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CONSULTANTS IN ENGINEERING, ENVIRONMENTAL SCIENCE & PLANNING

ENVIRONMENTAL IMPACT ASSESSMENT REPORT (EIAR) FOR THE PROPOSED BALLINAGREE WIND FARM

VOLUME 2 - MAIN EIAR

CHAPTER 9 – LAND, SOIL, HYDROGEOLOGY AND GEOLOGY

Prepared for: Ballinagree Wind DAC

Ballinagree Wind farm

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9 LAND, SOIL, HYDROGEOLOGY AND GEOLOGY

9.1 Introduction

This chapter has been prepared to examine the potential impacts of the proposed Ballinagree Wind Farm and associated infrastructure on existing geological conditions within the study area. The effects of the proposed Ballinagree Wind Farm are considered, taking account of mitigation measures to reduce or eliminate any residual impacts on land, soils and geology. The assessment also considers the cumulative impacts associated with other nearby developments.

The proposed project is comprised of the following key elements:

- The wind farm site (also referred to in this EIAR as 'the Site');
- The grid connection;
- The turbine delivery route (also referred to in this EIAR as 'the TDR');
- Biodiversity enhancement and management plan lands (also referred to in this EIAR as 'the BEMP lands').

A detailed description of the proposed Ballinagree Wind Farm is set out in Chapter 3 - Description of the Proposed Development.

9.2 Assessment Methodology

In summary the methodology adopted for this assessment includes:

- Review of appropriate guidance and legislation;
- Characterisation of the receiving environment;
- Review of the proposed development;
- Assessment of potential effects;
- Identification of mitigation measures; and
- Assessment of residual impacts.

The assessment methodology and criteria are outlined in Section 9.2.4.

9.2.1 Relevant Guidance

The general EIA guidelines are listed in Chapter 1, other topic specific reference documents used in the preparation of this section include the following:

- NRA (2009), Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes

- IGI (2013), Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements
- Scottish Executive (2017) Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments, 2nd Edition.
- European Union (2000/60/EC) Water Framework Directive
- European Union (2006/188/EC) Groundwater Directive
- Government of Ireland (2010) European Communities Environmental Objectives (Groundwater) Regulations (S.I. No. 9 of 2010)
- Government of Ireland (2003) European Communities (Water Policy) Regulations (S.I. No. 722 of 2003)
- EPA (2003), Towards Setting Guideline Values for the Protection of Groundwater in Ireland.

9.2.2 Water Framework and Groundwater Directives, Status and Risk Assessment

The Water Framework Directive provides for the protection, improvement and sustainable use of waters, including rivers, lakes, coastal waters, estuaries and groundwater within the EU Member States. It aims to prevent deterioration of these water bodies and enhance the status of aquatic ecosystems; promote sustainable water use; reduce pollution; and contribute to the mitigation of floods and droughts.

Under the Water Framework Directive large geographical areas of aquifer have been subdivided into smaller groundwater bodies for them to be effectively managed.

The overriding purpose of the WFD is to achieve at least "good status" in all European waters and ensure that no further deterioration occurs in these waters. European waters are classified as groundwaters, rivers, lakes, transitional and coastal waters. The first cycle of river basin management planning, which covered the period 2009-2015, developed plans and associated programmes of measures based on eight River Basin Districts (RBDs) within the island of Ireland. These plans set ambitious targets that envisaged that most water bodies would achieve good status by 2015 or at the latest by 2027.

The Groundwater Directive establishes a regime which sets groundwater quality standards and introduces measures to prevent or limit inputs of pollutants into groundwater. The directive establishes quality criteria that take account of local characteristics and allows for further improvements to be made based on monitoring data and new scientific knowledge. The directive thus represents a proportionate and scientifically sound response to the requirements of the Water Framework Directive as it relates to assessments on chemical status of groundwater and the identification and reversal of significant and sustained upward trends in pollutant concentrations in groundwater.

9.2.3 Consultation

The scope for this assessment has been informed by consultation with statutory consultees, bodies with environmental responsibility and other interested parties as summarised in Chapter 5 – Scoping, Consultation and Key Issues. Responses from the consultees identified a range of observations which have been taken into consideration in the preparation of the respective chapters of this EIAR. Specific issues raised during the scoping process with respect to Land, Soils and Geology are set out below;

9.2.3.1 Inland Fisheries Ireland (IFI)

Correspondence received from the IFI stated that:

- The site contains the head waters of both the Blackwater and Laney Rivers and both are important salmonid fisheries. Therefore, there should be no interference within the beds or banks of any watercourses within the site without prior consultation with the IFI.
- Any suspended solids and or hydrocarbon contaminated site run-off waters must be controlled to avoid any surface water contamination.
- Areas where there is a potential of peat slippage should be identified in the early stages. A plan for silt control should be set out and put into place in the early stages of construction.
- If bridges or culverts are to be used at water crossings, the IFI have stated that the free passage of fish must not be obstructed and the original slope of the river bed should be maintained avoiding any sudden drops on the downstream side. Any works being carried out 'instream' should be carried out between May and September.

The IFI's scoping response is considered within this Chapter with regard to works being carried out close to surface water bodies and at river crossings.

9.2.3.2 Geological Survey of Ireland, Department of Communications, Climate Action & Environment

The Geological Survey of Ireland (GSI) set out the following comments relating to the proposed Ballinagree Wind Farm and recommended various GSI resources for the EIAR assessment:

- The presence of an unaudited County Geological Site, Boggeragh Mountains (3km east of the site), has been identified as having potential significance in terms of geological importance and interest but has not yet been assessed as an individual site through a county audit.
- The Groundwater Vulnerability map (GSI resource) indicates the area covered by the proposed wind farm is variable. GSI recommended the use of the Groundwater Viewer to identify areas of High to Extreme Vulnerability and 'Rock at or near surface' in the EIAR.
- Landslides are common in areas of peat, such as areas which are found close to the proposed wind farm. Landslide susceptibility in the area of the proposed wind farm is variable and is classed from Moderately Low / Moderately High to High. The GSI recommended that geohazards be taken into consideration, especially when developing areas where these risks are prevalent.
- The Geological Survey Ireland highlighted the consideration of mineral resources and potential resources as a material asset which should be explicitly recognised within the environmental assessment process. The GSI further recommended that their geotechnical database resources should be consulted as part of any baseline geological assessment of the proposed development area.

The GSI's scoping response is considered within this Chapter with regard to geological heritage, groundwater vulnerability, landslide susceptibility and geohazards, and consideration of mineral resources. Mineral resources are considered further in Chapter 11 – Population, Human Health and Material Assets with regard to non-renewable resources. Chapter 10 – Hydrology & Water Quality deals with flood risk management at the proposed wind farm.

9.2.3.3 Irish Water

Irish Water have requested the following aspects of Water Services to generally be considered in the scope of the EIAR where relevant:

- Impacts of the development on the capacity of water services.
- Any up-grading of water services infrastructure that would be required to accommodate the development.
- In relation to a development that would discharge trade effluent – any upstream treatment or attenuation of discharges required prior to discharging to an IW collection network.
- In relation to the management of surface water; the potential impact of surface water discharges to combined sewer networks & potential measures to minimise/stop surface waters from combined sewers.
- Determine the location of public water services assets through consultation with IW prior to design.
- Any potential impacts on the assimilative capacity of receiving waters in relation to IW discharge outfalls including changes in dispersion /circulation characterises.
- Any potential impact on the contributing catchment of water sources either in terms of water abstraction for the development (and resultant potential impact on the capacity of the source) or the potential of the development to influence/present a risk to the quality of the water abstracted by IW for public supply.
- Where a development proposes to connect to an IW network and that network either abstracts water from or discharges waste water to a “protected”/sensitive area, consideration as to whether the integrity of the site/conservation objectives of the site would be compromised.
- Mitigation measures in relation to any of the above

Irish Water’s response is considered within this Chapter and Chapter 10 – Hydrology & Water Quality in relation to surface water and ground water. Following an information request by the applicant, no Irish Water Infrastructure was identified in the area of the proposed wind farm site.

9.2.4 Impact Appraisal Methodology

As outlined in Section 9.1, the aim of this is to identify the impacts of the construction, operation and decommissioning of the proposed Ballinagree Wind Farm and associated works on the existing land, soils and geology of the study area.

The following elements were examined to determine the potential impacts of the proposed Ballinagree Wind Farm on the Land, Soils and Geology within the study area:

- characterisation of the land, soils, geology and hydrogeology underlying the study area,
- evaluation of the potential impacts of the proposed development.

The baseline geological and hydrogeological conditions within the study area were determined following a desktop review of publicly available information, including aerial photography, EPA and GSI online databases. Site walkovers and intrusive investigations were also carried out.

Following the assessment of the existing environment, the unmitigated impacts of the proposed development during the construction, operational and decommissioning phases on sensitive receptors identified were determined. The evaluation of the significance of the impacts was undertaken in accordance with the IGI guidance (2013).

Where potential impacts were identified, mitigation measures were recommended to minimise impacts on the environment to acceptable levels of significance. The residual impact from the proposed Ballinagree Wind Farm was then appraised taking into account the recommended remedial measures. The residual impacts from the proposed development are presented in Section 9.5 of this chapter.

9.2.5 Evaluation Criteria

During each phase (construction, operation, maintenance and decommissioning) of the proposed development, several activities will take place on site, some of which will have the potential to cause impacts on the geological regime at the proposed site and the associated Land, Soil and Geology. These potential impacts are discussed throughout this chapter. Mitigation measures, where required, are presented in Section 9.4.

9.2.5.1 Assessment of Magnitude and Significance of Impact on Land, Soils and Geology

An impact rating has been developed for each of the phases of the proposed development based on the Institute for Geologists Ireland (IGI) 'Guidance for the preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements, 2013'. In line with the IGI Guidance, the receiving environment (Geological Features) was first identified.

Using the NRA rating criteria in Appendix C of the IGI Guidance, the importance of the geological and hydrogeological features are rated (Tables 9.1 and 9.2) followed by an estimation of the magnitude of the impacts on geological and hydrogeological features (Tables 9.3 and 9.4).

This determines the significance of the impact prior to application of mitigation measures as set out in Table 9.1:

Table 9-1: Criteria Rating Site Importance of Geological Features (NRA, 2009)

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

Table 9-2: Criteria Rating Site Importance of Hydrogeological Features (NRA, 2009)

Importance	Criteria	Typical Example
Extremely High	Attribute has a high quality or value on an international scale	Groundwater supports river, wetland or surface water body ecosystem protected by EU legislation e.g., SAC or SPA status
Very High	Attribute has a high quality or value on a regional or national scale	Regionally Important Aquifer with multiple wellfields. Groundwater supports river, wetland or surface water body ecosystem protected by national legislation – e.g., NHA status. Regionally important potable water source supplying >2500 homes Inner source protection area for regionally important

Importance	Criteria	Typical Example
		water source.
High	Attribute has a high quality or value on a local scale	Regionally Important Aquifer. Groundwater provides large proportion of baseflow to local rivers. Locally important potable water source supplying >1000 homes. Outer source protection area for regionally important water source. Inner source protection area for locally important water source.
Medium	Attribute has a medium quality or value on a local scale	Locally Important Aquifer Potable water source supplying >50 homes. Outer source protection area for locally important water source.
Low	Attribute has a low quality or value on a local scale	Poor Bedrock Aquifer. Potable water source supplying <50 homes.

The assessment of the magnitude of an impact incorporates the timing, scale, size and duration of the potential impact. The magnitude criteria for impact on Geological and Hydrogeological features are outlined in Tables 9.3 and 9.4 respectively.

Table 9-3: Estimation of Magnitude of Impact on Geological Features (NRA, 2009)

Magnitude	Criterion	Description and Example
Large Adverse	Results in loss of attribute	• Loss of high proportion of future quarry or pit reserves • Irreversible loss of high proportion of local high fertility soils • Removal of entirety of geological heritage feature • Requirement to excavate / remediate entire waste site • Requirement to excavate and replace high proportion of peat, organic soils and/or soft mineral soils beneath alignment
Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute	• Loss of moderate proportion of future quarry or pit reserves • Removal of part of geological heritage feature • Irreversible loss of moderate proportion of local high fertility soils • Requirement to excavate / remediate significant proportion of waste site • Requirement to excavate and replace moderate proportion of peat, organic soils and/or soft mineral soils beneath alignment

Magnitude	Criterion	Description and Example
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute	• Loss of small proportion of future quarry or pit reserves • Removal of small part of geological heritage feature • Irreversible loss of small proportion of local high fertility soils and/or • high proportion of local low fertility soils • Requirement to excavate / remediate small proportion of waste site • Requirement to excavate and replace small proportion of peat, organic soils and/or soft mineral soils beneath alignment
Negligible	Results in an impact on attribute but of insufficient magnitude to affect either use or integrity	No measurable changes in attributes
Minor Beneficial	Results in minor improvement of attribute quality	Minor enhancement of geological heritage feature
Moderate Beneficial	Results in moderate improvement of attribute quality	Moderate enhancement of geological heritage feature
Major Beneficial	Results in major improvement of attribute quality	Major enhancement of geological heritage feature

Table 9-4: Estimation of Magnitude of Impact on Hydrogeological Features (NRA, 2009)

Magnitude of Impact	Criteria	Typical Examples
Large Adverse	Results in loss of attribute and /or quality and integrity of attribute	Removal of large proportion of aquifer. Changes to aquifer or unsaturated zone resulting in extensive change to existing water supply springs and wells, river baseflow or ecosystems. Potential high risk of pollution to groundwater from routine run-off. Calculated risk of serious pollution incident >2% annually.
Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute	Removal of moderate proportion of aquifer. Changes to aquifer or unsaturated zone resulting in moderate change to existing water supply springs and wells, river baseflow or ecosystems. Potential medium risk of pollution to groundwater from routine run-off. Calculated risk of serious pollution incident >1% annually.
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute	Removal of small proportion of aquifer. Changes to aquifer or unsaturated zone resulting in minor change to water supply springs and wells, river baseflow or ecosystems.

Magnitude of Impact	Criteria	Typical Examples
		Potential low risk of pollution to groundwater from routine run-off. Calculated risk of serious pollution incident >0.5% annually.
Negligible	Results in an impact on attribute but of insufficient magnitude to affect either use or integrity	Calculated risk of serious pollution incident <0.5% annually.

The matrix in Table 9.5 determines the significance of the impacts based on the importance and magnitude of the impacts as determined by Tables 9.1 to 9.4.

Table 9-5: Ratings of Significance of Impact for Geology/Hydrogeology (NRA, 2009)

Importance of Attribute	Magnitude of Impact			
	Negligible	Small Adverse	Moderate Adverse	Large Adverse
Very High	Imperceptible	Significant/Moderate	Profound/Significant	Profound
High	Imperceptible	Moderate/Slight	Significant/Moderate	Profound/Significant
Medium	Imperceptible	Slight	Moderate	Significant
Low	Imperceptible	Imperceptible	Slight	Slight/Moderate

The determination of the significance of each impact for this site is discussed in Section 9.4.

9.2.6 Desk Study - Methodology

Prior to undertaking the site walkovers and intrusive site investigations, a desk study was undertaken to help determine the baseline conditions within the study area and planning boundary to provide relevant background information. The desk top study involved an examination of the following sources of information:

- OSI (2021), Current and historic Ordnance Survey Ireland mapping and ortho-photography.
- Taluntas (1980), General Soil Map of Ireland
- Geological Survey of Ireland (2021) GSI Public Data Viewer (www.spatial.dcenr.gov.ie)
- Environmental Protection Agency (2021) Review of the EPA online mapping (http://gis.epa.ie/Envision).
- Study of the proposed layout of the development.

To determine the existing hydrogeological regime within the study area the following EPA and GSI online datasets and mapping from the sources outlined above were reviewed:

- Catchment & Management Units;
- Groundwater Bodies Status and Risk;
- Drinking Water Protection Areas;
- Groundwater Resources (Aquifers);
- Groundwater Wells and Springs (Groundwater wells assumed to be present in every dwelling within 1km of the site boundary);
- Karst Features; and
- Groundwater Vulnerability.

9.2.7 Site Investigations and Field Assessments - Methodology

Site walkovers and peat stability assessments were undertaken by an Engineering Geologist working for Fehily Timoney and Company (FT) during January and August 2020 and during March 2021 to determine the baseline characteristics of the proposed development site.

The site assessment works undertaken comprised the following:

- Walk over inspections of the study area with recording of salient geomorphological features at proposed infrastructure locations (see Figure 9.11);
- Peat depth probing and slope stability assessments at proposed infrastructure locations and where peat deposits were encountered. Shear strengths were taken at infrastructure locations and at regular intervals across the site;
- Recording of GPS co-ordinates of site investigation locations using a hand-held GPS.

Intrusive site investigations were undertaken by Irish Drilling Ltd (IDL) under the supervision of an Engineering Geologist from FT during March and May 2021. These included trial pits and boreholes across the proposed site.

9.3 Receiving Environment

The receiving environment is described hereunder. This includes descriptions of the underlying quaternary and bedrock geology, areas of geological heritage, areas of economic interest with respect to geological resources and potential for soil contamination. This section also includes a summary of site-specific information obtained during site walkovers and intrusive site investigations undertaken as part of the baseline assessment works.

9.3.1 Quaternary Deposits

The Quaternary Geology underlying the proposed Ballinagree Wind Farm is discussed below and presented in Figure 9.1.

The subsoils present within the development site and wider study area were taken from the Geological Survey of Ireland (GSI) online mapping - Quaternary Geology of Ireland (1:50,000 scale) and comprise:

- Till derived from Devonian sandstones (TDSs);
- Bedrock outcrop or sub-crop (Rck);
- Blanket peat (BktPt);
- Alluvium (A).

As shown in Figure 9.1 the majority of turbine locations and associated infrastructure in the southern portion of the site are located within areas classified as Till derived from Devonian Sandstones and areas of bedrock outcrop or subcrop. Areas of blanket peat are concentrated in the north and north-eastern area of the site (T14 to T21).

The majority of the proposed grid connection route is underlain by Till derived from Devonian Sandstones with limited areas of bedrock sub-crop or outcrop and alluvium indicated along the proposed route.

During site walkovers it was found that peat depth recorded from over 124 probes ranged from 0 to 3m with an average peat depth of 0.6m. 86% of the probes recorded peat depths of less than 1.0m with 95% of peat depth probes recorded peat depths of less than 2.0m. A number of localised readings predominantly in the north-east of the site recorded peat depths from 2.0 to 3m. Peat probing was focused on areas of the site where peat was identified during the site walkover and desk study (the northern area of the site). . There are areas of peaty topsoil in the southern area that reach maximum depths of 0.3m. The locations of all peat probes are shown in Figure 6.1 in the Geotechnical and Peat Stability Assessment Report (see Appendix 9-1) and a table showing the information for each location is in Appendix B of the same report.

9.3.2 Solid Geology

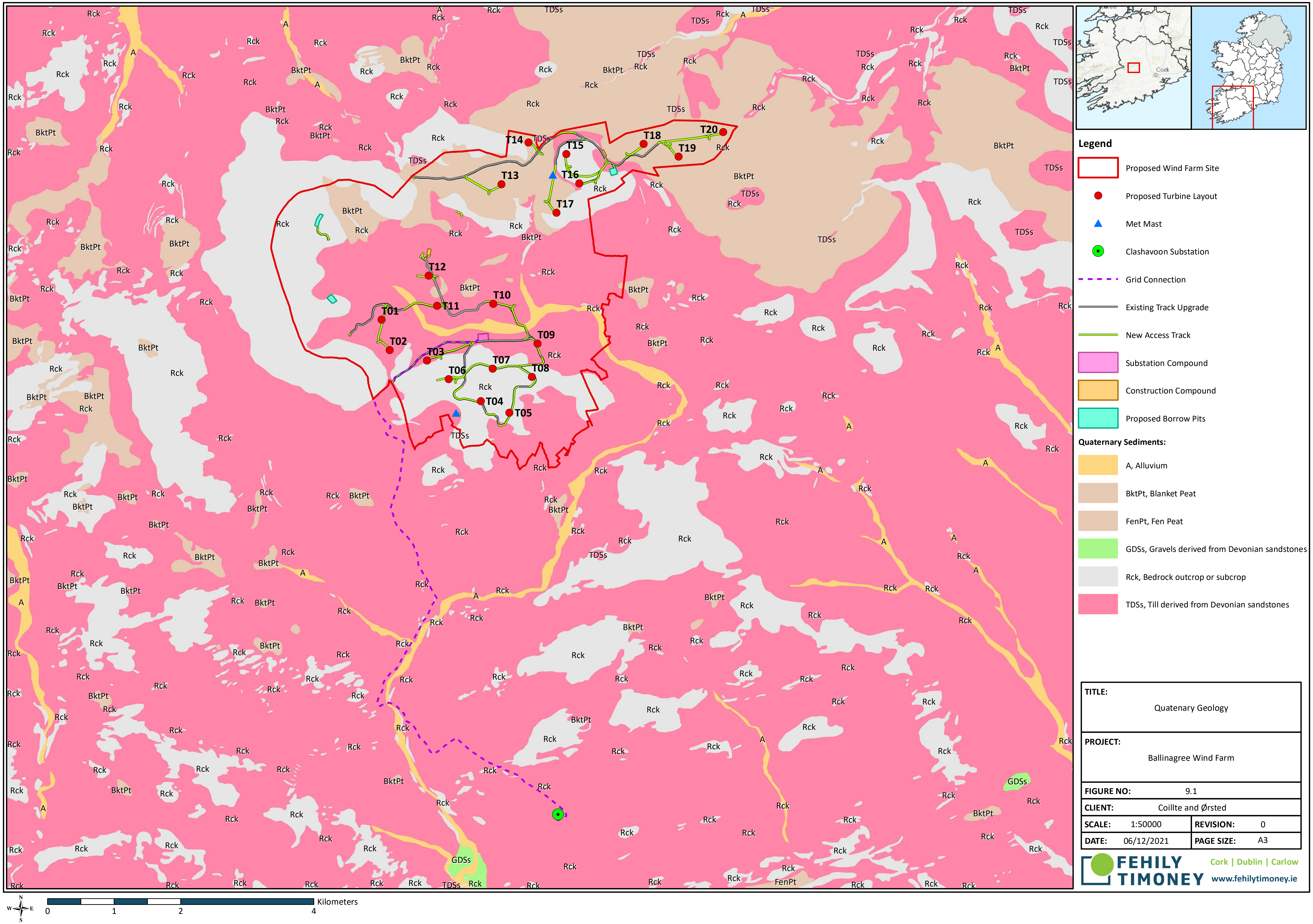
The Geological Survey of Ireland (GSI) 1:100,000 scale bedrock geology map shows that the proposed Ballinagree Wind Farm development site is predominantly underlain by the Devonian Ballytrasna Formation with a section of the southern area of the site underlain by the Caha Mountain Formation.

The Ballytrasna Formation is described as comprising dusky-red mudstone with subordinate pale-red sandstones occurring throughout the formation. The Caha Mountain Formation is described as comprising purple and green siltstones and sandstones.

The proposed grid connection route traverses the Ballytrasna Formation and Caha Mountain Formations, as described above for the majority of the route. The southern extent of the grid connection is underlain by the Gortanimill Formation. The Gortanimill Formation comprises medium to fine-grained green sandstone with some red siltstone.

The bedrock geology of the proposed Ballinagree Wind Farm and surrounding area is presented in Figure 9.2.

During the trial pit site investigations weathered bedrock was encountered at depths ranging from 0m to 3.8m BGL. A map showing the trial pit locations is located in the Irish Drilling ground investigation report included in Appendix 9.2.



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PROJECT:	Ballinagree Wind Farm
FIGURE NO:	9.1
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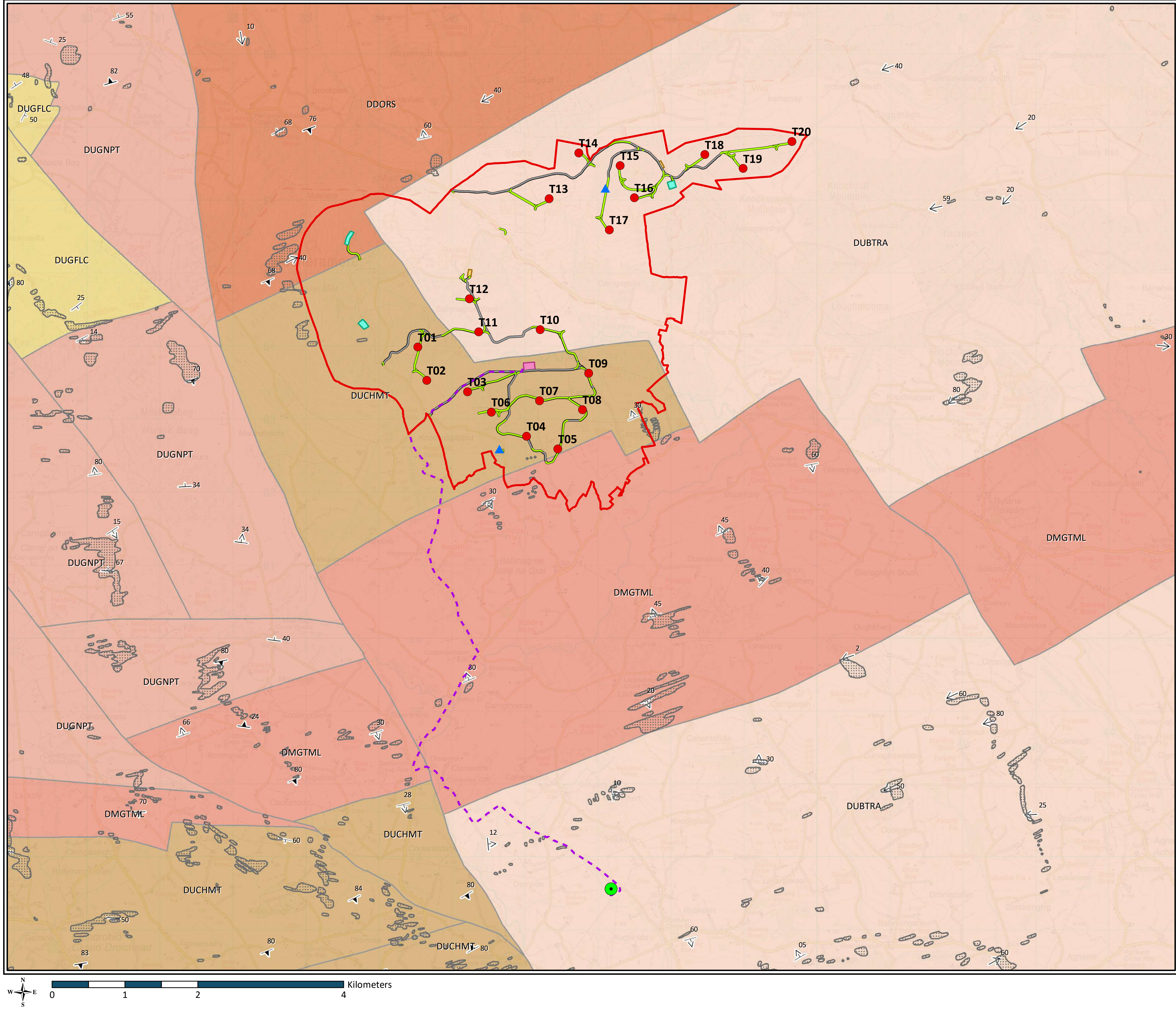

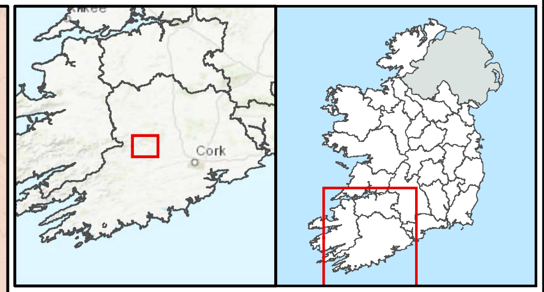

Legend

- Proposed Wind Farm Site
- Proposed Turbine Layout
- Met Mast
- Clashavoon Substation
- Grid Connection
- Existing Track Upgrade
- New Access Track
- Substation Compound
- Construction Compound
- Proposed Borrow Pits
- Bedrock Outcrop

Bedrock Geology:

- Old Red Sandstone (undifferentiated
- Gortanimill Formation
- Ballytrasna Formation
- Caha Mountain Formation
- Glenflesk Chloritic Sandstone Forma
- Gun Point Formation

Bedrock Structural Symbols

- Dip of bedding or main foliation, old GSI data
- Strike and dip of bedding, right way up
- Strike and dip of bedding, way up unknown
- Strike and dip of first foliation

TITLE: Bedrock Geology	
PROJECT: Ballinagree Wind Farm	
FIGURE NO: 9.2	
CLIENT: Coillte and Ørsted	
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9.3.3 Hydrogeology

9.3.3.1 Groundwater Vulnerability

The Groundwater Vulnerability within the proposed Ballinagree Wind Farm site boundary is classified by the GSI as ranging from 'High' to 'Extreme' with areas of exposed bedrock (X – Rock Near Surface) also present within the proposed development site. The GSI distribution of groundwater vulnerability for the site area is shown in Figure 9.5.

Based on the GSI aquifer vulnerability mapping, overburden deposits are generally between 3 and 10m deep in the central portion of the site; generally, 3 to 5m deep in the north and east of the site; and <3m deep in the west, south and a portion of the north of the site.

A summary of the groundwater vulnerability for the site is presented in Table 9.6. This table outlines the standard ratings of vulnerability used by the GSI, with the existing site conditions highlighted based on the findings of the site investigations. The ground investigations carried out confirm the findings from the aquifer vulnerability mapping as areas of shallow bedrock were encountered across the site.

Table 9-6: Groundwater Vulnerability

Vulnerability Rating	Hydrogeological Conditions		
	Subsoil Permeability (Type) and Thickness		
	High Permeability (sand/gravel)	Moderate Permeability (sandy soil)	Low Permeability (clayey subsoil, clay, peat)
Extreme (E)	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**
Moderate (M)	N/A	>10.0 m	**5.0 - 10.0 m**
Low (L)	N/A	N/A	>10 m

9.3.3.2 Groundwater Bodies Description

The majority of the proposed wind farm site and the proposed grid connection of the Ballinagree Wind Farm is located within the Ballinhassig West Groundwater Body (GWB). The north-eastern extremity of the proposed wind farm lies within the Glenville GWB as shown in Figure 9.3.

The descriptions of the GWBs within the study area have been taken from the 'Summary of Initial Characterisation' draft reports for each defined GWB published by the GSI in accordance with the Groundwater Working Group Publication: Guidance Document GW2 (2003). The GWB Characterisation Reports are available from the GSI Public Data Viewer. Site specific data including depth to bedrock and subsoil type encountered during intrusive investigations has been used to supplement and validate the published information.

Ballinhassig West GWB

The Ballinhassig West GWB underlies the majority of the proposed Ballinagree Wind Farm development and associated gid connection route. This GWB is bounded to the north by the Glenville GWB which is discussed in the section below. The dominant bedrock units of this GWB comprise the Devonian Old Red Sandstones which includes the Ballytrasna Formation which underlies much of the study area.

The GSI indicates that permeability within the GWB generally decreases rapidly with depth in all aquifers within this GWB. Aquifer categories within the Ballinhassig GWB are either Locally Important or Poor Aquifers. General transmissivities are reported by the GSI to be 'Low'.

However, 'Excellent' yielding wells are found within some of the Old Red Sandstone units – these yields are usually associated with boreholes that are located in fault zones.

The GSI states that diffuse recharge will occur via rainfall percolating through the subsoil or areas of outcropping rock. The generally Low permeability of the aquifer and the sloping topography in the north of the GWB indicate that a high proportion of recharge to the aquifer will discharge rapidly to surface water features. Groundwater flows within the GWB are relatively short from 30-300 m, with groundwater discharging to springs, or to the streams that traverse the aquifer.

Glenville GWB

Due to the general absence of intergranular permeability within the underlying Ballytrasna Formation, groundwater flow generally occurs in faults and joints within this GWB. The majority of the groundwater flow generally occurs in an upper, shallow weathered zone. This is due to the lesser frequency and connectivity of water-bearing fractures and fissures at depth within the GWB.

The main recharge mechanism for the GWB is via diffuse recharge from rainwater percolating through the subsoils. According the GSI, groundwater within this GWB is generally unconfined with local groundwater flow towards the rivers and streams, and flow paths will not usually exceed a few hundred metres in length.

The GSI classifications for the aquifer in the study area, including the principal aquifer characteristics are summarised in Table 9.7, and shown on Figure 9.3. All aquifers in the study area are bedrock aquifers; there are no gravel aquifers within the study area (i.e., a gravel deposit of greater than $1km^2$ with a saturated thickness of greater than 5m).

Table 9-7: Summary of Aquifer Classifications & Characteristics

Groundwater Body	European Code	Aquifer Name	GSI Aquifer Classification	Groundwater Body Status	Transmissivity (m^2/day)	Location
Ballinhassig West	IE_SW_G_004	Unnamed	Poor Aquifer – Bedrock which is generally unproductive except for local zones	Poor	Typically, 2- 10 m^2/d	South-west, south and south-east of site
		Unnamed	Locally important aquifer- bedrock which is moderately productive only in local zones	Good	2- 20 m^2/d	Middle and north of site
Glenville	IE_SW_G_037	Unnamed	Locally important aquifer- bedrock which is moderately productive only in local zones	Good	2- 20 m^2/d	North-east of site

According to interim classification work carried out as part of the Water Framework Directive and published by the EPA, the Ballinhassig West and the Glenville groundwater body are classified as having *'Good'* status in terms of water quality and quantity. There is an area of the Ballinhassig West groundwater body that is classified as having a '*Poor'* status in terms of water quality and quantity. The overall risk for both groundwater bodies is under review by the EPA with regards to groundwater quality.

9.3.3.3 Groundwater Supply Sources

A review of published information on groundwater supply sources within the study area was undertaken to identify potential groundwater dependant receptors at potential risk from the proposed development. These include group water schemes (GWS), source protection zones and private supply wells with information on these features obtained from the GSI Groundwater database and site walkovers. It is also assumed that all houses within 1km of the site boundary have a private well for the purposes of a conservative assessment.

9.3.3.4 Source Protection Zones

The GSI maintains a database of Public Supply Source Protection Areas. From a review of the database there are no Public Supply Source Protection Areas within the proposed development site boundary.

9.3.3.5 Groundwater Wells and Springs

Based on a review of the GSI Groundwater Wells and Springs database there are 6 No. Groundwater Wells recorded (500m to 1km accuracy) within 1km of the proposed development site. It is also assumed that there is a groundwater well located at each household within 1km of the development.

Table 9.8 below outlines details of groundwater wells and springs held within the GSI dataset and those identified during site assessments within 1km of the proposed development.

Table 9-8: Summary of Wells within 1km of the Proposed Development (GSI, 2021)

Location ID	Easting (ITM)	Northing (ITM)	Type	Total Depth (m BGL)	Current Use	Yield Class	GSI Location Accuracy (km)
1107NEW004	133970	80780	Borehole	24.7	Unknown	Poor	2
1107NEW003	133980	80840	Borehole	36.6	Unknown	Poor	2
1107NEW011	134540	81230	Borehole	10.4	Agri & domestic	Poor	0.1
1107NEW002	138320	80880	Dug Well	25.9	Unknown	Poor	2
1107NEW019	138330	80850	Borehole	9.1	Agri & domestic	Poor	0.05
1107NEW012	137740	81300	Borehole	41.1	Agri & domestic	Poor	0.05

9.3.3.6 Karst Features

The underlying bedrock (Waulsortian Formation) at the eastern extent of the proposed grid connection is prone to karstification. However, according to the GSI datasets, there are no karst features recorded within the proposed site. The nearest karst feature is Tubrid Well (526034E 590928N) which is located approximately 20km to the north-west of the proposed site.

Path: R:\Map Production\2019\P2114\Workspace\EIAR\P2114_GIS_Fig9-3_GroundwaterBodies_A3.mxd

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
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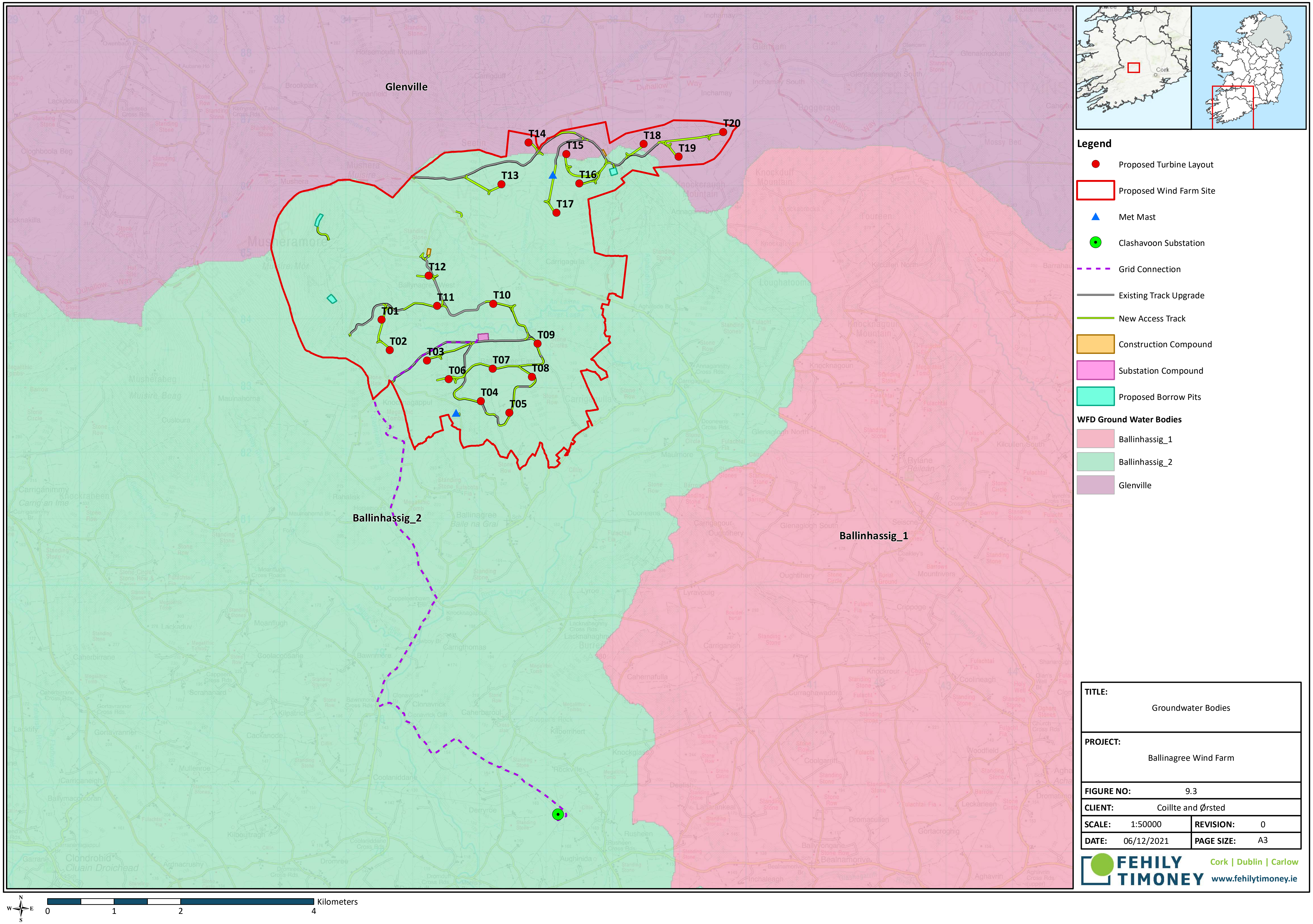

TITLE:	Groundwater Bodies
PROJECT:	Ballinagree Wind Farm
FIGURE NO:	9.3
CLIENT:	Coillte and Ørsted
SCALE: 1:50000	REVISION: 0
DATE: 06/12/2021	PAGE SIZE: A3

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Path: R:\Map Production\2019\P2114\Workspace\EIAR\P2114_GIS_Fig9-4_AquiferClassification_A3.mxd

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
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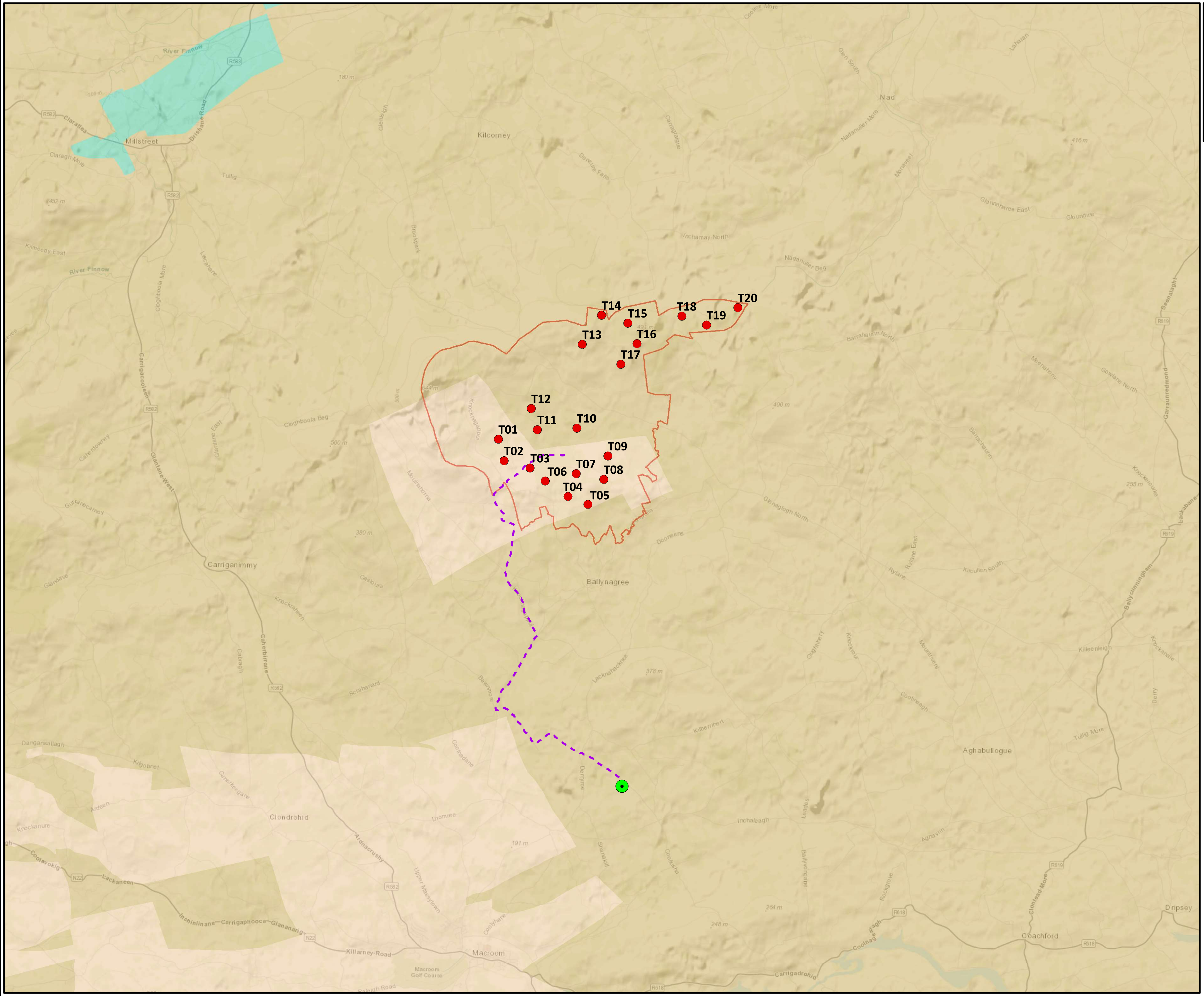

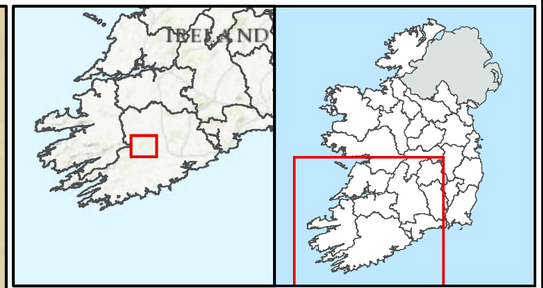

Legend

- Proposed Wind Farm Site
- Proposed Turbine Layout
- Clashavoon Substation
- Grid Connection

Bedrock Aquifers:

- LI: Locally Important Aquifer - Bedrock Mod Productive Locally
- PI: Poor Aquifer Bedrock Generally Unproductive Except Locally
- Rkd: Regionally Important Aquifer - Karstified (diffuse)

TITLE: Aquifer Classification	
PROJECT: Ballinagree Wind Farm	
FIGURE NO: 9.4	
CLIENT: Coillte and Ørsted	
SCALE: 1:80000	**REVISION:** 0
DATE: 06/12/2021	**PAGE SIZE:** A3

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Path: R:\Map Production\2019\P2114\Workspace\EIAR\P2114_GIS_Fig9-5_GroundwaterVulnerability_A3.mxd

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
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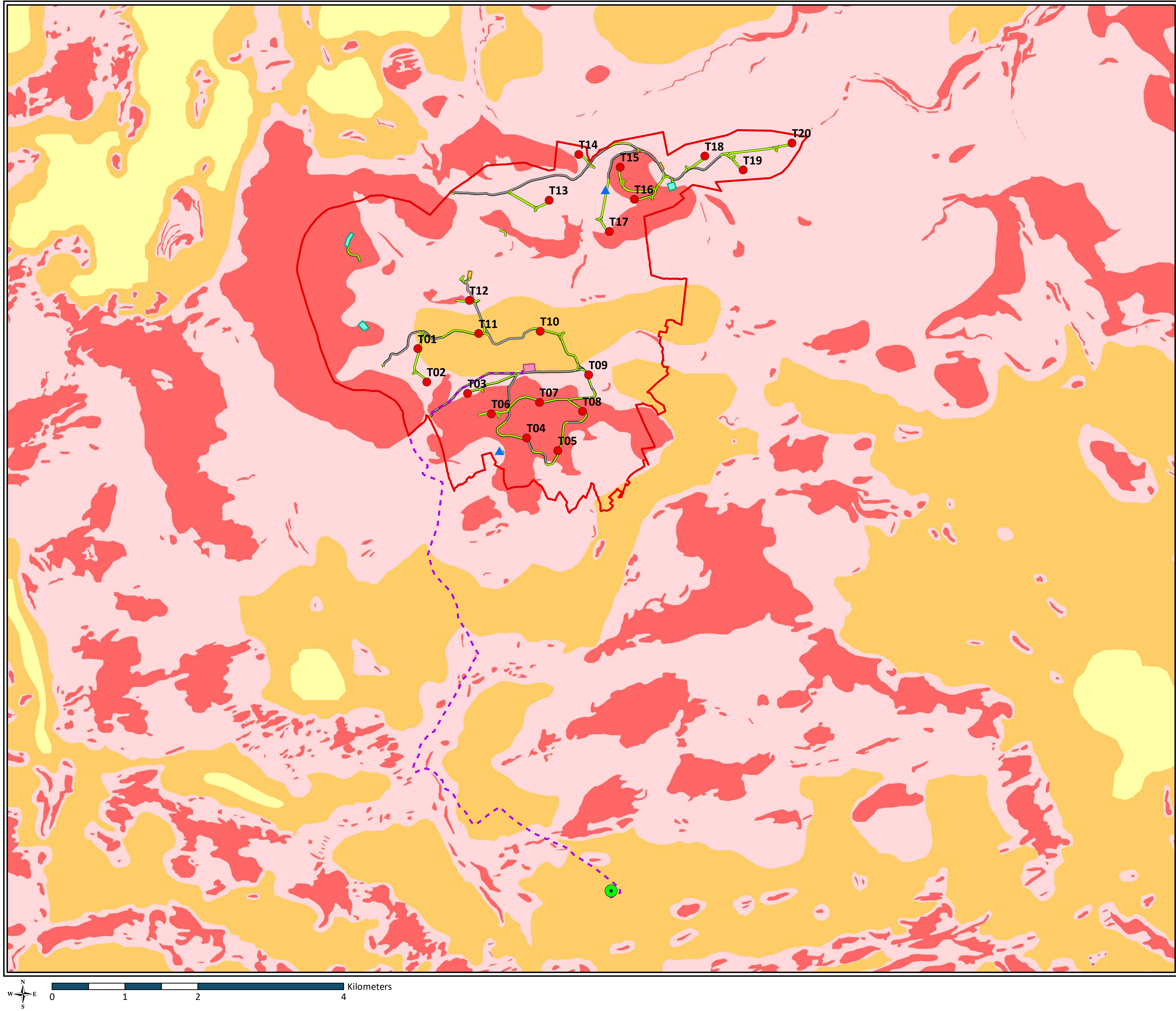

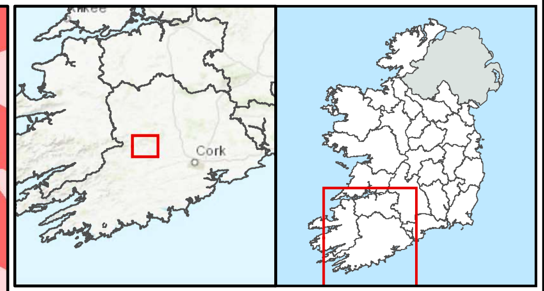

Legend

- Proposed Wind Farm Site
- Proposed Turbine Layout
- Met Mast
- Clashavoon Substation
- Grid Connection
- Existing Track Upgrade
- New Access Track
- Substation Compound
- Construction Compound
- Proposed Borrow Pits

Groundwater Vulnerability:

- E - Extreme
- H - High
- M - Moderate
- X - Rock Near Surface or Karst

TITLE: Groundwater Vulnerability			
PROJECT: Ballinagree Wind Farm			
FIGURE NO:	9.5		
CLIENT:	Coillte and Ørsted		
SCALE:	1:50000	**REVISION:**	0
DATE:	06/12/2021	**PAGE SIZE:**	A3

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9.3.4 Geological Heritage

The GSI - Irish Geological Heritage Section (IGH) and NPWS (National Parks and Wildlife Service) have undertaken a programme to identify and select important geological and geomorphological sites throughout the country for designation as NHAs (Natural Heritage Areas) – the Irish Geological Heritage Programme. This is being addressed under 16 different geological themes. For each theme, a larger number of sites (from which to make the NHA selection) are being examined, to identify the most scientifically significant. The criterion of designating the minimum number of sites to exemplify the theme means that many sites of national importance are not selected as the very best examples. However, a second tier of County Geological Sites (CGS) (as per the National Heritage Plan) means that many of these can be included in County Development Plans and receive a measure of recognition and protection through inclusion in the planning system.

The GSI Online Irish Geological Heritage database indicates that the proposed development area is not located in an area of specific geological heritage interest. The nearest site of significant geological heritage features to the study area is located approximately 3km to the east of the proposed development which is the Boggeragh Mountains. The Boggeragh Mountains is a Natural Heritage Area (NHA) that consists of upland blanket bog habitat.

The distribution of Geological Heritage sites is shown on Figure 9.6.

9.3.5 Economic Geology

The GSI Online Minerals Database accessed via the Public Data Viewer shows a number of active and historic quarries and mineral occurrences surrounding the study area. Their distribution is shown on Figure 9.7. These consist of sand and gravel quarries and recorded mineral occurrences none of which are located within the site boundary.

The nearest quarry is identified as Bweeng Quarry located near Mallow, Co. Cork. This is a Sand & Gravel quarry to the north-east of the Ballinagree site.

The GSI Aggregates database indicates that there is a very low to moderate potential for crushed rock aggregate across much of the site as shown in Figure 9.8. There is also a very low to low potential for granular aggregate across the site as shown in Figure 9.9. This means that there will be more imported material required during the construction phase of the development. The area of crushed rock aggregate with moderate potential may be beneficially used as site-won material, however testing would need to be carried out prior to using it on site. Based on the site walkovers and the ground investigations, the site-won material at the borrow pits is likely to be suitable for use as general fill. Structural fill will need to be imported to the site. Table 9-8 below displays the aggregate requirements and excavation volumes required for the site.

Table 9-8: Material Balance Tables

Infrastructure Element	Description	Peat Volume[1](m^3)	Spoil (non-peat) Volume [1] (m^3)
Material to be excavated			
20 no. Turbines and Hardstands	25m diameter excavation footprint for turbine foundation	34,351	25,708
Onsite access tracks	5m running surface with allowances for earthworks	34,488	70,000
2 no. Meteorological Mast	10 x 10m foundation footprint	0	72
Temporary Construction Compounds	Two temporary construction compounds	2,040	12,934
Substation	Substation footprint 15,750m^2	3,780	9,450
Cable Trench	1.2m x 0.9m	1,584	13,464
Borrow Pits	3 no. borrow pits.	14,400	213,600
Total material to be excavated (m^3)		**90,643**	**345,228**
		435,871	

Description	Material Volume (m3)
Total material to be excavated excluding borrow pit material[2] (m^3)	207,871
Total material to be excavated throughout the site that can be used for landscaping (m^3)	37,746
Remaining material to be excavated throughout the site excluding material that can be used for landscaping (m^3)	170,125
Borrow pit capacity (m^3)[3]	213,600
Material required for general fill throughout the site (m^3)	154,500

[1] A factor of 20% (bulking factor of 15% and contingency factor of 5%) has been applied to the excavated peat and spoil volumes to allow for expected increase in volume upon excavation and to allow for a variation in ground conditions across the site.

[2] Rock excavated from the borrow pits will be reused throughout the site and peat excavated from the borrow pits will be placed back into the borrow pits or used for landscaping

[3] Total spoil excavated from borrow pit including bulking factor

As can be seen in the above table, there is sufficient capacity in the proposed borrow pits to satisfy general fill requirements for the construction of the proposed onsite infrastructure. There is also sufficient capacity for excavated spoil material which will be generated across the site during the construction phase.

All excavated material across the site will be used to reinstate the borrow pits or used for landscaping and reinstatement purposes. Any additional general fill required for the construction of onsite infrastructure shall be imported from local quarries. Importation of material volumes from local quarries has been calculated as part of the traffic and transportation impact assessment. Details of this can be found in Chapter 13.

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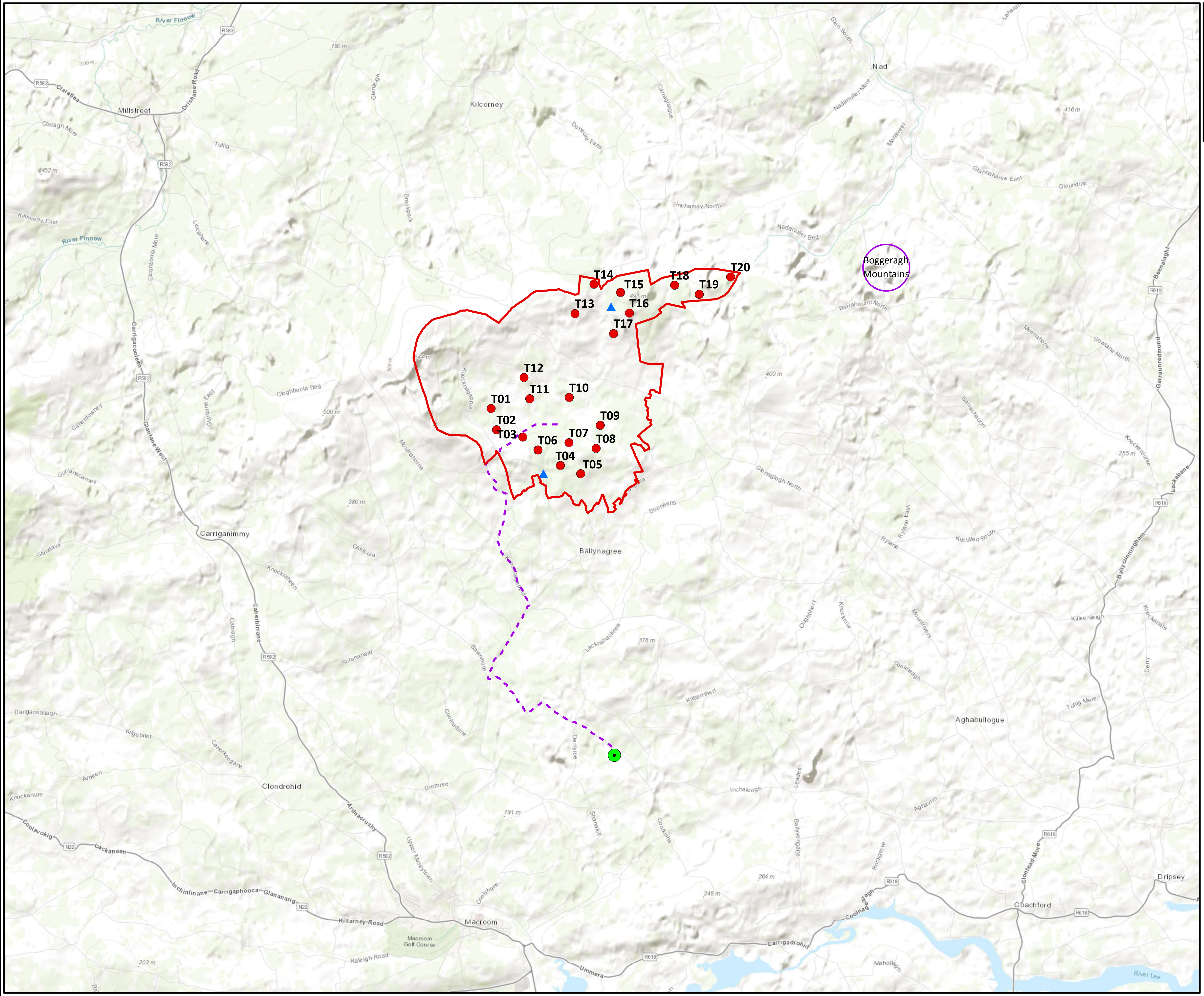
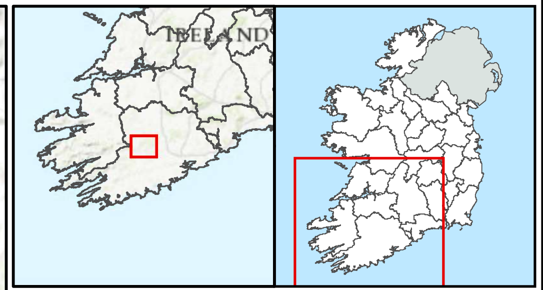
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community GSI





Legend

- Proposed Wind Farm Site
- Proposed Turbine Layout
- Met Mast
- Clashavoon Substation
- Grid Connection
- Geological Heritage Sites (Unaudited Boundaries)

TITLE:	Geological Heritage
PROJECT:	Ballinagree Wind Farm
FIGURE NO:	9.6
CLIENT:	Coillte and Ørsted

SCALE:	1:80000	REVISION:	0
DATE:	06/12/2021	PAGE SIZE:	A3

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Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
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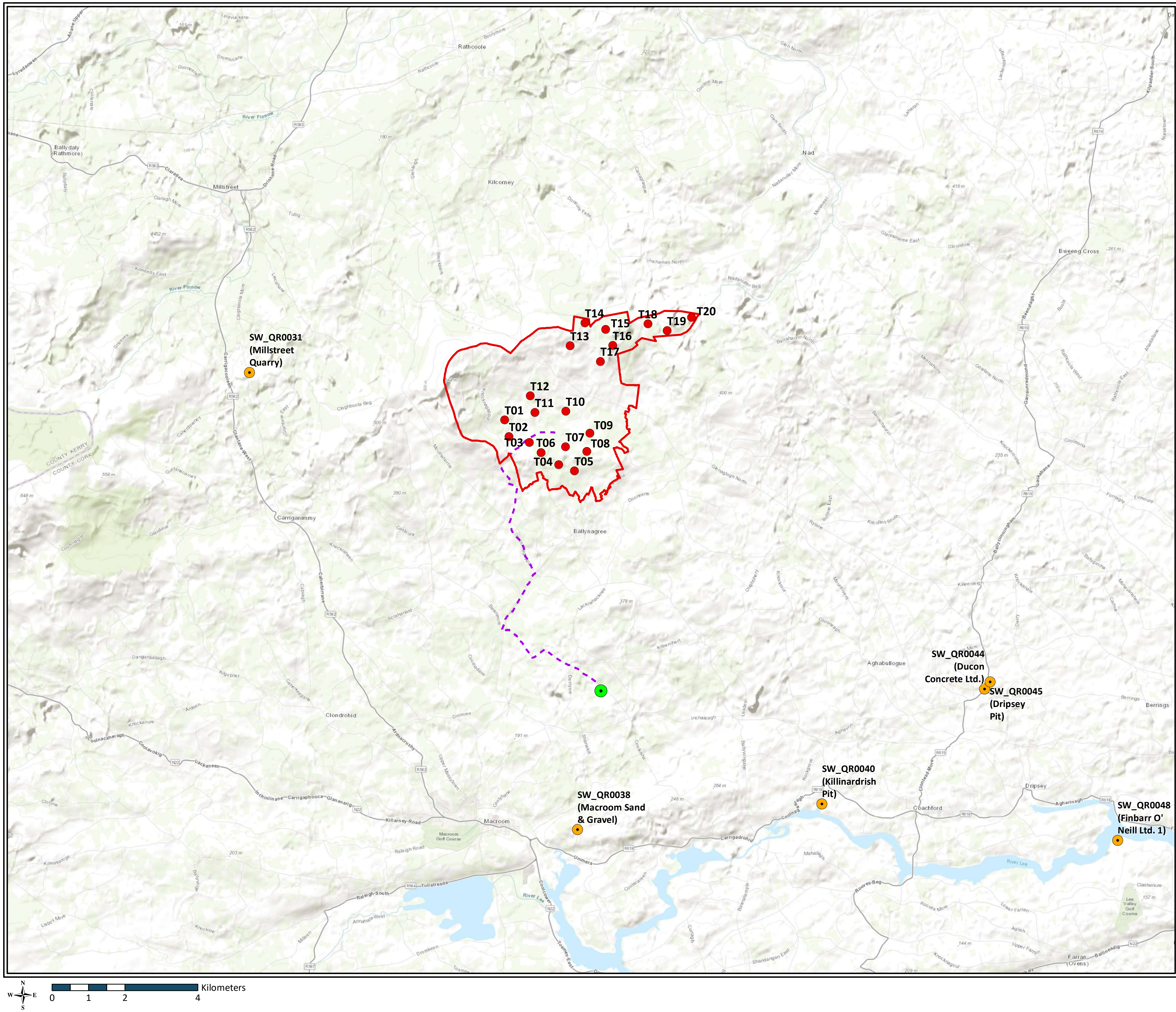

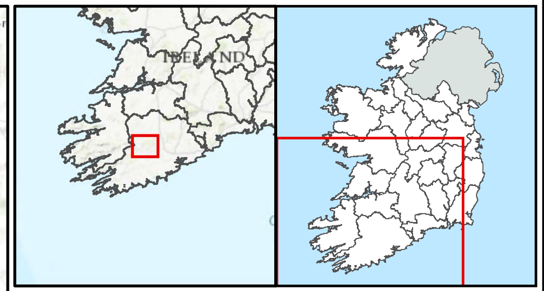

Legend

- Proposed Wind Farm Site
- Proposed Turbine Layout
- Clashavoon Substation
- Quarries
- Grid Connection

TITLE:	Economic Geology
PROJECT:	Ballinagree Wind Farm
FIGURE NO:	9.7
CLIENT:	Coillte and Ørsted
SCALE: 1:100000	**REVISION:** 0
DATE: 06/12/2021	**PAGE SIZE:** A3

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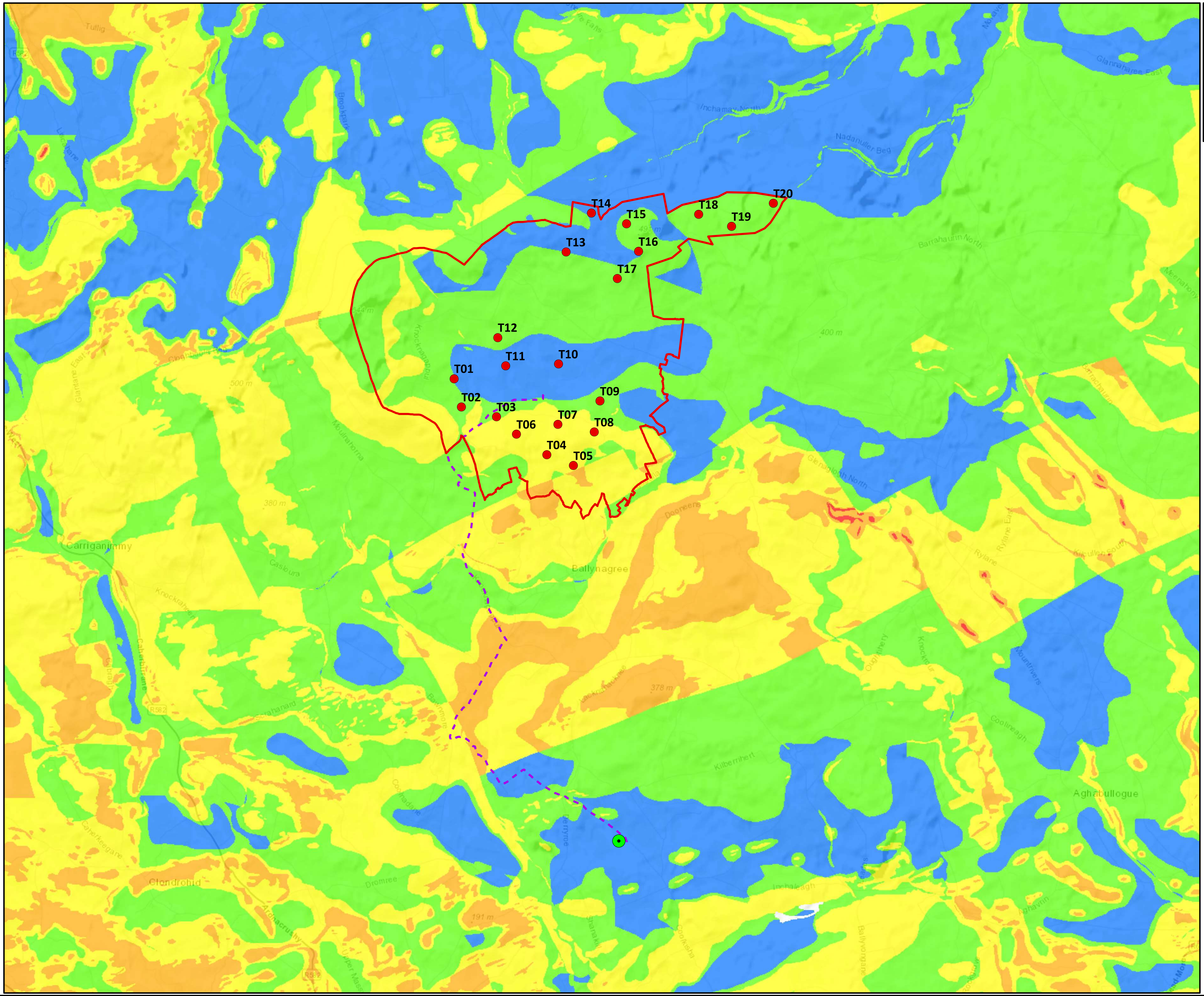

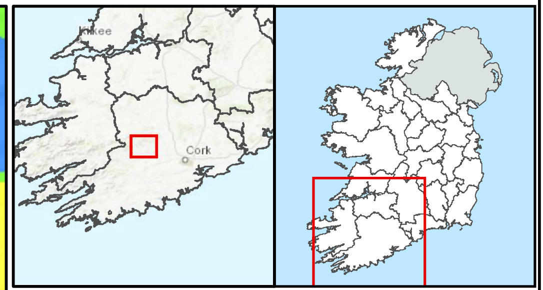

Kilometers
0 1 2 4

Legend

- Proposed Wind Farm Site
- Proposed Turbine Layout
- Clashavoon Substation
- Grid Connection

Crushed Rock Aggregate Potential

- Very High potential
- High potential
- Moderate potential
- Low potential
- Very Low potential

TITLE: Crushed Rock Potential			
PROJECT: Ballinagree Wind Farm			
FIGURE NO:	9.8		
CLIENT:	Coillte and Ørsted		
SCALE:	1:60000	**REVISION:**	0
DATE:	06/12/2021	**PAGE SIZE:**	A3

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Path: R:\Map Production\2019\P2114\Workspace\EIAR\P2114_GIS_Fig9-9_GranularAggregatePotential_A3.mxd

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
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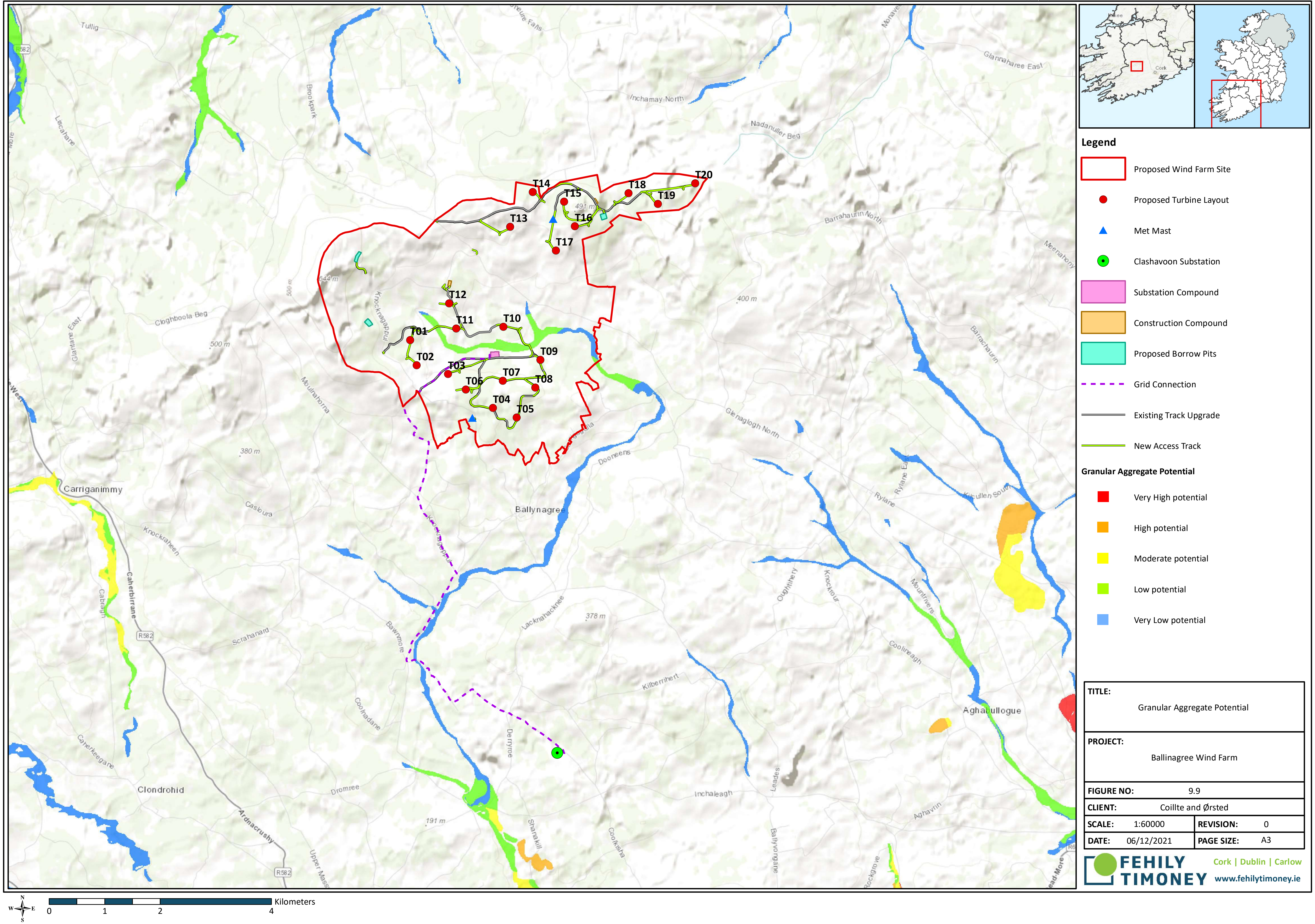

TITLE:	Granular Aggregate Potential		
PROJECT:	Ballinagree Wind Farm		
FIGURE NO:	9.9		
CLIENT:	Coillte and Ørsted		
SCALE:	1:60000	REVISION:	0
DATE:	06/12/2021	PAGE SIZE:	A3

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9.3.6 Site Investigation - Results

As outlined in Section 9.2.7 site walkovers and peat stability assessments were undertaken by an Engineering Geologist working for Fehily Timoney and Company (FT) during January and August 2020 and March 2021 to determine the baseline characteristics of the proposed development site. Intrusive site investigations were undertaken by Irish Drilling Ltd (IDL) under the supervision of an Engineering Geologist from FT during March and May 2021.

Intrusive investigations were undertaken at the proposed borrow pit locations, at selected proposed turbine locations, along the proposed access tracks. The purpose of the intrusive works was to confirm the geological succession underlying the site. The site investigations comprised the excavation of 64 no. trial pits to a maximum depth of 4.8m BGL and 5 no. rotary boreholes to a maximum depth of 15m BGL. Boreholes were carried out at all of the proposed borrow pit locations to assess the suitability of the material to be used as site-won material during construction. An additional borehole was carried out near proposed T8 location, upslope of the closest residences, to provide additional groundwater profile information in the site.

Topsoil was encountered in areas across the site during the site walkover and intrusive investigations. The Topsoil was predominantly a peaty *sandy gravelly CLAY* (0.1 to 0.8 mbgl) with areas of MADE GROUND and PEAT also present across the site. Peat deposits of an amorphous peat were found predominantly in the northern area of the site.

Peat deposits were generally noted to be limited to the northern area of the site and typical thicknesses of between 0.1 – 2.7m. Peaty topsoil was present in areas of the southern area of the site.

The Topsoil and Peat deposits described above were found to overlie Glacial Till deposits either cohesive or granular in nature. Cohesive deposits encountered typically comprised *Soft to Stiff sandy gravelly SILT with high cobble and boulder content*. The granular Glacial Till deposits encountered typically comprised *Silty sandy GRAVEL with high cobble content.*

Weathered Bedrock of the Ballytrasna Formation was encountered during site investigations at depths of between 0 to 3.8m BGL where it was typically described as comprising *Weathered SILTSTONE or SANDSTONE*.

During trial pit excavations minor shallow groundwater seepage at moderate ingress was noted in certain trial pits. Table 9.9 shows the groundwater strikes encountered during the intrusive site investigations. The remainder of site investigation locations, including rotary holes at borrow pit locations were noted as being dry during the works. A site walkover assessment summary is displayed below in Table 9.10.

Table 9-9: Summary of Groundwater Encountered

Exploratory Hole ID	Groundwater Strike (m BGL)
TP-T02	2.6
TP-T13	2
TP15	0.3
TP16	3
TP26	2
TP29	1.5

Exploratory Hole ID	Groundwater Strike (m BGL)
TP-T11	1
TP23	1
TP-T19	0.2
TP-T20	0.5
TP-T21	0.2
TP01	0.5
TP02	0.5
TP03	2
TP06	1.5
TP09	1.5
TP10	2.7
TP12	0.5
TP32	0.3
TP38	1
TP42	3

Table 9-10: Site Walkover Assessment Summary

Proposed Infrastructure	Land use	Quaternary Deposits (GSI Online Mapping)	Ground conditions encountered	Average Peat Depth (m)	Undrained Shear Strength (kpa)	Slope (degrees)	Overburden Encountered from Site Investigations	Depth to Bedrock (m) from Site Investigations	Groundwater Vulnerability (GSI Online Mapping)
T1	Forestry	Till derived from Devonian sandstones	Exposed mineral soil with gentle slopes	No peat		4	Peaty SILT overlying Silty sandy GRAVEL with cobbles	No rock met	High
T2	Agricultural	Till derived from Devonian sandstones	Soft peaty topsoil with gentle slopes	0.6	42	4	Peat overlying sandy gravelly SILT with cobbles	No rock met	Extreme
T3	Agricultural	Till derived from Devonian sandstones	Soft peaty topsoil with moderate slopes	0.6	40	12	Peat overlying SILTSTONE rock	0.8	Extreme
T4	Forestry	Bedrock outcrop or subcrop	Exposed mineral soil with gentle slopes	No peat		6	Topsoil overlying SILTSTONE rock	2.1	X – Rock Near Surface
T5	Agricultural	Till derived from Devonian sandstones	Soft peaty topsoil with gentle slopes	0.3	Too shallow	4	Peaty Made Ground overlying SILTSTONE rock	No rock met	Extreme
T6	Forestry	Bedrock outcrop or subcrop	Soft peaty topsoil with moderate slopes	0.1	Too shallow	10	Peaty overlying Silty sandy GRAVEL with cobbles	0.1	X – Rock Near Surface
T7	Agricultural	Bedrock outcrop or subcrop	Exposed mineral soil	No peat		12	Topsoil overlying silty sandy GRAVEL	2.5	X – Rock Near Surface

Proposed Infrastructure	Land use	Quaternary Deposits (GSI Online Mapping)	Ground conditions encountered	Average Peat Depth (m)	Undrained Shear Strength (kpa)	Slope (degrees)	Overburden Encountered from Site Investigations	Depth to Bedrock (m) from Site Investigations	Groundwater Vulnerability (GSI Online Mapping)
			with moderate slopes						
T8	Agricultural	Bedrock outcrop or subcrop	Exposed mineral soil with gentle slopes	No peat		4	Topsoil overlying silty sandy GRAVEL	2.5	X – Rock Near Surface
T9	Agricultural	Till derived from Devonian sandstones	Exposed mineral soil with gentle slopes	No peat		6	Topsoil overlying silty sandy GRAVEL	No rock met	Extreme
T10	Agricultural	Till derived from Devonian sandstones	Exposed mineral soil with gentle slopes	No peat		6	Topsoil overlying silty sandy GRAVEL	No rock met	High
T11	Forestry	Till derived from Devonian sandstones	Exposed mineral soil with gentle slopes	No peat		6	Topsoil overlying silty sandy GRAVEL	No rock met	High
T12	Forestry	Till derived from Devonian sandstones	Exposed mineral soil with gentle slopes	0.3	Too shallow	8	Peat overlying gravely SAND	1.6	Extreme
T13	Agricultural	Blanket Peat	Peat with a moderate to steep slope	0.5	44	14	Peat overlying silty sandy GRAVEL	No rock met	Extreme
T14	Agricultural	Blanket Peat	Peat with a gentle slope	1	26	8	Peat overlying silty sandy GRAVEL	3.8	Extreme

Proposed Infrastructure	Land use	Quaternary Deposits (GSI Online Mapping)	Ground conditions encountered	Average Peat Depth (m)	Undrained Shear Strength (kpa)	Slope (degrees)	Overburden Encountered from Site Investigations	Depth to Bedrock (m) from Site Investigations	Groundwater Vulnerability (GSI Online Mapping)
T15	Forestry	Bedrock outcrop or subcrop	Peat with a gentle slope	0.5	32	6	Peat overlying silty sandy GRAVEL	No rock met	X – Rock Near Surface
T16	Agricultural	Bedrock outcrop or subcrop	Peat with a moderate to steep slope	0.3	Too shallow	16	Peat overlying sandy gravelly SILT	1	X – Rock Near Surface
T17	Agricultural	Bedrock outcrop or subcrop	Peat with a moderate to steep slope	0.6	60	12	Peat overlying silty sandy GRAVEL	2	X – Rock Near Surface
T18	Forestry	Blanket Peat	Peat with a gentle slope	2	28	2	Peat overlying silty sandy GRAVEL	No rock met	Extreme
T19	Forestry	Blanket Peat	Peat with a gentle slope	0.4	62	2	Peat overlying sandy gravelly SILT	1.4	Extreme
T20	Forestry	Blanket Peat	Peat with a gentle slope	1	42	4	Peat overlying silty sandy GRAVEL	No rock met	Extreme
Substation	Forestry	Till derived from Devonian sandstones	Peaty topsoil with a gentle slope	0.2	Too shallow	2	Peat overlying silty sandy GRAVEL	No rock met	High
BP1	Forestry	Bedrock outcrop or subcrop	Peaty topsoil with a moderate to steep slope	0.3	Too shallow	14	Peat overlying silty sandy GRAVEL	No rock met	X – Rock Near Surface
BP2	Forestry	Bedrock outcrop or subcrop	Exposed mineral soil	No peat		16	Peat overlying silty sandy GRAVEL	No rock met	X – Rock Near Surface

Proposed Infrastructure	Land use	Quaternary Deposits (GSI Online Mapping)	Ground conditions encountered	Average Peat Depth (m)	Undrained Shear Strength (kpa)	Slope (degrees)	Overburden Encountered from Site Investigations	Depth to Bedrock (m) from Site Investigations	Groundwater Vulnerability (GSI Online Mapping)
			with gentle slopes						
BP3	Forestry	Till derived from Devonian sandstones	Peat with a gentle slope	0.9	34	4	Peat overlying silty sandy GRAVEL	1.8	Extreme

9.3.7 Existing Slope Stability – Cable Route

During the site walkovers a series of hand-held probes were undertaken to determine the presence/depth of peat and/or soft soils within the proposed Ballinagree Wind Farm site. From a desk top review of the proposed grid connection route, the majority of the proposed route is situated within existing public roadway. As such and given the limited extent of lateral and vertical excavations, it was not considered a risk was posed to slope stability along the grid connection route.

9.3.8 Topography of the Proposed Development Site

The slopes of the southern portion of the proposed development site is characterised by elevated lands with typical elevations of between 323m to 430m AOD with steep to moderate slopes to the west of the site boundary. Slopes within the proposed development and at proposed infrastructure locations generally range from between 2 to 16 degrees.

The northern portion of the proposed development which includes turbine locations T13 to T20 comprises elevated lands sloping relatively steeply to the south (ranging from 2 to 18 degrees). Slopes at all of the proposed infrastructure locations in the northern area range from 2 to 16 degrees.

Slopes at proposed turbine locations in this portion of the development range from gentle (2 degrees) to moderate with a maximum slope angle of 16 degrees at turbine T16. Slopes at the proposed borrow pits BP01, BP02 (western area of the site) are considered moderate to steep with slopes of 14 and 16 degrees, respectively. Slopes along the access roads range from 2 to 18 degrees.

Path: R:\Map Production\2019\P2114\Workspace\EIAR\P2114_GIS_Fig9-10_LandslideSusceptibility_A3.mxd

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
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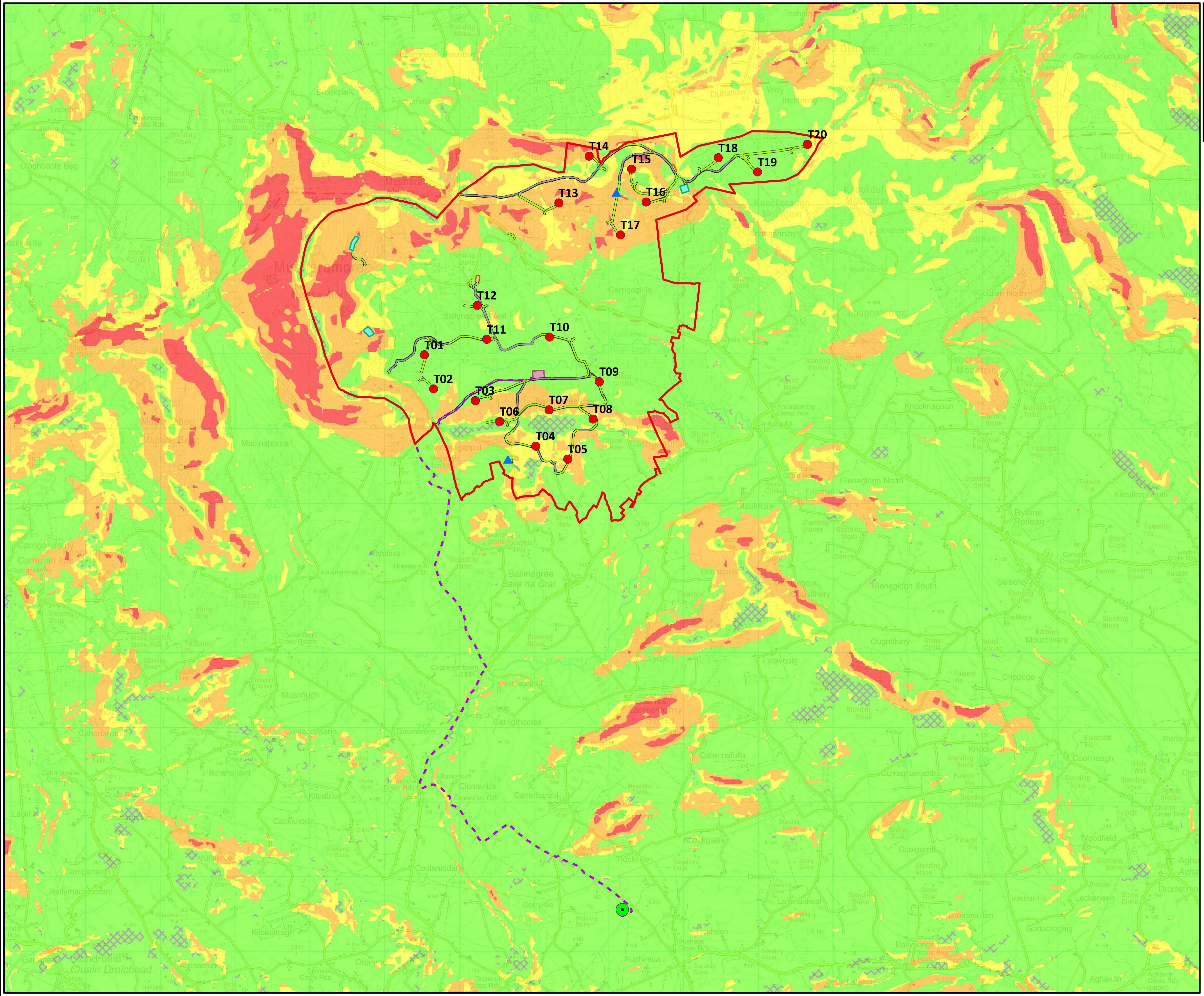

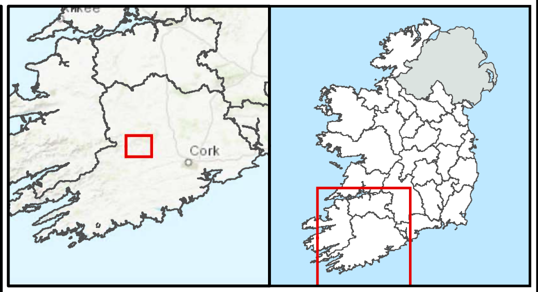

Legend

- Proposed Wind Farm Site
- Proposed Turbine Layout
- Met Mast
- Clashavoon Substation
- Grid Connection
- Existing Track Upgrade
- New Access Track
- Substation Compound
- Construction Compound
- Proposed Borrow Pits

Landslide Susceptibility:

- Low
- Low (inferred)
- Moderately Low
- Moderately High
- High

TITLE:	Landslide Susceptibility
PROJECT:	Ballinagree Wind Farm
FIGURE NO:	9.10
CLIENT:	Coillte and Ørsted
SCALE: 1:50000	REVISION: 0
DATE: 06/12/2021	PAGE SIZE: A3

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9.3.9 Slope Stability Assessment

From a review of the online GSI Landslide Susceptibility database, the proposed development and proposed infrastructure locations are generally located within areas of 'Low' to 'Moderately High' susceptibility. The mid-section and north-eastern most area of the site is classed as 'Low' with a strip of the southern-most area and the northern area classed as 'Moderately High'. The western-most part of the site where the borrow-pits are located is classed as 'Moderately High'. A summary of the GSI landslide susceptibility with respect to the proposed development is provided in Figure 9.10.

There was no evidence of active or historical slope instability observed across the site during the site walkover. There are no historical records of landslide activity within or close to the site, according to the GSI database. The GSI information is based on a national dataset and has been superseded following a more recent walkover and study of the area. The site walkover and ground investigations including trial pits and boreholes, peat probing and shear vane testing were all carried out across the site along with a detailed slope stability assessment that resulted in the Factor of Safety across the site to be above the minimum recommended 1.3 limit, indicating a low risk of slope instability. Both peat stability and general slope stability are included in this assessment.

Site investigations completed at the proposed borrow pit locations comprised the advancement of trial pits to refusal at each location and rotary core drilling to 15mbgl. Rock was not met at these locations during the trial pitting works. There was a shallow peaty topsoil overlying a coarse silty sandy GRAVEL with low cobble content. Siltstone Rock was encountered in all proposed borrow pit locations during the rotary core drilling at depths ranging from 0.7 to 5 mbgl. The upper layers of the Siltstone were described as '*weathered'* whereas beneath this there were layers of *'strong locally sandy SILTSTONE'*.

A more detailed summary of the site investigations completed at these locations and the results of the slope stability assessment are included in the Geotechnical and Peat Stability Assessment Report in Appendix 9.1 of the EIAR. The purpose of the stability analysis was to determine the stability i.e. Factor of Safety (FoS), of the peat slopes. The FoS provides a direct measure of the degree of stability of a peat slope. A FoS of less than 1.0 indicates that a slope is unstable; a FoS of greater than 1.0 indicates a stable slope. An acceptable FoS for slopes is generally taken as a minimum of 1.3. The stability analysis for this project, which analysed the turbine locations, access roads and borrow pits, resulted in a FoS above the minimum acceptable value of 1.3 and hence the site has a satisfactory margin of safety.

9.3.10 Peat Stability Assessment

Following the site walkover and given the presence of Peat deposits and peaty Topsoil within the proposed development boundary, a review of the published checklist for peat landslide hazard and risk assessment was carried out. This was undertaken in accordance with the following best practice guidance: Scottish Executive – Peat Landslide Hazard and Risk Assessments (2017).

The potential for a landslide risk is defined in the Scottish Executive "Peat Landslide Hazard and Risk Assessments, Best Practice Guide for Proposed Electricity Generation Developments" (2017) as the following:

- *Peat is present at the development site in excess of 0.5m depth, and;*
- *There is evidence of current or historical landslide activity at the site, or;*
- *Slopes > 2° are present on-site, or;*
- *The works will impinge on the peat covered areas and cannot be relocated to avoid peat covered areas.*

A peat survey was carried out by an FTC Engineering Geologist during January and August 2020 and during March 2021. Thin Blanket Peat deposits were encountered in localised areas during site walkovers. The peat deposits ranged in depth from 0.2 to 3m and the peat is predominantly located in the north and north-eastern area of the site.

Soft Peaty Topsoil deposits were noted at proposed infrastructure locations within the southern part of the site, but these were generally very thin (0.1 to 0.6m thick) and were not considered to constitute Peat Deposits but rather a highly organic Peaty Topsoil.

Due to the slope angles and peat depths found in the north and north-east of the site and in accordance with the Scottish Executive Best Practice Guide for Proposed Electricity Generation Developments (2017) where '*peat deposits >0.5m in depth*' were encountered and '*Slopes > 2° are present on-site',* a peat stability assessment was deemed necessary.

9.3.11 Soil Contamination

There are no known areas of soil contamination on the proposed development site or the grid connection route. No evidence of soil contamination was noted during site walkovers. As agricultural/forestry equipment is used across much of the proposed development site it is possible that minor fuel spills and leaks have occurred locally in the past.

Further, due to the presence of local roads within the study area and along the proposed grid connection route there is a risk of fuel leakages and other highway related contamination in the upper soils.

9.4 Potential Effects

The potential effects on the underlying land, soils and geology at the site are assessed in the following sections for the activities associated within each phase (construction, operation and decommissioning) for the proposed Ballinagree Wind Farm as described in Chapter 3.

The potential impacts are assessed in accordance with the evaluation criteria outlined in Section 9.1. The unmitigated potential impacts are summarised in Tables 9.8 and 9.9. The proposed mitigation measures are then considered to reduce or eliminate potential impacts.

9.4.1 Do Nothing Impact

If the proposed Ballinagree Wind Farm were not constructed, it is likely that the current land uses will continue for the foreseeable future. The impact on the Land, Soils and Geology would remain largely unaltered as a result.

9.4.2 Construction Phase

The following on-site activities have been identified as the sources of potential impacts on the existing geological and hydrogeological conditions during the construction phase of the proposed development and are discussed in the sub-headings below:

- Tree Felling;
- Earthworks;
- Borrow Pits;
- Slope Stability;
- Internal Cabling and Grid Connection;
- Horizontal Directional Drilling (HDD) Under Existing Structure;
- Turbine Delivery Route (TDR).

9.4.2.1 Tree Felling

An area of the proposed development site comprises commercial coniferous forestry.

Felling of approximately 70ha of coniferous forestry is required within and around the wind farm infrastructure to accommodate the construction of some turbines, hardstands, crane pads, access tracks, onsite substation, borrow pits, grid connection, temporary compounds and permanent met masts. A total of 10 No. turbines are located within forestry and consequently tree felling will be required as part of the project. A further 18ha of coniferous forestry felling shall be carried out as part of the Biodiversity Enhancement Management Plan measures. The total felling area associated with the project is therefore 88ha.

Proposed tree felling will involve the use of heavy felling machinery and exposure of underlying soils to surface water runoff, which could result in soil erosion. This also could lead to an increase in sediment and nutrient concentrations in the surface water run-off which may in turn impact groundwater in the Locally Important Aquifer beneath the proposed development site.

The use of plant and machinery during tree felling works will require the storage and use of fuels and oils. Their storage and use present potential for spills and leaks which could contaminate underlying exposed soils and groundwater.

The magnitude of these potential impacts, prior to mitigation, is considered to be of **Moderate significance.**

9.4.2.2 Earthworks

The proposed Ballinagree Wind Farm development will require construction phase earthworks associated with the excavation of turbine bases, removal of overburden deposits for the construction of turbine foundations, temporary site compounds, sub-stations, grid connection trenches, turbine hard standings, borrow pits, internal access roads and permanent met masts. Temporary accommodation works will also be required along the proposed turbine delivery route such as hedge or tree cutting, relocation of powerlines/poles, lampposts, signage and local road widening.

As such there is the potential for impact to Land, Soils and Geology from the excavation and movement of existing Glacial Till deposits during the construction phase of the proposed development.

The following earthworks excavations will be required:

- Excavation of Topsoil and Peaty Topsoil deposits
- Excavation of Glacial Till to bedrock (as required)
- Excavation of Peat to bedrock (as required)

The following filling and material deposition operations will be required:

- Deposition of surplus topsoil and Glacial Till deposits in berms for reinstatement purposes around turbine bases, hardstands and borrow pits
- Importation and Filling of site won and imported General Fill and Engineering Aggregates

Turbines of the size proposed for the Ballinagree Wind Farm have foundation depths in the order of 3m and diameters in the order of 25m.

During the trial pitting ground investigations, a suitable bearing stratum was encountered within 3m from ground surface so the turbine foundation can be finished at / near existing ground level.

Some temporary stockpiles (not exceeding 2m in height) of material will be necessary adjacent to the excavation areas prior to reinstatement, however no long-term stockpiles of material will remain after construction and no surplus/waste soil or rock will be removed from the proposed project site. Temporary stockpiles should be shaped and sealed to prevent the ingress of water from rainfall.

To mitigate against the compaction of soil at the site, prior to the commencement of any earthworks, the work corridor will be pegged, and machinery will stay within this corridor so that peatland/soils outside the work area are not damaged. Excavations will then be carried out from access tracks as they are constructed in order to reduce the compaction of soft ground.

To mitigate against erosion of the exposed soil or rock, all excavations will be constructed and backfilled as quickly as possible. Excavations will stop during or prior to heavy rainfall events (>10mm/hour). To mitigate against possible contamination of the exposed soils and bedrock, refuelling of machinery and plant will only occur at designated refuelling areas. Further details on soils management and the temporary stockpiles can be found in section 3.6.2.2 of Chapter 3 of this EIAR and the Soils Management Plan contained within section 4.3.4 of the CEMP in Appendix 3-1.

It is proposed that all onsite materials excavated shall be retained on site and re-used where suitable as part of the construction phase to minimise the import materials requirements.

Surplus Topsoil and Glacial Till recovered from excavations will be used for the reinstatement of the proposed borrow pits and for reinstatement proposed around turbine bases and hardstands.

Direct impacts to the existing geological regime associated with the construction phase of the proposed development are:

- Soil compaction may occur due to movement of construction traffic. This will occur particularly within areas of highly compressible soft deposits which are left in-situ during the construction phase, such as the northern area of the site where there is peat present. This could lead to an increase in surface water runoff due to reduced infiltration of rainfall and subsequently to an increase in erosion of overburden deposits left in-situ.
- The use of plant and machinery during construction will require the storage and use of fuels and oils. Their storage and use present potential for spills and leaks which could contaminate underlying exposed soils.

- During construction, imported engineering fill and excavated soils will be exposed in excavations and in temporary stockpiles. These soils will be subject to erosion by wind and rain which could deposit silt in streams with an indirect impact on surface water quality.

The magnitude of these potential impacts, prior to mitigation, is considered to be of **Moderate significance.**

Direct impacts to the existing hydrogeological regime associated with earthworks associated with the construction phase of the proposed development are:

- Potential for groundwater pollution from the removal of overburden deposits particularly at proposed turbine and borrow pit locations. The groundwater vulnerability underlying the proposed wind farm site and the majority of the proposed grid connection route is classified by the GSI as ranging from 'High' to 'Extreme' with areas of exposed bedrock also present in these areas. It is proposed to remove the overlying soft ground and Glacial Till deposits as outlined in the proposed design. The vulnerability of the aquifer to groundwater pollution particularly during construction stage will be increased as overburden is removed thus reducing the level of protection from groundwater pollution.
- Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer. Soil erosion as a result of exposure of soils in open excavations and temporary storage of excavated materials represents a potential impact to the underlying groundwater aquifer.

It is considered that other excavations associated with substation, temporary compound and grid connection trenches will not extend into the underlying bedrock aquifers. During the construction phase, the effect on groundwater will be negligible based on the depth of excavation required for the turbines. Any dewatering that will be required will be via sump pump and the effect will be localised to turbine locations.

The magnitude of these potential impacts, prior to mitigation, is considered to be of **Moderate significance.**

9.4.2.3 Borrow Pits

Three proposed borrow pit locations (BP01, BP02, BP03) have been identified as a potential source of site won general FILL for construction activities. The 3 No. locations were selected as potential sources of general FILL for the proposed development using the criteria of no/ shallow peat deposits, no environmental constraints, aggregate potential and proximity to existing access tracks and proposed infrastructure.

Each proposed borrow pit location is underlain by the Ballytrasna Formation which is classified by the GSI as being of 'Low' potential for crushed rock aggregate. However, intrusive site investigations undertaken at the proposed borrow pit locations identified overburden deposits comprising Gravels and Sands and Weathered Bedrock potentially suitable for use as General FILL for the construction of the proposed development. Bedrock excavated from the borrow pits will be suitable for reuse as a Class 1 fill material (well graded, granular material) in hardstands and access roads.

The proposed borrow pits will each have a footprint area of approximately 1ha. This will provide a potential volume of approximately 213,600m^3 of site won General FILL based on an aggregate (bedrock) resource thickness of up to 6.5m at each of the borrow pits.

At each borrow pit location approximately 1.0m of overburden material will be required to be stripped to access the underlying deposits. This material will be temporarily stockpiled prior to re-use in the reinstatement of the borrow pits. No permanent stockpiles of material will remain after construction.

Direct impacts to the existing environment associated with the proposed borrow pits include:

- Potential for groundwater pollution from the removal of overburden deposits particularly at proposed borrow pit locations. The groundwater vulnerability underlying the proposed wind farm site and the majority of the proposed grid connection route is classified by the GSI as ranging from 'High' to 'Extreme' with areas of exposed bedrock also present in these areas. It is proposed to remove the overlying Peat and Glacial Till deposits as outlined in the proposed design.

  The vulnerability of the aquifer to groundwater pollution particularly during the construction stage will be increased as overburden is removed thus reducing the level of protection from groundwater pollution.
- Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer. Soil erosion as a result of exposure of soils in open excavations and temporary storage of excavated materials represents a potential impact to the underlying groundwater aquifer.
- The extraction of rock from the borrow pits will represent a reduction in the availability of an exhaustible resource. The crushed rock potential across the site is classified as 'very low' to 'moderate', indicating that the bedrock in the area is not considered to be of high quality, and is not readily available due to the lack of bedrock exposures at the surface.

The magnitude of these potential impacts, prior to mitigation, is considered to be of **Moderate** significance.

9.4.2.4 Potential Effects of Slope Instability

The proposed development and proposed infrastructure locations are generally located within areas of 'Low' to 'Moderately High' susceptibility, according to the GSI. The mid-section and north-eastern most area of the site is classed as 'Low' with a strip of the southern-most area and the northern area class as 'Moderately High. The western-most part of the site where two of the borrow-pits are located is classed by the GSI as 'High'. This was investigated during the site walkovers where slope angles were taken and ranged from 4 to 16 degrees. On completion of the site walkovers and slope stability assessment at the proposed borrow pit locations it was determined that there is a low risk of potential instability.

Slopes at the proposed borrow pit and turbine locations were selected for slope stability assessment in accordance with the principals of Eurocode 7 (IS EN 1997-1). The results of those analyses are summarised in the Geotechnical and Peat Stability Assessment Report in Appendix 9.1 of the EIAR. The purpose of the stability analysis was to determine the stability i.e. Factor of Safety (FoS), of the peat slopes. The FoS provides a direct measure of the degree of stability of a peat slope. A FoS of less than 1.0 indicates that a slope is unstable; a FoS of greater than 1.0 indicates a stable slope. An acceptable FoS for slopes is a minimum of 1.3.

Peat thicknesses recorded during the site walkover ranged from 0 to 3m with an average depth of 0.6m. 85% of the probes recorded peat depths of less than 1.0m. 95% of peat depth probes recorded peat depths of less than 2.0m. A number of localised readings were recorded where peat depths range from 2.0 to 3m.

Peat probing was focused on areas of the site where peat was identified during the site walkover and desk study (the northern area of the site). Average peat depth is given for the probes carried out, which may be higher than the actual average peat depth for the site.

An analysis of peat sliding was carried out at the main infrastructure and borrow pit locations across the site for both the undrained and drained conditions. The purpose of the analysis was to determine the Factor of Safety (FoS) of the peat slopes.

For the undrained and drained analyses, the calculated FoS for the infrastructure locations, showed that all locations have an acceptable FoS of greater than 1.3, indicating a low risk of peat failure. The undrained analysis would be considered the most critical condition for the peat slopes. A summary table of the peat properties collected from site walkovers is presented below in Table 9.11.

The stability analysis for this project, which analysed the turbine locations, access roads and borrow pits, resulted in FoS above the minimum acceptable value of 1.3 and hence the site has a satisfactory margin of safety.

Following the site walkover, a review of the published checklist for peat landslide hazard and risk assessment was carried out, as outlined in Figure 1.1 of the Scottish Executive – Peat Landslide Hazard and Risk Assessments (2017). As >0.5m of peat has been recorded on the site and slopes greater than 2 degrees are present, a peat stability assessment was undertaken for the proposed development and is available in Appendix 9.1 of the EIAR.

Direct impacts to the existing environment associated with potential slope instability and failure include:

- Slope failures have the potential to impact the existing geological conditions from the removal and deposition of landslide/slope failure material and the exposure of underlying overburden deposits and bedrock to an increase in surface water runoff and subsequent increase in erosion. Slope failure also has the potential to have an impact on the safety of construction workers and forestry workers that could be in the vicinity of a landslide/slope failure event, existing infrastructure (roads, access tracks), streams and rivers, dwellings, the public, livestock and wildlife and areas designated for environmental protection.
- The impact of a slope failure could potentially result in the influx of acidic waters into downgradient surface water features resulting in a decrease in the receiving water's pH values. This could also cause an inflow of silt into nearby watercourses. This may impact groundwater quality in the underlying Locally Important Aquifer and in any groundwater abstractions in the vicinity of a landslide event.

The magnitude of these potential impacts, prior to mitigation, is considered to be of **negligible significance.**

Table 9-11: Summary of Peat Properties at Proposed Infrastructure Locations

Turbine	Easting	Northing	Peat Depth Range (m) (1)	Average Peat Depth (m)	Undrained Shear Strength (kpa)	Slope Angle (°) (2)
T1	534501	584042				4
T2	534621	583586	0.3-0.8	0.6	42	4
T3	535181	583428	0.5-0.6	0.6	40	12

Turbine	Easting	Northing	Peat Depth Range (m) (1)	Average Peat Depth (m)	Undrained Shear Strength (kpa)	Slope Angle (°) (2)
T4	535989	582819				6
T5	536420	582647	0.2-0.3	0.3		4
T6	535505	583151	0.2-0.3	0.1		10
T7	536168	583308				12
T8	536754	583185				4
T9	536843	583683				6
T10	536178	584279				6
T11	535332	584249				6
T12	535205	584703	0.2-0.4	0.3		8
T13	536298	586077	0.5-0.6	0.5	44	14
T14	536707	586702	0.5-1.5	1	26	8
T15	537272	586528	0.4-0.6	0.5	32	6
T16	537466	586089	0.2-0.4	0.3		16
T17	537125	585649	0.6-0.7	0.6	60	12
T18	538431	586680	1.7-2.3	2	28	2
T19	538959	586490	0.2-0.6	0.4	62	2
T20	539629	586861	0.8-1.3	1	42	4
BP1	533661	533661	0.1-0.4	0.3		14
BP2	533503	533503	0.2-0.3	0.3		18
BP3	533478	533478				16
BP4	537925	537925	0.8-1	0.9	34	4

9.4.2.5 Internal Cabling and Grid Connection

As outlined in Chapter 3 of this EIAR, electricity generated from the wind turbines across the site will consist entirely of underground electrical cable, communication cables and associated ducting, and will connect the on-site substation to the existing 110/220kV substation at Clashavoon.

Connection works to Clashavoon substation will involve the installation of ducting, joint bays and ancillary infrastructure and the subsequent running of cables along the existing road network. This will require excavation, laying of cables and subsequent reinstatement of trenches and road surfaces.

A similar construction methodology will apply for cable trenches laid within site access tracks. In this case the cable-ducts will generally be laid when the track is being constructed and will follow the edge of the site access tracks. The trenches within these locations will generally be backfilled using the excavated material.

Direct impacts to the existing environment associated with the proposed internal cabling and grid connection works include:

- The proposed gird connection, associated excavations and ducting may present a preferential pathway for the movement of groundwater and/or contamination in the subsurface.
- The excavations for the grid connection trenches and joint bays can have a direct impact on the exposed soils and rock in the form of increased erosion from surface water ingress.

Given that the open sections of the trench will be backfilled following the installation of each section of ducting the magnitude of these potential impacts, prior to mitigation, is of **Slight** Significance.

9.4.2.6 Horizontal Directional Drilling (HDD) Under Existing Watercourse

HDD will be employed at up to 4 No. locations along the proposed grid connection route, crossing existing watercourses.

The process will involve setting up a small, tracked drilling rig on one side of the watercourse, within the verge, and at least 10m back from the stream bank. A shallow starter pit will be excavated at the point of entry and will be located at a sufficient distance from the watercourse to achieve a minimum clearance depth below the bed of the watercourse.

A pilot hole will be bored as per the agreed alignment and shall be tracked and controlled using a transmitter in the drill head. By tracking the depth, position and pitch of the drill head the operator can accurately steer the line of the drilling operation. When the pilot hole has been drilled to the correct profile, its diameter is increased, if necessary, to match the external diameter of the cable duct. The flexible plastic ducting is then pulled through the pre-drilled hole and sealed at each end until required for cable installation.

The depth of the bore will be at least 3m below the level of the public road and stream bed. A pre-construction survey of buried services within the public road will be carried out by the contractor prior to commencement of the operation to confirm the conditions predicted in this EIAR.

Direct impacts to the existing environment associated with the proposed HDD works include:

- Potential for contamination to groundwater from spills/leakages during construction phase earthworks and HDD operations. The use of construction plant and associated refuelling and storage of fuels and hydrocarbons with potential for spills or leaks could result in contamination of the underlying aquifers.
- Potential for overburden collapse at the proposed HDD locations at water crossings W06, W08 and W19 during the advancement of the HDD bore.

The magnitude of these potential impacts, prior to mitigation, is considered to be of **Moderate significance.**

9.4.2.7 Turbine Delivery Route (TDR)

The proposed turbine delivery route (TDR) will be from the Port of Foynes and is described in more detail in Chapter 13 of this EIAR.

A list of the proposed accommodation works along the TDR are highlighted in Chapter 3 of this EIAR.

The accommodation works associated with the TDR route will include minor excavations of existing overburden deposits. The potential impact would be from the exposure of the over burden and underlying bedrock to erosion via surface water ingress during the works.

Given the limited extent of excavations associated with these works the magnitude of these potential impacts, is considered to be of **Slight Significance.**

9.4.2.8 Conclusion for Effects During Construction

In summary, the overall magnitude of these potential direct impacts associated with the construction phase of the proposed development, prior to mitigation, is considered to be a Short Term, Negative Impact of **Slight** to **Moderate Significance.**

Following the identification of the potential direct impacts during the construction phase, as outlined above, mitigation measures to reduce the risk to an acceptable level are discussed in Section 9.5.2 of this Chapter.

9.4.3 Potential Indirect Impacts

Large quantities of imported granular material will be required for the proposed development. This will place a demand on local aggregate extraction facilities and at the proposed borrow pits.

The magnitude of these potential impacts, prior to mitigation, is considered to be of **Slight Significance.**

9.4.4 Operational Phase

The potential impacts on land, soils, hydrogeology and geology from the operation of the proposed development are outlined hereunder.

9.4.4.1 Potential Direct Impacts

Very few potential direct impacts are envisaged during the operational phase of the wind farm.

These include:

- Some construction traffic may be necessary for maintenance of turbines, hardstands and access tracks which could result in minor accidental leaks or spills of fuel/oil which is a potential risk to groundwater.

- The grid transformer in the substation and transformers in each turbine are oil cooled. There is potential for spills / leaks of oils/battery fluids from this equipment resulting in contamination of soils and groundwater.

The magnitude of these potential impacts, prior to mitigation, is considered to be of **Slight Significance.**

9.4.4.2 Potential Indirect Impacts

A small amount of granular material may be required to maintain access tracks during operation which will place intermittent minor demand on local quarries.

The magnitude of these potential impacts, prior to mitigation, is considered to be of **Slight Significance.**

9.4.5 Potential Impacts during Decommissioning

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

During decommissioning, it may be possible to reverse or at least reduce some of the impacts caused during construction by rehabilitating construction areas such as turbine bases and hardstanding areas. This will be done by covering with topsoil to encourage vegetation growth and reduce run-off and sedimentation.

Other impacts such as possible soil compaction and contamination by fuel leaks will remain in the longer term but will be of reduced magnitude. Nevertheless, as noted in the Scottish Natural Heritage guidance on restoration and decommissioning of onshore wind farms (SNH, 2013) reinstatement proposals for a wind farm are made over 35 years in advance, so within the lifespan of the wind farm, technological advances and preferred approaches to reinstatement are likely to change. It is therefore 'b*est practice not to limit options too far in advance of actual decommissioning but to maintain informed flexibility until close to the end-of-life of the wind farm*'.

Table 9-13: Summary of Potential Unmitigated Impact Significance on Land, Soil and Geology Attributes

Activity	Potential Impact	Receptor	Sensitivity	Prior to Mitigation	
				Magnitude	Significance
Construction Phase					
Earthworks	Removal of overburden material, open excavations and subsequent exposure underlying overburden and bedrock leading to increased erosion. Construction traffic resulting soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils. Excavation of bedrock from Borrow Pits will reduce the availability of this natural resource.	Local organic soils and Glacial Till deposits. Bedrock	Medium	Moderate Adverse	Moderate
Felling Activities	Exposure of underlying overburden leading to increased erosion. Felling machinery resulting soil compaction of soft deposits and an increase in surface water runoff resulting in increased erosion of exposed soils.	Local organic soils and Glacial Till deposits.	Medium	Moderate Adverse	Moderate
Construction of Internal Site Access Tracks, Hardstands and Temporary Compound	Open excavations, increased runoff causing erosion of underlying overburden and bedrock. Construction traffic resulting soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils. Importation of engineering fill	Local, organic soils and Glacial Till deposits. Bedrock Local quarries	Medium	Moderate Adverse	Moderate
Construction of Turbine and Substation Foundations	Open excavations, increased runoff causing erosion of underlying overburden and bedrock.	Local organic soils and Glacial Till deposits.	Medium	Moderate Adverse	Moderate

Activity	Potential Impact	Receptor	Sensitivity	Prior to Mitigation	
				Magnitude	Significance
	Construction traffic resulting soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils. Importation of engineering fill and concrete products	Bedrock Local quarries			
Construction of the Grid Connection and Internal Cabling	Removal of overburden material and exposure underlying Gravel and Bedrock to erosion. Construction traffic resulting soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils. Importation of engineering fill and concrete products Disposal of surplus excavated material to licenced facility	Local, organic soils and Glacial Till deposits. Bedrock Local quarries Licenced Waste Facilities	Medium	Small Adverse	Slight
Horizontal Directional Drilling Under Existing Watercourse	Removal of overburden material and exposure to underlying Gravel and Bedrock to erosion. Construction traffic resulting soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils. Exposure to watercourse	Local organic soils and Glacial Till deposits. Bedrock	Medium	Small Adverse	Slight
Earthworks associated with the construction of the proposed development and associated infrastructure	Slope Failure	Local organic soils and Glacial Till deposits. Bedrock	Medium	Negligible	Imperceptible
Accommodation works along TDR	Removal of overburden material and exposure of underlying Gravel and Bedrock to erosion.	Local, organic soils and Glacial Till deposits.	Medium	Small Adverse	Slight

Activity	Potential Impact	Receptor	Sensitivity	Prior to Mitigation	
				Magnitude	Significance
	Construction traffic resulting soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils. Importation of engineering fill Disposal of surplus excavated material to licenced facility	Bedrock Local quarries Licenced Waste Facilities			
Operational Phase					
Maintenance Traffic, Substation	Release of hydrocarbons or fuel spill	Local organic soils and Glacial Till deposits. Bedrock	Medium	Small Adverse	Slight
Maintenance of access tracks	Importation of engineering fill	Local quarries	Medium	Small Adverse	Slight
Cumulative Impacts					
Construction of the proposed development and associated infrastructure Potential for requirement of imported aggregate for maintenance of access tracks, landfill infrastructure.	Cumulative impacts on local quarries from extraction of fill for proposed development	Local quarries	Medium	Negligible	Imperceptible

Table 9-14: Summary of Potential Unmitigated Impact Significance on Hydrogeology

Activity	Potential Impact	Receptor	Sensitivity	Prior to Mitigation	
				Magnitude	Significance
Construction Phase					
Earthworks	Potential for ground water pollution from the removal of overburden deposits. Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer Potential for contamination to groundwater from spills/leakages during construction phase earthworks. Reduction in groundwater levels from dewatering of excavation as required during the construction phase	Ballinhassig West GWB Locally Important Bedrock Aquifer Groundwater Wells and Springs	Medium	Moderate Adverse	Moderate
Felling Activities	Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer Potential for contamination to groundwater from spills/leakages from felling machinery	Ballinhassig GWB Locally Important Bedrock Aquifer Groundwater Wells and Springs	Medium	Moderate Adverse	Moderate
Construction of Internal Site Access Tracks, Hardstands and Temporary Compound	Potential for ground water pollution from the removal of overburden deposits.	Ballinhassig GWB	Medium	Moderate Adverse	Moderate

Activity	Potential Impact	Receptor	Sensitivity	Prior to Mitigation	
				Magnitude	Significance
	Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer Potential for contamination to groundwater from spills/leakages during construction phase earthworks. Potential for ground water pollution from the use of cement-based compounds during the construction phase	Locally Important Bedrock Aquifer Groundwater Wells and Springs			
Construction of Turbine and Substation Foundations	Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer Potential for contamination to groundwater from spills/leakages during construction phase earthworks. Potential for ground water pollution from the use of cement-based compounds during the construction phase. Reduction in groundwater levels from dewatering of excavation as required during the construction phase	Ballinhassig GWB Locally Important Bedrock Aquifer Groundwater Wells and Springs	Medium	Moderate Adverse	Moderate
Construction of the Grid Connection and Internal Cabling	Potential for ground water pollution from the removal of overburden deposits. Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer	Ballinhassig and Glenville GWBs Locally and Regionally Important Bedrock Aquifers	High	Small Adverse	Moderate/Slight

Activity	Potential Impact	Receptor	Sensitivity	Prior to Mitigation	
				Magnitude	Significance
	Potential for contamination to groundwater from spills/leakages during construction phase earthworks.	Groundwater Wells and Springs			
Earthworks associated with the construction of the proposed development and associated infrastructure	Slope Failure	Ballinhassig GWB Locally Important Bedrock Aquifer Site workers, the public, dwellings, water course, livestock and wildlife Groundwater Wells and Springs	High	Moderate Adverse	Moderate
Operation					
Operational traffic, refuelling of vehicles	Some operational traffic will be necessary for maintenance plus normal operational traffic which could result in minor accidental leaks or spills of fuel/oil.	Ballinhassig GWB Bedrock Aquifer Groundwater Wells and Springs	Medium	Small Adverse	Slight

9.5 Mitigation Measures

The following section outlines appropriate mitigation measures by design and best practice to avoid or reduce the potential impact of the proposed development. Further details are given in Section 4.3.4 of the CEMP which is contained in Appendix 3.1 of Volume 3.

9.5.1 Mitigation by Design and Best Practice

With regard to the proposed development, detailed design and best practice will be implemented. As part of the preliminary design, the following was carried out:

- **Extensive peat probing to identify areas of peat deposits across the site:**

  Peat probes were taken across the site area and it was established that peat is predominantly concentrated to the northern and north-eastern areas of the site. There are areas of peaty topsoil located in the southern part of the site however the maximum depth of this peaty topsoil is 0.3m. The peat probes carried out identified areas of deeper peat (2 to 3m) and areas of steeper slopes (16 to 18 degrees) so all infrastructure locations have been selected taking these factors into account.

- **Excavation of trial pits and advancement of boreholes to establish overburden and bedrock characteristics**:

  Trial pits were carried out at each infrastructure location across the site. The reason for the trial pits was to confirm the base of the peat depth already provided by the peat probing (predominantly in the north and north-eastern areas of the site), to identify the material underlying the peat or topsoil and to inform understanding of the depth of rock. Boreholes were carried out at all proposed borrow pit locations to establish depth to bedrock and bedrock properties. The results of this ground investigation determined the finalised three borrow pit locations.

- **Shear vane testing to establish characteristic peat strengths where peat deposits were identified:**

  Shear vane tests were carried out with the peat probes taken across the site. Shear vanes were taken at every infrastructure location and at intervals along the proposed access tracks. The shear strengths were assessed and indicate that the average peat strength at all turbine locations was 41kPa. Peat strength at sites of known peat failures (assuming undrained loading failure) are generally very low, for example the undrained shear strength at the Derrybrien failure (AGEC, 2004) as derived from back-analysis, was estimated at 2.5kPa. The recorded undrained strength at the proposed development site is significantly greater than the lower bound values for Derrybrien indicating that there is no close correlation to the peat conditions at the Derrybrien site and that there is significantly less likelihood of failure on the Ballinagree Wind Farm site.

- **Peat stability assessment and investigation of peat depths and strengths across the site:**

  A peat stability risk assessment was carried out for the main infrastructure elements at the wind farm. This approach takes into account guidelines for geotechnical/peat stability risk assessments as given in PLHRA (2017) and MacCulloch (2005). The risk assessment uses the results of the stability analysis (deterministic approach) in combination with qualitative factors, which cannot be reasonably included in a stability calculation but nevertheless may affect the occurrence of peat instability, to assess the risk for each infrastructure element. The findings of the peat stability assessment displayed that the proposed development site has an acceptable margin of safety at all proposed infrastructure locations and access tracks.

Each method listed above identified key constraints across the site such as peat depths, steep slopes, areas of weak peat and locations of deeper bedrock/ unsuitable borrow pit material. Infrastructure locations were amended based on all of these factors and all of the infrastructure for the site was located to minimise slope stability risk.

9.5.2 Construction Phase

The following sections outline appropriate mitigation measures to avoid or reduce the potential impact of the proposed development.

The primary mitigation measure employed has been the design of the wind farm in terms of locating the turbines, access roads, borrow pits, material storage areas and other site infrastructure within an area of commercial forestry where the soils are extensively worked and drained. In other sites, there have been issues with instability in peat areas adjacent to forestry. However, these areas have also had areas of steep slopes in the peat covered locations. Where the peat is located in forested areas within the Ballinagree site, the topography is relatively flat. In order to reduce the impacts on geology, hydrogeology and slope stability, infrastructure has been primarily located within areas of thinner peat/soft ground. Extensive work has already been undertaken at the preliminary design stage to apply risk avoidance by design which included:

- The layout of the proposed infrastructure is based on an assessment of the existing conditions which included site investigations, peat probing, shear vane testing and layout reviews and the preliminary design has sought to minimise negative effects by avoidance.
- The excavation and construction related works will be subject to further design risk assessment at detailed design stage to confirm risk levels for the construction, operation and maintenance of the works. Identified impacts will be minimised by the application of principles of avoidance, prevention and protection.
- A detailed method statement for each element of the works will be prepared by the Contractor prior to any element of the work being carried out.
- Given that the works comprise a significant proportion of excavation and earthworks, suitably qualified and experienced geotechnical personnel will be required on site to supervise the works.
- The Contract will require programming of the works such that earthworks are not scheduled during severe weather conditions such as red weather warnings or periods of heavy rainfall and wind.

9.5.2.1 Construction Environmental Management Plan

A Construction Environmental Management Plan (CEMP) has been prepared for the proposed development and is included in Volume 3, Appendix 3.1. The CEMP defines the work practices, environmental management procedures and management responsibilities relating to the construction phase of the proposed development.

The CEMP describes how the contractor for the main construction works will implement a site Environmental Management System (EMS) to meet the specified contractual, regulatory and statutory requirements including the requirements identified as part of the environmental impact assessment process.

The CEMP will be updated prior to construction to take account of any amendments arising during the consenting process and relevant conditions attached to the planning permission and will be implemented for the duration of the construction phase of the project. The CEMP will be a live document and will be reviewed and updated as required.

Reference to relevant sections of the CEMP with respect to the mitigation of potential impacts to Land, Soils and Geology from the proposed development include and are outlined below;

Tree Felling

As outlined in Section 9.3.2.1 potential impacts to the existing environment from the proposed tree felling works have been identified. The felling works will lead to the exposure of underlying soils to surface water runoff, which could result in soil erosion. This also could lead to an increase in sediment and nutrient concentrations in the surface water run-off which may in turn impact groundwater in the Locally Important Aquifer beneath the proposed development site.

One of the primary mitigation measures to be employed at the construction phase of the development is the management of silt laden runoff. The potential impact from silt laden surface water runoff from increased erosion of exposed overburden deposits will be assessed at site-specific locations particularly at drainage locations watercourses and where tree felling works are proposed.

Details of the proposed Surface Water Management System and mitigation measures is summarised below and are also outlined in Section 4.3.5 of the CEMP in Appendix 3.1 of Volume 3.

To minimise the impact to surface water quality, existing forestry drainage will be maintained outside the immediate site area, and where appropriate additional site drainage and settlement ponds will be installed as required prior to construction activities. Silt fencing will be installed in all drainage and monitoring of water quality undertaken during the tree felling works. This is discussed in more detail in section 4.7 of appendix 10.2 of this EIAR.

The use of plant and machinery during tree felling works will require the storage and use of fuels and oils. Details of oil spill protection measures adjacent to sensitive receptors and emergency spill response procedures are outlined in Section 4.3.5. of the CEMP which is contained in Appendix 3.1 of Volume 3.

Storage tanks, used to store fuel for the various items of machinery, will be self-contained and double-walled. Refuelling of felling plant and equipment will be carried out from these tanks or from delivery vehicles at designated refuelling areas.   This is discussed in more detail in section 4.7 of appendix 10.2 of this EIAR.

Specific mitigation measures relating to the management of hydrocarbons are as follows:

- Fuels, lubricants and hydraulic fluids for equipment used on the construction site will be carefully handled to avoid spillage.
- Any spillage of fuels, lubricants or hydraulic oils will be immediately contained, and the contaminated soil removed from the site and properly disposed of.
- Waste oils and hydraulic fluids will be collected in leak-proof containers and removed from the site for disposal or re-cycling; and
- Appropriate spill control equipment, such as oil soakage pads, will be kept within the construction area in the immediate vicinity of operating machinery and in each item of plant to deal with any accidental spillage.

9.5.2.2 Earthworks

The development will be constructed in a phased manner to reduce the potential impacts of the development on the Land, Soils and Geology at the site. Phased construction reduces the amount of open, exposed excavations at any one time. Given that the works comprises a significant proportion of excavation and earthworks, suitably qualified and experienced geotechnical personnel will be required on site to supervise the works.

Details of the proposed methodology and mitigation measures is summarised below and are also outlined in Section 4.3.4 of the CEMP in Appendix 3.1 of Volume 3.

One of the primary mitigation measures employed at the preliminary design stage is the minimisation of volumes of excavated overburden deposits to be exported off site. Reduction in off-site disposal reduces impact on local landfills, reduces emissions and impacts on the local area in terms of transportation. Excavated overburden will be retained on-site and reused as far as possible.

This will include:

- Use of suitable site won material (Siltstone and Sandstone bedrock) as general fill in the construction of access tracks, hardstands and in reinstatement around turbine foundations.
- Surplus overburden will be re-used on site in the form of landscaping and for reinstatement purposes at the proposed borrow pits.

Some temporary stockpiles (not exceeding 2m in height) of material will be necessary adjacent to the excavation areas prior to reinstatement, however no long-term stockpiles of material will remain after construction and no surplus/waste soil or rock will be removed from the proposed development site. Stockpiles will be covered over during extreme rainfall to prevent any surface water contamination and should be left in place for no longer than a week at a time.

To mitigate against the compaction of soil at the site, prior to the commencement of any earthworks, the work corridor will be pegged, and machinery will stay within this corridor so that peatland / soils outside the work area are not damaged. Excavations will then be carried out from access tracks, as they are constructed in order to reduce the compaction of soft ground.

To mitigate against erosion of the exposed soil or rock, all excavations will be constructed and backfilled as quickly as possible. However, timelines for this will depend on the level of excavation required and type of materials present at each location. Temporary drainage proposed of these conditions is further discussed in section 10.6 in Chapter 10 of this EIAR. Excavations will stop during or prior to heavy rainfall events.

Soil excavated from trenches along the proposed grid connection route will be reused where possible or will be taken to a licenced facility for disposal or recycling where required. If necessary, the upper layers of tarmac and asphalt will be excavated separately to the lower engineered fill layers. The lower engineered fill layers will be reused. The tarmac / asphalt layers will be taken to a licenced facility such as Ashgrove Recycling and Waste Management, Co. Cork for disposal or recycling.

Interceptor drains will be installed prior to any construction works commencing. These will be dug from the roads as the roads progress. Temporary settlement ponds and silt management measures will be installed to mitigate against sediment run-off as required.

A location map of these settlement ponds is located in Appendix 10.2 of the surface water management plan of this EIAR. Further assessment of potential impacts to surface water discharges during the construction phase are discussed in Chapter 10 of this EIAR.

9.5.2.3 Control of Sediment Laden Runoff

The potential impact from silt laden surface water runoff from increased erosion of exposed overburden deposits will be assessed particularly at drainage locations and where earthworks and tree felling are proposed.

Details of the proposed Surface Water Management System and mitigation measures is summarised below and are also outlined in Section 4.3.5 of the CEMP in Appendix 3.1 of Volume 3.

Best practices will be employed in the prevention of silt laden run-off from entering watercourses as discussed below.

To minimise the impact to surface water quality, existing forestry drainage will be maintained outside the immediate site area, and where appropriate additional site drainage and settlement ponds will be installed as required prior to construction activities. Silt fencing will be installed in new and existing drainage and monitoring of water quality undertaken during the construction phase.

Final drainage will be constructed following the completion of these activities with silt fencing maintained until such time as a vegetation cover has become established. Chapter 10 of this EIAR discusses surface water issues in more detail.

9.5.2.4 Measures for Spills

Details of oil spill protection measures adjacent to sensitive receptors and emergency spill response procedures are outlined in Section 4.3.5 of the CEMP which is contained in Appendix 3.1 of Volume 3.

Storage tanks, used to store fuel for the various items of machinery, will be self-contained and double-walled. Refuelling of construction vehicles will be carried out from these tanks or from delivery vehicles at designated refuelling areas.

Specific mitigation measures relating to the management of hydrocarbons are as follows:

- Fuels, lubricants and hydraulic fluids for equipment used on the construction site will be carefully handled to avoid spillage.
- Any spillage of fuels, lubricants or hydraulic oils will be immediately contained, and the contaminated soil removed from the site and properly disposed of.
- Waste oils and hydraulic fluids will be collected in leak-proof containers and removed from the site for disposal or re-cycling; and
- Appropriate spill control equipment, such as oil soakage pads, will be kept within the construction area and in each item of plant to deal with any accidental spillage.

Further information on measures for spills can be found in Chapter 10 of this EIAR.

9.5.2.5 Slope Stability

With regard to slope stability issues, detailed design and construction phase best practice will be implemented as follows:

- The works will be designed and supervised by a suitably qualified and experienced geotechnical engineer or engineering geologist, and hydrologist or drainage engineer.
- Drainage infrastructure will be put in place in advance of turbine excavations. Drains will divert surface water and groundwater away from excavations into the proposed surface drainage network. Uncontrolled, direct and concentrated discharges of water onto the ground surface will be avoided.
- Loading or stockpiling on the surface of soft ground will not take place.
- Turbines located in areas adjacent to peat deposits will incorporate drainage measures such that surface water will be drained away from the peat and will not be allowed to collect adjacent to the peat mass.
- Excavation will be carried out from access roads or hardstanding areas to preclude tracking of construction plant across areas of soft ground/peat.
- A detailed reassessment of the stability of conditions at proposed infrastructure locations will be undertaken by a suitably qualified and experienced geotechnical engineer prior to the commencement of all excavations to ensure these activities do not result in or contribute to slope failure.
- Earthworks will not be commenced when heavy or sustained rainfall (orange or red weather warnings) is forecast. A series of rainfall gauges will be installed across the site to provide a record of rainfall intensity. An inspection of site stability and drainage by the Geotechnical Engineer will be carried out on site when a daily rainfall of over 10mm/hr or 25mm/day is recorded on site, works will only recommence after heavy rain with the prior approval of the Geotechnical Engineer following their inspection.
- An emergency plan will be updated at pre-construction stage detailing the action plan which would be implemented in the unlikely event of a landslide/slope failure. Should a landslide/slope failure occur or if signs of instability/ground movement are observed, work will cease immediately.

Further details are given in the CEMP included in Appendix 3.1 of Volume 3 of this EIAR.

Prior to the progression of the project to detailed design and to inform the detailed design of the proposed development, the developer will also ensure that:

- Additional and more extensive ground investigation works are undertaken, and these will be tailored to the engineering requirements of the project.
- The scheme will be developed to full detailed design prior to construction to minimise the risk of ground instability.
- Adequate time will be afforded to any designers or contractors involved in the execution of the additional ground investigation works; detailed design and construction works.

9.5.2.6 Groundwater

To mitigate against the increased vulnerability of the underlying aquifer to groundwater pollution, all excavations will be constructed and backfilled as quickly as possible. Excavations will stop during or prior to heavy rainfall events. To mitigate against possible contamination of the underlying groundwater, refuelling of machinery and plant will only occur at designated refuelling areas. Details of mitigation measures related to spills and fuel storage are outlined above.

The dewatering of the foundation excavations is not expected to cause interference with domestic wells in the area, due to large offset distances to known and presumed wells, relatively shallow depths of excavation and temporary short-term nature of dewatering, if required. To monitor groundwater during the construction phase groundwater monitoring wells will be installed between areas of deeper excavations and sensitive groundwater receptors. The wells will be used to monitoring groundwater levels and quality to assess any potential impacts during the construction works.

The GSI database is however not complete; it is probable that there are other wells in addition to those in the GSI databases, but are generally associated with houses, the offset to which from the turbines is a minimum of 750m. It is assumed in this assessment that there is a well present in every household within 1km of the site boundary. Given the limited depth of the excavations during the construction phase and the distance to sensitive groundwater receptors the potential risk posed to groundwater supply wells is considered to be Imperceptible following the implementation of mitigation measures discussed above.

If, however, in the exceedingly unlikely event of a previously unknown domestic well being impacted by the proposed development, an alternative supply will be provided – either a connection to mains water or a replacement well will be drilled.

The GSI holds records of groundwater wells in the vicinity of the proposed grid connection route. However, trenches are shallow (1.2m deep) and will only be open for a couple of days at most.

Depending on the ground conditions, presence of services, traffic management required, weather conditions, etc., the rate of installation of cable ducting would vary between 50m and 100m per day. Dewatering is therefore unlikely to be required and no impacts on wells is envisaged.

Grid connection and internal cable trenches could provide preferential pathways for groundwater and contaminant movement. Trenches will be excavated during dry periods in short sections (of approximately 50m – 100m) and left open for minimal periods, to avoid acting as a conduit for surface water flows. No excavations will be carried out in heavy rainfall. To further mitigate the risk of cable trenches becoming preferential pathways, clay plugs (or other low permeability material) will be installed at regular intervals along the trench to stop / inhibit water movement.

9.5.3 Mitigation Measures during Operation

It is not envisaged that the operation of the proposed development will result in significant impacts on the geological and hydrogeological regimes within the study area, as there will be no further disturbance of overburden post-construction.

The main potential residual impact during the operation phase would be the risk to groundwater from contamination from spills, which is discussed in further detail in Chapter 10 of this EIAR.

9.5.4 Mitigation Measures during Decommissioning

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

The Irish Wind Energy Association (IWEA) (11) states that when decommissioning a wind farm "*the concrete bases could be removed, but it may be better to leave them under the ground, as this causes less disturbance*". It is proposed to leave the access tracks in-situ at the decommissioning stage. IWEA also state that "*it may be best*" to leave site tracks in-situ depending on the size and geography of the development.

It is considered that leaving the turbine foundations, access tracks and hardstanding areas in-situ will cause less environmental damage than removing and recycling them. It is proposed to retain the foundations and hardstanding areas of the construction and cover with overburden material from local sources or site won material, to allow for re-vegetation of the development site.

Mitigation measures to avoid contamination by accidental fuel leakage and compaction of soil by on-site plant will be implemented as per the construction phase mitigation measures outlined above.

9.6 Residual Impacts

It can be observed from Tables 9.15 and 9.16 that, following the implementation of mitigation measures, the residual impact significance to the receiving environment would be imperceptible during the construction period and imperceptible during the operation of the proposed development. Mitigation measures will be monitored throughout the construction, operational and decommissioning phases.

9.7 Cumulative Impacts

The proposed development is not expected to contribute to any significant, negative cumulative effects of other existing or known developments in the vicinity.

9.7.1.1 Boggeragh Wind Farm

Relevant projects in proximity to the proposed development are listed in Table 9.12:

Table 9-122: Potential Cumulative Impact from other Developments

Development	Distance to Proposed Development (km)	Status	Interface	Potential Cumulative Impact
Boggeragh Wind Farm	1	Operational	n/a	Imperceptible

The surrounding area predominantly comprises agricultural farmland and forestry with the Boggeragh Wind Farm located 1km away from the site. Furthermore, given the **Slight to Moderate** impact of the proposed development, it is considered there will be no cumulative impacts from other industrial developments on the geology and hydrogeology of the site.

Given that the Boggeragh Wind Farm is currently operational it is considered there are no cumulative impacts from these works on the existing geological or hydrogeological environments.

9.7.1.2 Existing Forestry Activities

The residual impact of the project is concluded to be not significant on the land, soils, geology and hydrogeology of the site. For each stage of the project mitigation measures are proposed to achieve a 'not significant' impact on the land, soils, geology and hydrogeology of the site. Tree felling will be permitted under limited felling license(s) from the Forest Service and will be subject to the conditions of such a license. Tree felling of the surrounding commercial forest will implement similar measures as proposed for the project. Therefore, no cumulative impact is envisaged.

9.7.1.3 Local Quarries

Slight residual cumulative effects from the excavation of fill material from local quarries (such as Bweeng Quarry Co. Cork) are considered to result from the proposed development by placing demand on existing quarries during the construction phase of the development. However, it is envisaged to use as much site-won material as possible therefore, the cumulative impact will be negligible.

Table 9-15: Residual Impact Significance for Sensitive Geological Attributes

Activity	Potential Impact	Receptor	Sensitivity	Prior to Mitigation		Post Mitigation	
				Magnitude	Significance	Magnitude	Significance
Construction Phase							
Earthworks	Removal of overburden material, open excavations and subsequent exposure underlying overburden and bedrock leading to increased erosion. Construction traffic resulting soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils. Extraction of bedrock from borrow pits resulting in the reduction in the availability of an exhaustible resource.	Local, organic Topsoil, Peat and Glacial Till deposits. Bedrock	Medium	Moderate	Moderate	Negligible	Imperceptible
Felling Activities	Exposure of underlying overburden leading to increased erosion. Felling machinery resulting soil compaction of soft deposits and an increase in surface water runoff resulting in increased erosion of exposed soils.	Local organic Topsoil, Peat and Glacial Till deposits.	Medium	Moderate	Moderate	Negligible	Imperceptible
Construction of Internal Site Access Tracks, Hardstands and Temporary Compound	Open excavations, increased runoff causing erosion of underlying overburden and bedrock. Construction traffic resulting soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils.	Local organic Topsoil, Peat and Glacial Till deposits. Bedrock Local quarries	Medium	Moderate	Moderate	Negligible	Imperceptible

Activity	Potential Impact	Receptor	Sensitivity	Prior to Mitigation		Post Mitigation	
				Magnitude	Significance	Magnitude	Significance
	Importation of engineering fill						
Construction of Turbine and Substation Foundations	Open excavations, increased runoff causing erosion of underlying overburden and bedrock. Construction traffic resulting soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils. Importation of engineering fill and concrete products	Local organic Topsoil, Peat and Glacial Till deposits. Bedrock Local quarries	Medium	Moderate	Moderate	Negligible	Imperceptible
Construction of the Grid Connection and Internal Cabling	Removal of overburden material and exposure underlying Gravel and Bedrock to erosion. Construction traffic resulting soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils. Importation of engineering fill and concrete products Disposal of surplus excavated material to licenced facility	Local organic Topsoil, Peat and Glacial Till deposits. Bedrock Local quarries Licenced Waste Facilities	Medium	Small Adverse	Slight	Small Adverse	Imperceptible
Earthworks associated with the construction of the proposed development and associated infrastructure	Slope Failure	Local organic Topsoil, Peat and Glacial Till deposits, site workers, the public, dwellings,	High	Small Adverse	Slight	Negligible	Imperceptible

Activity	Potential Impact	Receptor	Sensitivity	Prior to Mitigation		Post Mitigation	
				Magnitude	Significance	Magnitude	Significance
		water course, livestock and wildlife					
Accommodation works along TDR	Removal of overburden material and exposure underlying Gravel and Bedrock to erosion. Construction traffic resulting soil compaction and increase in surface water runoff resulting in increased erosion of exposed soils. Importation of engineering fill Disposal of surplus excavated material to licenced facility	Local organic Topsoil, Peat and Glacial Till deposits. Bedrock Local quarries Licenced Waste Facilities	Medium	Small Adverse	Slight	Negligible	Imperceptible
Operational Phase							
Maintenance Traffic	Release of hydrocarbons or fuel spill	Local organic Topsoil, Peat and Glacial Till deposits. Bedrock.	Medium	Small Adverse	Slight	Negligible	Imperceptible
Maintenance of access tracks	Importation of engineering fill	Local quarries	Medium	Small Adverse	Slight	Small Adverse	Imperceptible
Cumulative Impacts							
Construction of the proposed development	Cumulative impacts on local quarries from extraction of fill for proposed development	Local quarries	Medium	Negligible	Imperceptible	Negligible	Imperceptible

Activity	Potential Impact	Receptor	Sensitivity	Prior to Mitigation		Post Mitigation	
				Magnitude	Significance	Magnitude	Significance
and associated infrastructure							

Table 9-16: Residual Impact Significance for Sensitive Hydrogeological Attributes

Activity	Potential Impact	Receptor	Sensitivity	Prior to Mitigation		Post Mitigation	
				Magnitude	Significance	Magnitude	Significance
Construction Phase							
Earthworks	Potential for ground water pollution from the removal of overburden deposits. Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer Potential for contamination to groundwater from spills/leakages during construction phase earthworks. Reduction in groundwater levels from dewatering of excavation as required during the construction phase.	Ballinhassig GWB Locally Important Bedrock Aquifer Groundwater Wells and Springs	Medium	Moderate	Moderate	Negligible	Imperceptible
Felling Activities	Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer Potential for contamination to groundwater from spills/leakages from felling machinery	Ballinhassig GWB Locally Important Bedrock Aquifer Groundwater Wells and Springs	Medium	Moderate	Moderate	Negligible	Imperceptible
Construction of Internal Site Access Tracks, Hardstands and Temporary Compound	Potential for ground water pollution from the removal of overburden deposits. Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer	Ballinhassig GWB Locally Important Bedrock Aquifer Groundwater Wells and Springs	Medium	Moderate	Moderate	Negligible	Imperceptible

Activity	Potential Impact	Receptor	Sensitivity	Prior to Mitigation		Post Mitigation	
				Magnitude	Significance	Magnitude	Significance
	Potential for contamination to groundwater from spills/leakages during construction phase earthworks. Potential for ground water pollution from the use of cement-based compounds during the construction phase						
Construction of Turbine and Substation Foundations	Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer Potential for contamination to groundwater from spills/leakages during construction phase earthworks. Potential for ground water pollution from the use of cement-based compounds during the construction phase	Ballinhassig GWB Locally Important Bedrock Aquifer Groundwater Wells and Springs	Medium	Medium	Moderate	Negligible	Imperceptible
Construction of the Grid Connection and Internal Cabling	Potential for ground water pollution from the removal of overburden deposits. Potential for silt infiltration to groundwater as a result of increased surface runoff and reduced protection of the aquifer Potential for contamination to groundwater from spills/leakages during construction phase earthworks.	Ballinhassig and Glenville GWBs Locally and Regionally Important Bedrock Aquifers Groundwater Wells and Springs	High	Small Adverse	Moderate/Slight	Negligible	Imperceptible
Operation							
Maintenance Traffic	Some operational traffic will be necessary for maintenance plus normal operational	Ballinhassig GWB Bedrock Aquifer	Medium	Small Adverse	Slight	Negligible	Imperceptible

Activity	Potential Impact	Receptor	Sensitivity	Prior to Mitigation		Post Mitigation	
				Magnitude	Significance	Magnitude	Significance
	traffic which could result in minor accidental leaks or spills of fuel/oil.	Groundwater Wells and Springs					

9.8 Conclusion

The assessment of Land, Soil Hydrogeology & Geology has established a baseline for the receiving environment for the impact assessment. Potential impacts were considered for the construction, operational and decommissioning phases of the proposed development as well as potential residual and cumulative impacts. Mitigation measures have been proposed where relevant.

The proposed development site is not a sensitive site in terms of land, soil hydrogeology & geology and poses a low risk for peat slippage.

A number of potential impacts have been identified associated with the excavation of soil and rock on the site. The significance of these potential impacts is assessed as being slight to moderate significance prior to mitigation.

The findings of the peat assessment showed that the proposed development site has an acceptable margin of safety and is suitable for the proposed development. The findings include recommendations and control measures (Appendix 9.1) for construction work in peat lands to ensure that all works adhere to an acceptable standard of safety.

The Ballinagree Wind Farm is not expected to contribute to any significant, negative cumulative effects with other existing or proposed developments in the vicinity.

With mitigation measures, outlined in Section 9.4, put in place during construction, operational and decommissioning stage the proposed development will have imperceptible significance on the land, soils, hydrogeology and geology.

9.9 References

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