11. GEOLOGY, SOILS AND PEAT

Executive Summary

This chapter provides an assessment of the potential impacts on the geological setting resulting from the introduction of the proposed development. The assessment has been prepared with reference to environmental legislation, planning policy and general guidance. The effects on the site geology, soils and peat are considered **not significant** under the EIA regulations.

A review of the previous data that supported the 2014 application (Tangy III ES (2014)) was undertaken and been used as a basis of this report, updated with limited new data to accommodate minor modifications to the original layout. The potential effects of the proposed development on the local geological environments were then identified.

A range of potential effects from the proposed development has been considered, including physical damage to protected geological sites, reduced groundwater quality, contamination exposure to human health and ecological systems, damage to and/or loss of peat environment, chemical attach on buried concrete, and damage to on and off-site infrastructure. If the effect is not deemed significant it has been scoped out of the assessment.

Various mitigation measures are recommended as part of the pre-construction site investigation (SI) works and also as part of the Construction Environmental Management Plan (CEMP). Available measures range from carrying out detailed intrusive ground investigations, to implementing recognised good practice measures during the construction.

The assessment took into account appropriate and targeted mitigation during the construction phase such as the development and implementation of a CEMP and use of best practice construction techniques. The central conclusion being that where these measures are applied, the residual impact and effects would not be raised above low or negligible and therefore were assessed as **Not Significant** in the context of the EIA Regulations.

The effects on the site geology, soils and peat are therefore considered to be **not significant** under the EIA regulations.

11.1 Introduction

11.1.1 This chapter provides an assessment of the potential effects from the proposed development on the geology and ground conditions. The specific objectives of the chapter are to:

- describe the geological, soil and peat baseline;
- describe the assessment methodology and significance criteria used in completing the impact assessment;
- describe the potential effects, including direct, indirect and cumulative effects, on geology, soil and peat features;
- describe the mitigation measures proposed to address likely significant effects; and
- assess the significance of residual effects remaining following the implementation of mitigation.

11.1.2 The significance of potential effects from the proposed development has been assessed by considering two factors: the sensitivity of the receiving environment and the potential magnitude of impact, should that effect occur. The assessment methodology has also been informed by experience of carrying out such assessments for a range of wind farm and other developments, knowledge of the water environment characteristics in Scotland and cognisance of good practice. This approach provides a mechanism for identifying the areas where mitigation measures are required and for identifying mitigation measures appropriate to the significance of potential effects presented by the proposed development. Criteria for determining the significance of effect are provided in Table11-2, Table 11-3 and Table 11-4.

11.1.3 Effects on surface water and private water supplies are addressed separately in Chapter 12: Surface Water.

11.1.4 This chapter is supported by:

- Appendix 11.1: Peat Stability Risk Assessment.
- Appendix 11.2: Borrow Pit Search Report.
- Appendix 11.3: Peat Management Plan.

These are included as stand-alone reports and have been updated from original submission to address minor changes in layout design which could impact the findings.

11.1.5 Figures 11.1 – Figure 11.12 are referenced in the text where appropriate.

11.2 Scope of Assessment

Study Area

11.2.1 The site boundary, as defined in Chapter 5 (Description of Development), was the focus of the geological and ground condition study. Details of the proposed development are illustrated in Figure 5.1.

Receptors

11.2.2 The following receptors have been initially addressed as part of this assessment:

- Protected Geological Sites.
- Groundwater Resources.
- Construction workers primarily (Human Health).
- Peat Environment.
- Buried Concrete Structures.
- Infrastructure, On and Offsite.

11.2.3 Construction practices shall be managed through the wider context of a CEMP. The outline CEMP (Appendix 5.1) will be further developed post-consent and implemented, maintained and updated by the appointed principal contractor.

11.2.4 A full understanding of the geological setting of the proposed development is required as part of the Environmental Impact Assessment (EIA) process. The sequence of soils and rocks which are present beneath the proposed development may influence the design and methods of construction required. The geology of a site can also be fundamental to controlling topography, geomorphology, hydrology and hydrogeology of the environment.

11.2.5 Sites may be designated for their scientific importance for geology. Local Geodiversity Sites can represent locations important for geology, geomorphology and soils outside statutorily protected reserve areas and Sites of Special Scientific Interest (SSSI).

11.2.6 The presence of ground contamination on development sites may have the potential to impact the proposed development and sensitive environmental receptors. A preliminary assessment of ground contamination has been undertaken in order to complete the impact assessment. The site however has been reviewed utilising historical plans and there is no evidence of any past uses which could give rise to contamination, and hence could impact receptors as a consequence of construction works. As a consequence, risk to human health of construction workers from contamination has been scoped out of the assessment.

11.2.7 Geohazards are similarly a key aspect of the EIA and can include as examples compressible ground, deeply weathered bedrock, natural geological subsidence and landslide hazards. A comprehensive assessment of salient geohazards has been carried out as part of the impact assessment process.

11.2.8 Specific focus on peat deposits is included in this assessment, no other significant geohazards have been identified. Appendix 11.1 (Peat Stability Risk Assessment) documents a comprehensive risk assessment process which has been undertaken for the proposed development. The Peat Stability Risk Assessment has been carried out in accordance with the current published guidance: Peat Landslide Hazard and Risk Assessments, Best Practice Guide for Proposed Electricity Generation Developments, 2nd Edition, Scottish Government 2017. The Appendices have been reviewed in line with the updated guidance and scoping comments.

Scoping and Consultation

11.2.9 Table 11.1 below summarises the scoping responses relevant to the Geology & Ground Conditions Chapter. Further detail is provided in Appendix 7.1: Register of Scoping Responses.

Table 11.1: Summary of Scoping Responses

Consultee	Summary of Response	Where & How Addressed
Scottish Environment Protection Agency (SEPA) October 2017	• SEPA accept the modifications being proposed to the consented (Tangy III) site design are unlikely to prejudice our interests. • A Private Water Supply (PWS) assessment should be carried out in accordance with the Land Use Planning System Guidance Notes 4 and 31. • The layout and the general principles for commissioning must demonstrate waste minimisation and compliance with the waste regulatory position. • Site Layout -all maps must be provided at an adequate scale with which to assess the information.	• Noted. • PWS assessment is provided in Chapter 12: Surface Water. • The principles of waste management during construction are detailed in Appendix 5.1: CEMP. • Site Layout Maps are provided at appropriate scales – see Volume 3a: Figures. • Details of the site layout and interactions with the water environment are illustrated in Figure 12.1.

Table 11.1: Summary of Scoping Responses		
Consultee	**Summary of Response**	**Where & How Addressed**
	• Engineering activities in water environment - The site layout must be designed to avoid impacts upon the water environment. • Watercourse crossings must be designed to accommodate the 0.5% Annual Exceedance Probability (AEP) flows. • Peat - The planning submission must a) demonstrate how the layout has been designed to minimise disturbance of peat and consequential release of CO2 and b) outline the preventative/mitigation measures to avoid significant drying or oxidation of peat throughout. • GWDTE & Existing groundwater abstractions the layout and design of the development must avoid impact on such areas. • Forestry - we prefer a site layout which avoids large scale felling as this can result in large amounts of waste material and a peak in release of nutrients which can affect local water quality. • Borrow Pits - The submission must provide sufficient information to address SPP policy on borrow pits. • Pollution prevention and environmental management - One of SEPA's key interests is pollution prevention - a schedule of mitigation must be submitted.	• EIAR Chapter 12: Surface Water provides an assessment of the hydrology baseline and potential significant effects. • This chapter - Chapter 11: Geology, Soil and Peat provides an assessment of the peat baseline and potential significant effects. Summary of mitigation can be found Appendix 11.3: Peat Management Plan. CO2 emissions are addressed in Chapter 5: Description of Development. • The GWDTE present in the ecological study area are assessed in Chapter 10: Ecology and shown on Figure 10.4: GWDTE (Volume 3a: Figures). • Felling is illustrated in Figure 16.1 and Replanting in Figure 16.2 in Volume 3a: Figures. • A borrow pit assessment is included in Appendix 11.2. • Pollution prevention measures are detailed in the CEMP (Appendix 5.1).

11.2.10 The potential for contamination on site has been scoped out as there are no potential sources of contamination from past uses based on typical locality and review of historical ordnance survey plans.

11.3 Methodology

Policy, Legislation and Guidance

11.3.1 The following guidance has been reviewed and incorporated into the study of geology soils and peat conditions at the site:

- Peat Landslide Hazard & Risk Assessments - Best Practice Guide for Proposed Electricity Generation Developments, 2nd Edition - Scottish Government, 2017.
- Developments on Peatland - Guidance on the assessment of peat volumes, re-use of excavated peat and the minimisation of waste -, Scottish Renewables, SEPA, 2012.
- Guidance on the developments on Peatland - Site Survey, Scottish Government Guidance, Soil Survey of Scotland, 2017, Scottish Government, SNH & SEPA.
- Floating Roads on Peat - Report into Good Practice in Design, Construction and Use of Floating Roads on Peat with particular reference to Wind Farm Developments in Scotland, Forestry Commission Scotland (FCS), Scottish Natural Heritage (SNH), 2010.

- Guidelines for the Risk Management of Peat Slips on the Construction of Low Volume/Low Cost Roads Over Peat, FCS, 2006.
- Good Practice During Windfarm Construction, A joint publication by; Scottish Renewables, SNH, SEPA, FCS, 2015 Version 3.
- CIRIA C552: Contaminated Land Risk Assessment - A guide to good practice, DJ Rudland, RM Lancefield, PN Mayell, CIRIA London, 2001.

Desk Study

11.3.2 A review of published information on historical site uses and environmental conditions for the site has been undertaken. Information was obtained from the following sources:

- Ordnance Survey Map Data; (www.magic.defra.gov.uk).
- British Geological Survey Map Data (www.bgs.ac.uk).
- The Coal Authority & Mine Explorer (www.coal.decc.gov.uk).
- British Geological Survey Sheet 12, Campbeltown, 1: 50,000 scale.
- 5m Resolution Digital Terrain Model.
- Appendix 11.1 Peat Landslide Hazard and Risk Assessment.

11.3.3 These primary data sources have been used to inform the assessment of potential effects on the geology and ground conditions at the site and any mitigation measures which may be required.

Field Survey

11.3.4 A combined peat survey and ground condition survey was conducted by Natural Power between September 2013 and June 2014, undertaken to previous guidance (2007). Additional peat probing was undertaken by SLR in March 2018 (to current guidance) to determine final location of the temporary construction compound and refined access to T8 and T10. The temporary construction compound moved into a location with no significant peat and the turbine locations at T8 and T10 did not change.

11.3.5 An initial peat probing survey was carried out in order to gather peat depth distribution data on a 100 m grid within the proposed development. Data was collected during September 2013.

11.3.6 A detailed peat probing exercise was conducted across an early design iteration of the proposed development during November 2013. Final phases of peat probing, and surveys were completed in June 2014, with a few additional points collected to finalise design in March 2018.

11.3.7 Peat core sampling was undertaken at each proposed wind turbine location for visual inspection and Von Post classification (Von Post and Grunland, 1926). Up to three full depth peat cores were obtained from suitable locations at each proposed turbine location.

11.3.8 A detailed account of the peat surveys and peat stability risk assessment is provided in Appendix 11.1.

Impact Assessment Methodology

11.3.9 In order to determine whether an effect is significant, the sensitivity of a potential receptor and the scale of effect are assessed. Receptor sensitivity, magnitude of effect and significance criteria has been developed for the geology, soils and peat assessment of the proposed development. These are detailed in Table 11.2 and 11.3. The assessment has been undertaken with cognisance of the guidance set out in paragraph 11.3.1 (Policy Legislation & Guidance). Expert evaluation by suitably qualified engineering geologists and engineers has also been applied as part of the assessment to determine sensitivity, magnitude and significance.

Sensitivity of Receptor

11.3.10 The sensitivity of the receiving environment (i.e. the baseline quality of the receiving environment) is defined as its ability to absorb an effect without a detectable change. It can be considered through a combination of professional judgement and a set of pre-defined criteria which are set out in Table 11-2. Receptors in the receiving environment only need to meet one of the defined criteria to be categorised at that associated level of sensitivity.

Receptor Sensitivity

Table 11.2: Criteria for Assessing Sensitivity Criteria

Sensitivity	Criteria
Not Sensitive	Receptor would not be affected by the proposed development.
Low	Low sensitivity geological receptors e.g. • Receptor is a minor/secondary aquifer or unproductive strata. • Peat less than 0.5m deep and not extensive in coverage across the Development. • Not a peatland habitat/unlikely to be a peatland habitat.
Medium	Medium sensitivity geological receptors e.g. • Receptor is locally designated for its geology importance through the Scottish geo-diversity designation. • Receptor is a minor aquifer providing private water supplies for agricultural use, with limited connectivity (ground water dependency) to surface water systems. • Evidence of low level contaminants or point sources which are unlikely to represent Significant Harm. • Mean peat depths are greater than 0.5m deep and will require excavation in isolated areas across the proposed development. • Areas that may be defined as a peatland habitat.
High	High sensitivity geological receptors e.g. • Receptor is designated for its geological importance on a national statutory basis e.g. Site of Special Scientific Interest (SSSI) or subject to an international designation. • Receptor is a major aquifer and provides locally or regionally important groundwater resources or supports sensitive river ecosystems. Development in a groundwater source protection zone and there is a strong groundwater dependency for terrestrial ecosystems. • Contamination is present and is likely to represent Significant Harm. • High sensitivity land use in terms of contamination of ground. • Average peat depths greater than 0.5m and excavated extensively for foundations and access tracks across the proposed development. • Priority Peatland Habitats.

Magnitude of Effect

11.3.11 For the assessment of effects on geological setting, the magnitude of an effect is considered. Magnitude of effect is determined based on a wide variety of criteria with principally duration (timing), size and the development scale relative to the receptor being affected considered by the assessment. Permanent effects are considered irreversible and lasting for the lifespan of the proposed development and beyond. Temporary effects are reversible or cease to affect the potential receptors at key points within the timeline of the proposed development. Direct effects arise from the construction and operation of the proposed development, whilst indirect effects are

related to the development and may change after the proposed development has been constructed.

Table 11.3: Magnitude Criteria	
Magnitude	**Criteria**
Negligible	• Little of no change from baseline conditions.
Minor	• Detectable short-term change to protected geological site or hydrogeological conditions. • Development changes site conditions and resulting exposure to contamination represents a low risk to receptors*. • Development unlikely to be affected by geohazards and unlikely to alter any geohazards on or near the site.
Moderate	• Evident change (short to medium term) to protected geological site or hydrogeological conditions resulting in temporary or consequential changes to baseline. • Development changes site conditions and resulting exposure to contamination represents a moderate risk to receptors*. • Development may be affected by geohazards or could alter a geohazard on or near the site.
Major	• Large scale change to protected site or hydrogeological receptor. Change likely to be permanent or long term. • Development changes site conditions and resulting exposure to contamination represents a high or very high risk to receptors*. • Development represents a near or certain probability of encountering geohazards and/or altering geohazards over a wider area.

*Based on the risk definitions in CIRIA C552 Contaminated Land Risk Assessment A Guide to Good Practice (2001) (CIRIA C552) using a qualitative risk assessment.

Significance of Effect

11.3.12 The 'Significance of Effect' scale is defined in Table 11.4. For the purposes of the geology and ground conditions assessment the duration has been classified as:

- Temporary Short term - construction/de-commissioning (ground works).
- Temporary Long term - operational phase.

Table 11.4: Example Matrix for Determination of Significance of Effect			
Sensitivity / Magnitude	**Low**	**Medium**	**High**
Negligible	Negligible	Low	Low
Minor	Low	Low	Moderate
Moderate	Low	Moderate	High
High	Moderate	High	High

11.3.13 Effects of moderate significance and above are considered significant in the context of EIA Regulations. The assessment of Residual effects is based on accepted criteria and relevant guidance and augmented by professional judgement.

Limitations and Assumptions

11.3.14 The limitations of the assessment are bound by the 3rd party data sources listed below:

- Geological data sources, BGS maps and online BGS databases (including geoindex) consulted have been assumed as accurate in their geological content and mapping, however, the accuracy and completeness of supplied information cannot be guaranteed. The data has been reviewed as part of the updated chapter to ensure compliance with guidance.

11.3.15 Parts of the proposed development that are currently populated by dense forestry for commercial harvesting have not been investigated due to limited accessibility. The assessment for the proposed design layout provided however is considered robust and the level of investigation undertaken appropriate for an EIA. There are no areas proposed for development that have not been surveyed.

11.4 Baseline Conditions

Designations

11.4.1 There are no recorded geological designations within the proposed development or within 100 m of the boundary of the proposed development.

11.4.2 Bellochantuy and Tangy Gorges are located approximately 700 m west of the site boundary [NR 659278] and are designated as a Geological Conservation Review Site. Although located outside of the Development, the Tangy Burn watercourse, which is partially sourced within the development, flows through the identified Tangy Gorge designated site. Bellochantuy and Tangy Gorges are a tripartite site SSSI for quaternary geology and geomorphology, and the closest component sites are situated approximately 700 m south-west and 2.3 km north-west of the site boundary. These two sites are two discrete gorge features on the western coastline of the Kintyre Peninsula.

Desk Study - Geology

Superficial Geology

11.4.3 Beneath the peat, although spatially variable in its extent, a variety of glacial deposits are understood to be present. These materials are remnants from the last glacial retreat. All are erosional, transported sediments of glacial diamicton, sands and gravels, cobbles and boulders in a matrix of clay and silt. The rock fragments within these deposits are understood to originate from the surrounding country bedrock formations. Glacial deposits can be deposited under a wide variety of conditions including: lodgement (ice contact), glacio-fluvial (sub/en - glacial), ablation (melt-out) and in-situ weathering processes. Particle size composition can be highly variable.

11.4.4 Peri-glacial head deposits may also be obscured by the blanket peat. These deposits may comprise clay, sand and gravel in proportions which depend on the upslope provenance of material. These deposits are poorly sorted and poorly stratified and formed during the post glacial period predominantly by solifluction (down slope freeze/thaw transport and deposition) and/or hill wash and soil creep. Sand and gravel may exist locally with lenses of silt, clay or peat and organic material.

11.4.5 Alluvium may be present across parts of the site in proximity and restricted to watercourses. These deposits generally comprise differing proportions of clay, silt, sand and gravel, all transported and deposited under relatively recent fluvial environmental conditions.

11.4.6 Figure 11.3 depicts the BGS digital geological mapping data for the superficial geological units beneath the study area.

Bedrock Geology

11.4.7 The bedrock geology comprises of the Stonefield Schist Formation on the western area of the site. According to the British Geological Society this is a metamorphic bedrock formed approximately 542 to 1000 million years ago. This formation was originally sedimentary in origin and has been later altered by low-grade metamorphism to its current facies.

11.4.8 The Eastern area of the site consists of the Glen Sluan Schist Formation. The British Geological Society describes this formation as "*metamorphic bedrock approximately 542 to 1000 million years ago in the period. Originally sedimentary rocks formed in deep seas. Later altered by low-grade metamorphism.*"

11.4.9 The central region of the site has two bedrock formations developed as linear sub-crops orientated in a north-west to south-east direction. The eastern band is the Loch Tay Limestone Formation. The British Geological Society describes this formation as a "*metamorphic bedrock formed approximately 542 to 1000 million years ago in shallow carbonate seas. Later altered by low-grade metamorphism.*" The western band is the Neoproterozoic Basic Minor Intrusion Suite, Amphibolite & Horneblende Schist. The British Geological Society describes this formation as a "*metamorphic bedrock formed approximately 542 to 1000 million years ago in the Neoproterozoic period*."

11.4.10 Figure 11.4 depicts the BGS digital geological mapping data for the solid geological units beneath the study area.

Structural Geology and Tectonic Features

11.4.11 There are two regional faults located south and east of the proposed development. The fault on the eastern side of the site runs south-west to north-east with past movement affecting units on the western side of the structure. The fault to the south of the site is inferred and may be an anticlinal axis indicating large scale structural folding of bedrock units across the Kintyre peninsula. Faults can often be associated with a zone of weakness within the rock mass and additionally may act as a preferential flow pathway for groundwater flow. It should be highlighted that these structures are understood to not be active and seismic hazards have not been included as part of this assessment. The listed faults on the BGS maps are not within the vicinity of the infrastructure, although unmapped faults may lie within the site boundary.

Peat Probing Survey

11.4.12 The peat probing surveys undertaken across the proposed development identify localised areas of peat which are greater than 1.5 m deep, as illustrated in Figure 11.5. The areas of peat greater than 1.5 m deep are typically found in the upland areas of the site and in discrete pockets with shallow groundwater levels. The probing surveys recorded peat depths less than 1.5 m deep across the majority of the site. Improved grazing land within the southern part of the proposed development is generally devoid of peat cover with the exception of minor pockets of peat present adjacent to isolated wet flush areas. The calculated mean peat depth across the recorded deposits is 0.55 m, with a maximum recorded peat depth of approximately 3.6 m in a deep pocket of peat recorded on the north-eastern boundary of the study area. The mapped distribution of peat deposits across the study area is based on the interpolation of peat depth data collected during all phases of field survey, illustrated in Appendix 11.1. The peat encountered across the site is typically brown pseudo-fibrous peat with a thin surface of peaty topsoil. With a moderate amount of decomposition and large content of root structure; typical Von Post Classification values range between [H4] to [H7].

Peat Stability

11.4.13 The peat stability baseline was assessed based on the site walkover survey, supported by terrain mapping and desk study review of the geological setting (Figures 11.2 & 11.3). Following this process there are concluded to be no signs of active peat slide instability. This includes no evidence for tension cracking on peat slopes. A subtle and relict natural peat slide deposit has been recorded on the northern periphery of the operational wind farm, however this feature is deemed to be isolated and limited in extent. The feature represents a zone of weathered peat affected by its position close to a watershed line where a slow process of erosion has produced a small area of disturbed peat. This feature is not considered to be active nor has the existing operational wind farm impacted the stability of this area. Peat depth, slope angle and in-situ un-

drained shear strength of the peat deposits was recorded for the site and preliminary slope stability undertaken for the present site conditions.

11.4.14 The detailed Peat Stability Risk Assessment for the proposed development has been provided as Appendix 11.1. Therein the baseline data collected on the proposed development site is presented and analysed.

Ground Contamination

11.4.15 The site walkover, review of previous data and the assessment of historical plans (for past uses which could give rise to contamination) has not indicated any signs of land contamination across the proposed study area.

11.4.16 Agricultural use of agro chemicals in the surrounding land may also be a possible source of contamination (e.g. pesticides/herbicides), however this is considered to be of low sensitivity to the geological setting, particularly with the limited extent of arable farming.

Hydrogeology

11.4.17 The BGS Hydrogeological Map of Scotland shows the area of the proposed development to be in a region where 'there are fractured or potentially fractured rocks that do not have a high primary permeability, or other formations of variable permeability. Although these formations will seldom produce large quantities of water for abstraction, they are important for local supplies and in supplying base flow to rivers and in turn lochs. An assessment of any potential groundwater dependent private water supplies has been provided within Chapter 12 (Surface Water), and assessment of a PWS in vicinity of Borrow Pit C has been completed. These sources are very localised as a consequence of the fractured nature of the rock and so potential impact to a PWS can be potentially mitigated.

11.4.18 Connectivity of the groundwater systems within the peat, superficial glacial deposits and underlying solid geology are likely to be compartmentalised across the study area. The groundwater flow regime established in the peat mass is likely to be complex and highly variable governed by terrain and peat material properties. Typically, groundwater flows may be concentrated within the upper acrotelmic peat layers. Static groundwater bodies or groundwater with an extended residence time may exist in the lower catotelmic peat layers. Desiccation cracking, fissures and eroded peat pipes within the peat mass may facilitate increased flows of groundwater through a fracture style flow regime analogous to that observed in bedrock units. Finally, there may be a concentration of groundwater flow along the base of the peat deposit, at the interface with underlying superficial glacial or alluvial deposits.

11.4.19 A separate and similarly heterogeneous groundwater flow regime is likely to exist within the superficial deposits beneath the site. In general, within glacial till, groundwater may be confined to 'perched' pockets of granular materials with transmission via seepage and intra-granular flow. Weathered horizons and lenses of sand and gravel are likely to provide the pathways for groundwater flow within the superficial deposits across the study area. It is therefore difficult to predict and model the linkages between the superficial and bedrock geology groundwater systems. It is highly probable that the two systems broadly operate as compartmentalised regimes with only sporadic and slow or delayed interactions.

11.4.20 The SEPA superficial aquifer map and bedrock aquifer maps (2004) indicate that the bedrock and superficial aquifers underlying the site are dominated by fracture flow with low productivity. The hydrogeological map also suggests that the site is generally underlain by impermeable rocks without groundwater at shallow depth. In the vicinity of Tangy Loch there is a band of concealed aquifers with limited potential and without significant groundwater. Therefore, the published sources of hydrogeological information show that flows are dominantly in fissures and fractures and unlikely to be extensive across the site. Based on this, the hydrological and hydrogeological

conditions of the site conducive to potentially support GWDTEs are not extensive and limited to isolated areas.

11.4.21 The groundwater regime would be confirmed by intrusive ground investigations carried out post-consent during the pre-construction phase of the proposed development.

Geotechnical Considerations

11.4.22 Wind turbine foundation types depend upon a number of factors, including:

- Depth of superficial deposits and depth to engineering bedrock level.
- Rock mass strength of the underlying bedrock geology.
- Groundwater conditions.

11.4.23 As part of a detailed site investigation (post-consent), the distribution of superficial deposits would be determined across the infrastructure alignment. This would provide detailed information for the depth and composition of deposits beneath infrastructure locations. A geotechnical drilling investigation would determine the rock mass properties at each turbine foundation and within the potential borrow pit areas.

Future Baseline

11.4.24 In reference to the geological setting there are no known or predicted future processes (other than the wind farm) which are likely to change baseline conditions. No significant information gaps are noted in the geological assessment.

11.5 Effects Evaluation

Construction Phase

11.5.1 Activities that are likely to occur on-site during the construction phase of development and which could involve interaction with geology and ground conditions are included below:

- Soil stripping and excavation of superficial materials;
- Removal and harvesting of trees
- Excavation for foundation and sub-structures;
- Storage of materials and stockpiling of excavated soils on-site;
- Re-use of excavated material on-site or imported materials for re-profiling and access track capping;
- Vehicle and plant machinery movements in close proximity to watercourse crossings;
- Drainage works and cable trenching;
- Construction of crane hardstand areas, turbine foundations, temporary construction compound, substation/control building and access tracks including culverting works;
- Removal of existing (Tangy I and II) wind turbines, partial removal of access tracks, other infrastructure and reinstatement of surrounding ground conditions; and
- Storage, handling and use of chemicals, such as oils, lubricants, fuels etc.

Operational Phase

11.5.2 Activities that are likely to occur on-site during the operational phase of development and which could involve interaction with geology and ground conditions includes:

- Small scale storage of chemicals, such as oils or lubricants for electrical infrastructure; and
- Storage of excavated and/or restored materials including peat, glacial till and rock.

Decommissioning Phase

- Activities likely to be taking place on-site during the final decommissioning stage which could involve interaction with the geology and ground conditions includes:
- Removal of wind turbines, access tracks and other infrastructure on a scale of operations similar to the construction phase of development;
- Replacement of material from excavated infrastructures (turbine foundations, crane pads etc.); and
- Limited storage of chemicals, such as oils, lubricants, fuels etc.

Receptors

11.5.3 The assessment of effects on the geology and ground conditions includes consideration of a wide variety of receptors. The assessment has considered the following:

- Protected geological sites (scoped out as no sites are present);
- Groundwater resources;
- Construction Workers (human health);
- Peat environment;
- Buried concrete structures;
- Infrastructure on-site; and
- Infrastructure off-site.

Impact Assessment

Peat Stability

11.5.4 The proposed development occupies an upland area with complex terrain and widespread blanket peat cover in the central part of the site. The preliminary peat stability assessment has examined the proposed turbine locations and associated infrastructure locations with a series of pre and post mitigation peat stability hazard zonation maps presented within Appendix 11.1.

11.5.5 The mean peat depth recorded across the infrastructure location is calculated to be 0.55m with a maximum peat depth of 3.6m recorded in discrete pockets centrally across the forested upland plateau. The design and optimisation of the proposed layout is such that these deeper zones of peat are not impacted by the proposed development.

11.5.6 The peat stability risk assessment (Appendix 11.1) confirms that ground conditions for all proposed turbine locations are calculated to be stable for the present site conditions. For the predicted construction condition, where best practice methods will be applied, there is determined to be a negligible probability of translational slide failure based on the factor of safety analysis.

11.5.7 The overarching semi-quantitative peat slide hazard risk assessment has assigned an insignificant to significant ranking for peat failure events across proposed turbine measures for the case of no applied control measures (pre-mitigation). Three proposed turbine locations T8, T9 and T10 have been assessed to be at 'Serious' hazard of peat instability for the case of no applied control measures. This is attributed to multiple contributory factors including peat depth, slope angle and the overriding factor being a close proximity to a main watercourse on the northern section of the proposed Development (Figure 11. 1and 11.2).

11.5.8 It is highlighted that the preliminary peat stability assessment of proposed turbine location T8 is based on interpolated peat depth and slope data. This is a result of this section of the site being inaccessible through wind-blown forestry, preventing safe access for field survey. A refined risk assessment of this location will therefore be undertaken post consent, following clear access into this area.

11.5.9 The overall peat stability impact away from the higher risk areas has been presented in Appendix 11.1. There are prevailing peat depths of 0.0 - 0.5m which contributes to a negligible likelihood of peat failure. The majority of the site is classified under the slope geometry of 4 - 8^{o} which does contribute to an elevated likelihood of peat failure. The impact on peat land is additionally elevated across the site due to the frequency of mapped watercourses. The un-mitigated impact is therefore concluded to be high as the watercourses act as offsite receptors, entraining peat material in an uncontrolled failure event. With the application of the stated control measures the mitigated impact is determined to be Low.

Summary of Pre-Mitigation Effects

11.5.10 The potential effects for the proposed development are tabulated in Table 11.5 with comments on mitigation to ensure significance of impact is low to negligible:

Table 11.5: Summary of Pre-mitigation Effects						
Receptors	**Groundwater Resources**	**Human Health**	**Peat Environment**	**Buried Concrete Structures**	**Infrastructure Onsite**	**Infrastructure Offsite**
Potential Effect(s)	Reduced water quality through de-watering, pollution, modification of hydrogeology.	Exposure of construction workers to contaminated land. Contamination of ground water sourced private water supplies.	Loss of Peat as Carbon Sink through peat instability. Impact on sensitive watercourses through peat instability.	Chemical Attack	Failure of foundations and infrastructure due to land instability. Failure of infrastructure due to faulted strata. Compressible ground causes excessive settlement.	Subsidence or damage to buildings or structures due to construction activity.
Sensitivity of Receptor	Medium to High (PWS)	High	Low	Low	Low	Low
Magnitude of Impact	Minor	Minor	Moderate	Minor	Moderate	Negligible
Significance of Impact	Low	Low	Low	Low	Low	Negligible
Duration	Short Term & Temporary	Short Term & Temporary	Long Term & Permanent	Long Term & Permanent	Long Term & Permanent	Long Term & Permanent
Direct or Indirect	Direct	Direct	Direct	Direct	Direct	Indirect
Comments / Mitigation	Proposed development highly unlikely to affect groundwater resource, Chapter 12 outlines the mitigation to protect a Private Water Supply near Borrow Pit C.	Carry out Geo-Environmental Study pre-construction.	Effects on areas of deep peat limited by avoidance by project infrastructure where possible and use of floating track design where peat >1m. Mean peat depth across the proposed development calculated to be 0.55m. Application of control measures to reduce peat stability risk to acceptable levels.	Carry out detailed ground investigation and design foundations to correct concrete specification.	No evidence of ground instability within vicinity of proposed infrastructure; Carry out geotechnical site investigation and design.	Infrastructure excavations are remote from residential dwellings.

11.6 Environmental Management and Mitigation Measures

11.6.1 Table 11.5 summarises the potential effects on geology and ground conditions as low or negligible and not significant in the current setting. However, the requirement for further mitigation, as part of the construction process is outlined below and is detailed in the CEMP.

11.6.2 A site-specific outline Construction Environmental Management Plan (CEMP) is provided in Appendix 5.1. The CEMP will be further developed post-consent / pre-construction and implemented, maintained and updated by the appointed principal contractor.

11.6.3 The CEMP is a management tool to identify issues which may arise as part of the construction process and where it could impact the current geological setting. Mitigation will include but not be limited to the following issues and will be an on-going working document.

- Avoidance of arisings being placed as local concentrated loads on peat slopes without first establishing the stability condition of the ground and slope system. Stockpiling on pockets of deep peat and in close proximity to steep slopes shall be avoided.
- Avoidance of uncontrolled and concentrated surface water discharge onto peat slopes. All water discharged from excavations during construction phase shall be directed away from all sensitive areas and shall be managed by a suitably designed site drainage management plan.
- All excavations where required shall be adequately supported to prevent collapse and the destabilising ground adjacent to excavations.
- Environmentally compliant drainage designs for the proposed development will form a primary control and mitigation measure for maintaining surface hydrology and shallow groundwater flow during the lifespan of the scheme. This is discussed in detail within Chapter 12 (Surface Water).
- The pre-mitigation peat hazard will be reduced to a manageable 'Significant' hazard level through routine application of control measures. These are highlighted below and discussed further within Appendix 11.1:
- Undertake detailed intrusive ground investigation gathering additional basal peat contact data and where possible acquire high quality geotechnical data in order to refine and update the peat stability risk assessment.
- Maintain the hydrological regime within the local area preventing surface ponding of water on peat deposits and ensuring there is no build-up of pore pressures within the peat. No surcharge loading of peat slopes, with no overburden or temporary peat storage across any high-risk construction areas.
- Monitoring and assessment throughout pre-construction and construction phase considering the changing properties of stockpiled materials including the effects of weathering.
- Ensuring experienced geotechnical personnel throughout investigation, construction and operational monitoring.

Monitoring

11.6.4 A Geotechnical Engineer will maintain a geotechnical risk register, including peat slide risks, for the duration of the construction works phase. The Geotechnical Engineer will undertake regular inspections of relevant areas and provide recommendations as required to the Principal Contractor. Details on the Geotechnical Engineer's role will be provided in the CEMP.

11.7 Residual Effects

11.7.1 Where correct best practice is applied in environmental management and mitigations applied in line with the requirements of the site ground conditions it is not envisaged that there would be any significant effects as prescribed in Table 11.4.

11.8 Cumulative Effects

11.8.1 There are no anticipated effects on the local geology or hydrogeological regime envisaged from any known nearby developments. No cumulative effects are therefore anticipated at this stage.

11.9 Summary

11.9.1 A summary of the EIA Assessment and overall significance of potential impacts following mitigations is set out in Table 11.6:

Table 11.6: Summary of Assessed Significance of Impacts to Identified Receptors

Receptor	Significance of Impact
Protected Geological Sites	None
Groundwater Resources	Low
Human Health	Low
Peat Environment	Low
Buried Concrete Structures	Low
Infrastructure Onsite	Low
Infrastructure Offsite	Negligible

11.9.2 Suitable and targeted mitigation will be applied to ensure that residual effects will be no greater that 'low' as described above. A standalone and separate peat stability assessment has been undertaken which has identified a risk of peat slide where development proceeds without adequate control measures. Full details including a comprehensive range of conclusions and recommendations have been provided within Appendix 11.1. Therein specialist mitigation measures are proposed to reduce the risk to insignificant levels.

11.9.3 The effects on the site geology, soils and hydrogeological conditions are therefore **not significant** under the EIA regulations.

11.10 References

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