9. LAND, SOILS AND GEOLOGY

9.1 Introduction

9.1.1 Background and Objectives

Hydro-Environmental Services (HES) was engaged by MKO Ireland to carry out an assessment of the potential impacts of the proposed Lyrenacarriga Wind Farm (including 17 No. turbines and associated infrastructure, 110 kV substation, grid connection, met mast, turbine delivery route works, collector cabling route and replacement planting lands) on the land, soils and geological environment.

The Proposed Development site is located approximately 5 km southeast of Tallow, Co. Waterford and approximately 9 km northwest of Youghal, Co. Cork (11 No. proposed turbines are located in Co. Waterford and 6 No. turbines in Co. Cork).

This report provides a baseline assessment of the environmental setting of the proposed project, a full description of which is provided in Chapter 4, in terms of land, soils and geology and discusses the potential likely significant effects and cumulative effects that the construction, operation and decommissioning of the proposed Lyrenacarriga Wind Farm will have. Where required, appropriate mitigation measures to avoid any identified significant effects to land, soils, geology and natural resources are included and the residual effects of the Proposed Development post-mitigation are assessed.

The proposed forestry replanting lands are located in Co. Sligo. The baseline environment, potential direct and indirect impacts of replanting, on the lands and soils environment, have been assessed in Section 6 of Appendix 4-3 of this EIAR: Assessment of Proposed Replanting Lands. The replanting lands are assessed cumulatively in Section 9.5.8 of this chapter.

9.1.2 Statement of Authority

Hydro-Environmental Services (HES) is a specialist hydrological, hydrogeological and environmental practice which delivers a range of water and environmental management consultancy services to the private and public sectors across Ireland and Northern Ireland.

HES' core areas of expertise and experience include soils, subsoils, geology and hydrogeology. They routinely complete impact assessments for land, soils and geology, and hydrology and hydrogeology for a large variety of project types.

This chapter of the EIAR was prepared by Michael Gill and David Broderick of HES.

Michael Gill (P. Geo., B.A.I., MSc, Dip. Geol., MIEI) is an Environmental Engineer with over 18 years' environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological impact assessments of wind farms in Ireland. He has also managed EIAR assessments for infrastructure projects and private residential and commercial developments. In addition, he has substantial experience in wastewater engineering and site suitability assessments, contaminated land investigation and assessment, wetland hydrology/hydrogeology, water resource assessments, surface water drainage design and SUDs design, and surface water/groundwater interactions.

David Broderick (BSc, H. Dip Env Eng, MSc) is a hydrogeologist with over 13 years' experience in both the public and private sectors. Having spent two years working in the Geological Survey of Ireland working mainly on groundwater and source protection studies David moved into the private sector. David has a strong background in groundwater resource assessment and hydrogeological/hydrological

investigations in relation to developments such as quarries and wind farms. David has completed numerous geology and water sections for input into EIARs for a range of commercial developments.

Michael and David have worked on over 120 wind farm related projects across Ireland and Northern Ireland over the last 10 years.

9.1.3 Relevant Legislation

The EIAR is prepared in accordance with the requirements of European Union Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (the 'EIA Directive') as amended by Directive 2014/52/EU. The requirements of the following legislation are complied with:

- Circular Letter PL 1/2017:
- Planning and Development Act, 2000, as amended;
- Planning and Development Regulations 2001 as amended; and,
- The Heritage Act 1995, as amended.

9.1.4 Relevant Guidance

The land, soils and geology chapter of this EIAR was prepared having regard, where relevant, to the legislation and guidance outlined in Chapter 1: Introduction (please see Section 1.5) and the following documents:

Institute of Geologists Ireland (2013): *Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements*; and,
National Roads Authority (2008): *Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes. Implementation of Directive 2014/52/EU on the effects of certain public and private projects on the environment (EIA Directive).*

9.2 Schedule of Works

9.2.1 Desk Study

A desk study of the Proposed Development site, study area and overall project area was completed in advance of undertaking the walkover survey and site investigations. This involved collecting all relevant geological data for the site and surrounding area. This included consultation of the following:

- Environmental Protection Agency (EPA) database (www.epa.ie);
- Geological Survey of Ireland - Groundwater Database (www.gsi.ie);
- Bedrock Geology 1:100,000 Scale Map Series, Sheet 22 (Geology of East Cork - Waterford). Geological Survey of Ireland (GSI, 1995);
- Geological Survey of Ireland – 1:25,000 Field Mapping Sheets; and,
- General Soil Map of Ireland 2nd edition (www.epa.ie).

9.2.2 Baseline Monitoring and Site Investigations

Walkover surveys, site investigations and geological mapping were undertaken by HES on 30th and 31st August 2018 with further surveys completed in January, February and September 2019 and trial pitting undertaken in May 2020.

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

- Detailed walkover, geological mapping and ground conditions survey;
- A Geotechnical Assessment by Fehily Timoney and Company (included as Appendix 4-2 of this EIAR);
- Gouge cores were undertaken at key development locations such as proposed turbine locations, borrow pits, substation and compound locations to investigate soil and mineral subsoil lithology;
- A total of 27 no. trial pits were undertaken by HES across the site to assess soil/subsoil lithology and depth to bedrock (see Section 9.3.2 for further details and trial pit locations map);
- Logging of bedrock outcrops and subsoil exposures; and,
- Mineral subsoils and soil were logged according to BS: 5930 (2015).

9.2.3 Scoping and Consultation

The scope for this assessment has been informed by consultation with statutory consultees, bodies with environmental responsibility and other interested parties. This consultation process is described in Section 2.6 in Chapter 2 of this EIAR. Issues and concerns highlighted with respect land, soils and geology are summarised in Table 9-1 below.

Table 9-1 Summary of Scoping Responses Relating to Land, Soils and Geology

Consultee	Key Comment	Addressed in Section
Cork County Council	Applicant should provide soil and slope stability calculations along with details of soil management proposals.	**Appendix 4-2:** Geotechnical Assessment Report **Chapter 9:** Section 9.5.2 Construction Phase Impacts & Mitigation **Chapter 4 Description:** Section 4.3.4 Spoil Management Plan
Inland Fisheries Ireland (IFI)	Ground conditions need to be kept under constant review and works should be carried out in a manner that does not lead to the creation of unstable ground conditions	**Appendix 4-2** Geotechnical Assessment Report **Chapter 9:** Section 9.5.2 Construction Phase Impacts & Mitigation **Chapter 4 Description**: Section 4.8 Construction Methodologies

9.2.4 Impact Assessment Methodology

Using information from the desk study and data from the site investigation, an estimation of the importance of the soil and geological environment within the study area is assessed using the criteria set out in Table 9.2 below (NRA, 2008).

Table 9-2 Estimation of Importance of Soil and Geology Criteria (NRA, 2008)

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

The statutory criteria for the assessment of impacts require that likely impacts are described with respect to their extent, magnitude, complexity, probability, duration, frequency, reversibility and transfrontier nature (if applicable) (*'Draft Guidelines on the Information to be Contained in Environmental Impact Assessment Reports'*, EPA, 2017). The descriptors used in this environmental impact assessment are those set out in the 2017 EPA Glossary of Impacts, which is shown in Section 1.7.2 in Chapter 1 of this EIAR. In addition, the two impact characteristics proximity and probability are described for each impact and these are defined in Table 9.3 below.

Table 9-3 Additional Impact Characteristics

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

In order to provide an understanding of this descriptive system in terms of the geological/hydrological environment, elements of this system of the description of impacts are related to examples of potential impacts on the hydrology and morphology of the existing environment, as listed in Table 9.4.

Table 9-4 Impact descriptors related to the receiving environment

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

Impact Characteristics		Potential Hydrological Impacts
Quality	Significance	
		› The extent or morphology of a SAC / NHA / proposed NHA (pNHA)ecologically important area. › A minor hydrogeological feature. › Extent of floodplains. Mitigation measures can mitigate the impact OR residual impacts occur, but these are consistent with existing or emerging trends
Positive, Negative or Neutral	Slight	Local perceptible time dependent impacts not requiring mitigation.
Neutral	Imperceptible	No impacts, or impacts which are beneath levels of perception, within normal bounds of variation, or within the bounds of measurement or forecasting error.

9.2.5 Limitations and Difficulties Encountered

No limitations or difficulties were encountered during the preparation of the Land, Soils and Geology Chapter of this EIAR.

9.3 Existing Environment

9.3.1 Site Description and Topography

The Proposed Development site consists of two separate clusters of turbines. The eastern cluster of turbines (11 no. turbines) is located in Co. Waterford while the western cluster (6 no. turbines) is located in Co. Cork.

The turbine clusters are referred to herein as the western and eastern clusters. The two clusters will be connected via a 3.3km underground collector cable connection which will mainly cross grassland and short sections of public road (approximately 0.6 km in total) that run between the two clusters.

The western cluster, which has an area of approximately 206 hectares (ha), is located approximately 5 km south of Tallow, between the R627 and R634 Regional Roads. The northern half of the western cluster comprises largely coniferous forestry while the southern half comprises agricultural grassland. It is proposed that 6 no. turbines will be located in the western cluster (3 no. in forestry and 3 no. in grassland area). The forestry is accessible via a network of existing forest tracks. Ground elevation ranges from approximately 203m OD at the topographic peak of Kilcalfmountain north of the western cluster to approximately 130 m OD near the south of the western cluster, with the overall slope (gentle to moderate) is to the south – southeast.

The eastern cluster, which has an area of approximately 518 ha, is located approximately 1.7km to the west of the western cluster (approximately 6.5km to the southeast of Tallow) and comprises mainly coniferous forestry with areas of grassland in the central and south-eastern parts. The eastern cluster is located immediately east of the R634 Regional Road and has an elevated range between 200 m OD at the south of the cluster, and 120 m OD along the eastern boundary with the overall ground slope

(gentle to moderate) to the east. It is proposed that 11 no. turbines will be located in the eastern cluster (7 no. in forestry and 4 no. in grassland).

The grid connection will be made to the existing 110 kV Overhead Line (OHL), which passes through the site, at the location of the proposed 110 kV substation via a loop-in loop-out connection. The western cluster will be connected to the 110 kV substation via the underground collector cable.

Turbine delivery route works required along the route from Youghal (see Section 4.4.2 of EIAR) to the Proposed Development site include temporary road widening at Lombard's crossroads on the R634 comprising a small area (approx. 70 square metres) of hardsurfacing, and a new section of temporary access road (300m) on private land near Breeda Bridge (1.3km southwest of the western cluster) as well as temporary removal of some street signs and temporary levelling of the centre island of some roundabouts.

9.3.2 Soils and Subsoils

The published soils map (www.epa.ie) for the area shows that the majority of the soils within the Proposed Development site are formed from tills (subsoils) derived from Devonian sandstone (described below).

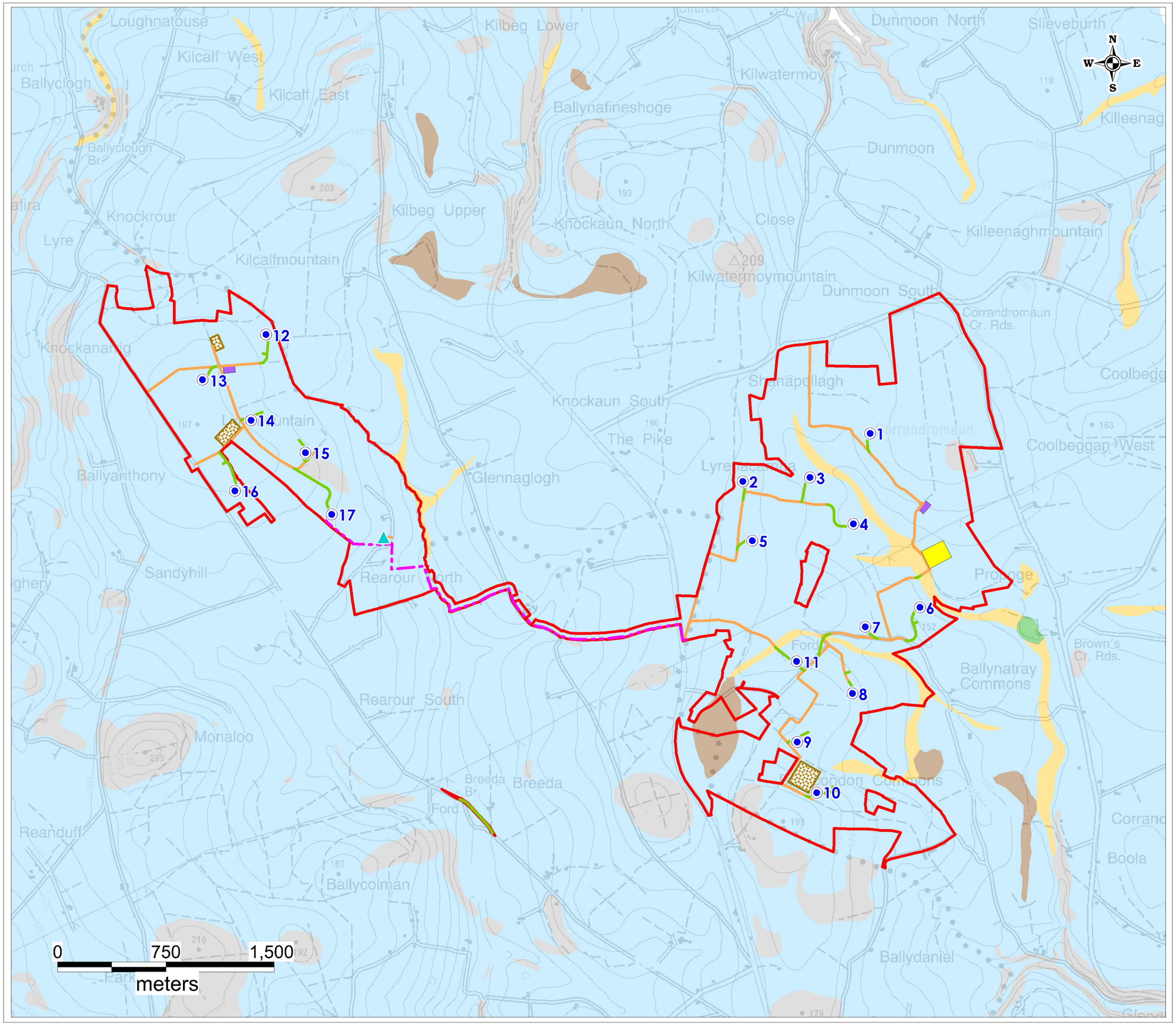
Deep, well-drained, mainly acidic mineral soil (AminDW) is the dominant soil type at the western cluster of the Proposed Development site with some localised areas of poorly drained mineral soils (AminPD) on the lower eastern section of the cluster.

At the eastern cluster, AminDW soils are mapped on the more elevated north-eastern and south-western sections of the cluster with AminPD mapped in the lower-lying north-western and south-eastern sections of the cluster. Alluvium is mapped along the watercourses particularly along the lower-lying central and south-eastern sections of the eastern cluster.

A map of the local subsoil cover is presented as Figure 9-1 (www.gsi.ie). This shows the mapped distribution of subsoil deposits around the proposed development site. The majority (>90%) of both cluster areas are overlain by tills derived from Devonian sandstone with localised areas of rock subcrop or outcrop on the most elevated parts. A localised area of cutover bog is mapped on the southwestern corner of the eastern cluster. The mapped cutover bog does not intercept any of the Proposed Development footprint. Site mapping, observations of exposed soils and trial pits (described below) confirm these mapped conditions.

Trial pits were undertaken across the site on 28th and 29th May 2020. Trial pits logs are attached as Appendix 9-1 of this EIAR. Fifteen trials pits were excavated on the eastern portion of the wind farm site, and 12 trial pits were excavated on the western portion of the wind farm site. The trial pit locations are shown in Figure 9-2.

Varying depths (0.8 to 4.0 metres below ground level (mbgl)) of Devonian-derived glacial tills were encountered at all trial pits excavated at the eastern portion of the wind farm site. No significant peat deposits (some organic topsoils were noted) were encountered anywhere on site during the trial pitting works. Deeper sand deposits (possibly in-situ weathered sandstone/siltstone bedrock) were encountered at TP03A, TP04B, and TP10A, while gravel deposits were found below glacial tills at TP04A and TP06. At TP06 the gravels were saturated and owing to the proximity to the stream to the north, these are fluvio-glacial gravels. Weathered bedrock (gravel and cobbles) was encountered at TP1, TP12, TP15 and TP16, at depths of 2.0mbgl, 2.05mbgl, 1.7mbgl and 0.8mbgl respectively. The weathered gravels/cobbles comprised sub-rounded and angular weathered siltstone and sandstone bedrock.



Legend

- Site Boundary
- Proposed Turbine Layout
- Proposed Cable Route
- Proposed Met Mast
- Proposed Substation
- Proposed Construction Compound
- Proposed Borrow Pit
- Existing Road Proposed to be Upgraded
- Proposed New Road
- Alluvium
- Cut over raised peat
- Gravels derived from Devonian sandstones
- Bedrock outcrop or subcrop
- Till derived from Devonian sandstones

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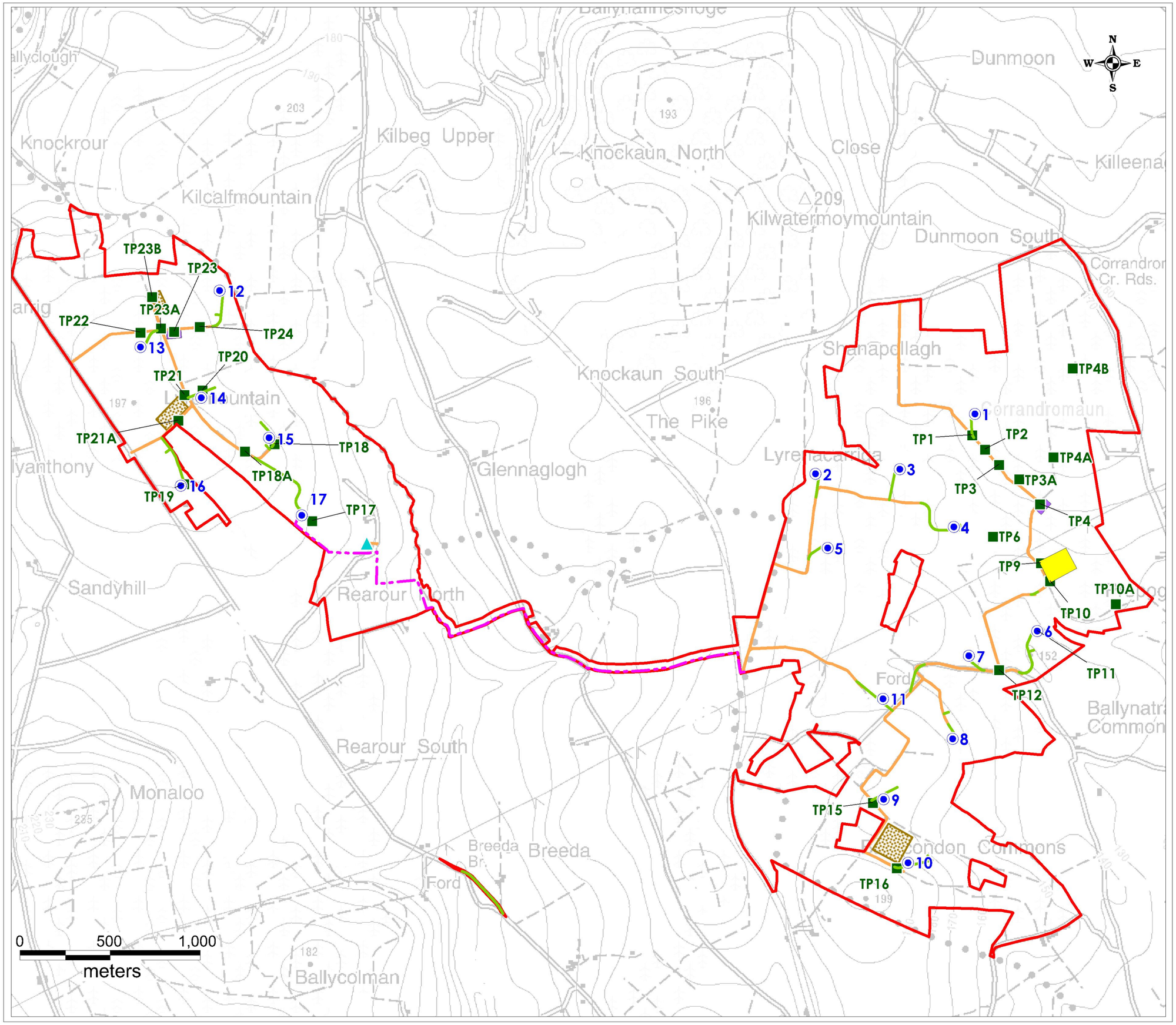
Client: Innogy Renewables	
Job: Lyrenacarriga WF, Co. Waterford/Co. Cork	
Title: Local Subsoils Map	
Figure No: 9-1	
Drawing No: P1453-0-1220-A3-901-0A	
Sheet Size: A3	Project No: P1453-0
Scale: 1:25,000	Drawn By: GD
Date: 02/12/2020	Checked By: MG



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Client: Innogy Renewables	
Job: Lyrenacarriga WF, Co. Waterford/Co. Cork	
Title: Site Investigation Map	
Figure No: 9-2	
Drawing No: P1453-0-1220-A3-902-0A	
Sheet Size: A3	Project No: P1453-0
Scale: 1:20,000	Drawn By: GD
Date: 02/12/2020	Checked By: MG

Varying depths (0.85 to 2.2mbgl) of Devonian-derived glacial tills were encountered at all trial pits excavated at the western eastern portion of the wind farm site. No significant peat deposits (some organic topsoils were noted) were encountered anywhere on site during the trial pitting works. Weathered bedrock was encountered at TP18, TP19, TP21A, TP22, TP23A and TP23B, at depths of 2.0mbgl, 1.5mbgl, 0.85mbgl, 1.2mbgl, 2.0mbgl, and 1.4mbgl respectively. The weathered gravels/cobbles comprised sub-rounded and angular weathered siltstone and sandstone bedrock. Subsoils are generally thicker across the eastern portion of the wind farm compared with the western portion.

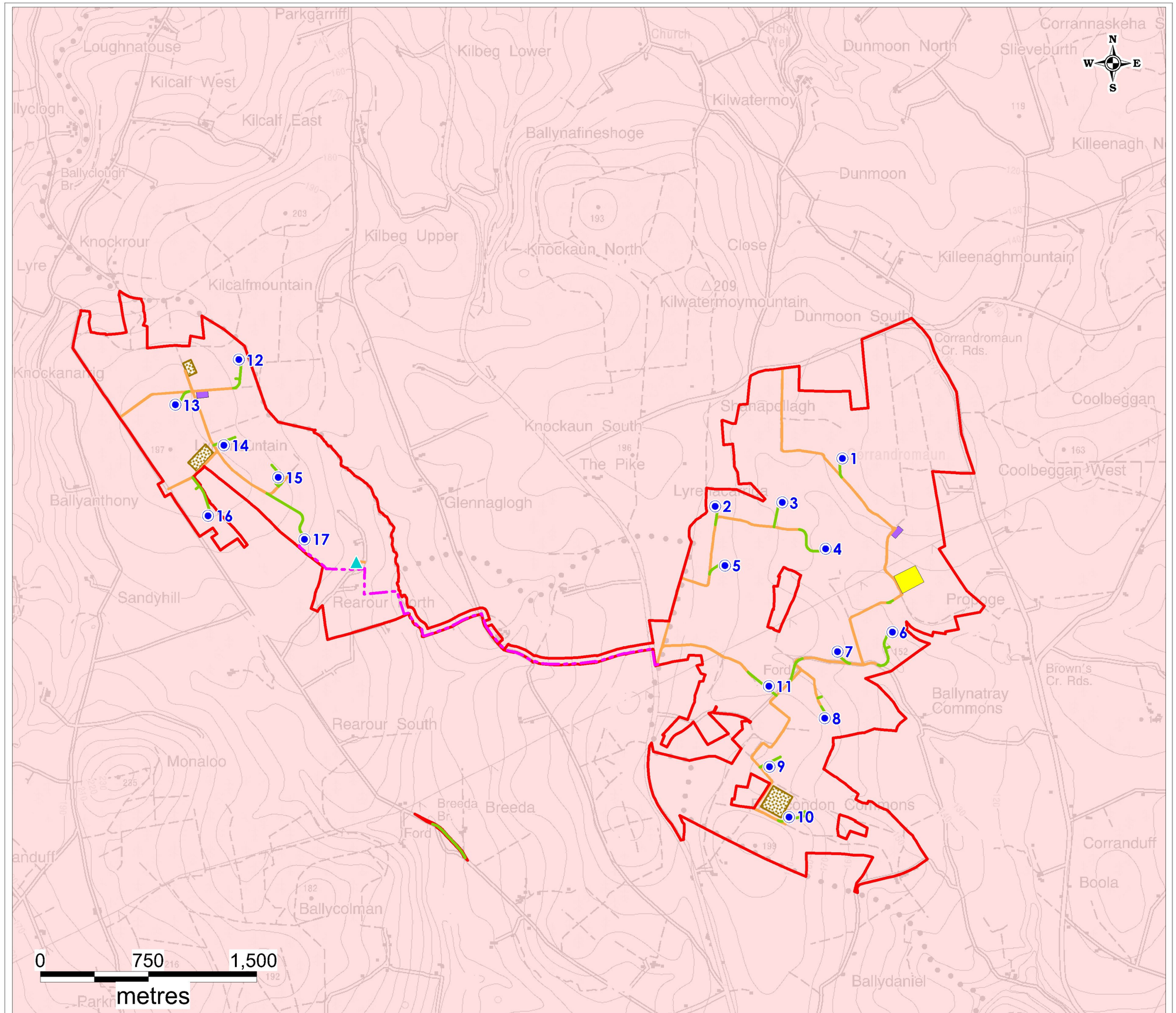
Particle size distribution (PSD) was completed on two samples, one taken from each of TP121 and TP22. TP11/S1 was taken at1.2mbgl and comprises Reddish brown, slightly gravelly, slightly sandy SILT. While sample TP22/S1 was taken at 1.5mbgl and comprises Reddish brown, very sandy, very silty coarse GRAVEL. The PSD plots are attached as Appendix 9-2 of this EIAR.

9.3.3 Bedrock Geology

The underlying bedrock at the Proposed Development site is mapped exclusively as the Ballytrasna Formation which comprises purple mudstone and sandstone (Figure 9-3). The Ballytrasna Formation dates to the Upper Devonian, with the type area characterised by ~90% dusky red mudstone with the remainder consisting of pale red fine-medium grained sandstone. Bedrock in the area is steeply dipping at ~60-80°and trend in both a northern and southern dipping direction.

Bedrock encountered during the trial pit investigation comprised of weathered siltstone and sandstone, and depths to weathered bedrock was recorded between 0.8 to 2.05mbgl.

There are no mapped faults in the area. Outcrop is relatively sparse on lower ground but is mapped locally on higher ground, particularly on the western cluster which has a slightly higher overall elevation than the eastern cluster. Site mapping, observations of exposed bedrock and trial pits confirm these mapped conditions.



Legend

- Site Boundary
- Proposed Turbine Layout
- Proposed Cable Route
- Proposed Met Mast
- Proposed Substation
- Proposed Construction Compound
- Proposed Borrow Pit
- Existing Road Proposed to be Upgraded
- Proposed New Road
- Mapped Faults
- Devonian Old Red Sandstones

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Client: Innogy Renewables	
Job: Lyrenacarriga WF, Co. Waterford/Co. Cork	
Title: Local Bedrock Geology Map	
Figure No: 9-3	
Drawing No: P1453-0-1220-A3-903-0A	
Sheet Size: A3	Project No: P1453-0
Scale: 1:25,000	Drawn By: GD
Date: 02/12/2020	Checked By: MG

9.3.4 Geological Resource Importance

The GSI online Aggregate Potential Mapping Database shows that the Proposed Development site is located within an area mapped as being typically Very Low to Low in terms of crushed rock aggregate potential. A small area along the southeast edge of the western cluster is mapped as having a low to moderate potential for granular aggregates (i.e. potential for gravel reserves).

There are no mapped active quarries within 4 – 5 km of the site. Typically, the mudstones/sandstones of the Ballytrasna formation are of low geological resource importance.

The soils and subsoils in the area of the proposed development site could be classified as "Medium" importance as they support agricultural and forestry activities in this area. Refer to Table 9-1 above for criteria.

9.3.5 Geological Heritage and Designated Sites

There are no recorded Geological Heritage sites, mineral deposit sites, or mining sites (current or historic) within 5 km of the proposed development site.

The Proposed Development site is not located within any designated site. The nearest Natura 2000 site, i.e. Special Area of Conservation (SAC) or Special Protection Area (SPA), is the Blackwater River (Cork/Waterford) SAC, the boundary of which is located within 10 metres of the north-eastern boundary of the proposed wind farm site, at its nearest point. The nearest national designated site, i.e. Natural Heritage Area (NHA) or proposed NHA (pNHA), is the Blackwater River and Estuary pNHA, which is located approximately 2.1 kilometres southeast of the site, at its nearest point.

Potential indirect hydrological impacts on the Blackwater River SAC are assessed in Chapter 10 (Water).

9.3.6 Soil Contamination

There are no known areas of soil contamination on the site of the Proposed Development. During the site walkovers and site investigations, no areas of contamination concern were identified.

According to the EPA online mapping (http://gis.epa.ie/Envision), there are no licensed waste facilities on or within the immediate environs of the site of the Proposed Development.

There are no historic mines at or in the immediate vicinity of the site of the Proposed Development that could potentially have contaminated tailings.

9.4 Characteristics of the Proposed Development

A full description of the proposed wind farm is provided in Chapter 4 of this EIAR. The Proposed Development will typically involve removal of soil, subsoil and bedrock for hardstanding emplacement. Crushed rock for construction will be sourced from 3 no. proposed onsite borrow pits (1 no. at the eastern cluster and 2 no. at the western cluster). It is proposed that these borrow pits will be reinstated with surplus spoil/overburden excavated as part of the construction phase of the Proposed Development.

Estimated volumes of soil, subsoil and bedrock to be removed during excavations are shown in Table 9.5 below. Not all of the soil and subsoil excavated will be sent to the borrow pits for reinstatement, a portion will be stored and used for reinstatement and landscaping works around the site. Any bedrock excavated during cut and fill works (i.e. as shown in Table 9-5) will be used for engineering fill along

the development footprint. Further details are provided in the Geotechnical Assessment report by FT which is included in Appendix 4-2 of this EIAR.

Table 9-5 Estimated Construction Spoil/Overburden and Rock Excavation Volumes

Development Component	Overburden (m^3)	Rock (m^3)	Comment
17 No. Turbines & Hardstands	42,890	44,950	Hardstand area and foundation footprint
Access Roads	35,235	64,500	-
Substation	26,320	27,410	-
Borrow Pits (3 no.)	90,115	-	Borrow Pit footprint
Construction Compound (2 no.)	4,420	9,200	Hardstand areas
Total	**198,080**	**146,060**	

The proposed extraction volumes, for construction material purposes, at the 3 No. proposed borrow pits are shown in Table 9-6.

Table 9-6 Estimated Bedrock Extraction Volumes

Development Component	Footprint (m^3)	Rock Volume (m^3)
Borrow Pit 1	25,900	25,000
Borrow Pit 2	5,850	18,000
Borrow Pit 3	14,220	105,000
Total	**45,970**	**148,000**

9.5 Likely and Significant Impacts on Land, Soils and Geology

9.5.1 Do-Nothing Scenario

Current land-use practices will continue. Coniferous forestry will be felled as forestry compartments reach maturity. Re-planting of these areas with more coniferous trees is likely to occur. Plantations will be reploughed where necessary to facilitate afforestation and to re-plant grassland. Other areas of the site will continue to be used for agriculture.

The land, soils and geology would remain largely unaltered as a result of the Do-Nothing Scenario.

The do-nothing scenario would also not contribute to renewable energy targets as set by the state.

9.5.2 Likely Impacts and Mitigation Measures: Construction Phase

The likely impacts of the proposed development and mitigation measures that will be put in place to eliminate or reduce them are shown below.

9.5.2.1 Soil, Subsoil and Bedrock Excavation

Excavation of soil, subsoil and bedrock will be required for site levelling and for the installation of infrastructure and foundations for the access roads and turbines and all elements of the proposed project as listed in Table 9-5 above. This will result in a permanent loss of soil, subsoil and bedrock at excavation locations. The proposed extraction volumes, for construction material purposes, at the 3 No. proposed borrow pits is shown in Table 9-6.

Pathway: Extraction/excavation
Receptor: Soil, subsoil and bedrock
Potential Pre-mitigation Impact: Negative, slight/moderate, direct, high probability, permanent impact on soil, subsoil and bedrock.

Assessment/Proposed Mitigation Measures:

- Use of the existing forestry road network as much as possible to reduce soil/subsoil excavation and borrow pit volumes;
- The soil and subsoil which will be removed during the construction phase will be localised to the Proposed Development infrastructure locations;
- No turbines or related infrastructure will be constructed near or on any designated sites such as NHAs or SACs;
- A minimal volume of soil and subsoil will be removed to allow for infrastructural work to take place in comparison to the total volume present on the site due to optimisation of the layout by mitigation by design;
- The bedrock at the site are classified as "Low to Medium" importance; and,
- The soils and subsoils deposits at the site are classified as "Medium" importance due to their role in supporting agriculture and forestry.

Residual Impact:

The granular soil/subsoil deposits and bedrock at the proposed development site is classified as of "Medium" and "Low to Medium" importance respectively (refer to Table 9-1). The soil is already affected by forestry and drainage. The overall proposed development site area is extensive while the proposed development footprint (23.3 ha) represents approximately only 3% of the overall development site area (733 ha). The impact is the disturbance and relocation of the above volumes of soil and bedrock during construction. The design measures incorporated into the project as described above combined with the 'low to medium' importance of the soil and bedrock means that the residual effect is considered - Negative, direct, slight, likely, permanent impact on soil, subsoil and bedrock.

Significance of Effects: For the reasons outlined above, no significant effects on land, soils, subsoils or bedrock will occur.

9.5.2.2 Contamination of Soil by Leakages and Spillages

Plant and machinery will be run on oils and fuels. Oils will also be present in the substation. Accidental spillage during refuelling of construction plant with petroleum hydrocarbons is a significant pollution risk to land, soils and associated ecosystems. The accumulation of small spills of fuels and lubricants

during routine plant use can also be a pollution risk. Hydrocarbon has a high toxicity to humans, and all flora and fauna, and is persistent in the environment.

Pathway: Soil and bedrock pore space.
Receptor: Soil, subsoil and bedrock
Potential Pre-mitigation Impact: Negative, slight, short term, medium probability impact on soil, subsoils and bedrock.

Proposed Mitigation Measures:

- On site re-fuelling will be undertaken by suitably trained personnel only;
- Fuels stored on site will be minimised. Storage areas where required will be bunded appropriately for the fuel storage volume for the time period of the construction and fitted with a storm drainage system and an appropriate oil interceptor;
- The electrical substation will be bunded appropriately to the volume of oils likely to be stored, and to prevent leakage of any associated chemicals and to groundwater or surface water. The bunded area will be fitted with a storm drainage system and an appropriate oil interceptor;
- The plant used during construction will be regularly inspected for leaks and fitness for purpose;
- All waste tar material arising from the chipping and resurfacing of the temporary construction access road will be removed off-site and taken to licenced waste facility; and,
- An emergency plan for the construction phase to deal with accidental spillages is contained within the Construction and Environmental Management Plan (Appendix 4-4 of this EIAR). Spill kits will be available to deal with any accidental spillage in and outside the re-fuelling area.

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

Significance of Effects: For the reasons outlined above, no significant effects on land, soils, subsoils or bedrock will occur.

9.5.2.3 Erosion of Exposed Subsoils and Soil During Tree Felling, Access Road and Turbine Base Construction Work

Spoil removed from turbine locations and access roads and all elements of the proposed project listed above in Table 9-5, will be used for landscaping, stored alongside designated access roads and used to reinstate the 3 No. proposed borrow pits.

Where possible, the surface vegetation layer will be stored with the vegetation part of the sod facing the right way up to encourage growth of plants and vegetation at the surface of the stored soil within the borrow pits and restored areas. Re-seeding and spreading/planting of native species will also be carried out in these areas. These measures will prevent erosion of stored spoil in the short term until vegetation has established and binds the soils together and prevents erosion.

Pathway: Vehicle movement, surface water and wind action.
Receptor: Soil, Subsoil & weathered bedrock
Potential Pre-mitigation Impact: Negative, slight, low probability impact on soil, subsoils and bedrock.

Proposed Mitigation Measures

All excavated material will be managed in accordance with the measures presented in the Geotechnical Assessment Report – see Appendix 4-2. Material will be moved over the least possible distance.

Any excess spoil will be moved to temporary storage areas or will be temporarily surrounded by earthen berms to prevent erosion. This will prevent erosion of soil. Silt fences will be installed around temporary stockpiles to limit movement of entrained sediment in surface water runoff. The use of earthen berms and silt fencing around earthworks and spoil mounds will prevent egress of water from the works.

In order to minimise erosion of mineral subsoils, stripping of topsoil will not take place during extremely wet periods[1] (to prevent increased silt rich runoff). Temporary drainage systems (as outlined in Section 10.3.17 in Chapter 10 of this EIAR) will be required to limit runoff impacts during the construction phase.

During tree felling, brash mats will be used to support vehicles on soft ground, reducing soil and mineral subsoil erosion and avoiding the formation of rutted areas, in which surface water ponding can occur. Brash mat renewal will take place when they become heavily used and worn. Provision will be made for brash mats along all off-road routes, to protect the soil from compaction and rutting.

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

Significance of Effects: For the reasons outlined above, no significant effects on land, soils, subsoils or bedrock will occur.

9.5.2.4 Ground/Slope Instability and Failure

Ground/slope instability or failure refers to a significant mass movement of a body of overburden that would have a significant effect on the proposed development site and the surrounding environment. Slope failure excludes localised movement of soil that could occur below an access road, creep movement or erosion type events. The consequence of ground/slope failure at the proposed development site may result in:

- Death or injury to site personnel;
- Damage to machinery;
- Damage or loss of access tracks;
- Drainage disrupted;
- Site works damaged or unstable;
- Contamination of watercourses, water supplies by particulates;
- Degradation of the environment.

Pathway: Vehicle movement and excavations.
Receptor: Soils/subsoils.
Potential Pre-mitigation Impact: Direct, negative, significant, low probability impact on soils and subsoils.

[1] >10 mm/hr (i.e. high intensity local rainfall events);
>25 mm in a 24-hour period (heavy frontal rainfall lasting most of the day); or,
>half monthly average rainfall in any 7 days.

Assessment/Mitigation Measures:

Based on the Geotechnical Assessment Report there is no evidence of past failures nor were there any signs of instability noted on the proposed development site.

Based on the observed site conditions, the Geotechnical Assessment Report provides recommendations which will be implemented regarding wind farm infrastructure construction, borrow pit construction and spoil placement/storage.

Residual Impacts: A detailed Geotechnical Assessment has been completed for the Proposed Development site proposal. The findings of that assessment have shown no evidence of past failures or any signs of instability noted at the Proposed Development site.

With the implementation of the recommended construction methods in the Geotechnical Assessment report, the residual effect is - Negative, imperceptible, direct, low probability, permanent effect on soil and subsoils.

Significance of Effects: For the reasons outlined above, no significant effects on land, soils, subsoils or bedrock will occur.

9.5.2.5 Turbine Delivery Route Works

Earthworks are required for the turbine delivery route (TDR) works. These include junction widening at Lombards crossroads, a new 300m stretch of access road on agricultural land at Breeda Bridge and temporary levelling of the centre island of some roundabouts. These accommodation works are described in Section 4.4.3 of this EIAR.

Pathway: Extraction/excavation/landscaping.

Receptor: Soil and subsoil

Potential Pre-Mitigation Impact: Negative, imperceptible, direct, likely, temporary effect on land, soil and subsoil.

Proposed Mitigation Measures:

- All works are relatively minor and localised and cover small areas;
- All works are at ground level and do not require significant excavations.
- All works are temporary in nature.
- The TDR works site will be reinstated after the construction phase has finished.

Residual Impact: The TDR related earthworks are minor in nature and will be temporary in duration. Residual effects are negative, imperceptible, direct, likely, temporary effect on land, soil and subsoil.

Significance of Effects: For the reasons outlined above, no significant effects on land, soils or subsoils will occur.

9.5.3 Likely Impacts and Mitigation Measures: Operational Stage

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

- Maintenance of site roads;
- Some construction vehicles or plant will be necessary for maintenance of turbines which could result in minor accidental leaks or spills of fuel/oil; and,

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

9.5.3.1 Site Road Maintenance during the Operational Stage

In relation to indirect impacts a small amount of granular material will be required to maintain access tracks/site roads during operation which will place intermittent minor demand on local quarries. Please note the on-site borrow pits will have been reinstated with excavated soil and spoil following the construction stage and will not be available to source aggregate during the operational phase.

Pathway: Soil, subsoil and bedrock pore space.

Receptor: Soil, subsoil and bedrock.

Potential Pre-Mitigation Impact: Negative, indirect, imperceptible, short term, likely impact bedrock

Proposed Mitigation Measures:

- Use of aggregate from authorised quarries for use in road and hardstand maintenance.

Residual Impact: The use of aggregate for site road maintenance will be minor and infrequent, and all material will be imported to the site from local authorised quarries (see Section 4.3.3.4 of Chapter 4 which addresses existing quarries within 25 km of the proposed wind farm site). The residual effect is considered to be - Negative, imperceptible, indirect, short-term, low probability effect on bedrock.

Significance of Effects: For the reasons outlined above, no significant effects on land, soils or geology will occur.

9.5.3.2 Site Vehicle/Plant Use During Operational Stage

Plant and site vehicles used in site maintenance will be run on fuels and use hydraulic oils. Accidental spillage during refuelling of construction plant with petroleum hydrocarbons is a significant pollution risk to land, soils and associated ecosystems. The accumulation of small spills of fuels and lubricants during routine plant use can also be a pollution risk. Hydrocarbon has a high toxicity to humans, and all flora and fauna, and is persistent in the environment.

Pathway: Soil, subsoil and bedrock pore space.

Receptor: Soil, subsoil and bedrock.

Potential Pre-Mitigation Impact: Negative, direct, slight, short term, unlikely impact on Soil, subsoil and bedrock.

Proposed Mitigation Measures:

- Vehicles used during the operational phase will be refuelled off site before entering the site;
- No fuels will be stored on-site during the operational phase; and
- Spill kits will be available in all site vehicles to deal with any accidental spillage and breakdowns; and,
- An emergency plan for the operational phase to deal with accidental spillages and breakdowns will be contained in the Environmental Management Plan for the wind farm operational phase. The plan will include access to spill kits, containment bins and absorbent material. Further details on emergency response are provided in the Construction and Environmental Management Plan in Appendix 4-4 of this EIAR.

Residual Impact: The use of hydrocarbons in plant and vehicles is a standard risk associated with all operational wind farm sites. Proven and effective measures to mitigate the risk of spills and leaks have been proposed above and will break the pathway between the potential source and the receptor. The residual effect is considered to be - Negative, imperceptible, direct, short-term, low probability effect on soil, subsoils and bedrock.

Significance of Effects: For the reasons outlined above, no significant effects on land, soils, subsoils or bedrock will occur.

9.5.3.3 Use of Oils in Turbine Transformers During Operational Stage

The transformer in the substation and transformers in each turbine will be oil cooled. There is potential for spills / leaks of oils from this equipment resulting in contamination of soils and groundwater. Hydrocarbon has a high toxicity to humans, and all flora and fauna, and is persistent in the environment.

Pathway: Soils, subsoil and bedrock pore space.

Receptor: Soil, subsoil and bedrock.

Potential Pre-Mitigation Impact: Negative, direct, slight, short term, unlikely impact on soils, subsoil and bedrock.

Proposed Mitigation Measures:

- All transformers and substation areas will be bunded to 110% of the volume of oil used in each transformer/substation;
- An emergency plan for the operational phase to deal with accidental spillages will be contained in the Environmental Management Plan for the wind farm operational phase. The plan will include access to spill kits, containment bins and absorbent material.

Residual Impact: The use of hydrocarbons in transformers and substations is a standard risk associated with all operational wind farm sites. Proven and effective measures to mitigate the risk of spills and leaks have been proposed above and will break the pathway between the potential source and the receptor. The residual effect is - Negative, imperceptible, direct, short-term, low probability effect on soil and subsoils and bedrock.

Significance of Effects: For the reasons outlined above, no significant effects on land, soils, subsoils or bedrock will occur.

9.5.4 Likely Impacts and Mitigation Measures: Decommissioning Stage

The potential impacts associated with decommissioning of the proposed development will be similar to those associated with construction but at a reduced magnitude due to the reduced scale of the works. Please refer to Section 9.5.2 above.

During decommissioning, it will be possible to reverse or at least reduce some of the potential impacts caused during construction by rehabilitating construction areas such as turbine bases, hard standing areas, and the substation. This will be done by covering hard surfaces with spoil to encourage vegetation growth and reduce run-off and sedimentation. Other impacts such as possible soil compaction and contamination by fuel leaks will remain but will be of reduced magnitude as the extent of the works will be less. However, as noted in the Scottish Natural Heritage report (SNH) *'Research and Guidance on Restoration and Decommissioning of Onshore Wind Farms'* (SNH, 2013) reinstatement proposals for a wind farm are made approximately 30 years in advance, so within the

lifespan of the wind farm, technological advances and preferred approaches to reinstatement are likely to change. According to the SNH guidance, it is therefore:

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

Mitigation measures applied during decommissioning activities will be similar to those applied during construction where relevant. Some of the impacts will be avoided by leaving elements of the Proposed Development in place, including the bases which will be rehabilitated by covering with local topsoil/spoil in order to regenerate vegetation which will reduce runoff and sedimentation effects. Mitigation measures to avoid contamination by accidental fuel leakage and compaction of soil by on-site plant will be implemented as per the construction phase mitigation measures.

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

9.5.5 Risk of Major Accidents and Disasters

None, as indicated above the risk of a landslide at the proposed development site is determined to be negligible/none.

9.5.6 Post Construction Monitoring

None required as no significant effects are anticipated.

9.5.7 Assessment of Health Effects

Potential health effects arise mainly through the potential for soil and ground contamination. A wind farm is not a recognized source of pollution and so the potential for effects during the operational phase are negligible. Hydrocarbons will be used onsite during construction however the volumes will be small in the context of the scale of the Proposed Development and will be handled and stored in accordance with best practice mitigation measures. The potential residual impacts associated with soil or ground contamination and subsequent health effects are negligible.

9.5.8 Potential Cumulative Impacts

The land, soils and geological impact assessment undertaken above in this chapter outlines that significant effects are unlikely due to the localised nature of the construction works. Impacts on land, soil and geology will not extend beyond the immediate vicinity of the Proposed Development Site. The proposed replanting works will have a negligible effect on land, soils and geology.

Therefore, no cumulative impacts between the Proposed Project, and other existing, permitted or proposed projects, listed in Section 2.7 in Chapter 2 of this EIAR, on land soils and geology will occur as there can be no interaction due to distance and separation.

Tree felling has negligible effects on land, soils and geology as no significant excavations are required during tree felling and therefore the surrounding commercial forestry will not contribute to cumulative effects associated with wind farm or cable route construction.

The proposed replanting lands are located in Co. Sligo and therefore will not contribute to potential cumulative impacts with the proposed wind farm development in terms of impacts on soils and geology. The potential direct, indirect and cumulative impacts of replanting lands on soils and geology has been assessed in the Section 6 of Appendix 4-3 Assessment of Forestry Replacement Lands.