CHAPTER 11: Geology and Carbon Balance

11.1 Executive Summary 11-1
11.2 Introduction 11-2
11.3 Scope of Assessment 11-2
11.4 Legislation, Policy and Guidance 11-6
11.5 Methodology 11-7
11.6 Baseline 11-10
11.7 Additional Information 11-13
11.8 Potential Effects 11-14
11.9 Mitigation 11-17
11.10 Residual Effects 11-17
11.11 Cumulative Effects 11-17
11.12 Conclusion 11-17
11.13 References 11-18

Figures (Volume 3)

Figure 11.1: Superficial Geology

Figure 11.2: Solid Geology

Figure 11.3 (A to G): Peat Depth

Figure 11.4: Carbon and Peat Class Drawing

Technical Appendices (Volume 4)

Technical Appendix 11.1: Borrow Pit Appraisal

Technical Appendix 11.2: Peat Landslide Hazard and Risk Assessment

Technical Appendix 11.3: Peat Management Plan

Technical Appendix 11.4: Carbon Calculation

11. Geology and Carbon Balance

11.1 Executive Summary

The potential effects that the construction and operation of the Proposed Development may have on the geology and soils has been identified and assessed as part of this Chapter and are considered **not significant** in terms of the EIA Regulations. Where relevant, mitigation measures are proposed to minimise potential effects. A carbon balance calculation has also been undertaken.

11.1.1 In order to optimise the proposed wind farm design layout, the disturbance of peat has been minimised by avoiding areas of thick peat deposits where possible and the re-use of peat would be maximised in accordance with best practice management.

11.1.2 Peat deposits have been located across most of the Site. Bedrock across the Site comprises of the Altnaharra Psammite Formation, a series of interbedded Psammite, Semi-pelite and Pelite. Extensive peat probing has been carried out during 2012 and 2020. Peat is generally of limited thickness across the Site (<1.0m) and the risk of instability is considered low to negligible (refer to Technical Appendix 11.2 – Peat Slide Risk Assessment for details).

11.1.3 Potential effects in relation to geology and carbon balance are most likely during the construction phase of the Proposed Development and may relate to effects on peat stability and excavation. The results of a peat slide risk assessment have helped to better inform the layout design, allowing for micro-siting of the wind farms infrastructure.

11.1.4 Ground conditions have been assessed during a preliminary desk study, site walkover and four phases of peat probing to establish peat depths across the Site. The assessments identify sensitive areas across the Site, namely areas of nationally important carbon rich soils including prioritised peatland habitats (Class 1 or 2). Peat is generally of limited thickness across the Site, however, in siting of infrastructure, efforts have been made to minimise impact on the peatland habitat with particular care taken to avoid isolated deeper pockets of peat.

11.2 Introduction

11.2.1 The Proposed Development is centred around grid reference: E:246180 N: 909181 on adjoining land to the north-west of the operational Achany Wind Farm and serves as an extension to this wind farm. This is approximately 1.5km from the River Cassley which runs parallel to the south-western boundary of the Site. Lairg is the closest settlement to the Site which is located approximately 11km to the south-east. The A839 single carriageway runs along the Site's southern extent, connecting the Achany and Rosehall Wind Farms to the public road network.

11.2.2 Tony Gee and Partners LLP (TG) geotechnical team have been commissioned by SSE Renewables (SSE) to provide an assessment of the prevailing geology, ground conditions and carbon balance associated with the Proposed Development. This Chapter considers the potential effects of the Proposed Development on the Site's geology and soils. It details the ground conditions on site followed by the identification and assessment of potential effects. Where relevant, mitigation measures are proposed to minimise potential effects.

11.2.3 The lead author of this Chapter is a Geotechnical Engineer with 4 years of consultancy experience and a member of the Geological Society of London. The development of the Chapter was overseen by a geotechnical engineer with over 15 years of consultancy experience, has received their PHD in geotechnics and is a Chartered Member of the Institution of Civil Engineers (C.Eng MICE).

11.2.4 This Chapter is supported by the following figures:

- Figure 11.1- Superficial Geology;
- Figure 11.2- Solid Geology;
- Figure 11.3 (A to G) - Peat Depth; and
- Figure 11.4- Carbon and Peat Class.

11.2.5 This Chapter is supported by the following Technical Appendices:

- Technical Appendix 11.1: Borrow Pit Appraisal;
- Technical Appendix 11.2: Peat Landslide Hazard and Risk Assessment;
- Technical Appendix 11.3: Peat Management Plan; and
- Technical Appendix 11.4: Carbon Calculation.

11.3 Scope of Assessment

Effects Assessed in Full

11.3.1 The following have been assessed in relation to the geological setting of the Site:

- Direct and indirect potential impact during construction:
  - Excavation, removal and storage of soils and peat;
  - Impact on ground conditions; and
  - Impact on hydrology of peat and groundwater.
- Direct and indirect potential impact during operation:
  - Impact on ground conditions.

Effects Scoped Out

11.3.2 Operational impact has been scoped out on the basis that regulatory and good practice measures are implemented throughout construction. This will continue throughout the operational phase of the Proposed Development.

11.3.3 The operational impacts scoped out include:

- Impact of both chemical and hydrocarbon pollution on superficial geology, peat and soils;
- Impact from erosion and sedimentation on superficial deposits, including both peat and soils;
- Impact from the loss and compaction of peat and soils; and
- The impact on peat stability.

11.3.4 The potential effects of decommissioning have been evaluated on the basis that the effect would be similar in nature to the construction stage but with a lesser impact and that the same principles and good practice would be adopted.

Study Area

11.3.5 The study area is defined by the area within the Site boundary where construction is proposed.

Consultation Responses

11.3.6 In undertaking this assessment, consideration has been given to Scoping Responses and other consultations undertaken as detailed in Table 11.1.

Table 11.1: Consultation Responses

Consultee	Issue Raised	Response/ Action Taken
Scottish Government	An assessment of peat landslide risks and details of mitigation measures should be included within the EIA Report, including the risk of pollution on watercourses and risk to population, human health and public safety where paths, roadways or properties could be impacted by landslides. Refer to the Scottish Governments document 'The Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (Second Edition) (Scottish Government, 2017, Peat Landslide, Hazard and Risk Assessments)	A Peat Slide Risk Assessment has been undertaken and included within Technical Appendix 11.2. The best practice and mitigation measures are discussed within this Chapter.
Scottish Environmental Protection Agency (SEPA)	The following information should be addressed in the EIA in support of the Proposed Development: a) Map and assessment of all engineering activities in or impacting on the water environment including proposed buffers, details of any flood risk assessment and details of any related Controlled Activity Regulations (CAR) applications; b) Map and assessment of impacts upon Groundwater Dependent Terrestrial Ecosystems (GWDTEs) and buffers;	a) Provided in Chapter 10: Hydrology and Hydrogeology b) Provided in Chapter 8: Ecology c) Provided in Chapter 10: Hydrology and Hydrogeology d) Peat depths are indicated on Figure 11.3 (A to G) and a PMP is included in Technical Appendix

Consultee	Issue Raised	Response/ Action Taken
	c) Map and assessment of impacts upon groundwater abstractions and buffers; d) Peat depth survey and table detailing re-use proposals; e) Map and site layout of borrow pits; and f) Schedule of mitigation including pollution prevention measures.	11.3 which highlights re-use proposals. e) A Borrow Pit Report is included in Technical Appendix 11.1. f) A Schedule of Mitigation is included in Chapter 18: "Schedule of Mitigation" and includes pollution prevention measures.
	It is important that the initial application is supported by enough peat probing information to inform the layout and should be clearly demonstrated to avoid the areas of deepest peat. The EIA Report must: a) Demonstrate how the layout has been designed to minimise disturbance of peat and consequential release of CO_2; and b) Outline the preventative / mitigation measures to avoid significant drying or oxidation of peat through, for example, the construction of access tracks, drainage channels, cable trenches, or the storage and re-use of excavated peat.	a) Chapter 2: "Site Selection and Design Evolution" details how the Proposed Development has been designed to minimise disturbance of peat. b) Construction methodologies and mitigation measures are described in the PSRA in Technical Appendix 11.2 and Peat Management Plan in Technical Appendix 11.3.
	The submission must include: a) A detailed map of peat depths to full depth and in accordance with 'Guidance on Developments on Peatland - Peatland Survey' with all the built elements (including peat storage areas) overlain to demonstrate how the development avoids areas of deep peat and other sensitive receptors such as GWDTE (Scottish Government, 2017, Guidance on Development on Peatlands). b) A table which details the quantities of acrotelmic, catotelmic and amorphous peat which will be excavated for each element and where it will be re-used during reinstatement. Details of the proposed widths and depths of peat to be re-used and how it will be kept wet permanently must be included.	a) Peat depths are indicated on Figure 11.3 (A to G) and PMP is included in Technical Appendix 11.3. Impacts on GWDTEs are assessed in Chapter 8: "Ecology" and Chapter 10: "Hydrology and Hydrogeology". b) A preliminary assessment of excavated peat volumes against re-used peat volumes has been included within the PMP in Technical Appendix 11.3.
	The information must be in accordance with SEPA's 'Guidance on the Assessment of Peat Volumes, Re-use of Excavated Peat and Minimisation of Waste' and 'Developments on Peat and Off-Site uses of Waste Peat'.	The information presented in this Chapter and its associated technical appendices is in accordance with SEPA requirements.
	Dependent upon the volumes of peat likely to be encountered and the scale of the Proposed Development, it must be considered whether a full Peat Management Plan (as detailed in the above guidance) is required or whether the above information would be best submitted as part of the schedule of mitigation.	A PMP has been included within Technical Appendix 11.3.
	If new borrow pits are proposed then a ground investigation needs to be carried out prior to the application being submitted to ensure that the areas proposed are likely to yield the material required.	Specific areas have been targeted based on site observations and a high level desk study. A ground

Consultee	Issue Raised	Response/ Action Taken
	Specific areas should be identified rather than large areas of search.	investigation will be undertaken at detailed design stage.
	A Site Management Plan should be submitted in support of the application containing the following information for each borrow pit:	
	a) A map showing the location, size, depths and dimensions;	a) Maps are included within Technical Appendix 11.5.
	b) A map showing any stocks of rock, overburden, soils and temporary and permanent infrastructure including tracks, buildings, oil storage, pipes and drainage, overlain with all lochs and watercourses to a distance of 250 metres. It must be demonstrated that a site-specific proportionate buffer can be achieved. On this map, a site-specific buffer must be drawn around each loch or watercourse proportionate to the depth of excavations and at least 10m from access tracks. If this minimum buffer cannot be achieved each breach must be numbered on a plan with an associated photograph of the location, dimensions of the loch or watercourse, drawings of what is proposed in terms of engineering works;	b) This will be included in the final submission of the CEMP document, post-consent. The outline CEMP has been included within Technical Appendix 3.1.
	c) A justification for the proposed location of borrow pits and evidence of the suitability of the material to be excavated for the proposed use, including any risk of pollution caused by degradation of the rock;	c) The suitability of borrow pits is discussed in Technical Appendix 11.1.
	d) A ground investigation report giving existing seasonally highest water table including sections showing the maximum area, depth and profile of working in relation to the water table;	d) A ground investigation will be undertaken post consent to inform borrow pit design.
	e) A site map showing cut-off drains, silt management devices and settlement lagoons to manage surface water and dewatering discharge. Cut-off drains must be installed to maximise diversion of water from entering quarry works;	e) Please refer to the Outline CEMP in Technical Appendix 3.1.
	f) A site map showing proposed water abstractions with details of the volumes and timings of abstractions;	f) Please refer to the Outline CEMP in Technical Appendix 3.1.
	g) A site map showing the location of pollution prevention measures such as spill kits, oil interceptors, drainage associated with welfare facilities, recycling and bin storage and vehicle washing areas. The drawing notes should include a commitment to check these daily;	g) Please refer to the Outline CEMP in Technical Appendix 3.1.
	h) A site map showing where soils and overburden will be stored including details of the heights and dimensions of each store, how long the material will be stored for and how soils will be kept fit for restoration purposes. Where the development will result in the disturbance of peat or other carbon rich soils then the submission must also include a detailed map of peat depths (this must be to full depth and follow the survey requirement of the 'Developments on Peatland - Peatland Survey with all the built elements and excavation areas overlain so it can	h) Proposed peat storage areas and dimensions are presented in the PMP in Technical Appendix 11.3. Peat depths are indicated on Figure 11.3 (A to G). The outline CEMP also identifies proposed peat storage areas and has been included within Technical Appendix 3.1.

Consultee	Issue Raised	Response/ Action Taken
	clearly be seen how the development minimises disturbance of peat and the consequential release of CO_2; i) Sections and plans detailing how restoration will be progressed including the phasing, profiles, depths and types of material to be used; and j) Details of how the rock will be processed in order to produce a grade of rock that will not cause siltation problems during its end use on tracks, trenches and other hardstanding.	i and j) Indicative borrow pit restoration profiles are provided in the PMP in Technical Appendix 11.3. Further details of phasing and rock processing, etc., will be provided post-consent upon completion of fully intrusive ground investigation, subsequent interpretation and development of the ground model.
Royal Society for the Protection of Birds (RSPB)	The carbon calculator should be used as early as possible in the planning process, to inform siting and micrositing of both turbines and tracks and other infrastructure, and not simply undertaken after the site layout has been determined. This must be clearly addressed in the EIA Report which should also include all the information input into the model. RSPB Scotland considers that the maximum payback period should be six months as a maximum and should ideally be as close to zero as possible.	Refer to Technical Appendix 11.4 which includes the Scottish Government Carbon Calculator results.
	The Proposed Development should achieve 'no net loss' of peatland, firstly through avoiding deep peat disturbance and secondly through commitments to restoration. A suitable area of modified blanket bog should be identified and restored as compensation for the loss of any functioning blanket bog. There are large areas within the proposed wind farm site where the peat is currently dissected by deep gullies that the applicant could consider restoring to blanket bog.	Please refer to Chapter 8: Ecology and Technical Appendix 8.10: Outline Habitat Management Plan.
	Peat probing indicates that peat is not extensive across the site and is generally less than 0.5m in depth. However, there are areas of "class 1- nationally important carbon rich soils, deep peat and priority peatland habitat" located within the site boundary. In such areas, Scottish Planning Policy states that further consideration will be required to demonstrate that any significant effects on the qualities of these areas can be substantially overcome by siting, design or other mitigation. In line with policy 55 of the Highland Wide LDP and national guidance, the EIA Report should show how damage to peat will be avoided and RSPB recommend all infrastructure avoids areas of deep peat in excess of 0.5m in depth.	All reasonable efforts have been made to locate wind farm infrastructure on areas of shallow peat. Due to the nature of the Site, not all deep peat can be avoided however and in some instances access track is required to go over sections of deep peat. In this instance floated track will be designed and will have minimal impact on areas of deep peat. Please refer to Technical Appendix 11.3 Peat Management Plan, which identifies these areas.

11.4 Legislation, Policy and Guidance

11.4.1 The following legislation, policy and guidance documents have been taken into account in the preparation of this Chapter:

- Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017;
- Scottish Planning Policy (Scottish Government, 2014); and

- All other publications as listed in section 11.4.2.

11.4.2 This assessment is carried out in accordance with the principles contained within the following documents:

- Scottish Renewables (2019) Good Practice During Windfarm Construction 4th Edition (co-authored by Scottish Natural Heritage, Scottish Environment Protection Agency, Forestry Commission Scotland, and Historic Environment Scotland);
- Scottish Government (2018) Carbon Calculator for Wind Farms on Scottish Peatlands;
- Scottish Government (2017) Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments;
- Scottish Government (2017) Guidance on Development on Peatlands: Peatland Survey; and
- SEPA (2012) Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and Minimisation of Waste.

11.5 Methodology

Desk Based Research and Data Sources

11.5.1 The following data sources have informed a generalised understanding of the ground conditions assessed:

- British Geological Survey (BGS) mapping sheet 102E "Lairg" (BGS, 2000);
- BGS Geoindex digital map viewer (BGS, 2021);
- Scottish Environment Protection Agency (SEPA) (SEPA, 2021);
- MAGIC Website (DEFRA, 2021);
- Scotland's Historic Land Use Map (HLA Map) (HES, 2021);
- Zetica UXO un-exploded bomb website (Zetica UXO, 2021);
- The Coal Authorities Interactive Map (Coal Authority, 2021);
- National Library of Scotland Map (NLS, 2021); and
- Scotland's Soils map viewer (Scottish Government, 2021).

Field Survey

11.5.2 A site walkover, including an inspection of potential borrow pit locations and three phases of peat probing were completed between June and December 2020. An earlier peat probing survey was undertaken in 2012 by SLR, and this data is also considered. This earlier survey included recovery of auger samples allowing limited lab testing, strength testing and logging in accordance with the Von Post criteria.

11.5.3 The surveys focused on undertaking preliminary and detailed peat probing to feed into the layout constraints for both peat depth and stability when identifying appropriate locations for wind farm infrastructure, including borrow pits.

Assessing Significance

11.5.4 The predicted significance of the risk was determined through a standard method of assessment based on professional judgement, guidance documents and best practice documents, taking account of three main factors:

1. Sensitivity of the receiving environment;
2. Potential magnitude of the risk; and
3. Probability of the risk occurring.

Sensitivity

11.5.5 The receptor sensitivity represents its ability to absorb the anticipated impact without any significant resultant change. Three levels of sensitivity have been used as shown in Table 11.2. Evaluating the sensitivity of geology and soils requires a considerable degree of judgement, based on defined characteristics and values and calling on professional experience, which is accordingly applied during evaluation.

Table 11.2: Geology risk sensitivity.

Risk Sensitivity	Criteria
High	Risk is in a designated site protected area under national or international legislation, such as Sites of Special Scientific Interest (SSSI), Special Areas of Conservation (SAC), and Special Protection Areas (SPA), for the disciplines assessed in this Chapter; Risk contains Geological Conservation Review (GCR) sites designated as SSSIs or Candidate SSSIs; Risk contains geological or geomorphological features considered to be of national importance, i.e. SSSI; and / or Risk contains areas of nationally important carbon rich soils with priority peatland habitat, i.e. Class 1 or 2.
Medium	Risk has areas containing geological features of Regionally Important Geological and Geomorphological Sites (RIGS) considered worthy of protection for their research, educational, historic importance; and / or Receptor has areas of soils with peatland vegetation, i.e. Class 3 and 4.
Low	Risk contains geological features not currently protected and not considered worthy of specific protection; Risk contains areas of soils that do not support peatland vegetation or mineral soils, i.e. Class 5 and 0; and / or Risk has areas of already altered geology / soils i.e. within quarries and areas of no soil.

Magnitude

11.5.6 The magnitude of change has been assessed by the criteria presented in Table 11.3. The magnitude of the impact takes into account the timing, scale, size and duration of the potential risk.

Table 11.3: Magnitude of change.

Magnitude	Criteria
Major	Long-term (≥12 months) or permanent loss of resource; and / or Partial loss of, or damage to, key characteristics, features or elements.
Moderate	Mid-term (≥6 months) measurable change in attributes, quality or vulnerability; Minor loss of, or alteration to, one or more key characteristics, features, elements or temporary loss of resource and / or quality; and / or Partial loss of, or damage to, key characteristics, features or elements.
Minor	Short-term (≥1 month) minor loss or detrimental alteration to one or more characteristics, features or elements or temporary measurable change in attributes, quality or vulnerability; and / or

Magnitude	Criteria
	Minor loss of, or alteration to, one or more key characteristics, features or elements.
Negligible	Temporary very minor loss, or no loss, or detrimental alteration to one or more characteristics, features or elements.

Significance

11.5.7 The predicted significance of the effect was determined through a standard method of assessment based on professional judgement, considering both sensitivity and magnitude of change as detailed in Table 11.4. Major and Moderate effects are considered significant in the context of the EIA Regulations.

11.5.8 The probability of occurrence of a risk has been evaluated as being high (≥50%), medium (<50% and ≥20%) or low (<20%) during the phase of work being assessed.

11.5.9 The application of good practice and mitigation measures greatly reduce the probability of a risk developing.

Table 11.4: Significance Criteria.

Sensitivity	Magnitude	Probability	Significance of Risk
High	**Major**	High	Major
		Medium	Major
		Low	Moderate
	Moderate	High	Moderate
		Medium	Moderate
		Low	Minor
	Minor	High	Minor
		Medium	Minor
		Low	Minor
	Negligible	High	Minor
		Medium	Negligible
		Low	Negligible
Medium	**Major**	High	Major
		Medium	Moderate
		Low	Minor
	Moderate	High	Moderate
		Medium	Minor
		Low	Minor
	Minor	High	Minor
		Medium	Minor
		Low	Negligible
	Negligible	High	Negligible
		Medium	Negligible
		Low	Negligible
Low	**Major**	High	Moderate
		Medium	Minor
		Low	Negligible
	Moderate	High	Minor
		Medium	Minor
		Low	Minor
	Minor	High	Minor
		Medium	Negligible

Sensitivity	Magnitude	Probability	Significance of Risk
		Low	Negligible
	Negligible	High	Negligible
		Medium	Negligible
		Low	Negligible

Assessment Limitations

11.5.10 Peat probing works were undertaken using a hand-held Global Positioning System (GPS) which is noted to be accurate to <5m.

11.5.11 Peat probing represents a record of peat depth at a discrete location. Underlying soils and/or geology cannot be determined solely from peat probing.

11.5.12 Peat has generally been recorded as having limited thickness (less than 1.0m). Augering of peat has been carried out at targeted areas and has allowed preliminary assessment of Von Post characteristics, undrained shear strength and moisture content. Further augering will be carried out at post-consent as part of a fully intrusive ground investigation.

11.6 Baseline

11.6.1 This section describes the ground conditions of the Site in relation to geology. A fully intrusive ground investigation will be conducted post-consent to confirm the ground conditions, obtain material properties and develop the ground model for detailed design.

Geology

Solid Geology

11.6.2 BGS GeoIndex and map sheet 102E depicts the Site geology to be consistent across the entirety of the study area comprising the Altnaharra Psammite Formation, a Psammitic rock formed by low grade metamorphism. BGS lexicon (BGS, 2020) infers the unit as being: "Siliceous Psammite and micaceous Psammite; generally grey to buff. Medium-fine grained, but locally gritty or pebbly (clast size up to 30 mm) layers, especially lower down in the stratigraphy. Locally Pelite or Semipelite layers up to a few metres thick; these increase in abundance upwards in the formation. Commonly deformed, then with flaggy structure. Where un-deformed, locally well-preserved sedimentary structures that include planar crossbedding, trough crossbedding, channels and abundant soft-sediment deformation structures, e.g. water escape structures and slump folds. Bed thickness where un-deformed ranges from 0.2 to 4 m thick." The Altnaharra Formation is thought to be deposited un-conformably upon the Lewisianoid Gneiss Complex.

11.6.3 Leucogranite igneous plutons are shown on the BGS maps to outcrop between the boundary of the Site and the A839, towards the south-east, and therefore may be encountered beneath the Psammite.

11.6.4 Due to the region's bedrock geology being metamorphosed, the general bedding dip is difficult to distinguish across the Site as the units are heavily foliated. The study area is located within the confines of a thrust belt, developing as an imbricated fan across the north of Scotland in a south-east to north-westerly orientation.

11.6.5 A Borrow Pit Assessment Report (Technical Appendix 11.1) completed for the Proposed Development was informed by assessment of five potential borrow pit areas identified at the Site, including one borrow pit utilised during construction of the existing Achany Wind

Farm site. This concludes that potential rock resources that can be won from the search areas are Psammite, Semi-pelite and Pelite.

Structural Geology

11.6.6 BGS mapping indicates there to be minor faulting running parallel to the Glen Cassley River, within the river valleys eastern side slopes. A significant fault has been recorded along the bed of Allt Bad an t-Sagairt, a minor tributary to the Glen Cassley River, situated to the north of the Site. No fault line directly underlies the Site, however faults within the region are identified as Thrust Faults with barbs on hanging wall side. The Faults also commonly share an easterly downthrow direction.

Superficial Deposits

11.6.7 BGS Geoindex indicates varying superficial deposits at surface across much of the proposed Site. Quaternary peat blankets most of the Site, in a north-westerly trend towards the eastern extent of the Site, where the topography begins to plateau, surrounding the hill lochs. Towards the south/south-west of the Site Glacial Till becomes more prevalent comprising undifferentiated till and hummocky ice-contact glacial deposits. The north-western extent of the Site hosts no superficial deposits except for small amounts of peat in places. Glacial till is anticipated beneath the peat where topographical lows are encountered. Alluvium deposits, comprising of clay, silt, sand and gravel, are found within the valley basin that hosts the Glencassley River, bordering the Site to the west and in stream beds located across the Site.

Peat

11.6.8 The bulk of peat probing was carried out by Tony Gee over the course of 3 phases between June and December 2020 to help inform the design of the Proposed Development. The data was added to the first phase of peat probing and augering by SLR in 2012 to support the initial Glencassley Wind Farm. The findings of all four surveys have been summarised within the Peat Slide Risk Assessment (Technical Appendix 11.2) and the Peat Management Plan (Technical Appendix 11.3).

11.6.9 In total, between the four phases of peat probing conducted, 4069 No. locations were probed. A summary of peat depths encountered across the entire Site has been included within Table 11.5. Some of the historic peat probes that were developed by SLR in 2012 extend to the north of the Proposed Development but are still considered to give an accurate indication of peat depths towards the north of the Site.

Table 11.5: Peat Depths Across the Site

Peat depth Range (m)	Total No. of Probes	Percentage of Probes
0.0 – 0.49	2198	54.02%
0.5 – 0.9	890	21.87%
1.0 – 1.49	546	13.42%
1.5 – 1.9	209	5.14%
2.0 – 2.49	148	3.64%
2.5 – 2.9	45	1.11%
3.0 – 3.49	13	0.32%
>3.5	20	0.49%
Total	**4069**	**100%**

11.6.10 A Quantitative Risk Assessment (QRA) has been undertaken to determine the baseline peat stability conditions in relation to the Proposed Development. The QRA approach is based on a system where factors and influences are multiplied together to generate a Risk Rating Score and corresponding qualitative relative risk. The QRA methodology is described in more detail in the Peat Slide Risk Assessment included within Technical Appendix 11.2.

11.6.11 The baseline Peat Slide Risk Assessment analysed 4069 No. peat probe locations to understand the risk of peat instability across the Site. The results found that the risk of peat instability occurring would be Negligible to Low across most of the Site. There were initially some concerns regarding slope gradient combined with peat depth encompassing Turbine 8. An additional stability analysis was conducted at this location which deemed Turbine 8 to be at low risk of peat instability. The Peat Slide Risk Assessment has been included within Technical Appendix 11.2.

11.6.12 Due to the Site's remote location, any peat instability is expected to impact the environment, ecology and the infrastructure associated with the Proposed Development. Post-consent, a fully instrusive ground investigation will be conducted and is likely to comprise boreholes, trial pits and Russian peat cores. Sampling will be possible along with in-situ and laboratory testing. Subsequently, the engineering properties and nature of the peat and underlying mineral soils and rock can be defined and peat stability can be analysed in greater detail.

11.6.13 Scotland's Carbon and Peatland area interactive map data set has been interrogated which presents soil classes of important environmental interest. The classes have been derived using a matrix of soil carbon categories (derived from Soil Survey of Scotland maps) and peatland habitat types (derived from Land Cover of Scotland 1988 map). Class 1 and 2 soils are considered priority peatland. On the basis of this mapping, as shown in Figure 11.4:

- The lower lying regions of the Site are predominantly Class 1 peat; and
- The hillsides and areas on a slope are predominantly Class 2 peat.

11.7 Additional Information

Environmental Designations

11.7.1 The Proposed Development is not situated in any areas designated for nature conservation. There are European and National designations in close proximity to the Sites eastern boundary and towards the south of the Site, namely the Caithness and Sutherlands Peatlands Special Protection Area (SPA), Special Area of Conservation (SAC), RAMSAR and associated Sites of Special Scientific Interest (SSSI) and the River Oykel SAC. There are no sites of geological importance present within the Site, or within 5km.

Site History and Land Use

11.7.2 According to the HLA mapping tool, plantation and managed woodland has been established along the River Cassley valley and to the south of the Site. In addition, rough grazing features across much of the Site.

11.7.3 According to the National Library of Scotland website, historic maps indicate that land use on the Site has remained relatively unchanged as moorland. The Site forms part of a sporting estate (primarily fishing). To the south of the Site lies the operational Achany and Rosehall wind farms, whilst other hydro and electrical infrastructure is present in the wider area. The Coal Authority Interactive Map shows no information related to any potential mine workings in the area. This is justified given the regional geology pertaining to the Site. Fossil fuel extraction can be ruled out for this reason.

Preliminary Unexploded Ordnance (UXO) Assessment

11.7.4 Unexploded ordnances (UXOs) are explosive weapons such as bombs, bullets, shells, grenades, and landmines that did not explode when they were first deployed and therefore still pose a risk from detonation.

11.7.5 The Zetica website indicative map classes the Site as within a low-risk area.

Carbon Balance

11.7.6 An assessment of the carbon impact of the Proposed Development has been carried out using the SEPA Carbon Calculator Tool v1.6.01 (Reference UIRC-LUK8-7CN3). The summarised results are as follows:

11.7.7 The net emissions of carbon dioxide from the project are expected to be 168,549 tonnes of CO2e. Because the project is expected to generate over 10.5 million MWh of electricity over its 50-year lifetime, this represents a savings of carbon dioxide for each unit of electricity generated by the project which otherwise would have been generated by other sources. Once the wind farm is operational, it is expected to result in an annual savings of 53,490 tonnes of CO2e versus grid-mix electricity generation. As such, the project has a payback time of 3.2 years compared to grid-mix electricity generation. These savings are even greater (and payback time faster) when compared to fossil fuel-mix electricity and coal-fired electricity. The project is expected to provide electricity at a ratio of 15.98 g/kWh. All values described here are for the expected scenario. Full details on the results for all three scenarios (expected, minimum, and maximum) are available in Technical Appendix 11.4.

11.8 Potential Effects

11.8.1 The assessment of effects is based on the Proposed Development description as outlined in Chapter 3: "Description of Development." Unless otherwise stated, potential effects identified are considered to be negligible. Assessments are based on the criteria for sensitivity, magnitude, probability and significance provided in Section 11.6 of this Chapter.

11.8.2 The assessment assumes that integral good practice measures in relation to design and construction methodology are employed. Such measures are discussed further in the technical appendices and highlighted in Table 11.7 and will be incorporated in the Construction Environmental Management Plan (CEMP).

11.8.3 Mitigation is considered as additional measures beyond the design principles and good practice; the application of such measures is separately noted and residual effects evaluated.

Sensitivity Assessment

11.8.4 Table 11.6 summarises the geology related conditions on site and assesses the sensitivity based on the requirements in Table 11.2.

Table 11.6: Sensitivity Assessment

Geological Unit	Description	Sensitivity
Peat	Site predominantly Class 1 and Class 2 peatland habitat.	High
Superficial Geology (excluding Peat)	No designated sites relating to superficial geology.	Low
Solid Geology	No designated sites relating to solid geology.	Low

Table 11.7: Predicted Construction Effects in Relation to Geology

Potential Construction Effects	Sensitivity of Receptor	Relevant Best/ Good Practice	Magnitude of Change	Probability of Change	Significance of Effect
Construction and/or plant movement in areas where peat deposits are thick, there is an increased risk of peat sliding, settling and/or displacing which has a potential effect on the sites hydrology, locally. The risk of peat slides has been assessed as being generally Negligible to Low across much of the Site.	High	A Peat Slide Risk Assessment report has been included within Technical Appendix 11.2. A Construction Environmental Management Plan has been included, see Technical Appendix 3.1. Regular inspections of peat stability will be carried out by the Contractor's Geotechnical Engineer throughout the construction phase of the project. Keep loading of peat to a minimum and maintain hydrology as best as possible.	Moderate	Low	Minor
Dewatering of peat during construction may degrade the structure of the peat, making it more susceptible to erosion.	High	A Construction Environment Management Plan has been included, see Technical Appendix 3.1. This details good practice in peat management including excavation and storage methods. Refer to SEPAs Guidance on the Assessment of Peat Volumes, re-use of Excavated Peat and the Minimisation of Waste (SEPA, 2012).	Minor	Medium	Minor
Excavated or disturbed peat may require disposal off site which will effect the sites carbon balance.	High	A Carbon Balance Calculation has been included within Technical Appendix 11.4. A Peat Management Plan has been included within Technical Appendix 11.3. Refer to SEPAs Guidance on the Assessment of Peat Volumes, re-use of Excavated Peat and the Minimisation of Waste. Excavation of peat should be kept to a minimum throughout the projects development.	Minor	Medium	Minor

Potential Construction Effects	Sensitivity of Receptor	Relevant Best/ Good Practice	Magnitude of Change	Probability of Change	Significance of Effect
Oversteepening cut faces when excavating during construction works could promote destabilisation within the cut material.	High	Peat stability has been assessed within the PMP included within Technical Appendix 11.3. This assessment is based on assumed ground conditions, however, a ground investigation is required to establish soil parameters where by an assessment can be carried out to establish safe slope angles to minimise the risk of slope destabilisation during construction.	Minor	Medium	Minor
Land erosion can be triggered by the stripping of vegetation, excavations, drainage installation and the construction of the wind farm. Superficial soil cover is not anticipated to be thick and therefore erosion would be minimal however groundwater may be present along the soil/rock interface which could increase the risk of instability as the groundwater lubricates the rock surface.	Medium	A Construction Environment Management Plan has been included within Technical Appendix 3.1. Good practice shall be implemented including careful minimisation of excavation, control of drainage and appropriate storage of materials. Drainage will be designed to ensure that the impact of water erosion on the Site is minimised. An intrusive ground investigation will be carried out post consent, to more fully understand the groundwater levels on site.	Moderate	Medium	Minor
Blasting of bedrock in recovering site won material may increase fracturing within the rock and decrease the rocks overall strength.	Low	Planning Advice Note (PAN) 50 Annex D 'The Control of Blasting at Surface Mineral Workings (Scottish Executive, 2000) and BS5607 'Code of practice for the safe use of explosives in the construction industry will be adhered to.	Moderate	Medium	Minor
Not understanding the bedrocks weathered zones and characteristics could result in insufficient bearing capacity when using this layer to found upon.	Low	An intrusive ground investigation will take place post consent to better understand the bedrock's characteristics and weathered bedrocks profile.	Moderate	Medium	Minor

11.9 Mitigation

11.9.1 Specific mitigation measures over and above relevant good practice and related guidance (see Table 11.6) would not be required. This is because the potential construction effects would be minor to negligible, thus **not significant**.

11.9.2 The CEMP has been included within Technical Appendix 3.1 and outlines good practice measures which are to be adopted throughout the proposed developments duration.

11.10 Residual Effects

11.10.1 As no specific mitigation measures are required, the residual effects on geology or soils would be as stated for potential effects (see Table 11.6).

11.11 Cumulative Effects

11.11.1 The Proposed Development is not expected to affect the geology out with the Site boundary assuming best practice measures are employed.

11.12 Conclusion

Further Survey Requirements and Monitoring

11.12.1 An intrusive ground investigation will be carried out, post-consent during the refinement phase to further establish ground conditions across the Site. This is likely to comprise fully intrusive soil boreholes, rotary boreholes, Russian peat cores and trial pits. The main focus will be on areas hosting wind farm infrastructure, including turbine foundations, crane hardstandings, water crossings, access track, substation, compound and borrow pit locations. The findings of the ground investigation will help inform civil design, quantify borrow pit resources, determine the re-usability of site won material and finalise the Peat Management Plan.

Summary of Significant Effects

11.12.2 The potential construction effects identified within this Chapter are considered to be minor and are therefore considered **not significant** in the context of the EIA Regulations.

11.13 References

British Geological Survey (2000): *Lairg, Scotland Sheet 102E, Solid and Drift Geology, 1:50k Provisional Series.*

British Geological Survey (2021): *GeoIndex map viewer*, available online at: https://www.mapapps2.bgs.ac.uk/geoindex/home.html.

Coal Authority (2021): *Map Viewer*, available online at: http://mapapps2.bgs.ac.uk/coalauthority/home.html.

DEFRA, (2021) *MAGIC Website*, available online at: https://magic.defra.gov.uk/home.htm.

HES (2021): *Scotland's Historic Land Use Map (HLA Map),* available online at: https://hlamap.org.uk/.

National Library of Scotland (2021): *Digital historic maps database Website*, available online at: https://www.nls.uk/.

SEPA (2012): *Developments of Peatland: Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and Minimisation of Waste.*

SEPA (2021): *SEPA Website*, available online at: https://www.sepa.org.uk/.

Scottish Government (2017): *Guidance on Development on Peatlands: Peatland Survey*.

Scottish Government (2017): *Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments.*

Scottish Government (2021): *Scotland's soil map viewer*, available online at: https://map.environment.gov.scot/Soil_maps/?layer=1

Zetica UXO (2021): *Unexploded Bombs Website*, available online at: https://zeticauxo.com/.