8. LAND SOILS AND GEOLOGY

8.1 Introduction

8.1.1 Background and Objectives

Hydro-Environmental Services (HES) was engaged by MKO to carry out an assessment of the potential impacts of the proposed wind farm development at Derrinlough and adjacent townlands, Co. Offaly on the soil and geological environment.

This report provides a baseline assessment of the environmental setting of the proposed development, as described in Chapter 4, in terms of land, soils and geology and discusses the potential likely significant effects that the construction, operation and decommissioning of the proposed development will have. Where required, appropriate mitigation measures to avoid any identified significant effects to land, soils and geology are recommended and the residual effects of the proposed development post-mitigation are assessed.

8.1.2 Statement of Authority

Hydro-Environmental Services (HES) are a specialist hydrological, hydrogeological and environmental practice which delivers a range of water and environmental management consultancy services to the private and public sectors across Ireland and Northern Ireland. HES was established in 2005, and our office is located in Dungarvan, County Waterford.

Our core areas of expertise and experience includes soils, subsoils and geology. We routinely complete impact assessments for land, soils and geology, hydrology and hydrogeology for a large variety of project types including wind farms and renewable energy projects.

This chapter of the EIAR was prepared by Michael Gill and Adam Keegan.

Michael Gill (BA, BAI, Dip Geol., MSc, MIEI) is an Environmental Engineer and Hydrogeologist with over 18 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms and renewable projects in Ireland. In addition, he has substantial experience in surface water drainage design and SUDs design and surface water/groundwater interactions. For example, Michael has worked on the EIS for Oweninny WF, Cloncreen WF, and Yellow River WF, and over 100 other wind farm related projects across the country.

Adam Keegan is a hydrogeologist with two years of experience in the environmental sector in Ireland. Adam has been involved in Environmental Impact Assessment Reports (EIARs) for numerous projects including wind farms, grid connections, quarries and small housing developments. Adam holds an MSc in Hydrogeology and Water Resource Management. Adam has worked on several wind farm EIAR projects, including Croagh WF, Lyrenacarriga WF (SID), Cleanrath WF, Carrownagowan WF (SID), and Fossy WF.

8.1.3 Relevant Guidance

The land, soils and geology chapter of this EIAR was prepared having regard, where relevant, to the legislation and guidance outlined in Chapter 1: Introduction and the following documents:

- Institute of Geologists Ireland (2013): Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements;
- National Roads Authority (2005): Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;

8.2 Assessment Methodology

8.2.1 Desk Study

A desk study of the site and the surrounding area was completed in advance of undertaking the walkover survey and site investigation. This involved collecting all relevant geological data for the site and surrounding area. This included consultation with the following data sources:

- Bord na Móna databases on peat depth and drainage;
- Environmental Protection Agency database (www.epa.ie);
- Geological Survey of Ireland - Groundwater and Geology Databases (www.gsi.ie);
- Geological Survey of Ireland – Geological Heritage site mapping (www.gsi.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 15 (Geology of Galway-Offaly). Geological Survey of Ireland (GSI, 2003);
- Geological Survey of Ireland – 1:25,000 Field Mapping Sheets; and,
- General Soil Map of Ireland 2nd edition (www.epa.ie).

8.2.2 Baseline Monitoring and Site Investigations

A walkover survey, including detailed drainage mapping and baseline monitoring/sampling, was undertaken by HES between the 5th and 9th April 2019, and again between 9th and 11th September 2019. HES staff have undertaken ~60 man-hours of site work. Geotechnical ground investigations and a peat stability assessment were also undertaken by Fehily Timoney & Company (FT) during 2019. The combined geological dataset collated by HES and FT has been used in the preparation of this EIAR Chapter.

In summary, site investigations to address the land, soils and geology chapter of the EIAR included the following:

- A total of 319 no. peat probe depths/investigations points were carried out by FT and HES to determine the depth and geomorphology of the cutover peat at the proposed site;
- GPR (ground penetrating radar) peat depth geophysical surveying from 2015;
- Trial pitting by FT across the site at 69 no. locations;
- A geotechnical and peat stability assessment report by FT (Feb, 2020a);
- A peat and spoil management plan by FT (Feb, 2020b);
- A total of 41 no. gouge core sample points were undertaken by HES across the site to investigate peat and mineral soil lithology;
- Logging of subsoil exposures across the site where mineral soils and peat profiles are exposed; and,
- Mineral subsoils and peat were logged according to BS: 5930 and Von Post Scale respectively.

The Geotechnical and Peat Stability Assessment Report prepared by FT is included as Appendix 8.1 of this EIAR.

8.2.3 Impact Assessment Methodology

Using information from the desk study and data from the site investigations, an assessment of the importance of the soil and geological environment within the study area and proposed site is assessed using the criteria set out in Table 8.1 (NRA, 2005).

Table 8.1 Estimation of Importance of Soil and Geology Criteria (NRA, 2008).

Importance	Criteria	Typical Example
Very High	Attribute has a high quality, significance or value on a regional or national scale. Degree or extent of soil contamination is significant on a national or regional scale. Volume of peat and/or soft organic soil underlying route is significant on a national or regional scale.	Geological feature rare on a regional or national scale (NHA). Large existing quarry or pit. Proven economically extractable mineral resource
High	Attribute has a high quality, significance or value on a local scale. Degree or extent of soil contamination is significant on a local scale. Volume of peat and/or soft organic soil underlying site is significant on a local scale.	Contaminated soil on site with previous heavy industrial usage. Large recent landfill site for mixed wastes Geological feature of high value on a local scale (County Geological Site). Well drained and/or highly fertility soils. Moderately sized existing quarry or pit Marginally economic extractable mineral resource.
Medium	Attribute has a medium quality, significance or value on a local scale. Degree or extent of soil contamination is moderate on a local scale. Volume of peat and/or soft organic soil underlying site is moderate on a local scale.	Contaminated soil on site with previous light industrial usage. Small recent landfill site for mixed Wastes. Moderately drained and/or moderate fertility soils. Small existing quarry or pit. Sub-economic extractable mineral Resource.
Low	Attribute has a low quality, significance or value on a local scale. Degree or extent of soil contamination is minor on a local scale. Volume of peat and/or soft organic soil underlying site is small on a local scale.	Large historical and/or recent site for construction and demolition wastes. Small historical and/or recent landfill site for construction and demolition wastes. Poorly drained and/or low fertility soils. Uneconomically extractable mineral Resource.

The guideline criteria (EPA, 2017) for the assessment of likely significant effects require that likely effects are described with respect to their extent, magnitude, type (i.e. negative, positive or neutral) probability, duration, frequency, reversibility, and transfrontier nature (if applicable). The descriptors used in this environmental impact assessment report are those set out in the EPA (2017) Glossary of effects as shown in Chapter 1 of this EIAR. In addition, the two impact characteristics proximity and probability are described for each impact and these are defined in Table 8.2.

In order to provide an understanding of this descriptive system in terms of the geological/hydrological environment, elements of this system of description of effects are related to examples of potential likely significant effects on the geology and morphology of the existing environment, as listed in Table 8.3.

Table 8.2: Additional Impact Characteristics.

Impact Characteristic	Degree/ Nature	Description
Proximity	Direct	An impact which occurs within the area of the proposed project, as a direct result of the proposed project.
	Indirect	An impact which is caused by the interaction of effects, or by off-site developments.
Probability	Low	A low likelihood of occurrence of the impact.
	Medium	A medium likelihood of occurrence of the impact.
	High	A high likelihood of occurrence of the impact.

Table 8.3: Impact descriptors related to the receiving environment.

Impact Characteristics		Potential Hydrological Impacts
Quality	Significance	
Negative only	Profound	Widespread permanent impact on: › The extent or morphology of a cSAC. › Regionally important aquifers. › Extents of floodplains. Mitigation measures are unlikely to remove such impacts.
Positive or Negative	Significant	Local or widespread time-dependent impacts on: › The extent or morphology of a cSAC / ecologically important area. › A regionally important hydrogeological feature (or widespread effects to minor hydrogeological features). › Extent of floodplains. Widespread permanent impacts on the extent or morphology of an NHA/ecologically important area. Mitigation measures (to design) will reduce but not completely remove the impact – residual impacts will occur.
Positive or Negative	Moderate	Local time-dependent impacts on: › The extent or morphology of a cSAC / NHA / ecologically important area. › A minor hydrogeological feature.

Impact Characteristics		Potential Hydrological Impacts
Quality	Significance	
		› Extent of floodplains. Mitigation measures can mitigate the impact OR residual impacts occur, but these are consistent with existing or emerging trends
Positive, Negative or Neutral	Slight	Local perceptible time-dependent impacts not requiring mitigation.
Neutral	Imperceptible	No impacts, or impacts which are beneath levels of perception, within normal bounds of variation, or within the bounds of measurement or forecasting error.

8.3 Existing Environment

8.3.1 Site Description and Topography

The Derrinlough Wind Farm site ("the site") which is a Bord na Móna peat bog is a combination of two bogs, Clongawny to the west and Drinagh to the east, split by the N62 which runs north-south. The site is located approximately 2km to the south of the village of Cloghan and 7km north-east of Birr in County Offaly. The total site area is approximately 2,360ha (23.6km^2).

The Bord na Móna Derrinlough Peat Briquette factory is located between the two bogs, along the N62 on the eastern side of the road. This plant processes the peat from a number of bogs in the midlands into briquettes and consists of the factory and a number of ancillary buildings. A site compound (known as Clongawny Tea Centre) relating to the currently ceased peat harvesting works exists close to the main site entrance on the western bog site (Clongawny). The vast majority of the overall site comprises drained cutover raised bog. A number of industrial railway lines intersect the site that service the adjacent bogs and the briquette factory.

The topography of the development site is relatively flat with an elevation range of between approximately 53 and 62mOD (metres above Ordnance Datum). Along the majority of the site boundaries, a ~1-2m high peat headland exists which is a remnant of the original bog. These headlands and in some areas remnant peat banks create a boundary berm, forming a basin effect within the extraction areas of the overall bogs. There are some areas of higher ground at the centre and southwest of Clongawny bog and these are covered with conifer forestry.

The surface of Clongawny bog is drained by a network of northeast / southwest orientated drains that are typically spaced every 15 to 20m. Larger arterial drains run northwest-southeast which connect the smaller field drains. On the western Clongawny bog, these drains typically slope gently towards perimeter settlement ponds and surface water outfalls. Surface water outflows from Clongawny bog are located at the north and north-eastern edges, and also at the south and southwestern boundaries of the site. All bar the northern outfall are drained by gravity.

The surface of Drinagh bog is drained by a network of north / south orientated drains that are typically spaced every 15 to 20m. Larger arterial drains also run north-south and these connect the smaller field drains. Surface water outflows from Drinagh bog are located at the northwest and southeast. Both outfalls are drained by gravity.

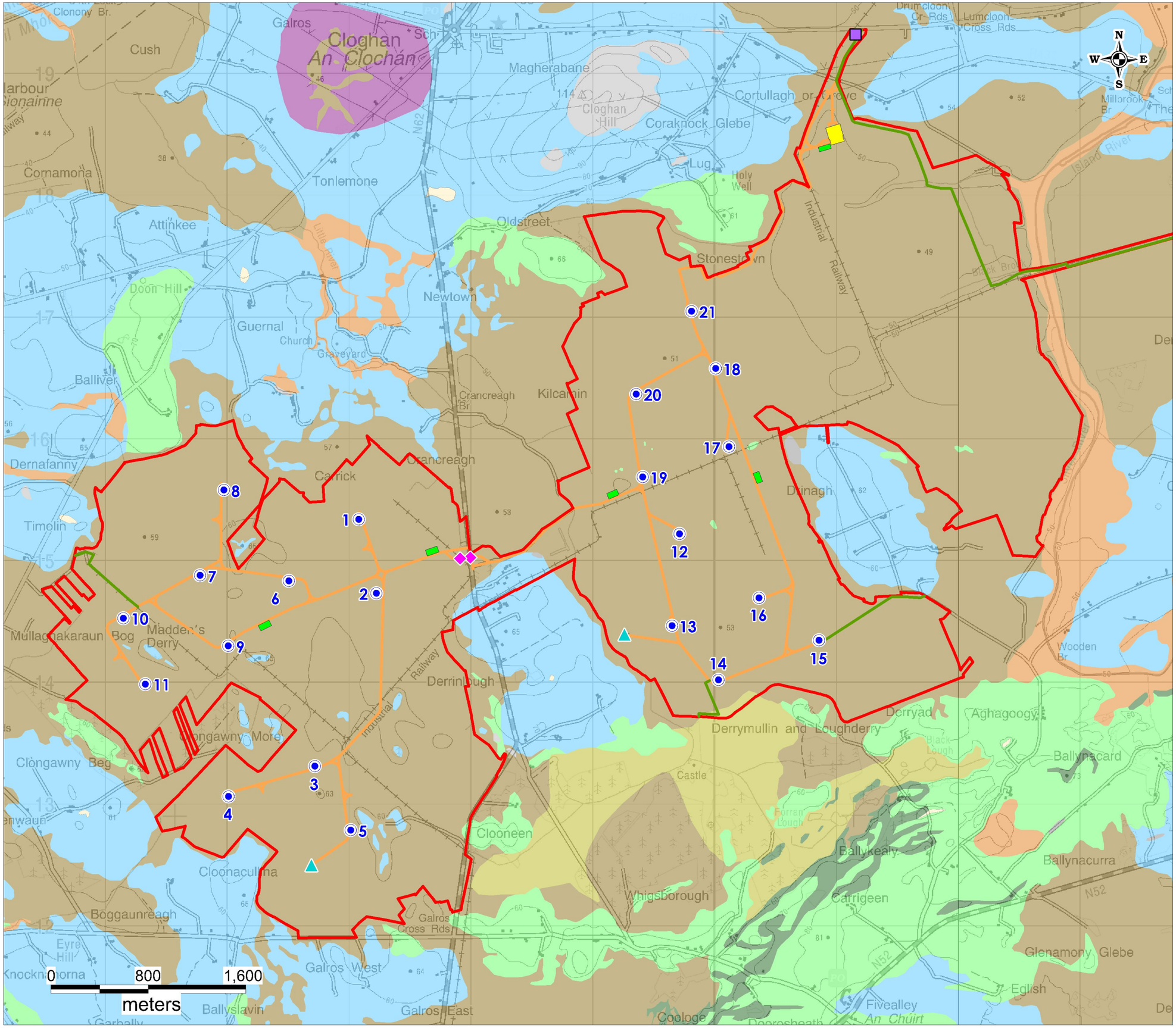
8.3.2 Peat/Soils and Subsoils

The published soils map (www.epa.ie) for the area shows that cutaway raised bog is exclusively mapped in the proposed development site. Other soil types mapped in the wider area outside of the site include Glacial Tills derived from Limestone (TLs), which are mapped predominantly north of the site, but exist as small pockets to the east, south and west. Gravels derived from Limestone (GLs) are also mapped north of the site, ~1km south of Cloghan Hill and near Doon Hill. Fen Peat is mapped south of the site, near Orran Lough, while Alluvium is mapped along the banks of the Silver River which flows along the eastern boundary of the site. A map of the local subsoil cover is attached as Figure 8.1 and again this shows the site to be entirely covered by cutover peat.

In order to investigate the peat and mineral subsoil lithology at the proposed turbine locations, a series of gouge core samples were taken at the turbine locations and also across the site at various proposed infrastructure locations. Shown on Table 8.4 below is a summary of the mineral subsoil lithology at the proposed development locations. The location of the gouge core investigation points and all peat depth data are shown on Figure 8.2.

Gouge core sampling undertaken at the proposed development locations typically encountered well-drained, black/brown, firm pseudo-fibrous or fibrous peat that was sometimes amorphous. Peat depth intervals recorded at the site (including all FT data) are shown on the histogram presented as Figure 8.3. Peat depths across the Clongawny bog area have a larger depth interval spread than across the Drinagh Bog area. The average recorded peat depth across Clongawny bog is (μ) 1.39m (with standard deviation σ = 1.12m). The average recorded peat depth across Drinagh bog is (μ) 0.7m (σ = 0.60m).

Peat depths at the proposed substation location vary between 0.3 and 1.1m, and underlying subsoil is logged as soft to firm grey sandy clay.



Legend

- EIAR Site Boundary
- Proposed Turbine Location
- Proposed Met Mast Location
- Proposed 110kV Electricity Substation Compound
- Proposed Temporary Construction Compound
- Proposed Amenity Link
- Proposed New Site Roads
- Proposed Visitor Car Park (Operational Phase)
- Proposed Underpass Locations
- Alluvium
- Eskers comprised of gravels of basic reaction
- Cut over raised peat
- Fen Peat
- Gravels derived from Limestones
- Kartsified bedrock outcrop or subcrop
- Lacustrine sediments
- Lake marl
- Bedrock outcrop or subcrop
- Till derived from limestones

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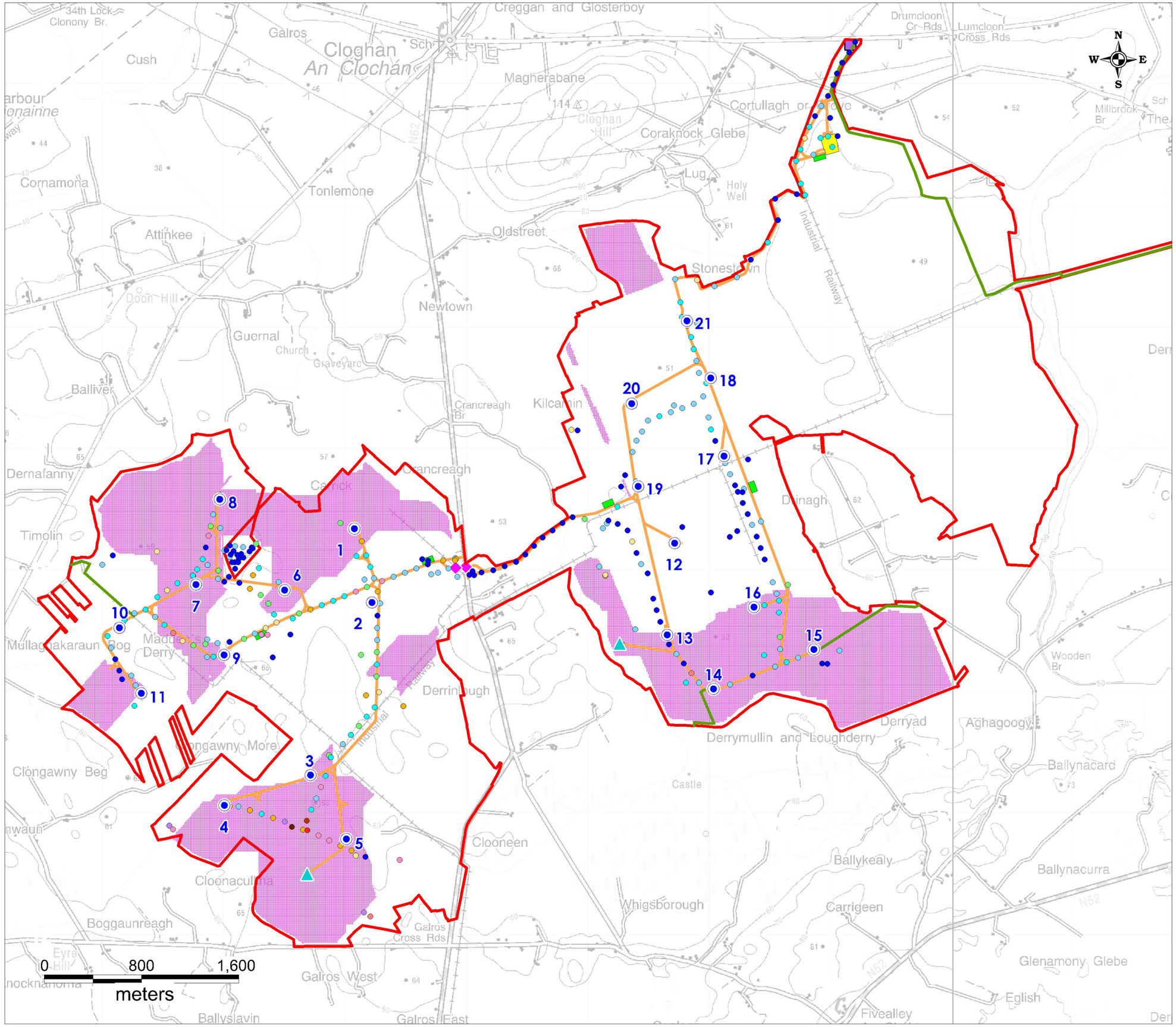
Client: Bord na Mona Powergen Ltd	
Job: Derrinlough, Co. Offaly	
Title: Local Subsoils Map	
Figure No: 8.1	
Drawing No: P1463-0-0220-A3-801-00A	
Sheet Size: A3	Project No: P1463-0
Scale: 1:30,000	Drawn By: GD
Date: 07/02/2020	Checked By: MG



Legend

- EIAR Site Boundary
- Proposed Turbine Location
- Proposed Met Mast Location
- Proposed 110kV Electricity Substation Compound
- Proposed Temporary Construction Compound
- Proposed Amenity Link
- Proposed New Site Roads
- Proposed Visitor Car Park (Operational Phase)
- Proposed Underpass Locations
- Lidar Inferred Peat Depth Location (65,483 no.)

Peat Depth Legend

- 0 - 0.5m
- 0.5 - 1.0m
- 1 - 1.5m
- 1.5 - 2.0m
- 2.0 - 2.5m
- 2.5 - 3.0m
- 3.0 - 3.5m
- 3.5 - 4.0m
- 4.0 - 4.5m
- 4.5 - 5.0m
- 5.0 - 5.5m
- 6.0 - 6.5m

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Client: Bord na Mona Powergen Ltd

Job: Derrinlough, Co. Offaly

Title: Peat Depth Map

Figure No: 8.2

Drawing No: P1463-0-0220-A3-802-00A

Sheet Size: A3	Project No: P1463-0
Scale: 1:30,000	Drawn By: GD
Date: 07/02/2020	Checked By: MG

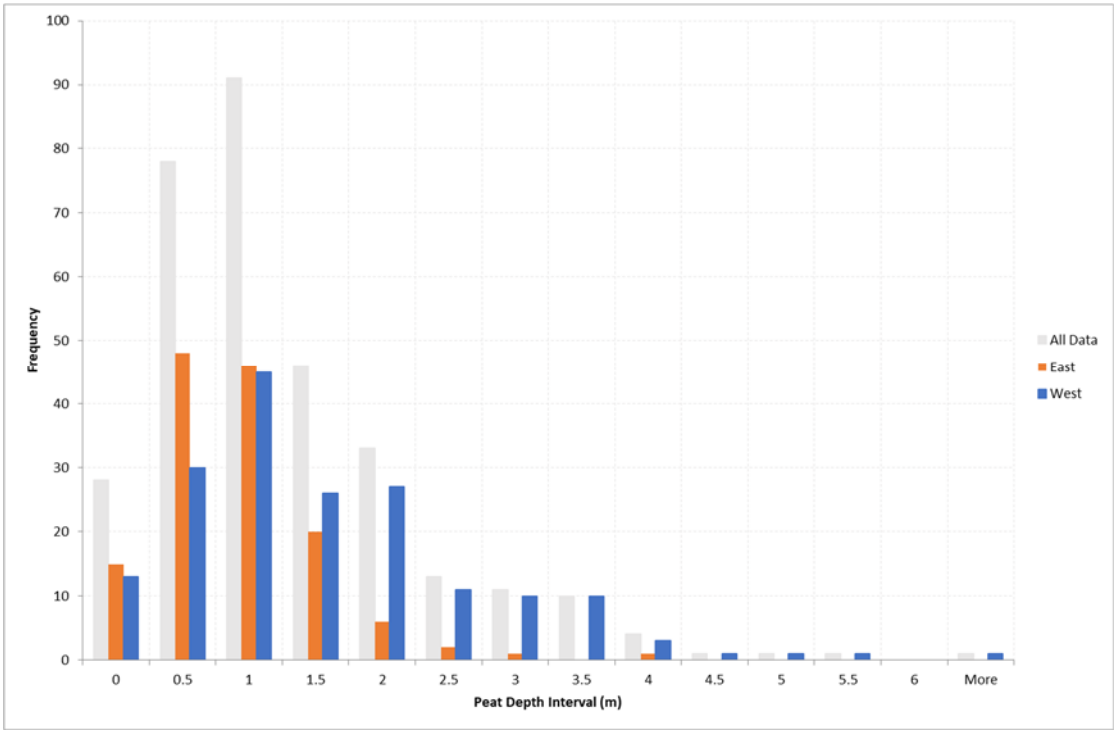
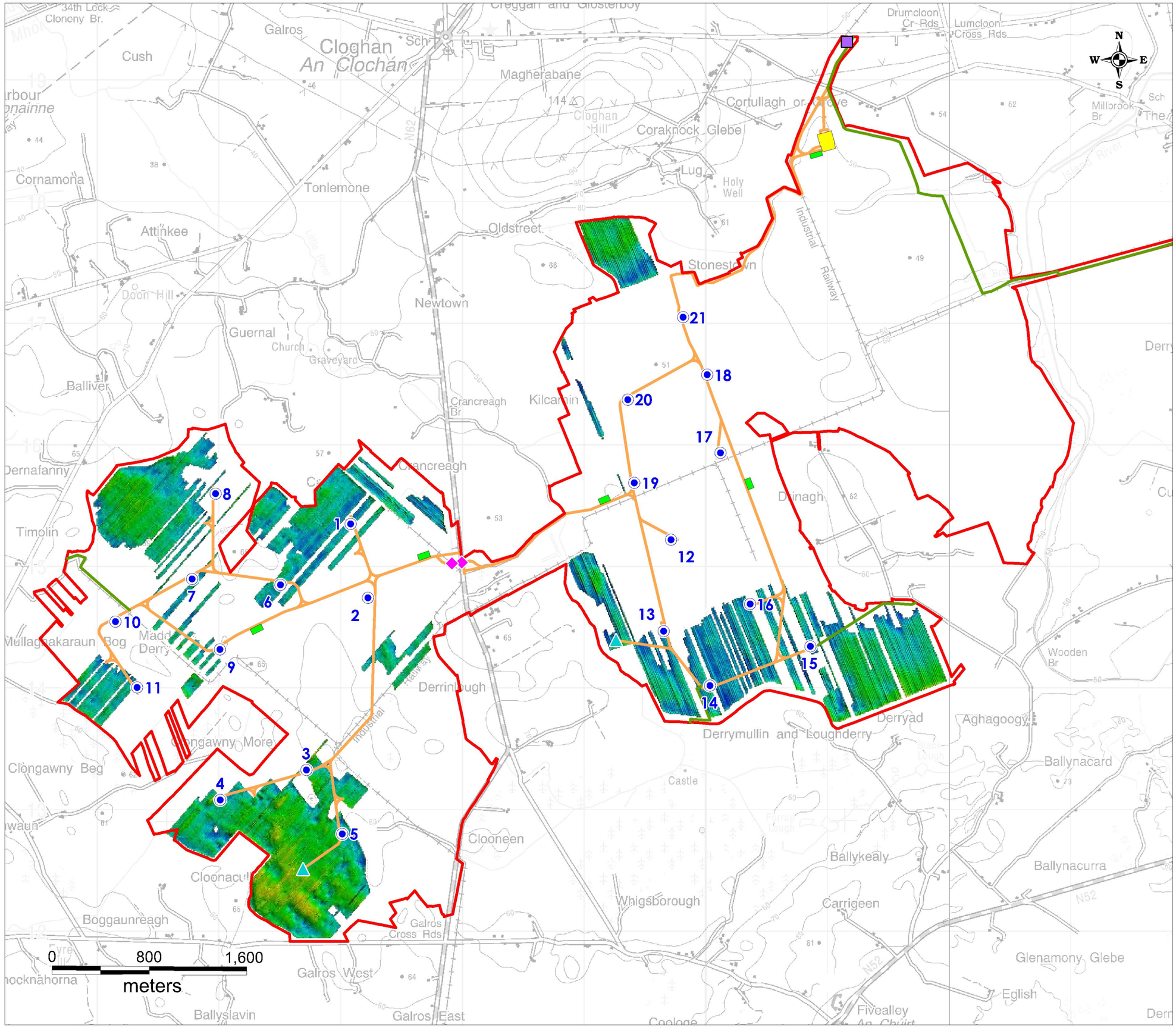


Figure 8.3: Peat depth frequency distribution plot

In addition to these hand recorded peat depths, Bord na Móna have also undertaken GPR (ground penetrating radar geophysical survey) surveys in 2015 to determine peat depths in both Clongawny and Drinagh Bogs. Grid data was extracted from these data at 5 x 5 m intervals, and a histogram of resulting data (228,219 data points) is presented as Figure 8.4. The survey areas and recorded peat depth intervals are shown on Figure 8.5. The average recorded peat depth in these areas is (μ) 1.7m (σ = 1.01m). There is a bias towards slightly deeper peat areas in these GPR survey areas as these areas were being targeted for further peat extraction, and they are also largely around the perimeter of the bogs which includes the headlands that would not have had as much peat removed historically.



Legend

- EIAR Site Boundary
- Proposed Turbine Location
- Proposed Met Mast Location
- Proposed 110kV Electricity Substation Compound
- Proposed Temporary Construction Compound
- Proposed Amenity Link
- Proposed New Site Roads
- Proposed Visitor Car Park (Operational Phase)
- Proposed Underpass Locations

Peat Depth GPR Legend

7.0m
6.0m
5.0m
4.0m
3.0m
2.0m
1.0m
0.0m
-0.8m

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Client: Bord na Mona Powergen Ltd

Job: Derrinlough, Co. Offaly

Title: Peat Depth GPR survey area Map

Figure No: 8.4

Drawing No: P1463-0-0220-A3-804-00A

Sheet Size: A3	Project No: P1463-0
Scale: 1:30,000	Drawn By: GD
Date: 07/02/2020	Checked By: MG

Trial pits were also completed at each of the 21 no. proposed turbine location points. Trial Pit locations are shown on Figure 8.6.

The mineral subsoil underlying the peat at the proposed turbine locations typically comprised shell marl, lacustrine deposits and glacial tills. Where the shell marl and lacustrine deposits are present, they overlie the glacial tills. The lacustrine deposits comprised soft, grey laminated clays and silts.

A summary of average peat depths and subsoils geology (from trial pit data) for the 21 no. proposed turbine locations, the substation location, and the underground cable route are included within Table 8.4.

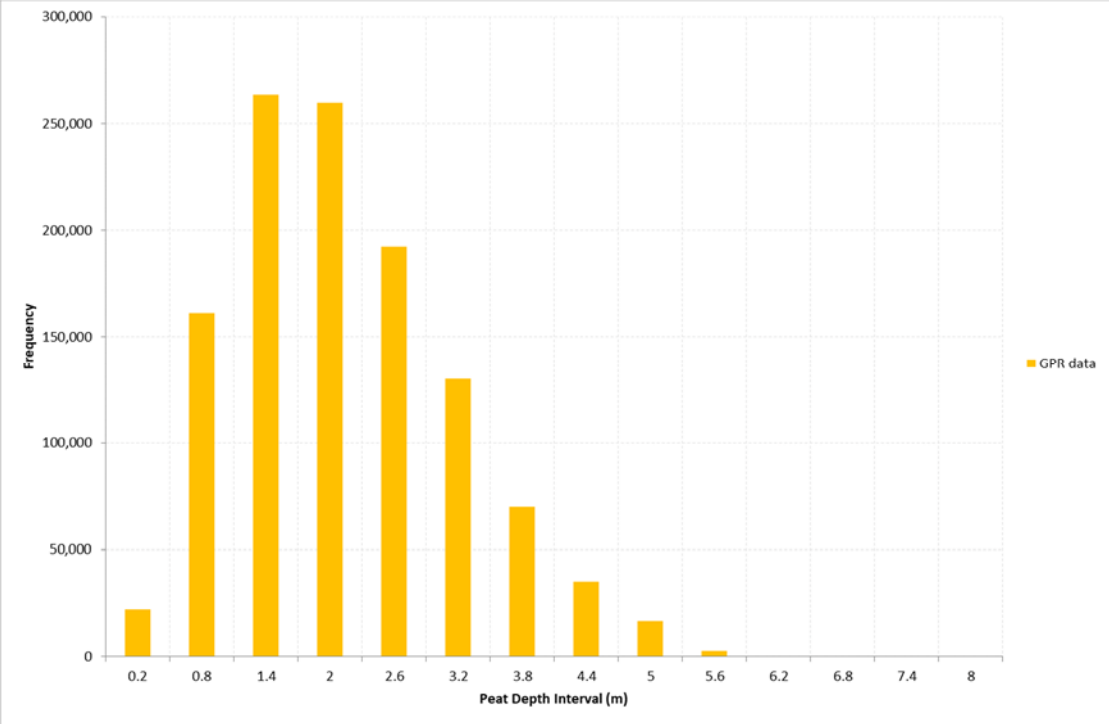
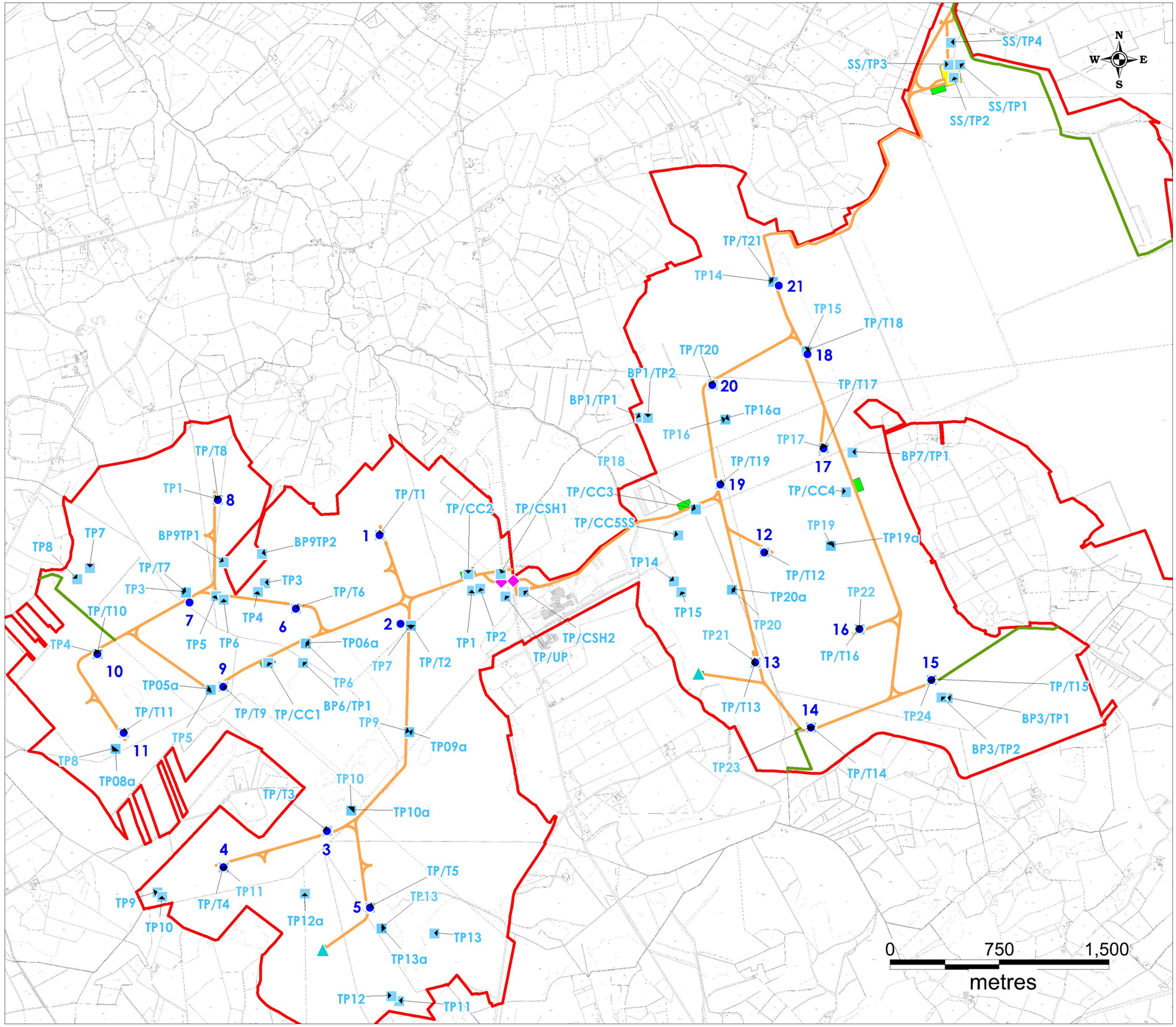


Figure 8.5: Peat depth frequency distribution plot from GPR data



Legend

- EIAR Site Boundary
- Proposed Turbine Location
- Proposed Met Mast Location
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- Proposed Temporary Construction Compound
- Proposed Amenity Link
- Proposed New Site Roads
- Proposed Underpass Locations
- FT Trial Pit Locations

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Client: Bord na Mona Powergen Ltd	
Job: Derrinlough, Co. Offaly	
Title: Trial Pit Location Map	
Figure No: 8.6	
Drawing No: P1463-0-0220-A3-806-00A	
Sheet Size: A3	Project No: P1463-0
Scale: 1:25,000	Drawn By: GD
Date: 07/02/2020	Checked By: MG

Table 8.4: Summary of Peat Depths and Mineral Subsoil Lithology at Proposed Development Locations

Infrastructure Location	Peat Depth Range (m)	Average Peat Depth (m)	Summary of Underlying Mineral Subsoil Lithology (from FT trial pit data)
T1	0.2 – 0.5	0.35	Very soft grey very sandy CLAY
T2	0.8 – 1.4	1.1	Firm grey slightly sandy slightly gravelly CLAY with occasional subangular to sub-rounded cobbles, stiff at 2mbgl
T3	0.8 – 1.4	1.3	Soft grey very sandy SILT with occasional subangular to sub-rounded cobbles
T4	1.1 – 1.8	1.5	Very soft light grey slightly organic SILT (MARL) to 2.2mbgl, over Firm grey slightly sandy CLAY with rare subangular to sub-rounded cobbles, stiff at 2.7mbgl
T5	1.7 – 2.3	2.0	Grey very silty SAND + GRAVEL with occasional sub-rounded cobbles
T6	1.0 – 1.6	1.3	Soft to firm grey sandy gravelly CLAY with sub-rounded cobbles and boulders
T7	2.0 – 2.3	2.2	Soft grey slightly sandy SILT with occasional gravel and boulders. Firm at 2mbgl.
T8	0.7 - 1.8	1.4	Soft grey sandy CLAY with occasional subangular to sub-rounded cobbles and boulders. Damp and firm to stiff at 2.2mbgl.
T9	1.2 – 1.7	1.4	Soft light grey sandy CLAY, over Very clayey sandy GRAVEL with occasional subangular to sub-rounded cobbles
T10	1.0 – 1.5	1.3	Firm grey slightly sandy slightly gravelly SILT with occasional subangular to sub-rounded cobbles and boulders
T11	0.8 – 1.8	1.1	Soft to firm grey very sandy slightly gravelly SILT, damp, occasional sub-rounded cobbles
T12	0.3 – 0.8	0.6	Grey silty SAND with occasional sub-rounded cobbles
T13	0.2 – 0.8	0.45	Firm to stiff grey slightly sandy CLAY with occasional gravel and cobbles below 2m: some subangular to sub-rounded boulders
T14	1.2 – 1.5	1.35	Grey silty SAND with occasional cobbles and boulders
T15	0.5 – 0.7	0.6	Soft grey slightly sandy CLAY with occasional gravel and cobbles firm at 1m more frequent boulders at 2m
T16	0.5 – 0.6	0.55	Soft grey sandy SILT with frequent subangular to sub-rounded cobbles and boulders firm at 1.2m stiff at 2m

Infrastructure Location	Peat Depth Range (m)	Average Peat Depth (m)	Summary of Underlying Mineral Subsoil Lithology (from FT trial pit data)
T17	0.15 – 0.8	0.5	Firm grey slightly gravelly sandy SILT with rare subangular cobbles 1.5m - some cobbles and boulders
T18	0.3 – 0.8	0.6	Soft grey slightly sandy CLAY (damp) gravelly below 1.5m, with occasional subangular to sub-rounded cobbles
T19	0.2 – 1.2	0.9	Firm to stiff grey slightly sandy slightly gravelly CLAY with occasional sub-rounded cobbles
T20	0.8 – 1.1	0.9	Firm grey sandy SILT with occasional sub-rounded boulders. Occasional gravel and cobbles below 1.8m.
T21	1.2 – 1.6	1.4	Soft grey sandy CLAY, damp gravelly below 1.5m occasional boulders at 2.3m.
Substation	0.3 – 1.1	0.9	Soft to Firm grey slightly sandy CLAY with occasional subangular to sub-rounded cobbles
Cable Route	0.0 - 2.0	0.86	Soft to Firm grey slightly sandy CLAY

8.3.3 Bedrock Geology

Based on the GSI bedrock mapping the bedrock units underlying the proposed development site comprises Dinantian Pure Unbedded Limestone (DPUL). Below the site, Waulsortian Limestones are mapped, and these comprise massive un-bedded lime-mudstone. There are 2 no. mapped faults intersecting the site, which trend in a northwest-southeast direction.

A mapped corehole completed at the Island townland, approximately 600m east of Drinagh Bog (at ITM: 612948, 718250.3) indicated overburden deposits of 12m depth over 244.5m of Waulsortian Limestone (www.gsi.ie).

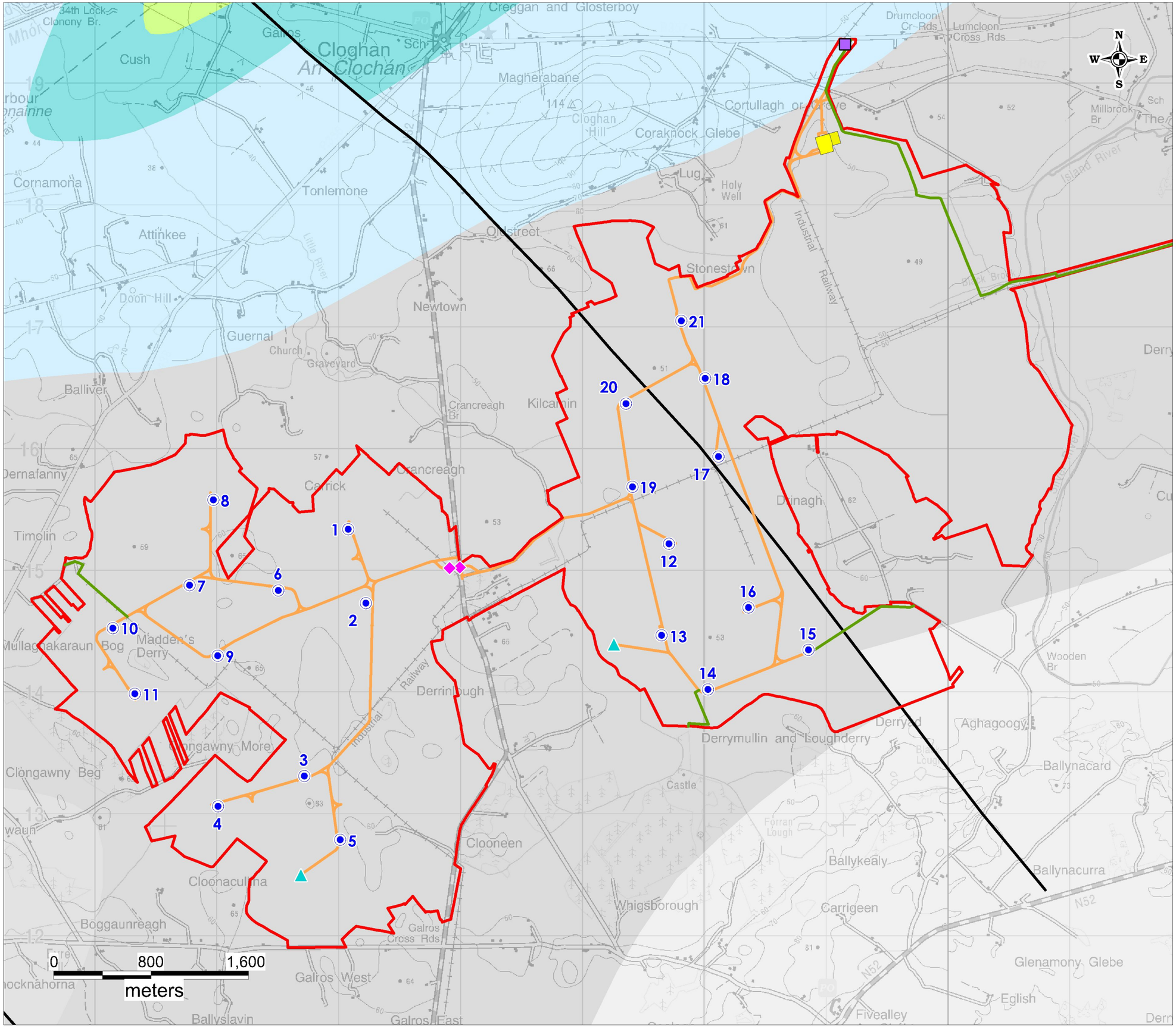
Boulders of fossiliferous pale limestone were observed at the site (especially across the Drinagh bog site). These boulders would have been deposited on top of glacial deposits towards the end of the last glacial maximum. The peat deposits accumulated around and above the boulders, and during peat extraction the boulders have been exposed at ground level. These boulders (probably derived from local underlying limestone bedrock) displayed brachiopod shells and crinoid ossicles in a pale calcium carbonate matrix. They have no real consequence for the proposed wind farm development. They are just a feature of the geology noted within the Drinagh bog.

No bedrock was encountered in any of the site investigation points. Depth to bedrock at the site is expected to be between 6-12mbgl.

A bedrock geology map of the area is attached as Figure 8.7.

8.3.4 Geological Resource Importance

The limestone bedrock underlying the site could be classified as “Medium” importance. The bedrock could be used on a “sub-economic” local scale for construction purposes. The bedrock has not been used



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Client: Bord na Mona Powergen Ltd

Job: Derrinlough, Co. Offaly

Title: Local Bedrock Geology Map

Figure No: 8.7

Drawing No: P1463-0-0220-A3-807-00A

Sheet Size: A3	Project No: P1463-0
Scale: 1:30,000	Drawn By: GD
Date: 07/02/2020	Checked By: MG

in the past at the site for this purpose, likely because of the covering of peat and glacial till overburden in the area.

The glacial subsoils (i.e. sands and gravels where present) could be classified as "Medium" importance. The glacial subsoils could be used on a "sub-economic" local scale for construction purposes. There is no evidence that it was used in the past.

The overlying peat deposits at the site could be classified as "Low" importance as the peat is not designated in this area and is significantly degraded in most places at the site as a result of industrial peat production/extraction and drainage. Refer to Table 8.1 for definition of these criteria.

8.3.5 Geological Heritage Sites

There are no recorded mineral deposit sites or mining sites (current or historic) within the proposed development area. There are no geological heritage sites near the proposed development. There are 2 no. County Geological Sites near the proposed site (Drinagh and Crancreah Mushroom rocks) and 1 no. within the site boundary (Derrinlough Mushroom Rock). These are Limestone standing rocks which have been eroded near their base by acidic waters towards the end of the last Glacial Maximum. The Crancreagh Mushroom rock is situated ~600m north of the Clongawny Bog, and is ~1,150m from any proposed wind farm infrastructure. The Drinagh Mushroom Rock is situated on the southern edge of the Drinagh Bog and is ~380m from any proposed wind farm infrastructure. The Derrinlough Mushroom Rock is situated ~160meast-northeast of Derrinlough Briquette factory between the Clongawny and Drinagh bogs. It is ~60m south of an existing internal access track (between Drinagh and Clongawny bogs) that will be upgraded and used within the proposed wind farm development.

The locations of these County Geological Heritage sites are shown on Figure 8.8 relative to the proposed site layout.

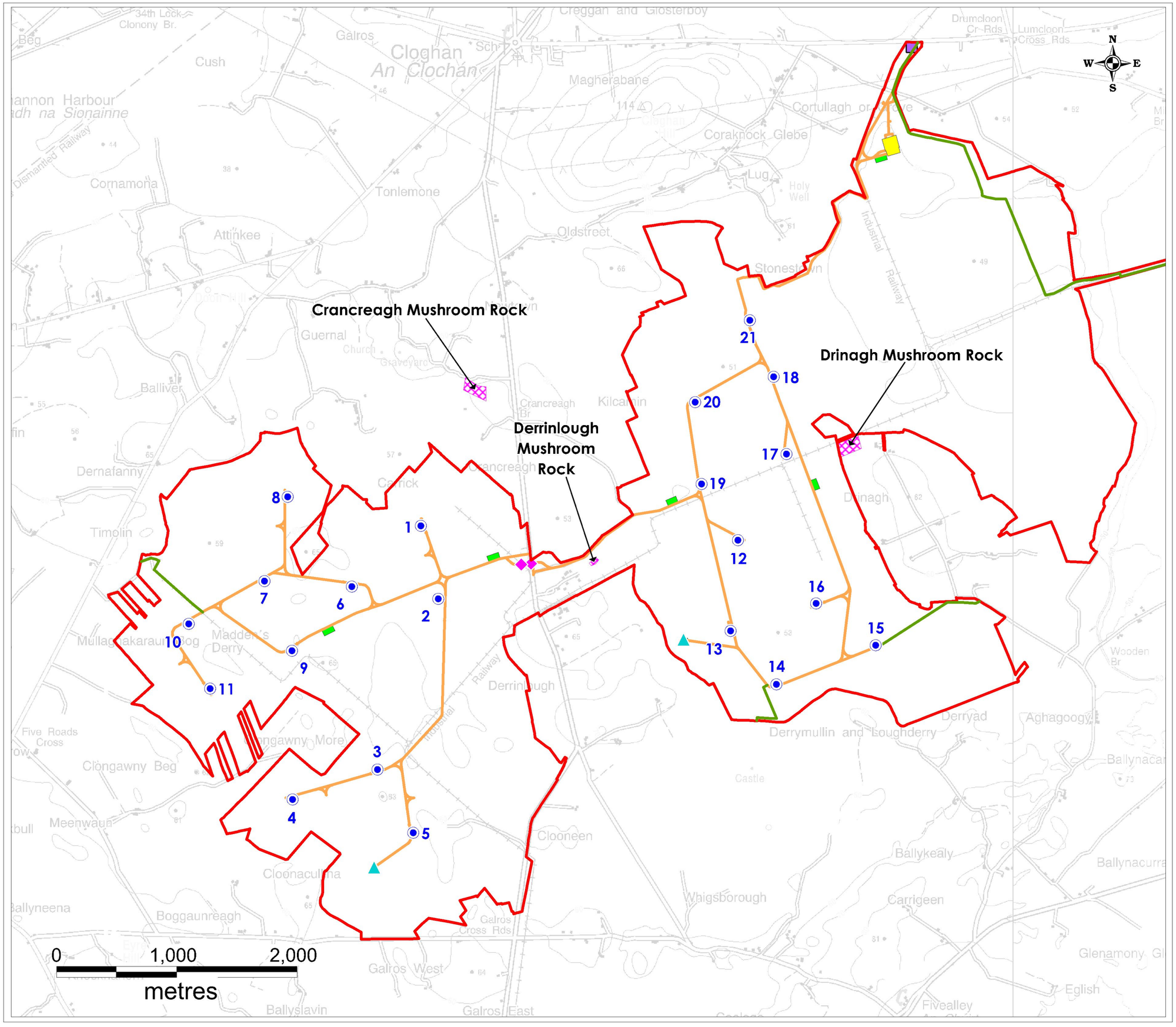
8.3.6 Peat Stability Assessment

A Geotechnical and Peat Stability Assessment Report (FT, 2020a) is attached in Appendix 8.1. Summary data and conclusions from that report are provided below.

The hand vane results indicate undrained shear strengths in the range 20 to 120kPa, with an average value of about 65kPa. The strengths recorded would be typical of well-drained peat as is present on the Derrinlough site.

Peat strength at sites of known peat failures (assuming undrained (short-term stability) loading failure) are generally very low, for example, the undrained shear strength at the Derrybrien failure (AGEC, 2004) as derived from essentially back-analysis, though some testing was carried out, was estimated at 2.5kPa. The recorded undrained strengths at the Clongawny/Drinagh site are significantly greater than the lower bound values for Derrybrien indicating that there is no close correlation to the peat conditions at the Derrybrien site and that there is significantly less likelihood of failure on the Clongawny/Drinagh site.

The minimum required Factor of Safety (FoS) is 1.3 based on BS6031:1981: Code of Practice for Earthworks (BSI, 2009). The assigned probability of instability associated with a given FoS value is described in Table 8.5 over.



Legend

- EIAR Site Boundary
- Proposed Turbine Location
- Proposed Met Mast Location
- Proposed 110kV Electricity Substation Compound
- Proposed Temporary Construction Compound
- Proposed Amenity Link
- Proposed New Site Roads
- Proposed Visitor Car Park (Operational Phase)
- Proposed Underpass Locations
- Geological Heritage Sites

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Client: Bord na Mona Powergen Ltd

Job: Derrinlough, Co. Offaly

Title: Location of County Geological Heritage Sites Map

Figure No: 8.8

Drawing No: P1463-0-0220-A3-808-00A

Sheet Size: A3	Project No: P1463-0
Scale: 1:30,000	Drawn By: GD
Date: 07/02/2020	Checked By: MG

Table 8.5: Probability Scale for Factor of Safety.

Scale	Factor of Safety	Probability
1	1.30 or greater	Negligible/None
2	1.29 to 1.20	Unlikely
3	1.19 to 1.11	Likely
4	1.01 to 1.10	Probable
5	<1.0	Very Likely

8.3.6.1 Peat Stability Assessment Results

Stability of a peat slope is dependent on several factors working in combination. The main factors that influence peat stability are slope angle, shear strength of peat, depth of peat, pore water pressure and loading conditions.

An adverse combination of factors could potentially result in peat sliding. An adverse condition 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. This model is based on a translational slide, which is a reasonable representation of the dominant mode of movement for peat failures.

To assess the factor of safety for a peat slide, an undrained (short-term stability) and drained (long-term stability) analysis has been undertaken to determine the stability of the peat slopes on site.

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

The drained loading condition applies in the long-term. The condition examines the effect of in particular, the change in groundwater level as a result of rainfall on the existing stability of the natural peat slopes.

As mentioned above, the Geotechnical and Peat Stability Assessment Report (FT, 2019a) is attached in Appendix 8.1.

8.3.6.1.1 *Undrained Analysis*

Undrained analysis results are presented in Table 8.6. As outlined above the undrained loading condition applies in the short-term during construction and until construction induced pore water pressures dissipate.

Table 8.6: Factor of Safety Results (undrained condition)

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T1	607027	715375	68.77	22.92
T2	607206	714769	16.38	9.55
T3	606666	713348	24.56	14.33
T4	605958	713100	9.56	6.14
T5	606961	712824	14.95	10.42
T6	606452	714870	11.32	6.96
T7	605724	714916	14.95	10.42
T8	605919	715618	19.10	12.28
T9	605954	714337	20.23	12.73
T10	605094	714562	11.47	6.88
T11	605273	714023	6.17	3.97
T12	609661	715257	42.98	19.10
T13	609600	714503	21.50	9.56
T14	609982	714058	11.47	6.88
T15	610807	714384	24.58	10.12
T16	610313	714732	57.31	21.49
T17	610068	715972	14.35	6.38
T18	609958	716616	10.52	4.67
T19	609360	715724	28.65	15.63
T20	609307	716406	31.26	16.37
T21	609761	717087	7.42	4.57
Substation	610966	718547	31.26	16.37
Temporary Construction Compound 1	606260	714498	10.42	8.00

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
Temporary Construction Compound 2	607630	715110	26.45	14.95
Temporary Construction Compound 3	609113	715577	16.37	11.09
Temporary Construction Compound 4	610305	715713	7.65	4.59
Temporary Construction Compound 5	610858	718421	31.26	16.37
Met Mast 1	606638	712525	9.82	7.64
Met Mast 2	609210	714421	31.26	16.37

8.3.6.1.2 Drained Analysis

Drained analysis results are presented in Table 8.7. As outlined above, the drained loading condition applies in the long-term. The condition examines the effect of in particular, the change in groundwater level as a result of rainfall on the existing stability of the natural peat slopes.

Table 8.7: Factor of Safety Results (drained condition)

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T1	607027	715375	45.85	33.09
T2	607171	714769	10.92	13.79
T3	606666	713348	16.37	20.68
T4	605958	713100	6.37	8.86
T5	606961	712824	9.97	15.04
T6	606452	714870	7.54	10.05
T7	605724	714916	9.97	15.04
T8	605919	715618	12.73	17.73
T9	605954	714337	13.48	18.38
T10	605094	714562	7.65	9.93

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T11	605273	714023	4.12	5.72
T12	609661	715257	28.65	27.58
T13	609600	714503	14.34	13.79
T14	609982	714058	7.65	9.93
T15	610807	714384	16.38	14.60
T16	610313	714732	38.20	31.02
T17	610068	715972	9.57	9.20
T18	609958	716616	7.01	6.73
T19	609360	715724	19.10	22.56
T20	609307	716406	20.84	23.64
T21	609761	717087	4.95	6.59
Substation	610966	718547	20.84	23.64
Temporary Construction Compound 1	606260	714498	6.95	11.54
Temporary Construction Compound 2	607630	715110	17.63	21.58
Temporary Construction Compound 3	609113	715577	10.92	16.01
Temporary Construction Compound 4	610305	715713	5.10	6.62
Temporary Construction Compound 5	610858	718421	20.84	23.64
Met Mast 1	606638	712525	6.55	11.03
Met Mast 2	609210	714421	20.84	23.64

The findings of the peat stability assessment showed that the site has an acceptable margin of safety and is suitable for the proposed wind farm development. The findings include recommendations and control measures (Section 12 of Appendix 8.1 of this EIAR) for construction work in peatlands to ensure that all works adhere to an acceptable standard of safety.

An analysis of peat stability was carried out at the turbine locations, substation compound, construction compounds and met masts for both the undrained and drained conditions. The purpose of the analysis was to determine the Factor of Safety (FoS) of the peat slopes.

An undrained analysis was carried out, which applies in the short-term during construction. For the undrained condition, the calculated FoS for load conditions (1) & (2)[1] for the locations analysed, show that all locations generally have an acceptable FoS of greater than 1.3, indicating a low risk of peat failure. The undrained analysis would be considered the most critical condition for the peat slopes.

The calculated FoS for load condition (1) is in excess of 1.30 for each of the locations (579 no. locations) analysed with a range of FoS of 1.62 to in excess of 10, indicating a low risk of peat instability.

The calculated FoS for load condition (2) is in excess of 1.30 for each of the locations (579 no. locations) except at 2 no. locations where FoS's of 1.21 and 1.26 were calculated. It should be noted that the locations where the marginally low FoS's were calculated, the slope angles were based on contour survey plans for site which give approximate values. Based on site data recorded during the walkover, it is likely that the slope angles derived from the contour survey plans overestimated the slope angle at these locations. The 2 no. marginally low FoS's are located alongside the proposed access road between turbines T12 and T13. The proposed works at these locations entails the construction of a floated section of access road i.e. no excavation works are proposed at these locations. Peat instability at these locations is not envisaged to be an issue.

The calculated FoS for load condition (2) for the remaining 577 no. locations were in excess of 1.30, indicating a low risk of peat instability.

The peat stability risk assessment at each infrastructure location (as listed above) identified a number of mitigation/control measures to reduce the potential risk of peat failure. Sections of access roads to the nearest infrastructure element should be subject to the same mitigation/control measures that apply to the nearest infrastructure element.

In summary, the findings of the peat assessment showed that the proposed Derrinlough wind farm site has an acceptable margin of safety, is suitable for the proposed wind farm development and is considered to be at low risk of peat failure. The findings include recommendations and control measures for construction work in peatlands to ensure that all works adhere to an acceptable standard of safety.

8.4 Characteristics of the Proposed Development

The proposed development will typically involve removal of peat and subsoils for access roads, internal access road networks, internal cable network, hardstanding emplacement, turbine foundations, substation, crane hardstands, construction compounds, and met mast installation. The construction grade granular fill and the higher quality, surfacing granular fill and sand will be sourced from local, authorised quarries. The locations of the existing quarries and typical proposed routes to site chosen for

[1] *For the stability analysis two load conditions were examined, namely*

Condition (1): no surcharge loading
Condition (2): surcharge of 10 kPa, equivalent to 1 m of stockpiled peat assumed as a worst case.

the purposes of assessment throughout this EIAR are shown in Figure 4.23. These and/or other authorised quarries will be used as sources of stone during the construction of the Proposed Development proposed development.

Estimated volumes of peat to be removed are shown in Table 8.8 below. It is estimated that up to 484,600m^3 of sand and gravel will be imported for proposed construction works.

In terms of peat handling and long-term storage of excavated peat, Bord na Móna has considerable experience in this area, both during peat production operations and during the rehabilitation processes associated with its cutaway bogs. This experience has shown that the most environmentally sensitive and stable way of handling and moving of excavated peat is its placement across the site and at locations as close as possible to the extraction areas. Placement of excavated peat and spoil within 1m high and 5m wide corridor on both sides of the proposed access roads is proposed, and additional peat material will be used at turbine locations for landscaping. The overall peat and spoil storage volumes are shown in Table 8.9. These are taken from the Peat and Spoil management Plan prepared by FT (FT. 2020b).

Proposed construction methodologies for each element of infrastructure is summarised in Table 8.10.

Table 8.8: Estimated Peat, Mineral Soil and Bedrock Excavation Volumes

Infrastructure Element (1)	Typical Dimensions	Peat Volume (m^3) (2)	Spoil (non-peat) Volume (m^3) (2)	Comments
21 no. Turbines and Hardstands	22m diameter excavation footprint for turbine foundation with hardstand area	152,535	57,700	Hardstanding area and foundation footprint
Access Roads including entrances	Assumed 6m wide road surface	57,150	29,465	Excludes proposed floating sections of access road where no excavation of peat will take place
Substation	17,564m^2 footprint	18,963	6,326	Hardstanding area and foundation footprint
2 no. Meteorological Masts	10 x 10m foundation footprint and 600m^2 hardstanding area	3,490	780	Hardstanding area and foundation footprint. Met Mast 1 likely a piled foundation
5 no. Temporary Construction Compounds and 2 no. Construction Phase Security Hut Platforms	Hardstanding areas – 5,000m^2	37,800	8,570	Hardstanding areas
2 no. Underpasses	Precast concrete box culverts	1,440	4,200	May be piled structures however excavation works will be required
Proposed Amenity Links	3m wide footpath	0	0	Floated construction hence no excavation works
Cable route and grid connection		7,345		Includes the internal network cabling works
N52/N62 Junction			6,920	
Sub-total		**278,723m^3**	**113,961m^3**	
Total Peat and Spoil volume		**392,684m^3**		

Note (1) The location of the infrastructure elements on-site are shown on Planning Drawings.
Note (2) A factor of 20% (bulking factor of 15% and contingency factor of 5%) has been applied to the excavated peat & spoil volumes to allow for expected increase in volume upon excavation and to allow for a variation in ground conditions across the site.

Table 8.9: Summary of Peat and Spoil Placement Areas on Site

Location	Peat & Spoil Volume (m^3)	Comment
Peat and spoil placement alongside infrastructure elements	352,000	1m in height and 14m wide corridor on both sides of proposed infrastructure elements on site. For example, 7m wide corridor on both sides of proposed access roads, see Section 7.4 of the report for further details and Figure 7-1. The placement of peat and spoil alongside infrastructure elements also includes around hardstanding areas, either side of cable trenches, etc.
Landscaping (1)	42,000	It is estimated that approximately 2,000m^3 of peat will be required for landscaping purposes at each of the 21 no. turbine locations
Total =	394,000m^3	

Table 8.10: Summary of Proposed Infrastructure construction methods

Location	Foundation/Construction Method
21 no. wind turbines	Turbine foundations indicated to be piled but may have a small number that have gravity foundations.
Access roads	Floating access roads and excavate and replace roads (road types A, B, and C) are the proposed road construction types proposed for the site which given the ground conditions and type of terrain present are deemed appropriate. The total length of new proposed access road to be constructed on-site is 29.3km (see Peat and Spoil Management Plan, Appendix 4.2).
Crane hardstands	The crane hardstands will be constructed using the founded technique (i.e. non-floated technique). Crane hardstands are generally constructed using compacted Class 1/6F material or granular fill in accordance with turbine manufacturer requirements on a suitable sub-formation to achieve the required bearing resistance. The hardstands will be designed for the most critical loading combinations from the crane. The hardstands will require to be founded on material underlying the peat deposits. The typical make-up of the hardstands may include up to 1200mm of granular stone fill with possibly a layer of geotextile and/or geogrid.
Substation foundations and platforms	The substation platforms will be constructed using the founded technique (i.e. non-floated technique). The substation foundations may comprise strip/raft foundations under the main footprint of the building with possibly a basement/pit for cable connections. Substation platforms are generally constructed using compacted Class 1/6F material or granular fill in accordance with Eirgrid/ESB network requirements on a suitable sub-formation to achieve the required bearing resistance. The substation platforms will require to be founded on material underlying the peat deposits. Typical founding depth for substation platform likely to be 0.5 to 2.0m.

Temporary Construction Compounds	The temporary construction compound platforms will be constructed using the founded technique (i.e. non-floated technique). The platforms are generally constructed using compacted Class 1/6F material or granular fill in accordance with turbine manufacturer requirements on a suitable sub-formation to achieve the required bearing resistance. The platforms will require to be founded on material underlying the peat deposits. Typical founding depth for temporary construction compound platforms will require excavations from 1m to 3.5m bgl.
Met Masts	The met mast foundations will likely comprise gravity type foundation and a piled foundation. Based on the ground conditions present at proposed met mast 1, it is envisaged that the foundation will require a piled foundation. Given the thickness of peat and lacustrine soils present at this location a gravity type foundation is not likely to be a suitable solution. This will be determined following confirmatory site investigation works prior to the construction of the proposed development. Based on the ground conditions present at proposed met mast 2, it is envisaged that the gravity type foundation will require to be founded on till. The peat and lacustrine soils are not likely to be suitable founding stratums for the met mast foundation. At the underside of the met mast foundation, a layer of structural upfill (class 6N/6P) or granular fill in accordance with met mast supplier requirements will likely be required. This will be determined following confirmatory site investigation works prior to the construction of the proposed development.
Permanent Underpasses	Two new permanent underpasses are proposed as part of the proposed development. The first underpass will traverse beneath the N62, immediately north of Derrinlough Briquette Factory. This underpass will provide amenity connectivity between Clongawny and Drinagh Bogs and will also be used during the operational phase for wind farm maintenance. A second underpass is proposed in Clongawny bog beneath an existing Bord na Móna railway line. This underpass will also be used for amenity purposes and for wind farm maintenance during the operational phase. The underpasses will take the form of precast concrete box culverts and will be founded on a competent stratum at depth. Given the ground conditions present across the site, the culvert foundations may need to be piled. This will be determined following confirmatory site investigation works prior to the construction of the proposed development. At the underside of the culvert foundations, a layer of structural up-fill (class 6N/6P) in accordance with Transport Infrastructure Ireland (TII) requirements will be required.

8.5 Likely Significant Effects and Associated Mitigation Measures

8.5.1 Do Nothing Scenario

If the proposed development were not to proceed, the site would continue to be managed under the requirements of the relevant IPC licence, and existing commercial forestry, telecommunications and wind measurement would continue. The rail lines that supply peat to Derrinlough Briquette Factory would continue to be used until the manufacture of peat briquettes ceases.

Localised 3rd party turbary peat cutting along the margins of the site will also continue.

When peat extraction activity ceases, a Rehabilitation Plan will be implemented in accordance with the IPC licence requirements, to environmentally stabilise the site through encouragement of re-vegetation of bare peat areas, with targeted active management being used to enhance re-vegetation and the creation of small wetland areas (if required).

8.5.2 Construction Phase - Likely Significant Effects and Mitigation Measures

The likely effects of the proposed development and mitigation measures that will be put in place during the construction phase to eliminate or reduce them are outlined below.

8.5.2.1 Peat and Subsoil Excavation

Excavation of peat and subsoil will be required for construction of works for the installation of access roads (floating and excavated roads, i.e. road type A, road type B and road type C (FT, 2020b)), gravity foundations for turbine bases, crane hardstands, met masts, substation, underpasses, internal cable network and turbine delivery route accommodation works. This will result in a permanent removal and relocation of in-situ peat and subsoil at most excavation locations. Estimated volumes of peat and subsoils to be relocated are summarised above. There is no loss of peat or subsoil, it will just be relocated within the site.

Pathway: Extraction/excavation.

Receptor: Peat and subsoil.

Pre-Mitigation Potential Impact: Negative, slight/moderate, direct, high probability, permanent effect on peat and subsoil due to relocation within the site.

Proposed Mitigation Measures by Design:

- Placement of turbines and associated infrastructure in areas with shallower peat where possible;
- Use of floating roads, where appropriate, to reduce peat excavation volumes;
- The peat and subsoil which will be removed during the construction phase will be localised to the wind farm infrastructure turbine location, substation and temporary compounds and access roads;
- The proposed development has been designed to avoid sensitive habitats within the application area;
- A minimal volume of peat and subsoil will be removed to allow for infrastructural work to take place in comparison to the total volume present on the site due to optimisation of the layout by mitigation by design;

- Excavated peat will only be moved short distances from the point of excavation and will be used locally for landscaping; and,
- Construction of settlement ponds will be volume neutral, and all excess material will be used locally to form pond bunds and surrounding landscaping.

Residual Effect Assessment: The granular soil at the site can be classified as of "Medium" importance and the peat deposits at the site can be classified as of "Low" importance as the raised bog is already degraded by historical harvesting and drainage. The overall site area is extensive while the proposed development footprint is approximately 1.45% of the overall site area. The impact is the disturbance and relocation of c 392,684 m3 of soil and subsoil during construction. The design measures incorporated into the project as described above in particular the avoidance of deeper peat areas combined with the 'Medium' and 'low' importance of the deposits means that the residual effect is considered - Negative, slight, direct, high probability, permanent effect on peat and subsoils due to disturbance and relocation within the site.

Significance of Effects: No significant effects on soils and subsoils are anticipated.

8.5.2.2 Contamination of Soil by Leakages and Spillages and Alteration of Peat/Soil Geochemistry

Accidental spillage during refuelling of construction plant with petroleum hydrocarbons is a pollution risk. The accumulation of small spills of fuels and lubricants during routine plant use can also be a significant pollution risk. Hydrocarbon has a high toxicity to humans, and all flora and fauna, including fish, and is persistent in the environment. Large spills or leaks have the potential to result in significant effects (i.e. contamination of peat, subsoils and pollution of the underlying aquifer) on the geological and water environment.

Pathway: Peat and subsoil and underlying bedrock pore space.

Receptor: Peat and subsoil, bedrock.

Pre-Mitigation Potential Impact: Negative, slight, direct, short-term, medium probability effect on peat, subsoils and bedrock.

Proposed Mitigation Measures:

- On-site re-fuelling will be undertaken using a double skinned bowser with spill kits kept on site for accidental leakages or spillages;
- Only designated trained operatives will be authorised to refuel plant on-site;
- Taps, nozzles or valves associated with refuelling equipment will be fitted with a lock system;
- Fuels stored on-site will be minimised. All storage areas will be bunded appropriately for the duration of the construction phase. All bunded areas will be fitted with a storm drainage system and an appropriate oil interceptor. Ancillary equipment such as hoses, pipes will be contained within the bunded area;
- Fuel and oil stores including tanks and drums will be regularly inspected for leaks and signs of damage;
- The electrical control building (at the substation) will be bunded appropriately to the volume of oils likely to be stored and to prevent leakage of any associated chemicals to groundwater or surface water. The bunded area will be fitted with a storm drainage system and an appropriate oil interceptor;
- The plant used during construction will be regularly inspected for leaks and fitness for purpose; and,
- An emergency response plan for the construction phase to deal with accidental spillages will be contained within the Construction Environmental Management Plan (which is contained in Appendix 4.3).

Residual Effect Assessment: The use and storage of hydrocarbons and small volumes of chemicals is a standard risk associated with all construction sites. Proven and effective measures to mitigate the risk of spills and leaks have been proposed above and will break the pathway between the potential source and the receptor. The residual effect is considered to be - Negative, imperceptible, direct, short-term, low probability effect on peat and subsoils and bedrock.

Significance of Effects: No significant effects on peat, subsoils and bedrock are anticipated.

8.5.2.3 Erosion of Exposed Subsoils and Peat During Construction of Infrastructure

There is a high likelihood of erosion of peat and spoil during its excavation and during landscaping works. The main impacts associated with this aspect is to the water environment, and therefore this aspect is further assessed in detail in Chapter 9.

Pathway: Vehicle movement, surface water and wind action.

Receptor: Peat and subsoil.

Pre-Mitigation Potential Impact: Negative, slight, direct, short-term, high probability effect on peat and subsoils by erosion and wind action.

Proposed Mitigation Measures:

- Peat removed from turbine locations and access roads will be used for landscaping close to the extraction area;
- Where possible, the upper vegetative layer (where still present) will be stored with the vegetation part of the sod facing the right way up to encourage growth of plants and vegetation at the surface of the stored peat within the peat storage areas;
- Re-seeding and spreading/planting will also be carried out in these areas; and,
- A full Peat and Spoil Management Plan for the development is shown as Appendix 4.2.

Residual Effect Assessment: Peat soils and spoil can be eroded by vehicle movements, wind action and by water movement. To prevent this all excavation works will be completed in accordance with a detailed Peat and Spoil Management Plan, material will be moved the least possible distance, and reseeding and planting will be completed to bind landscaped peat and spoil together. Following implementation of these measures the residual effected is considered - Negative, slight, direct, short-term, medium probability effect on peat and subsoils by erosion and wind action.

Significance of Effects: No significant effects on soils, subsoils or bedrock are anticipated.

8.5.2.4 Peat Instability and Failure

Peat instability or failure refers to a significant mass movement of a body of peat that would have an adverse impact on the proposed wind farm development and the surrounding environment. The potential significant effects of peat failure at the study area may result in:

- Death or injury to site personnel;
- Damage to machinery;
- Damage or loss of infrastructure;
- Drainage disruption by blockage of drainage pathway by relocated peat and spoil;
- Site works damaged or unstable;
- Contamination of watercourses, water supplies by particulates; and,
- Degradation of the peat environment by relocation of peat and spoil.

Pathway: Vehicle movement and excavations.

Receptor: Peat and subsoils.

Pre-Mitigation Potential Impact: Negative, significant, direct, low probability permanent effect on peat and subsoils. The findings of the peat stability assessment showed that the proposed Derrinlough wind farm site has an acceptable margin of safety, is suitable for the proposed wind farm development and is considered to be at low risk of peat failure. The findings include recommendations and control measures for construction work in peatlands to ensure that all works adhere to an acceptable standard of safety.

Proposed Mitigation Measures:

The following general control measures incorporated into the construction phase of the project will assist in the management of the risks for this site:

- Appointment of experienced and competent contractors;
- The site should be supervised by experienced and qualified personnel;
- Allocate sufficient time for the project (be aware that decreasing the construction time has the potential to increase the risk of initiating a localised peat movement);
- Prevent undercutting of slopes and unsupported excavations;
- Maintain a managed robust drainage system;
- Prevent placement of loads/overburden on marginal ground;
- Set up, maintain and report findings from monitoring systems (as outlined in the Geotechnical and Peat Stability Assessment);
- Ensure construction method statements are developed and agreed before commencement of construction and are followed by the contractor; and,
- Revise and amend the Construction Risk Register as construction progresses to ensure that risks are managed and controlled for the duration of construction.

Please refer to Appendix 8.1 for proposed turbine specific and road section design proposals.

Residual Effect Assessment: A detailed Geotechnical and Peat Stability Assessment has been completed for the development proposal. The findings of that assessment have demonstrated that there is a low risk of peat failure (at the site) as a result of the proposed development. With the implementation of the control measures outlined above the residual effect is considered - Negative, imperceptible, direct, low probability, permanent effect on peat and subsoils.

Significance of Effects: No significant effects on soils and subsoils are anticipated.

8.5.2.5 Piling Works

As a worst-case design scenario turbine and infrastructure locations may require piled foundations. For the piled turbine foundations, a typical piling type and configuration could be up to 50 no. 300mm square concrete driven piles. A similar type pile and configuration was used for the turbine foundations on the Mount Lucas wind farm. A similar piling system and array would be used under other infrastructure components (e.g. substation), but with a reduced pile frequency/spacing.

Pathway: piling works.

Receptor: peat/soils and subsoils.

Pre-Mitigation Potential Impact: Negative, slight, direct, permanent low probability impact on subsoils by piling works.

Proposed Mitigation Measures:

Other than surface level and minor excavation works, any piling works will not produce significant volumes of spoil as the proposed piling system are driven piles (these will displace soil/subsoil within the ground.

No mitigation measures are proposed or required for soils and geology environment.

Residual Effect Assessment: The effects of piling works on soils and geology have been assessed. Pile install works would only result in small volumes of spoil, and minimal displacement of in-situ peat and subsoils. This small displacement would not alter ground levels, nor change the local geological environment in any significant way. As such the residual effects are considered - negative, direct, imperceptible, permanent, low probability impact on peat and subsoils by piling works.

Significance of Effects No significant effects on soils and subsoils are anticipated.

8.5.2.6 Potential Impacts on County Geological Sites

There are 2 no. County Geological Sites (CGS) near the proposed development site and 1 no. CGS within the site boundary. These mushroom rocks were chemically weathered by acidic waters towards the end of the Last Glacial Maximum and consist of Limestone standing rocks which narrow towards their base due to this weathering action. The Crancreagh Mushroom rock is situated ~600m north of the Clongawny Bog, and is ~1,150m from any proposed wind farm infrastructure. The Drinagh Mushroom Rock is situated on the southern edge of the Drinagh Bog and is ~380m from any proposed wind farm infrastructure. The Derrinlough Mushroom Rock is situated ~160m east-northeast of Derrinlough Briquette factory between the Clongawny and Drinagh bogs. It is ~60m south of an existing internal access track (between Drinagh and Clongawny bogs) that will be upgraded and used within the proposed wind farm development.

No effects from the development will occur at Crancreagh Mushroom Rock and Drinagh Mushroom Rock as there will be no construction or operational works near either of these locations.

Pathway: Damage by vehicular/machinery movement.

Receptor: Mushroom Rock (CGS).

Pre-Mitigation Potential Impact: Negative, significant, indirect, medium probability impact on Derrinlough Mushroom Rock by damage or relocation by vehicular/machinery movements.

Proposed Mitigation Measures:

No mitigation measures are proposed for the Crancreagh CGS as there will be no construction or operational works near this site.

Mitigation measures for the Derrinlough Mushroom Rock include advising all vehicle and construction plant operators of the location of geological sites and instruct them to avoid those areas. No works will be completed within 30m of the Derrinlough Mushroom Rock. In addition, the geological heritage sites will be cordoned off with appropriate fencing to avoid accidental vehicular movement within these areas. The mitigation measures for the Mushroom Rock sites will be incorporated into the CEMP and access roads will be kept a minimum distance of 30m from the rocks.

Residual Effect Assessment: Crancreagh Mushroom Rock and Drinagh Mushroom Rock will not be affected by the proposed development due their remote locations from any intended wind farm works. Avoidance mitigation is outlined above for Derrinlough Mushroom Rocks. With the implementation of these avoidance measures the residual effects on Derrinlough Mushroom Rock are considered -

Negative, imperceptible, indirect, unlikely effect on County Geological Sites due to damage by vehicular/machinery movement.

Significance of Effects No significant effects on County Geological Sites are anticipated as a result of the proposed development.

8.5.2.7 Proposed Substation

As presented in Table 8.8 above the estimated volume of peat and spoil to be excavated at the proposed substation is 25,289 m^3 (18,963m^3 of peat and of 6,326m^3 of spoil). The exact location of the substation has been selected based on detailed geotechnical investigations and peat stability risk assessments. Material excavated at the substation location will be used for landscaping and the remainder will be permanently stored in low linear sections.

Pathway: Extraction/excavation of peat and soil/subsoils (spoil).

Receptor: Peat and underlying subsoil.

Pre-Mitigation Potential Impact: Negative, slight/moderate, direct, high probability, permanent effect on peat and subsoil.

Proposed Mitigation Measures:

Mitigation measures in respect of peat and subsoil excavation are outlined at Section 8.5.2.1.

Mitigation measures in respect of potential piling works are outlined at Section 8.5.2.5. The residual effect of all piling works is assessed in Section 8.5.2.5.

Mitigation measures to prevent soil / subsoil contamination (leaks / spills) are dealt with in Section 8.5.2.2 above and measures dealing with soil erosion are dealt with in Section 8.5.2.3. The residual effects of soil / subsoil contamination from leaks / spills is assessed in Section 8.5.3.2, and the residual effects of soil erosion are assessed in Section 8.5.2.3.

Residual Effect Assessment: The granular soil at the substation site can be classified as of "Medium" importance and the peat deposits at the site can be classified as of "Low" importance as the raised bog is already degraded by historical harvesting and drainage. The overall application site area is extensive (~2,360 Ha) while the proposed substation development footprint is small (~1.76a Ha), or ~0.07% of the overall site area. The impact is the disturbance and relocation of c 25,289 m^3 (note this is already included in the 392,684 m^3 assessed in Section 8.5.2.1) of peat and spoil during the construction of the substation and the residual effect of this is considered - Negative, slight, direct, high probability, permanent effect on peat and subsoils due to disturbance and relocation within the site.

Significance of Effects: No significant effects on soils and subsoils are anticipated.

8.5.2.8 Proposed Permanent Underpasses

Two permanent underpasses are proposed as part of the development. The first underpass will traverse beneath the N62, immediately north of Derrinlough Briquette Factory. This underpass will provide amenity connectivity between Clongawny and Drinagh Bogs and will also be used during the operational phase for wind farm maintenance. A second underpass is proposed in Clongawny bog beneath an existing Bord na Móna railway line. This underpass will also be used for amenity purposes and for wind farm maintenance during the operational phase.

The underpasses will take the form of precast concrete box culverts and will be founded on a competent stratum at depth. As a worst-case, the precast concrete boxes may need to be underpinned by piling.

Pathway: Extraction/excavation of peat and spoil and potential piling works

Receptor: Peat and underlying subsoil.

Pre-Mitigation Potential Impact: Negative, slight/moderate, direct, high probability, permanent effect on peat and subsoil due to excavation and relocation within the site.

Proposed Mitigation Measures:

Mitigation measures in respect of peat and subsoil excavation are outlined at Section 8.5.2.1.

Mitigation measures in respect of potential piling works are outlined at Section 8.5.2.5. The residual effect of all piling works is assessed in Section 8.5.2.5.

Mitigation measures to prevent soil / subsoil contamination (leaks / spills) are dealt with in Section 8.5.2.2 above and measures dealing with soil erosion are dealt with in Section 8.5.2.3. The residual effects of soil / subsoil contamination from leaks / spills is assessed in Section 8.5.3.2, and the residual effects of soil erosion are assessed in Section 8.5.2.3.

Residual Effect Assessment: The granular soil at the substation site can be classified as of "Medium" importance and the peat deposits at the site can be classified as of "Low" importance as the raised bog is already degraded by historical harvesting and drainage. The impact is the disturbance and relocation of c 5,640 m^3 of soil and subsoil during the construction of the underpass and the residual effect of this is considered - Negative, slight, direct, high probability, permanent effect on peat and subsoils due to excavation and relocation within the site.

Significance of Effects: No significant effects on soils and subsoils are anticipated.

8.5.2.9 Proposed Amenity Links

A total of approximately 18km of amenity pathways (including walkways and cycleways, and a carpark) will be provided as part of the construction of the proposed development. The amenity pathways will be mainly located on the proposed internal road network. These pathways will have a gravel/crushed stone finish surface.

In addition, approximately 6.5km of dedicated amenity pathways are proposed to provide access points/links into and out of the site as follows:

- Internal link to R437 allowing further access to Drinagh and Derrybrat and to facilitate potential future connection to Lough Boora Discovery Park.
- Link from the R357 and L7009 providing connectivity to the local Stonestown and wider Cloghan area.
- Link from the L7005 providing connectivity to the local Drinagh area.
- Link to the Bord na Móna boundary in Clongawny West to facilitate potential future connection to the R438.
- Link to the Bord na Móna boundary in southwest Drinagh to facilitate potential future connection to the proposed Whigsborough Walkway.

The proposed construction methodology for the amenity pathways is by floating road construction, with no requirement for additional excavation or spoil generation. Pathways will be created on the existing ground surface by adding crushed stone.

Pathway: Extraction/excavation of peat and soil/subsoils (spoil).

Receptor: Peat and underlying subsoil.

Pre-Mitigation Potential Impact: Negative, slight, direct, high probability, permanent effect on peat and subsoil.

Proposed Mitigation Measures:

Mitigation measures in respect of peat and subsoil excavation are outlined at Section 8.5.2.1.

Mitigation measures to prevent soil / subsoil contamination (leaks / spills) are dealt with in Section 8.5.2.2 above and measures dealing with soil erosion are dealt with in Section 8.5.2.3. The residual effects of soil / subsoil contamination from leaks / spills is assessed in Section 8.5.3.2, and the residual effects of soil erosion are assessed in Section 8.5.2.3.

Residual Effect Assessment: It is proposed to place amenity pathways on top of existing ground. Ground disturbance and peat and spoil relocation during these works will be minimal. As such the residual effects of these works are considered - Negative, imperceptible, direct, high probability, permanent effect on peat and subsoils by covering with 3m wide pathway.

Significance of Effects: No significant effects on soils and subsoils are anticipated.

8.5.2.10 Proposed Turbine Delivery Route Junction Works

A new temporary arrangement will be required at Kennedy's Cross, located in the townland of Ballindown, (junction of the N52 and N62 National Secondary Roads), comprising construction of a new road across third party lands, to facilitate the delivery of turbine components and other abnormal loads. The proposed new road will measure approximately 160 metres in length and have a 6-metre running width.

Pathway: Extraction/excavation of soil/subsoil.

Receptor: Soils and subsoils.

Pre-Mitigation Potential Impact: Negative, slight/moderate, direct, high probability, permanent effect on soil and subsoil.

Proposed Mitigation Measures:

Mitigation measures in respect of peat and subsoil excavation are outlined at Section 8.5.2.1.

Mitigation measures to prevent soil / subsoil contamination (leaks / spills) are dealt with in Section 8.5.2.2 above and measures dealing with soil erosion are dealt with in Section 8.5.2.3. The residual effects of soil / subsoil contamination from leaks / spills is assessed in Section 8.5.3.2, and the residual effects of soil erosion are assessed in Section 8.5.2.3.

Residual Effect Assessment: The proposed works footprint is small (960m^2), and there will be minimal disturbance to the local geology. As such the residual effects are considered as - Negative, direct, slight, high probability, permanent effect on local subsoils.

Significance of Effects: No significant effects on soils and subsoils are anticipated.

8.5.3 Operational Phase - Likely Significant Effects and Mitigation Measures

Very few potential direct impacts are envisaged during the operational phase of the Proposed Development. These may include:

- Some construction vehicles or plant may be necessary for maintenance of turbines which could result in minor accidental leaks or spills of fuel/oil; and,
- The transformer in the substation and transformers in each turbine are oil cooled. There is potential for spills / leaks of oils from this equipment resulting in contamination of soils and groundwater.
- In relation to indirect impacts a small amount of granular material may be required to maintain access tracks during operation which will place intermittent minor demand on local quarries.

None of these potential impacts are considered to be significant, as they are of such small scale and also of an intermittent nature.

Mitigation measures for soils and geology during the operational phase include the use of aggregate from authorised quarries for use in road and hardstand maintenance. Oil used in transformers (at the substation and within each turbine) and storage of oils in tanks at the substation could leak during the operational phase and impact on ground/peat and subsoils and groundwater or surface water quality. The substation transformer will be in a concrete bunded capable of holding 110% of the stored oil volume. Turbine transformers are located within the turbines, so any leaks would be contained within the turbine. These mitigation measures are considered sufficient to eliminate potential risks to ground/peat/soils and subsoils, and groundwater and surface water quality.

8.5.4 Decommissioning Phase - Likely Significant Effects and Mitigation Measures

The potential impacts associated with decommissioning of the proposed development will be similar to those associated with construction but of reduced magnitude.

During decommissioning, it may be possible to reverse or at least reduce some of the potential impacts caused during construction by rehabilitating construction areas such as turbine bases, hard standing areas. This will be done by covering with peatland vegetation/scraw or poorly humified peat to encourage vegetation growth and reduce run-off and sedimentation. Other impacts such as possible soil compaction and contamination by fuel leaks will remain but will be of reduced magnitude. However, as noted in the Scottish Natural Heritage report (SNH) Research and Guidance on Restoration and Decommissioning of Onshore Wind Farms (SNH, 2013) reinstatement proposals for a wind farm are made approximately 30 years in advance, so within the lifespan of the wind farm, technological advances and preferred approaches to reinstatement are likely to change. According to the SNH guidance, it is therefore:

> *"best practice not to limit options too far in advance of actual decommissioning but to maintain informed flexibility until close to the end-of-life of the wind farm".*

Mitigation measures applied during decommissioning activities will be similar to those applied during construction where relevant.

Some of the impacts will be avoided by leaving elements of the proposed development in place where appropriate. The substation will be retained by EirGrid. The turbine bases will be rehabilitated by covering with local topsoil/peat in order to regenerate vegetation which will reduce runoff and sedimentation effects. Internal roads will remain as amenity pathways. Mitigation measures to avoid contamination by accidental fuel leakage and compaction of soil by on-site plant will be implemented as per the construction phase mitigation measures.

No significant effects on the soils and geology environment are envisaged during the decommissioning stage of the proposed development.

8.5.5 Cumulative Effects

Due to the localised nature of the proposed construction works which will be kept within the proposed development site boundary, there is no potential for significant cumulative effects in-combination with other local developments on the land, soils and geology environment. The only way the wind farm proposal can have in combination effects with other off site projects and plans is via the drainage and off site surface water network, and this hydrological pathway is assessed in Chapter 9. The construction of the grid connection works will only require relatively localised excavation works within the site boundary and therefore will not contribute to any significant cumulative effects.

8.5.6 Post Construction Monitoring

None required.