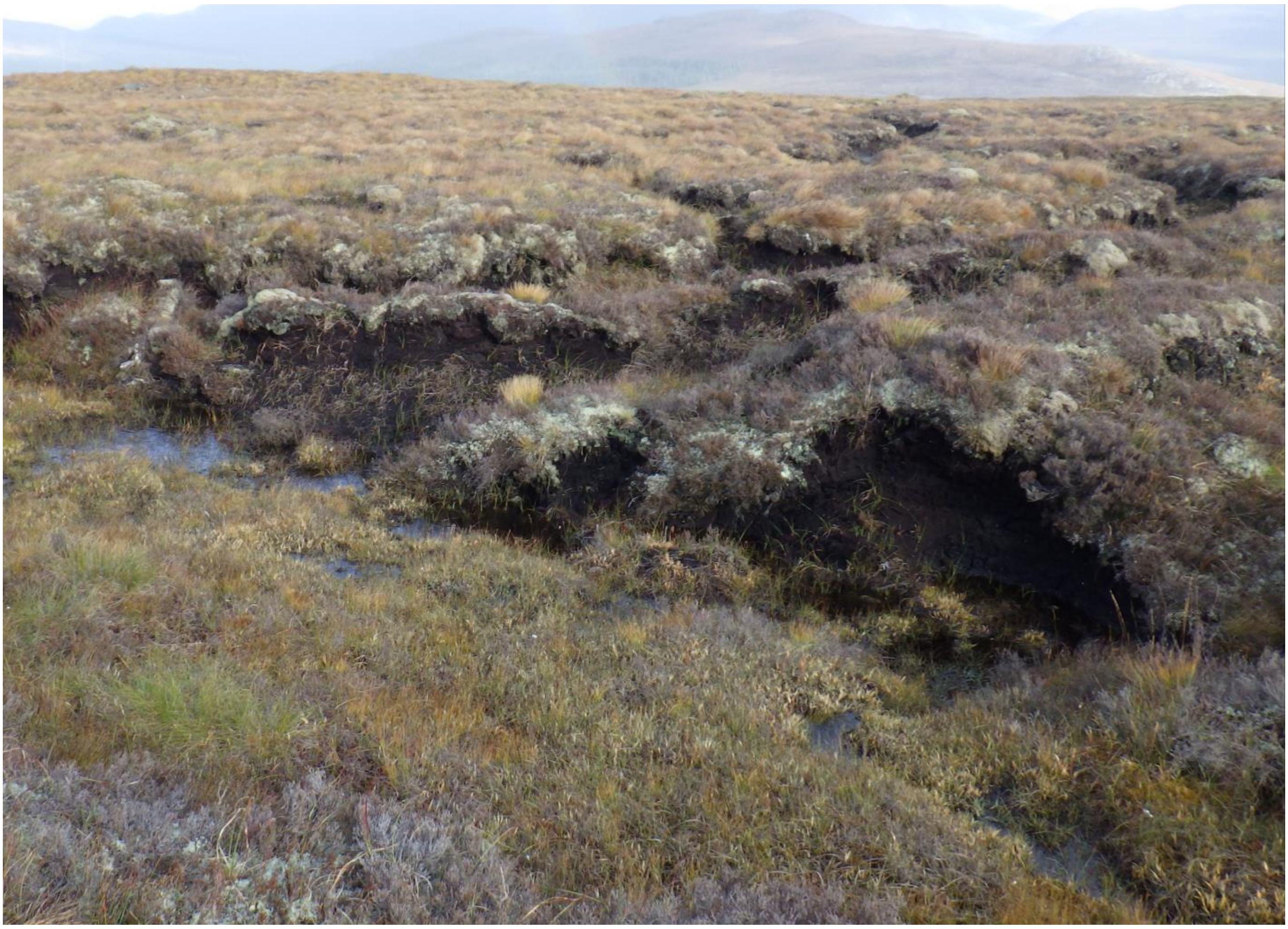

ScottishPower Renewables

Hollandmey Renewable Energy Development: Peat Slide Risk Assessment

Technical Appendix 10.1

655098-P10.1 (04)

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RSK

RSK GENERAL NOTES

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Author	Andrew Cunningham Casey McGuire	**Technical reviewer**	Catherine Isherwood
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Project manager	Robert Beck		
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1 INTRODUCTION

1.1 This report provides a Peat Slide Risk Assessment (PSRA) for Hollandmey Renewable Energy Development (RED) and associated infrastructure hereafter the 'proposed Development'.

1.2 The report forms a Technical Appendix to the Environmental Impact Assessment Report (EIA Report) for Hollandmey RED and should be read in conjunction with this document. It has been produced in response to concerns over development in areas of peatland relating specifically to the risk of induced instability within peat caused by the proposed development.

1.3 This report describes the existing peatland conditions within the application boundary (hereafter 'the Site'), and identifies and assesses the potential impacts that may be caused by the proposed development. This includes potential risks from induced peat instability. Design and mitigation methods to avoid or minimise these risks are set out, along with a number of good construction practices that would be employed during all project works.

1.4 Within this report, the study area is considered to include the planning application boundary (the 'Site') and an area up to 2 km from this boundary.

Location

1.5 The Site is located approximately 8 km south-west of John o' Groats and 16 km east of Thurso, situated within the north-eastern part of the Caithness and Sutherland area of the Highlands. The Site is privately owned. The Site lies within a Sweeping Moorland and Flows Landscape Character Area (LCA), which is described as a flat to gently undulating and smooth landform. The Site contains sections of agriculture and coniferous woodland plantation and is located within an area of carbon-rich soils. The Philips Mains Mire Site of Special Scientific Interest (SSSI), an area of Class 1 Peatland, is in the north-east part of the Site. The Site area is 1,195 hectares (ha) in total and the current land use is classified as agricultural, moorland and forestry.

Development proposals

1.6 The proposed Development includes the following key elements:

- ten wind turbines of up to 5 MW capacity and maximum tip height of 149.9 m;
- hardstanding areas and crane pads at the base of each turbine, with a maximum combined area of 3,146 m^2;
- 15 MW ground mounted solar arrays;
- 15 MW battery energy storage system (BESS);
- transformer/switchgear housings located adjacent to turbines & solar panels;
- 12.01 km of access tracks (8.93 km of which is new (6.18 km normal track and 2.75 km floating track), 2.71 is upgraded existing track and 0.37 km is existing access track), including passing places and turning heads;
- watercourse crossings (upgrade of existing or new as required);

- underground electrical cabling;
- permanent met mast and LIDAR compound;
- up to two temporary Power Performance Masts (PPM);
- a temporary windfarm construction compound area and a temporary solar construction compound area;
- a control compound comprising a permanent control building, substation and BESS;
- closed-circuit television mast(s);
- communication mast(s);
- permanent control building;
- up to three borrow pit search areas; and
- health & safety and other directional site signage.

1.7 In addition, felling of approximately 24 ha of commercial tree planting would be required to accommodate access for the turbines.

1.8 Full details of the proposed Development design are provided in **Chapter 2: Site Description and Design Evolution** of the EIA Report.

Aims

1.9 This report aims to undertake a review of available relevant Site information, including all peat depth and peat condition records, in order to provide an assessment of the risk of peat instability within the Site. Recommendations will be made for mitigation measures and specific construction methods that should be implemented in order to minimise the risk of inducing instability in the peat during construction works.

Assessment method

1.10 The assessment has involved the following stages:

- Desk study;
- Site reconnaissance;
- Peat condition assessment;
- Hazard and risk assessment;
- Detailed assessment; and
- Mitigation.

2 DESK STUDY

Information sources

2.1 The desk study involved a review of available relevant information sources on the ground conditions at the Site. Information sources included:

- Ordnance Survey mapping at 1:50,000, 1:25,000 and VectorMap Local raster mapping, Terrain 5 digital terrain model grid and contours, and OpenData mapping;
- Historical OS mapping as available to view online;
- High-resolution orthorectified aerial imagery;
- British Geological Survey online geological mapping, 1:50,000 scale;
- Scotland's Soils digital soil mapping, 1:250,000 scale;
- Data provided by the landowners and adjacent landowners;
- Data provided by the Client relating to windfarm and renewable energy developments nearby;
- Archive data from local newspapers, as available online;
- Peat depth data collected by RSK; and
- Archive and extensive Site data held by RSK Group.

Historical information

2.2 There are no available records that indicate any historical peat slides in and around the Site.

2.3 A detailed inspection of available current and historical satellite and aerial photography has been undertaken to identify any signs of recent or former peat or slope instabilities within the Site and its surroundings.

2.4 The only indications of historical slope instabilities are in coastal non-rocky slopes, such as at Harrow near the Castle of Mey and around Scotland's Haven and Gill's Bay, and along steeply-incised sections of watercourse channels, including the West and East Burns of Gills. These are most likely to be related to coastal and watercourse erosion causing removal of toe support to slopes. There are no signs of recent or historical slope failures within the proposed Site.

2.5 A detailed online search revealed no reports of ground instability within the proposed Development. The Press and Journal reported on a landslide on the A9 near Scrabster harbour in 2017; the material was described as 'mud, rocks and vegetation' (Press and Journal, 2017).

Climate

2.6 The proposed Development is located just inland of the north coast of Scotland, within the UK Meteorological (Met) Office's northern Scotland regional climatic area. The whole of the Caithness and Sutherland region has relatively high and regular rainfall with a natural gradient of climatic wetness from west to east, imposed by the prevailing westerly airstreams from the Atlantic. The combination of regular rainfall, high atmospheric humidity, relatively cool mean temperatures and a small annual temperature range is ideal for the formation of ombrotrophic bog and has given rise to extensive development of blanket bog across this part of Scotland (Lindsay *et al*., 1988).

2.7 The proposed Development's location towards the eastern part of the region means it is slightly drier than western areas, but still maintains a relatively wet and humid climate ideal for peat formation. Rainfall is generally well-distributed throughout the year, but normally greatest in the autumn and winter.

2.8 Average annual rainfall for the Site catchments varies between 888 mm and 894 mm (CEH, 2020), reflecting the elevation and slope aspect of the catchments. The mean catchment altitudes range from 39 m above Ordnance Datum (AOD) to 63 m AOD. Average annual rainfall for the climate monitoring station at Wick John o' Groats Airport is 814.3 mm (Met. Office, 2020).

2.9 The northern Scotland climatic area includes the wettest part of the UK, north-west of Fort William, which experiences over 4,000 mm of rainfall per year. In contrast, the Moray Coast east of Inverness experiences around 700 mm of rainfall.

Topography and Geomorphology

2.10 The Site is gently undulating and low-lying, with most of the Site having an elevation between 45 and 55 m AOD. The highest ground is located on isolated low hills in the north-east, south-east and south-west of the study area. The highest elevation is 80 m AOD at the Hill of Rigifa', just north of the application boundary. In the southern part of the Site, the Hill of Slickly reaches an elevation of 74 m AOD.

2.11 There are no distinct breaks in slope identifiable across the Site. All the slopes in the immediate area are gentle and undulating, in keeping with the broader landscape. The only exceptions to this are in coastal areas, where steep slopes and cliffs are common, and along some watercourse channels which are deeply incised, such as the lower reaches of the West and East Burns of Gills at Gills. Slope angles within the study area lie within the range 0-20°, with a mean slope of 2.2°. Slope mapping for the study area is provided on **Figure 10.1.2.**

2.12 Much of the Site is under active forestry. There is a significant network of drainage ditches within the forestry area and within the open Scoolary area in the south of the study area. Major or prominent ditches are indicated on **Figure 10.1.3**; it has not been possible to map all the ditches present as they are too numerous to map in detail. The ditches add to a network of natural and modified watercourse channels that span the study area. It is difficult in many areas to determine which watercourse channels are mainly natural and which are artificial or heavily modified.

2.13 Bedrock exposure at surface is limited and is restricted mainly to sections of watercourse channels and areas of former bedrock extraction.

2.14 Peatland areas adjacent to the Site show significant signs of modification. Some areas have clearly been used historically for peat cutting and show extensive evidence of cut peat banks. Other areas have been modified by excavation of drainage channels, mainly for agriculture or forestry.

Geology

2.15 Geological information is derived from the BGS GeoIndex online geological mapping bedrock and superficial geology 1:50,000 mapping (BGS, 2020) and the Geological Survey of Scotland 1:63,360/1:50,000 geological map series (Mykura, 1986; Peach *et al.,* 1914). Geology for the study area is shown on **Figure 10.1.4**.

Bedrock geology

2.16 The study area is underlain by bedrock of the Middle Old Red Sandstone group of Early-Middle Devonian age, part of the Old Red Sandstone Supergroup. Rocks from this Supergroup dominate the Caithness and Orkney areas of Scotland. Two distinct formations have been identified within the study area. The south-east, south-west and north-western quarters of the study area are underlain by the Spital Flagstone Formation, described as sedimentary rocks comprising siltstone, mudstone and sandstone. The north-eastern quarter of the study area is underlain by the younger Mey Flagstone Formation, described as sedimentary rocks comprising sandstone, siltstone and mudstone.

2.17 Bedrock exposure within the proposed development is limited, with the best exposure present in watercourse channels and an old flooded borrow pit near Hollandmey Steading. Where visible, it is characterised by a red colouration common in Old Red Sandstone strata and appears mainly to be formed of a strongly flaggy sandstone.

2.18 There are no mapped dykes or faults within the study area. There is inferred faulting shown 0.1 km east of the south easternmost part of the Site and extending eastward. There are two sets of inferred faults, trending ENE-WSW and NNW-SSE, respectively.

Superficial geology

2.19 Superficial deposits are shown to be present across the entire study area, except for a few very small zones within the northern section and surrounding area, and in part of the eastern study area. The majority of the study area is overlain by peat of Quaternary age. Parts of the study area (particularly in the middle and southern regions) are overlain by Devensian till, comprising diamicton deposited during the last glacial period. Diamicton is a very variable glacial sediment consisting of unsorted material ranging in size from clay to boulders, usually with a matrix of clay to sand.

2.20 Where visible, the till deposits are dominated by silts and clays. Some of the drainage channels are cut into the till and expose soft and moist clay-rich material below variable thickness peat and soil cover. Where the till has been exposed for some time, it dries out to form a hard clay-rich substrate.

2.21 Small areas of alluvium and river terrace deposits are present along the south western boundary of the proposed Development, loosely following but extending beyond the present-day river valley of the Link Burn. Alluvium is also present within the present-day river valley of the Gill Burn. Alluvium is a sorted or semi-sorted mixture of clay, silt, sand and gravel of fluvial origin deposited in the Holocene. This alluvium is bordered in some areas by river terrace deposits of gravel, sand, silt and clay of Quaternary age.

Soils and peat

2.22 The Site soils mainly consist of blanket peat and noncalcareous gleys, with a small area of alluvial soils, as shown on the Soil Survey of Scotland digital soils mapping (Soil Survey of Scotland, 1981). Soil mapping identifies extensive blanket peat within the study area, with deep blanket peat covering much of the study area, particularly in the north-east and north-west regions, surrounding a central strip of noncalcareous gleys.

2.23 Noncalcareous gleys extend from the northern to central study area and also cover a number of small areas to the east of the study area. Alluvial soils cover a small area on the south-west boundary of the study area. Further details on soils within the application boundary are provided in the **EIA Report Chapter 10: Hydrology, Hydrogeology, Geology and Soils**. Soil and peatland mapping are shown on **Figure 10.1.5**, with summary details provided in **Table 10.1.1.**

Table 10.1.1: Soil types within the Site

Soil Assoc.	Parent Material	Component Soils	Landforms	Vegetation	Area %
Organic soils	Organic deposits	Dystrophic blanket peat	Uplands and northern lowlands with gentle and strong slopes	Blanket and northern blanket bog. Upland and flying bent bog. Deer-grass bog. Sedge mires.	85.5
Thurso	Greyish brown drifts derived from Middle Old Red Sandstone flagstones and sandstones	Noncalcareous gleys	Undulating lowlands with gentle slopes	Arable and permanent pastures. Rush pastures and sedge mires. Acid bent-fescue grassland.	14.3
Alluvial soils	Recent riverine and lacustrine alluvial deposits	Mineral alluvial soils with peaty alluvial soils	Flood plains with river terraces and former lake beds	Arable and permanent pastures. White bent grassland. Swamp, rush pastures and sedge mires.	0.2

2.24 The Carbon and Peatland 2016 map has been consulted to understand the carbon-rich soils, deep peat and priority peatland habitat within the Site (NatureScot, 2016). The map classifies soils into five carbon classes plus three classes for mineral soils, non-soil or unknown. Classes 1 and 2 are considered to be nationally important carbon-rich soils. Within the Site, the soils are principally assigned Class 1; this correlates well with the mapped distribution of significant peat soils. Some areas of Class 5 are present; these represent areas of commercial forestry plantation on peat soils and have a lack of peatland vegetation. The remainder of the Site is Class 0 (mineral soils) with two small areas of Class 4 (unlikely to include carbon-rich soils). The areas of each carbon and peatland class within the Site are provided in **Table 10.1.2.**

Table 10.1.2: Carbon and peatland classes present within the Site

Peatland Class	Description	Area %
Class 0	Mineral soils; peatland habitats are not typically found on such soils	14.0
Class 1	All vegetation cover is priority peatland habitat; all soils are carbon-rich soils and deep peat	64.5
Class 4	Area unlikely to be associated with peatland habitat or wet and acidic type; area unlikely to include carbon-rich soils	1.1
Class 5	Soil information takes precedence over vegetation data; no peatland habitat recorded; may also show bare soil; all soils are carbon-rich and deep peat	20.4

2.25 There is widespread evidence of modification to peatland areas within, and around the Site. These mainly relate to historic peat cutting, notably within the peatland areas north and south of the application boundary. Within the Site, the peatland has been significantly modified for commercial forestry and agriculture with extensive drainage systems present in many areas.

2.26 The peat depth survey confirms that peat is present within the Site and has broad coverage. There are two main areas of extensive peat in the western and eastern parts of the Site, surrounded with areas of shallow peat or topsoils. The areas of deepest peat form well-defined basins with recorded peat depths in excess of 8 m in places.

2.27 No peat pipes were identified within the study area, although watercourse channels within the peat are present in some areas.

2.28 As the majority of the Site has been under forestry there were no significant areas of peat erosion or hagging present. The forestry planting has caused damage to the peatland through artificial drainage, which is extensive across the Site, and the development of tree roots.

Hydrogeology

2.29 The Site is entirely underlain by bedrock classed as having moderately productive fracture flow. The superficial deposits covering the Site have a range of potential permeabilities, and their productivity will depend on their composition and connectivity locally, with pockets of sand and gravel having high permeability and clay and silt having low permeability. The peat bodies in the area will also hold some groundwater. Flow within peat is known to be extremely slow, although it can contribute some limited baseflow to local burns.

2.30 Regional groundwater flow will tend to mimic the natural topography, flowing north and east towards the sea. No springs have been identified within the Site or wider study area.

Hydrology

2.31 The Site lies within the catchments of the Burn of Rattar, the Burn of Horsegrow, the West Burn of Gills, the Gill Burn and the Burn of Lyth. Nearly 70% of the application boundary is located within the Burn of Rattar catchment; this catchment has a total area of 20 km^2. The Burn of Hollandmey, the Link Burn and the Burn of Ormigill are all tributaries to the

Burn of Rattar and provide the main drainage to the study area, draining broadly west and north into the Pentland Firth.

2.32 The Catchment Wetness Index, PROPWET, for the Site catchments is 0.50, indicating the Site is wet for 50% of the time. The area has a relatively low Baseflow Index, indicating that groundwater contribution is of limited importance to Site watercourses. The Standard Percentage Runoff is relatively high, indicating that 50-55% of Site rainfall is converted into surface runoff from rainfall events. Catchment statistics are derived from the Flood Estimation Handbook Web Service (CEH, 2020).

Aerial photography

2.33 High-resolution orthorectified colour aerial photography for the study area has been made available for this assessment.

2.34 The study area is mainly shown as a series of areas of dark green broken by straight and curved lines of varying width. There is an area of brown and grey with a series of small dark shapes in the north-eastern part of the area. Immediately north of this is an area shown as pale brown with strong parallel lines. The southern part of the area is a mix of brown and green.

2.35 The dark green areas are forestry blocks, separated by forest rides and firebreaks. Some of the areas where the forestry is patchy indicate places where the plantation trees have not taken well, or are areas where natural broadleaved forestry remains in place rather than plantation. The stripy pale brown area is a recently felled section of forestry.

2.36 Immediately south of the clear-fell is Philips Mains Mire SSSI, an area of peatland with dubh lochans showing as a network of dark shapes. This area has never been planted and is relatively undisturbed.

2.37 The brown and green areas in the southern part of the Study area are agricultural land. The green areas represent crop fields, often with grass or cereal crops; the brown areas are generally rough grassland and bog, often with poor drainage.

2.38 There are no areas visible with exposed bedrock or bare peat, except in areas of peat cutting outwith the application boundary.

Vegetation

2.39 The majority of the study area is under coniferous forestry plantation with some areas of improved pasture.

2.40 National vegetation classification (NVC) survey mapping of the remaining areas indicates that there are five main communities present (**Figure 8.3**)

- M2 –*Sphagnum cuspidatum/recurvum* pog pool community;
- M15 – *Scirpus cespitosus – Erica tetralix* wet heath;
- M18 – *Erica tetralix – Sphagnum papillosum* raised and blanket mire;
- M19 – *Calluna vulgaris – Eriophorum vaginatum* blanket mire;
- M23 – *Juncus effusus/acutiflorus – Galium palustre* rush pasture.

2.41 The area of M2 is located entirely within the Philips Mains Mire SSSI. There are several areas of M18, all within the eastern half of the Site and in open areas away from the forestry.

2.42 Within the main Site, most of the open forest rides and watercourse corridors are characterised by M15, M19 and M23. All three habitats are relatively widespread throughout the Site.

3 SITE RECONNAISSANCE

3.1 A walkover survey of the Site was undertaken by RSK, accompanied by a member of the design team, on 25 August 2020. The scope of the survey included a reconnaissance survey of the Site and its immediate surroundings, plus mapping of the geomorphology and local-scale hydrology of the Site. The survey covered the entire Site, with a particular focus on the proposed Site where infrastructure is planned and potential access routes into and across the Site. The weather during the survey was sunny, becoming overcast with showers later in the day, and a strong breeze. Visibility was reasonable throughout, although deteriorating in the showers.

3.2 Reference is made to peat hagging, a form of erosion specific to peat. The peat develops channels which form breaks in the surface vegetation, exposing bare peat surfaces which are then more susceptible to erosion. Over time, this can lead to the development of a network of complex and sinuous channels through the peat and can lead to the formation of isolated peat 'islands'. In extreme situations, the peat body can be completely removed to leave bare mineral soil. Peat hagging is a natural process but can be exacerbated by poor land management practices including overgrazing and trampling from deer, sheep and cattle, extensive muirburn from grouse moor management, and uncontrolled off-road vehicle activity.

3.3 There is effectively no peat hagging at Hollandmey and there are no areas of exposed peat within the Site.

3.4 The areas shown in the photographs and described below provide good coverage of the Site, detailing the range of landforms, vegetation and erosion patterns encountered. As the area is largely forested, it is not possible to give a realistic indication of proposed infrastructure.

	**(A) View of existing track NGR ND 2968 7011.** View shows the existing access into the main Site. The two trackside ditches are clear, together with the bank to the RHS formed from excavated material during the track construction. Peat is absent across this area.

	**(B) View of existing farm track giving access to solar array, NGR ND 2908 7120** View shows the access route to the solar array and the southern margin of the solar array, with its rough vegetation. Peat is largely absent from this area, with only a few minor pockets identified in places. Peat depths are entirely below 1.0 m.
	**(C) View of forest margin near T08, NGR ND 2996 6938** View shows transition from forestry plantation to open rough boggy grassland in the southern part of the Development. This area has deep peat in some sections, with depths to over 8 m.
	**(D) View of boundary ditch, NGR ND 2996 6935** View east along a large ditch at the boundary of the Scoolary land parcel in the southern part of the Development. Much of this area has peat well in excess of 2 m in depth.

	**(E) Pasture field near T09, NGR ND 3013 6895** One of the open fields within the Scoolary land parcel. View to the north showing the rough grassland in the boggy areas, giving way to the forestry plantation in the distance. Within the fields, peat is not present. Parts of the boggy grassland have deep peat well in excess of 2 m depth.
	**(F) New ditch at forestry margin near T06, NGR ND 2937 6865** View shows an open ride in the forestry with a newly excavated ditch. The ditch has been cut through the upper peat layer into soft clay below. Ride vegetation is mainly tussocky grass and heather. Peat depths in this area are variable but rarely over 1.5 m in depth.
	**(G) View along the Link Burn, NGR ND 2864 6911** View west along the Link Burn towards Lochend windfarm. This area is a broad open section within the forestry. The burn is in a slightly incised channel, mostly within the peat body. Ground is fairly boggy. Peat in this area is mainly over 2 m in depth but shallower areas are present in places.

	**(H) Vehicle track and forest ride near T02, NGR ND 2866 6983** A vehicle access track with trackside drainage, and a typical forestry ride near T02. Vegetation is dominated by ling heather and rough grasses. The photo is from the margin of an area of deep peat towards an area with peat depths well over 2 m.
	**(I) Open area near T02, NGR ND 2867 6973** This open area forms the access to T02 and a proposed supporting borrow pit. Ground conditions are firm underfoot, with vegetation dominated by ling, sedges and tussock grass. The ridge in the centre has limited or no peat, although peat depths to either side are deeper (>2 m).
	**(J) Fire break between T02 and T05, NGR, ND 2923 6965** Typical view of an open area and drainage ditch within the main forestry area; this example is between Turbines 2 and 5. Ground conditions are dominated by tussock grass and moss. Peat in this area is deep, mainly over 3.0 m. Ground surface is almost flat.

4 MAPPING

Peat depth survey

4.1 Initial peat depth surveying was undertaken by RSK between 25 May and 5 June 2020. This Phase 1 survey consisted of a 100 m grid across the application boundary area in order to develop a picture of the overall pattern of peat development across the original study area. The survey results were used to inform the infrastructure design, in order to minimise incursion into areas of deeper peat.

4.2 A subsequent phase of peat depth surveying was undertaken by RSK between 20 and 25 September, with a supplementary survey on 10 November 2020. For this Phase 2 survey, peat depths were recorded at 50 m intervals along proposed tracks, crosshair probing at turbine base locations and in grids across hardstanding areas, site compounds and buildings, the solar array and borrow pit areas. Offset records were made alongside existing tracks that would require widening as part of the proposed Development.

4.3 An additional phase of peat depth surveying was undertaken by RSK on 5-6 October 2021 along the proposed access routes into the Site, to identify any areas of peat that may be present beside the existing roads.

4.4 Peat probing point locations were recorded using a handheld GPS with typical accuracy of ±5 m and peat depths were measured to an accuracy of ±0.01 m. All measurements were recorded to full depth/point of refusal.

4.5 The survey results are summarised in **Table 10.1.3** and shown on **Figures 10.1.6a-p**.

4.6 The peat depth survey indicates that approximately two-fifths of the study area has no peat, with 41.3% of the measured locations having topsoil or peaty soil cover up to 0.5 m deep. 74.1% of the area has peat depths of 1.5 m or shallower. The deepest recorded peat was 8.1 m.

Table 10.1.3: Summary of peat depth probing results

Peat depth range (m)	No. of points	Percentage of points (%)
0.00	36	2.2
0.01 – 0.50	632	39.1
0.51 – 1.00	371	22.9
1.01 – 1.50	160	9.9
1.51 – 2.00	88	5.4
2.01 – 2.50	86	5.3
2.51 – 3.00	83	5.1
3.01 – 3.50	36	2.2
3.51 – 4.00	34	2.1
4.01 +	91	5.6
Total:	**1,617**	**100.0**

4.7 The peat depth survey and reconnaissance survey both confirm that there are two main areas with extensive peat deeper than 2 m. The eastern part of the study area, including Philips Mains Mire SSSI and the area east of T08, appears to form a continuous area of very deep peat. A second area is present around the Link Burn between T02, T03, T05 and T06, extending north to Hollandmey Moss and the area immediately west of the solar array. Smaller additional areas of relatively deep peat (2 m or deeper) are present in parts of the Development but are generally not extensive. The probing data indicate that the peat depth can vary very substantially over short distances.

Indicative peat depth mapping

4.8 The combined peat depth survey results were used to produce an extrapolated indicative peat depth map for the study area. The extrapolated peat depth map was produced using a Gravity interpolation across the survey area with a 10 m cell size.

4.9 The advantage of using a digital interpolation is that the process is fully objective and there can be no subjective influence. However, the process is not able to allow for known variation in peat development in varying topographical settings. As a result, there may be over-estimation of peat development in areas of steep or well-drained ground, and potential under-estimation of peat development in flatter or poorly drained areas. Owing to the good resolution of the underlying data, the interpolation appears largely to give a representative indication of peat depth across the study area.

4.10 The indicative peat depth map for the study area is provided in **Figures 10.1.6a-p.**

Peat sampling and analysis

4.11 Peat core samples were taken at three locations and the peat cores were logged using the modified Von Post humification and wetness scale. Core logs and photographs are provided in **Annex 1**.

4.12 Three peat core samples were sent for analysis by Envirolab. Analysis results are provided in **Table 10.1.4** and sampling locations are shown on **Figures 10.1.6a-p.**

Table 10.1.4: Peat sample analysis results

Client Sample ID	Units	Limit of Detection	Method	C1A	C2	C3
Depth to Top				0.10	1.55	1.60
Depth to Bottom				0.30	1.80	1.80
Date Sampled				24-Sep-20	24-Sep-20	24-Sep-20
Sample Type				Soil	Soil	Soil
% Moisture at <40°C	% w/w	0.1	A-T-044	87.7	87.6	77.9
% Stones >10mm	% w/w	0.1	A-T-044	<0.1	<0.1	<0.1
pH	pH	0.01	A-T-031s	4.75	5.24	4.15
Total Carbon	% w/w	0.1	A-T-032s	47.2	42.6	49.4
Wet weight	g			181.3	192.2	151.3
Dry weight	g			0.1	4.1	10.2
Bulk density	g cm^{-3}			0.97	0.81	0.85

5 PEAT CONDITION

Developments on peat

Definition of peat

5.1 Scotland's Soils (2018a) classifies peat as:

> *'An accumulation of partially decomposed organic material, usually formed in waterlogged conditions. Peat soils have an organic layer more than 50 cm deep from the soil surface which has an organic matter content of more than 60%'.*

5.2 Organic soils which are 50 cm or thinner can also support peatland vegetation and as a result are also considered within Scotland's broader peatland system in Scotland's National Peatland Plan (NatureScot, 2015). These are often described as 'peaty gleys' or 'peaty podzols', reflecting key aspects of the underlying soil. Peaty soils have a higher plant fibre content and are less decomposed than peat.

5.3 Active peatland typically consists of two layers: the surface layer or *acrotelm* and the deeper layer or *catotelm*. The acrotelm contains the living vegetation and consists of living and partially decayed plant material. It typically has a low but variable hydraulic conductivity and allows some through-flow of water within the plant material. The underlying catotelm is denser, with a very low hydraulic conductivity, and is formed from older decayed plant material. The catotelm varies in structure, in some areas retaining a proportion of fibrous material and in other areas being more humified and amorphous. The degree of humification typically increases with depth.

5.4 Underneath the peat-forming layers, the basal substrate can be a mineral soil, a superficial deposit such as glacial material, or bedrock. There may be a transition zone through a mineral-rich peaty layer at the base of the peat, although this is usually no more than 5 cm in thickness.

Importance of peat

5.5 Peatland forms a key part of the Scottish landscape, covering more than 20% of the country's land area, and forming a significant carbon store (Scotland's Soils, 2018b). In addition, peatland is an internationally important habitat.

5.6 Active and healthy peatlands develop continuously, removing carbon dioxide from the atmosphere and storing it within the peat soil. Peatland protection and restoration form key parts of the Scottish Government's Climate Change Plan, which targets restoration of 50,000 hectares (ha) of degraded peatland by 2020 and 250,000 ha by 2030 (Scottish Government, 2018).

5.7 It is therefore important that developments in peatland areas, including extensive uplands as well as the Flow Country characteristic of much of Caithness and parts of Sutherland, take recognition of the importance of peatland as a habitat and carbon store. Careful planning of developments, and careful infrastructure design, can remove or minimise the disturbance of peat that would be needed to allow the development to proceed.

Peat condition survey

5.8 As part of the peat depth surveys, information was collected concerning the condition of the peat present within the Site. NatureScot recognises five categories of peatland condition:

- (1) Near-natural;
- (2) Modified;
- (3) Drained;
- (4) Actively eroding; and
- (5) Forested/Previously Afforested (NatureScot, 2018).

5.9 As the study area is principally within a forestry plantation, the majority of the area falls into category 5. The remaining open areas, except for the area of Philips Mains Mire SSSI, have been extensively drained for forestry and agriculture (category 3). Philips Mains Mire SSSI is the only part of the Site where the peatland remains in a near-natural (category 1) condition.

5.10 Where present in the study area, the peat is mainly in the form of blanket peat. There are two main sub-sections of the Site where peat forms a major part of the soil cover; these sub-sections are described separately below. The other sub-sections of the Site are largely without peat.

Peatland restoration

5.11 The two main bodies of extensive peat would both be potentially suitable for peatland restoration work. In particular, it may be possible and desirable to focus peatland restoration around the margins of the Philips Mains Mire SSSI, to bring more of this peat body into near-natural condition and to provide buffer areas around the SSSI margins. This would need to be discussed with NatureScot and the extent and nature of restoration agreed and consented, but it is an area of consideration.

5.12 Parts of the larger peat body in the western half of the study area would benefit from restoration, particularly in areas where the forestry is reaching maturity and harvesting. This may include: blocking of natural or artificial drainage channels to encourage re-wetting and regrowth of *Sphagnum* species; use of geotextile and/or mulches to prevent erosion and encourage natural regrowth of vegetation; and exclusion of grazers through fencing.

5.13 Peatland restoration proposals for the project are discussed in **Technical Appendix 10.2: Peat Management Plan** and **Technical Appendix 8.6: Draft Habitat Management Plan.**

6 HAZARD AND RISK ASSESSMENT

6.1 For the purposes of this peat slide risk assessment, the following definition of risk has been adopted:

Risk = Probability of a Peat Landslide x Adverse Consequences

6.2 Probability, or likelihood, can be estimated in a number of ways and should take account of both natural factors and man-made or man-imposed factors that could influence slope stability. Man-made or man-imposed factors can include overgrazing from over-stocking, excavation of drainage ditches or grips, or heather burning for land management purposes. Natural factors can include extreme weather events such as very high intensity rainfall, or prolonged dry periods followed by storms.

6.3 The methods of assessment of likelihood and adverse consequences used here are described below.

Assessing likelihood

6.4 As peat slope failures are mainly considered to resemble planar translational slides, the assessment of likelihood of a peat landslide makes use of the Infinite Slope Model (Boylan & Long, 2014) to assess stability of the peat across the slopes in the Site, in line with the Scottish Government guidance (Scottish Government, 2017). The Infinite Slope Model assesses slope stability by calculating the forces resisting failure (shear strength or cohesion) and the forces inducing failure (shear stress) and taking a ratio of these, known as the Factor of Safety. The modified Infinite Slope Model equation is as follows:

$$F = \frac{c'}{\gamma \, z \sin\beta \cos\beta}$$

where

F = Factor of Safety, the ratio of forces resisting a slide to forces causing a slide

c' = undrained shear strength of the material; kPa

γ = specific weight of peat, undrained in situ; kN/m^3

z = peat depth; m

β = slope of ground surface, assumed to be parallel to the slope of the failure plane; degrees

6.5 If $F > 1$, the slope is stable; if $F < 1$ the slope is unstable; if $F = 1$ the forces are exactly balanced. It is possible to state with some confidence, therefore, that if $F > 1.3$ the slope is stable and would have some resistance to change.

6.6 Values assigned to the parameters are provided in **Table 10.1.5**, along with an explanation for their selection.

Table 10.1.5: Parameters for the Infinite Slope Model

Parameter	Value and Derivation
F	Calculated value
c’	4.5 kPa Published shear strength values for peat vary from 4.5 to 60 kPa or more (e.g. Long, 2004). Published values from recent field tests tend to cluster between 10 and 20 kPa with some higher and lower values recorded.
γ	8.61 kN/m^3 Derived from density of peat multiplied by acceleration due to gravity (9.81 m/s^2). Density of peat varies depending on degree of decomposition and water content; published values range from 500 to 1,400 kg/m^3. This value is derived from peat core samples collected from the Development, which came to a mean value of 878 kg/m^3.
z	Where available, measured peat depths have been used. For grid analysis, the maximum interpolated depth within the grid has been taken to provide a conservative estimate.
β	Slope angles have been derived from the DTM for the Site. Grid cell slopes were all derived from the Site DTM. The DTM used for slope angle generation has a resolution of 5 m. The slope raster map was generated within the GIS software used for the analysis. Maximum slope angles were used for each cell, to provide a conservative analysis.

6.7 It is a fairly standard practice to estimate the shear strength, c’, from Site data. This is undertaken by assuming that the slope is just marginally stable at each point where peat depth has been measured, i.e. the slope has F = 1. The Infinite Slope Model equation can be rearranged to derive a value for c’, using the other parameters as described in **Table 10.1.5**.

6.8 It is important to note that the calculated values of c’ for each location represent the *minimum* shear strength needed for the peat to be stable. In fact, the shear strength may be, and in most cases probably is, considerably higher. For example, on very shallow slopes the peat needs only a very low shear strength to remain stable, whereas on steeper slopes a much higher shear strength is required to hold the peat on the slope. For this reason, the higher estimated values of c’ are of more relevance as they are more likely to be representative of the actual shear strength of the peat on the Site. Typically, the maximum value of the calculated shear strength is used in the stability analysis. For Hollandmey, this is a value of 3.15 kPa (**Figure 10.1.1**).

6.9 At the Site, 1,484 locations have been probed during the phases of fieldwork. c’ values have been calculated for each of these and the distribution is provided in **Figure 10.1.1**.

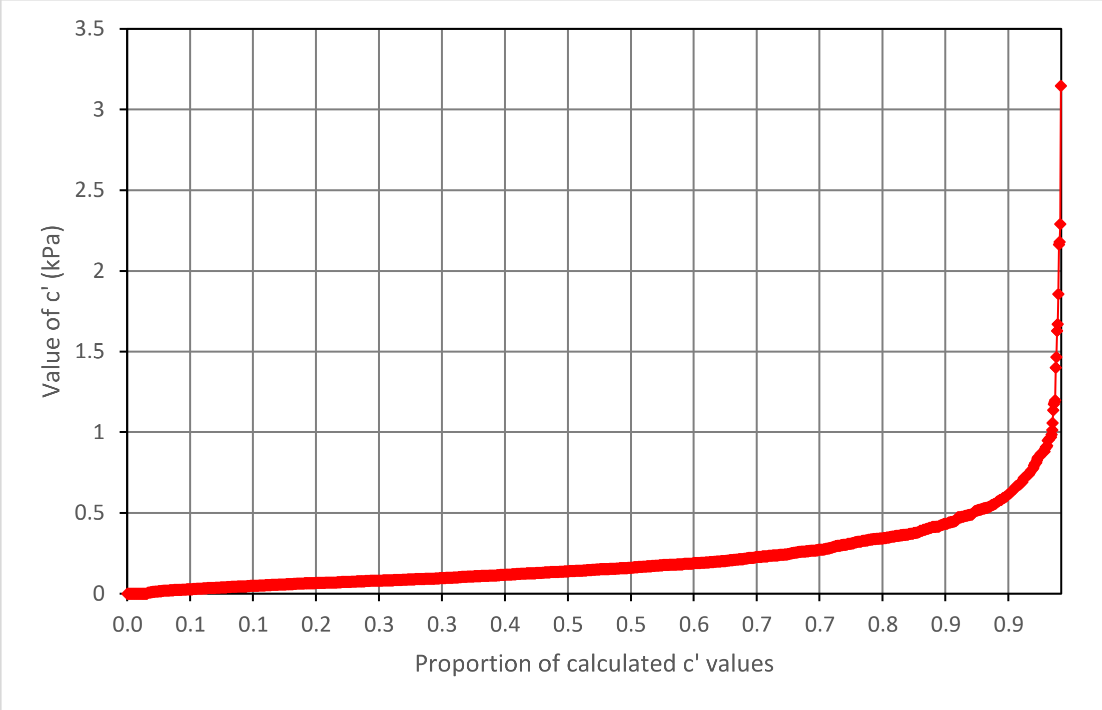


Figure 10.1.1: Estimate of minimum shear strength, c'

6.10 As the slopes at Hollandmey are naturally very gentle, the minimum required shear strength for the peat probing locations are comparatively low and are lower than usual quoted shear strength in peat. It is very likely, therefore, that this value for c' is a significant underestimate of the actual shear strength. Preliminary calculations indicated that using this value gave an unrealistic picture of the site-wide risks; as a result, the lowest published value for shear strength, 4.5 kPa, has been used in the analysis instead of the back-calculated values as it is considered that this will give a more representative assessment of risk while still remaining conservative.

6.11 In order to produce a study area-wide dataset for Factor of Safety, a grid of 50 x 50 m cells was overlain across the study area and a Factor of Safety calculated for each cell. It is a standard and widely recognised GIS technique to use a regular grid for terrain analyses of this kind. It allows a systematic process across the landscape and minimises the subjectivity of the analysis. The 50 x 50 m cells are referred to as 'grid cells' throughout the analysis.

6.12 The Factor of Safety, F, has been calculated for each peat probing location within the study area, and for each grid cell within the study area. A buffer of 250 m around the application boundary has also been included. The Factors of Safety have been divided into classes, which have been used to map the likelihood of a peat landslide occurring at each point and for each grid cell across the study area. The results are presented in **Table 10.1.6**.

6.13 For most windfarm assessments, the calculated Factor of Safety results are considered together with field observations and geomorphological assessment to take into account additional risk factors including breaks in slope or risk reduction factors such as areas of bedrock exposure. The almost flat nature of the study area has meant that this stage has not been possible as no significant geomorphological features have been identified that could influence the risk factors present. As a result, the Factor of Safety results have been mapped directly onto Likelihood categories. The Likelihood categories are also presented in **Table 10.1.6**.

Table 10.1.6: Summary of Infinite Slope Model results

Likelihood	Factor of Safety	No. of points	% of points	No. of cells	% of cells
Nil	No peat	669	41.3%	1,147	17.1%
Negligible	2.5 +	943	58.4%	5,333	79.4%
Unlikely	1.3 to <2.5	5	0.3%	187	2.8%
Likely	1.1 to <1.3	0	0.0%	27	0.4%
Probable	1.0 to <1.1	0	0.0%	11	0.2%
Almost certain	<1.0	0	0.0%	15	0.2%
	Totals	**1,617**	**100%**	**6717**	**100%**

6.14 The Likelihood map is provided in **Figure 10.1.7**.

Assessing adverse consequences

6.15 Potential adverse consequences resulting from a peat landslide cover a wide range, from environmental through to economic and, potentially, harm to life. Scottish Government (2017) gives five examples, as follows:

- Potential for harm to life during construction;
- Potential economic costs associated with lost infrastructure or delays in the construction programme;
- Potential for reputational damage associated with the occurrence of a peat landslide in association with construction activities;
- Potential for permanent, irreparable damage to the peat resource, in terms of both carbon store and habitat, through mobilisation and loss of peat in a landslide;
- Potential for ecological damage to watercourses and waterbodies subject to inundation by peat debris.

6.16 Adverse consequence has been assessed taking account of environmental sensitivity, including potential consequences to water quality from peaty debris and habitat loss by peat removal and by blanketing of sensitive areas with peat debris, and economic significance, including damage to infrastructure and construction delays resulting from a peat landslide, in line with current guidance (Scottish Government, 2017).

6.17 Adverse consequence has been assigned as follows:

- **Very high consequence:** public roads, all buildings, wind turbine foundations (including Lochend turbines), substation, solar array, designated sites;
- **High consequence:** watercourses and waterbodies, areas of sensitive habitat, turbine hardstandings, substation or construction compounds, Lochend cable;
- **Moderate consequence:** areas of moderately sensitive habitat, access tracks;
- **Low consequence:** areas of low sensitivity habitat, borrow pits; and
- **Very low consequence:** damaged or degraded habitat.

6.18 **Table 10.1.7** below provides a summary of the grid cells in the study area assigned the various consequence ratings. The adverse consequence map is provided in **Figure 10.1.8**.

Table 10.1.7: Summary of adverse consequence ratings

Adverse consequence	No. of cells	% of cells
Very high consequence	641	9.5%
High consequence	2,237	33.3%
Moderate consequence	871	13.0%
Low consequence	2,971	44.2%
Very low consequence	0	0.0%

Risk assessment

6.19 The Likelihood and Adverse Consequence are combined to produce an estimate of risk for each grid cell within the study area. The risk assessment matrix used to combine these two parameters is provided in **Table 10.1.8** below.

Table 10.1.8: Risk assessment matrix

		Adverse consequence				
		Extremely high	High	Moderate	Low	Very Low
Peat landslide likelihood	Almost certain	High	High	Moderate	Moderate	Low
	Probable	High	Moderate	Moderate	Low	Negligible
	Likely	Moderate	Moderate	Low	Low	Negligible
	Unlikely	Low	Low	Low	Negligible	Negligible
	Negligible	Low	Negligible	Negligible	Negligible	Negligible

6.20 **Table 10.1.9** below provides a summary of the risk ranking for the grid cells across the Site, together with an indication of appropriate mitigation from the Scottish Government (2017). The risk ranking map is provided in **Figure 10.1.9.**

Table 10.1.9: Summary of risk ranking and appropriate mitigation

Risk ranking	No. of grid cells	% of grid cells	Appropriate mitigation
High	11	0.2%	Avoid project development at these locations
Moderate	35	0.5%	Project should not proceed unless risk can be avoided or mitigated at these locations, without significant environmental impact, in order to reduce risk ranking to low or negligible
Low	654	9.7%	Project may proceed pending further investigation to refine assessment, and mitigate hazard through relocation or re-design at these locations
Negligible	4,873	72.5%	Project should proceed with monitoring and mitigation of peat landslide hazards at these locations as appropriate
No peat	1,147	17.1%	No peat landslide hazard

6.21 Most of the Site has been assessed as having a negligible risk of peat landslide, or of having no peat (89.6%). Thirty-five grid cells have been assessed as having a moderate risk of peat landslide and 11 with a high risk.

6.22 Of the 46 grid cells assessed as having moderate or high risk, only one is located adjacent to the Development. This cell and its immediate surroundings have been the subject of further investigation in order to refine the assessment in this area. This is detailed in **Section 7**.

6.23 The remaining moderate or high-risk cells have been considered in relation to natural peat slide and the risk this may cause to Development infrastructure. This is also discussed in **Section 7**.

Peat slide risk associated with blasting for aggregate

6.24 For many renewable energy developments, aggregate extraction is achieved by blasting of bedrock. The shock waves from blasting have the potential to travel through the bedrock and could, potentially, be associated with triggering instability in peat areas at some distance from borrow pit sites.

6.25 The bedrock within the Site is a sandstone and is considered to be suitable for extraction by ripping with an excavator. Blasting is not proposed for any of the borrow pit sites within this proposal, and peat instability resulting from blast shock waves are therefore not a concern.

7 DETAILED ASSESSMENT AND MITIGATION

7.1 One grid cell within the proposed Development footprint has been identified as having a moderate risk of peat landslide. In addition, two main clusters of cells within the study area have been identified as having moderate and high risk of peat landslide. The areas identified for detailed assessment is indicated on **Figure 10.1.9**.

7.2 These cells have been considered in greater detail, as three groups: Area 1 considers the cell within the proposed Development footprint, Area 2 considers the wider cell clusters that are located some distance from proposed Development infrastructure, and Area 3 considers an additional cell cluster located along the planning application boundary. Relevant photographs of the areas are included to provide additional context.

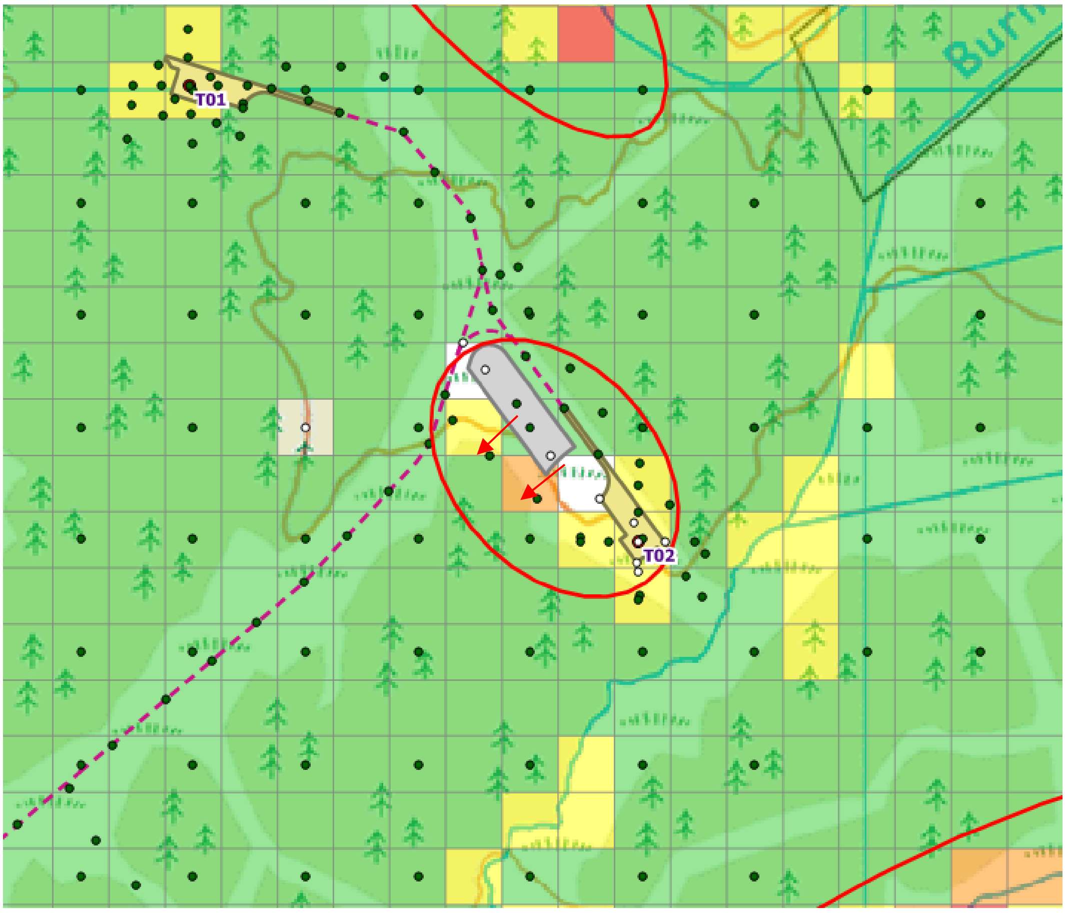
7.3 The inspection for cell in Area 1 includes a detailed inspection of the highlighted cell, the cells immediately around and downslope of it, the measured peat depths and slope angles present, drainage features and the nature of the proposed nearby infrastructure. Mitigation measures are recommended to reduce or control the risk for the area.

7.4 The inspection for the clusters of cells in Areas 2 and 3 have been further appraised to determine if there is any risk to downslope receptors including proposed Development infrastructure.

7.5 Following detailed consideration, the risk ranking has been re-appraised in the light of the presented information and proposed mitigation. Each description is accompanied by a map of the cell and its immediate surroundings. The grid cells in each map are 50 x 50 m, to give an indication of scale. Green cells have negligible risk; yellow cells have low risk; orange cells have moderate risk; red cells have high risk. Blank cells have no peat as defined in the PLHRA Guidelines (Scottish Government, 2017).

7.6 The points on the maps show the calculated Likelihood rating for all locations with directly measured peat depth, where grey is no peat, blue is negligible; green is unlikely; yellow is likely; orange is probable; and red is almost certain.

Detailed Assessment: Area 1

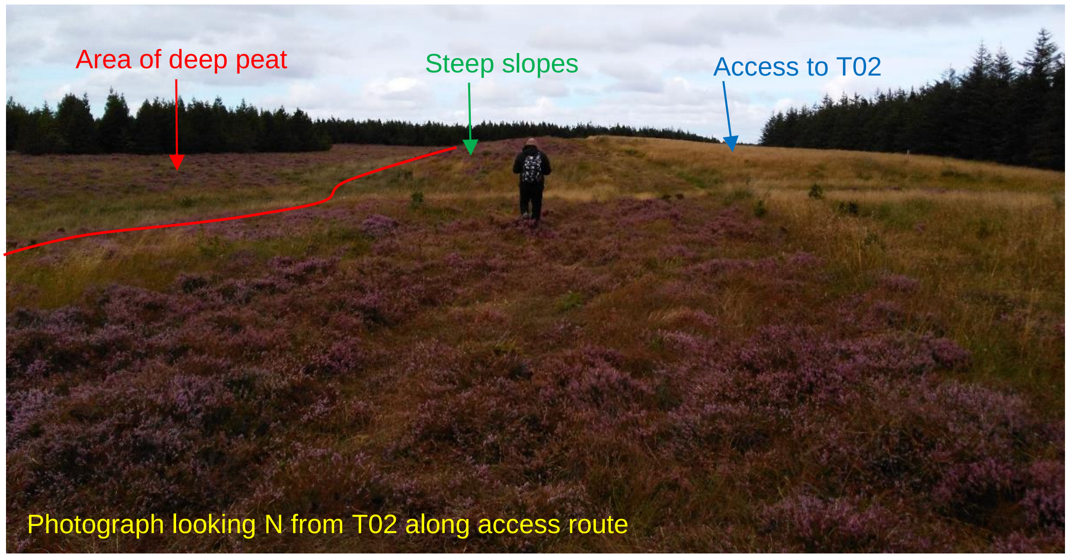


One cell adjacent to T02 has been assigned Moderate Risk. This relates to the calculated likelihood for the cells, combined with the High consequence for T02 and the sensitivity of the habitat in this area.

Calculated likelihood for the cell is Likely. This relates to the measured peat depths and slope angles calculated from the DTM.

The recorded maximum peat depth is 2.9 m, with a maximum slope angle for the cell of 9.3°.

Potential runout from any failure: Any failure in this or adjacent cells would travel south-west down the slope to the flat peatland area at the base of the ridge. The potential failure area is limited by the size and angle of the sloping ridge margin. Given the gentle slope below the ridge, any runout would be of limited distance and would be unlikely to reach the forestry margin. Runout paths are indicated by arrows.



This part of the site includes a low ridge (see photograph), along the top of which the track to T02 has been located. The SW side of the ridge has a short but distinct slope, giving rise to the comparatively steep slope angle identified above. At the foot of the slope, the area has deep peat developed with measured peat depths up to 2.9 m in the immediate area. Slopes are typically less than 1.5° in the area where deep peat has been identified. On the ridge top peat depths are up to 1.0 m, with depths of 0.6 m or less on the side slopes. In places there is no peat at all.

Calculated likelihood for the measured peat depth points are shown on the figure above. It can be observed that all the peat depth records have a calculated likelihood no greater than Negligible, based on the actual slope present at that peat depth record.

Mitigation

Closer inspection of the highlighted cell indicates that the slope angle and the area of deep peat are not coincident (as shown in the photograph above) and that the elevated Risk ranking is an artefact of the grid-based assessment.

The ridge is being proposed as a subsidiary borrow pit, subject to satisfactory ground investigation, as much of the ridge top will require levelling to construct the access track and turbine hardstanding/crane pad. It is considered practical to level the whole ridge top area to avoid leaving unnecessary cut slopes, and is likely to provide a better location for habitat restoration than an irregular slope.

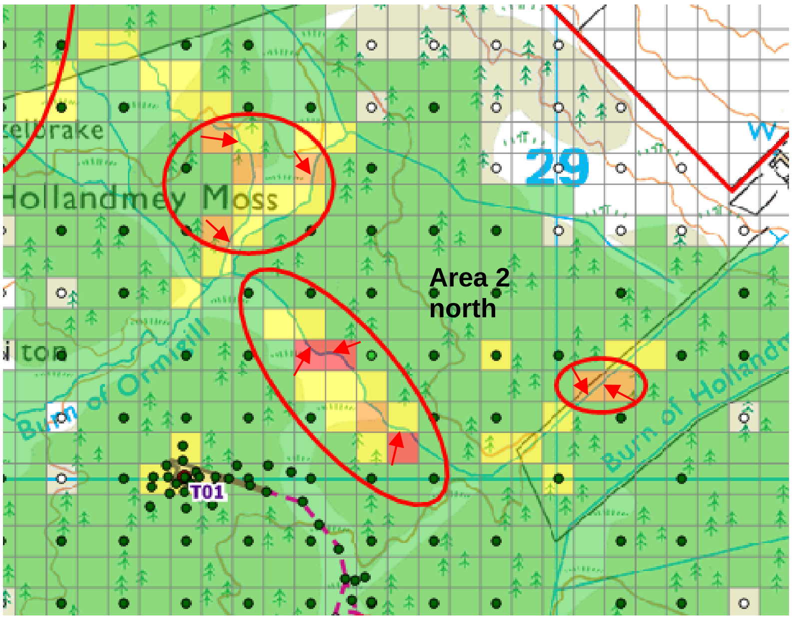
No working or vehicle movement would take place on the area of deep peat at the foot of the slope, and this would be clearly demarcated. Excavation of the ridge to form the access track, crane pad and borrow area would take place in a controlled manner from the proposed access track route and would involve excavation using an excavator bucket rather than blasting of any kind.

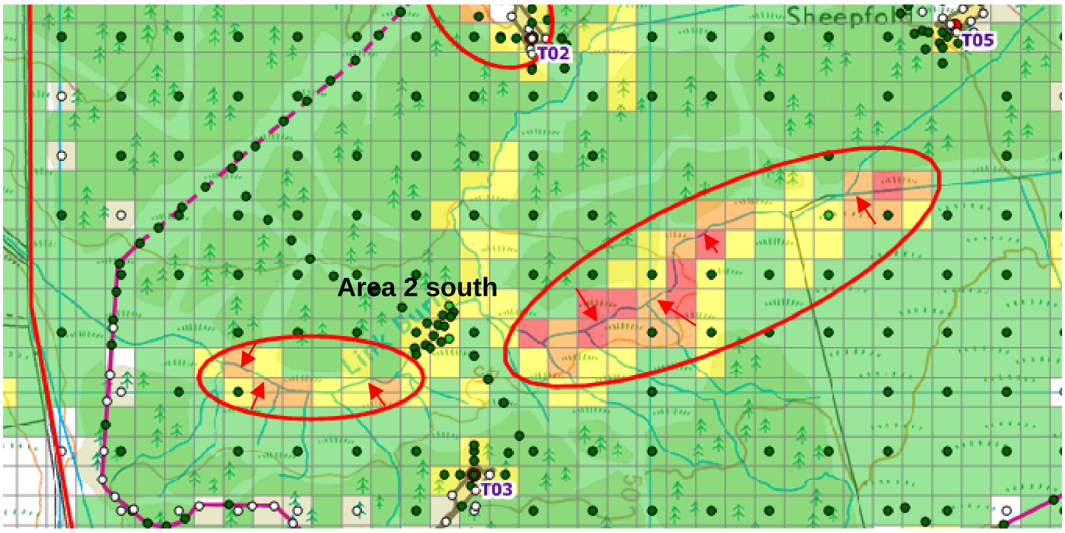
Work in the area would be under supervision of the Environmental Clerk of Works at all times.

Revised risk ranking:

Low

Detailed Assessment: Area 2





Clusters of cells are apparent along some of the Site watercourses, principally the Link Burn (south area) and Burn of Ormigill (north area) and their tributaries. Both watercourse systems have channels incised into the peat by around 1-1.5 m, giving rise to localised steep slopes. It is the presence of these slopes that have led to the High and Moderate risk ranking for these cells, combined with the High consequence value assigned to the watercourses themselves. This is also a consequence of using a comparatively low value of 4.5 kPa for shear strength, which gives rise to some false positives in locations where the actual shear strength within the peat is probably considerably higher.

Potential runout from any failure: In all cases, the length of any slide is restricted by the height (under 2 m) and length (up to 15 m) of the slope. Any slide would terminate in the watercourse channel, as these are the immediate down-slope receptors. A failure could affect the integrity of the channel and may cause temporary damming of the watercourse. Runout paths are indicated by arrows.

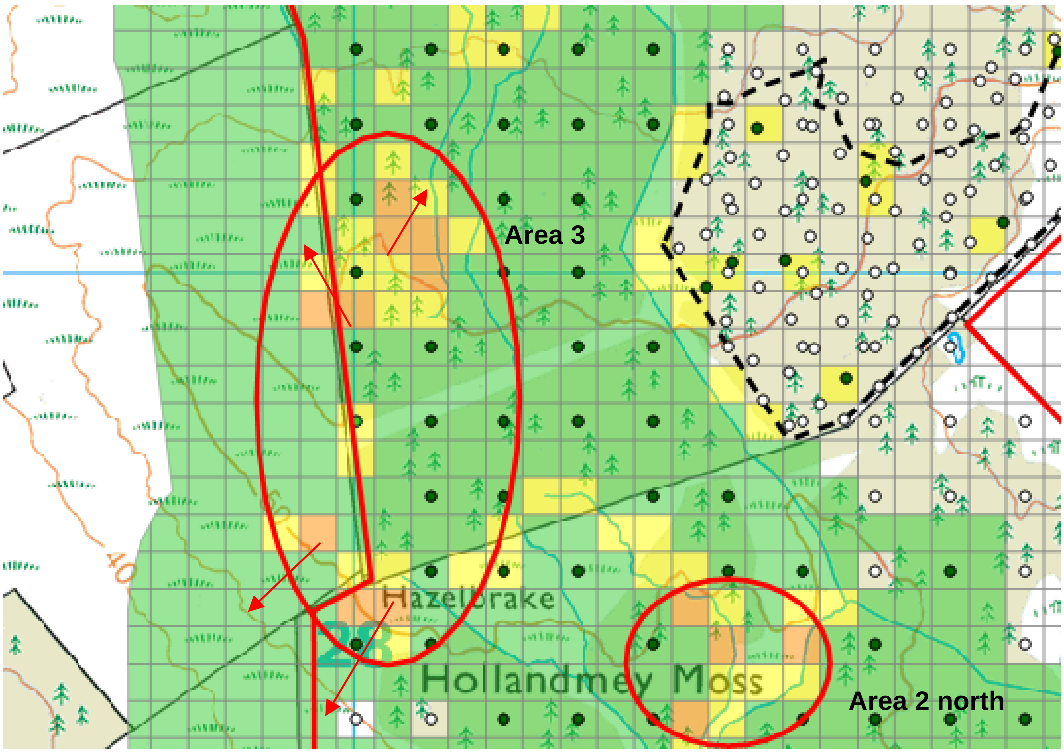
Photograph looking upstream along Burn of Hollandmey immediately SE of T02

No indications of peat landslide were observed along any of the watercourse channels. Small-scale bank instabilities are apparent in some areas, potentially associated with forestry works although they may be naturally occurring. Further small-scale bank instabilities can be expected as a result of natural undermining of banks by water movement, particularly at times of higher water level and flow velocity. However, along-channel slopes are almost flat and are therefore insufficient to allow momentum to build up along the watercourse channels. In the event of any instability, there would be a localised impact on the watercourse but limited wider impacts to the peatland, the hydrological environment or the Development

Mitigation

Plant and vehicle movement and all site activity will be limited to the construction corridor at all times.

No plant of vehicle movements will be permitted in the highlighted areas, to prevent induced bank instability in the watercourses.

Detailed Assessment: Area 3

Two clusters of cells are apparent adjacent to the application boundary approximately 300 m west of the solar array and 600 m north-west of T01. The cells all have deep peat estimates derived from interpolation and steeper than average slopes in the range 7-11.5°. Peat records in this area range from 1-4 m, with an area of peat over 6 m in the flatter low-risk area between the two cell clusters. *Potential runout areas:* These cells have potentially longer runout areas than those identified in Areas 1 and 2 and could extend to several hundred metres including beyond the application boundary. Runout paths are indicated by arrows. No indications of peat instability or developing instability were recorded during the peat depth surveys. **Mitigation** There are no plans for any Development activity to take place within 300 m of these cells and it is unlikely that construction activity would have any influence on their stability. A natural peat slide may affect areas downstream and downslope of the identified cells, including land outwith the application boundary.

Mitigation

7.7 The following mitigation measures would be implemented to ensure that slope stability is maintained across the Site and to minimise the risk of inducing a peat slide.

7.8 Construction work would make use of current best practice guidance relating to developments in peatland areas. A risk management system, such as a geotechnical risk register, would be developed as part of the post-consent detailed design works. This would be maintained through all subsequent stages of the project and updated as necessary whenever new information becomes available. During construction, members of project staff would undertake advance inspections and carry out regular monitoring for signs of peat landslide indicators. A geotechnical specialist would be on call to provide advice, if required by Site conditions.

7.9 Micrositing would be used to avoid possible problem areas. This would be assisted by additional verification of peat depths, to full depth, in any highlighted areas where construction work is required. Track drainage would be installed in accordance with published good practice documentation and would be minimised in terms of length and depth in order to minimise concentration of flows.

7.10 Construction activities would be restricted during periods of wet weather, particularly for any work occurring within 20 m of a watercourse or within areas of identified deeper peat. Careful track design would ensure that the volume and storage timescale for excavated materials would be minimised as far as practicable during construction works.

7.11 Monitoring checks would be undertaken along identified higher-risk watercourse channels following periods of heavy rain and/or high flow. These would look for any recent signs of bank instability that may affect the flow or lead to a larger destabilisation of the nearby bank area. Any identified instabilities would be brought to the attention of the Environmental Clerk of Works as soon as possible.

7.12 Vegetation cover would be re-established as quickly as possible on track and infrastructure verges and cut slopes, by re-laying of excavated peat acrotelm, to improve slope stability and provide erosion protection. Additional methods, including hydroseeding and/or use of a biodegradable geotextile, would be considered if necessary in specific areas.

7.13 Construction staff would be made aware of peat slide indicators and emergency procedures. Emergency procedures would include measures to be taken in the event that an incipient peat slide is detected.

7.14 Key early indicators of peat instability are:

- Tension cracks in the upper layers or to full depth of peat, and may indicate an accumulation of stress in peat soils. In addition, cracking can provide a route for surface water to infiltrate rapidly through the peat body, contributing to elevated pore water pressure and lubrication along lines of weakness;
- Compression ridges, usually indicative of displacement upslope which has led to formation of ridges within the peat body; and
- Peat creep, usually visible as tilting of fence posts or young trees. This may be accompanied by tension cracking and/or compression ridges.

Infrastructure design

7.15 Careful and informed infrastructure design forms a key measure for prevention of induced instability in peat. The collated peat depth information has been used to inform the proposed infrastructure layout throughout the design process. Incursion into areas of deeper peat has been kept to a practical minimum by careful design and will be reinforced by careful micrositing, in order to minimise disruption to peatland ecosystems and hydrology, and to avoid the risk of induced peat instability.

7.16 Access tracks are anticipated to be constructed using established cut-and-fill construction methods for peat of 1.2 m deep or less, with floating construction intended for the small areas where peat deeper than 1.2 m needs to be crossed. Any peat present along the cut-and-fill track routes would be excavated and stored for use in reinstatement of trackside verges and other elements of project infrastructure where appropriate.

7.17 Trackside ditches would be constructed as required. Given the almost flat nature of the site, it is likely that trackside ditches would be required on one or both sides of the majority of the tracks in order to minimise water ponding on the track surface. Cross-drains would be installed at regular intervals below the track to minimise flow concentration in areas of sloping ground. Cross-drains would discharge onto vegetated ground where possible, to encourage spread of surface flow rather than focused flow and the consequent development of new drainage channels. In all cases, lengths and depths of trackside drainage would be minimised, particularly in areas where peat deeper than 1.0 m is present.

8 CONCLUSIONS

8.1 A detailed assessment of peat slide risk has been carried out for the proposed Hollandmey Renewable Energy Development. All proposed new and upgraded infrastructure has been covered by the assessment.

8.2 The assessment found that the majority of the Site has a negligible or low risk of peat landslide.

8.3 One area within the Site identified as having a moderate risk of peat instability was appraised in greater detail, taking into account location-specific details. The apparent risk is an artefact of the assessment mechanism, which uses maximum peat depth and maximum slope for each grid cell. In the highlighted cell, the area of deep peat and steeper slope were not coincident, meaning that the actual risk of instability is Low rather than the initial assessment of Moderate.

8.4 Some additional areas of apparent high risk have been identified along watercourse channels and along the application boundary, again where localised steeper slopes are present. These areas are all distant from proposed infrastructure and there would be no requirement for construction activity to approach these areas. It is recommended that construction areas are demarcated and all site staff are made aware of the requirement to stay within the marked construction corridor at all times.

8.5 For all three areas, mitigation measures have been recommended to control the peat landslide hazard. For all areas, the peat landslide hazard can be controlled by use of good construction practice and micrositing.

8.6 Good construction methods and appropriate micrositing would also be effective at controlling residual peat landslide risk for lower risk locations at the Site. Providing that the recommended mitigation measures are put in place and adhered to, the risk of peat landslide as a result of the proposed Development is not significant.

9 REFERENCES

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10 ANNEX 1: PEAT CORE LOGS

Notes to accompany peat coring results
Peat coring was undertaken by RSK on 24 September 2020, during the Phase Two peat depth surveying. Three locations were identified by RSK to be targeted, prior to the works. One extra location was added during the works due to the presence of shallow peaty soils at the original location.

Main findings
Ground conditions were slightly boggy at all locations. C1/C1A and C3 were situated in open areas, close to the proposed locations of T05 and T06, respectively. C2 was situated within an area of forestry close to the proposed location of T08. Vegetation at all locations included rushes and grasses, with bog moss present in varying amounts at all core locations.

Core recovery was to shallower depths than was probed due to the tip of the peat corer preventing recovery from the basal 0.2 m. Soft clay was recovered from the base of C1/C1A and C2, the surface of which is likely to have been penetrated by the peat probe, indicating that probed peat depths are likely to be slightly overestimated in these areas.

Cores from C1 and C1A returned slightly to moderately decomposed peaty soils to depths between 0.25 m bgl and 0.40 m bgl, underlain by soft clay.

Cores from C2 returned peat to a depth of 1.95 m bgl. This consisted of a thin undecomposed layer at the surface, becoming moderately to highly decomposed amorphous peat with increasing depth. Large fragments of wood were identifiable within otherwise highly decomposed amorphous peat, close to the base; however, these were very soft and readily disintegrated when handled.

Cores from C3 returned peat to the maximum depth of 2.0 m bgl. Peat became increasingly decomposed with increasing depth to 1.80 m bgl. The basal 0.20 m appeared to be slightly less decomposed, however this could have been impacted by an increase in the content of woody material at this depth, which is likely to decompose at a slower rate. Cores from C3 returned very fibrous peat, particularly at shallow depths. This may have been impacted by the location of C3, within an area of forestry.

Photographs of all recovered cores are included at the end of this document.

Peat Core Logs

ID	X	Y	Peat Depth (m)	Notes
C1	329433.675	969654.384	0.70	Location moved due to lack of peat; no sample collected. 0.00 - 0.10 m bgl: H3 B3, slightly decomposed peaty soil, predominantly identifiable plant remains. Muddy brown water released. 0.10 - 0.25 m bgl: H4 B2, slightly decomposed peaty soil, some identifiable plant remains but less than above. 0.25 - 0.5 m bgl: Soft grey and light brown slightly sandy silty clay.

ID	X	Y	Peat Depth (m)	Notes
C1A	329422.554	969640.442	0.70	Sampled 0.10 - 0.30 m bgl 0.00 - 0.15 m bgl: H3 B4, slightly decomposed peaty soils, predominantly identifiable plant remains. Muddy brown water released. 0.15 - 0.40 m bgl: H5 B3, moderately decomposed peaty soils, primarily amorphous with some recognisable plant features. 0.40 - 0.50 m bgl: Soft light brown and grey slightly silty clay with frequent roots.
C2	330187.863	969429.996	2.20	Sampled 1.55 -1.80 m bgl 0.00 - 0.05 m bgl: H1 B2, undecomposed fibrous peat with significant Sphagnum growth at the surface. 0.05 - 0.15 m bgl: H5 B2, moderately decomposed peat, some larger plant fragments identifiable. 0.15 - 0.35 m bgl: H6 B2, moderately highly decomposed peat, plant fragments becoming less distinct. 0.35 - 0.5 m bgl: H5 B2, moderately decomposed peat, plant fragments more identifiable than above. 0.5 - 0.75 m bgl: H7 B2/3, highly decomposed peat with a small number of faintly recognisable plant structures. Very dark water released. 0.75 - 0.9 m bgl: H6 B2, moderately highly decomposed peat, plant fragments slightly more distinct than above. 0.9 - 1.0 m bgl: H6 B4, moderately highly decomposed peat, plant fragments slightly more distinct than 0.5-0.75 m bgl, becoming wetter than above. 1.0 - 1.15 m bgl: H7 B4, highly decomposed peat with lots of amorphous material. 1.15 - 1.50 m bgl: H6 B3, moderately highly decomposed peat, less amorphous material than above with slightly more recognisable structure. 1.5 - 1.95 m bgl: H7 B3, highly decomposed peat with lots of amorphous material, some larger recognisable fragments of wood at the base but these are very soft. 1.95 - 2.0 m bgl: Soft to firm light grey clay.

ID	X	Y	Peat Depth (m)	Notes
C3	329429.685	968805.012	2.20	Sampled 1.60 - 1.80 m bgl 0.00 - 0.05 m bgl: H1 B2, undecomposed fibrous peat with significant Sphagnum growth at the surface. 0.05 - 0.35 m bgl: H3 B2, very fibrous slightly decomposed peat. 0.35 - 0.50 m bgl: H4 B3, fibrous slightly decomposed peat, becoming slightly pasty. 0.50 - 1.0 m bgl: H5 B3, moderately decomposed peat, plant remains identifiable but less distinct and with more amorphous material than above. 1.0 - 1.10 m bgl: H7 B3, highly decomposed peat, small amounts of recognisable plant structure with lots of amorphous material. 1.10 - 1.80 m bgl: H7 B2, as above, becoming less wet. 1.80 - 2.0 m bgl: H6 B2, moderately highly decomposed peat, more recognisable plant fragments than above with some amorphous material.

Location: C1	Depth: 0.00 – 0.50 m bgl	Date:24/09/2020

Notes: Peaty soil overlying clay base (left of photo) from 0.25 m bgl.

Location: C1A	Depth: 0.00 – 0.50 m bgl	Date:24/09/2020

Notes: View showing interior of core sections. Primarily moderately decomposed peaty soils overlying clay at base (left of photo)

Location: C2	Depth: 0.00 – 0.50 m bgl	Date:24/09/2020

Notes: Core interior showing fibrous surface layer overlying primarily moderately decomposed peat with some recognisable plant structures.

Location: C2	Depth: 0.50 – 1.00 m bgl	Date:24/09/2020

Notes: Moderately/highly decomposed peat, plant fragments visible in core at base (right of photo).

Location: C2	Depth: 1.00 – 1.50 m bgl	Date:24/09/2020

Notes: Moderate/highly decomposed peat with very occasional larger wood fragments which are very soft.

Location: C2	Depth: 1.50 – 2.00 m bgl	Date:24/09/2020

Notes: Highly decomposed peat overlying light grey at the base (right of photo)

Location: C3	Depth: 0.00 – 0.50 m bgl	Date:24/09/2020

Notes: Highly fibrous, slightly decomposed peat. Surface layer visible to right of photo.

Location: C3	Depth: 0.50 – 1.00 m bgl	Date:24/09/2020

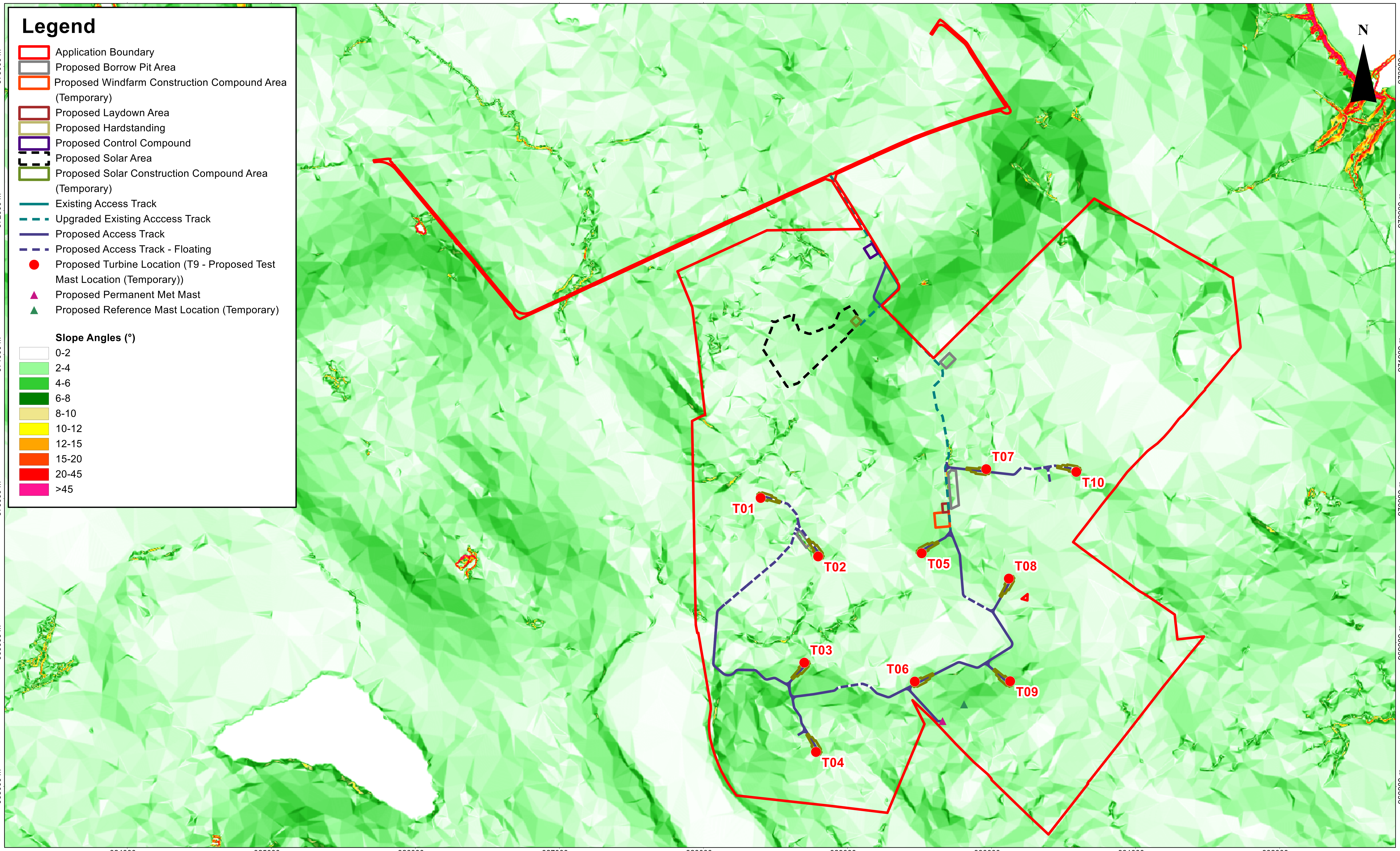
Notes: Moderately decomposed peat, fibrous with visible structure but containing significant amorphous material.

Location: C3	Depth: 1.00 – 1.50 m bgl	Date:24/09/2020

Notes: Highly decomposed peat, slightly wetter in top 10cm (right of photo).

Location: C3	Depth: 1.50 – 2.00 m bgl	Date:24/09/2020

Notes: Large wood fragment present at approximately 1.8 m bgl.



SCOTTISHPOWER RENEWABLES

Rev	Date	By	Comment
E	10/11/2021	CI	Layout change
D	28/10/2021	CI	Infrastructure & boundary updated
C	19/08/2021	CI	Infrastructure updated

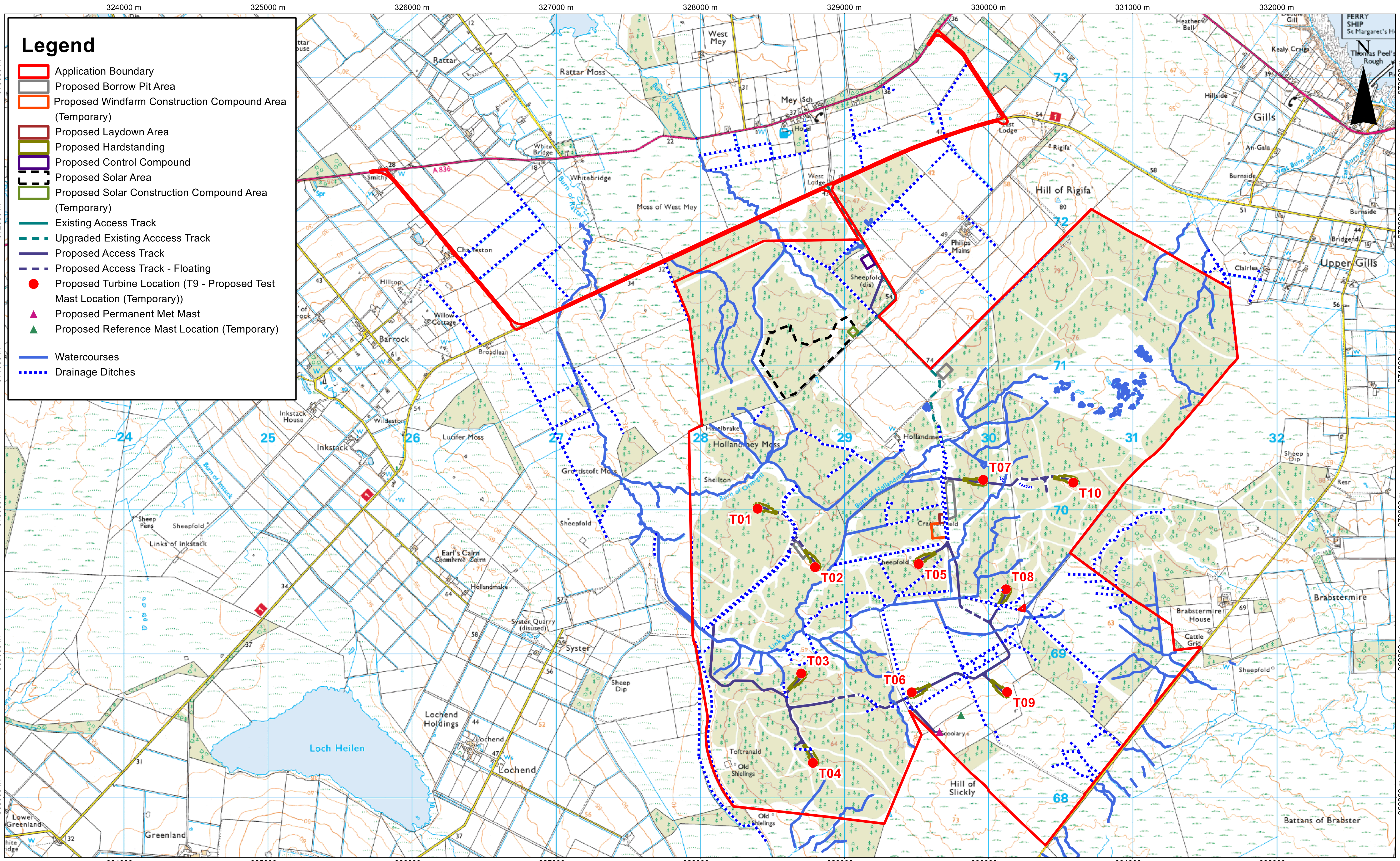
1:25,000 Scale @ A3

0 1 km

Hollandmey Renewable Energy Development

Figure 10.1.2: Slope Mapping

Drg No	HMY_Geo_CI	
Rev	E	Datum: OSGB36
Date	10/11/2021	Projection:
Figure	10.1.2	TM



SCOTTISHPOWER RENEWABLES

Rev	Date	By	Comment
E	11/11/2021	CI	Layout change
D	28/10/2021	CI	Infrastructure & boundary update
C	19/08/2021	CI	Infrastructure update

1:25,000 Scale @ A3

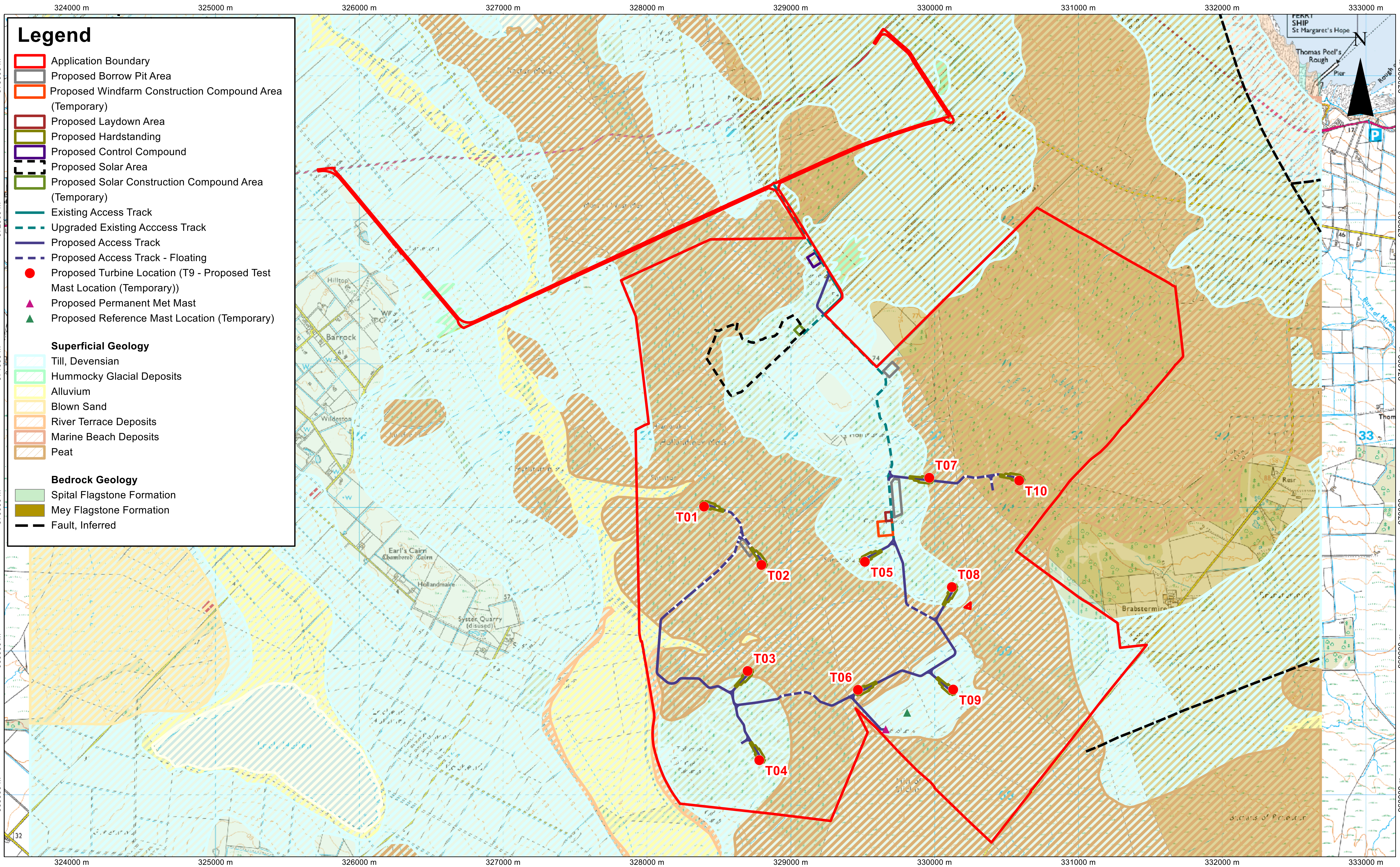
0 1 km

Hollandmey Renewable Energy Development

Figure 10.1.3: Geomorphology and Drainage Mapping

Drg No	HMY_Geo_CI
Rev	E
Date	11/11/2021
Figure	10.1.3

Datum: OSGB36
Projection: TM



SCOTTISHPOWER RENEWABLES

Rev	Date	By	Comment
E	10/11/2021	CI	Layout change
D	28/10/2021	CI	Infrastructure & Boundary update
C	19/08/2021	CI	Infrastructure update

1:25,000 Scale @ A3

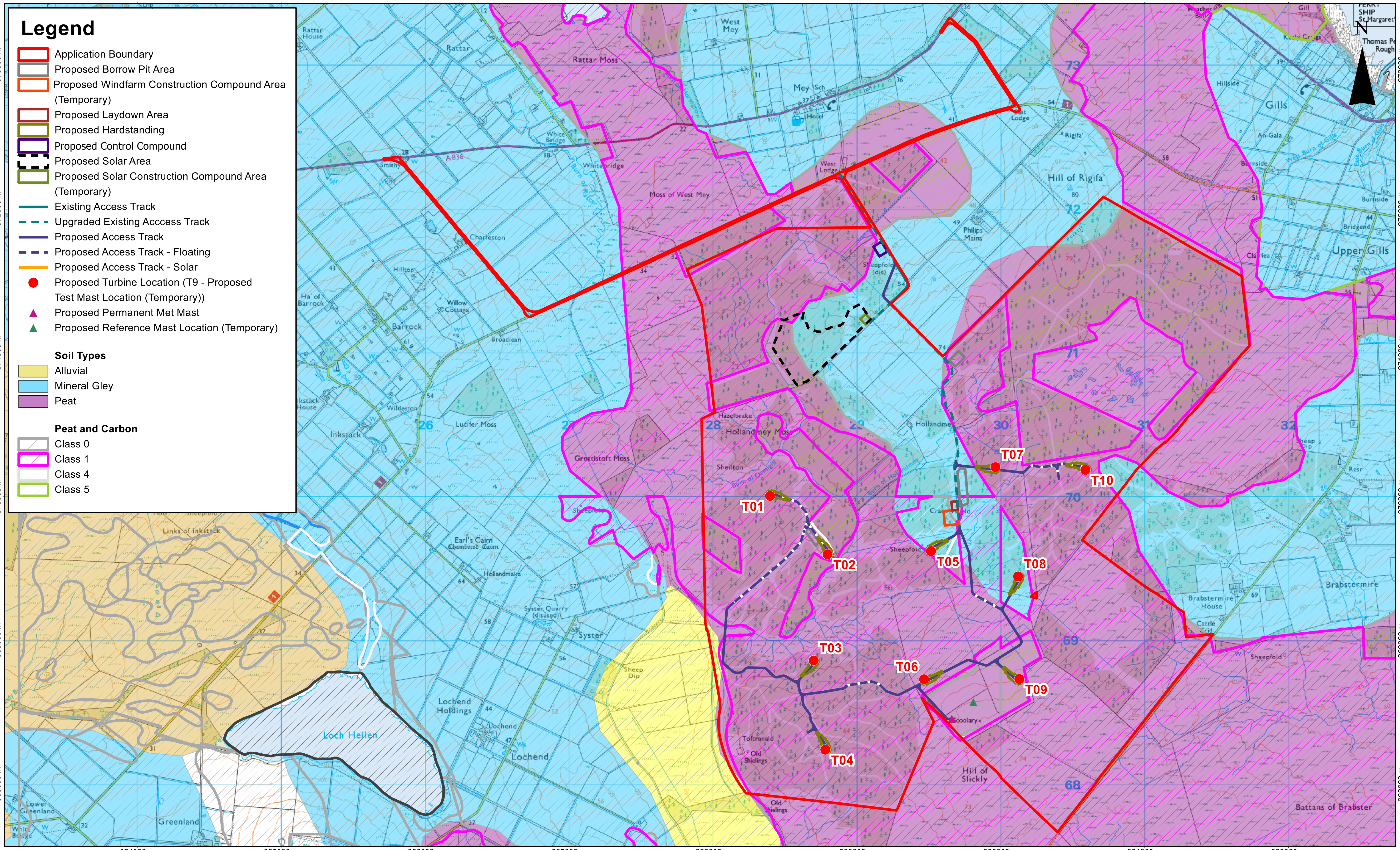
0 — 1 km

Hollandmey Renewable Energy Development

Figure 10.1.4: Geology Mapping Bedrock & Superficial

Drg No	HMY_Geo_CI
Rev	E
Date	10/11/2021
Figure	10.1.4

Datum: OSGB36
Projection: TM



E	10/11/2021	CI	Layout change
D	28/10/2021	CI	Infrastructure & boundary update
C	19/08/2021	CI	Infrastructure update
Rev	Date	By	Comment

1:25,000 Scale @ A3

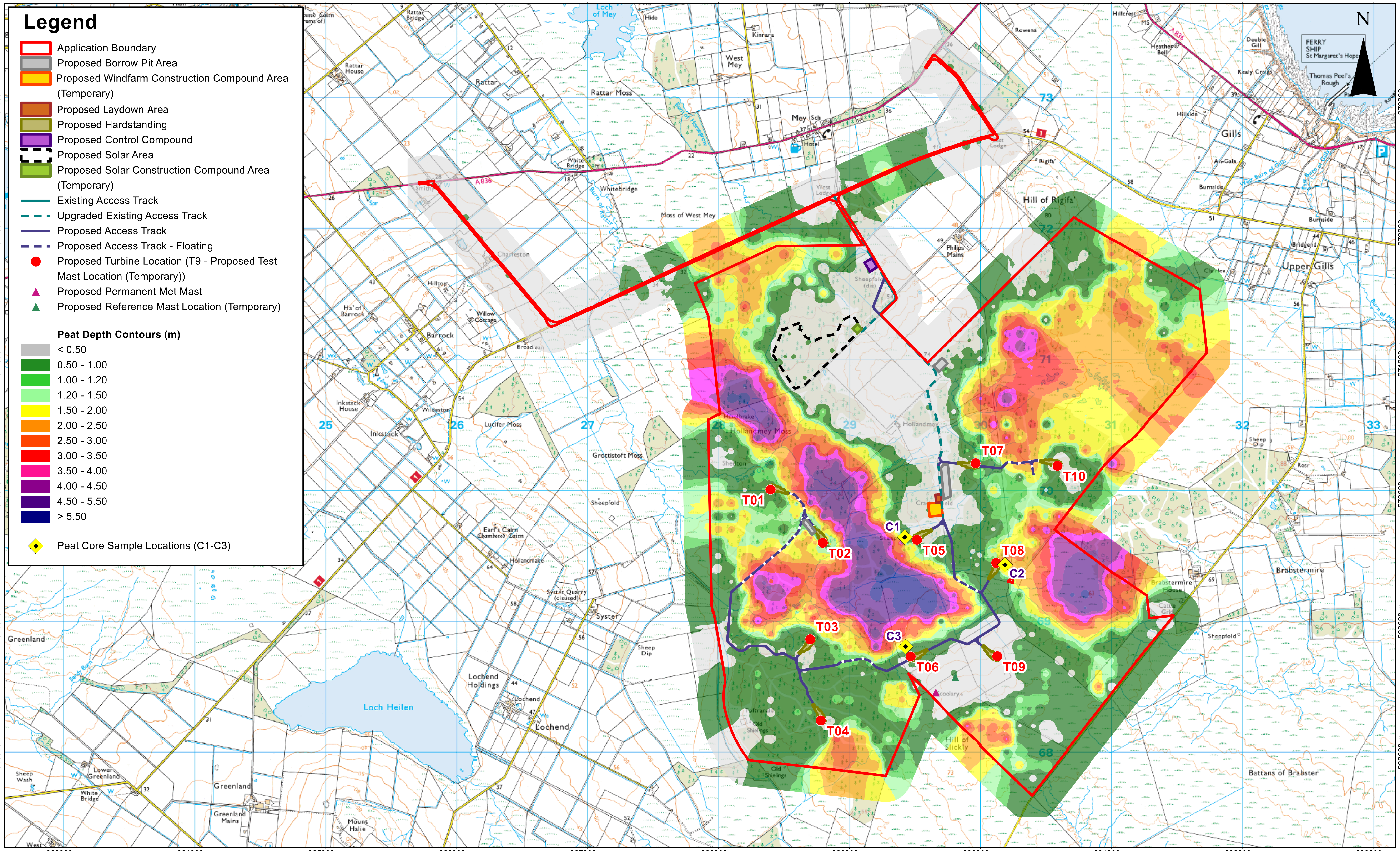
0 1 km

SCOTTISHPOWER RENEWABLES

Hollandmey Renewable Energy Development

Figure 10.1.5: Soil, Peat & Carbon Mapping

Drg No	HMY_Geo_CI	
Rev	E	Datum: OSGB36 Projection: TM
Date	10/11/2021	
Figure	10.1.5	



E	10/11/2021	CI	Layout change	1:27,500 Scale @ A3	0 — 1 km
D	28/10/2021	CI	Infrastructure & boundary update		
C	23/08/2021	CI	Infrastructure update		
Rev	Date	By	Comment		

SCOTTISHPOWER RENEWABLES

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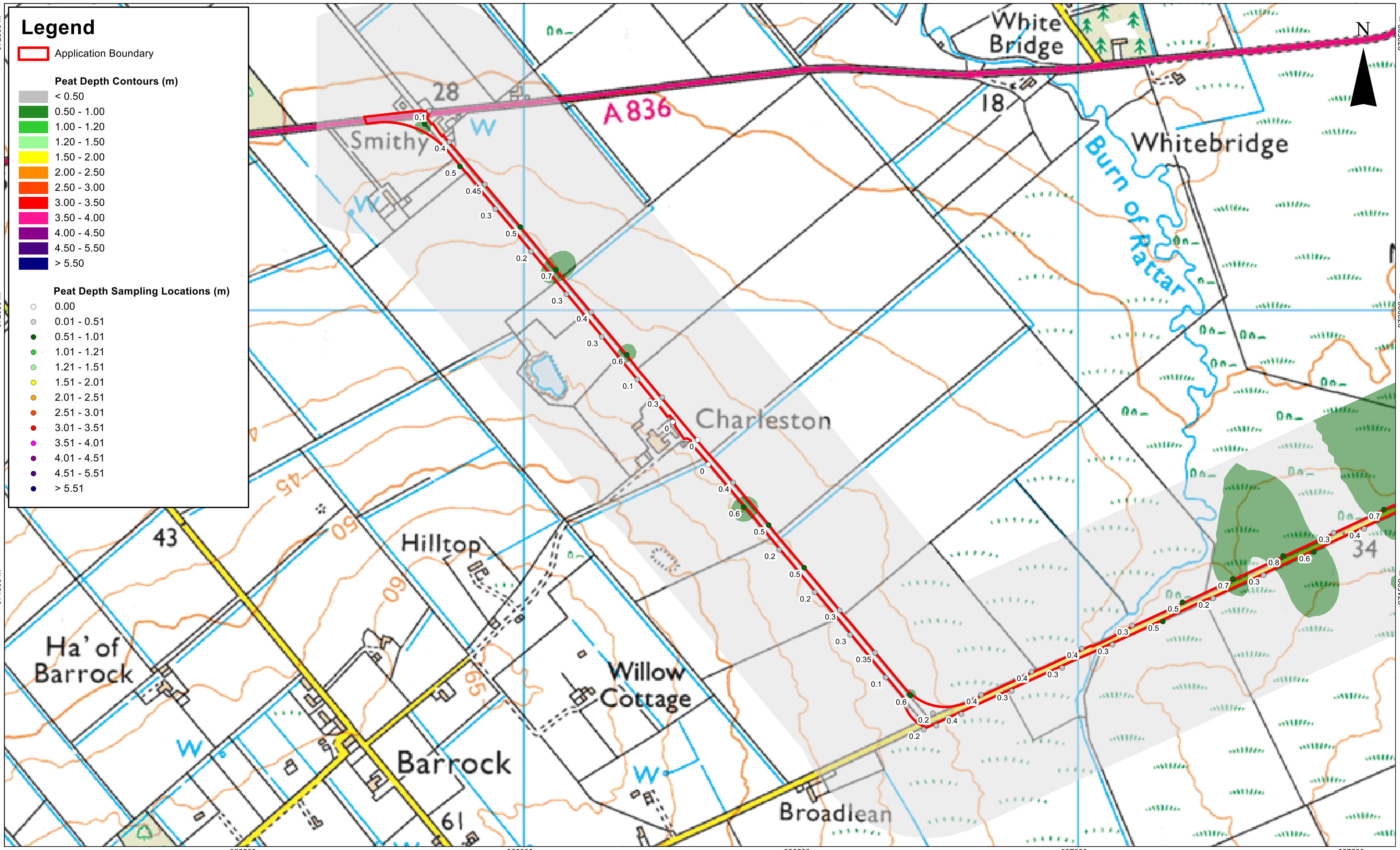
Figure 10.1.6a: Peat Depth Mapping - Overview

Drg No	HMY_Geo_CI	
Rev	E	Datum: OSGB36
Date	10/11/2021	Projection: TM
Figure	10.1.6a	



Rev	Date	By	Comment
E	11/11/2021	CI	Layout change
D	01/11/2021	CI	Infrastructure & boundary update
C	23/08/2021	CI	Infrastructure update

SCOTTISHPOWER RENEWABLES

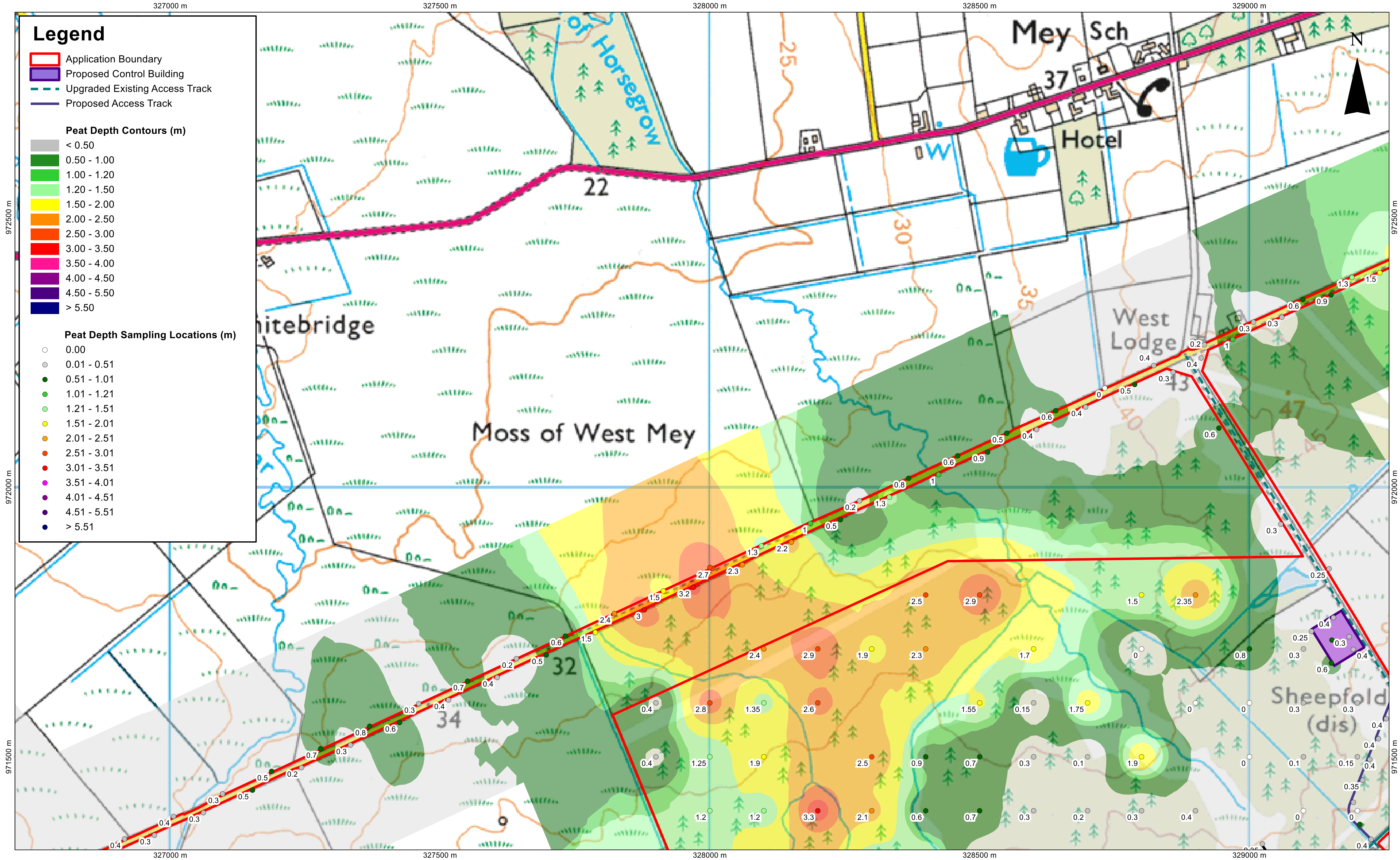
1:6,500 Scale @ A3

0 200 m

Hollandmey Renewable Energy Development

Figure 10.1.6b: Peat Depth Mapping - Access Route W

Drg No	HMY_Peat_CI		
Rev	E	Datum: OSGB36	
Date	11/11/2021	Projection: TM	
Figure	10.1.6b		



Rev	Date	By	Comment
E	11/11/2021	CI	Layout change
D	01/11/2021	CI	Infrastructure & boundary update
C	23/08/2021	CI	Infrastructure update

SCOTTISHPOWER RENEWABLES

1:6,500 Scale @ A3

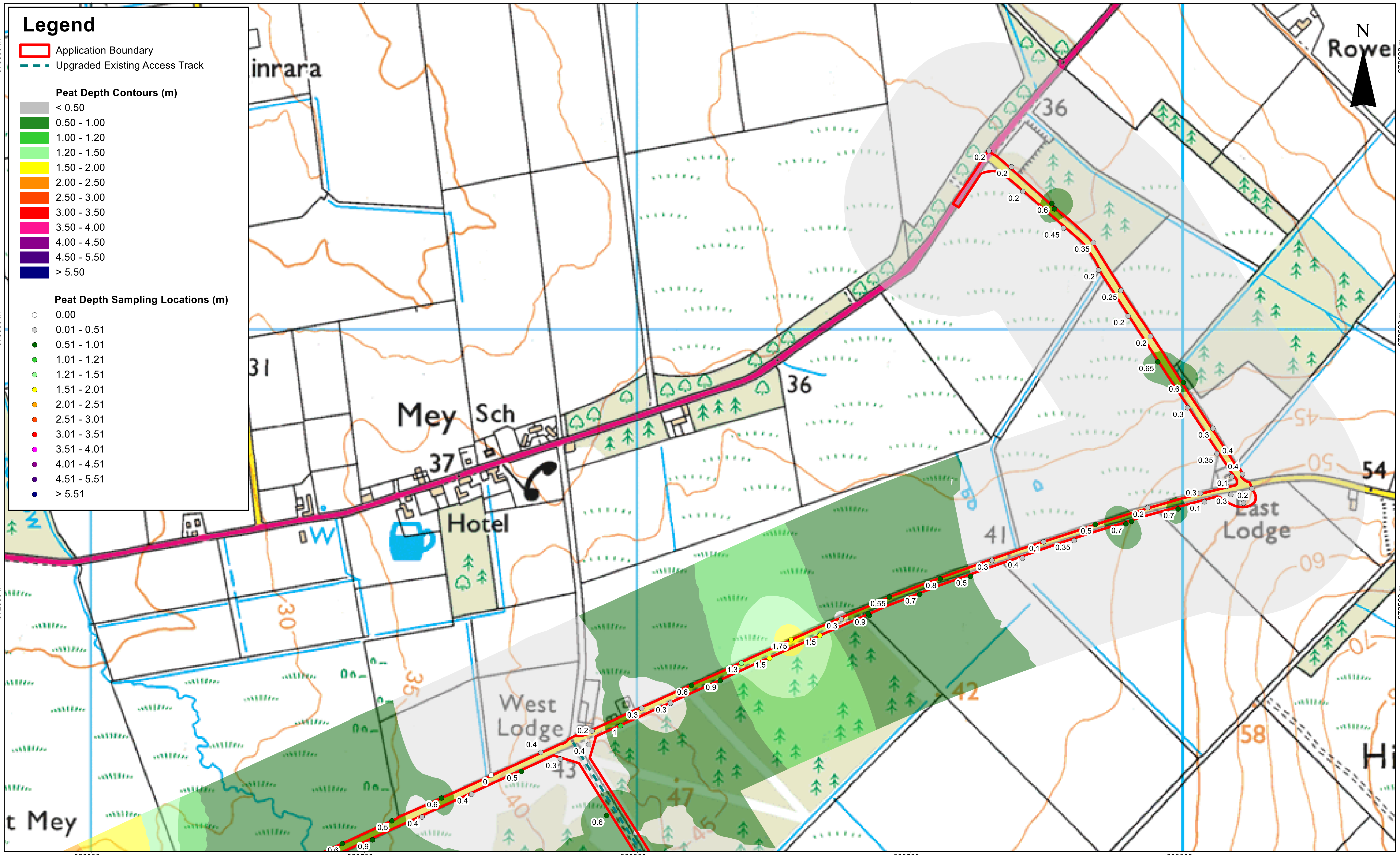
0 200 m

Hollandmey Renewable Energy Development

Figure 10.1.6c: Peat Depth Mapping - Access Route Centre

Drg No	HMY_Peat_CI
Rev	E
Date	11/11/2021
Figure	10.1.6c

Datum: OSGB36
Projection: TM



Rev	Date	By	Comment
E	11/11/2021	CI	Layout change
D	01/11/2021	CI	Infrastructure & boundary update
C	23/08/2021	CI	Infrastructure update

1:6,500
Scale @ A3

0 200 m

SCOTTISHPOWER RENEWABLES

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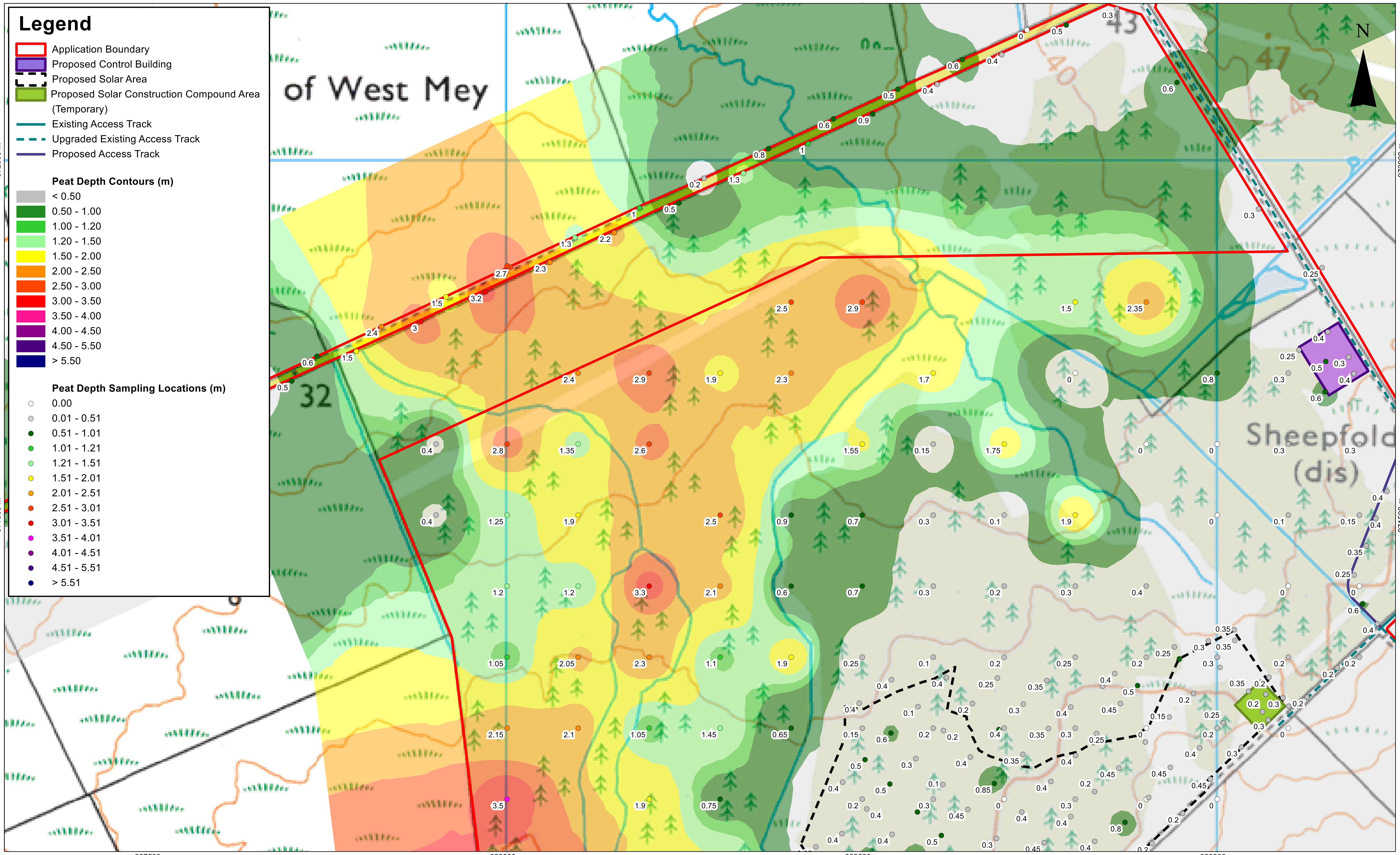
Figure 10.1.6d: Peat Depth Mapping - Access Route E

Drg No	HMY_Peat_CI
Rev	E
Date	11/11/2021
Figure	10.1.6d

Datum: OSGB36
Projection: TM

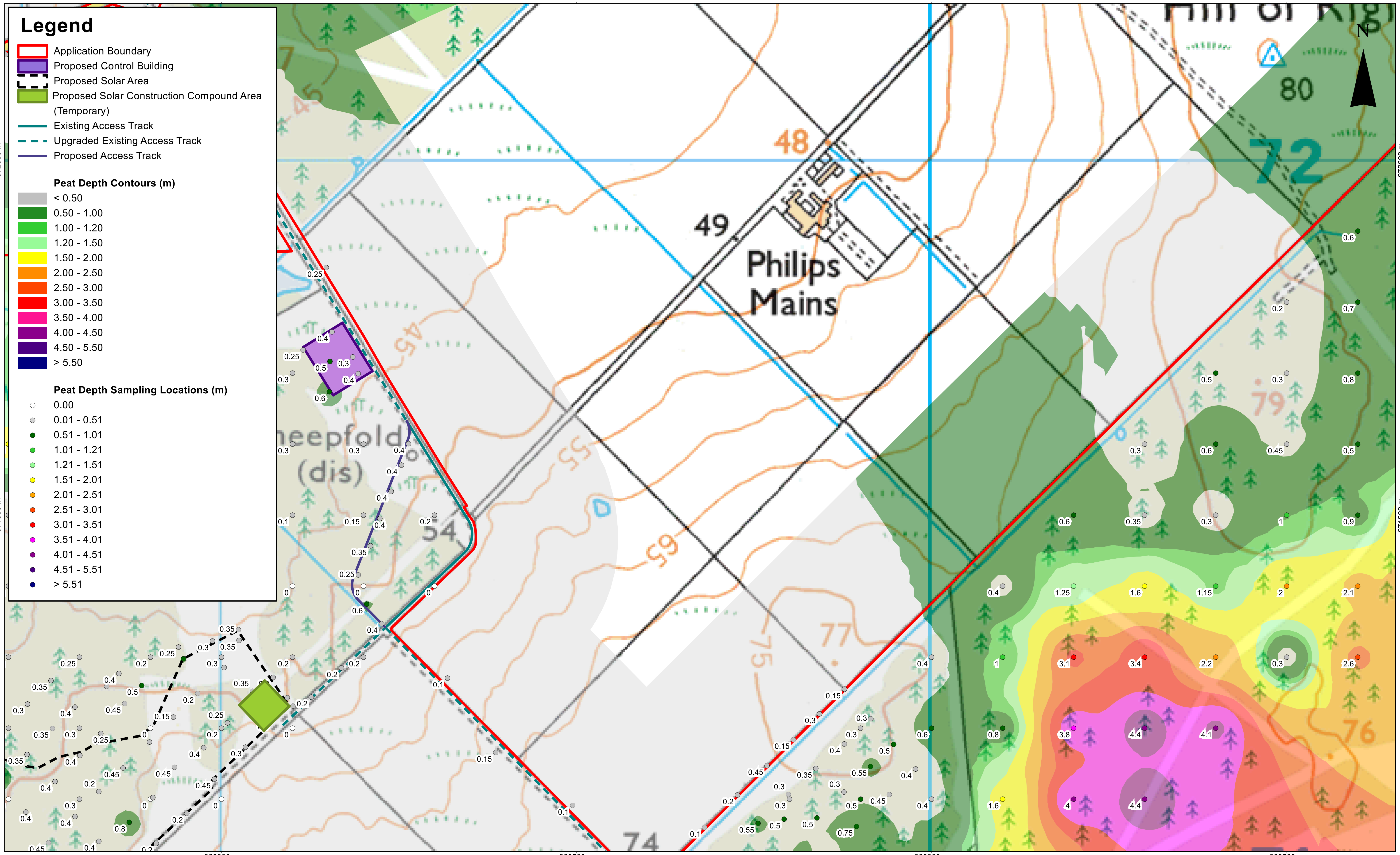


SCOTTISHPOWER RENEWABLES	E	11/11/2021	CI	Layout change	1:5,000 Scale @ A3	0 — 200 m
	D	01/11/2021	CI	Infrastructure & boundary update		
	C	23/08/2021	CI	Infrastructure update	© Crown Copyright 2021. All rights reserved. Ordnance Survey Licence 0100031673.	
	Rev	Date	By	Comment		

Hollandmey Renewable Energy Development

Figure 10.1.6e: Peat Depth Mapping - NW

Drg No	HMY_Peat_CI	
Rev	E	Datum: OSGB36 Projection: TM
Date	11/11/2021	
Figure	10.1.6e	



E	11/11/2021	CI	Layout change
D	01/11/2021	CI	Infrastructure & boundary update
C	23/08/2021	CI	Infrastructure update
Rev	Date	By	Comment

SCOTTISHPOWER RENEWABLES

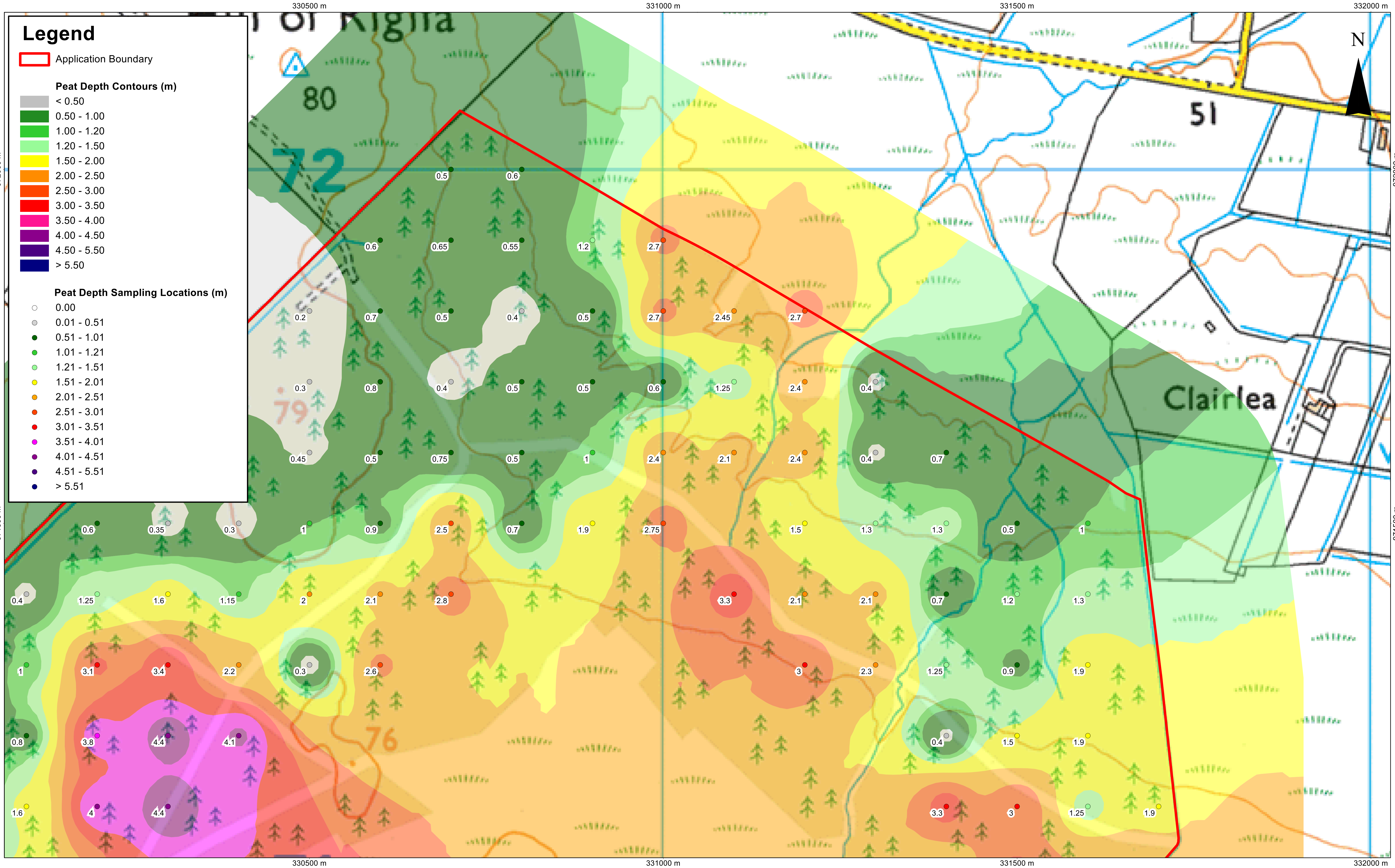
1:5,000 Scale @ A3

0 200 m

Hollandmey Renewable Energy Development

Figure 10.1.6f: Peat Depth Mapping - N

Drg No	HMY_Peat_CI	
Rev	E	Datum: OSGB36 Projection: TM
Date	11/11/2021	
Figure	10.1.6f	



SCOTTISHPOWER RENEWABLES

Rev	Date	By	Comment
E	11/11/2021	CI	Layout change
D	01/11/2021	CI	Infrastructure & boundary update
C	23/08/2021	CI	Infrastructure update

1:5,000
Scale @ A3

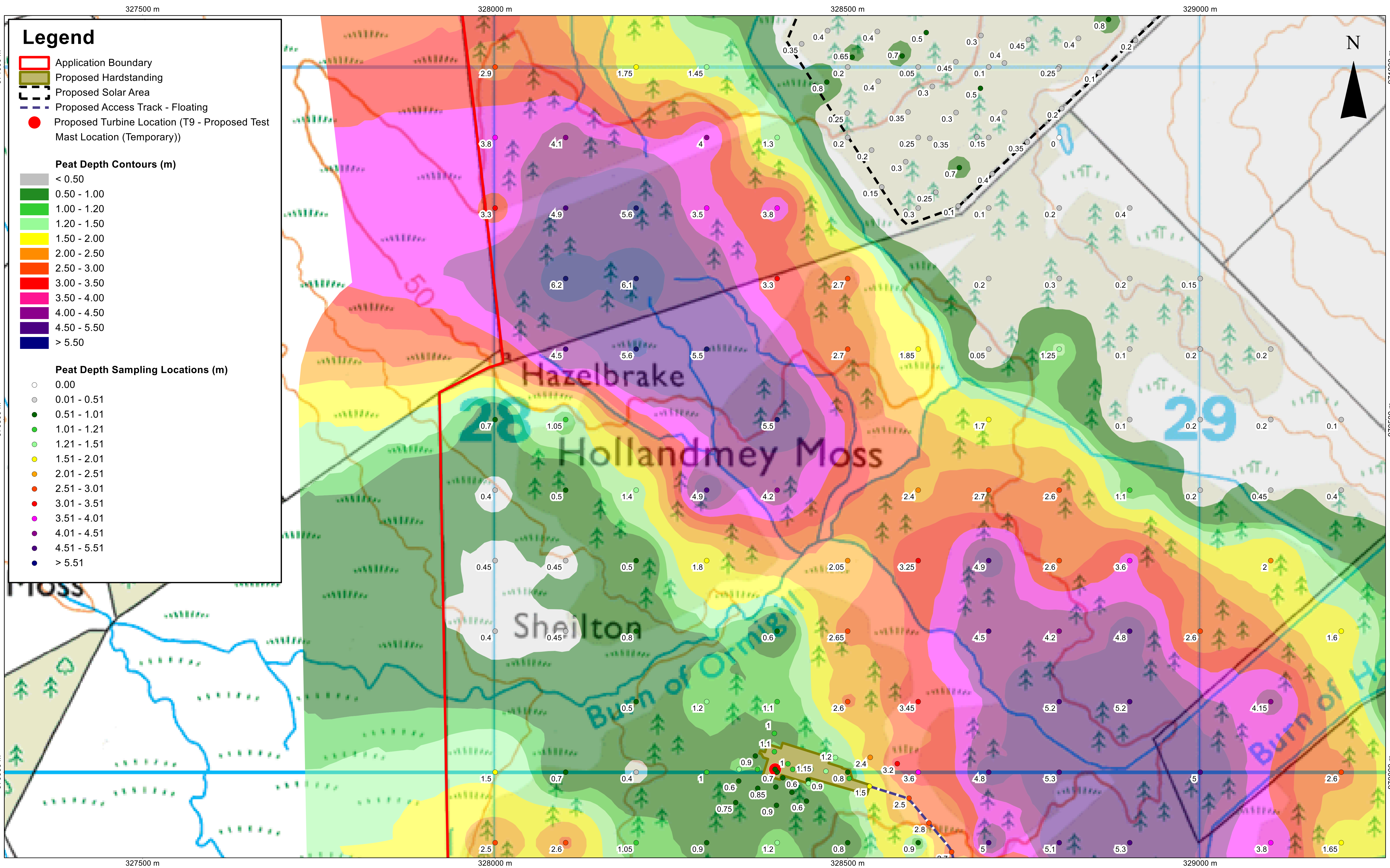
0 — 200 m

Hollandmey Renewable Energy Development

Figure 10.1.6g: Peat Depth Mapping - NE

Drg No	HMY_Peat_CI
Rev	E
Date	11/11/2021
Figure	10.1.6g

Datum: OSGB36
Projection: TM



SCOTTISHPOWER RENEWABLES

Rev	Date	By	Comment
E	11/11/2021	CI	Layout change
D	01/11/2021	CI	Infrastructure & boundary update
C	23/08/2021	CI	Infrastructure update

1:5,000 Scale @ A3

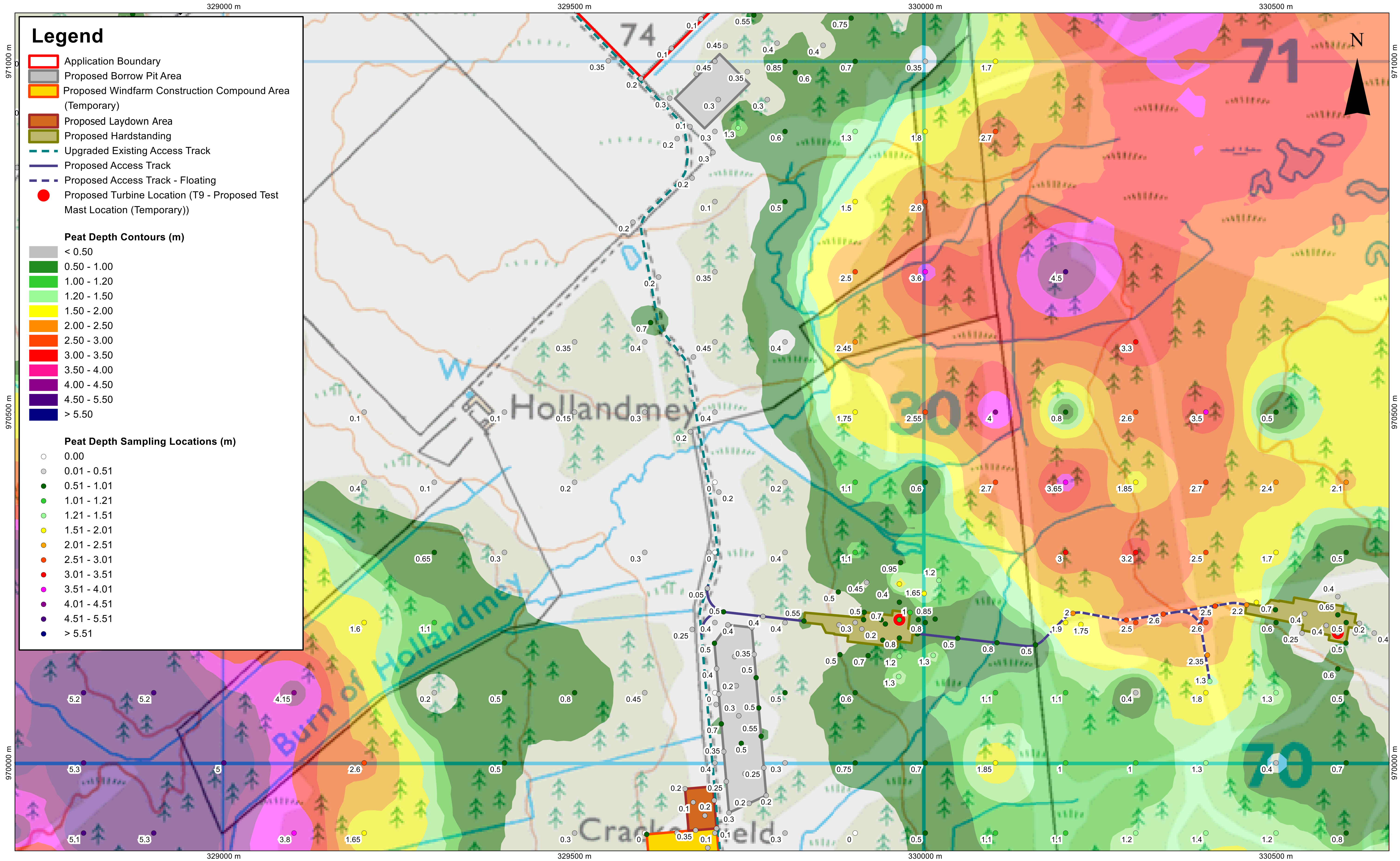
0 200 m

Hollandmey Renewable Energy Development

Figure 10.1.6h: Peat Depth Mapping - NW Centre

Drg No	HMY_Peat_CI
Rev	E
Date	11/11/2021
Figure	10.1.6h

Datum: OSGB36
Projection: TM



E	11/11/2021	CI	Layout change
D	01/11/2021	CI	Infrastructure & boundary update
C	23/08/2021	CI	Infrastructure update
Rev	Date	By	Comment

SCOTTISHPOWER RENEWABLES

1:5,000
Scale @ A3

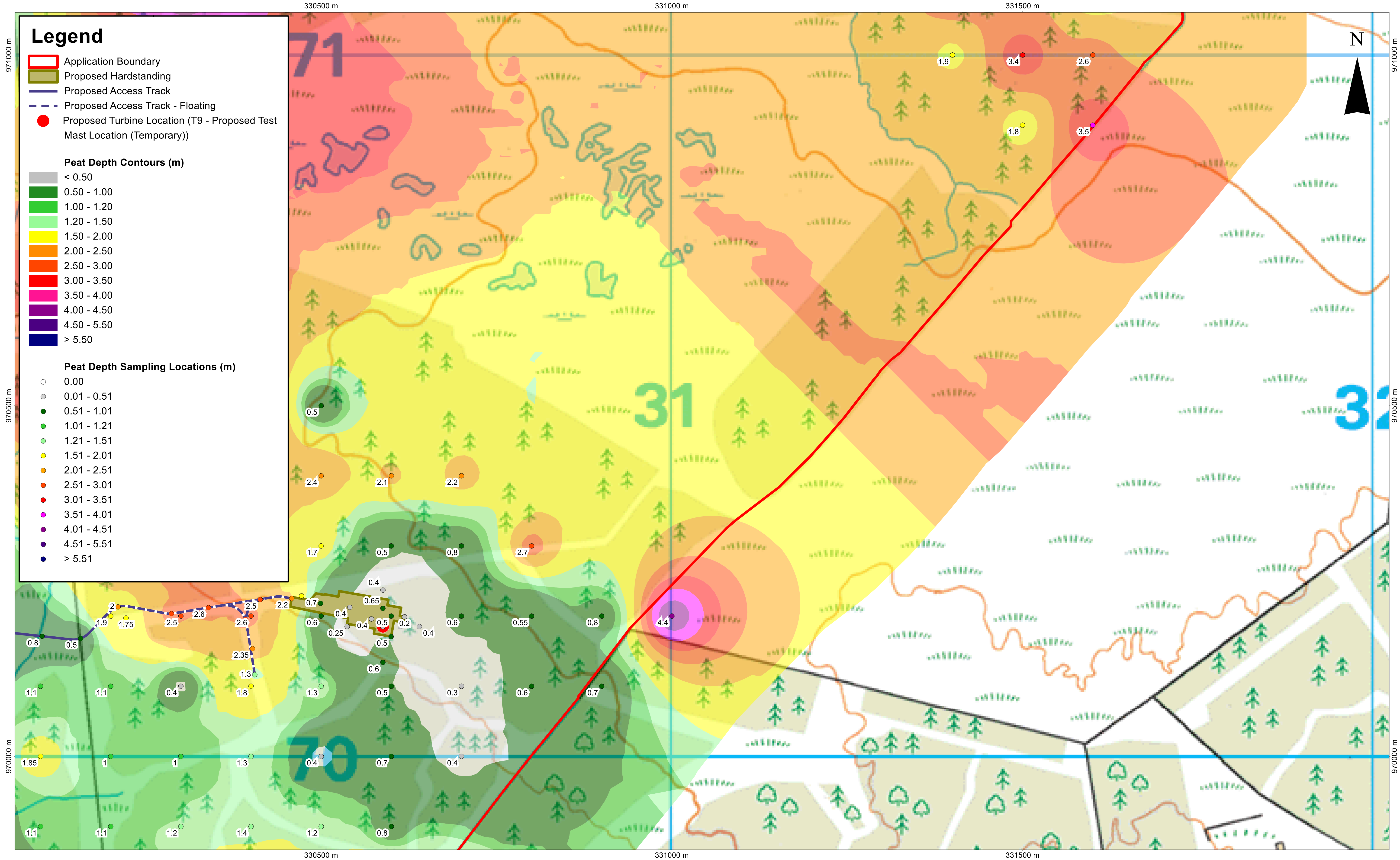
0 200 m

Hollandmey Renewable Energy Development

Figure 10.1.6i: Peat Depth Mapping - N Centre

Drg No	HMY_Peat_CI
Rev	E
Date	11/11/2021
Figure	10.1.6i

Datum: OSGB36
Projection: TM



Rev	Date	By	Comment
E	12/11/2021	CI	Layout change
D	01/11/2021	CI	Infrastructure & boundary update
C	23/08/2021	CI	Infrastructure update

SCOTTISHPOWER RENEWABLES

1:5,000
Scale @ A3

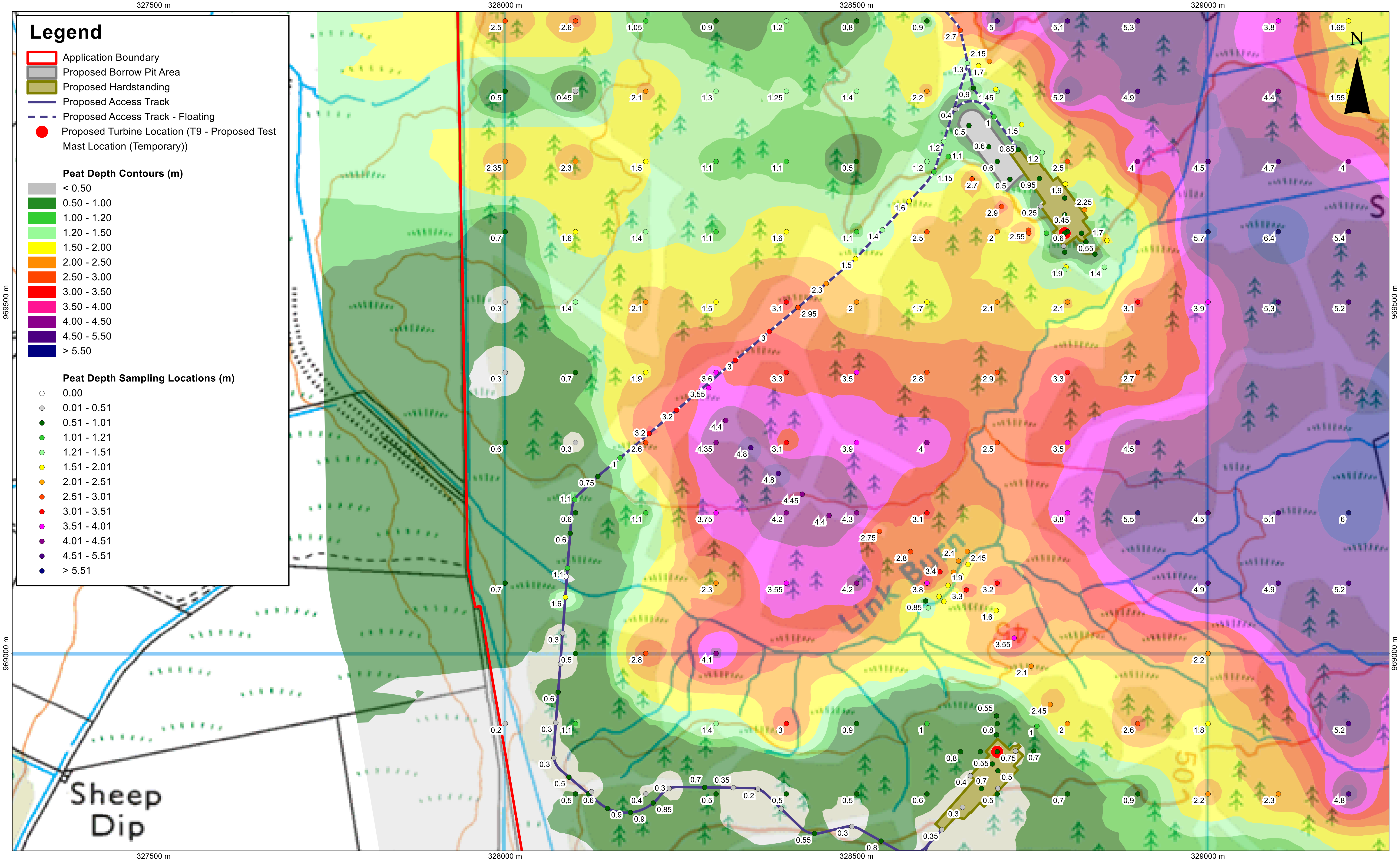
0 200 m

Hollandmey Renewable Energy Development

Figure 10.1.6j: Peat Depth Mapping - N

Drg No	HMY_Peat_CI
Rev	E
Date	12/11/2021
Figure	10.1.6j

Datum: OSGB36
Projection: TM



Rev	Date	By	Comment
E	12/11/2021	CI	Layout change
D	01/11/2021	CI	Infrastructure & boundary update
C	23/08/2021	CI	Infrastructure update

SCOTTISHPOWER RENEWABLES

1:5,000
Scale @ A3

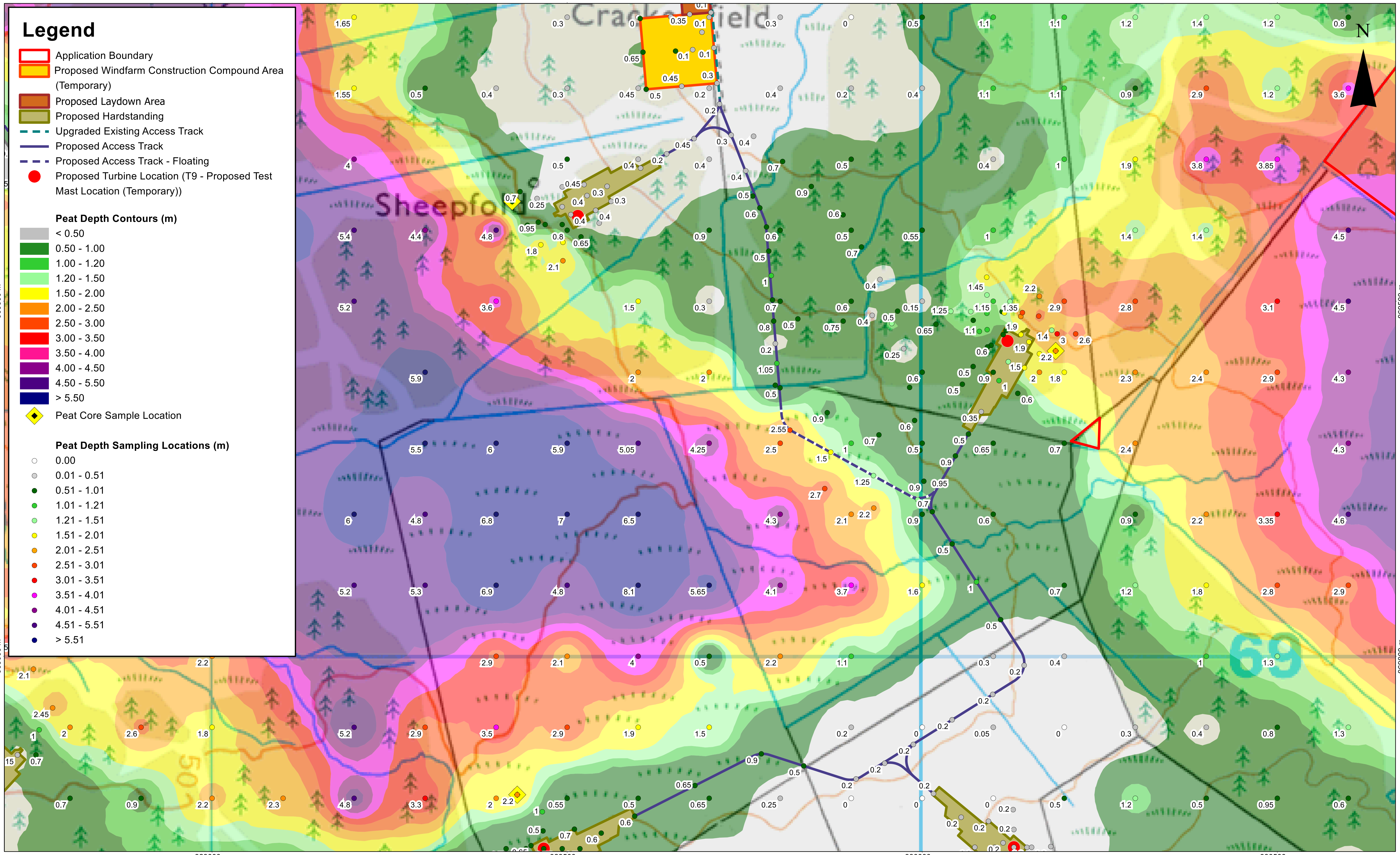
0 200 m

Hollandmey Renewable Energy Development

Figure 10.1.6k: Peat Depth Mapping - SW Centre

Drg No	HMY_Peat_CI
Rev	E
Date	12/11/2021
Figure	10.1.6k

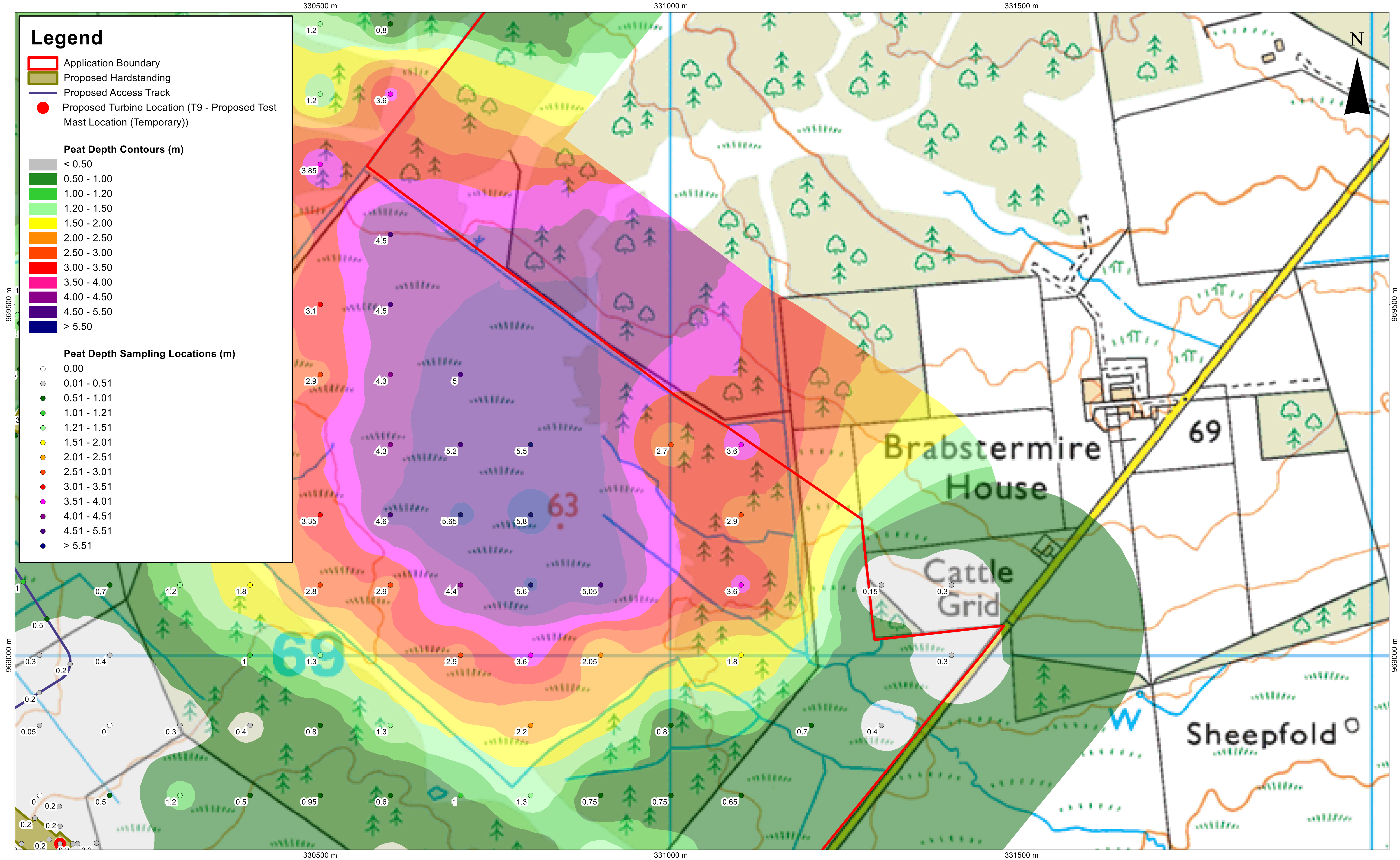
Datum: OSGB36
Projection: TM



E	12/11/2021	CI	Layout change	1:5,000 Scale @ A3	0 200 m	Hollandmey Renewable Energy Development
D	01/11/2021	CI	Infrastructure & boundary update			Figure 10.1.6l: Peat Depth Mapping - S Centre
C	23/08/2021	CI	Infrastructure update			
Rev	Date	By	Comment			

SCOTTISHPOWER RENEWABLES

Drg No	HMY_Peat_CI	
Rev	E	Datum: OSGB36
Date	12/11/2021	Projection: TM
Figure	10.1.6l	



Rev	Date	By	Comment
E	12/11/2021	CI	Layout change
D	01/11/2021	CI	Infrastructure & boundary update
C	23/08/2021	CI	Infrastructure update

SCOTTISHPOWER RENEWABLES

1:5,000 Scale @ A3

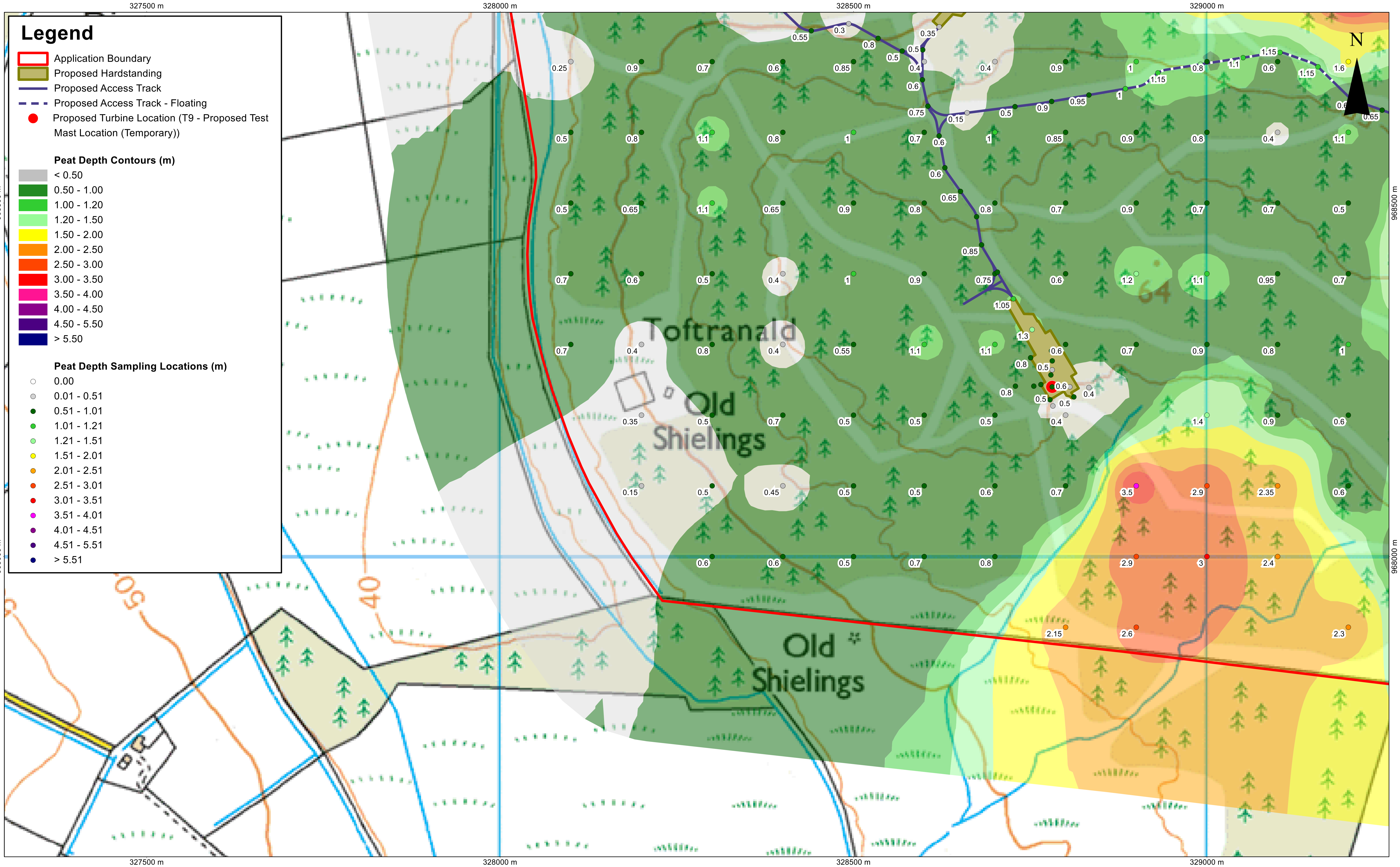
0 200 m

Hollandmey Renewable Energy Development

Figure 10.1.6m: Peat Depth Mapping - SE Centre

Drg No	HMY_Peat_CI
Rev	E
Date	12/11/2021
Figure	10.1.6m

Datum: OSGB36
Projection: TM



Rev	Date	By	Comment
E	12/11/2021	CI	Layout change
D	01/11/2021	CI	Infrastructure & boundary update
C	23/08/2021	CI	Infrastructure update

SCOTTISHPOWER RENEWABLES

1:5,000 Scale @ A3

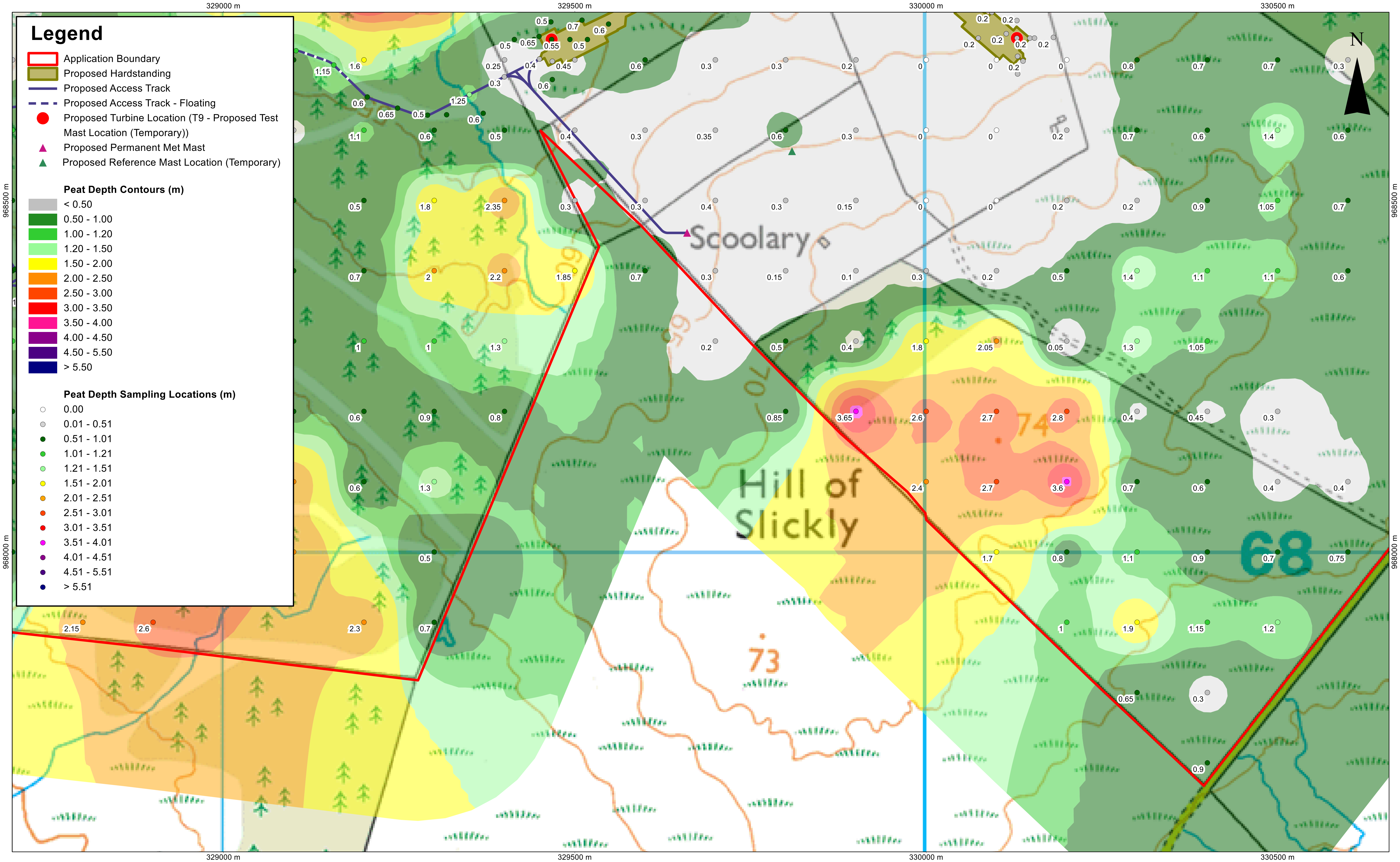
0 200 m

Hollandmey Renewable Energy Development

Figure 10.1.6n: Peat Depth Mapping - SW

Drg No	HMY_Peat_CI
Rev	E
Date	12/11/2021
Figure	10.1.6n

Datum: OSGB36
Projection: TM



SCOTTISHPOWER RENEWABLES

Rev	Date	By	Comment
E	12/11/2021	CI	Layout change
D	01/11/2021	CI	Infrastructure & boundary update
C	23/08/2021	CI	Infrastructure update

1:5,000
Scale @ A3

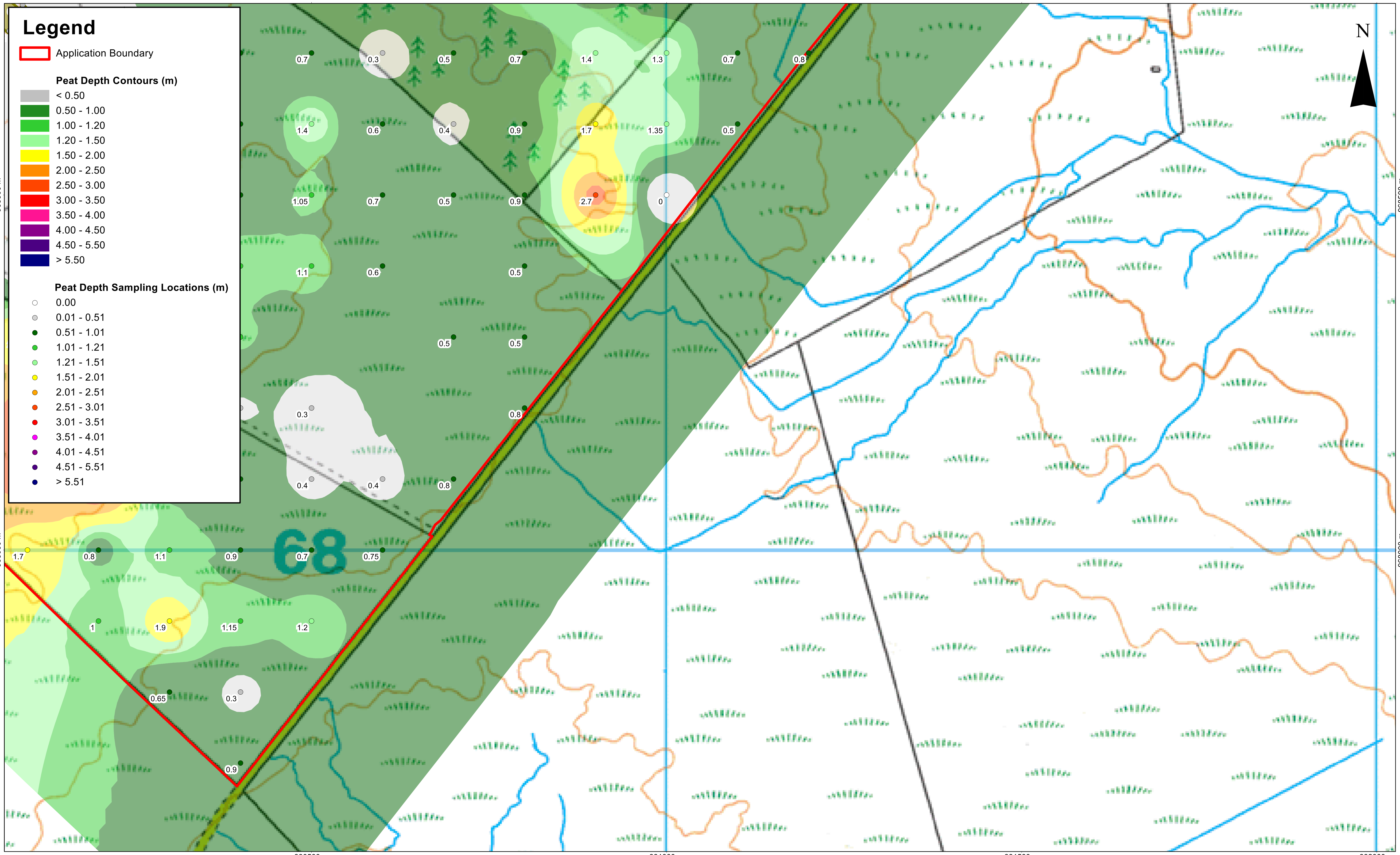
0 200 m

Hollandmey Renewable Energy Development

Figure 10.1.6o: Peat Depth Mapping - S

Drg No	HMY_Peat_CI
Rev	E
Date	12/11/2021
Figure	10.1.6o

Datum: OSGB36
Projection: TM



SCOTTISHPOWER RENEWABLES

Rev	Date	By	Comment
E	12/11/2021	CI	Layout change
D	01/11/2021	CI	Infrastructure & boundary update
C	23/08/2021	CI	Infrastructure update

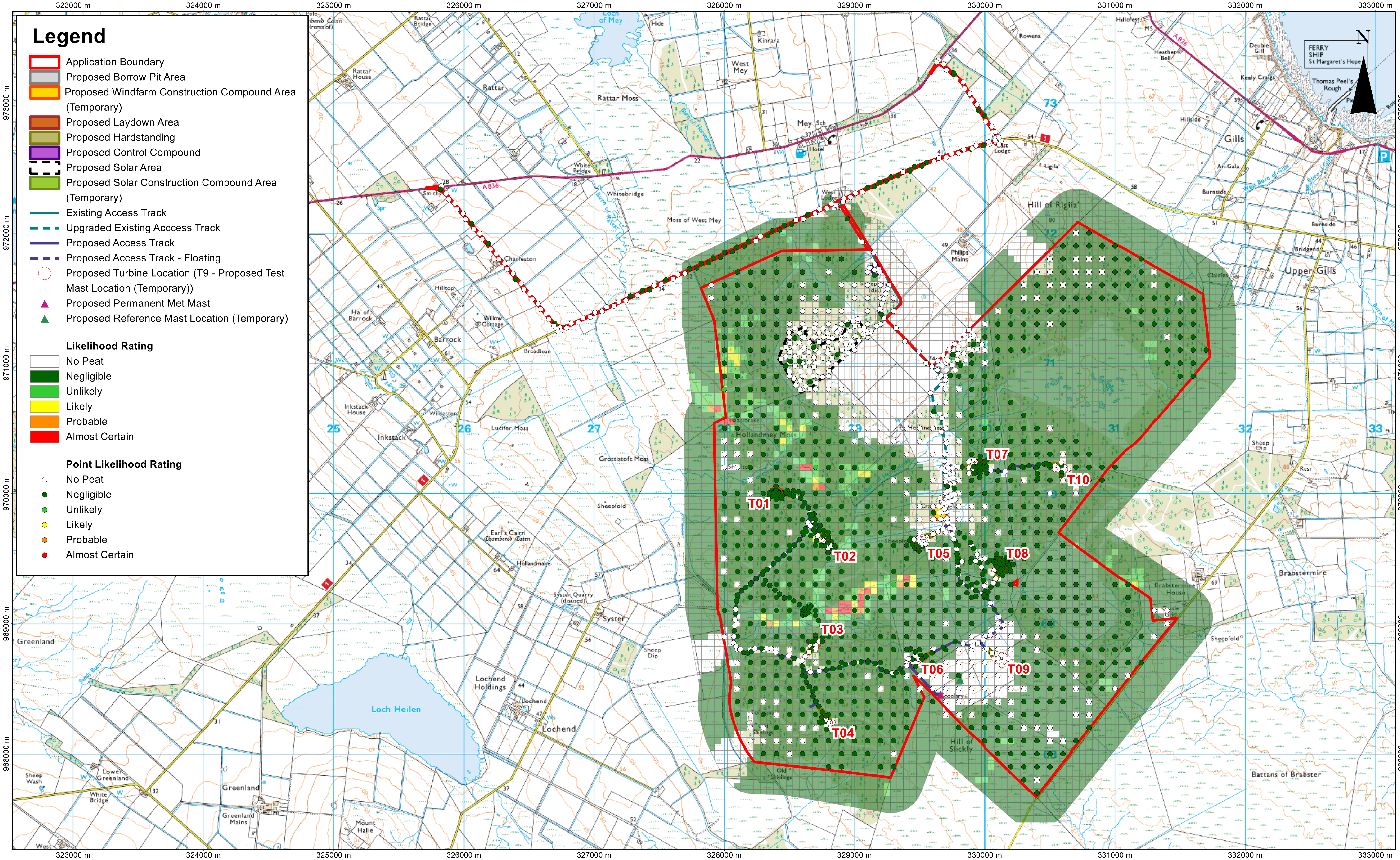
1:5,000
Scale @ A3

0 200 m

Hollandmey Renewable Energy Development

Figure 10.1.6p: Peat Depth Mapping - SE

Drg No	HMY_Peat_CI	
Rev	E	Datum: OSGB36 Projection: TM
Date	12/11/2021	
Figure	10.1.6p	



Rev	Date	By	Comment
E	15/11/2021	CI	Layout change
D	01/11/2021	CI	Infrastructure & boundary update
C	23/08/2021	CI	Infrastructure update

SCOTTISHPOWER RENEWABLES

1:27,500 Scale @ A3

0 1 km

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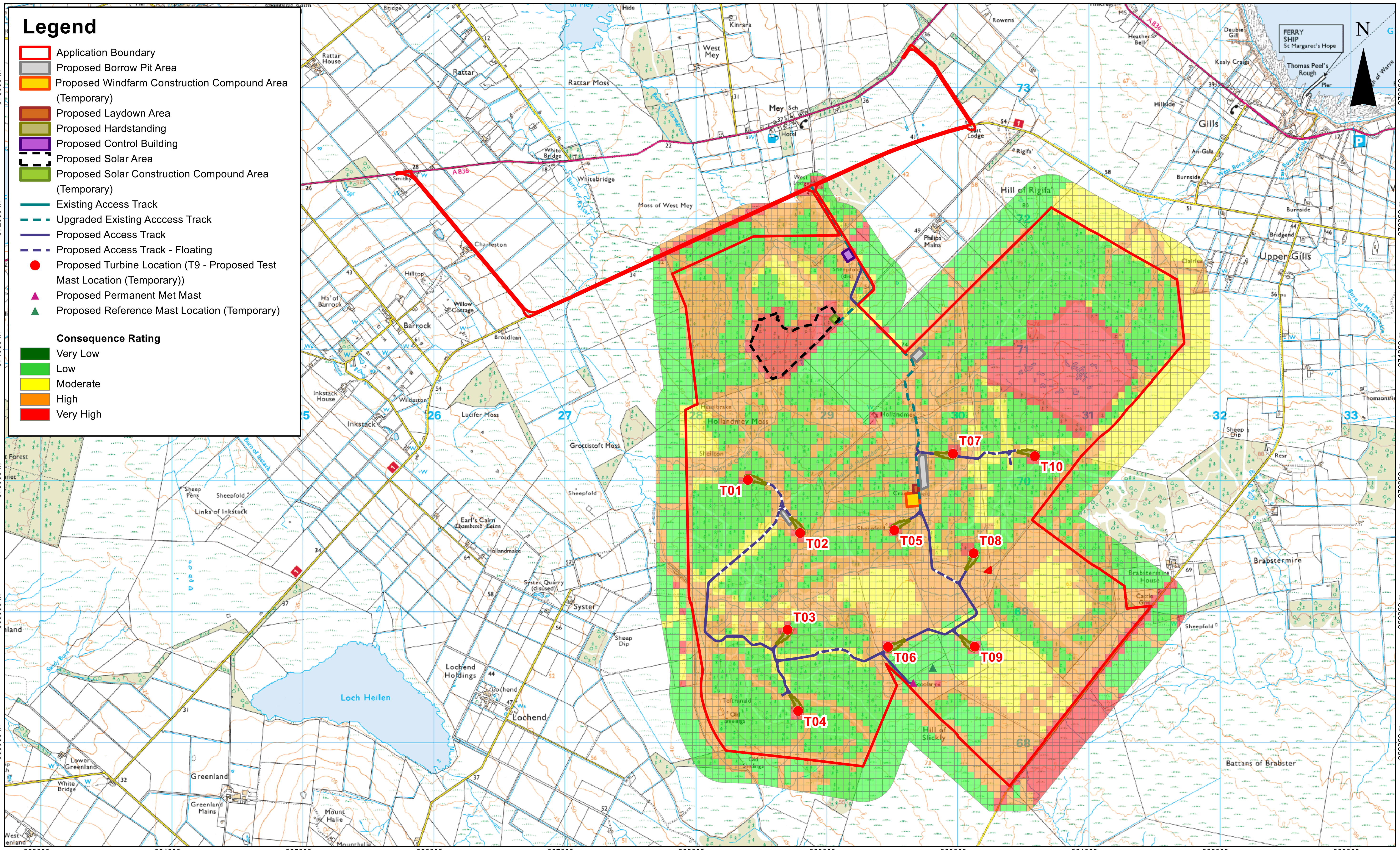
Figure 10.1.7: Likelihood Rating

Drg No	HMY_Peat_CI		
Rev	E	Datum: OSGB36	
Date	15/11/2021	Projection: TM	
Figure	10.1.7		



E	15/11/2021	CI	Layout change
D	01/11/2021	CI	Infrastructure & boundary update
C	23/08/2021	CI	Infrastructure update
Rev	Date	By	Comment

SCOTTISHPOWER RENEWABLES

1:27,500 Scale @ A3

0 1 km

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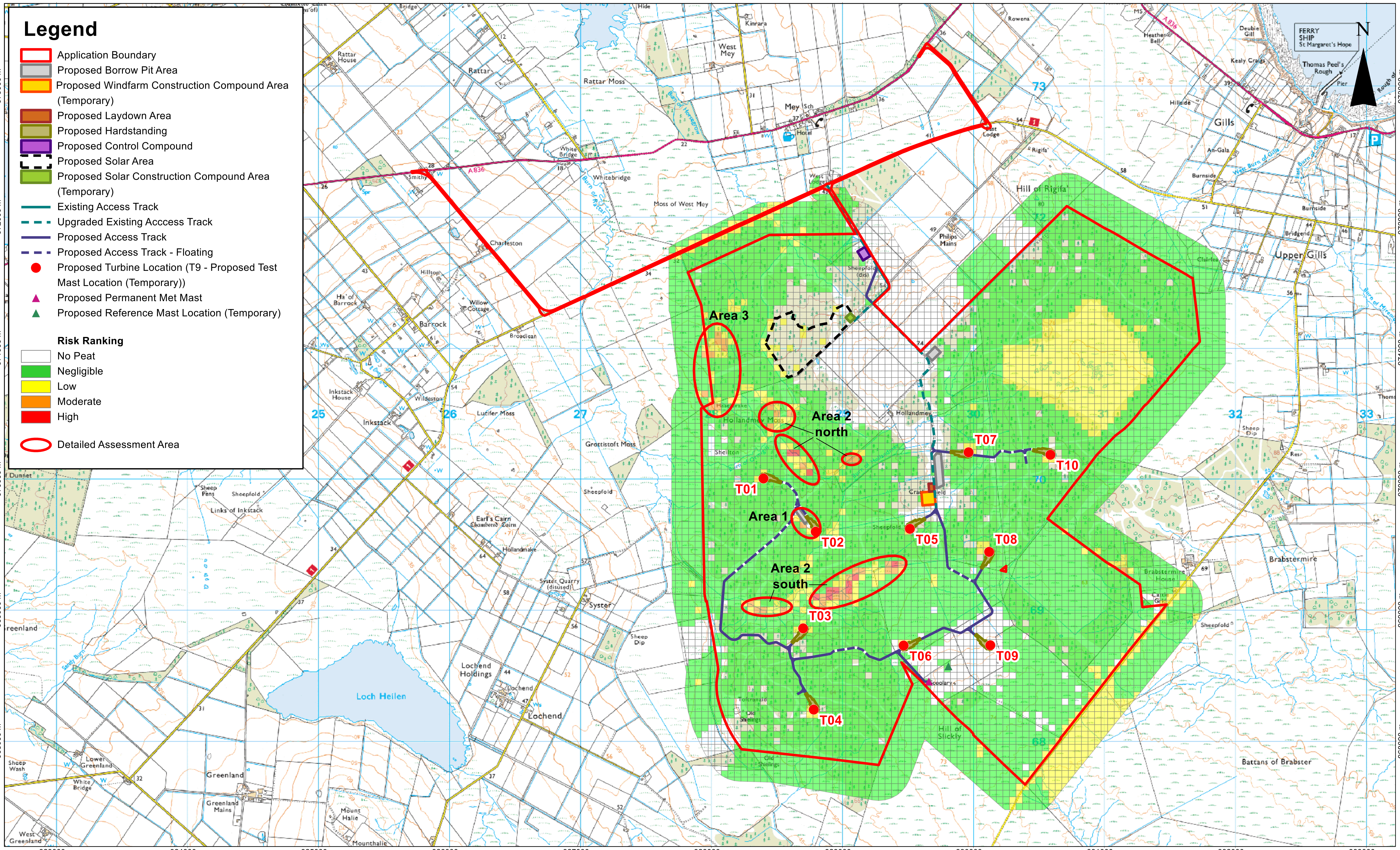
Figure 10.1.8: Consequence Rating

Drg No	HMY_Peat_CI	
Rev	E	Datum: OSGB36
Date	15/11/2021	Projection: TM
Figure	10.1.8	



E	15/11/2021	CI	Layout change
D	01/11/2021	CI	Infrastructure & boundary update
C	23/08/2021	CI	Infrastructure update
Rev	Date	By	Comment

SCOTTISHPOWER RENEWABLES

1:27,500 Scale @ A3

0 1 km

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Figure 10.1.9: Risk Ranking

Drg No	HMY_Peat_CI	
Rev	E	Datum: OSGB36
Date	15/11/2021	Projection: TM
Figure	10.1.9: F	