. Geo-Investigation
IDW. Inverse Distance Weighted
masl. meters above sea level
MKO. McCarthy Keville O'Sullivan
NIR. Near Infrared
OSi. Ordnance Survey Ireland
OTF. Orthophoto
PSR. peat stockpile restrictions
PSRA. Peat Stability Risk Assessment
SWIR. Short Wave Infrared

Non-technical summary

Gavin and Doherty Geosolutions (GDG) was commissioned by McCarthy Keville O'Sullivan (MKO) to undertake a Peat Stability Risk Assessment (PSRA) for the proposed Curraglass Renewable Energy Development site. 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, a peat stability assessment is required.

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.

Peat depths across the site generally vary up to 2.0m, with an average depth of 0.4m. There is a localised section of deeper peat up to a depth of 5.5m, this was recorded 2 m away from an existing track to be upgraded. The deeper peat areas have been avoided by optimising the proposed layout for the site.

A desk study, a walkover including peat depth probing, shear vane testing, stability analyses and a risk assessment were carried out to assess the risks presented 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 purpose of the stability analysis is to determine the stability i.e. the Factor of Safety (FoS) of the peat slopes. 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.

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, considering how damaging a peat slide would be to this particular site's environment.

The site was found to have both acceptable factors of safety and levels of risk against peat instability. Two areas, referred to as *safety buffers* (see Appendix L), have been highlighted and will have restricted construction activities and should not be used for the storage of peat or soils. The proposed layout avoids these areas. In addition to this, two smaller areas have been highlighted as not suitable for side casting or stockpiling of peat or soils (Appendix K). These areas are indicated on Figures K-2 to K-4 and Figure L-1.

1. Introduction

1.1. Background

Gavin and Doherty Geosolutions (GDG) was commissioned by McCarthy Keville O'Sullivan (MKO) to undertake a Peat Stability Risk Assessment (PSRA) for the proposed Curraglass Renewable Energy Development.

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, have 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.

The Curraglass Renewable Energy Development site is located in Co. Cork. The site is located approximately 5.6km northeast of Kealkill and 5.5km southwest of the village of Ballingeary (Figure 1-1).

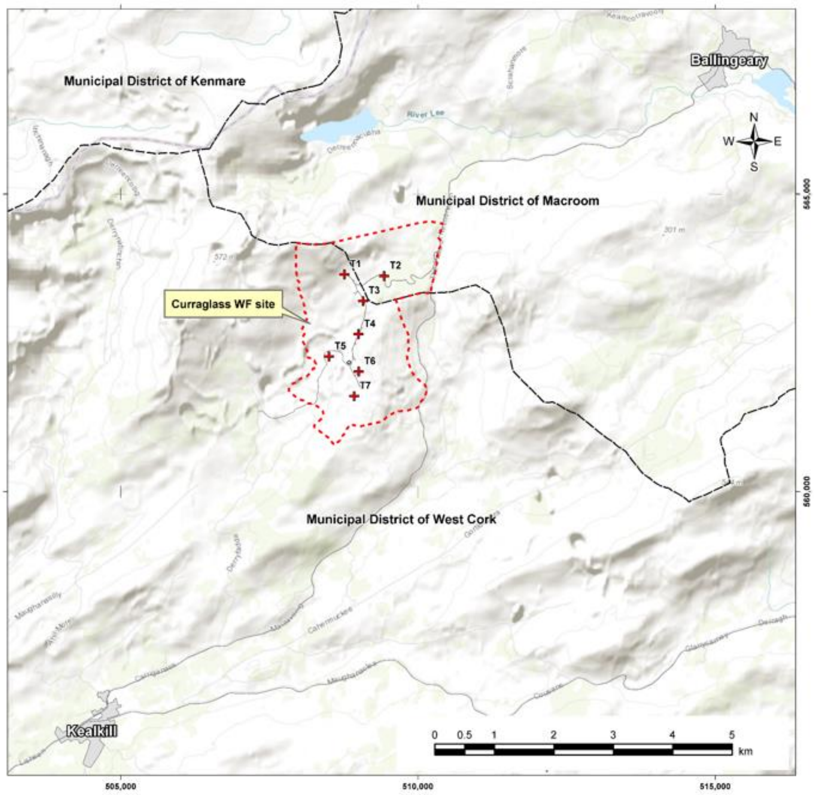


Figure 1-1: Administrative location of the proposed Curraglass site.

Note: A more detailed map of the proposed site's administrative locations is provided in Appendix A Figure A-1.

The previous wind turbines at the site were granted planning permission in 2002 and the site was constructed and became operational in 2006. The turbines were removed in June 2018. The previous development consisted of 10 turbines and associated site infrastructure.

Wingleaf Ltd. is now seeking to optimise the site with a renewable energy development comprising up to seven turbines with a tip height of up to 178.5 metres. The full description of the proposed development is as follows:

1. Up to 7 no. wind turbines with an overall blade tip height of up to 178.5 metres and all associated foundations and hard-standing areas;
2. 2 No. borrow pits;
3. 1 No. permanent meteorological mast with a maximum height of up to 112 metres;
4. Upgrade of existing and provision of new site access roads;
5. Upgrade to existing access junction;
6. A 38kV electricity substation, including 4 no. battery storage containers, 1 no. control building with welfare facilities, associated electrical plant and equipment, security fencing, wastewater holding tank,
7. Forestry Felling;
8. A temporary construction compound;
9. Site Drainage;
10. All associated internal underground cabling, including underground grid connection cabling to the existing overhead line; and
11. All associated site development and ancillary works.

1.2. Overview of peat landslides

1.2.1. 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
Spatial distribution	Scotland, England and Wales	Ireland

Evidence of past landslides has not been identified within the Proposed Development site and surroundings on the available Google Earth imagery (available from 2010 onwards), nor during the fieldwork. This does not necessarily mean that landslides have never occurred at the proposed site. 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 landslides.

1.2.2. 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 explain the spatial distribution of landslides 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.

1.2.3. Pre-failures 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.

1.3. Peat Stability Risk Assessment workflow

GDG has carried out the PSRA for the Curraglass Renewable Energy Development 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 in respect of consent applications for electricity generation projects.

Figure 1-2 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;
    - 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 hazard and consequences;
    - Reclassification of the risk values in four classes:
        - Negligible;
        - Low;
        - Medium; and
        - Serious.
4. Proposal of actions required for each infrastructure element.

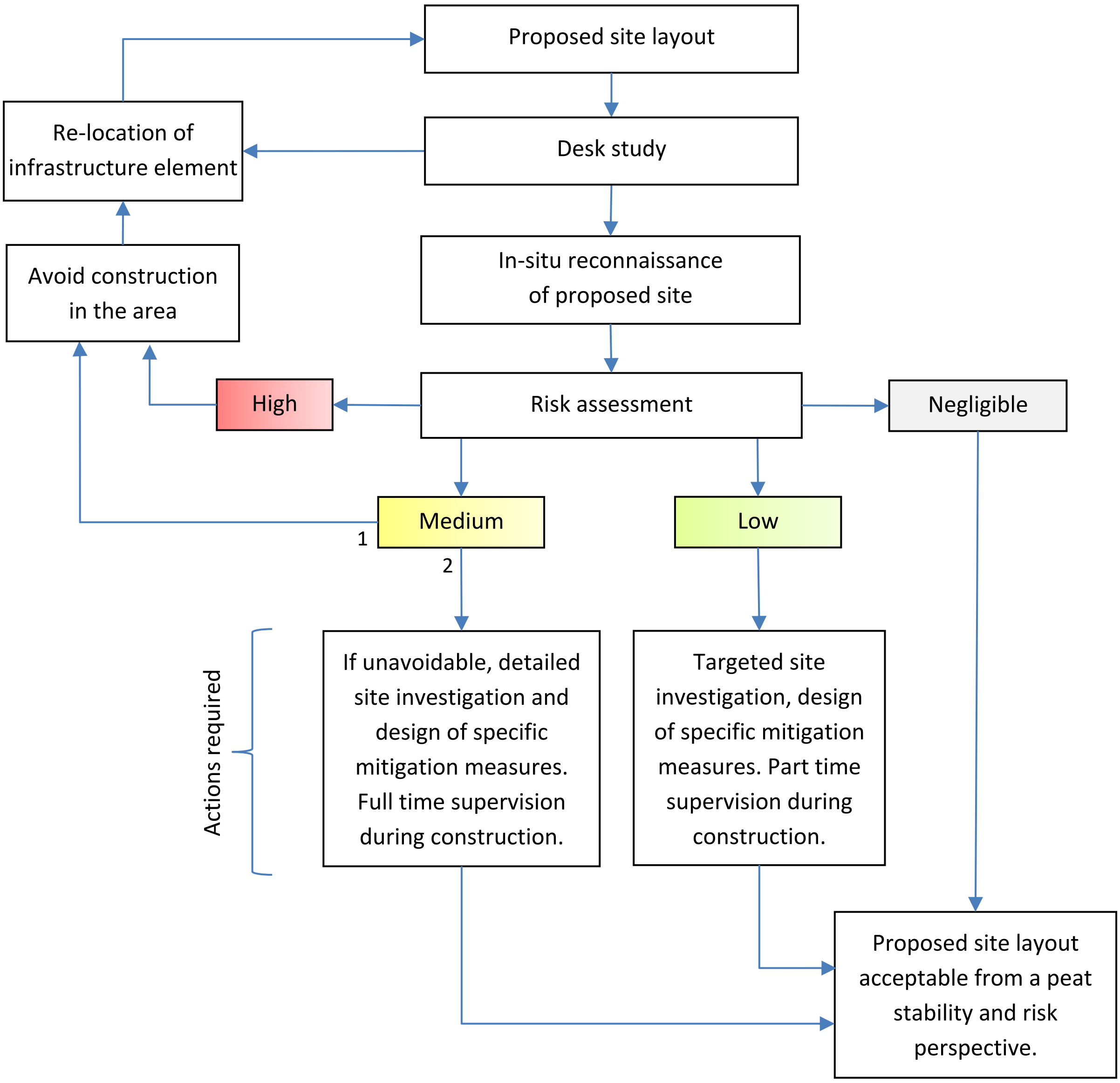


Figure 1-2: Workflow of the PSRA methodology for the acceptability of the proposed site layout.

2. Desk study

For a preliminary site suitability analysis and background knowledge of local peat stability and ground conditions, the following sources of information have been used:

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 sandstone and siltstone.

The map of Quaternary sediments at 1:500,000 scale (Figure B-2) (GSI, 2019) shows that most of the proposed infrastructure elements are located on bedrock outcrop/subcrop with some areas of peat and till indicated within the development boundary.

2.2. Soils

The Irish soil map at 1:250,000 scale (Figure C-1) (EPA, Teagasc, & Cranfield University, n.d.) shows that most of the proposed site is covered by peat. It is noted that the presence or absence of peat cover in the regional scale maps (Figure B-2 and 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:

- <u>Lubrication</u>. 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.
- <u>Softening</u>. It mainly affects the physical properties of filler materials in fractures and fault planes in rocks.

- Pore pressure. Water in soil pores exerts pressures 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 a 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 of 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 the cyclical pore pressures. In temperate climates, seasonal variations in temperature 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 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 very important 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 total collapse of the soil structure and the activation of landslides.
- 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, the stresses on slopes, and can produce the activation of a landslide, especially when erosion undercuts slopes.

The *Normalized Difference Moisture Index Colorized* GIS service or the United States Geological Survey (USGS) has been used to estimate levels of moisture 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**

Figure D-1 in Appendix D illustrates the levels of estimated soil moisture across the Proposed Development site. Wetlands and other vegetated areas with high levels of moisture appear as dark blue (e.g. along the SW-NE valley). Regions of high elevation (e.g. north sector) and slopes which face east exhibit lower values of moisture and are represented as light blue and green.

It is noted that RADAR images also provide estimates of terrain moisture. However, these have not been used in this report due to their high cost and to the time frame or this project.

2.4. Multi-temporal aerial / satellite imagery

The aerial / satellite imagery used for this report is the ESRI orthophoto (OTF) 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 as to identify old peat instability evidence that may have been eroded or re-vegetated with time or changes in the land management.

[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)

2.5. Topography

According to the 1m contour lines sourced from Bluesky and derived Digital Elevation Model (DEM), the site topography can be described as hilly undulated. The elevation varies between 150m and 520 mOD (meters above ordnance datum).

Three additional maps have been derived from the 1m contour data:

- The slope angle map (Figure F-1 in Appendix F) which shows the slopes angles range between 0° and 55°.
- The curvature of the terrain:
    - 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. Figure F-2 shows the plan curvature across the site. The current plan convexity and concavity is distinct at some hardstandings (e.g. T4 and T7).
    - Profile curvature (downslope): This affects the speed of surface water runoff along the terrain and so influences the infiltration rate and erosion capacity of surface waters.

      Convex slopes are also more prone to landslides due to their shape.

      Figure F-3 presents the profile curvature across the site. The current profile convexity and concavity is distinct at some hardstandings (e.g. T1, T4 and T7).

2.6. National landslide mapping

The landslide database (GSI, 2016a, 2018b), the multi-temporal aerial / satellite imagery, the DEM, the landslide susceptibility map (GSI, 2016b) and the rainfall information of Met Éireann have been used for this part of the desk study.

The project team has not identified any landslides during the desk study and fieldwork. Figure G-1 depicts the spatial relationship between the distribution of landslides (GSI, 2016a, 2018b) and the spatial distribution of rainfall across Ireland. While the study area is in a rainy and relatively hilly region, landslides have not been identified from the national landslide database. The closest landslides according to the GSI database are located 8 km northwest.

Figure G-2 illustrates the landslide susceptibility (GSI, 2016b) across the proposed site. This map was obtained by using an empiric probabilistic method at a regional scale and does provide input into site-specific scale engineering studies. For instance, turbine T4 is located in a sector of *high* susceptibility (red colour) due to the high slope angle in this sector. However, the field visits of the project team revealed that this sector of T4 is stable as the bedrock is very close to the surface.

Therefore, based on the available data and on GDG's professional judgement, it is concluded that significant peatslides are unlikely on the site.

2.7. Hydrology

According to the Ordnance Survey Ireland (OSi) shapefile of rivers, lakes (Figure H-1) and catchments/basins (Figure H-2), the site is located close to the watershed of three catchments:

- River Lee;
- River Owenbeg; and
- River Owvane.

2.8. Land cover and land use

According to the Corine Land cover map (Figure I-1), the surrounding landscape of the proposed site comprises blanket peat, pastures, woodland scrub, coniferous forests and agriculture sectors. The Curraglass renewable energy development is planned on a recently operational wind farm, predominantly surrounded with areas of commercial forestry.

3. Site reconnaissance and ground investigation

As part of the assessment, the project team carried out a site reconnaissance. This comprised two site visits (21st of January and 6th of February, 2020) 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.

Figure 3-1: Forestry on site.

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

The ground investigation (GI) consisted of:

- A total of 230 probes were carried out between December 2019 and May 2020 in addition to shear vane testing; and
- Gouge cores to sample the subsoils underlying the peat.

The investigation locations (Figure J-1) considered the following criteria:

- Spatial distribution of the proposed infrastructure;
- Distance between probe points to avoid interpolation pf peat depths across large distances;
- Changes in slope angle changes, 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.

It is noted that the peat in certain sections could not be penetrated to required depth due to either peat compaction (Figure 3-3) or due to the presence of loose rock within the peat itself (where peat was side-cast to construct existing tracks).

Figure 3-3: Compact peat side-cast along a track during previous construction works.

No evidence of any previous landslides or peat instability was identified during the walkovers.

A raster map was created in the ArcGIS software presenting the interpolated peat depth across a site from the peat probe points using the Inverse Distance Weighted (IDW) method. This interpolated raster of peat depth is represented in Figure J-1.

Table J-1 to Table J-13 present the observations made at the proposed infrastructure.

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 buffers and peat stockpile restricted areas.

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 engineering indication of physical stability as approach 2b does. In this report, the peat stability assessment is carried out by using a deterministic (FoS) approach (Bromhead, 1986).

4.2. A Factor of Safety (FoS) concept

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 (Figure 4-1).

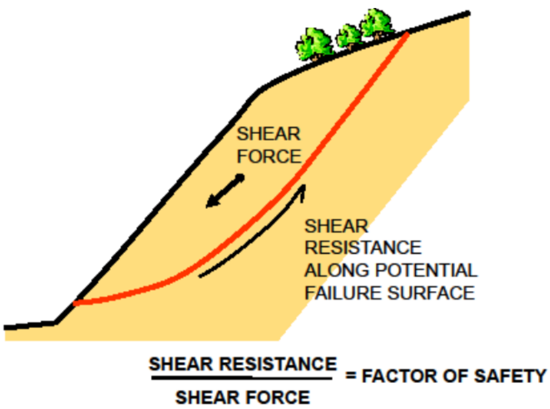


Figure 4-1: Balance of forces in a slope (Scottish Executive, 2017).

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 (BSI, 1981), provided advice on the design of earthworks slopes. 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 allows for 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 is dependent on several factors working in combination, namely the slope angle, the shear strength of peat, the depth of 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 above-mentioned factors alone is unlikely to result in peat failure. The infinite slope model (Skempton and DeLory, 1957) is used to combine these factors to determine a factor of safety for peat sliding in the study area. This model is based on a translational slide, which is a reasonable representation of the dominant mode of movement for peat failures.

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

4.3.1. Undrained conditions

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

Undrained shear strength values (c_u) for peat are used for the total stress analysis. 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 by using the hand shear vane tests in the proposed site, the lowest registered value was 10 kPa. However, based on GDG's experience in the assessment similar blanket peats, and values reviewed in literature, a more conservative value of 8 kPa has been adopted for the undrained calculation.

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 (8 kPa in the study area);
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 12 m. This is obtained from the 1-m contour lines provided by the client).

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 as a result of 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 disturbance experienced when sampling peat and the difficulties in interpreting test results due to the excessive strain induced within the peat. To determine suitable drained strength values a review of published information on peat was undertaken. Table 4-2 summarises published effective mechanical parameters of peat. According to this table, the values for c' range from 1.1 to 10 kPa and ø' ranges from 21.6 to 43°. The average values of c' and ø' are 5 kPa and 30°, respectively. Based on GDG's experience in the assessment of similar blanket peats, and the values reviewed in literature, it was considered appropriately conservative to use design values below the averages, namely c' = 4 kPa and ø' = 25°.

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 (4 kPa);

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

z = Depth to failure plane assumed as 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.at surface level);

α = Slope angle (in each pixel. This is obtained from the 1-m contour lines provided by the client); and

$ø'$ = Effective friction angle (25°).

Table 4-2: Effective cohesion and friction angle values from the literature.

Reference	Cohesion, c' (kPa)	Friction Angle, ø' (degs)	Testing Apparatus/ Comments
Hanrahan et al (1967)	5 to 7	36 to 43	From triaxial apparatus
Rowe and Mylleville (1996)	2.5	28	From simple shear apparatus
Landva (1980)	2 to 4	27.1 to 32.5	Mainly ring shear apparatus for normal stress greater than 13kPa
	5 to 6	-	At zero normal stress
Carling (1986)	6.5	0	-
Farrell and Hebib (1998)	0	38	From ring shear and shear box apparatus. Results are not considered representative.
	0.61	31	From direct simple shear (DSS) apparatus. Result considered too low therefore DSS not considered appropriate
Rowe, Maclean and Soderman (1984)	1.1	26	From simple shear apparatus
	3	27	From DSS apparatus
Sandorini et al (1984)	4.5	28	From triaxial apparatus
McGreever and Farrell (1988)	6	38	From triaxial apparatus using soil with 20% organic content
	6	31	From shear box apparatus using soil with 20% organic content
Hungr and Evans (1985)	3.3	-	Back-analysed from failure
Madison et al (1996)	10	23	-
Dykes and Kirk (2006)	3.2	30.4	Test within acrotelm
Dykes and Kirk (2006)	4	28.8	Test within catotelm
Warburton et al (2003)	5	23.9	Test in basal peat
Warburton et al (2003)	8.74	21.6	Test using fibrous peat
Entec (2008)	3.8	36.8	Generalised values derived from various peat tests (shear box and triaxial)

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 1m contour lines sourced from Bluesky 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 12 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.

4.4. FoS results

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

Table K-1 and Table K-2 show the FoS calculation process in the proposed turbine sites only for undrained and drained conditions, respectively. The FoS calculation for the rest of site i.e the proposed substation, temporary construction compound, existing and upgraded access roads, borrow pits and met mast (more than 5000 pixels of 12 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) are shown in Figure K-1. Each of the pixels exhibits a FoS > 1.3 (green: stable and safe).

4.4.2. FoS for undrained condition and surcharge of 10 kPa

Figure **K-2** depicts the spatial distribution of the FoS values calculated for undrained conditions and with a 10kPa surcharge. Almost all of the pixels are shown to be stable and safe (FoS > 1.3, green), but there are two small areas close to watercourses with FoS values between 1 and 1.3 (yellow: stable but not safe). One of these regions is located close to an existing road between T1 and T2 and the other is located east from T2.

4.4.3. FoS for drained conditions

The spatial distribution of the FoS values calculated for long term drained but saturated conditions with no surcharge is shown in Figure K-3 . Almost all of the pixels exhibit a FoS > 1.3 (green), however, there is a short zone between T1 and T2, close to a watercourse, with FoS values between 1.0 to 1.3 (yellow: stable but not safe).

4.4.4. FoS for drained condition and surcharge of 10 kPa

Figure K-4 shows the spatial distribution of the FoS for long term drained but saturated conditions and with 1-m peat stockpile surcharge. Almost all the studied fringe is stable and safe (FoS > 1). However, there are three areas with FoS values lower than 1.3 (two areas yellow: stable but not safe; one area red: unstable). Two of these regions are located close to watercourses east from T2 and between T1 and T2 (as already noted above in Section 4.4.2). The third one is located at a steep slope beside the proposed substation.

4.5. Safety buffers and stockpile restrictions

From the site reconnaissance and the calculations of the FoS for the peat slopes, two safety buffers and two peat stockpile restriction (PSR) areas are proposed. It is noted that the results from the various analyses carried out often identified the same areas as having a FoS < 1.3.

Safety buffer no. 1, presented in Figure L-1, is based on the walkover observations adjacent to but offset from the existing road between T1 and T2.

Two meters away from the southern margin of this road, the peat is very soft and reaches a depth of up to 5.5 m. It is waterlogged and unstable underfoot and potentially buoyant. There is also a drain offset from the road, covered with a thick layer of vegetation. The drain may be several metres deep and is hidden beneath the vegetation. The depth of the drainage was not measured for safety reasons. This is a potential hazard for any further works which will be carried out on site. This area is located two meters away from the existing road and so can be avoided during construction and will not restrict the upgrade of the existing track. The area itself should be restricted for construction and it should not be used for material/spoil storage or side casting.

Safety buffer no. 2, presented in Figure L-1, is based on the results of the peat FoS obtained for drained conditions without considering any surcharge. Note that this safety buffer is located at a small fluvial bank and the shape of the safety buffer has been adapted to match the topography. It is not immediately adjacent to any proposed infrastructure.

In addition to this, a number of areas were highlighted as having a FoS <1.3 when the analysis was carried out with a surcharge loading. These areas are not designated as safety buffers but are highlighted as PSR areas. Two of these are PSR areas are identified and presented in Appendix K, Figure K-4.

5. Peat Stability Risk Assessment (PSRA)

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 the stability of peat) 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 given 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 a variety weighted factors including the FoS and thirteen secondary factors related with geomorphic observations, topography, hydrology, vegetation, peat workings, existing loads and slide history (Appendix M). These secondary factors are difficult to quantify in a stability calculation but may contribute to the 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 not relevant, ratings 1, 2 and 3 indicate low, moderate and high correlation to peatslide hazard, respectively.

Weighting values have been assigned to these factors 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 its weight value. These factors and their corresponding weightings are presented in Table 5-1.

The hazard values for a given wind farm element is 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 drain and undrained conditions as well as the effective friction angle. This is the most complete factor. See Section 4 for further details.	10
Secondary factors	Topography	Curvature Plan (across slope)	This represent the curvature across the slope and therefore the funnelling / dispersion of the runoff.	1
		Curvature Profile (downslope)	This represent 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 as a proxy of the terrain moisture.	
		Evidence of piping	The presence of piping is a clear evidence of potential peat instability.	

Hazard factors			Role in peat stability	Weight
		Direction of existing drainage ditches	Drainage ditches that are aligned cross slope can affect the overall stability of a slope face.	1
	Vegetation	Bush	This is an indicator of the type of peat at the site and the hydrological nature of the site.	
		Forestry	The threes vigour is another indicator of peat stability, being stunted trees more frequent on 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.	
	Slide history	Distance to previous slides (km)	This suggests that if a peat slide has occurred at the site or within a 10-kilometre radius, then landslides at the site are likely. The weight assigned is the double than 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 on-site peat movement indicators such as tension cracks. The weight assigned is the double than the weights for the other secondary factors	

5.4. Adverse consequences assessment

The impacts of peat landslides on the wind farm elements and surrounding environment and existing assets may typically generate a variety of adverse consequences. In this report, these consequences have been assessed qualitatively 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
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 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 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 the impact of a peat slide event would have on the receiving aquatic environment.	
Public roads in potential peat flow path	Rates the impact of a peat slide striking a public road.	1
Overhead lines in potential peat flow path	Rates the impact of a peat slide striking a service line.	
Buildings in 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 in the same fashion the hazard factors were reclassified (Appendix M). A rating of 0 indicates that the consequence factor is not relevant and rating 3 indicates high consequences.

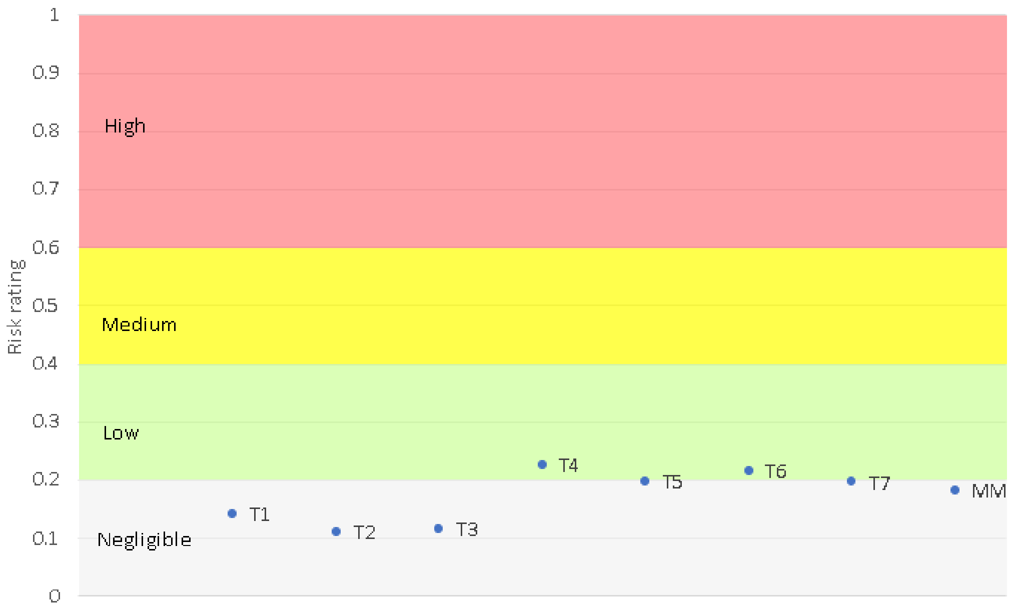
'Volume of potential landslide' has been assigned a weight of 3 to reflect its relative importance in the potential consequences. The rest of the factors have been assigned a weight of 1. Both the rating and the weighting values have been assigned according to the expert criteria of the project team.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

The consequences value for a given wind farm element is the sum of the nine scores of consequences. 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 scores of the hazard and the scores of the consequences. The risk rating ranges between 0 and 1 and the following levels of risk rating have been distinguished (Figure 5-1):

- High (0.6 to 1): Avoid project development at these locations. Mitigation is generally not feasible.
- Medium (0.4 to 0.6): 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): Project should proceed with monitoring and mitigation of peat landslide hazards at these locations as appropriate.



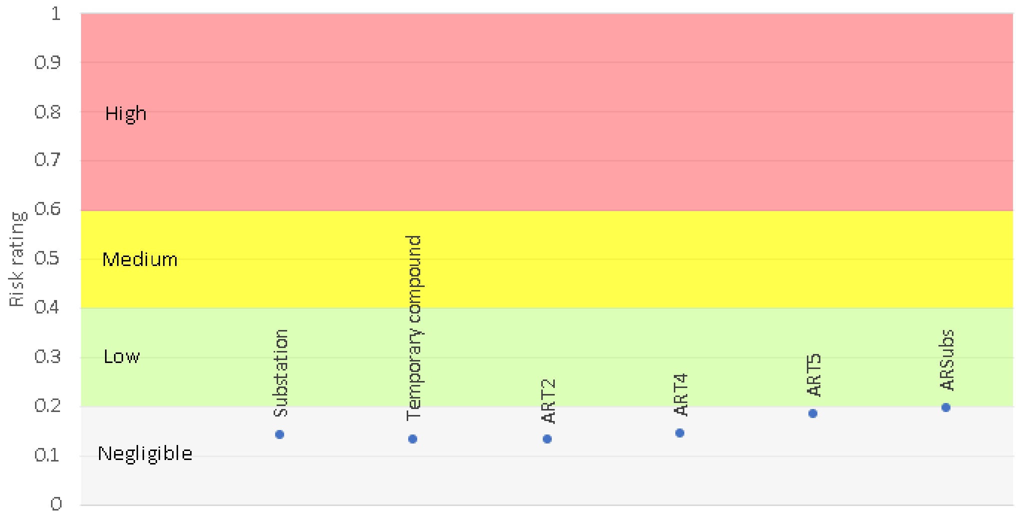


Figure 5-1: Risk ratings at the proposed infrastructure element sites.

Note: MM = Met mast; ART2 = Access road to T2; ARSubs = Access road to substation.

Appendix M gathers the risk calculation process at each wind farm element considering the four scenarios of hazard: Undrained; undrained with surcharge of 1 m; drained; and drained with a surcharge of 1 m. Figure 5-1 summarises the risk rating obtained. The sites for turbines T1, T2, T3, T5, T7 (note that risk values in both T5 and T7 are very close to, but less than 0.2) the met mast, the substation, the temporary compound and the access roads to the turbines are located in sectors of negligible risk.

Turbines T4 and T6 are located in sectors of low risk. For these turbines with low rating, the project may proceed pending further investigation to refine assessment and mitigate hazard through relocation or re-design at these locations, prior to construction.

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

6. Conclusions and recommendations

Following the guidance of the Scottish-Executive (2017), a review of the published thematic geographic information (e.g. geology, soils, protected areas) and relevant background literature was undertaken for the proposed development. Site reconnaissance and site investigations were carried out 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 significant peatslides are unlikely on the site.

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 renewable energy development.

The peat stability risk for the proposed infrastructure ranges between negligible and low. However, the results of the factor of safety deterministic calculation and the site walkover allowed for the identification of safety buffers (Appendix K and L) and peat stockpile restriction (PSR) areas (Appendix K). These must be adhered to in future stages of the proposed development.

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

Construction works shall follow the recommendations of the peat and overburden management plan prepared for the site (GDG, 2020). During construction, it is strongly recommended to carry out frequent monitoring works especially after heavy rainfall events or prolonged rainfall.

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Appendix A Location and administrative limits

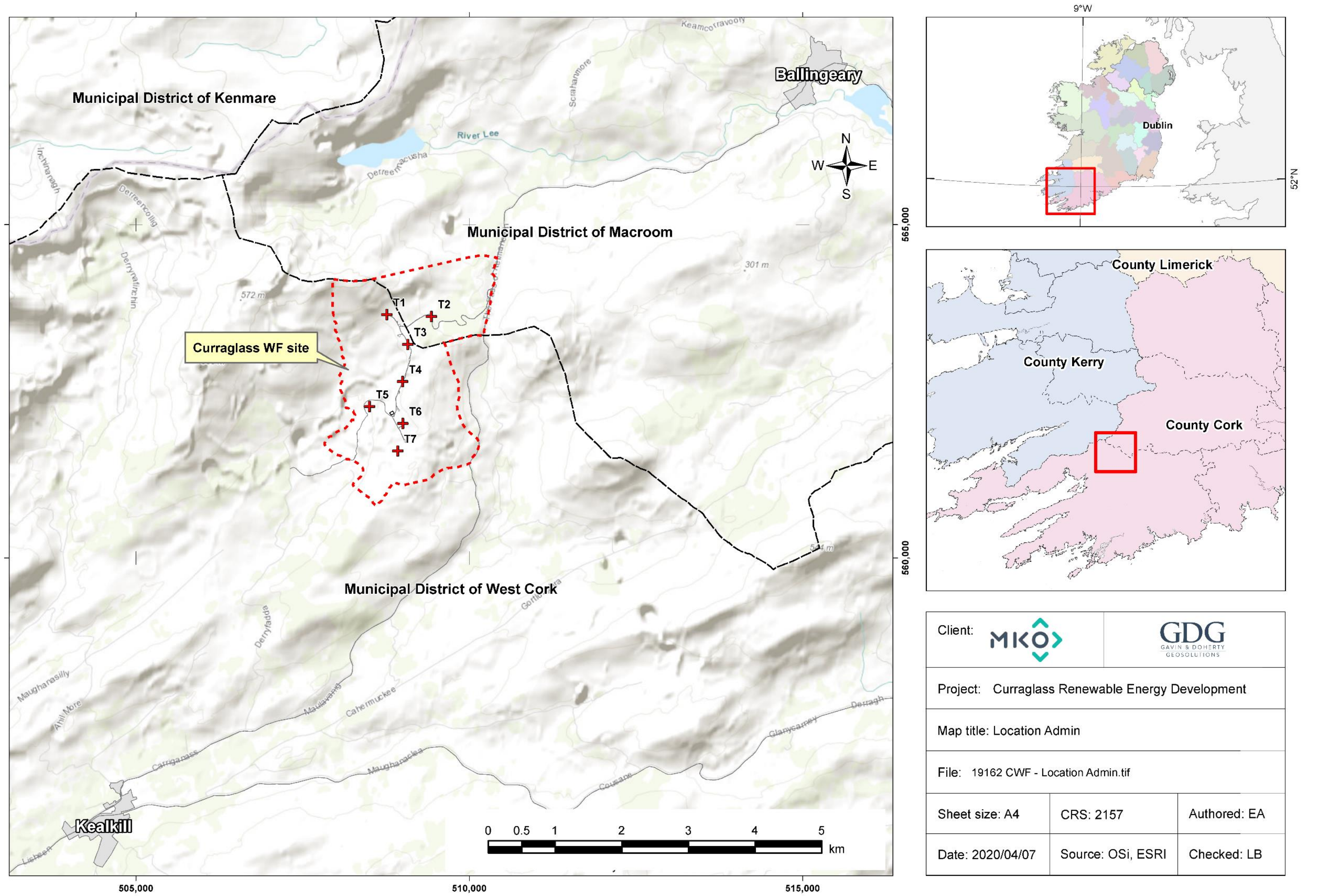


Figure A-1: Location of the proposed site and administrative limits.

Appendix B Geology

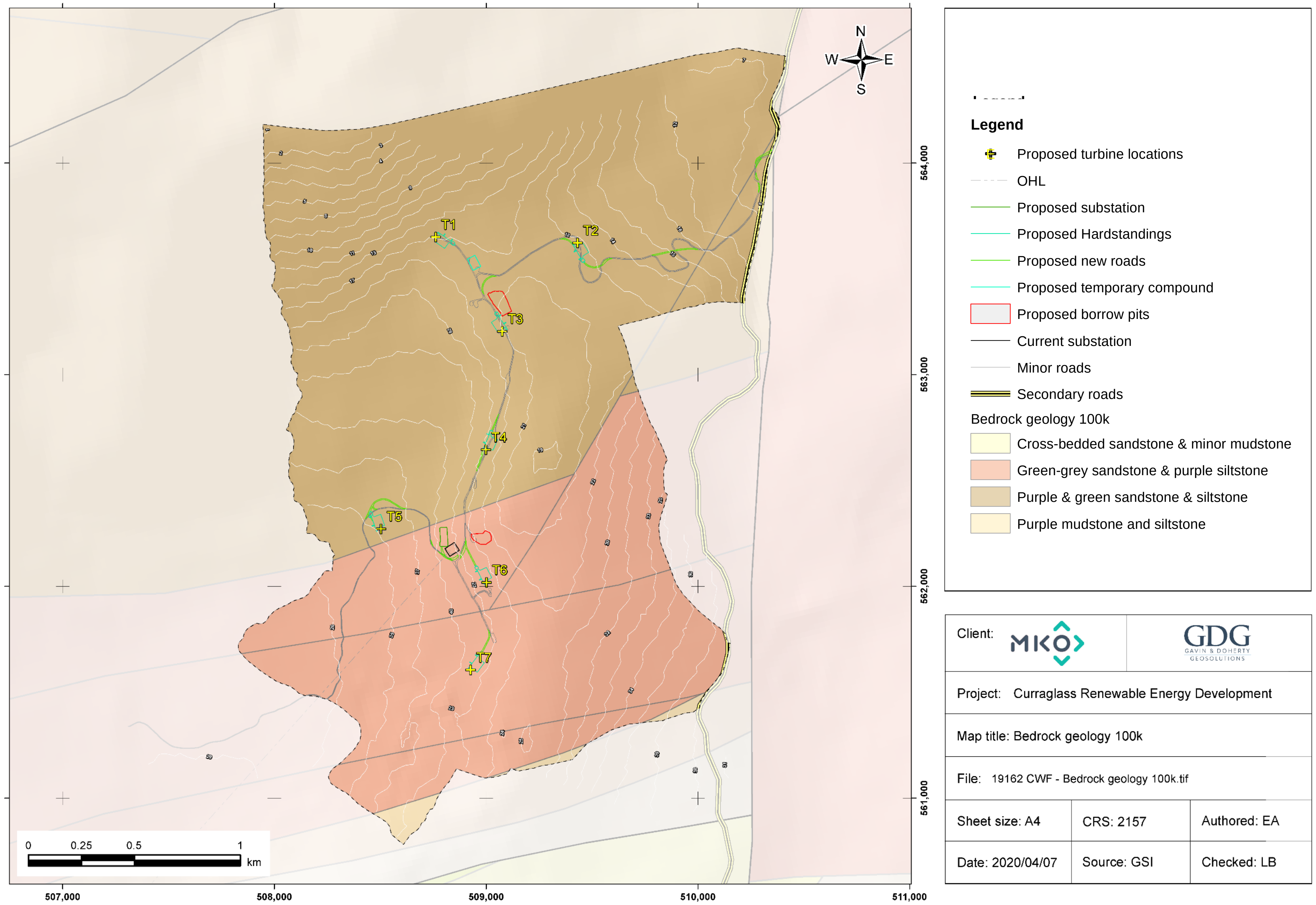


Figure B-1: Bedrock geology 100k (GSI).

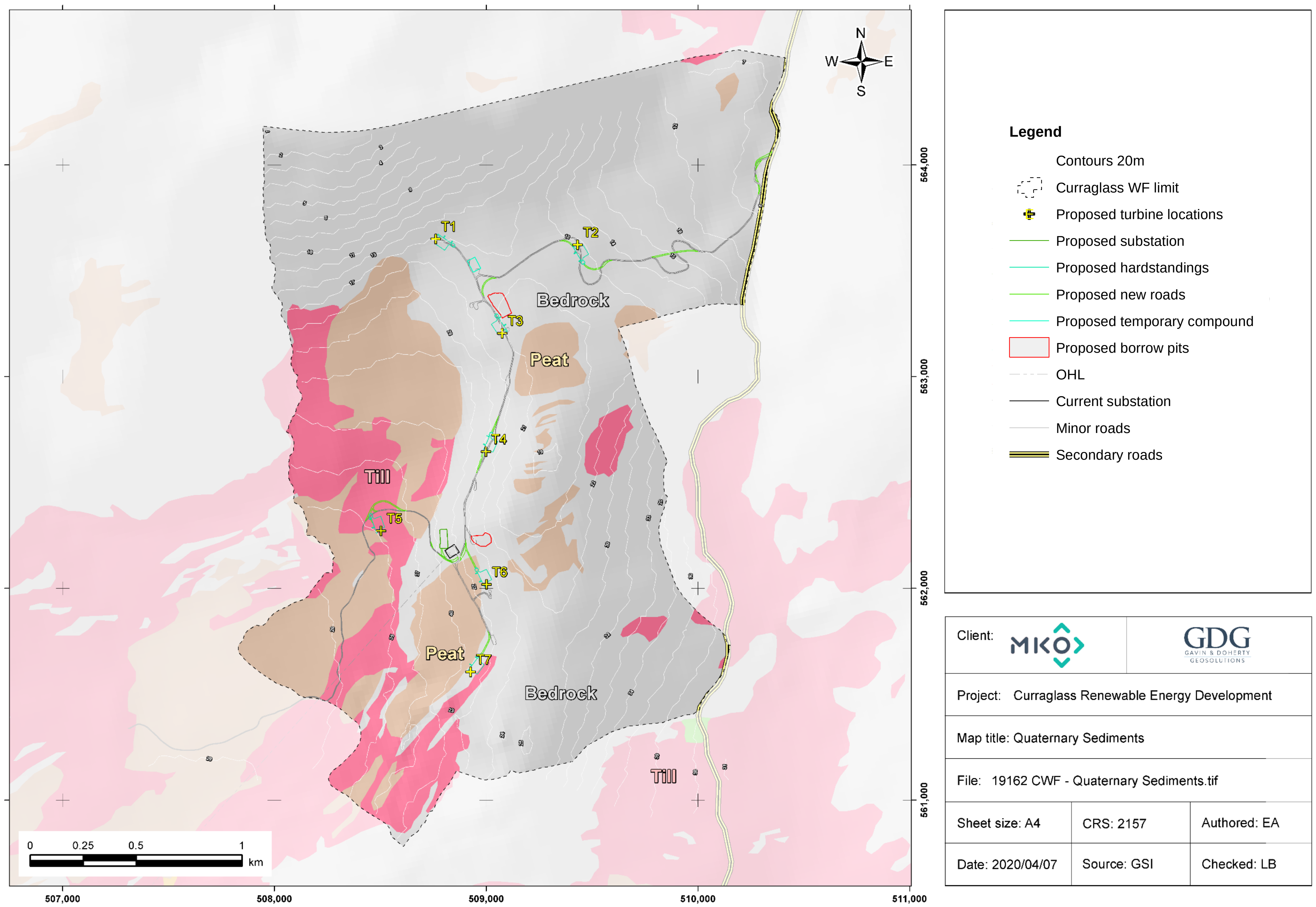


Figure B-2: Quaternary sediments (GSI).

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

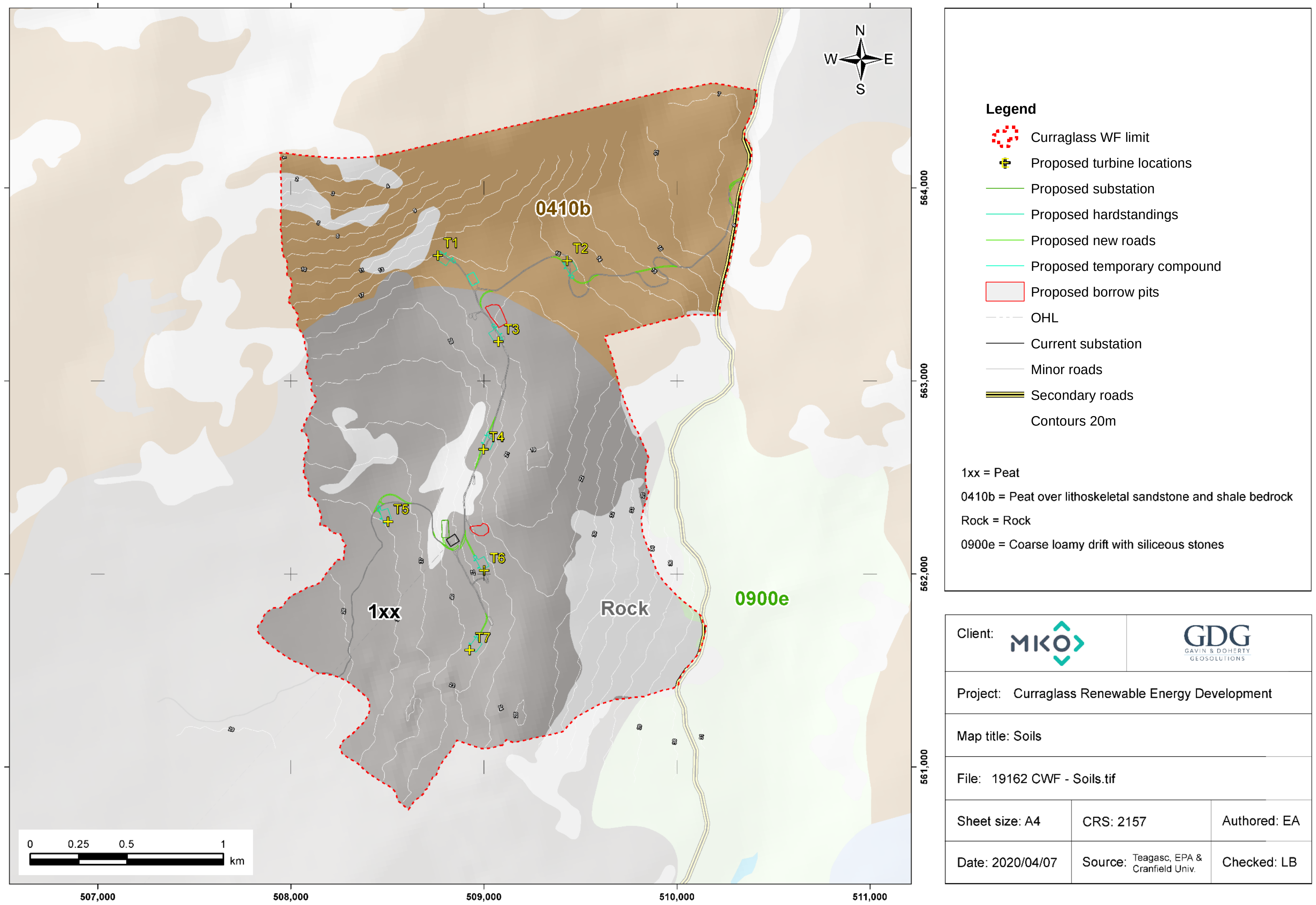


Figure C-1: Soils.

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

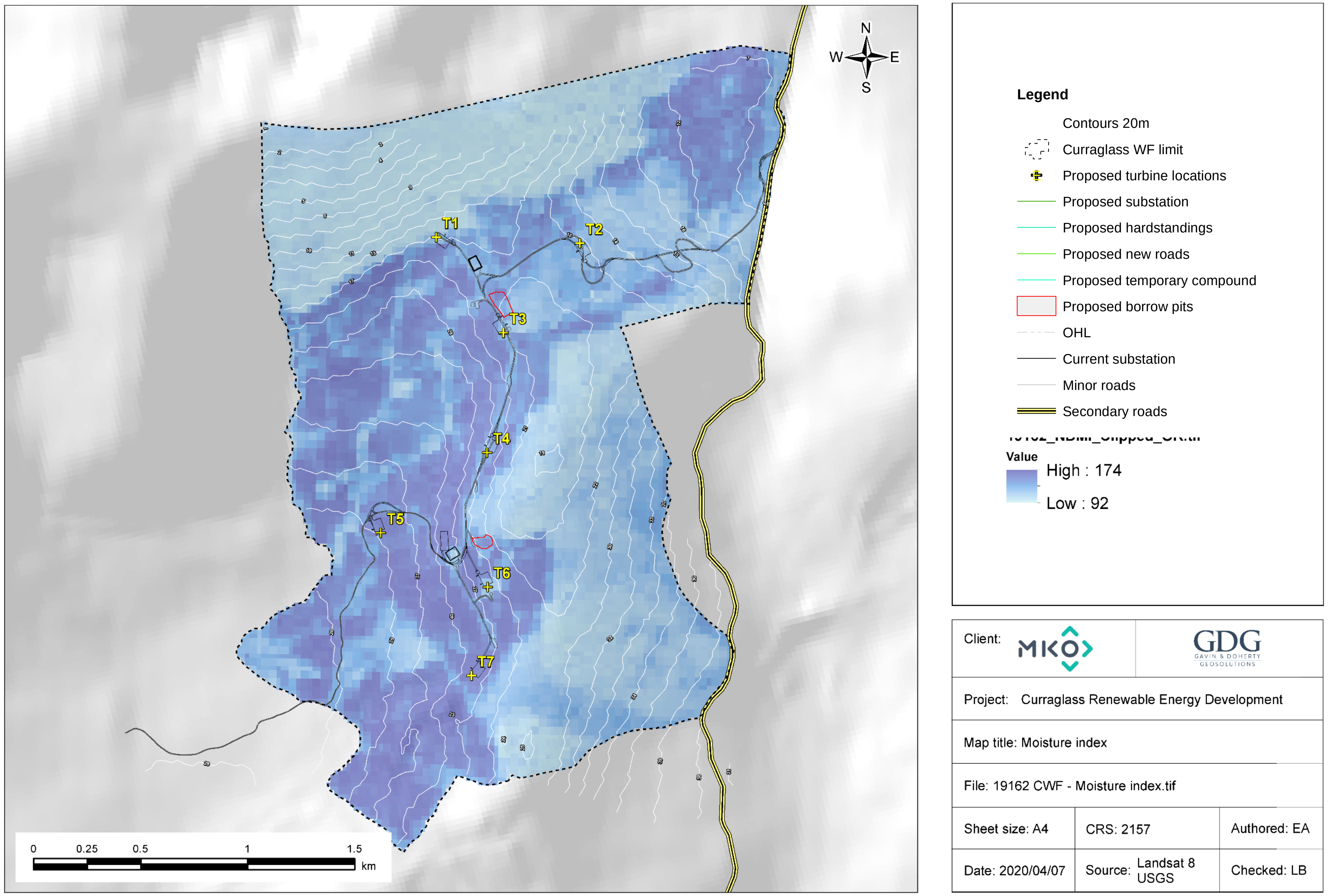


Figure D-1: Moisture Index developed from Landsat 8 and the USGS.

Appendix E Hydrogeology

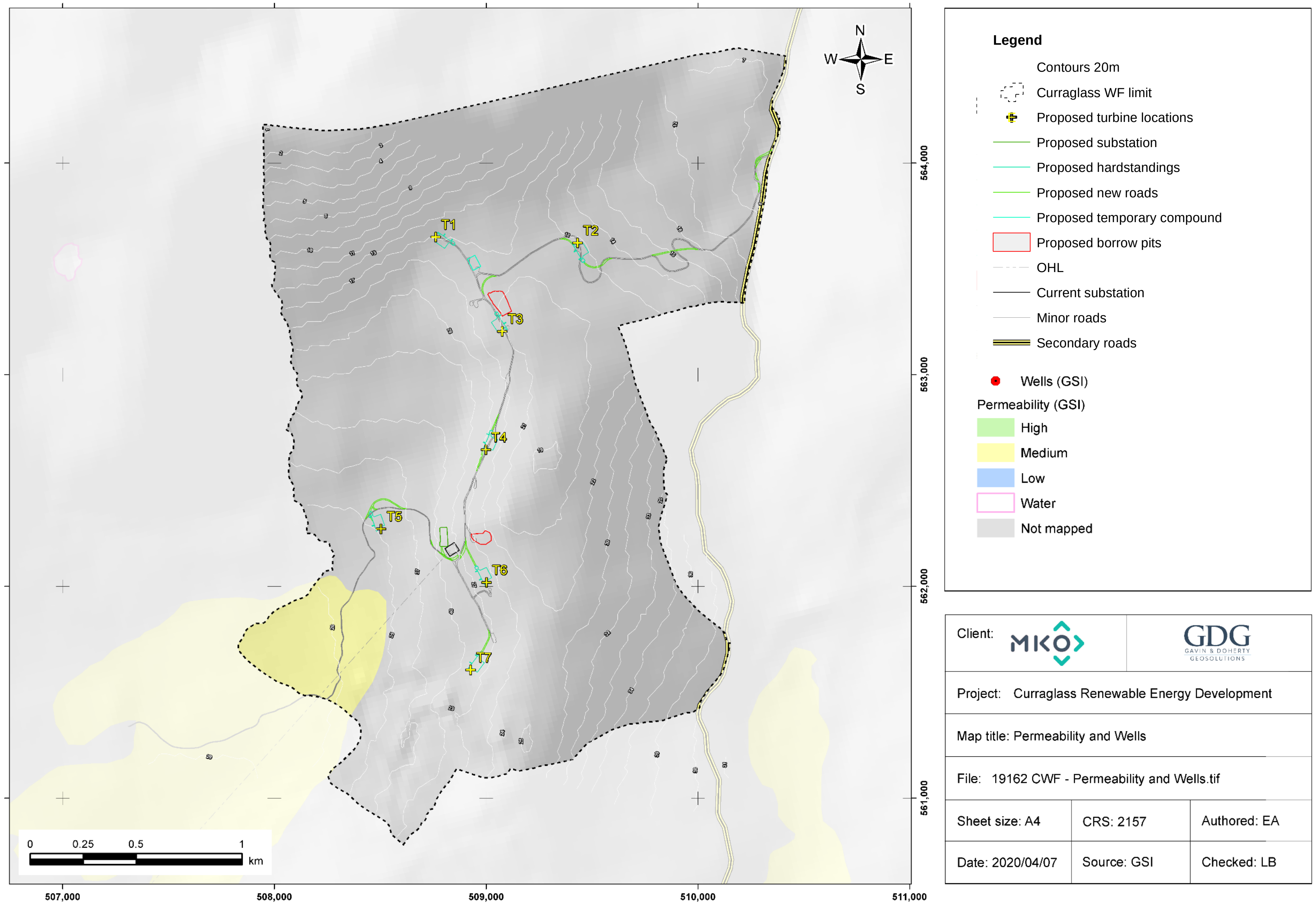
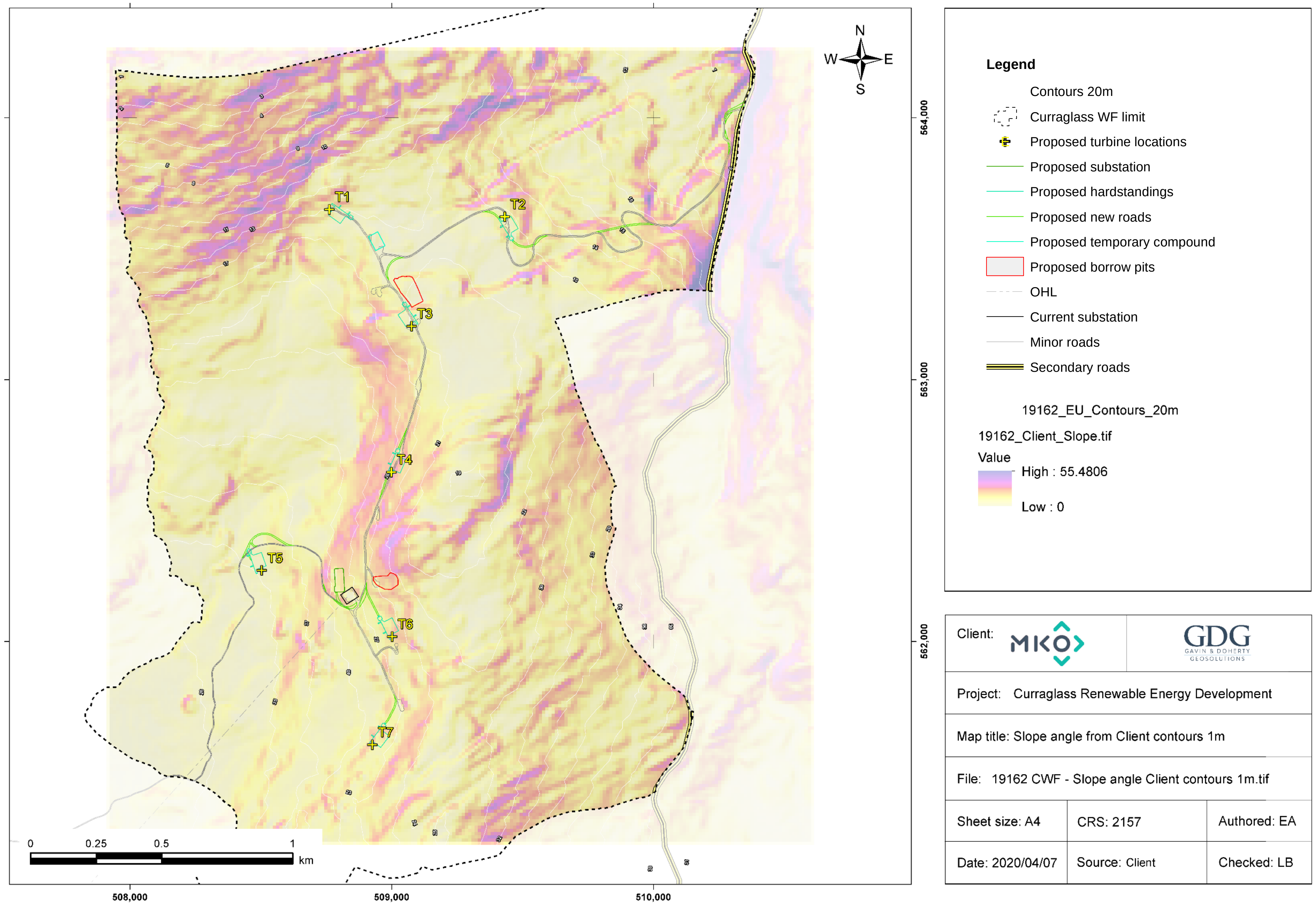


Figure E-1: Permeability and wells (GSI).

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

Appendix F Topography



Client: MKO	GDG	
Project: Curraglass Renewable Energy Development		
Map title: Slope angle from Client contours 1m		
File: 19162 CWF - Slope angle Client contours 1m.tif		
Sheet size: A4	CRS: 2157	Authored: EA
Date: 2020/04/07	Source: Client	Checked: LB

Figure F-1: Slope angle in degrees derived from the 1-meter contours sourced from Bluesky.

Note: The spatial resolution of this raster is 12 m and it has been used as an input for the calculation of the peat Factor of Safety (FoS).

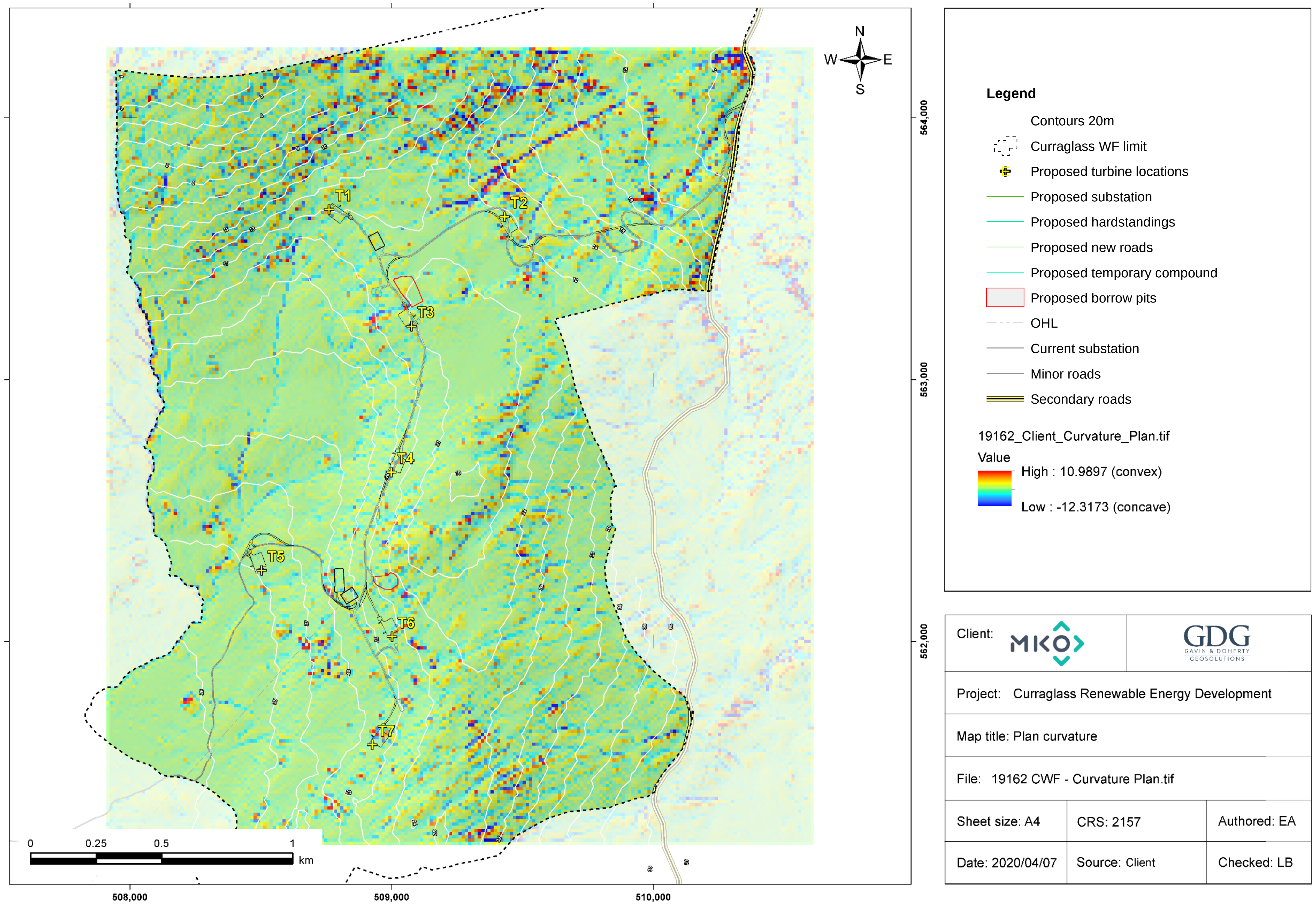


Figure F-2: Plan Curvature (across slope).

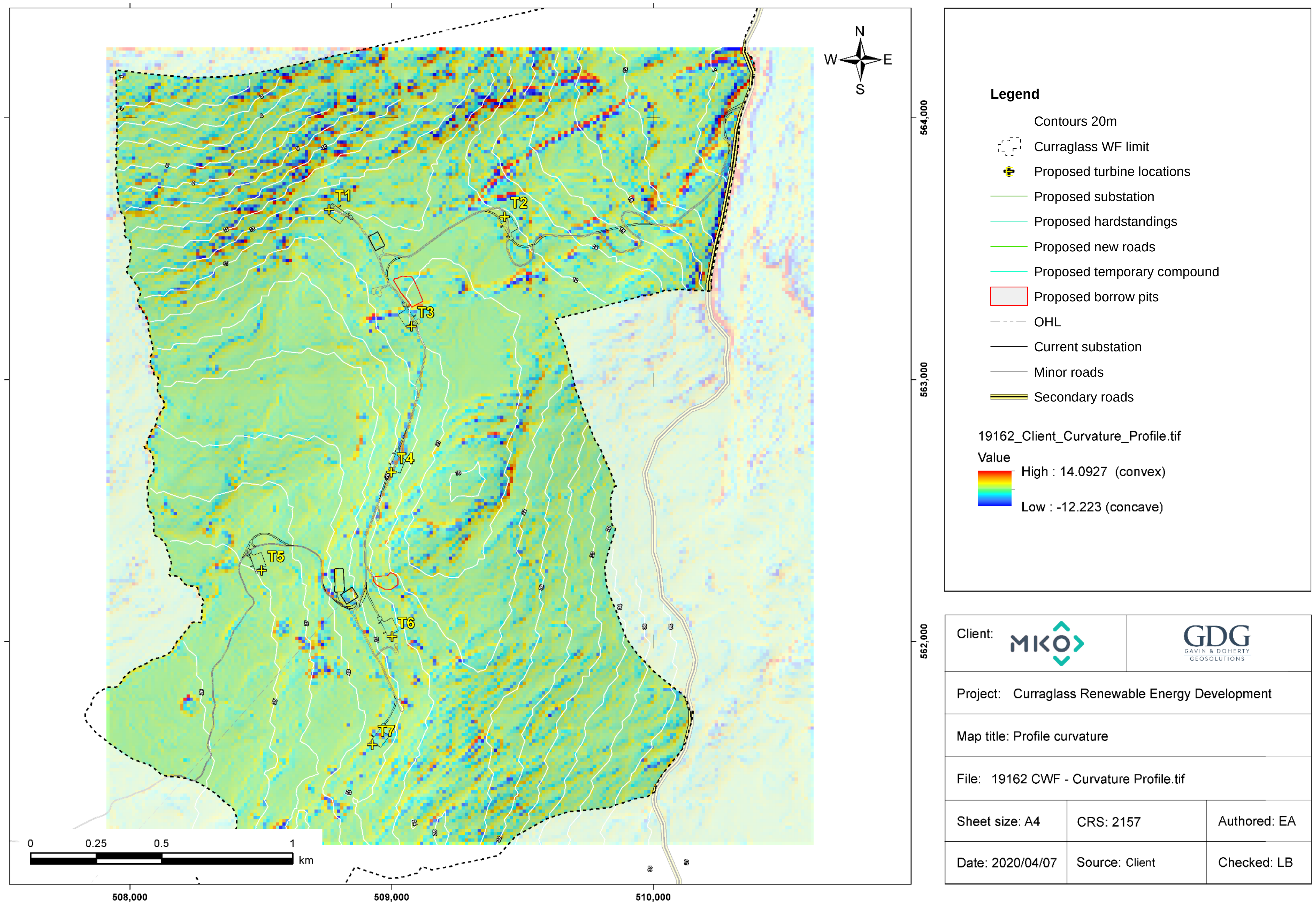


Figure F-3: Profile Curvature (Downslope).

Appendix G Slope instability mapping

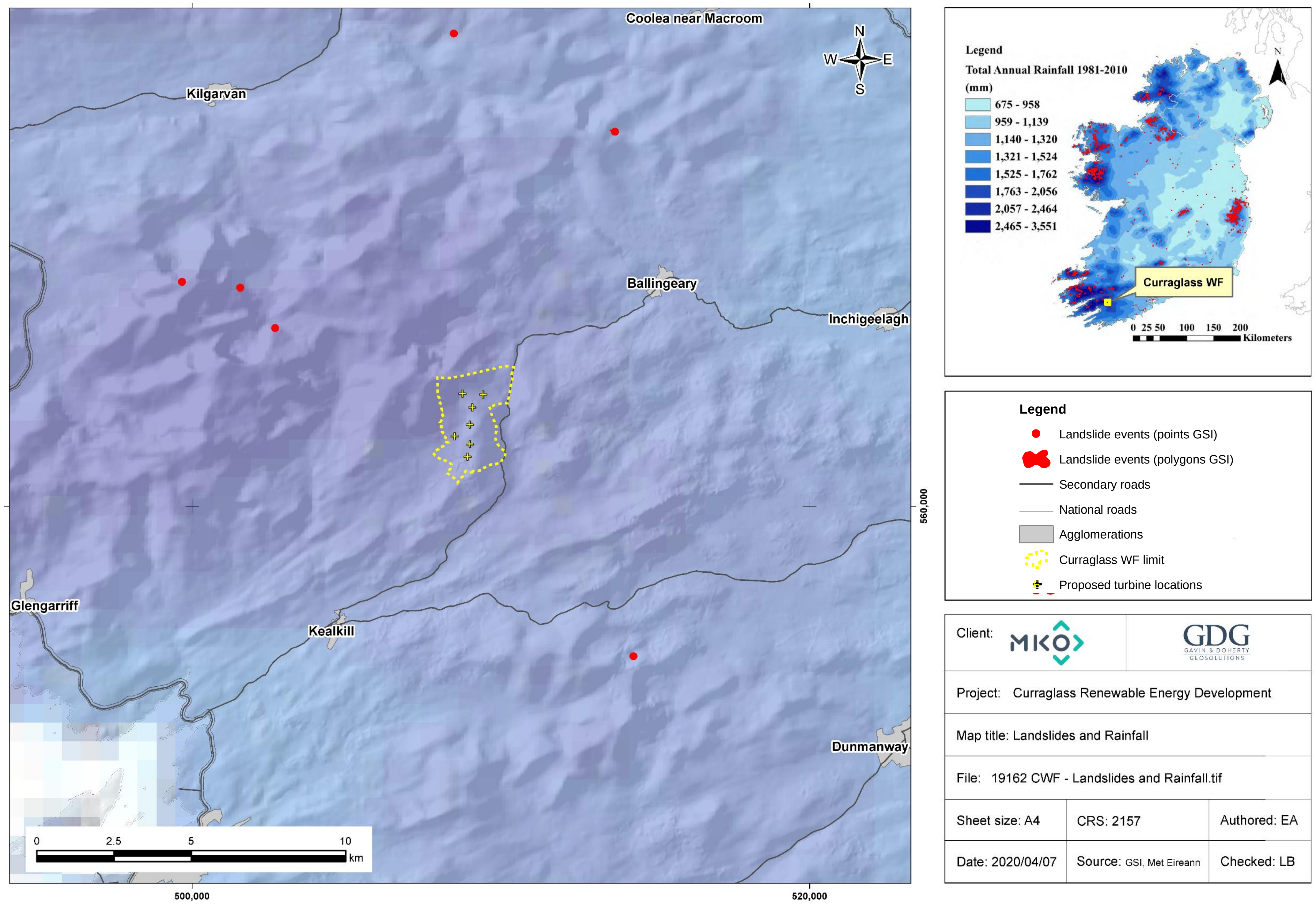


Figure G-1: Landslide from national database (GSI) and rainfall (Met Éireann).

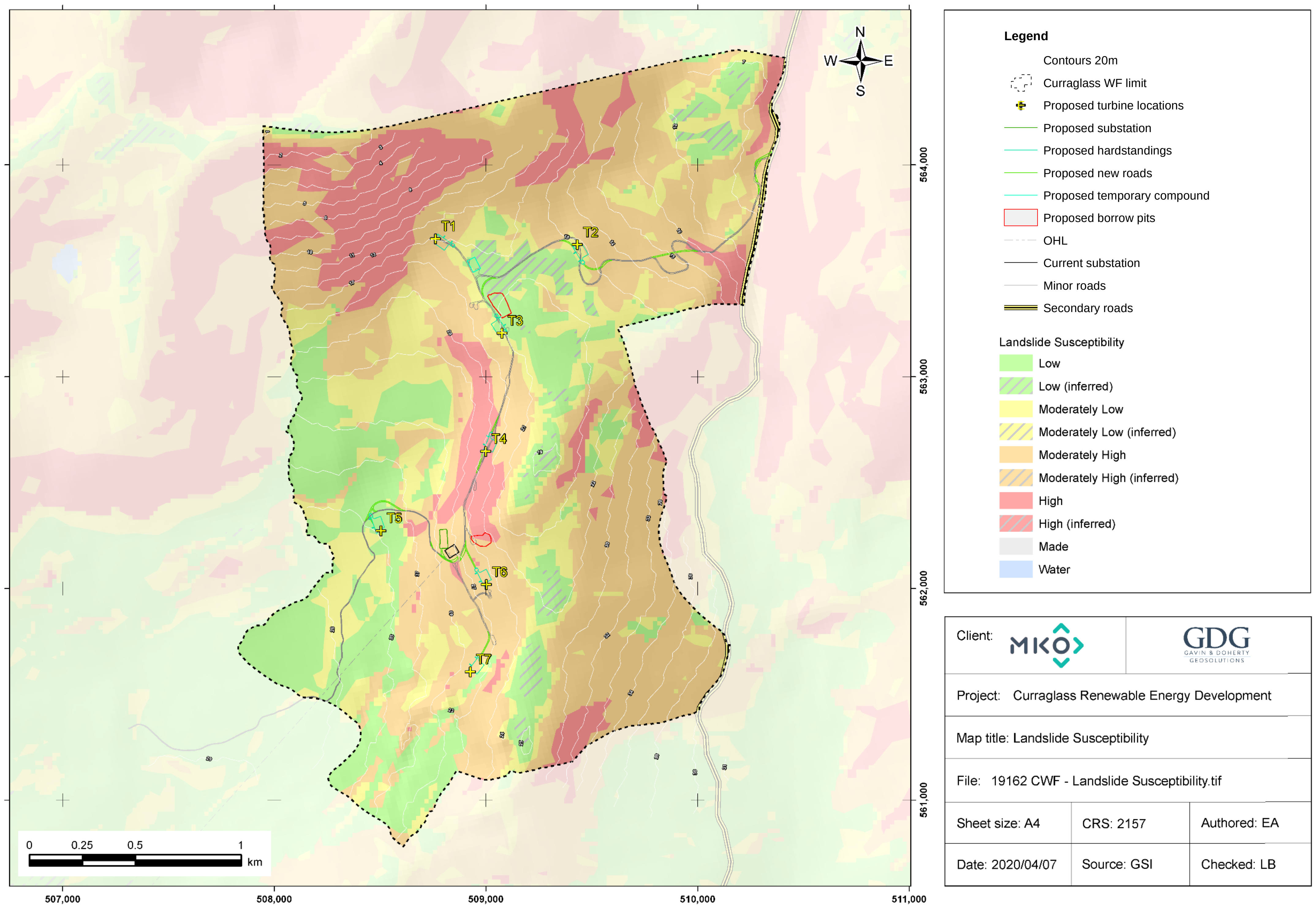


Figure G-2: Landslide Susceptibility (GSI).

Appendix H Hydrology

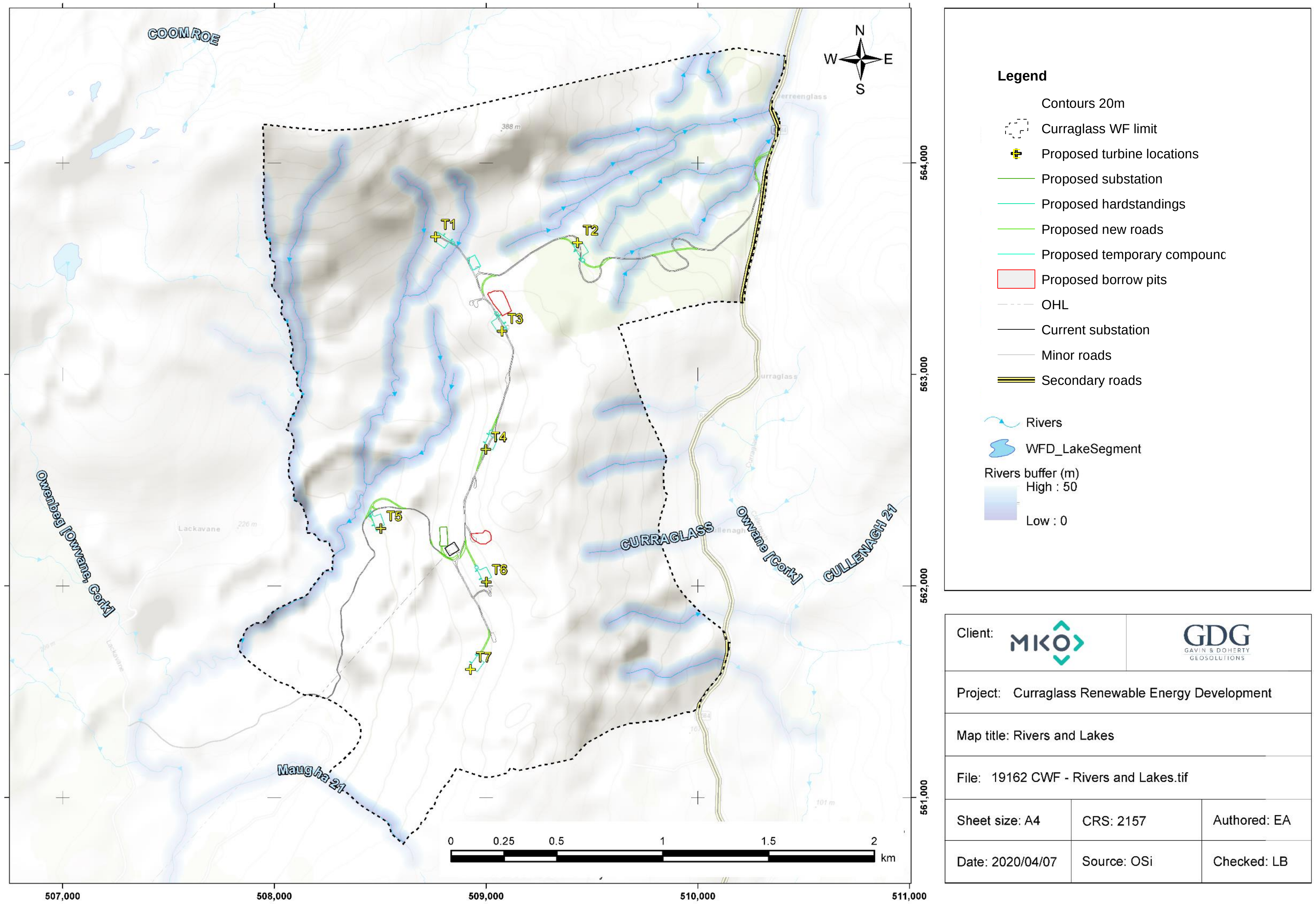


Figure H-1: Rivers and lakes.

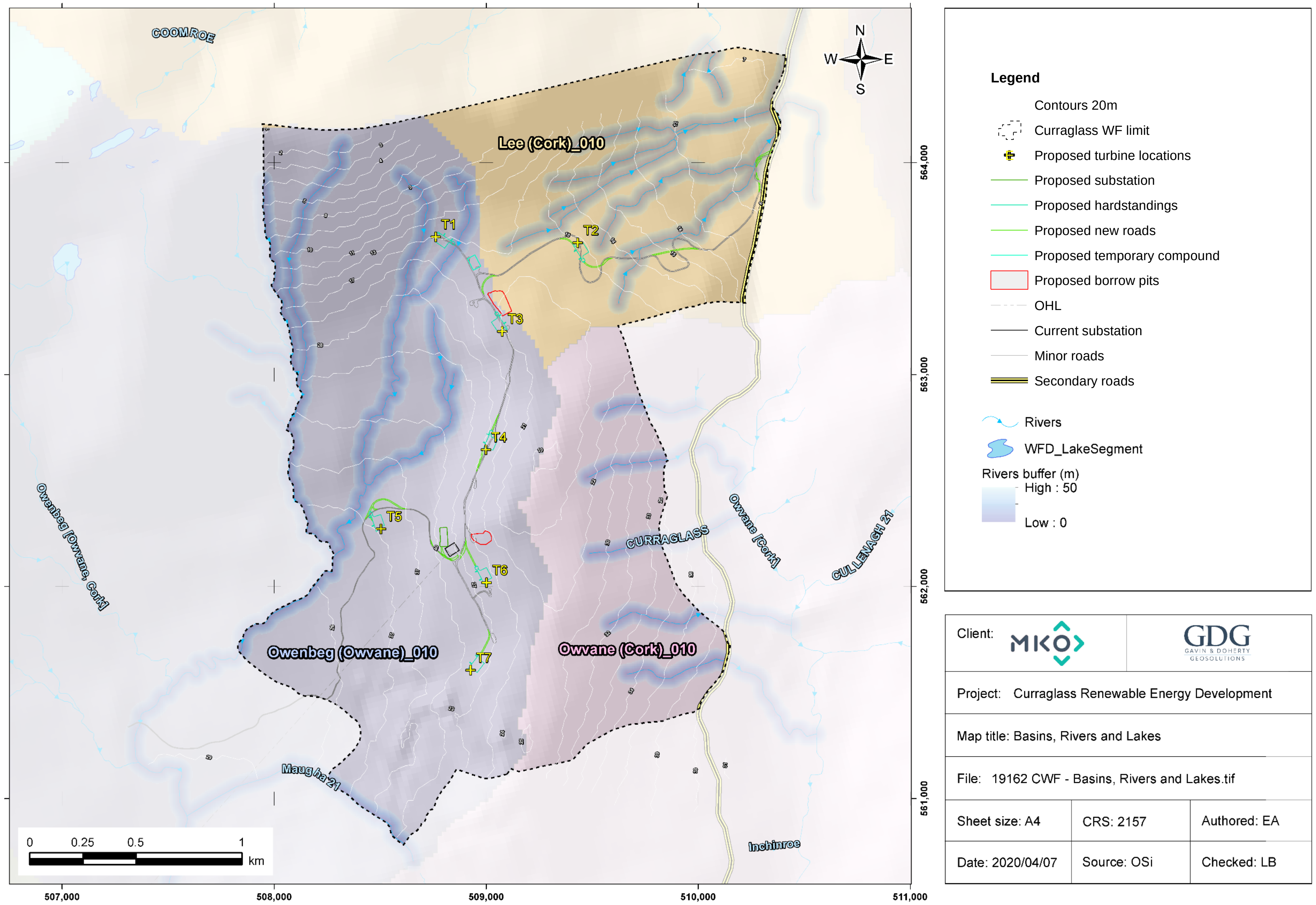


Figure H-2: Basins, rivers and lakes.

Appendix I Land cover and land use

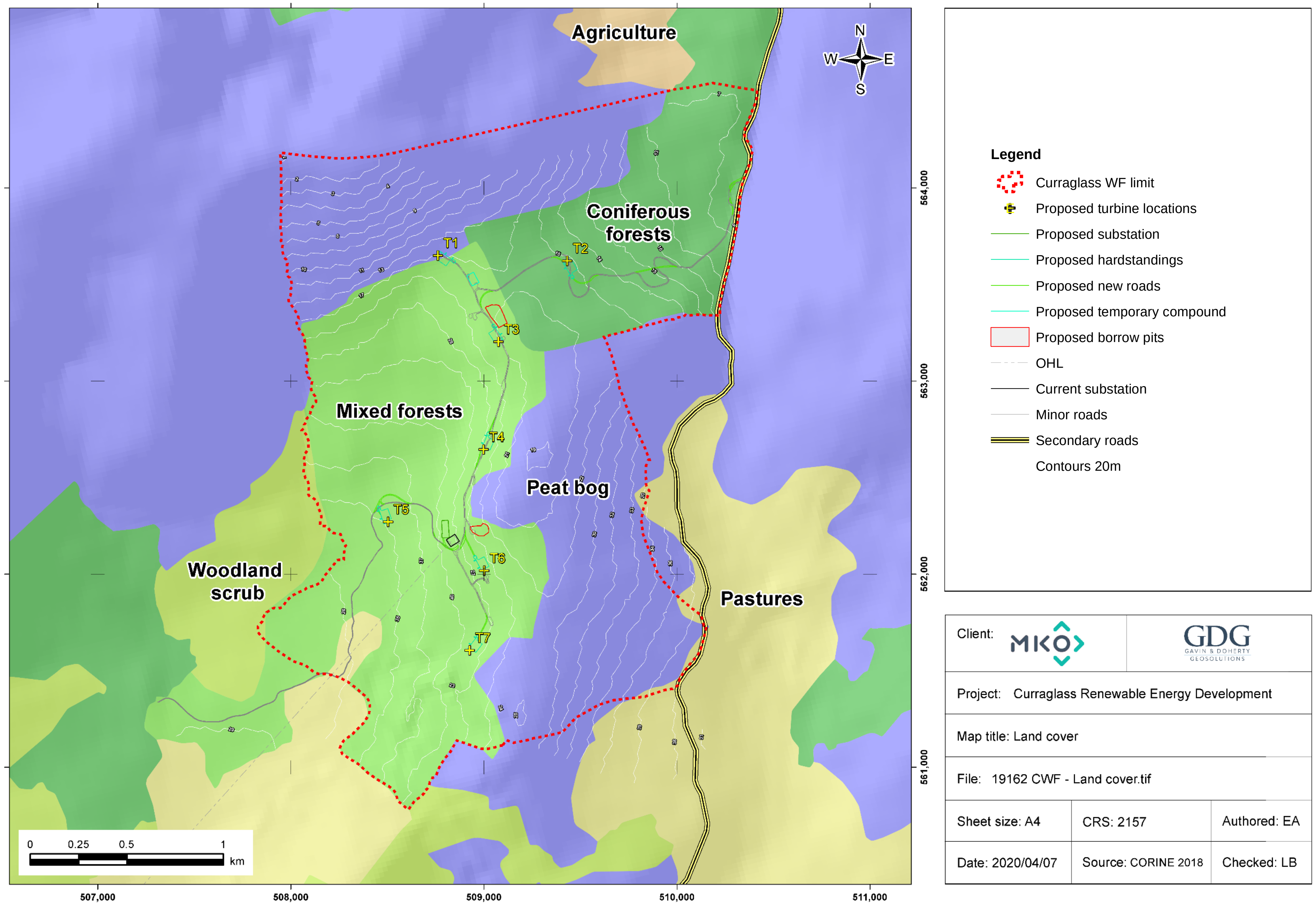


Figure I-1: Corine land cover map (2018).

Appendix J Geo-Investigations

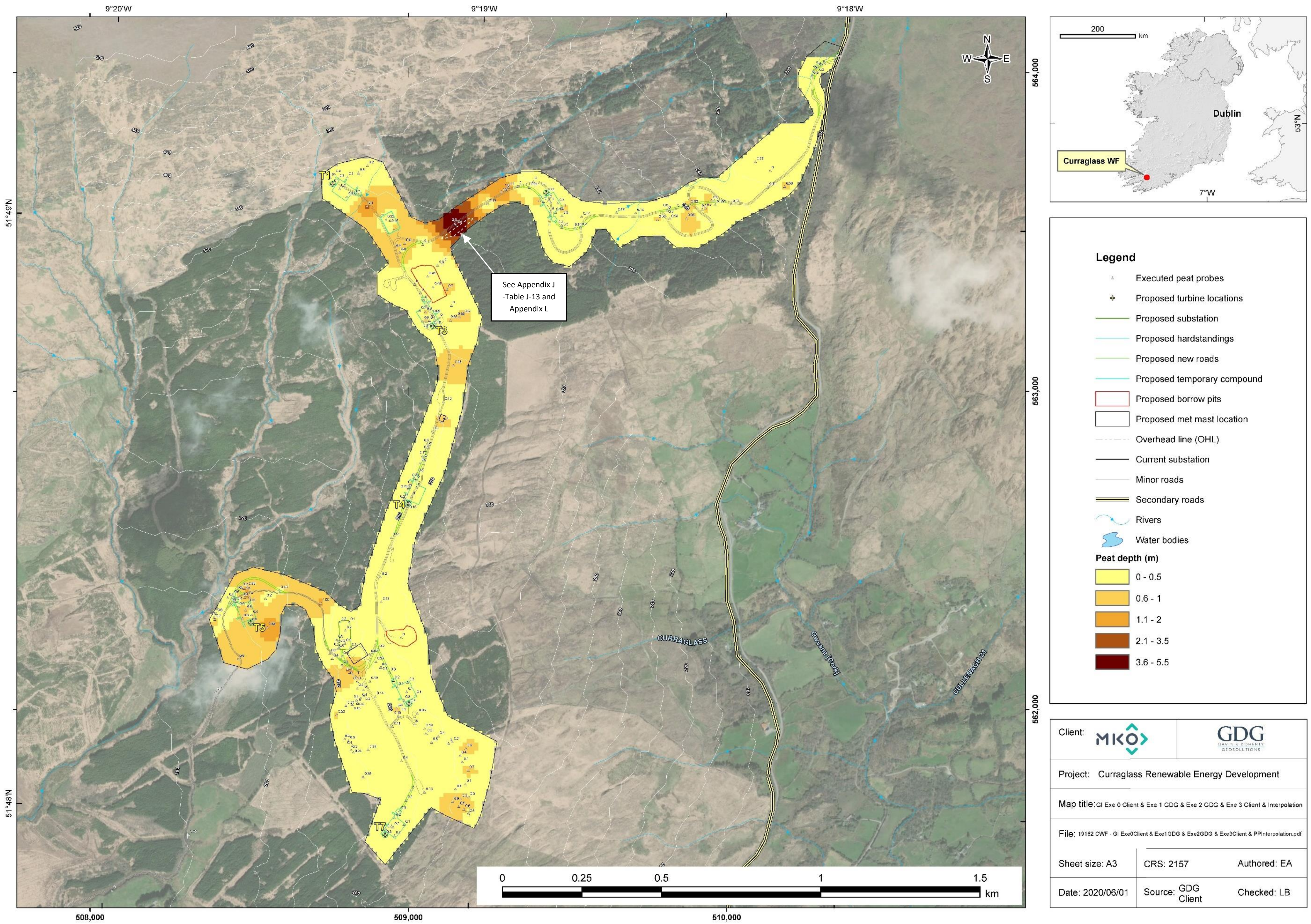
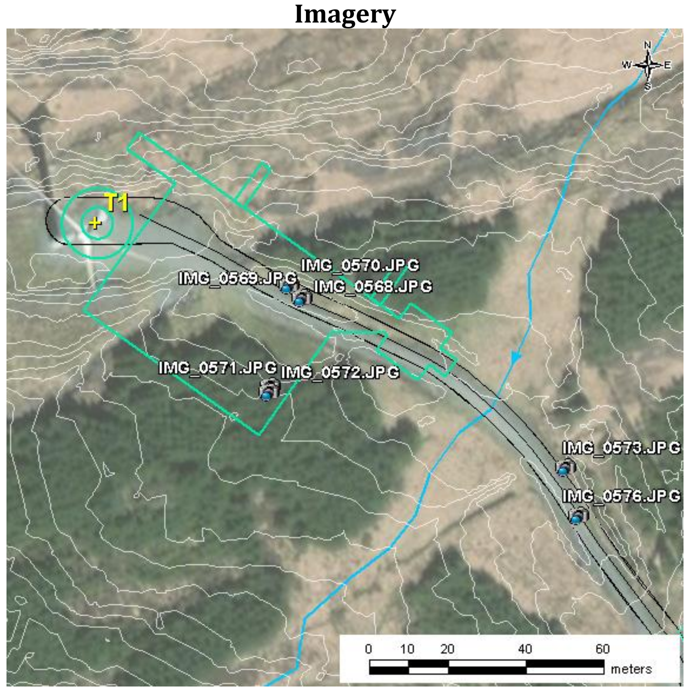


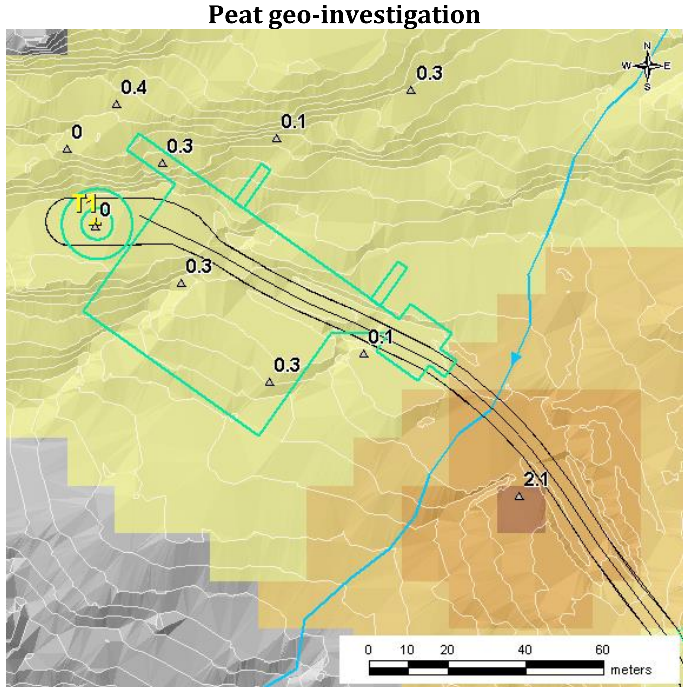
Figure J-1: Geo-investigation map and interpolated peat depth map.

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

Imagery



Peat geo-investigation



Shared legend

- Ground-based photo
- Contours 1m
- Executed peat probes
- Proposed turbine locations
- Proposed substation
- Proposed hardstandings
- Proposed new roads
- Proposed temporary compound
- Proposed borrow pits
- Proposed met mast location
- Existing road
- Rivers

Peat depth (m)

- 0 - 0.5
- 0.6 - 1
- 1.1 - 2
- 2.1 - 3.5
- 3.6 - 5.5

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: The topography is hilly. Excavation and fill will be needed for the hardstanding construction.

Peat: The peat depth at T1 is close to 0 m. Towards the SE the depth increases up to 2.1 m, at the junction of the hardstanding with the projected road. The peat may contain embedded rocks.

Instability evidences: No.

0572.JPG

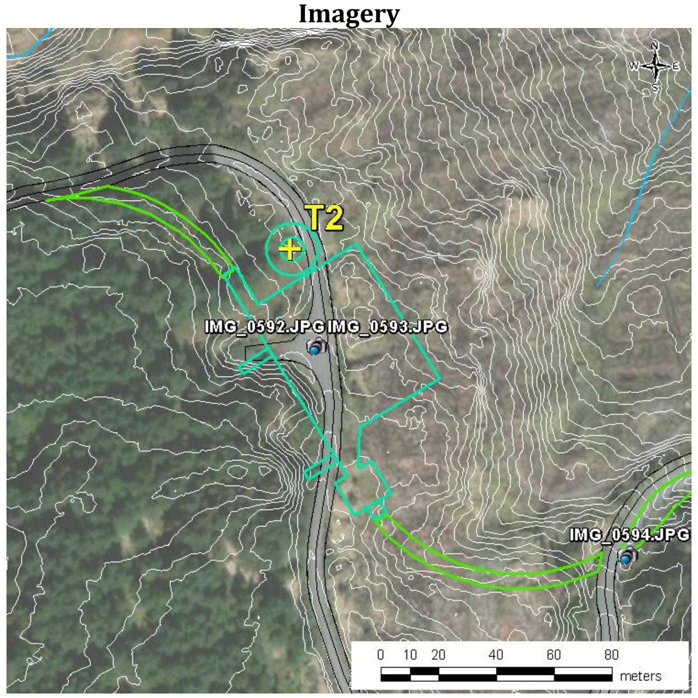
0573.JPG

0576.JPG

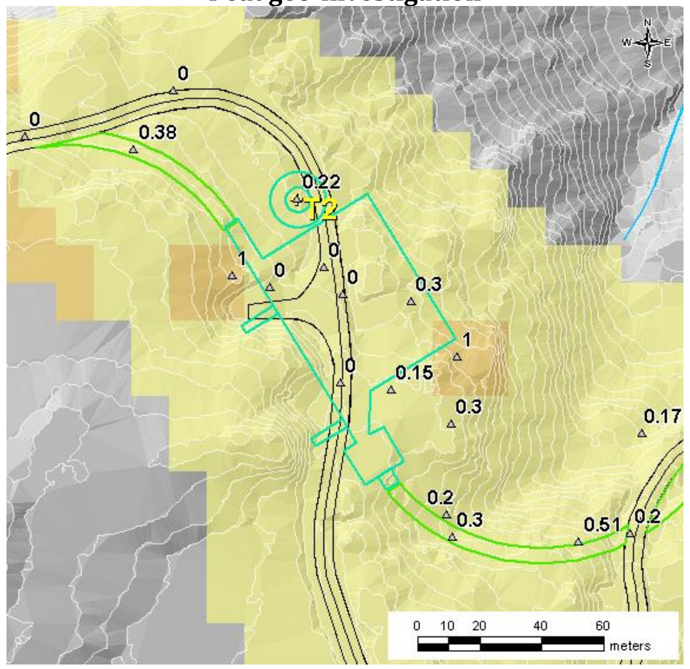
0570.JPG

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

Imagery



Peat geo-investigation



0592.JPG

0593.JPG

Shared legend

Ground-based photo

Contours 1m

Executed peat probes (

Proposed turbine locations

Proposed substation

Proposed hardstandings

Proposed new roads

Proposed temporary compound

Proposed borrow pits

Proposed met mast location

Existing road

Rivers

Peat depth (m)

0 - 0.5

0.6 - 1

1.1 - 2

2.1 - 3.5

3.6 - 5.5

Description

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

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

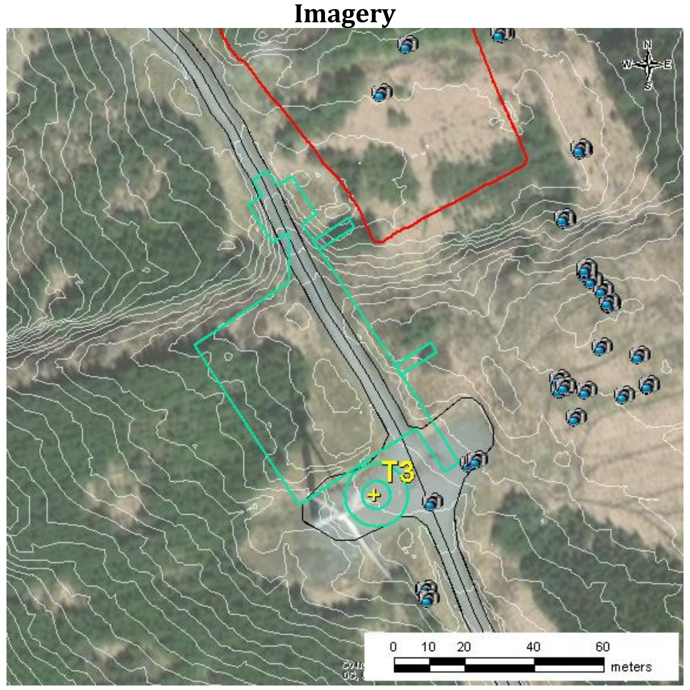
Geomorphology: The topography is partially hilly. Excavation and fill will be needed for the hardstanding construction.

Peat: The peat depth at T2 and across its hardstanding is less than 0.5 m.

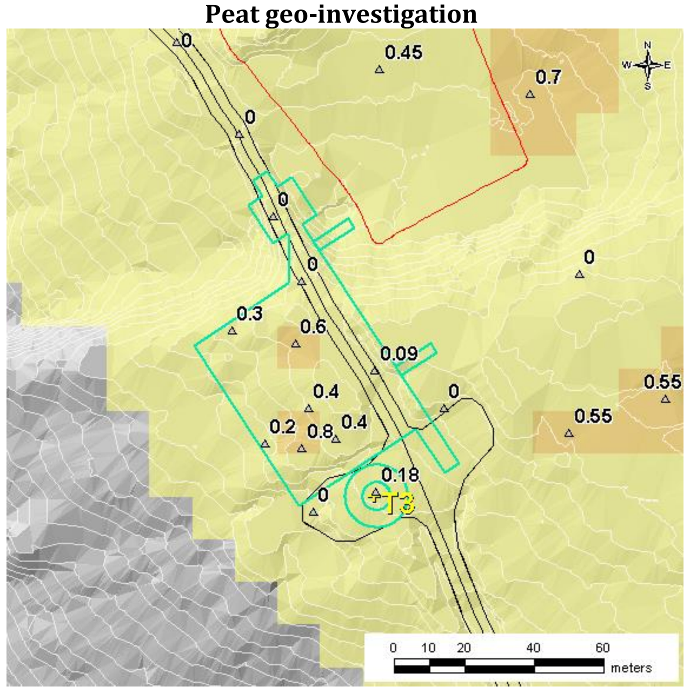
Instability evidences: No.

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

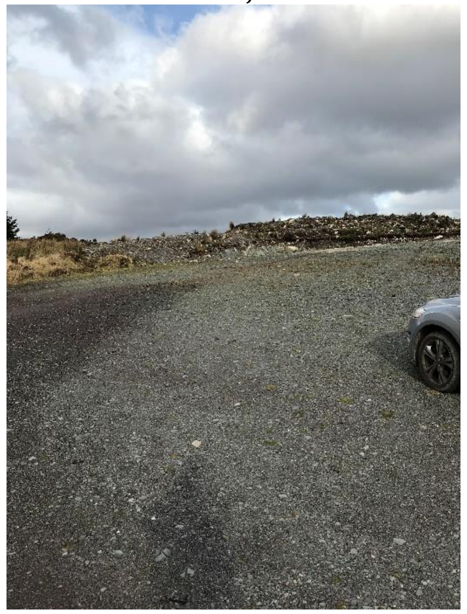
Imagery



Peat geo-investigation



0513.JPG



0517.JPG

Shared legend

Ground-based photo	Proposed substation	Proposed borrow pits	**Peat depth (m)**
Contours 1m	Proposed hardstandings	Proposed met mast location	0 - 0.5
Executed peat probes (	Proposed new roads	Existing road	0.6 - 1
Proposed turbine locations	Proposed temporary compound	Rivers	1.1 - 2
			2.1 - 3.5
			3.6 - 5.5

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: Moderate slope facing south-west with a 5-m in height scarp between the hardstanding and the borrow pit.

Peat: The peat depth is 0 m at T3 site and no greater than 0.8m across almost the whole hardstanding.

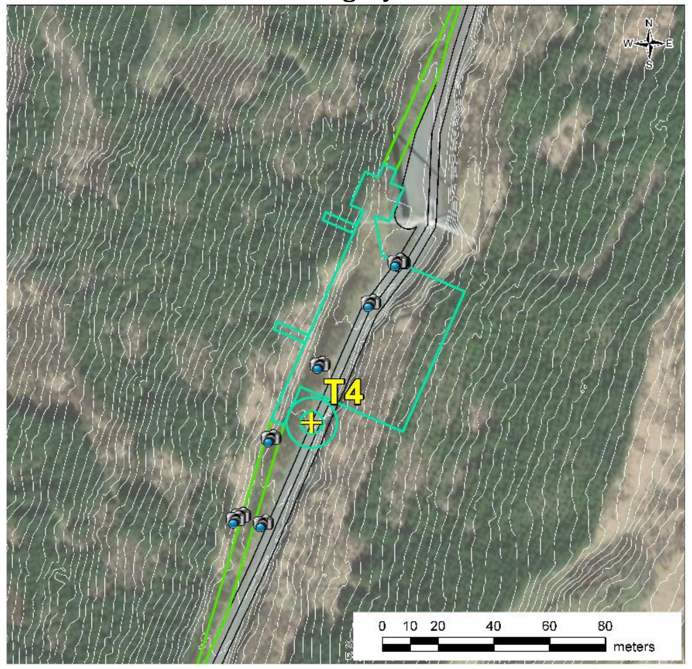
Instability evidences: No.

Comments: Close to a previous turbine location.

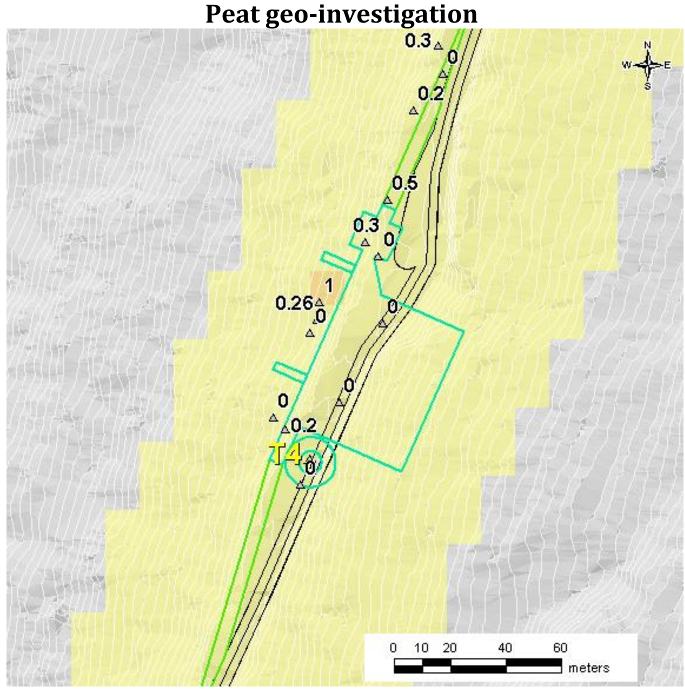
0518.JPG

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

Imagery



Peat geo-investigation



0493.JPG

0491.JPG

Shared legend

Ground-based photo	Proposed substation	Proposed borrow pits	**Peat depth (m)**
Contours 1m	Proposed hardstandings	Proposed met mast location	0 - 0.5
Executed peat probes (	Proposed new roads	Existing road	0.6 - 1
Proposed turbine locations	Proposed temporary compound	Rivers	1.1 - 2
			2.1 - 3.5
			3.6 - 5.5

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: Steep slope facing West and the road parallel to the contours.

Peat: The peat depth in this sector is 0 – 1 m. The photos show that this relatively thin layer of peat is onto a glacial deposit.

Instability evidences: Only at road cuts.

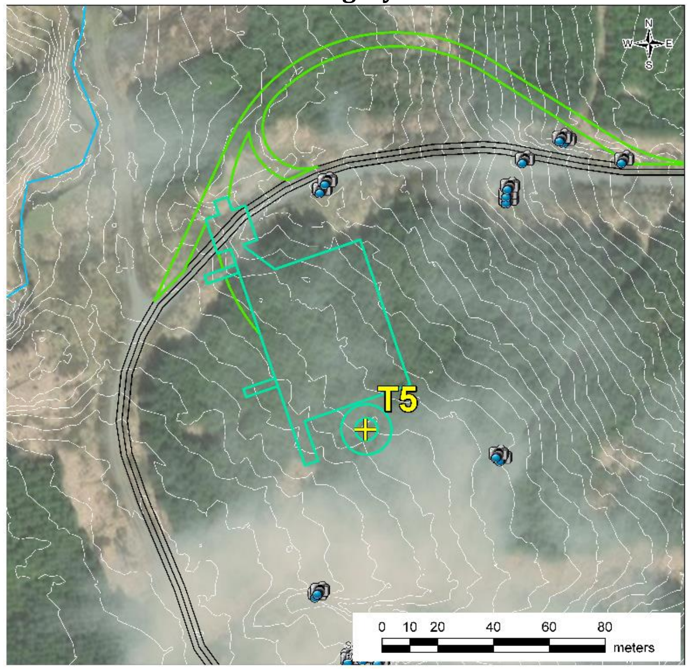
Comments: Close to a previous turbine location.

0488.JPG

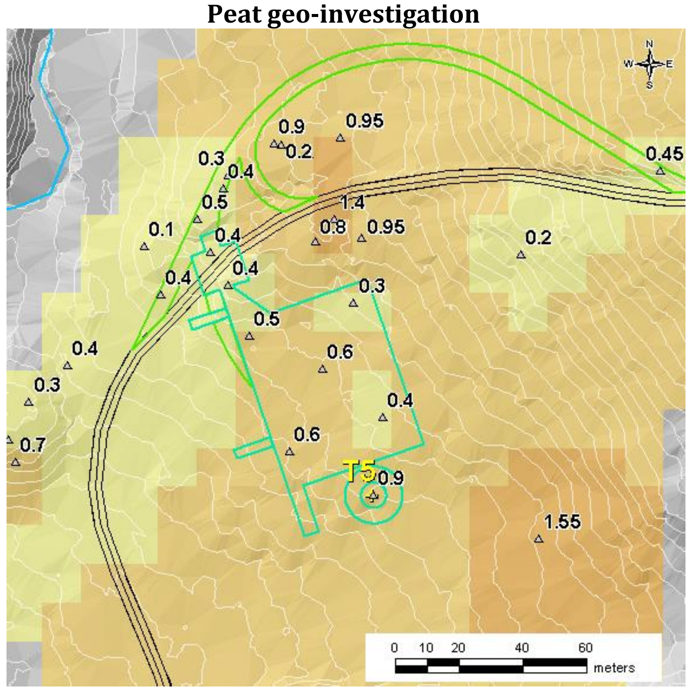
0489.JPG

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

Imagery



Peat geo-investigation



0408.JPG

0410.JPG

Shared legend

Ground-based photo
Contours 1m
Executed peat probes
Proposed turbine locations
Proposed substation
Proposed hardstandings
Proposed new roads
Proposed temporary compound
Proposed borrow pits
Proposed met mast location
Existing road
Rivers

Peat depth (m)
0 - 0.5
0.6 - 1
1.1 - 2
2.1 - 3.5
3.6 - 5.5

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: Moderated slope facing SW with some small downslope drainages to the East.

Peat: Depths of 0.6 m at the middle of the hardstanding and 0.9 m at T5.

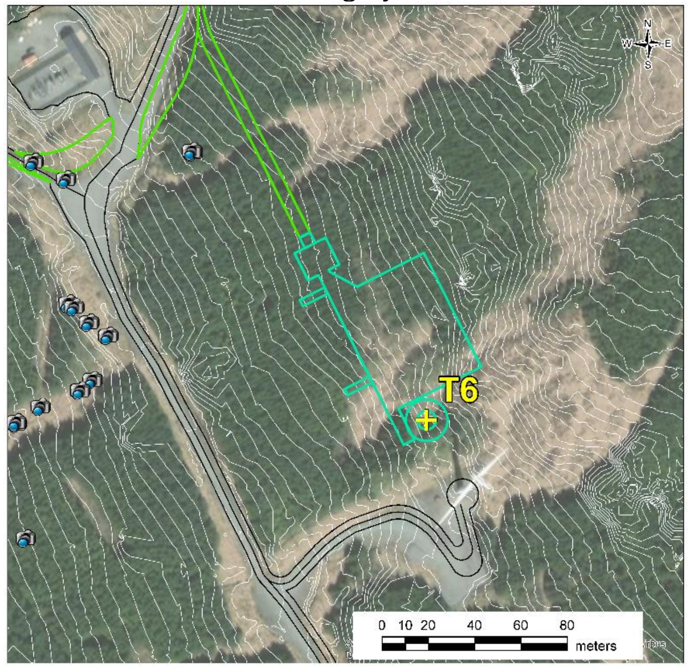
Instability evidences: No.

0406.JPG

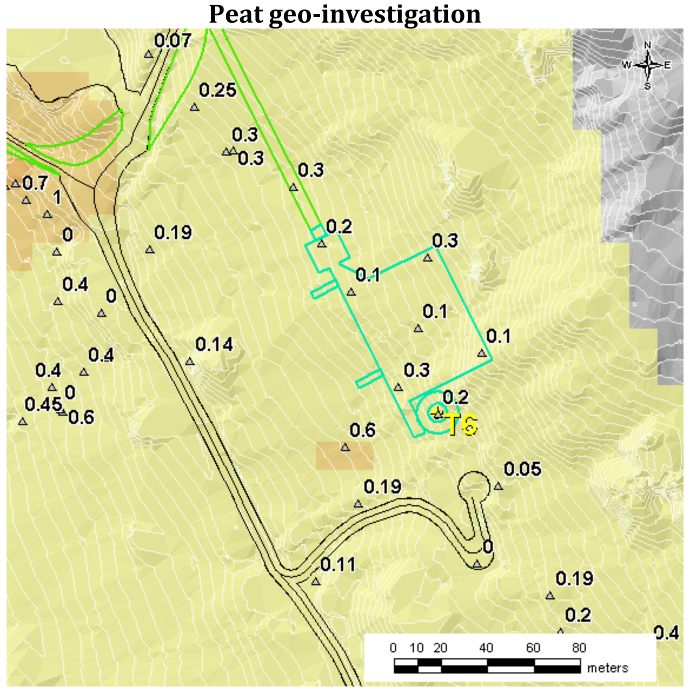
0412.JPG

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

Imagery



Peat geo-investigation



0465.JPG

0468.JPG

Shared legend

Ground-based photo	Proposed substation	Proposed borrow pits	**Peat depth (m)**
Contours 1m	Proposed hardstandings	Proposed met mast location	0 - 0.5
Executed peat probes	Proposed new roads	Existing road	0.6 - 1
Proposed turbine locations	Proposed temporary compound	Rivers	1.1 - 2
			2.1 - 3.5
			3.6 - 5.5

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: Steep slope facing West intersected by narrow water drainages (see photos 0460 and 0463).

Peat: Depths of 0.1 m at the middle of the hardstanding and 0.2 to 0.3 at T6 site.

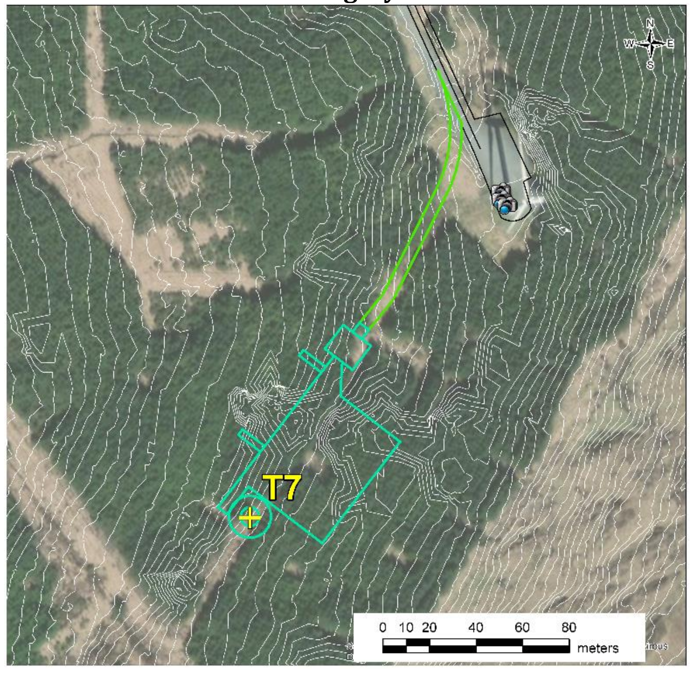
Instability evidences: No.

0470.JPG

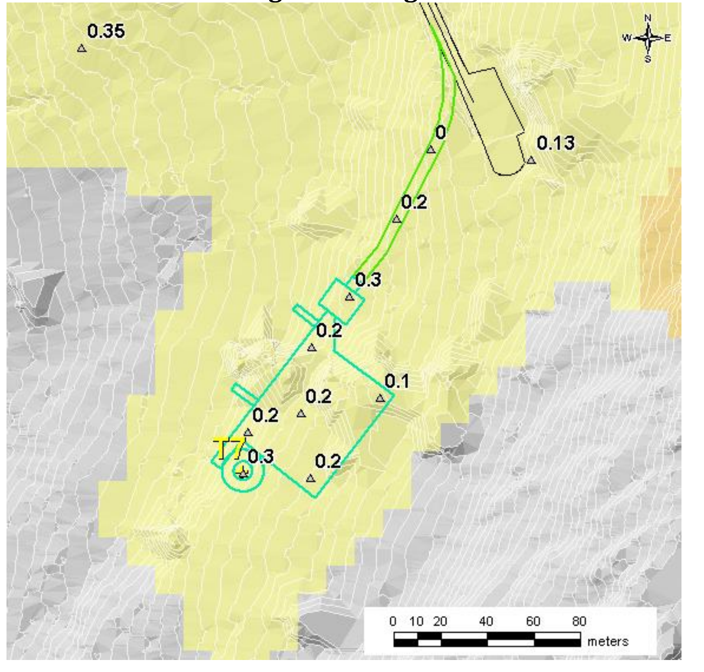
0460.JPG

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

Imagery



Peat geo-investigation



Shared legend

Ground-based photo	Proposed substation	Proposed borrow pits	**Peat depth (m)**
Contours 1m	Proposed hardstandings	Proposed met mast location	0 - 0.5
Executed peat probes	Proposed new roads	Existing road	0.6 - 1
Proposed turbine locations	Proposed temporary compound	Rivers	1.1 - 2
			2.1 - 3.5
			3.6 - 5.5

Description

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

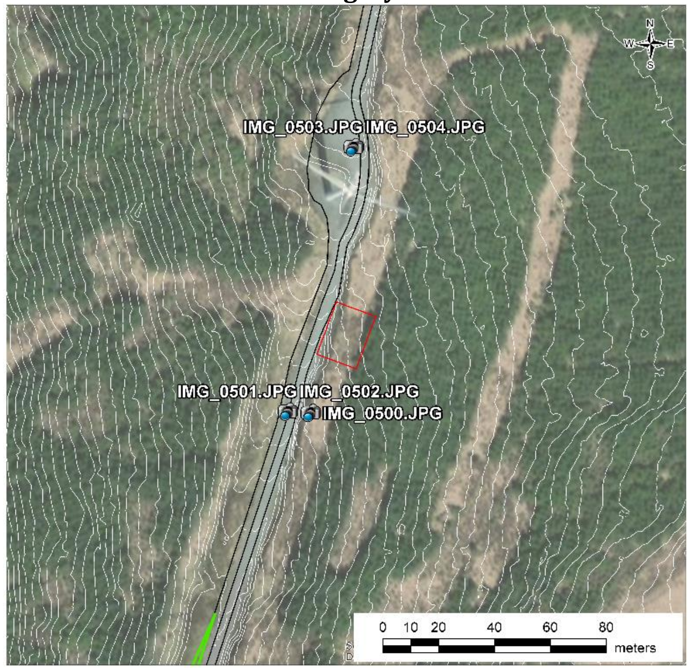
Geomorphology: Hilly and steep topography. Excavation and fill will be needed for this hardstanding.

Peat: Depths of 0.2 m at the middle of the hardstanding and 0.3 at T7 site.

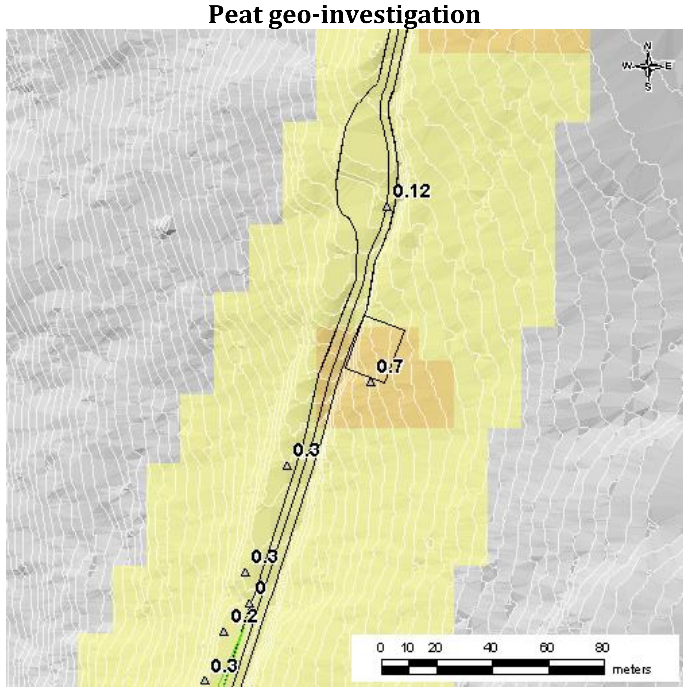
Instability evidences: No.

Table J-8: Site reconnaissance of Met Mast site.

Imagery



Peat geo-investigation



Shared legend

Ground-based photo	Proposed substation	Proposed borrow pits	**Peat depth (m)**
Contours 1m	Proposed hardstandings	Proposed met mast location	0 - 0.5
Executed peat probes	Proposed new roads	Existing road	0.6 - 1
Proposed turbine locations	Proposed temporary compound	Rivers	1.1 - 2
			2.1 - 3.5
			3.6 - 5.5

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: Moderate slope facing West.

Peat: Depth of 0.7 m.

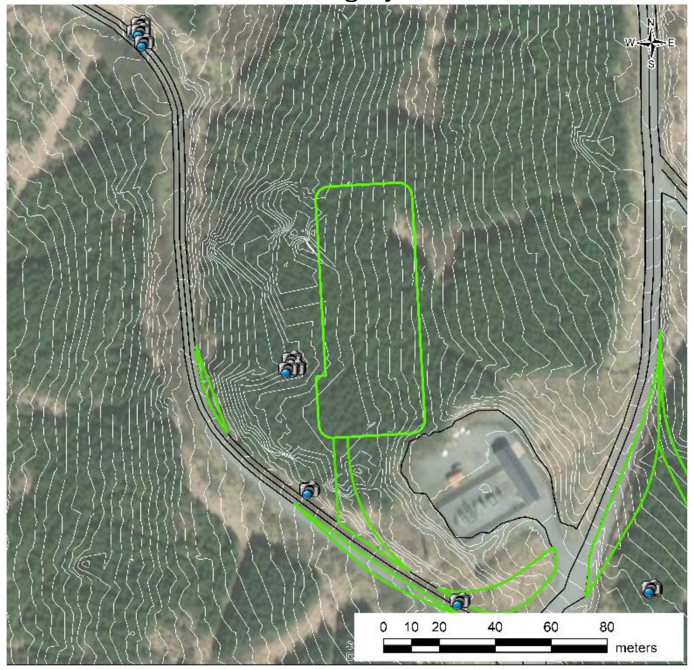
Instability evidences: No.

0500.JPG

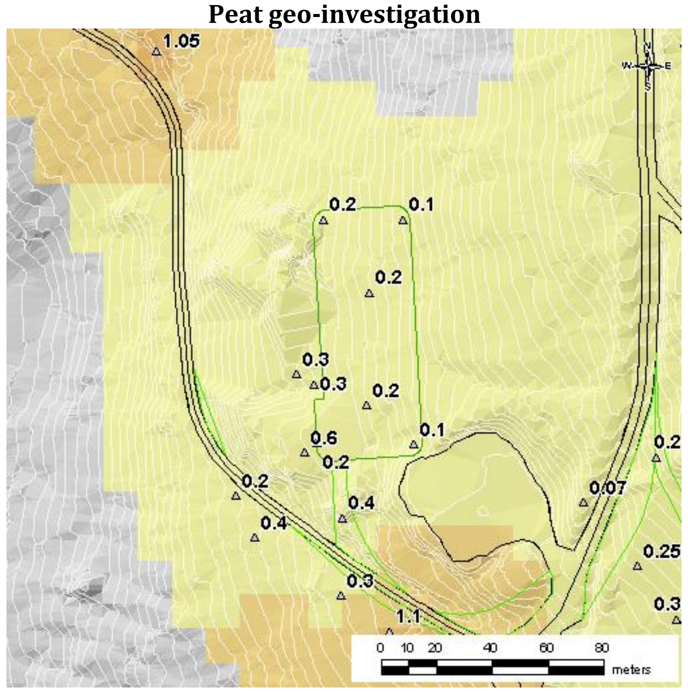
0501.JPG

Table J-9: Site reconnaissance of the proposed substation site.

Imagery



Peat geo-investigation



0436.JPG

0445.JPG

Shared legend

- Ground-based photo
- Contours 1m
- Executed peat probes
- Proposed turbine locations
- Proposed substation
- Proposed hardstandings
- Proposed new roads
- Proposed temporary compound
- Proposed borrow pits
- Proposed met mast location
- Existing road
- Rivers

Peat depth (m)

- 0 - 0.5
- 0.6 - 1
- 1.1 - 2
- 2.1 - 3.5
- 3.6 - 5.5

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: Steep slope facing West.

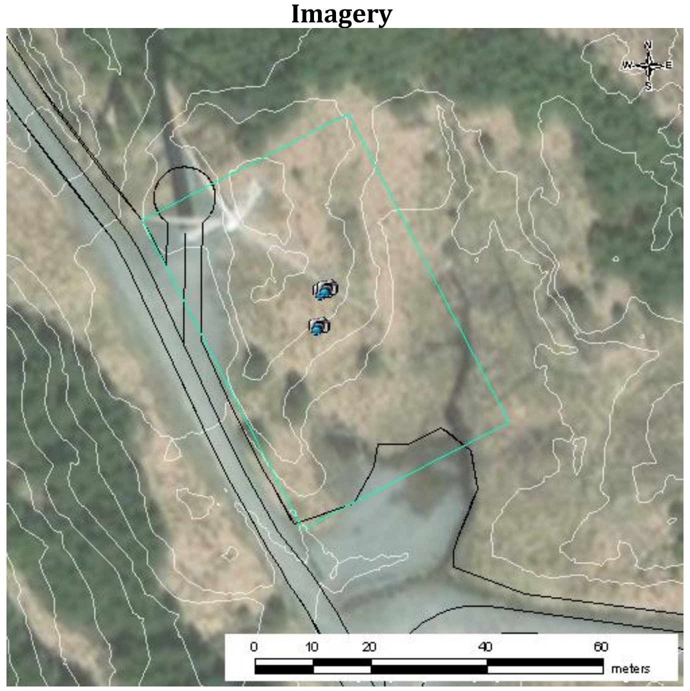
Peat: Depth ranges between 0.3 and 0.6 m.

Instability evidences: No.

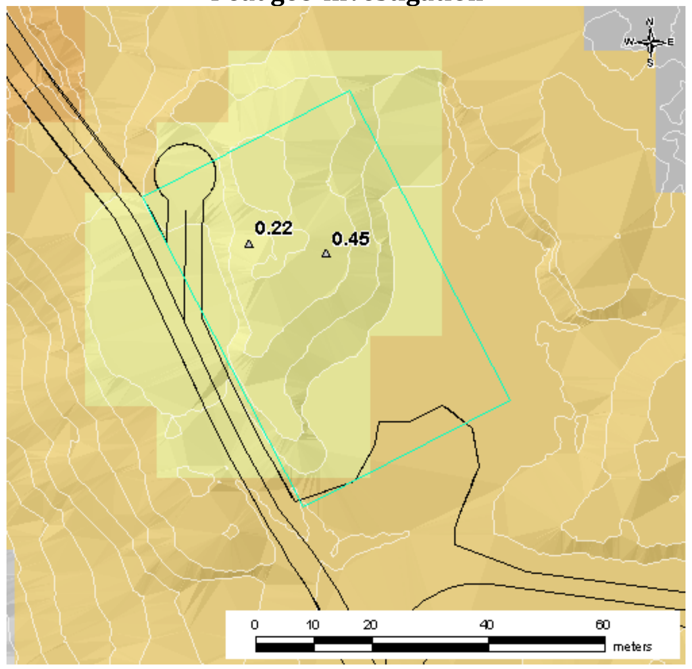
0433.JPG

Table J-10: Site reconnaissance of the temporary compound location site.

Imagery



Peat geo-investigation



0580.JPG

0577.JPG

Shared legend

Ground-based photo
Contours 1m
Executed peat probes (
Proposed turbine locations
Proposed substation
Proposed hardstandings
Proposed new roads
Proposed temporary compound
Proposed borrow pits
Proposed met mast location
Existing road
Rivers

Peat depth (m)
0 - 0.5
0.6 - 1
1.1 - 2
2.1 - 3.5
3.6 - 5.5

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: It is a watershed sector relatively horizontal with deficient drainage (note the pond).

Peat: The two probes carried out at this sector indicate depths of up to 0.45 m. At the SE of the compound polygon, the depths might higher as it is more horizontal.

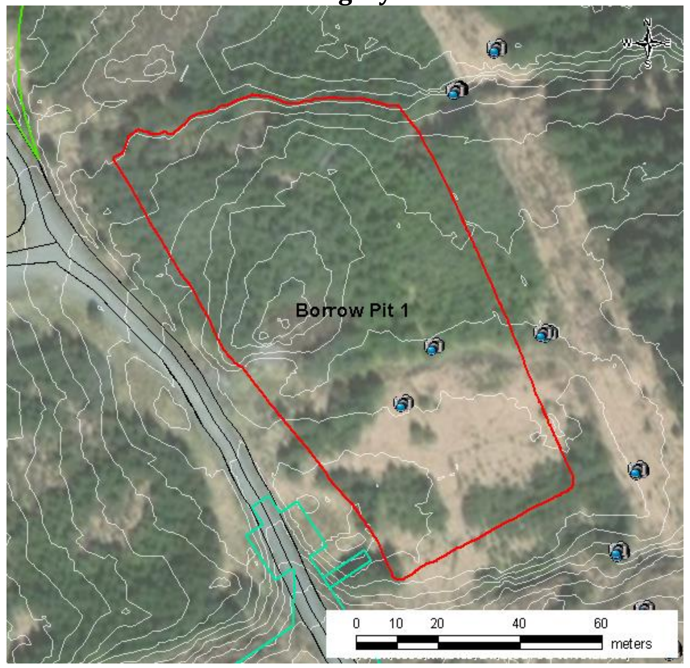
Instability evidences: No.

Comments: Close to a previous turbine location.

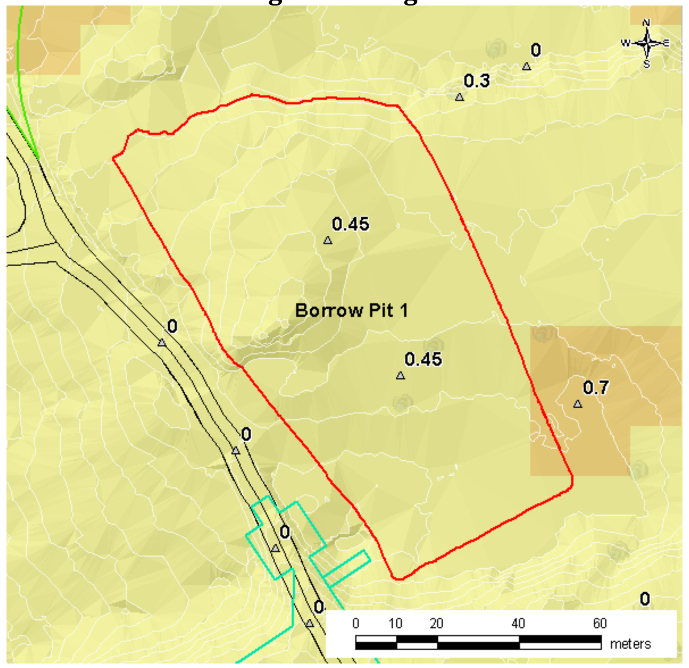
0578.JPG

Table J-11: Site reconnaissance of the Borrow Pit 1 site.

Imagery



Peat geo-investigation



Shared legend

Ground-based photo	Proposed substation	Proposed borrow pits	**Peat depth (m)**
Contours 1m	Proposed hardstandings	Proposed met mast location	0 - 0.5
Executed peat probes	Proposed new roads	Existing road	0.6 - 1
Proposed turbine locations	Proposed temporary compound	Rivers	1.1 - 2
			2.1 - 3.5
			3.6 - 5.5

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: The topography is convex in the northern half and horizontal in the south.

Peat: In the northern half the peat depth is almost 0. In the southern half, peat depths of up to 0.45 m can be found.

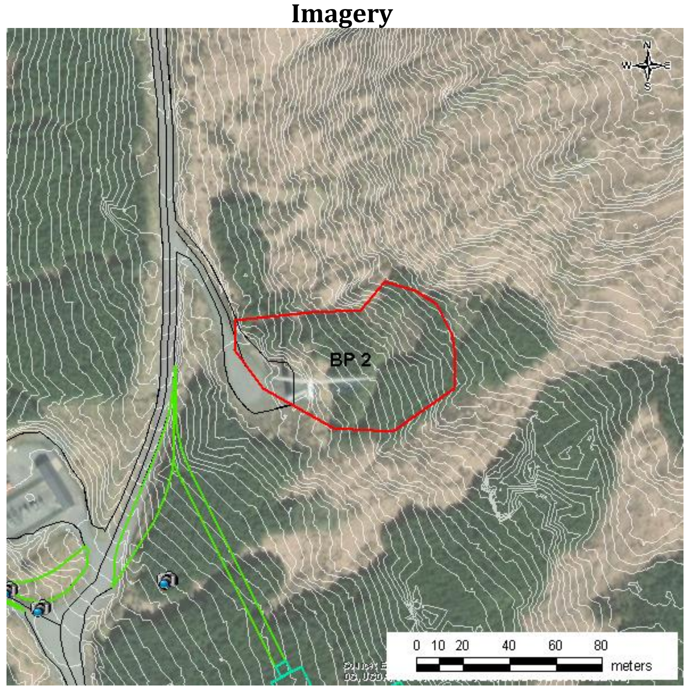
Instability evidences: No.

0550.JPG

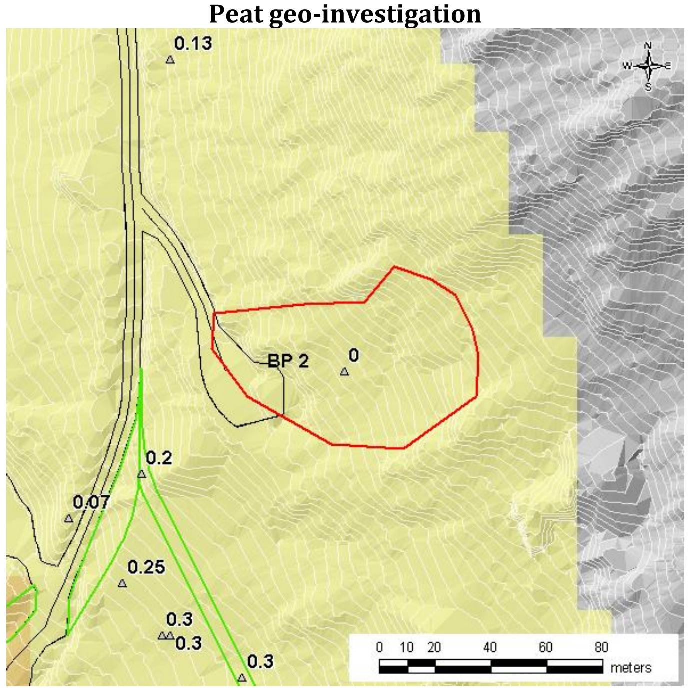
0554.JPG

Table J-12: Site reconnaissance of the Borrow Pit 2 site.

Imagery



Peat geo-investigation



Shared legend

Ground-based photo
Contours 1m
Executed peat probes
Proposed turbine locations
Proposed substation
Proposed hardstandings
Proposed new roads
Proposed temporary compound
Proposed borrow pits
Proposed met mast location
Existing road
Rivers

Peat depth (m)
0 - 0.5
0.6 - 1
1.1 - 2
2.1 - 3.5
3.6 - 5.5

Description

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

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

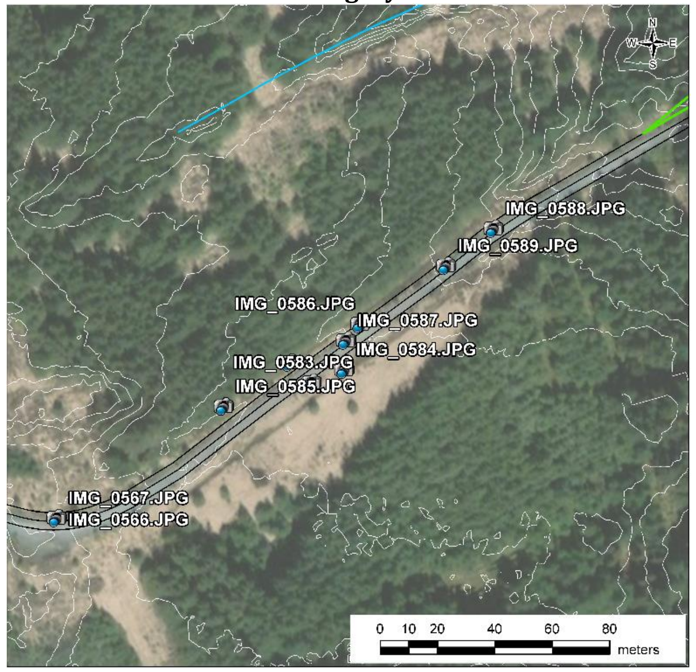
Geomorphology: The topography is slightly concave with a minor gully funnelling the runoff in this sector.

Peat: Based on nearby peat probes and geomorphic criteria, an average peat depth of 0.2 m is assumed for this borrow pit.

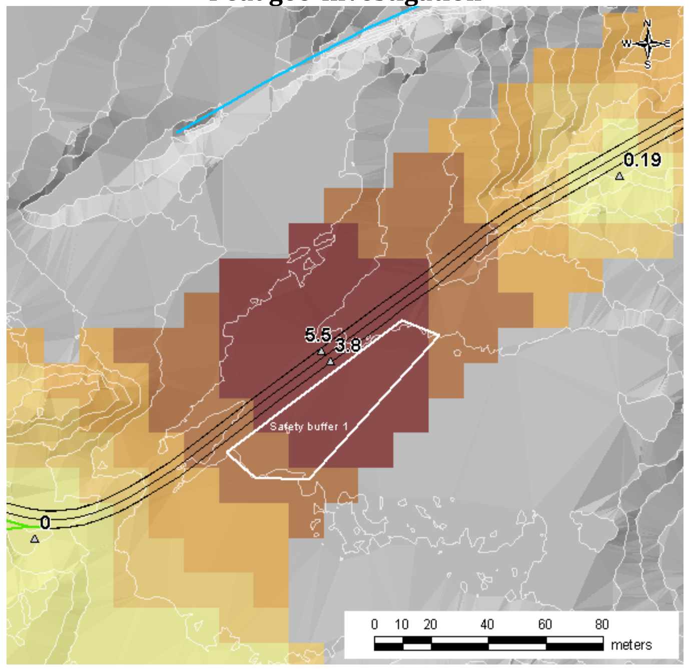
Instability evidences: No.

Table J-13: Site reconnaissance of a hazardous sector beside the existing and projected road, between T1 and T2.

Imagery



Peat geo-investigation



0584.JPG

0585.JPG

Shared legend

Ground-based photo
Contours 1m
Executed peat probes
Proposed turbine locations
Proposed substation
Proposed hardstandings
Proposed new roads
Proposed temporary compound
Proposed borrow pits
Proposed met mast location
Existing road
Rivers

Peat depth (m)
0 - 0.5
0.6 - 1
1.1 - 2
2.1 - 3.5
3.6 - 5.5

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: Horizontal terrain.

Peat: This is an area of soft and buoyant peat of up to 5.5 m deep, the deepest peat found in this study. This area is offset 2m from the existing track. Upgrade of the existing track only is proposed here and this will be safe to carry out. This soft, buoyant peat area however, which is offset from the existing track, should be restricted for construction and it should not be used for material/spoil storage or side casting. A safety buffer is proposed here.

Comments: There is a large drain running adjacent to the road covered with a thick layer of vegetation. The drain may be several metres deep and could easily have not been noticed and walked into accidentally as it is hidden beneath the vegetation. This is a potential hazard for any further works which will be carried out on site.

0586.JPG

0588.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
	(°)			Cu (kPa)	Y (kN/m^3)	(m)		(m)	
CWF T1	6.9	0.993	0.120	8	10	0.05	**134.15**	1	**6.39**
CWF T2	5.3	0.996	0.092	8	10	0.26	**33.45**	1	**6.90**
CWF T3	4.5	0.997	0.078	8	10	0.24	**42.62**	1	**8.25**
CWF T4	16.7	0.958	0.287	8	10	0.1	**29.07**	1	**2.64**
CWF T5	5.7	0.995	0.099	8	10	0.87	**9.30**	1	**4.33**
CWF T6	13.9	0.971	0.240	8	10	0.3	**11.44**	1	**2.64**
CWF T7	13.6	0.972	0.235	8	10	0.4	**8.75**	1	**2.50**

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

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 Cu (kPa)	Bulk unit weight of Peat Y (kN/m³)	Peat depth (m)	Bulk unit weight of water Y (kN/m³)	Height of water table above failure surface (m)	Slope (°)	Cos Slope	Cos² Slope	Sin Slope	ϕ'	Tan ϕ'	FoS	Surcharge (m)	FoS Surcharge
CWF T1	4	10	0.05	9.8	0.05	6.9	0.993	0.986	0.120	25	0.466	**67.15**	1	**6.87**
CWF T2	4	10	0.26	9.8	0.26	5.3	0.996	0.991	0.092	25	0.466	**16.83**	1	**7.46**
CWF T3	4	10	0.24	9.8	0.24	4.5	0.997	0.994	0.078	25	0.466	**21.43**	1	**8.93**
CWF T4	4	10	0.1	9.8	0.1	16.7	0.958	0.917	0.287	25	0.466	**14.56**	1	**2.74**
CWF T5	4	10	0.87	9.8	0.87	5.7	0.995	0.990	0.099	25	0.466	**4.75**	1	**4.71**
CWF T6	4	10	0.3	9.8	0.3	13.9	0.971	0.942	0.240	25	0.466	**5.76**	1	**2.78**
CWF T7	4	10	0.4	9.8	0.4	13.6	0.972	0.945	0.235	25	0.466	**4.41**	1	**2.64**

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

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
ϕ' = Effective friction angle

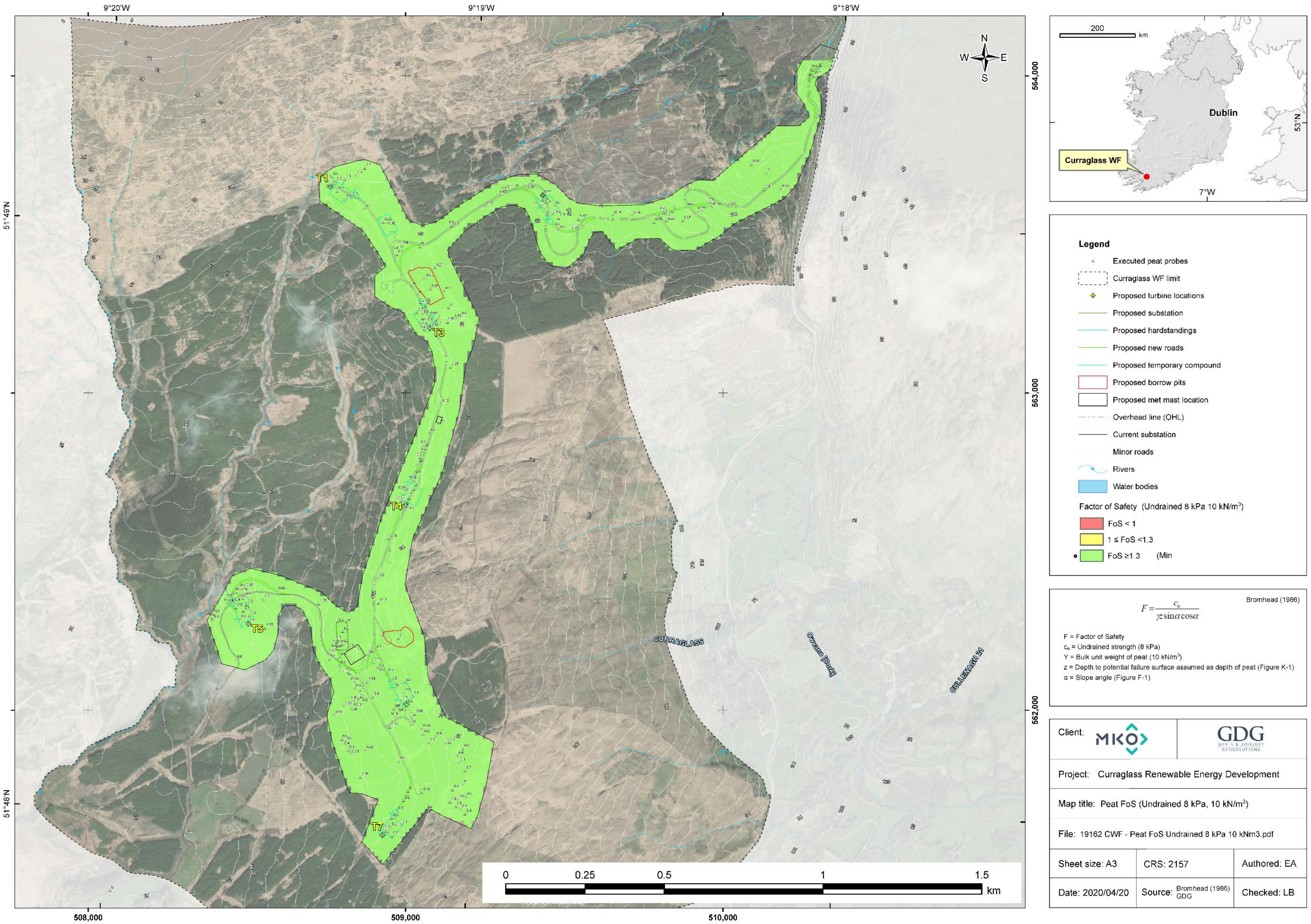


Figure K-1: FoS for undrained conditions.

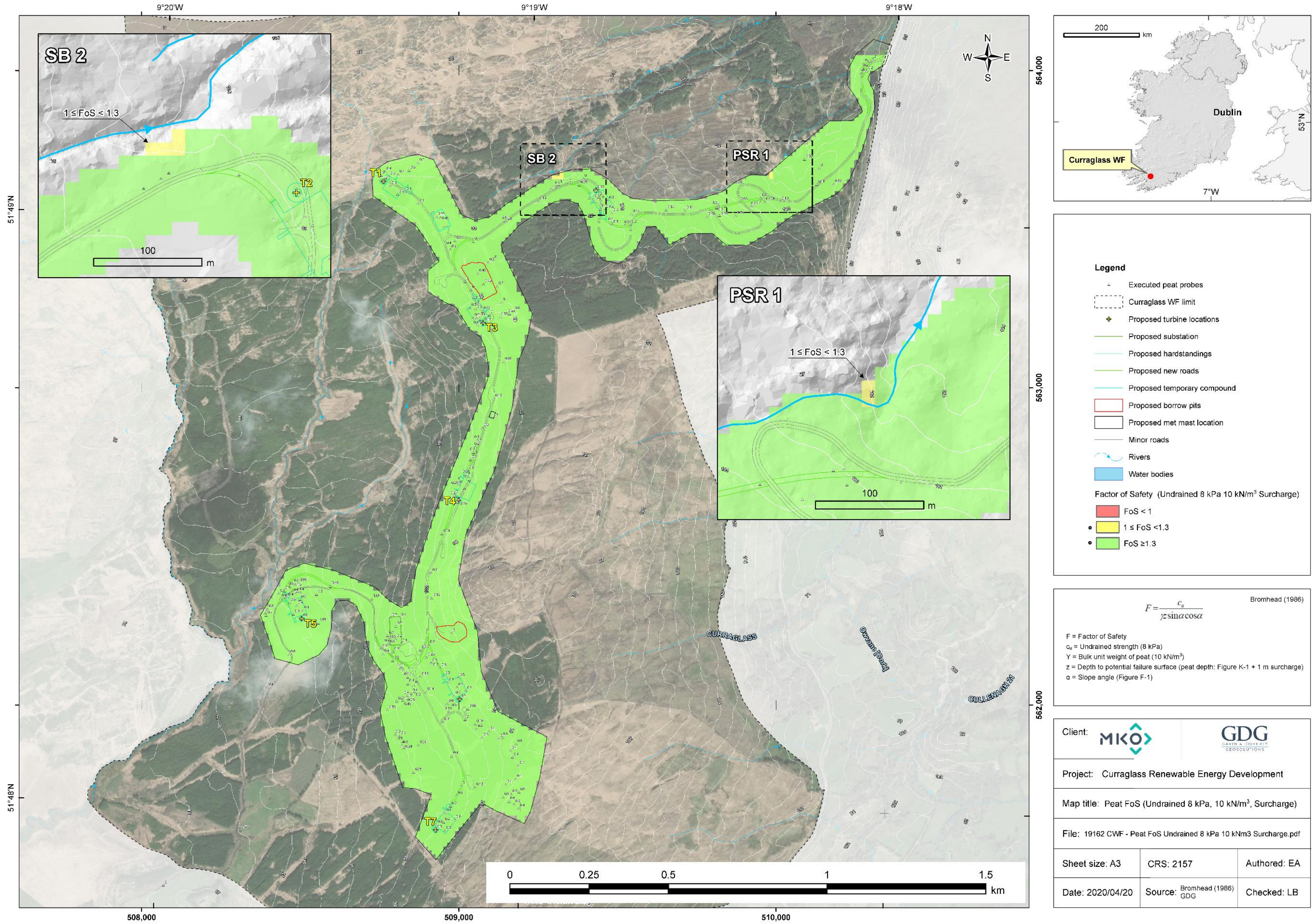


Figure K-2: FoS for undrained conditions and surcharge of 1 m (i.e. 10 kPa).

Note: Safety buffers (SB) and peat stockpile restriction (PSR) areas as identified through the FoS analysis are presented.

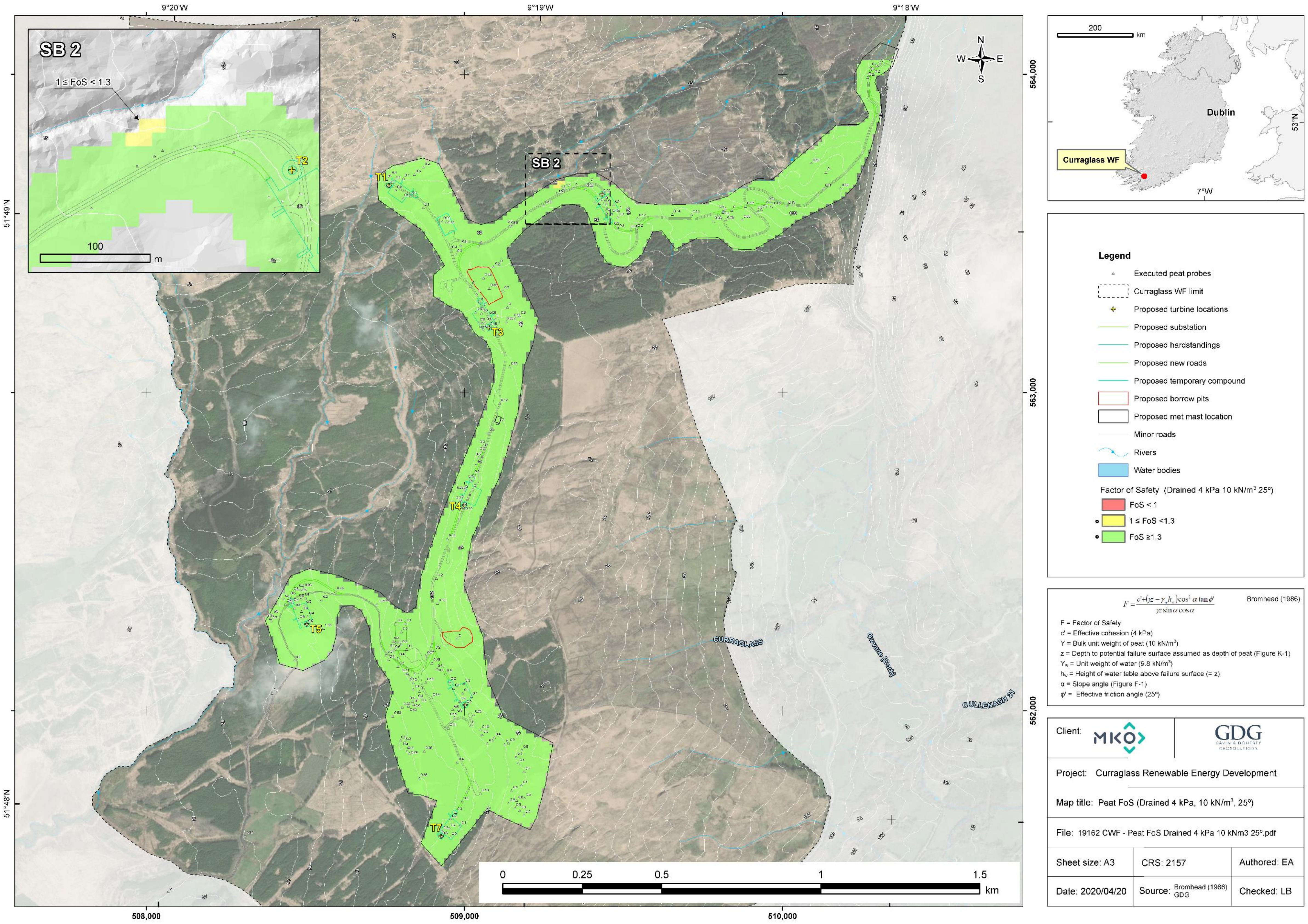


Figure K-3: FoS for drained conditions.

Note: Safety buffers (SB) as identified through the FoS analysis are presented.

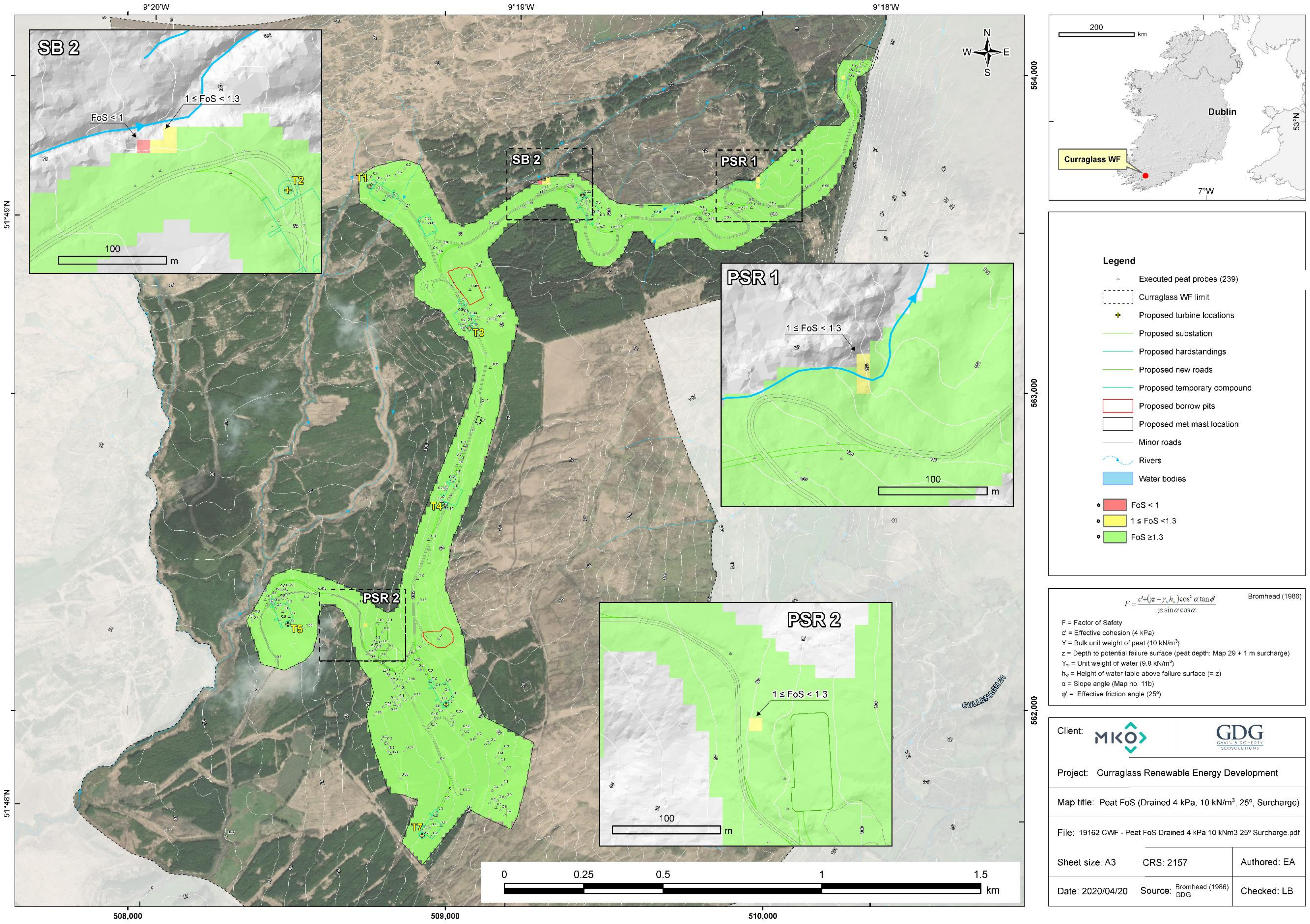


Figure K-4: FoS for drained conditions and surcharge of 1 m (i.e. 10 kPa).

Note: Safety buffers (SB) and peat stockpile restriction (PSR) areas as identified through the FoS analysis are presented.

Appendix L Safety buffers

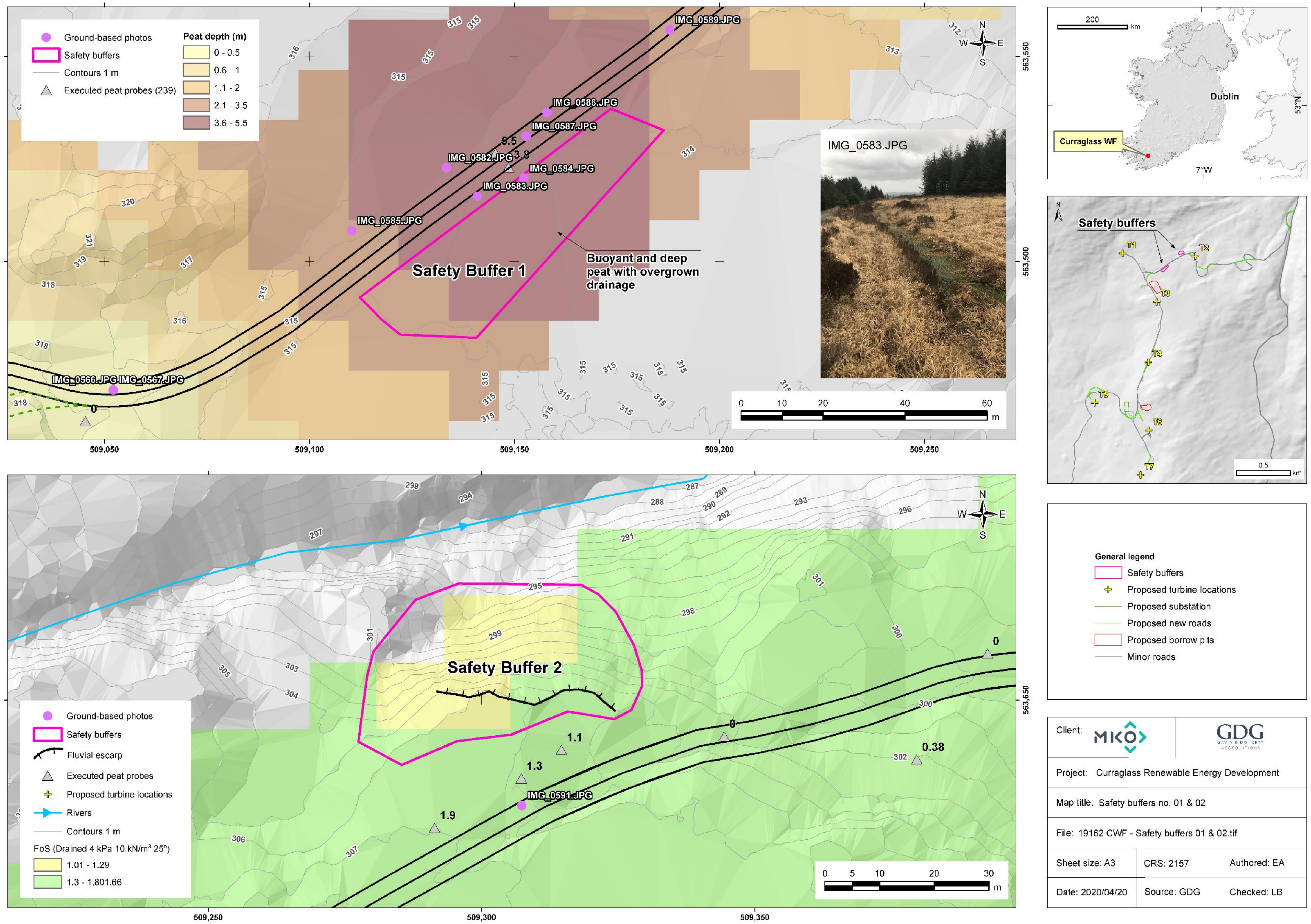


Figure L-1: Safety buffers.

Note: The delineation of Safety Buffer 1 here is not based on the FoS calculation, but based on the description of the peat as soft, unstable under foot and deep during the walkover.

Appendix M Peat stability risk calculation

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

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

MKO — **Curraglass renewable energy development site**

Location:	**Turbine 1**
Conditions:	**Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)**
Inspected on:	Feb-20
Inspected by:	PS / IP / KW
Completed by:	EA
Date:	April 2020

		Hazard factors	Value				Rating criteria 1	2	3	Rating value	Weighting	Score	Comment
			U	US	D	DS							
Factor of Safety			1829	6.7	915	7.2	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: ~0 m. Slope angle: 6.9º.
Secondary factors	Topography	Curvature Plan (across slope)	Planar				Convex	Planar	Concave	2	1	2	
		Curvature Profile (down slope)	Planar				Concave	Planar	Convex	2		2	
	Hydrology	Distance from watercourse (m)	320				> 300	200 - 300	< 200	1		1	
		Moisture index (NDMI)	121				0 - 96	96 -135	135 - 174	2		2	
		Evidence of piping	No				-	-	Yes	0		0	Existing hardstanding
		Existing drainage ditches	Varied				Down slope	Varied / Oblique	Across slope	2		2	Road and hardstanding ditches
	Vegetation	Bush	No				Dry heather	Grassland	Wetlands	0		0	Existing hardstanding
		Forestry	No				Good growth	Fair	Stunted growth	0		0	Existing hardstanding
	Peat workings	Peat cuts presence	No				-	Cutaway / Turbary	Machine cut	0		0	
		Peat cuts vs contour lines	No				Perpendicular	Oblique	Parallel	0		0	
	Existing loads	Roads	Solid				Solid	-	Floating	1		1	
	Slide history	Distance to previous slides (km)	8				5 - 10	< 5	On site	1	2	2	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	No				-	-	Yes	0		0	

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

Hazard $_{total}$	22
Max. possible	75
Hazard $_{0-1}$	**0.29**

Consequence factors	Value	Rating 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	Small	Medium	Large	2	3	6	
Downslope features	Minor undefined	Bowl / contained	Minor undefined watercourse	Valley	2	1	2	
Proximity from defined valley (m)	320	> 500	200 - 500	< 200	2		2	
Downhill slope angle	Intermediate	Horizontal	Intermediate	Steep	2		2	
Downstream aquatic environment	Drinking water and others	Non-sensitive	Sensitive	Drinking water supply	3		3	
Public roads in potential peat flow path	No	Minor road	Local road	Regional road	0		0	
Overhead lines in potential peat flow path	No	Phone lines	Electricity (LV)	Electricity (MV, HV)	0		0	
Buildings in potential peat flow path	No	Farm out-houses	-	Dweling	0		0	
Capability to respond (access and resources)	Good	Good	Fair	Poor	1		1	

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 =	0.29	0.48	=	**0.14**

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

Peat Stability Risk Assessment (PSRA)	
Curraglass renewable energy development site	
Location:	**Turbine 2**
Conditions:	**Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)**
Inspected on:	February 2020
Inspected by:	PS / IP / KW
Completed by:	EA
Date:	April 2020

Hazard factors			Value				Rating criteria 1	2	3	Rating value	Weighting	Score	Comment
			U	US	D	DS							
Factor of Safety			33.5	6.9	16.8	7.5	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: 0.26 m. Slope angle: 5.3º.
Secondary factors	Topography	Curvature Plan (across slope)	Planar				Convex	Planar	Concave	2	1	2	
		Curvature Profile (down slope)	Planar				Concave	Planar	Convex	2		2	
	Hydrology	Distance from watercourse (m)	130				> 300	200 - 300	< 200	3		3	
		Moisture index (NDMI)	129				0 - 96	96 -135	135 - 174	2		2	
		Evidence of piping	No				-	-	Yes	0		0	
		Existing drainage ditches	No				Down slope	Varied / Oblique	Across slope	0		0	
	Vegetation	Bush	No				Dry heather	Grassland	Wetlands	0		0	
		Forestry	Good growth				Good growth	Fair	Stunted growth	1		1	
	Peat workings	Peat cuts presence	No				-	Cutaway / Turbary	Machine cut	0		0	
		Peat cuts vs contour lines	No				Perpendicular	Oblique	Parallel	0		0	
	Existing loads	Roads	Solid				Solid	-	Floating	1		1	
	Slide history	Distance to previous slides (km)	8				5 - 10	< 5	On site	1	2	2	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	No				-	-	Yes	0		0	
											Hazard $_{total}$	23	
											Max. possible	75	
											Hazard $_{0-1}$	**0.31**	

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 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	Small	Medium	Large	1	3	3	
Downslope features	Minor undefined	Bowl / contained	Minor undefined watercourse	Valley	2	1	2	
Proximity from defined valley (m)	900	> 500	200 - 500	< 200	1		1	
Downhill slope angle	Intermediate	Horizontal	Intermediate	Steep	2		2	
Downstream aquatic environment	Drinking water supply	Non-sensitive	Sensitive	Drinking water supply	3		3	
Public roads in potential peat flow path	No	Minor road	Local road	Regional road	0		0	
Overhead lines in potential peat flow path	No	Phone lines	Electricity (LV)	Electricity (MV, HV)	0		0	
Buildings in potential peat flow path	No	Farm out-houses	-	Dweling	0		0	
Capability to respond (access and resources)	Good	Good	Fair	Poor	1		1	
						Consequences $_{total}$	12	
						Max. possible	33	
						Consequences $_{0-1}$	**0.36**	

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 =	0.31	0.36	=	**0.11**

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

Peat Stability Risk Assessment (PSRA)	Location: Turbine 3
	Conditions: Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)
	Inspected on: Feb-20
	Inspected by: PS / IP / KW
Curraglass renewable energy development site	Completed by: EA
	Date: April 2020

Hazard factors			Value U	Value US	Value D	Value DS	Rating criteria 1	Rating criteria 2	Rating criteria 3	Rating value	Weighting	Score	Comment
Factor of Safety			35.6	7.9	310	8.2	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: 0.3 m. Slope angle: 4.6º.
Secondary factors	Topography	Curvature Plan (across slope)	Planar				Convex	Planar	Concave	2	1	2	
		Curvature Profile (down slope)	Planar				Concave	Planar	Convex	2		2	
	Hydrology	Distance from watercourse (m)	370				> 300	200 - 300	< 200	1		1	
		Moisture index (NDMI)	139				0 - 96	96 -135	135 - 174	2		2	
		Evidence of piping	No				-	-	Yes	0		0	Existing hardstanding
		Existing drainage ditches	Varied				Down slope	Varied / Oblique	Across slope	2		2	Road and hardstanding ditches
	Vegetation	Bush	No				Dry heather	Grassland	Wetlands	0		0	Existing hardstanding
		Forestry	No				Good growth	Fair	Stunted growth	0		0	Existing hardstanding
	Peat workings	Peat cuts presence	No				-	Cutaway / Turbary	Machine cut	0		0	
		Peat cuts vs contour lines	No				Perpendicular	Oblique	Parallel	0		0	
	Existing loads	Roads	Solid				Solid	-	Floating	1		1	
	Slide history	Distance to previous slides (km)	8				5 - 10	< 5	On site	1	2	2	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	No				-	-	Yes	0		0	

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

$Hazard_{total}$	22
Max. possible	75
$Hazard_{0\text{-}1}$	**0.29**

Consequence factors	Value	Rating 1	Rating 2	Rating 3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Small	Small	Medium	Large	1	3	3	
Downslope features	Minor undefined	Bowl / contained	Minor undefined watercourse	Valley	2	1	2	
Proximity from defined valley (m)	370	> 500	200 - 500	< 200	2		2	
Downhill slope angle	Intermediate	Horizontal	Intermediate	Steep	2		2	
Downstream aquatic environment	Drinking water and others	Non-sensitive	Sensitive	Drinking water supply	3		3	Drinking and salmonid water, shellfish area, conservative objective.
Public roads in potential peat flow path	No	Minor road	Local road	Regional road	0		0	
Overhead lines in potential peat flow path	No	Phone lines	Electricity (LV)	Electricity (MV, HV)	0		0	
Buildings in potential peat flow path	No	Farm out-houses	-	Dweling	0		0	
Capability to respond (access and resources)	Good	Good	Fair	Poor	1		1	

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

$Consequences_{total}$	13
Max. possible	33
$Consequences_{0\text{-}1}$	**0.39**

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 =	0.29	0.39	=	**0.12**

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

Peat Stability Risk Assessment (PSRA)		**Location:**	**Turbine 4**
		Conditions:	**Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)**
		Inspected on:	Feb-20
		Inspected by:	PS / IP / KW
Curraglass renewable energy development site		Completed by:	EA
		Date:	April 2020

Hazard factors			Value U	Value US	Value D	Value DS	Rating criteria 1	Rating criteria 2	Rating criteria 3	Rating value	Weighting	Score	Comment
Factor of Safety			36.8	2.5	17.9	2.6	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: 0.08 m. Slope angle: 17º.
Secondary factors	Topography	Curvature Plan (across slope)	Planar				Convex	Planar	Concave	2	1	2	
		Curvature Profile (down slope)	Planar				Concave	Planar	Convex	2		2	
	Hydrology	Distance from watercourse (m)	290				> 300	200 - 300	< 200	2		2	
		Moisture index (NDMI)	129				0 - 96	96 -135	135 - 174	2		2	
		Evidence of piping	No				-	-	Yes	0		0	
		Existing drainage ditches	Across slope				Down slope	Varied / Oblique	Across slope	3		3	Road and hardstanding ditches
	Vegetation	Bush	Dry heather				Dry heather	Grassland	Wetlands	1		1	
		Forestry	Fair				Good growth	Fair	Stunted growth	2		2	
	Peat workings	Peat cuts presence	No				-	Cutaway / Turbary	Machine cut	0		0	
		Peat cuts vs contour lines	No				Perpendicular	Oblique	Parallel	0		0	
	Existing loads	Roads	Solid				Solid	-	Floating	1		1	
	Slide history	Distance to previous slides (km)	8				5 - 10	< 5	On site	1	2	2	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	Yes				-	-	Yes	3		6	
											Hazard $_{total}$	33	
											Max. possible	75	
											Hazard $_{0-1}$	**0.44**	

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 1	Rating 2	Rating 3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Medium	Small	Medium	Large	2	3	6	
Downslope features	Minor undefined	Bowl / contained	Minor undefined watercourse	Valley	2	1	2	
Proximity from defined valley (m)	290	> 500	200 - 500	< 200	2		2	
Downhill slope angle	Steep	Horizontal	Intermediate	Steep	3		3	
Downstream aquatic environment	Drinking water and others	Non-sensitive	Sensitive	Drinking water supply	3		3	Drinking and salmonid water, shellfish area, conservative objective.
Public roads in potential peat flow path	No	Minor road	Local road	Regional road	0		0	
Overhead lines in potential peat flow path	No	Phone lines	Electricity (LV)	Electricity (MV, HV)	0		0	
Buildings in potential peat flow path	No	Farm out-houses	-	Dweling	0		0	
Capability to respond (access and resources)	Good	Good	Fair	Poor	1		1	
						Consequences $_{total}$	17	
						Max. possible	33	
						Consequences $_{0-1}$	**0.52**	

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 =	0.44	0.52	=	**0.23**

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

Peat Stability Risk Assessment (PSRA)	
Curraglass renewable energy development site	
Location:	Turbine 5
Conditions:	Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)
Inspected on:	February 2020
Inspected by:	PS / IP / KW
Completed by:	EA
Date:	April 2020

Hazard factors			Value U	Value US	Value D	Value DS	Rating criteria 1	Rating criteria 2	Rating criteria 3	Rating value	Weighting	Score	Comment
Factor of Safety			9.3	4.3	4.7	4.7	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: 0.87 m. Slope angle: 5.7º.
Secondary factors	Topography	Curvature Plan (across slope)	Planar				Convex	Planar	Concave	2	1	2	
		Curvature Profile (down slope)	Planar				Concave	Planar	Convex	2		2	
	Hydrology	Distance from watercourse (m)	190				> 300	200 - 300	< 200	3		3	
		Moisture index (NDMI)	160				0 - 96	96 -135	135 - 174	3		3	
		Evidence of piping	No				-	-	Yes	0		0	
		Existing drainage ditches	Down slope				Down slope	Varied / Oblique	Across slope	1		1	
	Vegetation	Bush	Dry heather and grassland				Dry heather	Grassland	Wetlands	1.5		1.5	
		Forestry	Good growth				Good growth	Fair	Stunted growth	1		1	
	Peat workings	Peat cuts presence	No				-	Cutaway / Turbary	Machine cut	0		0	
		Peat cuts vs contour lines	No				Perpendicular	Oblique	Parallel	0		0	
	Existing loads	Roads	Solid				Solid	-	Floating	1		1	
	Slide history	Distance to previous slides (km)	8				5 - 10	< 5	On site	1	2	2	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	No				-	-	Yes	0		0	
											Hazard total	26.5	
											Max. possible	75	
											Hazard 0-1	0.35	

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 1	Rating 2	Rating 3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Medium	Small	Medium	Large	2	3	6	
Downslope features	Minor undefined watercourse & Valley	Bowl / contained	Minor undefined watercourse	Valley	2.5	1	2.5	
Proximity from defined valley (m)	190	> 500	200 - 500	< 200	3		3	
Downhill slope angle	Intermediate	Horizontal	Intermediate	Steep	2		2	
Downstream aquatic environment	Drinking water and others	Non-sensitive	Sensitive	Drinking water supply	3		3	Drinking and salmonid water, shellfish area, conservative objective.
Public roads in potential peat flow path	Minor road	Minor road	Local road	Regional road	1		1	
Overhead lines in potential peat flow path	No	Phone lines	Electricity (LV)	Electricity (MV, HV)	0		0	
Buildings in potential peat flow path	No	Farm out-houses	-	Dweling	0		0	
Capability to respond (access and resources)	Good	Good	Fair	Poor	1		1	
						Consequences total	18.5	
						Max. possible	33	
						Consequences 0-1	0.56	

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 =	0.35	0.56	=	**0.196**

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

Peat Stability Risk Assessment (PSRA)	
Curraglass renewable energy development site	
Location:	Turbine 6
Conditions:	Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)
Inspected on:	February 2020
Inspected by:	PS / IP / KW
Completed by:	EA
Date:	April 2020

Hazard factors			Value U	Value US	Value D	Value DS	Rating criteria 1	Rating criteria 2	Rating criteria 3	Rating value	Weighting	Score	Comment
Factor of Safety			11.4	2.6	5.8	2.8	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: 0.3 m. Slope angle: 14º.
Secondary factors	Topography	Curvature Plan (across slope)	Convex				Convex	Planar	Concave	1	1	1	
		Curvature Profile (down slope)	Planar				Concave	Planar	Convex	2		2	
	Hydrology	Distance from watercourse (m)	1200				> 300	200 - 300	< 200	1		1	
		Moisture index (NDMI)	114				0 - 96	96 -135	135 - 174	2		2	
		Evidence of piping	No				-	-	Yes	0		0	
		Existing drainage ditches	Down slope				Down slope	Varied / Oblique	Across slope	1		1	
	Vegetation	Bush	Grassland				Dry heather	Grassland	Wetlands	2		2	
		Forestry	Good growth				Good growth	Fair	Stunted growth	1		1	
	Peat workings	Peat cuts presence	No				-	Cutaway / Turbary	Machine cut	0		0	
		Peat cuts vs contour lines	No				Perpendicular	Oblique	Parallel	0		0	
	Existing loads	Roads	No				Solid	-	Floating	0		0	
	Slide history	Distance to previous slides (km)	8				5 - 10	< 5	On site	1	2	2	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	Yes				-	-	Yes	3		6	
											Hazard total	28	
											Max. possible	75	
											Hazard 0-1	**0.37**	

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 1	Rating 2	Rating 3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Medium	Small	Medium	Large	2	3	6	
Downslope features	Minor undefined	Bowl / contained	Minor undefined watercourse	Valley	2	1	2	
Proximity from defined valley (m)	1200	> 500	200 - 500	< 200	1		1	
Downhill slope angle	Intermediate	Horizontal	Intermediate	Steep	2		2	
Downstream aquatic environment	Drinking water and others	Non-sensitive	Sensitive	Drinking water supply	3		3	Drinking and salmonid water, shellfish area, conservative objective.
Public roads in potential peat flow path	Minor road	Minor road	Local road	Regional road	1		1	
Overhead lines in potential peat flow path	Electricity (MV, HV)	Phone lines	Electricity (LV)	Electricity (MV, HV)	3		3	
Buildings in potential peat flow path	No	Farm out-houses	-	Dweling	0		0	
Capability to respond (access and resources)	Good	Good	Fair	Poor	1		1	
						Consequences total	19	
						Max. possible	33	
						Consequences 0-1	**0.58**	

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 =	0.37	0.58	=	**0.21**

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

Peat Stability Risk Assessment (PSRA)	
Curraglass renewable energy development site	
Location:	Turbine 7
Conditions:	Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)
Inspected on:	
Inspected by:	PS / IP / KW
Completed by:	EA
Date:	April 2020

Hazard factors			Value U	Value US	Value D	Value DS	Rating criteria 1	Rating criteria 2	Rating criteria 3	Rating value	Weighting	Score	Comment
Factor of Safety			8.8	2.5	4.4	2.6	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: 0.4. Slope angle: 14º.
Secondary factors	Topography	Curvature Plan (across slope)	Planar				Convex	Planar	Concave	2	1	2	
		Curvature Profile (down slope)	Planar				Concave	Planar	Convex	2		2	
	Hydrology	Distance from watercourse (m)	980				> 300	200 - 300	< 200	1		1	
		Moisture index (NDMI)	164				0 - 96	96 -135	135 - 174	3		3	
		Evidence of piping	No				-	-	Yes	0		0	
		Existing drainage ditches	No				Down slope	Varied / Oblique	Across slope	0		0	
	Vegetation	Bush	No				Dry heather	Grassland	Wetlands	0		0	
		Forestry	Good growth				Good growth	Fair	Stunted growth	1		1	
	Peat workings	Peat cuts presence	No				-	Cutaway / Turbary	Machine cut	0		0	
		Peat cuts vs contour lines	No				Perpendicular	Oblique	Parallel	0		0	
	Existing loads	Roads	No				Solid	-	Floating	0		0	
	Slide history	Distance to previous slides (km)	8				5 - 10	< 5	On site	1	2	2	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	Yes				-	-	Yes	3		6	
											Hazard total	27	
											Max. possible	75	
											Hazard 0-1	0.36	

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 1	Rating 2	Rating 3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Medium	Small	Medium	Large	2	3	6	
Downslope features	Minor undefined	Bowl / contained	Minor undefined watercourse	Valley	2	1	2	
Proximity from defined valley (m)	980	> 500	200 - 500	< 200	1		1	
Downhill slope angle	Intermediate	Horizontal	Intermediate	Steep	2		2	
Downstream aquatic environment	Drinking water and others	Non-sensitive	Sensitive	Drinking water supply	3		3	Drinking and salmonid water, shellfish area, conservative objective.
Public roads in potential peat flow path	No	Minor road	Local road	Regional road	0		0	
Overhead lines in potential peat flow path	Electricity (MV, HV)	Phone lines	Electricity (LV)	Electricity (MV, HV)	3		3	
Buildings in potential peat flow path	No	Farm out-houses	-	Dweling	0		0	
Capability to respond (access and resources)	Good	Good	Fair	Poor	1		1	
						Consequences total	18	
						Max. possible	33	
						Consequences 0-1	0.55	

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 =	0.36	0.55	=	**0.198**

Table M-8: Peat risk assessment in met mast site.

Peat Stability Risk Assessment (PSRA)	
Curraglass renewable energy development site	
Location:	Met mast
Conditions:	Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)
Inspected on:	Feb-20
Inspected by:	PS / IP / KW
Completed by:	EA
Date:	April 2020

Hazard factors			Value				Rating criteria 1	2	3	Rating value	Weighting	Score	Comment
			U	US	D	DS	1	2	3				
Factor of Safety			6	2.3	3.1	2.5	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: 0.7 m. Slope angle: 12.4º.
Secondary factors	Topography	Curvature Plan (across slope)	Planar				Convex	Planar	Concave	2	1	2	
		Curvature Profile (down slope)	Planar				Concave	Planar	Convex	2		2	
	Hydrology	Distance from watercourse (m)	290				> 300	200 - 300	< 200	2		2	
		Moisture index (NDMI)	151				0 - 96	96 -135	135 - 174	3		3	
		Evidence of piping	No				-	-	Yes	0		0	
		Existing drainage ditches	Across slope				Down slope	Varied / Oblique	Across slope	3		3	Road ditch
	Vegetation	Bush	Dry heather & Grassland				Dry heather	Grassland	Wetlands	1.5		1.5	
		Forestry	No				Good growth	Fair	Stunted growth	0		0	
	Peat workings	Peat cuts presence	No				-	Cutaway / Turbary	Machine cut	0		0	
		Peat cuts vs contour lines	No				Perpendicular	Oblique	Parallel	0		0	
	Existing loads	Roads	Solid				Solid	-	Floating	1		1	
	Slide history	Distance to previous slides (km)	8				5 - 10	< 5	On site	1	2	2	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	No				-	-	Yes	0		0	
											Hazard $_{total}$	26.5	
											Max. possible	75	
											Hazard $_{0-1}$	0.35	

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 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	Small	Medium	Large	2	3	6	
Downslope features	Minor undefined watercourse	Bowl / contained	Minor undefined watercourse	Valley	2	1	2	
Proximity from defined valley (m)	290	> 500	200 - 500	< 200	2		2	
Downhill slope angle	Intermediate	Horizontal	Intermediate	Steep	2		2	
Downstream aquatic environment	Drinking water and others	Non-sensitive	Sensitive	Drinking water supply	3		3	Drinking and salmonid water, shellfish area, conservative objective.
Public roads in potential peat flow path	Minor road	Minor road	Local road	Regional road	1		1	
Overhead lines in potential peat flow path	No	Phone lines	Electricity (LV)	Electricity (MV, HV)	0		0	
Buildings in potential peat flow path	No	Farm out-houses	-	Dweling	0		0	
Capability to respond (access and resources)	Good	Good	Fair	Poor	1		1	
						Consequences $_{total}$	17	
						Max. possible	33	
						Consequences $_{0-1}$	0.52	

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 =	0.35	0.52	=	**0.18**

Table M-9: Peat risk assessment in the proposed substation site.

GDG / Peat Stability Risk Assessment (PSRA)	
MKO / Curraglass renewable energy development site	
Location:	Proposed substation site
Conditions:	Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)
Inspected on:	Feb-20
Inspected by:	PS / IP / KW
Completed by:	EA
Date:	April 2020

Hazard factors			Value				Rating criteria 1	2	3	Rating value	Weighting	Score	Comment
			U	US	D	DS							
Factor of Safety			9.4	2.8	4.8	3	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: 0.45 m. Slope angle: 12º.

Secondary factors			Value	1	2	3	Rating value	Weighting	Score	Comment
Secondary factors	Topography	Curvature Plan (across slope)	Planar	Convex	Planar	Concave	2	1	2	
		Curvature Profile (down slope)	Planar	Concave	Planar	Convex	2		2	
	Hydrology	Distance from watercourse (m)	540	> 300	200 - 300	< 200	1		1	
		Moisture index (NDMI)	165	0 - 96	96 -135	135 - 174	3		3	
		Evidence of piping	No	-	-	Yes	0		0	
		Existing drainage ditches	Down slope	Down slope	Varied / Oblique	Across slope	1		1	
	Vegetation	Bush	No	Dry heather	Grassland	Wetlands	0		0	
		Forestry	Good growth	Good growth	Fair	Stunted growth	1		1	
	Peat workings	Peat cuts presence	No	-	Cutaway / Turbary	Machine cut	0		0	
		Peat cuts vs contour lines	No	Perpendicular	Oblique	Parallel	0		0	
	Existing loads	Roads	No	Solid	-	Floating	0		0	
	Slide history	Distance to previous slides (km)	8	5 - 10	< 5	On site	1	2	2	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	No	-	-	Yes	0		0	

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

$Hazard_{total}$	22
Max. possible	75
$Hazard_{0-1}$	0.29

Consequence factors	Value	Rating 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	Small	Medium	Large	2	3	6	
Downslope features	Minor undefined watercourse	Bowl / contained	Minor undefined watercourse	Valley	2	1	2	
Proximity from defined valley (m)	540	> 500	200 - 500	< 200	1		1	
Downhill slope angle	Intermediate	Horizontal	Intermediate	Steep	2		2	
Downstream aquatic environment	Drinking water and others	Non-sensitive	Sensitive	Drinking water supply	3		3	Drinking and salmonid water, shellfish area, conservative objective.
Public roads in potential peat flow path	Minor road	Minor road	Local road	Regional road	1		1	
Overhead lines in potential peat flow path	No	Phone lines	Electricity (LV)	Electricity (MV, HV)	0		0	
Buildings in potential peat flow path	No	Farm out-houses	-	Dweling	0		0	
Capability to respond (access and resources)	Good	Good	Fair	Poor	1		1	

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 =	0.29	0.48	=	**0.14**

Table M-10: Peat risk assessment in temporary compound site.

GDG	**Peat Stability Risk Assessment (PSRA)**	
MKO	**Curraglass renewable energy development site**	

Location:	**Temporary compound site**
Conditions:	**Undrained (U), undrained surcharge (US), drained (D), drained surcharge (DS)**
Inspected on:	Feb-20
Inspected by:	PS / IP / KW
Completed by:	EA
Date:	April 2020

Hazard factors			Value U	Value US	Value D	Value DS	Rating criteria 1	Rating criteria 2	Rating criteria 3	Rating value	Weighting	Score	Comment
Factor of Safety			35	12	20	15	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: 0.3 m. Slope angle: 4º.
Secondary factors	Topography	Curvature Plan (across slope)	Planar				Convex	Planar	Concave	2	1	2	
		Curvature Profile (down slope)	Planar				Concave	Planar	Convex	2		2	
	Hydrology	Distance from watercourse (m)	220				> 300	200 - 300	< 200	2		2	
		Moisture index (NDMI)	121				0 - 96	96 -135	135 - 174	2		2	
		Evidence of piping	No				-	-	Yes	0		0	
		Existing drainage ditches	No				Down slope	Varied / Oblique	Across slope	0		0	
	Vegetation	Bush	Grass- / wetland				Dry heather	Grassland	Wetlands	2.5		2.5	
		Forestry	No				Good growth	Fair	Stunted growth	0		0	
	Peat workings	Peat cuts presence	No				-	Cutaway / Turbary	Machine cut	0		0	
		Peat cuts vs contour lines	No				Perpendicular	Oblique	Parallel	0		0	
	Existing loads	Roads	Solid				Solid	-	Floating	1		1	
	Slide history	Distance to previous slides (km)	8				5 - 10	< 5	On site	1	2	2	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	No				-	-	Yes	0		0	
											Hazard $_{total}$	23.5	
											Max. possible	75	
											Hazard $_{0-1}$	**0.31**	

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 1	Rating 2	Rating 3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Small	Small	Medium	Large	1	3	3	
Downslope features	Minor undefined	Bowl / contained	Minor undefined watercourse	Valley	2	1	2	
Proximity from defined valley (m)	220	> 500	200 - 500	< 200	2		2	
Downhill slope angle	Intermediate	Horizontal	Intermediate	Steep	2		2	
Downstream aquatic environment	Drinking water and others	Non-sensitive	Sensitive	Drinking water supply	3		3	Drinking and salmonid water, shellfish area, conservative objective.
Public roads in potential peat flow path	Minor road	Minor road	Local road	Regional road	1		1	
Overhead lines in potential peat flow path	No	Phone lines	Electricity (LV)	Electricity (MV, HV)	0		0	
Buildings in potential peat flow path	No	Farm out-houses	-	Dweling	0		0	
Capability to respond (access and resources)	Good	Good	Fair	Poor	1		1	
						Consequences $_{total}$	14	
						Max. possible	33	
						Consequences $_{0-1}$	**0.42**	

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 =	0.31	0.42	=	**0.13**

Table M-11: Peat risk assessment in new access road to T2.

Peat Stability Risk Assessment (PSRA)	
Curraglass renewable energy development site	
Location:	Access road to T2
Conditions:	Undrained (U), undrained surcharge (US), drained (D) & drained surcharge (DS)
Inspected on:	Feb-20
Inspected by:	PS / IP / KW
Completed by:	EA
Date:	April 2020

Hazard factors			Value U	Value US	Value D	Value DS	Rating criteria 1	Rating criteria 2	Rating criteria 3	Rating value	Weighting	Score	Comment
Factor of Safety			22.5	3.9	11.3	4.2	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: 0.2 m. Slope angle: 10º.
Secondary factors	Topography	Curvature Plan (across slope)	Planar				Convex	Planar	Concave	2	1	2	
		Curvature Profile (down slope)	Planar				Concave	Planar	Convex	2		2	
	Hydrology	Distance from watercourse (m)	150				> 300	200 - 300	< 200	3		3	
		Moisture index (NDMI)	126				0 - 96	96 -135	135 - 174	2		2	
		Evidence of piping	No				-	-	Yes	0		0	
		Existing drainage ditches	Varied / Oblique				Down slope	Varied / Oblique	Across slope	2		2	Road ditches
	Vegetation	Bush	Dry heather				Dry heather	Grassland	Wetlands	1		1	
		Forestry	No				Good growth	Fair	Stunted growth	0		0	Deforested
	Peat workings	Peat cuts presence	No				-	Cutaway / Turbary	Machine cut	0		0	
		Peat cuts vs contour lines	No				Perpendicular	Oblique	Parallel	0		0	
	Existing loads	Roads	Solid				Solid	-	Floating	1		1	
	Slide history	Distance to previous slides (km)	8				5 - 10	< 5	On site	1	2	2	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	No				-	-	Yes	0		0	
											Hazard total	25	
											Max. possible	75	
											Hazard 0-1	0.33	

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 1	Rating 2	Rating 3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Small	Small	Medium	Large	1	3	3	
Downslope features	Minor undefined	Bowl / contained	Minor undefined watercourse	Valley	2	1	2	
Proximity from defined valley (m)	150	> 500	200 - 500	< 200	2		2	
Downhill slope angle	Intermediate	Horizontal	Intermediate	Steep	2		2	
Downstream aquatic environment	Drinking water and others	Non-sensitive	Sensitive	Drinking water supply	3		3	Drinking and salmonid water, shellfish area, conservative objective.
Public roads in potential peat flow path	No	Minor road	Local road	Regional road	0		0	
Overhead lines in potential peat flow path	No	Phone lines	Electricity (LV)	Electricity (MV, HV)	0		0	
Buildings in potential peat flow path	No	Farm out-houses	-	Dweling	0		0	
Capability to respond (access and resources)	Good	Good	Fair	Poor	1		1	
						Consequences total	13	
						Max. possible	33	
						Consequences 0-1	0.39	

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 =	0.33	0.39	=	**0.13**

Table M-12: Peat risk assessment in new access road to T4.

Peat Stability Risk Assessment (PSRA)

Curraglass renewable energy development site

Location:	Access road to T4
Conditions:	Undrained (U), undrained surcharge (US), drained (D) & drained surcharge (DS)
Inspected on:	Feb-20
Inspected by:	PS / IP / KW
Completed by:	EA
Date:	April 2020

Hazard factors			Value	Rating criteria 1	Rating criteria 2	Rating criteria 3	Rating value	Weighting	Score	Comment
Factor of Safety			U 23.4, US 2.8, D 11.7, DS 2.9	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: 0.13 m. Slope angle: 15º.
Secondary factors	Topography	Curvature Plan (across slope)	Planar	Convex	Planar	Concave	2	1	2	
		Curvature Profile (down slope)	Concave	Concave	Planar	Convex	1		1	
	Hydrology	Distance from watercourse (m)	330	> 300	200 - 300	< 200	1		1	
		Moisture index (NDMI)	145	0 - 96	96 -135	135 - 174	3		3	
		Evidence of piping	No	-	-	Yes	0		0	
		Existing drainage ditches	No	Down slope	Varied / Oblique	Across slope	0		0	
	Vegetation	Bush	Dry heather / Grassland	Dry heather	Grassland	Wetlands	1.5		1.5	
		Forestry	Good growth	Good growth	Fair	Stunted growth	1		1	
	Peat workings	Peat cuts presence	No	-	Cutaway / Turbary	Machine cut	0		0	
		Peat cuts vs contour lines	No	Perpendicular	Oblique	Parallel	0		0	
	Existing loads	Roads	Solid	Solid	-	Floating	1		1	
	Slide history	Distance to previous slides (km)	8	5 - 10	< 5	On site	1	2	2	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	No	-	-	Yes	0		0	
								Hazard total	22.5	
								Max. possible	75	
								Hazard 0-1	**0.30**	

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 1	Rating 2	Rating 3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Medium	Small	Medium	Large	2	3	6	
Downslope features	Minor undefined	Bowl / contained	Minor undefined watercourse	Valley	2	1	2	Road
Proximity from defined valley (m)	330	> 500	200 - 500	< 200	2		2	
Downhill slope angle	Intermediate	Horizontal	Intermediate	Steep	2		2	
Downstream aquatic environment	Drinking water and others	Non-sensitive	Sensitive	Drinking water supply	3		3	Drinking and salmonid water, shellfish area, conservative objective.
Public roads in potential peat flow path	No	Minor road	Local road	Regional road	0		0	
Overhead lines in potential peat flow path	No	Phone lines	Electricity (LV)	Electricity (MV, HV)	0		0	
Buildings in potential peat flow path	No	Farm out-houses	-	Dweling	0		0	
Capability to respond (access and resources)	Good	Good	Fair	Poor	1		1	
						Consequences total	16	
						Max. possible	33	
						Consequences 0-1	**0.48**	

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 =	0.30	0.48	=	**0.15**

Table M-13: Peat risk assessment in new access road to T5.

Peat Stability Risk Assessment (PSRA)	
Curraglass renewable energy development site	
Location:	Access road to T5
Conditions:	Undrained (U), undrained surcharge (US), drained (D) & drained surcharge (DS)
Inspected on:	Feb-20
Inspected by:	PS / IP / KW
Completed by:	EA
Date:	April 2020

Hazard factors			Value U	Value US	Value D	Value DS	Rating criteria 1	Rating criteria 2	Rating criteria 3	Rating value	Weighting	Score	Comment
Factor of Safety			13.6	4.4	6.9	4.7	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: 0.5 m. Slope angle: 7º.
Secondary factors	Topography	Curvature Plan (across slope)	Concave				Convex	Planar	Concave	3	1	3	
		Curvature Profile (down slope)	Planar				Concave	Planar	Convex	2		2	
	Hydrology	Distance from watercourse (m)	340				> 300	200 - 300	< 200	1		1	
		Moisture index (NDMI)	146				0 - 96	96 -135	135 - 174	3		3	
		Evidence of piping	No				-	-	Yes	0		0	
		Existing drainage ditches	Down slope				Down slope	Varied / Oblique	Across slope	1		1	Road ditch
	Vegetation	Bush	Dry heather / Grassland				Dry heather	Grassland	Wetlands	1.5		1.5	
		Forestry	Good growth				Good growth	Fair	Stunted growth	1		1	
	Peat workings	Peat cuts presence	No				-	Cutaway / Turbary	Machine cut	0		0	
		Peat cuts vs contour lines	No				Perpendicular	Oblique	Parallel	0		0	
	Existing loads	Roads	Solid				Solid	-	Floating	1		1	
	Slide history	Distance to previous slides (km)	8				5 - 10	< 5	On site	1	2	2	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	No				-	-	Yes	0		0	
											Hazard total	25.5	
											Max. possible	75	
											Hazard 0-1	**0.34**	

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 1	Rating 2	Rating 3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Medium	Small	Medium	Large	2	3	6	
Downslope features	Minor undefined	Bowl / contained	Minor undefined watercourse	Valley	2	1	2	
Proximity from defined valley (m)	340	> 500	200 - 500	< 200	2		2	
Downhill slope angle	Intermediate	Horizontal	Intermediate	Steep	2		2	
Downstream aquatic environment	Drinking water and others	Non-sensitive	Sensitive	Drinking water supply	3		3	Drinking and salmonid water, shellfish area, conservative objective.
Public roads in potential peat flow path	Minor road and T5	Minor road	Local road	Regional road	2		2	
Overhead lines in potential peat flow path	No	Phone lines	Electricity (LV)	Electricity (MV, HV)	0		0	
Buildings in potential peat flow path	No	Farm out-houses	-	Dweling	0		0	
Capability to respond (access and resources)	Good	Good	Fair	Poor	1		1	
						Consequences total	18	
						Max. possible	33	
						Consequences 0-1	**0.55**	

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 =	0.34	0.55	=	**0.19**

Table M-14: Peat risk assessment in new access road to substation.

Peat Stability Risk Assessment (PSRA)	
Curraglass renewable energy development site	
Location:	**Access road to substation**
Conditions:	**Undrained (U), undrained surcharge (US), drained (D) & drained surcharge (DS)**
Inspected on:	Feb-20
Inspected by:	PS / IP / KW
Completed by:	EA
Date:	April 2020

Hazard factors			Value U	Value US	Value D	Value DS	Rating criteria 1	Rating criteria 2	Rating criteria 3	Rating value	Weighting	Score	Comment
Factor of Safety			5.6	2	2.8	2	≥ 1.3	1.3 - 1.0	≤ 1.0	1	10	10	Peat depth: 0.6 m. Slope angle: 15º.
Secondary factors	Topography	Curvature Plan (across slope)	Planar				Convex	Planar	Concave	2	1	2	
		Curvature Profile (down slope)	Planar				Concave	Planar	Convex	2		2	
	Hydrology	Distance from watercourse (m)	665				> 300	200 - 300	< 200	1		1	
		Moisture index (NDMI)	146				0 - 96	96 -135	135 - 174	3		3	
		Evidence of piping	No				-	-	Yes	0		0	
		Existing drainage ditches	Varied / Oblique				Down slope	Varied / Oblique	Across slope	2		2	Road ditch
	Vegetation	Bush	Dry heather / Grassland				Dry heather	Grassland	Wetlands	1.5		1.5	
		Forestry	Good growth				Good growth	Fair	Stunted growth	1		1	
	Peat workings	Peat cuts presence	No				-	Cutaway / Turbary	Machine cut	0		0	
		Peat cuts vs contour lines	No				Perpendicular	Oblique	Parallel	0		0	
	Existing loads	Roads	Solid				Solid	-	Floating	1		1	
	Slide history	Distance to previous slides (km)	8				5 - 10	< 5	On site	1	2	2	
		Evidence of peat movement (e.g. tension cracks, step features, compression features).	No				-	-	Yes	0		0	

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

Hazard $_{total}$	25.5
Max. possible	75
Hazard $_{0-1}$	**0.34**

Consequence factors	Value	Rating 1	Rating 2	Rating 3	Rating value	Weighting	Score	Comment
Volume of potential peat flow (function of distance from nearest watercourse and peat depth in the area)	Medium	Small	Medium	Large	2	3	6	
Downslope features	Minor undefined	Bowl / contained	Minor undefined watercourse	Valley	2	1	2	
Proximity from defined valley (m)	665	> 500	200 - 500	< 200	1		1	
Downhill slope angle	Intermediate	Horizontal	Intermediate	Steep	2		2	
Downstream aquatic environment	Drinking water and others	Non-sensitive	Sensitive	Drinking water supply	3		3	Drinking and salmonid water, shellfish area, conservative objective.
Public roads in potential peat flow path	Minor road	Minor road	Local road	Regional road	1		1	
Overhead lines in potential peat flow path	Electricity (MV, HV)	Phone lines	Electricity (LV)	Electricity (MV, HV)	3		3	
Buildings in potential peat flow path	No	Farm out-houses	-	Dweling	0		0	
Capability to respond (access and resources)	Good	Good	Fair	Poor	1		1	

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

Consequences $_{total}$	19
Max. possible	33
Consequences $_{0-1}$	**0.58**

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 =	0.34	0.58	=	**0.197**

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