Planning and Environmental Consultants

Environmental Impact Assessment Report Remedial

Derrybrien Wind Farm Development Decommissioning Project – Retained Development

Volume 2d: rEIAR Appendices 8-3 to 12-2 & 13-2 to 14-1

APPENDIX 8-3

PEAT STABILITY RISK ASSESSMENT (PSRA) FOR DECOMMISSIONING OF POLESETS PS-1A TO PS-4 OF DERRYBRIEN TO AGANNYGAL OVERHEAD LINE

PEAT STABILITY RISK ASSESSMENT FOR DECOMMISSIONING OF POLESETS PS-1A TO PS-4 OF THE 110kV DERRYBRIEN TO ANNYGAL OVERHEAD LINE (OHL)

for

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PEAT STABILITY RISK ASSESSMENT FOR DECOMMISSIONING OF POLESETS PS-1A TO PS-4 OF THE 110kV DERRYBRIEN TO ANNYGAL OVERHEAD LINE (OHL)

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PEAT STABILITY RISK ASSESSMENT FOR DECOMMISSIONING OF POLESETS PS-1A TO PS-4 OF THE 110kV DERRYBRIEN TO ANNYGAL OVERHEAD LINE (OHL)

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PEAT STABILITY RISK ASSESSMENT FOR DECOMMISSIONING OF POLESETS PS-1A TO PS-4 OF THE 110kV DERRYBRIEN TO ANNYGAL OVERHEAD LINE (OHL)

1 INTRODUCTION

This report presents the results of the Peat Stability Risk Assessment (PSRA) that was carried out for the decommissioning of Polesets PS-1a to PS-4 at the upper end of the 110kV Overhead Line (OHL) between the Derrybrien Wind Farm and the Annygal Substation. The location of the polesets is shown on Figure 1-1.

The assessment has been carried out in accordance with the best practice guidelines in "Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (Second Edition, April 2017)", by the Scottish Government Energy Consents Unit. The method of risk assessment is also consistent with the Institution of Civil Engineers' publication outlining UK best practice in "Managing Geotechnical Risk" (Clayton, 2001).

The 700m longsection of the OHL between polesets PS-1a and PS-4 has been split up into 2 No. representative zones with similar characteristics in terms of the peat depths, peat strengths and site topography: **Zone A**: PS-1a & PS-2 & **Zone B:** PS-3 & PS-4, as shown in Figure 1-2.

A qualitative risk assessment has been carried out for each zone to assess the **Risk Rating (R)** for a peat failure occurring during decommissioning of the OHL and twin polesets based on the interpreted **Likelihood (L)** (i.e. probability) of occurrence and **Impact (I)** of failure.

The **Likelihood (L)** of a peat failure has been assessed on a scale of 1-5 by evaluating factors related to peat and subsoil conditions, topography, site hydrology/hydrogeology and other significant contributory factors such as subsurface drainage, slide history and land use to determine where compounding conditions that could lead to an elevated risk of peat instability.

The potential **Impact (I)** of a peat failure in the area has been assessed on a scale of 1-5 by evaluating factors related to the potential volume of peat, degree of contamination, sensitivity of the receiving environment, access for intervention, and the land use and existing infrastructure within the potential run-out distance of a peat slide.

A **Risk Rating (R=L x I)** has then been calculated for each zone to characterise the risk of peat instability during decommissioning on a scale of 1-25, as summarised in Table 1-1.

The assessment was initially carried out for the existing site conditions prior to mitigation to identify where specific operational mitigation measures are required to reduce the risk of peat instability to an acceptable level.

The potential likelihood of a peat failure was then re-assessed for the site activities that will be carried out in the area during decommissioning of the 110kV OHL and twin polesets using appropriate mitigation measures and construction methodologies to minimise the impact on peat stability. It has been conservatively assumed that the mitigation measures that will be adopted will not reduce the potential impact of a peat slide in the area.

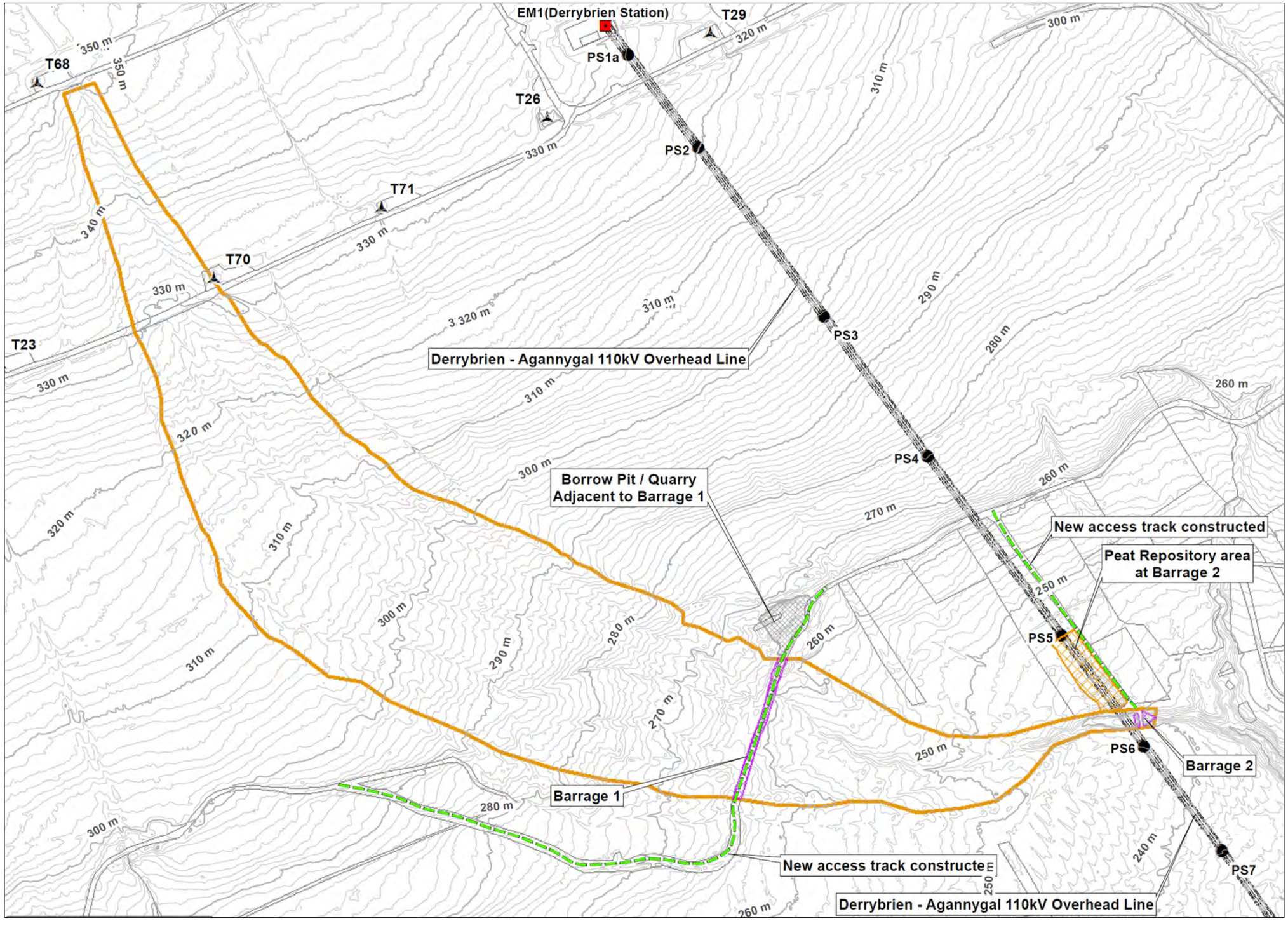


Figure 1-1 - Location of Polesets PS-1a to PS-4 along 110kV Derrybrien to Annygal Overhead Line (OHL)

Table 1-1 - Risk Rating Levels and Response

Risk Rating (R = L X I)		Response
1 to 5	Low (Trivial)	Monitor
6 to 10	Low to Medium (Tolerable)	Regular Attention
11 to 15	Medium (Significant)	Early Attention
16 to 20	Medium to High (Substantial)	Unacceptable
21 to 25	High (Intolerable)	Unacceptable

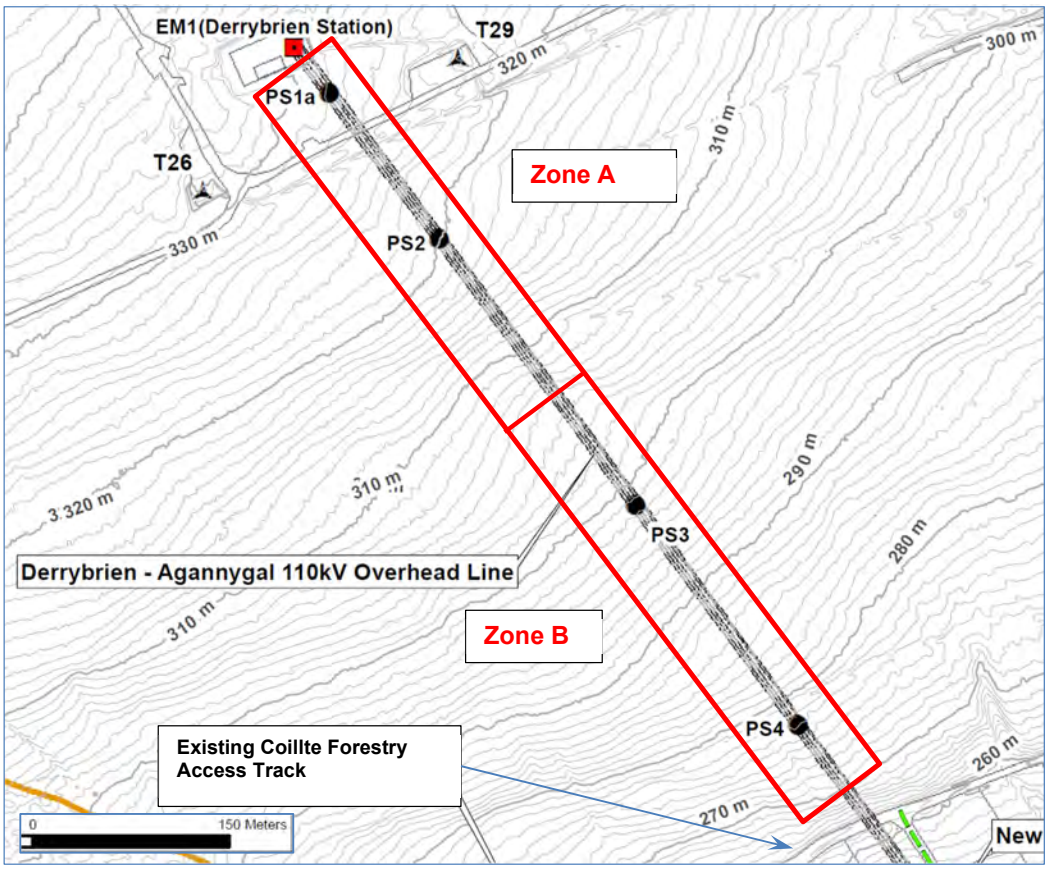


Figure 1-2 PSRA Zones for Polesets PS-1a to PS-4 along the 110kV Derrybrien-Agannygal OHL

2 PEAT STABILITY RISK ASSESSMENT (PSRA) PRIOR TO MITIGATION

Figure 2-1 shows the interpreted Risk Rating (R) for a peat slide occurring in the area based on the existing site conditions prior to the implementation of appropriate risk mitigation measures for decommissioning.

The **Likelihood** of peat slide in both areas prior to mitigation has been interpreted as **Possible (L=3)** using the worksheets in Appendix A. Other than the proximity to 2003 slide, which was 550m to the west on the same side of the mountain, there are no significant compounding high risk factors for peat instability along this section of the OHL. The interpreted likelihood of a peat slide is governed by the intermediate peat depths (1.0-2.2m) and relatively low peat strengths (c_u = 5.0-7.5kPa) that were recorded in the area combined with the convex breaking slopes to angles >5° at the polesets due to the terraced profile of the slopes. The polesets have generally been constructed on the more gently sloping terraces with slopes <4-5°.

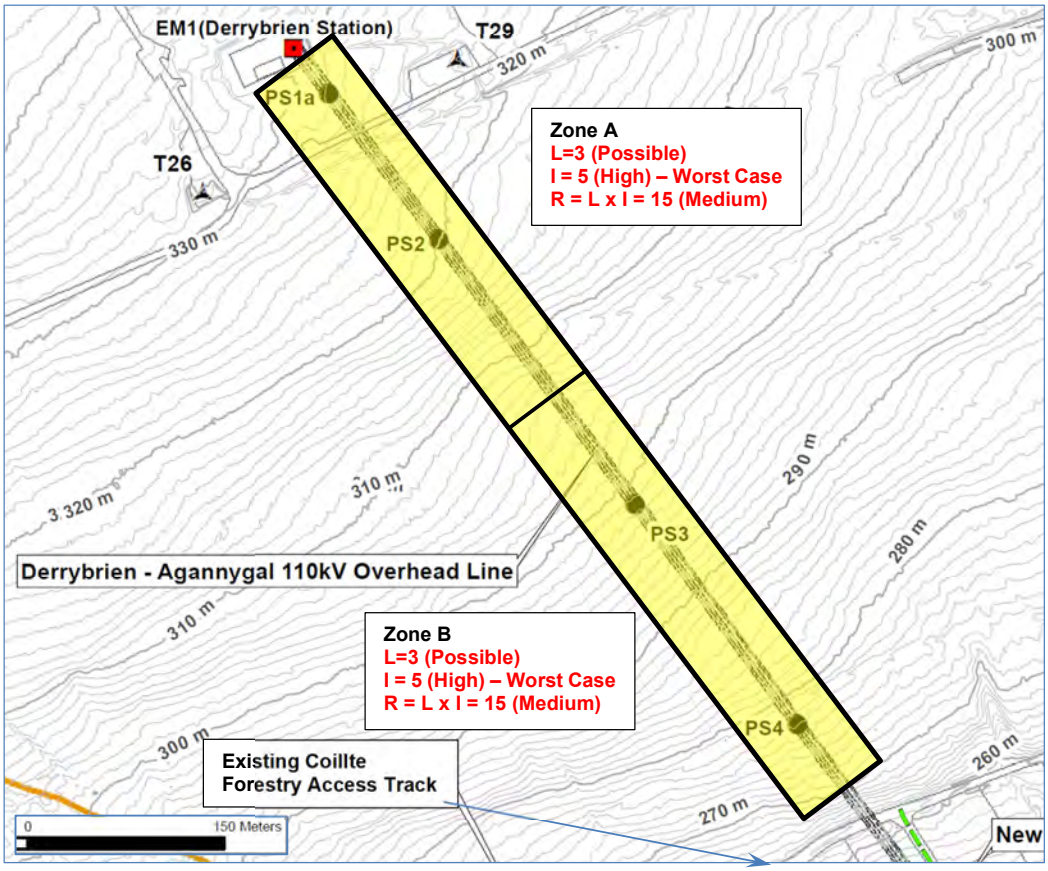


Figure 2-1 Interpreted Risk Rating (R) for a peat slide along OHL between PS-1a and PS-4 for existing conditions prior to mitigation

The conditions are slightly more unfavourable in Zone A (PS-1a & PS-2), where the peat is up to 1.9-2.2m deep and the lowest shear strengths were recorded (c_u = 5.0kPa).

In Zone B (PS-3 & PS-4) the peat depth was lower (1.0-1.9m) and the shear strengths were slightly higher (c_u = 7.5kPa). The slopes are locally steeper (up to 7°-10°) downslope from the polesets but the peat depths is shallower <0.5-1.0m.

Surface water conditions on the slopes are dry and favourable and there is no evidence of concentrated subsurface groundwater flow and the polesets are not located in a buried valley upslope from one of the streams on this side of the site.

The potential **Impact (I)** of a peat slide in the area has been assessed considering a large scale peat slide as the worst case scenario. The depth of peat reduces to 0.0-1.0m on the steep slopes downslope from PS-4, which will mitigate the extent and potential impact of a peat slide in this area. The existing Coillte track in the area is also constructed on glacial till or rock below the peat, which will impede the progression of a slide downslope from the track. Therefore, the potential Impact of a peat slide would be lower than the slide that occurred on the site in 2003 during construction.

In the worst case scenario, a large scale peat slide in the area under uncontrolled conditions could involve displacing approximately 35,000-50,000m^3 of peat up to 1.0-2.2m deep over an area of about 25Ha along the line of PS-1a to PS-4. The land within and downslop of the potential slide area is comprised of degraded blanket bog and coniferous forestry, which is of

low ecological importance. However, some of the remoulded peat slurry and organic sediment could enter the valley for the Owendalulleagh River and flow for a considerable distance downslope, potentially contaminating the watercourses and lakes downstream from the site, which would have a higher impact. There are also public roads on this side of the site which could be impacted by a peat slide. Therefore, the potential impact of a peat slide in the area has been assessed as **I=5 (High)**.

The resulting **Risk Rating**, R**,** for a peat slide in Zone A & Zone B prior to mitigation would be **R=15 (Medium)**, which is **Significant** requiring **Early Attention** based on the criteria in Table 1-1.

3 PEAT STABILITY RISK ASSESSMENT (PSRA) FOR DECOMMISSIONING

Decommissioning the OHL and twin polesets will involve trafficking across the surface peat to get to the polesets to take down the OHL, cut down the timber poles and transport them off site. This work will be carried out using low ground-bearing pressure wide-tracked excavators and ATVs suitable for working directly on the peat, similar to the equipment that would have been used to fell the conifer forests that were originally along the OHL corridor. The foundations for the polesets will also be left in place so there will be no excavations or temporary surcharge loading on the peat with spoil. Therefore, the Likelihood of a peat slide occurring during decommissioning of the OHL in Zones A & B under controlled conditions has been interpreted as **L=2 (Low).**

It has been conservatively assumed that the proposed construction methodology cannot reduce the potential Impact of a peat slide. Therefore, assuming that a large scale peat slide (35,00-50,000m^3) could occur in the worst case scenario, the potential Impact of the slide has been assessed as **I=5 (High)**.

Based on the criteria in Table 1-1, the corresponding **Risk Rating**, R**,** for a peat slide in Zone A & Zone B during decommissioning is **R=10 (Low to Medium)**, which is **Tolerable** requiring **Regular Attention** during the works, as illustrated in Figure 3-1.

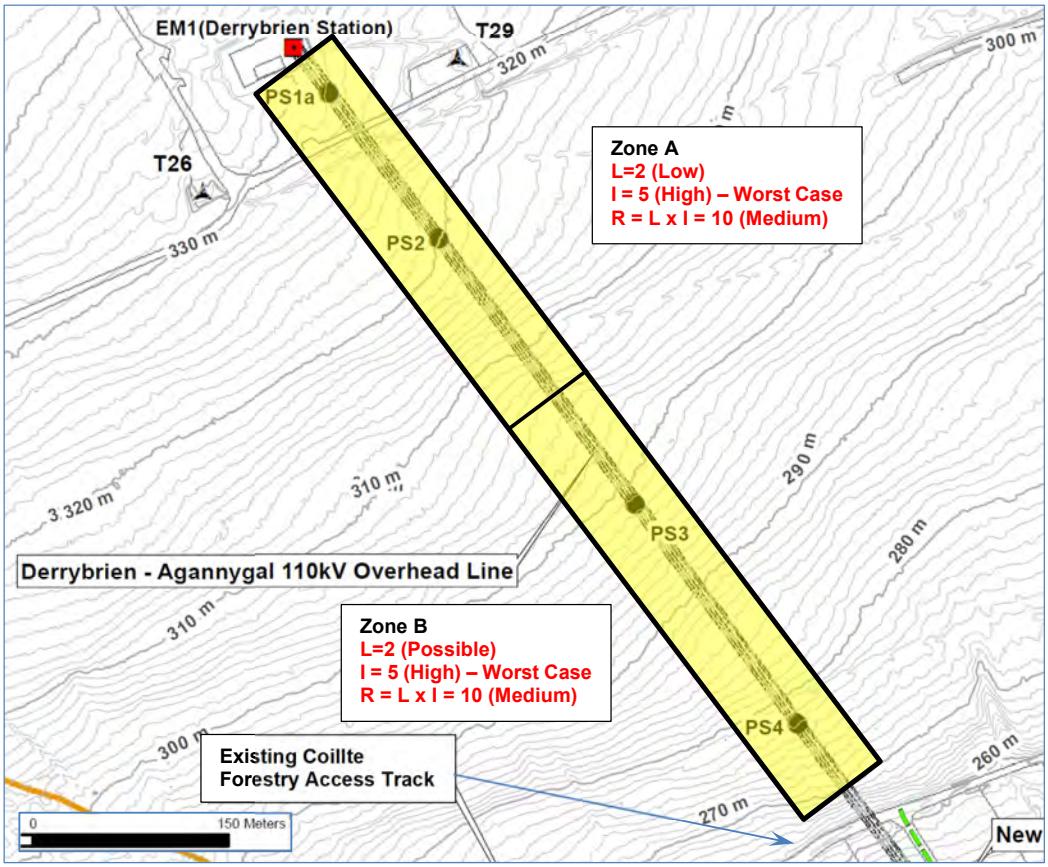


Figure 3-1 Interpreted Risk Rating (R) for a peat slide along OHL between PS-1a and PS-4 for proposed methodology for decommissioning.

Appendix A

Zonal Peat Stability Assessment (ZPSA) Worksheets

AGL CONSULTING GEOTECHNICAL ENGINEERS	**Derrybrien to Annygal 110kV Overhead Line (OHL) Peat Stability Assessment Worksheet (Hazard Likelihood) Zone A - Polesets P1a & P2**		
Factor	**Characteristic properties:**	**Hazard Rating**	
Peat/Subsoil Conditions	• **Peat depth:** 1.4 to 2.2m for PS-1a & PS-2 • **C_u (Geonor H-60) in Peat:** 5kPa (Conservatively use lower bound from ESBI VST data 2004-2005 – Geotech AB 140 x 280mm Vane). • **Water Content:** 1000-1500%* • **Max degree of humification:** H8-H10* • **Stability of peat in trial pits:** Slight spalling* • **Soft Clay layer at base of peat?:** No***** • **Subsoil conditions:** Cohesive Glacial Till*****	H	15
Topography	• **Slope angles:** Generally 4° at Polesets; locally steeper 5-6° between. • **General slope characteristics:** Polesets on intermediate slopes near the top of the mountain. Convex breaking slopes to steeper slopes south of PS-2. • **In broad flat or buried valley directly upslope from a watercourse?:** No • **Altitude:** 305-330mOD	H	10
Factors of Safety (Infinite Slope based on assumed min. Cu & worst case scenario)	**No surcharge:** • ****cu = 5kPa:** 2.9-3.9 • ****cu = 2.5kPa**: 1.4-2.0 – worst case scenario w/no surcharge; **13kPa surcharge (1m of Peat w/partial factor of 1.3)** • ****c_u = 5kPa:** 1.5-2.0 • ****c_u = 2.5kPa:** ≈ 1.0-1.5 – worst case scenario w/surcharge **Undrained shear strength at base of Peat*	H	10
Hydrology/ Hydrogeology	• **Surface Water:** Surface generally dry under foot. • **Drainage:** Generally well drained with downslope drains/furrows on steeper slopes and cross slope drains along firebreaks on terraces. • **Seepage in trial pits:** No trial pits – assume generally good groundwater conditions due to steeper slopes in the area. • **Evidence of piping/subsurface flow:** No	M	5
Significant Contributory Factors	• **Slide History:** Main slide area approximately 550m to west on same side of mountain. • **Tension Cracks:** No. • **Piping:** No • **Vegetation:** Conifer plantations felled along OHL. • **Peat Harvesting:** No	M	10
Notes: **1. Max hazard rating for each factor = 20 and ratings are assigned on the basis of interpreted significance, as follows: Negligible = 0, Low = 5, Medium = 10, High = 15, Very High = 20.** **2. Hazard Likelihood (L) prior to mitigation measures is interpreted from Total Hazard Rating as follows: 0-19: L=1 (Negligible); 20-39: L = 2 (Low); 40-59 L = 3 (Possible); 60-79: L = 4 (Very Possible); 80-100: L = 5 (Likely without appropriate mitigation measures).** ***Values conservatively assumed where information is not available based on general experience in this part of site.** **** Conservatively assumed Cu = 5kPa as lowest undrained shear strength for general condition at base of peat. 2.5kPa considered as worst case scenario if weak layer is present.**		**Total Hazard Rating**	50
		Hazard Likelihood (L)	3

AGL CONSULTING GEOTECHNICAL ENGINEERS	**Derrybrien to Annygal 110kV Overhead Line (OHL) Peat Stability Assessment Worksheet (Hazard Likelihood) Zone B - Polesets P3 & P4**		
Factor	**Characteristic properties:**	**Hazard Rating**	
Peat/Subsoil Conditions	• **Peat depth:** 1.0 to 1.9m for PS-3 & PS-4, <1.0m downslope from PS-4 • **C_u (Geonor H-60) in Peat:** 7.5-10kPa (Conservatively use lower bound from ESBI VST data 2004-2005 – Geotech AB 140 x 280mm Vane). • **Water Content:** 500-1000%* • **Max degree of humification:** H6-H8* • **Stability of peat in trial pits:** Stable* • **Soft Clay layer at base of peat?:** No***** • **Subsoil conditions:** Cohesive Glacial Till*****	H	10
Topography	• **Slope angles:** Locally 3.5-5.0° at Poleset PS-3; steeper 5-7° downslope to PS-4. Very steep slopes >10.0° in shallow peat downslope from PS-4. • **General slope characteristics:** Poleset PS-3 on terrace with convex break in slope to steep slopes down to PS-4. Convex break in slope to steep slopes >10° downslope from PS-4. • **In broad flat or buried valley directly upslope from a watercourse?:** No • **Altitude:** 265-305mOD	H	10
Factors of Safety (Infinite Slope based on assumed min. Cu & worst case scenario)	**No surcharge:** • ****cu = 5kPa:** 3.0-3.9 • ****cu = 2.5kPa**: 1.5-2.0 – worst case scenario w/no surcharge; **13kPa surcharge (1m of Peat w/partial factor of 1.3)** • ****c_u = 5kPa:** 1.6-2.0 • ****c_u = 2.5kPa:** ≈ 0.8-2.0 – worst case scenario w surcharge **Undrained shear strength at base of Peat*	H	5
Hydrology/ Hydrogeology	• **Surface Water:** Surface generally dry under foot. • **Drainage:** Generally well drained with downslope drains/furrows on steeper slopes and cross slope drains along firebreaks on terraces. • **Seepage in trial pits:** No trial pits – assume generally good groundwater conditions due to steeper slopes in the area. • **Evidence of piping/subsurface flow:** No	M	5
Significant Contributory Factors	• **Slide History:** Main slide area approximately 550m to west on same side of mountain. • **Tension Cracks:** No. • **Piping:** No • **Vegetation:** Conifer plantations felled along OHL. • **Peat Harvesting:** No	M	10
Notes: **1. Max hazard rating for each factor = 20 and ratings are assigned on the basis of interpreted significance, as follows: Negligible = 0, Low = 5, Medium = 10, High = 15, Very High = 20.** **2. Hazard Likelihood (L) prior to mitigation measures is interpreted from Total Hazard Rating as follows: 0-19: L=1 (Negligible); 20-39: L = 2 (Low); 40-59 L = 3 (Possible); 60-79: L = 4 (Very Possible); 80-100: L = 5 (Likely without appropriate mitigation measures).** ***Values conservatively assumed where information is not available based on general experience in this part of site.** **** Conservatively assumed Cu = 5kPa as lowest undrained shear strength for general condition at base of peat. 2.5kPa considered as worst case scenario if weak layer is present.**		**Total Hazard Rating**	40
		Hazard Likelihood (L)	3

TABLE A1 – PEAT/SUBSOIL CONDITIONS	Rating			
	Negligible	Low	Medium	High
Peat				
Peat Depth	<0.5 m	0.5 - 1.0	1.0 - 2.0	>2.0
Water Content	0-500%	500-1000%	1000-1500%	>1500%
Min Peak Undrained Shear Strength	>20 kPa	10-20 kPa	5-10 kPa	<=5 kPa
Peat Classification at c_u min	Very Fibrous	Fibrous	Pseudo-Fibrous/Slightly Fibrous	Amorphous/ Clayey
Stability of peat in trial pits	Stable	Slight spalling	Collapse @ >3 m Depth	Collapse/squeezing <3 m Depth
Very Soft Clay Layer Below Peat [applies to uniform clay of high plasticity, & excludes well-graded gravelly Cohesive Glacial Till or decomposed rock]				
Very soft clay layer at base of peat	No			Yes
Sensitivity Coefficient ($c_{u\ peak}/c_{u\ residual}$)	1.0	1.0-1.5	1.5 - 2.0	>2
Peak Undrained Shear Strength	>20 kPa	10-20 kPa	5-10 kPa	<=5 kPa
Residual Undrained Shear Strength	>20 kPa	10-20 kPa	5-10 kPa	<=5 kPa
Transition - Peat to Mineral Soil				
Sharp discontinuity (possible or potential shear plane) identified in peat or at base of peat in trial pits, probes or piston samples	No			Yes
Underlying Mineral Soil/Rock				
Granular soil/Fractured rock at base of peat	No			Yes
Nested Flat Boulders	No			Yes
Rock below Peat - Interface Characteristics	Rough/ Weathered	Rough/Fractured	Smooth Undulating	Smooth Planar

TABLE A2 - TOPOGRAPHY	Rating			
	Negligible	Low	Medium	High
Slope Angle	**Flat**	**Shallow**	**Intermediate**	**High**
Slope Angle - Ground Surface	**<1°**	**1-3°**	**3°-5°**	**>5°**
Slope Angle - Base of Peat	**<1°**	**1-3°**	**3°-5°**	**>5°**
In broad valley upslope from defined watercourses	**No**	**Yes, slopes <3°**	**Yes, slopes 3-5°**	**Yes, slopes > 5°**
Distance from topographical low-point upslope from defined watercourses	**>250 m**	**100-250 m**	**50-100 m**	**<50 m**
General slope characteristics downslope from road/turbine	**Concave**	**Planar to Concave**	**Planar to Convex**	**Convex**
Distance from break in convex slope	**>100 m**	**50-100 m**	**10-50 m**	**<10 m**

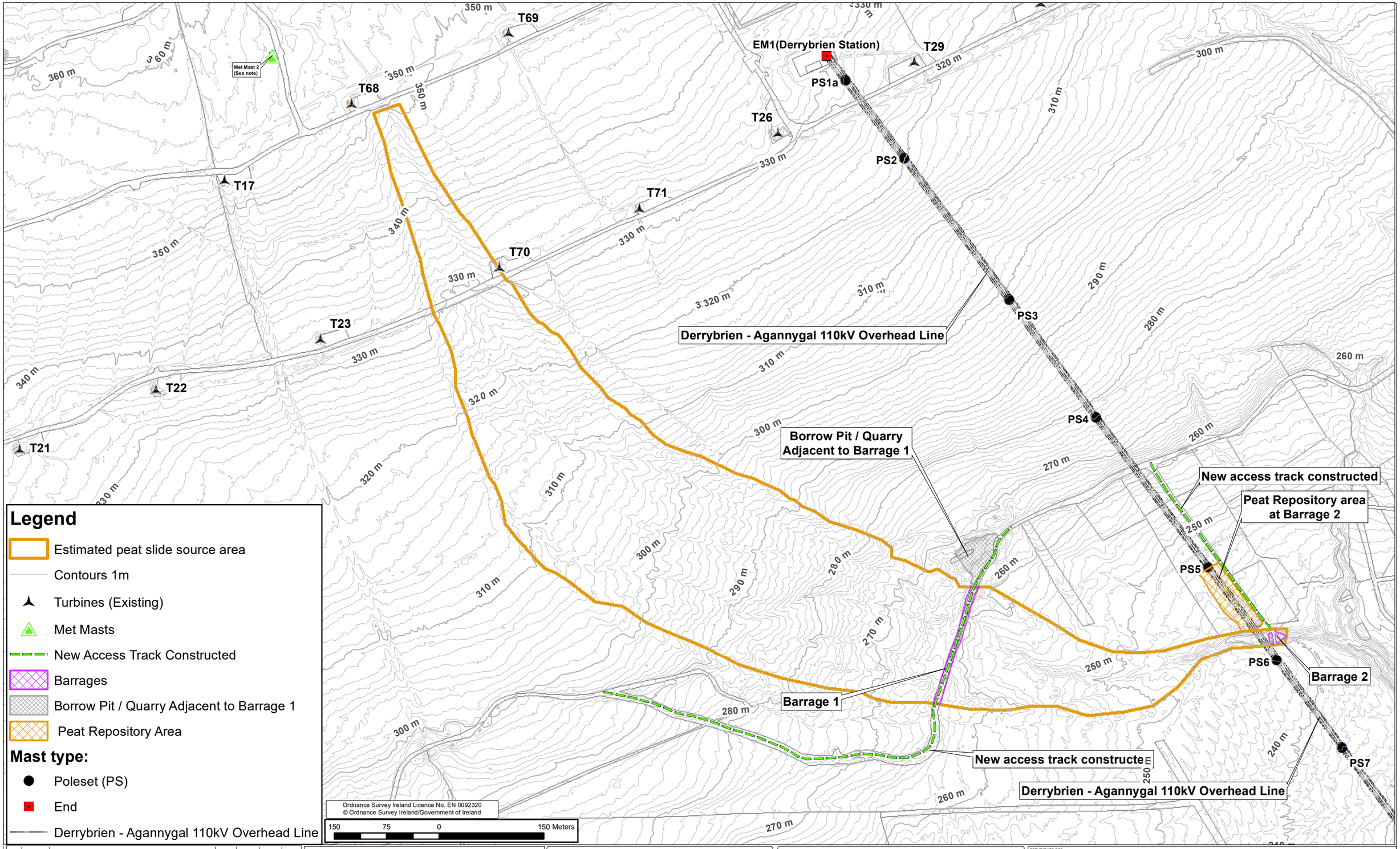
TABLE A3 – FACTOR OF SAFETY CALCULATIONS (INFINITE SLOPE)	Rating			
	Negligible	Low	Medium	High
FOS Infinite Slope - No Surcharge (Existing Condition)				
c_u = 5kPa (or minimum)	>3	2.0 - 3.0	1.5 - 2.0	<1.5
c_u = 2.5kPa (Worst Case)	>2	1.5 - 2.0	1.0 - 1.5	<1.0
FOS Infinite Slope - Surcharge of 1.0m Peat with Partial Factor = 1.3				
c_u = 5kPa (or minimum)	>3	2.0 - 3.0	1.5 - 2.0	<1.5
c_u = 2.5kPa (Worst Case)	>2	1.5 - 2.0	1.0 - 1.5	<1.0
FOS - Floating Road				
Planar Sliding (c_u = 5kPa)	>2	1.4 - 2.0	1.0 - 1.4	<1.0
Bearing Capacity	>2	1.4 - 2.0	1.0 - 1.4	<1.0
Extrusion	>2	1.4 - 2.0	1.0 - 1.4	<1.0

TABLE A4 – HYDROLOGY/HYDROGEOLOGY	Rating			
	Negligible	Low	Medium	High
Surface water	Dry	Localised/ Flowing in Drains	Ponded in drains	Springs/Surface Water
Existing drainage ditches	None/ Downslope	Varied (Gen. Downslope)	Varied (Gen. Across Slope)	Across slope
Groundwater observations in peat in trial pits.	Dry	Slight Seepage	Moderate Seepage	Strong Flow
Piping observed in trial pits	No	Slight Flow/Small Dia. (<25 mm)	Moderate Flow/Medium Dia. (25-50 mm)	Strong Flow/Large Dia. (>50 mm)
Seepage at Base of Peat	No			Yes
Evidence of piping from walkover survey	No	Possibly	Probably	Yes

TABLE A5 – OTHER CONTRIBUTORY FACTORS	Rating			
	Negligible	Low	Medium	High
Slide History				
Evidence of historic slides		General Area	On Site	<1 km
Tension Cracks in Peat				Yes
Aerial Photography				
Evidence of historic slides in area		Possibly	Probably	Yes
Evidence of subterranean drainage/piping		Possibly	Probably	Yes
Other notable contributory features		Possibly	Probably	Yes
Vegetation				
Tree Growth (Coniferous Forestry)	Good		Fair	Poor
Vegetation (no trees)	Grass/Crops	Improved Grass/Dry Heather	Wet grassland/juncus	Wetlands Sphagnum/ sedge
Land Use				
Peat Workings	None/Cutaway to <0.5 m Peat	Forestry	Turbury Plots	Sausage Cutter

Appendix B

Information On Site Characteristics, Peat Depth,
Peat Strength & Topography



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PURPOSE OF ISSUE - PRELIMINARY UNLESS INDICATED

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CLIENT REF.	NO. OF SHEETS	SIZE	SCALE
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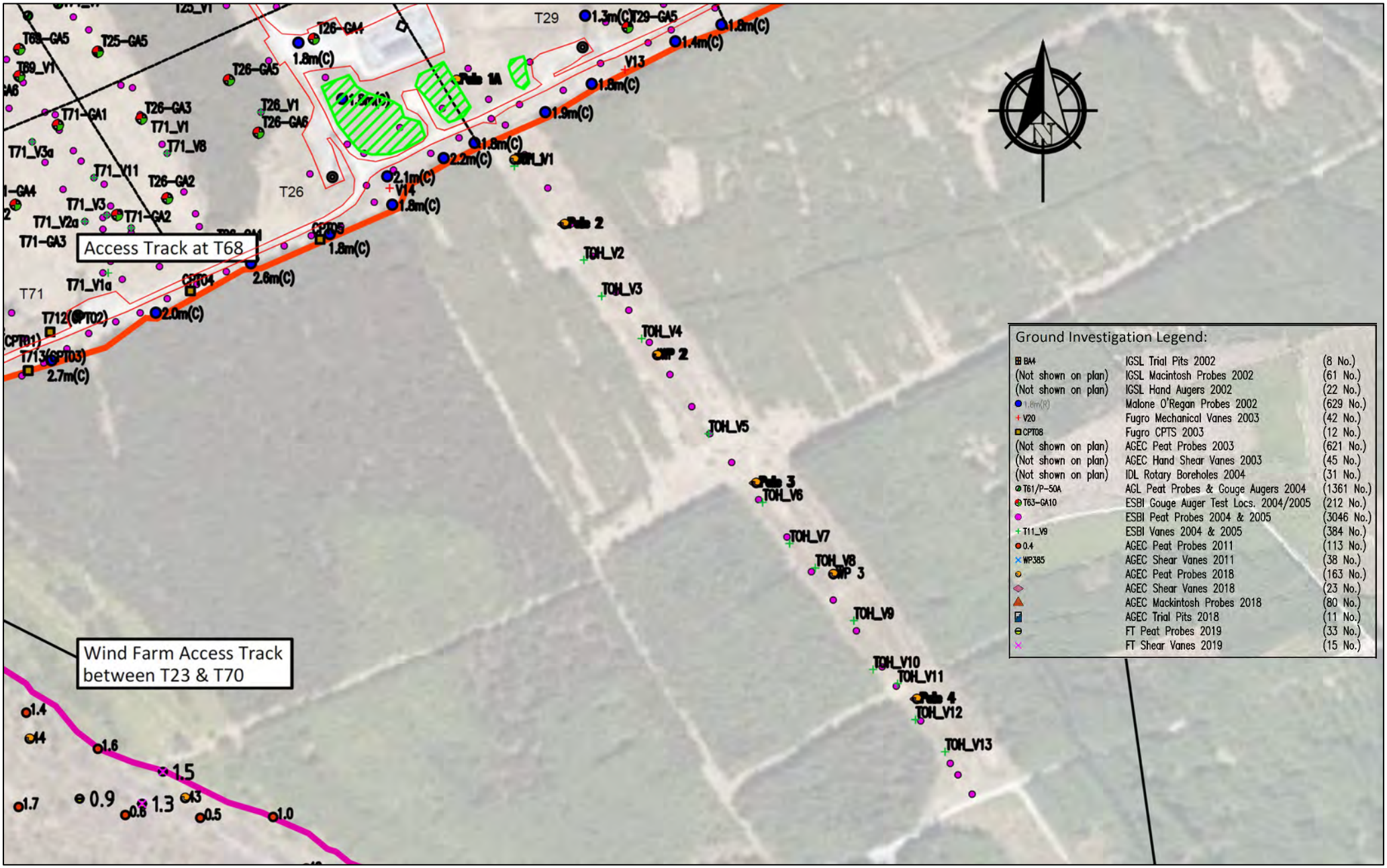

Figure 1 – Site Investigation Location Plan

Figure 2 – Aerial Photograph (Google Earth 2020)

Figure 3 – Hydrology & Ground Level Contours along OHL

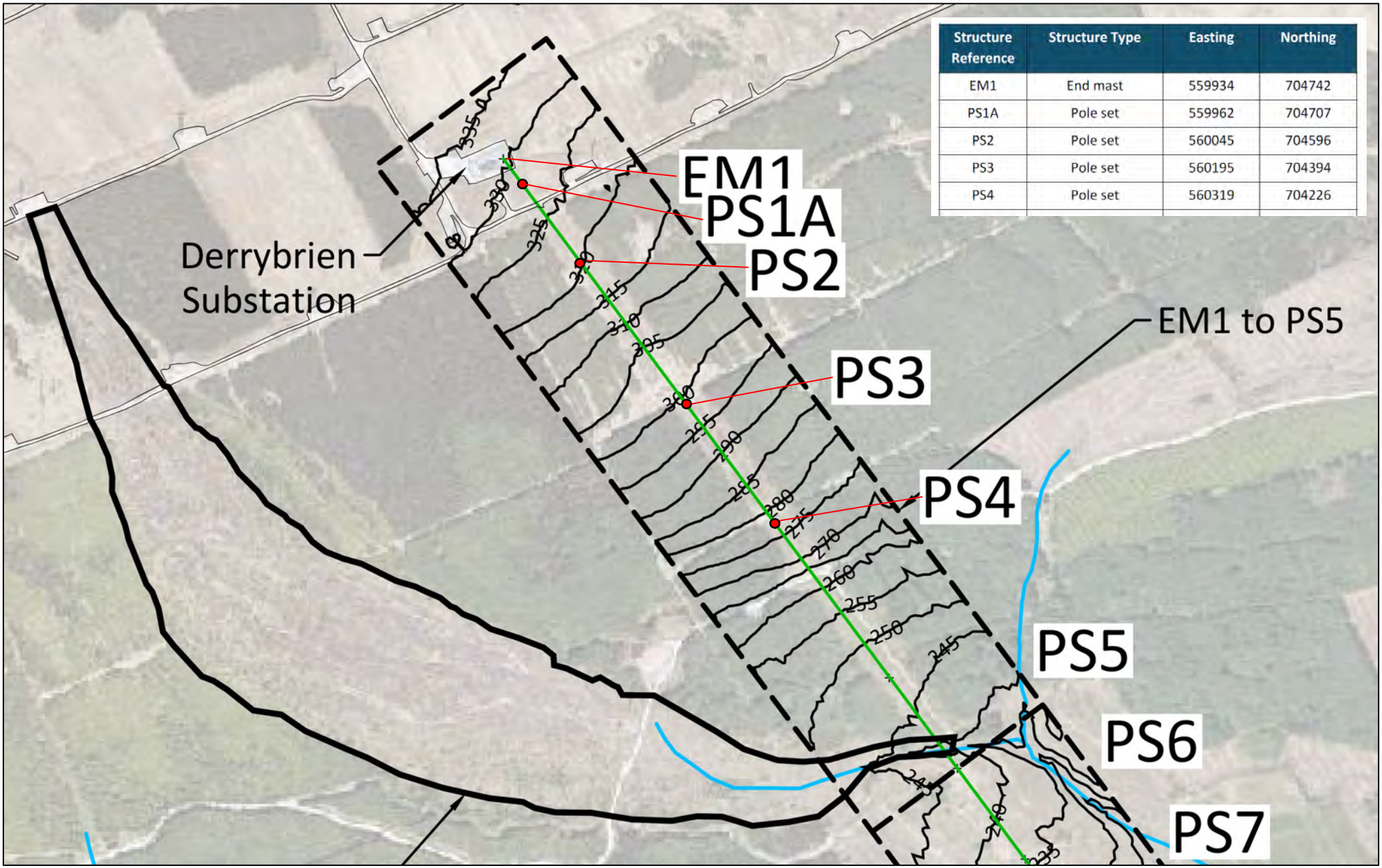

Figure 4 – Hydrology & Ground Level Contours along OHL PS-1A to PS-7

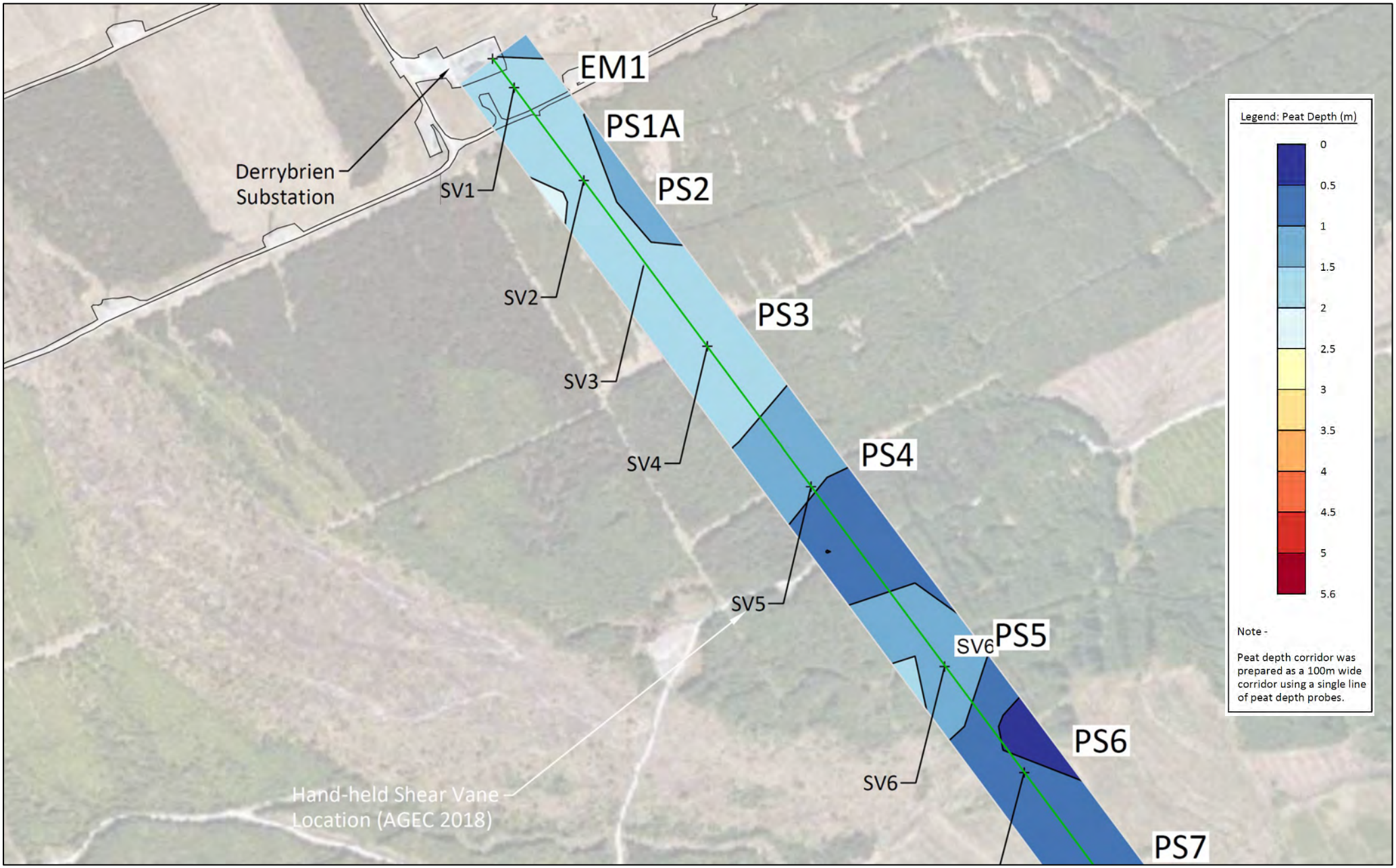

Figure 5 – Peat Depth along OHL PS-1A to PS-7

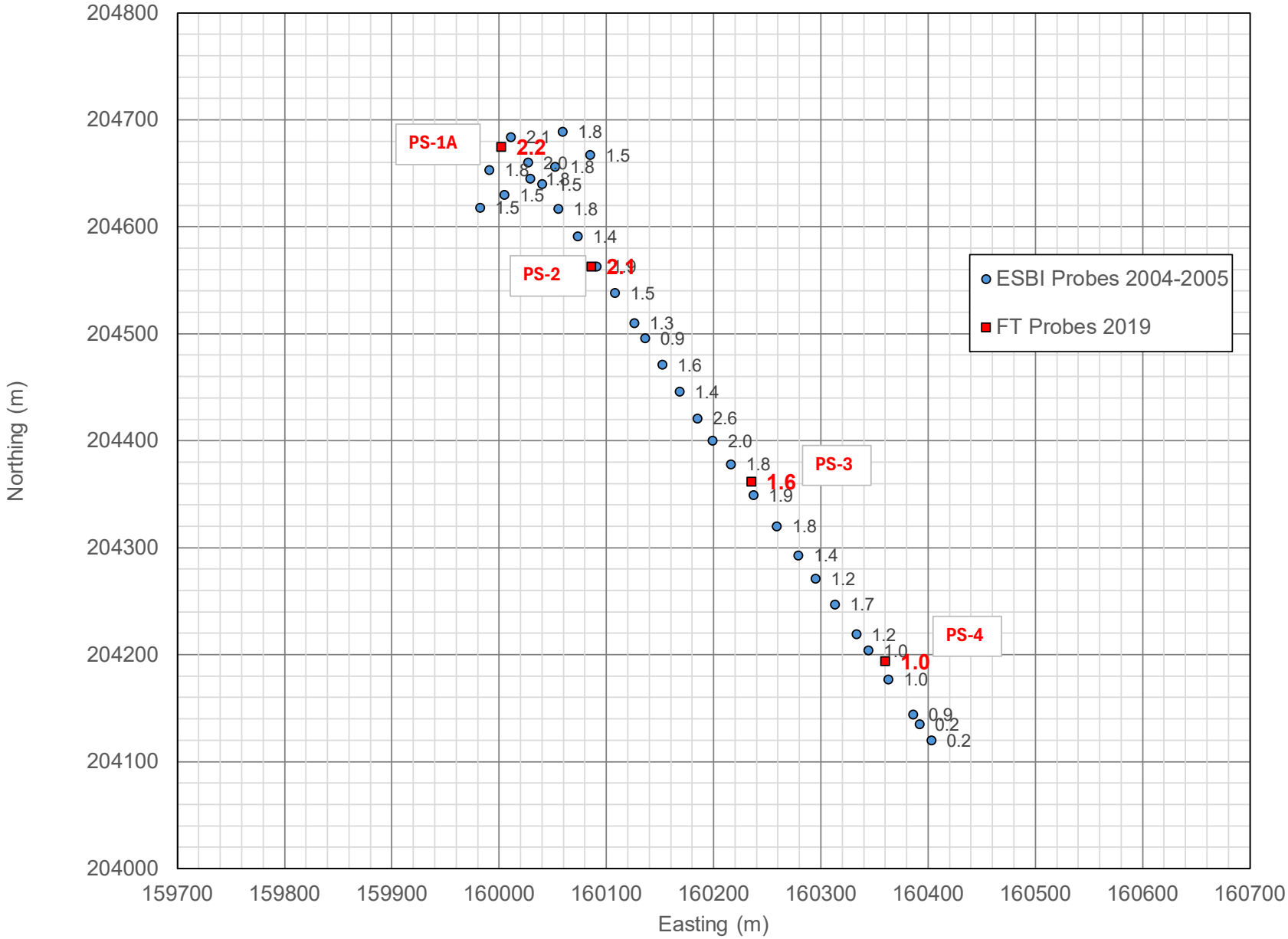

Figure 6 – Peat Depth from hand probes by ESBI (2004-2005) and Fehily Timoney (FT) along OHL PS-1A to PS-4

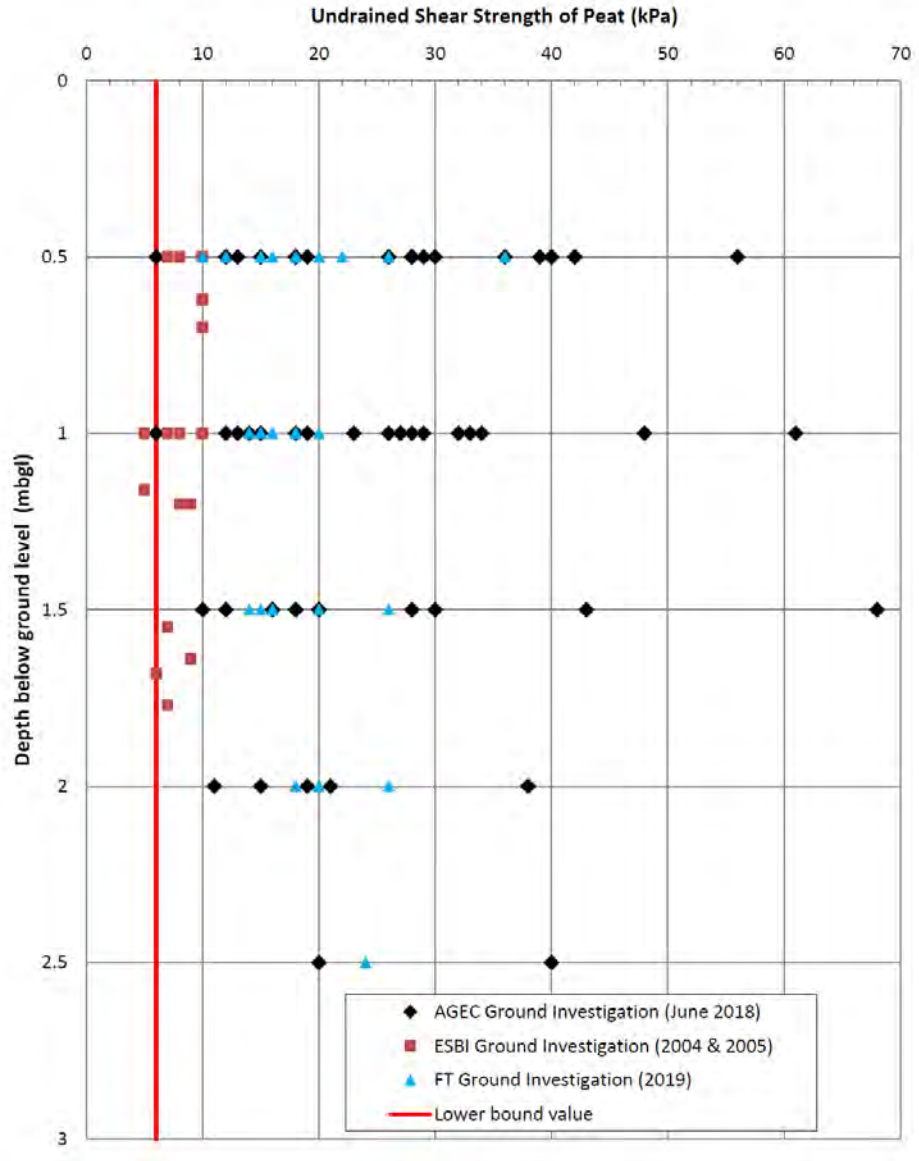

Figure 7 – Undrained Shear Strength, c_u, of Peat along OHL route measured by hand vane

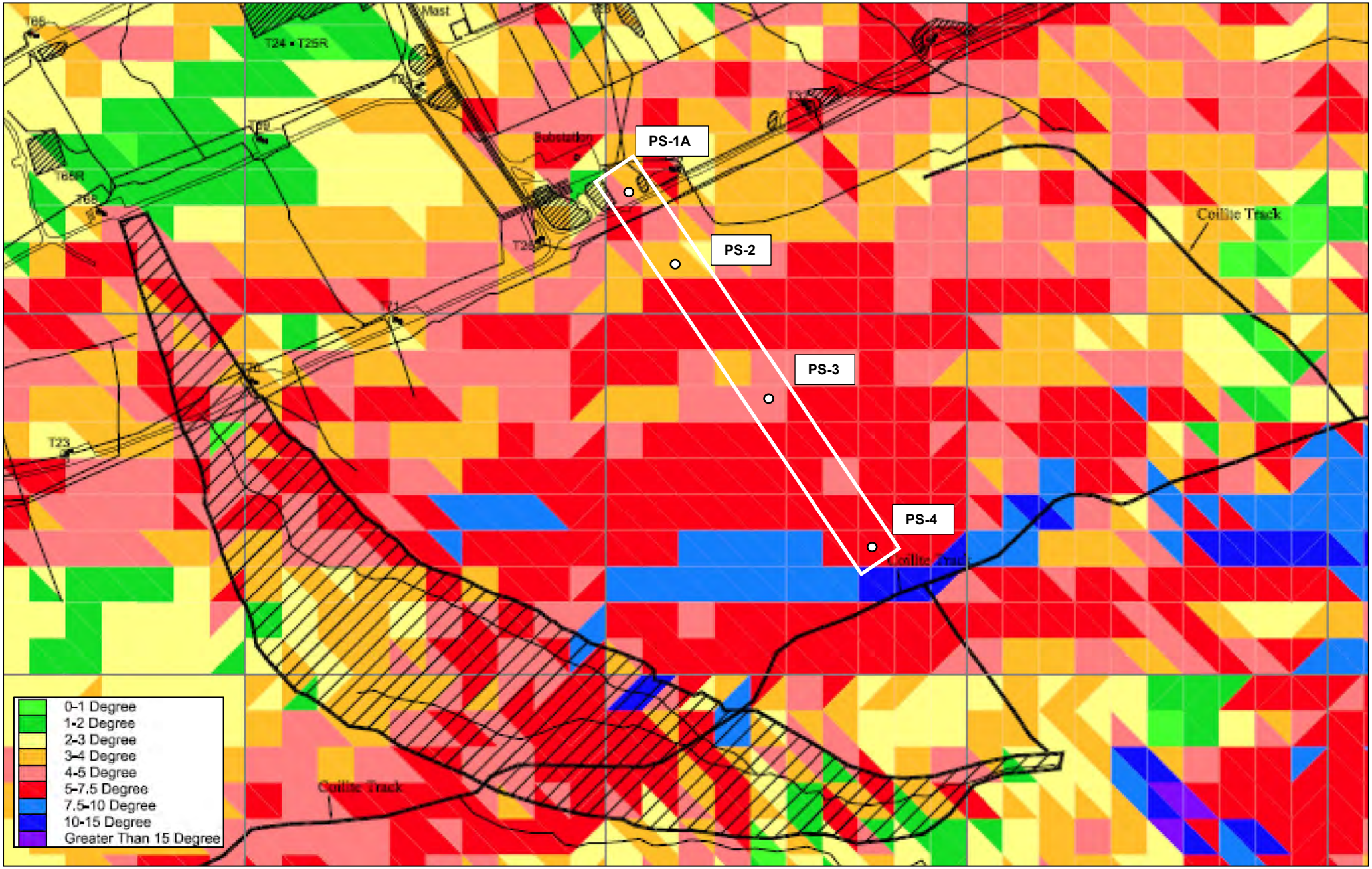

Figure 8 – Slope Angles along OHL PS-1A to PS-4

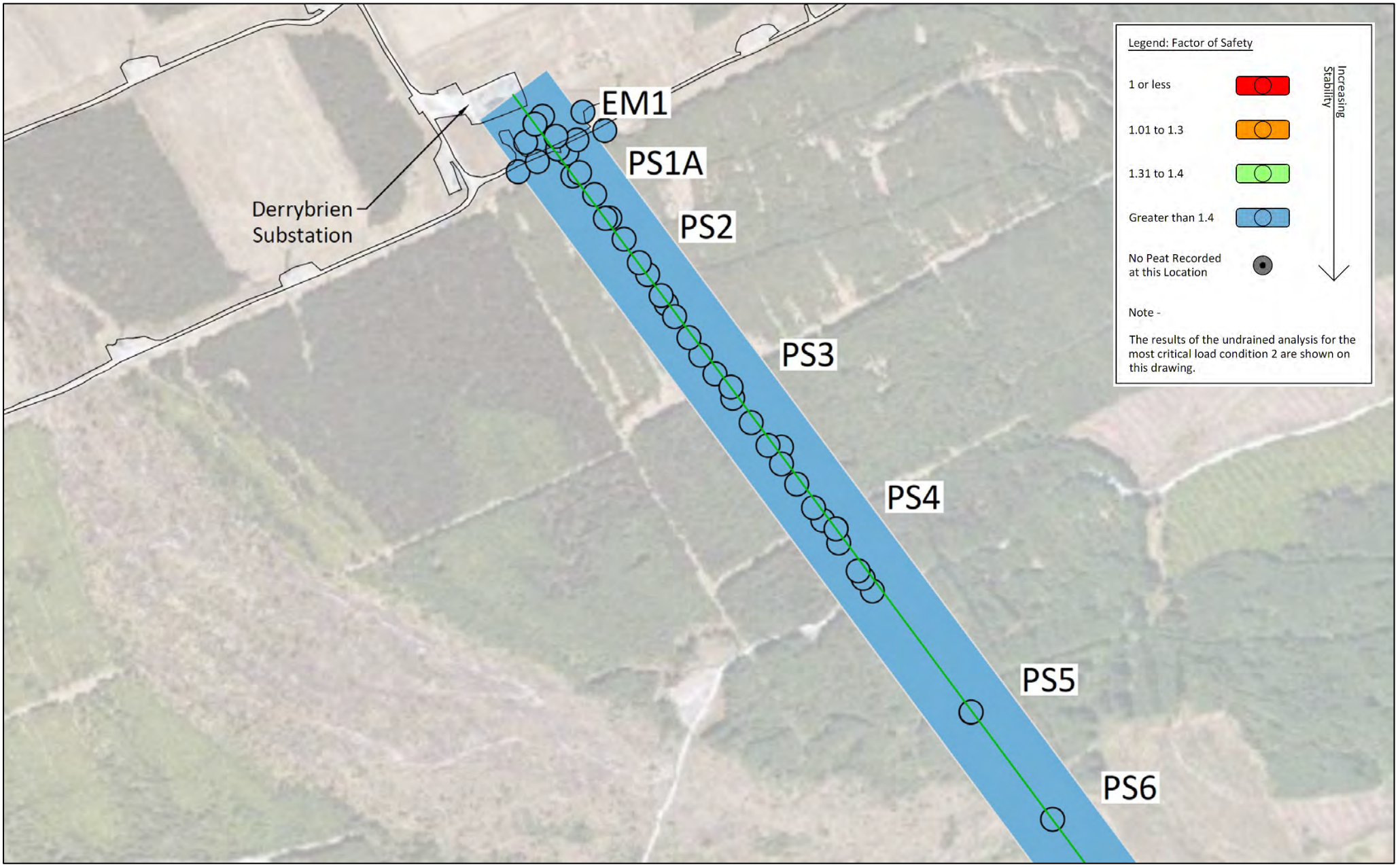

Figure 9 – Calculated Infinite Slope Factor of Safety (FoS) – Undrained Condition with 10kPa Surcharge (Condition 2 with c_u = 6kPa) along OHL PS-1A to PS-6

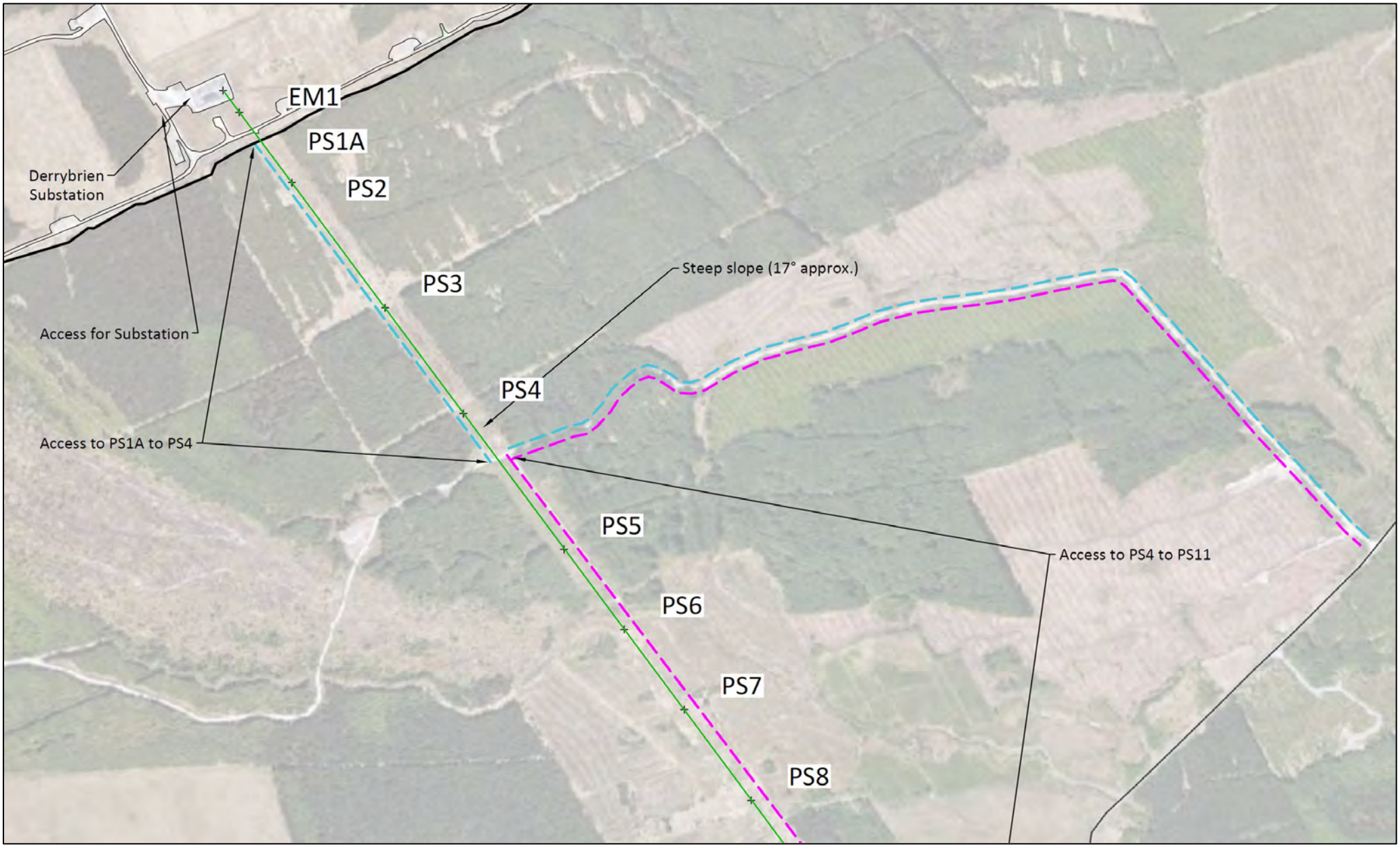

Figure 10 – Access to Polesets PS-1A to PS-4 along forestry access tracks for decommissioning of 110kV OHL

Table 1: Infinite Slope Factor of Safety (FoS) Calculations (Undrained) for 110kV OHL Polesets PS-1 to PS-4 [Fehily Timoney/AGEC Data]

Calculated FoS of Natural Peat Slopes for Derrybrien Wind Farm OHL (Undrained Analysis)									
Turbine No./Waypoint	Easting	Northing	Slope (Note 3)	Undrained shear strength	Bulk unit weight of Peat	Peat Depth (Note 5)	Surcharge Equivalent Placed Fill Depth (m) (Note 2)	Factor of Safety for Load Condition	
			β (deg)	c_u (kPa)	γ (kN/m^3)	(m)	Condition (2)	Condition (1)	Condition (2)
FT DATA (SEPTEMBER 2019)									
Pole 1A	160002	204675	5.0	6	10	2.2	3.2	**3.14**	**2.16**
Pole 2	160086	204563	6.0	6	10	2.1	3.1	**2.75**	**1.86**
Pole 3	160235	204362	4.0	6	10	1.6	2.6	**5.39**	**3.32**
Pole 4	160360	204194	6.0	6	10	1.0	2.0	**5.77**	**2.89**
AGEC DATA (JUNE 2018)									
Pole 1A	160002	204675	0.5	6	10	1.8	2.8	**38.20**	**24.56**
WP 1	160047	204613	3.0	6	10	1.4	2.4	**8.20**	**4.78**
Pole 2	160086	204563	0.5	6	10	2.4	3.4	**28.65**	**20.22**
WP 2	160158	204461	0.5	6	10	1.9	2.9	**36.19**	**23.71**
Pole 3	160235	204362	0.5	6	10	2.0	3.0	**34.38**	**22.92**
WP 3	160295	204291	0.5	6	10	1.8	2.8	**38.20**	**24.56**
Pole 4	160360	204194	6.0	6	10	1.1	2.1	**5.25**	**2.75**

Notes:

(1) Assuming a bulk unit weight of peat of 10 (kN/m^3)
(2) Assuming a surcharge equivalent to fill depth of 1m of peat i.e. 10kPa. (Condition 2)
(3) Slope inclination (β) based on site readings and contour survey plans of site.
(4) FoS is based on slope inclination and shear test results obtained from published data
(5) Peat depths based on probes carried out by AGEC and ESBI (June 2018)
(6) For load conditions see report text.
(7) Minimum acceptable factor of safety required of 1.3 for first-time failures based on BS: 6031:1981 Code of practice for Earthworks

Table 2: Infinite Slope Factor of Safety (FoS) Calculations (Undrained) for 110kV OHL Polesets PS-1 to PS-4 [Fehily Timoney/AGEC Data]

Calculated FoS of Natural Peat Slopes for Derrybrien Wind Farm OHL (Undrained Analysis)									
Turbine No./Waypoint	Easting	Northing	Slope (Note 3)	Undrained shear strength	Bulk unit weight of Peat	Peat Depth (Note 5)	Surcharge Equivalent Placed Fill Depth (m) (Note 2)	Factor of Safety for Load Condition	
Poleset (PS)			β (deg)	c_u (kPa)	γ (kN/m^3)	(m)	Condition (2)	Condition (1)	Condition (2)
ESBI DATA (2004 & 2005)									
1	160403	204120	4.0	6	10	0.2	1.2	**43.01**	**7.17**
2	160392	204135	6.0	6	10	0.2	1.2	**28.70**	**4.78**
3	160386	204144	6.0	6	10	0.9	1.9	**6.38**	**3.02**
4	160136	204496	0.5	6	10	0.9	1.9	**76.58**	**36.28**
PS-4 5	160363	204177	6.0	6	10	1.0	2.0	**5.77**	**2.89**
6	160344	204204	6.0	6	10	1.0	2.0	**5.77**	**2.89**
7	160333	204219	6.0	6	10	1.2	2.2	**4.78**	**2.61**
8	160295	204271	4.0	6	10	1.2	2.2	**7.21**	**3.93**
9	160126	204510	0.5	6	10	1.3	2.3	**53.18**	**30.06**
10	160279	204293	4.0	6	10	1.4	2.4	**6.18**	**3.60**
11	160168	204446	0.5	6	10	1.4	2.4	**49.23**	**28.72**
12	160073	204591	3.0	6	10	1.4	2.4	**8.19**	**4.78**
13	160108	204538	3.0	6	10	1.5	2.5	**7.66**	**4.60**
14	159982	204618	0.5	6	10	1.5	2.5	**45.84**	**27.50**
15	160005	204630	0.5	6	10	1.5	2.5	**45.90**	**27.54**
16	160040	204640	3.0	6	10	1.5	2.5	**7.65**	**4.59**
17	160085	204667	3.0	6	10	1.5	2.5	**7.64**	**4.59**
18	160152	204471	0.5	6	10	1.6	2.6	**42.97**	**26.45**
19	160313	204247	6.0	6	10	1.7	2.7	**3.38**	**2.13**
20	160259	204320	0.5	6	10	1.8	2.8	**38.25**	**24.59**
21	160216	204378	0.5	6	10	1.8	2.8	**38.20**	**24.56**
22	160055	204617	3.0	6	10	1.8	2.8	**6.40**	**4.12**
23	160029	204645	3.0	6	10	1.8	2.8	**6.37**	**4.09**
24	159991	204653	0.5	6	10	1.8	2.8	**38.20**	**24.56**
25	160052	204656	2.0	6	10	1.8	2.8	**9.56**	**6.15**
26	160059	204689	3.0	6	10	1.8	2.8	**6.38**	**4.10**
PS-3 27	160237	204349	0.5	6	10	1.9	2.9	**36.19**	**23.71**
PS-2 28	160091	204563	3.0	6	10	1.9	2.9	**6.04**	**3.96**
29	160199	204400	0.5	6	10	2.0	3.0	**34.43**	**22.95**
30	160027	204660	3.0	6	10	2.0	3.0	**5.73**	**3.82**
PS-1A 31	160011	204684	2.0	6	10	2.1	3.1	**8.20**	**5.55**
32	160185	204421	0.5	6	10	2.6	3.6	**26.45**	**19.10**

Table 3: Infinite Slope Factor of Safety (FoS) Calculations (Undrained) for 110kV OHL Polesets PS-1 to PS-4 [Fehily Timoney/AGEC Data]

Calculated FoS of Natural Peat Slopes for Derrybrien Wind Farm OHL (Drained Analysis)										
Turbine No./Waypoint	Slope (Note 3)	Design c'	Bulk unit weight of Peat	Unit weight of Water	100% Water to height of Peat	Depth of In situ Peat (Note 5)	Friction Angle	Equivalent Total Depth of Peat (m) (Note 2)	Factor of Safety for Load Condition	
	α (deg)	c' (kPa)	γ (kN/m^3)	γ_w (kN/m^3)	(m)	(m)	ø' (deg)	Condition (2)	Condition (1)	Condition (2)
									100% Water	100% Water
FT DATA (2019)										
Pole 1A	5.0	4	10.0	10.0	2.2	2.2	25	3.2	**2.09**	**3.11**
Pole 2	6.0	4	10.0	10.0	2.1	2.1	25	3.1	**1.83**	**2.67**
Pole 3	4.0	4	10.0	10.0	1.6	1.6	25	2.6	**3.59**	**4.78**
Pole 4	6.0	4	10.0	10.0	1.0	1.0	25	2.0	**3.85**	**4.14**
AGEC DATA (2018)										
Pole 1A	0.5	4	10.0	10.0	1.8	1.8	25	2.8	**25.47**	**35.45**
WP 1	3.0	4	10.0	10.0	1.4	1.4	25	2.4	**5.47**	**6.90**
Pole 2	0.5	4	10.0	10.0	2.4	2.4	25	3.4	**19.10**	**29.20**
WP 2	5.0	4	10.0	10.0	1.9	1.9	25	1.9	**2.42**	**2.42**
Pole 3	0.5	4	10.0	10.0	2.0	2.0	25	3.0	**22.92**	**33.09**
WP 3	0.5	4	10.0	10.0	1.8	1.8	25	1.8	**25.47**	**25.47**
Pole 4	6.0	4	10.0	10.0	1.1	1.1	25	2.1	**3.50**	**3.94**

Notes:

(1) Assuming a bulk unit weight of peat of 10 (kN/m^3)
(2) Assuming a surcharge equivalent to fill depth of 1m of peat i.e. 10kPa. (Condition 2)
(3) Slope inclination (β) based on site readings and contour survey plans of site.
(4) FoS is based on slope inclination and shear test results obtained from published data
(5) Peat depths based on probes carried out by AGEC and ESBI (June 2018)
(6) For load conditions see report text.
(7) Minimum acceptable factor of safety required of 1.3 for first-time failures based on BS: 6031:1981 Code of practice for Earthworks

Table 4: Infinite Slope Factor of Safety (FoS) Calculations (Undrained) for 110kV OHL Polesets PS-1 to PS-4 [Fehily Timoney/AGEC Data]

Calculated FoS of Natural Peat Slopes for Derrybrien Wind Farm OHL (Drained Analysis)										
Turbine No./Waypoint	Slope (Note 3)	Design c'	Bulk unit weight of Peat	Unit weight of Water	100% Water to height of Peat	Depth of In situ Peat (Note 5)	Friction Angle	Equivalent Total Depth of Peat (m) (Note 2)	Factor of Safety for Load Condition	
Poleset (PS)	α (deg)	c' (kPa)	γ (kN/m^3)	γ_w (kN/m^3)	(m)	(m)	ø' (deg)	Condition (2)	Condition (1)	Condition (2)
									100% Water	100% Water
ESBI DATA (2004 & 2005)										
1	4.0	4	10	10	0.2	0.2	25	1.2	**28.74**	**10.35**
2	6.0	4	10	10	0.2	0.2	25	1.2	**19.24**	**6.90**
3	6.0	4	10	10	0.9	0.9	25	1.9	**4.28**	**4.36**
4	0.5	4	10	10	0.9	0.9	25	1.9	**50.93**	**52.25**
PS-4 5	6.0	4	10	10	1.0	1.0	25	2.0	**3.85**	**4.14**
6	6.0	4	10	10	1.0	1.0	25	2.0	**3.85**	**4.14**
7	6.0	4	10	10	1.2	1.2	25	2.2	**3.21**	**3.77**
8	4.0	4	10	10	1.2	1.2	25	2.2	**4.79**	**5.64**
9	0.5	4	10	10	1.3	1.3	25	2.3	**35.26**	**43.16**
10	4.0	4	10	10	1.4	1.4	25	2.4	**4.11**	**5.17**
11	0.5	4	10	10	1.4	1.4	25	2.4	**32.74**	**41.36**
12	3.0	4	10	10	1.4	1.4	25	2.4	**5.47**	**6.90**
13	3.0	4	10	10	1.5	1.5	25	2.5	**5.10**	**6.62**
14	0.5	4	10	10	1.5	1.5	25	2.5	**30.56**	**39.71**
15	0.5	4	10	10	1.5	1.5	25	2.5	**30.56**	**39.71**
16	3.0	4	10	10	1.5	1.5	25	2.5	**5.10**	**6.62**
17	3.0	4	10	10	1.5	1.5	25	2.5	**5.10**	**6.62**
18	0.5	4	10	10	1.6	1.6	25	2.6	**28.65**	**38.18**
19	6.0	4	10	10	1.7	1.7	25	2.7	**2.26**	**3.07**
20	0.5	4	10	10	1.8	1.8	25	2.8	**25.47**	**35.45**
21	0.5	4	10	10	1.8	1.8	25	2.8	**25.47**	**35.45**
22	3.0	4	10	10	1.8	1.8	25	2.8	**4.25**	**5.91**
23	3.0	4	10	10	1.8	1.8	25	2.8	**4.25**	**5.91**
24	0.5	4	10	10	1.8	1.8	25	2.8	**25.47**	**35.45**
25	2.0	4	10	10	1.8	1.8	25	2.8	**6.37**	**8.86**
26	3.0	4	10	10	1.8	1.8	25	2.8	**4.25**	**5.91**
PS-3 27	0.5	4	10	10	1.9	1.9	25	2.9	**24.13**	**34.23**
PS-2 28	3.0	4	10	10	1.9	1.9	25	2.9	**4.03**	**5.71**
29	0.5	4	10	10	2.0	2.0	25	3.0	**22.92**	**33.09**
30	3.0	4	10	10	2.0	2.0	25	3.0	**3.83**	**5.52**
PS-1A 31	2.0	4	10	10	2.1	2.1	25	3.1	**5.46**	**8.01**
32	0.5	4	10	10	2.6	2.6	25	3.6	**17.63**	**27.58**

Photo 1: Pylon EM-1 and Poleset PS1 @ Substation

Photo 2: Looking South to Poleset PS-1

Photo 3: Looking North to Poleset PS-1

Photo 4: Looking South to Poleset PS-2

Photo 5: Looking North to Poleset PS-2

Photo 6: Poleset PS-3

Photo 7: Looking South from Poleset PS-3

Photo 8: Looking North to Poleset PS-2 from PS-3

Photo 9: Looking South at Poleset PS-4

Photo 10: Poleset PS-4

Appendix C

Infinite Slope Factor of Safety (FoS) Calculations

AGL CONSULTING GEOTECHNICAL ENGINEERS

Infinite Slope Calculations - 110kV OHL Polesets PS-1a to PS-4

Zone Number - PS-1a & PS-2

Case 1: 0m peat surcharge and Cu = 5.0kPa

Section & Slope	Slope, α (°)	Depth of Peat, D (m)	Unit Weight of Peat, γ (kN/m^3)	Undrained Shear Strength, c_u (kPa)	FOS - Infinite Slope
PS-1A	4.0	2.2	10.5	5.0	3.1
Between Polesets	5.0	1.4	10.5	5.0	3.9
Between Polesets	5.0	1.8	10.5	5.0	3.0
PS-2	4.0	2.1	10.5	5.0	3.3
Between Polesets	7.0	1.3	10.5	5.0	3.0
Between Polesets	6.0	1.6	10.5	5.0	2.9
$FoS = c_u/(D.\gamma.Cosa.Sina)$				Min FoS	2.9
				Max Fos	3.9

Zone Number - PS-1a & PS-2

Case 2: 0m peat surcharge and Cu = 2.5kPa (Worst Case Scenario with Weak Layer at Base of Peat but No Surcharge)

Section & Slope	Slope, α (°)	Depth of Peat, D (m)	Unit Weight of Peat, γ (kN/m^3)	Undrained Shear Strength, c_u (kPa)	FOS - Infinite Slope
PS-1A	4.0	2.2	10.5	2.5	1.6
Between Polesets	5.0	1.4	10.5	2.5	2.0
Between Polesets	5.0	1.8	10.5	2.5	1.5
PS-2	4.0	2.1	10.5	2.5	1.6
Between Polesets	7.0	1.3	10.5	2.5	1.5
Between Polesets	6.0	1.6	10.5	2.5	1.4
$FoS = c_u/(D.\gamma.Cosa.Sina)$				Min FoS	1.4
				Max Fos	2.0

Zone Number - PS-1a & PS-2

Case 3: 1.0m peat surcharge and Cu = 5.0kPa

Section & Slope	Slope, α (°)	Depth of Peat, D (m)	Unit Weight of Peat, γ (kN/m^3)	Undrained Shear Strength, c_u (kPa)	FOS - Infinite Slope
PS-1A	4.0	2.2	10.5	5.0	2.0
Between Polesets	5.0	1.4	10.5	5.0	2.0
Between Polesets	5.0	1.8	10.5	5.0	3.0
PS-2	4.0	2.1	10.5	5.0	2.0
Between Polesets	7.0	1.3	10.5	5.0	3.0
Between Polesets	6.0	1.6	10.5	5.0	2.9
$FoS = c_u/(D.\gamma.Cosa.Sina)$				Min FoS	2.0
				Max Fos	3.0

Zone Number - PS-1a & PS-2

Case 4: 1.0m peat surcharge and Cu = 2.5kPa (Worst Case Scenario with Surcharge & Weak Layer at Base of Peat)

Section & Slope	Slope, α (°)	Depth of Peat, D (m)	Unit Weight of Peat, γ (kN/m^3)	Undrained Shear Strength, c_u (kPa)	FOS - Infinite Slope
PS-1A	4.0	2.2	10.5	2.5	1.0
Between Polesets	5.0	1.4	10.5	2.5	1.0
Between Polesets	5.0	1.8	10.5	2.5	0.9
PS-2	4.0	2.1	10.5	2.5	1.0
Between Polesets	7.0	1.3	10.5	2.5	0.8
Between Polesets	6.0	1.6	10.5	2.5	0.8
$FoS = c_u/(D.\gamma.Cosa.Sina)$				Min FoS	0.8
				Max Fos	1.0

AGL CONSULTING GEOTECHNICAL ENGINEERS

Infinite Slope Calculations - 110kV OHL Polesets PS-1a to PS-4

Zone Number - PS3 & PS-4

Case 1: 0m peat surcharge and Cu = 5.0kPa

Section & Slope	Slope, α (°)	Depth of Peat, D (m)	Unit Weight of Peat, γ (kN/m^3)	Undrained Shear Strength, c_u (kPa)	FOS - Infinite Slope
Between Polesets	3.5	2.6	10.5	5.0	3.0
PS-3	4.5	1.9	10.5	5.0	3.2
Between Polesets	5.0	1.8	10.5	5.0	3.0
Between Polesets	7.0	1.2	10.5	5.0	3.3
Between Polesets	5.0	1.7	10.5	5.0	3.2
PS-4	7.0	1.0	10.5	5.0	3.9
$FoS = c_u/(D.\gamma.Cosa.Sina)$				Min FoS	3.0
				Max Fos	3.9

Zone Number - PS3 & PS-4

Case 2: 0m peat surcharge and Cu = 2.5kPa (Worst Case Scenario with Weak Layer at Base of Peat but No Surcharge)

Section & Slope	Slope, α (°)	Depth of Peat, D (m)	Unit Weight of Peat, γ (kN/m^3)	Undrained Shear Strength, c_u (kPa)	FOS - Infinite Slope
Between Polesets	3.5	2.6	10.5	2.5	1.5
PS-3	4.5	1.9	10.5	2.5	1.6
Between Polesets	5.0	1.8	10.5	2.5	1.5
Between Polesets	7.0	1.2	10.5	2.5	1.6
Between Polesets	5.0	1.7	10.5	2.5	1.6
PS-4	7.0	1.0	10.5	2.5	2.0
$FoS = c_u/(D.\gamma.Cosa.Sina)$				Min FoS	1.5
				Max Fos	2.0

Zone Number - PS3 & PS-4

Case 3: 1.0m peat surcharge and Cu = 5.0kPa

Section & Slope	Slope, α (°)	Depth of Peat, D (m)	Unit Weight of Peat, γ (kN/m^3)	Undrained Shear Strength, c_u (kPa)	FOS - Infinite Slope
Between Polesets	3.5	2.6	10.5	5.0	2.0
PS-3	4.5	1.9	10.5	5.0	1.9
Between Polesets	5.0	1.8	10.5	5.0	3.0
Between Polesets	7.0	1.2	10.5	5.0	1.6
Between Polesets	5.0	1.7	10.5	5.0	3.2
PS-4	7.0	1.0	10.5	5.0	3.9
$FoS = c_u/(D.\gamma.Cosa.Sina)$				Min FoS	1.6
				Max Fos	3.9

Zone Number - PS3 & PS-4

Case 4: 1.0m peat surcharge and Cu = 2.5kPa (Worst Case Scenario with Surcharge & Weak Layer at Base of Peat)

Section & Slope	Slope, α (°)	Depth of Peat, D (m)	Unit Weight of Peat, γ (kN/m^3)	Undrained Shear Strength, c_u (kPa)	FOS - Infinite Slope
Between Polesets	3.5	2.6	10.5	2.5	1.0
PS-3	4.5	1.9	10.5	2.5	1.0
Between Polesets	5.0	1.8	10.5	2.5	0.9
Between Polesets	7.0	1.2	10.5	2.5	0.8
Between Polesets	5.0	1.7	10.5	2.5	0.9
PS-4	7.0	1.0	10.5	2.5	0.9
$FoS = c_u/(D.\gamma.Cosa.Sina)$				Min FoS	0.8
				Max Fos	1.0

APPENDIX 8-4

PEAT STABILITY RISK ASSESSMENT (PSRA) FOR TURBARY PLOTS

DERRYBRIEN WINDFARM
PEAT STABILITY RISK ASSESSMENT (PSRA) FOR MECHANICAL PEAT HARVESTING IN TURBARY PLOTS AT EAST END OF WINDFARM SITE

for

ESB Engineering & Major Projects
One Dublin Airport Central
Dublin Airport
Cloghran
Co. Dublin

5th December, 2024
(Issue 03, Rev.3)

Document Approval Form

DERRYBRIEN WINDFARM
PEAT STABILITY RISK ASSESSMENT (PSRA) FOR MECHANICAL PEAT HARVESTING IN TURBARY PLOTS AT EAST END OF WINDFARM SITE

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DERRYBRIEN WINDFARM
PEAT STABILITY RISK ASSESSMENT (PSRA) FOR TURBARY PLOTS AT EAST END OF WINDFARM SITE

Non-Technical Summary

This report presents the results of the Peat Stability Risk Assessment (PSRA) that has been carried out for mechanical peat harvesting in the turbary plots on the east side of the Derrybrien Windfarm.

The Peat Stability Risk Assessment (PSRA) is an engineering risk assessment that has been carried out in accordance with the best practice guidelines in "Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (Second Edition, April 2017)", by the Scottish Government Energy Consents Unit. The method of risk assessment is also consistent with the Institution of Civil Engineers' publication outlining UK best practice in "Managing Geotechnical Risk" (Clayton, 2001).

The turbary area has been split up into 181 No. representative zones of approximate equal area corresponding to the boundaries of the 136 No. individual turbary plots, some of which have been subdivided for the assessment. A qualitative risk assessment has been carried out for each zone to assess the **Risk Rating (R)** for a peat failure occurring due to mechanical peat harvesting in the turbary plots based on the interpreted **Likelihood (L)** (i.e. probability) of occurrence and **Impact (I)** of failure. The assessment identifies where specific design, construction & operational risk mitigation measures are required to reduce the risk to an acceptable level.

The **Likelihood (L)** of a peat failure in each zone has been assessed on a scale of 1-5 by evaluating factors related to the peat and subsoil conditions, topography, site hydrology/hydrogeology and other significant contributory factors such as the method of peat harvesting or slide history to determine where there are compounding conditions that could lead to a higher risk of a peat failure.

The potential **Impact (I)** of a peat failure in the turbary area has been assessed on a scale of 1-5 by evaluating factors related to the potential volume of peat, degree of contamination, sensitivity of the receiving environment, access for intervention, and the land use and existing infrastructure within the potential run-out distance.

A **Risk Rating (R=L x I)** has then been calculated for each zone to characterise the risk of peat instability due to mechanical peat harvesting in the turbary areas prior to implementing any mitigation measures to identify where specific operational mitigation measures are required to reduce the risk of peat instability to an acceptable level.

The results show that there are significant areas of the turbary plots where the likelihood of a peat failure due to mechanical peat harvesting under uncontrolled conditions and without appropriate mitigation measures is **Very Possible** to **Likely (L=4.0 to 5.0)**. These zones are located in areas where there are compounding risk factors in relation to peat instability, including, for example:

- The zone of deep weak peat (3-6m deep) along the subsurface drainage channel between Turbines T27 and T35 where there is a convex break in slope at the head of the watercourse that flows off site to the south of T35 (Plots #7-13, #148-154; #191-195);
- The zone of deep weak peat upslope from the central turbary road between T28 and T37 where there are indications of subsurface seepage in the peat to the convex breaking slope downslope from the road (Plots #14-22);
- The plots on the convex breaking slope downslope from the central turbary road in the area of deep peat between Turbines T28 and T37 where there are indications of subsurface seepage in the peat (Plots #155-164, #197-204) and low Factors of Safety for infinite slope stability;
- Along the watercourse channel in the peat at the west end of the turbary areas between Turbines T24 and T29 (Plots #1-5, #147 & #191);

- The area of relatively deep peat (2-3m) with the convex breaking slope at the southeast corner of the wind farm (Plots #219-221 & #229-232); and
- Various plots at the east end of the site where there is locally a convex breaking slope in relatively deep peat (2-4m) and locally low FoS for slope stability (e.g. Plots #30-36, between #168 & 176, and #213-214)

Together these account for approximately **47%** of the total number of turbary areas that have been assessed (i.e. 85 No. out of 181 No. total).

In the remaining turbary plots within the turbary area the Likelihood of a peat failure, due to mechanical peat harvesting under uncontrolled conditions and without appropriate mitigation measures would be characterised as **Possible to Very Possible (L=3.0 to 3.5)**. These were in areas where there were mitigating conditions that reduced the baseline risk of peat instability. For example:

- Areas of shallow (<1.0 m) or relatively shallow (1-2 m) peat;
- Areas of gently sloping ground (<3°) set well back from any convex break in slope to slopes >5°.
- Areas of relatively high infinite slope Factor of Safety (FoS >1.3);
- Zones where there is well-developed drainage, and which are not directly upslope from the rivers and streams outside the wind farm site.

The type of failure that could occur could range from a localised shear failure in the peat on the upslope side of an open excavation, to a small-scale peat slide that is contained within the turbary area, or a large-scale peat slide comparable to the slide that occurred on the windfarm site during construction.

The Risk Rating, R, for peat failures occurring as a result of mechanical peat harvesting in the turbary areas has conservatively been calculated based on the possible impact of a large peat slide **(Impact, I=5: High)** as the worst case scenario. Without appropriate mitigation measures the Risk Rating generally ranges from 17.5 to 25.0, which is **Medium to High** or **High** and **Unacceptable**.

The risk only applies in areas where mechanical peat harvesting is active and at the time that the work is being carried out on the site. Based on available information, mechanical peat harvesting is only active in about 35 No. of the 136 No. turbary plots in the area. The work is normally carried out once a year in late spring/early summer. Only a small number of plots are active at any one time and the work in each area is completed within a few days.

When no work is being carried out in the turbary plots the residual risk reduces to **Low to Medium (R=10)**, which is **Acceptable** with the inspections that are currently carried out periodically on the site.

In recent years peat failures have occurred in 2 No. turbary plots (Plot Nos. 30 and 161), where mechanical peat harvesting was a likely or possible contributory factor. In both areas the failures involved small-scale peat slides or zones of peat movement which were contained within the turbary area. Therefore, the impact of the failures was **Low to Medium (I=2.0)**. The peat within the failed area is stable and some drainage works have been carried out to relieve ponded groundwater in tension cracks to prevent any further progressive movement of the peat. Survey monitoring points were also established on the peat in and around the failed area to record movement of the peat. They show that little movement has occurred in the peat upslope and downslope from the failed area, which indicates that the area is stable. Higher movements of 60-120mm have been recorded within the failed area, which is indicative of ongoing creep of the rafts of displaced peat, which is to be expected. Most of this movement occurred before the end of 2021. Recent inspections of the area in 2024 indicate that the area is stable and the displaced peat is supported by the buttressing effect of the intact peat on the downslope side of the turbary plot.

The following mitigation measures have been recommended for future mechanical peat harvesting in the turbary plots to reduce the likelihood of further peat failures in the turbary area over the remaining operational life of the windfarm and during decommissioning:

- No peat harvesting should be carried out by saw cutting in any of the turbary plots;
- No mechanical peat harvesting should be carried out in the turbary plots where the likelihood of a peat failure without appropriate mitigation measures is interpreted as **Very Possible** to **Likely (L=4.0 to 5.0)**. Manual turf cutting can be carried out but should be done during the drier months between May and September;
- Where the likelihood of a peat failure without appropriate mitigation measures is interpreted as **Possible** to **Very Possible (L=3.0 to 3.5)** the limitations recommended in Section 6.0 of this report on the type and size of equipment that can be used for mechanical peat harvesting in the turbary plots and on the maximum level of surcharge loading on the peat should be implemented;
- The operational control measures recommended in Section 6.0 should be implemented by the turbary plot owner and their turf cutting contractor to manage the stability of peat excavations and to prevent excessive damage to the integrity of the vegetated surface of the peat;
- Communication should be established between the turbary plot owners, turf cutting contractors and the windfarm site manager for Gort Wind Farms Ltd. to give notice of mechanical peat harvesting activities and to report any peat instability on the site;
- Ongoing maintenance should be carried out on the existing drainage network, where required, during the drier months of May to September;
- Periodic inspections of the mechanical peat harvesting should be carried out by the wind farm site manager for Gort Wind Farms Ltd.;
- Peat movement should be monitored where the small-scale peat failures occurred in Turbary Plots 30 and 161 and the areas should be periodically inspected by experienced geotechnical engineers from ESB Engineering and Major Projects; and
- No mechanical peat harvesting should be carried out in the turbary area during the decommissioning stage of the windfarm project.

The potential impacts of mechanical peat harvesting on the wind farm site will not arise as a direct result of activities related to the wind farm, but from the separate and unrelated activities for mechanical peat harvesting in the turbary areas under established turbary rights, which are outside of the control of Gort Wind Farms Ltd.

Warning signs have been erected at the site by Gort Wind Farms Ltd. to raise awareness of the peat stability risks associated with mechanical peat harvesting in the turbary area and to highlight the recommended mitigation measures. Where possible, communication has been established between the turbary plot owners, turf cutting contractors and the windfarm site manager for Gort Wind Farms Ltd. to establish procedures to give notice of mechanical peat harvesting activities and to report any peat instability on the site. This peat stability risk assessment and the associated mitigation measures have also been shared with the turbary rights holders whose plots have been harvested by mechanical means.

Drainage works were carried out in Turbary Plot 161 by GWFL in early August 2020 to relieve ponded water in the tension cracks as a mitigation measure to prevent any further movement of the peat. Survey pegs were also established in and around the failed area to monitor movement of the peat.

Where the remaining mitigation measures are implemented by the turbary plot holders, then the likelihood of a peat failure occurring as a result of mechanical peat harvesting in the turbary plots will reduce to a residual level of **Low (L=2)**. This would correspond to a **Risk Rating, R, of 10** for the worst case scenario of a large peat slide **(Impact, I=5)**, which is **Low to Medium** and acceptable with periodic inspections.

DERRYBRIEN WINDFARM
PEAT STABILITY RISK ASSESSMENT (PSRA) FOR TURBARY PLOTS AT EAST END OF WINDFARM SITE

1.0 INTRODUCTION AND METHODOLOGY

1.1 Introduction

The east end of the Derrybrien Windfarm site is sub-divided into a number of plots where peat harvesting (turf cutting) has historically been carried out by individuals with turbary rights, i.e. the right to cut and take away turf from the bog for use as fuel.

The layout and numbering of the turbary plots in the area is shown on Figure 1-1. There are a total of 136 No. plots which generally range in size from about 0.55ha to 1.10ha over a total area of approximately 103ha. The majority of the plots are within the windfarm site. However, 22 No. are partially or fully outside the site boundary to the east and southeast, as shown on the layout plan (i.e. #41-45, 178-180, 219-221 & 223-232). Not all of the turbary plots are active. Peat is harvested seasonally from some of the plots for domestic use. There has been no large-scale or commercial peat harvesting on the site.

This report presents the results of a Peat Stability Risk Assessment for activities related to mechanical peat harvesting on the turbary plots on and adjacent to the Derrybrien Windfarm site. The report has been prepared as a supplemental report to AGL Report No. 11-147-R04 – "*Derrybrien Windfarm, Geotechnical Stability Report & Assessment of Stability Impacts of On-Site Activities*", which addresses the activities related to the windfarm project on the site.

1.2 Methodology for Peat Stability Risk Assessment

The Peat Stability Risk Assessment (PSRA) is an engineering risk assessment that has been carried out in accordance with the best practice guidelines for peat landslide risk assessments in the report - "Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (Second Edition, April 2017)", by the Scottish Government Energy Consents Unit. The method of risk assessment is also consistent with the Institution of Civil Engineers' publication outlining UK best practice in "Managing Geotechnical Risk" (Clayton, 2001).

For this report, the turbary area has been split up into 181 No. representative zones of approximate equal area corresponding to the boundaries of the individual turbary plots, some of which have been subdivided for the assessment. A qualitative **Peat Stability Risk Assessment (PSRA)** has been carried out for each zone to assess the **Risk Rating (R)** for a peat failure as a result of mechanical peat harvesting based on the interpreted **Likelihood (L)** (i.e. probability) of occurrence and **Impact (I)** of failure. The assessment identifies where specific design, construction & operational risk mitigation measures are required to reduce the risk to an acceptable level.

The **Likelihood (L)** of a peat failure in each zone has been interpreted by evaluating factors related to the peat and subsoil conditions, topography, site hydrology/hydrogeology and other significant contributory factors such as the method of peat harvesting or slide history to determine where there are compounding conditions that could lead to a higher risk of a peat failure.

The potential **Impact (I)** of a peat failure in each zone has been interpreted by evaluating factors related to the potential volume of peat, degree of contamination, sensitivity of the receiving environment, access for intervention, and the land use and existing infrastructure within the potential run-out distance.

A baseline **Risk Rating (R=L x I)** has then been calculated for each zone to characterise the risk of peat instability across the site to identify where specific design, construction & operational mitigation measures are required to mitigate the risk of peat instability to an acceptable level.

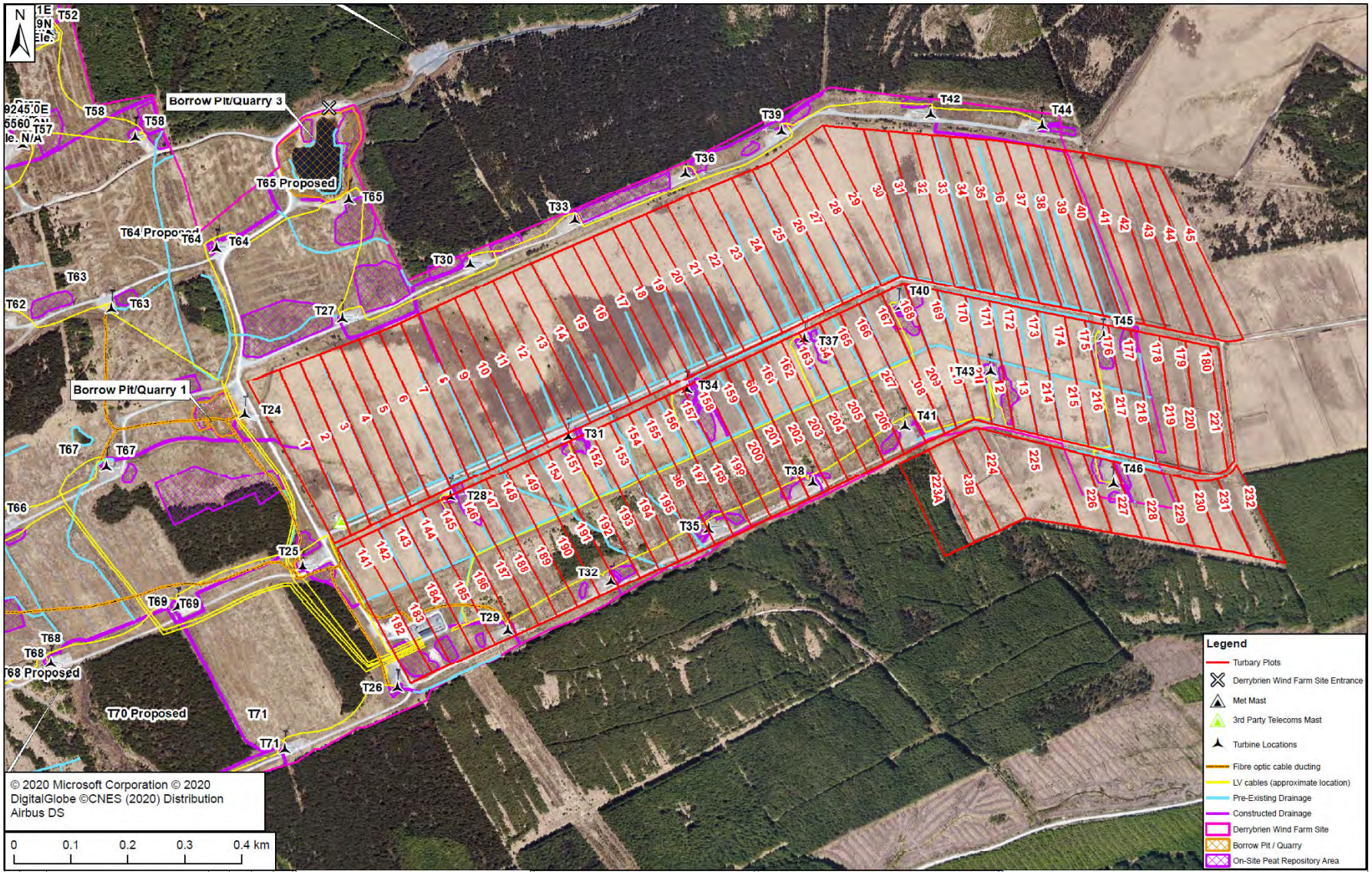


Figure 1-1 – Layout and numbering of turbary plots at the east end of the windfarm site

Zones of potential peat instability can be very localised, i.e. where there is a specific combination of factors on the site that can lead to a higher risk of a peat slide under uncontrolled conditions without appropriate mitigation measures, e.g. in deep peat within a buried channel at the head of a watercourse where the peat has been worked by peat harvesting. Therefore, the factors assessed are specific to each turbary area. In this way representative combinations of peat depth, shear strength and slope angles are used in the assessment. However, consideration is also given to the general characteristics of the site in the vicinity of the works that are interpreted to be relevant to peat stability at the works location, e.g. proximity to and location relative to watercourses or evidence of peat instability under similar conditions in the area or elsewhere on site.

The Risk Rating, R, has been assessed for mechanical peat harvesting in each zone in the turbary area for the existing baseline conditions prior to the implementation of appropriate mitigation measures. Mitigation and monitoring measures are then presented for reducing the risk to an acceptable level and the Risk Rating has been re-assessed for mechanical peat harvesting on the site over the remaining operational life of the windfarm, and during decommissioning.

The following is a more detailed description of the methodology that was used for interpreting the Likelihood, Impact and Risk Rating in the PSRA.

1.2.1.1 Likelihood (L) of a Peat Slide

For each zone of the site the **Likelihood (L)** of a peat slide has been assessed based on an evaluation of the principal geotechnical, topographical, hydrological and hydrogeological characteristics on the site that are considered to impact the stability of peat on upland bogs. Peat stability risk factors are sub-divided into 5 categories:

1. Peat & Subsoil Conditions
2. Topography
3. Factor of Safety Calculations
4. Hydrology
5. Other Contributory Factors

For the **peat and subsoil conditions** the depth, undrained shear strength, water content and degree of decomposition (humification) of the peat are considered, along with the characteristics of the subsoil and the interface with the peat. Higher risks of peat instability are associated with relatively deep deposits of low strength peat, which typically corresponds to high water contents and a higher degree of decomposition to less fibrous or clayey peat. The characteristics of the subsoil and the interface with the peat are also significant as previous peat slides in Ireland have been attributed to areas where there is a discontinuity at the interface (e.g. where the peat is directly on rock or nested boulders), where there is preferential flow of groundwater along permeable layers of granular soils or fractured rock at rockhead, or where there are weaker layers of sensitive low strength clayey soils at the base of the peat.

Topographical characteristics that are significant to peat stability include relatively steep slope angles (e.g. >5°), or the location of the turbary plots relative to a convex break in slope or a broad flat area directly upstream from a watercourse where there would be a higher risk of concentrated subsurface groundwater flow within or at the base of the peat that could contribute to a peat slide. Most of the peat slides that have occurred in Ireland have occurred above an elevation of 300mOD. Therefore, this is also considered in the assessment.

Topography is particularly significant where it is combined with other risk factors such as areas of deep low strength peat. Therefore, this is assessed by calculating **Factors of Safety (FoS)** against shear failure at the base of the peat as an index of peat stability on the slopes. This is done by infinite slope analysis, which assesses the resistance to shear failure on the inclined plane at the base of the peat under the downslope component of the gravitational loading due to the self-weight of the peat. The FoS is expressed as the ratio of the shear strength of the peat to the downslope shear force at the base of the

peat. An FoS >1.0 indicates that failure should not occur. An FoS >1.3 would provide a margin of safety against failure. To characterise the site the analyses are conservatively carried out assuming a low strength shear strength of 5kPa at the base of the peat. A worst case scenario is also assessed by assuming a residual shear strength of 2.5 kPa at the base of the peat, which would only apply where there is an existing failure surface of remoulded peat. The analyses are repeated under a surcharge load equivalent to the weight of 1.0 m of excavated peat on the slopes to characterise the sensitivity of the calculations.

Hydrology is very significant for assessing peat stability. Risk factors that are known to contribute to peat slides would include areas of poor drainage with ponded surface water, and areas where there is evidence of subsurface groundwater flow through open conduits called "pipes" within the peat, or along permeable layers of gravel or fractured rock at the base of the peat, which are typically identified in trial pits or exposures on site. The orientation of drains relative to the slope is also significant as drains that are cut across a peat slope in areas of deep peat have been known to contribute to peat instability by damaging the integrity of the vegetated crust of the peat and by restricting downslope surface runoff.

The PSRA also considers indirect **contributory factors** or site characteristics that can be used to identify sites or zones that could be particularly susceptible to peat slides, such as:

- Poor tree growth or wetlands vegetation and flushes associated with poor drainage;
- A history of previous slides on site or in the general area;
- Peat workings such as mechanical harvesting in turbary plots that impac the integrity of the peat mass, such as a saw-cutting machine;
- Evidence of peat slides, subsurface drainage or general anomalies such as disturbed peat or drainage patterns from aerial photographs; and
- The stability of peat and groundwater ingress in trial pit excavations on the site.

Each of the five risk categories is rated on a scale of **0** to **20** depending on how significant the corresponding factors are with respect to peat stability, as follows:

- Negligible = 0
- Low = 5
- Medium = 10
- High = 15
- Very High = 20

The individual ratings for each category are then added to calculate a **Total Hazard Rating** on a scale of **0-100** for each zone on the site. This is not a probability of occurrence of a peat slide. It is an index that takes into account the interaction between different risk factors to assess the relative risk of peat instability between zones across the site and to identify zones where there are compounding risk factors that could make them particularly susceptible to peat slides.

For example, in zones where there are steep slopes there would be a high hazard rating for topography. However, if this was compensated by lower peat depths and higher strength peat, which would reduce the risk of peat instability, then the combination of the two would reduce the overall Total Hazard Rating. On the other hand, if the steep slopes were associated with deeper deposits of low strength peat and other negative contributory factors, then the compounding effect of these factors would lead to an hig Total Hazard Rating and higher interpreted Likelihood of failure.

For the PRSA the interpreted Likelihood of a peat slide is correlated to the Total Hazard Rating on a scale of 1-5, as shown on Table 1-1.

Table 1-1 Total Hazard Rating and Likelihood (L) of a Peat Slide for Mechanical Peat Harvesting

Total Hazard Rating	Likelihood (L)		Indicative Probability of Occurrence (Event/yr – in each active turbary area)
0	**0**	Not Applicable (<0.5 m Peat)	<1/1000
0-19	**1.0**	Negligible	1/500 to 1/1000
20-39	**2.0**	Low	1/100 to 1/500
40-59	**3.0**	Possible	1/50 to 1/100
60-69	**3.5**	Possible to Very Possible	1/25 to 1/50
70-79	**4.0**	Very Possible	1/10 to 1/25
80-89	**4.5**	Very Possible to Likely	1/5 to 1/10
90-100	**5.0**	Likely	>1/5

Peat slides on upland bogs are still quite infrequent. Therefore, Table 1-1 lists possible ranges in probability of occurrence for each point on the Hazard Liklihood scale that are based on our experience with peat slides on windfarm sites in Ireland and on observations of recent small-scale peat failures that have occurred in the turbary area since the windfarm was completed. The probability of occurrence is expressed in terms of events per year for each turbary area.

The probability ranges in Table 1-1 are intended as indicative frequencies of failure for comparative purposes in a Qualitative Risk Assessment. They are not precise probabilities of occurrence calculated from a recorded database of case histories of peat slides that have occurred under similar conditions. Therefore, they should not be used for a Quantitative Risk Assessment.

It should also be noted that the failure frequencies listed in Table 1-1 do not reflect the **scale** of peat failures, which could range from small localised shear failures along the edge of an excavated peat bank, to a small-scale peat slide that is contained within the turbary area, or a large scale peat slide comparable to the slide that occurred at Turbine T68 on the windfarm site during construction. This is taken into account in the assessment of the **Impact** of a peat slide.

1.2.1.2 Impact of Occurrence:

The Impact of occurrence (**I**) is a qualitative assessment of the interpreted impact of a peat slide which has been assessed based on the following comprehensive list of primary impacts.

- Volume of peat in potential slide
- Possible run-out distance
- Sensitivity of the receiving environment & habitat
- Potential degree of contamination
- Access for intervention (onsite/offsite)
- Public / private infrastructure in potential peat flow path & within run-out distance (e.g. Roads, buildings, overhead power lines or telephone lines)
- Existing site infrastructure in potential peat flow path & within run-out distance (Access tracks, turbines, cable trenches, substations etc.)
- Land usage in potential peat flow path & within run-out distance

The volume of peat in a slide is assessed from the potential area that could be impacted by a slide and the depth of peat within that area. We have proposed the following bands based on past experience with peat slides in Ireland:

- Localised (<100 m^3)
- Very small (100-1,000m^3)
- Small (1,000-5,000 m^3)
- Medium (5,000 - 25,000 m^3)
- Large (25,000 - 100,000 m^3)
- Very Large (>100,000 m^3)

The potential run-out distances take into account the volume and nature of the peat as well as the topography and potential flow paths. For example, large-scale peat slides or bog bursts in deep very soft amorphous (non-fibrous) peat with a high water content upslope from a watercourse channel have the highest potential to become fluidised and to flow considerable distances along the river channel downslope from the site. On the other hand, a localised peat slide in shallow dry fibrous peat would have low mobility with a short run-out distance downslope from the slide.

In assessing the sensitivity of the receiving environment specific consideration is given to the ecological importance of protected habitats, National Heritage Areas or Special Areas of Conservation that could be disturbed by the slide, as well as the presence of protected freshwater fish or species in the watercourses downstream from the site.

The potential degree of contamination could range from diluted organic sediment from surface runoff, direct contamination by organic sediment, or direct inundation with a fluidised remoulded peat debris, which would have the greatest impact to a river or water body downstream from the theoretical slide.

On some sites rapid deployment of resources can be an effective measure to mitigate the impact of a peat slide, for example by the construction of rockfill bunds as barrages to stop the flow of peat downslope. However, this depends on the site access to key intervention points and many windfarms are constructed in remote areas with limited infrastructure, which can make intervention restrictive.

The remaining factors take into account public/private infrastructure within the potential run-out zone that might be directly or indirectly impacted by a peat slide. Land use within this area is also taken into account as it will have a bearing on the cost impact and the potential disruption to agricultural activity.

The potential **Impact** of a peat slide in the turbary areas has been qualitatively assessed for each zone on a scale of **1-5** based on the factors listed above. Table 1-2 gives some guidance on the corresponding environmental, cost and time impacts for each Impact rating. These bands are considered as general guidelines. The cost and time impact would typically be interrelated for activities on a construction project, and the time impact may only be significant for activities on a critical path. Also, where the environmental impact could be high or very high the cost of mitigation or remedial measures would need to be considered. In general, where there is a sensitive receptor within the potential run-outdistance downstream from the works, such as a stream or river in a Special Area of Conservation, then the impact of a medium to large peat slide is likely to be High (I=5). The upper limit of 5 on the Impact identifies zones where there are compounding risk factors which suggest that a peat slide would have a severe impact on cost and time, and also on the surrounding environment.

It should be noted that the “Impact” of a peat slide in this PSRA is different to the Impact of site activities in the environmental impact assessment methodology. The PSRA is an engineering impact assessment. Therefore, the possible Impact of a peat slide includes a broader assessment on the sensitivity of the receiving environment that is not limited to the direct impact on soils, geology and land. It also includes commercial impacts that can have a significant impact on cost or time for an engineering project, which is consistent with the guidelines in the Institution of Civil Engineers' publication outlining UK best practice in "*Managing Geotechnical Risk*" (Clayton, 2001).

Table 1-2 Impact of Occurrence (I)

Hazard Impact (I)	Environmental Impact	Cost Impact	Time Impact
1	Low	<€1,000	<1 week on activity
2	Low to Medium	€1,000 - €10,000	1-4 weeks on activity, none on completion
3	Medium	€10,000 - €100,000	>4 weeks on activity, <1 week on completion.
4	Medium to High	€100,000 - €1,000,000	> 1 week on completion
5	High	>€1,000,000	> 10 weeks on completion

1.2.1.3 Risk Rating before and after Mitigation Measures

The Risk Rating (R) is a product of the Likelihood of occurrence (L) and the Impact of failure (I) [i.e. R = L x I] and is calculated on a scale of 1 to 25. Table 1-3 and Table 1-4 show the different bands of Risk Rating ranging from Low (Trivial), to Medium (Significant) or High (Intolerable) with some intermediate levels. Where the interpreted risk of peat instability is unacceptably high (R=16-25) then risk mitigation measures are required to reduce the risk to an acceptable level.

Table 1-3 Risk Rating (R= L x I)

Likelihood (L)	Impact (I)				
	1	**2**	**3**	**4**	**5**
0	0	0	0	0	0
1.0	1	2	3	4	5
2.0	2	4	6	8	10
3.0	3	6	9	12	15
3.5	3.5	7	10.5	14	17.5
4.0	4	8	12	16	20
4.5	4.5	9	13.5	18	22.5
5.0	5	10	15	20	25

Table 1-4 - Risk Rating Levels and Response

Risk Rating (R = L X I)		Response
0 to 5	Low (Trivial)	Monitor
6 to 10	Low to Medium (Tolerable)	Regular Attention
11 to 15	Medium (Significant)	Early Attention
16 to 20	Medium to High (Substantial)	Unacceptable
21 to 25	High (Intolerable)	Unacceptable

The baseline PSRA for the site in its existing condition is presented in Section 4.0. It represents a characterisation of the relative risk of peat instability for mechanical peat harvesting across the turbary sites under uncontrolled conditions prior to the implementation of appropriate risk mitigation measures to reduce the likelihood or impact of a peat slide.

This report presents operational measures that will be implemented to mitigate against the risk of peat instability for mechanical peat harvesting on the site. The risk rating for a peat failure in each turbary area has then been re-assessed for mechanical peat harvesting on the site over the remaining operational life of the windfarm, and during decommissioning.

We have adopted the following general principles in re-assessing the risk rating with appropriate mitigation measures:

- Effective design, construction & operational risk mitigation measures and improvements in site conditions can be used to reduce the Likelihood of a peat slide to a low or negligible level, even in high risk zones.

However,

- The potential Impact of a peat slide at a particular location cannot be reduced significantly unless positive measures are taken to effectively contain the peat or sediment along potential flow paths prior to construction.

No further measures are currently scheduled to mitigate the Impact of a potential peat slide on the site of the Derrybrien Windfarm over the remaining operational life of the windfarm. Therefore, we have assumed that the Impact rating for a peat slide resulting from mechanical peat harvesting in the turbary area at the east end of the site will not be reduced, even after the mitigation measures are taken into account.

2.0 GROUND AND GROUNDWATER CONDITIONS IN THE TURBARY AREA

2.1 Introduction

This section of the report gives a characterisation of the baseline conditions for soils, geology and land on the site of the turbary plots in 1998, prior to the construction of the windfarm, as well as the existing ground and groundwater conditions on the site for the Peat Stability Risk Assessment.

All available information was used to establish the baseline conditions on the site, and in areas off-site that could be impacted by a peat slide. This included a comprehensive review of relevant information from the ground investigations that were carried out on the windfarm site, and a desk study review of historical aerial photographs, LiDAR topographical survey data, and relevant information on ground and groundwater conditions, bedrock, and geological heritage sites from online sources including the Geological Survey of Ireland (GSI), the Environmental Protection Agency (EPA) and the Ordnance Survey of Ireland (OSI).

Extensive ground investigations have been carried out across the windfarm site at different phases of the project, primarily at detailed design and construction stage, which would still be relevant to the baseline conditions for soils and geology on the site of the turbary plots. Comprehensive details of the geotechnical investigations that were carried out are presented in the AGL report titled "*Summary of supplemental investigations, stability analyses and peat stability risk mitigation measures adopted during the post-slide construction stage of the Derrybrien Windfarm*," Report No. 11-147-R01, dated 29th May, 2020. The investigations have largely been comprised of:

- An aerial LiDAR survey of the windfarm and surrounding area to obtain an accurate model of ground levels and topography across the site;
- Trial pits to determine the depth and characteristics of peat and subsoils, and the depth to bedrock at shallow depths up to 3.0-4.0 m;
- Extensive peat probing to establish a profile of the depth of peat across the site;
- In-site vane shear testing to establish the undrained shear strength of the peat;
- In-situ undisturbed piston sampling of the peat to obtain high-quality undisturbed samples for laboratory testing and inspection;
- Laboratory testing of the undisturbed samples to assess the material characteristics and undrained shear strength of the peat;
- Disturbed gouge-auger core samples of the peat and subsoil to inspect the characteristics of the peat at the interface with the underlying mineral soil; and
- Rotary coreholes to establish the depth to rock and the rock mass characteristics at a number of turbine locations; and

Further peat probing was carried out in the turbary plots in May/June 2020 by ESB Engineering & Major Projects to give a more detailed assessment of the depth of peat in the area. The results of the peat probing are presented in this report.

2.2 Site Conditions - Soils, Geology & Land Use

2.2.1 Land Use & Topography

Derrybrien Windfarm is located on the upper slopes of the Cashlaundrumlahan Mountain in the Slieve Aughty Mountains in Co. Galway. The site is primarily characterised by upland blanket bog which has historically been used for commercial conifer forestry over the central and western parts of the site, and turf cutting in turbary plots on the east side. An aerial photograph of the site taken in 2000 is shown on Figure 2-1. The photograph identifies the main features that were on the site prior to construction of the windfarm, including:

- The boundary of the windfarm site;
- The zone of turbary plots in the open blanket bog at the east end of the windfarm;
- The existing drainage network along the boundaries of the turbary plots;
- The existing access roads to the turbary plots, which were constructed as floating roads;
- The extent of the Coillte conifer forest plantations within the windfarm site, including those within turbary plots 182 to 207;
- The zones of darker vegetation associated with an area of deep peat and high water table along a natural subsurface drainage channel;
- A zone of possible concentrated subsurface flow in the peat upslope from the deep peat area;
- Existing watercourses and surface drainage channels; and
- A zone of patchy tree growth along the watercourse upslope from turbine T32.

Figure 2-2 shows a more recent aerial photograph of the turbary plots from circa 2015-2018. This shows the layout of the turbines, windfarm access tracks and substation at this end of the windfarm site. All of the new roads were constructed as floating roads on the peat. The existing turbary road was also upgraded with an additional layer of rockfill as capping for the construction of the windfarm. The turbine foundations are supported on bedrock below the peat and glacial till. The crane hardstandings are supported on the glacial till below the peat.

Most of the trees in turbary plots 182-207 were clear felled during the construction. A zone of trees along the watercourse at Turbine T32 were left in place. The felled area was not re-planted but some small trees have re-established naturally on the slopes. Figure 2-2 also shows indications of recent peat excavations, turf cutting and drainage in the turbary plots, as discussed in Section 3.0.

Figure 2-3 is a LiDAR survey showing the general topography of the site following completion of the windfarm (i.e. post 2005). With the exception of the areas at the borrow pit, turbines, crane hardstandings, and along the new site access tracks, the ground levels across the site would generally also be relevant to the original conditions on the site in 1998, prior to construction. Figure 2-4 shows the ground surface slope angles interpreted from the LiDAR survey.

Ground level in the turbary area falls from +353 mOD near Turbine T24 at the northwest corner, to +270mOD at the southeast corner of the turbary plots near Turbine T46. The ground surface is relatively flat or gently sloping on the north side of the central turbary access road. The slope angles are generally <3-4°, and locally up to 4-5° between Turbines T40 and T45 at the east end of the site. To the south of the central turbary road there is a convex break in slope to slope angles of up to 5.0-7.5°, particularly between Turbines T31 and T45, and at the south east corner of the turbary area.

The zone of deep peat and high water table identified on Figure 2-1 is on gently sloping ground with slope angles <3° upslope from the central turbary access road between Turbines T28 and T32.

2.2.2 Landslide Susceptibility Map

Figure 2-5 shows the Landslide Susceptibility Map for the turbary area from the Geological Survey of Ireland (GSI) superimposed on the OSI 1:50,000 Discovery Series map. This map provides information on areas which are pre-disposed to landslides using a classification system based on slope angle, soil type and a parameter referred to as the Topographic Flow Index (TFI), which is a measure of how overland flow of landslide debris is concentrated or dispersed by the terrain, also taking into account flow velocity.

The slope angle is derived from the 20m Digital Elevation Model (DEM) and values can range from 0 to 90 degrees. Soil types are generalised into 5 main groupings based on their grain size distribution (i.e. fine or coarse-grained), and/or particular characteristic, including Peat, which is particularly relevant for the turbary areas. The TFI is also derived from the 20m DEM and is calculated using factors related to slope angle, flow direction and flow accumulation.

The classification model is weighted by applying a known inventory of landslide events to particular combinations of factors that have a higher incidence of landslides. This includes the area where the peat slide occurred at Turbine T68, during construction of the windfarm, which is recorded on the GSI database. The location and extent of the peat slide are also identified on Figure 2-5.

The results are banded into four categories of landslide susceptibility ranging in classification from Low to High. The resolution of the mapping is on a local to regional level based on the accuracy of the DEM (20m) and the scale of the base mapping (1:50,000).

Figure 2-5 indicates that the turbary plots are classified as being of **Low** susceptibility to landslides on the gently sloping ground with slope angles typically <3-4° to the north (upslope) of the central access road between Turbines T25 and T40, and at the east end of the site.

The turbary plots on the steeper slopes with slope angles of 4.0-7.5° to the south of the central access road between T25 and T45, north of the road between T37 and T45, and in the turbary plots at the southeast corner of the site are classified as being of **Moderately Low** susceptibility to landslides.

A localised area in turbary plots 201-204, upslope from Turbine T38, has been classified as being of **Moderately High** susceptibility to landslides.

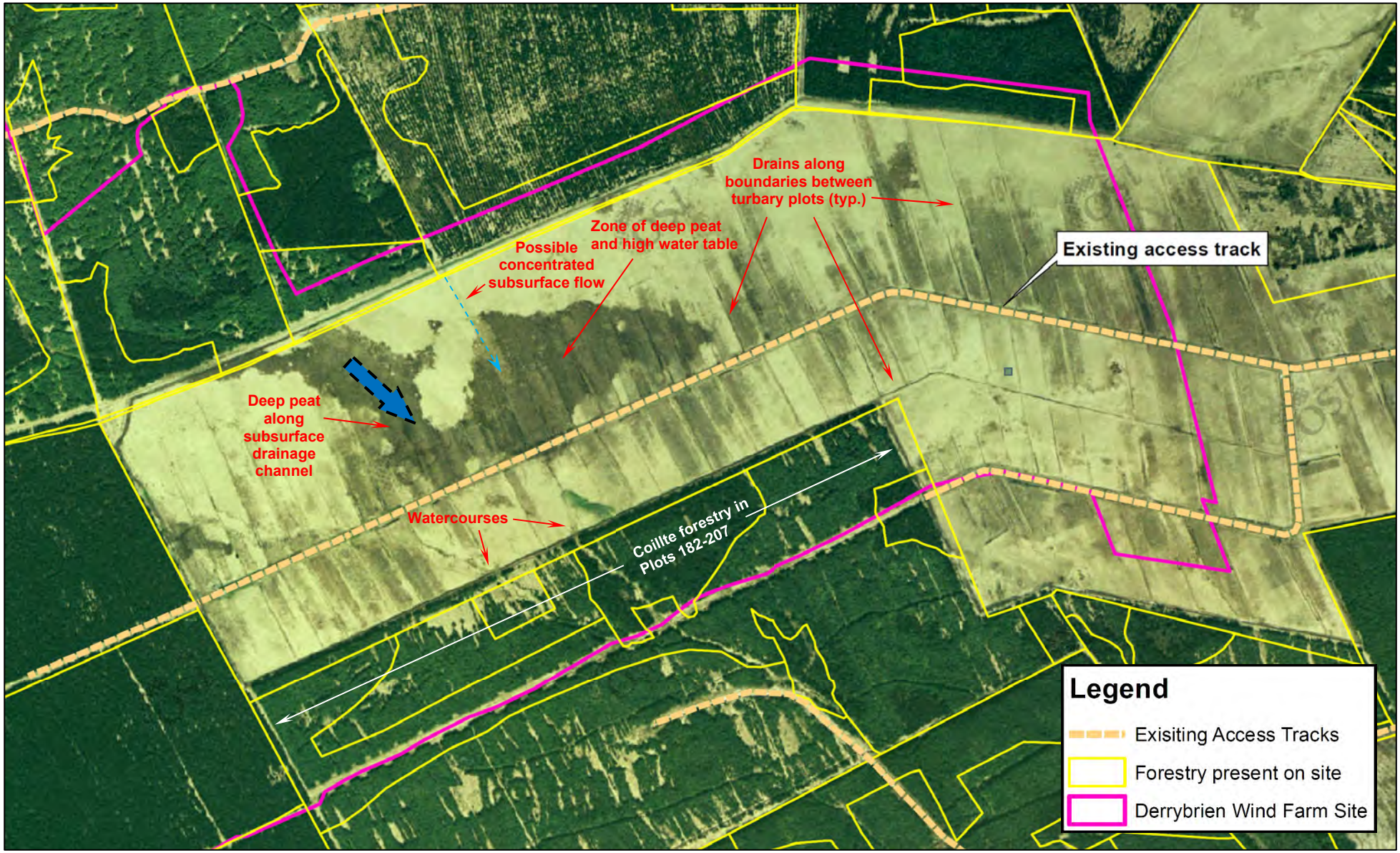


Figure 2-1 –Aerial Photograph of the turbary plots in 2000 (from ESBI Drawing No. QS-000280-01-D460-011-001-000)

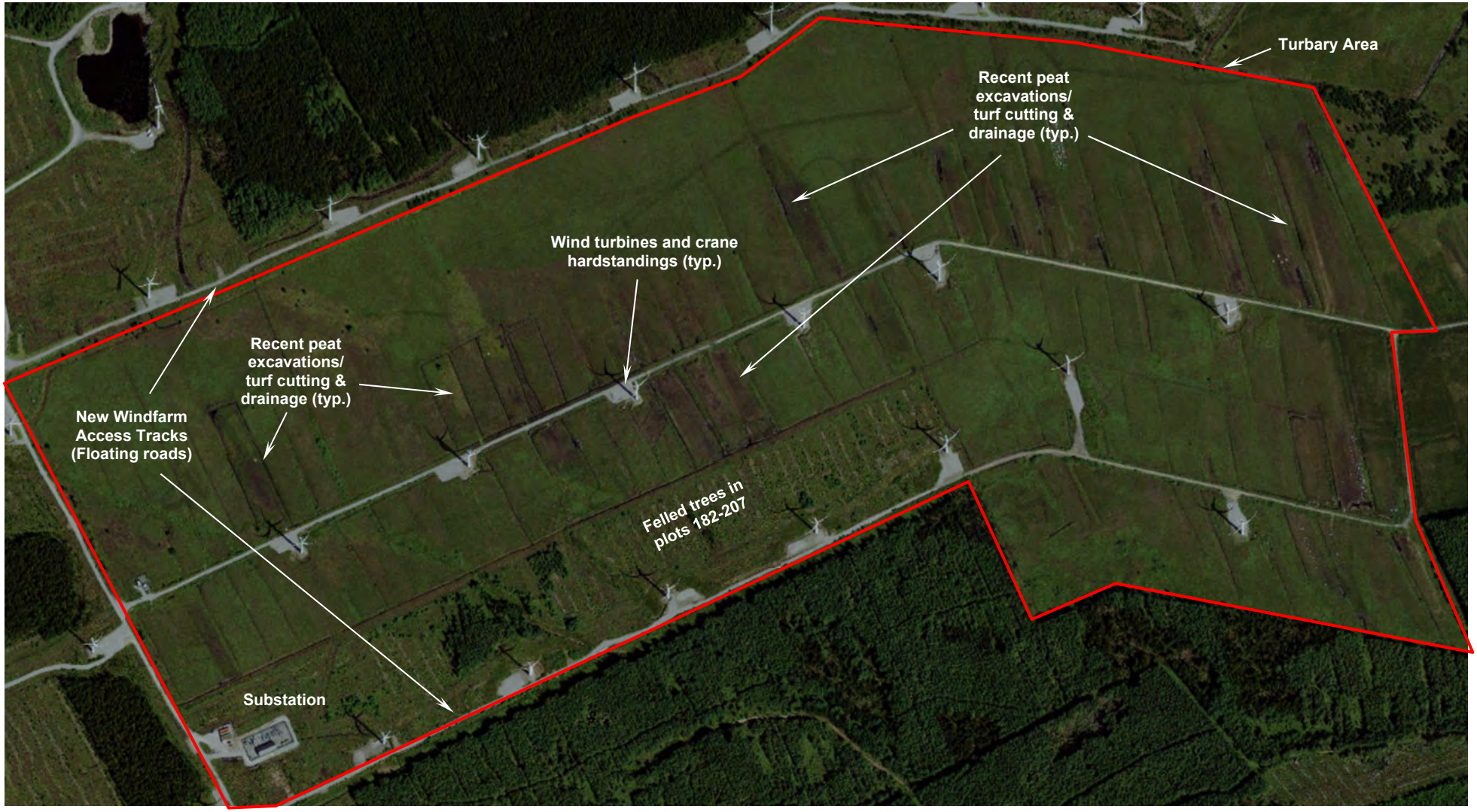


Figure 2-2 – Aerial Photograph of the turbary plots c2015-2018 (www.geohive.ie, July 2020)

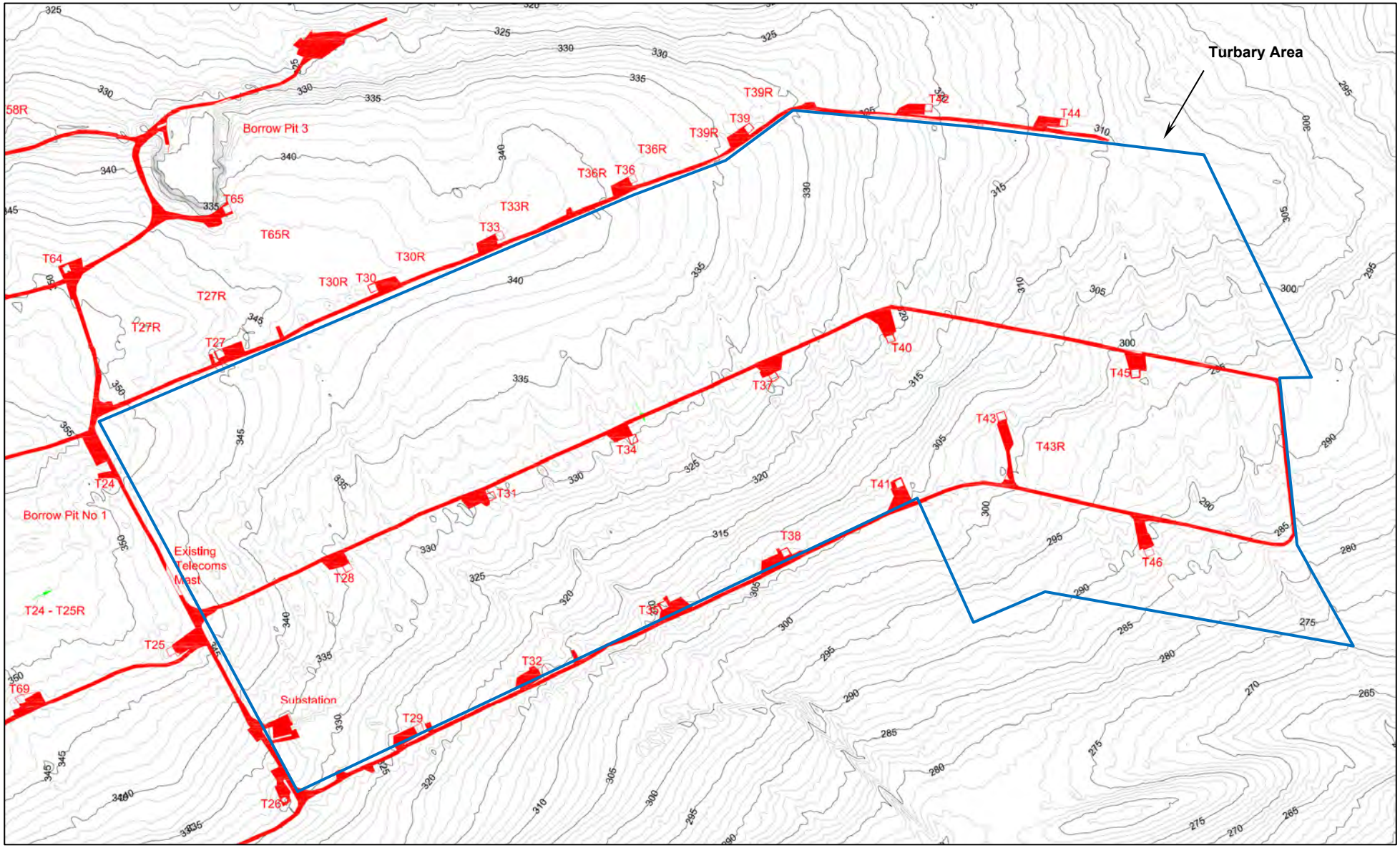


Figure 2-3 – LiDAR survey of turbary area

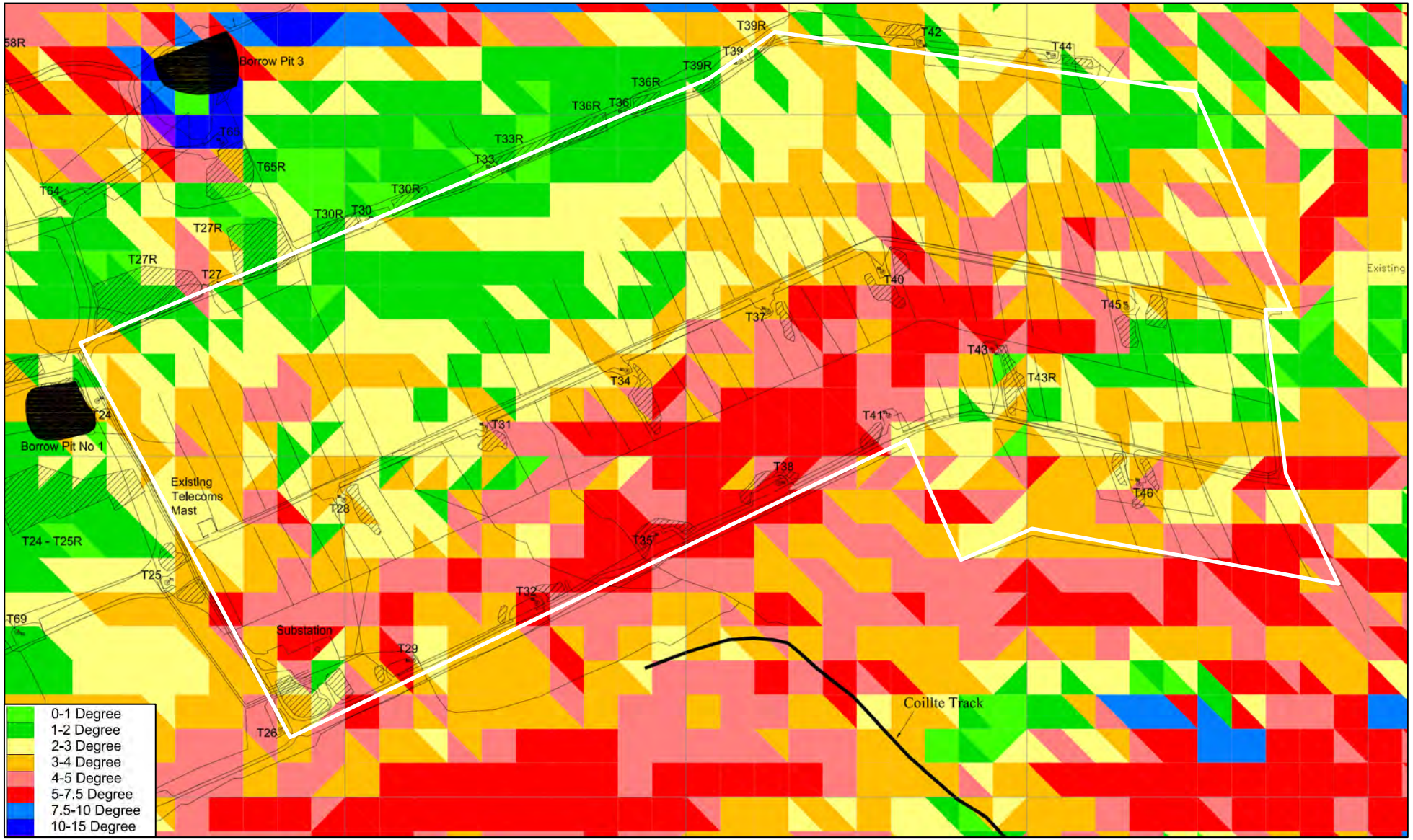


Figure 2-4 – Ground surface slope angles in turbary area

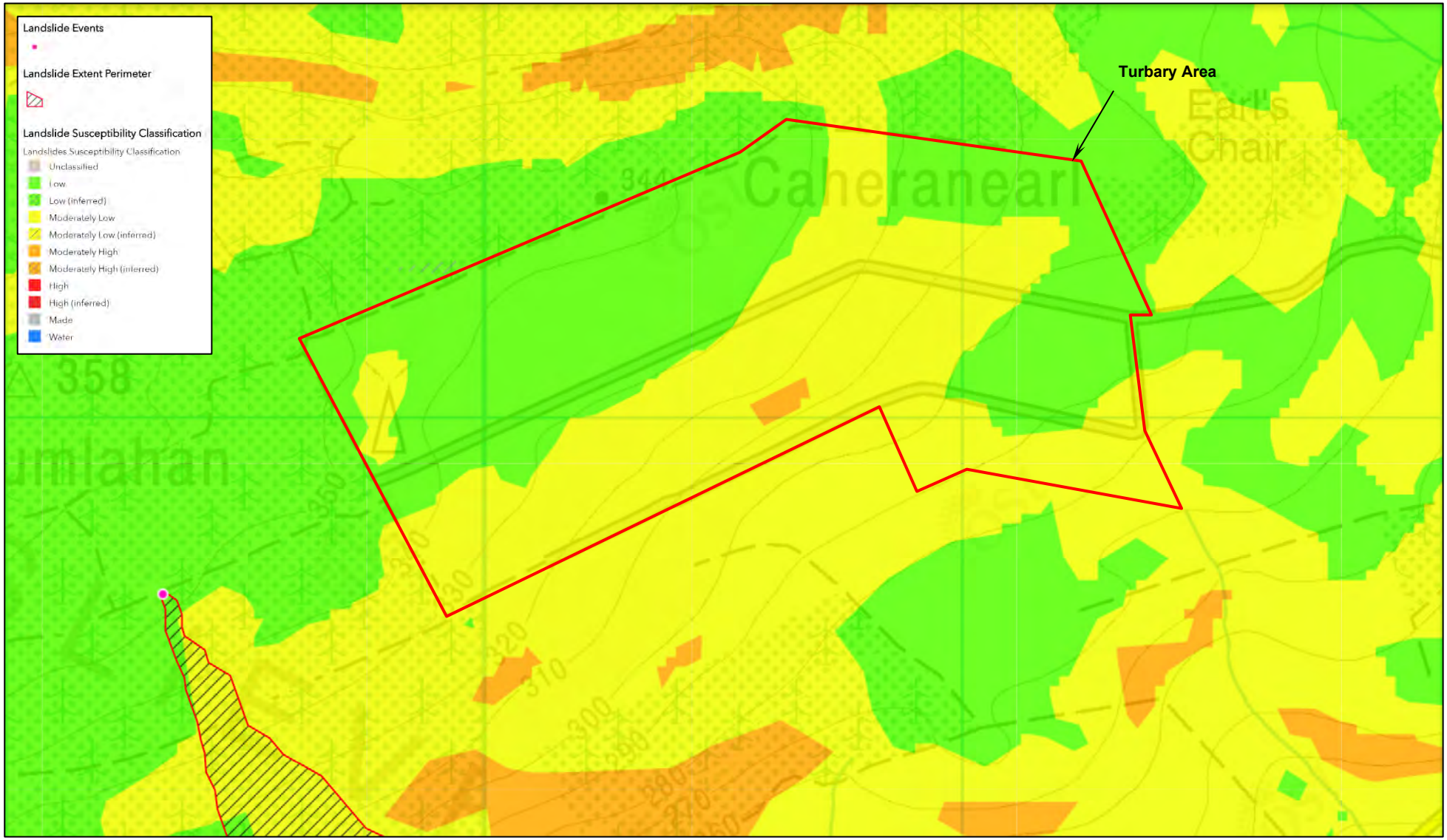


Figure 2-5 - Landslide susceptibility map for turbary area

2.2.3 Geotechnical Characterisation of Site Conditions

2.2.3.1 Peat

Figure 2-6 shows a map of the Quaternary Geology for the turbary area from the Geological Survey of Ireland online database. It shows that the area has a continuous cover of upland blanket peat (BkPt). Exposures of outcropping bedrock (Rck) are identified along the watercourse channel downslope from the turbary plots at the southeast corner of the windfarm site.

Extensive probing has been carried out to determine the depth of peat in the turbary plots. The location of the probes and the depth of peat at the each location are shown on Figure 2-7, which includes the probes that were carried out recently in the area in May/June 2020. Figure 2-8 shows contours of peat depth across the turbary area, which have been interpreted from the probes.

In general, the depth of peat is proportional to the slope angles. The areas of peat up to 3-6 m deep correspond to the broad flat or gently sloping ground with slope angles <3-4° on the north side of the central turbary access tracks (see Figure 2-4), along the subsurface drainage channel between Turbines T27 and T35, and at the southeast corner of the windfarm.

The areas of peat <2.0m deep are generally located along the steeper slopes up to 4.0-7.5° on the south side of the central access road between T25 and T45, north of the road between T37 and T45, and along the watercourse between T24 and T31 at the west end of the turbary area.

There is a broad zone of shallow peat <1.0m along the southern boundary of the windfarm site between Turbines T32 and T36.

The peat would generally be classified as very soft brown fibrous, slightly fibrous or amorphous (clayey) PEAT. The degree of decomposition (humification) of the peat varies with depth – typically ranging from fibrous in the upper vegetated layer (the acrotelm) where there is still living plant matter (Von Post H4-H6), to slightly fibrous, amorphous or clayey with depth in the underlying catotelm peat, which is comprised of dead plant matter generally below the water table (Von Post H7-H10). There is a more significant variability in the characteristics of the peat in the areas of deeper peat >2-3 m.

Figure 2-9 shows typical profiles of unfactored undrained shear strength recorded in the peat by AGL/BAM with the Geonor H-10 in-situ penetration vane during the construction stage of the project. In accordance with BS5930:2015 – BS Code of Practice for Site Investigations, the peat would be classified as Extremely Low Strength with an undrained shear strength <10 kN/m^2. The results were generally in the range of 5-10 kN/m^2, with a few locally lower values of 3.5-4.0 kN/m^2.

Specialised laboratory tests carried out on undisturbed samples of peat from the site by Trinity College Dublin indicated that the undrained shear strength of the samples tested in direct simple shear was generally greater than 4.5-6.0 kPa. However, some very low strengths on the order of 2.0-4.5 kPa were recorded on samples collected near the base of the peat in the vicinity of the slide that occurred during construction at Turbine T68 (average = 3.5 kPa).

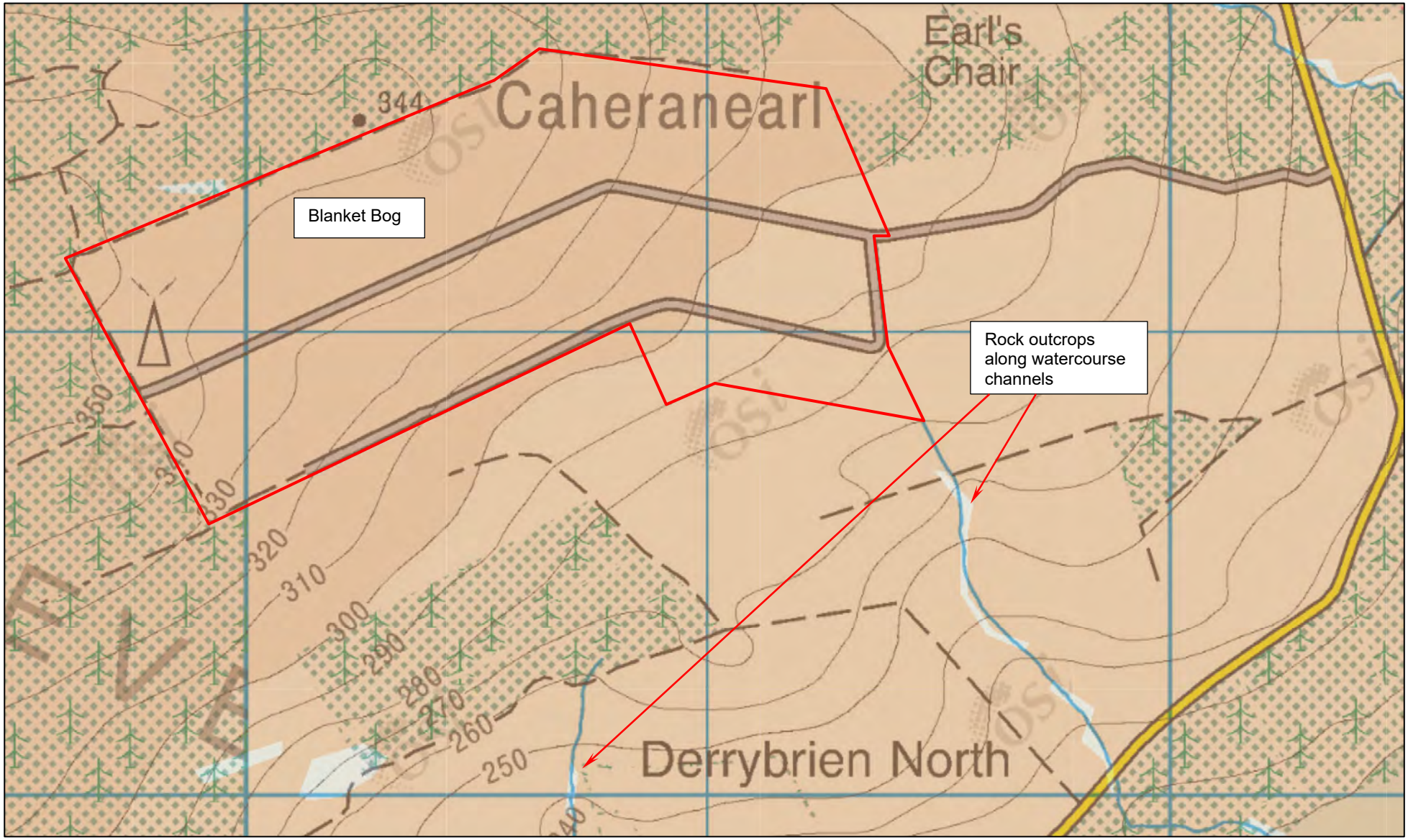


Figure 2-6 – Quaternary geology map for the turbary area (www.gsi.ie, July 2020)

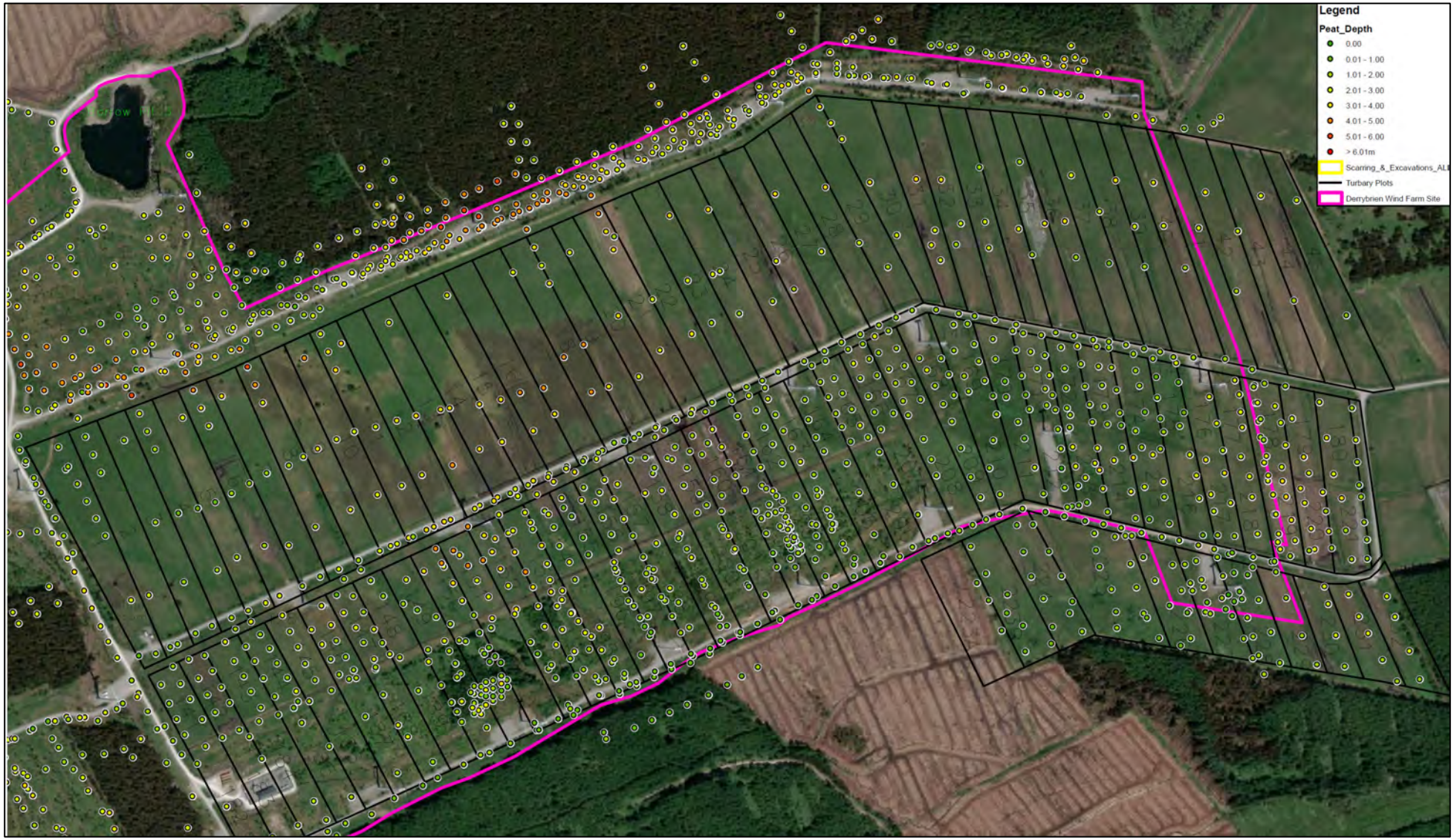


Figure 2-7 – Peat depth probes in the turbary area

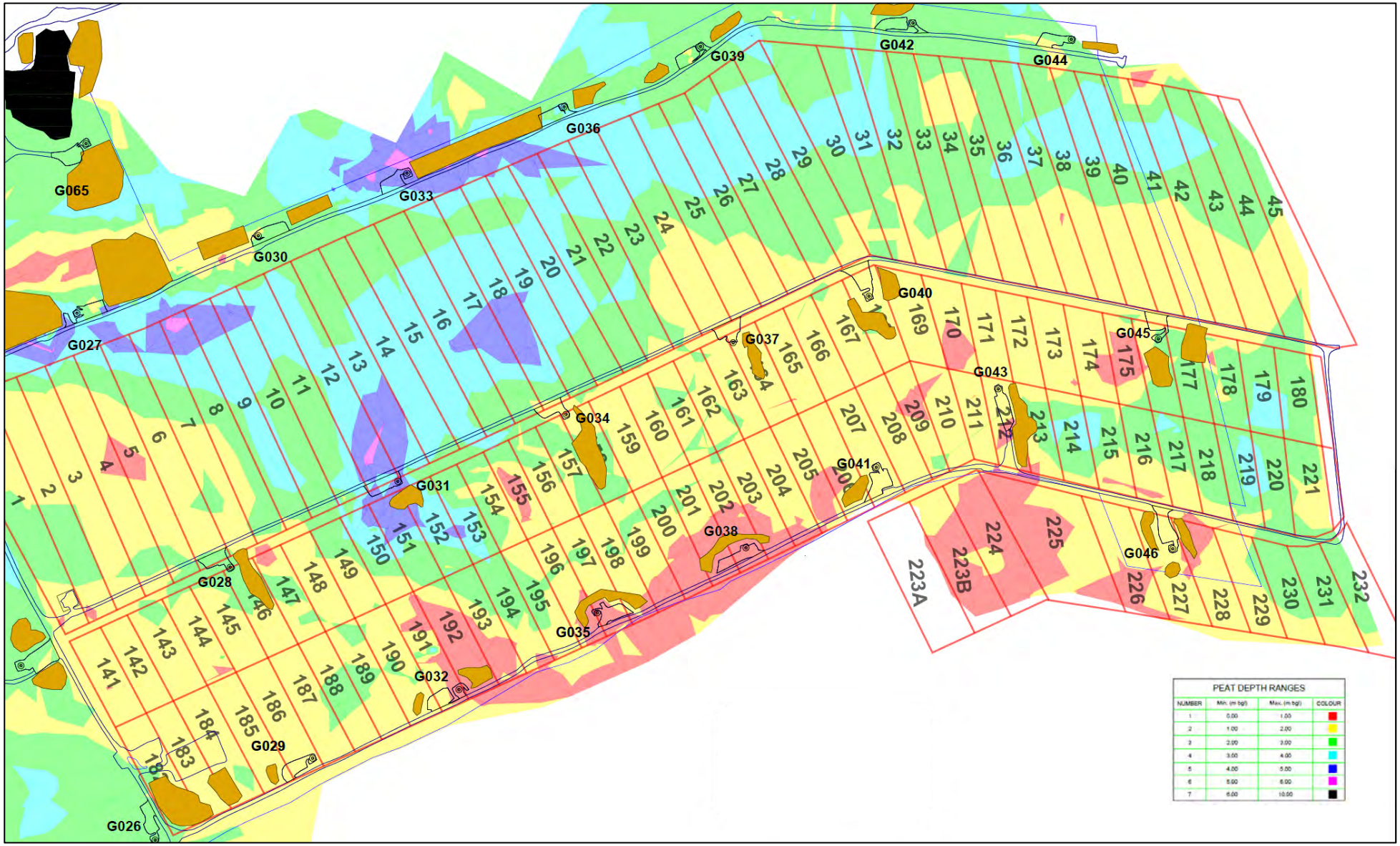


Figure 2-8 – Peat depth in the turbary area

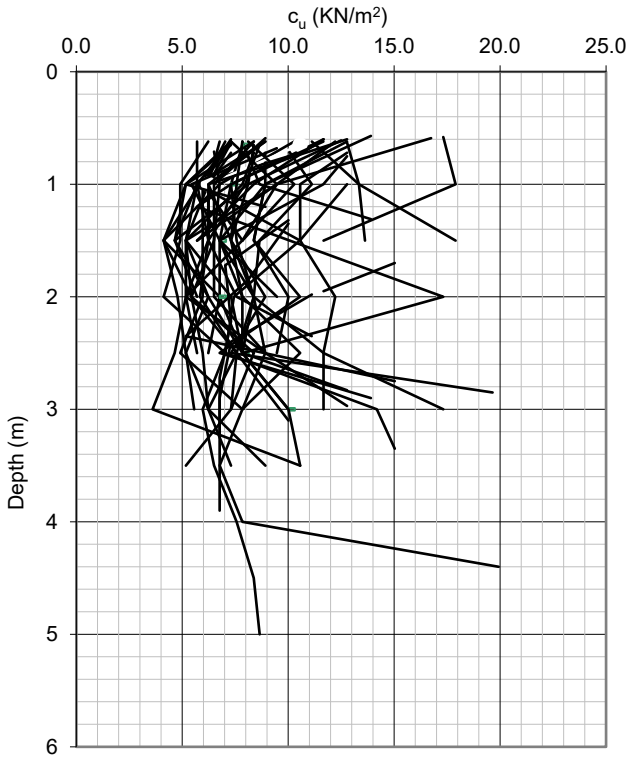


Figure 2-9: Profile of undrained shear strengths (c_u) with depth recorded in the peat with the Geonor H-10 penetration vane

2.2.3.2 Mineral Subsoil & Bedrock

The GSI map of Quaternary Geology for the windfarm site indicates that the blanket bog is underlain by glacial till derived from Devonian Sandstones (TDSs).

Where the full depth of peat was penetrated in 4 No. of the trial pits carried out by IGSL Ltd. prior to construction of the windfarm, the peat was shown to be underlain by a 0.1-0.6 m thick layer of soft grey-white sandy SILT over glacial till described as Firm purple sandy gravelly CLAY.

Within the turbary area rotary coreholes were carried out for the windfarm by Irish Drilling Ltd. at Turbines T30, T31, T33, T36 and T39. Bedrock was encountered at a depth of 3.5 to 6.0m. At T30 and T31 there was 1.7-3.2m of glacial till over the rock. SPT N-Values in the till ranged from 6 at T31, to 14-33 at T30. This would correspond to an undrained shear strength (c_u) of 30 to 165kPa using the approximate empirical correlation $c_u \approx 5 \times N_{SPT}$. In accordance with BS 5930 the strength of the till would therefore be classified as Low (20-40 kPa) to Very High Strength (150-300 kPa).

At Turbines T33, T36 and T39 the coreholes indicated that the peat was underlain directly by the rock at a depth of 3.5 to 5.4m. However, samples of the overburden recovered by conventional rotary coring may not be representative of the in-situ conditions.

The 1:100,000 Geological Map from the Geological Survey of Ireland (GSI) indicates that bedrock in the turbary area is comprised of Mudstones, Siltstones and Conglomerates from the Ayle River Formation.

Bedrock recovered in the rotary coreholes by IDL at T30, T31, T33, T36 and T39 was generally comprised of fresh to slightly weathered, strong to very strong, thinly bedded, locally thinly laminated, purple fine to medium and fine to coarse-grained SANDSTONE.

2.2.4 Hydrology and Hydrogeology

2.2.4.1 Groundwater Conditions

In the pre-construction ground investigation carried out by IGSL Ltd. water strikes were recorded in the trial pits at depths of 1.0m to 1.5m and were described as "seepage" in the peat. The trial pits were not left open long enough for the water to stabilize at the natural groundwater level so they only indicate where relatively permeable strata or pockets were encountered below the water table.

During construction, standpipes were installed by AGL Consulting at 6 No. locations along a north-south axis from the centre to the south of the windfarm in the vicinity of the peat slide to get a profile of the depth of groundwater down the slope. The readings that were taken from 17th November 2003 to 4th December 2003 indicated that the depth to groundwater ranged from 0.1m to 1.1mBGL.

In 2004, 3 No. electronic vibrating-wire piezometers (Pz-7 to Pz-9) were installed in a cluster in the peat in Turbary Plot 158, downslope from Turbine T34 and approximately 5m upslope from the 1.3m deep collector drain that runs east-west across the end of the turbary plot. Initially the piezometers indicated that the depth to groundwater generally fluctuated between 0.3 and 1.1 mBGL when construction on the windfarm was completed in 2005. Figure 2-10 shows the changes that occurred to the groundwater level over time after construction. The readings indicate that, on average, between December 2005 and November 2011 the groundwater level in the peat gradually dropped by about 0.7m due to drainage in the nearby drains.

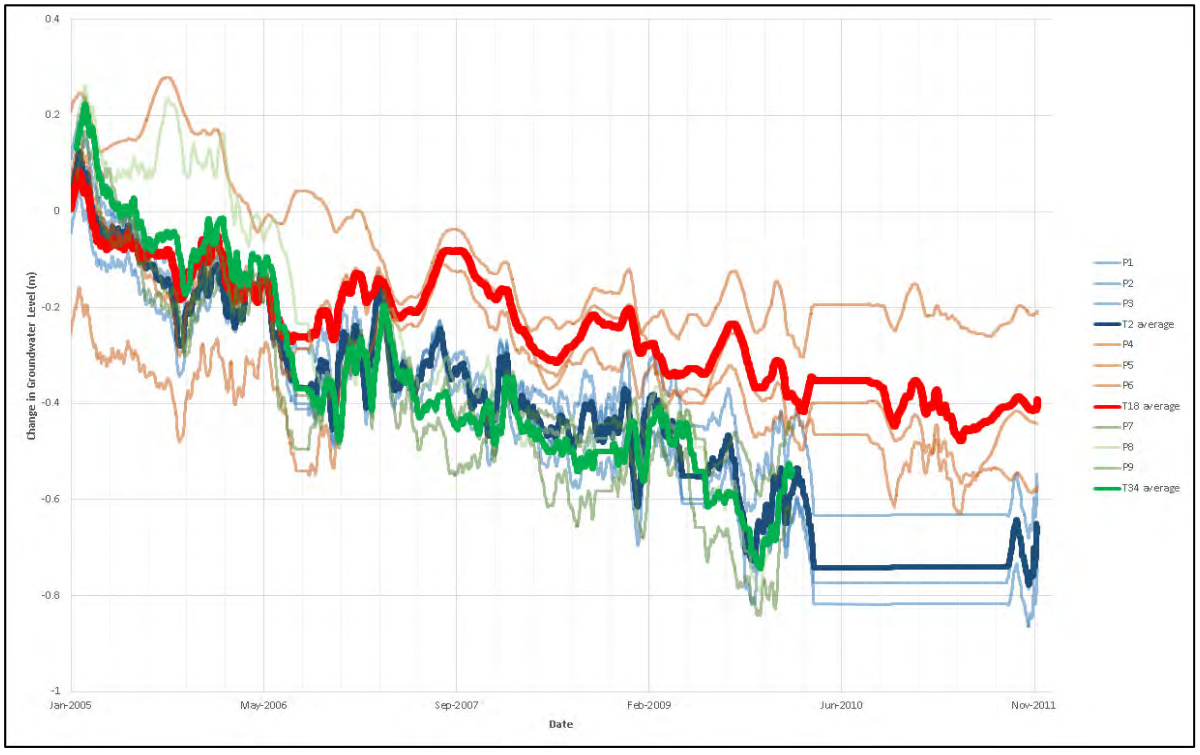


Figure 2-10 – Post-construction change in groundwater level readings from electronic piezometers in Turbary Plot 158 at Turbine T34

The aerial photograph in Figure 2-1 identifies an area of high groundwater and deep peat where the surface vegetation is darker on gently sloping ground upslope from the central turbary road between Turbines T31 and T37. The figure also identifies an area of possible concentrated subsurface groundwater flow in the peat between Turbines T30 and T33 along the northern boundary of the windfarm site.

The peat depth contours in Figure 2-8 would indicate that there is a subsurface channel in the zone of deep peat between Turbines T27 and T35. Groundwater in these areas would flow downslope through a network of natural open pipes within the peat as well as possibly through an open joint network in the underlying bedrock.

2.2.4.2 Hydrology - Surface Water, Drainage and Natural Watercourses

Figure 2-11 shows the network of natural watercourses and man-made drains in the peat in the turbary area prior to the construction of the windfarm. It also shows the additional drains that were constructed for the windfarm.

Prior to the construction of the windfarm there was an extensive network of drainage in the turbary area. The majority of the existing drains are shallow open drains within the peat, typically 1-2 m deep, which run along the north-south boundaries between turbary plots. There are also east-west collector drains that run along the length of the turbary area along the downslope side of the turbary plots. These connect the turbary drains with the network of natural and improved watercourses on the south side of the windfarm in this area.

Figure 2-12 shows the regional hydrology in the area from the EPA online Water Maps (www.epa.ie). All of the drains in the turbary area flow into the stream at the southeast corner of the windfarm, which is in sub-catchment SC7(a). This is a tributary of the Owendalulleegh River, which flows west into Lough Cutra.

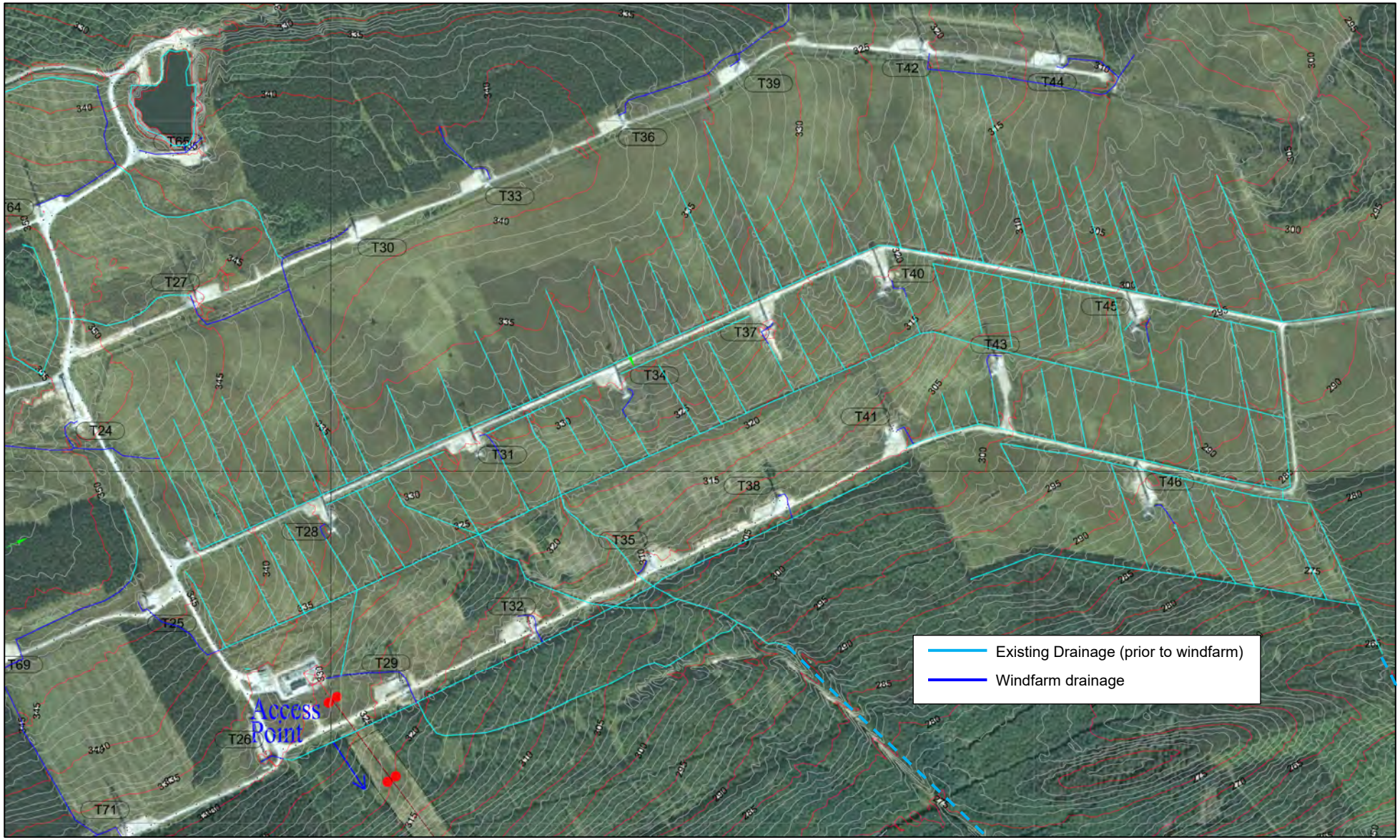


Figure 2-11: Surface hydrology and drainage network in the turbary area

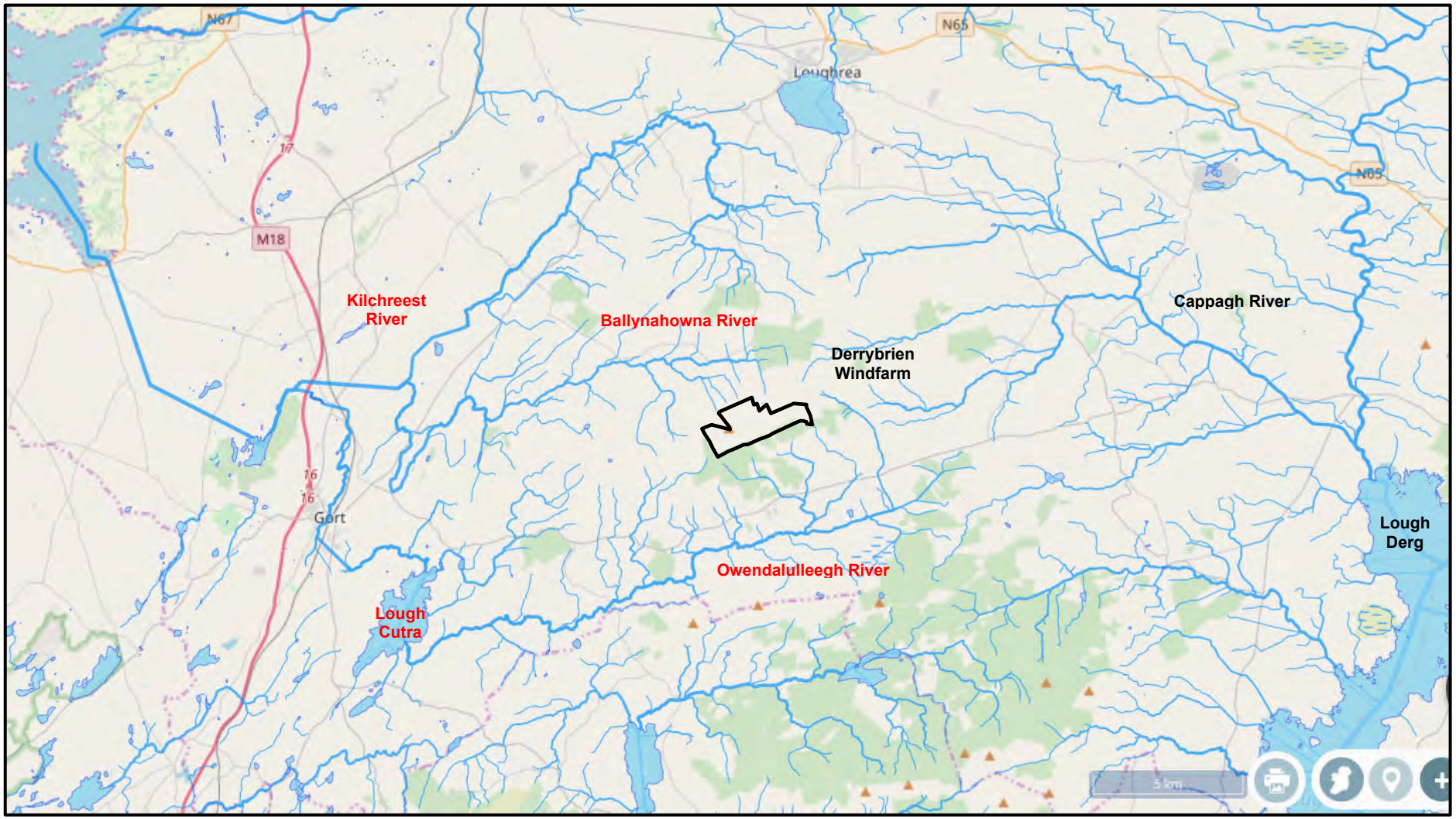


Figure 2-12: Regional hydrology (EPA Water Maps, www.epa.ie, July 2020)

3.0 SITE ACTIVITIES IN TURBARY PLOTS

3.1 Peat Harvesting (Turf Cutting)

There are no records for the mechanical peat harvesting or turf cutting that has been carried out in the turbary area since 1998, or prior to then. The following is a summary of general information on recent activity in the area which has been obtained from consultations with the windfarm manager for Gort Wind Farms Ltd. and with a local peat cutting contractor, who has worked on the site since 2012. It is not a complete or comprehensive record of mechanical peat harvesting on the site, but it does give an indication of the general nature of the methods of mechanical peat harvesting that have recently been utilised as well as the possible extent of mechanical peat harvesting in the turbary area.

- The extent of mechanical peat harvesting in the area up to 2012 is not known. However, the level of turf cutting after the windfarm was constructed has generally been low. Historically, turf cutting was carried out by hand on a number of plots, normally in late Spring/early Summer.
- Since 2012 a local peat cutting contractor has been retained by some of the plot owners to mechanically cut turf so there has been an increase in the number of plots where mechanical turf cutting has been carried out. The contractor has worked in 34 No. of the turbary plots as follows: **6, 7, 9, 10, 15, 24, 27-29, 31-35, 39, 40, 42-44, 142, 143, 155, 159-162, 219-221, 228-232.** These are identified on the aerial photograph in Figure 3-1. Figure 3-2 identifies typical evidence of recent mechanical peat harvesting and drainage that was evident in April 2020.
- The mechanical peat harvesting was carried out by the contractor with a wide track low ground bearing pressure hydraulic excavator and a Difco Bogmiser hopper, similar to that which is shown in Plate 3-1 . It is a specialised track-mounted self-propelled diesel-powered machine for peat harvesting that has a rear-mounted hopper and auger system to hold, compress, extrude and cut the peat into sods of turf. The peat below the vegetated surface layer is first loaded into the hopper by a hydraulic excavator that excavates the peat from the active bank or trench excavation. When fully-loaded, the hopper is then driven away from the excavation area and the peat is extruded in 8 No. continuous rows of turf sods 100mmx 90mm in cross-sectional area over an 80m long strip on the surface of the peat in the turbary plot to allow it to dry. Subsequent loads are laid out in parallel strips across the turbary area. They are left to air-dry over a number of weeks before being bagged and collected for transport off site.

Plate 3-1 – Difco Bogmiser Peat Hopper extruding rows of peat sods

- When the hopper is fully loaded with peat it weighs on the order of 32 tonnes (≈315 kN). The hopper is fitted with low ground bearing pressure wide-tracks to spread the load out on the surface of the peat. Each track is 1.5m wide x 6.0m long so that, when the hopper is fully-loaded the bearing pressure under the tracks is on the order of 17.5 kN/m^2. This is equivalent to the surcharge load from approximately a 1.75m thick layer of intact peat over the same area.
- The mechanical turf cutting is typically only carried out once in each turbary plot each year, in late Spring/early Summer. The volume of peat that is extracted in each area is on the order of 50-75m^3, which is equivalent to 8-10 hopper loads with each hopper load creating a single row of 8No. 80 m long strips of peat sods along the length of the turbary plot and spaced evenly out across the width of the plot.
- Peat is not extracted from all of the turbary plots each year. However, if all 34 No. of the plots operated by the peat cutting contractor were active each year, then this could involve the excavation of up to about 2,500m^3 of peat.
- Turf cutting has been carried out by saw cutting in 1 No. additional turbary plot between plots 20 and 30. The aerial photographs would indicate that this could have been in Plot #21 (Figure 3-2). Plate 3-2 shows a typical saw cutting device for peat harvesting. It is a specialised attachment that fits to the back of a tractor that resembles a large chainsaw. It cuts a narrow slot up to about 1.2m deep into the peat. Similar to the hopper system, an auger then compresses and extrudes the excavated peat directly into continuous rows of turf sods on the surface of the peat adjacent to the saw cut line. Again, the sods are left to air-dry over a number of weeks before being bagged and collected for transport off site. The saw cutting is normally carried out along closely-spaced parallel rows. The aerial photograph in Figure 3-2 indicates that these could be aligned north-south along the long axis of the turbary plot #21. Saw cutting is sometimes also carried out along perpendicular lines. However, this is not reflected in the marks on the peat and the narrow plot would make saw cutting less efficient across the width of the plot.

Plate 3-2 – Typical saw cutting attachment for extracting peat

- Traditionally peat harvesting would have been carried out in the turbary plots by hand using a specialised turf spade called a slane. Manual turf cutting is still carried out in a turbary plot in the general area, but not in the plots shown on or immediately adjacent to the windfarm site.

3.2 Drainage

Some minor drainage works have also been carried out in the area by or on behalf of the turbary plot owners, i.e.:

- The east-west collector drain along the downslope side of the turbary plots downslope from the central access road, has been cleared out once since the windfarm was constructed to ensure that the water is draining effectively from the area;
- When carrying out routine maintenance on the drainage for the windfarm, Gort Wind Farms Ltd. also cleared out a drain that had become blocked on one of the turbary plots on behalf of the plot owner;
- Recently, open drains have been excavated around the perimeter of some of the turbary plots that have become recently active for machine cutting, as shown on Figure 3-2.

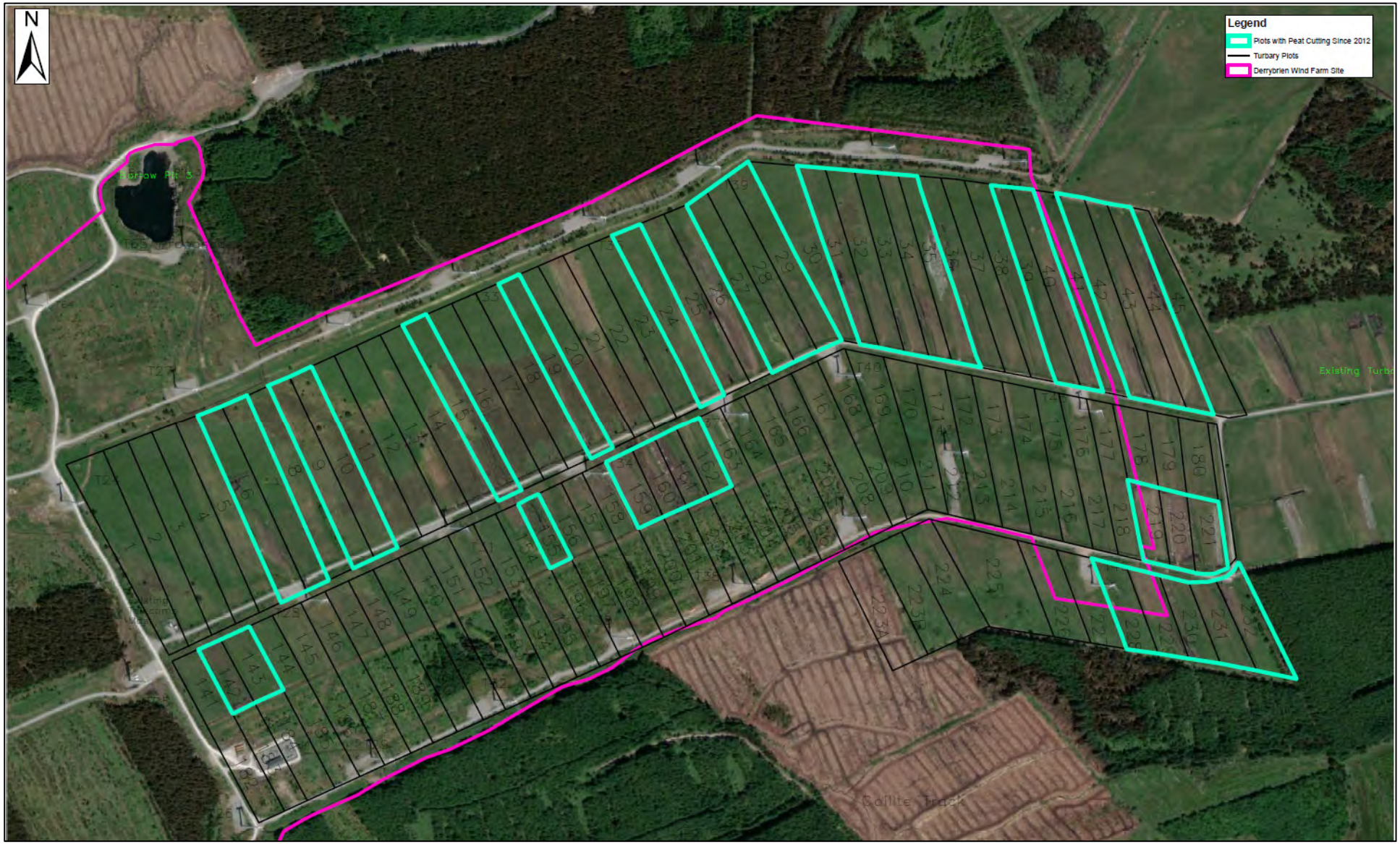


Figure 3-1 - Turbary plots where mechanical peat harvesting has been carried out by a local contractor since 2012

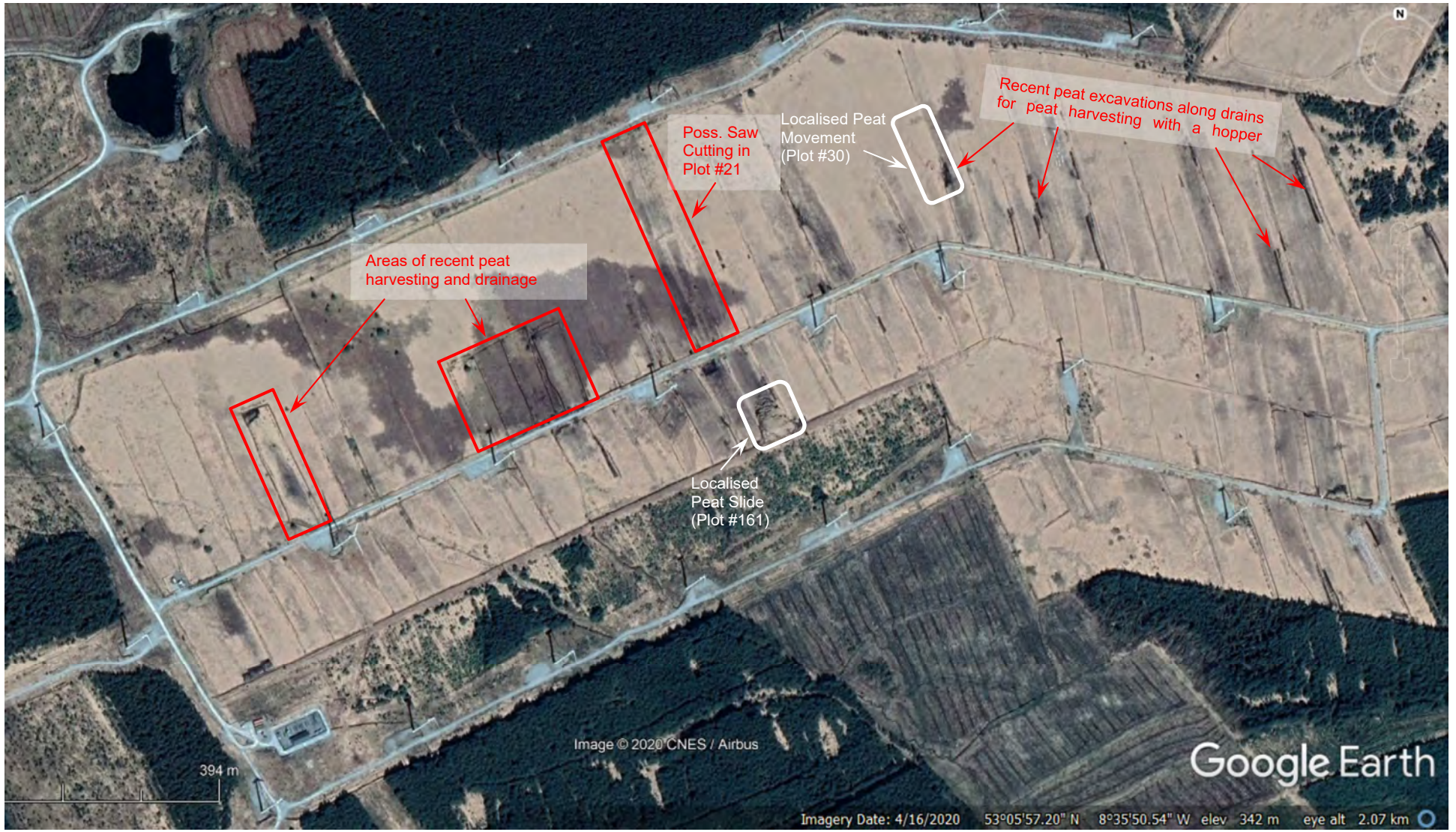


Figure 3-2 – Recent aerial photo of turbary plots illustrating recent peat harvesting (turf cutting) activities

4.0 PEAT STABILITY RISK ASSESSMENT (PSRA) - PRIOR TO IMPLEMENTATION OF RISK MITIGATION MEASURES.

A Peat Stability Risk Assessment (PSRA) has been carried out for the turbary plots to characterise the relative risk of peat instability in each plot prior to implementation of risk mitigation measures. The purpose of the PSRA is to identify where there are elevated risk factors that determine where mitigation measures are required to ensure that the risk of peat instability can be reduced to an acceptable level for mechanical peat harvesting. The assessment has been carried out based on existing site characteristics in each plot, also taking into account the level of mechanical harvesting that has been undertaken on the site since 2012.

There are a total of 136 No. turbary plots on the site, which are numbered as follows, as shown on Figure 1-1:

- 1-45
- 144-180
- 182-221
- 223A, 223B and 224-232

Plots 1-45 are relatively long and almost double the size of the other turbary plots on the site. Therefore, for this assessment they have been split up into two zones (north and south) that are of comparable area to the other turbary plots, as shown on Figure 4-1. Each of the zones has an area of about 0.55ha and there are a total of **181 No. zones** in the turbary area.

A qualitative risk assessment has been carried out for each turbary plot to assess the **Risk Rating (R)** for a peat failure occurring as a result of mechanical peat harvesting in the plot based on the interpreted **Likelihood (L)** (i.e. probability) of occurrence and **Impact (I)** of failure **(i.e. R = L x I)**.

In this assessment peat failures that could occur as a result of mechanical peat harvesting in the turbary plots could range from a localised shear failure in the peat on the upslope side of an open excavation, to a small-scale peat slide that is contained within the turbary area, or a large-scale peat slide comparable to the slide that occurred at Turbine T68 on the windfarm site in October 2003, which would be the worst case scenario. Further details on the methodology of the assessment are provided in Section 1.2. The following is a summary of the results of the assessment.

4.1.1 Likelihood (L)

The **Likelihood (L)** of a peat failure in each zone has been interpreted by evaluating factors related to the peat and subsoil conditions, topography, site hydrology/hydrogeology and other significant contributory factors such as the method of peat harvesting or slide history to determine where there are compounding conditions that could lead to a higher risk of a peat failure.

Tables A2 to A6 in Appendix A give guidance on the different factors that can contribute to peat instability that were evaluated in the assessment. Appendix A also includes figures showing the calculated Factor of Safety (FoS) against shear failure at the base of the peat across the turbary area for the following criteria:

- c_u = 5.0kPa, Surcharge = 0kPa (Figure A-1)
- c_u = 5.0kPa, Surcharge = 10kPa (Figure A-2)
- c_u = 2.5kPa, Surcharge = 0kPa (Figure A-3)
- c_u = 2.5kPa, Surcharge = 10kPa (Figure A-4)

Where:

- **c_u** is the assumed undrained shear strength at the base of the peat; and
- the surcharge load is an additional load applied at the surface of the peat and 10kPa is approximately equivalent to the weight of 1.0m of peat.

For each set of conditions the FoS have been calculated across the turbary area for the infinite slope condition using the peat depths interpreted from the probes (Figure 2-8) and the slope angles that were interpreted from the LiDAR survey (Figure 2-4). The FoS is calculated as the ratio of the downslope component of the self-weight of the peat on the slopes to the undrained shear strength at the base of the peat. A FoS ≥1.0 indicates that the shear strength of the peat is sufficient to support the peat on the slopes and an FoS >1.3 provides a margin of safety.

The resulting FoS without the surcharge load give an index of the stability of the slope in the undisturbed condition for the assumed lower bound strength criteria. The majority of the in-situ vane shear test results in the peat were in the range of 5-10kPa. An undrained shear strength of 2.5kPa would represent the worst case scenario where there was very weak or remoulded peat at the base of the peat. This would generally only apply where some movement or shear has already occurred in the peat.

The application of the surcharge load is a sensitivity analysis that is used to identify areas that might be more susceptible to a peat failure if a small load is applied to the surface of the peat, e.g. from turf cutting equipment or stockpiles of excavated peat.

Because of the range in the strength of the intact peat, the FoS calculations on their own do not indicate where a peat failure is likely to occur. The method of assessment that has been used for the PSRA in accordance with current best practice guidelines takes into account all of the contributory factors listed under the different criteria in Tables A1 to A6 to identify areas where there are compounding factors that could lead to a higher risk of a peat failure.

The results of the assessment are presented in Table A-1 in Appendix A and on Figure 4-1. Although mechanical peat harvesting is only being carried out in a small number of the turbary plots (see Section 3.0), it has conservatively been assumed that the activities are not restricted to those areas so that the assessment is applicable if mechanical peat harvesting is carried out in all of the turbary plots.

The results show that there are significant areas of the turbary plots where the likelihood of a peat failure due to mechanical peat harvesting under uncontrolled conditions and without appropriate mitigation measures is **Very Possible** to **Likely (L=4.0 to 5.0)**. These zones are located in areas where there are compounding risk factors in relation to peat instability, including, for example:

- The zone of deep weak peat (3-6m deep) along the subsurface drainage channel between Turbines T27 and T35 where there is a convex break in slope at the head of the watercourse that flows off site to the south of T35 (Plots #7-13, #148-154; #191-195);
- The zone of deep weak peat upslope from the central turbary road between T28 and T37 where there are indications of subsurface seepage in the peat to the convex breaking slope downslope from the road (Plots #14-22);
- The plots on the convex breaking slope downslope from the central turbary road in the area of deep peat between Turbines T28 and T37 where there are indications of subsurface seepage in the peat (Plots #155-164, #197-204) and low Factors of Safety for infinite slope stability;
- Along the watercourse channel in the peat at the west end of the turbary areas between Turbines T24 and T29 (Plots #1-5, #147 & #191);
- The area of relatively deep peat (2-3m) with the convex breaking slope at the southeast corner of the wind farm (Plots #219-221 & #229-232); and
- Various plots at the east end of the site where there is locally a convex breaking slope in relatively deep peat (2-4m) and locally low FoS for slope stability (e.g. Plots #30-36, between #168 & 176, and #213-214)

Together these account for approximately **47%** of the total number of zones on Figure 4-1 (i.e. 85 No. out of 181 No. total).

In the remaining turbary plots across the site the Likelihood of a peat failure, due to mechanical peat harvesting under uncontrolled conditions and without appropriate mitigation measures would be characterised as **Possible to Very Possible (L=3.0 to 3.5)**. These were in areas where there were mitigating conditions that reduced the risk of peat instability. For example:

- Areas of shallow (<1.0 m) or relatively shallow (1-2 m) peat;
- Areas of gently sloping ground (<3°) set well back from any convex break in slope where the slope angle increases to >5°.
- Areas of relatively high infinite slope Factor of Safety (FoS >1.3);
- Zones where there is well-developed drainage, and which are not directly upslope from the rivers and streams outside the wind farm site.

4.1.2 Impact (I)

The potential **Impact (I)** of a peat failure in each zone has been interpreted by evaluating factors related to the potential volume of peat, degree of contamination, sensitivity of the receiving environment, access for intervention, land use and existing infrastructure within the potential run-out distance.

As stated previously, in assessing the likelihood of a peat failure consideration has been given to the full range of failures that could occur as a result of mechanical peat harvesting in the turbary areas, from a localised shear failure in the peat on the upslope side of an open excavation, to a small-scale peat slide that is contained within the turbary area, or a large-scale peat slide comparable to the slide that occurred at Turbine T68 on the windfarm site in October 2003, which would be the worst case scenario.

The impact of a localised shear failure or small-scale peat slide would be relatively low as it would only involve a small volume of peat, which would be contained on site without direct inundation of the downslope watercourses. The degraded bog in the turbary area that would be impacted by the slide is of medium to low ecological importance and the risk of contamination to watercourses would be limited to sediment laden surface runoff, which can be mitigated or contained on site. The impact on land use would be limited to the loss of peat in the turbary plot. Depending on the proximity to the windfarm infrastructure a small-scale peat slide could damage a section of floating road, or some of the buried electrical transmission or fibre-optic communication cables. However, it is unlikely to cause significant damage to a wind turbine.

In comparison, although there would be a lower likelihood of a large-scale peat slide occurring on the site due to mechanical peat harvesting in the turbary areas, the impact of a large peat slide would be significantly higher.

Based on the extent and characteristics of the peat slide that occurred at the windfarm site during construction in October 2003, a large peat slide could result in the shear failure of a large volume of peat over a wide area on the side slopes of Cashlaundrumlahan Mountain, downslope from the turbary area. This would result in the loss of the blanket bog habitat within the slide, which could extend outside the site boundary on the upper slopes of the mountain.

The nature of peat slides such as these is that they typically occur directly upslope from natural watercourses, particularly where poor drainage is a contributory factor. Therefore, a significant portion of the failed peat would become fluidised into a viscous mass of remoulded peat debris that would flow down into the watercourse channels directly inundating the streams and rivers downslope. The material that remains within the failure scar on the upper slopes would typically be comprised of detached rafts of intact fibrous peat, remoulded peat debris and a thin cover of intact basal peat over the underlying mineral soil and rock.

The fluidised peat debris could have significant run-out distances along the river valleys, which could occur in pulses over a number of days if the peat becomes re-mobilised by subsequent periods of heavy rainfall. Where the volume of peat exceeds the capacity of the valley on flatter slopes it can spread out over the surrounding land to either side. Where rivers or streams cross public roads the peat can block culverts or bridges, sometimes overtopping the road and blocking public access. The downstream impact of the remoulded peat attenuates with distance from the site. The extent of organic sediment transported downstream would be a function of the volume and characteristics of the peat and the hydrological characteristics of the river and stream networks.

Drawing No. QS-000192-01-D451-018 by ESBI in Appendix A shows a map of the environmental constraints that have been identified in the region of the Derrybrien Windfarm. The following characteristics of the site and surrounding area are relevant in assessing the impact of a peat slide in the turbary area at the east end of the windfarm site:

- The turbary area is located within the Slieve Aughty Mountains Special Protection Area (SPA) which has Special Conservation Interest for Hen Harrier and Merlin;
- The Slieve Aughty Bog NHA identified on the south side of the R353 near Derrybrien village could be impacted by remoulded peat from a large-scale peat slide on the south side of the windfarm entering the stream in sub-catchment SC7(a), which flows through the NHA.
- The stream in sub-catchment SC7(a) is a tributary of the Owendalulleegh River on the south of the windfarm. Although the Owendalluleagh River does not have protected status, approximately 11 km southwest of the site the Owendalulleegh River flows into Lough Cutra, which is a designated SAC.
- Although the area is generally sparsely populated, particularly to the north of the windfarm, Derrybrien village is located along the R353 Regional Road approximately 2 km downslope from the south side of the site. At this distance, the impact of a peat slide would be concentrated in the areas where the tributaries to the Owendalulleegh River cross the R353 and a slide would be unlikely to impact the dwellings, monuments or Architectural Heritage features in the village. Access to the village could be restricted if the road becomes blocked.
- As the windfarm has been completed, the existing site infrastructure could be directly impacted by a peat slide on the site, particularly the site access tracks that have been constructed as floating roads, and the 110 kV overhead line that connects the substation on the site to the national grid at the Agannygal Substation, approximately 7.7 km south of the site.
- Land use in the turbary area and downslope from the windfarm site is limited to non-commercial peat harvesting and commercial forestry, with some agriculture on the lower slopes, where the land has relatively low agricultural value. These activities would be directly impacted by a large peat slide in the turbary area.

Also, a very large peat slide would have a significant commercial impact. In addition to the costs of remedial works to mitigate the impact of the peat slide on the receiving environment, the commercial impact could include the loss of windfarm infrastructure, damage to local or regional public infrastructure (bridges, roads etc), and/or loss of commercial forestry, turbayr areas and agricultural land. It could also lead to sustained periods of power outages where the windfarm is shut down or disconnected from the grid.

On the basis of these factors, the potential **Impact** of a large peat slide occurring as a result of mechanical peat harvesting in the tubary areas would be classified as **High (I=5)** and this has conservatively been applied to all of the zones in the turbary areas as the worst case scenario.

4.1.3 Risk Rating

A baseline **Risk Rating (R=L x I)** has then been calculated for mechanical peat harvesting in each turbary area to characterise the risk of peat instability across the site prior to the implementation of risk mitigation measures to identify where specific design, construction & operational mitigation measures are required to mitigate the risk of peat instability to an acceptable level.

The results of the baseline PSRA are presented in Figure 4-1 and in Table A-1 in Appendix A.

Assuming that the impact of a peat failure could reflect the potential impact a large peat slide in the worst case scenario (i.e. I=5), which is consistent with the methodology for the assessment of stability impacts for the wind farm:

- In the 85 No. zones (≈47%) where the likelihood of a peat failure due to mechanical peat harvesting without appropriate mitigation measures is **Very Possible** to **Likely (L=4.0 to 5.0)**, then the **Risk Rating, R**, for a peat failure in these areas would be between **20** and **25**, which is **Medium to High or High** (see Table 1-4).
- In the remaining 92 No. zones (≈53%) where the likelihood of a peat failure due to mechanical peat harvesting is generally **Possible** to **Very Possible (L=3.5)**, then the **Risk Rating, R**, for a peat failure in these areas would be **17.5**, which is **Medium to High**.

These risk ratings would be classified as unacceptable which means that appropriate mitigation measures would be required to reduce the risk of a peat failure to an acceptable level.

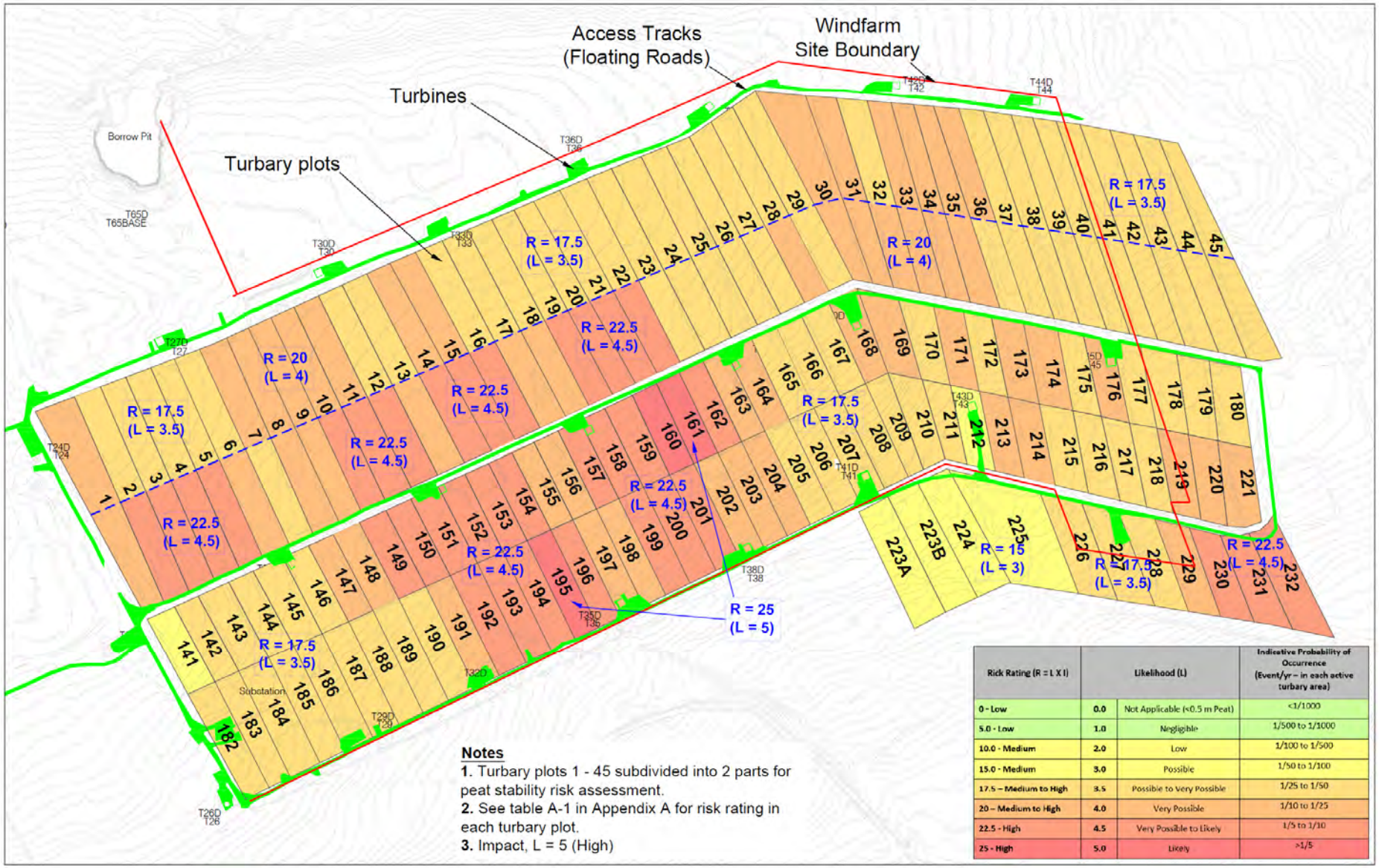
As stated previously, the likelihood of a peat failure in this assessment includes the full range of failures that could occur as a result of mechanical peat harvesting in the turbary plots - from a localised shear failure in the peat on the upslope side of an open excavation, to a small-scale peat slide that is contained within the turbary area, or a large-scale peat slide comparable to the slide that occurred at Turbine T68 on the windfarm site during construction. The likelihood of a large peat slide occurring would be comparatively lower. However, the assessment of the risk rating in this report has conservatively been calibrated by the potential impact of a large peat slide as the worst case scenario.

As summarised in Section 3.0, since 2012 mechanical peat harvesting has only being carried out in about 35 No. of the 136 No. turbary plots, not all of these are cut each year, and no mechanical peat harvesting is currently being carried out in Plots No. 182 to 207 along the southern boundary of the site, which were used for forestry by Coillte prior to the construction of the windfarm. Therefore, the risk rating for a peat failure shown on Figure 4-1 is limited to those areas where mechanical peat harvesting is actually carried out on the site

The risk rating for a peat failure is also only applicable for when the mechanical peat harvesting is being carried out on the site. The active turbary plots are only cut seasonally once a year in late spring/early summer so the frequency of the risk of a peat failure in any turbary plot is **Occasional**.

Harvesting is only active in a small number of turbary plots on any day and the mechanical peat harvesting within a turbary plot only takes a few days. Therefore, the duration of the risk in each area is **Brief**.

As will be discussed in Section 7.0, the residual likelihood of a peat failure in the turbary areas when there is no mechanical peat harvesting being carried out on the site would be **Low (L=2)**. This would correspond to a **Risk Rating, R, of 10** in the worst case scenario, which is **Low to Medium** and acceptable with periodic inspections.



Rick Rating (R = L X I)	Likelihood (L)		Indicative Probability of Occurrence (Event/yr – in each active turbary area)
0 - Low	0.0	Not Applicable (<0.5 m Peat)	<1/1000
5.0 - Low	1.0	Negligible	1/500 to 1/1000
10.0 - Medium	2.0	Low	1/100 to 1/500
15.0 - Medium	3.0	Possible	1/50 to 1/100
17.5 – Medium to High	3.5	Possible to Very Possible	1/25 to 1/50
20 – Medium to High	4.0	Very Possible	1/10 to 1/25
22.5 - High	4.5	Very Possible to Likely	1/5 to 1/10
25 - High	5.0	Likely	>1/5

Figure 4-1 – Baseline Peat Stability Risk Assessment for the site – prior to implementation of risk mitigation measures

5.0 PEAT STABILITY ON THE SITE – RECENT OBSERVATIONS

No large or very large-scale peat failures have occurred in the turbary plots on or immediately adjacent to the Derrybrien Wind Farm site during construction or during the operational life of the project. However, there are 2 No. areas where localised peat instability has occurred in the turbary plots, which are identified on the aerial photograph in Figure 3-2. The failures occurred in Plots No. 161 and 30.

5.1 Plot 161

Plate 5-1 shows an image of the peat failure that has occurred at the south (downslope) end of Turbary Plot No. 161, which is directly upslope from Turbine T38.

The slide occurred as a planar slide in peat up to 2.0m deep over an area of approximately 2,500m^2 on the steeper lower slopes of the turbary plot. There is a convex break in slope to angles of 5.0°-7.5° at this end, compared to slopes of 3.0°-4.0° on the upper half of the plot, near the central access track that runs between Turbines T34 and T37. The peat at the downslope end of the turbary plot has sheared along a surface at or near the base of the peat and slipped into the large open drain that runs along the southern edge of the turbary plots on this side of the site. The peat failure involved about 5,000m^3 of peat over an area of about 2,500m^2, which is a small-scale peat slide (1,000-5,000m^3).

The majority of the vegetated surface layer of the failed peat has remained intact. There are large open water-filled tension cracks at the upslope end of the failed area (Plate 5-2). At the downslope end the drain has been completely infilled and the displaced peat has "buckled" and spilled over onto the surface of the peat in the firebreak that runs along the downslope side of the open drain, where the slope angle is locally flatter (Plate 5-3).

Plate 5-1 – Peat slide in turbary plot #161 (Site Photo May 2020)

Plate 5-2 – Water-filled tension cracks at upslope end of peat slide in turbary plot #161 (AGL photo 7/5/2020)

Plate 5-3 - Infilled drain and "crumple zone" along the firebreak at the downslope end of turbary plot 161 (AGL photo 7/5/2020).

Plate 5-4 – Aerial view of slide area - 9th April, 2015 (Google Earth)

Plate 5-5 – Aerial view of slide area – 3rd July, 2018 (Google Earth)

Based on historical aerial photographs from Google Earth, the peat slide initiated sometime between April 2015 (Plate 5-4), when there were no tension cracks visible, and July 2018, when the tension cracks were visible in the peat and the drain on the downslope side had closed over (Plate 5-5). By May 2020 the peat failure had extended further upslope and formed a wider area of tension cracks on the upslope side. The main body of peat at the downslope end of the failed area has also been pushed further onto the firebreak, indicating progressive downslope movement of the peat between July 2018 and May 2020. Some drainage works were carried out in 2020 to relieve ponded water in the tension cracks as a mitigation measure to prevent the slide progressing further upslope, as recommended in this report. The area was inspected again in January 2024 by AGL and appeared to be stable. There was no apparent significant upslope progression of the slide, or downslope movement of the peat within the failed area.

The peat slide was not caused by site activities related to the wind farm. The slope was intact up to April 2015, approximately 10 years after construction of the wind farm was completed, and the slide is remote to the wind turbines and site access tracks. The trench for the electrical transmission cables along the firebreak at the south end of the turbary plot was also not impacted by the peat movement.

It is likely that the slide was caused by a combination of factors including groundwater seepage from the area of deep peat upslope from the turbary plot, poor or impeded drainage within the turbary plot, undercutting of the toe of the slope for the drain that runs across the downslope end of the plot, and possibly by the surcharge loads on the peat from mechanical harvesting equipment. Recent mechanical peat harvesting has been limited to the zone upslope from the failed area. However, there is evidence of old machine track marks on the peat within the failed area and there are excavations for peat harvesting along the edge of the drain to the east and west.

5.2 Plot 30

Plate 5-6 shows an aerial view of the peat failure that has occurred at the centre of Turbary Plot No. 30. The failure occurred as planar shear failure and downslope movement of peat 1.7 to 2.7m deep over an area of approximately 2,500m^2 along the boundary with Plot No.31 to the east. There is a local shallow convex break in slope to angles of 3.0°-4.0° in the area. The peat appears to have failed upslope from an excavation for peat harvesting in Plot No. 31. The peat has moved into the excavation and closed over a section of the drain along the boundary between the two turbary plots (Plate 5-7).

The peat failure involved about 5,000m^3 of peat over an area of about 2,500m^2, which is a small-scale peat slide (1,000-5,000m^3). The majority of the vegetated surface layer of the failed peat has remained intact. However, tension cracks have opened up along the edge of the failed area, within Plot No. 30 (Plate 5-8).

Based on historical aerial photographs from Google Earth and the OSI Geohive online portal, there may have been some movement of the peat in this area prior to 2011. However, it appears that the main movement occurred and the tension cracks formed when peat was excavated from the open excavation along the drain for peat harvesting sometime around 2018. Therefore, this is the most likely cause of the recent movement. Undercutting of the toe of the slope in the drain along the site boundary would also have contributed to the peat movement.

The area was re-inspected by AGL in January 2024 and appeared to be stable. There has been no apparent further movement of the peat, and the tension cracks are not as evident because thicker vegetation has established in the area.

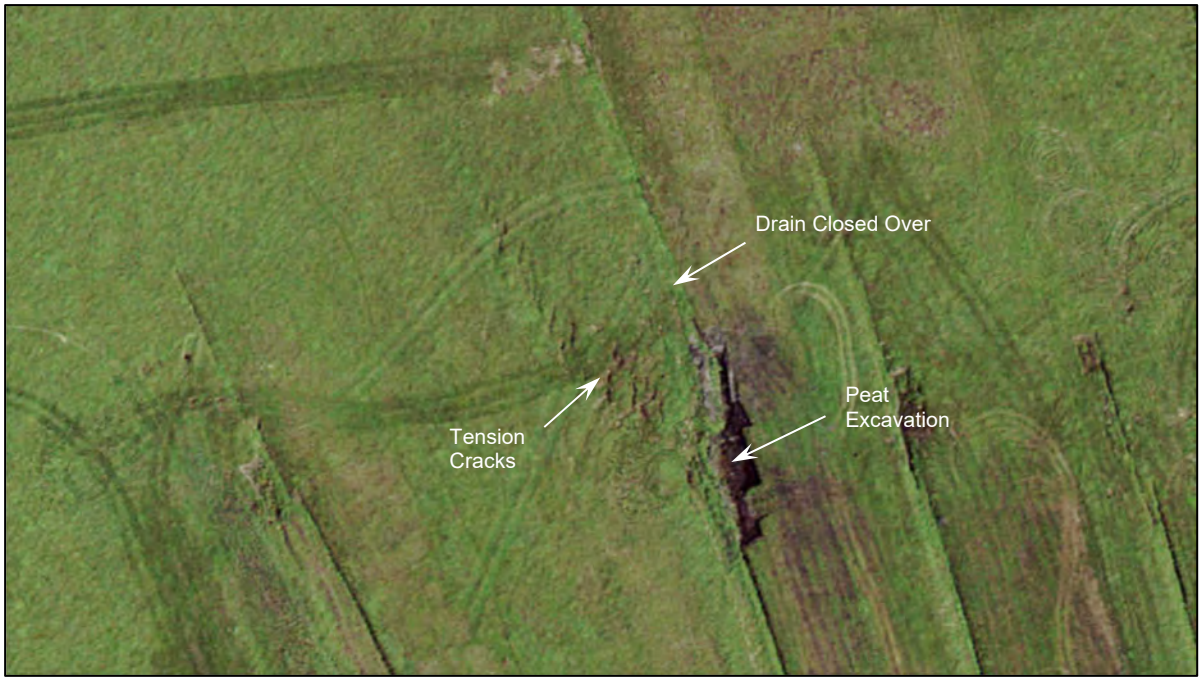


Plate 5-6 – Peat Movement in Turbary Plot #30 c2015-2018 (OSI Geohive Portal, 2020)

Plate 5-7 – Closed drain due to peat movement between turbary plots 30 and 31

Plate 5-8 – Tension cracks in the peat within the failed area (Plot 30)

5.3 Impact Assessment & Monitoring in Plot 161

Both of these peat failures involved about 5,000m^3 of peat over an area of about 2,500m^2, which are small scale peat slides (1,000-5,000m^3). The baseline sensitivity of the degraded blanket bog in the area has been classified as **Medium**. Therefore, the combined effect of the peat slides on the disturbed

peat would be classified as **Low** and only **Slightly Significant**. As these are pre-existing peat failures they will not lead to any cumulative impacts on the peat during the decommissioning of the windfarm.

Some drainage was carried out in Turbary Plot 161 in early August 2020 to relieve ponded water in the tension cracks as a mitigation measure to prevent any further movement of the peat. The details are shown on ESB Drawing No. QS-000314-01-D476-001-001-000 which is included as Figure 5-1.

Drains were hand excavated along the sides of the failed area to relieve the ponded water trapped in the tension cracks and divert it into the large open radial drain that runs east-west along the south end of the plots through this part of the site. Plot 161 is at a watershed along the drain so that the water diverted to either side of the failed area flows away from the turbary plot to the east and west. The existing drain along the west side of the turbary plot was also cleared out up to the access road between Turbines T34 and T27 at the north end of the plot. Check dams were installed in the radial drain for erosion and sediment control. The remedial drainage works were completed by early August 2020.

20 No. survey monitoring points were also installed on the surface of the peat within and around the failed area in Turbary Plot 161. The locations of the monitoring points are shown on the ESB Drawing reproduced in Figure 5-2. Points No. 10-20 are the most relevant in and around the failed area.

The location and elevation of the monitoring points was recorded to ITM coordinates by GPS survey over an initial period of 7 months between 21st May and 22nd December 2020 (Day 0 to Day 215). Follow up sets of readings were then taken on the 23rd November 2021 and again on the 23rd November, 2023.

Some of the points were damaged over the course of the monitoring period (#5, #8, #12 and #13) and had to be reset. Point No. 14 could not be located for the final set of readings in December 2021.

Figure 5-3 shows the change in the Northing coordinate for each of the monitoring points over the survey period. A negative reading represents downslope movement of the peat to the South, which would be the main direction that the failed peat could move if the slide area was unstable. Given the remote location and the variability in the readings, the degree of accuracy of the measurements is probably on the order of **+/- 10-20mm**. The peat could also exhibit movements of this order due to seasonal changes in moisture content and groundwater level.

Monitoring point MP-14 was located on the main body of displaced peat in the failed area. Although it could not be located for the set of readings taken in December 2021, the readings that were taken over the 7-month period between May and December 2020 indicated that the movement of the peg was within the range of +/-20mm (i.e. upslope/downslope), which is within the expected range of accuracy and indicates that main body of peat in the failed area is stable.

MP-17 to MP-20 were located along the approximate line of the wind farm underground cables along the south side of the drain downslope from the turbary plots in this area. MP-18 and MP-19 are on the downslope side of the peat slide. By November 2021 MP-18 and MP-19 had moved downslope by **<5mm** and **<25mm**, respectively. Most of this movement was recorded prior to the end of June 2020, which indicates that there has been no further movement in the peat downslope from the failed area since then. The failed peat is being supported by the buttressing effect of the intact peat downslope from the turbary plot. More recently an upslope change in position was recorded between the readings taken in 2021 and 2023. This could be an error or the survey pegs may have been disturbed. Nevertheless, the movements are slight and there is no indication of any significant downslope movement at this end of the slide, which confirms that the area of failed peat is stable.

Downslope movement of **60 mm** and **120mm** has been recorded at monitoring points MP-11 and MP-15, which are located on the surface of blocks of peat between tension cracks in and around the margins of the failed area. This is consistent with the movement that could occur in these areas due to the potential for the displaced blocks of peat to move or slump downslope into the tension cracks,

particularly when the ponded water was drained away. Significant eastward displacement of approximately 500mm was also recorded at MP-15, which is consistent with the location of the peg on the west side of the slide area. This is directly upslope from MP-18 where no downslope movement has been recorded. This indicates that the movement at MP-15 is localised displacement along the margins of the failed area, which is to be expected. MP-11 has been stable since 2021.

Downslope movement of about **50mm** has been recorded at monitoring point MP-16, which is on intact peat at the downslope end of Turbary Plot #159, to the west of the failed area. The aerial photo in Figure 5-1 indicates that the arterial drain at the south end of this plot could have partially closed over. This would be consistent with the movement that was recorded at MP-16 and identifies the risk of a potential peat failure in this area if any further mechanical peat extraction is carried out along the drain at the south end of the turbary plot, which could undermine the slope. MP-16 has been stable since 2011 and no downslope movement was recorded at MP-17 on the southern bank of the arterial drain, which indicates that the potential movement in the peat is localised to the upslope side of the drain.

The movements recorded at MP-1 to MP-10 and at MP-12 in 2023 were all very low and possibly within the degree of accuracy of the survey readings (i.e. ±10-15mm). Therefore, they indicate that the peat upslope from the failed area is stable, and that the peat slide has not progressed further upslope from the extent observed in Turbary Plot 161 in 2020.

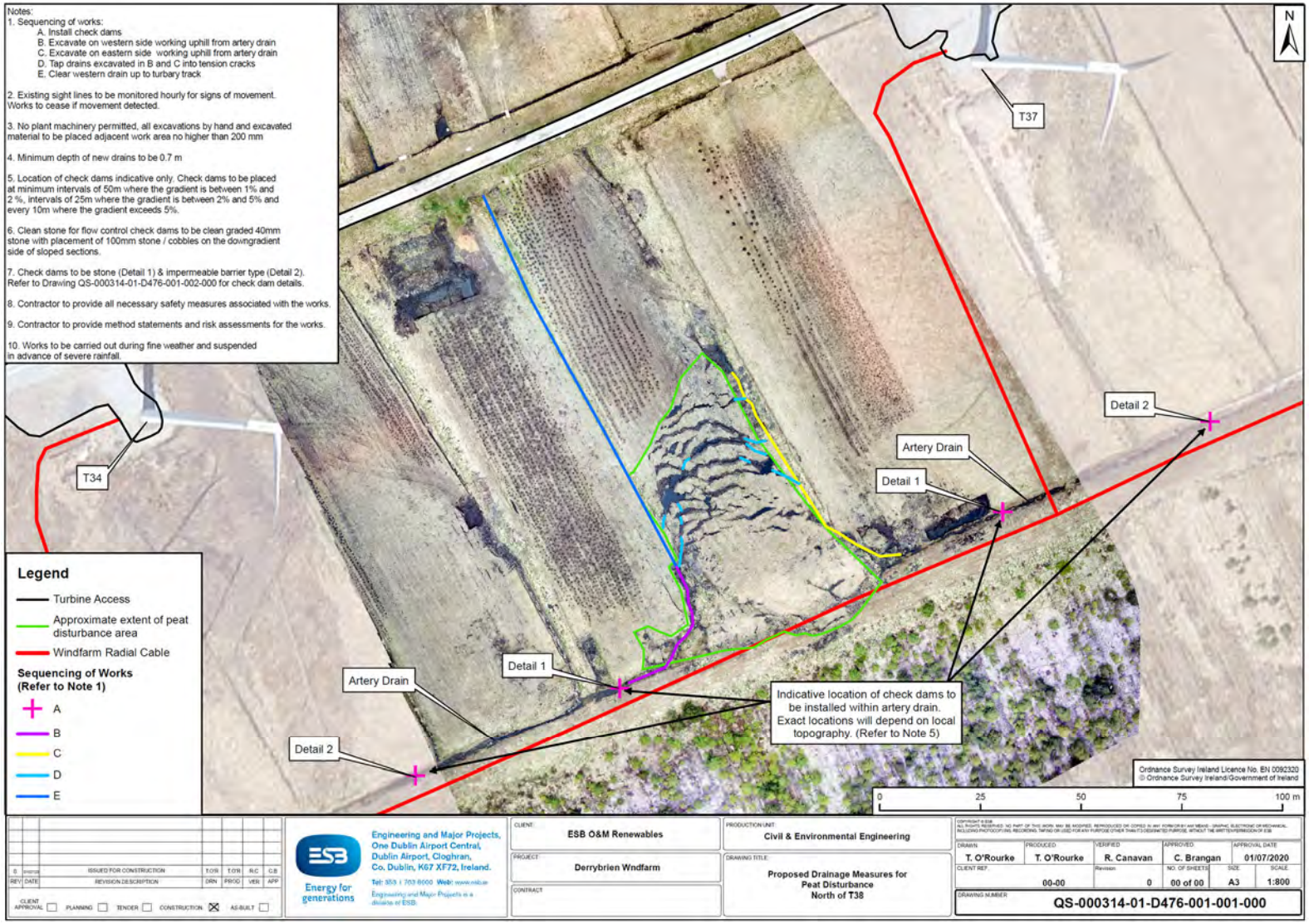


Figure 5-1 – Drainage works carried out in early August 2020 to relieve water pressures in zone of peat failure in Turbary Plot 161

Figure 5-2 – Survey monitoring points on the surface of the peat in and around the zone of peat failure in Turbary Plot 161

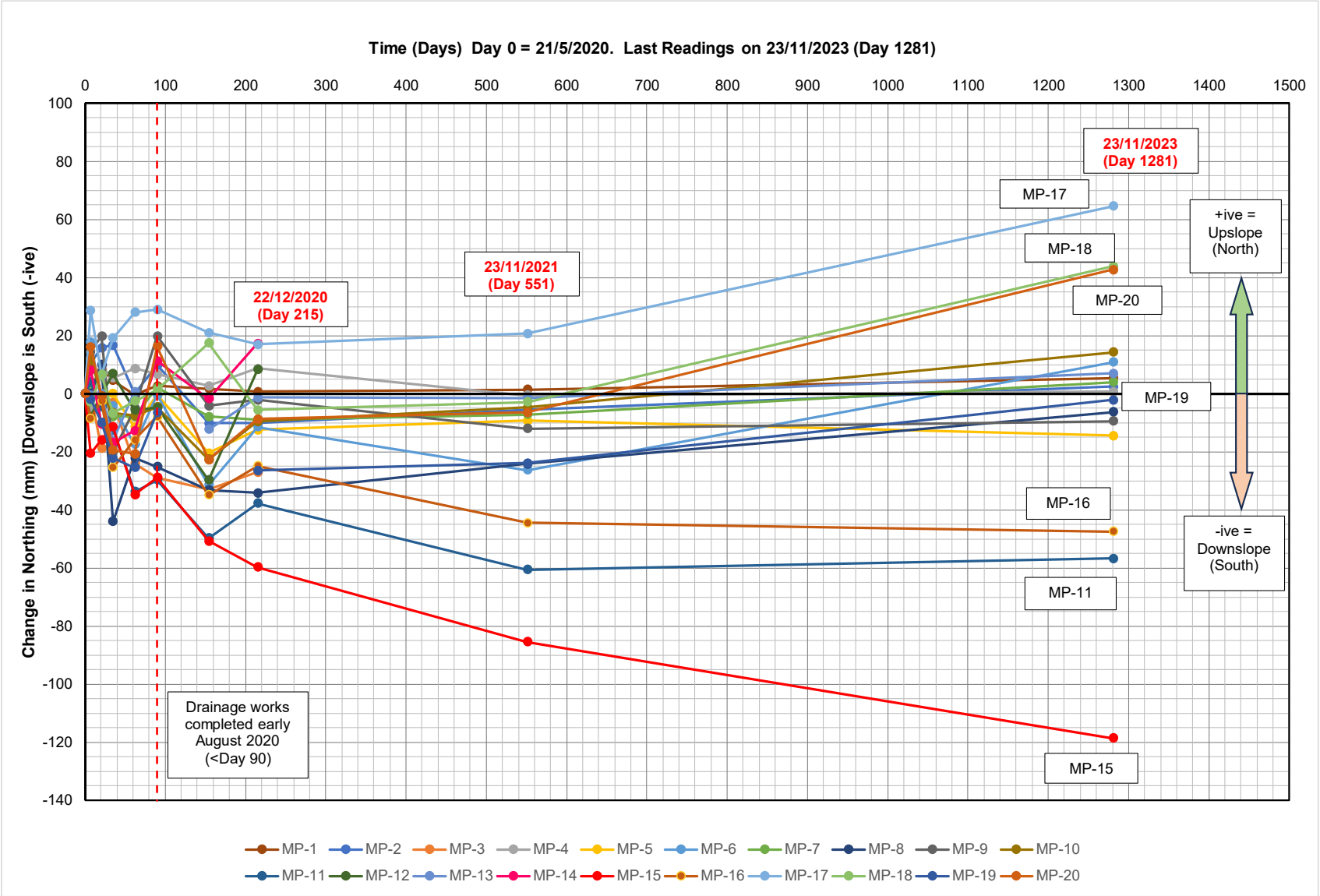


Figure 5-3 – Surveyed movement of monitoring points in zone of peat failure in Turbary Plot 161 in 2020/2021 (Day 0 = 21/5/2020)

6.0 MITIGATION AND MONITORING

As discussed in Section 1.2.1.3, effective risk mitigation measures can be used to reduce the Likelihood of a peat failure to a low level, even in high risk zones. Therefore, this section of the report presents the recommended mitigation measures for future mechanical peat harvesting in the turbary plots to reduce the risk of a peat failure to an acceptable level over the remaining operational life of the Derrybrien Windfarm and during decommissioning.

6.1 Turbary Areas where L=4.0 to 5.0 (Very Possible to Likely) for Mechanical Peat Harvesting Prior to Mitigation Measures

It is recommended that the following mitigation and monitoring measures should be implemented for the areas where the interpreted likelihood of a peat failure due to mechanical harvesting prior to mitigation measures is **Very Possible to Likely (L=4.0 to 5.0)**:

- No mechanical peat harvesting should be carried out in these areas during the decommissioning stage of the wind farm.
- Turf cutting can be carried out by hand excavation but should only be done during the months of May to September.
- Drainage works should be carried out where necessary between May and September to clear out blocked drains and to maintain the capacity and efficiency of the existing drainage network.
- The turbary plots and site drainage should be inspected in the periodic inspections by ESB Engineering & Major Projects, particularly where the small peat failures occurred in Plots #161 and #30.
- In area of the small-scale peat slide in Plot #161:
    - Additional drainage measures should be implemented by hand excavation to relieve water pressures in the tension cracks at the upslope end of the slide area;
    - The east-west collector drain running along the south end of the turbary plots in this area should be cleared out where necessary to ensure that the water is draining away from the failed area along the length of the drain to the east and west;
    - Monitoring points that have been established on the surface of the peat within the slide area should be surveyed periodically along with aerial drone surveys and photographs to monitor for further peat movement;
    - No mechanical peat harvesting should be carried out within the slide area.
- In area of the localised peat failure in Plot #30
    - Additional drainage measures should be implemented by hand excavation to relieve water pressures in the tension cracks and drain along the boundary between plots #30 and 31.
    - No further mechanical peat harvesting should be carried out in the zone of failed peat.

6.2 Turbary Areas where L=3.0 to 3.5 (Possible to Very Possible) for Mechanical Peat Harvesting Prior to Mitigation Measures

It is recommended that the following mitigation and monitoring measures should be implemented for the areas where the interpreted likelihood of a peat failure due to mechanical harvesting prior to mitigation measures is **Possible to Very Possible (L=3.0 to 3.5)**:

- Drainage works should be carried out in these areas between May and September, where necessary, to clear out blocked drains and to maintain the capacity and efficiency of the existing drainage network.
- No further peat harvesting by saw cutting should be carried out in the peat;
- Turf cutting can be carried out by hand excavation but should only be done during the months of May to September.
- The following restrictions and operational control measures should be implemented for mechanical peat harvesting by hydraulic excavator and sod hopper in the turbary plots:
    - The works should only be carried out between the months of May and September, inclusive;
    - The hydraulic excavator should be limited to a low ground bearing pressure (LGBP) wide-tracked excavator with a maximum operating weight of 10 tonnes;
    - The hopper should be limited to a LGBP wide-track sod machine, or equivalent rubber tyred machine, with an operating weight <5 tonnes when empty;
    - The volume of peat placed in the hopper for each load should be limited so that the maximum bearing pressure under the tracks or wheels is 12.5kN/m^2;
    - The contractor should adopt good practice when operating plant and machinery on the bog to avoid damaging the surface of the peat by excessive tracking, turning or track rotation;
    - The hopper and excavator should not be positioned on peat directly upslope from open peat excavations when the hopper is being loaded;
    - The excavator operator should monitor the stability of the excavated peat face and should backfill the excavation and stop mechanical peat harvesting immediately if any instability or peat movement is observed at any stage over the course of the works;
    - No further mechanical peat harvesting should be carried out in areas where instability or peat movement is observed;
    - The contractor should ensure that none of the existing drains are blocked or damaged over the course of the works, and that no surface water ponds in the areas where the peat has been excavated.
- Communication should be established between the turbary plot owners, turf cutting contractors and the windfarm site manager for Gort Wind Farms Ltd. to coordinate the works on site, i.e.:
    - The turbary plot owner and/or turf cutting contractor should notify the windfarm site manager at least 1 week in advance of starting the works on site.
    - The turbary plot owner and/or turf cutting contractor should notify the windfarm site manager if any peat instability is observed;
- Periodic inspections of the mechanical peat harvesting should be carried out by the wind farm site manager;
- No mechanical peat harvesting should be carried out during decommissioning of the wind farm.

6.3 Mitigation Measures Implemented by Gort Wind Farms Ltd.

The potential impacts of mechanical peat harvesting on the wind farm site will not arise as a direct result of activities related to the wind farm, but from the separate and unrelated activities for mechanical peat harvesting in the turbary areas under established turbary rights, which are outside of the control of Gort Wind Farms Ltd. Therefore, the following mitigation measures have been implemented by Gort Wind Farms Ltd to reduce the likelihood of a peat failure occurring:

- The peat stability risk assessment and the associated mitigation measures have been shared with the turbary rights holders whose plots have been or are proposed to be harvested by mechanical means, and the turbary rights holders have been made aware of the potential site stability risks associated with mechanical peat harvesting methods in the absence of mitigation;
- Warning signs have been erected at the site by Gort Wind Farms Ltd. to raise awareness of the peat stability risks associated with mechanical peat harvesting in the turbary area and to highlight the recommended mitigation measures;
- Where possible, communication has been established between the turbary plot owners, turf cutting contractors and the windfarm site manager for Gort Wind Farms Ltd. to establish procedures to give notice of mechanical peat harvesting activities and to report any peat instability on the site;
- Gort Wind Farms Ltd. have implemented the recommended remedial drainage works and survey monitoring in the failed area at the south end of Turbary Plot 161 to ensure that the peat there is stable.
- Periodic inspections of the mechanical peat harvesting are being carried out by the wind farm site manager for Gort Wind Farms Ltd.

Drainage works were carried out in Turbary Plot 161 in early August 2020 to relieve ponded water in the tension cracks as a mitigation measure to prevent any further movement of the peat. The details are shown on ESB Drawing No. QS-000314-01-D476-001-001-000 which is included as Figure 5-1.

Drains were hand excavated along the sides of the failed area to relieve the ponded water trapped in the tension cracks and divert it into the large open radial drain that runs east-west along the south end of the plots through this part of the site. Plot 161 is at a watershed along the drain so that the water diverted to either side of the failed area flows away from the turbary plot to the east and west. The existing drain along the west side of the turbary plot was also cleared out up to the access road between Turbines T34 and T27 at the north end of the plot. Check dams were installed in the radial drain for erosion and sediment control. The remedial drainage works were completed by early August 2020.

Any further maintenance that is required to maintain the existing drainage network will be carried out during decommissioning of the wind farm.

7.0 PEAT STABILITY RISK ASSESSMENT (PSRA) - AFTER IMPLEMENTATION OF MITIGATION MEASURES

Warning signs will be erected at the site by Gort Wind Farms Ltd. to raise awareness of the peat stability risks associated with mechanical peat harvesting in the turbary area and to highlight the mitigation measures recommended in Section 6.0 of this report. This peat stability risk assessment and the associated mitigation measures will also be shared with the turbary rights holders whose plots have been harvested by mechanical means. Where the mitigation measures are implemented, then the likelihood of a peat failure occurring as a result of mechanical peat harvesting in the turbary plots will reduce to a residual level of **Low (L=2),** as shown on Figure 7-1.

Gort Wind Farms Ltd. will implement the monitoring and remedial drainage works recommended for the areas where the peat failures occurred in Turbary Plots 161 and 30 and the areas will be inspected by geotechnical engineers from ESB Engineering & Major Projects during their periodic windfarm inspections. The windfarm site manager will also carry out periodic inspections of mechanical peat harvesting works that are active on the site over the remaining operational life of the windfarm.

No further measures are scheduled to mitigate the potential Impact of a peat slide in the area over the remaining operational life of the windfarm. Therefore, we have conservatively assumed that the Impact of a peat failure related to mechanical peat harvesting in the turbary plots will remain as **High (I=5)** to represent the worst case scenario of a large peat slide occurring at the site.

This would correspond to a **Risk Rating, R, of 10**, which is **Low to Medium** and acceptable with periodic inspections.

This would also represent the current residual level of risk with no mechanical peat harvesting in the turbary areas in their existing condition.

Plots #41-45, #178-180, #219-221, #223A, #223B, #224-232 are outside the boundary of the windfarm site. Due to the topography in the area, a peat failure in the turbary plots should not impact the windfarm as none of the windfarm infrastructure is in the potential flow path of a peat slide.

Between Turbines T41 and T45 the windfarm site access track was constructed as a floating road along the edge of turbary plots 223A, 223B and 224 to 227. However, the turbary plots are downslope from the track, the peat is generally shallow in the area (typ. <1.0m) and the site conditions in terms of topography and hydrology are relatively good in the area, which is reflected in the comparatively lower Likelihood of a peat failure due to mechanical peat harvesting prior to mitigation measures, as shown on Figure 4-1 (i.e. L=3.0). Therefore, there would be a low risk of the windfarm access track being impacted by a peat failure in the turbary plots. The turbines and crane hardstanding are constructed on the glacial till and rock below the peat so there is a negligible risk of them being impacted by a peat failure in the adjacent turbary plots downslope.

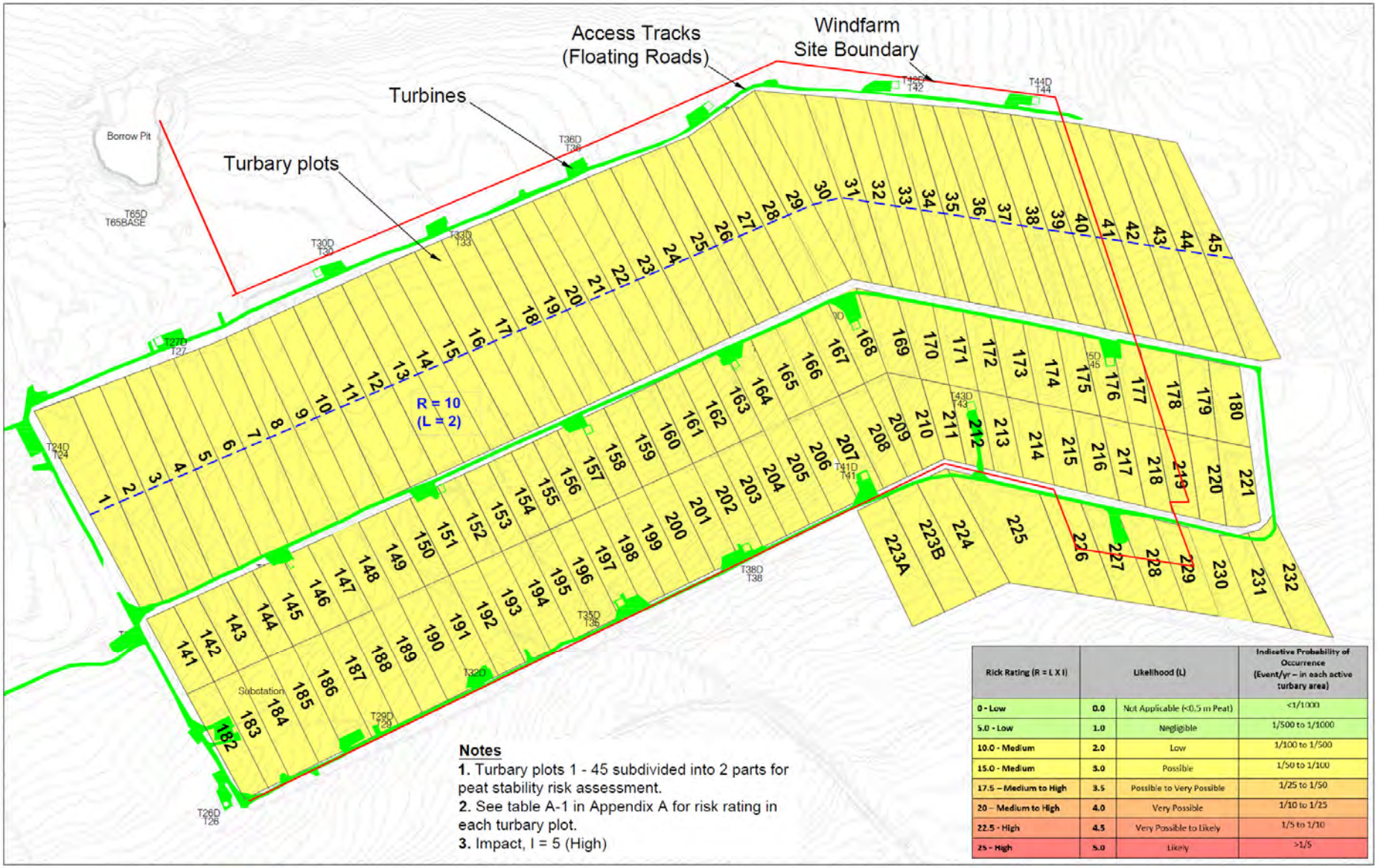


Figure 7-1 – Peat Stability Risk Assessment for turbary areas after implementation of mitigation measures

8.0 REFERENCES

1. Clayton, C.R.I, (2001) *Managing Geotechnical Risk: Improving Productivity in UK Building and Construction*, Published by the Department of the Environment, Transport and the Regions, and the Institution of Civil Engineers (Great Britain)
2. Scottish Government, Energy Consent Unit (2017) - *"Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Projects* (2nd Edition, April 2017).

APPENDIX A

RESULTS OF PEAT STABILTY RISK ASSESSMENT (PSRA)
FOR TURBARY AREAS

Table A-1 - Peat Stability Risk Assessment for Turbary Plots

Turbary Plot No.	North End									South End								
	Peat/Subsoil Conditions	Topography	FoS Calculations	Hydrology/ Hydrogeology	Other Contributary Factors	Total Hazard Rating	Likelihood (L)	Impact (I)	Risk Rating (R = LxI)	Peat/Subsoil Conditions	Topography	FoS Calculations	Hydrology/ Hydrogeology	Other Contributary Factors	Total Hazard Rating	Likelihood (L)	Impact (I)	Risk Rating (R = LxI)
1	15	15	10	15	15	70.0	4.0	5.0	20.0	20	15	10	10	15	70	**4.0**	5.0	**20.0**
2	15	15	10	10	10	60.0	3.5	5.0	17.5	20	15	10	15	20	80	**4.5**	5.0	**22.5**
3	15	15	10	10	10	60.0	3.5	5.0	17.5	15	15	15	15	20	80	**4.5**	5.0	**22.5**
4	15	15	10	10	10	60.0	3.5	5.0	17.5	15	15	15	15	20	80	**4.5**	5.0	**22.5**
5	15	10	10	15	10	60.0	3.5	5.0	17.5	15	15	15	15	20	80	**4.5**	5.0	**22.5**
6	20	10	10	15	10	65.0	3.5	5.0	17.5	15	15	10	15	20	75	**4.0**	5.0	**20.0**
7	20	10	15	15	15	75.0	4.0	5.0	20.0	15	10	15	10	10	60	**3.5**	5.0	**17.5**
8	20	10	15	15	15	75.0	4.0	5.0	20.0	20	10	15	15	15	75	**4.0**	5.0	**20.0**
9	20	10	10	15	20	75.0	4.0	5.0	20.0	20	10	10	15	15	70	**4.0**	5.0	**20.0**
10	20	10	10	15	20	75.0	4.0	5.0	20.0	20	10	15	15	20	80	**4.5**	5.0	**22.5**
11	20	10	10	15	20	75.0	4.0	5.0	20.0	20	10	15	15	20	80	**4.5**	5.0	**22.5**
12	20	10	10	10	10	60.0	3.5	5.0	17.5	20	10	15	15	20	80	**4.5**	5.0	**22.5**
13	20	10	10	10	10	60.0	3.5	5.0	17.5	20	10	15	10	20	75	**4.0**	5.0	**20.0**
14	20	10	10	15	20	75.0	4.0	5.0	20.0	20	10	15	15	20	80	**4.5**	5.0	**22.5**
15	20	10	10	15	20	75.0	4.0	5.0	20.0	20	10	15	15	20	80	**4.5**	5.0	**22.5**
16	20	10	10	10	15	65.0	3.5	5.0	17.5	20	10	15	15	20	80	**4.5**	5.0	**22.5**
17	20	10	10	10	10	60.0	3.5	5.0	17.5	20	10	15	10	15	70	**4.0**	5.0	**20.0**
18	20	10	10	10	10	60.0	3.5	5.0	17.5	20	10	15	10	15	70	**4.0**	5.0	**20.0**
19	20	10	10	10	10	60.0	3.5	5.0	17.5	20	10	15	15	20	80	**4.5**	5.0	**22.5**
20	20	10	10	10	10	60.0	3.5	5.0	17.5	20	10	15	15	20	80	**4.5**	5.0	**22.5**
21	20	10	10	10	15	65.0	3.5	5.0	17.5	20	10	15	15	20	80	**4.5**	5.0	**22.5**
22	20	10	10	10	10	60.0	3.5	5.0	17.5	20	10	15	15	20	80	**4.5**	5.0	**22.5**
23	20	10	10	10	10	60.0	3.5	5.0	17.5	20	15	10	10	10	65	**3.5**	5.0	**17.5**
24	20	10	10	10	10	60.0	3.5	5.0	17.5	15	15	10	10	10	60	**3.5**	5.0	**17.5**

Table A-1 - Peat Stability Risk Assessment for Turbary Plots

Turbary Plot No.	North End									South End								
	Peat/Subsoil Conditions	Topography	FoS Calculations	Hydrology/ Hydrogeology	Other Contributary Factors	Total Hazard Rating	Likelihood (L)	Impact (I)	Risk Rating (R = LxI)	Peat/Subsoil Conditions	Topography	FoS Calculations	Hydrology/ Hydrogeology	Other Contributary Factors	Total Hazard Rating	Likelihood (L)	Impact (I)	Risk Rating (R = LxI)
25	20	10	10	10	10	60.0	3.5	5.0	17.5	15	15	10	10	10	60	**3.5**	5.0	**17.5**
26	20	10	10	10	15	65.0	3.5	5.0	17.5	15	15	10	10	15	65	**3.5**	5.0	**17.5**
27	20	10	10	10	15	65.0	3.5	5.0	17.5	20	15	10	10	10	65	**3.5**	5.0	**17.5**
28	20	10	10	10	10	60.0	3.5	5.0	17.5	20	15	10	10	15	70	**4.0**	5.0	**20.0**
29	20	10	10	10	10	60.0	3.5	5.0	17.5	20	15	10	10	10	65	**3.5**	5.0	**17.5**
30	20	15	15	10	15	75.0	4.0	5.0	20.0	20	20	15	10	10	75	**4.0**	5.0	**20.0**
31	20	10	10	15	15	70.0	4.0	5.0	20.0	20	20	10	10	15	75	**4.0**	5.0	**20.0**
32	20	10	10	10	15	65.0	3.5	5.0	17.5	20	15	10	10	15	70	**4.0**	5.0	**20.0**
33	20	15	15	10	10	70.0	4.0	5.0	20.0	20	15	15	10	15	75	**4.0**	5.0	**20.0**
34	20	15	15	10	15	75.0	4.0	5.0	20.0	20	15	15	10	15	75	**4.0**	5.0	**20.0**
35	20	15	15	10	15	75.0	4.0	5.0	20.0	15	15	15	10	15	70	**4.0**	5.0	**20.0**
36	20	15	15	10	10	70.0	4.0	5.0	20.0	15	15	15	10	10	65	**3.5**	5.0	**17.5**
37	20	10	15	10	10	65.0	3.5	5.0	17.5	15	15	15	10	10	65	**3.5**	5.0	**17.5**
38	20	10	10	10	10	60.0	3.5	5.0	17.5	15	15	10	10	10	60	**3.5**	5.0	**17.5**
39	20	10	10	10	10	60.0	3.5	5.0	17.5	15	15	10	10	10	60	**3.5**	5.0	**17.5**
40	20	10	10	10	15	65.0	3.5	5.0	17.5	15	15	10	10	15	65	**3.5**	5.0	**17.5**
41	20	10	10	10	15	65.0	3.5	5.0	17.5	15	15	10	10	15	65	**3.5**	5.0	**17.5**
42	20	10	10	10	10	60.0	3.5	5.0	17.5	15	15	10	10	15	65	**3.5**	5.0	**17.5**
43	20	10	10	10	15	65.0	3.5	5.0	17.5	15	15	10	10	15	65	**3.5**	5.0	**17.5**
44	20	10	10	10	15	65.0	3.5	5.0	17.5	15	15	10	10	15	65	**3.5**	5.0	**17.5**
45	20	10	10	10	10	60.0	3.5	5.0	17.5	15	15	10	10	10	60	**3.5**	5.0	**17.5**

Table A-1 - Peat Stability Risk Assessment for Turbary Plots

Turbary Plot No.	Peat/Subsoil Conditions	Topography	FoS Calculations	Hydrology/ Hydrogeology	Other Contributary Factors	Total Hazard Rating	Likelihood (L)	Impact (I)	Risk Rating (R = LxI)
141	10	15	10	10	10	55	**3.0**	5.0	**15.0**
142	10	15	10	10	15	60	**3.5**	5.0	**17.5**
143	15	15	10	10	10	60	**3.5**	5.0	**17.5**
144	15	15	10	10	10	60	**3.5**	5.0	**17.5**
145	15	15	10	10	10	60	**3.5**	5.0	**17.5**
146	20	10	10	10	15	65	**3.5**	5.0	**17.5**
147	20	10	10	15	15	70	**4.0**	5.0	**20.0**
148	15	10	15	15	20	75	**4.0**	5.0	**20.0**
149	20	15	15	15	20	85	**4.5**	5.0	**22.5**
150	20	15	15	15	20	85	**4.5**	5.0	**22.5**
151	20	15	15	15	20	85	**4.5**	5.0	**22.5**
152	20	15	15	15	20	85	**4.5**	5.0	**22.5**
153	20	15	15	15	20	85	**4.5**	5.0	**22.5**
154	15	20	15	15	20	85	**4.5**	5.0	**22.5**
155	10	20	15	15	20	80	**4.0**	5.0	**20.0**
156	15	20	15	10	15	75	**4.0**	5.0	**20.0**
157	20	20	15	10	15	80	**4.5**	5.0	**22.5**
158	20	20	15	10	20	85	**4.5**	5.0	**22.5**
159	15	20	15	15	20	85	**4.5**	5.0	**22.5**
160	20	20	15	15	20	90	**5.0**	5.0	**25.0**
161	20	20	15	15	20	90	**5.0**	5.0	**25.0**
162	20	20	15	10	15	80	**4.5**	5.0	**22.5**
163	15	20	15	10	10	70	**4.0**	5.0	**20.0**
164	15	15	15	10	15	70	**4.0**	5.0	**20.0**
165	15	20	10	10	10	65	**3.5**	5.0	**17.5**
166	15	20	10	10	10	65	**3.5**	5.0	**17.5**
167	15	20	10	10	10	65	**3.5**	5.0	**17.5**
168	15	20	15	10	15	75	**4.0**	5.0	**20.0**
169	15	20	15	10	10	70	**4.0**	5.0	**20.0**
170	10	20	15	10	10	65	**3.5**	5.0	**17.5**
171	15	20	15	10	10	70	**4.0**	5.0	**20.0**

Table A-1 - Peat Stability Risk Assessment for Turbary Plots

Turbary Plot No.	Peat/Subsoil Conditions	Topography	FoS Calculations	Hydrology/ Hydrogeology	Other Contributary Factors	Total Hazard Rating	Likelihood (L)	Impact (I)	Risk Rating (R = LxI)
172	15	20	10	10	10	65	**3.5**	5.0	**17.5**
173	15	20	15	10	10	70	**4.0**	5.0	**20.0**
174	15	20	15	10	10	70	**4.0**	5.0	**20.0**
175	10	20	15	10	10	65	**3.5**	5.0	**17.5**
176	15	20	15	10	15	75	**4.0**	5.0	**20.0**
177	20	10	10	10	10	60	**3.5**	5.0	**17.5**
178	20	10	10	10	10	60	**3.5**	5.0	**17.5**
179	20	10	10	10	10	60	**3.5**	5.0	**17.5**
180	20	10	10	10	10	60	**3.5**	5.0	**17.5**
182	15	15	10	10	10	60	**3.5**	5.0	**17.5**
183	15	15	10	10	10	60	**3.5**	5.0	**17.5**
184	15	15	10	10	10	60	**3.5**	5.0	**17.5**
185	15	15	10	10	10	60	**3.5**	5.0	**17.5**
186	15	15	10	10	10	60	**3.5**	5.0	**17.5**
187	15	15	10	10	10	60	**3.5**	5.0	**17.5**
188	20	15	10	10	10	65	**3.5**	5.0	**17.5**
189	20	15	10	10	10	65	**3.5**	5.0	**17.5**
190	15	15	10	10	10	60	**3.5**	5.0	**17.5**
191	10	20	10	15	15	70	**4.0**	5.0	**20.0**
192	10	20	15	15	20	80	**4.5**	5.0	**22.5**
193	15	20	15	15	20	85	**4.5**	5.0	**22.5**
194	20	20	15	10	20	85	**4.5**	5.0	**22.5**
195	20	20	15	15	20	90	**5.0**	5.0	**25.0**
196	15	20	15	15	15	80	**4.5**	5.0	**22.5**
197	15	20	15	10	10	70	**4.0**	5.0	**20.0**
198	15	20	15	10	10	70	**4.0**	5.0	**20.0**
199	15	20	15	15	20	85	**4.5**	5.0	**22.5**
200	15	20	15	15	20	85	**4.5**	5.0	**22.5**
201	15	20	15	15	15	80	**4.5**	5.0	**22.5**
202	15	20	15	10	15	75	**4.0**	5.0	**20.0**
203	15	20	15	10	10	70	**4.0**	5.0	**20.0**

Table A-1 - Peat Stability Risk Assessment for Turbary Plots

Turbary Plot No.	Peat/Subsoil Conditions	Topography	FoS Calculations	Hydrology/ Hydrogeology	Other Contributary Factors	Total Hazard Rating	Likelihood (L)	Impact (I)	Risk Rating (R = LxI)
204	15	20	15	10	10	70	**4.0**	5.0	**20.0**
205	15	20	10	10	10	65	**3.5**	5.0	**17.5**
206	15	20	10	10	10	65	**3.5**	5.0	**17.5**
207	15	20	10	10	10	65	**3.5**	5.0	**17.5**
208	15	20	10	10	10	65	**3.5**	5.0	**17.5**
209	10	20	10	10	10	60	**3.5**	5.0	**17.5**
210	15	20	10	10	10	65	**3.5**	5.0	**17.5**
211	15	15	10	10	10	60	**3.5**	5.0	**17.5**
212	10	15	10	10	10	55	**3.0**	5.0	**15.0**
213	20	15	15	10	10	70	**4.0**	5.0	**20.0**
214	20	15	15	10	10	70	**4.0**	5.0	**20.0**
215	20	15	10	10	10	65	**3.5**	5.0	**17.5**
216	20	15	10	10	10	65	**3.5**	5.0	**17.5**
217	20	15	10	10	10	65	**3.5**	5.0	**17.5**
218	20	15	10	10	10	65	**3.5**	5.0	**17.5**
219	20	15	10	10	15	70	**4.0**	5.0	**20.0**
220	20	15	10	10	15	70	**4.0**	5.0	**20.0**
221	20	20	10	10	15	75	**4.0**	5.0	**20.0**
223A	10	10	10	15	10	55	**3.5**	5.0	**17.5**
223B	10	15	10	10	10	55	**3.5**	5.0	**17.5**
224	10	15	10	10	10	55	**3.0**	5.0	**15.0**
225	10	15	10	10	10	55	**3.0**	5.0	**15.0**
226	15	15	10	10	10	60	**3.5**	5.0	**17.5**
227	15	15	10	10	10	60	**3.5**	5.0	**17.5**
228	15	20	10	10	10	65	**3.5**	5.0	**17.5**
229	15	20	10	10	15	70	**4.0**	5.0	**20.0**
230	20	20	15	10	15	80	**4.5**	5.0	**22.5**
231	20	20	15	10	15	80	**4.5**	5.0	**22.5**
232	20	20	15	10	15	80	**4.5**	5.0	**22.5**

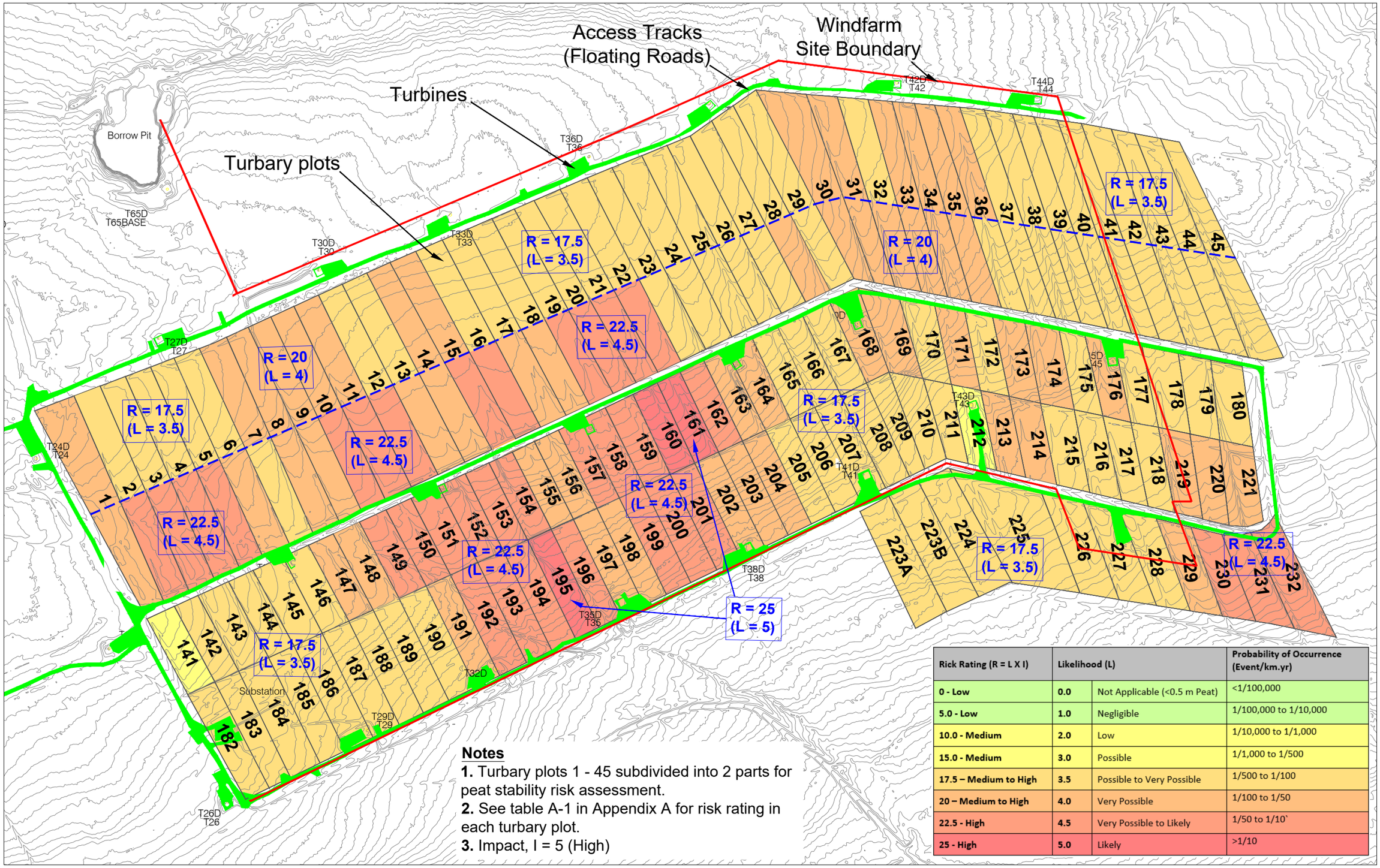
TABLE A1 – PEAT/SUBSOIL CONDITIONS	Rating			
	Negligible	Low	Medium	High
Peat				
Peat Depth	<0.5 m	0.5 - 1.0	1.0 - 2.0	>2.0
Water Content	0-500%	500-1000%	1000-1500%	>1500%
Min Peak Undrained Shear Strength	>20 kPa	10-20 kPa	5-10 kPa	<=5 kPa
Peat Classification at c_u min	Very Fibrous	Fibrous	Pseudo-Fibrous/Slightly Fibrous	Amorphous/ Clayey
Stability of peat in trial pits	Stable	Slight spalling	Collapse @ >3 m Depth	Collapse/squeezing <3 m Depth
Very Soft Clay Layer Below Peat [applies to uniform clay of high plasticity, & excludes well-graded gravelly Cohesive Glacial Till or decomposed rock]				
Very soft clay layer at base of peat	No			Yes
Sensitivity Coefficient ($c_{u\ peak}/c_{u\ residual}$)	1.0	1.0-1.5	1.5 - 2.0	>2
Peak Undrained Shear Strength	>20 kPa	10-20 kPa	5-10 kPa	<=5 kPa
Residual Undrained Shear Strength	>20 kPa	10-20 kPa	5-10 kPa	<=5 kPa
Transition - Peat to Mineral Soil				
Sharp discontinuity (possible or potential shear plane) identified in peat or at base of peat in trial pits, probes or piston samples	No			Yes
Underlying Mineral Soil/Rock				
Granular soil/Fractured rock at base of peat	No			Yes
Nested Flat Boulders	No			Yes
Rock below Peat - Interface Characteristics	Rough/ Weathered	Rough/Fractured	Smooth Undulating	Smooth Planar

TABLE A2 - TOPOGRAPHY	Rating			
	Negligible	Low	Medium	High
Slope Angle	**Flat**	**Shallow**	**Intermediate**	**High**
Slope Angle - Ground Surface	**<1°**	**1-3°**	**3°-5°**	**>5°**
Slope Angle - Base of Peat	**<1°**	**1-3°**	**3°-5°**	**>5°**
In broad valley upslope from defined watercourses	**No**	**Yes, slopes <3°**	**Yes, slopes 3-5°**	**Yes, slopes > 5°**
Distance from topographical low-point upslope from defined watercourses	**>250 m**	**100-250 m**	**50-100 m**	**<50 m**
General slope characteristics downslope from road/turbine	**Concave**	**Planar to Concave**	**Planar to Convex**	**Convex**
Distance from break in convex slope	**>100 m**	**50-100 m**	**10-50 m**	**<10 m**

TABLE A3 – FACTOR OF SAFETY CALCULATIONS (INFINITE SLOPE)	Rating			
	Negligible	Low	Medium	High
FOS Infinite Slope - No Surcharge (Existing Condition)				
c_u = 5kPa (or minimum)	>3	2.0 - 3.0	1.5 - 2.0	<1.5
c_u = 2.5kPa (Worst Case)	>2	1.5 - 2.0	1.0 - 1.5	<1.0
FOS Infinite Slope - Surcharge of 1.0m Peat with Partial Factor = 1.3				
c_u = 5kPa (or minimum)	>3	2.0 - 3.0	1.5 - 2.0	<1.5
c_u = 2.5kPa (Worst Case)	>2	1.5 - 2.0	1.0 - 1.5	<1.0
FOS - Floating Road				
Planar Sliding (c_u = 5kPa)	>2	1.4 - 2.0	1.0 - 1.4	<1.0
Bearing Capacity	>2	1.4 - 2.0	1.0 - 1.4	<1.0
Extrusion	>2	1.4 - 2.0	1.0 - 1.4	<1.0

TABLE A4 – HYDROLOGY/HYDROGEOLOGY	Rating			
	Negligible	Low	Medium	High
Surface water	Dry	Localised/ Flowing in Drains	Ponded in drains	Springs/Surface Water
Existing drainage ditches	None/ Downslope	Varied (Gen. Downslope)	Varied (Gen. Across Slope)	Across slope
Groundwater observations in peat in trial pits.	Dry	Slight Seepage	Moderate Seepage	Strong Flow
Piping observed in trial pits	No	Slight Flow/Small Dia. (<25 mm)	Moderate Flow/Medium Dia. (25-50 mm)	Strong Flow/Large Dia. (>50 mm)
Seepage at Base of Peat	No			Yes
Evidence of piping from walkover survey	No	Possibly	Probably	Yes

TABLE A5 – OTHER CONTRIBUTORY FACTORS	Rating			
	Negligible	Low	Medium	High
Slide History				
Evidence of historic slides		General Area	On Site	<1 km
Tension Cracks in Peat				Yes
Aerial Photography				
Evidence of historic slides in area		Possibly	Probably	Yes
Evidence of subterranean drainage/piping		Possibly	Probably	Yes
Other notable contributory features		Possibly	Probably	Yes
Vegetation				
Tree Growth (Coniferous Forestry)	Good		Fair	Poor
Vegetation (no trees)	Grass/Crops	Improved Grass/Dry Heather	Wet grassland/juncus	Wetlands Sphagnum/ sedge
Land Use				
Peat Workings	None/Cutaway to <0.5 m Peat	Forestry	Turbury Plots	Sausage Cutter



Notes

1. Turbary plots 1 - 45 subdivided into 2 parts for peat stability risk assessment.

2. See table A-1 in Appendix A for risk rating in each turbary plot.

3. Impact, I = 5 (High)

Rick Rating (R = L X I)	Likelihood (L)		Probability of Occurrence (Event/km.yr)
0 - Low	0.0	Not Applicable (<0.5 m Peat)	<1/100,000
5.0 - Low	1.0	Negligible	1/100,000 to 1/10,000
10.0 - Medium	2.0	Low	1/10,000 to 1/1,000
15.0 - Medium	3.0	Possible	1/1,000 to 1/500
17.5 – Medium to High	3.5	Possible to Very Possible	1/500 to 1/100
20 – Medium to High	4.0	Very Possible	1/100 to 1/50
22.5 - High	4.5	Very Possible to Likely	1/50 to 1/10`
25 - High	5.0	Likely	>1/10

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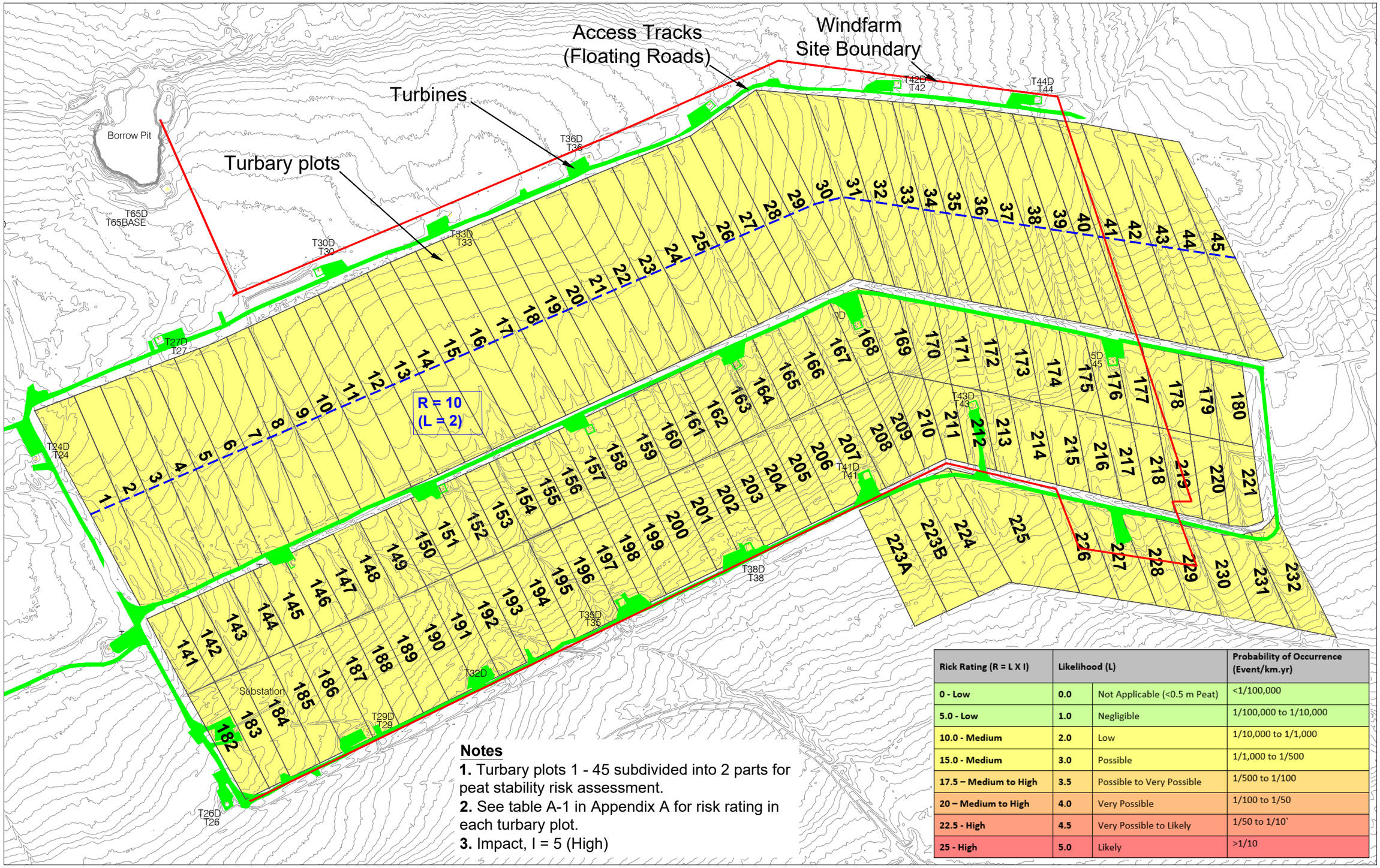
Peat Stability Risk Assessment for Turbary Areas

Project: Derrybrien Wind Farm

Title: Likelihood of Peat Failure & Risk Rating Prior to Mitigation Measures

Scales	Date	Page no.	
1:10,000	16/07/2020	1 of 1	Figure A-1
Version: Final	Drawn: NK	Checked: COD	



Rick Rating (R = L X I)	Likelihood (L)		Probability of Occurrence (Event/km.yr)
0 - Low	0.0	Not Applicable (<0.5 m Peat)	<1/100,000
5.0 - Low	1.0	Negligible	1/100,000 to 1/10,000
10.0 - Medium	2.0	Low	1/10,000 to 1/1,000
15.0 - Medium	3.0	Possible	1/1,000 to 1/500
17.5 – Medium to High	3.5	Possible to Very Possible	1/500 to 1/100
20 – Medium to High	4.0	Very Possible	1/100 to 1/50
22.5 - High	4.5	Very Possible to Likely	1/50 to 1/10`
25 - High	5.0	Likely	>1/10

Notes

1. Turbary plots 1 - 45 subdivided into 2 parts for peat stability risk assessment.

2. See table A-1 in Appendix A for risk rating in each turbary plot.

3. Impact, I = 5 (High)

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Project: Derrybrien Wind Farm			
Title: Likelihood of Peat Failure & Risk Rating Prior to Mitigation Measures			
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Version: Final	Drawn: NK	Checked: COD	

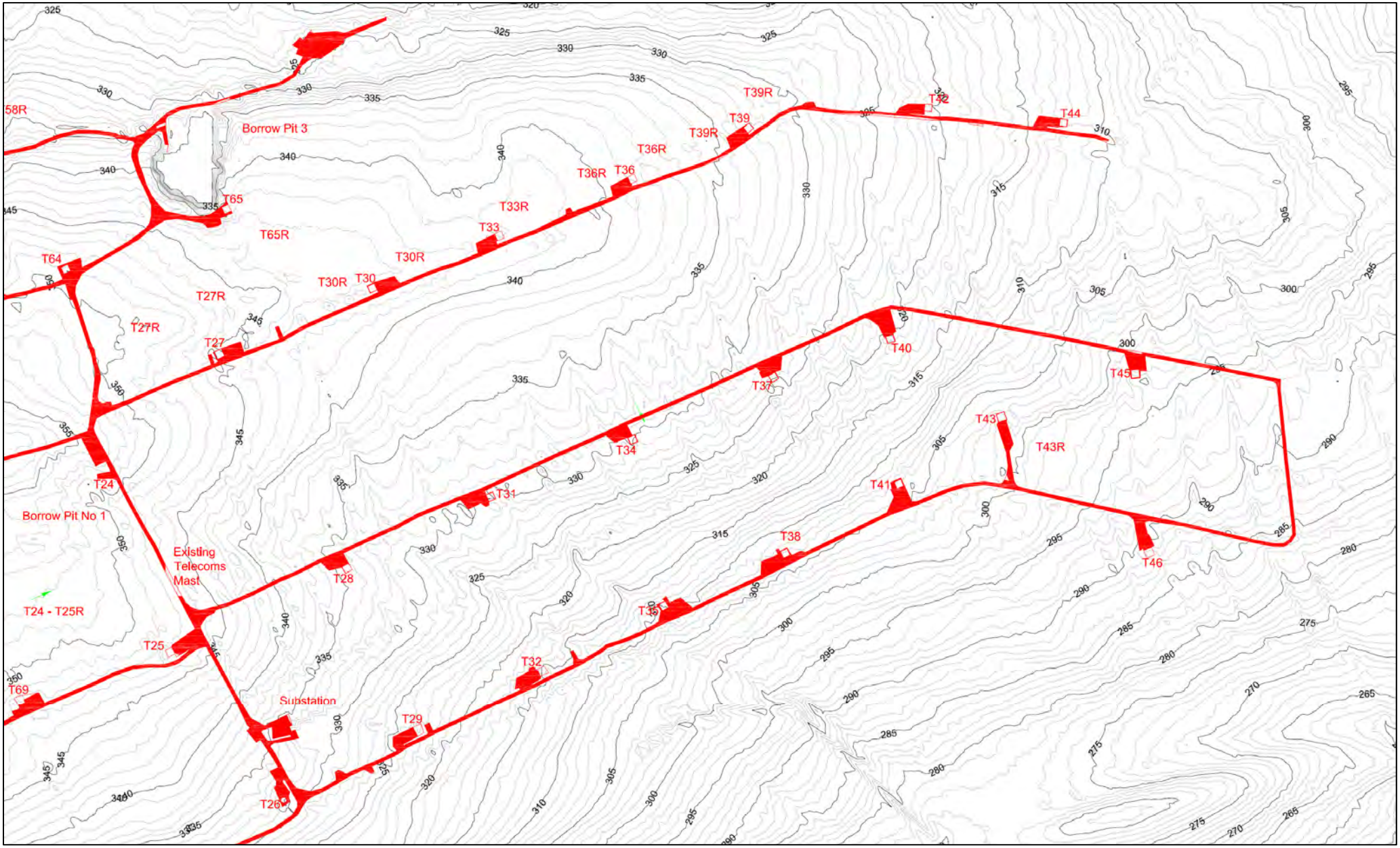


Figure A-3 – LiDAR Survey showing topography in turbary area

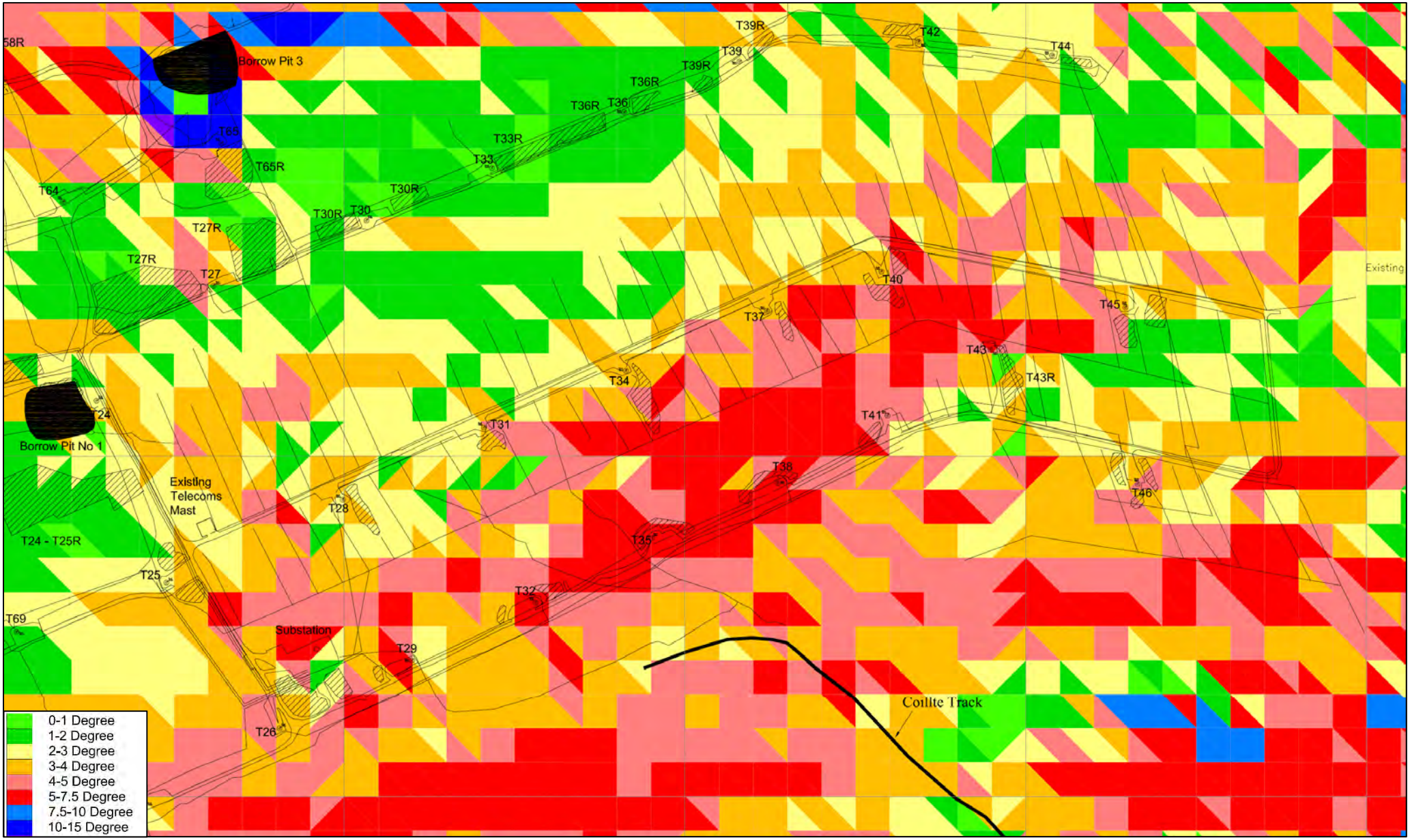


Figure A-4 – Ground surface slope angles in turbary area interpreted from LiDAR Survey

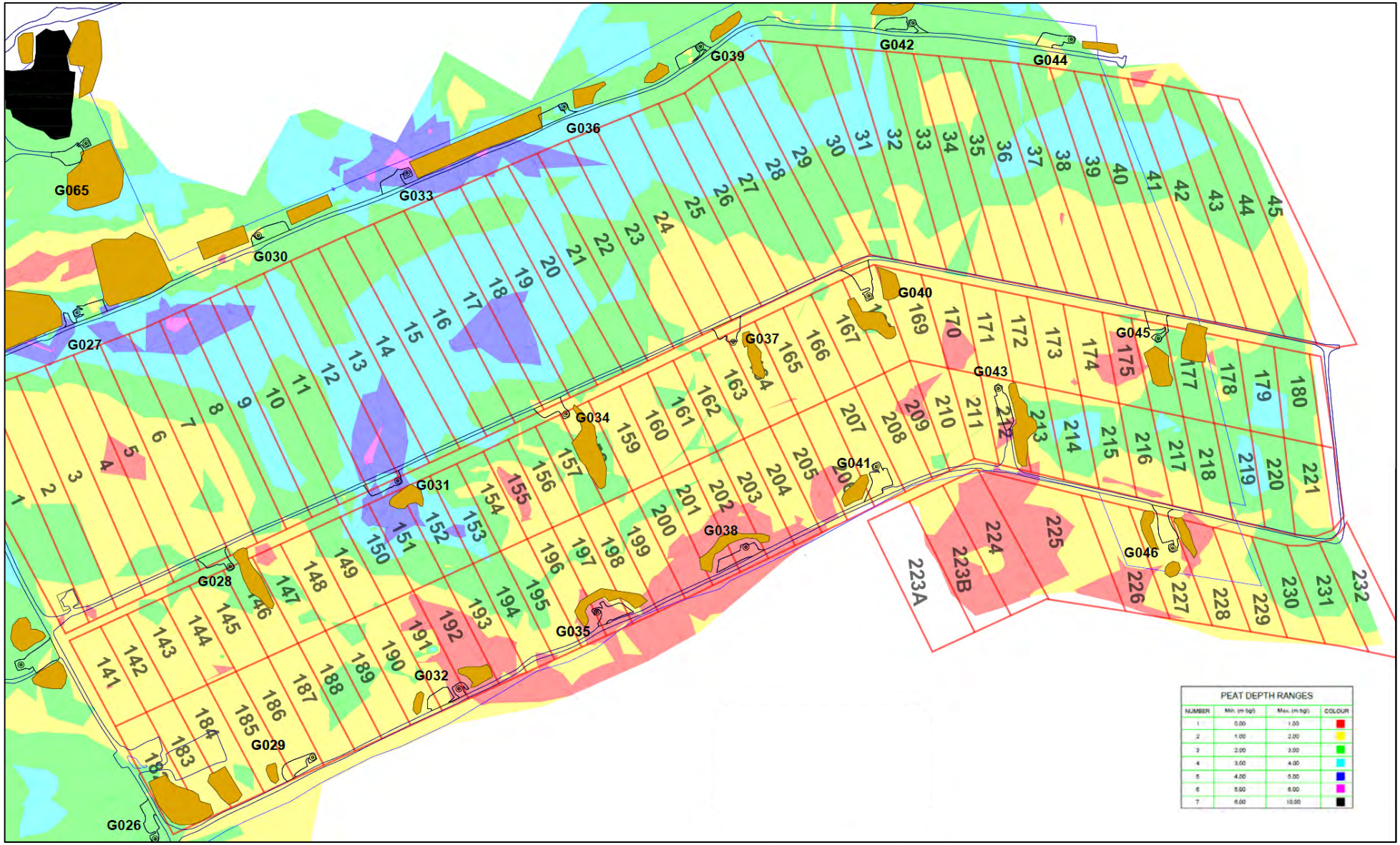


Figure A-5 – Peat depth in turbary area interpreted from LiDAR Survey

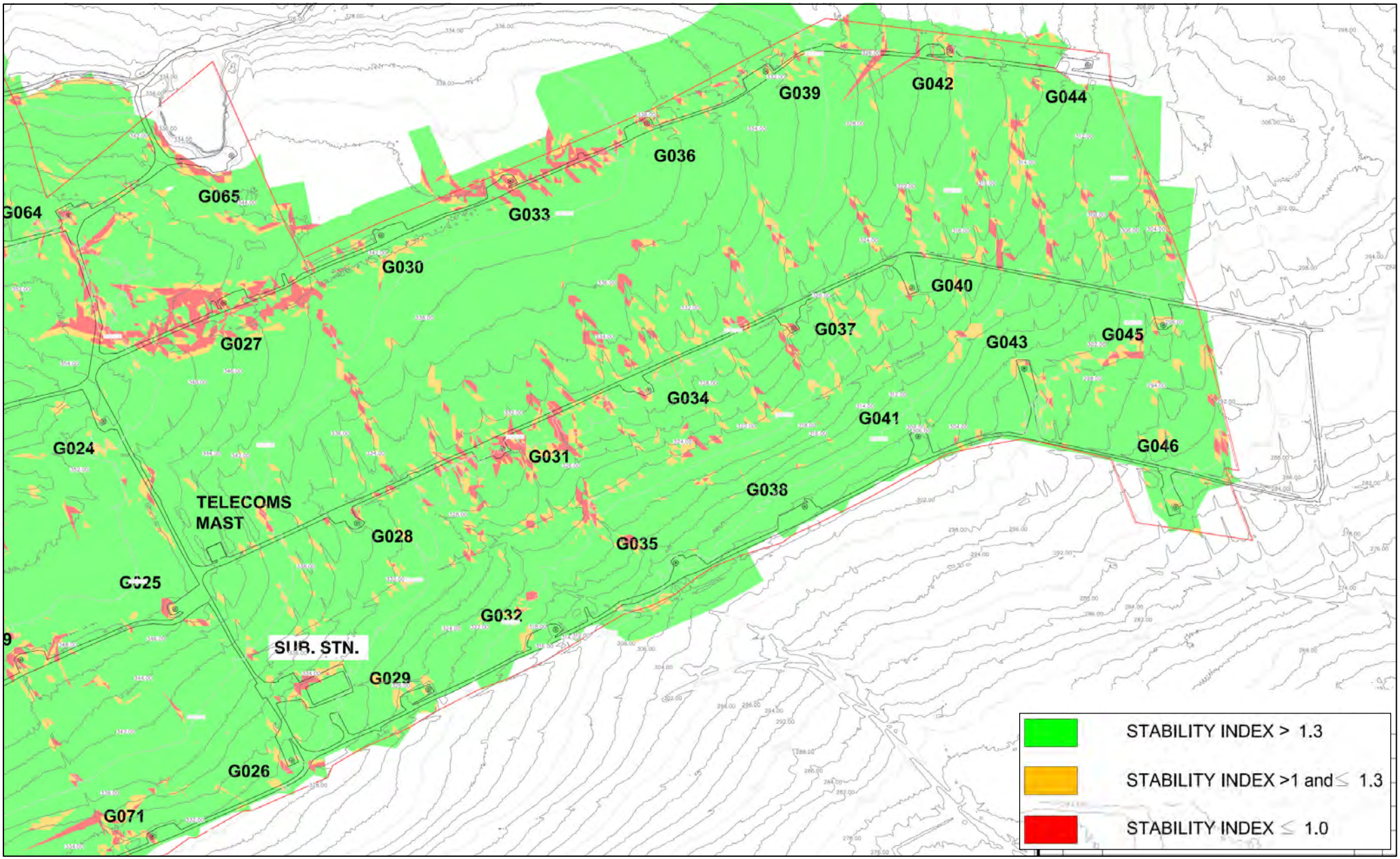


Figure A-6 – Infinite Slope Factor of Safety (FoS/Stability Index) [c_u = **5kPa** at base of peat, **0kPa** Surcharge on surface of peat]

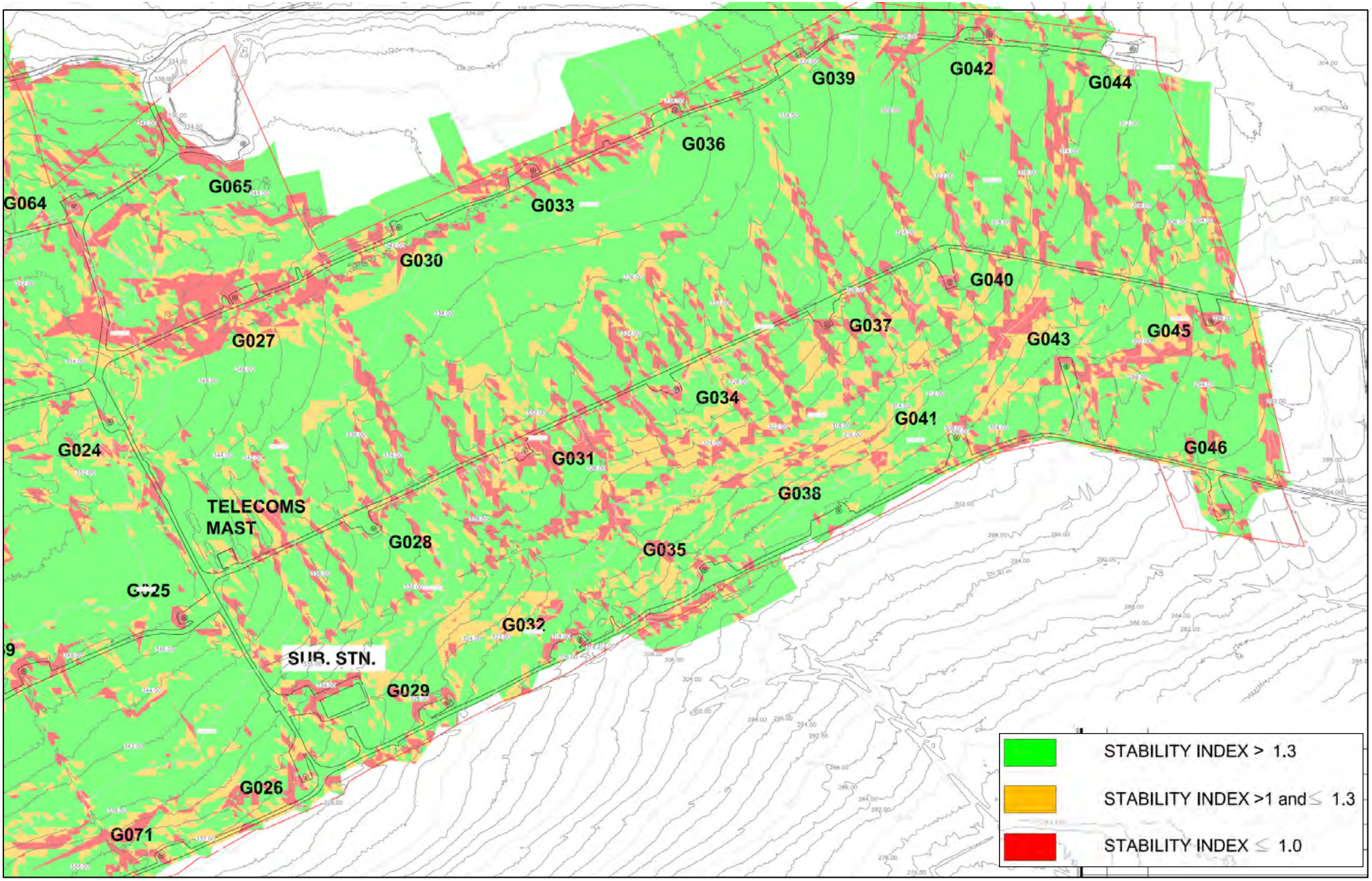


Figure A-7 – Infinite Slope Factor of Safety (FoS/Stability Index) [c_u = **5kPa** at base of peat, **10kPa** Surcharge on surface of peat]

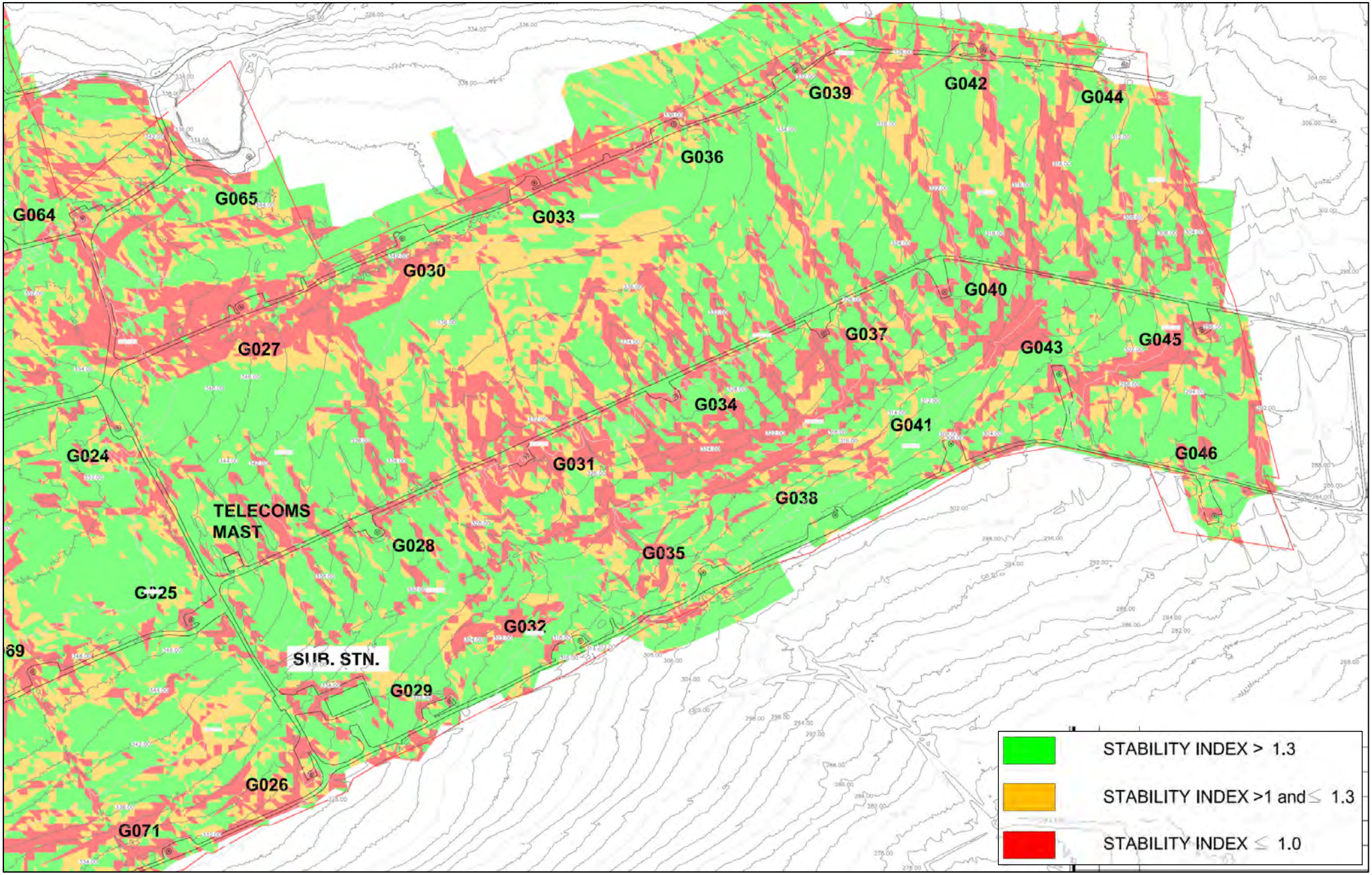


Figure A-8 – Infinite Slope Factor of Safety (FoS/Stability Index) [c_u = **2.5kPa** at base of peat, **0kPa** Surcharge on surface of peat]

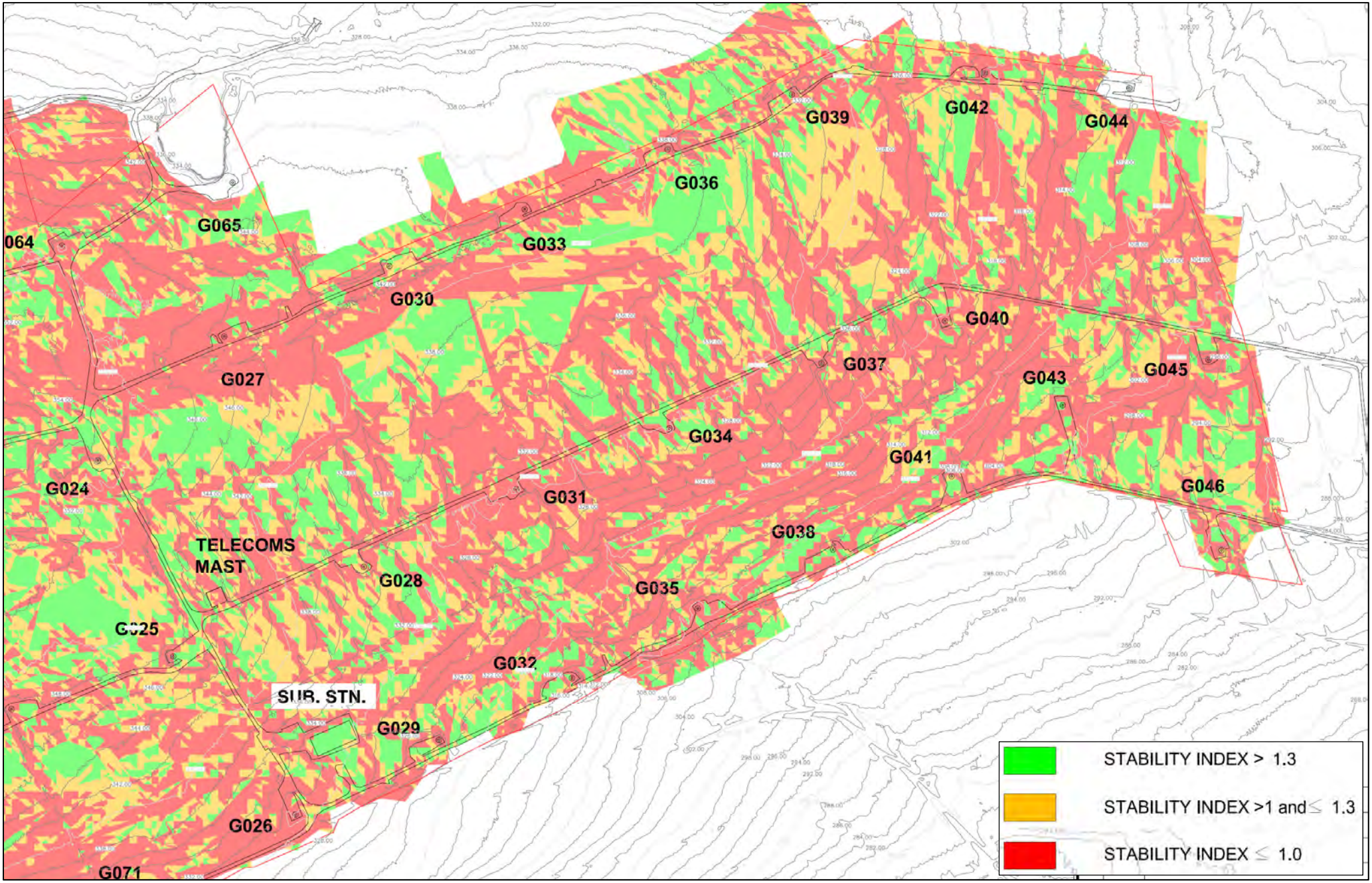
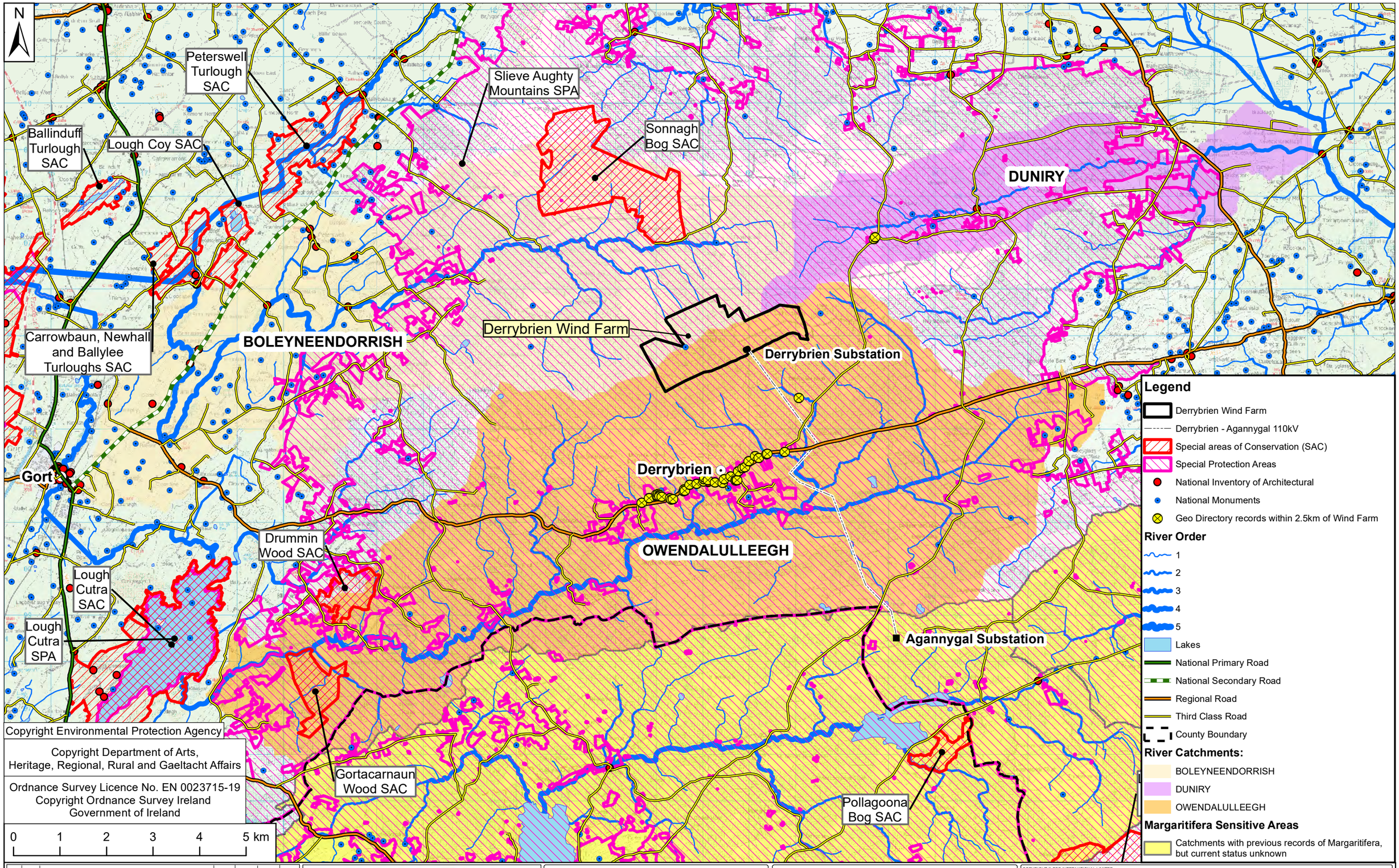


Figure A-9 – Infinite Slope Factor of Safety (FoS/Stability Index) [c_u = **2.5kPa** at base of peat, **10kPa** Surcharge on surface of peat]



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T. O'Rourke	T.O'Rourke	R.O'Donovan	J.Fitzpatrick	30/10/2018

CLIENT REF.	NO. OF SHEETS	SIZE	SCALE
00-00	00-00	A3	1:75,000

DRAWING NUMBER: QS-000192-01-D451-018

APPENDIX 8-5

GEOTECHNICAL & PEAT STABILITY REPORT JULY 2020)

FEHILY TIMONEY
30 YEARS

CONSULTANTS IN ENGINEERING,
ENVIRONMENTAL SCIENCE &

GEOTECHNICAL STABILITY REPORT 2
DERRYBRIEN WIND FARM
PEAT SLIDE AND ASSOCIATED WORKS

Prepared for: **ESB**

Date: July 2020

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DERRYBRIEN WIND FARM
PEAT SLIDE AND ASSOCIATED WORKS

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Abstract: The report contains the findings of a geotechnical assessment of the 2003 peat slide and associated response works at the Derrybrien wind farm.

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GLOSSARY OF TERMS

Barrage	Barrier of typically coarse rock fill placed across flow path of slide debris. Barrage is permeable and allows water to move through barrier but would retain peat debris, may also be referred to as a containment barrage. Typically located in stream/river channel.
Stabilisation and containment work	General term to describe works carried out to stabilise and contain the peat slide subsequent slide debris.
Repository area	Area of stable ground where slide debris was placed. Typically located outside of the debris path. Area could be surrounded with bunds to prevent spread of placed debris
Peat slide	Downslope movement of peat on a discrete sliding surface due to gravitational influence
Glacial till	Largely unsorted and unstratified material deposited directly underneath a glacier consisting of a mix of silt, sand, gravel and boulder sized particles
Borrow pit	Excavation of material for use in the works. Typically comprises nearby and localised excavation into bedrock, which is subsequently process for use in the works
Slide debris	Material that forms part of the slide that has moved downslope. The debris is dominantly peat. The word debris is used as original intact peat was broken down and mixed and also includes secondary materials such as trees and other vegetation.
Subsoil	Material generally found below peat that is likely derived from the in-situ weathering of rock. Typically encountered as a slightly silty sandy subsoil, and distinct from glacial till.
Tension crack	Typical vertical crack in the ground surface found where the ground has been subject to ground movement. The depth of a tension crack can extend from a few centimetres to metres
Relict	Refers to a feature that has been present for some time and is a remnant of a previous activity that is no longer active.
Factor of safety (FoS)	Measure of the stability of a particular slope. For any slope, the degree of stability depends on the ratio of stabilising force to destabilising force. Where the stabilising force is greater than the ratio is greater than 1, and the slope would be considered stable.

1 INTRODUCTION

1.1 General

Fehily Timoney and Company (FT) was engaged in August 2019 by ESB to undertake a geotechnical assessment of the 2003 peat slide and associated works at the Derrybrien wind farm. This assessment includes the peat slide source area, peat slide debris, containment barrages, repositories, accesses and related works.

A series of site inspections, walkover surveys and reports were carried out by AGEC (now part of FT) from 2003 to 2018. For the purpose of this report, any reports issued before 2019 have been referred to as 'AGEC' reports.

The Derrybrien wind farm site is located on Cashlaundrumlahan Mountain in the Slieve Aughty Mountains some 11km south of Loughrea town in County Galway.

The site and surrounding upland area are dominantly covered in blanket peat. The peat slide event in 2003 occurred during the construction of the wind farm, see AGEC (2004).

The geotechnical assessment carried out by FT in 2019, in this report, covers the 2003 peat slide source area, peat slide debris run-out and the associated stabilisation and containment works.

The wind farm comprises 70 wind turbines and associated infrastructure and was constructed over the period 2003 to 2006. The wind farm was commissioned from September 2005 to March 2006 and commenced commercial operation in 2006.

1.2 Background to Peat Slide Event & Associated Works

During the construction of the wind farm a peat slide occurred during excavation work for turbine foundation base T68. The peat slide was reported to have occurred on 16 October 2003 immediately south of the location of the turbine foundation base excavation. The slide event and likely causes are discussed in the report "Final Report on Derrybrien Wind Farm Post-Landslide Site Appraisal", AGEC (2004).

Stabilisation and containment works were installed following the 2003 peat slide to prevent further propagation of the peat slide and to prevent possible further release of slide debris into watercourses. The barrages were strategically placed along the flow path or potential flow path of the peat slide to mitigate further release of debris into any watercourses downstream.

A number of containment barrages were constructed (10 no. in total), generally using rock fill. Of these barrages, 4 no. barrages were temporary (referred to as B A, B, C and D) and were removed shortly following the 2003 peat slide.

Of the 6 no. barrages which remain, 2 no. form part of the access road infrastructure for the wind farm development (between turbine T23 and T70, and at T68) and are included separately within the geotechnical report for the wind farm site and do not form part of this assessment.

This report includes an assessment of the 4 no. remaining barrages.

Debris arising from the 2003 peat slide that accumulated behind a number of the containment barrages was removed and stored in repository areas located adjacent to the containment barrages. Repository areas were constructed adjacent to barrages 2 and 3, see below for details. In addition, a repository area was located upstream of a local road bridge (the Black Road Bridge) where during the slide the debris spread across an area of open flatter ground.

In total 3 no. repository areas were constructed to store peat debris from the slide.

1.3 Geotechnical Assessment & Contents of Report

This report presents the findings of a geotechnical assessment of the peat slide and associated works related to the 2003 peat slide at the Derrybrien wind farm and comprises the following:

(1) Description of associated works related to 2003 peat slide

(2) Review and summary of previous relevant reports

(3) Overview of site conditions

(4) Summary of AGEC ground investigation (2018)

(5) Summary of AGEC walkover survey findings (pre 2019)

(6) Summary of FT walkover findings (2019), which included:

- 2003 peat slide source area
- Stabilisation and containment work associated with 2003 peat slide, namely:
  - Containment barrage 1 (Coillte forestry access track)
  - Containment barrage 2 and associated repository area
  - Containment barrage 3 and associated repository area
  - Containment barrage 4
- Containment barrages (referred to as BD A, B, C and D) constructed by Galway County Council and ESB (these barrages were removed shortly following the 2003 peat slide)
- Borrow pit adjacent to Containment barrage 1 (Coillte borrow pit)
- Repository area at the Black Road Bridge
- Access tracks to barrages/repositories
- Trail of peat slide debris

(7) Stability assessments, which included:

- Stability assessment of the peat debris within the peat slide source area
- Stability assessment of containment barrages & repository areas

(8) Decommissioning – review of main geotechnical implications

(9) Conclusions

2 PEAT SLIDE AND ASSOCIATED WORKS

The peat slide and associated works assessed and included in this report are:

(1) 2003 peat slide source area and peat debris

(2) Containment barrages work associated with 2003 peat slide source area and debris:

- Containment barrage 1 and replaced access track
- Containment barrage 2 and associated access track
- Containment barrage 3 and associated access
- Containment barrage 4 and associated access
- Containment barrages (referred to as A, B, C and D) constructed by Galway County Council and ESB (these barrages were removed shortly following the 2003 peat slide)
- Borrow pit adjacent to Containment barrage 2 (Coillte borrow pit)

(3) Repository areas at:

- Barrage 2
- Barrage 3
- The Black Road Bridge

The location of the above are shown on Drawing 0001.

The associated works referred to include the containment barrages and their associated repository area and accesses where present, constructed typically downstream of the peat slide source area.

2.1 Description of Peat Slide and Associated Works

Peat Slide – Source Area

The peat slide source area is located on the upper southern slope of Cashlaundrumlahan Mountain which comprises a gently sloping plateau aligned on a northwest to southeast axis.

The upper southern slope of the mountain is generally uniform with inclinations of typically from 3° to 5°. The source area is located in the head of a shallow valley which forms a subdued topographic depression in the topography. The peat slide occurred at the head of the valley that contained a tributary stream of the Owendalulleegh River.

Prior to construction of the wind farm, the land use within the peat slide source area and on the upper slopes of Cashlaundrumlahan Mountain were managed commercial forestry, which extended downslope to above the Black Road Bridge.

Peat Slide - Debris

The path of the peat slide debris followed a tributary stream valley of the Owendalulleegh River. From the source area, the peat slide debris passed down the tributary stream valley which narrows to form a steep-sided channel at about 250m AOD before widening downslope above c.195m AOD, which is the location of the Black Road Bridge.

Below the Black Road Bridge (c.195m OD), the tributary stream follows a more southerly course within forestry to the Flaggy Bridge. Below the Flaggy Bridge (c.150m OD) the stream meanders around a number of shallow relief landforms in the floor of the Owendalulleegh River valley and is joined by further tributary streams before joining the Owendalulleegh River about 1.3km south of local road R353 (location of Flaggy Bridge).

The presence of the peat slide debris is notably reduced beyond the confluence with the Owendalulleagh River and essentially there is no reported debris deposited (Inis, 2004) on the river banks after about 3.1km downstream of the confluence with the Owendalulleagh River. At this location the peat slide debris would be entirely suspended within the river water and would be considered technically the termination point of the peat slide debris run-out for the purposes of the soils, geology and land impact assessment.

The length of the peat debris path from the end of the source area (assuming at about 280m OD) to the point where the peat slide debris was entirely suspended within river water is estimated at 6.9km.

Between barrage 2 and the Black Road Bridge the debris extended beyond the stream channel to an estimated total width of up to 100m before narrowing and passing downstream. Below the Black Road Bridge, the extent of the land affected by the peat debris comprised up to about 10m width on either bank of the stream/river. The amount of deposited debris on the banks reduced downstream.

Barrage 1 and Replaced Access Track

Containment barrage 1 is a re-instated forestry access track across the peat slide source area located approximately 1,200m downslope of the head at the source area. The barrage is located at an elevation of 265m OD. The material that was used to construct this barrage was excavated from an adjacent area of shallow rock (referred to in this Report as Coillte Borrow Pit). The replacement access track, which includes the barrage and a floated section of access track extending westerly from the barrage, is 830m long and 4.5m wide and was constructed to re-connect sections of forestry tracks existing prior to the slide in 2003.

Average slope at the barrage are about 3 degrees and along the replacement access track is 2 to 3 degrees.

Barrage 2 and Repository Area

Containment barrage 2 is located within a narrow steep-sided channel some 3 to 4m deep beyond the downslope end of the peat slide source area. The steep-sided channel is a tributary stream of the Owendalulleegh River. The barrage is located at an elevation of 245m OD. This barrage was constructed as part of the works shortly after the peat slide event. A floating access track approximately 300m in length was constructed from an existing Coillte forest track in order to access this location.

The repository area adjacent to containment barrage 2 comprises 2 no. separate storage areas which are referred to as the northern and southern repository areas. The total plan area of the repositories is approximately 4,200m^2. The repository areas contain peat, silt and sand which were removed from upslope of the containment barrage in the years following the peat slide.

Barrage 3 and Repository Area

Containment barrage 3 is located over 1,000m downslope of the end of the peat slide source area at an elevation of approximately 180m OD. The barrage was constructed as part of the works shortly after the peat slide event. The barrage comprised boulders placed within a section of an incised stream which forms a tributary of the Owendalulleegh River.

The repository area adjacent to containment barrage 3 has a plan area of approximately 600m^2. The repository is partially cut into a slope adjacent to the barrage with a bund placed at the lower slope and partially along the upper slope. The repository area contains silt and sand which were removed from the area following the peat slide. As part of the construction of the barrage, temporary access was gained by construction plant from the existing Black Road to the northwest to the site of barrage 3. The access route is approximately 100m long and about 3m wide. The access is aligned downslope and connects to the existing road at about 190m OD.

Barrage 4

Containment barrage 4 is located approximately 300m downstream of containment barrage 3 at an elevation of 165m OD. Similar to above, the barrage was constructed as part of the emergency works shortly after the peat slide event. The barrage comprised boulders placed within a section of an incised stream which forms a tributary of the Owendalulleegh River. Temporary access was gained from the existing Black Road to the west to the site of barrage 4. The footprint of the access route is 100m long and about3 m wide. The access is aligned downslope and connects to the existing road at about 175m OD.

Repository at Black Road Bridge

The repository area at the Black Road Bridge is located approximately 700m southeast of the end of the peat slide source area alongside a public road locally named as the Black Road. The repository comprises 2 no. separate storage areas with a combined storage area of approximately 8,220m^2. The repository areas essentially contain stored peat, together with some soil/rock debris from the peat slide.

Additional Barrages

A further four barrages were constructed as part of the stabilisation and containment works. Three of these were constructed by Galway County Council using material excavated at the barrage location and one by ESB. Two of these were located upstream of the Black Road Bridge, and the other two were located upstream and downstream of Flaggy Bridge. The three earthen barrages constructed by Galway County Council are believed to have been washed away following heavy rainfall in the weeks following the peat slide. The ESB barrage was removed at a later date.

The approximate locations of barrages A, B, C and D were inspected but no apparent traces of the barrages were identified.

2.2 Additional Works

In addition to the stabilisation and containment works described above, a bridge on private land, referred to as Slattery Bridge, located approximately 600m south of the R353, was replaced following the peat slide event. Bridge parapets on the Flaggy Bridge and Black Road Bridge were also replaced following the peat slide event.

Downstream, on the Owendalulleegh River, a set of stepping stones at a ford location were also replaced where they had been damaged by the peat slide event.

3 SUMMARY OF PREVIOUS RELEVANT REPORTS

3.1 Reports on the 2003 Peat Slide and Associated Elements at Derrybrien Wind Farm

Following the 2003 peat slide a number of technical reports were produced which investigated the causes of the peat slide. A number of these reports are given in Table 3.1 in chronological order.

Table 3.1: Summary of Technical Reports for 2003 Peat Slide & Associated Elements

Author	Title of Report	Date	Description
AGEC	Derrybrien Windfarm Project – Landslide Inspection – Preliminary Opinion	Oct 2003	Report includes a preliminary opinion outlining the cause of the peat slide
AGEC	Derrybrien Landslide - Preliminary Opinion	Oct 2003	Follow up report with updated preliminary opinion outlining the cause of the peat slide
AGEC	Final Report on Landslide Oct 2003 & Post Landslide Appraisal	Feb 2004	Final report on the causes of the peat slide based on investigations carried out in the weeks immediately following the peat slide and an assessment on the stability of the overall site (included in this report)
AGEC	Report on Geotechnical Inspection of Derrybrien Windfarm Following Substantial Completion of Works	Nov 2005	Report included an inspection and assessment of the substantially completed civil works for Derrybrien wind farm, inspection of the peat slide, identifies any outstanding issues relating to peat stability at the site and recommendations for the operational phase of the wind farm to ensure long-term stability at the site (included in this report)
AGEC	Report on Geotechnical Inspection of Failure Source area at Derrybrien Wind Farm Site	July 2008	Report includes a geotechnical assessment of the source area left by the peat slide in 2003. The objective of the geotechnical assessment was to determine the potential for further movement of debris within the source area (included in this report)

A number of reports on the peat slide at Derrybrien were completed by AGEC which are discussed below.

3.1.1 AGEC Reports (2003)

The 2003 AGEC reports, commissioned by ESB in October 2003, included a geotechnical investigation into the peat slide at the Derrybrien wind farm site. The report included a preliminary opinion and updated preliminary opinion based on AGEC's observations. A summary of the main findings is given below.

AGEC carried out a visual appraisal of the peat slide from a walkover inspection, recorded survey measurements of the extents of the peat slide using a hand-held GPS , undertook measurement of peat strength at the head of the peat slide source area, undertook a visual appraisal of adjacent turbine locations and a limited review of eye witness accounts and construction records.

The report noted that the peat slide occurred at 16.00 hours on 16th October 2003 in the vicinity of turbine T68. The reported weather at the time of peat slide was fine, with no rainfall recorded.

The head of the peat slide, as defined by a tension crack, was located a few metres downslope of excavation work for turbine base T68 and coincident with the upslope edge of a site access road. Measurements along the upper source area showed slope angles of between about 3° and 5°. At the head of the peat slide the slope angle was about 5°. The peat slide failure surface was within peat, some 200 to 400mm above mineral soil. The report noted that the peat slide was located within a natural shallow valley and that the peat failed as a large-scale translational failure (slide).

The dimensions of the source area were noted as about 45m wide at the head widening to a maximum of about 270m some 750m downslope. The approximate length of the peat slide source area was recorded on 18 October 2003 as approximately 2,450m. The likely mobilised peat slide volume was estimated at 450,000m^3.

Possible contributory factors for the 2003 peat slide presented in the 2003 AGEC reports included:

- Natural drainage line
- Zone of weaker peat
- Placement of access track
- Placement of arisings on slope
- Water-filled excavation
- Drainage works downslope
- Previous instability
- Forestry plough/drainage channels

In conclusion, the 2003 AGEC report considered that construction activity within the head of a shallow valley, an area of poorer ground, triggered a localised peat slide of the underlying in-situ peat. The localised peat slide initiated progressive failure of in-situ peat resulting in a runaway peat slide.

3.1.2 AGEC Report (2004)

The AGEC (2004) report was also commissioned by ESB and included a detailed geotechnical investigation into the peat slide and stability of the overall Derrybrien wind farm site. The main findings and contributory factors for the peat slide were as outlined above for the 2003 AGEC reports.

Additional investigations to the 2003 AGEC reports included further walkover surveys and a ground investigation that included cone penetration testing, in-situ shear vane, resistivity survey and the installation of monitoring instrumentation. The purpose of the investigations was to assess the stability of the wind farm site.

The report noted that construction activity had resulted in localised failures of peat at several locations, though these localised failures did not represent a risk of any further large-scale failure.

The report gave a number of recommendations that needed to be implemented at the site to ensure that the construction of the wind farm could be completed safely. Some of the key recommendations included:

- No concentrated loads such as excavated material from turbine foundation excavations, shall be placed on marginally stable ground. Concentrated water flow onto the peat slopes and unstable excavations are to be avoided
- Ongoing ground investigation work should continue with regular monitoring of specialist movement detection equipment, site roads and other works
- Modified construction work practices which do not adversely affect existing stability, are to be adopted
- A robust drainage plan is to be developed and implemented
- Periodic inspection of the site following completion of works by suitably experienced and qualified geotechnical personnel during the lifetime of the wind farm project

These and other recommendations within the 2003 AGEC reports were implemented during the construction works which allowed the wind farm to be safely constructed, without any further slide events.

3.1.3 AGEC Report (2005)

The AGEC (2005) report included an inspection and assessment of the substantially completed civil works for the wind farm, inspection of the 2003 peat slide, identified any outstanding issues relating to peat stability at the site and recommendations for the operational phase of the wind farm to ensure long-term stability at the site.

At the time of the AGEC inspection in 2005 all turbine bases were complete, and most turbine towers were also complete. Ongoing civil construction work included erection of the remaining turbine towers and general reinstatement of the site.

A site walkover including the following was carried out as part of the works:

- Visual inspection of all infrastructure locations on site i.e. turbines, hardstands and access tracks
- Detailed inspection of onsite areas of previous localised peat instability identified by AGEC in 2003/2004 post the 2003 peat slide event
- Inspection of ESB instrumentation locations i.e. tilt-sensor locations
- Inspection of the 2003 peat slide source area
- Inspection of the stabilisation and containment works associated with the 2003 peat slide

Some of the key recommendations in the report included:

- A periodic annual geotechnical inspection of the wind farm, peat slide source area and elements related to the 2003 peat slide
- Incorporation of further drainage works in the peat slide source area
- Establishment of survey points in the peat debris within the peat slide source area to monitor long-term movements
- Installation of a rain gauge that can record the hourly and daily rainfall totals as a minimum shall be permanently installed at the site. Whilst rainfall is considered to have had no/little significance on the October 2003 peat slide, it is likely that remobilisation of debris within the peat slide source area was related to rainfall intensity
- Other recommendations related to specific locations across the site including incorporation of drainage, installation of sighting/monitoring posts to identify any ground movements and the need for periodic inspections at certain location at the site

AGEC also carried out a preliminary assessment of correlations between events of remobilised peat within the peat slide source area and rainfall. This involved reviewing the rainfall data for the area and correlating it to recorded events of remobilised peat debris from within the peat slide source area. The purpose of the correlation was to establish the likely rainfall threshold amount at which discrete remobilisation of peat debris within the peat slide source area could be initiated. As reported, ESB staff recorded 3 no. remobilisation events from within the peat slide source area since the original peat slide in 2003. These remobilisation events occurred in October 2004, January 2005 and August 2005.

The results of the assessment showed that short-term rainfall records were best suited to predicting when remobilisation of peat debris can occur. Estimated values of between 20 and 25mm rainfall or greater in 24 hours was given as an approximate threshold value at which possible discrete remobilisation of debris may occur within the peat slide source area.

When these rainfall thresholds were exceeded an inspection of the barrages needed to be carried out to assess if a remobilisation event within the peat slide source area had occurred.

The recommendations given in the AGEC (2005) report were incorporated into the operation and maintenance manual for the operational phase of the wind farm which ensured that the development was safely constructed without further instability issues.

3.1.4 AGEC Report (2008)

The AGEC (2008) report includes a geotechnical assessment of the 2003 peat slide. The purpose of the assessment, which included a visual inspection of the peat slide and elements related to the peat slide, was to determine the potential for further movement of debris within the source area.

The main findings of the report included:

- The containment barrages were functioning normally and showed no signs of distress.
- There was no significant accumulation of recent peat debris at the containment barrages.
- Given the lack of peat debris accumulation on the upslope faces of the barrages this would indicate that peat debris within the source area has become less mobile.
- The network of drainage channels excavated in the source area to remove excess water was clear of debris and appeared to be functioning normally.
- General inspection of debris within the source area was also carried out by assessing the sites of re-mobilised peat events identified from 2005. The incident of peat re-mobilisation has notably decreased compared to the last inspection in 2005. No significant peat debris had accumulated behind the barrages.
- The results of the inspection found that the elements put in place to contain any subsequent movement of peat debris from the source area (containment barrages and drainage network) were functioning as required.

It was concluded in the AGEC (2008) report that it was highly unlikely that a large-scale re-mobilisation of peat debris from the source area would occur which is supported by the findings of the FT walkover completed in 2019, the AGEC walkover completed in 2018 and site records to date.

3.2 Summary of ESB Reports for Derrybrien Wind Farm

A number of other relevant ground-related reports were produced as part of the monitoring and inspections during the operational phase of the wind farm. Table 3.2 presents these reports in chronological order.

Table 3.2: Summary of ESB Ground-Related Reports for Derrybrien Wind Farm

Author	Title of Report	Date	Description
ESB	Derrybrien Wind Farm, Co. Galway – Operation & Maintenance Provisions for Long Term Site Stability	Feb 2006	The report includes a monitoring regime which was put in place for the post-peat slide phase of the project to ensure that stability of the site was not compromised by construction activities and for the operational life of the wind farm
ESB	Annual Site Inspection Report 2006	Dec 2006	Findings and recommendations of the annual site inspection carried out by ESB at Derrybrien wind farm
ESB	Annual Site Inspection Report 2007	Apr 2008	Findings and recommendations of the annual site inspection carried out by ESB at Derrybrien wind farm
ESB	Annual Site Inspection Report 2008 - Draft	Apr 2009	Findings and recommendations of the annual site inspection carried out by ESB at Derrybrien wind farm
ESB	Derrybrien Maintenance List 2009	2009	List of observations made during the ESB site walkover of issues to be addressed by wind farm operational manager
ESB	Derrybrien Maintenance List 2010	2010	List of observations made during the ESB site walkover of issues to be addressed by wind farm operational manager
ESB	Annual Geotechnical Inspection 2012	Jan 2013	Findings and recommendations of the annual site inspection carried out by ESB at Derrybrien wind farm
ESB	Annual Geotechnical Inspection 2013	July 2013	Findings and recommendations of the annual site inspection carried out by ESB at Derrybrien wind farm
ESB	Annual Geotechnical Inspection 2014	May 2015	Findings and recommendations of the annual site inspection carried out by ESB at Derrybrien wind farm
ESB	Annual Geotechnical Inspection 2017	Oct 2017	Findings and recommendations of the annual site inspection carried out by ESB at Derrybrien wind farm

The ESB (2006) report includes a monitoring regime which was put in place for the post peat slide phase of the project to ensure that stability of the site was not compromised by construction activities and for the operational life of the wind farm.

Three inspection regimes were proposed in the report for the operational phase of the wind farm which included:

- Weekly check of remote monitoring instrumentation at ESB head office (following the slide, tiltmeters and piezometers were installed at various locations in order to monitor ground water levels and peat movement).
- Monthly routine site inspections by wind farm operational staff
- Annual periodic site inspections by ESB staff

Guidance notes, check lists and contingency measures were given where any noticeable ground movements or anomalous readings/observations were identified.

As far as FT are aware, the weekly check of remote monitoring continued up until 2013 when the instrumentation was decommissioned. As far as FT are aware, the monthly routine inspections by wind farm operational staff and periodic (mainly annual) site inspections by ESB geotechnical staff are ongoing at the site.

The monitoring regime presented in the (ESB, 2006) report assisted in mitigating the risk of peat instability at the site during the operational phase.

In relation to the annual periodic inspections and associated reports completed by ESB (2006 to 2017), the reports contain findings and recommendations to ensure the continued stability of the site. Where required, the reports highlight maintenance for works associated with the 2003 peat slide i.e. stabilisation and containment works.

The periodic inspections carried out by ESB geotechnical engineers typically focused on the following items:

- Peat slide source area
- Repository areas
- Containment barrages
- Drainage network
- Site access roads
- Drainage local to turbine and associated hardstands
- Borrow pits
- Sighting posts and remote monitoring instrumentation

Typical maintenance and remedial works highlighted in the annual reports included:

- Drainage issues - blocked drainage lines, settlement of drain pipes within peat, inadequate fall in drainage runs, absence of drains, collapse of drainage ditches and inadequate drainage
- Localised instability of excavation faces
- Inadequate ballast placed at turbine foundations

- Presence of tension cracks alongside site access roads
- Maintenance of site access roads

The maintenance and remedial works highlighted in the ESB annual reports assisted in mitigating the risk of peat instability at the site during the operational phase of the wind farm.

3.3 Ground Investigation Reports

Several phases of ground investigation were carried out during the development of the Derrybrien wind farm . Initial phases of ground investigation were carried out in 2002 and included Mackintosh probes, hand augers and laboratory analysis together with over 600 peat depth probes.

Following the 2003 peat slide a phase of extensive ground investigations was carried out on behalf of ESB and BAM to establish, in particular, the characteristics of the blanket peat covering the site. The extensive ground investigations included gouge auger probes, Geonor H-10 and H-60 vane tests, cone penetration tests (CPT), rotary boreholes, geophysical surveys and laboratory testing.

In total the ground investigations included in excess of 7,200 exploratory locations which were carried out between 2002 and 2019 across the site and at a number of the works sites associated with the 2003 peat slide.

Table 3.3 shows a list of the ground investigations at the Derrybrien wind farm site along with a description for each investigation.

The ground investigation locations are shown on Drawing 0002.

Table 3.3: Summary of Ground Investigation Data for Derrybrien Wind Farm

Author	Title of Report/Data	Report Date	Description
IGSL	Report on Site Investigation at a Proposed Wind Farm Derrybrien Co. Galway	Jan 2002	Factual information from site investigation on sub soil conditions carried out by IGSL. Report includes trial pits, Mackintosh probes, hand augers and laboratory analysis
Malone O'Regan McGillicuddy	-	2002	Probing (629 no.) to determine the depth of peat
Fugro	Report no. 31614-1 (01)	2003	Factual information from natural vane tests and CPT's
AGEC	-	2003	Factual information from peat depth probes and hand shear vanes (in open excavations) –

Author	Title of Report/Data	Report Date	Description
IDL	Proposed Wind Farm at Derrybrien - Site Investigation Factual Report	Sept 2004	Site investigation factual report on an assessment of the ground conditions to provide data to assist in the design of foundations. Report includes rotary core boreholes
AGL	Report No. 03-104-R01-Rev 1	2004	Factual information from gouge auger probes and Geonor H-10 vane tests
ESB	Report on Geotechnical Testing Vol 1 of 2, Report on Geotechnical Testing Vol 2 of 2 & Stability analysis & Shear vane results	Jan 2005	Findings of ESB investigation including peat depth probes, shear vanes and gouge augers
AGEC	No report compiled for investigation – Summary spreadsheet with site recorded data	Dec 2011	Factual information from peat depth probes and hand shear vanes – included in this report as an Appendix
AGEC	No report compiled for investigation	June 2018	Factual information from peat depth probes, hand shear vanes, Mackintosh probes and trial pits – included in this report as an Appendix
Fehily Timoney and Company	This report	September 2019	Factual information from peat depth probes and hand shear vanes

4 OVERVIEW OF SITE CONDITIONS

4.1 Topography

The Derrybrien site is located on the upper slopes of Cashlaundrumlahan Mountain within the Slieve Aughty Mountains. The upper slopes form a gently sloping plateau aligned on a northeast to southwest axis with a summit elevation of 365m OD.

The southern slope of the mountain is generally uniform with inclinations of typically between 3° and 5°. Locally, inclinations increase towards shallow valleys. The heads of several shallow valleys are present on the upper slope, where they are generally represented by a subdued topographic depression in the landscape. These valleys become more distinct and confined downslope where the valleys form narrow steep-sided channels.

The topography and description of each of the works is presented in section 2 of this report.

4.2 Soils and Geology

The deposits comprise the following main types:

(1) Peat

(2) Glacial till and subsoil

(3) Weathered/solid rock

4.2.1 Peat

Based on a review of the soils map of Ireland (GSI, 2019), the area is covered in blanket peat. This is consistent with site walkover and ground investigation findings for the slide response works. The thickness of peat, based on ground investigation, typically ranged from 1 to 4m. There is no clear pattern of peat thickness, though locally thicker peat was recorded in the upper part of the site where slope angles are less.

Examination of peat exposures showed humification at the base of the peat varied between about H6 and H9 (Hobbs, 1986).

The upper about 1m of peat is generally very fibrous and locally desiccated which results in a relatively stronger and stiffer upper layer. The base of the peat, from observations within the peat slide, trial pits and in exposures in excavations and along drains, was described as very soft to soft brown to dark brown pseudo-fibrous and amorphous Peat. Peat appeared to be directly on bedrock or a glacial till/subsoil.

Blanket peat thickness reduces downslope, with peat thickness reducing notably just above the Black Road Bridge where agricultural fields are present. Below the Black Road Bridge there is a mix of thin peat cover and glacial soils with rock at shallow depth.

4.2.2 Glacial Till and Subsoil

Peat is underlain by till or slightly silty sandy subsoil. The subsoil is likely derived from weathered rock. Generally, in exposures both till and a subsoil layer were present below peat and above weathered rock/rockhead.

Glacial Till typically derived from sandstone overlies bedrock in some areas. The till was generally described as sandy gravelly Silt/Clay with occasional to many sub-angular to rounded cobbles and boulders of sandstone.

Subsoil was described as generally loose to medium dense silty Sand with occasional sandstone and quartz gravel.

Exposures of till/subsoil within streams in the peat slide source area (Photo 6 – Appendix A) shows peat over till and sub-soil/weathered bedrock.

4.2.3 Weathered/Solid Rock

The weathered rock comprises generally extensively decomposed rock that has essentially weathered to a soil. The subsoil (described above) represents a weathered rock layer (residual soil).

The bedrock geology consists of red siltstones, mudstones with carbonate concretions, sandstones, conglomerates and mud flake breccia from the Ayle River Formation (GSI, 2003 & 2019).

Across the area there are localised variations ranging from medium grained pale brown thinly to massively bedded sandstones in the central, northern, southern and eastern areas, fine grained pale pink thinly to medium bedded silty sandstones in the central, southern and western areas, and medium bedded conglomerates inter-bedded with sandstones in the northern areas.

Rock is exposed in parts of the stream and river channels, both in the banks and within the stream/river bed. Occasionally rock is exposed at the ground surface beyond the stream/river channels.

4.3 Hydrology and Hydrogeology

A number of natural minor streams drain the upper slopes of Cashlaundrumlahan Mountain. The streams on the southern slopes drain into the Owendalulleegh and Derrywee River whilst the streams on the northern slopes drain into the Boleyneendorrish River. Streams/watercourses in the area of the peat slide are shown on Drawing 0001.

Streams on the lower slopes are typically narrow gullies ranging in width from less than a metre to a few metres. Stream valleys in the upper peat slope are ill-defined, and where present form shallow valley features. Further downslope many streams are formalised into forestry drainage.

An extensive network of drains is present in the forested areas. The forestry drains were constructed during the development of the forestry plantation, pre 2003. A number of springs were present in the area. Groundwater from these springs appear to be transmitted through the open joint network of the underlying bedrock.

4.4 Land Use

Prior to construction of the wind farm, the site of the peat slide and associated works was dominantly commercial forestry. The land is still dominantly in use as commercial forestry with agricultural land, mostly for grazing, present at lower elevations.

5 AGEC GROUND INVESTIGATION (2018)

A ground investigation was carried out by AGEC in June 2018 at the location of associated works with the 2003 peat slide at and comprised peat depth probes, hand shear vanes, Mackintosh probes and trial pits.

A ground investigation location plan is included as Drawing 0002. This drawing includes the 2018 ground investigation data for the associated works related to the 2003 peat slide and also includes and lists all the historical ground investigation data.

The ground investigation carried out by AGEC in 2018 included the following:

- Trial pits in the peat slide source area and at containment barrages & associated repositories, where accessible. Total of 9 no. trial pits (TP01 to TP09) *.
- Mackintosh probes at the containment barrages & associated repositories and repository areas at the Black Road Bridge, where required and where accessible. Total of 80 no. Mackintosh probes (MP01 to MP80)
- Peat depth probing and shear vane strength testing at the following locations;
    - 2003 peat slide source area
    - Localised failure at turbine T17
    - Containment barrages & associated repositories, where relevant
    - Repository areas at the Black Road Bridge

* Altogether, 11 no. trial pits (TP01 to TP11) were carried out but TP10 and TP11 were located at the Agannygal Substation, which is included in a separate report.

The exploratory logs for the Mackintosh probes and trial pits are included as Appendix B to this report.

Note that TP01 to TP02 were carried out at the head of the peat source area, and TP03 and TP04 were carried out in the source area adjacent the wind farm access track between T23 & T70. The remaining trial pits (TP05 to TP09) were carried out at containment and repository locations.

A summary of the AGEC 2018 ground investigation and findings is included in Table 5.1.

A summary of the ground investigation findings is provided in Section 10 of the report.

In relation to the results of the Mackintosh probes, an interpretation of the thickness of placed arisings in the repository areas and the thickness of debris (from the peat slide source area) behind the containment barrages was made based on a review of the blow counts recorded with depth. Where low blow counts are recorded followed by a gradual or sudden increase in blow counts, this is likely to indicate the thickness of placed arisings in the repositories and the thickness of debris (from the peat slide) upslope of the containment barrages. Low blow counts are likely to indicate looser, less compact deposits such as placed arisings within the repositories and deposited debris (from the peat slide) upslope of the containment barrages.

It is not necessarily the case that the debris that was encountered behind barrages 3 and 4 originated in the peat slide source area, as there is a significant catchment area which feeds the water course at these locations.

Where arisings within a repository have been placed on in-situ peat, an interpretation of the blow counts as outlined above was carried out, as far as reasonably practical. It is likely given the time period since the placement of the arisings (in excess of 15 years) that the in-situ peat has increased in strength as a result of the applied loading (arisings). The likely increase in strength of the in-situ peat would lead to a slight increase in blow counts with depth hence the thickness of the placed arising was interpreted.

Recordings of recoil (rebound) of the Mackintosh probe as a result of encountering a possible cobble or boulder were taken into account when interpreting the results.

Where presented in Table 5.1, disturbed/displaced deposits refer to deposits emanating as a result of the 2003 peat slide. Arisings also refers to deposits emanating as a result of the 2003 peats slide which have been placed/stored in a repository area.

Table 5.1: Summary of AGEC 2018 Ground Investigation Findings for the Stabilisation & Containment Works

Stabilisation & Containment Element	Peat Depth Probes (no.)	Mackintosh Probes (no.)	Hand Shear Vanes (no.)	Trial Pits (no.)	Ground Conditions & Findings
Containment barrage 1 (Coillte Road)	-	-	2	3 (TP05, TP06 & TP07)	3 no. trial pits were carried out upslope of containment barrage 1. The trial pits show peat to a maximum depth of 1.5m bgl generally overlying organic sand to a maximum depth of 1.7m bgl overlying clay, silt, sand and gravel deposits to the base of the trial pits at 3.3m bgl. Sandstone cobbles and boulders are noted from 0.8m bgl to the base of trial pit TP06. The clay, silt and granular deposits typically increase in strength with depth from soft to very stiff and very loose to medium dense. The nature and layering of the deposits recorded in the trial pits are reflective of disturbed/displaced ground as a result of the peat slide in 2003. Undrained shear strengths recorded in peat using hand vanes ranged from 9 to 40kPa with an average of 24.5kPa. Based on the trial pits carried out adjacent to containment barrage 1, the founding conditions is likely on firm Silt/Clay or medium dense sand with many cobbles and boulders. These founding conditions would be deemed a competent stratum for the containment barrage.
Containment barrage 2	4	11 MP37 – MP47)	3	1 (TP08)	4 no. of peat depth probes were recorded upslope of containment barrage 2. The peat depth probes indicate minimal peat (less than 0.15m). The material retained behind the barrage is likely to comprise non-peat material i.e. silt and sand deposits. 11 no. of Mackintosh probes were recorded upslope of containment barrage 2. The Mackintosh probes indicate the disturbed/displaced deposits behind the barrage range in thickness from 0.3 to 1.7m with an average of 0.9m based on a review of the blow counts. Recoil (rebound) of the probe was recorded at 2 of the 11 probe locations, suggesting that it may have encountered a cobble or boulder. At all other locations recoil was not recorded, the Mackintosh probe was terminated because of the recorded increase in strength in the underlying deposits.

Stabilisation & Containment Element	Peat Depth Probes (no.)	Mackintosh Probes (no.)	Hand Shear Vanes (no.)	Trial Pits (no.)	Ground Conditions & Findings
					1 no. trial pit (TP08) was carried out between containment barrage 2 and its adjacent repository area. The trial pit shows peat to 1.4m bgl overlying a thin layer (0.1m) of very soft clay overlying very loose & loose silty sands to 2.5m bgl overlying firm to very stiff silt/clay to the base of the trial pit at 3.2m bgl. Undrained shear strengths recorded in peat using hand vanes ranged from 8 to 14kPa with an average of 11kPa. Based on a trial pit carried out adjacent to containment barrage 2, the founding conditions is likely on firm Silt/Clay with many cobbles and boulders. The aforementioned founding conditions would be deemed a competent stratum for the containment barrage.
Repository area at barrage 2	16	18 (MP48 – MP65)	3	1 (TP09)	The repository area adjacent to containment barrage 2 comprises 2 no. separate storage areas. For reporting purposes these are referred to as the northern and southern repository areas. The northern repository is not bunded whilst the southern repository has a mineral soil bund around the stored arisings. The following findings are for the southern (bunded) repository; 7 no. peat depth probes were carried out. The peat depth probes indicate peat thicknesses between 0.4m to 1.6m with an average of 1.0m. The variability in the peat depth recorded indicate that the stored arisings are likely to comprise peat and non-peat material i.e. silt and sand deposits. 9 no. Mackintosh probes were carried out in this area. The Mackintosh probes in the repository area indicate the placed arisings depth ranges from 1.2 to 1.9m with an average of 1.65m based on a review of the blow counts. Based on site observations there appears to be in-situ peat beneath the placed arisings. Recoil (rebound) of the probe was recorded at 3 of the 6 probe locations (within the repository), suggesting that it may have encountered a cobble or boulder. At all other locations recoil was not recorded, the Mackintosh probe was terminated because of the recorded increase in strength in the underlying deposits.

Stabilisation & Containment Element	Peat Depth Probes (no.)	Mackintosh Probes (no.)	Hand Shear Vanes (no.)	Trial Pits (no.)	Ground Conditions & Findings
					The Mackintosh probes carried out within the bund surrounding the stored arisings indicates the bund is likely constructed with material of variable nature and strength. The following findings are for the northern (unbunded) repository; 9 no. peat depth probes were carried out. The peat depth probes indicate peat thicknesses between 0.5m to 1.2m with an average of 0.9m. The variability in the peat depth recorded indicate that the stored arisings are likely to comprise peat and non-peat material i.e. silt and sand deposits. 9 no. of Mackintosh probes were carried out in this area. The Mackintosh probes in the repository area indicate the placed arisings depth range from 0.6 to 1.9m with an average of 1.55m based on a review of the blow counts (as described in Section 5 of the report). Based on site observations there appears to be in-situ peat beneath the placed arisings. At all locations recoil (rebound) was not recorded, the Mackintosh probe was terminated because of the recorded increase in strength in the underlying deposits. 1 no. trial pit (TP09) was carried out northwest of the repository area at containment barrage 2. The trial pit shows peat to 1.1m bgl overlying a thin layer (0.1m) of very soft clay overlying very loose & loose silty sands to 2.0m bgl overlying firm to very stiff silt/clay to the base of the trial pit at 2.8m bgl. Undrained shear strengths recorded in peat using hand vanes ranged from 8 to 14kPa with an average of 11kPa.
Containment barrage 3	11	14 (MP10 – MP23)	-	-	11 no. of peat depth probes were carried out upslope of containment barrage 3. The peat depth probes indicate minimal peat (less than 0.15m). The material retained behind the barrage is likely to comprise non-peat material i.e. silt and sand deposits. 14 no. of Mackintosh probes were recorded upslope of containment barrage 3. The Mackintosh probes indicate the displaced deposits behind the barrage range from 0.2m to 1.9m with an average of 0.7m based on a review of the blow counts (as described in section 5 of the report). It should be noted that the displaced deposits recorded upslope of

Stabilisation & Containment Element	Peat Depth Probes (no.)	Mackintosh Probes (no.)	Hand Shear Vanes (no.)	Trial Pits (no.)	Ground Conditions & Findings
					the containment barrage are not likely to be all from the 2003 peat slide, some of the deposits may be a result of natural displacement from rainfall events. Recoil (rebound) of the probe was recorded at all of the probe locations, suggesting that bedrock is likely to be at the base of the displaced deposits. Based on an inspection of an exposure along the watercourse bank in the area of containment barrage 3 and results of the Mackintosh probes, the founding conditions for the barrage are likely bedrock. These founding conditions would be deemed a competent stratum for the containment barrage.
Repository area at barrage 3	9	13 (MP24 – MP36)	-	-	9 no. peat depth probes were carried out. The peat depth probes indicate minimal peat (less than 0.15m) at the surface of the repository. The peat probe recordings indicate that the stored arisings are likely to comprise non-peat material i.e. silt and sand deposits, as would be expected based on site observations in the area. 13 no. Mackintosh probes were carried out in this area. The Mackintosh probes in the repository area indicate the placed arisings depth ranges from 1.0 to 1.6m with an average of 1.3m based on a review of the blow counts. Recoil (rebound) of the probe was recorded at 6 probe locations (within the repository), suggesting that it may have encountered a cobble, boulder or possibly bedrock. At all other locations recoil was not recorded, the Mackintosh probe was terminated because of the recorded increase in strength in the underlying deposits. The Mackintosh probes carried out within the bund surrounding the stored arisings indicates the bund is likely constructed with material of variable nature and strength.
Containment barrage 4	7	9 (MP1 – MP9)	-	-	7 no. peat depth probes were carried out upslope of containment barrage 4. The peat depth probes indicate minimal peat/topsoil (less than 0.1m). The material retained behind the barrage is likely to comprise non-peat material i.e. silt and sand deposits. 9 no. Mackintosh probes were recorded upslope of Containment barrage 2. The Mackintosh probes indicate the displaced deposits range from 0.1m to 1.6m with an average of 0.8m based on a review of the blow counts. It should be noted that the displaced deposits recorded upslope of the containment barrage are not likely to be all

Stabilisation & Containment Element	Peat Depth Probes (no.)	Mackintosh Probes (no.)	Hand Shear Vanes (no.)	Trial Pits (no.)	Ground Conditions & Findings
					from the 2003 peat slide, some of the deposits may be a result of natural displacement from rainfall events. Recoil (rebound) of the probe was recorded at all of the probe locations, suggesting that bedrock is likely to be at the base of the displaced deposits. Based on an inspection of an exposure along the watercourse bank in the area of containment barrage 4 and the results of the Mackintosh probes, the founding conditions for the barrage are likely bedrock. The aforementioned founding conditions would be deemed a competent stratum for the containment barrage.
Repository area at Black Road Bridge	12	15 (MP66 – MP80)	-	-	The repository area at the Black Road Bridge, comprises 2 separate storage areas. For reporting purposes these are referred to as the northern and southern repository areas. The northern and southern repository areas appear to be partially bunded. Ground conditions logged during the AGEC walkover from an exposure around the perimeter of the repository was typically 0.3m bgl of peaty topsoil overlying slightly gravelly very sandy Clay with occasional cobbles to in excess of 2.0m bgl, gravel and cobble content appears to increase with depth. The material excavated from this area is likely to have been used in the construction of the bunds around the repositories. The following findings are for the northern repository; 7 no. peat depth probes were carried out. The peat depth probes indicate peat thicknesses between 1.0m to 1.4m with an average of 1.2m. 8 no. Mackintosh probes were carried out in this area. The Mackintosh probes in the repository area indicate the placed arisings depth ranges from 1.3 to 2.0m with an average of 1.7m based on a review of the blow counts. Based on site observations there appears to be minimal in-situ peat beneath the placed arisings. Recoil (rebound) of the probe was recorded at 4 of the probe locations (within the repository), suggesting that it may have encountered a cobble, boulder or possible bedrock. At all other locations recoil was not recorded, the Mackintosh probes were terminated because of the recorded increase in strength in the underlying deposits.

Stabilisation & Containment Element	Peat Depth Probes (no.)	Mackintosh Probes (no.)	Hand Shear Vanes (no.)	Trial Pits (no.)	Ground Conditions & Findings
					The Mackintosh probes carried out within the bund surrounding the stored arisings indicates the bund is likely constructed with material of variable nature and strength. The following findings are for the southern repository; 5 no. peat depth probes were carried out. The peat depth probes indicate peat thicknesses between 0.3 to 1.4m with an average of 1.0m. The variability in the peat depth recorded indicate that the stored arisings are likely to comprise peat and non-peat material i.e. silt and sand deposits. 7 no. Mackintosh probes were carried out in this area. The Mackintosh probes in the repository area indicate the placed arisings depth ranges from 0.7 to 2.0m with an average of 1.4m based on a review of the blow counts. Based on site observations there appears to be minimal in-situ peat beneath the placed arisings. Recoil (rebound) of the probe was recorded at 1 of the probe locations (within the repository), suggesting that it may have encountered a cobble or boulder. At all other locations recoil was not recorded, the Mackintosh probes were terminated because of the recorded increase in strength in the underlying deposits. The Mackintosh probes carried out within the bund surrounding the stored arisings indicates the bund is likely constructed with material of variable nature and strength.

6 REVIEW OF PREVIOUS GROUND INSTABILITY

6.1 General

A review of historical records of peat/landslides (GSI, 2019) indicates that peat slides have occurred in the Slieve Aughty Mountains in the past. A summary of the peat slides within a 10km radius of Derrybrien wind farm are presented in Table 6.1 with a more detailed description of the 2003 peat slide at the Derrybrien Wind Farm given below. In general, records show that failures have affected many upland peat areas in Ireland.

Table 6.1: Historical Recorded Failures in Slieve Aughty Mountains

Year of Incident	Description of Incident	Reference
1890	Bog above Ballinlough, County Galway in an area called Loughatorick North. An area of 100 acres was covered with a foot of peat, the upper part of the bog subsiding 10 to 15 feet. The failure was described as a flow within blanket peat.	Pentland (1890)
1934	Slieve Aughty Mountains, County Clare. Bog burst following high antecedent rainfall.	Mitchell (1935)
2003	Sonnagh Old, Toberalatan County Galway. Failure is reported to have occurred on the edge of a wind farm site access road. Failure was described as a flow within blanket peat bog.	Dykes (2008)

As part of the national landslide susceptibility mapping project carried out by the Geological Survey Ireland (GSI, 2007-2013) for Ireland, all areas of land across the country are designated a landslide susceptibility rating, including the Derrybrien wind farm and surrounding area. The landslide susceptibility rating is based on a number of factors including incidences of previous failures, topography, type of deposits, etc. This rating is not confined to areas of peat, it applies to all soil types.

The Derrybrien wind farm is not located in an area of notable previous failure/landslide events and is classified as having 'low' to 'moderately low' failure/landslide susceptibility with locally 'moderately high' susceptibility (GSI, 2019).

As stated above, the land susceptibility rating typically relates to the type of deposits, topography in an area, incidences of previous failures/landslides, etc. For example, a rating of 'moderately high' can be assigned where rock is close to the surface, slope angles range from 10 to 20 degrees, etc. Hence the rating of 'moderately high' does not necessarily relate to a risk of peat failure.

It should be noted that at the time of the 2003 peat slide at Derrybrien Wind Farm Site no national landslide register/database existed.

6.2 2003 Peat Slide at Derrybrien Wind Farm

During the construction of the wind farm a peat slide occurred during construction. The peat slide occurred on the 16 October 2003 immediately south of the location for turbine T68 during excavation works for the base of

T68. The peat slide occurred as a result of construction activity within the head of a shallow valley and within an area of weak peat. The loading to the surface of the peat (from construction activity) triggered a failure of the underlying in-situ peat which initiated a progressive failure of the in-situ peat resulting in a runaway failure.

The dimensions of the peat slide source area are about 45m wide at the head widening to a maximum of about 270m some 750m downslope (Drawing 0001). The approximate length of the peat slide source area is about 1.5 km. The peat slide occurred in peat which overlies mineral soil comprising till/subsoil over bedrock.

The thickness of peat at the head of the peat slide source area was about 2m. The peat slide volume was estimated to be about 450,000m^3 (AGEC, 2004).

The peat slide source area was re-inspected as part of a walkover in 2018 by FT and an analysis of the stability of the peat material within the peat slide source area is included within Section 12 of this report.

7 ESB MONITORING AND INSPECTIONS (POST 2003)

7.1 Types of Monitoring

7.1.1 Tilt Sensors & Push-In Piezometers

Following the 2003 peat slide and as part of precautionary measures, ESB had ground movement and water pressure monitoring instrumentation installed to give early warning of irregular/unusual ground movements or water pressure build up.

Ground movement monitoring and water pressure instrumentation were installed at four locations on site. A total of 15 no. tilt sensors and 12 no. push-in piezometers were located in the vicinity of turbines T2, T18, T34 and T49/T50. Data from tilt sensors were fed by telemetry to ESB and were reviewed on a regular basis by ESB. Where data exceeds pre-determined threshold levels ESB followed a response protocol (ESB, 2006).

It should be noted that as of 2013, the tilt sensors and push-in piezometers were no longer in use as a result of malfunctions. Given the time period which had lapsed since the peat slide in 2003 and the negligible movement recorded in that period it was not considered necessary to replace the monitoring instrumentation.

7.1.2 Survey Monitoring Points within the Peat Slide Source Area

Following the peat slide in 2003 and as part of a precautionary measure, ESB had ground movement monitoring points installed within the peat slide source area. The survey monitoring points were positioned at 7 no. locations throughout the peat slide source area. The survey monitoring points are examined on an annual basis to determine if any significant movement of the peat is occurring. At the time of writing this report, monitoring of these survey points is ongoing by ESB.

In relation to the monitoring points installed by ESB within the failure scar, a review of the monitoring data between 2005 and 2017 was carried out. The survey monitoring points show negligible movement for this period of time.

The minimal ground movement recorded is likely attributed to both the natural wetting/drying of the peat with seasonal changes and the accuracy of the GPS survey equipment used. It should be noted that the accuracy of the original GPS equipment used in the monitoring of the survey points was +/- 25mm in the ‘x, y’ direction and +/- 60mm in the ‘z’ direction (based on information received from ESB). The continuous improvement of the correction service available for the surveying equipment used in the latter years of the monitoring period would also have led to minor differences in the monitoring of the survey points. No readings were noted that could be attributable to adverse peat movement.

8 OVERVIEW OF AGEC/FT WALKOVER SURVEYS

A number of walkover surveys of related to the 2003 peat slide were carried out by AGEC and FT. The inspections took place from 2003 (following the peat slide) to 2019.

The walkover surveys and investigations are separated into two timeframes namely pre 2019 and 2019. The walkover surveys and investigations pre-2019 are included in Sections 9 and 10, and those in 2019 are in Section 11.

The background and purpose of these walkover surveys for each walkover is given below.

8.1 2003 Peat Slide Source Area and Debris

The purpose of the walkover surveys was to identify any outstanding issues relating to peat stability and assess the long-term stability of the peat slide source area. This included recording/examining the following:

(1) Condition and strength of the peat

(2) Peat thickness

(3) Slope form

(4) Slope angle measurements

(5) Drainage lines – both natural and man-made

(6) Geomorphology of the peat slide source area

(7) Extent of the peat slide source area

(8) Extent of peat slide debris downstream of source area

8.2 Works Associated with 2003 Peat Slide

These associated works were constructed following the 2003 peat slide to prevent further propagation of the peat slide and to prevent possible further release of debris into the watercourse downstream. Numerous walkover surveys of these works were carried out. These stabilisation and containment works included:

- Containment barrage 1 and replaced access track
- Containment barrage 2 and repository area
- Containment barrage 3 and repository area
- Containment barrage 4
- Containment barrages (referred to as BD A, B, C and D)
- Borrow pit adjacent to Containment barrage 2 (Coillte borrow pit)

A visual inspection of the containment works listed above was carried out to assess the condition of the works and to identify any instability issues. Note that barrages A, B, C and D were either washed away or removed shortly following the 2003 peat slide.

8.3 Repository Area at the Black Road Bridge

The repository area is located in close proximity to the Black Road Bridge (see Drawing 0001) and contains essentially peat, together with some soil/rock debris, from the 2003 peat slide.

Following the initiation of the peat slide, debris from the peat slide moved downslope and entered a stream valley, which formed the upper reaches of the Owendalulleegh River. The debris passed down the valley and into an area of open flatter ground where the debris lost momentum and was deposited. A repository area was located in an area upstream of the Black Road Bridge to contain material deposited into the area of open flatter ground.

Numerous visual assessments of the repository areas were carried out which included Mackintosh probing, peat depth probing and shear vane strength testing.

9 WALKOVER SURVEY FINDINGS (PRE-2019)

A summary of the main findings from the walkover surveys undertaken pre-2019 since the wind farm became operational is given below for each of the works associated with the 2003 peat slide. These surveys were carried out by AGEC and ESB.

A more detailed review of the associated works related to the 2003 peat slide is given in Section 11 which is based on the findings from the more recent the 2019 walkover survey by FT .

In addition, and as part of the ongoing monitoring regime at the site, periodic inspections of the associated works related to the 2003 peat slide outlined below were carried out by ESB since the wind farm became operational in 2005 up to 2017. A summary of the periodic inspections carried out by ESB is given in Table 3.2 in Section 3 of the report.

9.1 2003 Peat Slide Source Area

The 2003 peat slide source area extends from turbine T68 to containment barrage 2 (Drawing 0001). An aerial photo of the extent of the peat slide which was taken shortly after the peat slide occurred in 2003 is shown in Figure 2.

Following the wind farm becoming operational in 2005, inspections of the peat slide source area were carried out by AGEC in 2005, 2008, 2011 and 2018.

In relation to the pre 2019 AGEC surveys, the walkovers were carried out to identify any outstanding issues relating to peat stability and assess the long-term stability of the peat slide source area. In addition, peat depth probing and shear vane testing was carried out as part of these walkovers.

The results of the inspections found that the elements put in place to contain any subsequent movement of debris from the peat slide source area (containment barrages and drainage network within the source area) were functioning as required.

As reported, ESB staff recorded 3 no. remobilisation events from within the peat slide source area since the original peat slide in 2003. These remobilisation events occurred in October 2004, January 2005 and August 2005. Up to the time of writing this report and as far as FT is aware, no other remobilisation events have occurred.

The various pre-2019 walkovers found that the debris that remains within the source area had been displaced downslope and has been disturbed as a consequence of the peat slide event. The debris comprised intact and non-intact peat. The intact peat was essentially large blocks of peat that have become detached as a result of the peat slide. The non-intact peat was the shallow material between the blocks of peat which previously flowed down the source area as a result of the peat slide but had become more stabilised together with a thin intact basal layer of peat that was largely found to be undisturbed by the peat slide.

The debris within the source area had been in place for over 15 years and had since consolidated and dried and become re-vegetated in areas and as a result was considered to be more stable than following the peat slide

event. The growth of numerous trees and shrubs throughout the extent of the source area is further evidence of the stability of the debris within the source area.

Undrained shear strengths (c_u) of the intact and non-intact peat debris recorded during AGEC walkovers within the peat slide source area ranged from 4 to 50kPa with an average of 17kPa (Figure 1). The strengths were measured using a hand-held shear vane (Geonor H60). Over time the undrained strength of the peat showed a general increase from the initial surveys to the most recent survey.

As part of the works to stabilise the debris contained within the source area a series of drains were constructed in the source area to allow excess water to effectively drain away. In addition, since the peat slide occurred a number of natural drains/flow paths formed in the source area as a result of the development of preferential flow paths following rainfall events.

A number of relict tensions cracks were evidenced around the perimeter of the source area. These tension cracks would have formed immediately following the peat slide in 2003 and developed as a result of a loss of support from the adjacent in-situ peat (as a result of the peat slide event). Tension cracks are a common occurrence in ground adjacent to a peat slide area. The walkover surveys pre-2019 indicated that since the slide these tension cracks had become stable.

Inspection of the debris over this period of time showed that it continued to consolidate over time due to the drainage of water from the debris which resulted in the peat gaining strength. The undrained strength of the peat showed a general increase over time (Figure 1).

No signs of instability or remobilisation events were noted during AGEC's pre-2019 walkovers. Since the peat slide, the stability of the debris within the source area has increased.

9.2 Works Associated with 2003 Peat Slide

Visual inspections of the containment barrages were carried out by AGEC in 2005, 2008, 2011 and 2018. Peat depth probing and shear vane testing was carried out as part of these walkovers, where relevant.

In relation to the pre 2019 AGEC surveys, the containment barrages were deemed to be functioning normally, stable and showed no signs of distress. There was no significant accumulation of recent debris upslope of the containment barrages at the end of this period.

It was noted from the 2005 survey carried out by AGEC that 3 no. remobilisation events from within the peat slide source area had occurred since the peat slide in 2003. These remobilisation events occurred in October 2004, January 2005 and August 2005. Up to the time of writing this report and as far as FT is aware, no other remobilisation events have occurred.

The AGEC inspections found that the measures put in place to contain any subsequent movement of debris within the source area (containment barrages and drainage network) were functioning as required.

9.2.1 Works Associated with 2003 Peat Slide - Maintenance

Discussions with the wind farm manager in 2018 indicated that the containment barrages were last cleared of debris in June 2007 and that the cleared debris essentially comprised silt. Only the upper two barrages were cleared, namely containment barrages 1 and 2. A small quantity of silt i.e. less than $2m^3$ was removed from a silt trap behind barrage 1 in February 2009. Since the commencement of operation of the wind farm the lower two barrages namely barrages 3 and 4 have not needed to be cleared as accumulated debris was not evident.

9.3 Repository Area at the Black Road Bridge

The repository areas at the Black Road Bridge contain stored peat, together with some soil/rock debris from the 2003 peat slide, up to about 2m high with a relatively flat upper surface.

Visuals inspections of the repository areas were carried out by AGEC in 2011 and 2018. Peat depth probing and shear vane testing was carried out as part of these walkovers.

In relation to the pre 2019 AGEC surveys, the repository areas were noted as having re-vegetated and were firm underfoot. Visual inspection of the stored material showed that they are stable.

Some cracking of the upper surface of the stored material was noted during the earlier AGEC inspections. This was noted as desiccation cracking of the peat due to drying out over time of the peat and was not deemed critical to the stability of the repository.

The outer margin of the repository partially comprises a bund constructed using soil and rock. This bund, though not required for stability, affords protection against surface erosion of the peat.

10 FINDINGS OF GROUND INVESTIGATION (2018)

The ground investigation was carried out by AGEC from 12 to 22 June 2018 at the location of the containment barrages (1 to 4) and the repository at the Black Road Bridge. As part of the ground investigation, there were inspections and observation of the conditions of the various elements, which is also included below.

A detailed stability assessment of all the containment barrages is included in Section 14 of this report.

Location of associated works is shown on Drawing 0001.

In relation to the containment barrages and repository areas the disturbed/displaced deposits refer to material emanating as a result of the 2003 peat slide. Arisings refers to materials emanating as a result of the 2003 peat slide which have been placed/stored in a repository area.

10.1 Works Associated with 2003 Peat Slide Source area

10.1.1 Containment Barrage 1 (Coillte Road)

This barrage was a re-instated forestry access track that crossed the peat slide source area. The barrage was constructed of coarse fill founded on mineral soil sometime after the peat slide event.

3 no. trial pits (TP05, TP06 & TP07) were carried out upslope and adjacent to the containment barrage 1. Based on these trial pits the founding conditions of the barrage is likely on firm Silt/Clay or medium dense sand with many cobbles and boulders. The aforementioned founding conditions would be deemed a competent stratum for the containment barrage.

10.1.2 Containment Barrage 2 and Repository Area

This containment barrage is located within the gorge beyond the downslope end of the peat slide source area. This barrage was constructed as part of the emergency works shortly after the peat slide event. The barrage was heavily vegetated at the time of inspection.

11 no. Mackintosh probes were undertaken upslope of containment barrage 2. The Mackintosh probes indicate the disturbed/displaced deposits behind the barrage range in thickness from 0.3 to 1.7m with an average of 0.9m based on a review of the blow counts (as described in Section 5 of the report). The estimated volume of silt/sand material that has accumulated on the upslope side of the barrage is 200m^3.

1 no. trial pit (TP08) was carried out between containment barrage 2 and its adjacent repository area. Based on the results of the trial pit and from visual inspection, the founding conditions at the barrage is likely firm Silt/Clay with many cobbles and boulders. The aforementioned founding conditions would be deemed a competent stratum for the containment barrage.

The repository area adjacent to containment barrage 2 comprises 2 no. separate storage areas which are referred to as the northern and southern repository areas, see Drawing 0005.

18 no. Mackintosh probes were carried out in the repository areas. The Mackintosh probes in the repository areas indicate the placed arisings depth ranges from 0.6 to 1.9m with an average of about 1.6m.

The Mackintosh probes carried out within the bund on the southern repository surrounding the stored arisings indicates the bund is likely constructed with material of variable nature and strength.

1 no. trial pit (TP09) was carried out northwest of the repository area at barrage 2. Ground conditions in the area were described as peat to 1.1m bgl overlying a thin layer (0.1m) of very soft clay overlying very loose & loose silty sands to 2.0m bgl overlying firm to very stiff silt/clay to the base of the trial pit at 2.8m bgl.

10.1.3 Containment Barrage 3 and Repository Area

This containment barrage is located over 1km downstream of the peat slide source area. This barrage was constructed as part of the emergency works shortly after the peat slide event. The barrage was heavily vegetated at the time of inspection.

14 no. Mackintosh probes were recorded upslope of containment barrage 3. The Mackintosh probes indicate the disturbed/displaced deposits behind the barrage range in thickness from 0.2 to 1.9m with an average of 0.7m based on a review of the blow counts (as described in Section 5 of the report). It should be noted that the source of the deposited material upslope of the containment barrage, which was dominantly a silt material, would have originated in the upper catchment of the stream and is not necessarily from the peat slide source area. Most of the deposits are likely the result of natural stream sedimentation. The estimated volume of silt/sand material that has accumulated on the upslope side of the barrage is 350m^3.

Based on an inspection of an exposure along the watercourse bank in the area of barrage 3 and results of the Mackintosh probes, the founding conditions for the barrage are likely to be bedrock. The aforementioned founding conditions would be deemed a competent stratum for the containment barrage.

The repository area adjacent to barrage 3 has a plan area of approximately 600m^2, see Drawing 0005. The repository is partially cut into a slope adjacent to the barrage with a bund placed at the lower slope and partially along the upper slope. The repository area contains silt and sand which were removed from the area following the peat slide.

13 no. Mackintosh probes were carried out in the repository areas. The Mackintosh probes in the repository area indicate the placed arisings depth ranges from 1.0 to 1.6m.

The Mackintosh probes carried out within the bund on the lower slope indicates the bund is likely constructed with material of variable nature and strength.

The repository area has become re-vegetated and a visual inspection shows that it is stable and has no signs of instability.

10.1.4 Containment Barrage 4

This containment barrage is located approximately 300m downstream of containment barrage 3. This barrage was constructed as part of the emergency works shortly after the peat slide event. The barrage comprised competent boulders placed within a section of an incised stream. The containment barrage is approximately 20m long and 3m wide at the surface.

9 no. of Mackintosh probes were recorded upslope of containment barrage 4. The Mackintosh probes indicate the disturbed/displaced deposits behind the barrage range in thickness from 0.1 to 1.6m with an average of 0.8m based on a review of the blow counts (as described in Section 5 of the report). It should be noted that the source of the deposited material upslope of the containment barrage, which was dominantly a silt material, would have originated in the upper catchment of the stream and is not necessarily from the peat slide source area. Most of the deposits are likely the result of natural stream sedimentation. The estimated volume of silt/sand material that has accumulated on the upslope side of the containment barrage is 150m^3.

Based on an inspection of an exposure along the watercourse bank in the area of barrage 4 and results of the Mackintosh probes, the founding conditions for the barrage are likely to be bedrock. The aforementioned founding conditions would be deemed a competent stratum for the containment barrage.

Based on a visual inspection, the containment barrage appears stable. The lack of particularly recent peat accumulation on the upslope face of the barrage indicates that the peat debris in the peat slide source area is no longer mobile.

10.2 Repository Area at the Black Road Bridge

The repository areas at the Black Road Bridge essentially contain stored peat, together with some soil/rock debris from the peat slide and were placed up to about 2m high with a flat upper surface. The repository area comprises 2 separate storage areas, see Drawing 0004. The repository areas contain peat and possibly some non-peat debris.

12 no peat depth probes and 15 no. Mackintosh probes were carried out in the repository areas. The probes indicate the placed peat & debris depth ranges from 0.3 to 2.0m.

The Mackintosh probes carried out within the bund indicates the bund is likely constructed with material of variable nature and strength.

Ground conditions logged during the walkover from an exposure around the perimeter of the repository recorded 0.3m of peaty topsoil overlying slightly gravelly very sandy Clay with occasional cobbles to in excess of 2m bgl, gravel and cobble content increased with depth. The material excavated from this area is likely to have been used in the construction of the bunds partially located around the repositories (Photo 15).

11 FINDINGS OF WALKOVER (2019)

The walkover was carried out by FT from 24 to 27 September and from 2 to 3 October 2019.

11.1 2003 Peat Slide Source Area

The 2003 peat slide source area extends from turbine T68 to containment barrage 2 located to the southeast of the head of the peat slide (Drawing 0001). Photos 1 to 6 included as Appendix A to this report show the current condition (in 2019) of the source area.

The peat slide volume was estimated to be about 450,000m^3 (AGEC, 2004). The plan area of the source area is estimated at 253,000m^2. The source area represents the source area of the peat slide, and still contains a significant volume of debris from the peat slide. The estimated volume of debris currently within the extents of the source area is estimated at 200,000m^3, therefore the volume which is estimated to have left the source area is 250,000m^3. It should be noted that the volumes quoted above are estimates only.

The debris which left the source area was deposited downstream of the source area, namely along the peat slide flow path, carried downstream following the peat slide event or placed into repositories constructed downslope of the peat slide.

As part of the recent (2019) inspection carried out by FT, the source area was entered, and a walkover survey carried out.

The debris that remains within the source area has been displaced downslope and has been disturbed as a consequence of the peat slide event. The debris comprises disparate arrangement of intact and non-intact peat debris (Appendix A - Photos 1 to 6). The intact peat is essentially large blocks of peat that have become detached as a result of the peat slide. The shallow peat material between the blocks of peat is the non-intact peat which flowed down the source area (during the peat slide) but has now become stabilised over time together with a thin intact basal layer of peat that was not mainly undisturbed by the peat slide.

The debris within the source area has been in place for over 15 years and has since consolidated and dried and become revegetated in areas and as a result is considered to be more stable than following the peat slide event (Photos 1 and 3). The growth of numerous trees and shrubs throughout the extent of the source area is further evidence of the stability of the debris within the source area.

The debris within the source area, which includes both intact and non-intact peat, has depths from 0 to 2.7m.

Undrained shear strengths (c_u) of the intact and non-intact peat debris recorded during AGEC and FT walkovers within the source area ranged from 4 to 50kPa with an average of 17kPa (Figure 1). The strengths were measured using a hand-held shear vane (Geonor H60).

The undrained peat strength results show that the peat within the source area has drained over time resulting in an increase in strength. The peat strength immediately after the 2003 peat slide would have had similar characteristics to a thick viscous medium, with undrained shear strengths typically in the range 1 to 3kPa.

Inspection of the debris shows that it has consolidated over time due to drainage of water from the peat which has resulted in the peat gaining strength and stabilising, see Figure 1.

Ground conditions within the source area are typically peat overlying till or slightly silty sandy subsoil. The subsoil is likely derived from weathered rock. Generally, in exposures both till and subsoil layer were present below peat and above weathered rock/rockhead. The till was generally described as sandy gravelly Silt/Clay with occasional to many sub-angular to rounded cobbles and boulders of sandstone.

Slope angles recorded for the terrain at the source area range from 2 to 5 degrees with localised variations. The relatively shallow nature of the slopes represents a low risk of debris remobilising within the source area. Drawing 0003 shows longitudinal and cross section drawings through the source area which highlight the shallow nature of the topography in the area.

There has been some localised erosion due to the flow of water over bare peat surfaces over time within the source area (Photos 4 and 5). In such areas the thickness of peat is generally minimal (less than 0.1m) and hence vegetation has not grown in the underlying till/subsoil.

As part of the works to stabilise the debris contained within the source area a series of drains have been constructed in the source area to allow excess water to effectively drain away. In addition, since the peat slide occurred a number of natural drains/flow paths have formed in the source area as a result of the development of preferential flow paths following rainfall events.

The relict tension cracks around the source area which would have formed following the peat slide remain evident. These would have formed immediately following the peat slide in 2003 and developed as a result of a loss of support from the adjacent in-situ peat (as a result of the peat slide event). Tension cracks are a common occurrence in ground adjacent to a peat slide area. The walkover surveys pre-2019 indicated that since the slide these tension cracks had become stable.

The in-situ peat around the perimeter of the source area was noted as having a relatively high strength and indicative of well drained peat. It should be noted that no evidence of recent movement at the perimeter of the source area was recorded during FT's walkover and based on the re-vegetation that has taken place, the perimeter of the source area has been stable for a number of years.

No signs of recent instability or remobilisation events within the source area were noted during FT's walkover. Since the peat slide, the stability of the debris within the source area has increased.

11.2 Works Associated with 2003 Peat Slide Source area

A detailed stability assessment of all the containment barrages is included in Section 14 of this report.

In relation to the containment barrages and repository areas the disturbed/displaced deposits refer to material emanating as a result of the 2003 peat slide. Arisings refers to materials emanating as a result of the 2003 peat slide which have been placed/stored in a repository area.

11.2.1 Containment Barrage 1 (Coillte Road)

This barrage was a reinstated forestry access track across the peat slide source area (Photo 7). The barrage was constructed of coarse fill founded on mineral soil sometime after the peat slide event. The dimensions of the sandstone/conglomerate boulders used in the construction of the containment barrage vary from 0.6 to 1.3m. The size of the boulders used in the parapet wall on the containment barrage was up to about 2m. The containment barrage footprint is approximately 94m long and 8m wide. A localised sump approximately 3m deep has been excavated on the upslope side of the barrage for drainage purposes.

An access track 830m in length was constructed from an existing Coillte forest track in order to access the location of barrage 1 and replace the Coillte access track removed by the slide. The access track comprised a western and eastern section. The access track to the west of barrage 1 was constructed as a floating track on peat. The eastern access track was founded on competent ground. Average slope angle along the track is 2 to 3 degrees.

ESB undertook peat probing in 2020 in the area of the floated road section. The floating access track is estimated to be placed on peat about 0 to 1.4 m depth.

Based on a visual inspection, the containment barrage appears stable. The lack of recent accumulation of debris on the upslope face of the barrage indicates that the debris in the upslope peat slide source area is no longer mobile.

11.2.2 Containment Barrage 2 and Repository Area

This containment barrage is located within the gorge beyond the downslope end of the source area (Photo 11). This barrage was constructed as part of the emergency works shortly after the peat slide event. The barrage comprised boulders placed within a section of an incised stream. The dimensions of the boulders used in the construction of the containment barrage range from 1.0 to 1.2m. The containment barrage is approximately 17m long and 20m wide at the surface. The barrage was heavily vegetated at the time of inspection.

The lack of recent accumulation of silt/sand debris on the upslope face of the barrage indicates that the debris in the source area is no longer mobile. Based on a visual inspection, the containment barrage appears stable.

The repository area adjacent to containment barrage 2 comprises 2 no. separate storage areas which are referred to as the northern and southern repository areas, see Drawing 0005. The northern repository has no bund whilst the southern repository has a bund comprising soil and rock around the stored arisings. The total plan area of the repositories is approximately 3,700m^2. The repository areas contain peat, silt and sand which were removed from behind the barrage in the years following the peat slide.

As part of the construction of the barrage, a floated access track was constructed from the existing Coillte forestry track to the site of barrage 2. This track is 3m in width and was constructed using crushed rock imported from local quarries. The track is still present but is currently overgrown. The floating access track is 300m in length and was constructed on peat. Average slope angle along the track is 3 to 4 degrees.

The floating access track is estimated to be placed on peat up to about 1.5m depth based on nearest available data.

The critical time for stability of the stored material would have been shortly after initial placement when the peat was at its weakest with a notable degree of entrapped water within the peat. Since that time the degree of stability would have increased as a result of consolidation and the possible draining of entrapped water from the repository area. The repository areas have become re-vegetated and a visual inspection shows that they are stable and have no signs of instability (Photo 10).

11.2.3 Containment Barrage 3 and Repository Area

This containment barrage is located over 1km downstream of the source area (Photo 11). This barrage was constructed as part of the emergency works shortly after the peat slide event. The barrage comprised boulders placed within a section of an incised stream. The maximum dimension of the boulders used in the construction of the containment barrage range from 0.9 to 2.5m. The containment barrage is approximately 41m long and 9m wide at the surface. The barrage was heavily vegetated at the time of inspection.

Based on an inspection of an exposure along the watercourse bank in the area of barrage 3 and results of the Mackintosh probes (AGEC, 2018), the founding conditions for the barrage are likely to be bedrock. The aforementioned founding conditions would be deemed a competent stratum for the containment barrage. Based on a visual inspection, the containment barrage appears stable.

The repository area adjacent to barrage 3 has a plan area of approximately 600m^2, see Drawing 0005. The repository is partially cut into a slope adjacent to the barrage with a bund placed at the lower slope and partially along the upper slope. The repository area contains silt and sand which were removed from the area following the peat slide.

The repository area has become re-vegetated and a visual inspection shows that it is stable and has no signs of instability (Photo 12).

11.2.4 Containment Barrage 4

This containment barrage is located approximately 300m downstream of containment barrage 3. This barrage was constructed as part of the emergency works shortly after the peat slide event (Photo 13). The barrage comprised competent boulders placed within a section of an incised stream. The maximum dimension of the boulders used in the construction of the containment barrage range from 1.0 to 2.1m. The containment barrage is approximately 25m long and 10m wide at the surface.

Based on an inspection of an exposure along the watercourse bank in the area of barrage 4 and results of the Mackintosh probes (AGEC, 2018), the founding conditions for the barrage are likely to be bedrock. The aforementioned founding conditions would be deemed a competent stratum for the containment barrage. Based on a visual inspection, the containment barrage appears stable. The lack of recent accumulation of peat debris on the upslope face of the barrage indicates that the debris in the source area is no longer mobile.

11.2.5 Temporary Barrages

A series of four barrages (A, B, C and D) were also constructed by Galway County Council and ESB during October and November 2003 following the peat slide. The barrages were constructed to retain the disturbed peat material.

Barrages A and B were located upstream of Black Road Bridge. Barrages C and D were located upstream and downstream of Flaggy Bridge on R353 respectively.

The barrages were constructed using a combination of locally sourced material (GCC barrages) and materials imported from local quarries (ESB barrage). It appears that the barrages constructed by GCC were either washed away during heavy rainfall in the weeks or removed following the peat slide event.

Inspection of the approximate location of these temporary barrages during the site walkover showed no apparent evidence of the barrages.

11.3 Repository Area at the Black Road Bridge

The repository areas at the Black Road Bridge essentially contain stored peat, together with some soil/rock debris from the peat slide and were placed up to about 2m high with a flat upper surface. The repository areas comprise 2 separate storage areas, see Drawing 0004 (Photo 14). Both storage areas are located on relatively flat ground and are heavily vegetated and are partially bunded. The total plan area of the repositories is approximately 11,900m^2. The repository areas contain peat and possibly some non-peat debris.

The critical time for stability of the stored material would have been shortly after initial placement when the peat was at its weakest with a notable degree of entrapped water within the peat. Since that time the degree of stability would have increased as a result of consolidation and the possible draining of entrapped water from the repository area.

The repository areas have become re-vegetated and walking across the stored peat/debris indicated that the peat/debris was firm underfoot. Inspection of the stored peat/debris showed that they are stable.

11.4 Coillte Borrow Pit

In order to construct containment barrage 1, rock was excavated from an area to the northeast of the barrage, within Coillte land. This area was inspected as part of the 2019 walkover. The borrow pit comprises an excavation into intact bedrock (Photo 8), which is approximately 50m in length, 35m in width and is up to 3m deep.

11.5 Peat Slide Debris Route

As part of the 2019 walkover, the route of the stream from the Black Road Bridge to the confluence with the Owendalulleegh River, and the route of the Owendalulleegh River downstream to Lough Cutra was examined. The banks of the stream and the river were viewed in order to determine if any peat debris remained from the 2003 peat slide.

A river inspection which followed the line of the of the peat slide debris shortly after the peat slide (Inis, 2004 – Appendix F) recorded that peat slide debris was notably reduced beyond the confluence with the Owendalulleagh River with only some (c. 3000m^3) peat debris deposits recorded on the river banks downstream of the Flaggy Bridge. There was essentially no debris reported deposited on the river banks after about 3.1km downstream of the confluence with the Owendalulleagh River. The extent of the peat debris deposits along the banks approximated to around 0.6m^3 per linear metre, less than 0.3m^3 per bank per linear metre when taken over the extent of the surveyed river (to the end of the debris run out), which would not have represented a stability issue.

After about 3.1km downstream of the confluence with the Owendalulleagh River, Inis (2004) recorded that the river in “this section is unchanged from its original form”. At this location the peat slide debris would be entirely suspended within the river water and would be considered technically the termination point of the peat slide debris run-out. The peat slide debris route is presented in Drawing 0001.

Much of the route of the river was accessed during the walkover though locally there were access difficulties meaning that at locations along the river only short sections of the river bank could be accessed from public roads and from within areas of Coillte forestry. The sections of the river that were walked showed no evidence of any peat deposition. This is not unexpected given the high flow rate on the river during winter and the length of time that has elapsed since the peat slide.

Furthermore, since the commencement of operation of the wind farm there has been no requirement to remove any material from behind the barrages along this stretch of the river (Barrage 3 & 4). This would suggest that any erosion of the residual peat following the peat slide would have been gradual and would not have been material from a stability perspective, and that significant quantities of unstable peat are not present along the river channel.

Based on an aerial survey in 2004, it is estimated peat deposited in the private land above the Black Road Bridge covered a corridor some 50m wide by 250m long with an estimated depth of say 0.5m to 0.8m. This peat debris would have degraded over time and would not be readily discernible in 2019. Considering the shallow nature of the peat deposited and the time over which it has been in place the peat debris does not represent a stability risk.

As there is no clear visual evidence of any remaining substantive peat debris thickness along the line of the peat slide debris there is considered to be no stability risk, and as such the stability of the peat slide debris is not considered further.

12 PEAT STABILITY ASSESSMENT OF PEAT DEBRIS WITHIN PEAT SLIDE SOURCE AREA

12.1 Main Approaches for Assessing Peat Stability

The main approaches for assessing peat stability include the following:

(a) Geomorphological

(b) Qualitative (judgement)

(c) Index/Probabilistic (probability)

(d) Deterministic (factor of safety)

Approaches (a) to (c) listed above would be considered subjective for the assessment of these aspects of the project and do not provide a definitive indication of stability; in addition, a high level of judgement/experience is required which makes it difficult to relate the findings to actual conditions present within the peat slide source area. FT apply a more objective approach, the deterministic approach.

A deterministic assessment requires geotechnical information and site characteristics which are obtained from a desk study and site walkover, e.g. strength properties of peat, slope geometry, depth of peat, underlying strata, groundwater, etc. The stability of a peat slope is dependent on several factors working in combination. 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 a peat slide.

Using the information above a factor of safety (FoS) is calculated to determine the stability of the peat debris within the peat slide source area.

The factor of safety is a measure of the stability of a particular slope. For any slope, the degree of stability depends on the balance of forces between the weight of the soil/peat working downslope (destabilising force) and the inherent strength of the peat/soil (shear resistance) to resist the downslope weight.

The undrained peat strength results show that the peat within the source area has drained over time resulting in an increase in strength (Figure 1). The peat strength immediately after the 2003 peat slide would have had similar characteristics to a thick viscous medium, with undrained shear strengths typically in the range 1 to 3kPa. Inspection of the debris shows that it has consolidated over time due to drainage of water from the peat which has resulted in the peat gaining strength and stabilising.

12.2 Methodology for Stability Assessment of Peat

A stability assessment of the peat debris within the 2003 source area was carried out to provide an indication of the likely susceptibility of slope failure of the debris within the source area.

To assess the FoS for a peat slide, an undrained and drained analysis has been undertaken to determine the stability of the peat debris within the source area.

The infinite slope model (Skempton and DeLory, 1957) is used to combine these factors to determine a FoS 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 FoS for a peat slide, an undrained and drained analysis has been undertaken to determine the stability of the peat debris within the peat slide source area.

(1) The undrained loading condition applies in the short-term typically following the application of a load and until load induced pore water pressures have dissipated. Most anthropogenic peat failures occur in the undrained condition i.e. in fully saturated conditions. The undrained condition uses undrained strength parameters in the assessment. Given the timeframe since the peat slide occurred, the drained condition would be deemed the most relevant however the undrained condition is included for completeness.

(2) The drained loading condition applies in the long-term following partial or full dissipation of excess pore water pressure from the peat over time. In the drained condition the pore water pressure (groundwater level) is in equilibrium with in-situ conditions which can vary with seasonal changes. The drained condition examines the effect of the change in groundwater level as a result of rainfall on the stability of the peat slope (following the draining or partial draining of the peat). As a worst case and for the purpose of the assessment the groundwater level is assumed to be at the surface of the peat, to reflect an extreme rainfall event. The drained condition uses effective strength parameters in the assessment.

As stated above, given the timeframe since the peat slide occurred, the drained condition would be deemed the most relevant however the undrained condition is included for completeness.

12.3 Peat Strength

As outlined above, an undrained and drained analysis was carried out for the peat debris within the peat slide source area.

Undrained shear strength values (c_u) for the peat were recorded using the hand shear vane (Geonor H60) and are used for the undrained analysis. For the analysis a lower bound value of 6kPa for the undrained shear strength of the peat was used (Figure 1). Approximately 130 no. shear vane readings, giving indicative undrained shear strength values, were carried out within the peat slide source area, of these none of the readings were less than 4kPa. 6 no. readings recorded values ranged from 4 to 6kPa, all remaining values were in excess of 6kPa with an average of 17kPa. A lower bound undrained shear strength of 6kPa is used in the stability analysis of the peat slide source area. These values would be considered appropriate and conservative for the undrained condition. A comparison of the undrained strength values over time indicates a gradual increase in undrained strength, which is likely due to drainage of the peat, Figure 1.

A drained analysis requires effective cohesion (c') and effective friction angle (ø') values for the calculations. These values can be difficult to obtain because of disturbance experienced when sampling peat and the difficulties in interpreting test results due to the excessive strain induced within the peat. To determine suitable drained strength values a review of published information on peat was carried out.

Table 12.1 shows a summary of the published information on peat together with drained strength values.

Table 12.1: List of Effective Cohesion and Friction Angle Values for Peat

Reference	Cohesion, c' (kPa)	Friction Angle, ø' (degs)	Testing Apparatus/ Comments
Hanrahan et al (1967)	5 to 7	36 to 43	From triaxial apparatus
Rowe and Mylleville (1996)	2.5	28	From simple shear apparatus
Landva (1980)	2 to 4	27.1 to 32.5	Mainly ring shear apparatus for normal stress greater than 13kPa
	5 to 6	-	At zero normal stress
Carling (1986)	6.5	0	-
Farrell and Hebib (1998)	0	38	From ring shear and shear box apparatus. Results are not considered representative.
	0.61	31	From direct simple shear (DSS) apparatus. Result considered too low therefore DSS not considered appropriate
Rowe, Maclean and Soderman (1984)	1.1	26	From simple shear apparatus
	3	27	From DSS apparatus
McGreever and Farrell (1988)	6	38	From triaxial apparatus using soil with 20% organic content
	6	31	From shear box apparatus using soil with 20% organic content
Hungr and Evans (1985)	3.3	-	Back-analysed from failure
Dykes and Kirk (2006)	3.2	30.4	Test within acrotelm
Dykes and Kirk (2006)	4	28.8	Test within catotelm
Warburton et al (2003)	5	23.9	Test in basal peat
Warburton et al (2003)	8.74	21.6	Test using fibrous peat
Hendry et al (2012)	0	31	Remoulded test specimen
Komatsu et al (2011)	8	34	Remoulded test specimen
Zwanenburg et al (2012)	2.3	32.3	From DSS apparatus
Den Haan & Grognet (2014)	-	37.4	From large DSS apparatus
O'Kelly & Zhang (2013)	0	28.9 to 30.3	Tests carried out on reconstituted, undisturbed and blended peat samples

From Table 12.1 the values for c' ranged from about 1.1 to 8.74kPa and ø' ranged from 21.6 to 43°. The average c' and ø' values are 4.5kPa and 30° respectively. Based on the above, it was considered to adopt a conservative approach and to use values less than the average.

Drained strength parameters have been chosen to reflect the current condition of the peat within the peat slide source area. The peat in this area has been drained in the time since the peat slide, which will have led to

consolidation of the peat left within the source area, and an improvement in the drained strength of the peat. As such, drained strength values similar to those of intact peat are considered reasonable.

For the analysis, the following general drained strength values were used:

c' = 4kPa
ϕ' = 25 degrees

12.4 Analysis to Determine Factor of Safety

The purpose of the analysis was to determine the FoS of the peat debris within the 2003 peat slide source area using infinite slope analysis. The analysis was carried out for the entire source area where peat debris is present.

The purpose of the analysis is to provide an indication of the likely susceptibility of instability. As the analysis uses generalised lower bound peat strength values the results provide an indication only of areas where instability might occur. The analysis assumes that all areas have lower bound peat strength values, which in the majority of instances is not expected to be the case.

The FoS provides a direct measure of the degree of stability of the peat slope for the conservative conditions assumed in the model. A FoS of less than unity indicates instability and a FoS of greater than unity indicates stability.

The acceptable safe range for FoS typically ranges from 1.3 to 1.4. A FoS of 1.4 is used in the calculations which would be deemed a conservative approach.

Eurocode 7 (EC7) (IS EN 1997-1:2005) serves as the reference document and the basis for design geotechnical engineering works. The design philosophy used in EC7 applies partial factors to soil parameters, actions and resistances. Unlike the traditional approach, EC7 does not provide a direct measure of stability, since global FoS's are not used.

As such, and in order to provide a direct measure of the level of safety on a site, EC7 partial factors have not been used in this stability assessment. The results are given in terms of global FoS.

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

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

Where,

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

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

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

Where,

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

For the drained analysis the level of the water table above the failure surface is required to calculate the FoS for the slope. Since the water level in blanket peat can be variable and can be recharged by rainfall, it is not feasible to establish its precise location. Therefore, a conservative assumption was adopted in the analysis by assuming the peat is fully saturated i.e. water level at the peat surface.

In addition, the following general assumptions were made in the analysis:

(1) Peat depths are based on the maximum peat depths recorded at each location from the walkover survey.

(2) A lower bound undrained shear strength, c_u for the peat of 6kPa was selected for the assessment based on the c_u values recorded within the peat slide source area. It should be noted that a c_u of 6kPa for the peat is considered a conservative value for the analysis and is not representative of all peat present within the peat slide source area. In reality the peat generally has a higher undrained strength.

(3) Conservative drained shear strength values were used in the analysis based on a review of published data on strength testing of peat.

(4) Slope angles for the stability analysis are based on 5m LIDAR survey data for the peat slide source area supplied by ESB, along with site measurements taken during walkovers undertaken in 2018 and 2019.

(5) Slope angle on base of sliding assumed to be parallel to ground surface.

12.5 Results of Stability Analysis for the 2003 Peat Slide Source area

12.5.1 Undrained Analysis

The results of the undrained stability analysis for the peat slide source area are graphically shown on Drawing 0006.

For the peat slopes the calculated FoS is typically in excess of 1.0 for each location analysed. A summary of the various FoS ranges calculated are presented in Table 12.2 along with their respective percentage of area coverage for the source area.

Table 12.2: Summary of Undrained Slope Stability Analysis Results for Peat Slide Source Area

Factor of Safety (FoS)	% of Peat Slide Source Area
Less than 1.0	0.5
1.0 to 1.3	0.5
1.3 to 1.4	0.5
Greater than 1.4	98.5

From Table 12.2 and in terms of land within the source area, 99.5% of the land area has a FoS greater than 1.0, 98.5% has a FoS greater than 1.4.

As previously outlined, the undrained loading condition applies in the short-term typically following the application of a load and until load induced pore water pressures have dissipated. Given the timeframe since the peat slide occurred, the drained condition would be deemed the most relevant however the undrained condition is included for completeness.

Analysis of the spatial distribution of the areas where the lower FoS values are present shows the following:

(1) Areas with a FoS of less than 1.3 are located around the edges of the source area in locations where possible intact lumps of peat have detached from the in-situ peat in the area or have been deposited following the peat slide event. The intact lumps of peat and deposited peat are likely to have a significantly higher strength than that used in the analysis. Applying higher strengths to these intact lumps of peat in the assessment would likely result in FoS's greater than 1.0 in these areas.

(2) Areas with a low FoS frequently coincide with steeper slopes, typically between 7.5 and 15 degrees. These slope angles are not a reflection of the topography of the source area. The slope angles are based on 5m LIDAR survey data for the area and the steeper slope angles calculated and are likely as a result of localised undulations in the failed debris or vegetation within the peat slide source area, and specifically along the edge of the source area where localised steeper slopes would be expected due to level difference between the peat outside of the source area and the lower peat within the source area. Applying slope angles reflective of site conditions at these locations in the assessment would likely result in FoS's greater than 1.0 in these areas.

(3) In general, the FoS's less than 1.4 generated from the analysis are not unexpected as generalised lower bound peat strength values are used in the analysis, which does not take into account areas of higher strength peat. In reality the peat debris within the peat slide source area has a significantly higher undrained shear strength than that used in the analysis.

(4) >95% of the land area within the source area has a FoS greater than 1.0 indicating the risk of future peat failure/instability within the source area is considered low. Notwithstanding the above should any instability events occur within the peat slide source area; they are likely to be localised in nature given the disparate nature of peat debris and the overall stability of the source area.

12.5.2 Drained Analysis

The results of the drained stability analysis for the peat slide source area are graphically shown on Drawing 0007.

A summary of the various FoS ranges calculated are presented in Table 12.3 along with their respective percentage of area coverage for the peat slide source area.

Table 12.3: Summary of Drained Slope Stability Analysis Results for Peat Slide Source Area

Factor of Safety (FoS)	% of Peat Slide Source Area
Less than 1.0	0
1.0 to 1.3	1
1.3 to 1.4	0
Greater than 1.4	99

From Table 12.3 and in terms of land within the peat slide source area, 100% of the land area has a FoS greater than 1.0 and 99% has a FoS greater than 1.4.

As previously outlined, the drained loading condition applies in the long-term. This condition examines the effect of the change in groundwater level as a result of rainfall on the existing stability of the natural peat slopes within the peat slide source area. Given the timeframe since the peat slide occurred, this condition would be deemed the most relevant.

Analysis of the spatial distribution of the areas where the lower FoS values are present shows the following, which is similar to the undrained results above:

(1) Areas with a FoS of less than 1.3 are located around the edges of the source area in areas where possible intact lumps of peat have detached from the in-situ peat in the area or have been deposited following the peat slide event. The intact lumps of peat and deposited peat are likely to have a significantly higher strength than that used in the analysis. The higher strength of these intact lumps of peat would be as a result of porewater draining from the free-standing lump peat over time so that porewater pressures reach an equilibrium with the surrounding conditions. Applying higher strengths to these intact lumps of peat in the assessment would likely result in FoS's greater than 1.3 in these areas.

(2) Areas with a low FoS frequently coincide with steeper slopes, typically between 7.5 and 15 degrees. These slope angles are not a reflection of the overall topography of the peat slide source area. The slope angles are based on 5m LIDAR survey data for the area and the steeper slope angles calculated are likely as a result of localised undulations in the failed debris or vegetation within the source area and specifically along the edge of the source area where localised steeper slopes would be expected due to level difference between the peat outside of the source area and the lower peat within the source area.

Applying slope angles reflective of site conditions at these locations in the assessment would likely result in FoS's greater than 1.3 in these areas.

(3) In general, the FoS less than 1.4 generated from the analysis is not unexpected as generalised lower bound peat strength values are used in the analysis, which does not take into account areas of higher strength peat. In reality the peat debris within the source area has a significantly higher undrained shear strength than that used in the analysis.

(4) 100% of the land area within the source area has a FoS greater than 1.0 indicating the risk of future peat failure/instability within the source area is considered relatively low. Notwithstanding the above should any instability events occur within the source area; they are likely to be localised in nature given the disparate nature of peat debris and the overall stability of the source area.

12.5.3 Summary

An analysis was carried out to provide an indication of the likely susceptibility of future instability of peat debris in the source area. The analysis showed that using conservative lower bound strength parameters for the peat debris in the source area, the debris has an adequate factor of safety and hence a low risk of future instability. As outlined above the use of conservative strength parameters, and unrealistic (overly steep) slope angles (from the LIDAR survey data) in localised areas of the source area, has contributed to localised low FoS results, specifically around the edge of the source area where localised steeper slopes are present.

Based on the findings of the above stability assessment, the risk of future peat instability within the source area is considered low. Notwithstanding the above should any instability events occur within the peat slide source area; they are likely to be localised in nature given the disparate nature of peat debris and the overall stability of the peat slide source area.

The analytical results above confirm the findings of the of the periodic inspections of the source area have been carried out by ESB, AGEC and FT post the 2003 landslide up to the recent 2019 inspection, which showed that since the time of the peat slide, the debris had essentially drained and was locally desiccated, which would have increased the peat strength and stability In addition, movement monitoring survey points installed within the source area showed negligible movement within this period.

13 PEAT SLIDE VOLUME ASSESSMENT

The 2003 peat slide source area extends from turbine T68 to containment barrage 2 located to the southeast of the head of the peat slide (Drawing 0001). Photos 1 to 6 show the current condition (in 2019) of the peat slide source area.

The peat slide volume was estimated to be about 450,000m^3 (AGEC, 2004). The plan area of the peat slide source area is estimated at 253,000m^2. The source area represents the volumetric extent of peat debris mobilised during the peat slide; the source area still contains a significant volume of debris from the peat slide. The estimated volume of debris currently within the extent of the source area is estimated at 200,000m^3, therefore the volume of material which is estimated to have left the source area is 250,000m^3.

The debris which left the source area was deposited downstream of the source area, namely along the peat slide flow path, carried downstream following the peat slide event or placed into repositories constructed downslope of the peat slide. It should be noted that the volumes quoted above are estimates only.

13.1 Debris Deposition

The remaining debris from the peat slide is located in several locations, notably within the source area and within the peat repositories. The site walkover along the slide's flow path showed no evidence of any peat material deposited along the banks of the streams/river's downslope of the source area, though there is peat debris deposited in private land above the Black Road Bridge.

Based on aerial survey in 2004, the estimated peat deposited in the private land above the Black Road Bridge covered a corridor some 50m wide by 250m long with an estimated average depth of say 0.5m to 0.8m which during the slide event would have varied notably as peat slide debris passed through the area; this gives a volume of about 6,250m^3, and possibly up to 10,000m^3. This peat debris would have degraded over time and would not be readily discernible.

The volume of material stored within the three repositories has been assessed based on survey and ground investigation information. The total peat stored within these repositories is estimated as approximately 20,000m^3.

The total volume of failed material that remains in the source area is estimated as 200,000m^3.

Based on the above this leaves a further 220,000m^3 not contained within the repositories or on land above Black Road Bridge.

13.2 Volume Difference

The difference between the peat slide volume left within the source area and the material stored in the repositories, or deposited on land elsewhere, represents the volume of failed material that was washed downstream along the Owendalulleegh River. Over time, any material deposited along the river banks has been

either eroded by water or has become degraded and re-vegetated and is no longer present or discernible. Some of this material is likely to have been deposited in the bed of Lough Cutra, however, as disturbed peat disintegrates into relatively small, suspended particles, a proportion of this material is likely to have been washed through Lough Cutra to eventually outfall into the Atlantic.

It is noted that material stored within the peat repositories will have become drier over the years since it was placed, and as such will have settled and reduced in volume. The original volume of peat placed into the repositories is therefore highly likely to have been greater than that noted above.

14 STABILITY ASSESSMENT OF ASSOCIATED WORKS

The stability assessment of the associated works related to the 2003 peat slide include the containment barrages and the repository areas, and floating accesses at barrage 1 and 2. Each element is assessed separately below.

14.1 Containment Barrages

14.1.1 Methodology

A stability analysis was carried out for the 4 no. containment barrages constructed following the peat slide in 2003. The purpose of the analysis was to check that there is an adequate safety margin (that is utilisation ratio in accordance with Eurocode 7) for the containment works against global stability should a further movement of debris occur and for retaining of water under flood conditions. 4 no. barrages were assessed (Drawing 0001), namely:

(1) Containment barrage 1 (Coillte Road)

(2) Containment barrage 2

(3) Containment barrage 3

(4) Containment barrage 4

The analysis was carried out based on the assumption that the barrages constructed would be required to retain material/water to their full height. The assessment was carried out for three loading conditions to be retained by the barrage (where relevant), namely;

- Case 1: Retaining remobilised peat (theoretical scenario)
- Case 2: Retaining of silt/sand
- Case 3: Retaining water under flood conditions

Both a short-term (undrained) and long-term (drained) analysis was carried out for the containment barrages.

Temporary access routes to the barrages were generally by trafficking over existing ground by low ground bearing pressure (LGBP) plant. The stability of these temporary accesses does not represent a stability risk.

The stability analysis was carried out using both hand calculations and Talren 5 software which is a slope stability program for soil structures. The assessment was carried out in accordance with Eurocode 7 (EC7).

A summary of the stability analysis results is provided in Table 14.3 with the graphical outputs from the Talren software provided in Appendix C.

14.1.2 Drained Analysis

The parameters for the stability assessment have been derived for the following ground profiles:

(1) Remobilised Peat. This refers to peat within the peat slide source area that has been mobilised as a result of the 2003 peat slide.

(2) Silt/Sand. This refers to silt/sand that has been eroded/mobilised and has slowly migrated downslope to the containment barrages as a result of the slide.

(3) Mineral Soil. This refers to the strata upon which the containment barrages are generally founded albeit barrages 3 and 4 are founded on bedrock.

(4) Rock in Barrage. This refers to the large boulders used to construct the containment barrages. Finer grade stone material was placed at the surface of barrage 1 and the two wind farm roads.

(5) Bedrock. This refers to the bedrock which is typically present beneath the mineral soil.

For the potential failure mechanisms both undrained (short-term) and drained (long-term) analyses were considered. A summary of the material types and strength parameters used in the assessment are given in Table 14.1.

14.1.2.1 Remobilised Peat

The remobilised peat parameters are based on a review of the ground investigation information and published data. The following parameters were used for the remobilised peat in the assessments.

(1) Weight density of peat, $\gamma_p = 10.5 kN/m^3$

(2) Undrained shear strength (c_u). The c_u is estimated as 2kPa. This estimate is based on the worst-case assumption that the peat will have exceeded its liquid limit i.e. having become remobilised or failed.

(3) Drained strength (ϕ' & c'). A drained analysis requires effective friction angle (ϕ') and effective cohesion (c') values for the calculations. These values can be difficult to obtain because of disturbance experienced when sampling peat and the difficulties in interpreting test results due to the excessive strain induced within the peat. To determine suitable drained strength values a review of published information on peat was carried out.

Table 12.1 provides a summary of the published information on peat together with drained strength values. From Table 12.1, remoulded (remobilised) peat value for c' range from 0 to 8kPa and the values for ϕ' range from 31 to 34°. For the stability assessment the following general drained strength values have been used based on a cautious estimate of the value affecting the occurrence of the limit state:

c' = 0kPa

ϕ' = 5 degrees

It is considered that the remoulded values given in Table 12.1 are relatively high, hence lower values are used for the stability analyses to reflect the fact than any remobilised peat will have low drained strength parameters, reflecting the fluid nature of a remobilised peat mass. The remobilised peat strength is not a critical factor for the stability analyses.

14.1.2.2 Silt/Sand

The silt/sand parameters are based on FT's experience, observations during the ground investigation information and site walkover and are chosen taking a cautious approach. The parameters are as follows;

(1) Weight density of remobilised silt/sand, γ_{ss} = 19kN/m^3.

(2) Undrained shear strength of remobilised silt/sand, c_u of 40kPa. The silt/sand was typically described as silty to very silty Sand or very sandy Silt. An undrained strength has been applied to represent the cohesive element of this material and will be used in the undrained assessment.

(3) Effective angle of friction of remobilised silt/sand, ϕ' = 28° is representative of very loose to loose sand deposits (Tomlinson, 2001).

(4) Effective cohesion, c' = 0kPa

14.1.2.3 Mineral Soil

The mineral soil parameters are based on FT's experience, observations during the ground investigation and site walkover and are chosen taking a cautious approach. Mineral soil refers to the strata upon which the containment barrages is generally founded. The parameters are as follows;

(1) Weight density of mineral soil, γ_{ms} = 19kN/m^3.

(2) Undrained shear strength of mineral soil, c_u of 40kPa. The mineral soil was typically described as firm to very stiff sandy gravelly Silt/Clay.

(3) Effective angle of friction of mineral soil, ϕ' = 30°. Based on a relationship from Kenny (1959), for a material with a PI of 15% (which would be typical for this type of material based on FT's experience).

(4) Effective cohesion, c' = 0kPa

14.1.2.4 Rock in Barrage

The rock parameters for the barrage are based on FT's experience, observations from the site walkover and are chosen taking a cautious approach. The parameters are as follows;

(1) Weight density of rock in barrage. The unit weight of the rock in the barrage was estimated to be 22kN/m^3, however due to the voids between the rocks and the size of the rocks used in the

construction of the barrages a reduction factor of 25% was applied to the unit weight, which results in a lowered value of 16.5kN/m^3.

(2) For case 3, assuming the rock in the barrage is buoyant (under flood conditions), it is assumed that the unit weight of the buoyant rock is 6.5kN/m^3 (i.e. 16.5kN/m^3 minus the unit weight of water of 10kN/m^3).

(3) Undrained shear strength of rock in barrage, c_u of 0kPa.

(4) Effective angle of friction of rock in barrage, ϕ' = 45°. Based on site observations, the rock material used in the construction of the barrages is typically standing at an angle of at least 45°.

(5) Effective cohesion, c' = 0kPa.

14.1.2.5 Bedrock

The bedrock parameters are based on FT's experience, observations from the site walkover and are chosen taking a cautious approach. The parameters are as follows;

(1) Weight density of bedrock, γ_r = 22kN/m^3.

(2) Undrained shear strength of bedrock, c_u of 0kPa.

(3) Effective angle of friction of bedrock, ϕ' = 45°.

(4) Effective cohesion, c' = 100kPa.

Conservative parameters have been used in the assessment for the bedrock.

A summary of the material parameters used in the stability assessment are given in Table 14.1.

Table 14.1: Summary of Characteristic Material Parameters for Assessment of Containment Barrages

Material Type	Unit Weight (kN/m^3)	Undrained Strength, c_u (kN/m^2)	Effective Cohesion, c' (kPa)	Effective Angle of Friction, ϕ' (deg)	Notes
Remobilised Peat	10.5	2	1	22	-
Silt/Sand	19	40	0	28	The silt/sand was typically described as silty to very silty Sand or very sandy Silt. An undrained strength has been applied to represent the cohesive element of this material.
Mineral Soil	19	40	0	30	The mineral soil was typically described as firm to very stiff sandy gravelly Silt/Clay.

Material Type	Unit Weight (kN/m^3)	Undrained Strength, c_u (kN/m^2)	Effective Cohesion, c' (kPa)	Effective Angle of Friction, ϕ' (deg)	Notes
Rock in Barrage	16.5 (6.5) [(1)]	0	0	45	Unit weight of the rock boulders in the barrage was estimated to be $22kN/m^3$, however due to the voids in the rock in the barrages a reduction factor of 25% was applied to the unit weight, which results in more realistic lowered value of $16.5kN/m^3$. (1) For case 3, assuming the rock in the barrage is buoyant (under flood conditions), it is assumed that the unit weight of the buoyant rock is $6.5kN/m^3$ (i.e. $16.5kN/m^3$ minus the unit weight of water of $10kN/m^3$).
Bedrock	22	0	100	45	Conservative parameters have been used in the assessment for the bedrock.

14.1.3 Stability Profile Assumptions

Each analysis assumes that the barrages constructed would be required to retain peat, silt/sand or water to its full height should the debris within the peat slide source area become re-mobilised or a flood event occur. The following additional assumptions were made during the analysis:

(1) The geological models for the analyses are based on site observations and recordings during the 2019 FT site walkover and 2018 AGEC ground investigation.

(2) In their current condition the containment barrages are retaining significantly less material than assumed in this stability assessment however a conservative approach was adopted. For completeness the containment barrages were assessed on the basis of retaining peat and/or silt/sand to the full height of the barrage to model a conservative scenario.

(3) Dimensions of each of the barrages vary and are based on data recorded on site, photographs and survey information collected by ESB.

(4) The slopes used in each analysis were estimated using topographical survey information and site readings.

(5) As the barrages are generally founded on mineral soil, this is included in the model and is assumed to be 2m in thickness based on recordings from trial pits. In the case of containment barrages 3 and 4, the barrages are founded on bedrock.

(6) A hydrostatic head is assumed to be at the surface (worst case) of the intact peat, remobilised peat and silt/sand upslope of the barrages. It should be noted that this is a hypothetical situation and is not likely to occur.

(7) In practice, it is considered that water within the remobilised peat and silt/sand would drain through the free draining rock barrage. No hydrostatic head of water was considered at the front face of the barrages, except for case 3 as outlined below. Notwithstanding this, the analysis modelled the likely worst case where water pressure was assumed to act at the total height of the barrage and ignored any passive resistance at the front of the barrage.

(8) Containment barrages 3 and 4 were assessed to retain silt/sand (case 2) since the barrages are located a significant distance downslope of the 2003 peat slide and the movement of remobilised peat to these areas has not occurred to date and is considered highly unlikely.

(9) Containment barrages 3 and 4 were assessed to retain water to the full height of the barrage should a flood event occur, as the barrages were constructed within sections of incised streams. Buoyant conditions were assumed in the assessment for the barrages under flood conditions.

(10) All other containment barrages were assessed using loading conditions case 2 and case 3.

In relation to case 3, net hydrostatic forces were calculated by ESB for containment barrages 3 and 4 (for a 100-year return storm event). These net hydrostatic forces are applied upstream of the barrages in the assessment.

14.1.4 Utilisation Ratio (EC7)

The stability analysis used partial factors from Eurocode 7 (EC7) (BS EN 1997-1:2004) to factor the soil parameters, actions and resistances for the analyses. A summary of the partial factors from EC7 used in the analyses are given in Table 14.2.

Table 14.2: Summary of EC7 Partial Factors for Stability Analyses

Action/Soil Parameter	Design Approach 1	
	Combination 1	Combination 2
Permanent Action (unfavourable)	1.35	1.0
Permanent Action (favourable)	1.0	1.0
Variable Action (unfavourable)	1.5	1.3
Variable Action (favourable)	0	0
Angle of shearing resistance	1.0	1.25
Effective cohesion	1.0	1.25
Undrained shear strength	1.0	1.4
Weight Density	1.0	1.0
Sliding Resistance	1.0	1.0
Earth Resistance – Retaining Structures	1.0	1.0

Stability was assessed using short-term (undrained) and long-term (drained) geotechnical design parameters and an interpreted ground model. Stability was assessed for the criteria in Design Approaches 1 (combination 1 and 2). The most critical situation arises using Design Approach 1 (Combination 2) for global stability and Design Approach 1 (Combination 1 or 2) for the sliding assessment.

The results are presented as a ratio of R_d/E_d, where:

R_d – design value of the resistance to an action
E_d – design value of the effect of an action

As outlined above, the Talren stability analysis was carried out using EC7 partial factors to soil parameters, actions and resistances. Unlike the traditional approach, EC7 does not provide a direct measure of stability, since a global factor of safety is not used.

In accordance with EC7, where the resulting utilisation ratio is greater than unity i.e. 1.0, then satisfactory stability is achieved.

14.1.5 Results of Analysis

A summary of the stability analysis results is provided in Table 14.3.

Table 14.3: Summary of Stability Analysis Results for Containment Barrages

Containment Barrage	Loading Case (note 1, 2)	Utilisation Ratio for Global Stability (note 1, 2)					
		Undrained			Drained		
		Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
Containment barrage 1	1 & 2	4.09	3.20	-	1.67	1.50	-
Containment barrage 2	1 & 2	2.69	2.48	-	1.48	1.35	-
Containment barrage 3	2 & 3	-	3.58	1.86	-	3.83	2.95
Containment barrage 4	2 & 3	-	3.66	1.91	-	3.79	2.59

Notes:

(1) The following load cases are used in the analyses:
Case 1: Retaining remobilised peat (theoretical scenario) – applies to the containment barrages where peat may remobilise from the peat slide source area. Remobilised peat from the peat slide source area is not deemed likely to reach containment barrages 3 and 4, and if it were to mobilise it is most probable that it would be small volumes only.
Case 2: Retaining silt/sand – applies to all containment barrages.
Case 3: Retaining water under flood conditions – applies to containment barrages 3 and 4 only, which were constructed within sections of incised streams. Load from flood water moelled directly to the back of the barrage as a hydrostatic force.

(2) The Utilisation Ratio stated above is for the most conservative design approach, namely Design Approach 1 (Combination 2), in accordance with EC7.

14.1.5.1 Utilisation Ratio for Global Stability

(1) Undrained Results

In the undrained condition, which corresponds to the initial period for which the barrage is retaining remobilised material and for a period afterwards, the utilisation ratio is greater than 1.0 for all cases, therefore satisfactory stability is achieved, see Table 14.3.

The assessment conducted for the barrages shows that the barrages are stable in the undrained condition.

An assessment on the internal stability of the rock barrages is likely to yield lower utilisation ratio results (however still in excess of 1.0 in accordance with EC7) than those reported for the global stability of the barrage. It is deemed highly unlikely that there will be any instability issues regarding the internal stability of the barrage due to the size and nature of the material used in their construction.

The graphical outputs from the Talren software are provided in Appendix C.

(2) Drained Results

In the drained condition, which assesses the long-term stability of the barrages, the utilisation ratio is greater than 1.0 for all cases, therefore satisfactory stability is achieved, see Table 14.3.

The assessment conducted for the barrages shows that the barrages are stable in the drained condition.

An assessment on the internal stability of the rock barrages is likely to yield lower utilisation ratio results (however still in excess of 1.0 in accordance with EC7) than those reported for the global stability of the barrage. It is deemed highly unlikely that there will be any instability issues regarding the internal stability of the barrage due to the size and nature of the material used in their construction.

The graphical outputs from the Talren software are provided in Appendix C.

In conclusion and in accordance with EC7, the assessment conducted shows that all containment barrages have an adequate global stability should a remobilisation or flood event occur where debris or water is required to be retained to the full height of the barrage. Inspection of the barrages also clearly confirms that the barrages are in stable condition.

14.2 Repository Areas

The assessment of the repository areas included a stability assessment using infinite slope analysis and an observational approach. The assessments and results for each are given below.

A summary of the repository areas is given in Table 14.4. Plan and cross section drawings of the repositories are shown on Drawings 0004 and 0005.

Table 14.4: Summary of Repository Areas

Repository Area	Founding Stratum (1)	Thickness of Placed Arisings
Repository Area at Containment Barrage 2	Peat	0.6 to 1.9m (2m used in assessment)
Repository Area at Containment Barrage 3	Mineral Soil	1 to 1.6m (2m assumed in assessment)
Repository Area at Black Road Bridge	Peat	0.7 to 2m (2m assumed in assessment)

Notes

(1) The founding stratum for each repository area refers to the ground conditions upon which the arisings were placed.
(2) The thickness of the placed arisings in the repository areas is based on an interpretation of the ground investigation carried out by AGEC in 2018.

14.2.1 Methodology for Stability Assessment

A stability assessment of the placed arisings within the repository areas was carried out using an infinite slope model (Skempton and DeLory, 1957). The purpose of the assessment was to assess the stability of the placed arisings on the slopes present within the repository areas and to determine the factor of safety (FoS) for sliding. The assessment was carried out for both the undrained (short-term) and drained (long-term) conditions.

(1) The undrained loading condition applies in the short-term typically following the application of a load and until load induced pore water pressures have dissipated. The undrained condition uses undrained strength parameters in the assessment. Given the timeframe since the placement of the arisings in the repository (in excess of 15 years), the drained condition would be deemed the most relevant however the undrained condition is included for completeness.

(2) The drained loading condition applies in the long-term following partial or full dissipation of excess pore water pressure from the peat/mineral soil over time. In the drained condition the pore water pressure (groundwater level) is in equilibrium with in-situ conditions which can vary with seasonal changes. As a worst case and for the purpose of the assessment the groundwater level is assumed to be at the surface of the in-situ peat/mineral soil, to reflect an extreme rainfall event. The drained condition uses effective strength parameters in the assessment.

As stated above, given the timeframe since the placement of the arisings in the repository areas (in excess of 15 years), the drained condition would be deemed the most relevant however the undrained condition is included for completeness.

14.2.2 Analysis to Determine Factor of Safety

The purpose of the assessment was to assess the stability of the placed arisings on the slopes present within the repository areas and to determine the factor of safety for sliding.

The FoS provides a direct measure of the degree of stability of a slope for the conservative conditions assumed in the model. A FoS of less than unity indicates that a slope is unstable, an FoS of greater than unity indicates a stable slope.

The acceptable safe range for FoS typically ranges from 1.3 to 1.4. A FoS of 1.4 is used in the calculations which would be deemed a conservative approach.

Eurocode 7 (EC7) (IS EN 1997-1:2005) serves as the reference document and the basis for design geotechnical engineering works. The design philosophy used in EC7 applies partial factors to soil parameters, actions and resistances. Unlike the traditional approach, EC7 does not provide a direct measure of stability, since global FoS's are not used.

As such, and in order to provide a direct measure of the level of safety on a site, EC7 partial factors have not been used in this stability assessment. The results are given in terms of FoS.

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

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

Where,

F = Factor of Safety (FoS)
c_u = Undrained strength
γ = Bulk unit weight of material (including any applied loading)
z = Depth to failure plane assumed as depth of peat
α = Slope angle

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

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

Where,

F = Factor of Safety (FoS)
c' = Effective cohesion
γ = Bulk unit weight of material
z = Depth to failure plane
γ_w = Unit weight of water
h_w = Height of water table
α = Slope angle
ϕ' = Effective friction angle

The following assumptions are used in the assessment.

(1) The placed arisings in the repository areas comprises peat and non-peat spoil.

(2) Assuming an applied loading equivalent to fill depth of 2m of placed arisings i.e. 38kPa (maximum thickness of placed arisings recorded in the repository with a bulk unit weight of 19kN/m^3). For the purpose of this assessment it is assumed that the placed arisings comprise non-peat spoil – conservative assumption.

(3) Slope inclination in the assessment are based on site observations.

(4) Undrained shear strengths for the peat and mineral soil are based on the ground investigation carried out by AGEC (2018) and site observations from the 2019 walkover. In reality the founding strata have significantly higher undrained shear strengths than those used in the assessment.

(5) Founding strata thicknesses of peat and mineral soil are based on the ground investigation carried out by AGEC (2018) and site observations from the 2019 walkover.

(6) A bulk unit weight for peat of 10.5kN/m^3 and for mineral soil of 19kN/m^3 is used in the assessment.

(7) Conservative drained shear strength values were used in the analysis based on a review of published data on strength testing of peat, see Table 12.1. Conservative drained shear strength values for the mineral soil were used in the assessment.

(8) For the drained analysis the level of the water table is assumed to be at the surface of the in-situ ground.

(9) It should be noted that the perimeter of the repository areas is either partially or fully bunded which provides additional stability to the repository areas. This has not been taken into account in the assessment. This is a conservative approach.

14.2.3 Results of Stability Assessment

The calculated FoS's for the assessment of the stability of the placed arisings on the slopes present within the repository areas for both the undrained and drained condition were in excess of 1.4 with FoS's ranging from 2.9 to in excess of 5.0.

In addition to the above, the perimeter of the repository areas is either partially or fully bunded which provides additional stability to the repository areas. This has not been taken into account in the assessment which is a conservative approach.

The calculated FoS's show adequate stability for the placed arisings and indicate a low risk of instability within the repository areas. The calculations are included within Appendix D.

14.2.4 Methodology for Observational Approach

In addition to the Factor of Safety approach, an observational approach was adopted for assessing the behaviour and stability of the 3 no. repository areas. The observational method is not a predefined design approach/check. The observational method is a continuous, managed monitoring and review approach which requires periodic visual inspections of the repositories. The purpose of the observational approach is to ensure the continued stability of the repository areas.

A total of 3 no. repository areas were constructed south of Derrybrien wind farm (Drawing 0001) which include:

(1) Repository area adjacent to containment barrage 2 – see Drawing 0005

(2) Repository area adjacent to containment barrage 3 – see Drawing 0005

(3) Repository area at the Black Road Bridge – see Drawing 0004

Stabilisation and containment works were carried out following the 2003 peat slide to prevent further propagation of the peat slide and to prevent possible further release of debris into the watercourse downstream. A volume of debris accumulated in the areas of containment barrages 2 and 3. As part of the remedial and clearance works, debris was removed from these areas and placed in adjacent repositories.

The repository area adjacent to containment barrage 2 comprises 2 no. separate storage areas, see Drawing 0005. The northern repository has no bund whilst the southern repository has a bund around the stored arisings. The total plan area of the repositories is approximately 1,980m^2. The repository areas contain peat, silt and sand which were removed from behind the barrage up to the end of 2007 following the peat slide.

The repository area adjacent to barrage 3 has a plan area of approximately 600m^2, see Drawing 0005. The repository is partially cut into a slope adjacent to the barrage with a bund placed at the lower slope and partially along the upper slope. The repository area contains silt and sand which were removed from the area following the peat slide.

The repository area at the Black Road Bridge was also constructed following the peat slide event in 2003. During the peat slide, debris passed down the valley and into an area of open flatter ground where debris lost momentum and was deposited. A repository area was located in an area upstream of the Black Road Bridge to contain material displaced from the peat slide area.

The repository areas at the Black Road Bridge essentially contain stored peat, together with some soil/rock debris from the peat slide and were placed up to about 2m high. The repository areas comprise 2 no. separate repository areas, see Drawing 0004. Both repository areas are heavily vegetated and are partially bunded. The total plan area of the repositories is approximately 11,900m^2. The repository areas contain predominantly peat with some non-peat debris.

A ground investigation was carried out at the repository areas by AGEC in 2018. The findings of the investigation are presented in Section 10 of this report.

As outlined above a monitoring system was established following the construction of the repositories. The monitoring system involved periodic visual inspections of the repositories by ESB and less regular inspections by AGEC and FT.

The visual inspections were carried out to identify the condition of the stored materials, evidence of adverse porewater pressures/surface water, stability of the retaining bunds and stored material and the stability of the repository area as a whole.

14.2.5 Results of Observational Approach

The observational approach involved periodic inspections of the repositories by ESB and less regular inspections by AGEC. Periodic visual inspections of the repositories were undertaken by ESB from 2004 to 2017. Visual inspections of the repositories were undertaken by AGEC in 2005, 2011 and 2018 and FT in 2019. No significant issues regarding the stability of the repositories were raised in the periodic inspections carried out by ESB. Likewise, no significant issues regarding the stability of the repositories were raised in the inspections carried out by AGEC or FT.

The critical time for stability of the repository areas would have been shortly after initial placement when the peat/debris was at its weakest with a possible degree of entrapped water within the peat/debris. Since that time the stability of the repository areas would have increased as a result of consolidation and the possible draining of entrapped water from the peat/debris. The repository areas have become re-vegetated and walking across the stored peat/spoil indicates that the placed material was generally firm underfoot.

Given the time frame which has lapsed (in excess of 15 years) since the placement of arisings in these repository areas and the subsequent increase in strength expected for the underlying founding strata as a result of the applied loading (placed arisings), the repository areas are deemed to have adequate stability.

Based on the findings of the AGEC and FT visual inspections and the ground investigation carried out, the repositories are deemed stable and it is anticipated that the repository areas will be stable in the long-term.

14.3 Floating Access Tracks at Barrage 1 and 2

The access track to the west of barrage 1 was constructed as a floating track on peat. The average slope angle along the track is 2 to 3 degrees. The floating access track is estimated to be placed on peat about 0 to 1.4 m depth based on nearest available data.

As part of the construction of barrage 2, a floated access track was constructed from the existing Coillte forestry track to the site of barrage 2. The floating access track is 300m in length and was constructed on peat. Average slope angle along the track is 3 to 4 degrees. The floating access track is estimated to be placed on peat up to about 1.5 m depth based on nearest available data. The loading, slopes and peat depths, and therefore FoS would be similar to that of the peat repository immediately adjacent to it.

Visual inspections were carried out to identify the condition of the floating tracks, evidence of adverse track deformation, stability of the adjoining peat and general stability of the floating tracks as a whole.

The critical time for stability of the floating tracks would have been shortly after initial construction. Since that time the stability of the track would have increased as a result of consolidation of the underlying peat. Given

the time frame which has lapsed (in excess of 15 years) since the construction of the roads and the subsequent increase in strength expected for the underlying founding peat as a result of the applied loading, the roads are deemed to have adequate stability.

The FT visual inspection of the floating roads identified no signs of adverse conditions.

Based on the findings of the FT visual inspection, consideration of the peat depths and slopes angles, and considering the nature of the peat under the floating roads, it is considered that the roads are stable and it is anticipated that the roads will be stable in the long-term.

14.4 Summary

A stability assessment of the barrages, repositories and associated works was carried out for various loading conditions in accordance with the relevant standards (EC7) to check the global stability of the barrages (listed above) for both the undrained (short-term) and drained (long-term) condition.

In relation to the global stability calculations, the assessment conducted showed that all barrages have an adequate margin of safety (utilisation ratio) should a remobilisation or flood event occur where debris or water is required to be retained to the full height of the barrage(s).

In addition, it should be noted that periodic inspections of the barrages, repositories and associated works were undertaken by ESB from 2004 to 2017. No significant issues regarding the stability of the containment barrages were raised in the periodic inspections. Likewise, no significant issues regarding the stability of the containment barrages were raised in the inspections carried out by AGEC or FT.

Based on the above assessment and the inspections carried out by ESB, AGEC and FT, the containment barrages are stable in their current condition and anticipated to be stable in the long-term.

In relation to the 3 no. repository areas, a stability assessment using infinite slope analysis and an observational approach which involved periodic inspections of the repositories was undertaken. The calculated FoS's from the stability assessment show adequate stability for the placed arisings and indicate a low risk of instability within the repository areas. The observational approach which involved periodic inspections of the repositories from 2004 to 2018 was undertaken by ESB and AGEC. No significant issues regarding the stability of the repositories were raised in the periodic inspections.

Based on the findings of the above assessments and given the time frame which has lapsed (in excess of 15 years) since the placement of arisings in these repository areas, the repository areas are deemed stable and it is anticipated that the repository areas will be stable in the long-term.

With respect to the floating access tracks, based on the findings of the FT visual inspection and considering the nature of the peat under the floating roads, it is considered that the roads are stable and it is anticipated that the roads will be stable in the long-term.

15 DECOMMISSIONING OF PEAT SLIDE ASSOCIATED WORKS

15.1 Decommissioning Works

A review of the methodology and implications for the decommissioning of the peat slide associated works was carried out. The source area itself is considered to be stable in its current condition.

Drawing 0001 shows the location of these works. The works are also shown in Photos 7 to 13 of Appendix A.

The stabilisation and containment works include:

- Containment barrage 1 (Coillte road)
- Containment barrage 2 and associated repository area
- Containment barrage 3 and associated repository area
- Containment barrage 4

The barrages were strategically placed along the flow path or potential flow path of the peat slide to mitigate against further propagation of the peats slide and to mitigate possible further release of debris into any watercourses downstream.

The access tracks at T68 and between T23 and T70 form part of the wind farm infrastructure on site, in addition to acting as stabilisation and containment barrages for the upper section of the peat slide. It is not proposed to decommission these tracks.

It is noted that the current proposal is to only remove barrages 3 and 4 following the End of Operation of the Wind Farm. It is not proposed to decommission any of the repositories.

Consultation and agreement with statutory bodies and relevant landowners should be carried out in advance of any decommissioning works. The designated location for the storage of any removed material should be finalised and agreed prior to commencing works.

15.2 Decommissioning of Barrages

The following general construction sequence is given for the removal of the barrages:

Preparatory work

(1) For each of the barrages to be decommissioned, works shall be undertaken after at least 4-5 days of dry weather and during a period when further dry weather is expected, preferably in late spring / early summer to allow for vegetation growth on the banks ahead of the next winter. The works at each barrage are expected to last no more than one week.

(2) In-stream works shall be carried out in accordance with the "Guidelines on Protection of Fisheries during Construction Works in and adjacent to Waters". Contact shall be made with Inland Fisheries Ireland prior to works commencing including agreement of methodology.

(3) Each watercourse shall be blocked upstream of the works area using sand bags and a timber weir and the remaining water shall be over-pumped. The pump will be bunded and located away from the watercourse and a have a silt bag on its outlet. A tight mesh will be fitted on the suction hose before pumping commences. Water will be discharged to vegetation, preferably on the downstream side of the barrage.

(4) As any vehicular access to Barrages 3 and 4 from the nearest roads will be over very soft peatland, bog mats shall be used where required for at least the final approach to the barrages.

(5) Inspection of access routes from the public road to the west of the barrages shows thin peat cover. The proposed access to Barrage 4 has peat thickness of typically 0.1 to 0.5m. This would not represent a stability issue, though suitable plant would be required to track across this ground.

(6) The presence of overhead lines close to the location of Barrage 3 will need to be considered when vehicles are accessing and removing the barrages.

(7) Any retained debris up against the barrage on the upstream side should be removed prior to removal works commencing on the actual barrage. The debris should be removed for a distance of 3 – 5m upstream of the upslope toe of the barrage.

(8) For removing the retained debris from upstream side of the barrage, for Barrages 3 and 4 the excavator may need to access and position itself on the upstream side of the barrage. However, if feasible it is preferable that a long-reach excavator remove debris from a distance outside the banks of the watercourse so as to avoid the risk of unnecessary destabilisation of the banks.

(9) The debris upslope of the barrage should be trimmed to a stable configuration so the debris is stable following the removal of the barrage. A stable configuration will vary depending on the type of debris. The debris is likely to comprise peat, clay/silt and sand and possibly fragments of rock. The following guidance on slope configuration is given for the anticipated types of debris:

a. Peat – 1 (v): 3 – 5 (h) depending on ground conditions encountered

b. Clay/Silt/Sand – 1 (v): 2 (h)

Barrage Removal Work

(1) Excavation should commence at the top of one end of the barrage and progress over its full width in one direction laterally before moving to the next 'layer' below.

(2) Low ground pressure tracked dumpers should be reversed up to and positioned behind the excavator for filling. Appropriate measures such as bog mats shall be in place to manage the accumulation of silt arising from the movement of plant. A rigid-body self-loading lorry will be positioned at the access point to the barrages on the public road. From here the dumper contents shall be loaded into the lorry for removal to the designated disposal location.

(3) The barrages are constructed of highly permeable material that allow the passage of water but prevent the passage of peat/landslip debris. Material to be removed from the barrages are likely to comprise well-graded coarse rocks/boulders from about 300mm up to typically 1,200mm.

(4) Where fine-packing material is situated between the boulders, this shall be removed with care prior to the heavier armoured elements (if possible)

(5) Excavation works should continue to the base layer of the barrage over the full width of the watercourse profile. The base layer should be left in place, particularly outside the banks of the river, until potential erosion arising from their removal is assessed by an engineer on site.

(6) Where an existing watercourse profile/channel passes through the location of the barrage it should be ensured that the natural profile of the watercourse and neighbouring banks are preserved by matching the reclaimed channel section as closely as possible with the upstream and downstream channel sections.

(7) Temporary stockpiling of rock upon removal from Barrages 3 and 4 will be required due to access restrictions in these areas. The rock should be stockpiled adjacent to the barrage in an accessible location for loading and transporting to a designated location for storage.

(8) All material (either debris from the landslip or rock from the barrage) requiring removal from the barrages should be loaded separately for transporting to the designated storage locations.

Post-Removal

(1) Boulders removed from the barrages can be placed at their natural angle of repose (circa 40 to 60 degrees) within designated storage locations. The manner in which material is placed within the storage area will depend on site conditions at these locations.

(2) Debris removed from the barrages will likely require a retainment bund solution to prevent debris run-off and to ensure stability of the stored material within the designated storage areas. The retainment bund could be formed from the rock removed from the barrages or an alternative suitable material.

(3) Upon completion of these decommissioning works, the weir and sand bags will be removed slowly to prevent a surge in the river. Silt fences shall be installed on the stream-side of the banks and the other side spread with grass-seed to encourage re-vegetation.

15.3 Summary of Main Geotechnical Implications

The removal of the containment barrages will have a number of geotechnical implications including:

- Generation of spoil (rock fill from the containment barrages) which will require storage.
- Identification of suitable storage solutions for the removed spoil.
- Potential additional loading on peat slopes as a result of decommissioning plant/traffic accessing the area.
- Instability of peat and non-peat debris upslope of the barrages (following the removal of the barrages).

- Potential for erosion and remobilisation of peat and non-peat debris upslope of the barrages where present.

15.4 Individual Considerations

Individual considerations for each of the containment barrages are given below.

Drawing 0008 shows potential access routes to remove the containment barrages from the local/public road (Black Road). Access routes from the barrages to the potential designated storage locations are also shown on Drawing 0008.

15.4.1 Containment Barrage 3

Containment Barrage 3 is currently stable, and the barrage is unlikely to require any intervention to maintain this stability should the barrage be left in place

However, should decommissioning of the barrage be considered, material removed from Barrage 3 could be placed/stored in an existing borrow pit alongside the main site entrance to the wind farm site, see Drawing 0008. The travel distance for removal of materials from the barrage to the proposed designated storage area is approximately 7.5km. Material would likely have to be double handled, firstly to move the barrage material north to the existing local road, where it would be transferred onto road trucks which would then be used to transport the material to the existing borrow pit.

The access route to the barrage from the local road has minimal peat and therefore stability of peat associated with the works is not deemed to be of consequence however a temporary access (such as bog mats) may be required to access the barrage site, which would need to be removed following the works.

Estimated volume of rock from the barrage is possibly up to 425m^3. This estimated rock volume uses an average barrage width in the calculations and includes a 10% bulking and 10% contingency factor. Based on this volume the estimated number of traffic/lorry movements is 43 (one direction, assuming 10m^3 is transported per lorry movement). Note this excludes the volume of debris to be removed adjacent to the barrage.

Given the volume of material to be removed from barrage 3 and the associated truck movements, the removal of material to the designated storage area is deemed feasible, if required.

15.4.2 Containment Barrage 4

Containment Barrage 4 is currently stable, and the barrage is unlikely to require any intervention to maintain this stability should the barrage be left in place

However, should decommissioning of the barrage be considered, similar to Containment Barrage 3, material removed from Barrage 4 could also be placed/stored in an existing borrow pit alongside the main site entrance to the wind farm site, see Drawing 0008. The travel distance for removal of materials from the barrage to the proposed designated storage area is approximately 7.8km. Material would likely have to be double handled, firstly to move the barrage material north to the existing local road, where it would be transferred onto road

trucks which would then be used to transport the material to the existing borrow pit. Alternatively, a new temporary access track would have to be constructed from the local road to the barrage to allow for road trucks to be loaded directly at the barrage location. The temporary access to the barrage site would need to be removed following the works.

Estimated volume of rock from the barrage is 365m^3. This estimated rock volume uses an average barrage width in the calculations and includes a 10% bulking and 10% contingency factor. Based on this volume the estimated number of traffic/lorry movements is 37 (one direction, assuming 10m^3 is transported per lorry movement). Note this excludes the volume of debris to be removed adjacent to the barrage.

Given the relatively small volume of material to be removed from Barrage 4 and the associated truck movements, the removal of material to the designated storage area is deemed feasible, if required.

The access route to the barrage is on minimal peat thickness and therefore stability of peat associated with the works is not deemed to be of consequence however a temporary access may be required to access the barrage site, which would need to be removed following the works.

15.5 Summary

It is not anticipated that the decommissioning works associated with Barrage 3 and Barrage 4 will have an impact on the stability of the site. Whilst it is not anticipated that a further peat slide or remobilisation event of the debris within the peat slide source area will occur, it would be considered prudent to leave the upstream containment barrages.

It is considered that decommissioning (removal) of the repositories would have a greater environmental and. geotechnical implications than leaving them in place, such as the generation of a significant amount of spoil, identifying suitable storage solutions for the removed spoil, potential additional loading to peat slopes as a result of decommissioning plant/traffic, erosion of peat slopes and change to surface water flow regimes.

16 CONCLUSIONS

The following conclusions are given.

(1) FT was engaged by ESB to undertake a geotechnical assessment of the 2003 peat slide and associated works at the Derrybrien wind farm. This assessment includes the peat slide source area, peat slide debris, containment barrages, repositories, accesses and related works.

(2) The associated works related to the 2003 peat slide included in this report are:

a) 2003 peat slide source area and peat debris

b) Stabilisation and containment works associated with the peat slide which include the following barrages and associated repositories;

- Containment barrage 1 and replaced access track
- Containment barrage 2 and repository area
- Containment barrage 3 and repository area
- Containment barrage 4
- Containment barrages (referred to as A, B, C and D)
- Borrow pit adjacent to Containment barrage 2 (Coillte borrow pit)

c) Repository area at the Black Road Bridge

(3) Ground conditions in the area are typically blanket peat overlying glacial till or subsoil overlying weathered to intact bedrock. The bedrock comprises siltstones, mudstones, sandstones and conglomerate. The till is typically derived from sandstone deposits.

(4) A ground investigation was carried out by AGEC in 2018 for a number of the associated works related to the 2003 peat slide and comprised peat depth probes, hand shear vanes, Mackintosh probes and trial pits. Based on ground investigation and site observation findings, the containment barrages are shown to be founded on competent stratum. Approximate volumes of material retained upslope of the containment barrages and within the adjacent repository areas were calculated.

(5) Based on a review of the ESB monitoring data & periodic inspection reports carried out post the 2003 peat slide, the following was concluded;

a) In relation to the monitoring points installed within the peat slide source area, the monitoring points show negligible movement. The minimal ground movement recorded is likely attributed to both the natural wetting/drying of the peat with seasonal changes and the accuracy of the GPS survey equipment used in the monitoring. No readings were noted that could be attributable to adverse peat movement.

b) In relation to the inspections completed between 2006 and 2017 by ESB, which includes some of the peat slide associated works, the reports contain findings and recommendations to ensure the continued stability of the works. No significant stability issues were identified, the reports essentially highlight maintenance of associated works related to the 2003 peat slide.

(6) Numerous walkover inspections were carried out by AGEC and FT from 2003 to 2019 to assess the condition and ensure the continued stability of the various associated works related to the 2003 peat

slide. These inspections were carried out by engineering staff with particular experience of peat instability and large-scale failures. The main findings of the 2019 walkover inspection carried out by FT are as follows:

a) In relation to the 2003 peat slide source area, no signs of recent instability or remobilisation events within the source area were noted. Since the time of the peat slide, the stability of the debris within the source area has not deteriorated and conditions have likely reached a steady state.

b) Based on a visual inspection, the containment barrages appear stable. No recent peat movement or accumulation of debris upslope of the barrages was identified which indicates that conditions have likely reached a steady state. It is anticipated that the containment barrages will be stable in the long-term.

c) Based on a visual inspection, the repository areas appear stable. The areas have become revegetated, are firm underfoot and no signs of distress were noted. It is anticipated that the repository areas will be stable in the long-term.

(7) A stability assessment of the peat debris within the peat slide source area was carried out for both the undrained and drained condition.

a) The purpose of the assessment was to provide an indication of the likely risk of slope failure.

b) The analysis showed that using conservative strength parameters for the peat debris in the source area the peat debris/slopes generally had an adequate factor of safety.

c) Based on the findings of the stability assessment, the risk of future peat instability within the source area is considered low. Notwithstanding the above should any instability events occur within the source area; they are likely to be localised in nature given the overall stability of the peat slide source area.

d) In addition, it should be noted that periodic inspections of the peat slide source area have been carried out by ESB and AGEC post the 2003 peat slide up to the recent 2019 inspection by FT, which showed that since the time of the peat slide, the stability of the debris within the source area has not deteriorated and conditions have likely reached a steady state.

(8) As part of the 2019 walkover, the route of the stream from the Black Road Bridge to the confluence with the Owendalulleegh River, and downstream to Lough Cutra was examined. The banks of the stream and the river were viewed in order to determine if any peat debris remained from the 2003 peat slide. There was no clear visual evidence of any remaining substantive peat debris thickness along the line of the peat slide debris, as such it is considered that there is no stability risk.

(9) A stability assessment of the associated works related to the 2003 peat slide was carried out for various loading conditions in accordance with the relevant standards (EC7) to check stability of the barrages (listed above) for both the undrained and drained condition.

a) The loading conditions included retaining of remobilised peat, silt/sand and water under a flood event. Conservative assumptions and material parameters were used in the assessment.

b) The analyses modelled a hypothetical situation where water pressure was assumed to act at the total height of the barrage and ignored any passive pressure at the front of the barrage.

c) In relation to the sliding resistance calculations, the assessment conducted showed that barrages 3 and 4 have an adequate sliding resistance should flood event occur where debris or water is required to be retained to the full height of the barrage.

d) In relation to the global stability assessment, the assessment conducted showed that all barrages have an adequate global stability should a remobilisation or flood event occur where debris or water is required to be retained to the full height of the barrage.

e) Based on the assessment (outlined above) and the inspections carried out by both ESB, AGEC and FT, the containment barrages are stable in their current condition and anticipated to be stable in the long-term.

f) Temporary barrages A, B, C and D were removed/washed away following the peat slide event and no evidence of the barrages was identified from the site walkover.

(10) A stability analysis and observational approach was adopted for assessing the behaviour and stability of the 3 no. repository areas at barrages 2, 3 and at the Black Road Bridge.

a) The purpose of the stability assessment was to assess the stability of the placed arisings on the slopes present within the repository areas and to determine the FoS for sliding.

b) The calculated FoS's from the stability assessment show adequate stability for the placed arisings and indicate a low risk of instability within the repository areas.

c) The purpose of the observational approach is to monitor and to ensure the continued stability of the repository areas.

d) Periodic visual inspections of the repositories were undertaken by ESB between 2004 and 2017. No significant issues regarding the stability of the repositories were raised in the ESB periodic inspections. Likewise, no significant issues regarding the stability of the repositories were raised in the inspections carried out by AGEC and FT.

e) Based on the findings of the above assessments and given the time which has lapsed (in excess of 15 years) since the placement of arisings in these repository areas, the repository areas are deemed stable and it is anticipated that the repository areas will be stable in the long-term.

(11) Visual inspection of the floating roads at barrages 1 and 2 identified no signs of adverse conditions. Based on the findings of the visual inspection and considering the nature of the peat under the floating roads, it is considered that the roads are stable and it is anticipated that the roads will be stable in the long-term.

(12) Whilst it is not anticipated that a further peat slide or remobilisation event of the debris within the peat slide source area will occur, it would be considered prudent to leave the upstream containment barrages and repositories in place. The decommissioning of these works would have a number of environmental and geotechnical implications, such as the generation of a significant amount of spoil, identifying suitable storage solutions for the removed spoil, potential additional loading to peat slopes as a result of decommissioning plant/traffic, erosion of peat slopes and change to surface water flow regimes.

17 REFERENCES

Applied Ground Engineering Consultants (AGEC) 2004. Final Report on Derrybrien Wind Farm Post-Landslide Site Appraisal. February 2004.

Bromhead, E. N. (1986). The Stability of Slopes.

Carling, P. A. (1986). Peat slides in Teesdale and Weardale, northern Pennines, July 1983: Description and failure mechanisms. Earth Surface Processes and Landforms, 11.

Den Haan, E. J. and Grognet, M. (2014). A large direct simple shear device for the testing of peat at low stresses. Géotechnique Letters 4(4): 283–288, http://dx.doi.org/10.1680/geolett. 14.00033.

Dykes, A. P. (2008) Geomorphological maps of Irish peat landslides created using hand-held GPS, Journal of Maps, 4:1, 258-276, DOI: 10.4113/jom.2008.1029.

Dykes, A. P. and Kirk, K. J. (2006). Slope instability and mass movements in peat deposits. In Martini, I.P., Martinez Cortizas, A. and Chesworth, W. (Eds.) Peatlands: Evolution and Records of Environmental and Climatic Changes. Elsevier, Amsterdam.

EPA (2017). Guidelines on the Information to be Contained in Environmental Impact Assessment Reports (Draft).

ESB (2006). Derrybrien Wind Farm, Co. Galway. Operation & Maintenance Provisions for Long Term Site Stability. Report no. P78015-R476-001. Dated 2nd February 2006.

Inis Environmental Services (2004). Derrybrien Windfarm Peat Slip - Environmental Impact Assessment on the Owendalluleegh River. March 2004

NSAI (2013). I.S. EN 1997-1:2004+A1:2013 - Eurocode 7: Geotechnical design - Part 1: General rules.

Farrell, E.R. & Hebib, S. (1998). The determination of the geotechnical parameters of organic soils. Proceedings of International Symposium on problematic soils, IS-TOHOKU 98, Sendai, Japan.

Fehily Timoney & Company (FT) (2020). Geotechnical Stability Report 3 – Derrybrien Wind Farm Grid Connection and Ancillary Works

Geological Survey of Ireland (2003). Geology of Galway Bay. Sheet 14.

Geological Survey of Ireland (2019). Online dataset public viewer October 2019: http://spatial. dcenr.gov.ie/imf/imf.jsp?site=GSI_Simple.

Hanrahan, E. T., Dunne, J. M. and Sodha, V. G. (1967). Shear strength of peat. Proc. Geot. Conf., Oslo, Vol. 1.

Hendry, M. T., Sharma, J. S., Martin, C .D. and Barbour, S. L. (2012). Effect of fibre content and structure on anisotropic elastic stiffness and shear strength of peat. Canadian Geotechnical Journal 49(4): 403–415, http://dx.doi.org/10.1139/t2012-003.

Hobbs, N. B. (1986). Mire morphology and the properties and behaviour of some British and foreign peats. Quarterly Journal of Engineering Geology, London, 1986, vol. 19, pp. 7-80.

Hungr, O. and Evans, S. G. (1985). An example of a peat flow near Prince Rupert, British Columbia. Canadian Geotechnical Journal, 22.

Kenney, K. C. (1959). Discussion: Journal of the Soil Mechanics and Foundation Engineering Division, ASCE, v.85:SM3, p. 67-79.

Komatsu, J., Oikawa, H., Tsushima, M. and Igarashi, M. (2011). Ring shear test on peat. In Proceedings of the 21st International Offshore and Polar Engineering Conference, Maui, Hawaii, USA (Chung JS, Hong SY, Langen I and Prinsenberg SJ (eds)). International Society of Offshore and Polar Engineers, Cupertino, CA, USA, vol. 2, pp. 393–396.

Landva, A. O. (1980). Vane testing in peat. Canadian Geotechnical Journal, 17(1).

Malone O'Regan McGillicuddy (2002). Derrybrien Windfarm - Site Survey. Drawing No. 20206-01 at 1:5000 scale.

McGeever J. and Farrell E. (1988). The shear strength of an organic silt. Proc. 2nd Baltic Conf., 1, Tallin USSR.

Mitchell, G. F. (1935). On a Recent Bog-Flow in County Clare. Sci. Proc. R. Dubl. Soc. 21, pp. 247-52.

O'Kelly, B. C .and Zhang, L. (2013). Consolidated-drained triaxial compression testing of peat. Geotechnical Testing Journal 36(3): 310–321, http://dx.doi.org/10.1520/ GTJ20120053.

Pentland, A. T. (1890). Report to the Board of Public Works. 24 November 1890.

Rowe, R. K. & Mylleville, B .L. J. (1996). A geogrid reinforced embankment on peat over organic silt; a case history. Can. Geotech. J. 33 (1), 106 – 122.

Rowe, R. K., MacLean, M. D., Soderman, K. L. (1984). Analysis of a geotextile reinforced embankment constructed on peat. Can. Geotech. J. 21 (3), 563 – 576.

Skempton, A. W. and DeLory, F. A. (1957). Stability of natural slopes in London Clay. Proc 4th Int. Conf. On Soil Mechanics and Foundation Engineering, Rotterdam, vol. 2, pp.72-78.

Terzaghi, K., Peck, R. B. & Mesri, G. (1996). Soil Mechanics in Engineering Practice. Third Edition (1996).

Tomlinson, M. J. (1995) 'Foundation Design and Construction'. 6th edition, Longman Scientific and Technical, 1995.

Warburton, J., Higgett, D. and Mills, A. (2003). Anatomy of a Pennine Peat Slide. Earth Surface Processes and Landforms.

Warburton, J., Holden, J. and Mills, A. J. (2003). Hydrological controls of surficial mass movements in peat. Earth-Science Reviews 67 (2004), pp. 139-156.

Zwanenburg, C., Den Haan, E .J., Kruse, G. A. M. and Koelewijn, A.R. (2012). Failure of a trial embankment on peat in Booneschans, the Netherlands. Géotechnique 62(6): 479–490.

FIGURES

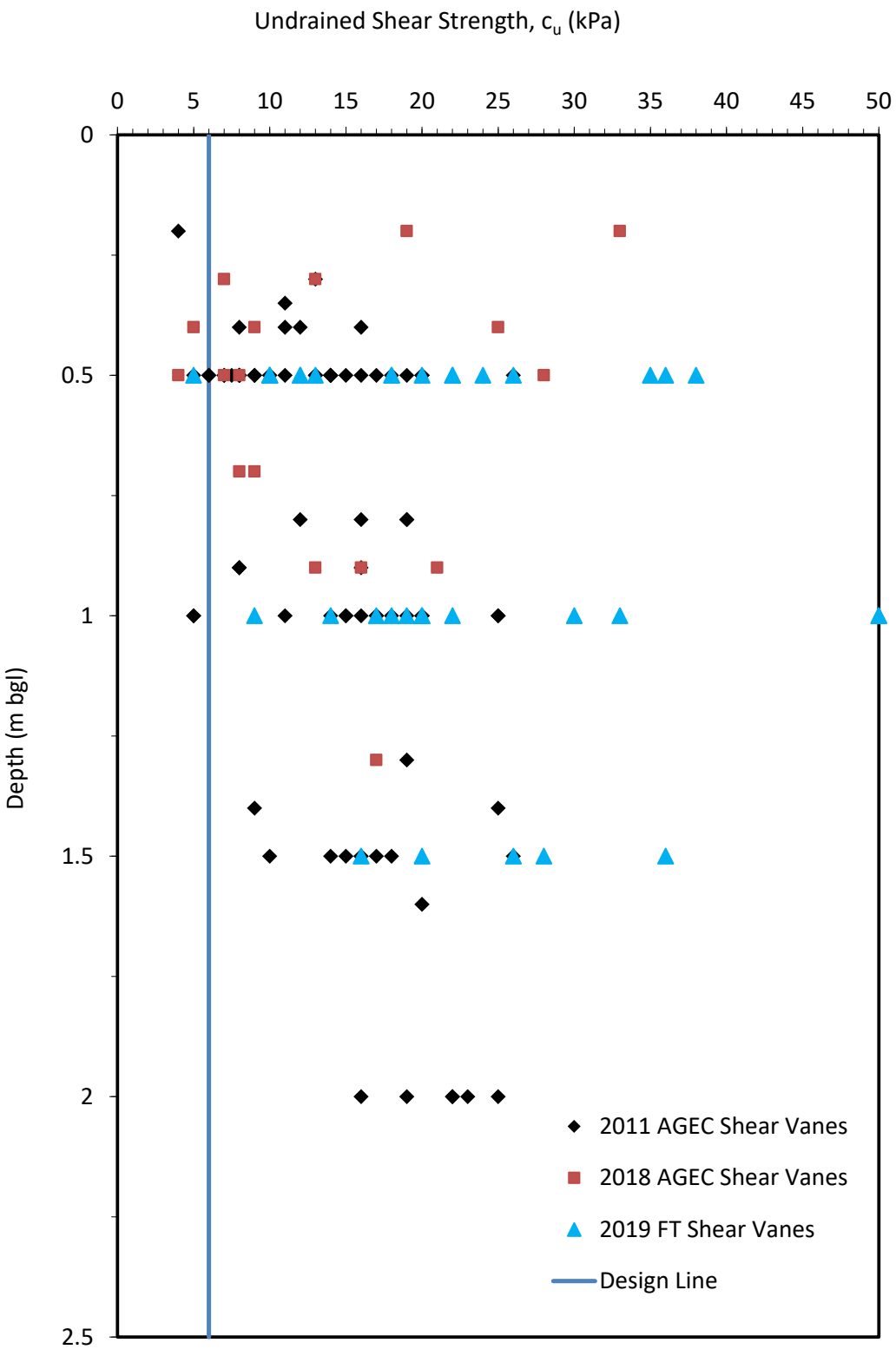


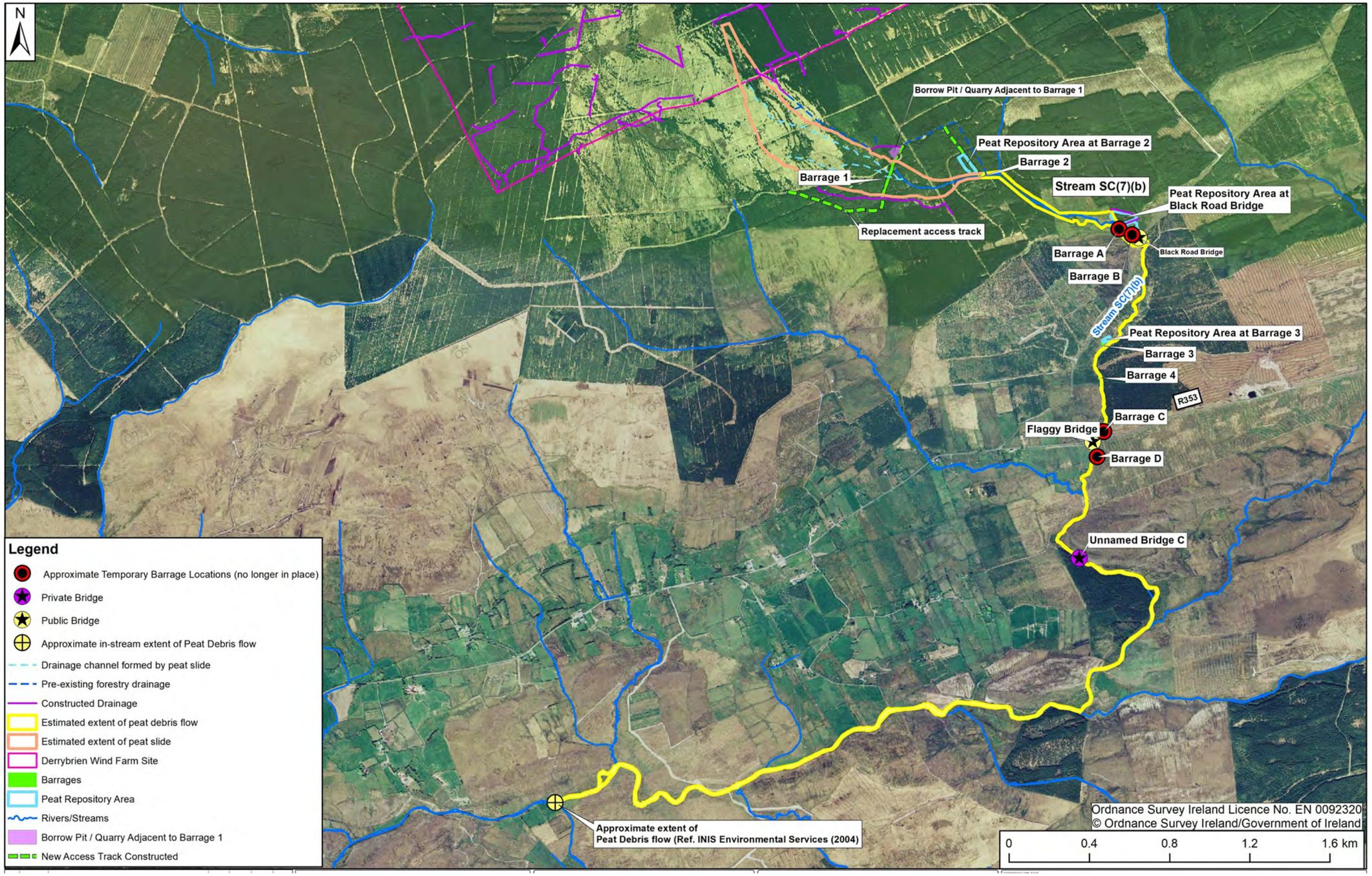
Figure 1 Range of Undrained Shear Strength (c_u) of Peat within Peat Slide Source area

Notes

(1) Results were recorded by AGEC and FT using a Geonor H-60 hand shear vane in 2011, 2018 and 2019.

Figure 2 Aerial Photo of 2003 Derrybrien Peat Slide (taken post 2003 – looking southeast from head of peat slide source area)

DRAWINGS



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Rev.	Description	App By	Date
A	FOR INFORMATION	BDH	15.11.19
B	FOR INFORMATION	BDH	30.03.20
C	FOR INFORMATION	BDH	31.07.20

PROJECT: DERRYBRIEN WIND FARM PROJECT - REIAR

CLIENT: ESB

SHEET: SITE LAYOUT PLAN - PEAT SLIDE AND ASSOCIATED WORKS

Date: 31.07.20

Project number: P2159

Scale (@ A3): 1:20000

Drawn by: POR

Checked by: IH

Drawing Number: P2159-0600-OFF-0001

Rev: C

O:\ACAD\2019\P2159\P2159-0600-OFF-0001

Friday 31 July 2020

Ground Investigation Legend:

BA4	IGSL Trial Pits 2002	(8 No.)
(Not shown on plan)	IGSL Macintosh Probes 2002	(61 No.)
(Not shown on plan)	IGSL Hand Augers 2002	(22 No.)
1.8m(R)	Malone O'Regan Probes 2002	(629 No.)
V20	Fugro Mechanical Vanes 2003	(42 No.)
CPT08	Fugro CPTS 2003	(12 No.)
(Not shown on plan)	AGEC Peat Probes 2003	(621 No.)
(Not shown on plan)	AGEC Hand Shear Vanes 2003	(45 No.)
(Not shown on plan)	IDL Rotary Boreholes 2004	(31 No.)
T61/P-50A	AGL Peat Probes & Gouge Augers 2004	(1361 No.)
T63-GA10	ESBI Gouge Auger Test Locs. 2004/2005	(212 No.)
	ESBI Peat Probes 2004 & 2005	(3046 No.)
T11_V9	ESBI Vanes 2004 & 2005	(384 No.)
0.4	AGEC Peat Probes 2011	(113 No.)
WP385	AGEC Shear Vanes 2011	(38 No.)
	AGEC Peat Probes 2018	(163 No.)
	AGEC Shear Vanes 2018	(23 No.)
	AGEC Mackintosh Probes 2018	(80 No.)
	AGEC Trial Pits 2018	(11 No.)
	FT Peat Probes 2019	(33 No.)
	FT Shear Vanes 2019	(15 No.)

7,204 investigation points in total to date. (plus further ground investigation as stated below)

T68R — Outline of repository areas where AGL carried out ground investigation on a typical 25 X 25 metre grid system in 2004.

Access Track at T68
Wind Farm Access Track between T23 & T70
Repository Adjacent to Containment Barrage 2
Turbine Location
Site Boundary of Wind Farm Development
Outline of Peat Slide Source Area
Containment Barrage 1
Containment Barrage 2
View 1
Repository Area at Black Road Bridge
View 2
Barrage A
Barrage B
Repository Adjacent to Barrage 3
Containment Barrage 4
View 3
View 4
Containment Barrage 3
Scale 1:8000

Repository Adjacent to CB2
Containment Barrage 2 (CB2)
VIEW 1
Scale 1:3000

Repository Area at Black Road Bridge
VIEW 2
Scale 1:4000

Repository Adjacent to CB3
Containment Barrage 3 (CB3)
VIEW 3
Scale 1:2000

Containment Barrage 4 (CB4)
VIEW 4
Scale 1:2000

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B	FOR INFORMATION	BDH	30.03.20
C	FOR INFORMATION	BDH	31.07.20

PROJECT: DERRYBRIEN WIND FARM PROJECT - REIAR

CLIENT: ESB

SHEET: GROUND INVESTIGATION LOCATION PLAN - PEAT SLIDE AND ASSOCIATED WORKS

Date: 31.07.20
Project number: P2159
Scale (@ A3): 1:8000
Drawn by: POR
Checked by: IH
Drawing Number: P2159-0600-OFF-0002
Rev: C

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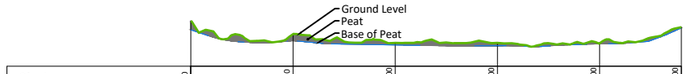
Friday 31 July 2020



Chainage	0.000	50.000	100.000	150.000	200.000	240.000
Base of Peat Level	317.747	312.419	310.368	309.987	310.901	318.744
Extg Ground Level	322.100	315.650	311.434	311.402	311.245	319.089
Lvl Difference	-4.352	-3.231	-1.066	-1.415	-0.344	-0.345

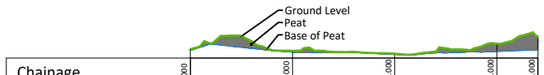
SECTION 1 - CROSS SECTION

Scale 1:3000

Chainage	0.000	50.000	100.000	150.000	200.000	245.000
Base of Peat Level	293.645	293.231	293.028	292.195	291.687	294.046
Extg Ground Level	296.792	294.728	293.449	292.709	291.754	295.109
Lvl Difference	-3.147	-1.496	-0.421	-0.513	-0.067	-1.063

SECTION 2 - CROSS SECTION

Scale 1:3000



Chainage	0.000	50.000	100.000	150.000	170.000
Base of Peat Level	263.757	262.939	261.788	263.232	264.007
Extg Ground Level	264.367	263.584	262.160	267.049	270.662
Lvl Difference	-0.610	-0.646	-0.374	-3.816	-6.596

SECTION 3 - CROSS SECTION

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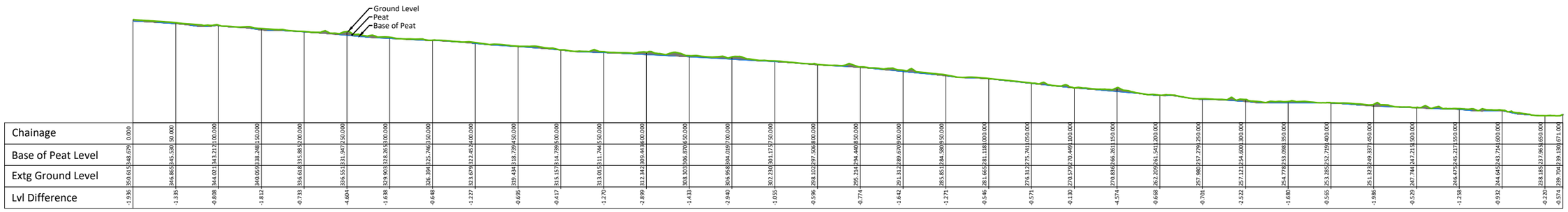
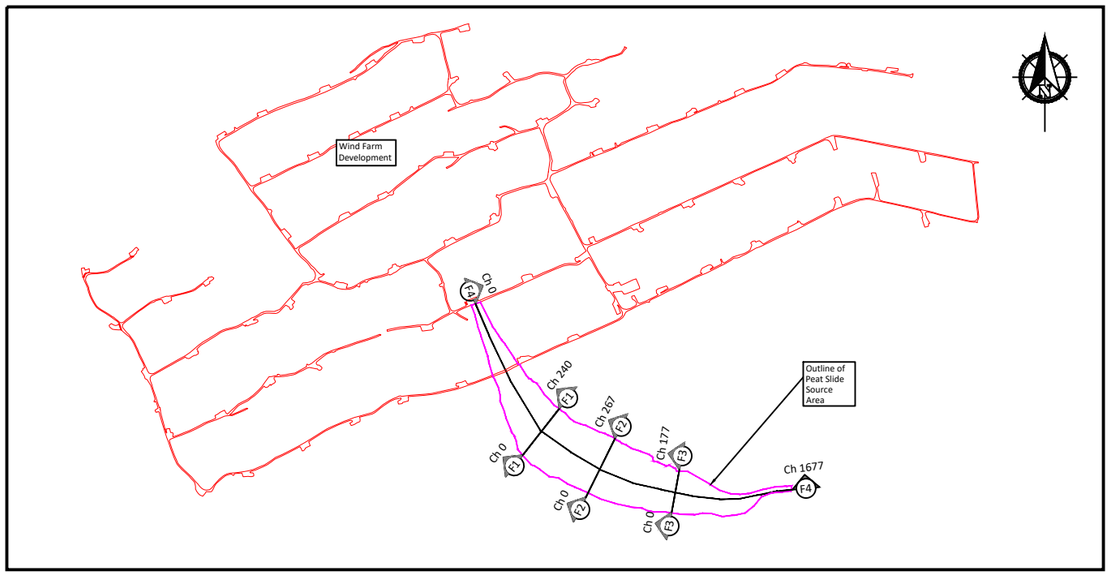


Chainage	0.000	50.000	100.000	150.000	200.000	250.000	300.000	350.000	400.000	450.000	500.000	550.000	600.000	650.000	671.000
Base of Peat Level	348.679	345.530	343.212	338.248	335.883	331.947	328.265	326.746	325.894	323.452	322.679	319.434	316.739	315.157	313.015	309.443	308.303	306.870	305.104	302.210	301.175	298.102	297.506	295.214	294.440	285.853	285.124	281.665	281.118	276.312	275.741	270.679	270.469	266.261	262.209	261.541	257.980	257.279	254.778	253.098	252.719	253.285	249.337	247.744	246.475	245.217	243.743	244.645	238.185	237.963	237.130	239.704
Extg Ground Level	350.615	346.865	344.021	340.059	336.618	336.551	329.903	326.394	326.746	323.679	323.452	319.434	318.789	315.157	314.739	313.015	311.744	308.303	306.870	305.104	302.210	301.175	298.102	297.506	295.214	294.440	285.853	285.124	281.665	281.118	276.312	275.741	270.679	270.469	270.616	266.261	262.209	261.541	257.980	257.279	254.778	253.098	252.719	253.285	249.337	247.744	246.475	245.217	243.743	244.645	238.185	237.963	237.130	239.704
Lvl Difference	-1.936	-1.335	-0.808	-1.812	-0.733	-4.604	-1.638	-0.648	-1.227	-0.695	-0.417	-1.270	-2.899	-1.433	-2.940	-1.055	-0.596	-0.774	-1.642	-1.271	-0.546	-0.571	-0.130	-4.574	-0.668	-0.701	-2.522	-1.680	-0.565	-1.986	-0.529	-1.258	-0.932	-0.220	-0.574	1.239	1.704	1.739	1.130	1.671	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

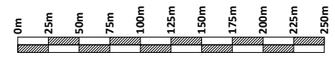
SECTION 4 - LONGITUDINAL SECTION

Scale 1:5000



KEYPLAN

Scale 1:25000



Scale 1:5000

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Rev.	Description	App By	Date
A	FOR INFORMATION	BDH	15.11.19
B	FOR INFORMATION	BDH	30.03.20

PROJECT: **DERRYBRIEN WIND FARM PROJECT - REIAR**

CLIENT: **ESB**

SHEET: **LONGITUDINAL & CROSS SECTIONS THROUGH PEAT SLIDE SOURCE AREA**

Date: 30.03.20

Project number: P2159

Scale (@ A3): 1:5000

Drawn by: POR

Checked by: IH

Drawing Number: **P2159-0600-OFF-0003**

Rev: **B**

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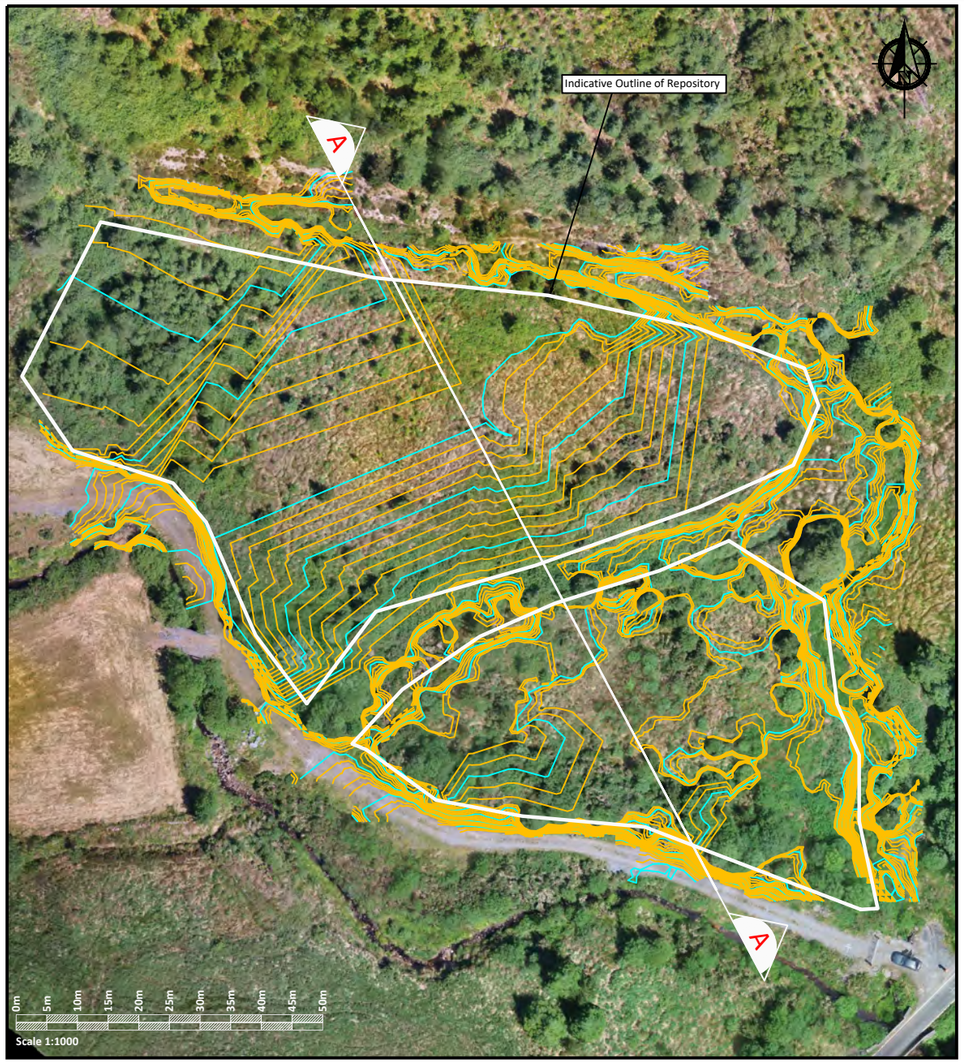
Monday 30 March 2020



REPOSITORY AREA AT BLACK ROAD BRIDGE

Scale 1:1000

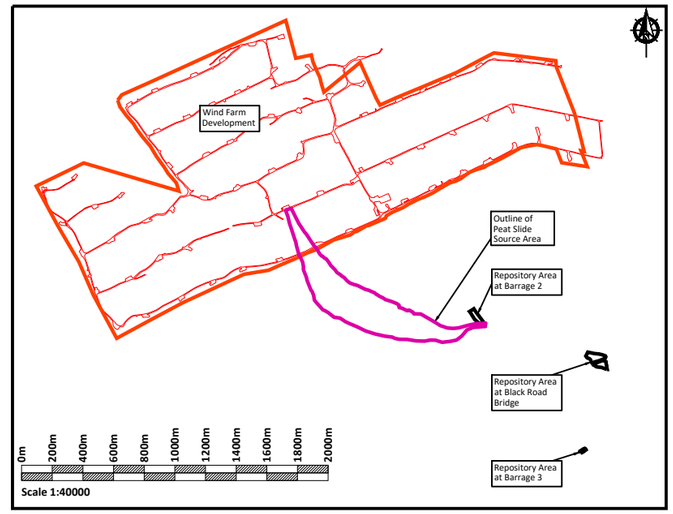
Notes:

1) Topographical survey data shown on drawing was received from ESBI in 2018.

2) The outline of the repositories shown on the drawing are indicative only.

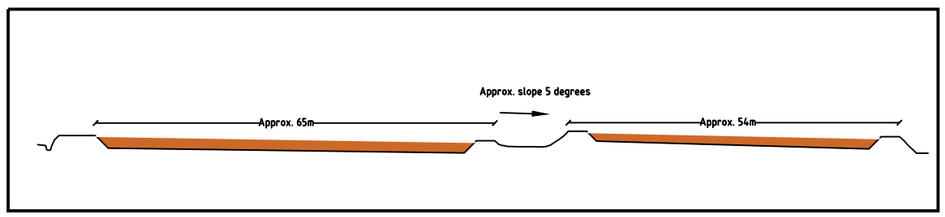
3) The cross section of the repositories shown on the drawing are indicative only and are based on site observations recorded during the FT walkover (2019) and survey data received from ESBI.

4) The depth of the stored peat and debris in the repository areas is based on peat depths and mackintosh probes carried out by AGEC in 2018.



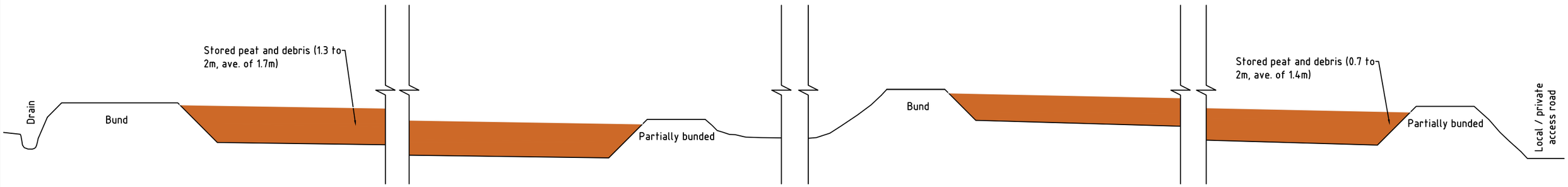
KEYPLAN

Scale 1:40000



SECTION A - A REPOSITORY AT BLACK ROAD BRIDGE FULL VIEW

Scale 1:1000



SECTION A - A REPOSITORY AT BLACK ROAD BRIDGE FULL VIEW

Scale 1:200

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Rev.	Description	App By	Date
A	FOR INFORMATION	BDH	15.11.19
B	FOR INFORMATION	BDH	30.03.20

PROJECT: DERRYBRIEN WIND FARM PROJECT - REIAR

CLIENT: ESB

SHEET: PLAN & CROSS SECTION DRAWING OF REPOSITORY AREAS (1 OF 2)

Date: 30.03.20

Project number: P2159

Scale (@ A3): 1:1000

Drawn by: POR

Drawing Number: P2159-0600-OFF-0004

Rev: B

Checked by: IH

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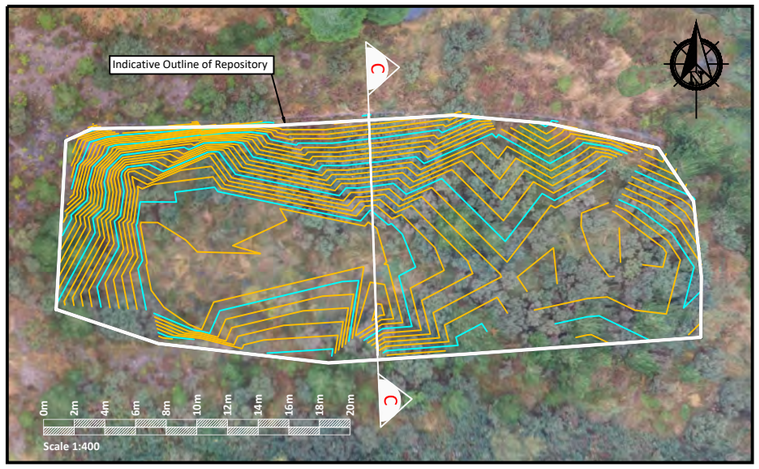
Tuesday 31 March 2020

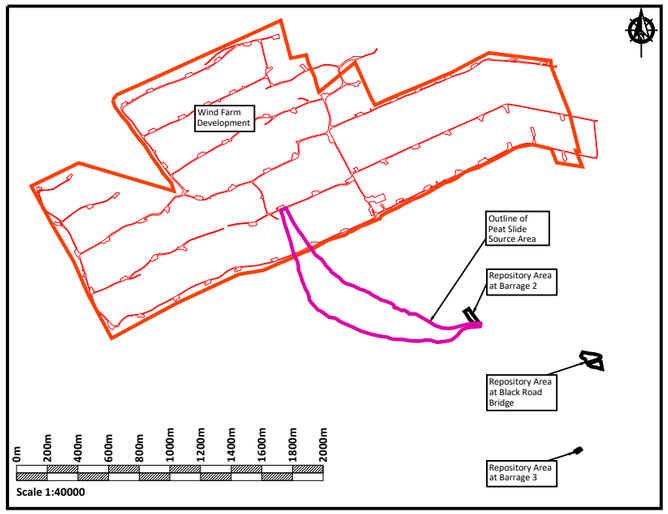
REPOSITORY AREA AT CONTAINMENT BARRAGE 2

Scale 1:1000



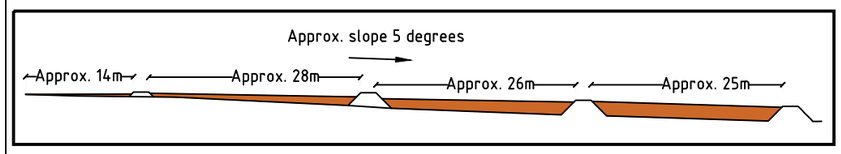
REPOSITORY AREA AT CONTAINMENT BARRAGE 3

Scale 1:400



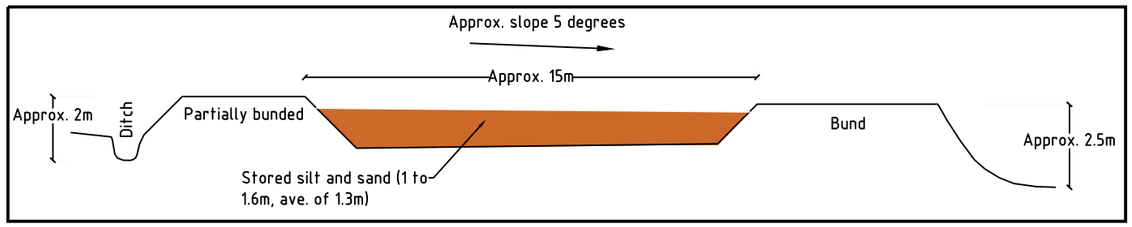
KEYPLAN

Scale 1:40000



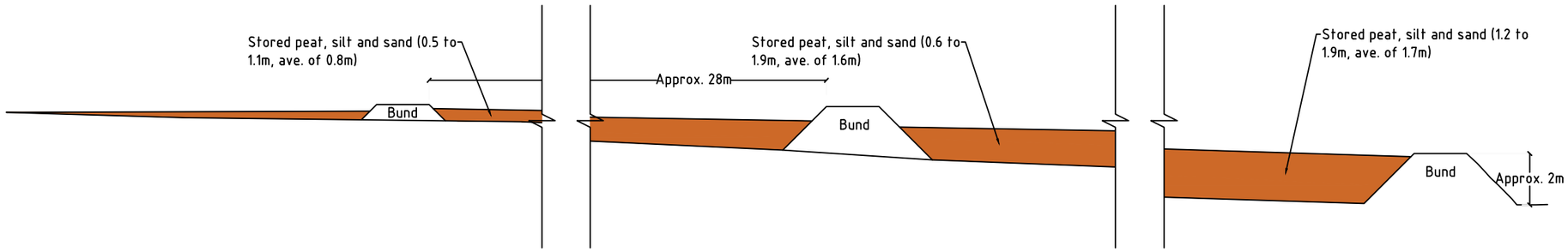
SECTION B - B REPOSITORY AT CONTAINMENT BARRAGE 2

Scale 1:800



SECTION C - C REPOSITORY AT CONTAINMENT BARRAGE 3

Scale 1:200



SECTION B - B REPOSITORY AT CONTAINMENT BARRAGE 2

Scale 1:100

Notes:

1) Topographical survey data shown on drawing was received from ESBI in 2018.
2) The outline of the repositories shown on the drawing are indicative only.
3) The cross section of the repositories shown on the drawing are indicative only and are based on site observations recorded during the FT walkover (2019) and survey data received from ESBI.
4) The depth of the stored peat and debris in the repository areas is based on peat depths and mackintosh probes carried out by AGEC in 2018.

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Rev.	Description	App By	Date
A	FOR INFORMATION	BDH	15.11.19
B	FOR INFORMATION	BDH	30.03.20

PROJECT: DERRYBRIEN WIND FARM PROJECT - REIAR		CLIENT: ESB	
SHEET: PLAN & CROSS SECTION DRAWING OF REPOSITORY AREAS (2 OF 2)	Date: 30.03.20	Project number: P2159	Scale (@ A3): 1:1000
	Drawn by: POR	Drawing Number: P2159-0600-OFF-0005	Rev: B
	Checked by: IH		

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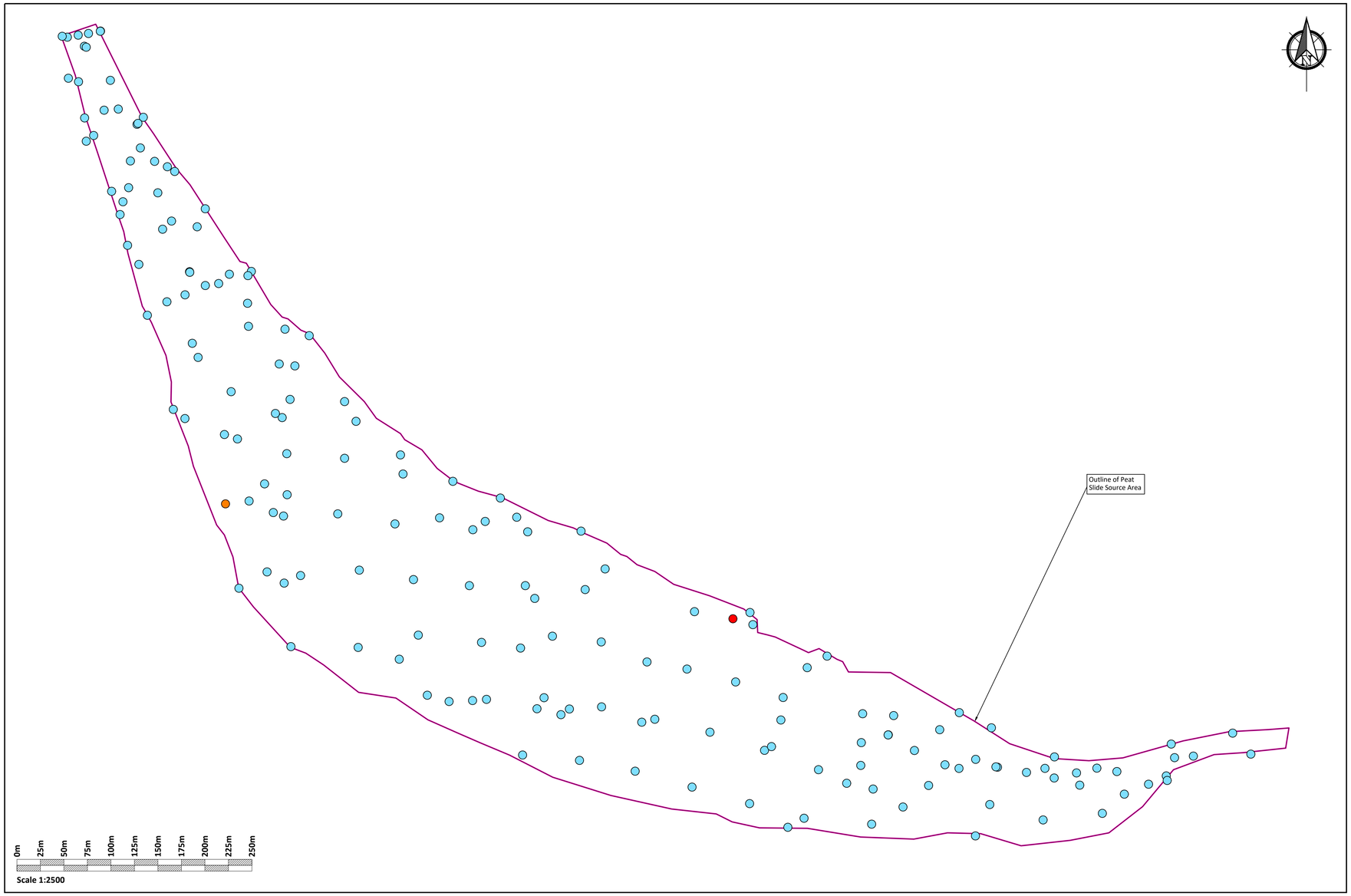
Tuesday 31 March 2020



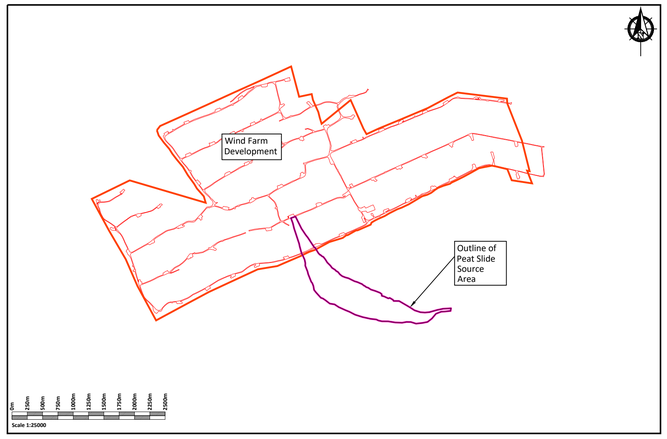
Scale 1:2500

Legend: Factor of Safety

1 or less	
1.01 to 1.3	
1.31 to 1.4	
Greater than 1.4	

Notes:

1) This drawing should be reviewed in conjunction with section 11 of the report.



KEYPLAN

Scale 1:25000

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Rev.	Description	App By	Date
A	FOR INFORMATION	BDH	30.03.20

PROJECT: DERRYBRIEN WIND FARM PROJECT - REIAR

CLIENT: ESB

SHEET: FACTOR OF SAFETY FOR PEAT SLOPES WITHIN THE PEAT SLIDE SOURCE AREA (UNDRAINED LOAD CONDITION)

Date: 30.03.20
Drawn by: POR
Checked by: IH
Project number: P2159
Scale (@ A1): 1:2500
Drawing Number: P2159-0600-OFF-0006
Rev: A

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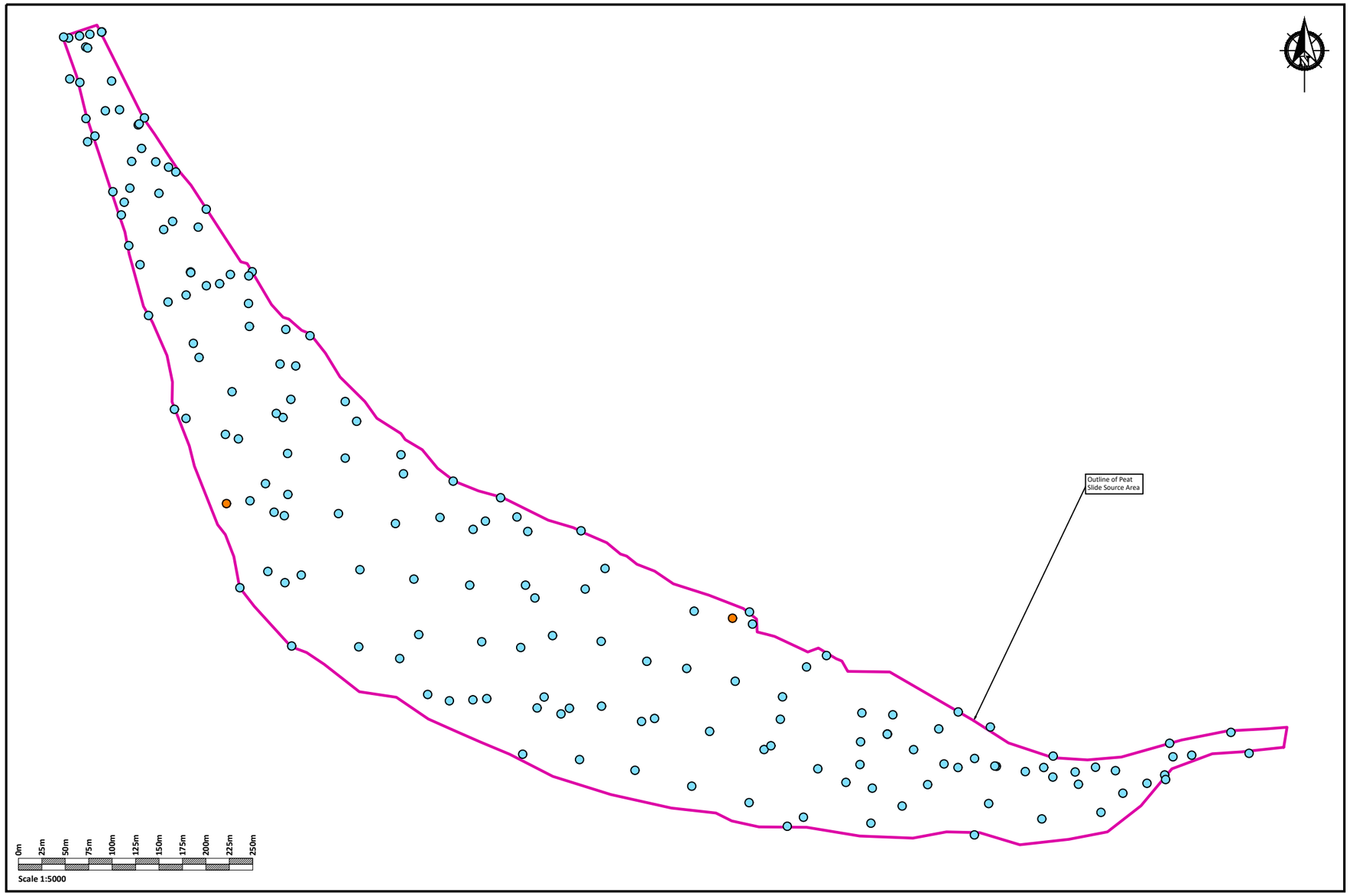
Monday 30 March 2020



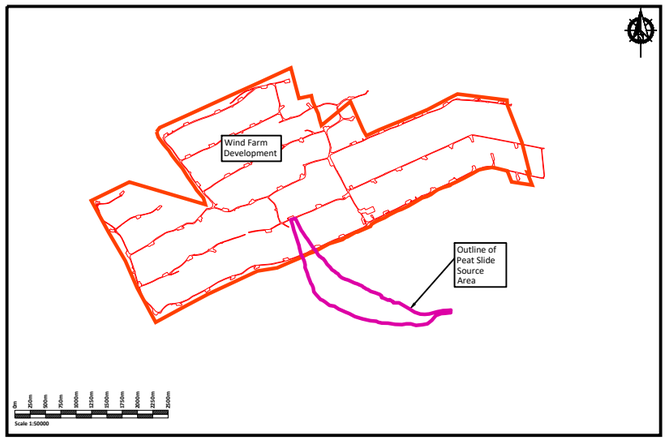
Scale 1:5000

Legend: Factor of Safety

1 or less	
1.01 to 1.3	
1.31 to 1.4	
Greater than 1.4	

Notes:

1) This drawing should be reviewed in conjunction with section 11 of the report.



KEYPLAN

Scale 1:50000

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Rev.	Description	App By	Date
A	FOR INFORMATION	BDH	30.03.20
B	FOR INFORMATION	BDH	31.07.20

PROJECT: DERRYBRIEN WIND FARM PROJECT - REIAR

CLIENT: ESB

SHEET: FACTOR OF SAFETY FOR PEAT SLOPES WITHIN THE PEAT SLIDE SOURCE AREA (DRAINED LOAD CONDITION)

Date: 31.07.20	Project number: P2159	Scale (@ A3): 1:5000	
Drawn by: POR	Drawing Number: P2159-0600-OFF-0007		Rev: B
Checked by: IH			

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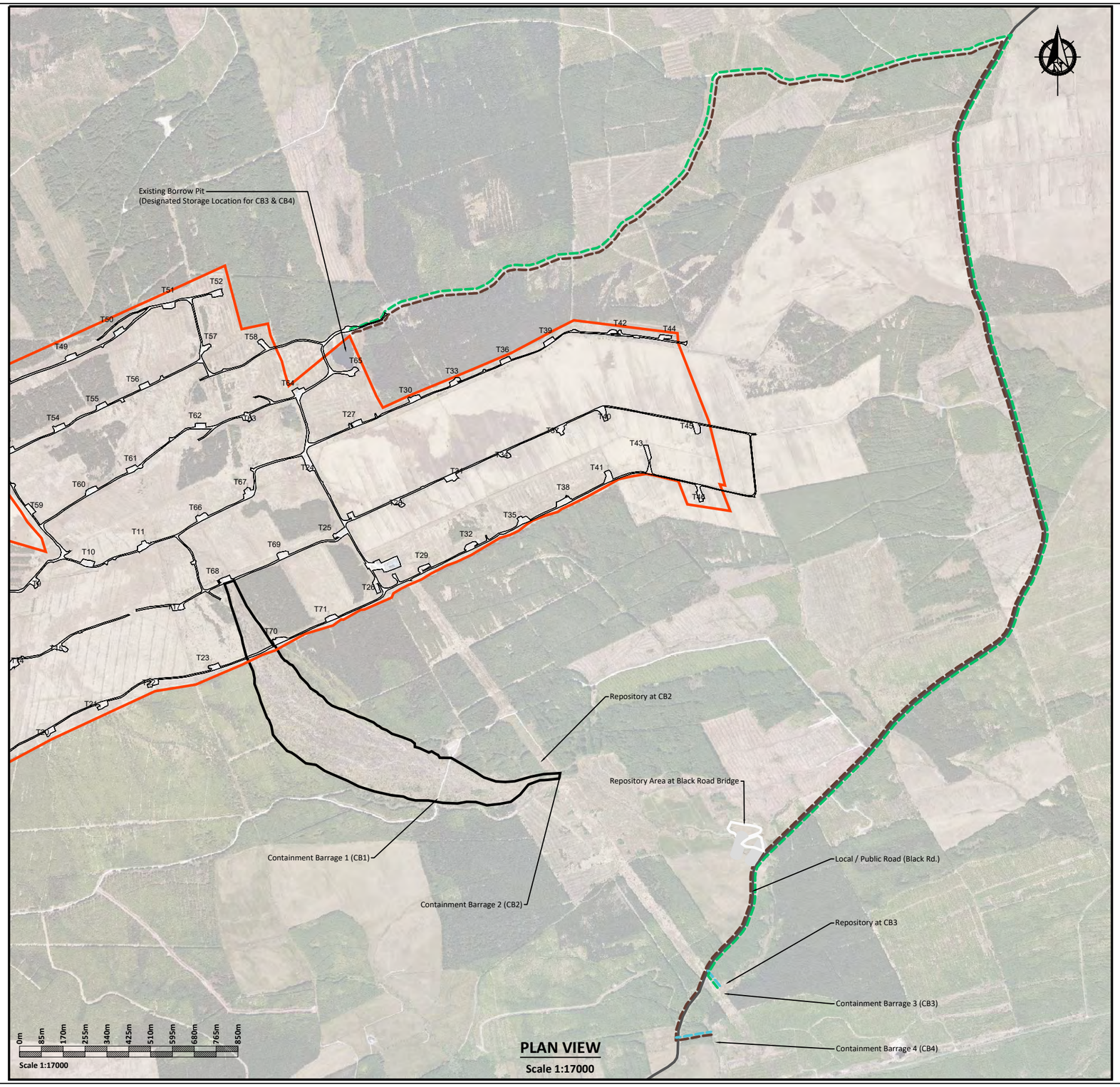
Friday 31 July 2020

Legend -

- Access Routes to containment barrages and repositories from public road (shown in black)
- Decommissioning route for CB3 to designated storage location
- Decommissioning route for CB4 to designated storage location



PLAN VIEW
Scale 1:17000

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Rev.	Description	App By	Date
A	FOR INFORMATION	BDH	30.03.20
B	FOR INFORMATION	BDH	31.07.20

PROJECT: DERRYBRIEN WIND FARM PROJECT - REIAR

CLIENT: ESB

SHEET: PLAN DRAWING FOR DECOMMISSIONING OF STABILISATION & CONTAINMENT WORKS

Date: 31.07.20
Project number: P2159
Scale (@ A3): 1:17000
Drawn by: POR
Checked by: IH
Drawing Number: P2159-0600-OFF-0008
Rev: B

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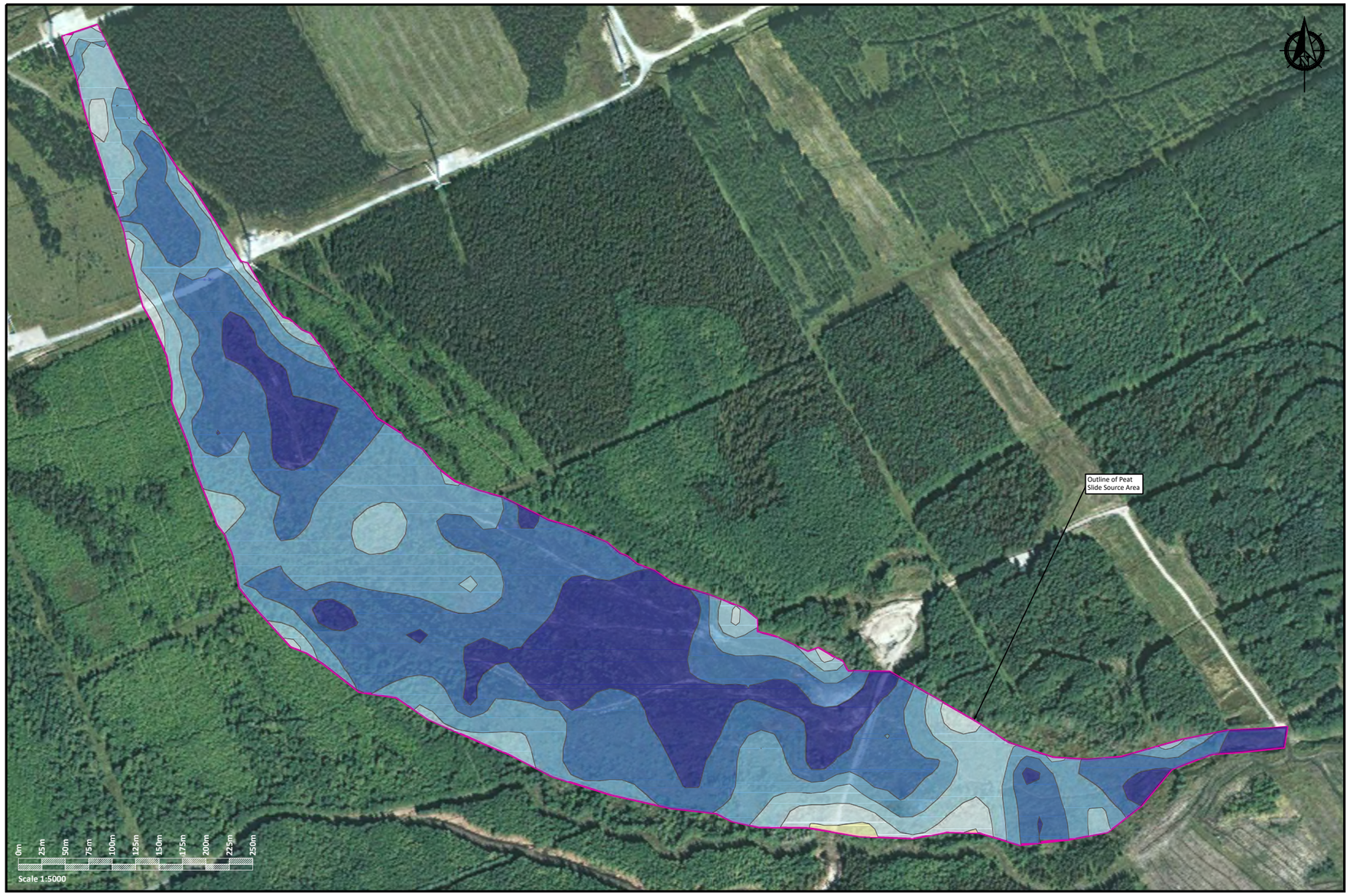
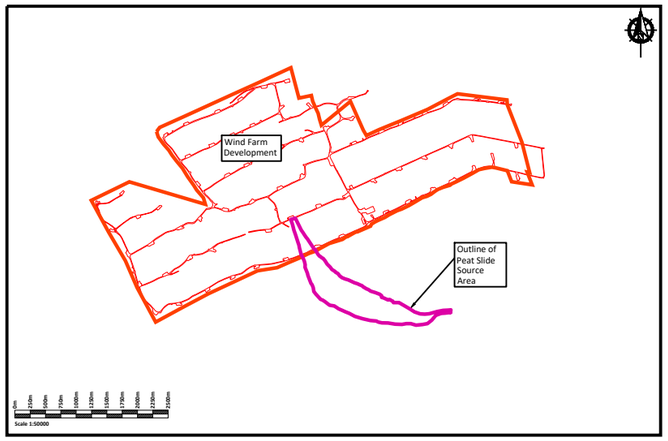
Friday 31 July 2020



Scale 1:5000

Legend: Peat Depth (m)

0
0.5
1
1.5
2
2.5
3
3.5



KEYPLAN

Scale 1:50000

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Rev.	Description	App By	Date
A	FOR INFORMATION	BDH	31.07.20

PROJECT: DERRYBRIEN WIND FARM PROJECT - REIAR

CLIENT: ESB

SHEET: PEAT DEPTH CONTOURS INSIDE PEAT SLIDE SOURCE AREA

Date: 31.07.20
Project number: P2159
Scale (@ A3): 1:5000
Drawn by: POR
Checked by: IH
Drawing Number: P2159-0600-OFF-0009
Rev: A

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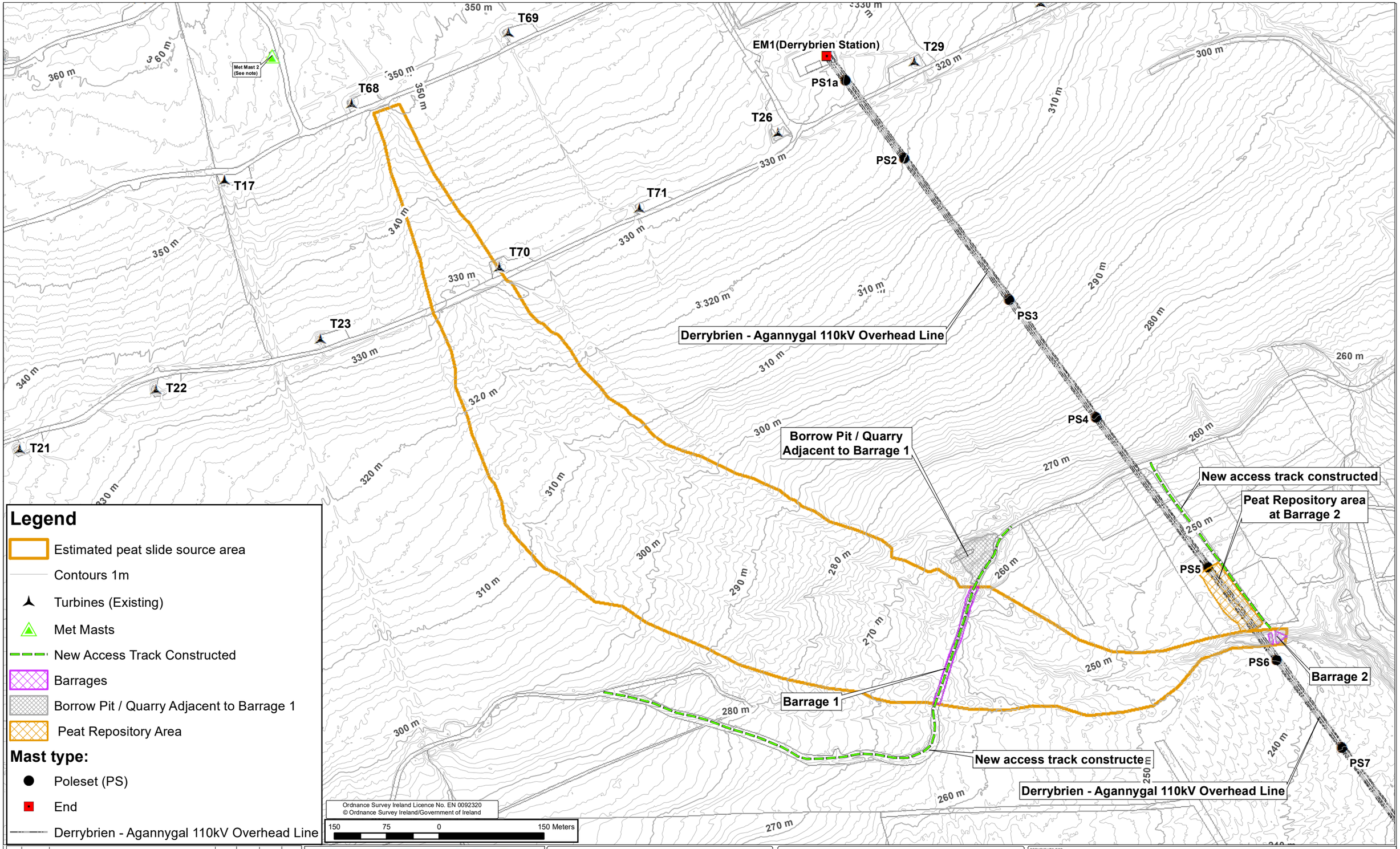
Friday 31 July 2020



REV	DATE	REVISION DESCRIPTION	DRN	PROD	VER	APP
0	28/07/20	Issued for substitute consent	E.O'S	E.O'S	M.B	J.McL

PURPOSE OF ISSUE - PRELIMINARY UNLESS INDICATED

CLIENT APPROVAL ☐ PLANNING ☒ TENDER ☐ CONSTRUCTION ☐ AS-BUILT ☐

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One Dublin Airport Central,
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Tel: 353 1 703 8000 Web: www.esb.ie
Engineering and Major Projects is a division of ESB.

CLIENT: Gort Windfarms Ltd

PROJECT: Derrybrien Wind Farm Project

CONTRACT

PRODUCTION UNIT: Civil & Environmental Engineering

DRAWING TITLE: Estimated peat slide source area - Contours 1m

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DRAWN	PRODUCED	VERIFIED	APPROVED	APPROVAL DATE
E.O'Shea	E.O'Shea	M.Brides	J.McLoughlin	28/07/2020

CLIENT REF.	NO. OF SHEETS	SIZE	SCALE
00-00	00-00	A3	1:5,000

DRAWING NUMBER: QS-000280-01-D460-011-018-000

Appendix A

Site Photographs from FT Site Walkover (2019)

Photo 1 Overview of re-vegetated area within the peat slide source area

Photo 2 Example of a drain within the peat slide source area

Photo 3 Example of vegetated debris (intact & non-intact) within the peat slide source area

Photo 4 Example of bare/eroded peat surface within the peat slide source area

Photo 5 Example of bare peat surface (no vegetation growth) within the peat slide source area

Photo 6 Example of ground conditions within the peat slide source area

Photo 7 View along containment barrage 1 (Coillte road)

Photo 8 Coillte borrow pit adjacent to containment barrage 1

Photo 9 Containment barrage 2 (heavily vegetated and highlighted in photo)

Photo 10 Example of site conditions within repository area adjacent to containment barrage 2

Photo 11 Containment barrage 3 (stream flows from left to right in photo)

Photo 12 Repository area adjacent to containment barrage 3

Photo 13 Containment barrage 4 (looking downstream)

Photo 14 Example of conditions at repository area at Black Road Bridge

Photo 15 Example of ground conditions at repository area at Black Road Bridge

Photo 16 Bridge parapets at Black Road Bridge

Appendix B

Ground Investigation (2018) – Trial Pit Logs with Associated Photos & Mackintosh Probe Logs

Trial Pit Log

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Trialpit No **TP01** Sheet 1 of 1

Project Name: Derrybrien Wind Farm	Project No. 1806	Co-ords: 159311.00 - 204662.00 Level: 0.00	Date 18/06/2018
Location: Co. Galway		Dimensions (m): 4 × 1.4, Depth 3.60	Scale 1:25
Client: ESBI			Logged M.L.

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
			HVP=12				Very soft brown to dark brown moderately decomposed Peat (H4-H5) with pockets of pink clay, steel rebar, wood. (Disturbed Ground)
				0.90	-0.90		
			HVP=14				Very soft brown to dark brown moderately decomposed PEAT (H4-H5).
▼			HVP=19	1.60	-1.60		Very soft dark brown highly decomposed amorphous PEAT (H8-H9)
			HVP=17	1.80	-1.80		Very soft to soft grey sandy CLAY becoming light brown clayey sand in places.
				2.50	-2.50		Soft becoming firm with depth grey sandy gravelly CLAY/ SILT with many cobbles and boulders (Sub-rounded to sub-angular sandstone).
				3.20	-3.20		Firm becoming stiff light reddish brown sandy very gravelly (weak siltstone) SILT/CLAY with many cobbles and some boulders (Sub-rounded to sub-angular sandstone, sub-angular siltstone)
				3.40	-3.40		Stiff to very stiff light reddish brown sandy very gravelly (weak siltstone) SILT/CLAY with some cobbles and boulders (Sub-rounded to sub-angular sandstone, siltstone)
				3.60	-3.60		End of pit at 3.60 m

1 2 3 4 5

Remarks: HVP - Hand vane peak strength (Cu, kPa)
Water strike at 1.70m, moderate flow from handstanding.
End of TP - Hard digging, possible bedrock or large boulder at 3.4m at south end of pit.

Stability: Generally stable, some spalling above 3.00m.

Trial Pit Log

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Trialpit No **TP02** Sheet 1 of 1

Project Name: Derrybrien Wind Farm	Project No. 1806	Co-ords: 159328.00 - 204630.00 Level: 0.00	Date 18/06/2018
Location: Co. Galway		Dimensions (m): 3 × 1.5, Depth 2.90	Scale 1:25
Client: ESBI			Logged M.L.

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
▼			HVP=8	0.80	-0.80		Very soft brown to dark brown moderately decomposed PEAT (H4)
			HVP=18	1.00	-1.00		Very soft dark brown highly decomposed amorphous PEAT (H7- H8)
				1.25	-1.25		Soft/loose light brown clayey organic SAND with many decayed rootlets with some cobbles and occasional boulder (Sub-angular to sub-rounded sandstone)
				2.00	-2.00		Very soft becoming firm with depth grey sandy to very sandy slightly gravelly CLAY with some cobbles and occasional boulder (Rounded to sub-angular sandstone).
				2.90	-2.90		Firm becoming stiff to very stiff light reddish brown sandy very gravelly (weak siltstone) SILT/CLAY with many cobbles and some boulders (Sub-rounded to sub-angular). Boulder approx 1.00m.
							End of pit at 2.90 m

1 2 3 4 5

Remarks: HVP - Hand vane peak strength (Cu, kPa)
Water seepage at base of peat (0.8m), generally dry.
End of TP - Hard digging

Stability: Generally stable. Peat slumping, minor spalling in soft clayey sand.

Trial Pit Log

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Trialpit No **TP03** Sheet 1 of 1

Project Name: Derrybrien Wind Farm	Project No. 1806	Co-ords: 159430.00 - 204365.00 Level: 0.00	Date 18/06/2018
Location: Co. Galway		Dimensions (m): 3.8 × 1.2 Depth 2.90	Scale 1:25
Client: ESBI			Logged M.L.

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.40	-0.40		Soft brown to dark brown moderately decomposed PEAT with pockets and lenses of light reddish brown sandy gravelly clay and cobbles (Sub-angular to sub-rounded sandstone). (Disturbed Ground)
				0.70	-0.70		Very soft brown to dark brown moderately decomposed PEAT (H4- H5)
				0.80	-0.80		Very soft dark brown highly decomposed amorphous PEAT (H8-H9)
				1.00	-1.00		Loose light brown clayey organic SAND with many decayed rootlets, Very loose/ soft grey slightly sandy gravelly very clayey SAND to very sandy CLAY/SILT with occasional cobbles.
				1.50	-1.50		Firm light reddish brown slightly sandy gravelly CLAY/ SILT with occasional cobbles and boulders (Sub-rounded to sub-angular).
▼				1.90	-1.90		Very loose light reddish brown very silty sandy GRAVEL with many cobbles and boulders (Sub-rounded to sub-angular). Water ingress - gravels liquifying and slumping.
				2.60	-2.60		Loose/ Firm light reddish brown very silty sandy GRAVEL/ very gravelly SILT/CLAY with some cobbles and boulders (Sub-rounded to sub-angular).
				2.90	-2.90		End of pit at 2.90 m

1 2 3 4 5

Remarks: Water ingress from 1.90m and 2.60m, slow to moderate.
End of TP - Hard digging.

Stability: Material liquifying between 1.90m and 2.60m, slumping into pit. Undercutting side walls.

Trial Pit Log

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Trialpit No **TP04** Sheet 1 of 1

Project Name: Derrybrien Wind Farm	Project No. 1806	Co-ords: 159465.00 - 204376.00 Level: 0.00	Date 18/06/2018
Location: Co. Galway		Dimensions (m): 4 × 1.5, Depth 3.00	Scale 1:25
Client: ESBI			Logged M.L.

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
							Very soft brown to dark brown moderately decomposed PEAT (H4).
				0.80	-0.80		
				0.90	-0.90		Very soft dark brown highly decomposed amorphous PEAT (H8-H9).
							Loose light brown slightly gravelly clayey organic SAND with many decayed rootlets and with some cobbles and large boulders.
				1.20	-1.20		
							Very loose/ very soft light greyish brown slightly gravelly to gravelly very clayey SAND/ very sandy CLAY/SILT with occasional cobbles.
				1.40	-1.40		
							Soft becoming firm and stiff with depth light reddish brown very gravelly CLAY/SILT to very silty GRAVEL of mudstone/ siltstone with some to many cobbles and boulders (Sub-rounded to sub-angular, sandstone).
				3.00	-3.00		End of pit at 3.00 m

1 2 3 4 5

Remarks: Generally dry.
End of TP - Hard digging.

Stability: Generally stable, some minor spalling.

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Trial Pit Log

Trialpit No **TP05**

Sheet 1 of 1

Project Name: Derrybrien Wind Farm	Project No. 1806	Co-ords: 160131.00 - 203828.00 Level: 0.00	Date 18/06/2018
Location: Co. Galway	Dimensions (m): 4.3 × 1.5, Depth 3.30		Scale 1:25
Client: ESBI			Logged M.L.

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
			HVP=9				Very soft brown to dark brown moderately decomposed PEAT with pockets of decomposed vegatation, brash and wood. (Disturbed Ground)
			HVP=40	1.10	-1.10		Very soft brown to dark brown moderately decomposed PEAT (H4)
				1.40	-1.40		Very soft dark brown highly decomposed amorphous PEAT (H8)
				1.50	-1.50		Firm (friable) light brown slightly gravelly silty organic SAND with decaying rootlets and occasional cobble.
				1.70	-1.70		Soft / loose grey slightly gravelly very silty organic SAND with occasional cobble.
				2.00	-2.00		Firm becoming stiff and very stiff with depth light reddish brown very gravelly CLAY/SILT to very silty GRAVEL of mudstone/ siltstone with some cobbles and occasional boulders (Sub-rounded to sub-angular, sandstone). Some damp/wet pockets.
				3.30	-3.30		End of pit at 3.30 m

1 2 3 4 5

Remarks: HVP - Hand vane peak strength (Cu, kPa).
Generally dry, with some wet/damp areas.
End of TP - Hard digging.

Stability: Generally stable, some minor spalling.

Trial Pit Log

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Trialpit No **TP06** Sheet 1 of 1

Project Name: Derrybrien Wind Farm	Project No. 1806	Co-ords: 160157.00 - 203874.00 Level: 0.00	Date 18/06/2018
Location: Co. Galway	Dimensions (m): Depth 2.30	2.9 × 1.5	Scale 1:25
Client: ESBI			Logged M.L.

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.70	-0.70		Very soft brown to dark brown moderately decomposed PEAT (H3-H4). (No humified peat layer)
				0.75	-0.75		Very soft greyish brown slightly sandy CLAY.
				0.80	-0.80		Soft brown slightly gravelly sandy organic SILT/CLAY with some cobbles and boulders (Sub-angular to sub-rounded)
							Loose greyish sandstone COBBLES and BOULDERS (Sub-angular to sub-rounded) with much very sandy silty gravel.
▼				1.50	-1.50		Loose reddish brown and grey green sandstone COBBLES and BOULDERS (Sub-angular to rounded) with much very sandy silty gravel. Water ingress at 1.50m - Slow to moderate.
				2.30	-2.30		End of pit at 2.30 m

1 2 3 4 5

Remarks: Water ingress at 1.50m - Slow to moderate.
End of TP - Very hard digging, something solid, possible bedrock.

Stability: Pit generally collapsing from 1.50m with water ingress.

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Trial Pit Log

Trialpit No **TP07**

Sheet 1 of 1

Project Name: Derrybrien Wind Farm	Project No. 1806	Co-ords: 160167.00 - 203921.00 Level: 0.00	Date 18/06/2018
Location: Co. Galway		Dimensions (m): 3 × 1.5 Depth 2.90	Scale 1:25
Client: ESBI			Logged M.L.

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
							Very soft brown to dark brown moderately decomposed PEAT (H4-H6), amorphous at base.
				0.55	-0.55		
				0.60	-0.60		Soft brown slightly gravelly sandy SILT (possible relic topsoil).
							Medium dense light brown very gravelly silty organic SAND with decaying rootlets and many cobbles and boulders.
				1.30	-1.30		Medium light reddish brown very sandy very silty GRAVEL with many cobbles and boulders (Sub-angular to sub-rounded).
				2.00	-2.00		Stiff and very stiff reddish brown slightly sandy very gravelly SILT/CLAY with many cobbles and boulders. (Sub-angular to sub-rounded)
				2.90	-2.90		End of pit at 2.90 m

1 2 3 4 5

Remarks: Generally dry. 1.60m deep ditch adjacent to road embankment/barrage.
TP dug away from ditch so water would not enter pit.
End of TP - Hard digging.

Stability: Generally stable, some minor spalling.

Trial Pit Log

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Trialpit No **TP08** Sheet 1 of 1

Project Name: Derrybrien Wind Farm	Project No. 1806	Co-ords: 160516.00 - 203968.00 Level: 0.00	Date 19/06/2018
Location: Co. Galway		Dimensions (m): 3.5 × 1.5, Depth 3.20	Scale 1:25
Client: ESBI			Logged M.L.

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
			HVP=14	0.80	-0.80		Very soft brown to dark brown moderately decomposed PEAT (H3-H5).
			HVP=8				Very soft dark brown highly decomposed amorphous PEAT (H6-H8) with wood. (Possible made ground)
▼			HVP=11	1.40	-1.40		Very soft greyish brown CLAY.
				1.45	-1.45		Very soft/ very loose greyish brown silty gravelly organic SAND with occasional cobbles and boulders.
				2.00	-2.00		Loose (damp) light reddish brown very gravelly very silty SAND with some cobbles and occasional boulders. (Sub-rounded to sub-angular, sandstone)
				2.50	-2.50		Firm becoming stiff and very stiff with depth light reddish brown very gravelly CLAY/SILT with some cobbles and occasional boulders. (Sub-rounded to sub-angular, sandstone)
				3.20	-3.20		End of pit at 3.20 m

1 2 3 4 5

Remarks: HVP - Hand vane peak strength (Cu, kPa).
Generally dry, slow ingress at base of peat (1.4m).
End of TP - Hard digging.

Stability: Generally stable, some minor spalling.

Trial Pit Log

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Trialpit No **TP09** Sheet 1 of 1

Project Name: Derrybrien Wind Farm	Project No. 1806	Co-ords: 160597.00 - 203897.00 Level: 0.00	Date 19/06/2018
Location: Co. Galway		Dimensions (m): 3 × 2, Depth 2.80	Scale 1:25
Client: ESBI			Logged M.L.

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
							Very soft brown to dark brown moderately decomposed PEAT (H4-H5) with piece of wood. (Possible made ground)
				1.10	-1.10		Very soft grey organic CLAY.
▼				1.20	-1.20		Loose greyish brown organic gravelly silty SAND (medium) with some cobbles and occasional boulder. (Sub-rounded to sub-angular, sandstone)
				1.70	-1.70		Loose light reddish brown very gravelly very silty SAND with some cobbles and occasional boulders. (Sub-rounded to sub-angular)
				2.00	-2.00		Firm becoming stiff to very stiff light reddish brown sandy very gravelly SILT/CLAY with many cobbles and some boulders. (Sub-rounded to sub-angular)
				2.80	-2.80		End of pit at 2.80 m

1 2 3 4 5

Remarks: Water strike at 1.30m, slow flow.
End of TP - Hard digging.

Stability: Generally stable, minor spalling in sands.

Photo 1 Ground conditions at trial pit TP1

Photo 2 Ground conditions at trial pit TP2

Photo 3 Ground conditions at trial pit TP3

Photo 4 Ground conditions at trial pit TP4

Photo 5 Ground conditions at trial pit TP5

Photo 6 Ground conditions at trial pit TP6

Photo 7 Example of arisings from base of trial pit TP7

Photo 8 Ground conditions at trial pit TP8

Photo 9 Example of arisings from trial pit TP9

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 4	Easting =	161235	**MP1**
		Northing =	202897	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	3	
200	8	
300	9	
400	10	
500	12	
600	8	
700	8	
800	6	
900	9	
1000	7	
1100	4	
1200	6	
1300	5	
1400	8	
1500	20	
1600	21	
1700	50	**
1800		
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2000		
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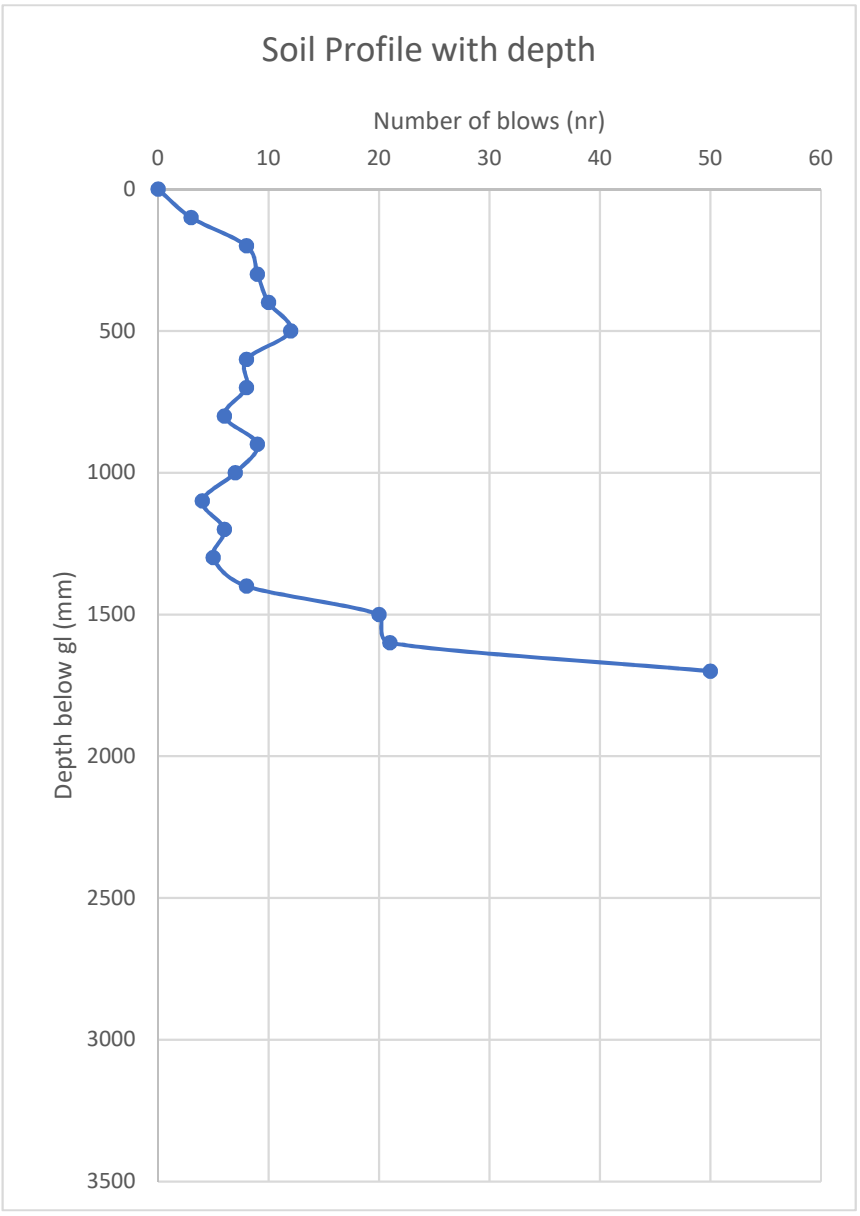
2600		
2700		
2800		
2900		
3000		



** At depth 1700mm, testing terminated at 50 blows. No movement - recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 4	Easting =	161208	**MP2**
		Northing =	202885	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	3	
300	5	
400	6	
500	8	
600	4	
700	3	
800	6	
900	20	**
1000		
1100		
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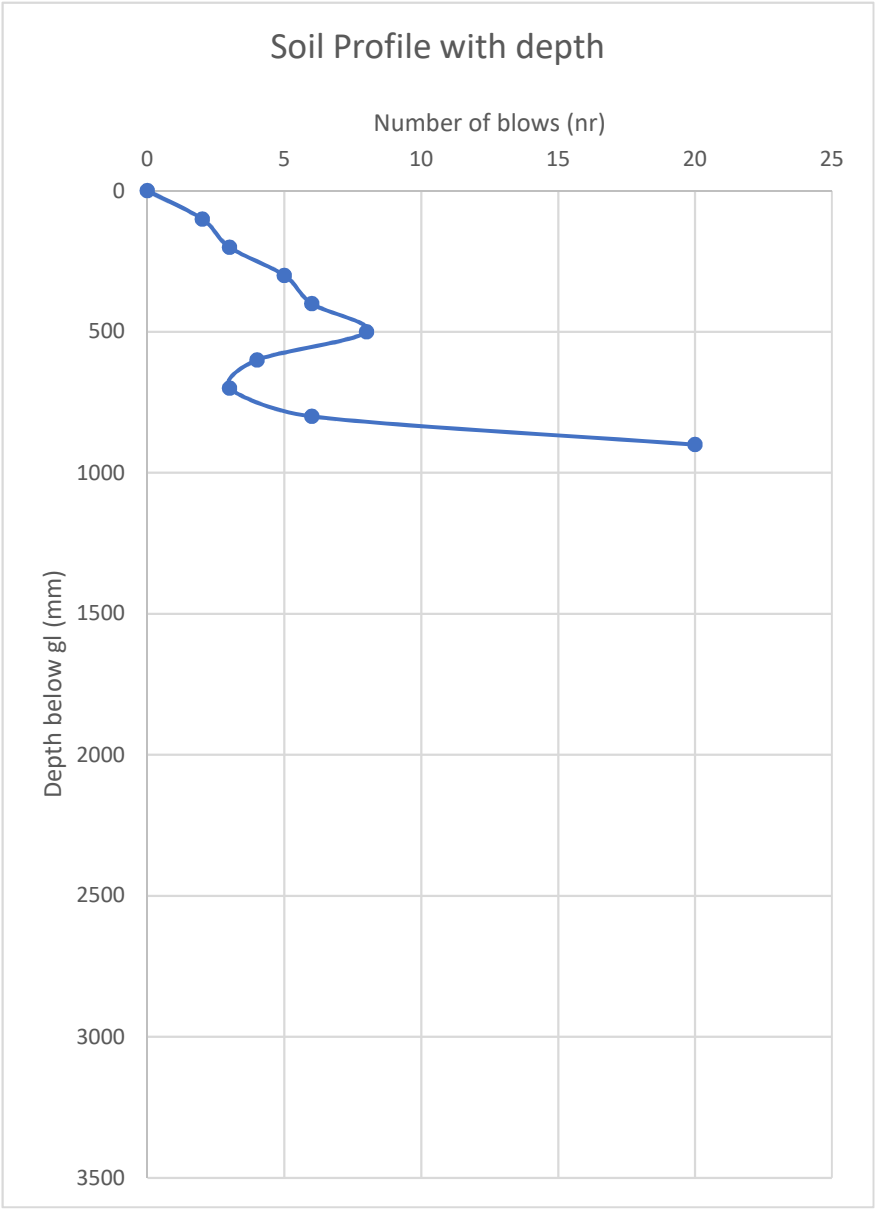

** At depth 900mm, testing terminated at 20 blows. No movement - recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 4	Easting =	161201	**MP3**
		Northing =	202894	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	1	
300	6	
400	20	**
500		
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
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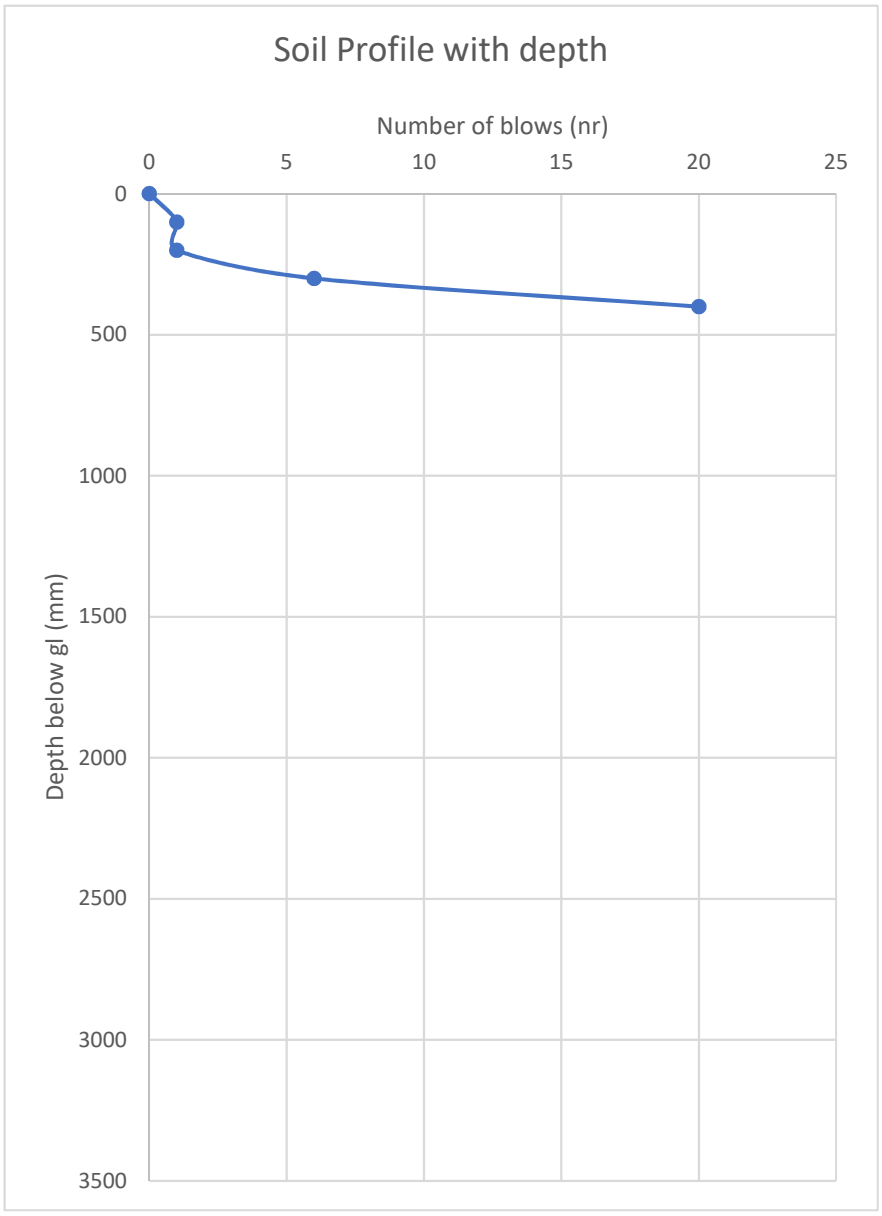

** At depth 400mm, testing terminated at 20 blows. No movement - recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 4	Easting =	161198	**MP4**
		Northing =	202892	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	5	**
200		
300		
400		
500		
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
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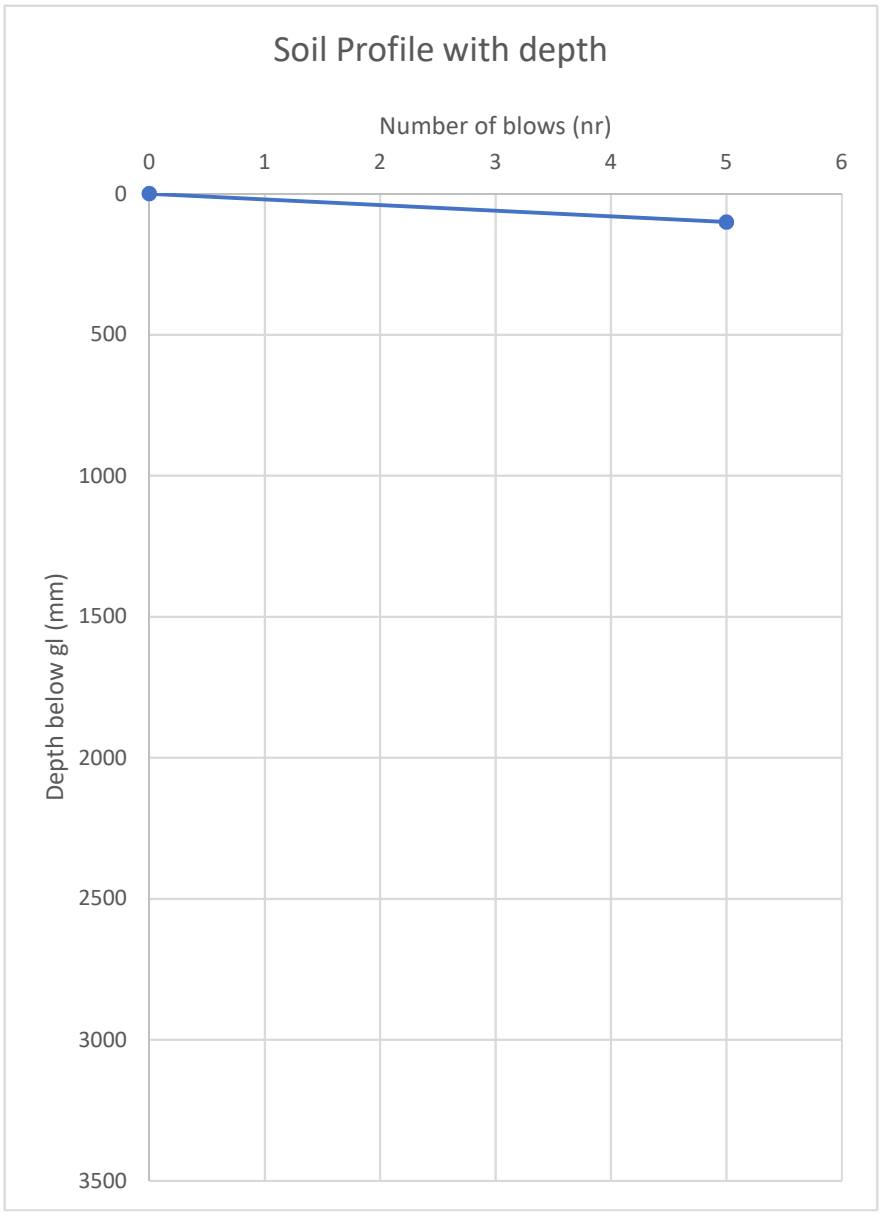

** At depth 100mm, testing terminated at 5 blows. No movement - recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 4	Easting =	161203	**MP5**
		Northing =	202885	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	3	
300	2	
400	7	
500	20	**
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
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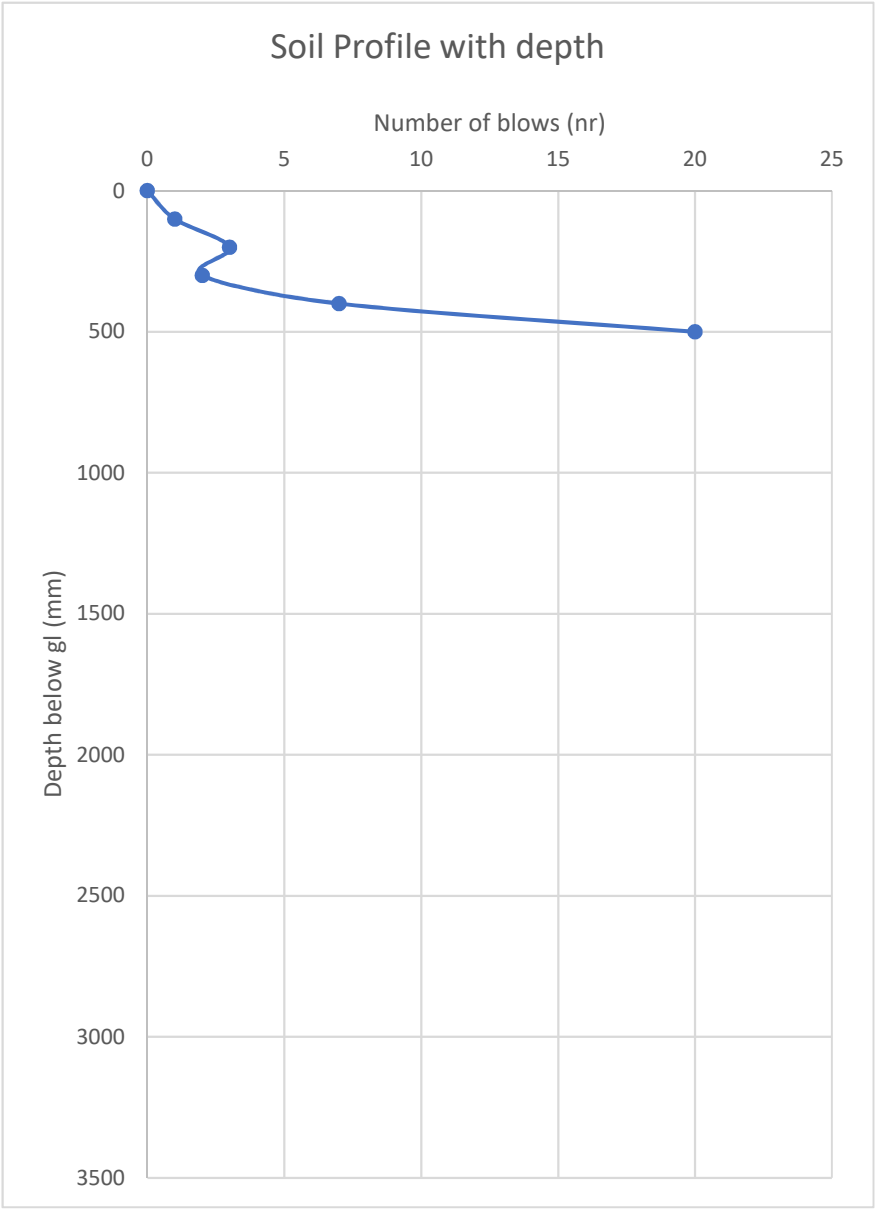

** At depth 500mm, testing terminated at 20 blows. No movement - recoil of probe.

*Peat depth approximately 400mm at this location.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 4	Easting =	161208	**MP6**
		Northing =	202875	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	3	
300	5	
400	3	
500	5	
600	1	
700	2	
800	7	
900	20	**
1000		
1100		
1200		
1300		
1400		
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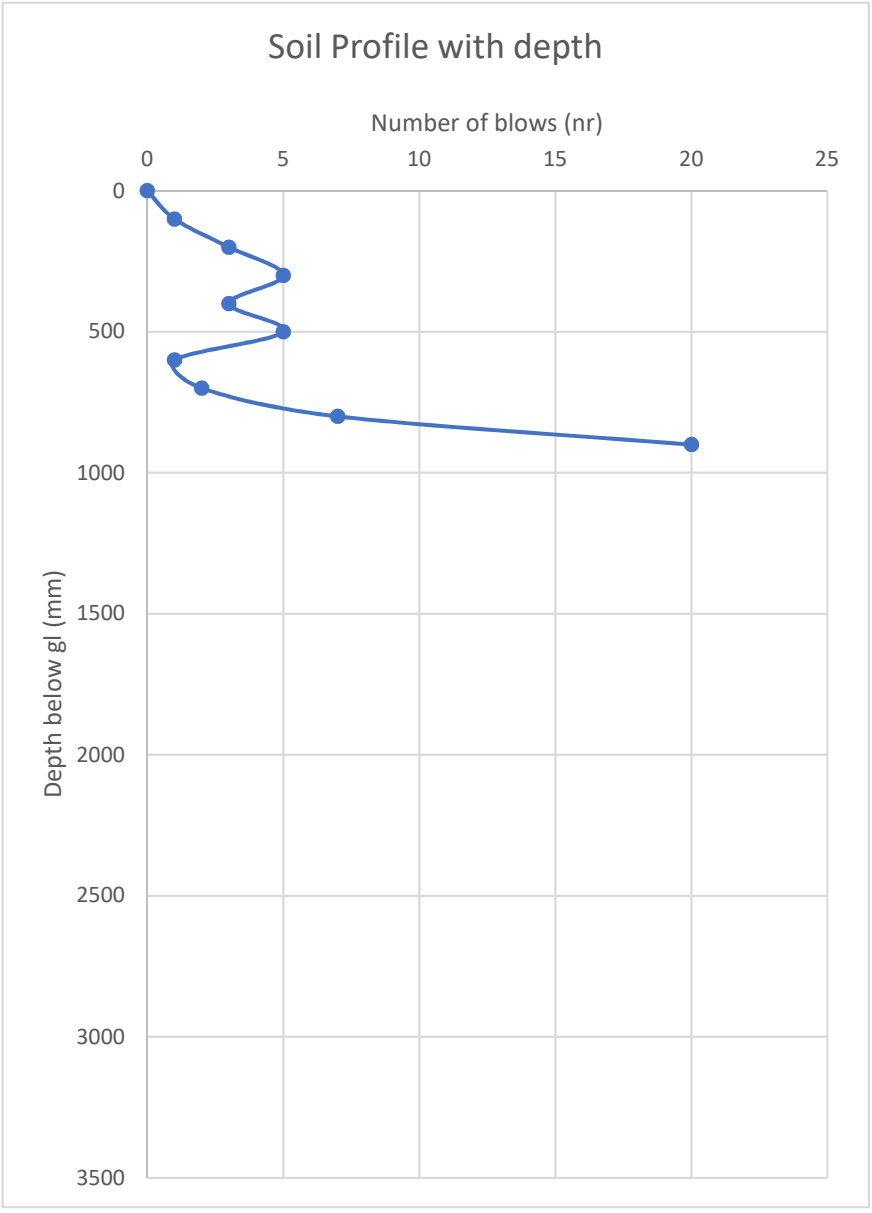

** At depth 900mm, testing terminated at 20 blows. No movement - recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 4	Easting =	161211	**MP7**
		Northing =	202885	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	5	
300	5	
400	3	
500	7	
600	4	
700	2	
800	3	
900	2	
1000	3	
1100	5	
1200	20	**
1300		
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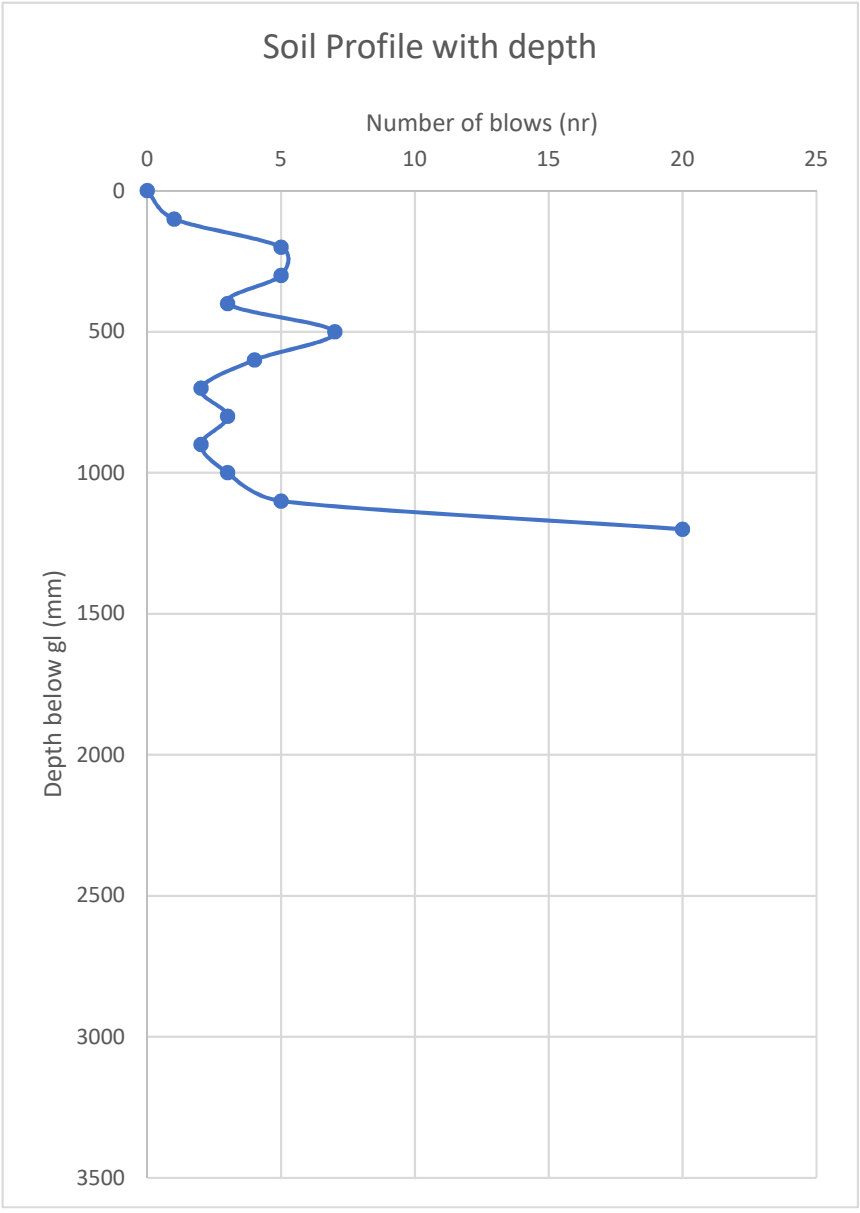

** At depth 1200mm, testing terminated at 20 blows. No movement - recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 4	Easting =	161207	**MP8**
		Northing =	202900	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	4	
300	10	
400	8	
500	8	
600	4	
700	20	**
800		
900		
1000		
1100		
1200		
1300		
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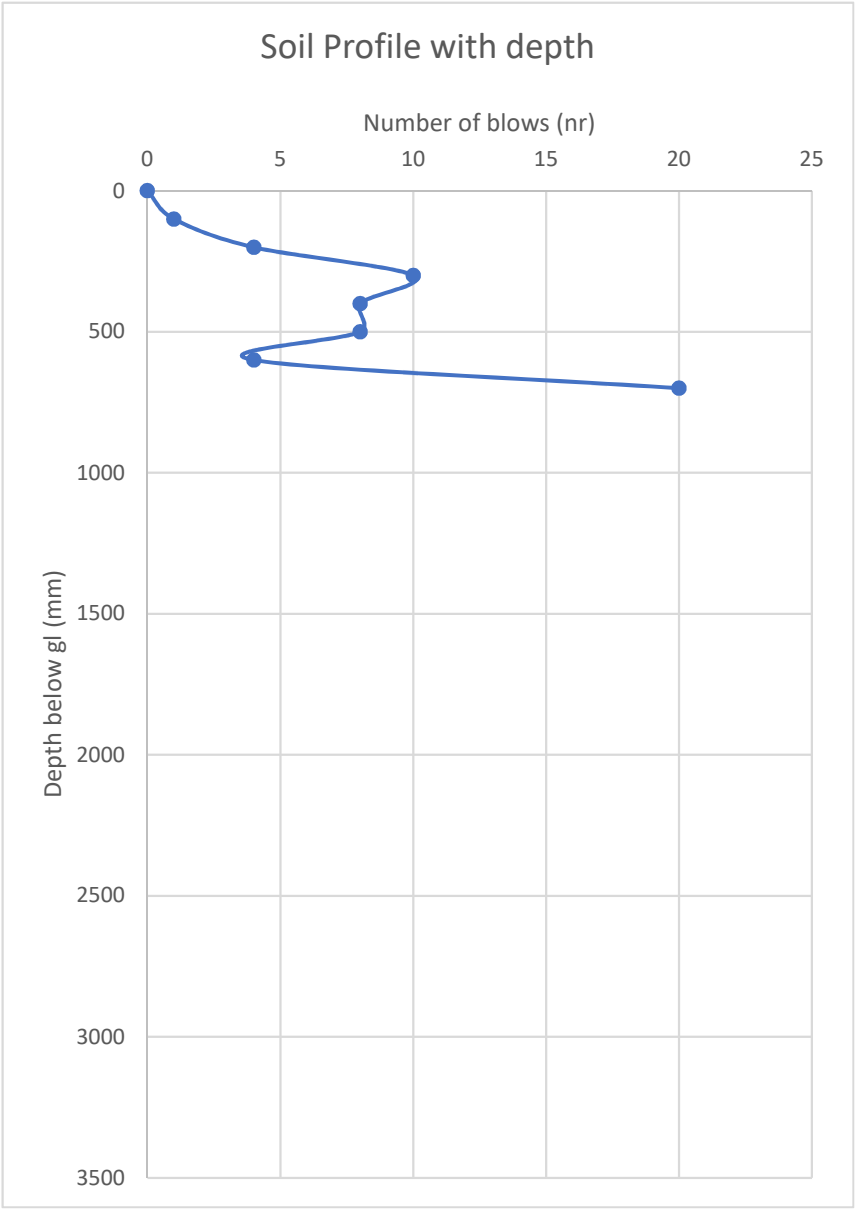

** At depth 700mm, testing terminated at 20 blows. No movement - recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 4	Easting =	161219	**MP9**
		Northing =	202881	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	8	
300	8	
400	4	
500	6	
600	4	
700	3	
800	2	
900	2	
1000	2	
1100	3	
1200	5	
1300	5	
1400	20	**
1500		
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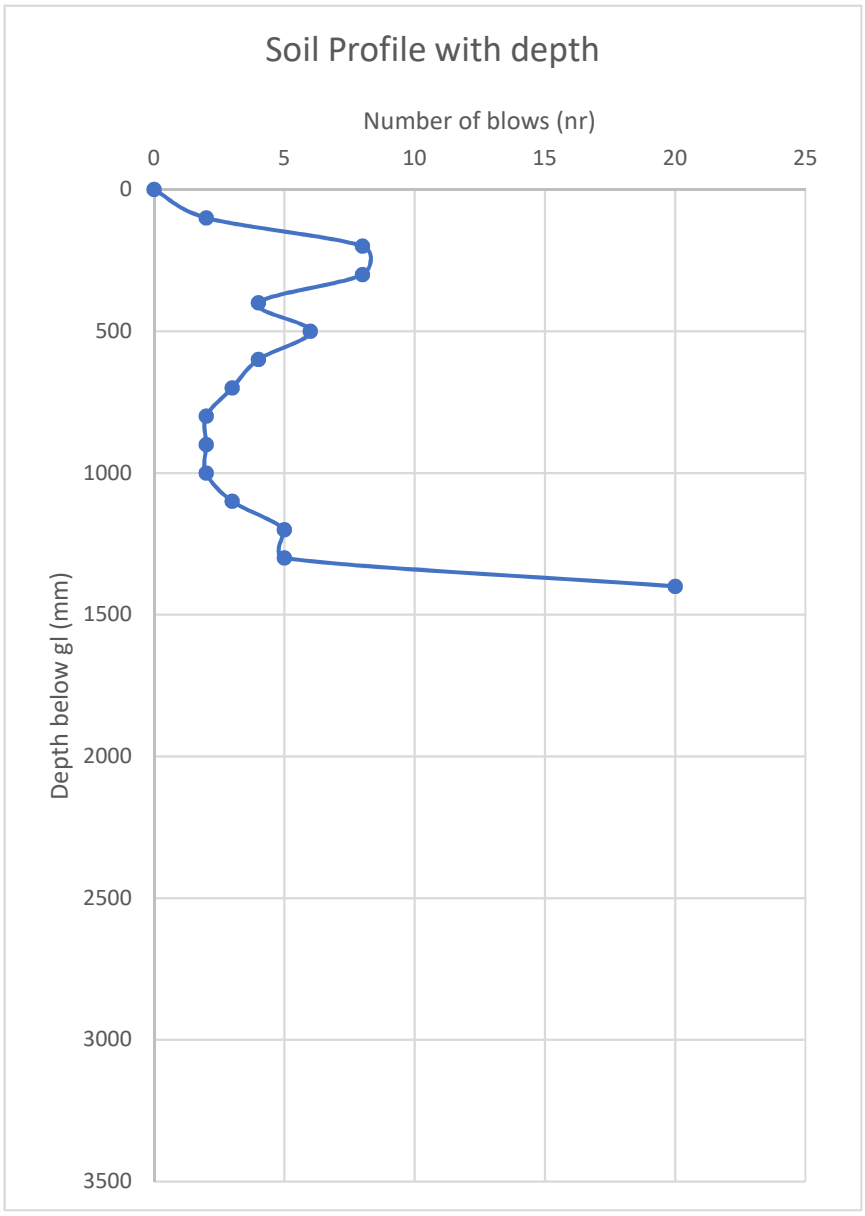
3000		



** At depth 1400mm, testing terminated at 20 blows. No movement - recoil of probe.
*Possible rock.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 3	Easting =	161244	**MP10**
		Northing =	203022	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	3	
200	7	
300	6	
400	8	
500	8	
600	20	**
700		
800		
900		
1000		
1100		
1200		
1300		
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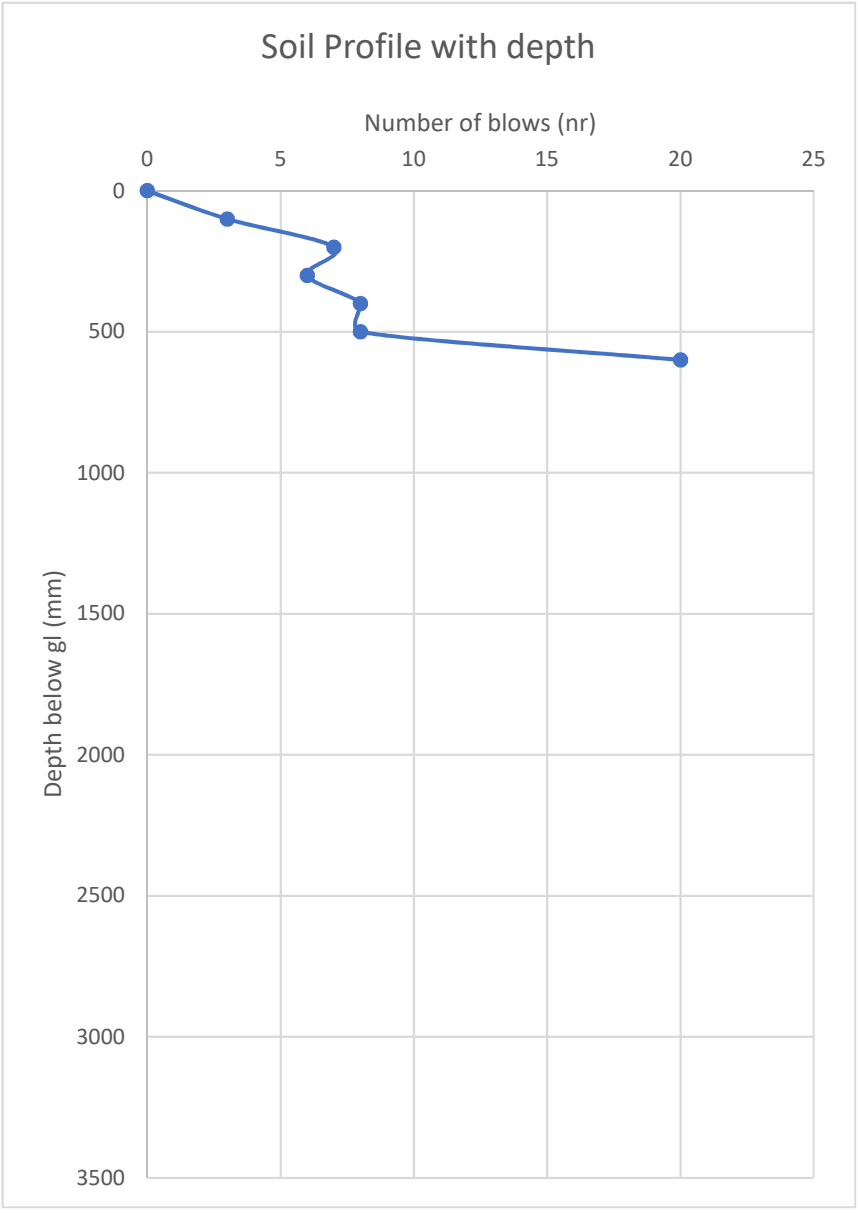

** At depth 600mm, testing terminated at 20 blows. No movement - recoil of probe.
*Possible rock.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 3	Easting =	161252	**MP11**
		Northing =	203031	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	5	
300	5	
400	4	
500	4	
600	2	
700	2	
800	1	
900	2	
1000	2	
1100	13	
1200	15	
1300	16	
1400	11	
1500	9	
1600	5	
1700	4	
1800	3	
1900	1	
2000	20	**
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2200		
2300		
2400		
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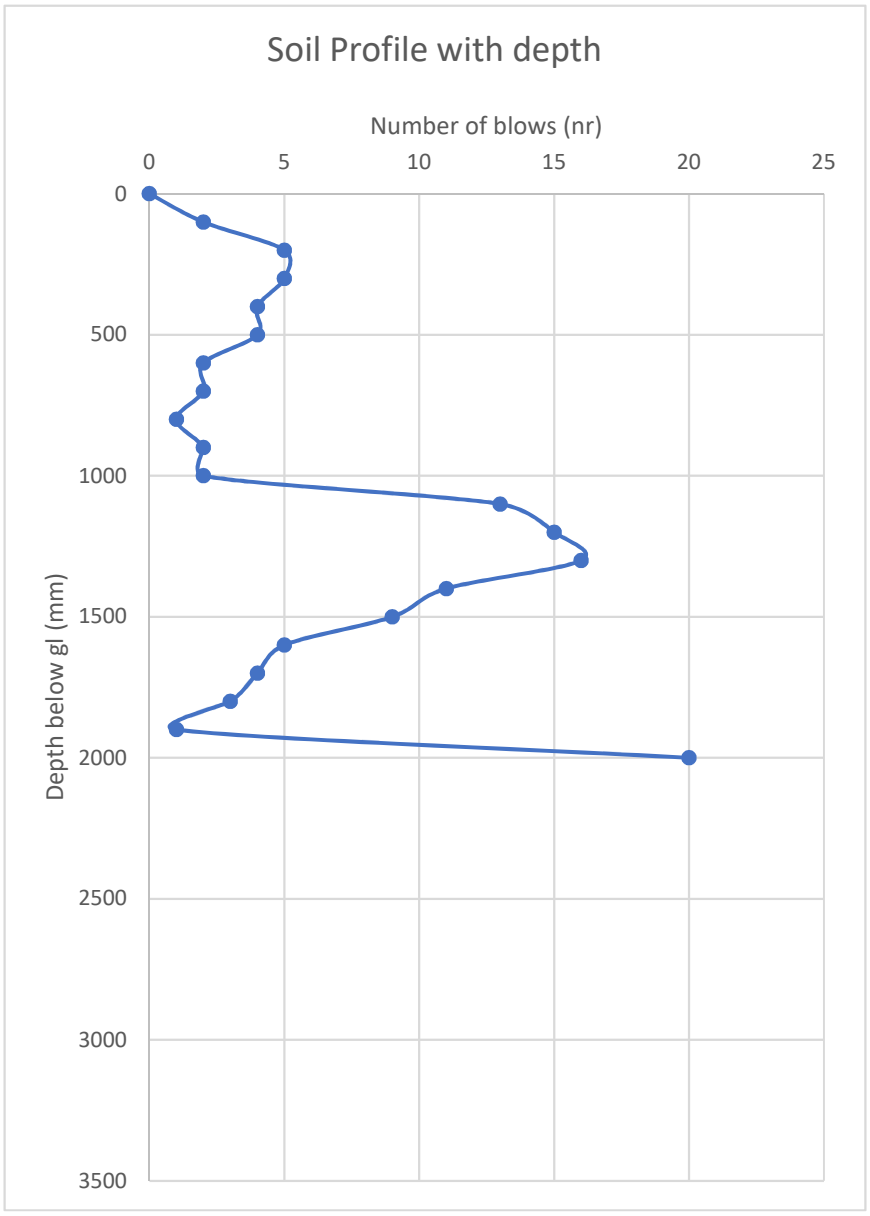
2700		
2800		
2900		
3000		



** At depth 2000mm, testing terminated at 20 blows. No movement - recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 3	Easting =	161247	**MP12**
		Northing =	203024	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	5	
200	11	
300	8	
400	10	
500	11	
600	13	
700	20	**
800		
900		
1000		
1100		
1200		
1300		
1400		
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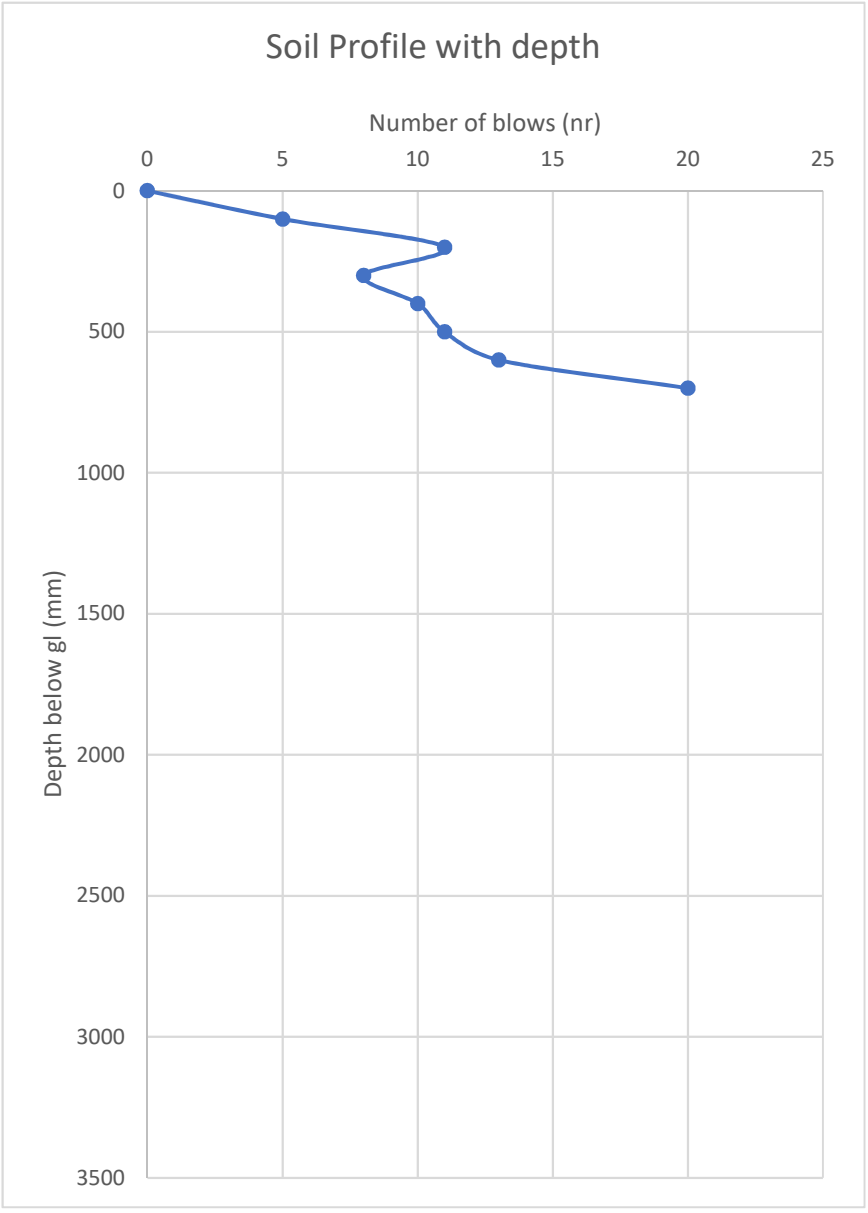
3000		

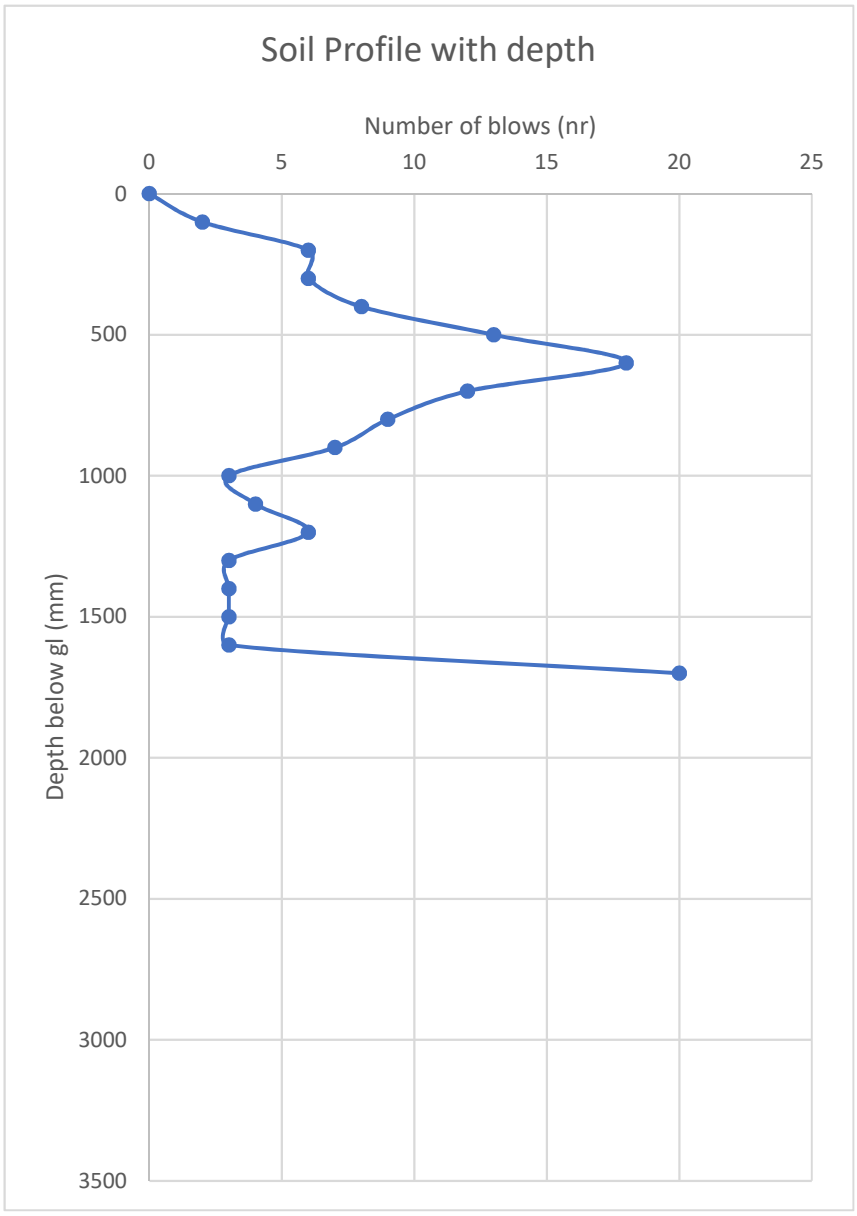


** At depth 700mm, testing terminated at 20 blows. No movement - recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 3	Easting =	161248	**MP13**
		Northing =	203035	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	6	
300	6	
400	8	
500	13	
600	18	
700	12	
800	9	
900	7	
1000	3	
1100	4	
1200	6	
1300	3	
1400	3	
1500	3	
1600	3	
1700	20	**
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

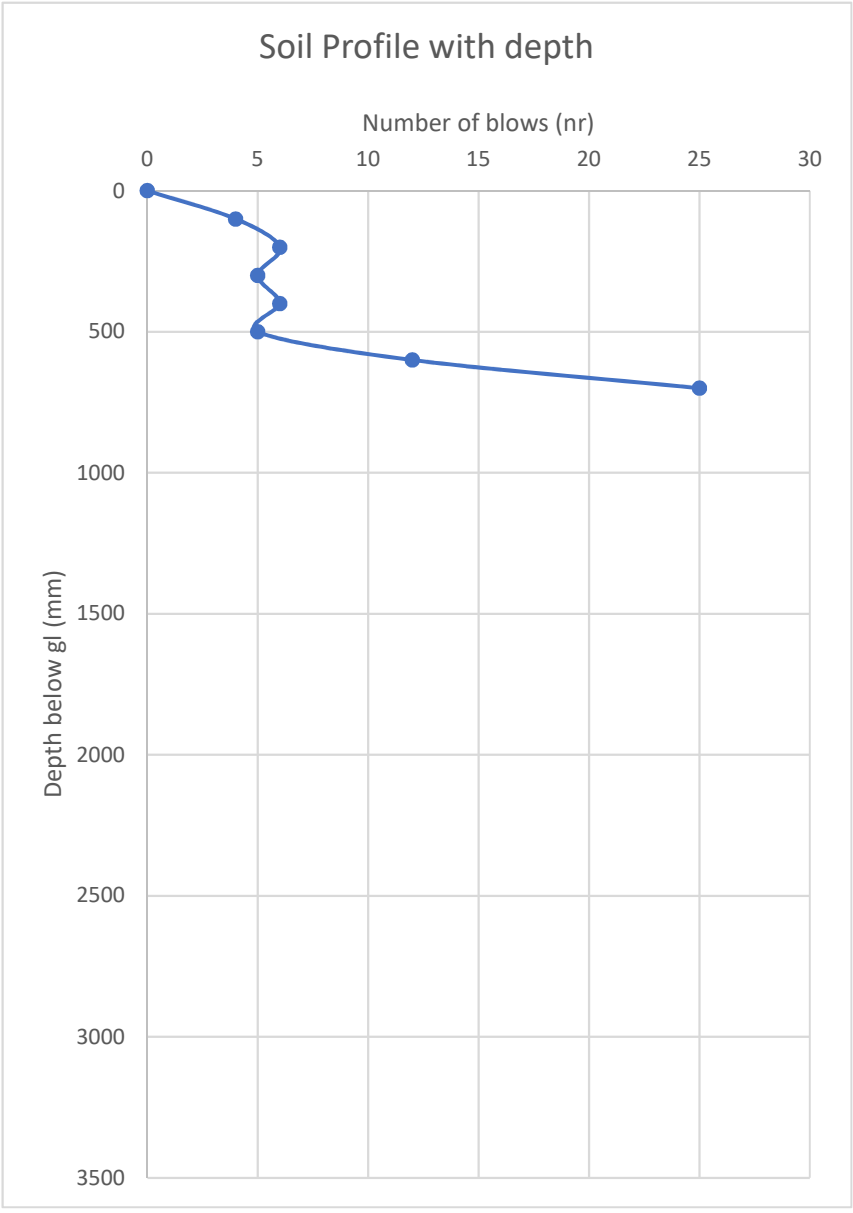


** At depth 1700mm, testing terminated at 20 blows. No movement - recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 3	Easting =	161260	**MP14**
		Northing =	203038	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	4	
200	6	
300	5	
400	6	
500	5	
600	12	
700	25	**
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

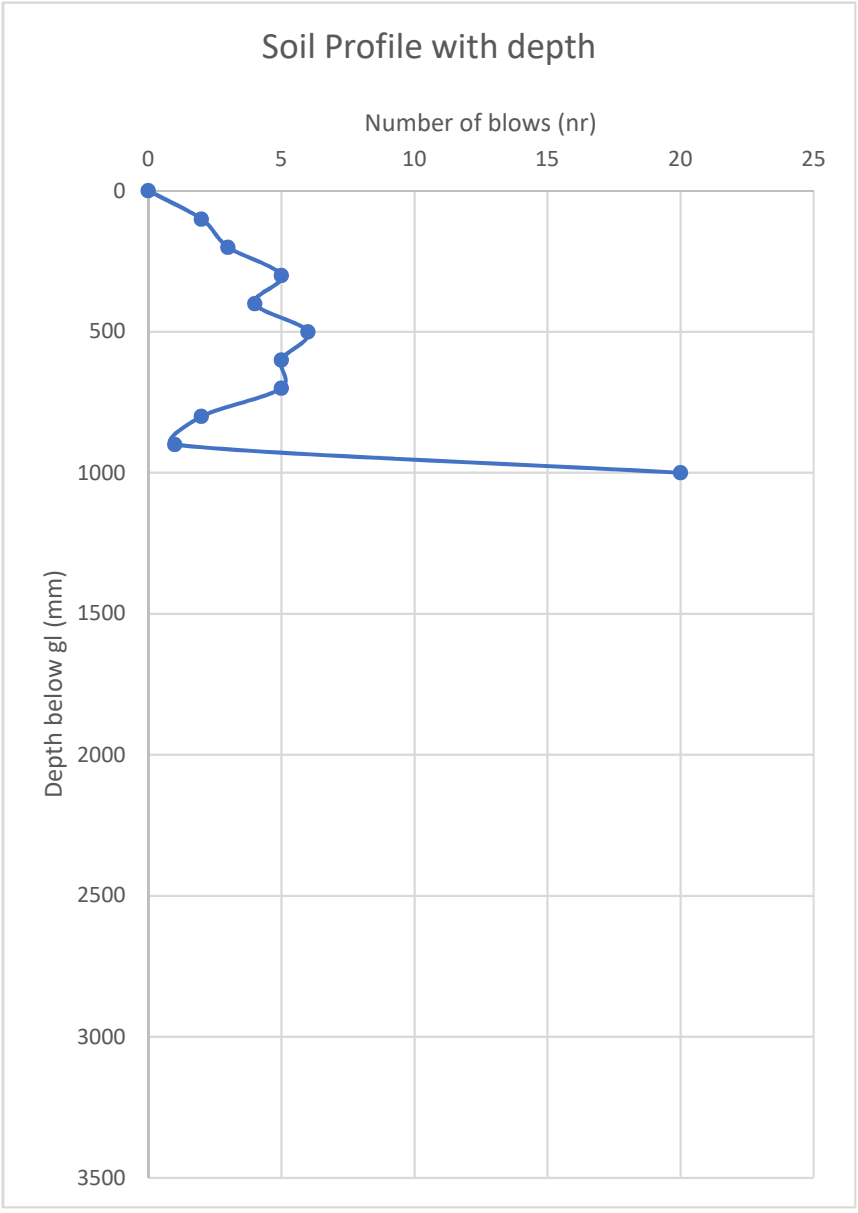


** At depth 700mm, testing terminated at 25 blows. No movement - recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 3	Easting =	161249	**MP15**
		Northing =	203037	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	3	
300	5	
400	4	
500	6	
600	5	
700	5	
800	2	
900	1	
1000	20	**
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

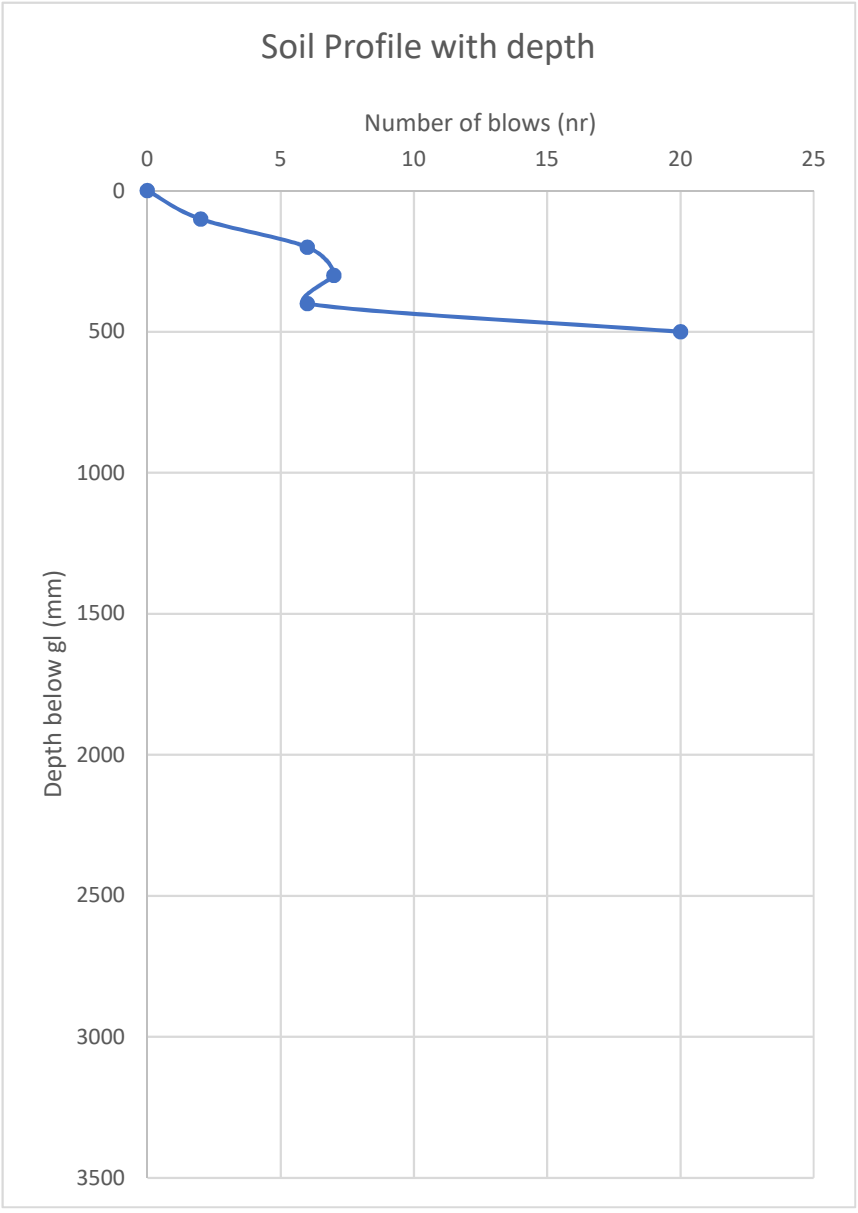


** At depth 1000mm, testing terminated at 20 blows. No movement - recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 3	Easting =	161258	**MP16**
		Northing =	203039	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	6	
300	7	
400	6	
500	20	**
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		



** At depth 500mm, testing terminated at 20 blows. No movement - recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 3	Easting =	161265	**MP17**
		Northing =	203046	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	3	
300	3	
400	4	
500	20	**
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
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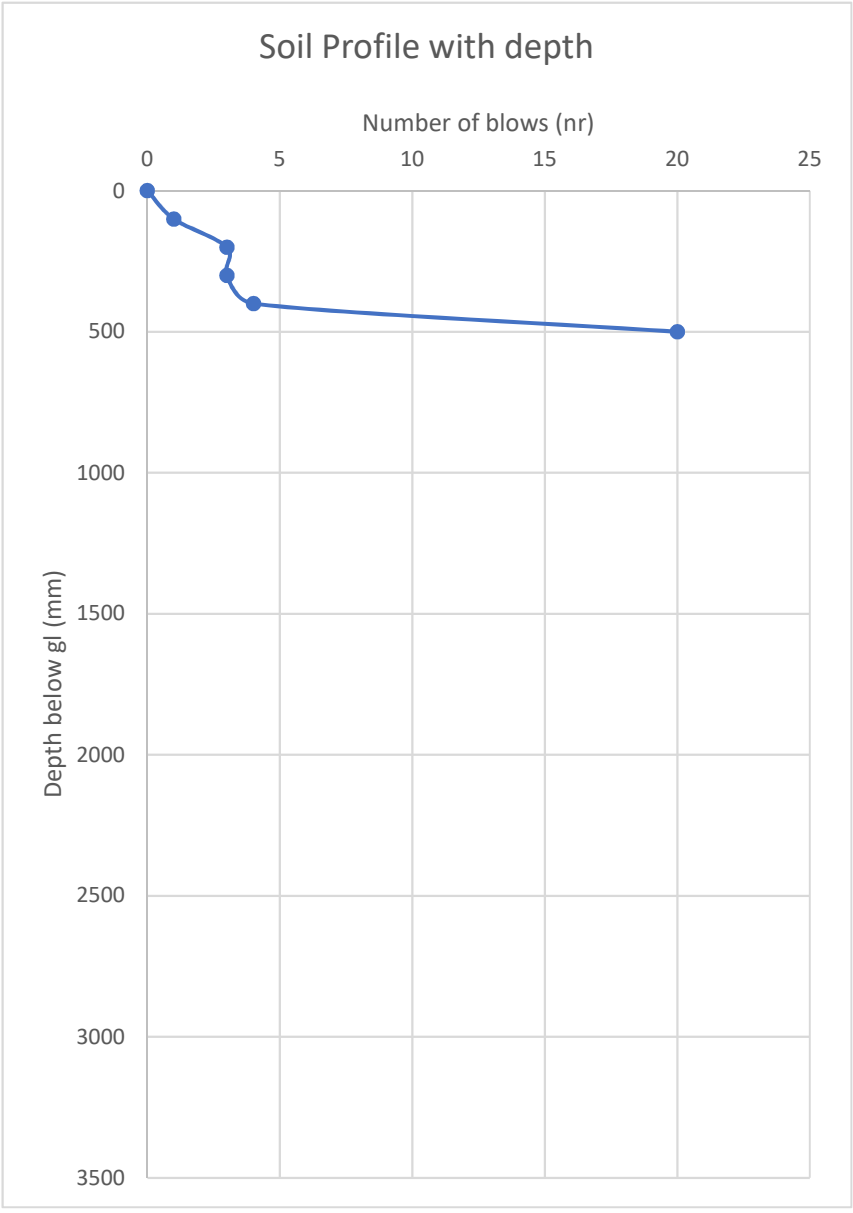
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

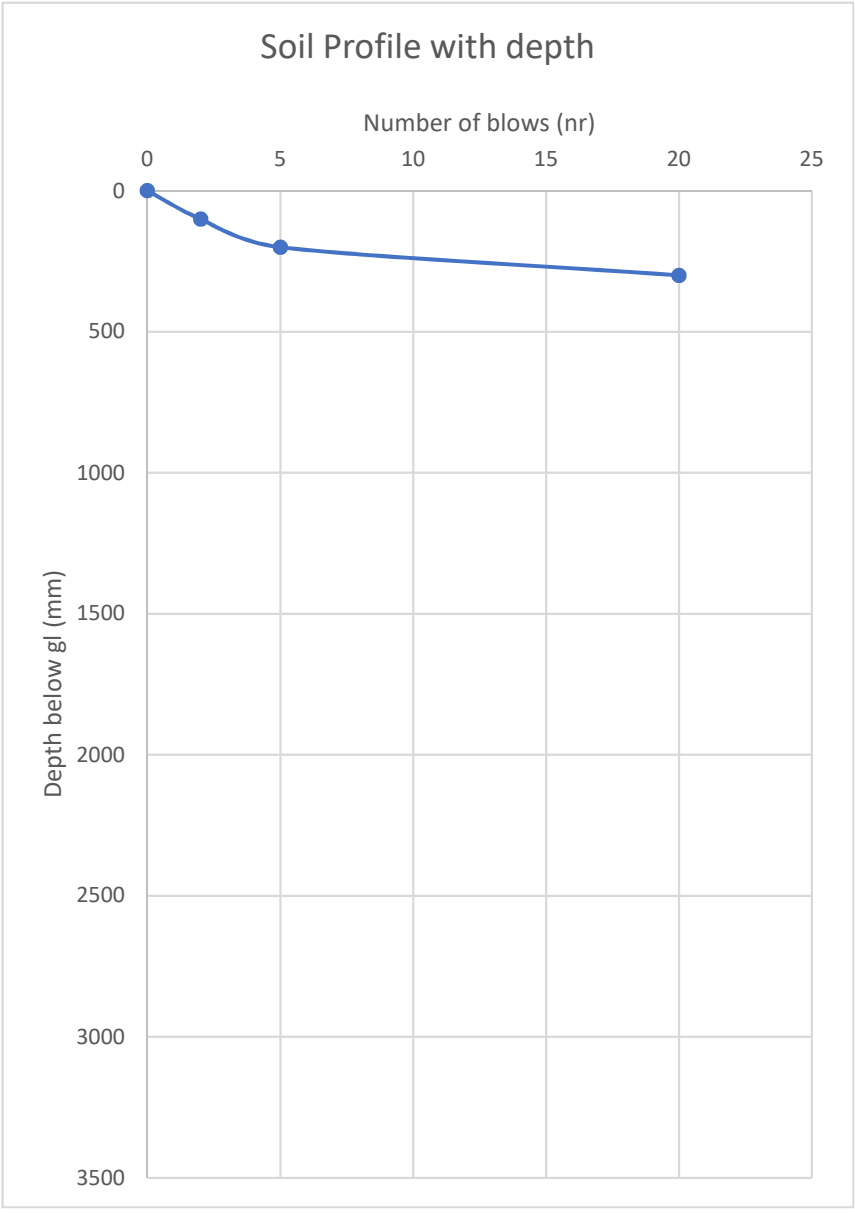


** At depth 500mm, testing terminated at 20 blows. No movement - recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 3	Easting =	161283	**MP18**
		Northing =	203052	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	5	
300	20	**
400		
500		
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

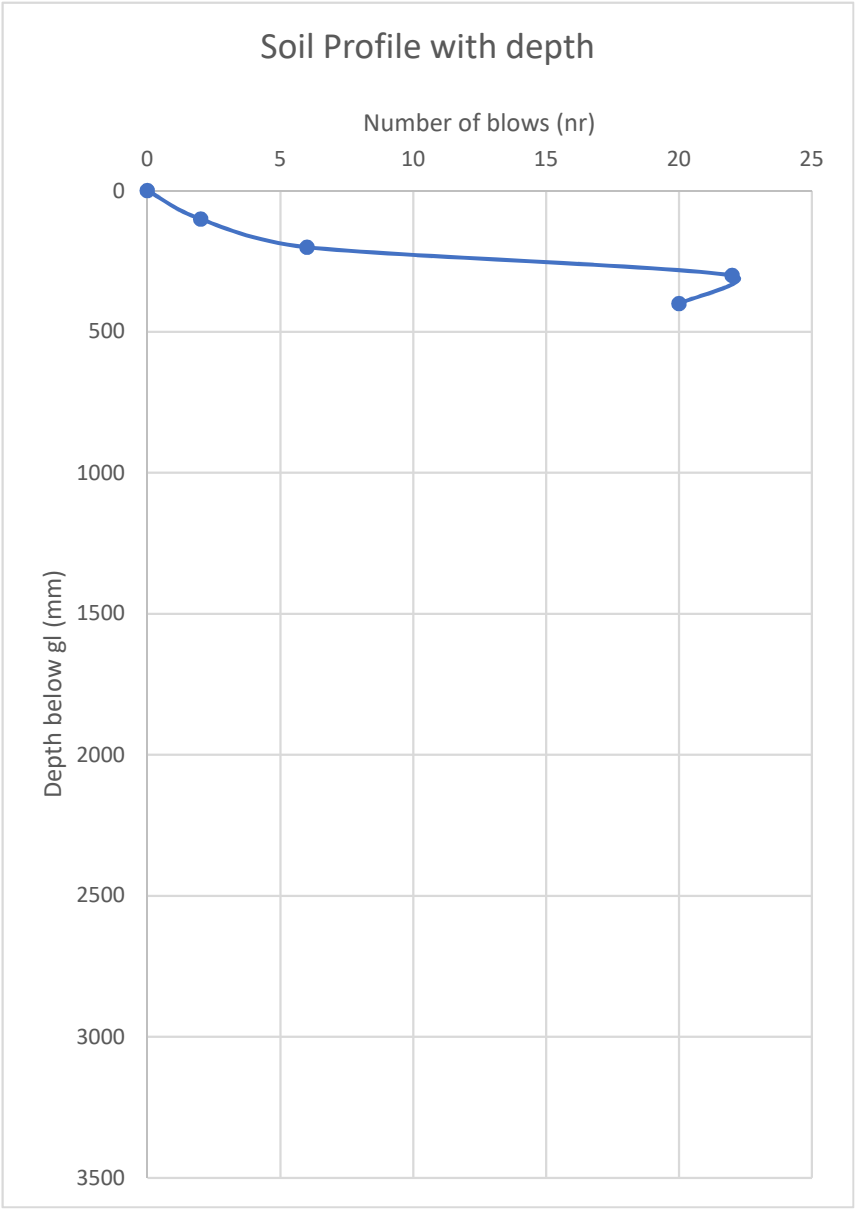


** At depth 300mm, testing terminated at 20 blows. No movement - recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 3	Easting =	161278	**MP19**
		Northing =	203052	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	6	
300	22	
400	20	**
500		
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

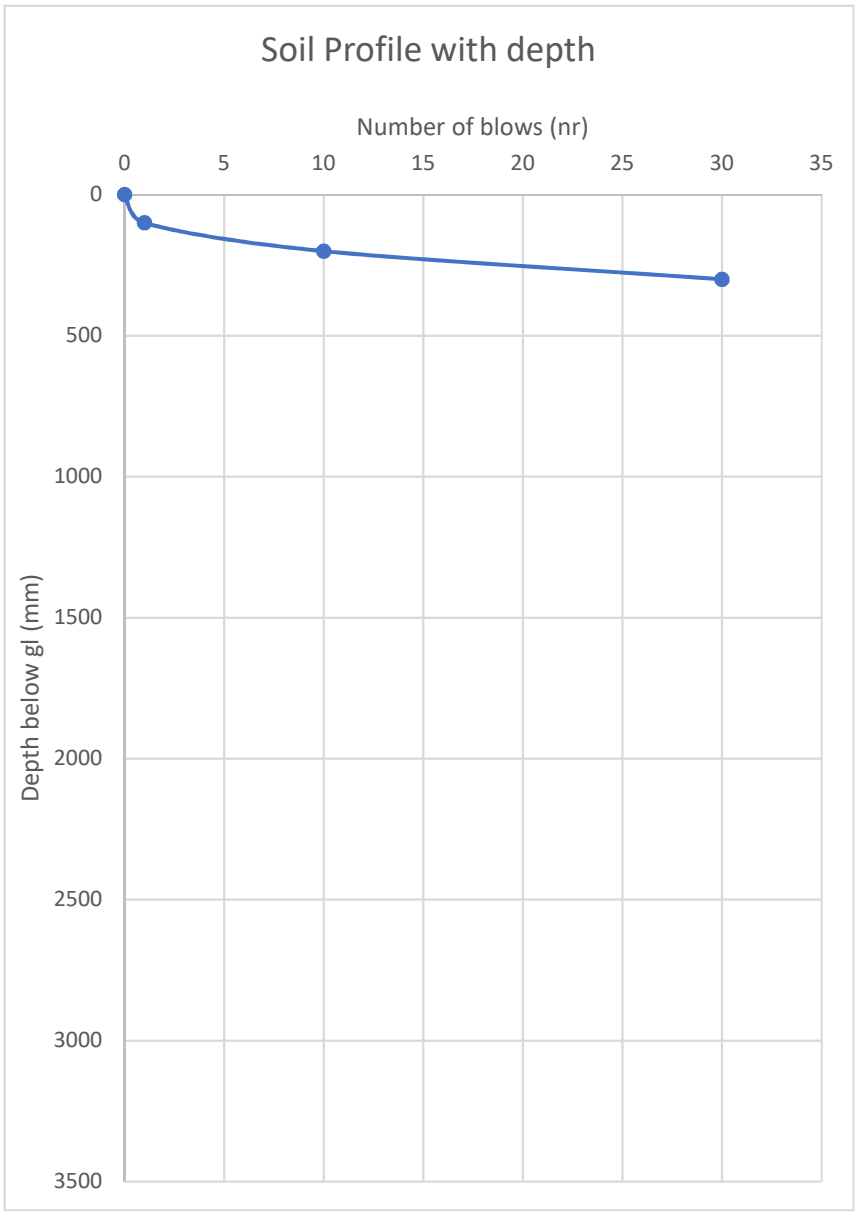


** At depth 400mm, testing terminated at 20 blows. No movement - recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 3	Easting =	161284	**MP20**
		Northing =	203062	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	10	
300	30	**
400		
500		
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

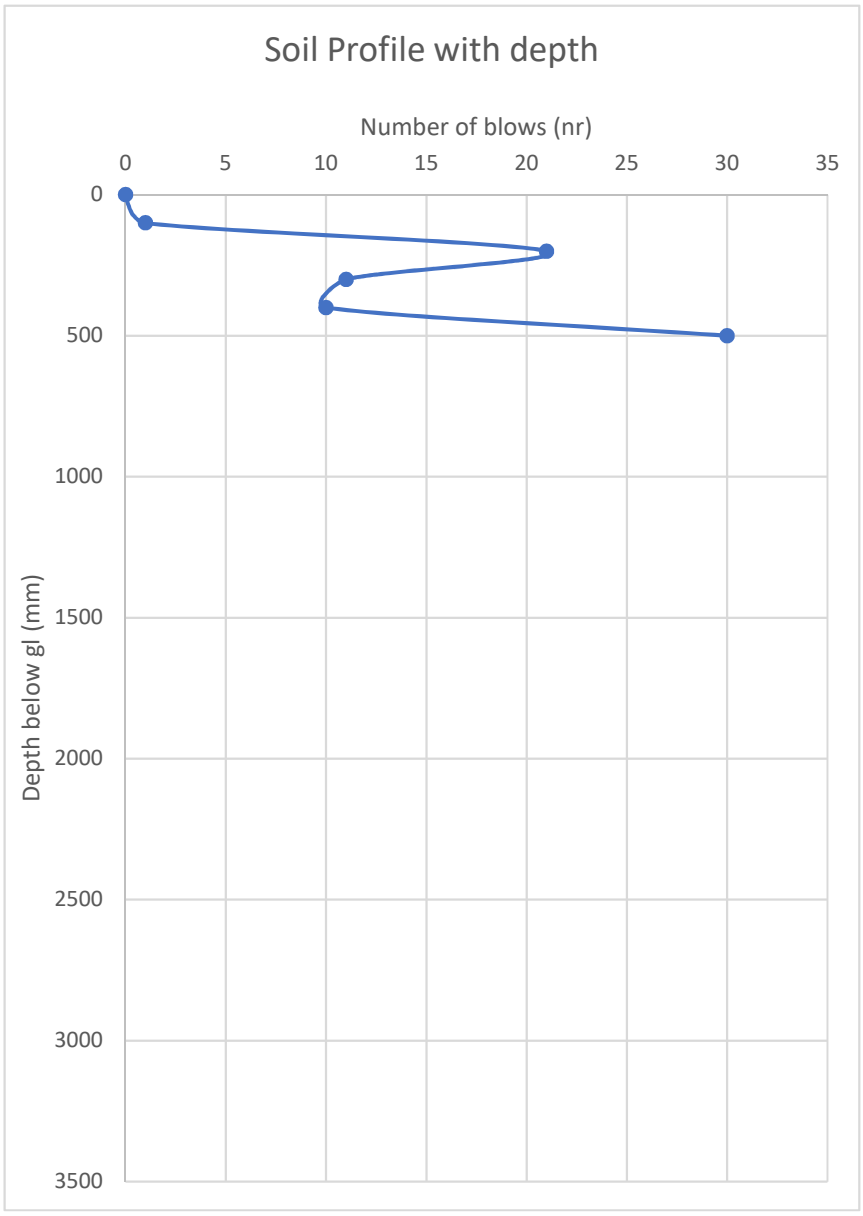


** At depth 300mm, testing terminated at 30 blows. No movement - recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 3	Easting =	161271	**MP21**
		Northing =	203059	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	21	
300	11	
400	10	
500	30	**
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

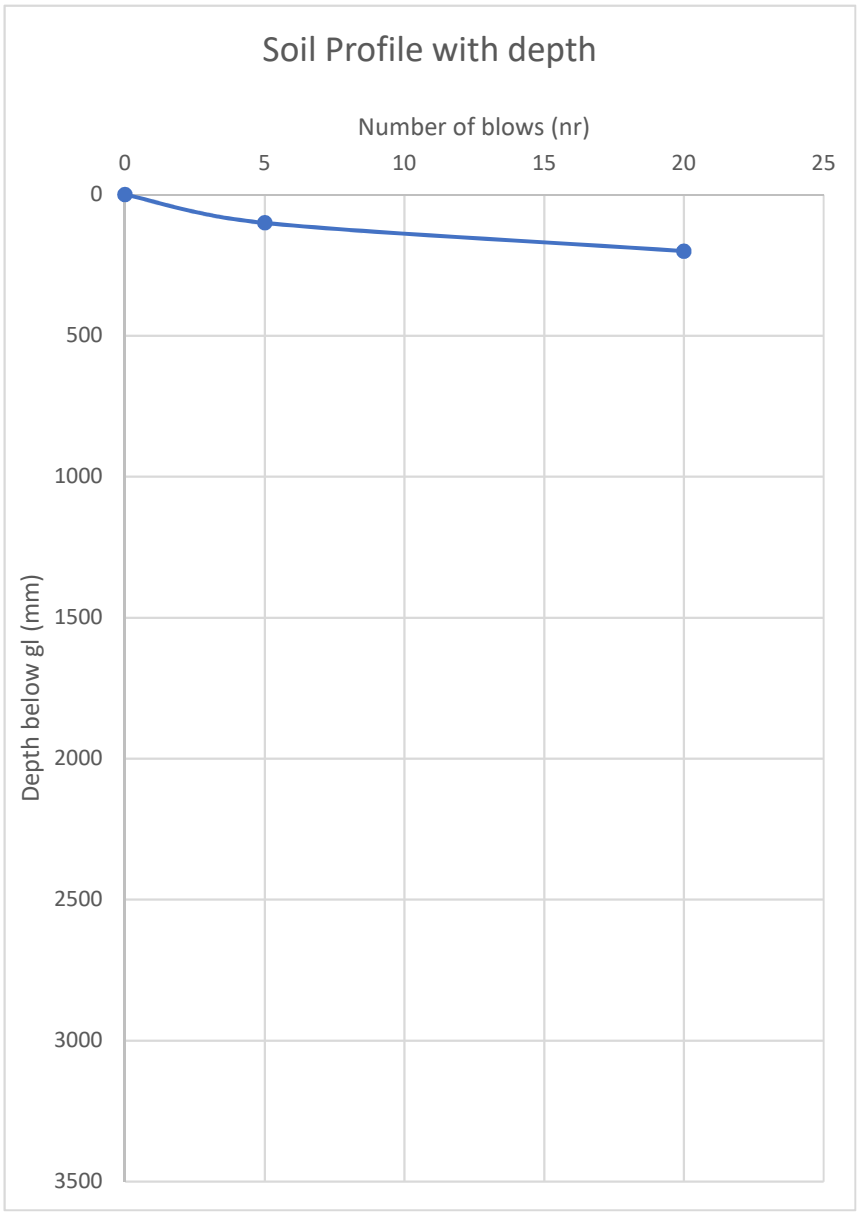


** At depth 500mm, testing terminated at 30 blows. No movement - recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 3	Easting =	161269	**MP22**
		Northing =	203054	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	5	
200	20	**
300		
400		
500		
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

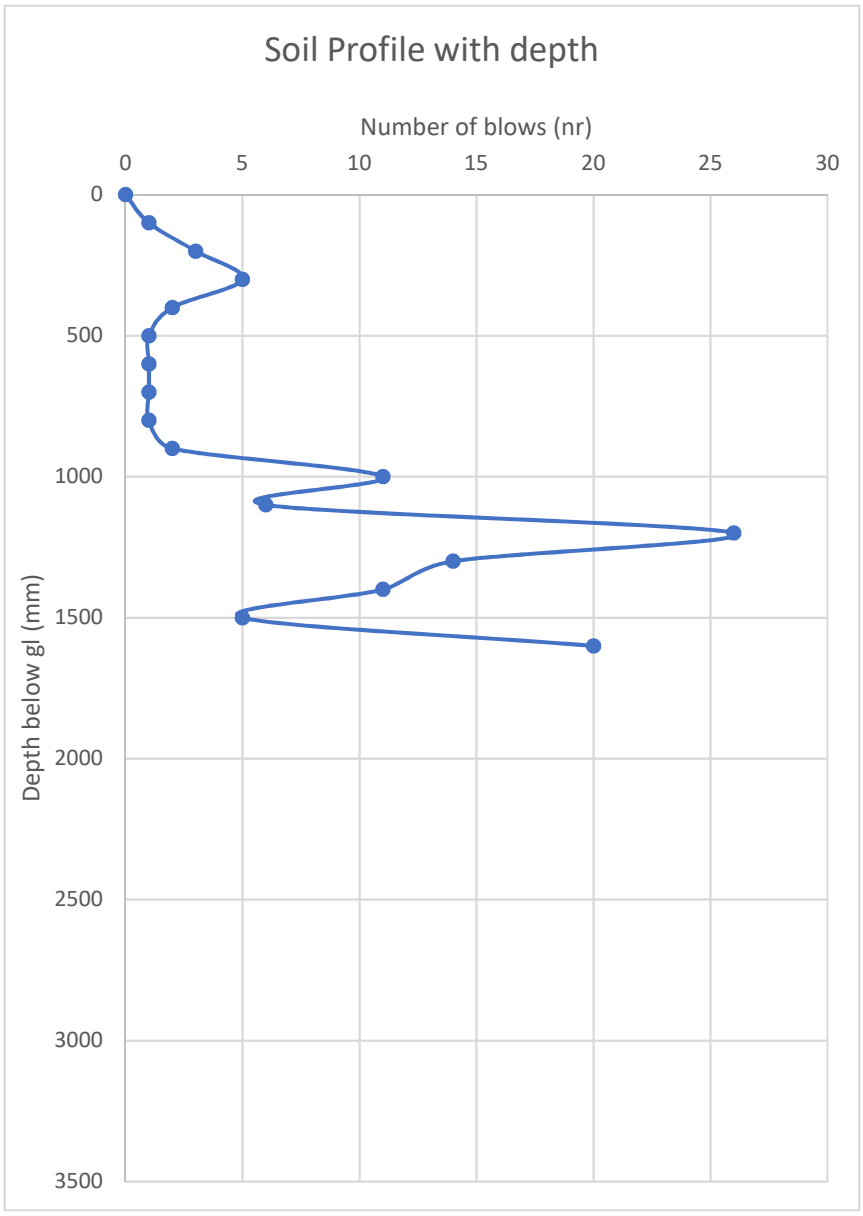


** At depth 200mm, testing terminated at 20 blows. No movement - recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 3	Easting =	161250	**MP23**
		Northing =	203025	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	20/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	3	
300	5	
400	2	
500	1	
600	1	
700	1	
800	1	
900	2	
1000	11	
1100	6	
1200	26	
1300	14	
1400	11	
1500	5	
1600	20	**
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

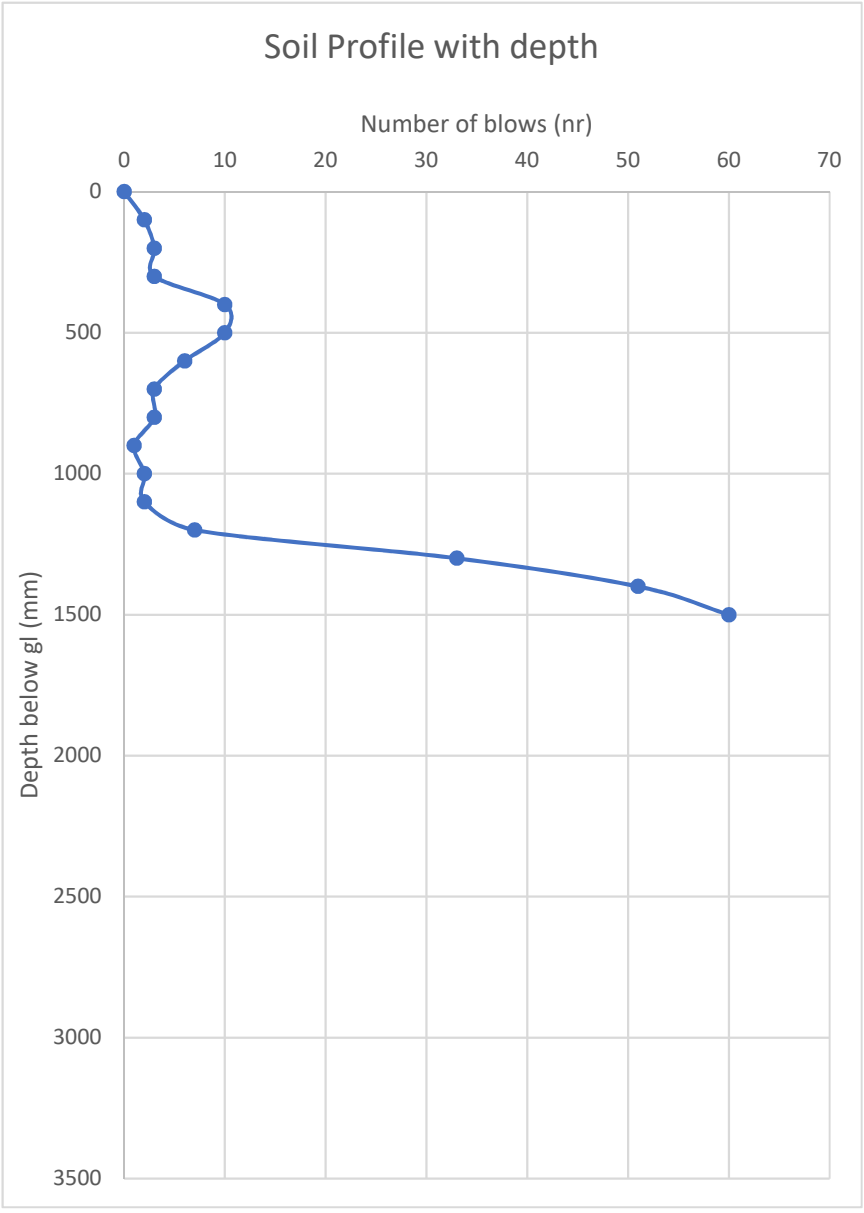


** At depth 1600mm, testing terminated at 20 blows. No movement - recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repositary Area @ Barrage 3	Easting =	161236	**MP24**
		Northing =	203051	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	3	
300	3	
400	10	
500	10	
600	6	
700	3	
800	3	
900	1	
1000	2	
1100	2	
1200	7	
1300	33	
1400	51	
1500	60	**
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

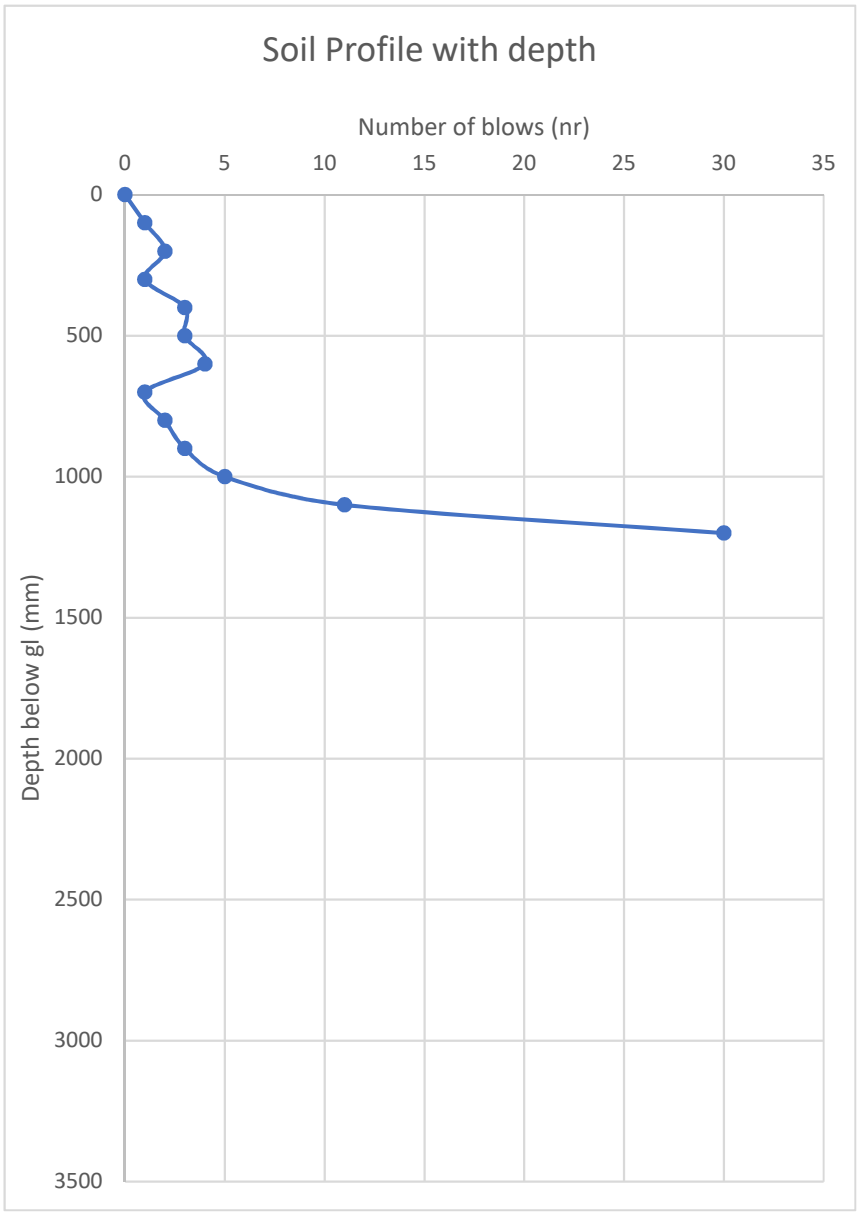


** At depth 1500mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repositary Area @ Barrage 3	Easting =	161247	**MP25**
		Northing =	203056	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	2	
300	1	
400	3	
500	3	
600	4	
700	1	
800	2	
900	3	
1000	5	
1100	11	
1200	30	**
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

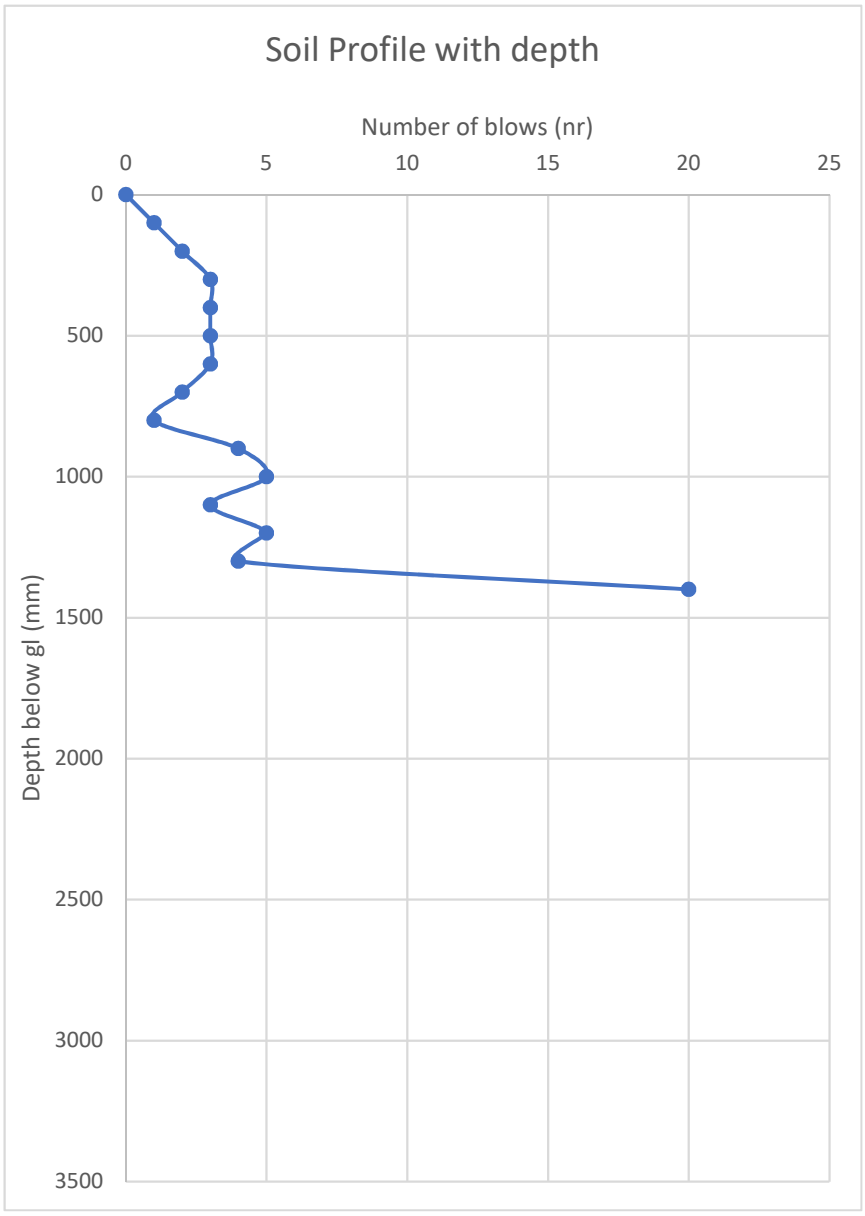


** At depth 1200mm, testing terminated at 30 blows. No movement - Recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repositary Area @ Barrage 3	Easting =	161250	**MP26**
		Northing =	203061	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	2	
300	3	
400	3	
500	3	
600	3	
700	2	
800	1	
900	4	
1000	5	
1100	3	
1200	5	
1300	4	
1400	20	**
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

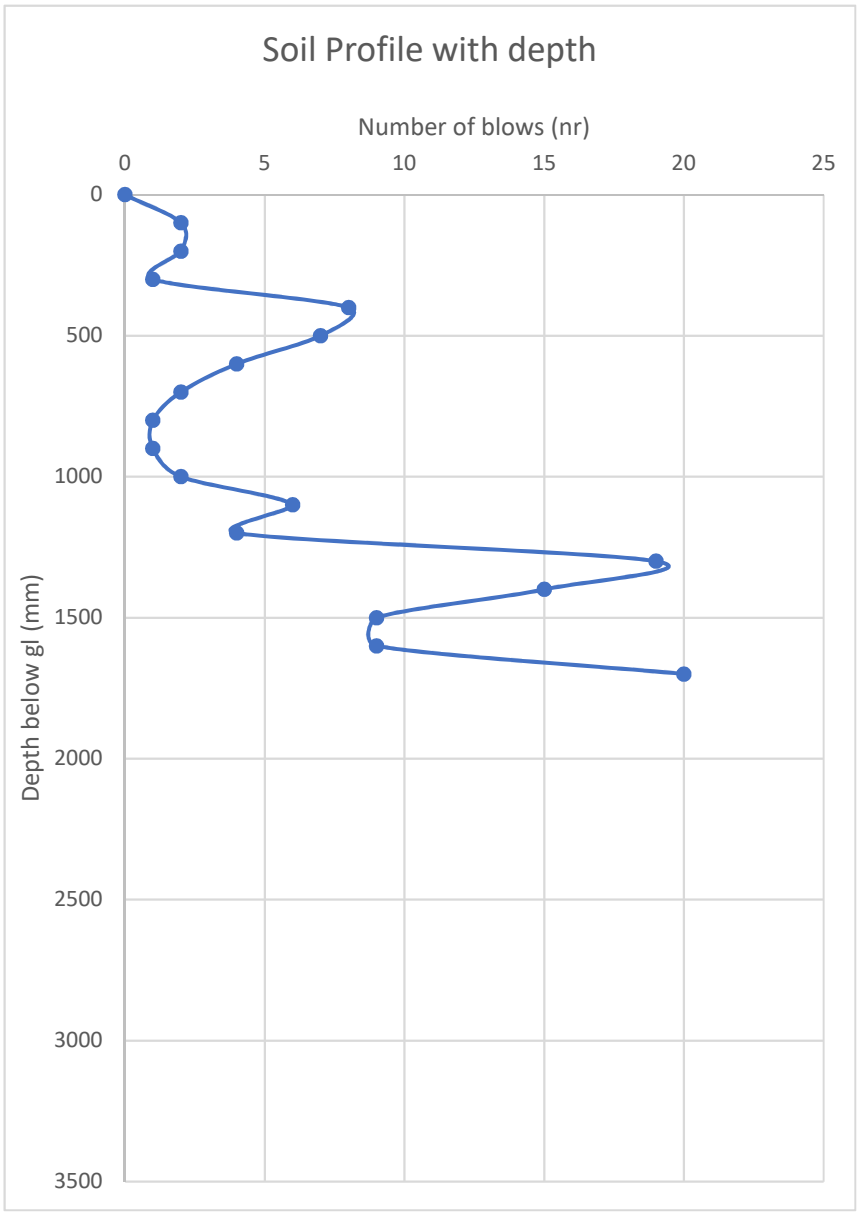


** At depth 1400mm, testing terminated at 20 blows. No movement - Recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repositary Area @ Barrage 3	Easting =	161261	**MP27**
		Northing =	203065	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	2	
300	1	
400	8	
500	7	
600	4	
700	2	
800	1	
900	1	
1000	2	
1100	6	
1200	4	
1300	19	
1400	15	
1500	9	
1600	9	
1700	20	**
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

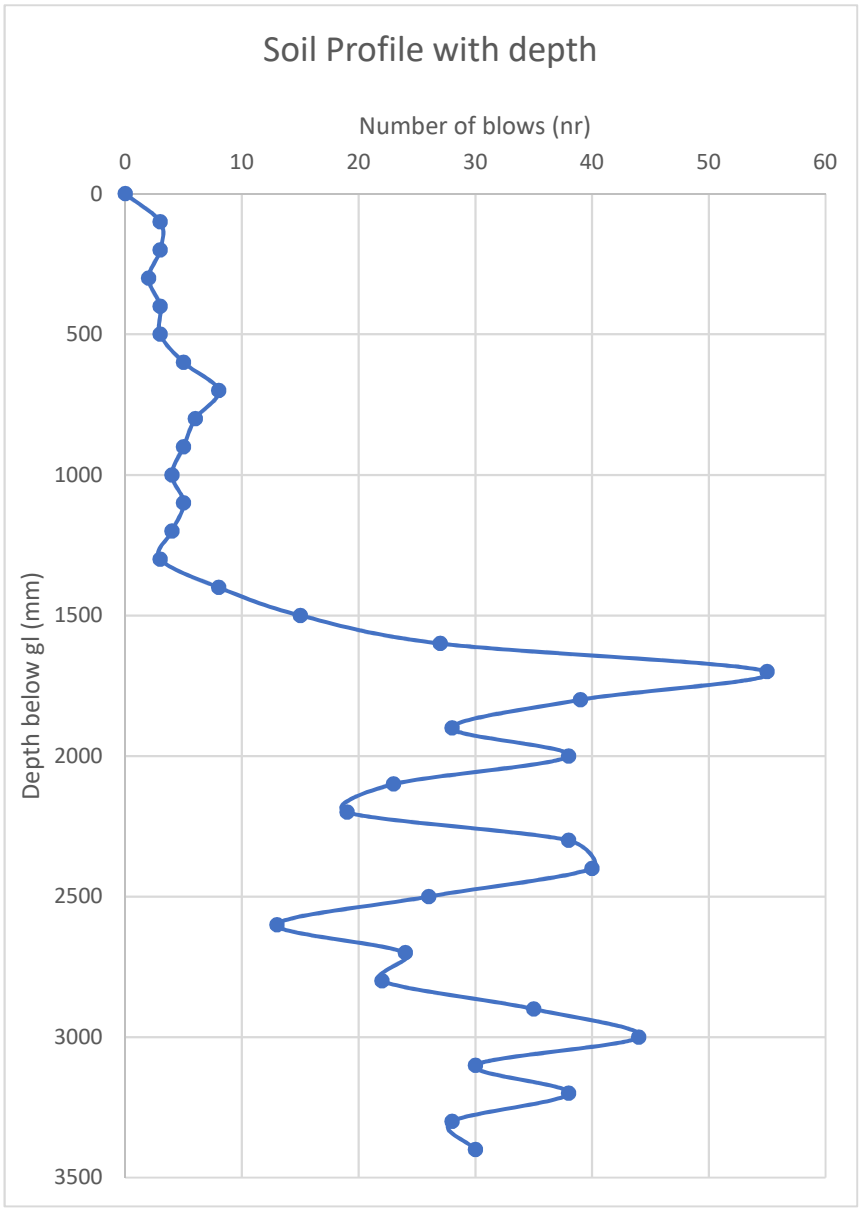


** At depth 1700mm, testing terminated at 20 blows. No movement - Recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repositary Area @ Barrage 3	Easting =	161259	**MP28**
		Northing =	203072	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows
0	0
100	3
200	3
300	2
400	3
500	3
600	5
700	8
800	6
900	5
1000	4
1100	5
1200	4
1300	3
1400	8
1500	15
1600	27
1700	55
1800	39
1900	28
2000	38
2100	23
2200	19
2300	38
2400	40
2500	26
2600	13
2700	24
2800	22
2900	35
3000	44
3100	30
3200	38
3300	28
3400	30 **

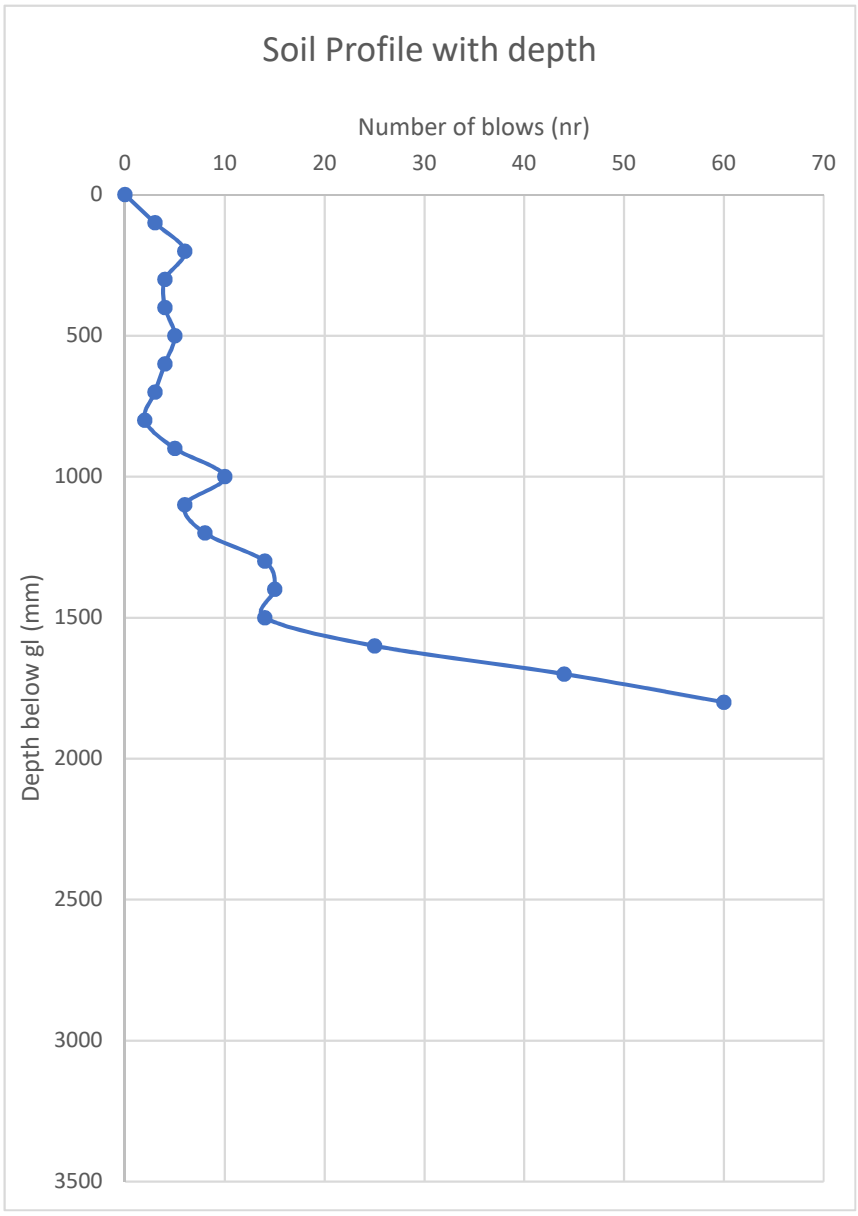


** At depth 3400mm, testing terminated at 30 blows. No movement - Recoil of probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repositary Area @ Barrage 3	Easting =	161255	**MP29**
		Northing =	203070	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	3	
200	6	
300	4	
400	4	
500	5	
600	4	
700	3	
800	2	
900	5	
1000	10	
1100	6	
1200	8	
1300	14	
1400	15	
1500	14	
1600	25	
1700	44	
1800	60	**
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

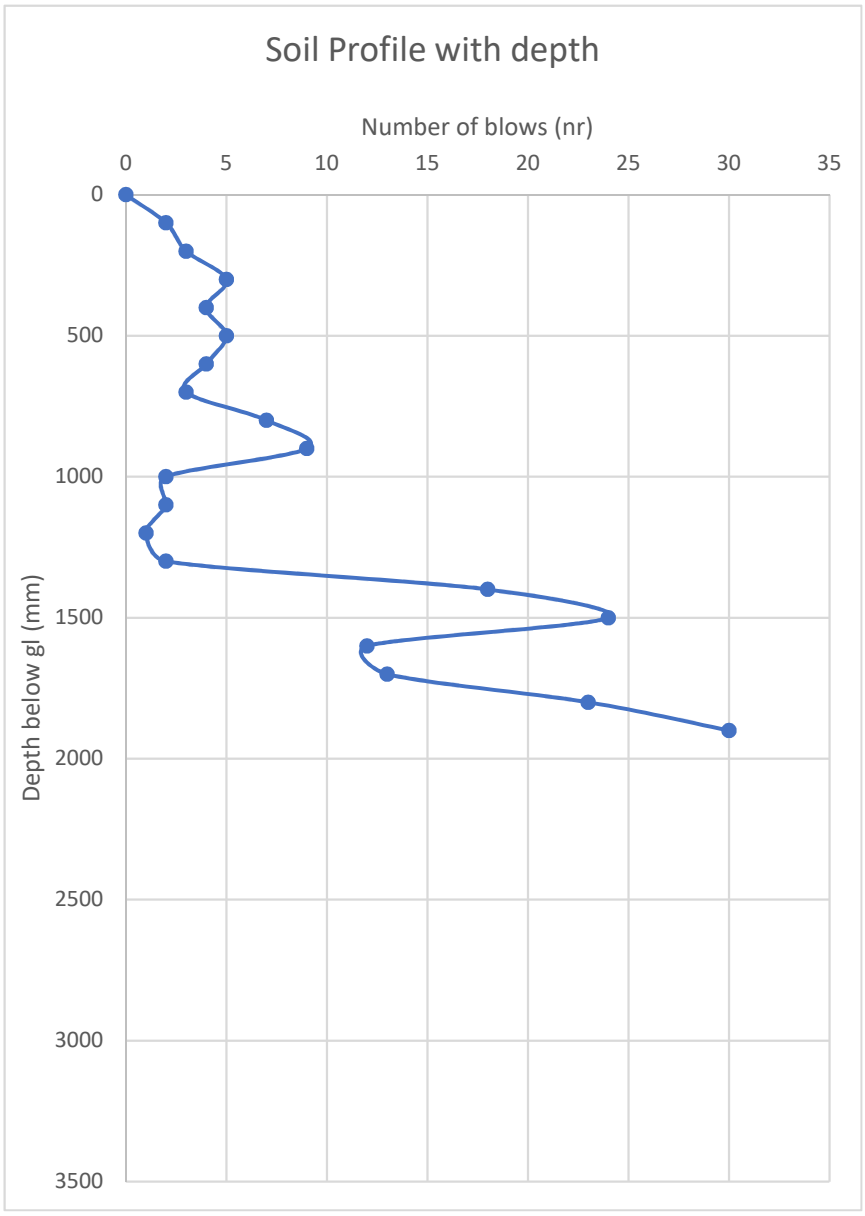


** At depth 1800mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repositary Area @ Barrage 3	Easting =	161247	**MP30**
		Northing =	203060	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	3	
300	5	
400	4	
500	5	
600	4	
700	3	
800	7	
900	9	
1000	2	
1100	2	
1200	1	
1300	2	
1400	18	
1500	24	
1600	12	
1700	13	
1800	23	
1900	30	**
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

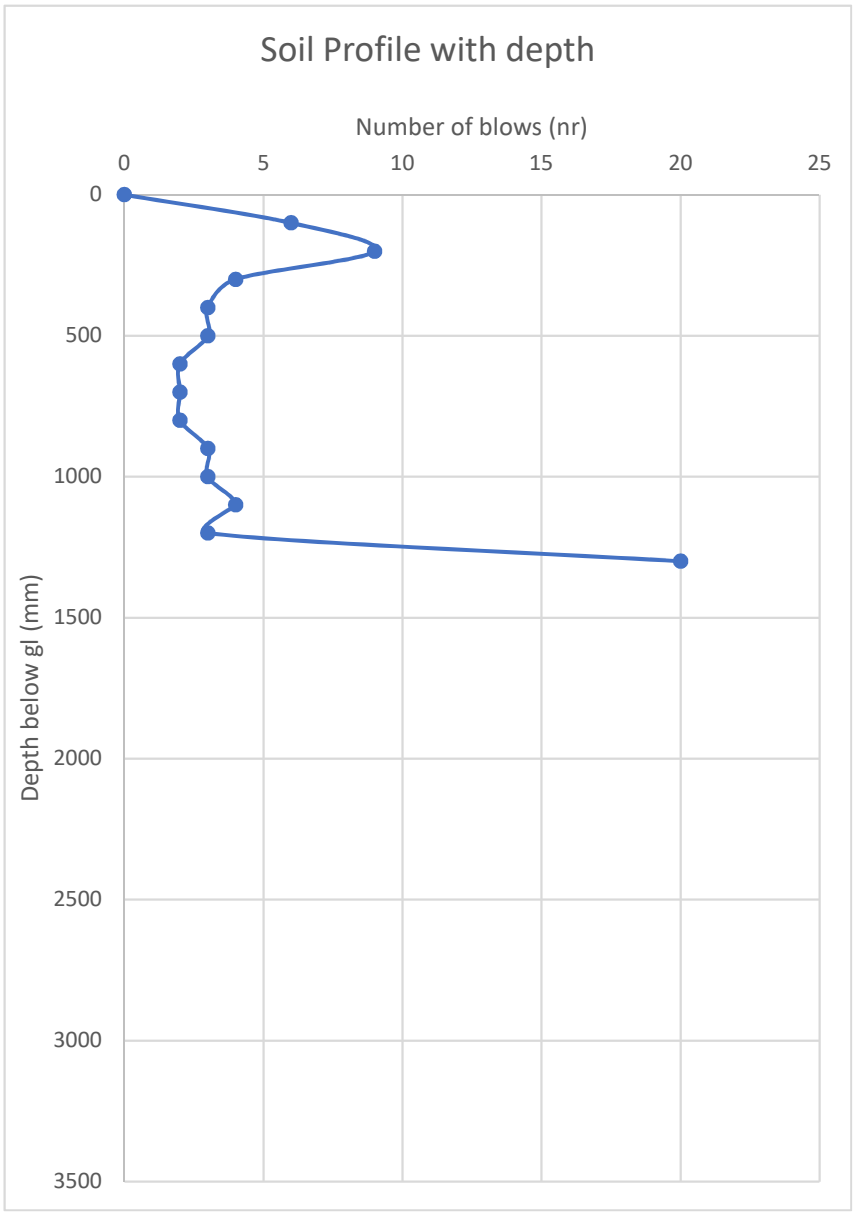


** At depth 1900mm, testing terminated at 30 blows. No movement - Recoil on probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repositary Area @ Barrage 3	Easting =	161235	**MP31**
		Northing =	203059	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	6	
200	9	
300	4	
400	3	
500	3	
600	2	
700	2	
800	2	
900	3	
1000	3	
1100	4	
1200	3	
1300	20	**
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

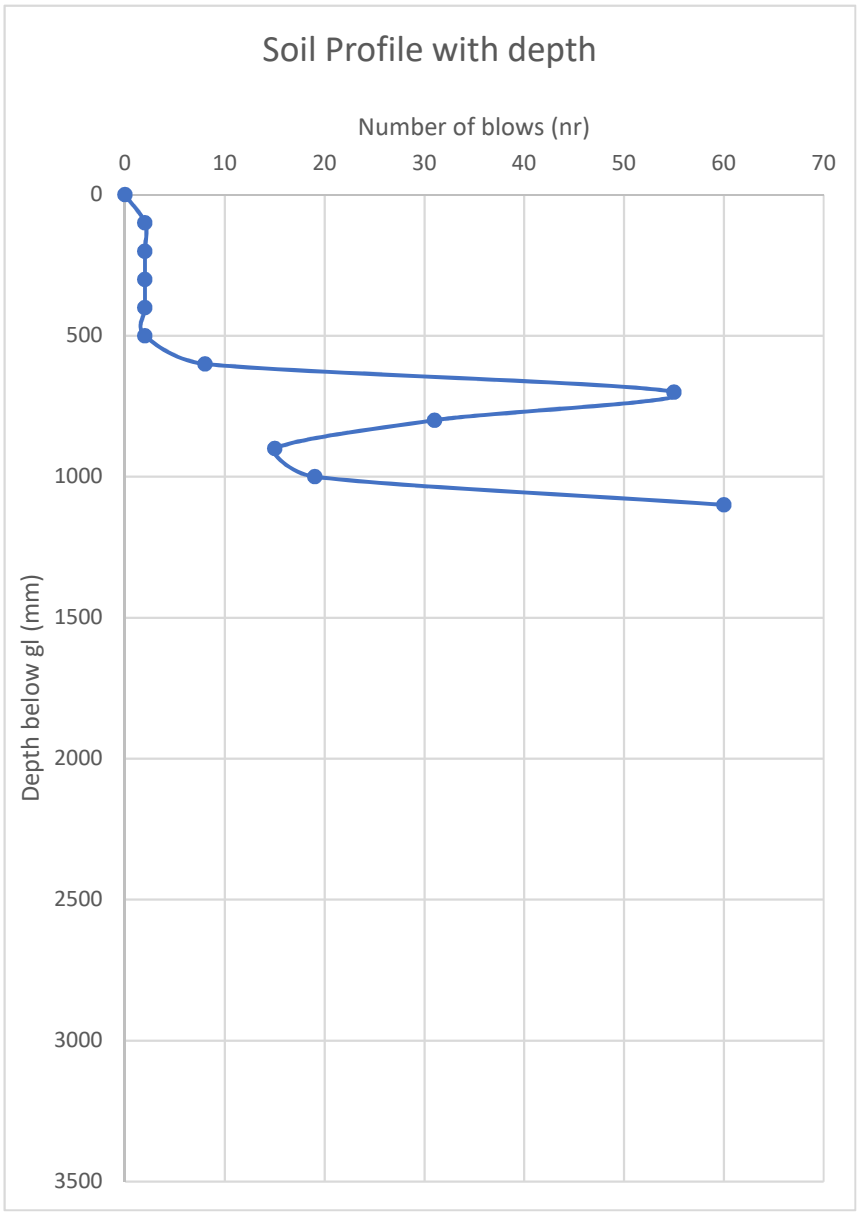


** At depth 1300mm, testing terminated at 20 blows. No movement - Recoil on probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repositary Area @ Barrage 3	Easting =	161237	**MP32**
		Northing =	203052	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	2	
300	2	
400	2	
500	2	
600	8	
700	55	
800	31	
900	15	
1000	19	
1100	60	**
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

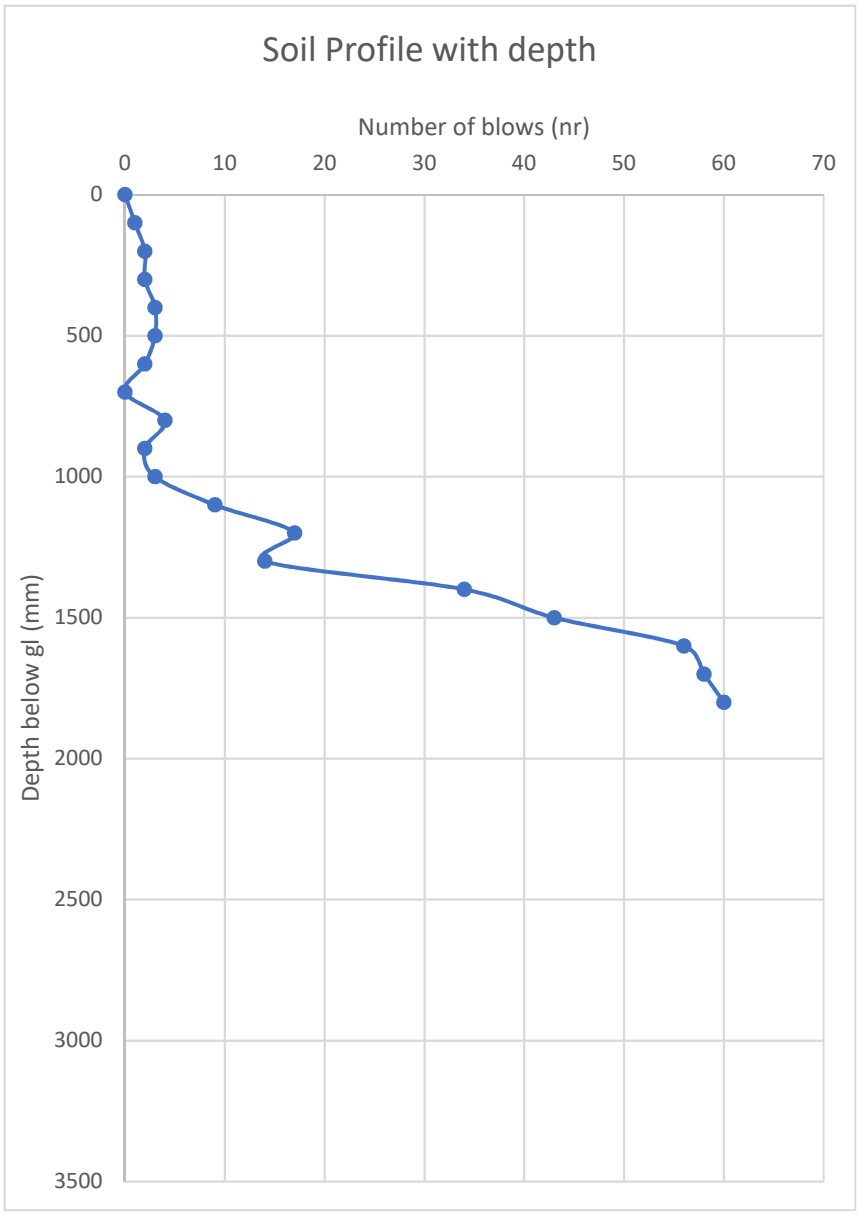


** At depth 1100mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repositary Area @ Barrage 3	Easting =	161247	**MP33**
		Northing =	203059	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	2	
300	2	
400	3	
500	3	
600	2	
700	0	
800	4	
900	2	
1000	3	
1100	9	
1200	17	
1300	14	
1400	34	
1500	43	
1600	56	
1700	58	
1800	60	**
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

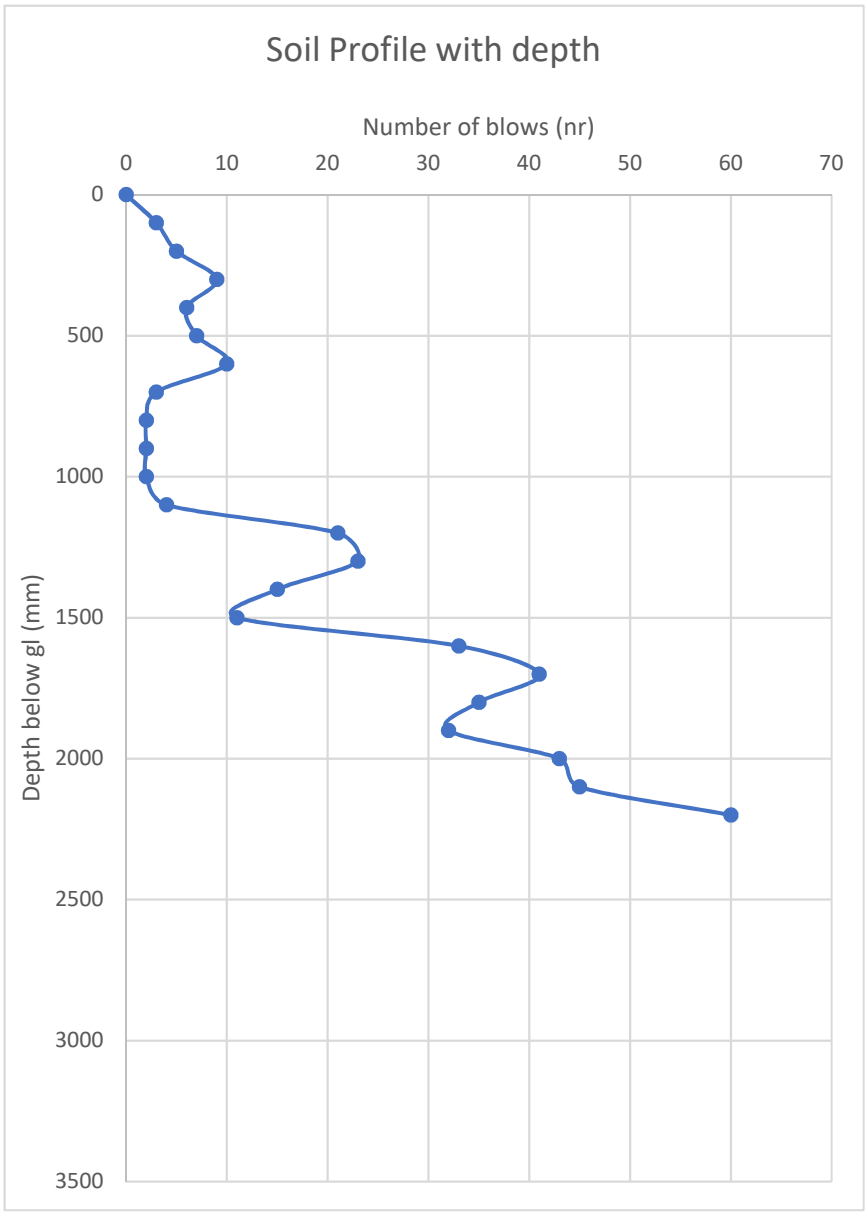


** At depth 1800mm, testing terminated at 60 blows. Slight movement - Firm ground.
** Water ingress during probing **

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repositary Area @ Barrage 3	Easting =	161255	**MP34**
		Northing =	203075	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	3	
200	5	
300	9	
400	6	
500	7	
600	10	
700	3	
800	2	
900	2	
1000	2	
1100	4	
1200	21	
1300	23	
1400	15	
1500	11	
1600	33	
1700	41	
1800	35	
1900	32	
2000	43	
2100	45	
2200	60	**
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

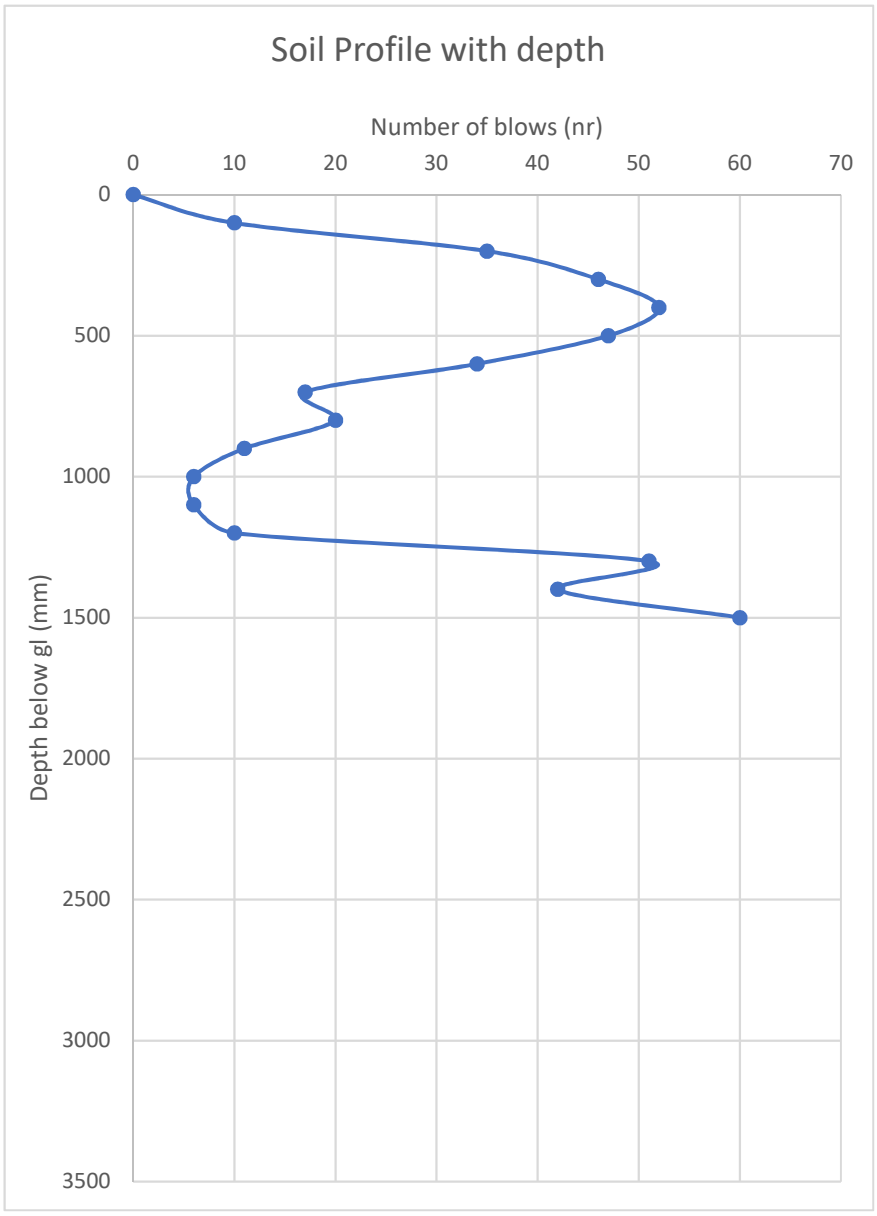


** At depth 2200mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repositary Area @ Barrage 3	Easting =	161257	**MP35**
		Northing =	203078	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	10	
200	35	
300	46	
400	52	
500	47	
600	34	
700	17	
800	20	
900	11	
1000	6	
1100	6	
1200	10	
1300	51	
1400	42	
1500	60	**
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

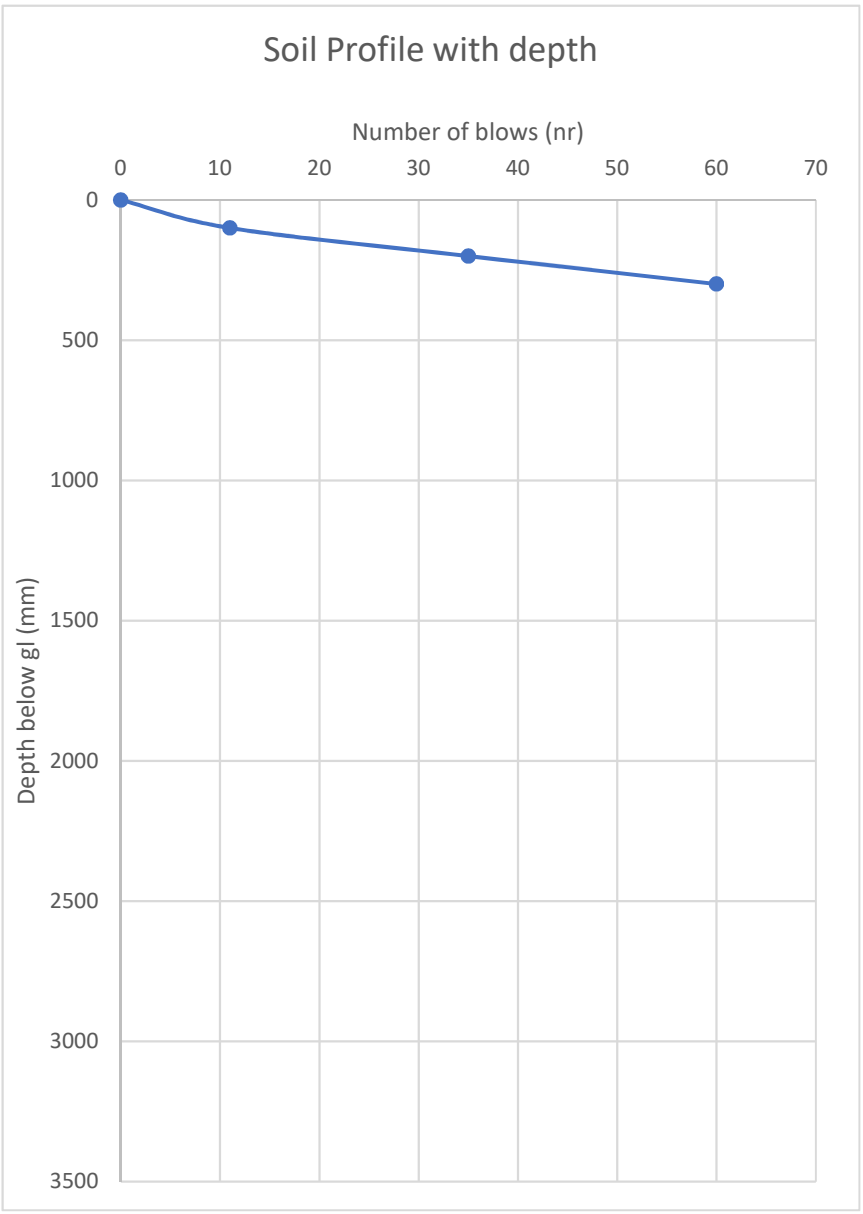


** At depth 1500mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repositary Area @ Barrage 3	Easting =	161240	**MP36**
		Northing =	203045	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	11	
200	35	
300	60	**
400		
500		
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

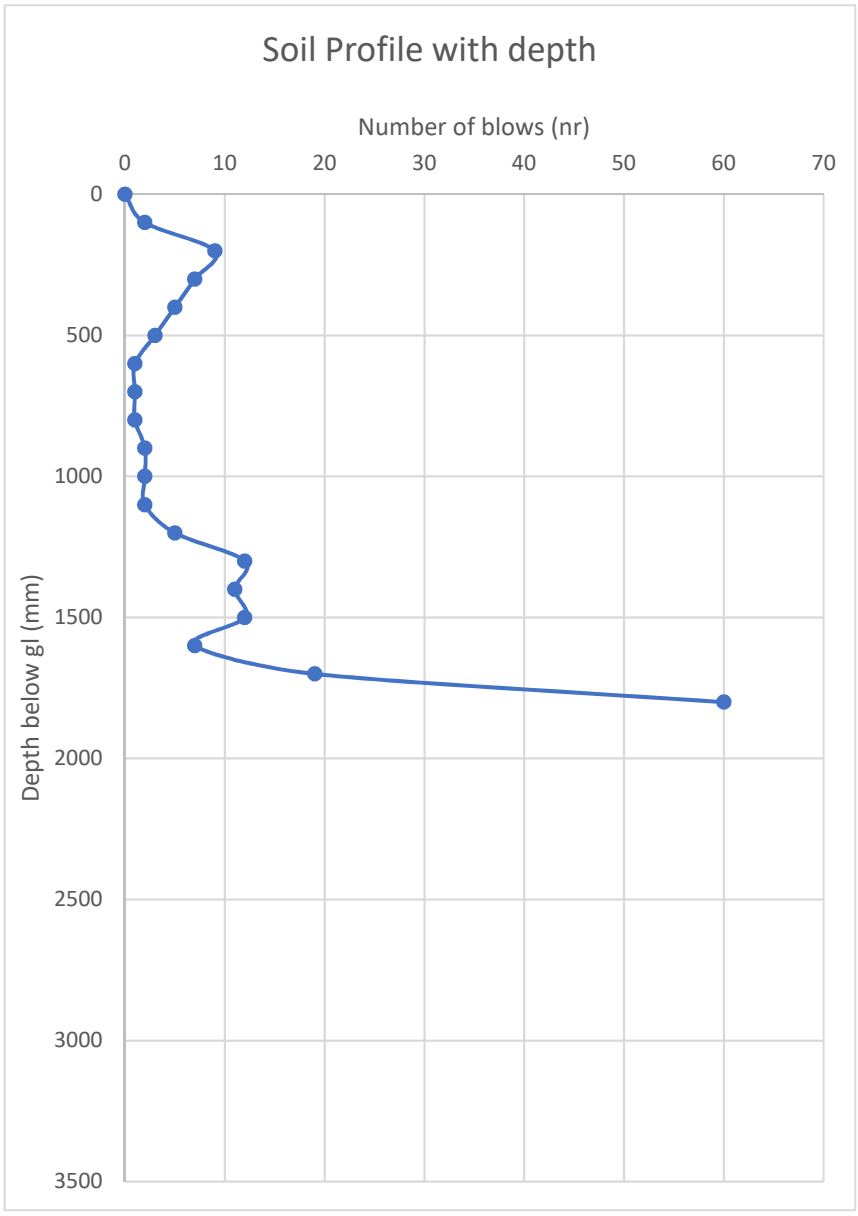


** At depth 300mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 2	Easting =	161180	**MP37**
		Northing =	203096	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	9	
300	7	
400	5	
500	3	
600	1	
700	1	
800	1	
900	2	
1000	2	
1100	2	
1200	5	
1300	12	
1400	11	
1500	12	
1600	7	
1700	19	
1800	60	**
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

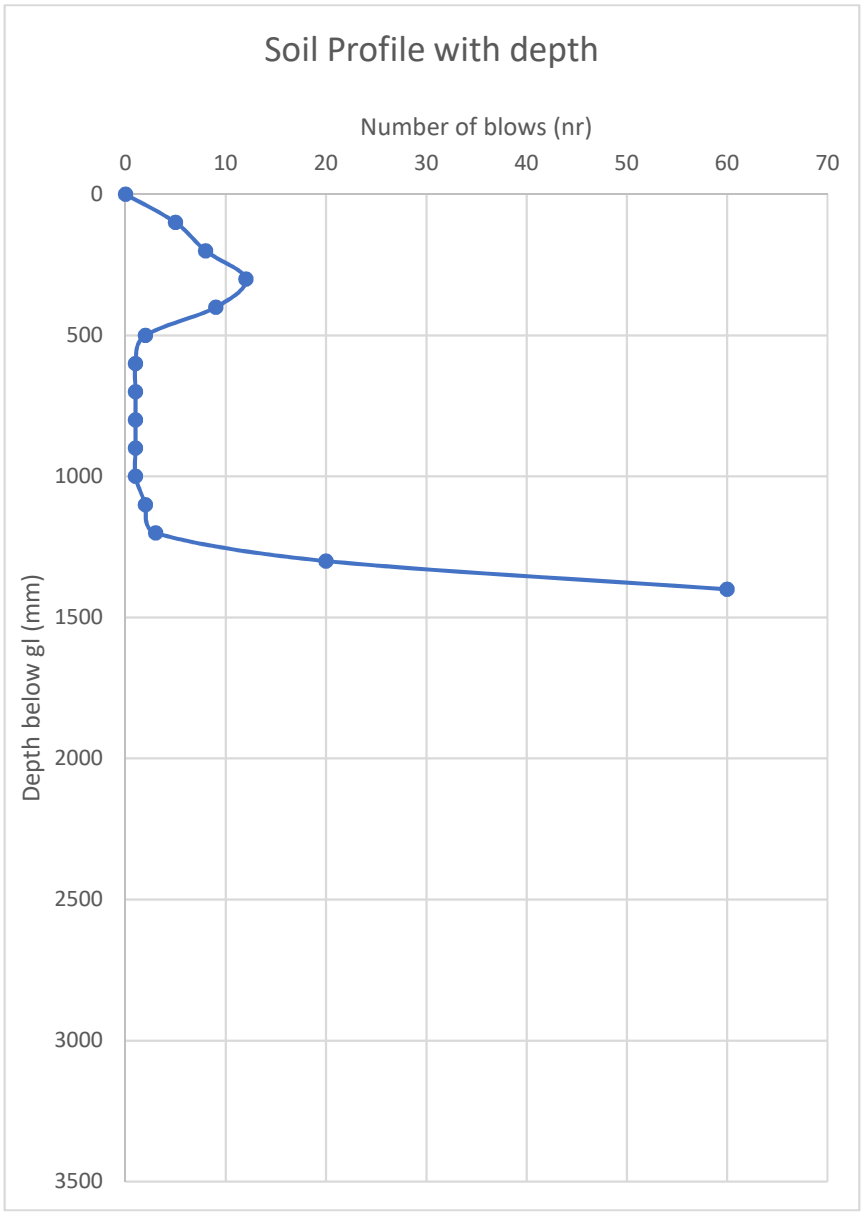


** At depth 1800mm, testing terminated at 60 blows. Slight movement - Firm ground.
Slight water ingress

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 2	Easting =	160603	**MP38**
		Northing =	203869	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	5	
200	8	
300	12	
400	9	
500	2	
600	1	
700	1	
800	1	
900	1	
1000	1	
1100	2	
1200	3	
1300	20	
1400	60	**
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

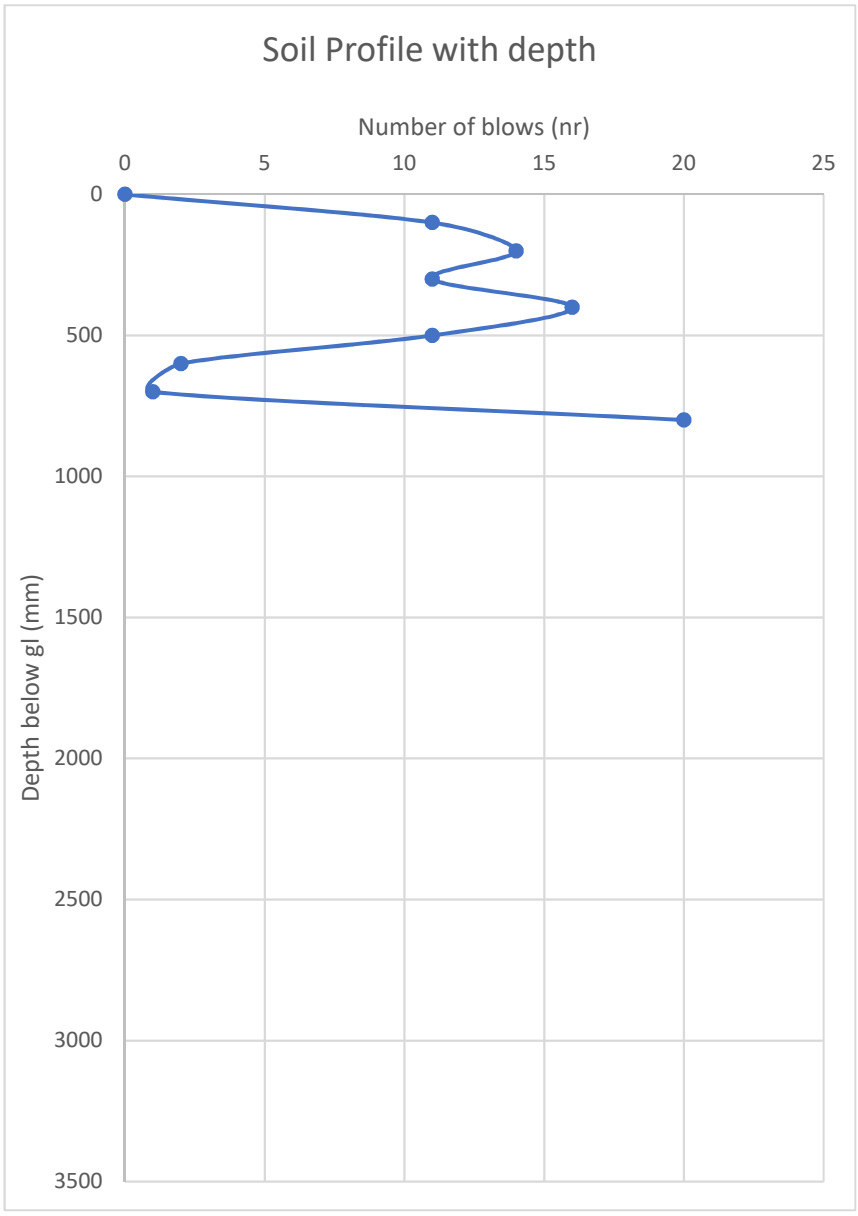


** At depth 1400mm, testing terminated at 60 blows. Slight movement - Firm ground.
Water present

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 2	Easting =	160580	**MP39**
		Northing =	203881	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	11	
200	14	
300	11	
400	16	
500	11	
600	2	
700	1	
800	20	**
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

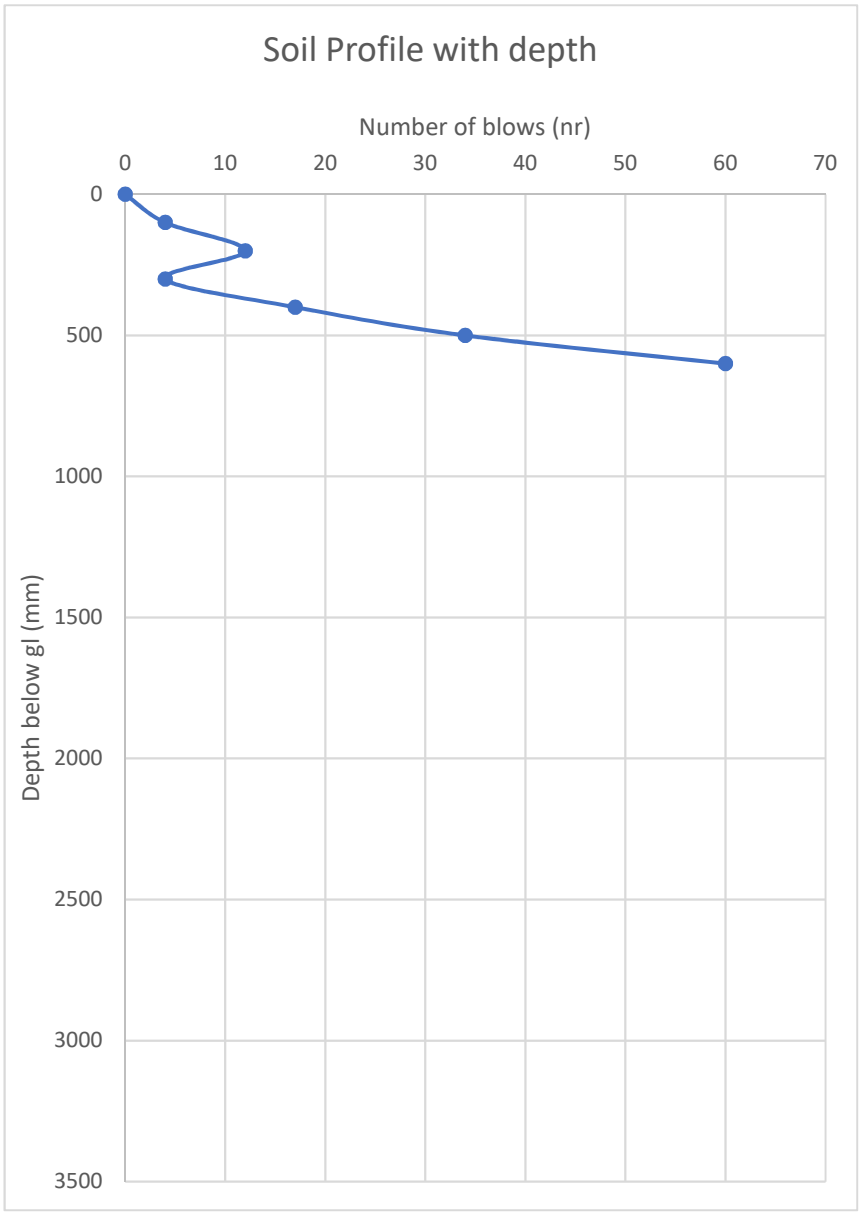


** At depth 800mm, testing terminated at 20 blows. No movement - Recoil on probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 2	Easting =	160566	**MP40**
		Northing =	203876	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	4	
200	12	
300	4	
400	17	
500	34	
600	60	**
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

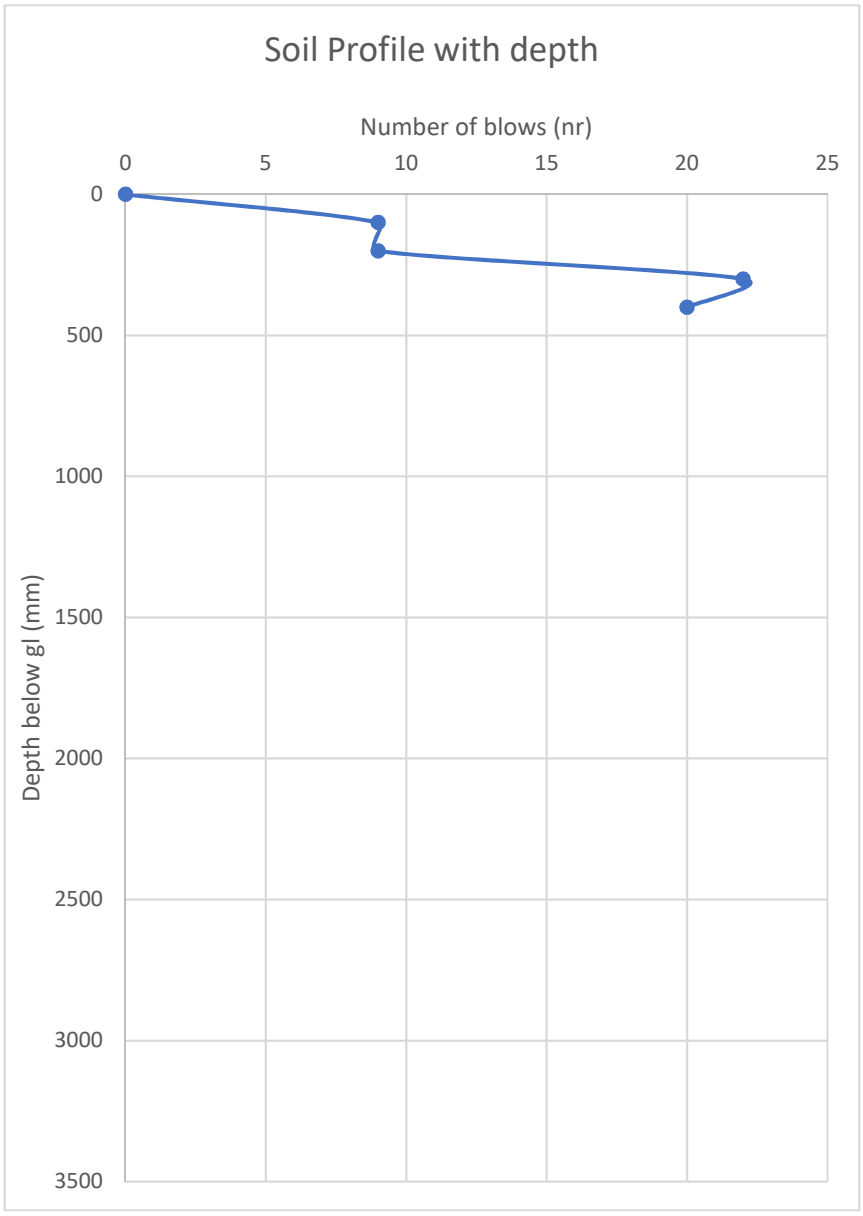


** At depth 600mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 2	Easting =	160561	**MP41**
		Northing =	203874	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	9	
200	9	
300	22	
400	20	**
500		
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

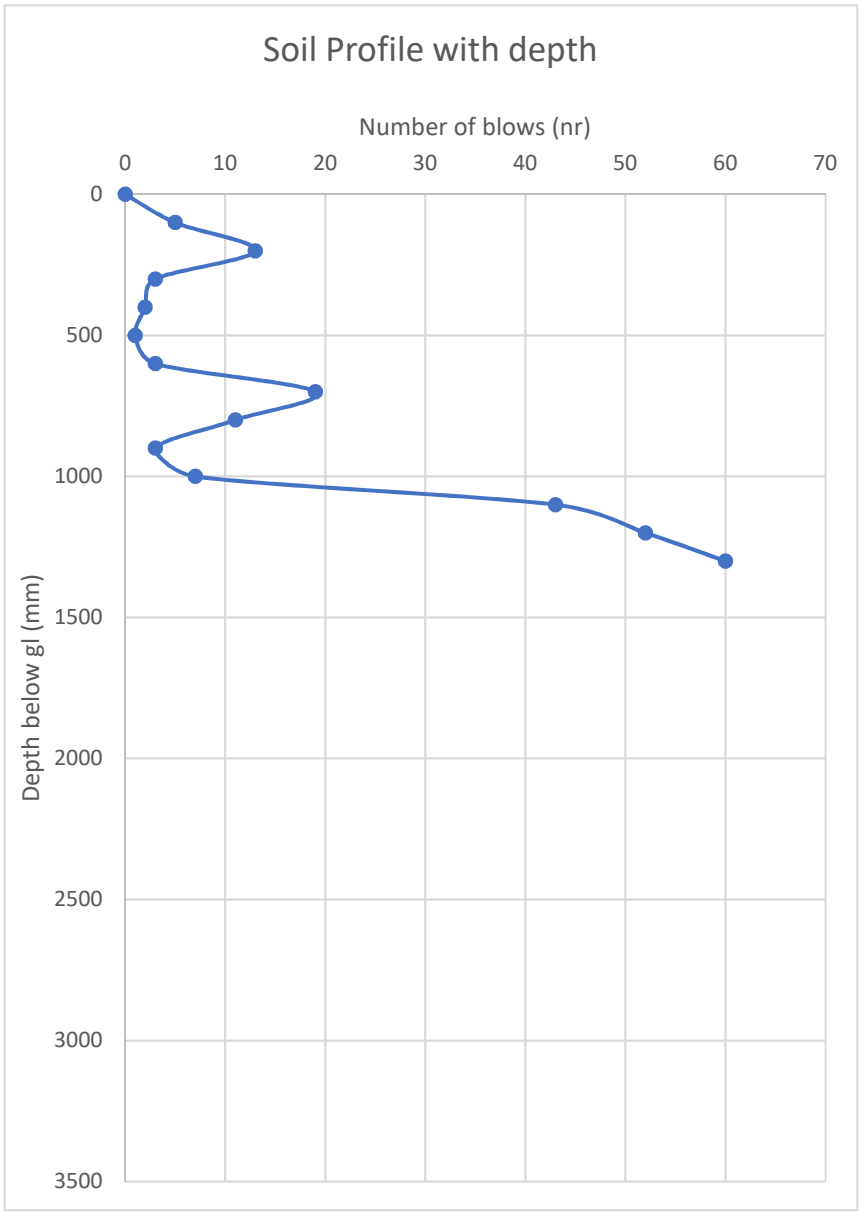


** At depth 400mm, testing terminated at 20 blows. No movement - Recoil on probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 2	Easting =	160582	**MP42**
		Northing =	203871	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	5	
200	13	
300	3	
400	2	
500	1	
600	3	
700	19	
800	11	
900	3	
1000	7	
1100	43	
1200	52	
1300	60	**
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

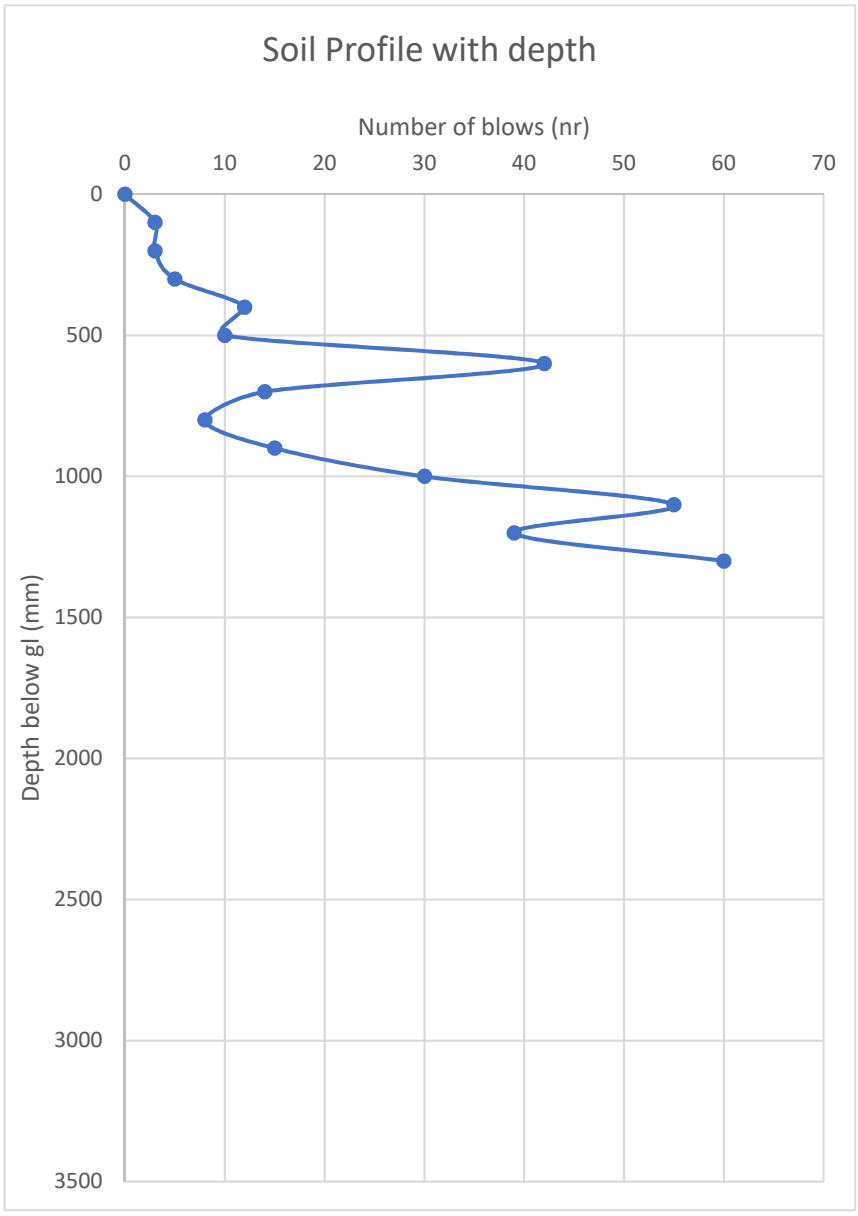


** At depth 1300mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 2	Easting =	160592	**MP43**
		Northing =	203872	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	3	
200	3	
300	5	
400	12	
500	10	
600	42	
700	14	
800	8	
900	15	
1000	30	
1100	55	
1200	39	
1300	60	**
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

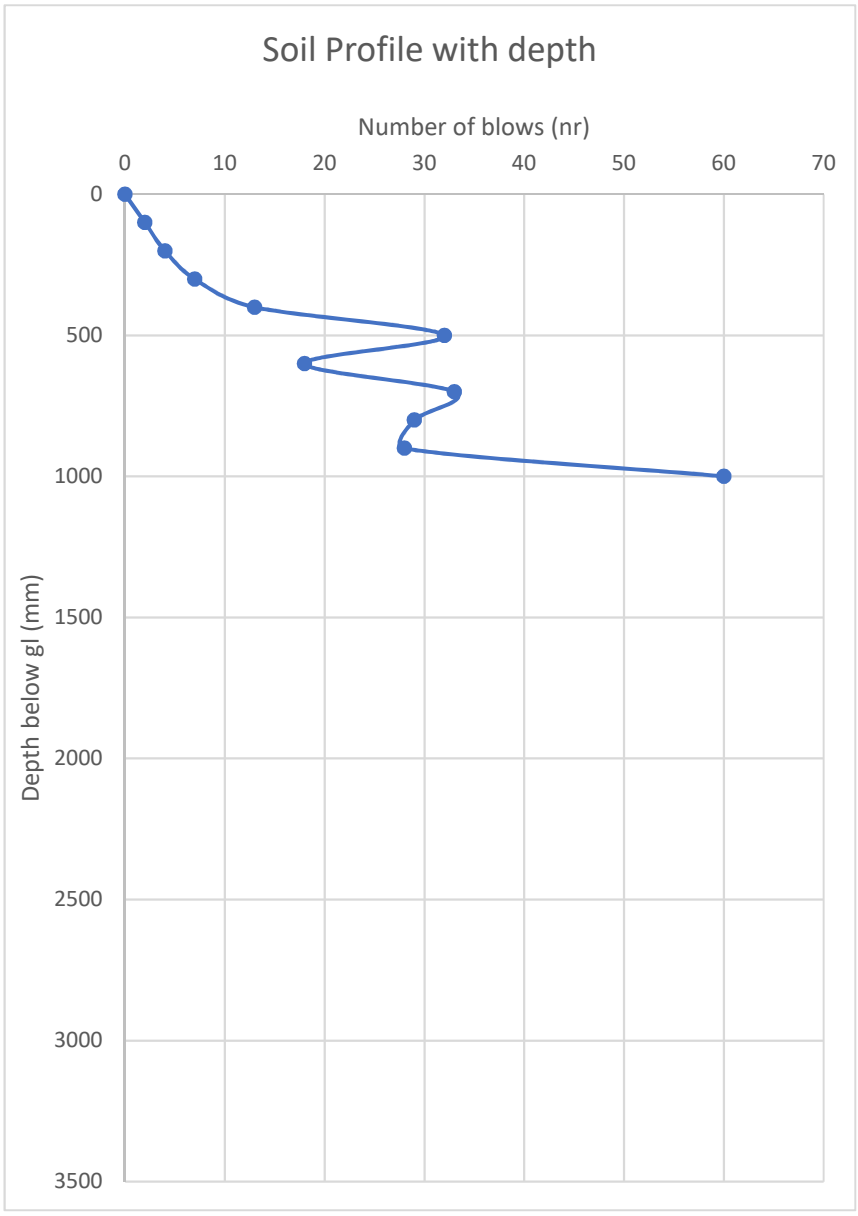


** At depth 1300mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 2	Easting =	160602	**MP44**
		Northing =	203870	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	4	
300	7	
400	13	
500	32	
600	18	
700	33	
800	29	
900	28	
1000	60	**
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

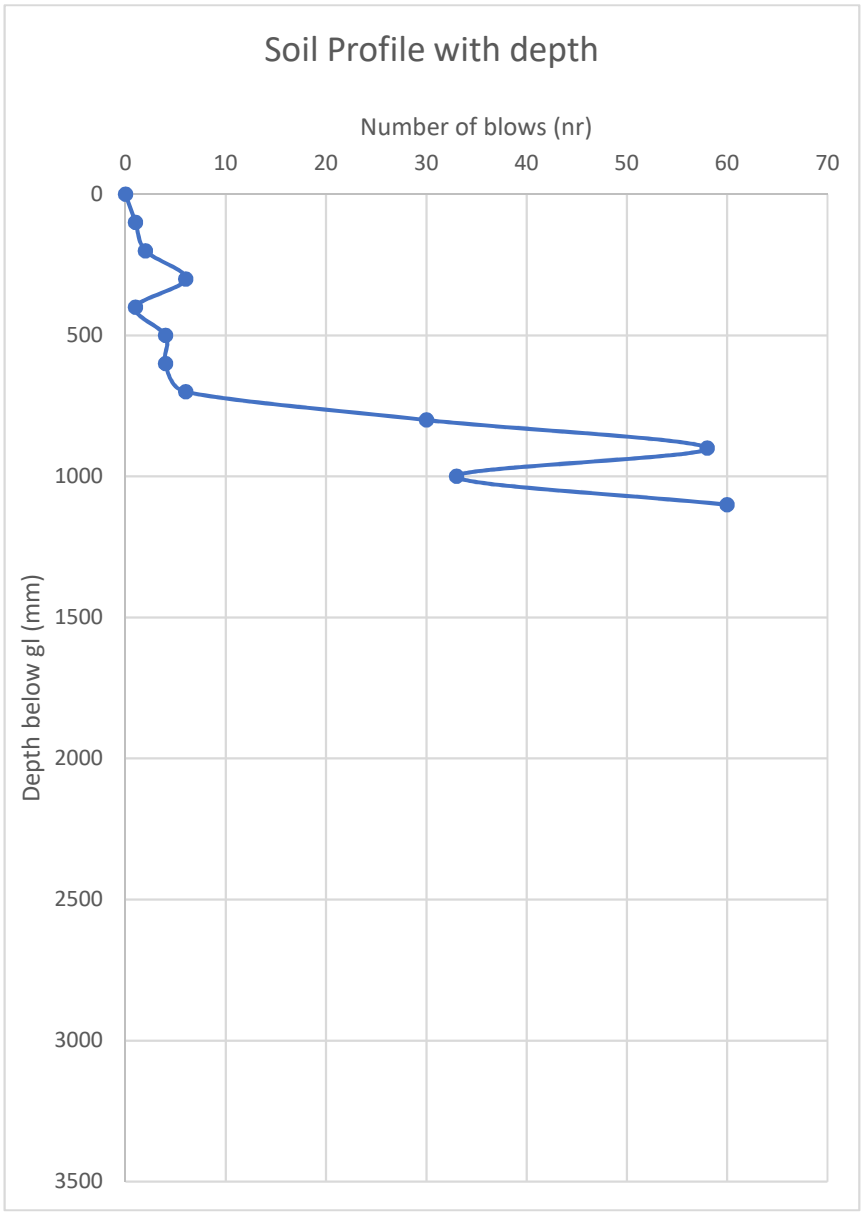


** At depth 1000mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 2	Easting =	160602	**MP45**
		Northing =	203881	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	2	
300	6	
400	1	
500	4	
600	4	
700	6	
800	30	
900	58	
1000	33	
1100	60	**
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

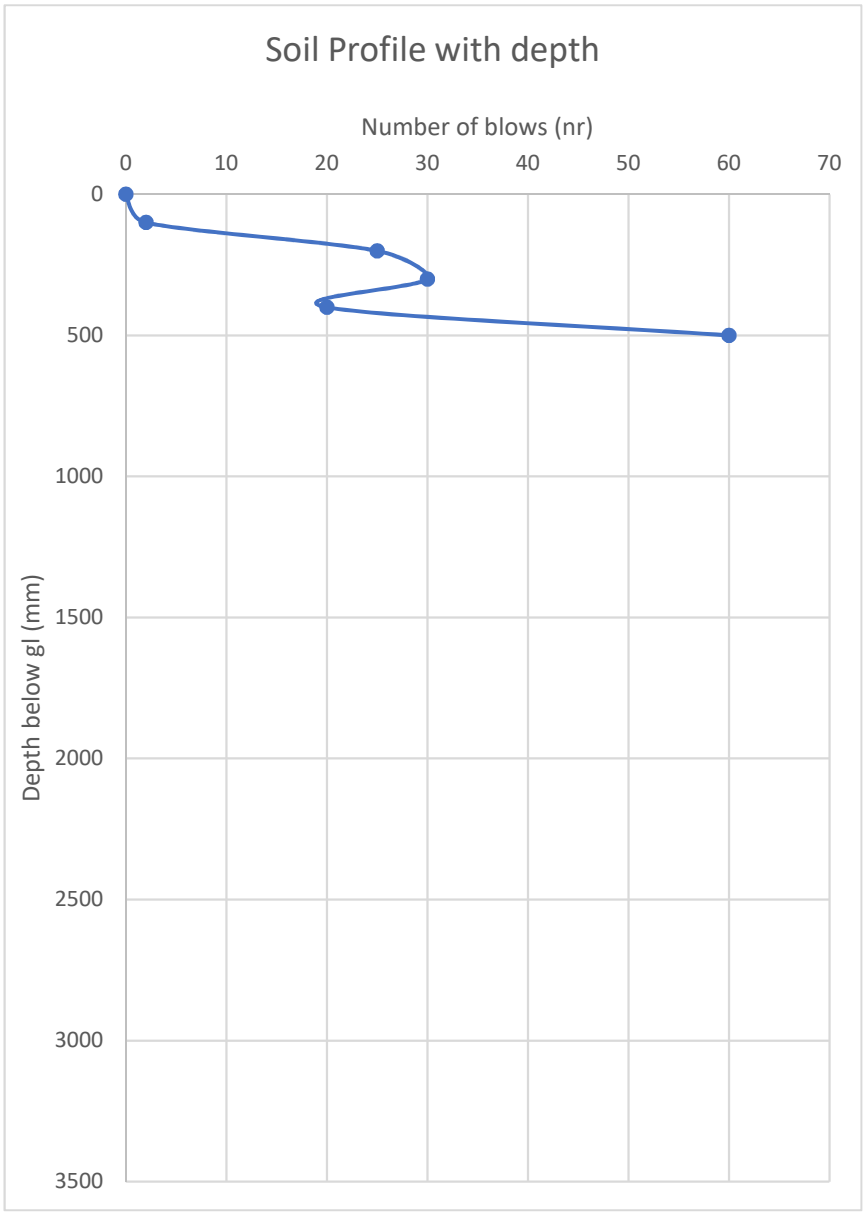


** At depth 1100mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 2	Easting =	160580	**MP46**
		Northing =	203878	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	25	
300	30	
400	20	
500	60	**
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

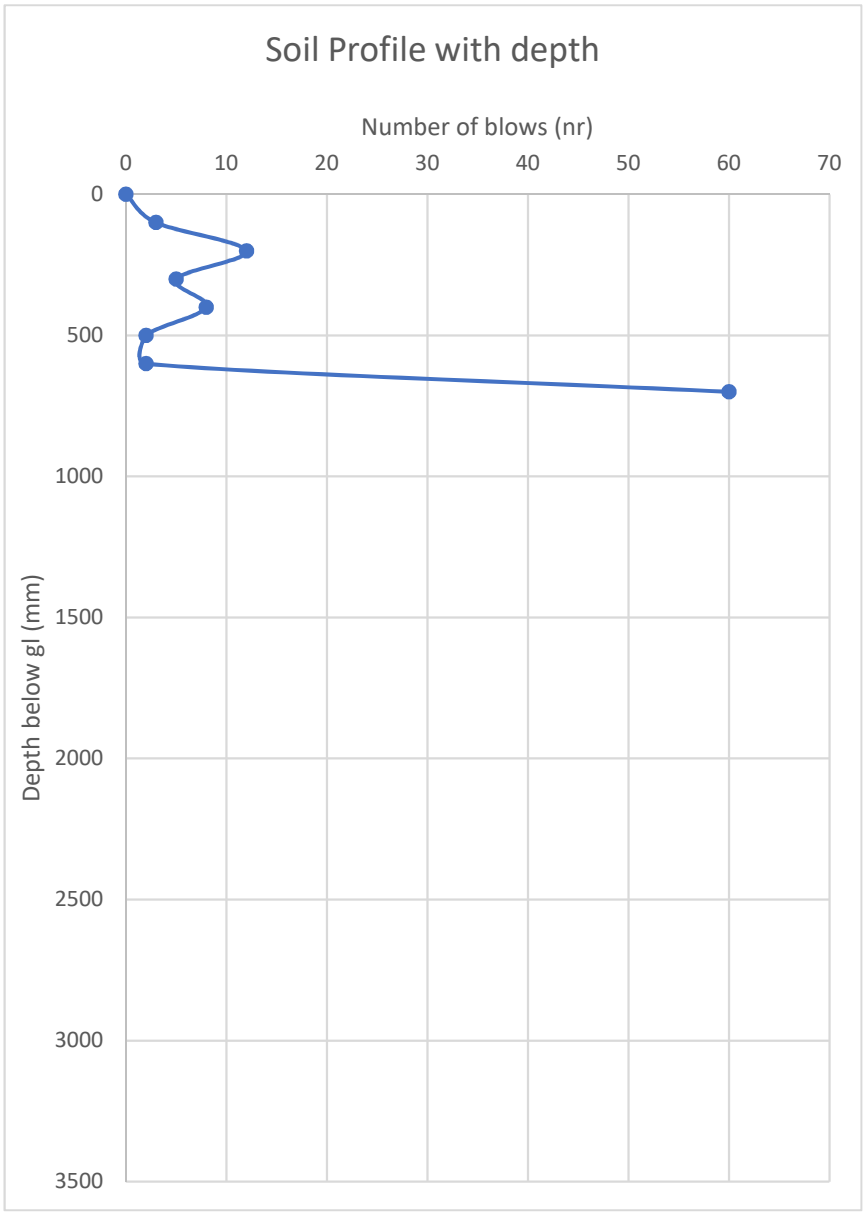


** At depth 500mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Containment Barrage 2	Easting =	160592	**MP47**
		Northing =	203880	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	3	
200	12	
300	5	
400	8	
500	2	
600	2	
700	60	**
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		



** At depth 700mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Barrage 2 (No Bund)	Easting =	160547	**MP48**
		Northing =	203951	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	2	
300	3	
400	6	
500	2	
600	2	
700	60	**
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
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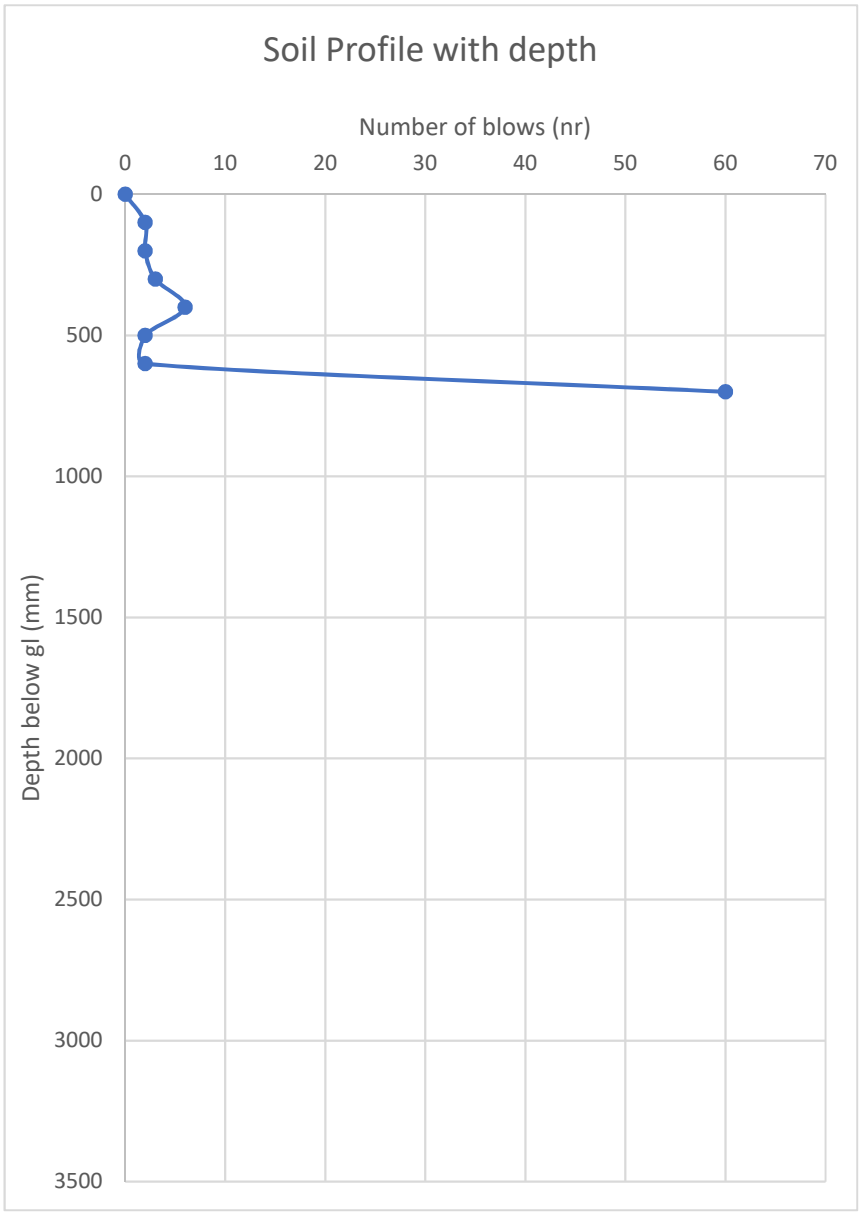
2500		
2600		
2700		
2800		
2900		
3000		

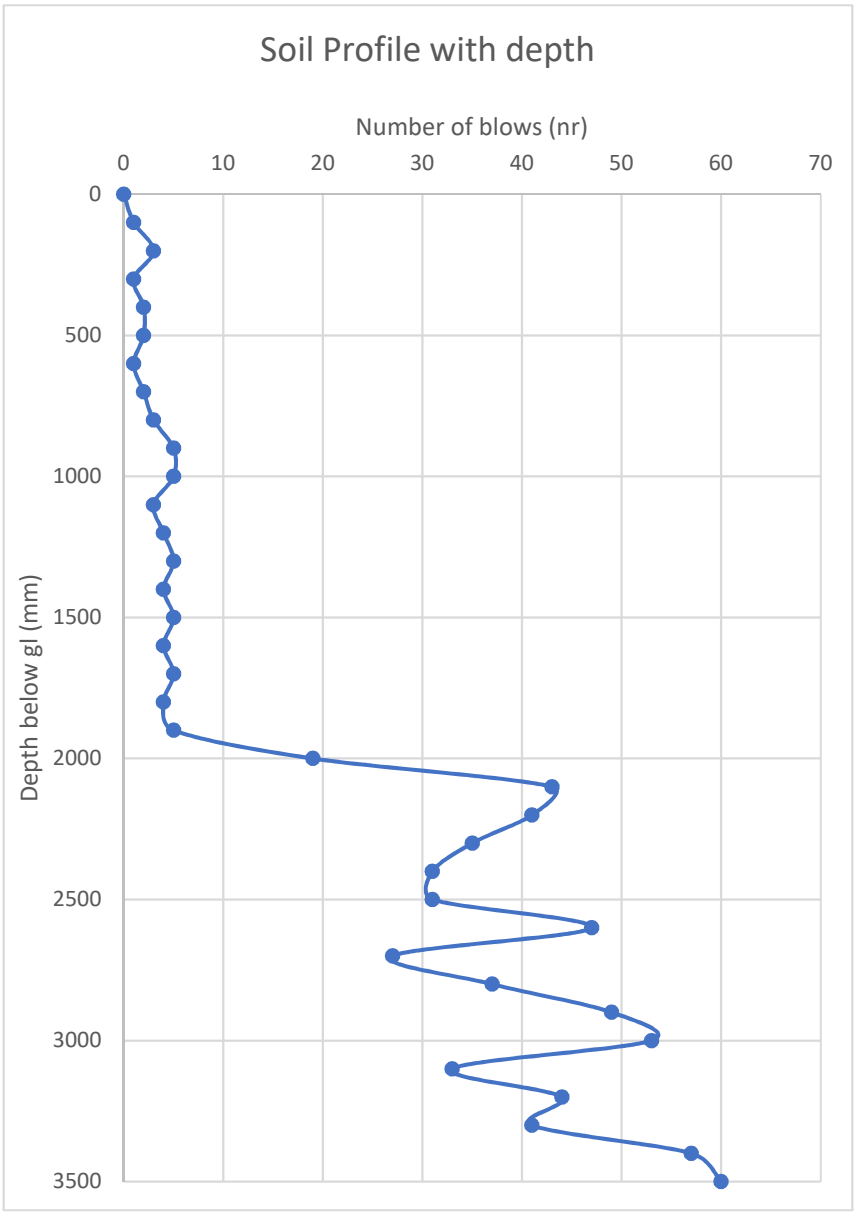


** At depth 700mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Barrage 2 (No Bund)	Easting =	160535	**MP49**
		Northing =	203944	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows
0	0
100	1
200	3
300	1
400	2
500	2
600	1
700	2
800	3
900	5
1000	5
1100	3
1200	4
1300	5
1400	4
1500	5
1600	4
1700	5
1800	4
1900	5
2000	19
2100	43
2200	41
2300	35
2400	31
2500	31
2600	47
2700	27
2800	37
2900	49
3000	53
3100	33
3200	44
3300	41
3400	57
3500	60 **

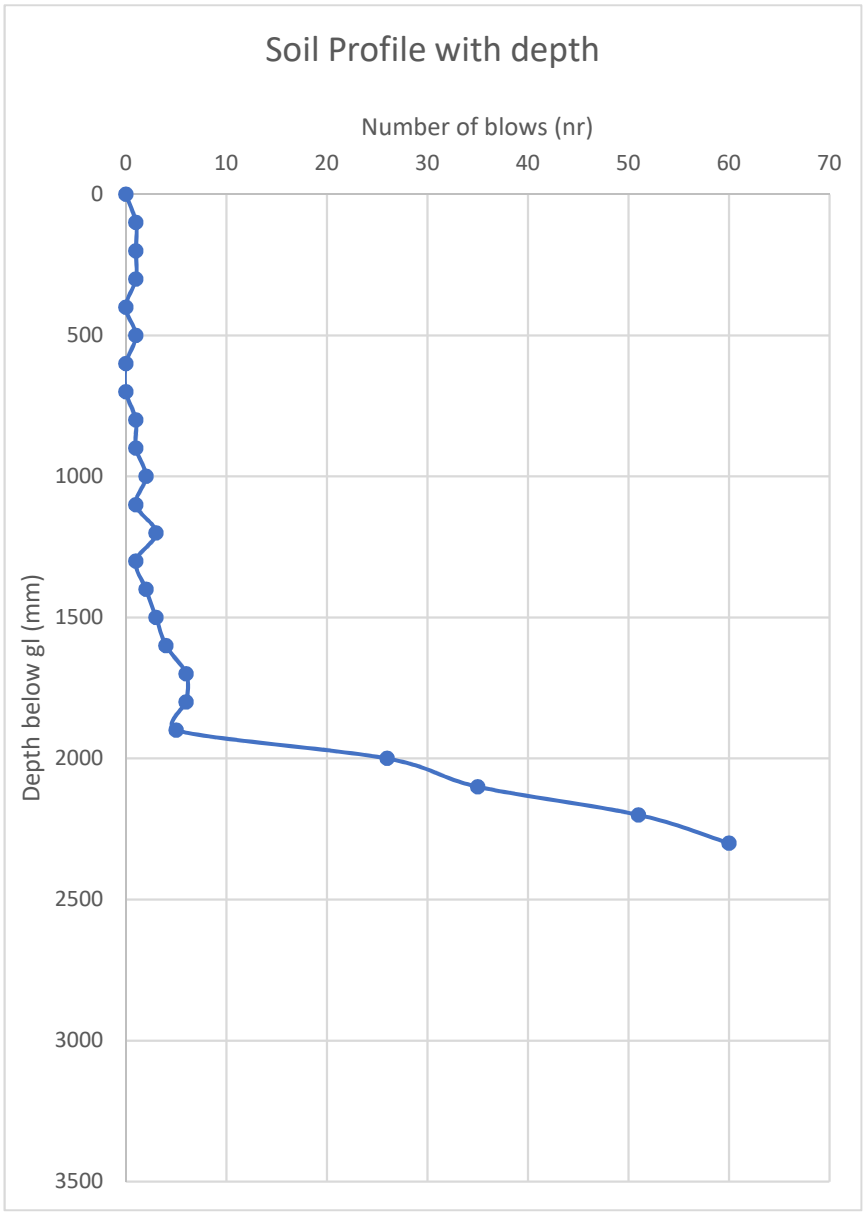


** At depth 3500mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Barrage 2 (No Bund)	Easting =	160524	**MP50**
		Northing =	203939	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	1	
300	1	
400	0	
500	1	
600	0	
700	0	
800	1	
900	1	
1000	2	
1100	1	
1200	3	
1300	1	
1400	2	
1500	3	
1600	4	
1700	6	
1800	6	
1900	5	
2000	26	
2100	35	
2200	51	
2300	60	**
2400		
2500		
2600		
2700		
2800		
2900		
3000		

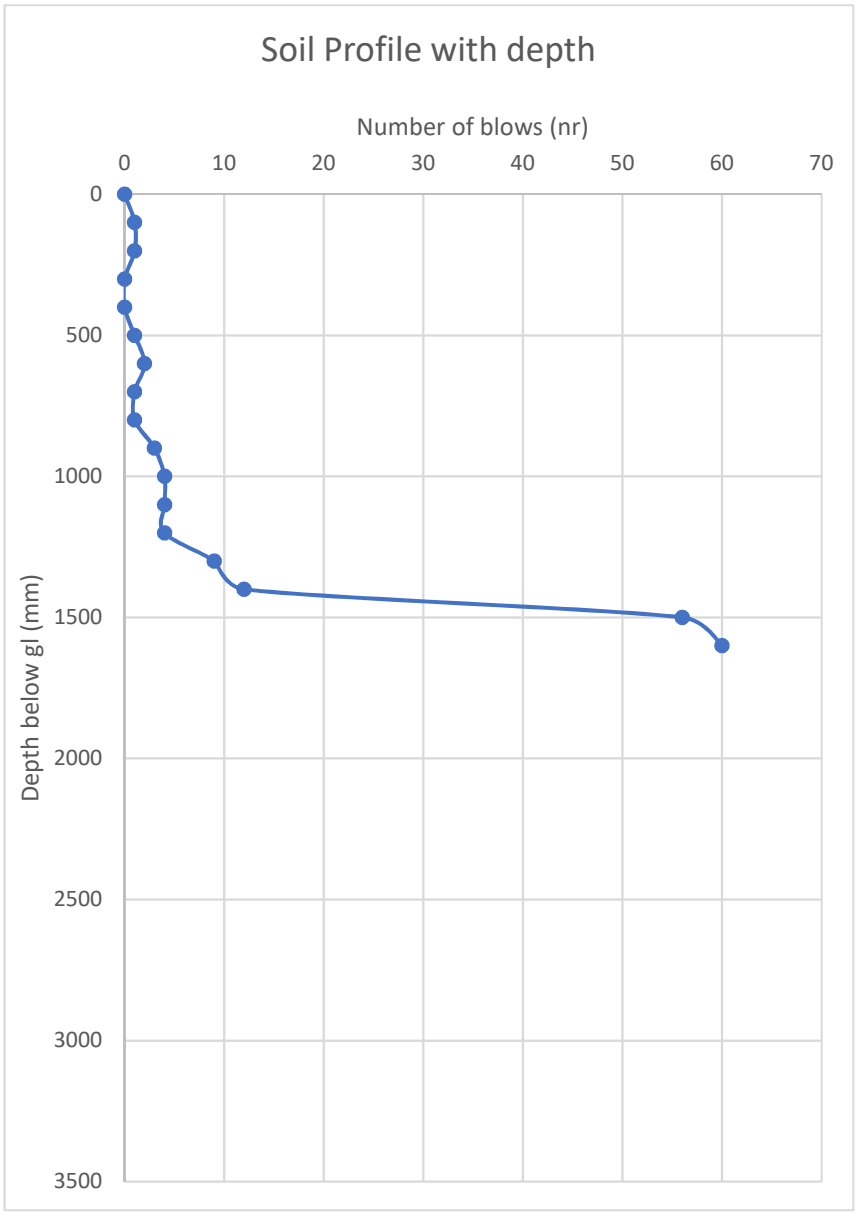


** At depth 2300mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Barrage 2 (No Bund)	Easting =	160536	**MP51**
		Northing =	203930	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	1	
300	0	
400	0	
500	1	
600	2	
700	1	
800	1	
900	3	
1000	4	
1100	4	
1200	4	
1300	9	
1400	12	
1500	56	
1600	60	**
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

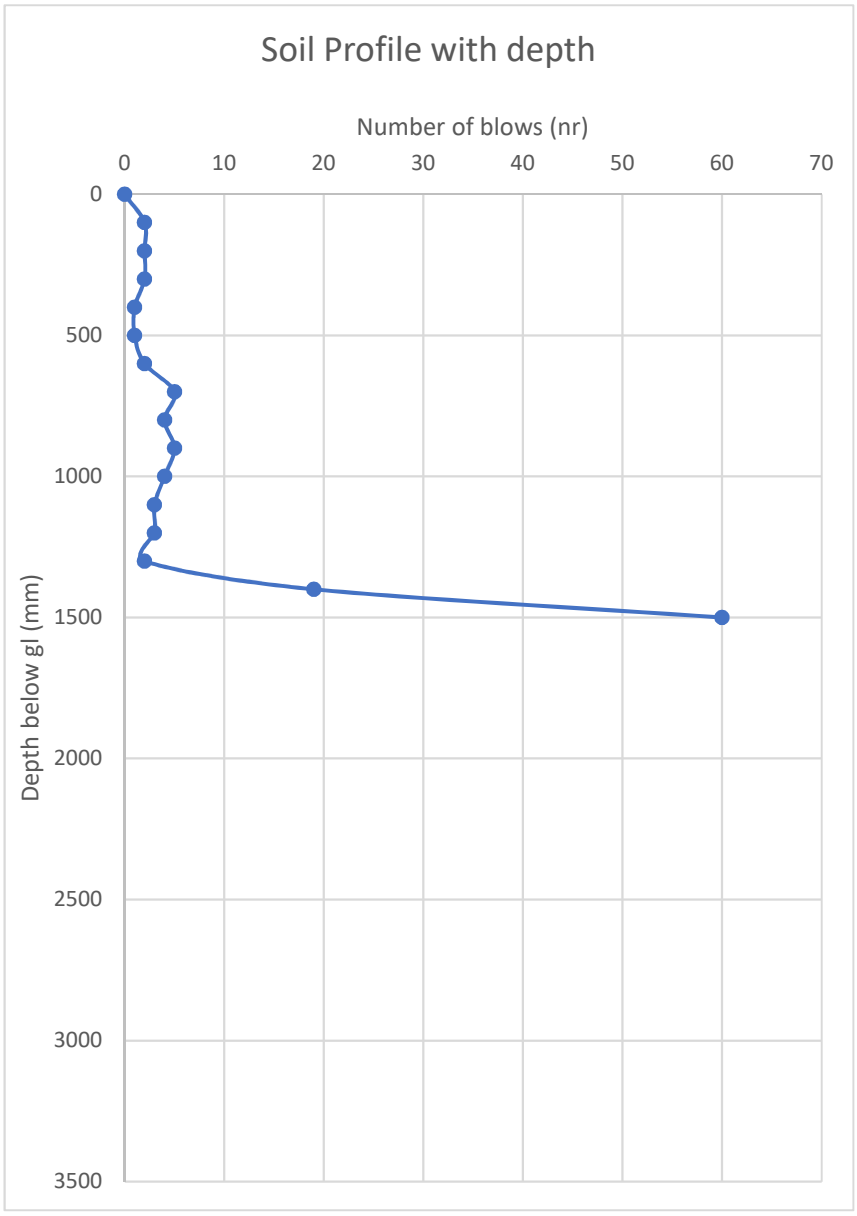


** At depth 1600mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Barrage 2 (No Bund)	Easting =	160546	**MP52**
		Northing =	203931	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	2	
300	2	
400	1	
500	1	
600	2	
700	5	
800	4	
900	5	
1000	4	
1100	3	
1200	3	
1300	2	
1400	19	
1500	60	**
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

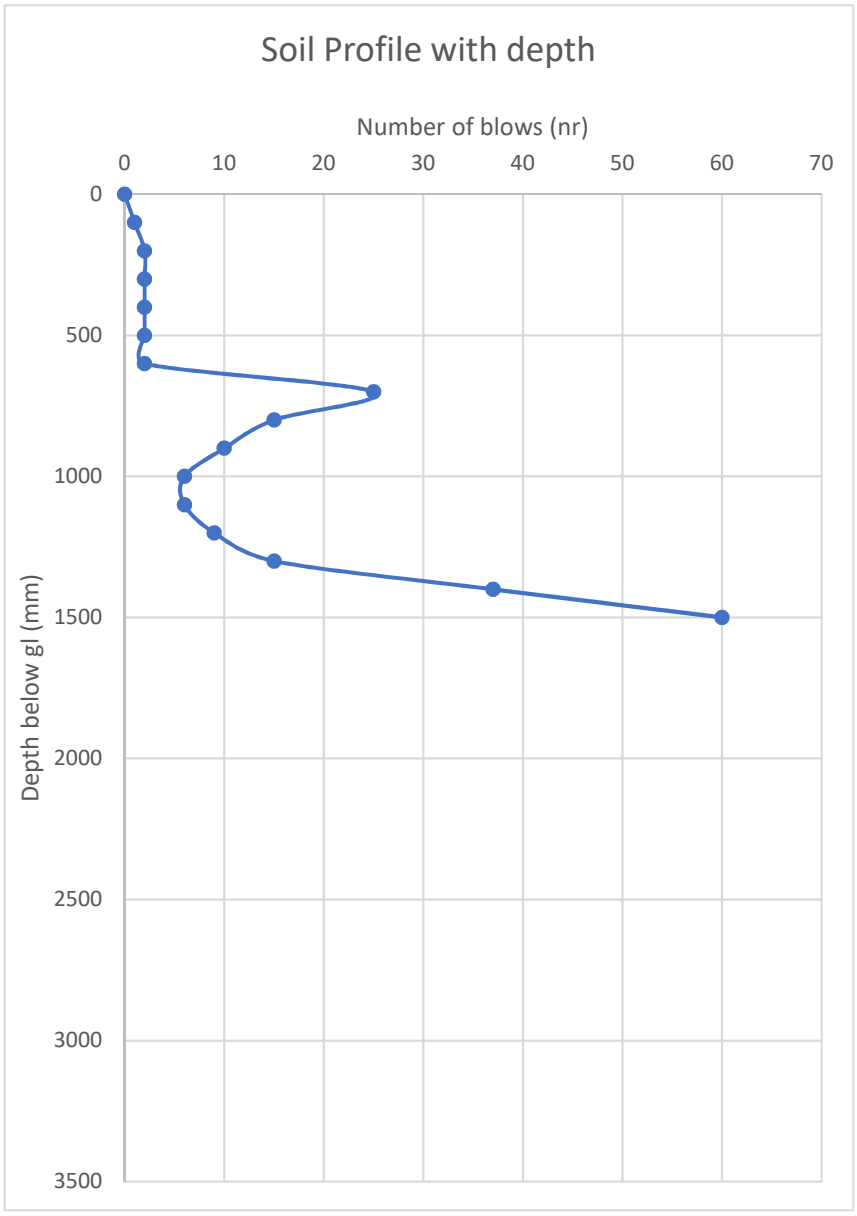


** At depth 1500mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Barrage 2 (No Bund)	Easting =	160546	**MP53**
		Northing =	203949	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	2	
300	2	
400	2	
500	2	
600	2	
700	25	
800	15	
900	10	
1000	6	
1100	6	
1200	9	
1300	15	
1400	37	
1500	60	**
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

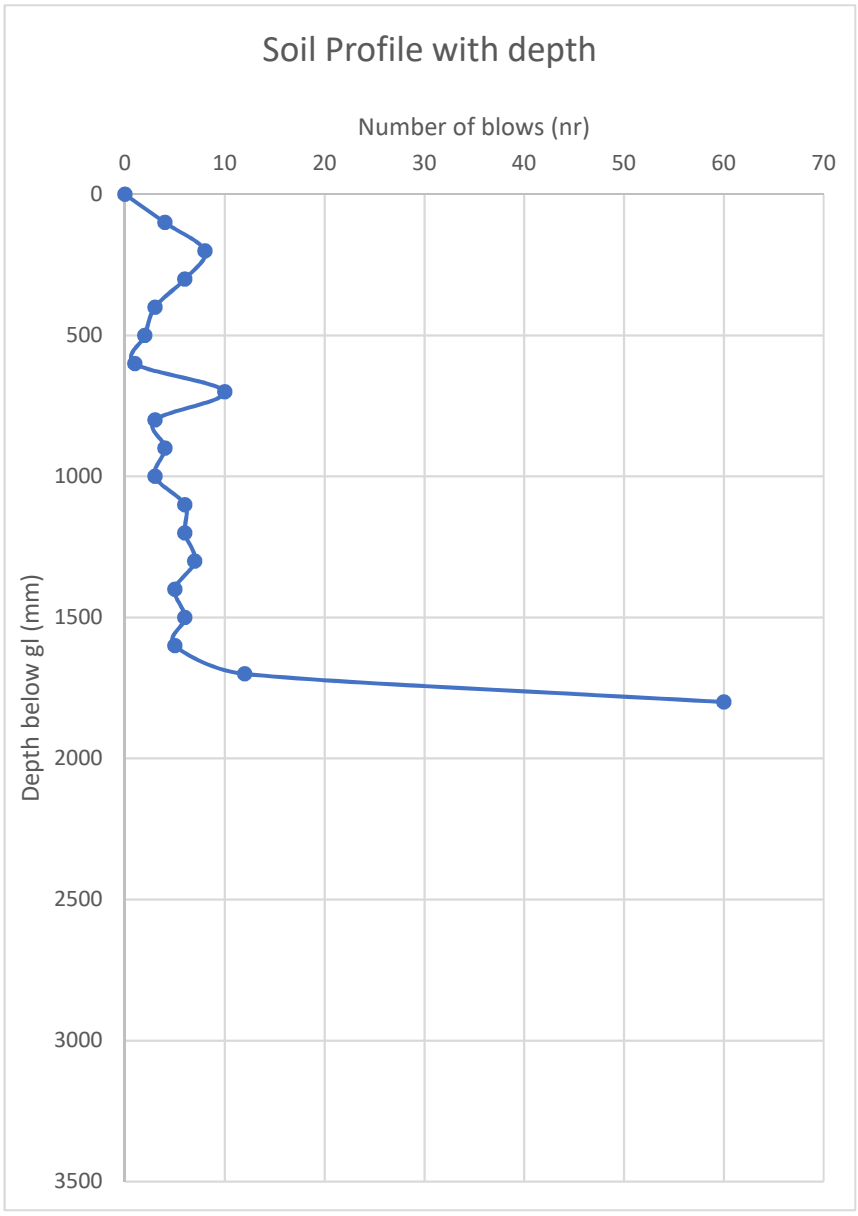


** At depth 1500mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Barrage 2 (No Bund)	Easting =	160542	**MP54**
		Northing =	203956	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	4	
200	8	
300	6	
400	3	
500	2	
600	1	
700	10	
800	3	
900	4	
1000	3	
1100	6	
1200	6	
1300	7	
1400	5	
1500	6	
1600	5	
1700	12	
1800	60	**
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

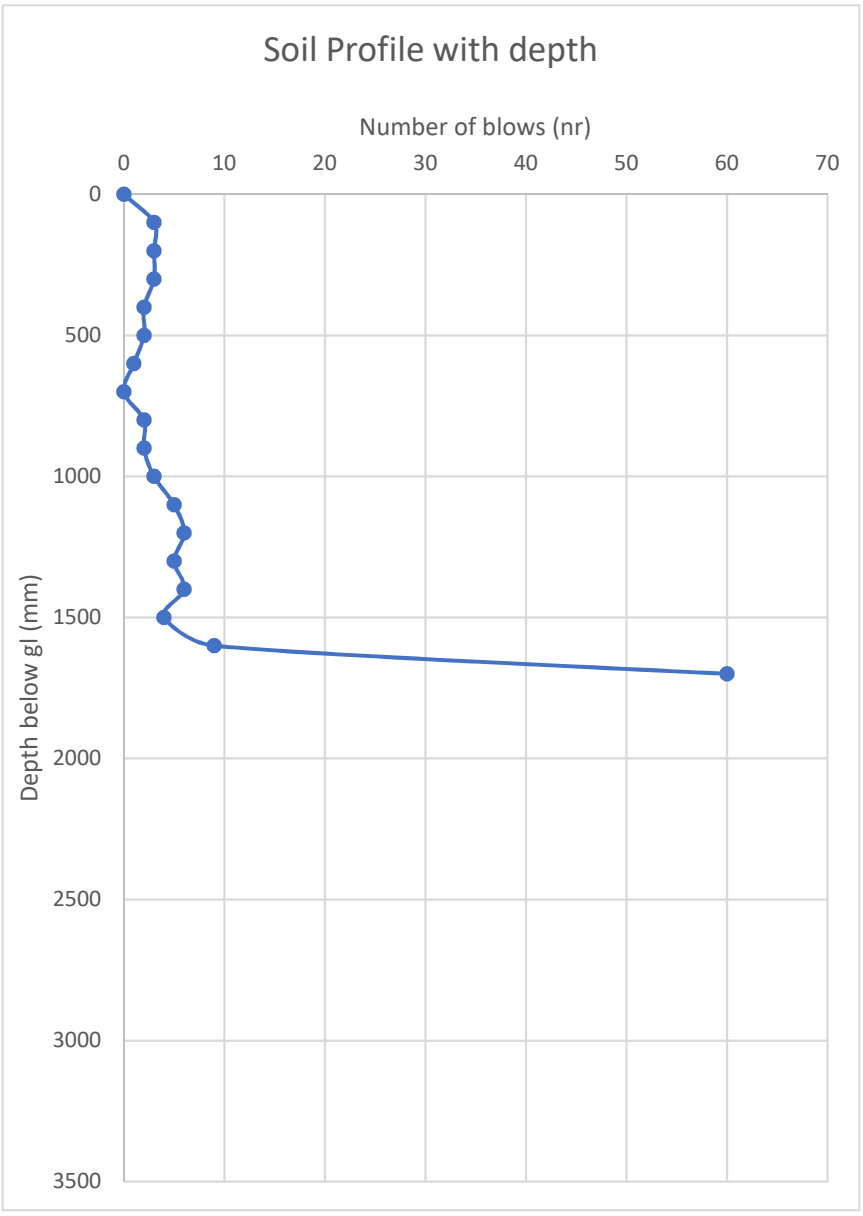


** At depth 1800mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Barrage 2 (No Bund)	Easting =	160537	**MP55**
		Northing =	203952	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	3	
200	3	
300	3	
400	2	
500	2	
600	1	
700	0	
800	2	
900	2	
1000	3	
1100	5	
1200	6	
1300	5	
1400	6	
1500	4	
1600	9	
1700	60	**
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

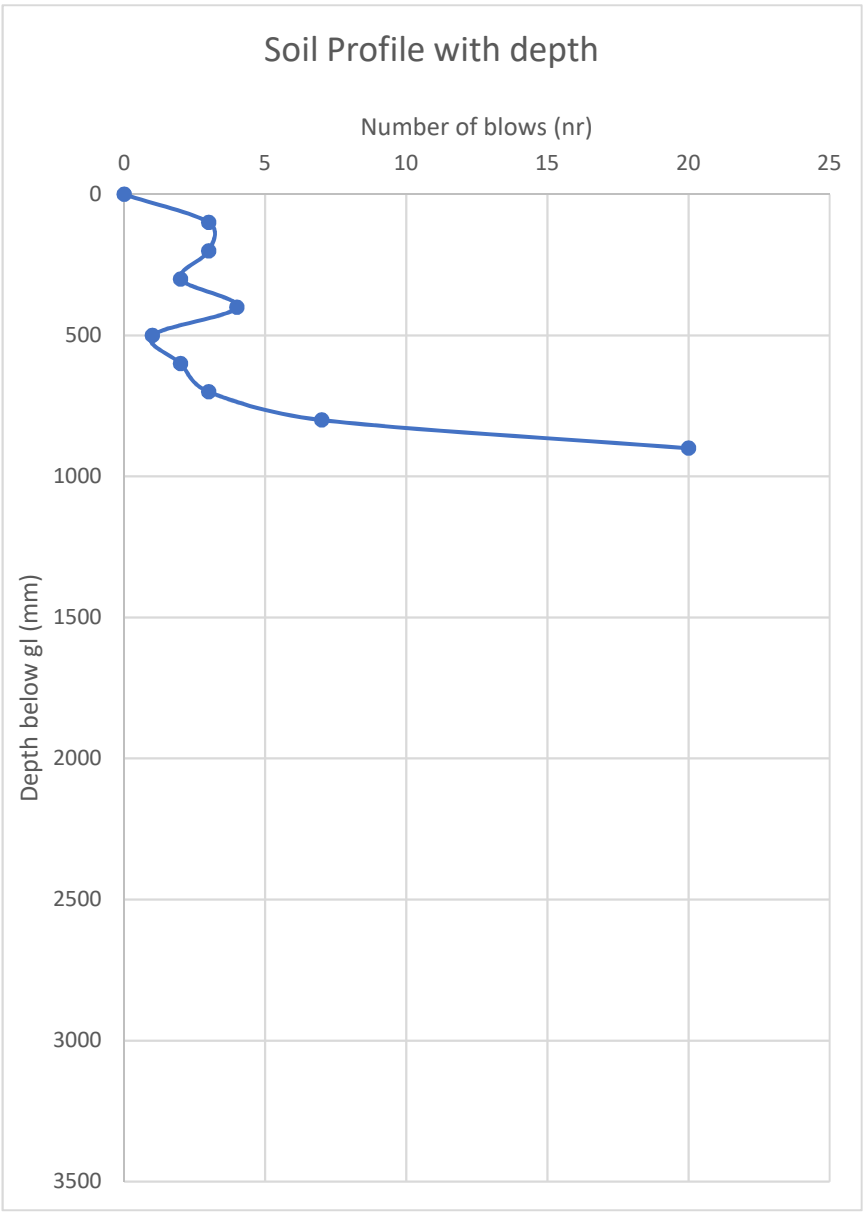


** At depth 1700mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Barrage 2 (No Bund)	Easting =	160531	**MP56**
		Northing =	203949	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	21/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	3	
200	3	
300	2	
400	4	
500	1	
600	2	
700	3	
800	7	
900	20	**
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

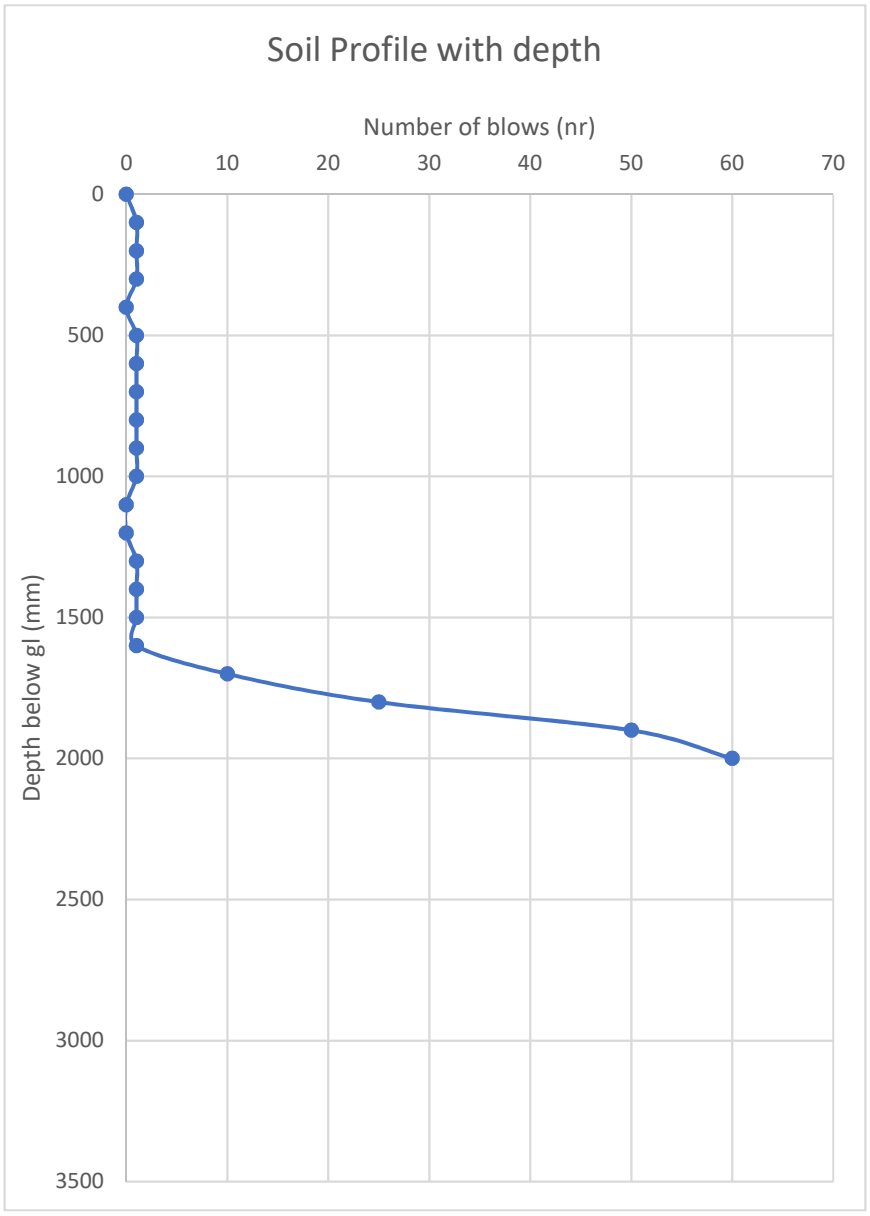


** At depth 900mm, testing terminated at 20 blows. No movement - Recoil to probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Barrage 2		Easting =	160560	**MP57**
	(Bunded)		Northing =	203915
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	1	
300	1	
400	0	
500	1	
600	1	
700	1	
800	1	
900	1	
1000	1	
1100	0	
1200	0	
1300	1	
1400	1	
1500	1	
1600	1	
1700	10	
1800	25	
1900	50	
2000	60	**
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

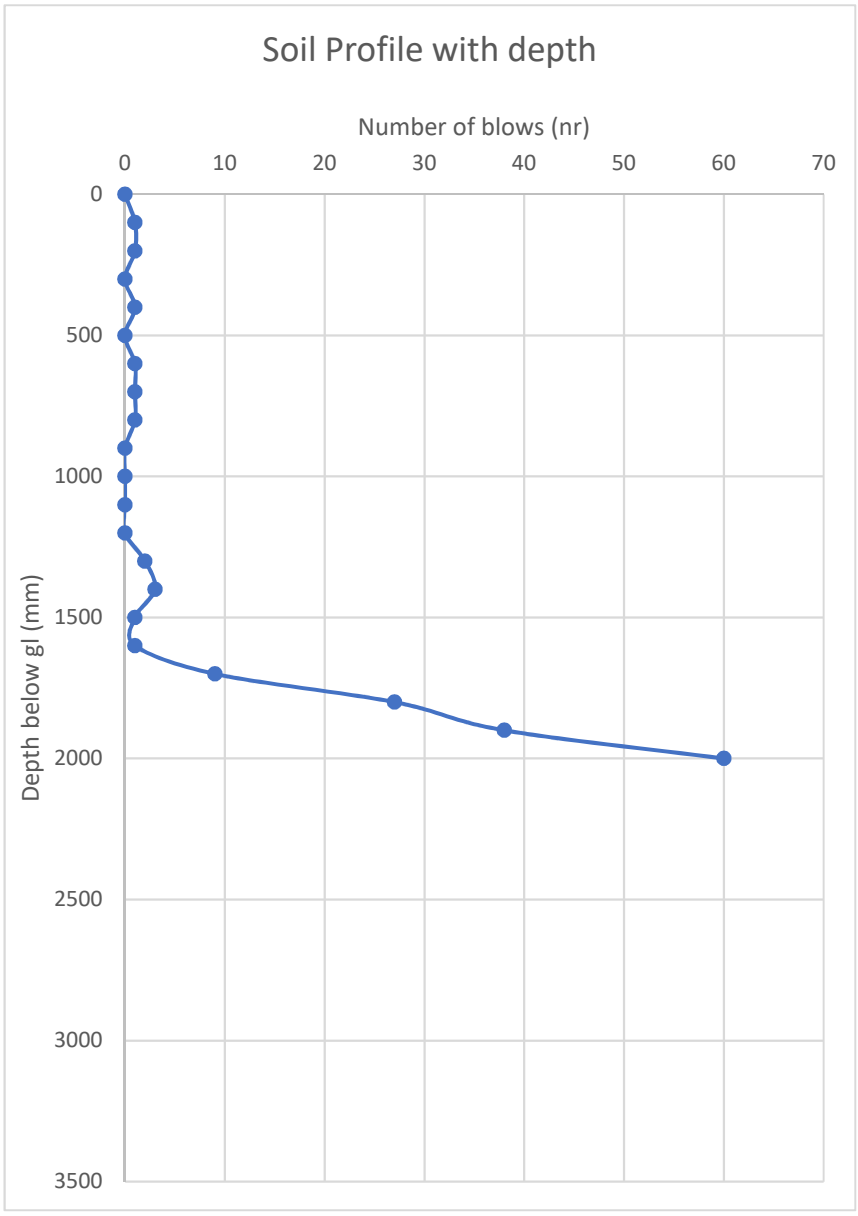


** At depth 2000mm, testing terminated at 60 blows. Slight movement - Firm ground.
*Peat depth 1600mm.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Barrage 2 (Bunded)	Easting =	160542	**MP58**
		Northing =	203906	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	1	
300	0	
400	1	
500	0	
600	1	
700	1	
800	1	
900	0	
1000	0	
1100	0	
1200	0	
1300	2	
1400	3	
1500	1	
1600	1	
1700	9	
1800	27	
1900	38	
2000	60	**
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		



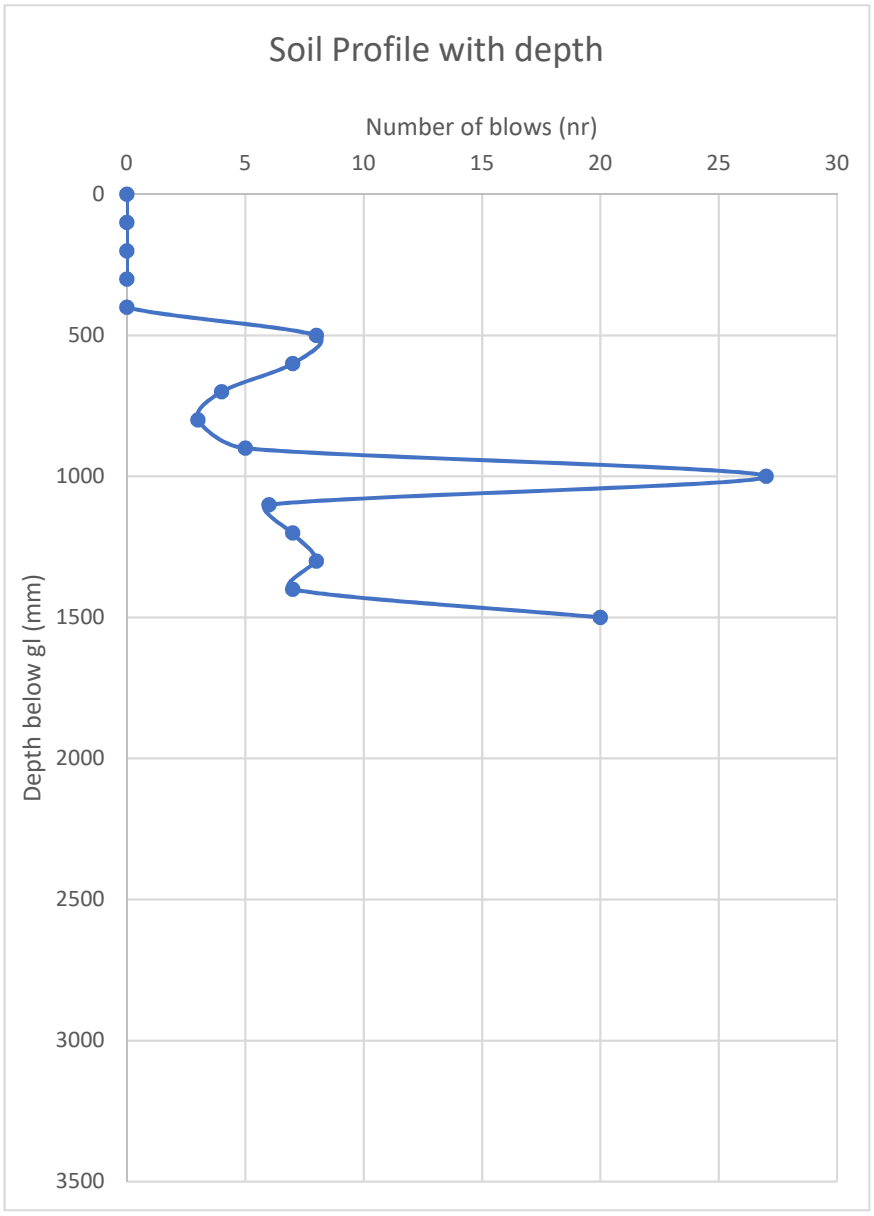
** At depth 2000mm, testing terminated at 60 blows. Slight movement - Firm ground.

*Peat depth 1600mm.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Barrage 2 (Bunded)	Easting =	160548	**MP59**
		Northing =	203914	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	0	
200	0	
300	0	
400	0	
500	8	
600	7	
700	4	
800	3	
900	5	
1000	27	
1100	6	
1200	7	
1300	8	
1400	7	
1500	20	**
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		



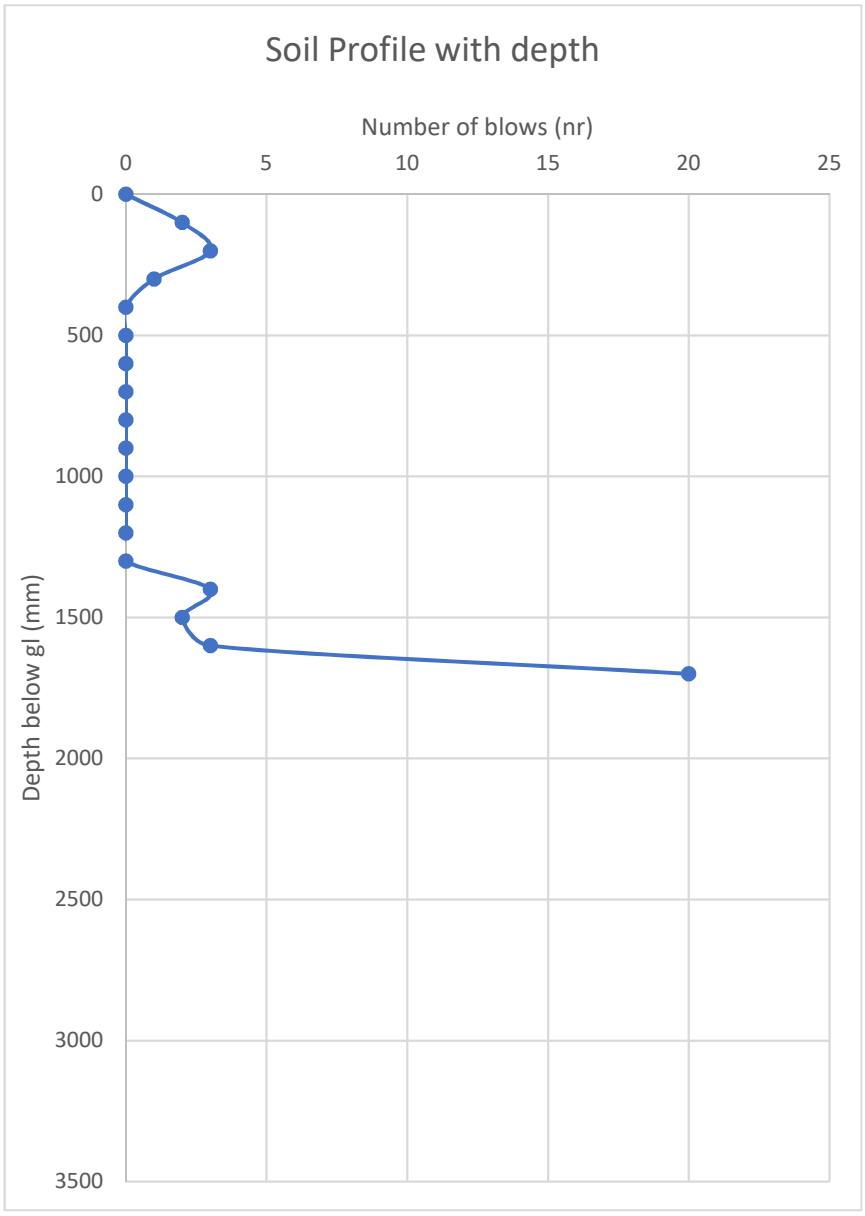
** At depth 1500mm, testing terminated at 20 blows. No movement - Recoil to probe.

*Peat depth 400mm.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Barrage 2 (Bunded)	Easting =	160571	**MP60**
		Northing =	203922	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	3	
300	1	
400	0	
500	0	
600	0	
700	0	
800	0	
900	0	
1000	0	
1100	0	
1200	0	
1300	0	
1400	3	
1500	2	
1600	3	
1700	20	**
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		



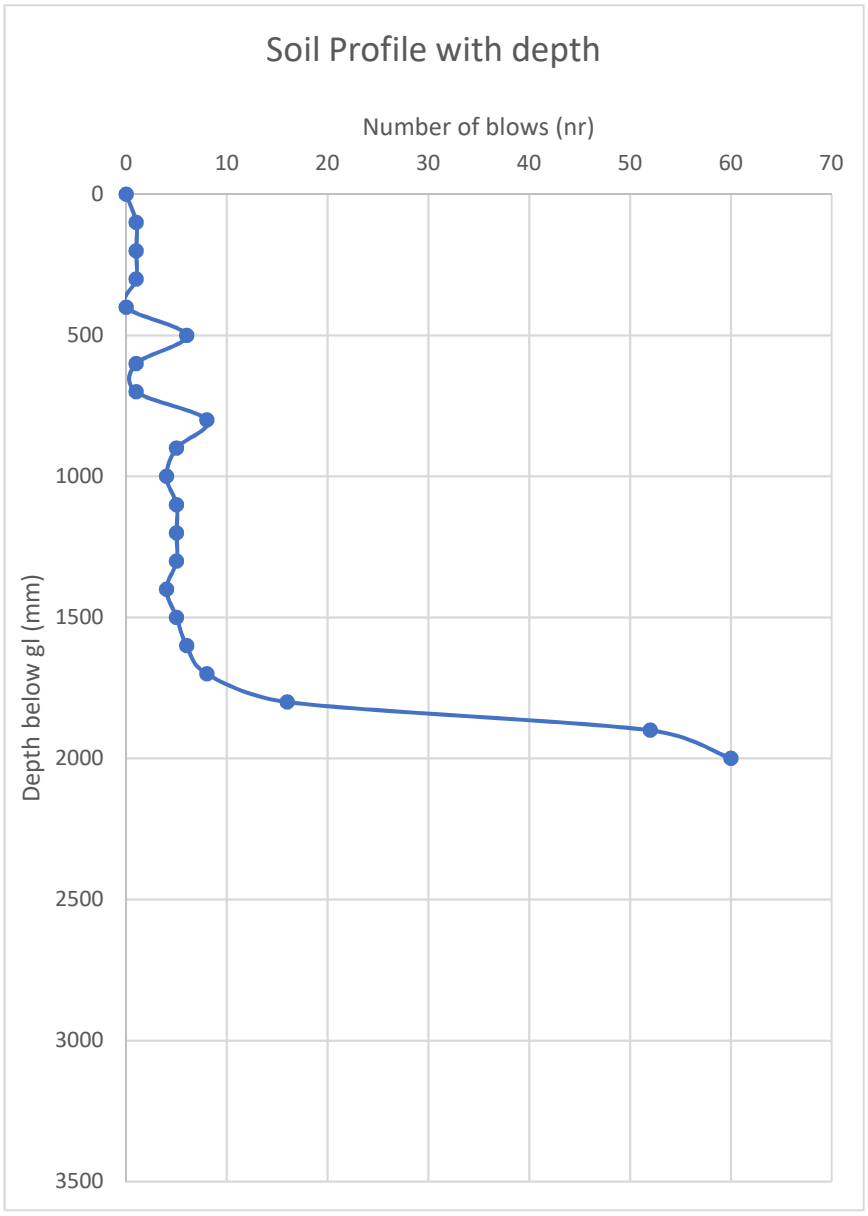
** At depth 1700mm, testing terminated at 20 blows. No movement - Recoil to probe.

*Peat depth 1300mm.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Barrage 2 (Bunded)	Easting =	160558	**MP61**
		Northing =	203917	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	1	
300	1	
400	0	
500	6	
600	1	
700	1	
800	8	
900	5	
1000	4	
1100	5	
1200	5	
1300	5	
1400	4	
1500	5	
1600	6	
1700	8	
1800	16	
1900	52	
2000	60	**
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		



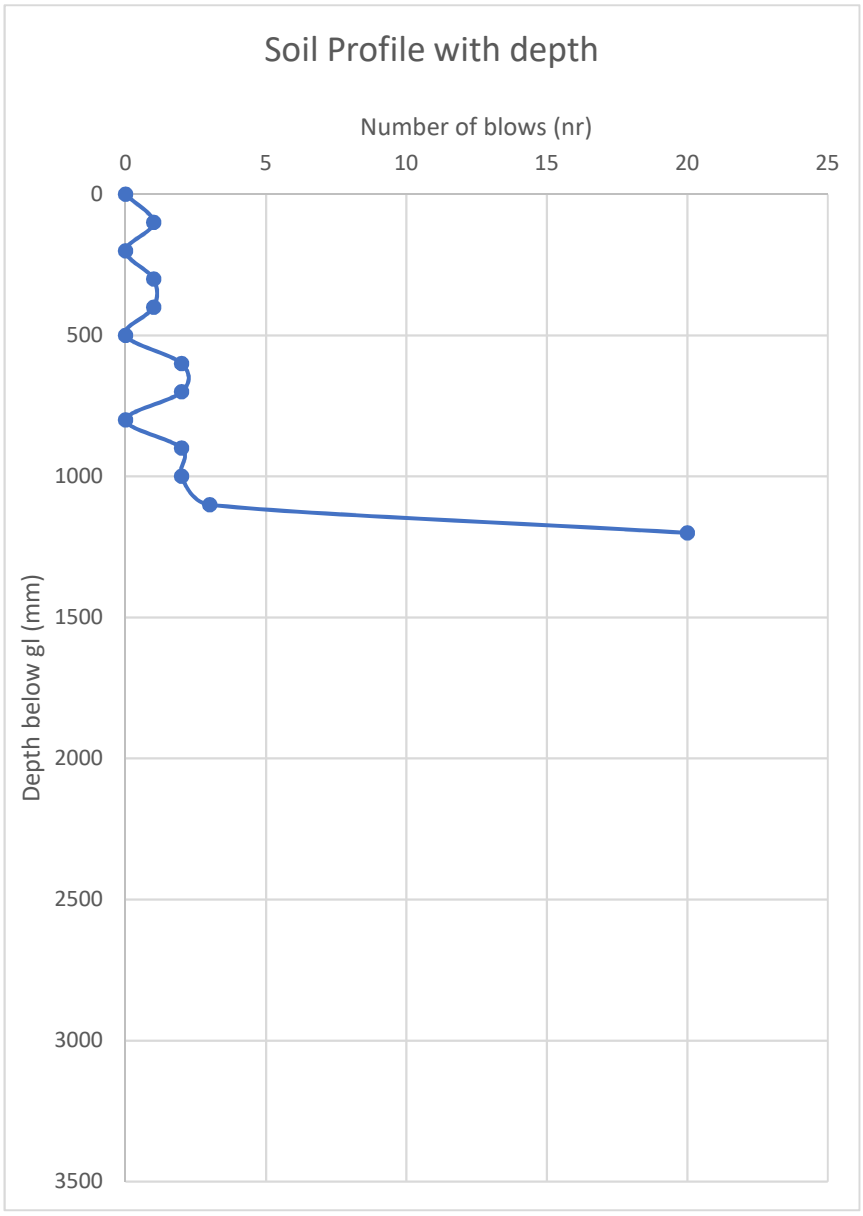
** At depth 2000mm, testing terminated at 60 blows. Slight movement - Firm ground.

*Peat depth 600mm.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Barrage 2 (Bunded)	Easting =	160553	**MP62**
		Northing =	203913	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	0	
300	1	
400	1	
500	0	
600	2	
700	2	
800	0	
900	2	
1000	2	
1100	3	
1200	20	**
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		



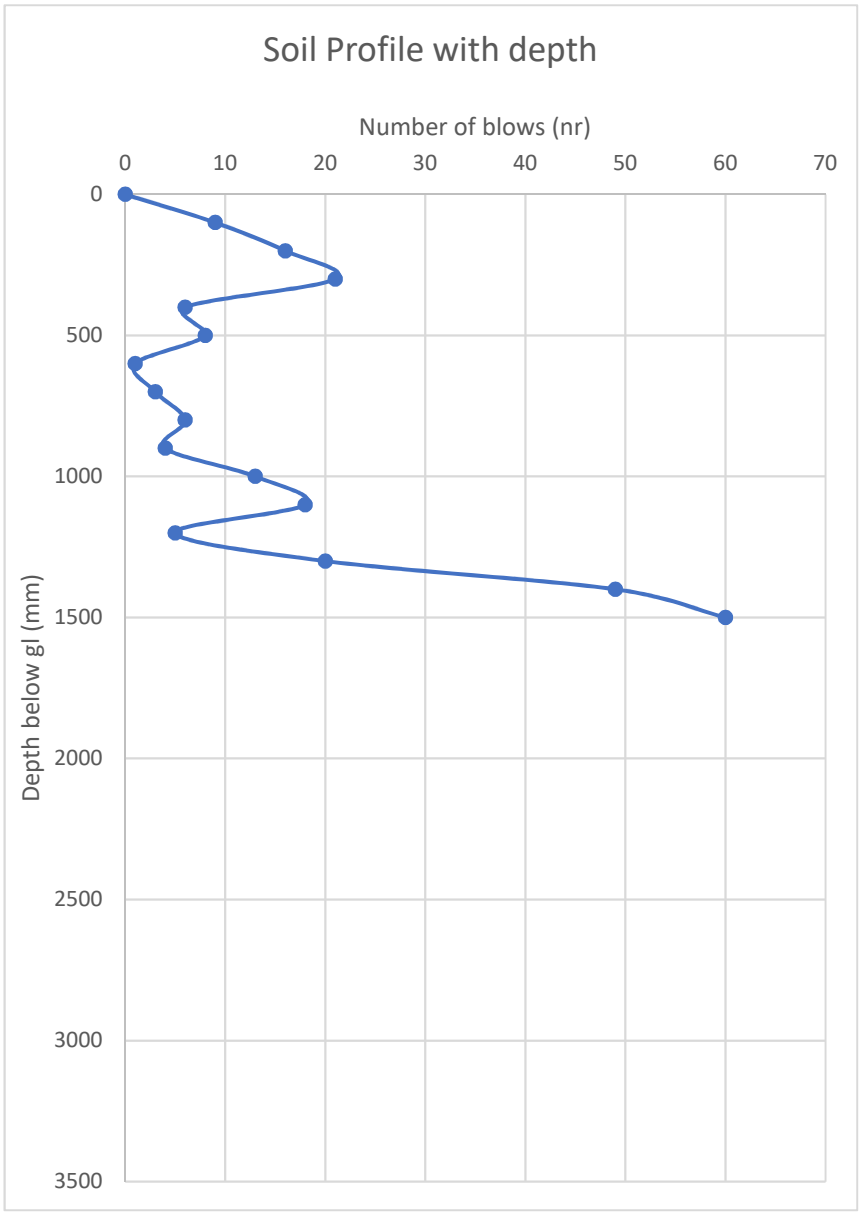
** At depth 1200mm, testing terminated at 20 blows. No movement - Recoil to probe.

*Peat depth 550mm.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Barrage 2 (Bunded)	Easting =	160554	**MP63**
		Northing =	203910	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	9	
200	16	
300	21	
400	6	
500	8	
600	1	
700	3	
800	6	
900	4	
1000	13	
1100	18	
1200	5	
1300	20	
1400	49	
1500	60	**
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

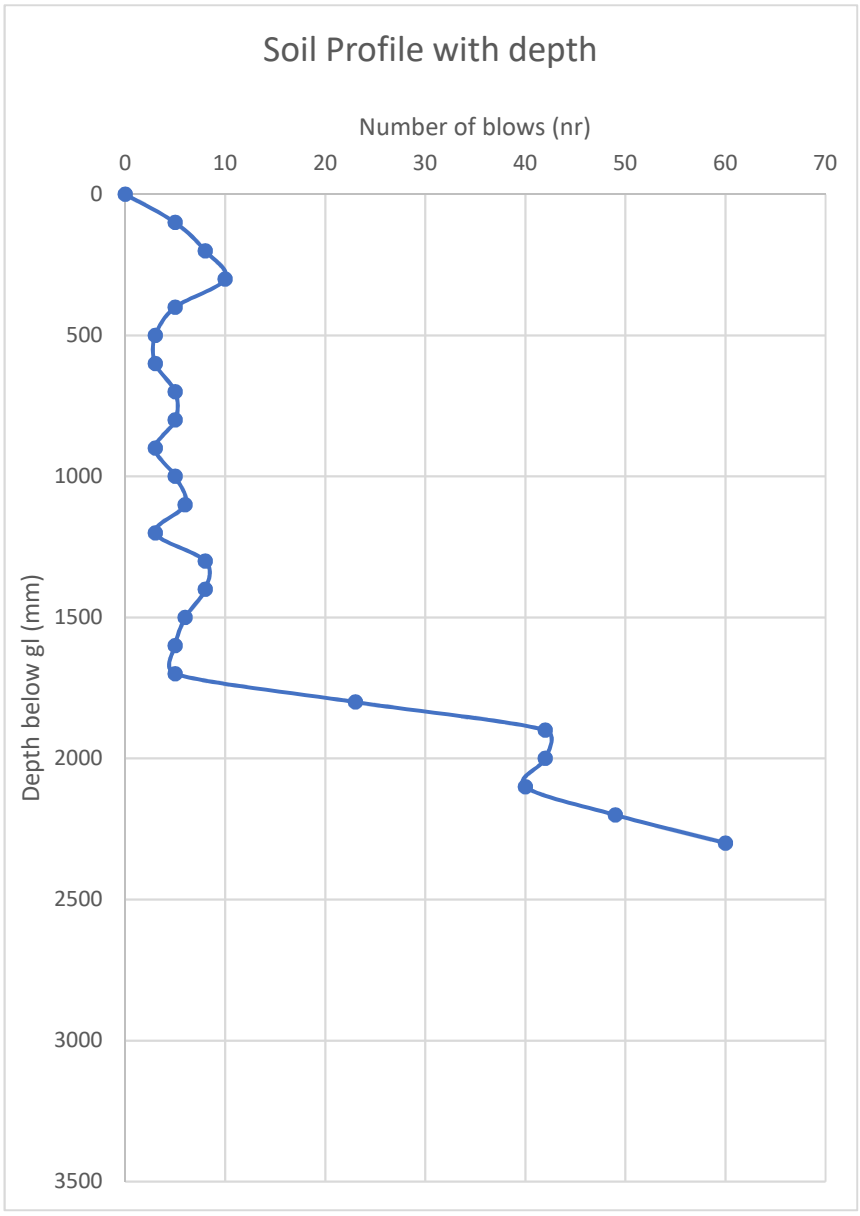


** At depth 1500mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Barrage 2 (Bunded)	Easting =	160570	**MP64**
		Northing =	203930	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	5	
200	8	
300	10	
400	5	
500	3	
600	3	
700	5	
800	5	
900	3	
1000	5	
1100	6	
1200	3	
1300	8	
1400	8	
1500	6	
1600	5	
1700	5	
1800	23	
1900	42	
2000	42	
2100	40	
2200	49	
2300	60	**
2400		
2500		
2600		
2700		
2800		
2900		
3000		



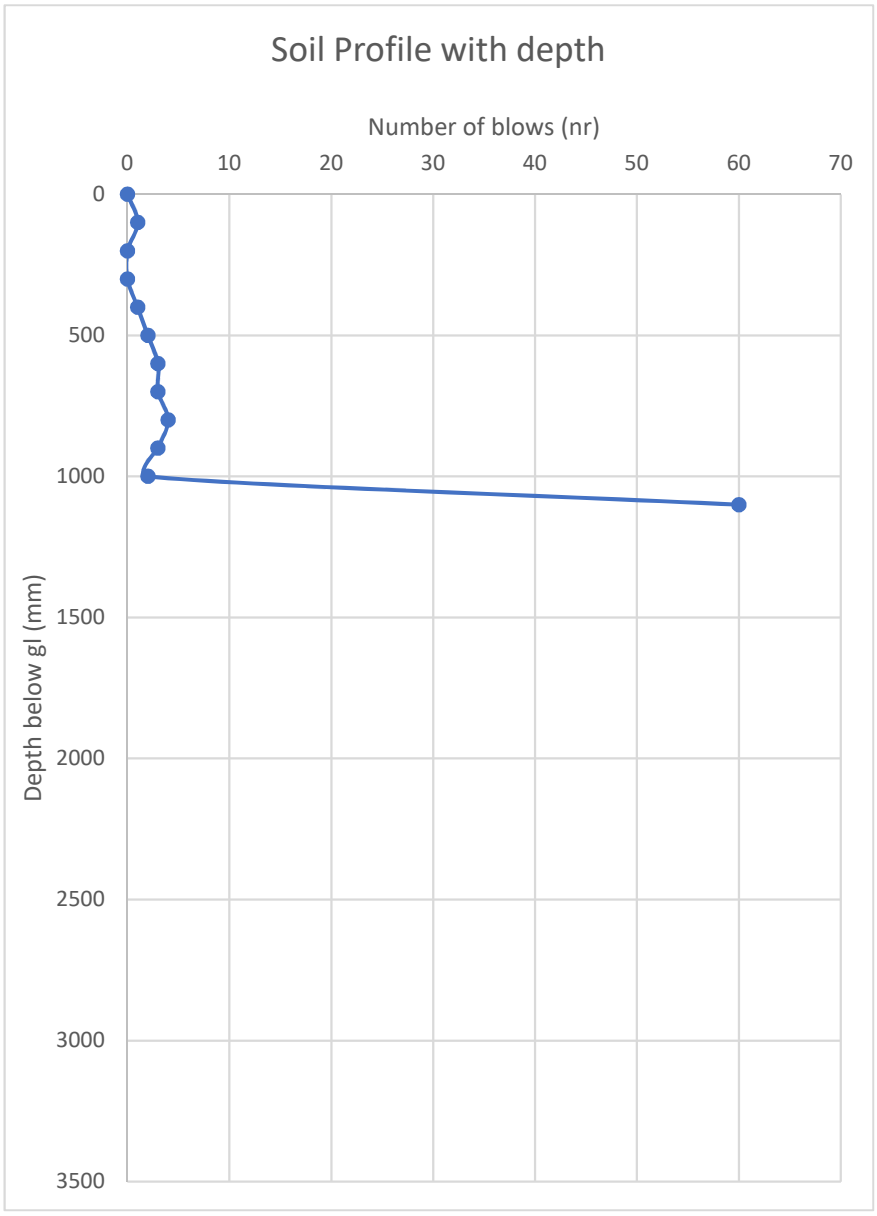
** At depth 2300mm, testing terminated at 60 blows. Slight movement - Firm ground.

*Probing completed closer to peat side.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Barrage 2 (Bunded)	Easting =	160557	**MP65**
		Northing =	203910	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	0	
300	0	
400	1	
500	2	
600	3	
700	3	
800	4	
900	3	
1000	2	
1100	60	**
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

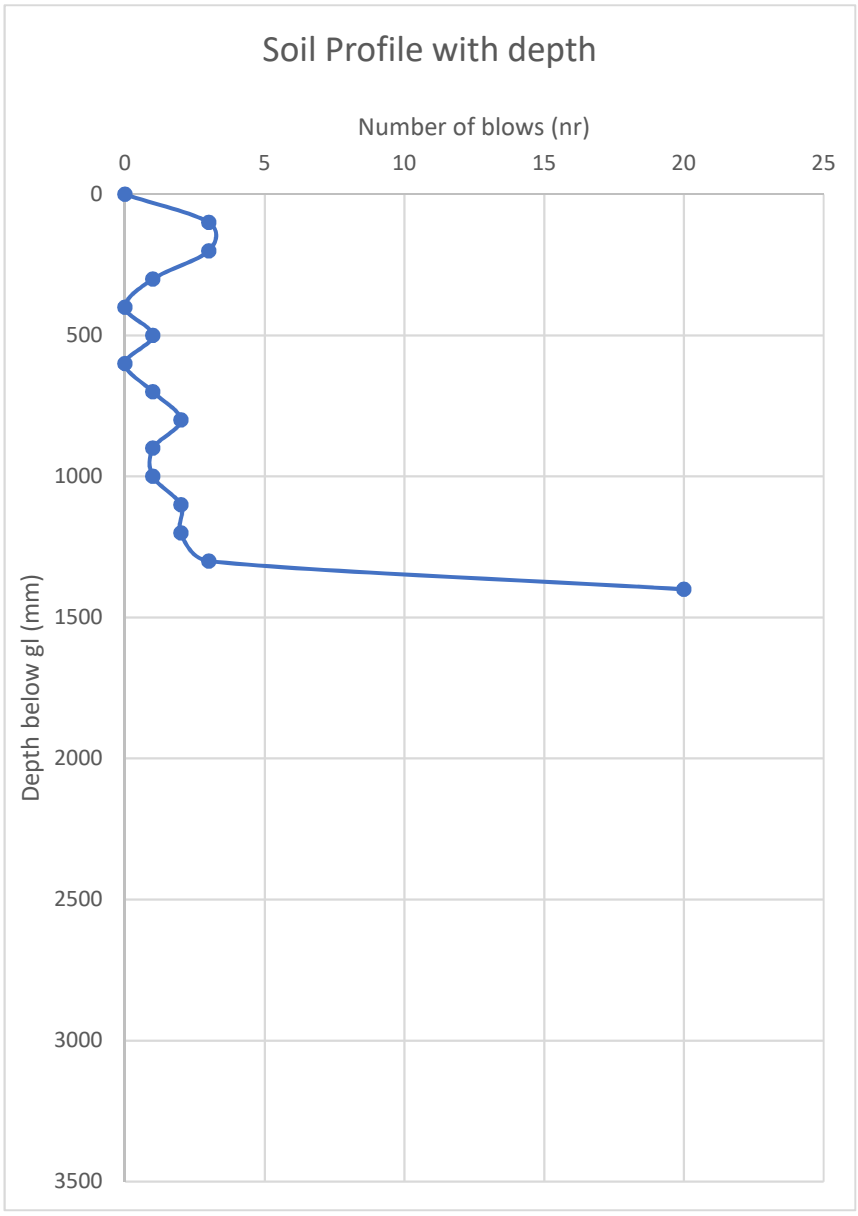


** At depth 1100mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Blackbridge	Easting =	161321	**MP66**
		Northing =	203689	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	3	
200	3	
300	1	
400	0	
500	1	
600	0	
700	1	
800	2	
900	1	
1000	1	
1100	2	
1200	2	
1300	3	
1400	20	**
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		



** At depth 1400mm, testing terminated at 20 blows. No movement - Recoil to probe.

*Peat depth 1000mm.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Blackbridge	Easting =	161320	**MP67**
		Northing =	203698	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	9	
200	15	
300	14	
400	6	
500	6	
600	9	
700	10	
800	20	**
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
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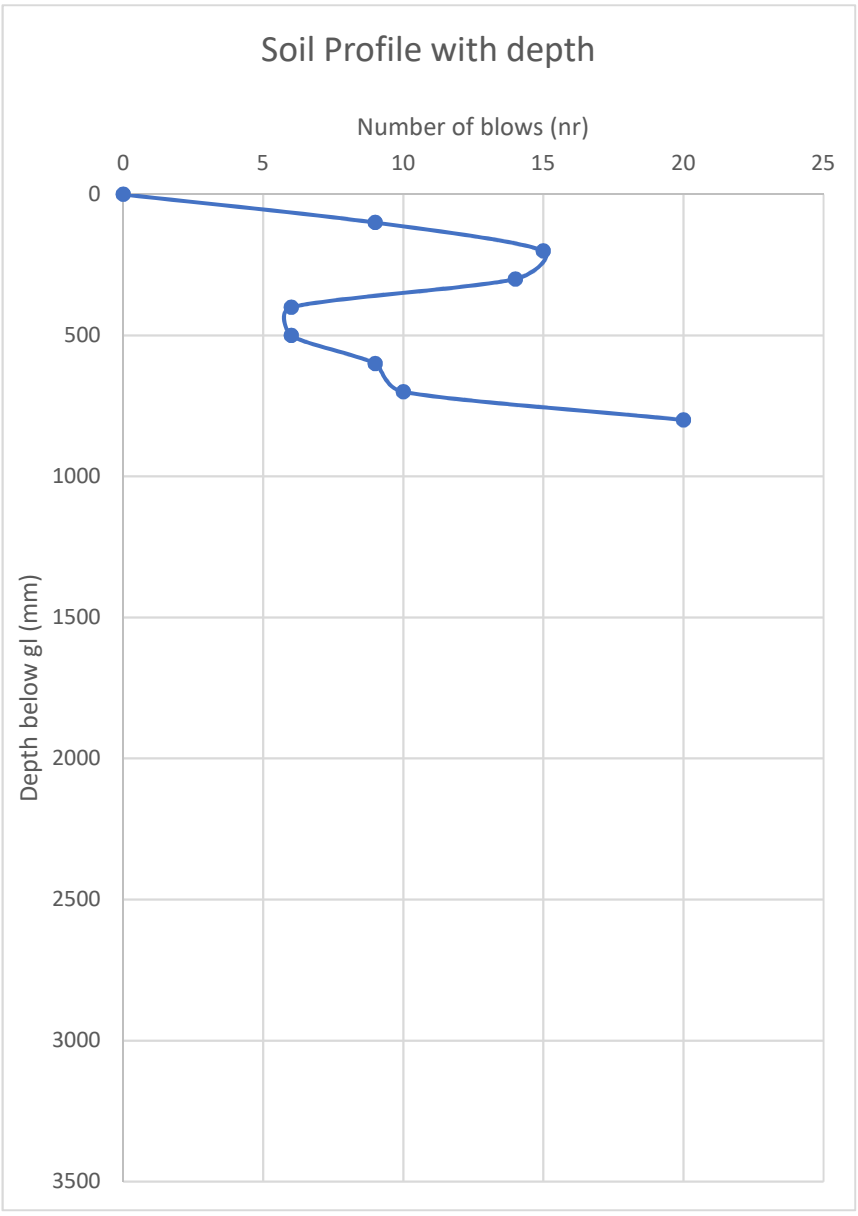
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

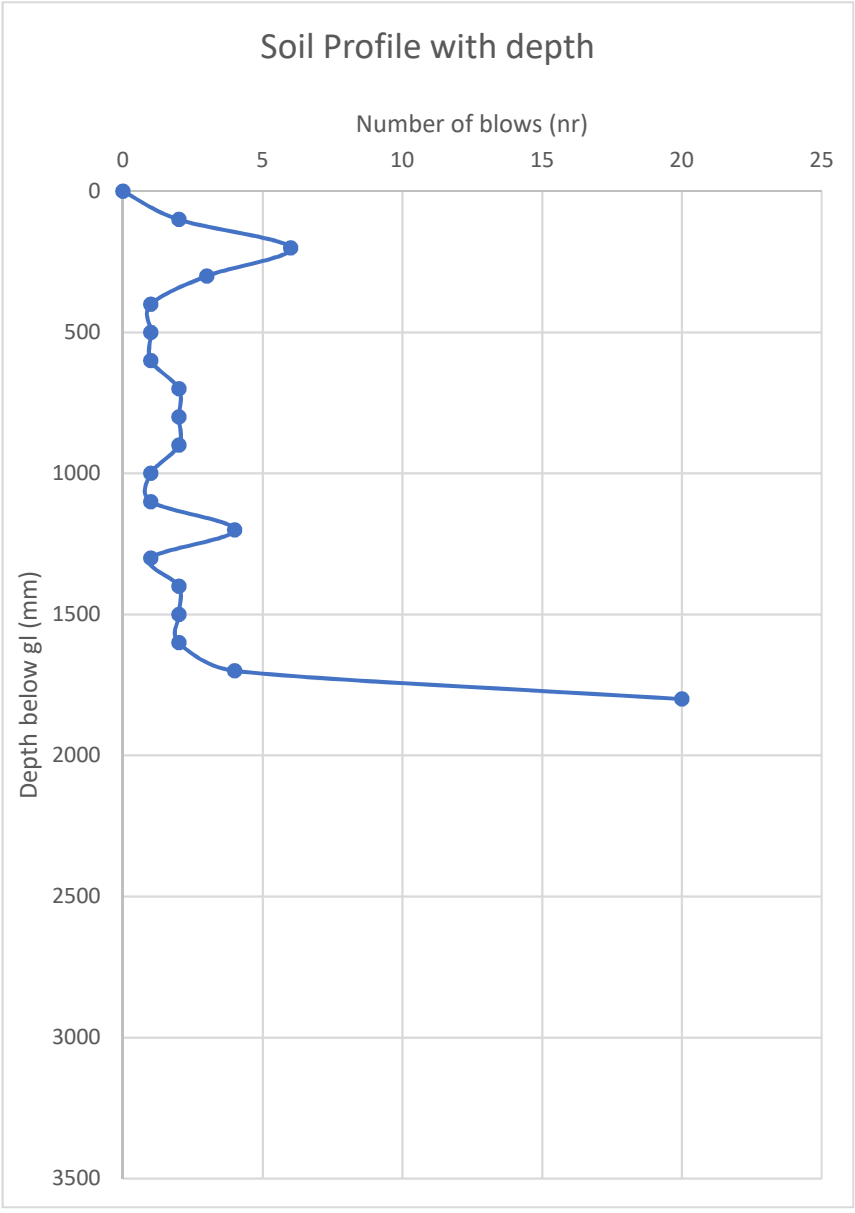


** At depth 800mm, testing terminated at 20 blows. No movement - Recoil to probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Blackbridge	Easting =	161298	**MP68**
		Northing =	203669	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	6	
300	3	
400	1	
500	1	
600	1	
700	2	
800	2	
900	2	
1000	1	
1100	1	
1200	4	
1300	1	
1400	2	
1500	2	
1600	2	
1700	4	
1800	20	**
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		



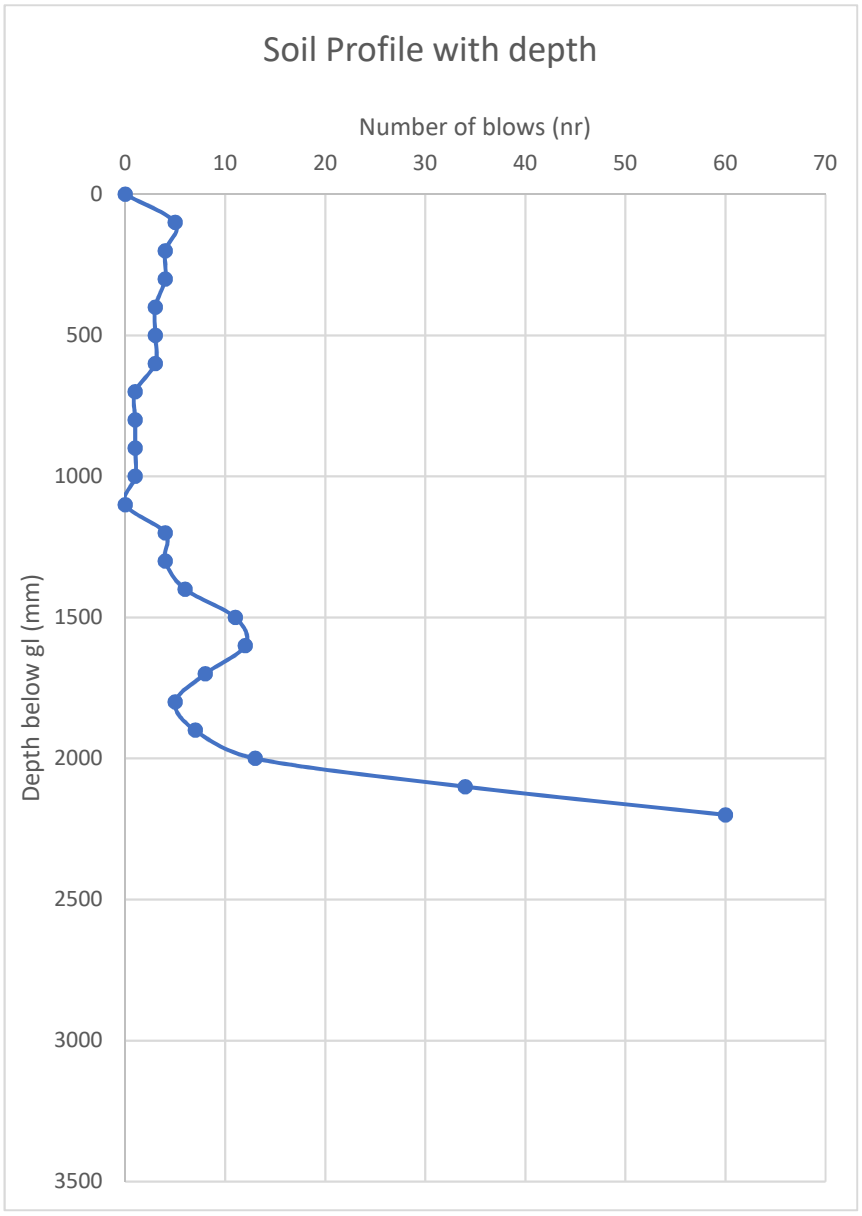
** At depth 1800mm, testing terminated at 20 blows. No movement - Recoil to probe.

*Peat depth 1100mm.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Blackbridge	Easting =	161291	**MP69**
		Northing =	203665	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	5	
200	4	
300	4	
400	3	
500	3	
600	3	
700	1	
800	1	
900	1	
1000	1	
1100	0	
1200	4	
1300	4	
1400	6	
1500	11	
1600	12	
1700	8	
1800	5	
1900	7	
2000	13	
2100	34	
2200	60	**
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

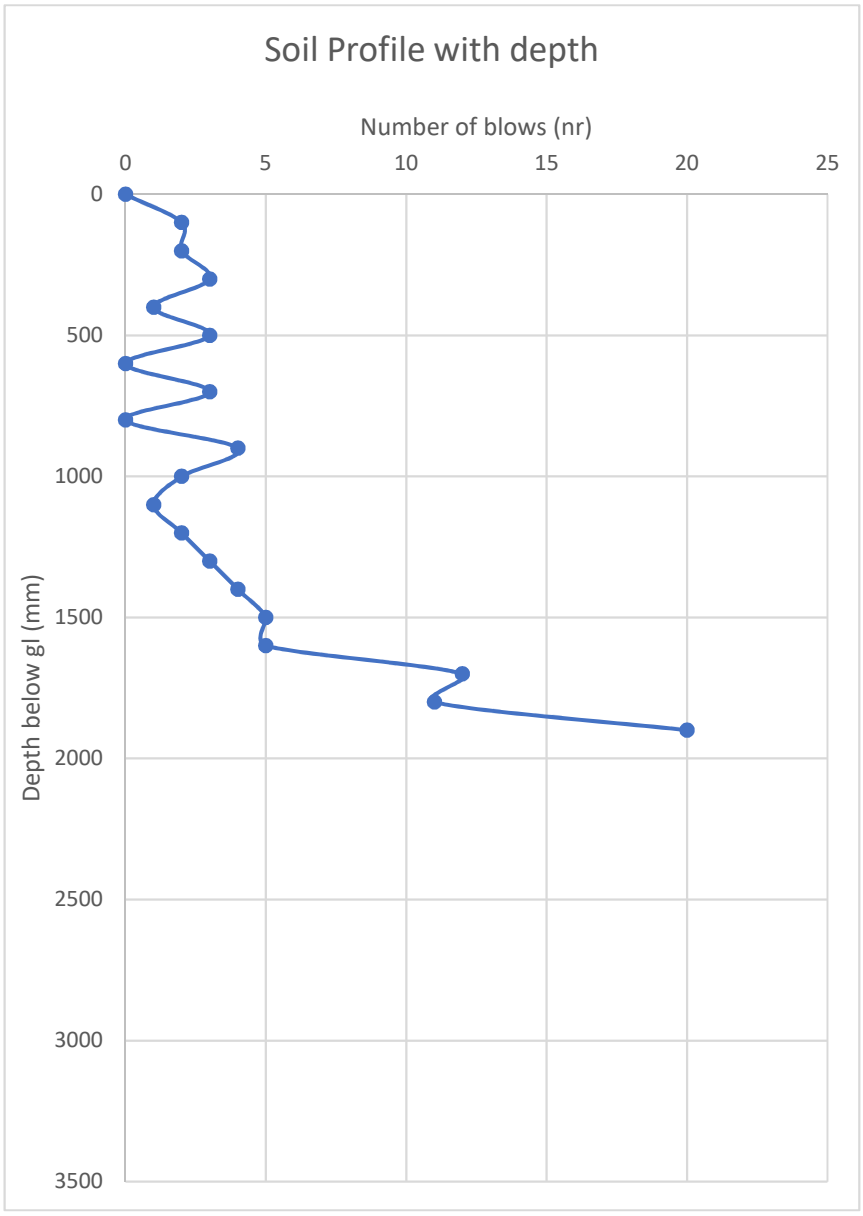


** At depth 2200mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Blackbridge	Easting =	161316	**MP70**
		Northing =	203640	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	2	
300	3	
400	1	
500	3	
600	0	
700	3	
800	0	
900	4	
1000	2	
1100	1	
1200	2	
1300	3	
1400	4	
1500	5	
1600	5	
1700	12	
1800	11	
1900	20	**
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		



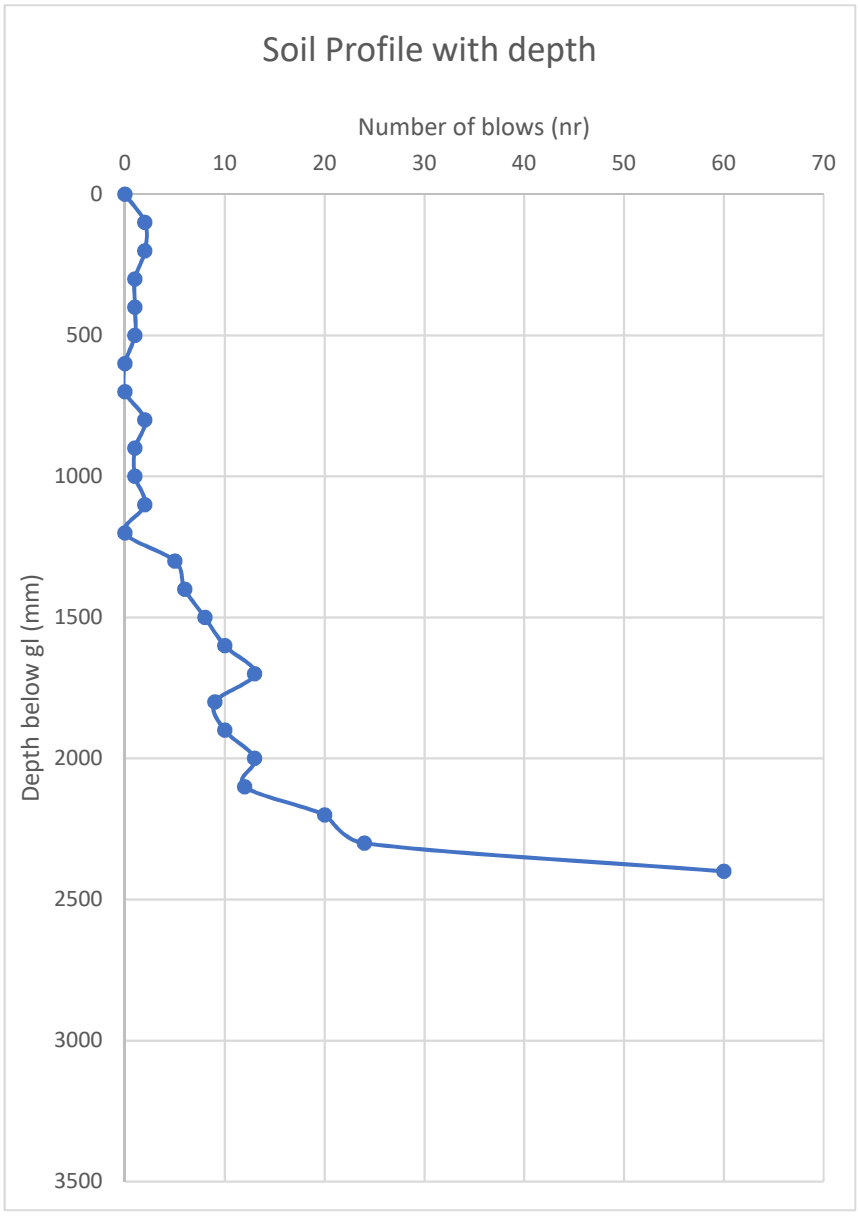
** At depth 1900mm, testing terminated at 20 blows. No movement - Recoil to probe.

*Peat depth 1400mm.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Blackbridge	Easting =	161343	**MP71**
		Northing =	203660	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	2	
300	1	
400	1	
500	1	
600	0	
700	0	
800	2	
900	1	
1000	1	
1100	2	
1200	0	
1300	5	
1400	6	
1500	8	
1600	10	
1700	13	
1800	9	
1900	10	
2000	13	
2100	12	
2200	20	
2300	24	
2400	60	**
2500		
2600		
2700		
2800		
2900		
3000		



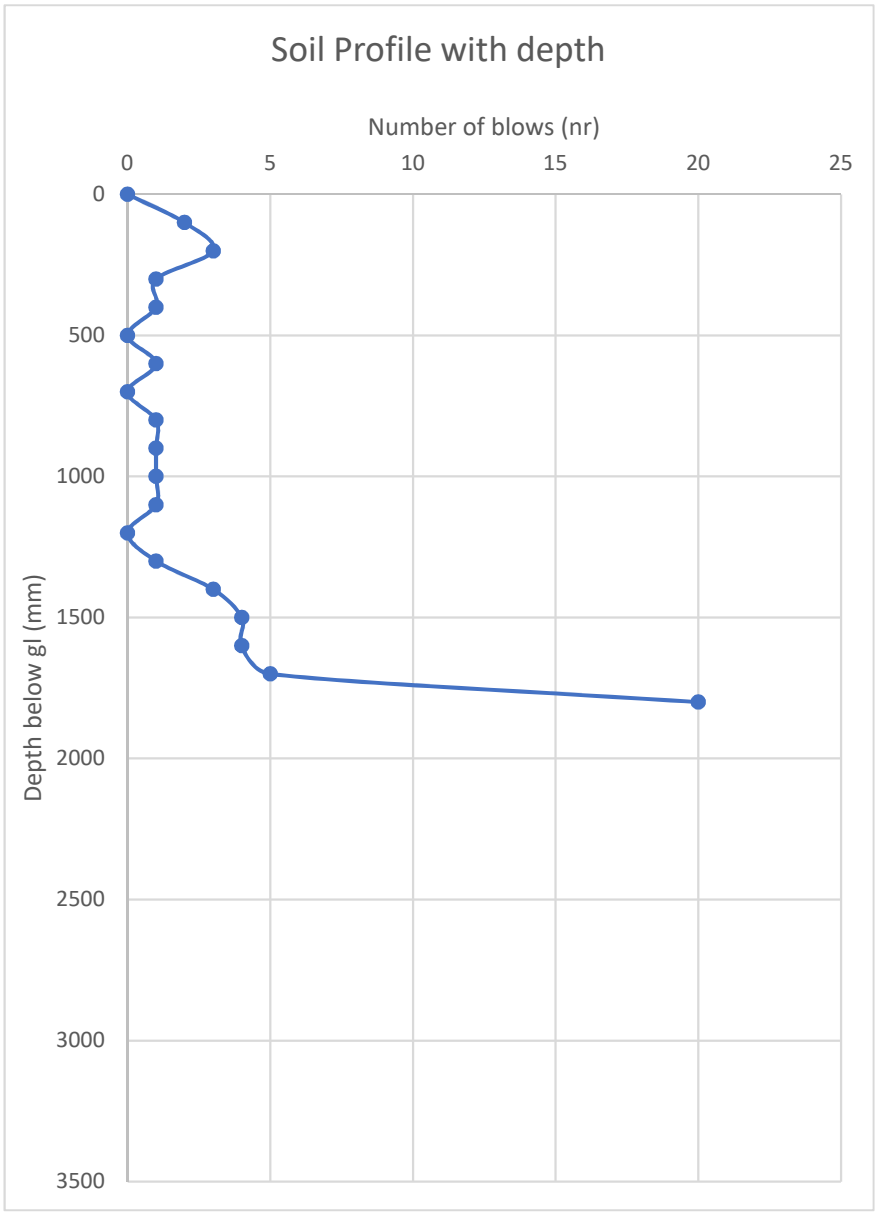
** At depth 2400mm, testing terminated at 60 blows. Slight movement - Firm ground.

*Peat depth 1200mm.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Blackbridge	Easting =	161323	**MP72**
		Northing =	203673	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	3	
300	1	
400	1	
500	0	
600	1	
700	0	
800	1	
900	1	
1000	1	
1100	1	
1200	0	
1300	1	
1400	3	
1500	4	
1600	4	
1700	5	
1800	20	**
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		



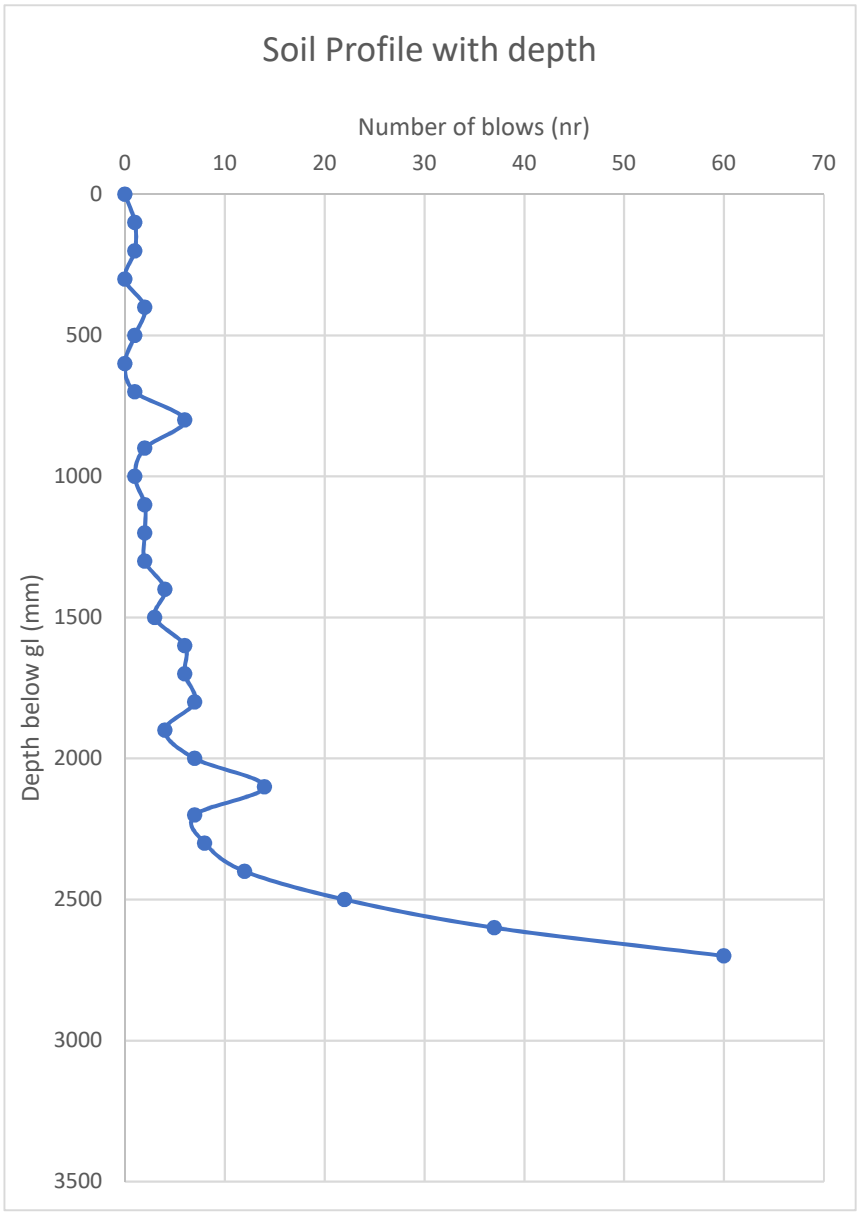
** At depth 1800mm, testing terminated at 20 blows. No movement - Recoil to probe.

*Peat depth 1300mm.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Blackbridge	Easting =	161370	**MP73**
		Northing =	203660	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	1	
300	0	
400	2	
500	1	
600	0	
700	1	
800	6	
900	2	
1000	1	
1100	2	
1200	2	
1300	2	
1400	4	
1500	3	
1600	6	
1700	6	
1800	7	
1900	4	
2000	7	
2100	14	
2200	7	
2300	8	
2400	12	
2500	22	
2600	37	
2700	60	**
2800		
2900		
3000		



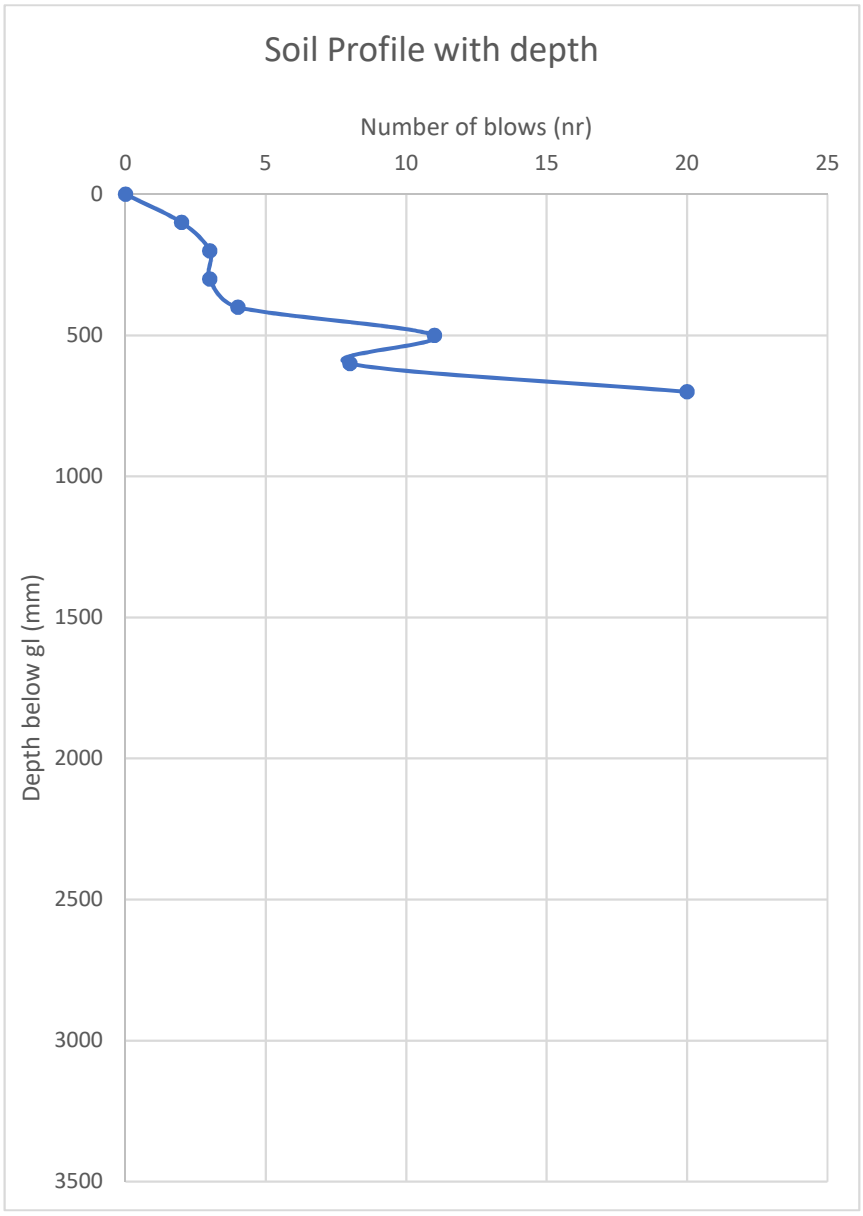
** At depth 2400mm, testing terminated at 60 blows. Slight movement - Firm ground.

*Peat depth 1300mm.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Blackbridge	Easting =	161332	**MP74**
		Northing =	203621	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	3	
300	3	
400	4	
500	11	
600	8	
700	20	**
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		



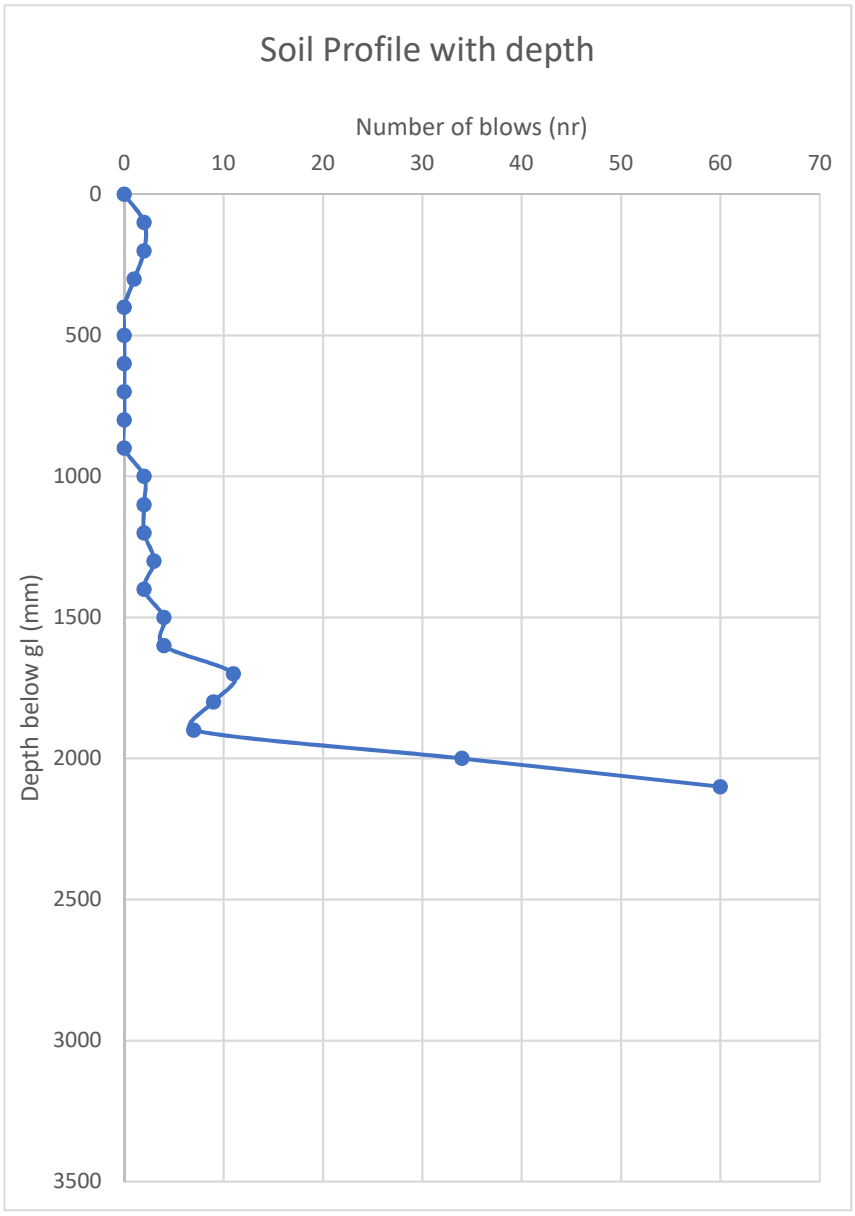
** At depth 700mm, testing terminated at 20 blows. No movement - Recoil to probe.

*Peat depth 300mm.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Blackbridge	Easting =	161365	**MP75**
		Northing =	203635	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	2	
300	1	
400	0	
500	0	
600	0	
700	0	
800	0	
900	0	
1000	2	
1100	2	
1200	2	
1300	3	
1400	2	
1500	4	
1600	4	
1700	11	
1800	9	
1900	7	
2000	34	
2100	60	**
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

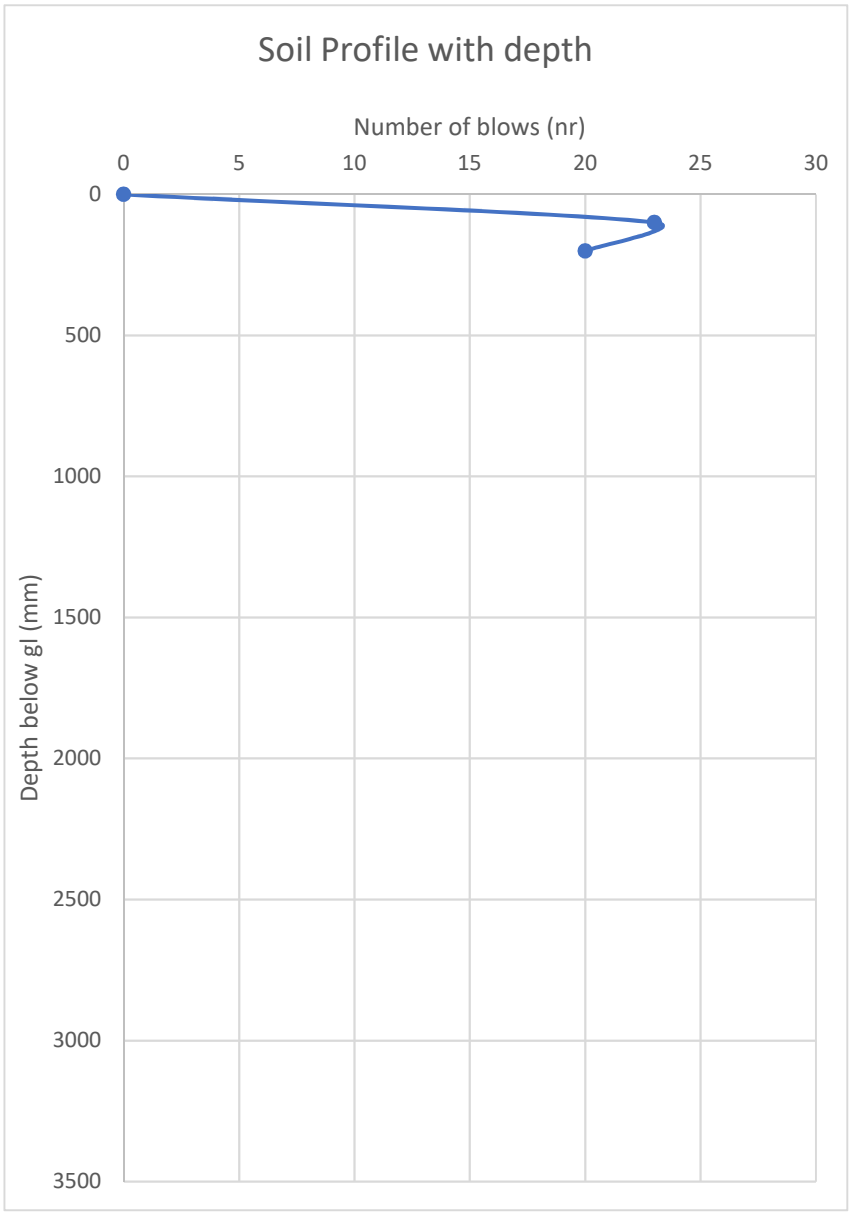


** At depth 2100mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Blackbridge	Easting =	161338	**MP76**
		Northing =	203637	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	23	
200	20	**
300		
400		
500		
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

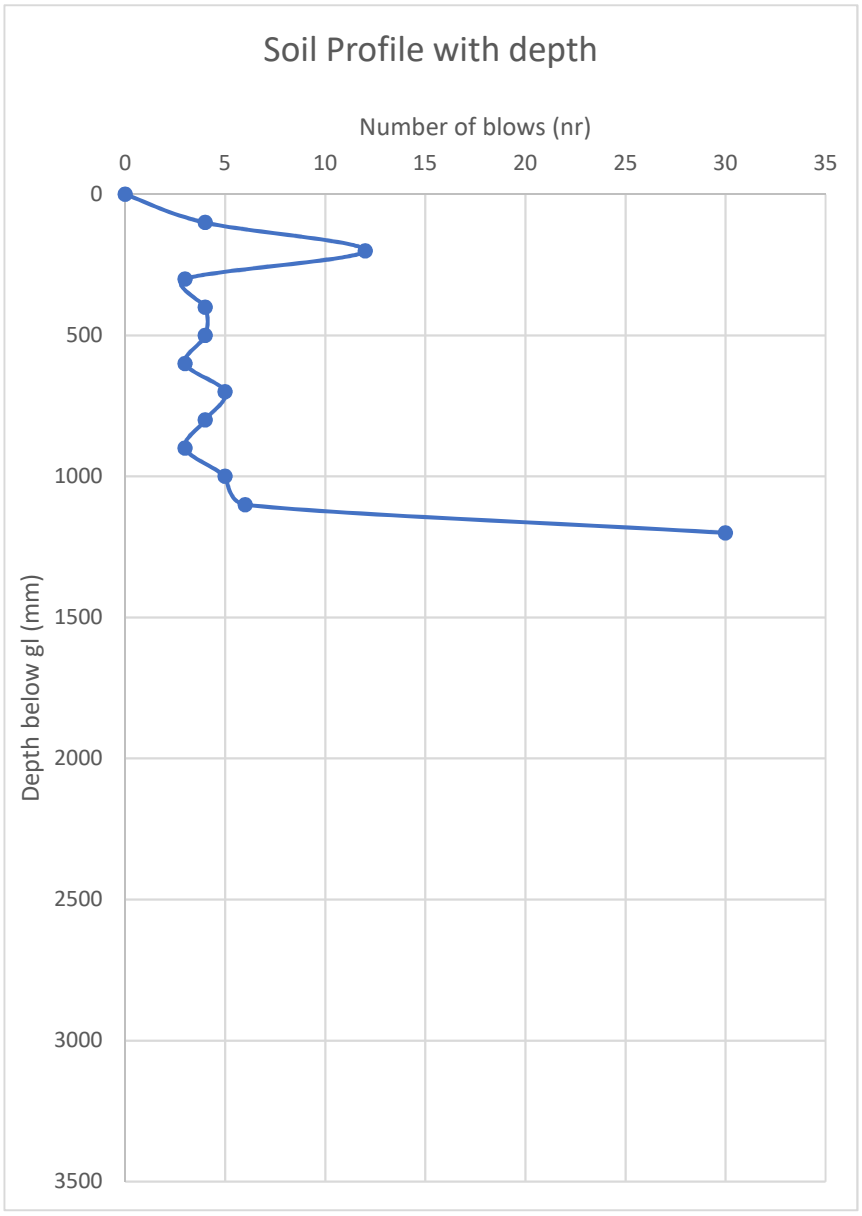


** At depth 200mm, testing terminated at 20 blows. No movement - Recoil on probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Blackbridge	Easting =	161398	**MP77**
		Northing =	203628	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	4	
200	12	
300	3	
400	4	
500	4	
600	3	
700	5	
800	4	
900	3	
1000	5	
1100	6	
1200	30	**
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

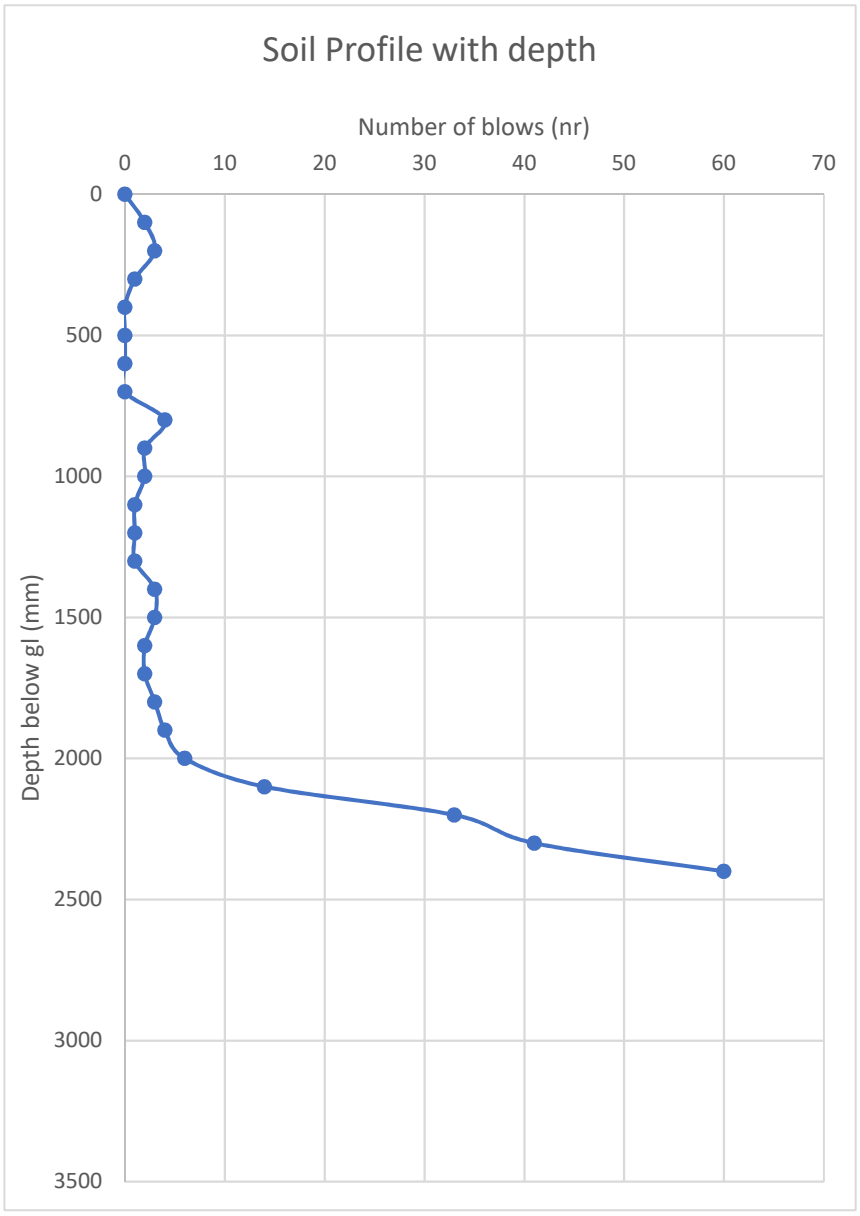


** At depth 1200mm, testing terminated at 30 blows. No movement - Recoil on probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Blackbridge	Easting =	161386	**MP78**
		Northing =	203635	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	2	
200	3	
300	1	
400	0	
500	0	
600	0	
700	0	
800	4	
900	2	
1000	2	
1100	1	
1200	1	
1300	1	
1400	3	
1500	3	
1600	2	
1700	2	
1800	3	
1900	4	
2000	6	
2100	14	
2200	33	
2300	41	
2400	60	**
2500		
2600		
2700		
2800		
2900		
3000		

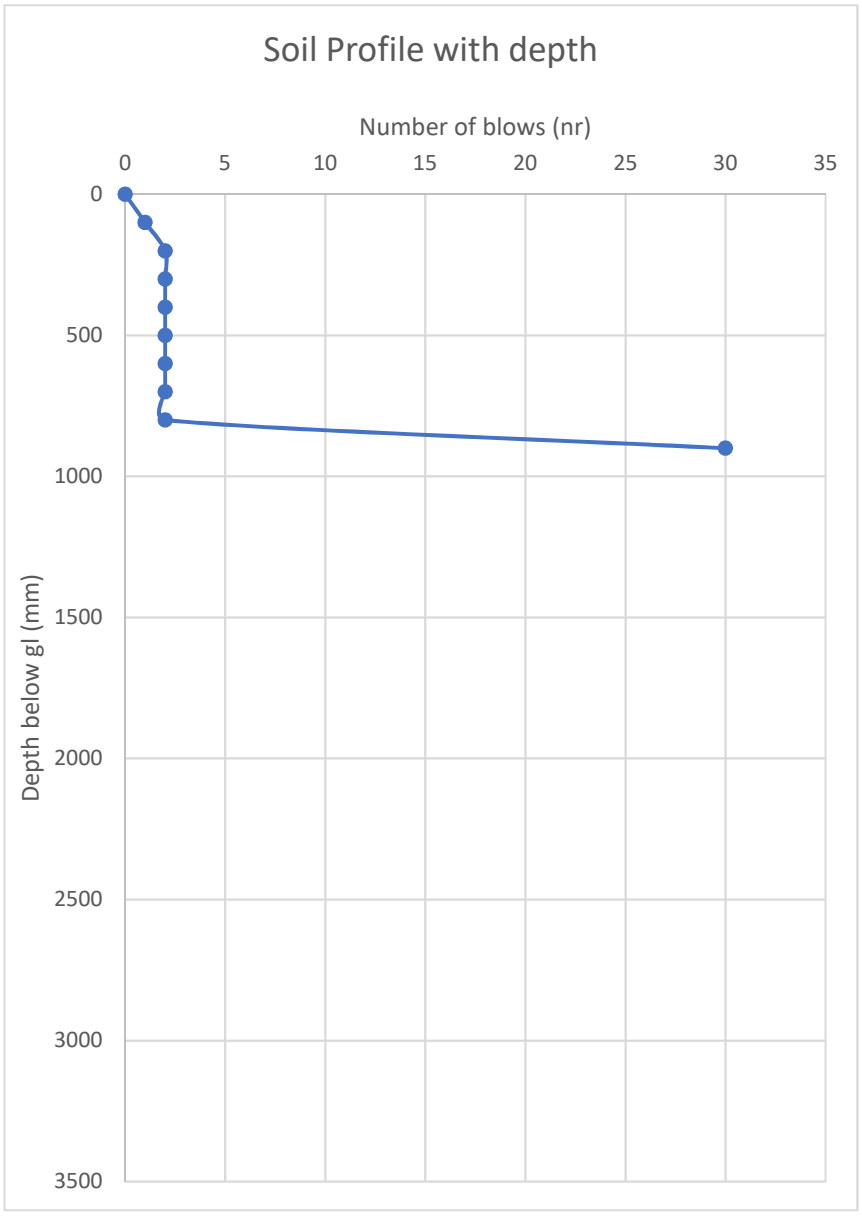


** At depth 2400mm, testing terminated at 60 blows. Slight movement - Firm ground.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Blackbridge	Easting =	161396	**MP79**
		Northing =	203613	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	2	
300	2	
400	2	
500	2	
600	2	
700	2	
800	2	
900	30	**
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

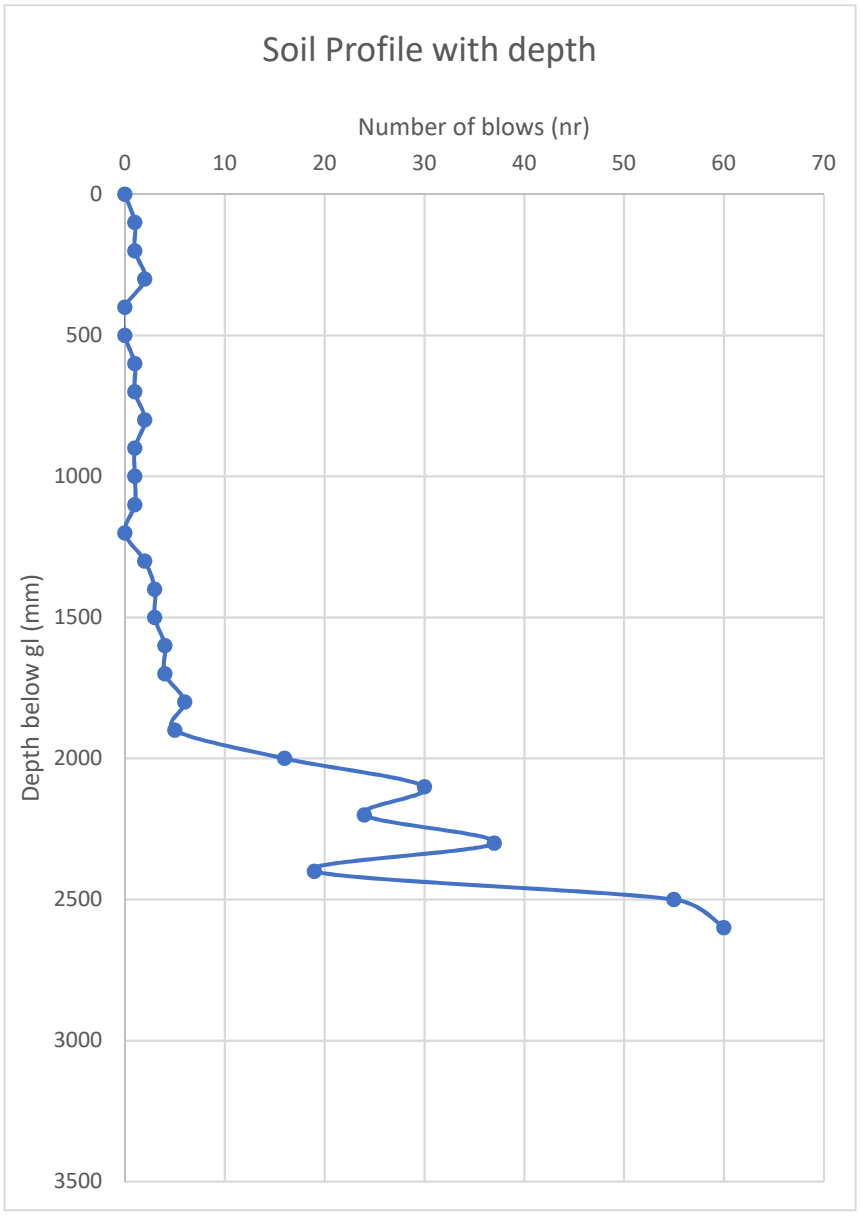


** At depth 900mm, testing terminated at 30 blows. No movement - Recoil on probe.

Site :	Derrybrien Wind Farm, Co. Galway.			Mackintosh Probe No.
Test Location :	Repository Area @ Blackbridge	Easting =	161373	**MP80**
		Northing =	203611	
Weight of hammer :	4.5kg			
Tested By / On:	Raymond Grennan, Alan Whelan.	22/06/2018		

Mackintosh Probe Test

Depth (mm bgl)	Number of blows	
0	0	
100	1	
200	1	
300	2	
400	0	
500	0	
600	1	
700	1	
800	2	
900	1	
1000	1	
1100	1	
1200	0	
1300	2	
1400	3	
1500	3	
1600	4	
1700	4	
1800	6	
1900	5	
2000	16	
2100	30	
2200	24	
2300	37	
2400	19	
2500	55	
2600	60	**
2700		
2800		
2900		
3000		



** At depth 2600mm, testing terminated at 60 blows. Slight movement - Firm ground.

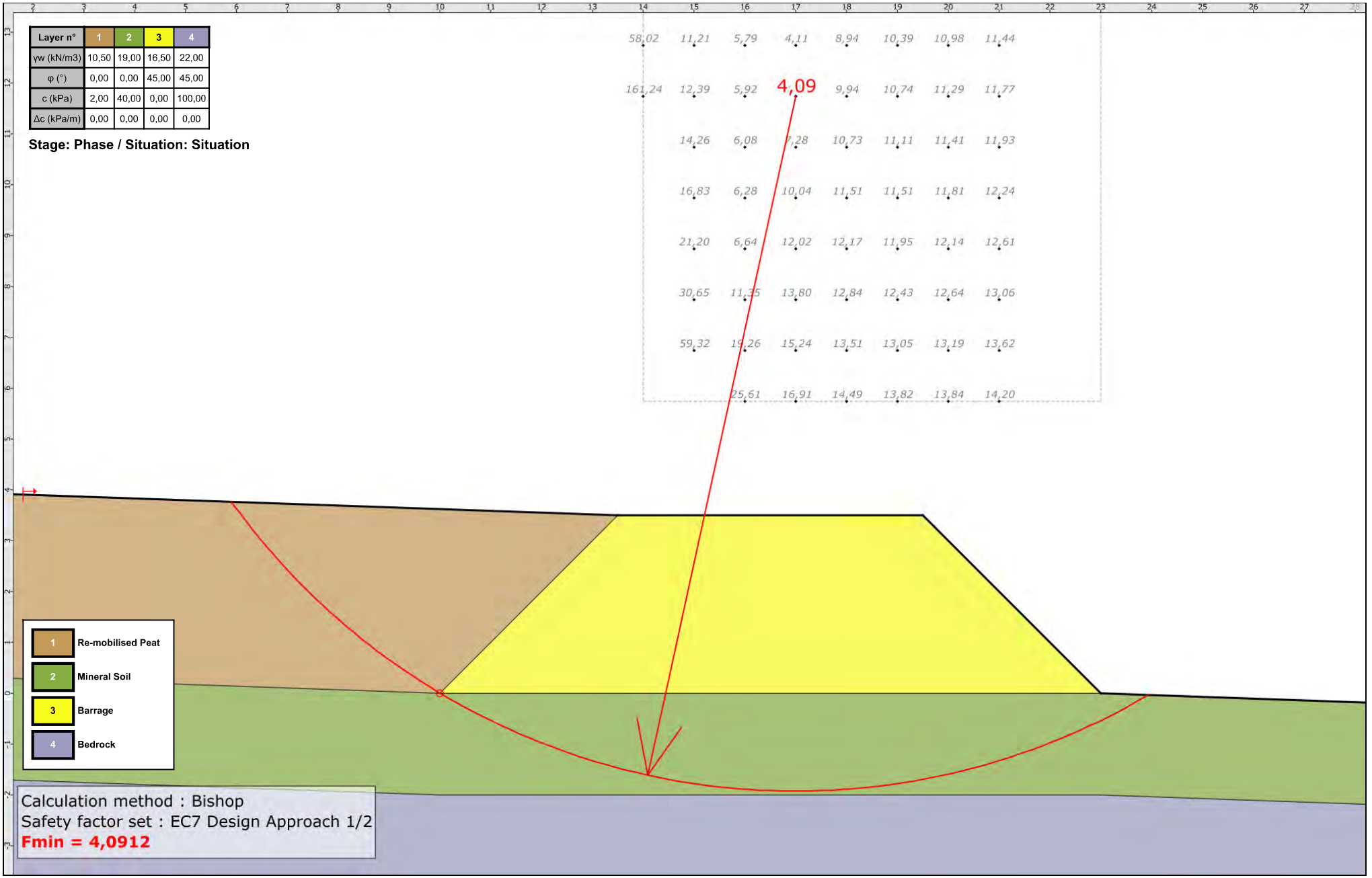
Appendix C

Graphical Outputs & Calculations for Containment Barrages

Scale 1:100

Layer n°	1	2	3	4
γw (kN/m3)	10,50	19,00	16,50	22,00
φ (°)	0,00	0,00	45,00	45,00
c (kPa)	2,00	40,00	0,00	100,00
Δc (kPa/m)	0,00	0,00	0,00	0,00

Stage: Phase / Situation: Situation



terrasol
setec

Talren v5
v5.2.5

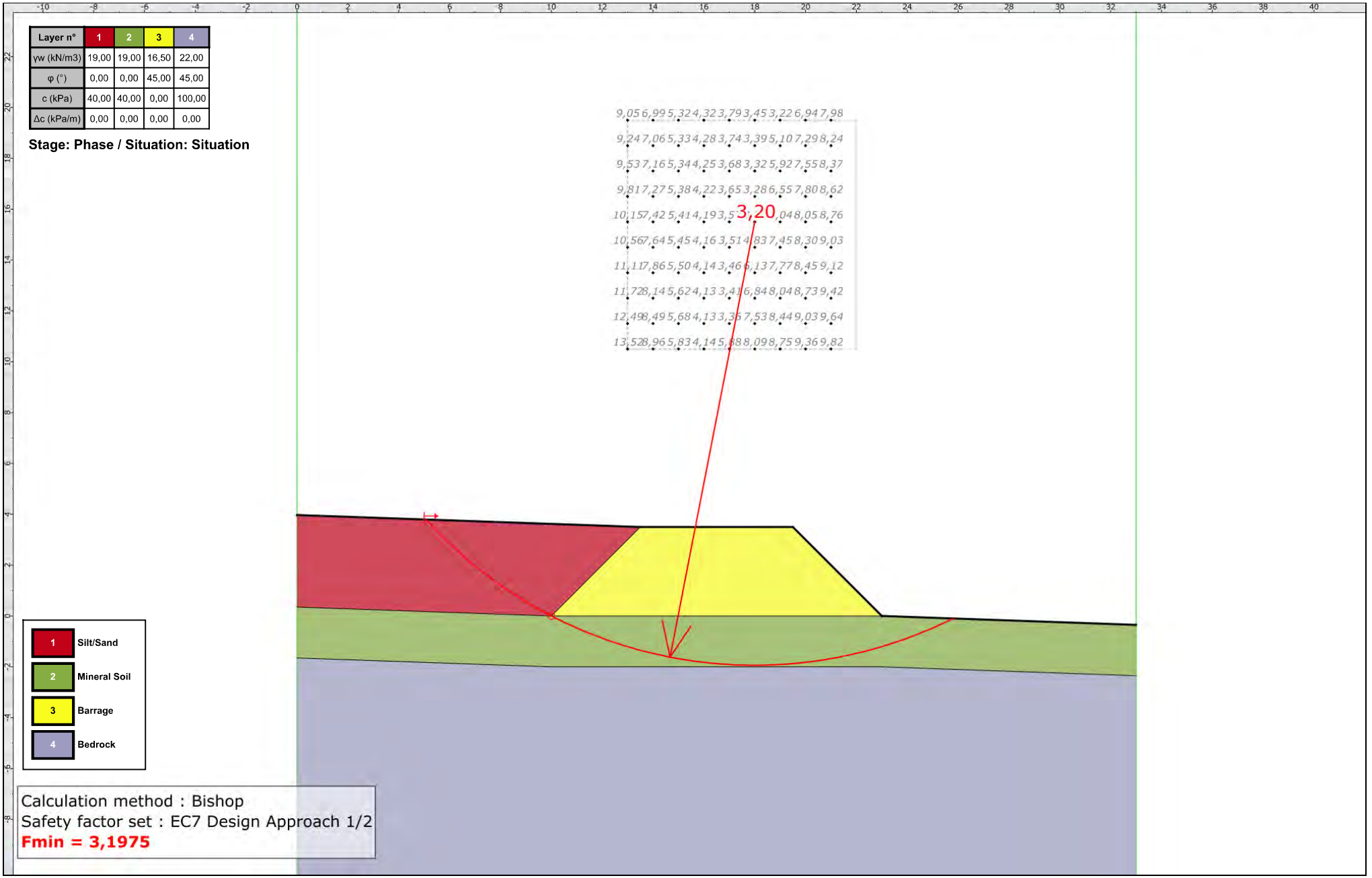
Printed on : 24-Jul-2018 17:14:43
Calculation made by : AGEC

Project : Stability Analysis of Barrage 1 - Undrained Condition - Case 1

Scale 1:200

Layer n°	1	2	3	4
γw (kN/m3)	19,00	19,00	16,50	22,00
φ (°)	0,00	0,00	45,00	45,00
c (kPa)	40,00	40,00	0,00	100,00
Δc (kPa/m)	0,00	0,00	0,00	0,00

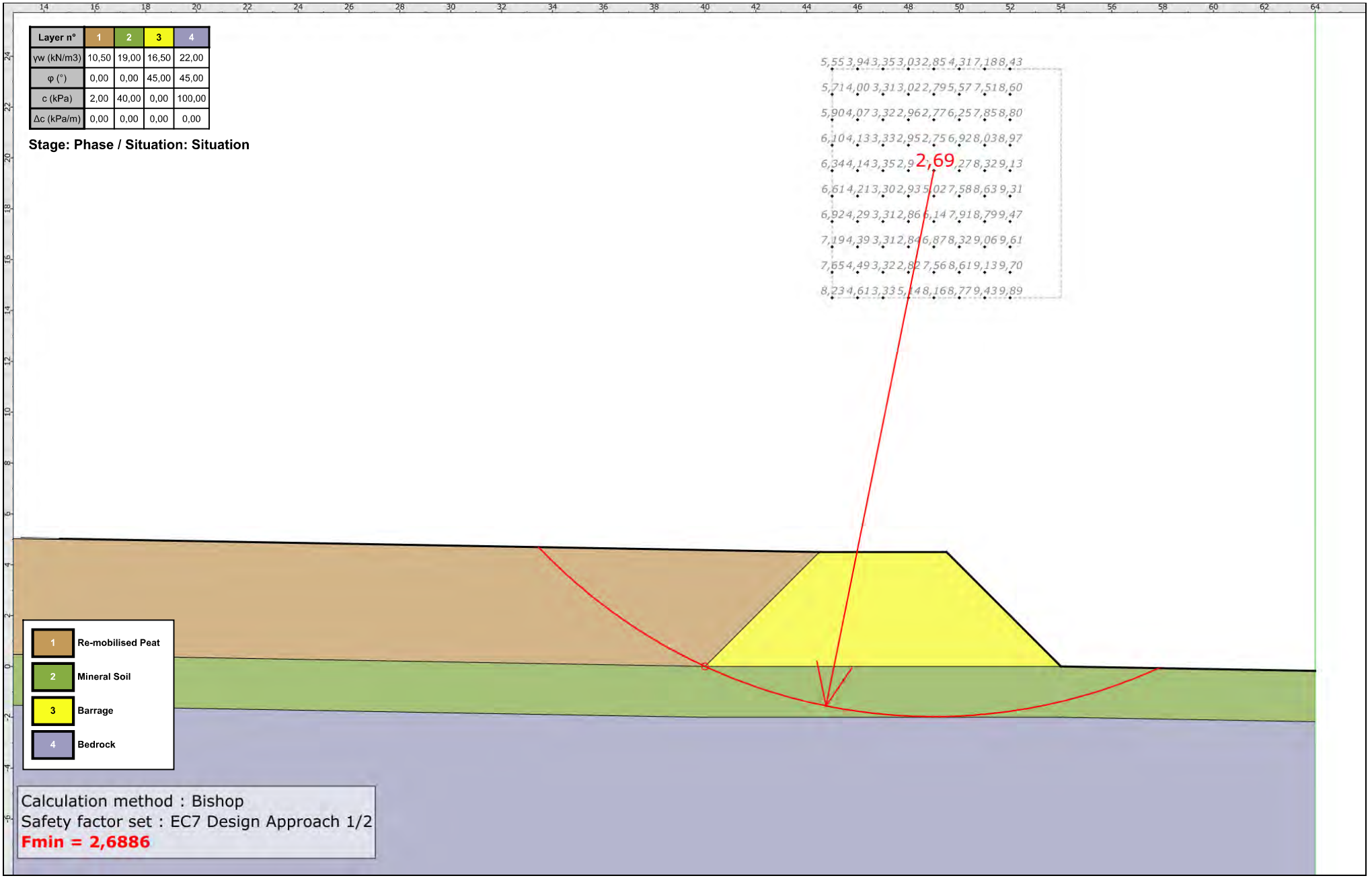
Stage: Phase / Situation: Situation



Scale 1:200

Layer n°	1	2	3	4
γw (kN/m3)	10,50	19,00	16,50	22,00
φ (°)	0,00	0,00	45,00	45,00
c (kPa)	2,00	40,00	0,00	100,00
Δc (kPa/m)	0,00	0,00	0,00	0,00

Stage: Phase / Situation: Situation



terrasol
setec

Talren v5
v5.2.5

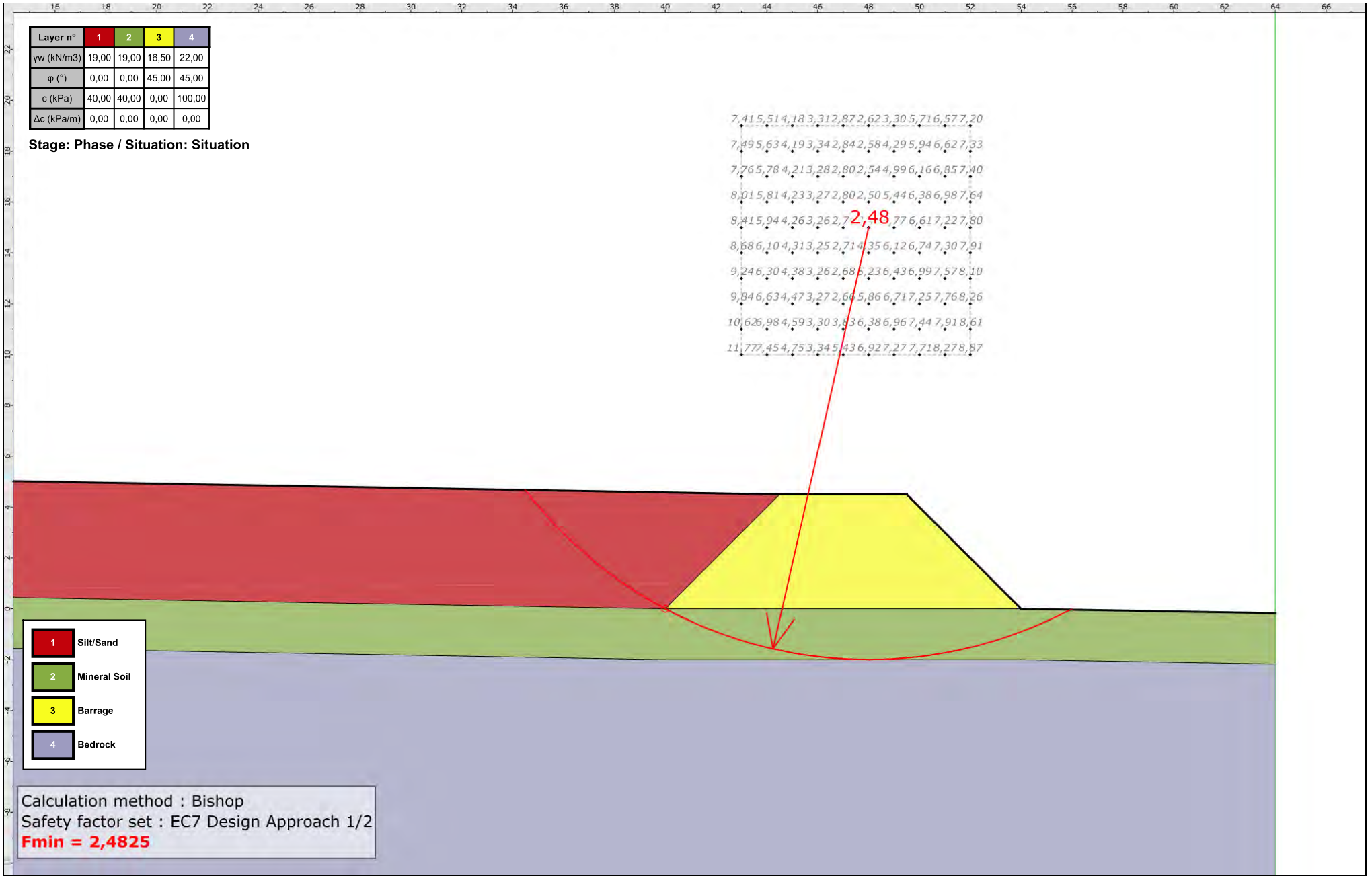
Printed on : 25-Jul-2018 09:29:59
Calculation made by : AGEC

Project : Stability Analysis of Barrage 2 - Undrained Condition - Case 1

Scale 1:200

Layer n°	1	2	3	4
γw (kN/m3)	19,00	19,00	16,50	22,00
φ (°)	0,00	0,00	45,00	45,00
c (kPa)	40,00	40,00	0,00	100,00
Δc (kPa/m)	0,00	0,00	0,00	0,00

Stage: Phase / Situation: Situation



terrasol
setec

Talren v5
v5.2.5

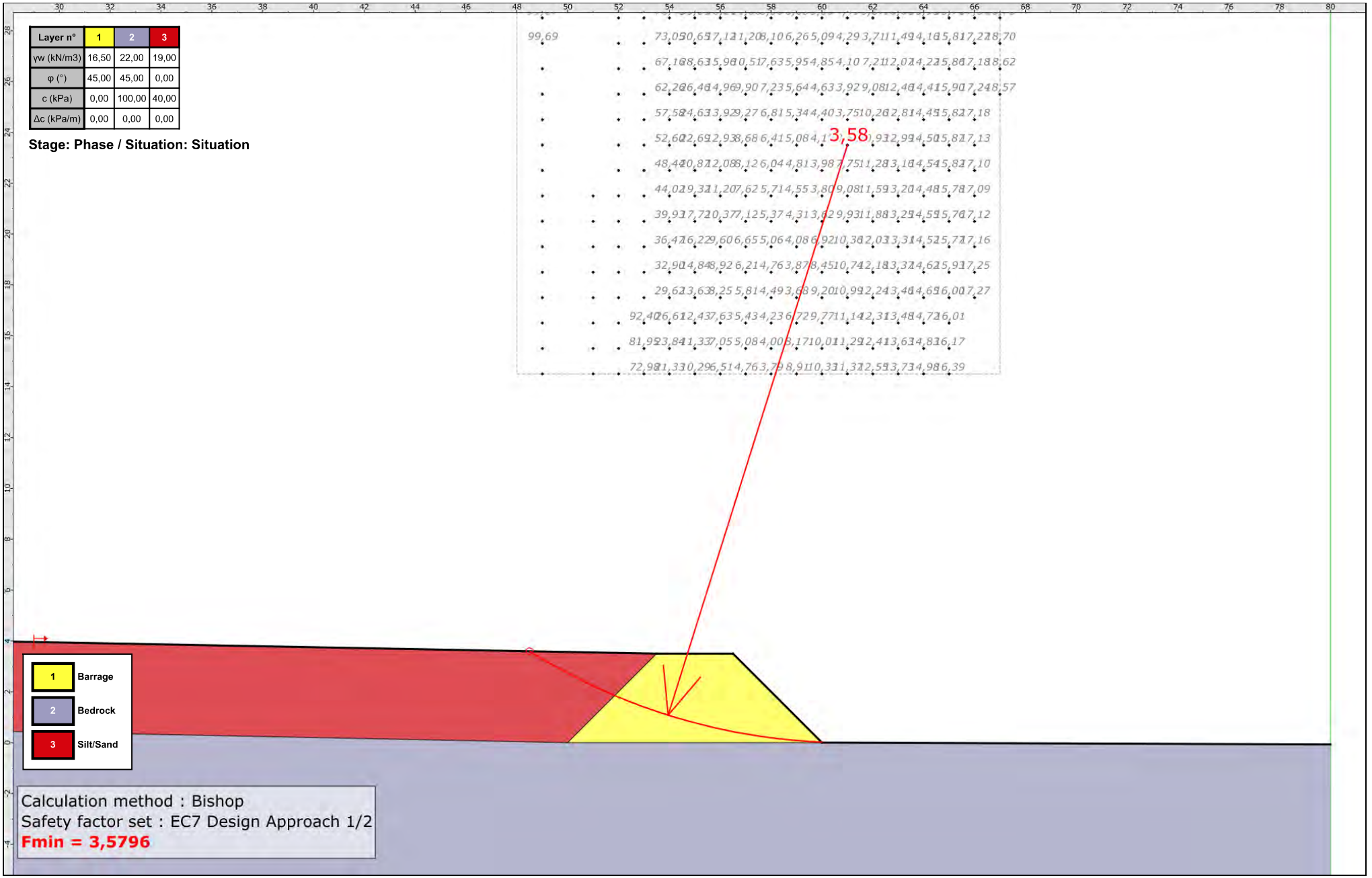
Printed on : 25-Jul-2018 09:32:50
Calculation made by : AGEC

Project : Stability Analysis of Barrage 2 - Undrained Condition - Case 2

Scale 1:200

Layer n°	1	2	3
γw (kN/m3)	16,50	22,00	19,00
φ (°)	45,00	45,00	0,00
c (kPa)	0,00	100,00	40,00
Δc (kPa/m)	0,00	0,00	0,00

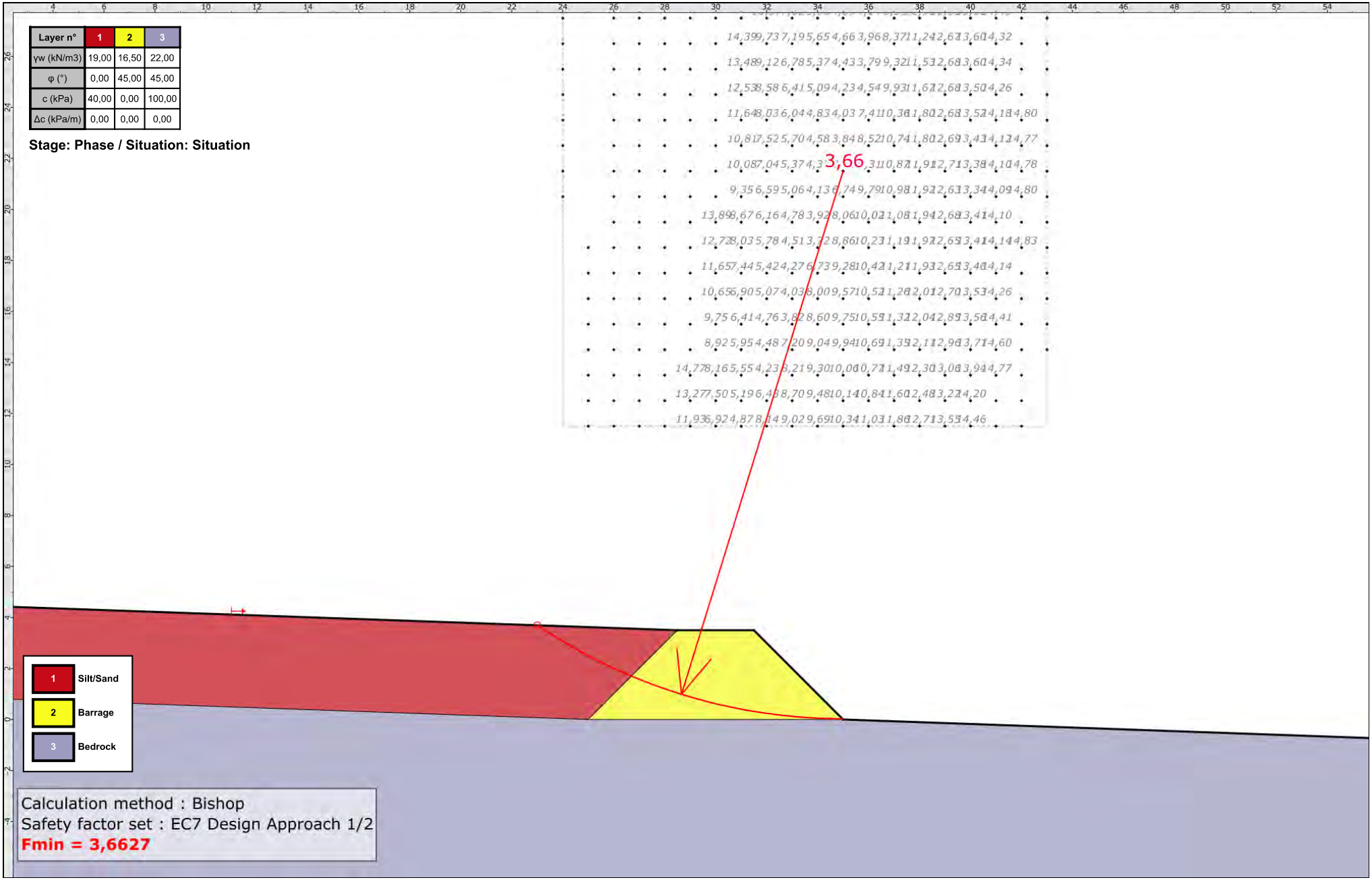
Stage: Phase / Situation: Situation



Scale 1:200

Layer n°	1	2	3
γw (kN/m3)	19,00	16,50	22,00
φ (°)	0,00	45,00	45,00
c (kPa)	40,00	0,00	100,00
Δc (kPa/m)	0,00	0,00	0,00

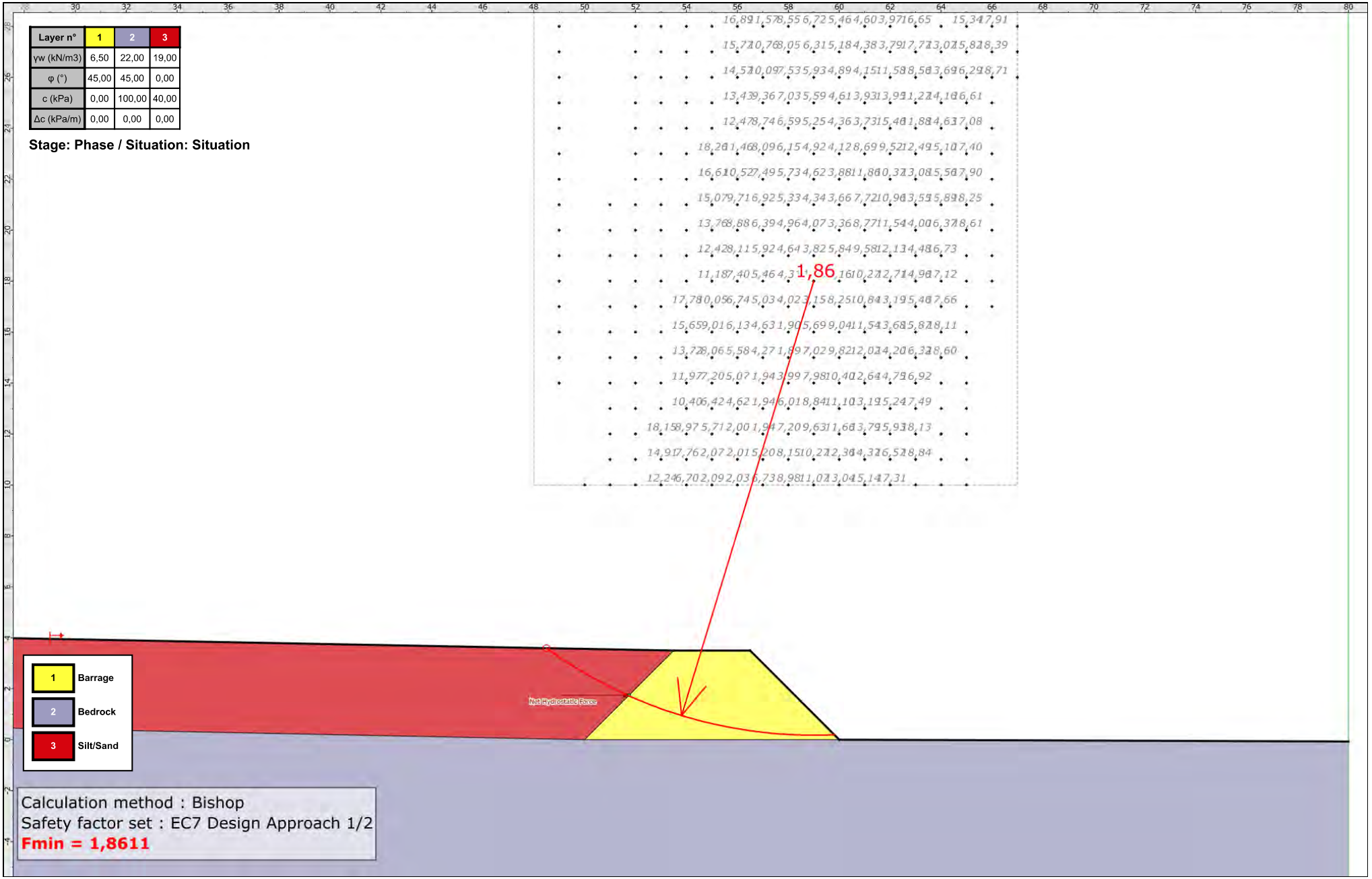
Stage: Phase / Situation: Situation



Scale 1:200

Layer n°	1	2	3
γw (kN/m3)	6,50	22,00	19,00
φ (°)	45,00	45,00	0,00
c (kPa)	0,00	100,00	40,00
Δc (kPa/m)	0,00	0,00	0,00

Stage: Phase / Situation: Situation



terrasol
setec

Talren v5
v5.2.5

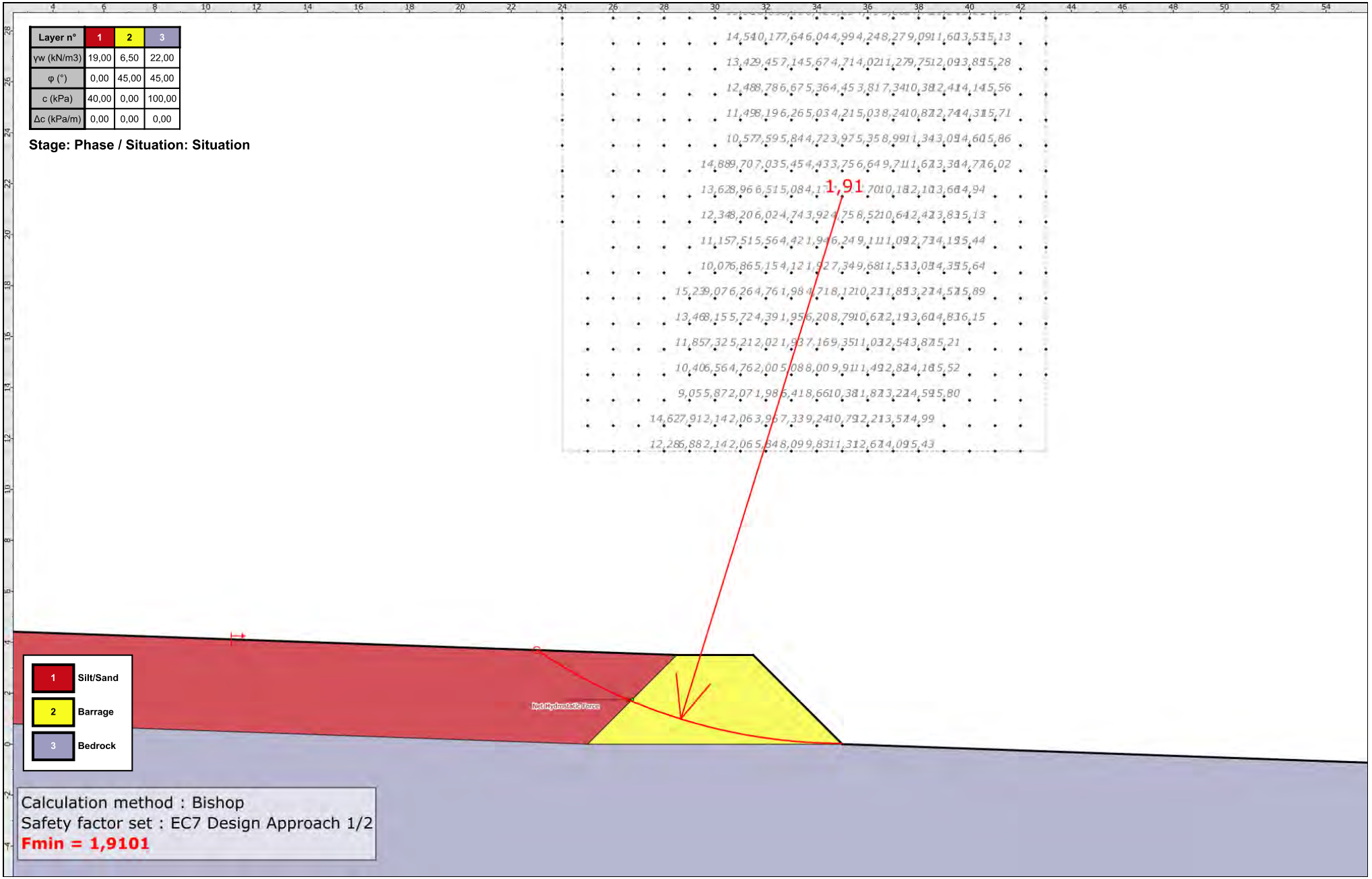
Printed on : 24-Oct-2018 11:19:08
Calculation made by : AGEC

Project : Stability of Barrage 3 - Undrained Condition - Case 3

Scale 1:200

Layer n°	1	2	3
γw (kN/m3)	19,00	6,50	22,00
φ (°)	0,00	45,00	45,00
c (kPa)	40,00	0,00	100,00
Δc (kPa/m)	0,00	0,00	0,00

Stage: Phase / Situation: Situation



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φ (°)	5,00	30,00	45,00	45,00
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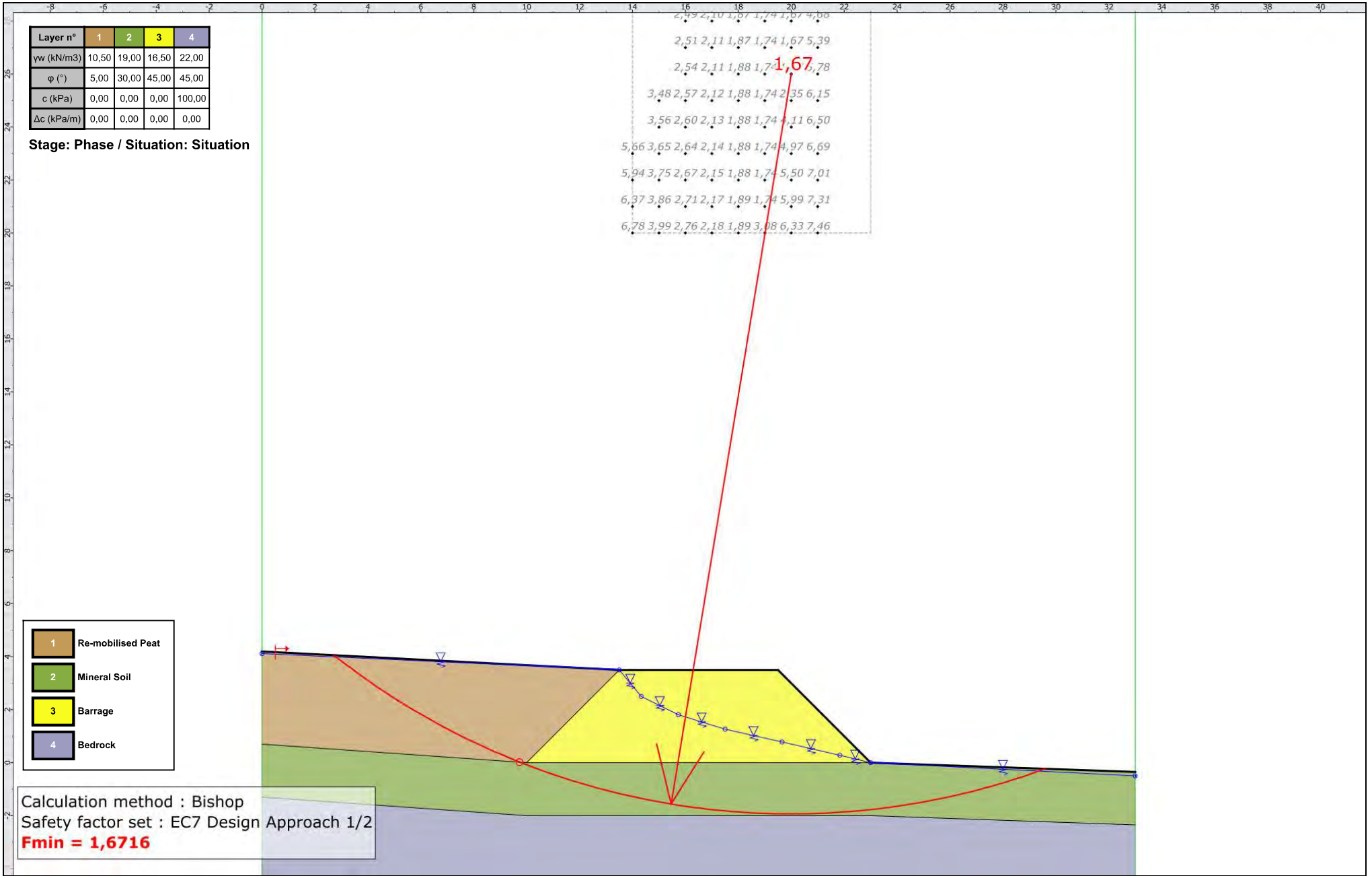
Δc (kPa/m)	0,00	0,00	0,00	0,00

Stage: Phase / Situation: Situation



Scale 1:200

Layer n°	1	2	3	4
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φ (°)	28,00	30,00	45,00	45,00
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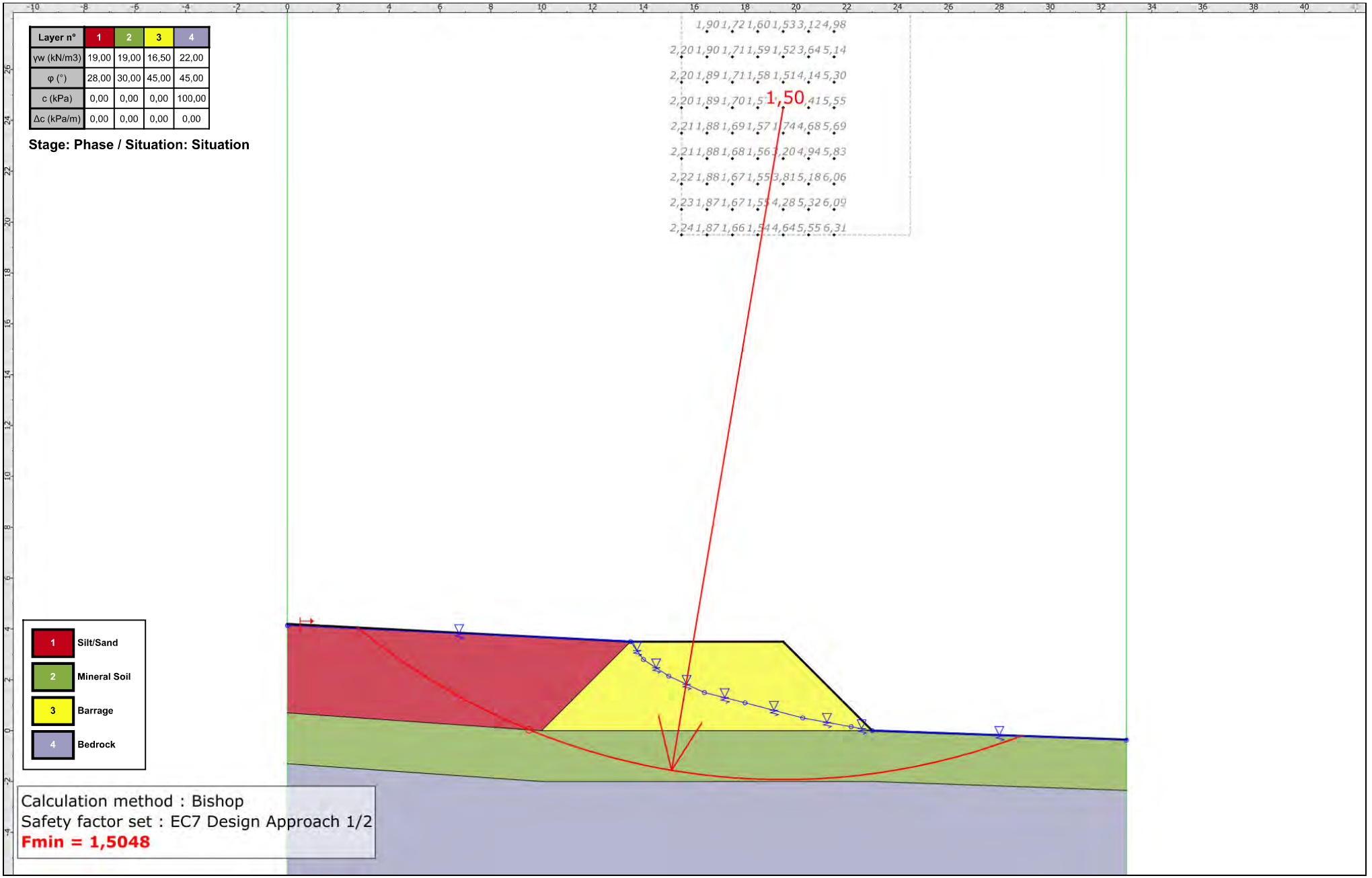
Δc (kPa/m)	0,00	0,00	0,00	0,00

Stage: Phase / Situation: Situation



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Calculation made by : AGEC

Project : Stability Analysis of Barrage 1 - Drained Condition - Case 2

Scale 1:178

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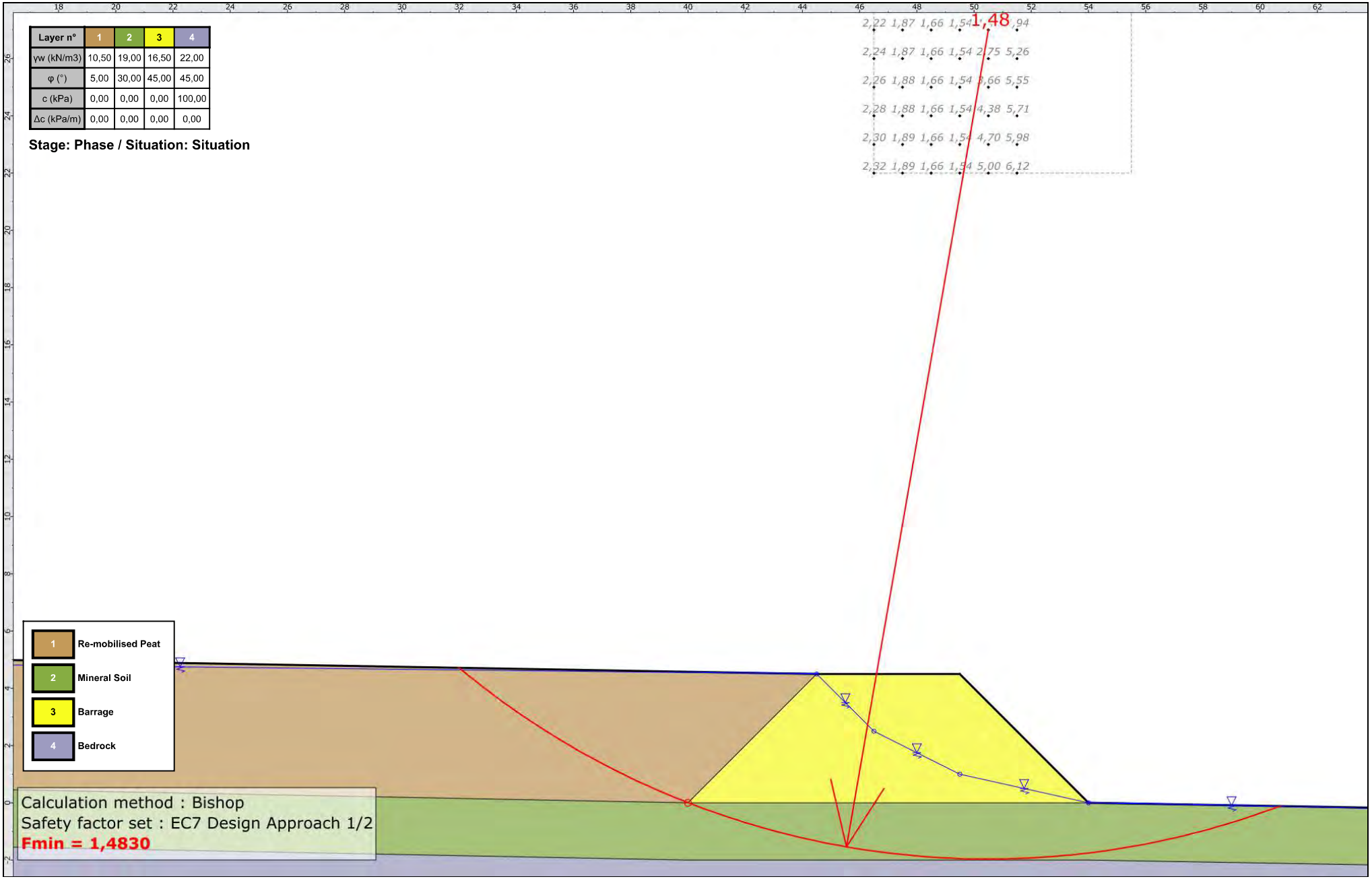
φ (°)	5,00	30,00	45,00	45,00
c (kPa)	0,00	0,00	0,00	100,00
Δc (kPa/m)	0,00	0,00	0,00	0,00

Stage: Phase / Situation: Situation



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Talren v5
v5.2.7

Printed on : 14-Apr-2020 12:33:23
Calculation made by : Fehily Timoney & Company

Project : Stability Analysis of Barrage 2 - Drained Condition - Case 1

Scale 1:200

Layer n°	1	2	3	4
γw (kN/m3)	19,00	19,00	16,50	22,00
φ (°)	28,00	30,00	45,00	45,00
c (kPa)	0,00	0,00	0,00	100,00
Δc (kPa/m)	0,00	0,00	0,00	0,00

Stage: Phase / Situation: Situation

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3,152,44 1,97 1,67 1,49 1,37 2,80 4,11 4,85
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3,222,50 1,97 1,66 1,47 1,36 3,66 4,50 5,07
3,262,52 1,98 1,66 1,47 1,36 3,86 4,60 5,18
3,352,54 1,98 1,65 1,46 2,55 4,05 4,78 5,28
3,422,57 1,99 1,65 1,45 3,13 4,24 4,89 5,39
3,492,61 2,01 1,65 1,45 3,51 4,49 5,07 5,50
3,592,65 2,03 1,65 1,45 3,89 4,67 5,11 5,55
3,702,70 2,05 1,66 2,64 4,23 4,79 5,29 5,68

1,35

1 Silt/Sand
2 Mineral Soil
3 Barrage
4 Bedrock

Calculation method : Bishop
Safety factor set : EC7 Design Approach 1/2
Fmin = 1,3510

terrasol
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Talren v5
v5.2.5

Printed on : 24-Jul-2018 16:04:43
Calculation made by : AGEC

Project : Stability Analysis of Barrage 2 - Drained Condition - Case 2

Scale 1:200

Layer n°	1	2	3
γw (kN/m3)	16,50	22,00	19,00
φ (°)	45,00	45,00	28,00
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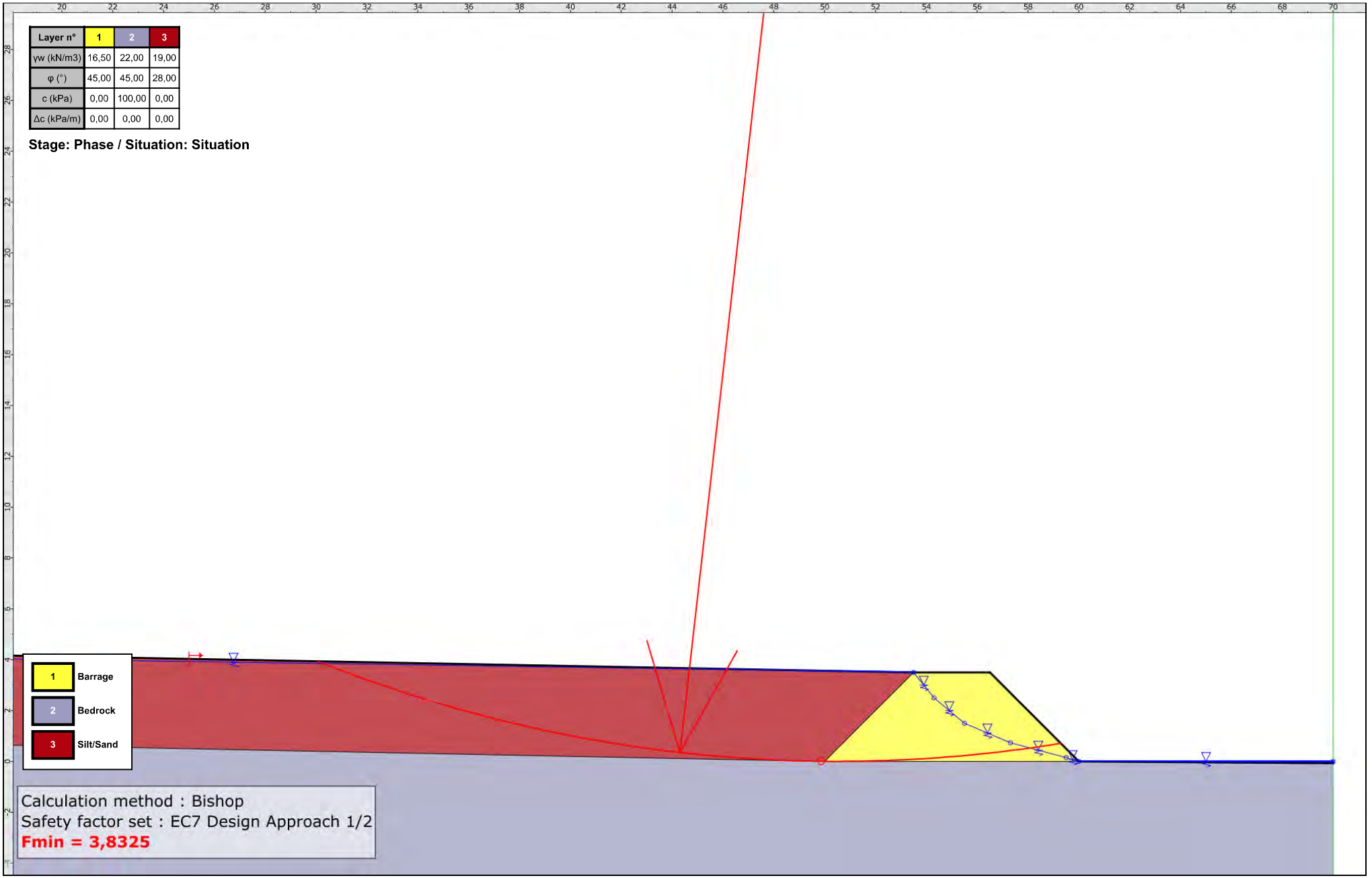
Δc (kPa/m)	0,00	0,00	0,00

Stage: Phase / Situation: Situation



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Calculation made by : AGEC

Project : Stability of Barrage 3 - Drained Condition - Case 2

Scale 1:200

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φ (°)	28,00	45,00	45,00
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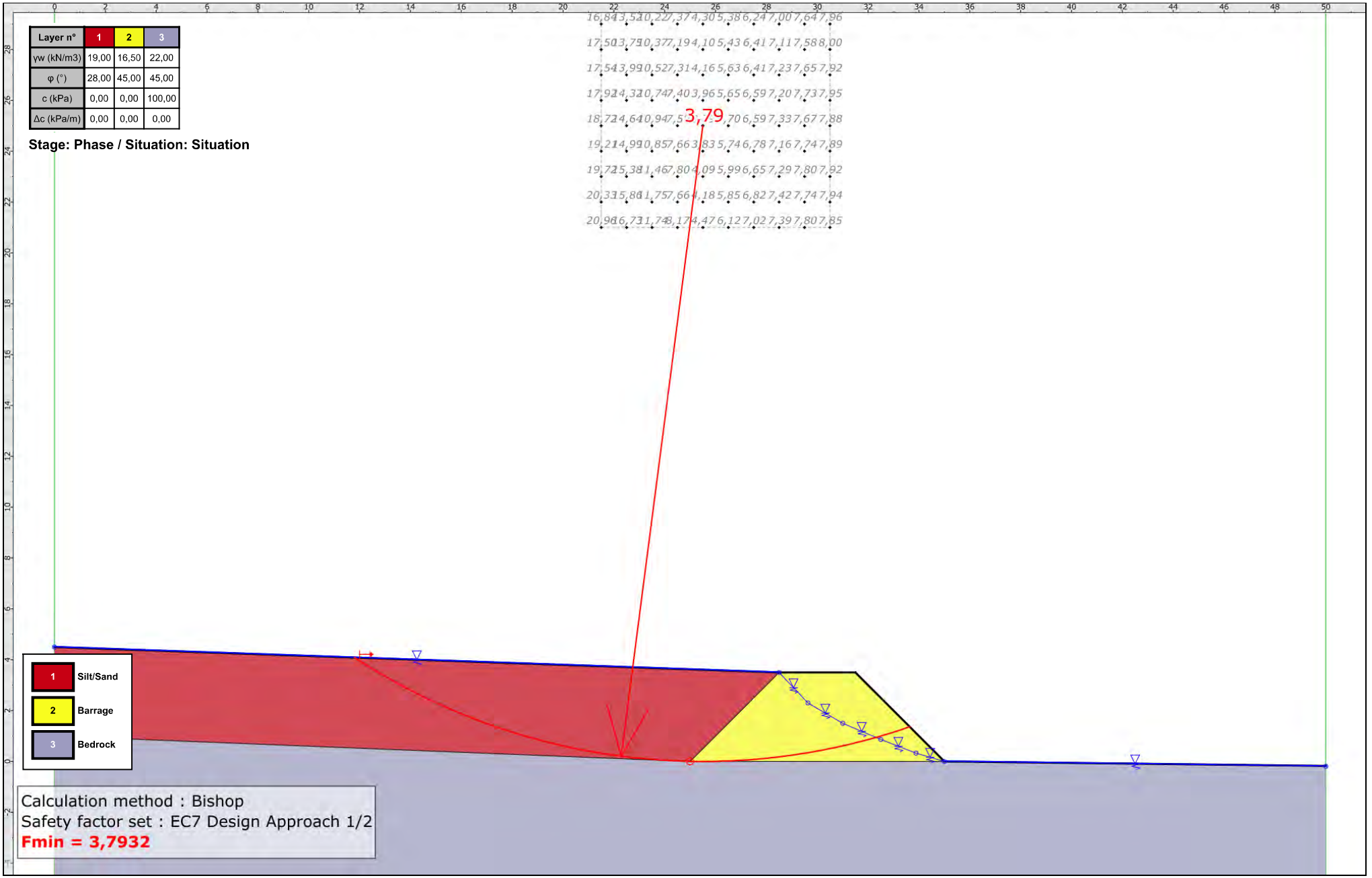
Δc (kPa/m)	0,00	0,00	0,00

Stage: Phase / Situation: Situation



Scale 1:200

Layer n°	1	2	3
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φ (°)	45,00	45,00	28,00
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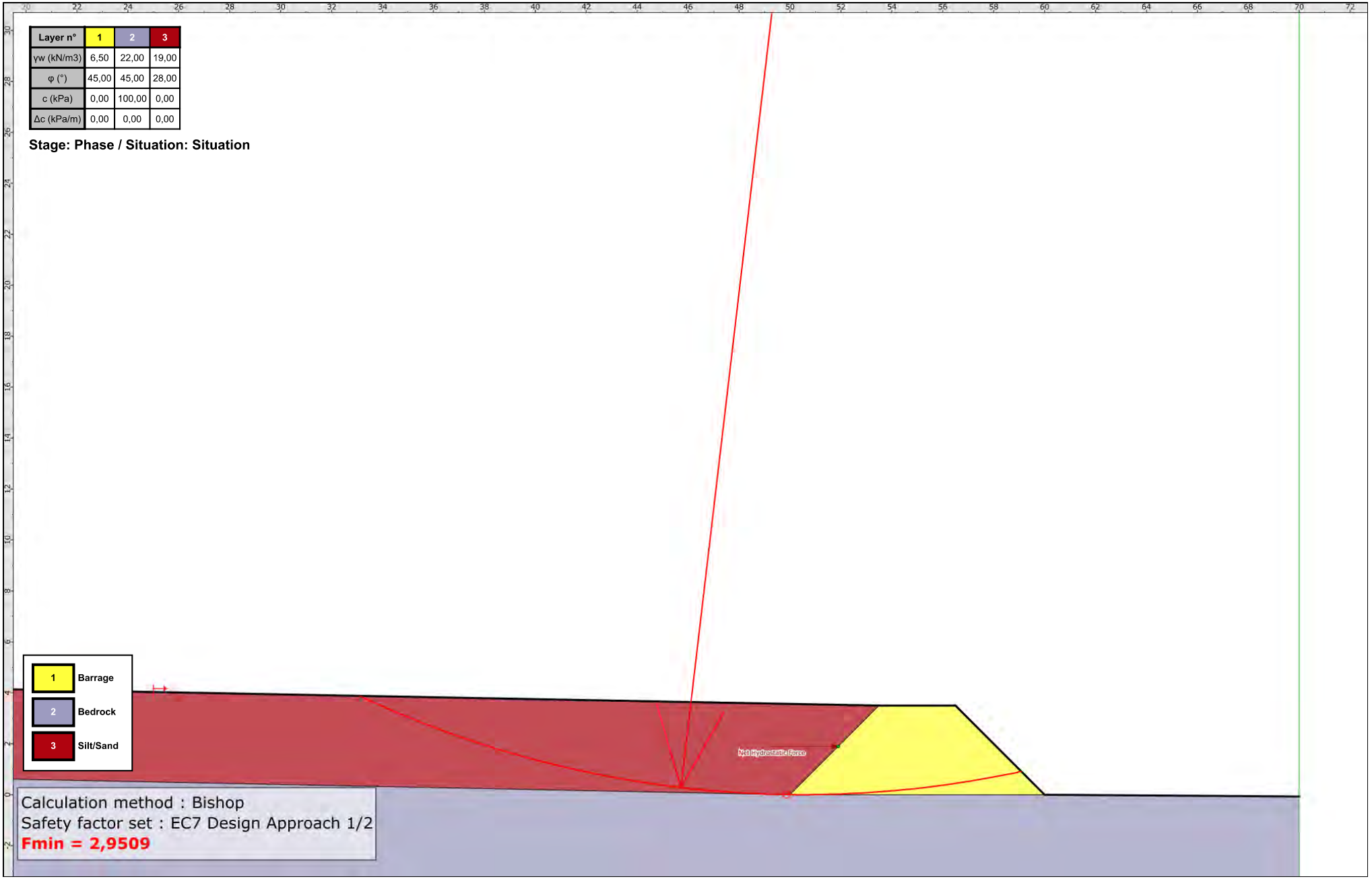
Δc (kPa/m)	0,00	0,00	0,00

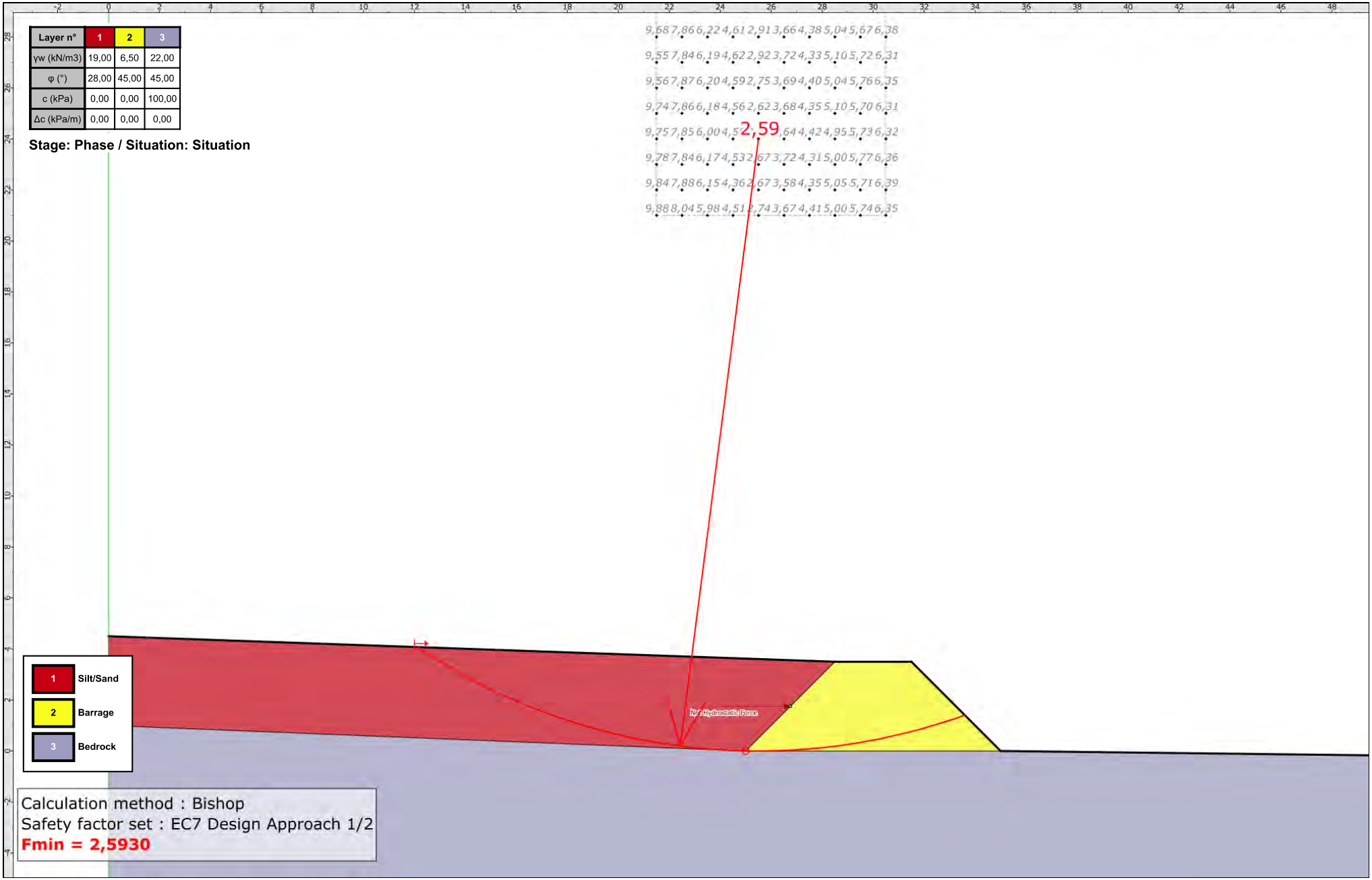
Stage: Phase / Situation: Situation



Scale 1:200

Layer n°	1	2	3
γw (kN/m3)	19,00	6,50	22,00
φ (°)	28,00	45,00	45,00
c (kPa)	0,00	0,00	100,00
Δc (kPa/m)	0,00	0,00	0,00

Stage: Phase / Situation: Situation



Appendix D

Calculations for Stability Assessment of Repository Areas

Calculated Factor of Safety for Repository Areas (Undrained Analysis)

Repository Area	Type of Founding Stratum	Slope	Undrained Shear Strength of Founding Stratum	Bulk unit weight of Material (Founding Stratum)	Thickness of Founding Stratum	Applied Loading - Equivalent Thickness of Placed Arisings	Factor of Safety of Slope with Applied Loading
		β (deg)	c_u (kPa)	γ (kN/m^3)	(m)	(m)	
Repository Area at Containment Barrage 2	Peat	4	10	10.5	1.1	2	**2.90**
Repository Area at Containment Barrage 3	Mineral Soil	5	40	19.0	1.0	2	**8.08**
Repository Area at Black Bridge	Peat	3	10	10.5	1.0	2	**3.94**

Notes:

(1) Assuming a bulk unit weight for peat of 10.5kN/m^3 and mineral soil of 19kN/m^3.

(2) Assuming an applied loading equivalent to a fill depth of 2m of placed arisings i.e. 38kPa (2m * unit weight of 19kN/m^3)

(3) Slope inclination (β) based on site observations.

(4) Undrained shear strengths for the peat and mineral soil based on the ground investigation carried out by AGEC (2018) have been used in the analysis. In reality the founding stratums have significantly higher undrained shear strengths

(5) Peat and mineral soil thickness are based on the ground investigation carried out by AGEC (2018) and site observations.

Calculated Factor of Safety for Repository Areas (Drained Analysis)

Repository Area	Type of Founding Stratum	Slope	Effective Cohesion (c') for Founding Stratum	Bulk unit weight of Material (Founding Stratum)	Thickness of Founding Stratum	Friction Angle for Founding Stratum	Applied Loading - Equivalent Thickness of Placed Arisings	Factor of Safety of Slope with Applied Loading
		α (deg)	c' (kPa)	γ (kN/m^3)	(m)	ø' (deg)	(m)	
Repository Area at Containment Barrage 2	Peat	4	4	10.5	1.1	25	2	**6.35**
Repository Area at Containment Barrage 3	Mineral Soil	5	0	19.0	1.0	30	2	**5.46**
Repository Area at Black Bridge	Peat	3	4	10.5	1.0	25	2	**8.64**

Notes:

(1) Assuming a bulk unit weight for peat of 10.5kN/m^3 and mineral soil of 19kN/m^3.

(2) Assuming an applied loading equivalent to a fill depth of 2m of placed arisings i.e. 38kPa (2m * unit weight of 19kN/m^3)

(3) Slope inclination (β) based on site observations.

(4) Drained shear strengths for the peat and mineral soil based published data and conservative assumptions have been used in the analysis.
In reality the founding stratums have significantly higher drained shear strengths.

(5) Peat and mineral soil thickness are based on the ground investigation carried out by AGEC (2018) and site observations.

Appendix E

Historical AGEC Reports

Appendix F

INIS Report (2004)

Inis
ENVIRONMENTAL SERVICES

DERRYBRIEN WINDFARM

PEAT SLIP

ENVIRONMENTAL IMPACT ASSESSMENT

ON

THE OWENDALLULEEGH RIVER

MARCH 2004

Inis Environmental Services, Edenvale, Ennis, Co. Clare, Tel/Fax: +353 (0) 65 6842465, Mobile: +353 (0) 87 2831725
e-mail: inisenvironmental@ireland.com

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1.0 INTRODUCTION

A landslide occurred near the southern boundary of the Derrybrien Wind Farm on the evening of 16th October 2003. The slide involved disturbance and partial displacement of approximately 450,000m^3 of peat. On 17th October, the limit of the displaced peat was measured at approximately 100m from the Black Road Bridge, a distance of approximately 2.45 km from the head of the slide. On 29th/30th October, following heavy rain, the slip mass re-mobilised before the emergency stabilisation measures were substantially underway, and solid peat entered the watercourse downstream of Black Road Bridge. The flow of solid peat continued for approximately 24 hours.

As a result of the landslide, an estimated 6000 m^3 of peat entered the upper reaches of the Owendallulleegh River (ESBI, unpublished data) and flowed along its length to Lough Cutra. This watercourse is of ecological and fisheries importance. A visible plume was observed at the confluence of the Owendallulleegh River with Lough Cutra (aerial photo and observations made by Shannon Regional Fisheries Board – Preliminary Assessment Report)

Inis Environmental Services was appointed by ESBI to undertake a joint survey with ESBI and the Shannon Regional Fisheries Board to assess the extent of impact of the peat slip on the Owendallulleegh river system.

The current report provides an assessment of the integrity of aquatic habitats in the river and provides information of the extent of peat deposition in the main stem corridor. It reports the results of a walkover type survey, carried out in December 2003, and a desk appraisal. The key aims of the study were as follows: -

- To assess the extent of peat deposition along the river;
- to determine the habitat integrity of aquatic and riparian areas;
- to provide a preliminary assessment of the potential impact of the land slide on the river;
- to suggest mitigation measures to assist the rehabilitation of the river, and,
- to recommend further survey work, where necessary, to assess fish stocks and other ecological indicators.

This study was undertaken by Inis Environmental Services on behalf of ESB International (ESBI). Field work was carried out by Inis Environmental Services in association with ESBI and the Shannon Regional Fisheries Board (ShRFB).

2.0 METHODOLOGY

2.1 Survey area

The survey area comprised of the entire length of the main stem Owendallulleegh River from Flaggy Bridge (NOS Grid Reference M61161 62512) to the mouth of the river, where it enters Lough Cutra, (NOS Grid Reference R47811 97721). This represents a study length of approximately 22 kilometres. The study area was divided into eleven sections. The overall area is shown in figure 1 and the eleven sections of river assessed are shown in figures A1.1 to A1.11 in appendix 1.

The survey was carried out over a two-week period comprising a team of

- Inis Environmental - (two persons);
- Shannon Regional Fisheries Board – (Three to five persons).
- ESBI (three persons).

Weather conditions were good and water level was low facilitating the survey. The survey comprised a walk down of the entire river main stem with recording of observations. A Health and Safety Induction course was held on the first morning of the survey to advise all survey members of the potential hazards and work methodology to be followed.

The survey was completed within a two-week period (9th – 22nd December 2003). The following maps, provided by ESBI under Licence from GSI, were utilised for the assessment:

- Ordnance Survey of Ireland, Discovery Series 1:50,000. Sheets 52.
- Ordinance Survey of Ireland, local 1:5000 sheets.

2.2 Aquatic Habitat Assessment

The aquatic habitats present in the eleven study sections were defined with reference to the habitat classification scheme published by the Heritage Council in *A Guide to Habitats in Ireland* (Fossitt, 2000). Codes such as FW1, refers to habitat types of eroding upland rivers, as defined in this publication. The diversity (species richness) of aquatic/riparian fauna is primarily a function of the integrity and physical diversity of the aquatic habitats. The more diverse the aquatic habitat is in terms of substrate, depth, riparian vegetation, etc. the richer the biological community is likely to be. Salmonid fish (trout and salmon) in particular have specific habitat requirements and the presence and abundance of these fish has been shown to be strongly correlated with key physical habitat variables (Haury, 1999). Habitat considerations for juvenile salmonids in streams and rivers include stream size and flow (Hatfield & Bruce 2000), depth and gradient (Kennedy & Strange 1986), substrate (Greenberg & Dahl 1998), and canopy (O'Grady, 1993). Physical habitat assessments were undertaken at intervals along the river. These sites were assessed in terms of: -

- Wetted width (m)
- Depth (m)
- Bank height (m)
- Riffle (%)
- Glide (%)
- Pool (%)
- Bedrock (%)
- Cobble (%)
- Gravel (%)
- Boulder (%)
- Sand/Silt (%)

Aquatic Flora Assessment

Qualitative assessments of instream vegetation were undertaken during the habitat assessment study. The species present were identified and the percentage cover of riparian and instream vegetation was

estimated visually. An impact on vegetation was recorded where vegetation had been eroded, or covered by peat to a depth likely to affect growth. As the survey was carried out mid-winter, plants were identified from overwintering parts and were not always identifiable to species level. Similarly, cover of emergent aquatic species is lower in winter than at the peak of the growing season (summer). A list of aquatic and riparian plant species for the 10km grid squares containing the Owendallulleegh River was also extracted from the CD ROM of Preston, C. D., Pearman, D. A. and Dines, T. D., eds (2002). *New Atlas of the British and Irish Flora*. Oxford University Press, Oxford.

3.0 EXISTING ENVIRONMENT

3.1 General

The Owendallulleegh River within the study area is described and evaluated on the basis of aquatic and riparian habitats. The presence of protected aquatic species is also considered. The areas investigated are described below.

3.2 Designated Areas

The National Parks and Wildlife Service (NPWS) is responsible for natural heritage conservation in Ireland. It is responsible for the designation of the following areas of statutory protection:

- *Special Areas of Conservation (SACs)* - These were established under the 1992 Habitats Directive of the Council of the EU for the conservation of natural and semi-natural habitats and species of flora and fauna.

- *Special Protection Areas (SPAs)* – These areas are designated for the protection of birds, and were established under the Birds Directive of the EU in 1979.

- *Natural Heritage Areas (NHAs)* – These are nationally important protection areas and were established under Irish law.

- *Statutory Nature Reserves* - These are relatively small land areas, very often forest or previously afforested areas that are maintained as protected nature reserves.

The Owendallulleegh River is not on or within a site designated or being considered for designation for statutory nature conservation. However, it flows into Lough Cutra, which is a candidate Special Area of Conservation (cSAC) and a designated Special Protection Area (SPA) under the EU Birds Directive. Gortacarnaun Wood, a designated SAC, is also adjacent to the river. In table 1, these and other designated areas adjacent to the study area are described. The location of these sites in relation to the Owendallulleegh River is shown in figures 2 and 3. Additional information on Lough Cutra (Site code 00299) and Lough Coy (002117) are provided in appendix 2. No information on the Newhall site (002293) was available at the time of preparing this report. Under Article 6 of the Habitats Directive the onus is on the developer to assess the indirect impacts on any designated sites (Special Areas of Conservation –SACs or Special Protected Areas SPAs) as a result of a plan or project.

3.3 Hydrology of the area

The study area is located in the Owendallulleegh River (or Derrywee River) river system (EPA code 29/O/01). This is an undrained river system located in EPA hydrometric area 29. The Owendallulleegh is an upland spate river that rises in the Slieve Aughty Mountains in south County Galway. It flows west through the townlands of Derrybrien, Inchamore, Lahardaun, Derreen, and Kilafeen to enter the southern end of Lough Cutra. It has a main channel length of 22.5km (McGarrigle *et al*, 2002). The catchment area is approximately 40km^2 and includes extensive areas of cutover bog and coniferous forestry. Lough Cutra is an oligo/mesotrophic landlocked lake, which has a surface area of 3.9km^2. Catchment details and selected physical characteristics of the Owendallulleegh River (from source to Lough Cutra) are provided in tables 2 and 3 respectively.

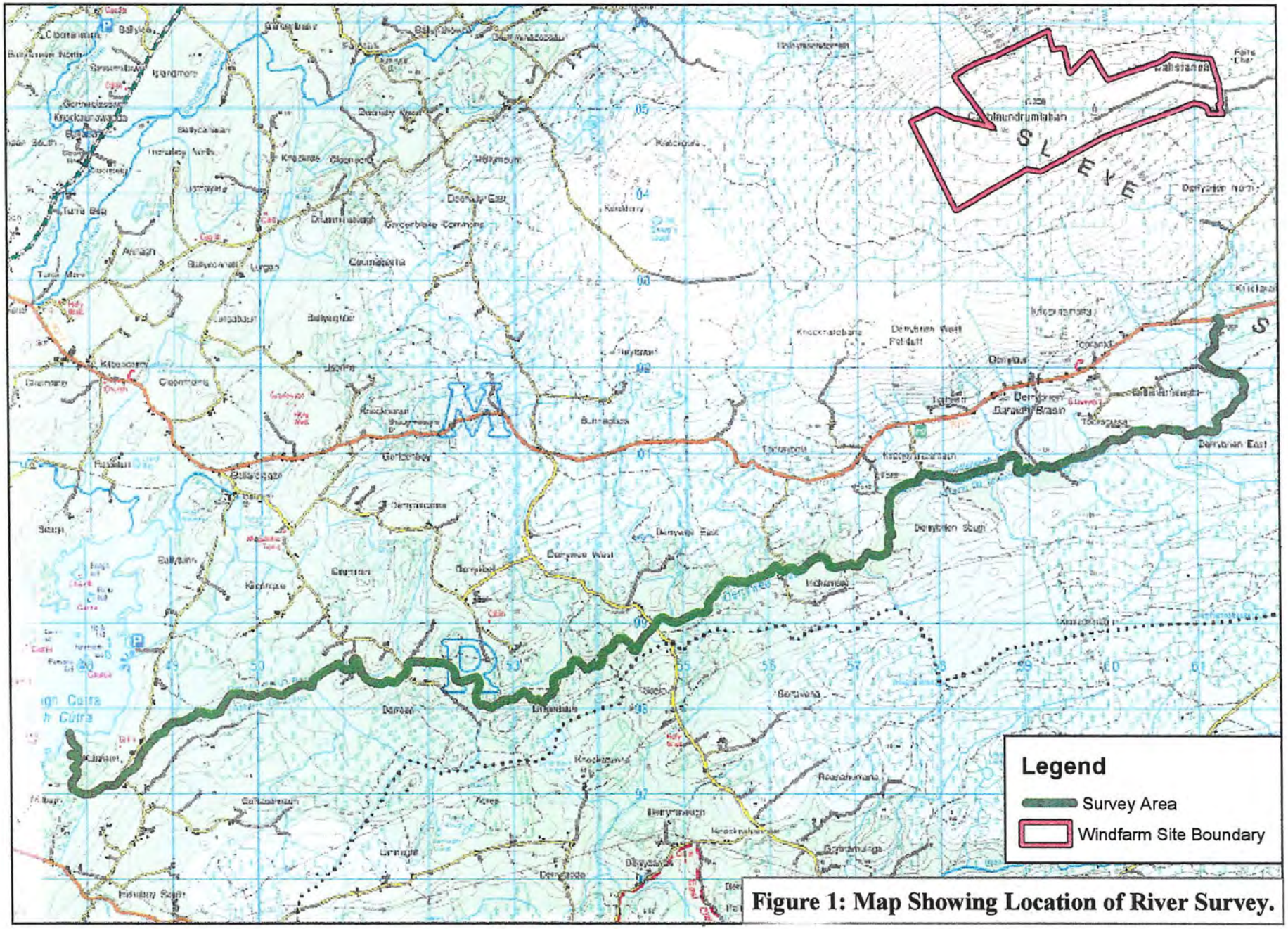

Figure 1: Map Showing Location of River Survey.

The Owendallulleegh River flows for a distance of approximately 22 km and flows into Lough Cutra. The outlet of Lough Cutra forms the Beagh river, which sinks at the Punch Bowl and remerges as the Cannahowna river (Gort River and Castletown river), where water is abstracted for the Gort Water supply. It then disappears underground again and re-emerges into Lough Coole and feeding into the turlough system at Coole – Garryland. Ultimately it is thought to discharge to the sea at Kinvarra.

Table 1 Designated sites surrounding river survey area (Source: NPWS).

Name	Site Code	Designation	Notes	Distance and direction from river survey area
Lough Cutra	000299	pNHA SAC SPA	Lough Cutra is an oligo/mesotrophic freshwater lake lying on limestone. The main habitats of this site are; aquatic lake vegetation, reedbeds confined to sheltered bays and mixed woodland. The site is internationally important for its breeding and wintering population of Cormorants (166 pairs in 1985 and max 300 individuals in winter) (Information compiled in 1987). The Cormorants use the off-shore islands for breeding purposes. The internationally important populations of Cormorants and Lesser Horseshoe Bats should be especially protected. Lough Cutra is an important site with its diverse habitat types and the presence of both calcicole and calcifuge floras.	0km Includes and adjacent to river mouth
Gortacarnaun Wood	002180	SAC	Old oak woodlands are scarce in Ireland and the habitat is of particular conservation importance as it is listed on Annex I of the EU Habitats Directive.	0km Adjacent to south bank river
Drummin Wood	002181	SAC	Drummin Wood is of considerable conservation significance as it conforms to a woodland habitat type that is scarce in Ireland and one that is listed on Annex I of the EU Habitats Directive. The occurrence of Red Data Book plant and animal species adds to the importance of the site.	0.2km North
Lough Coy	002117	SAC	The site consists of a small permanent lake in the middle of an almost circular turlough basin. Lough Coy is an excellent example of a 'riverine' type of turlough, and is in essence the floodplain of an underground river. The entire site consists of turlough habitat, an EU Habitats Directive Annex I priority habitat. Of particular note is the occurrence of three Red Data Book plant species at this site - these are Mudwort (*Limosella aquatica*), Fen Violet (*Viola persicifolia*) and Northern Yellow-cress (*Rorippa islandica*). Lough Coy is an excellent example of a eutrophic (nutrient-rich) turlough. The extreme water fluctuation supports a distinctive zonation of vegetation and provides many niches for specialist plants. It is an important site for wintering waterfowl.	7.7km North
Newhall	002293	SAC	No synopsis available	7.8km North North-west
Coole-Garryland	000252	SAC	Turloughs and protected bird species are the qualifying interests of this designated area.	6km south

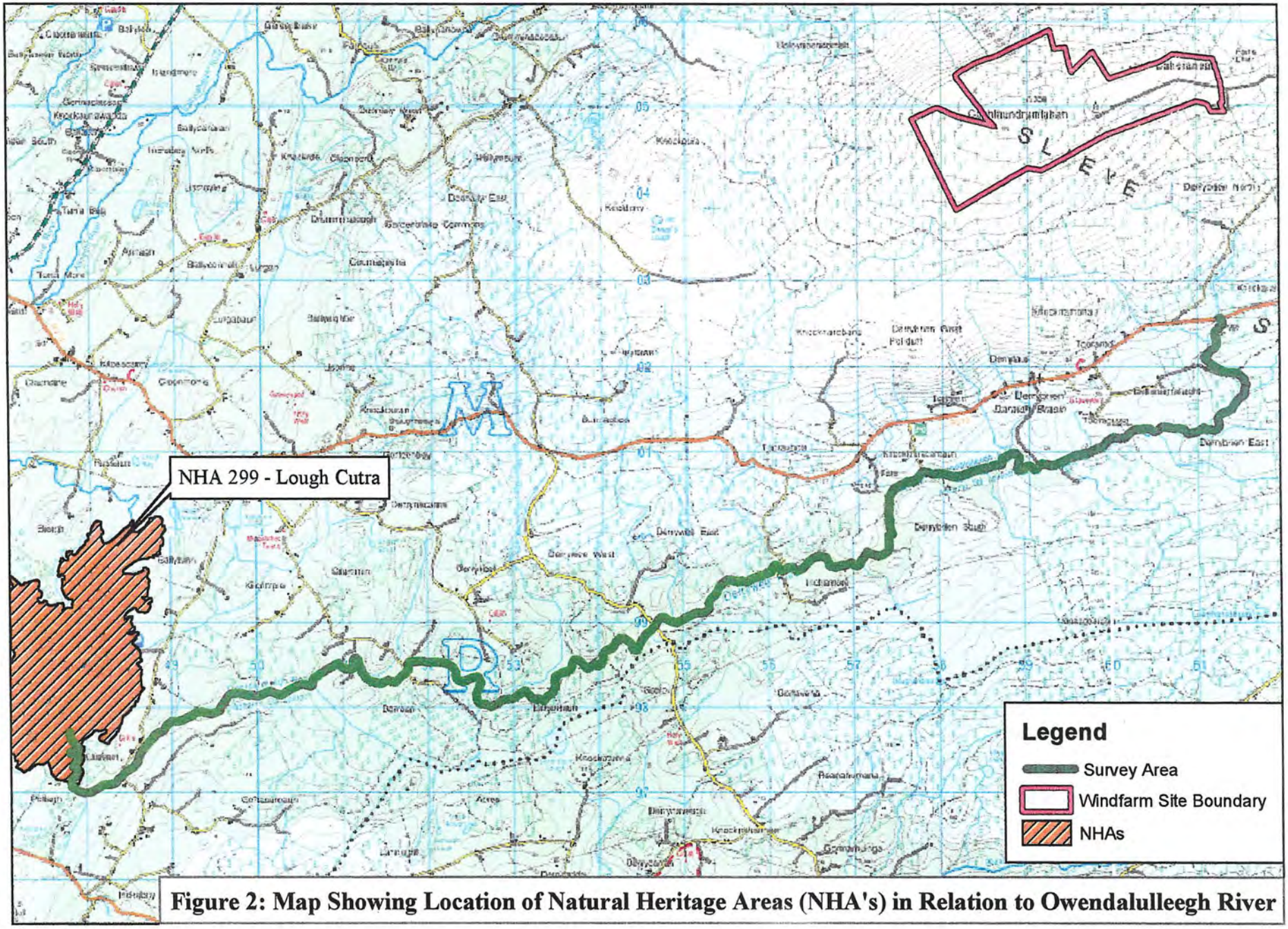

Figure 2: Map Showing Location of Natural Heritage Areas (NHA's) in Relation to Owendalulleegh River

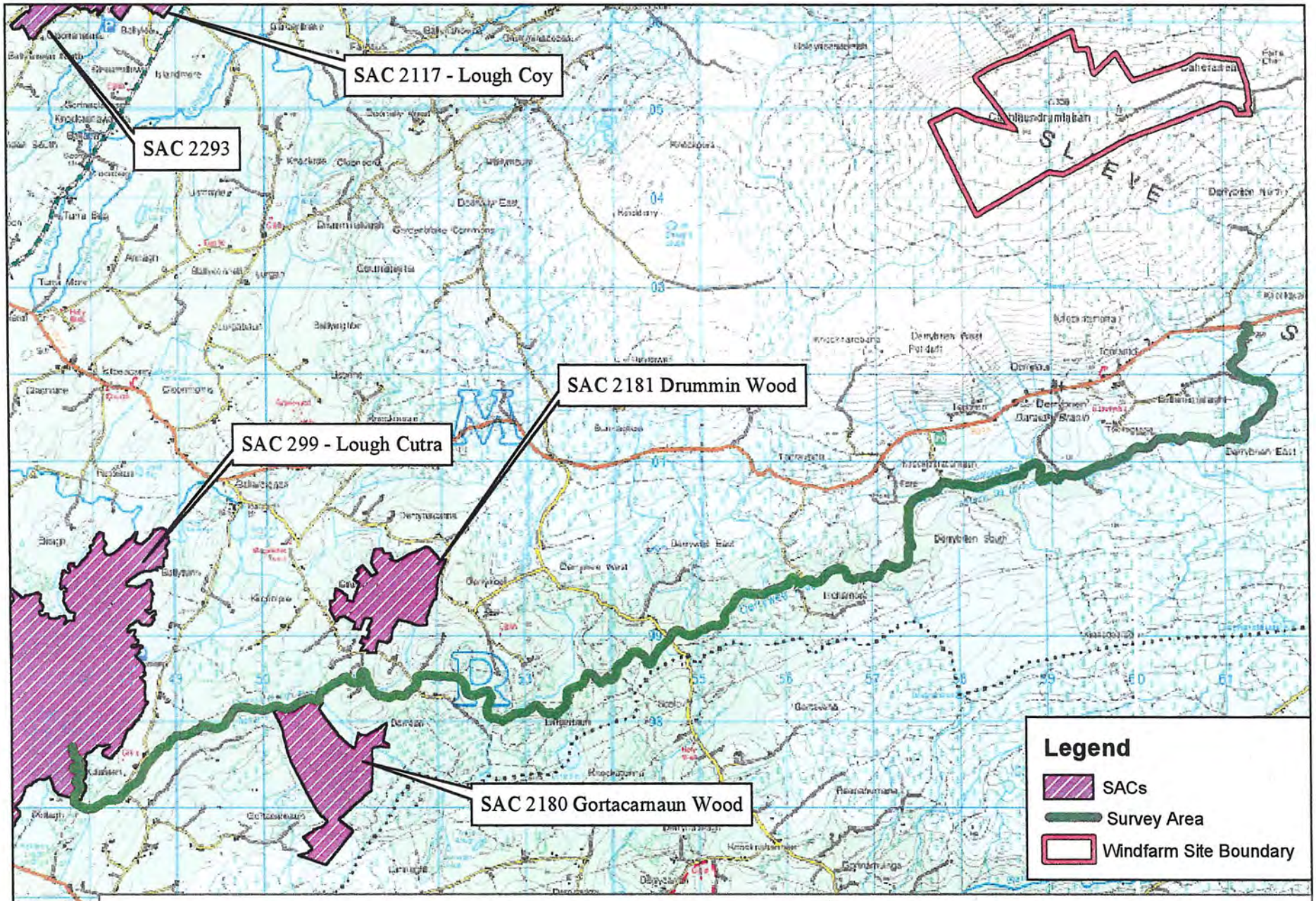

Figure 3: Map Showing Location of Special Areas of Conservation (SAC's) in Relation to Owendalulleegh River

Table 2 Catchment details of the Owendallulleegh River (from source to Lough Cutra). Adapted from McGarrigle *et al* (2002).

Detail	Value
EPA Code	29/O/01
OS Catchment number	146
NOS Grid Reference	R 478 976
Hydrometric area	29
Tributary of	Lough Cutra

Table 3 Physical characteristics of the Owendallulleegh River (from source to Lough Cutra). Calculated from the features shown on the NOS Discovery Series Map 52 and information provided in McGarrigle *et al*, 2002).

Characteristic	Value
Catchment area (km^2)	40
Length (km)	22.5
Basin length (km) [1]	17.2
Basin surface storage (%) [2]	0.005
Drainage density [3]	1.09
Stream order	3rd
Beneficial uses	General amenity and angling
Status	Tributary of designated SAC

Stream order was calculated using the Strahler method (Strahler, 1964).

3.4 Previous studies

3.4.1 Fish and fisheries of the Lough Cutra catchment

The fish fauna of Ireland is not as diverse as other European countries due to the impact of glaciation. Most of the fish species present in Irish river catchments have colonized from the sea or have been artificially introduced. The fact that the Lough Cutra catchment is landlocked will further reduce the number of fish species present. Native fish species in the Lough Cutra catchment include brown trout *Salmo trutta* and one out of the three Irish lamprey species (brook lamprey *Lampetra planeri*). Brook lamprey are listed under the European Union Directive on the Conservation of Natural and Semi-Natural Habitats and of Wild Fauna and Flora (Habitats Directive, 92:43:EEC). The catadromous[4] European eel *Anguilla anguilla* is thought to access Lough Cutra via underground river channels. Introduced fish species in the catchment include northern pike *Esox lucius*, stone loach *Barbatula barbatula*, perch *Perca fluviatilis*, and gudgeon *Gobio gobio*. There have been reports that carp *Cyprimus carpio* has been introduced to the lake but the ShRFB has not confirmed this. A list of the fish species, which are known to occur in the Lough Cutra catchment, and the Owendallulleegh River, along with their distribution and conservation status, is given in table 4. Lough Cutra is a privately owned lake and coarse/mixed fishery.

[1] Basin length is the straight-line distance between the mouth of the basin (in this case the confluence with the Lough Cutra) and the drainage divide nearest the source of the main stream.
[2] Basin surface storage (%) is the percentage of the basin covered in lentic water bodies (i.e. lakes).
[3] Drainage density is an index of the length of stream per unit area of basin. It is calculated by dividing the catchment area by the total length of perennial streams in the catchment.
[4] A fish species which spends most of its life in freshwater but migrates to the sea to spawn.

Table 4 A list of fish species recorded from the Lough Cutra catchment, and Owendallulleegh River, indicating their distribution, protection status, and utilisation (compiled from a number of unpublished sources).

				Protection			*Exploitation*		
Common name	**Scientific name**	**Origin**	**Distribution**	**EU HD**	**Berne**	**RDB**	**Recreational**	**Commercial**	**Present in Owendallulleegh River**
Brown Trout	*Salmo trutta*	N	W				•		•
European Eel	*Anguilla anguilla*	N	W				•	•	•
Carp*	*Cyprinus carpio*	I	L				•		
Gudgeon	*Gobio gobio*	I	L						•
Northern Pike	*Esox lucius*	I	W				•		
Perch	*Perca fluviatilis*	I	W				•		•
Brook lamprey	*Lampetra planeri*	N	L	II	Annex III	I			•
Stone Loach	*Barbatula barbatula*	I	L						•

*Not confirmed.

N=Native, I=Indigenous, W=Widespread, L=Local, E=Extinct.
EU Habitats Directive (EU HD) - Annex II (Species whose conservation requires the designation of SACs), Annex V (Exploitation subject to management)
Berne Convention (Berne) - Annex II (Strictly Protected fauna species), Annex III (Protected fauna species).
Red Data Book (RDB) - Ex – Extinct, E - Endangered, V - Vulnerable, R - Rare, I – Indeterminate, II – Internationally Important

3.4.2 Plant records

The following rare species are recorded for the 10km squares between Flaggy Bridge and L. Cutra. As this data was recorded on a 10km-square basis, it is not possible to state definitively whether the plant record is from the Owendallulleegh River, or from other wetland/streams in the 10km square.
As can be seen from the descriptions of the species' preferred habitats, most of these species prefer slow-moving or standing water or damp ground, and may have been recorded from L. Cutra or other areas of standing water within the relevant 10km squares and thus are less likely to have been affected by the peat slip event. These are marked +.

Orange foxtail *Alopecurus aequalis* – grows in muddy, marshy areas,

Slender tufted-sedge *Carex acuta* – grows along rivers and in ditches and marshes

Water sedge *Carex aquatilis* – grows in swampy areas by rivers and marshes

+Rigid hornwort *Ceratophyllum demersum* – grows in ponds, ditches and slow rivers

+Mudwort *Limosella aquatica* – grows in wet sandy mud by ponds

+Lesser pondweed *Potamogeton pusillus* – grows in lakes, streams and ponds usually in base-rich water

+Northern yellow-cress *Rorippa islandica* – grows on pond sides and other damp places

+Marsh yellow-cress *Rorippa palustris* – grows in open damp ground

+Blue-eyed grass *Sisyrinchium bermudiana* – grows in wet meadows and stony ground by lakes

+Greater bladderwort *Utricularia vulgaris sens. lat.* – grows in base-rich still or slow-moving water

+Fen violet *Viola persicifolia* – grows in fens

3.4.3 Protected aquatic fauna

The status of fauna listed in the European Union Directive on the Conservation of Natural and Semi-Natural Habitats and of Wild Fauna and Flora (Habitats Directive, 92:43:EEC) in the Owendallulleegh catchment is presented as follows;

Common name	Scientific name	Lough Cutra	Owendallulleegh River
Brook lamprey	*Lampetra planeri*	Not known	Present
Eurasian Otter	*Lutra lutra*	Common	Common

3.4.3.1 Brook lamprey

The brook lamprey is the smallest of the three lamprey species native to Ireland and it is the only one of the three species that is non-parasitic and spends all its life in freshwater. Brook lamprey is listed in Annex II of the Habitats Directive (92:43:EEC) and Appendix III of the Bern Convention. The Shannon Regional Fisheries Board has recently recorded Brook lamprey in the Owendallulleegh catchment.

3.4.3.2 Eurasian Otter

The otter is a legally protected species under the Wildlife Act, 1976 (and Wildlife (Amendment) Act, 2000). It is listed under Annex II of the EU Habitats Directive and under Annex II[5] of the Berne Convention. It is found throughout Ireland where it has apparently avoided the population declines that have occurred in many other countries. During the survey, the signs of otters (spraints and tracks) were recorded from many areas in the study area and up as far as chainage 182.

3.5 On-site Investigations

3.5.1 Aquatic habitats

The principal habitat type surveyed is categorised as eroding/upland river (FW1, Fossit 2000). For the purposes of this study, this was subdivided into in-stream areas and riparian, or riverbank, areas. A full aquatic and riparian habitat evaluation is presented in tables 5, 6, 7 and 8. The results of the physical habitat survey are given in table 9. The river length has been divided into 100m chainage lengths for the purpose of assessment, commencing at chainage zero at the Lough Cutra confluence.

3.5.2 Vegetation

A list of plant species recorded during the walkover study is given in Appendix 3. Very little vegetation was recorded from the deeper pools. Pondweed *Potamogeton* sp. was recorded at a few locations. Shallow areas were found to support a limited number of species. These areas were dominated by aquatic mosses such as *Fontinalis* and *Racomitrium* spp. Alternate water-milfoil *Myriophyllum alterniflorum* was recorded as being locally abundant. Emergent, marginal-type vegetation was found along the banks, particularly where these were shelved rather than steep-sided, and on islands and elevated cobble/gravel areas in the channel. The principal species recorded were watercress *Rorippa nasturtium-aquaticum*, water dropwort *Oenanthe* sp., fool's water-cress *Apium nodiflorum* and bulbous rush *Juncus bulbosus*. Willowherbs *Epilobium* spp., floating sweet-grass *Glyceria fluitans*, lesser spearwort *Ranunculus flammula* and brooklime *Veronica beccabunga* were locally frequent. Liverworts were locally dominant or abundant on steep-sided, shaded or overhanging banks, where they were constantly damp but rarely submerged. The dominant riparian species recorded were willows *Salix* spp., ash *Fraxinus excelsior*, hazel *Corylus avellana* and rowan *Sorbus aucuparia*, with an abundant great wood-rush *Luzula sylvatica* ground layer. Gorse *Ulex europaeus*, blackthorn *Prunus spinosa*, hawthorn *Crataegus monogyna* and bramble *Rubus fruticosus* were locally dominant, while bilberry *Vaccinium myrtillus* and soft rush *Juncus effusus* were locally abundant. Sedges *Carex* spp. were locally frequent. Some sections were dominated by planted evergreens such as sitka spruce *Picea sitchensis*. Most of the riverbank above the influence of flood events was dominated by either woodland or heath/bog flora, with unimproved grassland found in a few areas.

3.5.3 Peat Deposition

Estimates of peat deposition were made on the basis of bank side surface area and depth of peat. In general depths of peat at some locations ranged form 0.1 m thickness up to 0.5 m thickness. Larger deposits tended to occur at river bends where peat mounding was observed and at fords used on the river by local farming communities. Areas where larger depths of peat were observed tended to be small in area and could easily be removed if required.

[5] Annex II Berne Convention: Strictly protected fauna species.

Table 5 Aquatic, riparian and fisheries habitat evaluation chainage section 169-200.

Chainage section	Description	Map number	Aquatic habitat appraisal	Fisheries habitat appraisal	Level of instream impact	Level of riparian impact	Comment	Mitigation
200 - 189	From Flaggy Bridge downstream. The start point of the survey. Steep banks and a narrow channel characterize this section. There are hillocks on the eastern edge of the river that rise to 140m asl. Liverworts grow where moisture seeps down to the river.	1	One of the most heavily impacted areas of the river – strong scouring and removal of all instream vegetation. Degree to which instream habitats were affected depended on their relative exposure to the flow of moving peat i.e. whether they were on the inside or outside of a bend. Marginal species are showing good recovery three weeks after the peat slip where peat cover is light.	Here there are large amounts of peat deposited on the margins of the river. Sand banks are evident at bends in the river. These should dissipate with precipitation over time. Instream the riverbed has been scoured gravels and rocks transported downstream. All fish would have been displaced or killed by this flow of material.	Profound Negative	Profound Negative	Physical nature of river has been significantly altered here.	Large areas of peat on the margins may require removal. Alternatively could be planted and stabilized. Damage directly above and around culvert at M 61137 02304. This dam (005) should be removed. The culvert size and gauge should be changed. Instream physical enhancements may be required.
189 – 169	The section from chainage 189 – 182 is still fast moving and narrow until it meets a distributary at 182. From 182 – 169 the river widens and slows.	2	Aquatic vegetation is minimal from 189 – 182. Large amounts of siltation evident. Again there is recovery evident where peat cover is light. From 182 – 169 not as much impact due to the increasing river width.	Area between chainages 189 – 182 has been severely impacted. However, not much scouring has occurred in this section. From 182 – 169 there is good habitat available with good pools and glides - but siltation is evident. The banks have not been eroded as in chainage 200 – 189.	Substantial - Profound Negative	Substantial - Profound Negative	Fish were seen moving upstream within chainage 183. Because the fractions of peat are now small the pools seem clear enough but silt is present. Otter activity was observed at chainage 177.	Areas of peat need to be removed from the margins. Trees and shrubs instream should be left, as removal would be deleterious to habitats and fish.

Table 6 Aquatic, riparian and fisheries habitat evaluation chainage section 169-111.

Chainage section	Description	Map number	Aquatic habitat appraisal	Fisheries habitat appraisal	Level of instream impact	Level of riparian impact	Comment	Mitigation
169 151	River structure consists of long pools with alternating glide/run habitat. River widths up to 12m	3	This section is less severely impacted. Deposition on the river margins is reduced and vegetation is intact at most locations. Cover is much reduced where cobbles and boulders have been turned and scoured. Sheltered areas in the bends of the river have more moderate cover.	Despite some physical impacts, much of the instream habitat along this stretch has been left intact. Areas suitable for salmonid spawning, nursery, rearing and foraging continue to occur.	Moderate – Substantial Negative	Moderate – Substantial Negative	Impacts predicted to be short-tem at this section. Banks are still intact and good habitat is evident in the majority of the length of this section.	No action needed here. Natural recovery processes would suffice.
151 – 129	Long wide sections of slow water with some extensive riffles. Some very wide sections here (up to 19m). Substrate consists of cobble and gravel.	4	Fluctuation in instream vegetation cover reflects variations in streambed disturbance. Cover is much reduced where cobbles and boulders have been turned and scoured. However this damage was not recorded frequently in this section.	No scouring evident. No serious instream damage evident. No peat deposits. There are good areas of gravel evident. Periphyton present on gravels. The majority of larger peat material has been 'sieved out' by the narrow nature and overhanging shrubs from 200-182 of the river	Slight Negative	Slight Negative	This section is physically unchanged from its original form. Banks are still intact and good habitat is evident in the majority of the length of this section. Impacts negligible. Otter activity evident in this section.	No action needed here
129 – 111	Some large pools along this stretch, three small distributaries and three fords characterize this section. Bank height rises here along this section. Fish (salmonids) were noted moving in the pools here. This section is for the most part slow moving with some good riffles evident at the fords.	5	Cover of peat on the margins here is very light except for small pockets. Liverwort flora, the most abundant riparian-type marginal vegetation, is undamaged. Instream vegetation is low and scouring damage is not evident.	Good spawning areas in this section with gravels intact. Also good holding pools and nursery areas available. Damage is limited to marginal areas where peat has deposited. No instream damage evident with the exception of some trees and shrubs that have been washed down. These will form extra habitat for fish in future.	Slight Negative	Slight Negative	This section seems largely undamaged to the eye. There is no evidence of scouring or of large movements of gravels and cobbles. Because the fractions of peat are now small the pools seem clear enough but silt is present in the interstitial spaces. Otter activity in the form of paw prints and anal jelly was observed.	No action needed here

Table 7 Aquatic, riparian and fisheries habitat evaluation chainage section 111-31.

Chainage section	Description	Map number	Aquatic habitat appraisal	Fisheries habitat appraisal	Level of instream impact	Level of riparian Impact	Comment	Mitigation
111- 91	Deep pools and large sections of bedrock characterize this section. There is good bankside vegetation and some good stands of mixed forestry line the edges of the river in places. Tunneling (trees) was observed at two locations.	6	Due to the depth of water in areas instream vegetation was low where it was possible to assess. Again liverworts were undamaged.	Large deep holding pools that are impossible to assess for benthic damage. However there are good areas of glide (50%) accessible and these seem untouched. Peat has not deposited instream with the exception of areas in the lee of trees in the river. Peat has deposited on the margins in some areas.	Slight Negative	Slight Negative	This section seems largely undamaged to the eye. Large numbers of deer are using this area. The only discernable difference is the peat that has deposited on the banks.	No action needed here
91 – 70	This entire section has deciduous woodland on the bankside. As a result shading occurs on most of the sections. Long pools are evident with no damage recorded.	7	Vegetation that was seen was intact. There is impoverished riparian flora as a result of shading. The instream flora is low where shading occurs but is relatively undisturbed. The lower areas 64-56 supports very good areas of instream vegetation and also seems undisturbed by then peat slip event.	Where possible to assess instream predictors no damage was recorded. Gravels were evident but on a whole deep areas and glides predominated. Siltation was observed. Peat has deposited on the margins in some areas.	Slight Negative	Slight Negative	This section was undamaged and instream vegetation was intact where noted. Areas of peat deposition were apparent.	No action needed here
70 – 50	Wide sections of river bordered on the northern bank by good improved agricultural grassland complexes. The river exhibits deep pools again with glides predominating.	8	Good sections of instream growth are evident at the lower end of this section. Again heavy shading by overhanging trees has stunted growth in some sections. All instream vegetation that was observed was undisturbed.	Where wading permitted inspection of the instream predictors these seemed undisturbed. Peat has deposited on the margins in places.	Slight Negative	Slight Negative	This section was undamaged and instream vegetation was intact where noted. Areas of peat deposition were apparent.	No action needed here
50 – 31 (SAC 2180 Gortacarnaun Wood)	Characterized by widening sections of river with good pool systems. Some nice fast water at chainage 45 with nice undisturbed gravels present. Between chainages 39 – 34 on the southern bank there is heavy woodland cover entailing observers to make use of the northern bank.	9	There have been no impacts on vegetation found in this section. Open unshaded areas support good instream vegetation.	Minimal impacts were observed in this section. Peat has deposited on the banks at various locations and overhanging trees bear the detritus of the deluge.	Imperceptible Negative	Imperceptible Negative	Fresh otter spraints were noted in this section. There is no perceptible damage in this section.	No action needed here

Table 8 Aquatic, riparian and fisheries habitat evaluation chainage section 31-1.

Chainage section	Description	Map number	Aquatic habitat appraisal	Fisheries habitat appraisal	Level of instream impact	Level of riparian impact	Comment	Mitigation
31 – 11	Extensive areas of riffle separate some long deep pools. Instream predictors were difficult to assess in places due to the depth of pools.	10	There have been no impacts on vegetation found in this section. Open unshaded areas support good instream vegetation.	No impacts recorded on this section. Some small amounts of peat have settled on the margins at certain points.	Slight Negative	Slight Negative	There is no perceptible damage in this section.	No action needed here
11 – 1	Due to the depth of this section the ShRFB surveyed this section in boats. This section leads onto the mouth of the river and a large sand bank is present at this mouth.	11	There have been no impacts on vegetation found in this section. Depth of channel made assessment of instream vegetation impossible.	Although no impacts were recorded on this section some peat may have settled at the mouth of this river. Some small amounts of peat have settled on the margins at certain points.	Slight Negative	Slight Negative	There is no perceptible damage in this section.	No action needed here

Table 9 Approximate amount of peat (m^3) deposition observed on the river margins. (Estimated by ESBI)

Chainage section	Amount of peat (m^3) deposition observed on the margins (approx.)
200 - 189	1260.1
189 – 169	936.59
169 – 151	102.35
151 – 129	51.25
129 – 111	45
111- 91	21.5
91 – 70	276.25
70 – 50	79.75
50 – 31	16.15
31 - 11	65.15
11 - 1	67

Table 10 Results of the physical habitat survey.

Site number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Grid co-ords.	M611 625	M611 624	M 6113 623	M611 272	M610 206	M 611 196	M 611 345	M611 121	M604 119	M 601 121	M 579 702	M 575 538	M 57371 125
Bank height range (m)		1 - 2m	1 - 2m	3 - 7m	.5 - 3.5	.4 - 3.5	.4 - 2	.2 - .6	.5 - 1.5	1.5 - 2	.1 - 2	.1 - 2	.1 - 1.2
River width range (m)		1 - 2m	.2 - 1.1m	2 - 4m	.3 - 1.5m	1 - 4m	.7 - 4m	2 - 4m	3 - 8m	5 - 10m	5 - 14m	7 - 15m	8 - 19m
Depth range (m)		.1 - .5	.1 - .5m	.5 - .75m	.1 - .5m	.1 - .75m	.1 - .8m	.1 - .7m	.1 - 1.5m	.1 - .75m	.1 - 8m	.1 - .8m	.2 - .6m
Riffle %		50	20	10		10	10	10	50	20	30	20	5
Glide %		40	10	30	10	20	80	80	40	70	50	5	75
Pool %		10	70	40	60	70	10	10	10	10	20	75	20
Bedrock %		90	60	85	30	30	50		10				
Cobble %				5	10	10	30	75	20	60	15	15	80
Gravel %		10	40	15	60	60		25	70		15	85	20
Boulder %							20			40	70		
Sand/Silt %													

Site number	**14**	**15**	**16**	**17**	**18**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Grid co-ords.	R572 997	R561 996	R557 994	R546 989	R517 984	R517 984	R510 984	R502 981	R484 971	R482 972	R480 972	R487 978	R487 978
Bank height range (m)	.1 - 2.5	.1 - 5	0.5 - 2	0.1 - 2	1-3m	1-3m	1 - 3m	1-15m	1-3m	.1-2	.5-2m	.1 - 2.5	.1 - 5
River width range (m)	10 - 19m	2 - 20m	2 - 8m	3 - 30m	2-17m	5-14m	2-12m	10-14m	6-12m	17-25m	16-30m	10 - 19m	2 - 20m
Depth range (m)	.1 - .75m	.1 - 1m	.1 - 1.5m	.1 - >2m	.1-3	.2-3.5	.1 - 2.5	.1 -4.5	.2->2m	.2 -.4m	.75-5m	.1 - .75m	.1 - 1m
Riffle %	25	25	10	20	10	10	20	5		10		25	25
Glide %	75	25	80	50	60	35	30	10	50	90		75	25
Pool %		50	10	30	30	55	50	85	50		100		50
Bedrock %	10	60		70	30	30	5	80	10			10	60
Cobble %	20			20	40	20						20	
Gravel %	70	10	20	10	10	10	90					70	10
Boulder %		30	80		20	40	5	20	30	5			30
Sand/Silt %									60	95	100		

4.0 IMPACT

4.1 Characteristics of the impact

The results of this preliminary investigation suggest that the peat, which entered the upper reaches of the Owendallulleegh River, had a significant impact on the aquatic habitats in the river. The impacts were related to (1) physical impacts of peat on the river (i.e. scouring, bed erosion, etc.) and (2) impacts on water quality through elevated suspended solids and other parameters.

4.1.1 Physical impacts

Evidence of physical impacts are particularly apparent in the upper reaches of the river where an acute slide of peat into the channel scoured the river bed and denuded it of deposited materials such as gravels and cobbles. Physical impacts on the middle section of the river were less significant where suspended peat was transported. Deposition along this stretch of river was confined primarily to river bends and islands. No evidence of scouring was apparent along this section.

On the lower section of river, evidence of impacts were much reduced due to the spatial and temporal dilution of peat flocs and the riparian deposition of peat in the upper and middle section of the river. Suspended peat was transported along this stretch by river flows and deposition was confined primarily to river bends, islands and areas of reduced flow. No evidence of scouring was apparent along this section.

4.4.2 Scale of the impact

The most severe impact occurred in the upper section of the river, from Flaggy Bridge to confluence at Derrybrien East. In this area, the energy of moving peat, water and debris was greatest, and resulted in the near total loss of vegetation and scouring of the riverbed in some parts. Heavy deposition of peat on the banks also occurred in this area. The impact on the remaining downstream section was less significant. The presence of a 'high water mark' of debris deposited along the entire length of channel from Derrybrien to Lough Cutra indicates the ultimate height to which the banks were affected. In most areas below Tooraglassa, this is limited to a light covering of twigs and plant debris.

The main physical impact of peat silt on instream and riparian habitats is to be found within 0.5km downstream of Flaggy Bridge, where heavy peat deposition and scouring of the river channel had a profound impact. In contrast with this, practically the entire remaining habitat, from Bellaghnamallaght to L. Cutra, shows low/no impact, with localised areas of moderate impact. Habitat quality and species composition in areas of low/no impact is as expected for this type of river, where low nutrient availability and a spate-type flood regime do not favour the growth of emergent aquatic plants. Low cover of instream vegetation in areas of low/no impact is coincident with areas of heavy shading or deep pools, both of which are unsuitable for the growth of the most instream species typical of upland rivers. Those areas where instream vegetation has suffered moderate/low damage would be expected to recover naturally over the next 2-3 years.

Areas of deposited peat will provide new habitat for colonisation by some emergent species that are tolerant of its low pH, e.g. lesser spearwort, over the coming growing season (spring/summer 2004). However most of these deposits will be moved or modified by spate floods and are generally unlikely to provide habitat beyond approximately two years, given the eroding nature of this type of river. Most of the instream species found on this river prefer a mineral- (rock) derived substrate for growing, as opposed to one derived from organic matter (e.g. peat) – that is why they are found in this eroding type of river. While some deposition of fine peat is evident in the streambed, this is not of sufficient quantity to significantly affect plant growth.

With regard to plants and habitats along most of the affected stretch of the Owendallulleegh River, no remedial action is necessary, or even desirable, as the communities present will regenerate naturally over the next 1-3 years. Peat deposits should not be removed except where they present a possible danger to humans/livestock, or a potential threat to fisheries. Accessing and removing deposits is more likely to cause harm to habitats and plants than if they are left to naturally recolonise and/or be eroded (assuming that heavy plant such as caterpillar-tracked vehicles would be used to carry out the work).

5.0 MITIGATION

Some remedial works are desirable in the upper section at Flaggy Bridge in order to stabilise denuded areas of river channel and prevent unnecessary release of sediment into the watercourse. The use of matting, geotextile or similar 'soft' engineering solution to stabilise the bank sides and allow natural regeneration to occur is preferable over the use of 'hard' engineering. As well as facilitating habitat restoration and quickly fitting in with the natural landscape, 'soft' solutions have long-term advantages of being better adapted than hard bank retention engineering to absorbing some of the energy of spate events. Planting of vegetation 'plugs' at intervals along the stabilization structure would accelerate recolonisation. Any plants used should be taken from a suitable nearby site and the use of native species is recommended.

The planting of trees to replace those damaged in the flood would help to stabilise adjacent areas. The most suitable species are those native species already found growing naturally in this area – ash, mountain ash and downy birch.

Remediation of instream vegetation is problematic as aquatic mosses are slow growing. Two options are available. The first,'do nothing', option will leave the channel to recover by itself with no interference. This will be a slow process (3+ years). Alternatively, a small number of medium-sized (football-sized) boulders with moss growth could be introduced from unaffected parts of the river, preferably from the closest point possible (to retain a species composition as close to the original as possible). Such boulders would create a more diverse flow regime and variety of instream microhabitats. It is recommended that this option be considered only when all other remediation and stabilisation works have been completed, at which stage the condition of the streambed in the worst affected area should be re-assessed. The possible introduction of such boulders should be discussed with ShRFB staff.

5.1 Proposed further work

It was not possible to assess the status of fish populations and other fauna in the river during the current survey. It is therefore recommended that a fish stock assessment coupled with a macroinvertebrate survey be undertaken. This survey should use standard quantitative methods (electrical fishing and serber sampling) and should be undertaken at 5-10 sites along the river corridor. The ideal time to undertake this survey would be during the period July-September when the maximum numbers of juvenile fish would be expected to be present in a stream of this nature. At this time detailed recommendations regarding instream physical mitigation work can be made.

REFERENCE

Greenberg, L.A. and Dahl, J. 1998. Effect of habitat type on growth and diet of brown trout (*Salmo trutta* L.) in stream enclosures. *Fisheries Management & Ecology* **5:** 331-348.

Haury, J, Ombredane, D, & Bagliniere, JL (1999) The habitat of the Brown Trout (*Salmo trutta* L.) in watercourses. *Biology and ecology of the brown and sea trout. 37-89. (1999).*

Hatfield, T. & Bruce, J. (2000) Predicting Salmonid Habitat–Flow Relationships for Streams from Western North America. *North American Journal of Fisheries Management* **20**:1005–1015, 2000

Kennedy, GJA & Strange, CD (1986) The effects of intra- and inter-specific competition on the distribution of stocked juvenile Atlantic salmon, Salmo salar L., in relation to depth and gradient in an upland trout, Salmo trutta L., stream. J. Fish. Biol., **29**(2):199-214.

O'Grady, M.F. (1993) Initial observations on the effects of varying levels of deciduous bankside vegetation on salmonid stocks in Irish waters. *Aquacult. Fish. Manage.*, **24**(4):563-573.

APPENDIX 1 SURVEY AREAS ON THE OWENDALLULLEEGH.

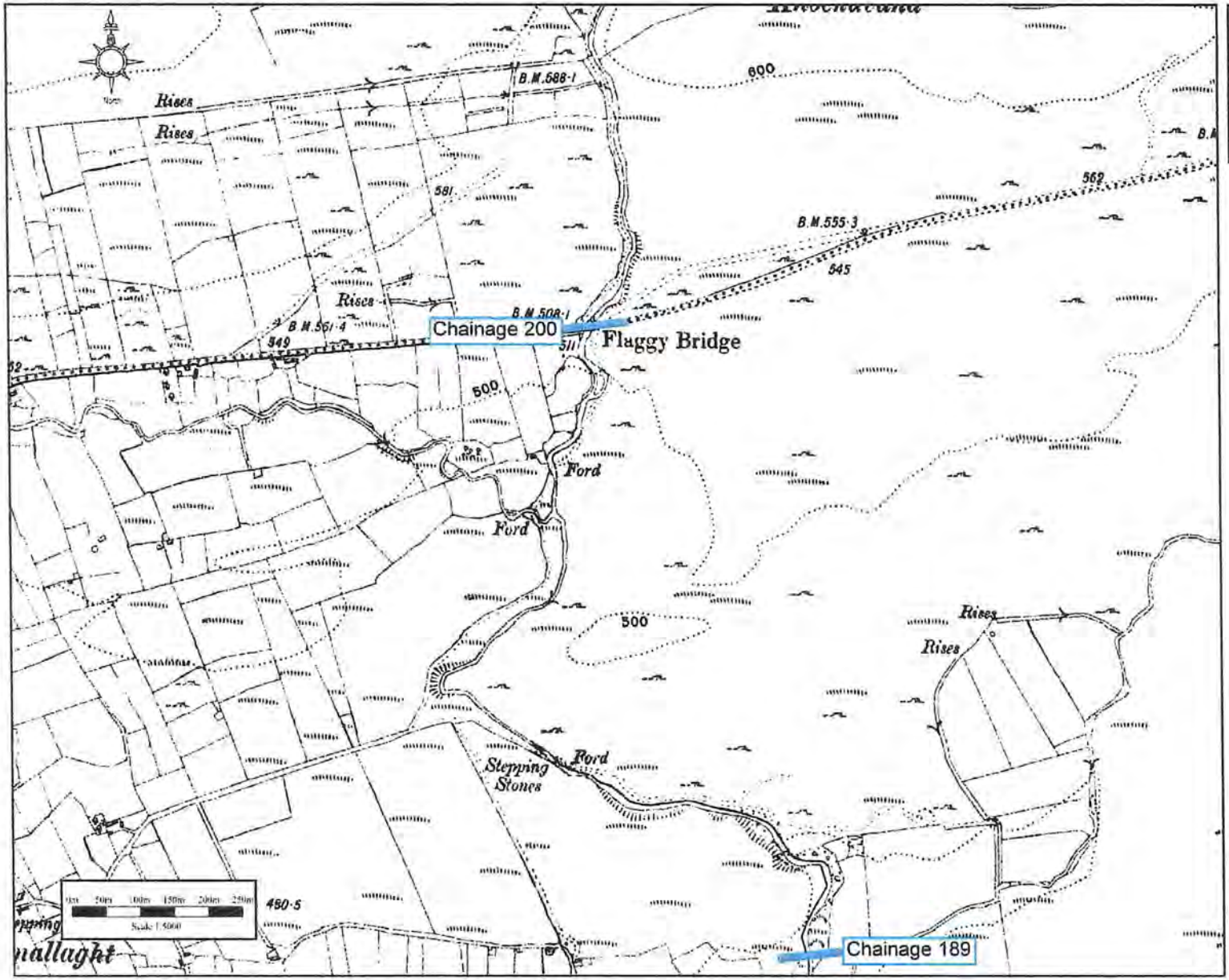

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Figure A1.1
Section one was located downstream of Flaggy Bridge. Survey section was between chainages 200 - 189.

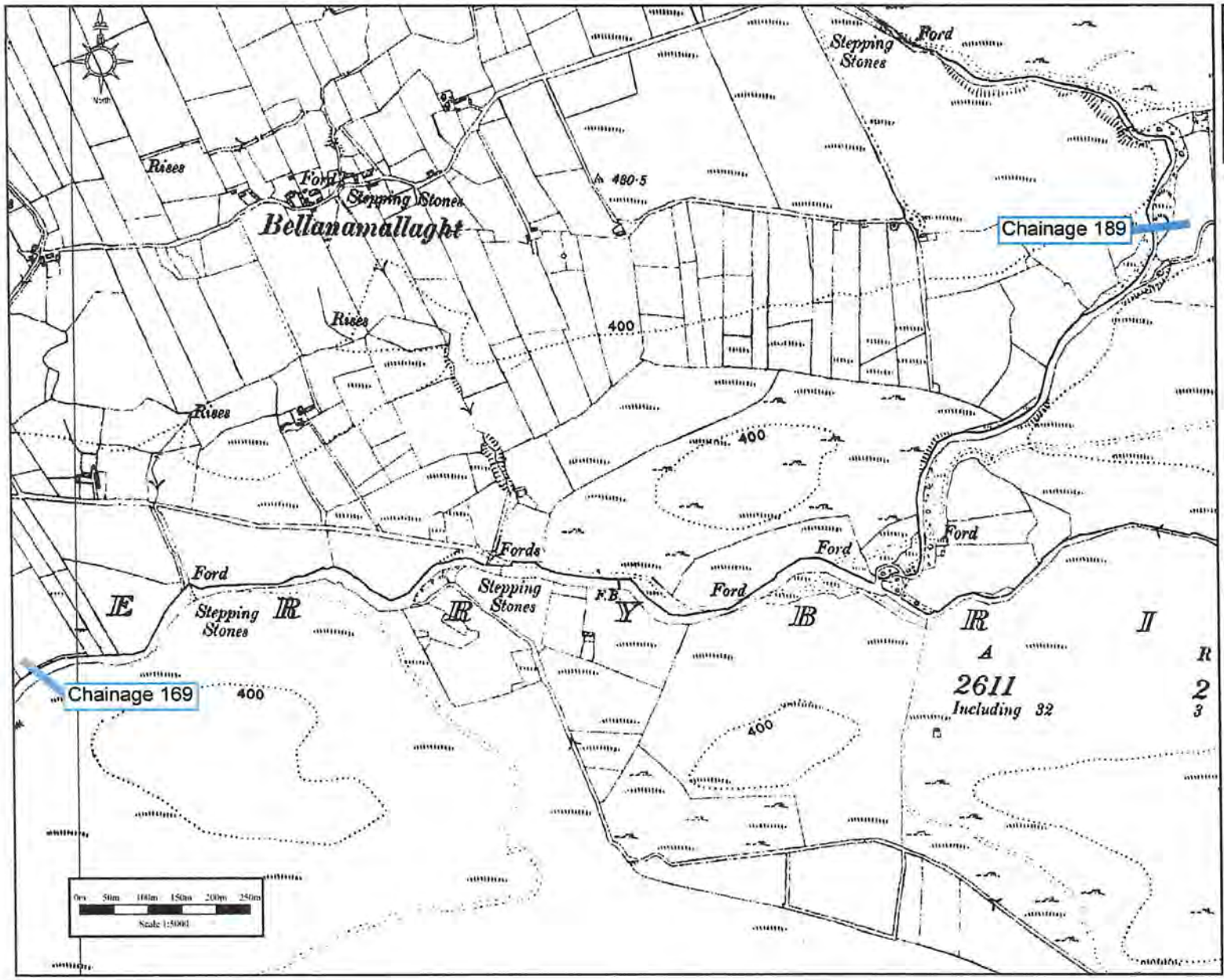

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Figure A1.2
Section two was located on the second section down-stream of Flaggy Bridge. Survey section was between chainages 189 - 169.

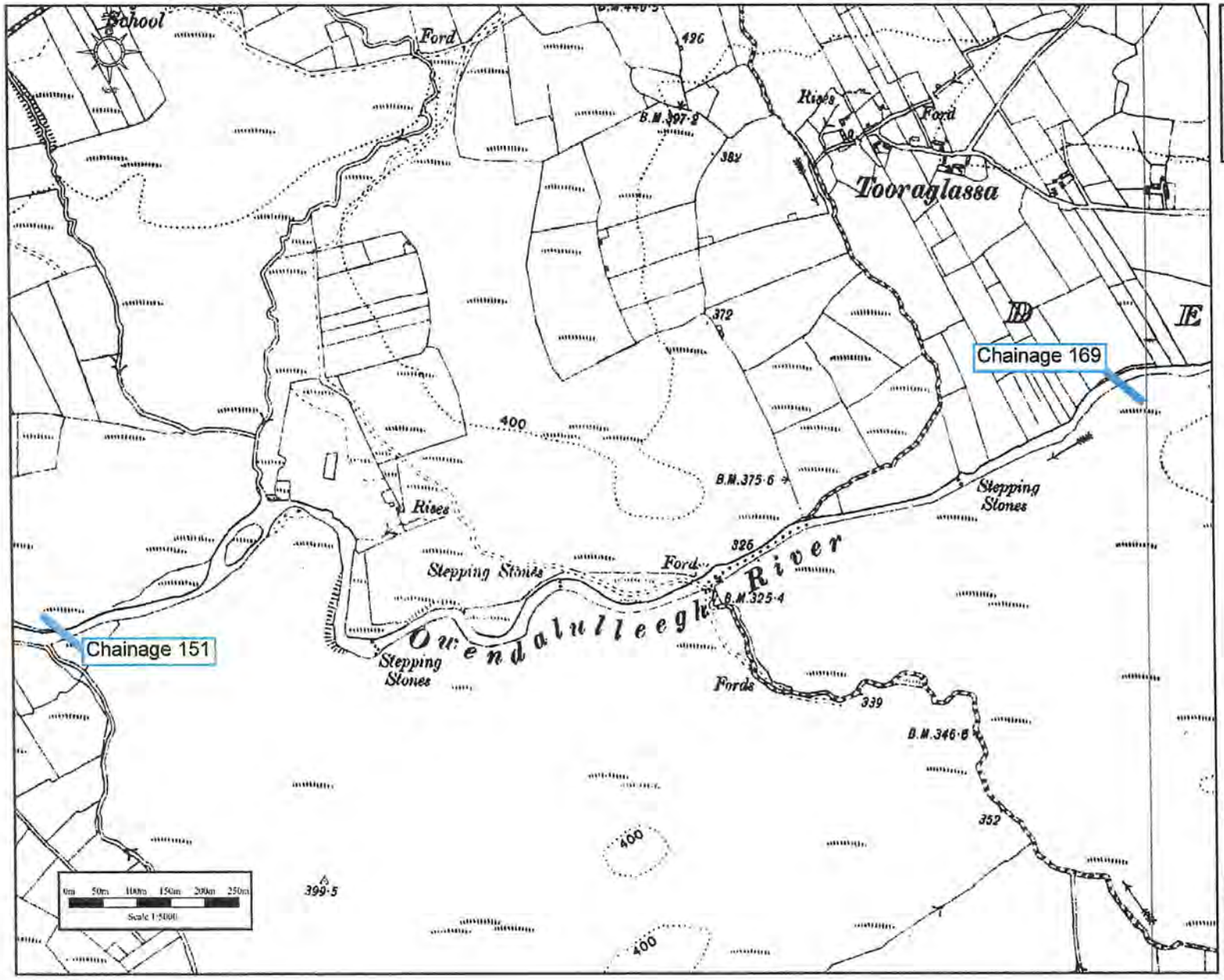

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Figure A1.3
Section three was located in the townland of Toorglassa. Survey section was between chainages 169 - 151.

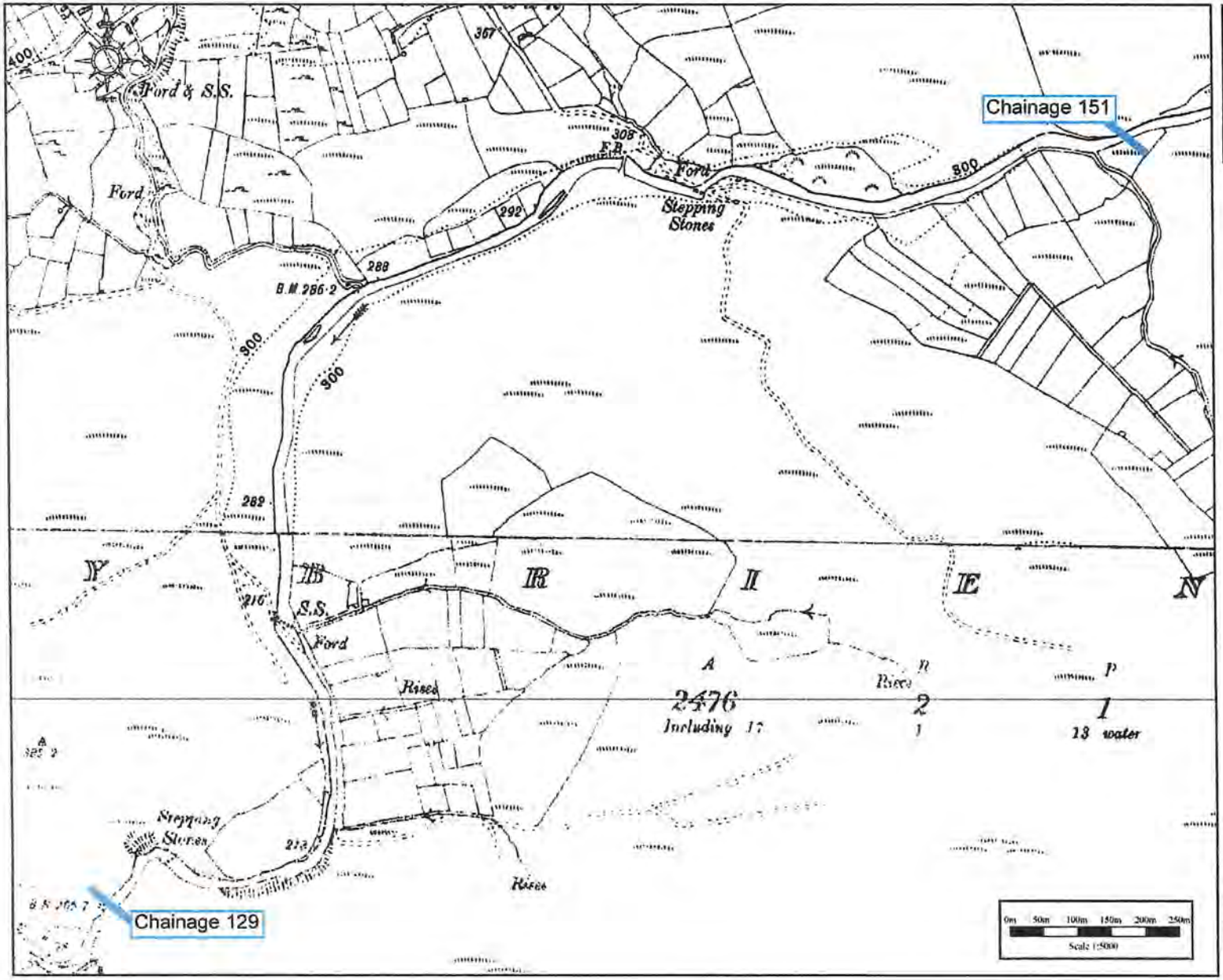

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Figure A1.4
Section four was between chainages 151 and 129.

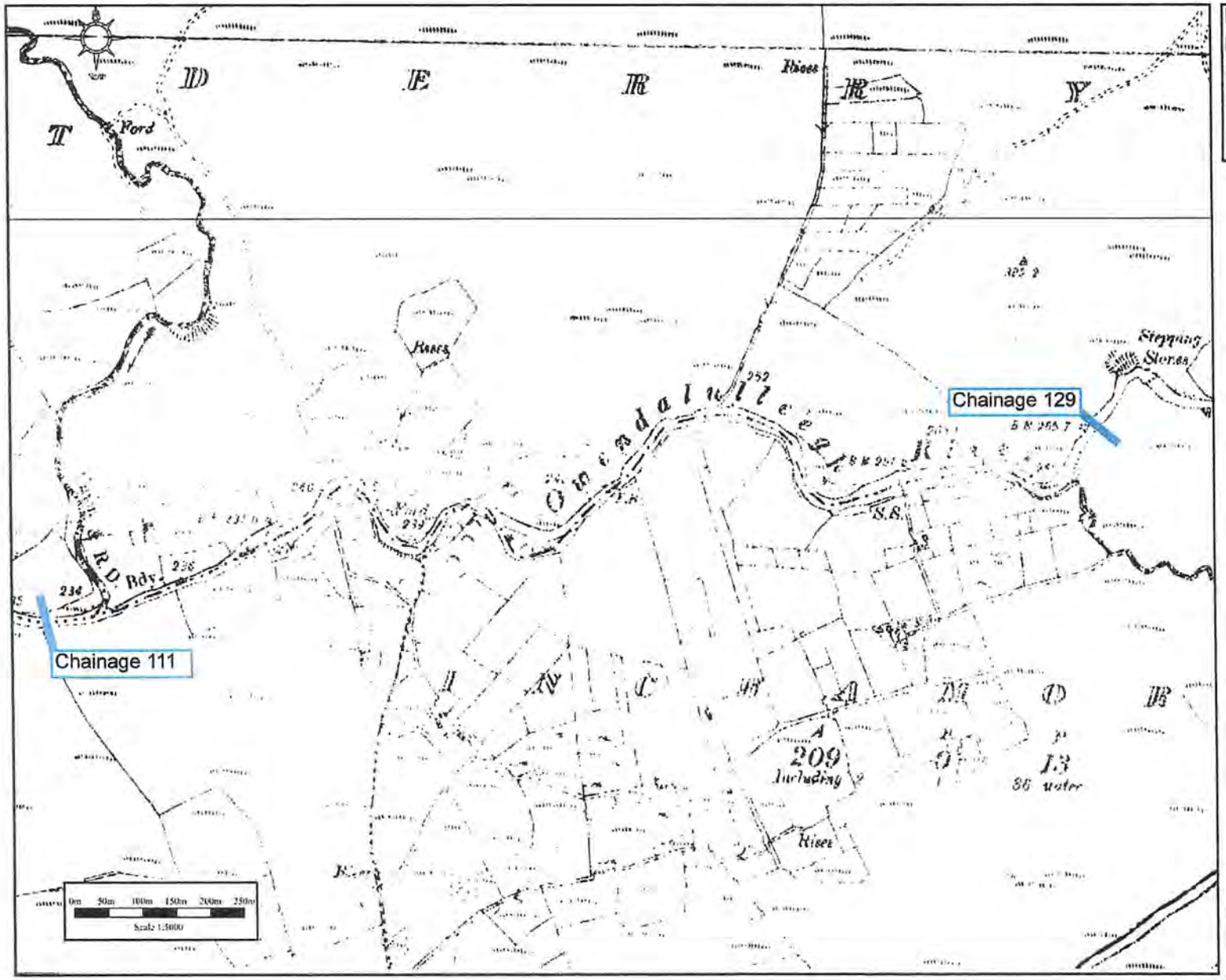

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Figure A1.5
Section five was between chainages 129 and 111.

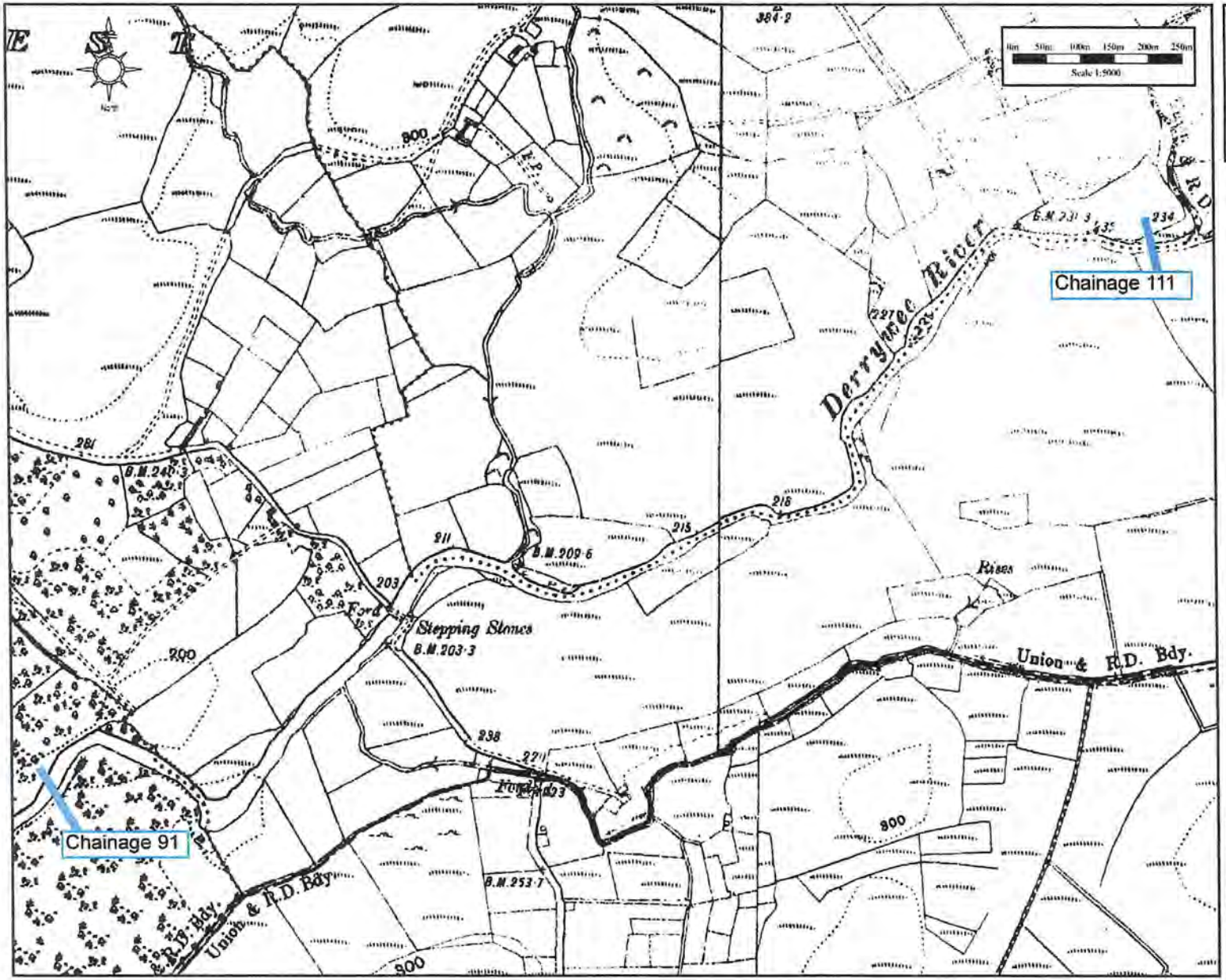

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Figure A1.6
This figure shows the extent of survey section six.This section extended from chainage 111 to chainage 91.

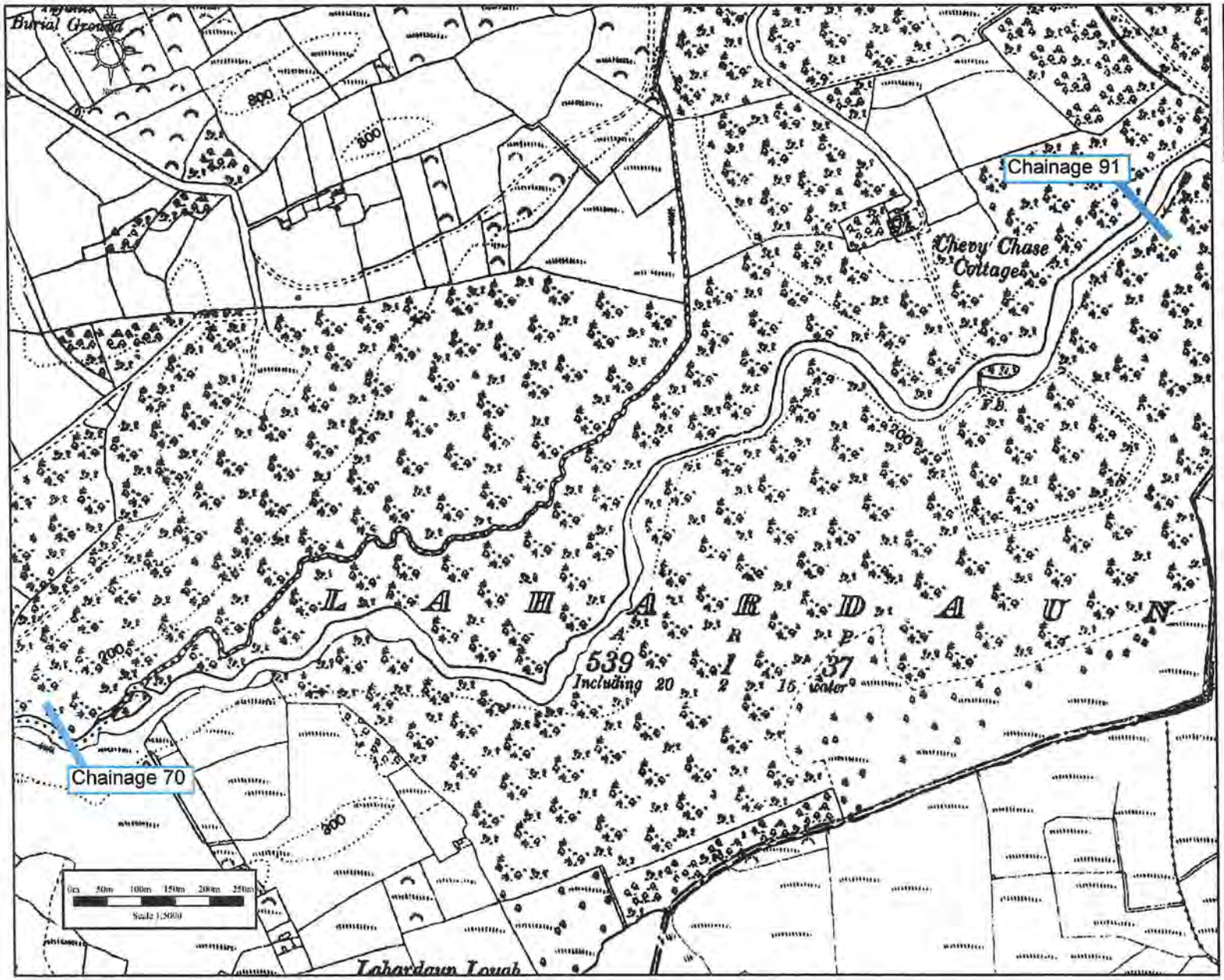

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Figure A1.7
Section seven was located in the stretch of river near Chevy Chase cottage. Survey section was between chainages 91 - 70.

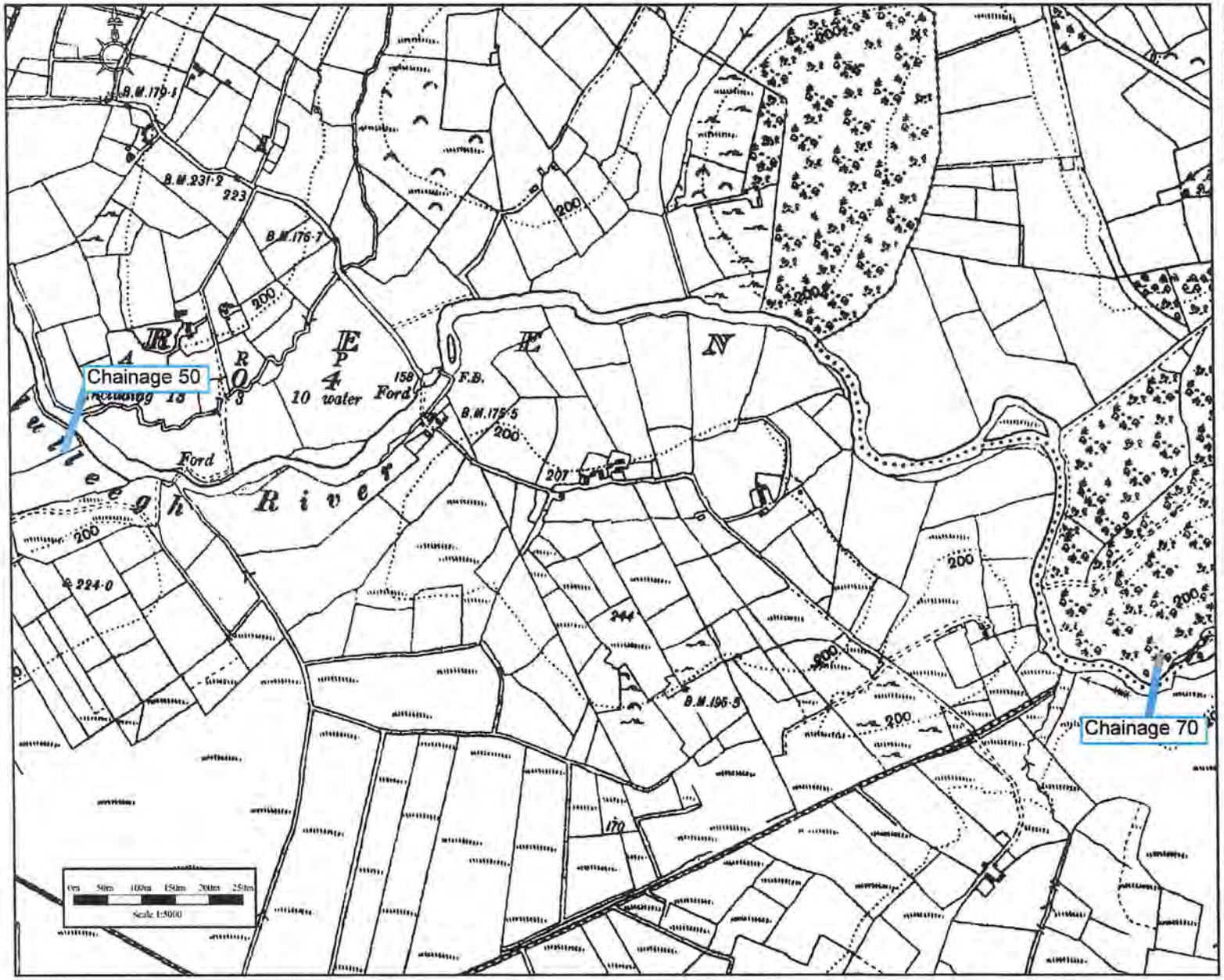

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Figure A1.8
Section eight was located immediately downstream of the Chevy Chase cottage stretch and extended from chainage 70 to 50.

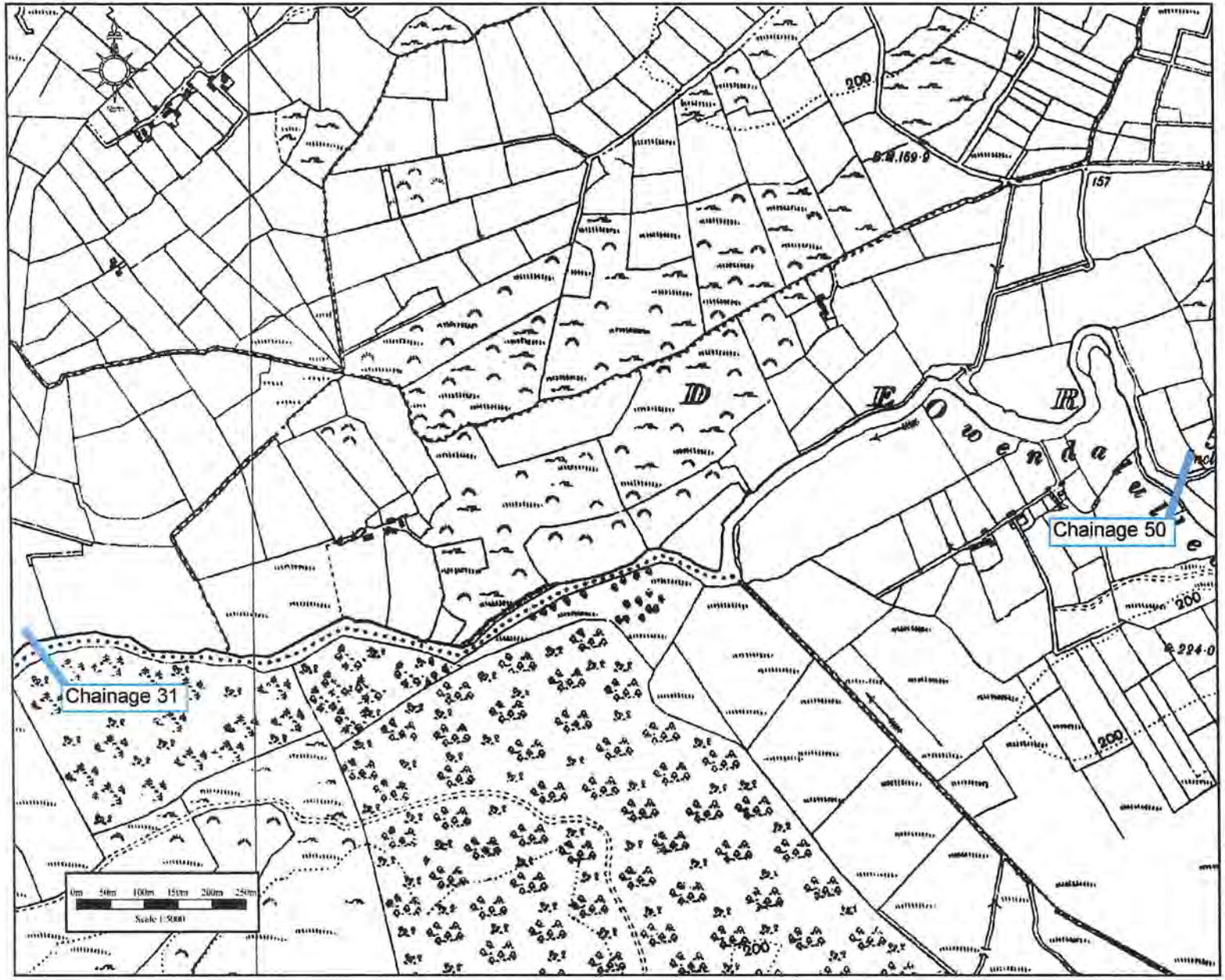

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Figure A1.9
This figure shows the extent of survey section nine. This section extended from chainage 50 to chainage 31.

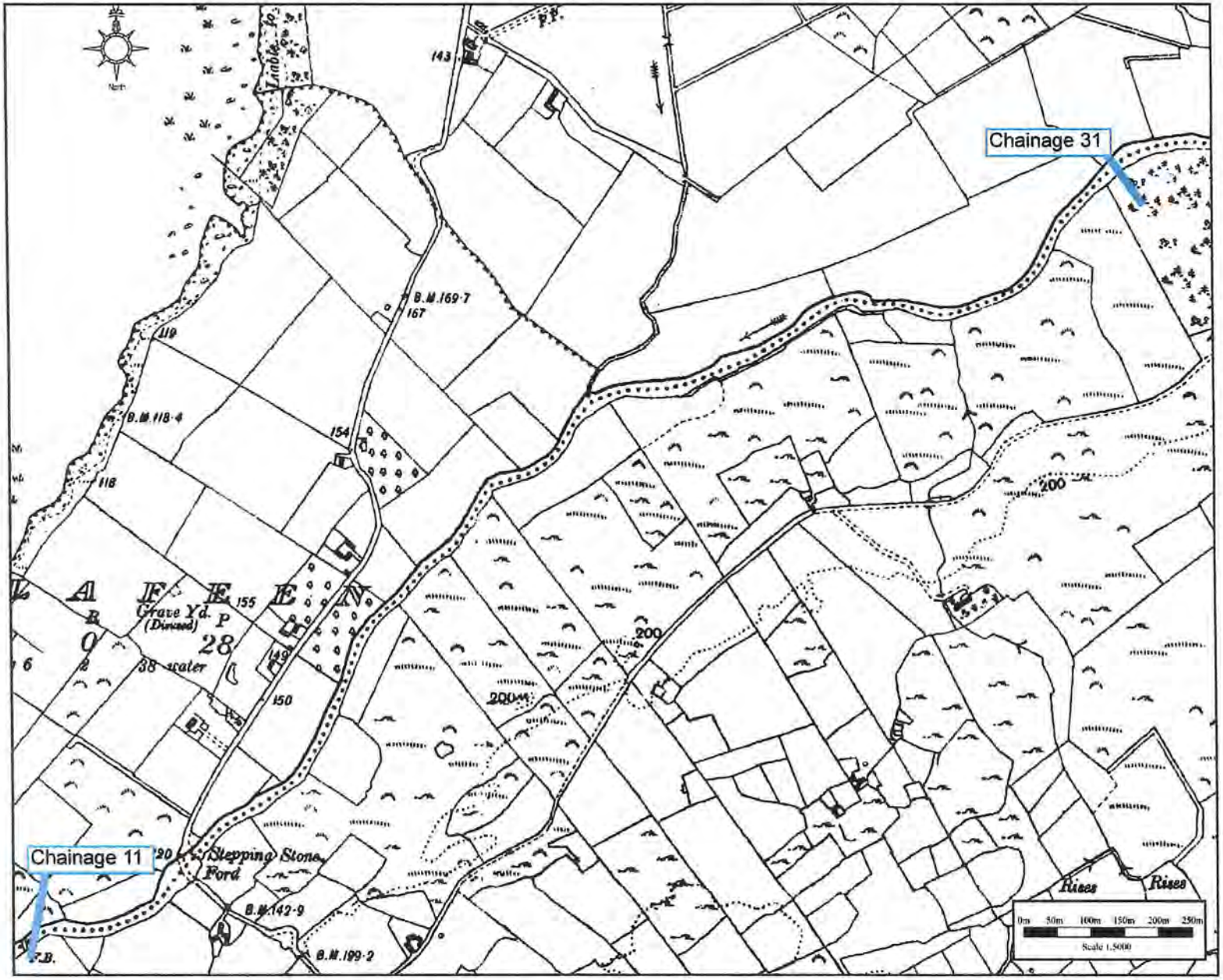

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Figure A1.10
Section ten was located in the lower reaches of the river river. Survey section was between chainages 31 and 11.

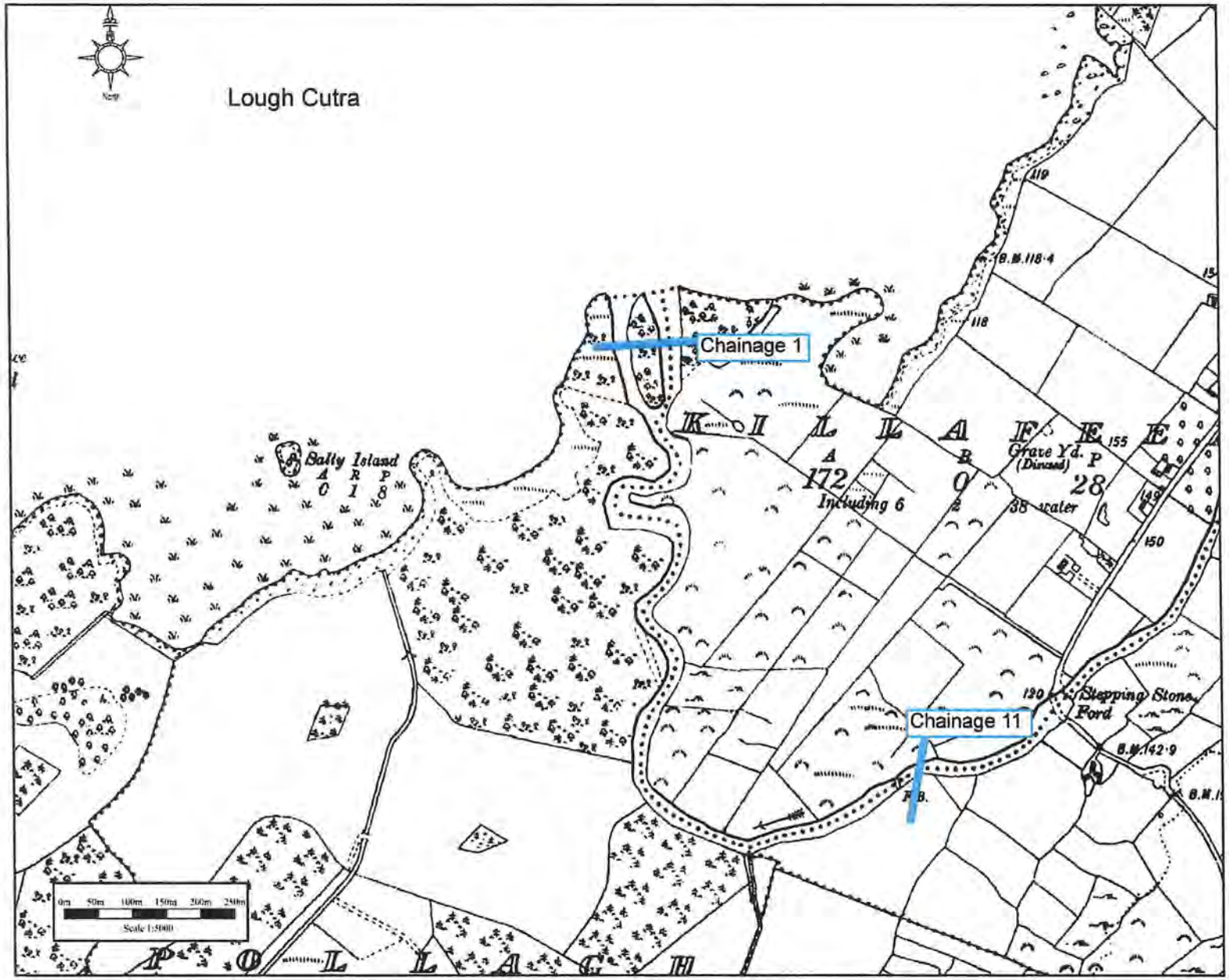

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Figure A1.11
This section was the lower-most section of the river and extended from chainage 1 at the mouth of the river to chainage 11.

APPENDIX 2 NPWS SITE SYNOPSES

SITE NAME LOUGH CUTRA

SITE CODE 000299

Lough Cutra is an oligo/mesotrophic freshwater lake lying on limestone. This lake is located 4km south-east of Gort. The lake covers an area of 390 ha and has a catchment consisting of blanket bog and mineral soils.

The main habitats of this site are; aquatic lake vegetation, reedbeds confined to sheltered bays and mixed woodland. Reedbeds of Common Reed (*Phragmites australis*), Common Club-rush (*Scirpus lacustris*) and Great Fen-sedge (*Cladium mariscus*) exist. The flora shows a mixture of calcicole and calcifuge species with the Irish Spurge (*Euphorbia hyberna*) noted in the area. There is no information available on the status of the woodland habitats in this site.

The site is internationally important for its breeding and wintering population of Cormorants (166 pairs in 1985 and max 300 individuals in winter) (Information compiled in 1987). The Cormorants use the off-shore islands for breeding purposes.

The lake is used for fishing and tourism. Precautions should be taken to ensure the lake and its surrounding area is protected from damaging operations such as application of artificial fertilizers, development close to the lakeshore, drainage and felling of woodland areas. The internationally important populations of Cormorants and Lesser Horseshoe Bats should be especially protected.

Lough Cutra is an important site with its diverse habitat types and the presence of both calcicole and calcifuge floras. The site is also of interest as it has internationally important numbers of Cormorants on the Island.

SITE NAME: LOUGH COY

SITE CODE: 002117

Lough Coy is situated approximately 6.5 km north-east of Gort and lies close to the Slieve Aughty hills. The site consists of a small permanent lake in the middle of an almost circular turlough basin. There are drift deposits as well as outcropping rocks and boulders on the relatively steep side walls and small areas of scrub towards the top of the basin. The underlying soils consist of alluvial gleys and a gleyed rendzina-like soil.

A large swallowhole occurs at one side of the basin slightly above summer water level and water enters and leaves the turlough mostly through this. During the winter the fluctuation in levels is extreme and there are no emergent plants such as Common Club-rush (*Scirpus lacustris)* or Common Reed (*Phragmites australis)* in the lake. The turlough experiences a large throughput of water and is dependant on the flows in the tributaries of the Coole River. Lough Coy is an excellent example of a 'riverine' type of turlough, and is in essence the floodplain of an underground river.

Practically the entire site consists of turlough habitat, an EU Habitats Directive Annex I priority habitat. In summer the water area contracts to a degree depending on the prevailing weather and flat mud is exposed which splits into polygonal plates. This is the habitat for a variety of specialised plants such as Mudwort (*Limosella aquatica*), Needle Spike-rush (*Eleocharis acicularis*), Northern Yellow-cress (*Rorippa islandica*) and the liverwort *Riccia cavernosa*. The lakeshore itself has some of these species along with Knotgrass (*Polygonum aviculare*) and Redshank (*Polygonum persicaria*). Above this is a more continuous cover of the sedges *Carex nigra* and *C. hirta*, Reed Canary-grass (*Phalaris arundinacea*), Creeping Cinquefoil (*Potentilla reptans*), Corn Mint (*Mentha arvensis*) and Creeping Buttercup (*Ranunculus repens*). A vegetation characterised by Meadowsweet (*Filipendula ulmaria*), Northern Bedstraw (*Galium boreale*), Common Bird's-foot-trefoil (*Lotus corniculatus*) and Adder's-tongue (*Ophioglossum vulgare*) grows amongst the rocks and includes both Dog Violet (*Viola canina*) and Fen Violet (*V. persicifolia*). The limestone boulders on the upper slopes have a covering of the moss *Cinclidotus fontinaloides*. The fringe of scrub at the edge of the basin is mostly of Blackthorn (*Prunus spinosa*), Buckthorn (*Rhamnus catharticus*) and Ash (*Fraxinus excelsior*), with some Hazel (*Corylus avellana*).

Lough Coy is part of a complex of small sites (along with nearby Blackrock, Ballylee and Bullaunagh turloughs) which supports a nationally important population of Whooper Swans and regionally/locally important numbers of several duck and wader species. Maximum counts at Lough Coy in winter 1995/96 were as follows: Whooper Swan 78, Wigeon 285, Teal 283, Pochard 45, Lapwing 300, Dunlin 120 and Curlew 80. Birds move frequently between the various sites in response to water levels and disturbance. Lough Coy is often one of the few sites in the district which holds water in late summer and autumn and consequently is of importance for post-breeding birds and early autumn arrivals - 132 Mallard were counted in August 1996 and 149 Wigeon in September 1996.

Of particular note is the occurrence of three Red Data Book plant species at this site - these are Mudwort (*Limosella aquatica*), Fen Violet (*Viola persicifolia*) and Northern Yellow-cress (*Rorippa islandica*).

The main landuse within the site is cattle grazing which is quite heavy at the lake margins and on parts of the slopes. There is some removal of gravel from the drift deposits on the north western edge.

Lough Coy is an excellent example of an eutrophic (nutrient-rich) turlough. The extreme water fluctuation supports a distinctive zonation of vegetation and provides many niches for specialist plants. It is an important site for wintering waterfowl.

SITE NAME : COOLE-GARRYLAND COMPLEX

SITE CODE : 000252

The Coole-Garryland Complex is situated in a low-lying karstic limestone area west of Gort, County Galway. It contains a series of seasonal lakes (turloughs), which are fed by springs and a partly submerged river, surrounded by woodland, pasture and limestone heath. The more well-known turloughs present in the site include Lydacan, Crannagh North, Raheen, Crannagh South, Coole, Garryland, Newtown and Hawkhill.

Turloughs are listed as priority habitat on Annex I of the EU Habitats Directive, and the turloughs at Coole-Garryland are particularly good examples of this habitat type. Vegetation

of the turloughs includes Shoreweed (*Littorella uniflora*), Spike-rush (*Eleocharis palustris*), Water-purslane (*Lythrum portula*) and Fen Violet (*Viola persicifolia*). A species of Starwort, *Callitriche palustris*, has recently been recorded from the site, its only known station in Ireland. The Coole river itself is of particular interest for the occurrence of a rare riverine habitat characterised by Trifid Bur-marigold (*Bidens tripartita*), Red Goosefoot (*Chenopodium rubrum*) and species of Knotgrass (*Polygonum* spp.).

The turloughs are fringed by a range of habitats on limestone pavement, including scrub communities containing Buckthorn (*Rhamnus catharticus*) and Hawthorn (*Crataegus monogyna*). In places, heath communities have developed over the limestone pavement, consisting of Ling Heather (*Calluna vulgaris*), Juniper (*Juniperus communis*), Blue Moor-grass (*Sesleria albicans*) and occasional Yew (*Taxus baccata*). In addition, the site contains good examples of smooth pavement and associated species-rich grasslands. Small areas of orchid-rich grassland occur at Coole-Garryland. The colourful array of orchids which can be found here include Pyramidal Orchid (*Anacamptis pyramidalis*), Spotted Orchids (*Dactylorhiza* spp.), Fragrant Orchid (*Gymnadenia conopsea*), Fly Orchid (*Ophrys insectifera*) and Greater Butterfly Orchid (*Platanthera chlorantha*).

A remarkable feature of the turloughs at Coole-Garryland is that they are closely associated with areas of woodland. Although substantial parts of the original deciduous forest have been converted to coniferous woodland composed of non-native species, stands of semi-natural deciduous woodland survive. Pedunculate Oak (*Quercus robur*) and Ash (*Fraxinus excelsior*) are the dominant species on deeper, more fertile soils, where there is also some Hazel (*Corylus avellana*), occasional Yew (*Taxus baccata*) and Elm (*Ulmus* spp.). There are also some unusual areas of dwarf Pedunculate Oak woodland growing on limestone pavement. This species of oak does not typically colonise this type of substrate.

Some of the deciduous woodlands have a mixture of native and non-native species. These mixed woodlands have a diverse shrub layer comprised of Spindle (*Euonymus europaeus*), Privet (*Ligustrum vulgare*), Burnet Rose (*Rosa pimpinellifolia*), Guelder Rose (*Viburnum opulus*), Blackthorn (*Prunus spinosa*), Pear (*Pyrus pyraster*) and Honeysuckle (*Lonicera periclymenum*). The ground flora is rich and includes Wood Anemone (*Anemone nemorosa*), Dog Violet (*Viola riviniana*), Shining Crane's-bill (*Geranium lucidum)*, Maidenhair Spleenwort (*Asplenium trichomanes*), Northern Bedstraw (*Galium boreale*), Biting Stonecrop (*Sedum acre*), Harebell (*Campanula rotundifolia*) and Bitter Vetch (*Lathyrus montanus*). The woodlands are notable for the presence of rare species of Myxomycete fungi, namely, *Licea idris*, *Licea marginata* and *Macbrideola decapillata*, the first-named in one of only three known sites for the species.

The nationally rare Mudwort (*Limosella aquatica*) and Dropwort (*Filipendula vulgaris*) also occur at this site. These two plant species are listed in the Irish Red Data Book.

The complex of habitats at Coole-Garryland provides habitat for a variety of mammal species, including Otter and Pine Marten. The otter is listed on Annex II of the EU Habitats Directive, while Pine Marten is considered to be threatened in Europe. The Coole-Garryland complex is also home to one of the most important and unique assemblages of insects in the country, including several notable species of beetles and flies.

The area is of importance for wintering waterfowl, especially Whooper Swan (mean peak of 324 in 1995/96 - 98/99), Bewick Swan (79 in winter 96/97), Wigeon (mean peak of 1044 in 1995/96 - 98/99), Mallard (mean peak of 330 in 1995/96 - 98/99), Pochard (mean peak of 176 in winter 1995/96 - 98/99), along with smaller numbers of Teal, Tufted Duck, Lapwing, Curlew and Dunlin.

In 1996 seven pairs of Lapwing bred at Newtown Turlough and two pairs of Common Sandpiper bred at Coole Lough.

A substantial portion of this site is in the ownership of the National Parks and Wildlife Service. It is a popular amenity area, and uncontrolled visitor access would pose a threat to sensitive animals. Other threats to the site may result from the intensification of agriculture (e.g. fertiliser application or pollution of water courses) outside the Nature Reserve.

The turlough system at Coole-Garryland is considered to be the most diverse in the country, for both its physiography and vegetation. It is unique in that it is so closely associated with woodland. The juxtaposition of these two distinct habitats, in addition to the presence of a variety of turloughs, has led to the development of uncommon communities, and rare species of insect and plant occur which are associated with both the turlough and the turlough/woodland transition. Overall, the range of good quality habitats at Coole-Garryland supports a high diversity of plant and animal species, rendering this site of prime importance for conservation.

APPENDIX 3 AQUATIC AND RIPARIAN PLANT SPECIES

Appendix 3.1 Plant species recorded

Common name	**Botanical name**
Instream species	
Alternate water milfoil	*Myriopyllum alternifolium*
Aquatic moss	*Fontinalis sp.*
Aquatic moss	*Racomitrium sp.*
Pondweed	*Potamogeton sp*
Emergent aquatic species	
Brooklime	Veronica beccabunga
Bulbous rush	Juncus bulbosus
Floating sweet-grass	Glyceria fluitans
Fool's water-cress	*Apium nodiflorum*
Lesser spearwort	*Ranunculus flammula*
Lesser water-parsnip	*Berula erecta*
Water dropwort	*Oenanthe* sp.
Water starwort	*Callitriche* sp.
Watercress	*Rorippa nasturtium-aquaticum*
Marginal species	
Ash	*Fraxinus excelsior*
Bilberry	*Vaccinium myrtillus*
Blackthorn	*Prunus spinosa*
Bog stitchwort	*Stellaria uliginosa*
Bracken	*Pteridium aquilinum*
Bramble	*Rubus fruticosus*
Common marsh bedstraw	*Galium palustre*
Creeping buttercup	*Ranunculus repens*
Downy birch	*Betula pubescens*
Gorse	*Ulex europaeus*
Great wood-rush	*Luzula sylvatica*
Hawthorn	*Crataegus monogyna*
Hazel	*Corylus avellana*
Horsetail	*Equisetum* sp.
Lady's smock	*Cardamine pratensis*
Liverworts	
Marsh ragwort	*Senecio aquaticus*
Rowan	*Sorbus aucuparia*
Sedges	*Carex* spp.
Sharp-flowered rush	*Juncus acutiflorus*
Sitka spruce	*Picea sitchensis*
Soft rush	*Juncus effusus*
Wild angelica	*Angelica sylvestris*
Willowherbs	*Epilobium* spp.
Willows	*Salix* spp

Appendix 3.2 Aquatic/riparian plant species recorded for the 10km-squares between Flaggy Bridge (Derrybrien) and Lough Cutra, as listed in the 'New Atlas of the British & Irish Flora (Preston, C. D., Pearman, D. A. and Dines, T. D., eds (2002). Oxford University Press, Oxford).

Species of limited distribution in Ireland are marked thus: *
Red data book species are marked thus: #
Flora Protection Order species are marked thus: !

Common name	Scientific name	Record	Status
Hemp agrimony	*Agrimonia eupatoria*	1987-1999	Native
Water plantain	*Alisma plantago-aquatica*	1987-1999	Native
!Orange foxtail	*Alopecurus aequalis*	1987-1999	Native
Marsh foxtail	*Alopecurus geniculatus*	1987-1999	Native
Wild angelica	*Angelica sylvestris*	987-1999	Native
Lesser marshwort	*Apium inundatum*	1987-1999	Native
Fool's water-cress	*Apium nodiflorum*	1987-1999	Native
Lesser water-plantain	*Baldellia ranunculoides*	1987-1999	Native
Lesser water-parsnip	*Berula erecta*	1987-1999	Native
Common water starwort	*Callitriche stagnalis sens. lat.*	1987-1999	Native
Marsh marigold	*Caltha palustris*	1987-1999	Native
Lady's smock	*Cardamine pratensis*	1987-1999	Native
*Slender tufted-sedge	*Carex acuta*	1987-1999	Native
Lesser pond-sedge	*Carex acutiformis*	Pre-1970	Native
*Water sedge	*Carex aquatilis*	1987-1999	Native
Lesser tussock-sedge	*Carex diandra*	Pre-1970	Native
Lesser tussock-sedge	*Carex diandra*	1987-1999	Native
Brown sedge	*Carex disticha*	Pre-1970	Native
Brown sedge	*Carex disticha*	1987-1999	Native
Tufted sedge	*Carex elata*	Pre-1970	Native
Tufted sedge	*Carex elata*	1987-1999	Native
Glaucous sedge	*Carex flacca*	1987-1999	Native
Hairy sedge	*Carex hirta*	1987-1999	Native
Slender sedge	*Carex lasiocarpa*	Pre-1970	Native
Slender sedge	*Carex lasiocarpa*	1987-1999	Native
Bog sedge	*Carex limosa*	1987-1999	Native
Common sedge	*Carex nigra*	1987-1999	Native
False fox-sedge	*Carex otrubae*	1987-1999	Native
Oval sedge	*Carex ovalis*	1987-1999	Native
Bottle sedge	*Carex rostrata*	1987-1999	Native
Bladder-sedge	*Carex vesicaria*	1987-1999	Native
Yellow-sedge subspecies	*Carex viridula subsp. brachyrrhyncha*	1987-1999	Native
Yellow-sedge subspecies	*Carex viridula subsp. viridula*	1987-1999	Native
*Rigid hornwort	*Ceratophyllum demersum*	1987-1999	Native
Great fen-sedge	*Cladium mariscus*	Pre-1970	Native
Great fen-sedge	*Cladium mariscus*	1987-1999	Native
Needle spike-rush	*Eleocharis acicularis*	1987-1999	Native
Many-stalked spike-rush	*Eleocharis multicaulis*	Pre-1970	Native
Many-stalked spike-rush	*Eleocharis multicaulis*	1987-1999	Native
Common spike-rush	*Eleocharis palustris*	Pre-1970	Native
Common spike-rush	*Eleocharis palustris*	1987-1999	Native

Floating club-rush	*Eleogiton fluitans*	1987-1999	Native

Common name	**Scientific name**	**Record**	**Status**
Canadian pondweed	*Elodea canadensis*	1987-1999	Alien
Marsh willowherb	*Epilobium palustre*	1987-1999	Native
Water horsetail	*Equisetum fluviatile*	1987-1999	Native
Marsh horsetail	*Equisetum palustre*	1987-1999	Native
Meadowsweet	*Filipendula ulmaria*	1987-1999	Native
Marsh bedstraw	*Galium palustre*	1987-1999	Native
Water avens	*Geum rivale*	1987-1999	Native
Small sweet-grass	*Glyceria declinata*	Pre-1970	Native
Small sweet-grass	*Glyceria declinata*	1987-1999	Native
Floating sweet-grass	*Glyceria fluitans*	1987-1999	Native
Marestail	*Hippuris vulgaris*	Pre-1970	Native
Marestail	*Hippuris vulgaris*	1987-1999	Native
Marsh pennywort	*Hydrocotyle vulgaris*	1987-1999	Native
Wild iris	*Iris pseudacorus*	1987-1999	Native
Slender club-rush	*Isolepis cernua*	1987-1999	Native
Sharp-flowered rush	*Juncus acutiflorus*	1987-1999	Native
Jointed rush	*Juncus articulatus*	1987-1999	Native
Bulbous rush	*Juncus bulbosus*	1987-1999	Native
Soft rush	*Juncus effusus*	1987-1999	Native
Hard rush	*Juncus inflexus*	1987-1999	Native
Duckweed	*Lemna minor*	1987-1999	Native
Ivy-leaved duckweed	*Lemna trisulca*	1987-1999	Native
#!Mudwort	*Limosella aquatica*	1987-1999	Native
Shoreweed	*Littorella uniflora*	1987-1999	Native
Yellow loosestrife	*Lysimachia vulgaris*	1987-1999	Native
Water purslane	*Lythrum portula*	1987-1999	Native
Purple loosestrife	*Lythrum salicaria*	1987-1999	Native
Water mint	*Mentha aquatica*	1987-1999	Native
Hybrid water mint	*Mentha aquatica x M. arvensis*	1987-1999	Native
Bog bean	*Menyanthes trifoliata*	1987-1999	Native
Blinks	*Montia fontana*	1987-1999	Native
Water forget-me-not	*Myosotis scorpioides*	1987-1999	Native
Alternate water-milfoil	*Myriophyllum alterniflorum*	1987-1999	Native
Yellow water-lily	*Nuphar lutea*	1987-1999	Native
White water-lily	*Nymphaea alba*	1970-1986	Native
White water-lily	*Nymphaea alba*	1987-1999	Native
Fine-leaved water-dropwort	*Oenanthe aquatica*	1987-1999	Native
Hemlock water-dropwort	*Oenanthe crocata*	1970-1986	Native
Hemnlock water-dropwort	*Oenanthe crocata*	1987-1999	Native
Water-pepper	*Persicaria hydropiper*	1987-1999	Native
Reed canary-grass	*Phalaris arundinacea*	1987-1999	Native
Common reed	*Phragmites australis*	1987-1999	Native
Small pondweed	*Potamogeton berchtoldii*	1987-1999	Native
Fen pondweed	*Potamogeton coloratus*	1987-1999	Native
Curled pondweed	*Potamogeton crispus*	1987-1999	Native
Various-leaved pondweed	*Potamogeton gramineus*	1987-1999	Native
Shining pondweed	*Potamogeton lucens*	1987-1999	Native
Broad-leaved pondweed	*Potamogeton natans*	1987-1999	Native
Fennel pondweed	*Potamogeton pectinatus*	1987-1999	Native

Common name	Scientific name	Record	Status
Perfoliate pondweed	*Potamogeton perfoliatus*	1987-1999	Native
Bog pondweed	*Potamogeton polygonifolius*	1987-1999	Native
*Lesser pondweed	*Potamogeton pusillus*	1987-1999	Native
Common water-crowfoot	*Ranunculus aquatilis*	Pre-1970	Native
Lesser celandine	*Ranunculus ficaria*	Pre-1970	Native
Lesser celandine	*Ranunculus ficaria*	1987-1999	Native
L. celandine subspecies	*Ranunculus ficaria subsp. bulbilifera*	1987-1999	Native
L. celandine subspecies	*Ranunculus ficaria subsp. ficaria*	1987-1999	Native
Lesser spearwort	*Ranunculus flammula*	1987-1999	Native
Ivy-leaved crowfoot	*Ranunculus hederaceus*	1987-1999	Native
Pond water-crowfoot	*Ranunculus peltatus*	1987-1999	Native
Celery-leaved buttercup	*Ranunculus sceleratus*	1987-1999	Native
Thread-leaved water-crowfoot	*Ranunculus trichophyllus*	1987-1999	Native
Great yellow-cress	*Rorippa amphibia*	1987-1999	Native
#Northern yellow-cress	*Rorippa islandica*	1987-1999	Native
Water-cress	*Rorippa nasturtium-aquaticum*	1987-1999	Native
Water-cress	*Rorippa nasturtium-aquaticum* agg.	1987-1999	Native
*Marsh yellow-cress	*Rorippa palustris*	1987-1999	Native
Eared willow	*Salix aurita*	1987-1999	Native
Goat willow	*Salix caprea*	1987-1999	Native
Olive willow	*Salix caprea x S. viminalis*	1987-1999	Native
Grey willow	*Salix cinerea*	1987-1999	Native
Sally	*Salix cinerea subsp. oleifolia*	1987-1999	Native
Crack willow	*Salix fragilis*	1987-1999	Alien
Creeping willow	*Salix repens*	1987-1999	Native
Osier willow	*Salix viminalis*	Pre-1970	Alien
Brookweed	*Samolus valerandi*	1987-1999	Native
Common club-rush	*Schoenoplectus lacustris*	1987-1999	Native
Water figwort	*Scrophularia auriculata*	1987-1999	Native
Common figwort	*Scrophularia nodosa*	1987-1999	Native
Lesser clubmoss	*Selaginella selaginoides*	1987-1999	Native
Marsh ragwort	*Senecio aquaticus*	1987-1999	Native
#Blue-eyed grass	*Sisyrinchium bermudiana*	Pre-1970	Native
Unbranched bur-reed	*Sparganium emersum*	1987-1999	Native
Branched bur-reed	*Sparganium erectum*	1987-1999	Native
Least bur-reed	*Sparganium natans*	Pre-1970	Native
Bog stitchwort	*Stellaria uliginosa*	1987-1999	Native
Comfrey	*Symphytum officinale*	1987-1999	Native
Meadow-rue	*Thalictrum flavum*	1987-1999	Native
Bulrush	*Typha latifolia*	1987-1999	Native
Intermediate bladderwort	*Utricularia intermedia sens. lat.*	Pre-1970	Native
Lesser bladderwort	*Utricularia minor*	Pre-1970	Native
Lesser bladderwort	*Utricularia minor*	1987-1999	Native
*Greater bladderwort	*Utricularia vulgaris sens. lat.*	Pre-1970	Native
Wild valerian	*Valeriana officinalis*	1987-1999	Native
Blue water-speedwell	*Veronica anagallis-aquatica*	1987-1999	Native
Brooklime	*Veronica beccabunga*	1987-1999	Native
Pink water-speedwell	*Veronica catenata*	1987-1999	Native
Viburnum	*Viburnum opulus*	1987-1999	Native
Marsh violet	*Viola palustris*	1987-1999	Native
#Fen violet	*Viola persicifolia*	1987-1999	Native

APPENDIX 4: SITE PHOTOS

Plate 1 Chainage 196 showing level to which peat slip material reached on this section of river. Bedrock is visible as a result of scouring by transported peat.

Plate 2 Chainage 198 showing silt deposition and level of peat on the banks.

Plate 3 Chainage 199. It is recommended that this blockage be removed. The left bank should be planted in high density formation with shrubs or trees that are ecologically similar to the surrounding flora.

Plate 4 Chainage 198-199 the gauge of the pipes here should be increased to assist flow through.

Plate 5 Chainage 199 – just south of Flaggy Bridge (chainage 200) showing peat deposition on the banks.

Plate 6 Scene of river from bridge (M 547 990) showing negligible impacts. This is the scenario for most of the lower sections of the river.

Plate 7 River showing some small light detritus on the banks

Plate 8 sand/silt washed down from the mountains. This photo was taken in the lower reaches of the river.

Plate 9 Section of river at confluence (chainage 182) exhibiting very little physical change. Gravels are still in situ here. River has widened considerably and accordingly the power of the slip has dissipated.

Plate 10 Fish were seen moving upstream in this section (Chainage 184)

Appendix G

Ground Investigation Background Information

AGEC (2011)

Peat Depths and Shear Vane Data

Waypoint No.	Easting	Northing	Peat Depth (m)					
341	159348.1	204634.1	1.5					
342	159348	204634	0.3					
343	159358.7	204581.8	1.6					
344	159367.1	204551.2	0.4					
345	159390.6	204509.9	0.35					
346	159419.3	204489.9	1					
347	159409.1	204462.1	0.6					
348	159423.8	204432.1	0.6					
350	159442.9	204378.2	1.1					
351	159443.1	204377.6	1.2					
352	159473.9	204365.6	0.4					
353	159505.6	204320.1	0.35					
354	159538.3	204280.1	0.4					
355	159549.8	204242.4	0.5					
356	159541.5	204223	0.4					
358	159493.8	204200.3	1.3					
359	159522.7	204152.5	0.9					
360	159546.7	204141	1					
361	159542.9	204118.3	0.5					
362	159525.3	204058.9	1					
363	159543.5	204046.9	0.6					
366	159622.3	203978.5	0.6					
367	159686.2	203991.6	0.4					
368	159753.5	203983.9	0.4					
369	159795.1	203977.8	0.5					
371	159829	203990.5	0.3					
372	159880.9	203984.3	0.15					
373	159929.6	203963.1	0.4					
374	159972.1	203955.5	0.5					
375	160023.9	203941.8	0.5					
376	160074.4	203925.2	0.1					
379	160186.2	203885.5	0.6					
380	160186.1	203885.4	1.3					
381	160214.1	203868.9	1					
383	160261.5	203849.9	1.6					
384	160279.2	203859.4	1.8					
385	160302.5	203851.1	2.2					
386	160333.3	203845.5	0.2					
387	160353	203849.9	0.6					
388	160362.8	203839.6	1					
389	160386.6	203845	1					
390	160408.2	203850.1	0.4					
391	160437.4	203822.4	0.4					
392	160463.2	203833	0.2					
393	160482	203841.9	0.1					
It should be noted that the co-ordinates of the above peat depths were recorded using a handheld GPS								

Waypoint No.	Easting	Northing	Peat Depth (m)				
1	159307.433	204628.61	2.4	Intact Peat			
2	159324.77	204580.27	1.8	Intact Peat			
3	159340.897	204523.06	2.5	Intact Peat			
4	159360.006	204463.73	2.2	Intact Peat			
5	159376.958	204406.25	2.5	Intact Peat			
6	159393.691	204542.47	2.4	Intact Peat			
7	159398.02	204331.82	2.6	Intact Peat			
8	159425.586	204231.75	2.1	Intact Peat			
9	159445.793	204302.05	1.3	Debris			
10	159459.605	204445.13	1.7	Intact Peat			
11	159481.176	204131.22	1.6	Intact Peat			
12	159487.114	204250.54	0.9	Debris			
13	159495.448	204041.52	1	Intact Peat			
14	159546.326	204184.65	0.1	Debris			
15	159550.723	203979.38	2.4	Debris			
16	159570.232	204310.17	1.8	Intact Peat			
17	159585.07	204014.63	0				
18	159600.614	204120.6	1.4	Debris			
19	159607.86	204240.06	0.5	Debris			
20	159607.86	204179.72	0.9	Debris			
21	159623.478	204060.72	1.4	Debris			
22	159642.594	203899.77					
23	159661.446	204109.93	1.7	Debris			
24	159667.297	204183.33	1.4	Intact Peat			
25	159681.111	204050.69	1.25	Debris			
26	159695.829	203927.69	1.5	Debris			
27	159723.022	204155.2	1.6	Intact Peat			
28	159736.914	203865.94	2.1	Intact Peat			
29	159740.627	204044.23	1.7	Debris			
30	159744.316	204103.72	0.6	Debris			
31	159758.823	203923.26	1	Debris			
32	159797.226	203864.08	1.6	Intact Peat			
33	159800.144	204044.23	0.7	Debris			
34	159802.61	204101.48	0.5	Debris			
35	159820.043	203925.03	0.2	Debris			
36	159857.769	203858.33	0.6	Debris			
37	159859.41	204102.22	1	Intact Peat			
38	159863.812	204040.08	0.2	Debris			
39	159881.263	203915.28	0.75	Debris			
40	159887.459	203791.8	1.7	Intact Peat			
41	159916.958	203846.84	0.9	Intact Peat			
42	159921.945	204030.4	0				
43	159937.868	203902.09	0.5	Debris			
44	159944.53	203767.82	1.5	Intact Peat			
45	159977.501	203829.94	0.4	Debris			
46	159980.077	204016.57	0.1	Debris			
47	159996.551	203888.37	0.3	Debris			
48	160038.72	203812.37	1.2	Intact Peat			
49	160039.132	204015.65	1.8	Intact Peat			
50	160047.832	203770.32	1.8	Intact Peat			
51	160054.609	203869.03	1.6	Debris			
52	160096.668	203796.81	2.5	Debris			
53	160112.043	203848.45	0.2	Debris			
54	160121.189	203969.26	2.5	Debris			
55	160157.575	203877.26	0.6	Beside Road			
56	160168.591	203790.48	2.6	Intact Peat			
57	160170.101	203827.86	1	Intact Peat			
58	160184.144	203952.32	0				
59	160229.169	203831.67	1.1	Debris			
60	160261.807	203909.12	2.6	Intact Peat			
61	160294.286	203811.39	2	Intact Peat			
62	160363.041	203862.05	2	Intact Peat			
63	160487.288	203875.71	1.9	Intact Peat			
64	160510.838	203862.92	0.7	Intact Peat			
65	160536.93	203849.68	0.5	Intact Peat			
66	160552.668	203887.34	0.4	Intact Peat			
67	160580.831	203872.85	0				
68	160612.492	203891.93	0	Barrage			
69	160617.747	203863.29	0	Barrage			
It should be noted that the co-ordinates of the above peat depths were recorded using a handheld GPS							

	Location	WP No.	Depth (m)	Cu (kPa)	Residual (kPa)	Comment
Sep-11	South Repository at entrance to Curvey's	WP320	0.5	10	6	
			1	8	6	
			1.5	11	8	
			1.9	14	10	
		WP321	0.5	8	6	
			1	14	9	
			1.5	22	14	
			1.8	33	13	Possibly mineral soil
		WP322	0.5	9	6	
			1	15	9	
		WP323	0.5	13	7	
			1	20	9	
			1.5	32	11	
		WP324	0.5	14	8	
			1	17	8	
			1.5	25	14	
	North Repository	WP325	0.5	12	7	
			1	22	15	
			1.5	23	16	
		WP326	0.5	12	9	
			1	30	14	
		WP327	0.5	17	8	
			1	15	12	
			1.5	18	15	
			2	32	21	
		WP328	0.5	14	7	
			1	21	12	
			1.4	30	16	
		WP329	0.5	16	12	
			1	42	25	
		WP330	0.5	8	6	
			1	14	12	
			1.5	25	13	
			1.8	30	19	
	Barrage 2 Repository	WP331	0.5	11	7	
			1	10	6	
			1.5	11	9	
		WP333	0.5	6	5	
			1	7	6	
			1.5	11	10	
		WP334	0.5	10	6	
			1	7	5	
			1.5	14	9	
		WP335	0.5	20	10	
		WP336	0.5	25	12	Silt/Sand
		WP337	0.5	21	10	Silt/Sand
		WP338	0.4	25	14	Silt/Sand
		WP339	0.4	26	14	Silt/Sand

	Location	WP No.	Depth (m)	Cu (kPa)	Residual (kPa)	Comment
	Shear vanes within failure scar	WP341	0.5	19	10	
			1	17	12	
			1.4	25	11	
		WP343	0.5	17	7	
			1	20	11	
			1.3	19	9	
		WP345	0.35	11	7	
		WP346	0.5	6	4	
			0.9	8	6	
		WP347	0.2	4	2	
			0.5	10	5	
		WP348	0.5	7	5	
		WP350	0.5	20	12	
			1	17	11	
		WP351	0.5	16	8	
			1	18	12	
		WP355	0.4	8	6	
		WP358	0.5	8	6	
			1	16	8	
		WP358	0.5	13	9	Same location as previous
			1	17	7	
		WP359	0.5	9	8	
			0.8	12	10	
		WP360	0.5	7	5	
			0.9	8	7	
		WP362	0.5	8	5	
			0.9	16	7	
		WP366	0.5	9	5	
		WP369	0.4	11	9	
		WP374	0.4	16	11	
		WP380	0.5	15	8	
			1	15	7	
		WP381	0.5	14	9	
			0.8	19	11	
		WP383	0.5	5	4	
			1	5	5	
			1.4	9	8	
		WP384	0.5	10	6	
			1	20	10	
			1.5	15	11	
		WP385	0.5	8	7	
			1	20	12	
			1.5	26	14	
			2	22	16	
		WP388	0.5	8	5	
		WP389	0.5	6	5	
			0.8	16	10	

	Location	WP No.	Depth (m)	Cu (kPa)	Residual (kPa)	Comment
Nov-11	Taken within Failure Scar	WP001	0.5	20	8	
			1	14	10	
			1.5	17	12	
			2	19	11	
		WP005	0.5	13	5	
			1	11	7	
			1.5	10	6	
			2	16	10	
		WP012	0.5	11	5	
		WP018	0.5	7.5	5.5	
			1	5	4.5	
		WP015	0.5	13	5	
			1	19	9	
			1.5	14	8	
			2	22	8	
		WP029	1.6	20	18	
		WP033	0.5	18	8	
		WP031	0.5	20	6	
		WP043	0.4	12	6	
		WP048	0.5	14	6	
			0.8	19	9	
		WP032	0.5	14	5	
			1	15	8	
			1.5	16	7	
		WP056	0.5	14	7	
			1	25	12	
			1.5	16	11	
			2	25	15	
		WP054	0.5	26	9	
			1	25	13	
			1.5	18	14	
			2	23	14	
		WP065	0.3	13	7	

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APPENDIX 8-6

GEOTECHNICAL STABILITY REPORT (JULY 2020)

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GEOTECHNICAL STABILITY REPORT 3
DERRYBRIEN WIND FARM
GRID CONNECTION AND ANCILLARY WORKS

Prepared for: **ESB**

Date: July 2020

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GEOTECHNICAL STABILITY REPORT 3

DERRYBRIEN WIND FARM

GRID CONNECTION AND ANCILLARY WORKS

User is responsible for Checking the Revision Status of This Document

Rev. Nr.	Description of Changes	Prepared by:	Checked by:	Approved by:	Date:
0	Draft report for comment	IH	TC	BdeH	21/10/19
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Client: **ESB**

Keywords: Grid connection, peat stability

Abstract: The report contains the findings of a geotechnical assessment along the route of the grid connection from the Derrybrien to the Agannygal substation. The geotechnical assessment includes a deterministic and qualitative peat stability risk assessment of the grid connection route.

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DMP 02 Derrybrien-Agannygal OHL – Indicative Decommissioning Access Routes (Sheet 2 of 2)

DMP 14 Agannygal Substation - Indicative Decommissioning Access Route

APPENDICES

Appendix A Site Photographs from FT Site Walkover (2019)
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1 INTRODUCTION

1.1 General

Fehily Timoney and Company (FT) was engaged in August 2019 by ESB to undertake a geotechnical assessment of the grid connection route from the Derrybrien wind farm site to the Agannygal substation. The grid connection comprises the Derrybrien-Agannygal 110kV Overhead Line (OHL) and Agannygal Substation and ancillary works. The geotechnical assessment carried out includes an assessment of the peat stability of the 110kV OHL route, substation site and associated permanent and temporary works during construction, operation (maintenance) and during possible decommissioning works in the future.

The Derrybrien wind farm project is located on Cashlaundrumlahan Mountain in the Slieve Aughty Mountains some 11km south of the town of Loughrea in County Galway (Figure 1).

The wind farm comprises 70 wind turbines and associated infrastructure and was constructed over the period 2003 to 2005. The wind farm became operational in December 2005.

The OHL route connects the substation on the Derrybrien wind farm site to a substation in the townland of Agannygal and is approximately 7.8km in length. The OHL and substation were constructed between 2003 and 2005.

For the purposes of assessment, the OHL route was broken into 9 subsections (including the substation at Agannygal). These subsections were chosen based on having similar topography and peat depth within each individual section (Drawing 0001).

1.2 Contents of Report

This report presents the findings of a geotechnical assessment of the OHL route connecting Derrybrien wind farm site with Agannygal substation, and comprises the following elements:

(1) Desk Study Review

The review included the following:

- Review of previous relevant reports
- Review of publicly available information

(2) Summary of FT walkover survey findings (2019)

The walkover included the following:

- OHL route
- Access routes from the public road to the OHL route
- Agannygal substation

(3) Summary of AGEC ground investigation (2018)

The ground investigation included the following:

- Peat depth probing and shear vane strength testing along the OHL route
- Trial pits at the Agannygal substation

(4) Peat stability assessment

A deterministic stability assessment and qualitative peat stability risk assessment of the peat along the OHL route and at the substation, which includes:

- Methodology for deterministic stability assessment of peat
- Analysis to determine factor of safety
- Peat stability risk assessment methodology
- Results of stability analysis and risk assessments

(5) Conclusions

2 PREVIOUS RELEVANT REPORTS

2.1 Foundation Records at Mast Locations

During construction of the OHL masts from 2004 to 2005 a number of trial pits were carried out at mast locations to record ground conditions to a depth of typically 3m. In total, trial pits were carried out at 18 no. mast locations at each of the 4 mast legs giving a total of 72 no. trial pits. The records included a description of the ground conditions encountered and depths.

2.2 ESB Report on Slope Stability for Section of OHL

ESB (2006) assessed the stability of the peat along the OHL route between the Derrybrien wind farm substation and containment barrage 2 (Figure 1). Containment barrage 2 was constructed following a peat slide in 2003 at the wind farm site within the flow path of the peat slide to prevent further propagation of the peat slide and to prevent possible further release of debris into watercourses downstream.

The stability of the peat in this area was assessed based on shear vane tests carried out over a section 700m in length directly south of the wind farm substation, as this area was considered the critical section in terms of existing slope angles and peat thickness. The infinite slope method of Skempton and DeLory (1957) was used to check for stability in combination with an external surcharge of 20kPa. Peat depths up to 2.0m were recorded and peat strengths ranged from 5 to 10kPa. A “lumped” or overall factor of safety of at least 1.4 under a 20kPa surcharge was shown for the OHL route between the substation and containment barrage 2, which is considered an acceptable level of safety.

3 DESCRIPTION OF OVERHEAD LINE ROUTE

3.1 General Description

The existing Derrybrien to Agannygal OHL connects the onsite substation at Derrybrien wind farm (ITM coordinates: E 559914, N 704737) to the substation at Agannygal (ITM coordinates: E 563119, N 698591), approximately 7km to the south. The layout of the OHL is shown in Figure 1 and Drawing 0001. The OHL is about 7.8km long.

The pole sets, intermediate masts, angle masts, and end masts along the route are numbered 1 to 41. A typical timber pole set is shown in Photo 1 (Appendix A) and a typical steel angle mast is shown in Photo 2. A listing of the pole sets and masts is given in Table 3.1 and the locations of the substations, pole sets, and masts are shown in Drawing 0001.

Table 3.1: Summary of Overhead Line Structures

Structure Reference	Structure Type	Easting	Northing
EM1	End mast	559934	704742
PS1A	Pole set	559962	704707
PS2	Pole set	560045	704596
PS3	Pole set	560195	704394
PS4	Pole set	560319	704226
PS5	Pole set	560480	704011
PS6	Pole set	560578	703879
PS7	Pole set	560671	703754
PS8	Pole set	560777	703612
PS9	Pole set	560883	703469
PS10	Pole set	561011	703298
PS11	Pole set	561145	703117
PS12	Pole set	561252	702972
PS13	Pole set	561345	702847
AM14	Angle mast	561432	702731
PS15	Pole set	561337	702624
PS16	Pole set	561167	702437
PS17	Pole set	560990	702239
AM18	Angle mast	560840	702074
PS19	Pole set	560951	701972
AM20	Angle mas	561049	701883

Structure Reference	Structure Type	Easting	Northing
PS21	Pole set	561216	701810
PS22	Pole set	561373	701743
PS23	Pole set	561599	701646
AM24	Angle mast	561758	701577
PS25	Pole set	561814	701428
PS26	Pole set	561919	701145
PS27	Pole set	561975	700996
PS28	Pole set	562055	700784
PS28A	Pole set	562090	700690
PS29	Pole set	562148	700535
IM30	Intermediate mast	562211	700366
PS31	Pole set	562293	700146
PS32	Pole set	562366	699953
PS33	Pole set	562429	699785
PS34	Pole set	562470	699676
PS35	Pole set	562664	699481
PS36	Pole set	562761	699383
PS37	Pole set	562836	699308
AM38	Angle mast	563022	699121
PS39	Pole set	563062	698923
PS40	Pole set	563094	698766
EM41	End mast	563118	698643

Notes:
(1) Coordinates are in ITM format and were provided by ESB.

3.2 Description and Topography of Overhead Line Route

The Derrybrien wind farm site is located on the upper slopes of Cashlaundrumlahan Mountain, within the Slieve Aughty Mountains. The OHL route is 7.8km long and is aligned essentially north-south. The topography of the route is illustrated in Drawing 001.

Slope angles at the pole set and mast locations typically range from 0 to 15 degrees. The topography is relatively steep (10 - 15 degrees) initially over the initial c. 1.5km of the route and then crosses the more gently sloping terrain (0 - 8 degrees) of the Owendalluleagh River valley to the Agannygal substation where the site has been cut and filled locally to proide a level platform.

The OHL route starts within the boundaries of the wind farm site at the Derrybrien substation at an elevation of approximately 330mAOD. From the Derrybrien substation, the elevation along the route falls to a flat-

bottomed valley where it crosses the R353 road and the tributaries of the Owendalulleagh River at an elevation of approximately 130mAOD. From here, the route skirts around the Slieve Aughty Bog NHA (site number 001229) before gaining elevation again as it passes Lough Agannygal, at about 195mAOD. The route ends at the Agannygal substation, which is located to the south east of Cashlaundrumlahan Mountain and about 1km north of Lough Atorick, at an elevation of approximately 190mAOD.

The land adjacent to the OHL route and the substation location is dominated by commercial forestry plantations which have been planted over the blanket bog. Directly along the OHL route appears to have been colonised by conifer and deciduous tree growth from the adjacent plantations (regrowth of previously felled area).

The route crosses the lower end of the source area of the peat slide of 16 October 2003 between pole sets 5 and 6, and also passes close to 2 no. containment barrages (Figure 1). The containment barrages were constructed following the peat slide to prevent propagation of the peat slide and to restrict possible further release of debris into watercourses downstream.

3.3 Description of Infrastructure and Construction

The OHL mainly consists of double timber pole sets with galvanised steel angle masts at changes in direction and an intermediate galvanised steel mast (IM30) on a longer straight section. These angle masts and other mast structures were located as close as possible to existing roads and access tracks, in order to minimise trafficking on undisturbed ground. This section of this report sets out the methods of construction based on observations made during the walkover and information provided by ESB.

None of the OHL structures are constructed within the area of the peat slide, and no access was required through the peat slide area to access the OHL pole set locations.

3.3.1 Access to Pole sets/Angle Masts

Where trees were present on the OHL route, then within a 60m corridor width all trees were felled mostly by machine using Coillte subcontractors. Where the trees were felled, they were cut as close as possible to the ground. The trunks and roots were left in place so that there was no excavation or disturbance of the peat. The surface of the peat was tracked over by the harvesting machines and forwarders that were used to cut, gather and stockpile the timber for transport off-site. In areas where the surface of the peat was very soft, brash and small branches were placed on the ground under the tracks of the harvester. Where the trees were small or where tree growth was poor the trees were felled by hand, arranged in windrows and left in place on the slopes

Following this the location of pole sets and angle, intermediate and end masts were identified and set out.

The methods used to access the pole sets/angle masts during the construction of the OHL were recorded where they were visible during the OHL survey. The access routes recorded consisted of two types:

(1) There are a number of locations, primarily around the angle masts, where the peat has been stripped away exposing the mineral soil beneath. These areas are typically located in close proximity to existing forestry access tracks (see Photos 3 & 4) to facilitate the import of additional fill material and members for the angle masts, and for foundation construction.

(2) In other areas, primarily around the pole sets in areas of deep peat, timber sleepers from felled trees were used by construction plant to gain access for erecting the line, where necessary. This method of construction was particularly noticeable around pole set 36 where peat depths of over 4m were recorded. An example of such an access route is shown in Photo 5.

Access to the masts/pole sets was most likely from nearby roads and forestry tracks. Access from the existing tracks to the mast locations was generally achieved by the excavation of the peat and any tree stumps to a competent material. In order to access AM24, the Owendalulleagh River was crossed from the south side of the river at the location of a ford along the founded access track. In order to access AM38, existing trees were felled and placed to form a temporary floating access track from the south.

3.3.2 Foundations for Pole Sets and Angle Masts

Foundations varied according to ground conditions along the OHL route. In some locations where the depth to competent material was deeper than the embedment of the pole, stone and/or timber sleepers were used to strengthen the foundation and timber sleepers were used to fill to the correct level and as support to pole sets for stability. A greater number of timber sleepers would have been used to support pole sets in deep peat.

A number of pole sets in peat have been secured using timber baulks, fixed to the lower part of each pole and set in excavated holes in the peat which were backfilled with imported granular fill.

The angle masts and end masts are founded on concrete footings cast on mineral soil. Peat, where present, was excavated over the footprint of the foundation and working area prior to the construction of the foundation for these masts. The excavated peat was typically stored adjacent to the foundation excavations.

3.3.3 Agannygal Substation

The substation at Agannygal comprises a stone platform, substation equipment and a single storey control building. Construction of the substation required the excavation of overburden in order to create a level platform on which to build the substation. Excavated material was stored to the south of the substation compound. A stone platform approximately 1-1.5m thick was then constructed on the overburden using imported crushed rock fill. The platform is approximately 65m in length and 50m in width. In order to provide access to construct the substation, approximately 2.9km of existing forestry track was upgraded by adding imported stone fill and a thin surfacing layer. A permanent access road, around 140m in length, was also constructed from the adjacent local road to the substation.

The site of the substations and current topographical levels are provided on Drawing 0006.

3.3.4 Cuttings

During the site walkover of the OHL route, several cuttings were recorded, primarily around the footprint of a number of pole sets and angle masts. These included cuttings through the undulating ground from local access tracks to gain entrance for construction plant and materials, such as that shown in Photo 7. Minor cuttings are

also present where stripping/excavation of peat/mineral soil was undertaken to form a suitable area to erect the masts and pole sets.

Founded access tracks constructed by others for the purpose of accessing the forested areas surrounding the overhead line required cutting through the undulating ground. Several cut sections were identified during the site walkover. It is considered that these access tracks were already in existence and not created for the purpose of the construction of the OHL, however these were used for the construction of the OHL.

Between pole set 28A and 29 the OHL route crosses a 400kV overhead line route. This area is shown in Photos 8 and 9. A cut approximately 25m wide and 120m long was formed in the mineral soil to allow the OHL from the Derrybrien substation to pass beneath the 400kV line, allowing sufficient clearance for trafficking under the route and removal of forestry that could pose a risk to the OHL route. The location and extent of this cutting is shown on Drawing 0006 . This cutting is up to 3.8m deep and the slope angle ranges between 25 and 39 degrees based on site readings. The average slope angle is approximately 32 degrees, based on the available topographic survey information of the area.

Another significant cutting is located adjacent to Agannygal substation and shown in Photo 12. This cutting is up to 3.0m deep and has an average slope angle of 35 degrees in mineral soil, which was excavated in order to create a level platform for the construction of the substation.

Additional, less significant cuttings included drainage ditches in the vicinity of the pole sets/angle masts and the access tracks.

4 GROUND CONDITIONS

4.1 Soils and Geology

The deposits along the OHL route comprise the following main types:

(1) Peat
(2) Glacial till and subsoil
(3) Alluvium
(4) Weathered/solid rock
(5) Peat debris within peat slide scar

4.1.1 Peat

Based on a review of the soils map of Ireland (Geological Survey of Ireland, 2018), the OHL route is covered in blanket peat. The walkover survey and ground investigation taken by AGEC and FT indicates that the upper 1m of the peat is generally very fibrous and also locally desiccated in appearance. The base of the peat, from observations within the peat slide scar and in exposures in excavations and along drains, was described using BS 5930 (BSI, 2015) as very soft brown amorphous Peat with recognisable plant structure. Peat appeared to lay directly on bedrock or a weathered rock/glacial till.

Shear strength profiles were measured using a Geonor H-60 hand vane tester at thirteen locations by ESB in 2004 and 2005 (ESB, 2006). 27 no. shear vane strength tests were undertaken at depths from 0.5m bgl to 1.8m bgl. Values for vane shear strength measured ranged from 5kPa to 10kPa with an average of 8.3kPa. Shear strength testing was also undertaken by AGEC in 2018 and FT in 2019. 95 no. shear vane strength tests were undertaken at depths from 0.5m bgl to 2.5m bgl. Values for vane shear strength measured ranged from 6kPa to 68kPa with an average of 23kPa. The values are plotted in Figure 2.

Peat depth probing was also undertaken by ESB and the results of this are used, along with recent peat depth probing carried out by AGEC and FT, to plot peat depth contours shown in Drawings 0002 and 0003. The depth of peat recorded along the OHL route ranged from 0.2 to 5.6m bgl with an average depth of 1.1m bgl.

4.1.2 Glacial Till and Subsoil

Based on the available data, varying thicknesses of glacial till are present beneath the peat along of the OHL route. The publicly-available GSI (2018) mapping shows glacial till in the vicinity of the site to be derived from Devonian sandstones. Exposures of glacial till showed a reddish brown or whiteish brown well-graded material consisting of sandy slightly gravelly Clay/Silt with occasional sub-angular to rounded cobbles and boulders of sandstone.

Typically, glacial till was encountered below the peat at depths that ranged from 0.2 to 5.6m, though locally glacial till was at or close to the surface below a layer of peaty topsoil.

The GSI (2018) mapping shows a line of ribbed moraines, which are hummocky wave ridges of sediment deposited by glacial movement, trending in a west-south-west to east-north-east direction traversing the OHL route around the Owendalulleagh River.

4.1.3 Alluvium

Alluvium recorded along the OHL route is associated with the Owendalulleagh River which runs between pole sets 25 and 26. It was observed during the site walkover that the Owendalulleagh River riverbed consisted of sand, gravel, cobbles, and boulders, and hence it is expected that this alluvium is predominantly coarse-grained.

4.1.4 Weathered/Solid Rock

The bedrock geology along the OHL route comprises the Ayle River Formation, the Derryfadda Formation, the Scalpnagown Formation, and Undifferentiated Visean Limestone. The Ayle River Formation consists of red siltstones, mudstones with carbonate concretions, sandstones, conglomerates and mud-flake breccia from the Ayle River Formation, the Derryfadda Formation consists of greywackes, siltstones, and mudstones, and the Scalpnagown Formation consists of conglomerate, sandstone & siltstone. The Undifferentiated Visean Limestones are impure Dinantian limestones (GSI, 2003 & 2019).

Rare bedrock exposures, consisting of sandstone, were observed in the vicinity of containment barrage 1 and 3. The bedding was horizontal to sub-horizontal. Exposed bedrock was not encountered elsewhere.

4.1.5 Peat Debris within Peat Slide Source Area

Peat debris within the 2003 peat slide source area at the Derrybrien site was encountered only between pole sets 5 and 6. The debris within the peat slide source area comprises mainly non-intact peat. As the extent of the material is extremely limited, it is not considered further in this report.

4.2 Hydrology

Several watercourses exist within the footprint of the OHL route (see Drawing 0001 for locations), the largest being the Owendalulleagh River, which is approximately 6m wide where it passes beneath the OHL between pole sets 25 and 26 (Photo 6). Major hydrological features tend to run east to west across the OHL corridor, with minor tributary features aligned approximately north to south to tie into the major drainage features.

There are several flat areas where local ponding of surface water occurs. Such a feature, Lough Agannygal, is located between pole set 37 and angle mast 38 (Photos 10 and 11).

Streams and ditches have typically been regraded for use as forestry drainage where land use is commercial forestry. It is reported that this commercial forestry was established in the 1970's (ESB, 2006). This is consistent with observations made on site that several areas have been clear felled and replanted.

4.3 Hydrogeology (Groundwater)

Based on information from the GSI database, the majority of the OHL route and the substation is underlain by rock which is considered a poor aquifer (bedrock which is generally unproductive except for local zones). However, the segment of the route underlain by Visean Limestone (between pole set 23 and 26 approximately) is considered a locally important aquifer (bedrock which is moderately productive only in local zones) although no evidence for groundwater usage from this aquifer was found.

Groundwater vulnerability (GSI, 2019) ranges from low to extreme across the route, due to the generally shallow depth to bedrock. All drainage features along the OHL route are noted as giving rise to extreme groundwater vulnerability.

4.4 Previous Landslides

A review of historical records of peat slides/landslides (GSI, 2019) indicates that peat slides have occurred in the Slieve Aughty Mountains in the past. With the exception of the 2003 peat slide on the Derrybrien wind farm site, two previous slides have been noted within 5km of the OHL. One was in 1890 and occurred at a location some 2.5km to the east of the substation at the southern end of the OHL, in an area called Loughatorick North. An area of 100 acres was covered with a 'foot' of peat, the upper part of the 'bog subsiding 10 to 15 feet'. The peat slide was described as a flow within blanket peat. The other slide occurred 5km to the north of the OHL, on the Sonnagh Old Wind Farm site. This occurred during October 2003 and is described as a flow in blanket peat adjacent to an access road.

As part of the national landslide susceptibility mapping project carried out by the Geological Survey Ireland (GSI, 2007-2013) for Ireland, all areas of land across the country are designated a landslide susceptibility rating including the OHL route, substation and surrounding area. The landslide susceptibility rating is based on a number of factors including incidences of previous peat slides, topography, type of deposits, etc.

The OHL route and substation is classified as having 'low' to 'moderately low' peat/landslide susceptibility with locally 'moderately high' susceptibility (GSI, 2019).

As stated above, the land susceptibility rating/bands typically relates to the type of deposits, topography in an area, incidences of previous peat/landslides, etc.. For example, a rating of 'moderately high' can be assigned where rock is close to the surface, slope angles range from 10 to 20 degrees, etc. Hence the rating of 'moderately high' does not necessarily relate to a risk of peat slide.

It should be noted that at the time of the 2003 peat slide no national landslide register/database existed.

5 SITE WALKOVER SURVEY

5.1 Background to Walkover Survey

The purpose of the walkover survey was to investigate the ground conditions at the pole set and angle mast locations, identify geotechnical constraints and to gather data for a peat stability assessment along the OHL route.

The walkover survey comprised an inspection of the entire length of the OHL route and likely access points to the OHL. This was carried out from 24 September to 2 October 2019. Weather conditions for the site visit were light to heavy mist/rain with some dry periods. A previous walkover of the OHL route and the substation had been undertaken by AGEC in June 2018. The findings below are a combination of the findings from the two walkover surveys (2018 and 2019)

5.2 Findings of Walkover Survey

The findings of the walkover survey are as follows:

(1) The OHL route is located approximately 10km south of Loughrea and is constructed on undulating terrain. The majority of the route is covered by shallow to locally deep blanket peat that was previously colonised by commercially grown conifer and deciduous forest. Some regrowth has occurred along the OHL since the original felling works. There are a number of areas where peat has been removed from the footprint of the pole sets/angle masts and overburden is exposed at the ground surface.

(2) The elevation along the OHL route falls from the wind farm substation (c. 330m AOD) to pole set 11 (c. 180m AOD). From pole set 11 the elevation decreases over undulating ground to angle mast 14 (c. 170m AOD) and crosses the local R353 road. The terrain gently undulates as it descends from the R353 (public road) to pole set 22 (c. 115m AOD) from where the OHL route crosses several relatively shallow watercourses. The ground level rises significantly over a short distance to pole set 23 (c. 130m AOD), then levels and quickly descends again between pole set 25 and 26 (c. 125m AOD). The terrain undulates gently as it ascends towards pole set 38 (c. 195m AOD), levels over localised deep deposits of peat and gently falls from pole set 38 to the substation at Agannygal.

(3) Peat thicknesses were recorded during the site walkover with in excess of 200 peat probes. Peat thicknesses measured ranged from 0m to 5.6m. Approximately 70 percent of the probes recorded peat depths of less than 1.0m. Over 90 percent of peat depth probes recorded peat depths of less than 2.5m. Several localised readings were recorded where peat depths of between 2.5 and 5.6m are present. The deepest peat (5.6m) was recorded in the area of angle mast 38 where the topography is flatter than the remainder of the route.

(4) The peat depths recorded at the pole sets and angle masts varied from 0.0m to 5.6m. 28 no. of the pole sets and angle masts have less than 1.0m thickness of peat in their vicinity. 6 no. of the pole sets

and angle masts have greater than 2.0m thickness of peat. The greatest depth of peat encountered, a depth of 5.6m, was recorded at the location of angle mast 38.

(5) The undrained shear strengths of peat recorded ranged from 6kPa to 68kPa with an average of 23kPa. Peat shear strength is discussed in Section 8.

(6) There are a number of locations, primarily around the angle masts, where the peat has been locally removed exposing the mineral soil beneath. This was primarily to do with gaining access for construction of the angle masts. An example of such an area is shown in Photo 7.

(7) In other areas, primarily around the pole sets in areas of deep peat, timber sleepers from felled trees have been used by machinery to gain access during construction, as shown in Photo 5.

(8) The mineral soil composition along the OHL route, based on a visual inspection of exposures, is a sandy gravelly silt or clay with gravel, cobbles and boulders of various sizes and lithology. The mineral soil colour is primarily red-brown, as shown in Photos 7 and 9, with localised areas of white-grey, situated around pole sets 19 and 20. Dispersed throughout the white-grey mineral soil are gravels and small cobbles, which appear to be a mixture of marble, quartz and sandstone in nature. Elsewhere the cobbles and boulders present appear to be sandstone in nature and sandstone would appear to be the dominant rock type present along the route.

(9) Slope angles at the pole set and mast locations typically range from 0 to 15 degrees. There were several steeper slope angles between pole set and mast locations, particularly south of pole set 25 and near the Owendalulleagh River, where an inclination of about 35 degrees was recorded.

(10) The peat situated towards the northern end of the route has a notable vegetation cover, which is generally indicative of relatively well-drained (stronger) peat. However, there are some areas towards the south of the OHL route where poorly-drained (weaker) peat deposits were recorded in deforested areas.

(11) Localised areas of waterlogged peat and surface water are present at numerous areas along the OHL route, particularly between pole sets 37 and AM 38 (Photos 10 and 11). This is not unexpected given the flat nature of the terrain and watercourses present along the OHL route, including Lough Agannygal.

(12) Apart from where the OHL crosses the 2003 peat slide source area, which is between pole sets 5 and 6, no evidence of past peat slides were recorded on the OHL route or directly adjacent to it.

(13) The Agannygal substation is constructed on the edge of a forested area to the north of Lough Atorick. The substation compound has been created by excavating material along the eastern side of the site to create a level platform on competent ground. A cutting 3m deep is present along the eastern side of the substation compound.

(14) Several cuttings were identified along the OHL route, see Section 3.3.4 for details. Of these, the most significant were between pole set 28A and 29 and at Agannygal substation. Between pole set 28A and 29, the cutting is up to 3.8m deep and the cutting slopes have an average slope angle of around 32 degrees in glacial till. There is evidence of minor surface erosion leading to the washing out of soil in local areas of this cutting. At Agannygal substation the cutting is up to 3m deep and has an average slope angle of 35 degrees in glacial till. Based on a visual inspection these cutting slopes appear to be stable. Minor surface erosion was noted in the vicinity of pole set 28A and 29 which would not give rise to a concern over a deeper and more significant slip occurring.

(15) The conclusions from the walkover survey are as follows:

(a) The peat depths recorded at the pole sets/angle masts varied from 0m to 5.6m. 28 no. of the surveyed poleset/angle mast locations have less than 1.0m thickness of peat.

(b) The peat depths recorded near pole set 28 and 36, ranging from 2.5m to 5.6m, would be considered relatively deep. Further, peat strengths in this area were relatively low, ranging from 12kPa to 30kPa. Suitable access techniques and plant such as the use of bog mats and low load bearing machinery would be required when operating in these areas.

(c) Mitigation/control measures for access and potential decommissioning activities at each subsection of the OHL route and substation are given in the Peat Stability Risk Register (Appendix D).

(d) Cuttings up to 3.8m deep in glacial till were observed. These appear to be stable based on a visual assessment.

6 AGEC GROUND INVESTIGATION (2018)

The ground investigation carried out by AGEC along the OHL route and at the Agannygal substation in June 2018 comprised peat depth probes, hand shear vanes and 2 no. trial pits. The locations of the trial pits are shown in Drawings 0001 and 0006. Additional peat depth probes and hand shear vanes were undertaken by FT in 2019.

6.1 Peat Depth Probing and Shear Vane Testing

During the walkover survey, peat depth probing and shear vane testing were carried out at each pole set, mast location and at selected intermediate points along the OHL route to provide representative coverage of indicative peat depths and strengths.

The results of peat depth probing are presented as a peat depth contour plan in Drawings 0002 and 0003 and indicate peat depths ranging from 0 to 5.6m bgl. The depth of peat varies from sections where there is no peat over the footprint of 4 or 5 consecutive pole sets to deep areas of peat, especially near the Agannygal substation site, although inspection of the substation itself shows that it is founded on mineral soil.

Shear vane testing was carried out using a Geonor H-60 hand field vane tester. From FT's experience hand vanes give indicative results for the in-situ undrained shear strength of peat and would be considered best practice for the field assessment of peat strength. 75 no. hand shear vane strength tests were undertaken by AGEC at depths from 0.5 to 2.5m bgl. The hand vane results indicate undrained shear strengths in the range 6 to 68kPa with an average value of 26kPa. Peat strength values are plotted in Figure 2.

6.2 Trial Pits

2 no. trial pits were excavated out at Agannygal substation in June 2018, referred to as TP10 and TP11. The trial pit locations are shown on Drawings 0001 and 0006 and are downslope of the substation. The results of these trial pits are presented in the logs included as Appendix B. Trial pit TP10 found 1.0m of fill over natural ground consisting of mineral soil to a depth of 2.9m bgl. Trial pit TP11 found 0.7m of peaty fill over natural ground consisting of soft slightly organic clay to 1.7m bgl over mineral soil to 2.5m bgl.

The 2 no. trial pits are consistent with each other and suggest a ground profile consisting of deposited construction arisings from the substation excavation over a natural ground profile of soft organic topsoil over glacial till. A cutting is exposed at the Agannygal substation site, shown in Photo 12, and the exposed soil here is consistent with the descriptions from the trial pits.

7 MAINTENANCE AND DECOMMISSIONING

7.1 Description of Maintenance Works

At the time of writing this report, the only planned maintenance works along the OHL which would have an impact on the site stability involves the cutting back of tree growth under the OHL route.

7.2 Methodology for the Cutting back of Tree Growth

Where tree regrowth beneath the OHL has occurred, it is planned that cutting back of this tree growth will take place. Trees will be cut but not extracted. As advised by ESB, the proposed methodology for the cutting back of tree growth is outlined as follows:

(1) Cutting works will be undertaken using a 10-tonne low ground pressure machinery and is envisaged to be minimally invasive.

(2) The excavator will have a saw head attachment rather than a digging bucket.

(3) All of the trimmed vegetation will be cut and left in place on the peat slopes with no additional handling, which minimises machine movements and loading on the peat.

It is expected that a uniform surcharge loading of 10kPa over the affected ground surface will adequately model the pressure imposed on the ground by the plant involved.

7.3 Description of Decommissioning Works

The OHL including the conductors, pole sets and masts may be decommissioned in the future and for completeness the methodology is included below. This work would involve the removal of the OHL infrastructure between the Derrybrien and Agannygal substations, as well as the removal of the above ground infrastructure at the Agannygal substation.

7.3.1 Access for Decommissioning Works

Based on the observations made during the walkover survey, the access routes for decommissioning works which would likely be used are presented in Drawings DMP 01, DMP 02 and DMP 14. These access routes are presented as preliminary suggestions only and would be subject to detailed design. The proposed routes are briefly summarised below. The existing forestry access tracks typically comprise a 3m wide track constructed of crushed rock which has been founded on the mineral soil underlying the peat. Minor upgrades of sections of these tracks may be required.

Notable constraints encountered included several steep slope angles between pole set and mast locations, particularly south of pole set 25 and near the Owendalulleagh River, where an inclination of about 35 degrees was recorded. Where constraints have been identified, alternative access routes are proposed (Drawings DMP

01 and 14). For example, the proposed access routes allow the steep slopes between pole set 3 and pole set 4 and between pole set 25 and pole set 26 to be avoided.

New access construction may include the use of low ground bearing pressure (LGBP) plant and bog mats to provide access to pole sets.

EM1 to PS4

Route follows existing OHL route from Derrybrien substation, requiring possible construction of new access, depending on level of access required for decommissioning works. Alternate access to PS4 is from a local road following an existing track north with access upslope towards the substation using LGBP plant or bog mats.

PS5 to PS11

Route follows existing founded access track from local road north to close to PS4. Existing (floating) track from founded access track to containment barrage 2, located between PS5 and PS6, may be upgraded to allow access to this section of the OHL Access to PS6-PS10 requires the use of LGBP plant or bog mats along the OHL route, depending on level of access required for decommissioning works. PS11 is located immediately adjacent to a local road and can be accessed directly from the local road.

PS12 to AM14

Route follows existing founded access track from local road north to AM14, which would require upgrading. Access from AM14 to PS12 requires the use of LGBP plant or bog mats along the OHL route , depending on level of access required for decommissioning works.

PS15 to PS22

Route follows existing founded access track from local road south to PS22. The track may require upgrading between PS19 and PS21.

PS23 to PS25

Route follows existing founded access track from local road north to PS25. This access may require the upgrade of the existing ford at the Owendalulleagh River and the use of LGBP plant or bog mats along the OHL route, depending on the level of access required for decommissioning works.

PS26 to PS27

Route follows existing founded access track from local road north towards PS26. Access from PS26 to PS27 requires the use of LGBP plant or bog mats along the OHL route, depending on level of access required for decommissioning works.

PS28 to PS31

Route follows existing founded access track from local road north to PS28A. Access from PS28A to PS28 and PS31 requires the use of LGBP plant or bog mats along OHL route, depending on level of access required for decommissioning works.

PS32 to PS34

Route follows existing founded access track from local road north to PS34. Access from PS34 to PS32 requires the use of LGBP plant or bog mats along OHL route, depending on level of access required for decommissioning works.

PS35 to PS37

Requires the use of LGBP plant or bog mats from local road north to PS35 and south to PS37 along OHL route, depending on level of access required for decommissioning works.

AM38 to EM41

Requires the use of LGBP plant or bog mats from Agannygal substation north to AM38 along OHL route, depending on level of access required for decommissioning works.

Substation Access

Access to the substation would use the previously upgrade Coillte track that runs from the local road some 2.5km away.

7.3.2 Methodology for the Decommissioning of the Overhead Line

As advised by ESB, the proposed methodology for the decommissioning of the OHL and timber pole sets is as follows:

(1) Decommissioning works will be undertaken using low ground pressure (LGBP) machinery.

(2) It is currently expected that decommissioning works will be carried out using a light-weight tracked dumper with a winch and 2 no. tracked excavators fitted with pole handling equipment.

(3) Conductor lines will be de-tensioned and removed at various points along the OHL route.

(4) A winch will be brought to the site of the particular pole set to be removed by means of light-weight tracked dumper.

(5) The winch will be attached to the steel cross member of the pole set from ground level.

(6) The cross member will be un-bolted from the pole on the opposite side as the winch.

(7) The winch will allow the cross member to rotate until it is hanging vertical and it will then be lowered to the ground.

(8) The first excavator, fitted with pole handling equipment, will grab the poles at about mid height or higher.

(9) The second excavator will loosen the ground around the base of the pole.

(10) Once the ground is sufficiently loosened, the pole will be raised from its hole and lowered to the ground by the first excavator.

(11) The empty hole will be backfilled and made safe.

(12) If one excavator is capable of carrying it, the pole will be removed by that excavator to a suitable loading point. If one excavator cannot safely carry the pole, both excavators will be used.

(13) Steps (8) to (12) are repeated for the second pole.

(14) The OHL poles and mast elements will be removed from site for reuse and if necessary, disposal in accordance with the relevant legislation.

As advised by ESB, the proposed methodology for the removal of angle masts, intermediate masts and ends masts is as follows:

(1) Conductor lines will be de-tensioned and removed at various points along the OHL route.

(2) Rope access personnel (linesmen) will climb the particular mast to be decommissioned and will work to dismantle the structural members of the mast one by one.

(3) A light pulley block will be secured to the mast and the selected member for removal. The selected member for removal will be unbolted or cut away from the mast structure. Alternatively, if there are no site restrictions then a mobile crane is usually used on site for the dismantling.

(4) The dismantled member will be winched safely to the ground using the pulley system and loaded onto a light weight tracked dumper for disposal. Depending on the type of transportation available, the dismantled member may need to be cut up into smaller segments for transportation.

(5) The workers will progress through each mast, member by member, in this manner.

(6) Where steel structural members are cast into concrete foundations, steel members will be cut flush with the concrete foundation.

(7) The concrete foundations will typically be left in place, this may vary depending on site requirements. Generally, the concrete foundations are removed to 1m below ground level. This would be done using an excavator with a rock breaker. All removed concrete and steel would be removed to a registered waste disposal facility.

It is expected that a uniform surcharge loading of 10kPa over the affected ground surface will adequately model the pressure imposed on the ground by the plant involved. For access and egress purposes bog mats may be deployed to spread the loading of the plant where deemed necessary, thus avoiding the construction of stone access tracks.

7.3.3 Summary of Geotechnical Implications of Decommissioning

The geotechnical implications of the decommissioning process detailed above are as follows:

- Increased risk of a peat slide due to increased surcharge loading over the peat surface during the works.
- Increased risk of peat slide due to loading from temporary floating access roads, if temporary floating access roads are built to gain access to sites for decommissioning, although it is not envisaged that this will be necessary given the available forestry access tracks across the OHL route and the intended use of LGBP plant.
- Local alteration of the surface water flow regime or the surface profile by disturbances during the works, allowing for ponding of surface water on the peat, and hence a potential increase in the risk of a peat slide.

In general, the likely geotechnical impacts of decommissioning are related to an increased risk of a peat slide in the areas of the site where peat is present. In areas where peat is not present, the geotechnical impacts will be insignificant.

The geotechnical implications of any maintenance works are considered negligible.

8 DETERMINISTIC PEAT STABILITY ASSESSMENT

The main approaches for assessing peat stability include the following:

(a) Geomorphological

(b) Qualitative (judgement)

(c) Index/Probabilistic (probability)

(d) Deterministic (factor of safety)

Approaches (a) to (c) listed above would be considered subjective and do not provide a definitive indication of stability; in addition, a high level of judgement/experience is required which makes it difficult to relate the findings to real conditions. FT apply a more objective approach, the deterministic approach.

As part of FT's deterministic approach, a qualitative risk assessment is also carried out (see Section 10) taking into account qualitative factors, which cannot necessarily be quantified, such as the presence of mechanically cut peat, quaking peat, bog pools, sub peat water flow, slope characteristics and numerous other factors. The qualitative factors used in the risk assessment are compiled based on FT's experience of assessments and construction in peat land sites and peat slides throughout Ireland and the UK. This approach takes into account current guidelines for geotechnical/peat stability risk assessments as given in Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (PLHRAG, 2017) and MacCulloch (2005).

8.1 Methodology for Deterministic Peat Stability Assessment

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 a peat slide. To assess the factor of safety for a peat slide, undrained and drained analyses have been undertaken to determine the stability of the peat slopes along the OHL route and at the substation.

The infinite slope model (Skempton and DeLory, 1957) is used to combine these factors to determine a factor of safety against peat sliding. This model is based on a translational slide, which is a reasonable representation of the dominant mode of movement for peat slides.

8.2 Peat Strength

Undrained (short term stability) and drained (long term stability) analyses were carried out to determine the stability of the peat slopes on the site.

(1) The undrained loading condition applies in the short term typically following the application of a load and until load induced pore water pressures have dissipated. Most anthropogenic peat slides occur in the undrained condition i.e. in fully saturated conditions. The undrained condition uses undrained strength parameters in the assessment. Given the timeframe since the OHL was constructed, the drained condition would be deemed the most relevant however the undrained condition is included for completeness.

(2) The drained loading condition applies in the long-term following partial or full dissipation of excess pore water pressure from the peat over time. In the drained condition the pre water pressure (groundwater level) is in equilibrium with in-situ conditions which can vary with seasonal changes. The drained condition examines the effect of the change in groundwater level as a result of rainfall on the stability of the peat slope (following the draining or partial draining of the peat). As a worst case and for the purpose of the assessment the groundwater level is assumed to be at the surface of the peat, to reflect an extreme rainfall event. The drained condition uses effective strength parameters in the assessment.

Undrained shear strength values (c_u) for peat recorded on site using the hand shear vane are used for the undrained analysis.

For the analysis of the peat slopes along the OHL route a lower bound value of 6kPa for the undrained shear strength of the peat was used (Figure 2). This is based on the analysis of a total of over 100 no. shear vane tests (carried out by FT (2019) AGEC (2018) and ESB (2006)) which have provided undrained shear strength values for the peat. Of 123 test results, 3 results showed a shear strength value of less than 6kPa. This value would be considered appropriate and conservative for the undrained condition.

A drained analysis requires effective cohesion (c') and effective friction angle (ø') values for the calculations. These values can be difficult to obtain because of disturbance experienced when sampling peat and the difficulties in interpreting test results due to the excessive strain induced within the peat. To determine suitable drained strength values a review of published information on peat was carried out.

Table 8.1 shows a summary of the published information on peat together with drained strength values.

Table 8.1: List of Effective Cohesion and Friction Angle Values for Peat

Reference	Cohesion, c' (kPa)	Friction Angle, ø' (degs)	Testing Apparatus/ Comments
Hanrahan et al (1967)	5 to 7	36 to 43	From triaxial apparatus
Rowe and Mylleville (1996)	2.5	28	From simple shear apparatus
Landva (1980)	2 to 4	27.1 to 32.5	Mainly ring shear apparatus for normal stress greater than 13kPa
	5 to 6	-	At zero normal stress
Carling (1986)	6.5	0	-
Farrell and Hebib (1998)	0	38	From ring shear and shear box apparatus. Results are not considered representative.

Reference	Cohesion, c' (kPa)	Friction Angle, ø' (degs)	Testing Apparatus / Comments
	0.61	31	From direct simple shear (DSS) apparatus. Result considered too low therefore DSS not considered appropriate
Rowe, Maclean and Soderman (1984)	1.1	26	From simple shear apparatus
	3	27	From DSS apparatus
McGreever and Farrell (1988)	6	38	From triaxial apparatus using soil with 20% organic content
	6	31	From shear box apparatus using soil with 20% organic content
Hungr and Evans (1985)	3.3	-	Back-analysed from failure
Dykes and Kirk (2006)	3.2	30.4	Test within acrotelm
Dykes and Kirk (2006)	4	28.8	Test within catotelm
Warburton et al (2003)	5	23.9	Test in basal peat
Warburton et al (2003)	8.74	21.6	Test using fibrous peat
Hendry et al (2012)	0	31	Remoulded test specimen
Komatsu et al (2011)	8	34	Remoulded test specimen
Zwanenburg et al (2012)	2.3	32.3	From DSS apparatus
Den Haan & Grognet (2014)	-	37.4	From large DSS apparatus
O'Kelly & Zhang (2013)	0	28.9 to 30.3	Tests carried out on reconstituted, undisturbed and blended peat samples

From Table 8.1 the values for c' ranged from 1.1 to 8.74kPa and ø' ranged from 21.6 to 43°. The average c' and ø' values are 4.5kPa and 30° respectively. Based on the above, it was considered to adopt a conservative approach and to use design values less than the average.

For design the following general drained strength values have been used for the site:

c' = 4kPa
$ø'$ = 25 degrees.

8.3 Analysis to Determine Factor of Safety

The purpose of the analysis was to determine the Factor of Safety (FoS) of the peat slopes along the OHL route. As the analysis uses generalised lower bound peat strength values, the results provide an indication of areas where instability might occur. The analysis assumes that all areas have lower bound peat strength, which in the majority of instances is not the case.

The FoS provides a direct measure of the degree of stability of the peat slope. A FoS of less than unity indicates that a slope is unstable, an FoS of greater than unity indicates a stable slope.

The acceptable safe range for FoS typically ranges from 1.3 to 1.4. Where there is minimal risk from a slope slide a FoS of just greater than 1 may in some cases be acceptable. The previous code of practice for earthworks BS 6031:1981 (BSI, 1981), provided advice on design of earthworks slopes. It stated that for a first-time slide with a good standard of site investigation the design FoS should be greater than 1.3. A FoS of 1.4 is taken as indicative of sufficient stability within this report, which would be deemed a conservative approach.

Eurocode 7 (EC7) (I.S. EN 1997-1:2005+AC: 2013) serves as the reference document and the basis for design geotechnical engineering works. The design philosophy used in EC7 applies partial factors to soil parameters, actions and resistances. Unlike the traditional approach, EC7 does not provide a direct measure of stability, since global Factors of Safety are not used.

As such, and in order to provide a direct measure of the level of safety on a site, EC7 partial factors have not been used in this stability assessment. The results are given in terms of FoS.

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

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

Where,

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

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

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

Where,

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

For the drained analysis the level of the water table above the peat slide surface is required to calculate the factor of safety for the slope. Since the water level in upland peat can be variable, it is not feasible to establish

its precise location along the OHL route. Therefore, a worst-case approach was assumed, and the water level is taken to be at the surface of the peat i.e. at 100% of the peat depth which equates to the peat been fully saturated.

The following general assumptions were used in the analysis of peat slopes at each location:

(1) Peat depths are based on the maximum peat depth recorded at each location from the walkover surveys (2018 and 2019).

(2) For the analysis of the peat slopes across the site a lower bound value of 6kPa for the undrained shear strength of the peat was used (Figure 2).

(3) Slope angle on base of sliding assumed to be parallel to ground surface.

For the stability analysis two load conditions were examined, namely:

Condition (1): no surcharge loading

Condition (2): surcharge of 10kPa, equivalent to construction, operational and decommissioning plant and access loading

8.4 Results of the Stability Analysis for the Overhead Line Route

8.4.1 Undrained Analysis

The results of the undrained stability analysis for the OHL route and substation are graphically shown in Drawings 0004 and 0005 and are tabulated in Appendix E.

For the peat slopes the calculated FoS for load condition (1) and (2) is typically in excess of 1.4 for each location analysed.

A summary of the FoS range calculated for load condition (1) and load condition (2) are presented in Table 8.2 along with their respective percentage of site area.

Table 8.2: Summary of Undrained Slope Stability Results

Factor of Safety (FoS)	% of OHL Route (Condition 1)	% of OHL Route (Condition 2)
Less than 1.0	0	0
1.0 to 1.3	0	3.5
1.3 to 1.4	0	0
Greater than 1.4	100	96.5

For Condition (1), 100% of the OHL route and substation has a FoS greater than 1.0 and for Condition (2) 96.5% of the OHL route has a FoS greater than 1.4. Analysis of the spatial distribution of the areas (3 locations) where the lower FoS are present for load condition (2) shows that they are located in areas where steeper slopes are present between pole sets i.e. typically between 10 and 15 degrees. These are located between PS8 and PS9, PS25 and PS26, and PS34 and PS35, as shown on Drawing 0004 and 0005. Information on mitigation measures

for these areas is provided within the Peat Stability Risk Assessment in Appendix D. In one case a low FoS is present where the slope angle is particularly steep, being 21 degrees (between PS34 and PS35), however the peat depth at this location is shallow (0.6m) and no peat instability issues are envisaged either for the maintenance period or during decommissioning. No FoS of less than 1.4 was recorded at a pole set or angle mast location.

In general, the factors of safety less than 1.4 generated from the analysis are not unexpected as generalised lower bound peat strength values are used in the analysis, which cannot take into account areas of higher strength peat. The analysis is intended to provide an indication of likely peat instability and is to be used as an input to a further qualitative risk assessment of the peat stability along the OHL route.

8.4.2 Drained Analysis

The results of the drained stability analysis for the OHL route and substation can be found in Appendix E.

For the peat slopes the calculated FoS for load condition (1) and (2) is typically in excess of 1.4 for each location analysed. A summary of the various FoS's calculated for load condition (1) and load condition (2) are presented in Table 8.3 along with their respective percentage of site area.

Table 8.3: Summary of Drained Slope Stability Results

Factor of Safety (FoS)	% of OHL Route (Condition 1)	% of OHL Route (Condition 2)
Less than 1.0	0	0
1.0 to 1.3	1	0
1.3 to 1.4	0	0
Greater than 1.4	99	100

From Table 8.3 for load condition (1) 99% of the OHL route and substation has a FoS greater than 1.4 and for Condition (2) 100% of the OHL route has a FoS greater than 1.4. No FoS of less than 1.4 was recorded at a pole set or angle mast location.

While it has been found, somewhat counterintuitively, that Condition (1), the natural condition, presents a less favourable outcome than Condition (2), where the slope is surcharged, this is reasonable due to the effective stress analysis undertaken. In this analysis, an increase in the surface loading and hence the vertical effective stress leads to an increase in the confining pressure on the potential failure plane under consideration and therefore a greater resistance to movement on that plane.

In general, the factors of safety less than 1.4 generated from the analysis are not unexpected as generalised lower bound peat strength values are used in the analysis, which cannot take into account areas of higher strength peat. The analysis is used to provide an indication of the likely susceptibility of instability within the OHL route and at the substation.

8.5 Stability of Agannygal Substation Site

The Agannygal substation site is founded on mineral soil, which would be considered a competent founding medium. As the peat was stripped away as part of the construction and there is no peat present within the footprint the Agannygal substation site, the substation site is not included in the stability analysis as it is considered stable.

8.6 Summary

The analysis was carried out to provide an indication of likely peat instability along the OHL route. The analysis showed that, using conservative strength parameters, the peat generally has an adequate factor of safety and hence a low risk of instability. However, the use of conservative undrained and drained strength parameters has contributed to a small number (3 number) of relatively low FoS results, particularly around areas of high slope angles and deep deposits of peat. These are located between PS8 and PS9, between PS25 and PS26, and between PS34 and PS35.

In general, the areas of relatively low FoS generated from the analysis are not unexpected as generalised lower bound peat strength values are used in the analysis, which cannot take into account areas of higher strength peat. The analysis is intended to provide an indication of likely peat instability.

An estimate of potential peat slide volume and run-out distance has been undertaken for the three areas with relatively lower FoS results. This is to provide an indication of the scale of a potential peat slide, it does not imply that a slide would occur. The potential peat slide volume has been calculated based on information recorded on site. The run-out distance is based on a comparison with historical peat slides in Ireland. These are plotted on Figure 3. The potential peat slide volumes range from 8,000m^3 to 16,000m^3 based on peat depth readings in these areas. Run-out distances are from 500m to 700m based on comparisons with historical peat slides.

The deterministic and quantitative results obtained from the analysis presented in this section are used in Section 9 of this report to undertake a peat stability risk assessment. As part of this assessment, appropriate control measures will be identified to mitigate the risk of a peat slide.

9 PEAT STABILITY RISK ASSESSMENTS

9.1 Methodology

A peat stability risk assessment was carried out for the OHL infrastructure and Agannygal substation. This approach takes into account guidelines for geotechnical/peat stability risk assessments as given in PLHRAG (2017) and MacCulloch (2005).

The risk assessment uses the results of the stability analysis (deterministic approach) in combination with qualitative factors, which cannot be reasonably included in a stability calculation but nevertheless may affect the occurrence of peat instability, to assess the risk for each infrastructure element.

As previously outlined, the OHL route was broken into 9 no. subsections (including the substation at Agannygal) for assessment. These subsections were chosen based on having similar topography and peat depth within each individual section

For each subsection of the OHL, a risk rating (product of probability and impact) is calculated for every contributory/qualitative factor in the subsection. The range of risk ratings is shown in Table 9.1.

The risk rating assigned to any subsection is based on the highest risk rating calculated for any contributory/qualitative factor within that subsection.

Where a subsection is rated 'Medium' or 'High', specific control measures are required to reduce the risk to at least a 'Low' risk rating. Where a subsection is rated 'Low' or 'Negligible', only routine control measures, if any, are required. The control measures are targeted at the specific contributory/qualitative factors that give the highest risk rating.

Table 9.1: Risk Rating Legend

17 to 25	High: avoid works in area or significant control measures required
11 to 16	Medium: specific control measures required
5 to 10	Low: only routine control measures required
1 to 4	Negligible: none or only routine control measures required

A full methodology for the peat stability risk assessment is given in Appendix C.

The impact of a peat slide on the receiving environment within and beyond the OHL route and substation is assessed based on the potential travel distance and potential volume of a peat slide and the effect on receptors such as local property, infrastructure, and the natural environment.

Where a peat slide enters a watercourse it can travel a considerable distance downstream. Therefore, the proximity of a potential peat slide to a drainage feature is a significant indicator of the likely potential impact. Furthermore, given the elevation of the terrain along the OHL route, the topography in some areas may result in the formation of potential flow paths through naturally occurring features such as dips and falls in the terrain, valleys, etc. Such features would have the effect of increasing the travel distance of and the areas affected by any potential peat slide.

The potential damage to private property is also assessed using this approach. The OHL is located in a sparsely populated location; however, land owners and domestic dwellings may still be at risk in certain areas if a peat slide were to occur. In addition, property such as pasture and tillage farms, private landholdings, and communication/power infrastructure can be susceptible to peat slides. The list of such potential features or receptors identified are outlined in Table 9.2.

Table 9.2: Potential Receptors

Receptor	Control
Watercourse (rivers, streams, flow channels, etc.)	Topography
Dwellings (domestic)	
Road (local roads excluding wind farm access tracks)	
Infrastructure (overhead lines, communications infrastructure, etc.)	
Agricultural Land (pasture, etc.)	
Natural Heritage Area (Slieve Aughty Bog NHA)	

The primary controlling aspect when determining the impact of a potential peat slide, once that slide has occurred, is the topography along the slide run-out route.

9.2 Summary of Risk Assessment Results

The results of the risk assessment for potential of a peat slide at the 9 no. subsections are presented in Appendix D and are summarised in Table 9.3.

The risk rating for the identified areas of infrastructure along the OHL route and the substation is designated low or less following mitigation/control measures being implemented. If any sections of new temporary access track are required for any decommissioning works on the OHL, these should be subject to the same mitigation/control measures that apply to that particular subsection of the OHL. Where the proposed access

routes use the existing founded forest tracks the risk rating is considered to be negligible, due to the minor nature of any required upgrade works and the absence of peat beneath the tracks.

Details of the required mitigation/control measures can be found for each OHL subsection in Appendix D.

The upgrade of the c. 2.5km of access track to access the substation site during construction is not considered to present a risk of instability given the minor nature of the work involved and the relatively flat topography of the area.

Table 9.3: Summary of Peat Stability Risk Assessment

Infrastructure	Pre-Control Measure Implementation Risk Rating	Post-Control Measure Implementation Risk Rating
EM1 to PS5	Low	Negligible
PS5 to AM14	Medium	Negligible
AM14 to AM18	Negligible	Negligible
AM18 to AM24	Medium	Negligible
AM24 to PS28A	Medium	Low
PS28A to PS34	Low	Negligible
PS34 to AM38	Medium	Negligible
AM38 to EM41	Medium	Negligible
Agannygal Substation	Negligible	Negligible

Note
(1) For mitigation/control measures refer to Appendix D.

9.3 Likelihood of Instability - Combining Deterministic and Qualitative Factors

The results of the stability analysis (Section 8) have been combined with qualitative factors, to provide an indication of the probability of instability. The qualitative factors are given in Appendix C.

The purpose of combining deterministic and qualitative factors is to provide a likelihood of failure that can be applied to a variety of potential specific receptors, other than those included in this report, see Table C in Appendix C. The peat stability risk assessment included in Section 9.2 of this report uses a number of general receptors such as local property, infrastructure, and the natural environment.

The deterministic factor of safety and qualitative factors are combined as follows:

- The deterministic factor of safety and qualitative factors are scored from 0 to 5 using Table B in Appendix C.
- The maximum score that can be obtained by combining the deterministic factor of safety and qualitative factors, that is a total of 12 factors (5 x 12), is 60, and the lowest score is 0. The greater the total combined score the greater the likelihood of failure.
- Where the stability analysis is not applicable because, for example, no peat is present, then the deterministic score is 0, and combined score defaults to negligible irrespective of the qualitative factors.
- Where stability analysis shows FoS less than 1 then the likelihood defaults to very likely irrespective of qualitative score
- In all cases, experienced engineering judgement is used, the actual combined scoring provides a guide.

Table 9.4 shows the peat landslide combined likelihood ranges for lifetime of proposed development.

Table 9.4: Peat Stability Combined Likelihood Ranges

Scale	Likelihood	Combined Score	Probability of Occurrence (Event/year)
0	Not applicable	0	Not applicable
1	Negligible	1 to 10	>1 in 100,000 to 1 in 10,000
2	Unlikely	11 to 30	>1 in 10,000 to 1 in 1,000
3	Probable	31 to 40	>1 in 1,000 to 1 in 100
4	Likely	41 to 50	>1 in 100 to 1 in 10
5	Very Likely	50 to 60	>1 in 10

shows the results of the peat stability combined likelihood for the 9 no. subsections presented in Appendix D.

Table 9.5: Summary of Peat Stability Likelihood

Infrastructure	Combined Likelihood Score	Likelihood of Failure Pre-Control Measure Implementation
EM1 to PS5	10	Negligible
PS5 to AM14	14	Low
AM14 to AM18	3	Negligible
AM18 to AM24	9	Negligible
AM24 to PS28A	19	Low
PS28A to PS34	10	Negligible

Infrastructure	Combined Likelihood Score	Likelihood of Failure Pre-Control Measure Implementation
PS34 to AM38	16	Low
AM38 to EM41	10	Negligible
Agannygal Substation	2	Negligible

10 CONCLUSIONS

The following conclusions are given.

(1) Fehily Timoney & Company (FT) was engaged by ESB to undertake a geotechnical stability assessment of the OHL route from the Derrybrien wind farm site to the Agannygal substation. In line with the brief, the assessment took account of the geotechnical stability of the route and the substation during its construction phase, operational phase and during possible decommissioning works in the future.

(2) The geotechnical stability assessment included the completion of a desk study, a site walkover, and an additional ground investigation. A deterministic peat stability assessment and a qualitative peat stability risk assessment were undertaken.

(3) Apart from the peat slide scar left by the peat slide in October 2003, which is between pole sets 5 and 6, no evidence of past peat slides have been recorded on the OHL route. The nearest other historical peat slide was located approximately 2.5km east of the offsite substation and occurred in 1890.

(4) Cuttings up to 3.8m deep in glacial till were observed. These appear to be stable based on a visual inspection and are considered to have a low risk of future instability.

(5) The deterministic peat stability assessment found that the peat along the OHL route generally has an adequate factor of safety against peat slide and hence a low risk of instability. However, the use of conservative shear strength parameters for the peat has contributed to a small number (3 no. – 3.5% of total route) of low FoS results, particularly around areas of high slope angles and relatively deep deposits of peat. The Risk Assessments in Appendix D provide mitigation measures for these areas.

(6) Potential peat slide volumes and run-out distance have been calculated for these three areas with relatively lower FoS. This is to provide an indication of the scale of a potential peat slide, it does not imply that a slide would occur. The potential slide volumes range from 8,000m^3 to 16,000m^3 and the run-out distance ranges from 500m to 700m.

(7) A qualitative peat stability risk assessment was carried out by separating the OHL route into 9 no. subsections and assessing these subsections based on the probability of a peat slide for a number of indicators and the likely impact of a peat slide, should it occur. The peat stability risk assessment found that 5 no. subsections were assigned a 'medium' risk rating while the remaining subsections were assigned 'low' or 'negligible' risk ratings.

(8) To bring the risks of a peat slide at the locations where a 'medium' risk exists to 'low' or 'negligible' levels, it is recommended that control measures are implemented. These include routine measures such as avoiding accessing the areas of peat with the greatest slopes with plant, the use of suitable plant and equipment, and adequate monitoring of the works. Other control measures are outlined in Appendix D.

(9) Overall the stability of the OHL and Agannygal substation with respect to peat slide risk is considered to be acceptable. Where localised areas of elevated risk have been identified the level of risk can be reduced by the application of routine control measures.

(10) Should any sections of new temporary access track be required for any decommissioning works running below the OHL, these should be subject to the same mitigation/control measures that apply

to that particular subsection of the OHL. Where the proposed access routes use the existing founded forest tracks the risk rating is considered to be negligible, due to the minor nature of any required upgrade works and the absence of peat beneath the tracks.

(11) Based on the results of both the deterministic and qualitative stability assessments, there are two subsections where control/mitigation measures are required at the decommissioning stage to reduce the level of risk to an acceptable level (Appendix D). These localised areas are between PS5 and AM14 and between AM24 and PS28A. Both of these areas recorded relatively low FoS results as well as containing areas of steeper slopes.

11 REFERENCES

Fehily Timoney and Company (FT) 2019. Geotechnical Stability Report 2 for Derrybrien Wind Farm Project. Draft, October 2019.

Bromhead, E. N. (1986). The Stability of Slopes.

BSI (1981). BS 6031:1981 Code of practice for earthworks.

BSI (2015). BS 5930:2015 Code of practice for site investigations.

Carling, P. A. (1986). Peat slides in Teesdale and Weardale, northern Pennines, July 1983: Description and failure mechanisms. Earth Surface Processes and Landforms, 11.

Den Haan, E. J. and Grognet, M. (2014). A large direct simple shear device for the testing of peat at low stresses. Géotechnique Letters 4(4): 283–288, http://dx.doi.org/10.1680/geolett. 14.00033.

Dykes, A. P. and Kirk, K. J. (2006). Slope instability and mass movements in peat deposits. In Martini, I.P., Martinez Cortizas, A. and Chesworth, W. (Eds.) Peatlands: Evolution and Records of Environmental and Climatic Changes. Elsevier, Amsterdam.

Environmental Protection Agency, EPA (2017): Draft Guidelines on the Information to be contained in Environmental Impact Assessment Reports. August 2017.

ESB (2006). Derrybrien Wind Farm, Co Galway. Slope stability assessment of a section of ground under overhead line. Report Number P78015-R476-002. 16th February 2006.

Eurocode 7 (EC7). BS EN 1997-1: 2005, Geotechnical Design, Part 1 – General Rules, British Standards Institution, London.

Farrell, E. R. & Hebib, S. (1998). The determination of the geotechnical parameters of organic soils. Proceedings of International Symposium on problematic soils, IS-TOHOKU 98, Sendai, Japan.

Geological Survey of Ireland (2003). Geology of Galway Bay. Sheet 14.

Geological Survey of Ireland (2018). Online dataset public viewer http://spatial.dcenr.gov.ie/imf/imf.jsp?site=GSI_Simple September 2019.

Hanrahan, E. T., Dunne, J. M. and Sodha, V.G. (1967). Shear strength of peat. Proc. Geot. Conf., Oslo, Vol. 1.

Hendry MT, Sharma JS, Martin CD and Barbour SL (2012). Effect of fibre content and structure on anisotropic elastic stiffness and shear strength of peat. Canadian Geotechnical Journal 49(4): 403–415, http://dx.doi.org/10.1139/t2012-003.

Hungr, O. and Evans, S. G. (1985). An example of a peat flow near Prince Rupert, British Columbia. Canadian Geotechnical Journal, 22.

Komatsu, J. Oikawa, H. Tsushima, M. and Igarashi, M. (2011). Ring shear test on peat. In Proceedings of the 21st International Offshore and Polar Engineering Conference, Maui, Hawaii, USA (Chung JS, Hong SY, Langen I and Prinsenberg SJ (eds)). International Society of Offshore and Polar Engineers, Cupertino, CA, USA, vol. 2, pp. 393–396.

Landva, A. O. (1980). Vane testing in peat. Canadian Geotechnical Journal, 17(1).

MacCulloch, F. (2005). Guidelines for the Risk Management of Peat Slips on the Construction of Low Volume/Low Cost Roads over Peat. RoadEx 11 Northern Periphery.

NSAI (2005). I.S. EN 1997-1:2005 + AC: 2013. Eurocode 7: Geotechnical Design - Part 1: General Rules.

O'Kelly B. C., and Zhang, L. (2013). Consolidated-drained triaxial compression testing of peat. Geotechnical Testing Journal 36(3): 310–321, http://dx.doi.org/10.1520/ GTJ20120053.

PLHRAG (2017). Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments. Prepared for Energy Consents Unit Scottish Government, 2nd Edition. Dated April 2017.

Rowe, R. K. & Mylleville, B. L .J. (1996). A geogrid reinforced embankment on peat over organic silt; a case history. Can. Geotech. J. 33 (1), 106 – 122.

Rowe, R. K., MacLean, M. D., Soderman, K. L. (1984). Analysis of a geotextile reinforced embankment constructed on peat. Can. Geotech. J. 21 (3), 563 – 576.

Skempton, A. W. and DeLory, F. A. (1957). Stability of natural slopes in London Clay. Proc 4th Int. Conf. On Soil Mechanics and Foundation Engineering, Rotterdam, vol. 2, pp.72-78.

Warburton, J., Higgett, D. and Mills, A. (2003). Anatomy of a Pennine Peat Slide. Earth Surface Processes and Landforms.

Warburton, J., Holden, J. and Mills, A. J. (2003). Hydrological controls of surficial mass movements in peat. Earth-Science Reviews 67 (2004), pp. 139-156.

Zwanenburg, C., Den Haan E. J., Kruse G. A. M. and Koelewijn, A. R. (2012). Failure of a trial embankment on peat in Booneschans, the Netherlands. Géotechnique 62(6): 479–490, http://dx.doi.org/10.1680/geot.9.P.094

Figures

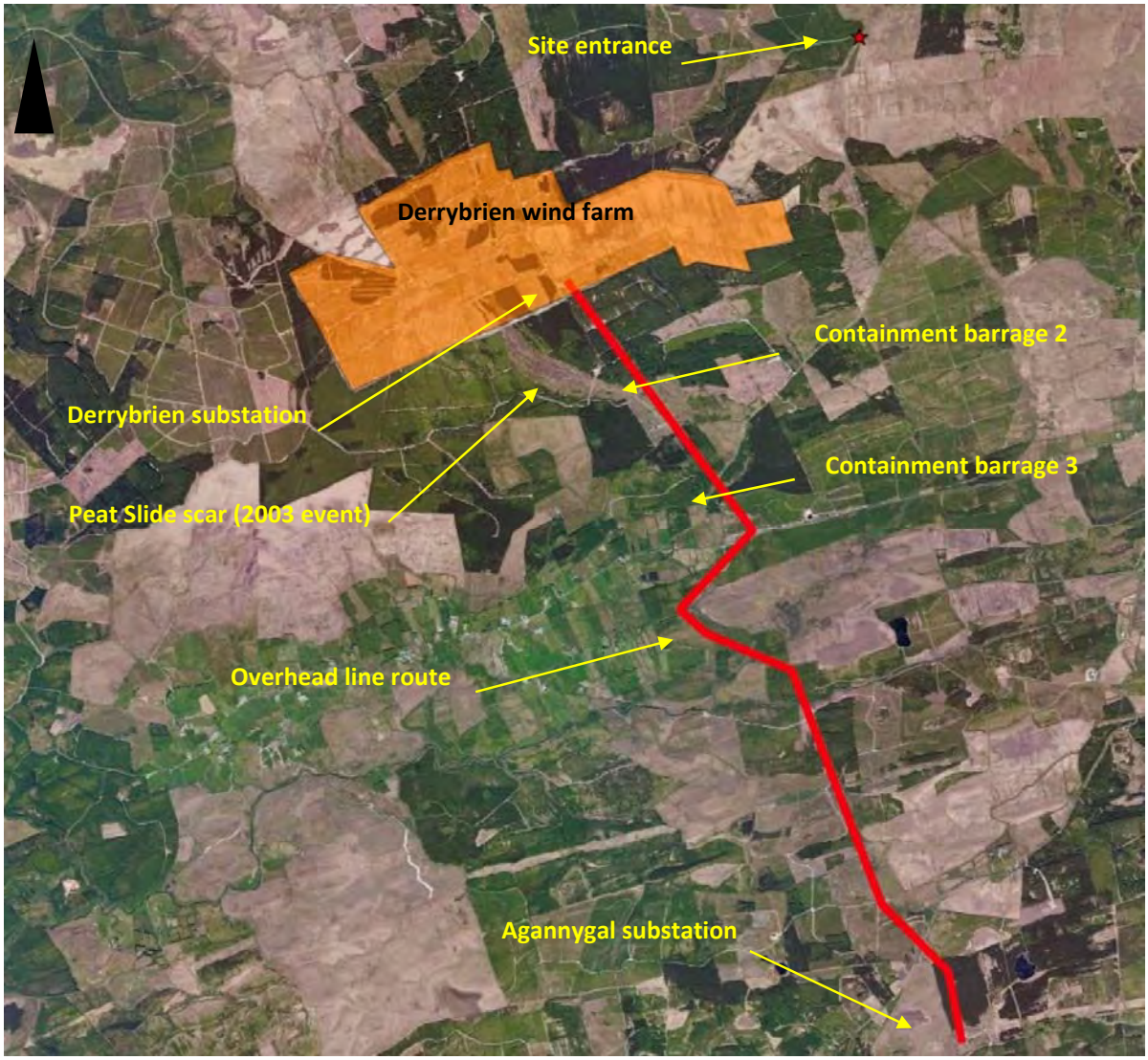


Figure 1 Location of Grid Connection (source: Bing Maps)

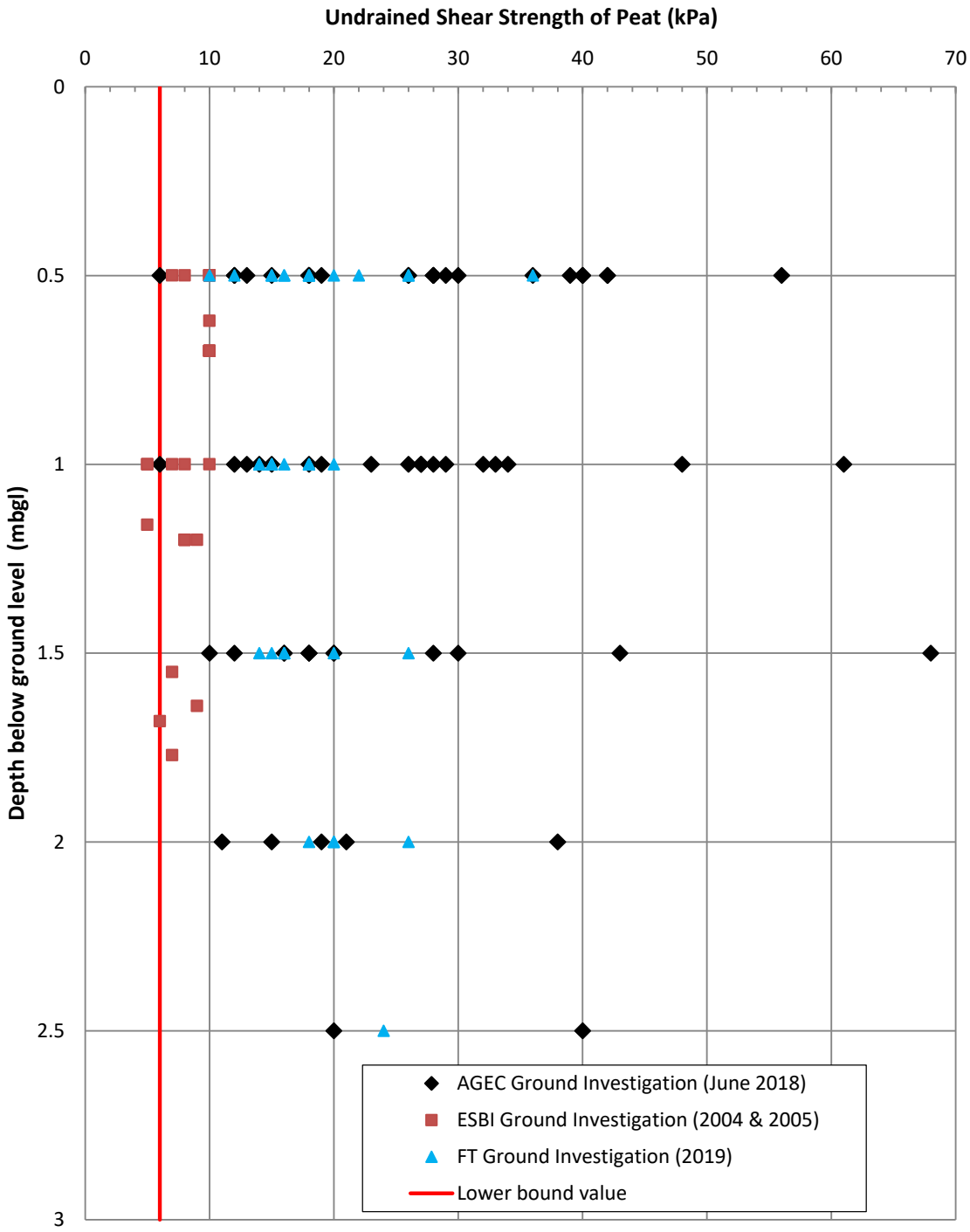


Figure 2 Undrained Shear Strength of Peat along Overhead Line Route

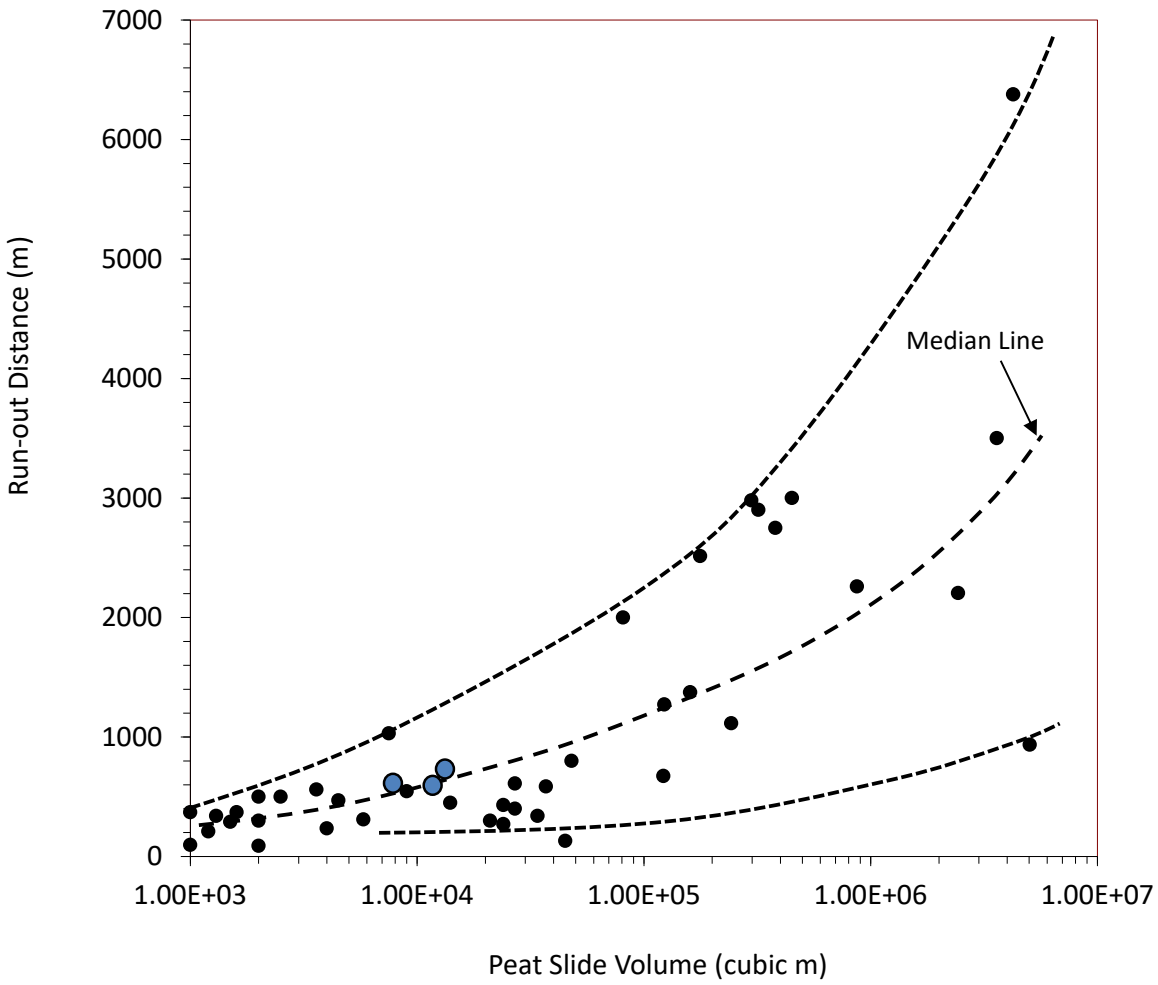
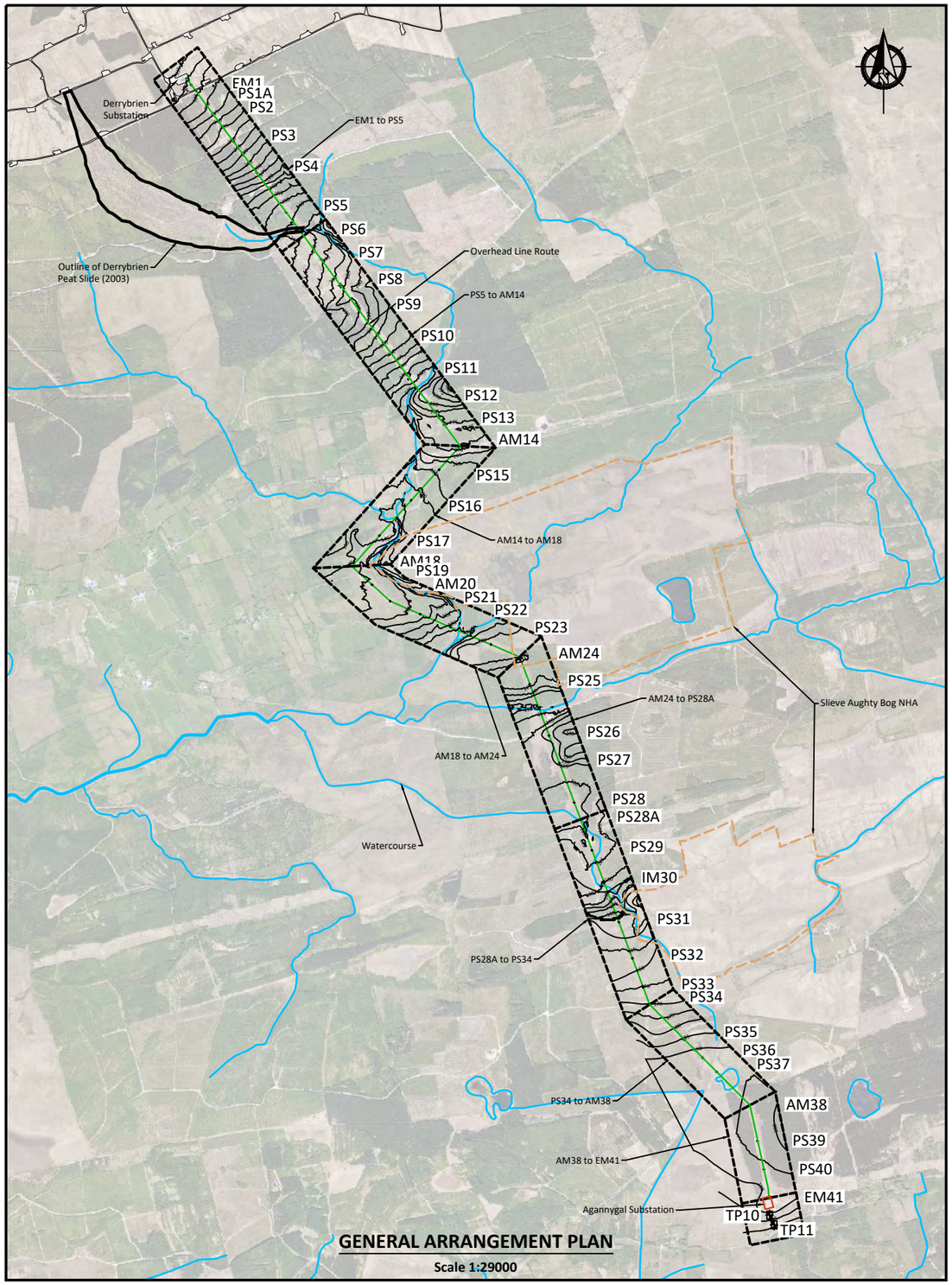


Figure 3 Peat slide volume versus run-out distance

Notes:

(1) Potential future peat slides shown with blue dot.

Drawings



GENERAL ARRANGEMENT PLAN

Scale 1:29000

GI Legend and notes:

AGEC Trial Pit Locations (June 2018)

Background aerial mapping shown taken from the latest available Bing Mapping.

Notes:

1. The OHL route was broken into a number of subsections (including the substation at Agannygal) for assessment. These subsections were chosen based on having comparable topography and peat depth.

0m 145m 290m 435m 580m 725m 870m 1015m 1160m 1305m 1450m

Scale 1:29000

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B	FOR INFORMATION	BDH	30.03.20
C	FOR INFORMATION	BDH	31.07.20

PROJECT: DERRYBRIEN WIND FARM PROJECT - REIAR

CLIENT: ESB

SHEET: GENERAL ARRANGMENT

Date: 31.07.20

Project number: P2159

Scale (@ A3): 1:29000

Drawn by: POR

Checked by: IH

Drawing Number: P2159-0600-OHL-0001

Rev: C

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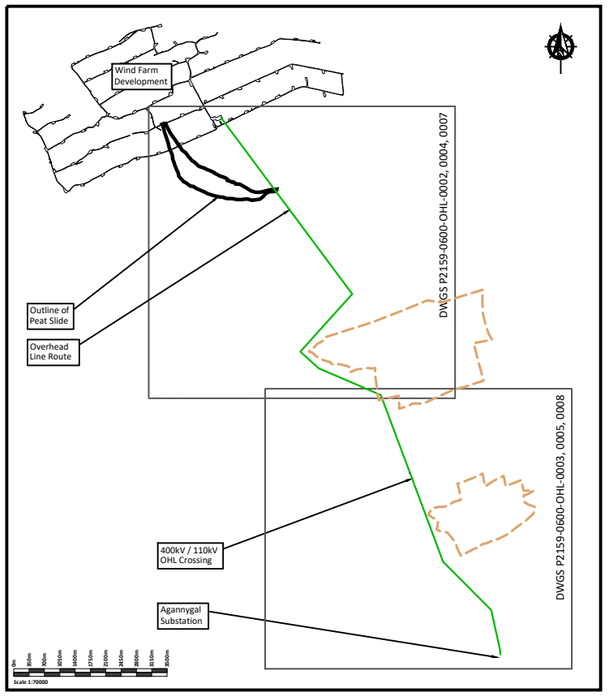
Friday 31 July 2020



KEYPLAN

Scale 1:70000

PEAT DEPTH CORRIDOR PLAN

Scale 1:14000

Legend: Peat Depth (m)

0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.6

Note -

Peat depth corridor was prepared as a 100m wide corridor using a single line of peat depth probes.

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PROJECT	DERRYBRIEN WIND FARM PROJECT - REIAR
CLIENT	ESB
SHEET	PEAT DEPTH CONTOUR PLAN DRAWING 1 OF 2
Date	31.07.20
Project number	P2159
Scale (@ A3)	1:14000
Drawn by	POR
Checked by	IH
Drawing Number	P2159-0600-OHL-0002
Rev	C

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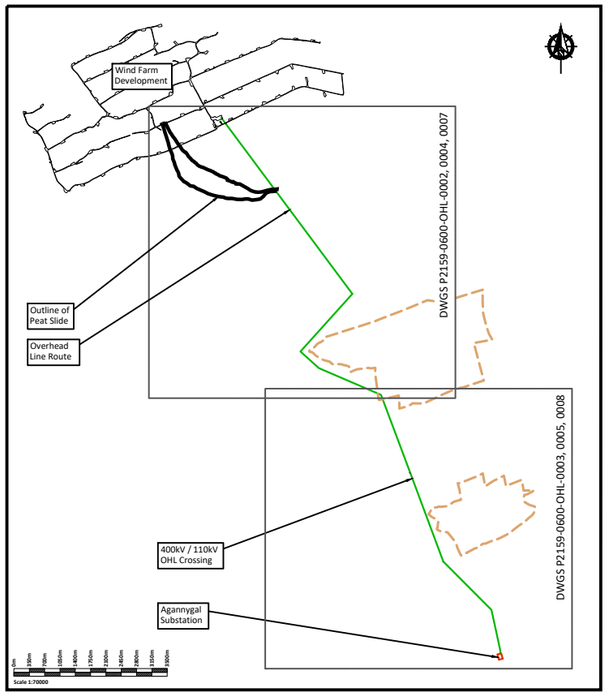

KEYPLAN

Scale 1:70000

Legend: Peat Depth (m)

0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.6

Note -

Peat depth corridor was prepared as a 100m wide corridor using a single line of peat depth probes.

PEAT DEPTH CORRIDOR PLAN

Scale 1:14000

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PROJECT: DERRYBRIEN WIND FARM PROJECT - REIAR	CLIENT: ESB
SHEET: PEAT DEPTH CONTOUR PLAN DRAWING 2 OF 2	Date: 31.07.20 · Project number: P2159 · Scale (@ A3): 1:14000
	Drawn by: POR · Checked by: IH · Drawing Number: P2159-0600-OHL-0003 · Rev: C

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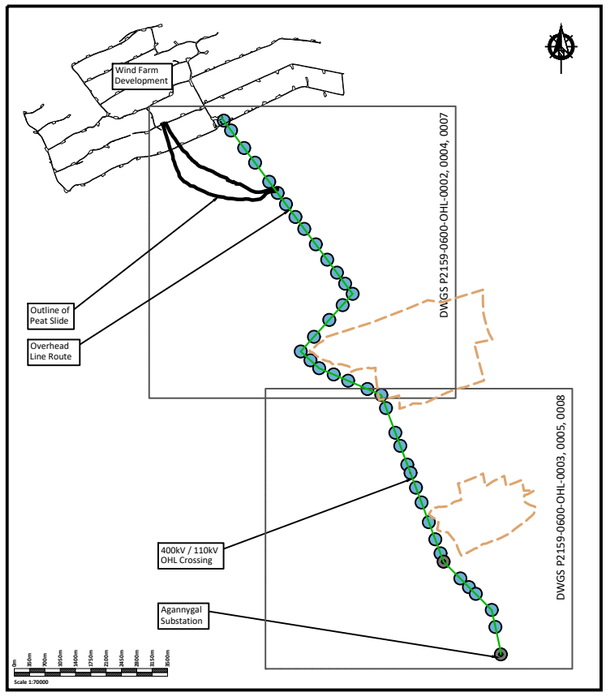

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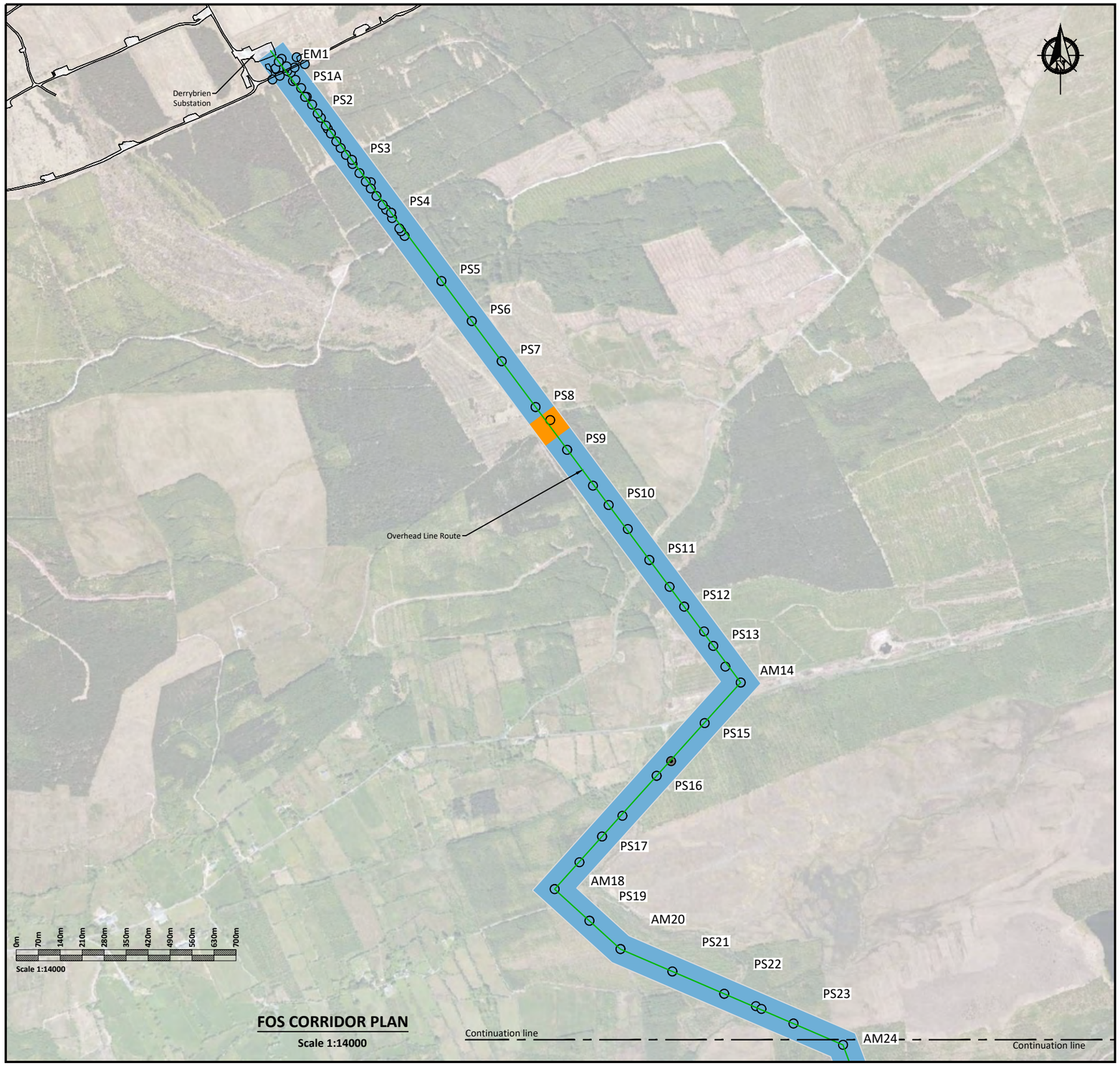

FOS CORRIDOR PLAN

Scale 1:14000

Legend: Factor of Safety

- 1 or less
- 1.01 to 1.3
- 1.31 to 1.4
- Greater than 1.4
- No Peat Recorded at this Location

Increasing Stability

Note -

The results of the undrained analysis for the most critical load condition 2 are shown on this drawing.

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PROJECT: **DERRYBRIEN WIND FARM PROJECT - REIAR**

CLIENT: **ESB**

SHEET: **FACTOR OF SAFETY FOR PEAT SLOPES DRAWING 1 OF 2**

Date: 31.07.20

Project number: P2159

Scale (@ A3): 1:14000

Drawn by: POR

Checked by: IH

Drawing Number: **P2159-0600-OHL-0004**

Rev: **C**

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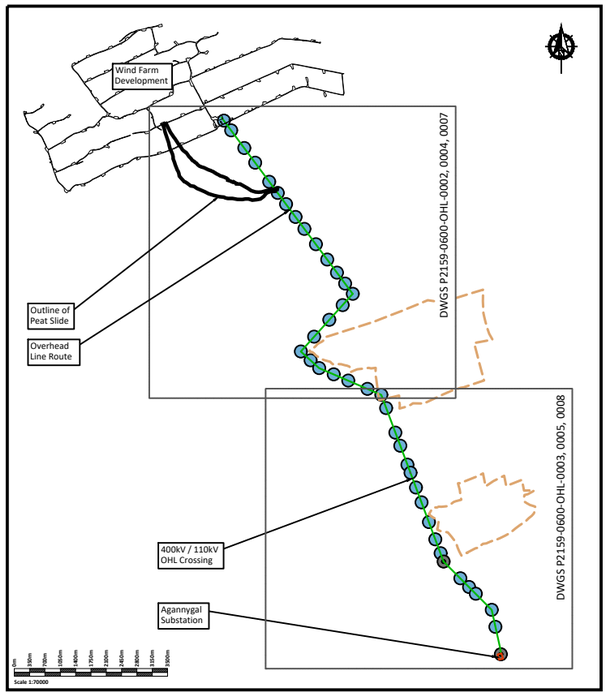

KEYPLAN

Scale 1:70000

Legend: Factor of Safety

- 1 or less
- 1.01 to 1.3
- 1.31 to 1.4
- Greater than 1.4
- No Peat Recorded at this Location

Increasing Stability

Note -

The results of the undrained analysis for the most critical load condition 2 are shown on this drawing.

PEAT DEPTH CORRIDOR PLAN

Scale 1:14000

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PROJECT: DERRYBRIEN WIND FARM PROJECT - REIAR

CLIENT: ESB

SHEET: FACTOR OF SAFETY FOR PEAT SLOPES DRAWING 2 OF 2

Date: 31.07.20 | Project number: P2159 | Scale (@ A3): 1:14000

Drawn by: POR | Drawing Number: P2159-0600-OHL-0005 | Rev: C

Checked by: IH

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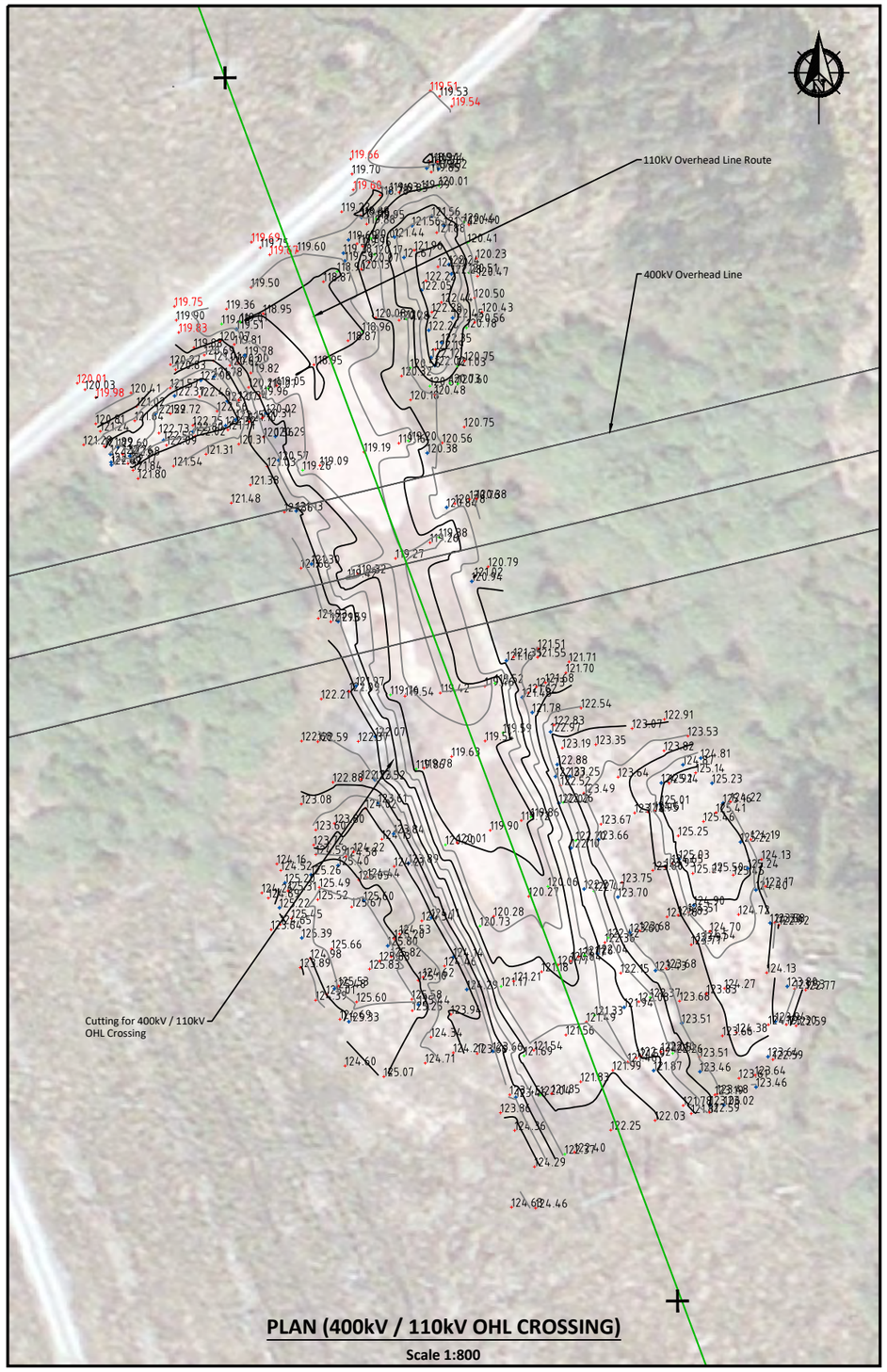
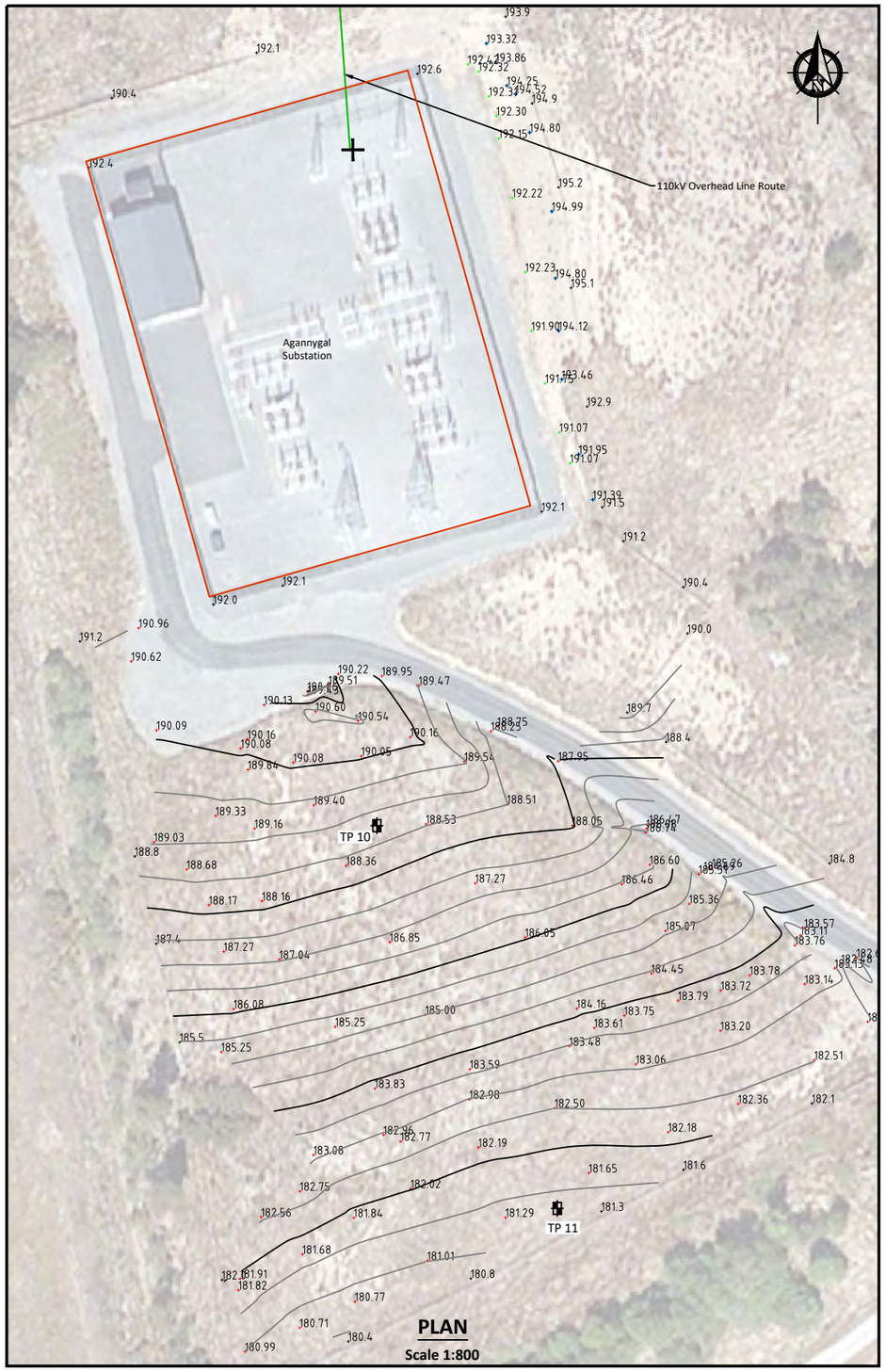


PLAN (400kV / 110kV OHL CROSSING)

Scale 1:800



PLAN

Scale 1:800

GI Legend and notes:

AGEC Trial Pit Locations (June 2018)

Background aerial mapping shown taken from the latest available Bing Mapping.

Notes:

1. Topographical survey information shown on this drawing is based on survey data recorded on site by ESBI in 2018.

0m 4m 8m 12m 16m 20m 24m 28m 32m 36m 40m

Scale 1:800

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PROJECT: **DERRYBRIEN WIND FARM PROJECT - REIAR**

CLIENT: **ESB**

SHEET: **DETAILS OF 400kV / 100kV CROSSING & AGANNYGAL SUBSTATION**

Date 31.07.20	Project number P2159	Scale (@ A3) 1:800	
Drawn by POR	Drawing Number P2159-0600-OHL-0006		Rev C
Checked by IH			

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Friday 31 July 2020

N

EM1(Derrybrien Station)

PS1a

Derrybrien Substation

PS2

PS3

PS4

PS5

PS6

PS7

PS8

PS9

PS10

PS11

PS12

PS13

AM14

PS15

PS16

PS17

AM18

PS19

AM20

PS21

PS22

PS23

AM24

PS25

Black Road

R353

Point D
E-561084.25
N-702394.884

Point C
E-561040.6337
N-702331.6321

Point A
E-561123.4388
N-702367.5429

Point B
E-561061.14
N-702260.8798

Insert Map

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See Insert Map

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0 0.5 1 1.5 2 km

Legend

Derrybrien - Agannygal 110 kV Overhead Line

Decommissioning Access Routes:

- Decommissioning access route EM1 to PS4
- Decommissioning access route PS12 to PS14
- Decommissioning access route PS15 to PS22
- Alternative Decommissioning access route to PS15 to PS22
- Alternative Decommissioning access route to PS 17 to PS22
- Decommissioning access route PS23 to PS25
- Decommissioning access route PS26 to PS27
- Decommissioning access route PS5 to PS11

Mast type:

- Poleset (PS)
- Angle Mast (AM)
- End Mast (EM)

REV	DATE	REVISION DESCRIPTION	DRN	PROD	VER	APP
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PRODUCTION UNIT: Civil Environmental & Renewable Engineering

PROJECT: Derrybrien Wind Farm Decommissioning Project

DRAWING TITLE: Figure DMP 01 - Derrybrien - Agannygal OHL - Indicative Decommissioning Access Routes (Sheet 1 of 2)

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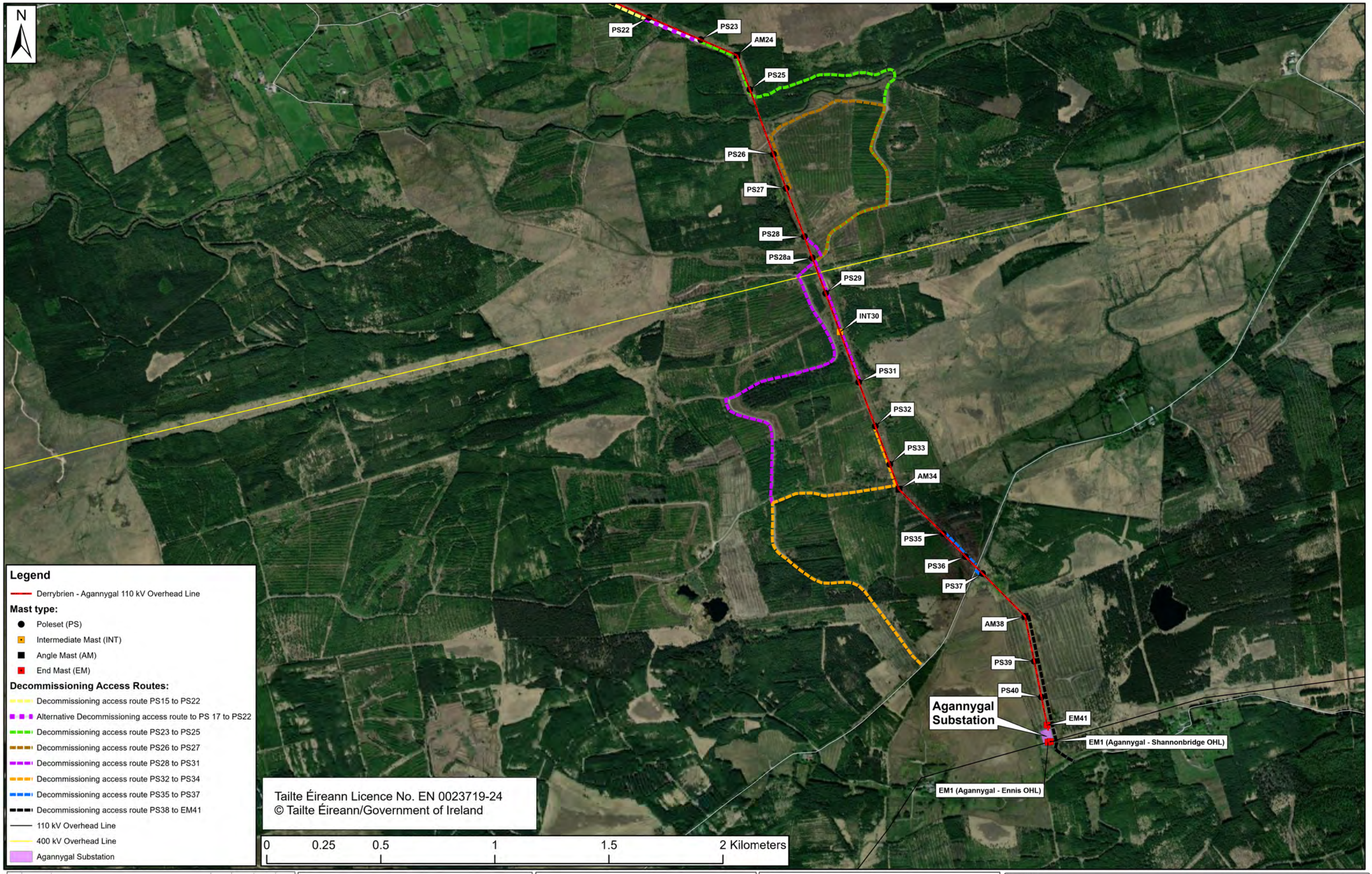

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DRAWING TITLE: Figure DMP 02 - Derrybrien - Agannygal OHL - Indicative Decommissioning Access Routes (Sheet 2 of 2)

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DRAWING NUMBER: **DRAFT FOR INFORMATION ONLY**

N

S37

AM38

PS39

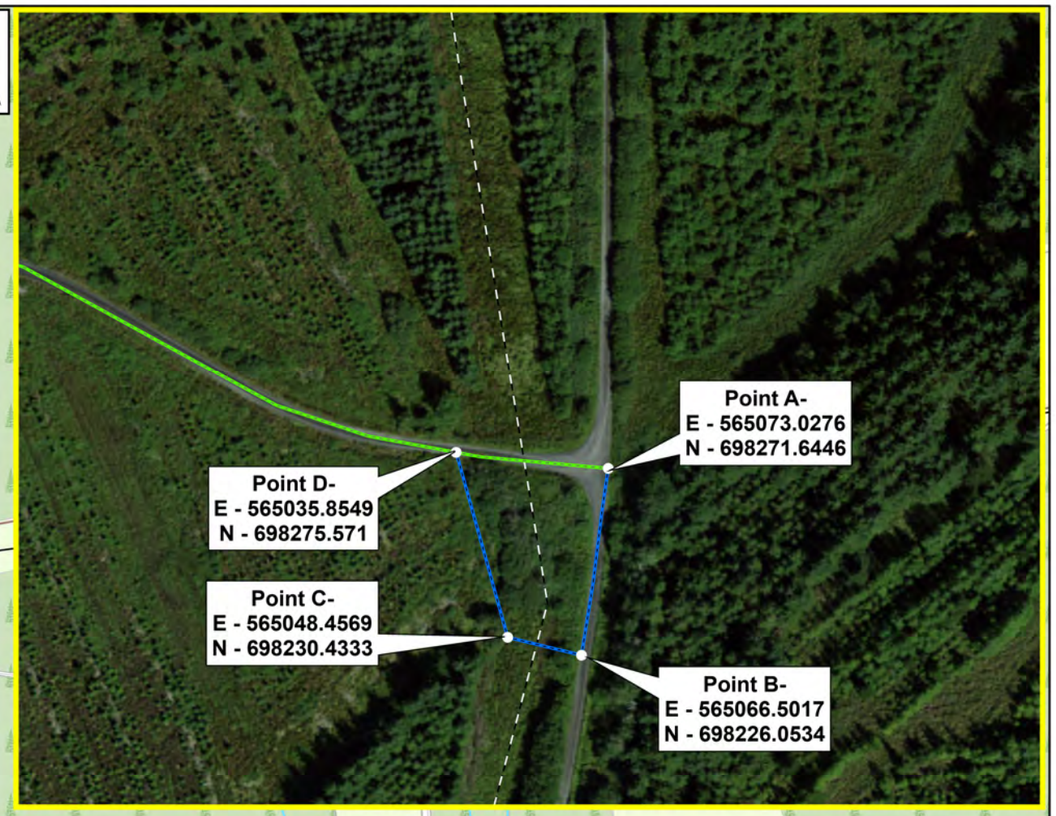
PS40

Agannygal Substation

EM41

EM1 (Agannygal - Shannonbridge OHL)

EM1 (Agannygal - Ennis OHL)



Legend

- Decomissioning Access Route to Substation
- Alternative Decomissioning Access Route to Substation

Mast type:

- Poleset (PS)
- Angle Mast (AM)
- End Mast (EM)
- Derrybrien - Agannygal 110 kV Overhead Line
- 110 kV Overhead Line
- Agannygal Substation

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0 0.13 0.25 0.5 0.75 1 Kilometers

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Figure DMP 14 - Agannygal Substation - Indicative Decommissioning Access Route

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CLIENT REF.	NO. OF SHEETS	SIZE	SCALE
00-00	1/1	A3	1:8,000

DRAWING NUMBER: **DRAFT FOR INFORMATION ONLY**

Appendix A

Site Photographs from FT Site Walkover (2019)

Photo 1 Typical timber pole set

Photo 2 Typical steel angle mast

Photo 3 Typical forest track access route

Photo 4 Access track to pole sets PS5 to PS10

Photo 5 Remnants of sleepers from felled trees as access

Photo 6 Owendalluleagh River crossing (access to pole sets PS22 to PS25)

Photo 7 Shallow cutting in exposed mineral soil as access to pole set PS22

Photo 8 Cutting at 400 kV crossing looking south (400 kV line runs left to right in image)

Photo 9 Cutting at 400 kV crossing looking north (400 kV line runs left to right in image)

Photo 10 View of area between pole set PS37 and angle mast AM38 looking north showing Lough Agannygal

Photo 11 View of area between pole set PS37 and angle mast AM38 looking south showing Lough Agannygal (mast 38 in background)

Photo 12 Cutting in mineral soil at Agannygal substation

Appendix B

AGEC Ground Investigation (2018) – Relevant Trial Pit Logs

Trial Pit Log

agec geotechnical engineering consultants

Trialpit No **TP10** Sheet 1 of 1

Project Name: Derrybrien Wind Farm	Project No. 1806	Co-ords: 163168.00 - 198491.00 Level: 0.00	Date 19/06/2018
Location: Co. Galway		Dimensions (m): 3 × 1.3, Depth 2.90	Scale 1:25
Client: ESBI			Logged M.L.

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
							Soft to firm light orange grey, brown, grey, slightly gravelly slightly sandy CLAY with some cobbles and occasional boulders, (Sub-angular to sub-rounded), and some wood, pockets of peat etc. (Made ground.)
				0.60	-0.60		Soft woody brown fibrous PEAT with branches, brash and vegetation. (Possible made ground or disturbed ground.)
				1.00	-1.00		Soft greyish brown slightly gravelly sandy organic CLAY and clayey organic SAND with decaying rootlets and some cobbles and occasional boulders. (up to 1.0m) (Sub-angular to sub-rounded)
				1.50	-1.50		Firm becoming stiff to very stiff light reddish brown sandy very gravelly SILT/CLAY with many cobbles and some boulders. (Sub-rounded to sub-angular)
				2.00	-2.00		Stiff to very stiff light reddish brown sandy very gravelly (weak siltstone) SILT/CLAY with many cobbles and some boulders. (Sub-rounded to sub-angular)
				2.90	-2.90		End of pit at 2.90 m

1 2 3 4 5

Remarks: TP - DRY.
End of TP - Hard digging.

Stability: Generally stable, minor spalling.

Trial Pit Log

agec geotechnical engineering consultants

Trialpit No **TP11** Sheet 1 of 1

Project Name: Derrybrien Wind Farm	Project No. 1806	Co-ords: 163193.00 - 198438.00 Level: 0.00	Date 19/06/2018
Location: Co. Galway		Dimensions (m): 3 × 1.5 Depth 2.50	Scale 1:25
Client: ESBI			Logged M.L.

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
							Soft to firm light orange grey, reddish brown, brown, grey slightly gravelly slightly sandy CLAY with some cobbles and occasional boulders, (Sub-angular to sub-rounded), and some wood, pockets of peat etc. (Made ground.)
				0.60	-0.60		Disturbed peaty layer - discontinuous.
				0.70	-0.70		Soft grey and orange brown slightly gravelly sandy organic CLAY and clayey organic SAND with decaying rootlets and some cobbles and occasional large boulders. (Sub-angular to sub-rounded)
				1.70	-1.70		Stiff to very stiff light reddish brown sandy very gravelly SILT/CLAY with many cobbles and some boulders. (Sub-rounded to sub-angular)
				2.50	-2.50		End of pit at 2.50 m

1 2 3 4 5

Remarks: No water strike - dry.
End of TP - Hard digging.

Stability: Generally stable, minor spalling.

Appendix C

Methodology for Peat Stability Risk Assessment

Methodology for Peat Stability Risk Assessment

A peat stability risk assessment was carried out for the OHL route between the Derrybrien substation and Agannygal substation. This approach takes into account guidelines for geotechnical/peat stability risk assessments as given in PLHRAG (2017) and MacCulloch (2005). The degree of risk is determined as a Risk Rating (R), which is the product of probability (P) and impact (I). How these factors are determined and applied in the analysis is described below.

The main approaches for assessing peat stability include the following:

(a) Geomorphological
(b) Qualitative (judgement)
(c) Index/Probabilistic (probability)
(d) Deterministic (factor of safety)

Approaches (a) to (c) listed above would be considered subjective and do not provide a definitive indication of stability; in addition, a high level of judgement/experience is required which makes it difficult to relate the findings to real conditions. FT apply a more objective approach, the deterministic approach, in combination with qualitative factors.

Probability

The likelihood of a peat slide occurring is been assessed based on the results of both the quantitative results of stability calculations (deterministic approach using factors of safety) and the assessment of the severity of several qualitative factors which cannot be reasonably included in a stability calculation but nevertheless may affect the occurrence of peat instability.

The qualitative factors used in the risk assessment are outlined in Table A and have been compiled based on FT's experience of assessments and construction in peat land sites and peat slides throughout Ireland and the UK.

Table A Qualitative Factors used to Assess Potential for Peat Failure

Qualitative Factor	Type of Feature / Indicator for each Qualitative Factor (1)	Explanation / Description of Qualitative Factor
Evidence of sub peat water flow	No	Based on site walkover observations. Sub peat water flow generally occurs in the form of natural piping at the base of peat. Where there is a constriction or blockage in natural pipes a build-up of water can occur at the base of the peat causing a reduction in effective stress at the base of the peat resulting in failure; this is particularly critical during periods of intense rainfall.
	Possibly	
	Probably	
	Yes	
Evidence of surface water flow	Dry	Based on site walkover observations. The presence of surface water flow indicates if peat in an area is well drained or saturated and if any additional loading
	Localised/Flowing in drains	

Qualitative Factor	Type of Feature / Indicator for each Qualitative Factor [1]	Explanation / Description of Qualitative Factor
	Ponded in drains	from the ponding of surface water onto the peat is likely.
	Springs/surface water	
Evidence of previous failures/slips	No	Based on site walkover observations. The presence of clustering of relict failures may indicate that particular pre-existing site conditions predispose a site to failure.
	In general area	
	On site	
	Within 500m of location	
Type of vegetation	Grass/Crops	Based on site walkover observations. The type of vegetation present indicates if peat in an area is well drained, saturated, etc. Vegetation that indicates wetter ground may also indicate softer underlying peat deposits.
	Improved Grass/Dry Heather	
	Wet Grassland/Juncus (Rushes)	
	Wetlands Sphagnum (Peat moss)	
General slope characteristics upslope/downslope from infrastructure location	Concave	Based on site walkover observations. Slope morphology in the area of the infrastructure location is an important factor. A number of recorded peat failures have occurred in close proximity to a convex break in slope.
	Planar to concave	
	Planar to convex	
	Convex	
Evidence of very soft/soft clay at base of peat	No	Based on inspection of exposures in general area from site walkover. Several reported peat failures identify the presence of a weak layer at the base of the peat along which shear failure has occurred.
	Yes	
Evidence of mechanically cut peat	No	Based on site walkover observations. Mechanically cut peat typically cut using a 'sausage' machine to extract peat for harvesting. Areas which have been cut in this manner have been linked to peat instability. The mechanical cuts can notably reduce the intrinsic strength of the peat and also allow ingress of rainfall/surface water.
	Yes	

Qualitative Factor	Type of Feature / Indicator for each Qualitative Factor (1)	Explanation / Description of Qualitative Factor
Evidence of quaking or buoyant peat	No	Based on site walkover observations. Quaking/buoyant peat is indicative of highly saturated peat, which would generally be considered to have a low strength. Quaking peat is a feature on sites that have been previously linked with peat instability.
	Yes	
Evidence of bog pools	No	Based on site walkover observations. Bog pools are generally an indicator of areas of weak, saturated peat. Commonly where there are open areas of water within peat these can be interconnected, with the result that there may be sub-surface bodies of water. The presence of bog pools have been previously linked with peat instability.
	Yes	
Other	Varies	In addition to the above features/ indicators and based on site recordings the following are some of the features which may be identified: Excessively deep peat, weak peat, overly steep slope angles, etc.

Note (1) The list of features/indicators for each qualitative factor are given in an approximate increasing order of probability of leading to peat instability/failure.

It should be noted that the presence of one of the qualitative factors alone from Table A is unlikely to lead to peat instability. Peat instability at a site is generally the combination of a number of these factors occurring at the same time at a particular location.

The probability rating assigned to the quantitative and qualitative factors is judged on a 5-point scale from 1 (indicating negligible or no probability of failure) to 5 (indicating a very likely failure), as outlined in Table B. Not applicable occurs where it is not physically possible for failure to occur, for example where no peat is present.

Table B Probability Scale

Scale	Factor of Safety	Probability of Failure
0	Not applicable	Not applicable
1	1.30 or greater	Negligible
2	1.29 to 1.20	Low
3	1.19 to 1.11	Possible
4	1.01 to 1.10	Very Possible
5	≤1.0	Likely

Scale	Likelihood of Qualitative Factor leading to Peat Failure	Probability of Failure
0	Not applicable	Least
1	Negligible	
2	Low	
3	Possible	
4	very Possible	
5	Likely	Greatest

Impact

The severity of the risk is also assessed qualitatively in terms of impact. The impact of a peat slide on the receiving environment within and beyond the overhead line route is assessed based on the potential travel distance and potential volume of a peat slide and the effect on receptors such as local property, infrastructure, and the natural environment.

Where a peat slide enters a watercourse it can travel a considerable distance downstream. Therefore, the proximity of a potential peat slide to a drainage feature is a significant indicator of the likely potential impact. Furthermore, given the elevation of the terrain along the OHL route, the topography in some areas may result in the formation of potential flow paths through naturally occurring features such as dips and falls in the terrain, valleys, etc. Such features would have the effect of increasing the travel distance of and the areas affected by any potential peat slide .

The potential damage to private property is also assessed using this approach. The OHL is located in a sparsely populated location; however, land owners and domestic dwellings may still be at risk in certain areas if a peat slide were to occur. In addition, property such as pasture and tillage farms, private landholdings, and communication/power infrastructure can be susceptible to peat slide. The list of such potential features or receptors identified are outlined in Table C.

Table C Potential Receptors

Receptor	Control
Watercourse (rivers, streams, flow channels, etc.)	Topography
Dwellings (domestic)	
Road (local roads excluding wind farm access tracks)	
Infrastructure (overhead lines, communications infrastructure, etc.)	
Agricultural Land (pasture, etc.)	
Natural Heritage Area (Slieve Aughty Bog NHA)	

Taking the above into consideration, the primary controlling aspect when determining the impact of a potential peat slide, once that slide has occurred, is the topography along the route. For the purposes of this report, the route has been divided into 9 no. subsections for ease of assessment and risk identification.

Topographical data for each subsection has been used to identify the potential flow path(s) in a peat slide situation and as such will be used for determining the severity of the impact. The risk is determined based on the combination of hazard and impact. A 5-point qualitative scale has been devised for the impact of the hazard based on the distance of a potential peat slide arising from works on or near the OHL subsection to a receptor and this is shown in Table D.

Table D Impact Scale

Scale	Criteria	Impact
1	OHL element without potential to effect watercourses, dwellings, infrastructure elements, etc.	Negligible
2	OHL element with low potential to effect watercourses, dwellings, infrastructure elements, etc.	Low
3	OHL element with medium potential to effect watercourses, dwellings, infrastructure elements, etc.	Medium
4	OHL element with high potential to effect watercourses, dwellings, infrastructure elements, etc.	High
5	OHL element with extremely high potential to effect watercourses, dwellings, infrastructure elements, etc.	Extremely High

Each subsection of the route is assigned an impact rating based on a qualitative assessment taking into account the topography and the distance between the OHL route and the receptor and any aggravating or mitigating factors observed during the walkover survey. The location of potential flow paths, watercourses, dwellings, infrastructure, and other such receptors and features are based on topographic maps, aerial imagery, and site observations made during the walkover survey. Note that not all features are shown on maps.

Risk Rating

The degree of risk is determined as the product of probability (P) and impact (I), which gives the Risk Rating (R) as follows:

$$R = P \times I$$

Due to the 5-point scales used to assess Probability and Impact; the Risk Rating can range from 1 to 25 as shown in Table E.

Table E Qualitative Risk Rating

Impact \ Probability	**1**	**2**	**3**	**4**	**5**
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5

Risk Rating & Control Measures	
17 to 25	High: avoid working in area or significant control measures required
11 to 16	Medium: specific control measures required
5 to 10	Low: only routine control measures required
1 to 4	Negligible: none or only routine control measures required

The risk rating is calculated individually for each contributory factor. Control measures are required to reduce the risk to at least a 'Low' risk rating for every individual contributory factor. The control measures in response to the qualitative risk ratings are included in the peat stability risk registers for each OHL subsection in Appendix D. The control measures are targeted at the specific contributory factors that give the highest risk rating.

The risk rating assigned to any subsection is based on the highest risk rating calculated for any contributory factor within that subsection.

Note that some geotechnical interpretation of the results is required as it is the combination of individual contributory factors that are important in determining the risk of a peat slide. For example, in certain sections deep peat may be present that would be given a high risk rating but where the section is on level ground then the risk of a peat slide is not significant.

Appendix D

Results of Peat Stability Risk Assessment

Derrybrien Wind Farm (OHL) - Peat Stability Risk Register (Rev 1)

Location:	**EM1 to PS5**

Start of Subsection (Easting, Northing):	**559935**	**704743**
End of Subsection (Easting, Northing):	**560480**	**704010**
Worst Case Receptor(s):	**Watercourse**	
Potential Impact on Receptor (Note 4):	**High**	
Peat Depth Range (m):	**1.0 to 2.4**	
Control Required:	**Yes**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 5)	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during decommissioning	Prob	Impact	Risk	Risk Rating
1	FOS (worst case) = 2.75(u), 1.83(d)	1	4	4	Negligible	No	See Below	1	4	4	Negligible
2	Evidence of sub peat water flow	0	4	0	Not Applicable	No		0	4	0	Not Applicable
3	Evidence of surface water flow	1	4	4	Negligible	No		1	4	4	Negligible
4	Evidence of previous failures/slips	0	4	0	Not Applicable	No		0	4	0	Not Applicable
5	Type of vegetation	2	4	8	Low	Yes		1	4	4	Negligible
6	General slope characteristics upslope/downslope across section	2	4	8	Low	Yes		1	4	4	Negligible
7	Evidence of very soft/soft clay at base of peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
10	Evidence of bog pools	0	4	0	Not Applicable	No		0	4	0	Not Applicable
11	Low peat strength (<10kPa)	2	4	8	Low	Yes		1	4	4	Negligible
12	Relatively deep peat	2	4	8	Low	Yes		1	4	4	Negligible

	Control Measures to be Implemented during Decommissioning for **EM1 to PS5**
i	Due to relatively deep peat in the section, this will require additional measures such as : - access the working area from the north only, alternative access to the south of pole set 4. Refer to Drawing no. 0007& 0008 Plan Drawing for Decommissioning of Overhead line - use of suitable low load bearing track machinery to gain access to works area - use of suitable plant and equipment for completion of works - routine detailed inspection of area, while works are being carried out - monitoring (in the form of timber stakes as sightlines) to be installed in working areas and monitored regularly during the works - contractor to provide method statement for any proposed works in areas of peat/sloping ground/overhead power lines etc
ii	Maintain hydrology of area as far as possible;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Use of experienced geotechnical staff for site supervision.

Note Ref

(1) Location M1 to PS5 is an abbreviation for Mast 1 to Pole Set 5
(2) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(3) Slope characteristics are typically 6-8 degrees across the section. Locally steep between pole set 4 and 5, up to 17 degree inclination recorded
(4) Impact based on OHL route crossing a watercourse with a PS within 100m upslope of the watercourse.
(5) Probability assessed as per Table A and B of Appendix C

Derrybrien Wind Farm (OHL) - Peat Stability Risk Register (Rev 1)

Location:	**PS5 to AM14**

Start of Subsection (Easting, Northing):	**560480**	**704010**
End of Subsection (Easting, Northing):	**564133**	**702732**
Worst Case Receptor(s):	**Road**	
Potential Impact on Receptor (Note 4):	**High**	
Peat Depth Range (m):	**0.0 to 1.9**	
Control Required:	**Yes**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 5)	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during decommissioning	Prob	Impact	Risk	Risk Rating
1	FOS (worst case) = 1.21(u), 1.23(d)	2	4	8	Low	Yes	See Below	1	4	4	Negligible
2	Evidence of sub peat water flow	0	4	0	Not Applicable	No		0	4	0	Not Applicable
3	Evidence of surface water flow	1	4	4	Negligible	No		1	4	4	Negligible
4	Evidence of previous failures/slips	2	4	8	Low	Yes		1	4	4	Negligible
5	Type of vegetation	3	4	12	Medium	Yes		1	4	4	Negligible
6	General slope characteristics upslope/downslope across section	4	4	16	Medium	Yes		1	4	4	Negligible
7	Evidence of very soft/soft clay at base of peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
10	Evidence of bog pools	0	4	0	Not Applicable	No		0	4	0	Not Applicable
11	Low peat strength (<10kPa)	0	4	0	Not Applicable	No		0	4	0	Not Applicable
12	Relatively deep peat	2	4	8	Low	Yes		1	4	4	Negligible

	Control Measures to be Implemented during Decommissioning for **PS5 to AM14**
i	Due to relatively deep peat in the section, this will require additional measures such as : - Refer to Drawing no. 0007 & 0008 Plan Drawing for Decommissioning of Overhead Line for suitable access routes - use of suitable low load bearing track machinery to gain access to works area - use of suitable plant and equipment for completion of works - routine detailed inspection of area, while works are being carried out - contractor to provide method statement for any proposed works in areas of peat/sloping ground/overhead power lines etc
ii	Maintain hydrology of area as far as possible;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Use of experienced geotechnical staff for site supervision.

Note

(1) Location PS5 to AM14 is an abbreviation for Pole Set 5 to Angle Mast 14
(2) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(3) Slope characteristics are typically 10 degrees across the section. Locally steep around pole set 12 and barrage 2, up to 20 degree inclination recorded
(4) Impact based on presence of road crossing OHL route within 100m downslope of a PS.
(5) Probability assessed as per Table A and B of Appendix C

Derrybrien Wind Farm (OHL) - Peat Stability Risk Register (Rev 1)

Location:	AM14 to AM18

Start of Subsection (Easting, Northing):	**564133**	**702732**
End of Subsection (Easting, Northing):	**560840**	**702074**
Worst Case Receptor(s):	**Watercourse**	
Potential Impact on Receptor (Note 3):	**High**	
Peat Depth Range (m):	**0.2 to 0.6**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 4)	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during decommissioning	Prob	Impact	Risk	Risk Rating
1	FOS (worst case) = 5.39(u), 7.76(d)	1	4	4	Negligible	No	See Below	1	4	4	Negligible
2	Evidence of sub peat water flow	0	4	0	Not Applicable	No		0	4	0	Not Applicable
3	Evidence of surface water flow	0	4	0	Not Applicable	No		0	4	0	Not Applicable
4	Evidence of previous failures/slips	0	4	0	Not Applicable	No		0	4	0	Not Applicable
5	Type of vegetation	1	4	4	Negligible	No		1	4	4	Negligible
6	General slope characteristics upslope/downslope across section	1	4	4	Negligible	No		1	4	4	Negligible
7	Evidence of very soft/soft clay at base of peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
10	Evidence of bog pools	0	4	0	Not Applicable	No		0	4	0	Not Applicable
11	Low peat strength (<10kPa)	0	4	0	Not Applicable	No		0	4	0	Not Applicable
12	Other	0	4	0	Not Applicable	No		0	4	0	Not Applicable

	Control Measures to be Implemented during Decommissioning for **AM14 to AM18**
i	Although specific control measures are not required in the area, good practice should be followed, such as; - Refer to Drawing no. 0007 & 0008 Plan Drawing for Decommissioning of Overhead Line for suitable access routes - use of suitable low load bearing track machinery to gain access to works area - use of suitable plant and equipment for completion of works - routine detailed inspection of area, while works are being carried out - contractor to provide method statement for any proposed works in areas of peat/sloping ground/overhead power lines etc
ii	Maintain hydrology of area as far as possible;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Use of experienced geotechnical staff for site supervision.

Note
(1) Location AM14 to AM18 is an abbreviation for Angle Mast 14 to Angle Mast 18
(2) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(3) Impact based on OHL route crossing a watercourse with a PS within 100m upslope of the watercourse.
(4) Probability assessed as per Table A and B of Appendix C

Derrybrien Wind Farm (OHL) - Peat Stability Risk Register (Rev 1)

Location:	**AM18 to AM24**

Start of Subsection (Easting, Northing):	**560840**	**702074**
End of Subsection (Easting, Northing):	**561759**	**701578**
Worst Case Receptor(s):	**Watercourse**	
Potential Impact on Receptor (Note 4):	**High**	
Peat Depth Range (m):	**0.2 to 0.8**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 5)	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during decommissioning	Prob	Impact	Risk	Risk Rating
1	FOS (worst case)= 1.85(u), 2.57(d)	1	4	4	Negligible	No	See Below	1	4	4	Negligible
2	Evidence of sub peat water flow	0	4	0	Not Applicable	No		0	4	0	Not Applicable
3	Evidence of surface water flow	2	4	8	Low	Yes		1	4	4	Negligible
4	Evidence of previous failures/slips	0	4	0	Not Applicable	No		0	4	0	Not Applicable
5	Type of vegetation	3	4	12	Medium	Yes		1	4	4	Negligible
6	General slope characteristics upslope/downslope across section	3	4	12	Medium	Yes		1	4	4	Negligible
7	Evidence of very soft/soft clay at base of peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
10	Evidence of bog pools	0	4	0	Not Applicable	No		0	4	0	Not Applicable
11	Low peat strength (<10kPa)	0	4	0	Not Applicable	No		0	4	0	Not Applicable
12	Other	0	4	0	Not Applicable	No		0	4	0	Not Applicable

	Control Measures to be Implemented during Decommissioning for **AM18 to AM24**
i	Although specific control measures are not required in the area, good practice should be followed, such as; - Refer to Drawing no. 0007 & 0008 Plan Drawing for Decommissioning of Overhead Line for suitable access routes - use of suitable low load bearing track machinery to gain access to works area - use of suitable plant and equipment for completion of works - routine detailed inspection of area, while works are being carried out - contractor to provide method statement for any proposed works in areas of peat/sloping ground/overhead power lines etc
ii	Maintain hydrology of area as far as possible;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Use of experienced geotechnical staff for site supervision.

Note

(1) Location AM18 to AM24 is an abbreviation for Angle Mast 18 to Angle Mast 24
(2) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(3) Slope characteristics are typically 3-4 degrees across the section. Locally steep between pole set 22 and 23, up to 15 degree inclination recorded
(4) Impact based on OHL route crossing a watercourse with a PS within 100m upslope of the watercourse.
(5) Probability assessed as per Table A and B of Appendix C

Derrybrien Wind Farm (OHL) - Peat Stability Risk Register (Rev 1)

Location:	AM24 to PS28A

Start of Subsection (Easting, Northing):	561759	701578
End of Subsection (Easting, Northing):	562092	700690
Worst Case Receptor(s):	Watercourse	
Potential Impact on Receptor (Note 6):	High	
Peat Depth Range (m):	0.1 to 3.8	
Control Required:	Yes	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 7)	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during decommissioning	Prob	Impact	Risk	Risk Rating
1	FOS (worst case) = 1.09(u), 2.60(d)	4	4	16	Medium	Yes	See Below	1	4	4	Negligible
2	Evidence of sub peat water flow	0	4	0	Not Applicable	No		0	4	0	Not Applicable
3	Evidence of surface water flow	2	4	8	Low	Yes		1	4	4	Negligible
4	Evidence of previous failures/slips	0	4	0	Not Applicable	No		0	4	0	Not Applicable
5	Type of vegetation	2	4	8	Low	Yes		1	4	4	Negligible
6	General slope characteristics upslope/downslope across section	4	4	16	Medium	Yes		2	4	8	Low
7	Evidence of very soft/soft clay at base of peat	2	4	8	Low	Yes		1	4	4	Negligible
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	1	4	4	Negligible	No		1	4	4	Negligible
10	Evidence of bog pools	1	4	4	Negligible	No		1	4	4	Negligible
11	Low peat strength (<10kPa)	0	4	0	Not Applicable	No		0	4	0	Not Applicable
12	Relatively deep peat	3	4	12	Medium	Yes		1	4	4	Negligible

	Control Measures to be Implemented Prior to/and During Construction for **AM24 to PS28A**
i	Due to the depth of peat in the section, this will require additional measures such as : - Refer to Drawing No. 0007 & 0008 Plan Drawing for Decommissioning of Overhead Line for suitable access routes - use of suitable low load bearing track machinery to gain access to works area - use of suitable plant and equipment for completion of works - routine detailed inspection of area, while works are being carried out - monitoring (in the form of timber stakes as sightlines) to be installed in working areas and monitored regularly during the works - contractor to provide method statement for any proposed works in areas of peat/sloping ground/overhead power lines etc
ii	Maintain hydrology of area as far as possible;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Use of experienced geotechnical staff for site supervision.

Note
(1) Location AM24 to PS28A is an abbreviation for Angle Mast 24 to Pole Set 28A
(2) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(3) Slope characteristics are typically 3-5 degrees across the section. Locally steep south of pole set 25, up to 30 degree inclination recorded
(4) Localised areas of very soft, waterlogged and buoyant peat between pole set 27 and 28A
(5) Deepest peat recorded around pole set 28
(6) Impact based on OHL route crossing a watercourse with a PS within 100m upslope of the watercourse.
(7) Probability assessed as per Table A and B of Appendix C

Derrybrien Wind Farm (OHL) - Peat Stability Risk Register (Rev 1)

Location:	**PS28A to PS34**

Start of Subsection (Easting, Northing):	**562092**	**700690**
End of Subsection (Easting, Northing):	**562470**	**699676**
Worst Case Receptor(s):	**Watercourse**	
Potential Impact on Receptor (Note 3):	**High**	
Peat Depth Range (m):	**0.2 to 3.1**	
Control Required:	**Yes**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 4)	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during decommissioning	Prob	Impact	Risk	Risk Rating
1	FOS (worst case)= 1.69(u), 1.49(d)	1	4	4	Negligible	No	See Below	1	4	4	Negligible
2	Evidence of sub peat water flow	0	4	0	Not Applicable	No		0	4	0	Not Applicable
3	Evidence of surface water flow	1	4	4	Negligible	No		1	4	4	Negligible
4	Evidence of previous failures/slips	0	4	0	Not Applicable	No		0	4	0	Not Applicable
5	Type of vegetation	2	4	8	Low	Yes		1	4	4	Negligible
6	General slope characteristics upslope/downslope across section	2	4	8	Low	Yes		1	4	4	Negligible
7	Evidence of very soft/soft clay at base of peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
10	Evidence of bog pools	0	4	0	Not Applicable	No		0	4	0	Not Applicable
11	Low peat strength (<10kPa)	2	4	8	Low	Yes		1	4	4	Negligible
12	Other	2	4	8	Low	Yes		1	4	4	Negligible

	Control Measures to be Implemented Prior During Decommissioning for **PS28A to PS34**
i	Due to the depth of peat in the section, this will require additional measures such as : - Refer to Drawing no. 0007 & 0008 Plan Drawing for Decommissioning of Overhead Line for suitable access routes - use of suitable low load bearing track machinery to gain access to works area - use of suitable plant and equipment for completion of works - routine detailed inspection of area, while works are being carried out - contractor to provide method statement for any proposed works in areas of peat/sloping ground/overhead power lines etc
ii	Maintain hydrology of area as far as possible;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Use of experienced geotechnical staff for site supervision.

Note
(1) Location PS28A to PS34 is an abbreviation for Pole Set 28A to Pole Set 34
(2) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(3) Impact based on OHL route crossing a watercourse with a PS within 100m upslope of the watercourse.
(4) Probability assessed as per Table A and B of Appendix C

Derrybrien Wind Farm (OHL) - Peat Stability Risk Register (Rev 1)

Location:	**PS34 to AM38**

Start of Subsection (Easting, Northing):	**562470**	**699676**
End of Subsection (Easting, Northing):	**563020**	**699126**
Worst Case Receptor(s):	**Road**	
Potential Impact on Receptor (Note 6):	**High**	
Peat Depth Range (m):	**0.0 to 5.6**	
Control Required:	**Yes**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 7)	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during decommissioning	Prob	Impact	Risk	Risk Rating
1	FOS (worst case)= 1.12(u), 1.51(d)	3	4	12	Medium	Yes	See Below	1	4	4	Negligible
2	Evidence of sub peat water flow	0	4	0	Not Applicable	No		0	4	0	Not Applicable
3	Evidence of surface water flow	1	4	4	Negligible	No		1	4	4	Negligible
4	Evidence of previous failures/slips	0	4	0	Not Applicable	No		0	4	0	Not Applicable
5	Type of vegetation	3	4	12	Medium	Yes		1	4	4	Negligible
6	General slope characteristics upslope/downslope across section	3	4	12	Medium	Yes		1	4	4	Negligible
7	Evidence of very soft/soft clay at base of peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	3	4	12	Medium	Yes		1	4	4	Negligible
10	Evidence of bog pools	0	4	0	Not Applicable	No		0	4	0	Not Applicable
11	Low peat strength (<10kPa)	0	4	0	Not Applicable	No		0	4	0	Not Applicable
12	Very deep peat	3	4	12	Medium	Yes		1	4	4	Negligible

	Control Measures to be Implemented during Decommissioning for **PS34 to AM38**
i	Due to the depth of peat in the section, this will require additional measures such as : - Refer to Drawing no. 0007 & 0008 Plan Drawing for Decommissioning of Overhead Line for suitable access routes - use of suitable low load bearing track machinery to gain access to works area - use of suitable plant and equipment for completion of works - routine detailed inspection of area, while works are being carried out - monitoring (in the form of timber stakes as sightlines) to be installed in working areas and monitored regularly during the works - contractor to provide method statement for any proposed works in areas of peat/sloping ground/overhead power lines etc
ii	Maintain hydrology of area as far as possible;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Use of experienced geotechnical staff for site supervision.

Note

(1) Location PS34 to AM38 is an abbreviation for Pole Set 34 to Angle Mast 38
(2) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(3) Slope characteristics are typically 3-5 degrees across the section. Locally steep north of pole set 35, up to 21 degree inclination recorded
(4) Significant area of very soft, waterlogged and buoyant peat between pole set 37 and 38
(5) Deepest peat recorded angle mast 38, about 5.6m deep
(6) Impact based on OHL route crossing a road with a PS within 100m upslope of the road.
(7) Probability assessed as per Table A and B of Appendix C

Derrybrien Wind Farm (OHL) - Peat Stability Risk Register (Rev 1)

Location:	AM38 to EM41

Start of Subsection (Easting, Northing):	**563020**	**699126**
End of Subsection (Easting, Northing):	**563124**	**698618**
Worst Case Receptor(s):	**Dwelling**	
Potential Impact on Receptor (Note 6):	**High**	
Peat Depth Range (m):	**0.0 to 5.6**	
Control Required:	**Yes**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 7)	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during decommissioning	Prob	Impact	Risk	Risk Rating
1	FOS (worst case)= 10.42(u), 8.19(d)	1	4	4	Negligible	No	See Below	1	4	4	Negligible
2	Evidence of sub peat water flow	0	4	0	Not Applicable	No		0	4	0	Not Applicable
3	Evidence of surface water flow	1	4	4	Negligible	No		1	4	4	Negligible
4	Evidence of previous failures/slips	0	4	0	Not Applicable	No		0	4	0	Not Applicable
5	Type of vegetation	3	4	12	Medium	Yes		1	4	4	Negligible
6	General slope characteristics upslope/downslope across section	2	4	8	Low	No		1	4	4	Negligible
7	Evidence of very soft/soft clay at base of peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
10	Evidence of bog pools	0	4	0	Not Applicable	No		0	4	0	Not Applicable
11	Low peat strength (<10kPa)	0	4	0	Not Applicable	No		0	4	0	Not Applicable
12	Very deep peat	3	4	12	Medium	Yes		1	4	4	Negligible

	Control Measures to be Implemented Prior to/and During Construction for **AM38 to PS41**
i	Due to the depth of peat in the section, this will require additional measures such as : - Refer to Drawing no. 0007 & 0008 Plan Drawing for Decommissioning of Overhead Line for suitable access routes - use of suitable low load bearing track machinery to gain access to works area - use of suitable plant and equipment for completion of works - routine detailed inspection of area, while works are being carried out - monitoring (in the form of timber stakes as sightlines) to be installed in working areas and monitored regularly during the works - contractor to provide method statement for any proposed works in areas of peat/sloping ground/overhead power lines etc
ii	Maintain hydrology of area as far as possible;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Use of experienced geotechnical staff for site supervision.

Note

(1) Location AM38 to PS41 is an abbreviation for Angle Mast 38 to Pole Set 41
(2) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(3) Slope characteristics are typically 3-5 degrees across the section.
(4) Deepest peat recorded around angle mast 38, about 5.6m deep
(5) Impact based on OHL route 500m upslope of the dwelling in an area of deep peat.
(6) Probability assessed as per Table A and B of Appendix C

Derrybrien Wind Farm (OHL) - Peat Stability Risk Register (Rev 1)

Location:	Sub-station

Start of Subsection (Easting, Northing):	**563123**	**698619**
End of Subsection (Easting, Northing):	**563123**	**698619**
Worst Case Receptor(s):	**Infrastructure**	
Potential Impact on Receptor (Note 2):	**Negligable**	
Peat Depth Range (m):	**0.0 to 0.0**	
Control Required:	**No**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 3)	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during decommissioning	Prob	Impact	Risk	Risk Rating
1	FOS = na(u), na(d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	0	1	0	Not Applicable	No		0	1	0	Not Applicable
3	Evidence of surface water flow	0	1	0	Not Applicable	No		0	1	0	Not Applicable
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	0	1	0	Not Applicable	No		0	1	0	Not Applicable
6	General slope characteristics upslope/downslope across section	1	1	1	Negligible	No		1	1	1	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Low peat strength (<10kPa)	0	1	0	Not Applicable	No		0	1	0	Not Applicable
12	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	Control Measures to be Implemented during Decommissioning for **Agannygal Sub-Station**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced contractors and trained operators to carry out the work;

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Impact based on absence of peat.
(3) Probability assessed as per Table A and B of Appendix C

Appendix E

Calculated FOS for Peat Stability of Slopes

Calculated FoS of Natural Peat Slopes for Derrybrien Wind Farm OHL (Undrained Analysis)

Turbine No./Waypoint	Easting	Northing	Slope (Note 3)	Undrained shear strength	Bulk unit weight of Peat	Peat Depth (Note 5)	Surcharge Equivalent Placed Fill Depth (m) (Note 2)	Factor of Safety for Load Condition	
			β (deg)	c_u (kPa)	γ (kN/m^3)	(m)	Condition (2)	Condition (1)	Condition (2)
FT DATA (SEPTEMBER 2019)									
Pole 1A	160002	204675	5.0	6	10	2.2	3.2	**3.14**	**2.16**
Pole 2	160086	204563	6.0	6	10	2.1	3.1	**2.75**	**1.86**
Pole 3	160235	204362	4.0	6	10	1.6	2.6	**5.39**	**3.32**
Pole 4	160360	204194	6.0	6	10	1.0	2.0	**5.77**	**2.89**
Pole 5	160520	203976	3.0	6	10	1.3	2.3	**8.83**	**4.99**
Pole 6	160617	203849	3.0	6	10	0.6	1.6	**19.13**	**7.18**
Pole 7	160712	203721	3.0	6	10	0.9	1.9	**12.76**	**6.04**
Pole 8	160820	203575	3.0	6	10	1.5	2.5	**7.65**	**4.59**
Pole 9	160921	203439	4.0	6	10	0.5	1.5	**17.24**	**5.75**
Pole 10	161053	203263	4.0	6	10	0.8	1.8	**10.78**	**4.79**
Pole 11	161183	203088	4.0	6	10	0.1	1.1	**86.22**	**7.84**
Pole 12	161294	202940	4.0	6	10	0.5	1.5	**17.24**	**5.75**
Pole 13	161386	202815	2.0	6	10	0.2	1.2	**86.01**	**14.34**
Angle Mast 14	161474	202698	1.0	6	10	0.7	1.7	**49.12**	**20.23**
Pole 15	161359	202569	3.0	6	10	0.5	1.5	**22.96**	**7.65**
Pole 16	161206	202401	2.0	6	10	0.3	1.3	**57.34**	**13.23**
Pole 17	161032	202208	2.0	6	10	0.6	1.6	**28.67**	**10.75**
Angle Mast 18	160881	202041	5.0	6	10	0.3	1.3	**23.04**	**5.32**
Pole 19	160992	201940	2.0	6	10	0.9	1.9	**19.11**	**9.05**
Angle Mast 20	161091	201850	3.0	6	10	0.2	1.2	**57.40**	**9.57**
Pole 21	161256	201778	5.0	6	10	0.4	1.4	**17.28**	**4.94**
Pole 22	161421	201707	10.0	6	10	0.5	1.5	**7.02**	**2.34**
Pole 23	161642	201613	3.0	6	10	0.5	1.5	**22.96**	**7.65**
Angle Mast 24	161800	201545	4.0	6	10	0.8	1.8	**10.78**	**4.79**
Pole 25	161854	201394	10.0	6	10	0.2	1.2	**17.54**	**2.92**
Pole 26	161960	201114	6.0	6	10	0.6	1.6	**9.62**	**3.61**
Pole 27	162016	200964	10.0	6	10	0.5	1.5	**7.02**	**2.34**
Pole 28	162097	200749	2.0	6	10	3.8	4.8	**4.53**	**3.58**
Pole 28A	162133	200656	2.0	6	10	0.8	1.8	**21.50**	**9.56**
Pole 29	162196	200487	2.0	6	10	0.9	1.9	**19.11**	**9.05**
Angle Mast 30	162259	200318	4.0	6	10	0.1	1.1	**86.22**	**7.84**
Pole 31	162343	200093	7.0	6	10	0.4	1.4	**12.40**	**3.54**
Pole 32	162417	199897	3.0	6	10	0.3	1.3	**38.27**	**8.83**
Pole 33	162476	199738	2.0	6	10	2.3	3.3	**7.48**	**5.21**
Angle Mast 34	162511	199643	3.0	No peat encountered					
Pole 35	162702	199452	5.0	6	10	1.1	2.1	**6.28**	**3.29**
Pole 36	162801	199353	3.0	6	10	3.2	4.2	**3.59**	**2.73**
Pole 37	162878	199275	1.0	6	10	0.5	1.5	**68.77**	**22.92**
Angle Mast 38	163060	199092	1.0	6	10	2.5	3.5	**13.75**	**9.82**
Pole 39	163102	198897	2.0	6	10	1.8	2.8	**9.56**	**6.14**
Pole 40	195225	363039	4.0	6	10	1.0	2.0	**8.62**	**4.31**
Angle Mast 41	163164	198584	2.0	No peat encountered					

Calculated FoS of Natural Peat Slopes for Derrybrien Wind Farm OHL (Undrained Analysis)

Turbine No./Waypoint	Easting	Northing	Slope (Note 3)	Undrained shear strength	Bulk unit weight of Peat	Peat Depth (Note 5)	Surcharge Equivalent Placed Fill Depth (m) (Note 2)	Factor of Safety for Load Condition	
			β (deg)	c_u (kPa)	γ (kN/m^3)	(m)	Condition (2)	Condition (1)	Condition (2)
AGEC DATA (JUNE 2018)									
Pole 1A	160002	204675	0.5	6	10	1.8	2.8	**38.20**	**24.56**
WP 1	160047	204613	3.0	6	10	1.4	2.4	**8.20**	**4.78**
Pole 2	160086	204563	0.5	6	10	2.4	3.4	**28.65**	**20.22**
WP 2	160158	204461	0.5	6	10	1.9	2.9	**36.19**	**23.71**
Pole 3	160235	204362	0.5	6	10	2.0	3.0	**34.38**	**22.92**
WP 3	160295	204291	0.5	6	10	1.8	2.8	**38.20**	**24.56**
Pole 4	160360	204194	6.0	6	10	1.1	2.1	**5.25**	**2.75**
Pole 5	160520	203976	2.0	6	10	1.8	2.8	**9.56**	**6.14**
Pole 6	160617	203849	3.0	6	10	1.0	2.0	**11.48**	**5.74**
Pole 7	160712	203721	6.0	6	10	0.5	1.5	**11.54**	**3.85**
WP 4	160867	203534	10.0	6	10	1.9	2.9	**1.85**	**1.21**
Pole 8	160820	203575	0.5	6	10	1.7	2.7	**40.45**	**25.47**
Pole 9	160921	203439	0.5	6	10	0.8	1.8	**85.95**	**38.20**
WP 5	161003	203325	0.5	6	10	0.5	1.5	**137.52**	**45.84**
Pole 10	161053	203263	4.0	6	10	0.8	1.8	**10.78**	**4.79**
WP 6	161114	203187	4.0	6	10	0.2	1.2	**43.11**	**7.19**
Pole 11	161183	203088	0.5	No peat encountered					
WP 7	161247	203003	20.0	6	10	0.2	1.2	**9.33**	**1.56**
Pole 12	161294	202940	0.5	6	10	0.3	1.3	**229.19**	**52.89**
WP 8	161357	202861	0.5	6	10	0.8	1.8	**85.95**	**38.20**
Pole 13	161386	202815	0.5	No peat encountered					
WP 9	161425	202749	0.5	6	10	0.5	1.5	**137.52**	**45.84**
Angle Mast 14	161474	202698	5.0	No peat encountered					
Pole 15	161359	202569	12.0	No peat encountered					
WP 10	161252	202448	5.0	No peat encountered					
Pole 16	161206	202401	4.0	6	10	0.2	1.2	**43.11**	**7.19**
WP11	161097	202274	0.5	6	10	0.5	1.5	**137.52**	**45.84**
Pole 17	161032	202208	4.0	6	10	0.2	1.2	**43.11**	**7.19**
WP 12	160960	202126	4.0	6	10	0.6	1.6	**14.37**	**5.39**
Angle Mast 18	160881	202041	0.5	No peat encountered					
Pole 19	160992	201940	4.0	No peat encountered					
Pole 20	161091	201850	0.5	No peat encountered					
Pole 21	161256	201778	0.5	6	10	0.8	1.8	**85.95**	**38.20**
Pole 22	161421	201707	6.0	6	10	0.8	1.8	**7.21**	**3.21**
WP 15	161522	201668	0.5	6	10	0.5	1.5	**137.52**	**45.84**
WP 16	161540	201659	15.0	6	10	0.3	1.3	**8.00**	**1.85**
Pole 23	161642	201613	0.5	6	10	0.6	1.6	**114.60**	**42.97**
Pole 24	161800	201545	7.0	6	10	0.4	1.4	**12.40**	**3.54**
WP 17	161832	201460	2.0	6	10	1.5	2.5	**11.47**	**6.88**
Pole 25	161854	201394	7.0	6	10	0.2	1.2	**24.80**	**4.13**
WP 18	161885	201296	12.0	6	10	1.7	2.7	**1.74**	**1.09**
WP 19	161893	201193	5.0	6	10	0.9	1.9	**7.68**	**3.64**
Pole 26	161960	201114	12.0	6	10	0.6	1.6	**4.92**	**1.84**
WP 20	161987	201046	3.0	6	10	0.2	1.2	**57.40**	**9.57**
Pole 27	162016	200964	8.0	6	10	0.2	1.2	**21.77**	**3.63**
WP 21	162093	200863	0.5	6	10	2.6	3.6	**26.45**	**19.10**
Pole 28	162097	200749	0.5	6	10	3.8	4.8	**18.09**	**14.32**
Pole 28A-WP 22	162133	200656	0.5	6	10	1.6	2.6	**42.97**	**26.45**
Pole 29	162196	200487	0.5	6	10	1.4	2.4	**49.11**	**28.65**
Pole 30	162259	200318	0.5	6	10	0.4	1.4	**171.90**	**49.11**
Pole 31	162343	200093	7.0	6	10	0.2	1.2	**24.80**	**4.13**
Pole 32	162417	199897	0.5	6	10	0.4	1.4	**171.90**	**49.11**
Pole 33	162476	199738	5.0	6	10	3.1	4.1	**2.23**	**1.69**
Pole 34	162511	199643	3.0	6	10	2.2	3.2	**5.22**	**3.59**
WP23	162631	199512	21.0	6	10	0.6	1.6	**2.99**	**1.12**
Pole 35	162702	199452	8.0	6	10	1.2	2.2	**3.63**	**1.98**
Pole 36	162801	199353	0.5	6	10	4.7	5.7	**14.63**	**12.06**
Pole 37	162878	199275	0.5	6	10	1.2	2.2	**57.30**	**31.25**
WP 26	162952	199157	1.0	6	10	2.2	3.2	**15.63**	**10.75**
Angle Mast 38	163060	199092	0.5	6	10	5.6	6.6	**12.28**	**10.42**
Pole 39	163102	198897	0.5	6	10	2.2	3.2	**31.25**	**21.49**
Pole 40	195225	363039	0.5	6	10	1.1	2.1	**62.51**	**32.74**
Angle Mast 41	163164	198584	0.5	No peat encountered					

Calculated FoS of Natural Peat Slopes for Derrybrien Wind Farm OHL (Undrained Analysis)

Turbine No./Waypoint	Easting	Northing	Slope (Note 3)	Undrained shear strength	Bulk unit weight of Peat	Peat Depth (Note 5)	Surcharge Equivalent Placed Fill Depth (m) (Note 2)	Factor of Safety for Load Condition	
			β (deg)	c_u (kPa)	γ (kN/m^3)	(m)	Condition (2)	Condition (1)	Condition (2)
ESBI DATA (2004 & 2005)									
1	160403	204120	4.0	6	10	0.2	1.2	**43.01**	**7.17**
2	160392	204135	6.0	6	10	0.2	1.2	**28.70**	**4.78**
3	160386	204144	6.0	6	10	0.9	1.9	**6.38**	**3.02**
4	160136	204496	0.5	6	10	0.9	1.9	**76.58**	**36.28**
5	160363	204177	6.0	6	10	1.0	2.0	**5.77**	**2.89**
6	160344	204204	6.0	6	10	1.0	2.0	**5.77**	**2.89**
7	160333	204219	6.0	6	10	1.2	2.2	**4.78**	**2.61**
8	160295	204271	4.0	6	10	1.2	2.2	**7.21**	**3.93**
9	160126	204510	0.5	6	10	1.3	2.3	**53.18**	**30.06**
10	160279	204293	4.0	6	10	1.4	2.4	**6.18**	**3.60**
11	160168	204446	0.5	6	10	1.4	2.4	**49.23**	**28.72**
12	160073	204591	3.0	6	10	1.4	2.4	**8.19**	**4.78**
13	160108	204538	3.0	6	10	1.5	2.5	**7.66**	**4.60**
14	159982	204618	0.5	6	10	1.5	2.5	**45.84**	**27.50**
15	160005	204630	0.5	6	10	1.5	2.5	**45.90**	**27.54**
16	160040	204640	3.0	6	10	1.5	2.5	**7.65**	**4.59**
17	160085	204667	3.0	6	10	1.5	2.5	**7.64**	**4.59**
18	160152	204471	0.5	6	10	1.6	2.6	**42.97**	**26.45**
19	160313	204247	6.0	6	10	1.7	2.7	**3.38**	**2.13**
20	160259	204320	0.5	6	10	1.8	2.8	**38.25**	**24.59**
21	160216	204378	0.5	6	10	1.8	2.8	**38.20**	**24.56**
22	160055	204617	3.0	6	10	1.8	2.8	**6.40**	**4.12**
23	160029	204645	3.0	6	10	1.8	2.8	**6.37**	**4.09**
24	159991	204653	0.5	6	10	1.8	2.8	**38.20**	**24.56**
25	160052	204656	2.0	6	10	1.8	2.8	**9.56**	**6.15**
26	160059	204689	3.0	6	10	1.8	2.8	**6.38**	**4.10**
27	160237	204349	0.5	6	10	1.9	2.9	**36.19**	**23.71**
28	160091	204563	3.0	6	10	1.9	2.9	**6.04**	**3.96**
29	160199	204400	0.5	6	10	2.0	3.0	**34.43**	**22.95**
30	160027	204660	3.0	6	10	2.0	3.0	**5.73**	**3.82**
31	160011	204684	2.0	6	10	2.1	3.1	**8.20**	**5.55**
32	160185	204421	0.5	6	10	2.6	3.6	**26.45**	**19.10**
							Minimum =	**1.74**	**1.09**
							Maximum =	**229.19**	**52.89**
							Average =	**32.53**	**12.88**

Notes:

(1) Assuming a bulk unit weight for peat of 10kN/m^3

(2) Assuming a surcharge equivalent to fill depth of 1m of peat i.e. 10kPa. (Condition 2)

(3) Slope inclination (β) based on site readings and site contour plans.

(4) A lower bound undrained shear strength, cu for the peat of 6kPa was selected for the assessment. It should be noted that a cu of 6kPa for the pea is considered a conservative value for the analysis and is not representative of all peat present across the site. In reality the peat on site has a significantly higher undrained strength.

(5) Peat depths based on probes carried out by FT (2019), AGEC and ESBI (June 2018

(6) For load conditions see report text.

Calculated FoS of Natural Peat Slopes for Derrybrien Wind Farm OHL (Drained Analysis)

Turbine No./Waypoint	Slope (Note 3)	Design c'	Bulk unit weight of Peat	Unit weight of Water	100% Water to height of Peat	Depth of In situ Peat (Note 5)	Friction Angle	Equivalent Total Depth of Peat (m) (Note 2)	Factor of Safety for Load Condition	
	α (deg)	c' (kPa)	γ (kN/m^3)	γ_w (kN/m^3)	(m)	(m)	ø' (deg)	Condition (2)	Condition (1)	Condition (2)
									100% Water	100% Water
FT DATA (2019)										
Pole 1A	5.0	4	10.0	10.0	2.2	2.2	25	3.2	**2.09**	**3.11**
Pole 2	6.0	4	10.0	10.0	2.1	2.1	25	3.1	**1.83**	**2.67**
Pole 3	4.0	4	10.0	10.0	1.6	1.6	25	2.6	**3.59**	**4.78**
Pole 4	6.0	4	10.0	10.0	1.0	1.0	25	2.0	**3.85**	**4.14**
Pole 5	3.0	4	10.0	10.0	1.3	1.3	25	2.3	**5.89**	**7.20**
Pole 6	3.0	4	10.0	10.0	0.6	0.6	25	1.6	**12.76**	**10.34**
Pole 7	3.0	4	10.0	10.0	0.9	0.9	25	1.9	**8.50**	**8.71**
Pole 8	3.0	4	10.0	10.0	1.5	1.5	25	2.5	**5.10**	**6.62**
Pole 9	4.0	4	10.0	10.0	0.5	0.5	25	1.5	**11.50**	**8.28**
Pole 10	4.0	4	10.0	10.0	0.8	0.8	25	1.8	**7.19**	**6.90**
Pole 11	4.0	4	10.0	10.0	0.1	0.1	25	1.1	**57.48**	**11.29**
Pole 12	4.0	4	10.0	10.0	0.5	0.5	25	1.5	**11.50**	**8.28**
Pole 13	2.0	4	10.0	10.0	0.2	0.2	25	1.2	**57.34**	**20.68**
Angle Mast 14	1.0	4	10.0	10.0	0.7	0.7	25	1.7	**32.75**	**29.20**
Pole 15	3.0	4	10.0	10.0	0.5	0.5	25	1.5	**15.31**	**11.03**
Pole 16	2.0	4	10.0	10.0	0.3	0.3	25	1.3	**38.23**	**19.09**
Pole 17	2.0	4	10.0	10.0	0.6	0.6	25	1.6	**19.11**	**15.51**
Angle Mast 18	5.0	4	10.0	10.0	0.3	0.3	25	1.3	**15.36**	**7.64**
Pole 19	2.0	4	10.0	10.0	0.9	0.9	25	1.9	**12.74**	**13.06**
Angle Mast 20	3.0	4	10.0	10.0	0.2	0.2	25	1.2	**38.27**	**13.79**
Pole 21	5.0	4	10.0	10.0	0.4	0.4	25	1.4	**11.52**	**7.10**
Pole 22	10.0	4	10.0	10.0	0.5	0.5	25	1.5	**4.68**	**3.32**
Pole 23	3.0	4	10.0	10.0	0.5	0.5	25	1.5	**15.31**	**11.03**
Angle Mast 24	4.0	4	10.0	10.0	0.8	0.8	25	1.8	**7.19**	**6.90**
Pole 25	10.0	4	10.0	10.0	0.2	0.2	25	1.2	**11.70**	**4.15**
Pole 26	6.0	4	10.0	10.0	0.6	0.6	25	1.6	**6.41**	**5.18**
Pole 27	10.0	4	10.0	10.0	0.5	0.5	25	1.5	**4.68**	**3.32**
Pole 28	2.0	4	10.0	10.0	3.8	3.8	25	4.8	**3.02**	**5.17**
Pole 28A-WP 22	2.0	4	10.0	10.0	0.8	0.8	25	1.8	**14.34**	**13.79**
Pole 29	2.0	4	10.0	10.0	0.9	0.9	25	1.9	**12.74**	**13.06**
Angle Mast 30	4.0	4	10.0	10.0	0.1	0.1	25	1.1	**57.48**	**11.29**
Pole 31	7.0	4	10.0	10.0	0.4	0.4	25	1.4	**8.27**	**5.07**
Pole 32	3.0	4	10.0	10.0	0.3	0.3	25	1.3	**25.51**	**12.73**
Pole 33	2.0	4	10.0	10.0	2.3	2.3	25	3.3	**4.99**	**7.52**
Angle Mast 34	3.0	No peat encountered								
Pole 35	5.0	4	10.0	10.0	1.1	1.1	25	2.1	**4.19**	**4.73**
Pole 36	3.0	4	10.0	10.0	3.2	3.2	25	4.2	**2.39**	**3.94**
Pole 37	1.0	4	10.0	10.0	0.5	0.5	25	1.5	**45.85**	**33.09**
Angle Mast 38	1.0	4	10.0	10.0	2.5	2.5	25	3.5	**9.17**	**14.18**
Pole 39	2.0	4	10.0	10.0	1.8	1.8	25	2.8	**6.37**	**8.86**
Pole 40	4.0	4	10.0	10.0	1.0	1.0	25	2.0	**5.75**	**6.21**
Angle Mast 41	2.0	No peat encountered								

Calculated FoS of Natural Peat Slopes for Derrybrien Wind Farm OHL (Drained Analysis)

Turbine No./Waypoint	Slope (Note 3)	Design c'	Bulk unit weight of Peat	Unit weight of Water	100% Water to height of Peat	Depth of In situ Peat (Note 5)	Friction Angle	Equivalent Total Depth of Peat (m) (Note 2)	Factor of Safety for Load Condition	
	α (deg)	c' (kPa)	γ (kN/m^3)	γ_w (kN/m^3)	(m)	(m)	ø' (deg)	Condition (2)	Condition (1)	Condition (2)
									100% Water	100% Water
AGEC DATA (2018)										
Pole 1A	0.5	4	10.0	10.0	1.8	1.8	25	2.8	**25.47**	**35.45**
WP 1	3.0	4	10.0	10.0	1.4	1.4	25	2.4	**5.47**	**6.90**
Pole 2	0.5	4	10.0	10.0	2.4	2.4	25	3.4	**19.10**	**29.20**
WP 2	5.0	4	10.0	10.0	1.9	1.9	25	1.9	**2.42**	**2.42**
Pole 3	0.5	4	10.0	10.0	2.0	2.0	25	3.0	**22.92**	**33.09**
WP 3	0.5	4	10.0	10.0	1.8	1.8	25	1.8	**25.47**	**25.47**
Pole 4	6.0	4	10.0	10.0	1.1	1.1	25	2.1	**3.50**	**3.94**
Pole 5	2.0	4	10.0	10.0	1.8	1.8	25	2.8	**6.37**	**8.86**
Pole 6	3.0	4	10.0	10.0	1.0	1.0	25	2.0	**7.65**	**8.28**
Pole 7	6.0	4	10.0	10.0	0.5	0.5	25	1.5	**7.70**	**5.52**
WP 4	10.0	4	10.0	10.0	1.9	1.9	25	2.9	**1.23**	**1.72**
Pole 8	0.5	4	10.0	10.0	1.7	1.7	25	2.7	**26.96**	**36.77**
Pole 9	0.5	4	10.0	10.0	0.8	0.8	25	1.8	**57.30**	**55.15**
WP 5	0.5	4	10.0	10.0	0.5	0.5	25	1.5	**91.68**	**66.18**
Pole 10	4.0	4	10.0	10.0	0.8	0.8	25	1.8	**7.19**	**6.90**
WP 6	4.0	4	10.0	10.0	0.2	0.2	25	1.2	**28.74**	**10.35**
Pole 11	4.0	No peat encountered								
WP 7	20.0	4	10.0	10.0	0.2	0.2	25	1.2	**6.22**	**2.10**
Pole 12	0.5	4	10.0	10.0	0.3	0.3	25	1.3	**152.80**	**76.36**
WP 8	0.5	4	10.0	10.0	0.8	0.8	25	1.8	**57.30**	**55.15**
Pole 13	2.0	No peat encountered								
WP 9	0.5	4	10.0	10.0	0.5	0.5	25	1.5	**91.68**	**66.18**
Angle Mast 14	1.5	No peat encountered								
Pole 15	12.0	No peat encountered								
WP 10	5.0	No peat encountered								
Pole 16	0.5	4	10.0	10.0	0.2	0.2	25	1.2	**229.19**	**82.73**
WP11	0.5	4	10.0	10.0	0.5	0.5	25	1.5	**91.68**	**66.18**
Pole 17	4.0	4	10.0	10.0	0.2	0.2	25	1.2	**28.74**	**10.35**
WP 12	4.0	4	10.0	10.0	0.6	0.6	25	1.6	**9.58**	**7.76**
Angle Mast 18	0.5	No peat encountered								
Pole 19	4.0	No peat encountered								
Pole 20	0.5	No peat encountered								
Pole 21	0.5	4	10.0	10.0	0.8	0.8	25	1.8	**57.30**	**55.15**
Pole 22	6.0	4	10.0	10.0	0.8	0.8	25	1.8	**4.81**	**4.60**
WP 15	0.5	4	10.0	10.0	0.5	0.5	25	1.5	**91.68**	**66.18**
WP 16	15.0	4	10.0	10.0	0.3	0.3	25	1.3	**5.33**	**2.57**
Pole 23	0.5	4	10.0	10.0	0.6	0.6	25	1.6	**76.40**	**62.05**
Pole 24	0.5	4	10.0	10.0	0.4	0.4	25	1.4	**114.60**	**70.91**
WP 17	0.5	4	10.0	10.0	1.5	1.5	25	2.5	**30.56**	**39.71**
Pole 25	7.0	4	10.0	10.0	0.2	0.2	25	1.2	**16.53**	**5.92**
WP 18	2.0	4	10.0	10.0	1.7	1.7	25	2.7	**6.75**	**9.19**
WP 19	5.0	4	10.0	10.0	0.9	0.9	25	1.9	**5.12**	**5.23**
Pole 26	12.0	4	10.0	10.0	0.6	0.6	25	1.6	**3.28**	**2.60**
WP 20	3.0	4	10.0	10.0	0.2	0.2	25	1.2	**38.27**	**13.79**
Pole 27	8.0	4	10.0	10.0	0.2	0.2	25	1.2	**14.51**	**5.18**
WP 21	2.5	4	10.0	10.0	2.6	2.6	25	3.6	**3.53**	**5.52**
Pole 28	0.5	4	10.0	10.0	3.8	3.8	25	4.8	**12.06**	**20.68**
Pole 28A-WP 22	0.5	4	10.0	10.0	1.6	1.6	25	2.6	**28.65**	**38.18**
Pole 29	0.5	4	10.0	10.0	1.4	1.4	25	2.4	**32.74**	**41.36**
Pole 30	0.5	4	10.0	10.0	0.4	0.4	25	1.4	**114.60**	**70.91**
Pole 31	7.0	4	10.0	10.0	0.2	0.2	25	1.2	**16.53**	**5.92**
Pole 32	0.5	4	10.0	10.0	0.4	0.4	25	1.4	**114.60**	**70.91**
Pole 33	5.0	4	10.0	10.0	3.1	3.1	25	4.1	**1.49**	**2.42**
Pole 34	3.0	4	10.0	10.0	2.2	2.2	25	3.2	**3.48**	**5.17**
WP23	21.0	4	10.0	10.0	0.6	0.6	25	1.6	**1.99**	**1.51**
Pole 35	8.0	4	10.0	10.0	1.2	1.2	25	2.2	**2.42**	**2.83**
Pole 36	0.5	4	10.0	10.0	4.7	4.7	25	5.7	**9.75**	**17.42**
Pole 37	0.5	4	10.0	10.0	1.2	1.2	25	2.2	**38.20**	**45.12**
WP 26	1.0	4	10.0	10.0	2.2	2.2	25	3.2	**10.42**	**15.51**
Angle Mast 38	0.5	4	10.0	10.0	5.6	5.6	25	6.6	**8.19**	**15.04**
Pole 39	0.5	4	10.0	10.0	2.2	2.2	25	3.2	**20.84**	**31.02**
Pole 40	0.5	4	10.0	10.0	1.1	1.1	25	2.1	**41.67**	**47.27**
Angle Mast 41	0.5	No peat encountered								

Calculated FoS of Natural Peat Slopes for Derrybrien Wind Farm OHL (Drained Analysis)

Turbine No./Waypoint	Slope (Note 3)	Design c'	Bulk unit weight of Peat	Unit weight of Water	100% Water to height of Peat	Depth of In situ Peat (Note 5)	Friction Angle	Equivalent Total Depth of Peat (m) (Note 2)	Factor of Safety for Load Condition	
	α (deg)	c' (kPa)	γ (kN/m^3)	γ_w (kN/m^3)	(m)	(m)	ø' (deg)	Condition (2)	Condition (1)	Condition (2)
									100% Water	100% Water
ESBI DATA (2004 & 2005)										
1	4.0	4	10	10	0.2	0.2	25	1.2	**28.74**	**10.35**
2	6.0	4	10	10	0.2	0.2	25	1.2	**19.24**	**6.90**
3	6.0	4	10	10	0.9	0.9	25	1.9	**4.28**	**4.36**
4	0.5	4	10	10	0.9	0.9	25	1.9	**50.93**	**52.25**
5	6.0	4	10	10	1.0	1.0	25	2.0	**3.85**	**4.14**
6	6.0	4	10	10	1.0	1.0	25	2.0	**3.85**	**4.14**
7	6.0	4	10	10	1.2	1.2	25	2.2	**3.21**	**3.77**
8	4.0	4	10	10	1.2	1.2	25	2.2	**4.79**	**5.64**
9	0.5	4	10	10	1.3	1.3	25	2.3	**35.26**	**43.16**
10	4.0	4	10	10	1.4	1.4	25	2.4	**4.11**	**5.17**
11	0.5	4	10	10	1.4	1.4	25	2.4	**32.74**	**41.36**
12	3.0	4	10	10	1.4	1.4	25	2.4	**5.47**	**6.90**
13	3.0	4	10	10	1.5	1.5	25	2.5	**5.10**	**6.62**
14	0.5	4	10	10	1.5	1.5	25	2.5	**30.56**	**39.71**
15	0.5	4	10	10	1.5	1.5	25	2.5	**30.56**	**39.71**
16	3.0	4	10	10	1.5	1.5	25	2.5	**5.10**	**6.62**
17	3.0	4	10	10	1.5	1.5	25	2.5	**5.10**	**6.62**
18	0.5	4	10	10	1.6	1.6	25	2.6	**28.65**	**38.18**
19	6.0	4	10	10	1.7	1.7	25	2.7	**2.26**	**3.07**
20	0.5	4	10	10	1.8	1.8	25	2.8	**25.47**	**35.45**
21	0.5	4	10	10	1.8	1.8	25	2.8	**25.47**	**35.45**
22	3.0	4	10	10	1.8	1.8	25	2.8	**4.25**	**5.91**
23	3.0	4	10	10	1.8	1.8	25	2.8	**4.25**	**5.91**
24	0.5	4	10	10	1.8	1.8	25	2.8	**25.47**	**35.45**
25	2.0	4	10	10	1.8	1.8	25	2.8	**6.37**	**8.86**
26	3.0	4	10	10	1.8	1.8	25	2.8	**4.25**	**5.91**
27	0.5	4	10	10	1.9	1.9	25	2.9	**24.13**	**34.23**
28	3.0	4	10	10	1.9	1.9	25	2.9	**4.03**	**5.71**
29	0.5	4	10	10	2.0	2.0	25	3.0	**22.92**	**33.09**
30	3.0	4	10	10	2.0	2.0	25	3.0	**3.83**	**5.52**
31	2.0	4	10	10	2.1	2.1	25	3.1	**5.46**	**8.01**
32	0.5	4	10	10	2.6	2.6	25	3.6	**17.63**	**27.58**
								Minimum =	**1.23**	**1.51**
								Maximum =	**229.19**	**82.73**
								Average =	**24.06**	**19.46**

Notes:

(1) Assuming a bulk unit weight of peat of 10 (kN/m^3)
(2) Assuming a surcharge equivalent to fill depth of 1m of peat i.e. 10kPa. (Condition 2)
(3) Slope inclination (β) based on site readings and contour survey plans of site.
(4) FoS is based on slope inclination and shear test results obtained from published data
(5) Peat depths based on probes carried out by AGEC and ESBI (June 2018)
(6) For load conditions see report text.
(7) Minimum acceptable factor of safety required of 1.3 for first-time failures based on BS: 6031:1981 Code of practice for Earthworks

Appendix F

ESB Report on Slope Stability Assessment of a Section of Ground under OHL

Hibernian Wind Power

Derrybrien Wind Farm, Co Galway

Slope stability assessment of a section of ground under overhead line

Report Number: P78015-R476-002

ESBI Engineering and Facilities Management

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16th February 2006

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File Reference: *P78015-F476-030*

Client: *Hibernian Wind Power*

Project Title: *Derrybrien Wind Farm, Co. Galway*

Report Title: *Slope stability assessment of a section of ground under overhead line*

Report No.: **P78015-R476-002**

Rev. No.:

Volume 1 of 1

PRODUCED: Samir Hebib	*DATE: 16th February 2006*
CHECKED: Con Sheahan	*DATE: 16th February 2006*
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Change History of Report

Date	New Rev	Author	Summary of Change

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Summary

A slope stability assessment of a section of ground under the existing overhead line between the windfarm substation and the containment barrage BD2 has been carried out.

Results of that assessment shows that the ground has adequate factor of safety against a slip failure under an external surcharge of 20kPa.

1.0 Introduction

A geotechnical site investigation was carried out along a section of the overhead line at the Derrybrien windfarm. The investigation focused on a section of ground, under the overhead line, between the windfarm substation and a location approximately 700m south of the substation, which coincides with an existing Coillte track, as this section was considered to be the most critical one in terms of existing slope gradients and thickness of peat subsoil. The remaining section of ground, under the overhead line, extending south from the Coillte track to the containment barrage BD2, see Figure 2, is characterised by shallower slope gradients and a peat thickness of less than 1m; rock exposures can in fact be observed in the vicinity of the containment barrage. Furthermore, a 0.5m thick peat layer has been laid out on the existing peat surface close to the containment barrage.

The geotechnical investigation comprised measurement of ground slope angles at regular intervals; frequency was dictated by changes in ground topography, probing of the ground using 0.9m long coupled rods to assess in-situ peat thickness and shear vane tests to assess the shear strength of the peat subsoil. The shear vane tests were carried out subsequent to slope angle measurements and probing of peat depth in order to concentrate in locations which were considered to present a critical combination of steep slope angles and thick peat layer – see Figure 2 for location of shear vane tests and Figure 1 for a profile of the ground topography and peat depths.

2.0 Slope stability assessment

The stability of the existing ground was assessed at different locations along the section investigated assuming critical combination of slope angle, peat depth and shear strength and using an infinite slope method of analysis (Skempton & Delory, 1957). This method is suited to long downslope lengths where the mode of failure is translational sliding, such as that which occurred at the site in October 2003. The infinite slope method is conservative in that no end resistance is assumed.

Stability of the existing ground was assessed assuming two different loading conditions: (1) load condition no.1 where no external load is imposed on the peat surface and (2) load condition no.2 where an external load of 20kPa is applied on the peat surface to simulate pressure applied by a typical 20t weight tracked construction plant. The British Standard "Code of Practice for Earthworks" BS6031:1981 states that for a first time failure with a good standard of site investigation, the design factor of safety should be between 1.3 and 1.4. For the purpose of this exercise a factor of safety of 1.4 was used.

Results of slope stability analyses for the section of ground, described above are shown in Table 1. These results have been also presented in a previous report on ESBIE geotechnical testing (report 78015-C11-R1-REV1). For the remaining section of ground, under the overhead line, between the Coillte track and the containment barrage BD2, a conservative slope angle of 5deg and peat thickness of 1m was assumed throughout. A

minimum required shear strength value for the peat was therefore computed in order to achieve a factor of safety of 1.4. This minimum value was subsequently compared to the lowest results obtained from the shear vane tests carried out north of the Coillte track.

Table 1: Results of stability analyses

Vane ID	Shear vane result (lowest unless stated) (kPa)	Slope angle (deg)	Peat depth at vane location (m)	Factor of safety for load condition 1 (no surcharge)	Factor of safety for Load condition 2 (20kPa surcharge)	Acceptable surcharge to achieve factor of Safety of 1.4 (kPa)
TOH_V1	6.48	5	1.8	4.15	1.96	35
TOH_V2	5.07	6	1.5	3.25	1.39	20
TOH_V3	4.79	6	1.3	3.54	1.40	20
TOH_V4	5.44	6	1.5	3.49	1.50	22
TOH_V5	7.43	5	2	4.28	2.14	41
TOH_V6	7.69	6	1.85	4.00	1.92	34
TOH_V7	7.49	6	1.8	4.00	1.90	33
TOH_V8	7.05	7	1.4	4.16	1.71	28
TOH_V9	8.11	3.5	1.7	7.83	3.60	78
TOH_V10	8.73	5	1.2	8.38	3.14	60
TOH_V11	9.59	8	1	6.96	2.32	40
TOH_V12	9.59	7	0.95	8.35	2.69	47
TOH_V13	9.59	6	0.85	10.85	3.24	57

3.0 Conclusion

Results of slope stability analyses for the section of ground, under the overhead line, between the windfarm substation and the Coillte track show that the ground exhibits a factor of safety above 1.4 when analysed using the lowest shear strength at each location and assuming a surcharge loading of 20kPa. For the remaining section, under the overhead line, from the Coillte track to the containment barrage BD2, the minimum shear strength value for the peat required to achieve a factor of safety of 1.4 under an external surcharge of 20kPa is of the order of 3.6kPa which is well below the lowest shear strength values measured north of the Coillte track.

Therefore, it can be concluded that the portion of ground, under existing overhead line, between the windfarm substation and the containment barrage BD2 is considered to have adequate factor of safety against a slip failure under an external surcharge of 20kPa. This also infers that the factor of safety will be higher in a situation where no external loading is applied.

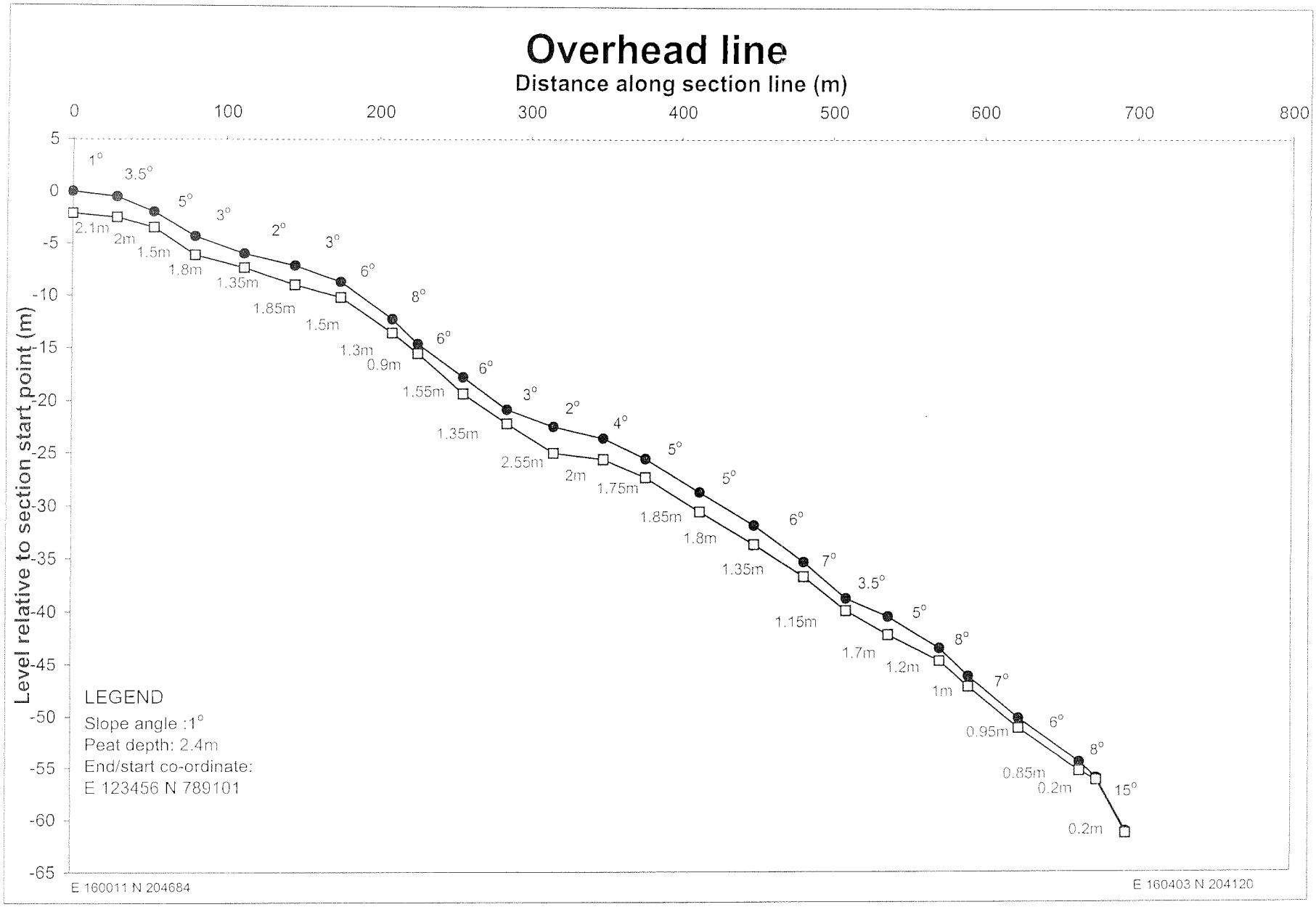
The 0.5m thick peat layer currently laid out on top of the existing peat surface in the vicinity of containment barrage BD2 is not considered to be undermining stability of the existing ground at that location. The surcharge applied by that peat layer would be of the order of 5kPa which well below the 20kPa surcharge assumed in the stability assessment.

4.0 References

1 Skempton, A.W.& DeLory, F.A. (1957). "*Stability of natural slopes in London Clay*". Proc. 4th Int. Conf. on Soil Mechanics and Foundation Engineering, Rotterdam, Vol. 2.

FIGURES

Figure 1 Profile of ground topography and peat depths
Figure 2 Location of shear vane tests


Overhead line
Distance along section line (m)
0
100
200
300
400
500
600
700
800
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
Level relative to section start point (m)
1°
3.5°
5°
3°
2°
3°
6°
8°
6°
6°
3°
2°
4°
5°
5°
6°
7°
3.5°
5°
8°
7°
6°
8°
15°
2.1m
2m
1.5m
1.8m
1.35m
1.85m
1.5m
1.3m
0.9m
1.55m
1.35m
2.55m
2m
1.75m
1.85m
1.8m
1.35m
1.15m
1.7m
1.2m
1m
0.95m
0.85m
0.2m
0.2m
LEGEND
Slope angle :1°
Peat depth: 2.4m
End/start co-ordinate:
E 123456 N 789101
E 160011 N 204684
E 160403 N 204120

A1 CAD

Notes :–

1. All dimensions are in millimetres – figured dimensions to be taken in preference to scaled dimensions.
2. All levels are in metres.

Legend:

Forestry

Streams/Drains

Boundary

10m Contour

50m Contour

Existing Road

Site Area 345ha

Turbine Foundation shown thus

Concreted Turbine Base (T##)

Site Compound

Borrow Pit 3

Clay Borrow Pit

Existing Telecoms Mast

Borrow Pit 2

110kV Substation & Compound Ref. Drg. No. 20206-31

Existing Turbary Road

Coillte Track

Coillte Track

Coillte Track

Approximate Line Of New 110kV Overhead Line

TOH-V1 TOH-V2 TOH-V3 TOH-V4 TOH-V5 TOH-V6 TOH-V7 TOH-V8 TOH-V9 TOH-V10 TOH-V11 TOH-V12 TOH-V13

Containment Barrage BD2

Coillte Forestry

Coillte Forestry

Coillte Forestry

Coillte Forestry

T1 T2 T3 T4 T5 T6 T7 T8 T9 T10 T11 T12 T13 T14 T15 T16 T17 T18 T19 T20 T21 T22 T23 T24 T25 T26 T27 T28 T29 T30 T31 T32 T33 T34 T35 T36 T37 T38 T39 T40 T41 T42 T43 T44 T45 T46 T48 T49 T50 T51 T52 T53 T54 T55 T56 T57 T58 T59 T60 T61 T62 T63 T64 T65 T66 T67 T68 T69 T70 T71

Site Layout Plan

Scale 1 : 10,000

0 100 200 300 400 500m

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PROJECT: DERRYBRIEN WIND FARM Co. GALWAY

CONTRACT: DERRYBRIEN WINDFARM

DRAWING TITLE: SLOPE STABILITY ASSESSMENT OF SECTION OF GROUND UNDER OVERHEAD LINE LINE

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Figure 2 (P378015-D01-84)

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APPENDIX 8-7

GEOTECHNICAL AND PEAT STABILITY REPORT (JANUARY 2023)

FEHILY TIMONEY

CONSULTANTS IN ENGINEERING, ENVIRONMENTAL SCIENCE & PLANNING

GEOTECHNICAL & PEAT STABILITY REPORT

DERRYBRIEN WIND FARM – GRID CONNECTION AND ANCILLARY WORKS

Prepared for: **ESB**

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GEOTECHNICAL & PEAT STABILITY ASSESSMENT REPORT

DERRYBRIEN WIND FARM – GRID CONNECTION AND ANCILLARY WORKS

User is responsible for Checking the Revision Status of this Document

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Client: ESB

Keywords: Geotechnical, Peat Stability, Grid Connection, Risk Assessment

Abstract: The report contains the findings of a geotechnical assessment along the route of the grid connection from the Derrybrien Wind Farm site to the Agannygal substation. The geotechnical assessment includes a deterministic and qualitative peat stability risk assessment of the grid connection route.

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DMP 14 Agannygal Substation – Indicative Decommissioning Access Routes

1. INTRODUCTION

1.1 General

Fehily Timoney and Company (FT) was engaged in August 2022 by ESB to undertake a geotechnical assessment of the grid connection route from the Derrybrien wind farm site to the Agannygal substation. The grid connection comprises the Derrybrien-Agannygal 110kV Overhead Line (OHL) and Agannygal Substation and ancillary works. The geotechnical assessment carried out includes an assessment of the peat stability of the 110kV OHL route, Agannygal substation site and associated permanent and temporary works during the proposed decommissioning of Derrybrien Wind Farm.

The Derrybrien wind farm project is located on Cashlaundrumlahan Mountain in the Slieve Aughty Mountains some 11km south of the town of Loughrea in County Galway (Figure 1).

The wind farm comprises 70 wind turbines and associated infrastructure and was constructed over the period 2003 to 2005. The wind farm became operational in December 2005.

The OHL route connects the substation on the Derrybrien wind farm site to a substation in the townland of Agannygal and is 7.8km in length. The OHL and substation were constructed between 2003 and 2005.

For the purposes of assessment, the OHL route was broken into 8 subsections (including the substation at Agannygal). These subsections were chosen based on having similar topography and peat depth within each individual section (Drawing 0001).

1.2 General

This report presents the findings of a geotechnical assessment of the OHL route connecting Derrybrien wind farm site with Agannygal Substation, and comprises the following elements:

(1) Desk Study Review
The review included the following:
- Review of previous relevant reports
- Review of publicly available information

(2) Summary of FT walkover survey findings (2022)
The walkover included the following:
- OHL route (excluding polesets 1-4)
- Access routes from the public road to the OHL route
- Agannygal substation

(3) Summary of AGEC ground investigation (2018)
The ground investigation included the following:
- Peat depth probing and shear vane strength testing along the OHL route
- Trial pits at the Agannygal substation

(4) Peat stability assessment
A deterministic stability assessment and qualitative peat stability risk assessment of the peat along the OHL route and at the substation, which includes:

- Methodology for deterministic stability assessment of peat
- Analysis to determine factor of safety
- Peat stability risk assessment methodology
- Results of stability analysis and risk assessments

(5) Conclusions

2. PREVIOUS RELEVANT REPORTS

2.1 Foundation Records at Mast Locations

During construction of the OHL masts from 2004 to 2005 a number of trial pits were carried out at mast locations to record ground conditions to a depth of typically 3m. In total, trial pits were carried out at 18 no. mast locations at each of the 4 mast legs giving a total of 72 no. trial pits. The records included a description of the ground conditions encountered and depths.

2.2 ESB Report on Slope Stability for Section of the OHL

ESB (2006) assessed the stability of the peat along the OHL route between the Derrybrien wind farm substation and containment barrage 2 (Figure 1). Containment barrage 2 was constructed following a peat slide in 2003 at the wind farm site within the flow path of the peat slide to prevent further propagation of the peat slide and to prevent possible further release of debris into watercourses downstream.

The stability of the peat in this area was assessed based on shear vane tests carried out over a section 700m in length directly south of the wind farm substation, as this area was considered the critical section in terms of existing slope angles and peat thickness. The infinite slope method of Skempton and DeLory (1957) was used to check for stability in combination with an external surcharge of 20kPa. Peat depths up to 2.0m were recorded and peat strengths ranged from 5 to 10kPa. A “lumped” or overall factor of safety of at least 1.4 under a 20kPa surcharge was shown for the OHL route between the substation and containment barrage 2, which is considered an acceptable level of safety.

3. DECSRIPTION OF OVERHEAD LINE ROUTE

3.1 General Description

The existing Derrybrien to Agannygal OHL connects the onsite substation at Derrybrien Wind Farm (ITM coordinates: E 559914, N 704737) to the substation at Agannygal (ITM coordinates: E 563119, N 698591), approximately 7km to the south. The layout of the OHL is shown in Figure 1 and Drawing 0001. The OHL is 7.8km long.

The pole sets, intermediate masts, angle masts, and end masts along the route are numbered 1 to 41. A typical timber pole set is shown in Photo 1 (Appendix A) and a typical steel angle mast is shown in Photo 2. A listing of the pole sets and masts is given in Table 3.1 and the locations of the substations, pole sets, and masts are shown in Drawing 0001.

Table 3.1: Peat Depth & Slope Angle along Grid Connection Route

Structure Reference	Structure Type	Easting (1)	Northing(1)
EM1(2)	End mast	559934	704742
PS1A(2)	Pole set	559962	704707
PS2(2)	Pole set	560045	704596
PS3(2)	Pole set	560195	704394
PS4(2)	Pole set	560319	704226
PS5	Pole set	560480	704011
PS6	Pole set	560578	703879
PS7	Pole set	560671	703754
PS8	Pole set	560777	703612
PS9	Pole set	560883	703469
PS10	Pole set	561011	703298
PS11	Pole set	561145	703117
PS12	Pole set	561252	702972
PS13	Pole set	561345	702847
AM14	Angle mast	561432	702731
PS15	Pole set	561337	702624
PS16	Pole set	561167	702437
PS17	Pole set	560990	702239
AM18	Angle mast	560840	702074
PS19	Pole set	560951	701972
AM20	Angle mas	561049	701883

Structure Reference	Structure Type	Easting (1)	Northing(1)
PS21	Pole set	561216	701810
PS22	Pole set	561373	701743
PS23	Pole set	561599	701646
AM24	Angle mast	561758	701577
PS25	Pole set	561814	701428
PS26	Pole set	561919	701145
PS27	Pole set	561975	700996
PS28	Pole set	562055	700784
PS28A	Pole set	562090	700690
PS29	Pole set	562148	700535
IM30	Intermediate mast	562211	700366
PS31	Pole set	562293	700146
PS32	Pole set	562366	699953
PS33	Pole set	562429	699785
PS34	Pole set	562470	699676
PS35	Pole set	562664	699481
PS36	Pole set	562761	699383
PS37	Pole set	562836	699308
AM38	Angle mast	563022	699121
PS39	Pole set	563062	698923
PS40	Pole set	563094	698766
EM41	End mast	563118	698643

Notes:
(1) Coordinates are in ITM format and were provided by ESB.
(2) Polesets 1-4 do not form part of this report, and are covered in the report by AGL on the Derrybrien Wind Farm Site

3.2 Description and Topography of OHL

The Derrybrien wind farm site is located on the upper slopes of Cashlaundrumlahan Mountain, within the Slieve Aughty Mountains. The OHL route is 7.8km long and is aligned essentially north-south. The topography of the route is illustrated in Drawing 001.

Slope angles at the pole set and mast locations typically range from 0 to 15 degrees. The topography is relatively steep (10 - 15 degrees) initially over the initial c. 1.5km of the route and then crosses the more gently sloping terrain (0 - 8 degrees) of the Owendalluleagh River valley to the Agannygal substation where the site has been cut and filled locally to provide a level platform.

The OHL route corridor starts within the boundaries of the wind farm site at the Derrybrien substation at an elevation of approximately 330mAOD. From the Derrybrien substation, the elevation along the route falls to a flat-bottomed valley where it crosses the R353 road and the tributaries of the Owendalulleagh River at an elevation of approximately 130mAOD. From here, the route skirts around the Slieve Aughty Bog NHA (site number 001229) before gaining elevation again as it passes Lough Agannygal, at about 195mAOD. The route ends at the Agannygal Substation, which is located to the southeast of Cashlaundrumlahan Mountain and about 1km north of Lough Atorick, at an elevation of approximately 190mAOD.

The land adjacent to the OHL route corridor and the Agannygal Substation is dominated by commercial forestry plantations which have been planted over the blanket bog. Directly along the OHL route corridor appears to have been colonised by conifer and deciduous tree growth from the adjacent plantations (regrowth of previously felled area).

The route crosses the lower end of the source area of the peat slide of 16 October 2003 between pole sets 5 and 6, and also passes close to 2 no. containment barrages (barrages 2 and 3, Figure 1). The containment barrages were constructed following the peat slide to prevent propagation of the peat slide and to restrict possible further release of debris into watercourses downstream.

3.3 Description of Infrastructure and Construction

The OHL mainly consists of double timber pole sets with galvanised steel angle masts at changes in direction and an intermediate galvanised steel mast (IM30) on a longer straight section. These angle masts and other mast structures were located as close as possible to existing roads and access tracks, in order to minimise trafficking on undisturbed ground. This section of this report sets out the methods of construction based on observations made during the walkover and information provided by ESB.

None of the OHL structures are constructed within the area of the peat slide, and no access was required through the peat slide area to access the OHL pole set locations.

3.3.1 Access to Pole Sets and Angle Masts

Where trees were present on the OHL route, then within a 60m corridor width all trees were felled mostly by machine using Coillte subcontractors. Where the trees were felled, they were cut as close as possible to the ground. The trunks and roots were left in place so that there was no excavation or disturbance of the peat. The surface of the peat was tracked over by the harvesting machines and forwarders that were used to cut, gather and stockpile the timber for transport off-site. In areas where the surface of the peat was very soft, brash and small branches were placed on the ground under the tracks of the harvester. Where the trees were small or where tree growth was poor the trees were felled by hand, arranged in windrows and left in place on the slopes.

Following this the location of pole sets and angle, intermediate and end masts were identified and set out.

The methods used to access the pole sets/angle masts during the construction of the OHL were recorded where they were visible during the OHL survey. The access routes recorded consisted of two types:

(1) There are a number of locations, primarily around the angle masts, where the peat has been stripped away exposing the mineral soil beneath. These areas are typically located in close proximity to existing forestry access tracks (see Photos 3 & 4) to facilitate the import of additional fill material and members for the angle masts, and for foundation construction.

(2) In other areas, primarily around the pole sets in areas of deep peat, timber sleepers from felled trees were used by construction plant to gain access for erecting the line, where necessary. This method of construction was particularly noticeable around pole set 36 where peat depths of over 4m were recorded. An example of such an access route is shown in Photo 5.

Access to the masts/pole sets was most likely from nearby roads and forestry tracks. Access from the existing tracks to the mast locations was generally achieved by the excavation of the peat and any tree stumps to a competent material. In order to access AM24, the Owendalulleagh River was crossed from the south side of the river at the location of a ford along the founded access track. In order to access AM38, existing trees were felled and placed to form a temporary floating access track from the south.

3.3.2 Foundations for Pole Sets and Angle Masts

Foundations varied according to ground conditions along the OHL route. In some locations where the depth to competent material was deeper than the embedment of the pole, stone and/or timber sleepers were used to strengthen the foundation and timber sleepers were used to fill to the correct level and as support to pole sets for stability. A greater number of timber sleepers would have been used to support pole sets in deep peat.

A number of pole sets in peat have been secured using timber baulks, fixed to the lower part of each pole and set in excavated holes in the peat which were backfilled with imported granular fill.

The angle masts and end masts are founded on concrete footings cast on mineral soil. Peat, where present, was excavated over the footprint of the foundation and working area prior to the construction of the foundation for these masts. The excavated peat was typically stored adjacent to the foundation excavations.

3.3.3 Agannygal Substation

The substation at Agannygal comprises a stone platform, substation equipment and a single storey control building. Construction of the substation required the excavation of overburden in order to create a level platform on which to build the substation. Excavated material was stored to the south of the substation compound. A stone platform approximately 1-1.5m thick was then constructed on the overburden using imported crushed rock fill. The platform is approximately 65m in length and 50m in width. In order to provide access to construct the substation, approximately 2.9km of existing forestry track was upgraded by adding imported stone fill and a thin surfacing layer. A permanent access road, around 140m in length, was also constructed from the adjacent local road to the substation.

The site of the substations and current topographical levels are provided on Drawing 0006.

3.3.4 Cuttings

During the site walkover of the OHL route, several cuttings were recorded, primarily around the footprint of a number of pole sets and angle masts. These included cuttings through the undulating ground from local access tracks to gain entrance for construction plant and materials, such as that shown in Photo 7. Minor cuttings are also present where stripping/excavation of peat/mineral soil was undertaken to form a suitable area to erect the masts and pole sets.

Founded access tracks constructed by others for the purpose of accessing the forested areas surrounding the overhead line required cutting through the undulating ground. Several cut sections were identified during the

site walkover. It is considered that these access tracks were already in existence and not created for the purpose of the construction of the OHL, however these were used for the construction of the OHL.

Between pole set 28A and 29 the OHL route crosses the Moneypoint-Oldstreet 400kV overhead line. This area is shown in Photos 8 and 9. A cut approximately 25m wide and 120m long was formed in the mineral soil to allow the OHL from the Derrybrien substation to pass beneath the 400kV line, allowing sufficient clearance for trafficking under the route and removal of forestry that could pose a risk to the OHL route. The location and extent of this cutting is shown on Drawing 0006 . This cutting is up to 3.8m deep and the slope angle ranges between 25 and 39 degrees, based on site readings. The average slope angle is approximately 32 degrees, based on the available topographic survey information of the area.

Another significant cutting is located adjacent to Agannygal substation and shown in Photo 12. This cutting is up to 3.0m deep and has an average slope angle of 35 degrees in mineral soil, which was excavated in order to create a level platform for the construction of the substation.

Additional, less significant cuttings included drainage ditches in the vicinity of the pole sets/angle masts and the access tracks.

4. GROUND CONDITIONS

4.1 Soils and Geology

The deposits along the OHL route comprise the following main types:

(1) Peat

(2) Glacial till and subsoil

(3) Alluvium

(4) Weathered/solid rock

(5) Peat debris within peat slide scar

4.1.1 Peat

Based on a review of the soils map of Ireland (Geological Survey of Ireland, 2022), the OHL route is covered in blanket peat. The walkover survey and ground investigation undertaken by AGEC and FT indicates that the upper 1m of the peat is generally very fibrous and also locally desiccated in appearance. The base of the peat, from observations within the peat slide scar and in exposures in excavations and along drains, was described using BS 5930 (BSI, 2015) as very soft brown amorphous Peat with recognisable plant structure. Peat appeared to lay directly on bedrock or a weathered rock/glacial till.

Shear strength profiles were measured using a Geonor H-60 hand vane tester at thirteen locations by ESB in 2004 and 2005 (ESB, 2006). 27 no. shear vane strength tests were undertaken at depths from 0.5m bgl to 1.8m bgl. Values for vane shear strength measured ranged from 5kPa to 10kPa with an average of 8.3kPa. Shear strength testing was also undertaken by AGEC in 2018 and FT in 2019 and 2022. 95 no. shear vane strength tests were undertaken at depths from 0.5m bgl to 3.5m bgl. Values for vane shear strength measured ranged from 3kPa to 68kPa with an average of 20kPa. The values are plotted in Figure 2.

Peat depth probing was also undertaken by ESB and the results of this are used, along with recent peat depth probing carried out by AGEC and FT, to plot peat depth contours shown in Drawings 0002 and 0003. The depth of peat recorded along the OHL route ranged from 0.2 to 5.6m bgl with an average depth of 1.3m bgl.

4.1.2 Glacial Till and Subsoil

Based on the available data, varying thicknesses of glacial till are present beneath the peat along of the OHL route. The publicly available GSI (2022) mapping shows glacial till in the vicinity of the site to be derived from Devonian sandstones. Exposures of glacial till showed a reddish brown or whiteish brown well-graded material consisting of sandy slightly gravelly Clay/Silt with occasional sub-angular to rounded cobbles and boulders of sandstone.

Typically, glacial till was encountered below the peat at depths that ranged from 0.2 to 5.6m, though locally glacial till was at or close to the surface below a layer of peaty topsoil.

The GSI (2022) mapping shows a line of ribbed moraines, which are hummocky wave ridges of sediment deposited by glacial movement, trending in a west-south-west to east-north-east direction traversing the OHL route around the Owendalulleagh River.

4.1.3 Alluvium

Alluvium recorded along the OHL route is associated with the Owendalulleagh River which runs between pole sets 25 and 26. It was observed during the site walkover that the Owendalulleagh River riverbed consisted of sand, gravel, cobbles, and boulders, and hence it is expected that this alluvium is predominantly coarse-grained.

4.1.4 Weathered/Solid Bedrock

The bedrock geology along the OHL route comprises the Ayle River Formation, the Derryfadda Formation, the Scalpnagown Formation, and Undifferentiated Visean Limestone. The Ayle River Formation consists of red siltstones, mudstones with carbonate concretions, sandstones, conglomerates and mud-flake breccia from the Ayle River Formation, the Derryfadda Formation consists of greywackes, siltstones, and mudstones, and the Scalpnagown Formation consists of conglomerate, sandstone & siltstone. The Undifferentiated Visean Limestones are impure Dinantian limestones (GSI, 2003 & 2019).

Rare bedrock exposures, consisting of sandstone, were observed in the vicinity of containment barrage 1 and 3. The bedding was horizontal to sub-horizontal. Exposed bedrock was not encountered elsewhere.

4.1.5 Peat Debris within Peat Slide Source Area

Peat debris within the 2003 peat slide area at the Derrybrien site was encountered only between pole sets 5 and 6. The debris within the peat slide area comprises mainly non-intact peat. As the extent of the material is extremely limited, it is not considered further in this report.

4.2 Hydrology

Several watercourses exist within the footprint of the OHL route (see Drawing 0001 for locations), the largest being the Owendalulleagh River, which is approximately 6m wide where it passes beneath the OHL between pole sets 25 and 26 (Photo 6). Major hydrological features tend to run east to west across the OHL corridor, with minor tributary features aligned approximately north to south to tie into the major drainage features.

There are several flat areas where local ponding of surface water occurs. Such a feature, Lough Agannygal, is located between pole set 37 and angle mast 38 (Photos 10 and 11).

Streams and ditches have typically been regraded for use as forestry drainage where land use is commercial forestry. It is reported that this commercial forestry was established in the 1970's (ESB, 2006). This is consistent with observations made on site that several areas have been clear felled and replanted.

4.3 Hydrogeology

Based on information from the GSI database, the majority of the OHL route and the substation is underlain by rock which is considered a poor aquifer (bedrock which is generally unproductive except for local zones).

However, the segment of the route underlain by Visean Limestone (between pole set 23 and 26 approximately) is considered a locally important aquifer (bedrock which is moderately productive only in local zones) although no evidence for groundwater usage from this aquifer was found.

Groundwater vulnerability (GSI, 2022) ranges from low to extreme across the route, due to the generally shallow depth to bedrock. All drainage features along the OHL route are noted as giving rise to extreme groundwater vulnerability.

4.4 Previous Landslides

A review of historical records of peat slides/landslides (GSI, 2022) indicates that peat slides have occurred in the Slieve Aughty Mountains in the past. With the exception of the 2003 peat slide on the Derrybrien wind farm site, two previous slides have been noted within 5km of the OHL. One was in 1890 and occurred at a location some 2.5km to the east of the substation at the southern end of the OHL, in an area called Loughatorick North. An area of 100 acres was covered with a 'foot' of peat, the upper part of the 'bog subsiding 10 to 15 feet'. The peat slide was described as a flow within blanket peat. The other slide occurred 5km to the north of the OHL, on the Sonnagh Old Wind Farm site. This occurred during October 2003 and is described as a flow in blanket peat adjacent to an access road.

As part of the national landslide susceptibility mapping project carried out by the Geological Survey Ireland all areas of land across the country are designated a landslide susceptibility rating. The landslide susceptibility rating is based on a number of factors including incidences of previous peat slides, topography, type of deposits, etc. The OHL route and substation is classified as having 'low' to 'moderately low' peat/landslide susceptibility with locally 'moderately high' susceptibility (GSI, 2022).

As stated above, the land susceptibility rating/bands typically relates to the type of deposits, topography in an area, incidences of previous peat/landslides, etc. For example, a rating of 'moderately high' can be assigned where rock is close to the surface, slope angles range from 10 to 20 degrees, etc. Hence the rating of 'moderately high' does not necessarily relate to a risk of peat slide.

It should be noted that at the time of the 2003 peat slide no national landslide register/database existed.

5. SITE WALKOVER SURVEY

5.1 Background to Walkover Survey

The purpose of the walkover survey was to investigate the ground conditions at the pole set and angle mast locations, identify geotechnical constraints and to gather data for a peat stability assessment along the OHL route.

The walkover survey comprised an inspection of the OHL route and likely access points to the OHL. This was carried out from 11 to 12 October 2022. Weather conditions for the site visit were light to heavy mist/rain with some dry periods. A previous walkover of the OHL route and the Agannygal Substation had been undertaken by AGEC in June 2018 and FT in September 2019. The findings below are a combination of the findings from the three walkover surveys (2018, 2019 and 2022)

5.2 Findings of Walkover Survey

The findings of the walkover survey are as follows:

(1) The OHL route is located approximately 10km south of Loughrea and is constructed on undulating terrain. The majority of the route is covered by shallow to locally deep blanket peat that was previously colonised by commercially grown conifer and deciduous forest. Some regrowth has occurred along the OHL since the original felling works. There are a number of areas where peat has been removed from the footprint of the pole sets/angle masts and overburden is exposed at the ground surface.

(2) The elevation along the OHL route falls from the wind farm substation (c. 330m AOD) to pole set 11 (c. 180m AOD). From pole set 11 the elevation decreases over undulating ground to angle mast 14 (c. 170m AOD) and crosses the local R353 road. The terrain gently undulates as it descends from the R353 (public road) to pole set 22 (c. 115m AOD) from where the OHL route crosses several relatively shallow watercourses. The ground level rises significantly over a short distance to pole set 23 (c. 130m AOD), then levels and quickly descends again between pole set 25 and 26 (c. 125m AOD). The terrain undulates gently as it ascends towards pole set 38 (c. 195m AOD), levels over localised deep deposits of peat and gently falls from pole set 38 to the substation at Agannygal.

(3) Peat thicknesses were recorded during the site walkover with in excess of 150 peat probes undertaken. Peat thicknesses measured ranged from 0m to 5.6m. Approximately 50 percent of the probes recorded peat depths of less than 1.0m. Over 80 percent of peat depth probes recorded peat depths of less than 2.5m. Several localised readings were recorded where peat depths of between 2.5 and 5.6m are present. The deepest peat (5.6m) was recorded close to the location of angle mast 38 where the topography is flatter than the remainder of the route.

(4) The peat depths recorded at the pole sets and angle masts varied from 0.0m to 5.6m. 28 no. of the pole sets and angle masts have less than 1.0m thickness of peat in their vicinity. 6 no. of the pole sets and angle masts have greater than 2.0m thickness of peat. The greatest depth of peat encountered, a depth of 5.6m, was recorded close to the location of angle mast 38.

(5) The undrained shear strengths of peat recorded ranged from 3kPa to 68kPa with an average of 20kPa. Peat shear strength is discussed in Section 8.

(6) There are a number of locations, primarily around the angle masts, where the peat has been locally removed exposing the mineral soil beneath. This was primarily to do with gaining access for construction of the angle masts. An example of such an area is shown in Photo 7.

(7) In other areas, primarily around the pole sets in areas of deep peat, timber sleepers from felled trees have been used by machinery to gain access during construction, as shown in Photo 5.

(8) The mineral soil composition along the OHL route, based on a visual inspection of exposures, is a sandy gravelly silt or clay with gravel, cobbles and boulders of various sizes and lithology. The mineral soil colour is primarily red-brown, as shown in Photos 7 and 9, with localised areas of white-grey, situated around pole sets 19 and 20. Dispersed throughout the white-grey mineral soil are gravels and small cobbles, which appear to be a mixture of marble, quartz and sandstone in nature. Elsewhere the cobbles and boulders present appear to be sandstone in nature and sandstone would appear to be the dominant rock type present along the route.

(9) Slope angles at the pole set and mast locations typically range from 0 to 15 degrees. There were several steeper slope angles between pole set and mast locations, particularly south of pole set 25 and near the Owendalulleagh River, where an inclination of about 35 degrees was recorded.

(10) The peat situated towards the northern end of the route has a notable vegetation cover, which is generally indicative of relatively well-drained (stronger) peat. However, there are some areas towards the south of the OHL route where poorly-drained (weaker) peat deposits were recorded in deforested areas.

(11) Localised areas of waterlogged peat and surface water are present at numerous areas along the OHL route, particularly between pole set 37 and AM 38 (Photos 10 and 11). This is not unexpected given the flat nature of the terrain and watercourses present along the OHL route, including Lough Agannygal.

(12) Apart from where the OHL crosses the 2003 peat slide source area, which is between pole sets 5 and 6, no evidence of past peat slides were recorded on the OHL route or directly adjacent to it.

(13) The Agannygal Substation is constructed on the edge of a forested area to the north of Lough Atorick. The substation compound has been created by excavating material along the eastern side of the site to create a level platform on competent ground. A cutting 3m deep is present along the eastern side of the substation compound.

(14) Several cuttings were identified along the OHL route, see Section 3.3.4 for details. Of these, the most significant were between pole set 28A and 29 and at Agannygal Substation. Between pole set 28A and 29, the cutting is up to 3.8m deep and the cutting slopes have an average slope angle of around 32 degrees in glacial till. There is evidence of minor surface erosion leading to the washing out of soil in local areas of this cutting. At Agannygal Substation the cutting is up to 3m deep and has an average slope angle of 35 degrees in glacial till. Based on a visual inspection these cutting slopes appear to be stable. Minor surface erosion was noted in the vicinity of pole set 28A and 29 which would not give rise to a concern over a deeper and more significant slip occurring.

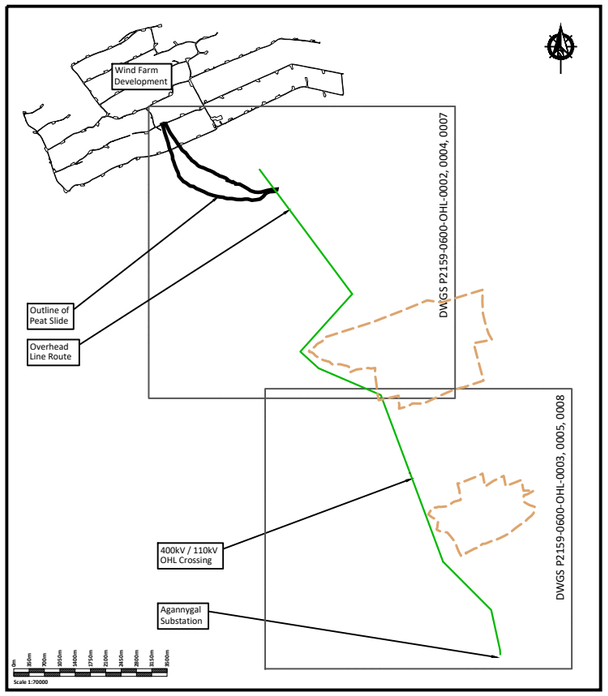
(15) The conclusions from the walkover survey are as follows:

(a) The peat depths recorded at the pole sets/angle masts varied from 0m to 5.6m. 28 no. of the surveyed poleset/angle mast locations have less than 1.0m thickness of peat.

(b) The peat depths recorded near pole set 28 and 36, ranging from 2.5m to 5.6m, would be considered relatively deep. Further, peat strengths in this area were relatively low, ranging from 6kPa to 20kPa. Suitable access techniques and plant such as the use of bog mats and low load bearing machinery would be required when operating in these areas.

(c) Mitigation/control measures for access and potential decommissioning activities at each subsection of the OHL route and substation are given in the Peat Stability Risk Register (Appendix D).

(d) Cuttings up to 3.8m deep in glacial till were observed. These appear to be stable based on a visual assessment.



KEYPLAN

Scale 1:70000

PEAT DEPTH CORRIDOR PLAN

Scale 1:14000

Legend: Peat Depth (m)

0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.6

Note -

Peat depth corridor was prepared as a 100m wide corridor using a single line of peat depth probes.

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Rev.	Description	App By	Date
A	FOR INFORMATION	BDH	20.01.23

PROJECT: DERRYBRIEN WIND FARM DECOMMISSIONING

CLIENT: ESB EMP

SHEET: PEAT DEPTH CONTOUR PLAN DRAWING 1 OF 2

Date: 20.01.23

Project number: P22-133

Scale (@ A3)

Drawn by: POR

Checked by: IH

Drawing Number: P22-133-0600-OHL-0002

Rev: A

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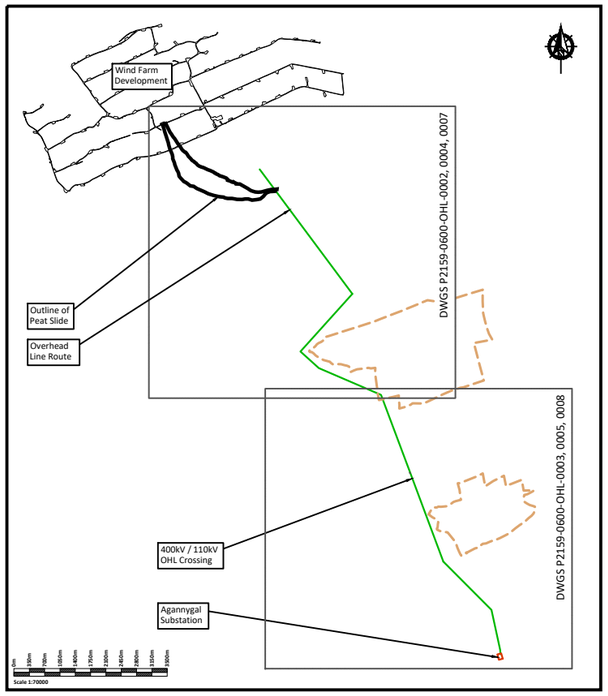
Friday 20 January 2023



KEYPLAN

Scale 1:70000

Legend: Peat Depth (m)

0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.6

Note -

Peat depth corridor was prepared as a 100m wide corridor using a single line of peat depth probes.

PEAT DEPTH CORRIDOR PLAN

Scale 1:14000

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Rev.	Description	App By	Date
A	FOR INFORMATION	BDH	20.01.23

PROJECT: DERRYBRIEN WIND FARM DECOMMISSIONING

CLIENT: ESB EMP

SHEET: PEAT DEPTH CONTOUR PLAN DRAWING 2 OF 2

Date: 20.01.23

Project number: P22-133

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Drawing Number: P22-133-0600-OHL-0003

Rev: A

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Friday 20 January 2023

6. AGEC GROUND INVESTIGATION (2018)

The ground investigation carried out by AGEC along the OHL route and at the Agannygal Substation in June 2018 comprised peat depth probes, hand shear vanes and 2 no. trial pits. The locations of the trial pits are shown in Drawings 0001 and 0006. Additional peat depth probes and hand shear vanes were undertaken by FT in 2019 and 2022.

6.1 Peat Probing and Shear Vane Testing

During the walkover survey, peat depth probing and shear vane testing were carried out at each pole set, mast location and at selected intermediate points along the OHL route to provide representative coverage of indicative peat depths and strengths.

The results of peat depth probing are presented as a peat depth contour plan in Drawings 0002 and 0003 and indicate peat depths ranging from 0 to 5.6m bgl. The depth of peat varies from sections where there is little to no peat over the footprint of 4 or 5 consecutive pole sets to deep areas of peat, especially near the Agannygal substation site, although inspection of the substation itself shows that it is founded on mineral soil.

Shear vane testing was carried out using a Geonor H-60 hand field vane tester. From FT's experience hand vanes give indicative results for the in-situ undrained shear strength of peat and would be considered best practice for the field assessment of peat strength. 75 no. hand shear vane strength tests were undertaken by AGEC at depths from 0.5 to 2.5m bgl. The hand vane results indicate undrained shear strengths in the range 3 to 68kPa with an average value of 26kPa. Peat strength values are plotted in Figure 2.

6.2 Trial Pits

2 no. trial pits were excavated out at Agannygal Substation in June 2018, referred to as TP10 and TP11. The trial pit locations are shown on Drawings 0001 and 0006 and are downslope of the substation. The results of these trial pits are presented in the logs included as Appendix B. Trial pit TP10 found 1.0m of fill over natural ground consisting of mineral soil to a depth of 2.9m bgl. Trial pit TP11 found 0.7m of peaty fill over natural ground consisting of soft slightly organic clay to 1.7m bgl over mineral soil to 2.5m bgl.

The 2 no. trial pits are consistent with each other and suggest a ground profile consisting of deposited construction arisings from the substation excavation over a natural ground profile of soft organic topsoil over glacial till. A cutting is exposed at the Agannygal Substation site, shown in Photo 12, and the exposed soil here is consistent with the descriptions from the trial pits.

7. PROPOSED DECOMMISSIONING WORKS

7.1 Description of Decommissioning works

The OHL including the conductors, pole sets and masts will be decommissioned and the methodology is included below. This work would involve the removal of the OHL infrastructure between the Derrybrien and Agannygal Substations, as well as the removal of the above ground infrastructure at the Agannygal substation.

7.1.1 Access for Decommissioning works

Based on the observations made during the walkover surveys, the access routes for decommissioning works which would likely be used are presented in Drawings DMP 01, DMP 02 and DMP 14. These access routes are presented as preliminary suggestions only and would be subject to detailed design. The proposed routes are briefly summarised below. The existing forestry access tracks typically comprise a 3m wide track constructed of crushed rock which has been founded on the mineral soil underlying the peat. Minor upgrades of sections of these tracks may be required.

Notable constraints encountered included several steep slope angles between pole set and mast locations, particularly south of pole set 25 and near the Owendalulleagh River, where an inclination of about 35 degrees was recorded. Where constraints have been identified, alternative access routes are proposed (Drawings DMP 01 and 14). For example, the proposed access routes allow the steep slopes between pole set 3 and pole set 4 and between pole set 25 and pole set 26 to be avoided.

New access construction may include the use of low ground bearing pressure (LGBP) plant and bog mats to provide access to pole sets.

PS5 to PS11
Route follows existing founded access track from local road north to close to PS4. Existing (floating) track from founded access track to containment barrage 2, located between PS5 and PS6, may be upgraded to allow access to this section of the OHL Access to PS6-PS10 requires the use of LGBP plant or bog mats along the OHL route, depending on level of access required for decommissioning works. PS11 is located immediately adjacent to a local road and can be accessed directly from the local road.

PS12 to AM14
Route follows existing founded access track from local road north to AM14, which would require upgrading. Access from AM14 to PS12 requires the use of LGBP plant or bog mats along the OHL route , depending on level of access required for decommissioning works.

PS15 to PS22
Route follows existing founded access track from local road south to PS22. The track may require upgrading between PS19 and PS21.

PS23 to PS25
Route follows existing founded access track from local road north to PS25. This access may require the upgrade of the existing ford at the Owendalulleagh River and the use of LGBP plant or bog mats along the OHL route, depending on the level of access required for decommissioning works.

PS26 to PS27

Route follows existing founded access track from local road north towards PS26. Access from PS26 to PS27 requires the use of LGBP plant or bog mats along the OHL route, depending on level of access required for decommissioning works.

PS28 to PS31
Route follows existing founded access track from local road north to PS28A. Access from PS28A to PS28 and PS31 requires the use of LGBP plant or bog mats along OHL route, depending on level of access required for decommissioning works.

PS32 to PS34
Route follows existing founded access track from local road north to PS34. Access from PS34 to PS32 requires the use of LGBP plant or bog mats along OHL route, depending on level of access required for decommissioning works.

PS35 to PS37
Requires the use of LGBP plant or bog mats from local road north to PS35 and south to PS37 along OHL route, depending on level of access required for decommissioning works.

AM38 to EM41
Requires the use of LGBP plant or bog mats from Agannygal substation north to AM38 along OHL route, depending on level of access required for decommissioning works.

Substation Access
Access to the substation would use the previously upgrade Coillte track that runs from the local road some 2.5km away.

7.1.2 Methodology for the Decommissioning of the Overhead Line

As advised by ESB, the proposed methodology for the decommissioning of the OHL and timber pole sets is as follows:

(1) Decommissioning works will be undertaken using low ground pressure (LGBP) machinery.

(2) It is currently expected that decommissioning works will be carried out using a lightweight tracked dumper with a winch and 2 no. tracked excavators fitted with pole handling equipment.

(3) Conductor lines will be de-tensioned and removed at various points along the OHL route.

(4) A winch will be brought to the site of the particular pole set to be removed by means of lightweight tracked dumper.

(5) The winch will be attached to the steel cross member of the pole set from ground level.

(6) The cross member will be un-bolted from the pole on the opposite side as the winch.

(7) The winch will allow the cross member to rotate until it is hanging vertical and it will then be lowered to the ground.

(8) The first excavator, fitted with pole handling equipment, will grab the poles at about mid height or higher.

(9) The second excavator will loosen the ground around the base of the pole.

(10) Once the ground is sufficiently loosened, the pole will be raised from its hole and lowered to the ground by the first excavator.

(11) The empty hole will be backfilled and made safe.

(12) If one excavator is capable of carrying it, the pole will be removed by that excavator to a suitable loading point. If one excavator cannot safely carry the pole, both excavators will be used.

(13) Steps (8) to (12) are repeated for the second pole.

(14) The OHL poles and mast elements will be removed from site for reuse and if necessary, disposal in accordance with the relevant legislation.

As advised by ESB, the proposed methodology for the removal of angle masts, intermediate masts and ends masts is as follows:

(1) Conductor lines will be de-tensioned and removed at various points along the OHL route.

(2) Rope access personnel (linesmen) will climb the particular mast to be decommissioned and will work to dismantle the structural members of the mast one by one.

(3) A light pulley block will be secured to the mast and the selected member for removal. The selected member for removal will be unbolted or cut away from the mast structure. Alternatively, if there are no site restrictions then a mobile crane is usually used on site for the dismantling.

(4) The dismantled member will be winched safely to the ground using the pulley system and loaded onto a light weight tracked dumper for disposal. Depending on the type of transportation available, the dismantled member may need to be cut up into smaller segments for transportation.

(5) The workers will progress through each mast, member by member, in this manner.

(6) Where steel structural members are cast into concrete foundations, steel members will be cut flush with the concrete foundation.

(7) The concrete foundations will typically be left in place, this may vary depending on site requirements. Generally, the concrete foundations are removed to 1m below ground level. This would be done using an excavator with a rock breaker. All removed concrete and steel would be removed to a registered waste disposal facility.

It is expected that a uniform surcharge loading of 10kPa over the affected ground surface will adequately model the pressure imposed on the ground by the plant involved. For access and egress purposes bog mats may be deployed to spread the loading of the plant where deemed necessary, thus avoiding the construction of stone access tracks.

8. DETERMINISTIC PEAT STABILITY ASSESSMENT

The main approaches for assessing peat stability include the following:

(a) Geomorphological

(b) Qualitative (judgement)

(c) Index/Probabilistic (probability)

(d) Deterministic (factor of safety)

Approaches (a) to (c) listed above would be considered subjective and do not provide a definitive indication of stability; in addition, a high level of judgement/experience is required which makes it difficult to relate the findings to real conditions. FT apply a more objective approach, the deterministic approach.

As part of FT's deterministic approach, a qualitative risk assessment is also carried out (see Section 9) taking into account qualitative factors, which cannot necessarily be quantified, such as the presence of mechanically cut peat, quaking peat, bog pools, sub peat water flow, slope characteristics and numerous other factors. The qualitative factors used in the risk assessment are compiled based on FT's experience of assessments and construction in peat land sites and peat slides throughout Ireland and the UK. This approach takes into account current guidelines for geotechnical/peat stability risk assessments as given in Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (PLHRAG, 2017) and MacCulloch (2005).

8.1 Methodology for Deterministic Peat Stability Assessment

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 a peat slide. To assess the factor of safety for a peat slide, undrained and drained analyses have been undertaken to determine the stability of the peat slopes along the OHL route and at the substation.

The infinite slope model (Skempton and DeLory, 1957) is used to combine these factors to determine a factor of safety against peat sliding. This model is based on a translational slide, which is a reasonable representation of the dominant mode of movement for peat slides.

8.2 Peat Strength

Undrained (short term stability) and drained (long term stability) analyses were carried out to determine the stability of the peat slopes on the site.

(1) The undrained loading condition applies in the short term typically following the application of a load and until load induced pore water pressures have dissipated. Most anthropogenic peat slides occur in the undrained condition i.e. in fully saturated conditions. The undrained condition uses undrained strength parameters in the assessment. The undrained conditions is considered to be the more relevant for the Decommissioning Phase however the drained condition is included for completeness.

(2) The drained loading condition applies in the long-term following partial or full dissipation of excess pore water pressure from the peat over time. In the drained condition the pre water pressure (groundwater level) is in equilibrium with in-situ conditions which can vary with seasonal changes. The drained condition examines the effect of the change in groundwater level as a result of rainfall on the stability of the peat slope (following the draining or partial draining of the peat). As a worst case and for the purpose of the assessment the groundwater level is assumed to be at the surface of the peat, to reflect an extreme rainfall event. The drained condition uses effective strength parameters in the assessment.

Undrained shear strength values (c_u) for peat recorded on site using the hand shear vane are used for the undrained analysis.

For the analysis of the peat slopes along the OHL route a lower bound value of 6kPa for the undrained shear strength of the peat was used (Figure 2). This is based on the analysis of a total of 90 no. shear vane tests (carried out by FT (2019, 2022) AGEC (2018) and ESB (2006)) which have provided undrained shear strength values for the peat. Of 123 test results, 3 results showed a shear strength value of less than 6kPa. This value would be considered appropriate and conservative for the undrained condition.

A drained analysis requires effective cohesion (c') and effective friction angle (ø') values for the calculations. These values can be difficult to obtain because of disturbance experienced when sampling peat and the difficulties in interpreting test results due to the excessive strain induced within the peat. To determine suitable drained strength values a review of published information on peat was carried out.

Table 8.1 shows a summary of the published information on peat together with drained strength values.

Table 8.1: List of Effective Cohesion and Friction Angle Values for Peat

Reference	Cohesion, c' (kPa)	Friction Angle, ø' (degs)	Testing Apparatus/ Comments
Hanrahan et al (1967)	5 to 7	36 to 43	From triaxial apparatus
Rowe and Mylleville (1996)	2.5	28	From simple shear apparatus
Landva (1980)	2 to 4	27.1 to 32.5	Mainly ring shear apparatus for normal stress greater than 13kPa
	5 to 6	-	At zero normal stress
Carling (1986)	6.5	0	-
Farrell and Hebib (1998)	0	38	From ring shear and shear box apparatus. Results are not considered representative.
	0.61	31	From direct simple shear (DSS) apparatus. Result considered too low therefore DSS not considered appropriate
Rowe, Maclean and Soderman (1984)	1.1	26	From simple shear apparatus
	3	27	From DSS apparatus
McGreever and Farrell (1988)	6	38	From triaxial apparatus using soil with 20% organic content

	6	31	From shear box apparatus using soil with 20% organic content
Hungr and Evans (1985)	3.3	-	Back-analysed from failure
Dykes and Kirk (2006)	3.2	30.4	Test within acrotelm
Dykes and Kirk (2006)	4	28.8	Test within catotelm
Warburton et al (2003)	5	23.9	Test in basal peat
Warburton et al (2003)	8.74	21.6	Test using fibrous peat
Hendry et al (2012)	0	31	Remoulded test specimen
Komatsu et al (2011)	8	34	Remoulded test specimen
Zwanenburg et al (2012)	2.3	32.3	From DSS apparatus
Den Haan & Grognet (2014)	-	37.4	From large DSS apparatus
O'Kelly & Zhang (2013)	0	28.9 to 30.3	Tests carried out on reconstituted, undisturbed and blended peat samples

From Table 8.1 the values for c' ranged from 1.1 to 8.74kPa and ø' ranged from 21.6 to 43°. The average c' and ø' values are 4.5kPa and 30° respectively. Based on the above, it was considered to adopt a conservative approach and to use design values less than the average.

For design the following general drained strength values have been used for the site:

c' = 4kPa
ø' = 25 degrees.

8.3 Analysis to Determine Factor of Safety (Deterministic Approach)

The purpose of the analysis was to determine the Factor of Safety (FoS) of the peat slopes along the OHL route. As the analysis uses generalised lower bound peat strength values, the results provide an indication of areas where instability might occur. The analysis assumes that all areas have lower bound peat strength, which in the majority of instances is not the case.

The FoS provides a direct measure of the degree of stability of the slope. A FoS of less than unity indicates that a slope is unstable, a FoS of greater than unity indicates a stable slope.

The acceptable safe range for FoS typically ranges from 1.3 to 1.4. Where there is minimal risk from a slope slide a FoS of just greater than 1 may in some cases be acceptable. The previous code of practice for earthworks BS 6031:1981 (BSI, 1981), provided advice on design of earthworks slopes. It stated that for a first-time slide with a good standard of site investigation the design FoS should be greater than 1.3. A FoS of 1.4 is taken as indicative of sufficient stability within this report, which would be deemed a conservative approach.

As a general guide the FoS limits for peat slopes in this report are summarised in Table 8.2.

Table 8.2: Factor of Safety Limits for Slopes

Factor of Safety (FoS)	Degree of Stability
Less than 1.0	Unstable (red)
Between 1.0 and 1.3	Marginally stable (yellow)
1.3 or greater	Acceptable (green)

Eurocode 7 (EC7) (I.S. EN 1997-1:2005+AC: 2013) now serves as the reference document and the basis for design geotechnical engineering works. The design philosophy used in EC7 applies partial factors to soil parameters, actions and resistances. Unlike the traditional approach, EC7 does not provide a direct measure of stability, since global Factors of Safety are not used.

As such, and in order to provide a direct measure of the level of safety on a site, EC7 partial factors have not been used in this stability assessment. The results are given in terms of FoS. This is considered to be in line with best practice guidance as provided in PLHRAG (2017).

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

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

Where:

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

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

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

Where:

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

For the drained analysis the level of the water table above the failure surface is required to calculate the factor of safety for the slope. Since the water level in blanket peat can be variable and can be recharged by rainfall, it is not feasible to establish its precise location throughout the site. Therefore, a sensitivity analysis using water level ranging between 0% and 100% of the peat depth was conducted, where 0% equates to the peat being completely dry and 100% equates to the peat been fully saturated.

The following general assumptions were used in the analysis of peat slopes at each location:

(1) Peat depths are based on the maximum peat depth recorded at each location from the walkover surveys (2018, 2019 and 2022).

(2) For the analysis of the peat slopes across the site a lower bound value of 6kPa for the undrained shear strength of the peat was used (Figure 2).

(3) Slope angle at base of sliding assumed to be parallel to ground surface.

For the stability analysis two load conditions were examined, namely

Condition (1): no surcharge loading
Condition (2): surcharge of 10 kPa, equivalent to 1m of stockpiled peat assumed as a worst case. This case assumes that the groundwater stays at the original surface level.

8.4 Results of the Stability Analysis for the OHL

8.4.1 Undrained Analysis

The results of the undrained stability analysis for the OHL route and Agannygal Substation are graphically shown in Drawings 0004 and 0005 and are tabulated in Appendix E.

For the peat slopes the calculated FoS for load condition (1) and (2) is typically in excess of 1.4 for each location analysed.

A summary of the FoS range calculated for load condition (1) and load condition (2) are presented in Table 8.3 along with their respective percentage of site area.

Table 8.3: Summary of Undrained Slope Stability Results

Factor of Safety (FoS)	% of OHL Route (Condition 1)	% of OHL Route (Condition 2)
Less than 1.0	0	0
1.0 to 1.3	0	1
1.3 to 1.4	0	0
Greater than 1.4	100	99

For Condition (1), 100% of the OHL route and substation has a FoS greater than 1.0 and for Condition (2) 99% of the OHL route has a FoS greater than 1.4. Analysis of the spatial distribution of the areas (1 location) where the lower FoS are present for load condition (2) shows that it is located in areas where steeper slopes are present between pole sets i.e. typically between 10 and 15 degrees. This is located between PS25 and PS26, between PS25 and the Owendalulleagh River, in an area where no works are proposed. Information on mitigation measures for these areas is provided within the Peat Stability Risk Assessment in Appendix D. No FoS values of less than 1.4 was recorded at a pole set or angle mast location.

In general, the factors of safety less than 1.4 generated from the analysis are not unexpected as generalised lower bound peat strength values are used in the analysis, which cannot take into account areas of higher strength peat. The analysis is intended to provide an indication of likely peat instability and is to be used as an input to a further qualitative risk assessment of the peat stability along the OHL route.

8.4.2 Drained Analysis

The results of the drained stability analysis for the OHL route and Agannygal Substation can be found in Appendix E.

For the peat slopes the calculated FoS for load condition (1) and (2) is in excess of 1.4 for each location analysed. A summary of the various FoS's calculated for load condition (1) and load condition (2) are presented in Table 8.4 along with their respective percentage of site area.

Table 8.4: Summary of Drained Slope Stability Results

Factor of Safety (FoS)	% of OHL Route (Condition 1)	% of OHL Route (Condition 2)
Less than 1.0	0	0
1.0 to 1.3	0	0
1.3 to 1.4	0	0
Greater than 1.4	100	100

From Table 8.4 for load condition (1) 100% of the OHL route and substation has a FoS greater than 1.4 and for Condition (2) 100% of the OHL route has a FoS greater than 1.4. No FoS of less than 1.4 was recorded at a pole set or angle mast location.

While it has been found, somewhat counterintuitively, that Condition (1), the natural condition, presents a less favourable outcome than Condition (2), where the slope is surcharged, this is reasonable due to the effective stress analysis undertaken. In this analysis, an increase in the surface loading and hence the vertical effective stress leads to an increase in the confining pressure on the potential failure plane under consideration and therefore a greater resistance to movement on that plane.

In general, the factors of safety less than 1.4 generated from the analysis are not unexpected as generalised lower bound peat strength values are used in the analysis, which cannot take into account areas of higher strength peat. The analysis is used to provide an indication of the likely susceptibility of instability within the OHL route and at the substation.

8.5 Stability of Agannygal Substation Site

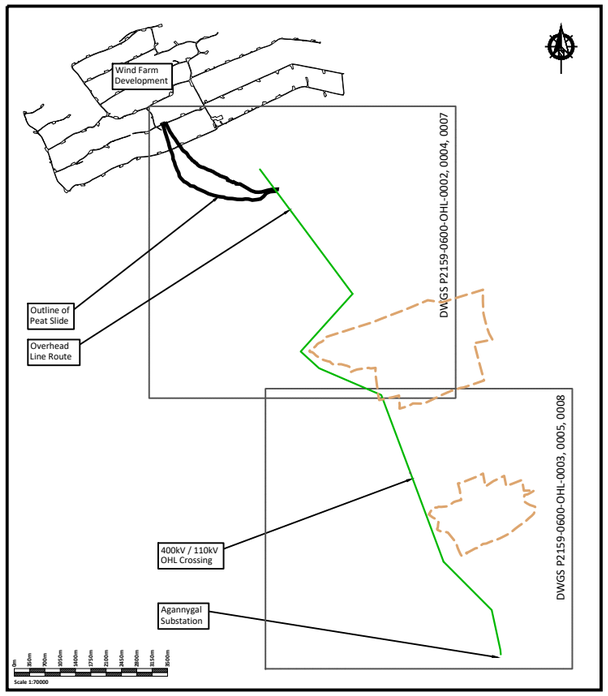
The Agannygal Substation site is founded on mineral soil, which would be considered a competent founding medium. As the peat was stripped away as part of the construction and there is no peat present within the footprint the Agannygal substation site, the substation site is not included in the stability analysis as it is considered stable.

8.6 Summary

The analysis was carried out to provide an indication of likely peat instability along the OHL route. The analysis showed that, using conservative strength parameters, the peat generally has an adequate factor of safety and hence a low risk of instability. However, the use of conservative undrained and drained strength parameters has contributed to a small number (1 number) of relatively low FoS results, particularly around areas of high slope angles. This is located between PS25 and PS26.

In general, the areas of relatively low FoS generated from the analysis are not unexpected as generalised lower bound peat strength values are used in the analysis, which cannot take into account areas of higher strength peat. The analysis is intended to provide an indication of likely peat instability.

The deterministic and quantitative results obtained from the analysis presented in this section are used in Section 9 of this report to undertake a peat stability risk assessment. As part of this assessment, appropriate control measures will be identified to mitigate the risk of a peat slide.



KEYPLAN

Scale 1:70000

FOS CORRIDOR PLAN

Scale 1:14000

Legend: Factor of Safety

- 1 or less
- 1.01 to 1.3
- 1.31 to 1.4
- Greater than 1.4
- No Peat Recorded at this Location

Increasing Stability

Note -

The results of the undrained analysis for the most critical load condition 2 are shown on this drawing.

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Rev.	Description	App By	Date
A	FOR INFORMATION	BDH	20.01.23

PROJECT: **DERRYBRIEN WIND FARM DECOMMISSIONING**

CLIENT: **ESB EMP**

SHEET: **FACTOR OF SAFETY FOR PEAT SLOPES DRAWING 1 OF 2**

Date: 20.01.23 | Project number: P22-133 | Scale (@ A3):

Drawn by: POR | Drawing Number: P22-133-0600-OHL-0004 | Rev: A

Checked by: IH

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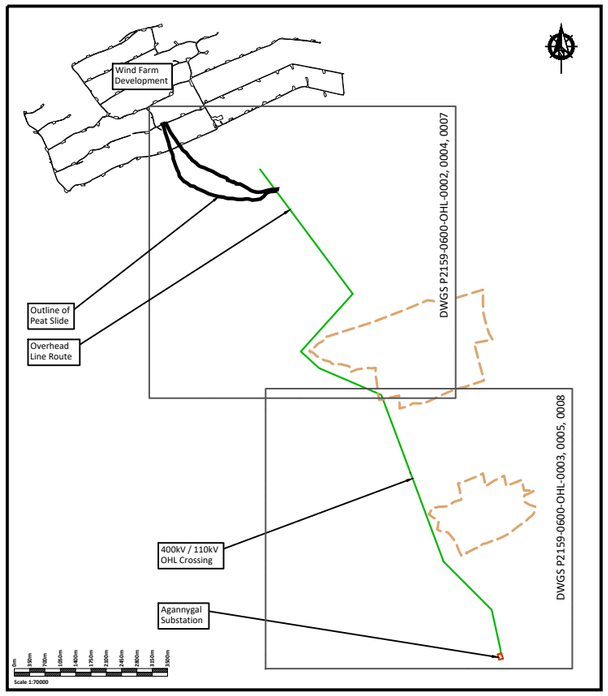
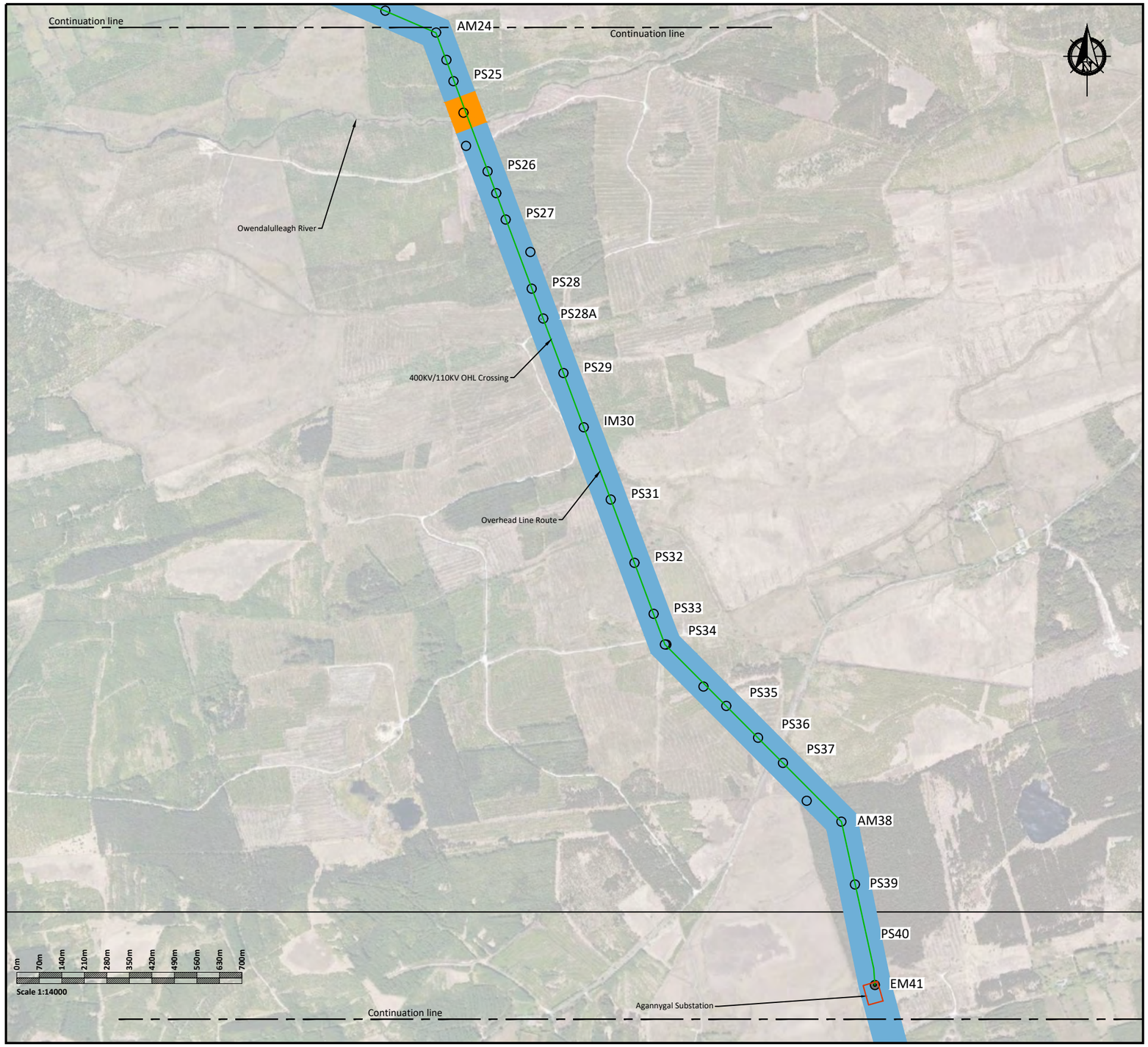
Friday 20 January 2023



KEYPLAN

Scale 1:70000



Legend: Factor of Safety

- 1 or less
- 1.01 to 1.3
- 1.31 to 1.4
- Greater than 1.4
- No Peat Recorded at this Location

Increasing Stability

Note -

The results of the undrained analysis for the most critical load condition 2 are shown on this drawing.

PEAT DEPTH CORRIDOR PLAN

Scale 1:14000

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Rev.	Description	App By	Date
A	FOR INFORMATION	BDH	20.01.23

PROJECT: DERRYBRIEN WIND FARM DECOMMISSIONING

CLIENT: ESB EMP

SHEET: FACTOR OF SAFETY FOR PEAT SLOPES DRAWING 2 OF 2

Date: 20.01.23 | Project number: P22-133 | Scale (@ A3) |

Drawn by: POR | Drawing Number: P22-133-0600-OHL-0005 | Rev: A

Checked by: IH

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Friday 20 January 2023

9. PEAT STABILITY RISK ASSESSMENT

9.1 Methodology

A peat stability risk assessment was carried out for the OHL infrastructure and Agannygal substation. This approach takes into account guidelines for geotechnical/peat stability risk assessments as given in PLHRAG (2017) and MacCulloch (2005).

The risk assessment uses the results of the stability analysis (deterministic approach) in combination with qualitative factors, which cannot be reasonably included in a stability calculation but nevertheless may affect the occurrence of peat instability, to assess the risk for each infrastructure element.

As previously outlined, the OHL route was broken into 8 no. subsections (including the substation at Agannygal) for assessment. These subsections were chosen based on having similar topography and peat depth within each individual section

For each subsection of the OHL, a risk rating (product of probability and impact) is calculated for every contributory/qualitative factor in the subsection. The range of risk ratings is shown in Table 9.1.

The risk rating assigned to any subsection is based on the highest risk rating calculated for any contributory/qualitative factor within that subsection.

Where a subsection is rated 'Medium' or 'High', specific control measures are required to reduce the risk to at least a 'Low' risk rating. Where a subsection is rated 'Low' or 'Negligible', only routine control measures, if any, are required. The control measures are targeted at the specific contributory/qualitative factors that give the highest risk rating.

Table 9.1: Risk Rating Legend

17 to 25	High: avoid works in area or significant control measures required
11 to 16	Medium: notable control measures required
5 to 10	Low: only routine control measures required
1 to 4	Negligible: none or only routine control measures required

A full methodology for the peat stability risk assessment is given in Appendix C.

The impact of a peat slide on the receiving environment within and beyond the OHL route and substation is assessed based on the potential travel distance and potential volume of a peat slide and the effect on receptors such as local property, infrastructure, and the natural environment.

Where a peat slide enters a watercourse it can travel a considerable distance downstream. Therefore, the proximity of a potential peat slide to a drainage feature is a significant indicator of the likely potential impact. Furthermore, given the elevation of the terrain along the OHL route, the topography in some areas may result in the formation of potential flow paths through naturally occurring features such as dips and falls in the terrain, valleys, etc. Such features would have the effect of increasing the travel distance of and the areas affected by any potential peat slide.

The potential damage to private property is also assessed using this approach. The OHL is located in a sparsely populated location; however, landowners and domestic dwellings may still be at risk in certain areas if a peat slide were to occur. In addition, property such as pasture and tillage farms, private landholdings, and communication/power infrastructure can be susceptible to peat slides. The list of such potential features or receptors identified are outlined in Table 9.2.

Table 9.2: Potential Receptors

Receptor	Control
Watercourse (rivers, streams, flow channels, etc.)	Topography
Dwellings (domestic)	
Road (local roads excluding wind farm access tracks)	
Infrastructure (overhead lines, communications infrastructure, etc.)	
Agricultural Land (pasture, etc.)	
Natural Heritage Area (Slieve Aughty Bog NHA)	

The primary controlling aspect when determining the impact of a potential peat slide, once that slide has occurred, is the topography along the slide run-out route.

9.2 Summary of Risk Assessment Results

The results of the risk assessment for potential of a peat slide at the 8 no. subsections are presented in Appendix D and are summarised in Table 9.3.

The risk rating for the identified areas of infrastructure along the OHL route and the substation is designated low or less following mitigation/control measures being implemented. If any sections of new temporary access track are required for any decommissioning works on the OHL, these should be subject to the same mitigation/control measures that apply to that particular subsection of the OHL. Where the proposed access routes use the existing founded forest tracks the risk rating is considered to be negligible, due to the minor nature of any required upgrade works and the absence of peat beneath the tracks.

Details of the required mitigation/control measures can be found for each OHL subsection in Appendix D.

The upgrade of the c. 2.5km of access track to access the Agannygal substation site during construction is not considered to present a risk of instability given the minor nature of the work involved and the relatively flat topography of the area.

Table 9.3: Summary of Peat Stability Risk Assessment

Infrastructure	Pre-Control Measure Implementation Risk Rating	Post-Control Measure Implementation Risk Rating
PS5 to AM14	Medium	Negligible
AM14 to AM18	Negligible	Negligible
AM18 to AM24	Medium	Negligible
AM24 to PS28A	Medium	Low
PS28A to PS34	Medium	Negligible
PS34 to AM38	Medium	Negligible
AM38 to EM41	Medium	Negligible
Agannygal Substation	Negligible	Negligible

Note
(1) For mitigation/control measures refer to Appendix D.

9.3 Likelihood of Instability – Combining Deterministic and Qualitative Factors

The results of the stability analysis (Section 8) have been combined with qualitative factors, to provide an indication of the probability of instability. The qualitative factors are given in Appendix C.

The purpose of combining deterministic and qualitative factors is to provide a likelihood of failure that can be applied to a variety of potential specific receptors, other than those included in this report, see Table C in Appendix C. The peat stability risk assessment included in Section **Error! Reference source not found.**.2 of this report uses a number of general receptors such as local property, infrastructure, and the natural environment.

The deterministic factor of safety and qualitative factors are combined as follows:

- The deterministic factor of safety and qualitative factors are scored from 0 to 5 using Table B in Appendix C.
- The maximum score that can be obtained by combining the deterministic factor of safety and qualitative factors, that is a total of 12 factors (5 x 12), is 60, and the lowest score is 0. The greater the total combined score the greater the likelihood of failure.
- Where the stability analysis is not applicable because, for example, no peat is present, then the deterministic score is 0, and combined score defaults to negligible irrespective of the qualitative factors.
- Where stability analysis shows FoS less than 1 then the likelihood defaults to very likely irrespective of qualitative score
- In all cases, experienced engineering judgement is used, the actual combined scoring provides a guide.

Error! Reference source not found. shows the peat landslide combined likelihood ranges for the lifetime of a proposed development, and Table 9.5 provides the combined likelihood score for each of the sections assessed.

Table 9.4: Summary of Peat Stability Liklihood and Probability

Scale	Likelihood	Combined Score	Probability of Occurrence (Event / year)
0	Not applicable	0	Not applicable
1	Negligible	1 to 10	>1 in 100,000 to 1 in 10,000
2	Unlikely	11 to 30	>1 in 10,000 to 1 in 1,000
3	Probable	31 to 40	>1 in 1,000 to 1 in 100
4	Likely	41 to 50	>1 in 100 to 1 in 10
5	Very Likely	51 to 60	>1 in 10

Table 9.5: Summary of Peat Stability Likelihood along OHL

Infrastructure	Combined Likelihood Score	Likelihood of Failure Pre-Control Measure Implementation
PS5 to AM14	13	Unlikely
AM14 to AM18	3	Negligible
AM18 to AM24	9	Negligible
AM24 to PS28A	19	Unlikely
PS28A to PS34	12	Unlikely
PS34 to PS38	17	Unlikely
AM38 to EW41	14	Unlikely
Agannygal	2	Negligible

10. CONCLUSIONS

The following conclusions are given.

(1) Fehily Timoney & Company (FT) was engaged by ESB to undertake a geotechnical stability assessment of the OHL route from the Derrybrien wind farm site to the Agannygal Substation. In line with the brief, the assessment took account of the geotechnical stability of the route and the substation during its construction phase, operational phase and during possible decommissioning works in the future.

(2) The geotechnical stability assessment included the completion of a desk study, a site walkover, and an additional ground investigation. A deterministic peat stability assessment and a qualitative peat stability risk assessment were undertaken.

(3) Apart from the peat slide scar left by the peat slide in October 2003, which is between pole sets 5 and 6, no evidence of past peat slides have been recorded on the OHL route. The nearest other historical peat slide was located approximately 2.5km east of the offsite substation and occurred in 1890.

(4) Cuttings up to 3.8m deep in glacial till were observed. These appear to be stable based on a visual inspection and are considered to have a low risk of future instability.

(5) The deterministic peat stability assessment found that the peat along the OHL route generally has an adequate factor of safety against peat slide and hence a low risk of instability. However, the use of conservative shear strength parameters for the peat has contributed to a small number (1 no. – 1% of total route) of low FoS results, particularly around areas of high slope angles. The Risk Assessments in Appendix D provide mitigation measures for these areas.

(6) A qualitative peat stability risk assessment was carried out by separating the OHL route into 8 no. subsections and assessing these subsections based on the probability of a peat slide for a number of indicators and the likely impact of a peat slide, should it occur. The peat stability risk assessment found that 6 no. subsections were assigned a ‘medium’ risk rating while the remaining subsections were assigned ‘low’ or ‘negligible’ risk ratings.

(7) To bring the risks of a peat slide at the locations where a ‘medium’ risk exists to ‘low’ or ‘negligible’ levels, it is recommended that control measures are implemented. These include routine measures such as avoiding accessing the areas of peat with the greatest slopes with plant, the use of suitable plant and equipment, and adequate monitoring of the works. Other control measures are outlined in Appendix D.

(8) Overall the stability of the OHL and Agannygal Substation with respect to peat slide risk is considered to be acceptable. Where localised areas of elevated risk have been identified the level of risk can be reduced by the application of routine control measures.

(9) Should any sections of new temporary access track be required for any decommissioning works running below the OHL, these should be subject to the same mitigation/control measures that apply to that particular subsection of the OHL. Where the proposed access routes use the existing founded forest tracks the risk rating is considered to be negligible, due to the minor nature of any required upgrade works and the absence of peat beneath the tracks.

11. REFERENCES

Fehily Timoney and Company (FT) (2019). Geotechnical Stability Report 2 for Derrybrien Wind Farm Project. Draft, October 2019.

Bromhead, E. N. (1986). The Stability of Slopes.

BSI (1981). BS 6031:1981 Code of practice for earthworks.

BSI (2015). BS 5930:2015 Code of practice for site investigations.

Carling, P. A. (1986). Peat slides in Teesdale and Weardale, northern Pennines, July 1983: Description and failure mechanisms. Earth Surface Processes and Landforms, 11.

Den Haan, E. J. and Grognet, M. (2014). A large direct simple shear device for the testing of peat at low stresses. Géotechnique Letters 4(4): 283–288, http://dx.doi.org/10.1680/geolett. 14.00033.

Dykes, A. P. and Kirk, K. J. (2006). Slope instability and mass movements in peat deposits. In Martini, I.P., Martinez Cortizas, A. and Chesworth, W. (Eds.) Peatlands: Evolution and Records of Environmental and Climatic Changes. Elsevier, Amsterdam.

Environmental Protection Agency, EPA (2017): Draft Guidelines on the Information to be contained in Environmental Impact Assessment Reports. August 2017.

ESB (2006). Derrybrien Wind Farm, Co Galway. Slope stability assessment of a section of ground under overhead line. Report Number P78015-R476-002. 16th February 2006.

Eurocode 7 (EC7). BS EN 1997-1: 2005, Geotechnical Design, Part 1 – General Rules, British Standards Institution, London.

Farrell, E. R. & Hebib, S. (1998). The determination of the geotechnical parameters of organic soils. Proceedings of International Symposium on problematic soils, IS-TOHOKU 98, Sendai, Japan.

Geological Survey of Ireland (2003). Geology of Galway Bay. Sheet 14.

Geological Survey of Ireland (2018). Online dataset public viewer http://spatial.dcenr.gov.ie/imf/imf.jsp?site=GSI_Simple September 2019.

Hanrahan, E. T., Dunne, J. M. and Sodha, V.G. (1967). Shear strength of peat. Proc. Geot. Conf., Oslo, Vol. 1.
Hendry MT, Sharma JS, Martin CD and Barbour SL (2012). Effect of fibre content and structure on anisotropic elastic stiffness and shear strength of peat. Canadian Geotechnical Journal 49(4): 403–415, http://dx.doi.org/10.1139/t2012-003.

Hungr, O. and Evans, S. G. (1985). An example of a peat flow near Prince Rupert, British Columbia. Canadian Geotechnical Journal, 22.

Komatsu, J. Oikawa, H. Tsushima, M. and Igarashi, M. (2011). Ring shear test on peat. In Proceedings of the 21st International Offshore and Polar Engineering Conference, Maui, Hawaii, USA (Chung JS, Hong SY, Langen I and Prinsenberg SJ (eds)). International Society of Offshore and Polar Engineers, Cupertino, CA, USA, vol. 2, pp. 393–396.

Landva, A. O. (1980). Vane testing in peat. Canadian Geotechnical Journal, 17(1).

MacCulloch, F. (2005). Guidelines for the Risk Management of Peat Slips on the Construction of Low Volume/Low Cost Roads over Peat. RoadEx 11 Northern Periphery.

NSAI (2005). I.S. EN 1997-1:2005 + AC: 2013. Eurocode 7: Geotechnical Design - Part 1: General Rules.

O'Kelly B. C., and Zhang, L. (2013). Consolidated-drained triaxial compression testing of peat. Geotechnical Testing Journal 36(3): 310–321, http://dx.doi.org/10.1520/ GTJ20120053.

PLHRAG (2017). Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments. Prepared for Energy Consents Unit Scottish Government, 2nd Edition. Dated April 2017.

Rowe, R. K. & Mylleville, B. L .J. (1996). A geogrid reinforced embankment on peat over organic silt; a case history. Can. Geotech. J. 33 (1), 106 – 122.

Rowe, R. K., MacLean, M. D., Soderman, K. L. (1984). Analysis of a geotextile reinforced embankment constructed on peat. Can. Geotech. J. 21 (3), 563 – 576.

Skempton, A. W. and DeLory, F. A. (1957). Stability of natural slopes in London Clay. Proc 4th Int. Conf. On Soil Mechanics and Foundation Engineering, Rotterdam, vol. 2, pp.72-78.

Warburton, J., Higgett, D. and Mills, A. (2003). Anatomy of a Pennine Peat Slide. Earth Surface Processes and Landforms.

Warburton, J., Holden, J. and Mills, A. J. (2003). Hydrological controls of surficial mass movements in peat. Earth-Science Reviews 67 (2004), pp. 139-156.

Zwanenburg, C., Den Haan E. J., Kruse G. A. M. and Koelewijn, A. R. (2012). Failure of a trial embankment on peat in Booneschans, the Netherlands. Géotechnique 62(6): 479–490, http://dx.doi.org/10.1680/geot.9.P.094

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FIGURES

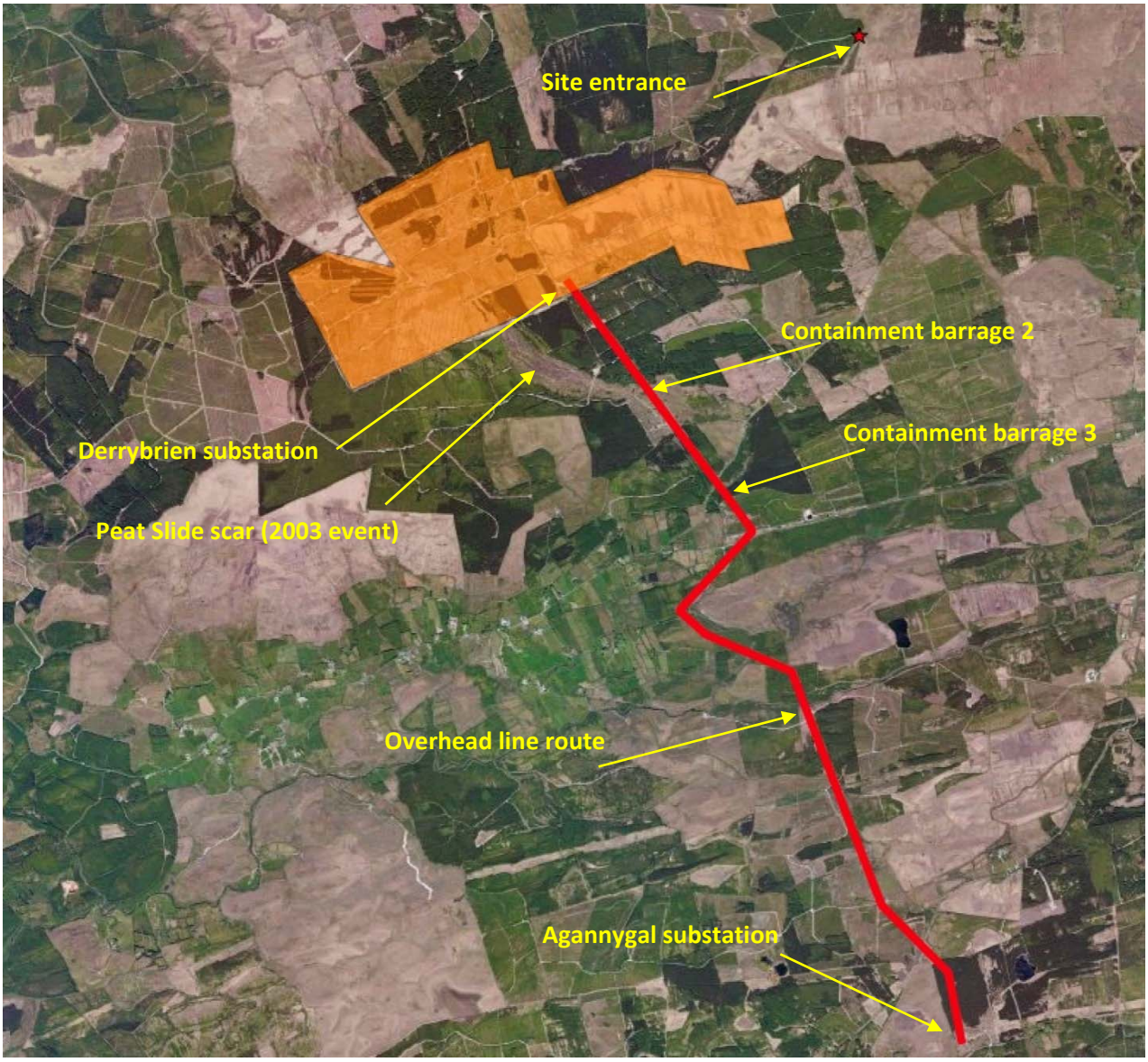
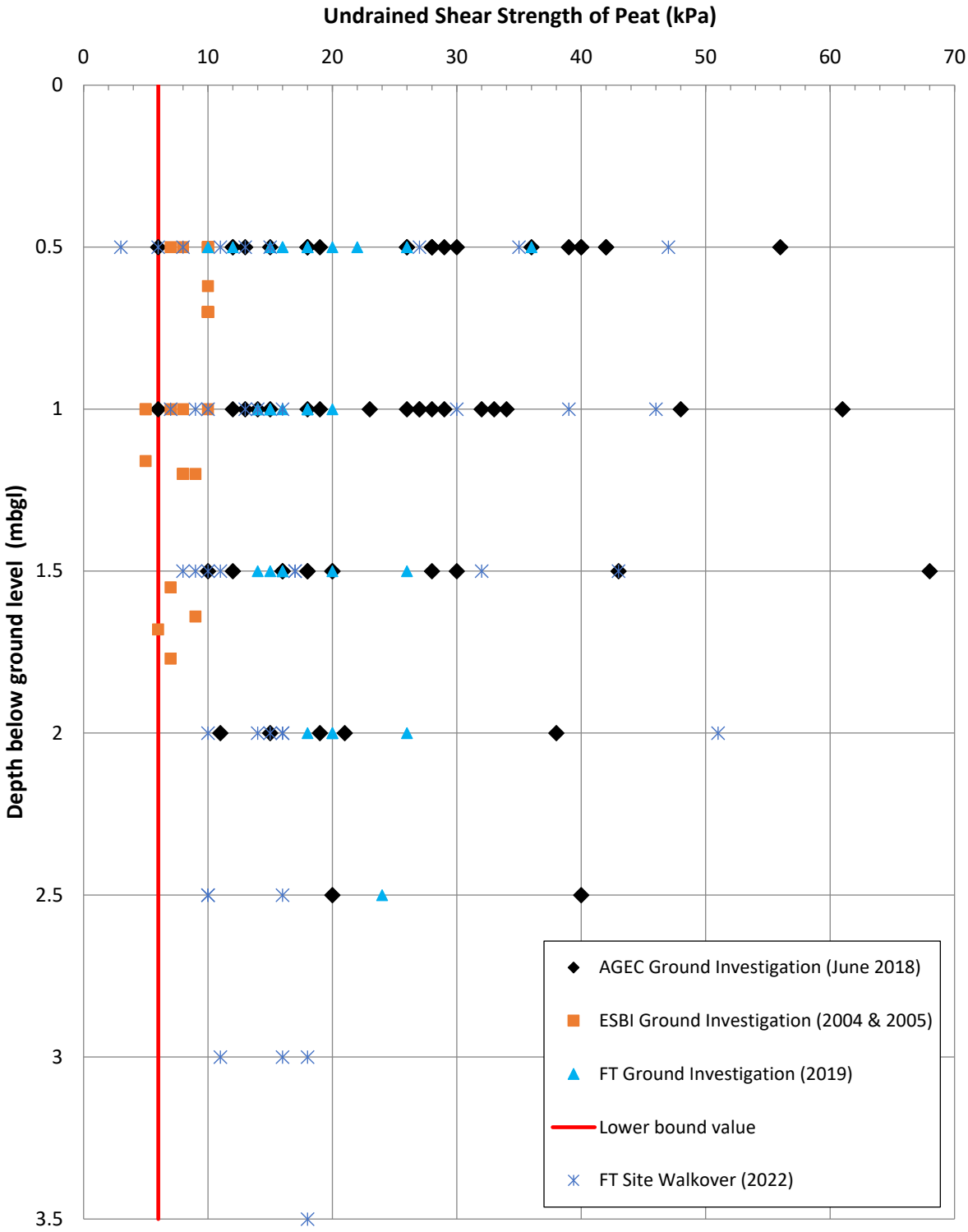
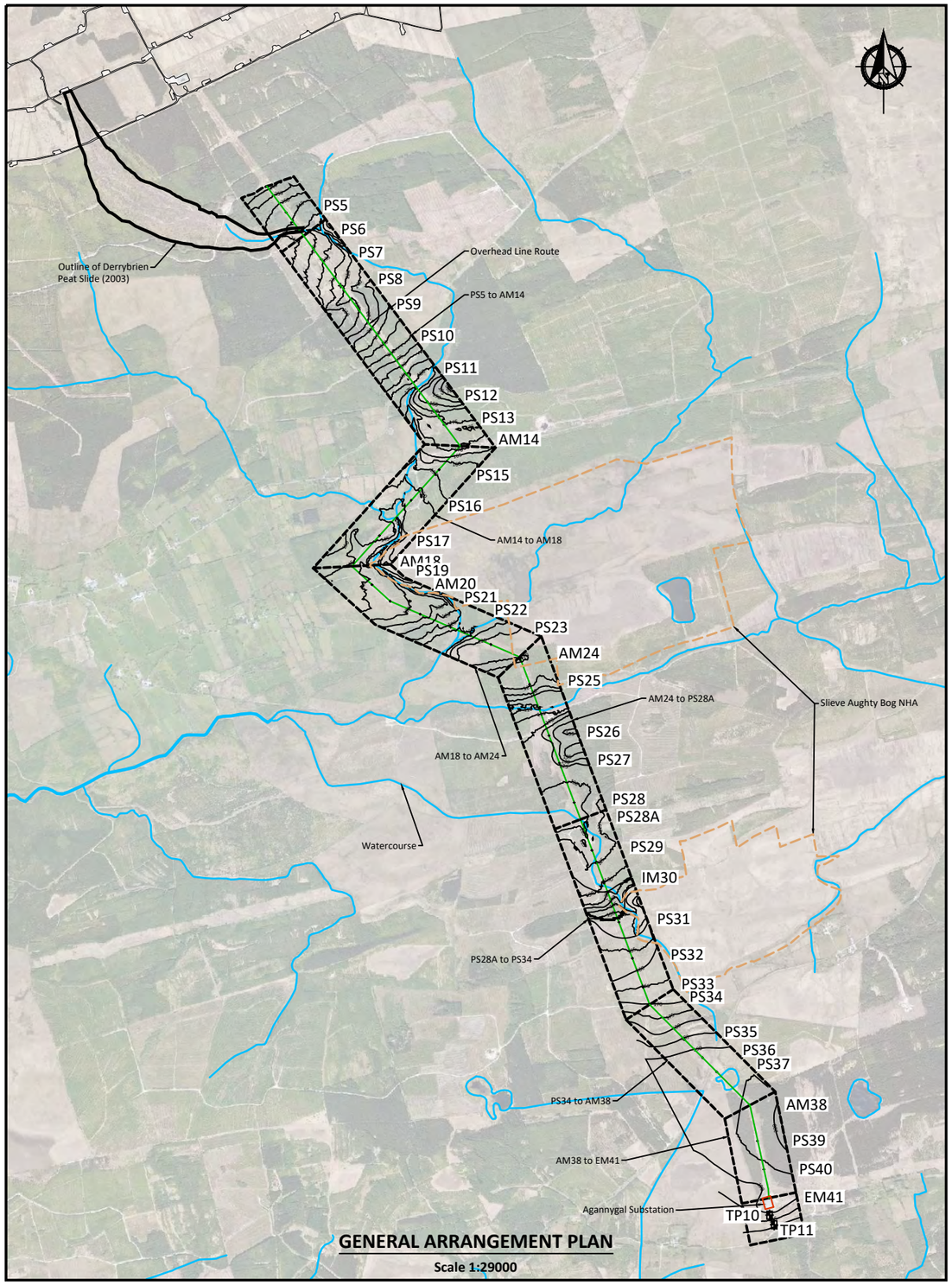


Figure 1 Location of Grid Connection (source: Bing Maps)

Figure 2 Undrained Shear Strength of Peat along Overhead Line Route





GENERAL ARRANGEMENT PLAN

Scale 1:29000

GI Legend and notes:

AGEC Trial Pit Locations (June 2018)

Background aerial mapping shown taken from the latest available Bing Mapping.

Notes:

1. The OHL route was broken into a number of subsections (including the substation at Agannygal) for assessment. These subsections were chosen based on having comparable topography and peat depth.

0m 145m 290m 435m 580m 725m 870m 1015m 1160m 1305m 1450m

Scale 1:29000

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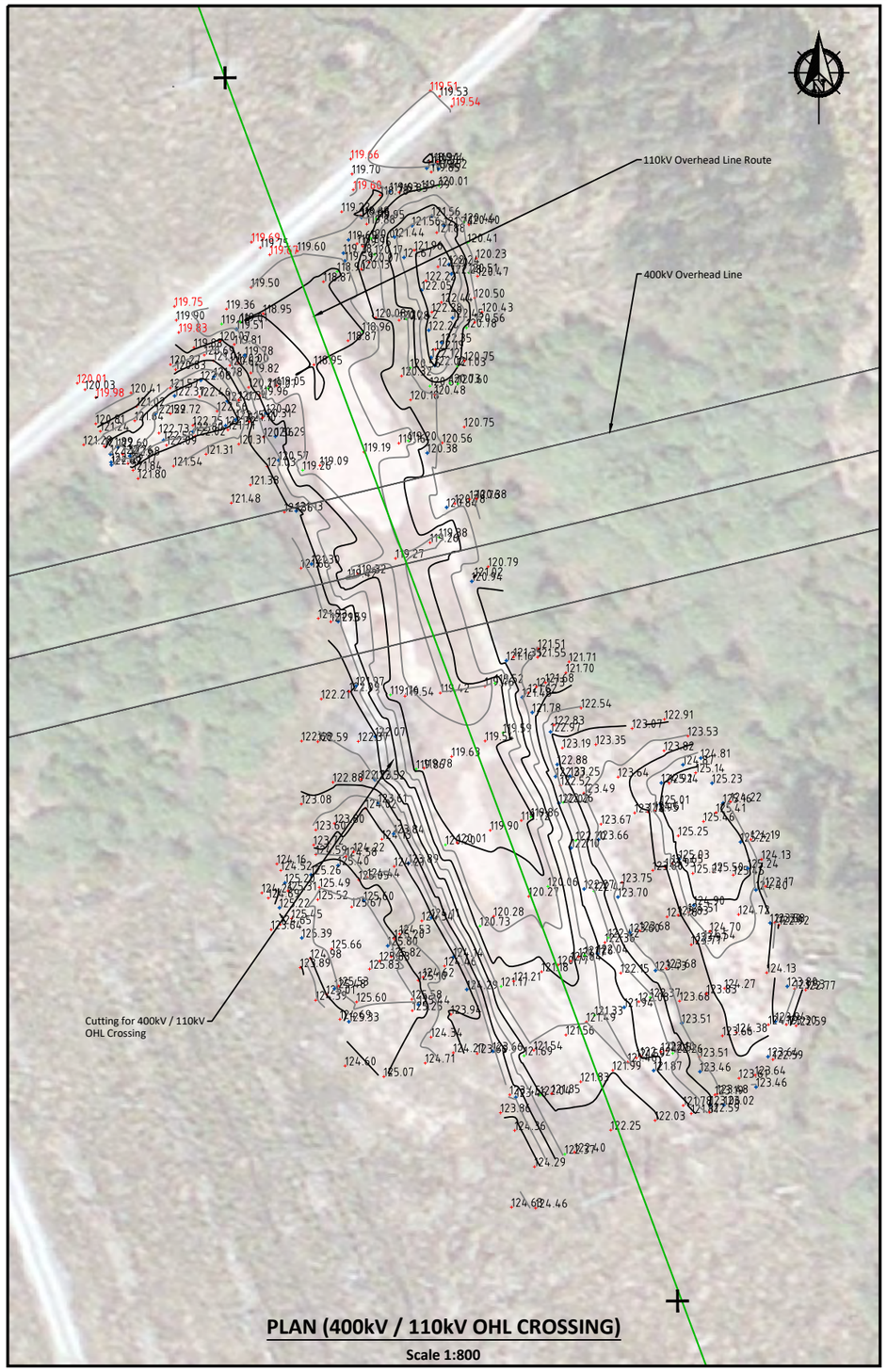
Rev.	Description	App By	Date
A	FOR INFORMATION	BDH	20.01.23

PROJECT	DERRYBRIEN WIND FARM DECOMMISSIONING
CLIENT	ESB EMP
SHEET	GENERAL ARRANGMENT
Date	20.01.23
Project number	P22-133
Scale (@ A3)	
Drawn by	POR
Checked by	IH
Drawing Number	P22-133-0600-OHL-0001
Rev	A

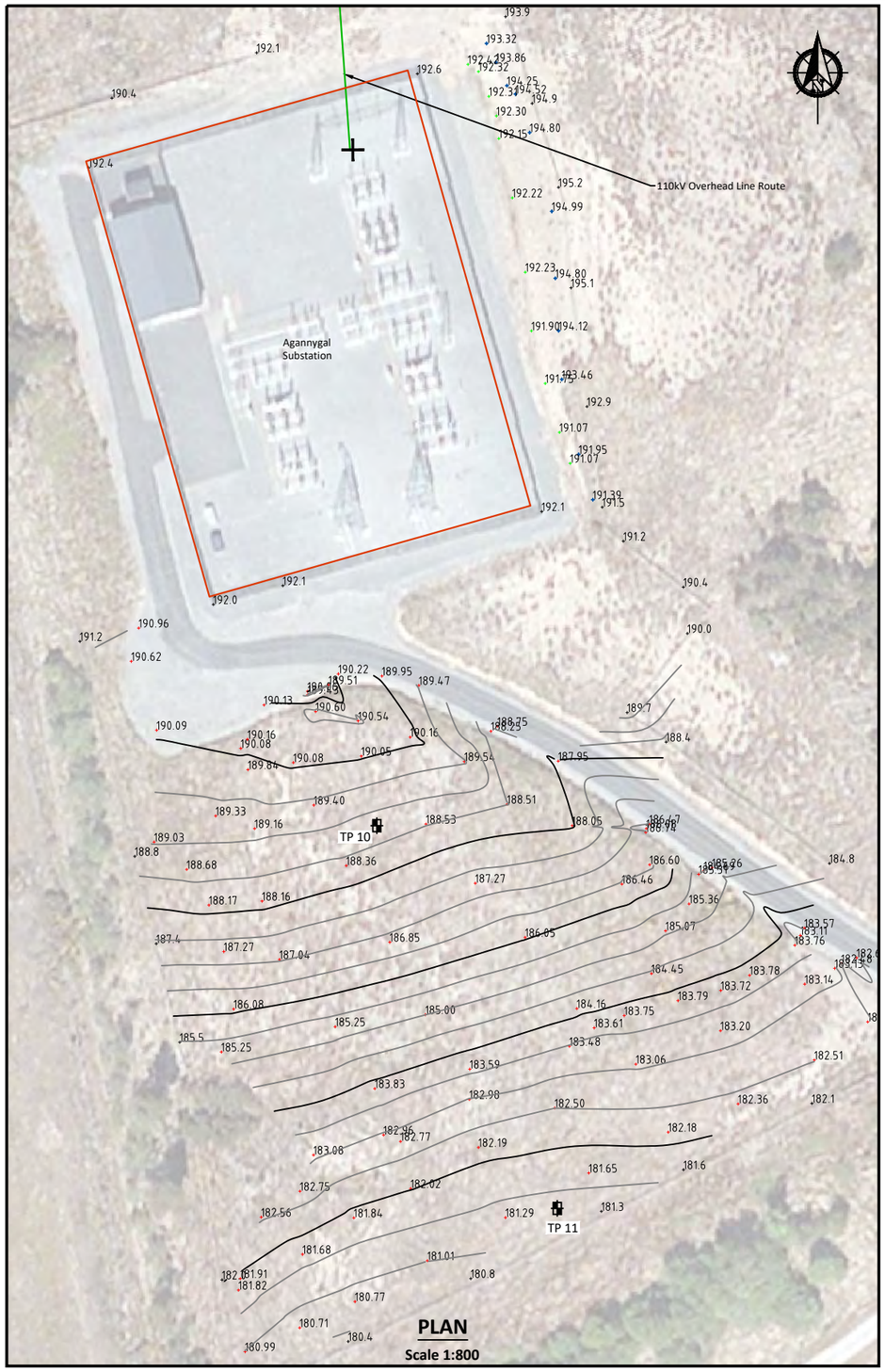
O:\ACAD\2022\P22-133\P22-133-0600-OHL-0001

Friday 20 January 2023



PLAN (400kV / 110kV OHL CROSSING)

Scale 1:800



PLAN

Scale 1:800

GI Legend and notes:

AGEC Trial Pit Locations (June 2018)

Background aerial mapping shown taken from the latest available Bing Mapping.

Notes:

1. Topographical survey information shown on this drawing is based on survey data recorded on site by ESBI in 2018.

0m 4m 8m 12m 16m 20m 24m 28m 32m 36m 40m

Scale 1:800

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Rev.	Description	App By	Date
A	FOR INFORMATION	BDH	20.01.23

PROJECT: DERRYBRIEN WIND FARM DECOMMISSIONING

CLIENT: ESB EMP

SHEET: DETAILS OF 400kV / 100kV CROSSING & AGANNYGAL SUBSTATION

Date: 20.01.23	Project number: P22-133	Scale (@ A3):	
Drawn by: POR	Drawing Number: P22-133-0600-OHL-0006		Rev: A
Checked by: IH			

O:\ACAD\2022\P22-133\P22-133-0600-OHL-0006

Friday 20 January 2023

N

EM1(Derrybrien Station)

PS1a

Derrybrien Substation

PS2

PS3

PS4

PS5

PS6

PS7

PS8

PS9

PS10

PS11

PS12

PS13

AM14

PS15

PS16

PS17

AM18

PS19

AM20

PS21

PS22

PS23

AM24

PS25

Black Road

R353

Point D
E-561084.25
N-702394.884

Point C
E-561040.6337
N-702331.6321

Point A
E-561123.4388
N-702367.5429

Point B
E-561061.14
N-702260.8798

Insert Map

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See Insert Map

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0 0.5 1 1.5 2 km

Legend

Derrybrien - Agannygal 110 kV Overhead Line

Decommissioning Access Routes:

- Decommissioning access route EM1 to PS4
- Decommissioning access route PS12 to PS14
- Decommissioning access route PS15 to PS22
- Alternative Decommissioning access route to PS15 to PS22
- Alternative Decommissioning access route to PS 17 to PS22
- Decommissioning access route PS23 to PS25
- Decommissioning access route PS26 to PS27
- Decommissioning access route PS5 to PS11

Mast type:

- Poleset (PS)
- Angle Mast (AM)
- End Mast (EM)

REV	DATE	REVISION DESCRIPTION	DRN	PROD	VER	APP
0	21/11/2023	Issued for Decommissioning Application	E.O'S	***	***	***

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PRODUCTION UNIT: Civil Environmental & Renewable Engineering

PROJECT: Derrybrien Wind Farm Decommissioning Project

DRAWING TITLE: Figure DMP 01 - Derrybrien - Agannygal OHL - Indicative Decommissioning Access Routes (Sheet 1 of 2)

CONTRACT

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CLIENT REF.	NO. OF SHEETS	SIZE	SCALE
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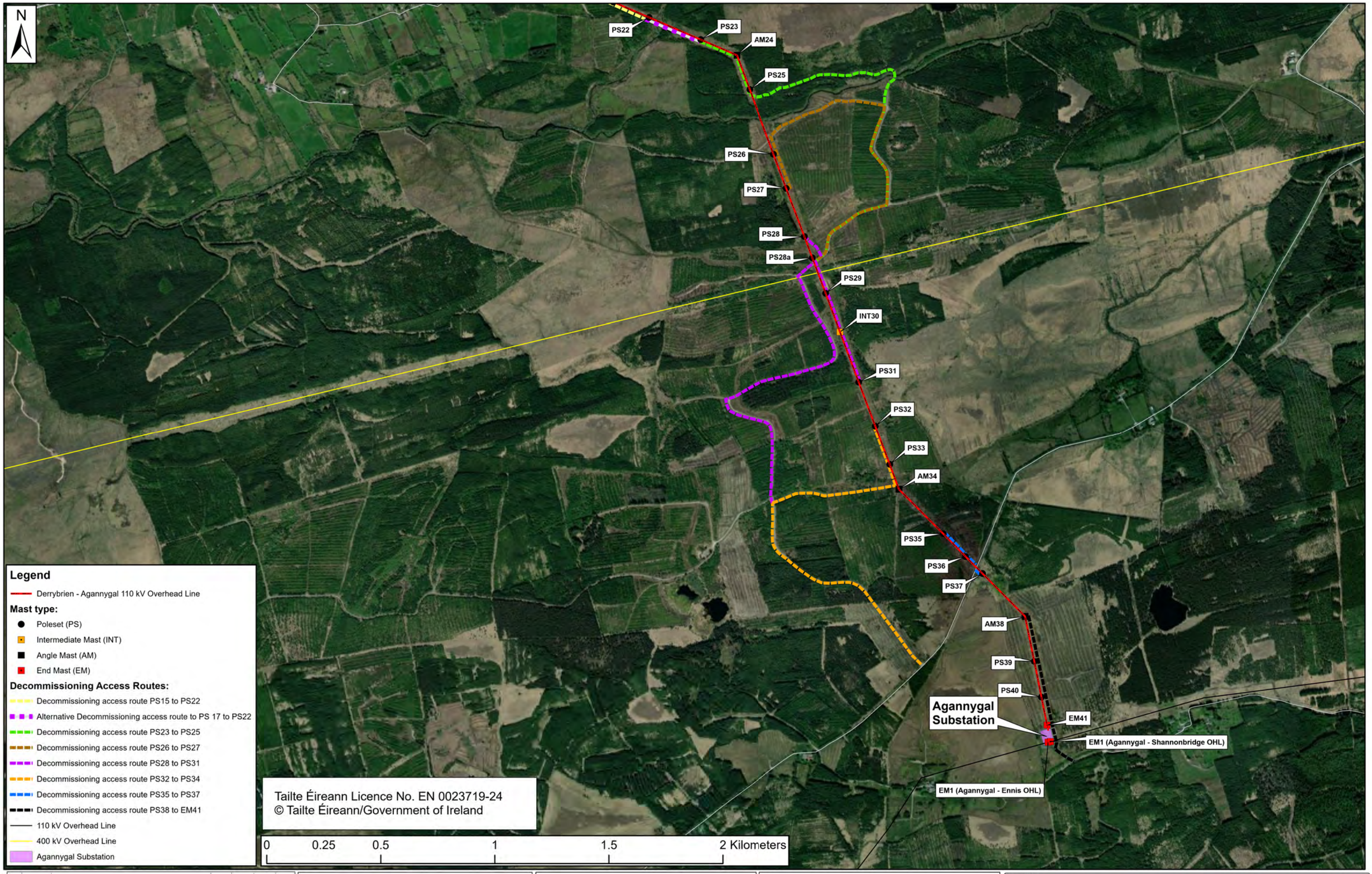
DRAWING NUMBER: **DRAFT FOR INFORMATION ONLY**



REV	DATE	REVISION DESCRIPTION	E.O'S	DRN	PROD	VER	APP
0	xx/xx/xx	Issued for Decommissioning Application	E.O'S	XXX	XXX	XXX	

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DRAWING TITLE: Figure DMP 02 - Derrybrien - Agannygal OHL - Indicative Decommissioning Access Routes (Sheet 2 of 2)

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DRAWING NUMBER: **DRAFT FOR INFORMATION ONLY**

N

S37

AM38

PS39

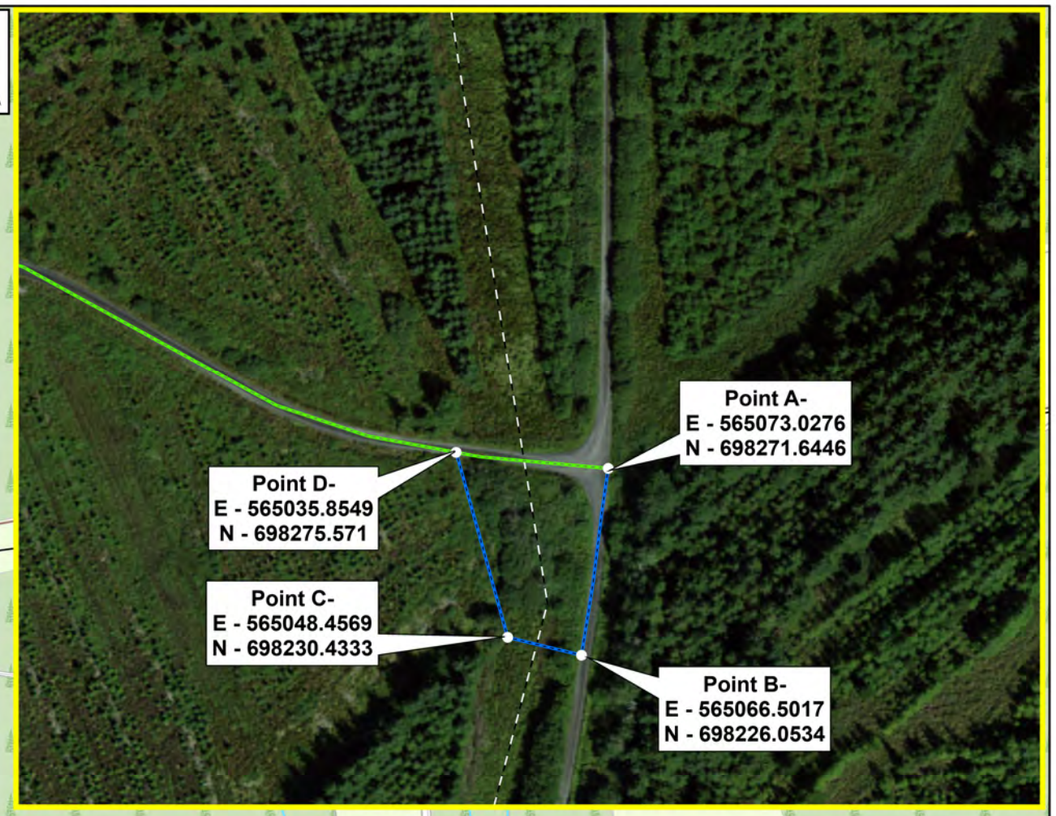
PS40

Agannygal Substation

EM41

EM1 (Agannygal - Shannonbridge OHL)

EM1 (Agannygal - Ennis OHL)



Legend

- Decomissioning Access Route to Substation
- Alternative Decomissioning Access Route to Substation

Mast type:

- Poleset (PS)
- Angle Mast (AM)
- End Mast (EM)
- Derrybrien - Agannygal 110 kV Overhead Line
- 110 kV Overhead Line
- Agannygal Substation

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0 0.13 0.25 0.5 0.75 1 Kilometers

REV	DATE	REVISION DESCRIPTION	DRN	PROD	VER	APP
0	05/05/20	Issued for Decommissioning Application	E.O'S	XXX	XXX	XXX

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DRAWING TITLE:

Figure DMP 14 - Agannygal Substation - Indicative Decommissioning Access Route

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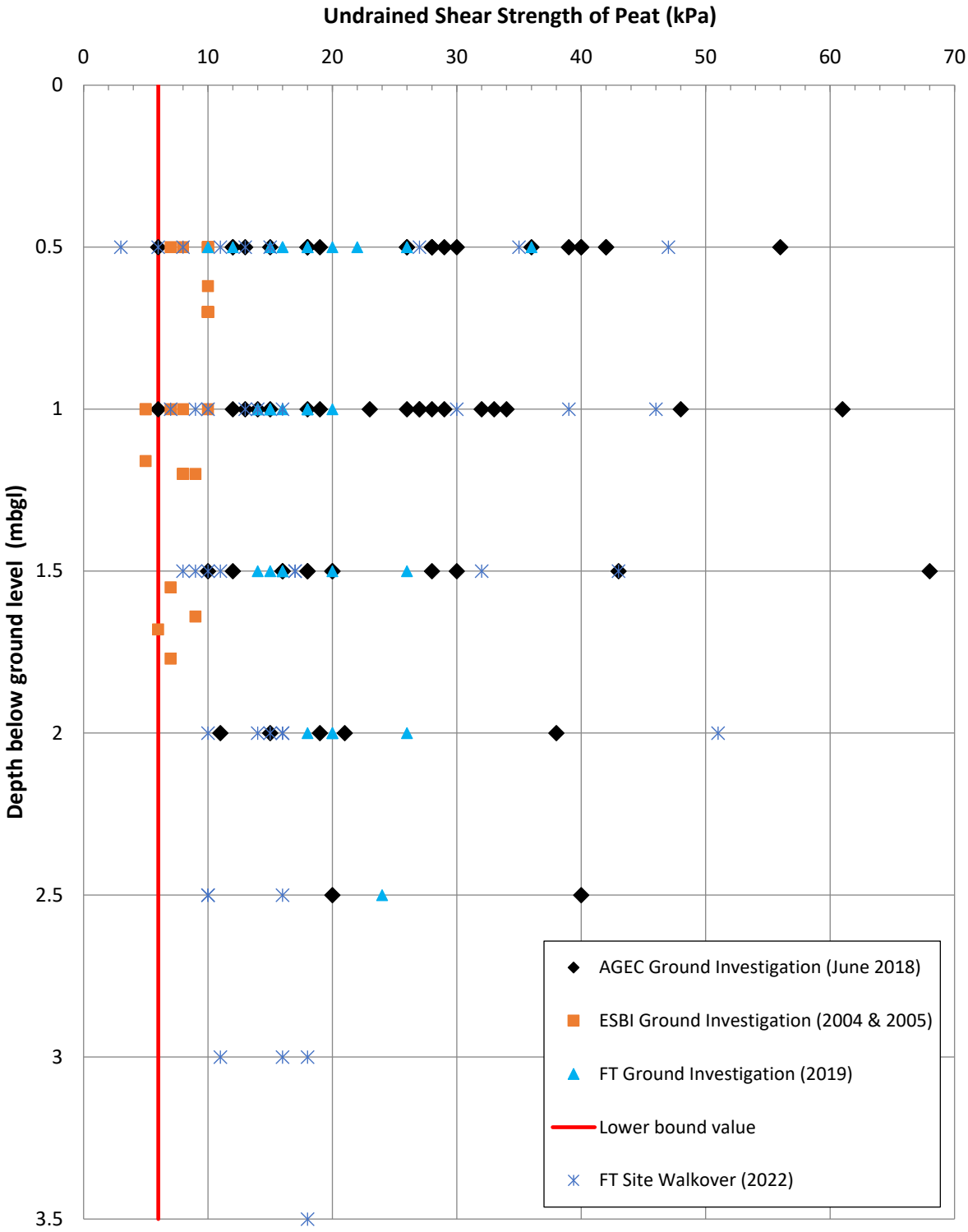
Figure 2 Undrained Shear Strength of Peat along Overhead Line Route



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APPENDIX A

Photos from Site Walkover

Photo 1 Typical timber pole set

Photo 2 Typical steel angle mast

Photo 3 Typical forest track access route

Photo 4 Access track to pole sets PS5 to PS10

Photo 5 Remnants of sleepers from felled trees as access

Photo 6 Owendalluleagh River crossing (access to pole sets PS22 to PS25)

Photo 7 Shallow cutting in exposed mineral soil as access to pole set PS22

Photo 8 Cutting at 400 kV crossing looking south (400 kV line runs left to right in image)

Photo 9 Cutting at 400 kV crossing looking north (400 kV line runs left to right in image)

Photo 10 View of area between pole set PS37 and angle mast AM38 looking north showing Lough Agannygal

Photo 11 Existing forestry access track leading to Agannygal substation

Photo 12 Cutting in mineral soil at Agannygal substation

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APPENDIX B

AGEC Ground Investigation (2018) – Relevant Trial Pit Logs

Trial Pit Log

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Trialpit No **TP10** Sheet 1 of 1

Project Name: Derrybrien Wind Farm	Project No. 1806	Co-ords: 163168.00 - 198491.00 Level: 0.00	Date 19/06/2018
Location: Co. Galway		Dimensions (m): 3 × 1.3, Depth 2.90	Scale 1:25
Client: ESBI			Logged M.L.

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
							Soft to firm light orange grey, brown, grey, slightly gravelly slightly sandy CLAY with some cobbles and occasional boulders, (Sub-angular to sub-rounded), and some wood, pockets of peat etc. (Made ground.)
				0.60	-0.60		Soft woody brown fibrous PEAT with branches, brash and vegetation. (Possible made ground or disturbed ground.)
				1.00	-1.00		Soft greyish brown slightly gravelly sandy organic CLAY and clayey organic SAND with decaying rootlets and some cobbles and occasional boulders. (up to 1.0m) (Sub-angular to sub-rounded)
				1.50	-1.50		Firm becoming stiff to very stiff light reddish brown sandy very gravelly SILT/CLAY with many cobbles and some boulders. (Sub-rounded to sub-angular)
				2.00	-2.00		Stiff to very stiff light reddish brown sandy very gravelly (weak siltstone) SILT/CLAY with many cobbles and some boulders. (Sub-rounded to sub-angular)
				2.90	-2.90		End of pit at 2.90 m

1 2 3 4 5

Remarks: TP - DRY.
End of TP - Hard digging.

Stability: Generally stable, minor spalling.

Trial Pit Log

agec geotechnical engineering consultants

Trialpit No **TP11** Sheet 1 of 1

Project Name: Derrybrien Wind Farm	Project No. 1806	Co-ords: 163193.00 - 198438.00 Level: 0.00	Date 19/06/2018
Location: Co. Galway		Dimensions (m): 3 × 1.5 Depth 2.50	Scale 1:25
Client: ESBI			Logged M.L.

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
							Soft to firm light orange grey, reddish brown, brown, grey slightly gravelly slightly sandy CLAY with some cobbles and occasional boulders, (Sub-angular to sub-rounded), and some wood, pockets of peat etc. (Made ground.)
				0.60	-0.60		Disturbed peaty layer - discontinuous.
				0.70	-0.70		Soft grey and orange brown slightly gravelly sandy organic CLAY and clayey organic SAND with decaying rootlets and some cobbles and occasional large boulders. (Sub-angular to sub-rounded)
				1.70	-1.70		Stiff to very stiff light reddish brown sandy very gravelly SILT/CLAY with many cobbles and some boulders. (Sub-rounded to sub-angular)
				2.50	-2.50		End of pit at 2.50 m

1 2 3 4 5

Remarks: No water strike - dry.
End of TP - Hard digging.

Stability: Generally stable, minor spalling.

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APPENDIX C

Methodology for Peat Stability Risk Assessment

Methodology for Peat Stability Risk Assessment

A peat stability risk assessment was carried out for the OHL route between the Derrybrien substation and Agannygal substation. This approach takes into account guidelines for geotechnical/peat stability risk assessments as given in PLHRAG (2017) and MacCulloch (2005). The degree of risk is determined as a Risk Rating (R), which is the product of probability (P) and impact (I). How these factors are determined and applied in the analysis is described below.

The main approaches for assessing peat stability include the following:

(a) Geomorphological
(b) Qualitative (judgement)
(c) Index/Probabilistic (probability)
(d) Deterministic (factor of safety)

Approaches (a) to (c) listed above would be considered subjective and do not provide a definitive indication of stability; in addition, a high level of judgement/experience is required which makes it difficult to relate the findings to real conditions. FT apply a more objective approach, the deterministic approach. As part of FT's deterministic approach, a qualitative risk assessment is also carried out taking into account qualitative factors, which cannot necessarily be quantified.

Probability

The likelihood of a peat failure occurring was assessed based on the results of both the quantitative results of stability calculations (deterministic approach using factors of safety) and the assessment of the severity of several qualitative factors which cannot be reasonably included in a stability calculation but nevertheless may affect the occurrence of peat instability.

The qualitative factors used in the risk assessment are outlined in Table A and have been compiled based on FT's experience of assessments and construction in peat land sites and peat failures throughout Ireland and the UK.

Table A: Qualitative Factors used to Assess Potential for Peat Failure

Qualitative Factor	Type of Feature/Indicator for each Qualitative Factor [1]	Explanation/Description of Qualitative Factor
Evidence of sub peat water flow	No	Based on site walkover observations. Sub peat water flow generally occurs in the form of natural piping at the base of peat. Where there is a constriction or blockage in natural pipes a build-up of water can occur at the base of the peat causing a reduction in effective stress at the base of the peat resulting in failure; this is particularly critical during periods of intense rainfall.
	Possibly	
	Probably	
	Yes	
	Dry	

Qualitative Factor	Type of Feature/Indicator for each Qualitative Factor [1]	Explanation/Description of Qualitative Factor
Evidence of surface water flow	Localised/Flowing in drains	Based on site walkover observations. The presence of surface water flow indicates if peat in an area is well drained or saturated and if any additional loading from the ponding of surface water onto the peat is likely.
	Ponded in drains	
	Springs/surface water	
Evidence of previous failures/slips	No	Based on site walkover observations. The presence of clustering of relict failures may indicate that particular pre-existing site conditions predispose a site to failure.
	In general area	
	On site	
	Within 500m of location	
Type of vegetation	Grass/Crops	Based on site walkover observations. The type of vegetation present indicates if peat in an area is well drained, saturated, etc. Vegetation that indicates wetter ground may also indicate softer underlying peat deposits.
	Improved Grass/Dry Heather	
	Wet Grassland/Juncus (Rushes)	
	Wetlands Sphagnum (Peat moss)	
General slope characteristics upslope/downslope from infrastructure location	Concave	Based on site walkover observations. Slope morphology in the area of the infrastructure location is an important factor. A number of recorded peat failures have occurred in close proximity to a convex break in slope.
	Planar to concave	
	Planar to convex	
	Convex	
Evidence of very soft/soft clay at base of peat	No	Based on inspection of exposures in general area from site walkover. Several reported peat failures identify the presence of a weak layer at the base of the peat along which shear failure has occurred.
	Yes	
Evidence of mechanically cut peat	No	Based on site walkover observations. Mechanically cut peat typically cut using a ‘sausage’ machine to extract

Qualitative Factor	Type of Feature/Indicator for each Qualitative Factor [1]	Explanation/Description of Qualitative Factor
	Yes	peat for harvesting. Areas which have been cut in this manner have been linked to peat instability. The mechanical cuts can notably reduce the intrinsic strength of the peat and also allow ingress of rainfall/surface water.
Evidence of quaking or buoyant peat	No	Based on site walkover observations. Quaking/buoyant peat is indicative of highly saturated peat, which would generally be considered to have a low strength. Quaking peat is a feature on sites that have been previously linked with peat instability.
	Yes	
Evidence of bog pools	No	Based on site walkover observations. Bog pools are generally an indicator of areas of weak, saturated peat. Commonly where there are open areas of water within peat these can be interconnected, with the result that there may be sub-surface bodies of water. The presence of bog pools have been previously linked with peat instability.
	Yes	
Other	Varies	In addition to the above features/ indicators and based on site recordings the following are some of the features which may be identified: Excessively deep peat, weak peat, overly steep slope angles, etc.

Note (1) The list of features/indicators for each qualitative factor are given in increasing order of probability of leading to peat instability/failure.

It should be noted that the presence of one of the qualitative factors alone from Table A is unlikely to lead to peat instability/failure. Peat instability/failure at a site is generally the combination of a number of these factors occurring at the same time at a particular location.

The probability rating assigned to the quantitative and qualitative factors is judged on a 5-point scale from 1 (indicating negligible or no probability of failure) to 5 (indicating a very likely failure), as outlined in Table B. Not applicable occurs where it is not physically possible for failure to occur, for example where no peat is present.

Table B: Probability Scale

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

Scale	Likelihood of Qualitative Factor leading to Peat Failure	Probability of Failure
1	Negligible/None	Least
2	Unlikely	
3	Probable	
4	Likely	
5	Very Likely	Greatest

Impact

The severity of the risk is also assessed qualitatively in terms of impact. The impact of a peat slide on the receiving environment within and beyond the overhead line route is assessed based on the potential travel distance and potential volume of a peat slide and the effect on receptors such as local property, infrastructure, and the natural environment.

Where a peat slide enters a watercourse it can travel a considerable distance downstream. Therefore, the proximity of a potential peat slide to a drainage feature is a significant indicator of the likely potential impact. Furthermore, given the elevation of the terrain along the OHL route, the topography in some areas may result in the formation of potential flow paths through naturally occurring features such as dips and falls in the terrain, valleys, etc. Such features would have the effect of increasing the travel distance of and the areas affected by any potential peat slide .

The potential damage to private property is also assessed using this approach. The OHL is located in a sparsely populated location; however, land owners and domestic dwellings may still be at risk in certain areas if a peat slide were to occur. In addition, property such as pasture and tillage farms, private landholdings, and communication/power infrastructure can be susceptible to peat slide. The list of such potential features or receptors identified are outlined in Table C.

Table C: Potential Receptors

Receptor	Control
Watercourse (rivers, streams, flow channels, etc.)	Topography
Dwellings (domestic)	
Road (local roads excluding wind farm access tracks)	
Infrastructure (overhead lines, communications infrastructure, etc.)	
Agricultural Land (pasture, etc.)	
Natural Heritage Area (Slieve Aughty Bog NHA)	

Taking the above into consideration, the primary controlling aspect when determining the impact of a potential peat slide, once that slide has occurred, is the topography along the route. For the purposes of this report, the route has been divided into 9 no. subsections for ease of assessment and risk identification.

Topographical data for each subsection has been used to identify the potential flow path(s) in a peat slide situation and as such will be used for determining the severity of the impact. The risk is determined based on the combination of hazard and impact. A 5-point qualitative scale has been devised for the impact of the hazard based on the distance of a potential peat slide arising from works on or near the OHL subsection to a receptor and this is shown in Table D.

Table D: Impact Scale

Scale	Criteria	Impact
1	Proposed infrastructure element greater than 150m of watercourse	Negligible/None
2	Proposed infrastructure element within 150 to 101m of watercourse	Low
3	Proposed infrastructure element within 100 to 51m of watercourse	Medium
4	Proposed infrastructure element within 50 m of watercourse	High
5	Proposed infrastructure element within 50 m of watercourse, in an environmentally sensitive area	Extremely High

Risk Rating

The degree of risk is determined as the product of probability (P) and impact (I), which gives the Risk Rating (R) as follows:

The Risk Rating is calculated from: $R = P \times I$

Due to the 5-point scales used to assess Probability and Impact, the Risk Rating can range from 1 to 25 as shown in Table E.

Table E: Qualitative Risk Rating

Impact \ Probability	1	2	3	4	5
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5

Risk Rating & Control Measures	
17 to 25	High: avoid working in area or significant control measures required
11 to 16	Medium: notable control measures required
5 to 10	Low: only routine control measures required
1 to 4	Negligible: none or only routine control measures required

The risk rating is calculated individually for each contributory factor. Control measures are required to reduce the risk to at least a 'Low' risk rating for every individual contributory factor. The control measures in response to the qualitative risk ratings are included in the peat stability risk registers for each OHL subsection in Appendix D. The control measures are targeted at the specific contributory factors that give the highest risk rating.

The risk rating assigned to any subsection is based on the highest risk rating calculated for any contributory factor within that subsection.

Note that some geotechnical interpretation of the results is required as it is the combination of individual contributory factors that are important in determining the risk of a peat slide. For example, in certain sections deep peat may be present that would be given a high risk rating but where the section is on level ground then the risk of a peat slide is not significant.

FEHILY TIMONEY

CONSULTANTS IN ENGINEERING, ENVIRONMENTAL SCIENCE & PLANNING

APPENDIX D

Results of Peat Stability Risk Assessment

Derrybrien Wind Farm (OHL) - Peat Stability Risk Register (Rev 1)

Location:	**PS5 to AM14**

Start of Subsection (Easting, Northing):	**560480**	**704010**
End of Subsection (Easting, Northing):	**564133**	**702732**
Worst Case Receptor(s):	**Road**	
Potential Impact on Receptor (Note 4):	**High**	
Peat Depth Range (m):	**0.0 to 1.9**	
Control Required:	**Yes**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 5)	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during decommissioning	Prob	Impact	Risk	Risk Rating
1	FOS (worst case) = 1.56(u), 2.03(d)	1	4	4	Negligible	Yes	See Below	1	4	4	Negligible
2	Evidence of sub peat water flow	0	4	0	Not Applicable	No		0	4	0	Not Applicable
3	Evidence of surface water flow	1	4	4	Negligible	No		1	4	4	Negligible
4	Evidence of previous failures/slips	2	4	8	Low	Yes		1	4	4	Negligible
5	Type of vegetation	3	4	12	Medium	Yes		1	4	4	Negligible
6	General slope characteristics upslope/downslope across section	4	4	16	Medium	Yes		1	4	4	Negligible
7	Evidence of very soft/soft clay at base of peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
10	Evidence of bog pools	0	4	0	Not Applicable	No		0	4	0	Not Applicable
11	Low peat strength (<10kPa)	0	4	0	Not Applicable	No		0	4	0	Not Applicable
12	Relatively deep peat	2	4	8	Low	Yes		1	4	4	Negligible

	Control Measures to be Implemented during Decommissioning for **PS5 to AM14**
i	Due to relatively deep peat in the section, this will require additional measures such as : - Refer to Drawing no. 0007 & 0008 Plan Drawing for Decommissioning of Overhead Line for suitable access routes - use of suitable low load bearing track machinery to gain access to works area - use of suitable plant and equipment for completion of works - routine detailed inspection of area, while works are being carried out - contractor to provide method statement for any proposed works in areas of peat/sloping ground/overhead power lines etc
ii	Maintain hydrology of area as far as possible;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Use of experienced geotechnical staff for site supervision.

Note

(1) Location PS5 to AM14 is an abbreviation for Pole Set 5 to Angle Mast 14
(2) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(3) Slope characteristics are typically 10 degrees across the section. Locally steep around pole set 12 and barrage 2, up to 20 degree inclination recorded
(4) Impact based on presence of road crossing OHL route within 100m downslope of a PS.
(5) Probability assessed as per Table A and B of Appendix C

Derrybrien Wind Farm (OHL) - Peat Stability Risk Register (Rev 1)

Location:	AM14 to AM18

Start of Subsection (Easting, Northing):	564133	702732
End of Subsection (Easting, Northing):	560840	702074
Worst Case Receptor(s):	Watercourse	
Potential Impact on Receptor (Note 3):	High	
Peat Depth Range (m):	0.2 to 0.6	
Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 4)	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during decommissioning	Prob	Impact	Risk	Risk Rating
1	FOS (worst case) = 5.32(u), 7.64(d)	1	4	4	Negligible	No	See Below	1	4	4	Negligible
2	Evidence of sub peat water flow	0	4	0	Not Applicable	No		0	4	0	Not Applicable
3	Evidence of surface water flow	0	4	0	Not Applicable	No		0	4	0	Not Applicable
4	Evidence of previous failures/slips	0	4	0	Not Applicable	No		0	4	0	Not Applicable
5	Type of vegetation	1	4	4	Negligible	No		1	4	4	Negligible
6	General slope characteristics upslope/downslope across section	1	4	4	Negligible	No		1	4	4	Negligible
7	Evidence of very soft/soft clay at base of peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
10	Evidence of bog pools	0	4	0	Not Applicable	No		0	4	0	Not Applicable
11	Low peat strength (<10kPa)	0	4	0	Not Applicable	No		0	4	0	Not Applicable
12	Other	0	4	0	Not Applicable	No		0	4	0	Not Applicable

	Control Measures to be Implemented during Decommissioning for **AM14 to AM18**
i	Although specific control measures are not required in the area, good practice should be followed, such as; - Refer to Drawing no. 0007 & 0008 Plan Drawing for Decommissioning of Overhead Line for suitable access routes - use of suitable low load bearing track machinery to gain access to works area - use of suitable plant and equipment for completion of works - routine detailed inspection of area, while works are being carried out - contractor to provide method statement for any proposed works in areas of peat/sloping ground/overhead power lines etc
ii	Maintain hydrology of area as far as possible;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Use of experienced geotechnical staff for site supervision.

Note

(1) Location AM14 to AM18 is an abbreviation for Angle Mast 14 to Angle Mast 18
(2) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(3) Impact based on OHL route crossing a watercourse with a PS within 100m upslope of the watercourse.
(4) Probability assessed as per Table A and B of Appendix C

Derrybrien Wind Farm (OHL) - Peat Stability Risk Register (Rev 1)

Location:	AM18 to AM24

Start of Subsection (Easting, Northing):	560840	702074
End of Subsection (Easting, Northing):	561759	701578
Worst Case Receptor(s):	Watercourse	
Potential Impact on Receptor (Note 4):	High	
Peat Depth Range (m):	0.2 to 0.8	
Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 5)	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during decommissioning	Prob	Impact	Risk	Risk Rating
1	FOS (worst case)= 1.85(u), 2.57(d)	1	4	4	Negligible	No	See Below	1	4	4	Negligible
2	Evidence of sub peat water flow	0	4	0	Not Applicable	No		0	4	0	Not Applicable
3	Evidence of surface water flow	2	4	8	Low	Yes		1	4	4	Negligible
4	Evidence of previous failures/slips	0	4	0	Not Applicable	No		0	4	0	Not Applicable
5	Type of vegetation	3	4	12	Medium	Yes		1	4	4	Negligible
6	General slope characteristics upslope/downslope across section	3	4	12	Medium	Yes		1	4	4	Negligible
7	Evidence of very soft/soft clay at base of peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
10	Evidence of bog pools	0	4	0	Not Applicable	No		0	4	0	Not Applicable
11	Low peat strength (<10kPa)	0	4	0	Not Applicable	No		0	4	0	Not Applicable
12	Other	0	4	0	Not Applicable	No		0	4	0	Not Applicable

	Control Measures to be Implemented during Decommissioning for **AM18 to AM24**
i	Although specific control measures are not required in the area, good practice should be followed, such as; - Refer to Drawing no. 0007 & 0008 Plan Drawing for Decommissioning of Overhead Line for suitable access routes - use of suitable low load bearing track machinery to gain access to works area - use of suitable plant and equipment for completion of works - routine detailed inspection of area, while works are being carried out - contractor to provide method statement for any proposed works in areas of peat/sloping ground/overhead power lines etc
ii	Maintain hydrology of area as far as possible;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Use of experienced geotechnical staff for site supervision.

Note

(1) Location AM18 to AM24 is an abbreviation for Angle Mast 18 to Angle Mast 24
(2) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(3) Slope characteristics are typically 3-4 degrees across the section. Locally steep between pole set 22 and 23, up to 15 degree inclination recorded
(4) Impact based on OHL route crossing a watercourse with a PS within 100m upslope of the watercourse.
(5) Probability assessed as per Table A and B of Appendix C

Derrybrien Wind Farm (OHL) - Peat Stability Risk Register (Rev 1)

Location:	AM24 to PS28A

Start of Subsection (Easting, Northing):	**561759**	**701578**
End of Subsection (Easting, Northing):	**562092**	**700690**
Worst Case Receptor(s):	**Watercourse**	
Potential Impact on Receptor (Note 6):	**High**	
Peat Depth Range (m):	**0.1 to 3.8**	
Control Required:	**Yes**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 7)	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during decommissioning	Prob	Impact	Risk	Risk Rating
1	FOS (worst case) = 1.09(u), 3.02(d)	4	4	16	Medium	Yes	See Below	1	4	4	Negligible
2	Evidence of sub peat water flow	0	4	0	Not Applicable	No		0	4	0	Not Applicable
3	Evidence of surface water flow	2	4	8	Low	Yes		1	4	4	Negligible
4	Evidence of previous failures/slips	0	4	0	Not Applicable	No		0	4	0	Not Applicable
5	Type of vegetation	2	4	8	Low	Yes		1	4	4	Negligible
6	General slope characteristics upslope/downslope across section	4	4	16	Medium	Yes		2	4	8	Low
7	Evidence of very soft/soft clay at base of peat	2	4	8	Low	Yes		1	4	4	Negligible
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	1	4	4	Negligible	No		1	4	4	Negligible
10	Evidence of bog pools	1	4	4	Negligible	No		1	4	4	Negligible
11	Low peat strength (<10kPa)	0	4	0	Not Applicable	No		0	4	0	Not Applicable
12	Relatively deep peat	3	4	12	Medium	Yes		1	4	4	Negligible

	Control Measures to be Implemented Prior to/and During Construction for **AM24 to PS28A**
i	Due to the depth of peat in the section, this will require additional measures such as : - Refer to Drawing No. 0007 & 0008 Plan Drawing for Decommissioning of Overhead Line for suitable access routes - use of suitable low load bearing track machinery to gain access to works area - use of suitable plant and equipment for completion of works - routine detailed inspection of area, while works are being carried out - monitoring (in the form of timber stakes as sightlines) to be installed in working areas and monitored regularly during the works - contractor to provide method statement for any proposed works in areas of peat/sloping ground/overhead power lines etc
ii	Maintain hydrology of area as far as possible;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Use of experienced geotechnical staff for site supervision.

Note

(1) Location AM24 to PS28A is an abbreviation for Angle Mast 24 to Pole Set 28A
(2) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(3) Slope characteristics are typically 3-5 degrees across the section. Locally steep south of pole set 25, up to 30 degree inclination recorded
(4) Localised areas of very soft, waterlogged and buoyant peat between pole set 27 and 28A
(5) Deepest peat recorded around pole set 28
(6) Impact based on OHL route crossing a watercourse with a PS within 100m upslope of the watercourse.
(7) Probability assessed as per Table A and B of Appendix C

Derrybrien Wind Farm (OHL) - Peat Stability Risk Register (Rev 1)

Location:	**PS28A to PS34**

Start of Subsection (Easting, Northing):	**562092**	**700690**
End of Subsection (Easting, Northing):	**562470**	**699676**
Worst Case Receptor(s):	**Watercourse**	
Potential Impact on Receptor (Note 3):	**High**	
Peat Depth Range (m):	**0.2 to 3.1**	
Control Required:	**Yes**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 4)	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during decommissioning	Prob	Impact	Risk	Risk Rating
1	FOS (worst case)= 1.69(u), 1.49(d)	1	4	4	Negligible	No	See Below	1	4	4	Negligible
2	Evidence of sub peat water flow	0	4	0	Not Applicable	No		0	4	0	Not Applicable
3	Evidence of surface water flow	1	4	4	Negligible	No		1	4	4	Negligible
4	Evidence of previous failures/slips	0	4	0	Not Applicable	No		0	4	0	Not Applicable
5	Type of vegetation	2	4	8	Low	Yes		1	4	4	Negligible
6	General slope characteristics upslope/downslope across section	2	4	8	Low	Yes		1	4	4	Negligible
7	Evidence of very soft/soft clay at base of peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
10	Evidence of bog pools	0	4	0	Not Applicable	No		0	4	0	Not Applicable
11	Low peat strength (<10kPa)	4	4	16	Medium	Yes		1	4	4	Negligible
12	Other	2	4	8	Low	Yes		1	4	4	Negligible

	Control Measures to be Implemented Prior During Decommissioning for **PS28A to PS34**
i	Due to the depth of peat in the section, this will require additional measures such as : - Refer to Drawing no. 0007 & 0008 Plan Drawing for Decommissioning of Overhead Line for suitable access routes - use of suitable low load bearing track machinery to gain access to works area - use of suitable plant and equipment for completion of works - routine detailed inspection of area, while works are being carried out - contractor to provide method statement for any proposed works in areas of peat/sloping ground/overhead power lines etc
ii	Maintain hydrology of area as far as possible;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Use of experienced geotechnical staff for site supervision.

Note

(1) Location PS28A to PS34 is an abbreviation for Pole Set 28A to Pole Set 34
(2) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(3) Impact based on OHL route crossing a watercourse with a PS within 100m upslope of the watercourse.
(4) Probability assessed as per Table A and B of Appendix C

Derrybrien Wind Farm (OHL) - Peat Stability Risk Register (Rev 1)

Location:	PS34 to AM38

Start of Subsection (Easting, Northing):	562470	699676
End of Subsection (Easting, Northing):	563020	699126
Worst Case Receptor(s):	Road	
Potential Impact on Receptor (Note 6):	High	
Peat Depth Range (m):	0.0 to 5.6	
Control Required:	Yes	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 7)	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during decommissioning	Prob	Impact	Risk	Risk Rating
1	FOS (worst case)= 1.98(u), 2.39(d)	1	4	4	Negligible	Yes	See Below	1	4	4	Negligible
2	Evidence of sub peat water flow	0	4	0	Not Applicable	No		0	4	0	Not Applicable
3	Evidence of surface water flow	1	4	4	Negligible	No		1	4	4	Negligible
4	Evidence of previous failures/slips	0	4	0	Not Applicable	No		0	4	0	Not Applicable
5	Type of vegetation	3	4	12	Medium	Yes		1	4	4	Negligible
6	General slope characteristics upslope/downslope across section	3	4	12	Medium	Yes		1	4	4	Negligible
7	Evidence of very soft/soft clay at base of peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	3	4	12	Medium	Yes		1	4	4	Negligible
10	Evidence of bog pools	0	4	0	Not Applicable	No		0	4	0	Not Applicable
11	Low peat strength (<10kPa)	3	4	12	Medium	No		0	4	0	Not Applicable
12	Very deep peat	3	4	12	Medium	Yes		1	4	4	Negligible

	Control Measures to be Implemented during Decommissioning for **PS34 to AM38**
i	Due to the depth of peat in the section, this will require additional measures such as : - Refer to Drawing no. 0007 & 0008 Plan Drawing for Decommissioning of Overhead Line for suitable access routes - use of suitable low load bearing track machinery to gain access to works area - use of suitable plant and equipment for completion of works - routine detailed inspection of area, while works are being carried out - monitoring (in the form of timber stakes as sightlines) to be installed in working areas and monitored regularly during the works - contractor to provide method statement for any proposed works in areas of peat/sloping ground/overhead power lines etc
ii	Maintain hydrology of area as far as possible;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Use of experienced geotechnical staff for site supervision.

Note

(1) Location PS34 to AM38 is an abbreviation for Pole Set 34 to Angle Mast 38
(2) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(3) Slope characteristics are typically 3-5 degrees across the section. Locally steep north of pole set 35, up to 21 degree inclination recorded
(4) Significant area of very soft, waterlogged and buoyant peat between pole set 37 and 38
(5) Deepest peat recorded angle mast 38, about 5.6m deep
(6) Impact based on OHL route crossing a road with a PS within 100m upslope of the road.
(7) Probability assessed as per Table A and B of Appendix C

Derrybrien Wind Farm (OHL) - Peat Stability Risk Register (Rev 1)

Location:	**AM38 to EM41**

Start of Subsection (Easting, Northing):	**563020**	**699126**
End of Subsection (Easting, Northing):	**563124**	**698618**
Worst Case Receptor(s):	**Dwelling**	
Potential Impact on Receptor (Note 6):	**High**	
Peat Depth Range (m):	**0.0 to 5.6**	
Control Required:	**Yes**	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 7)	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during decommissioning	Prob	Impact	Risk	Risk Rating
1	FOS (worst case)= 4.31(u), 5.75(d)	1	4	4	Negligible	No	See Below	1	4	4	Negligible
2	Evidence of sub peat water flow	0	4	0	Not Applicable	No		0	4	0	Not Applicable
3	Evidence of surface water flow	1	4	4	Negligible	No		1	4	4	Negligible
4	Evidence of previous failures/slips	0	4	0	Not Applicable	No		0	4	0	Not Applicable
5	Type of vegetation	3	4	12	Medium	Yes		1	4	4	Negligible
6	General slope characteristics upslope/downslope across section	2	4	8	Low	No		1	4	4	Negligible
7	Evidence of very soft/soft clay at base of peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
8	Evidence of mechanically cut peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	4	0	Not Applicable	No		0	4	0	Not Applicable
10	Evidence of bog pools	0	4	0	Not Applicable	No		0	4	0	Not Applicable
11	Low peat strength (<10kPa)	4	4	16	Medium	No		0	4	0	Not Applicable
12	Very deep peat	3	4	12	Medium	Yes		1	4	4	Negligible

	Control Measures to be Implemented Prior to/and During Construction for **AM38 to PS41**
i	Due to the depth of peat in the section, this will require additional measures such as : - Refer to Drawing no. 0007 & 0008 Plan Drawing for Decommissioning of Overhead Line for suitable access routes - use of suitable low load bearing track machinery to gain access to works area - use of suitable plant and equipment for completion of works - routine detailed inspection of area, while works are being carried out - monitoring (in the form of timber stakes as sightlines) to be installed in working areas and monitored regularly during the works - contractor to provide method statement for any proposed works in areas of peat/sloping ground/overhead power lines etc
ii	Maintain hydrology of area as far as possible;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Use of experienced geotechnical staff for site supervision.

Note

(1) Location AM38 to PS41 is an abbreviation for Angle Mast 38 to Pole Set 41
(2) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(3) Slope characteristics are typically 3-5 degrees across the section.
(4) Deepest peat recorded around angle mast 38, about 5.6m deep
(5) Impact based on OHL route 500m upslope of the dwelling in an area of deep peat.
(6) Probability assessed as per Table A and B of Appendix C

Derrybrien Wind Farm (OHL) - Peat Stability Risk Register (Rev 1)

Location:	Sub-station

Start of Subsection (Easting, Northing):	563123	698619
End of Subsection (Easting, Northing):	563123	698619
Worst Case Receptor(s):	Infrastructure	
Potential Impact on Receptor (Note 2):	Negligable	
Peat Depth Range (m):	0.0 to 0.0	
Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 3)	Impact	Risk	Risk Rating	Control Required	Control measures to be implemented during decommissioning	Prob	Impact	Risk	Risk Rating
1	FOS = na(u), na(d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	0	1	0	Not Applicable	No		0	1	0	Not Applicable
3	Evidence of surface water flow	0	1	0	Not Applicable	No		0	1	0	Not Applicable
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	0	1	0	Not Applicable	No		0	1	0	Not Applicable
6	General slope characteristics upslope/downslope across section	1	1	1	Negligible	No		1	1	1	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Low peat strength (<10kPa)	0	1	0	Not Applicable	No		0	1	0	Not Applicable
12	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	Control Measures to be Implemented during Decommissioning for **Agannygal Sub-Station**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced contractors and trained operators to carry out the work;

Note
(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Impact based on absence of peat.
(3) Probability assessed as per Table A and B of Appendix C

FEHILY TIMONEY

CONSULTANTS IN ENGINEERING, ENVIRONMENTAL SCIENCE & PLANNING

APPENDIX E

Calculated FoS for Peat Slopes

Calculated FoS of Natural Peat Slopes for Derrybrien Wind Farm OHL (Undrained Analysis)

Turbine No./Waypoint	Easting	Northing	Slope (Note 3)	Undrained shear strength	Bulk unit weight of Peat	Peat Depth (Note 5)	Surcharge Equivalent Placed Fill Depth (m) (Note 2)	Factor of Safety for Load Condition	
			β (deg)	c_u (kPa)	γ (kN/m^3)	(m)	Condition (2)	Condition (1)	Condition (2)
FT DATA (OCTOBER 2022)									
Pole 5	560479	704010	3.0	6	10	1.5	2.5	**7.65**	**4.59**
Pole 8	560779	703609	3.0	6	10	1.8	2.8	**6.38**	**4.10**
Pole 17	560991	702242	3.0	6	10	0.2	1.2	**57.40**	**9.57**
Angle Mast 18	560840	702075	5.0	6	10	0.2	1.2	**34.55**	**5.76**
Pole 19	560951	701974	2.0	6	10	0.6	1.6	**28.67**	**10.75**
Angle Mast 20	561050	701884	3.0	6	10	0.2	1.2	**57.40**	**9.57**
Pole 21	561215	701812	5.0	6	10	0.4	1.4	**17.28**	**4.94**
Pole 22	561380	701741	10.0	6	10	0.6	1.6	**5.85**	**2.19**
Pole 23	561601	701647	3.0	6	10	0.5	1.5	**22.96**	**7.65**
Angle Mast 24	561759	701579	3.0	6	10	0.3	1.3	**38.27**	**8.83**
Pole 25	561813	701428	10.0	6	10	0.2	1.2	**17.54**	**2.92**
Pole 28	562056	700783	1.0	6	10	3.4	4.4	**10.11**	**7.81**
Pole 28A-WP 22	562092	700690	1.0	6	10	1.4	2.4	**24.56**	**14.33**
Pole 33	562435	699773	2.0	3	10	2.3	3.3	**3.74**	**2.61**
Angle Mast 34	562470	699678	2.0	6	10	2.2	3.2	**7.82**	**5.38**
Pole 36	562760	699388	1.0	6	10	3.7	4.7	**9.29**	**7.32**
Angle Mast 38	563019	699127	2.0	6	10	3.4	4.4	**5.06**	**3.91**
Pole 39	563061	698932	2.0	6	10	2.2	3.2	**7.82**	**5.38**
WP27	564711	689241	3.0	6	10	0.2	1.2	**57.40**	**9.57**
WP28	564229	698041	3.0	6	10	0.3	1.3	**38.27**	**8.83**
WP29	563549	697849	0.5	6	10	5.8	6.8	**11.85**	**10.11**
WP30	563276	698049	3.0	6	10	0.5	1.5	**22.96**	**7.65**
Point A	561123	702367	4.0	No peat encountered					
Point B	561061	702260	4.0	6	10	0.3	1.3	**28.74**	**6.63**
Point C	561040	702331	5.0	No peat encountered					
Point D	561084	702394	3.0	6	10	0.3	1.3	**45.92**	**9.18**
Point 1	565073	698271	1.0	6	10	3.6	4.6	**9.55**	**7.47**
Point 2	565066	698226	1.0	6	10	2.0	3.0	**17.19**	**11.46**
Point 3	565048	698230	1.0	6	10	3.5	4.5	**9.82**	**7.64**
Point 4	565035	698275	2.0	6	10	2.2	3.2	**7.82**	**5.38**
FT DATA (SEPTEMBER 2019)									
Pole 1A	160002	204675	5.0	6	10	2.2	3.2	**3.14**	**2.16**
Pole 2	160086	204563	6.0	6	10	2.1	3.1	**2.75**	**1.86**
Pole 3	160235	204362	4.0	6	10	1.6	2.6	**5.39**	**3.32**
Pole 4	160360	204194	6.0	6	10	1.0	2.0	**5.77**	**2.89**
Pole 5	160520	203976	3.0	6	10	1.3	2.3	**8.83**	**4.99**
Pole 6	160617	203849	3.0	6	10	0.6	1.6	**19.13**	**7.18**
Pole 7	160712	203721	3.0	6	10	0.9	1.9	**12.76**	**6.04**
Pole 8	160820	203575	3.0	6	10	1.5	2.5	**7.65**	**4.59**
Pole 9	160921	203439	4.0	6	10	0.5	1.5	**17.24**	**5.75**
Pole 10	161053	203263	4.0	6	10	0.8	1.8	**10.78**	**4.79**
Pole 11	161183	203088	4.0	6	10	0.1	1.1	**86.22**	**7.84**
Pole 12	161294	202940	4.0	6	10	0.5	1.5	**17.24**	**5.75**
Pole 13	161386	202815	2.0	6	10	0.2	1.2	**86.01**	**14.34**
Angle Mast 14	161474	202698	1.0	6	10	0.7	1.7	**49.12**	**20.23**
Pole 15	161359	202569	3.0	6	10	0.5	1.5	**22.96**	**7.65**
Pole 16	161206	202401	2.0	6	10	0.3	1.3	**57.34**	**13.23**
Pole 17	161032	202208	2.0	6	10	0.6	1.6	**28.67**	**10.75**
Angle Mast 18	160881	202041	5.0	6	10	0.3	1.3	**23.04**	**5.32**
Pole 19	160992	201940	2.0	6	10	0.9	1.9	**19.11**	**9.05**
Angle Mast 20	161091	201850	3.0	6	10	0.2	1.2	**57.40**	**9.57**
Pole 21	161256	201778	5.0	6	10	0.4	1.4	**17.28**	**4.94**
Pole 22	161421	201707	10.0	6	10	0.5	1.5	**7.02**	**2.34**
Pole 23	161642	201613	3.0	6	10	0.5	1.5	**22.96**	**7.65**
Angle Mast 24	161800	201545	4.0	6	10	0.8	1.8	**10.78**	**4.79**
Pole 25	161854	201394	10.0	6	10	0.2	1.2	**17.54**	**2.92**
Pole 26	161960	201114	6.0	6	10	0.6	1.6	**9.62**	**3.61**
Pole 27	162016	200964	10.0	6	10	0.5	1.5	**7.02**	**2.34**
Pole 28	162097	200749	2.0	6	10	3.8	4.8	**4.53**	**3.58**
Pole 28A	162133	200656	2.0	6	10	0.8	1.8	**21.50**	**9.56**
Pole 29	162196	200487	2.0	6	10	0.9	1.9	**19.11**	**9.05**
Angle Mast 30	162259	200318	4.0	6	10	0.1	1.1	**86.22**	**7.84**
Pole 31	162343	200093	7.0	6	10	0.4	1.4	**12.40**	**3.54**
Pole 32	162417	199897	3.0	6	10	0.3	1.3	**38.27**	**8.83**
Pole 33	162476	199738	2.0	6	10	2.3	3.3	**7.48**	**5.21**
Angle Mast 34	162511	199643	3.0	No peat encountered					
Pole 35	162702	199452	5.0	6	10	1.1	2.1	**6.28**	**3.29**
Pole 36	162801	199353	3.0	6	10	3.2	4.2	**3.59**	**2.73**
Pole 37	162878	199275	1.0	6	10	0.5	1.5	**68.77**	**22.92**
Angle Mast 38	163060	199092	1.0	6	10	2.5	3.5	**13.75**	**9.82**
Pole 39	163102	198897	2.0	6	10	1.8	2.8	**9.56**	**6.14**
Pole 40	195225	363039	4.0	6	10	1.0	2.0	**8.62**	**4.31**
Angle Mast 41	163164	198584	2.0	No peat encountered					

Calculated FoS of Natural Peat Slopes for Derrybrien Wind Farm OHL (Undrained Analysis)

Turbine No./Waypoint	Easting	Northing	Slope (Note 3)	Undrained shear strength	Bulk unit weight of Peat	Peat Depth (Note 5)	Surcharge Equivalent Placed Fill Depth (m) (Note 2)	Factor of Safety for Load Condition	
			β (deg)	c_u (kPa)	γ (kN/m^3)	(m)	Condition (2)	Condition (1)	Condition (2)
AGEC DATA (JUNE 2018)									
Pole 1A	160002	204675	0.5	6	10	1.8	2.8	**38.20**	**24.56**
WP 1	160047	204613	3.0	6	10	1.4	2.4	**8.20**	**4.78**
Pole 2	160086	204563	0.5	6	10	2.4	3.4	**28.65**	**20.22**
WP 2	160158	204461	0.5	6	10	1.9	2.9	**36.19**	**23.71**
Pole 3	160235	204362	0.5	6	10	2.0	3.0	**34.38**	**22.92**
WP 3	160295	204291	0.5	6	10	1.8	2.8	**38.20**	**24.56**
Pole 4	160360	204194	6.0	6	10	1.1	2.1	**5.25**	**2.75**
Pole 5	160520	203976	2.0	6	10	1.8	2.8	**9.56**	**6.14**
Pole 6	160617	203849	3.0	6	10	1.0	2.0	**11.48**	**5.74**
Pole 7	160712	203721	6.0	6	10	0.5	1.5	**11.54**	**3.85**
WP 4	160867	203534	6.0	6	10	1.9	2.9	**3.04**	**1.99**
Pole 8	160820	203575	0.5	6	10	1.7	2.7	**40.45**	**25.47**
Pole 9	160921	203439	0.5	6	10	0.8	1.8	**85.95**	**38.20**
WP 5	161003	203325	0.5	6	10	0.5	1.5	**137.52**	**45.84**
Pole 10	161053	203263	4.0	6	10	0.8	1.8	**10.78**	**4.79**
WP 6	161114	203187	4.0	6	10	0.2	1.2	**43.11**	**7.19**
Pole 11	161183	203088	0.5	No peat encountered					
WP 7	161247	203003	20.0	6	10	0.2	1.2	**9.33**	**1.56**
Pole 12	161294	202940	0.5	6	10	0.3	1.3	**229.19**	**52.89**
WP 8	161357	202861	0.5	6	10	0.8	1.8	**85.95**	**38.20**
Pole 13	161386	202815	0.5	No peat encountered					
WP 9	161425	202749	0.5	6	10	0.5	1.5	**137.52**	**45.84**
Angle Mast 14	161474	202698	5.0	No peat encountered					
Pole 15	161359	202569	12.0	No peat encountered					
WP 10	161252	202448	5.0	No peat encountered					
Pole 16	161206	202401	4.0	6	10	0.2	1.2	**43.11**	**7.19**
WP11	161097	202274	0.5	6	10	0.5	1.5	**137.52**	**45.84**
Pole 17	161032	202208	4.0	6	10	0.2	1.2	**43.11**	**7.19**
WP 12	160960	202126	4.0	6	10	0.6	1.6	**14.37**	**5.39**
Angle Mast 18	160881	202041	0.5	No peat encountered					
Pole 19	160992	201940	4.0	No peat encountered					
Pole 20	161091	201850	0.5	No peat encountered					
Pole 21	161256	201778	0.5	6	10	0.8	1.8	**85.95**	**38.20**
Pole 22	161421	201707	6.0	6	10	0.8	1.8	**7.21**	**3.21**
WP 15	161522	201668	0.5	6	10	0.5	1.5	**137.52**	**45.84**
WP 16	161540	201659	15.0	6	10	0.3	1.3	**8.00**	**1.85**
Pole 23	161642	201613	0.5	6	10	0.6	1.6	**114.60**	**42.97**
Pole 24	161800	201545	7.0	6	10	0.4	1.4	**12.40**	**3.54**
WP 17	161832	201460	2.0	6	10	1.5	2.5	**11.47**	**6.88**
Pole 25	161854	201394	7.0	6	10	0.2	1.2	**24.80**	**4.13**
WP 18	161885	201296	12.0	6	10	1.7	2.7	**1.74**	**1.09**
WP 19	161893	201193	5.0	6	10	0.9	1.9	**7.68**	**3.64**
Pole 26	161960	201114	12.0	6	10	0.6	1.6	**4.92**	**1.84**
WP 20	161987	201046	3.0	6	10	0.2	1.2	**57.40**	**9.57**
Pole 27	162016	200964	8.0	6	10	0.2	1.2	**21.77**	**3.63**
WP 21	162093	200863	0.5	6	10	2.6	3.6	**26.45**	**19.10**
Pole 28	162097	200749	0.5	6	10	3.8	4.8	**18.09**	**14.32**
Pole 28A-WP 22	162133	200656	0.5	6	10	1.6	2.6	**42.97**	**26.45**
Pole 29	162196	200487	0.5	6	10	1.4	2.4	**49.11**	**28.65**
Pole 30	162259	200318	0.5	6	10	0.4	1.4	**171.90**	**49.11**
Pole 31	162343	200093	7.0	6	10	0.2	1.2	**24.80**	**4.13**
Pole 32	162417	199897	0.5	6	10	0.4	1.4	**171.90**	**49.11**
Pole 33	162476	199738	5.0	6	10	3.1	4.1	**2.23**	**1.69**
Pole 34	162511	199643	3.0	6	10	2.2	3.2	**5.22**	**3.59**
WP23	162631	199512	2.0	6	10	0.6	1.6	**28.67**	**10.75**
Pole 35	162702	199452	8.0	6	10	1.2	2.2	**3.63**	**1.98**
Pole 36	162801	199353	0.5	6	10	4.7	5.7	**14.63**	**12.06**
Pole 37	162878	199275	0.5	6	10	1.2	2.2	**57.30**	**31.25**
WP 26	162952	199157	1.0	6	10	2.2	3.2	**15.63**	**10.75**
Angle Mast 38	163060	199092	0.5	6	10	5.6	6.6	**12.28**	**10.42**
Pole 39	163102	198897	0.5	6	10	2.2	3.2	**31.25**	**21.49**
Pole 40	195225	363039	0.5	6	10	1.1	2.1	**62.51**	**32.74**
Angle Mast 41	163164	198584	0.5	No peat encountered					

Calculated FoS of Natural Peat Slopes for Derrybrien Wind Farm OHL (Undrained Analysis)

Turbine No./Waypoint	Easting	Northing	Slope (Note 3)	Undrained shear strength	Bulk unit weight of Peat	Peat Depth (Note 5)	Surcharge Equivalent Placed Fill Depth (m) (Note 2)	Factor of Safety for Load Condition	
			β (deg)	c_u (kPa)	γ (kN/m^3)	(m)	Condition (2)	Condition (1)	Condition (2)
ESBI DATA (2004 & 2005)									
1	160403	204120	4.0	6	10	0.2	1.2	**43.01**	**7.17**
2	160392	204135	6.0	6	10	0.2	1.2	**28.70**	**4.78**
3	160386	204144	6.0	6	10	0.9	1.9	**6.38**	**3.02**
4	160136	204496	0.5	6	10	0.9	1.9	**76.58**	**36.28**
5	160363	204177	6.0	6	10	1.0	2.0	**5.77**	**2.89**
6	160344	204204	6.0	6	10	1.0	2.0	**5.77**	**2.89**
7	160333	204219	6.0	6	10	1.2	2.2	**4.78**	**2.61**
8	160295	204271	4.0	6	10	1.2	2.2	**7.21**	**3.93**
9	160126	204510	0.5	6	10	1.3	2.3	**53.18**	**30.06**
10	160279	204293	4.0	6	10	1.4	2.4	**6.18**	**3.60**
11	160168	204446	0.5	6	10	1.4	2.4	**49.23**	**28.72**
12	160073	204591	3.0	6	10	1.4	2.4	**8.19**	**4.78**
13	160108	204538	3.0	6	10	1.5	2.5	**7.66**	**4.60**
14	159982	204618	0.5	6	10	1.5	2.5	**45.84**	**27.50**
15	160005	204630	0.5	6	10	1.5	2.5	**45.90**	**27.54**
16	160040	204640	3.0	6	10	1.5	2.5	**7.65**	**4.59**
17	160085	204667	3.0	6	10	1.5	2.5	**7.64**	**4.59**
18	160152	204471	0.5	6	10	1.6	2.6	**42.97**	**26.45**
19	160313	204247	6.0	6	10	1.7	2.7	**3.38**	**2.13**
20	160259	204320	0.5	6	10	1.8	2.8	**38.25**	**24.59**
21	160216	204378	0.5	6	10	1.8	2.8	**38.20**	**24.56**
22	160055	204617	3.0	6	10	1.8	2.8	**6.40**	**4.12**
23	160029	204645	3.0	6	10	1.8	2.8	**6.37**	**4.09**
24	159991	204653	0.5	6	10	1.8	2.8	**38.20**	**24.56**
25	160052	204656	2.0	6	10	1.8	2.8	**9.56**	**6.15**
26	160059	204689	3.0	6	10	1.8	2.8	**6.38**	**4.10**
27	160237	204349	0.5	6	10	1.9	2.9	**36.19**	**23.71**
28	160091	204563	3.0	6	10	1.9	2.9	**6.04**	**3.96**
29	160199	204400	0.5	6	10	2.0	3.0	**34.43**	**22.95**
30	160027	204660	3.0	6	10	2.0	3.0	**5.73**	**3.82**
31	160011	204684	2.0	6	10	2.1	3.1	**8.20**	**5.55**
32	160185	204421	0.5	6	10	2.6	3.6	**26.45**	**19.10**
							Minimum =	**1.74**	**1.09**
							Maximum =	**229.19**	**52.89**
							Average =	**30.76**	**11.91**

Notes:

(1) Assuming a bulk unit weight for peat of 10kN/m^3

(2) Assuming a surcharge equivalent to fill depth of 1m of peat i.e. 10kPa. (Condition 2

(3) Slope inclination (β) based on site readings and site contour plans

(4) A lower bound undrained shear strength, cu for the peat of 6kPa was selected for the assessment. It should be noted that a cu of 6kPa for the pea is considered a conservative value for the analysis and is not representative of all peat present across the site. In reality the peat on site typically has a significantly higher undrained strength.

(5) Peat depths based on probes carried out by FT (2019 and 2022), AGEC and ESBI (June 2018

(6) For load conditions see report text.

Calculated FoS of Natural Peat Slopes for Derrybrien Wind Farm OHL (Drained Analysis)

Turbine No./Waypoint	Slope (Note 3)	Design c'	Bulk unit weight of Peat	Unit weight of Water	100% Water to height of Peat	Depth of In situ Peat (Note 5)	Friction Angle	Equivalent Total Depth of Peat (m) (Note 2)	Factor of Safety for Load Condition	
	α (deg)	c' (kPa)	γ (kN/m^3)	γ_w (kN/m^3)	(m)	(m)	ø' (deg)	Condition (2)	Condition (1)	Condition (2)
									100% Water	100% Water
FT DATA (2022)										
Pole 5	3.0	4	10.0	10.0	1.5	1.5	25	2.5	**5.10**	**6.62**
Pole 8	3.0	4	10.0	10.0	1.8	1.8	25	1.8	**4.25**	**4.25**
Pole 17	3.0	4	10.0	10.0	0.2	0.2	25	0.2	**38.27**	**38.27**
Angle Mast 18	5.0	4	10.0	10.0	0.2	0.2	25	0.2	**23.04**	**23.04**
Pole 19	2.0	4	10.0	10.0	0.6	0.6	25	0.6	**19.11**	**19.11**
Angle Mast 20	3.0	4	10.0	10.0	0.2	0.2	25	0.2	**38.27**	**38.27**
Pole 21	5.0	4	10.0	10.0	0.4	0.4	25	0.4	**11.52**	**11.52**
Pole 22	10.0	4	10.0	10.0	0.6	0.6	25	0.6	**3.90**	**3.90**
Pole 23	3.0	4	10.0	10.0	0.5	0.5	25	0.5	**15.31**	**15.31**
Angle Mast 24	3.0	4	10.0	10.0	0.3	0.3	25	0.3	**25.51**	**25.51**
Pole 25	10.0	4	10.0	10.0	0.2	0.2	25	0.2	**11.70**	**11.70**
Pole 28	1.0	4	10.0	10.0	3.4	3.4	25	3.4	**6.74**	**6.74**
Pole 28A-WP 22	1.0	4	10.0	10.0	1.4	1.4	25	1.4	**16.37**	**16.37**
Pole 33	2.0	4	10.0	10.0	2.3	2.3	25	2.3	**4.99**	**4.99**
Angle Mast 34	2.0	4	10.0	10.0	2.2	2.2	25	2.2	**5.21**	**5.21**
Pole 36	1.0	4	10.0	10.0	3.7	3.7	25	3.7	**6.20**	**6.20**
Angle Mast 38	2.0	4	10.0	10.0	3.4	3.4	25	3.4	**3.37**	**3.37**
Pole 39	2.0	4	10.0	10.0	2.2	2.2	25	2.2	**5.21**	**5.21**
WP27	3.0	4	10.0	10.0	0.2	0.2	25	0.2	**38.27**	**38.27**
WP28	3.0	4	10.0	10.0	0.3	0.3	25	0.3	**25.51**	**25.51**
WP29	0.5	4	10.0	10.0	5.8	5.8	25	5.8	**7.90**	**7.90**
WP30	3.0	4	10.0	10.0	0.5	0.5	25	0.5	**15.31**	**15.31**
Point A	4.0	No peat encountered								
Point B	4.0	4	10.0	10.0	0.3	0.3	25	0.3	**19.16**	**19.16**
Point C	5.0	No peat encountered								
Point D	3.0	4	10.0	10.0	0.3	0.3	25	0.3	**25.51**	**25.51**
Point 1	1.0	4	10.0	10.0	3.6	3.6	25	3.6	**6.37**	**6.37**
Point 2	1.0	4	10.0	10.0	2.0	2.0	25	2.0	**11.46**	**11.46**
Point 3	1.0	4	10.0	10.0	3.5	3.5	25	3.5	**6.55**	**6.55**
Point 4	2.0	4	10.0	10.0	2.2	**2.2**	25	2.2	**5.21**	**5.21**
FT DATA (2019)										
Pole 1A	5.0	4	10.0	10.0	2.2	2.2	25	3.2	**2.09**	**3.11**
Pole 2	6.0	4	10.0	10.0	2.1	2.1	25	3.1	**1.83**	**2.67**
Pole 3	4.0	4	10.0	10.0	1.6	1.6	25	2.6	**3.59**	**4.78**
Pole 4	6.0	4	10.0	10.0	1.0	1.0	25	2.0	**3.85**	**4.14**
Pole 5	3.0	4	10.0	10.0	1.3	1.3	25	2.3	**5.89**	**7.20**
Pole 6	3.0	4	10.0	10.0	0.6	0.6	25	1.6	**12.76**	**10.34**
Pole 7	3.0	4	10.0	10.0	0.9	0.9	25	1.9	**8.50**	**8.71**
Pole 8	3.0	4	10.0	10.0	1.5	1.5	25	2.5	**5.10**	**6.62**
Pole 9	4.0	4	10.0	10.0	0.5	0.5	25	1.5	**11.50**	**8.28**
Pole 10	4.0	4	10.0	10.0	0.8	0.8	25	1.8	**7.19**	**6.90**
Pole 11	4.0	4	10.0	10.0	0.1	0.1	25	1.1	**57.48**	**11.29**
Pole 12	4.0	4	10.0	10.0	0.5	0.5	25	1.5	**11.50**	**8.28**
Pole 13	2.0	4	10.0	10.0	0.2	0.2	25	1.2	**57.34**	**20.68**
Angle Mast 14	1.0	4	10.0	10.0	0.7	0.7	25	1.7	**32.75**	**29.20**
Pole 15	3.0	4	10.0	10.0	0.5	0.5	25	1.5	**15.31**	**11.03**
Pole 16	2.0	4	10.0	10.0	0.3	0.3	25	1.3	**38.23**	**19.09**
Pole 17	2.0	4	10.0	10.0	0.6	0.6	25	1.6	**19.11**	**15.51**
Angle Mast 18	5.0	4	10.0	10.0	0.3	0.3	25	1.3	**15.36**	**7.64**
Pole 19	2.0	4	10.0	10.0	0.9	0.9	25	1.9	**12.74**	**13.06**
Angle Mast 20	3.0	4	10.0	10.0	0.2	0.2	25	1.2	**38.27**	**13.79**
Pole 21	5.0	4	10.0	10.0	0.4	0.4	25	1.4	**11.52**	**7.10**
Pole 22	10.0	4	10.0	10.0	0.5	0.5	25	1.5	**4.68**	**3.32**
Pole 23	3.0	4	10.0	10.0	0.5	0.5	25	1.5	**15.31**	**11.03**
Angle Mast 24	4.0	4	10.0	10.0	0.8	0.8	25	1.8	**7.19**	**6.90**
Pole 25	10.0	4	10.0	10.0	0.2	0.2	25	1.2	**11.70**	**4.15**
Pole 26	6.0	4	10.0	10.0	0.6	0.6	25	1.6	**6.41**	**5.18**
Pole 27	10.0	4	10.0	10.0	0.5	0.5	25	1.5	**4.68**	**3.32**
Pole 28	2.0	4	10.0	10.0	3.8	3.8	25	4.8	**3.02**	**5.17**
Pole 28A-WP 22	2.0	4	10.0	10.0	0.8	0.8	25	1.8	**14.34**	**13.79**
Pole 29	2.0	4	10.0	10.0	0.9	0.9	25	1.9	**12.74**	**13.06**
Angle Mast 30	4.0	4	10.0	10.0	0.1	0.1	25	1.1	**57.48**	**11.29**
Pole 31	7.0	4	10.0	10.0	0.4	0.4	25	1.4	**8.27**	**5.07**
Pole 32	3.0	4	10.0	10.0	0.3	0.3	25	1.3	**25.51**	**12.73**
Pole 33	2.0	4	10.0	10.0	2.3	2.3	25	3.3	**4.99**	**7.52**
Angle Mast 34	3.0	No peat encountered								
Pole 35	5.0	4	10.0	10.0	1.1	1.1	25	2.1	**4.19**	**4.73**
Pole 36	3.0	4	10.0	10.0	3.2	3.2	25	4.2	**2.39**	**3.94**
Pole 37	1.0	4	10.0	10.0	0.5	0.5	25	1.5	**45.85**	**33.09**
Angle Mast 38	1.0	4	10.0	10.0	2.5	2.5	25	3.5	**9.17**	**14.18**
Pole 39	2.0	4	10.0	10.0	1.8	1.8	25	2.8	**6.37**	**8.86**
Pole 40	4.0	4	10.0	10.0	1.0	1.0	25	2.0	**5.75**	**6.21**
Angle Mast 41	2.0	No peat encountered								

Calculated FoS of Natural Peat Slopes for Derrybrien Wind Farm OHL (Drained Analysis)

Turbine No./Waypoint	Slope (Note 3)	Design c'	Bulk unit weight of Peat	Unit weight of Water	100% Water to height of Peat	Depth of In situ Peat (Note 5)	Friction Angle	Equivalent Total Depth of Peat (m) (Note 2)	Factor of Safety for Load Condition	
	α (deg)	c' (kPa)	γ (kN/m^3)	γ_w (kN/m^3)	(m)	(m)	ø' (deg)	Condition (2)	Condition (1)	Condition (2)
									100% Water	100% Water
AGEC DATA (2018)										
Pole 1A	0.5	4	10.0	10.0	1.8	1.8	25	2.8	**25.47**	**35.45**
WP 1	3.0	4	10.0	10.0	1.4	1.4	25	2.4	**5.47**	**6.90**
Pole 2	0.5	4	10.0	10.0	2.4	2.4	25	3.4	**19.10**	**29.20**
WP 2	5.0	4	10.0	10.0	1.9	1.9	25	1.9	**2.42**	**2.42**
Pole 3	0.5	4	10.0	10.0	2.0	2.0	25	3.0	**22.92**	**33.09**
WP 3	0.5	4	10.0	10.0	1.8	1.8	25	1.8	**25.47**	**25.47**
Pole 4	6.0	4	10.0	10.0	1.1	1.1	25	2.1	**3.50**	**3.94**
Pole 5	2.0	4	10.0	10.0	1.8	1.8	25	2.8	**6.37**	**8.86**
Pole 6	3.0	4	10.0	10.0	1.0	1.0	25	2.0	**7.65**	**8.28**
Pole 7	6.0	4	10.0	10.0	0.5	0.5	25	1.5	**7.70**	**5.52**
WP 4	6.0	4	10.0	10.0	1.9	1.9	25	2.9	**2.03**	**2.86**
Pole 8	0.5	4	10.0	10.0	1.7	1.7	25	2.7	**26.96**	**36.77**
Pole 9	0.5	4	10.0	10.0	0.8	0.8	25	1.8	**57.30**	**55.15**
WP 5	0.5	4	10.0	10.0	0.5	0.5	25	1.5	**91.68**	**66.18**
Pole 10	4.0	4	10.0	10.0	0.8	0.8	25	1.8	**7.19**	**6.90**
WP 6	4.0	4	10.0	10.0	0.2	0.2	25	1.2	**28.74**	**10.35**
Pole 11	4.0	No peat encountered								
WP 7	20.0	4	10.0	10.0	0.2	0.2	25	1.2	**6.22**	**2.10**
Pole 12	0.5	4	10.0	10.0	0.3	0.3	25	1.3	**152.80**	**76.36**
WP 8	0.5	4	10.0	10.0	0.8	0.8	25	1.8	**57.30**	**55.15**
Pole 13	2.0	No peat encountered								
WP 9	0.5	4	10.0	10.0	0.5	0.5	25	1.5	**91.68**	**66.18**
Angle Mast 14	1.5	No peat encountered								
Pole 15	12.0	No peat encountered								
WP 10	5.0	No peat encountered								
Pole 16	0.5	4	10.0	10.0	0.2	0.2	25	1.2	**229.19**	**82.73**
WP11	0.5	4	10.0	10.0	0.5	0.5	25	1.5	**91.68**	**66.18**
Pole 17	4.0	4	10.0	10.0	0.2	0.2	25	1.2	**28.74**	**10.35**
WP 12	4.0	4	10.0	10.0	0.6	0.6	25	1.6	**9.58**	**7.76**
Angle Mast 18	0.5	No peat encountered								
Pole 19	4.0	No peat encountered								
Pole 20	0.5	No peat encountered								
Pole 21	0.5	4	10.0	10.0	0.8	0.8	25	1.8	**57.30**	**55.15**
Pole 22	6.0	4	10.0	10.0	0.8	0.8	25	1.8	**4.81**	**4.60**
WP 15	0.5	4	10.0	10.0	0.5	0.5	25	1.5	**91.68**	**66.18**
WP 16	15.0	4	10.0	10.0	0.3	0.3	25	1.3	**5.33**	**2.57**
Pole 23	0.5	4	10.0	10.0	0.6	0.6	25	1.6	**76.40**	**62.05**
Pole 24	0.5	4	10.0	10.0	0.4	0.4	25	1.4	**114.60**	**70.91**
WP 17	0.5	4	10.0	10.0	1.5	1.5	25	2.5	**30.56**	**39.71**
Pole 25	7.0	4	10.0	10.0	0.2	0.2	25	1.2	**16.53**	**5.92**
WP 18	2.0	4	10.0	10.0	1.7	1.7	25	2.7	**6.75**	**9.19**
WP 19	5.0	4	10.0	10.0	0.9	0.9	25	1.9	**5.12**	**5.23**
Pole 26	12.0	4	10.0	10.0	0.6	0.6	25	1.6	**3.28**	**2.60**
WP 20	3.0	4	10.0	10.0	0.2	0.2	25	1.2	**38.27**	**13.79**
Pole 27	8.0	4	10.0	10.0	0.2	0.2	25	1.2	**14.51**	**5.18**
WP 21	2.5	4	10.0	10.0	2.6	2.6	25	3.6	**3.53**	**5.52**
Pole 28	0.5	4	10.0	10.0	3.8	3.8	25	4.8	**12.06**	**20.68**
Pole 28A-WP 22	0.5	4	10.0	10.0	1.6	1.6	25	2.6	**28.65**	**38.18**
Pole 29	0.5	4	10.0	10.0	1.4	1.4	25	2.4	**32.74**	**41.36**
Pole 30	0.5	4	10.0	10.0	0.4	0.4	25	1.4	**114.60**	**70.91**
Pole 31	7.0	4	10.0	10.0	0.2	0.2	25	1.2	**16.53**	**5.92**
Pole 32	0.5	4	10.0	10.0	0.4	0.4	25	1.4	**114.60**	**70.91**
Pole 33	5.0	4	10.0	10.0	3.1	3.1	25	4.1	**1.49**	**2.42**
Pole 34	3.0	4	10.0	10.0	2.2	2.2	25	3.2	**3.48**	**5.17**
WP23	2.0	4	10.0	10.0	0.6	0.6	25	1.6	**19.11**	**15.51**
Pole 35	8.0	4	10.0	10.0	1.2	1.2	25	2.2	**2.42**	**2.83**
Pole 36	0.5	4	10.0	10.0	4.7	4.7	25	5.7	**9.75**	**17.42**
Pole 37	0.5	4	10.0	10.0	1.2	1.2	25	2.2	**38.20**	**45.12**
WP 26	1.0	4	10.0	10.0	2.2	2.2	25	3.2	**10.42**	**15.51**
Angle Mast 38	0.5	4	10.0	10.0	5.6	5.6	25	6.6	**8.19**	**15.04**
Pole 39	0.5	4	10.0	10.0	2.2	2.2	25	3.2	**20.84**	**31.02**
Pole 40	0.5	4	10.0	10.0	1.1	1.1	25	2.1	**41.67**	**47.27**
Angle Mast 41	0.5	No peat encountered								

Calculated FoS of Natural Peat Slopes for Derrybrien Wind Farm OHL (Drained Analysis)

Turbine No./Waypoint	Slope (Note 3)	Design c'	Bulk unit weight of Peat	Unit weight of Water	100% Water to height of Peat	Depth of In situ Peat (Note 5)	Friction Angle	Equivalent Total Depth of Peat (m) (Note 2)	Factor of Safety for Load Condition	
	α (deg)	c' (kPa)	γ (kN/m^3)	γ_w (kN/m^3)	(m)	(m)	ø' (deg)	Condition (2)	Condition (1)	Condition (2)
									100% Water	100% Water
ESBI DATA (2004 & 2005)										
1	4.0	4	10	10	0.2	0.2	25	1.2	**28.74**	**10.35**
2	6.0	4	10	10	0.2	0.2	25	1.2	**19.24**	**6.90**
3	6.0	4	10	10	0.9	0.9	25	1.9	**4.28**	**4.36**
4	0.5	4	10	10	0.9	0.9	25	1.9	**50.93**	**52.25**
5	6.0	4	10	10	1.0	1.0	25	2.0	**3.85**	**4.14**
6	6.0	4	10	10	1.0	1.0	25	2.0	**3.85**	**4.14**
7	6.0	4	10	10	1.2	1.2	25	2.2	**3.21**	**3.77**
8	4.0	4	10	10	1.2	1.2	25	2.2	**4.79**	**5.64**
9	0.5	4	10	10	1.3	1.3	25	2.3	**35.26**	**43.16**
10	4.0	4	10	10	1.4	1.4	25	2.4	**4.11**	**5.17**
11	0.5	4	10	10	1.4	1.4	25	2.4	**32.74**	**41.36**
12	3.0	4	10	10	1.4	1.4	25	2.4	**5.47**	**6.90**
13	3.0	4	10	10	1.5	1.5	25	2.5	**5.10**	**6.62**
14	0.5	4	10	10	1.5	1.5	25	2.5	**30.56**	**39.71**
15	0.5	4	10	10	1.5	1.5	25	2.5	**30.56**	**39.71**
16	3.0	4	10	10	1.5	1.5	25	2.5	**5.10**	**6.62**
17	3.0	4	10	10	1.5	1.5	25	2.5	**5.10**	**6.62**
18	0.5	4	10	10	1.6	1.6	25	2.6	**28.65**	**38.18**
19	6.0	4	10	10	1.7	1.7	25	2.7	**2.26**	**3.07**
20	0.5	4	10	10	1.8	1.8	25	2.8	**25.47**	**35.45**
21	0.5	4	10	10	1.8	1.8	25	2.8	**25.47**	**35.45**
22	3.0	4	10	10	1.8	1.8	25	2.8	**4.25**	**5.91**
23	3.0	4	10	10	1.8	1.8	25	2.8	**4.25**	**5.91**
24	0.5	4	10	10	1.8	1.8	25	2.8	**25.47**	**35.45**
25	2.0	4	10	10	1.8	1.8	25	2.8	**6.37**	**8.86**
26	3.0	4	10	10	1.8	1.8	25	2.8	**4.25**	**5.91**
27	0.5	4	10	10	1.9	1.9	25	2.9	**24.13**	**34.23**
28	3.0	4	10	10	1.9	1.9	25	2.9	**4.03**	**5.71**
29	0.5	4	10	10	2.0	2.0	25	3.0	**22.92**	**33.09**
30	3.0	4	10	10	2.0	2.0	25	3.0	**3.83**	**5.52**
31	2.0	4	10	10	2.1	2.1	25	3.1	**5.46**	**8.01**
32	0.5	4	10	10	2.6	2.6	25	3.6	**17.63**	**27.58**
								Minimum =	**1.49**	**2.10**
								Maximum =	**229.19**	**82.73**
								Average =	**22.44**	**18.66**

Notes:

(1) Assuming a bulk unit weight of peat of 10 (kN/m^3)
(2) Assuming a surcharge equivalent to fill depth of 1m of peat i.e. 10kPa. (Condition 2
(3) Slope inclination (β) based on site readings and contour survey plans of site
(4) FoS is based on slope inclination and shear test results obtained from published data
(5) Peat depths based on probes carried out by AGEC, FT and ESBI (June 2018)
(6) For load conditions see report text.
(7) Minimum acceptable factor of safety required of 1.3 for first-time failures based on BS: 6031:1981 Code of practice for Earthworks

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APPENDIX F

ESB Report on Slope Stability Assessment of a Section of Ground below the OHL

Hibernian Wind Power

Derrybrien Wind Farm, Co Galway

Slope stability assessment of a section of ground under overhead line

Report Number: P78015-R476-002

ESBI Engineering and Facilities Management

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16th February 2006

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File Reference: *P78015-F476-030*

Client: *Hibernian Wind Power*

Project Title: *Derrybrien Wind Farm, Co. Galway*

Report Title: *Slope stability assessment of a section of ground under overhead line*

Report No.: **P78015-R476-002**

Rev. No.:

Volume 1 of 1

PRODUCED: Samir Hebib	*DATE: 16th February 2006*
CHECKED: Con Sheahan	*DATE: 16th February 2006*
APPROVED: Con Sheahan *TITLE: Senior Project Manager*	*DATE: 16th February 2006*

Latest Revision Summary:

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Change History of Report

Date	New Rev	Author	Summary of Change

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2.0 Slope stability assessment 1

3.0 Conclusion 3

4.0 References 3

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Summary

A slope stability assessment of a section of ground under the existing overhead line between the windfarm substation and the containment barrage BD2 has been carried out.

Results of that assessment shows that the ground has adequate factor of safety against a slip failure under an external surcharge of 20kPa.

1.0 Introduction

A geotechnical site investigation was carried out along a section of the overhead line at the Derrybrien windfarm. The investigation focused on a section of ground, under the overhead line, between the windfarm substation and a location approximately 700m south of the substation, which coincides with an existing Coillte track, as this section was considered to be the most critical one in terms of existing slope gradients and thickness of peat subsoil. The remaining section of ground, under the overhead line, extending south from the Coillte track to the containment barrage BD2, see Figure 2, is characterised by shallower slope gradients and a peat thickness of less than 1m; rock exposures can in fact be observed in the vicinity of the containment barrage. Furthermore, a 0.5m thick peat layer has been laid out on the existing peat surface close to the containment barrage.

The geotechnical investigation comprised measurement of ground slope angles at regular intervals; frequency was dictated by changes in ground topography, probing of the ground using 0.9m long coupled rods to assess in-situ peat thickness and shear vane tests to assess the shear strength of the peat subsoil. The shear vane tests were carried out subsequent to slope angle measurements and probing of peat depth in order to concentrate in locations which were considered to present a critical combination of steep slope angles and thick peat layer – see Figure 2 for location of shear vane tests and Figure 1 for a profile of the ground topography and peat depths.

2.0 Slope stability assessment

The stability of the existing ground was assessed at different locations along the section investigated assuming critical combination of slope angle, peat depth and shear strength and using an infinite slope method of analysis (Skempton & Delory, 1957). This method is suited to long downslope lengths where the mode of failure is translational sliding, such as that which occurred at the site in October 2003. The infinite slope method is conservative in that no end resistance is assumed.

Stability of the existing ground was assessed assuming two different loading conditions: (1) load condition no.1 where no external load is imposed on the peat surface and (2) load condition no.2 where an external load of 20kPa is applied on the peat surface to simulate pressure applied by a typical 20t weight tracked construction plant. The British Standard "Code of Practice for Earthworks" BS6031:1981 states that for a first time failure with a good standard of site investigation, the design factor of safety should be between 1.3 and 1.4. For the purpose of this exercise a factor of safety of 1.4 was used.

Results of slope stability analyses for the section of ground, described above are shown in Table 1. These results have been also presented in a previous report on ESBIE geotechnical testing (report 78015-C11-R1-REV1). For the remaining section of ground, under the overhead line, between the Coillte track and the containment barrage BD2, a conservative slope angle of 5deg and peat thickness of 1m was assumed throughout. A

minimum required shear strength value for the peat was therefore computed in order to achieve a factor of safety of 1.4. This minimum value was subsequently compared to the lowest results obtained from the shear vane tests carried out north of the Coillte track.

Table 1: Results of stability analyses

Vane ID	Shear vane result (lowest unless stated) (kPa)	Slope angle (deg)	Peat depth at vane location (m)	Factor of safety for load condition 1 (no surcharge)	Factor of safety for Load condition 2 (20kPa surcharge)	Acceptable surcharge to achieve factor of Safety of 1.4 (kPa)
TOH_V1	6.48	5	1.8	4.15	1.96	35
TOH_V2	5.07	6	1.5	3.25	1.39	20
TOH_V3	4.79	6	1.3	3.54	1.40	20
TOH_V4	5.44	6	1.5	3.49	1.50	22
TOH_V5	7.43	5	2	4.28	2.14	41
TOH_V6	7.69	6	1.85	4.00	1.92	34
TOH_V7	7.49	6	1.8	4.00	1.90	33
TOH_V8	7.05	7	1.4	4.16	1.71	28
TOH_V9	8.11	3.5	1.7	7.83	3.60	78
TOH_V10	8.73	5	1.2	8.38	3.14	60
TOH_V11	9.59	8	1	6.96	2.32	40
TOH_V12	9.59	7	0.95	8.35	2.69	47
TOH_V13	9.59	6	0.85	10.85	3.24	57

3.0 Conclusion

Results of slope stability analyses for the section of ground, under the overhead line, between the windfarm substation and the Coillte track show that the ground exhibits a factor of safety above 1.4 when analysed using the lowest shear strength at each location and assuming a surcharge loading of 20kPa. For the remaining section, under the overhead line, from the Coillte track to the containment barrage BD2, the minimum shear strength value for the peat required to achieve a factor of safety of 1.4 under an external surcharge of 20kPa is of the order of 3.6kPa which is well below the lowest shear strength values measured north of the Coillte track.

Therefore, it can be concluded that the portion of ground, under existing overhead line, between the windfarm substation and the containment barrage BD2 is considered to have adequate factor of safety against a slip failure under an external surcharge of 20kPa. This also infers that the factor of safety will be higher in a situation where no external loading is applied.

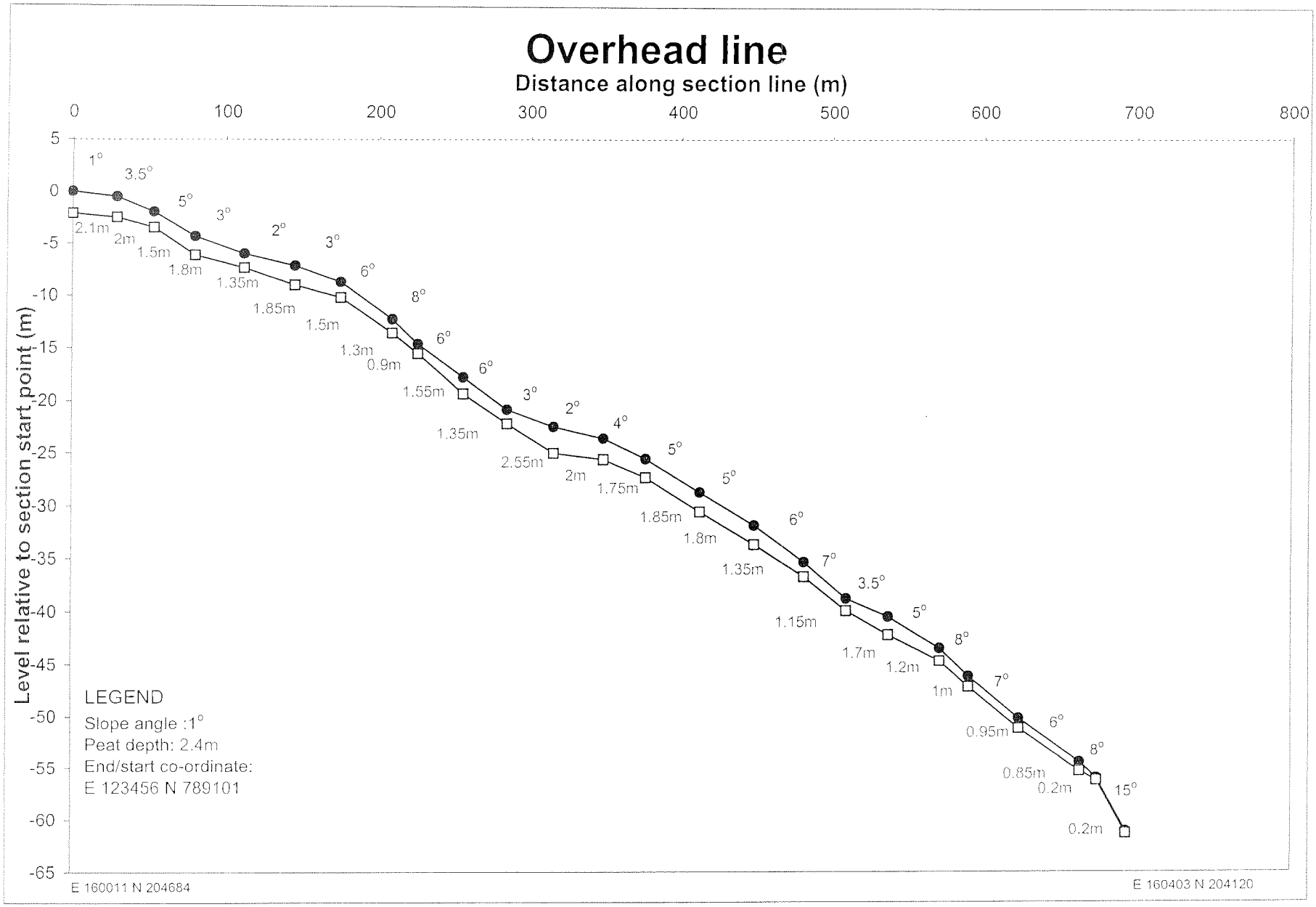
The 0.5m thick peat layer currently laid out on top of the existing peat surface in the vicinity of containment barrage BD2 is not considered to be undermining stability of the existing ground at that location. The surcharge applied by that peat layer would be of the order of 5kPa which well below the 20kPa surcharge assumed in the stability assessment.

4.0 References

1 Skempton, A.W.& DeLory, F.A. (1957). "*Stability of natural slopes in London Clay*". Proc. 4th Int. Conf. on Soil Mechanics and Foundation Engineering, Rotterdam, Vol. 2.

FIGURES

Figure 1 Profile of ground topography and peat depths
Figure 2 Location of shear vane tests


Overhead line
Distance along section line (m)
0
100
200
300
400
500
600
700
800
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
Level relative to section start point (m)
1°
3.5°
5°
3°
2°
3°
6°
8°
6°
6°
3°
2°
4°
5°
5°
6°
7°
3.5°
5°
8°
7°
6°
8°
15°
2.1m
2m
1.5m
1.8m
1.35m
1.85m
1.5m
1.3m
0.9m
1.55m
1.35m
2.55m
2m
1.75m
1.85m
1.8m
1.35m
1.15m
1.7m
1.2m
1m
0.95m
0.85m
0.2m
0.2m
LEGEND
Slope angle :1°
Peat depth: 2.4m
End/start co-ordinate:
E 123456 N 789101
E 160011 N 204684
E 160403 N 204120

A1 CAD

Notes :–

1. All dimensions are in millimetres – figured dimensions to be taken in preference to scaled dimensions.
2. All levels are in metres.

Legend:

Forestry

Streams/Drains

Boundary

10m Contour

50m Contour

Existing Road

Site Area 345ha

Turbine Foundation shown thus

Concreted Turbine Base (T##)

Site Compound

Borrow Pit 3

Clay Borrow Pit

Existing Telecoms Mast

Borrow Pit 2

110kV Substation & Compound Ref. Drg. No. 20206-31

Existing Turbary Road

Coillte Track

Coillte Track

Coillte Track

Approximate Line Of New 110kV Overhead Line

TOH-V1 TOH-V2 TOH-V3 TOH-V4 TOH-V5 TOH-V6 TOH-V7 TOH-V8 TOH-V9 TOH-V10 TOH-V11 TOH-V12 TOH-V13

Containment Barrage BD2

Coillte Forestry

Coillte Forestry

Coillte Forestry

Coillte Forestry

T1 T2 T3 T4 T5 T6 T7 T8 T9 T10 T11 T12 T13 T14 T15 T16 T17 T18 T19 T20 T21 T22 T23 T24 T25 T26 T27 T28 T29 T30 T31 T32 T33 T34 T35 T36 T37 T38 T39 T40 T41 T42 T43 T44 T45 T46 T48 T49 T50 T51 T52 T53 T54 T55 T56 T57 T58 T59 T60 T61 T62 T63 T64 T65 T66 T67 T68 T69 T70 T71

Site Layout Plan

Scale 1 : 10,000

0 100 200 300 400 500m

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PURPOSE OF ISSUE – PRELIMINARY UNLESS INDICATED

TENDER ☐ CLIENT APPROVAL ☐ CONSTRUCTION ☐ AS-BUILT ☐ REVISED ☐

CLIENT: GORT WINDFARM LTD

PROJECT: DERRYBRIEN WIND FARM Co. GALWAY

CONTRACT: DERRYBRIEN WINDFARM

DRAWING TITLE: SLOPE STABILITY ASSESSMENT OF SECTION OF GROUND UNDER OVERHEAD LINE LINE

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Figure 2 (P378015-D01-84)

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ENVIRONMENT ISO 14001:2015 NSAI Certified

APPENDIX 9-1

FLOOD RISK ASSESSMENT

Derrybrien Wind Farm Development Decommissioning Project – Retained Development

Gort Windfarms Ltd.

Flood Risk Assessment

Document No.: QS-000280-01-R460-007-000

December 2024

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Project Location and Setting

The boundaries of the Derrybrien Wind Farm Development area on a regional scale lie almost entirely in the Kinvara Water Management Unit (total drainage area of 637 km^2) within the Western River Basin District (RBD) (hydrometric area 29). A small area (<0.02 km^2) to the north-east corner of the wind farm site lies within the neighbouring Shannon Upper and Lower Water Management Unit within the Shannon International RBD (IRBD) (Figure 1).

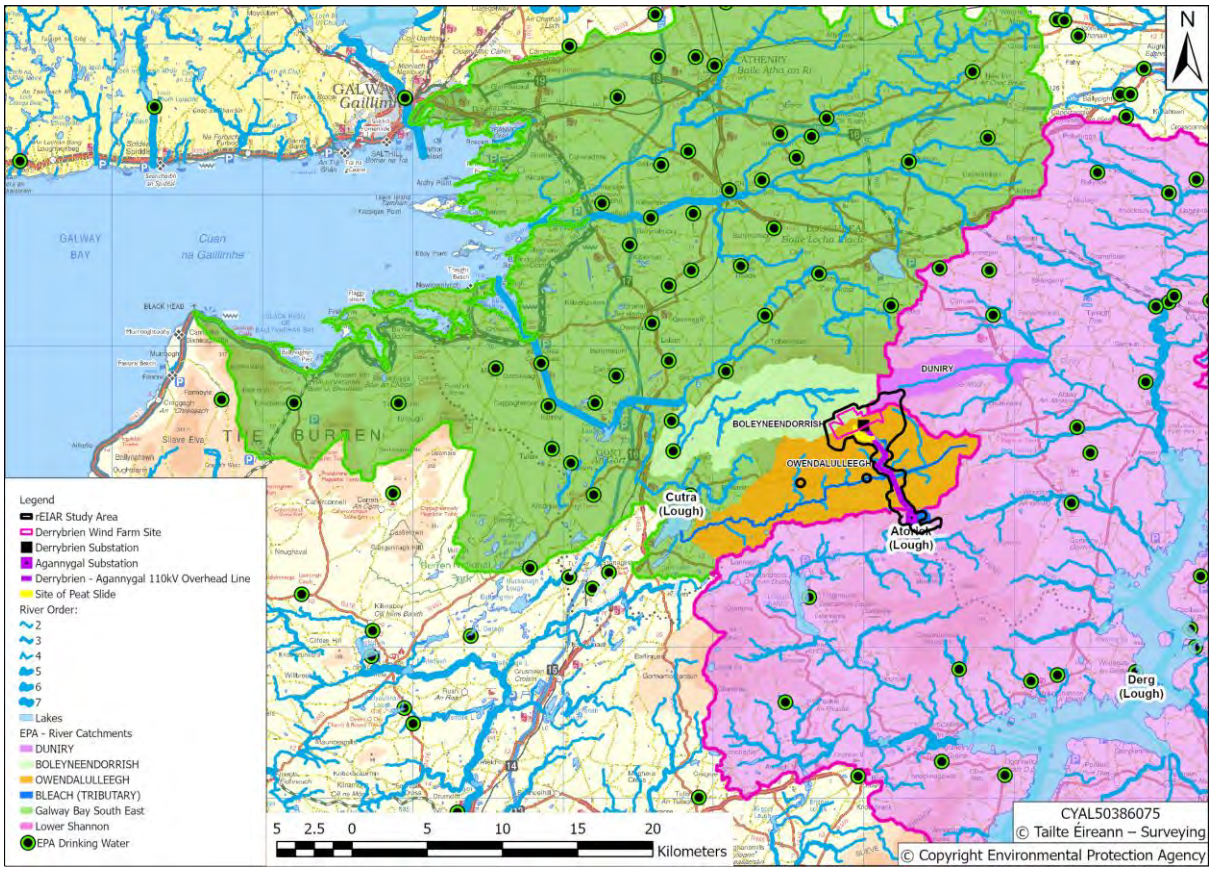


Figure 1 Catchments in relation to Derrybrien Wind Farm Development

The Derrybrien Wind Farm Development lies on Cashlaundrumlahan Mountain in the northern part of the Slieve Aughty Mountains in south County Galway, 15 km east-northeast of Gort, 12.7 km due south of Loughrea and 25 km west of Portumna. The lands within the wind farm site comprise disturbed peat bog, all of which was formerly used either for commercial Coillte forestry plantation (263 ha) or turbary bog lands (81 ha) (i.e. cut-over bog). The overall area of the wind farm site is approximately 344 ha (3.44 km^2) but the wind farm infrastructure comprises approximately 5% of the site area in terms of tracks, turbine bases and access areas). Site elevations range from 320–365 mOD on the upper hill slope forming the wind farm, which form a gently sloping plateau aligned on a northeast to southwest axis. Slopes range from less than 3 degrees locally up to 10 degrees in places with the typical slopes falling between 3 and 7.5 degrees (Figure 2). There is a broad zone that runs across the full width of the site for a distance of approximately 250 – 300 m to the north and south of the peak of the mountain where the ground surface slopes gently away from the peak at slope angles of less than 3 degrees, representing almost a plateau top. This is within the central three rows of turbines. To the south of this zone the slope is convex in profile with slopes generally

increasing up to 4 – 5 degrees and locally 5.0 – 7.5 degrees within the site boundary, particularly between Turbines T21 and T41. In general, the depth of peat is inversely proportional to the slope angles, i.e. peat is deeper across the middle of the site and shallower around the boundaries.

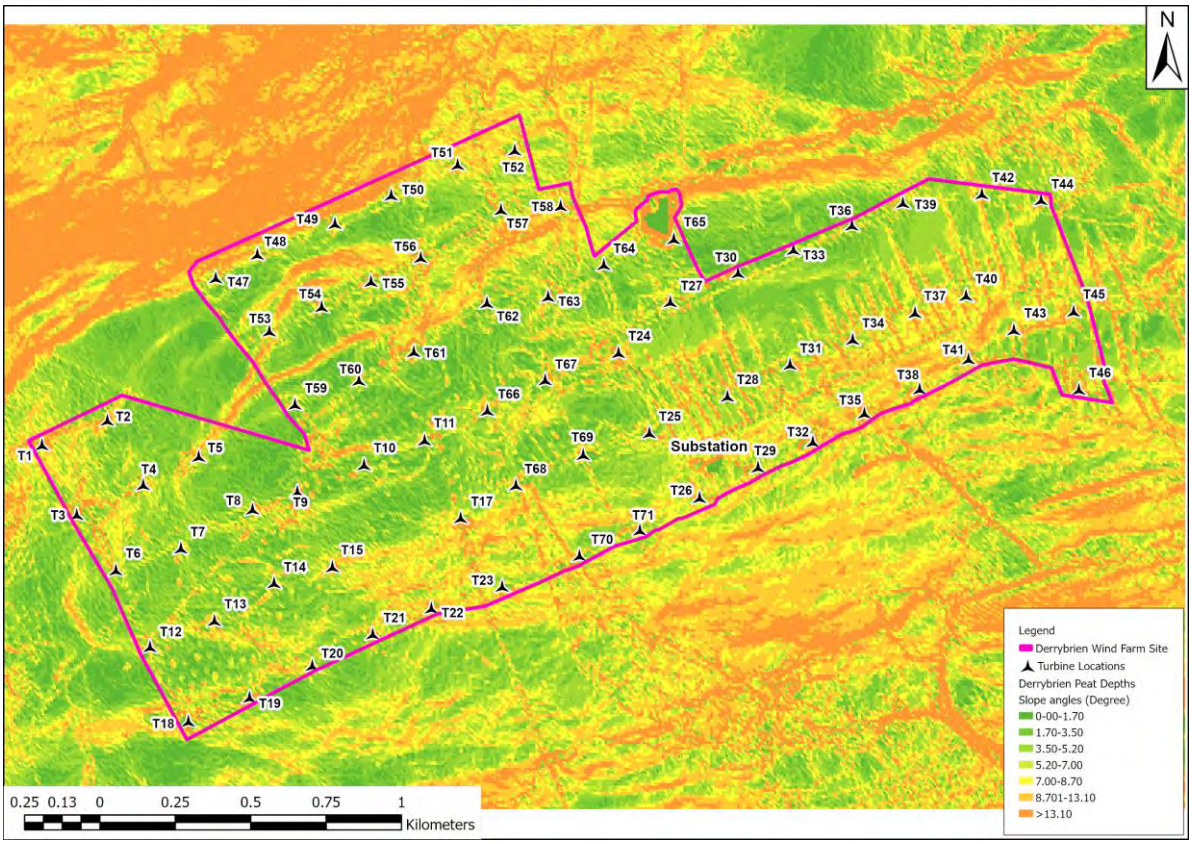


Figure 2 Ground surface slope angles based on post construction LIDAR Survey

Downslope from the site in this area the slopes increase up to 7.5 degrees more consistently and locally up to 10.0 degrees. The peat slide during construction in 2003, occurred within this zone of locally steeper slopes between Turbines T68 and T70.

The full site had been drained in the past, prior to any wind farm construction, by a series of parallel open ditches to facilitate peat production (Turf cutting and peat harvesting) and commercial forestry. These ditches and drains in the worked bog and forestry areas discharged to the natural surface watercourses conveying downstream to the south the hill slope runoff (**Plate 1** and **Plate 2**).

Plate 1 Typical site land at Derrybrien Wind Farm

Plate 2 Original drainage channel at Derrybrien

Turf cutting (peat harvesting) continues to take place on the eastern part of the site. Farming is also undertaken in the lower lying areas away from the site. The principal economic activity in the immediate area is forestry and farming, the latter being dominated by grazing of cattle. Commercial forestry at various stages of planting, growing and harvesting continues on adjacent lands to the wind farm site but not on the wind farm site itself.

The roads on site prior to the wind farm project generally followed an east-west axis parallel to topographical contours. The road layout of the wind farm also, generally follows an east-west orientation, with a number of spur roads connecting these from north to south, including along the internal boundary of the wind farm site.

In addition to the wind farm site, the study area also comprises the approximately 10 m wide corridor of the 7.7 km overhead line running southward from the wind farm site and the grid connection substation at Agannygal connecting the wind farm to the National Grid (Figure 3). The elevation along the route falls to a flat-bottomed valley where it crosses the R353 road and the tributaries of the Owendalulleegh River at an elevation of approximately 130 mOD. From here, the route skirts around the outside of the Slieve Aughty Bog Natural Heritage Area (NHA, site number 001229) before gaining elevation again as it passes Lough Agannygal, at about 195 mOD. The route ends at the Agannygal Substation, which is located to the southeast of Cashlaundrumlahan Mountain and north of Lough Atorick, at an elevation of approximately 190 mOD.

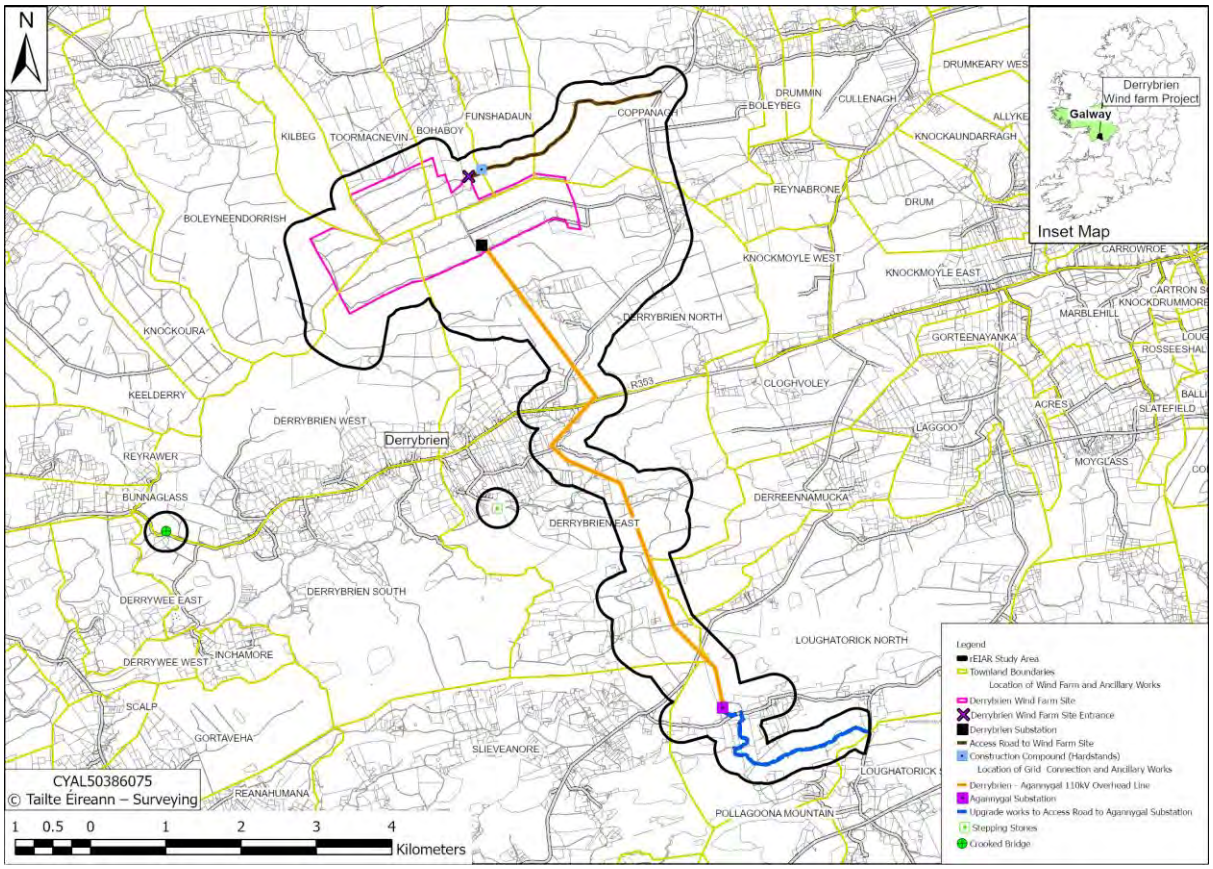


Figure 3 Location of the Derrybrien Wind Farm Development Project - Retained Works

Scope

This assessment considers the following:

I. The Department of Environment, Heritage and Local Government guideline document to Planning Authorities in relation to Flood Risk Management (November 2009);
II. Climate Change;
III. Review of data on recorded historic floods;
IV. Flood Risk to the Project Areas from flood fluvial flows in neighbouring watercourses and direct rainfall causing pluvial flooding;
V. Risk of flooding from groundwater;
VI. The impact of surface water runoff from the Project Areas on the flow regimes in downstream watercourses;
VII. Loss of floodplain.

I. Planning Guidelines

In November 2009 the Department of Environment, Heritage and Local Government issued "The Planning System and Flood Risk Management Guidelines for Planning Authorities".

These Guidelines set out the policy on development and flood risk in Ireland and provide a framework for the integration of flood risk assessment into the planning process. The objective is to ensure that flood risk is taken into account at all stages in the planning process and as a result to:

- Avoid inappropriate development in areas at risk of flooding,
- Avoid new developments that cause an increase in flood risk elsewhere,
- Ensure effective management of residual risks for development permitted within floodplains.

The Guidelines set out a staged approach for the consideration of flood risk in relation to developments as follows: -

"*Stage 1: Flood risk identification – to identify whether there may be any flooding or surface water management issues related to either the area of regional planning guidelines, development plans and LAP's or a proposed development site that may warrant further investigation at the appropriate lower level plan or planning application levels;*"

"*Stage 2: Initial flood risk assessment – to confirm sources of flooding that may affect a plan area or proposed development site, to appraise the adequacy of existing information and to scope the extent of the risk of flooding which may involve preparing indicative flood zone maps. Where hydraulic models exist the potential impact of a development on flooding elsewhere and of the scope of possible mitigation measures can be assessed. In addition, the requirements of the detailed assessment should be scoped;*" and

"*Stage 3: Detailed flood risk assessment – to assess flood risk issues in sufficient detail and to provide a quantitative appraisal of potential flood risk to a proposed or existing development or land to be zoned, of its potential impact on flood risk elsewhere and of the effectiveness of any proposed mitigation measures.*"

The Guidelines classify developments into three vulnerability classes based on the effects of flooding

i) Highly vulnerable development,

ii) Less vulnerable development and

iii) Water Compatible development.

Essential infrastructure such as electricity substations and wind turbines are classed as highly vulnerable developments.

The Guidelines classify land areas within three flood zones based on the probability of flooding. Flood zones are defined as follows in the Guidelines:

- Zone A is at high risk. In any one year, Zone A has a 1 in 100 year (1%) chance of flooding from rivers and a 1 in 200 year (0.5%) chance of flooding from the sea.
- Zone B is at moderate risk. The outer limit of Zone B is defined by the 1 in 1,000 year (or 0.1%) flood from rivers and the sea.
- Zone C is at low risk. In any one year, Zone C has less than 1 in 1,000 year (<0.1%) chance of flooding from rivers, estuaries or the sea.

In the identification of flood zones, no account should be taken of any flood defences present (i.e. flood relief walls or embankments), as though such flood defences did not exist.

Development Classification	**Flood Zone A (High Probability of Flooding)**	**Flood Zone B (Moderate Probability of Flooding)**	**Flood Zone C (Low Probability of Flooding)**
Highly Vulnerable Development (including essential infrastructure)	Justification Test	Justification Test	Appropriate
Less Vulnerable Development	Justification Test	Appropriate	Appropriate
Water-Compatible Development	Appropriate	Appropriate	Appropriate

Table 1 Matrix of vulnerability versus flood zone to illustrate appropriate development and that required to meet the Justification Test (reproduced from Planning Guidelines)

Table 1, which is reproduced from the guideline document to Planning Authorities in relation to Flood Risk Management states that essential infrastructure, including electricity substations and electricity generating wind turbines should be located within the low flood risk zone - Flood Zone C (as highlighted above). The retained development following decommissioning can be reclassified as a Less Vulnerable Development and a moderate probability of flooding is therefore acceptable.

Table 1 refers to the use of a Justification Test under certain circumstances. In cases where there are insufficient sites available to locate a development in the appropriate low flood risk zone, the guideline documents allows for consideration of sites within flood risk zones. A Justification Test is then required to assess such proposals in the light of proper planning and sustainable development objectives.

II. Climate Change

The Planning System and Flood Risk Management Guidelines for Planning Authorities recommend that climate change be factored into consideration for flood risk assessments although there is no national guideline on how to account for the additional risk. The Guidelines instead recommend a precautionary approach to climate change effects in respect to flooding due to the high level of uncertainty in predicting its effects.

The Fluvial Flood Zone extents arising from the Catchment Flood Risk Assessment Management Studies (CFRAMS) mapping represent the current status in relation to flood risk with no account taken of climate change. However, an additional interactive flood map layer is available on floodinfo.ie to show the extent accounting for the different future scenarios. There is a high degree of uncertainty in relation to the potential effects of climate change, and therefore a precautionary approach is required. Examples of precautionary approach include:

- Recognising that significant changes in the flood extent may result from an increase in rainfall or tide level and accordingly adopting a cautious approach to zoning lands in these potential transitional areas.
- Ensuring that the finish levels of structures are sufficient to cope with the effects of climate change over the lifetime of the development.
- Ensuring that structures to protect against flooding (e.g. defence walls) are capable of adaptation to the effects of climate change when there is more certainty about the effects (e.g. foundations of flood defence designed to allow future raising of flood wall to combat climate change).

Climate Change Adaptation Planning

The overall, long-term goal adopted by the OPW on climate adaptation for flooding and flood risk management is:

"Promoting sustainable communities and supporting our environment through the effective management of the potential impacts of climate change on flooding and flood risk."

Flooding is a cross-sectoral issue that needs to be considered by all sectors and local authorities in considering future development and adaptation to future climatic changes.

The Electricity & Gas Networks Sector Climate Change Adaptation Plan (DECCAE, 2019) aims to identify the potential impacts of climate change on energy infrastructure, assess the associated risks and set out an action plan for adapting to those impacts. The process of climate adaptation evolves over time in response to on-going assessments of impacts and vulnerabilities. Adaptation planning is therefore an iterative process, where plans and actions can be modified and changed as new information and research becomes available.

In Ireland general practice is to use a medium-range climate change allowance of 20% for flood flows over the next 100 years. This rate has been adopted by the OPW for all of its CFRAM Studies. Research into climate change in Ireland is coordinated by Met Éireann through Community Climate Change Consortium for Ireland (www.c4i.ie). The OPW have recommended allowances of +20% on fluvial flows for climate change as recommended in the draft guidelines entitled "Climate Change Sectoral Adaptation Plan, Flood Risk Management"

(OPW, 2015) for mid-range future scenario (MRFS) and +30% for the high-end future scenario (HEFS).

Notwithstanding the precautionary principle, the flood risk zones defined in the 'The Planning System and Flood Risk Management Guidelines for Planning Authorities' are based on the present-day assessment of the 100-year (1% Annual Exceedance Probability (AEP)) and 1000-year (0.1% AEP) return period for fluvial flooding and the 200-year (0.5% AEP) and 1000-year return period for tidal flooding. The OPW provide specific guidance as to the allowances in their publication entitled "Climate Change Sectoral Adaptation Plan" and these allowances are summarised in Table 2.

Parameter	**Mid-Range Future Scenario MRFS**	**High-End Future Scenario HEFS**
Mean Sea Level Rise	+500 mm	+1000 mm
Land Movement	-0.5 mm/year	-0.5 mm/year
Extreme Rainfall Depths	+20%	+30%
Flood Flows	+20%	+30%

Table 2 OPW-recommended Climate Change Allowances in Flood Parameters for Future Scenarios

III. Historical Floods

A desk review of historical flooding was undertaken primarily using OPW website floodinfo.ie. The 'Past Flood Events' layer forms a record of all available flood records held by the OPW, all local authorities and other relevant state organisations such as the EPA and the Department of Communications, Climate Action and Environment. There are no mapped reports of recurring flooding within the site and there is no significant risk of flooding due to the elevated nature of the majority of the Project area relative to the surrounding area (Figure 4). The nearest area downstream affected by extensive flooding in the catchment which drains the north side of the wind farm site is 15 km downstream at Ballylee on the Streamstown River. The nearest area downstream affected by extensive flooding in the catchment draining the south side of the wind farm is over 20 km downstream close to Gort. The history of flooding in the Gort Lowlands area is discussed in detail in Appendix 9-2.

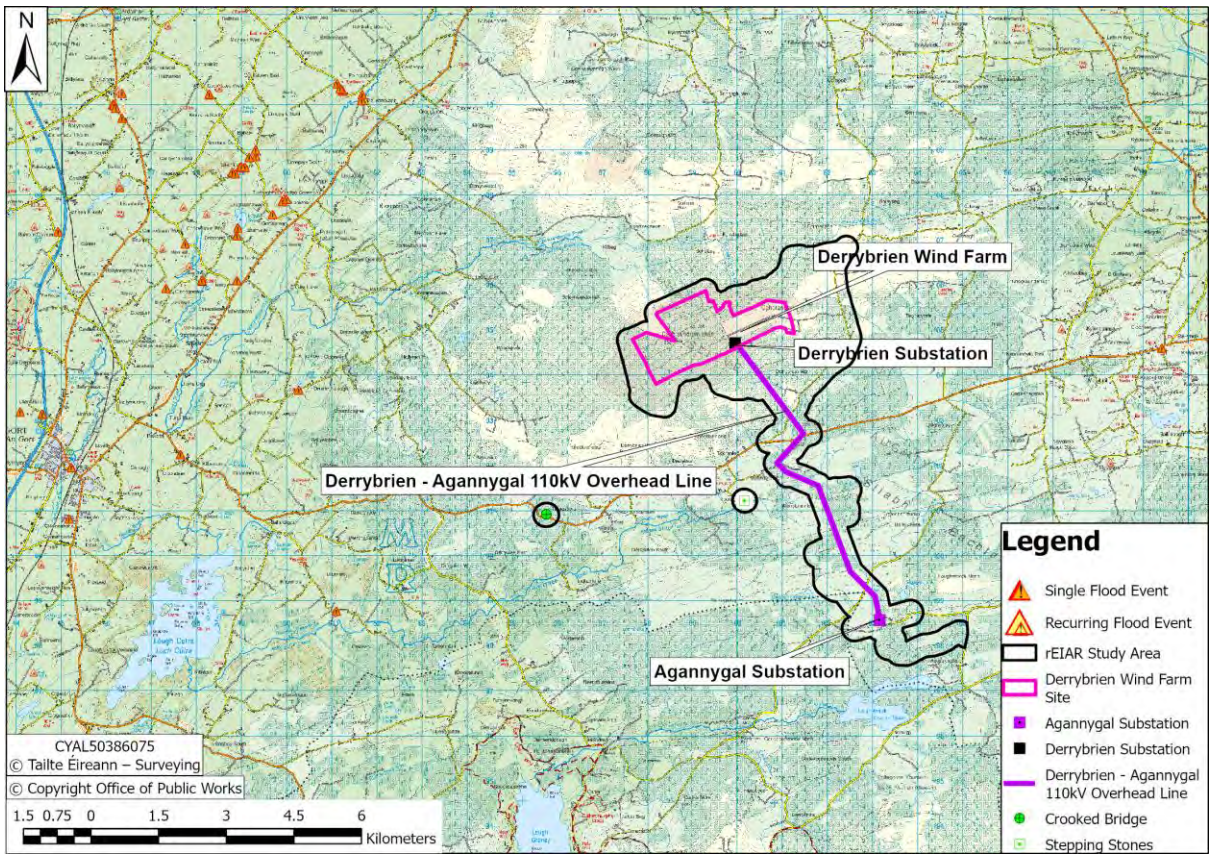


Figure 4 Past Flood Events mapped by OPW

There is no "liable to flood lands" or flood symbols on the historical 6" or 25" mapping for the Project areas that identifies areas that are "prone to flooding" within or immediately downstream of the site. There are also no areas within the site or immediately downstream of it mapped as "Benefiting Lands" identified as subject to flooding or poor drainage which have been the subject of a public works drainage scheme, either as an OPW arterial drainage scheme or a Local Authority drainage district. The nearest such drainage district to the Project study area is the Annagh Drainage District located downstream of Peterswell in the Boleyneendorrish catchment.

With regard specifically to groundwater flood risk, there is no history of groundwater flooding arising on the wind farm site, the Geological Survey of Ireland (GSI) has produced a national-scale flood map presenting the maximum historic observed extent of karst groundwater flooding. The map is primarily based on the winter 2015/2016 flood event, which in most areas including south Galway represented the largest groundwater flood event on record. The map was produced based on remote sensing imagery of the 2015/2016 event as well as any available supplementary evidence. The floods were classified by flood type differentiating between floods dominated by groundwater (GW) and floods with significant contribution of groundwater and surface water (GWSW) (https://dcenr.maps.arcgis.com/apps/webappviewer/index.html?id=848f83c85799436b808652f9c735b1cc – accessed 23rd October 2024). The mapping does not indicate historical groundwater flooding affecting the Derrybrien wind farm site.

The wind farm site has been managed for almost 20 years and there is no record of any serious flooding on or in the vicinity of the Project areas in that time despite a number of large flood events affecting the surrounding region. Gort Town was and is affected by flooding with an OPW Flood Relief Scheme successfully implemented for the Main Street bridge area in 1997. However, the areas downstream of Gort have experienced inundation during prolonged winter floods. Lough Cutra is gauged by the OPW and the lake level generally rises and falls by 1.2 m between the winter/spring period high to the summer period low in an annual cycle.

IV. Flooding Risk to Project Area

CFRAMS and NIFM Mapping

As part of Ireland's obligations under the EU "Floods" Directive (Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks), the OPW is currently engaged in the generation of new mapping which will provide predictive estimates of the extent of floodplains as part of its CFRAM Studies. This programme is being undertaken on a River Basin District basis. The Derrybrien Wind Farm Project site is primarily located within the Western River Basin District with a very small section of the site within the Shannon District. The Western CFRAMS programme was carried out between 2011 and 2016. Finalised flood maps were released through floodinfo.ie in April 2018. The OPW CFRAMS river flood maps and CFRAMS National Indicative Fluvial Mapping (NIFM) maps were consulted to identify those areas at risk of flooding.

The NIFM mapping shows the extents of the indicative 100-year flood zone which relates to fluvial (river) flood events. This mapping is based on fluvial sources for catchments in excess of 5km^2 and assumes within channel has capacity for 80% of the annual flood and remainder floods its overbanks based on hydraulic modelling using a DTM ground level model. There is no 100-year or 1000-year fluvial flood zone mapped within the Project area, which includes the overhead line (OHL) route and Agannygal substation (Figure 5, Figure 6). Where it is mapped in close proximity to the development, it typically exists in close proximity to the main Owendalulleegh and Boleyneendorrish River channels or its contributing second or third order streams. No pluvial flood zones are mapped within the site, as would be expected in mountainous rural terrain with sloping topography. CFRAMS interactive flood mapping (www.floodinfo.ie) does not identify and analyse areas at risk of flooding close to the wind farm site as it was not considered by the OPW as an Area for Further Assessment (AFA) as part of the CFRAMS programme.

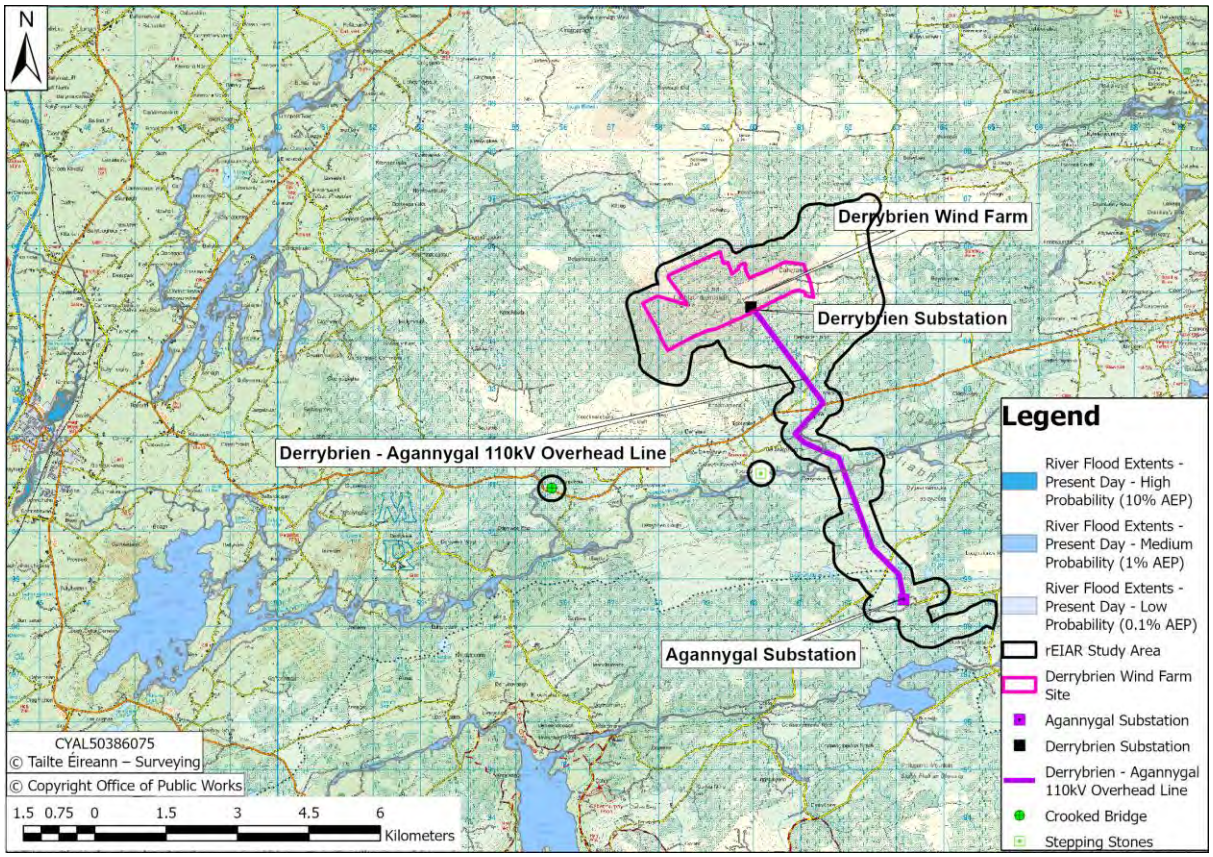


Figure 5 OPW Fluvial Flood Mapping – Present day

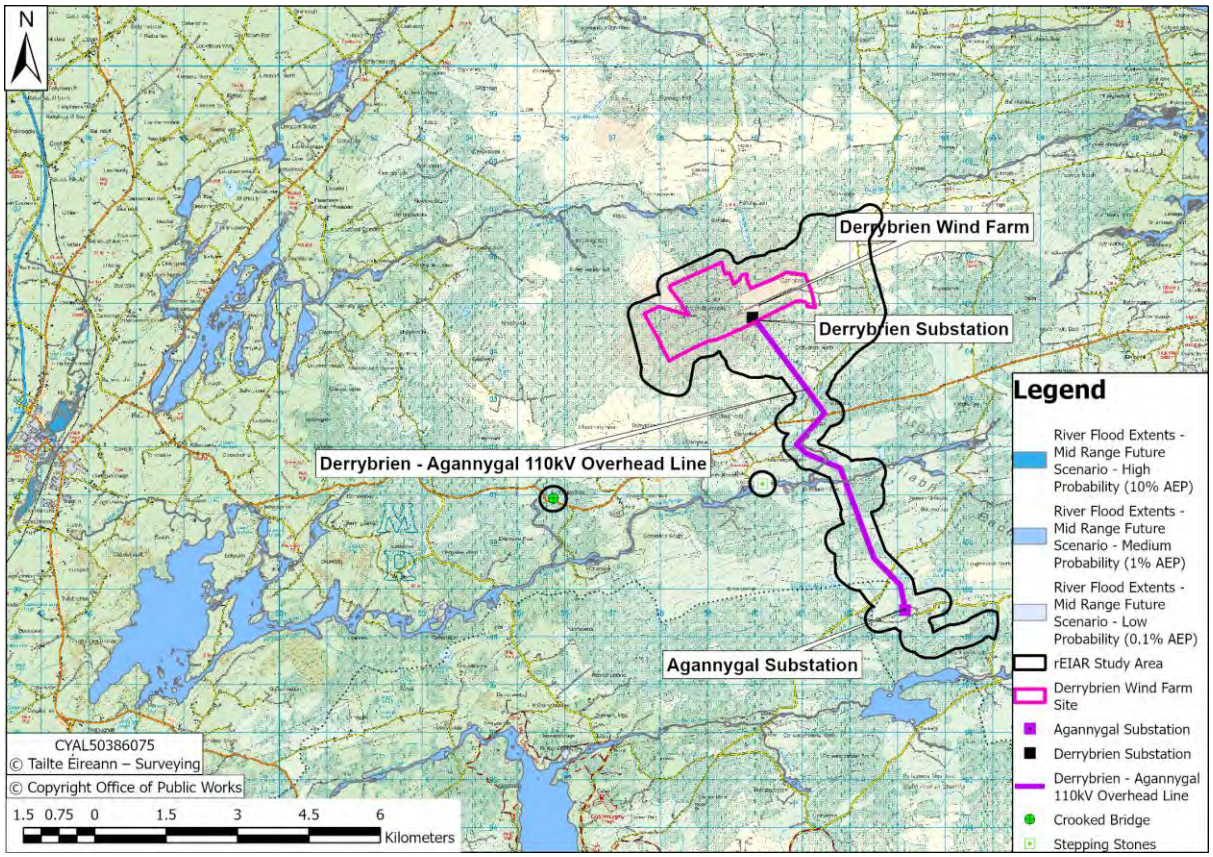


Figure 6 OPW Fluvial Flood Mapping – Mid Range Future Scenario

During the post-construction phase of the wind farm, the drainage network has experienced a variety of large storm events. These have ranged from intense short-duration events in which approximately 60 mm of rain fell in 24 hours (as measured at Gort Derrybrien II Met Station) (7th June 2012, Storm Desmond on 5th December 2015) to long-duration winter floods which saturated the wider area (November 2009, December 2015 to January 2016, February 2020).

The drainage network on the wind farm has to date demonstrated sufficient capacity to convey floodwaters without excessive flooding of access tracks and turbine bases or erosion of drainage channels. Similarly, the drainage networks associated with both substations have no record of flooding issues since commissioning (14 years). It is reasonable to conclude that the wind farm site, OHL route and Agannygal substation site, being on elevated upland sites, with the exception of a small area on the OHL line, are located in Flood Zone C and are therefore at low risk of flooding as defined by the Planning Guidelines. Notwithstanding the low fluvial and pluvial flood risk, the raised bog acts as a saturated sponge and retains the water table at or close to ground level in undrained areas.

GSI Mapping

The predictive groundwater flood map produced by GSI presents the probabilistic flood extents for locations of recurrent karst groundwater flooding. It consists of a series of stacked polygons at each site representing the flood extent for specific AEP's mapping floods that are expected to occur every 10, 100 and 1000 years (AEP of 0.1, 0.01, and 0.001 respectively). The map is focussed primarily (but not entirely) on flooding at seasonally inundated wetlands known as turloughs. Sites were chosen for inclusion in the predictive map based on existing turlough databases as well as manual interpretation of SAR imagery.

The mapping process tied together the observed and remote sensing-derived hydrograph data, hydrological modelling, stochastic weather generation and extreme value analysis to generate predictive groundwater flood maps for over 400 qualifying sites. It should be noted that not all turloughs are included in the predictive map as some sites could not be successfully monitored with remote sensing technology and/or modelled. This mapping suggests the wind farm site, substations and OHL route all lie in Flood Zone C and are at low risk of groundwater flooding.

Derrybrien Wind Farm Development

Baseline Environment (1998)

The pre-existing drainage system on the wind farm site (Figure 7) moved water by gravity following the natural gradient of the site, utilising a network of longitudinal drains and stream channels to discharge surface drainage waters off site to the local river systems. These were c. 30 km of drainage channels in the form of ditches dug prior to the wind farm project and ran parallel to existing floating access roads on one or both sides of the track to avoid problems of localised ponding affecting turbary and forestry access. These drains discharged to perpendicular drains which discharged surface water away from the mountain. Drainage channels on the eastern side of the site were maintained by turbary landowners prior to the wind farm Project and on the remainder of the site by Coillte.

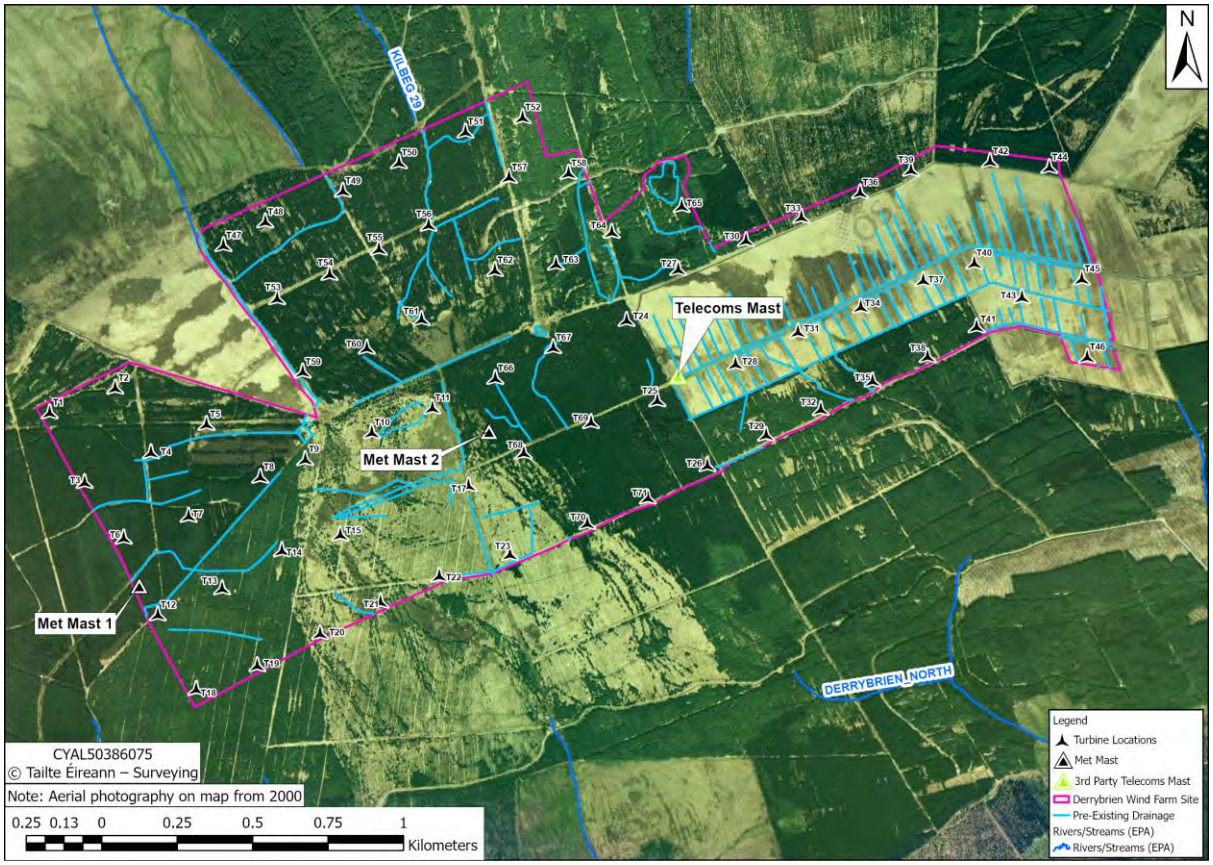


Figure 7 Drainage layout prior to construction (circa 2000)

All of the drains (both pre-existing and constructed) and watercourses are narrow open channels, typically 1-3 m deep, with culverts under the site access tracks. Where the peat is shallow the drains penetrate into the underlying glacial till. However, in peat greater than 1-2 m deep the drains are only excavated into the peat. At the east end of the site the drainage network reflects the outline of the turbary plots on that side of the site. Slope angles in the drainage network vary from 2 to 5 degrees (i.e. gradients of 1:10 to 1:30) in this area, with the steepest channels draining toward the southeast.

Blanket bogs such as that on which Derrybrien Wind Farm was sited was historically (priory to commercial forestry and turbary activity) wetlands fed directly by rainfall to give rise to their

characteristic saturated and water logging surface conditions. The living surface peat layer (0.1 – 0.3 m thick), the acrotelm, can have a moisture content of 90 – 98% and features the peat-forming vegetation, i.e. sphagnum moss, cotton grass and other materials including purple moor grass, heather stems and roots. The acrotelm supplies plant material which then slowly forms peat in the underlying catotelm layer. Typically, active peat bogs grow slowly at 0.5 – 1.0 mm per annum. In active bogs sphagnum mosses form a protective carpet which is a mosaic of sphagnum species growing as dense hummocks, low growing lawns and as hollows that create the characteristically undulating bog surface. In these undrained conditions the saturated bog promotes increased surface ponding as pools and mires, also generating overland runoff as sheet flow across the surface of the bog. Active blanket bog generally remains close to saturation throughout the year and therefore has limited available storage except in depressions where larger pools can form before spilling overland.

In the case of Derrybrien the former land use was primarily i) turbary and ii) commercial forestry, which both represent a drained bog situation.

i) Turbary Bog

In a damaged or degraded bog, the acrotelm has been lost because of drainage, burning, trampling / grazing, afforestation or agriculture (which includes fertiliser application as well as drainage). The degradation exposes the unprotected underlying catotelm layer to atmospheric conditions including surface water runoff. Subsequently, non-wetland vegetation becomes established, accelerating the aeration, drying and shrinkage process (primary consolidation). The loss of moisture and thus buoyancy in the upper layers further squeezes water from the catotelm layer (secondary compression).

Drainage of peat bogs is generally focused on lowering the water table through a network of deep connecting drains often for domestic and commercial peat production, for forestry production or for agricultural grassland reclamation to provide an unsaturated soil root zone that enables plant growth to succeed. The construction of drainage ditches in a bog provides shorter pathways for surface water to run off and, depending on the density of the drainage network, will ultimately reduce water logging and over time dry out the surface acrotelm layer and more gradually the upper layers of the catotelm. The acrotelm layer offers relatively low resistance to vertical and lateral water movement and, consequently, drainage tends to empty water reasonably readily from the acrotelm layer. However, given this layer is relatively thin, the drainage effects on the surrounding water table are minor. The drying process will over time alter the surface topography and increase the range in the water table between summer and winter levels.

ii) Commercial Forestry

Forestry plantations such as that which occupied the majority of the wind farm site prior to 2003 cannot tolerate permanently waterlogged conditions such as the saturated conditions found in blanket bogs. For forestry to flourish it is necessary to drain the peat and remove excess surface water to locally lower the perched water table level. It is also necessary to plough the surface to provide a slightly raised ridge that acts as a micro-habitat for tree seedlings to establish with the ploughed furrow conveying the drainage away from the planted ridge. Tree planting takes place in rows parallel to the ploughed furrow with the areas in between the ridges often an efficient avenue for runoff to migrate downgradient to receiving

watercourses. As such, the overall effect of forestry plantations like this is to increase peak winter flood runoff rates from upland areas. It should be noted however that this only applies when antecedent conditions are wet such as during winter. In drier conditions, the soil moisture deficit may be greater where the root zone promotes drying of the underlying peat, thus effectively providing a degree of attenuation.

Given the upland nature and gradients of the area, the site on which the wind farm was developed represented high runoff category lands.

Impact of Wind Farm Project on Flood Regime

Approximately 12 km of road drainage and turbine foundation drainage was constructed for the wind farm Project, most of which connect the turbine foundation drainage to the pre-existing drains on site. Figure 8 shows the network of open drains on the site, both existing former drainage (cyan) and constructed collector drainage (magenta). The vast majority of the circa 27 km of pre-existing channels were left unchanged during construction except where there was a conflict with new infrastructure. In areas where high concentrations of flow upstream of access tracks and / or close to turbine foundations, sections of drainage were re-aligned or deepened to reduce any risk of localised surface ponding and saturate conditions that could give rise to buoyancy issues in respect to the turbine structure. Some minor cleaning out and maintenance work took place as required.

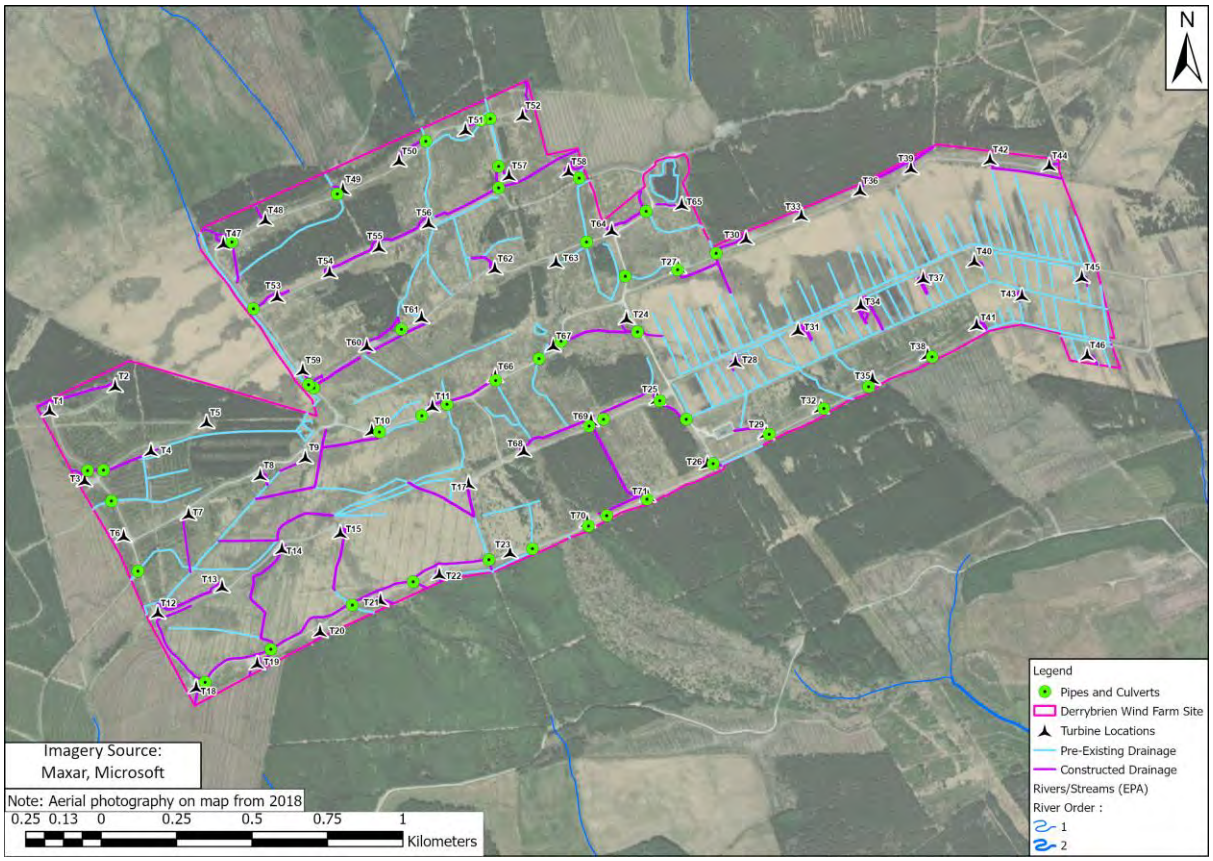


Figure 8 Wind Farm Pre-existing and Constructed Drainage

Regular maintenance has been carried out as necessary since commissioning of the site. Drainage inspections are carried out monthly and following heavy rainfall or snow events. In

addition to this, annual geotechnical inspections have identified drainage maintenance issues which generally involve localised clearing out and maintaining sections of site drains.

The use of floating road, which accounts for 18.8 km out of 19.7 km of on-site access tracks (both pre-existing and constructed), facilitate rainwater infiltration into the peat layer beneath and as such do not require additional roadside drainage with rainwater falling onto the road allowed to spill over the edge into the undisturbed peat. Floating roads are sympathetic to the natural drainage as they do not act as a barrier nor as a deep wide permeable drain that would dewater the adjacent saturated peat into its formation layer and convey elsewhere with the gradient of the road. It should be noted that all of the 2.24 km of tracks on the site prior to construction were floating roads. These allowed surface water to pass without issues or need for diversions. It is therefore with confidence that one can comment on the effect of floating roads on drainage at this wind farm site. The remaining 0.9 km of road which was non-floating were in small sections around Borrow Pit / Quarry 3 in the north-east corner of the site and at turbines T68 and T70 which were rebuilt with rockfill embankments following the peat slide in October 2003.

During storm events, runoff from hardstanding areas has been conveyed through the nearest drains to outlets from the site. These drains have been and continue to be inspected and maintained on a regular basis to form a more efficient route to the outlet point of the wind farm site before meeting with rivers downstream.

Culverts have been inserted at various wind farm access road crossings as necessary to maintain the conveyance path of the existing drains crossed and thus prevent excessive ponding of water on the uphill sides of these roads. The culverts installed are necessary to maintain the drainage runs and avoid unnecessary diversions of drainage on the site.

It should be noted that the extent of constructed wind farm drainage is, in comparison to similar developments of this type and scale, minor relative to the overall existing drainage.

The wind farm site lies on relatively gently sloping ground surrounding the Peak of Cashlaundrumlahan Mountain and is composed of the headwaters of several small subcatchments which drain from this summit to downstream rivers to the north and south of the wind farm site (see Figure 9). As such there are no external surface water inflows and only the direct rainwater falling on the site contributes to increases in flows and water levels. The site is ungauged in respect of flood flow estimation and requires ungauged flood estimation methods to determine the Greenfield runoff rate and the return period design flows.

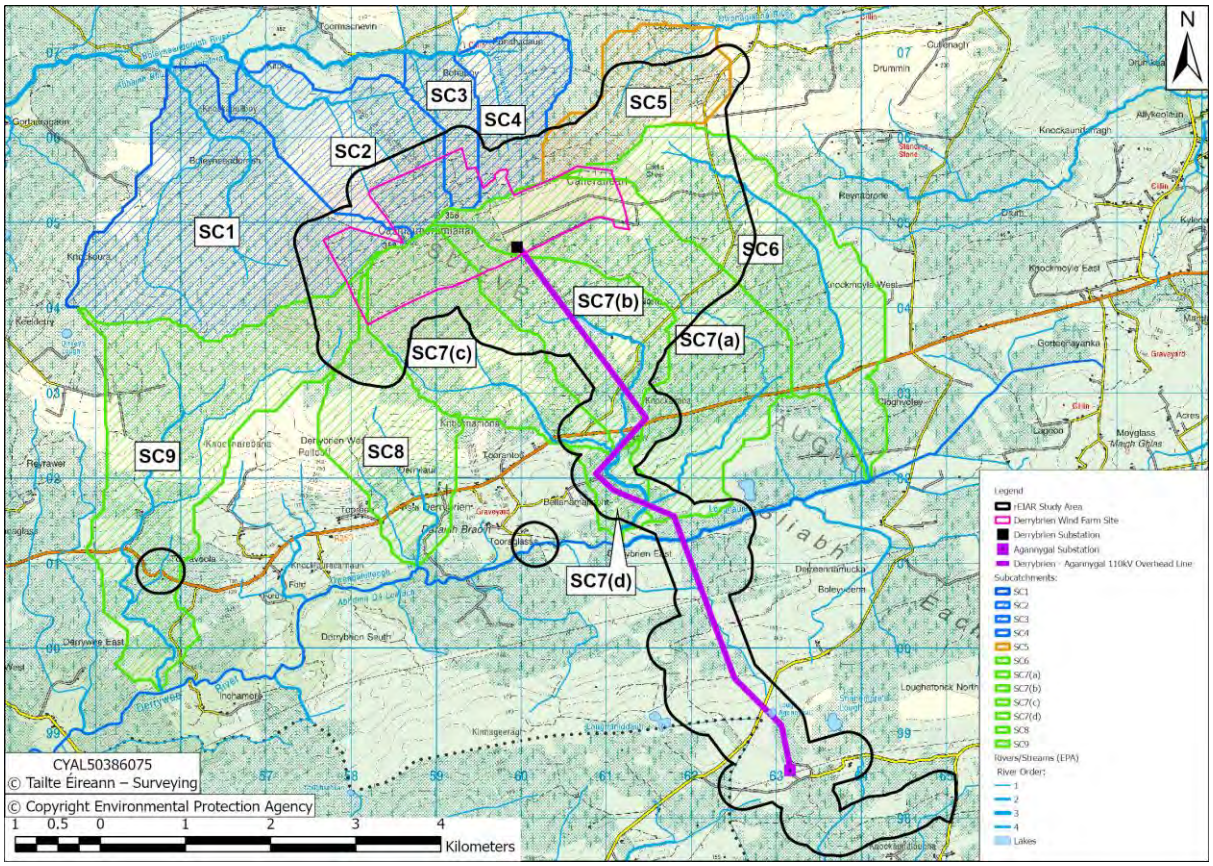


Figure 9 Subcatchments draining from wind farm site to major rivers

Impact of Retained Development on flood regime

The Retained Development, being no longer in operation, can be considered a Less Vulnerable Development, as it is assumed that the land use will revert to agriculture/turbary and forestry as defined by Table 3.1 of the Planning Guidelines.

The flood regime from the 100-year rainfall event has been analysed to review its potential impact. According to the Flood Studies Update (FSU) Rainfall Depth Duration Frequency (DDF) model the 100-year return period rainfall depth for a 1 hour event is 35.9 mm. By including allowance for a climate change factor of 20% this increases the 100-year rainfall depth to 43 mm. LIDAR data taken across the wind farm site in 2012 at 1 m x 1 m resolution was used to build a representative digital elevation model (DEM) of the wind farm. Simulation of the 100-year flood levels using the HEC-RAS River Analysis System for the critical flood period (1 hour) generally shows the greatest depths of water draining to within and to the vicinity of drainage channels (Figure 10). The two-dimensional (2D) model has 1 m^2 resolution and simply relies on the inputted DEM, rainfall hydrograph and Manning's roughness coefficients for the 2D flow area to compute rainwater depths and their change for a prescribed time step and simulation duration.

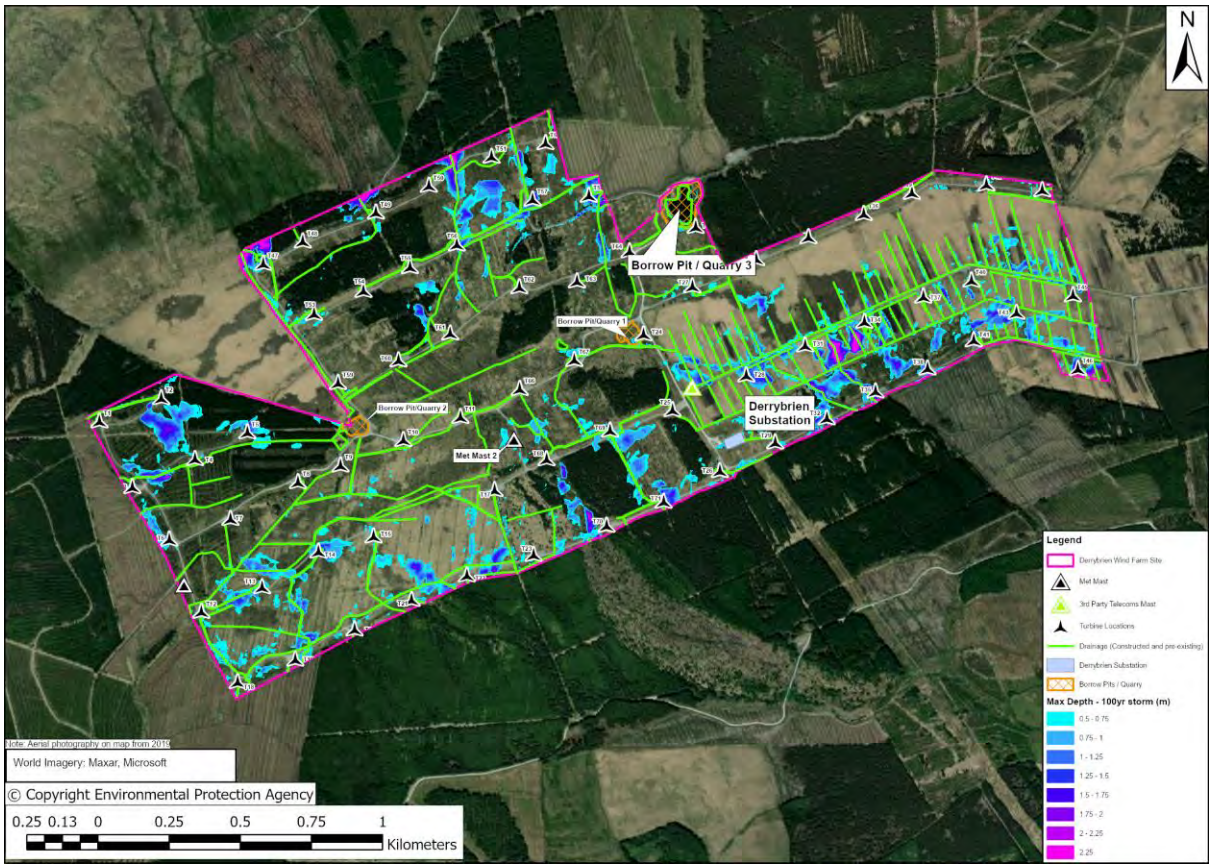


Figure 10 Maximum flood depth for 100-year rainfall event

Given the inherent limitations associated with a LIDAR survey, the DEM cannot account for pipes and culverts which pass underneath access tracks and so, the greatest depths modelled are at the most significant pipe crossings, the largest of which is just downstream of Turbine T35. During the operational life of the wind farm, Turbine T35 was identified by ESB Engineering & Major Projects (EMP) engineers and the wind farm manager as being vulnerable to a sudden increase in water ground level due to its level and proximity to one of the existing drains leaving the site and potential blockage of a single 600 mm diameter culvert under the adjacent track downstream of T35. In response to this risk an additional 600 mm diameter pipe was installed at this location along with a screen upstream of this to capture any removed peat and vegetation debris (Plate 3 and Plate 4). No other drainage issues have arisen in this area since these works were completed but it continues to be monitored closely. It was noted in the first annual inspection following commissioning of the wind farm in 2006 that erosion of the banks adjacent to the drain between T32 and T35 had caused collapse of overlying peat into the drain crossing. This erosion was due to the high water velocities in this area which are associated with the steep channel gradients – according to the DEM the average gradient is 1:10 in this area. Therefore, it may be asserted that the outputs of the flood model corroborate the observations made in annual inspections since commissioning.

Plate 3 Looking downstream at crossing near T35

Plate 4 Looking upstream at crossing near T35

Overall, the topography of the wind farm site and its relatively even distribution of drainage channels ensures that that there is no risk of large localised flooding, even in the event of future pipe blockages. The Planning Guidelines state that vulnerability is classed depending largely on –

1. the risks to people who will use the development,
2. the effects of damage to buildings and structures that might be caused by flooding, and
3. the potential environmental damage that could be caused arising from pollution caused by the development were it to flood.

In this context, it is reasoned that the vulnerability of the decommissioned wind farm site is at the lower end for the three criteria set out above and that no additional action should be required to protect against on-site flood risk due to low risk to people, structures and the environment arising from any surface flooding.

Derrybrien 110 kV Substation

Baseline Environment

The 110-kV substation location prior to the wind farm project was in afforested land close to the boundary with extensively drained turbary land to the north. There was no existing drainage running through the site of the substation prior to the wind farm. The topography of the area is generally from northwest to southeast.

Impact of Derrybrien Substation on Flood Regime

Flood Risk Assessment

The substation lies in an area with topography sloping generally from northwest to southeast. Any surface runoff affecting the substation area should constitute direct rainfall and / or overland flow from a small area of c. 0.05 km^2 (5 ha). The total fall between the top of this small catchment and the station is 17 m (347 mOD to 330 mOD) with an average gradient of 1:30 across the area.

The permeable area of substation compound constructed as part of the wind farm Project is finished on 50 mm single size clean compound stone. The permeable compound stone provides a means of attenuation for runoff and allows rainwater to infiltrate to ground similar to a Greenfield site. Rainwater from the roof of the control building connects via downpipes and drainage pipes away from the compound into the wind farm drainage system. The concrete access road within the compound is cambered to drain to the permeable compound stone. A deep drain to the southeast of the substation constructed as part of the Project conveys water using the natural steep gradient (approximately 1:10) via a culvert underneath the wind farm access track off-site to a pre-existing drain close to turbine T29 (Plate 5 and Plate 6). This pre-existing drain then conveys water to the southeast passing through the steeply sloping Coillte forestry before joining the Derrybrien North River, a tributary of the Owendalulleegh River, just below the October 2003 slide area.

The substation was classed as a highly vulnerable development throughout the operational life of the wind farm but did not experience any flood events.

Plate 5 Drainage channel downstream of Derrybrien substation

Plate 6 Continuation of channel downstream of Derrybrien substation

Impact of Retained Development on flood regime

The high voltage equipment, the substation, and control building will be dismantled, and all equipment removed from site. The drainage channel running downstream from the substation will not be impacted by decommissioning activities. The hardstand area for the substation will be left in place after decommissioning. As no elements of the substation are in operation, it can be considered as a Less Vulnerable Development as defined by Table 3.1 of the Planning Guidelines. Similar to the reasoning used in assessing the impact of the retained wind farm site, the flood risk for the substation post-decommissioning is deemed acceptably low.

Agannygal Substation

Baseline Environment

The substation location prior to construction was in afforested Coillte-owned land. The land is elevated with respect to the surrounding area to the north, west and south. There is no record of pre-existing drainage or flooding issues on the site of the substation prior to construction and it is provisionally placed in Flood Zone C.

Impact of Agannygal substation on Flood Regime

As with Derrybrien 110 kV substation, the Agannygal substation increased the impermeable area of the site, bringing a slightly increased risk of pluvial flooding on site and in the surrounding area if not properly managed. The level of the station compound is 192.5 mOD. The overall area of the compound is approximately 3,000 m^2, of which 350 m^2 or 12% is impermeable roof drainage. The permeable area of substation site constructed as part of the wind farm Project is finished on 50 mm single size clean compound stone. The permeable compound stone provides a means of attenuation of runoff and allows rainwater to infiltrate to ground as it would on a Greenfield for this portion of the site. A system of land drains installed around the substation collects additional surface water drainage, particularly overland flow to the higher eastern boundary of the substation. This water drains offsite as per Figure 11 where it leaves site with the land drainage. Runoff then flows down a steep vegetated shallow channel next to the substation access road to where it joins with the local public road at an elevation of 181 m OD (Plate 7 and Plate 8).

The substation was classed as a highly vulnerable development throughout the operational life of the wind farm but did not experience any flood events.

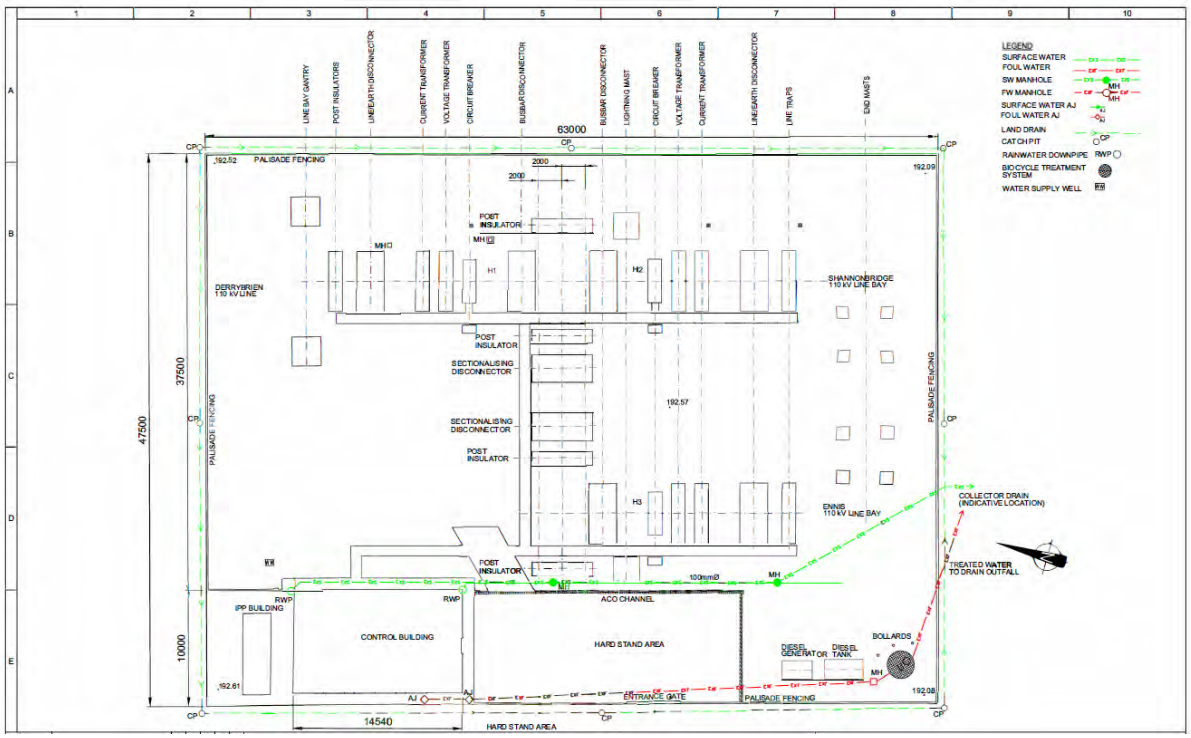


Figure 11 Agannygal Substation Drainage Infrastructure

Plate 7 Looking north toward Agannygal substation

Plate 8 Channel downstream of Agannygal substation

Impact of Retained Development on flood regime

The decommissioning of Agannygal Substation will involve the removal of the above ground elements of the substation and will entail de-energising of the electrical equipment in site and removal of the control building and equipment. The hardstand area for the substation and control building will be left in place after decommissioning as will the access road to the site. As no elements of the substation are in operation, it can be considered as a Less Vulnerable Development as defined by Table 3.1 of the Planning Guidelines.

It is reasonable to assume that there would be no increase in overall runoff rates associated with the decommissioned substation. Compared to the original Greenfield condition, there will be a small increase in runoff rates arising from the continued presence of hardstanding substation areas and its tarmac access road. Rather than rainfall runoff being dispersed over the area per its Greenfield condition, runoff from around the site is concentrated to a single flow path down a steep gradient to the local road. Based on the gradients on the access road (approximately 10% on average), in an extreme rainfall event flood waters would likely flow south across the road to the adjacent Coillte forestry ditch rather than ponding and blocking local road access.

V. Groundwater Flood Risk

The Ayle River Formation, comprising Devonian mudstones, siltstones and conglomerates, underlies most of the wind farm site. This bedrock formation is predominantly classified by the GSI (www.gsi.ie) as a poor bedrock aquifer (Pl), having bedrock that is generally unproductive except for local zones. This bedrock is a muddy impermeable bedrock that is not very conducive to transmitting and storing groundwater flow. There are no mapped fault lines traversing the site.

The upland areas comprise blanket peat, which underlies all the forestry in the area, with acid brown earths/brown podzolics and peaty gleys acidic underlying most of the agricultural lands farther down the valleys in both the Boleyneendorrish and Owendalulleegh catchments.

There are no mapped karst features associated with these Devonian Old red sandstones and conglomerates. The closest karst features to the Project area according to GSI mapping are a number of springs and depressions associated with the Ballysteen limestone formation near Ballynakill, approximately 5 km to the southeast of the wind farm site at its closest point (Figure 12). These springs are at the source of the Owendalulleegh River where the bedrock is a combination of dark muddy limestone / shale and massive unbedded lime-mudstone.

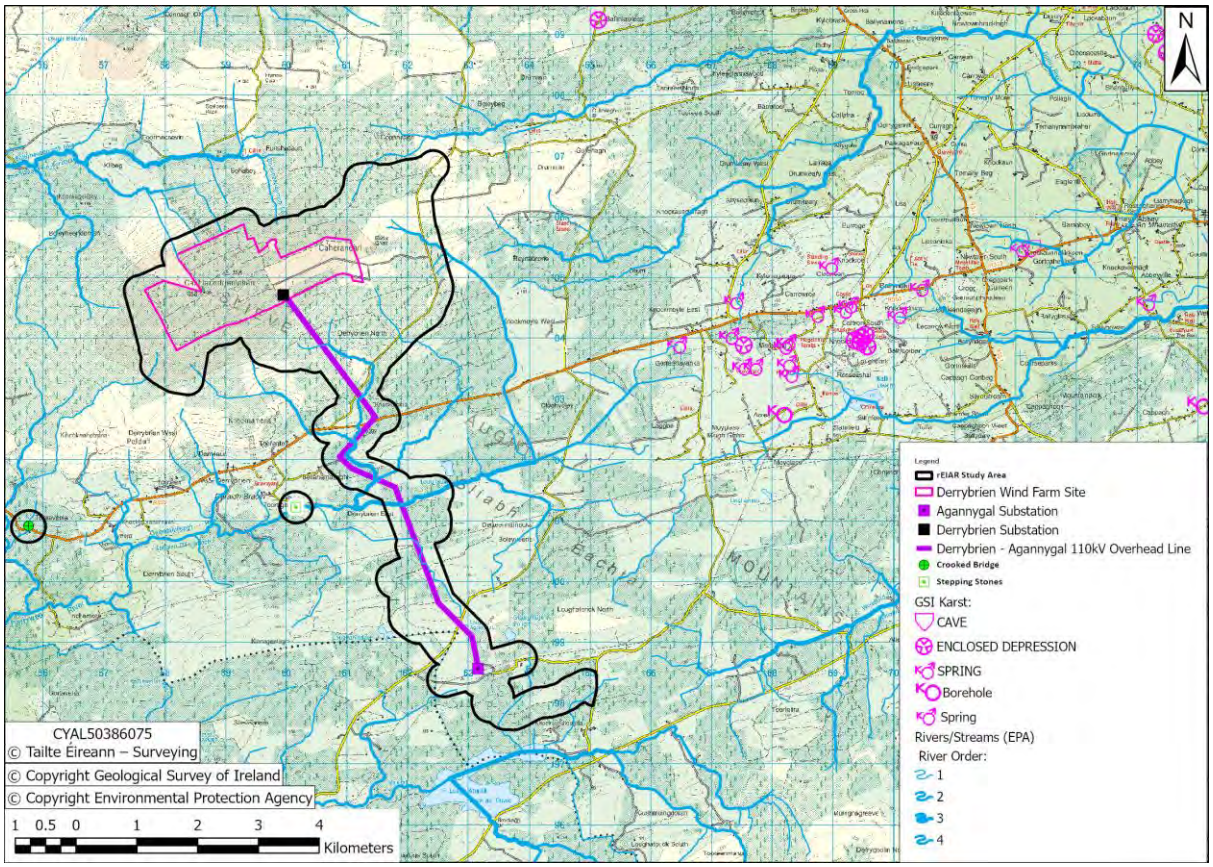


Figure 12 Karst features in relation to Derrybrien Wind Farm Development

Groundwater on the wind farm can reasonably be expected to flow downslope through a network of natural open pipes within the peat as well as possibly through an open joint network in the underlying bedrock, particularly where it is weathered. Several springs have been identified on site in the past, particularly within scarp faces on the northern slopes, although

these are not karst features. Linear tree patterns such as in the south-western corner of the site are possibly indicative of areas where subsurface flow has previously concentrated.

During construction, standpipes were installed by AGL Consulting Ltd. at 6 no. locations along a north-south axis from the centre to the south of the site in the vicinity of the peat slide to get a profile of the depth of groundwater down the slope. The readings that were taken from 17th November to 4th December 2003 indicated that the depth to groundwater ranged from 0.1 m to 1.1 m below ground level (BGL).

In addition to this, 12 no. electronic vibrating-wire piezometers were also installed to the base of the peat layer in clusters of three at 4 No. locations across the site to provide continuous readings of water levels in the peat. At each of these locations, newly constructed drainage could be expected to result in a fall in groundwater levels in the years following their excavation. The piezometers were installed adjacent to turbines T2 and T18 near the western boundary and near T34 in the middle of the former turbary land at the eastern end of the site (Figure 13). Piezometers installed at the northern end of the site at T49 / T50 malfunctioned and provided no useful measurements. The piezometers indicated that the depth to groundwater generally fluctuated between 0.3 and 1.1 mBGL at the end of construction in 2005, which was consistent with the pre-construction site investigation.

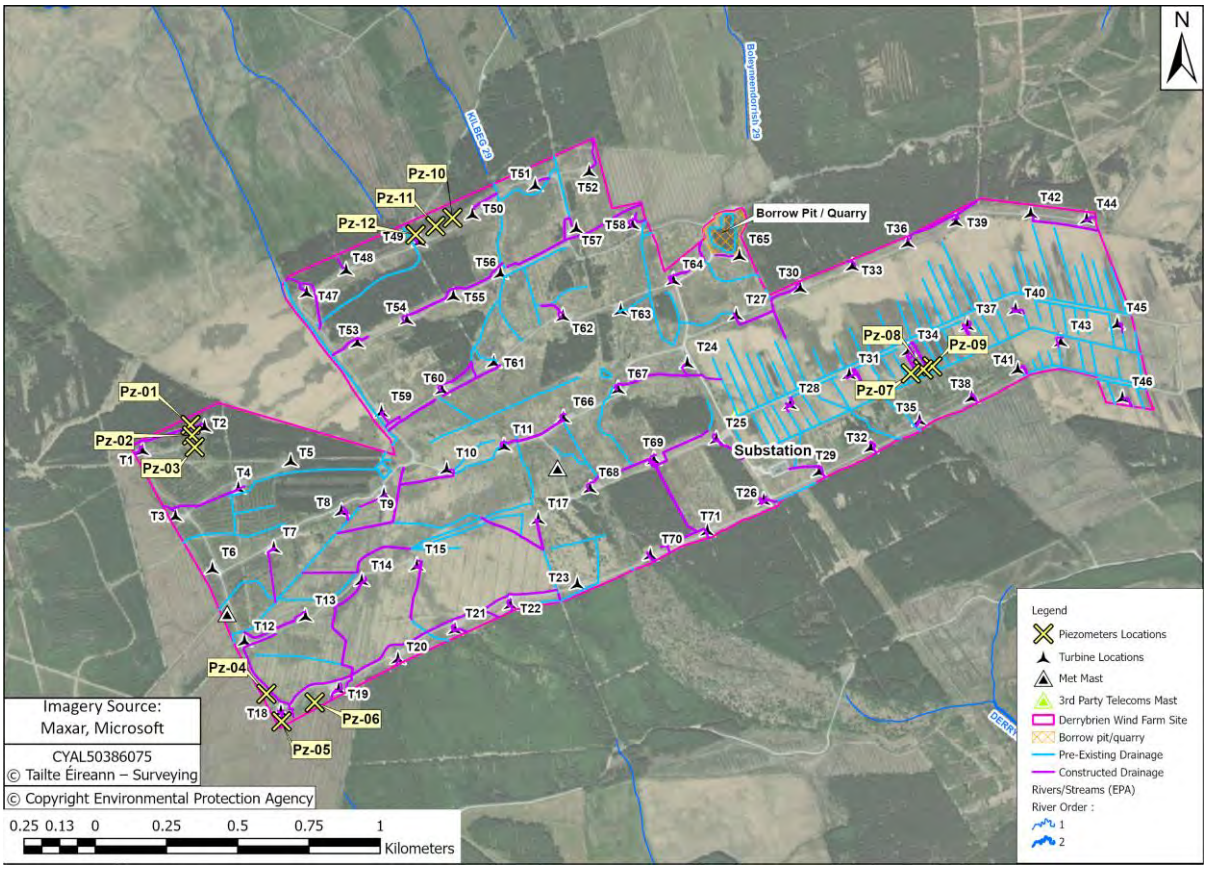


Figure 13 Approximate Location of Piezometers on site 2005-2011

In the years following commissioning, groundwater levels in the peat at these piezometers gradually reduced by between 0.2 and 0.85 m (Figure 14). This gradual reduction is consistent with the very low permeability and correspondingly slow reaction time of groundwater levels

in peat to newly excavated drainage lines. The ultimate reduction in groundwater levels was dependent on the depth to which the channels were excavated and the distance of measuring points from the channels (Table 3). For instance, piezometers 4 – 6 are further away from the nearest excavated drains and therefore have taken longer to reduce towards a final drawdown level. Piezometers 1 – 3, given their relative proximity to newly excavated drainage, should stabilise at no lower than 0.85 mBGL. Given the baseline level in this area was close to the surface it was already close to stabilising by the end of 2011. At T34 the nearby drain was a pre-existing turbary drain which was likely cleaned out and was most likely deepened as part of the wind farm construction, resulting in the drawdown in groundwater levels.

Figure 14 Piezometer Data (2005-2011)

Piezometers / Turbine No.	Piezo Distance from Nearest Drain (m)	Drain depth (m)	Average fall in Groundwater Level 2005-2012 (m)(range)	Years of data
P1 – P3 / T2	4.5	0.85	0.7 (0.6 – 0.8)	Jan-05 to Nov-11
P4 – P6 / T18	13	1.4	0.4 (0.2 – 0.6)	Jan-05 to Nov-11
P7 – P9 / T34	5	1.3	0.6 (0.4 – 0.85)	Jan-05 to Feb-10

Table 3 Summary information of piezometers installed on site between 2005 and 2011

As no further drainage has been installed on site and no measures have been taken to restore the baseline groundwater levels by blocking or infilling drains in the meantime, it is most likely

that groundwater levels across the site have stabilised over the intervening years since 2012. In general, the vast majority of dewatering of the peat took place in the early years following construction, but the degree and rate of change would have varied significantly with the greatest changes most likely taking place in the southwest of the site where most of the new drainage channels were introduced while the relatively undisturbed areas such as the peatland and lake between T62 and T67 in the centre of the site undergoing little evident change and remaining largely intact.

An empirical Sichardt formula can be used to determine the zone of influence of the channel drains cut across the site –

$R_0 = C*(H-h_w)*\sqrt{K}$ where

R_0 = Zone of influence (m)

C = 3000 (constant)

K = hydraulic conductivity in peat (m/s)

$H-h_w$ = drawdown (m). Calculated using drainage channel depth below ground level and highest water level in channel.

Assuming $K = 10^{-6}$ and $H-h_w = 0.6$ m (on average), therefore $R_0 = 1.8$ m.

Given 12 km of drains were excavated for the wind farm and drawdown occurs 1.8m either side of drains, this suggests 0.043 km^2 of the site was subject to drawdown in the long-term from their installation. Given these drains were situated across 3.4 km^2, this suggest 1.3% of the overall wind farm area was subject to drawdown from the installation of new drainage as a result of the wind farm construction while the remainder saw groundwater levels unchanged.

The fall in groundwater levels was consistent and gradual at a rate of approximately 0.1 m/year (or 0.03 l/s per ha) across the site and would not have any significant impact on the downstream environment with respect to flood risk, given that falls in groundwater level are not correlated with periods of high surface water runoff. There is no reason to believe that since the development of the wind farm the groundwater flood risk to the wind farm site has increased given the general reduction in groundwater levels and the nature of the bedrock and quaternary geology and the topography of the site. In the long-term following decommissioning, with drains no longer maintained, locally the groundwater table will if anything increase very slowly but these local rises close to drains will not result in an increase in groundwater flooding on or off the site.

Derrybrien 110 kV Substation

The substation is located within the wind farm site. As discussed above there is no reason to believe groundwater poses a particular flood risk to the substation area.

Agannygal Substation

As with the wind farm development site, the Ayle River Formation comprising a muddy impermeable bedrock underlies the substation site. As with the wind farm, no mapped fault lines traverse the site. The GSI groundwater vulnerability rating of the underlying aquifer is classified as High suggesting that the total thickness of the soil is 3 – 5 m in this area. There

are no mapped karst features and no mapped groundwater sources within the vicinity of the site. There is no reason to believe groundwater poses a flood risk to the site.

VI. Impact of Retained Development on Baseline Flood Regime in Downstream Watercourses

A flood risk assessment needs not only to assess the risk to a development from flooding but also the flooding impact potential or otherwise from a development to other lands and the public.

None of the streams draining from the wind farm site are gauged due to their very small size and low importance. The nearest hydrometric gauging station (measuring flow / water level) is located on the Owendalulleegh approximately 15 km downstream at Killafeen, 1 km upstream of Lough Cutra, station no. 29023. Therefore, the calculated discharge to the major rivers from each subcatchment for a mean annual flood (commonly denoted QBAR) requires use of a flood estimation method based on catchment characteristics that is not calibrated against site specific observed data.

A range of methods of estimating runoff rates – both runoff type and flow frequency methods – have been reviewed previously by Cawley & Cunnane (2003). The rainfall runoff methods reviewed include the rational method (considered most appropriate for very small catchments), the FSR unit hydrograph design rainstorm method and the Ministry of Forestry and Food (MAFF) method, while the flow frequency methods include those described in the FSR, Flood Studies Supplementary Report (FSSR 6), Institute of Hydrology (IH) 124, Flood Estimation Handbook (FEH) and Flood Studies Update (FSU).

It is recommended by Transport Infrastructure Ireland (TII, 2019) to use one of two methods depending on the size of the catchments in question:

a) The IH124 Method for catchments > 0.4 km^2; and

b) The Agricultural Development and Advisory Service (ADAS) Method for catchments ≤ 0.4km^2.

Given the area of the respective subcatchments at the point at which they join the rivers offsite – Boleyneendorrish, Owendalulleegh and Duniry – the IH124 Method was selected to estimate the average annual flow.

The IH124 Method (Marshall & Bayliss, 1994) is dedicated to the hydrology catchments less than 25 km^2. A regression equation was produced to calculate QBAR in m^3/s:

$$Q_{BAR} = 0.00108 AREA^{0.89} SAAR^{1.17} SOIL^{2.17}$$

The catchment descriptors adopted to calculate QBAR using the IH124 Method are summarised in Table 4.

Subcatchments	SC1	SC2	SC3	SC4	SC5	SC6	SC7	SC7(a)	SC7(b)	SC7(c)	SC8	SC9
Area (AREA) km²	6.44	3.17	0.96	1.74	2.22	5.14	13.04	5.87	3.02	3.55	2.81	6.48
Annual Average Rainfall (SAAR) mm	1284	1269	1275	1275	1285	1308	1305	1308	1308	1297	1285	1274
Soil Index (SOIL)	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Area within Site km²	0.31	0.525	0.223	0.09	0.013	0.059	2.126	0.23	1.11	0.786	0.044	0.05

Table 4 Areas for each of the subcatchments draining from wind farm site

The FSU methodologies (for catchment less than 25 km^2) are recommended by the OPW as being the preferred method for extreme rainfall and flood estimation in Ireland and has become the accepted norm for application on rivers and streams that are ungauged. The FSU model estimates QMED (the median annual flood, usually the bank-full condition) at ungauged sites using the following seven variable equation:

$$QMED_{rural} = 1.237 \times 10^{-5} AREA^{0.937} BFISOIL^{-0.922} SAAR^{1.306} FARL^{2.217} DRAIND^{0.341} S1085^{0.185}(1+ARTDRAIN2)^{0.408}$$

QMED (m^3/s) is the index flood used in the FSU methodologies. The index flood is a reference flood that can be relatively reliably estimated from gauged data which for FSU methodologies is the median of floods in the annual maximum (A-max) series for a given location. QMED is said to have a return period of two years on the annual maximum scale of frequency. The factorial standard error associated with the FSU method is 1.37 which compares favourably to the IH124 (error = 1.65), FSSR 6 (1.48) and FEH (1.55).

$QMED_{rural}$ is estimated from seven catchment descriptors:

i) AREA = drainage area (km^2)

ii) BFISOIL = catchment soil and geology index

iii) SAAR = average annual rainfall (mm)

iv) FARL = an index of flood attenuation by reservoirs and lakes

v) DRAIND = an index of drainage density

vi) S1085 = the mainstream slope (m/km)

vii) ARTDRAIN2 = length of upstream network included in OPW scheme channels (km).

A data analysis was carried out by the OPW as part of the FSU Work Packages (OPW, 2012) to evaluate a number of flow estimation methods for small catchments. These included the 7-variable FSU equation above and a 3-variable FSU equation. The 7-variable method was judged not to be suitable for catchments at the scale of interest. The 3-variable equation was modified to become a new regression equation called the FSU4.2a equation:

$$QMED_{rural} = 2.0951 \times 10^{-5} AREA^{0.9245} SAAR^{1.2695} BFI^{-0.9030} FARL^{2.3163} S1085^{0.2513}$$

The nearest downstream ungauged catchment nodes on the 'Flood Frequencies' module in the FSU portal were used to estimate the baseline discharge magnitude $QMED_{rural}$.

	FSU ungauged subject site no.	AREA	SAAR	BFI	FARL	S1085	$QMED_{rural}$
SC1	29_390_3	6.44	1274	0.40	1	28.71	5.45
SC2	29_577_4	3.17	1266	0.40	1	38.07	3.02
SC3	29_566_2	0.96	1270	0.45	1	50.00	0.97

	FSU ungauged subject site no.	AREA	SAAR	BFI	FARL	S1085	$QMED_{rural}$
SC4	29_590_2	1.74	1275	0.45	1	73.48	1.85
SC5	25_940_3	2.22	1270	0.45	1	36.02	1.93
SC6	29_372_9	5.14	1302	0.44	1	28.95	4.19
SC7	29_327_2	13.04	1308	0.44	1	23.84	9.48
SC7(a)	29_330_6	5.87	1312	0.44	1	27.40	4.71
SC7(b)	29_278_6	3.02	1309	0.44	1	43.87	2.86
SC7(c)	29_322_5	3.55	1300	0.44	1	52.76	3.45
SC8	29_179_2	2.81	1290	0.41	1	78.21	3.24
SC9	29_292_5	6.48	1277	0.41	1	79.67	6.95

Table 5 $QMED_{rural}$ calculated using FSU4.2a equation

The $QMED_{rural}$ value must be adjusted by using data from a similar gauged catchment – a Pivotal Site. This can be either the nearest downstream or upstream gauge on the same river, the nearest gauged catchment, selected from the user's knowledge of the subject catchment, or selected on the basis of hydrological similarity using AREA, SAAR and BFI values.

For each of the subcatchments, the gauge downstream on the Owendalulleegh River at the inlet to Lough Cutra (gauge no. 29071) was chosen as the pivotal site.

$$Piv.\ Adjfac = QMED_{gauged} / QMED_{rural}$$

The FSR-based methods such as IH124 calculate QBAR while the Flood Studies Update uses QMED as the index flood. The introduction to the FSR suggests a relationship between QBAR and QMED where:

$$QBAR = 1.07 \times QMED$$

	FSU ungauged subject site no.	FSU $QMED_{rural}$	Piv. Adjfac $QMED_{rural}$	FSU $QMED_{adj}$	FSU $QBAR_{adj}$ (=1.07*QMED)
SC1	29_390_3	5.45	0.83	4.54	4.86
SC2	29_577_4	3.02	0.83	2.51	2.69
SC3	29_566_2	0.97	0.83	0.81	0.86
SC4	29_590_2	1.85	0.83	1.54	1.65
SC5	25_940_3	1.93	0.83	1.61	1.72
SC6	29_372_9	4.19	0.83	3.49	3.73
SC7	29_327_2	9.48	0.83	7.90	8.45
SC7(a)	29_330_6	4.71	0.83	3.93	4.20
SC7(b)	29_278_6	2.86	0.83	2.38	2.55
SC7(c)	29_322_5	3.45	0.83	2.87	3.08
SC8	29_179_2	3.24	0.83	2.70	2.89
SC9	29_292_5	6.95	0.83	5.79	6.20

Table 6 Estimated average annual flows (m^3/s) for each subcatchment using FSU4.2a method

The estimated QBAR figure derived from the FSU methodologies is compared to that calculated using the IH124 method in Table 7. The FSU derived QBAR is generally higher, between 2% and 43% higher; 15% higher on average.

Subcatchment	FSU QBAR (m^3/s)	IH124 QBAR (m^3/s)	Ratio of FSU : IH124
SC1	4.86	4.34	1.12
SC2	2.69	2.28	1.18
SC3	0.86	0.79	1.09
SC4	1.65	1.34	1.23
SC5	1.72	1.69	1.02
SC6	3.73	3.63	1.03
SC7	8.45	8.29	1.02
SC7(a)	3.34	4.09	1.03
SC7(b)	3.54	2.26	1.13
SC7(c)	3.08	2.59	1.19
SC8	2.89	2.08	1.39
SC9	6.20	4.33	1.43

Table 7 Comparison of estimated average annual flows from IH124 and FSU methods for subcatchments connected to wind farm site

For the subcatchments associated with the wind farm the calculated time of concentration ranges from 45 to 160 minutes between the smallest and largest catchments. As such, any flooding effects for the wind farm pre-construction are thought to be brief (i.e. less than a day) at the subcatchment level.

Estimated impacts of hardstanding

The rainfall runoff response of a catchment can be significantly altered by urbanisation where impervious surfaces inhibit infiltration and reduce surface retention, resulting in an increase in surface runoff volume combined with an increase in the rapidity of the response. Each of the subcatchments (SC1 – SC9) draining to the major rivers (Owendalulleegh, Boleyneendorrish and Duniry) has an upstream area that includes part of the wind farm site. Within each respective subcatchment the road and concrete hardstanding areas were measured to estimate the urbanised extent of the subcatchment.

In assessing the effects of urbanisation it is the change in catchment response that is sought, with the rural model, described above, assumed to be capable of predicting this response for the catchments in the FSU dataset. The FSU urban adjustment factor can be used to supplement the performance of the rural model for catchments that have undergone at least partial urbanisation (Murphy, 2009).

The FSU4.2a regression equation adopted above can take into account urban extent with a catchment in the same manner as in the general FSU method, i.e.:

$$QMED = QMED_{adjusted} \times (1+URBEXT)^{1.482}$$

where URBEXT is simply the proportion of the catchment which has been urbanised.

	Roads and Concrete Area (km²)	Subcatchment urbanised (%)	FSU QMED (m^3/s)	FSU QMED with URBEXT factor (m^3/s)
SC1	0.012	0.18%	4.54	4.56
SC2	0.019	0.61%	2.51	2.54
SC3	0.010	1.06%	0.81	0.82
SC4	0.007	0.38%	1.54	1.55
SC5	0.001	0.06%	1.61	1.61
SC6	0.004	0.08%	3.49	3.49
SC7	0.071	0.55%	7.90	7.96
SC7(a)	0.038	0.65%	3.93	3.96
SC7(b)	0.008	0.28%	2.38	2.39
SC7(c)	0.025	0.70%	2.87	2.90
SC8	0.001	0.05%	2.70	2.70
SC9	0.003	0.05%	5.79	5.80

Table 8 Calculated change in QMED for each subcatchment due to addition of wind farm hardstanding areas

The URBEXT factors for each subcatchment are small and have no significant effect on QMED values down to the major rivers (Table 8).

It should be noted that this urban adjustment factor assumes the urbanised areas are impervious surfaces which inhibit infiltration and reduce surface water retention. However, the use of floating road, which accounts for 18.8 km of the 19.7 km of on-site access tracks (the 2.0 km of tracks existing on site prior to the Project was all floating), facilitates rainwater infiltration into the peat layer beneath with additional rainwater which does not infiltrate allowed to spill over the edge into the undisturbed peat. Floating roads are sympathetic to the natural drainage as they do not act as a barrier nor as a deep wide permeable drain that would dewater the adjacent saturated peat into its formation layer and convey elsewhere with the gradient of the road.

Similarly, for Agannygal substation, which lies in the Bleach catchment in the Shannon IRBD, urbanised areas including access track and compound amounted to less than 0.01 km^2, approximately 0.35% of the catchment area down to Lough Atorick (Figure 15).

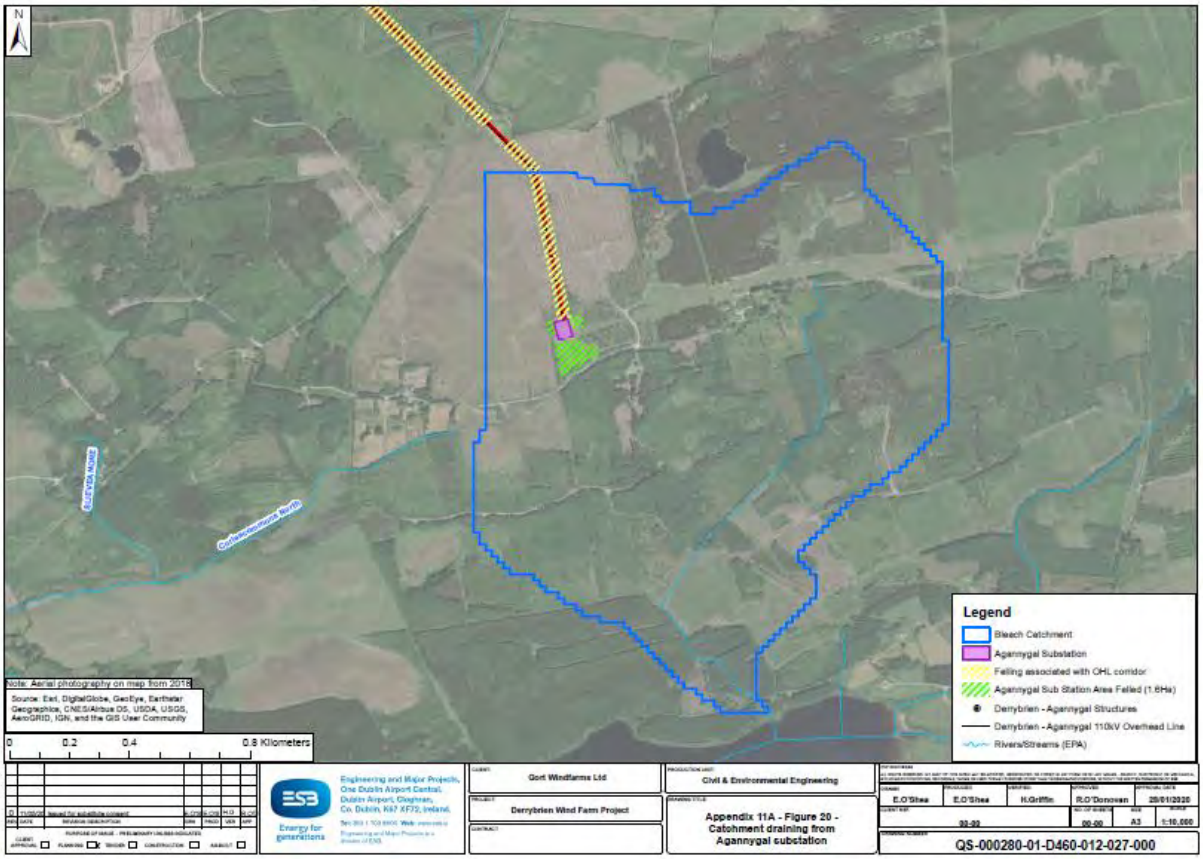


Figure 15 Catchment draining from Agannygal substation

Estimated impacts of constructed drainage

Circa 12 km of drains were constructed as part of the wind farm project on site which effectively maintained overland flow paths which may otherwise have been obstructed by new turbine hardstanding and roads. Culverts were also constructed at various access track crossings so as to maintain the conveyance path of the existing and constructed drains crossed and thus prevent excessive ponding of water on the uphill sides of these roads. The culverts installed were necessary to maintain the drainage runs and avoid unnecessary diversion of drainage on the site. This increased the overall length of the drainage network in a given subcatchment.

The natural runoff characteristics of this upland site prior to the project would be classified as a high flood runoff site (SOIL index 0.45). The effect of the new drainage runs and deepening of existing drains, as a worst-case assessment, is to increase the runoff class of the wind farm site from high runoff to very high runoff (0.05). This effect increases the peak flood rate as opposed to the total flood volume which will remain similar.

The impact of this on QMED is to increase it compared to pre-project value by 0 – 9% depending on the fraction of each subcatchment within the wind farm site boundary. Similarly, by reducing the BFI value in the FSU equation by a similar factor (0.07) the expected QMED is increased in proportion with the share of each subcatchment belonging within the wind farm.

	Pre-existing QBAR (m^3/s)	Increased QBAR (m^3/s)	Change (m^3/s)	Change (%)
SC1	4.34	4.39	0.05	1.2%
SC2	2.28	2.37	0.09	4.0%
SC3	0.79	0.84	0.05	5.7%
SC4	1.34	1.36	0.02	1.3%
SC5	1.69	1.69	0.00	0.1%
SC6	3.63	3.64	0.01	0.3%
SC7	8.29	8.62	0.33	4.0%
SC7(a)	4.09	4.13	0.04	0.9%
SC7(b)	2.26	2.47	0.21	9.1%
SC7(c)	2.59	2.73	0.14	5.4%
SC8	2.08	2.09	0.01	0.4%
SC9	4.33	4.34	0.01	0.2%

Table 9 Changes in IH124-calculated QBAR due to constructed drainage

	Pre-existing QMED (m^3/s)	FSU QMED with reduced BFI (m^3/s)	FSU QMED with URBEXT factor (m^3/s)	Change (m^3/s)	Change (%)
SC1	4.54	4.58	4.59	0.05	1.0%
SC2	2.51	2.58	2.60	0.09	3.6%
SC3	0.81	0.83	0.85	0.04	5.0%
SC4	1.54	1.56	1.56	0.02	1.3%
SC5	1.61	1.61	1.61	0.00	0.2%
SC6	3.49	3.49	3.50	0.01	0.3%
SC7	7.90	8.09	8.15	0.26	3.2%
SC7(a)	3.93	3.95	3.99	0.06	1.5%
SC7(b)	2.38	2.52	2.53	0.14	6.0%
SC7(c)	2.87	2.97	3.00	0.13	4.4%
SC8	2.70	2.70	2.71	0.01	0.3%
SC9	5.79	5.80	5.80	0.01	0.2%

Table 10 Changes in FSU-calculated QMED due to urbanisation and constructed drainage

Estimated impacts of tree felling

Prior to the development of the wind farm, the site was a combination of turbary and Coillte forestry lands. The total area of forestry present on site following completion of the Project within the site boundary was 0.41 km^2 in 2009. This compares to 2.63 km^2 of forestry present on site in 2000, prior to construction. Therefore, the total area of forestry removed on site from 2000 onward to the end of construction was 2.22 km^2 (Figure 16). Table 11 summaries the area of trees removed in each subcatchment draining to the major rivers downstream off-site.

Sub-catchment	Area (km^2)	On-Site Area (km^2)	Area felled on-site (km^2)	Area felled on OHL route (km^2)	Felled as a % of subcatchment area
SC1	6.44	0.31	0.18	0	2.86%
SC2	3.17	0.53	0.37	0	11.61%
SC3	0.96	0.22	0.20	0	20.73%
SC4	1.74	0.09	0.09	0	5.06%
SC5	2.22	0.01	0.01	0	0.41%

Sub-catchment	Area (km^2)	On-Site Area (km^2)	Area felled on-site (km^2)	Area felled on OHL route (km^2)	Felled as a % of subcatchment area
SC6	5.14	0.06	0.02	0	0.33%
SC7	13.04	2.13	1.26	1	9.68%
SC7(a)	5.87	1.11	0.34	0	5.79%
SC7(b)	3.02	0.23	0.18	0.08	8.61%
SC7(c)	3.60	0.79	0.75	0	21.04%
SC7(d)	0.61	0	0	0.02	2.9%
SC8	2.81	0.04	0.04	0	1.56%
SC9	6.48	0.05	0.05	0	0.71%
Agannygal	2.00	0	0	0.04	2%

Table 11 Areas felled in subcatchments on wind farm site between 2000 and 2009

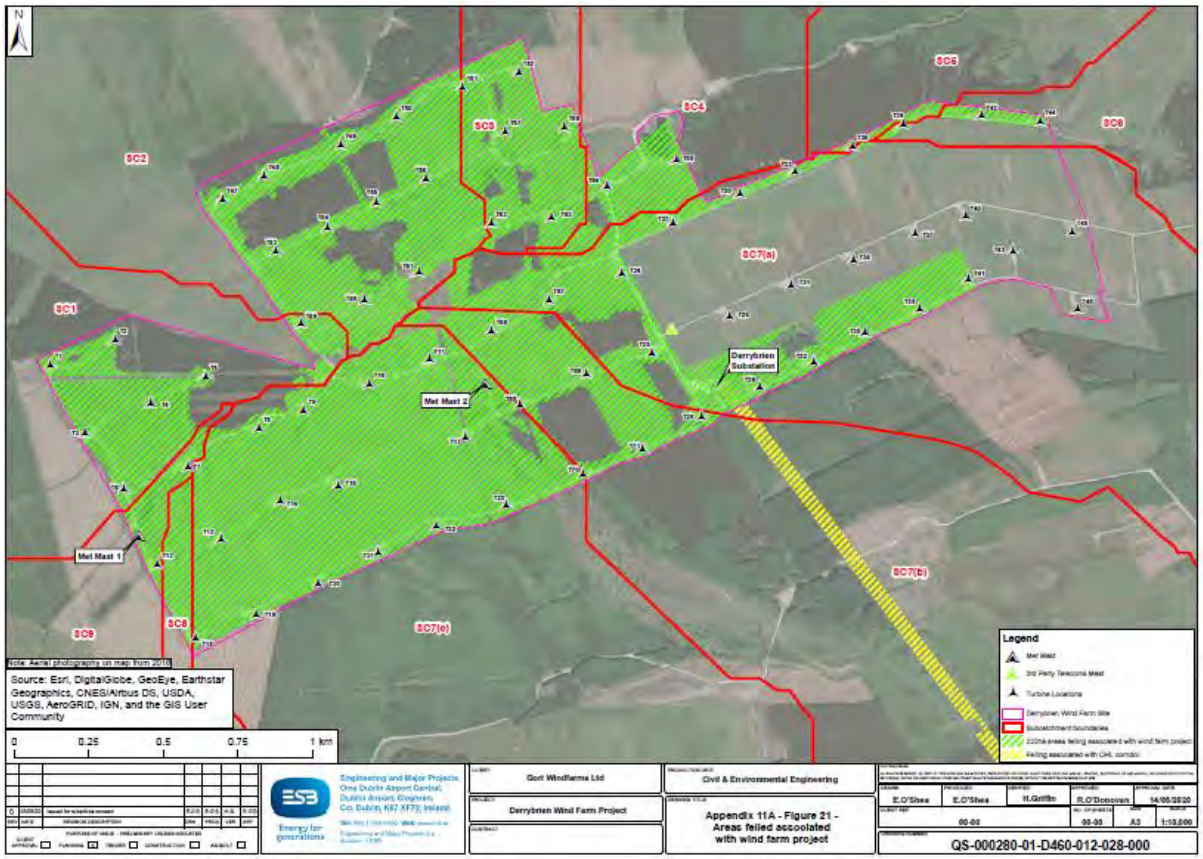


Figure 16 Areas felled associated with wind farm project

The subcatchment which underwent the greatest amount of felling during wind farm construction was SC7 where 1.28 km^2 of forestry was felled on site, representing just under 10% of the total catchment area to the Owendalulleegh River and almost 60% of the subcatchment within the site boundary. In addition to this, 0.25 km^2 of forestry was removed by the landslide offsite in October 2003. However, unlike the forestry removed on the wind farm site, this area has since been gradually replaced by natural re-growth of forestry.

Unlike urbanisation, there is no well-established recommended approach to quantitatively assess the impacts of felling on downstream flow regimes, though there are a number of examples in the literature of peer-reviewed studies on the subject.

Through uptake of soil moisture from roots, evapo-transpiration and interception of rainfall, trees can reduce the soil moisture levels in the ground. In peatland areas, where groundwater would generally be considered as close to the ground surface, some depression of groundwater levels may be expected in areas under tree cover. Following tree removal, re-establishment of groundwater levels to post-tree planting levels would be expected with a resultant rise in the local groundwater level. In addition to this, there would be a relative increase in surface water runoff.

Consequently, most peer-reviewed scientific studies have generally found forests to be associated with reducing peak and low flows. However, despite multiple literature reviews investigating links between land use and river flows, the link between forests and river flooding remains conflicted (CEH, 2017). The UK's Centre for Ecology & Hydrology (CEH) report on this matter concluded that for decreasing tree cover, there is a significant difference between categories of influence on flood peak, arising largely as a result of the lack of recorded statements for peak flow increase. However, the number of observation-based statements reporting a flow increase due to decreasing cover was similar to the number reporting no influence, and it was not possible to reach a clear conclusion on this basis. The results for scenarios where there was a decrease in tree cover showed that for small events there was an increase in flood peak while for large events it was seen as having no influence.

Robinson et al. (2003) highlighted coniferous plantations on poorly drained soils in northwest Europe as among the situations where the most marked changes to flows are likely to occur. One particular study site was on an upland blanket bog in Co. Mayo similar to Derrybrien. It was noted that the lack of response to clear felling in some catchments may have been due to the limited change in the interception capacity between the standing forest and that of felled areas covered by large amounts of tree brash. Forest cutting generally leads to short-term increases in both peak flows and baseflows at the local scale, although this may not be detectable at the larger catchment scales. For all the forest types studied the changes to extreme flows will be diluted at the larger basin scale, where forest management is phased across a catchment. Overall, the results from the studies conducted under realistic forest management procedures have shown that the potential for forest clearance to increase peak and low flows is much less than has often been widely claimed.

A European Environment Agency (EEA) technical report on the water retention potential of forests in Europe concluded that in small sub-basins the water retention potential of forests was clear. This may be explained by the fact that the influence of forest cover on the runoff dynamics is easier to delineate and observe at smaller catchment scales. A simple statistical analysis indicated that a 10-15% decline in forest cover can increase the runoff. In general, with all other hydrological factors being equal, a catchment with 30% forest cover has a 25% higher water retention than an equivalent catchment with forest cover of 10%. Water retention is 50% higher in catchments with 70% forest cover than where forest cover is 10%.

The OPW (2015) recommend, as an allowance in assessing flood risk, reduction in the time to peak to allow for potential accelerated runoff that may arise as a result of drainage of

afforested land. For the MRFS and HRFS this amounts to a reduction by one-sixth and one-third respectively in the time to peak. Conversely, it is recommended to increase the runoff rate by a factor of 10% in the HEFS for the temporary period following felling of forestry (note no factor is recommended for the MRFS). This recommended runoff rate factor has been applied for this analysis.

As summarised in Table 11 the greatest changes in forest cover in any of the subcatchments encompassing Derrybrien wind farm were 21% reductions in SC3 and SC7(c). In subcatchments SC2 and SC7 there was a 1.26 km^2 reduction in forest cover due to on-site felling activities, amounting to just under 10% of the subcatchment to its confluence with the Owendalulleegh River. In all the other subcatchments less than 0.4 km^2 of forestry was felled. Considering increased hardstanding, additional drainage and forestry felling in combination the most affected subcatchment draining to a major river with respect to hydrology is SC7. According to the IH124 method (the more conservative estimate) there is a 4% increase in the mean annual maximum flow (QBAR). The 10% reduction in forestry conservatively is assumed to result in a 1% increase in runoff rates.

Combined, the Project has resulted in a 0.27 m^3/s increase in mean annual flood flow rates to the Boleyneendorrish compared to pre-Project flow rates. Note that if pre- and post-Project flow rates are scaled up to more extreme flow rates, the percentage increase in flow rates due to the Project will be the same. In the Owendalulleegh, the Project has resulted in at most a 0.47 m^3/s increase in mean annual flood flow to the Owendalulleegh (Table 12).

Sub-catchment	Felled as a % of subcatchment area	Approx. change in flow rate due to felling %	Change in flow rate due to drainage (IH124, %)	Change in QBAR due to felling and drainage (%)	Change in QBAR due to felling and drainage (m^3/s)
SC1	2.86%	0.3%	1.2%	1.5%	0.06
SC2	11.43%	1.1%	4.0%	5.2%	0.12
SC3	20.94%	2.1%	5.7%	7.8%	0.06
SC4	5.07%	0.5%	1.3%	1.8%	0.02
Boleyneendorrish					0.27
SC5	0.58%	0.1%	0.1%	0.2%	0.00
Duniry					0.00
SC6	0.36%	0.0%	0.3%	0.3%	0.01
SC7	13.11%*	1.3%	4.0%	5.3%	0.44
SC7(a)	6.30%	0.6%	0.9%	1.6%	0.06
SC7(b)	9.93%	1.0%	9.1%	10.1%	0.23
SC7(c)	21.05%	2.1%	5.4%	7.5%	0.19
SC8	1.56%	0.2%	0.4%	0.5%	0.01
SC9	0.71%	0.1%	0.2%	0.3%	0.01
Owendalulleegh					0.47

Table 12 Summary of calculated change in QBAR due to wind farm Project

***includes offsite forestry lost in landslide scar and on OHL Route**

It should be noted that the time to peak in each of these subcatchments will vary depending on their individual physical characteristics. As well as this, the time at which the peak of each

of these flows arrive at the same points of the main Owendalulleegh and Boleyneendorrish Rivers respectively will vary such that flood hydrographs will overlap at different points in time. The larger river catchments will thus have a longer time to peak (of the order of 6 to 12 hours) and effectively the increased QBAR figure will be attenuated rather than simply superpositioned. As such, summing the changes in QBAR as per Table 12 is a very conservative approach when looking at the broader scale impact of the wind farm Project.

Considering the Boleyneendorrish catchment in isolation, the total catchment to where the relevant wind farm subcatchments (SC1 to SC4) meet this river is 20.4 km^2 (Figure 17) (EPA Ref: 29_595_1). The total area felled within this for the wind farm Project was 0.84 km^2. This represents 4% of the catchment area at this location. The FSU-calculated QMED at this point of the river system is 10 m^3/s (corresponding to a QBAR of 10.7 m^3/s) while the IH124-calculated QBAR is 11.8 m^3/s. As such, by the most conservative estimate, the Project has resulted, in the most conservative analysis, in a 2.5% increase in the peak mean annual flow rates at this scale.

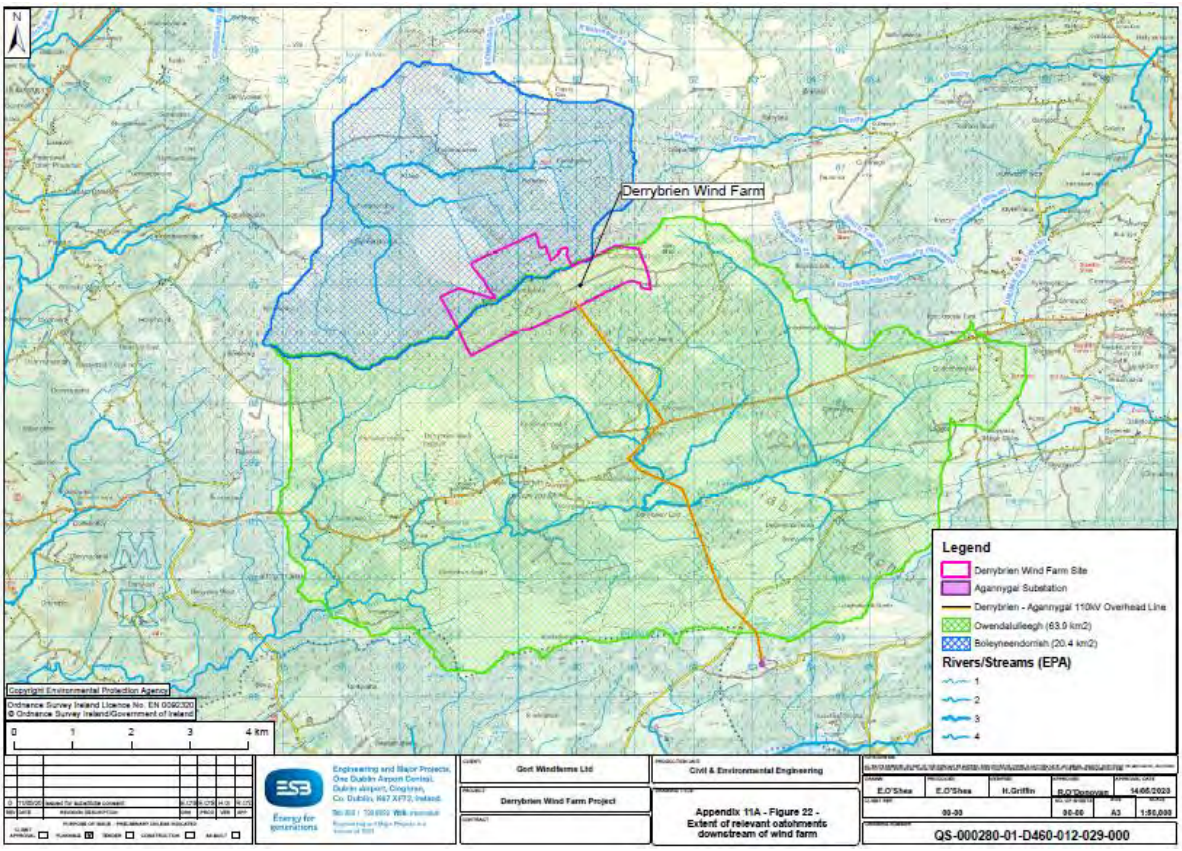


Figure 17 Extent of relevant catchments downstream of wind farm

At a broader scale, the areas that have been identified as having a recorded history of flooding downstream (**Error! Reference source not found.**) lie to the west of the N66 national road 2 km downstream of where the Ballycahalan (formerly Boleyneendorrish) River meets the Streamstown River (EPA Ref: 29_190_4). The catchment area to this point is 62.8 km^2 (Figure 18). This area was identified by the OPW as being prone to turlough/groundwater flooding on an annual basis (ESBI, 2005). The felled area associated with the wind farm Project to this point in the catchment amounts to 1.3% of the total area. This represents 4% of the catchment area at this location. The FSU-calculated QMED at this point of the river system is 17 m^3/s

(corresponding to a QBAR of 18.2 m^3/s) while the IH124-calculated QBAR is much higher. As such, by the most conservative estimate, the Project has resulted in a 1.5% increase in the peak mean annual flow rates at this scale. As such changes in flood peaks emanating from the wind farm Project can reasonably be expected to dissipate and not have any significant impact at larger catchment scales.

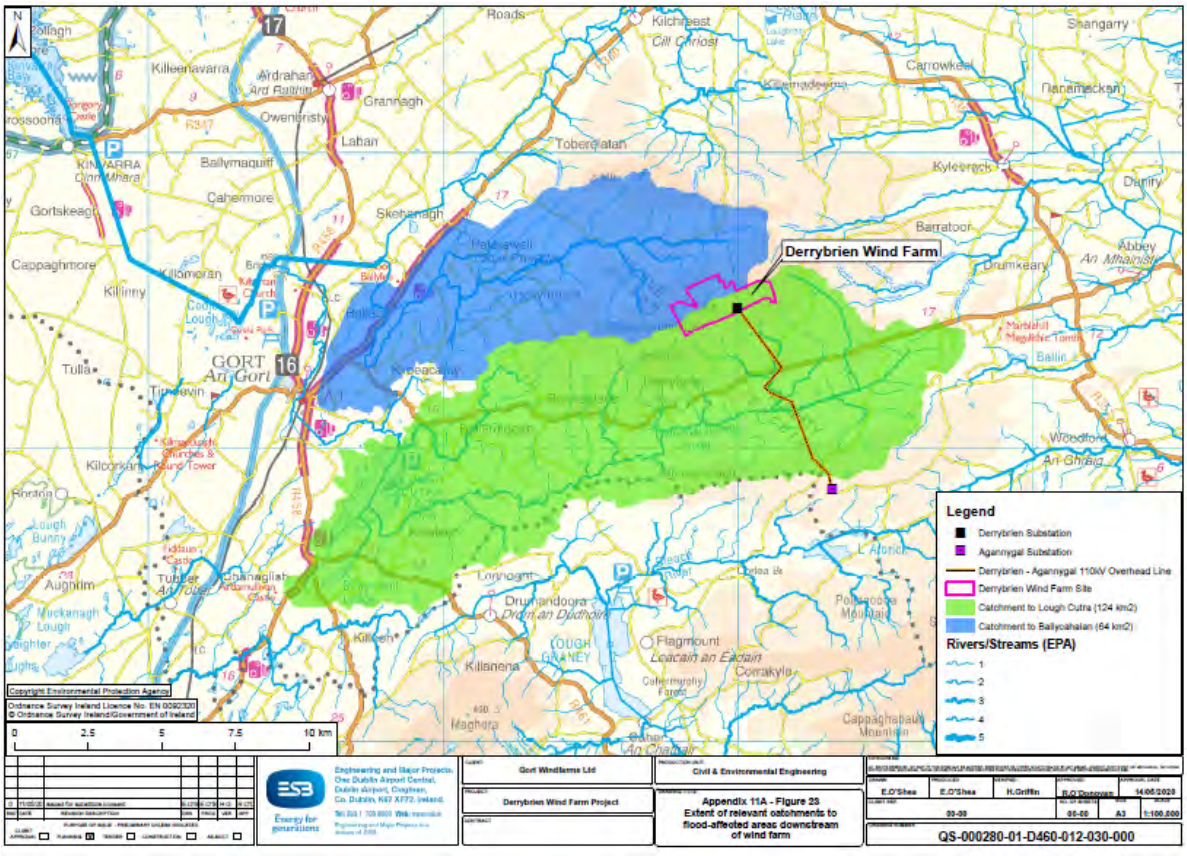


Figure 18 Extent of relevant catchments to flood-affected areas downstream of wind farm

Considering the Owendalulleegh catchment in isolation, the total catchment to where all the wind farm subcatchments (SC6 to SC9) meet this river is 64 km^2 (Figure 17) (EPA Ref: 29_136_2). The total area felled within this for the wind farm site was 1.37 km^2. Including the felled trees associated with the 2003 peat slide (0.25 km^2) and the construction of the OHL (0.31 km^2) in the catchment, this area increases to a total of 1.93 km^2. This represents 3% of the catchment area at this location. The FSU-calculated QMED at this point of the river system is 24 m^3/s (corresponding to a QBAR of 25.7 m^3/s) while the IH124-calculated QBAR is 34 m^3/s. As such, by the most conservative estimate, the Project has resulted, in the most conservative analysis, a 1.8% increase in the peak mean annual flow rates at this scale.

At a broader scale, the areas identified as having a recorded history of flooding downstream (**Error! Reference source not found.**) lie downstream of Lough Cutra on the Beagh River between Beagh and Gort (EPA Ref: 29_187_1). The catchment area to the outlet point of Lough Cutra totals 124 km^2 (Figure 18). The felled area associated with the wind farm site to this point in the catchment amounts to 1.6% of the total area. The FSU-calculated QMED at this point of the river system is 18.2 m^3/s (corresponding to a QBAR of 19.5 m^3/s) while the

IH124-calculated QBAR is higher. As such, by the most conservative estimate, the Project has resulted in a 2.4% increase in the peak mean annual flow rates at this scale. Note that Lough Cutra effectively attenuates flood peaks such that the predicted mean annual peak upstream of the lake is higher than it is downstream, despite it containing a smaller catchment. As with the Boleyneendorrish, any increased impact on downstream flood peaks from the wind farm Project can reasonably be expected to dissipate and not have any significant impact at larger catchment scales.

It follows that the scale of the impact from the wind farm project in relation to the catchment to Kiltartan (302 km^2) where the two river catchments meet is small with felling accounting for less than 1% of the overall catchment area. For longer duration winter events of a number of days, the effect of the wind farm construction on peak runoff rates will be significantly curtailed and will be imperceptible downstream in the flood prone areas at Coole and Kiltartan which are more susceptible to longer duration flood events. This is discussed in more detail in Appendix 9-2.

Agannygal substation and a short southern section of the OHL corridor lies upstream of the Bleach River in a separate catchment to the remainder of the Project area (Figure 15). 0.04 km^2 of felling took place in this catchment to enable the construction. The size of the catchment from this site draining to Lough Atorick to the south is just under 2 km^2. As such 2% of this catchment area was felled to enable the construction. All land downgradient to the south of the station access track is in Coillte ownership. As such there are no properties downstream within this area that could be adversely affected by the increased runoff rates associated with this change. It can therefore be concluded that the impact of the substation on the downstream flood regime is imperceptible.

VII. Loss of Floodplain

No element of the Retained Development is located within a fluvial floodplain.

VIII. Conclusions

It is concluded that there will be no perceptible change in the risk of flooding arising from the Retained Development given the size of the local downstream population and the proportion that could be affected in a flood event. On the broader regional scale, any changes in flood risk is deemed imperceptible given the broader extent of the Boleyneendorrish and Owendalulleegh catchments.

It can be concluded that all Retained Development areas are not within floodplains and lie within Flood Zone C (Low risk of flooding) as defined by the guidance document to Planning Authorities in relation to Flood Risk Management. Furthermore, the existing flood risk in the downstream catchment has not to date and is not expected to be increased by any proposed decommissioning works at the wind farm.

The Retained Development as a whole is therefore considered to be in overall compliance with the objectives of the Planning and Flood Risk Management Guidelines. The Project therefore has not and is not anticipated to give rise to any significant impacts related to flood risk within or downstream of the Project areas.

This flood risk assessment meets the requirements of the planning guidelines in respect to a site-specific FRA as the entire proposed retained development falls under the category of less vulnerable type development and therefore suitable in Flood Zone B and C. The proposed decommissioned site will not impede access to watercourses nor does the project result in an increase in flood risk to third party lands locally or downstream.

IX. References

Bransby Williams, G. (1922). Flood discharge and the dimensions of spillways in India. The Engineer (London) 121: 321-322.

Cawley A.M. and Cunnane C., (2003) Comment on estimation of Greenfield runoff rates. Proceedings of UNESCO International Hydrological Programme, OPW.

Chow V.T., (1959) Open channel hydraulics, McGraw Hill, New York.

DECCAE (2019) Electricity & Gas Networks Sector Climate Change Adaptation Plan - Prepared under the National Adaptation Framework. Department of Communications, Climate Action and Environment. Government of Ireland.

DEFRA (2008). Flood and Coastal Defence Project Appraisal Guidance. Supplementary Note to Operating Authorities. Assessing and Valuing the Risk to Life from Flooding for Use in Appraisal of Risk Management Measures. Department of Environment, Food and Rural Affairs.

ESBI (2005). OPW Flood Hazard Mapping – Phase 1. Meeting with Electoral Engineer for Loughrea. 10th May 2005.

Fitzgerald, D.L. (2007) Estimates of Point Rainfall Frequencies, Technical Note No. 61, Met Éireann, Dublin.

Flood Studies Report (FSR) (1975). National Environment Research Council.

French, R., Pilgrim, D. H. And Laurenson, E. M. (1974) Experimental examination of the rational method for small rural catchments. Civil Engineering Transactions CE16: 95-102.

NERC (1975). Flood Studies Report (5 volumes). National Environmental Research Council (Institute of Hydrology).

OPW (2009). The Planning System and Flood Risk Management – Guidelines for Planning Authorities. November 2009.

OPW (2019). Climate Change Sectoral Adaptation Plan. Flood Risk Management. FRAM Section, Office of Public Works. September 2019.

TII (2019). Drainage of Runoff from Natural Catchments. Volume 4 Section 2 Part 1. NRA HD 106/15. March 2015.

APPENDIX 9-2

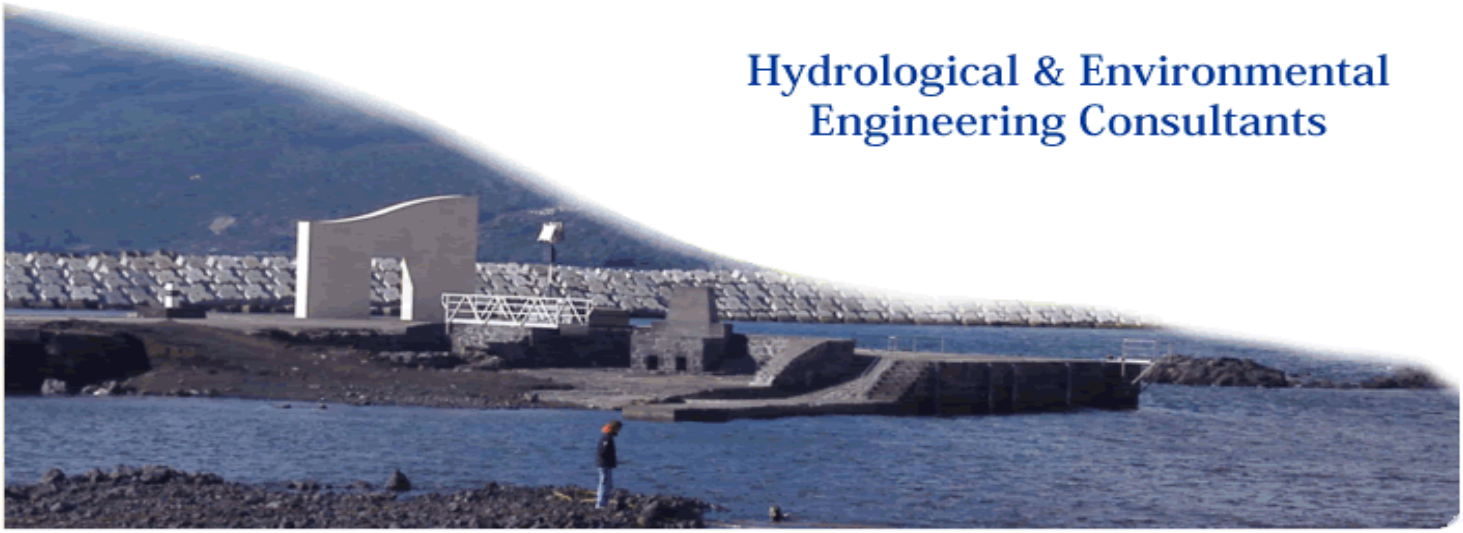
FLOOD REVIEW OF GORT LOWLANDS

Flooding Assessment of the Derrybrien Wind Farm Decommissioning Project on Downstream Flooding in the Gort Lowlands

On behalf of

ESB

December 2024



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Flooding Assessment of the Derrybrien Wind Farm Decommissioning Project on Downstream Flooding in the Gort Lowlands

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1. Introduction

The scope of this report is to examine the downstream flooding of the Derrybrien Wind Farm Site, particularly in the Cutra and Gort lowlands area and the potential effect that the proposed decommissioning of the Derrybrien Wind Farm development, comprising decommissioning of the wind farm site, the overhead line and the Agannygal substation has on downstream flooding.

The Derrybrien Wind Farm site is located on the upper slopes of the Cashlaundrumlahan Mountain in Slieve Aughty mountain range in south County Galway. The total area of the Derrybrien Wind Farm site measures 3.44 km^2 (344 ha). The site and its drainage is located principally within two river systems – the Boleyneendorrish and Owendalulleegh catchments – which drain into the Gort Lowlands area and eventually by groundwater karst conduit flow, out to sea at Kinvarra (Hydrometric Area 29). A very small area of the Derrybrien site (< 1%), at the northeast corner of the site, drains eastward to the Duniry River, a tributary of the Kilcrow River in the Shannon catchment (Hydrometric area 25), which discharges into upper Lough Derg to the west of Portumna. Approximately 66% of the site drains through surface drains SSW to the Owendalulleegh River (flows into Lough Cutra) and 33% of the site drains NNW into the Boleyneendorrish (Ballycahalan R.) River. This represents drainage areas of 2.3 km^2 and 1.1 km^2 in the Owendalulleegh and Boleyneendorrish river catchments respectively. These rivers discharge into the Gort lowlands area, which is prone to turlough flooding at times of prolonged heavy winter rainfall. The flooding lasts over a period of many weeks. In addition to the wind farm site, the study area also comprises the corridor of the 7.7 km overhead line running southward from the wind farm site and the grid connection substation at Agannygal. The corridor is situated in two separate catchments, i.e., structure 1-39 in the Owendalulleegh catchment and 40-42 in the Bleach River catchment. The Agannygal Substation Site is located within the Bleach River Catchment. The Bleach River is a tributary of the Graney River and Lough Graney that discharges into Lough Derg near the village of Scarrif and is part of the Lower Shannon River System (Hydrometric Area 25).

2. Decommissioning Works

The demolition phase activities associated with the subject development are limited to the decommissioning of the 70-turbine wind farm and a grid connection, comprising c. 7.8km 110kV overhead line (OHL) connecting into the Ennis-Shannonbridge 110kV line, together with Derrybrien and Agannygal substations. Decommissioning will entail dismantling of all turbines (blades, hub, nacelle and towers) and electrical disconnection. The reinforced concrete turbine basses shall remain in place as well as the crane hardstand areas and the internal access roads. The OHL poles and mast elements will be removed from the corridor running between Derrybrien and Agannygal substation.

The high voltage equipment, the substation, and control building will be dismantled, and all such equipment removed from the site. All hardstanding areas for the substation, the turbine crane hardstanding and internal roads will be left in place after decommissioning.

The drainage system and much of the buried electrical cabling between the turbines bases and the Derrybrien Substation at the wind farm site will be left in place. The drainage system at decommissioning will be maintained and thereafter will not be maintained, so that over time these drains will naturally infill and become more vegetated and gradually less effective in respect to water table lowering. Similarly the pipe culverts under the access tracks will remain. Over time the drainage performance at the wind farm site is expected to gradually reduce resulting in slightly lower peak runoff rates and slightly higher groundwater levels on the site.

The 4 no. rock barrages that were constructed as emergency works during the peat slippage in 2003 to stabilise the area and protect downstream lands and receiving watercourses are to be left in place as their retention does not result in any significant residual negative impact on the environment, whereas their removal could result in significant impact in respect to land disturbance and the potential for sediment and peat runoff into the downstream watercourses. The upper Barrages no's 1 and 2 are considered important for peat stability along this slip pathway.

3. Regional Hydrology

3.1 General Description

The basin area lying between the Dunkellin catchment to the north and the River Fergus Catchment to the south is referred to as the Gort Lowlands catchment. There is no direct river outlet to the sea and drainage from the 500km^2 catchment area discharges in underground conduits and caverns within the karst limestone bedrock to Galway Bay. The long-term annual average rainfall for the Gort Lowlands Catchment is measured to be 1140 mm (from the most recent Met Eireann (2020) Standard Annualised Average Rainfall (SAAR) map). The expected annual average groundwater flow rate discharging to the sea from this catchment is approximately 10 m^3/s based on an annual average evapotranspiration rate of 510 mm giving an effective rainfall (recharge) of 630 mm per annum. The median annual maximum flow rate from this catchment is likely to be c. 50 m^3/s and the 100-year flow based on a national flood growth curve factor of 2 is of the order of 100 m^3/s. These are substantial flow rates for karst groundwater flow and result in substantial turlough flooding with overland flow cascading from one turlough to another.

The total drainage catchment to Kinvara sea outlets can be split between the impermeable catchment area to the east (including the Slieve Aughties to the south of Loughrea), of some 240 km^2 in area that is underlain by muddy limestones, old sandstones, shales, mudstone and siltstone conglomerates and having generally low groundwater recharge rates and conversely naturally high surface runoff coefficients. The catchment area to the west is underlaid by permeable pure limestones having an area of a further 260 km^2 with moderate to high groundwater recharge rates and very low surface runoff rates. What is noticeable between

east and west is the high density of stream and drainage channels in the east with the very sparse surface drainage features in the pure limestones due to the underground network of karst conduits. Higher annual rainfalls occur in the more elevated lands to the east with the highest annual rainfalls occurring in the Slieve Aughty uplands at on average 1430 mm per annum whereas in the lowlands area the annual rainfall is typically 1125 to 1175mm per annum.

3.2 Contributing upland Catchments

Three main upland rivers drain westwards into the Gort Lowlands area off the relatively impervious eastern section of the catchment which includes the Slieve Aughty uplands. These rivers from south to north are:

- the Owendalulleegh River that inflows to Lough Cutra and on to Gort Town as the Beagh / Cannahowna / Gort Rivers;
- the Boleyneendorrish (Ballycahalan) River to Ballylee; and
- the Owenshree River that discharges into Blackrock Turlough which overflows to Ballylee.

Refer to Figure 1 for the catchment extents of these rivers.

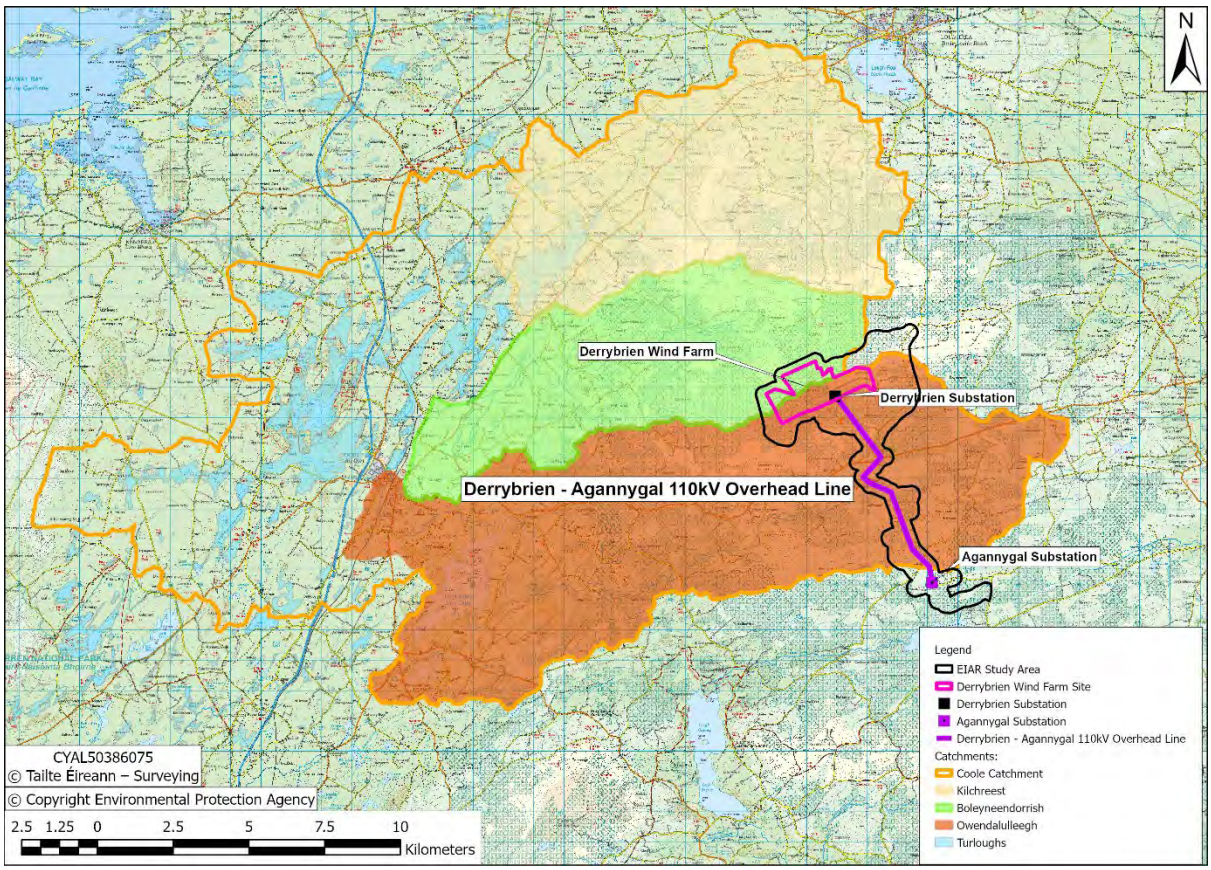


Figure 1 River catchments discharging to the Gort Lowlands

3.2.1 Owendalulleegh Catchment

The Owendalulleegh River rises in the townland of Gorteenayanka and flows westward to Lough Cutra. The catchment area of the Owendalulleegh River to Lough Cutra is 90 km^2 and to the Lough Cutra outflow (Beagh River) is 124 km^2 and to Gort Town (Gort River) is 134.6 km^2. Lough Cutra is a large lake with a permanent surface area of 3.8 km^2 which increases to c. 4.4 km^2 in flood periods. Lough Cutra provides important flood attenuation for the downstream river through Gort Town. Typical lake levels are 32.9 mOD Malin and the typical summer-winter lake level range is 1.2 m (EPA hydronet resource). This lake provides some attenuation to the Owendalulleegh River flood inflow which has a flashy flood hydrograph and to a certain extent protects downstream reaches through Gort Town. The outflow (Beagh River) from Lough Cutra sinks underground at the Punch Bowl, 2 km downstream of the lake and re-emerges as the Gort River at the Pollduagh Cave, south of Gort, and flows northwards through Gort Town before sinking again at the Castletown Swallow-holes (3 km north of Gort). There is a groundwater connection between the Castletown Swallow-holes and the Kiltartan spring risings. During large floods an overland flood route exists at Castletown, discharging northwards to Ballyloughan and Kiltartan floodplains before entering the Lough Coole and Garryland Turlough system.

The time to peak (t_p) for flood runoff to reach the inlet to Lough Cutra from the Owendalulleegh catchment is estimated to be 8 hours, which is relatively rapid given its steep upland catchment. The estimated median flood peak rate just upstream of Lough Cutra is 30.5 m^3/s from the Flood Studies Update (FSU) flood estimation method and the critical rainstorm duration for peak catchment runoff is 19 hours, which represents a reasonably flashy catchment that produces maximum flood rates during 1-day events. The maximum outflow rate and critical rainstorm duration depends on the level the lake is at and can typically delay the peak by between 12 to 24 hours through lake storage.

3.2.2 Boleyneendorrish Catchment

The Boleyneendorrish (Ballycahalan) River like the Owendalulleegh River has its headwaters in the Slieve Aughty uplands, located on the northern side, whereas the Owendalulleegh River is on the southern side of the mountain and wind farm. The Boleyneendorrish River conveys runoff in a westerly direction towards the N66 (Loughrea Road). Downstream (west) of the N66 it becomes the Streamstown River and the Turra River inflows to it before flowing northwards to Ballylee where it sinks at the Ballylee swallow holes. The total catchment area of this river to the Ballylee swallowholes is 61 km^2. Two large turloughs, Skehanagh and Newhall, form to the north and northeast of Ballylee. During extreme floods these turloughs become one and the entire Ballylee area floods out. Upstream of Ballylee on this river the Lough Coy and Peterswell Turloughs form. There is an overland flood route from Ballylee floodplain to Ballyloughaun Floodplain to the east of Kiltartan. The estimated catchment area to Ballyloughaun is c. 152 km^2, which also includes the Owenshree catchment. There is a groundwater connection between the sinks at Ballylee and the Kiltartan Springs. Downstream of Kiltartan the flow sinks underground and enters the Coole-Garryland Turlough complex. At times of large floods an important overland flow route is available from Kiltartan via the Corker Turlough and under the M18 at Raheen / Kilkelly to the Coole-Garryland Turlough. The time

to peak for flood runoff in the Boleyneendorrish catchment to reach the Streamstown Section at Thoor, Ballylee is 6 hours based on the Flood Study Report time to peak method using catchment characteristics (NERC 1997, Cawley and Cunnane 2003). The median flood peak rate is 16 m^3/s using the FSU method. Similarly to the Owendalulleegh catchment this represents a relatively flashy catchment that enters the Gort Lowland system.

3.2.3 Owenshree / Kilchreest Catchment

The Owenshree River has its headwaters in the northern extremity of the Slieve Aughty upland and flows south-westwards before terminating at the Blackrock Sinkhole near Peterswell. The Blackrock turlough swallow hole system is understood to drain to Lough Coy and the Polleelin / Pollanoween system at Ballylee. At times of large floods an overland flow path from Blackrock Turlough through to Skehanagh village towards Skehanagh Turlough and Ballylee becomes established. The catchment area of the Owenshree River to Blackrock Swallow-holes is 78.5 km^2. The time to peak for flood runoff to reach the Blackrock Turlough Swallow hole is estimated to be 7.5 hours. The estimated annual median flow rate in the upstream catchment to Blackrock Turlough is 16.35 m^3/s using the FSU flood estimation method.

3.2.4 Kiltartan Floodplain

The catchment area to Kiltartan Springs includes all of the above three river catchments and the local turlough basins and surrounding lands, which based on surface topography is c. 301 km^2 in area. It should be noted that the karst groundwater conduit flow system in the Gort Lowlands is complicated and has multiple connections between various sinks and springs with some groundwater connections bypassing the springs at Kiltartan and discharging directly to other more downstream turloughs and to the coastal springs near Kinvara (GSI, 2020). The flow rising from the springs at Kiltartan and its overland component discharges into the Coole-Garryland turlough complex via swallow holes and an overland flow route via Corker and Raheen. Past flood events have caused extensive flooding at Kiltartan Village with houses, roads (including the former N18) and the church at Kiltartan seriously flooded.

3.2.5 Lough Cutra

The EPA-gauged outflow from Lough Cutra gives a median flood (2-year return period) peak outflow rate of 19.15 m^3/s whereas the median flood inflow rate is 30.5 m^3/s . This suggests that Lough Cutra attenuates the flood peak by upto 30% for the median annual flood. The historical highest flooding recorded for Lough Cutra, since the EPA gauge record began in 1976, occurred on 19th – 20th November 2009. In a 48-hour period from 4:00am on 18th November 2009 to 4:00am on the 20th, the lake level rose by 0.86 m to 34.67 mOD representing a flood storage volume of approximately 3.44 million m^3 based on a lake surface area of 4 km^2. To fill such a volume in a 48-hour period requires an inflow rate to be on average 20 m^3/s in excess of the outflow rate during that period. The gauged peak outflow from Lough Cutra gives a flow rate estimate of 55.6 m^3/s suggesting a peak inflow rate in excess of 75 m^3/s. The estimated peak outflow from Lough Cutra using the EPA rating curve involves considerable extrapolation beyond the gauged range of flows and is likely to be significantly overestimated being backwatered from downstream by the limited flow capacity

of the Punch Bowl Swallow-holes. It is more likely that the peak inflow and outflow were c. 60 and 40 m^3/s respectively. The flooding of the lands surrounding the downstream reach from Lough Cutra is caused by the throttle effect at the Punch Bowl swallow-hole and by the hydraulic capacity of the Beagh River outflow channel from the lake to the Punch Bowl. In 2009 the lake effectively delayed the flood peak by almost 24 hours between the inflow and outflow hydrograph peaks.

3.3 Land use

The general land use cover in the Gort Lowlands catchment and its 3 no. upland catchments is summarised below in Tables 1 to 4 and also shown in Figure 2. This land-use mapping is based on the latest available Corine land-use mapping (2018). This shows that forestry and wetlands / bogs make up a significant portion of the land use in these catchments at c. 46% for the overall Coole catchment of 388 km^2 and slightly over 50% is grassland / pasture. In the upland catchments of the Boleyneendorrish and Owendalulleegh River systems, forestry and peatlands represent 60 to 67% of the land use; refer to Tables 3 and 4.

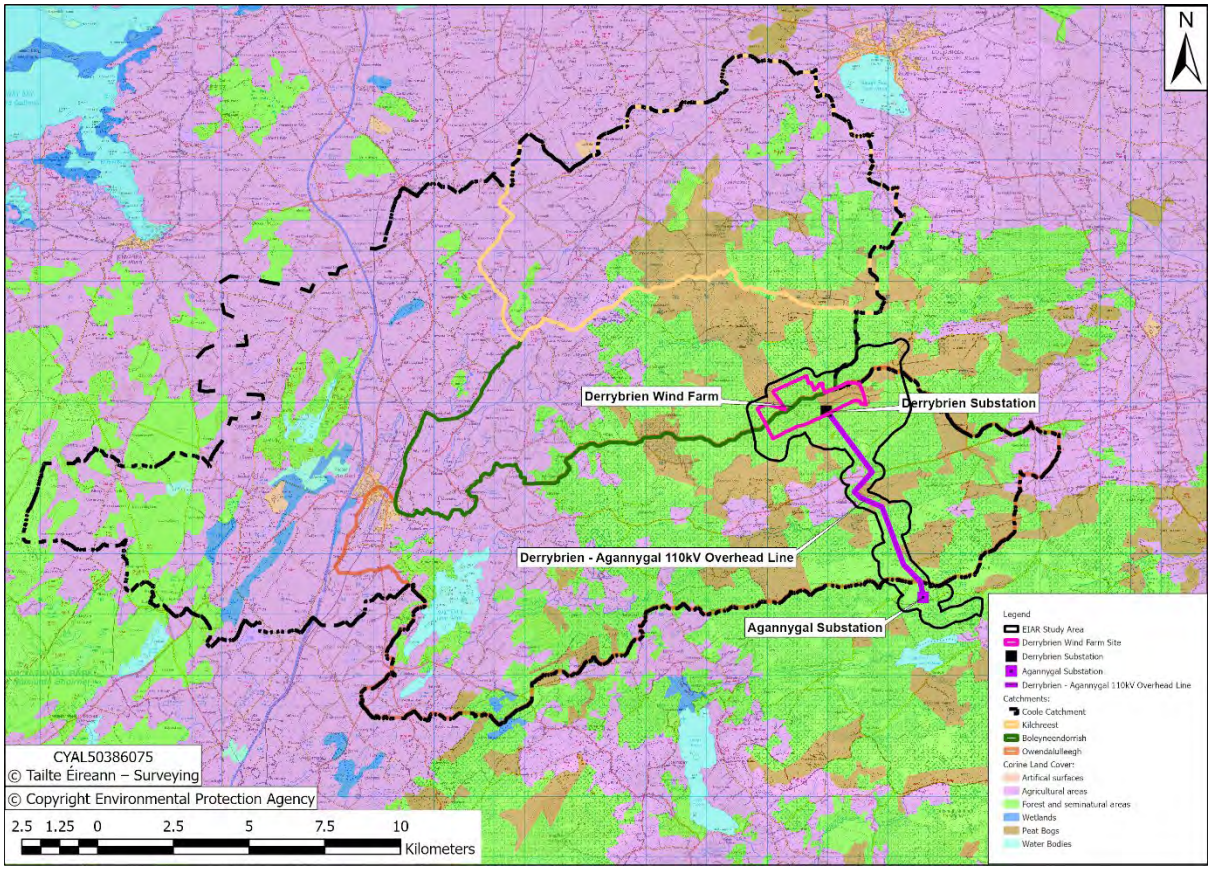


Figure 2 Corine land use mapping

The Boleyneendorrish and Owendalulleegh catchments have significant fraction of their catchments associated with forestry at 41 and 50% respectively.

Table 1 Corine Landcover for the overall Coole Catchment

Class Description	Area (Ha)	Area (km^2)	Area (%)
Artificial surfaces	190.64	1.96	0.50%
Agricultural areas (grassland and pastures)	20155.50	201.56	51.90%
Forest and seminatural areas	12810.15	128.10	33.00%
Wetlands & Peat bogs	4982.23	49.82	12.80%
Water bodies	668.51	6.69	1.70%

Table 2 Corine Landcover for the Owenshree (Kilchreest) Catchment

Class Description	Area (Ha)	Area (km^2)	Area (%)
Artificial surfaces	0.045	0	0.00%
Agricultural areas (grassland and pastures)	5313.75	53.14	67.50%
Forest and seminatural areas	1519.40	15.19	19.30%
Wetlands & Peat bogs	1040.33	10.40	13.20%
Water bodies			

Table 3 Corine Landcover for the Boleyneendorrish Catchment

Class Description	Area (Ha)	Area (km^2)	Area (%)
Artificial surfaces	3.31	0.03	0.10%
Agricultural areas (grassland and pastures)	2424.00	24.24	39.50%
Forest and seminatural areas	2521.71	25.22	41.10%
Wetlands & Peat bogs	1179.96	11.80	19.20%
Water bodies			

Table 4 Corine Landcover for the Owendalulleegh Catchment

Class Description	Area (Ha)	Area (km^2)	Area (%)
Artificial surfaces	83.81	0.84	0.62%
Agricultural areas (grassland and pastures)	3978.43	39.70	29.46%

Forest and seminatural areas	6703.61	67.04	49.64%
Wetlands & Peat bogs	2317.72	23.18	17.16%
Water bodies	421.75	4.22	3.10%

4. Regional Hydrogeology

4.1 General Description

The outlet from the Gort Lowlands catchment to the sea is underground via karst groundwater flow from swallow-holes in the pure limestones within turlough-forming basins of the numerous turloughs in the Gort-Ardrahan area which includes some of the bigger turloughs at Blackrock, Ballylee, Kiltartan, Corker, Coole-Garryland, Caherglassaun and Cahermore. There is limited capacity in these underground conduit systems to discharge in flood conditions resulting in the groundwater table rising and the flooding out of the surrounding turlough basins until they reach their natural threshold levels and spill overland, flowing from one turlough area to another.

The catchment extents of the Gort Lowlands to the Cahermore Turlough 4 km southeast of Kinvara Village is presented in Figure 3. Also shown for reference on this figure is the Geological Survey of Ireland (GSI, 2019) maximum historical groundwater turlough flood extents and the 3.44 km^2 Derrybrien wind farm site in the Slieve Aughty Mountains to the east.

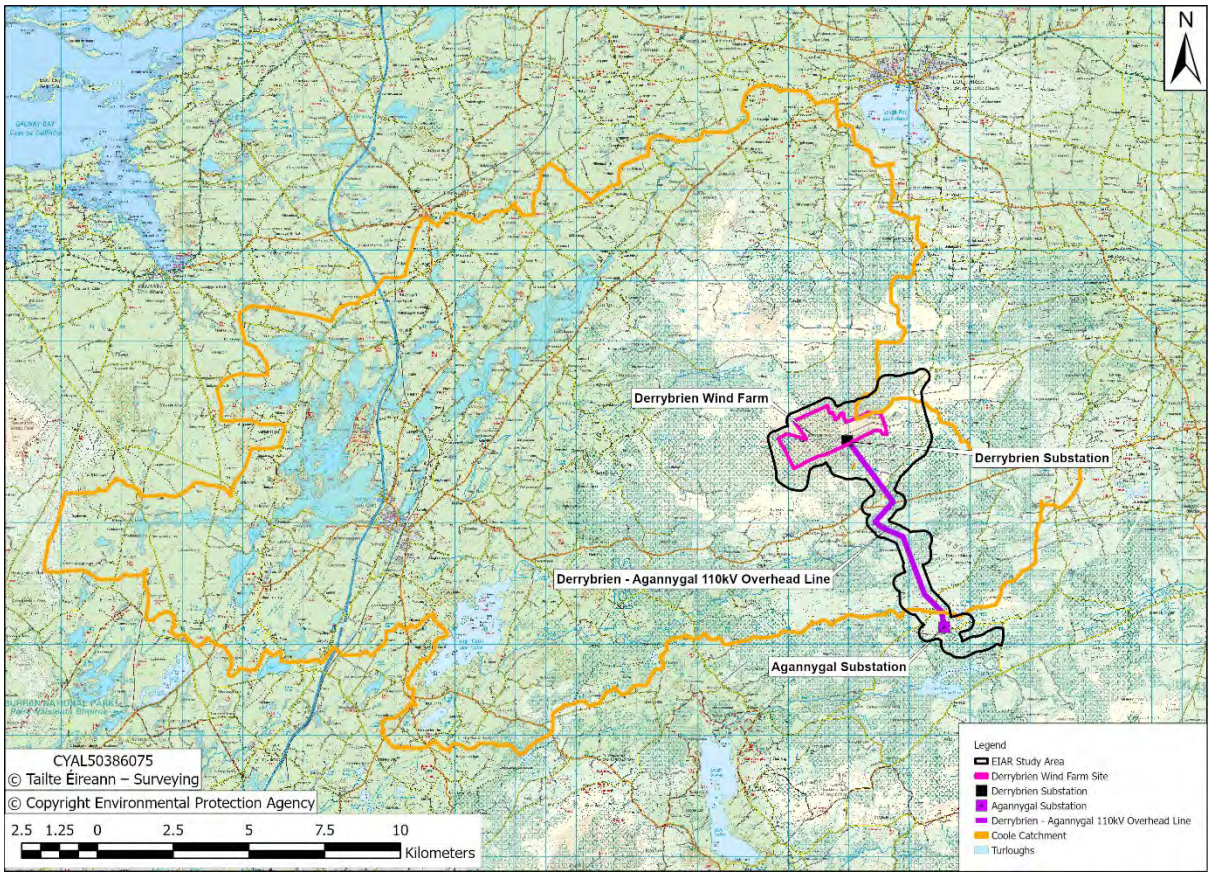


Figure 3 Catchment extents draining to the Coole – Garryland Turlough System showing maximum historical Flood Extents (GSI)

Groundwater and overland flow that enters the Coole and Garryland turlough system is stored until such time that it can discharge via its groundwater conduits. This can result in extensive overland flooding during large flood events when the groundwater outflow capacity is significantly exceeded. There are groundwater connections between Lough Coole and

Caherglassaun and Cahermore turloughs and the Kinvarra springs where it enters the sea. The entire Kinvara catchment to Slieve Aughty potentially drains an area of 500 km^2.

A line running southwest from Kilchreest to Peterswell to Gort and south to the west of Lough Cutra represents the divide between Pure Limestone Bedrock formations to the west of this line and the more impervious, muddy bedrocks that include conglomerates of Mudstone and Siltstone and Greywackes, Siltstones and Mudstones to the east. These conglomerates represent poorly productive bedrock aquifers (low storativity and transmissivity) and are overlaid by peats and silts resulting in low groundwater recharge rates, typically of less than 10%. The pure limestone formations with a free draining limestone till have groundwater recharge rates of c. 60% and the limestone outcrop areas have recharge rates of c. 85%. There is a contrasting picture in the density of surface drainage features between east and west of the catchment with a high density of surface drainage features in the muddy impervious bedrock areas and a near absence of surface drainage features in the highly karstified pure limestone formations to the west.

The pure limestones in the Gort Lowlands area to Kinvara are highly karstified and there are no surface flow outlets to the sea, with drainage outflow from the area entirely via groundwater flow in large conduits and caverns. Extensive dye tracing of the Gort Lowlands karst system has been conducted by David Drew, Trinity College, GSI and the Gort Lowlands Flood Study (Drew and Daly 1993, Southern Water Global 1997 and GSI 2020) to identify preferential pathways between sinks and springs. These investigations have shown widespread groundwater flow linkages between turloughs and inland and coastal springs at Kinvara and surrounding coastal areas. The Gort Lowlands system is completely dependent on groundwater flow for outflow. There are no watercourse channels present to convey runoff to the coast. Turloughs begin to fill with the rising regional groundwater table and fill further when the inflow to the turlough exceeds its limited outflow capacity.

The many large turloughs in the Gort Lowlands system are presented in Figure 4. The flooding of these turloughs is influenced by the inflow but also by downstream flood conditions in the interconnected turloughs and in extreme winter flooding events such as 2009 and 2015/2016 these turloughs rose significantly resulting in overland spills between turloughs in a cascade-like manner.

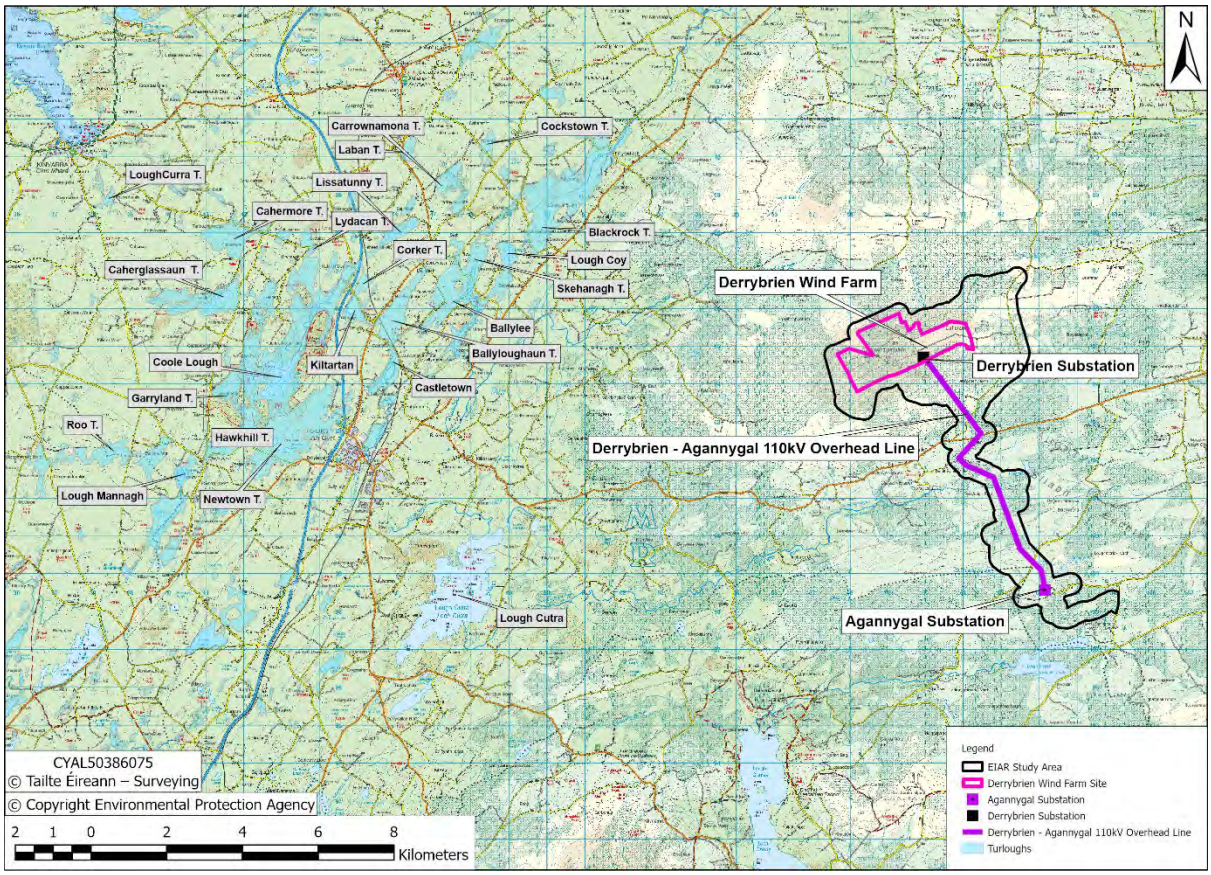


Figure 4 Main Turlough Flooding areas in the Gort Lowlands area (2009 groundwater flood extents, GSI)

5. Flooding

5.1 General

Flood prone areas downstream of the project windfarm site are associated with fluvial flooding in the river valleys of the Owendalulleegh and Boleyneendorrish Rivers and combined fluvial and groundwater flooding within the karst basins surrounding the numerous turloughs in the Gort Lowlands area. Flash flooding on the smaller mountain streams of the Slieve Aughties is associated with high intensity short duration rainfall events, with the sites of flooding occurring at road and land access culvert crossings either due to flow capacity restrictions or debris obstructions leading to flooding of local roads in the vicinity of the culvert crossings. Further downstream in the Gort lowlands area flooding is associated with much longer duration rainfall events (days and weeks), caused by the volume of floodwaters generated exceeding the flow capacity of the river reach or the flow capacity of the groundwater outlet from the Turlough basin.

The National Indictive Flood Mapping (NIFM) provides fluvial flood extents along the stream and river channel network for estimated 100-year and 1000-year flood events for all river reaches exceeding 5 km^2 catchment area. It is a useful screening tool identifying potential flood prone areas. This mapping is based on fluvial sources for catchments in excess of 5 km^2 and assumes within channel has capacity of 80% of the annual flood (QMED) and remainder floods its overbanks based on hydraulic modelling using a DTM ground level model, refer to Table 5 below. The QMED flow estimate is based on the FSU Physical Catchment Descriptors equation and the return period growth factors are based on the FSU pooled analysis of selected reliable gauged stations providing 500 station years of annual maximum flows. A full description of the methodology for the National Indictive Flood Mapping is available at https://www.floodinfo.ie/map/nifm_user_guidance_notes/ . This mapping is considered to be of moderate reliability.

This mapping identifies the potential floodplains of the Owendalulleegh and Boleyneendorrish Rivers, whose floodplain extents only become more extensive downstream in the flatter gradients at Derreen townland upstream of Lough Cutra on the Owendalulleegh and in the turlough areas at Farnaun and Doonally West on the Boleyneendorrish, refer to Figure 5.

Table 5 Channel Capacities modelled in the National Indicative Flood Mapping

Channel Type	Channel Capacity as % of Qmed
Rural area - shallow slope	100%
Rural area - moderate slope	80%
Rural area - steep slope	80%
Urban areas	100%
Arterial Drainage	135%

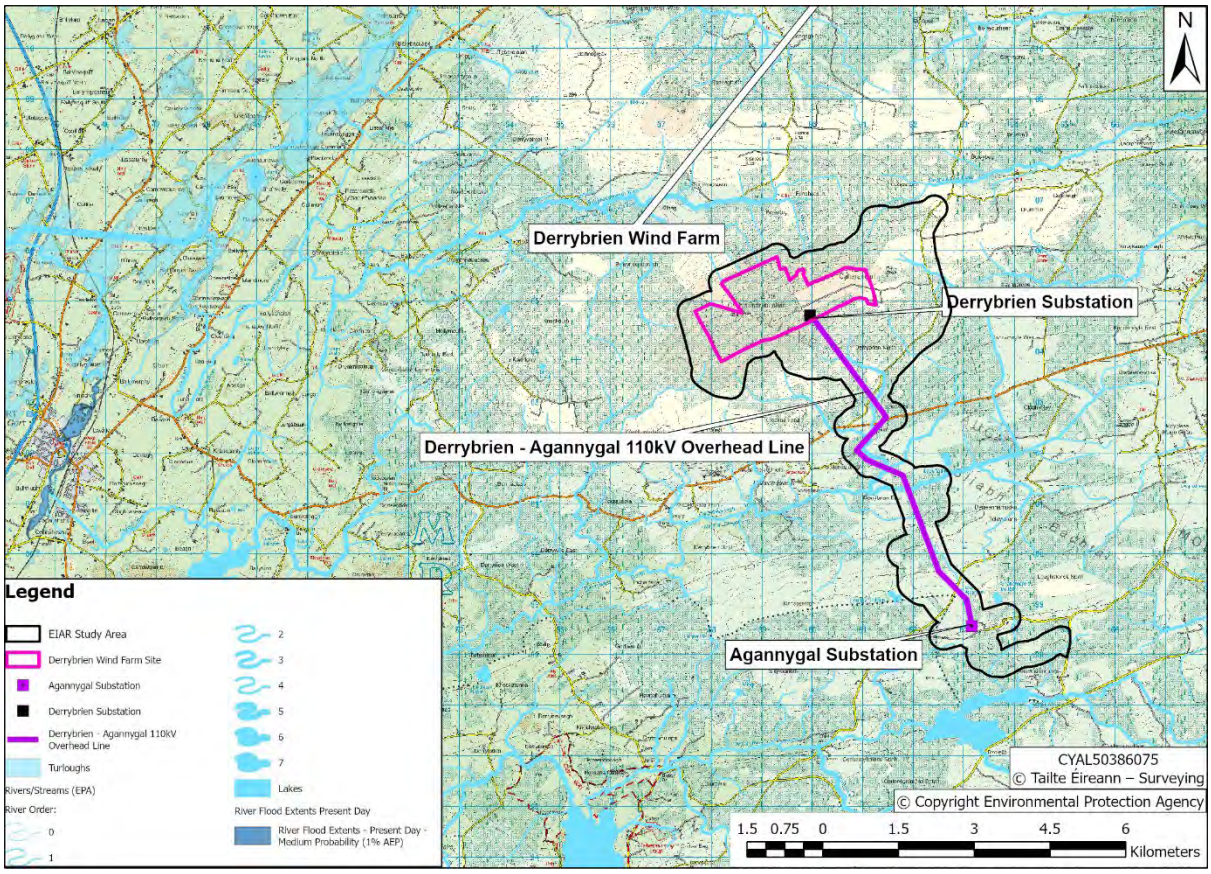


Figure 5 National Indicative 100-year Fluvial Flood Extents for the Boleyneendorrish and Owendalulleegh Rivers

Historical information on flooding events is available from the OPW Floodinfo Website (https://www.floodinfo.ie/), refer to Plate 1. This public resource does not represent an exhaustive list of historical events and is generally related to Local Authority information on flooding within their local areas. The majority of flood events shown are associated with the Turlough Flooding in the Gort Lowlands area. However a flood event was identified on the Owendalulleegh River at Drummin Townland associated with fluvial flooding of the floodplain area. Recurring flooding of floodplain lands by the Owendalulleegh River at Drummin and

Derreen townlands occur. The catchment area of the Owendalulleegh to Drummin and Derreen c. 80 km^2.

The Geological Survey of Ireland provide groundwater flood maps and groundwater level and turlough level gauging measurements principally for karst limestone areas including the Gort Lowlands and this information is relied upon in this report.

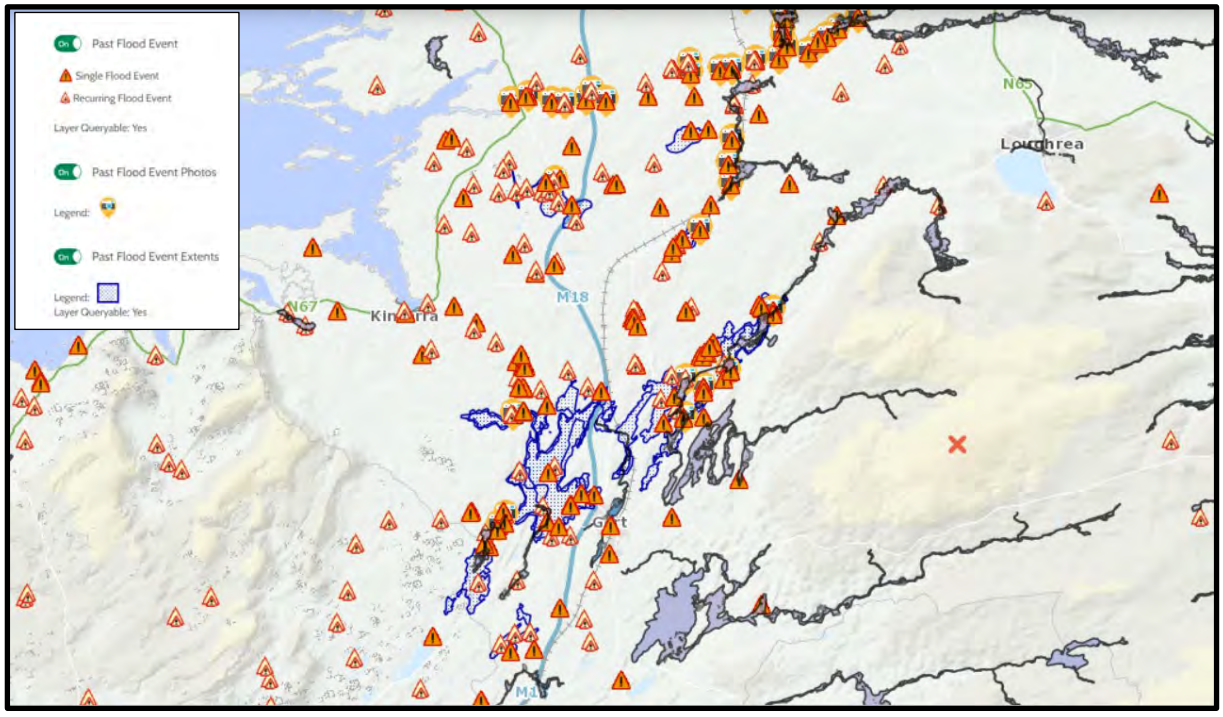


Plate 1 – Past Flood events from Floodinfo.ie

5.2 Historical Flooding

Severe turlough flooding in the Gort Lowlands system is associated with heavy prolonged winter rainfall events over many weeks and generally associated with sustained heavy rainfall between December and February (except for 2009 when extreme rainfall in November produced peak levels towards the end of November and early December).

Historically severe turlough flooding in the Gort Lowlands area occurred in

- 1989/1990
- 1993/1994
- 1994/1995
- 1999/2000
- 2009
- 2015/2016

- February-March 2020

Fluvial flooding in the Owendalulleegh and Boleyneendorrish Rivers and the Gort River were associated with December 1999, November 2009 and December 2015 events.

Plate 2 Flooding in the Kiltartan Area on 26th February 2020

The most extensive flooding occurred in the Coole-Garryland Turlough in 2015/2016 (with the peak occurring in early January 2016). This event was followed in severity by the Nov/Dec 2009 flood (rainfall primarily fell in late October and November 2009) and the third ranked flood was the 1994/1995 flood that peaked at the end of January and early February1995. All flooding in the Gort Lowlands turloughs is winter-dominated flooding produced by prolonged rainfall events over many weeks as opposed to short duration flooding events over hours and days. The most recent event that peaked at the end of February / early March 2020 is ranked in terms of severity as the fourth worst event behind 2015/16, 2009 and 1994/95 events.

The observed peak flood levels in 2009 and 1994/1995 were similar at Blackrock and Thoor Ballylee Tower, but the 2009 flooding progressively exceeded 1994/95 in down-gradient turloughs, with flood levels in Caherglassaun approximately 0.7m higher in 2009. A comparison between 2009 and 2015/2016 showed that flood levels were higher in 2009 at Blackrock by c. 0.3 m but were surpassed by the 2015/16 event in the downstream turloughs at Kiltartan and Corker, Coole-Garryland, Caherglassaun and Cahermore Turloughs due to the greater volume and longer duration of the flooding event. In 2015/2016 the peak flood levels surpassed the 2009 event in the Caherglassaun Turlough by c. 0.8m and at Cahermore by over 1m. Table 6 below presents estimated historical maximum flood levels at the various Gort Lowlands turloughs.

Table 6 Historical maximum flood levels in a number of the turlough areas

Location	**Maximum Flood Level mOD**	**Year**
Blackrock Turlough	29.45 (29.15)	2009 (2015/16)

Lough Coy	19.3 (19.15)	2009 (2015/16)
Ballylee floodplain and Swallow hole area	19.15 to 19.4	2015/2016 and 2009
Ballyloughaun and lower Castletown Floodplains	18.0 to 18.2 (<16.5) **	2009 (2015/2016)
Kiltartan	14.9 – 15.2 (14.9 at Kiltartan Church)	2015/2016 (2009)
Coole Lough (Garyland)	14.65 (13.7)	2015/2016 (2009)
Hawkhill (Coole)	14.63 (13.75) (13.3)	2015/2016 (2009) (1994/1995)
Caherglassaun	14.5 (13.8)	2015/2016 (2009)
Cahermore	13.4 (12.5)	2015/2016 (94/95 and 2009)

** the flooding at Ballyloughaun floodplain in 2015/2016 was significantly reduced due to the replacement of undersized culverts beneath the former N18 road near Kiltartan, otherwise it would have been expected to be similar to 2009 max flood levels which had spilt across the road.

A review of long-term rainfall records in the earlier Gort Lowlands Flooding Study (Southern Global Water, 1997) concluded that in the 50 years preceding the first notable flood event in 1989/1990 that the prolonged rainfall events recorded, except for 1959, were not sufficient in rainfall amount to have produced severe turlough flooding in the Gort Lowlands compared to the more recent listed significant events above.

A review of the daily rainfall records from the Derrybrien II (St. No 2121) rain gauge (at altitude of 155 mOD) for the available record period 1st July 1982 to 31 August 2022 showed the following amounts in respect to the historical rainfall events:

- In 89/90 586 mm of rainfall fell in 3 months, namely December ' 89, January '90, February '90 having an average rate of 6.51 mm/day.
- In 93/94 646 mm of rainfall fell in a 3-month period from the 27th Nov 94 to 26th Feb 95 producing an average rate of 7.18 mm/day.
- In 94/95 820 mm of rainfall fell in 101 days from 2nd Dec 1994 to 10th Mar 1995 producing an average daily rate of 8.12 mm/day and this event followed a moderately wet November having a monthly total of 121 mm.
- In 99/00 631 mm rainfall fell in 102 days representing an average daily rate of 6.19 mm/day.
- In 2009 following a wet July (190 mm) and August (191 mm), a moderately dry September (58 mm) and a wet October (139.3 mm) 469 mm fell in a 29-day period from 30 October to 27 November producing an average daily rate of 16.2 mm/day.

- In 2015/16, similarly to 2009, a wet summer with 111 mm in July and 122 mm in August followed by moderate rainfall amounts in September and October of 75 mm and 66.6 mm respectively was followed by 708 mm from 4th Nov to 7th January (10.9 mm/day).
- In 2020 a record wet month in February recorded over three times its monthly average with the bulk of the rain falling in a 24-day period with an average in excess of 10 mm per day over the month of February.
-

Derrybrien II rain station is a point measurement at an altitude of c. 155 mOD and does not necessarily reflect the actual catchment-wide rainfall amounts as the lower altitudes within the Owendalulleegh catchment are likely to have had lower rainfall amounts, but the rainfall pattern from Derrybrien II represents well the prolonged nature of the rainfall that produced the significant downstream flooding in the Gort Lowlands turloughs. Figure 6 presents the location of the rain gauge network in the North Clare / South Galway area. There is not a complete record at all of these stations for the period of floods from 1989 onwards but a review of the available daily record shows similar trends to the Derrybrien II rain gauge.

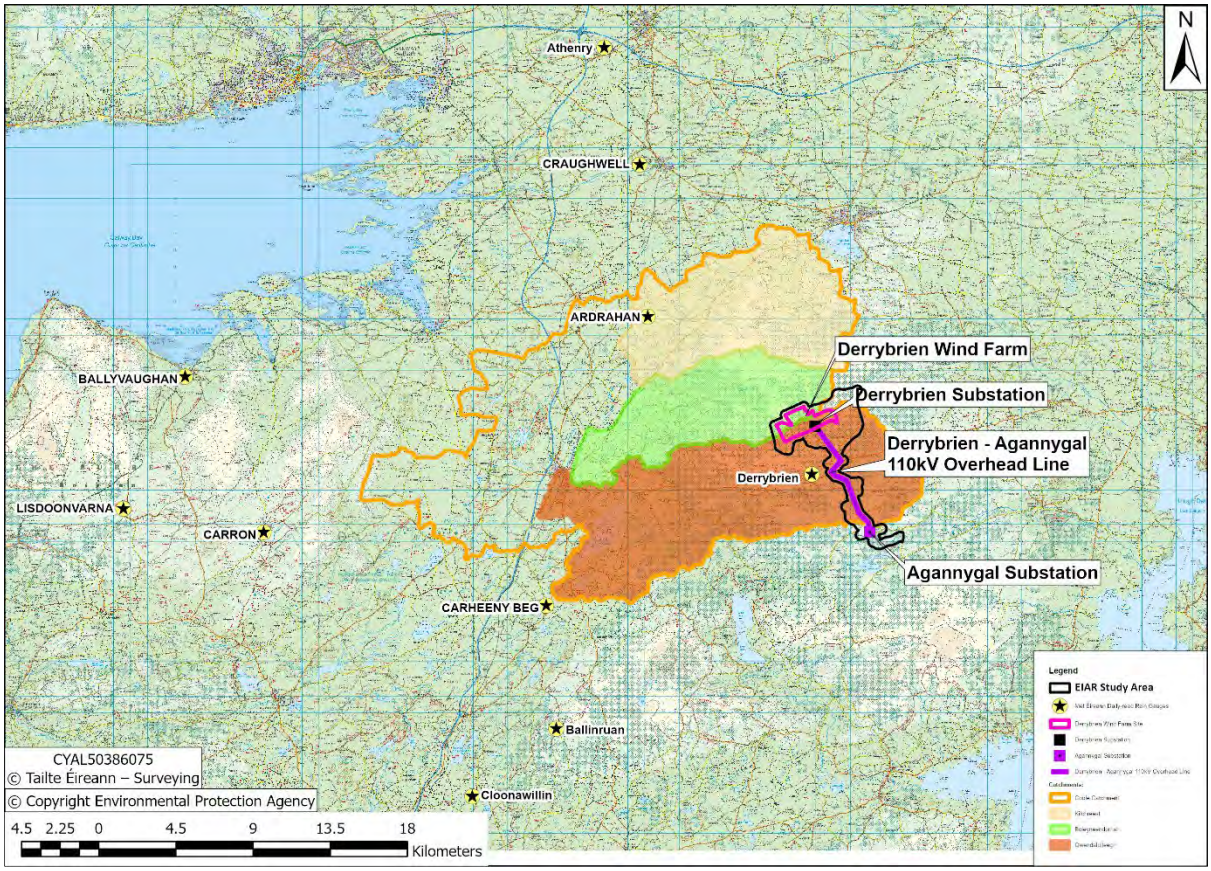


Figure 6 Location of Daily Read Rainfall Gauges in proximity to the Gort lowlands catchment

The flood extents for the Gort Lowlands turloughs associated with the 2009 flood event that has been produced by the GSI is shown in Figure 4. The total surface area of turlough flood inundation in 2009 was 20.75 km^2. Based on these flood extents a 10 cm rise in flood level represents c. 2 million m^3 of flood storage which in terms of the contributing catchment area of 338 km^2 represents a rainfall depth of 5 mm. It should be noted that all the flood events listed above the prolonged rainfall depths over one or two months were well in excess of 5 mm/day. At a certain rainfall rate the groundwater outflow capacity of the turloughs (this will

vary from turlough to turlough) is surpassed and the excess rainfall must store and eventually flood and spill overland. Essentially the turlough flooding in the lowlands area surrounding Coole, Kiltartan and Ballylee is dominated by the flood volume entering over a prolonged period as opposed to high intensity short duration inflows that would be more critical to flooding in the upland valley sections of the catchment to the east and northeast of the Gort Lowlands area.

The 2015/2016 flood extents have been produced by Ryan Hanley Consulting Engineers for the Gort Lowlands Flood Relief scheme but is currently in draft form and is not published. A paper by Naughton and McCormack (2016) of the GSI presented the flood extents for the winter 2015/2016 event, refer to Plate 3 below.

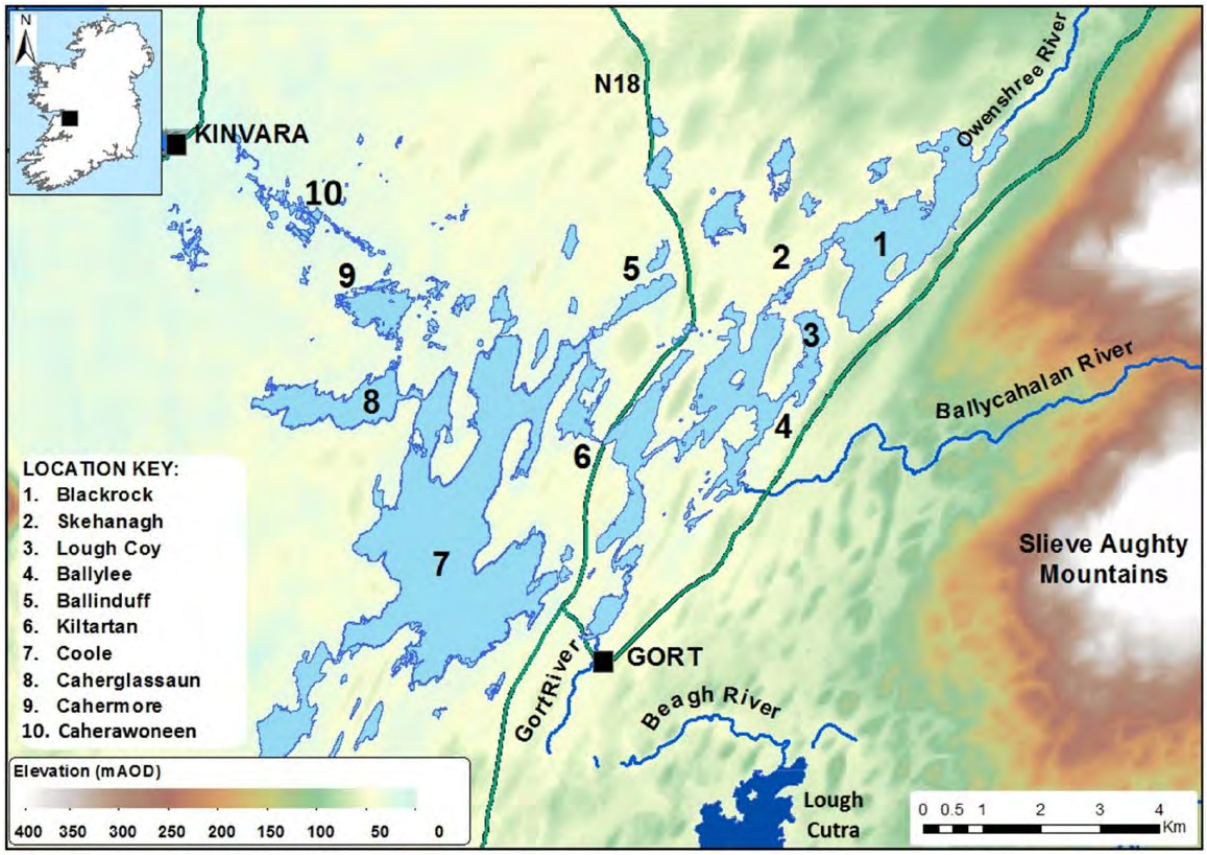


Plate 3 – Groundwater Flood extent map for the Gort Lowland, winter 2015-2016 (copied from McCormack and Naughton, 2016)

5.3 Turlough Flooding

Turlough flooding occurs when for a sustained period the inflow exceeds the capacity of groundwater outflow from the turlough basin via its karst conduit flow system. During prolonged and intense rainfall, the subterranean flow paths are unable to drain its catchment and the limited subsurface storage is quickly exhausted resulting in surface flooding in the low-lying topographical depression. Under normal flood conditions this inundation is necessary for the flood-dependent turlough habitat. The excess floodwater builds-up in the turlough basin which increases the hydraulic head available to drive increased groundwater outflow and / or continues to rise until it discharges as shallow groundwater flow within the epi-karst or overtops the basin crest and spills as overland flow. As water builds-up in the turlough basin, this does not always necessarily increase the head available for the groundwater flow, as the water level in the downstream receiving turlough basins may also be rising due to their limited outflow capacity causing a backwatering effect from restrictions further downstream. As the flood event proceeds and water levels continue to rise some of the turloughs become as one or become severely backwatered from the downstream turlough. Under normal flood conditions this inundation is necessary for the flood dependent turlough habitat. However, under extreme conditions, extensive surface flooding and overland flow can develop, posing a flood risk to surrounding properties, roads and agricultural land.

A review of water level records in the various monitored turloughs of the Gort Lowlands clearly indicates a highly damped attenuated system where flood levels gradually rise, producing a prolonged peak and receding slowly over many weeks. In these turloughs the change can be dramatic between summer low levels and max winter flood levels, for example Coole Lough summer level is c. 5.5 mOD and the maximum winter flood level observed is 14.7 mOD (c. 9.2m water depth difference).

The dye tracing carried out by David Drew (1994), GSI and the Gort Lowlands Flood Study (1997) shows multiple linkages to spring and turloughs from the various swallow-holes and turlough areas. These studies do not quantify the magnitude of these connections from these features only that there is a possible linkage. The main groundwater conduit flow linkages identified within the Gort Lowlands system are summarised as follows:

- Lough Bunny to Lough Skeardee and via Cloonteen River and swallow hole to Lough Mannagh and Hawkhill Turloughs
- Punch Bowl 2 km downstream of Lough Cutra, where the Beagh River from Lough Cutra sinks and rises at Pollduagh Cave in the townland of Cannahowna to becomethe Gort River.
- Blackrock Turlough to Lough Coy to Thor Ballylee Swallow-holes (Pollanoween and Pollaleen)
- Thoor-Ballylee Swallow-holes to Polldeelin Springs at Kiltartan and to the Lough Coole springs.

- The Gort River sinks at Pollatoophil swallow hole near Kiltartan castle and rises at Polldeelin Springs Kiltartan and to the Lough Coole Southern Springs
- Lough Coole-Garryland Turlough to Caherglassaun Turlough and also to the Kinvara springs
- Caherglassaun Turlough caves and swallow holes to Kinvara Springs (West, Central, and East)

5.4 Turlough overland spill pathways

As the inflow volume to the Gort Lowlands turlough basins exceeds the underground flow capacity of the karst conduit system the groundwater levels rise locally and the excess inflow volume is stored as standing water in the turlough basins. The turloughs continue to fill with the excess inflow until they spill overland or become joined with other nearby turloughs. The main overland flow spill pathways for the various Turloughs in the Gort Lowlands system are described as follows:

- Blackrock Turlough spills at Rahaly south in a southwest direction through Skehanagh to Carrowbaun East and onto the Ballylee floodplain at Newhall and Thoor Ballylee
- Overland flow from the Ballylee floodplain southwest via Rinrush and Deerpark to the Ballyloughaun Floodplain at the Athenry Rail line near the 44-mile post.
- The Castletown River at the Castletown Swallow-holes floods out and spills northwards to the Ballyloughaun floodplain crossing over the Castletown local road and the Galway-Ennis Railway line near the 44-mile post and joins with the Ballylee overflow in the Ballyloughlaun Floodplain.
- The Ballyloughaun floodplain spills westward across the R458 via the recently upgraded culvert crossing into the Kiltartan floodplain.
- The Kiltartan flood plain spills overland north to Corker turlough where it crosses west under the new M18 road to the Raheen turlough and south joining the Coole - Garryland Turlough
- To the south of Garryland-Coole Turlough the Cloonteen River drains Lough Mannagh to Hawkhill Turlough. Both Hawkhill and Newtown Turloughs all form part of the Garryland-Coole Turlough floodplain.
- The Garryland-Coole turlough spills northwards to Crannaghand then west into the Caherglassaun Turlough.
- Historically there is no overland spill from Caherblassaun Turlough to reach Cahermore Turlough located to the north.
- Cahermore Turlough spills northwards across the local Kinvara to Gort road c. 5km from Kinvara (southeast) and then spills overland northwest through Caherawoneen South and North to Shessaragh and eventually to Kinvara Bay to the northeast of Dungory Castle. This overland route was assisted by emergency flood relief works carried out by Galway Co. Co during the flood of 2015/2016.

5.5 Identified flood-prone areas requiring flood relief measures

A significant impact of flooding in the Gort Lowlands is the duration that areas are flooded or cut-off which extends to weeks and months during the most extreme events. The main flood-prone areas identified by the OPW PFRA (Preliminary Flood Risk Assessment) Groundwater and GSI flood risk mapping, the previous flooding studies and by the current Gort Lowlands Flood Relief Scheme carried out by Ryan Hanley Consulting Engineers (Ryan Hanley, 2018b) are summarised as follows:

Drummin and Derreen Townlands

- Extensive flood plan area due to flat nature of land with flooding associated with fluvial flows in the Owendalulleegh River. Catchment area is c. 80lkm2 with flood flows estimated to be at c. 2 cumec at the median annual flood and 56cumec at the 1000year flood. Channel gradient is flat with significant channel meandering present and extensive network of field drains within the floodplain lands. Local Road cut-off and flooded by the river.

Cahermore Turlough Area

- Cahermore Turlough peak flood level is 13.6 mOD (Dec 15/Jan 16 event) (overland spill prevented this level rising further). There are at least 10 houses and up to 5 farm sheds/slatted sheds at risk including cut-off and flooding of local roads.

Caherglassaun Turlough Area

- Caherglassaun Turlough reported historical maximum flood level reached 14.48 mOD during 2015/2016 event. 1 house and slatted shed and large sections of local road flooded.

Garryland – Coole Turlough Area

- At Garryland – Coole Turlough System the reported maximum flood level from the 2015/2016 is 14.74 mOD. In this area three houses, a farm yard, warehouse and interpretative centre along with slatted sheds and numerous local roads and farm access roads and potentially the new M18 road at the Gort Interchange (based on evidence from 2015/16 flood).

Lough Mannagh area

- At Lough Mannagh south of the Coole-Garryland turlough system the historical maximum flood level was reported to be 15.15 mOD in the lough and 14.9 mOD in the floodplain on the north side of the Poulataggle Road during the 2015/16 event. Lough Coole and Garryland turlough back up in Lough Mannagh during extreme flooding. In this area there are up to 7 houses, Tirneevin Church and three slatted sheds at risk of flooding and a number of local roads and farm accesses.

Kiltartan floodplain area

- At Kiltartan floodplain the maximum historical flood level is c. 14.9 to 15.0 mOD for the 2015/16 event with Coole-Garryland Turlough reaching 14.7 mOD. There is significant

flood risk at Kiltartan including the church (which has flooded on a number of occasions) and at least 5 houses classified and a number of farm sheds and a number of public local roads including private access roads.

Ballyloughaun and Castletown floodplains

- The Ballyloughaun and Castletown floodplains located to the east of the R458 (formerly the N18) at Kiltartan suffered its historical maximum flood level in the 2009 event when the R458 road flooded with a maximum flood level of 18 to 18.2 mOD. However during the 2015/16 flood event the maximum flood levels in the Ballyloughaun floodplain were between 16.2 and 16.5 mOD. This reduction in flood levels of 1.7 to 1.8 m was due substantially to the construction of a flood relief culvert under the R458 (former N18) road at Kiltartan (box culvert 2.9 m wide by 2.1 m in height) in the intervening years. Even at the much-reduced flood levels in 2015/16 both the railway line and the Castletown road still flooded. No houses in the vicinity of this floodplain flooded or were at risk of flooding during either event. A number of local roads and the Limerick rail line (in excess of 400 m flooded) remain at significant flood risk.

Ballylee Floodplain Area

- At Thoor-Ballylee the peak flooding associated with the 2015/16 flood was of the order of 19.15 to 19.4 mOD. The main impact of flooding at Ballylee is flooding of the Thoor-Ballylee Yeats Centre, flooding of local roads leaving the Rinrush community cut-off and many houses stranded and access roads to farms and land cut-off.

Lough Coy

- The Ballylee floodplain backed up to Lough Coy in the 2015/16 flood event producing a maximum flood level of 19.5 mOD. At Lough Coy both 2009 and 2015/16 flood events produced similar maximum flood levels at Lough Coy. Such flood levels produce a flood risk to a number of slatted sheds and flood 350 m of the Dromorehill Road.

Blackrock Turlough

- The peak flood levels at Blackrock Turlough during the 2009 and the 2015/16 floods were surveyed at 29.45 and 29.15 mOD respectively. During the 2015/16 event at least 2 houses and 1 business flooded and almost 17 houses were cut-off. Flooding at Blackrock turlough produces a significant flood risk to 5 houses and 10 farm sheds in the vicinity of the turlough and many local roads and farm accesses may become submerged or cut-off.

6. Proposed Flood Relief Measures for Gort Lowlands

An extensive flood study of the Gort Lowlands catchment was carried out by Southern Global Water and Jennings's O Donovan in 1996/1997 (SGW/JOD, 1997). This study outlined various potential flood mitigation options which involved:

- Improving the conveyance (overland channel flow) for water from the Coole area to get to the sea at Kinvara
- Impounding water upstream of the major flooded areas (4 large impoundment (i.e. dam) locations on the principal rivers including the damming of Lough Cutra, and the Ballycahalan River).
- Diverting flow to other catchments upstream of the major flooded areas.

None of these options were considered to be viable and therefore were not progressed any further. It was found given the duration and flood volumes involved that the damming was not viable economically nor very effective in reducing flooding downstream in the Coole Area (Southern Global Water, 1997).

As a consequence of more extreme flooding, particularly the November 2009 and December 2015 / January 2016 events, a review of the flood relief options for the Gort Lowlands was implemented by the OPW in association with Galway County Council and this culminated in the appointment of engineering consultants Ryan Hanley to bring forward a viable flood relief scheme for the Gort Lowlands area. Ryan Hanley have through extensive surveys and assessments including the involvement of Trinity College, who undertook the groundwater flood modelling, identified a preferred flood relief solution that involves overland flood conveyance between turloughs and eventually to the sea at Kinvarra Bay.

The preferred flood relief solution to the turlough flooding in the Gort Lowlands area is to lower the peak flood levels to prescribed target levels to protect, where feasible, properties that are at risk. These proposed reductions in flood level would typically be between 1 and 2 m at the 100-year design flood event. This solution would be in combination with raising local roads, the possible provision of alternative road access routes to cut-off communities, the possible relocation of some lower lying dwellings which cannot be feasibly protected and /or individual property defences (Ryan Hanley, 2019/2020). This approach of lowering only the top flood levels was adopted so as to protect the Annex I priority Turlough Habitats.

The mechanism for lowering the peak turlough levels is through enhancing the existing overland spill pathways between turloughs allowing them to spill earlier and at a lower level so as to cascade from one turlough to the next in controlled overland channels with suitably sized culverts under local roads and accesses until reaching the sea at Kinvara (i.e. Blackrock to Ballylee to Ballyloughaun to Kiltartan to Corker to Coole-Garryland to Caherglassaun to Cahermore and to the sea at Dungory, Kinvara). The scheme requires a continuous overland

pathway of spilling from one turlough to another to the sea and without such an integrated pathway to the sea, spilling from one turlough to another could potentially increase the flood risk in a given downstream turlough.

Other flood relief options were considered by the Consultants, such as upstream attenuation and land management on the inflowing tributaries of the Owenshree, Boleyneendorrish and Owendalulleegh Rivers as stand-alone measures or in combination with the above proposed overland turlough spill conveyance measures were found not to be very effective given the sheer flood volume involved and the long duration (typically two months) required to protect these downstream lowland areas. Such measures would have to involve damming of the river valleys for extended periods requiring the construction of major dams and the inundation of extensive area of upstream lands and only releasing a much smaller prescribed flow (i.e. 10 m^3/s from Lough Cutra and 4 m^3/s from Ballycahalan impoundments based on the Gort Lowlands Flood Study (Southern Global Water, 1997). It was also noted in this Study that the more serious turlough flooding of the lowlands areas occurred when prolonged winter rainfall over a 2-month period exceeded an average daily rainfall rate of 5 mm per day from the catchment. The total catchment area to Kiltartan is 301 km^2 and for the 2015/2016 flood event the average daily rainfall over a 66 day period was recorded at Derrybrien II to be 10.8 mm/day. Restricting runoff from the catchment to 5 mm/day (17.4 m^3/s) would have required the storage of 5.8 mm/day which represents a storage volume of 115 million m^3 of runoff. This is equivalent to a lake 11.5 km^2 in surface area and 10 m average depth which could only be emptied over many months.

Large scale land management changes of the entire Slieve Aughty Mountains in terms of returning the hill slopes and plateau (watershed) areas, which are predominantly commercial forestry, to undrained peatlands will not produce the desired effect of achieving any measurable flood reduction in the downstream Gort Lowlands area. The blocking of drains and generation of more saturated conditions on the bog surface will only, at most, slow the rapid runoff of surface water but will have minimal effect on altering the flood volume generated, particularly for the prolonged winter flood events critical to causing the flooding in the downstream Gort Lowlands basin.

Attenuation and land management measures (i.e. restoring undrained peatlands and reducing drainage affects in forestry) can be effective in reducing the flood runoff rates for short duration flood events. Such measures are not very effective for prolonged winter rainfall events where the flood volume as opposed to the flood rate is critical, and this applies in particular to the case of the Gort Lowlands turlough flooding situation. These attenuation and land management measures do not provide a sink or longer-term store for rainfall with the volume of rainfall becoming the runoff volume particularly on these elevated winter-saturated catchments which have low permeability sub-soils overlying a low permeability agrillaceous limestone bedrock.

It is important to note that the Derrybrien wind farm site of 3.44 km^2 is a relatively small section of the overall Slieve Aughty Mountain catchment and therefore land use changes there would have had no perceptible effect on flooding in the downstream Gort Lowlands catchment.

Currently the Gort Lowland Flood Relief Scheme is completing the environmental studies to support the preferred scheme of providing an overland spilling route to Kinvara, including Appropriate Assessments for the numerous SACs within the zone of influence of the Scheme. These Special Areas of Conservation (SAC) Natura Sites are listed as follows:

- East Burren Complex SAC
- Coole-Garryland Complex SAC and SPA (Special Protection Area)
- Carrowbaun, Newhall and Ballylee Turloughs SAC
- Peterswell Turlough SAC
- Cahermore Turlough SAC
- Caherglassaun Turlough SAC
- Inner Galway Bay SPA
- Galway Bay Complex SAC

7. Derrybrien Wind Farm Project Potential Flood Impact

This section examines the potential downstream flood impacts from the Derrybrien Wind Farm development on downstream flood receptors such as the Owendalulleegh and Boleyneendorrish Rivers, Lough Cutra and the turloughs and flood areas within the Gort Lowlands area. The Derrybrien site measures 3.44 km^2 in area of which 66.3% drains to the Owendalulleegh River (i.e. 2.28 km^2) and 33.1% to the Boleyneendorrish River (i.e. 1.15 km^2) and 0.6% to the Duniry River (which is part of the Shannon System). The lands within the wind farm site represent disturbed peat bog with 263ha formerly Coillte forestry plantation and 81 ha turbary bog lands. The peat slip area is 0.26 km^2 and the OHL corridor is 0.34 km^2, located in the Owendalulleegh Catchment and the southern end of the OHL in the neighbouring Bleach catchment draining to Lough Atorick and the River Fergus system. The OHL is almost entirely located in the former Coillte Forestry. The total combined site area within the Owendalulleegh catchment is 2.86 km^2.

The former (pre the wind farm development) turbary and forestry land uses introduced significant drainage of the mountain-side peatland giving rise to its disturbed and degraded peatland state at the site. The wind farm project cleared Coillte forestry (felling approximately 28 ha of forestry between the wind farm site, landslide and OHL route), introduced additional floating roads and hardcored areas, increased the drainage network to protect the turbine bases, peat deposit sites, site compound and substation sites and maintained and enhanced the existing drainage channels. The site was extensively drained prior to the wind farm project,

with 27 km out of 39 km of drains on the site pre-existing the wind farm project. The remaining almost 12 km of drains on the site were constructed for the wind farm project.

During the operation of the wind farm these drains were inspected and where such inspections identified obstruction and peat build-up were locally cleaned.

The removal of trees from the site has enabled the peatland vegetation to re-establish in parts of the site and with some evidence of slow regeneration of blanket bog habitat on the site (refer to Chapter 7 – Biodiversity (Aquatic Ecology & Fisheries). Overall it is considered that the wind farm project through its drainage has increased the rate (speed) of runoff from the site. The natural runoff characteristics of this upland site prior to the project would be classified as a high flood runoff site. The effect of the wind farm project, at a worst-case assessment, was to increase the runoff class of the site from high runoff to very high runoff. This effect would have increased the flood rate as opposed to the total flood volume, which will have remained relatively similar given the poor recharge rates associated with low permeability soils and sub-soils. The effect of this is more acute in the immediate locality of the site and rapidly diminishes downstream as the time to peak and the critical rainstorm duration increases with the increasing catchment area and travel distance involved. By the time the flood wave reaches the sensitive lower reaches of the Boleyneendorrish/Ballycahalan River upstream of the Thoor Ballylee turlough area (catchment 56 km^2) and the Owendalulleegh River upstream of Derreen and Lough Cutra (catchment area 80 and 90 km^2 respectively) the effect of increased runoff rates from the Derrybrien wind farm site are insignificant in respect to flows and flood levels at these downstream receptors.

The estimated change using the FSU Equation peak flow to Lough Cutra under an increase from high to very high runoff category lands achieved by reducing the BFI (baseflow index) in the FSU flood estimation equation is an increase of 0.58% in peak flood rate, increasing the annual maximum hydrograph peak (Qmed) from 31.07 m3/s to 31.25 m^3/s. In the Boleyneendorrish catchment the impact of the wind farm Project on peak downstream fluvial flood rate at Cloonbeg will be an increase of 0.28% in peak flood rate, increasing the annual maximum hydrograph peak (Qmed) from 16.14 m^3/s to 16.19 m^3/s. The estimated potential increases in flood flow peak of 0.58% and 0.28% in the downstream reaches of these catchments is considered minor in the context of downstream flooding and will have no perceptible impact on flood levels and duration of flooding. The Derrybrien Wind Farm does not change the overall flood volume discharging from the site which is the critical factor for flooding in the downstream Gort Lowlands area.

The decommissioning proposal for the Windfarm site is to retain the drainage network but not to maintain it post decommissioning, allowing it over time to naturally infill and become more vegetated and gradually less effective in respect to water table lowering in the surrounding peat. Similarly the pipe culverts under the access tracks will remain. Over time the drainage performance at the wind farm site is expected to gradually reduce resulting in slightly lower peak runoff rates and slightly higher groundwater levels on the site.

The four number rock barrages that were constructed as emergency works during the peat slippage in 2003 to stabilise the area and protect downstream lands and receiving watercourses are to be left in place as their retention does not result in any significant residual negative impact on flooding, whereas their removal could result in significant impact in respect to land disturbance and the potential for sediment and peat runoff into the downstream watercourses. The upper Barrages no's 1 and 2 are considered important for peat stability along this slip pathway.

Options of attenuating and slowing the flow on the Derrybrien wind farm site through damming drains so as to achieve pre-existing greenfield runoff rates or lower will be of little benefit with respect to reducing downstream flooding at critical flood locations near Lough Cutra and in the downstream Gort Lowlands area. This measure would potentially only delay the onset of flooding by a matter of hours, whereas the downstream flooding occurs over days, weeks and months. Critical to the Gort Lowlands flooding is the total flood volume generated as opposed to the peak flow rates and as such the rainfall volume falling on the upland catchment will make its way to the Gort Lowlands area where it naturally stores until such time that it can empty to the sea via the groundwater system. The Gort Lowlands area acts as the natural floodplain and provides essential flood storage that protects surrounding and downstream lands from more serious flooding.

There is limited opportunity for flood risk management measures at the Derrybrien wind farm site. Such measures if applicable would involve slowing the flow through the provision of on-site flood storage attenuation through creating engineered attenuation reservoirs/dams and through damming drains. Such on-site attenuation measures would be ineffective given the nature of the flood risk in the downstream catchments which are caused by prolonged winter rainfall which is flood volume rather than flood rate sensitive. Attenuation is only effective for short duration events of hours as opposed to weeks. Over a prolonged flood period of weeks the same volume would be transmitted from the site with or without attenuation measures and therefore would have no perceptible effect on flooding in the critical Gort Lowlands area. Whether the site is a wind farm, forestry, cutaway bog or an upland blanket bog the same flood volume over a prolonged wet winter flood period would be generated and released downstream to Lough Cutra in the Owendalulleegh River and to Thoor Ballylee in the Ballycahalan. It also is important to note that construction of large reservoirs on the Derrybrien wind farm site or the blocking of the primary trunk drains could pose an unacceptable geotechnical peat stability risk with respect to future land slides.

The increased frequency of flooding in recent decades (i.e. commencing 1989/90 onwards) that has been witnessed in the downstream Gort Lowlands area is due to Meteorological factors of increased frequency and magnitude of prolonged winter rainfall events (critical duration four to eight weeks). Prior to the 1990s rainfall records show that the preceding decades of the 1960s, 1970s and 1980s were benign in comparison. There is no evidence to suggest that development of the wind farm in 2003 onwards is responsible for increased

flooding in the downstream Gort Lowlands areas. The scale of the Gort Lowlands catchment relative to the Derrybrien wind farm site at less than 1% logically suggests minimal impact this is further reinforced given that the site prior to the wind farm Project was already a drained site for forestry and turbary extraction.

8. Conclusions

The flooding in the downstream Gort Lowlands area and in the lower reaches of the Owendalulleegh and Boleyneendorrish Rivers is produced by extreme prolonged rainfall events being more a function of the flood volume generated by direct recharge to karst limestone basins and indirect fluvial flow off the upland impervious sandstone catchments of the Slieve Aughty Mountains. The flooding in these downstream reaches and the Gort Lowlands area is not overly sensitive to the speed of the runoff from the mountains as the turloughs and wide floodplain areas and Lough Cutra itself provide large natural flood storage that attenuate the runoff hydrograph over many days and weeks as opposed to hours.

It is clear from the flooding history that these lowland turlough areas have suffered more extreme flooding events from 1990 onwards with no significant flooding identified in the previous 50 years (rainfall analysis by Southern Global Water, 1997). The cause of this is meteorological with the recent three decades producing a number of extreme and prolonged winter rainfall events in comparison to a relatively benign rainfall/flood period in the 1950s, 1960s, 1970s and 1980s. In other large winter-flood dominated catchments such as the River Shannon, in which records go back to the 1930s, the same flood pattern can be observed with more extreme flood events favouring the more recent three decades. For instance, the largest inflows from Lough Derg to the Lower Shannon since the Shannon Scheme commenced operation in 1929 have occurred during the 2009, 2015/16 and 2020 floods.

Flood relief solutions for the Gort Lowlands are being progressed by OPW and Galway Co. Council through their consultants Ryan Hanley to protect vulnerable properties, farmyards, communities and roads in the Gort Lowlands area. The preferred flood relief options is to reduce turlough levels to specific target levels through engineering overland spill channels between turloughs until eventually reaching the sea at Dungory Kinvara. Currently the Gort Lowlands Flood Relief Scheme is completing its environmental impact assessments and a planning application is expected in 2025.

In the case of Derrybrien, the former land use on the wind farm site was primarily commercial forestry and turbary which represents a drained bog situation and given it upland nature and gradients represents high flood runoff category land. The wind farm project introduced additional drainage and also maintained a number of the existing turbary drains. The drainage solution for the wind farm was not designed to extensively lower the water table level but

focused on collecting and conveying surface water runoff away from the turbine bases and therefore for the scale of the 344-ha site the improved drainage does not represent a substantial network of drainage channels over its former forestry and turbary uses. The removal of trees from the site has enabled the peatland vegetation to re-establish throughout the site and with some evidence of slow regeneration of blanket bog habitat on the site, refer to ecology assessment. Overall it is considered that the wind farm Project through its drainage has increased the flood runoff rate over its former forestry and turbary uses from a high runoff category to a very high runoff category site. The effect of this on receiving surface water flood flows is assessed to be slight locally with the effect rapidly diminishing downgradient with increasing river catchment such that by the time it reaches flood affected areas at Derreen and Drummin, Lough Cutra and the Thoor Ballylee floodplain areas from the respective Owendalulleegh and Boleyneendorrish Rivers it is insignificant. The increased runoff rate by the Windfarm during its operation phase and pre-decommissioning is insignificant in respect to flooding and flood risk. The proposed decommissioning of the windfarm site, the OHL and the Agannygal Substation will not negatively impact flooding and flood risk in the downstream reaches.

The drainage network at the windfarm site is to be retained but not maintained post decommissioning and is expected over time (many years) to become less effective resulting in potential for slightly lower peak flood runoff rates from the 344ha site. The effect of this on downstream flooding in the lower reaches of the Owendalulleegh and Boleyneendorrish Rivers and the Gort Lowland area is expected to be imperceptible. The proposal to retain the rock barrages installed as emergency works in 2003 during the Derrybrien peat spill have no implications for causing any negative impact on downstream flooding or flood risk.

Attenuation at the site, located at the mountain top, through physical blockage of drains or the construction of pond areas etc. is not recommended given the limited effect it would have on downstream flooding and more critically due to the potential for increased peak stability risk and uncontrolled consequences by blocking such drains. The proposed decommissioning works for the OHL and Agannygal Substation will not impact flooding or flood risk locally or downstream.

References

Daly D (1985) “Groundwater in County Galway with particular reference to its protection from pollution.”, Geological Survey of Ireland report for Galway County Council.

Daly D (1992) “A report on the flooding in the Gort-Ardrahan area.” Geological Survey of Ireland, 209pp.

Drew D.P. and Daly D. (1993) “Groundwater and karstification in mid-Galway, South Mayo and North Clare”, Dept of Transport Energy and communications, ISBN 0790-0279.

EPA Hydronet Resource – www.epa.ie/hydronet/#29071GSI (2020) https://www.gsi.ie/en-ie/data-and-maps/Pages/Groundwater.aspx#KarstFeaturesGSI (2019) “Maximum Historical Groundwater Flooding Extents” Shape files for the Gort Lowlands Catchment.

Jennings O’Donovan (2011) “Review of the South Galway Flood Study Report- Engineering proposals for the reinstatement of culverts on the N18 and the Provision of New culverts on Minor Roads at Kiltartan, - Feasibility of an overland Channel from Coole to Kinvara”, report to OPW Jan 2011.

McCormack T. and Naughton O. (2016) “Groundwater Flooding in the Gort Lowlands”, GSI Newsletter, 2016.

Met Eireann (2020) https://www.met.ie/cms/assets/uploads/2018/07/IE_AAR_8110_V1.txt

Morrissey P, Gill L, Naughton O., McCormack T. and Johnston P. (2018) “Groundwater flood modelling in the karst lowlands of South Galway.”

NERC 1975 “Flood Studies Report” Vol 1 to 5, Natural Environmental Research Council, London.

OPW (1994) “Report on Flooding in South Galway in 1994” OPW Engineering Services, May 1994.

Ryan Hanley (2019/2020) “ Personal Communication regarding the South Galway (Gort Lowlands) Flood Relief Scheme” 2019/2020.

Southern Water Global and Jennings & O’Donovan (1997) “An Investigation of the Flooding Problems in the Gort-Ardrahan area of South Galway – Final Report. Vol 1 to 3.”, OPW?, April 1997.

Trinity College (2018) “Land use changes, flood alleviation options and the associated impacts on a lowland karst catchment in Western Ireland” technical Report for the Gort Lowlands Flood Relief Scheme, by P. Morrissey, Trinity College (2018).

Walsh S. (2010). “Report on Rainfall of November 2009”, Met Eireann, Dublin Ireland.

APPENDIX 10-1

CLIMATE LEGISLATION POLICY AND GUIDANCE

1. CLIMATE LEGISLATION POLICY AND GUIDANCE

Although variation in climate is thought to be a natural process, the rate at which the climate is changing has been accelerated rapidly by human activities. Climate change is one of the most challenging global issues facing the world today and is primarily the result of increased levels of greenhouse gases in the atmosphere. Increasing human emissions of carbon dioxide and other greenhouse gases cause a positive radiative imbalance at the top of the atmosphere, meaning energy is being trapped within the climate system. The imbalance leads to an accumulation of energy in the Earth system in the form of heat that is driving global warming.[1,2] Greenhouse gases come primarily from the combustion of fossil fuels in energy use.

In March 2023 the European Environment Agency (EEA) published the European Climate Risk Assessment.[3] This assessment states that Europe is the fastest warming continent on the planet and is warming at about the twice the global rate. The average global temperature in the 12-month period between February 2023 and January 2024 exceeding pre-industrial levels by 1.5°C. 2023 was the warmest year on record over more than 100,000 years globally, at 1.48°C above pre-industrial levels, with the world's ocean temperature also reaching new heights.

The Intergovernmental Panel on Climate Change (IPCC), in their AR6 Synthesis Report: Climate Change 2023[4], state that widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred. This has led to widespread adverse impacts and related losses and damages to people and nature due to the pressures of climate change and the inability to adapt to a rapidly changing environment. Moving away from our reliance on coal, oil and other fossil fuel-driven power plants is essential to reduce emissions of greenhouse gases and mitigate the human activity catalysing climate change.

1.1.1 International Greenhouse Gas Emission and Climate Targets

Globally, governance relating to climate change has changed significantly since 1994 when the United Nations Framework Convention on Climate Change (UNFCCC) entered into force. Greenhouse gas emissions have been a primary focus of climate related international agreements for almost two decades.

International greenhouse gas emission and climate targets play an important role in stimulating and enabling action for developed and developing nations. The following sections provide an overview of the international agreements that have played key roles in establishing climate governance.

1.1.1.1 Kyoto Protocol

The Kyoto Protocol was adopted on 11 December 1997; this Protocol operationalised the UNFCCC and was the first international agreement that committed countries to reduce their greenhouse gas emissions. It set limitations and reduction targets for greenhouse gases for developed countries (Annex I countries) and set a special obligation for certain countries to provide financial resources and facilitate

[1] *Hansen, J.; Sato, M.; Kharecha, P. et al. Earth's Energy Imbalance and Implications. Atmospheric Chemistry and Physics 2011, 11 (24), 13421–13449.* https://doi.org/10.5194/acp-11-13421-2011

[2] *von Schuckmann, K.; Palmer, M. D.; Trenberth, K. E. et al. An Imperative to Monitor Earth's Energy Imbalance. Nature Clim Change 2016, 6 (2), 138–144.* https://doi.org/10.1038/nclimate2876.

[3] *European Environment Agency (2023) European Climate Risk Assessment* <https://climate-adapt.eea.europa.eu/en/eu-adaptation-policy/key-eu-actions/climate_risk_assessment/index_html/>

[4] *IPCC AR6 Synthesis Report: Climate Change 2023.* https://www.ipcc.ch/report/sixth-assessment-report-cycle/

technology transfer to developing countries (Annex II countries). The EU, and therefore Ireland, was both an Annex I and Annex II country.

The Kyoto Protocol came into effect in 2005, as a result of which, emission reduction targets agreed by developed countries, including Ireland, became binding for the first time.

Under the Kyoto Protocol, the EU agreed to achieve a significant reduction in total greenhouse gas emissions in the period 2008 to 2012. These EU emission targets are legally binding in Ireland. Ireland's contribution to the EU commitment for the period 2008 – 2012 (the first commitment period) was to limit its greenhouse gas emissions to no more than 13% above 1990 levels. Ireland achieved its Kyoto Protocol targets under the EU burden-sharing agreement.

1.1.1.1.1 *Doha Amendment to the Kyoto Protocol*

In Doha, Qatar, on 8th December 2012, the "Doha Amendment to the Kyoto Protocol" was adopted. The amendment includes:

- New commitments for Annex I Parties to the Kyoto Protocol who agreed to take on commitments in a second commitment period from 1 January 2013 to 31 December 2020;
  - The amendment entered into force on 31 December 2020
- A revised list of greenhouse gases to be reported on by Parties in the second commitment period; and
- Amendments to several articles of the Kyoto Protocol which specifically referenced issues pertaining to the first commitment period and which needed to be updated for the second commitment period.

During the first commitment period, 37 industrialised countries and the European Community committed to reduce greenhouse gases emissions to an average of 5% below 1990 levels. During the second commitment period, Parties committed to reduce greenhouse gases emissions by at least 18% below 1990 levels in the eight-year period from 2013 to 2020. The composition of Parties in the second commitment period is different from the first; however, Ireland and the EU signed up to both the first and second commitment periods. Under the protocol, countries must meet their targets primarily through national measures, although market-based mechanisms (such as international emissions trading) can also be utilised.

Although the 1997 Kyoto Protocol and 2012 Doha Amendment were in force in 2020, the 2015 Paris Agreement superseded the Kyoto Protocol as the principle regulatory instrument governing the global response to climate change.

1.1.1.2 Conference of the Parties

Every year since 1995, the Conference of the Parties (COP) has gathered the 196 Parties (195 countries and the European Union) that have ratified the Convention in a different country, to evaluate its implementation and negotiate new commitments, and is the supreme decision-making body of the UNFCCC.

The following details the most significant COPs in terms of impact on climate action as well as a summary of the most recent COP, COP28, which took place in Dubai.

1.1.1.2.1 *COP21 Paris Agreement*

COP21 was the 21st session of the COP to the UNFCCC. COP21 was organised by the United Nations in Paris and held from 30th November to 12th December 2015.

COP21 closed on 12th December 2015 with the adoption of the first international climate agreement (concluded by 195 countries and applicable to all). The twelve-page text, made up of a preamble and 29 articles, provides for a limitation of the temperature rise to below 2°C above pre-industrial levels and even to tend towards 1.5°C. It is flexible and takes into account the needs and capacities of each country. It is balanced as regards adaptation and mitigation, and durable, with a periodical ratcheting-up of ambitions.

1.1.1.2.2 COP25 Climate Change Conference- Madrid

The 25th United Nations Climate Change conference COP25 was held in Madrid and ran from December 2nd to December 13th, 2019. While largely regarded as an unsuccessful conference, the European Union launched its most ambitious plan, 'The European Green New Deal' which aims to lower CO_2 emissions to zero by 2050. The deal includes proposals to reduce emissions from the transport, agriculture and energy sectors and will affect the technology, chemicals, textiles, cement, and steel industries. Measures such as fines and pay-outs by member states who rely on coal power will be in place to encourage the switch to renewable clean energies such as wind. On the 4th of March 2020, the European Commission put forward the proposal for a European climate law. This aims to establish the framework for achieving EU climate neutrality. It aims to provide a direction by setting a pathway to climate neutrality and to this end, aims to set in legislation the EU's 2050 climate-neutrality objective.

1.1.1.2.3 COP28 Climate Change Conference – Dubai

The 28th COP for the UNFCCC (COP28) took place in Dubai from the 30th of November 2023 to the 13th of December 2023.

COP28 resulted in a landmark deal to 'transition away' from fossil fuels, the UAE Consensus. The agreement calls for 'transitioning away from fossil fuels in energy systems, in a just, orderly, and equitable manner.' This is the first time in 28 years that fossil fuels have been mentioned in a COP outcome. However, it is noted that the text of 'phase out as soon as possible inefficient fossil fuel subsidies' does not address energy poverty or the just transition. The UAE Consensus also calls for more explicit near-term goals in the lead up to 2050, calling for the world to cut greenhouse gas emissions by 43% by 2030 as compared to 2019 levels. However, many island states have criticised that despite the text being an improvement over previous agreements, there is a litany of loopholes that will enable destructive environmental practices to continue and do not assuage their concerns over rising sea levels and other climate change impacts.

COP28 concluded the first ever Global Stocktake under the Paris Agreement. The Global Stocktake recognises that the world is not on track to meet 1.5°C and will require Parties to align their national targets and measures with the Paris Agreement. Parties have two years to submit their Nationally Determined Contributions for 2035, these need to be aligned with the best available science and the outcomes of the Global Stocktake.

An unusual aspect that came out of COP28 in the final hours of discussion was the number of decisions and documents which remain unfinished and not signed off. Notably, discussions on carbon markets collapsed in the final days of COP28 as no consensus could be reached on the country-to-country trading regimes or rules for the market in relation to Article 6 of the Paris Agreement. Negotiations will be continued at COP29 in Azerbaijan.

1.1.1.2.4 COP29 Climate Change Conference – Azerbaijan

The 29th COP of the UNFCCC, (COP29), held in Baku, Azerbaijan, from November 11th 2024 to November 22nd 2024.

COP29 focused on accelerating global efforts to address climate change, in particular global efforts related to climate finance. The New Collective Quantified Goal on Climate Finance (NCQG) was

agreed in the final days of COP; while developing countries advocated for at least USD 1 trillion annually by 2035, developed nations agreed to triples finance to developing countries, with commitments increasing from USD 100 billion annually to USD 300 billion annually by 2035. The NCQG has already drawn criticism for being inadequate given the global financial need of developing nations to mitigate and adapt to climate change effects and due to its lack of strong terminology in relation to the requirements of developed nations and detailed implementation strategies.

At COP29, significant progress was made in the discussions surrounding carbon markets, with nearly 200 nations agreeing on critical rules under Article 6 of the Paris Agreement. These rules aim to establish an UN-backed international carbon market. The adoption of these rules is seen as a crucial step towards operationalising a robust and credible carbon market. Despite the advances, concerns were expressed about the potential for weak governance and risks of exploitation in the system; these issues must be addressed to ensure the market's full functionality.

Energy transition discussions focused on accelerating the global shift toward sustainable energy systems, aligned with the Paris Agreement goals of limiting warming to 1.5°C. The conference emphasized the need for robust policies to phase out coal, expand renewable energy infrastructure, and develop green hydrogen as a low-carbon alternative for hard-to-electrify sectors.

COP29 operationalized the Fund for responding to Loss and Damage ('the Fund') with $50 billion in initial pledges aimed at assisting vulnerable countries. The Fund is expected to begin financing initiatives by 2025, focusing on the most vulnerable populations facing extreme weather events and slow-onset climate impacts. Despite these advancements, ongoing discussions are required to define the Fund's vision, scope, and integration with existing climate finance mechanisms.

1.1.1.3 United Nations Sustainable Development Goals Report

Transforming our World: the 2030 Agenda for Sustainable Development which includes 17 Sustainable Development Goals (SDGs), and 169 targets was adopted by all UN Member States at a UN summit held in New York in 2015. The agenda is universally applicable with all countries having a shared responsibility to achieve the goals and targets which came into effect on January 1st, 2016. The goals and targets are to be actions over the 15-year period, are integrated and indivisible i.e., all must be implemented together by each Member State.

On the 28th of June 2024, the United Nations published '*The Sustainable Development Goals Report 2024*'[5] (hereafter referred to as the UN SDG 2024 Report) highlighting how the lasting impacts of the COVID-19 pandemic, the war in Ukraine, ongoing and escalating geopolitical conflicts, and the increasing consequences of the climate crisis have hindered the achievement of the SDGs. The UN SDG 2024 Report finds that, following an assessment of all 169 targets, for which trend data is available, only 17% of the SDG targets are on track, 48% of SDG targets are showing minimum or moderate progress, 18% having stalled in progress and 17% having regressed from 2023. The UN SDG 2024 Report highlights the urgent need for stronger and more effective international cooperation to maximize progress, with immediate effect.

On the 17th of June 2024 the Dublin University Press published the *'Sustainable Development Report 2024'*.[6] The report highlights five key findings:

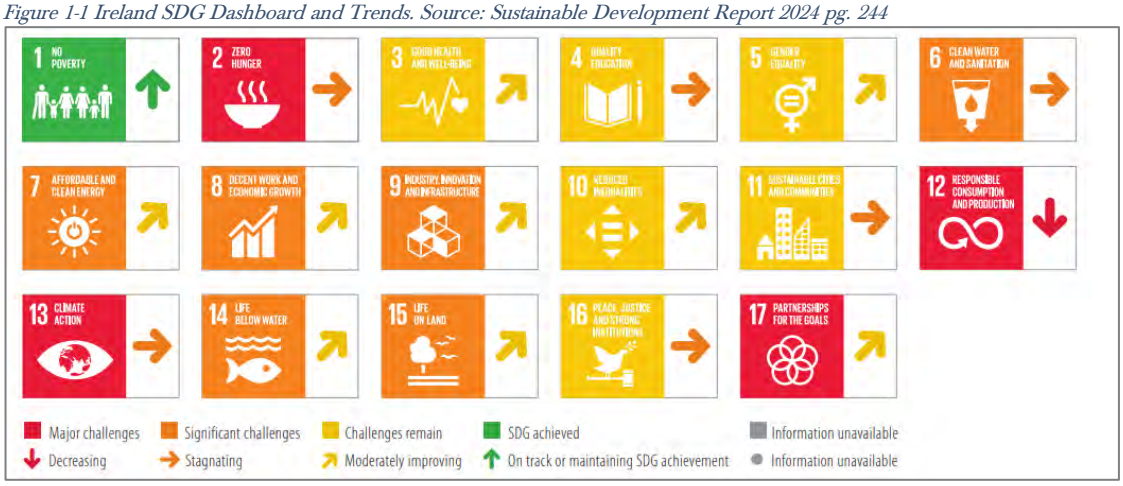
- On average, only 16% of the SDG targets are on track to be met globally by 2030, with the remaining 84% showing limited progress or a reversal of progress.
  - At the global level, SDG progress has been stagnant since 2020.
- The pace of SDG progress varies significantly across country groups.

[5] *The Sustainable Development Goals Report (2024). Available at: https://unstats.un.org/sdgs/report/2024/*
[6] *Dublin University Press (2024) Sustainable Development Report 2024 The SDGs and the UN Summit of the Future Includes the SDG Index and Dashboards. <https://s3.amazonaws.com/sustainabledevelopment.report/2024/sustainable-development-report-2024.pdf>*

- As in previous years, European countries – notably the Nordic countries – top the 2024 SDG Index.

- Sustainable development remains a long-term investment challenge. Reforming global financial architecture is more urgent than ever. The world requires many essential public goods that far transcend the nation-state.
- Global challenges require global cooperation.
  - The report's new Index of support to UN-based multilateralism ranks countries based on their engagement with the UN system – including treaty ratification, votes at the UN General Assembly, membership in UN organisations, participation in conflicts and militarisation, use of unilateral sanctions, and financial contributions to the United Nations.
    - Ireland is ranked 28/167 with an overall country score of 78.7/100 (this is higher than the regional average 77.2); please see Figure 9-1 below for a detailed breakdown of Irelands SDG trends for each goal.
- The SDG targets related to food and land systems are particularly off-track.
  - Greenhouse gas emissions from agriculture, forestry, and other land use account for almost a quarter of total annual global GHG emissions.
  - The Food, Agriculture, Biodiversity, Land-Use, and Energy (FABLE) Consortium determined a "global sustainability" pathway which would avoid up to 100 million hectares of deforestation by 2030 and 100 gigatons of CO_2 emissions by 2050.

Figure 1-1 Ireland SDG Dashboard and Trends. Source: Sustainable Development Report 2024 pg. 244



In October 2022 the Department of Communications, Climate Action & Environment in partnerships with all Government Departments, key stakeholders, and based on input from two public consultation processes published the Sustainable Development Goals National Implementation Plan 2022-2024 ('the SDG Plan').[7] The SDG Plan identifies that, overall, the world is not on track to achieve the global Goals by 2030. The SDG Plan sets out how Ireland will work to achieve the goals and targets of the Agenda for Sustainable Development both domestically and internationally. Irelands first National Implementation Plan provided a framework for Ireland to work towards the implementation of the SDGs; the SDG Plan aims to build on the structures and mechanisms from the first National Implementation Plan and to develop and integrate additional approaches in areas identified as requiring further action.

In September 2023, the UN Summit on the SDGs took place in New York and was co-facilitated by Ireland and Qatar. Representing the halfway mark to achieving the SDGs by 2030, it marked the

[7] *National Implementation Plan for the Sustainable Development Goals 2022-2024. Available at:* <https://www.gov.ie/en/publication/e950f-national-implementation-plan-for-the-sustainable-development-goals-2022-2024/>

beginning of a new phase of accelerated progress towards the SDGs with high-level political guidance on transformative and accelerated actions. The Global Sustainable Development Report 2023[8] was published in September 2023. The previous Global Sustainable Development Report (2019[9]) found that for some targets the global community was on track, but for many others the world would need to quicken the pace. In 2023, the situation is much more worrisome owing to slow implementation and a confluence of crises. The 2023 Report goes on to highlight the current standing of each SDG and its relevant indicators. A 2023 UN Special Report[10] found that over 30% of the SDGs have seen either no improvement or reverse trends in progress. The push for transformation to achieve the SDGs will come through shifts in six key entry points:

1. *Human Well Being and Capabilities*
2. *Sustainable and Just Economies*
3. *Food Systems and Healthy Nutrition*
4. *Energy Decarbonisation with Universal Access*
5. *Urban and Peri-Urban Development*
6. *Global Environmental Commons*

The Proposed Project will contribute to Entry Point 4 due to the clean and renewable energy it will provide over its operational life. The phase out of fossil fuels in a manner that is globally and domestically just, while strengthening the transition to renewables by increasing energy efficiency and encouraging behavioural change will be key to achieving the relevant SDGs to the Proposed Development.

Relevant SDGs to the Proposed Project and how they are implemented into Irish National plans and policies can be found in Table 1 below.

[8] *Global Sustainable Development Report 2023* <https://sdgs.un.org/sites/default/files/2023-09/FINAL%20GSDR%202023-Digital%20-110923_1.pdf>

[9] *Global Sustainable Development Report 2019* <https://sdgs.un.org/sites/default/files/2020-07/24797GSDR_report_2019.pdf>

[10] *The Sustainable Development Goals Report 2023: Special Edition* <https://unstats.un.org/sdgs/report/2023/The-Sustainable-Development-Goals-Report-2023.pdf>

Table 1 Sustainable Development Goals Report 2023, Relevant SDGs to the Proposed Development, and Implementation into Irish National Plans

SDG	Targets	International Progress/Downfalls to Date (2024)[11]	National Relevant Policy
SDG 7 Affordable and Clean Energy: *Ensure access to affordable, reliable, sustainable and modern energy for all*	› By 2030, ensure universal access to affordable, reliable and modern energy services › By 2030, increase substantially the share of renewable energy in the global energy mix › By 2030, double the global rate of improvement in energy efficiency › By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology › By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support	In 2022, global electricity access declined for the first time in a decade, primarily due to disruptions from COVID-19 and the Ukraine conflict. Despite improvements in energy intensity and renewable energy growth, international financial flows for clean energy in developing countries remain insufficient. At the current rate, 660 million people will still lack electricity and 1.8 billion will not have access to clean cooking by 2030. To achieve universal access to energy by 2030, we need to expedite electrification efforts, boost investments in renewable energy, enhance energy efficiency, and establish supportive policies and regulatory frameworks. In 2021 the global share of renewable sources in total final energy consumption stood at 18.7%. Excluding traditional use of biomass, the share of modern renewable sources rose gradually from 10% in 2015 to 12.5% in 2021. The electricity sector led the charge with renewables, contributing 28.2% to total final electricity consumption. However, insufficient progress in the heat and transport sectors underscores the need for stronger conservation measures and policy actions. Tripling world's installed renewable energy generation agreed at the COP28 is an important step aligning with the SDG7. Installed renewable energy capacity is on the rise worldwide, reaching 424 watts per person globally in 2022. Developed nations averaged 1,073 watts per person, while developing countries averaged 293 watts per person. This represents an 8.5% increase from 2021, maintaining a steady compound annual growth rate of 8.1% over five-year periods.	*Ireland's Transition to a Low Carbon Energy Future 2015-2030;* *Energy Poverty Action Plan;* *Ireland's Transition to a Low Carbon Energy Future 2015- 2030;* *National Mitigation Plan;* *National Energy Efficiency Action Plan;* *One World, One Future;* *The Global Island* *Economic Recovery Plan* *Project Ireland 2040: National Planning Framework;* *Project 2040;* *National Development Plan 2021-2030;* *Climate Action Plan 2024*
SDG 9: Industry, Innovation, and Infrastructure *Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation*	› Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all. › Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries	Since 2022, the manufacturing sector has faced stagnation, attributed to geopolitical instability, inflation, logistical challenges, rising energy costs, and a broader global economic slowdown. Globally, manufacturing's share in employment has regressed. While there has been progress in reducing CO2 intensity in manufacturing, it falls short of 2030 target values. To expedite progress towards SDG 9, efforts should prioritize accelerating the green transition, strategically prioritizing sectors, and addressing inequalities in digital and innovation sectors. The manufacturing sector rebounded strongly in 2021 post-COVID, but growth has plateaued at around 2.7% since 2022, expected to continue in 2024. Despite	*National Development Plan 2021-2030;* *National Economic Recovery Plan;* *Climate Action Plan 2024;* *National Implementation Plan on Persistent Organic Pollutants;* *Waste Action Plan for a Circular Economy;* *National Waste Prevention Programme;* *A Better World*

[11] *United Nations, the 17 Goals – Sustainable Development* <https://sdgs.un.org/goals>

SDG	Targets	International Progress/Downfalls to Date (2024)[11]	National Relevant Policy
	› Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities	this, global manufacturing value added per capita rose by 16% from 2015 to 2023, reaching $1,922 per capita. Regional gaps are stark, with Europe and Northern America hitting a record $4,986 per capita, contrasting with stagnant levels of $163 in sub-Saharan Africa. Since 2015, global manufacturing employment has fluctuated. Starting at 14.3% in 2015, it dipped to 14.2% in 2020 but saw a marginal recovery in 2021. However, by 2022, it declined to 14.1%, with notable regional disparities.	
SDG 11: Sustainable Cities and Communities *Make cities and human settlements inclusive, safe, resilient and sustainable*	› By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums › By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons › Strengthen efforts to protect and safeguard the world's cultural and natural heritage › By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management › By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement holistic disaster risk management at all levels	More than half the world's population currently reside in cities. However, cities are grappling with a multitude of complex issues, made more difficult by rising global urban poverty levels in the wake of COVID-19. From rising slum populations, insufficient public transport, city expansion outpacing population growth to threats to critical infrastructure and disruption of basic services by disasters, it is essential that cities are equipped to adequately handle these challenges. As the world turns more urban, with nearly 70% of the global population projected to reside in cities by 2050, critical infrastructure, affordable housing, efficient transport and essential social services are crucial for creating resilient, sustainable cities for all. On average, 104,049 critical infrastructure units and facilities were destroyed or damaged by disasters annually from 2015 to 2022. Furthermore, disasters disrupted over 1.6 million basic services, including educational and health services, each year. A comparison of air pollution five-year average before and after the development of the SDGs showed a significant decrease of 9% in fine particulate matter global levels and current alignment with the WHO Air Quality Guideline (AQG) Interim Target 1 value of 35 ug/m3.	*Rebuilding Ireland Action Plan for Housing and Homelessness;* *Housing for All;* *EU Regulation 1370/2007 on Public Passenger Transport Services by Rail and by Road;* *Project Ireland 2040 National Planning Framework;* *National Clean Air Strategy;* *Rural Development Programme 2014-2022;* *National Implementation Plan on Persistent Organic Pollutants;* *Waste Action Plan for a Circular Economy;* *National Waste Prevention Programme;* *A Better World*
SDG 12 Responsible Consumption and production: *Ensure sustainable consumption and production patterns.*	› By 2030, achieve the sustainable management and efficient use of natural resources. › By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment	Unsustainable patterns of consumption and production are the root cause of the triple planetary crisis: 1. *Climate Change* 2. *Biodiversity Loss* 3. *Pollution*	*National Implementation Plan on Persistent Organic Pollutants;* *Waste Action Plan for a Circular Economy;* *National Waste Prevention Programme;* *Climate Action Plan 2024* *Tourism Action Plan;* *National Clean Air Strategy;*

SDG	Targets	International Progress/Downfalls to Date (2024)[11]	National Relevant Policy
	› Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle › Promote public procurement practices that are sustainable, in accordance with national policies and priorities. › Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products	The world is seriously off track in its effort to halve per-capita food waste and losses by 2030. While countries are fulfilling their environmental agreement obligations and embracing comprehensive approaches to address environmental degradation, public funding supporting the production and consumption of fossil fuels has more than tripled since 2015, impeding the transition to net-zero emissions. Each stage of production or manufacturing presents an opportunity to reduce resource and fossil fuel use, foster innovation, conserve energy, cut emissions, and advocate for a circular economy approach. From 2019 to 2023, one-third of member states (63 countries) have reported 516 policy instruments related to sustainable consumption and production. In 2021-2022, 73% of companies included in the sample published sustainability reports, with the number of companies tripling since 2016. This growth was observed in all regions in 2022. Fossil fuel subsidies hit a record high of $1.53 trillion in 2022, reversing the declining trend observed from 2012 to 2020. The post-COVID energy price surge inflated these subsidies, prompting some governments to introduce new support measures. Consequently, public funding for oil, coal, and gas production and consumption more than doubled from 2021 to 2022 and tripled since 2015, impeding progress towards net-zero transition.	*Towards Responsible Business: Ireland's Second National Plan on Corporate Social Responsibility (CSR) 2017-2020;* *Sustainable, Inclusive and Empowered Communities 2019-2024;* *Climate Action Plan 2024*
SDG 13 Climate Action: *Take urgent action to combat climate change and its impacts** **Acknowledging that the United Nations Framework Convention on Climate Change is the primary international, intergovernmental forum for negotiating the global response to climate change.*	› Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries › Integrate climate change measures into national policies, strategies and planning › Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	Climate records were shattered in 2023, with the world watching the climate crisis unfold in real time. Communities around the world are suffering the effects of extreme weather, which is destroying lives and livelihoods on a daily basis. The roadmap to limit the rise in global temperature to 1.5°C and avoid the worst of climate chaos cannot afford any delays, indecision or half measures by the global community. It demands immediate action for drastic reductions in global greenhouse gas emissions in this decade and the achievement of net zero by 2050. The number of disaster-related deaths and missing persons per 100,000 population (excluding COVID-19 deaths) has nearly halved from 1.62 in the decade 2005-2014 to 0.82 in 2013-2022. However, the absolute number remains high. Between 2013 and 2022, disasters worldwide claimed 42,553 mortalities each year. Further, the number of persons affected by disasters per 100,000 population has increased by over two-third, from 1,169 in 2005-2014 to 1,980 in 2013-2022. The year 2023 broke every single climate indicator and was the warmest year on record according to the World Meteorological Organization. Global	*National Adaptation Framework;* *Building on Recovery: Infrastructure and Capital Investment 2016-2021;* *National Mitigation Plan;* *National Biodiversity Action Plan 2017-2021;* *National Policy Position on Climate Action and Low Carbon Development;* *Project 2040: National Development Plan 2021-2030;* *Climate Action Plan 2024;* *National Dialogue on Climate Action;* *Agriculture, Forest, and Seafood Climate Change Sectoral Adaptation Plan;*

SDG	Targets	International Progress/Downfalls to Date (2024)[11]	National Relevant Policy
		temperatures rose to 1.45°C, dangerously close for the first time to the 1.5°C lower limit of the Paris Agreement on climate change. Despite some reduction in greenhouse gas emissions in developed countries, concentrations of greenhouse gases reached record high observed levels in 2022 and real-time data in 2023 show greenhouse gases continuing to increase. Carbon dioxide levels are 150% above pre-industrial levels. Climate finance, reported by Annex I Parties as support provided to developing countries, has increased at a compound rate of 5% from 2015 to 2020, amounting to $41 billion. Although there are a range of estimates and a lack of an agreed accounting methodology on the $100 billion per year goal, the goal was not yet met as of 2021. However, recent progress made in the provision and mobilization of climate finance amounted to $89.6 billion in 2021.	*The National Strategy on Education for Sustainable Development in Ireland*

1.1.1.4 Climate Change Performance Index 2025

Established in 2005, the Climate Change Performance Index (CCPI)[12] is an independent monitoring tool which tracks countries climate protection performance. It assesses individual countries based on climate policies, energy usage per capita, renewable energy implementation and greenhouse gas emissions and ranks their performance in each category and overall. The 2025 CCPI was published in December 2024. While the CCPI 2025 indicates signs of potential reductions in global emissions, no country achieved its Paris Climate targets and therefore the first three places of the ranking system remain unoccupied.

Ireland, ranked 43rd in 2024, has risen 14 places to 29th for 2025, and is now considered a 'medium' performer in international performance. The CCPI states that Ireland's policies are missing a long-term strategy for phasing out fossil fuel infrastructure and shifting investments from natural gas towards an emissions-neutral energy supply. Coupled with low levels of battery storage and ongoing gas connections, the state is set to remain greatly dependent on fossil fuel generation. Ireland has remained in the 'low' category in 2025 on the Greenhouse Gas Emissions ratings.

In 2022, Ireland's government introduced legally binding five-year carbon budgets and sectoral emissions ceilings. It also resolved a legislative framework with annually revised Climate Action Plans to align with the country's 2030 net emissions reduction target of 51% (compared with 2018 levels) and net zero by 2050. The CCPI national experts note that, despite these legal requirements, the policy implementation remains problematic. Recent EPA projections indicate that while considerable emissions decline in 2023 (6.8%) brought Ireland closer to achieving its first carbon budget, the lack of substantial progress makes it unlikely Ireland will meet its second carbon budget in 2026–2030.

The CCPI experts indicate an urgent need for port infrastructure and grid strengthening to ensure medium-to-long-term offshore wind expansion and heating and transport electrification. Coupled with low levels of battery storage and ongoing gas connections, the state is set to remain greatly dependent on fossil fuel generation.

Ireland has remained in the 'low' category in 2025 on the Greenhouse Gas Emissions ratings and has risen from 54th in 2024 to 40th in 2025. Ireland remains in the 'Medium' category in the Renewable Energy rating table and has risen from 31st in 2024 to 21st in 2025.

1.1.1.5 State of the Global Climate 2024

In November 2024, the World Meteorological Organisation (WMO) published a report entitled the '*State of the Global Climate 2024*.[13] This report provided a summary on the state of the climate indicators in 2023 with sections on key climate indicators, extreme events and impacts. The key messages in the report include:

- Greenhouse gases reached record observed levels in 2023. Real time data indicate that they continued to rise in 2024.
- January – September 2024 global mean surface air temperature was 1.54 ± 0.13°C above the pre-industrial average.

The State of the Global Climate report goes on to state that renewable energy generation, primarily driven by the dynamic forces of solar radiation, wind and the water cycle, has surged to the forefront of climate action for its potential to achieve decarbonization targets. There has been a substantial worldwide energy transition, with global renewable capacity expected to grow by 2.7 times by 2030, surpassing countries' current ambitions by nearly 25%, but it still falls short of tripling.[14] This growth represents the highest rate observed in the past two decades, signalling a significant momentum toward achieving the clean energy goal set at COP28 meeting in 2023 to triple renewable energy capacity globally to 11,000 GW by 2030.

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[12] *Climate Change Performance Index 2024* <https://ccpi.org/>

[13] *WMO (2024) State of the Global Climate 2024* < ttps://library.wmo.int/records/item/69075-state-of-the-climate-2024>

[14] *IEA (2024), Renewables 2023, IEA, Paris* <https://www.iea.org/reports/renewables-2024>

Alterations in the physical climate can trigger a series of repercussions on national advancement and the pursuit of SDGs (Section 1.1.3 above). The interconnections between the climate emergency and development pathways can foster synergistic endeavours, resulting in positive benefits for communities and human well-being (refer to Chapter 5 of this EIAR for more details). This synergy serves as a potent driver for adapt to climate change and lay the groundwork for the global energy transition. Emphasizing wind energy and other renewable sources enables the global energy transition towards sustainability.

1.1.1.6 European Green Deal

The European Green Deal was introduced by the European Commissioning in December 2019 as the EUs response to the Paris Agreement ambitions (COP21 (please see section 1.1.2.1 above)). The European Green Deal is a comprehensive package of policy initiatives aimed at achieving climate neutrality across the EU by 2050. It features a wide range of actions and targets in different sectors such as energy, transport, industry, environment and agriculture. The goal is to transform the EU into a resource-efficient, competitive circular economy that is fair and inclusive for every individual and region.

Key aspects of the European Green Deal include the adoption of the European Climate Law, which legally binds the EU to achieve net-zero emissions by 2050, and the establishment of a Carbon Border Adjustment Mechanism to prevent carbon leakage. Additionally, the Deal focuses on boosting green technologies, fostering clean energy, improving energy efficiency, and promoting biodiversity and sustainable agriculture.

To finance these ambitious goals, the European Green Deal is supported by the EU's Green Deal Investment Plan, also known as the "Just Transition Mechanism," which aims to mobilize at least €1 trillion in investments over the next decade. This funding will be used to help EU regions and industries transition to greener alternatives while mitigating social and economic impacts on communities and workers. The European Green Deal also emphasizes the importance of international collaboration in tackling climate change and aims to align European policies with the global agenda of the Paris Agreement.

In its approach to decarbonisation, the EU has split greenhouse gas emissions into two categories, the Emissions Trading System (ETS) and the non-ETS. Under the European Green Deal, the targets for the ETS and non-ETS sectors will be revised upwards in order to achieve the commitment, at EU level, to reach an economy-wide 2030 reduction in emissions of at least 55%, compared to 1990 levels.

1.1.1.7 Renewable Energy Directive

The Renewable Energy Directive (RED) is the legal framework for the development of clean energy across all sectors of the EU economy, supporting cooperation between EU countries towards this goal.

The first RED[15] is legislation that influenced the growth of renewable energy in the EU and Ireland for the decade ending in 2020. The directive set and confirmed mandatory national targets consistent with the EU's overall goal. It also required EU countries to develop indicative trajectories for achieving their targets, submit national renewable energy action plans and publish national renewable energy progress reports every two years.

In 2018, as part of the 'Clean Energy for all Europeans' package, the first revision of RED entered into force (the second Renewable Energy Directive (REDII)[16]) which continued to promote the growth of renewable energy out to 2030. REDII introduced a binding EU-wide target for overall RES of 32% in 2030 and requires Member States to set their national contributions to the EU-wide target. As per the National Energy and Climate Plan (NECP) 2021-2030, Ireland's overall RES target is 34.1% in 2030. This directive, which had to be transposed into national law by EU countries by June 2021, established a new binding renewable energy target for the EU of at least 32% of gross final energy consumption by 2030, along with an increased target of 14% for the share of renewable fuels in transport by 2030.

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[15] *Directive 2009/28/EC on the promotion of the use of energy from renewable sources. Available from: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:en:PDF*

[16] *Directive (EU) 2018/2001 on the promotion of the use of energy from renewable resources (recast). Available from: https://eurlex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32018L2001*

Under REDII, Ireland's National Energy and Climate Plan 2021-2030 included a planned renewable energy share in electricity (RES-E) of 70% in 2030, which has been replaced by the 80% by 2030 RES-E target as detailed in the most recent Climate Action Plan (2024).

Given the need to ratchet up the EUs clean energy transition, RED was revised in 2023, and the amending Directive EU/2023/2413 (REDIII)[17] entered into force on 20 November 2023. REDIII amended the EU-wide overall 2030 RES target from 32% to at least 42.5%, and it is assumed that Irelands 2030 RES target will increase accordingly. REDIII establishes the following sectoral and innovation targets for EU countries:

- In the industry sector, a binding target of 42% for renewable hydrogen in total hydrogen consumption by 2030 and 60% by 2035, with an indicative target of an annual average increase of 1.6 percentage points in renewable sources.
- In the buildings sector, an indicative target of 49% for the share of renewable energy by 2030, with heating and cooling targets to increase by 0.8 percentage points per year until 2025 and by 1.1 percentage points from 2026 to 2030.
- In the transport sector, either a 29% target for the share of renewable energy by 2030, or a 14.5% reduction of greenhouse gas emissions, through greater use of advanced biofuels and renewable fuels of non-biological origin (RFNBO), such as hydrogen.
- In research and innovation, an indicative target of 5% of newly installed renewable energy capacity from innovative technologies by 2030.

1.1.1.8 EU Effort Sharing Regulation

The EU Effort Sharing Regulation (ESR[18]) was adopted in 2018 and establishes annual binding greenhouse gas emissions targets from 2020 to 2030 for each Member State. In its approach to decarbonisation, the EU has split greenhouse gas emissions into two categories, the Emissions Trading System (ETS) and the non-ETS. Emissions from electricity generation and large industry in the ETS are subject to EU-wide targets which require that emissions from these sectors be reduced by 43% by 2030, relative to 2005 levels. Within the ETS, participants are required to purchase allowances for every tonne of emissions, with the amount of these allowances declining over time to ensure the required reduction of 43% in greenhouse gas emissions is achieved at EU-level[19]. Emissions from all other sectors, including buildings, agriculture, waste, small industry, and transport, which account for around 60% of EU emission, are covered by the EU ESR.

The EU ESR focus on national accountability helps drive climate action at the local level while maintaining flexibility to account for economic disparities across Member States.

Considerable progress has been made in the decarbonisation of the electricity sector, with emissions falling by 45% between 2001 and 2022.[20] The decarbonisation of the Electricity Sector has been made possible through the deployment of renewables and their successful integration into the national grid, further facilitating the decarbonisation other sectors, such as transport, heating and industry as they look towards electrification.

1.1.1.9 Council Regulation (EU) 2022/2577 and 2024/223

Arising from REPowerEU, Council Regulation (EU) 2022/2577 laying down a framework to accelerate the deployment of renewable energy was adopted on the 22 December 2022. Regulation 2022/2577 came into effect on the 23 December 2022 and has effect until the 30 June 2024. The Regulation made provision for a review by

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[17] *Directive (EU) 2023/2413 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources and repealing Council Directive (EU) 2015/652. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202302413*

[18] *Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013 (Text with EEA relevance)*

[19] *Department of the Environment, Climate and Communications (2023) - Climate Action Plan 2024 https://www.gov.ie/en/publication/79659-climate-action-plan-2024/*

[20] *Department of the Environment, Climate and Communications (2023) - Climate Action Plan 2024 https://www.gov.ie/en/publication/79659-climate-action-plan-2024/*

the commission within 12 months. Following this review the Council introduced Regulation 2024/223 on the 22 December 2023 amending Regulation 2022/2577. Regulation 2022/2577 and 2024/223 recognises the relative importance of renewable energy deployment in the current difficult energy context and provides significant policy and legislative support to enabling renewable energy projects.

Article 2(2) of Regulation EU 2022/2577 requires priority to be given to projects that are recognised as being of overriding public interest whenever the balancing of legal interests is required in individual cases and where those projects introduce additional compensation requirements for species protection. An analogous provision is not present in Directive (EU) 2018/2001. The first sentence of Article 3(2) of Regulation (EU) 2022/2577 has the potential, in the current urgent and still unstable energy situation on the energy market which the Union is facing, to further accelerate renewable energy projects since it requires Member States to promote those renewable energy projects by giving them priority when dealing with different conflicting interests beyond environmental matters in the context of Member States' planning and the permit-granting process. The Commission's report demonstrated the value of the first sentence of Article 3(2) of Regulation (EU) 2022/2577 which beyond the specific objectives of the derogations foreseen in the Directives referred to in Article 3(1) of Regulation (EU) 2022/2577. (emphasis added).

1.1.1.10 EU Nature Restoration Law

The Nature Restoration Law is the first continent-wide, comprehensive law of its kind. It is a key element of the EU Biodiversity Strategy, which sets binding targets to restore degraded ecosystems, in particular those with the most potential to capture and store carbon and to prevent and reduce the impact of natural disasters.

The law aims to restore ecosystems, habitats and species across the EU's land and sea areas in order to

- Enable the long-term and sustained recovery of biodiverse and resilient nature.
- Contribute to achieving the EU's climate mitigation and climate adaptation objectives.
- Meet international commitments.

The EU Nature Restoration Law was approved on June 17th 2024; EU countries are expected to submit National Restoration Plans to the Commission within two years of the Regulation coming into force (by mid-2026), showing how they will deliver on the targets. They will also be required to monitor and report on their progress.

Considerable progress has been made in the decarbonisation of the electricity sector, with emissions falling by 45% between 2001 and 2022.[21] The decarbonisation of the Electricity Sector has been made possible through the deployment of renewables and their successful integration into the national grid, further facilitating the decarbonisation other sectors, such as transport, heating and industry as they look towards electrification

1.2 National Greenhouse Gas Emission and Climate Targets

1.2.1 Programme for Government

The Programme for Government was published in October 2020 and last updated July 2021. In relation to climate change the programme recognises that the next ten years are a critical period in addressing the climate crisis. It is an ambition of the programme to more than halve carbon emissions over the course of the decade (2020-2030). The programme notes that the government are committed to reducing greenhouse gas emissions by an average 7% per annum over the next decade in a push to achieve a net zero emissions by the year 2050. The programme also recognises the severity of the climate challenge as it clarifies that:

> *"Climate change is the single greatest threat facing humanity".*

[21] *Department of the Environment, Climate and Communications (2023) - Climate Action Plan 2024* https://www.gov.ie/en/publication/79659-climate-action-plan-2024/

1.2.2 Climate Action and Low Carbon Development (Amendment) Act 2021

The Climate Action and Low Carbon (Amendment) Act 2021 is a piece of legislation which commits the country to move to a climate resilient and climate neutral economy by 2050. This was passed into law in July 2021.

The Programme for Government has committed to a 7% average yearly reduction in overall greenhouse gas emissions over the next decade, and to achieve net zero emissions by 2050. This Act will manage the implementation of a suite of policies to assist in achieving these annual targets.

The Act includes the following key elements, among others:

- Places on a statutory basis a 'national climate objective', which commits to pursue and achieve no later than 2050, the transition to a climate resilient, biodiversity-rich, environmentally sustainable and climate-neutral economy.
- Embeds the process of carbon budgeting into law, the Government are required to adopt a series of economy-wide five-year carbon budgets, including sectoral targets for each relevant sector, on a rolling 15-year basis, starting in 2021.
- Actions for each sector will be detailed in the Climate Action Plan, updated annually.
- A National Long Term Climate Action Strategy will be prepared every five years.
- Government Ministers will be responsible for achieving the legally binding targets for their own sectoral area with each Minister accounting for their performance towards sectoral targets and actions before an Oireachtas Committee each year.
- Strengthens the role of the Climate Change Advisory Council, tasking it with proposing carbon budgets to the Minister.

Provides that the first two five-year carbon budgets proposed by the Climate Change Advisory Council should equate to a total reduction of 51% emissions over the period to 2030, in line with the Programme for Government commitment.

1.2.3 Climate Change Advisory Council

The Climate Change Advisory Council (CCAC) was established on 18th January 2016 under the Climate Action and Low Carbon Development Act 2015. The CCAC aims to provide independent evidence-based advice and recommendations on policy to support Ireland's Just Transition to a biodiversity-rich, environmentally sustainable, climate-neutral, and resilient society.

In July 2023, the CCAC published the 2023 Annual Review[22], which is the seventh annual review carried out by CCAC and details the CCAC concerns that the necessary national actions are not taking place or being enabled at the required speed, going on to state that 'at the current rate of policy implementation, Ireland will not meet the targets set in the first and second carbon budget periods unless urgent action is taken immediately, and emissions begin to fall much more rapidly.'

In 2024 the CCAC has changed it approach to produce sector specific annual reviews in order to emphasise the requirement for greater effort across all sectors to remain within their sectoral emission ceiling. In a statement released on 9th July 2024 the CCAC state that while '*the provisional greenhouse gas emissions data published today by the EPA shows some positive results across the sectors but overall, it is increasingly unlikely that the first carbon budget will be achieved. Much more urgent action is required from Government if Ireland is to achieve its climate change objectives.*'[23]

[22] *Climate Change Advisory Council 2023 Review* <https://www.climatecouncil.ie/councilpublications/annualreviewandreport/CCAC-AR-2023-FINAL%20Compressed%20web.pdf>
[23] https://www.climatecouncil.ie/news/chairs-statement-irelands-provisional-greenhouse-gas-emissions-1990-2023.html

1.2.4 Carbon Budgets

The first national carbon budget programme proposed by the CCAC, approved by Government and adopted by both Houses of the Oireachtas in April 2022 comprises three successive 5-year carbon budgets. The total emissions allowed under each budget are shown in Table 10-15.

Table 1-2 Proposed Carbon Budgets of the Climate Change Advisory Council

	2021 – 2025 Carbon Budget 1	2026 – 2030 Carbon Budget 2	2031 – 2035 Provisional Carbon Budget 3
	All Gases		
Carbon Budget (Mt CO_2eq)	295	200	151
Annual Average Percentage Change in Emissions	-4.8%	-8.3%	-3.5%
The figures are consistent with emissions in 2018 of 68.3 Mt CO_2eq reducing to 33.5 Mt CO_2eq in 2030 thus allowing compliance with the 51% emissions reduction target by 2030			

1.2.5 Sectoral Emissions Ceilings

The Sectoral Emissions Ceilings were launched in September 2022. The objective of the initiative is to inform on the total amount of permitted greenhouse gas emissions that each sector of the Irish economy can produce during a specific time period. The Sectoral Emissions Ceilings alongside the annual published Climate Action Plan provide a detailed plan for taking decisive action to achieve a 51% reduction in overall greenhouse gas emissions by 2030.

Section C of the Climate Action and Low Carbon Development (Amendment) Act 2021 provides the minister with a method of preparing the Sectoral Emissions Ceiling within the bounds of the carbon budget. The Sectoral Emission Ceilings for each 5-year carbon budget period was approved by the government on the 28th of July 2022 and are shown in Table 10-16 below.

Table 1-3 Sectoral Emission Ceilings 2022

Sector	Sectoral Emission Ceilings for each 5-year carbon budget period (MtCO2eq.)	
	2021 – 2025 Carbon Budget 1	2026 – 2030 Carbon Budget 2
Electricity	**40**	**20**
Transport	54	37
Built Environment- Residential	29	23
Built Environment- Commercial	7	5
Industry	30	24
Agriculture	106	96
LULUCF[1]	Yet to be determined	Yet to be determined
Other (F-Gases, Waste & Petroleum refining)	9	8
Unallocated Savings		*-26*
Total[2]	Yet to be determined	Yet to be determined
Legally binding Carbon budgets and 2030 Emission Reduction Targets	295	200

[1] Finalising the Sectoral Emissions Ceiling for the land-use, Land-use Change and Forestry (LULUCF) sector has been deferred for up to 18 months to allow for the completion of the Land-use Strategy
[2] Once LULUCF sector figures are finalised, total figures will be available.

1.2.6 Climate Action Plan 2025

The National Climate Action Plan 2025 (CAP 2025)[24] was launched in April 2025. CAP 2025 marks the fourth update to the Climate Action Plan 2019, and the third to be prepared under the Climate Action and Low Carbon Development (Amendment) Act 2021, and the introduction of the 2022 Sectoral Emissions Ceilings (SEC) and the establishment of economy-wide carbon budgets.

CAP 2025 seeks to build on the progress made under Climate Action Plan 2024 by delivering policies, measurements and actions that will support the achievement of Irelands carbon budgets, sectoral emission ceilings, and 2030 and 2050 climate targets; while further enabling the closure of identified emissions gaps and the allocation of unallocated emission savings associated with each carbon budget period.

Building on previous iterations, CAP25 offers a detailed sector-by-sector roadmap outlining the key actions required to transition Ireland to a low-carbon society and reaffirms the goals of a 51% reduction in greenhouse gas emissions by 2030 and reaching climate neutrality no later than 2050. Major measures include a significant scale-up of renewable energy, especially wind and solar power, extensive retrofitting of homes to improve energy efficiency, support for nearly one million electric vehicles by 2030, and reforms in agriculture and land use aimed at promoting sustainability. CAP25 also emphasises public engagement, a just transition, and effective carbon pricing to ensure that the costs and benefits of climate action are distributed equitably across society. As with Climate Action Plan 2024, CAP 2025 provides an Annex of Actions[25], which only contain new, high-impact actions for delivery in 2025. The full set of measures for CAP 2025 (i.e., proposed new actions and existing actions) are still located within CAP 2025.

Six Vital High Impact Sectors were identified within Climate Action Plan 2023[26] relating to the sectoral emission ceilings. CAP 2025 has reaffirmed the following sectors and targets with no proposed changes:

Powering Renewables – 75% Reduction in emissions by 2030

We will facilitate a large-scale deployment of renewables that will be critical to decarbonising the power sector as well as enabling the electrification of other technologies.

- Accelerate the delivery of onshore wind, offshore wind, and solar.
- Dial up to 9 GW onshore wind, 8 GW solar, and at least 7 GW of offshore wind by 2030 (with 2 GW earmarked for green hydrogen production).
- Support at least 500 MW of local community-based renewable energy projects and increased levels of new micro-generation and small-scale generation.
- Phase out and end the use of coal and peat in electricity generation.

Achievement of the 75% reduction in emissions by 2030 and the decarbonisation of the grid in Ireland would assist in the achievement of the Electricity sectoral emission ceiling.

Building Better – 45% (Commercial/Public) and 40% (Residential) Reduction in Emissions by 2030

We will increase the energy efficiency of existing buildings, put in place policies to deliver zero-emissions new builds, and continue to ramp up our retrofitting programme.

- Ramp up retrofitting to 120,000 dwellings to BER B2 by 2025, jumping to 500,000 by 2030.
- Generation up to 0.8 TWh of district heating by 2025 and up to 2.5 TWh by 2030.

[24] *Department of the Environment, Climate and Communications (2025) Climate Action Plan 2025. Available at: https://www.gov.ie/en/department-of-the-environment-climate-and-communications/publications/climate-action-plan-2025/*
[25] *https://assets.gov.ie/static/documents/Climate_Action_Plan_2025_-_Annex_of_Actions.pdf*
[26] *Department of the Environment, Climate and Communications (2022) Climate Action Plan 2023 – Summary Document*

Achievement of the 45% (Commercial/Public) and 40% (Residential) reduction in emissions by 2030 would assist in the achievement of the Built Environment (Commercial/Residential) sectoral emission ceiling.

Turning Transport Around – 50% Reduction in Emissions by 2030

We will drive policies to reduce transport emissions by improving our town, cities, and rural planning, and by adopting the Avoid-Shift-Improve approach: reducing or avoiding the need for travel, shifting to public transport, walking, and cycling and improving the energy efficiency of vehicles.

- Change the way we use our road space.
- Reduce the total distance driven across all car journeys by 20%.
- Walking, cycling and public transport to account for 50% of our journeys.
- Nearly 1 in 3 private cars will be an Electric Vehicle.
- Increase walking and cycling networks.
- 70% of people in rural Ireland will have buses that provide at least 3 trips to the nearby town daily by 2030.

Achievement of the 50% reduction in emissions relating to transport by 2030 would assist in the achievement of the Transport sectoral emission ceiling.

Making Family Farms More Sustainable – 25% Reduction in Emissions by 2030

We will support farmers to continue to produce world class, safe and nutritious food while also seeking to diversify income through tillage, energy generation and forestry.

- Significantly reduce our use of chemical nitrogen as a fertilizer.
- Increase uptake of protected urea on grassland farms to 90-100%.
- Increase organic farming to up to 450,000 hectares, the area of tillage to up to 400,000 ha.
- Expand the indigenous biomethane sector through anaerobic digestion, reaching up to 5.7TWh of biomethane.
- Contribute to delivery of the land use targets for afforestation and reduced management intensity of organic soils.

Achievement of a 25% reduction in emissions by 2030 in agriculture and farming practices would assist in the achievement of the agriculture sectoral emission ceiling.

Greening Business and Enterprise – 35% Reduction in Emissions by 2030

We're changing how we produce, consume, and design our goods and services by breaking the link between fossil fuels and economic progress. Decarbonising industry and enterprise are key to Ireland's economy and future competitiveness.

- Reduce clinker content in cement and substitute products with lower carbon content for construction materials, ensuring 35% reduction in emissions by 2030 (against 2018).
- Reduce fossil fuel use from 64% of final consumption (2021) to 45% by 2025 and further by 2030.
- Increase total share of heating to carbon neutral to 50-55% by 2025, up to 70-75% by 2030.
- Significantly grow the circular economy and bioeconomy.

Achievement of a 35% reduction in emissions by 2030 in relation to Irish production and consumption would enable a more circular economy and assist in the achievement of the Industry and Other sectoral emission ceilings.

Changing our land use

The first phase of the land use review will tell us how we are using our land now. Then, we can map, with evidence, how it can be used most effectively to capture and store carbon and to produce better, greener food and energy.

- Increase our annual afforestation rates to 8,000 hectares per annum from 2023 onwards.
- Promote forest management initiatives in both public and private forests to increase carbon sinks and stores.
- Improve carbon sequestration of 450,000 ha of grasslands on mineral soils and reduce the management intensity of grasslands on 80,000 ha of drained organic soils.
- Rehabilitate 77,600 hectares of peatlands.

Exact reduction target for this sector is yet to be determined. By improving the manner in which Ireland utilises its land use, Ireland can achieve emission reductions and mitigate the ongoing climate and biodiversity crisis's. The LULUCF sectoral emission ceiling will be set after completion of the Land-use Strategy.

Adaptation

CAP 2025 highlights the need for adaptation to climate change. Adaptation is the process of adjustment to actual or expected climate change and its effects. Observations show that Irelands climate is changing in terms of coastline, sea level rise, seasonal temperatures, and changes in typical weather patterns. Climate change is expected to have diverse and wide-ranging impacts on Ireland's environment, society, and economic development, including managed and natural ecosystems, water resources, agriculture and food security, the built environment, human health, and coastal zones.

Climate Sectoral Adaptation Planning[27] includes for 12 sectoral adaptation plans that describe and assess the extent of the risks presented by climate change to a sector, and present contingency plans to address these risks and ensure climate resilience. They include actions to mainstream adaptation into policy and administration at sectoral level to improve the resilience of existing and planned critical infrastructure, systems, and procedures, to the effects and variability of climate change, as well as to improve cooperation and coherence within and across sectors, as well as on a local and national level.

CAP 2025 acknowledges the current shortfalls towards interim (2025) targets and underscores the need for faster implementation, stronger governance, and more coordinated cross-sectoral action to close the gap between ambition and delivery.

1.2.7 Irelands Climate Change Assessment

In 2023, the EPA published Ireland's Climate Change Assessment (ICCA).[28] This assessment provides a comprehensive overview and breakdown of the state of knowledge around key aspects of climate change with a focus on Ireland. The ICCA report is presented in four volumes.

- Volume 1: Climate Science – Ireland in a Changing World
- Volume 2: Achieving Climate Neutrality in 2050
- Volume 3: Being Prepared for Irelands Future
- Volume 4: Realising the Benefits of Transition and Transformation

The ICCA Synthesis Report states that having peaked in 2001, Irelands greenhouse gas emissions have reduced in all sectors except agriculture. However, Ireland currently emits more greenhouse gases per person than the EU average. The report goes on to state that there has been an identified gap in policy that indicates that Ireland

[27] *Department of the Environment, Climate and Communications (2020) Sectoral Adaptation Planning.* https://www.gov.ie/en/collection/51df3-sectoral-adaptation-planning/

[28] *EPA (2023) Irelands Climate Change Assessment* <https://www.epa.ie/our-services/monitoring--assessment/climate-change/irelands-climate-change-assessment-icca/>

will not meet its statutory greenhouse gas emission targets. Already Ireland has seen significant and ongoing deterioration in environmental quality, including declines in water quality, biodiversity and ecosystem quality. Developing a climate-resilient Ireland will require sufficient public and private investment and financial support in ways that adequately recognise the value of ecosystem services and the importance of societal wellbeing.

There are well-established 'no-regret options' that need to happen now, which can get Ireland most of the way to net zero carbon dioxide emissions. Beyond that, there are 'future energy choices' relating to the scale and magnitude of technologies that will assist in achieving Ireland statutory climate targets. Ireland's no-regret options are demand reduction (e.g. through energy efficiency and reduced consumption), electrification (e.g. electric vehicles and heat pumps), deployment of market-ready renewables (e.g. wind energy and solar photovoltaics) and low-carbon heating options (e.g. district heating). Irelands future choices include hydrogen, carbon capture and storage, nuclear energy and electro-fuels.

Achieving net zero carbon dioxide emissions by 2050 requires significant and unprecedented changes to Ireland's energy system. Policies tailored to suit different stages of technology development are critical for achieving a net zero energy system. Established technologies, such as wind energy, solar photovoltaics and bioenergy, will be key in meeting short-term emission reduction targets (i.e. 2030), whereas offshore wind infrastructure is expected to be the backbone of future energy systems (i.e., 2050).

The ICCA serves as a stark warning: Ireland stands to face a myriad of challenges in efforts to mitigate and adapt to climate change at the almost halfway mark to 2030. Further decisive action is imperative to mitigate the escalating impacts of climate change on Irelands environment, economy, and society that are highlighted throughout the four volumes of the ICCA.

APPENDIX 10-2

CARBON CALCULATIONS

Appendix 10-1: Estimated carbon payback time (including peat slide event)

Payback Time and CO_2 emissions • 07WD-YVHM-4CJQ v14

1. Windfarm CO2 emission saving over...	Exp.	Min.	Max.
...coal-fired electricity generation (t CO2 / yr)	112,688	110,290	115,085
...grid-mix of electricity generation (t CO2 / yr)	31,060	30,399	31,721
...fossil fuel-mix of electricity generation (t CO2 / yr)	55,119	53,946	56,292
Energy output from windfarm over lifetime (MWh)	4,287,035	4,195,821	4,378,248

Total CO2 losses due to wind farm (tCO2 eq.)	Exp.	Min.	Max.
2. Losses due to turbine life (eg. manufacture, construction, decomissioning)	33,314	33,156	33,472
3. Losses due to backup	20,523	0	41,046
4. Lossess due to reduced carbon fixing potential	3,078	1,009	7,575
5. Losses from soil organic matter	97,502	9,716	265,817
6. Losses due to DOC & POC leaching	0	0	2
7. Losses due to felling forestry	73,392	64,681	86,754
Total losses of carbon dioxide	227,809	108,562	434,666

8. Total CO2 gains due to improvement of site (t CO2 eq.)	Exp.	Min.	Max.
8a. Change in emissions due to improvement of degraded bogs	0	0	0
8b. Change in emissions due to improvement of felled forestry	0	0	0
8c. Change in emissions due to restoration of peat from borrow pits	-122	0	-432
8d. Change in emissions due to removal of drainage from foundations & hardstanding	0	0	0
Total change in emissions due to improvements	-122	0	-432

RESULTS	Exp.	Min.	Max.
Net emissions of carbon dioxide (t CO2 eq.)	227,688	108,130	434,666
Carbon Payback Time			
...coal-fired electricity generation (years)	2.0	0.9	3.9
...grid-mix of electricity generation (years)	7.3	3.4	14.3
...fossil fuel-mix of electricity generation (years)	4.1	1.9	8.1
Ratio of soil carbon loss to gain by restoration (not used in Scottish applications)	801.57	22.48	No gains!
Ratio of CO2 eq. emissions to power generation (g/kWh) (for info. only)	53.11	24.70	103.59

Appendix 10-1: Estimated carbon payback time (excluding the peat slide)

Payback Time and CO_2 emissions • 07WD-YVHM-4CJQ v19

1. Windfarm CO2 emission saving over...	Exp.	Min.	Max.
...coal-fired electricity generation (t CO2 / yr)	112,688	110,290	115,085
...grid-mix of electricity generation (t CO2 / yr)	31,060	30,399	31,721
...fossil fuel-mix of electricity generation (t CO2 / yr)	55,119	53,946	56,292
Energy output from windfarm over lifetime (MWh)	4,287,035	4,195,821	4,378,248

Total CO2 losses due to wind farm (tCO2 eq.)	Exp.	Min.	Max.
2. Losses due to turbine life (eg. manufacture, construction, decomissioning)	33,314	33,156	33,472
3. Losses due to backup	20,523	0	41,046
4. Lossess due to reduced carbon fixing potential	1,996	575	5,358
5. Losses from soil organic matter	28,600	-1,526	115,075
6. Losses due to DOC & POC leaching	0	0	2
7. Losses due to felling forestry	70,818	62,448	83,366
Total losses of carbon dioxide	155,250	94,652	278,319

8. Total CO2 gains due to improvement of site (t CO2 eq.)	Exp.	Min.	Max.
8a. Change in emissions due to improvement of degraded bogs	0	0	0
8b. Change in emissions due to improvement of felled forestry	0	0	0
8c. Change in emissions due to restoration of peat from borrow pits	-122	0	-432
8d. Change in emissions due to removal of drainage from foundations & hardstanding	0	0	0
Total change in emissions due to improvements	-122	0	-432

RESULTS	Exp.	Min.	Max.
Net emissions of carbon dioxide (t CO2 eq.)	155,129	94,220	278,319
Carbon Payback Time			
...coal-fired electricity generation (years)	1.4	0.8	2.5
...grid-mix of electricity generation (years)	5.0	3.0	9.2
...fossil fuel-mix of electricity generation (years)	2.8	1.7	5.2
Ratio of soil carbon loss to gain by restoration (not used in Scottish applications)	235.13	-3.53	No gains!
Ratio of CO2 eq. emissions to power generation (g/kWh) (for info. only)	36.19	21.52	66.33

APPENDIX 11-1

NOISE MONITOR CALIBRATION CERTIFICATES

CERTIFICATE OF CALIBRATION

0653

Date of Issue: 10 October 2019

Certificate Number: UCRT19/2137

Issued by:
ANV Measurement Systems
Beaufort Court
17 Roebuck Way
Milton Keynes MK5 8HL
Telephone 01908 642846 Fax 01908 642814
E-Mail: info@noise-and-vibration.co.uk
Web: www.noise-and-vibration.co.uk
Acoustics Noise and Vibration Ltd trading as ANV Measurement Systems

Approved Signatory

K. Mistry

CUSTOMER	AWN Consulting Limited The Tecpro Building IDA Business & Technology Park Clonshaugh Dublin 17 Ireland
ORDER No	DOD/19/Cal012
Job No	UKAS19/10679
DATE OF RECEIPT	09 October 2019
PROCEDURE	Calibration Engineer's Handbook, section 25: periodic testing of sound level meters to IEC 61672-3:2006 (BS EN 61672-3:2006) as modified by UKAS TPS 49 Edition 2:June 2009
IDENTIFICATION	Sound level meter Brüel & Kjær type 2250 serial No 2818091 connected via a preamplifier type ZC 0032 serial No 28531 to a half-inch microphone type 4950 serial No 2626657. Associated calibrator Brüel & Kjær type 4231 serial No 2022651 with one-inch housing and adapter type UC 0210 for half-inch microphone.
CALIBRATED ON	10 October 2019
PREVIOUS CALIBRATION	Calibrated on 10 November 2017, Certificate No. UCRT17/2010 issued by this laboratory.

This certificate is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to the SI system of units and/or to units of measurement realised at the National Physical Laboratory or other recognised national metrology institutes. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.

The sound level meter was set up using the type 4231 sound calibrator supplied; it was set to frequency weighting A, and initially read 94.0 dB. It was then adjusted to read 93.9 dB (corresponding to 93.9 dB at standard atmospheric pressure). This reading was derived from Calibration Certificate no. UCRT19/2105 supplied by this laboratory and manufacturers' information on the free-field response of the sound level meter. The calibration check frequency was 1 kHz. The final microphone sensitivity calculated and stored by the instrument was 41.59 mV/Pa.

Procedures from IEC 61672-3:2006 (BS EN 61672-3:2006) as modified by UKAS TPS 49 Edition 2:June 2009 were used to perform the periodic tests.

RESULTS

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2006 (BS EN 61672-3:2006), for the environmental conditions under which the tests were performed. As public evidence was available, from an independent testing organization responsible for approving the results of pattern evaluation tests performed in accordance with IEC 61672-2 : 2003 (BS EN 61672-2 : 2003), to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1 : 2002 (BS EN 61672-1 : 2003), the sound level meter submitted for testing conforms to the class 1 requirements of IEC 61672-1 : 2002 (BS EN 61672-1 2003).

The self-generated noise recorded with the microphone replaced by the electrical input device was:

13.0 dB (A) 13.8 dB (C) 19.0 dB (Z) 25.3 dB (Z, Extended low frequency range)

The environmental conditions recorded at the start and end of testing were:

Start: 24 to 25 °C, 34 to 44 %RH and 100.1 to 100.2 kPa
End: 24 to 25 °C, 34 to 44 %RH and 100.1 to 100.2 kPa

Technical information including adjustment data specified in the manufacturers' Instruction Manual BE 1712-19 (2012) and User Manual BE 1713-24 (2009) has been used to carry out this verification. These data include manufacturer-specified uncertainties.

Publicly-available evidence has been found that the B&K 2250 sound level meter design has successfully undergone pattern evaluation in accordance with IEC 61672-2:2002 (BS EN 61672-2:2003) by Physikalisch-Technische Bundesanstalt (PTB), an independent testing organisation responsible for pattern approvals.

All measurement data are held at ANV Measurement Systems for a period of at least six years.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor *k*=2, providing a coverage probability of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

CERTIFICATE OF CALIBRATION

UKAS ACCREDITED CALIBRATION LABORATORY No 0653

Certificate No UCRT19/2137

NOTES

Any opinions or interpretations which may be expressed in the following notes are not UKAS Accredited.

1 All tests were carried out in "Broad Band".

2 Windscreen autodetect was set to "off", windscreen correction to "None", soundfield to "Free-field" and microphone to "4950".

3 The extended low-frequency facility was set to "off" for all tests except for the additional self-generated noise reading and "Frequency and time weightings at 1kHz" test.

4 No suitable microphone frequency response information was supplied with the instrument. It was therefore measured by this laboratory using the electrostatic actuator method. This response in isolation is not UKAS Accredited.

5 It was noted that in order to obtain the correct A-weighted response to the sound calibrator, the relevant software setting in the meter had to be changed from '4231' to 'custom' with the appropriate calibration level entered.

6 The electrical tests have been carried out with the instrument set for the nominal microphone sensitivity, as specified in the Instruction Manual. This may mean that the instrument has a slightly different linearity range when in normal use.

7 Typical case reflection factors specified by the manufacturer have been used for this verification.

The instrument was running on hardware version 4.0

The instrument firmware settings were:

Module i.d.	Function	Version	Active?	Licenced?	Template used?
BZ 7222	SLM	4.7.2	Y	Y	N
BZ 7223	Frequency analysis	4.7.2	Y	Y	N
BZ 7224	Logging	4.7.2	Y	N	N
BZ 7225	Enhanced logging	4.7.2	Y	Y	Y
BZ 7226	Signal recording	4.7.2	Y	Y	N
BZ 7227	Reverberation time	4.7.2	Y	N	N
BZ 7228	Building acoustics	4.7.2	Y	N	N
BZ 7230	FFT analysis	4.7.2	Y	N	N
BZ 7231	Tone assessment	4.7.2	Y	N	N
BZ 7232	Noise monitoring	4.7.2	Y	N	N
BZ 7234	Enh. Vibration and LF Option	4.7.2	Y	Y	N
BZ 7235	TM Basic engine	4.7.2	Y	N	N
BZ 7236	TM Z41 Gear	4.7.2	Y	N	N
BZ	N/A	N/A	N/A	N	N
BZ	N/A	N/A	N/A	N	N

The results on this certificate only relate to the items calibrated as identified above.

END

Brüel & Kjær

The Calibration Laboratory
Skodsborgvej 307, DK-2850 Nærum, Denmark

ilac-MRA DANAK CAL Reg.nr. 307

CERTIFICATE OF CALIBRATION

No: CDK1802564

CALIBRATION OF

Sound Level Meter:	Brüel & Kjær Type 2250	No: 3010911	Id: - 3010911
Microphone:	Brüel & Kjær Type 4189	No: 2846376	
Preamplifier:	Brüel & Kjær Type ZC-0032	No: 7637	
Supplied Calibrator:	Brüel & Kjær Type 4231	No: 2626210	
Software version:	BZ7222 Version 2.1	Pattern Approval:	PTB1.63-4046158
Instruction manual:	BE1712-18		

CUSTOMER

Enfonic Ltd
Charlestown Centre
Dublin
D11 KXC7
Ireland

CALIBRATION CONDITIONS

Preconditioning: 4 hours at 23°C ± 3°C

Environment conditions: *See actual values in **Environmental conditions** sections.*

SPECIFICATIONS

The Sound Level Meter Brüel & Kjær Type 2250 has been calibrated in accordance with the requirements as specified in IEC61672-1:2002 class 1. Procedures from IEC 61672-3:2006 were used to perform the periodic tests. The accreditation assures the traceability to the international units system SI.

PROCEDURE

The measurements have been performed with the assistance of Brüel & Kjær Sound Level Meter Calibration System 3630 with application software type 7763 (version 4.9 - DB: 4.90) by using procedure 2250-4189.

RESULTS

Calibration Mode: **Calibration as received.**

The reported expanded uncertainty is based on the standard uncertainty multiplied by a coverage factor $k = 2$ providing a level of confidence of approximately 95 %. The uncertainty evaluation has been carried out in accordance with EA-4/02 from elements originating from the standards, calibration method, effect of environmental conditions and any short time contribution from the device under calibration.

Date of calibration: 2018-04-04

Date of issue: 2018-04-04

M. Önder

Mikail Önder
Calibration Technician

Susanne Jørgensen

Susanne Jørgensen
Approved Signatory

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Brüel & Kjær

The Calibration Laboratory
Skodsborgvej 307, DK-2850 Nærum, Denmark

ilac-MRA DANAK CAL Reg.nr. 307

CERTIFICATE OF CALIBRATION

No: CDK1806712

CALIBRATION OF

Sound Level Meter:	Brüel & Kjær Type 2250	No: 2818081	Id: - 2820751
Microphone:	Brüel & Kjær Type 4189	No: 2785433	
Preamplifier:	Brüel & Kjær Type ZC-0032	No: 24941	
Supplied Calibrator:	Brüel & Kjær Type 4231	No: ---	
Software version:	BZ7222 Version 2.1	Pattern Approval:	PTB1.63-4046158
Instruction manual:	BE1712-18		

CUSTOMER

Enfonic Ltd
Level 2, Charlestown Centre
Dublin
D11 KXC7
Ireland

CALIBRATION CONDITIONS

Preconditioning: 4 hours at 23°C ± 3°C

Environment conditions: *See actual values in* ***Environmental conditions*** *sections.*

SPECIFICATIONS

The Sound Level Meter Brüel & Kjær Type 2250 has been calibrated in accordance with the requirements as specified in IEC61672-1:2002 class 1. Procedures from IEC 61672-3:2006 were used to perform the periodic tests. The accreditation assures the traceability to the international units system SI.

PROCEDURE

The measurements have been performed with the assistance of Brüel & Kjær Sound Level Meter Calibration System 3630 with application software type 7763 (version 4.9 - DB: 4.90) by using procedure 2250-4189.

RESULTS

Calibration Mode: **Calibration as received.**

The reported expanded uncertainty is based on the standard uncertainty multiplied by a coverage factor $k = 2$ providing a level of confidence of approximately 95 %. The uncertainty evaluation has been carried out in accordance with EA-4/02 from elements originating from the standards, calibration method, effect of environmental conditions and any short time contribution from the device under calibration.

Date of calibration: 2018-08-18

Date of issue: 2018-08-18

M. Önder

Mikail Önder
Calibration Technician

Susanne Jørgensen

Susanne Jørgensen
Approved Signatory

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CERTIFICATE OF CALIBRATION

UKAS CALIBRATION
0653

Date of Issue: 03 June 2019

Certificate Number: UCRT19/1648

Issued by:
ANV Measurement Systems
Beaufort Court
17 Roebuck Way
Milton Keynes MK5 8HL
Telephone 01908 642846 Fax 01908 642814
E-Mail: info@noise-and-vibration.co.uk
Web: www.noise-and-vibration.co.uk
Acoustics Noise and Vibration Ltd trading as ANV Measurement Systems

Approved Signatory

K. Mistry

CUSTOMER	AWN Consulting Limited The Tecpro Building IDA Business and Technology Park Clonshaugh Dublin 17 Ireland
ORDER No	1978
Job No	UKAS19/05370
DATE OF RECEIPT	31 May 2019
PROCEDURE	Procedure TP 1 Calibration of Sound Calibrators
IDENTIFICATION	Sound Calibrator Larson Davis type CAL200 serial number 13532 with half-inch housing
CALIBRATED ON	03 June 2019
PREVIOUS CALIBRATION	Calibrated on 04 May 2018, Certificate No. UCRT18/1486 issued by this laboratory.

This certificate is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to the SI system of units and/or to units of measurement realised at the National Physical Laboratory or other recognised national metrology institutes. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.

CERTIFICATE OF CALIBRATION

UKAS ACCREDITED CALIBRATION LABORATORY No 0653

Certificate No UCRT19/1648

MEASUREMENTS

The sound pressure level generated by the Sound Calibrator in its half-inch configuration was measured using a B&K type 4134 microphone with the protective grid in position. The microphone sensitivity was traceable to National Standards.

RESULTS

The mean level of the calibrator output and its fundamental frequency and total distortion were:

Nominal Setting dB	Mean Level	Frequency	Distortion
94	93.85 ± 0.1 dB rel 20 µPa	1000 Hz ± 0.06 %	(0.44 ± 0.04) %
114	113.87 ± 0.1 dB rel 20 µPa	1000 Hz ± 0.06 %	(0.36 ± 0.04) %

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor *k* =2, providing a coverage probability of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

During the measurements the laboratory environmental conditions were:

Setting dB	Temperature	Atmospheric pressure	Relative Humidity
94	23 to 24 °C	100.1 to 100.2 kPa	45 to 56 %
114	23 to 24 °C	100.1 to 100.2 kPa	46 to 56 %

The tests carried out were as specified in Annex B of BS EN 60942:2003, but with five determinations of sound pressure level, and limited to the above level(s) & freq(s). As public evidence was available from a testing organisation responsible for approving the results of pattern evaluation tests, to demonstrate that the model of sound calibrator fully conformed to the reqirements for pattern evaluation decribed in Annex A of IEC 60942:2003, the sound calibrator tested is considered to conform to all the class 1 requirements of IEC 60942:2003.

Calibrator adjusted No R 2

END

APPENDIX 12-1

ARCHEOLOGICAL SURVEY OF IRELAND RECORDS

Archaeological Survey of Ireland descriptions of archaeology sites in study area

Monument No.	Classification	Archaeological Survey of Ireland description
GA115-007----	Children's burial ground	On the crest of a locally prominent hill overlooking bogland and a small stream to the S. Marked on the 1920 edition of the OS 6-inch map as a subcircular unenclosed area (c. 12m N-S). It consists of an irregularly shaped unenclosed area (L 7.6m; Wth 4.3m) within which small set stones, projecting through the heather, indicate graves aligned N-S.
GA124-001----	Cashel	Located at the junction of four townlands, in an area of upland bog. Named 'Cashlaundrumlahan' on the OS 6-inch maps. According to local information, a 'double wall' once existed here but it was destroyed when the area was forested. No visible surface trace survives but a curving trackway may respect the circuit of the monument.
GA124-003----	Redundant record	This is a curving field wall. It is not an archaeological monument.
GA124-004----	Enclosure	On a S-facing slope in marshy grassland, overlooking the Owendalulleegh River. This poorly preserved oval enclosure (63m E-W; 42m N-S) is defined by a scarp. It is overlain by a field boundary at NW.
GA124-005----	Burial ground	On a S-facing slope in marshy grassland. This irregularly shaped burial ground (c. 55m E-W; c. 30m N-S) is enclosed by a stone wall and is accessed by a gateway at NW. It is still in use and all the headstones are modern. However, there is a bullaun stone (GA124-005001-) within it.
GA124-005001-	Bullaun stone	In pastureland sloping steeply to the S and overlooking woodland. Aspect is limited to the N. This bullaun lies the E end of a graveyard (GA124-005----). It is set in the ground and comprises an irregularly shaped, moss-covered boulder (1.2m N-S; 0.9m E-W; H 0.4m). Two bowls are visible: the N (diam. 0.4m; D 0.12m) bowl is circular in plan, while the S one (0.45m E-W; 0.35m N-S; D 0.18m), which is filled with water, is oval.
GA124-006----	Monumental structure	No published description
GA124-008----	Redundant record	This is a curving field boundary. It is not an archaeological monument.
GA124-009----	Boundary mound	No published description
GA124-010----	Boundary mound	No published description

Monument No.	Classification	Archaeological Survey of Ireland description
GA124-013----	Church	No published description
GA115-021----	Field boundary	On a N-facing slope in pastureland, overlooking the Owenglanna valley. Marked on the 1838 edition of the OS 6-inch map as subrectangular field and on the 1920 edition as a field boundary curving from SE through W to NE. On inspection in May 1984 it proved to be a subcircular drystone field wall (44.5m N-S), similar to others in the area. No trace of it survived from NE to SE where a low scarp indicated its outline. The current evidence is insufficient to warrant accepting this as an archaeological monument.

APPENDIX 12-2

SITE PHOTOGRAPHS

Plate 12- 1 View of wind farm from east

Plate 12- 2 View of wind farm from south

Plate 12- 3 View of wind farm entrance

Plate 12- 4 View of central area of wind farm from west

Plate 12- 5 View of north end of wind farm from west

Plate 12- 6 View of turbines in forestry from east

Plate 12- 7 View of turbines in peatland

Plate 12- 8 View of typical turbine base

Plate 12- 9 View of Derrybrien substation

Plate 12- 10 View of approx. recorded location of Cashel GA124-001----

Plate 12- 11 View of Borrow Pit 3 from north

Plate 12- 12 View of earth-cut drain within wind farm

Plate 12- 13 View of regrowth at location of peat slide

Plate 12- 14 View of overhead line looking north from Black Road

Plate 12- 15 View of Barrage 3 from north

Plate 12- 16 View of Black Road from north

Plate 12- 17 View of Black Road bridge from north

Plate 12- 18 View of Flaggy Bridge from northwest

Plate 12- 19 View of overhead line within forestry to south of R353 road

Plate 12- 20 View of overhead line entering Agannygal substation from north

APPENDIX 13-2

SITE LOCATION MAP

25km

25km

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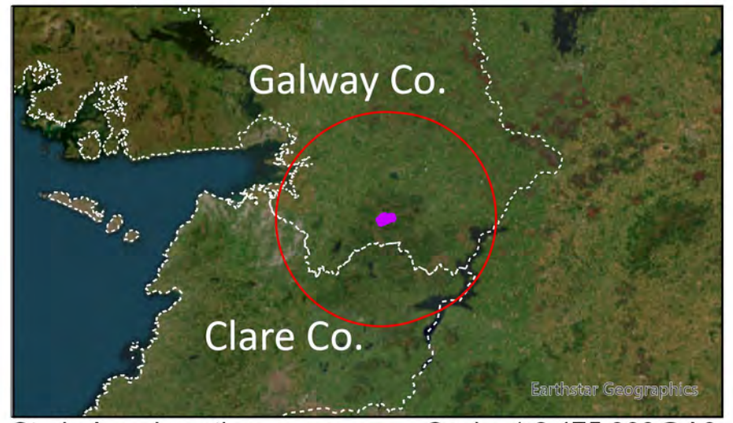
Legend

Galway County Boundary

Derrybrien Wind Farm Decommissioning Project - Retained Development

Study Area - 25km

Existing Derrybrien Turbines



Study Area Location

Scale: 1:2,475,000@A3

Site Location Map, Galway County
Derrybrien Wind Farm Decommissioning Project - Retained Development
Drawn: GN
Date: 10/2024

N

Scale 1:200,000@A3

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APPENDIX 13-3

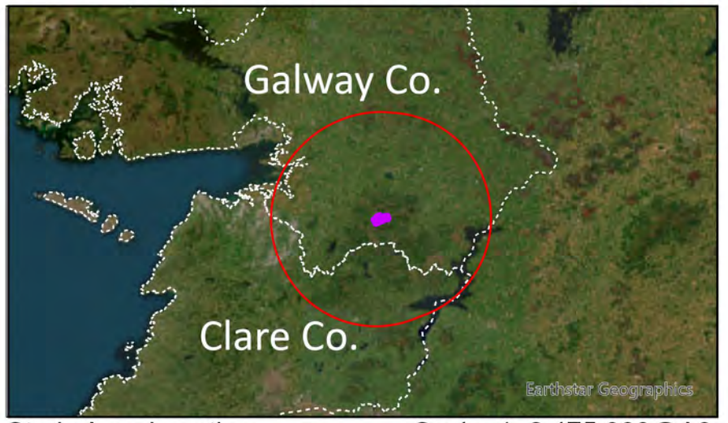
TOPOGRAPHIC MAP (A3)

Legend

- △ Highest Elevations

Derrybrien Wind Farm Decommissioning Project - Retained Development

- 5km buffer
- Existing Derrybrien Turbines



Study Area Location

Scale: 1: 2.475.000@A3

Topographic Map
Derrybrien Wind Farm Decommissioning Project - Retained Development
Drawn: GN
Date: 10/2024

N

Scale 1:70.000@A3

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APPENDIX 13-4

EPA CORINE LANDCOVER MAP

Legend

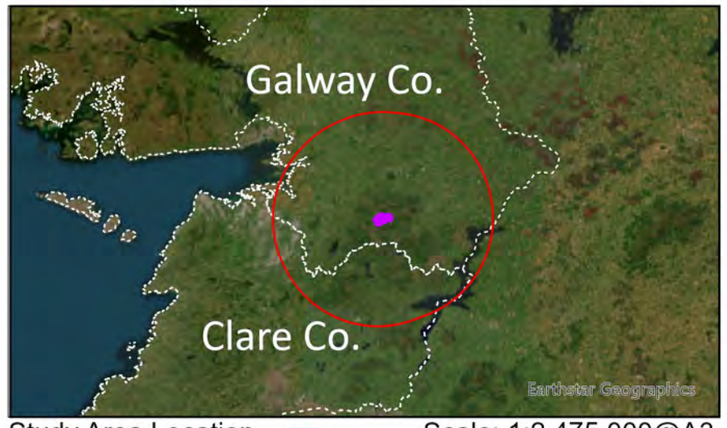
- Galway County Boundary

Derrybrien WF Decommissioning Project - Retained Development

- Study Area - 25km
- Existing Derrybrien Turbines

CORINE Land Cover 2018

- Pastures
- Coniferous forest
- Mixed forest
- Transitional woodland-shrub
- Land principally occupied by agriculture, with significant areas of natural vegetation
- Non-irrigated arable land
- Sport and leisure facilities
- Bare rocks
- Peat bogs
- Broad-leaved forest
- Complex cultivation patterns
- Discontinuous urban fabric
- Inland marshes
- Mineral extraction sites
- Natural grasslands
- Sparsely vegetated areas
- Water bodies



Study Area Location

Scale: 1:2,475,000@A3

CORINE Land Cover 2018 Map
Derrybrien Wind Farm Decommissioning Project - Retained Development
Drawn: GN
Date: 10/2024

N

Scale 1:200,000@A3

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APPENDIX 13-5

CORINE LAND COVER 2018 & AGANNYGAL SUBSTATION

5Km

5Km

Agannygal Substation

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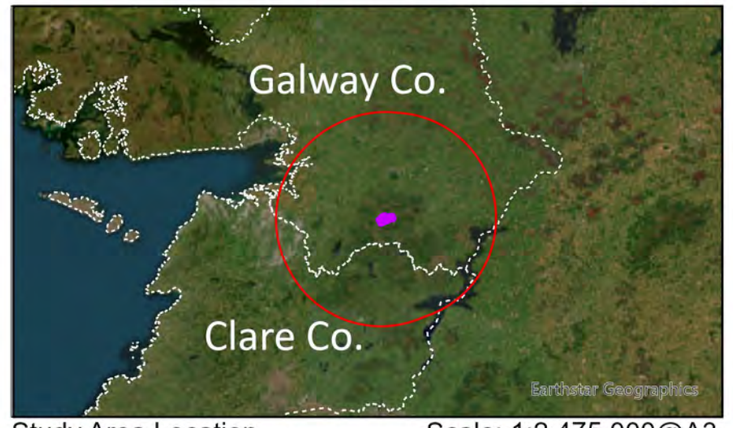
Legend

Derrybrien WF Decommissioning Project - Retained Development

- 5km buffer
- Existing Derrybrien Turbines
- Agannygal Substation

CORINE Land Cover 2018

- Pastures
- Coniferous forest
- Mixed forest
- Transitional woodland-shrub
- Land principally occupied by agriculture, with significant areas of natural vegetation
- Peat bogs



Study Area Location

Scale: 1:2,475,000@A3

CORINE Land Cover 2018 Map
Derrybrien Wind Farm Decommissioning Project - Retained Development
Drawn: GN
Date: 10/2024

N

Scale 1:50,000@A3

CUNNANE STRATTON REYNOLDS
LAND PLANNING & DESIGN

APPENDIX 13-6

LANDSCAPE CHARACTER AREAS

North River Clare Basin Unit

North Loughrea Unit

Castlegar Basin Unit

Southern River Clare Basin Unit

South Loughrea Unit

25km

Loughrea

Inner Galway Bay Unit

Kilcrow Basin Unit

LCA 1

Karst Landscape Unit

Kilchreest Basin Unit

Slieve Aughty Landscape Unit

Gort

Lough Derg Environs Unit

LCA 1

LCA 2

LCA 6

LCA 5

LCA 4

25km

LCA 7

LCA 12

LCA 11

LCA 8

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Legend

Galway County Boundary

Derrybrien WF Decommissioning Project - Retained Development

Study Area - 25km

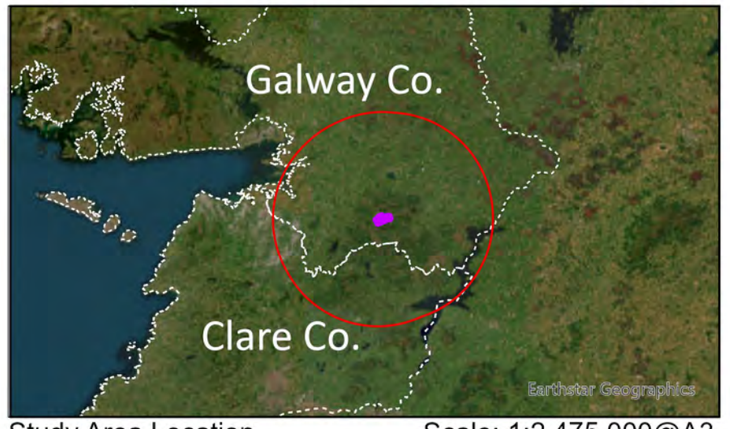
Existing Derrybrien Turbines

Landscape Character Units - Galway CDP 2022-2028

- Urban Environs Landscape
- Inner Galway Bay Unit
- Karst Landscape Unit
- Kilchreest Basin Unit
- Kilcrow Basin Unit
- Lough Derg Environs Unit
- Slieve Aughty Landscape Unit
- South Loughrea Unit
- Southern River Clare Basin Unit
- North River Clare Basin Unit
- Castlegar Basin Unit

Landscape Character Areas - Clare CDP 2023-2029

- LCA 1 Buren Uplands
- LCA 2 Low Burren
- LCA 4 Fergus Loughlands
- LCA 5 Slieve Aughty Uplands
- LCA 6 Lough Graney
- LCA 7 Lough Derg Basin
- LCA 8 Slieve Bernagh Uplands (Co Clare)
- LCA 11 East Clare Loughlands
- LCA 12 Tulla Drumlin Farmland



Study Area Location

Scale: 1:2,475,000@A3

Landscape Character Areas Map
Derrybrien Wind Farm Decommissioning Project - Retained Development
Drawn: GN
Date: 10/2024

N

Scale 1:200,000@A3

CUNNANE STRATTON REYNOLDS
LAND PLANNING & DESIGN

APPENDIX 13-7

LANDSCAPE AND VISUAL DESIGNATIONS

Galway Bay Scenic Route

Slieve Aughty Scenic Route

8 29 32 34 35 36 37 38 40 41 43 44 45 46 47 48 49 50

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Legend

- Galway County Boundary

Derrybrien WF Decommissioning Project - Retained Development

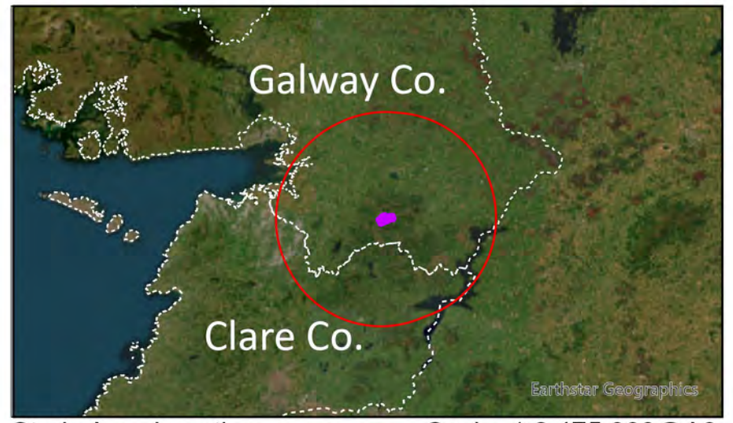
- Study Area - 25km
- Existing Derrybrien Turbines

County Galway Protected Views - Galway CDP 2022-2028

- Scenic Routes
- Protected Views
- Angles of View

County Clare Landscape Designations - Clare CDP 2023-2029

- Clare Scenic Routes
- Clare Heritage Landscape



Study Area Location

Scale: 1:2,475,000@A3

Landscape Designations Map
Derrybrien Wind Farm Decommissioning Project - Retained Development
Drawn: GN
Date: 10/2024

N

Scale 1:200,000@A3

CUNNANE STRATTON REYNOLDS
LAND PLANNING & DESIGN

APPENDIX 13-8

EXISTING ZTV MAP

Zone of Theoretical Visibility (ZTV) Map indicating areas with a theoretical view of the windfarm at Derrybrien, Co. Galway

Calculated to Hub Height (49m)

Derrybrien Turbine Locations

Number of Turbines Visible

3.6%	1 - 14
3.3%	15 - 28
5.2%	29 - 42
12.9%	43 - 56
37.7%	57 - 70

Photograph Location

Derrybrien 25km Extent

FINAL

Date: 8th April 2024

Scale when printed at A1 Size = 1:90,000

1 centimeter = 900 meters

Notes:

- *Theoretical visibility is based on an observer being able to see at least a full turbine blade (26m).*
- *Theoretical visibility is based on an observer eye level of 2m above ground level.*
- *Calculation does not account for screening due to vegetation, forestry, buildings or any other similar forms of screening.*
- *Calculation has been run using Ordnance Survey 10m DTM height data.*
- *Earth curvature and light refraction has been included in this calculation.*

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APPENDIX 13-9

VIEWPOINT MAP

VRP 1
VRP 17b
VRP 17
VRP 2
VRP 8
VRP 3
VRP 14
VRP 7
VRP 4
VRP 5
VRP 6
VRP 15
VRP 9
VRP 10
VRP 11
VRP 12
VRP 13
VRP 16

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Legend

- Galway County Boundary

Derrybrien WF Decommissioning Project - Retained Development

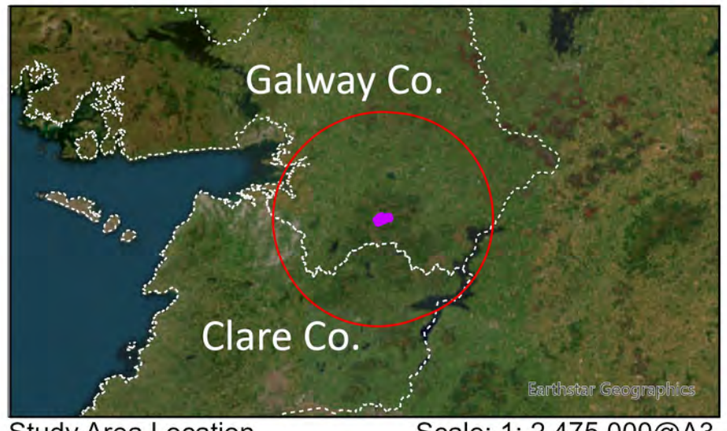
- Study Area - 25km
- Existing Derrybrien Turbines
- Viewpoints

County Galway Protected Views - Galway CDP 2022-2028

- Scenic Routes
- Protected Views
- Angles of View

County Clare Landscape Designations - Clare CDP 2023-2029

- Clare Scenic Routes
- Clare Heritage Landscape



Study Area Location

Scale: 1: 2,475,000@A3

Viewpoint Map
Derrybrien Wind Farm Decommissioning Project - Retained Development
Drawn: GN
Date: 10/2024

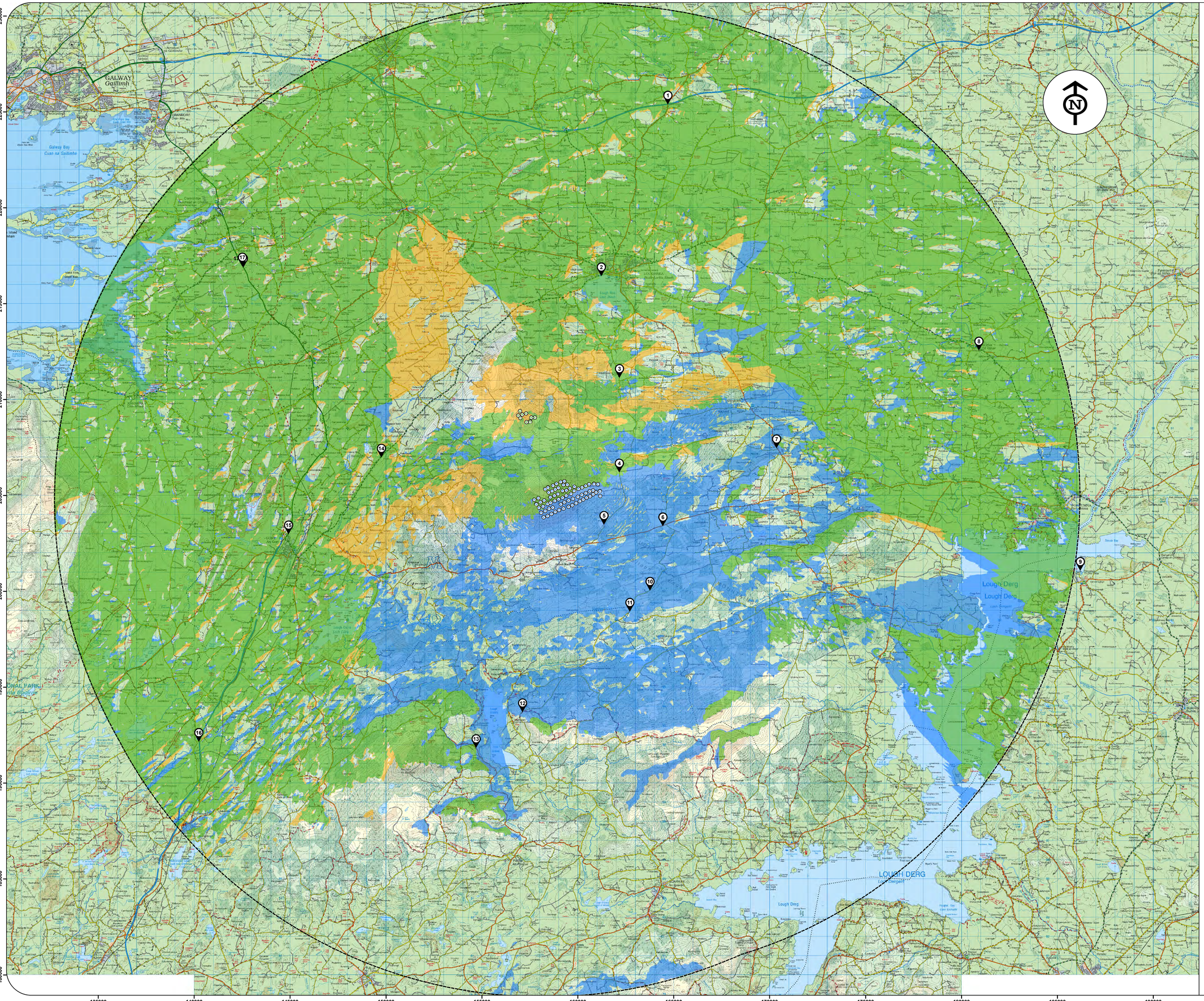
N

Scale 1:200,000@A3

CUNNANE STRATTON REYNOLDS
LAND PLANNING & DESIGN

APPENDIX 13-10

CUMULATIVE ZTV



Zone of Theoretical Visibility (ZTV) Map indicating areas with a theoretical view of the windfarm at Derrybrien, in combination with the existing Sonnagh Old windfarm

Derrybrien Turbine Locations

Sonnagh Old Turbine Locations

Wind Farms Visible

- *Derrybrien Only*
- *Both Windfarms Visible*
- *Sonnagh Old Only*

Photograph Location

Derrybrien 25km Extent

FINAL
Date: 8th April 2024
Scale when printed at A1 Size = 1:90,000 *1 centimeter = 900 meters*

Notes:

- *Theoretical visibility is based on an observer being able to see at least a full turbine blade (26m).*
- *Theoretical visibility is based on an observer eye level of 2m above ground level.*
- *Calculation does not account for screening due to vegetation, forestry, buildings or any other similar forms of screening.*
- *Calculation has been run using Ordnance Survey 10m DTM height data.*
- *Earth curvature and light refraction has been included in this calculation.*

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APPENDIX 14-1

SCOPING RESPONSES JUNE 2003 - MARCH 2006 ACTIVITY TIMEFRAMES

Table 14-A June 2003 – March 2006 Activity Timeframes

Activity	Approximate Dates	Duration
General Project Requirements: • Personnel movements • Plant movements • Material import	• June 2003 – March 2006 • Intermittent; primarily at start / finish of phases • June 2003 – end 2005	• Approx. 34 months • Intermittent • Approx. 31 months
Site Preparation Works: • Coillte track upgrade • Tree felling	• June 2003 – July 2003 • May 2003 – September 2005	• Approx. 1 month • Approx. 29 months
Civil Works: • Roads within wind farm site • Ancillary works; roads • Ancillary works; road to Agannygal Substation • Ancillary works; bridges • Turbine foundations, hardstands • Agannygal Substation Earthworks • Substation foundations • OHL foundations	• June 2003 – September 2003 • Between June 2003 – September 2003 • Between July 2004 – August 2004 • Between June 2003 – September 2003 • Between August 2003 – September 2005 (with gap during response to peat slide) • Between August 2004 – September 2004 • Between December 2005 – February 2005 • Between July 2005 – September 2005	• Approx. 4 months • Approx. 1-2 months • Approx. 1-2 months • Approx. 1-2 months • Approx. 18 months • Approx. 3 months • Approx. 3 months
Electrical Works: • Grid connection	• July 2004 – September 2005	• Approx. 15 months
Wind Turbines: • Turbine delivery	• April 2005 – September 2005	• Approx. 6 months