Derrybrien Wind Farm Project

Gort Wind Farms Ltd.

Remedial Environmental Impact Assessment Report

Chapter 10 – Soils, Geology and Land

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10.1 Introduction

10.1.1 Chapter Scope

This chapter presents an assessment of impacts of the project on soils, geology and land for the

- Derrybrien Wind Farm and associated ancillary works;
- Grid connection comprising Derrybrien-Agannygal 110 kV Overhead Line and Agannygal Substation connecting into the Shannonbridge -Ennis 110 kV Overhead Line and associated ancillary works; and
- Works undertaken in response to the peat slide and associated ancillary works

The baseline sensitivity of the receiving soils, geology and land has been assessed based on the site conditions in 1998, prior to the construction of the wind farm.

Impacts on the receiving soils, geology and land have been assessed over three stages of the life cycle of the project:

- *Impacts that have occurred*, i.e. during construction (2003-2006) and during the operation and maintenance phase of the project up to the end of Q2 2020;
- *Impacts that are occurring*, i.e. impacts from construction or from the initial operation and maintenance phase of the project that are still occurring at the end of Q2 2020; and
- *Impacts that are likely to occur,* i.e. during the remaining operation and maintenance phase of the wind farm, or during decommissioning, expected in 2040.

Specific consideration has been given to the peat failures that occurred on the wind farm site during construction, particularly the large peat slide that occurred in October 2003.

Remedial mitigation and monitoring measures that were implemented on the site during construction and during the initial operation and maintenance period of the project are summarised, along with the mitigation measures that are recommended for the remaining design life of the project and for decommissioning.

Residual impacts after decommissioning are also assessed, along with cumulative impacts from other projects in the area.

Figures are contained in A4 format as they are referenced within the chapter. Where necessary for clarity these are reproduced at A3 in Appendix F of this chapter.

10.1.2 Peat Slide of 16th October 2003

The peat slide that occurred on the site on the 16th October 2003, during the first phase of construction on the wind farm, had a significant effect on soils, geology and land in the area. Therefore, it forms an integral part of the impact assessment for the project and specifically in this Chapter of the report.

This section gives an overview of the characteristics of the peat slide as well as the likely cause of the slide, possible failure mechanism and contributory factors that were interpreted based on site inspections and investigations carried out at the time.

Section 10.1.2.2 then describes how the impact of the peat slide and the issue of peat stability in general are necessarily assessed to current best practice guidelines in this Chapter for the project within the context and scope of the rEIAR.

10.1.2.1 Overview of the Peat Slide, Likely Cause and Possible Failure Mechanism

Over 450,000 m^3 of blanket bog was disturbed in the slide over an area of approximately 25 Hectares on the forested slopes on the south side of the wind farm. Approximately 250,000 m^3 of the disturbed peat moved downslope from the slide area, broke up and entered the natural drainage channel for the watercourse in subcatchment SC7(b) (as defined in Chapter 11 – Hydrology and Hydrogeology) as a viscous flow of fluidised remoulded peat debris. Some of this material was deposited in lobes on flatter ground to either side of the channel upslope from the Black Road Bridge. A proportion of the debris moved further downslope along the stream channel below the bridge ultimately reaching the Owendalulleagh River, approximately 5.25 km downstream from the site.

The movement of the debris along the stream channel occurred in pulses in the days and weeks following the slide in response to subsequent rainfall events, which remobilised the peat debris in the upper reaches of the stream when surface runoff entered the channel. Immediately following the peat slide a number of barrages were constructed across the stream channel and slide area in an effort to contain the downstream movement of the debris.

The material that remained within the failure scar on the upper slopes and wind farm site was typically comprised of detached rafts of intact peat, remoulded peat debris and a thin cover of intact basal peat over the underlying mineral soil and rock. Sections of the site access tracks on the south side of the wind farm were also damaged in the slide and had to be re-constructed. Over time, surface runoff and groundwater has become concentrated along natural drainage channels within the slide area, increasing the level of drainage to the blanket bog on the surrounding slopes.

Applied Ground Engineering Consultants, Ltd. (AGEC) carried out an inspection and supplemental investigations on the site at the time of the slide to provide an opinion on the likely cause of the failure. A copy of their report - "*Derrybrien Windfarm – Final Report on Landslide of October 2003*" - is included in Appendix A of this Chapter.

The peat slide was initially reported to have occurred immediately downslope of Turbine T68 on the southern slopes of the wind farm, and AGEC have identified this as the likely initiation point for the slide. At the time of the failure, peat was being excavated from the site of the turbine and the arisings were being placed or "sidecast" onto the intact peat slopes on the downslope side of the turbine and floating road. Other drainage works were being carried out along the floating road within the slide area approximately 300 m downslope from T68.

AGEC concluded that the construction activity, and particularly the placing of arisings onto the intact peat slopes, most likely triggered the slide. The failure mechanism that they proposed is shown schematically in Figure 10-1. The additional surcharge load on the intact peat slopes could have initially caused a localised shear failure in the underlying intact peat, which would have reduced its shear resistance and resulted in a redistribution or transfer of lateral load to the adjacent peat downslope. Additional transfer of lateral loading as more material was placed on the slopes could have led to a progressive shear failure and reduction in shear resistance along the base of the peat further downslope. Ultimately, this could have led to the large planar or translational peat slide that occurred on the inclined slopes.

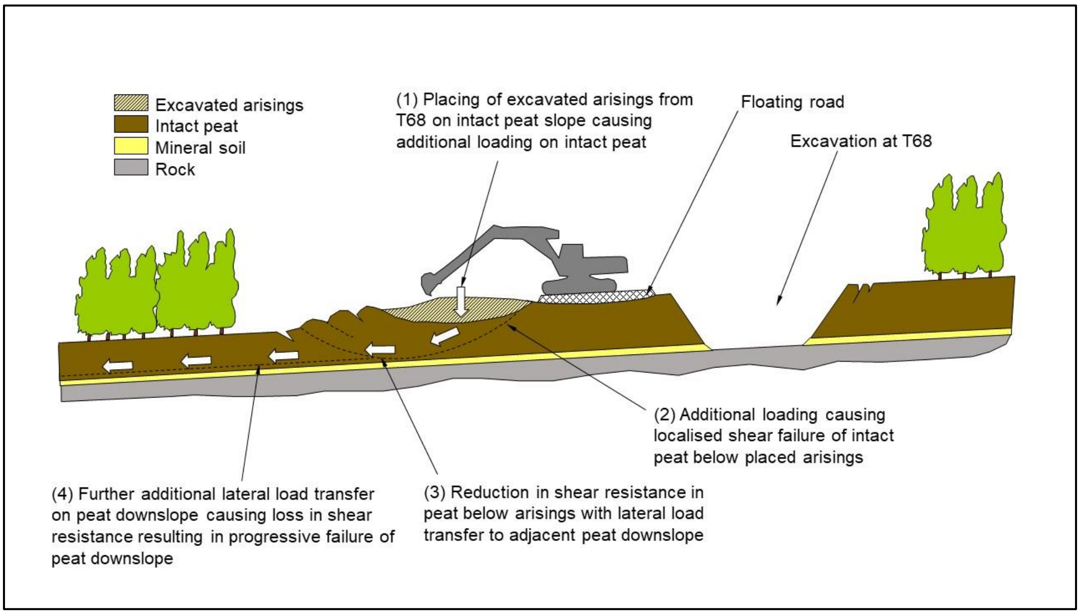

Figure 10-1: Schematic of likely failure mechanism of 16th October peat slide

The magnitude of the load on the intact peat slopes from the arisings was low relative to the scale of the peat slide. Furthermore, excavated arisings from the turbine foundations had already been sidecast on the intact peat slopes in a number of other locations on the site without causing a failure in the peat. Therefore, on its own it does not fully explain why the slide occurred at Turbine T68.

Based on their investigations into the failure, AGEC have identified additional contributory factors that would have made the slope predisposed to failure in that area including, *inter alia*:

- Its location within a shallow valley along a natural drainage line where there would likely have been a concentration of both surface and sub-surface water flow;
- A zone of weaker peat at depth within the centre of the drainage line;
- The additional surcharge load from the floating road at the top of the slide, which was constructed directly on the intact peat slopes;
- The drainage works that were being carried out within the slide area approximately 300 m downslope from the turbine; and
- The existing furrows and drainage lines within the conifer forests which would have dissected the vegetative upper layers of the peat creating lines of weakness within the peat mass.

This is consistent with additional investigations carried out subsequently on the site, and also with current best practice guidelines for assessing the risk of peat instability for wind farm developments on upland blanket bogs, which are based on assessing a range of similar contributory risk factors related to site characteristics to identify areas where there is an elevated risk of peat instability, as will be discussed in this Chapter.

10.1.2.2 Treatment of the October 2003 Peat Slide in the rEIAR

Section 10.1.5 gives a detailed description of the methodology that was used for the assessment of the impact of the project on the receiving soils, geology and land. This section describes how the impact of the peat slide and the issue of peat stability in general have been necessarily assessed for the project within the context and scope of the rEIAR.

- In Section 10.3 direct impacts of project activities that have an effect on peat stability have been assessed separately as **stability impacts** over the full project life cycle, from construction through to decommissioning, including residual impacts after decommissioning.
- The methodology for assessing the **effect** of stability impacts reflects the risk of a peat slide occurring for each activity based on the characteristics of the activity (e.g. the magnitude, extent, frequency and duration of loading on the peat), the probability of a peat failure occurring as a result of that activity, and the possible nature and extent of the peat failure.
- The **probability of a peat failure** occurring has been assessed based on the site characteristics and relevant contributory factors that increase the risk of a peat slide in accordance with current best practice guidelines for peat landslide hazard and risk assessments for wind farm developments on upland blanket bogs (e.g. Scottish Government – Energy Consent Unit, 2017).

- The **possible nature and extent of a peat failure** has been calibrated by the characteristics and scale of the peat slide that occurred on the site in October 2003, which has been assessed as the worst case scenario for this project.
- In determining the **significance** of the effect of stability impacts, the sensitivity of the receiving environment has been assessed based on the characteristics of the soils, geology and land that could be impacted by a peat failure in the worst case scenario.
- In Section 10.3.2.1.1.3 the October 2003 peat slide has been identified as an **"*impact that has occurred*"** during the construction stage of the wind farm, specifically in the assessment of the impact of sidecasting materials excavated from the turbine foundations on the intact peat slopes, which has been attributed to triggering the slide at Turbine T68.
- The monitoring and mitigation measures that were implemented on the site in response to the slide to successfully prevent any further peat failures during the remaining construction phase of the project, and over the operation and maintenance period of the wind farm to date are presented in Section 10.5.
- Given the significance of the peat slide on this project, the impact of the slide and related response works on the receiving soils, geology and land in the area have been assessed separately over the full project life cycle in Section 10.3.4. The baseline sensitivity of the receiving environment within the area impacted by the slide has been assessed in Section 10.2 and residual impacts of the slide after decommissioning are assessed in Section 10.6.
- The peat slide has been treated as a **single event** that occurred on the 16th October 2003 and includes the pulses of debris movement that occurred down the channel of stream SC7(b) in the days and weeks after the slide.

This represents a comprehensive assessment of the direct impacts that the project had on the receiving soils, geology and land with regard to peat stability, including an assessment of the direct impact of the peat slide itself. The impact assessment has necessarily been carried out in accordance with the current EPA Guidelines (EPA, 2017) as well as current best practice guidelines for peat landslide hazard and risk assessments for wind farm developments on upland blanket bogs (Scottish Government – Energy Consent Unit, 2017). However, it does not reflect the state of practice and understanding of the risk of peat slope failures in the construction industry at the time of the slide. Therefore, to put the assessment in context:

- At the time of the peat slide at the Derrybrien Wind Farm in 2003 the construction industry's general knowledge of failures on peat slopes was very limited. While there had been some failures previously, these generally remained largely unreported and none were of the scale or impact of the slide that occurred at Derrybrien. The Derrybrien peat slide was an unprecedented event and is still the largest peat slide to have occurred in Ireland or the UK.
- The peat slide at Derrybrien stimulated numerous investigations, research projects and publications into peat slope failures in Ireland and the UK which

have greatly increased our knowledge of the behaviour of peat and of peat failures on upland blanket bogs.

- The best practice guidelines for peat landslide and risk assessments for electricity generation developments on upland blanket bogs (Scottish Government - Energy Consent Unit, 2017) were developed as a result of the peat slide at Derrybrien. The first version of the guidelines was published in the UK in December 2006 (Scottish Executive, 2006). In Ireland they were first referenced for assessing the impact of wind farms on peat soils in the 2008 version of the Best Practice Guidelines for the Irish Wind Energy Industry (IWEA, 2008).
- The mitigation and monitoring measures that were implemented on the Derrybrien Wind Farm site in response to the peat slide were successful at preventing any further peat slides on the site during the remaining construction and operation phases of the project. Although many of these measures have become standard practice in the industry, they would not have reflected standard practice at the time that the slide occurred in 2003.

In general, the most significant effects of the project on soils, geology and land occurred during the construction stage of the project, particularly up to and including the peat slide at the wind farm site in October 2003.

As will be shown in this Chapter, the impact of site activities on the peat and the significance of the effects with regard to peat stability reduces considerably over the project life cycle from the second phase of construction after the peat slide (2004-2006), through the operation and maintenance phases of the project (2006-2020 & 2020-2040), to decommissioning in circa 2040, particularly on the wind farm site. This is due to changes in the characteristics of the site activities as well as changes to the probability of occurrence of a peat slide as a result of:

- Implementation of effective design mitigation measures and alternative construction methods (e.g. alternative methods of spoil management);
- Additional geotechnical investigations, stability analyses, testing, monitoring and geotechnical supervision (e.g. geotechnical assessment and full-scale proof testing of floating roads); and
- Changes to the site characteristics due to improved drainage and an increase in the strength of the peat under sustained dead load surcharges (i.e. the floating roads, peat repositories and material sidecast areas).

10.1.3 Statement of Authority – Wind Farm Site Activities

The assessment of the impacts related to the Derrybrien Wind Farm elements of the project was carried out by **Mr. Conor O'Donnell (BA, BAI, MS, FGS, CEng, MIEI, FConsEI)**, Managing Director at AGL Consulting. Mr. O'Donnell is a Chartered Engineer with over 20 years' experience as a geotechnical engineer in Ireland and the United States. He has an Honours Bachelor's Degree in Civil, Structural and Environmental Engineering from Trinity College Dublin, and a Master's Degree in Geotechnical Engineering and Structural Mechanics from Cornell University, Ithaca, New York.

Mr. O'Donnell has extensive experience with civil and earthworks design for wind farms in Ireland and the UK, and has developed a particular area of expertise in assessing and managing the risk of peat instability for wind farms on upland blanket bogs at planning, detailed design and construction stage. He was the lead project geotechnical engineer responsible for managing the risk of peat instability for the completion of the civil works on the Derrybrien Wind Farm site after the peat slide in October 2003.

Mr. O'Donnell was the geotechnical advisor to An Bord Pleanála on peat stability and ground movement for the Oral Hearing into the 2009 application for the Corrib Onshore Gas Pipeline. He was geotechnical consultant to Sligo County Council on spoil management for excess peat and mineral soil for the EIS and 2014 Oral Hearing for the N4 Collooney to Castlebaldwin Road Improvement Scheme. Mr. O'Donnell has also provided expert opinion to the Health and Safety Authority and to insurance companies in relation to peat slides that occurred on wind farm sites in Ireland.

Mr. O'Donnell was assisted by **Ms. Niamh Farrell (BA, BAI, CEng, MIEI)**, Principal Geotechnical Engineer at AGL Consulting. Ms. Farrell has an Honours Bachelor's Degree in Civil, Structural and Environmental Engineering from Trinity College Dublin and is a Chartered Engineer with over 9 years' experience as a geotechnical engineer. One of her specialist areas of expertise is in geotechnical design and earthworks for large civil engineering infrastructure projects, including wind farms and motorways. She has also extensive experience in the geotechnical characterisation of peat, and on earthworks designs on soft ground. Ms. Farrell was project geotechnical engineer for the 2014 contract to upgrade the floating roads on the Derrybrien Wind Farm, and she was a part-time resident engineer on site over the course of the works.

10.1.4 Statement of Authority – Grid Connection and Peat Slide and Response Works

The assessment of the impact of the Grid Connection and Peat Slide and Response Works elements of the Project was made **by Dr Paul Jennings (PhD, BEng, DipArb, CEng, MIEI),** Chartered Geotechnical Engineer, UK Registered Ground Engineering Professional (Advisor) with over 30 years' geotechnical consultancy experience in Ireland, and internationally. Paul has completed numerous geotechnical & geological impact assessments for wind farm developments in Ireland and Scotland. In addition, he has attended and provided oral evidence at numerous oral hearings for wind energy developments on peatland sites.

Ian Higgins (BSc, MSc, FGS, MIEI) is a Principal Geotechnical Engineer with over 20 years' geotechnical consultancy experience in Ireland and the UK. Ian has completed numerous geotechnical & geological impact assessments for wind farm developments in Ireland. In addition, he has significant experience in the geotechnical/civil design of wind energy projects at construction stage.

Gerry Kane (BEng, PGradDip, CEng, MIEI) is a Chartered Senior Civil/Geotechnical Engineer with over 10 years' geotechnical consultancy experience in Ireland and the UK. Gerry has completed numerous geotechnical & geological impact assessments for wind farm developments in Ireland. In addition, he has significant experience in the geotechnical/civil design of wind energy projects at construction stage.

10.1.5 Methodology

The baseline date for the site conditions used in the impact assessment is 1998, prior to the construction of the wind farm.

All available information was used to establish the baseline conditions for the soils, geology and land on the project and in areas off-site that could be impacted by a peat slide. This included a comprehensive desk study of available information from published sources as well as a review of all the relevant ground investigation information.

The desk study included a review of historical aerial photographs, LiDAR topographical survey data, and relevant information on ground conditions, bedrock geology and Geological Heritage Sites from the Geological Survey of Ireland (GSI) the Environmental Protection Agency (EPA) and the Ordnance Survey of Ireland (OSI).

Additional ground investigations were carried out during the construction stage of the wind farm in 2004/2005, after the peat slide, to supplement the original investigations for the wind farm prior to construction, which were completed in 2001. The majority of the information from the construction stage investigations would also be representative of the conditions on the wind farm site prior to construction, particularly outside the slide area and where the ground conditions were not impacted by the project. Therefore, all of the relevant information from these investigations was used to establish the baseline site conditions.

The baseline sensitivity of the receiving soils, geology and land impacted by the project has been assessed on a 7-point scale from **Negligible** to **High** based on a combination of a number of factors including the characteristics of the materials (i.e. peat, glacial till or rock), the ecological importance of the blanket bog, carbon storage potential (peat), geological heritage (glacial till/rock), and land use characteristics. In assessing the impact of a peat slide related to project activities, consideration has also been given to the characteristics of the receiving soils, geology and land outside the site that could be directly impacted by a slide.

In this Chapter:

- An **'Impact'** is defined as an action from a site activity that results in a change to the receiving soils, geology and land e.g. for construction of the turbine foundations the impact on the receiving soils, geology and land is the excavation of the peat and glacial till to construct the foundation on the underlying rock.
- The **'Effect** is defined as the change or changes resulting from that impact, e.g., the changes to the characteristics of the peat and glacial till that occur after they are excavated.

Impacts of the project on soils, geology and land have been assessed over the full project life cycle under three categories:

- Impacts that have occurred;
- Impacts that are occurring; and
- Impacts that are likely to occur.

The first category relates to impacts that occurred during the construction of the project between 2003 and 2006 as well as during the operation and maintenance period of the project between 2006 and Q2 of 2020. The assessment of impacts over this period is based on a comprehensive record of project activities that were carried out and any related impacts that occurred, including the peat slide that occurred on the site during construction in October 2003.

The second category relates to impacts from the construction, operation and maintenance stages of the project between 2003 and 2020 that are still occurring at the end Q2 2020. These are typically ongoing long-term impacts such as groundwater lowering due to improved drainage or permanent and sustained surcharge loads on the intact peat slopes from site access tracks or material deposition areas that were left in place at the end of construction.

The third category relates to impacts that are likely to occur on the site over the remaining operation and maintenance phase of the project between 2020 and c. 2040, and during the subsequent decommissioning phase. It includes an assessment of the impact of the project activities that are likely to be carried out over that period based on the nature and scope of the maintenance works that are anticipated or could be required, and based on the proposed decommissioning plan.

The methodology that was used to assess the impact of the various project activities on the receiving soils, geology and land on the site is based on the recommendations in Section 3.7 of the 2017 Draft EPA Guidelines on Information to be Contained in Environmental Impact Assessment Reports (Environmental Protection Agency, 2017).

Given the history of peat instability on the site, for each phase of the project the impacts of site activities have been assessed separately as **Direct Impacts** and as **Site Stability Impacts**, as shown in the flow chart on Figure 10-2.

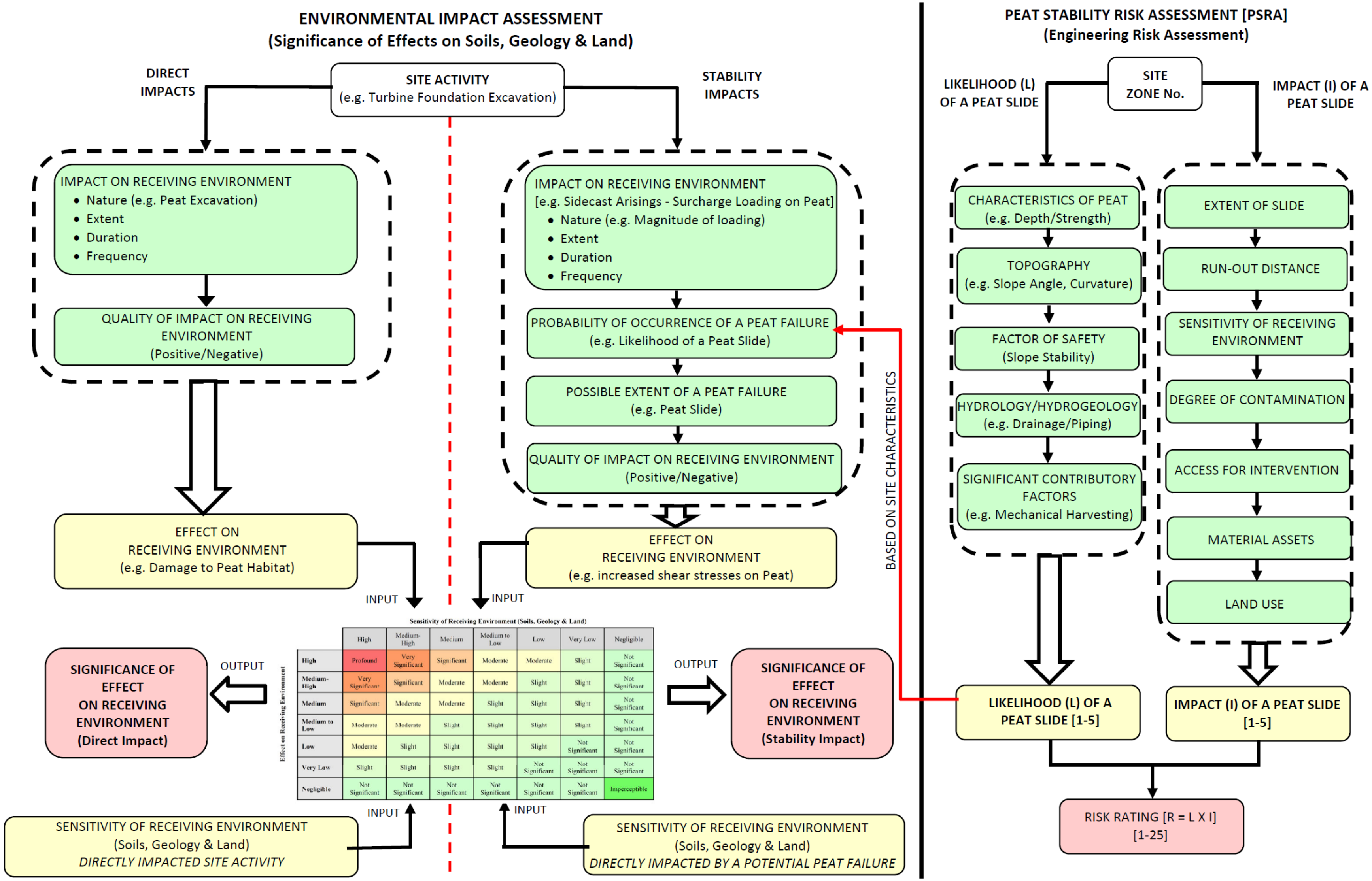

Figure 10-2: Flow chart for assessment of direct impacts on soils & geology and impacts on site stability

Direct Impacts: Direct Impacts of project activities are those that are assessed based on the direct physical impact on the receiving soils, geology and land use. For example - excavation of peat and glacial till for the construction of the turbine foundations has a direct impact on the peat habitat that is disturbed at the turbine site, and the physical characteristics of the excavated materials.

The **Effects** of direct impacts are assessed on a 7-point scale from **Negligible** to **High** based on the nature, extent, duration and frequency of the effects. Many of the impacts for different project activities have the same effect at different locations across the site. Therefore, the combined effect of these impacts has been assessed to determine the significance of the effect. For example, there are 70 No. turbines on the wind farm, all of which involved excavation of peat for the turbine foundations. Peat excavation was also required for the borrow pits, substation, site compound and anemometer masts. Therefore, the combined volume of peat excavated from these sites and the total area of disturbed habitat on the blanket bog have been calculated to assess the significance of the effect on the receiving soils, geology and land. In assessing the combined effect for the whole project, consideration has also been given to the volume of peat that was disturbed in the peat slide that occurred at the site in October 2003. Where appropriate, impacts that are specific to a particular activity or location have been assessed independently.

For impacts that have occurred (e.g. during construction), the assessment is based on comprehensive records of project activities and the works that were carried out for the project. However, for impacts that are likely to occur over the remaining life of the project, the probability of occurrence of the impact is also considered.

The **Significance** of the effects of direct impacts have then been determined as a function of the sensitivity of the receiving soils, geology and land directly impacted by the project activity using the matrix in Figure 10-3, which has been adapted from the chart in Figure 3.5 of the 2017 EPA Guidelines.

Effect on Receiving Environment ↓ / Sensitivity of Receiving Environment (Soils, Geology & Land) →	High	Medium-High	Medium	Medium to Low	Low	Very Low	Negligible
High	Profound	Very Significant	Significant	Moderate	Moderate	Slight	Not Significant
Medium-High	Very Significant	Significant	Moderate	Moderate	Slight	Slight	Not Significant
Medium	Significant	Moderate	Moderate	Slight	Slight	Slight	Not Significant
Medium to Low	Moderate	Moderate	Slight	Slight	Slight	Slight	Not Significant
Low	Moderate	Slight	Slight	Slight	Slight	Not Significant	Not Significant
Very Low	Slight	Slight	Slight	Slight	Not Significant	Not Significant	Not Significant
Negligible	Not Significant	Not Significant	Not Significant	Not Significant	Not Significant	Not Significant	Imperceptible

Figure 10-3: Significance of Effect on Receiving Soils, Geology & Land

Stability Impacts: Stability impacts are direct impacts where the effect on the receiving soils, geology and land increases or decreases the risk of instability on the site, typically in the peat, potentially triggering a large peat slide as a worst case scenario.

For example, where peat and glacial till excavated from the turbine foundations are placed on the intact peat slopes adjacent to the excavations (i.e. sidecast), covering the peat habitat with the excavated material is the **direct impact** on the receiving soils, geology and land. However, the dead load surcharge that is applied on the surface of the peat due to the weight of the materials is the **stability impact**. In this case the primary effect of the stability impact is the increase in shear stress in the underlying peat, which increases the risk of a peat failure, potentially triggering a peat slide on sloping ground where the magnitude of loading is such that the downslope shear stresses exceed the strength of the peat.

Therefore, to identify site activities that have a higher risk of triggering a peat slide, the effects of site stability impacts have been qualitatively assessed on a 7-point scale from **Negligible** to **High** as a function of:

- The characteristics of the site activity and stability impact (e.g. the magnitude, extent, frequency and duration of loading on the peat)
- The quality of the effect on the receiving soils, geology and land with respect to site stability [i.e. negative (increases risk of peat instability), or positive (reduces risk)];
- The probability of a peat failure occurring as a result of the effect; and
- The possible nature and extent of a peat failure.

Characteristics of Stability Impacts: In the majority of cases the stability impact of project activities involves a dead or live load surcharge on the intact peat slopes. The magnitude, extent and frequency of loading is a function of the characteristics of the project activities, which have been assessed based on the comprehensive site records from the construction stage of the project and from the initial operating phase of the wind farm to date. For impacts that are likely to occur over the remaining design life of the project, the probability of occurrence of the impact is also considered.

Where appropriate, stability impacts of different site activities in the same part of the site have been assessed in-combination to determine the significance of the effect. For example, the effect of the live load surcharge from construction traffic on the floating roads has been assessed in combination with the dead load surcharge from the road itself, which was constructed directly on the peat. Also, in assessing the impact of material sidecasting on the intact peat slopes, consideration has also been given to the fact that the material was typically placed adjacent to the floating roads with the excavators operating on the roads, which would have led to a concentrated combined surcharge loading and activity on the peat in those areas at the time.

In some cases, it was not appropriate to assess stability impacts in combination. For example, while consideration has been given to the magnitude, frequency and duration of construction traffic loading on the floating roads for each activity, the live load surcharges from different site activities have not been combined because they do not lead to a cumulative loading on the road, i.e. the roads were not wide enough to accommodate two-way traffic. Furthermore, not all of the activities were carried out in the same part of the site or at the same time. For example, while excavations for some of the turbine foundations were active, the construction of the floating roads was being completed, they were typically being carried out in different parts of the site due to logistical constraints and traffic control. The heavy surcharge loading on the floating roads from the mobile cranes that were used to erect the turbines would also have occurred after the turbines and crane hardstandings had been completed. Site activities related to the 110 kV overhead line and Agannygal Substation were remote to the wind farm site.

Fundamentally, site activities that were carried out in different parts of the site or at different times did not have a combined stability impact on the peat. However, where activities that were carried out in the same area and at the same time did have a combined stability impact then this has been considered in the assessment.

Quality of Impact: The direct physical effect of surcharge loads on the peat slopes involves an increase in shear stresses in the peat, which increases the risk of a peat failure, potentially triggering a large peat slide as a worst case scenario. Therefore, surcharge loading has a **negative** impact on the peat with respect to site stability.

Project activities that have a **positive impact** on the peat with respect to site stability are those which reduce the risk of peat failure – for example drainage improvements that reduce groundwater pressures within and below the peat and increase the strength of the peat where the groundwater table is lowered.

Probability of Occurrence (Peat Failure): The probability of a peat failure occurring has been assessed for each project activity based on the characteristics of the stability impact (e.g. the magnitude, extent, duration and frequency of loading) as well as the physical characteristics of the site such as the topography, peat depth, peat strength and groundwater conditions. This is consistent with the EPA Guidelines (EPA, 2017) as well as current best practice guidelines for peat landslide hazard and risk assessments in *"Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Projects,* 2nd Edition, April 2017 (Scottish Government – Energy Consent Unit, 2017).

On this project a peat stability risk assessment has been carried out for the various components of the project in accordance with the 2017 best-practice guidelines from the Scottish Government Energy Consent Unit to assess the likelihood of a peat slide in zones across the site based on the site characteristics and other contributory factors that are known to lead to a higher risk of peat instability. As illustrated in Figure 10-2, the results have been used to assess the probability of occurrence of a peat failure for the assessment of stability impacts in this chapter.

The peat stability risk assessments for the wind farm site, the peat slide response works, and the grid connection are presented in Section 0.

The probability of occurrence of a peat failure is expressed as a range (e.g. Low to Possible) to characterise the range in conditions across the site. The probability is also assessed at each stage in the project life cycle to take account of any changes to the characteristics of the site activities - for example by alternative design or method of construction - or any changes in site conditions that could change the likelihood of a peat slide, such as the increase in strength that occurs in peat over time as it consolidates under sustained surcharge loads left in place on the slopes.

For this project, the possible **Extent** of a peat slide and the **Sensitivity of the receiving soils, geology and land** have been calibrated by the scale of the very large peat slide that occurred on the site on the 16th October 2003, and by the land that that was directly impacted by the slide. The slide covered an area of approximately 25 ha and is the largest peat slide that has ever been recorded in Ireland. The characteristics of the land use, topography, ground and groundwater conditions within the slide area are also representative of the general conditions that could be impacted by the project in other areas around the site where there is a risk of a large peat slide. Therefore, it has reasonably been considered as the worst-case scenario in assessing stability impacts on this project.

To accurately characterise the possible extent of a slide for each project activity, consideration has also been given to the scale and characteristics of smaller, more localised peat failures that occurred on the site during construction – for example the localised shear failure or small scale peat slides that occurred around the perimeter of some of the open excavations in peat for the turbine foundations, which had a significantly lower impact on the receiving environment on the wind farm site.

The **Significance** of the effects of stability impacts was then determined using the matrix in Figure 10-3 as a function of the **Effect** that the impacts had on the peat with respect to site stability (which reflects the likelihood and possible extent of a peat failure), and the baseline **Sensitivity** of the receiving soils, geology and land potentially impacted by the peat failure, including land downslope and off-site from the wind farm in the case of a large peat slide.

This chapter identifies where peat failures actually occurred during construction as a result of project activities. Although the probability of a peat failure occurring has been assessed as Very Possible or Likely for some site activities that were carried out extensively across the site, only a small number of peat failures actually occurred, and all but one of these were localised or small scale failures within the site where the effect on the peat was Low and only Slightly Significant. This is because there are usually a number of other natural and anthropogenic factors that contribute to peat failures occurring in any area of the site in addition to the stability impact of the site activities.

To ensure that there is a consistent and representative methodology for assessing stability impacts of project activities on the receiving soils, geology and land, and the direct impact of peat failures that can occur as a result of those activities:

- The worst case scenario for the possible extent of a peat failure has been used to assess the significance of the effect of stability impacts on the receiving environment; and
- Where there is a high probability of a peat failure occurring as a result of a site activity (i.e. very possible to likely), the significance of the effect of the stability impact of that activity on the receiving environment is the same as the significance of the effect of the direct impact of the peat failure that could occur in the worst case scenario as a result of that activity.

In this way the methodology identifies stability impacts that have significant effects whether or not a failure occurs so that appropriate design and construction mitigation measures can be implemented as a preventative measure.

Cumulative impacts: Cumulative impacts from other projects on site or in the area are assessed in Section 10.4 of this chapter. Most of the other projects in the area are remote to the project and will not have cumulative impacts on soils, geology and land in the project area. Therefore, the assessment of cumulative impacts is limited to any significant impacts from other wind farms within close proximity to the project, commercial forestry and peat extraction in turbary plots on the wind farm site and in the general area.

Remedial (Mitigation) Measures and Monitoring: Section 10.5 gives a comprehensive record of the mitigation measures that were implemented during construction of the project, particularly after the peat slide, and during the operation and maintenance phase up to the end of Q2 2020. Section 10.5 also gives details of the monitoring that was carried out to monitor peat movement and changes to ground water levels in selected areas across the wind farm site after the peat slide in October 2003.

The majority of the mitigation and monitoring measures that were implemented on the project were used to successfully manage the risk of peat instability and prevent another peat slide on the site. Apart from some changes to the layout and extent of the floating roads, or to the number of turbines that were constructed on the site, there were no significant changes to the design of the project. The mitigation measures were generally related to spoil management, management of site activities on the peat slopes (e.g. drainage, tree felling etc) and to the evaluation, testing and use of the floating roads. Many of the measures that were adopted were developed from first principles and are included in this chapter to give context to the assessment of stability impacts on soils, geology and land.

At this stage the mitigation measures that are relevant to the ongoing operation and maintenance of the wind farm have been incorporated into the standard operating procedures on the site. They will continue to be implemented for the remaining design life of the project and for comparable construction/demolition activities during decommissioning. Section 10.5 also includes additional specific mitigation measures that will be implemented over the remaining operation and maintenance phase up to c. 2040 and for decommissioning, which are consistent with the measures that have been successfully implemented on site to date.

Residual impacts: Residual impacts that are likely to occur after the decommissioning of the project are addressed in Section 10.6. These are based on the proposed decommissioning plan for the project and include impacts that are occurring and are likely to continue after decommissioning.

10.1.6 Difficulties Encountered

No significant difficulties were encountered that prevented a comprehensive assessment of impacts of the project on the receiving soils, geology and land.

This section presents a summary of the difficulties that were encountered during the assessment and the actions that were taken to overcome those difficulties, where possible.

10.1.6.1 Wind Farm Site

The main difficulties that were encountered in the assessment of the impact of the wind farm on soils, geology and land on the site were related to the limited information that was available for the ground and groundwater conditions on the site prior to construction, and for some of the construction activities prior to the peat slide on October 2003, i.e.:

- There was very limited ground investigation information available for the site prior to construction to establish the baseline conditions for the ground and groundwater conditions on the site in 1998;
- There are limited records for some of the construction activities that were completed prior to the 2003 peat slide, particularly the management and disposal of spoil excavated from the site compound, borrow pits and 39 No. turbine foundation excavations that were completed prior to the slide.
- There is also limited information on the remedial measures and monitoring procedures that were implemented to mitigate the impact of the project on soils, geology and land.

Due to access restrictions on the wind farm site the pre-construction ground investigation that was carried out in 2002 was limited to a small number of trial pits and light dynamic probes in the peat with limited laboratory classification testing of disturbed samples, which did not provide full coverage of the site. However, this was compensated for by the extensive ground investigations, topographical surveys and laboratory testing that were carried out on the wind farm site during the second phase of construction after the slide, which provided comprehensive coverage of the site. This information was necessarily considered representative of the baseline conditions on the site, prior to construction, particularly where the information was not affected by the works that had been completed on the site.

Prior to the peat slide in October 2003 peat, mineral soil and, in some cases, weathered rock were excavated from the site of the borrow pits, site compound and 44 No. turbine foundations that had been completed or excavated. There is limited information on the volume of the different materials that were excavated from these areas, and the records of where the materials were disposed of are incomplete, particularly for the site compound and borrow pits. However, the majority of the materials were excavated from the sites of the turbine foundations and it is known that these were sidecast on the peat slopes adjacent to or within close proximity of the excavation. Although there are limited records of the volume of the materials that were excavated from each turbine, a detailed survey of the material sidecast areas was completed by Applied Ground Engineering Consultants (AGEC) immediately after the peat slide. The survey provides sufficient information on the location, extent, characteristics and depth of the materials deposited in each area to carry out the assessment of the impacts on the receiving soils, geology and land. AGEC also recorded details of observed peat instability in the sidecast areas which has facilitated the assessment of the site stability impacts. The results of their survey are included in their report “Final Report on Derrybrien Windfarm Post-Landslide Site Appraisal”, dated 4th February 2004 (Ref. 378_099), which is included in Appendix A.

Although, there are limited records for the materials excavated from the sites of the borrow pits and site compound, it has been assumed that the same construction methodology was used for disposing of the excavated materials so that it had a similar impact on the receiving soils, geology and land on the wind farm site.

There was also limited information on the groundwater levels in the peat across the wind farm site. This made it difficult to quantitatively establish the baseline conditions on the site, prior to construction, and also to assess the impact of drainage on the peat and subsoils during and after construction. For example:

- No piezometers were installed on the site during the original ground investigation in 2002, prior to construction, or during the initial phase of construction before the peat slide in October 2003;
- After the peat slide, a combination of manual standpipe piezometers and automated electronic piezometers were installed in selected areas across the site to monitor groundwater levels during and after construction. However, there was an insufficient number of piezometers to give a comprehensive record of groundwater levels for the diverse range of topography, ground conditions, surface hydrology and drainage conditions across the entire site.
- The electronic piezometers were monitored continuously over a period of over 6 years after construction, up to January 2012. However:
    - As noted above, there was an insufficient number of piezometers to characterise the full range of conditions that would be expected across the site;
    - There were no manual backup readings to confirm that the piezometers were functioning correctly over such an extended period of time; and
    - Monitoring of the piezometers were discontinued before the groundwater levels had stabilised at the monitoring locations.

Although there is limited quantitative information on groundwater levels across the wind farm site, it is considered that there is still enough information on the topography, hydrology, drainage, soil, rock and groundwater conditions across the site to carry out a sufficiently detailed and conservative qualitative assessment of the likely impact of drainage on the receiving soils, geology and land based on experience and sound engineering judgement. In assessing the impact, some judgement has necessarily been applied to interpreting the limited piezometer data that is available and how representative it is for the range of conditions that would be expected across the site given the location of the piezometers and the reliability of the data.

10.1.6.2 Peat Slide: Temporary Barrages and Run-Out Distance of Slide Debris

Some difficulty was also encountered in determining details of temporary barrages. Following the peat slide event, a number of temporary barrages were constructed a distance downstream to intercept the flow path of the peat slide debris. These temporary barrages were constructed immediately following the peat slide and were subsequently removed within an estimated year or so following the peat slide. Details of the extent of these temporary barrages is not known, and inspection (in 2020) of the location of these temporary barrages showed no evidence of the barrage. For impact assessment purposes, an estimate of the construction and extent of temporary barrages has been included below based on reasonable estimates.

The extent of the run-out distance of the peat slide debris is difficult to estimate with certainty and has been estimated based on the presence of peat debris on the stream/river banks based on records following the slide event. The peat slide debris would have initially comprised dominantly a remobilised peat flow, but as the debris entered a stream/river channel the debris flow would have become more fluidised due to the presence of water. The channelised debris flow would have eventually become sufficiently degraded and saturated that it would act as a suspension in water, which in the context of the impact on Soil, Geology and Land would have effectively marked the end of the peat debris flow.

10.2 Baseline Environment

This section gives an interpretation of the baseline conditions for soils, geology and land use for the project in 1998, prior to construction of the project.

10.2.1 Baseline Environment – Wind Farm Site

10.2.1.1 Introduction

All available information was used to establish the baseline conditions on the wind farm 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 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).

Section 10.2.1.2 gives a summary of the ground investigations that were carried out on the wind farm site in 2001, prior to construction, and in 2004/2005 during the construction stage of the project. The majority of the information from the construction stage investigations would also be considered representative of the baseline conditions on the wind farm site, particularly outside the slide area and also where the ground conditions were not impacted by the project. Therefore, all of the relevant information from these investigations was used to establish the baseline site conditions.

Section 10.2.1.3 gives a summary of the baseline conditions for the topography and land use on the site, as well as the geotechnical characterisation of the peat and glacial till, and the geological classification of the bedrock geology.

Sections 10.2.1.3.4 and 10.2.1.3.5 give a summary of the groundwater conditions on the site and an overview of the surface hydrology and hydrogeology in the peat, which are relevant to the assessment of the impacts on soils, particularly in relation to the peat and site stability.

The characteristics and sensitivity of any Geological Heritage Sites (GHS) within the wind farm site are assessed in Section 10.2.1.3.3.5 based on the information that is included in the GSI database.

The baseline sensitivity of the receiving soils, geology and land impacted by the project has been assessed in Section 10.2.1.4 based on a number of factors including the characteristics of the materials that were impacted (i.e. peat, glacial till or rock), the ecological importance of the blanket bog, carbon storage (peat), geological heritage (glacial till/rock), and land use characteristics. In assessing the impact of a peat slide related to activities on site for the project, consideration has also been given to the characteristics of the receiving soils and geology outside the wind farm site that could be directly impacted by a slide, downslope from the wind farm.

The results of the baseline peat stability risk assessment are presented in Section 10.2.2.1 to characterise the likelihood of a peat slide across the site based on baseline site characteristics related to topography, peat and subsoil conditions, hydrology, hydrogeology and other known contributory risk factors related to peat instability. The assessment identifies areas on the site where there were compounding risk factors with regard to peat stability that could lead to an elevated risk of a peat failure prior to the implementation of appropriate risk mitigation measures.

10.2.1.2 Geotechnical Investigations

10.2.1.2.1 Introduction

Extensive ground investigations have been carried out across the site to date at different phases of the project, primarily at detailed design and construction stage. Drawing No. 003 by AGEC Ltd. in Appendix A of the "*Derrybrien Windfarm - Geotechnical Stability Report & Assessment of Stability Impacts of On-Site Activities*" by AGL Consulting (Report No. 11-147-R01), which is included as Appendix B of this Chapter, shows a consolidated layout plan of the majority of the investigation points, which illustrates the high level of site coverage that has been achieved. The investigations have largely been comprised of:

- A comprehensive desk study of available information on soils, geology and groundwater conditions.
- An aerial LiDAR survey of the wind farm 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-situ 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.
- 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.
- Rotary coreholes to establish the depth to rock and the rock mass characteristics at a number of turbine locations;

The following is an outline summary of the different phases of site investigations that were carried out on the wind farm site. Further details on the investigations and related factual reports are included in AGL Report No. 11-147-R04 in Appendix B. Further details of the investigations are also included in the remedial mitigation and monitoring measures for the wind farm project in Section 10.5.

10.2.1.2.2 Pre-Construction Ground Investigation - IGSL Site Investigation (2002)

IGSL Ltd. carried out the pre-construction ground investigation on the site in December 2001. Access to the turbine locations was not possible for conventional ground investigation equipment to carry out trial pits, boreholes or rotary coreholes because of the poor ground conditions and extensive forestry coverage on the site. Therefore, the works was comprised of the following:

- 8 No. trial pits to depths of 2.5-3.3 m with a wide-track hydraulic excavator;
- 58 No. dynamic probes using a light hand-held Mackintosh Probe – primarily located at Turbines T1-T46, with 12 No. additional probes at selected locations over the rest of the site;
- 24 No. auger samples of the peat at depths of 1.5 m across the site;
- Laboratory testing of the disturbed samples of the peat, which included 12 No. water contents and 6 No. chemical tests (SO_3 & pH)

10.2.1.2.3 AGL/BAM Supplemental Site Investigations – Construction Stage (Post-Slide – 2004/2005)

Extensive supplemental ground investigations were carried out on the site by AGL Consulting and the main civil works contractor, Ascon Ltd. (now BAM Civil) during the second phase of construction in 2004/2005, after the peat slide, to accurately characterise the topography and the depth, strength and characteristics of the peat and underlying glacial till across the site so that the risk of peat instability could be adequately assessed and managed for the completion of the wind farm.

The investigations were primarily concentrated along the site access tracks and at proposed peat deposition areas on the intact peat slopes. The fieldwork consisted of:

- Peat depth probing and sampling with a hand-operated 20 mm diameter steel probe with the 1.0 m long 20 mm diameter gouge-auger core sampler;
- Slope angle measurements on the surface of the peat by GPS, optical survey and hand-held Abney Level;
- In situ vane-shear tests to determine the undrained shear strength of the peat using a Geonor H-10 65/130 mm penetration vane;
- Rotary coreholes by Irish Drilling Ltd. at 27 No. turbine bases to determine the depth to rock and rock mass characteristics, with Standard Penetration Tests (SPT) in the overburden to assess the in-situ undrained shear strength of the glacial till;
- Installation of 10 No. 19 mm diameter push-in piezometers to record groundwater levels in the peat across the site;
- Collection of high-quality undisturbed samples of the peat with 75 & 100 mm thin wall Geonor piston samplers and by block sampling in trial pits; and
- Specialist laboratory testing of undisturbed samples to classify the strength and material characteristics of the peat.

10.2.1.2.4 AGEC Ground Investigation (2003)

AGEC carried out a ground investigation on the site after the peat slide in 2003. The investigation was comprised of:

- In-situ shear vane tests using hand-held vanes. AGEC carried out shear vane tests using the hand held Geonor H-60, 25.4 mrn diameter vane.
- In-situ shear vane tests by Fugro Ltd. to determine the undrained shear strength of the peat using a Geonor H-10 55/110 mm penetration vane mounted on a 3 tonne mini crawler rig.
- Detailed walkover survey inspections and geotechnical mapping of site characteristics and material sidecast areas at turbine locations.

The investigations that were carried out by AGEC are included in their report titled "Final Report on Derrybrien Windfarm Post-Landslide Site Appraisal" dated 04/02/2004 (Report no. 378_099)", which is included in Appendix A. Their investigations formed part of an initial preliminary investigation of peat stability across the site after the peat slide in October 2003. Therefore, they are located along the floating roads and near the turbine foundations that had been completed prior to the slide, where excavated material had been sidecast on the intact peat slopes.

10.2.1.2.5 ESBIE Ground Investigation (2004)

Extensive supplemental geotechnical investigations were also carried out on the site by ESB International Engineering (ESBIE) between June 2004 and December 2004 to assess the stability of the site for the planned tree felling operations following the peat slide in October 2003. The fieldwork provided comprehensive coverage of the site between the floating roads and turbines and was comprised of:

- Slope angle measurements with a hand-held Abney level at 15-25 m intervals along 219 No. profiles at representative locations across the site.
- 3162 No. peat depth probes with a hand-operated 20 mm diameter steel probe to establish the variation in peat depth and the slope at the interface with the underlying mineral soil or rock along the survey profiles.
- Peat sampling at 222 No. locations with the 1.0 m long 20 mm diameter steel gouge-auger core sampler to provide visual classification of the peat
- 1179 No. in-situ vane shear tests in the peat at representative locations with the Geotech AB 140 mm x 280 mm automated vane.
- Installation of piezometers in the peat at selected locations around the site in February 2004.

10.2.1.3 Baseline Conditions (1998) – Soils, Geology & Land Use

10.2.1.3.1 Land Use and Topography

The Derrybrien Wind Farm site 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 10-4. The wind farm site is identified on the photo. The photograph identifies the main features that were on the site prior to construction of the wind farm, including:

- The extent of existing forestry access roads on the site prior to construction;
- The extent of the conifer plantations and firebreaks within the wind farm site;
- The turbary plots in the open blanket bog at the east end of the site;
- The existing access roads to the turbary plots which were constructed as floating roads;
- Patches of poor tree growth across the site – generally associated with deep peat and high water table;
- Existing watercourses and drainage channels;
- Potential subsurface drainage channels along lines of vegetation; and
- The zone of young trees in an area that may have been damaged by fire.

The pattern of tree furrows and the surface drainage network can be identified on the aerial photograph. In the area of peat harvesting on the east side of the site the network of surface drains is defined by the boundaries of the turbary plots. On the west side of the site there is a large area where the tree growth is smaller than the surrounding area – as indicated by the lighter shade of green, possibly indicating where there was a historic fire that damaged the trees in the area. The area has been re-planted and the strips of darker vegetation within this area are indicative of subsurface drainage paths or concentrated subsurface flow.

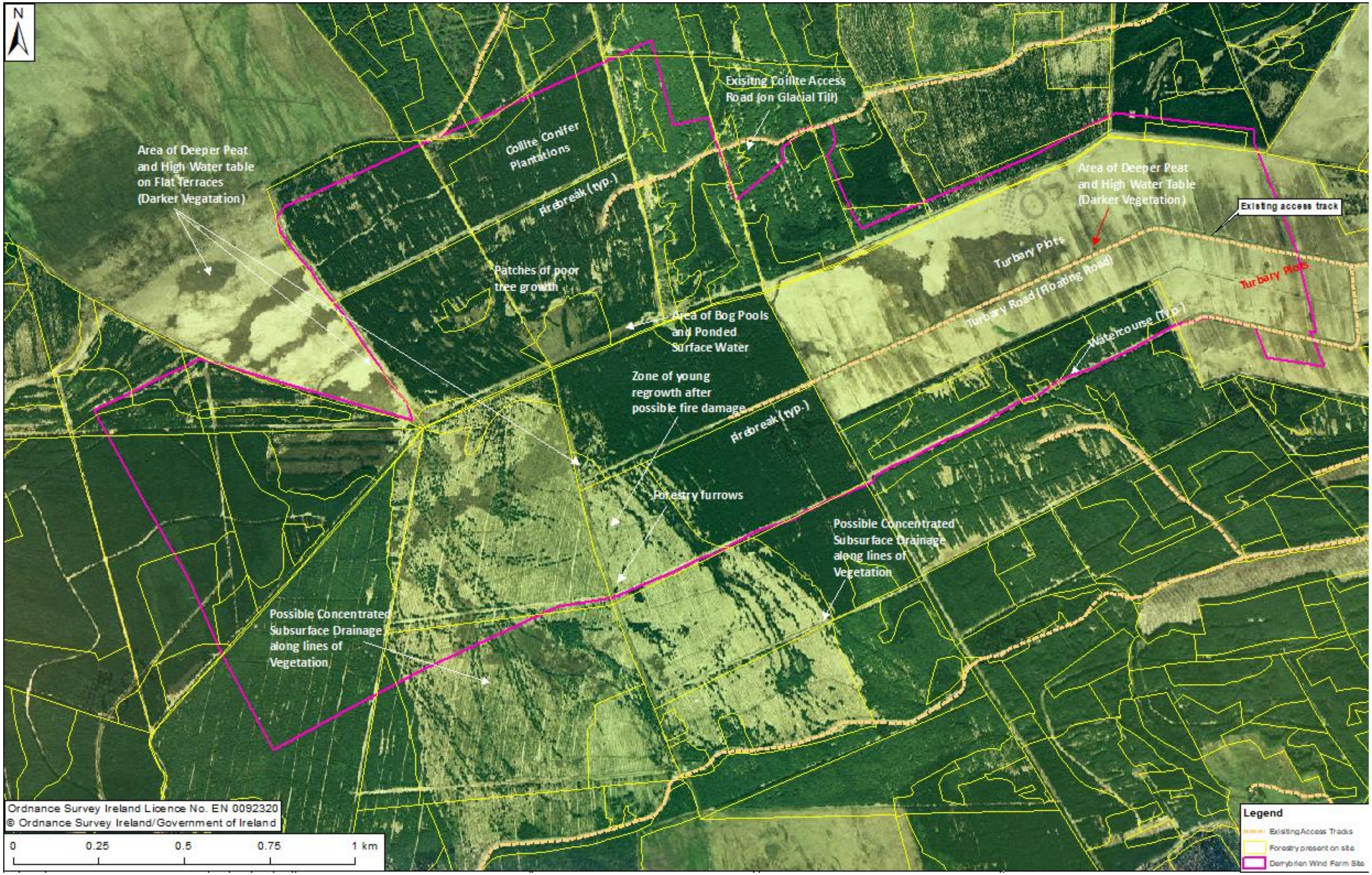

Figure 10-4: Aerial Photograph of the project area prior to construction (2000)

Figure 10-5 and Figure 10-6 show the general topography of the site following completion of construction (i.e. post 2005). However, with the exception of the borrow pits, the slide area at Turbines T68 and T70, and along the site access tracks, the ground surface elevations and slope angles across the site would generally also be relevant to the original conditions on the site in 1998, prior to construction.

The peak of Cashlaundrumlahan Mountain is at Elev. +365 mOD near Turbine T10 near the centre of the site. Within the site the ground level drops away gently to between approximately Elev. +325 mOD and +345 mOD along the perimeter of the wind farm site over a distance of approximately 700 m to the north and south, and 1.2 km to the west. At the east end of the site the ground surface is lower and drops down to Elev. +290 mOD and +298 mOD at Turbines T46 and T44, respectively, which are approximately 2.6 km from the peak.

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 typically <3°. This is within the central three rows of turbines on the site layout in Figure 10-5.

To the south of this zone the slope is convex in profile with slopes generally increasing up 4-5° degrees and locally 5.0-7.5° within the wind farm site, particularly between Turbines T21 and T41. Downslope from the site in this area the slopes increase more consistently typically up to 7.5° and locally up to 10.0°.

The northern upper slopes of the mountain within the wind farm site are characterised by a terraced profile with broad flat areas where the slope angles are <3°, separated by benches where the slopes are locally steeper at up to approximately 5.0-7.5°, locally up to 10°. This reflects a stepped profile to the underlying bedrock, which has sub-horizontal bedding. There are areas of deeper peat and ponded surface water on the flat terraces, as identified on the aerial photograph in Figure 10-4. These are characterised by the change in colour to the darker natural vegetation on the blanket bog, or by pools of surface water, like the area near Turbine T61.

North of the wind farm site there is a convex break in slope to steeper more uniformly graded slopes up to 7.5-15.0°. Turbines T47 to T52 are located along the convex break in slope on this side of the site.

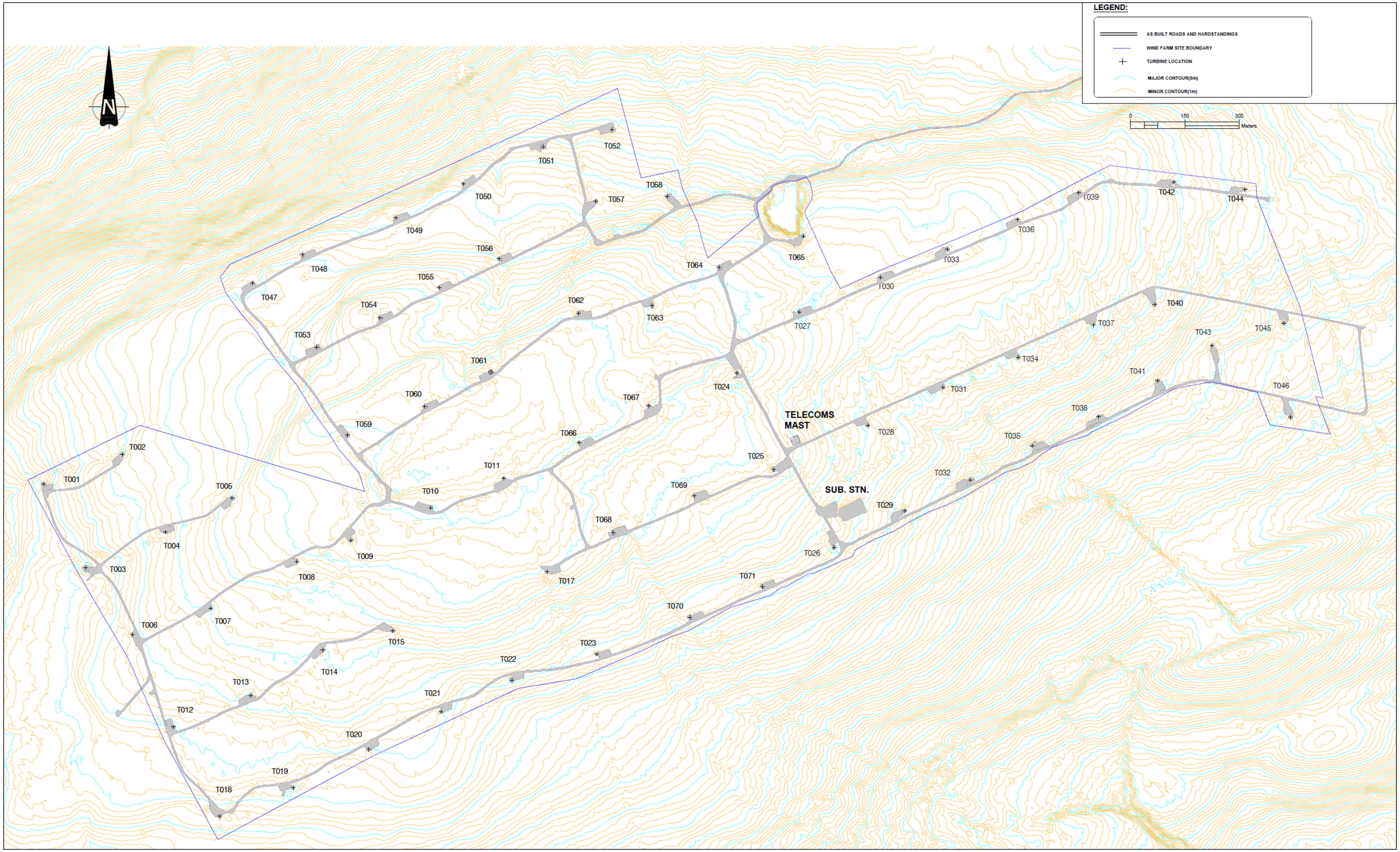

Figure 10-5: LiDAR Survey of the Site (Post-Construction)

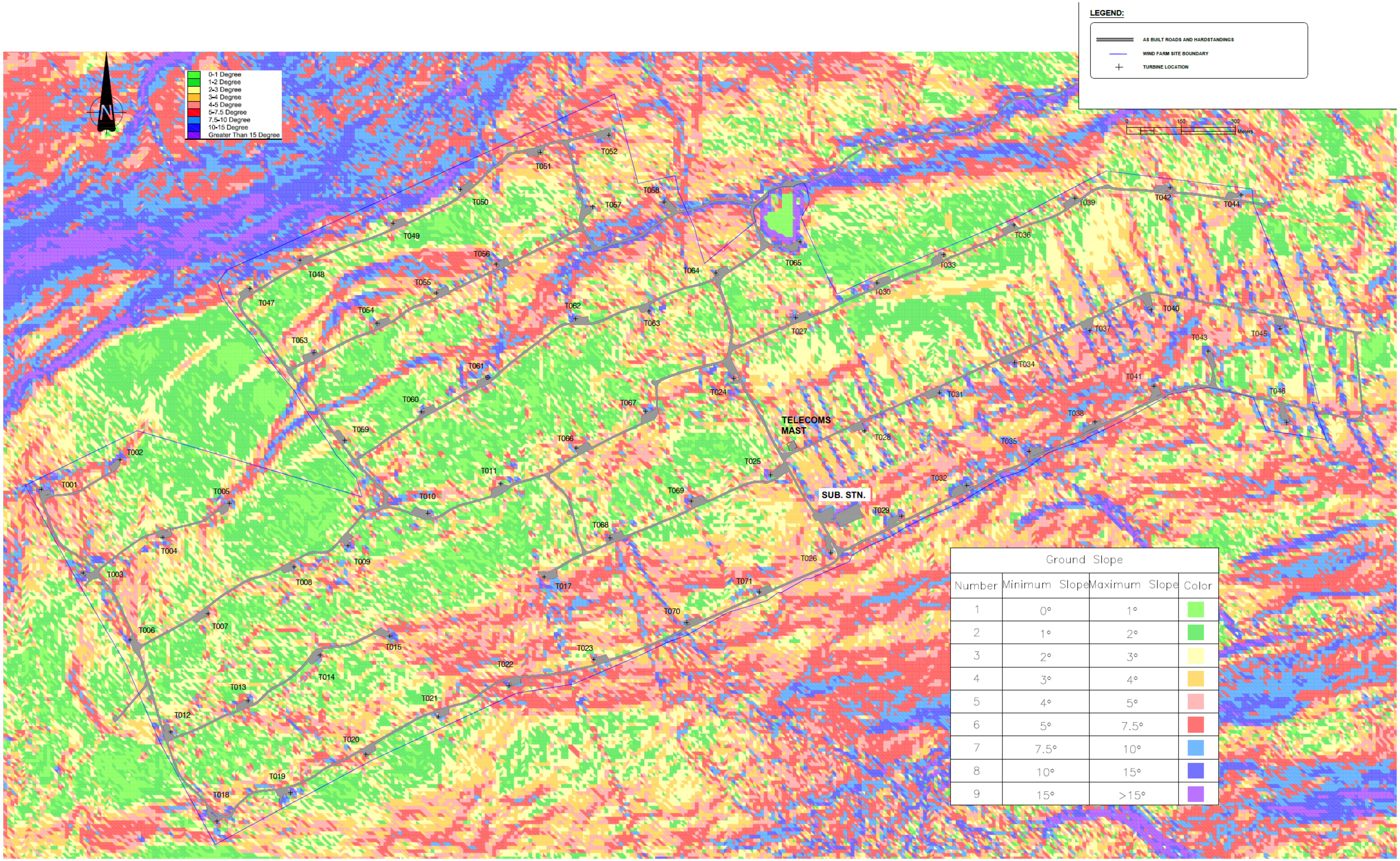

Figure 10-6: Ground surface slope angles based on post-construction LiDAR survey

10.2.1.3.2 Landslide Susceptibility Mapping

Figure 10-7 shows the Landslide Susceptibility Map for the Project 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 20 m 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 Derrybrien Wind Farm. The TFI is also derived from the 20 m 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. 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 (20 m) and the scale of the base mapping (1:50,000).

The landslide susceptibility map for the Project area shows that much of the wind farm site would be classified as being of Low susceptibility to landslides. There is a broad area on the steeper slopes on the south side of the wind farm and across the turbary plots on the east side of the wind farm where the susceptibility is classified as Moderately Low. This includes the area where the peat slide occurred at Turbine T68 in October 2003, during construction of the wind farm. The location and extent of the peat slide are recorded on the GSI database.

The Landslide Susceptibility Map indicates that conditions on the windfarm site are suitable for the project with appropriate design and mitigation measures for working in peat, particularly in the areas of Moderately Low susceptibility. The areas of Moderately High and High susceptibility are generally limited to the steeper slopes to the north and south of the wind farm site, particularly to the north.

The GSI National Landslide Susceptibility Map was developed as part of a mapping project that was completed between 2007 and 2016. Therefore, it was not available for characterising the baseline conditions in the project area prior to construction.

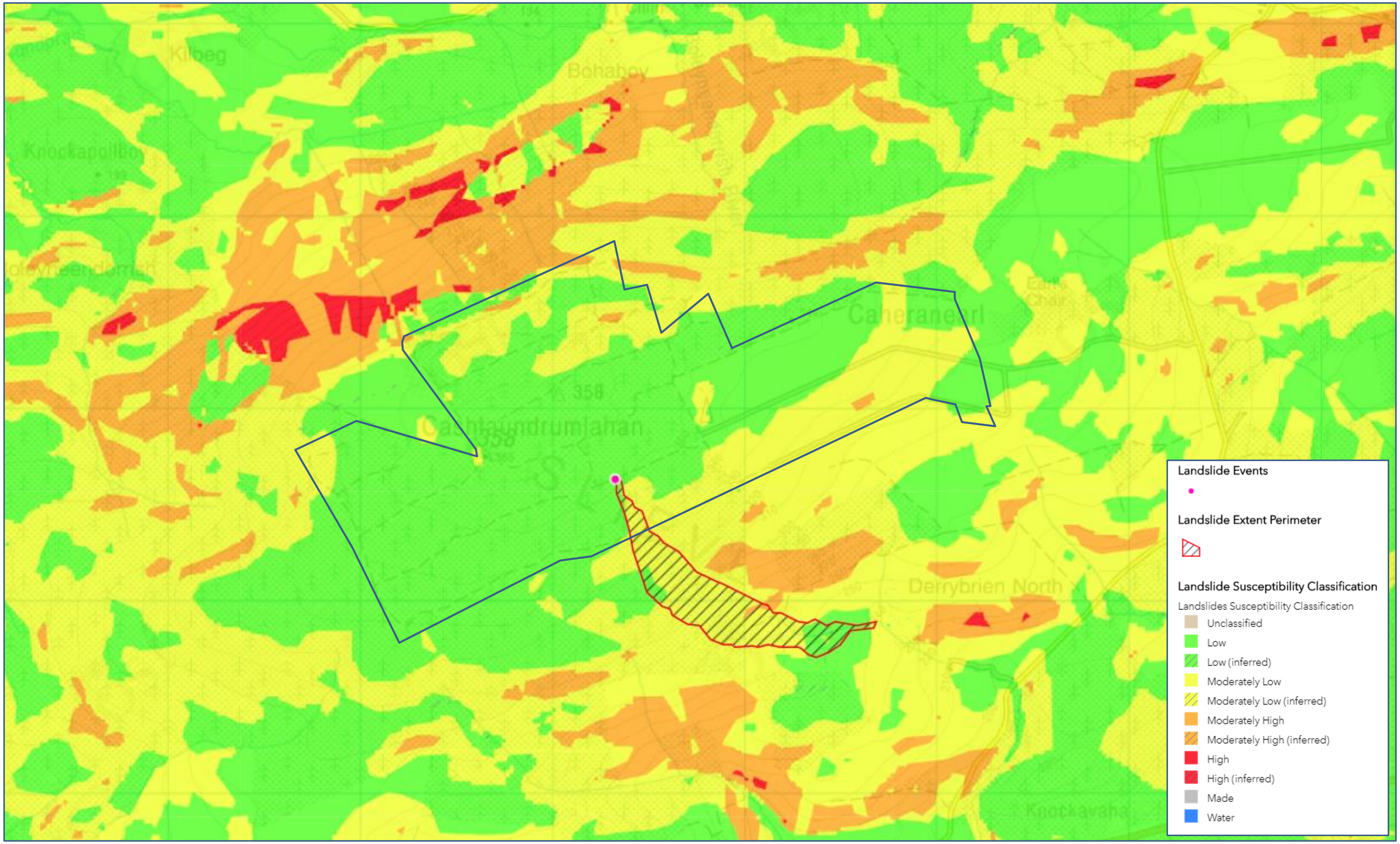

Figure 10-7: GSI Landslide Susceptibility Map for Project Area (Geological Survey of Ireland – online mapping, 2020)

10.2.1.3.3 Geotechnical characterisation of baseline site conditions

10.2.1.3.3.1 Quaternary Geology & Subsoils Map - GSI

Figure 10-8 shows a map of the Quaternary Geology for the wind farm site and local area which was generated from the Geological Survey of Ireland online database. The wind farm site is covered by upland blanket peat (BkPt). Exposures of glacial till derived from Devonian Sandstones (TDSs) are identified on the steep slopes on the north side of the site and on the lower slopes downslope from the wind farm.

There are many exposures of outcropping bedrock (Rck), particularly along the banks of streams and watercourses and on the lower slopes downslope from the wind farm.

10.2.1.3.3.2 Peat

The majority of the wind farm site is covered by blanket peat. Figure 10-9 shows the depth of peat across the wind farm superimposed on the LiDAR survey. The depth of peat has been interpreted from the extensive number of peat probes that have been carried out on the site.

In general, the depth of peat is proportional to the slope angles. The areas of deep peat up to 3-6 m deep, and locally >6.0 m, correspond to the broad flat or gently sloping ground across the central and western sections of the wind farm, and on the flat terraces on the north side. The slope angles in these areas are typically <2-3° (see Figure 10-6).

Peat depths <2 m are generally confined to the areas of steeper slopes up to 5.0-7.5°, with shallow peat <1.0 m on slopes typically up to 7.5-10.0° along the benches at the edge of the terraces on the north side of the wind farm, and on the steep slopes along the perimeter of the wind farm between Turbines T47 and T50 to the north, and between Turbines T32 to T41 to the south. Peat depths of 2-3 m typically occur on the intermediate slopes of 3-5°.

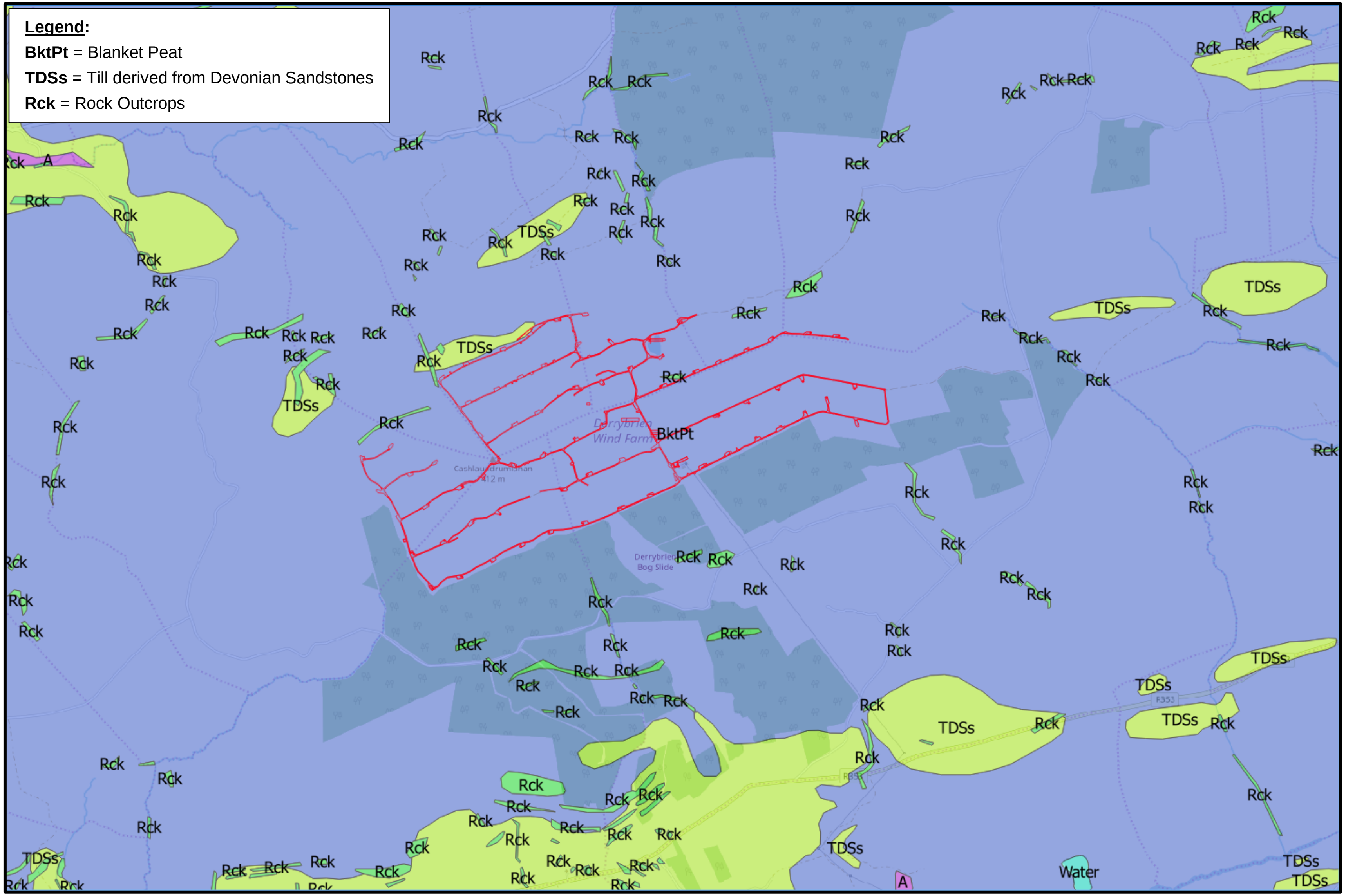

Figure 10-8: Quaternary Geology Map (Geological Survey of Ireland)

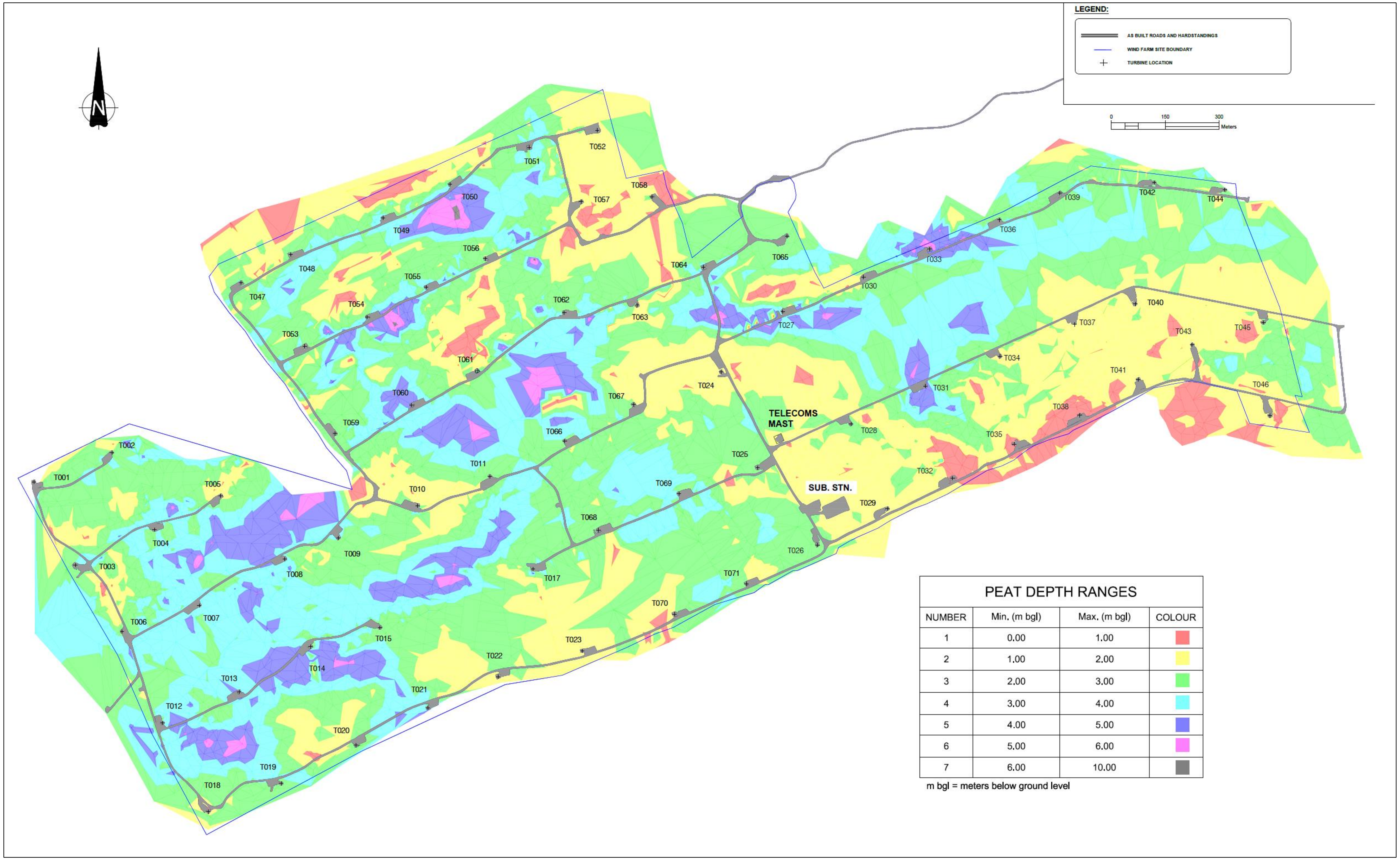

Figure 10-9: Peat depths across the site

In the trial pits carried out pre-construction by IGSL Ltd. the peat is described as soft brown fibrous organic PEAT. In general, 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.

Water contents recorded by IGSL in the peat ranged from 150-450%, which are very low for peat. Water contents recorded by AGL during the construction stages of the project were typically in the range of 800-1250%, which is more representative (Figure 10-10). The water content is expressed as the ratio between the mass of water to the mass of solids in the soil. Therefore, for water contents >1000%, over 90% of the peat mass is comprised of water, which is representative for blanket peat. Lower water contents of 20-75% were recorded in the clayey peat and organic clay layers at the base of the peat.

Mass loss on ignition tests carried out on samples of the peat indicated that the organic content is generally >95% (Figure 10-11). Lower values of 20-75% were recorded in the clayey peat and organic clay layers at the base of the peat. The bulk density of the peat samples tested by AGL ranged from 0.98 to 1.03 Mg/m^3 (Figure 10-12), increasing to 1.35-1.40 Mg/m^3 in the clayey peat and organic clay layers at the base.

Figure 10-13 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. The unfactored shear strengths recorded with the Geonor H-10 vane were validated on site by proof load testing on a test section of floating road during construction.

Figure 10-14 shows the results of laboratory tests carried out on undisturbed samples of peat collected from the site by AGL. The tests were carried out at the soils laboratory of Trinity College Dublin for AGL/BAM and they included results of direct simple shear tests on samples collected adjacent to the slide. The results indicated that the undrained shear strength of the samples of peat 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 near the base of the peat in the vicinity of the slide (average = 3.5 kPa).

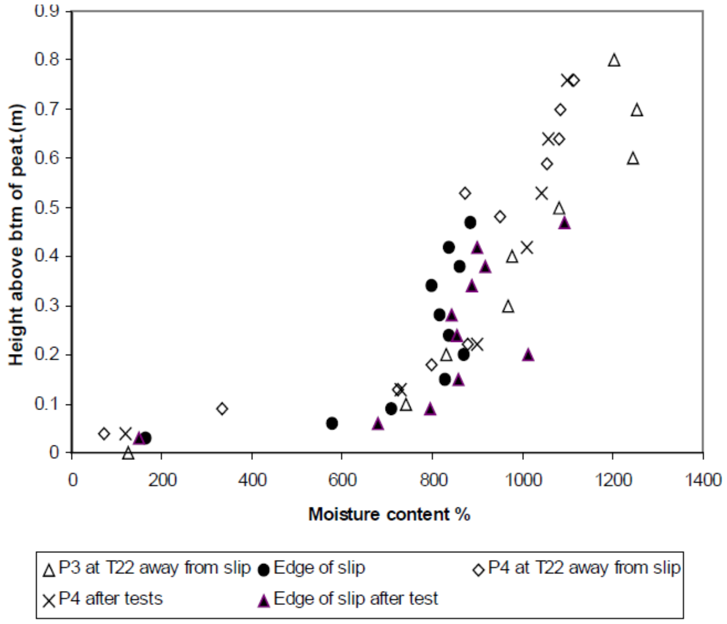

Figure 10-10: Water content of peat

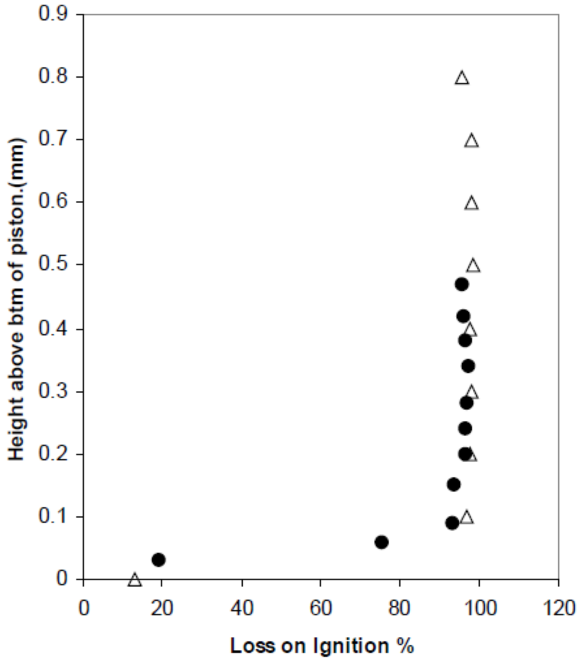

Figure 10-11: Organic content of peat by Mass Loss on Ignition

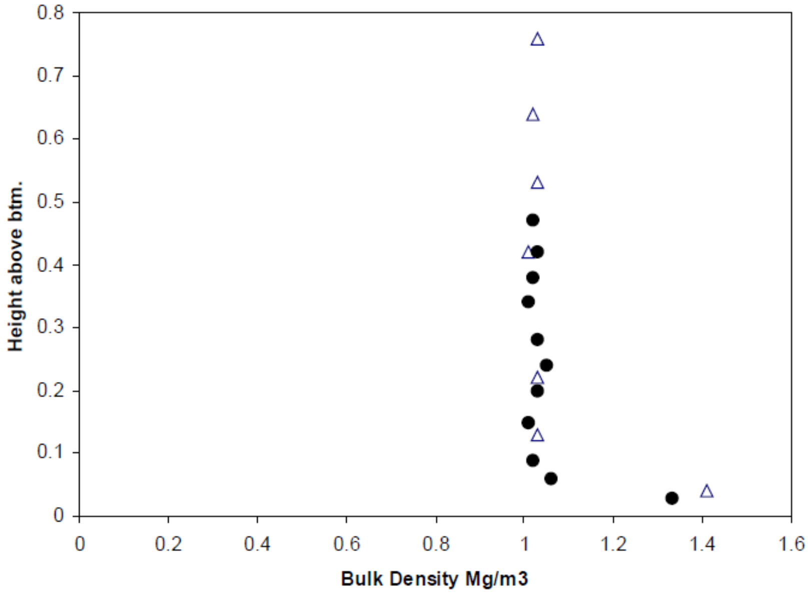

Figure 10-12: Bulk Density of Peat

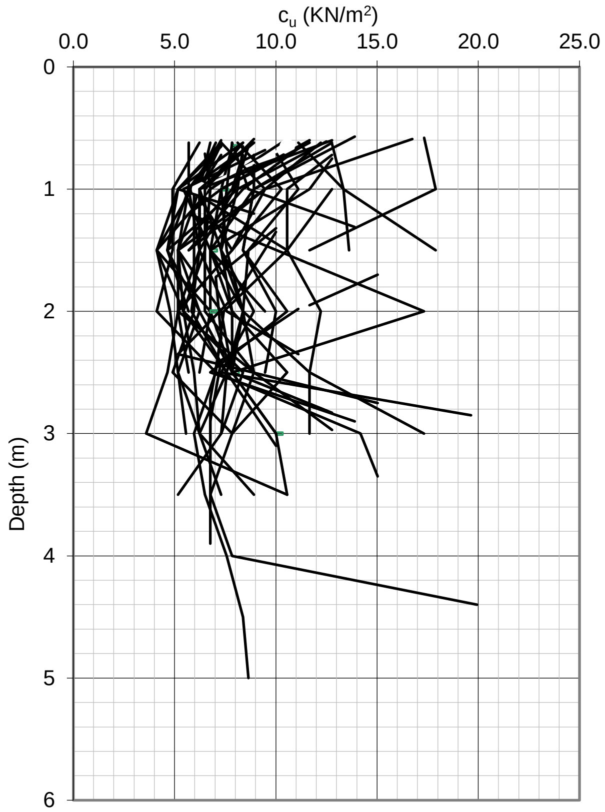

Figure 10-13: Profile of undrained shear strength (c_u) with depth in peat recorded with the Geonor H-10 in-site vane

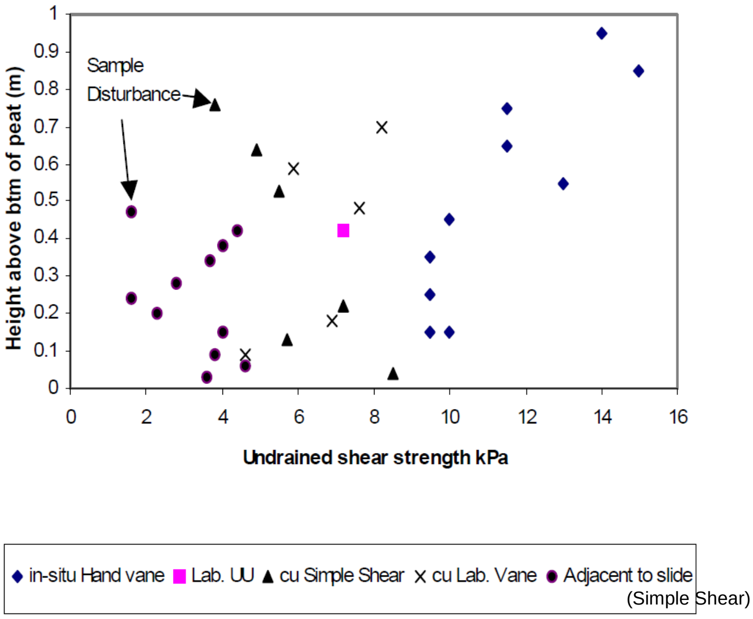

Figure 10-14: Undrained shear strengths recorded on undisturbed samples of peat by hand vane, triaxial tests and direct simple shear tests

10.2.1.3.3.3 Mineral Subsoil & Glacial Till

Where the full depth of peat was penetrated in 4No. of the trial pits carried out by IGSL Ltd. it is 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. In areas of shallow rock, the peat may also be directly underlain by rock, although this was not generally the case.

Based on the rotary coreholes carried out by Irish Drilling Ltd. (IDL) at 27 No. of the turbines across the site (Turbines T6 – T8, T30, T33, T34, T36, T39, T47-T62, T64 & T70-T71), the glacial till layer ranges in thickness from 0.6 m to 7.6 m (typically between 0.6 m and 3.5 m) and is underlain by a weathered rock or rock. IDL generally describe the till as slightly sandy gravelly SILT, although samples recovered by conventional rotary coring may not be representative of the in-situ conditions.

Standard Penetration Tests (SPT) were carried out in the glacial till by IDL in some of the rotary coreholes. The SPT N-Values generally ranged from 10-33, which would correspond to an undrained shear strength (c_u) of 50 to 165 kPa using the approximate empirical correlation $c_u \approx 5 \times N_{SPT}$. In accordance with BS 5930 the strength of the till would be classified as Medium (40-75 kPa) to High (75-150 kPa) or Very High Strength (150-300 kPa).

Some lower SPT N-Values of 6-9 were recorded in the glacial till at depths of 3.5-4.5 m in the coreholes at Turbines T31, T33 and T64. These would locally correspond to undrained shear strengths of 30-45 kPa, which would be classified as Low (20-40 kPa) to Medium Strength in accordance with BS5930.

10.2.1.3.3.4 Rock

Figure 10-15 shows the bedrock geology on the site of the Derrybrien Wind Farm and in the surrounding area from the 1:100,000 Geological Map from the Geological Survey of Ireland (GSI).

The site lies in a zone of bedrock from the Ayle River Formation which is described as a Mudstones, Siltstones and Conglomerates. The lower part of the formation is characterised by red Siltstones, Mudstones with carbonate concretions, Sandstones and Conglomerates. Sandstones are generally large-scale trough and planar bedded. Conglomerates are large-scale cross-bedded.

Figure 10-8 and Figure 10-15 identify where rock outcrops have been mapped in the area, generally on the steeper slopes downslope from the perimeter of the wind farm site, particularly to the north of the site. The geological map also shows the dip angle and dip direction of the bedding in the rock. It is typically sub-horizontal (0-10^{o}) and dipping to the NE/NW on the north side of the mountain, and to the south and southeast on the south side of the mountain.

On the steeper slopes to the north of the wind farm there is a zone of bedrock from the Derryfadda Formation, which is comprised of Greywackes, Siltstone and Mudstone. The Formation is dominated by grey-green, medium to thickly bedded (<3 m), fine to coarse grained Greywacke, commonly containing conspicuous and diagnostic basal units of granule grade conglomerate.

Bedrock was cored by Irish Drilling Ltd. (IDL) at 27 No. turbines across the wind farm site (Turbines T6 – T8, T30, T33, T34, T36, T39, T47-T62, T64 & T70-T71). Bedrock at these turbines was generally comprised of slightly weathered, strong to very strong, thinly to medium bedded, locally thinly laminated, purple fine to medium-grained SANDSTONE.

At Turbines T8, T53 and T60 the rock within the depth of the corehole was locally comprised of moderately strong or strong, slightly weathered purple thinly laminated slightly sandy SILTSTONE. Siltstone layers were also encountered within the Sandstone elsewhere on the site.

Along the north side of the site, the rock encountered in the coreholes at Turbines T47 to T51 was generally comprised of slightly weathered, strong to very strong, thinly to thickly bedded and massive cream fine to coarse-grained CONGLOMERATE.

The depth to the top of competent rock was variable but typically ranged from 3.0 m to 6.2 m. Shallower rock was encountered at a depth of 1.3-1.7 m at Turbines T47 and T49 at the north end of the site, and at a depth of 2.5 m at Turbine T58, near the site entrance.

Competent rock at Turbines T51 and T64 was initially at a depth of 8.0-10.3 m. However, additional coreholes carried out at the turbines indicated that the depth to rock was variable and rose to a depth of 5.5-5.6 m in places.

The Total Core Recovery (TCR) of the rock was generally 90-100%. The Rock Quality Designation (RQD) was variable and generally ranged from 0% to 57%, partially due to the thickness of the bedding in the rock. Higher RQD values of 78% and 100% were recorded in more competent Sandstone layers with thicker bedding. Bedding in the rock was generally sub-horizontal (0-10°) to gently dipping (10-20°).

There are sections of highly weathered rock noted at the transition from the overburden to rock. The weathered rock is described in the logs as a:

- Weak to moderately strong highly (locally completely) weathered green purple white medium grained thinly to medium bedded SANDSTONE with residual soil horizons

- Gravel and cobble sized fragments of strong highly weathered purple thinly laminated SILTSTONE.

- Weak to moderately weak, highly to completely weathered orange brown medium grained thinly to very thinly bedded SANDSTONE

The weathered rock was encountered predominantly in the north and northwest part of the wind farm, however, it was locally identified in T71 at the south end of the site and in T7 at the west end of the site. The weathered rock is noted above the bedrock at depths from 2.9 m to 6.3 mbgl, and it ranges in thickness from 0.8 m to 3.4 m. The Total Core Recovery (TCR) of the weathered rock ranged from 67% to 100% and the RQD was generally zero in the non-intact rock.

10.2.1.3.3.5 Geological Heritage Sites

There are no audited or unaudited geological heritage sites identified on the wind farm site on the Geological Survey of Ireland Spatial Resources interactive map viewer.

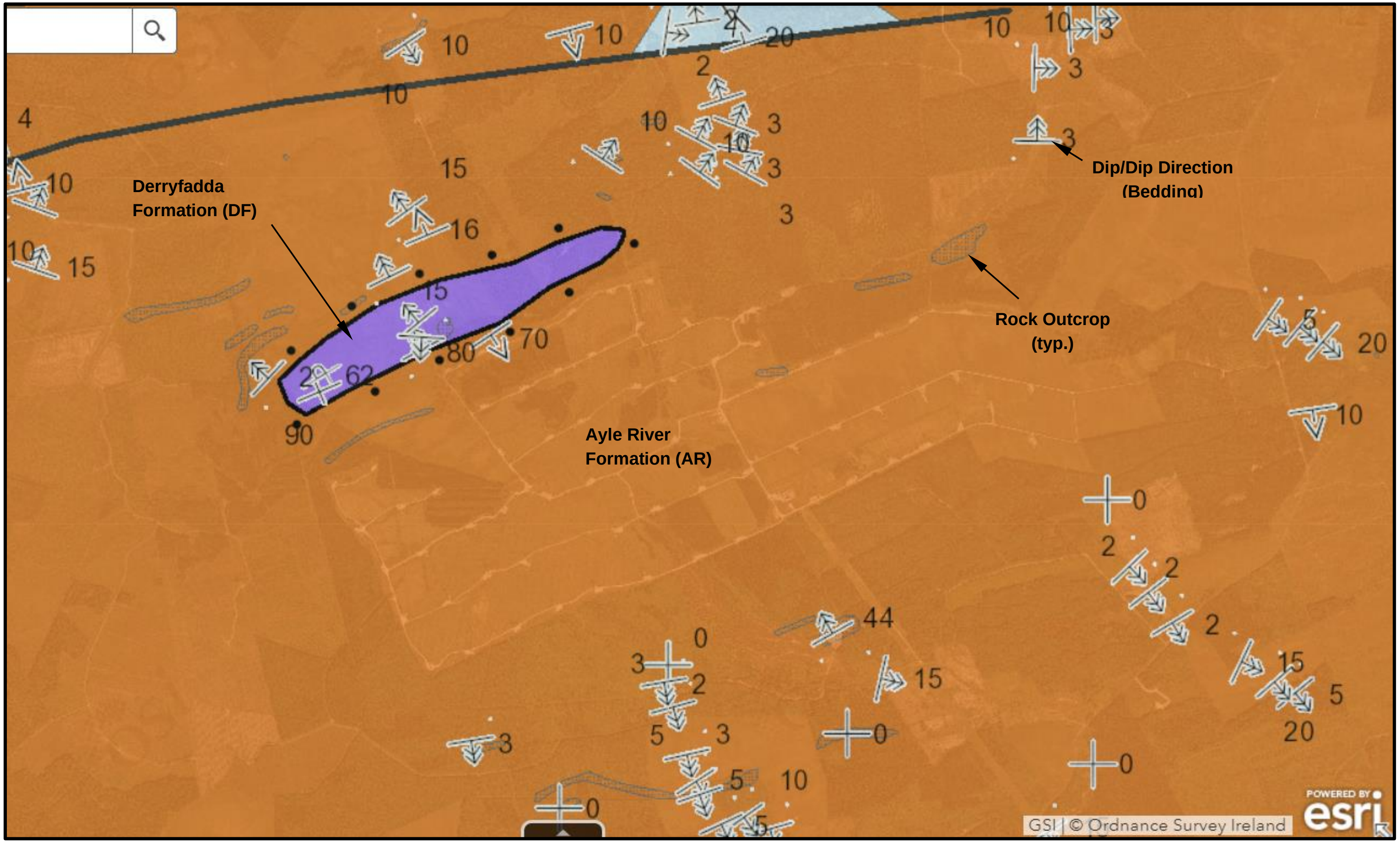

Figure 10-15: 1:100,000 Bedrock Geology Map – Geological Survey of Ireland

10.2.1.3.4 Groundwater

The wind farm site is predominantly covered in Blanket Peat and there are areas of ponded water and small streams across the site. The aerial photograph in Figure 10-4 identifies areas of high groundwater level on the flat terraces or gently sloping ground across the site including:

- an area of ponded surface water with bog pools adjacent to Turbine T61 on the flat ground near the peak of the mountain;
- areas of high groundwater level on the flat terraces associated with the change to the darker natural surface vegetation on the blanket bog.

In the pre-construction ground investigation carried out by IGSL Ltd. water strikes were recorded in the trial pits at depths of 1.0 m to 1.5 m and were described as seepage.

During construction, standpipes were installed by AGL at 6 No. locations along a north-south axis from the centre to the south of the wind farm 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 0.1 m to 1.1 mBGL.

12 No. electronic vibrating-wire piezometers were also installed in clusters at 4 No. locations around the perimeter of the site to get continuous readings of water levels in the peat. The piezometers were installed adjacent to turbines T2, T18, T34 and T49/T40. The piezometers indicated that the depth to groundwater generally fluctuated between 0.3 and 1.1 mBGL at the end of construction in 2005.

Groundwater on the wind farm site would 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. Several springs have been identified on site, particularly within scarp faces on the northern slopes. The linear pattern of trees identified on the aerial photograph in Figure 10-4 is possibly indicative of concentrated subsurface drainage in the peat.

10.2.1.3.5 Surface Water, Watercourses and Surface Drainage

Figure 10-16 shows the network of natural watercourses and man-made drains that were on the wind farm site prior to construction. All of the existing drains and watercourses are narrow open drains, typically 1-2 m deep. Where the peat is shallow the drains and watercourses penetrate into the underlying glacial till. However, in deeper peat >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. Over the rest of the site the drains follow improved natural watercourses or forestry furrows.

Figure 10-16 also illustrates how the site drainage feeds into the regional network of streams and rivers downslope from the site. Further information on the surface hydrology is provided in Chapter 11 – Hydrology and Hydrogeology.

Hydrology plays an important role in peat stability. Figure 10-16 illustrates how the peat slide that occurred during construction in 2003 is in the natural drainage channel for the watercourse in subcatchment SC7(b) (as described in Chapter 11). Groundwater and surface runoff from that part of the site has formed streams of concentrated flow in shallow channels on the glacial till or rock below the disturbed peat within the slide area. These streams flow into stream SC7(b) downslope from the site.

10.2.1.3.6 Bedrock Aquifer Classification

Figure 10-17 and shows the bedrock aquifer classification in the project area from the Geological Survey of Ireland (GSI). Bedrock on the site has been classified as a Poor Aquifer (Pl), i.e. bedrock which is generally unproductive except for local zones. This is characteristic of a low permeability rock with concentrated zones of higher permeability along open fissures or seams of highly fractured, highly weathered rock, particularly along fault lines.

The GSI classify aquifer vulnerability in terms of the geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities. The criteria with which aquifers are classified is described in the publication "Groundwater Protection Schemes" (DELG/EPA/GSI, 1999) and reproduced here as Table 10-1. Figure 10-18 shows the GSI vulnerability rating for the bedrock aquifer in the project area.

The GSI aquifer vulnerability area classification is based on desk study information on subsoil characteristics and depth to rock. Glacial tills are assigned a permeability category on the basis of a field assessment of texture, particle size distribution and mass characteristics of the exposure in combination with recharge observations such as vegetation and artificial drainage density. In-situ permeability test results are taken into account where available. The extent of the different zones using the criteria in Table 10-1 would generally be based on limited site-specific information. Therefore, the boundaries could be subject to change based on the results of the ground investigation on the site.

The aquifer vulnerability map of the area shown in Figure 10-18 indicates that the site is predominantly within an area of High (H) vulnerability with rock at a typical depth of 3-5 m covered by low permeability peat and clayey subsoil. There are some areas of Extreme (E) vulnerability where rock is shallow or outcropping on the steep slopes and stream channels to the north of the wind farm, and along the existing forestry access road into the site from the northeast.

Areas of Moderate (M) and Low (L) vulnerability have been identified in the southeast corner of the site, where the turbary plots are located. The lower classification in this area would be indicative of deeper bedrock.

Further information on the hydrogeology of the project area is presented in Chapter 11 – Hydrology and Hydrogeology.

Table 10-1: Aquifer vulnerability criteria (DELG/EPA/GSI, 1999)

Vulnerability Rating	**Hydrogeological Conditions**				
	Subsoil Permeability (Type) and Thickness			**Unsaturated Zone**	**Karst Features**
	High Permeability (sand/gravel)	Moderate Permeability (e.g. sandy subsoil)	Low Permeability (e.g. Clayey subsoil, clay, peat)	(Sand/gravel aquifers only)	(<30 m radius)
Extreme (E)	0 – 3.0 m	0 – 3.0 m	0 – 3.0 m	0 – 3.0 m	-
High (H)	>3.0 m	3.0 - 10.0 m	3.0 – 5.0 m	>3.0 m	N/A
Moderate M)	N/A	> 10.0 m	5.0 – 10.0 m	N/A	N/A
Low (L)	N/A	N/A	>10.0 m	N/A	N/A

Notes:

(1) N/A = not applicable

(2) Precise permeability values cannot be given at present

(3) Release point of contaminants is assumed to be 1-2 m below ground surface

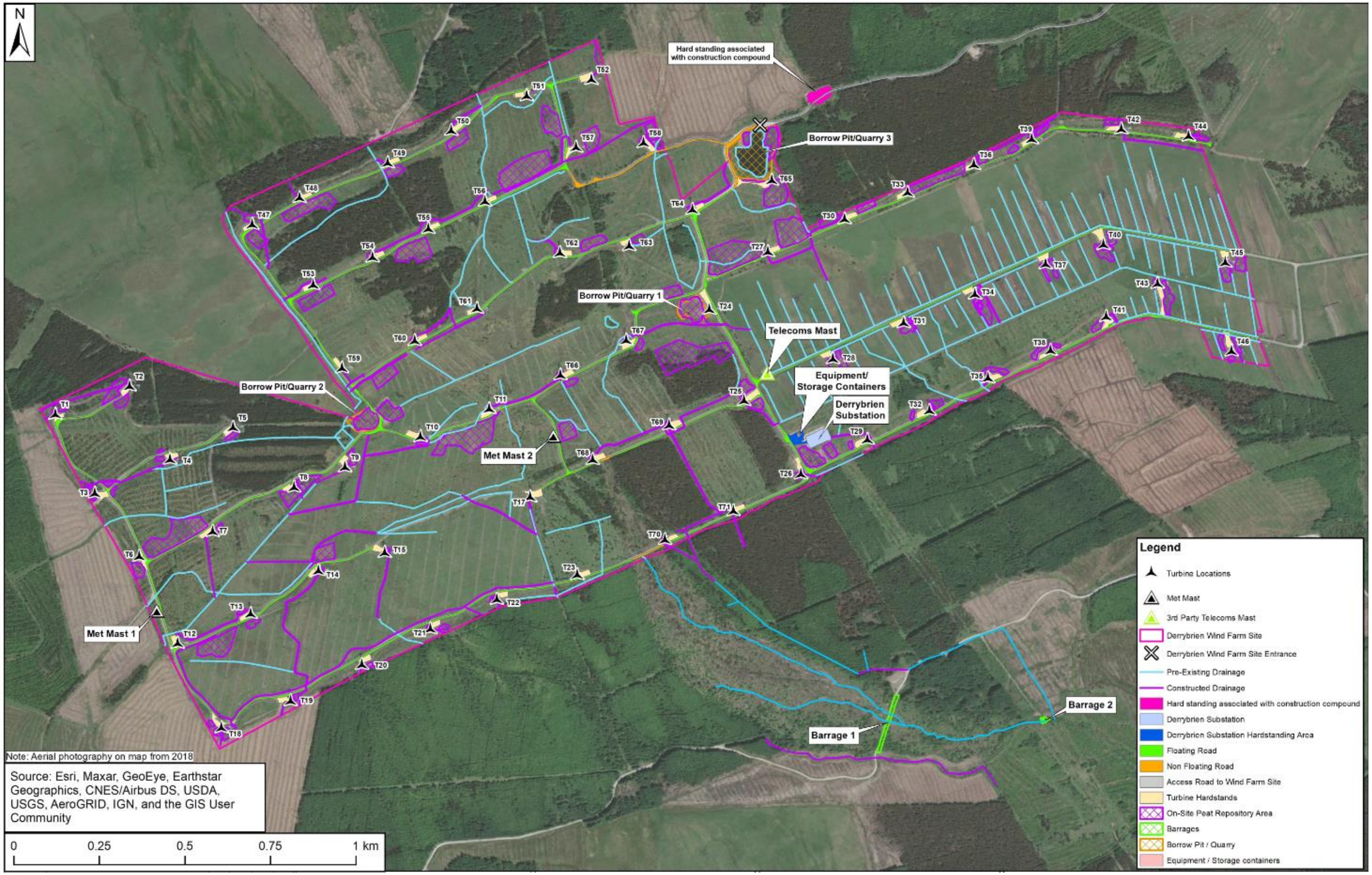

Figure 10-16: Layout of existing (pre-construction) and constructed drainage on the wind farm site

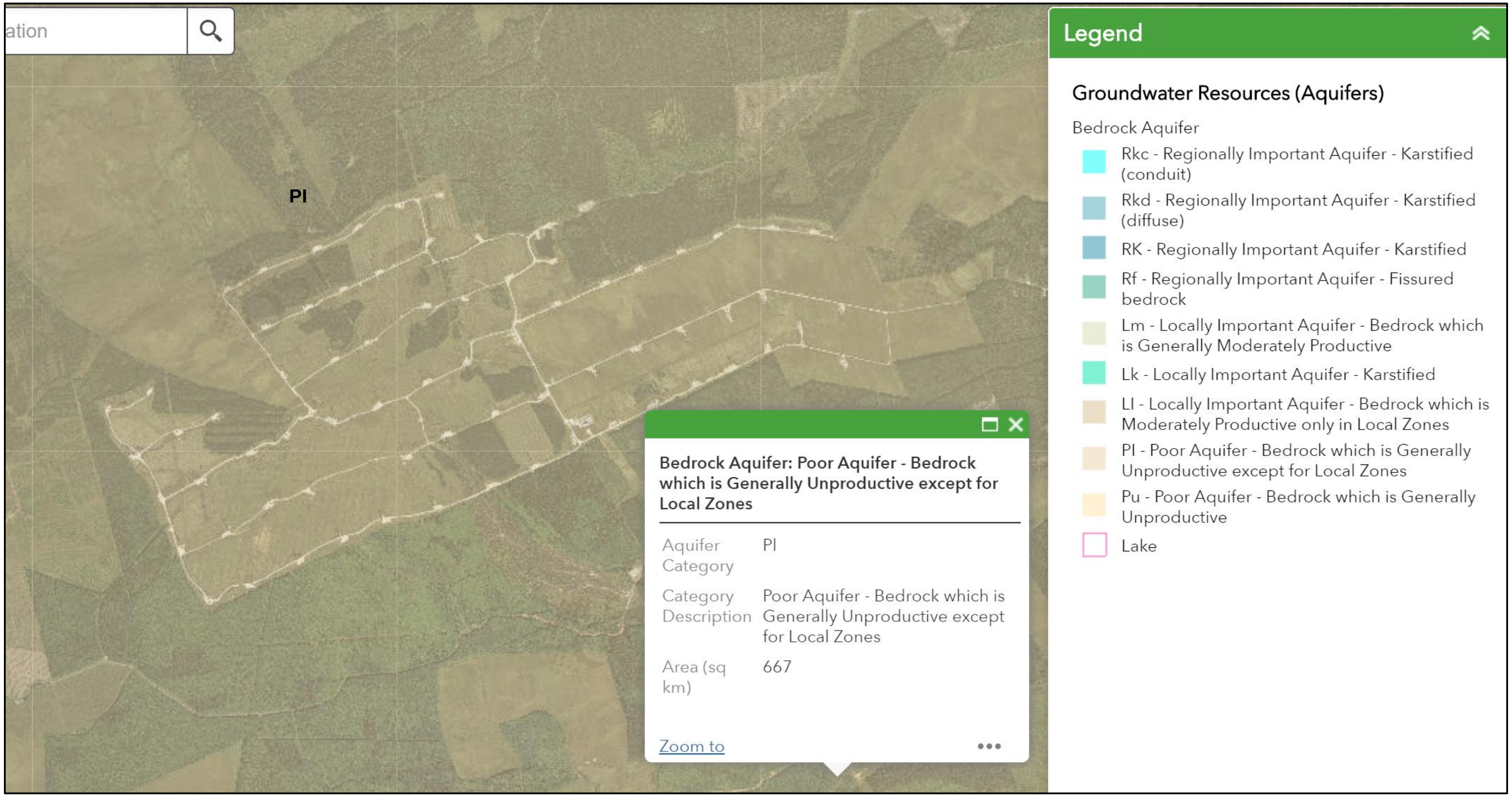

Figure 10-17: Bedrock Aquifer Classification (www.gsi.ie)

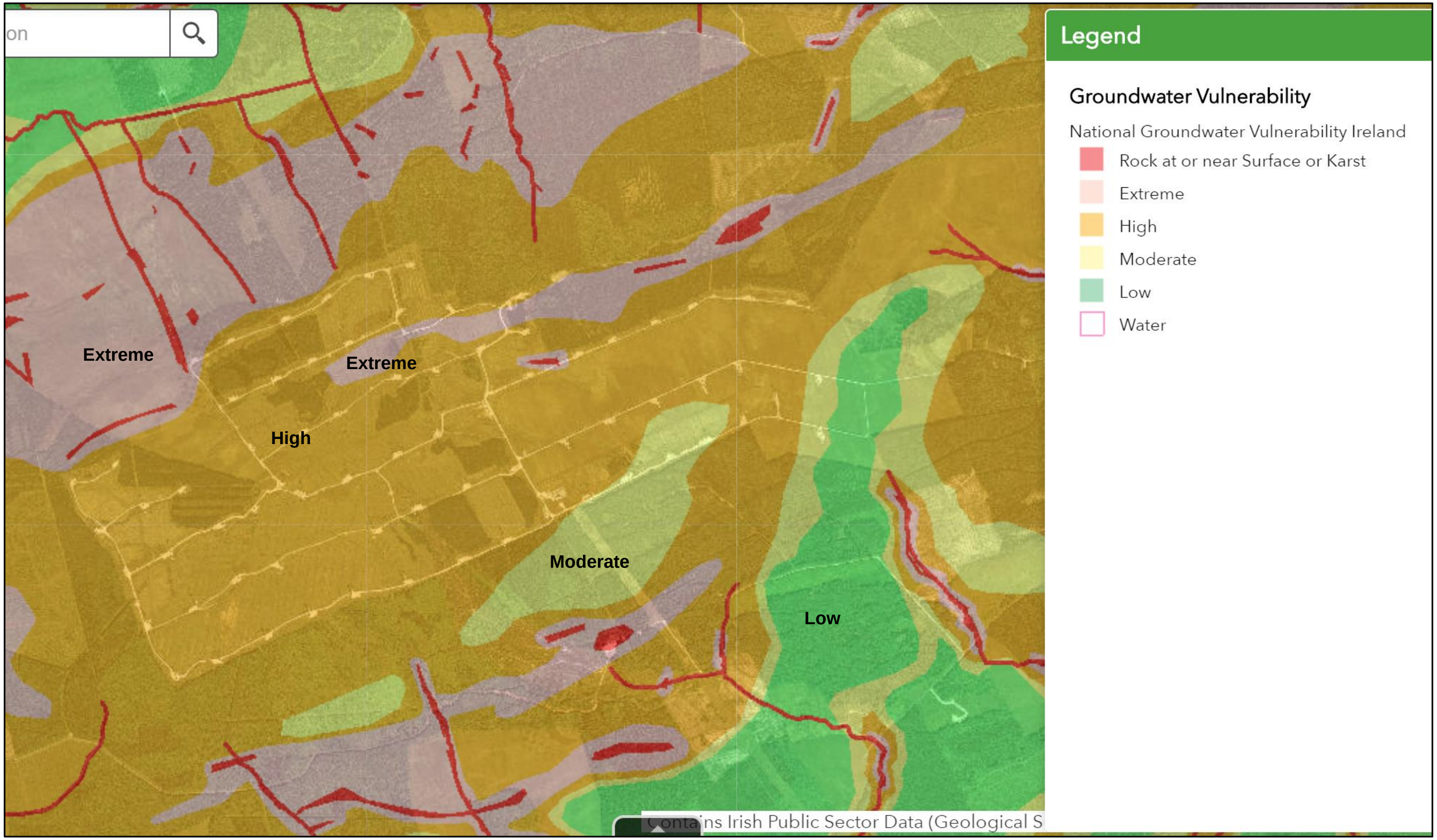

Figure 10-18: Bedrock Aquifer Vulnerability (www.gsi.ie)

10.2.1.4 Baseline Sensitivity of the Receiving Environment (Soils, Geology & Land Use) for the Wind Farm Site

The significance of effects on soils, geology and land on the site has been assessed as a function of the sensitivity of the receiving environment using the matrix in Figure 10-3. The sensitivity of the receiving environment is classified on a 7-point scale from Negligible to High as a function of the characteristics of the soils, geology and land that are directly impacted by the project.

For this project, the majority of the significant effects on soils, geology and land relate to the upland blanket bog that covers most of the wind farm site and surrounding area. Therefore, the characteristics of the blanket bog in the area govern the classification of the sensitivity of the receiving environment for assessing the significance of effects on soils, geology and land on this project. For stability impacts, consideration has also been given to the sensitivity of the blanket bog outside the wind farm site that could be directly impacted by a peat slide at the site. The potential impact of the project on Geological Heritage Sites has also been assessed.

For this project the sensitivity of the receiving soils, geology and land has been classified as **MEDIUM** based on a combination of factors, i.e.:

- Geological Heritage Sites that could be impacted by the project;
- The ecological importance of the blanket bog;
- The significance of the peat for carbon sequestration;
- The use and value of the land impacted by the project;

There are no audited or unaudited Geological Heritage Sites identified on the wind farm site or in the project area on the Geological Survey of Ireland Spatial Resources interactive map viewer. Therefore, the bedrock is not a sensitive receptor on the project.

The habitat impacted by the project is predominately conifer plantation on upland blanket bog that had been degraded by drainage and by the planting of the trees, and is therefore of low ecological value.

The open bog in the eastern portion of the site that was used for turbary was degraded due to drainage and turf cutting and was also of low ecological value. However, the open areas are rare in the wider landscape and suitable for use by hen harrier. Therefore, when all habitats are taken into account, the overall ecological value of the habitats is of Local Importance (higher value). This would be equivalent to a Medium to Low sensitivity.

Blanket bog is a significant source of carbon sequestration in Ireland. Stored carbon in the peat can be negatively impacted by excavation, disturbance, and drainage. The rate of decomposition of peat significantly increases when exposed to an aerobic environment above the water table and this results in a release of stored carbon as carbon dioxide. Carbon can also be lost in solution due to erosion of disturbed peat.

To give context to the scale of the impact of the project on carbon storage in the peat:

- The extent of upland blanket bog on the wind farm site (approximately 340 ha) is <0.1% of the total area of upland blanket bog in Ireland (≈436,690 ha in 1979 Hammond (1981), Conaghan (2000))
- Less than 9.0% (≈30 ha) of the blanket bog on the site was directly impacted by the project (i.e. by the turbines, crane hardstandings, substation, borrow pits, material sidecast areas and peat repositories).
- A similar area of blanket bog (≈25 ha) outside the wind farm site boundary was directly impacted by the peat slide that occurred at the site in October 2003.
- The mass of carbon stored in peat is on the order of **0.055 tonnes/m^3** (Holden & Connolly (2011) & Milne & Brown (1997))**.** This is equivalent to **0.2 tonnes CO_2 /m^3** if fully oxidised by decomposition.
- The total volume of peat excavated for the turbines, crane hardstandings, substation and borrow pits was approximately **185,000 m^3**. About a further **450,000 m^3** of peat was displaced in the peat slide at the site in October 2003. If it is assumed that 100% of the combined volume of excavated peat is lost due to decomposition on exposure, which is very conservative (i.e. there is still approximately 200,000 m^3 of disturbed peat within the slide rea), then this is equivalent to releasing **127,000 tonnes of CO_2** into the atmosphere.
- In terms of recent national statistics for CO_2 emissions in Ireland, 127 kt CO_2 is **≈ 0.2%** of the total annual emissions (60,750 kt-CO_2) in 2017 (SEAI, 2020) and **≈ 0.6%** of our total annual emissions related to energy (21,265 kt-CO_2) in that year.

Therefore, the impact of the project on carbon storage is relatively Low and would be compensated by the net carbon gain over the design life of the wind farm.

In terms of land use, the value of the land impacted by the project is largely determined by the forestry plantations and turbary plots on the wind farm site, which are of relatively low commercial value. The mature timber on the site was harvested during construction, but the trees could not be re-planted after the wind farm was completed. The wind farm also directly impacted approximately 25 ha of land on the site for the turbines, crane hardstandings, substation, borrow pits, material sidecast areas and peat repositories.

Based on the relatively low ecological importance of the land, the sensitivity of the receiving environment could be characterised as Medium to Low. However, when combined with the additional environmental value of the land as a carbon store and the relatively low commercial value of the land for forestry/agriculture, this is sufficient to raise the combined level of sensitivity of the peat to "**MEDIUM**".

For the assessment of stability impacts the sensitivity of the receiving soils, geology and land that could be impacted by a peat slide has also been classified as MEDIUM based on the characteristics of the very large peat slide that occurred on the site in October 2003, and the land that that was directly impacted by the slide, i.e.:

- The land that was disturbed by the peat slide covered an area of approximately 25 ha, which is comparable to the wind farm, and it was comprised of coniferous forests of low ecological and commercial value;
- Approximately 450,000 m^3 of peat was displaced in the slide, but about 200,000 m^3 of this is still present on the slope;
- The agricultural land downslope from the main slide area that was impacted by peat from the slide was also of low ecological and commercial value;

Therefore, the impact on the blanket bog habitat, carbon storage and land use is of a similar scale and sensitivity to the wind farm project. The characteristics of the topography, ground and groundwater conditions in the area are also representative of the general conditions around the site that could be impacted by the project where there is a risk of a large peat slide. Therefore, for this project it has reasonably been considered as the worst-case scenario for assessing the impact of site activities on the receiving soils, geology and land with respect to site stability.

To accurately assess stability impacts on soils, geology and land, consideration has also been given to the scale and characteristics of the smaller, more localised peat failures that occurred on site during construction. For example, around the perimeter of the open excavations for the turbine foundations, the risk of peat instability was limited to localised shear failure or very small scale peat slides where the side slopes were not adequately supported, which had a significantly lower impact on the receiving soils, geology and land.

10.2.2 Baseline Environment (1998) – Grid Connection

10.2.2.1 Introduction

This section gives an interpretation of the baseline conditions for soils, geology and land use for the grid connection in 1998, prior to construction of the windfarm project. The grid connection comprises the Derrybrien-Agannygal 110 kV Overhead Line and Agannygal Substation and associated ancillary works, see Chapter 2.

All available information was used to establish the baseline conditions on the grid connection 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, a desk study review of historical aerial photographs, topographical 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).

Section 10.2.2.2 includes a summary of the ground investigations carried out on the grid connection site in 2004 to 2006, 2018 and 2019, which would be considered representative of the baseline conditions as most of the information is from areas not impacted by the project.

Section 10.2.2.3 gives a summary of the baseline conditions for the topography and land use, as well as the geotechnical characterisation of the soils, and the geological classification of the bedrock geology. Sections 10.2.2.3.3 and 10.2.2.3.4 give a summary of the groundwater conditions and an overview of the surface water, watercourses and surface drainage, which are particularly relevant to stability.

The characteristics and sensitivity of Geological Heritage Sites (GHS) are assessed in Section 10.2.2.3.2.5.

The baseline sensitivity of the receiving soils, geology and land impacted by the grid connection has been assessed in Section 10.2.2.4.

10.2.2.2 Geotechnical Investigations

10.2.2.2.1 Introduction

Details of ground investigations carried out along the grid connection are included in Appendix C within report entitled *"Geotechnical Stability Report 3 - Overhead Line and Substation Impact Assessment"* (FT, 2020). The ground investigations comprised:

- A comprehensive desk study of available information on soils, geology and groundwater conditions;
- Walkover survey (2 no.) to inspect ground conditions;
- Trial pits (72 no.) to determine the depth and characteristics of peat and subsoils at foundation mast locations to depths of about 3 m;

- Trial pits (2 no.) to determine the depth and characteristics of peat and subsoils at Agannygal substation to depths of about 3 m;
- Extensive peat probing (+160 no.) to establish a profile of the depth of peat;
- In-situ vane shear testing (+120 no.) to establish the undrained shear strength of peat.

10.2.2.2.2 Foundation Records at Mast Locations (2004/2005)

During construction of OHL masts from 2004 to 2005 excavations (trial pits) were carried out at mast locations which recorded ground conditions.

Trial pits with recorded ground conditions were carried out at 18 no. mast locations at each of the 4 no. mast legs giving a total of 72 no. trial pits. The records included a description of the ground conditions encountered and depths.

10.2.2.2.3 ESB Report on Stability for Section of Grid Connection (2006)

ESB (2006) assessed the stability of the peat along the grid connection from the windfarm substation to containment barrage 2, which was constructed following the peat slide in 2003. The stability of the peat in this area was assessed based on shear vane tests and peat probes.

27 no. shear vane tests and peat probes were carried out over a section 700 m in length directly south of the windfarm substation, as this area was considered the critical section in terms of existing slope angles and peat thickness.

The results of stability assessment showed a “lumped” or overall factor of safety of at least 1.4 under a 20 kPa surcharge, which would be considered an acceptable level of safety.

10.2.2.2.4 AGEC Ground Investigation & Walkover (2018)

Ground investigation and walkover survey was carried out by AGEC along the grid connection and at the Agannygal Substation in June 2018. This comprised peat depth probes, hand shear vanes and trial pits.

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 grid connection to provide representative coverage of indicative peat depths and strengths.

60 no. hand shear vane strength tests were undertaken in peat at depths from 0.5 to 2.5m bgl.

75 no. peat probes were carried out along the route.

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.

The depth of recorded peat varied from no peat to localised deeper areas of peat, especially near Lough Agannygal, although the Agannygal Substation which is only about 0.5 km further south is founded on mineral soil.

2 no. trial pits were excavated at Agannygal substation, referred to as TP10 and TP11. The 2 no. trial pits were consistent with each other and showed a ground profile consisting of deposited construction arisings from the substation excavation over a natural ground profile of soft organic topsoil over glacial till.

10.2.2.2.5 FT Ground Investigation & Walkover (2019)

Ground investigation and walkover survey was carried out by FT along the grid connection, access routes to public roads and at the Agannygal Substation in September and October 2019. This comprised hand shear vanes and peat depth probes.

35 no. hand shear vane strength tests were undertaken at depths from 0.5 to 2.5 m bgl.

In excess of 60 no. peat probes were carried out during the site walkover. Approximately 70 percent of the probes recorded peat depths of less than 1 m with over 90 percent of probes recorded peat depths of less than 2.5 m.

10.2.2.3 Baseline Conditions (1998) – Soils, Geology & Land Use

10.2.2.3.1 Land Use and Topography

The grid connection comprises the Derrybrien-Agannygal 110 kV Overhead Line (OHL) and Agannygal Substation and associated ancillary works. The substation connects into the existing Shannonbridge-Ennis 110kV Overhead Line.

The OHL route is 7.8 km long and is aligned essentially north-south. The OHL route extends from the lower slopes of Cashlaundrumlahan Mountain (location of windfarm site) to the Agannygal Substation located about 1 km to the north of Lough Atorick. The OHL is supported on double pole sets and mast structures founded in the underlying competent ground. Further construction details of the OHL are included in Chapter 2.

The Agannygal Substation consists of a compound (approximately 63 m x 47.5 m) containing outdoor electrical equipment and a Control Building. The foundations for the control building and outdoor electrical equipment are supported on granular rockfill or the underlying competent ground. The compound hardstanding is capped with hardcore surfacing. Further construction details of the Agannygal Substation are included in Chapter 2.

In 1998 most of the grid connection site was managed commercial forestry. Forestry was planted in the project site from 1963 to 1994. An aerial photograph of the site in 2000, which would reasonably represent the baseline conditions in 1998, is shown on Figure 10-19. The OHL route corridor is highlighted with the OHL masts and pole sets shown. The figure shows the main features and land use that were on the route prior to construction, which includes:

- Extent of existing roads prior to construction;

- Extent of existing mature conifer plantations, recently planted/felled plantations and firebreaks; and
- Existing watercourses and drainage channels.

The land use along the OHL route and at the Agannygal Substation prior to construction was essentially managed commercial forestry.

It is noted that the OHL 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 constructed following the peat slide.

Figure 10-20[1] shows the general topography along the grid connection post construction (i.e. post 2005). With the exception of the Agannygal Substation site and several localised cuttings along the OHL route, for example where the OHL passes below an existing 400 kV overhead line between pole sets 28 and 29, the topography of the grid connection site would generally reflect the original topography in 1998, prior to construction works.

The grid connection route connects to the windfarm at the Derrybrien Substation located within the boundaries of the windfarm site at an elevation of approximately 330 mOD. From the Derrybrien Substation, the elevation along the route gradually falls to a wide valley floor where it crosses the R353 road and the tributaries of the Owendalulleegh River at an elevation of approximately 130 mOD. From here, the route passes around the Slieve Aughty Bog NHA (site number 001229) before gaining some elevation again as it passes Lough Agannygal, at about 195 mOD. The OHL route ends at the Agannygal Substation.

The Agannygal Substation site is located about 1 km to the north of Lough Atorick, at an elevation of approximately 190 mOD. The land is elevated with respect to the surrounding area to the north, west and south.

Slope angles at the pole set and mast locations typically range from 0 to 15 degrees. The topography is relatively steep initially over the initial c. 1.5 km and then crosses the more gently sloping terrain of the Owendalluleagh River valley to the Agannygal substation where the site has been cut and filled locally to provide a level platform.

[1] Based on Geological Survey of Ireland, "*Geological Survey Ireland Spatial Resources*" https://dcenr.maps.arcgis.com/apps/MapSeries/index.html?appid=a30af518e87a4c0ab2fbde2aaac3c228,

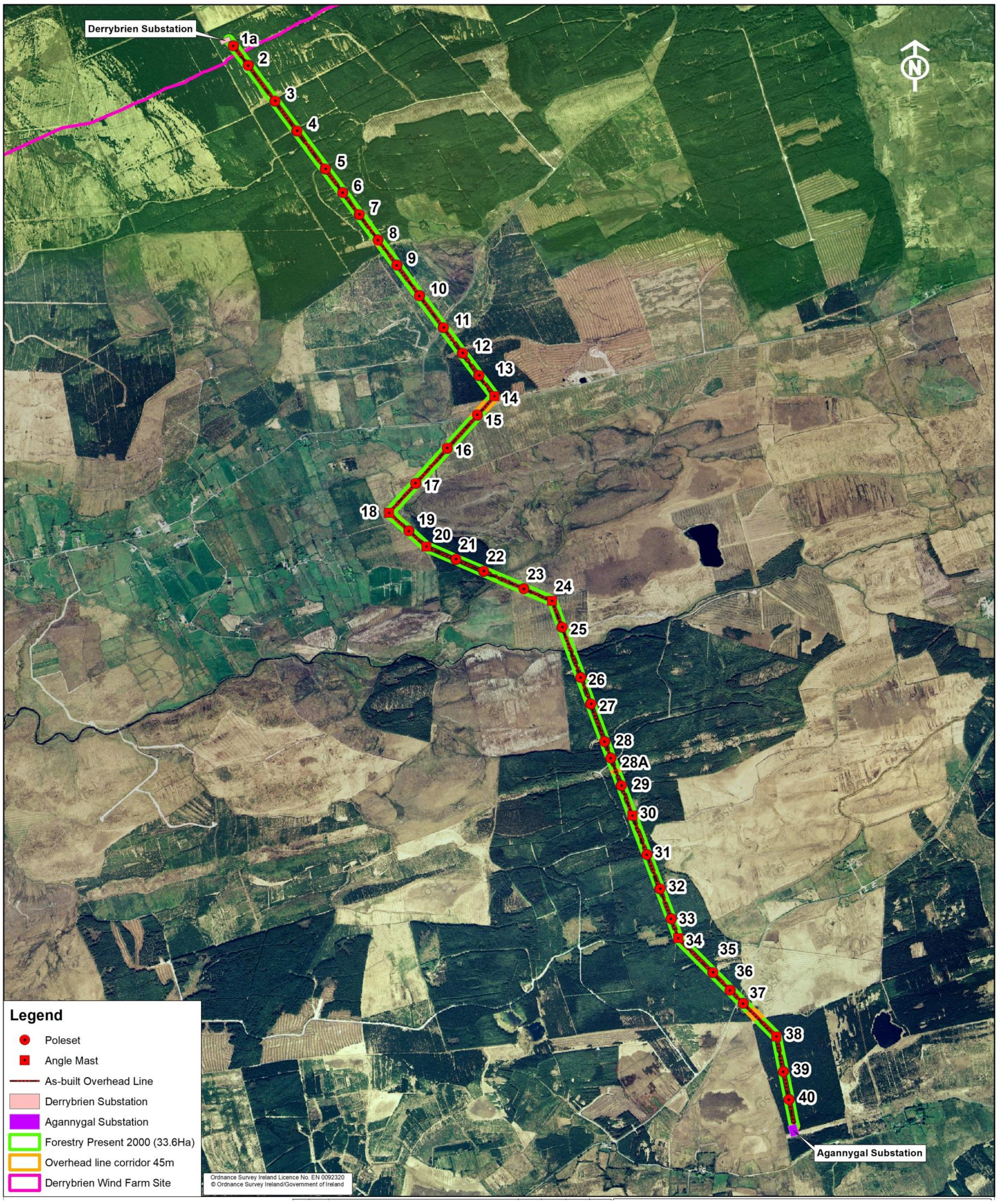

Figure 10-19: Aerial photograph of grid connection prior to construction in 2000

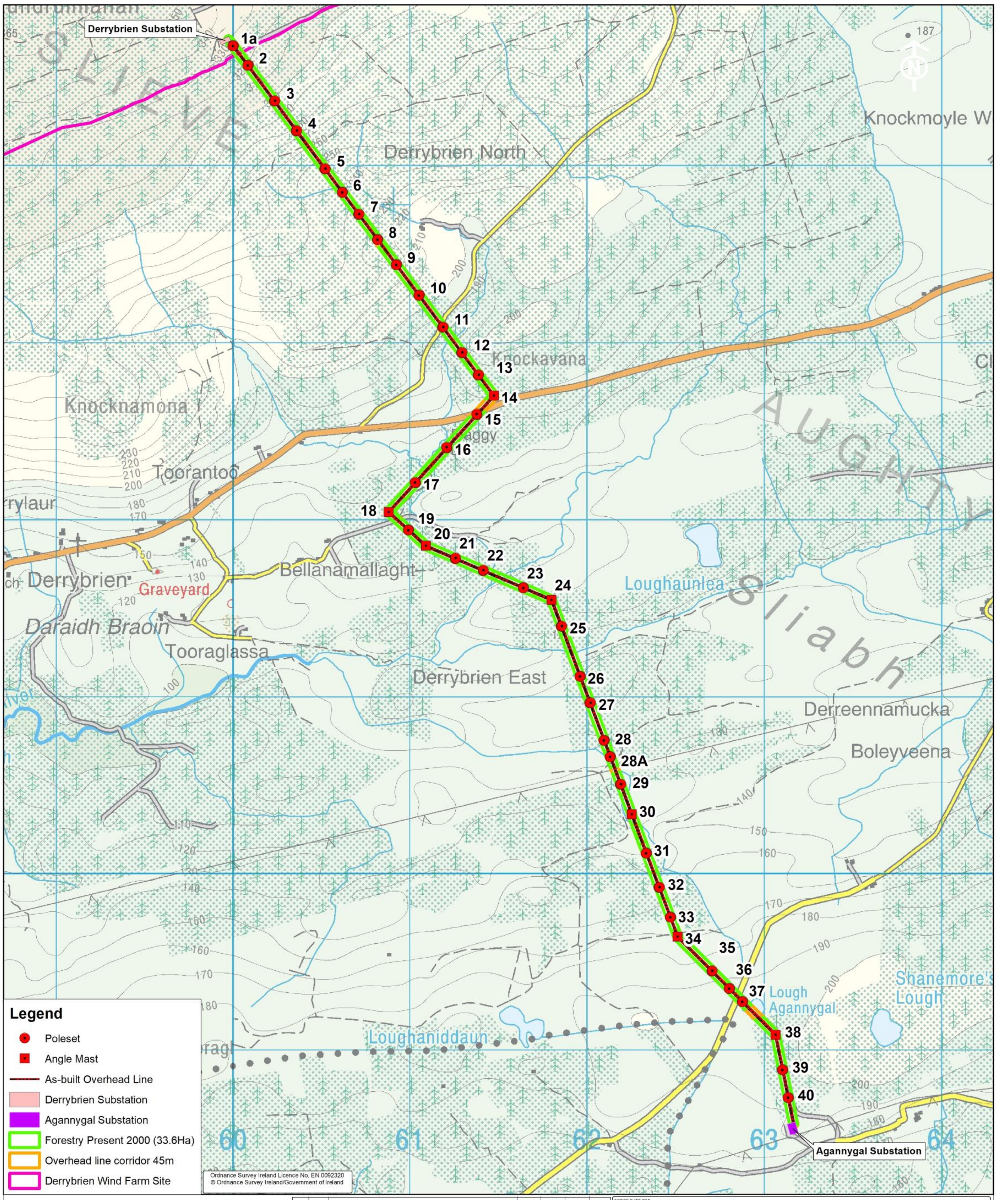

Figure 10-20: General topography along grid connection

10.2.2.3.2 Geotechnical Characterisation of Baseline Conditions

10.2.2.3.2.1 Quaternary Geology & Subsoils Map - GSI

Figure 10-21 shows a map of the Quaternary Geology along the grid connection generated from the Geological Survey of Ireland [2] online database. The grid connection site is covered by blanket peat (BktPt) with locally glacial till (TDSs) present. There are occasional bedrock exposures (Rck), particularly along the banks of the nearby streams and watercourses, together with alluvium (A).

10.2.2.3.2.2 Peat

Most of the grid connection site is covered by blanket peat. Figure 10-22 and Figure 10-23 shows the depth of peat along the grid connection. The depth of peat has been interpreted from the peat probes carried out by ESB, AGEC and FT along the grid connection route over a corridor width of 100 m.

The depth of peat recorded along the route ranged from 0.2 to 5.6 m with an average depth of 1.35 m. The peat is generally shallower along the northern part of the route, where the terrain is relatively steeper on the lower slopes of Cashlaundrumlahan Mountain. The deeper peat, say greater than 2.5 m, is localised in a few flatter areas within the southern part of the route.

The deeper peat areas correspond to shallow topographic depressions along the line of the Derrybrien East stream and around Lough Agannygal see Figure 10-20. The area around Lough Agannygal has the deepest recorded peat with a depth of 5.6 m. This low-lying area was likely a topographic depression that would have originally contained an enclosed water body which over time has slowly infilled with peat leaving a much smaller partially infilled waterbody, namely Lough Agannygal.

The nature of the blanket peat was assessed from the walkover surveys and ground investigation undertaken by AGEC in 2018 and FT in 2019 which showed that the upper 1 m (approx.) of peat was generally very fibrous and locally desiccated becoming less fibrous with depth. The base of the peat from observations from exposures in excavations and along drains on the route, was described using BS5930[3] 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 a number of locations by ESB in 2004 and 2005, AGEC in 2018 and FT in 2019. A total of +120 no. shear vane strength tests were undertaken at depths from 0.5 to 2.5 m. Values for vane shear strength (unfactored) ranged from 5 to 68 kPa with an average of about 18 kPa, see Figure 10-24.

Typically for undisturbed blanket peat of significant depth there is a decrease in strength with depth. In this case the discernible trend appears to be a slight increase

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[2] Geological Survey of Ireland, "*Geological Survey Ireland Spatial Resources*" https://dcenr.maps.arcgis.com/apps/MapSeries/index.html?appid=a30af518e87a4c0ab2fbde2aaac3c228

[3] British Standard Institute, *"BS5930:2015 Code of practice for site investigations",* 2015

in strength with depth, which would suggest that the peat has been affected by existing forestry drainage.

There are no notable zones of low strength peat recorded. Typically, low strength would be considered to be less than about 5 kPa. The deeper peat areas around enclosed low-lying Lough Agannygal would be expected to have the lowest strength values.

Overall, the vane shear strength (unfactored) of peat along the grid connection was notably greater than that recorded on the windfarm site, this is primarily due to the shallower depth of peat along the grid connection. Shallower peat depth tends to have relatively greater strength due to its more fibrous nature and for it to be more prone to desiccation due to disturbance and drainage, for example.

The peat areas within the grid connection site have been used for commercial managed forestry and are of limited and marginal agricultural land use. There are no identified peat cuttings within the grid connection site, which would reflect the general shallow nature of peat along the route, as such the peat has very limited economic extractable significance.

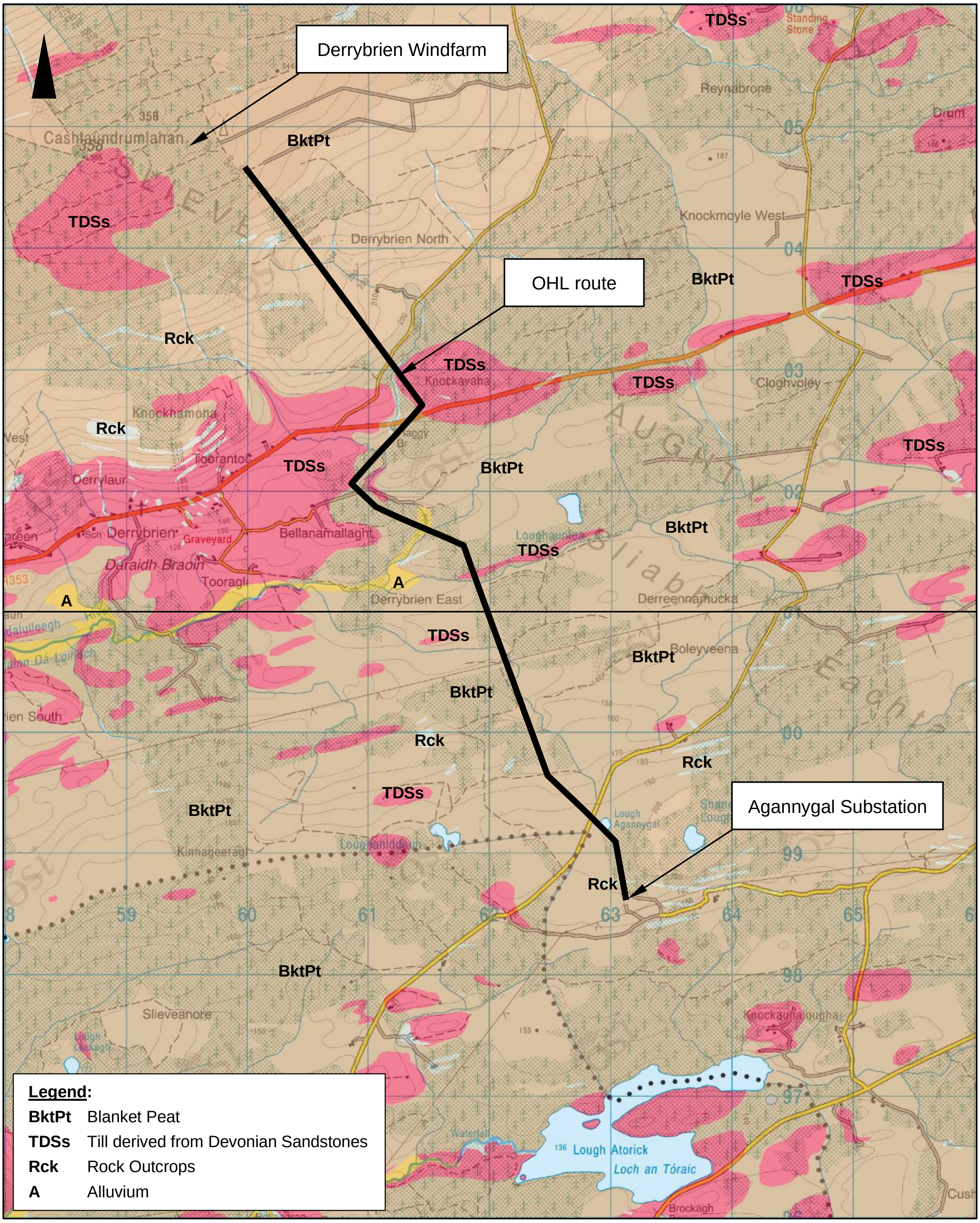

Figure 10-21: Quaternary geology map - grid connection

Figure 10-22: Peat depths along grid connection (1 of 2) (FT, 2020)

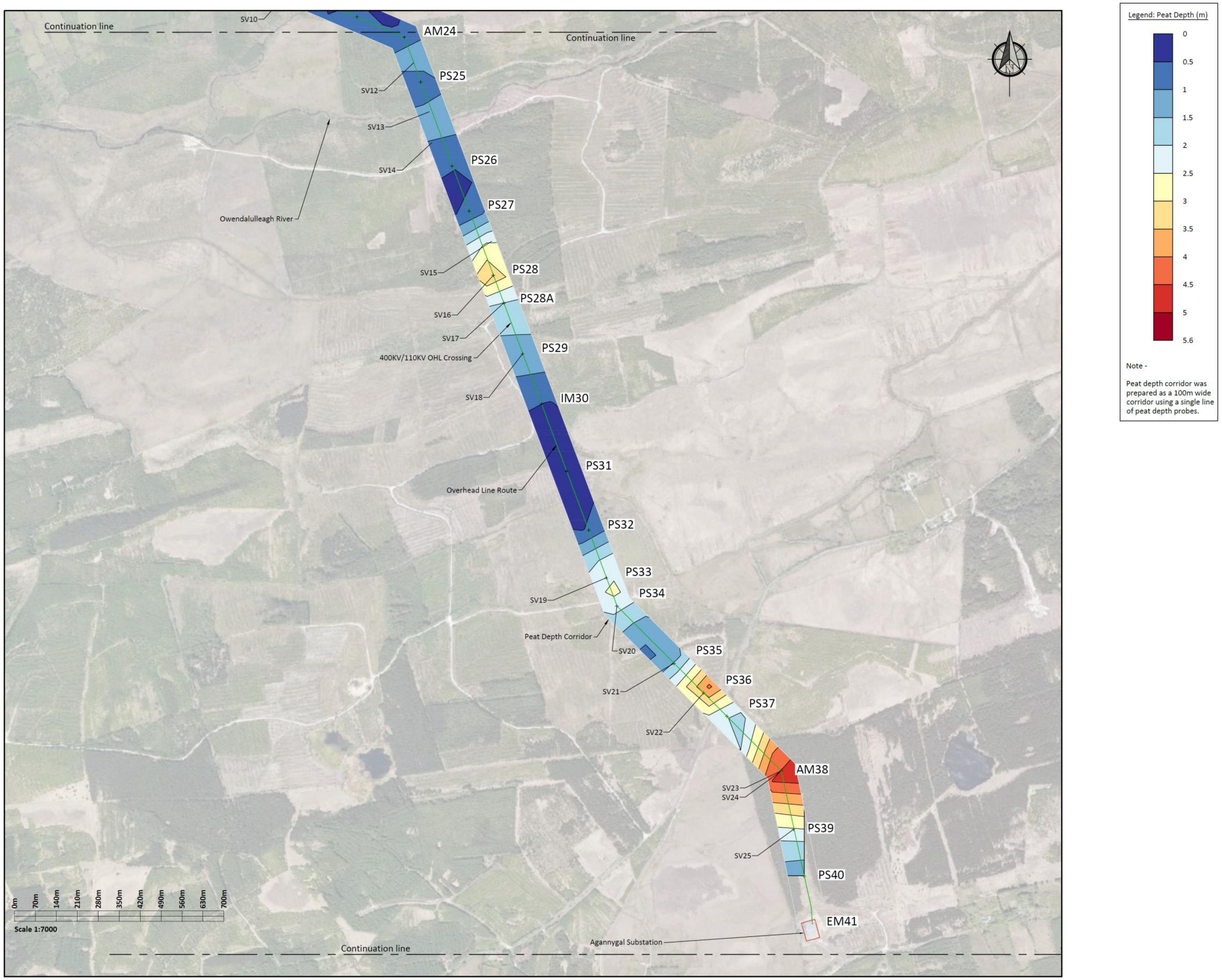

Figure 10-23: Peat depths along grid connection (2 of 2) (FT, 2020)

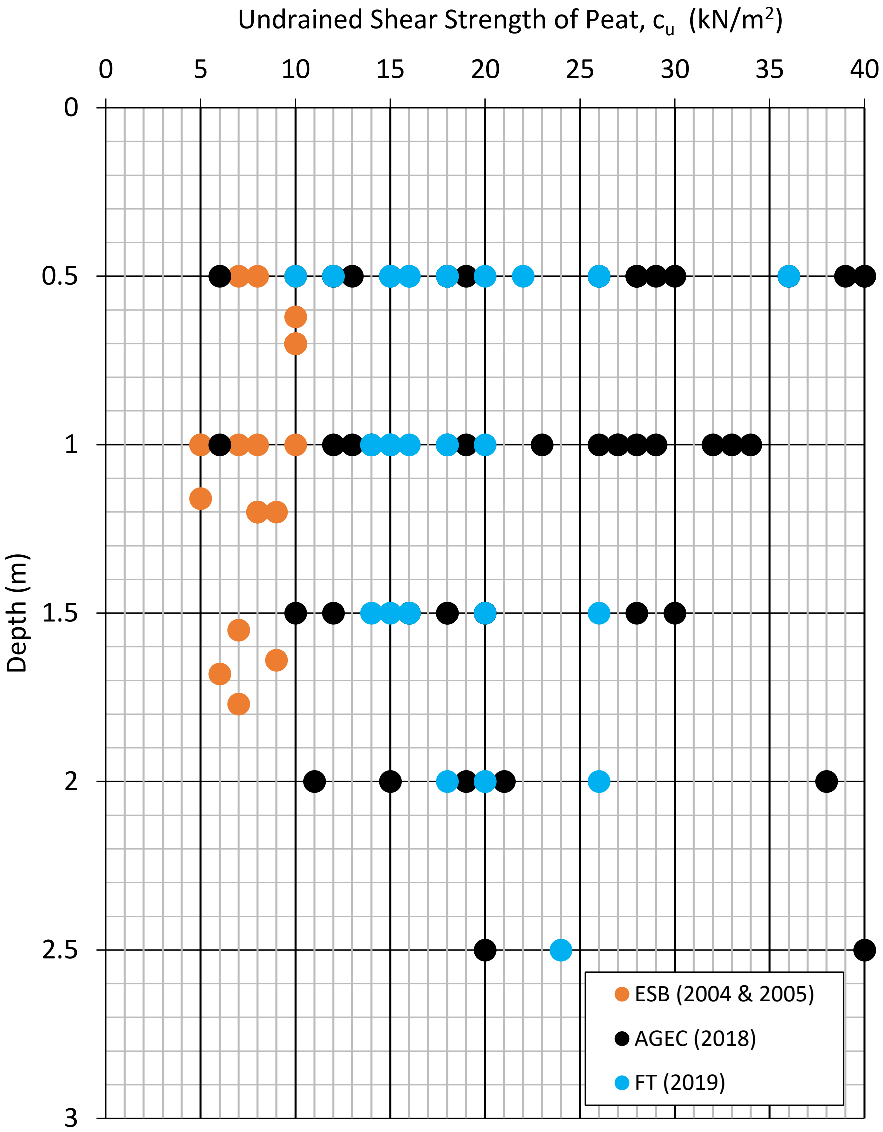

Figure 10-24: Profile of undrained shear strength with depth in peat recorded with Geonor H-60 – grid connection (FT, 2020)

10.2.2.3.2.3 Mineral Subsoil & Glacial Till

Varying thicknesses of glacial soils are present beneath the peat along the grid connection route. Figure 10-21 shows glacial till is locally present and in the vicinity of the route. Exposures of glacial till noted during the walkover surveys were described using BS5930 as 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. The observed till is similar to that described in the above figure, that is till derived from Devonian Sandstones.

Typically, glacial till was encountered below the peat at depths that ranged from 0.2 to 5.6 m, though locally glacial till was at or close to the surface below a layer of peaty topsoil.

Alluvium was recorded along the grid connection route where the Owendalulleagh River and its tributaries cross the route. Alluvium deposits are localised and based on observations during the site walkover by FT comprise predominantly coarse-grained alluvial soil comprising sand, gravel, cobbles, and boulders.

The mineral subsoil & glacial till are of no proven economic extractable significance.

10.2.2.3.2.4 Rock

Figure 10-25 shows the bedrock geology along the grid connection generated from the Geological Survey of Ireland[4] online database.

The route lies dominantly within the Ayle River Formation which comprises mudstones, siltstones and conglomerates. The lower part of the formation is characterised by red siltstones, mudstones with carbonate concretions, sandstones and conglomerates. The nearest boreholes to the route are located within the windfarm site and these show that the Ayle River Formation varied from a medium-grained SANDSTONE to a thinly laminated slightly sandy SILTSTONE.

Localised parts of the route lie within the Derryfadda Formation (greywacke, siltstone and mudstone) and the Visean Limestones (undifferentiated limestone).

There are occasional bedrock exposures at the surface along the route particularly along the banks of the nearby streams and watercourses. A number of the trial pits at the mast locations encountered bedrock within 3 m of the surface. Overall, based on the ground investigation and walkover records the depth to bedrock along the route would be considered shallow with depth varying from near surface to locally greater than 5 m depth.

The general bedrock structure along the grid connection route comprises beds dipping to the southeast at about 0 to 5 degrees. A major fault aligned approximately east-west, which underlies the Owendalulleegh River valley, passes across the route.

The bedrock is not, nor does it contain minerals, of proven economic extractable significance.

10.2.2.3.2.5 Geological Heritage Sites

The Geological Survey of Ireland Spatial Resources interactive map viewer has been reviewed to identify the nearest designated Geological Heritage site to the grid connection as recorded from the Geological Survey of Ireland.

The grid connection route does not lie on or effect any designated Geological Heritage site.

[4] Geological Survey of Ireland, *"Geological Survey Ireland Spatial Resources"* https://dcenr.maps.arcgis.com/apps/MapSeries/index.html?appid=a30af518e87a4c0ab2fbde2aaac3c228

10.2.2.3.2.6 Geomorphology and Landslide Susceptibility

Figure 10-26 shows the geomorphology along the grid connection generated from the Geological Survey of Ireland[5] online database.

The geomorphology represents essentially glacial landforms created during previous Ice Ages. The landforms along the grid connection comprise a diverse range of glacial features that were created by either sub-glacial or ice marginal mechanisms.

The route crosses within the floor of the Owendalulleegh River valley ribbed moraines, which are hummocky wave ridges of sediment deposited by glacial movement, trending in a west-south-west to east-north-east direction. Numerous linearised drumlins are also present along the valley floor.

For most of the route there is very limited earthworks cuttings into the existing landforms. Localised cuttings are present around a number of pole sets and angle masts and on access tracks through the undulating terrain. Between 28A and 29 the OHL route crosses a 400 kV exiting OHL where a cut approximately 25 m wide and 120 m long was formed in the mineral soil up to 3.8 m deep.

The landforms along the route are relatively common regionally and nationally and are not designated Geological Heritage sites.

The GSI online database also includes a landslide susceptibility map which provides a classification of the susceptibility of the ground to landslide. The susceptibility map uses a limited number of general factors (i.e. slope, soil type and a Topographic Flow Index) to asses landslide susceptibility. The susceptibility map at best provides a general indication of landslide susceptibility and is not a substitute for detailed investigation, which has been carried out for this assessment.

Along the grid line route, the GSI landslide susceptibility ranges from generally ‘moderately low’ to ‘low’ with localised areas of ‘moderately high’. The path of the 110 kV overhead line crosses zones of Moderately Low and Moderately High susceptibility from the substation on the wind farm site to the crossing of the R353 near Flaggy Bridge which reflects more challenging conditions. However this is not unusual for overhead transmission lines. To the south of the R353 the topography is varied and there are also broad zones of Low susceptibility along the route of the 110 kV overhead line. The site of the Agannygal substation is in an area of Low susceptibility, which is suitable for the project.

[5] Geological Survey of Ireland, “*Geological Survey Ireland Spatial Resources”* https://dcenr.maps.arcgis.com/apps/MapSeries/index.html?appid=a30af518e87a4c0ab2fbde2aaac3c228

10.2.2.3.3 Groundwater

The grid connection route passes across a number of watercourses and an area of ponded water (Lough Agannygal) which would indicate that groundwater is close to the surface.

Based on information from the GSI online database, most 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 (Figure 10-25) 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 [6] ranges from low to extreme across the route, due to the shallow depth to bedrock. All drainage features along the route are noted as giving rise to extreme groundwater vulnerability. Details of hydrogeology are included in Chapter 11.

10.2.2.3.4 Surface Water, Watercourses and Surface Drainage

Figure 10-20 shows the topography and natural watercourses in proximity and that cross the grid connection route. Major watercourses tend to run east to west in the area, such as the Owendalulleagh River, which is approximately 6m wide where it passes beneath the OHL. The minor tributary watercourses are generally aligned approximately north to south and run approximately parallel to the route. Details of surface hydrology are included in Chapter 11.

The terrain along the route comprises several areas of naturally shallow depressions where local ponding of surface water naturally occurs. Such a feature, Lough Agannygal, is located near the southern end of the route.

Surface drainage along the route is generally associated with man-made drainage within the managed commercial forestry. This drainage comprises parallel drain furrows typically less than 1 m deep generally within the peat. Due to the general shallow nature of the peat the drains would essentially drain the full depth of the peat, which would tend to cause a degree of desiccation of the shallow peat.

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[6] Geological Survey of Ireland, "*Geological Survey Ireland Spatial Resources*" https://dcenr.maps.arcgis.com/apps/MapSeries/index.html?appid=a30af518e87a4c0ab2fbde2aaac3c228

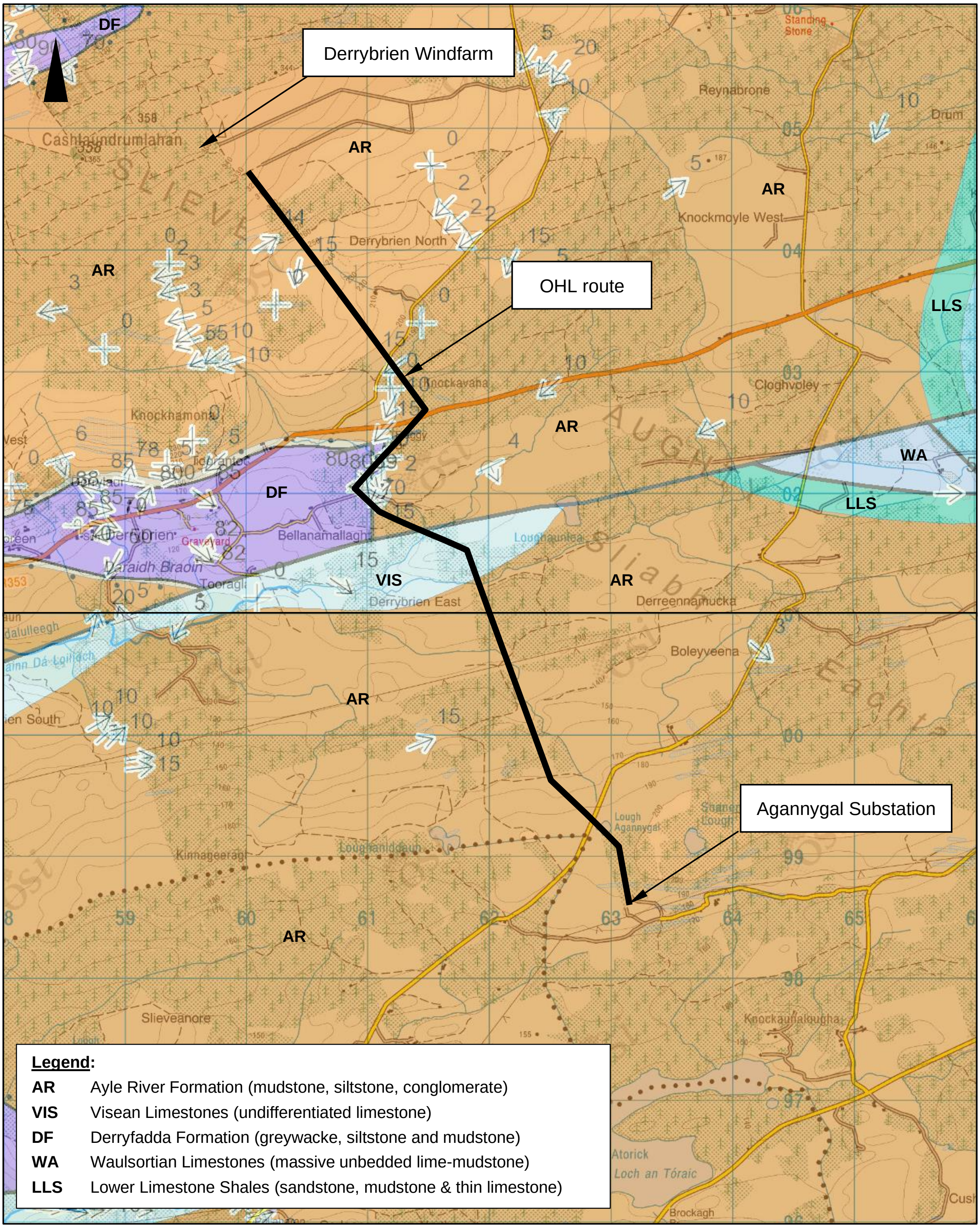

Figure 10-25: Bedrock geology map - Grid connection site

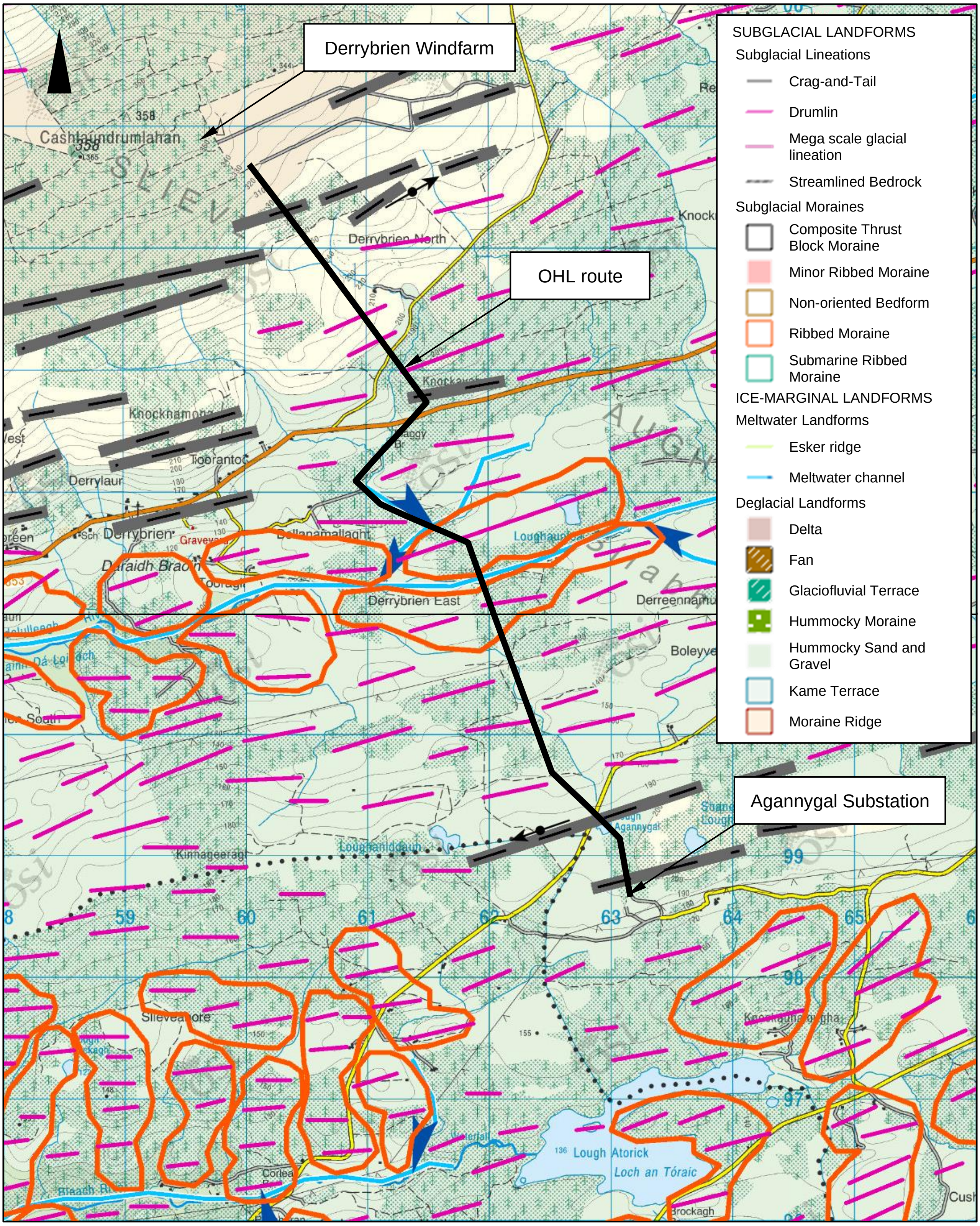

Figure 10-26: Geomorphological map - Grid connection Site

10.2.2.4 Baseline Sensitivity of the Receiving Environment (Soils, Geology & Land Use) for the Grid Connection

The significance of effects on soils, geology and land on the site has been assessed as a function of the sensitivity of the receiving environment using Figure 10-3. The sensitivity of the receiving environment is classified on a 7-point scale from Negligible to High as a function of the characteristics of the soils, geology and land that are directly impacted by this part of the project.

For this part of the project, the majority of the significant effects on soils, geology and land relate to the blanket bog that covers most of the project site, including the grid connection, and surrounding area. Therefore, the characteristics of dominantly the blanket bog govern the classification of the sensitivity of the receiving environment for assessing the significance of impacts on soils, geology and land on this project. For site stability impacts, consideration has also been given to the characteristics of the blanket bog outside the project site that could be directly impacted by a peat slide on the project site.

For this project the sensitivity of the receiving soils, geology and land has been classified as **MEDIUM** for the Wind Farm site, see details provided in the previous section 10.2.1.4.

For the assessment of site stability impacts the sensitivity of the receiving soils, geology and land that could be impacted by a peat slide has also been classified as **MEDIUM** for the Wind Farm site based on the scale of the very large peat slide that occurred on the site in October 2003, and by the land that that was directly impacted by the slide, see details provided in the previous section 10.2.1.4.

As the soils, geology and land use along the Grid Connection site, and those lands which could be impacted by a peat slide, are predominantly consistent with the Wind Farm site, the sensitivity of the soils geology and land is also assessed as **MEDIUM.**

10.2.3 Baseline Environment – Peat Slide and Associated Works

10.2.3.1 Introduction

This section gives an interpretation of the baseline conditions for soils, geology and land use for the peat slide and response works in 1998, prior to construction of the windfarm project.

The peat slide which occurred in 2003 covered about 25 ha (within the source area) and contained an estimated peat volume of about 450,000 m^3. The associated works included the measures undertaken in response to the peat slide, which comprised the rebuilding of short sections of access tracks within the wind farm site at two locations in the vicinity of T68 and between T23 and T70, the rebuilding of a section of access track on Coillte lands outside of the site, and the construction of 8 no. containment barrages (1 to 4 and A to D) and 3 no. repositories. Of the constructed barrages, 4 no. barrages (A to D) were temporary and are no longer present. Stone from a borrow pit nearby to Barrage 1 was used for some local barrage construction. Further details of barrages and repositories construction are included in Chapter 2.

The assessment includes the following:

- Peat slide – source area (1);
- Peat slide – debris (1);
- Barrage 1 and associated replacement access track;
- Barrage 2, adjacent repository area and associated access track;
- Barrage 3 and repository area;
- Barrage 4;
- Construction and sourcing of material from borrow pit adjacent to Barrage 1
- Repository at Black Road Bridge;
- Temporary barrages A to D.

(1) Note that the peat slide event has been divided into source area and debris. This is because, even though they are assessed as a single impact, the components of the impact of the source area and debris are different and vary over time.

All available information was used to establish the baseline conditions at the peat slide and associated works sites, 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, a desk study review of historical aerial photographs, topographical 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).

Section 10.2.3.2 includes a summary of the ground investigations carried out on the peat slide and response works sites from 2003 to 2019, which would be considered representative of the baseline condition.

Section 10.2.3.3 gives a summary of the baseline conditions for the topography and land use, as well as the geotechnical characterisation of the soils, and the geological classification of the bedrock geology. Sections 10.2.3.3.3 and 10.2.3.3.4 give a summary of the groundwater conditions and an overview of the surface water, watercourses and surface drainage, which are particularly relevant to stability.

The characteristics and sensitivity of Geological Heritage Sites (GHS) are assessed in Section 10.2.3.3.2.6.

The baseline sensitivity of the receiving soils, geology and land impacted by the peat slide and response works has been assessed in Section 10.2.3.4.

10.2.3.2 Geotechnical Investigations

10.2.3.2.1 Introduction

Details of ground investigations carried out in the peat slide and response works sites are included in Appendix D within report entitled *"Geotechnical Stability Report 2 - Peat Slide and Associated Works"* (FT, 2020). The ground investigation information comprised:

- A comprehensive desk study of available information on soils, geology and groundwater conditions;
- Periodic, (predominantly performed annually), site inspection reports from 2006 to 2019;
- Walkover surveys (from 2006 to 2019) to inspect ground conditions and site stability;
- Trial pits (9 no.) to determine depth and characteristics of peat and subsoils at containment barrages and repositories to depths of about 3 m;
- Mackintosh probes (80 no.) to determine depth and characteristics of peat and subsoils at containment barrages and repositories to depths of about 3 m;
- Peat probing (59 no.) and in-situ vane shear (12 no.) to establish a profile of the depth of peat at containment barrages and repositories;
- Extensive peat probing (+200 no.) to establish a profile of the depth of peat in peat slide source area;
- In-situ vane shear testing (+130 no.) to establish the undrained shear strength of the peat in peat slide source area.

10.2.3.2.2 Ground Investigations in Peat Slide Source Area (2003 to 2005)

Following the peat slide extensive ground investigations were carried out at the wind farm site which included the upper part of the source area of the peat slide. These ground investigations are detailed in the previous section and included the following:

- AGEC Ground Investigation (2003) – Appendix A of this chapter
- ESBI Ground Investigation (2004) – Appendix B of this chapter
- AGL/BAM Supplemental Site Investigations – Construction Stage (Post-Slide – 2004/2005) – Appendix B of chapter

10.2.3.2.3 ESB Ground-Related Reports for Derrybrien Wind Farm (2006 to 2019)

ESB International undertook site inspections on a near annual basis which covered the wind farm site and the peat slide and associated works from to 2006 to 2019. The findings of these inspections are presented in a number of “Annual Site Inspection Reports”. The reports included for example the findings and recommendations of the monitoring regime for the project based on site walkovers. The recommendations included various site stability related issues to be addressed by wind farm operational manager (e.g. drainage maintenance, road maintenance, performance of retention measures (barrages) etc.).

10.2.3.2.4 AGEC Ground Investigation (2011)

Ground investigations were carried out by AGEC in the source area of the peat slide in December 2011. This comprised peat depth probes and hand shear vanes.

80 no. hand shear vane strength tests were undertaken in the source area of the peat slide in peat at depths from 0.5 to 2 m bgl.

80 no. peat probes were also undertaken in the source area of the peat slide in peat at depths from 0.5 to 2 m bgl.

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.

10.2.3.2.5 AGEC Ground Investigation (2018)

Ground investigations were carried out by AGEC in the source area of the peat slide, at containment barrages and repository sites in June 2018. This comprised trial pits, peat depth probing and shear vane testing.

17 no. hand shear vane strength tests were undertaken in the source area of the peat slide in peat at depths from 0.2 to 1.3 m bgl.

+20 no. peat probes were also carried out in the source area of the peat slide.

9 no. trial pits at containment barrages and repositories to depths of about 3 m (of which 4 no. were located in the peat slide source area).

80 no. Mackintosh probes were undertaken at containment barrages and repository sites at depths to about 3 m bgl.

12 no. hand shear vane strength tests were undertaken at containment barrages and repositories.

59 no. peat probes were also carried out at containment barrages and repositories.

Shear vane testing was carried out using a Geonor H-60 hand field vane tester. Trial pits were located adjacent to barrages and repositories where there was available access. The purpose of the trial pits was to expose the founding materials.

10.2.3.2.6 FT Ground Investigation & Walkover (2019)

Ground investigation and walkover survey was carried out by FT in the source area of the peat slide and at containment barrages and repository sites in September and October 2019. This comprised hand shear vanes and peat depth probes.

34 no. hand shear vane strength tests were undertaken in the source area of the peat slide in peat at depths from 0.2 to 1.5 m bgl.

+40 no. peat probes were also carried out in the source area of the peat slide.

Shear vane testing was carried out using a Geonor H-60 hand field vane tester.

10.2.3.3 Baseline Conditions (1998) – Soils, Geology & Land Use

10.2.3.3.1 Topography and Land Use

An aerial photograph of the site in 2000 which would reasonably represent the baseline conditions in 1998, is shown on Figure 10-27. The peat slide and the associated works are shown and the land use in the area can be inspected from this figure.

In 1998 most of peat slide footprint and the associated works was managed commercial forestry. Forestry was planted in the project site from 1963 to 1994. The figure shows the main features and land use that were in the area prior to construction, which includes:

- Extent of existing roads prior to construction;
- Extent of existing mature conifer plantations, recently planted/felled plantations and firebreaks;
- Extent of agricultural area; and
- Existing watercourses and drainage channels.

In general, the land use prior to the peat slide and the associated works was dominantly managed commercial forestry with some agricultural (pastoral) land.

The topography and land-use for all 8 no. barrages (1 to 4 and A to D) and 3 no. repositories together with the peat slide, which is divided into source area and the debris path is included below.

Peat Slide – Source Area

The peat slide source area is located on the upper southern slope of Cashlaundrumlahan Mountain, see Figure 10-28[7]. The upper southern slope forms a gently sloping plateau aligned on a northeast to southwest 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

[7] Based on Geological Survey of Ireland, "*Geological Survey Ireland Spatial Resources"* https://dcenr.maps.arcgis.com/apps/MapSeries/index.html?appid=a30af518e87a4c0ab2fbde2aaac3c228,

occurred at the head of the valley that contained a tributary stream (SC7b) of the Owendalulleegh River.

Prior to construction of the project, 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 (SC7b) 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 250 m AOD before widening downslope above c.195 m AOD, which is the location of the Black Road Bridge, see Figure 10-28.

Below the Black Road Bridge (c.195 m AOD), the tributary stream follows a more southerly course within forestry to the Flaggy Bridge. Below the Flaggy Bridge (c.150 m AOD) 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 (SC7a and SC7c) before joining the Owendalulleegh River about 1.3 km 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 on the river banks after about 3.1 km downstream of the confluence with the Owendalulleagh River, see Figure 10-27.

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 250 m AOD) to the point where the peat slide debris was entirely suspended within river water is estimated at 6.9 km. Assuming an average width of debris path of 30 m then the footprint of the debris was about 17.4 ha.

Between barrage 2 and the Black Road Bridge the debris extended beyond the stream channel to an estimated total width of up to 100 m 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.

Prior to construction of the project, the land use on the banks of the river/stream was a mix of managed commercial forestry and agricultural land. The mix of managed commercial forestry and agricultural land is typically classed as coniferous forestry and transitional woodland scrub by the EPA Corine mapping dataset [8].

[8] EPA *"EPA Maps"* https://gis.epa.ie/EPAMaps/

Barrage 1 and Replaced Access Track

Containment barrage 1 is located within the source area of the peat slide about 1.2 km downslope of the head of the source area. The barrage was constructed to contain peat debris but it also provides part of the replacement access road for the previous forestry access that was destroyed during the peat slide.

The barrage, which is predominantly constructed from large boulders, is located on the southern slope of Cashlaundrumlahan Mountain at an elevation of about 265m OD. The footprint of the barrage is approximately 94 m long and 8 m wide and it is aligned in a northeast to southwest direction.

The replacement access track, 830m long and 4.5 m wide, constructed to re-connect sections of forestry tracks existing prior to the slide in 2003 includes the barrage and a floated section of access track extending westerly from the barrage.

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

Ground conditions prior to the barrage and replaced access track would have comprised an estimated 1.5 to 2.5 m of peat over firm Silt/Clay or medium dense sand with many cobbles and boulders. The barrage was founded below the peat, the replaced access track is floating on the peat.

Prior to the peat slide the land-use was managed commercial forestry.

Barrage 2 and Repository Area

Containment barrage 2, which is predominantly constructed from large boulders, is located within the downstream end of a narrow steep-sided channel at approximately 245 m AOD (Figure 10-28). The footprint of the barrage is approximately 17 m long and 20 m wide. The general area comprises level ground, except within the stream channel, which is incised some 3 to 4 m.

There is a repository area adjacent to barrage 2 which comprises 2 no. separate storage areas used for storage of material removed from the upslope face of the barrage. The footprint of the repository is approximately 108 m long and 34 m wide.

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. The footprint of the access track is 284 m long and about 4.5 m wide. The track is aligned downslope and connects to the existing Coillte forestry track at 265 m AOD. Average slope angle along the track is 3 to 4 degrees.

Prior to the peat slide the land-use was managed commercial forestry with the barrage located in the existing stream channel.

Barrage 3 and Repository Area

Containment barrage 3, which is predominantly constructed from large boulders, is located within the stream channel at 180 m AOD (Figure 10-28). At the barrage site, rock is exposed within the stream channel. The general area comprises level ground.

The footprint of the barrage is approximately 41 m long and 9 m wide.

There is a sunken repository area adjacent to barrage 3 used for storage of material removed from the upslope face of the barrage. The footprint of the repository is approximately 41.5 m long and 16 m wide.

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 100 m long and about 3 m wide. The access is aligned downslope and connects to the existing road at about 190 m AOD.

Prior to the peat slide the land use was managed commercial forestry with the barrage located in the existing stream channel.

Barrage 4

Containment barrage 4, which is predominantly constructed from large boulders is located within the stream channel at 170 m AOD (Figure 10-28). At the barrage site, rock is exposed within the stream channel. The general area comprises level ground.

The footprint of the barrage is approximately 25 m long and 10 m wide.

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 100 m long and about 3 m wide. The access is aligned downslope and connects to the existing road at about 175 m AOD

Ground conditions included shallow peaty topsoil overlying shallow bedrock beside the stream with bedrock exposed in the stream.

Prior to the peat slide the land-use in the area of Barrage 4 was managed commercial forestry with the barrage located in the existing stream channel.

Repository at Black Road Bridge

The repository at Black Road Bridge is located to the east of the stream on essentially level ground within Coillte land at 200 m AOD (Figure 10-28). The repository comprises 2 no. separate storage areas used for storage of slide debris that accumulated on the open area of ground above the Black Road Bridge.

The north west section is approximately 130 m long and 73 m wide with an estimated area 5322 m^2, the south east section is approximately 68 m long and 51 m wide; estimated area 2898 m^2.

Access to the repository was from an existing track from the Black Road.

Ground conditions included shallow peaty topsoil overlying slightly gravelly very sandy Clay.

Prior to the peat slide the land-use was managed commercial forestry, though few trees were planted in the footprint of the repository.

Temporary Barrages A to D

Temporary containment barrages were constructed after the peat slide event from October to November 2003 and were subsequently eroded or removed sometime after the slide event. Date of removal is not known. The location and dimension of these temporary barrages is estimated.

The topography and land-use at the location of the temporary barrages is given in Table 10-2.

Table 10-2: Temporary Containment Barrages (A to D)

Barrage	Footprint Dimensions	Topography and Land-use
Temporary Containment Barrage A	Estimated: 80m (long), 3m (wide)	Located upstream of Black Road Bridge on open level ground across stream channel at 200 m AOD. Access direct from existing road. Prior to the peat slide the land-use was agricultural grass land.
Temporary Containment Barrage B	Estimated: 80m (long), 3m (wide)	Located upstream of Black Road Bridge on open level ground across stream channel at 200 m AOD. Access direct from existing road. Prior to the peat slide the land-use in the area was agricultural grass land.
Temporary Containment Barrage C	Estimated: 20m (long), 3m (wide)	Located upstream of Flaggy Bridge on R353 within stream channel at 160 m AOD. Temporary access direct from existing road through managed commercial forestry. Prior to the peat slide the land-use in the area was managed commercial forestry with the barrage located in the existing stream channel.
Temporary Containment Barrage D	Estimated: 20m (long), 3m (wide)	Located downstream of Flaggy Bridge on R353 within stream channel at 150 m AOD. Temporary access direct from existing road through managed commercial forestry. Prior to the peat slide the land-use in the area was managed commercial forestry with the barrage located in the existing stream channel.

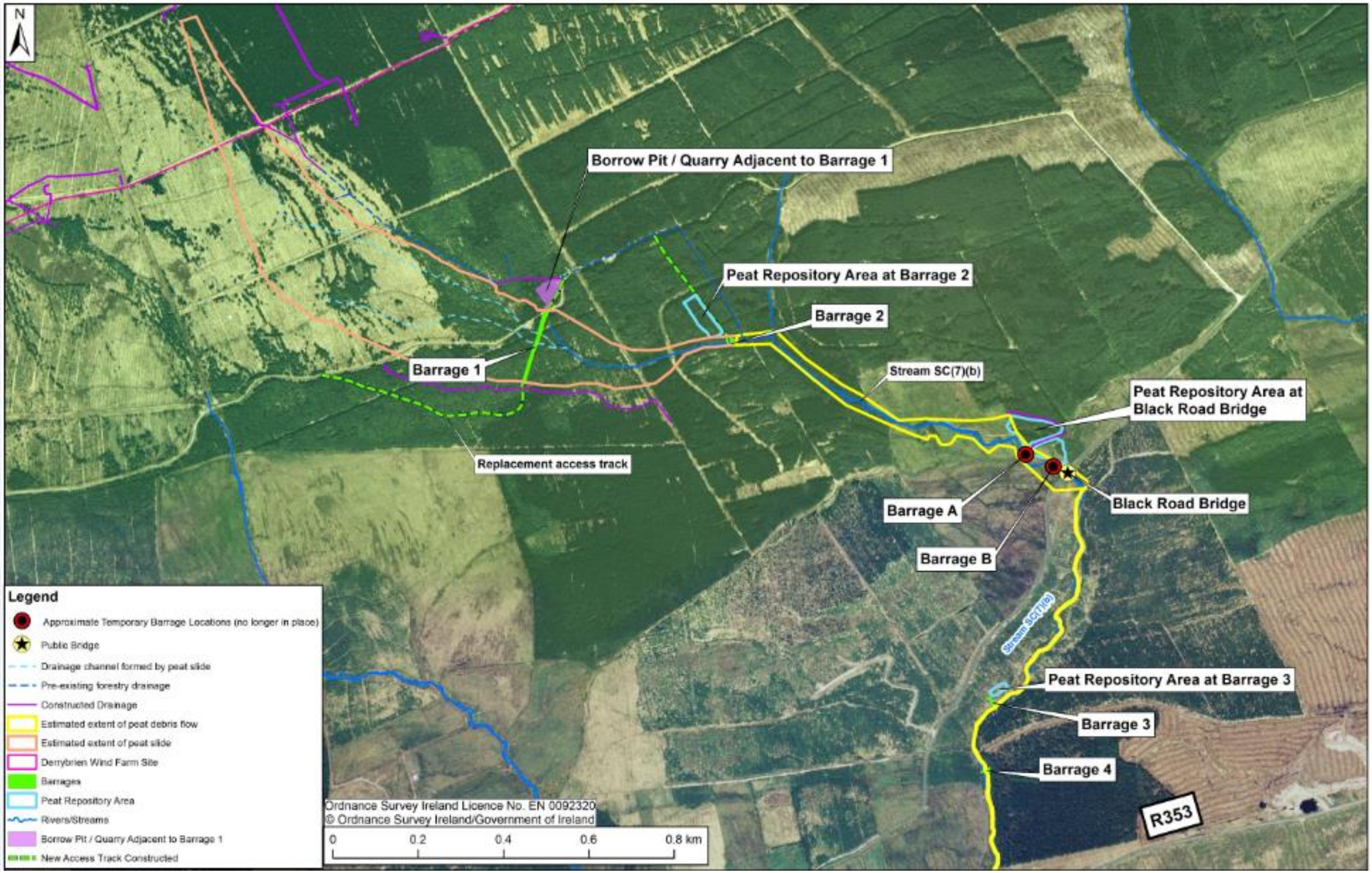

Figure 10-27: Aerial photograph of peat slide and associated works (c. 2000) (1 of 3)

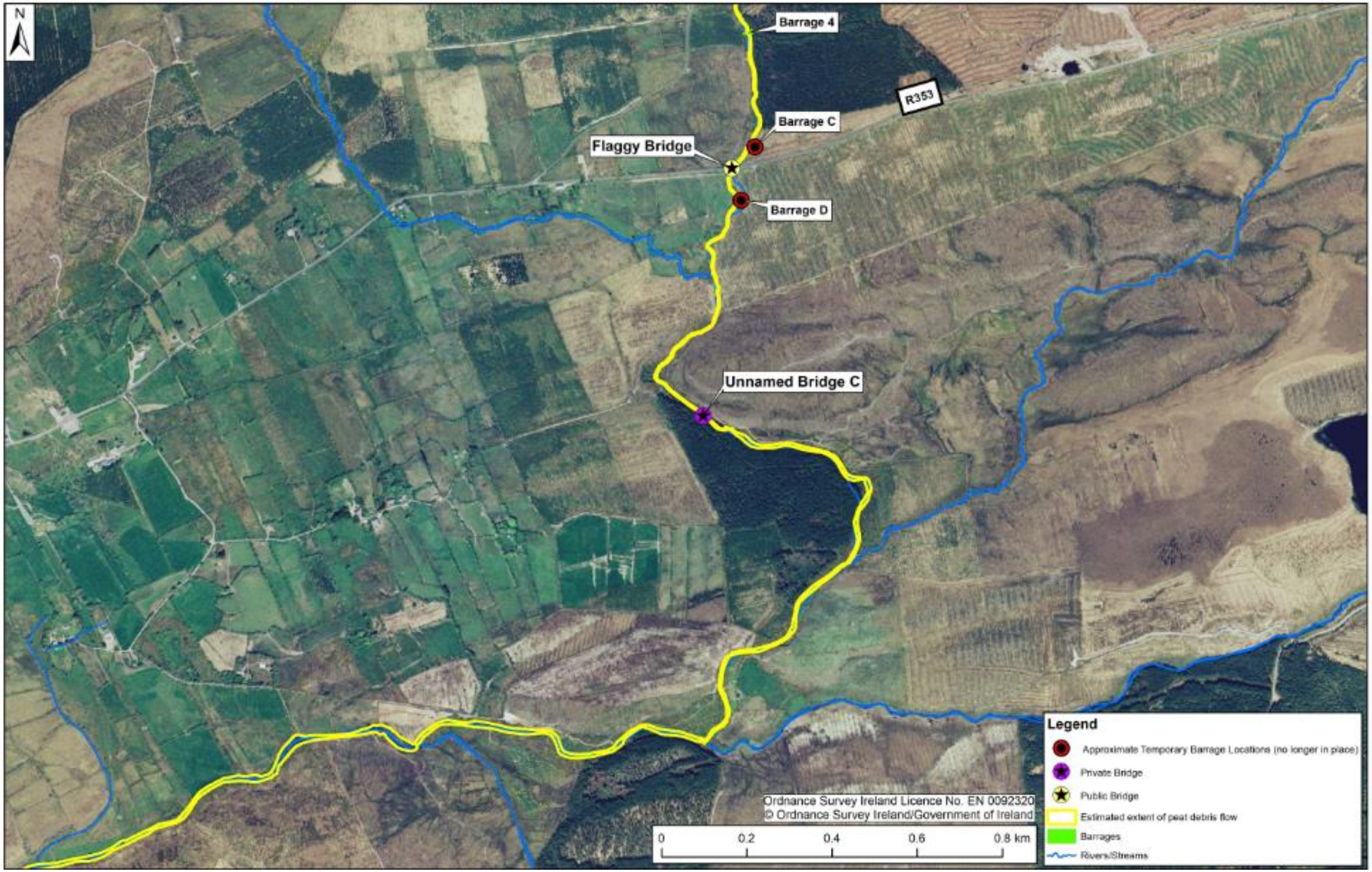

Figure 10-27: Aerial photograph of peat slide and associated works (c. 2000) (2 of 3)

Figure 10-27: Aerial photograph of peat slide and associated works (c. 2000) (3 of 3)

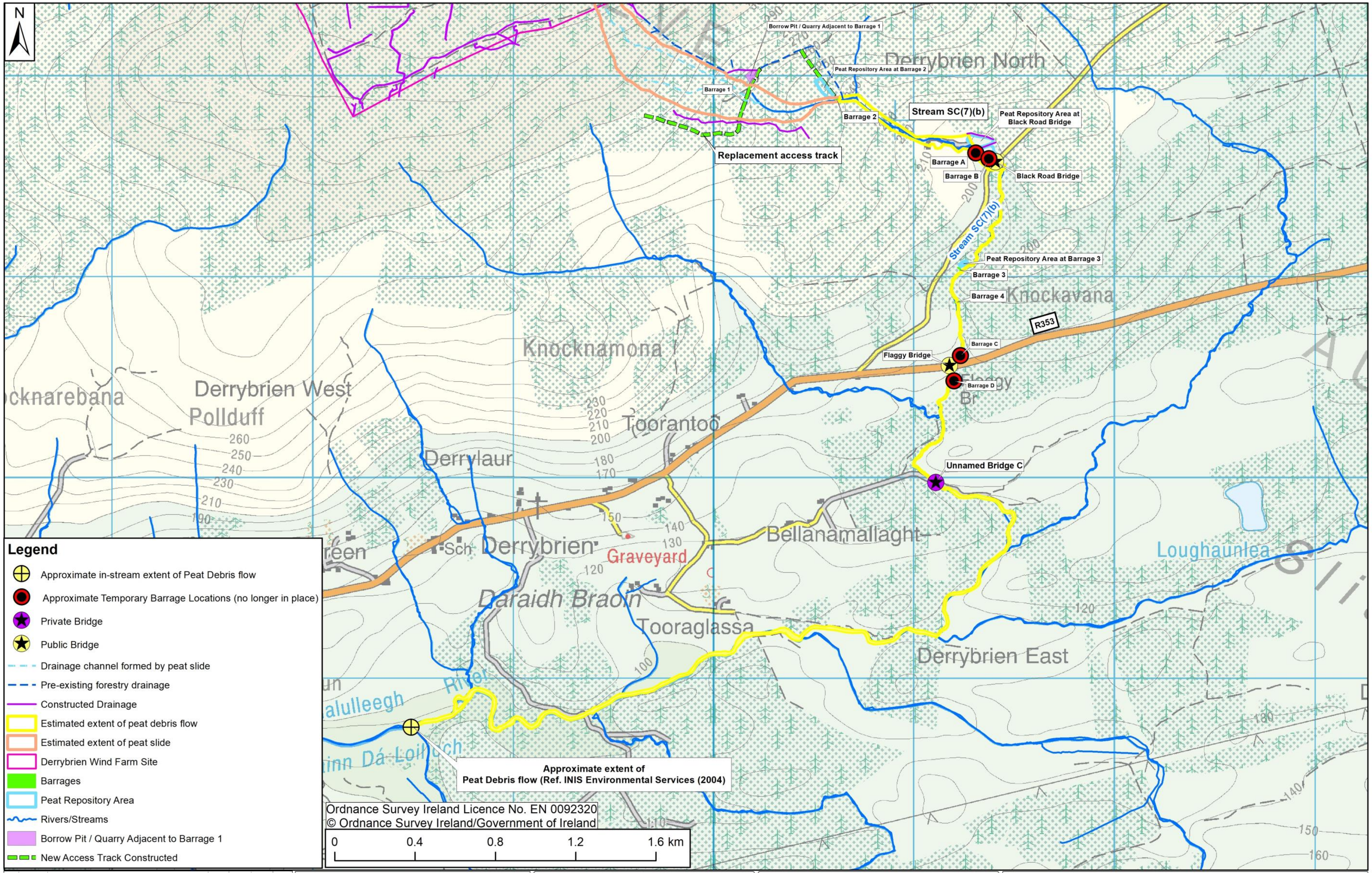

Figure 10-28: General topography – peat slide and associated works

10.2.3.3.2 Geotechnical Characterisation Conditions

10.2.3.3.2.1 Quaternary Geology & Subsoils Map - GSI

Figure 10-29 shows a map of the Quaternary Geology for the peat slide and associated work sites generated from the Geological Survey of Ireland[9] online database. The peat slide and associated work sites are dominated by blanket peat (BktPt) with locally glacial till (TDSs) present. There are occasional bedrock exposures (Rck), particularly along the banks and bed of the stream, together with alluvium (A).

10.2.3.3.2.2 Peat

Peat Slide – Source Area

The peat slide source area is within blanket peat. This is consistent with site walkover and ground investigation findings. The thickness of peat, based on ground investigation, typically ranged from 1 to 4 m. There is no clear pattern of peat thickness, though locally thicker peat was recorded in the upper part of the area where slope angles are less. Further downslope, blanket peat thins.

Examination of peat exposures within the slide source area showed humification at the base of the peat varied from about H6 to H9 (Hobbs, 1986)[10]. The upper 1 m (approximately) 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 source area, trial pits and in exposures in excavations and along drains, was described using BS5930[11] as very soft to soft brown to dark brown pseudo-fibrous and amorphous PEAT. Peat appeared to lie directly on bedrock or a glacial till/subsoil.

Shear strength profiles were measured using a Geonor H-60 hand vane tester at a number of locations by AGEC in 2011, 2018 and by FT in 2019. A total of +130 no. shear vane strength tests were undertaken at depths from 0.3 to 2 m. Values for vane shear strength (unfactored) ranged from 4 to 38 kPa with an average of about 17 kPa, see Figure 10-30.

Peat Slide - Debris

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 or exposed and alluvium along the river channel.

Barrage 1 and Replacement Access Track

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[9] Geological Survey of Ireland, "*Geological Survey Ireland Spatial Resources*" https://dcenr.maps.arcgis.com/apps/MapSeries/index.html?appid=a30af518e87a4c0ab2fbde2aaac3c228

[10] 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.

[11] British Standard Institute, *"BS5930:2015 Code of practice for site investigations",* 2015

Barrage 1 is located in the source area and is founded on competent glacial soils. The original peat depth at this location prior to the peat slide is estimated at about 2 m.

No peat is present below the barrage.

The section of access track extending westerly from barrage 1 was constructed as a floating track on peat. The floating access track is estimated to be placed on peat about 0 to 1.5 m depth based on nearest available data.

Barrage 2 and Repository Area, and Access

Based on a trial pit carried out adjacent to barrage 2, the barrage is founded on glacial soil within the stream. Prior to the peat slide it is highly unlikely that peat would have been present at the location of the barrage.

The repository area adjacent to barrage 2 is founded on about 1 m depth of peat.

The floated access track to the barrage is estimated to be placed on peat up to about 1.5 m depth.

Barrage 3 and Repository Area

Barrage 3 located within the stream channel is founded on likely bedrock. Prior to the peat slide it is highly unlikely that peat would have been present at the location of the barrage.

The repository area adjacent to barrage 3 is founded on mixed ground conditions which are likely to comprise non-peat material i.e. silt and sand deposits. No in situ peat is present.

Barrage 4

Barrage 4 located within the stream channel is founded on likely bedrock. Prior to the peat slide it is highly unlikely that peat would have been present at the location of the barrage.

Repository at Black Road Bridge

The repository area is founded on minimal (about 0.3 m) insitu peat. Inspection of the general area shows generally peaty topsoil present at existing ground level in the area. The insitu peat cover in this area is unlikely to have been greatly affected by the peat slide.

Temporary Barrages A to D

Temporary barrages A and B were located in proximity to the repository at Black Road Bridge. Inspection of the general area shows generally peaty topsoil present at the existing ground level.

Temporary barrages C and D were located within the stream close to the Flaggy Bridge. Inspection of the ground conditions in the stream at these locations shows mixed rock and granular alluvial deposits, which may include some glacial soil. No peat was present.

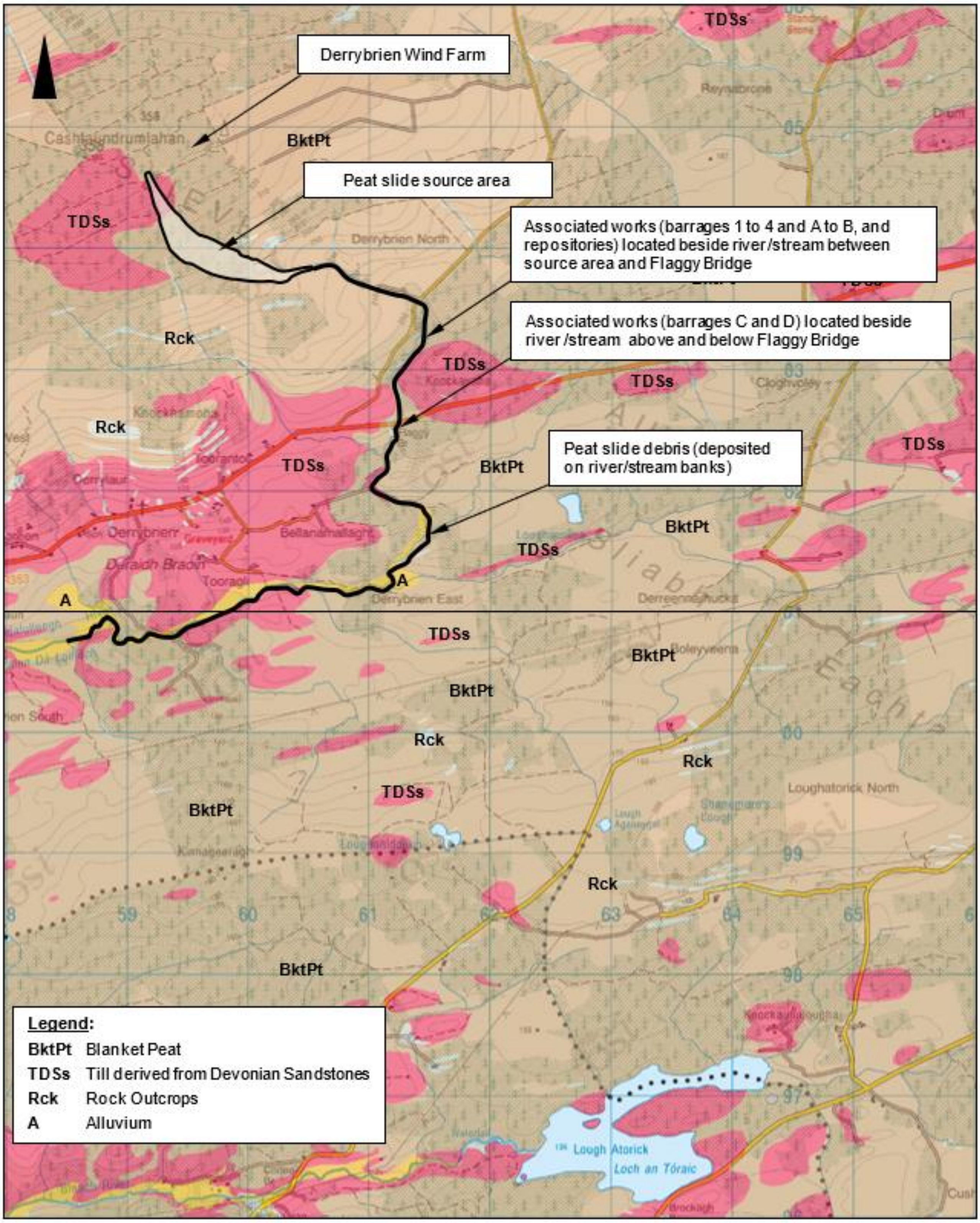

Figure 10-29: Quaternary geology map – peat slide and associated works

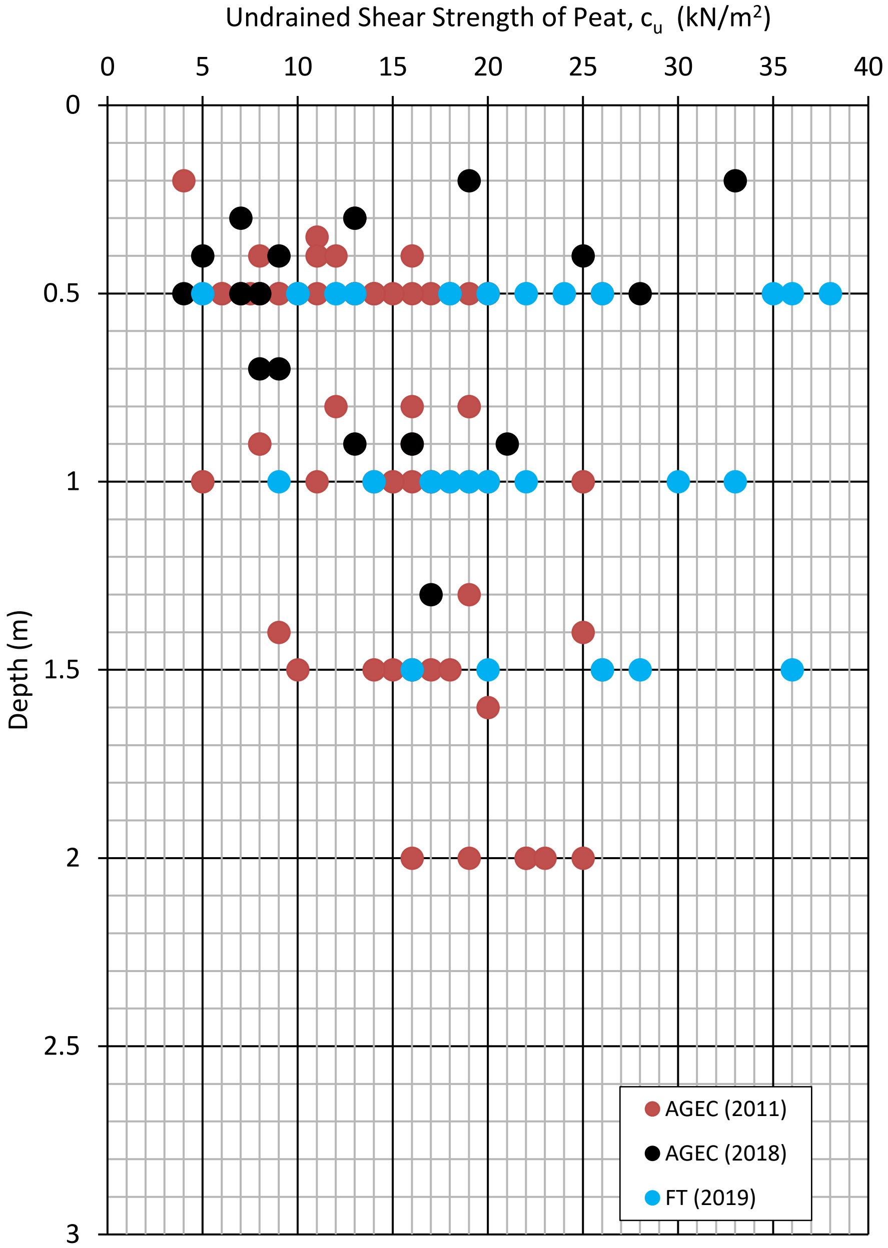

Figure 10-30: Profile of undrained shear strength with depth in peat recorded with Geonor H-60 – peat slide source area (FT, 2020)

10.2.3.3.2.3 Glacial Soils

Peat Slide – Source Area

Within the peat slide source area, peat is underlain by glacial soil or slightly silty sandy subsoil. The subsoil is likely derived from weathered rock. Generally, in exposures in the source area, both glacial soil and a subsoil layer were present below the peat and above weathered rock/rockhead.

The glacial soil within the source area 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.

Peat Slide - Debris

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 over glacial soils or exposed rock or alluvium.

Barrage 1

Barrage 1 located in the source area is founded on glacial soils, which prior to the peat slide would have underlain the peat. The description of the glacial soil is as given for the peat slide source area.

The access track to the barrage is either underlain directly by glacial soil (or weathered rock) or peat which would be underlain by glacial soil.

Barrage 2 and Repository Area

Based on a trial pit carried out adjacent to barrage 2, the barrage is founded on glacial soil. The repository area adjacent to barrage 2 and the floated access track are founded on about 1 to 1.5 m depth of peat, which is likely underlain by glacial soil.

Barrage 3 and Repository Area

Barrage 3, located within the stream channel, and the adjacent repository area are likely founded on bedrock. Localised glacial soil may also be present in particular at the base of the repository.

Barrage 4

Barrage 4 located within the stream channel is likely founded on bedrock. Localised glacial soil may also be present.

Repository at Black Road Bridge

The repository area is founded on minimal in situ peat which is likely underlain by glacial soil. Inspection of the drainage channels and watercourse surrounding the repository indicates glacial soils underlay the peat deposits at shallow depths.

Temporary Barrages A to D

Temporary barrages A and B were located in proximity to the repository at Black Road Bridge. Inspection of the area shows generally peaty topsoil present, which is likely underlain by glacial soil based on inspection of local watercourses and drainage channels.

Temporary barrages C and D were located within the stream close to the Flaggy Bridge. Inspection of the ground conditions in the stream at these locations shows mixed rock and granular alluvial deposits, which may include some glacial soil.

10.2.3.3.2.4 Alluvial Soils

Alluvial soils are present within the lower part of the tributary stream that flows from Cashlaundrumlahan Mountain and within the Owendalulleagh River about 1 km below the Flaggy bridge (Figure 10-29). Alluvial deposits are confined essentially to the stream/river bed and consist of essentially a mix of sand, gravel, cobbles, and boulders. Whilst there may be some minor alluvial deposits below some of the barrages this would not be considered significant.

10.2.3.3.2.5 Rock

Figure 10-31 shows the bedrock geology along the peat slide and associated work sites generated from the Geological Survey of Ireland[12] online database.

The dominant rock is the Ayle River Formation which comprises mudstones, siltstones and conglomerates. The lower part of the formation is characterised by red siltstones, mudstones with carbonate concretions, sandstones and conglomerates. The nearest boreholes to the route are located within the windfarm site and these show that the Ayle River Formation varied from a medium-grained SANDSTONE to a thinly laminated slightly sandy SILTSTONE.

Localised parts of the tributary lie within the Derryfadda Formation (greywacke, siltstone and mudstone) and the Visean Limestones (undifferentiated limestone).

There are occasional bedrock exposures at the surface particularly along the banks and bed of the stream. Overall, based on the ground investigation and walkover records the depth to bedrock along the tributary would be considered shallow.

The general bedrock structure in the area comprises beds dipping to the southeast at about 0 to 5 degrees. A major fault aligned approximately east-west, which underlies the Owendalulleegh River valley, passes across the route.

The bedrock is not, nor does it contain minerals, of proven economic extractable significance.

10.2.3.3.2.6 Geological Heritage Sites

The Geological Survey of Ireland Spatial Resources interactive map viewer has been reviewed to identify the nearest designated Geological Heritage site to the Peat Slide Response Works as recorded from the Geological Survey of Ireland.

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[12] Geological Survey of Ireland, "*Geological Survey Ireland Spatial Resources*" https://dcenr.maps.arcgis.com/apps/MapSeries/index.html?appid=a30af518e87a4c0ab2fbde2aaac3c228

The Peat Slide Response Works do not lie on or effect any designated Geological Heritage sites.

10.2.3.3.2.7 Geomorphology and Landslide Susceptibility

Figure 10-32 shows the geomorphology in the peat slide and associated work sites generated from the Geological Survey of Ireland[13] online database.

The geomorphology represents essentially glacial landforms created during previous Ice Ages. The landforms in the area comprise a diverse range of glacial features that were created by either sub-glacial or ice marginal mechanisms.

The peat slide and associated work sites are located along an existing river/stream course which naturally passes around the mapped landforms, such as the ribbed moraines and linearised drumlins present on the floor of the Owendalulleegh River valley.

For most of the peat slide and associated work sites there is very limited disturbance of the existing landforms except in the peat slide source area. In the peat slide source area, the peat has been disturbed and moved, however the geomorphological landforms at this location comprise streamlined bedrock. The peat itself is not part of the mapped landforms.

The landforms in the area are relatively common regionally and nationally and are not designated Geological Heritage sites.

The GSI online database also includes a landslide susceptibility map which provides a classification of the susceptibility of the ground to landsliding. The susceptibility map uses a limited number of general factors (i.e. slope, soil type and a Topographic Flow Index) to asses landslide susceptibility. The susceptibility map at best provides a general indication of landslide susceptibility and is not a substitute for detailed investigation, which has been carried out for this assessment. Within the peat slide and associated works areas, the GSI landslide susceptibility ranges from generally ‘moderately low’ to ‘low’.

10.2.3.3.3 Groundwater

The peat slide and associated work sites are essentially within the tributary stream valley (SC7b) of the Owendalulleegh River which would indicate that groundwater is close to the surface.

Based on information from the GSI online database, most peat slide and associated work sites are underlain by rock which is considered a poor aquifer (bedrock which is generally unproductive except for local zones). However, the lower part of the peat slide debris path is underlain by Visean Limestone (Figure 10-31) which is considered

[13] Geological Survey of Ireland, “*Geological Survey Ireland Spatial Resources”* https://dcenr.maps.arcgis.com/apps/MapSeries/index.html?appid=a30af518e87a4c0ab2fbde2aaac3c228

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[14] ranges from low to extreme across the route, due to the shallow depth to bedrock. Details of hydrogeology are included in Chapter 11.

10.2.3.3.4 Surface Water, Watercourses and Surface Drainage

Figure 10-28 shows the topography and natural watercourses in proximity to the peat slide and associated work sites, which are essentially within the tributary stream valley (SC7b) of the Owendalulleegh River. Details of surface hydrology are included in Chapter 11.

Within the peat slide source area man-made drains, which were within the forestry prior to the peat slide, comprised a series of narrow open drains, typically 1 to 2 m deep with closely spaced furrows. The forestry drainage would have connected to the natural valley drainage in the area and flowed downslope.

The peat slide debris followed the tributary stream valley (SC7b) of the Owendalulleegh River. Peat slide debris passed down this valley which widens above the Black Road Bridge. Below the Black Bridge Road (c.195 m AOD), the tributary stream follows a more southerly course within forestry to the Flaggy Bridge. Below the Flaggy Bridge (c.150 m AOD) the stream is joined by further tributary streams (SC7a and SC7c) before joining the Owendalulleegh River about 1.3 km south of local road R353 (location of Flaggy Bridge).

The impact of the peat slide debris is notably reduced beyond the confluence with the Owendalulleagh River with only some peat debris deposits recorded on the river banks. There was essentially no debris reported deposited on the river banks after about 3.1 km downstream of the confluence with the Owendalulleagh River. A survey of the river following the peat slide by Inis Environmental Services[15] 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 for the purposes of the assessment of impacts on soils, geology and land.

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

The Owendalulleagh River flows westward to Lough Cutra approximately 22 km downstream.

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[14] Geological Survey of Ireland, "*Geological Survey Ireland Spatial Resources"* https://dcenr.maps.arcgis.com/apps/MapSeries/index.html?appid=a30af518e87a4c0ab2fbde2aaac3c228

[15] Inis Environmental Services, 2004, *"Derrybrien Windfarm Peat Slip - Environmental Impact Assessment on the Owendalluleegh River*", March 2004.

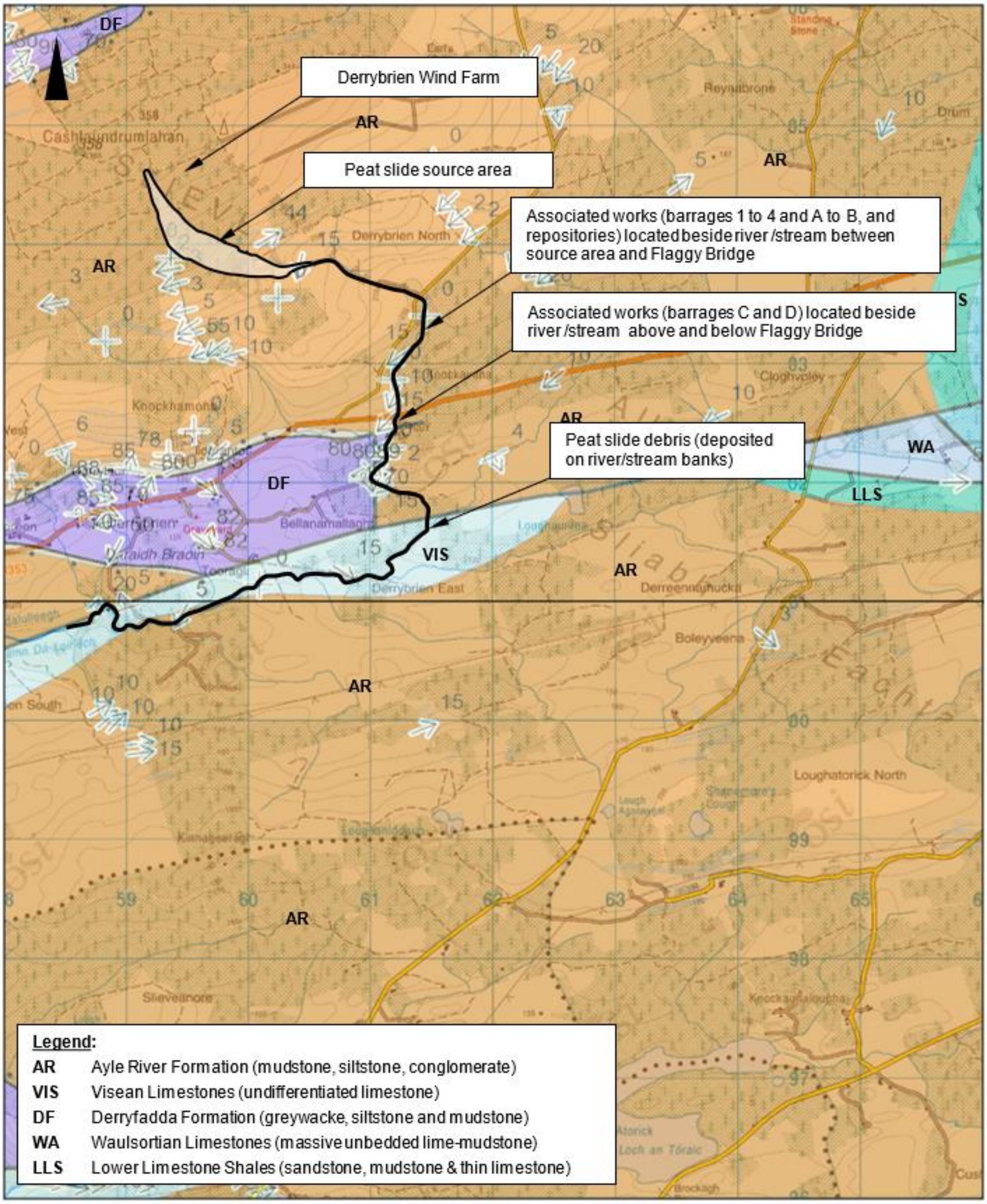


Figure 10-31: Bedrock geology map – peat slide and associated works

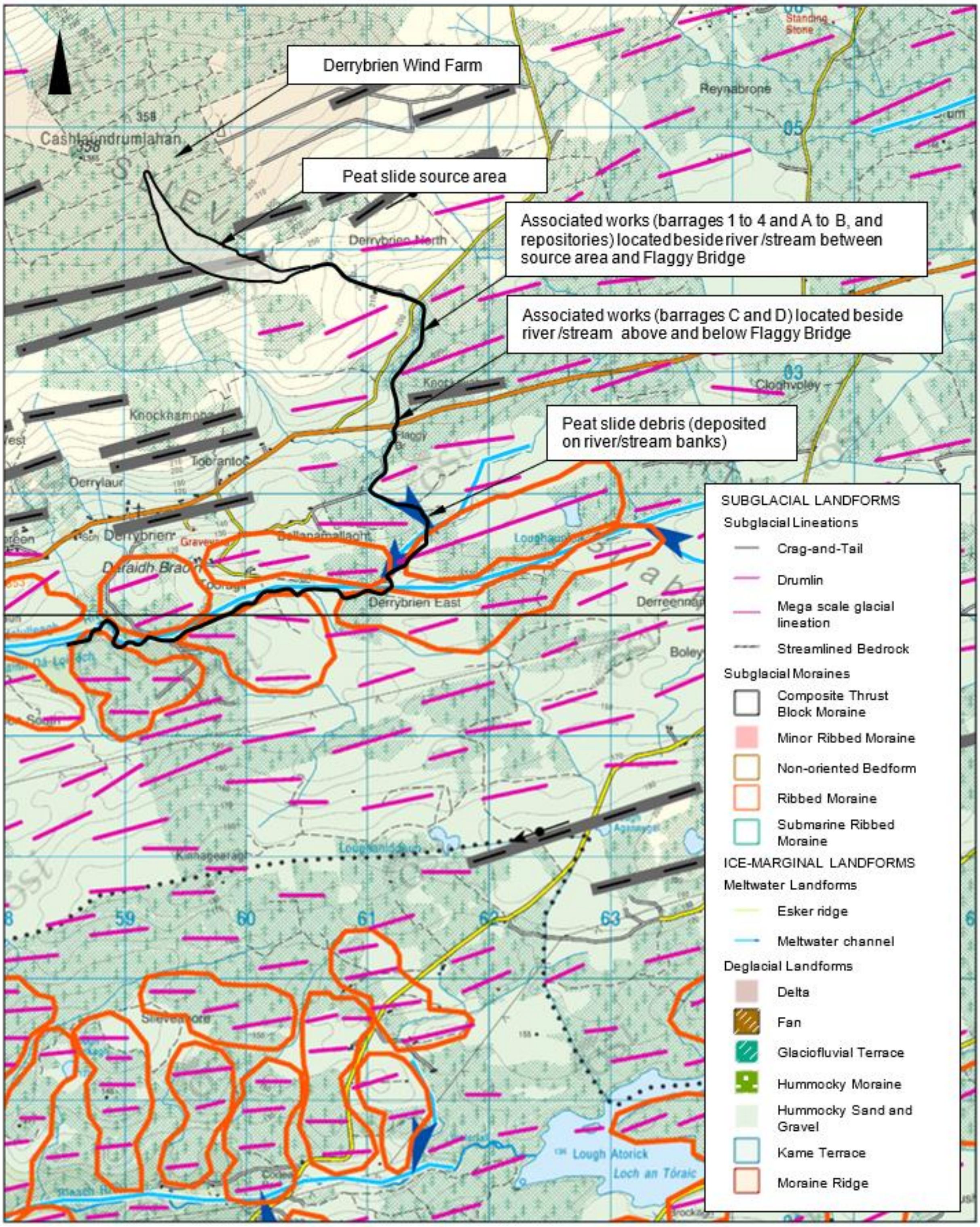


Figure 10-32: Geomorphological map – peat slide and associated works

10.2.3.4 Baseline Sensitivity of the Receiving Environment (Soils, Geology & Land Use) for the Peat Slide and Associated Works

The significance of effects on soils, geology and land on the site has been assessed as a function of the sensitivity of the receiving environment using Figure 10-3. The sensitivity of the receiving environment is classified on a 7-point scale from Negligible to High as a function of the characteristics of the soils, geology and land that are directly impacted by this part of the project.

For this part of the project, the majority of the significant effects on soils, geology and land relate to the blanket bog that covers most of the project site, including the peat slide and associated works, and surrounding area. Therefore, the characteristics of dominantly the blanket bog govern the classification of the sensitivity of the receiving environment for assessing the significance of impacts on soils, geology and land on this project. For site stability impacts, consideration has also been given to the characteristics of the blanket bog outside the project site that could be directly impacted by a peat slide on the project site.

For this project the sensitivity of the receiving soils, geology and land has been classified as **MEDIUM** for the Wind Farm site, see details provided in the previous section 10.2.1.4.

For the assessment of site stability impacts the sensitivity of the receiving soils, geology and land that could be impacted by a peat slide has also been classified as **MEDIUM** for the Wind Farm site based on the scale of the very large peat slide that occurred on the site in October 2003, and by the land that that was directly impacted by the slide, see details provided in the previous section 10.2.1.4.

As the soils, geology and land use for the Peat Slide response works site, and those lands which could be impacted by a peat slide, are predominantly consistent with the Wind Farm site, the sensitivity of the soils geology and land is also assessed as **MEDIUM.**

10.2.4 Baseline Peat Stability Risk Assessment & Likelihood of a Peat Slide Based on Site Conditions in 1998

Baseline peat stability risk assessments have been carried out for the project site that includes the following areas:

- Derrybrien Wind Farm and associated ancillary works;
- Grid connection comprising Derrybrien-Agannygal 110 kV Overhead Line and Agannygal Substation connecting into the Shannonbridge – Ennis 110 kV Overhead Line and associated ancillary works; and
- Works undertaken in response to the peat slide and associated ancillary works

The peat stability assessments have been carried out in accordance with the best practice guidelines given in *"Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Projects, published by the Scottish Government Energy Consent Unit (2nd Edition, April 2017)".* The best practice guidelines identify a number of techniques that can be used to assess peat stability, and a number of these techniques are used in this case to suit the proposed construction works, ground conditions and type of development.

The best practice guidelines give no preferred technique but note that whatever techniques are employed should be clearly explained and incorporate consideration of the likelihood of instability and the consequences should it occur. Details of the techniques employed are included in the following documents contained in Appendix B, C and D of this chapter, respectively, as outlined in the sections below:

- Derrybrien Wind Farm Site – see *"Derrybrien Windfarm - Geotechnical Stability Report & Assessment of Stability Impacts of On-Site Activities",* by AGL Consulting, (2020).
- Peat slide and Work undertaken in response to the peat slide, see "*Geotechnical Stability Report 2"* (FT, 2020)
- Grid connection, see "*Geotechnical Stability Report 3"* (FT, 2020)

Considering that the origin of the peat slide on 16th October 2003 was within the wind farm site, a more detailed description of the peat stability risk assessment carried out at the wind farm site is provided in this chapter.

10.2.4.1 Baseline Peat Stability Risk Assessment – Wind farm Site

A baseline Peat Stability Risk Assessment (PSRA) has been carried out for the wind farm site to characterise the relative risk of peat instability in defined zones across the site in 1998, prior to construction of the wind farm. The purpose of the PSRA is to identify where there are compounding risk factors that lead to a higher risk of peat instability so that appropriate mitigation measures can be implemented to ensure that the risk of peat instability can be reduced to an acceptable level for each site activity. The results of peat stability risk assessment are presented in the report titled

"*Derrybrien Windfarm - Geotechnical Stability Report & Assessment of Stability Impacts of On-Site Activities",* by AGL Consulting in Appendix B of this Chapter. The following is an overview of the methodology.

For this assessment, the wind farm site has been split up into 71 No. representative zones corresponding to sections of the site around the turbines and access tracks on peat. A qualitative **Peat Stability Risk Assessment (PSRA)** has been carried out for each zone to assess the **Risk Rating (R)** for a peat slide based on the interpreted **Likelihood (L)** (i.e. probability) of occurrence and **Impact (I)** of failure.

The PSRA has been carried out in accordance with the current best practice guidelines for peat landslide risk assessments for wind farms on upland blanket bogs (Scottish Government, Energy Consent Unit, 2017). 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 **Likelihood (L)** of a peat slide 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 peat harvesting or slide history to determine where there are conditions that could lead to an elevated risk of a peat slide.

The potential **Impact (I)** of a peat slide 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 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 prior to the implementation of risk mitigation measures 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.

The PSRA presented in the AGL report in Appendix B is an engineering risk assessment where the potential Impact of a peat slide includes factors other than those that are relevant to the environmental impact of the project on the receiving soils, geology and land. Therefore, only the interpreted Likelihood of a peat slide across the wind farm site is introduced here because it is an index of the probability of a peat slide based on the site conditions, which is an input parameter for the environmental assessment of stability impacts presented in this chapter, as shown on the flow chart in Figure 10-2.

Figure 10-34 shows the interpreted **Likelihood (L)** of a peat slide across the site for the baseline conditions on the site in 1998, prior to construction. It should be noted that this is a qualitative assessment that reflects the interpreted probability of a peat slide occurring on the site based on site conditions in 1998 prior to the implementation of appropriate design and construction risk mitigation measures. It identifies areas of the site where there were compounding risk factors that lead to a higher likelihood of peat instability on the site without appropriate controls.

The site conditions vary across each zone. Therefore, the interpreted Likelihood of a peat slide in each zone is generally representative of the worst conditions within the zones. However, greater emphasis is applied to the site conditions along the corridor of the wind farm project, where the majority of the site activities related to the wind farm occurred.

The peat stability risk assessment identifies 38 No. zones across the site where the Likelihood of a peat slide, prior to mitigation measures, is characterised as **Very Possible (L=4) or Likely (L=5)**. These zones are located in areas across the site where there are compounding risk factors in relation to peat stability, including, for example:

- Deposits of deep (3-6 m) and relatively deep (2-3m) weak peat ($c_u \approx 5$ kPa) with low Factor of Safety (FoS) for infinite slope stability analyses;
- Areas of intermediate slope angles of 3-5° in close proximity to a convex break in slope to slope angles >5°;
- Zones that are in the broad valleys directly upslope from the rivers and streams downslope from the perimeter of the wind farm site;
- Zones of deep peat with poor drainage and ponded surface water at the head of a watercourse, or along the edges of the terraces on the north side of the site; and
- Areas adjacent to the previous slide that have similar site characteristics;

The highest Likelihood (L=5) occurs where there are compounding risk factors leading to an elevated likelihood of peat instability i.e.

- at **Turbines T17, T68** and **T21 to T70** in the vicinity of the slide in relatively deep peat on a convex breaking slope directly upslope from the rivers and streams on the south side of the site;
- at **Turbines T49 to T51** where there are deep deposits of peat in close proximity to a distinct convex break in slope to slopes >5.0-7.5° directly upslope from the rivers and streams on the north side of the site; and
- at **Turbines T60 to T62** where there are deep deposits of very soft peat with a high water table and ponded surface water at the head of a watercourse and along the edge of a terraced slope.

In the remaining 33 No. zones across the site the Likelihood of a peat slide, prior to mitigation measures would be characterised as **Possible (L=3)** or **Low (L=2)**, which would require early or regular attention with appropriate mitigation measures to reduce the risk of peat instability or to manage the risk on site. 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 >1.4);
- Zones where there is well-developed drainage, and which are not directly upslope from the rivers and streams outside the wind farm site.

It should be noted that the methodology that was used in this case for the baseline peat stability risk assessment was developed after the peat slide at the site of the Derrybrien Wind Farm, based on research and guidelines published as a result of the slide, as discussed in Section 10.1.2.2. The methodology has also been calibrated by the peat slide at the Derrybrien site, as well as by peat slides that occurred on the site of other wind farm projects on upland blanket bogs in Ireland since 2003. Therefore, while it is consistent with current best practice guidelines and is representative of the conditions on the Derrybrien wind farm site, it represents a level of assessment that far exceeds that which would have been carried out for the site in 1998 or at the time of construction in 2003 when the construction industry's general knowledge of failures on peat slopes was very limited.

Furthermore, although the baseline PSRA identifies that there are areas of the Derrybrien wind farm site that had a high baseline risk of peat instability, prior to implementing appropriate mitigation measures, based on our current experience with managing peat stability under similar conditions it would not be considered an abnormal or exceptional risk for a wind farm project on an upland blanket bog in Ireland. The qualitative risk assessment methodology is simply a tool that is used to identify where appropriate risk mitigation measures need to be implemented to reduce the risk of a peat slide to an acceptable level. Many of the design and construction mitigation measures that were successfully implemented on the Derrybrien site after the slide are now standard measures that are commensurate with the geotechnical risk of a peat slide and are routinely implemented on similar sites on upland blanket bogs across Ireland and the UK. However, they would not have been standard practice at the time of construction on the Derrybrien Wind Farm in 2003.

10.2.4.2 Baseline Peat Stability Risk Assessment – Grid Connection

A baseline peat stability risk assessment has been carried out for the grid connection works to characterise the relative risk of peat instability in defined zones in 1998, prior to construction of the windfarm. The purpose of the peat stability risk assessment is to identify where there are compounding risk factors that lead to a higher risk of peat instability so that appropriate mitigation measures can be implemented to ensure that the risk of peat instability can be reduced to an acceptable level for each site activity.

The results of the peat stability risk assessment are presented in the report included in Appendix C entitled *"Geotechnical Stability Report 3 - Overhead Line and Substation Impact Assessment"* (FT, 2020). The following is an overview of the methodology.

The peat stability risk assessment employed for the grid connection comprises a deterministic approach in combination with a qualitative risk assessment in accordance with best practice guidelines[16]. This approach is a variation to that employed in the windfarm to suit the proposed construction works, ground conditions and type of development.

The deterministic aspects of the approach uses the infinite slope model (Skempton and DeLory, 1957)[17] to combine a number of key factors in order to determine a factor of safety (FoS) 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.

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 FoS is calculated for the undrained (short term) and drained (long term) conditions.

The FoS was calculated at the location of all pole sets and mast locations, and at the Agannygal Substation. The FoS calculated for the grid connection generally shows an adequate FoS (>1.4) 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 of low FoS results (3 no. comprising about 3.5% of OHL route), particularly around areas of relatively steep slope angles, but where there is shallow peat and areas of relatively deep deposits of peat, but where there are shallow slope angles.

The qualitative risk assessment aspect of the approach takes into account factors which cannot necessarily be quantified in the deterministic approach (MacCulloch (2005)[18], such as the presence of mechanically cut peat, previous local failures, vegetation type, slope characteristics and numerous other factors. The qualitative factors used in the risk assessment have been compiled based on experience of assessments and construction in peat land sites and peat slides throughout Ireland and the UK.

The PSRA presented in the FT report in Appendix C is a general risk assessment where the potential Impact of a peat slide includes factors other than those that are relevant to the environmental impact of the project on the receiving soils, geology and land. Therefore, only the interpreted Likelihood of a peat slide across the grid connection site is introduced here because it is an index of the probability of a peat slide based on the site conditions, which is an input parameter for the environmental

[16] Energy Consents Unit Scottish Government. *"Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments"* (Second Edition, April 2017).
[17] Skempton, A. W. and DeLory, F. A. *"Stability of natural slopes in London Clay"*. Proc 4th Int. Conf. on Soil Mechanics and Foundation Engineering, Rotterdam, vol. 2, pp.72-78, 1957.
[18] MacCulloch, F. "*Guidelines for the Risk Management of Peat Slips on the Construction of Low Volume/Low Cost Roads over Peat"*, RoadEx 11 Northern Periphery, 2005

assessment of stability impacts presented in this chapter, as shown on the flow chart in Figure 10-2.

For the purpose of the peat stability risk assessment, the grid connection was divided into 9 no. sections, including the Agannygal Substation. Sections were defined based on having similar topography and peat depth within each individual section. For each section the FoS results were combined with the qualitative factors to determine the peat slide likelihood, see Table 10-3. This represents peat slide likelihood prior to the application of mitigation measures.

The peat slide likelihood results clearly show that for the baseline condition the likelihood of a peat slide ranges from negligible (L=1) to low (L=2), which would be expected along the grid connection route given the relatively shallow nature of the peat and its relatively greater strength compared to the windfarm site.

Table 10-3: Peat Slide Likelihood - Grid Connection

Section	Likelihood
EM1 to PS5	Negligible (L = 1)
PS5 to AM14	Low (L = 2)
AM14 to AM18	Negligible (L = 1)
AM18 to AM24	Negligible (L = 1)
AM24 to PS28A	Low (L = 2)
PS28A to PS34	Negligible (L = 1)
PS34 to AM38	Low (L = 2)
AM38 to EM41	Negligible (L = 1)
Agannygal Substation	Negligible (L = 1)

Notes

(1) PS – pole set, AM – angle mast

(2) See Figure 10-19 for location of sections.

(3) For mitigation measures see Section0

For the grid connection, the sections are classed as Low to Negligible likelihood of a peat slide and would require only at best routine construction practice and mitigation/control measures for working on peat. The proposed mitigation measures are considered routine and would include for example avoiding accessing areas of peat with the greatest slopes with plant, the use of suitable plant and equipment, and adequate monitoring of the works.

Overall, peat stability risk for the grid connection is considered to be acceptable. Where localised areas of elevated risk have been identified the level of risk is reduced by the application of mitigation measures see Section 0.

10.2.4.3 Baseline Stability Risk Assessment – Peat Slide and Associated Works

A stability assessment of the remaining peat debris within the peat slide source area and at locations of associated works was carried out to provide an indication of risk of instability. The results of the peat stability risk assessment are presented in the report included in Appendix D entitled *"Geotechnical Stability Report 2 - Peat Slide and Associated Works"* (FT, 2020). The following is an overview of the methodology.

The stability risk assessment for the peat slide and associated work sites is different from the preceding sections as follows:

(1) **Peat slide source area –** The risk of peat instability in the source area, which is the location of the 2003 peat slide, is included above in the baseline conditions (1998) for peat stability risk assessment for the wind farm site (Section 10.2.1.4). The assessment included below is the stability of the remaining peat in the source area based on current (2020) conditions.

(2) **Peat slide debris** – The peat debris from the source area extended downstream for a distance of about 5.8 km. The peat debris would have had little to no effect on the stability of the existing ground. Typical effects on the existing ground would be limited to localised scouring and erosion of the stream channel, details of which are included in the report in Appendix D.

(3) **Associated works** – A stability risk assessment has been carried out for each of the associated work's sites to characterise the relative risk of general instability in 1998, prior to construction of the windfarm.

10.2.4.3.1 Peat Slide – Source Area

The stability risk assessment employed for the peat slide source area comprises a deterministic approach in accordance with best practice guidelines[19]. This approach is a variation to that employed above to suit the proposed construction works, ground conditions and type of development.

The deterministic approach uses the infinite slope model as above to combine a number of key factors in order to determine a factor of safety (FoS) 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.

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 FoS is calculated for the undrained (short term) and drained (long term) conditions.

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

[19] Energy Consents Unit Scottish Government. *"Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments"* (Second Edition, April 2017).

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 was calculated at about 190 no. individual locations within the source area where in situ measurements were taken. The results of the analysis are summarised in Table 10-4.

Table 10-4: Peat Slide Source Area - Stability FoS

Factor of Safety (FoS)	Short-term (undrained)	Long-term (drained)
	% of Peat Slide Source Area	% of Peat Slide Source Area
Less than 1.0	0.5	0
1.0 to 1.3	0.5	1
1.3 to 1.4	0.5	0
Greater than 1.4	98.5	99

The FoS calculated shows an adequate FoS (>1.4) for both the short and long-term conditions.

For the short-term condition, 99.5% of the source area has a FoS greater than 1.0 and 98.5% has a FoS greater than 1.4. For the long-term condition, which is more representative of the current (2020) condition, 100% of the source area has a FoS greater than 1.0 and 99% has a FoS greater than 1.4. The results are shown graphically in Figure 10-33, which shows that the significant majority of the calculated FoS values are notably high, which would indicate that the source area is stable.

The above results confirm the findings of the periodic inspections of the source area 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 within the source area had essentially drained and was locally desiccated, which would have increased the peat strength and overall stability. In addition, movement monitoring survey points installed within the source area showed negligible movement within this period.

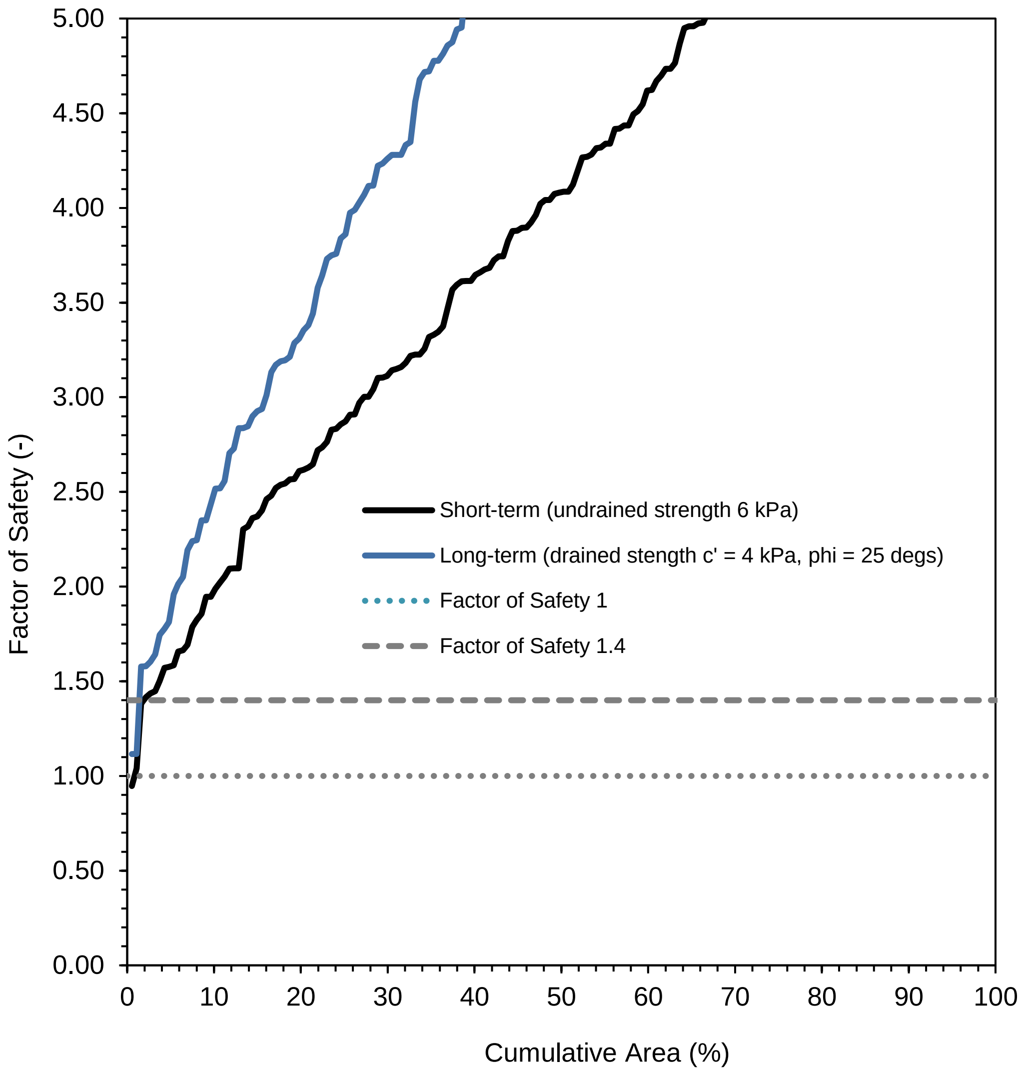


Figure 10-33: Peat slide source area factor of safety for short and long-term conditions

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 source area has a significantly higher undrained shear strength than that used in the analysis.

Areas with a low FoS coincide with steeper slopes, typically from about 8.5 to 14 degrees. These slope angles are not a reflection of the overall topography of the peat slide source area. The slope angles are based on 5 m 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.

10.2.4.3.2 Peat Slide – Debris

As mentioned above, the peat debris would have had little to no effect on the stability of the existing ground. Typical effects on the existing ground would be limited to localised scouring and erosion of the stream channel, details of which are included in the report in Appendix D.

10.2.4.3.3 Associated Works

The associated works which included the measures undertaken in response to the peat slide comprised 8 no. containment barrages (1 to 4 and A to D) and 3 no. repositories. The stability of each of these works was assessed individually.

The purpose of the analysis was to check that there is an adequate safety margin for the works against global stability taking into account loading from debris and possible flood conditions.

The stability of these works is based on ground conditions and loadings recorded from recent inspections and investigation which would also reasonably represent the conditions in 1998. The ground conditions and loadings are unlikely to change notably over the project life cycle and therefore in most cases the stability will remain relatively constant over time. For the repositories and floating roads, the loadings would have caused an increase in strength within any underlying peat with time which would result in an increase in stability with time.

Floating Roads

Inspection of the floating roads shows no signs of instability, this would be expected given the characteristics and relatively shallow peat thickness under the roads.

The access track to the west of barrage 1 was constructed as a floating road on peat with average slope angle along the track of 2 to 3 degrees and peat depth of about 0 to 1.5 m.

The floating road access to barrage 2 has an average slope angle along the road of 3 to 4 degrees with peat depth estimated to be up to about 1.5 m.

Periodic inspections of the floating roads were undertaken by ESB from 2004 to 2019. No significant issues regarding the stability of these floating roads were raised in the periodic inspections. Likewise, no significant issues regarding the stability of the floating roads were raised in the recent (2019) inspection by FT.

Barrages 1 to 4

The stability analysis for the barrages was carried out in accordance with accepted best practice as given in Eurocode 7 (EC7)[20] to determine the safety margin (that is utilisation ratio). For an acceptable safety margin, the utilisation ratio is 1 or greater.

[20] National Standards Authority of Ireland, *"I.S. EN 1997-1:2004+A1:2013 - Eurocode 7: Geotechnical design - Part 1: General rules",* 2013

A summary of the results of the global stability for barrages 1 to 4 are given in Table 10-5. Temporary barrages A to D are no longer present and no calculations have been carried out for these barrages.

The results clearly show that the utilisation ratio is greater than 1, which represents an acceptable margin of safety. This is to be expected as the barrages are constructed of dominantly rock, and in many cases are founded on bedrock or other competent material.

Periodic inspections of the barrages were undertaken by ESB from 2004 to 2019. 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.

Table 10-5: Associated Works – Stability of Barrages 1 to 4

Barrage	Loading Case (note 1, 2)	Utilisation Ratio for Global Stability (note 1, 2)					
		Short-term (undrained)			Long-term (drained)		
		Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
1	1 & 2	4.09	3.20	-	1.67	1.50	-
2	1 & 2	2.69	2.48	-	1.48	1.35	-
3	2 & 3	-	3.58	1.86	-	3.83	2.95
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 had remobilised from the peat slide source area.
Case 2: Retaining silt/sand – applies to all containment barrages. This is a highly unlikely theoretical situation where a build-up of silt or sand to the full height of the barrages would take place.
Case 3: Retaining water under flood conditions – applies to containment barrages 3 and 4 only, which were constructed within sections of incised streams and could experience such high water flow levels.

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

Repositories at Barrage 2 and 3, and Black Road Bridge

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

The deterministic approach uses the infinite slope model as above to determine a factor of safety (FoS) against peat sliding. The results are shown in Table 10-6.

Table 10-6: Associated Works – Stability of Repositories at Barrage 2 and 3, and Black Road Bridge

Repository Area	Founding Stratum (1)	Thickness of Placed Arisings	Factor of Safety (FoS)	
			Short-term (undrained)	Long-term (drained)
Barrage 2	Peat	0.6 to 1.9m	>1.4	>1.4
Barrage 3	Mineral Soil	1 to 1.6m	>1.4	>1.4
Black Road Bridge	Peat	0.7 to 2m(2)	>1.4	>1.4

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. 2m arising thickness assumed in assessment.

The FoS calculated shows an adequate FoS (>1.4) for both the short and long-term conditions.

In addition to the FoS approach, an observational approach was adopted for assessing the 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 observational approach which involved periodic inspections of the repositories from 2004 to 2019 was undertaken by ESB and AGEC. No significant issues regarding the stability of the repositories were raised in the periodic inspections.

10.2.4.4 Changes in the Likelihood of a Peat Slide over the Project Life Cycle.

10.2.4.4.1 Windfarm Site

The impact of site activities with respect to site stability reduces significantly over the project life cycle from the second phase of construction after the peat slide (2004-2006), through the operation and maintenance phases of the project (2006-2020 & 2020-2040), to decommissioning in circa 2040. This is due to changes to the probability of occurrence of a peat slide as a result of:

- Implementation of effective design mitigation measures and alternative construction methods (e.g. alternative methods of spoil management);
- Additional geotechnical investigations, stability analyses, testing, monitoring and geotechnical supervision (e.g. geotechnical assessment and full-scale proof testing of floating roads); and
- Changes to the site characteristics due to improved drainage and an increase in the strength of the peat under sustained dead load surcharges (i.e. the floating roads, peat repositories and material sidecast areas)

The assessment of the impact of site activities on the peat necessarily takes into account the reduction in the likelihood of a peat slide in the medium to long-term. This is because, for activities that result in sustained dead load surcharges on the peat (e.g. construction of the floating roads, peat repositories and material sidecast areas on the intact peat slopes), the highest stability risk is in the short-term condition when the load is initially placed on the slope. The peat increases in strength as it consolidates and compresses under the applied load so that the probability of a peat slide reduces significantly over time. This is a fundamental geotechnical principle, which has been verified by testing on site. It is also consistent with the 2017 EPA Guidelines which includes the probability of occurrence as an input parameter for impact assessments. The significance of the impacts on the receiving soils, geology and land has still been assessed relative to the baseline conditions on the site in 1998, prior to construction, so it does not constitute a change in the baseline condition.

The changes in the Likelihood of a peat slide over the life cycle of the wind farm site are illustrated on Figure 10-34 to Figure 10-36.

- Figure 10-34 shows the baseline conditions on the site in 1998 prior to construction and prior to implementation of effective design and construction mitigation measures;
- Figure 10-35 reflects the reduced likelihood of a peat slide on the site with the mitigated site activities during the second phase of construction (e.g. the alternative methods of spoil management), and with the improved site conditions at the end of construction (e.g. improved drainage, increased strength under the floating roads – verified by full scale proof load testing).
- Figure 10-36 reflects the reduced likelihood of a peat slide on the site for the residual site activities that are anticipated over the remaining operational phase of the wind farm from 2020 onwards, and during decommissioning. It also reflects ongoing improvements in site conditions and performance of the floating roads due the drainage improvements and the increased strength of the peat.

In each case the likelihood of a peat slide is representative of the range of site activities that occurred or are likely to occur over the corresponding period within the project life cycle.

Significantly, at this stage (Q2 2020), with the improvement of site conditions, the likelihood of a peat slide has reduced to **negligible** across the site for the project activities that are likely to be carried out on site over the remaining operation and maintenance life of the project and during decommissioning.

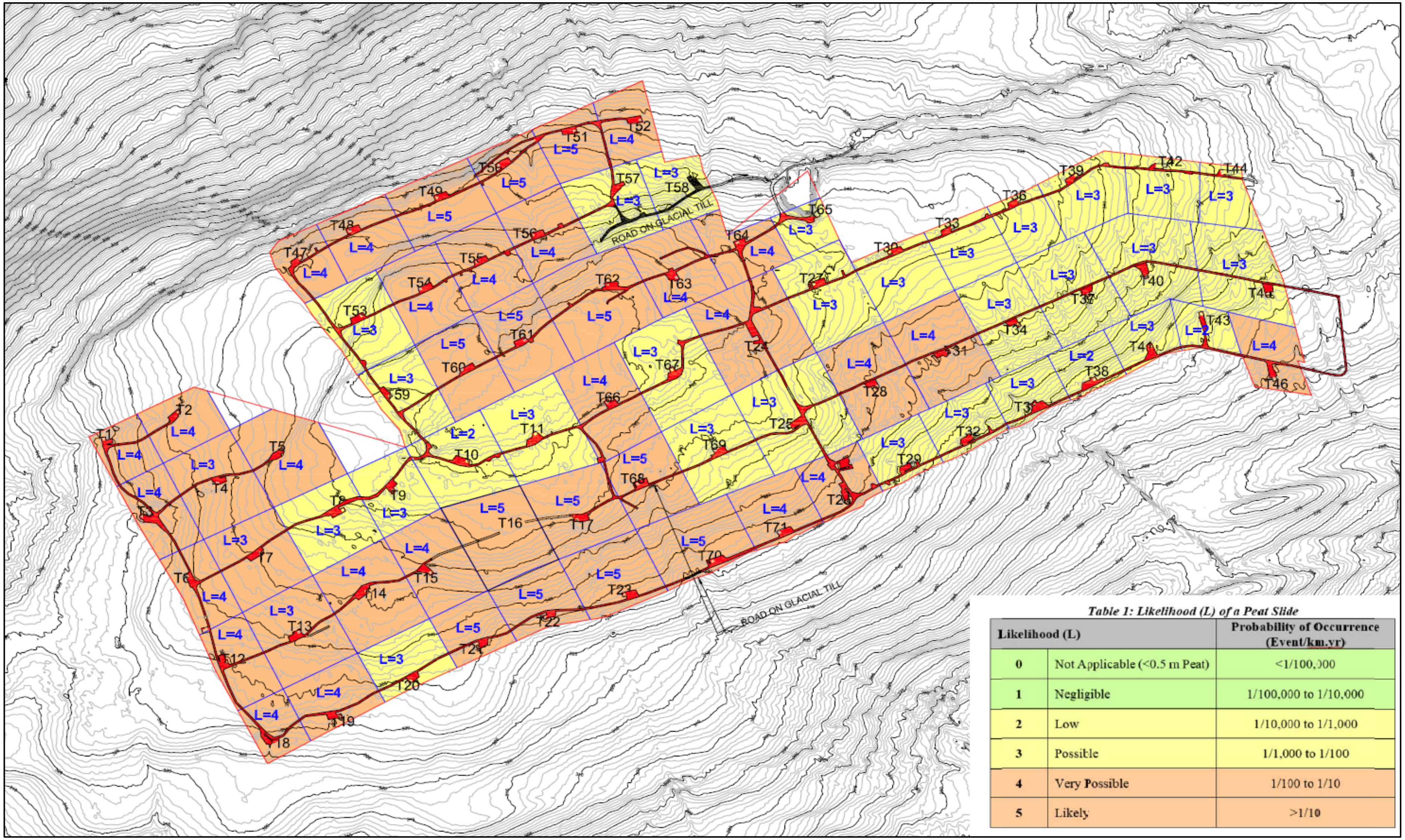
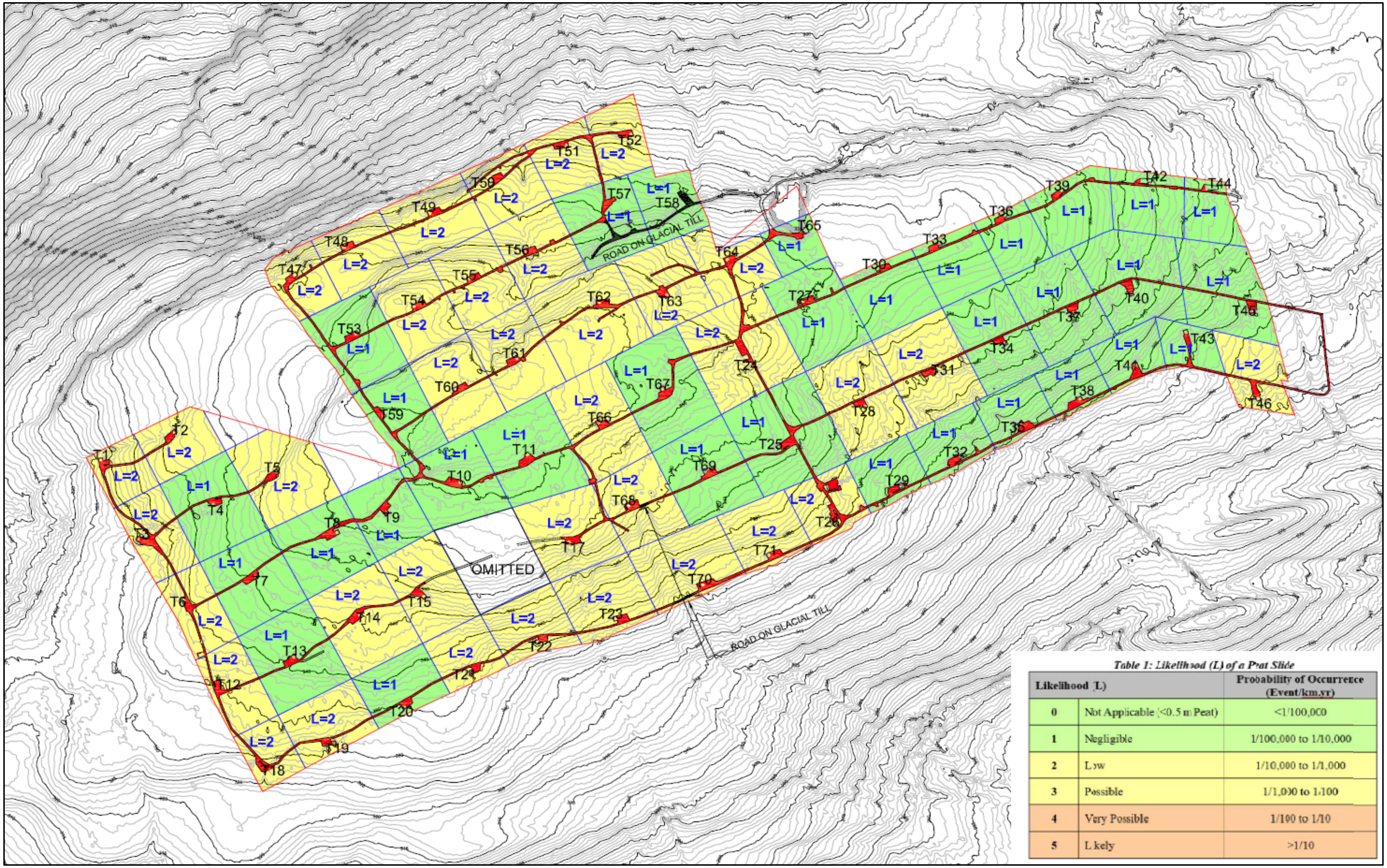


Table 1: Likelihood (L) of a Peat Slide

Likelihood (L)		Probability of Occurrence (Event/km.yr)
0	Not Applicable (<0.5 m Peat)	<1/100,000
1	Negligible	1/100,000 to 1/10,000
2	Low	1/10,000 to 1/1,000
3	Possible	1/1,000 to 1/100
4	Very Possible	1/100 to 1/10
5	Likely	>1/10

Figure 10-34: Likelihood (L) of a peat slide across the wind farm site for Baseline Peat Stability Risk Assessment based on site conditions in 1998



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0	Not Applicable (<0.5 m Peat)	<1/100,000
1	Negligible	1/100,000 to 1/10,000
2	Low	1/10,000 to 1/1,000
3	Possible	1/1,000 to 1/100
4	Very Possible	1/100 to 1/10
5	Likely	>1/10

Figure 10-35: Likelihood (L) of a peat slide for mitigated site activities and improved site conditions at the end of construction in 2006

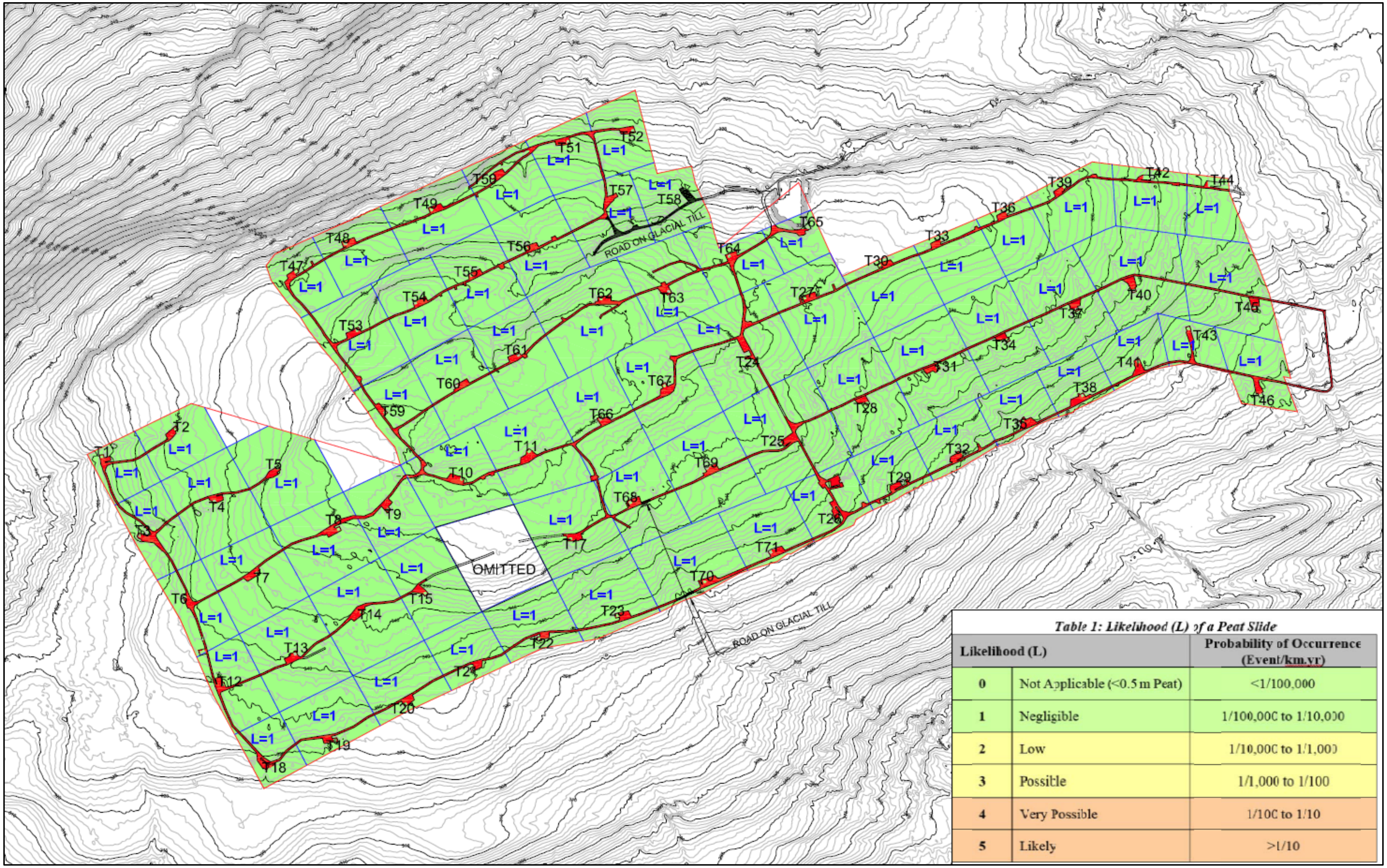


Table 1: Likelihood (L) of a Peat Slide

Likelihood (L)		Probability of Occurrence (Event/km.yr)
0	Not Applicable (<0.5 m Peat)	<1/100,000
1	Negligible	1/100,000 to 1/10,000
2	Low	1/10,000 to 1/1,000
3	Possible	1/1,000 to 1/100
4	Very Possible	1/100 to 1/10
5	Likely	>1/10

Figure 10-36: Likelihood (L) of a peat slide for mitigated site activities and improved site conditions in 2020

10.2.4.4.2 Grid Connection

The impact of site activities associated with the grid connection and site stability reduces significantly over the project life cycle. For the grid connection this is due to changes to the probability of occurrence of a peat slide as a result of primarily the following factors:

(1) Implementation of effective mitigation/control measures during construction
(2) Changes to the site characteristics due to localised improved drainage

Overall, for the baseline condition of 1998 the peat stability risk for the grid connection is considered to be acceptable. Taking into account the above factors the probability of occurrence of a peat slide would reduce over time.

10.2.4.4.3 Peat Slide and Associated Works

The impact of the peat slide and associated works on ground stability reduces significantly over the project life cycle. For the peat slide and associated works this is due to changes to the probability of occurrence of a peat slide as a result of a number of factors that are addressed below for each element of these works.

Peat Slide – Source Area

For the peat slide source area, the reduction in the probability of occurrence of a peat slide over the project life cycle is as a result of primarily the following factors:

(1) Additional geotechnical investigations, stability analyses to identify critical areas
(2) Implementation of effective mitigation/control measures to contain debris (i.e. barrage 1 and 2, reconstruction of windfarm roads across source area)
(3) Changes to the site characteristics due to natural drainage of the source area
(4) Re-vegetation of peat within source area.

An estimate of the reduction in likelihood of occurrence of a peat slide within the source area is provided in Figure 10-37. The likelihood is given in terms of FoS, where an FoS of 1.0 or greater indicates stability, and FoS of less than 1 indicates instability. The FoS has been calculated based on the measured gain in peat strength from 2003 to 2019 due to consolidation and drying out of the peat over time.

Overall, from 2003 the probability of occurrence of a peat slide from the source area over the project life cycle is reducing. At the time following the peat slide in 2003 over 10% of the remaining peat in the source area was likely unstable (FoS less than 1); with time the percentage of the source area containing unstable peat has reduced to the present (2020) to less than about 1%.

The further reduction in the probability of occurrence of a peat slide from the source area will continue over the project life cycle.

The low FoS's are localised within the source area and 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. The low FoS's are associated with locally steeper slope inclinations 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.

The distribution of calculated FoS for the source area are shown in Figure 10-38 and Figure 10-39 for 2020 and 2040 (postulated) respectively.

The above results reflect the actual reduction of peat debris leaving the source area over time, as recorded by say the reduced need for debris removal from behind barrage 2. The results are also confirmed by the findings of the periodic inspections of the source area carried out by ESB, AGEC and FT up to the recent 2019 inspection, which showed that the debris within the source area had essentially drained and was locally desiccated, which would have increased the peat strength and overall stability.

Peat Slide – Debris

As mentioned above, the peat debris would have had little to no effect on the stability of the existing ground. Typical effects on the existing ground would be limited to localised scouring and erosion of the stream channel immediately following the peat slide. Over time the peat debris would have been eroded or degraded from the area of the stream. Taking into account, the probability of occurrence of a peat slide as a consequence of the peat slide debris would have been essentially negligible to minimal in 2003 which would have further reduced over time.

Overall, from the probability of occurrence of a peat slide over the project life cycle is negligible.

Associated Works – Barrages 1 to 4

The impact of the associated works of barrages 1 to 4 and floating access tracks at barrage 1 and barrage 2 on the stability of the existing ground was minimal over the project life cycle is as a result of primarily the following factors:

(1) Baseline (1998) conditions show an acceptable margin of safety.
(2) Barrages are constructed of dominantly rock, and in many cases are founded on bedrock or other competent material.
(3) Additional geotechnical investigations, stability analyses to identify critical areas
(4) Increase in the strength of the peat under sustained dead load form the floating roads at barrage 1 and 2.

Overall, from 2003 the probability of occurrence of a peat slide over the project life cycle is minimal.

Associated Works – Peat Repositories

The impact of site activities associated with the 3 no. peat repositories on stability of the existing ground reduces over the project life cycle. For the 3 no. peat repositories this is due to changes to the probability of occurrence of a peat slide as a result of primarily the following factors:

(1) Additional geotechnical investigations, stability analyses to identify critical areas (i.e. periodic inspections)
(2) Implementation of effective mitigation/control measures (i.e. bunds around some of the repositories)
(3) Changes to the site characteristics due to improved drainage
(4) Increase in the strength of the peat under sustained dead load surcharges under peat repositories

Taking into account the above factors the probability of occurrence of a peat slide would further reduce over the project life cycle.

Overall, for the baseline condition of 1998 the peat stability risk for the 3 no. peat repositories is considered to be acceptable and the peat stability risk would further further reduce over the project life cycle.

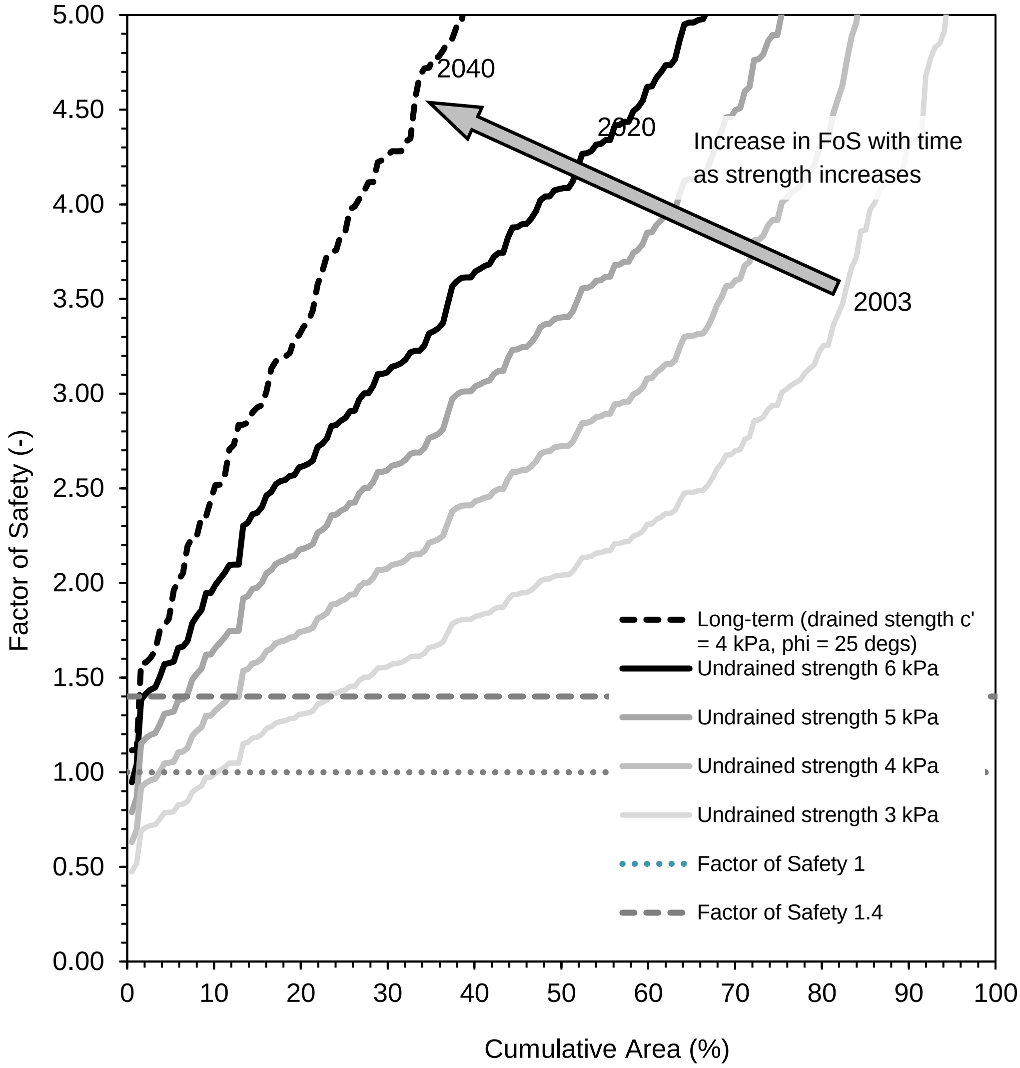


Figure 10-37: Likelihood (in terms of FoS) of a peat slide in source area with improved site conditions from 2003 to 2040 (decommissioning)

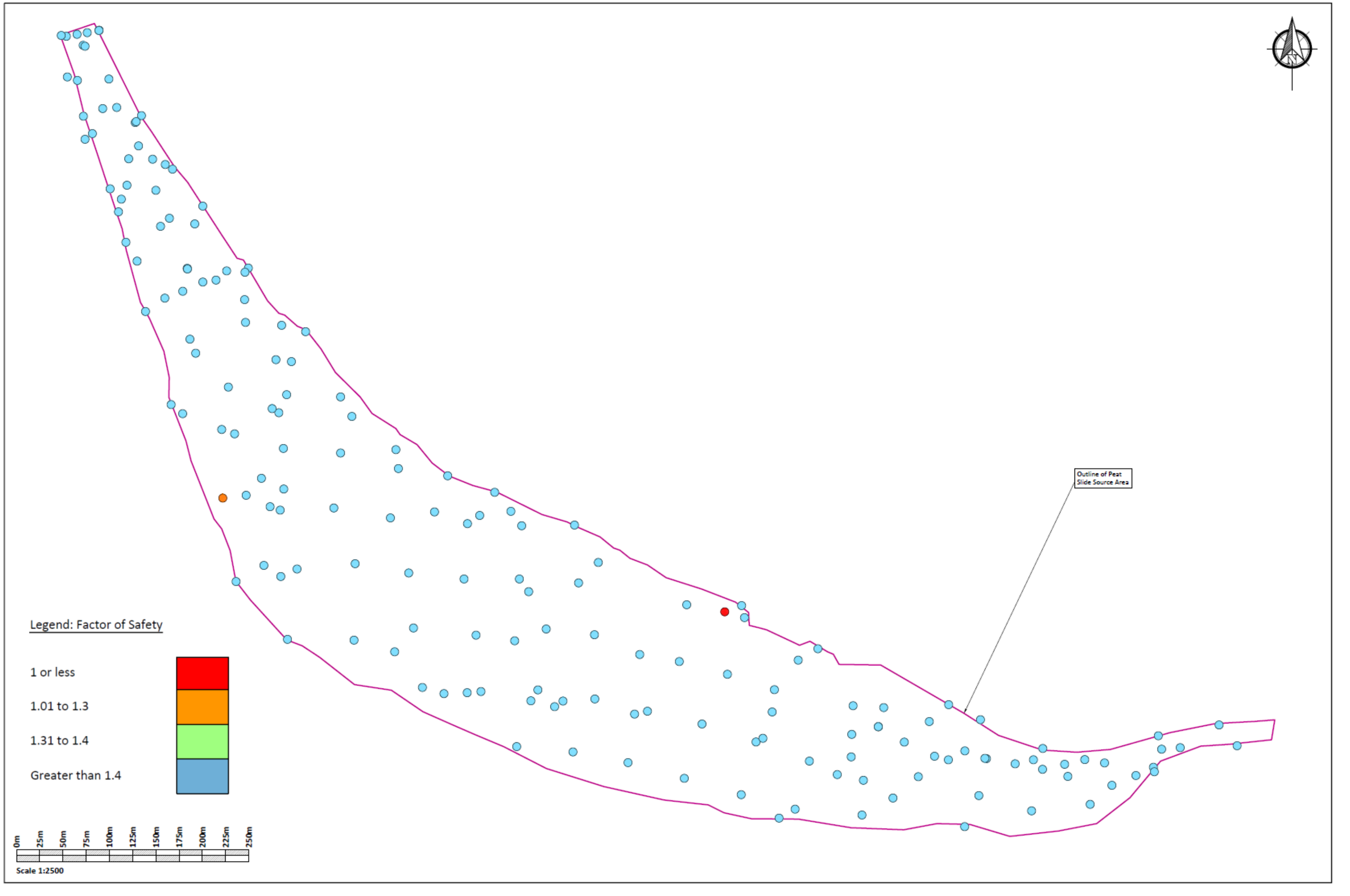


Figure 10-38: Likelihood (in terms of FoS) of a peat slide source area in 2020

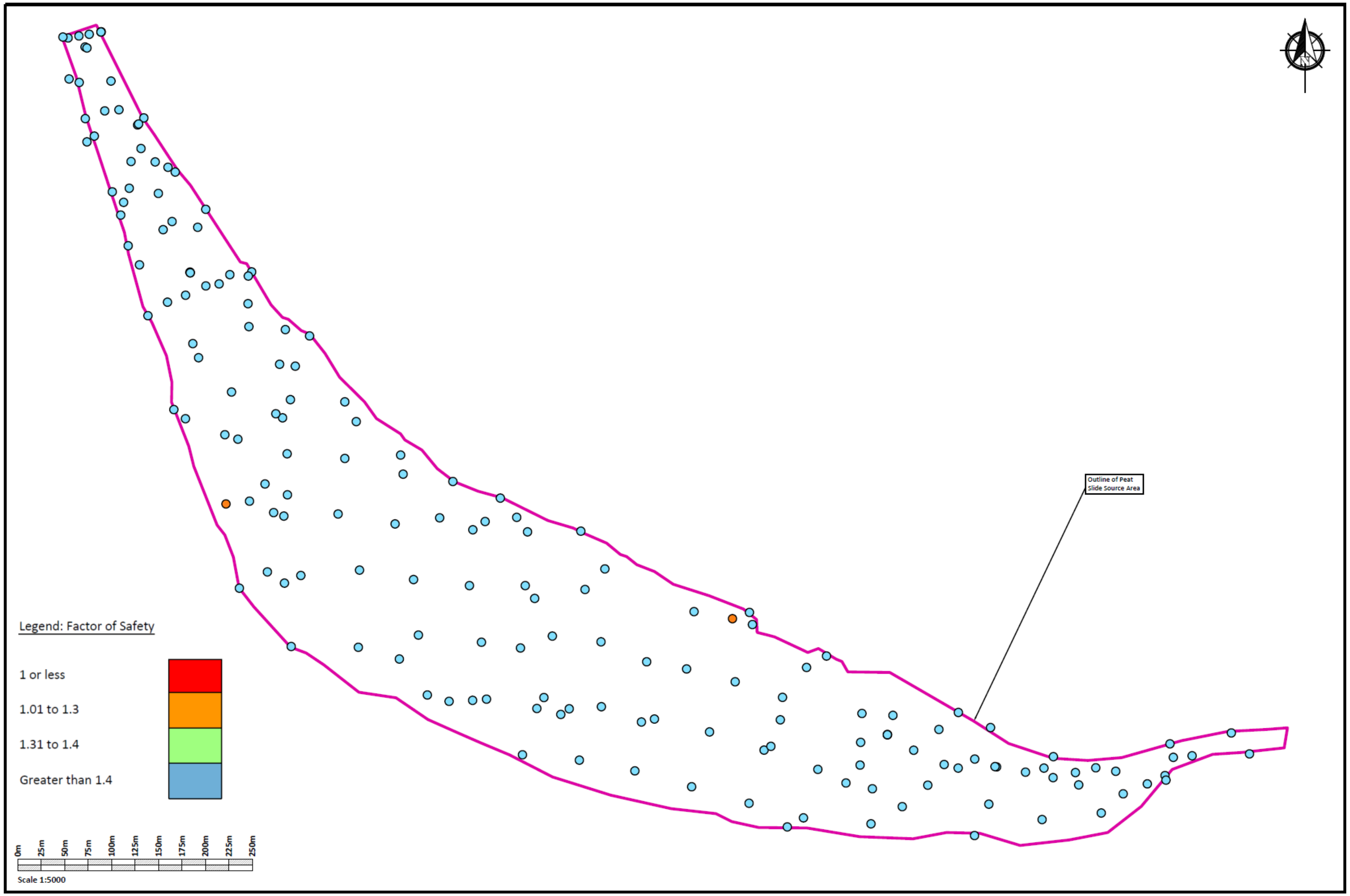


Figure 10-39: Likelihood (in terms of FoS) of a peat slide source area with improved site conditions 2040 (decommissioning)

10.3 Impact of the Project

10.3.1 Introduction

This section of the Chapter presents the assessment of impacts of the project on soils, geology and land. The impact assessment has been split up into the following parts of the project:

- the Derrybrien Wind Farm (Section 10.3.2);
- the Grid connection comprising the Derrybrien-Agannygal 110 kV Overhead Line and Agannygal Substation connecting into the Shannonbridge – Ennis 110 kV Overhead Line and associated ancillary works (Section 10.3.3); and
- the Works undertaken in response to the peat slide and associated ancillary works (Section 10.3.4), including an assessment of the impact of the peat slide that occurred at the site in October 2003.

For each part, impacts have been assessed over the full project life cycle under three categories:

- Impacts that ***have occurred*** (i.e. impacts which occurred at some time during construction or during the operation and maintenance phase of the project up to the end of 2020);
- Impacts that ***are occurring*** (i.e. impacts which initiated at some time during construction or during the operation and maintenance phase of the project up to the end of 2020 and have not yet concluded); and
- Impacts that ***are likely to occur*** over the remaining operational life of the project or during decommissioning.

Within each of these categories the direct impacts, the stability impacts and the secondary impacts, where relevant, are assessed, and the corresponding effects on the receiving soils, geology and land are presented in order of decreasing significance.

Where appropriate, impacts of site activities have been assessed in-combination to determine the significance of the effects (for example to assess the impact of the total volume of peat excavated from all of the turbine foundations; or to assess the combined effect of dead and live load surcharges on the intact peat slopes along the floating roads).

10.3.2 Derrybrien Wind Farm Site Impact Assessment

10.3.2.1 Impacts Which Have Occurred

10.3.2.1.1 Construction Phase (2003 -2006)

This section of the report assesses the impact of wind farm site works during the construction stage of the wind farm project between June 2003 and March 2006.

Section 10.3.2.1.1.1 gives a summary of the construction stage site activities that had an impact on soils, geology and land. The **direct impacts** of these activities are assessed in Section 10.3.2.1.1.2.

The **stability impacts** are addressed in Section 10.3.2.1.1.3, i.e. the direct impacts of site activities that had an effect on site stability, potentially causing a peat failure.

10.3.2.1.1.1 Site Activities – Construction Stage

The primary works that were carried out on the wind farm site during this period that had an impact on soils, geology and land included the following:

- Tree felling;
- Construction of the site compound;
- Construction of the wind farm access tracks;
- Excavation and construction of the turbine foundations;
- Excavation and construction of the crane hardstanding areas;
- Deposition and storage of surplus excavated materials on site;
- Excavation and processing of glacial till and bedrock from the borrow pits;
- Assembly and erection of the wind turbines;
- Drainage improvements;
- Excavation of cable trenches and installation of electrical cables and ducts;
- Construction of the substation and control building;
- Construction of the on-site twin poleset for the overhead 110 kV line; and
- Construction and assembly of the anemometer masts.

Chapter 2 and the AGL Report No. 11-147B-R04 – "*Geotechnical Stability Report & Assessment of Site Stability Impacts on Soils, Geology and Land*" in Appendix B of this Chapter give a detailed summary of the construction activities associated with each of these works. The following is an assessment of the impact of these activities on soils, geology and land during the construction phase of the project between 2003 and 2006.

10.3.2.1.1.2 Direct Impacts of Site Activities – Construction Stage (2003-2006)

A number of the works that were carried out during the construction stage of the project involved similar site activities. Therefore, the direct impacts of the construction stage activities can be combined and assessed under the following headings:

- Removing forestry – tree felling;
- Construction and material deposition on the intact peat slopes;
- Excavation and disposal of peat;
- Excavation and disposal of glacial subsoil and bedrock; and
- Improved drainage

As discussed in Section 10.2.1.4, the baseline sensitivity of the receiving soils, geology and land impacted by the works has been assessed as **Medium** on the basis of the relatively low overall ecological value of the blanket bog in combination with its value for carbon sequestration, forestry, peat harvesting (turbary plots) and agricultural land use in the context of the overall wind farm project.

The following sections give a summary of the assessment of the direct impacts of the site activities and the significance of the corresponding primary effects on the receiving soils, geology and land. The effects are presented in order of decreasing significance.

10.3.2.1.1.2.1 Significant and Moderately Significant Effects

The direct impact of site activities for the wind farm that had a **Moderately Significant** effect on soils, geology and land during construction was:

- Excavation and disposal of peat

The peat slide that occurred on the site in October 2003 had a similar effect on the peat that was displaced within the slide area. The direct impact of the peat slide on the peat is assessed in Section 10.3.4.1.1.2. When the impact on the displaced peat is assessed in combination with the excavation and disposal of peat for the wind farm the combined effect on the peat is **Significant**, as discussed here.

Excavation and Disposal of Peat:

The main on-site activities that involved excavation and disposal of peat included construction of the 70 No. turbine foundations and adjacent crane hardstanding areas; opening up the borrow pits; and constructing the hardstanding areas and structure foundations for the site compound, substation and anemometer masts.

All of these activities were carried out on the blanket bog in peat depths generally ranging from 1.0-4.0 m, but locally up to 4-5 m. In the hardstanding areas all of the peat was excavated out and the excavation was backfilled with crushed rock granular fill supported on the underlying glacial till. The excavations for the turbine foundations were taken down to competent rock below the till. The foundations for the anemometer masts and substation control building were supported on the glacial till.

At the borrow pits the peat was initially stripped off the sites to access the underlying glacial till and bedrock, as required.

Table 10-7 gives a summary of the extent of blanket bog impacted by the peat excavations for each activity along with the corresponding volume of peat that was excavated. The total volume of excavated peat was approximately 185,000 m^3. This was extracted from an area of 10.1 ha. The majority of the peat was excavated from the site of the turbines, crane hardstandings and borrow pits.

Table 10-7: Extent of site impacted by peat excavation and estimated volume of peat excavated

Construction Activity	Area of Site Impacted (ha)	Volume of Peat Excavated (m^3)
70 No. Turbine foundations and crane hardstandings	4.87 ha	135,815 m^3
Borrow Pits	2.43 ha	43,000 m^3
Substation	0.42 ha	5,250 m^3
Anemometers	0.004 ha	125 m^3
Total	**7.72 ha**	**184,190 m^3**

All of the excavated peat was stored on the wind farm site. Prior to the peat slide in 2003 the peat that was excavated from 39 No. turbine foundation excavations that had been completed was sidecast on the peat slopes adjacent to the excavations along with some of the glacial soils that were excavated for the foundations. Peat was also excavated for the site compound and to open up Borrow Pits No. BP-1 to BP-3 during this time.

For the second phase of construction in 2004/2005 all of the peat that was excavated for the construction of the turbines, crane hardstanding areas, substation, and anemometer masts, as well as for the expansion of Borrow Pit No.3, was segregated from the glacial till and disposed of in designated peat repositories on the peat slopes within the wind farm site. In each of these areas the excavated peat was spread out uniformly over the surface of the intact peat to a maximum depth of 1.0 m. Some of the peat that was excavated from the site during the second phase of construction was stored in Borrow Pits BP-2 and BP-3 where it was contained within rockfill bunds.

The effect of the excavation and disposal of the peat on soils, geology and land was the loss of peat habitat and the corresponding carbon loss due to the disturbance of the peat in the short-term, and due to decomposition of the excavated peat stored in the deposition areas in the long-term.

A total of about 7.7 ha of blanket bog was excavated for the wind farm infrastructure, which is only 2.3% of the total site area. The effect that this had on the peat was

Medium to Low because, although the peat was fully excavated out in this area, it was only within a small portion of the site and the degraded habitat in the areas of forestry and turbary plots was of low ecological value.

However, excavating the peat also had an effect on carbon sequestration as the disturbed material spread out over the slopes in the repository areas dried out and had an increased level of exposure to decomposition in an aerobic environment above the water table, which resulted in a release of stored carbon as carbon dioxide.

A total of approximately **185,000 m^3** of peat was excavated from the site for the construction of the wind farm. All of this was stored on site and left in place at the end of construction. As discussed in Section 10.2.1.4, if it is assumed that 100% of this was lost to decomposition and erosion, which is very conservative, then this is equivalent to releasing **32,000 tonnes CO_2** at a rate of 0.2 tonnes/m^3. In terms of Ireland's 2017 national statistics for CO_2 emissions, 32 kt CO_2 is **0.05%** of Ireland's total annual emissions (60,750 kt-CO_2) and **0.15%** of our total annual emissions related to energy (21,265 kt-CO_2). Therefore, when taken into account with the loss of habitat over 7.7 ha, the effect that this had on the peat was **Medium to High** and the Significance of the effect was **Moderate**. This should be considered in context with the overall carbon balance for the wind farm project as it was related to the construction of the site infrastructure.

The disturbance of the peat occurred frequently during active periods of construction of the civil works for the wind farm. However, the effect of carbon loss is a **Long-Term** effect because all of the peat was retained on the wind farm site and the release in carbon occurs over time as the material placed in the repository sites decomposes on exposure. Much of this material is still evident on the site. The excavated peat has settled into the underlying intact peat on the slopes, which has reduced the rate of decomposition of the peat that has settled below the water table. The surface of the excavated peat has also dried out and re-vegetated so that a new state of equilibrium is establishing in the natural rate of decomposition and accumulation of peat in the repository areas.

The peat excavation had a negligible effect on geology. In terms of land use, the peat excavation resulted in a loss of about 7.7 ha of land used for forestry. However, it has provided the necessary infrastructure for the construction and operation of the wind farm, which is a significant positive impact as a more concentrated alternative land use for renewable energy generation.

As discussed in Section 10.3.4.1.1.2, the peat slide that occurred at the wind farm site in October 2003 disturbed about 450,000 m^3 of intact peat over an area of approximately 25ha in blanket bog that was covered in coniferous forest plantations, the majority of which was outside the wind farm site boundary. There is about 200,000m^3 of peat debris still remaining in the slide area. The balance was displaced and flowed downslope from the slide area along the channel for the stream in sub-catchment SC7(b).

When the direct impact of the peat slide on the peat in the slide area is assessed in combination with the peat that was excavated for the wind farm infrastructure:

- The total area of blanket bog disturbed was about **32.7 ha**;
- The total volume of peat excavated or displaced was **635,000 m^3**;
- If it is assumed that 100% of this will be lost to decomposition over time, which is very conservative, then this will release **127kt of CO_2**.
- This is equivalent to **≈0.2%** of Ireland's total annual emissions (60,750 kt-CO_2) and **≈0.6%** of the total annual emissions related to energy (21,265 kt-CO_2).

The combined effect of this on the blanket bog on the site and in the slide area was **High**. Similar to the wind farm site, the blanket bog in the slide area was of low ecological importance as it had been degraded by coniferous forest plantations and drainage. Therefore, the sensitivity of the receiving soils, geology and land in the slide area was **Medium** and the combined effect of the peat excavations on the wind farm site and the disturbance to the peat in the slide was **Significant**.

Some peat was excavated for the foundations of the twin polesets along the 110 kV overhead line for the grid connection, and at the Agannygal Substation. However, these were small volumes that would not give rise to a further significant combined effect on the peat for the Project.

10.3.2.1.1.2.2 Slightly Significant Effects

The direct impacts of site activities that had a **Slightly Significant** effect on soils, geology and land during construction were:

- Removing forestry – tree felling
- Construction and material deposition on the intact peat slopes.
- Rock excavation
- Improved drainage

<u>Removing Forestry – Tree Felling</u>:

Felling the trees on the wind farm site was a project requirement related to the performance of the turbines. The felled trees were not re-planted and the site will not be used for forestry over the design life of the project. This is a restriction on land use. However, this is balanced by the alternative use of the land for renewable energy generation, with positive environmental benefits.

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. Therefore, the effect on carbon storage in the peat was negligible.

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. The overall effect that this work had on the peat habitat was very low, particularly given the low ecological value of the degraded blanket bog in the forested areas.

The duration of the forestry trafficking on the peat was **Temporary** during tree felling. However, the restriction on land use is **Long-term** as it applies over the design life of the project. The **Extent** of the impact was in areas where the trees were felled on the site.

Overall, the effect of felling the trees on the soils, geology and land in the felled areas was **Very Low** and the Significance of the effect was **Slight**.

<u>Construction & Material Deposition on the Intact Peat Slopes</u>:

The on-site activities that involved construction directly on the intact peat surface included:

- Construction of the floating roads;
- Sidecasting of excavated peat and glacial till from the turbine excavations that were completed prior to the peat slide in 2003; and
- Disposal of peat excavated from the turbines, crane hardstanding areas, substation and borrow pits in designated peat repository areas;

This section assesses the direct impact of these activities on soils, geology and land, particularly the intact peat. The issue of peat instability under the applied surcharge loads is addressed separately as a stability impact in Section 10.3.2.1.1.3.

Approximately 14.6 km of new floating roads were constructed across the site for the project. They typically are comprised of 600-1000 mm of crushed rock granular fill reinforced with 1-2 layers of geogrids, as necessary, on a basal layer of timber brash, branches and logs from the site that was placed directly on the intact vegetated surface of the peat. The roads are typically 4.5-5.0 m wide at the surface and up to about 6-7 m wide at the base and cover an area of approximately 8.75 ha (2.6%) on the approximate 340 ha wind farm site.

During the first phase of construction prior to the peat slide in 2003, peat and mineral soil excavated from the foundation excavations that were completed for 38 No. turbines was sidecast and spread out over the intact peat surface adjacent to the excavations at depths typically less than 0.5-1.5 m, but locally up to 2.0-2.5 m at 3 No. turbines (T24, T27 & T40). Where there are records available for the extent of the sidecast material, it was spread out over an area ranging from 215 m^2 and 2,240 m^2, but was generally between 600 m^2 and 1340 m^2, with an average of 1,000 m^2. Therefore, the total extent of the site covered by sidecast material from the turbine excavations is on the order of 38,000 m^2, or 3.8 ha, which is only approximately 1% of the total wind farm site area.

During the second phase of construction in 2004/2005, peat excavated from the site of the remaining turbine foundations as well as from the crane hardstandings, the substation site and the expanded area of Borrow Pit BP-3 was disposed of in designated peat repository areas on the intact peat slopes within the wind farm site. The surveyed location of these repositories is shown on Figure 10-16. There are a total of 32 No. repositories, covering an area of about 114,700 m^2, or 11.47 ha, which is approximately 3.4% of the total site area. In each of these areas excavated peat was spread out over the surface of the intact peat slopes to a maximum depth of 1.0 m.

All of the material that was placed on the peat slopes for the floating roads and material deposition areas covered an area of approximately 24.02 ha, which is 7.2% of the total area of the wind farm site. These materials covered the vegetation that was originally on the intact peat slopes. However, the effect that this had on the peat was **Medium to Low** because the peat was left in place and the degraded habitat in the areas of forestry and turbary plots was of low ecological value.

Placing the materials directly on the slopes had a negligible effect on carbon storage in the underlying peat because the peat was left intact on the slopes and the loss of the existing surface vegetation covered by the deposited materials would have been compensated for by the reduction in the rate of decomposition of the additional volume of peat that was submerged below the water table as it compressed under the applied surcharge loads. The rate of decomposition of peat is dramatically slowed under anaerobic conditions below the water table. Therefore, the

Significance of the effect of the floating roads and material deposition areas on the peat was **Slight**.

The site access tracks and material deposition areas will be left in place after the wind farm is decommissioned. However, the main effect occurred in the **Short-term** during construction. The effect on the underlying glacial soils and bedrock was negligible and not significant.

In terms of land use, the material deposition areas are degraded habitats that would not be suitable for reforestation in the short to medium term. However, they would not restrict future forestry on the site after decommissioning of the wind farm because the disturbed peat and glacial subsoils dry out and re-vegetated over time. Also, the floating roads provide improved access across the site.

Rock Excavation:

The Sandstone bedrock on the site was excavated from the borrow pits and processed into crushed rock granular fill for use in the construction of the site access tracks, and for the hardstanding areas at the turbines, substation, site compound and anemometer masts.

No rock was excavated from Borrow Pit BP-1. A small volume of rock was initially excavated from Borrow Pit BP-2, which was extracted by mechanical excavation without blasting. However, the main source of rockfill on the project was Borrow Pit BP-3, near the site entrance.

Borrow Pit BP-3 covers an area of approximately 1.20ha and it was excavated approximately 11-13 m into the bedrock. Assuming an average depth of rock of 12 m, the total volume of rock that was excavated from the borrow pit was approximately 144,000 m^3. This equates to approximately 180,000 m^3 of granular rockfill in the access tracks and hardstanding areas, assuming a net bulking factor of 1.25 (i.e. the volume change between the intact rock in-situ and the volume of well-graded crushed rock granular fill processed from the rock and placed and compacted on site).

As described in Section 10.2.1.3.3.5, no audited or unaudited geological heritage sites are identified on the wind farm site on the Geological Survey of Ireland Spatial Resources interactive map viewer. Therefore, the environmental sensitivity of the bedrock in the borrow pits was **Very Low**.

The effect of the significant rock excavation on the site geology would be classified as **Medium**. Therefore, the Significance of the effect was **Slight**.

Rock excavation was a **Frequent** activity during active periods of construction for the civil works on the wind farm. On completion of the works Borrow Pit BP-3 was left open and was not backfilled. Therefore, the effect of the rock excavation on the site geology is **Permanent**. Temporary dewatering inside the pit was ceased at the end of construction and the groundwater was allowed to rise back up to its current equilibrium level.

<u>Improved Drainage</u>:

There was an extensive existing network of drains on the site prior to the construction of the wind farm, particularly for the turbary plots on the east side of the site, as shown on Figure 10-16.

During construction of the wind farm, additional drains were constructed in the peat to provide drainage for the turbine foundations, which was a design requirement, and to improve the control of groundwater and surface runoff in areas of poor drainage and high water table, particularly in the coniferous forests where the majority of the additional drains were constructed. The locations of the new drains are also shown on Figure 10-16. These were constructed as shallow open trenches in the peat with piped culverts under the site access tracks.

Control of groundwater on the site has a positive impact on the peat with respect to site stability, which is addressed in Section 10.3.2.1.1.3. In terms of direct impact, the additional drains primarily increased the capacity of the existing drainage network to intercept and drain surface runoff or ponded surface water from poorly drained areas of flat or gently sloping ground on the site. It also provided drainage to groundwater accumulating in the permeable pockets of crushed rock granular fill at the turbines.

As the permeability of the peat is low, the extent of drawdown from the shallow open drains is limited to within a few meters of the drains rather than generally across the site. Nevertheless, the increased rate of surface runoff from the site reduces the rate of surface water infiltration into the peat, and this would have had a negative impact on the ecology of the blanket bog by draining areas of ponded surface water and gradually lowering the water level in the upper acrotelm layers.

The improved drainage would also have had a negative impact on the peat with respect to carbon storage in areas where the groundwater table was lowered i.e. the rate of decomposition of peat is greater in aerobic conditions above the water table, which releases stored carbon as CO_2. As the existing habitat was of low ecological value and was already degraded by drainage for the forestry and turbary plots, the effect that the improved drainage had on the peat was **Low** and the **Significance** of the effect was **Slight**. The effect on the peat would be **Long-Term.**

The impacts of the project on hydrology and hydrogeology are assessed further in Chapter 11.

10.3.2.1.1.2.3 Effects that were Not Significant

The direct impact of site activities that did not have a significant effect on soils, geology and land during construction was:

- Excavation of glacial subsoil

Excavation of Glacial Subsoil:

The volume of excavation of the glacial till on the site was relatively low. All of the crane hardstanding areas adjacent to the turbines were supported on competent cohesive glacial till below the peat with only minor excavation of soft till at the interface. At the site compound and substation site, some minor cut and fill was carried out in the glacial till across the site to create a level platform prior to capping with the crushed rockfill. Glacial till was also excavated to access the shallow bedrock in Borrow Pits BP-2 and BP-3, and to source suitable material to backfill over the turbine foundations in Borrow Pit BP-1.

The majority of the glacial till was excavated from the turbine foundations and from Borrow Pit BP-3 near the site entrance. Based on the rotary coreholes and construction records, the total volume of cohesive glacial till that was excavated for the 70 No. foundations that were constructed on the site was in the order of about 26,500 m^3, which is relatively low. Assuming an average 1.0 m depth of glacial till over the footprint of the borrow pit, the total volume of glacial till excavated from the 1.2 ha site could have been in the order of 12,000 m^3.

In comparison to the peat, the environmental sensitivity of the glacial subsoil was **Very Low**. Therefore, the effect of the excavations on the glacial soils on the site would be classified as **Low** and **Not Significant**.

10.3.2.1.1.3 Stability Impacts (Construction Stage 2003-2006)

This section of the chapter presents the assessment of stability impacts for the construction stage of the wind farm project, i.e. the direct impacts of site activities on the receiving soils, geology and land that had an effect on site stability.

AGL Report No.11-147-R04 – "*Derrybrien Windfarm - Geotechnical Stability Report & Assessment of Stability Impacts of On-Site Activities*" in Appendix B of this Chapter gives a detailed assessment of the characteristics of site activities during construction and the corresponding impacts on soils, geology and land that had an effect on site stability, particularly in relation to the peat. The results are summarised in Table 10-8.

For each activity, Table 10-8 states the nature of the corresponding stability impact on soils, geology and land – typically a dead or live load surcharge on the intact peat slopes - as well as the extent, duration and frequency of that impact.

As described in Section 10.1.5, the corresponding effect on soils, geology and land is a function of the characteristics of the site activity, the quality of the effect with respect to site stability, the probability of a peat failure occurring, and the possible nature and extent of a peat failure. For example, surcharge loads on the intact peat slopes increase shear stresses in the underlying peat that increase the risk of a peat slide, which is a negative impact on the peat with respect to site stability.

The probability of a peat failure has been assessed for each site activity based on the physical characteristics of the site (e.g. the topography, peat depth, strength and groundwater conditions), as well as the characteristics of the corresponding stability impact (e.g. the magnitude, extent, duration and frequency of loading). This is consistent with the EPA Guidelines (2017) as well as current best practice guidelines for peat stability risk assessments (Scottish Government, Energy Consent Unit, 2017).

Where peat failures did not occur the **Significance** of the **Effect** on Table 10-8 reflects the probability of a peat failure occurring due to the effect of the stability impact on the peat (e.g. due to the increased shear stresses under applied surcharge loads), as well as the sensitivity of the soils, geology and land potentially impacted by a peat slide, which has been calibrated by the peat failures that occurred during construction and assessed as **Medium**, as discussed in Section 10.2.1.4.

Table 10-8 identifies where peat failures actually occurred during construction as well as the nature and extent of the failures. In those cases, the effect of the stability impact on Table 10-8 and the significance of that effect are also consistent with the effect of the direct impact of the peat failure on the receiving soils, geology and land.

Many of the site activities during construction had similar effects on the stability of the peat slopes. Therefore, in the following summary, stability impacts have been combined by the characteristics of the impact and the significance of the corresponding effect on soils, geology and land (i.e. to group similar impacts with similar effects). The effects are presented in order of decreasing significance.

Table 10-8: Assessment of Stability Impacts – Construction Stage 2003 to 2006

Activity	Characteristics of Direct Impact of Site Activities with respect to Site Stability (Stability Impacts)				Assessment of Effect of Stability Impacts on Soils, Geology & Land						Did Peat Failure Occur? (Yes/No)
	Impact	Extent of Impact	Duration	Frequency	Quality of Impact	Possible Extent of a Peat Failure	Probability of Occurrence of a Peat Failure	Effect on Receiving Soils, Geology & Land	Sensitivity of Receiving Soils, Geology & Land	Significance of Effect	
Tree Felling	Loading from the tree felling equipment on the peat slopes	Across site, except turbary plots	Temporary	Frequently	Negative	Small (100m^2-2500m^2) to Very Large (>10Ha) Peat Slide	Very Low to Low	**Medium to Low**	**Medium**	**Slight**	**No**
	Loading of the stockpiled logs on the peat slopes in localised areas along the floating roads.	Localised areas along floating roads	Temporary	Frequently	Negative	Small (100m^2-2500m^2) to Very Large (>10Ha) Peat Slide	Very Low to Low	**Medium to Low**	**Medium**	**Slight**	**No**
	Unloading of the peat slopes with the removal of the felled trees	Across site, except turbary plots	Permanent	Sustained	Positive	Not Applicable - Reduced risk of a peat slide due to unloading of peat slopes where trees were felled	Positive Impact - Reduced Probability of a Peat Slide	**Very Low (Positive)**	**Medium**	**Slight (Positive)**	**No**
Site Compound	Loading on peat slopes due to disposal of excavated peat & possibly glacial till (Prior to Peat Slide)	On-Site	Permanent	Sustained	Negative	Small (100m^2-2500m^2) to Very Large (>10Ha) Peat Slide	Possible to Very Possible	**High**	**Medium**	**Significant**	**No**
	Loading from engineered fill materials to form a level platform and hardstanding area	At site compound	Permanent	Sustained	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**	**No**
	Loading on hardstanding area from temporary structures	At site compound	Short-term	Occasional	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**	**No**
	Construction traffic loading on hardstanding area	At site compound	Short-term	Frequently	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**	**No**
Site Access: Floating Roads	Live loading on the peat from wide-track excavator placing small trees as basal reinforcement.	Along the floating roads	Temporary	Frequently	Negative	Small (100m^2-2500m^2) to Very Large (>10Ha) Peat Slide	Very Low to Low	**Medium to Low**	**Medium**	**Slight**	**No**
	Dead load surcharge on the peat from 5.0 m wide strip of rockfill used to construct roads	Along the floating roads	Permanent	Sustained	Negative	Small (100m^2-2500m^2) to Very Large (>10Ha) Peat Slide	Possible to Very Possible	**High**	**Medium**	**Significant**	**No**
	Live load surcharge from construction traffic on floating roads - prior to peat slide in October 2003	Along the floating roads	Short-term	Frequently	Negative	Small (100m^2-2500m^2) to Very Large (>10Ha) Peat Slide	Possible to Very Possible	**High**	**Medium**	**Significant**	**No**
	Live load surcharge from construction traffic on completed floating roads - 2nd Phase of Construction - After Testing	Along the floating roads	Short-term	Frequently	Negative	Small (100m^2-2500m^2) to Very Large (>10Ha) Peat Slide	Low to Possible	**Medium**	**Medium**	**Moderate**	**No**
Site Access: Access Tracks on Glacial Subsoil	Additional dead load from layer of rockfill used to upgrade existing access tracks	Along existing access tracks on glacial subsoil	Permanent	Sustained	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**	**No**
	Construction traffic loading on upgraded access tracks	Along upgraded access tracks on glacial subsoil	Temporary	Frequently	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**	**No**

Table 10-8 (Contd.): Assessment of Stability Impacts – Construction Stage 2003 to 2006

Activity	Characteristics of Direct Impact of Site Activities with respect to Site Stability (Stability Impacts)				Assessment of Effect of Stability Impacts on Soils, Geology & Land						Did Peat Failure Occur? (Yes/No)
	Impact	Extent of Impact	Duration	Frequency	Quality of Impact	Possible Extent of a Peat Failure	Probability of Occurrence of a Peat Failure	Effect on Receiving Soils, Geology & Land	Sensitivity of Receiving Soils, Geology & Land	Significance of Effect	
Site Access: Access tracks across slide area at Turbines T68 and T70	Rockfill loading on the glacial subsoil	Along reconstructed access tracks at T68 and T70	Permanent	Sustained	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**	**No**
	Construction traffic loading on upgraded access tracks	Along reconstructed access tracks at T68 and T70	Temporary	Frequently	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**	**No**
	Containment of disturbed peat upslope from the access tracks	Slide area directly upslope from reconstructed access tracks at T68 and T70	Permanent	Sustained	Positive	Not Applicable - Disturbed peat in slide area upslope from access track contained by rockfill berms	Positive Impact - Reduced Probability of a Peat Slide	**Medium (Positive)**	**Medium**	**Moderate (Positive)**	**No**
Construction of Turbine Foundations	Temporary stability of peat slopes around perimeter of excavation due to excavation of peat and mineral soil to rockhead	At turbine foundations	Temporary	Once at each turbine	Negative	Localised (<10m^2) to Very Small (10m^2-100m^2) Peat Slide [Upslope from excavation]	Possible to Very Possible	**Medium to Low**	**Medium**	**Slight**	**Yes** [**T52** - V.Small Shear Failure Upslope from Excavation, **T66** - Tension Cracks over V. Small Area Upslope]
	Excavation backfilling and construction of RC Foundation – loading from structural fill, steel and concrete	At turbine foundations	Temporary	Once at each turbine	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**	**No**
	Construction traffic loading on floating roads	At turbine foundations and along floating roads	Short-term	Frequently	Negative	Small (100m^2-2500m^2) to Very Large (>10Ha) Peat Slide	Low to Possible	**Medium**	**Medium**	**Moderate**	**No**
Crane Hardstanding Areas	Temporary stability of peat due to excavation to suitable formation on glacial subsoil	At each turbine	Temporary	Once at each turbine	Negative	Localised (<10m^2) to Very Small (10m^2-100m^2) Peat Slide [Upslope from excavation]	Very Low to Low	**Low**	**Medium**	**Slight**	**No**
	Excavation backfilling and construction of crane hardstanding – loading from crushed rock granular fill on glacial subsoil	At turbine foundations	Permanent	Sustained	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**	**No**
	Construction traffic loading on crane hardstanding	At turbine foundations	Temporary	Frequently	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**	**No**
	Construction traffic loading on floating roads.	At each turbine and along floating roads	Short-term	Frequently	Negative	Small (100m2-2500m2) to Very Large (>10Ha) Peat Slide	Low to Possible	**Medium**	**Medium**	**Moderate**	**No**
Spoil Management: Prior to Peat Slide on 16th October, 2003	Shear Failure due to sidecasting of excavated peat and glacial till	At 43 No. turbines - 39 No. completed, 2 No. in progress (T62 & T68), 2 No. partially completed (T6 & T31) prior to slide.	Permanent	Sustained	Negative	Small (100m2-2500m2) to Very Large (>10Ha) Peat Slide	Very Possible to Likely	**High**	**Medium**	**Significant**	**Yes** [**T68** - Very Large (25Ha); **T17** - Small (1,800m^2); **T23,T29 & T66**-Local Bearing Failure]
	Disposal of surplus excavated glacial subsoil in borrow pits	At Borrow Pits #1 & #2	Permanent	Sustained	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**	**No**

Table 10-8 (Contd.): Assessment of Stability Impacts – Construction Stage 2003 to 2006

Activity	Characteristics of Direct Impact of Site Activities with respect to Site Stability (Stability Impacts)				Assessment of Effect of Stability Impacts on Soils, Geology & Land						Did Peat Failure Occur? (Yes/No)
	Impact	Extent of Impact	Duration	Frequency	Quality of Impact	Possible Extent of a Peat Failure	Probability of Occurrence of a Peat Failure	Effect on Receiving Soils, Geology & Land	Sensitivity of Receiving Soils, Geology & Land	Significance of Effect	
Spoil Management: Post Peat Slide	Medium Term Impact of sidecasting of excavated peat and possibly glacial subsoil	At 36 No. of turbines completed prior to slide [i.e. arisings partially/fully removed at T18, T23, T29, T34, T66; Slides at T17 & T68]	Permanent	Sustained	Negative	Small (100m2-2500m2) to Very Large (>10Ha) Peat Slide	Low to Possible	**Medium**	**Medium**	**Moderate**	**No**
	Dead load surcharge from up to 1.0m of excavated peat in designated peat repository areas on flat peat slopes	At designated peat repository areas	Permanent	Sustained	Negative	Small (100m2-2500m2) to Very Large (>10Ha) Peat Slide	Very Low to Low	**Medium to Low**	**Medium**	**Slight**	**No**
	Disposal of surplus excavated glacial subsoil in borrow pits	At Borrow Pits #1 & #2	Permanent	Sustained	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**	**No**
	Construction traffic loading on floating roads to transport spoil	Along floating roads	Temporary	Frequently	Negative	Small (100m2-2500m2) to Very Large (>10Ha) Peat Slide	Low to Possible	**Medium**	**Medium**	**Moderate**	**No**
Turbine Erection	Construction traffic loading on floating roads to access turbines	Along floating roads	Temporary	Frequently	Negative	Small (100m2-2500m2) to Very Large (>10Ha) Peat Slide	Low to Possible	**Medium**	**Medium**	**Moderate**	**No**
	Mobile crane loading on crane hardstanding areas	At each turbine	Brief	Frequently	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**	**No**
Substation	Loading on peat slopes due to disposal of excavated peat	In designated peat repository areas	Permanent	Sustained	Negative	Small (100m2-2500m2) to Very Large (>10Ha) Peat Slide	Very Low to Low	**Medium to Low**	**Medium**	**Slight**	**No**
	Earthworks to construct hardstanding for substation hardstanding – Loading from Engineered Fill Materials.	At substation	Permanent	Sustained	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**	**No**
	Loading on hardstanding compound from permanent structures	At substation compound	Permanent	Sustained	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**	**No**
	Construction traffic loading on floating roads	Along floating roads	Temporary	Frequently	Negative	Small (100m2-2500m2) to Very Large (>10Ha) Peat Slide	Low to Possible	**Medium**	**Medium**	**Moderate**	**No**
Borrow Pits	Disposal/Sidecasting of excavated peat and Glacial Till from Borrow Pits No.1 and 2 in 2003	In vicinity of borrow pits – no detailed records	Permanent	Sustained	Negative	Small (100m2-2500m2) to Very Large (>10Ha) Peat Slide	Very Possible to Likely	**High**	**Medium**	**Significant**	**No**
	Medium Term Impact of sidecasting of excavated peat and possibly glacial subsoil (2nd Phase of Construction - 2004/2005)	In vicinity of borrow pits – no detailed records	Permanent	Sustained	Negative	Small (100m2-2500m2) to Very Large (>10Ha) Peat Slide	Low to Possible	**Medium**	**Medium**	**Moderate**	**No**

Table 10-8 (Contd.): Assessment of Stability Impacts – Construction Stage 2003 to 2006

Activity	Characteristics of Direct Impact of Site Activities with respect to Site Stability (Stability Impacts)				Assessment of Effect of Stability Impacts on Soils, Geology & Land						Did Peat Failure Occur? (Yes/No)
	Impact	Extent of Impact	Duration	Frequency	Quality of Impact	Possible Extent of a Peat Failure	Probability of Occurrence of a Peat Failure	Effect on Receiving Soils, Geology & Land	Sensitivity of Receiving Soils, Geology & Land	Significance of Effect	
Borrow Pits (Contd.)	Controlled disposal of excavated peat from Borrow Pits No.3 - 2nd Phase of Construction (2004/2005)	In designated peat repository areas	Permanent	Sustained	Negative	Small (100m2-2500m2) to Very Large (>10Ha) Peat Slide	Very Low to Low	Medium to Low	Medium	Slight	No
	Backfilling borrow pits with Glacial Subsoil (Borrow Pit No.2)	Borrow Pit No.2	Permanent	Sustained	Slight Negative	Not Applicable	Negligible	Negligible	Medium	Not Significant	No
	Backfilling borrow pits with Peat below ground level or contained by rockfill bunds (BP No.2 and small sections of BP No.3)	In BP No.2 and BP No.3 (small sections)	Permanent	Sustained	Negative	Localised flow slide of remoulded peat due to failure of containment bunds	Very Low	Very Low	Medium	Slight	No
	Blast-induced vibrations (BP No.3 Only)	Within 200-500 m of BP No.3	Momentary	Occasional	Negative	Small (100m2-2500m2) to Very Large (>10Ha) Peat Slide	Very Low to Low	Very Low	Medium	Slight	No
Drainage	Loading on peat slopes from wide-track excavators and locally sidecast peat.	Along open drains	Temporary	Occasional	Negative	Small (100m2-2500m2) to Very Large (>10Ha) Peat Slide	Very Low to Low	Low	Medium	Slight	No
	Improvement of groundwater conditions	In areas of improved drainage	Permanent	Sustained	Positive	Not Applicable - Reduced risk of a peat slide due to improved groundwater conditions	Positive Impact - Reduced Probability of a Peat Slide	Medium (Positive)	Medium	Moderate (Positive)	No
Cable Trenching and Ducting	Loading on peat slopes from wide-track excavators and cable transporting equipment	Across site, generally along site access tracks	Temporary	Frequently	Negative	Small (100m2-2500m2) to Very Large (>10Ha) Peat Slide	Very Low to Low	Low	Medium	Slight	No
	Installation of cable ducts under floating roads	At cable crossing points	Brief	Once at each crossing point	Slight Negative	Localised (<10m^2) at duct crossings under road	Very Low	Very Low	Medium	Slight	No
Erection of 110kv Twin Poleset	Live load surcahrge on intact peat from construction activities to excavate the foundations and erect the poleset	At the 110kv twin poleset on the windfarm site (adjacent to substation)	Temporary	Once	Slight Negative	Localised (<10m^2) to Very Small (10m^2-100m^2) Peat Slide	Very Low	Very Low	Medium	Slight	No
Construction of Anemometer Towers	Controlled excavation of peat for hardstand & RC foundation	At 2 No. anemometer locations	Temporary	Once at each location	Negative	Localised (<10m^2) to Very Small (10m^2-100m^2) Peat Slide [Upslope from excavation]	Very Low to Low	Low	Medium	Slight	No
	Permanent loading on glacial subsoil from hardstand and anemometer structure	At 2 No. anemometer locations	Permanent	Sustained	Slight Negative	Not Applicable	Negligible	Negligible	Medium	Not Significant	No
	Construction traffic loading on floating roads - spoil management, tranpsorting backfill materials & components	Along floating roads to anemometer locations	Brief	Occasional	Negative	Small (100m2-2500m2) to Very Large (>10Ha) Peat Slide	Low to Possible	Medium	Medium	Moderate	No

10.3.2.1.1.3.1 Significant Effects

The following impacts of site activities had a **Significant** effect on the receiving soils, geology and land with respect to site stability during construction:

1. The dead load surcharge on the intact peat slopes from the construction of the floating roads.
2. The initial live load surcharge from the construction traffic on the floating roads i.e. during construction of the floating roads; and
3. The dead load surcharge on the intact peat slopes due to sidecasting and disposal of excavated peat and glacial subsoils on the surface of the peat prior to the peat slide in October 2003 for the site compound, borrow pits and turbine foundations.

This section includes a summary of the peat failures that occurred on the site during the initial phase of construction, including the large peat slide that occurred at Turbine T68 on the 16th October 2003. As discussed in Section 10.1.2.2, the October 2003 peat slide has been recorded in this section as an **"*impact that has occurred*"**, specifically in the assessment of the impact of sidecasting materials excavated from the turbine foundations onto the intact peat slopes, which has been attributed to triggering the large slide at T68 along with more localised smaller scale peat failures at 4 No. other locations on the wind farm site.

<u>Floating Road Construction & Live Load Surcharge</u>:

The majority of the site access tracks (15.1 km) were constructed as floating roads on the peat. The 0.6-1.0 m thick layer of granular rockfill that was used to construct the floating roads was equivalent to a dead load surcharge of 12.5-20.0 kN/m^2 on the surface of the peat, which was spread out over typically a 6.0-7.0 m wide strip along the base of the roads. On sloping ground this applied a downslope shear stress in the peat, which increased the risk of instability due to shear failure in the peat. At the time that the floating roads were constructed the risk of a small to very large scale peat slide across the site under this loading was **Possible** to **Very Possible**, with the higher risk associated with the sections of the site where there was a higher likelihood of a peat slide based on the baseline site characteristics (see Figure 10-34). Therefore, the effect of the dead load surcharge on the peat was **High** and **Significant** with respect to the baseline sensitivity of the receiving soils, geology and land.

The rockfill that was used to construct the floating roads was transported along the site access tracks in standard 3 and 4 axle tipper trucks, and then spread out over the surface of the peat along the line of the roads using 13 tonne and 20 tonne hydraulic tracked excavators. The maximum construction traffic loading was from the 4-axle trucks, which weighed up to 36.5 tonnes when fully loaded. This was equivalent to a live load surcharge of 20.75 kN/m^2 over the 7.5 x 2.3 m wide footprint of the truck, with a maximum axle load of 12 tonnes. The 20 tonne Hitachi EX200 long-reach tracked hydraulic excavator had a similar live load surcharge (20.8 kN/m^2) but over a smaller area (3.37 m x 2.8 m wide). This additional surcharge on the peat increased the risk of a peat slide during the construction of the floating roads. Therefore, the effect of the live load surcharge on the peat was **High** and **Significant**.

The construction traffic loading on the floating roads was **Frequent** during the construction of the roads. However, the **Duration** of the loading was **Temporary**.

At the end of construction, the floating roads were left in place. Therefore, the dead load surcharge was **Permanent** and **Sustained.** However, the highest risk for peat instability was in the short-term undrained condition during construction. Over time, the peat consolidated and increased in shear strength under the weight of the road, which significantly reduced the risk of peat instability. This was verified by in-situ measurements of the shear strength of the peat under the roads.

No peat failures occurred during the construction of the floating roads.

Sidecasting of Peat and Glacial Subsoil:

Prior to the peat slide in October 2003 material excavated from the site of the compound, borrow pits and turbine foundation excavations was stored on site and typically sidecast and spread out on the peat adjacent to the excavations. The majority of the sidecast material was from the turbine foundation excavations, where the material was comprised of peat, glacial till and occasionally weathered rock.

By the 16th October 2003 the Contractor had completed the excavation for the foundations of 39 No. turbines across the site, predominately in areas of shallow bedrock where the depth of excavation for the foundations was shallower (i.e. Turbines T1-T5, T9-T13, T17- T29, T32, T34, T35, T37, T38, T40-T46, T63, T66, T67 & T69). The extent of excavation was limited to the turbine foundations and did not include the adjacent crane hardstanding areas. Excavation was underway for the foundations at Turbines T62 and T68 at the time of the slide. The foundations for Turbines T6 and T31 had also been partially excavated in the peat.

The peat, glacial till and occasionally weathered rock excavated from these turbines was sidecast and spread out over a wide area across the surface of the peat slopes adjacent to the excavations generally to a depth of 0.5-1.5 m, but locally up to 2.0-2.5 m at T24, T27 and T40.

Applied Ground Engineering Consultants (AGEC) inspected each of the sidecast areas in their walkover inspections of the site after the slide. Records of the depth, extent, material characteristics and stability of the sidecast materials are presented in their final report on the post-landslide site appraisal (Ref. AGEC Report No. 378_099 dated 4/2/2004), which is included as Appendix A of this chapter.

Some slumping or localised flow of the saturated excavated material on the peat slopes was noted by AGEC. However, in terms of site stability, the impact of the material sidecasting was the dead load surcharge that was applied to the intact peat on the slopes.

There are no detailed records of the relative volume of peat and glacial subsoil sidecast at each turbine. In their post-landslide site appraisal report AGEC made some visual observations on the characteristics of the sidecast material – i.e. whether it was predominately peat, glacial till or some combination of both. Based on the ground investigation data and construction records, the average ratio of peat to glacial till in the excavation to rock at the turbines was approximately 1:1, excluding a few outliers in deep peat over shallow rock where the arisings were predominately comprised of peat (e.g. T2, T12 & T13). Assuming a unit weight of 10kN/m^3 for the peat and 20 kN/m^3 for the glacial till, an average unit weight of 15.0 kN/m^3 would give in indicative surcharge weight for the sidecast material.

Where the depth of sidecast material generally ranged from 0.5 to 1.5 m this was equivalent to a surcharge load of 7.5 - 22.5 kN/m^2. At turbines T24, T27 and T40 the surcharge was locally up to 30.0-37.5 kN/m^2 where the sidecast material was up to 2.0-2.5 m deep.

Where the extent of the sidecast material on the slopes was recorded by AGEC it covered an area ranging from 215 m^2 at Turbine T29 to 2,240 m^2 at T9. However, it was generally between 600 m^2 and 1,340 m^2, with an average of 1,000 m^2 (approximately 25 m x 40 m).

With respect to site stability, the primary effect of the surcharge load applied by the sidecast material was to increase shear stresses in the underlying intact peat, which increased the risk of a peat slide on the slopes. The surcharge also applied a concentrated bearing pressure on the peat which increased the risk of localised bearing failure. The probability of a peat slide or bearing failure under the surcharge load was **Possible** to **Very Possible**, with the higher risk associated with the sections of the site where there was a higher likelihood of a peat slide based on the baseline site characteristics (see Figure 10-34). Therefore, the effect of the surcharge on the peat was **High** and **Significant** with respect to the baseline sensitivity of the receiving soils, geology and land that could be impacted by a slide, which has been assessed as **Medium**.

The probability of a peat failure would also have been higher where a greater depth and volume of excavated material was placed on the slopes, and where the sidecast material included a significant proportion of glacial till or weathered rock which are almost twice the weight of peat.

Peat Failures related to Sidecasting of Peat and Glacial Subsoil (Impacts that occurred):

Based on the records of the inspections carried out by AGEC, **the majority of the material sidecast areas [35 No. (≈90%)] were stable** with only minor slumping or localised flow of the excavated material, in some cases blocking drains on the site. In these areas the sidecast material was left in place so that the loading is **Permanent** and **Sustained**.

Of the 4 No. (≈10%) remaining sidecast areas inspected by AGEC where the turbine excavation had been completed:

- A local bearing failure was recorded under the sidecast material at Turbines T23, T29 and T66; and
- A small scale peat slide occurred at Turbine T17 on 2nd October 2003.

Excavation was underway for the foundation at Turbine T68 at the time of the slide and the excavated material was being sidecast on the slopes downslope from the turbine and floating road, where the slide is thought to have initiated (AGEC, 2004).

The following is a description of the failures that occurred. The impact of the large peat slide at Turbine T68 on the receiving soils, geology and land is assessed in Section 10.3.4.

Local bearing failure that occurred in the peat at T23, T29 and T66:

At 3 No. turbine bases (Turbines T23, T29 and T66) there was a localised bearing capacity failure in the intact peat under the weight of the sidecast material. At each of these turbines the arisings from the foundation excavation were placed on the intact peat slopes along the edge of the forest on the downslope side of the turbine and floating road.

The bearing capacity failures were characterised by a rotational shear failure in the intact peat under the arisings, which caused slumping of the excavated material and heave with tension cracks in the intact peat downslope, giving the slope an irregular stepped profile, as shown in Figure 10-40. Some trees within the zone of ground movement were tilted over.

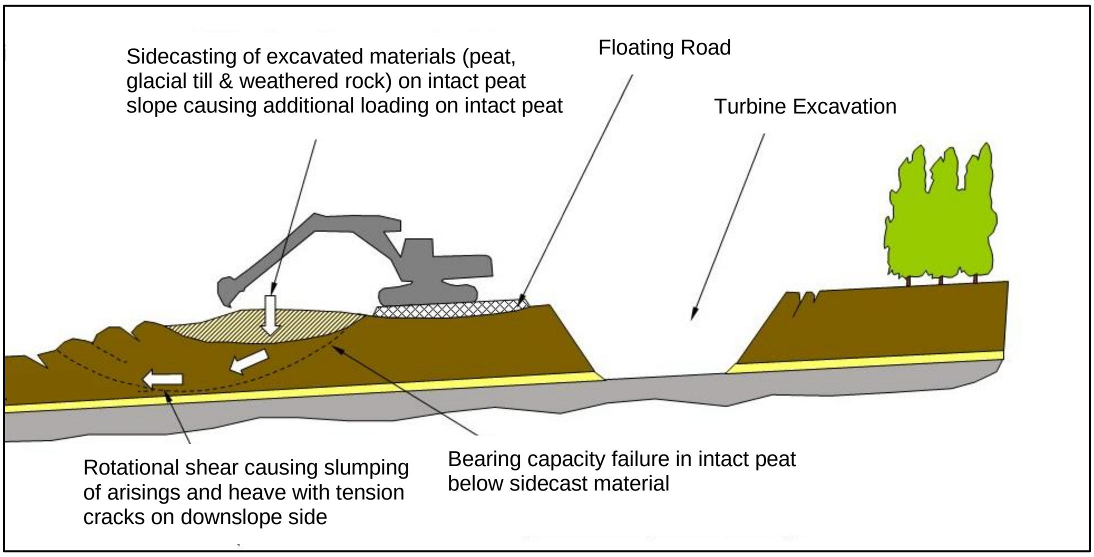


Figure 10-40: Bearing capacity failure below sidecast materials

Turbines T23 and T29 are located along the southern boundary of the site. The bearing capacity failure at these turbines occurred in relatively shallow peat (1.0-1.5 m deep) on gently sloping ground (2-4°).

Turbine T66 is located near the centre of the site, 250 m upslope from Turbine T68 where the large peat slide occurred in October 2003. At T66 the excavated material was placed on intact peat up to 2.8 m deep on intermediate slopes of 3-5°.

At each turbine the failure within the peat was localised and limited to an area that extended a few metres downslope from the sidecast material. The peat outside the zone of the bearing failure remained undisturbed and intact. Therefore, the effect that this had on the peat was **Very Low**, which is of **Slight** significance.

In these areas some or all of the sidecast material was removed after the failures occurred to stabilise the slope so that the impact of the loading was **Temporary**.

Small scale peat slide that occurred at Turbine T17:

On the 2nd October 2003, at Turbine T17, there was a shear failure in the peat under the sidecast material which gave rise to a small peat slide over an area of about 22 m x 90 m (1,980 m^2) approximately 10 m east of the turbine on the south side of the floating road. The slide occurred as a planar shear failure near the base of the peat in peat up to 1.5-2.0 m deep on slopes of 2-4°.

The disturbed remoulded peat from the failed area flowed out in a lobe over the intact peat downslope from the failure for a run-out distance of about 45 m, where it came to rest on flatter slopes with shallower peat about 1.0 m deep.

There was no evidence of failure in the in-situ peat below the lobe of remoulded peat in the run-out zone. The slide was small (<2,500 m^2) and the peat slopes downslope from the failed area remained undisturbed and intact. Therefore, the effect that this had on the peat was **Low**, which is of **Slight** significance.

Very large scale peat slide that occurred at Turbine T68 on 16th October 2003:

At the time of the peat slide on the 16th October 2003 peat up to 3.5 m deep was being excavated from the site of Turbine T68 and placed on the intact peat slopes on the downslope side of the floating road, opposite the turbine, using 2 No. 20 tonne Hitachi EX200 long-reach excavators. Some of the excavated material was also placed on the slopes to either side of the turbine. The excavators were operating on the floating road and on a small section of granular hardstanding on the glacial till between the turbine and the hardstanding. The excavation had not progressed into the glacial till so only peat was sidecast on the slopes (see Plate 10-1 and Plate 10-2).

Plate 10-1: Excavation at Turbine T68 at the time of the slide

Plate 10-2: Aerial view of the head of the slide at Turbine T68 (October 2003)

As discussed in Section 10.1.2.1, Applied Ground Engineering Consultants, Ltd. (AGEC) carried out an inspection and supplemental investigations on the site at the time of the slide to provide an opinion on the likely cause of the failure. A copy of their report - "*Derrybrien Windfarm – Final Report on Landslide of October 2003*" - is included in Appendix A of this Chapter.

AGEC concluded that the construction activity, and particularly the placing of arisings onto the intact peat slopes, most likely triggered the slide. The failure mechanism that they proposed is shown schematically in Figure 10-1.

The peat slope and sidecast arisings downslope from the turbine were damaged in the slide. However, based on their site observations AGEC proposed that the additional surcharge load on the intact peat slopes could have initially caused a localised shear failure or bearing capacity failure in the underlying intact peat slope similar to that shown on Figure 10-40. This would have reduced the shear resistance in the failed peat, resulting in a redistribution or transfer of lateral load to the adjacent peat downslope. Additional transfer of lateral loading as more material was placed on the slopes could have led to a progressive shear failure and reduction in shear resistance along the base of the peat further downslope. Ultimately, this could have led to the large planar or translational peat slide that occurred on the inclined slopes.

Although the peat slide occurred while the excavated peat was being sidecast on the intact peat slopes, site observations at the time of the slide indicated that the failed mass of peat initially moved as a rigid body in a large planar slide over a wide area on the slopes of the mountain. The magnitude of loading from the sidecast material over a very small area at the top of the slide was actually quite low relative to the scale and characteristics of the slide. Furthermore, excavated arisings from the turbine foundations had already been sidecast on the intact peat slopes in a number of other locations on the site without causing a failure in the peat. Therefore, on its own it does not fully explain why the slide occurred at Turbine T68.

At the time of the peat slide at the Derrybrien Wind Farm the construction industry's general knowledge of failures on peat slopes was very limited. As discussed in Section 10.1.2.210-13, as a result of the Derrybrien slide there have been numerous investigations, research projects and publications into peat slope failures in Ireland and the UK which have greatly increased our knowledge of the behaviour of peat and of peat failures on upland blanket bogs. Subsequent investigations into peat slope failures have also shown similar types of triggering events and failure mechanisms to the slide that occurred at Derrybrien - specifically large peat slides caused by the placement of relatively small loads at the head of an intact peat slope (Dykes & Warburton (2007), Kane et al (2020)).

Based on their investigations into the peat slide at Derrybrien in 2003, AGEC identified additional contributory factors that would have made the slope predisposed to the failure in that area, as discussed in Section 10.1.2.1.

Their findings are consistent with the results of subsequent investigations and testing carried out on the site after the slide, as well as our current understanding of peat slope failures on upland blanket bogs. Based on the additional investigations that were carried out in the area and on subsequent developments in our understanding of peat slope failures on blanket bogs, it is recognised that the following expanded list of significant compounding factors and site conditions contributed to the peat slide occurring in that area of the wind farm at that time:

- There was a convex break in slope to locally steeper slopes >4-5° on the downslope side of the floating road at the top of the slide, where the excavated material was being sidecast on the peat slopes (see Figure 10-6);
- The slide occurred within a shallow buried valley that was filled with locally deeper peat, which would not have been evident from the ground surface;
- Laboratory testing of undisturbed samples from the base of the peat adjacent to the slide indicated that the failure occurred within a layer of uncharacteristically weak highly decomposed and possibly disturbed peat that was not encountered elsewhere on the site and may have been indicative of a previous historic peat slide in the area;
- The shallow buried valley where the slide occurred is directly upslope from the valley for the stream in sub-catchment SC7(b). Therefore it is likely that there was concentrated subsurface flow of groundwater within and below the peat in the valley at Turbine T68 which has since formed a stream within the disturbed peat in the slide area;
- Aerial photographs of the site from before the slide also showed evidence of concentrated subsurface drainage in the peat within the slide area in the form of lines of dark green vegetation on the slopes (see Figure 10-4).
- The historical aerial photographs of the site (Figure 10-4) also show that there was a large irregular area of smaller tree growth in the conifer plantations on the west side of the wind farm where the trees may have been destroyed by fire at some point in the past. The peat slide occurred at the eastern edge of this area.
- Prior to construction of the wind farm, the integrity of the upper fibrous layer of intact peat in the slide area would also have been damaged by the drains and furrows that were cut into the slope for the conifer forest plantations.
- At the time of the slide drainage works were also being carried out on the peat slope within the slide area approximately 300m downslope from the turbine;

All of these compounding factors would indicate that the peat on the slope in this area could have been at or close to the point of failure when the construction works were being carried out.

This is consistent with the current best practice guidelines for assessing the risk of peat instability for wind farm developments on upland blanket bogs (Scottish Government – Energy Consent Unit, 2017), which are based on assessing a range of similar contributory risk factors related to site characteristics to identify areas where there is an elevated risk of peat instability, as described in Section 10.2.2.1.

The peat slide displaced peat and forestry on the slopes over an area of about 25 ha that extended 1.68 km downslope from Turbine T68, which is very large (>10 ha). The majority of this (≈90%) was in the Coillte coniferous forests outside the wind farm site. From here fluidised remoulded peat from the slide entered the valley of the Derrybrien River North and impacted farmland down to the Black Road Bridge approximately 1.0 km downslope from the slide area where rockfill barrages were constructed to contain much of the material. This was the primary run-out zone for the slide. Some of the remoulded peat was transported further downstream along the river channel.

The total volume of peat from the slide area has been estimated at about 450,000 m^3, of which approximately 200,000 m^3 has remained on the slopes within the slide area.

The significance of the effect of the peat slide on the receiving soils, geology and land is discussed in further detail in Section 10.3.4.1.1.2 along with a more detailed description of the characteristics of the slide, the slide area and the debris runout zone downslope.

The effect of the slide has been assessed as **High** due to the extent of the slide and the volume of peat that was displaced from the slopes in the slide area.

The baseline sensitivity of the receiving soils, geology and land directly impacted by the slide has been assessed as **Medium** based on the low overall ecological value of the degraded blanket bog, the relatively low value of the land for forestry and agriculture, and the potential carbon loss in the disturbed peat in the context of the overall wind farm project and national annual carbon emissions. Therefore, the effect of the peat slide on soils, geology and land was **Significant**.

This is consistent with the assessment of the effect of the surcharge load from the sidecast materials on the intact peat slopes, which has also been assessed as **Significant,** even where no peat failure occurred. This is because it reflects the relatively high probability of a peat failure occurring under the sidecast material and the possible extent and characteristics of a peat failure that could occur under the surcharge loading, which in this case has been calibrated by the peat slide that occurred at Turbine T68 as a worst case scenario.

10.3.2.1.1.3.2 Moderately Significant Effects

The following impacts of site activities had a **Moderately Significant** effect on the receiving soils, geology and land with respect to site stability during construction:

1. The medium term impact of the dead load surcharge from the excavated materials that were sidecast on the intact peat slopes during the initial phase of construction in 2003;
2. The live load surcharge from the construction traffic on the floating roads during the second phase of construction in 2004/2005 for:
   - Construction of the turbine foundations, crane hardstanding areas and substation;
   - Transporting spoil to designated disposal areas; and
   - Transporting, assembling and erecting the turbines.
3. Improvement of groundwater conditions with improved drainage, which has a **positive** impact on the peat with respect to site stability.
4. The access tracks constructed as rockfill embankments across the slide area at T68 & T70, which have a **positive** stability impact on the disturbed peat within the slide area.

Dead Load Surcharge from Sidecast Materials: Most of the excavated peat and glacial till that was sidecast adjacent to the turbine foundations prior to the slide was stable and was left in place on the slopes to avoid disturbing the peat. Material was only removed from selected areas where there was concerns for the stability of the slopes (e.g.T18 & T34), or where there was evidence of instability, such as at the turbines where the localised bearing capacity failures occurred (T23, T29 and T66). The highest risk for peat instability in the material sidecast areas was in the short-term undrained condition during initial construction, specifically at the time that the material was placed on the slopes. Over time, the intact peat on the slope under the sidecast material consolidated and increased in shear strength, which significantly reduced the likelihood of a peat slide. As a result, in the medium-term the effect of the loading on the peat reduced to **Medium**, which is of **Moderate** significance relative to the baseline sensitivity of the receiving soils, geology and land.

Construction Traffic Loading on Floating Roads: Similarly, the peat under the floating roads gained strength as it consolidated under the weight of the rockfill so that the highest risk of a peat slide from the construction traffic loading was during initial construction of the roads and the likelihood of a peat slide reduced over time due to the improved site conditions, as discussed in Section 10.2.4.4. The increase in strength of the peat and the capacity of the roads was verified by site testing and analyses prior to resuming construction on the site in 2004. Therefore, the effect of the live load surcharge from the construction traffic on the floating roads on the peat reduced to **Medium** for the second phase of construction in 2004/2005, which is of **Moderate** significance relative to the baseline conditions.

Improved Drainage (Positive Impact) – Poor drainage is a recognised contributory risk factor for peat instability. During periods of heavy or sustained rainfall it can lead to elevated hydrostatic uplift pressures below the peat, or hydraulic surcharge pressures in the existing drainage network of pipes and seepage channels within the peat, which have a finite capacity. These elevated groundwater pressures within and below the peat can contribute to peat slides. The improved drainage has reduced that risk on the wind farm site.

In the medium to long-term, improved drainage would also have increased the shear strength of the peat, which has had a positive impact on the peat with respect to site stability. Wherever the groundwater table is lowered it reduced the buoyancy forces in the peat. This would have caused the peat to consolidate (compress) under the increased self-weight, which increased its shear strength, similar to the effect of a surcharge load. The peat above the lowered water table would also have increased in strength as it dried out.

Therefore, the improved drainage network that was constructed on the site would have a **Permanent** and **Sustained positive impact** on the peat with respect to site stability. The effect of the drainage improvements was **Medium,** and of **Moderate** significance.

Access Tracks Across Slide Area at T68 & T70: After the peat slide on the 16th October 2003, a 30 m long section of the floating road at Turbine T68, and a 105 m long section of the floating road to the west of Turbine T70 had to be reconstructed. The new sections of road were reconstructed across the slide area as rockfill embankments on competent glacial subsoil below the disturbed peat. The embankments have a **positive impact** as they act as a barrage to contain the disturbed peat within the slide area upslope from the roads. The effect of the barrages on the stability of the peat was **Medium** and of **Moderate Significance**. The embankments were left in place after construction. Therefore, the positive impact is **Permanent** and **Sustained**.

There have been no peat slides on the site related to the medium-term loading of the sidecast materials on the peat slopes in the areas that were stable at the time of the slide. Similarly, no peat slides have occurred due to the live load surcharge of the construction traffic loading on the floating roads.

10.3.2.1.1.3.3 Slightly Significant Effects

The following impacts of site activities had a **Slightly Significant** effect on the receiving soils, geology and land with respect to site stability during construction:

- Loading from 1.0 m of excavated peat on the intact peat slopes in designated peat repository sites (after the peat slide in October 2013).
- The local stability of the temporary peat slopes around the perimeter of the excavations for the turbine foundations and crane hardstandings;
- The live load surcharge on peat slopes from low ground bearing pressure construction and forestry equipment operating on the peat slopes for:
    - Tree felling, and gathering and stockpiling logs;
    - Laying the basal layer of timber and brash along the line of the floating roads;
    - Spreading peat out on the slopes in designated peat repository sites;
    - Excavating drainage trenches; and
    - Cable trenching
- Stockpiling timber logs
- Local sidecasting of peat along drainage trenches and cable trenches.
- Installation of cable ducts below floating roads
- Backfilling peat within Borrow Pit BP-2 and BP-3 – below ground level or within bunded pits.
- Dynamic inertial loading from blast-induced vibrations from rock excavation in Borrow Pit BP-3.
- Unloading of peat slopes from tree felling (Positive Impact)

Dead Load Surcharge in Peat Repository Sites: For the second phase of construction in 2004/2005, after the peat slide, alternative methods of managing and disposing of material excavated from the site of the turbines, crane hardstandings, substation, borrow pits and other minor infrastructure and civil works were adopted as a preventative design mitigation measure to reduce the likelihood of a peat slide. The majority of the excavated peat was stored to a maximum depth of 1.0 m in designated repository areas on the intact peat slopes in suitable areas of flat or gently sloping ground on the site. The suitability of each repository area was verified by on-site testing and stability analyses so that the likelihood of a peat slide in each area under the applied surcharge loads was reduced to **Very Low to Low**, as discussed in Section 10.2.4.4, with the higher risk associated with the sections of the site where there was a higher likelihood of a peat slide based on the site characteristics (see Figure 10-35). Therefore, the effect of the dead load surcharge on the peat was **Medium to Low** and the significance of the loading with respect to the baseline sensitivity of the receiving soils, geology and land was **Slight**.

The peat was left in place at the end of construction. Therefore, the impact of the surcharge load was **Permanent** and **Sustained**. However, the highest risk of a peat slide was at the time that the material was placed on the slopes during construction.

No peat slides occurred in the designated peat repository areas.

Local Stability in Peat at Excavations for Turbines and Crane Harstandings: The turbine foundations were constructed in open excavations in the peat and glacial till down to rock. For the short period of time that the excavations were open there was a risk of shear failure in the side slopes around the perimeter of the excavations. Where the slopes were left unsupported, they were trimmed back to stable temporary slope angles. In deep very soft peat rockfill berms were used to support the peat. The likelihood of shear failure in the sides of the turbine excavations was **Possible to Very Possible**. However, the extent of the possible effect was limited to localised shear failure of the side slopes or a localised to very small peat slide (<100 m^2) on the upslope side of the turbine excavation. Therefore, the effect of the excavation on the peat was **Medium to Low** and the significance of the effect was **Slight**.

During excavation for the foundation at Turbine T52 in January 2005 there was a very small planar peat slide (<100 m^2) in the intact peat on the upslope side of the turbine. The disturbed peat slid into the excavation so that the direct impact of the slide was limited to the effect on the peat that was disturbed within the slide area, which was **Low**. The baseline sensitivity of the peat in the slide area was **Medium**. Therefore, the significance of the slide was **Slight**, which is consistent with the assessment of the stability impact.

The excavations in the peat for the crane hardstandings were backfilled immediately with rockfill so that there was a lower risk of shear failure around the perimeter of the excavation. There was some movement in the peat upslope from the excavation for the turbine foundation and crane hardstanding at Turbine T66. Some of the peat slumped and large tension cracks opened up in the intact peat on the slope. However, the excavation was backfilled before a peat slide occurred. Therefore, at T66 the effect of the movement on the peat was **Negligible** and **Not Significant**.

Construction Traffic Live Load Surcharge on Peat: Many of the site activities during construction involved working directly on the surface of the intact peat slopes. Where construction plant and machinery were required to operate on the slopes, the machines were specially adapted as low ground bearing pressure (LGBP) machines suitable for working on peat. For example, 13-20 tonne wide-tracked hydraulic excavators were used for harvesting and handling trees, for spreading out peat in the repository areas, and for excavating trenches for drainage and electrical cables. In areas of very soft peat small branches and timber brash were placed on the surface of the peat under the tracks of the harvesting machines. Large rubber-tyred 8 and 12 tonne forestry forwarders were used to gather and stockpile the cut timber logs. The live load surcharge from these types of equipment was localised and spread out over the surface of the peat to prevent concentrated loading so that the risk of a peat slide was generally **Very Low to Low**. Therefore, the effect of the live load surcharge on the peat was **Medium to Low** or **Low,** depending on the volume of construction traffic and the magnitude of loading, and the significance of the effect was **Slight**.

No peat slide occurred due to equipment operating on the peat during the construction stage of the project.

Temporary Stockpiling of Timber Logs: The trees that were felled on the site were cut into 3 m long logs that were temporarily stockpiled on the intact peat adjacent to the floating roads. The stockpiles were 2.5-3.0 m high and extended over a length of about 20m along the side of the roads. This was equivalent to a localised surcharge of 12.5-15.0 kN/m^2 over the footprint of the stockpiles. The logs were regularly removed from the site by Coillte, so the loading was short-term. Therefore, the effect of the live load surcharge on the peat was **Medium to Low** and the significance of the impact was **Slight**.

No peat failures occurred under the timber stockpiles.

Miscellaneous Construction Activities: The following site activities had a **Very Low** effect on the peat that was of **Slight** significance with respect to site stability:

- Where shallow drainage trenches or cable trenches were constructed across the slopes the excavated peat was locally sidecast and spread out on the peat adjacent to the trenches. The excavated peat was used to backfill the cable trenches but was left in place permanently for the drainage trenches. The sidecasting only resulted in minor localised redistribution of loading on the peat slopes along the line of the trenches.
- Where the electrical cables had to be installed below the floating roads PVC ducts were installed below the roads by pushing through the peat rather than by excavating a trench to minimise the impact on the roads.
- Some of the peat that was excavated from the turbines, crane hardstandings, substation and borrow pits was deposited inside Borrow Pits BP-2 and BP- 3. The excavated peat in each area was placed on glacial till or rock and fully contained below ground level or within rockfill bunds so that there was a very low likelihood of a peat slide due to failure or overtopping of the bunds.
- Rock was extracted from Borrow Pit No.3 by blasting. Vibration monitoring carried out during blasting confirmed that the large peat slide that occurred in 2003 was outside the range of the blast-induced vibrations from the borrow pit, and that the peak particle velocity and acceleration of the vibrations was within acceptable limits so that the likelihood of causing a peat slide from the dynamic inertial loads generated by the blasting was very low to low and primarily limited to the peat slopes around the perimeter of the borrow pit.

None of these activities caused a peat failure on the site during construction.

<u>Tree felling – Positive Impact of Unloading</u>: None of the areas where the trees were felled were re-planted. Therefore, tree felling also had a long-term **<u>positive</u>** impact on the peat with respect to site stability, i.e. where the large trees were felled and removed from site this has resulted in a **Permanent** and **Sustained** unloading of the peat slopes. However, the level of unloading was low (<1 kN/m^2). Therefore, the effect of the unloading on the peat was **Very Low** and the **Significance** of the effect was **Slight**.

10.3.2.1.1.3.4 Effects that were Not Significant

The following impacts of site activities did not have a significant effect on the receiving soils, geology and land with respect to site stability during construction:

1. The dead load from engineered fill materials on competent glacial till or rock at the site compound, substation, turbine and crane hardstanding areas;
2. The dead load from structures and equipment supported on the granular hardstanding areas at the site compound (short-term) and substation (permanent);
3. Live loading on hardstanding areas (crane hardstandings, site compound, substation) which are comprised of granular rockfill on competent glacial till;
4. Dead and live loading on the bedrock from the turbine foundations;
5. The dead load from the additional capping layer of granular fill that was used to resurface the existing site access tracks that were constructed on the glacial till below the peat;
6. The live load from the construction vehicles on the site access tracks constructed on the glacial till below the peat (i.e. not the floating roads);
7. The loading on competent glacial till from the foundations for the control building and anemometers; and
8. Disposal of surplus excavated glacial subsoil in the borrow pits.

None of these impacts involved loading on the peat. Therefore, the risk of the corresponding site activities causing a peat slide was **Negligible**. All of the foundations for the turbines, structures and electrical equipment on the site were supported on competent soils and bedrock with sufficient bearing capacity to support the applied loads. The earthworks for the site compound and substation only involved minor cut and fill in the glacial till below the peat.

10.3.2.1.2 Operation and Maintenance Phase: 2006 - 2020

This section of the report assesses the impact of wind farm site activities during the operation and maintenance stage of the wind farm between 2006 and 2020.

Section 10.3.2.1.2.1 gives a summary of the site activities that were carried out on site between 2006 and 2020 that had an impact on soils, geology and land. The **direct impacts** of these activities are assessed in Section 10.3.2.1.2.2.

The **stability impacts** are addressed in Section 10.3.2.1.2.3 i.e. the direct impacts of site activities that had an effect on site stability, potentially causing a peat failure.

10.3.2.1.2.1 Site Activities – Operation & Maintenance Stage: 2006-2020

The primary works that were carried out on the site during this period that had an impact on soils, geology and land included the following:

- Power Generation and Transmission
- Maintenance/Repair of Turbines
- Maintenance/Repair of Substation & Control Building
- Maintenance/Repair of Access Tracks
- Cables & Ducting Improvements
- Drainage Improvements
- Maintenance of Instrumentation
- Forestry – Tree Felling to the West of the Wind Farm Site and Temporary Stockpiling of Logs
- Forestry - Tree Topping on the Wind Farm Site.
- Remedial works to right a crane that went off the narrow turbary road

Chapter 2 and the AGL Report No. 11-147B-R04 – "*Geotechnical Stability Report & Assessment of Site Stability Impacts on Soils, Geology and Land*" in Appendix B of this Chapter give a detailed summary of the site activities associated with each of these works. The following is an assessment of the impact of these activities on soils, geology and land during the operation and maintenance phase of the project between 2006 and 2020.

10.3.2.1.2.2 Direct impacts (O&M Phase 2006-2020)

This section addresses the direct impact of site activities on soils, geology and land during the operation and maintenance phase of the wind farm project between 2006 and 2020.

10.3.2.1.2.2.1 Significant Effects

None of the direct impacts of site activities during the operation and maintenance phase of the project between 2006 and 2020 had a **Significant** effect on soils, geology and land.

10.3.2.1.2.2.2 Moderately Significant Effects

None of the direct impacts of site activities during the operation and maintenance phase of the project between 2006 and 2020 had a **Moderately Significant** effect on soils, geology and land.

10.3.2.1.2.2.3 Slightly Significant Effects

The impact of the following site activities had a **Slightly Significant** effect on soils, geology and land during the operation and maintenance phase of the project between 2006 and 2020:

- Cables and Ducting – 2017 upgrade of turbine control systems
- Drainage Improvements – to improve the performance and efficiency of the existing system
- Forestry – Tree felling, tree topping and temporary stockpiling of logs; and
- Remedial works to right a mobile crane that went off the narrow turbary road to Turbine T40.

Cables and Ducting: The 2017 upgrade of the turbine control systems involved installation of fibre-optic cables in 2.55 km of new 50 mm uPVC ducting in the intact peat across the site. The uPVC ducting and warning tape were installed directly into the peat at a depth of typically 0.5-0.6 m using a mole plough without having to open up a trench. At 5 No. road crossings the cables were installed in 75 mm uPVC ducts that were pushed through the peat under the floating roads to avoid having to open up a trench that would damage the basal reinforcement. At 7 No. junctions the peat was locally excavated to support manholes on the underlying glacial till. The direct impact of this work was limited to local disturbance of the peat along the line of the cable ducts, manholes and crossings. The effect that this had on the intact peat slopes was **Very Low**. Therefore, the significance of the effect was **Slight**. The duration of the work was **temporary** and was only carried out once in each area.

Drainage Improvements: The drainage improvements that were carried out during the operation and maintenance period generally involved minor excavation of peat along existing drains to:

- Clear out the inlet and outlet of blocked or collapsed drains;
- Deepen/widen drains to increase capacity and flatten side slopes along access tracks at main watercourse crossings;
- Regrade drains with insufficient fall;
- Repair/replace collapsed culverts; and

In some existing drains cobbles and boulders were used to reduce flow velocity to prevent localised scour or erosion in the peat and glacial till.

The drainage works on the peat were carried out by hand or with an LGBP wide-tracked hydraulic excavator suitable for working on the peat. Some new drains were constructed to relieve ponded groundwater at the turbines, or to improve the connection between existing drains. However, in general the drainage works were required to improve the performance and efficiency of the existing drainage network without significantly increasing the capacity of the system. Therefore, the direct impact on the soils, geology and land was limited to local disturbance of the peat along the line of the drains where maintenance was carried out, with some additional groundwater lowering due to the improved efficiency of the drainage system. The effect of these works on the peat was **Low** and the Significance of the effect was **Slight**. The drainage works were carried out periodically so that the impact on the peat during each phase was temporary. Most of the significant works were completed within 6 years of completion of construction, up to 2012.

Forestry – Tree Felling & Temporary Stockpiling to the West of the Wind Farm Site: Between 2016 and 2018 trees were clear-felled for the Project over an area of approximately 46 ha in the mature conifer plantations on the west side of the wind farm, just outside the site boundary, as shown in Figure 10-41. The trees were felled by experienced contractors working for Coillte using the same standard forestry equipment that was used for tree felling on the blanket bog during the construction of the wind farm, i.e. 10-13 tonne wide tracked low ground-bearing pressure excavators fitted with harvesting attachments to cut and trim the trees, and 8-12 tonne rubber-tyred forwarders to gather and stockpile the cut timber logs.

Short-sections of floating road ≈25-35 m long were constructed at Turbines T3 and T19 to access the area for felling. The roads were comprised of 300 mm of crushed rock on a layer of timber brash constructed directly on the surface of the peat. A short section of the existing Coillte track at the met mast between Turbines T6 and T12 was also re-surfaced with an approx. 150 mm thick capping layer of crushed rockfill. Felled timber logs 3 m long were temporarily stockpiled at stacking points adjacent to Turbines T3 and T19, and off the existing Coillte track near the met mast and Turbine T6, as show on Figure 10-41.

The stockpiled logs were periodically collected by Coillte using articulated trucks fitted with a HIAB crane and then transported off site. Approximately half of the timber was transported off site along the access tracks on the wind farm site. The remainder were removed via the existing Coillte tracks to the south.

The conifer plantation at the northwest corner of the wind farm, which is highlighted in green in Figure 10-41, will not be felled. The areas that were clear felled will be re-planted.

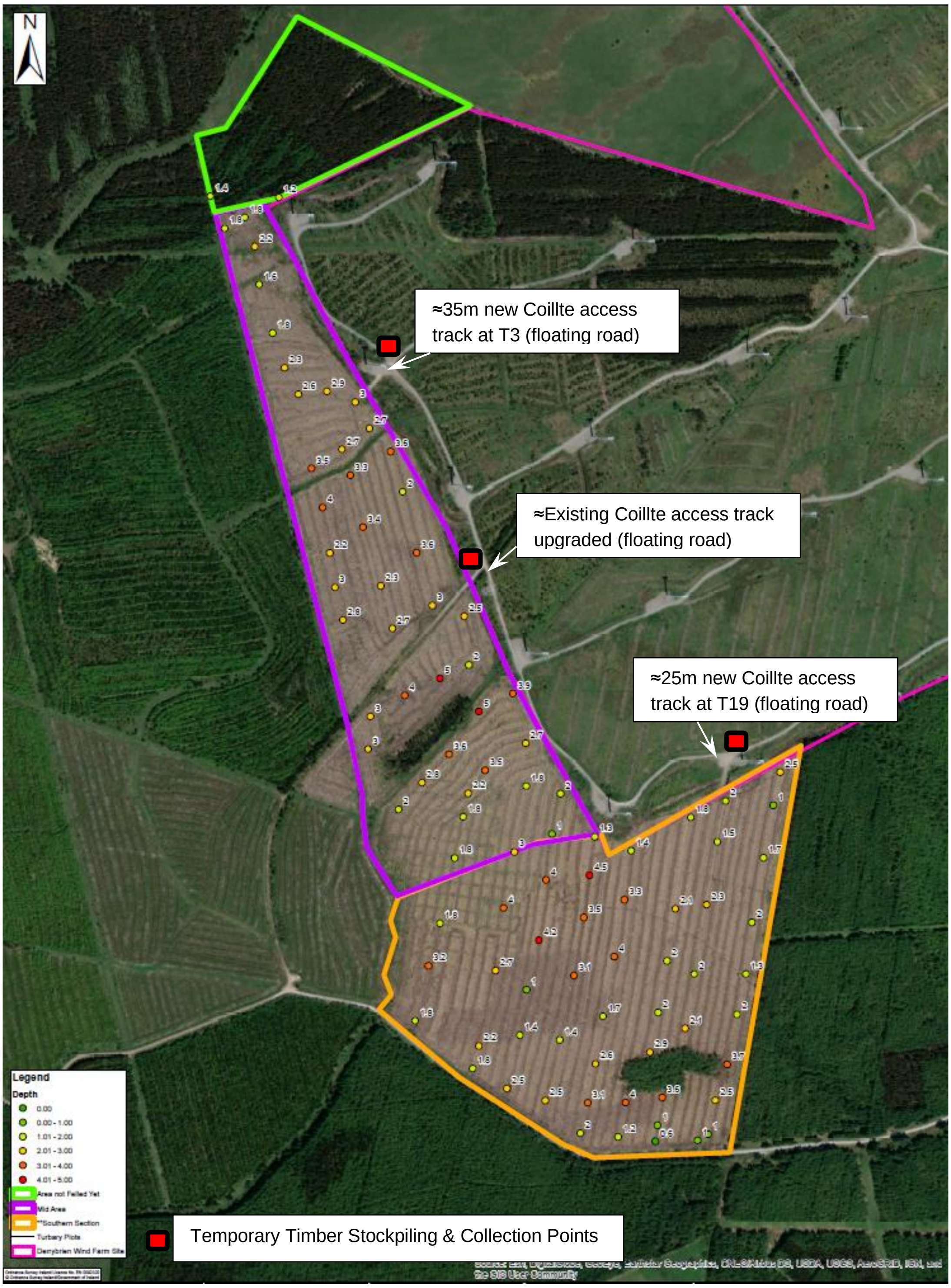


Figure 10-41: Location and extent of tree felling on the west side of the wind farm site in 2018 (including peat depth probes)

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. Therefore, the effect on carbon storage in the peat was **Negligible**.

The surface of the peat was tracked over by the harvesting machines and forwarders operating on the surface of the peat. It was also locally covered by the new sections of floating roads and temporarily timber stockpiling areas. The overall effect that this work had on the peat habitat was **Very Low**.

The duration of the forestry trafficking on the peat was **Temporary** during tree felling. The **Extent** of the impact was in 46 ha of forest where the trees were felled to the west of the wind farm site. The blanket bog in the area has been degraded by forestry and drainage. Therefore, the sensitivity of the receiving soils, geology and land is **Medium** and the significance of the effect of the tree felling on the peat is **Slight**.

<u>Tree Topping on the Wind Farm Site</u>:

None of the areas on the site where trees were felled during construction were re-planted and no additional tree felling was carried out on site between 2006 and 2018. During this time however, some of the timber logs that were felled from the slopes outside the wind farm site were temporarily stockpiled on the site for collection and transport off-site. In 2018 and 2020 some scheduled tree topping was carried out on the site to trim back some of the small trees that had re-established naturally on the slopes where clear felling had taken place. The tree topping was carried out along a corridor within 10 m to either side of the site access tracks in selected areas. The work was carried out using standard LGBP wide tracked harvesters. The small trees were cut down and left in place on the slopes. No forwarders were used. Therefore, the direct impact that this work had on the soils, geology and land was limited to tracking over the surface of the peat where the works were carried out. The effect that this had on the degraded blanket bog was **Very Low** and the significance of the impact was **Slight**.

<u>Remedial works to right a mobile crane that went off the narrow turbary road</u>:
In July 2007 a 250 tonne mobile crane travelling along the narrow turbary road to Turbine T40 to carry out maintenance on the turbine went off the edge of the floating road where there was a soft verge and overturned onto the peat on the downslope side of the road. Righting the crane involved excavating out the section of floating road adjacent to the crane and reconstructing it with granular rockfill supported on the underlying glacial till. The crane was then winched up onto the road using the rockfill as a reaction for the winching loads. The direct impact of this work was limited to the local peat excavation. The effect that this had on the peat was **Very Low** and the significance of the effect was **Slight**. The impact only occurred once.

10.3.2.1.2.2.4 Effects that were Not Significant

The impact of the following site activities did not have a significant effect on soils, geology and land during the operation and maintenance phase of the project between 2006 and 2020:

- Power Generation/Power Transmission
- Maintenance/Repair of Turbines
- Maintenance/repair of substation & control building:
- Maintenance/repair of access tracks
- Maintenance/repair of instrumentation on site

This is because:

- The wind turbine foundations are designed to adequately support the static and dynamic wind loads on rock. Also, all of the transmission lines, electrical equipment and substation were in place and operational by the end of construction. Therefore, power generation and transmission had an imperceptible impact on soils and geology on the site.
- All of the maintenance and repair work carried out on the turbines, substation and control building was carried out from the existing granular hardstanding areas, which were designed to support the live loads from the cranes and service vehicles with negligible impact on the peat or underlying glacial till;
- The maintenance and repair work that was carried out on the site access tracks was carried out along the existing network of roads. No new access tracks were constructed.
- The 150 mm thick capping layer placed on some of the floating roads to upgrade them was imported from off-site quarries and has resulted in additional compression of the peat under the increased load. However, this had a negligible effect on the peat as no further vegetation was damaged. It has slightly increased the volume of peat submerged below the groundwater table, which reduces the rate of carbon release due to natural decomposition – a positive impact on carbon flux.
- The repair work and recalibration carried out on the instrumentation and protective fencing was carried out by hand with negligible effect on the peat.

10.3.2.1.2.3 Stability Impacts (O&M Phase 2006-2020)

This section presents the assessment of stability impacts for the operation and maintenance stage of the wind farm project between 2006 and 2020, i.e. the direct impacts of site activities on the receiving soils, geology and land that had an effect on site stability.

AGL Report No.11-147B-R04 – "*Geotechnical Stability Report & Assessment of Stability Impacts on Soils, Geology and Land*" in Appendix B of this Chapter gives a detailed assessment of the characteristics of the activities carried out on site between 2006 and Q2 2020 and the corresponding impacts on soils, geology and land that had an effect on site stability, particularly in relation to the peat. The results are summarised in Table 10-9.

As discussed in Section 10.2.4.4, due to an improvement in site conditions since construction, Figure 10-35 reflects the reduced likelihood of a peat slide on the site based on the site conditions in 2006 and the range of activities that were carried out during the operation and maintenance phase of the project between 2006 and 2020.

There were no incidents of peat instability on the site related to the wind farm project between 2006 and 2020. Therefore, the **Significance** of the effect in Table 10-9 reflects the probability of a peat failure occurring due to the effect of the stability impact on the peat (e.g. due to the increased shear stresses under applied surcharge loads), as well as the baseline sensitivity of the soils, geology and land potentially impacted by a peat slide, which has been calibrated by the peat failures that occurred on the site during construction, and assessed as **Medium**, as discussed in Section 10.2.1.4.

Many of the site activities had similar effects on the stability of the peat slopes. Therefore, in the following summary, stability impacts have been combined by the characteristics of the impact and the significance of the corresponding effect on soils, geology and land (i.e. to group similar impacts with similar effects). The effects are presented in order of decreasing significance.

10.3.2.1.2.3.1 Significant Effects

None of the impacts of site activities had a **Significant** effect on soils, geology and land with respect to site stability during the operation and maintenance phase of the project between 2006 and 2020.

10.3.2.1.2.3.2 Moderately Significant Effects

The impact of the following site activities had a **Moderately Significant** effect on soils, geology and land with respect to site stability during the operation and maintenance phase of the project between 2006 and 2020:

- Drainage Improvements (Positive Impact)

Table 10-9: Assessment of Stability Impacts – Operation & Maintenance Phase (2006-2020)

Activity	Characteristics of Direct Impact of Site Activities with respect to Site Stability (Stability Impacts)				Assessment of Effect of Stability Impacts on Soils, Geology & Land						Did Peat Failure Occur? (Yes/No)
	Impact	Extent of Impact	Duration	Frequency	Quality of Impact	Possible Extent of a Peat Failure	Probability of Occurrence of a Peat Failure	Effect on Receiving Soils, Geology & Land	Sensitivity of Receiving Soils, Geology & Land	Significance of Effect	
Power Generation	Turbine Foundation Loading on Glacial Till	At turbine locations	Continuous		Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant (Impreceptible)**	**No**
Power Transmission	Eletricity Transmission & Conversion	At Turbines and substation; along buried MV cables on-site & along 110 kV line off-site	Continuous		Neutral	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant (Imperceptible)**	**No**
Maintenance/ Repair of Turbines	Crane Loading on Hardstanding Areas	Hardstanding areas adjacent to turbines	Temporary	Occasional	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**	**No**
	Crane Loading on Floating Roads	Along Floating Roads travelled by Crane	Brief	Occasional	Negative	Small ($100m^2$-$2500m^2$) to Very Large (>10Ha) Peat Slide	Very Low to Low	**Low**	**Medium**	**Slight**	**No**
Maintenance/ Repair of Substation & Control Building	MEWP Loading on Hardstanding Areas	Hardstanding area at Substation site	Temporary	Occasional	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**	**No**
	Service Vehicle Loading on Floating Roads	Along Floating Roads to Substation Site	Brief	Occasional	Slight Negative	Small ($100m^2$-$2500m^2$) to Very Large (>10Ha) Peat Slide	Very Low	**Very Low**	**Medium**	**Slight**	**No**
Maintenance/ Repair of Access Tracks	Increased Capping Load on Floating Roads - Roads Upgrade 2014	Extent of 2014 Floating Road Upgrade Works - ESBI Drawing No.P378015-C-003	Long-Term	Sustained	Negative (Short-term)	Small ($100m^2$-$2500m^2$) to Very Large (>10Ha) Peat Slide	Very Low to Low	**Low**	**Medium**	**Slight (Short Term)**	**No**
					Slight Negative (Medium-Term)	Small ($100m^2$-$2500m^2$) to Very Large (>10Ha) Peat Slide	Very Low	**Very Low**	**Medium**	**Slight (Medium Term)**	**No**
	Increased Capping Load on Floating Roads - Localised Repairs	Localised Sections of Floating Roads (See Section 3.1.4.3)	Long-Term	Sustained	Negative (Short-term)	Small ($100m^2$-$2500m^2$) to Very Large (>10Ha) Peat Slide	Very Low to Low	**Low**	**Medium**	**Slight (Short Term)**	**No**
					Slight Negative (Medium-Term)	Small ($100m^2$-$2500m^2$) to Very Large (>10Ha) Peat Slide	Very Low	**Very Low**	**Medium**	**Slight (Medium Term)**	**No**
Cables & Ducting	Equipment loading on peat during 2017 Fibre-Optic Cable Installation	Along route of new fibre-optic cable ducts (see Figure 3.1)	Temporary	Once	Slight Negative	Small ($100m^2$-$2500m^2$) to Very Large (>10Ha) Peat Slide	Very Low to Low	**Low**	**Medium**	**Slight**	**No**

Table 10-9 (Contd.): Assessment of Stability Impacts – Operation & Maintenance Phase (2006-2020)

Activity	Characteristics of Direct Impact of Site Activities with respect to Site Stability (Stability Impacts)				Assessment of Effect of Stability Impacts on Soils, Geology & Land						Did Peat Failure Occur? (Yes/No)
	Impact	Extent of Impact	Duration	Frequency	Quality of Impact	Possible Extent of a Peat Failure	Probability of Occurrence of a Peat Failure	Effect on Receiving Soils, Geology & Land	Sensitivity of Receiving Soils, Geology & Land	Significance of Effect	
Drainage Improvements	Low ground-bearing machine loading on Peat during Improvement Works	Along site drains at specified locations (see ESBI Geotechnical Inspection Reports)	Temporary	Occasional	Slight Negative	Small ($100m^2$-$2500m^2$) to Very Large (>10Ha) Peat Slide	Very Low to Low	Low	Medium	Slight	No
	Improvement of Groundwater Conditions	Sitewide - particularly upstream of drainage improvements	Long-Term	Sustained	Positive	In areas where drainage works were carried out	Positive Impact - Reduced Probability of a Peat Slide	Medium (Positive)	Medium	Moderate (Positive)	No
	Installation of drain to prevent overtopping of water in Borrow Pit No.3	Along adjacent site access road	Temporary	Once	Slight Positive	Not Applicable - Drain not required	Negligible	Negligible	Medium	Not Significant	No
Instrumentation	Manual repair work to instrumentation and fencing on peat.	At the 4 No. instrumentation logger units	Brief	Once	Slight Negative	Not Applicable	Negligible	Negligible	Medium	Not Significant	No
Forestry (Offsite) Clear Felling	Localised live load surcharge on peat from timber harvesters and forwarders	46ha conifer forest plantation offsite, along the west side of wind farm site	Temporary	Occasional (2016 to 2018)	Negative	Small ($100m^2$-$2500m^2$) to Very Large (>10Ha) Peat Slide	Low	Medium to Low	Medium	Slight	No
Forestry (Offsite) New Access Tracks (Floating) & Re-Surfacing of Existing Coillte Track	Small additional dead load surcharge on the peat	Short sections (25-35m) of new floating road at T3 and T19 & re-surfacing approx. 50m of existing Coillte track near T6	Permanent	Once	Negative	Small ($100m^2$-$2500m^2$) to Very Large (>10Ha) Peat Slide	Low	Medium to Low	Medium	Slight	No
Forestry (Offsite) Timber Stockpiling on WF site	Localised surcharge on peat from timber stockpile	Adjacent to Floating Road near Turbines T3, T6 & T19	Temporary	Occasionally (2016-2018)	Negative	Small ($100m^2$-$2500m^2$) to Very Large (>10Ha) Peat Slide	Low	Medium to Low	Medium	Slight	No
Forestry (Onsite) - Tree Topping	Low ground bearing pressure equipment loading on peat	10 m either side of access track in areas specified for 2018 (see Section 3.17.4)	Temporary	Once	Slight Negative	Small ($100m^2$-$2500m^2$) to Very Large (>10Ha) Peat Slide	Very Low to Low	Low	Medium	Slight	No
Mobile Crane Going off the Turbary Road While Travelling	Localised surcharge on Peat from overturned crane.	Along turbary road near Turbine T40	Temporary	Once	Negative	Small ($100m^2$-$2500m^2$) to Very Large (>10Ha) Peat Slide	Low	Medium to Low	Medium	Slight	No
	Reaction loads on rockfill road from winching during crane righting	Along turbary road near Turbine T40	Brief	Once	Slight Negative	Small ($100m^2$-$2500m^2$) to Very Large (>10Ha) Peat Slide	Negligible	Negligible	Medium	Not Significant	No

Drainage Improvements (Positive Impact) – As discussed in Section 10.3.2.1.1.3.2, poor drainage is a recognised contributory risk factor for peat instability as it can lead to elevated hydrostatic uplift pressures below the peat, or hydraulic surcharge pressures in the existing drainage network of pipes and seepage channels within the peat, both of which can contribute to peat slides. The improved drainage has reduced this risk on the wind farm site. In the medium to long-term, improved drainage would also have increased the shear strength of the peat where the groundwater table was lowered (i.e. the peat compresses and dries out where the groundwater table is lowered, increasing in shear strength in the process). This has also had a positive impact on the peat with respect to site stability.

The drainage improvements that were carried out on site during the operation and maintenance period between 2006 and 2020 were primarily required to improve the performance and efficiency of the existing drainage network without significantly increasing the capacity of the system. However, relative to the baseline condition in 1998 the impact of the improved drainage network that was constructed on the site was **Permanent and Sustained** and it had a **positive impact** on the peat with respect to site stability. Therefore, the effect of the drainage improvements on the peat was **Medium,** and of **Moderate** significance.

10.3.2.1.2.3.3 Slightly Significant Effects

The following impacts of site activities had a **Slightly Significant** effect on soils, geology and land with respect to site stability during the operation and maintenance phase of the project between 2006 and 2020:

- The increased dead load on the peat from the additional layer of granular rockfill that was placed on the floating roads that were upgraded or repaired;
- The dead load surcharge on the peat from the short sections of floating roads constructed at Turbines T3 and T19 to access the conifer forests at the west end of the wind farm site for clear-felling;
- The live load surcharge of maintenance and repair vehicles, tree-felling equipment and mobile cranes on the floating roads;
- The live load surcharge from light mechanical equipment operating on the intact peat slopes, including:
    - Wide tracked 10-13 tonne LGBP excavators carrying out drainage improvements.
    - Wide tracked 10-13 tonne LGBP excavators with harvester attachments used for felling trees and tree topping;
    - 8-12 tonne rubber-tyred forwarders used for gathering and stockpiling felled timber;
    - The mole-trench machine used for installation of cable ducts for the new fibre-optic cables;

- The localised temporary dead load surcharge on the peat from the stockpiled logs.
- The localised live load surcharge on the peat from the crane that overturned near Turbine T40.

Additional dead load on the floating roads: In 2014 4.5 km of the floating roads across the site were upgraded with an additional layer of geogrid reinforcement and 150 mm of imported Class 6F2 crushed rock granular capping material blinded with a nominal 20 mm thick layer of fine gravel (0-6 mm). The works were carried out in areas where the condition and performance of the road had deteriorated significantly since the completion of the wind farm. In some cases, this was due to the basal layer of trees rotting and breaking over relatively deep very soft peat.

The additional thickness of granular fill was kept to a minimum to minimise the additional dead load surcharge on the peat (≈3.2 kN/m^2). Analyses were also carried out to demonstrate that the additional load had only a minor effect on the stability of the road, which was within its design capacity. It was also proportional to the increase in undrained shear strength that would have already occurred in the underlying peat as it consolidated (compressed) under the weight of the original road.

Between 2016 and 2018 Coillte also re-surfaced a short section (≈50 m) of access track on the west side of the wind farm site with an additional 150 mm of crushed rock granular fill to provide access for forestry equipment.

The probability of a peat slide due to the increase in shear stresses in the peat from the additional layer of capping material and surfacing on the floating roads was **Very Low to Low** with the higher risk associated with the sections of the site where there was a higher likelihood of a peat slide based on the site characteristics (see Figure 10-35). The effect of the increased dead load on the stability of the peat was **Low** and the Significance of the effect was **Slight**.

Additional dead load on peat from of new (short) sections of floating roads for access to forestry at west end of windfarm site: Between 2016 and 2018 short-sections of floating road ≈25-35 m long were constructed at Turbines T3 and T19 to provide access for forestry harvesters and forwarders to the area off-site to the west for clear-felling of the conifer plantations. The roads were comprised of 300 mm of crushed rock on a layer of timber brash constructed directly on the surface of the peat. The tracks were only constructed over a short length to avoid damage to the electrical cables on the wind farm site. The thickness of rockfill was kept to a minimum so that the applied dead load surcharge on the peat was only approximately 6kPa, which is less than the dead weight of a layer of peat 1.0 m thick. A short (50 m) section of an existing Coillte access track near the met mast at T6 was also re-surfaced with a 150 mm thick layer of granular rockfill, which would apply a small additional load of 3 kPa on the underlying peat.

The probability of a peat slide occurring due to the increase in shear stresses in the peat under the small additional surcharge load from the new sections of floating roads and from the additional surfacing layer on the existing Coillte track was **Low**. Therefore, the effect of the increased dead load on the stability of the peat was **Medium to Low** and the Significance of the effect was **Slight**.

Live load surcharge on the floating roads: All of the mobile cranes and service vehicles accessing the turbines and substation during the O&M phase between 2006 and 2020 travelled along the existing site access tracks which were designed, tested and certified for the corresponding maximum live load surcharge. In addition to the tests that were carried out during construction, full scale proof tests were carried out on all of the floating roads except the turbary road in December 2011 and again after sections of the floating roads were upgraded in 2014. The 2014 tests were carried out using a large mobile crane with additional ballast to simulate the maximum axle load and live load surcharge from the crane that was used to erect the turbines. Therefore, the probability of a peat slide occurring as a result of the live load surcharge on the floating roads was **Very Low to Low,** the effect of the load on the stability of the peat was **Low** and the Significance of the effect was **Slight**.

Construction Traffic Live Load Surcharge on Peat: Very little work was carried out on the intact peat slopes within the wind farm site during the operation and maintenance phase of the project between 2006 and 2020. It was limited to the excavators that were periodically carrying out drainage improvements, the mole trench machine that was used for the installation of the cable ducts for the new fibre-optic cables, and the 10-tonne Hitachi 100 harvesters that were used for tree topping. All of these machines were light or low ground bearing pressure (LGBP) wide-tracked machines suitable for working on the peat. Therefore, the risk of a peat slide under the localised live load surcharge was **Very Low to Low**, the effect of the load on the stability of the peat was **Low**, and the Significance of the impact was **Slight**.

Between 2016 and 2018 trees were clear-felled for the Project over an area of approximately 46 ha in the mature conifer plantations on the west side of the wind farm, just outside the site boundary, as shown in Figure 10-41. The trees were felled by experienced contractors working for Coillte using the same standard forestry equipment that was used for tree felling on the blanket bog during the construction of the wind farm, i.e. 10-13 tonne wide tracked low ground-bearing pressure excavators fitted with harvesting attachments to cut and trim the trees, and 8-12 tonne rubber-tyred forwarders to gather and stockpile the cut timber logs.

The live load surcharge from these types of equipment was localised and spread out over the surface of the peat to prevent concentrated loading so that the risk of a peat slide was generally **Low**. Therefore, the effect of the live load surcharge on the peat was **Medium to Low**, and the significance of the effect was **Slight**.

No peat slide occurred due to equipment operating on the peat during the operation and maintenance stage of the project between 2006 and Q2 2020.

<u>Live Load Surcharge from Stockpiled Timber</u>: No further clear felling of conifer plantations was carried out on the wind farm site by Coillte after construction. However, when the trees were clear felled from the conifer plantation outside the site boundary to the west between 2016 and 2018 approximately half of the trees were temporarily stockpiled within the wind farm at stacking points adjacent to Turbines T3 and T19, and along the Coillte track near the met mast at Turbine T6, as shown on Figure 10-41. Plate 10-3 shows an image of the stockpile near T6 in May 2017, as noted in the ESBI site inspection report from 2017 (Document No. P378015-F105-016-R-0005, dated 6th October 2017).

Plate 10-3: Felled timber from an adjacent plantation stockpiled on the peat within the wind farm site near Turbine T6 in May 2017 (ESBI, 2017)

The 3 m long timber logs were typically stockpiled to a height of 2.5-3.0 m on the intact peat slopes over a length of about 20 m along the road. This is equivalent to a live load surcharge of 12.5-15.0 kN/m^2 over the footprint of the stockpile. The stockpiles were removed from the site periodically by Coillte, so the localised loading was **short-term**. The effect of the surcharge load on the stability of the peat was **Medium to Low** and the significance of the effect was **Slight**.

<u>Remedial works to right a mobile crane that went off the narrow turbary road</u>: Where the 250 tonne mobile crane went off the road and overturned onto the peat on the downslope side of the turbary road near Turbine T40 it would have applied a load of 60 tonnes over an area of approximately 15.0 x 4.0 m on the peat, which is equivalent to a surcharge of about 10 kN/m^2. This is similar to the weight of 1.0 m of excavated peat over the same area, although the load from the overturning crane would have had a dynamic component. The probability of a peat slide occurring under the crane load in this part of the site was **Low** (see Figure 10-35**)**. Therefore, the effect of the load on the stability of the peat was **Medium to Low** and the Significance of the effect was **Slight**.

10.3.2.1.2.3.4 Effects that were Not Significant

The following site activities and corresponding stability impacts did not have a significant effect on the receiving soils, geology and land with respect to site stability during the operation and maintenance phase of the project between 2006 and 2020:

- Power Generation & Transmission.
- Live loading from maintenance and repair vehicles on the granular hardstanding areas at the turbines and substation;
- Winching loads on the reconstructed access track at T40 to right the overturned crane;
- Installation of drain at Borrow Pit 3 to prevent groundwater overtopping the access road into the site; and
- Minor repairs/recalibration of instrumentation.

This is because:

- The wind turbine foundations are designed to adequately support the static and dynamic wind loads on rock. Also, all of the transmission lines, electrical equipment and substation were in place and operational by the end of construction. Therefore, the impact of the power generation and transmission had an imperceptible effect on site stability.
- The granular hardstanding areas at the turbines and substation are designed to support the applied live load surcharges from the mobile cranes and the maintenance and repair vehicles on competent cohesive glacial till and rock below the peat. None of the live loads exceeded the maximum loads applied during construction and steel outrigger pads were used to spread out the concentrated loads from the mobile cranes.
- Similarly, the reconstructed section of access track adjacent to the overturned crane near Turbine T40 was constructed on glacial till below the peat so that it could provide adequate reaction to the winching loads to right the crane.
- At Borrow Pit No.3 a drain was installed to prevent the rising water levels from flooding the site access track at the entrance to the pit. However, the groundwater level stabilised below the level of the road so that the drain was not required.
- The repair work and recalibration carried out on the instrumentation and protective fencing was carried out by hand with negligible impact on the peat.

10.3.2.2 Impacts which are occurring – since Construction & O&M Period 2006 to 2020

This section of the chapter assesses significant effects of impacts from the construction, operation and maintenance stages of the wind farm from 2003 to 2020 that are still occurring at the end of 2020. The effects of direct impacts on soils, geology and land on the site are assessed in Section 10.3.2.2.1, and the effects of stability impacts, particularly in relation to peat stability, are assessed in Section 10.3.2.2.2.

10.3.2.2.1 Impacts which are occurring – Direct Impacts

The significant effects of direct impacts from the construction, operation and maintenance stages of the wind farm from 2003 to 2020 that are still occurring at the end of 2020 include:

- Decomposition of excavated peat (carbon flux)
- Groundwater lowering and accelerated peat decomposition due to drainage improvements

Decomposition of Excavated Peat in Peat Storage Areas: All of the peat that was excavated from the site of the turbines, crane hardstandings, substation, borrow pits, anemometers and site compound was stored on-site. The total estimated volume of peat that was excavated was approximately 160,000m^3 (Table 10-7), which was placed in material sidecast areas and peat repositories on the intact peat slopes, and within bunded storage areas in the borrow pits. In Section 10.3.2.1.1.2.1 it was concluded that the effect that this had on soils, geology and land relative to the baseline site conditions was of **Moderate** significance because of the loss of peat habitat and the corresponding release of stored carbon in the peat. The release of stored carbon is primarily due to the increased rate of decomposition of the disturbed peat above the water table as it dries out on exposure to the atmosphere on the slopes in the material storage areas. This is a **Long-Term** effect as it occurs slowly over time. Therefore, it is likely to be still occurring at the end of 2020, albeit at a lower rate.

Plate 10-4 shows a typical image of the peat repositories at the end of 2018. Since the end of construction, the surface layer of excavated peat has settled significantly into the slope as the underlying intact peat has compressed under the dead load surcharge from the excavated peat. This has partially compensated for the increased rate of decomposition in the excavated peat on the surface of the slope because more of the underlying intact peat has settled below the water table, where the rate of decomposition is significantly lower. Furthermore, the surface of the excavated peat in the repository areas has re-vegetated so that a new rate of carbon flux has been established with the decomposition and accumulation of peat on the slopes. Therefore, the net rate of carbon release has significantly reduced.

Plate 10-4: Peat Repository near turbine T48 at the end of 2018

In Section 10.3.2.1.1.2.1 the effect of the peat excavations on carbon storage was assessed by conservatively assuming that 100% of the excavated peat and stored carbon will be lost due to decomposition and erosion, which is consistent with standard practice for calculating the carbon balance for wind farms. In many of the peat storage areas it is evident that some of the excavated peat is still in place on the slopes and in the bunded peat repository areas in the borrow pits. Therefore, on this site it is conservative to assume that all of the stored carbon in the excavated peat will be released to the atmosphere as CO_2 over the life cycle of the project.

Groundwater lowering due to drainage improvements: During construction, some drains were excavated in the peat to provide drainage for the turbine foundations and to improve the control of groundwater and surface runoff in some areas of poor drainage and high water table. There was an extensive existing network of drains on the site prior to the construction of the wind farm, particularly for the turbary plots on the east side of the site. Therefore, in Section 10.3.2.1.1.2.2 it was concluded that the effect that the additional drainage had on the peat relative to the baseline site conditions was of **Slight** significance because the new drains resulted in further lowering of the groundwater level in the peat in the areas of improved drainage. Groundwater lowering also effects the carbon flux in the peat because the rate of decomposition of peat is significantly higher above the water table.

Electronic piezometers were installed to monitor water levels in the peat at locations around the perimeter of the site near Turbines T2, T18, T34 and T49/T50.

Groundwater levels were monitored in the piezometers over a period of 8 years between 2004 and 2012 before the instruments were decommissioned. Figure 10-42 shows the readings from the piezometers at T2, T18 and T34 up to November 2011. The readings from the piezometers at T49/T50 are not plotted because they malfunctioned after installation.

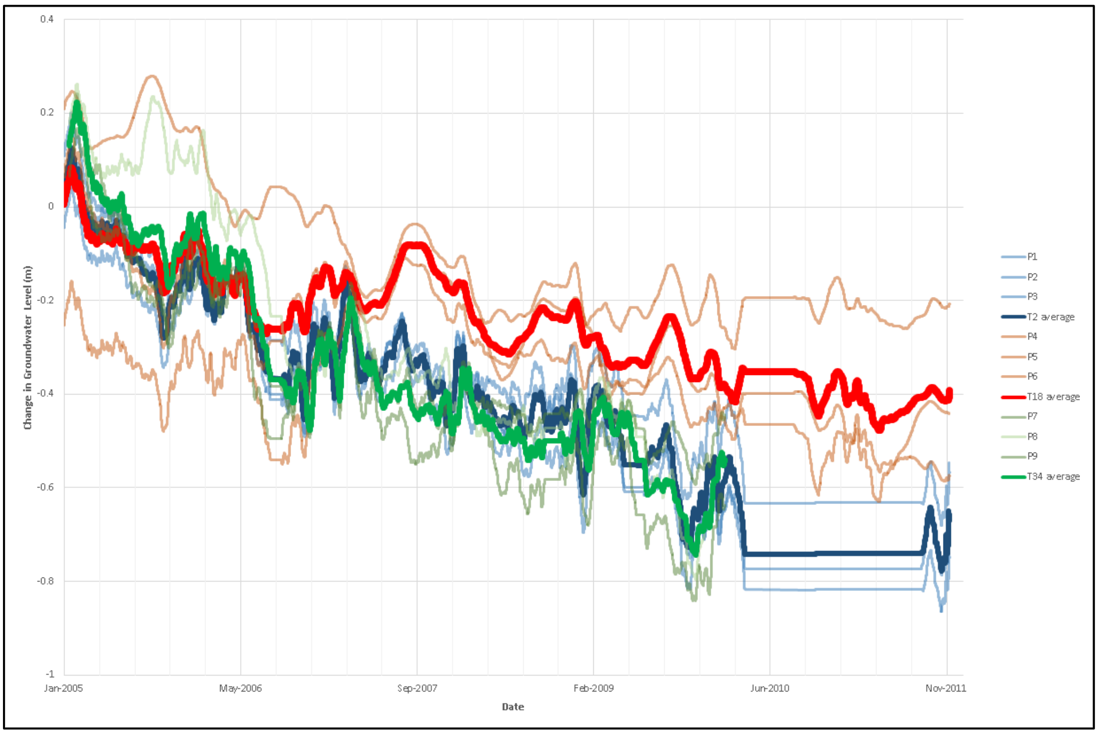


Figure 10-42: Water level readings from vibrating wire piezometers (January 2005 to November 2012)

The short-term regular fluctuation in the data reflects seasonal fluctuations in groundwater level as well as changes in atmospheric pressure, which directly affect the water level readings as they are based on pressure. Nevertheless, the results indicate that, on average, between December 2005 and November 2011 the groundwater level in the peat gradually dropped by about 0.40 m at Turbine T18 in the SW corner of the wind farm site, and by about 0.75 m at T2 and T34 in the NW corner of the site and in the turbary plots at the east end of the site, respectively.

This level of groundwater lowering would not have occurred uniformly across the wind farm site. As discussed in Section 10.3.2.1.1.2.2, the permeability of the peat is low, therefore, the extent of drawdown from the shallow open drains would be limited to within a few meters of the drains rather than generally across the site. However, the new drains that were installed during construction would have increased the rate of surface runoff from the wind farm site, which would have reduced the rate of infiltration into the peat. Over time this has resulted in a gradual lowering of the groundwater levels on the site. The impact would be greatest on the steeper slopes at the downslope perimeter of the site, where the piezometers were located. Less drawdown would be expected at the upper levels of the wind farm and on the terraces of flat or gently sloping ground across the wind farm site where surface water accumulates.

During the operation and maintenance phase of the wind farm between 2006 and 2020, maintenance works were carried out to improve the performance and efficiency of the drainage network. However, the capacity of the system was not significantly increased and most of the works were completed by 2012. The groundwater levels in the piezometers had not stabilised fully by the end of 2011, but they did show a reduced rate of drawdown towards the end of the monitoring period.

It will take many years for the groundwater in the peat to stabilise at new equilibrium levels across the site. However, most of the major drainage works were completed during construction and during the maintenance period prior to 2012. Therefore, the majority of the groundwater lowering would have occurred by the end of 2020 and any further changes over the remaining design life of the wind farm should be minor.

None of the drains have been blocked or infilled. Therefore, the effect of the lowered groundwater level on the peat is still occurring. The rate of decomposition of peat is significantly higher in the aerobic conditions above the water table and peat releases stored carbon as CO_2 as it decomposes. Therefore, there has been a change in the carbon flux in the degraded blanket bog on the site, with an increase in the rate of depletion of stored carbon. It will take time for the carbon flux to reach a new equilibrium for the lowered groundwater levels. This is a long-term effect that would be still occurring at the end of 2020.

A more detailed assessment of the impact of drainage in the project area is presented in Chapter 11 – Hydrology and Hydrogeology.

10.3.2.2.2 Impacts which are occurring –Stability Impacts

The significant effects of stability impacts from the construction, operation and maintenance stages of the wind farm from 2003 to 2020 that are still occurring at the end of 2020 are related to:

- Surcharge loading on the peat from the floating roads, material sidecast areas and peat repository sites that were left in place at the end of construction; and
- Groundwater lowering due to drainage improvements

Surcharge loading on the peat: During construction dead load surcharges were applied to the intact peat slopes from:

- the construction of the floating roads;
- the sidecasting of peat and glacial till excavated from the turbine foundations that were completed prior to the peat slide; and
- the controlled disposal of up to 1.0 m of peat excavated from the site of the remaining turbines, crane hardstanding areas, substation and anemometers in designated peat repository areas after the peat slide.

The initial loading on the intact peat slopes from the floating roads and material sidecast areas was assessed as having a **Significant** effect on the peat with regard to site stability for the construction stage of the project.

No peat failures occurred during the construction of the floating roads. However, the large peat slide on the 16th October 2003 occurred as material excavated from the foundation for Turbine T68 was being sidecast on the slopes downslope from the turbine. There was also a small scale peat slide where material was sidecast on the slopes adjacent to Turbine T17, and local bearing failure was noted in the peat under the excavated material that was sidecast at Turbines T23, T29 and T66.

Strict controls were implemented in the selection and usage of the peat repository areas for disposing of peat excavated after the slide. Therefore, they were assessed as having a **Slight** effect on peat stability and no peat failures occurred as a result of the loading.

With the exception of the sidecast areas at T18, T34, T23, T29 and T66, where some of the material was removed due to concerns with the local bearing failure in the peat, all of the remaining dead load surcharges from the floating roads, material sidecast areas and peat repository sites were left in place at the end of construction as a permanent and sustained load on the intact peat slopes. The dead load surcharge on the floating roads was increased slightly where they were upgraded with an additional 150 mm thick layer of capping material in 2014.

The effect of these dead load surcharges on the peat would therefore still be occurring at the end of 2020. However, the highest risk for peat instability under the surcharge loads was in the short-term undrained condition at the time that the material was placed on the slopes during construction. Over time, the undrained shear strength of the underlying peat increased as it consolidated and compressed under the applied loads, which has significantly reduced the likelihood of a peat slide. The increase in shear strength that occurs in cohesive soils such as peat when they are consolidated under an increased load is an established engineering principle and it was verified by in-situ testing in the peat under the floating roads on the site. Full scale proof load testing was also carried out on all of the floating roads in 2018 to verify their capacity and performance under the design crane loads.

As discussed in Section 10.2.4.4, due to an improvement in site conditions, Figure 10-36 reflects the reduced likelihood of a peat slide on the site in 2020 based on the site characteristics and the activities that are likely to be carried out as part of the wind farm project during the remaining operation and maintenance period and during decommissioning in circa 2040. This does not represent a change in the baseline condition of the receiving environment. In the assessment there is no change to the possible extent of a peat slide or the baseline sensitivity of the receiving soils, geology and land that could be impacted by a slide, which has been assessed as **Medium** based on the site conditions in 1998, prior to construction.

By the end of Q2 2020 primary consolidation of the peat would be complete under the existing dead load surcharge of the floating roads, material sidecast areas and peat repositories that were stable and intact at the end of construction, including the additional load on the floating roads from the 2014 upgrade programme. Therefore, with the corresponding increase in undrained shear strength in the underlying peat, the likelihood of a peat slide under the surcharge loads has reduced to **Negligible,** so that by now the effect of the surcharge on the peat with regard to site stability is **Not Significant**.

Drainage Improvements in the peat: As discussed in Section 10.3.2.1.1.3.2, poor drainage is a recognised contributory risk factor for peat instability as it can lead to elevated hydrostatic uplift pressures below the peat, or hydraulic surcharge pressures in the existing drainage network of pipes and seepage channels within the peat during periods of heavy or sustained rainfall. The improved drainage has reduced this risk on the wind farm site. In the medium to long-term, improved drainage would also have increased the shear strength of the peat where the groundwater table was lowered (i.e. the peat compresses and dries out where the groundwater table is lowered, increasing in shear strength in the process). This has also had a positive impact on the peat with respect to site stability.

Therefore, the improved drainage network that was constructed on the site for the wind farm is a **Permanent** and **Sustained** impact on groundwater levels that has had a **positive** stability impact on the peat relative to the baseline conditions on site in 1998, prior to construction. The effect of the drainage improvements on the stability of the peat has been assessed as **Medium,** and of **Moderate** significance.

As discussed in Section 10.3.2.2.1, it will take many years for the groundwater in the peat to stabilise at new equilibrium levels across the site. However, the majority of the groundwater lowering would have occurred by the end of 2020 and any further changes would be expected to be minor. None of the drains have been blocked or infilled. Therefore, relative to the baseline site conditions, the effect would still be occurring on the site at the end of 2020.

10.3.2.3 Impacts which are likely to occur

10.3.2.3.1 Operation and Maintenance Phase: 2020 to End of Operation (c. 2040)

This section of the report assesses the impact of site activities during the remaining operation and maintenance stage of the wind farm project between 2020 and the end of operation in circa 2040.

Section 10.3.2.3.1.1 gives a summary of the activities that are likely be carried out on site during this period that could have an impact on soils, geology and land. The **direct impact** of these is assessed in Section 10.3.2.3.1.2.

The **stability impacts** are assessed in Section 10.3.2.3.1.3 i.e. the direct impacts that site activities could have on soils, geology and land that could have an effect on site stability, potentially causing a peat failure.

10.3.2.3.1.1 Site Activities – Operation & Maintenance Stage: 2020 - c. 2040

The primary works that are likely to be carried out on the wind farm site during this period that could have an impact on soils, geology and land include the following:

- Power Generation and Transmission
- Maintenance/Repair of Turbines
- Maintenance/Repair of Substation & Control Building
- Maintenance/Repair of Access Tracks
- Cables & Ducting Improvements
- Drainage Improvements
- Forestry – Tree Topping & Tree Felling
- Widening of the Turbary Road to T45

This is based on records of works carried out on site during the operation and maintenance period prior to 2020 as well as works that are currently scheduled or likely to occur.

Chapter 2 and AGL Report No. 11-147B-R04 – "*Geotechnical Stability Report & Assessment of Site Stability Impacts on Soils, Geology and Land*" in Appendix B of this Chapter give a detailed summary of the construction activities associated with each of these works. The following is an assessment of the impact of these activities on soils, geology and land during the operation and maintenance phase of the wind farm project between 2020 and c. 2040.

10.3.2.3.1.2 Direct impacts of project (O&M Phase 2020-2040)

This section addresses the direct impact of the site activities on soils, geology and land during the operation and maintenance phase of the wind farm project between 2020 and c2040.

10.3.2.3.1.2.1 Significant Effects

None of the direct impacts of site activities during the operation and maintenance phase of the project between 2020 and c. 2040 will have a **Significant** effect on soils, geology and land.

10.3.2.3.1.2.2 Moderately Significant Effects

None of the direct impacts of site activities during the operation and maintenance phase of the project between 2020 and c. 2040 will have a **Moderately Significant** effect on soils, geology and land.

10.3.2.3.1.2.3 Slightly Significant Effects

The direct impact of the following site activities will have a **Slightly Significant** effect on soils, geology and land during the operation and maintenance phase of the project between 2006 and 2020:

- Forestry – Tree Topping
- Widening of Turbary Road to Turbine T45

<u>Forestry – Tree Topping</u>: None of the areas on the site where trees were clear felled during construction were re-planted. However, some small trees have re-established naturally on the slopes. Therefore, between 2020 and 2040 tree topping and tree felling will be carried out periodically on the site to trim back small trees on the slopes. The work will be carried out using light LGBP wide-tracked harvesters operating on the peat. The small trees will be cut down and left in place on the slopes so that no forwarders will be required. The direct impact that this work will have is the damage to the surface of the peat habitat where machines operate on the intact surface of the peat. Therefore, the effect that this work will have on the degraded blanket bog will be **Very Low** and the significance of the effect will be **Slight**. The works will generally be carried out within a distance of 10m to either side of the site access tracks.

<u>Widening of Turbary Road to Turbine T45</u>: It is not currently proposed to widen the narrow turbary road to Turbine T45 as part of the scheduled maintenance programme for the wind farm. However, if it becomes necessary to widen the road to provide safe access to the turbines for a large mobile crane, then this will involve constructing an additional 2-3 m width of floating road directly on the surface of the intact peat on the upslope side of the existing road. Timber or bog mats will be laid on the peat longitudinally along the widened section of the road and then the full width of the road will be capped with a 150 mm thick layer of crushed rock granular fill reinforced with a layer of geogrid. The effect that this will have on the degraded bog in the turbary area will be **Very Low** and the Significance of the effect will be **Slight**.

10.3.2.3.1.2.4 Effects that are Not Significant

The direct impact of the following site activities will not have a significant effect on soils, geology and land during the remaining operation and maintenance phase of the project up to c. 2040:

- Power Generation/Power Transmission
- Maintenance/Repair of Turbines
- Maintenance/repair of substation & control building:
- Maintenance/repair of access tracks
- Cables & Ducting Improvements
- Drainage Improvements

This is because:

- The wind turbine foundations are designed to support the static and dynamic wind loads, and electricity transmission through the existing cable and substation network will have an imperceptible effect on soils and geology.
- All of the maintenance and repair work on the turbines, substation and control building will be carried out from the existing granular hardstanding areas, which are designed to support the live loads from the mobile cranes and service vehicles with negligible effect on the peat or underlying glacial till.
- The full-scale serviceability and proof load tests that were carried out on the floating roads in 2018 confirmed that they are currently in very good condition and perform very well under the design loads from the vehicles and mobile cranes that will be used for the maintenance and repair work on the turbines, substation and control building. Therefore, it is not anticipated that the roads will require any significant upgrade or maintenance works. Any remaining works will be limited to localised resurfacing, repairs, or infilling of potholes, which will have a negligible effect on the peat or underlying glacial till.
- No new cable or duct installations are anticipated or scheduled for the remaining operational life of the wind farm. Any works over the remaining operational life of the wind farm will be limited to localised repairs to existing cables and ducts, if required.
- No significant drainage improvements are anticipated or scheduled for the site, and any work on the existing network over the remaining design life of the wind farm will be limited to a residual low level of general maintenance to maintain the existing capacity which will have a negligible effect on soils and geology.

10.3.2.3.1.3 Stability Impacts (O&M Phase 2020-c2040)

This section presents the assessment of stability impacts for the operation and maintenance stage of the wind farm project between 2020 and c.2040, i.e. the direct impacts of site activities on the receiving soils, geology and land that had an effect on site stability.

AGL Report No. 11-147B-R04 – "*Geotechnical Stability Report & Assessment of Site Stability Impacts on Soils, Geology and Land*" in Appendix B of this Chapter gives a detailed assessment of the characteristics of the activities that are likely to be carried out on site over the remaining operation and maintenance period and the corresponding impacts on soils, geology and land that had an effect on site stability, particularly in relation to the peat. The results are summarised in Table 10-10.

As discussed in Section 10.2.4.4, due to continued improvement in site conditions since construction, Figure 10-36 reflects the reduced likelihood of a peat slide on the site based on the site conditions in 2020 and the range of activities that are likely to be carried out during the remaining operation and maintenance phase of the project between 2020 and 2040.

Therefore, the **Significance** of the effect on Table 10-10 reflects the probability of a peat failure occurring due to the effect of the stability impact on the peat (e.g. due to the increased shear stresses under applied surcharge loads), as well as the baseline sensitivity of the soils, geology and land potentially impacted by a peat slide, which has been calibrated by the peat failures that occurred on the site during construction, and assessed as **Medium**, as discussed in Section 10.2.1.4.

Many of the site activities had similar effects on the stability of the peat slopes. Therefore, in the following summary, stability impacts have been combined by the characteristics of the impact and the significance of the corresponding effect on soils, geology and land (i.e. to group similar impacts with similar effects). The effects are presented in order of decreasing significance.

Table 10-10: Assessment of Stability Impacts: Operation & Maintenance Phase (2020 to End of Operation (c.2040))

Activity	Characteristics of Direct Impact of Site Activities with respect to Site Stability (Stability Impacts)					Assessment of Effect of Stability Impacts on Soils, Geology & Land					
	Impact	Probability of Occurrence (Impact)	Extent of Impact	Duration	Frequency	Quality of Impact	Possible Extent of a Peat Failure	Probability of Occurrence of a Peat Failure	Effect on Receiving Soils, Geology & Land	Sensitivity of Receiving Soils, Geology & Land	Significance of Effect
Maintenance/ Repair of Turbines	Crane Loading on Hardstanding Areas	Likely	Hardstanding areas adjacent to turbines	Temporary	Occasional	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**
	Crane Loading on Floating Roads	Likely	Along Floating Roads travelled by Crane	Brief	Occasional	Negative	Small (100m^2-2500m^2) to Very Large (>10Ha) Peat Slide	Very Low	**Very Low**	**Medium**	**Slight**
Maintenance/ Repair of Substation & Control Building	MEWP Loading on Hardstanding Areas	Likely	Hardstanding area at Substation site	Temporary	Occasional	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**
	Service Vehicle Loading on Floating Roads	Likely	Along Floating Roads to Substation Site	Brief	Occasional	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**
	Crane or Heavy Transporter Loading on Floating Roads	Low	Along Floating Roads to Substation Site	Brief	Very Rare	Negative	Small (100m^2-2500m^2) to Very Large (>10Ha) Peat Slide	Very Low	**Very Low**	**Medium**	**Slight**
Maintenance/ Repair of Floating Roads	Increased Capping Load on Floating Roads - Localised Repairs, Re-surfacing & Pothole Filling	Possible	Localised Sections of Floating Roads, as required.	Long-Term	Sustained	Negative (Short-term)	Small (100m^2-2500m^2) to Very Large (>10Ha) Peat Slide	Very Low to Low	**Low**	**Medium**	**Slight (Short Term)**
						Slight Negative (Medium-Term)	Small (100m^2-2500m^2) to Very Large (>10Ha) Peat Slide	Very Low	**Very Low**	**Medium**	**Slight (Medium Term)**
Widening of Turbary Road	Additional dead and live load surcharge on peat on upslope side of existing floating road	Possible	Turbary Rd.betwen Turbine T31 and T45	Permanent	Sustained	Negative	Small (100m^2-2500m^2) to Very Large (>10Ha) Peat Slide	Very Low to Low	**Low**	**Medium**	**Slight**
Cables & Ducting	Low-ground bearing machine loading on peat to carry out localised excavations for repairs	Low	Along route of existing cables and ducts	Temporary	Rare	Slight Negative	Small (100m^2-2500m^2) to Very Large (>10Ha) Peat Slide	Very Low	**Very Low**	**Medium**	**Slight**
Drainage Improvements	Low ground-bearing machine loading on peat to carry out localised repairs	Likely	Localised sections of existing drainage network, as required.	Temporary	Occasional	Slight Negative	Small (100m^2-2500m^2) to Very Large (>10Ha) Peat Slide	Very Low	**Very Low**	**Medium**	**Slight**
	Improvement of Groundwater Conditions (Groundwater lowering, draining of ponded surface water)	Likely	Sitewide - where drainage improvements were implemented	Long-Term	Sustained	Positive	N/A	Positive Impact - Reduced Probability	**Medium (Positive)**	**Medium**	**Moderate (Positive)**
Forestry - Tree Topping	Low ground bearing pressure equipment loading on peat	Likely	10 m either side of access track in specified areas on muti-annual maintenance plan	Temporary	Occasional - Summer/Autumn	Slight Negative	Small (100m^2-2500m^2) to Very Large (>10Ha) Peat Slide	Very Low	**Very Low**	**Medium**	**Slight**

10.3.2.3.1.3.1 Significant Effects

None of the impacts of site activities will have a **Significant** effect on soils, geology and land with respect to site stability during the operation and maintenance phase of the project between 2020 and c. 2040.

10.3.2.3.1.3.2 Moderately Significant Effects

The impact of the following site activities will have a **Moderately Significant** effect on soils, geology and land with respect to site stability during the operation and maintenance phase of the project between 2020 and c. 2040:

- Drainage Improvements

Drainage Improvements (Positive Impact) – No significant drainage improvements are anticipated or scheduled for the remaining operational phase of the wind farm between 2020 and c. 2040. Any work on the drainage network on site will be limited to a residual low level of maintenance to maintain the existing capacity. However, the drainage network that was constructed on the site has reduced the risk of peat instability and has also increased the strength of the peat where the groundwater level has been lowered, which has a surcharge effect. Therefore, relative to the baseline condition of the site in 1998, the improved drainage network that was constructed on the site will continue to have a **Permanent** and **Sustained positive** impact on the peat with regard to site stability. The effect of the drainage improvements on the stability of the peat will be **Medium,** and of **Moderate** significance.

10.3.2.3.1.3.3 Slightly Significant Effects

The following impacts of site activities will have a **Slightly Significant** effect on soils, geology and land with respect to site stability during the operation and maintenance phase of the project between 2020 and c. 2040:

- The increased dead load on the floating roads where it is necessary to locally re-surface or repair them with an additional capping layer of crushed rock granular fill;
- The live load surcharge of the large mobile cranes or heavy low-loader transporters on the floating roads;
- The live load surcharge on the intact peat slopes from low ground-bearing pressure (LGBP) wide-tracked harvesters or excavators carrying out tree-topping, localised drainage improvements, or repairs to existing cable ducts and trenches; and
- The additional dead load and live load surcharge on the intact peat slopes along the upslope side of the road to Turbine T45 if the road is widened;

Additional dead load on the floating roads – localised repairs/resurfacing: No significant upgrade or maintenance works are scheduled or anticipated for the floating roads over the remaining operational phase of the wind farm between 2020 and c. 2040. Maintenance on the roads will be limited to localised resurfacing, repairs, or infilling of potholes, as required. If it is necessary to re-surface any section of the floating roads then the approach that will be adopted will be the same as for the roads upgrade programme in 2014, as described in Section 10.3.2.1.2.3.3, i.e. the roads will be resurfaced with an additional layer of geogrid reinforcement and a maximum of 150 mm of imported Class 6F2 crushed rock granular capping material blinded with a nominal 20 mm thick layer of fine gravel (0-6 mm). In this way the impact of the additional dead load surcharge on the peat will be minimised so that it only has a minor effect on the stability of the road that will be within its design capacity. Therefore, the probability of a peat slide during the works will be **Very Low to Low**. The effect of the increased load on the peat with respect to site stability will be **Low** and the Significance of the effect will be **Slight**. The highest risk of peat instability will be at the time that the roads are re-surfaced. In the medium to long-term the probability of a peat slide under the increased load will reduce as the strength of the peat increases under the additional load.

Live load surcharge on the floating roads: All of the large mobile cranes and heavy transporters that will be required to access the turbines and substation during the O&M phase between 2020 and c. 2040 will travel along the existing site access tracks which have been designed, tested and certified for the corresponding maximum live load surcharge. The full scale proof load tests that were carried out on all of the floating roads in 2018 confirmed that the performance of the roads has significantly improved since they were tested in 2005, 2011 and 2014 due to the increase that has occurred in the strength and stiffness of the peat as it consolidated and compressed under the weight of the roads. Therefore, for the period from 2020 to c. 2040, the probability of a peat slide occurring under the design live load surcharge from the large mobile cranes will be **Very Low** (see Figure 10-36)**,** so that the effect of the load on the stability of the peat will also be **Very Low** and the Significance of the effect will be **Slight**.

Live Load Surcharges on the Intact Peat Slopes: Work that will be carried out on the intact peat slopes between 2020 and c. 2040 will be limited to periodic tree topping and localised maintenance or repairs to the existing network of drainage trenches and cable ducts, where required. Tree-topping and non-essential repairs or maintenance works will be scheduled for the drier summer months when the risk of peat instability is lower. All of the works will be carried out using LGBP wide-tracked excavators suitable for working on the peat. Therefore, the risk of a peat slide under the localised live load surcharge will be **Very Low**, the effect of the load on the stability of the peat will be **Low**, and the Significance of the effect will be **Slight**.

Additional dead and live load on the peat – widened turbary road: If it becomes necessary to widen the narrow turbary road between Turbines T31 and T45 to provide safe access to the turbines for a large mobile crane, then this will involve placing a layer of timber logs or bog mats and 150mm of crushed rock granular fill on the intact peat over a 2-3 m wide strip along the upslope side of the existing floating road. The impact of this will be a small dead load surcharge of approximately 4 kN/m^2

on the peat upslope from the road. This is equivalent to the dead load from less than 0.5 m of peat over the same area, which is low. The existing 3.0-3.5 m road was fully proof load tested for the design live load surcharge in 2018 and the peat has consolidated and gained strength under the road since it was originally constructed (prior to the wind farm) and also after it was upgraded during the construction of the wind farm. The widened road will spread the same traffic load out over a wider area (approx. 5-6 m). Therefore, the effect that the load from the widened road will have on the stability of the peat will be **Very Low**, and the Significance of the effect will be **Slight**.

10.3.2.3.1.3.4 Effects that were Not Significant

The following impacts of site activities will not have a significant effect on the receiving soils, geology and land with respect to site stability during the operation and maintenance phase of the project between 2020 and c. 2040:

- Live loading from maintenance and repair vehicles on the granular hardstanding areas at the turbines and substation; and
- Light live loading on the floating roads from service vehicles and trucks.

This is because:

- The granular hardstanding areas at the turbines and substation are designed to support the applied live load surcharges from the mobile cranes and maintenance and repair vehicles on competent cohesive glacial till and rock below the peat.
- The full-scale serviceability and proof load tests that were carried out on the floating roads in 2018 demonstrated that the roads are in very good condition and perform very well under the design loads from the large mobile cranes that will be used for the maintenance and repair work on the turbines. Therefore, the effect of the lower live load surcharge from light service vehicles and standard commercial trucks on site stability will be negligible.

10.3.2.3.2 Decommissioning

This section of the report assesses the impact of site activities during the decommissioning stage of the wind farm at the end of operation in c. 2040.

Section 10.3.2.3.2.1 gives a summary of the activities that are likely to be carried out on the wind farm site during decommissioning that could have an impact on soils, geology and land. The **direct impact** of these is assessed in Section 10.3.2.3.2.2.

The **stability impacts** are assessed in Section 10.3.2.3.2.3 i.e. the direct impacts that site activities could have on soils, geology and land that could have an effect on site stability, potentially causing a peat failure.

10.3.2.3.2.1 Site Activities – Decommissioning

The primary works that are likely to be carried out on the site during decommissioning that could have an impact on soils, geology and land include the following:

- De-energising the substation and electrical cables, and removing all of the buried cables;
- Widening the turbary road between Turbines T31 and T45 (if not completed prior to decommissioning);
- Dismantling the turbines, substation and anemometers and transporting the components off-site for re-use, recycling or disposal;
- Demolition of the control building and transporting the demolition waste off-site for disposal;
- Demolition and disposal of the twin poleset for the 110 kV line.

This is based on the proposed decommissioning plan for the project. Chapter 2 and the AGL Report No. 11-147-R04 – "*Derrybrien Wind Farm - Geotechnical Stability Report & Assessment of Stability Impacts of On-Site Activities*" in Appendix B of this Chapter give a detailed summary of the decommissioning activities associated with each of these works. The following is an assessment of the impact of these activities on soils, geology and land during decommissioning in c. 2040.

10.3.2.3.2.2 Direct impacts of project (Decommissioning)

This section addresses the direct impact of site activities on soils, geology and land during the decommissioning phase of the wind farm project in c. 2040.

10.3.2.3.2.2.1 Significant Effects

None of the direct impacts of site activities during decommissioning will have a **Significant** effect on soils, geology and land.

10.3.2.3.2.2.2 Moderately Significant Effects

None of the direct impacts of site activities during decommissioning will have a **Moderately Significant** effect on soils, geology and land.

10.3.2.3.2.2.3 Slightly Significant Effects

The direct impact of the following site activity will have a **Slightly Significant** effect on soils, geology and land during decommissioning:

- Removing all of the buried electrical cables
- Widening of the turbary road between Turbines T31 and T45.

Removing all of the Buried Electrical Cables: The electrical cables and copper earth & Scada cables connecting the turbines to the substation are all direct buried without uPVC ducts in shallow trenches in the peat at a depth of 0.9-1.1 m below ground level. The trenches were backfilled over the cables with the excavated peat. The cables were only laid in ducts at the road crossings and at the turbine connections.

Where possible the cables will be extracted by winching from the crane hardstanding areas at the turbines and buried uPVC ducts will be left in place. However, in general removing the cables will involve re-excavating the peat from the trenches to remove the cables. The work will be carried out with a mini-digger or 10 tonne LGBP wide-tracked excavator operating directly on the peat. The excavated peat will be temporarily sidecast adjacent to the trench to a maximum depth of 0.5 m and subsequently used to backfill the trench when the cables have been removed.

Vegetation that has re-established on the surface of the peat since the cables were initially laid will be damaged in the process and the peat within the trench will be disturbed again. The trenches only cover a small area of the site, which was already disturbed during the initial installation. Therefore, the effect that removing the cables will have on the peat relative to the baseline condition is **Low** and only **Slightly Significant**.

Widening of Turbary Road to Turbine T45: If the narrow turbary road between Turbines T31 and T45 is not widened prior to decommissioning then it may be necessary to widen it to provide access for the large mobile crane that will be needed to dismantle the turbines. As discussed in Section 10.3.2.3.1.2.3, this will involve widening the road by 2-3 m on the upslope side of the existing floating road with a layer of timber logs or bog mats and 150 mm of crushed rock granular fill reinforced with a single layer of geogrid across the full width of the road. The effect that this will have on the degraded bog in the turbary area will be **Very Low** and the Significance of the effect will be **Slight**.

10.3.2.3.2.2.4 Effects that are Not Significant

The direct impact of the majority of the activities that will be carried out on site during decommissioning will not have a significant effect on the soils, geology and land. This is because:

- De-energising the electrical generation and transmission components will have an imperceptible effect on soils and geology;

- The timber twin pole-set for the 110 kV overhead line will be cut down at ground level without disturbing the peat;
- Dismantling of the turbines, substation, anemometers and control building will be carried out from the existing granular hardstanding areas;
- All of the decommissioned components of the turbines, substation and anemometers will be temporarily stockpiled or stored on the hardstanding areas, loaded onto standard trucks or specialist low-loader transporters and transported off site along the existing site access tracks for re-use, recycling or disposal in suitably licensed waste facilities;
- All construction and demolition waste will be temporarily stockpiled on the hardstanding areas, loaded onto dump trucks and transported off-site for disposal in a suitably licensed waste facility – none of this material will be disposed of on site; and
- All of the remaining site infrastructure will be left in place, including:
    - The below-ground elements of the turbine foundations (i.e. the steel base can, reinforced concrete pad foundations and 50/50 lean mix and granular structural fill down to rock);
    - The granular hardstanding areas at the turbines, substation and anemometer masts;
    - The site access tracks;
    - The drainage trenches and piped culverts under the access tracks; and
    - The buried uPVC cable ducts and fibre-optic cables.

10.3.2.3.2.3 Stability Impacts (Decommissioning Phase - 2040)

This section presents the assessment of stability impacts for the decommissioning of the wind farm in c.2040, i.e. the direct impacts of site activities on the receiving soils, geology and land that had an effect on site stability.

AGL Report No. 11-147B-R04 – "*Geotechnical Stability Report & Assessment of Stability Impacts on Soils, Geology and Land*" in Appendix B of this Chapter gives a detailed assessment of the characteristics of the activities that are likely to be carried out on site during decommissioning and the corresponding impacts on soils, geology and land that had an effect on site stability, particularly in relation to the peat. The results are summarised in Table 10-11.

As discussed in Section 10.2.4.4, due to continued improvement in site conditions since construction, Figure 10-36 reflects the reduced likelihood of a peat slide on the site based on the site conditions in 2020 and the range of activities that are likely to be carried out during decommissioning.

Therefore, the **Significance** of the effect on Table 10-11 reflects the probability of a peat failure occurring due to the effect of the stability impact on the peat (e.g. due to the increased shear stresses under applied surcharge loads), as well as the sensitivity of the soils, geology and land potentially impacted by a peat slide, which has been calibrated by the peat failures that occurred on the site during construction and assessed as **Medium**, as discussed in Section 10.2.1.4.

In the following summary, stability impacts have been combined by the characteristics of the impact and the significance of the corresponding effect on soils, geology and land (i.e. to group similar impacts with similar effects). The effects are presented in order of decreasing significance.

10.3.2.3.2.3.1 Significant Effects

None of the impacts of site activities will have a **Significant** effect on soils, geology and land with respect to site stability during decommissioning.

10.3.2.3.2.3.2 Moderately Significant Effects

None of the impacts of site activities will have a **Moderately Significant** effect on soils, geology and land with respect to site stability during decommissioning.

10.3.2.3.2.3.3 Slightly Significant Effects

The following impacts of site activities will have a **Slightly Significant** effect on soils, geology and land with respect to site stability during decommissioning:

- The live load surcharge of the large mobile cranes or heavy low-loader transporters on the floating roads;
- The additional dead load and live load surcharge on the intact peat slopes along the upslope side of the widened road to Turbine T45 (if the turbary road is not widened prior to decommissioning);
- The live load surcharge on the peat from the low ground bearing pressure (LGBP) wide-tracked excavator used to remove the buried electrical cables.

Live load surcharge on the floating roads: All of the large mobile cranes and heavy transporters that will be required to access the turbines and substation during decommissioning will travel along the existing site access tracks which have been designed, tested and certified for the corresponding maximum live load surcharge. Therefore, the probability of a peat slide occurring under the design live load surcharge will be **Very Low,** so that the effect of the load on the stability of the peat will also be **Very Low** and the Significance of the effect will be **Slight**.

Table 10-11: Assessment of Stability Impacts: Decommissioning Phase

Activity	Characteristics of Direct Impact of Site Activities with respect to Site Stability (Stability Impacts)					Assessment of Effect of Stability Impacts on Soils, Geology & Land					
	Impact	Probability of Occurrence (Impact)	Extent of Impact	Duration	Frequency	Quality of Impact	Possible Extent of a Peat Failure	Probability of Occurrence of a Peat Failure	Effect on Receiving Soils, Geology & Land	Sensitivity of Receiving Soils, Geology & Land	Significance of Effect
Dismantling of Turbine Blades, Nacelle & Mast	Crane Loading on Hardstanding Areas	Likely	Hardstanding areas adjacent to turbines	Temporary	Frequently	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**
	Crane Loading on Floating Roads	Likely	Along floating roads between turbines and site entrance	Temporary	Frequently	Negative	Small (100m^2-2500m^2) to Very Large (>10Ha) Peat Slide	Very Low	**Very Low**	**Medium**	**Slight**
	Low-Loader Transporter Loading on Floating Roads	Likely	Along floating roads between turbines and site entrance	Temporary	Frequently	Slight Negative	Small (100m^2-2500m^2) to Very Large (>10Ha) Peat Slide	Very Low	**Very Low**	**Medium**	**Slight**
Dismantling of Substation & Demolition of Control Building	MEWP Loading on Hardstanding Areas	Likely	Hardstanding area at Substation site	Temporary	Frequently	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**
	Service Vehicle Loading on Floating Roads	Likely	Along Floating Roads to Substation Site	Temporary	Frequently	Slight Negative	Not Applicable	Negligible	**Negligible**	**Medium**	**Not Significant**
	Crane or Heavy Low-Loader Transporter Loading on Floating Roads	Likely	Along Floating Roads to Substation Site	Brief	Occasional	Negative	Small (100m^2-2500m^2) to Very Large (>10Ha) Peat Slide	Very Low	**Very Low**	**Medium**	**Slight**
Widening of Turbary Road	Additional dead and live load surcharge on peat on upslope side of existing floating road	Possible	Turbary Rd.betwen Turbine T31 and T45	Temporary	Occasional	Negative	Small (100m^2-2500m^2) to Very Large (>10Ha) Peat Slide	Very Low	**Very Low**	**Medium**	**Slight**
Cables & Ducting	De-energising and removing buried electrical cables	Likely	Along cable trenches	Temporary	Frequently	Slight Negative	Small (100m^2-2500m^2) to Very Large (>10Ha) Peat Slide	Very Low to Low	**Low**	**Medium**	**Slight**

<u>Additional dead and live load on the peat – widened turbary road</u>: If the narrow turbary road between Turbines T31 and T45 has not been widened prior to decommissioning and if it becomes necessary to widen it to provide access for the large mobile crane that will be used to dismantle the turbines then this will involve placing a layer of timber logs or bog mats and 150 mm of crushed rock granular fill on the intact peat over a 2-3 m wide strip along the upslope side of the existing floating road. This will result in a small dead load surcharge of approximately 4 kN/m^2 on the peat upslope from the road. This is equivalent to the dead load from less than 0.5 m of peat over the same area, which is low. The existing 3.0-3.5 m road was fully proof load tested for the design live load surcharge in 2018 and the peat has consolidated and gained strength under the road since it was originally constructed (prior to the wind farm) and then upgraded for the wind farm. The widened road will spread the same traffic load out over a wider area (approx. 5-6 m). Therefore, the effect that the load from the widened road will have on the stability of the peat will be **Very Low**, and the Significance of the effect will be **Slight**.

<u>Removing all of the Buried Electrical Cables:</u> The electrical cables and copper earth & Scada cables connecting the turbines to the substation are all direct buried in shallow trenches in the peat at a depth of 0.9-1.1 m below ground level without ducts.

Where possible the cables will be extracted by winching from the crane hardstanding areas at the turbines. However, in general removing the cables will involve re-excavating the peat from the shallow trenches with a mini-digger or 10 tonne LGBP wide-tracked excavator operating directly on the peat. The excavated peat will be temporarily sidecast adjacent to the trench to a maximum depth of 0.5 m and subsequently used to backfill the trench when the cables are removed.

The weight of the excavator is a small localised load that will be distributed across the surface of the peat. Temporarily sidecasting the excavated peat to a maximum depth of 0.5 m only results in a small localised re-distribution of loads on the peat slopes along the line of the cable trenches. Therefore, the probability of a peat slide occurring under these surcharge loads will be **Very Low to Low**, so that the effect of the loads on the stability of the peat will be **Low**, which is only **Slightly Significant**.

10.3.2.3.2.3.4 Effects that are Not Significant

The following site activities and their stability impacts will not have a significant effect on the receiving soils, geology and land with respect to site stability during decommissioning:

- De-energising the site;
- Live loading from the mobile cranes, low-loader transporters and general construction plant on the granular hardstanding areas at the turbines and substation; and
- Light live loading on the floating roads from commercial vehicles, trucks and standard construction plant.

This is because:

- De-energising the site will have an imperceptible effect on the peat;
- The granular hardstanding areas at the turbines and substation are designed to support the applied live load surcharges from the mobile cranes, low-loader transporters and construction plant on competent cohesive glacial till and rock below the peat. None of the live loads will exceed the maximum loads applied during construction, and steel outrigger pads will be used to spread out the concentrated loads from the mobile cranes.
- The full-scale serviceability and proof load tests that were carried out on the floating roads in 2018 demonstrated that the roads are in very good condition and perform very well under the design loads from the large mobile cranes and low-loader transporters that will be used for dismantling the turbines and substation. Therefore, the effect of the lower live load surcharge from light service vehicles and standard commercial trucks on the stability of the peat will be negligible.

10.3.3 Grid Connection Impact Assessment

10.3.3.1 Impacts Which Have Occurred

10.3.3.1.1 Construction Stage: 2003 to 2006 - Grid Connection

This section of the chapter assesses the impact of the Grid Connection works with respect to soils, geology and land for the above period.

The section includes a summary of the Grid Connection activities that occurred during this period and the related impacts on soils, geology and land.

An assessment of the significance of these effects on soils, geology and land is included. In addition, given the previous peat slide in the area, a specific assessment of the significance of these effects with regards to peat stability is included.

It is noted that given the general low level of construction activity associated with the grid connection compared to the wind farm site, together with the generally thinner peat cover and relatively greater peat strength that there is a lower risk of peat instability compared to the wind farm site.

10.3.3.1.1.1 Grid Connection– Construction Phase

The primary work activities that occurred during this period that have been assessed as having an impact on soils, geology and land included the following:

- Tree felling;
- Construction of temporary access tracks to poleset and mast locations;
- Construction of the twin polesets and masts for the overhead 110 kV line
- Deposition and storage of surplus excavated materials at mast locations;
- Construction of the Agannygal substation and control building;
- Polesets and masts
- Upgrading of existing Coillte track to provide access to the Agannygal substation location
- Construction of a new section of road at the entrance to Agannygal Substation
- Ground lowering below the existing 400 kV line

The Project Description (Chapter 2) and the *"Geotechnical Stability Report 3"* (FT, 2020) give a detailed summary of the construction activities and associated events during this period.

10.3.3.1.1.2 Direct Impacts of Grid Connection– Construction Stage (2003 to 2006)

The following section gives a summary of the assessment of the primary work activities that had a direct impact on soils, geology and land that were of significance.

The assessment details of the potential significance of these impacts on soils, geology and land is given in Table 10-12.

10.3.3.1.1.2.1 Significant Effects

There were no primary effects during the construction phase of the project from 2003 to 2006 where the direct impact on soils, geology and land use was Significant.

10.3.3.1.1.2.2 Effects of Moderate Significance

There were no primary effects during the construction phase of the project from 2003 to 2006 where the direct impact on soils, geology and land use was Moderate.

10.3.3.1.1.2.3 Effects of Slight Significance

The significance of the effect of the following primary work activities on soils, geology and land during this period was Slight:

- Tree felling;
- Construction of temporary access tracks;
- Deposition and storage of surplus excavated materials;
- Construction of the Agannygal substation and control building, and access track;
- Construction of the twin polesets and masts for the overhead 110 kV line
- Loading of competent ground at poleset and mast locations
- Ground lowering below the existing 400 kV line

Tree Felling

Felling the trees present along the route of the Grid Connection was a project requirement. 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.

The effect that this work had on the peat habitat was Low, particularly given the low ecological value of the degraded blanket bog in the forested areas.

The duration of the forestry trafficking on the peat was Temporary during tree felling. However, the restriction on land use is Long-term as it applies over the design life of the project. The Extent of the effect was directly along the route of the Grid Connection. However, the effect with regards to land use is Low.

The overall significance of these effects during the construction phase (2003 - 2006) is **Slight.**

Construction of temporary access track

In a single area of deep peat along the route of the OHL, a temporary access was constructed in order to provide access to AM38, around 600 m north of the Agannygal substation. In this instance existing trees were felled and placed to form a 'floating road' mat of timber on the OHL corridor for access to the mast location.

Loading resulting in consolidation/settlement of the underlying ground would have occurred, and the effect is assessed as Very low.

The effect on land use is assessed as Low. As this was a temporary access, no significant sealing of the peat would have occurred.

The overall significance of these effects during the construction phase (2003 - 2006) is **Slight.**

Deposition and storage of surplus excavated materials

Access to the masts was from nearby road/forestry tracks. Construction for access to masts consisted of removal and disposal locally of peat (less than 1 m typically) and tree stumps/brash to competent material to allow access for tracked excavators, dumpers and a rough terrain crane. Mast construction consisted of excavation of a hole to competent material at each of the 4 no. tower legs. The excavated material was side cast in the area around the individual polesets and masts.

Loading resulting in consolidation/settlement of the underlying ground would have occurred, and the effect is assessed as Very low. The removal of the excavated peat will have resulted in the release of carbon into the environment through decomposition and erosion, however the volume of peat excavated is very small, and therefore the effect is assessed as Very Low.

The area covered by this side casting is relatively small, around 20-30 m^2 at each poleset. The effect on land use is assessed as Low.

The overall significance of these effects during the construction phase (2003 - 2006) is **Slight.**

Construction of Agannygal substation and control building, and access track

Following tree felling, earthworks were completed to form a level site in advance of the construction activities at the substation. An approximate 72 m x 52 m levelled earth platform was constructed by cutting into the existing ground by up to 2.5 m. Excess excavated material from this cutting activity was used to create an earth embankment around the external perimeter of the sub-station on three sides of approximately 2 m height. Imported granular fill from local quarries was used to create a platform to allow for the construction of the control building and substation equipment.

The granular fill platform, substation equipment, earth embankments and control building all apply a load to the underlying competent ground. The duration of this load is Long Term and the load is Constant. The effect of this load in relation to settlement and consolidation of the underlying ground is Low.

The removal of the excavated peat will have resulted in the release of carbon into the environment through decomposition and erosion, however the volume of peat excavated is very small, and therefore the effect is assessed as Very Low.

The footprint of the substation platform is small when related to the extent of the surrounding forestry, and as such the effect on land use is Low.

The cut slope has had the topsoil removed which will have resulted in gradual erosion of the underlying soils. The effect of this was Low.

The overall significance of these effects during the construction phase (2003 - 2006) is **Slight.**

Construction of twin polesets and masts for the overhead 110 kV

The excavation of peat along the OHL was undertaken in localised areas to provide access to the pole set locations where the peat was shallow. The volume of excavation of the peat along the route of the OHL was relatively small. Peat was also excavated at the pole set locations in order to construct the foundations for the pole sets. Excavations, where undertaken, were less than 1 m in depth.

Land use of the masts and pole sets is assessed as minimal.

Loading due to the general construction resulting in consolidation/settlement of the underlying ground would have occurred.

The overall effect is assessed as Low.

The overall significance of these effects during the construction phase (2003 - 2006) is **Slight.**

Loading of ground at poleset and mast locations

The foundations for the individual polesets and masts apply a load to the underlying competent ground.

Loading resulting in consolidation/settlement of the underlying ground would have occurred, and the effect is assessed as Very low.

The footprint of the foundations is very small, and the effect of the change in land use is assessed as Very low.

The overall significance of these effects during the construction phase (2003 - 2006) is **Slight.**

Ground lowering below the existing 400 kV line

In order to provide the required separation between pre-existing 400 kV line and Derrybrien - Agannygal 110 kV line passing underneath the 400 kV line, and to provide sufficient ground clearance for the 110 kV line, the ground was lowered by up to 3.8 m below the crossing point of the two lines. Based on the available data and the findings of site walkovers, the total volume of glacial soils excavated at this location was of the order of 3,000 m^3.

The excavated material was side cast onto the area around the excavation.

The effect of the excavation and deposition on land use is Negligible, as the land use in this area was already restricted by the presence of the 400 kV line.

There is minimal peat present at this location, so the carbon release and oxidisation from the disturbance of the ground is also considered to be Negligible.

A cut slope in glacial soils was created as part of the works. The cut slope and area of ground beneath the 110 kV line has had the topsoil removed which will have resulted in some erosion of the underlying soils. The effect of this is Low.

The overall significance of these effects during the construction phase (2003 - 2006) is **Slight.**

10.3.3.1.1.2.4 Effects that were Not Significant

The following primary effects of the construction stage activities did not have a significant direct impact on soils, geology and land use during construction:

- Upgrade of an existing founded Coillte track
- Construction of a new access road to the Agannygal substation

The works associated with the above included widening of the track, removal of bend and resurfacing and construction of 0.14 km of new access track. The overall significance of these effects during the construction phase (2003 - 2006) is **Not Significant.**

10.3.3.1.1.3 Site Stability Impacts (Construction Stage 2003 - 2006)

The following section gives a summary of the assessment of the primary work activities that had a direct impact with regards to site stability that were of significance.

The assessment details of the potential significance of these site stability impacts is given in Table 10-13.

10.3.3.1.1.3.1 Significant Effects

No primary effects had a Significant effect with regards to site stability during the construction phase of the project between 2003 and 2006.

10.3.3.1.1.3.2 Effects of Moderate Significance

No primary effects had a Moderate significance with regards to site stability during the construction phase of the project from 2003 to 2006.

10.3.3.1.1.3.3 Effects of Slight Significance

The significance of the effect of the following primary work activities with regards to site stability during this period was Slight:

- Tree felling;
- Construction of temporary access tracks;
- Deposition and storage of surplus excavated materials;
- Construction of the Agannygal substation and control building, and access track;
- Construction of the twin polesets and masts for the overhead 110 kV line
- Ongoing loading of competent ground at poleset locations

Tree Felling

Felling the trees present along the route of the Grid Connection was a project requirement. 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. The risk of a peat slide under such machines loading would be limited. The effect in terms of site stability is Low, and the significance of the effect is **Slight.**

Construction of temporary access track

In a single area of deep peat along the route of the OHL, a temporary floating access was constructed in order to provide access to AM38, around 600 m north of the Agannygal substation. In this instance existing trees were felled and placed to form a ‘floating road’ mat of timber on the OHL corridor for access to the mast location. The area around AM38 is essentially level with slope angles measured from 0.5 to 1 degrees. The construction traffic loading on the floating access was frequent during the construction of the access and the erection of the angle mast. However, the duration of the loading was temporary.

Given the temporary nature of the floating road and essentially the flat nature of the ground, the effect of these works in terms of site stability was Low, and the significance of the effect is **Slight**.

Deposition and storage of surplus excavated materials

Access to the masts was from nearby road/forestry tracks. Construction for local access to masts and clearance of the footprint of the masts consisted of removal and disposal locally of peat (less than 1 m typically) and tree stumps/brash to competent material to allow access for tracked excavators, dumpers and a rough terrain crane. The excavated material was side cast in the area around the individual polesets and masts.

The side casting of this material will have resulted in an additional load on the peat and competent ground. Due to the small volume of material stored, the shallow depth of peat in most locations, and the relatively high peat strength, the effect as this activity in terms of site stability is Very low, and the significance of the effect is **Slight.**

Construction of Agannygal substation and control building, and access track

Following tree felling, earthworks were completed to form a level site in advance of the construction activities at the substation. An approximate 72 m x 52 m levelled earth platform was constructed by cutting into the existing ground by up to 2.5 m. Excess excavated material from this cutting activity was used to create an earth embankment around the external perimeter of the sub-station on three sides of approximately 2 m height. Imported granular fill from local quarries was used to create a platform to allow for the construction of the control building and substation equipment.

A cut slope in predominantly glacial soils was created as part of the works along the eastern side of the compound. There was minimal peat cover in the area. The effect of the excavation of this cut slope on the site stability would be Negligible.

The granular fill platform, substation equipment, earth embankments and control building all apply a load to the underlying competent ground. The duration of this load is Long Term and the load is Constant. The effect of this load in relation to site stability is Low, and the significance of the effect is **Slight**.

Construction of twin polesets and masts for the overhead 110 kV

The excavation of peat along the OHL was undertaken in localised areas to provide access to the pole set locations where the peat was shallow. The volume of excavation of the peat along the route of the OHL was relatively small. Peat was also excavated at the pole set locations in order to construct the foundations for the pole sets. Excavations, where undertaken, were less than 1 m in depth. The effect of these excavations and the construction on site stability was Low and the significance of the effect is **Slight.**

Loading of ground at poleset and mast locations.

The foundations for the individual polesets and masts apply a load to the underlying competent ground. However, given that the foundations bear on competent glacial soils the effect in terms of site stability was Very low**,** and the significance of the effect of loading on the competent ground is **Slight**.

10.3.3.1.1.3.4 Effects that were Not Significant

The following primary effects of the construction stage activities did not have a significant direct impact with regards to site stability use during construction:

- Upgrade of an existing founded Coillte track
- Construction of a new access road to the Agannygal substation.
- Ground lowering below the existing 400 kV line

The works associated with the above included widening of the track, removal of bend and resurfacing and construction of 0.14 km of new access track founded on competent material. The overall significance of these effects during the construction phase (2003 - 2006) is **Not Significant.**

The nature of the works associated with the ground lowering below the 400 kV line had minimal impact on site stability and is assessed as **Not Significant.**

10.3.3.1.1.4 Secondary Effects of Grid Connection (Construction Phase 2003-2006)

There are no construction activities related to the Grid Connection that had any secondary effect on soils, geology and land.

Table 10-12: Impact Assessment on Soils, Geology and Land – Construction Phase 2003 to 2006

Activity/Item	Characteristic of Primary Effect of Site Activties				Impact Assessment - Soils, Geology and Land				
	Nature of Primary Effect	Extent of Activity	Duration	Frequency	Quality of Impact	Probability of Occurrence (Impact)	Impact of Primary Effect on Soils, Geology and Land	Sensitivity of Receiving Soils, Geology and Land	Significance of Impact
Tree Felling	Loading from low ground pressure machinery on peat slopes, removal of trees - change of habitat, compression of peat, disturbance of peat surface	Along the OHL route	Short Term	Once	Slight Negative	Likely	Low	Medium	Slight
Construction of temporary access track to poleset location	Loading from low ground pressure machinery on peat slopes - compression of peat, sealing of peat surface	Along the OHL route	Temporary	Once	Slight Negative	Likely	Low	Medium	Slight
Construction of twin polesets and masts for 110kV line	Loading from low ground pressure machinery on peat slopes - compression of peat, loading of peat surface	Along the OHL route	Temporary	Once	Slight Negative	Possible	Low	Medium	Slight
	Loading on ground from pole set foundations - compaction/consolidation of ground	At pole set/mast locations	Long Term	Constant	Slight Negative	Likely	Very low	Medium	Slight
Deposition and storage of excavated materials on site	Loading on ground from placed excavated material - loss of habitat, compaction, sealing, carbon release.	At pole set/mast locations	Long Term	Constant	Slight Negative	Likely	Very low	Medium	Slight
Construction of Agannygal Substation	Removal of peat/placing stone for compound - loss of habitat	At the substation location only	Long Term	Constant	Slight Negative	Likely	Low	Medium	Slight
	Loading from stone platform/ substation equipment/ buildings - compaction/consolidation of ground, sealing of underlying soil, carbon release/oxidisation, erosion of exposed slopes	At the substation location only	Long Term	Constant	Negative	Likely	Very low	Medium	Slight
Upgrade of access road to substation	Additional load on existing track/widening of track - loss of habitat, use of construction materials	Along access track	Long Term	Constant	Slight Negative	Posssible	Negligible	Medium	Not Significant
Construction of entrance road to substation	Additional load on ground - Stability of ground, loss of habitat, construction materials, sealing of ground	Along entrance road	Long Term	Constant	Slight Negative	Posssible	Negligible	Medium	Not Significant
Ground Lowering below 400kV Line	Excavation /depostion of material and formation of cut slopes - loss of material, carbon release/oxidisation, erosion of exposed slopes	Below 400kV line	Long Term	Constant	Negative	Likely	Very Low	Medium	Slight

Table 10-13: Site Stability Impact Assessment– Construction Phase 2003 to 2006

Activity	Characteristics of Primary Effect of Site Activties with respect to Site Stability				Assessment of Site Stability Impacts on Soils, Geology & Land						Did Peat Failure occur? (Yes/No)
	Nature of Primary Effect	Extent of Primary Effect	Duration	Frequency	Quality of Impact	Possible Extent of a Peat Failure	Probability of Occurrence (Peat Failure)	Impact on Receiving Environment	Sensitivity of Receiving Soils, Geology & Land	Significance of Impact	
Tree Felling	Low ground pressure machinery on peat slopes	Along the OHL route	Short Term	Once	Slight Negative	Small (100m^2-2,500m^2) to Medium (2,500m^2-25,000m^2)	Negligible to Low	Low	Medium	Slight	No
Construction of temporary access track to poleset location	Low ground pressure machinery on peat slopes	Along the OHL route	Temporary	Once	Slight Negative	Small (100m2-2,500m2)	Negligible to Low	Low	Medium	Slight	No
Construction of twin polesets and masts for 110kV line	Low ground pressure machinery on peat slopes	Along the OHL route	Temporary	Once	Slight Negative	Small (100m^2-2,500m^2) to Medium (2,500m^2-25,000m^2)	Negligible to Low	Low	Medium	Slight	No
	Loading on ground from pole set & masts foundations	At pole set/mast locations	Long Term	Constant	Slight Negative	Small (100m^2-2,500m^2)	Negligible to Low	Very Low	Medium	Slight	No
Deposition and storage of excavated materials on site	Loading on ground from placed excavated material	At pole set/mast locations	Long Term	Constant	Slight Negative	Small (100m^2-2,500m^2)	Negligible to Low	Very Low	Medium	Slight	No
Construction of Agannygal Substation	Removal of peat/placing stone for compound	At the substation location only	Short Term	Constant	Slight Negative	Small (100m^2-2,500m^2) to Medium (2,500m^2-25,000m^2)	Negligible	Low	Medium	Slight	No
	Loading from stone platform/ embankments/ substation equipment/ buildings	At the substation location only	Long Term	Constant	Negative	Not Applicable	Negligible	Very low	Medium	Slight	No
Upgrade of access road to substation	Additional load on existing track	Along access track	Long Term	Constant	Slight Negative	Not Applicable	Negligible	Negligible	Medium	Not Significant	No
Construction of entrance road to substation	Additional load on ground	Along entrance road	Long Term	Constant	Slight Negative	Not Applicable	Negligible	Negligible	Medium	Not Significant	No
Ground Lowering below 400kV Line	Excavation/deposition of material and formation of cut slopes	Below 400kV line	Temporary	Constant	Negative	Not Applicable	Negligible	Negligible	Medium	Not Significant	No

The above table includes all effects that could impact stability

10.3.3.1.2 Operation and Maintenance Phase: 2006 to 2020 – Grid Connection

This section of the chapter assesses the effect of the works activities related to the – grid connection during the operation and maintenance stage of the project from 2006 to 2020.

10.3.3.1.2.1 Grid Connection – Operation & Maintenance Phase

The primary work activities and events that occurred during this period that have been assessed as having an effect on soils, geology and land included the following:

- Forestry - Felling of regrowth
- Maintenance/Repair of Substation & Control Building

The Project Description (Chapter 2) and the *"Geotechnical Stability Report 3"* (FT, 2020) give a detailed summary of the construction activities and associated events during this period.

10.3.3.1.2.2 Direct Impacts of Grid Connection (O&M Phase 2006-2020)

The following section gives a summary of the assessment of the Grid Connection that had a direct impact on soils, geology and land that were of significance.

The assessment details of the potential significance of these impacts on soils, geology and land is given in Table 10-14.

10.3.3.1.2.2.1 Significant Effects

There were no primary effects during the operation and maintenance phase of the project from 2006 to 20120 where the direct impact on soils, geology and land use was Significant.

10.3.3.1.2.2.2 Effects of Moderate Significance

There were no primary effects during the operation and maintenance phase of the project from 2006 to 2020 where the significance of the direct impact on soils, geology and land use was Moderate.

10.3.3.1.2.2.3 Effects of Slight Significance

The significance of the effect of the following primary work activities on soils, geology and land during this period was slight:

- Forestry – Felling of Regrowth

Forestry – Felling of Regrowth

In 2018 and 2019 some scheduled tree topping was carried out along the route of the OHL to trim back some of the small trees that had re-established naturally on the slopes where clear felling had taken place. The small trees were cut down and left in place on the slopes. The work was carried out using standard light or low ground bearing pressure (LGBP) wide tracked harvesters. All of these machines LGBP wide-tracked machines are suitable for working on peat. The duration of the work was temporary and was only carried out once in each area.

Loading resulting in settlement and consolidation of the underlying peat from trafficking of LGBP machines would be transient and very limited in extent. The effect is assessed as Very low.

The overall significance of these effects during the O&M phase (2006 - 2020) is **Slight**.

10.3.3.1.2.2.4 Effects that were Not Significant

The following operation and maintenance stage activities did not have a significant direct effect on soils, geology and land use during the operation and maintenance phase:

- Maintenance/repair of substation and control building

10.3.3.1.2.3 Site Stability Impacts - Grid Connection (O&M Phase 2006 to 2020)

The following section gives a summary of the assessment of the primary work activities that had a direct effect with regards to stability that were of significance.

The assessment details of the potential significance of these effects with regards to stability is given in

Table 10-15: .

10.3.3.1.2.3.1 Significant Effects

No primary effects had a Significant effect with regards to site stability during the operation and maintenance phase of the project from 2006 to 2020.

10.3.3.1.2.3.2 Effects of Moderate Significance

No primary effects had a Moderate significance with regards to site stability during the operation and maintenance phase of the project between 2006 and 2020.

10.3.3.1.2.3.3 Effects of Slight Significance

The significance of the effect of the following primary work activities with regards to site stability during this period was Slight:

- Forestry – Felling of Regrowth

Forestry – Felling of Regrowth

In 2018 and 2019 some scheduled tree topping was carried out along the route of the OHL using standard LGBP wide tracked harvesters.

The risk of a peat slide under such machine loading would be limited. The effect in terms of site stability is Very Low, and the significance of the effect is **Slight.**

10.3.3.1.2.3.4 Effects that were Not Significant

The following primary effects of the operation and maintenance stage activities did not have a significant direct effect with regards to site stability use during construction:

- Maintenance/repair of substation and control building

10.3.3.1.2.4 Secondary Effects of Grid Connection (O&M Phase 2006-2020)

There are no operation and maintenance activities related to the OHL and Agannygal substation that had any secondary effect on soils, geology and land.

Table 10-14: Impact Assessment on Soils, Geology and Land Use – O&M Phase 2006 to 2020

Activity/Item	Characteristic of Primary Effect of Site Activties				Impact Assessment - Soils, Geology and Land				
	Nature of Primary Effect	Extent of Activity	Duration	Frequency	Quality of Impact	Probability of Occurrence (Impact)	Impact of Primary Effect on Soils, Geology and Land	Sensitivity of Receiving Soils, Geology and Land	Significance of Impact
Forestry - Felling of Regrowth	Loading from low ground pressure machinery on peat slopes, removal of trees - change of habitat, compression of peat, disturbance of peat surface	Along the OHL route	Temporary	Once	Slight Negative	Likely	Negligible	Medium	Slight
Maintenance/Repair of Substation	Loading from maintenance vehicles	At the substation location only	Brief	Occasional	Negative	Likely	Negligible	Medium	Not Significant

Table 10-15: Site Stability Impact Assessment– O&M Phase 2006 to 2020

Activity	Characteristics of Primary Effect of Site Activties with respect to Site Stability				Assessment of Site Stability Impacts on Soils, Geology & Land						Did Peat Failure occur? (Yes/No)
	Nature of Primary Effect	Extent of Primary Effect	Duration	Frequency	Quality of Impact	Possible Extent of a Peat Failure	Probability of Occurrence (Peat Failure)	Impact on Receiving Environment	Sensitivity of Receiving Soils, Geology & Land	Significance of Impact	
Forestry - Felling of Regrowth	Low ground pressure machinery on peat slopes	Along the OHL route	Temporary	Once	Slight Negative	Small (100m^2-2,500m^2) to Medium (2,500m^2-25,000m^2)	Negligible to Low	Very low	Medium	Slight	No
Substation Maintenance	Loading from maintenance equipment	At the substation location only	Brief	Rarely	Slight Negative	Not applicable	Negligible	Negligible	Medium	Not Significant	No

The above table includes all effects that could impact stability

10.3.3.2 Impacts Which Are Occurring

This section of the chapter assesses the ongoing impact of the Grid Connection with respect to soils, geology and land that are still occurring at the end of Q2 2020.

10.3.3.2.1 Grid Connection (2003 to 2020)

The primary work activities and events that occurred during this period that have been assessed as having an ongoing effect on soils, geology and land include the following:

- Decomposition of Excavated Peat

The Project Description (Chapter 2) and the *"Geotechnical Stability Report 3"* (FT, 2020) give a detailed summary of the construction activities and associated events during this period.

10.3.3.2.2 Ongoing Direct Impacts of Grid Connection

The following section gives a summary of the assessment of the ongoing direct impacts on soils, geology and land that were of significance.

The assessment details of the potential significance of these impacts on soils, geology and land is given in Table 10-16.

10.3.3.2.2.1 Effects of Slight Significance

The significance of the ongoing effect of the following primary work activities on soils, geology and land during this period was slight:

- Decomposition of Excavated Peat

Decomposition of Excavated Peat

Access to the masts was from nearby road/forestry tracks. Construction for access to masts consisted of removal and disposal locally of peat (less than 1 m typically) and tree stumps/brash to competent material to allow access for tracked excavators, dumpers and a rough terrain crane. The excavated material was side cast in the area around the individual polesets and masts.

The removal and side casting of the excavated peat will have resulted in the release of carbon into the environment through decomposition and erosion, however the volume of peat excavated is very small, and therefore the effect is assessed as Very Low. The significance of this effect relative to the baseline conditions has been assessed as Slight. This is a Long-Term effect as it occurs slowly over time. Therefore, it is likely to be still occurring at the end of Q2 2020, albeit at a lower rate than during the Construction phase. Some revegetation of this excavated peat has occurred since the end of construction, which will have slowed the decomposition of the peat.

10.3.3.2.3 Site Stability Impacts (Grid Connection)

The following section gives a summary of the assessment of the primary work activities from the construction and operation and maintenance stages of the OHL from 2003 to 2019 that are having an ongoing effect with regards to site stability in 2020.

There are no ongoing impacts on site stability that have adversely changed in significance since the construction phase, and therefore no change to the effects of these impacts on site stability has been included.

Table 10-16: Impact Assessment on Soils, Geology and Land Use (Ongoing)

Activity/Item	Characteristic of Primary Effect of Site Activties				Impact Assessment - Soils, Geology and Land				
	Nature of Primary Effect	Extent of Activity	Duration	Frequency	Quality of Impact	Probability of Occurrence (Impact)	Impact of Primary Effect on Soils, Geology and Land	Sensitivity of Receiving Soils, Geology and Land	Significance of Impact
Deposition and storage of excavated materials on site	Loading on ground from placed excavated material - loss of habitat, compaction, sealing, carbon release.	At pole set locations	Long Term	Constant	Slight Negative	Likely	Very low	Medium	Slight

10.3.3.3 Impacts Which Are Likely To Occur

10.3.3.3.1 Operation and Maintenance Phase: 2020 to End of Operation (2040) -Grid Connection

This section of the chapter assesses the likely impacts of the Grid Connection with respect to soils, geology and land for the above period.

10.3.3.3.1.1 Grid Connection (2020 to 2040)

The primary works that may be carried out on the site during this period that could have an impact on soils, geology and land include the following:

- Forestry - Felling of Regrowth
- Maintenance/Repair of Agannygal Substation & Control Building

The Project Description (Chapter 2) and the *"Geotechnical Stability Report 3"* (FT, 2020) give a detailed summary of the construction activities and associated events during this period.

10.3.3.3.1.2 Direct Impacts of Grid Connection (O&M Phase 2020 to 2040)

The following section gives a summary of the assessment of the Grid Connection activities that had a direct impact on soils, geology and land that were of potential significance.

The assessment details of the potential significance of these impacts on soils, geology and land is given in Table 10-17.

10.3.3.3.1.2.1 Significant Effects

There are no primary effects during the operation and maintenance phase of the project from 2020 to 2040 where the direct impact on soils, geology and land use will be Significant.

10.3.3.3.1.2.2 Effects of Moderate Significance

There are no primary effects during the operation and maintenance phase of the project from 2020 to 2040 where the direct effect on soils, geology and land use will be Moderate.

10.3.3.3.1.2.3 Effects of Slight Significance

The significance effect of the following primary work activities on soils, geology and land during this period was slight:

- Forestry - Felling of Regrowth

Forestry – Felling of Regrowth

Some tree topping is likely to be carried out along the route of the OHL to trim back some of the small trees that re-established naturally on the slopes where clear felling had taken place. The work will be carried out using LGBP wide-tracked harvesters operating on the peat. The small trees will be cut down and left in place on the slopes so that no forwarders will be required.

Loading resulting in settlement and consolidation of the underlying peat from trafficking of LGBP machines would be transient and very limited in extent. The effect is assessed as Very low.

The overall significance of these effects for the period 2020 to 2040 is **Slight.**

10.3.3.3.1.2.4 Effects that were Not Significant

The significance of the effect of the following primary work activities/events on soils, geology and land during this period was Not Significant:

- Maintenance/repair of Agannygal substation & control building

10.3.3.3.1.3 Site Stability Impacts (Grid Connection - 2020 to 2040)

The following section gives a summary of the assessment of the primary work activities that had a direct impact with regards to site stability that were of significance.

The assessment details of the potential significance of these impacts with regards to stability is given in Table 10-18.

10.3.3.3.1.3.1 Significant Effects

None of the primary effects will have a potentially Significant effect with regards to site stability during the operation and maintenance phase of the project from 2020 to 2040.

10.3.3.3.1.3.2 Effects of Moderate Significance

None of the primary effects will have a potentially Moderate significance with regards to site stability during the operation and maintenance phase of the project from 2020 to 2040.

10.3.3.3.1.3.3 Effects of Slight Significance

The potential significance of the effect of the following primary work activities on site stability during this period will be Slight:

- Forestry – Felling of Regrowth

Forestry – Felling of Regrowth

Some tree topping is likely to be carried out along the route of the OHL to trim back some of the small trees that re-established naturally on the slopes where clear felling had taken place. The work will be carried out using LGBP wide-tracked harvesters operating on the peat. The small trees will be cut down and left in place on the slopes so that no forwarders will be required.

The risk of a peat slide under such machines loading would be limited. The effect in terms of site stability is Low, and the significance of the effect is **Slight.**

10.3.3.3.1.3.4 Effects that were Not Significant

The following primary effects of the operation and maintenance stage activities will not have a significant site stability effect from 2020 to 2040:

- Maintenance/repair of substation and control building

10.3.3.3.1.4 Secondary Impacts of Grid Connection (2020 to 2040)

There are no operation and maintenance activities related to the Grid Connection that will have any secondary impact on soils, geology and land.

Table 10-17: Impact Assessment on Soils, Geology and Land Use (2020 to 2040)

Activity/Item	Characteristic of Primary Effect of Site Activties				Impact Assessment - Soils, Geology and Land				
	Nature of Primary Effect	Extent of Activity	Duration	Frequency	Quality of Impact	Probability of Occurrence (Impact)	Impact of Primary Effect on Soils, Geology and Land	Sensitivity of Receiving Soils, Geology and Land	Significance of Impact
Forestry - Tree Topping	Loading from low ground pressure machinery on peat slopes, removal of trees - change of habitat, compression of peat, disturbance of peat surface	Along the OHL route	Temporary	Rarely	Slight Negative	Possible	Low	Medium	Slight
Maintenance/Repair of Substation	Loading from maintenance vehicles	At the substation location only	Brief	Occasional	Negative	Likely	Negligible	Medium	Not Significant

Table 10-18: Site Stability Impact Assessment (2020 to 2040)

Activity	Characteristics of Primary Effect of Site Activties with respect to Site Stability				Assessment of Site Stability Impacts on Soils, Geology & Land					
	Nature of Primary Effect	Extent of Primary Effect	Duration	Frequency	Quality of Impact	Possible Extent of a Peat Failure	Probability of Occurrence (Peat Failure)	Impact on Receiving Environment	Sensitivity of Receiving Soils, Geology & Land	Significance of Impact
Forestry - Felling of Regrowth	Low ground pressure machinery on peat slopes	Along the OHL route	Temporary	Rarely	Slight Negative	Small ($100m^2$-$2,500m^2$) to Medium ($2,500m^2$-$25,000m^2$)	Negligible to Low	Low	Medium	Slight
Substation Maintenance	Additional loading from maintenance vehicles	At substation	Brief	Rarely	Slight Negative	Not Applicable	Negligible	Negligible	Medium	Not Significant

The above table includes all effects that could impact stability

10.3.3.3.2 Grid Connection (Decommissioning)

This section of the chapter assesses the likely impacts of decommissioning of the grid connection, including the Agannygal Substation with respect to soils, geology and land.

Decommissioning the grid connection (c.2040) would entail the removal of the OHL above ground infrastructure between the Derrybrien and Agannygal substations. Potential access routes for decommissioning works have been identified and these will be subject to detailed design. However the accesses for the construction will be those used for the decommissioning and while these will be reviewed prior to decommissioning the significance of the effects (direct and site stability) associated with the access to the pole sets or mast locations will not be more than that during construction. The OHL poles and mast elements will be removed from site for reuse and if necessary, disposal in accordance with the relevant legislation. See chapter 2 for details.

10.3.3.3.2.1 Grid Connection - Decommissioning

The primary work activities and events that are to occur during this period that have been assessed as having an ongoing impact on soils, geology and land include the following:

- Forestry – Felling of Regrowth
- Demolition of the Agannygal substation and removal of the components off-site,
- Removal of the polesets and masts for the 110 kV line.

10.3.3.3.2.2 Direct Impacts of Grid Connection (Decommissioning)

The following section gives a summary of the assessment of the decommissioning of the OHL, Agannygal substation and Ancillary work activities that could have a direct impact on soils, geology and land that are of significance.

The assessment details of the potential significance of these impacts on soils, geology and land is given in Table 10-19.

10.3.3.3.2.2.1 Significant Effects

There are no primary effects during the decommissioning phase of the project where the direct impact on soils, geology and land use will be **Significant**.

10.3.3.3.2.2.2 Effects of Moderate Significance

There are no primary effects during the decommissioning phase of the project where the Significance of the direct impact on soils, geology and land use will be Moderate.

10.3.3.3.2.2.3 Effects of Slight Significance

The potential significance of the effect of the following primary work activities/events on soils, geology and land during the decommissioning phase will be Slight:

- Forestry – Felling of Regrowth
- Removal of polesets and masts for the 110kV line

Forestry – Felling of Regrowth

Some tree topping is likely to be carried out along the route of the OHL to trim back some of the small trees that re-established naturally on the slopes where clear felling had taken place. The work will be carried out using light LGBP wide-tracked harvesters operating on the peat. The small trees will be cut down and left in place on the slopes so that no forwarders will be required.

Loading resulting in settlement and consolidation of the underlying peat from trafficking of LGBP machines would be transient and very limited in extent. The potential effect is assessed as Very low.

The overall potential significance of these effects during decommissioning is **Slight.**

Removal of pole sets and masts for the 110 kV line (deep peat area)

One of the angle mast locations (AM38) was accessed during construction by the use of a temporary floating road constructed from felled trees, and by the use of LGBP wide tracked excavators and similar methods will be used in the decommissioning of the OHL. This will result in a live load on the peat surface during the decommissioning.

Construction traffic loading will result in negligible consolidation of the underlying peat. The potential effect of the additional traffic loading is assessed as Low.

The overall potential significance of these effects during decommissioning is **Slight.**

10.3.3.3.2.2.4 Effects that are Not Significant

The potential significance of the effect of the following primary work activities/events on soils, geology and land during the decommissioning phase will be Not Significant:

- **Removal of polesets and masts for the 110 kV line**: The majority of the polesets and masts will be removed using existing Coillte access tracks, and the effect of this works is assessed as Negligible. The potential significance of these works is **Not Significant**.
- **Demolition of the Agannygal Substation and removal of components off-site:** Decommissioning of the Agannygal substation will involve the removal of all substation equipment and buildings from the substation site. This work will be undertaken from the existing granular fill platform at the substation and the existing Coillte access track will be used to access the substation and to remove the equipment. The effect of these works is assessed as Negligible**.** The potential significance of these works is **Not Significant**.

10.3.3.3.2.3 Site Stability Impacts (Decommissioning Phase)

The following section gives a summary of the assessment of the primary work activities that will have a direct impact with regards to site stability that are of significance.

The assessment details of the potential significance of these impacts with regards to stability is given in Table 10-20.

10.3.3.3.2.3.1 Significant Effects

None of the primary effects will have a potentially Significant effect with regards to site stability during decommissioning.

10.3.3.3.2.3.2 Effects of Moderate Significance

None of the primary effects will have a potentially Moderate significance with regards to site stability during decommissioning.

10.3.3.3.2.3.3 Effects of Slight Significance

The potential significance of the effect of the following primary work activities with regards to site stability during decommissioning will be Slight:

- Forestry – Felling of Regrowth
- Removal of polesets and masts for the 110 kV line (deep peat area)

Forestry – Felling of Regrowth

Some tree topping is likely to be carried out along the route of the OHL to trim back some of the small trees that re-established naturally on the slopes where clear felling had taken place. The work will be carried out using light LGBP wide-tracked harvesters operating on the peat. The small trees will be cut down and left in place on the slopes so that no forwarders will be required.

The risk of a peat slide under such machine loading would be limited. The effect in terms of site stability is Low, and the potential significance of the effect is **Slight.**

Removal of polesets and masts for the 110 kV line (deep peat area)

One of the poleset locations (AM38) was accessed during construction by the use of a temporary floating road constructed from felled trees, and by the use of LGBP wide tracked excavators and similar methods will be used in the decommissioning of the OHL. This will result in a live load on the peat surface during the decommissioning of these particular pole sets. The effect of the additional traffic loading is assessed as Low. The potential significance of this effect in terms of site stability is **Slight**.

10.3.3.3.2.3.4 Effects that were Not Significant

The following primary effects of the decommissioning stage activities will not have a significant effect with regards to site stability:

- **Removal of polesets and masts for the 110 kV line**: The majority of the polesets and masts will be removed using existing Coillte access tracks, and the effect of this works is assessed as Negligible in terms of site stability. The potential significance of these works is **Not Significant**.

- **Dismantling of the Agannygal Substation and removal of components off-site:** Decommissioning of the Agannygal substation will involve the removal of all substation equipment and building from the substation site. This work will be undertaken from the existing granular fill platform at the substation and the existing Coillte access track will be used to access the substation and to remove the equipment. The effect of this works is assessed as Negligible in terms of site stability. The potential significance of these works is **Not Significant**.

10.3.3.3.2.4 Secondary Impacts of Grid Connection (Decommissioning)

There are no decommissioning activities related to the OHL and Agannygal substation that will have any secondary effect on soils, geology and land.

Table 10-19: Impact Assessment on Soils, Geology and Land Use (Decommissioning)

Activity/Item	Characteristic of Primary Effect of Site Activties				Impact Assessment - Soils, Geology and Land				
	Nature of Primary Effect	Extent of Activity	Duration	Frequency	Quality of Impact	Probability of Occurrence (Impact)	Impact of Primary Effect on Soils, Geology and Land	Sensitivity of Receiving Soils, Geology and Land	Significance of Impact
Forestry - Tree Topping	Loading from low ground pressure machinery on peat slopes, removal of trees - change of habitat, compression of peat, disturbance of peat surface	Along the OHL route	Temporary	Once	Slight Negative	Possible	Low	Medium	Slight
Demolition and removal of Agannygal Substation	Removal of substaion equipment on building, excavation of foundations, removal of stone platform	At substation location only	Temporary	Once	Slight Positive	Possible	Low	Medium	Not Significant
Removal of polesets & masts for 110kV line (deep peat area)	Loading from low ground pressure machinery on peat slope, compression of peat, disturbance of peat surface	At AM38 only	Brief	Once	Negative	Possible	Medium to Low	Medium	Slight
Removal of polesets & masts for 110kV line	Loading from machinery on competent ground, disturbance of ground when removing polesets	Along the OHL route	Temporary	Once	Negative	Possible	Medium to Low	Medium	Not Significant

Table 10-20: Site Stability Impact Assessment (Decommissioning)

Activity	Characteristics of Primary Effect of Site Activties with respect to Site Stability				Assessment of Site Stability Impacts on Soils, Geology & Land					
	Nature of Primary Effect	Extent of Primary Effect	Duration	Frequency	Quality of Impact	Possible Extent of a Peat Failure	Probability of Occurrence (Peat Failure)	Impact on Receiving Environment	Sensitivity of Receiving Soils, Geology & Land	Significance of Impact
Forestry - Felling of Regrowth	Low ground pressure machinery on peat slopes	Along the OHL route	Temporary	Once	Slight Negative	Small (100m^2-2500m^2) to Medium (2,500m^2-25,000m^2)	Negligible to Low	Low	Medium	Slight
Demolition and removal of Agannygal Substation	Excavation of foundations, removal of stone platform	At substation location only	Temporary	Once	Slight Negative	Not Applicable	Negligible	Low	Medium	Not Significant
Removal of polesets & masts for 110kV line (deep peat area)	Low ground pressure machinery on peat slopes	At AM38	Brief	Once	Negative	Small (100m^2-2,500m^2)	Negligible to Low	Medium to Low	Medium	Slight
Removal of polesets & masts for 110kV line	Loading from machinery on competent ground	Along the OHL route	Temporary	Once	Negative	Not Applicable	Negligible	Low	Medium	Not Significant

The above table includes all effects that could impact stability

10.3.4 Peat Slide and Response Works

10.3.4.1 Impacts Which Have Occurred

10.3.4.1.1 Construction Phase: 2003 to 2006 – Peat Slide and Response Works

This section of the chapter assesses the impact of the peat slide of 16th October 2003 and the associated works undertaken in response to the slide with respect to soils, geology and land use for the above period.

An assessment of the significance of these effects on soils, geology and land use is included, in addition, given the peat slide event, a specific assessment of the significance of the site stability impacts is included.

10.3.4.1.1.1 Peat Slide and Response Works – Construction Phase

The primary work activities and events that occurred during this period that have been assessed as having an impact on soils, geology and land use included the following:

- Peat slide - source area (1);
- Peat slide - debris (1);
- Construction of barrages to stop movement of slide debris (peat);
- Construction of peat repositories to store slide debris;
- Construction of borrow pit adjacent barrage 1;
- Construction traffic on intact peat;
- Construction of floating access tracks to location of barrage 1 and 2;
- Repairs to the Black Road Bridge, Flaggy Bridge and Unnamed Bridge C;
- Replacement of stepping stones.

(1) Note that the peat slide event has been divided into source area and debris. This is because, even though they are assessed as a single impact, the impact of the source area and debris are different and vary over time.

Whilst the peat slide has been separated and assessed as source area and debris, the significance of the effect of the peat slide event as a whole has been assessed as a single event for the period 2003 to 2006. Following 2006, the impacts of the peat slide source area and debris differ over time and as such the impacts are assessed separately.

The Project Description (Chapter 2) and the *“Geotechnical Stability Report 2”* (FT, 2020) provided in Appendix D give a detailed summary of the construction activities and associated events during this period.

10.3.4.1.1.2 Direct Impacts of Peat Slide and Response Works (2003 to 2006)

The following section gives a summary of the assessment of the peat slide and primary work activities that had a direct impact on soils, geology and land use that were of significance.

The assessment details of the potential significance of these impacts on soils, geology and land use is given in Table 10-23.

The assessment details of the potential significance of these impacts with regards to specifically stability is given in Table 10-13: .

10.3.4.1.1.2.1 Significant Effects

The significance of the effect of the following primary work activities/events on soils, geology and land use during this period was Significant:

- Peat slide – source area;
- Peat slide - debris.

Peat Slide - Source Area

The peat slide source area represents the area where the peat slide originated which has a plan area estimated at 253,000 m^2. The peat slide volume was estimated to be about 450,000 m^3 (AGEC, 2004). The volume of debris that remains within the source area is estimated at 200,000 m^3.

Degradation (oxidisation) of peat significantly increases when exposed to aerobic conditions, such as within the peat slide source area where peat was exposed above the water table. This results in release of stored carbon as carbon dioxide, which would have a negative effect and the immediate effect is Medium, which over time to the present the effect has reduced to Negligible, as exposed peat has been revegetated.

The loss of peat cover in the source area would have exposed the underlying mineral soil to adverse climatic conditions, resulting in leaching and erosion of the exposed soil. The effect with respect to loss of peat cover is given as Medium to High.

The source area would have occupied a substantial footprint comprising disturbed and weakened peat which would be unsafe for any practical use. The immediate effect following the slide would have rendered the land unusable. The effect on the land use would have been High.

Peat Slide - Debris

The path of the peat slide debris followed a tributary stream valley (SC7b) of the Owendalulleegh River. From the source area, the peat slide debris passed down the tributary stream valley passed the Black Road Bridge to the Flaggy Bridge. Below the Flaggy Bridge the stream is joined by further tributary streams (SC7a and SC7c) before joining the Owendalulleegh River about 1.3 km south of local road R353 (location of Flaggy Bridge), see Figure 10-27.

The extent of the run-out distance of the peat slide debris is estimated based on the presence of peat debris on the stream/river banks. The peat slide debris would have initially comprised dominantly a remobilised peat flow. As the debris flow entered a stream/river channel the debris flow would have become more fluidised due to the presence of water. A survey in December 2003[21] showed that the river banks below

[21] Inis Environmental Services, 2004, *“Derrybrien Windfarm Peat Slip - Environmental Impact Assessment on the Owendalluleegh River*”, March 2004.

the confluence with Owendalulleagh River had signs of erosion and some peat deposition, which was reducing downstream. It is considered that the debris flow was degrading downstream of the confluence with Owendalluleagh River with the debris essentially entering into suspension within the river water, which effectively marked the end of the actual peat debris flow for the purposes of this assessment. The survey reported essentially no debris on the river banks after about 3.1 km downstream of the confluence with the Owendalulleagh River. The length of the peat debris path from the end of the source to the point where the peat slide debris was entirely suspended within river water is estimated at 6.9 km.

As debris from the peat slide moved downslope it was deposited in a number of locations. A significant amount of the debris remains within the source area (estimated at 200,000 m^3). Peat debris was deposited along the run-out area, that is along existing stream/river banks and in depositional lobes notably above Black Road Bridge, within an area of grazing pasture. Based on aerial survey in 2004, the estimated peat deposited in the land above the Black Road Bridge covered a corridor some 50 m wide by 250 m long with an estimated average depth of say 0.5 m to 0.8 m, which during the slide event would have varied notably as peat slide debris passed through the area. Following the cessation of the slide event, the estimated volume was about 6,250 m^3, and possibly up to 10,000 m^3, which excludes material placed in the subsequent repository. This peat debris would have degraded over time and the extent of the peat debris would not be readily discernible.

Below the Black Road Bridge to the Flaggy Bridge there would have been notable peat deposition along the banks of the stream/channel. The survey of December 2003 found that there was notable peat debris deposition extending along the stream/river banks for about 4.9 km below the Flaggy Bridge. The survey estimated that within this 4.9 km length there was about 2,200 m^3 of peat debris present along the banks. Beyond 4.9 km below the Flaggy Bridge the survey noted that the deposition on the river/steam margins was reduced and vegetation was intact at most locations.

An amount of peat debris was subsequently placed within peat repositories, which is assessed separately under peat repositories.

A site walkover in 2019 (downslope of Black Road Bridge) showed little to no visual evidence of any remaining peat debris deposited along the banks of the stream/river. Over time, any material deposited along the river banks has been eroded/degraded.

Degradation (oxidisation) of peat significantly increases when exposed to aerobic conditions, such as peat slide debris exposed above the water table. This results in release of stored carbon as carbon dioxide, which would have a negative effect and the immediate effect is Medium.

Immediately after the event the debris would have occupied a substantial footprint which would have included most of the stream/river channels and adjacent banks downstream of the source area. The debris would have comprised a moving disturbed and weakened peat mass which would be unsafe for any practical use. The immediate effect following the slide would have rendered the land unusable. The effect on the land use would have been High

The overall significance of the effects from the peat slide source area and debris during the construction phase (2003 - 2006) is **Significant.**

10.3.4.1.1.2.2 Effects of Moderate Significance

The significance of the effect of the following primary work activities/events on soils, geology and land use during this period was Moderate:

- None

10.3.4.1.1.2.3 Effects of Slight Significance

The significance of the effect of the following primary work activities on soils, geology and land use during this period was Slight:

- Construction of barrages to restrict movement of slide debris (peat);
- Construction of peat repositories to store slide debris;
- Construction of borrow pit adjacent to barrage 1
- Construction traffic on intact peat.
- Construction of floating access tracks to location of barrage 1 and 2.

Construction of Barrages to Restrict Movement of Slide Debris (Peat)

In order to restrict the movement of the slide debris, which was essentially peat, a series of barrages were constructed. These were constructed between the wind farm project site boundary and downslope of the Flaggy Bridge on the R353 local road. The permanent barrages (1 to 4) comprised coarse rock fill which was placed onto competent ground. The temporary barrages (A to D) typically consisted of a mixture of earthen and rock fill material, which were all removed during the construction period.

A summary of the barrages is given in Table 10-21.

Table 10-21: Containment Barrages

Barrage	Typical Dimensions	Comments
Containment Barrage 1 (Coillte Road)	94m (long), 8m (wide), 2m (high)	Located within slide s source area Access directly from existing Coillte track
Containment Barrage 2	17m (long), 20m (wide), 5.5m (high)	Located within incised section of stream Access via constructed floating access track 300m (long), 3m (wide)
Containment Barrage 3	41m (long), 9m (wide), 3m (high)	Located across stream Temporary access from public road. Access route 100 m long and about 3 m wide
Containment Barrage 4	25m (long), 10m (wide), 3m (high)	Located across stream Temporary access from public road. Access route 100 m long and about 3 m wide

Barrage	Typical Dimensions	Comments
Temporary Containment Barrage A	Estimated: 80m (long), 3m (wide), 3m (high)	Located upstream of Black Road Bridge Barrage removed sometime after slide event Access direct from existing road
Temporary Containment Barrage B	Estimated: 80m (long), 3m (wide), 3m (high)	Located upstream of Black Road Bridge Barrage removed sometime after slide event Access direct from existing road
Temporary Containment Barrage C	Estimated: 20m (long), 3m (wide), 3m (high)	Located upstream of Flaggy Bridge on R353 Barrage removed sometime after slide event Access direct from existing road
Temporary Containment Barrage D	Estimated: 20m (long), 3m (wide), 3m (high)	Located downstream of Flaggy Bridge on R353 Barrage removed sometime after slide event Access direct from existing road

Notes:

(1) The temporary containment barrages were constructed from October to November 2003 by Galway County Council and were subsequently removed sometime after the slide event. Date of removal is not known.

(2) The dimensions of the temporary containment barrages are estimated based on available records and site inspection.

(3) Access track lengths to temporary containment barrages C and D are estimates.

Loading resulting in consolidation/settlement of the underlying ground would have occurred at each of these barrage locations however given the existing barrages are founded, and temporary barrages are assumed to be founded on competent material, the effect is assessed as Very low.

The footprint of the permanent barrages was relatively small and ranged from typically 250 to 750 m^2. The footprint of the temporary barrages was also relatively small and ranged from typically 60 to 240 m^2. The volume of coarse rock fill used in the permanent barrages was also relatively small and ranged from about 750 to 1500m^3 with approximately 4,500 m^3 of rock fill used in total. The rock used in the barrages 1 and 2 was extracted from a local borrow pit adjacent to one of the barrages. It is understood that the temporary barrages were constructed of locally sourced material (mix of soil and rock).

Associated access tracks were constructed to a few of the barrages, most notably barrages 1 and 2 where floating access tracks were constructed, which is addressed separately below. The accesses to the remaining barrages were either direct from existing roads or by essentially tracking plant and material over existing terrain to the barrage site (barrages 3 and 4).

The overall effect on land use as a consequence of the barrages and access for Barrage 3 and Barrage 4 is assessed as Low to Medium.

The permanent barrages would have sealed the ground. The barrages were placed onto glacial soil or a granular/rocky stream bed. The permanent barrages were constructed with materials that allowed water to flow through the barrage.

The effect with respect to sealing is given as Low.

The overall significance of these effects during the construction phase (2003 - 2006) is **Slight**.

Construction of Peat Repositories to Store Slide Debris

Following the peat slide, a series of repositories were constructed along the path of the peat slide between the project site and the Flaggy Bridge on the R353 local road.

A summary of the peat repositories is given in Table 10-22.

Table 10-22: Peat Repositories

Repository	Typical Dimensions (max.)	Comments
Repository at Barrage 2	108m (long), 34m (wide), 2m (high)	Founded on peat, partially bunded/bunded on the downslope side with earthen material
Repository at Black Road Bridge	140m (long), 85m (wide), 2m (high)	Founded on shallow peat, partially bunded/bunded with earthen material from drainage excavations. Removal of some Coillte forestry required.
Repository at Barrage 3	41.5m (long), 16m (wide), 1.6m (high)	Sunken in bunded excavation and founded on mineral soil

Loading resulting in some consolidation of the underlying peat in Repositories at Black Road Bridge and Barrage 2, where present, would have occurred but the effect is assessed as Low. In general, construction machines that trafficked over particularly deeper peat would have been light or low ground bearing pressure (LGBP) wide-tracked machines suitable for working on the peat. As the Repository at Barrage 3 is founded on mineral soil the effect is assessed as Negligible.

The footprint of the repositories was relatively small and ranged from typically 600 to 12,000 m^2. In total, the repositories covered an area of about 16,200 m^2 (1.6 ha), typically in forested areas which had been felled. The volume of material, comprising dominantly slide debris, within the repositories ranged from about 1,200 to 14,000 m^3. These repositories were filled with slide debris of dominantly peat and other minor material removed from the adjacent river/stream channel and in particular material which had accumulated on the upstream side of the barrages 1, 2 and 3. Material in the repository at the Black Road Bridge was removed from the lands and stream in the area where peat deposition had occurred.

The repository material was laid directly onto the ground surface. There was a very limited amount of construction material used for the repositories (such as in forming containment bunds).

The effect on land use is assessed as Low to Medium.

The repositories would have initially sealed the ground and prevented the previous land use, though the placed peat would in time have dried and allowed re-growth of vegetation to occur.

The placed peat will also have led to consolidation of the underlying peat. The effect is given as Low.

The overall significance of these effects during the construction phase (2003 - 2006) is **Slight**.

Construction of Borrow Pit Adjacent to Barrage 1

A portion of the rock for the containment barrages was excavated from a borrow pit to the northeast of barrage 1, within Coillte forestry.

The borrow pit comprised an excavation into intact bedrock approximately 78 m in length, 48 m in width and is up to approximately 2 m deep. The footprint was about 2,314 m^2 (0.231 ha). The volume of material extracted from the borrow pit was about 1,371 m^3. The effect on land use is assessed as Low.

The overall significance of these effects during the construction phase (2003 - 2006) is **Slight**.

Construction Traffic on Intact Peat

Construction traffic was required to pass over intact peat during the construction of some of the barrages, peat repositories and other construction activities. In general, construction machines that trafficked over particularly deeper peat would have been light or low ground bearing pressure (LGBP) wide-tracked machines suitable for working on the peat.

Loading resulting in settlement and consolidation of the underlying peat from trafficking of LGBP machines would be transient and very limited. The effect is assessed as Very low.

The footprint under the track of LGBP would be transient and have no implications for land use, as such the effect is assessed as Negligible.

The overall significance of these effects during the construction phase (2003 - 2006) is **Slight**.

Construction of Floating Access Tracks to Location of Barrage 1 and 2

An access track 830 m in length was constructed from an existing Coillte forest track in order to access the location of barrage 1. 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 and is assessed above for direct impacts.

The floating track was typically about 4 m wide and assumed to be constructed in a similar fashion to the floated access tracks on site with varying thickness of 0.6 to 1 m of crushed rock granular fill with, 1 to 2 layers of geogrid reinforcement on a basal reinforcing layer of small trees/branches placed directly onto the surface of the intact peat.

A floating access track approximately 300 m in length was constructed from an existing Coillte forest track in order to access the location of barrage 2. The floating access track was constructed on peat and assumed to be constructed in a similar fashion to the floated access tracks on site. The track was typically about 4 m wide with varying thickness of 0.6 to 1 m of crushed rock granular fill with 1 to 2 layers of geogrid reinforcement on a basal reinforcing layer of small trees/branches placed directly onto the surface of the intact peat.

The peat below these floating accesses is relatively thin. The section of access track extending westerly from barrage 1 was constructed as a floating track on peat about 0 to 1.5 m depth. The access track to barrage 2 was constructed as a floating track on peat up to about 1.5 m depth.

Notable settlement and consolidation of the underlying peat would have occurred from the construction loading where floated on peat, and the effect on the peat is assessed as Low to Medium.

The footprint of the access tracks was about 4500 m^2. The volume of crushed rock granular fill was about 3000 m^3. The rock used for the track was extracted from a local borrow pit adjacent to one of the barrages or imported from an external source. The effect on the land use is assessed as Low to Medium.

The access track would have effectively sealed the ground. The effect with respect to sealing is given as Low.

The overall significance of these effects during the construction phase (2003 - 2006) is **Slight**. (Note that the significance relative to site stability is given below)

10.3.4.1.1.2.4 Effects that were Not Significant

The significance of the effect of the following primary work activities on soils, geology and land use during this period was not significant:

- Repairs to the Black Road Bridge, Flaggy Bridge and Unnamed Bridge C
- Replacement of stepping stones

Repairs to the Black Road Bridge, Flaggy Bridge and Unnamed Bridge C were carried out due to damage as a result of the peat slide debris. These repairs were of structural nature and the effect with respect to land soil and geology was **Not Significant**.

Downstream, on the Owendalulleegh River, a set of stepping stones at a ford location were replaced where they had been damaged by the peat slide debris. The effect with respect to land soil and geology was **Not Significant**.

10.3.4.1.1.3 Site Stability Impacts - Peat Slide and Response Works (Construction Stage 2003 to 2006)

The following section gives a summary of the assessment of the primary work activities that had a direct impact with regards to stability that were of significance.

The assessment details of the potential significance of these impacts specifically with regards to stability is given in Table 10-24.

10.3.4.1.1.3.1 Significant Effects

The significance of the effect of the following primary work activities/events with regards to stability during this period was Significant:

- Peat slide - source area;
- Peat slide – debris.

Whilst the peat slide has been separated and assessed as source area and debris, the significance of the effect of the peat slide event as a whole has been assessed as a single event for the period 2003 to 2006. Following 2006, the impacts of the peat slide source area and debris differ over time and as such the impacts are assessed separately.

Peat Slide - Source Area

The peat slide source area represents the area where the peat slide originated which has a plan area estimated at 253,000 m^2. The peat slide volume was estimated to be about 450,000 m^3 (AGEC, 2004). The estimated volume of debris that remains within the source area is estimated at 200,000 m^3.

The highly fluid debris within the source area would have been notably unstable and prone to remobilisation. There would have also been a risk of potential further expansion of the source area, though inspection of the perimeter of the source area immediately following the slide by AGEC found no clear evidence of this. Any expansion of the source area that possibly occurred would have been localised failure of the perimeter of the source area.

An assessment of peat stability within the peat slide source area was carried out (FT, 2020). The effect with regards to intrinsic stability of the debris within the source stability immediately after the slide would be initially Medium to High.

Over time this would reduce to Low, which would reduce further with time to Very low, this is assessed as part of the later phases (see for example Section 10.3.4.1.2)**.** The reduction in effect with time would be due to drainage of water from the peat slide source area (included as a secondary positive effect below) and re-establishment of vegetation. Notwithstanding the above, should any instability events occur within the peat slide source area, they are likely to be localised in nature.

Peat Slide - Debris

Immediately after the slide event there was a considerable amount of peat debris that moved downslope following an existing natural valley. The highly fluid debris would have been notably unstable and would have caused erosion of the stream channel. As the debris was essentially confined in a stream/river channel, the risk of the load from the debris causing further ground failure was limited, and there was possibly very localised failure/erosion of the stream banks.

As the debris passed downslope the effect on stability would have reduced as the debris became more diluted within the water of the stream/river channel. The length of the peat debris path from the end of the source area to the point where the peat slide debris was entirely suspended within river water is estimated at 5.8 km.

The immediate effect with regards to the intrinsic stability of the debris would have been initially negative and High.

A site walkover in 2019 (downslope of Black Road Bridge) showed little/no visual evidence of any peat debris deposited along the banks of the stream/river.

The overall significance of the effects from the peat slide source area and debris during the construction phase (2003 - 2006) is **Significant.**

10.3.4.1.1.3.2 Effects of Moderate Significance

The significance of the effect of the following primary work activities/events with regards to stability during this period was Moderate:

- Construction of floating access tracks to location of barrage 1 and 2.

Construction of Floating Access Tracks to location of Barrage 1 and 2

An access track 830 m 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.

A floating access track 300 m in length was constructed from an existing Coillte forest track in order to access the location of barrage 2. The floating access track was constructed on peat.

The peat below these floating accesses is relatively thin. The section of access track extending westerly from barrage 1 was constructed as a floating track on peat about 0 to 1.5 m depth. The access track to barrage 2 was constructed as a floating track on peat up to about 1.5 m depth. Given the relatively thin peat and shallow slope angles the risk of instability is not considered significant.

As the floating tracks were constructed on peat there would be an elevated risk of instability. The highest risk for instability is in the short-term undrained condition during construction. Over time, the peat consolidates and increases in strength under the weight of the road, which significantly reduces the risk of peat instability.

No failures of floating road resulting in peat slides have occurred on the project. The effect in terms of stability would have been Medium during construction.

The overall significance of these effects during the construction phase (2003 - 2006) is **Moderate.**

10.3.4.1.1.3.3 Effects of Slight Significance

The significance of the effect of the following primary work activities with regards to stability during this period was Slight:

- Construction of barrages to restrict movement of slide debris (peat);
- Construction of peat repositories to store slide debris;
- Construction traffic on intact peat.
- Construction of borrow pit adjacent to barrage 1

Construction of Barrages to Restrict Movement of Slide Debris (Peat)

The permanent barrages (1 to 4) were constructed on competent ground comprising either cohesive glacial soils or bedrock that would not be susceptible to instability or consolidation. It is considered the temporary barrages were constructed on similar competent ground. The effect with regards to stability is Very low. Over time, consolidation would increase underlying soil strength and further reduce the effect.

The overall significance of these effects during the construction phase (2003 - 2006) is **Slight**.

Construction of Peat Repositories to Store Slide Debris

The repositories were founded on mineral soil (cohesive glacial soil) and peat. These repositories stored pre-dominantly material removed from the upstream side of the barrages. The assessment of ground stability (“*Geotechnical Stability Report 2”* (FT, 2020)) showed that the effect with regards to stability was low, and is discussed in detail above, see Table 10-6. Over time, consolidation would increase underlying soil/peat strength and together with removal of water and re-establishment of vegetation this would further reduce the effect.

The significance of these effects during the construction phase (2003 - 2006) is **Slight**.

Construction Traffic on Intact Peat

Construction traffic was required to pass over intact peat during the construction of some of the barrages, peat repositories and other construction activities. In general, construction machines that trafficked over particularly deeper peat would have been light or low ground bearing pressure (LGBP) wide-tracked machines suitable for working on the peat. The risk of a peat slide under such machines loading would be limited. The effect in terms of stability is Very low.

The overall significance of these effects during the construction phase (2003 - 2006) is **Slight**.

Construction of Borrow Pit adjacent to Barrage 1

A portion of the rock for the containment barrages was excavated from a borrow pit to the northeast of barrage 1, within Coillte forestry.

The borrow pit comprised an excavation into intact bedrock approximately 78 m in length, 48 m in width and is up to approximately 2 m deep. The footprint was about 2,314 m^2 (0.231 ha). The volume of material extracted from the borrow pit was about 1,371 m^3. The effect of this excavation on site stability is assessed as Negligible to Very Low.

The overall significance of these effects during the construction phase (2003 - 2006) is **Slight**.

10.3.4.1.1.3.4 Effects that were Not Significant

The following primary effects of the construction stage activities did not have a significant direct effect with regards to stability during construction:

- Repairs to the Black Road Bridge, Flaggy Bridge and Unnamed Bridge C
- Replacement of stepping stones

Repairs to the Black Road Bridge, Flaggy Bridge and Unnamed Bridge C were carried out due to damage as a result of the peat slide debris. These repairs were of structural nature and the effect with respect to land soil and geology was **Not Significant**.

Downstream, on the Owendalulleegh River, a set of stepping stones at a ford location were replaced where they had been damaged by the peat slide debris. The effect with respect to land soil and geology was **Not Significant**.

10.3.4.1.1.4 Secondary Impacts of Peat Slide and Response Works (2003 to 2006)

The following section gives a summary of the assessment of the peat slide and primary work activities that had a secondary impact on soils, geology and land use that were of significance.

The assessment details of the significance of these impacts on soils, geology and land use is given in Table 10-23.

The assessment details of the significance of these impacts specifically with regards to stability is given in Table 10-24.

10.3.4.1.1.4.1 Significant Effects

There were no secondary effects during the construction phase from 2003 to 2006 where the secondary impact on soils, geology and land use was Significant.

10.3.4.1.1.4.2 Effects of Moderate Significance

There were no secondary effects during the construction phase from 2003 to 2006 where the secondary impact on soils, geology and land use was Moderate.

10.3.4.1.1.4.3 Effects of Slight Significance

The significance of the secondary impact of the following primary work activities/events on soils, geology and land use during this period was Slight:

- Peat slide - source area

Peat Slide - Source Area

The peat slide source area is 1 to 2 m in depth relative to the surrounding ground levels. As a result of the difference in ground level between the adjacent insitu peat and the floor of the slide source area, groundwater from the surrounding peat would drain into the slide source area, particularly from the upper more fibrous peat layer. This would result in a positive effect as the surrounding peat would become relatively drier, which would tend to stabilise the surrounding area.

Immediately after the event there would have been little change in the drainage regime with the effect that instability would be Medium to High. Over time the drainage would have a positive effect and would reduce the effect with regards to instability to Very low as drainage occurred.

With respect to stability, the overall significance of these effects during the construction phase (2003 - 2006) is positive and **Slight.**

10.3.4.1.1.4.4 Effects that were Not Significant

There were no secondary effects during the construction phase from 2003 to 2006 where the secondary impact on soils, geology and land use was Not Significant.

Table 10-23: Impact Assessment on Soils, Geology and Land Use - Construction Phase 2003 to 2006

Activity/Item	Characteristic of Primary Effect of Site Activties				Impact Assessment - Soils, Geology and Land				
	Nature of Primary Effect	Extent of Activity	Duration	Frequency	Quality of Impact	Probability of Occurrence (Impact)	Impact of Primary Effect on Soils, Geology and Land	Sensitivity of Receiving Soils, Geology and Land	Significance of Impact
Peat slide - source area	Land use within peat slide source area. Change of habitat due to loss of peat cover. Carbon release/oxidisation of exposed peat. Erosion of underlying soil.	Within peat slide source area	Long term	Once	Negative	Possible to Likely	Medium to high	Medium	Significant
Peat slide - debris	Increased loading on slope from weight of slide debris. Land covered by peat debris. Carbon release/oxidisation.	Within extent of peat debris	Short term	Once	Negative	Possible to Likely	Medium to high	Medium	
Construction of barrages to restrict movement of slide debris (peat)	Increased loading on slope from weight of barrage fill. Consolidation/settlement and sealing of underlying soil. Land use.	At barrage locations	Long term	Constant	Negative	Likely	Very low to medium	Medium	Slight
Construction of peat repositories to store slide debris	Increased loading on slope from weight of stored material. Consolidation./settlement and sealing of underlying peat. Land use. Carbon release/oxidisation. Removal of some forestry at repository at Black Road Bridge	At repository locations	Long term	Constant	Negative	Likely	Low to medium	Medium	Slight
Construction of borrow pit adjacent barrage 1	Removal of rock and land-take	At borrow pit location	Long term	Constant	Negative	Likely	Low	Medium	Slight
Construction traffic on intact peat	Loading from machinery on peat slopes. Consolidation/settlement of peat. Land use.	At barrage locations	Temporary	Rarely	Negative	Likely	Negligble to very low	Medium	Slight
Construction of a floating access track to location of barrage 1 and 2	Loading from floated access track constructed to Barrage 1 and 2. Loss of habitat. Consolidation/settlement and sealing. Land use.	Along route of track	Long term	Constant	Negative	Possible to likely	Low to medium	Medium	Slight
Other Activities/Items	Repairs to Black Road and Flaggy Bridge	At bridge location	Long term	Constant	Neutral	Likely	Negligible	Medium	Not Significant
	Replacement of Slattery Bridge	At bridge location	Long term	Constant	Slight Negative	Likely	Negligible	Medium	Not Significant
	Replacement of Stepping Stones	At stepping stones location	Long term	Constant	Neutral	Likely	Negligible	Medium	Not Significant

Table 10-24: Site Stability Impact Assessment - Construction Phase 2003 to 2006

Activity	Characteristics of Primary Effect of Site Activities with respect to Site Stability				Assessment of Site Stability Impacts on Soils, Geology & Land						Did Peat Failure occur? (Yes/No)
	Nature of Primary Effect	Extent of Primary Effect	Duration	Frequency	Quality of Impact	Possible Extent of a Peat Failure	Probability of Occurrence (Peat Failure)	Impact on Receiving Environment	Sensitivity of Receiving Soils, Geology & Land	Significance of Impact	
Peat slide source area	Localised retrogressive collapse of edge of peat slide source area	Within extent of peat slide source area	Temporary	Once	Negative	Small (100m^2-2,500m^2) to Medium (2,500m^2-25,000m^2)	Possible to Likely (see note 3)	Medium to high	Medium	Significant	Yes (see note 3)
Peat slide debris	Increased loading on slope from weight of slide debris	Within extent of peat debris, most likely occurring in peat slide source area	Temporary	Once	Negative	Small (100m^2-2,500m^2) to Medium (2,500m^2-25,000m^2)	Possible to Likely (see note 3)	High	Medium		
Construction of barrages to restrict movement of slide debris (peat)	Increased loading on slope from weight of barrage fill	At barrage locations	Long term	Constant	Negative	Small (100m^2-2,500m^2)	Negligible to Low	Very Low	Medium	Slight	No
Construction of peat repositories to store slide debris	Increased loading on slope from weight of stored material	At repository locations	Long term	Constant	Negative	Small (100m^2-2,500m^2) to Medium (2,500m^2-25,000m^2)	Negligible to Low	Low	Medium	Slight	No
Construction of borrow pit adjacent barrage 1	Excavation of slopes in overburden and bedrock	At borrow pit location	Long term	Constant	Negative	Small (100m^2-2,500m^2)	Negligible to Low	Very low to Low	Medium	Slight	No
Construction traffic on intact peat	Loading from machinery on peat slopes	At barrage/repository locations	Temporary	Rarely	Negative	Small (100m^2-2500m^2) to Medium (2500m^2-25000m^2)	Negligible to Low	Very Low	Medium	Slight	No
Construction of floating access tracks to location of barrage 1 and 2	Loading from floated access track	Along route of track	Long term	Constant	Negative	Small (100m^2-2,500m^2)	Negligible to Low	Mediim	Medium	Moderate	No
Other Activities/Items	Repairs to Black Road and Flaggy Bridge	At bridge location	Long term	Constant	Neutral	Not Applicable	Negligible	Negligible	Medium	Not Significant	No
	Replacement of Slattery Bridge	At bridge location	Long Term	Constant	Slight Negative	Not Applicable	Negligible	Negligible	Medium	Not Significant	No
	Replacement of Stepping Stones	At stepping stones location	Medium Term	Constant	Neutral	Not Applicable	Negligible	Negligible	Medium	Not Significant	No

(1) The above table includes all effects that could impact stability

(2) The above table commences immediately after the October 2003 peat slide - it does not include the slide event

(3) These events were both the result of the 16 October peat slide and the "Yes" refers to the material that failed during the peat slide. Records show no subsequent notable failure of in-situ ground occurred due to the already failed material.

10.3.4.1.2 Operation and Maintenance Phase: 2006 to 2020 - Peat Slide and Response Works

This section of the chapter assesses the impact of the peat slide and response works undertaken in response to the slide with respect to soils, geology and land use during the above operation and maintenance (O&M) period.

An assessment of the significance of these impacts on soils, geology and land use is included, in addition, given the peat slide event, a specific assessment of the significance of the impacts with regards to peat stability is included.

10.3.4.1.2.1 Peat Slide and Response Works - Operation and Maintenance Phase

The primary work activities that occurred during this period that have been assessed as having an impact on soils, geology and land use included the following:

- Maintenance of barrages.

The Project Description (Chapter 2) and the *"Geotechnical Stability Report 2"* (FT, 2020) give a detailed summary of the of activities during this period.

10.3.4.1.2.2 Direct Impacts of Peat Slide and Response Works (O&M Phase 2006 to 2020)

The following section gives a summary of the assessment of the peat slide and primary work activities that had a direct impact on soils, geology and land use that were of significance.

The assessment details of the significance of these impacts on soils, geology and land use is given in Table 10-25.

10.3.4.1.2.2.1 Significant Effects

There were no primary effects during the operation and maintenance phase of the project from 2006 to 2020 where the direct impact on soils, geology and land use was Significant.

10.3.4.1.2.2.2 Effects of Moderate Significance

There were no primary effects during the operation and maintenance phase of the project from 2006 to 2020 where the direct impact on soils, geology and land use was Moderate.

10.3.4.1.2.2.3 Effects of Slight Significance

The significance of the effect of the following primary work activities/events on soils, geology and land use during this period was Slight:

- Maintenance of barrages.

Maintenance of Barrages

In this time period, slide debris accumulated behind some of the barrages. Works were undertaken in 2007 to remove this debris from behind barrages 1 and 2. Works were undertaken from the barrage and the adjacent access tracks with the peat debris placed into the adjacent repository. This likely resulted in an additional live load due to machinery during the works, plus an additional load within the adjacent repositories when the material removed from behind the barrages was placed in the repositories.

The additional loading in the repositories likely resulted in some consolidation of the underlying peat. As this peat would have previously been compressed by the construction of the repository, the effect of the additional placed debris is assessed as Very low.

The footprint of the repositories would not have increased greatly due to the additional placement of peat during this period. The additional effect on land use due to maintenance is assessed as Very low.

The overall significance of these effects during the O&M phase (2006 - 2020) is **Slight**.

10.3.4.1.2.2.4 Effects that were Not Significant

There were no primary effects during the operation and maintenance phase of the project from 2006 to 2020 where the direct impact on soils, geology and land use was Not Significant.

Impacts on Stability - Peat Slide and Response Works (O&M Phase 2006 to 2020)

The following section gives a summary of the assessment of the peat slide and primary work activities that had a direct impact with regards to stability that were of significance.

The assessment details of the significance of these effects specifically with regards to stability is given in Table 10-26.

10.3.4.1.2.2.5 Significant Effects

No primary effects had a Significant effect with regards to stability during the operation and maintenance phase of the project from 2006 to 2020.

10.3.4.1.2.2.6 Effects of Moderate Significance

No primary effects had a Moderate significance with regards to stability during the operation and maintenance phase of the project from 2006 to 2020.

10.3.4.1.2.2.7 Effects of Slight Significance

The significance of the effect of the following primary effects with regards to stability during this period was Slight:

- Maintenance of barrages

Maintenance of Barrages

In this time period, slide debris accumulated behind some of the barrages. Works were undertaken in 2007 to remove this debris from behind barrages 1 and 2. Works were undertaken from the barrage and the adjacent access tracks with the peat debris placed into the adjacent repository. This likely resulted in an additional live load due to machinery during the works, plus an additional load within the adjacent repositories when the material removed from behind the barrages was placed in the repositories.

Assessment of ground stability, including accessing the barrage, and placing additional material in the repositories, showed that the effect of this work in terms of instability was Very low.

With respect to stability, the overall significance of these effects during the O&M phase (2006 - 2020) is **Slight**.

10.3.4.1.2.2.8 Effects that were Not Significant

No primary effects had a Not Significant effect with regards to stability during the operation and maintenance phase of the project from 2006 to 2020.

10.3.4.1.2.3 Secondary Impacts of Peat Slide and Response Works (2006 to 2020)

There were no secondary impacts during the O&M phase from 2006 to 2020 on soils, geology and land use.

Table 10-25: Impact Assessment on Soils, Geology and Land Use - O&M Phase 2006 to 2020

Activity/Item	Characteristic of Primary Effect of Site Activities				Impact Assessment - Soils, Geology and Land				
	Nature of Primary Effect	Extent of Activity	Duration	Frequency	Quality of Impact	Probability of Occurrence (Impact)	Impact of Primary Effect on Soils, Geology and Land	Sensitivity of Receiving Soils, Geology and Land	Significance of Impact
Maintenance of barrages	Loading from machinery and debris on peat slopes. Consolidation/settlement of peat in repository. Change in land use.	At barrage/repository locations	Brief to Long Term	Occasional to Constant	Negative	Likely	Very low	Medium	Slight

Table 10-26: Site Stability Impact Assessment - O&M Phase 2006 to 2020

Activity	Characteristics of Primary Effect of Site Activities with respect to Site Stability				Assessment of Site Stability Impacts on Soils, Geology & Land						Did Peat Failure occur? (Yes/No)
	Nature of Primary Effect	Extent of Primary Effect	Duration	Frequency	Quality of Impact	Possible Extent of a Peat Failure	Probability of Occurrence (Peat Failure)	Impact on Receiving Environment	Sensitivity of Receiving Soils, Geology & Land	Significance of Impact	
Maintenance of barrages	Loading from plant and weight of stored material on slope	At barrage/repository locations	Brief to Long Term	Occasional to Constant	Slight Negative	Small ($100m^2$-$2,500m^2$) to Medium ($2,500m^2$-$25,000m^2$)	Negligible	Very low	Medium	Slight	No

10.3.4.2 Impacts Which Are Occurring

10.3.4.2.1 Peat Slide and Response Works

This section of the chapter assesses the ongoing impact of the peat slide and the response works undertaken in response to the slide with respect to soils, geology and that are still occurring at the end of Q2 2020.

An assessment of the significance of these impacts on soils, geology and land use is included, in addition, given the peat slide event, a specific assessment of the significance of the impacts with regards to peat stability is included.

10.3.4.2.1.1 Peat Slide and Response Works

The primary work activities and events that occurred during this period that have been assessed as having an ongoing impact on soils, geology and land use include the following:

- Peat slide - source area;
- Peat slide - debris;
- Barrages to stop movement of slide debris (peat);
- Peat repositories to store slide debris;
- Borrow pit adjacent barrage 1;
- Floating access track to location of barrage 1 and 2.

The Project Description (Chapter 2) and the *“Geotechnical Stability Report 2”* (FT, 2020) give a detailed summary of the construction activities and associated events during this period.

10.3.4.2.1.2 Impacts which are occurring - Direct Impacts (Peat Slide and Response Works)

The following section gives a summary of the assessment of the peat slide and primary work activities that have a direct ongoing impact on soils, geology and land use that were of significance.

The assessment details of the significance of these impacts on soils, geology and land use is given in Table 10-27.

10.3.4.2.1.2.1 Significant Effects

There were no primary effects during the phase of the project still occurring at the end of Q2 2020 where the direct impact on soils, geology and land use was Significant.

10.3.4.2.1.2.2 Effects of Moderate Significance

There were no primary effects during the phase of the project still occurring at the end of Q2 2020 where the direct impact on soils, geology and land use was Moderate.

10.3.4.2.1.2.3 Effects of Slight Significance

The significance of the effect of the following primary work activities/events on soils, geology and land use during this period was **Slight**:

- Peat slide - source area;
- Peat slide - debris

Peat Slide - Source Area

As previously assessed for the construction stage, except as follows.

Degradation (oxidisation) of peat significantly increases when exposed to aerobic conditions. The release of stored carbon as carbon dioxide has reduced over time to the present as particularly exposed peat has revegetated with the effect becoming Negligible.

The loss of peat cover in the source area would have exposed the underlying mineral soil to adverse climatic conditions, resulting in leaching and erosion of the exposed soil. Revegetation would have reduced the effect to Very Low.

The source area would have occupied a substantial footprint which would have initially affected the potential land use. The land use potential would have improved over time as the source area has stabilised, revegetated and become more accessible resulting in the effect being negative and Low.

The overall significance of these effects still occurring at the end of Q2 2020 is **Slight.**

Peat Slide - Debris

As previously assessed for the construction stage, except as follows.

A site walkover in 2019 (below Black Road Bridge) showed little/no visual evidence of any remaining peat debris deposited along the banks of the streams/rivers. Over time, any material deposited along the river banks has been eroded/degraded with removal of water and re-establishment of vegetation. The river banks and bed appear to have returned to baseline conditions. The overall ongoing effect is reduced to Negligible to Very low.

Based on the site walkover in 2019 on the accessible lands, there is negligible volume of peat debris present outside the source area, and as such the footprint of the peat debris area is considered minimal.

Degradation (oxidisation) of peat significantly increases when exposed to aerobic conditions, such as peat slide debris exposed above the water table. This results in release of stored carbon as carbon dioxide, which would have a negative effect, which over time to the present the effect has reduced to Negligible, as exposed peat debris volumes have reduced.

The overall significance of these effects still occurring at the end of Q2 2020 is **Slight**.

10.3.4.2.1.2.4 Effects that were Not Significant

The following primary effects during this phase of the project were still occurring at the end of Q2 2020 where the direct impact on soils, geology and land use was **Not Significant** are as follow:

- Barrages to stop movement of slide debris (peat);
- Peat repositories to store slide debris;
- Borrow pit adjacent barrage 1;
- Floating access track to location of barrage 1 and 2.

10.3.4.2.1.3 Impacts which are occurring – Site Stability Impacts (Peat Slide and Response Works)

The following section gives a summary of the assessment of the peat slide and primary work activities that are having an ongoing impact with regards to stability at the end of 2019.

The assessment details of the significance of these impacts with regards to specifically stability is given in Table 10-28.

10.3.4.2.1.3.1 Significant Effects

No primary effects had a Significant effect with regards to stability still occurring at the end of Q2 2020.

10.3.4.2.1.3.2 Effects of Moderate Significance

No primary effects had a Moderate significance with regards to stability still occurring at the end of Q2 2020.

10.3.4.2.1.3.3 Effects of Slight Significance

The significance of the impact of the following primary effects on stability during this period was slight:

- Peat slide - source area;
- Floating access track to location of barrage 1 and 2.

Peat Slide - Source Area

Immediately after the peat slide there would have been little change in the drainage conditions of the source area, and the effect with regards to stability would have been Medium to High. However over time to the present the effect of the drainage of the source area would be positive in terms of site stability and reduce the effect to Low.

Commentary with regards to stability of the source area over time is included in Section 10.2.4.4.3.

Plate 10-5 shows a general overview of the revegetated source area in 2019.

The overall significance of these effects still occurring at the end of Q2 2020 is **Slight.**

Plate 10-5: Overview of re-vegetated area within the peat slide source area

Floating Access Tracks to Location of Barrage 1 and 2
As previously assessed for the construction stage, except as follows.

Over time, under the weight of the road the underlying peat consolidates and increases in strength, which significantly reduces the risk of peat instability. No failures of floating road resulting in peat slides have occurred on the project. The potential effect in terms of stability is reduced to Very Low to Low.

The overall significance of these effects still occurring at the end of Q2 2020 is **Slight.**

10.3.4.2.1.3.4 Effects that were Not Significant

The following effects that are Not Significant effect with regards to stability were still occurring at the end of Q2 2020:

- Peat slide - debris;
- Barrages to stop movement of slide debris (peat);
- Peat repositories to store slide debris;
- Borrow pit adjacent barrage 1;

Peat Slide - Debris

With particular reference to the peat slide-debris, a site walkover in 2019 (below Black Road Bridge) showed little/no visual evidence of any remaining peat debris deposited along the banks of the streams/rivers. The overall ongoing effect with regards to stability is given as Negligible to Very low.

The overall significance of these effects still occurring at the end of Q2 2020 is **Not Significant.**

10.3.4.2.1.4 Ongoing Secondary Direct Impacts of Peat Slide and Response Works (2003 to 2019)

There were no secondary impacts still occurring at the end of Q2 2020.

Table 10-27: Impact Assessment on Soils, Geology and Land Use (Ongoing)

Activity/Item	Characteristic of Primary Effect of Site Activities				Impact Assessment - Soils, Geology and Land				
	Nature of Primary Effect	Extent of Activity	Duration	Frequency	Quality of Impact	Probability of Occurrence (Impact)	Impact of Primary Effect on Soils, Geology and Land	Sensitivity of Receiving Soils, Geology and Land	Significance of Impact
Peat slide - source area	Land use within peat slide source area. Change of habitat due to loss of peat cover. Carbon release/oxidisation of exposed peat. Erosion of underlying soil.	Within peat slide source area	Long term	Once	Negative	Possible to Likely	Negligible to low	Medium	Slight
Peat slide debris	Land covered by peat debris. Carbon release/oxidisation.	Within extent of peat debris	Long term	Once	Negative	Possible to likely	Negligible to very low	Medium	Slight

Table 10-28: Site Stability Impact Assessment (Ongoing)

Activity	Characteristics of Primary Effect of Site Activties with respect to Site Stability				Assessment of Site Stability Impacts on Soils, Geology & Land					
	Nature of Primary Effect	Extent of Primary Effect	Duration	Frequency	Quality of Impact	Possible Extent of a Peat Failure	Probability of Occurrence (Peat Failure)	Impact on Receiving Environment	Sensitivity of Receiving Soils, Geology & Land	Significance of Impact
Peat slide - source area	Localised retrogressive collapse of edge of peat slide source area. Removal of water from peat slide source area. Re-establishment of vegetation	Within peat slide source area	Long term	Rarely	Negative	Small (100m^2-2,500m^2) to Medium (2,500m^2-25,000m^2)	Positive Impact – Reduced Probability	Low	Medium	Slight
Floating access tracks to location of barrage 1 and 2	Loading from floated access track	Along route of track	Long term	Constant	Negative	Small (100m^2-2,500m^2)	Negligible to Low	Very low to low	Medium	Slight

The above table includes all effects that could impact stability

The above table commences immediately after the October 2003 peat slide - it does not include the slide event

10.3.4.3 Impacts Which Are Likely To Occur

10.3.4.3.1 Operation and Maintenance Phase: 2020 to End of Operation (2040) - Peat Slide and Response Works

This section of the chapter assesses the likely impacts of the peat slide and the response works undertaken in response to the slide with respect to soils, geology and land use for the above period.

An assessment of the significance of these impacts on soils, geology and land use is included, in addition, given the peat slide event, a specific assessment of the significance of the impacts on peat stability is included.

10.3.4.3.1.1 Peat Slide and Response Works (2020 to 2040)

The primary works that may be carried out on the site during this period that could have an impact on soils, geology and land use include the following:

- Maintenance of barrages 1 and 2

The Project Description (Chapter 2) gives a detailed summary of the construction activities and associated events during this period.

10.3.4.3.1.2 Direct Impacts of Peat Slide and Response Works (2020 to 2040)

The following section gives a summary of the assessment of the peat slide and primary work activities that had a direct impact on soils, geology and land use that were of significance.

The assessment details of the significance of these impacts on soils, geology and land use is given in Table 10-29.

10.3.4.3.1.2.1 Significant Effects

There are no primary effects during the phase of the project from 2020 to 2040 where the direct impact on soils, geology and land use will be Significant.

10.3.4.3.1.2.2 Effects of Moderate Significance

There are no primary effects during the phase of the project from 2020 to 2040 where the direct impact on soils, geology and land use will be Moderate.

10.3.4.3.1.2.3 Effects of Slight Significance

The effect of the following primary work activities/events on soils, geology and land use during this period was slight:

- Maintenance of barrages 1 and 2

Maintenance of Barrages 1 and 2

As previously assessed for the construction stage, except as follows.

No material has been removed from behind barrages since 2007 and inspection has shown that there is no adverse accumulation of debris on upslope side of barrages.

The frequency of maintenance is likely to reduce further as peat debris accumulation behind barrages reduces. The general effect, which includes plant accessing the barrage and storage of material in the repositories, is assessed as Negligible to Very low.

The overall significance of these effects for the period 2020 to 2040 is **Slight.**

10.3.4.3.1.2.4 Effects that were Not Significant

There are no primary effects during the phase of the project from 2020 to 2040 where the direct impact on soils, geology and land use will be Not Significant.

10.3.4.3.1.3 Impacts on Stability (Peat Slide and Response Works - 2020 to 2040)

The following section gives a summary of the assessment of the peat slide and primary work activities that had a direct impact with regards to stability that were of significance.

The assessment details of the significance of these impacts with regards to specifically stability is given in Table 10-30.

10.3.4.3.1.3.1 Significant Effects

No primary effects had a Significant effect with regards to stability during the phase of the project from 2020 to 2040.

10.3.4.3.1.3.2 Effects of Moderate Significance

No primary effects had a Moderate significance with regards to stability during the phase of the project from 2020 to 2040.

10.3.4.3.1.3.3 Effects of Slight Significance

The significance of the effect of the following primary effects on stability during this period was slight:

- Maintenance of barrages 1 and 2

Maintenance of Barrages 1 and 2

As previously assessed for the construction stage, except as follows.

No material has been removed from behind barrages since 2007 and inspection has shown that there is no adverse accumulation of debris on upslope side of barrages. The frequency of maintenance is likely to reduce further as peat debris accumulation behind barrages reduces.

Assessment of ground stability, including accessing the barrage, and placing additional material in the repositories, showed that the effect of this work in terms of stability is Very low.

With respect to stability, the overall significance of these effects during the O&M phase (2020 - 2040) is **Slight**.

10.3.4.3.1.3.4 Effects that were Not Significant

No primary effects had a Not Significant effect with regards to stability during the phase of the project from 2020 to 2040.

10.3.4.3.1.4 Secondary Impacts of Peat Slide and Response Works (2020 to 2040)

There are no secondary impacts during the phase of the project from 2020 to 2040.

Table 10-29: Impact Assessment on Soils, Geology and Land Use (2020 to 2040)

Activity/Item	Characteristic of Primary Effect of Site Activities				Impact Assessment - Soils, Geology and Land				
	Nature of Primary Effect	Extent of Activity	Duration	Frequency	Quality of Impact	Probability of Occurrence (Impact)	Impact of Primary Effect on Soils, Geology and Land	Sensitivity of Receiving Soils, Geology and Land	Significance of Impact
Maintenance of barrages 1 and 2	Loading from machinery on peat slopes. Consolidation/settlement of peat in repository. Change in land use.	At barrage/repository locations	Brief to long term	Rarely to constant	Negative	Possible	Negligible to very low	Medium	Slight

Table 10-30: Site Stability Impact Assessment (2020 to 2040)

Activity	Characteristics of Primary Effect of Site Activities with respect to Site Stability				Assessment of Site Stability Impacts on Soils, Geology & Land						Did Peat Failure occur? (Yes/No)
	Nature of Primary Effect	Extent of Primary Effect	Duration	Frequency	Quality of Impact	Possible Extent of a Peat Failure	Probability of Occurrence (Peat Failure)	Impact on Receiving Environment	Sensitivity of Receiving Soils, Geology & Land	Significance of Impact	
Maintenance of barrages 1 and 2	Loading from plant and weight of stored material on slope	At barrage/repository locations	Brief to Long Term	Rarely to constant	Slight Negative	Small (100m^2-2,500m^2) to Medium (2,500m^2-25,000m^2)	Negligible	Very low	Medium	Slight	No

The above table includes all effects that could impact stability

The above table commences immediately after the October 2003 peat slide - it does not include the slide event

10.3.4.3.2 Peat Slide and Response Works (Decommissioning)

This section of the chapter assesses the likely impact of the peat slide and the response works undertaken in response to the slide with respect to soils, geology and land use during decommissioning.

For decommissioning the peat slide and the response works (c. 2040) it is proposed that barrages 3 and 4 will be removed, subject to the approval of Inland Fisheries Ireland. It is proposed that the barrage material would be brought to a designated storage area. Further details with respect to the decommissioning works are presented in chapter 2. These are summarised here as follows:

- Access to barrages will be from the Black Road and by bog mat if necessary
- Works to be carried out during a dry weather period with outlook of dry weather
- Water course to be blocked and water to be pumped over
- Debris to the upstream side of the barrage followed by the removal of the barrage shall be undertaken
- All ground shall be trimmed to suitably stable slopes
- Existing channel profiles shall be matched with reclaimed channel section

As set out in Chapter 2, it is envisaged that the following works will remain in place into the future and therefore will not be removed:

- Barrage 1
- Barrage 2 & associated repository area
- Repository area at Barrage 3
- Repository area at the Black Bridge

The above works represent a relatively small footprint and have been investigated and analysed and are shown to be stable.

10.3.4.3.2.1 Decommissioning - Peat Slide and Response Works

This section of the chapter assesses the likely impact of the peat slide and the response works undertaken in response to the slide with respect to soils, geology and land use during decommissioning.

10.3.4.3.2.2 Peat Slide and Response Works (Decommissioning)

The work activities that are to occur during this period that have been assessed as having a direct impact on soils, geology and land use include the following:

- Removal of barrages 3 and 4

10.3.4.3.2.3 Direct Impacts of Peat Slide and Response Works (Decommissioning)

The following section gives a summary of the assessment of the work activities that may have a direct impact on soils, geology and land use that ware of significance.

The assessment details of the potential significance of these impacts on soils, geology and land use is given in Table 10-31.

10.3.4.3.2.3.1 Significant Effects

There are no primary effects during the decommissioning phase of the project where the direct impact on soils, geology and land use will be Significant.

10.3.4.3.2.3.2 Effects of Moderate Significance

There are no primary effects during the decommissioning phase of the project where the significance of the direct impact on soils, geology and land use will be Moderate**.**

10.3.4.3.2.3.3 Effects of Slight Significance

The significance of the effect of the following primary work activities/events on soils, geology and land use during this period is considered to be slight:

- Removal of barrages 3 and 4

Removal of Barrages 3 and 4

The barrages were founded on mineral soil (cohesive glacial soil/bedrock). A description of the proposed decommissioning methodology for barrages 3 and 4 is contained in Chapter 2.

Construction traffic loading will result in negligible consolidation of the underlying peat, where present. Inspection of access routes from the public road to the west of the barrages shows thin peat cover. For example, the proposed access to barrage 4, has peat thickness of typically 0.1 to 0.5 m. This would not represent a stability issue, though suitable plant would be required to track across this ground. The significance of the effect of the additional traffic loading on the peat habitat is assessed as Negligible**.**

The barrages will be removed so the effect on land use will be positive. However, removed fill material is to be placed in a designated storage area see Project Description (Chapter 2). The significance of the effect on land use is likely to remain Very low for the activities associated with the removal of barrage 3 and 4**.**

The overall potential significance of these effects during decommissioning is negative and **Slight.**

10.3.4.3.2.3.4 Effects that were Not Significant

There are no primary effects during the decommissioning phase of the project where the direct impact on soils, geology and land use will be Not Significant.

10.3.4.3.2.4 Site Stability Impacts (Peat Slide and Response Works – Decommissioning Phase)

The following section gives a summary of the assessment of the peat slide and primary work activities that will have a direct impact on stability that are of significance.

The assessment details of the significance of these impacts on specifically stability is given Table 10-32.

10.3.4.3.2.4.1 Significant Effects

No primary effects will have a Significant effect with regards to stability during decommissioning.

10.3.4.3.2.4.2 Effects of Moderate Significance

No primary effects will have a Moderate significance with regards to stability during decommissioning.

10.3.4.3.2.4.3 Effects of Slight Significance

The significance of the effect of the following primary effects with regards to stability during this period is considered to be slight:

- Removal of barrages 3 and 4

Removal of Barrages 3 and 4

The barrages were founded on mineral soil (cohesive glacial soil/bedrock). An assessment of ground stability for the proposed decommissioning methodology, including the proposed access routes to the barrages, showed that the effect in terms of stability is Very low.

The proposed accesses to the barrages are within areas of thin peat. For example, the proposed access to barrage 4 has peat thickness of typically 0.1 to 0.5 m. This would not represent a stability issue, though suitable plant would be required to track across this ground.

Removed fill material is to be placed in a designated storage area with the effect in terms of stability for storage and transport is Negligible.

The overall potential significance of these effects occurring during decommissioning is negative and **Slight.**

10.3.4.3.2.4.4 Effects that were Not Significant

No primary effects during the decommissioning phase of the project with regards to stability that are Not Significant.

10.3.4.3.2.5 Secondary Impacts of Peat Slide and Response Works (Decommissioning)

There are no secondary impacts expected to occur during decommissioning.

Table 10-31: Impact Assessment on Soils, Geology and Land Use (Decommissioning)

Activity/Item	Characteristic of Primary Effect of Site Activities				Impact Assessment - Soils, Geology and Land				
	Nature of Primary Effect	Extent of Activity	Duration	Frequency	Quality of Impact	Probability of Occurrence (Impact)	Impact of Primary Effect on Soils, Geology and Land	Sensitivity of Receiving Soils, Geology and Land	Significance of Impact
Removal of barrages 3 and 4	Loading from machinery on peat/access tracks. Localised consolidation/settlement. Disturbance of peat surface. Removal of barrage - change in land- use. Storage of material.	At barrage locations	Brief to Long Term	Once to constant	Slight Negative	Possible	Negligible to very low	Medium	Slight

Table 10-32: Site Stability Impact Assessment (Decommissioning)

Activity	Characteristics of Primary Effect of Site Activities with respect to Site Stability				Assessment of Site Stability Impacts on Soils, Geology & Land						Did Peat Failure occur? (Yes/No)
	Nature of Primary Effect	Extent of Primary Effect	Duration	Frequency	Quality of Impact	Possible Extent of a Peat Failure	Probability of Occurrence (Peat Failure)	Impact on Receiving Environment	Sensitivity of Receiving Soils, Geology & Land	Significance of Impact	
Removal of barrages 3 and 4	Loading from machinery on peat slopes/access tracks. Decreased loading on slope from weight of barrage fill. Storage of material.	At barrage locations	Brief to Long Term	Once to constant	Slight Negative	Small (100m^2-2,500m^2)	Negligible	Very Low	Medium	Slight	No

The above table includes all effects that could impact stability

The above table commences immediately after the October 2003 peat slide - it does not include the slide event

10.4 Cumulative Impacts

10.4.1 Introduction

Section 2.5 in Chapter 2 of this report gives a description of the projects in the vicinity of Derrybrien Wind Farm Project that have been considered in the assessment of cumulative impacts. These include:

- Turf cutting (peat extraction) in the turbary plots within and immediately adjacent to the wind farm site;
- Peat extraction outside the Project site;
- Other wind farms in the Slieve Aughty Mountains:
    - Sonnagh Old Wind Farm;
    - Keelderry Wind Farm;
- Adjacent coniferous forestry plantations;
- Planting in lieu of felling on the wind farm site;
- Thermal Generation - Tynagh 400 MW Power Station, Derryfrench, Co. Galway;
- Overhead Transmission Lines:
    - Moneypoint-Oldstreet 400 kV Overhead Line;
    - Ennis-Shannonbridge 100 kv Line;
- Gort Regional Water Supply Scheme;
- Flood Relief Schemes:
    - Local OPW Flood Relief Scheme – Gort
    - Local Flood Relief Works at Kiltartan
    - Flood Relief Works at Kinvarra
    - Proposed Gort Lowlands Flood Relief Scheme
- M18 Gort to Tuam Motorway Project
- Quarries/Sand Extraction
    - Sand extraction at Cloghvoley
    - Coillte Quarry (R353/Black Rd. Junction)
    - Ballynakill Quarry
- Works to Beagh Bridge

The locations of these projects are identified on the map in Figure 2.7. The majority were carried out remote to the site of the Derrybrien Wind Farm Project and the related activities did not have and are not likely to have cumulative impacts with significant effects on soils, geology and land within the Project area. The following sections assess the potential cumulative impacts of activities related to the other wind farm projects in the Slieve Aughty Mountains, adjacent coniferous forestry plantations and turf cutting on the wind farm site and adjacent land, where there was more potential for significant cumulative impacts.

10.4.2 Cumulative Impacts from Adjacent Wind Farm Projects in the Slieve Aughty Mountains

10.4.2.1 Sonnagh Old Wind Farm

The Sonnagh Old Wind Farm is located in the Slieve Aughty Mountains in Sonnagh Old, approximately 3.5 km northwest of the Derrybrien Wind Farm site. It is comprised of 9 No. Vestas V52/850 turbines and associated access roads and electrical transmission infrastructure, including a 38 kV overhead grid connection to the 38 kV Loughrea substation at Caherlavin. The turbines on Sonnagh Old are the same as those that were erected on the Derrybrien Wind Farm.

Construction of the Sonnagh Old Wind Farm coincided with the initial phase of construction on the Derrybrien Wind Farm in 2003, but it was commissioned in 2004, approximately two years before Derrybrien Wind Farm.

The characteristics of the soils, geology and land on the site of the Sonnagh Old Wind Farm are very similar to those in the Project are for the Derrybrien Wind Farm. Figure 10-43 shows the location of the Sonnagh Old Wind Farm on the Ordnance Survey of Ireland (OSI) 1:50,000 Discovery Series topographical map with the quaternary geology map from the Geological Survey of Ireland (GSI) superimposed. The wind farm was constructed within a coniferous forest plantation at an elevation of 290 to 320 mOD on the northern slopes of Sonnagh Old mountain. The GSI quaternary geology map indicates that the ground conditions on the site were comprised of upland blanket bog over Devonian Sandstone till. There are numerous rock outcrops in the vicinity of the site. The 1:100,000 geological map for the area from the GSI (Figure 10-15) indicates that bedrock in the area is comprised of Mudstone, Siltstone and Conglomerate of the Ayle River Formation. The site is outside the limits of the Sonnagh Bog SAC.

The site activities during construction on the Sonnagh Old Wind Farm would be broadly similar to those on the Derrybrien Wind Farm site, depending on the design for the site access tracks (i.e. whether they were constructed as floating roads on the peat or as rockfill embankments on the glacial till below the peat by excavate/replace). Therefore, the corresponding impacts on the receiving soils, geology and land would be similar in nature, albeit on a much smaller scale at Sonnagh Old due to the significantly lower number of turbines. However, the impact of the reasonably anticipated past and future site activities at Sonnagh Old would not have given rise to cumulative direct or stability impacts on the receiving soils, geology and land in the Derrybrien Wind Farm project area because Sonnagh Old Wind Farm is a separate project with an independent grid connection and it is located on a different mountain in the Slieve Aughty Mountains, and is topographically remote and in a different river sub-catchment to the Derrybrien Wind Farm, as shown in Figure 10-44.

Figure 10-43 also shows the location of a peat slide that occurred at Sonnagh Old during the construction of the wind farm in 2003, prior to the large peat slide that occurred at the Derrybrien Wind Farm on the 16th October 2003. The cause of the slide at Sonnagh Old has not been reported in literature on the subject. However, Lyndsay and Bragg (2005) state that it appears to have originated along an access road on the wind farm site and that at involved 15,000 m^3 of peat.

An aerial photograph of the site from 2005 showing the location and extent of the slide is presented in Figure 10-45 along with a geomorphological map of the slide area produced by Dykes (2009). Based on this information it appears that the slide initiated in an area of peat on shallow slopes of 2.5-4.0° along the upslope edge of a steep scarp of 3-4 m high cliffs. Peat was displaced to the north over an area of about 0.50 to 0.75 ha from the upper slope and deposited over an area of about 1.25-1.50 ha on the shallow slopes of 3.5° downslope from the escarpment. Debris from the slide appears to have reached the channel for the stream flowing from Lough Belsrah, approximately 450 m downslope. The stream is within a sub-catchment of the Kilchreest River to the north of Sonnagh Old.

The peat slide at Sonnagh Old was more localised and significantly smaller than the slide that occurred at the Derrybrien Wind Farm, which displaced approximately 450,000 m^3 of peat over an area of about 25 ha. Based on the criteria presented in Section 10.1.5, the sensitivity of the degraded blanket bog in the coniferous forest impacted by the peat slide at Sonnagh Old would be classified as **Medium**, and the effect of the slide on the receiving soils, geology and land in the area would also be classified as **Medium**, which is of **Moderate Significance**. However, this does not give rise to a cumulative impact on soils, geology and land for the Derrybrien Wind Farm Project area because the slide at Sonnagh Old occurred in a different river sub-catchment to the large peat slide that occurred on the south side of the Derrybrien Wind Farm.

10.4.2.2 Keelderry Wind Farm

The site for the Keelderry Wind Farm is located on the Slieve Aughty Mountains approximately 3.0 km west of the Derrybrien Wind Farm. Planning permission was granted to a developer in July 2002 for a 48 x 1 MW wind farm and associated works on the site. The site access roads were constructed c. 2007. However, the rest of the project was never completed and a subsequent application for the site was refused.

Figure 10-46 shows the location of the Keelderry Wind Farm on the Ordnance Survey of Ireland (OSI) 1:50,000 Discovery Series topographical map with the quaternary geology map from the Geological Survey of Ireland (GSI) superimposed. Figure 10-47 shows a recent aerial photograph of the site.

The wind farm site is located at an elevation of 240 to 290 mOD at the west end of Cashlaundrumlahan Mountain. The GSI quaternary geology map indicates that the ground conditions on the site are comprised of upland blanket bog over Devonian Sandstone till. There are numerous rock outcrops in the vicinity of the site. The 1:100,000 geological map for the area from the GSI (Figure 10-15) indicates that the bedrock is comprised of Mudstone, Siltstone and Conglomerate of the Ayle River Formation.

The east side of the site is partially covered in coniferous forest plantations and there are turbary plots and areas of cutaway bog on the west side of the site. The aerial photo in Figure 10-47 shows the extent of access roads that have been constructed on the site. The main track along the west side of the site is an access road for the turbary plots that existed prior to 2007. Dirney's Lough is at the centre of the site.

On this site the site activities were limited to the construction of the site access tracks across the blanket bog – either as floating roads or as embankments of rockfill on the underlying glacial till. No peat slides occurred during the construction of the access tracks.

Although the wind farm site is located within the same river sub-catchment as the Derrybrien Wind Farm, the Keelderry Wind Farm was never constructed and the site is at lower elevation and topographically remote to the Derrybrien site. Therefore, the impact of the site activities at Keelderry would not have given rise to cumulative direct or stability impacts on the receiving soils, geology and land in the Derrybrien Wind Farm Project area.

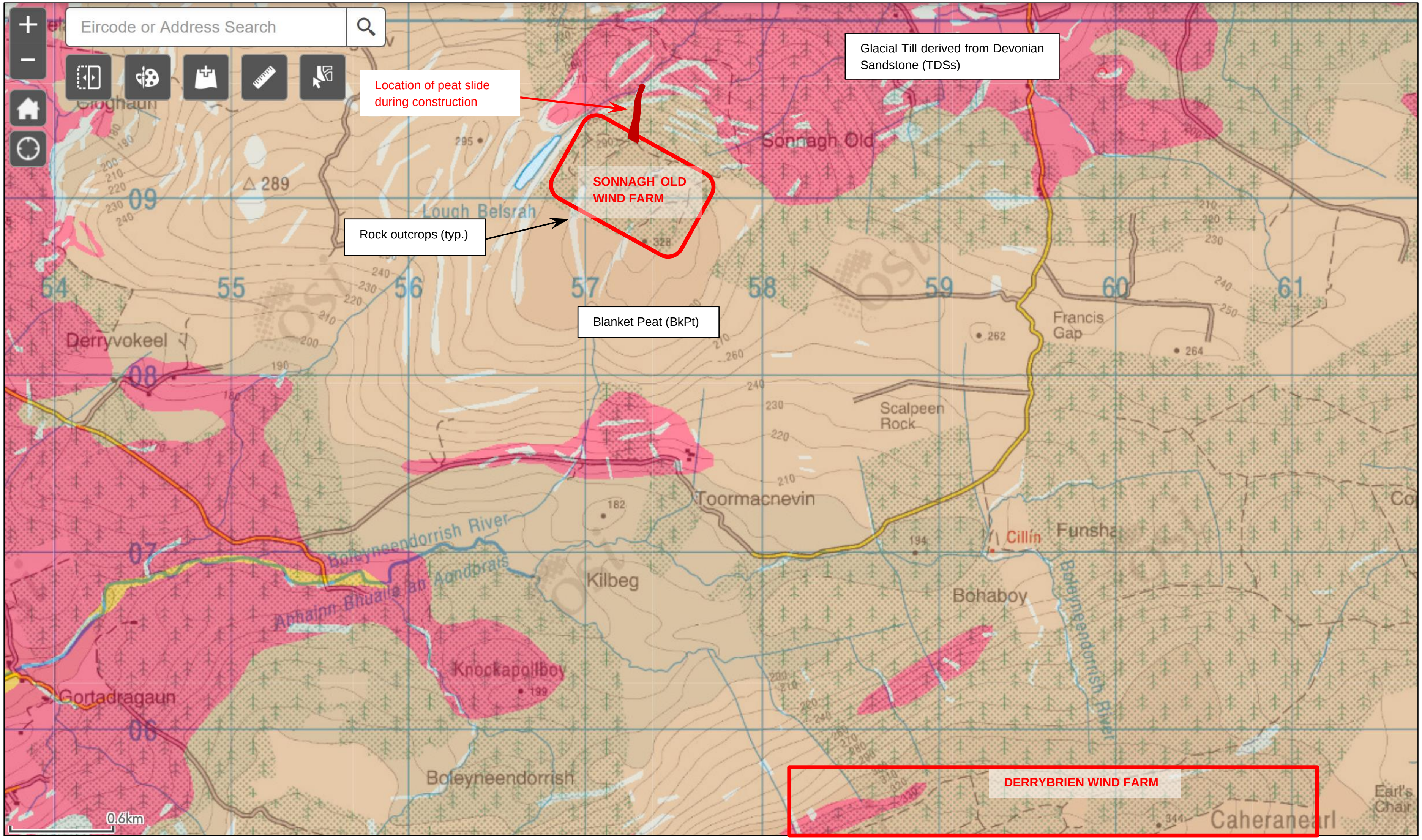


Figure 10-43: Sonnagh Old Wind Farm – Location, Topography and Quaternary Geology (GSI Online Portal, 2020)

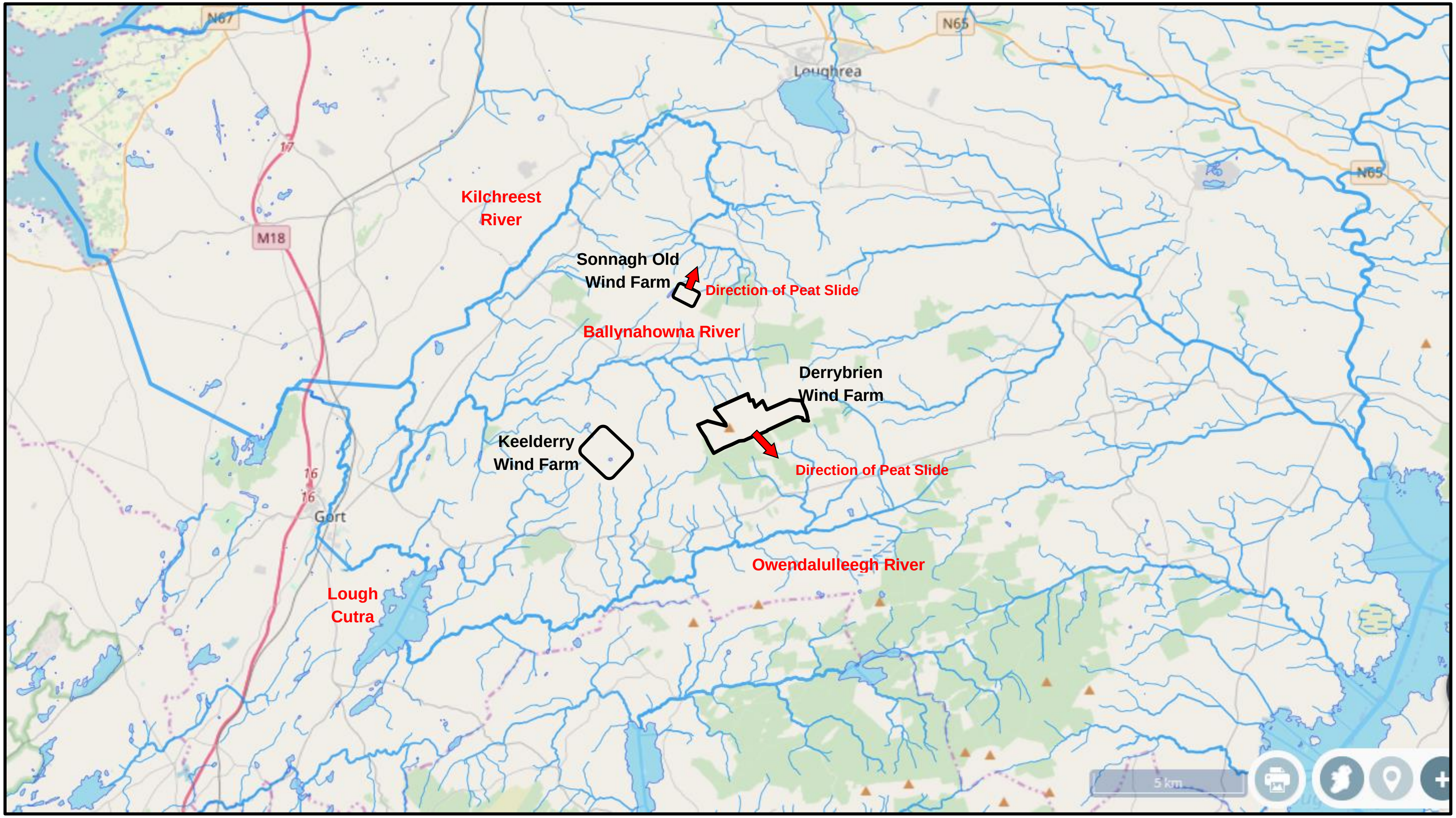


Figure 10-44: Regional hydrology for other wind farms in the Slieve Aughty Mountains

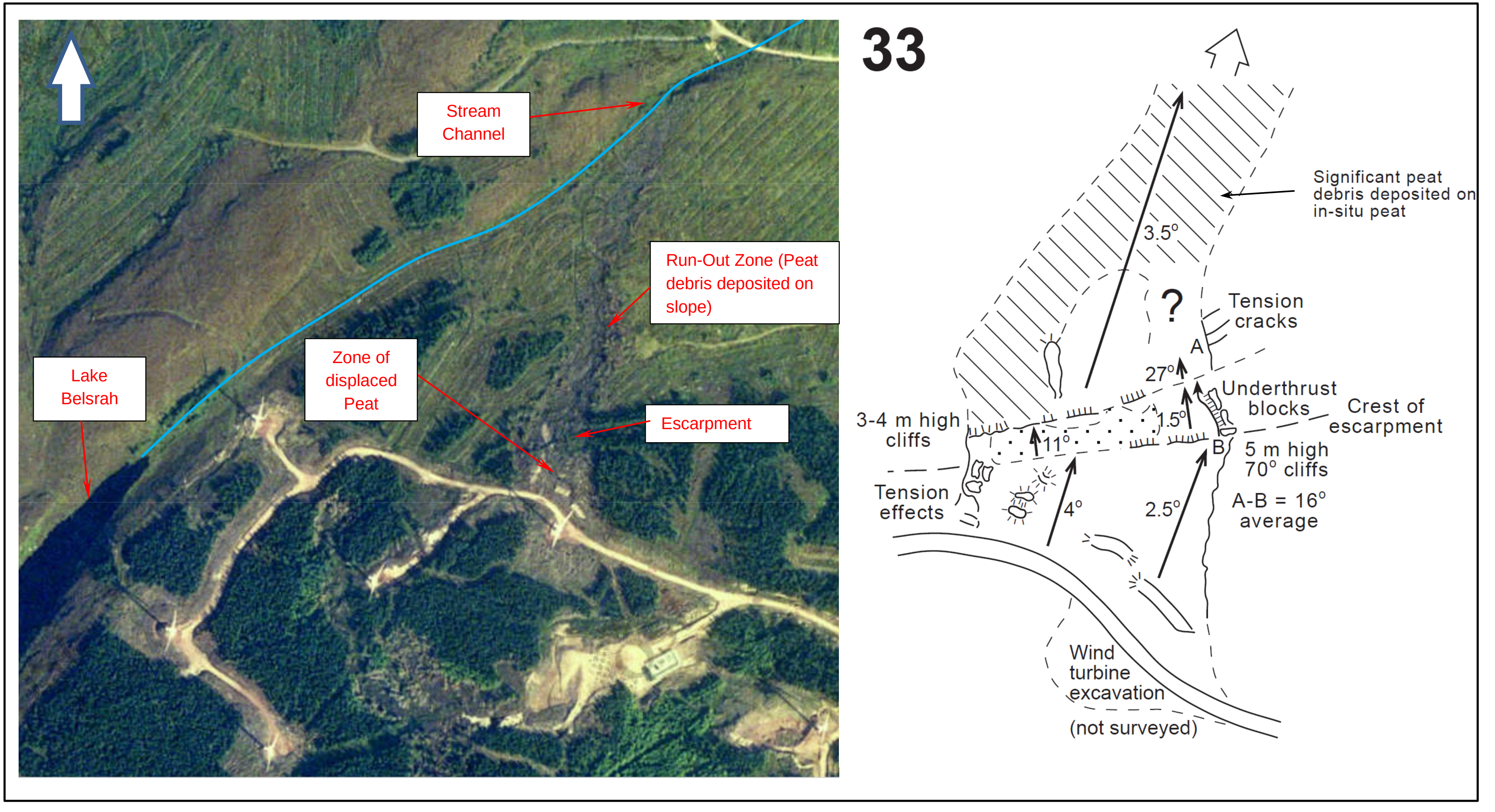


Figure 10-45: Characteristics of peat slide at Sonnagh Old Wind Farm (2005 Aerial Photo (OSI - Geohive Online Portal, 2020) & Geomorphological Map of Slide Area (Dykes, 2009)

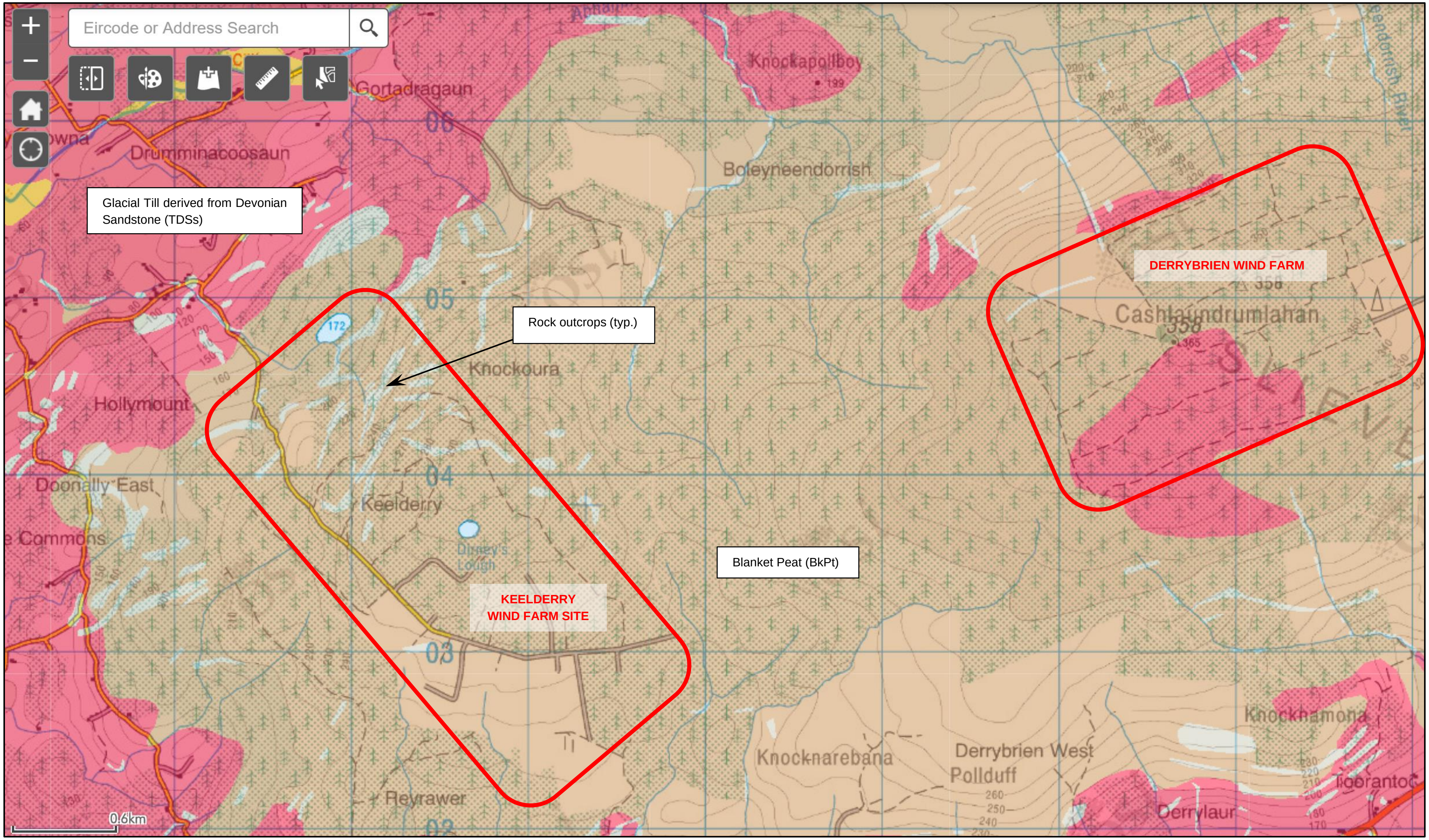


Figure 10-46: Keelderry Wind Farm – Location, Topography and Quaternary Geology (GSI Online Portal, 2020)

Figure 10-47: Keelderry Wind Farm – Recent Aerial Photograph [c 2015] (OSI Geohive Online Portal, 2020)

10.4.3 Cumulative Impacts from Adjacent Coniferous Forestry Plantations (Not Part of Project)

The impact of tree felling that was required as part of the project on soils, geology and land has been addressed in Section 10.3. This section assess the potential cumulative impact of forestry operations on adjacent lands in the Project area.

The extent and age of forestry in the Slieve Aughty Mountains in the vicinity of the project area is shown on Figure 2.7 in Chapter 2. The majority of these are owned and operated by Coillte. According to their records forestry represents over 50% of land use within the river sub-catchment areas within which the wind farm site is located.

The forests in the area were mainly planted in the 1960s and 1970s. Therefore, most of the drainage, access tracks and site infrastructure required for the planting and management of the forests was in place prior to the construction of the Derrybrien Wind Farm. The extent of forestry has not changed significantly since the wind farm was constructed. However, due to its age profile, much of the forestry has recently required felling and replanting as part of the normal life-cycle of such commercial operations. For example, between 2016 and 2018 a total of 275 ha of forestry was earmarked for felling on Coillte land within the catchments within which Derrybrien Wind Farm is located, although the actual date of felling is no known. It is likely that felling and replanting of the forests in the project area will continue over the remaining operational life of the wind farm.

Figure 10-48 shows the forestry in the project area plotted on the Ordnance Survey of Ireland (OSI) 1:50,000 Discovery Series topographical map with the quaternary geology map from the Geological Survey of Ireland (GSI) superimposed. This indicates that the many of the forests around Derrybrien Wind Farm are located on the upland blanket bog. On the lower slopes to the west and east the blanket bog is absent and some of the forests are on the glacial till subsoil.

Coillte have extensive experience with management, felling and planting of conifer trees in these conditions. Assuming that the work will be carried out by experienced contractors using standard harvesting equipment and forwarders, as on the Derrybrien Wind Farm, then the direct impact that this will have on the degraded blanket bog will be very low, which is of slight significance. The effect of the live load surcharge from the forestry equipment and temporary timber stockpiles on the stability of the peat should be medium to low, which is also of slight significance, as discussed in Section 10.3.2.1.1.3.3.

All of the drainage, tree felling and planting on adjacent forestry plantations has been and will be carried out outside the site of the Derrybrien Wind Farm and downslope or topographically remote from the site (i.e. in different river sub-catchments, or on different slopes within the same river sub-catchment). Furthermore, all of the forestry along the Grid Connection route, at the site of the Agannygal substation and in the areas of the Peat Slide and Response Works were cleared for the project during construction. Therefore, the impact of the site activities for the forestry on the adjacent plantations will not give rise to significant cumulative direct or stability impacts on the receiving soils, geology and land in the Project area.

The impact of temporary stockpiling of felled trees on the Derrybrien Wind Farm site from adjacent plantations prior to removal by Coillte has been assessed in Section 10.3.2.1.2. When forestry equipment accesses the stockpiles or adjacent plantations using the site access tracks on the Derrybrien Wind Farm site they would be infrequent and they would have a live load surcharge less than the design load for the floating roads. Therefore, the effect that this would have on the stability of the peat would be slight and would not lead to a significant cumulative stability impact on the wind farm site.

10.4.4 Cumulative Impacts from Peat Extraction outside the Project Site

Figure 2.7 in Chapter 2 shows the extent of habitat identified as “cutover bog” by the National Parks and Wildlife Service (NPWS) Hen Harrier mapping project for the Slieve Aughty Mountains SPA. As discussed in Section 2.5.1.2, this category identifies areas where part of the original mass of peat has been removed through turf cutting or other forms of peat extraction. No peat extraction activities subject to a development consent have been identified in the vicinity of the Project. Therefore, the extent of cutover bog identified by the NPWS has been used as an indication of the extent of turbary turf cutting in the Project area.

Turf cutting has likely been carried out and will continue to be carried out in many of these areas under turbary rights. This typically involves small scale seasonal peat extraction or turf cutting by individuals for personal use as fuel. It does not involve large scale intensive commercial peat harvesting. Historically turbary turf cutting in turbary plots has been carried out by hand using traditional peat spades or slanes. More recently, in some areas, where possible, the peat has been extracted by mechanical means using saw cutting machines, hydraulic excavators and hoppers to excavate the peat and extrude it into peat sods. Where turf cutting has been carried out on blanket bog a network of drains has normally been developed along the boundaries between turbary plots to drain and dry out the peat. It is likely that most of the areas of cutover bog identified on Figure 2.7 in Chapter 2 were existing prior to the construction of the Derrybrien Wind Farm.

The cumulative impact of the turbary turf cutting on the Derrybrien Wind Farm site is assessed in Section 10.4.5. With the exception of the turbary plots just outside the site boundary at the east end of the wind farm, (which are also addressed in Section 10.4.5), all of the areas of cutover bog outside the site that are shown on Figure 2.7 in Chapter 2 are remote to the site and separated from it by conifer plantations. Therefore, the site activities related to the turf cutting will not give rise to significant cumulative direct or stability impacts on the receiving soils, geology and land in the Project area.

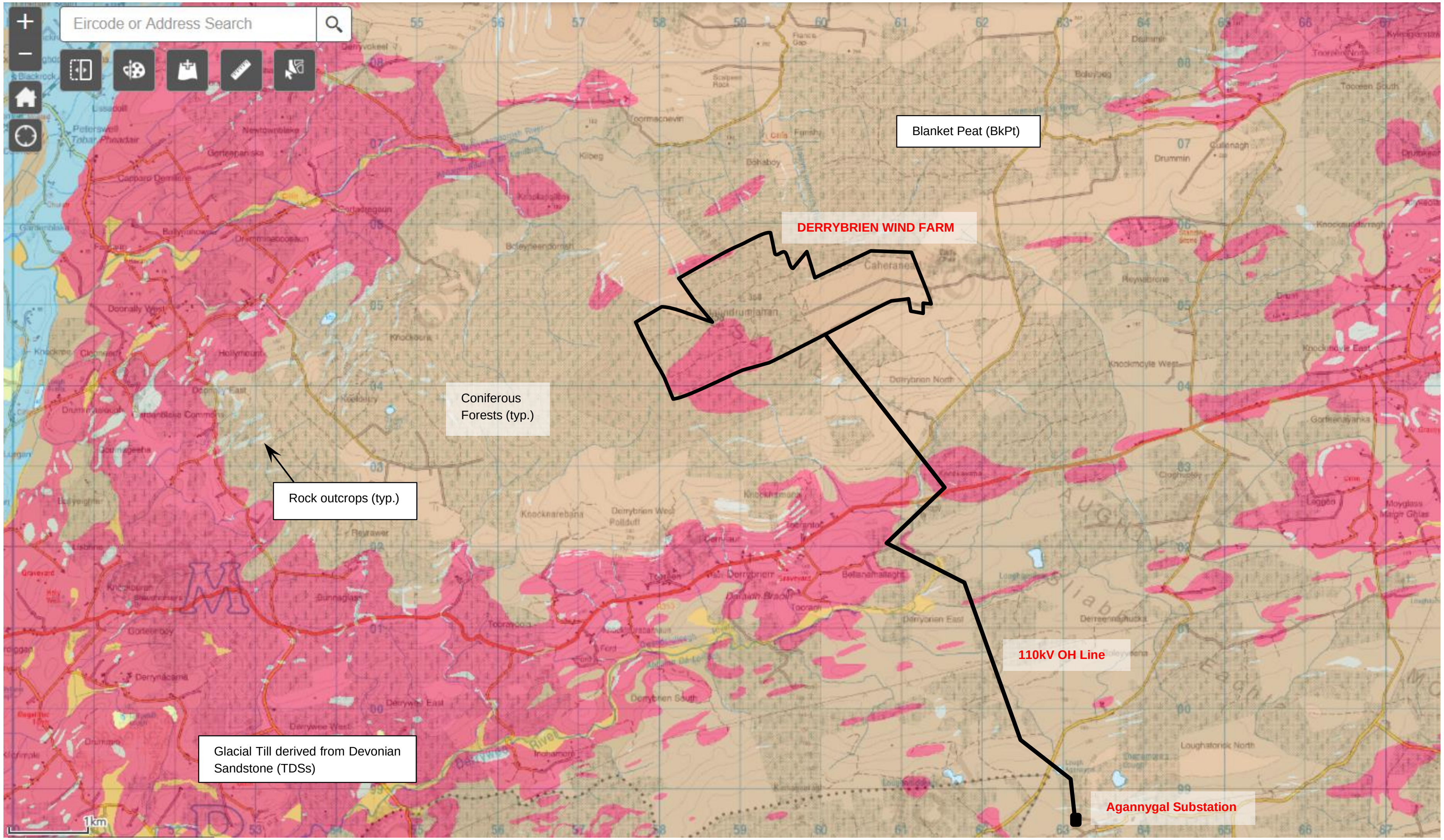


Figure 10-48 - Quaternary Geology for the Coniferous Forest Plantations in the Project Area (GSI Online Portal, 2020)

10.4.5 Cumulative Impacts from Peat Extraction in Turbary Plots Within and Immediately Adjacent to the Wind Farm Site

Figure 10-49 shows the extent and layout of the turbary plots at the east end of the wind farm. There are a total of 136 No. plots. 114 of these are within the wind farm site boundary. The remaining 22 No. (#41-45, #178-180, #219-221, #223A, #223B, #224-232) are just outside the site at the east end of the wind farm.

26 No. of the plots (#182-207) have been used by Coillte for commercial forestry. The majority of the conifer trees that had been planted in this area were felled in 2004/2005, during construction of the wind farm, and were not subsequently re-planted. Some small trees have re-grown naturally in the area since construction was completed. However, the turbary plots have not been used for peat extraction since the windfarm was constructed and are unlikely to be used for peat extraction over the remaining operational life of the wind farm.

Many of the remaining plots in the turbary area at the east end of the wind farm have been used for low-volume seasonal peat extraction (also referred to as peat harvesting or turf cutting) for individual use as fuel. There has been no high-volume intensive commercial peat harvesting in the area.

The baseline conditions on the wind farm site in 1998, prior to construction of the windfarm, which includes the turbary plots in this area, are summarised in Section 10.2.1. Prior to construction of the wind farm peat had been historically extracted from a significant number of the turbary plots and an extensive network of drains had been developed along the north-south boundaries between the turbary plots. East-west collector drains had also been constructed to link these to the main watercourses at this end of the wind farm site. The network of pre-existing drains is also shown on Figure 10-49. The access tracks that had been constructed on the site prior to the construction of the wind farm are identified on the aerial photograph from 2000 in Figure 10-4. These are floating roads on the peat.

There are no records for the peat extraction 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 turf cutting contractor, who has worked on the site since 2012. It is not a complete or comprehensive record of peat extraction on the site, but it does give an indication of the general nature of the methods of peat extraction that have recently been utilised as well as the possible extent of peat extraction 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 10-50. Figure 10-51 identifies typical evidence of recent peat extraction and drainage that was evident in April 2020.

- The 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 10-6 . 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 100mm x 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 10-6: 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 1.5 m wide x 6.0 m 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 peat harvesting 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 50-75 m^3, which is equivalent to 8-10 hopper loads each hopper load creating a single row of 8 No. 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 2,500 m^3 of peat.

- Turf cutting has been carried out by saw cutting in 1 No. turbary plot between plots 20 and 30. The aerial photographs would indicate that this could have been in Plot #21 (Figure 10-51). Plate 10-7 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 1.2 m deep into the peat. Similar to the hopper system, an auger system 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 10-51 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 10-7: Typical saw cutting attachment for extracting peat

- Traditionally peat harvesting would probably have been carried out in the turbary plots by hand using a specialised turf spade called a slane. Manual turf cutting is still being carried out in a turbary plot in the vicinity of the windfarm site, but not in any of the plots on or immediately adjacent to the windfarm that are part of this assessment.

- 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 10-51.

10.4.5.1 Peat Extraction in Turbary Plots - Cumulative Direct Impacts

The direct impacts of site activities related to peat extraction from the turbary plots on the receiving soils, geology and land on the wind farm site are:

- the damage to the peat habitat from the peat excavation and from the machinery tracking over the surface of the bog; and
- groundwater lowering due to drainage.

Although these activities are not related to the wind farm project, they have been carried out within and immediately adjacent to the wind farm site. Therefore, the cumulative impact on soils, geology and land in the project area has been assessed here.

The turbary plots, drainage network and turbary access roads were pre-existing on the site prior to the construction of the wind farm. Therefore, as described in Section 10.2.1.4, the baseline sensitivity of the degraded blanket bog in the area was **Medium**.

Tracking across the surface of the peat damages the surface vegetation. The peat that is excavated from the site is used for fuel so there is a corresponding loss in stored carbon as CO^2. However, the volume of annual peat extraction is low, probably less than 2,500 m^3 per annum. Therefore, the effect that this has on the peat is **Low** and only **Slightly Significant**.

In comparison, the volume of the peat excavated for construction of the wind farm project (185,000 m^3) and the volume of peat displaced in the large peat slide that occurred at the site on the 16th October 2003 (450,000 m^3) were significantly higher. The combined effect that this had on the peat has been assessed as **High** and **Significant**, as described in Section 10.3.2.1.1.2. Therefore, the small additional volume of peat extracted from the turbary plots on and immediately adjacent to the wind farm site would not have a significant cumulative direct impact on the peat in the Project area.

The electronic piezometers that were installed in the turbary plot downslope from Turbine T34 indicate that the average groundwater level recorded in the peat gradually reduced by about 0.75 m over the monitoring period between December 2005 and November 2011. This resulted in an increased rate of decomposition of the peat in the aerobic environment above the water table, as discussed in Section 10.3.2.2.1. The effect that this has had on the peat relative to the baseline condition has been assessed as **Low,** which is **Slightly Significant** (Section 10.3.2.1.2.2.3). However, the extent of drainage that was carried out for the turbary plots was very minor. Therefore, it is considered that the reduction in groundwater level was largely due to the network of existing drains as well as the improved drainage for the wind farm. The impact of the minimal drainage improvements for the turbary plots on the peat did not have a significant cumulative effect on the peat.

10.4.5.2 Peat Extraction in Turbary Plots On Wind Farm Site - Cumulative Stability Impacts

The direct impacts of site activities related to peat extraction from the turbary plots that have an effect on the stability of the peat are:

- the live load surcharge from the mechanical peat harvesting equipment operating directly on the surface of the peat;
- damage to the integrity of the peat mass due to mechanical extraction by saw cutting or peat excavations, or by excessive plant movements from heavy machinery operating directly on the surface of the peat; and
- removal of support to peat faces by bulk excavation for peat harvesting, or along drainage trenches.

As discussed in Section 10.3.2.2.2, drainage on the site has had and will continue to have a long-term sustained positive impact on the peat with respect to site stability. However minimal drainage improvements have been carried out for the turbary plots. Therefore, it is considered that the positive stability impact of drainage in this area is primarily related to the network of drains along the boundaries of the turbary plots that existed prior to construction of the windfarm as well as the improved drainage for the wind farm development. The minimal drainage improvements that have been carried out for the turbary plots since the windfarm was constructed would not have a significant cumulative effect on the stability of the peat.

10.4.5.2.1 Cumulative Impacts which have occurred

A peat stability risk assessment (PSRA) has been carried out for the turbary plots to assess the likelihood of a peat slide in each plot based on the existing site characteristics for peat and subsoil conditions, topography, hydrology, slope stability factor of safety calculations, and other factors that are known contributory factors for peat instability such as the methods of mechanical peat extraction that has been carried out on the site since 2012, and evidence of existing peat instability in the area.

There are a total of 136 No. turbary plots on the site, which are numbered as follows, as shown on Figure 10-49:

- 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

The results of the PSRA are presented in AGL Report No. 11-147-R06 - *"Derrybrien Windfarm – Peat Stability Risk Assessment (PSRA) for Turbary Plots at East End of Windfarm Site"*, which is included in Appendix E.

The PSRA has been carried out in accordance with the methodology described in Section 10.2.2.1. However, to get better definition of where there is a higher risk of peat instability in the turbary areas, additional intermediate categories of Likelihood (L) have been added at **L=3.5** and **L=4.5** based on the interpreted hazard rating for the site characteristics as described in the report and as shown on Table 10-33.

Table 10-33: Total Hazard Rating and Likelihood (L) of a Peat Slide due to Mechanical Peat Harvesting in the Turbary Plots

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

The results of the PSRA for the site activities related to peat harvesting and turf cutting in the turbary areas on and adjacent to the wind farm site *prior to implementing appropriate mitigation measures* are shown on Figure 10-52. This is representative of the existing site characteristics within the turbary plots and the methods of mechanical peat extraction that have been carried out on the site up to Q2 2020 *(i.e. impacts that have occurred)*, particularly since 2012. It has been assumed that the activities have not been restricted to the turbary plots where mechanical peat harvesting has been undertaken previously. Consideration has also been given to the areas where saw cutting is likely to have been carried out based on the available information.

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 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 (3-6 m 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 (FoS) 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 (2-3 m) with the convex breaking slope at the southeast corner of the wind farm (Plots #219-221 & #229-232).
- 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 10-52 (i.e. 85 No. out of 181 No. total).

In the remaining turbary plots (≈53%) across the site the Likelihood of a peat failure due to mechanical peat harvesting under uncontrolled conditions without appropriate mitigation measures would be characterised as **Possible to Very Possible (L=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.

A peat failure in the turbary plots could range from localised instability or shear failure of an unsupported peat face in an open excavation, to a small scale peat slide confined within the turbary plot, or a very large scale peat slide along existing drainage channels similar to the slide that occurred at the site during construction of the windfarm in October 2003.

The likelihood of a very large scale peat slide occurring would be comparatively lower than the more localised peat failures that would have a significantly lower impact. However, assuming that a very large peat slide could occur in the worst case scenario, which is consistent with the methodology for the assessment of stability impacts for the wind farm (Section 10.1.5), then:

- Where the likelihood of a peat failure is **Very Possible** to **Likely (L=4.0 to 5.0)** as a result of mechanical peat harvesting on the turbary plots without appropriate mitigation measures, then the effect of the stability impact on the peat would be **High** and **Significant.**
- Where the likelihood of a peat failure is **Possible** to **Very Possible (L=3.5)**, then the effect of the stability impact on the peat would be **Medium to High** and **Moderately Significant.**

In this assessment, the interpreted likelihood of a peat failure and the corresponding effect of the stability impact are only applicable in those areas where mechanical peat harvesting is actually carried out in the turbary area and also to when the works are being carried out in a particular turbary plot as this is when heavy plant and machinery are operating on the peat and the peat is being extracted from open excavations or by saw cutting.

Mechanical peat harvesting is currently only being carried out in about 35 No. of the 136 No. turbary plots and not all of these are cut each year (see Figure 10-50), so the stability impact is most applicable to those areas. The remaining turbary plots are generally inactive and no peat extraction has been or is likely to be carried out in Plots No. 182 to 207 along the southern boundary of the site, which have been used for forestry by Coillte.

The active turbary plots are only cut seasonally once a year in late spring/early summer so the frequency of the stability impact is **Occasional**. Peat extraction within any single turbary plot only takes a few days. Therefore, the duration of the impact is **Brief** to **Temporary**.

When no mechanical peat harvesting is being carried out in a turbary plot then the Likelihood of a peat failure reduces to a residual level of Low (L-2), as discussed in Section 10.4.5.2.4 and the corresponding effect of the stability impact on the peat in the turbary areas reduces to **Medium to Low**, which is only of **Slight Significance**.

To assess the cumulative effect of stability impacts related to peat extraction in the turbary plots, the interpreted likelihood of a peat failure as a result of mechanical peat harvesting in the turbary plots up to Q2 2020 in Figure 10-52 needs to be compared to the corresponding figure for site activities related to the operation and maintenance of the wind farm between 2006 and Q2 202 shown in Figure 10-35.

As discussed in Section 10.2.4.1 and 10.2.4.4, the interpreted Likelihood of a peat failure in each zone of the wind farm on Figure 10-35 is generally representative of the worst conditions within that zone but with a greater emphasis applied to the site conditions along the corridor of the wind farm infrastructure, where the majority of the site activities related to the wind farm occurred. Also, for the operation and maintenance phase of the project between 2006 and Q2-2020 there is a lower probability of occurrence of a peat slide for the likely wind farm site activities compared to the baseline condition (Figure 10-34) as a result of:

- Additional geotechnical investigations, stability analyses, testing, monitoring and geotechnical supervision during the construction stage of the project (e.g. geotechnical assessment and full-scale proof testing of floating roads); and
- Changes to the site characteristics due to improved drainage and an increase in the strength of the peat under sustained dead load surcharges (i.e. the floating roads, peat repositories and material sidecast areas)

Therefore, for the wind farm site activities between 2006 and Q2 2020 the interpreted Likelihood of a peat failure based on the site characteristic has been generally classified as Negligible (L=1) for the zones of the wind farm across the turbary plots at the east end of the site, and locally as Low (L=2) in the vicinity of Turbines T28, T31 and T46.

For the range of wind farm activities that occurred on the site during this period and involved surcharge loads on the peat or floating roads, the effect that surcharge loads had on the stability of the peat was **Low** to **Very Low** and only **Slightly Significant** (see Table 10-9). No peat failures occurred as a result of the wind farm activities during this time.

When this is compared to the significance of the stability impacts of site activities for peat extraction in the turbary plots it can be seen that, due to the increased level of mechanical extraction carried out in the area since 2012, the cumulative effect on the stability of the peat temporarily increased to **Moderately Significant** or **Significant** in the plots where the mechanical peat extraction was being carried out. The highest risk of a peat failure was at the time that the works were being carried out and the effect was brief or temporary, lasting only a few days in each area.

In the worst case scenario, a large scale peat slide related to the impact of mechanical peat extraction in the turbary plots could impact the infrastructure for the wind farm and could have a similar direct impact on soils, geology and land in the Project area as a large scale peat slide related to the wind farm site activities.

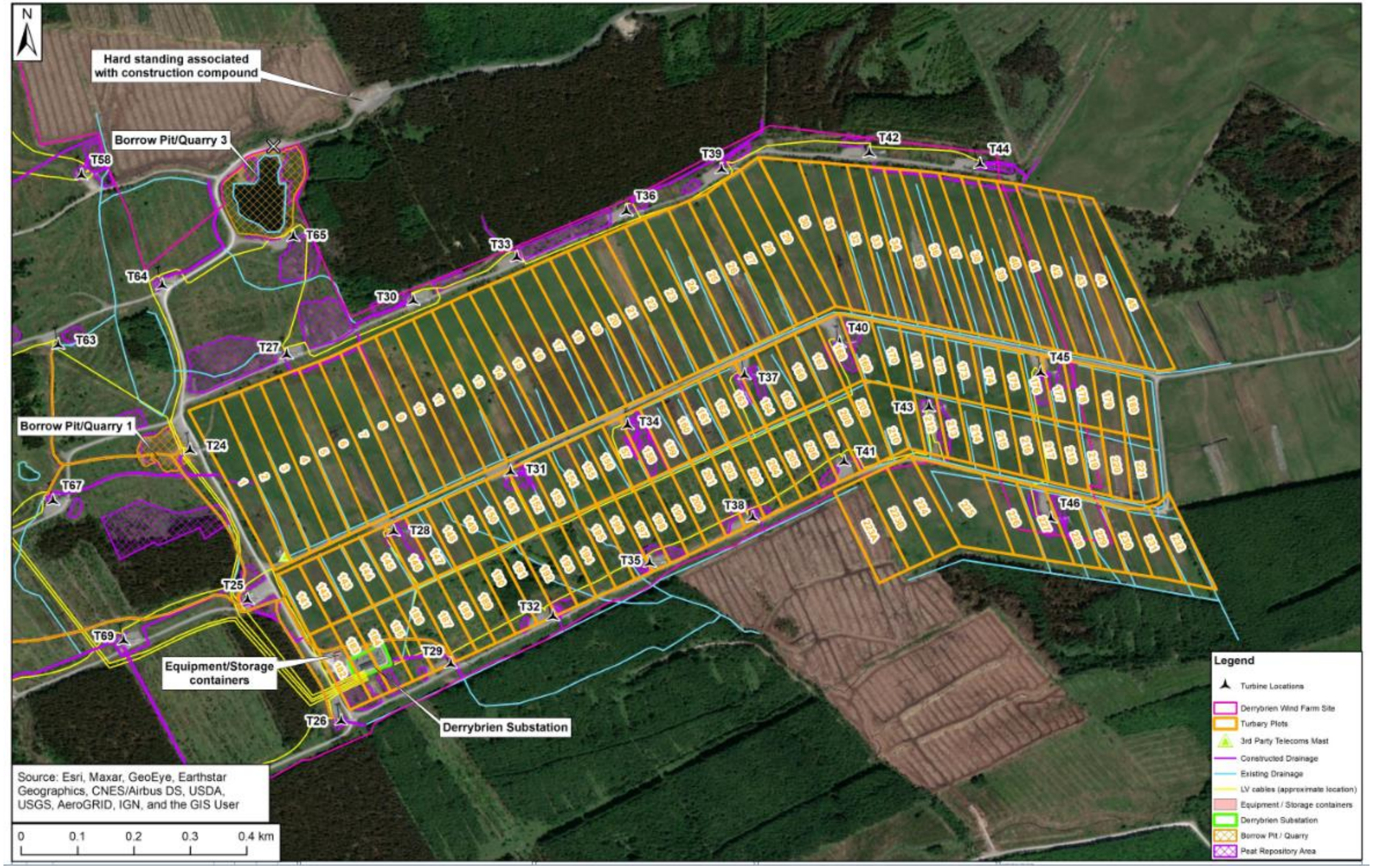


Figure 10-49: Turbary plots at east end of wind farm site (ESBI Drawing No. QS-000280-01-0460-011-020-000)

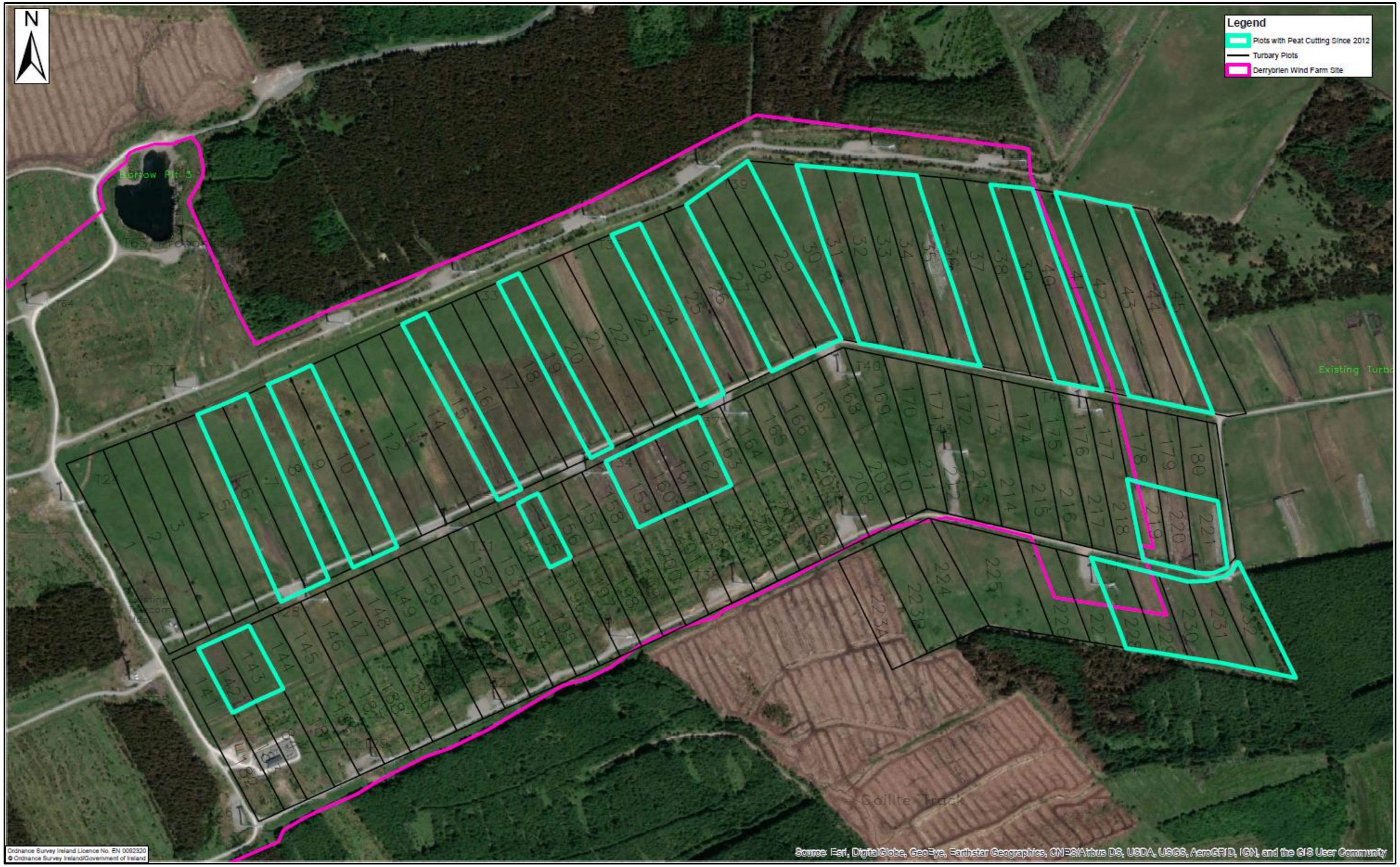


Figure 10-50: Turbary plots where mechanical peat harvesting has been carried out by a local contractor since 2012

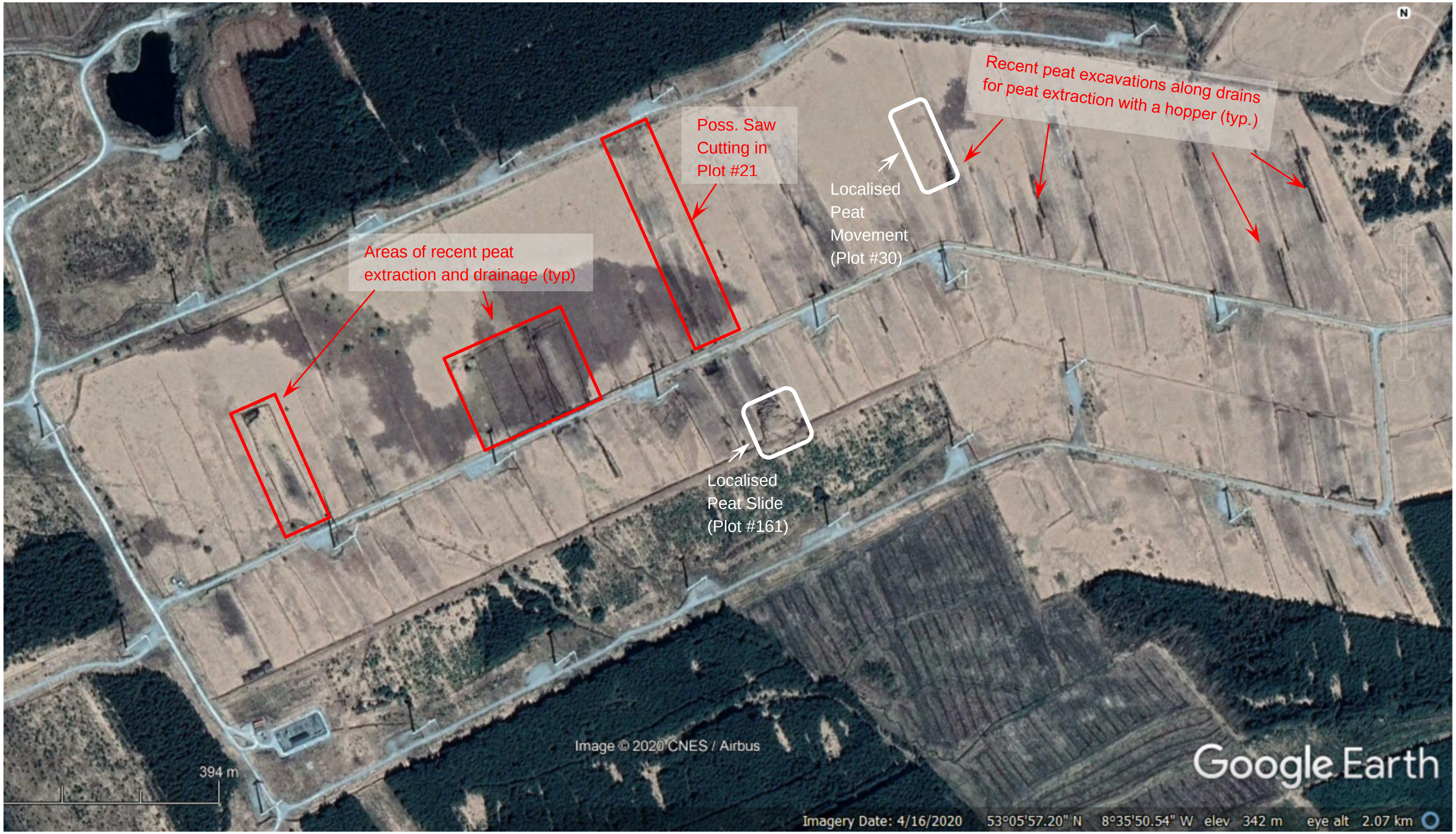


Figure 10-51: 2020 Aerial Photo of turbary plots illustrating recent peat harvesting activity & areas of local peat instability

10.4.5.2.3 Evidence of Peat Instability in the Turbary Plots

No large or very large scale peat failures have occurred in the turbary area at the east end of the Derrybrien Wind Farm site. 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 10-51. The failures occurred in Plots No. 161 and 30.

Plate 10-8 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 2.0 m deep over an area of approximately 2,500 m2 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. 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 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. 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 10-8: Peat Failure in Turbary Plot #161 (Site Photo May 2020)

Plate 10-9: Aerial view of slide area - 9th April, 2015 (Google Earth)

Plate 10-10: Aerial view of slide area – 3rd July, 2018 (Google Earth)

Based on historical aerial photographs from Google Earth and the OSI Geohive online portal, the peat slide appears to have initiated sometime between April 2015 (Plate 10-9), 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 10-10). By May 2020 the peat failure had extended further upslope with 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. The peat in the failed area is stable in its present condition. However, some drainage will be carried out on the site to relieve ponded water in the tension cracks as a mitigation measure to prevent the slide progressing further upslope, as described in AGL Report No. 11-147-R06 in Appendix E.

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

Plate 10-11 shows an aerial view of the peat failure that has occurred at the centre of Turbary Plot No. 30. The failure occurred as planar movement in peat 1.7 to 2.7 m deep over an area of approximately 2,500 m^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 extraction 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. 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.

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 extraction 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 peat within the failed area is stable in its present condition. However, some drainage will be carried out on the site to relieve ponded water in the tension cracks as a mitigation measure to prevent any further movement of the peat, as described in AGL Report No. 11-147-R06 in Appendix E.

Plate 10-11: Peat Movement in Turbary Plot #30 c2015-2018 (OSI Geohive Portal, 2020)

Both of these peat failures involved about 5,000 m^3 of peat over an area of about 2,500 m^2, which are small scale peat slides (1,000-5,000 m^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**.

10.4.5.2.4 Cumulative Impacts which are likely to occur

Cumulative site stability impacts arising from peat extraction in turbary plots on the wind farm site and adjacent to it could potentially occur where specific peat harvesting methodologies are utilised. The potential impact will not arise as a direct result of wind farm continued operational activities or decommissioning activities as these have been mitigated against but from the separate peat turbary activities occurring outside of the control of Gort wind farms as exercised under turbary rights**.** These potential site stability impacts from turbary activities relate primarily to the use of mechanical peat harvesting equipment on turbary plots which have been assessed as having a possible likelihood of a peat failure which could range from localised instability to potentially a large scale peat slide in the worst case scenario.

The AGL Report No. 11-147-R06 in Appendix E presents mitigation measures that, when employed by Gort Windfarms Ltd and turbary rights users for future mechanical peat harvesting in the turbary plots on and adjacent to the windfarm site, will reduce the likelihood of a peat failure and the cumulative effect of the activities on the stability of the peat in the Project area to an acceptable level over the remaining operational life of the windfarm and during decommissioning.

The following mitigation measures will be 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 will be made available to the turbary rights holders whose plots have been or are proposed to be harvested by mechanical means, and the turbary rights holders will be made aware of the potential site stability risks associated with mechanical peat harvesting methods in the absence of mitigation;

- 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 recommended mitigation measures;

- Communication will be established between the turbary plot owners, turf cutting contractors and the windfarm site manager for Gort Wind Farms Ltd.;
- Ongoing maintenance will 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 will be carried out by the wind farm site manager for Gort Wind Farms Ltd.; and
- 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 following is a summary of the mitigation measures that are recommended in the AGL Report No. 11-147-R06 which specifically relate to turbary peat harvesting and which are recommended to be implemented by the turbary rights holders:

- 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 AGL Report No. 11-147-R06 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 of AGL Report No. 11-147-R06 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;
- No mechanical peat harvesting should be carried out in the turbary area during the decommissioning stage of the windfarm project.
- Communication will be established between the turbary plot owners, turf cutting contractors and the windfarm site manager for Gort Wind Farms Ltd. to allow the turbary rights holders to give notice of peat harvesting activities and to report any peat instability on the site

The next sections discuss the cumulative impacts which are likely to occur on the basis that the turbary rights holders implement the recommended mitigation measures as laid out in the AGL Report No. 11-147-R06 in addition to the measures that will be implemented by Gort Wind Farms Ltd..

10.4.5.2.4.1 Cumulative impacts which are likely to occur once all Mitigation Measures are Implemented

Where the mitigation measures are implemented by the turbary rights holders, their agents and by Gort Wind Farms Ltd. then the interpreted 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 illustrated on Figure 10-53. The corresponding effect on the stability on the peat will be **Medium to Low**, which is of **Slight Significance**. This would also represent the residual effect of stability impacts on the peat where no mechanical peat harvesting is being carried out in the turbary areas in their existing condition.

The stability impact for mechanical peat harvesting will only occur in the turbary plots where peat extraction is likely to be carried out, which is currently about 35 No. of the 136 No. plots in the area. The active turbary plots will only be cut seasonally once a year between May and September so the frequency of the stability impact will be **Occasional**. Annual peat extraction within any turbary plot will only take a few days. Therefore, the duration of the impact will be **Brief** to **Temporary**.

To assess the <u>cumulative</u> effect of stability impacts related to peat extraction in the turbary plots, the interpreted likelihood of a peat failure for mitigated peat harvesting over the remaining operational life of the wind farm in Figure 10-53 needs to be compared to the corresponding figure for site activities related to the operation and maintenance of the wind farm between 2020 and the end of operation in circa 2040 shown in Figure 10-36, and the assessment of the stability impacts related to the wind farm site activities in Table 10-10.

As discussed in Section 10.2.4.4, the interpreted Likelihood of a peat failure in each zone of the wind farm, based on the site characteristics, has now reduced to

Negligible (L=1) due to an improvement in the conditions along the wind farm infrastructure since construction was completed in 2006.

For the range of wind farm activities that are likely to occur on the site during the remaining operational life of the wind farm and involve surcharge loads on the peat or floating roads, the effect that surcharge loads will have on the stability of the peat will be **Very Low** to **Low** and only **Slightly Significant** (see Table 10-10).

Therefore, mitigated activities related to peat harvesting in the turbary area will occasionally result in a slightly increased Likelihood of a peat failure where the activities are carried out on the site [i.e. **L=2.0 (Low)** for mechanical peat harvesting vs **L=1.0 (Negligible)** for the windfarm site activities] and the corresponding cumulative effect on the stability of the peat will be raised to **Medium to Low**, which is still only **Slightly Significant**.

It should be noted that the site activities for mechanical harvesting in the turbary area and for the operation and maintenance of the wind farm are completely unrelated. Furthermore, the stability impacts related to mechanical peat harvesting do not increase or amplify the effects of stability impacts related to the operation and maintenance of the wind farm. Instead, the cumulative impact in the area represents the impact of the activity that has a greater effect on the stability of the peat at that time.

To use an analogy of noise effects, at this stage the effects of stability impacts related to the operation and maintenance of the wind farm over its remaining design life are analogous to a low-level background "noise". However, when peat harvesting is being carried out in one of the turbary plots the increased effect on the stability of the peat in the area is analogous to a comparatively higher level of "noise" of short duration that is "louder" than that generated by the wind farm activities in the same area and therefore governs the effect of stability impacts in that area. It does not <u>increase</u> the effect of the stability impacts (the "noise") related to the wind farm activities.

The cumulative effect of turbary activities on the stability of the peat will be brief or temporary, lasting only a few days in each area, and will only apply where mechanical peat harvesting or turf cutting is carried out at the same time and in the same area as the wind farm site activities that involve surcharge loading on the peat or on the floating roads.

As described in Section 10.4.5.2.1, a peat failure in the turbary plots could range from localised instability or shear failure of an unsupported peat face in an open excavation such as that which occurred in Plot No. 30, to a small scale peat slide confined within the turbary plot such as that which occurred in Plot No. 161, or a very large scale peat slide along existing drainage channels similar to the slide that occurred at the site during construction of the windfarm in October 2003.

A localised or small scale peat failure within a turbary plot would have a slightly significant effect on the receiving soils, geology and land within or adjacent to the turbary area. However, it would only impact the wind farm infrastructure if the floating roads or the buried electrical transmission and/or fibre-optic cables were within the area of failed peat. The turbines and crane hardstanding areas are supported on the glacial till and rock below the peat and are therefore unlikely to be impacted by a localised or small scale peat failure in the adjacent turbary plots.

Although the likelihood of a large or very large scale peat slide occurring as a result of peat harvesting in the turbary areas is comparatively lower, if one did occur in the worst case scenario then it would have a significant direct impact on the receiving soils, geology and land in the Project area, including on all of the windfarm infrastructure within the slide area and within the flow path of the slide debris (site access tracks, cables and turbines).

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 would not have a significant direct impact on 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. <1.0 m) 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 extraction prior to mitigation in these areas, as shown on Figure 10-52 (L=3.0).

Therefore, a peat failure in these turbary plots would not have a significant direct impact on the windfarm access track. The turbines and crane hardstanding are constructed on the glacial till and rock below the peat and would also not be impacted by a peat failure in the adjacent turbary plots downslope.

Therefore it is assessed that mechanical peat harvesting outside of the wind farm site would not result in a cumulative impact with regards to site stability.

10.4.5.2.4.2 Cumulative Impacts which are likely to occur if some Mitigation Measures are not Implemented by all Turbary Rights Holders

Where the mitigation measures are implemented by Gort Windfarms Ltd but not by the turbary rights holders then the interpreted likelihood of a peat failure occurring as a result of mechanical peat harvesting in the turbary plots will remain at that shown on Figure 10-52. Therefore, as discussed in Section 10.4.5.2.1, assuming that a very large peat slide could occur in the worst case scenario, then:

- Where the likelihood of a peat failure is **Very Possible** to **Likely (L=4.0 to 5.0)** as a result of mechanical peat harvesting on the turbary plots without appropriate mitigation measures, then the effect of the stability impact on the peat would be **High** and **Significant.**

- Where the likelihood of a peat failure is **Possible** to **Very Possible (L=3.5)**, then the effect of the stability impact on the peat would be **Medium to High** and **Moderately Significant.**

The interpreted likelihood of a peat failure and the corresponding effect of the stability impact are only applicable in those areas <u>where</u> mechanical peat harvesting is actually carried out in the turbary area and also to <u>when</u> the works are being carried out in a particular turbary plot as this is when heavy plant and machinery are operating on the peat and the peat is being extracted from open excavations or by saw cutting.

The active turbary plots are only cut seasonally once a year in late spring/early summer so the frequency of the stability impact is **Occasional**. Peat extraction within any single turbary plot only takes a few days. Therefore, the duration of the impact is **Brief** to **Temporary**.

When no mechanical peat harvesting is being carried out in a turbary plot then the Likelihood of a peat failure reduces to a residual level of Low (L-2), and the corresponding effect of the stability impact on the peat in the turbary areas reduces to **Medium to Low**, which is only of **Slight Significance**.

For the range of wind farm activities that are likely to occur on the site during the remaining operational life of the wind farm and which involve surcharge loads on the peat or floating roads, the effect that surcharge loads will have on the stability of the peat will be **Very Low** to **Low** and only **Slightly Significant** (see Table 10-10).

When this is compared to the significance of the stability impacts of site activities for mechanical peat extraction in the turbary plots, the cumulative effect on the stability of the peat will temporarily increase to **Moderately Significant** or **Significant** in the turbary plots where the mechanical peat extraction is being carried out and where the turbary rights holders or their agents do not implement the recommended mitigation measures. The highest risk of a peat failure will be at the time that the works are being carried out so the effect will be brief or temporary, lasting only a few days in each area.

As discussed previously, a peat failure in the turbary plots could range from localised instability or shear failure of an unsupported peat face in an open excavation, to a small scale peat slide confined within the turbary plot, or a very large scale peat slide along existing drainage channels similar to the slide that occurred at the site during construction of the windfarm in October 2003 in the worst case scenario.

The likelihood of a very large scale peat slide occurring would be comparatively lower than the more localised peat failures that would have a significantly lower impact. The effect of a large scale peat slide would also not be the same throughout the entire turbary area. The highest risk of a large scale peat slide would occur along the buried channels of locally deeper peat upslope from the watercourse in the central part of the turbary area (i.e. Plots 149-162, 192-201 and the southern end of plots 10-22, where the interpreted likelihood of a peat failure without mitigation measures, **L=4.5**, as shown on Figure 10-52). A large peat slide in that area could impact the turbines, floating roads and buried electrical transmission and control cables where they lie within the potential flow path of the peat. The turbines that could be impacted in the area include Turbines T31, T34, T32, T35 and T38, particularly those located along the southern boundary of the wind farm site. There would be a significantly lower risk of the other turbines in the turbary area from being impacted by a peat failure related to mechanical peat harvesting in the turbary plots since there is a lower risk of a large scale peat slide and also because the turbines and hardstanding areas are supported on the glacial till and rock below the peat and would provide significant resistance to peat movement.

The turbines along the northern boundary of the site would be at the lowest risk of being impacted by a peat failure because they are at the upslope end of the turbary plots. As discussed in 10.4.5.2.4.1, a peat failure due to mechanical peat harvesting in the turbary plots outside the wind farm site boundary at the east end of the site would not impact the turbines in that area.

It should also be noted that since the turbines and crane hardstanding areas have been constructed on the glacial till and rock below the peat they have a sustained positive effect on the stability of the peat in the turbary area since they act as a shear key supporting the peat directly upslope from the turbines. The above-ground elements of the turbines (mast/nacelle/rotors) have a negligible effect on peat stability. Therefore, decommissioning the turbines or restricting will not have a significant mitigating effect on peat stability in the area, or on the cumulative stability impact related to mechanical peat harvesting in the turbary plots.

10.4.5.2.4.3 Cumulative Impacts from Peat Extraction in Turbary Plots Within and Immediately Adjacent to the Wind Farm Site

Remedial measures and monitoring associated with this phase of the project relating to peat extraction in the turbary plots within and immediately adjacent to the wind farm site are presented in Section 10.5.

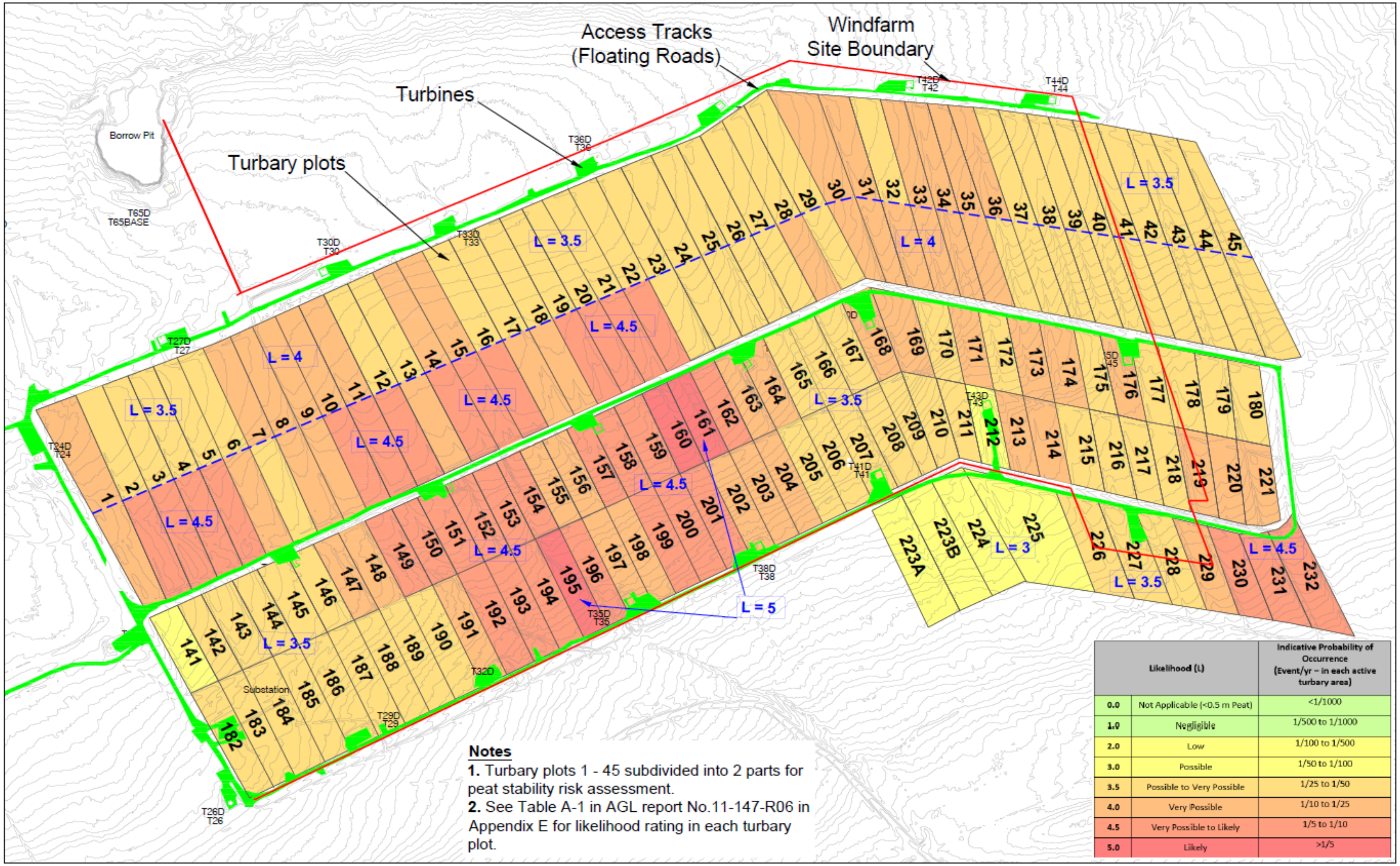
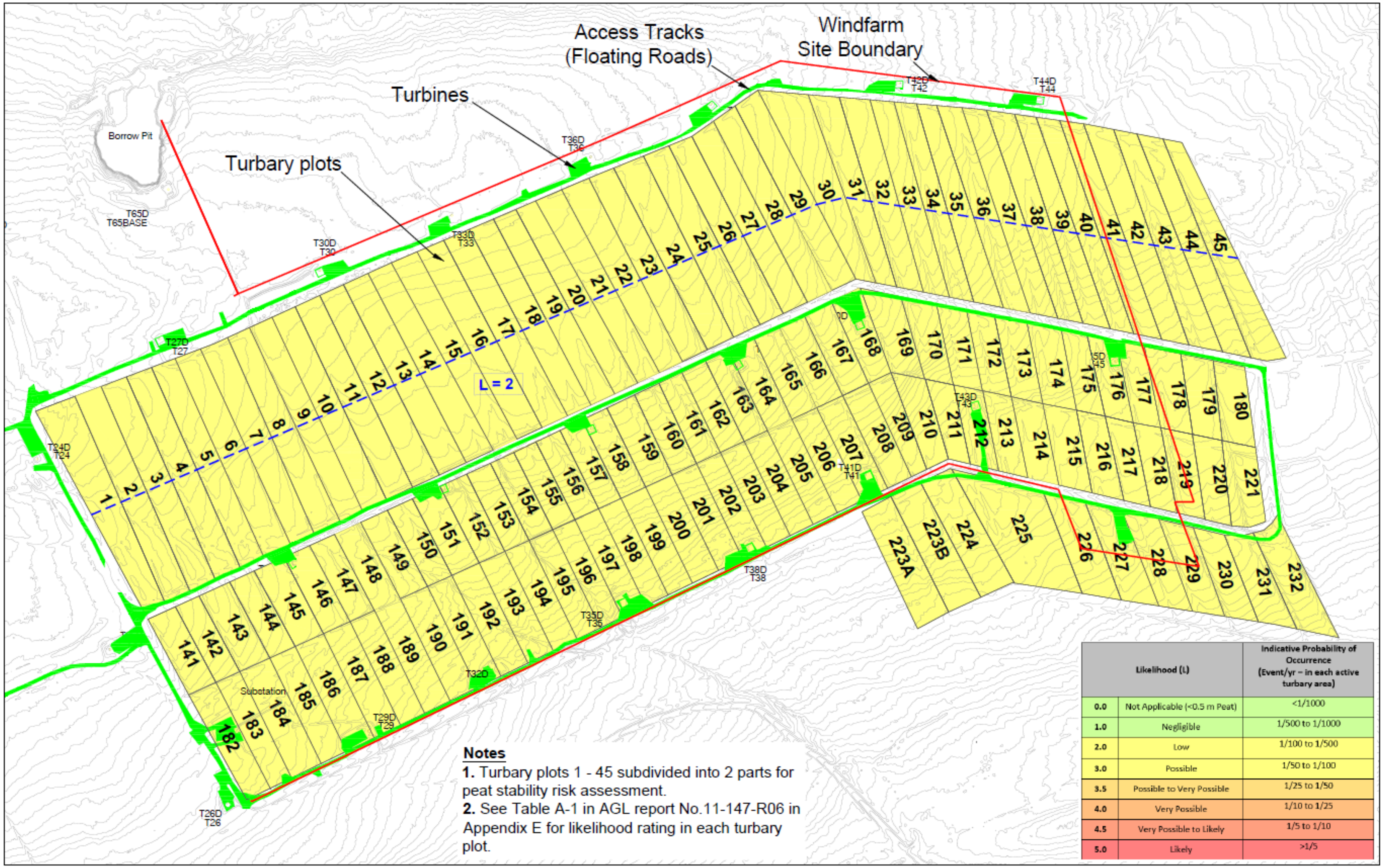


Figure 10-52: Likelihood of a peat failure due to mechanical peat harvesting in the turbary plots prior to mitigation



Likelihood (L)		Indicative Probability of Occurrence (Event/yr – in each active turbary area)
0.0	Not Applicable (<0.5 m Peat)	<1/1000
1.0	Negligible	1/500 to 1/1000
2.0	Low	1/100 to 1/500
3.0	Possible	1/50 to 1/100
3.5	Possible to Very Possible	1/25 to 1/50
4.0	Very Possible	1/10 to 1/25
4.5	Very Possible to Likely	1/5 to 1/10
5.0	Likely	>1/5

Figure 10-53: Likelihood of a peat failure due to mechanical peat harvesting in the turbary plots after mitigation

10.5 Remedial (Mitigation) Measures and Monitoring

10.5.1 Introduction

This section presents a summary of the remedial measures that were implemented to mitigate or monitor significant effects of the project on soils, geology and land during construction and during the operation and maintenance phase of the project up to the end of 2020. Mitigation and monitoring measures that will be implemented for significant effects over the remaining design life of the project and during decommissioning are also presented.

10.5.2 Remedial Measures & Monitoring for Significant Effects – Wind Farm Site

Remedial measure to mitigate or monitor significant effects of impacts on soils, geology and land are presented in this section of the Chapter for the following stages of the wind farm project:

- Construction Stage – Prior to the peat slide in October 2003
- Construction Stage – 2nd Phase of Construction after the peat slide
- Operation and Maintenance Phase 2006-2020
- Operation and Maintenance Phase 2020 to c. 2040 (End of Operation)
- Decommissioning

For clarity, “significant effects” in this context refers to all of the effects that have been assessed as ***slightly significant***, ***moderately significant*** or ***significant*** using the methodology described in Section 10.1.5 and the matrix in Figure 10-3. None of the impacts on soils, geology and land for the wind farm project had effects that would be classified as ***very significant*** or ***profound***.

10.5.2.1 Construction Stage – prior to the peat slide on 16th October 2003

The activities that were carried out on the wind farm site during this period that had an impact on soils, geology and land with significant effects included the following:

- Tree felling;
- Construction of the site compound;
- Construction of the wind farm access tracks;
- Excavation and construction of turbine foundations;
- Deposition and storage of surplus excavated materials on site;
- Excavation and processing of bedrock from the borrow pits;
- Drainage improvements;

10.5.2.1.1 Mitigation of Direct Impacts

The direct impact of the site activities that had a **Moderately Significant** effect on soils geology and land was the excavation of peat for the turbines, crane hardstandings and site compound.

The site activities and direct impacts that had a **Slightly Significant** effect were:

- Damage to the degraded peat habitat from the construction of the floating roads and deposition of excavated peat and glacial till on the intact peat slopes;
- Groundwater drawdown in the peat due to drainage improvements; and
- Trafficking on the surface of the peat by the machinery used to fell the coniferous forests on the site;
- Excavation of rock from Borrow Pit No.3 to process it into granular fill for the access tracks and granular hardstand areas;

As discussed in Section 10.1.6.1, there is limited information on measures that were taken to mitigate the effect of direct impacts of the wind farm project on soils, geology and land during the initial construction stage of the project, prior to the peat slide in October 2003. However, there are aspects of the wind farm design prepared on behalf of the Contractor that had significant mitigating effects that are notable, i.e.

- Approximately 17.5 km of new access tracks on the site were designed as floating roads on the peat rather than as rockfill roads on the underlying glacial till. Construction of the floating roads did not involve any peat excavation. The alternative method of constructing the roads on the glacial till would have involved excavating all of the peat out from under the roads and backfilling the excavation with crushed rock granular fill, which would have had a significantly higher effect on the peat habitat.
- Constructing the new access tracks as floating roads rather than on the underlying glacial till by excavate/replace also significantly reduced the volume of excavated peat that had to be disposed of on site, which reduced the effect on the peat habitat in the peat storage areas.
- The floating road design also significantly reduced the volume of crushed rockfill that had to be generated from the borrow pits on the site, which would have significantly increased the size of the pits.
- On the east side of the site the length of new site access tracks that had to be constructed on the blanket bog was significantly reduced by incorporating the existing turbary roads into the layout of the site access tracks for the wind farm.

10.5.2.1.2 Mitigation of Stability Impacts

The impacts of site activities that had a **Significant** effect on the peat with respect to site stability were:

- The dead load surcharge on the intact peat slopes from the construction of the floating roads with 0.6-1.0 m of crushed rock granular fill;
- The live load surcharge on the floating roads from the vehicles and machinery that were used to construct the floating roads; and

- The dead load surcharge on the intact peat slopes where peat, glacial till and occasionally weathered rock excavated from the turbine foundations was sidecast on the peat adjacent to the excavation.

None of the negative impacts of the site activities had a **Moderately Significant** effect on the peat with respect to site stability. The improved drainage was a positive impact that had a **Moderately Significant** effect on the stability of the peat.

The impacts of site activities that had a **Slightly Significant** effect on the peat with respect to site stability were:

- The live load surcharge on peat slopes from low ground bearing pressure construction and forestry equipment operating on the peat slopes;
- The local stability of the temporary peat slopes around the perimeter of the excavations for the turbine foundations and crane hardstandings;
- Dynamic inertial loading on the peat from blast-induced vibrations from rock excavation in Borrow Pit No.3; and
- Miscellaneous localised loading on the peat slopes from work related to tree felling and drainage.

The following is a summary of the peat stability risk mitigation measures were implemented on the project prior to the peat slide in October 2013:

10.5.2.1.2.1 Construction Management and Supervision

The civil works were carried out by an experienced earthworks and civil contractor – Ascon Ltd. (now BAM Civil).

The works were carried out under the supervision of ESBI engineers with experience of construction for wind farms on upland blanket bogs in Ireland.

10.5.2.1.2.2 Site Access Tracks

A basal layer of brash and small trees and 1-2 layers of geogrid reinforcement were incorporated into the design of the floating roads to minimise the thickness of granular rockfill used to construct the roads, and to spread the dead load of the road evenly over the surface of the intact peat.

On the north side of the site the access track between Turbines T50 and T47 was originally aligned along the north side of the turbines – in close proximity to the edge of the steep slopes on that side of the site. At an early stage in construction the track was re-aligned to the south side of the turbines to move it further back from the edge of the steep slopes.

10.5.2.1.2.3 Spoil Management

Peat and glacial till excavated from the turbine foundations sidecast on the intact peat slopes adjacent to the excavations was spread out over the surface of the peat, generally to a depth of 0.5-1.5 m, to minimise the dead load surcharge and distribute it over a wide area.

The live load surcharge from construction plant operating on the peat slopes was minimised through a combination of long reach excavators operating on the access tracks, and LGBP (low ground-bearing pressure) wide-tracked excavators operating on the peat.

10.5.2.1.2.4 Stability of Peat Excavations at Turbine Foundations

Wherever possible the temporary peat slopes at the turbine foundations were battered back to a stable temporary slope angle of 1V:1H or flatter. Where the sides of the excavations were unstable in deep weak peat, rockfill was backfilled up against the slopes as temporary support.

10.5.2.1.2.5 Drainage

Some improvements were carried out to the existing drainage network on the site to clear out blocked drains, to relieve groundwater levels in areas of deep peat, and to prevent ponding of surface runoff in areas where the access roads and turbines were constructed. Culverts were also installed under the new site access tracks to preserve the existing hydrology.

10.5.2.1.2.6 Borrow Pits

Borrow pits were opened up on the site to extract rock and process it into the granular rockfill that was used to construct the site access tracks and crane hardstandings. Blasting was only carried out in Borrow Pit No.3, near the site entrance. The blasting was carried out by an experienced licensed professional and charge delays were used to minimise blast-induced vibrations.

10.5.2.1.2.7 Tree Felling

Tree felling works were carried out by experienced specialist subcontractors under the management of Coillte. The trees were felled and gathered using specialised forestry equipment comprised of a wide-tracked hydraulic excavator fitted with a harvesting attachment and 8-12 tonne rubber-tyred forwarders that have been widely used in commercial conifer forests on upland blanket bogs in Ireland.

In areas of soft peat the contractors placed timber brash and trimmed branches along the access routes of the harvesters and forwarders through the forest to spread out the concentrated live load surcharge under the tracks or tyres of the machines.

10.5.2.2 Construction Stage – 2nd Phase of Construction after the peat slide (on-site works)

The activities that were carried out on the wind farm site during this period that had an impact on soils, geology and land with significant effects included the following:

- Tree felling;
- Construction of the remaining wind farm access tracks;
- Excavation and construction of the remaining turbine foundations;
- Excavation and construction of the remaining crane hardstanding areas;
- Deposition and storage of surplus excavated materials on site;
- Excavation and processing of bedrock from the borrow pits;
- Assembly and erection of the wind turbines;
- Drainage improvements;
- Excavation of cable trenches and installation of electrical cables and ducts;
- Construction of the substation and control building;
- Construction of the on-site twin poleset for the overhead 110 kV line; and
- Construction and assembly of the anemometer masts.

After the peat slide in October 2003 a significant level of mitigation was implemented on site to prevent any further peat instability on the site. AGL Report No. 11-147B-R04 – "*Geotechnical Stability Report & Assessment of Site Stability Impacts on Soils, Geology and Land*" in Appendix B of this Chapter gives a detailed assessment of the mitigation measures that were implemented on site. This section presents a summary of the measures that mitigate the impact of the wind farm on soils, geology and land.

The majority of the mitigation measures related to stability impacts, i.e. to reduce the risk of a peat slide. In general, there were no changes to the overall design of the wind farm. However, there were some changes to the scope of the works which were implemented as a precautionary measure to mitigate against stability impacts which also mitigated the direct impact of the project, as summarised here.

10.5.2.2.1 Mitigation of Direct Impacts

The direct impact of the site activities that had a **Moderately Significant** effect on soils, geology and land for this phase of construction was the excavation of peat for the turbines, crane hardstandings, substation and anemometer mast foundation.

The site activities and corresponding direct impacts that had a **Slightly Significant** effect on the soils, geology and land were:

- Damage to the degraded peat habitat from the construction of the floating roads and deposition of excavated peat on the intact peat slopes;
- Groundwater drawdown in the peat due to drainage improvements; and
- Excavation of rock from Borrow Pit No.3 to process it into granular fill for the access tracks and granular hardstand areas;
- Trafficking on the surface of the peat by the machinery used to fell the coniferous forests on the site;

During the second phase of construction in 2004/2005, Turbine T16 and a 475 m long section of floating road between Turbines T15 and T17 were omitted from the scope of work on the project as a precautionary measure out of concerns for site stability in the area, which was close to where the peat slide occurred in October 2003 and had similar topography and ground/groundwater conditions. The sections of partially completed floating roads that had been constructed between T15 and T17 at the time of the slide were closed and abandoned. In addition to mitigating against the risk of peat stability, this reduced the direct impact of the project on the peat habitat in this part of the site, i.e.:

- It reduced the total volume of peat excavated on the site at the turbine foundation and crane hardstanding; and
- It reduced the area of peat habitat covered by the floating roads.

10.5.2.2.2 Mitigation of Site Stability Impacts

The impacts of site activities that had a **Significant** effect on the peat with respect to site stability during the second phase of construction were:

- The dead load surcharge on the intact peat slopes from the construction of the remaining floating roads with 0.6-1.0 m of crushed rock granular fill; and
- The live load surcharge on the floating roads from the vehicles and machinery that were used to construct the remaining floating roads;

The negative impacts of site activities that had a **Moderately Significant** effect on the stability of the peat were:

- The dead load surcharge on the peat from the material sidecast areas in the medium-term as the peat gained strength under the load;
- The live load surcharge from the construction traffic on the floating roads during the second phase of construction in 2004/2005, which was within the proven capacity of the roads;

The improved drainage was a positive impact that had a **Moderately Significant** effect on the stability of the peat.

The impacts of site activities that had a **Slightly Significant** effect on the stability of the peat were:

- The dead load surcharge from up to 1.0 m of excavated peat placed on the intact peat slopes in designated peat repository areas in 2004/2005;
- The local stability of the temporary peat slopes around the perimeter of the excavations for the turbine foundations and crane hardstandings;
- The live load surcharge on peat slopes from low ground bearing pressure construction and forestry equipment operating on the peat slopes;
- Dynamic inertial loading on the peat from blast-induced vibrations from rock excavation in Borrow Pit BP-3; and

- Miscellaneous localised loading on the peat slopes from work related to tree felling, drainage, and cable trenching.

The following is a summary of the measures that were implemented on the site to mitigate the effect of the stability impacts on soils, geology and land.

10.5.2.2.2.1 Instrumentation and Monitoring

4 No. clusters of instrumentation were installed to monitor groundwater levels and ground movements in the peat around the perimeter of the site near Turbines T2, T18, T34 and T49/50. At each location:

- 3 No. vibrating-wire push-in piezometers were installed to provide a continuous record of daily and seasonal groundwater level fluctuations [12 No. total]; and
- 3-4 No. electronic tiltmeters provided a continuous record of any downslope movement or creep in the peat at the sensor locations [15 No. total].

The electronic sensors were connected to a central logger unit in each area. The logger units were fitted with GSM cards to allow remote access to the data, which was downloaded regularly to a central server. The tiltmeters were set up with an automated alarm system to alert wind farm technical representatives of incidents of peat movement that exceeded pre-defined limits for rapid response.

10.5.2.2.2.2 Geotechnical Supervision and Certification

The level of geotechnical supervision for the civil works contract was significantly increased for the second phase of construction on the site in 2004/2005.

AGL Consulting were appointed by the main contractor Ascon Ltd. (now BAM Civil) to provide geotechnical analysis, design, supervision and inspection services for the project from October 2003 and the end of the civil works in 2005. The scope of services included:

- An assessment of the peat slide, including walkover surveys, specialised sampling and testing of the peat, stability analyses and computer modelling;
- Specification, supervision and reporting of supplemental geotechnical investigations on the site;
- Slope stability analyses for all of the floating roads;
- Identification and assessment of suitable peat repository sites;
- Inspection of full-scale load testing on the floating roads;
- Assessment and monitoring of the impact of blast-induced vibrations on peat;
- Periodic site inspections and attendance at progress meetings by a Geotechnical Director;
- Full-time on call office-based technical support; and
- Review and certification of the Contractor’s Method Statements;

Engineers from ESB International had a full-time presence on site to supervise the civil works, manage the Permit to Work scheme, and coordinate with the mechanical/electrical sub-contractors. Geotechnical engineers from ESBI also carried out extensive supplemental ground investigations to establish the depth and strength of the peat across the site to assess the potential impact of tree felling operations on peat stability. They also carried out site inspections, reviewed Contractor's design submittals and attended project meetings.

Applied Ground Engineering Consultants (AGEC) provided geotechnical services to ESBI between October 2003 and the end of the civil works contract in 2005 including:

- An appraisal of site stability after the peat slide, with detailed walkover surveys, supplemental ground investigations (peat probing and in-situ vane shear testing), and slope stability analyses;
- Review of technical submittals from the Contractor, including certified method statements and reports for additional geotechnical investigations, site stability analyses, and in-situ testing;
- Periodic site inspections and attendance at project meetings.

10.5.2.2.2.3 Supplemental Geotechnical Investigations

As summarised in Section 10.2.1.2, comprehensive supplemental geotechnical investigations were carried out after the peat slide in October 2003 to characterise the depth and material characteristics of the peat, glacial till and bedrock across the site, as well as the groundwater levels in the peat. In general, the scope of the supplemental investigations included:

- A desk study review of aerial photography – including 3D stereoscopic imaging;
- Detailed walkover surveys and inspections by suitably qualified and experienced geotechnical engineers;
- Aerial LiDAR surveys, satellite GPS surveys, and in-situ slope angle measurements with a hand-held Abney Level to characterise the site topography;
- Extensive peat probing, in-situ vane shear testing, undisturbed sampling and specialised laboratory testing to characterise the depth, strength and material characteristics of the peat;
- Rotary coring at the remaining turbine foundations to determine the strength of the cohesive glacial till overburden below the peat and the depth to competent rock; and
- Installation of manual and electronic piezometers in the peat to monitor groundwater levels

10.5.2.2.2.4 Analysis and Testing of the Floating Roads

The mitigation measures for the floating roads on the peat consisted of:

- Supplemental investigations;
- Stability analyses;
- Full-scale serviceability and proof load tests on the working roads;
- A trial load test on a test section of floating road;
- Remedial works to improve the performance of sections of the floating roads;
- Site controls; and
- Modifications to the site access tracks in the vicinity of the slide.

Supplemental investigations comprised of peat probes, in-situ vane shear tests and slope angle measurements were carried out at regular intervals along the floating roads to characterise the depth, strength and material characteristics of the peat, and the topography of the slope. At 1 No. location near Turbine T55, vane shear tests were carried out in the peat under a section of floating road to confirm that the strength of peat had increased as it consolidated under the weight of the road.

Slope stability analyses were carried out at representative profiles along the roads using the Slope/W computer software to demonstrate that there was an acceptable margin of safety against shear failure in the peat under the self-weight of the roads and the design live load surcharge from the construction traffic in accordance with IS EN 1997-1:Eurocode 7 for Geotechnical Design, Part 1– General Rules.

Full-scale serviceability and proof load tests were carried out on all of the floating roads to confirm their capacity and performance under the design live load surcharges prior to resuming construction on the site. Initially the tests were carried out by incrementally increasing the load on the floating roads with a standard 4-axle tipper truck to model the maximum construction traffic load for the completion of the access tracks, turbine foundations and crane hardstanding areas (37.5 tonnes). Prior to the transportation, assembly and erection of the turbines the roads were tested again with 2 No. fully-loaded 4-axle tipper trucks travelling back to back to simulate the design live load surcharge from the largest mobile crane that was used to erect the turbines (72 tonnes). Prior to bringing the heavy step-up transformer to the substation a full-scale proof load test was carried out on a trial section of floating road on very soft peat along the access route to the substation to validate the method of in-situ testing and stability analyses so that the site access tracks along the route to the substation could be certified for the full 130 tonne combined load of the transformer and low-loader transporter.

Remedial works were carried out on sections of the floating roads that performed poorly under the initial load tests with the 4-axle trucks, i.e. where visual observations and measurements identified that there were excessive concentrated deflections under the wheel and axle loads from the fully loaded truck. The remedial works involved re-surfacing the roads with an additional layer of geogrid and a 150 mm capping layer of crushed rock granular fill. All of the re-surfaced roads were retested to verify their load capacity, and to confirm that the additional geogrid reinforcement and capping layer effectively spread out the concentrated axle loads across the surface of the peat to significantly reduce the deflections under the concentrated wheel and axle loads.

Site controls were implemented for the use of the floating roads during the second phase of construction, i.e.:

- All of the roads had to be certified for use by AGL Consulting for the Permit to Work protocols based on the results of the additional investigations, stability analyses and full-scale serviceability and proof load tests;
- All of the construction vehicles were driven slowly and steadily across the floating roads within the specified site speed limit of 10 mph.
- The size and weight of the construction vehicles using the floating roads was not permitted to exceed the design surcharge load from the mobile crane that was used to erect the turbines, or from the low-loader transporter that was used to bring the step-up transformer to the substation;
- The cranes were stripped of any unnecessary ballast when travelling across the floating roads to the turbine sites;
- The mobile cranes and large low-loader transporters were transported across the site under the direct supervision of site personnel using the shortest and most direct route possible;
- The cranes were not stopped on the floating roads. All intermediate stopping points were on crane hardstandings adjacent to turbines; and
- Where necessary, steel plates were placed along on the edges of the floating roads to facilitate access around tight bends where there was a risk of excessive deflection and overturning on a soft verge.

Modifications to the site access tracks in the vicinity of the slide:

A 30 m long section of the floating road at Turbine T68, and a 105 m long section of the floating road to the west of Turbine T70 had to be reconstructed because they were damaged in the peat slide on October 2003. These sections of the site access tracks were reconstructed as rockfill embankments on competent glacial till below the disturbed peat. The roads performed a dual function of reinstating the site access tracks that had been damaged in the slide, and acting as a permeable barrage across the slide area to contain the disturbed peat upslope from the embankments while allowing free drainage of groundwater through the rockfill.

As a further risk mitigation measure in this area, Turbine T16 and a 475 m long section of floating road between Turbines T15 and T17 were omitted from the scope of work on the project as a precautionary measure out of concerns for site stability in the area, which was close to where the peat slide occurred in October 2003 and had similar topography and ground/groundwater conditions. The sections of partially completed floating roads that had been constructed between T15 and T17 at the time of the slide were closed and abandoned.

10.5.2.2.2.5 Assessment of the Excavations for the Turbine Foundations & Crane Hardstandings

The mitigation measures for the excavation of the turbine foundations and crane hardstanding areas consisted of:

- Supplemental investigations;
- Stabilisation measures and temporary works designs for the side slopes around the perimeter of the excavations;
- Review and certification of the Contractor's Method Statements;

Supplemental investigations were carried out at the remaining turbine foundations and crane hardstanding areas in advance of excavation. They were comprised of peat probes and vane shear tests in the peat, with rotary coreholes at the majority of the remaining turbine foundations. The peat probes were used to determine the depth and volume of peat that needed to be excavated and disposed of on site, while the vane shear tests measured the undrained shear strength of the peat to assess the stability of the excavation side slopes and the requirements for temporary support. The rotary coreholes at the turbine foundations were used to determine the depth of excavation to suitable formation on competent rock. Standard Penetration Tests (SPT) were carried out in the overlying cohesive glacial till to determine the undrained shear strength of the till to assess the stability of the temporary excavation slopes.

Stabilisation measures: Wherever possible the sides of the temporary excavations were battered back to stable slopes of about 1V:1H (=45 degrees) or flatter. Side slopes in stiff glacial till and weathered rock were increased to 2V:1H (=63.4 degrees) or steeper to minimize the extent of the excavation. In areas relatively deep (>2.5 - 3.0 m), weak peat in poorly drained areas with a high water table a rockfill berm was constructed down to mineral soil around the perimeter of the excavation to provide temporary support to the peat during construction.

Review and Certification of the Contractor's Method Statements: Method statements were produced by the Contractor for each turbine to detail the following:

- The depth of peat and the depth to formation for the foundations on rock;
- Drainage requirements;
- The method of excavation and temporary support requirements for the side slopes;
- The plant requirements for the handling and transporting of peat;
- The location of the approved repository site for the peat;
- Traffic management plan with the proposed haul routes; and
- Risk assessment and health and safety considerations.

The method statements were reviewed by AGL Consulting prior to works commencing on site and a Geotechnical Approval Certificate was signed by a Geotechnical Director as part of the Permit to Work system.

10.5.2.2.2.6 Spoil Management & Disposal – Peat Repository Sites

After the peat slide strict controls were placed on the disposal of peat and glacial till excavated from the turbine foundations, crane hardstanding areas, substation site, borrow pits and anemometer masts. The heavier glacial till was segregated from the peat and stored in the borrow pits so that it was not placed on the intact peat slopes. The majority of the excavated peat was stored to a maximum depth of 1.0 m in designated repository areas on the intact peat slopes in suitable areas of flat or gently sloping ground on the site. A small volume of the peat was stored within rockfill bunds in Borrow Pits BP-2 and BP-3.

The additional mitigation measures that were implemented for the peat repository sites on the slopes included:

- Desk studies and walkover surveys
- Supplemental investigations
- Stability analyses
- Geotechnical certification, and
- Site control measures.

Desk studies and walkover surveys: A comprehensive desk study was carried out to identify suitable peat repository areas on the site. Topographical maps, aerial photographs and 3D stereoscopic imaging of 1970s black and white aerial photographs of the site were used to locate areas of gently sloping ground (≤3°) set back >25 m from any defined or steep convex break in slope and outside the influence of the main hydrological features. Detailed walkover surveys were then carried out by geotechnical engineers from AGL Consulting to confirm which areas were suitable for further consideration.

Supplemental investigations comprised of peat probes and slope angle measurements to define the peat depth and topography on a 25 m grid within the plan area of each peat repository site with additional peat probes 50 and 100 m downslope from the sites on two orthogonal planes. In-site vane shear tests were used to measure the undrained shear strength of the peat and undisturbed sampling was carried out to inspect the material characteristics of the peat at the interface with the underlying glacial till.

Slope stability analyses were carried out for representative profiles within the repository sites using the Slope/W computer software to demonstrate that there was an acceptable margin of safety against a planar shear failure in the intact peat under the surcharge of 1.0 m of excavated peat in accordance with IS EN 1997-1:Eurocode 7 for Geotechnical Design, Part 1 – General Rules.

Geotechnical Certification: For the Permit to Work system a Geotechnical Approval Certificate was signed by a Geotechnical Director for AGL Consulting for each repository site that was confirmed to be suitable based on the supplemental investigations and stability analyses.

Site controls were implemented on site for the use of the peat repository areas, i.e.:

- The boundaries of the approved repository sites were clearly marked out on site with survey tape between probe locations;
- The depth of excavated peat that was placed in the site was strictly limited to 1.0 m and no temporary stockpiling was permitted on the peat slopes;
- "Floating" depth markers were set up within the repository sites to control the depth of peat placed on the slopes. These were wooden stakes that were embedded in the peat so that they could settle with the peat as it compressed under the weight of the additional material that was placed on the slopes.
- The live load surcharge on the peat slopes was minimised using a combination of long reach excavators operating on the access tracks, and LGBP (low ground-bearing pressure) wide-tracked excavators on the peat.
- Geotechnical engineers from AGL Consulting carried out periodic inspections of the works to ensure that they complied with the method statements and specified risk mitigation measures.

10.5.2.2.2.7 Tree Felling

The following monitoring and risk mitigation measures were implemented for the felling of the trees that were remaining on the site after the slide:

- Extensive geotechnical investigations comprised of peat depth probes, in-situ vane shear tests, slope angle measurements, piezometers and undisturbed gouge auger core sampling were carried out across the site by ESB International to assess the stability of the peat on the site for the tree felling operations;
- Site stability analyses were carried out in order to inform the appropriate felling methodology for various areas across the site
- The trees were left tin place in areas that were considered unsuitable for the mechanical harvesting and forwarding equipment;
- Where clear felling was permitted the works were carried out by experienced specialist subcontractors under the management of Coillte;
- The trees were felled and gathered using specialised equipment that has been widely used in commercial conifer forests on upland blanket bogs in Ireland;

- In areas of soft peat the contractors placed timber brash and branches under the harvester tracks to spread out the concentrated live load surcharge on the surface of the peat; and
- Where the trees were too small for the harvesting machinery the trees were felled by hand. Some of the larger trees in these areas were felled with a light machine harvester, formed into windrows and left in place on the slopes.

10.5.2.2.2.8 Rock Blasting in Borrow Pit No.3

Blasting was carried out in Borrow Pit No.3 (BP3) to extract the rock that was processed into granular fill for the construction of the floating roads, and the hardstanding areas for the crane pads, substation and anemometer masts. The following monitoring and mitigation measures were implemented to confirm that the large peat slide that occurred in 2003 was outside the range of the blast-induced vibrations from the borrow pit, and that the peak particle velocity and acceleration of the vibrations were within acceptable limits:

- The blasting was carried out by a suitably qualified fully licensed professional;
- The pattern, sequence, timing and maximum instantaneous charge of the blasts were designed to minimise blast-induced vibrations on the slopes around the perimeter of the borrow pit;
- Vibration monitoring was carried out on the site for the blasts;
- AGL Consulting carried out a comprehensive review of the blast monitoring records to establish threshold limits for the Peak Particle Velocity (PPV) and Peak Particle Acceleration (PPA) of the blast-induced vibrations, and to establish the radius of impact for the blasting;
- Glacial till excavated from the site was used to construct a berm along the face of the peat at the top of the rock slope around the perimeter of the borrow pit to act as a shear key to prevent a localised peat slide inundating the pit where the surrounding slopes were sloping down towards the pit.

10.5.2.2.2.9 Drainage

The following risk mitigation measures were also implemented for the drainage works:

- Wherever possible, minor drainage works were carried out by hand to avoid machine or equipment loading on the peat;
- Where mechanical excavators were required the works were carried out using wide-tracked LGBP 10-13 tonne excavators suitable for working directly on the peat;
- The peat excavated from the trenches was sidecast on the adjacent intact peat slopes and spread out to depths typically <0.5 m;

- Where large culverts were constructed at road crossings over the main watercourses on the site all of the peat was excavated out from under the culverts and granular surround to avoid surcharge loading on the peat.

10.5.2.2.2.10 Cable Trenching & Ducting

The following risk mitigation measures were implemented for the cable trenching and ducting:

- The alignment of the cable trenches were designed to follow the shortest, most direct route across the site to the control building with the minimum number of road crossings;
- Most of the cable trenches were aligned alongside the site access tracks so that the cable spools could be transported along the floating roads, minimising construction traffic on the intact peat slopes;
- The cable trenches in the peat were excavated using wide-tracked LGBP 10-13 tonne excavators suitable for working directly on the peat;
- To minimise the impact of the road crossings on the floating roads the new ducts were pushed horizontally through the peat under the roads to avoid having to open up a trench across the road, which would cut through the geogrid reinforcement.
- The works were carried out by specialist sub-contractors who were experienced with similar work for wind farms on upland blanket bogs in Ireland.

10.5.2.3 Operation and Maintenance Phase 2006-2020

The activities that were carried out on the site during this period that had an impact on soils, geology and land with significant effects included the following:

- Maintenance/Repair of Turbines;
- Maintenance/Repair of Substation & Control Building;
- Maintenance/Repair of Access Tracks;
- Cables & Ducting Improvements;
- Drainage Improvements;
- Forestry – Tree Topping/Log Stockpiling; and
- Remedial works to right a crane that went off the narrow turbary road.

AGL Report No. 11-147B-R04 – "*Geotechnical Stability Report & Assessment of Site Stability Impacts on Soils, Geology and Land*" in Appendix B of this Chapter gives a detailed assessment of the mitigation measures that were implemented on site for this phase of the wind farm. There were no changes to the design of the wind farm. Therefore, this section presents a summary of the measures that were implemented to mitigate stability impacts on soils, geology and land, i.e. to reduce the risk of a peat slide.

10.5.2.3.1 Mitigation of Stability Impacts

The drainage improvements had a permanent and sustained positive impact on the peat that had a **Moderately Significant** effect on peat stability relative to the baseline conditions on site in 1998, prior to construction.

The negative impacts of site activities that had a **Slightly Significant** effect on the peat with respect to site stability were:

- The additional dead load surcharge on the 4.5 km of floating roads that were upgraded in 2014 with an additional 150 mm of crushed rock capping material and a nominal 10 mm thick surfacing layer of fine gravel;
- The live load surcharge on the floating roads from the general maintenance and repair vehicles, and from the large mobile cranes that were occasionally required to carry out repairs to the turbines;
- The occasional live load surcharge on the intact peat slopes from low ground bearing pressure equipment that was required for tree topping, to install the new cable ducts and to carry out improvements to the drainage network; and
- The one-off temporary live load surcharge of 10 kN/m^2 on the peat slope at Turbine T40, where the 250 tonne mobile crane overturned when travelling along the floating road.

The following is a summary of the monitoring and mitigation measures that were implemented on the Project to mitigate the effect of the stability impacts on soils, geology and land.

10.5.2.3.1.1 Instrumentation and Monitoring

Between 2006 and 2012 ESBI continued to monitor groundwater levels and movement in the peat at the clusters of electronic piezometers and tiltmeters installed near Turbines T2, T18, T34 and T49/50.

The instruments were decommissioned in 2014 as some of them showed signs of malfunction. It was considered that they had been in place for a sufficient period of time to ensure that they were exposed to a range of environmental conditions on the site, and they did not indicate any evidence of peat instability.

In May 2005, 7 No. monitoring points were established on the peat within the slide area for long-term monitoring of movement and settlement of the disturbed peat. The ITM coordinates and level of the monitoring points were recorded periodically by GPS surveys between 2005 and 2020.

10.5.2.3.1.2 Geotechnical Supervision and Inspections

Gort Wind Farms Ltd. (GWL) appointed a site manager who was responsible for coordinating and managing the operation of the wind farm and the maintenance of the turbines and site infrastructure. His responsibilities included regular site inspections and managing health and safety for the operation and maintenance of the wind farm, including co-ordinating and supervising access to the turbines for the large mobile cranes.

ESBI engineers carried out regular periodic geotechnical inspections of the site between 2005 and 2020 to assess maintenance requirements for short and long-term stability. The majority of the recommendations in the reports relate to maintenance works on the site access roads and site drainage which were incorporated into the maintenance programme for the site.

AGL Consulting were appointed by ESB International to provide geotechnical support services periodically over the operation and maintenance phase of the project between 2011 and 2020, including:

- Site inspections and walkover surveys by Senior Geotechnical Engineers and Geotechnical Directors (2011, 2014 & 2018);
- Inspection and certification of full-scale proof load tests on the floating roads in 2011, 2014 and 2018;
- Geotechnical analysis and design services for the upgrade of the floating roads in 2014, including a site-wide Peat Stability Risk Assessment; and
- Site supervision and office-based technical support services during construction stage of the 2014 civil contract to upgrade the floating roads, including a review and certification of the Contractor’s Method Statements.

10.5.2.3.1.3 Maintenance and Repair of the Site Access Tracks

The following design, construction & operational risk mitigation measures were implemented for the main roads upgrade contract in 2014, which accounts for the majority of the works that were carried out on the floating roads on the site between 2006 and 2020.

- In 2011 all of the site access tracks were inspected by a geotechnical engineer from AGL Consulting and full-scale proof load tests were carried out on the floating roads to assess the nature and extent of the upgrade works that would be required, and to verify the capacity and stability of the floating roads under the design crane load prior to designing the upgrade works.
- For continuity of geotechnical risk management, the geotechnical engineer for AGL Consulting who carried out the 2011 inspections and the design for the 2014 upgrade works was the same person who evaluated the design and stability of the roads for the Contractor after the peat slide during the construction stage of the project in 2003/2004 – Mr. Conor O'Donnell.
- To minimise the additional load on the peat where the floating roads were upgraded:
    - The roads were reinforced with an additional layer of geogrid to reduce the thickness of granular capping material required;
    - The thickness of the capping material was limited to 150 mm; and
    - The coarse granular capping material was surfaced with a nominal 20 mm thick blinding layer of fine gravel in lieu of a thicker layer of granular subbase material (Clause 804) that would normally be used.
- The additional dead load on the floating roads was designed to be within the factor applied to the live load surcharge in the stability analyses [i.e. <30% of characteristic (unfactored) live load surcharge].
- Stability analyses were carried out to demonstrate that the additional load had only a minor impact on the factor of safety against bearing capacity or shear failure in the peat under the roads, and that the difference (<5-10%) was proportional to the increase in undrained shear strength that would have already occurred in the underlying peat as it consolidated (compressed) under the weight of the roads since they were constructed in 2003-2005;
- The construction stage traffic and live load surcharges were also restricted so that the combination of the temporary live load surcharge and the increased dead load on the road did not exceed the design live load surcharge for the floating roads.
- A Peat Stability Risk Assessment (PSRA) was carried out in advance of construction in accordance with industry best practice guidelines to characterise the risk of peat instability across the site during the 2014 road upgrade works.

- Construction stage risk mitigation measures were incorporated into the Geotechnical Risk Register for the works on site, including:
    - Designated access routes for construction plant and machinery;
    - Limits on the maximum size of plant that could be used on the roads, particularly in areas where there was a higher risk of peat instability;
    - A requirement to stockpiling granular fill materials in the crane hardstanding areas to avoid concentrated loading on the floating roads;
    - Restrictions on the way in which the fill was tipped and spread on the roads to minimise dynamic impact loads and to avoid concentrated static loads from temporary piles of rockfill that exceeded the design surcharge load of the road;
    - Compaction by static rolling only;
- During construction full-time supervision of the works was carried out jointly by geotechnical engineers from AGL Consulting and ESB International to ensure that the works complied with the specification and that the specified risk mitigation measures were implemented on site.
- A certification procedure was implemented for the review and approval of the Contractor's method statements to certify that reasonable skill and care was taken in ensuring that appropriate measures were implemented to mitigate against the risk of peat instability during construction. The Geotechnical Approval Certificates were issued by AGL Consulting and signed by a Director of the company.
- On completion of the works, full scale proof load tests were successfully carried out on the upgraded roads, to verify the capacity of the roads under the design crane load using a mobile crane loaded with additional ballast.

10.5.2.3.1.4 Maintenance/repair of turbines

The following design, construction & operational risk mitigation measures were implemented for the maintenance and repair of the turbines on the site:

- All heavy lifting operations involving mobile cranes were carried out from the hardstanding areas adjacent to the turbines so that the loads were adequately supported on the glacial till and rock below the peat.
- Steel bearing plates were used to reduce the bearing pressure under the crane outrigger pads to prevent any localised bearing failure on the hardstanding areas.
- The capacity of the floating roads to support the design load for the mobile cranes carrying out maintenance at the turbines was verified by full-scale proof loading at the end of the construction period in 2005, after the roads were upgraded in 2014, and again in 2018, when the narrow turbary road was also re-tested.

- The comprehensive upgrade programme that was carried out on the floating roads in 2014 improved the condition and performance of the sections of roads that had deteriorated significantly since they were constructed in 2005.
- The number of crane mobilisations to site during the operation and maintenance period between October 2005 and Q2 2020 was minimised by combining maintenance work on turbines, wherever possible;
- The smallest size and of mobile crane with sufficient capacity for the required maintenance lifting loads was mobilised to the site; for example, based on an audit of crane movements between 2005 and 2018, which is representative of the typical operations on site to date:
  - Approximately 80% of the 86 No. crane operations on the site were carried out using a 100 tonne crane (e.g. the Liebherr LTM 1100-5.2 which is 2.75 m wide and has a total travelling weight of 60 tonnes on 5 axles, with a maximum axle load of 12 tonnes/axle);
  - All but one of the remaining operations were carried out using a 130 tonne crane (e.g. the Liebherr LTM 1130-5.1 which is also 2.75 m wide and has a total travelling weight of 60 tonnes on 5 axles, with a maximum axle load of 12 tonnes/axle); and
  - 1 No. operation at Turbine T17 in July 2018 required the larger 200 tonne Liebherr LTM 1200-5.1 mobile crane, which is 3.0 m wide and has a total travelling weight of 60 tonnes on 5 axles, with a maximum axle load of 12 tonnes/axle.

    In comparison, the design crane load for the floating roads is the 300 tonne Grove GMK6300 All-Terrain crane, which is 3.0 m wide and has a total travelling weight of 72 tonnes on 6 axles with a maximum axle load of 12 tonnes/axle;
- All of the cranes were stripped of any unnecessary additional ballast when travelling across the floating roads to the turbine sites.
- The cranes were transported across the site under the direct supervision of the ESB site maintenance manager.
- The cranes were driven directly to the required turbine using the shortest route across the floating roads, avoiding unnecessary turns at tight junctions where there was a risk of going off the road, or sections of floating roads that were in poor condition prior to the 2014 roads upgrade programme.
- The mobile cranes were driven slowly and steadily across the floating roads within the specified site speed limit of 5 km/hr. All intermediate stopping points were on crane hardstandings adjacent to turbines, not on the roads.
- Where necessary, steel plates were placed along on the edges of the floating roads to facilitate access around tight bends where there was a risk of excessive deflection on a soft verge.

- Strict restrictions were placed on access for cranes along the narrow 3.0-3.5 m wide turbary road between Turbines T25 and T45.

10.5.2.3.1.5 Maintenance/repair of Derrybrien substation and control building

The following design, construction & operational risk mitigation measures were implemented for the maintenance and repair of the substation and control building:

- All maintenance operations were carried out from the hardstanding area around the substation and control building which was designed to support the loads from the vehicles and equipment on the glacial till below the peat.
- All of the vehicles and equipment were driven directly to the substation site across the minimum length of floating road.
- The dead weight and axle loads of the vehicles and equipment was kept to a minimum and the loads were within the design crane load that was verified by the proof load tests that were carried out on the floating roads.
- Trucks that were used to bring materials or large equipment such to the substation were escorted along the roads by the ESB site maintenance manager.
- The vehicles were driven slowly and steadily across the floating roads within the specified site speed limit of 15 km/hr.

10.5.2.3.1.6 Drainage Improvements

The primary negative impact of the drainage improvements was the occasional localised temporary loading on the peat slopes by mechanical excavators used to clear out, deepen or realign existing drains. The following risk mitigation measures were implemented to mitigate the effect of the loading on the stability of the peat:

- Wherever possible, minor maintenance works and drain clearing was carried out by hand to avoid machine or equipment loading on the peat.
- Where mechanical excavators were required the works were carried out using wide-tracked low ground bearing pressure 10-13 tonne excavators suitable for working directly on the peat.
- Where significant excavations were required the excavated peat and mineral soil was removed to a secure material disposal area to avoid side-casting the material on the peat adjacent to the drain.
- Where culverts were widened at road crossings all of the peat was excavated out from under the rockfill used to widen the road to avoid surcharge loading on the peat.
- The inspections used to assess the requirements for maintenance and improvement works to the drainage network were typically carried out over

the wetter months in winter or early spring when groundwater levels on the site were higher and drainage issues would have been more apparent.

- The drainage improvement works were prioritised so that:
  - Only priority work to improve the drainage at the turbine foundations was carried out urgently in the winter or early spring; and
  - All other general maintenance and drainage improvement works on the site were carried out during the drier summer months when there would be a lower risk of peat instability on the site.

Poor drainage is a recognised contributory risk factor for peat slides. Therefore, as such, the drainage improvement would in itself be a significant risk mitigation measure for site stability during the operation and maintenance of the wind farm.

10.5.2.3.1.7 Cable Ducting

The main work that was carried out on the cables and ducting on the site of the wind farm between October 2005 and Q2 2020 was the installation of the new ducting and fibre-optic cables for the upgrade of the turbine control systems in September 2017. The following risk mitigation measures were implemented for the works:

- The length of new cable ducts that had to be installed on the site was minimised by optimising the layout of the ducts to combine clusters of fibre-optic cables on different circuits into the same duct. In this way it was possible to reduce the total length of new ducts to 2.55 km to house 7.6 km of fibre-optic cables.
- The alignment of each of the ducts follows the shortest, most direct route across the site to the control building and the number of road crossings was minimised.
- The ducts were installed using a mole-plough capable of installing the ducts directly into the peat without the need for open-trench excavation and backfilling.
- The mole-plough was a low ground-bearing tracked machine suitable for working directly on the peat.
- To minimise the impact of the road crossings on the floating roads the new ducts were pushed horizontally through the peat under the roads to avoid having to open up a trench across the road, which would cut through the geogrid reinforcement.
- The manholes were constructed on the glacial till below the peat to avoid any loading on the peat.
- The works were carried out by personnel that were experienced with similar work for wind farms on upland peat bogs in Ireland.

10.5.2.3.1.8 Forestry – Tree Topping

No commercial forestry planting or felling was permitted on the wind farm site during the operation and maintenance period between October 2005 and Q2 2020.

In September/October 2018, tree topping was carried out for a distance of 10 m either side of the access track in selected areas around the site. The following risk mitigation measures were implemented for the works:

- The tree-topping works were limited to clearing small trees (typically conifers <4-5 m high) and shrubs that had re-grown naturally within areas that had been cleared during the construction of the wind farm.
- The tree topping was carried out using a light 10 tonne wide-tracked excavator with a saw head attachment, which is a specialist low-ground bearing pressure forestry machine suitable for working directly on the peat.
- All of the trimmed vegetation was cut and left in place on the peat slopes with no additional handling, which minimises machine movements and loading on the peat.
- The works were carried out at the end of the drier summer months when the risk of peat instability on the site is lower.
- The tree topping works were scheduled on a priority basis as part of a multi-year annual maintenance plan under the supervision of the ESB site maintenance manager. No unscheduled works were carried out.

10.5.2.3.1.9 Forestry – Timber Stockpiling

In the 2017 Geotechnical Inspection Report by ESBI it was noted that stockpiles of timber that had been felled outside the wind farm site had been stockpiled on the peat near Turbine T6. Therefore, the following measures were implemented to mitigate the impact of the live load surcharge on the peat:

- The timber stockpile was removed shortly after it had been reported.
- No further timber stockpiling was permitted on the site.

10.5.2.3.1.10 Cumulative Impacts from Peat Extraction in Turbary Plots Within and Immediately Adjacent to the Wind Farm Site

Remedial measures and monitoring associated with this phase of the project relating to peat extraction in the turbary plots within and immediately adjacent to the wind farm site are presented in Section 10.4.5.

10.5.2.4 Operation and Maintenance Phase 2020-2040

The site activities that are likely be carried out on the site during the remaining operational period of the wind farm from now until c. 2040 that could have an impact on soils, geology and land with significant effects include the following:

- Maintenance/Repair of Turbines
- Maintenance/Repair of Substation & Control Building
- Maintenance/Repair of Access Tracks
- Cables & Ducting Improvements
- Drainage Improvements
- Forestry – Tree Topping

This is based on records of works carried out on site during the operation and maintenance period prior to 2020 as well as works that are currently scheduled or likely to occur. At this stage there are no major maintenance or upgrade works scheduled or anticipated for the drainage, roads, electrical transmission network or turbines so that all of the work over the remaining operation life on the wind farm will be limited to ongoing minor maintenance and repair works on the existing infrastructure with some tree topping to clear small trees re-establishing on the site.

Section 10.5.2.3 outlines the measures that were implemented for these activities during the operation and maintenance phase of the project up to the end of 2020 to mitigate and monitor their impact on the receiving soils, geology and land. These measures have been incorporated into the standard operating procedures for maintenance works on the wind farm and will continue to be applied over the remaining operational life of the project up to decommissioning. Therefore, none of the activities will have a direct impact or stability impact that will have a **Significant** or **Moderately Significant** effect on the receiving soils, geology and land.

The site activities and corresponding direct impacts that could have that could have a **Slightly Significant** effect are limited to:

- The impact of harvesting equipment trafficking on the peat for periodic tree topping to remove small trees that have re-established naturally on the slopes;
- Widening of the turbary road to Turbine T45 (if required), which will involve loading on a 2-3 m wide strip of intact peat upslope from the existing road between T31 and T45;

The impacts of site activities during this phase of the project that could have a **Slightly Significant** effect on the stability of the peat are limited to:

- The increased dead load on the floating roads where they are locally resurfaced or repaired;
- The live load surcharge of the large mobile cranes or heavy low-loader transporters on the floating roads;

- The occasional live load surcharge on the intact peat slopes from low ground-bearing pressure excavators or harvesters carrying out tree-topping or localised repairs on the existing network of drains or cable ducts;
- The additional dead and live load surcharge on the peat along the widened turbary road between Turbines T31 and T45 (if required).

Therefore, in addition to the standard operation procedures that are already being implemented on the site, the following additional measures will be implemented over the remaining operational life of the wind farm to mitigate the effect of the impacts on soils, geology and land.

- Periodic inspections of the site will be carried out by a suitably qualified geotechnical engineer on behalf of Gort Wind Farms Ltd.
- If a large mobile crane has to be mobilised to carry out substantial repair works to the turbines along the narrow section of turbary road between Turbines T31 and T45 then the carriageway requirements for the crane will be reviewed and the road will be widened where required to prevent the crane going off the road.
- If the turbary road is widened:
    - Detailed design of the widened road will be carried out by a suitably qualified geotechnical engineer.
    - Additional site investigations will be carried out, where necessary, to characterise the depth and strength of the peat and the composition of the existing floating road.
    - Stability analyses will be carried out in advance of the works on site to confirm that the stability of the widened road is acceptable in accordance with IS EN 1997-1: Eurocode 7 for Geotechnical Design, Part 1 – General Rules.
    - The works on site will be supervised by a suitably qualified geotechnical engineer on behalf of Gort Wind Farms Ltd.
- If it is necessary to carry out more substantial upgrade works on sections of the floating roads on the site (i.e. other than minor repairs to fill potholes and regulate the surface of the road), then:
    - The proposed works will be reviewed by a suitably qualified geotechnical engineer.
    - Additional site investigations and stability analyses will be carried out, where necessary, to confirm that the proposed works will not result in an unacceptable risk with regard to site stability.
    - The works will be supervised by a suitably qualified engineer from ESB Engineering and Major Projects.

10.5.2.4.1.1 Cumulative Impacts from Peat Extraction in Turbary Plots Within and Immediately Adjacent to the Wind Farm Site

Remedial measures and monitoring associated with this phase of the project relating to peat extraction in the turbary plots within and immediately adjacent to the wind farm site are presented in Section 10.4.5.

10.5.2.5 Decommissioning Phase

The site activities that are likely be carried out on the site during decommissioning of the wind farm that could have an impact on soils, geology and land with significant effects include the following:

- De-energising the site and removing all of the buried LV electrical cables and fibre-optic cables;
- Widening the turbary road between Turbines T31 and T45 (if required);
- Dismantling the turbines, substation and anemometers and transporting the components off-site for re-use, recycling or disposal;
- Demolition of the control building and transporting the demolition waste off-site for disposal;
- Demolition and disposal of the twin poleset for the 110 kV line.

This is based on the proposed decommissioning plan for the project, which will involve removing all of electrical cables and above ground elements of the turbines, substation and transmission structures. The turbine foundations and granular hardstanding areas for the cranes, substation, site compound and anemometer masts will be left in place along with the improved drainage network.

Section 10.5.2.2 and Section 10.5.2.3 outline the mitigation measures that were implemented during the construction stage of the project and during the operation and maintenance phase of the wind farm up to the end of Q2 2020 to mitigate the impact of site activities at the turbines, substation and along cable trenches. These measures have been incorporated into the standard operating procedures for maintenance works on the wind farm site and will continue to be applied for activities that have a comparable impact during decommissioning of the wind farm (i.e. for dismantling/demolition vs assembly/construction/maintenance of turbines and substation, and for construction traffic loading on floating roads and on intact peat slopes). Therefore, none of the activities will have a direct impact or stability impact that will have a **Significant** or **Moderately Significant** effect on the receiving soils, geology and land.

If it is necessary to widen the narrow turbary road to Turbine T45 for decommissioning, then the direct impact of construction on the 2-3 m wide strip of intact peat upslope from the existing road between T31 and T45 will have a **Slightly Significant** effect on the peat.

The impacts of site activities during decommissioning that could have a **Slightly Significant** effect on the peat with respect to site stability are limited to:

- The live load surcharge of the large mobile cranes or heavy low-loader transporters on the floating roads; and

- The additional dead and live load surcharge on the peat along the widened turbary road between Turbines T31 and T45 (if required).

Therefore, in addition to the standard operation procedures that are already being implemented on the site, the following additional mitigation measures will be implemented during decommissioning to mitigate the effect of the impacts on soils, geology and land:

- The carriageway requirements for the large mobile crane that will be used to dismantle the turbines along the narrow section of turbary road between Turbines T31 and T45 will be reviewed in advance of the works and the road will be widened, where necessary, to prevent the crane going off the road;
- If it is necessary to widen the narrow turbary road:
    - Detailed design of the widened road will be carried out by a suitably qualified geotechnical engineer.
    - Additional site investigations will be carried out, where necessary, to characterise the depth and strength of the peat and the composition of the existing floating road.
    - Stability analyses will be carried out in advance of the works on site in accordance to confirm that the stability of the widened road is acceptable in accordance with IS EN 1997-1: Eurocode 7 for Geotechnical Design, Part 1 – General Rules.
    - The works on site will be supervised by a suitably qualified geotechnical engineer on behalf of Gort Wind Farms Ltd.
- The size, weight and axle load of the large mobile crane that is used to dismantle the turbines shall not exceed the design load for the floating roads (i.e. the 300 tonne Grove GMK6300 all-terrain mobile crane with a travelling weight of 72 tonnes on 6 axles – max 12 tonnes/axle).
- The size, weight and axle load of the low-loader transporter used to transport the transformer off the site shall not exceed the combined design load of the vehicle that was used to bring the transformer to the substation site during construction (i.e. a total combined load of 130 tonnes over 28.5 m x 3.0 m area with 12 axles and a maximum axle load of 12 tonnes).
- The electrical cables that have been direct-buried in the peat will be pulled out by winching from hardstanding areas, manholes or junction boxes, where possible, to minimise the extent of trench excavations in the peat.
- The decommissioning works will be supervised by a suitably qualified engineer from ESB Engineering and Major Projects.
- A permit to work scheme will be implemented on the site for the works.
- The Contractor’s method statements will be reviewed and certified by a suitably qualified geotechnical engineer.

10.5.2.5.1.1 Cumulative Impacts from Peat Extraction in Turbary Plots Within and Immediately Adjacent to the Wind Farm Site

Remedial measures and monitoring associated with this phase of the project relating to peat extraction in the turbary plots within and immediately adjacent to the wind farm site are presented in Section 10.4.5.

10.5.3 Remedial Measures & Monitoring for Significant Effects – Grid Connection

10.5.3.1 Construction Stage

As noted above no peat stability issues occurred during the construction of the grid connection. Notwithstanding, the following is a summary of the typical risk mitigation measures that were implemented to avoid stability risk and minimise the impact on soils, land and geology during the construction stage:

- 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 inspections and toolbox talks of ground conditions and working practices
- Contractor providing method statement for any proposed works in areas of peat/sloping ground/overhead power lines
- Maintenance of hydrology of area as far as possible;
- Use of experienced contractors and trained operators to carry out the work;
- Use of experienced geotechnical staff for site supervision where necessary.
- Use of the existing forestry access tracks

With control/mitigation measures in place, none of the construction stage activities had an effect on the receiving soils, geology and land, or stability that is **Significant**, or of **Moderate** Significance.

10.5.3.2 Operation and Maintenance Phase 2006-2019

No peat instability was observed or recorded along the grid connection or at the substation during the operation and maintenance period from 2006 to Q2 2020.

In relation to operation and maintenance, the main works are the cutting back of tree growth, the main effect that this work may have on site stability is the loading from the plant and equipment operating directly on the peat slopes. The impact of this on site stability and soils, geology and land is very low and only slightly negative, and the significance of the impact is slight. Nevertheless, the following risk mitigation measures will be implemented for the works:

- The cutting back of tree growth will be carried out using a light 10 tonne wide-tracked excavator with a saw head attachment, which is a specialist low-ground bearing pressure forestry machine suitable for working directly on the peat
- 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

- The works will be carried out at the end of the drier summer months when the risk of peat instability is lower
- The works will be scheduled on a priority basis as part of a multi-year annual maintenance plan under the supervision of the ESB site maintenance manager.

As above, with control/mitigation measures in place, none of the operation and maintenance activities had have an effect on the receiving soils, geology and land, or stability that is **Significant**, or of **Moderate** Significance.

10.5.3.3 Operation and Maintenance Phase 2019-2040

No peat instability issues are envisaged from 2019 to 2040 based on the anticipated site activities within this period, which are as given above.

As above, with control/mitigation measures in place, none of the above activities will have an effect on the receiving soils, geology and land, or stability that is **Significant**, or of **Moderate** Significance.

10.5.3.4 Decommissioning Phase

In relation to decommissioning, and particularly the construction/upgrade of access routes for decommissioning and the dismantling of the grid connection infrastructure, the main effects that this work has on site stability is the loading from the plant and equipment operating directly on the peat slopes and localised alteration of surface water on the peat slopes.

In relation to the removal of the substation infrastructure, the main effects that this work has on site stability is the loading of the founded access track and hardstanding with decommissioning vehicles and plant.

Typical control/mitigation measures for the grid connection and substation and their associated access routes comprise:

- 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 inspections and toolbox talks of ground conditions and working practices
- Contractor providing method statement for any proposed works in areas of peat/sloping ground/overhead power lines
- Maintenance of hydrology of area as far as possible;
- Use of experienced contractors and trained operators to carry out the work;
- Use of experienced geotechnical staff for site supervision where necessary.

With control/mitigation measures in place, none of the decommissioning activities will have an effect on the receiving soils, geology and land, or stability that is **Significant**, or of **Moderate** Significance.

10.5.4 Remedial Measures & Monitoring for Significant Effects – Peat Slide Response Works

10.5.4.1 Construction Stage

Following the peat slide a number of response activities were carried out, which are included and described in Section 10.3.4.1.1. With respect to these activities, a summary of the typical risk mitigation measures that were implemented during the construction stage are as follows:

- 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 inspections and toolbox talks of ground conditions and working practices
- Contractor providing method statement for any proposed works in areas of peat/sloping ground
- Maintenance of hydrology of area as far as possible;
- Use of experienced contractors and trained operators to carry out the work;
- Use of experienced geotechnical staff for site supervision.

Following the peat slide extensive ground investigations were carried out in the upper part of the source area of the peat slide to determine the ground conditions and potential stability issues. These ground investigations are detailed in the previous section and included the following:

- AGEC Ground Investigation (2003)
- ESBI Ground Investigation (2004)
- AGL/BAM Supplemental Site Investigations – Construction Stage (Post-Slide – 2004/2005)

In addition, a survey of the extent of the debris slide long river following the peat slide was carried out by Inis Environmental Services[22]. This identified the extent of the effect of the debris on the river.

Immediately following the slide event ESB and the wind farm construction contractor mobilised emergency resources which included plant and personnel to limit the effects of the peat and to manage the situation.

In response to the peat slide event, four permanent and four temporary barrages were constructed at various locations along the extent of the peat slide to limit the

[22] Inis Environmental Services, 2004, *“Derrybrien Windfarm Peat Slip - Environmental Impact Assessment on the Owendalluleegh River”*, March 2004

rate and volume of debris which would have flowed downstream. The four temporary barrages were removed by the end of the construction phase.

In addition, repository areas located at a number of the barrages were used to store peat debris that was removed from behind the barrages and deposited along the run-out area.

Repositories were selected in areas deemed to be of low peat stability risk. Prior to construction of the floating road and repository at Barrage 2 ESBI undertook an analysis and assessment of the appropriateness of the locations for access an storing peat.

Maintenance of the barrages was carried out during this period, which comprised the inspection and removal of material from behind barrages 1, 2 and 3. Discussions with the wind farm manager indicated that the containment barrages (1 and 2) were routinely cleared of debris up to June 2007 and that the cleared debris essentially comprised silt. Beyond 2007, there was minimal material build-up behind the barrages.

Inspections of the peat slide response works including the source area and debris track were carried out during this period.

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

- 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

With control/mitigation measures in place, none of the activities and events given in Section 10.3.4.1.1 had or will have an effect on the receiving soils, geology and land, or stability that is **Significant**, or of **Moderate** Significance.

10.5.4.2 Operation and Maintenance Phase 2006-2020

During this phase, a number of activities were carried out, which are included in Section 10.3.4.1.2. No peat instability issues were recorded from 2006 to Q2 2020. With respect to these activities, a summary of the typical risk mitigation measures that were implemented during this phase are as follows:

- 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 inspections and toolbox talks of ground conditions and working practices
- Contractor providing method statement for any proposed works in areas of peat/sloping ground
- Maintenance of hydrology of area as far as possible;
- Use of experienced contractors and trained operators to carry out the work;
- Use of experienced geotechnical staff for site supervision.

Maintenance of the barrages was carried out during this period, which comprised the inspection and removal of material from behind barrages 1 and 2 up to June 2007. Beyond 2007, there was minimal material build-up behind the barrages. A small quantity of silt i.e. less than 2 m^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.

A number of periodic inspections of the wind farm site and the peat slide response works were carried out during this phase, see Table 10-34.

Table 10-34: Periodic Inspection Reports

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

Author	Title of Report	Date	Description
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
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.

In relation to the 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 and remedial works for the site and for a number of the onsite and offsite elements associated with the 2003 peat slide i.e. stabilisation and containment works.

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

- Peat slide source area (onsite and offsite sections)
- Repository areas
- Containment barrages (onsite and offsite)
- 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 was required for the wind farm site only and highlighted in the 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 at turbine locations
- 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.

AGEC (2008) report includes a geotechnical assessment of the 2003 peat slide. The main findings of the report included:

- Containment barrages were functioning normally and showed no signs of distress.
- No significant accumulation of recent peat debris at the containment barrages.
- Given the lack of peat debris accumulation at the barrages this would indicate that peat debris within the source area was less mobile.
- 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 had 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.

As above, with control/mitigation measures in place, none of the activities included in Section 10.3.4.1.2 had or will have an effect on the receiving soils, geology and land, or stability that is **Significant**, or of **Moderate** Significance.

10.5.4.3 Operation and Maintenance Phase 2019-2040

No peat instability issues are envisaged from 2019 to 2040 based on the anticipated site activities within this period, which are given in Section 10.3.4.3.1. With respect to these activities, a summary of the typical risk mitigation measures that are to be implemented during this phase are as follows:

- 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 inspections and toolbox talks of ground conditions and working practices
- Contractor providing method statement for any proposed works in areas of peat/sloping ground
- Maintenance of hydrology of area as far as possible;

- Use of experienced contractors and trained operators to carry out the work;
- Use of experienced geotechnical staff for site supervision.

Maintenance of barrages 1 and 2 together with periodic inspections of the wind farm site and the peat slide response works are to be continued as the previous phase. It is not expected that significant maintenance of the barrages will be required.

As above, with control/mitigation measures in place, none of the above activities given in Section 10.3.4.3.1 will have an effect on the receiving soils, geology and land, or stability that is **Significant**, or of **Moderate** Significance.

10.5.4.4 Decommissioning Phase

In relation to decommissioning, the activities to be carried out are given in Section 10.3.4.3.2.

The main effects that this work has on site stability is the loading from the plant and equipment operating directly on the peat slopes and localised alteration of surface water on the peat slopes.

Typical control/mitigation measures for the works and their associated access routes comprise:

- 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 inspections and toolbox talks of ground conditions and working practices
- Contractor providing method statement for any proposed works in areas of peat/sloping ground/overhead power lines
- Maintenance of hydrology of area as far as possible;
- Use of experienced contractors and trained operators to carry out the work;
- Use of experienced geotechnical staff for site supervision.

With control/mitigation measures in place, none of the activities given in Section 10.3.4.3.2 will have an effect on the receiving soils, geology and land, or stability that is **Significant**, or of **Moderate** Significance.

10.6 Residual Impacts

10.6.1 Residual Impacts – Derrybrien Wind Farm

The following elements of the wind farm will be left in place at the end of decommissioning:

- The site access tracks and floating roads;
- The turbine foundations and granular crane hardstandings:
- The hardstanding areas for the substation, site compound and anemometers;
- The peat repositories and material sidecast areas; and
- The drainage.

The significant effects of residual **direct impacts** of the project on the soils, geology and land after decommissioning include the following:

- Ongoing changes in the carbon flux in the excavated peat that was stored in the material sidecast areas and peat repositories; and
- Ongoing changes in the carbon flux in the intact peat on the peat slopes due to groundwater lowering from the drainage.

The residual **site-stability impacts** with significant effects include:

- The sustained positive impact of the site drainage on groundwater pressures in and below the peat; and
- The sustained impact of the dead load surcharge from the floating roads, peat repositories and material sidecast areas that were left in place after decommissioning.

These are a continuation of the effects of impacts that were assessed in Section 10.3.2.2 of this chapter (Impacts which are occurring).

10.6.1.1 Residual Impacts - Direct Impacts

All of the peat that was excavated from the site of the turbines, crane hardstandings, substation, borrow pits, anemometers and site compound was stored on-site in material sidecast areas and peat repositories on the intact peat slopes, and within bunded storage areas in the borrow pits. In Section 10.3.2.1.1.2 it was concluded that the effect that the peat excavations had on soils, geology and land relative to the baseline site conditions was of **Moderate** significance because of the loss of peat habitat and the corresponding release of stored carbon in the peat, assuming that 100% of the excavated peat was lost to decomposition, which is very conservative. The release of stored carbon from the peat is primarily due to the increased rate of decomposition of the disturbed peat above the water table as it dries out on exposure to the atmosphere on the slopes. This is a **Long-Term** impact as the effects occur slowly over time. The rate of decomposition of peat is significantly lower below the water table.

In Section 10.3.2.2.1 it was concluded that by the end of Q2 2020 the net rate of carbon release in the peat repositories had significantly reduced because the surface of the excavated peat had re-vegetated and some of the underlying intact peat had settled below the water table under the dead load surcharge from the excavated material. It is likely that it will take a long time for the peat to reach a new carbon flux equilibrium under the changes that occurred during construction. The repositories will be left in place on the slopes when the wind farm is decommissioned. Therefore, it is likely that there will be an ongoing effect on the carbon flux in the peat after decommissioning.

Similarly, in Section 10.3.2.1.1.2.2 it was concluded that the effect that the improved drainage had on the peat relative to the baseline site conditions was **Slightly Significant.** The impact of the improved drainage was to lower the groundwater level in the peat where new drains were constructed for the project. The effect that this had on soils, geology and land was to increase the rate of decomposition and carbon release from the intact peat in the aerobic environment above the lowered groundwater level. The sensitivity of the degraded blanket bog impacted by the drainage has been assessed as **Medium**.

The piezometer data indicated that the average groundwater level in the piezometers around the perimeter of the wind farm site had lowered by between 0.40 m and 0.75 m by November 2011 (Figure 10-42). This would not have occurred uniformly across the site. The extent of direct drawdown from the shallow open drains in the peat would have been limited to within a few meters of the drains. However, the groundwater levels would have gradually lowered over a wider area where new drains were constructed on the site due to the increased rate of surface runoff. The impact of the new drains would have been greatest on the steeper slopes at the downslope perimeter of the site, where the piezometers were located. Less drawdown would have occurred at the upper levels of the wind farm and on the terraces of flat or gently sloping ground across the site where surface water accumulates.

It takes many years for the groundwater in the peat to stabilise at new equilibrium levels across the site. However, most of the major drainage works were completed during construction and during the operation and maintenance period prior to 2012. Therefore, at this stage the majority of the groundwater lowering due to the improved drainage would already have occurred so that any further changes over the remaining design life of the wind farm should be minor.

The existing drainage capacity will be maintained over the remaining design life of the wind farm and none of the drains will be blocked or infilled during decommissioning. Therefore, the extent of groundwater lowering will be maintained until the wind farm is decommissioned and the impact of the improved drainage will occur as a long-term residual impact after decommissioning. The effect that the residual impact will have on the peat will be the ongoing higher rate of decomposition of the peat above the lowered groundwater level.

No maintenance will be carried out on the drains after decommissioning. Therefore, in the long-term the efficiency of the drains is likely to reduce as they become clogged by vegetation. This will result in a partial gradual restoration of groundwater levels on the site, which will reduce the effect on the peat.

A more detailed assessment of the residual impact of drainage on hydrology and hydrogeology in the project area is presented in Chapter 11.

10.6.1.2 Residual Impacts – Stability Impacts

In Section 10.3.2.2.2 it was concluded that there has been a long-term reduction in the likelihood of a peat slide occurring on the wind farm site due to the increase in shear strength that occurred in the peat as it compressed under the sustained dead load surcharge from the floating roads, and from the excavated material placed on the intact peat slopes in the peat repositories and material sidecast areas that were left in place at the end of construction. Over time this has reduced the effect of the surcharge loads on the stability of the peat so that the likelihood of a peat slide under the surcharge loads has reduced to **Negligible,** and the effect of the loading on the peat is **Not Significant**.

The floating roads, material sidecast areas and peat repository sites will be left in place at the end of decommissioning so that they will have a residual impact on the peat after decommissioning. By that time the majority of the strength increase due to initial compression of the peat under the applied surcharge loads will have occurred. However, some ongoing creep settlements will continue after decommissioning which will result in further small increases in the strength of the peat over time. This will further reduce the effect of the surcharge loads on the stability of the peat.

As discussed in Section 10.3.2.2.2, poor drainage is a recognised contributory risk factor for peat instability. Therefore, the improved drainage network that was constructed on the site for the wind farm has had a **permanent** and **sustained positive** stability impact on the peat relative to the baseline conditions on site in 1998, prior to construction. Improved drainage would also have increased the shear strength of the peat where the groundwater table was lowered.

The drains will be left open and in-service at the end of decommissioning. Therefore, the impact of the improved drainage will continue as a residual impact after decommissioning. The effect of the drainage improvements on the stability of the peat has been assessed as **Medium,** and of **Moderate** significance.

No maintenance will be carried out on the drains after decommissioning. Therefore, in the long-term the efficiency of the drains is likely to reduce as they become clogged by vegetation, which will result in a partial gradual restoration of groundwater levels on the site. In the long-term, the positive impact of the drainage and the corresponding effect on the stability of the peat will likely reduce to **Medium to Low** or **Low**, which is of **Slight** significance.

10.6.2 Residual Impacts – Grid Connection

The residual impacts associated with the Grid Connection are assessed relate the mast locations, the area of land reduced in level to facilitate the necessary clearance and separation at the overhead line intersections and the substation site.

The following elements of the works will be left in place at the end of decommissioning:

- The substation site hardstand and access road;
- The area of land where the ground was lowered beneath the 400 kV overhead line.

There will therefore be direct residual impacts only. It is assessed that there will be no residual site stability impacts following the decommissioning of the Grid Connection.

The residual **direct impacts** of the project on the soils, geology and land after decommissioning include the following:

- Ongoing changes in the carbon flux in the peat that was excavated during the original works
- Land use associated with the substation hard stand and access track

10.6.2.1 Residual Impacts – Grid Connection – Direct Impacts

Substation and associated access track

The direct impact of the substation and associated access track at the time of their construction is presented in Section 10.3.3.1.1.2.

At the end of decommissioning the access track and substation hardstand will be left in place. The excavation formed to create a level site will also remain. This will have an ongoing direct impact on land use due to the footprint of the substation and access track. As part of the original works material was excavated and resulted in the exposure of the underlying till which was originally subject to the direct impact of erosion. The works included excavating material included peat, which would have resulted in the release of carbon. This is likely to be on-going albeit at a much-reduced rate by the end of decommissioning.

The overall significance of the direct impact at construction stage for these elements of the project was assessed as slight. Given that the release of carbon from the peat and the rate of erosion of the soil will have reduced, and that the rate of consolidation will have reduced to imperceptible levels, the significance of the residual direct impact of these works is considered **not significant.**

Ground lowering beneath the existing 400 kV line

The direct impact of the ground lowered beneath the existing 400 kV line at the time of its construction is presented in Section 10.3.3.1.1.2.

At the end of decommissioning this area will remain as it current is. This will have an ongoing direct impact on land use due to the footprint of the area. As part of the original works material was excavated and resulted in the exposure of the underlying till which was originally subject to the direct impact of erosion. The works included excavating material included peat, which would have resulted in the release of carbon. This is likely to be on-going albeit at a much-reduced rate by the end of decommissioning.

The overall significance of the direct impact at construction stage for these elements of the project was assessed as slight. Given that the release of carbon from the peat and the rate of erosion of the soil will have reduced, that the rate of consolidation will have reduced to imperceptible levels, and that the area of land is relatively very small the significance of the residual direct impact of these works is considered **not significant.**

10.6.3 Residual Impacts – Peat Slide and Response Works

The residual impacts associated with the Peat Slide and Response Works relate to the slide area, repository areas and barrages.

The following elements of the works will be left in place at the end of decommissioning:

- The floating roads;
- The borrow pit;
- The repositories at Barrage 2, Barrage 3 and at the Black Road Bridge;
- Barrage 1 and Barrage 2.

The Peat Slide source area will continue to recover post the planned decommissioning phase of the project.

There will therefore be direct residual impacts and site stability residual impacts associated with this part of the project.

The residual **direct impacts** of the project on the soils, geology and land after decommissioning include the following:

- Ongoing changes in the carbon flux in the peat that was stored in the material peat repositories;
- Ongoing changes in the carbon flux in the disturbed peat in the peat slide area;
- Ongoing covering/sealing of the land in the areas of barrages 1 and 2 and their associated access tracks;
- Land use associated with the Borrow Pit adjacent to Barrage 1.

The residual **site-stability impacts** include:

- The sustained positive impact of the increase in strength of the peat due to drainage and revegetation of the peat slide source area.
- The sustained reduction of the stability impact due to the increase in strength of the peat due to loading from barrages, repositories and floating roads.

10.6.3.1 Residual Impacts – Peat Slide and Response Works – Direct Impacts

Peat Slide – Source Area

All of the peat that was disturbed as a consequence of the peat slide will continue to undergo ongoing changes in carbon flux after decommissioning. Furthermore, it is likely that, at the end of decommissioning there will be a residual impact on the land use of the peat slide source area In Section 10.3.4.1.1.2 it was concluded that the direct impact that this had on soils, geology and land relative to the baseline site conditions was significant. .

In Section 10.3.4.1.1.2 it was concluded that by the end Q2 2020 the net rate of carbon release in the Peat Slide source area had significantly reduced to a significance of negligible. The significance of the impact on land use at decommissioning is assessed as slight therefore the overall significance of the direct impact in the peat slide source area is **not significant** at the end of decommissioning.

Peat Repositories

All of the peat that formed part of the peat debris flow that was stored in repositories will also continue to undergo ongoing changes in carbon flux after decommissioning. The peat repositories also initially impacted the previous land use. In Section 10.3.4.1.1.2 the overall significance of the direct impact of the repositories was assessed as slight. At decommissioning it is assessed to be **not significant** as the repositories have undergone natural revegetation and are sufficiently stable to support the previous vegetation that was present at the baseline.

Barrage 1 and 2 and associated access tracks.

At the end of decommissioning the two barrages, barrage 1 and barrage 2, and their associated access tracks will remain in pace. This will have a residual impact on the land use in the area. In Section 10.3.4.1.1.2 the overall direct impact associated with the barrages and the access tracks was assessed as slight. However, as some of those barrages will be removed at the end of decommissioning and leading to a reduced impact on land use, the significance of the impact is assessed as **not significant**.

Borrow Pit

There will be a residual direct impact due to the removal of construction material from the borrow and the impact on land use in the area. Given the extents of the borrow pit and the sensitivity of the receiving environment the residual impact of the borrow pit is assessed as **not significant**.

10.6.3.2 Residual Impacts – Peat Slide and Response Works – Site Stability Impacts

Peat Slide – Source Area

In Section 10.3.4.2.1.3 it was assessed that due to the improvement in drainage the significance of the impact with regards to site stability is assessed at slight. Due to improvements in revegetation and ongoing drainage of the area it is assessed that the residual impact with regards to site stability in the area of the peat slide source area is **not significant**.

Ongoing inspections and monitoring of the area over many years have not indicated or recorded any instability in the peat slide source area. It is therefore anticipated that any event of instability in the area is expected to be localised in nature and unlikely to occur.

Repositories and Floating

In Section 10.3.4.2.1 it was assessed that due to the increase in strength of the peat due to sustained loading from barrages, repositories and floating road it is assessed that the residual impact with regards to site stability is **not significant**.

10.7 Conclusions

This section of the chapter presents a summary and conclusions of the impact assessment of site activities for the Derrybrien Windfarm Project that have a direct effect on the soils, geology and land and direct effect on stability of the receiving soils, geology and land (i.e. stability impacts). The assessment has been carried out in accordance with the 2017 EPA Draft Guidelines on the Information to be Contained in Environmental Impact Assessment Reports.

An impact is defined here as an action from a site activity that results in a change to the receiving soils, geology and land. Therefore, stability impacts increase or decrease the risk of instability on the site, depending on whether they are negative or positive impacts. The effect of that impact is the change that occurs either directly to the receiving soils, geology and land environment (due to direct impacts) or directly to the stability of the receiving soil and geology potentially triggering a peat slide (due to site stability impacts).

The impacts of the Project activities on the receiving soils, geology and land have been assessed at key stages of the project life cycle as:

- Impacts that have occurred, i.e. during construction (2003-2005) and during the operation and maintenance phase of the project up to the end of Q2 2020;
- Impacts that are occurring, i.e. impacts from construction or from the initial operation and maintenance phase that are still occurring at the end of Q2 2020; and
- Impacts that are likely to occur, i.e. during the remaining operation and maintenance phase, or during decommissioning (c2040).

Residual impacts after decommissioning and cumulative impacts with other relevant projects have also been assessed. Remedial measures that have been applied and will be applied for the remainder of the Project life are also presented.

The effects of stability impacts on the peat have been qualitatively assessed as a function of:

- The characteristics of the site activity and the corresponding impact on the peat (e.g. the location, magnitude, extent, frequency and duration of surcharge loading on the peat);
- The quality of the impact (i.e. positive or negative impacts with respect to stability);
- The probability of a peat failure occurring as a result of the impact on the peat; and
- The possible extent and characteristics of a peat failure.

The probability of a peat failure occurring is a function of the characteristics of the site as well as the stability impacts of the site activities on the peat. Therefore, a Peat Stability Risk Assessment (PSRA) has been carried out for the Project in accordance with current best practice guidelines to interpret the risk of a peat slide across the site based on factors that are relevant to peat stability such as topography, peat depth, peat strength, hydrology, and groundwater conditions. The probability of a peat failure occurring for each site activity has then been assessed based on the results of the PSRA and on the characteristics of the stability impacts. For recurring activities, the probability of a peat slide has also been reassessed at key stages of the project to take account of improvements in site conditions that occur over time, such as the medium to long-term effects of the drainage improvements on the wind farm site, which reduce the risk of a peat slide – a positive stability impact.

For the project, activities that have negative stability impacts on the receiving soils, geology and land typically involve temporary or permanent loading on the surface of the blanket bog that covers the site. For example, where peat and glacial till excavated from the turbine foundations were placed or “sidecast” on the intact peat slopes adjacent to the excavations, the stability impact was the surcharge load that was applied to the surface of the peat due to the weight of the materials. The corresponding effect on the peat was the increase in stress that occurred under the applied loads that could potentially have triggered a failure where the stresses exceed the strength of the peat. Failures could range from a local bearing failure in very weak peat under a concentrated load, to a large peat slide on the slopes such as that which occurred at the site during construction on the 16th October 2003.

The significance of the effects due to site stability impacts reflects the probability of a peat failure occurring as a result of a stability impact as well as the baseline sensitivity of the receiving soils, geology and land potentially impacted by a peat failure.

The available desktop information and the numerous geotechnical site investigations undertaken on the Project site have been used to inform the baseline Soils, Geology and Land conditions in 1998 and to undertake the assessment of the impacts for the Project. The majority of the Project site is characterised by a continuous cover of upland blanket bog.

The wind farm site topography (365 m AOD and 325 m AOD) typically consists of flat or gently sloping ground (<3-5º) with steeper slopes closer to the southern and northern boundaries of the site (>5-7º). From the wind farm site, the overhead line (OHL) is routed in a southernly direction where the topography is relatively steep initially over the initial 1.5 km and then crosses the more gently sloping terrain of the Owendalluleagh River valley to the Agannygal substation where the site has been cut and filled locally to provide a level platform at about 190 m AOD.

The depth of peat on the wind farm site ranged from 1-6 m, with the deeper peat (>3 m) located on the flat or gently sloping terraces on the site. The depth to rock typically ranged from 3.0 to 6.2 m.

For the grid connection route and substation, the peat depths typically vary between 0.2 to 5.6 m with an average of 1.35 m. The peat is generally shallower along the northern part of the route, where the terrain is relatively steeper on the lower slopes of Cashlaundrumlahan Mountain. The deeper peat is localised in a few flatter areas within the southern part of the route.

Prior to construction of the Project, most of the Project site and surrounding land downslope had been used by Coillte for commercial coniferous forestry. The open area at the east end of the wind farm site was used for peat harvesting and is sub-divided into turbary plots.

The characteristics of the site activities and the impacts on the peat are based on records from construction and from the operation and maintenance phase of the Project up to Q2 2020, which are summarised in this report. It has been assumed that the characteristics of the activities that are likely to occur over the remaining life of the windfarm and during decommissioning will be similar. Both positive and negative impacts have been assessed.

For this project, the possible extent of a peat slide and the characteristics of the soils, geology and land potentially impacted by a slide have been calibrated by the very large peat slide that occurred on the site in October 2003, which has reasonably been considered the worst case scenario. Consideration has also been given to the smaller more localised peat failures that occurred in a few areas on site during construction, which had a significantly lower impact on the soils, geology and land.

Stability Impacts

All of the stability impacts that have significant effects on the receiving soils, geology and land relate to the blanket bog that covers the site and surrounding area. Prior to construction of the wind farm the bog had been degraded by drainage, forestry plantations and peat harvesting. Therefore, the baseline sensitivity of the soils, geology and land that could be impacted by the project has been assessed as MEDIUM based on a combination of the ecological value of the bog, the significance of carbon storage in the peat and the value of the land for forestry, agriculture and turbary rights. There are no recorded Geological Heritage Sites in the area.

In general, the stability impacts with the most significant effects occurred during the construction stage of the project when there would have been a higher level of activity on the site. On the wind farm site this would have been prior to the large peat slide that occurred at the site in October 2003. The impact of site activities reduces significantly over the project life cycle from the second phase of construction after the peat slide (2004-2005), through the operation and maintenance phases of the project (2005-2020 & 2020-c.2040), to decommissioning in c. 2040. This is mainly because of the nature of the activities and improved site stability conditions as a consequence of drainage, which has been and will be maintained throughout the life of the project, and consolidation of the peat.

Table 10-35, Table 10-36 and Table 10-37 give a summary of the stability impacts that had significant effects on the stability of the peat for the different phases of the Project.

During the first phase of construction, prior to the peat slide on the 16th October 2003, the stability impacts with effects that were significant were related to the construction of the site access tracks as “floating roads” directly on the peat, the construction traffic loading on the floating roads, and the sidecasting of excavated materials on the intact peat slopes adjacent to the turbine foundation excavations.

In comparison, the stability impacts from other activities that were being carried out on the wind farm site at the time only had slightly significant effects on the stability of the peat. These included the live load surcharge from low ground bearing pressure construction and forestry equipment operating directly on the peat, the vibrations induced by rock blasting in the main borrow pit, and the local stability of temporary peat slopes around the perimeter of the turbine foundation excavations.

Prior to the peat slide, the majority of the c. 15 km of new floated site access tracks were constructed and excavation to suitable formation on rock had been completed at 39 No. turbines and the excavated materials were sidecast on the intact peat slopes adjacent to the excavation.

No peat failures occurred under the floating roads. However, at the excavations for the turbine foundations there was a local bearing failure in the peat under the sidecast materials at Turbines T23, T29 and T66 and a small scale peat slide occurred at Turbine T17. At the time of the very large peat slide on the 16th October 2003 excavation was underway at Turbine T68 and the excavated materials were being sidecast on the slope downslope from the turbine, where the slide is thought to have initiated.

The loading from the sidecast materials has been attributed with triggering the slide, although there were a number of other contributory factors related to the topography, hydrology and peat strength in the area that made the location particularly susceptible to a peat failure. This resulted in a direct significant effect on soils, geology, and land when the peat slide, with a footprint of approximately 25 ha, occurred on the southern slopes of the wind farm site.

The peat slide source area contained approximately 450,000 m^3 of peat at the time of the slide and 250,000 m^3 of this material flowed from the footprint into the downslope stream where it was routed down the mountain slopes to an elevation of approximately 200 mAOD where is spread out on a relatively flat area of agricultural land and to approximately the Black Road Bridge. Following some heavy rainfall, the debris material was forced further downslope along the Owendalluleagh River channel before reaching a phase of dispersion in the river water approximately 5.8 km downstream from the source area. At the time the immediate slide source area and the debris extent significantly impacted the use of the lands and the integrity of the peat from the slide source area. This included the forestry lands, the agricultural lands and the river channel. A number of the wind farm and forestry access tracks were also removed as part of the event.

In response to the slide a number of temporary and permanent retention barrages were constructed along the slide route. These had a positive impact in terms of site stability by controlling further peat discharges from the source area and along the debris footprint as they retained some of the peat which had been mobilised and re-mobilised and provided stability support to the slide area and debris.

While there were negative site stability impacts associated with the construction of repositories to store the discharged peat, and various floating access tracks, these were considered to be of slight significance primarily based on their site location, ground conditions, topography, loadings and the extent of a potential slide event which could be caused.

For the second phase of construction after the peat slide there was a significant reduction in the effects of stability impacts due to some improvement in conditions on the wind farm site under sustained surcharge loads from the first phase of construction, and as a result of additional risk mitigation measures that were implemented on the site for the second phase of construction. In particular this was due to additional extensive site investigation, the testing and analysis of the existing floating roads and peat repositories, the storage of excavated materials (including that from turbines where localised failures had previously occurred) in designated repositories and the removal of spoil from areas of elevated risk. However, the stability impact associated with the construction of the remaining minor lengths of floating roads was assessed as significant and the live loading on the roads moderate for the remainder of the construction phase.

The highest risk of peat instability was at the time that the side cast materials were placed on the slopes. Over time the peat compressed and increased in strength under the weight of the material so that the effect of the load on the stability of the peat reduced to moderately significant for the second phase of construction.

Other stability impacts that had a slightly significant effect on the stability of the peat during the second phase of construction included the live load surcharge from low ground bearing pressure construction and forestry equipment operating directly on the peat, the vibrations induced by rock blasting in the main borrow pit, the local stability of temporary peat slopes around the perimeter of the remaining turbine foundation excavations, and miscellaneous localised live loads on the peat slopes from work related to tree felling, drainage and cable-trenching. The positive impact of drainage was sustained with further improvements during the second phase of construction, which had a moderately significant effect on the stability of the peat relative to the baseline conditions on the site prior to construction.

The site stability impacts associated with the grid connection were assessed as considerably less than the wind farm site mainly due to the nature of the activities (discrete pole and angle mast construction, substation of relatively small footprint) and topography of the OHL route, the majority of which was at a lower elevation and typically on more gently sloping ground. Site stability impacts associated with the construction of the grid connection did not exceed slight significance.

The site activities during the operation and maintenance phases of the windfarm between 2005 and the end of operation in c.2040 have a much lower impact on the peat. There are no negative stability impacts that have significant or moderately significant effects on the stability of the peat. Operation and maintenance traffic loading on the floating roads is less frequent than during construction and the size of the mobile cranes that are used to service the turbines is kept to a minimum. Also, the performance and capacity of the road has continued to improve due to the increase in the strength and stiffness of the underlying peat, which has compressed under the weight of the roads.

Upgrading works to c. 4.5 km of access tracks were undertaken in 2014 however the thickness of the fill material was minimised to reduce the additional dead load on the roads, and all of the upgraded roads were proof tested to the design crane load on completion to verify their capacity and performance. Therefore, the effect of the additional dead load on the stability of the peat was slightly significant.

The stability impacts associated with the peat in the source area and peat debris are currently considered to be of slight significance. This is mainly due to the drainage and the revegetation of the source area, the degrading of the deposited peat debris along the flow footprint and the positive impact that barrages, in particular 1 and 2, have on site stability.

Other routine operation and maintenance activities for the whole Project, such as tree regrowth topping (including that for the grid connection), drainage works, maintenance of barrages (which took place in the ear stages of the O&M phase) etc. have a slightly significant effect on the stability of the peat.

Decommissioning the Project in about 2040 will broadly involve the dismantling and removal of all above ground structures on the wind farm site and the grid connection route, including the Agannygal substation, the underground cables on the wind farm site and Barrage 3 and Barrage 4.

The primary stability impact of this work will be the live load surcharges on the floating roads on the wind farm site from the construction vehicles, trucks, low-loader transporters and mobile cranes which will not exceed the design and proven capacity of the floating roads. Therefore, the effect of the live load surcharge on the stability of the peat will be slightly significant. There may be a requirement to widen the access track between T31 and T45, depending on the necessary crane requirements, this will only involve a small increase in load on the peat along the edge of the road, which will only have a slightly significant effect on peat stability.

For the grid connection the predominant stability impacts during decommissioning will be the live loadings on the peat due to removal of the OHL structures. Insofar as possible the construction stage access routes will be reused to access the structure locations, the effect of which is assessed as not significant except in a single location at AM38 which is assessed as slight due to the presence of deeper peat.

The removal of Barrages 3 and Barrages 4 will involve loading of very shallow peat in order to access and remove the barrage materials. The significance of this impact is considered slight.

When the wind farm is decommissioned the site access tracks, turbine foundations, material deposition areas, and hardstanding areas at the turbines and substation will all be left in place on the site. The substation platform will remain in place and the remaining barrages, repositories and floating roads associated with the slide will also remain.

The residual stability impact of the sustained surcharge loads on the peat along the floating roads and in the material deposition areas will not have a significant effect on the stability of the peat. The turbine foundations and crane hardstandings, substation hardstand and barrages are constructed on the glacial till and rock below the peat so they will provide permanent support to the peat, which is a positive stability impact that is slightly significant.

The improved drainage network on the wind farm site will be maintained up to decommissioning so that it will continue to have a positive impact with a moderately significant effect on the stability of the peat relative to the baseline conditions prior to construction. However, over time the drains will become clogged with vegetation which will result in partial restoration of groundwater levels on the site. In the long-term this will reduce the effect on the stability of the peat to slightly significant.

The combined effect of the stability impacts which have occurred or will occur in close proximity and the same time have been considered in this assessment.

Direct Impacts

The vast majority of direct impacts on Soil, Land and Geology occurred during the construction phase. These impacts mainly include the excavation of peat and the covering/sealing of the land and the change in the water table levels within the peat. The direct effects are assessed based on a combined level of sensitivity of the peat.

The excavation and disposal of the peat for the Project had the most significant direct impact on soils geology and land as overall the excavation of peat for the Project was in the order of 185,000 m^3. The majority of this excavated peat was on the wind farm site, all other peat excavations (i.e. for Grid Connection and Peat Slide Response Works) are negligible in comparison. The significance of the effect of excavation of peat combined with the impact of the large peat slide was assessed as significant. In particular the oxidisation of carbon and impact on land use due to the removal of peat on the peat slopes has led to this effect.

Other direct impacts have resulted in effects of lesser significance including the tracking of plant across the bog, the removal of forestry, drainage works, rock excavation and the side casting of peat on peat slopes across the project site. In addition, for the grid connection works the construction of Agannygal substation and the lowering of the ground below the 400 kV line are assessed as of slight significance. For the peat slide response works the impact of the construction of the were considered of slight significance also.

Over the life time of the project the direct impact on land use has not and will not significantly vary from the construction phase however where the peat has been excavated or where disturbed peat has compressed or revegetated a new carbon flux regime will result and this will lead to a reduction in the rate of decomposition of the excavated peat. Ongoing maintenance activities such as drainage works, or tree regrowth topping will have an effect of slight significance. For the continued drainage of the wind farm site the effect, in particular, with respect to carbon flux is assessed as of slight significance.

For the decommissioning phase of the project the direct impacts on soils land and geology of significance will be restricted to the tracking of plant across the deeper peat slopes for the OHL and barrage decommissioning works. These have been assessed as of slight significance.

The residual direct impact on soils, geology and land following decommissioning of the project that are of significance will be the ongoing release of stored carbon predominantly as a consequence of the excavated and/or deposited peat across the Project footprint and the peat slide event in 2003. On the wind farm site specifically, another residual impact is the ongoing drainage of the site however this is likely to be reduced overtime as the drainage channels become partially blocked over time.

Cumulative impacts

The cumulative impacts due to adjacent projects and activities has been assessed also. It is assessed that there are no direct or stability cumulative impacts of significance due to adjacent projects or activities with the exception of the turbary activities on the site. The cumulative stability effect of impacts that have already occurred as a consequence of the increase in mechanical peat harvesting activities in the turbary area since 2012 has been assessed as moderately significant to significant, the impact being brief or temporary and limited to those areas where mechanical peat harvesting was carried out.

For the remainder of the operational phase of the project mitigation measures have been recommended for the turbary rights holders and/or their agents to implement to reduce the likelihood of a peat failure due to mechanical peat harvesting. These will consist of restricting mechanical harvesting of some plots with a higher likelihood of instability and implementing appropriate controls and restrictions for mechanical harvesting in the remaining turbary plots. It is recommended that no harvesting take place during decommissioning. Warning signs will be erected at the site by Gort Wind Farms Ltd. (GWFL) to raise awareness of the peat stability risks associated with mechanical peat harvesting in the turbary area and to highlight the recommended mitigation measures. This peat stability risk assessment and the associated mitigation measures will also be shared with the turbary rights holders whose plots have been or potentially will be harvested by mechanical means in the future. GWFL will also carry out periodic inspections, remedial drainage works and monitoring of peat movement in the area.

Where the recommended mitigations are implemented by GWFL, the turbary rights holders and their agents then the cumulative effect of the harvesting with the site activities is assessed as having a slight significance. However, if the turbary rights holders and/or their agents do not implement the recommended mitigation measures, then the cumulative effect on the stability of the peat will remain as moderately significant to significant. The effect on peat stability would be limited to the turbary plots where mechanical peat harvesting is active on the site, and at the time that the work is being carried out.

Remedial Measures and Monitoring

Direct Impacts

Wind Farm Site

Mitigation for direct impacts which were of significance, mainly excavation and deposition of peat included the construction of floating roads extensively across the site which minimised the amount of peat to be excavated and deposited on the peat surface. This approach also minimised the volume of crushed rock which was required to construct the roads. Also, the existing network of access tracks (approx. 2.0 km) were upgraded and integrated with the turbine layout.

Grid Connection

For the grid connection works the remedial measures to mitigate the direct impacts on soils, geology and land which were of significance included the used of the existing forestry roads and access tracks were used insofar as possible. Where necessary (i.e. for access to Agannygal substation) these were upgraded as opposed to the construction of new roads. LGBP plant was used for the construction and felling works. These minimised the requirement to excavate or cover the peat with temporary or permanent access. Furthermore, this meant that the used of crushed rock was minimised for the construction of the grid connection.

Peat Slide Response Works

For the peat slide response floated roads were constructed in order to gain access to specific points along the slide and to reinstate the existing forestry access track. These minimised the requirement to excavate the peat permanent access. Furthermore, this meant that the used of crushed rock was minimised for the construction of the grid connection. LGBP plant was used for the construction and felling works. These minimised the requirement to excavate or cover the peat with temporary or permanent access.

Site Stability Impacts

Prior to the slide in 2003, site stability impacts, specifically with regards to the peat where mitigated by the following primary measures: 1) minimising road thickness by integrating geogrid reinforcement into the road design, 2) spreading of sidecasted materials to a depth of typically 0.5 – 1.5 m 3) minimising loading from plant on peat slopes by utilising appropriate LGBP plant for construction and tree felling 4) some improvements to the site drainage

Following the slide in 2003 more extensive remedial measures were adopted to minimise the risk of further site instability on the wind farm site. The primary additional remedial measures included:

- The installation and monitoring of 4 clusters of piezometers and tiltmeter which were linked to an automated alarm system
- The implementation of a geotechnical certification process which controlled the future site activities with involve working with peat

- Extensive geotechnical investigations and geotechnical analysis of the existing and future elements of the project, in particular those elements or works which could have an impact on the peat stability including foundation construction, road construction, peat repository construction and tree felling
- Full time supervision of the works by geotechnical engineers
- Full-scale serviceability and proof load testing of the floating roads
- Upgrade works to the roads where necessary
- Implementation of controls for the use of the floating roads – loading and manoeuvres
- Construction of rockfill embankments to replace two sections of access track removed during the slide which provided a shear key for further loading of the debris in the slide source area
- Controlled deposition of peat into investigated, designed and designated peat repositories
- Where the potential of further peat instability was considered to be excessive works were avoided e.g. the use of mechanical plant to fell trees in particular areas, the construction of floating road between T17 and T68
- The design and monitoring of the rock blasting at borrow BP-3
- Drainage improvement works to assist in the drainage of the peat

For the grid connection works the primary remedial measures adopted were the undertaking of site investigations and stability analysis along the steeper section of the OHL, the use of appropriate LGBP plant on the peat slopes, the use of established forestry access tracks to minimising loading of the peat and the implementation of appropriate monitoring and supervision of the works by an experienced contractor.

For the peat slide response works 8 no. barrages in total were originally constructed to minimise the peat debris from leaving the slide source area and from progressing down the river channel. The siting of the three repositories in areas suitable for storing peat and the partial construction of bunds around their perimeter minimised the risk of further peat stability in the area. The routing of the two sections of floating roads adjacent to barrage 1 and barrage 2 were such that they were constructed in areas suitable for this type of road construction. The access routes to Barrages 3 and Barrages 4 were chosen in areas with shallow peat cover.

7 No. monitoring points along the peat slide source are also monitored on a regular basis.

For the Project, much of the remedial measures adopted during the construction have been also adopted for the O&M phase in order to minimise the risk of further peat instability e.g. regular monitoring of the wind farm site and peat slide response measures by ESB geotechnical engineers and other geotechnical consultants familiar with the Project, limitations on traffic loading to the access tracks, site controls with regards to use of the site access tracks, the use of hardstandings for cranage and lifting operations. On the wind farm site, the drainage network has been upgraded and maintained regularly where necessary in order to continue the improved drainage regime on the site.

Where works are required to be carried out directly on the peat, which are relatively minor in nature appropriate LGBP plant is operated.

During much of the O&M the monitoring of ground water level (piezometers) and site stability (tiltmeters) continued until the instrumentation was decommissioned in 2014.

For the decommissioning activities for the Project the same remedial measures that were established during the second phase of construction will be adopted for the relevant activities e.g. the site controls with regards to use of the roads and hardstandings shall be enforced, the established forestry access routes will be used insofar as possible along the grid connection route and where necessary temporary access shall be established by appropriate means (e.g. bog mats) and the access to Barrage 3 and Barrage 4 shall by routes of minimal peat cover.

Table 10-35: Summary of impacts of Wind Farm site activities on soils, geology and land that had significant effects with regard to site stability (i.e. Stability Impacts)

	*Stability Impacts with Significant Effects	*Stability Impacts with Moderately Significant Effects	*Stability Impacts with Slightly Significant Effects
Construction Stage – Phase 1 (2003) (prior to peat slide on 16th October 2003) ***(Impacts which have occurred)***	• Dead load surcharge from floating roads constructed on the peat slopes with 0.6-1.0m of granular rockfill. • Live load surcharge from construction traffic on the floating roads. • Dead load surcharge from excavated peat, glacial till and occasionally weathered rock placed on the intact peat slopes in material sidecast areas adjacent to turbine foundation excavations.	• **[Positive Impact]** Reduction of groundwater levels and groundwater pressures in peat due to improved drainage. • No negative impacts	• Live load surcharge on peat slopes from low ground bearing pressure construction & forestry equipment. • Local stability of temporary peat slopes around the perimeter of turbine foundation & hardstanding excavations. • Dynamic inertial loading on peat from blast-induced vibrations due to rock blasting in Borrow Pit BP-3. • Miscellaneous localised live loads on peat slopes from work related to tree felling and drainage.
Construction Stage – Phase 2 (2004/2005) (after the peat slide) ***(Impacts which have occurred)***	• Dead load surcharge from the remaining floating roads constructed on the peat slopes with 0.6-1.0m of granular rockfill. • Live load surcharge on the new floating roads from the construction traffic used to construct the roads.	• **[Positive Impact]** Reduction of groundwater levels and groundwater pressures in peat due to improved drainage. • Dead load surcharge on the intact peat slopes from the excavated peat, glacial till and weathered rock in the material sidecast areas in the medium-term as the peat compressed and gained strength under the loads. • Live load surcharge from the construction traffic on the floating roads after the capacity and performance of the roads had been verified by full-scale proof load tests.	• Dead load surcharge from up to 1.0m of excavated peat placed on the peat slopes in designated repository areas. • Local stability of temporary peat slopes around the perimeter of turbine foundation & hardstanding excavations. • Live load surcharge on peat slopes from low ground bearing pressure construction & forestry equipment. • Dynamic inertial loading on peat from blast-induced vibrations due to rock blasting in Borrow Pit BP-3. • Miscellaneous localised live loads on peat slopes from work related to tree felling, drainage and cable-trenching.
Operation & Maintenance Phase 2005-2020 ***(Impacts which have occurred)***	• None	• **[Positive Impact]** Sustained long-term reduction of groundwater levels and groundwater pressures in peat due to maintenance of improved drainage network. • No negative impacts	• Increased dead load surcharge on the peat from crushed rock granular fill used to re-surface 4.5km of floating roads in 2014 (150mm capping + 20mm surfacing). • Live load surcharge on the floating roads from maintenance vehicles, trucks and mobile cranes used to carry out repairs to the access tracks, turbines and substation; • Occasional live loads on the peat slopes from low ground bearing pressure equipment used for the cable installations, drainage improvements, tree felling (west of the windfarm), and topping/felling small trees on the windfarm site. • Localised surcharge load from temporary timber stockpiles at T3, T19 & Coillte forestry track on west side of windfarm. • One-off localised live load surcharge (10kPa) on the peat from a large mobile crane that went off the road and overturned at Turbine T40 in 2007.

**all stability impacts are negative unless otherwise stated*

Table 10 35 (Contd.): Summary of impacts of Wind Farm site activities on soils, geology and land that had significant effects with regard to site stability (i.e. Stability Impacts)			
	***Stability Impacts with Significant Effects**	***Stability Impacts with Moderately Significant Effects**	***Stability Impacts with Slightly Significant Effects**
Existing Conditions (2020) ***(Impacts which are occurring)***	• None	• **[Positive Impact]** Sustained long-term reduction of groundwater levels and groundwater pressures in peat due to improved drainage network – relative to baseline condition in 1998, prior to construction. • No negative impacts	• **[Positive Impact]** Permanent support provided to the peat slopes by the turbine foundations and crane hardstandings, which are constructed on rock and glacial till below the peat. • No negative impacts
Operation & Maintenance Phase 2020-End of Operation (c2040) ***(Impacts which are likely to occur)***	• None	• **[Positive Impact]** Sustained long-term reduction of groundwater levels and groundwater pressures in peat due to maintenance of improved drainage network. • No negative impacts	• Increased dead load surcharge on the peat from the weight of crushed rock granular fill used to locally re-surface or repair floating roads. • Live load surcharge on the floating roads from maintenance vehicles, trucks and mobile cranes used to carry out repairs to the access tracks, turbines and substation. • Occasional live load surcharges on the peat slopes from low ground bearing pressure equipment used to carry out topping/felling of small trees and localised repairs to the existing network of drains or cable ducts. • The additional dead and live load surcharge on the intact peat where the existing turbary road is widened between T31 and T45, if required.
Decommissioning at End of Operation (c2040) ***(Impacts which are likely to occur)***	• None	• None	• Live load surcharge on the floating roads from construction vehicles, trucks, low-loader transporters and mobile cranes used to dismantle turbines and substation and transport the components offsite for re-use, recycle or disposal in a suitably licensed facility. • The additional dead and live load surcharge on the intact peat where the existing turbary road is widened between T31 and T45, if required.
Residual Impacts after Decommissioning ***(Impacts which are likely to occur)***	• None	• **[Positive Impact]** Sustained long-term reduction of groundwater levels and groundwater pressures in peat due to improved drainage network – relative to baseline condition in 1998, prior to construction. Reduces to **Slightly Significant** over time as drains become clogged by vegetation, resulting in partial restoration of groundwater levels on site. • No negative impacts	• **[Positive Impact]** Permanent support provided to the peat slopes by the turbine foundations and crane hardstandings, which are constructed on rock and glacial till below the peat. • No negative impacts

**all stability impacts are negative unless otherwise stated*

Table 10-36: Summary of impacts of Grid Connection site activities on soils, geology and land that had significant effects with regard to site stability (i.e. Stability Impacts)

	***Stability Impacts with Significant Effects**	***Stability Impacts with Moderately Significant Effects**	***Stability Impacts with Slightly Significant Effects**
Construction Stage – (2003 - 2005) ***(Impacts which have occurred)***	• None	• None	• Dead load surcharge from surplus excavated material. • Live load surcharge on peat slopes from low ground bearing pressure construction & forestry equipment. • Surcharge from temporary access track (AM38) • Excavation for construction of twin pole sets and angle masts • Construction of substation and angle masts and pole sets on competent ground
Operation & Maintenance Phase 2005-2020 ***(Impacts which have occurred)***	• None	• None	• Live load surcharge on peat slopes from low ground bearing pressure construction & forestry equipment.
Existing Conditions (2020) ***(Impacts which are occurring)***	• None	• None	• None
Operation & Maintenance Phase 2020-2040 ***(Impacts which are occurring)***	• None	• None	• Live load surcharge on peat slopes from low ground bearing pressure forestry equipment.
Decommissioning at End of Operation (c2040) ***(Impacts which are likely to occur)***	• None	• None	• Live load surcharge on peat slopes from low ground bearing pressure forestry equipment.
Residual Impacts after Decommissioning ***(Impacts which are likely to occur)***	• None	• None	• None

**all stability impacts are negative unless otherwise stated*

Table 10-37: Summary of impacts of Peat Slide Response Measures site activities on soils, geology and land that had significant effects with regard to site stability (i.e. Stability Impacts)

	***Stability Impacts with Significant Effects**	***Stability Impacts with Moderately Significant Effects**	***Stability Impacts with Slightly Significant Effects**
Construction Stage – (2003 - 2005) ***(Impacts which have occurred)***	• Intrinsic stability of peat in peat slide source area and in peat slide debris	• Construction of floating access tracks at Barrage 1 and Barrage 2	• Construction of barrages to restrict movement of slide debris (Initially negative impact, positive impact once constructed) • Live load surcharge on peat slopes from low ground bearing pressure construction & forestry equipment. • Loading on peat from peat repositories to store slide debris • Construction of borrow pit adjacent to Barrage 1 • Construction of substation and angle masts and pole sets on competent ground
Operation & Maintenance Phase 2005-2020 ***(Impacts which have occurred)***	• None	• None	• Loading of peat from the works associated with maintenance of barrages
Existing Conditions (2020) ***(Impacts which are occurring)***	• None	• None	• Stability of material in peat slide source area and peat slide debris flow
Operation & Maintenance Phase 2020-2040 ***(Impacts which are occurring)***	• None	• None	• Loading of peat from the works associated with maintenance of barrages
Decommissioning at End of Operation (c2040) ***(Impacts which are likely to occur)***	• None	• None	• Impacts associated with the removal of Barrages 3 and Barrage 4 including loading of shallow peat for access and decommissioning works along the river banks
Residual Impacts after Decommissioning ***(Impacts which are likely to occur)***	• None	• None	• None

**all stability impacts are negative unless otherwise stated*

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Inís
ENVIRONMENTAL SERVICES

DERRYBRIEN WINDFARM

PEAT SLIP

ENVIRONMENTAL IMPACT ASSESSMENT

ON

THE OWENDALLULEEGH RIVER

MARCH 2004

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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 (9^{th} – 22^{nd} 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.

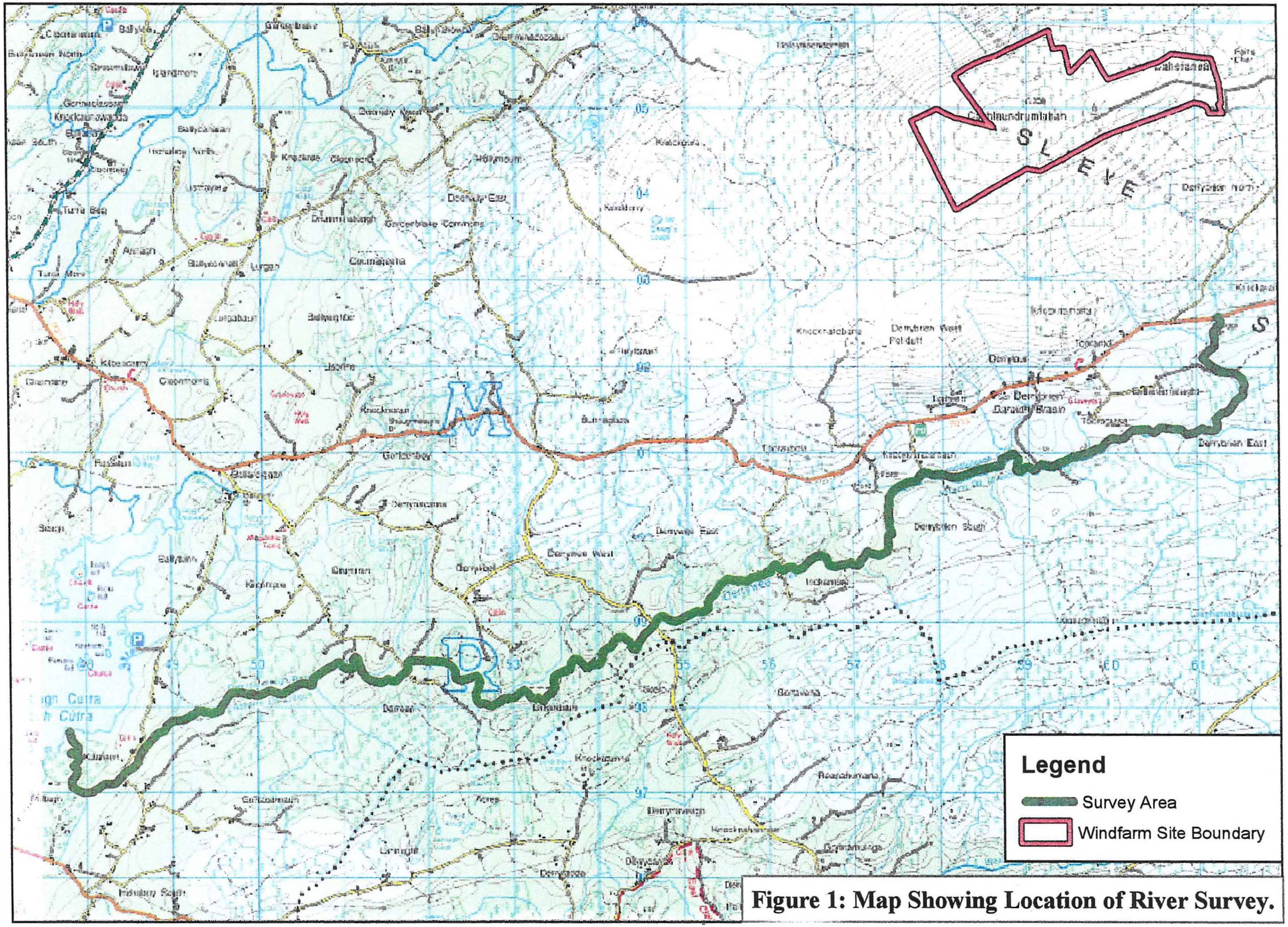

Figure 1: Map Showing Location of River Survey.

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

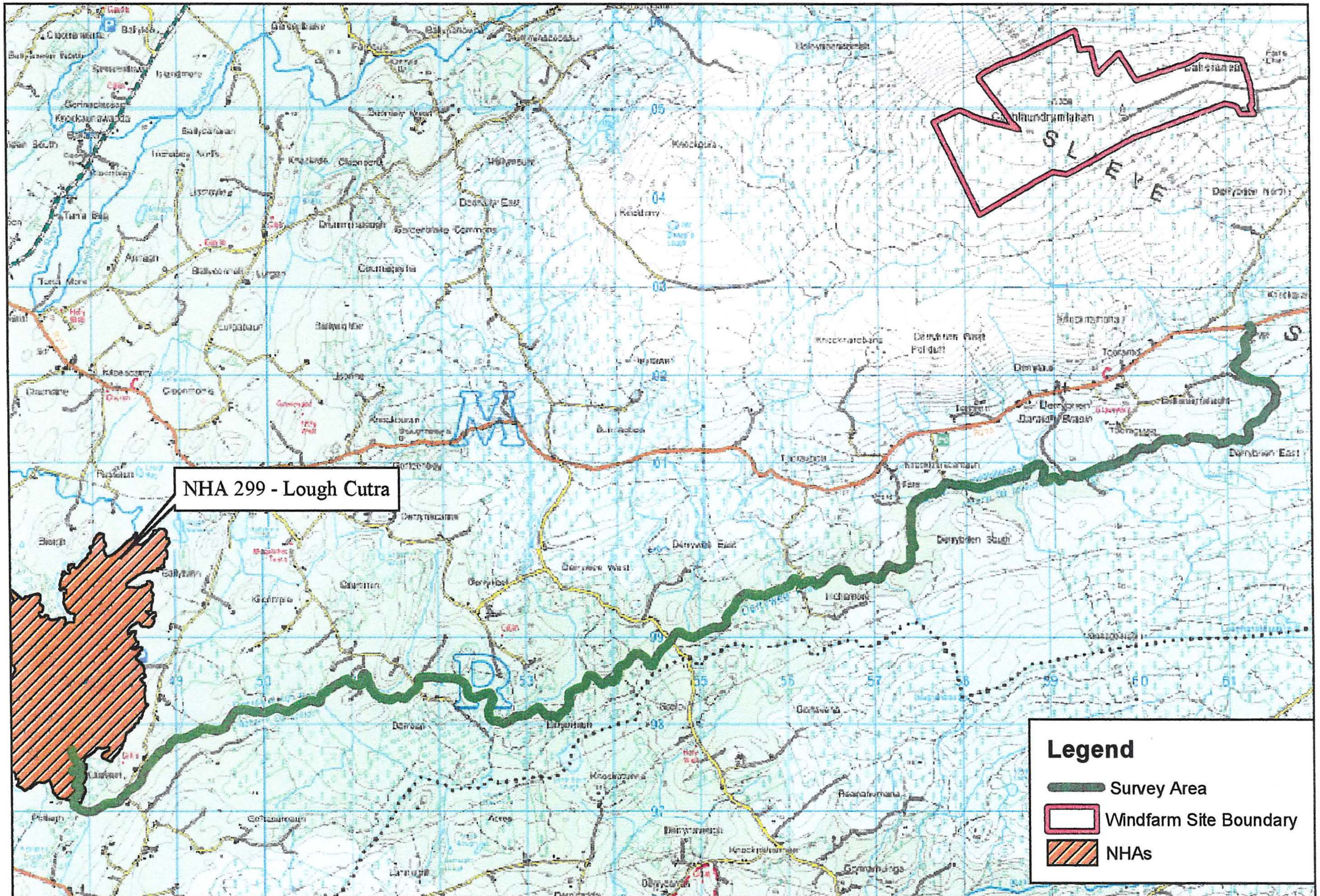

Figure 2: Map Showing Location of Natural Heritage Areas (NHA's) in Relation to Owendalulleegh River

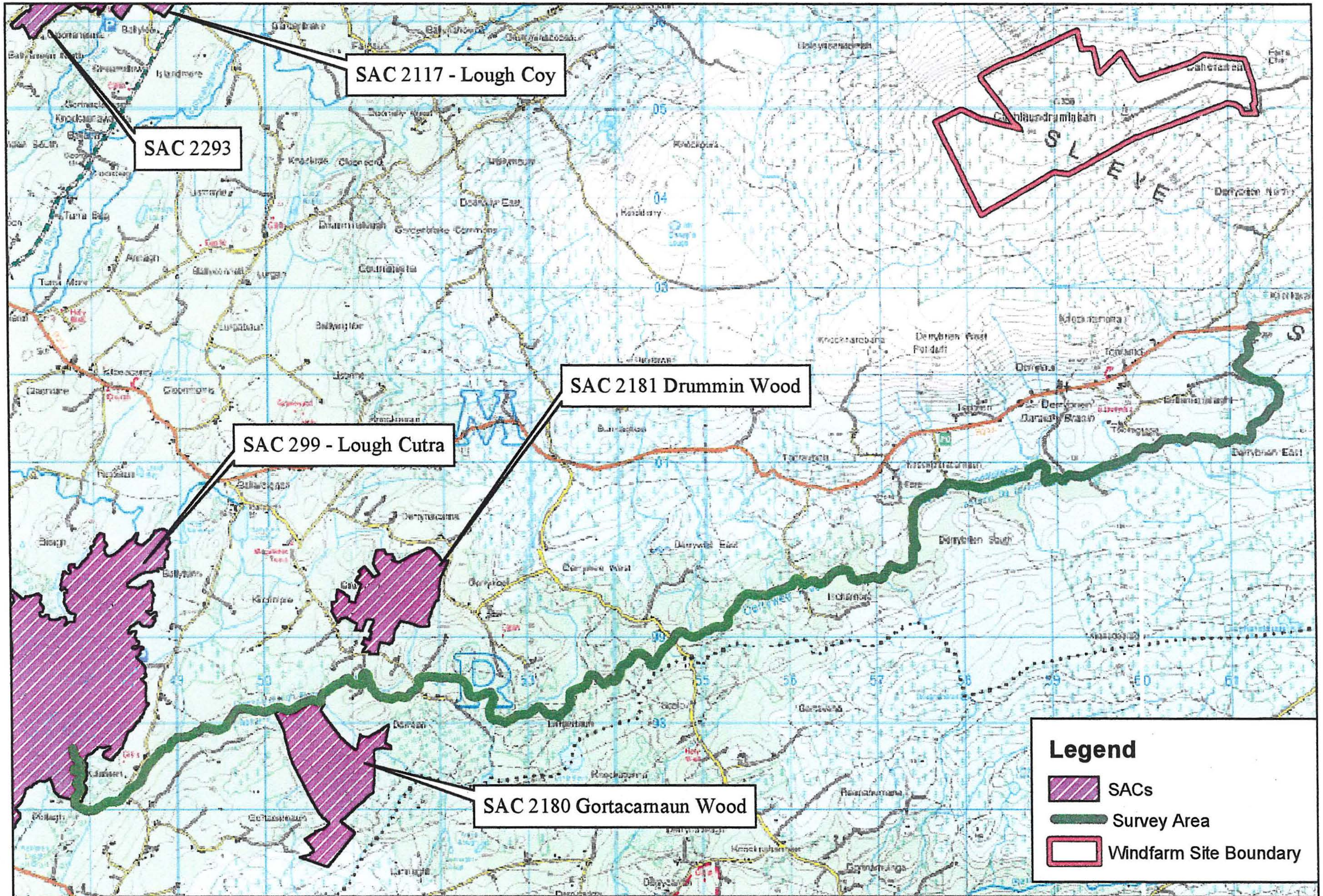

Figure 3: Map Showing Location of Special Areas of Conservation (SAC's) in Relation to Owendalulleegh River

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 *Cyprinus 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
X 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.

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APPENDIX 1 SURVEY AREAS ON THE OWENDALLULLEEGH.

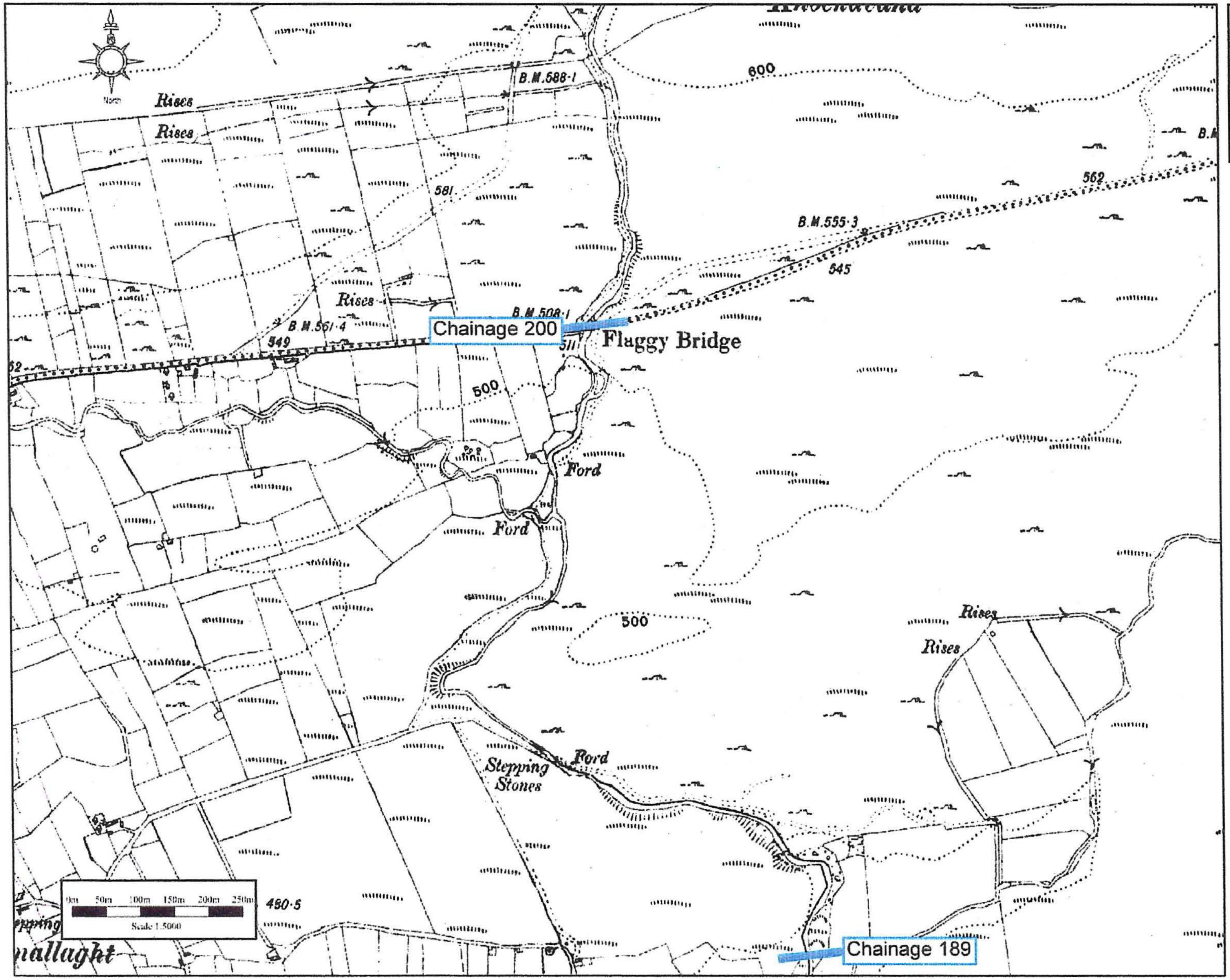

Figure A1.1
Section one was located downstream of Flaggy Bridge. Survey section was between chainages 200 - 189.

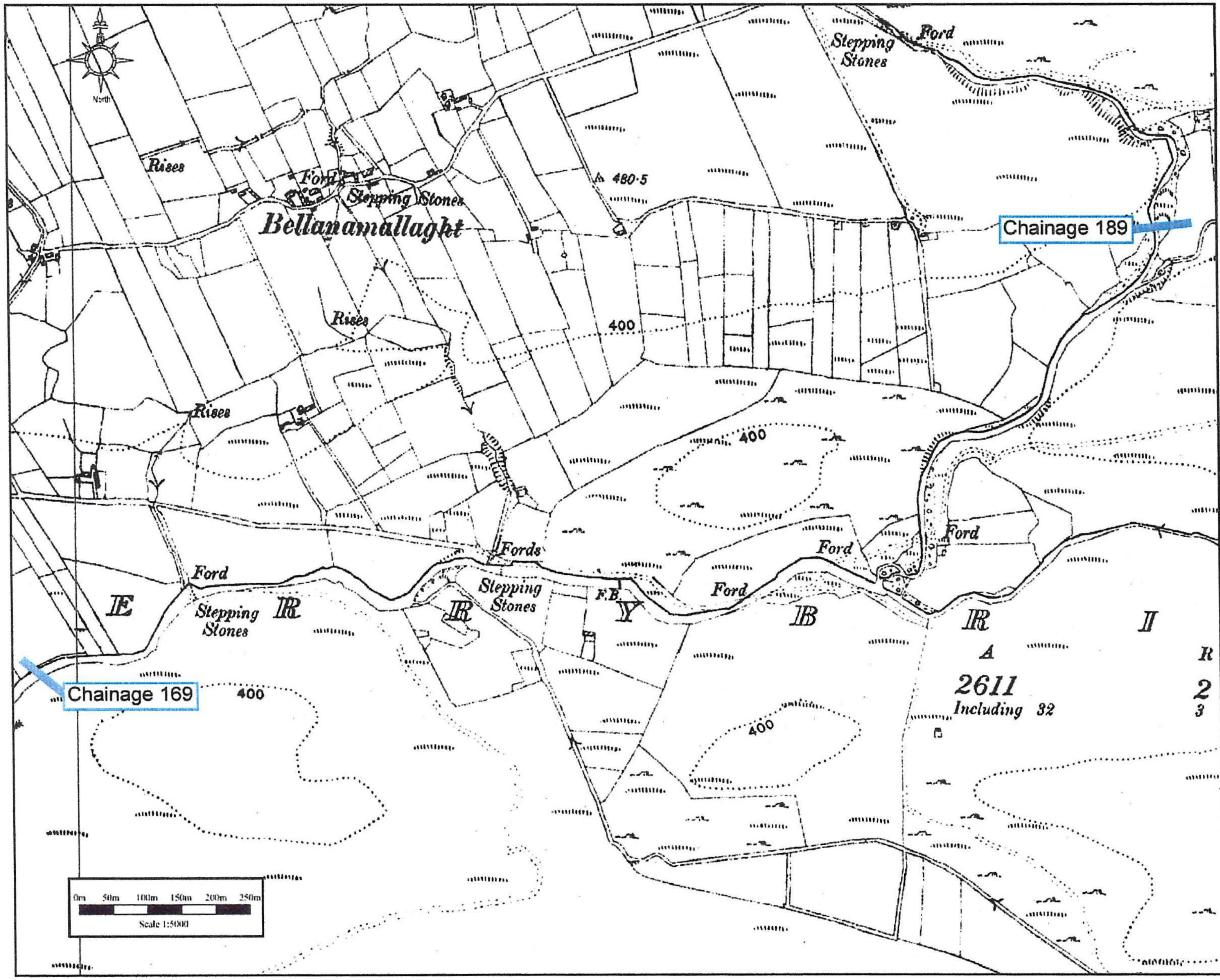

Figure A1.2
Section two was located on the second section downstream of Flaggy Bridge. Survey section was between chainages 189 - 169.

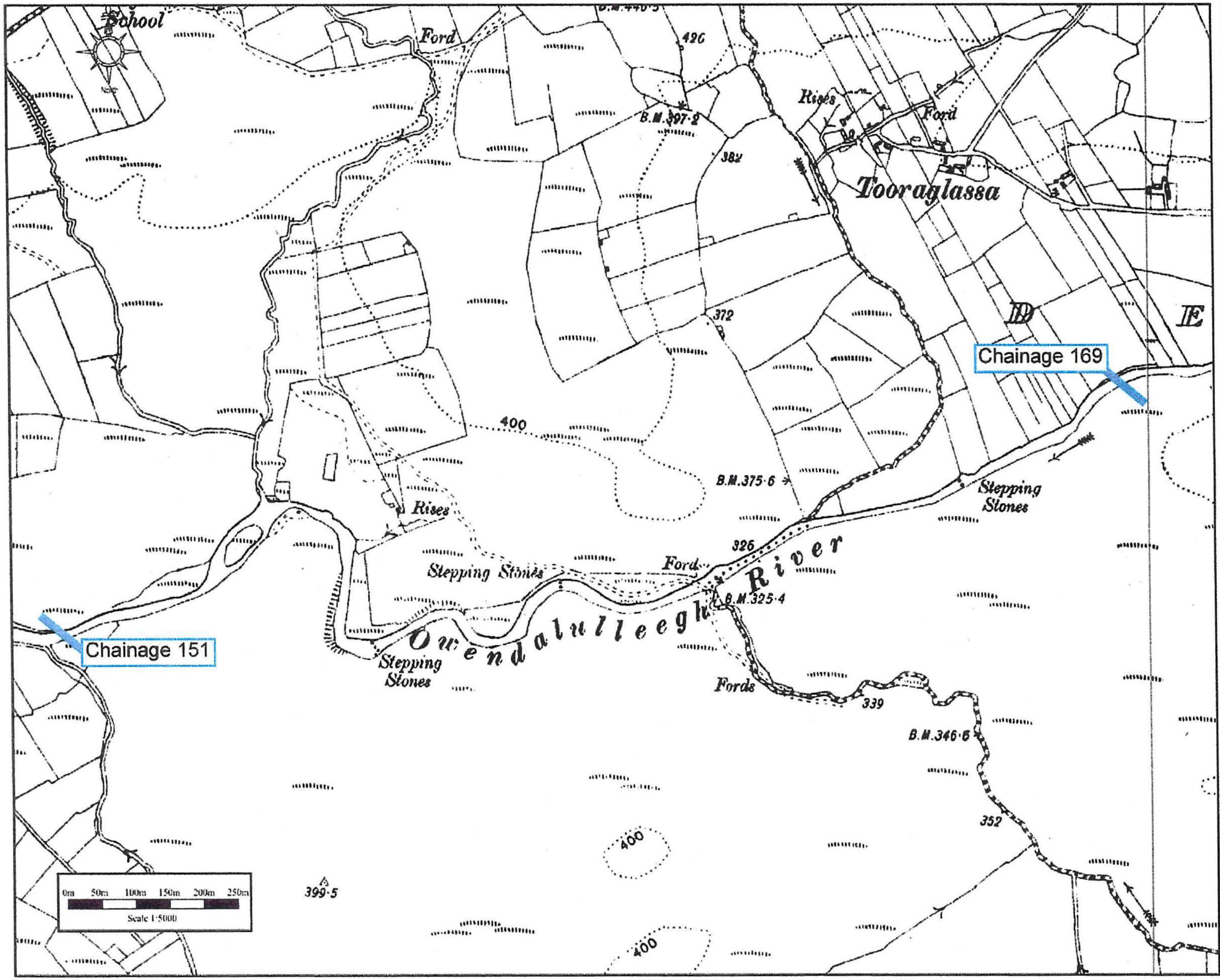

Figure A1.3
Section three was located in the townland of Toorglassa. Survey section was between chainages 169 - 151.

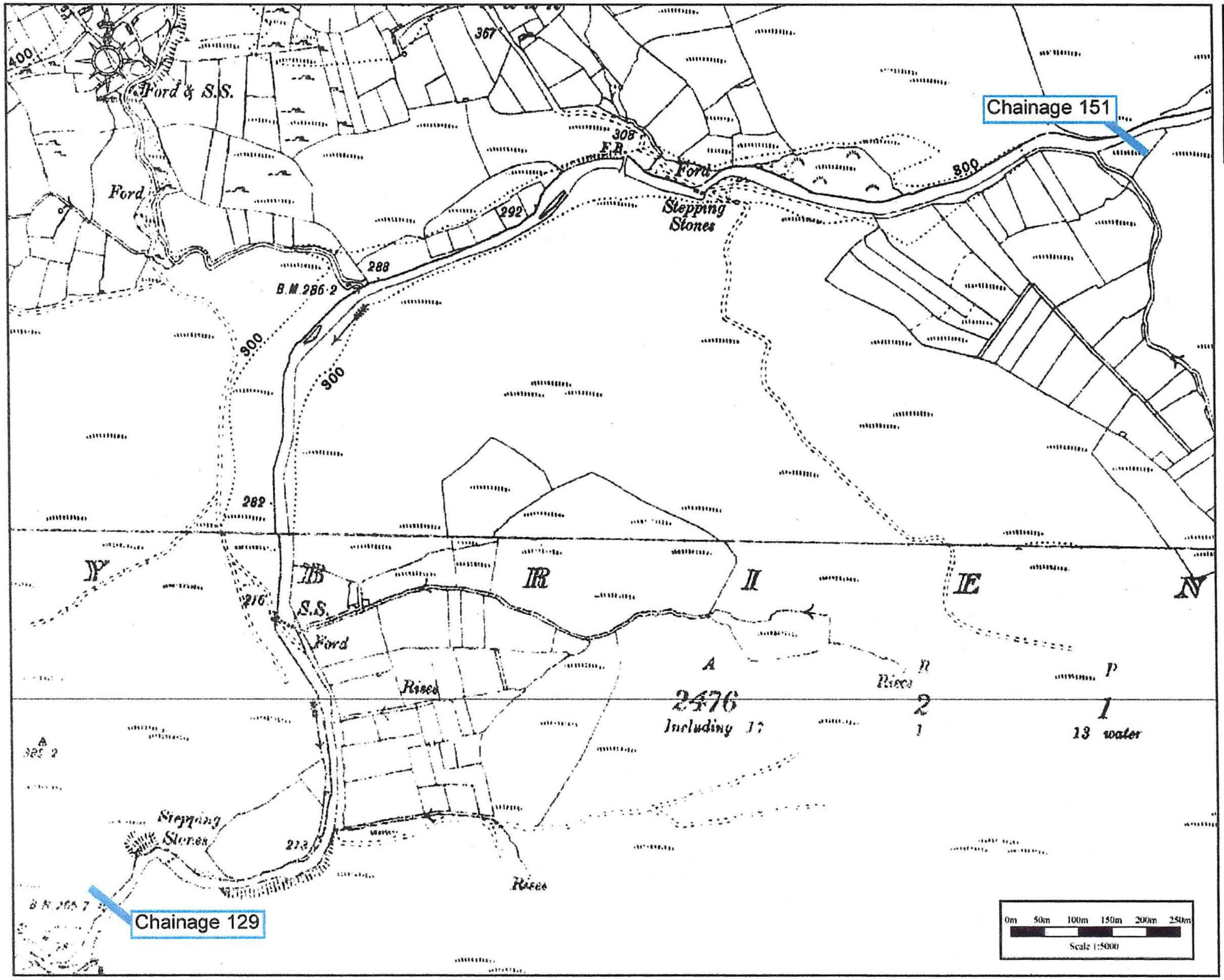

Figure A1.4
Section four was between chainages 151 and 129.

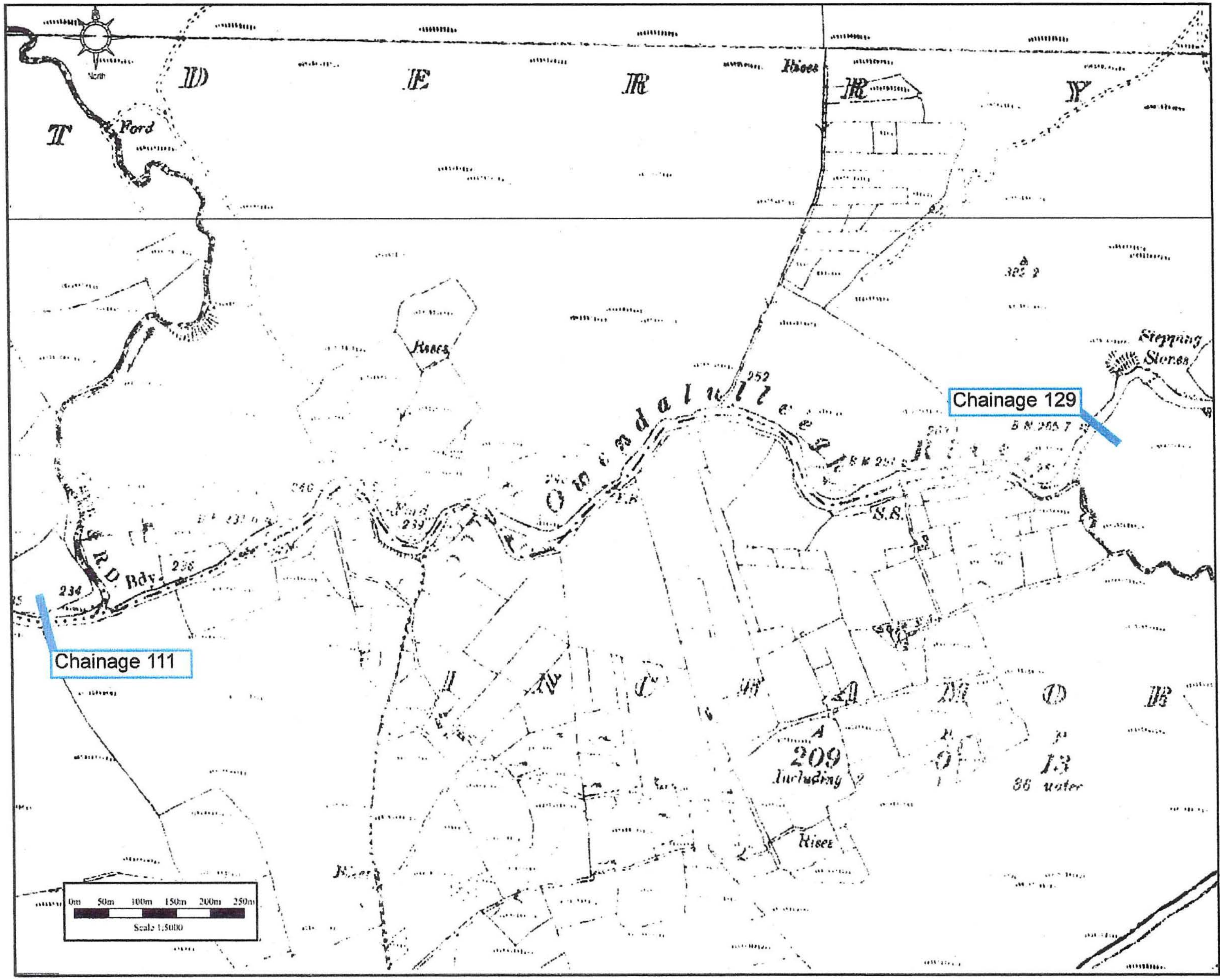

Figure A1.5
Section five was between chainages 129 and 111.

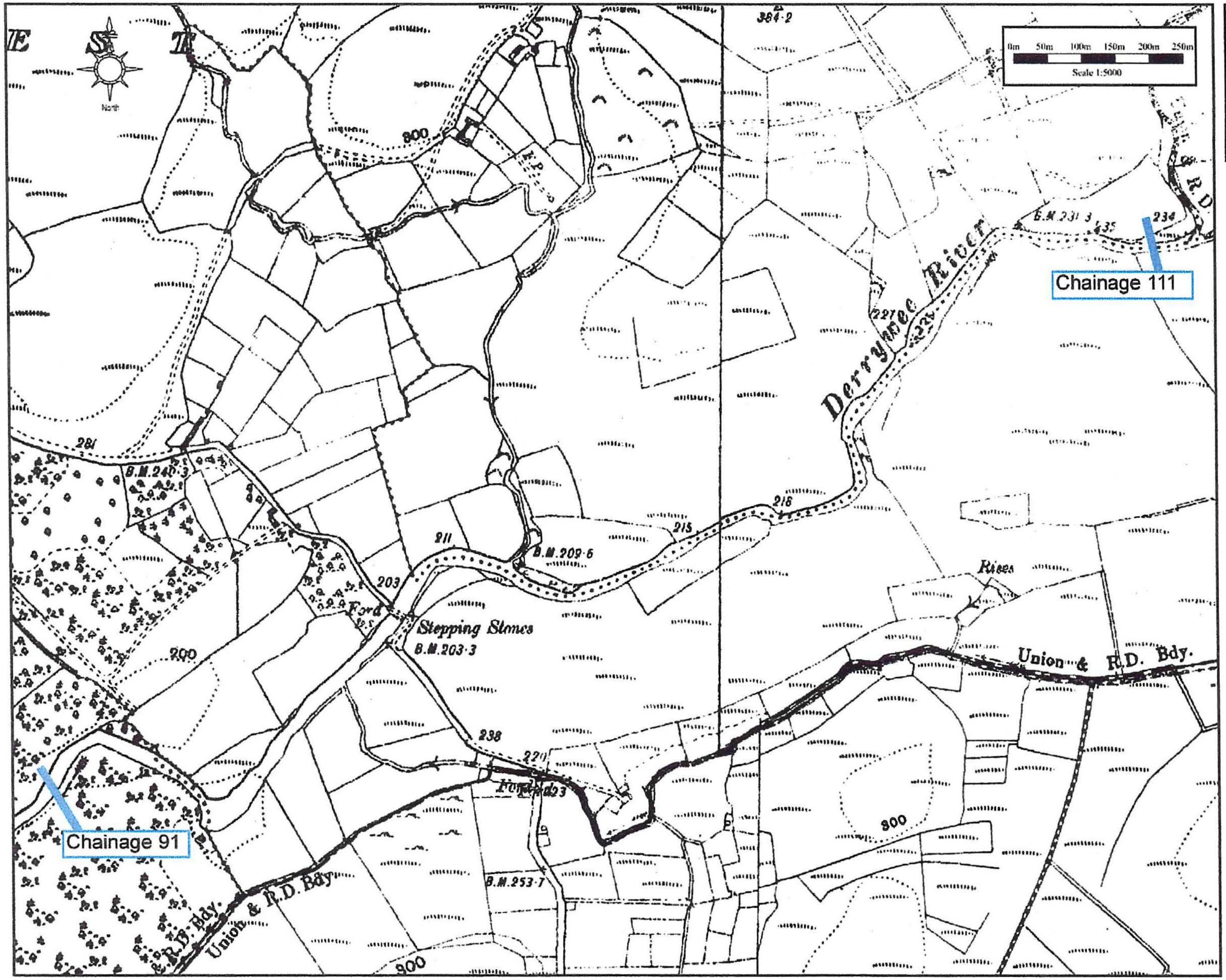

Figure A1.6
This figure shows the extent of survey section six.This section extended from chainage 111 to chainage 91.

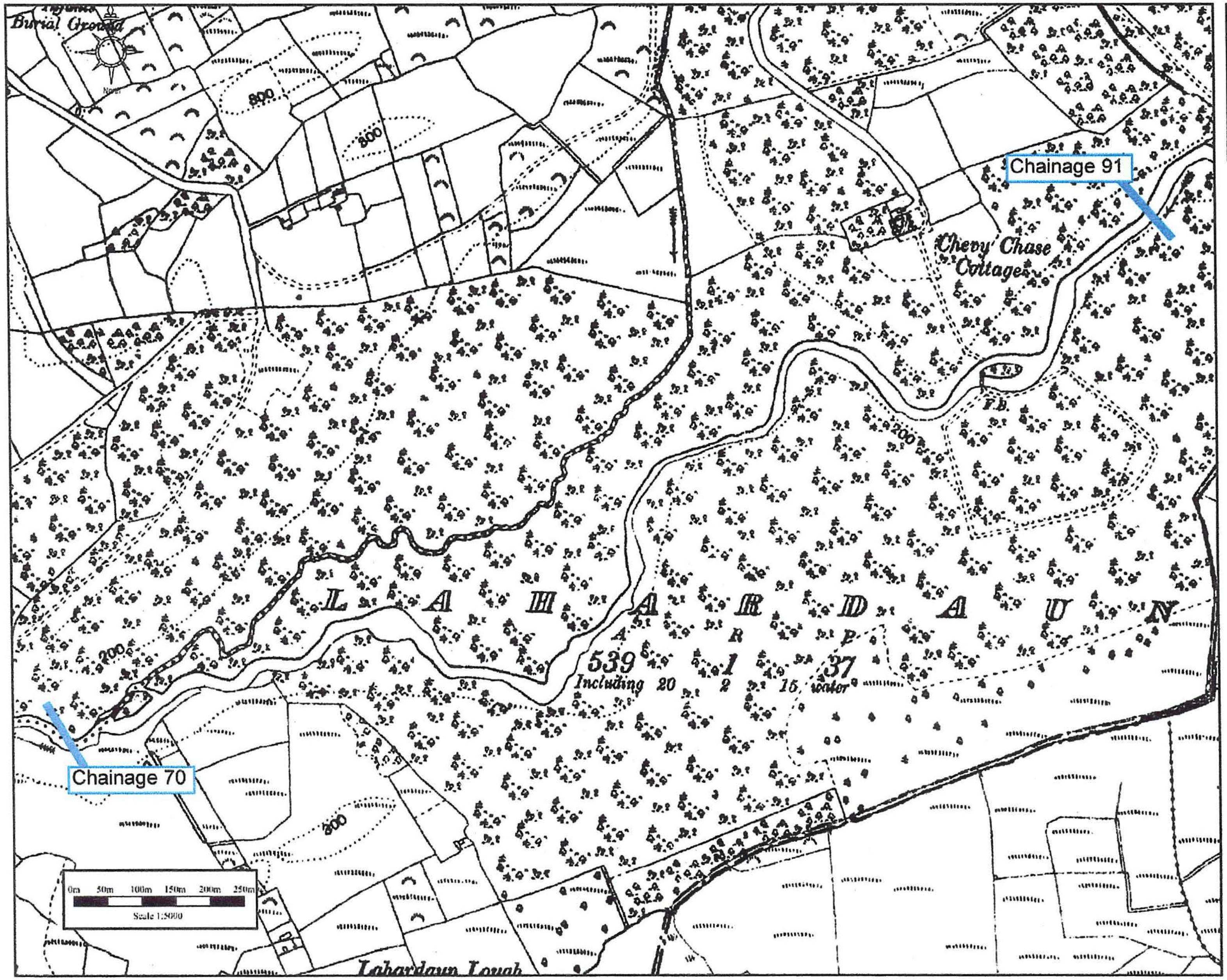

Figure A1.7
Section seven was located in the stretch of river near Chevy Chase cottage. Survey section was between chainages 91 - 70.

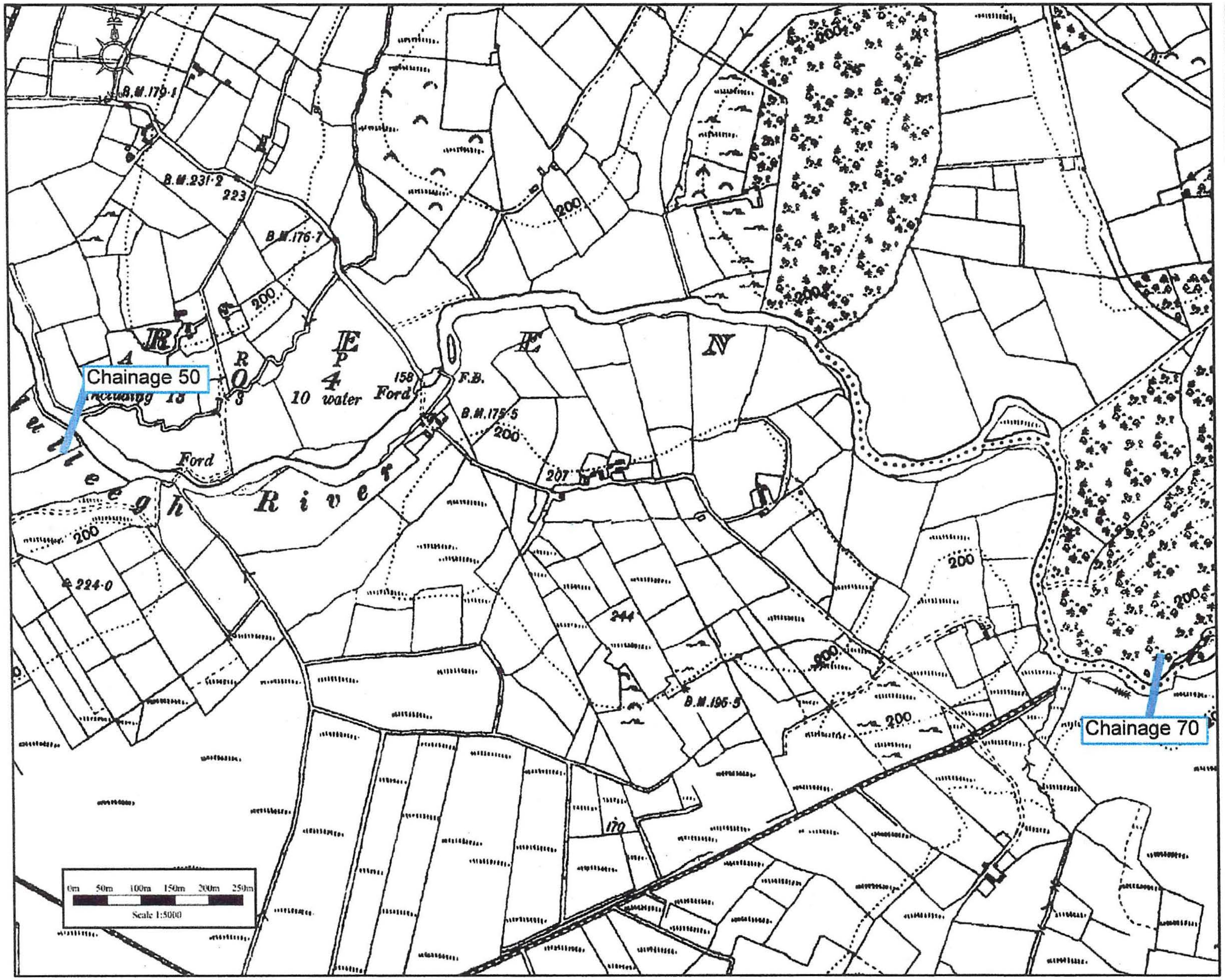

Figure A1.8
Section eight was located immediately downstream of the Chevy Chase cottage stretch and extended from chainage 70 to 50.

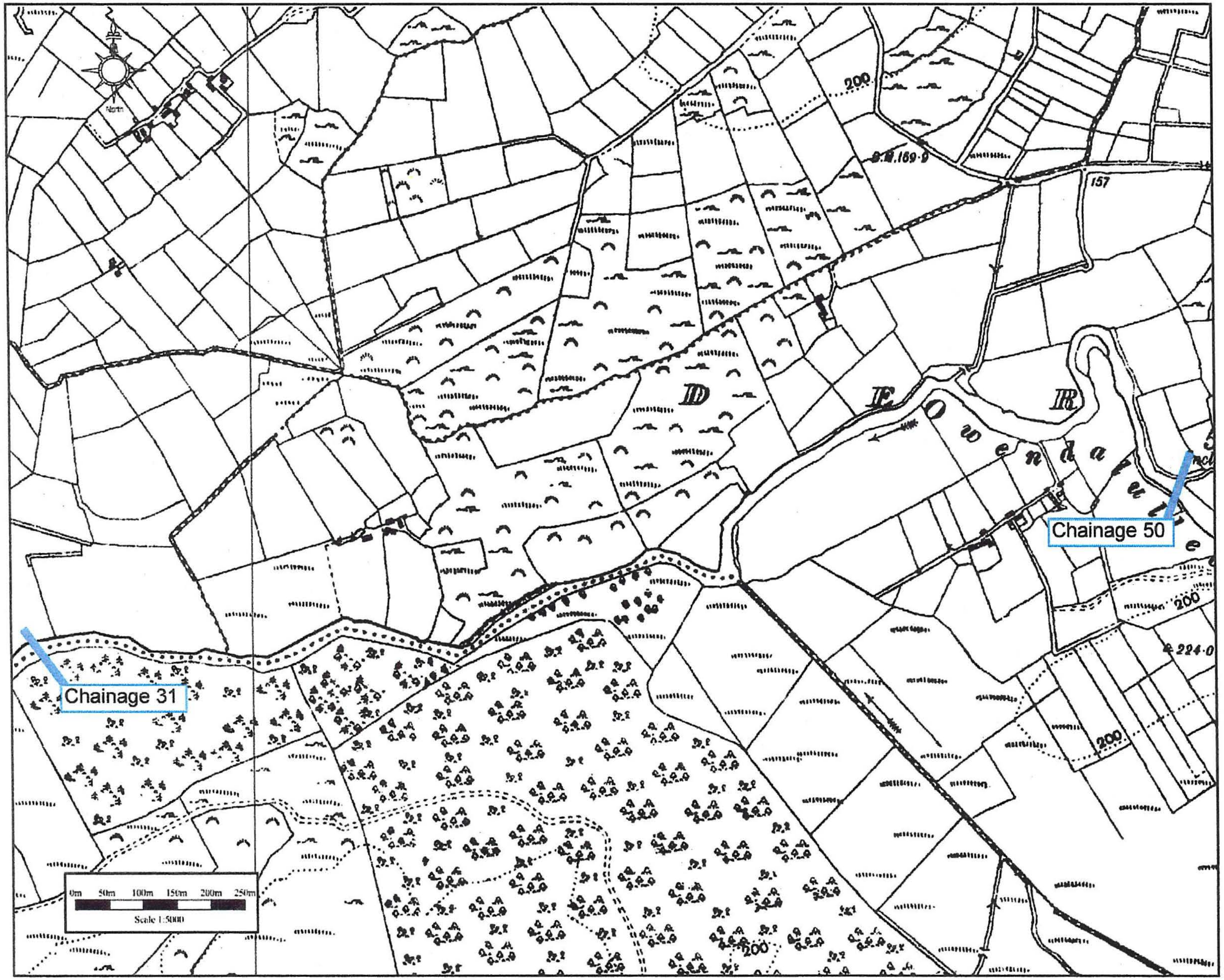

Figure A1.9
This figure shows the extent of survey section nine. This section extended from chainage 50 to chainage 31.

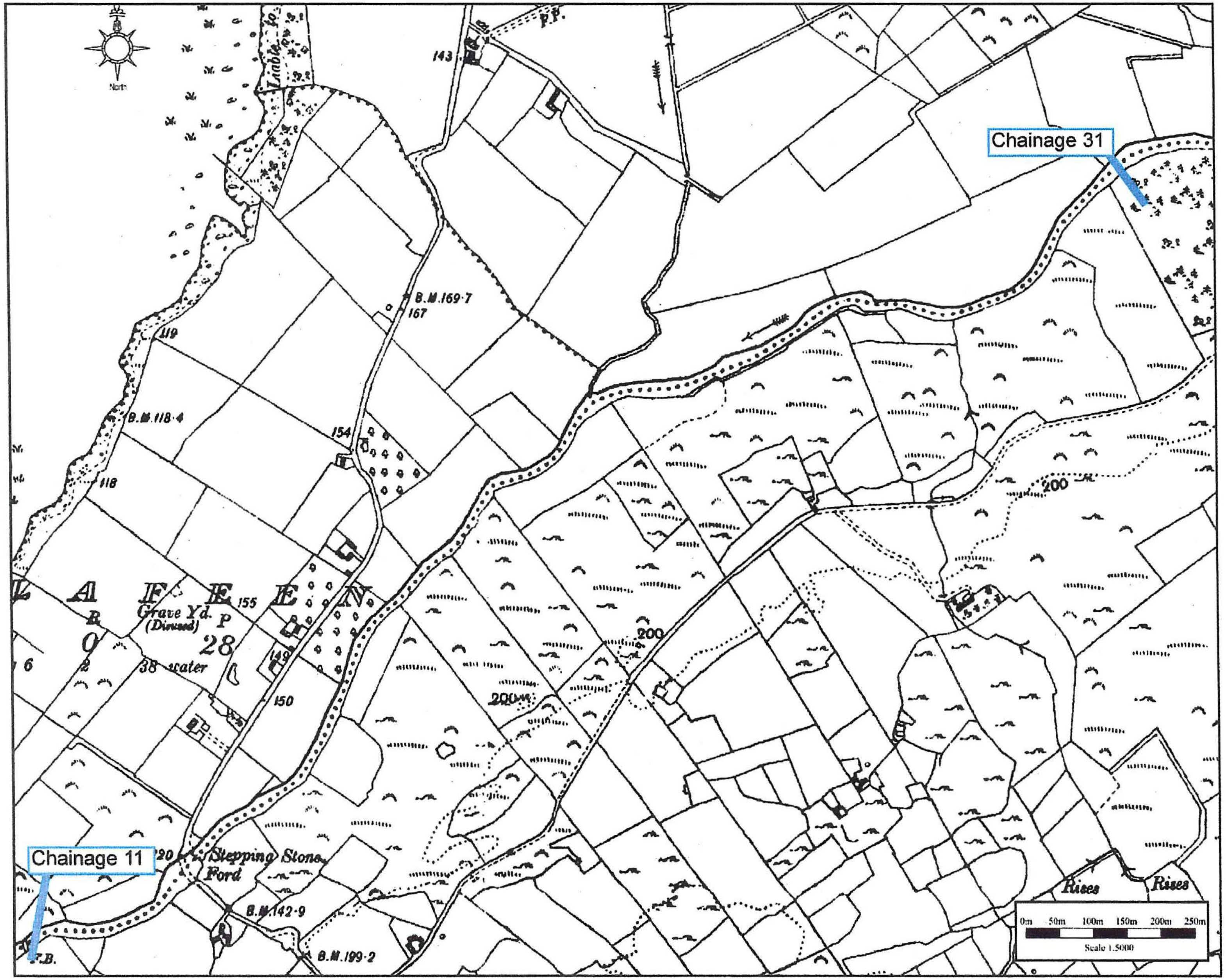

Figure A1.10
Section ten was located in the lower reaches of the river river. Survey section was between chainages 31 and 11.

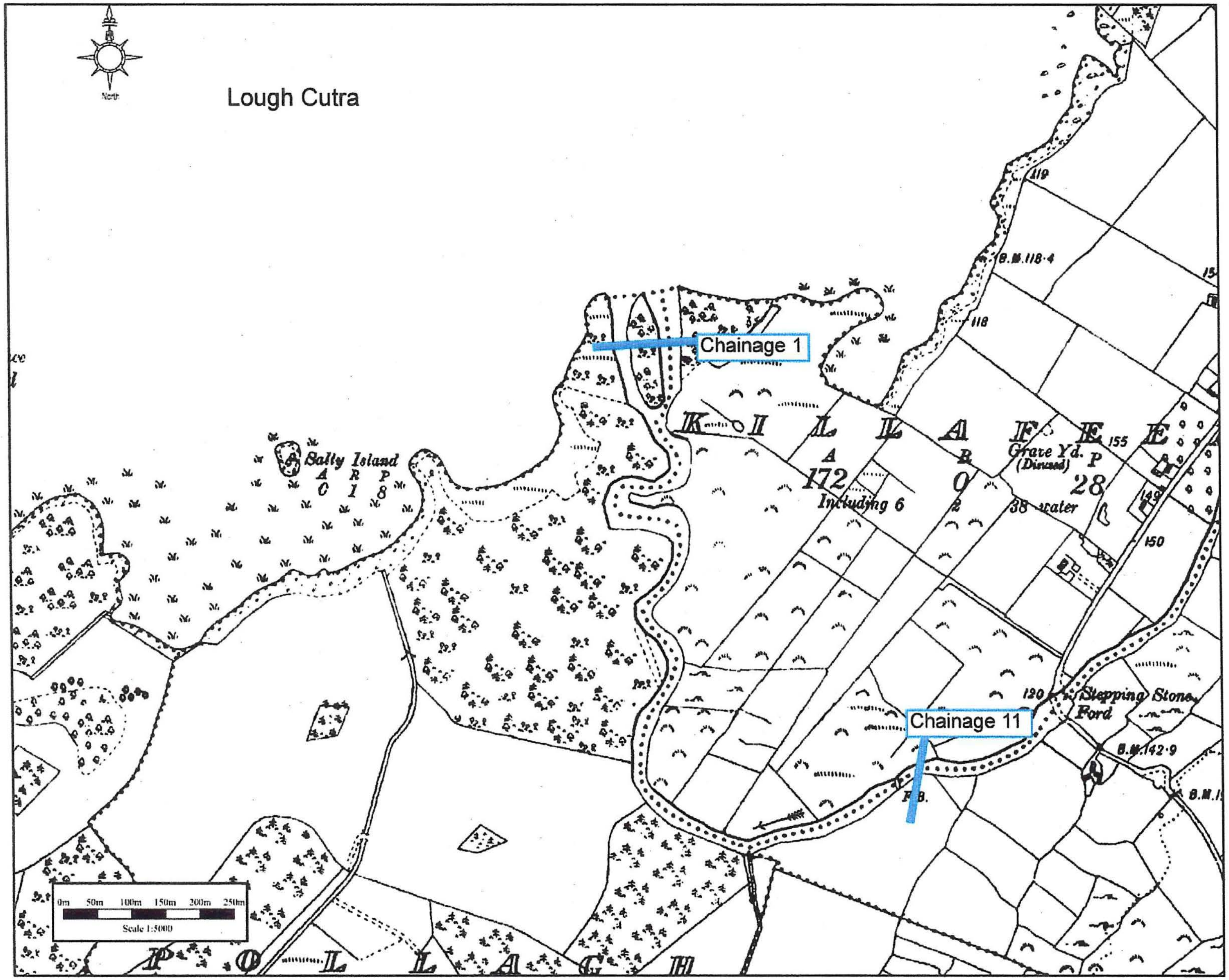

Figure A1.11
This section was the lower-most section of the river and extended from chainage 1 at the mouth of the river to chainage 11.

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

Perfoliate pondweed	*Potamogeton perfoliatus*	1987-1999	Native
Bog pondweed	*Potamogeton polygonifolius*	1987-1999	Native
Common name	**Scientific name**	**Record**	**Status**
*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)