Chapter 6

Hydrology, Hydrogeology, Geology and Soils

SCOTTISHPOWER RENEWABLES

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Chapter 6

6 Hydrology, Hydrogeology, Geology and Soils

6.1 Introduction

1. This chapter considers the likely significant environmental effects of Carrick Windfarm (hereafter reffered to as the 'Proposed Development') on hydrology, hydrogeology, geology and soils receptors. For each of these topics it details the baseline description, identifies and assesses the effects on each receptor and, where relevant, identifies proposed mitigation.

2. This chapter should be read in conjunction with the following appendices, including their figures:

- **Appendix 4.1 Offsite Access Appraisal;**
- **Appendix 6.1 Peat Landslide Hazard and Risk Assessment;**
- **Appendix 6.2 Soil and Peat Management Plan;**
- **Appendix 6.3 Groundwater Dependent Terrestrial Ecosystems** (GWDTE)**;**
- **Appendix 6.4 Private Water Supply (PWS) Asssessment;**
- **Appendix 6.5 Watercourse Crossings Report;** and
- **Appendix 6.6 Initial Borrow Pit Assessment.**

This chapter is also supported by figures within **Volume 2: Figures 6.1 – 6.7**. Together with the above, this chapter completes the assessment of effects from the Proposed Development on Hydrology, Hydrogeology, Geology and Soils.

3. This assessment considers the likely significant environmental effects of the Proposed Development on the following:

- geomorphology and geology – geomorphological characteristics of the Site and changes to geological structures or effects on designated sites;
- soils and peat – changes to soil and peat characteristics related to erosion, compaction and soil quality, changes to peat stability within and immediately adjacent to the Site;
- hydrology – changes to groundwater infiltration and groundwater levels, water quality and wetland characteristics; and
- hydrology – changes to drainage regime and associated alteration to surface water runoff rates and volumes, erosion/sedimentation and water quality characteristics across the Site and the wider catchment, including designated sites. Also, changes to water resources such as public and PWS.

Appendix 4.1 Offsite Access Appraisal considers the potential effects of the proposed offsite access route to the Site on hydrology, hydrogeology, geology and soil receptors, concluding that there would be no potential significant effects likely to occur as a result of the offsite access route upgrade works and as a result, these have not been assessed further within this chapter.

6.2 Legislation, Policy and Guidance

6.2.1 Legislation

4. This assessment is carried out in accordance with the principles contained within the following legislation:

- The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017;
- The Water Environment and Water Services (Scotland) Act 2003;
- The Water Environment (Controlled Activities) (Scotland) Regulations 2011, as amended;
- The Water Intended for Human Consumption (Private Supplies) (Scotland) Regulations 2017; and
- The Electricity Act 1989.

6.2.2 Policy

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

- Scottish Planning Policy (SPP) 2014. The Scottish Government;
- Scottish Environment Protection Agency (SEPA) Environmental Policy Number 19, Groundwater Protection Policy for Scotland v3; and
- South Ayrshire Council Local Development Plan (October 2014).

6.2.3 Guidance

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

- Construction Industry Research and Information Association (CIRIA) (2001) Report C532, Control of water pollution from construction sites: Guidance for consultants and contractors;
- CIRIA (2006) Report C648, Control of water pollution from linear construction projects: Technical guidance;
- CIRIA (2006) Report C649, Control of water pollution from linear construction sites: Site guide;
- CIRIA (2018) Report C753, The Sustainable Drainage Systems (SuDS) Manual;
- Forestry Commission (2019) Managing forest operations to protect the water environment. Practice Guide;
- Scottish Executive (2012) River crossings & migratory fish: Design guidance;
- Scottish Executive (2017) Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments, 2nd Edition;
- Scottish Natural Heritage (SNH)[1] (2017) Siting and designing wind farms in the landscape, Version 3a;
- SNH (2018) Environmental Impact Assessment Handbook, Version 5;
- SNH (2001) Guidelines on the environmental impacts of windfarms and small-scale hydroelectric schemes; SNH (2010) Floating roads on peat;
- SEPA (Controlled Activities) (Scotland) Regulations 2011 (as amended) A Practical Guide;
- SEPA (2009) Policy No. 19, Groundwater protection policy for Scotland Version 3;
- SEPA (2015) Position Statement WAT-PS-06-02, Culverting of watercourses;
- SEPA (2010) WAT-SG-25, Engineering in the water environment: good practice guide;
- SEPA (2006) WAT-SG-31, Prevention of Pollution from Civil Engineering Contracts: Special Requirements;
- SEPA (2010) Regulatory Position Statement – Developments on Peat;
- SEPA (2017) Land Use Planning System SEPA Guidance Note 31, Guidance on assessing the impacts of development proposals on groundwater abstractions and groundwater dependent terrestrial ecosystems, Version 3;
- Scottish Renewables/SEPA (2012) Developments on Peatland: Guidance on the assessment of peat volumes, reuse of excavated peat and the minimisation of waste; and

[1] Now known as NatureScot.

- Scottish Renewables (2019) Good Practice During Wind Farm Construction (joint publication by Scottish Renewables, SNH, Scottish Environment Protection Agency, Forestry Commission Scotland, Historic Environment Scotland, Marine Scotland Science and AEECoW), 4th Edition.

7. The following SEPA (jointly with the Environment Agency and the Northern Ireland Environment Agency) Pollution Prevention Guidelines (PPG) and Guidance for Pollution Prevention (GPP) were also considered:

- GPP1 Understanding your environmental responsibilities – good environmental practices (October 2020);
- GPP2 Above ground oil storage tanks (January 2018);
- PPG3 Use and design of oil separators in surface water drainage systems (April 2006);
- GPP4 Treatment and disposal of wastewater where there is no connection to the public foul sewer (November 2017);
- GPP5 Works and maintenance in or near water (February 2018);
- PPG6 Working at construction and demolition sites (2012);
- PPG7 Safe storage – the safe operation of refuelling facilities (July 2011);
- GPP8 Safe storage and disposal of used oils (July 2017);
- GPP13 Vehicle washing and cleaning (April 2017);
- PPG18 Managing fire water and major spillages (June 2000);
- GPP21 Pollution incident response planning (June 2021);
- GPP22 Dealing with spills; (October 2018); and
- GPP26 Safe storage – drums and intermediate bulk containers (February 2019).

6.3 Consultation

8. **Table 6.1 Consultation Responses** summarises the consultation undertaken as part of the assessment. The response/action taken to the points raised by consultees is provided within the table, showing where the issues raised have been assessed, or where the Proposed Development has been altered in relation to the issue.

Consultee	Response	Action
South Ayrshire Council	The Council provided PWS information within 10 kilometres (km) area surrounding Site centre point.	This information is considered further in the **'Water Supplies'** section of this assessment, including details of appropriate mitigation measures proposed.
	The Council confirmed that there was no specific information available relating to historic flooding, within 10km of the Site.	This information is considered further in the **'Surface Water Flows and Flooding'** section of this assessment.
SEPA	SEPA provided authorisations under the Controlled Activities Regulations (CAR) found within a 10km radius of the Site centre point.	This information is considered further within **'Water Supplies'** section of this assessment, including details of appropriate mitigation measures proposed.
	Phase 1 Peat probing methodology was agreed. The method targets peat surveys within the identified developable area onsite, focussing particularly on provisional wind turbine locations, open ground and forest rides.	Peat probing was undertaken in accordance with methodology agreed, via consultation with SEPA, and is presented in **Appendix 6.2 Soil and Peat Management Plan** and in **Figure 6.5 Peat Overview**.
	Requested a detailed map of peat depths and table detailing quantities of acrotelmic, catotelmic and amorphous peat that would be excavated.	This information is presented in **Appendix 6. Peat Landslide Hazard and Risk Assessment** and **Appendix 6.2 Soil and Peat Management Plan,** and shown in **Figure 6.5 Peat Overview**.
	Map and assessment sought for all engineering activities in or impacting on the water environment including proposed buffers, details of any flood risk assessment and details of any related CAR applications.	This information is provided in **Appendix 6.5 Watercourse Crossings Report** and shown in **Figure 6.7 Hydrology Overview**.
	Requested a map detailing GWDTE within 100 metres (m) radius of all excavations shallower than 1m and within 250m of all excavations deeper than 1m.	This is presented in **Figure 6.6 GWDTE Overview**.
	The assessment should consider surface water flows and potential impacts upon this and downstream receptors associated with the infrastructure layout and outline potential mitigation.	This is considered further in the **'Modification of Surface Water Drainage Pattern'** section and **Appendix 6.5 Watercourse Crossings Report**.
	Information and plans sought showing borrow pits, pollution prevention measures, water abstractions and restoration measures.	This is provided in **Appendix 6.6 Initial Borrow Pit Assessment.**
	SEPA requested a general site layout/map showing the Proposed Development infrastructure in context with the water environment which demonstrates relevant buffers and pollution pathways have been appropriately considered. Justification would be required for any instances where standard buffer distances would not be met, including details of mitigation.	This is shown in **Figure 6.7 Hydrology Overview** and considered further in the Modification of **'Surface Water Drainage Patterns'** section.
	SEPA stated that management of surface water run-off and the highest level of detail regarding the exact sizing and location of mitigation features would form part of the Pollution Prevention Plan (PPP), required as part of the Construction Site Licence.	Noted.
	SEPA queried the potential for micrositing potential of wind turbines.	When applicable, this is considered further in **Appendix 6.1 Peat Landslide Hazard and Risk Assessment** and shown in **Figure 6.5 Peat Overview.**

Consultee	Response	Action
	SEPA were content with the approach to the GWDTE Assessment. The National Vegetation Classification (NVC) surveys are based on SEPA's Guidance LUPS-31 and then clustered based on their hydrogeological setting. The groundwater dependency is then revised for each cluster based on site visit notes, topography, hydrology and geology.	This information is explained further in **Appendix 6.3 GWDTE** and shown in **Figure 6.6 Groundwater Dependent Terrestrial Ecosystems**.
Scottish Water (SW)	Scottish Water advise that according to their records, the development proposals impact on existing Scottish Water assets. Scottish Water records indicate that the proposed activity falls within a drinking water catchment where a Scottish Water abstraction is located. Scottish Water abstractions are designated as Drinking Water Protected Areas (DWPA) under Article 7 of the Water Framework Directive (WFD). Stinchar Aqueduct supplies Afton, Bradan, Penwhapple and Camphill. Scottish Water state that given this area is located within a drinking water catchment, this should be noted in future documentation. Also anyone working onsite should be made aware of this during Site inductions. Scottish Water request further involvement at the more detailed design stages, to determine the most appropriate proposals and mitigation within the catchment to protect water quality and quantity. Scottish Water request that three months in advance of any works commencing onsite, Scottish Water is notified at protectdwsources@scottishwater.co.uk.	This information is considered further within the **'Water Supplies'** section of this assessment, including details of appropriate mitigation measures proposed. Further consultation will be carried out with Scottish Water during detailed design stage.
Forestry and Land Scotland (FLS)	Information regarding Scottish Water Assets provided for the Site.	This information is considered further within **'Water Supplies'** section of this assessment, including details of appropriate mitigation measures proposed.

Table 6.1: Consultation Responses

6.4 Assessment Methodology and Significance Criteria

6.4.1 Study Area

9. The Study Area was based upon the land within the Site, with a wider Study Area of 5km from the Site Boundary for hydrologically relevant designations and surface water receptors (following watercourse pathways). A Study Area of 1km from the Site Boundary was used to assess the effects on groundwater receptors. All other surveys related to this assessment were conducted within the Site Boundary. It is considered that at distances in excess of 5km, the Proposed Development is unlikely to have a hydrological or water quality effect, as attenuation and dilution of substances is likely to occur. In addition, areas down-catchment from the Proposed Development were included in the Study Area where there is potential for cumulative effects to occur, through the interaction between other windfarm developments with the Proposed Development. The Study Areas were based upon professional judgement and experience of assessing similar developments in similar environments.

10. The Study Area for the assessment undertaken in **Appendix 6.1 Peat Landslide Hazard and Risk Assessment** and **Appendix 6.2 Soil and Peat Management Plan** extends beyond the Site Boundary to include data gathered within a superseded Site Boundary, as shown in **Figure 3.3 Design Iteration of Wind Turbine and Infrastructure Layouts (A-D)**. As the Study Area covers the Site and more, the data is considered robust.

11. The Proposed Development is shown in **Figure 4.1 Site Layout Plan** in **Chapter 4: Development Description** and an aerial photograph is provided in **Figure 6.1.4 Aerial Photography** in **Appendix 6.1 Peat Landslide Hazard and Risk Assessment**.

6.4.2 Desk Study

12. The following sources of information have been reviewed during the desk-based study:

- Ordnance Survey (OS) (2017) digital mapping, 1:10,000, 1:25,000 and 1:50,000 scales.
- SEPA Water Classification Hub (2019) (River Basin Management Plan interactive web map);
- Scotland's Environment Main River and Coastal Catchments (2019) (interactive web map);
- SEPA Flood Maps (2020) (interactive web map);
- British Geological Survey (BGS) Hydrogeological Map of Scotland (2019), 1:625,000 scale;
- BGS Geoindex Onshore Bedrock and Superficial Deposits geology (2019) 1:50,000 scale (interactive web map);
- BGS Groundwater Vulnerability (Scotland) User Guide: Geographic Information Systems (GIS) dataset (2011), Version 2.
- NatureScot[2] SiteLink (2021) (interactive web map);
- James Hutton Institute Soil mapping 1:250,000 scale (2013) (interactive web map);
- Drinking Water Quality Regulator for Scotland (DWQR) PWS (2019) mapping;
- email correspondence with Scottish Water regarding public water supplies;
- email correspondence with the South Ayrshire Environmental Health Officer regarding PWS information; and
- email correspondence with SEPA regarding surface water and groundwater abstractions, authorised by SEPA under the CAR.

6.4.3 Field Surveys

13. The following field surveys were carried out to inform the assessment:

- Phase 1 peat probing between March and July 2020;
- Phase 2 peat probing between August and September 2020;
- Phase 2a peat probing on 2 October 2020;
- Substation peat probing between July and August 2021; and

[2] Formerly Scottish Natural Heritage (SNH).

- Watercourse Crossings surveys and PWS surveys between August 2020 and August 2021.

6.4.4 Assessment Methodology

14. The general methodology used to assess the effect of the Proposed Development on the geology, hydrology, hydrogeology and soils receptors of the Site is as follows:

- desktop study to obtain baseline and historical data;
- consultation with SEPA and South Ayrshire Council to identify water abstractions and PWS;
- field surveys undertaken in August 2020 and August 2021 to obtain watercourse crossings baseline data and confirm PWS data;
- identification of the likely significant environmental effects of the proposal on sensitive receptors; and
- identification of options for the mitigation of likely significant environmental effects, taking account of Good Practice measures.

15. The likely significance of environmental effect was determined through a standard method of assessment based on SNH (2018) Environmental Impact Assessment Handbook, taking account of three key factors:

- sensitivity of the receiving receptor;
- likely magnitude of the effect; and
- probability of the effect occurring.

6.4.4.1 Sensitivity

16. Sensitivity has been determined on the basis of the receptor's ability to absorb the anticipated effect without perceptible change resulting. Three levels of sensitivity have been used, as shown in **Table 6.2 Sensitivity of Receptors**. Evaluation of sensitivity of hydrology, hydrogeology, 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.

Sensitivity	Definition
High	• receptor has 'High' or 'Good' WFD overall status and/or water quality status for surface water or groundwater body; • receptor is a designated site protected under national or international legislation, such as Sites of Special Scientific Interest (SSSI), Special Area of Conservation (SAC), and Special Protection Areas (SPA), for the disciplines assessed in this chapter; • receptor contains Geological Conservation Review (GCR) sites designated as SSSIs or Candidate SSSIs; • receptor contains areas of regionally important economic mineral deposits; • receptor supports key species and habitats sensitive to changes in suspended sediment concentrations and turbidity, such as salmon or freshwater pearl mussels; • receptor supports GWDTE confirmed as highly groundwater dependent; • receptor contains a range of hydromorphological features with very little modification; • receptor is a watercourse or floodplain, with a possibility of direct flood risk to populated areas, which are sensitive to increased flood risk by the possible increase in water levels; • receptor provides clear flood alleviation benefits; • receptor used for abstraction or storage for public water supply or large PWS serving ≥10 properties; • receptor is classed as a high productivity aquifer; and • receptor groundwater vulnerability contains classes 5, 4a and 4b.
Medium	• receptor has 'Moderate' WFD overall status and/or water quality status for surface water or groundwater body; • receptor contains GCR sites with Local Geodiversity Site (LGS) status; • receptor contains areas of locally important economic mineral deposits; • receptor supports GWDTE confirmed as moderately groundwater dependent; • receptor contains limited hydromorphological features and a limited range of fluvial processes, such areas may have been subject to past modification such as straightening, bank protection and culverting or other anthropogenic pressures; • receptor is a watercourse or floodplain, with a possibility of direct flood risk to high value agricultural areas, which are moderately sensitive to increased flood risk by the possible increase in water levels; • receptor provides limited flood alleviation benefits; • receptor used for abstraction or storage for PWS serving <10 properties or for agricultural/industrial use; • receptor is classed as a moderate or low productivity aquifer; and • receptor groundwater vulnerability contains classes 2 and 3.
Low	• receptor has 'Poor' or 'Bad' WFD overall status and/or water quality status for surface water or groundwater body; • receptor contains GCR sites without SSSI (or Candidate SSSI) designation or LGS status, and non GCR sites with potential geodiversity interest; • receptor supports no key species and habitats sensitive to changes in suspended sediment concentrations and turbidity; • receptor supports GWDTE based on NVC mapping, with local water sources not considered as predominantly groundwater; • receptor contains no hydromorphological diversity and/or are identified as 'heavily modified water bodies' or 'artificial water bodies'; • receptor is a watercourse or floodplain which passes through low value agricultural areas, which are less sensitive to increased flood risk by the possible increase in water levels; • receptor provides limited flood alleviation benefits; • receptor does not support any water abstractions; • receptor is classed as a very low productivity aquifer; and • receptor groundwater vulnerability contains classes 0 and 1.

Table 6.1: Sensitivity of Receptor

6.4.4.2 Magnitude

17. The magnitude of change has been assessed taking account of the timing, scale, size, duration and reversibility of the likely effect. Four levels of magnitude have been used in this assessment, as shown in **Table 6.3 Magnitude of Change**.

Magnitude	Definition
Major	• long-term (≥12 months) or permanent change in surface water quality, resulting in a permanent change in WFD status and/or prevention of attainment of target status of 'Good'; • loss of feature(s) and failure of hydromorphological elements (morphology, quantity and dynamics of flow), loss or damage to existing habitats, replacement of natural bed and/or banks with artificial materials, extensive change to channel planform; • loss of floodplain due to construction within flood risk area; • permanent loss of water supply; • major or total loss of a geological Site or mineral deposit, where the value of the Site would be severely affected; • major or total loss of soils or where the value of the Site would be severely affected; • long-term (≥12 months) or permanent change in groundwater quality, resulting in a permanent change in WFD status and/or prevention of attainment of target status of 'Good'; • major loss of an aquifer in terms of water level or yield, with total loss of or major changes to dependent abstractions/habitats; and • major change or total loss of a GWDTE, where the value of the Site would be severely affected.
Moderate	• mid-term (≥six months) change in local surface water quality, potentially resulting in a temporary change of WFD status (or equivalent status at local scale) or preventing attainment of target overall status of 'Good' during this period; • adverse change to the integrity of hydrological feature(s) or loss of part of feature/moderate shift away from baseline conditions, failure of one or more hydromorphological elements (morphology, quantity and dynamics of flow), some damage or loss to habitat due to modifications, replacement of the natural bed and/or banks with artificial material; • floodplain reduction due to extensive increases in impermeable area within catchment and/or drainage design which would result in an increase in peak flood level; • temporary loss of water supply; • partial loss of a geological site or mineral deposit, with major change to the settings, or where the value of the Site would be affected; • partial loss of soils or where the value of the Site would be affected; • mid-term (≥six months) change in local groundwater quality, not affecting overall WFD status. • changes to an aquifer in terms of water level or yield, with small changes to nearby dependent abstractions/habitats; and • partial change or loss of a GWDTE, where the value of the Site would be affected.
Minor	• short-term (≥one month) change in local surface water quality, resulting in minor temporary changes such that ecology is affected for short-term. Equivalent to a temporary minor, but measurable, change within WFD status class; • potential failure of one of the hydromorphological elements (morphology, quantity and dynamics of flow), minimal shift away from baseline conditions or partial loss or damage to habitat due to modifications; • floodplain changes due to limited increases in impermeable area within catchment and/or drainage design which would result in a minor increase in peak flood level; • temporarily reduced quality and quantity of water supply; • small loss to a geological site or mineral deposit, such that the value of the Site would not be affected; • small loss of soils or where soils will be disturbed but the value not affected; • short-term (0-6 months) change in local groundwater quality; • small change to an aquifer in terms of water level or yield, with little discernible change to dependent abstractions/habitats; and • small change to or loss of a GWDTE, where the value of the Site would not be affected.
Negligible	• negligible change to surface water quality, very slight temporary change in water quality with no discernible change to watercourse ecology; • no alteration to hydromorphological elements, some change to feature(s), but of insufficient level to affect the use/integrity, approximating to a 'no change' situation; • floodplain variations of negligible change; • no anticipated change to water supply; • minimal or no change to a geological site or mineral deposit; • minimal or no change to soils; • negligible change to groundwater quality, very slight temporary change in local water quality. • minimal or no change to an aquifer in terms of water level or yield, with no discernible change to dependent abstractions/habitats; and • minimal or no change to or loss of a GWDTE.

Table 6.2: Magnitude of Change

6.4.4.3 Probability

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

19. The application of good practice and mitigation measures predominantly reduce the probability of an effect occurring.

6.4.5 Significance Criteria

20. The findings of the three criteria considered in the evaluation of an effect has been evaluated via a matrix for each potential effect (see **Table 6.4 Significance Matrix**) to assess the likely significance of an effect.

21. Through the assessment, potential effects are concluded to be of likely **major, moderate, minor** or **negligible** significance (before and after applicable proposed mitigation measures have been taken account of). For the purpose of this assessment, moderate and major effects are considered significant and minor and neligible effects are considered not significant.

22. Effects are considered adverse, unless stated otherwise.

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

Table 6.3: Significance Matrix

6.4.6 Limitations to Assessment

23. The fieldwork followed standard 'reconnaissance' field methods in which watercourses were visited close to planned access routes and peat probing was completed on a representative sampling basis initially, followed by a targeted approach within a refined Developable Area as the design evolved. Following the provision of the infrastructure design, specific infrastructure locations were visited for peat probe survey and stability assessment.

24. It is recognised that the equipment employed to determine peat depth will also pass through other soil types before 'refusal depth', thus peat depth results incorporate all soil through which probing rods pass, such as podzols, and gleys. This is a conservative approach to ensure soil depths are accurately gauged but is anticipated to provide an overestimate of peat depths, given visual evidence from the Site and the fact that the mapping indicates peat overlying other soil types.

25. PWS information was provided by South Ayrshire Council and used to plan site visits to assess PWS sources and properties served. It is recognised that Council information may be incomplete and that information on supplies serving abandoned properties and livestock welfare may not be available. However, it is considered unlikely that such types of supply exist at the Site.

26. Whilst some potential information gaps have been identified above, it is considered that there is sufficient information to enable an informed decision to be taken in relation to the identification and assessment of likely significant environmental effects on hydrology, hydrogeology, geology and soils.

6.5 Baseline Conditions

6.5.1 Site Description

27. The Proposed Development is located approximately 5.9km south of Straiton, entirely within the South Ayrshire Council area. There are a number of existing forestry tracks within the Site due to current forestry operations.

28. The Site consists mainly of mature coniferous woodland, dominating much of the northern part of the Site, and some areas of clear felled plantation. Peat is notable in open areas, such as forestry rides, clearings and in the vicinity of surface water bodies.

29. The steepest areas of the Site have been avoided for the development of infrastructure. The topography within the Site Boundary consists of undulating forested foothills, ranging between 242m to 430m above ordnance datum (AOD). Lower lying areas are in the east, with rising ground to the west including Garleffin Fell as the highest point within the Site. Linfern Loch lies just to the south of the centre of the Site at approximately 290m AOD. Beyond the Site Boundary to the south, the land is characterised by the steep valleys of the River Stinchar. To the north and north east, beyond the foothills at the edge of the Site, the land falls steeply to the Water of Girvan valley. Beyond the southern boundary of the Site, the forestry opens out to the rugged moorland uplands of Eldrick Hill and Balloch forest plantation.

6.5.2 Designated Sites

30. NatureScot SiteLink mapping (2021) indicates there are no nationally designated sites within 5km of the Site Boundary.

6.5.3 Climate

31. This section details:

- the climate characteristics for the Proposed Development and the surrounding region; and
- the historic rainfall data for the surrounding region.

32. The Site is recognised by the Met Office (2016) as within the Western Scotland climatic region. Much of Western Scotland's climate is influence by westerly winds from the Atlantic Ocean and the Gulf Stream. Coastal areas of the region are milder than the east of Scotland with temperatures falling inland and with altitude.

33. The Site is likely to experience a higher level of precipitation compared with lower areas nearby, with air cooling at altitude causing more cloud and precipitation.

34. The long-term average monthly rainfall is shown in **Plate 6.1** using details from the Eskdalemuir Met Office station (242m AOD and located approximately 84km east of the Site). The upper area of the Site is at approximately 480m AOD and the lower Site area on the east at around 115m AOD.

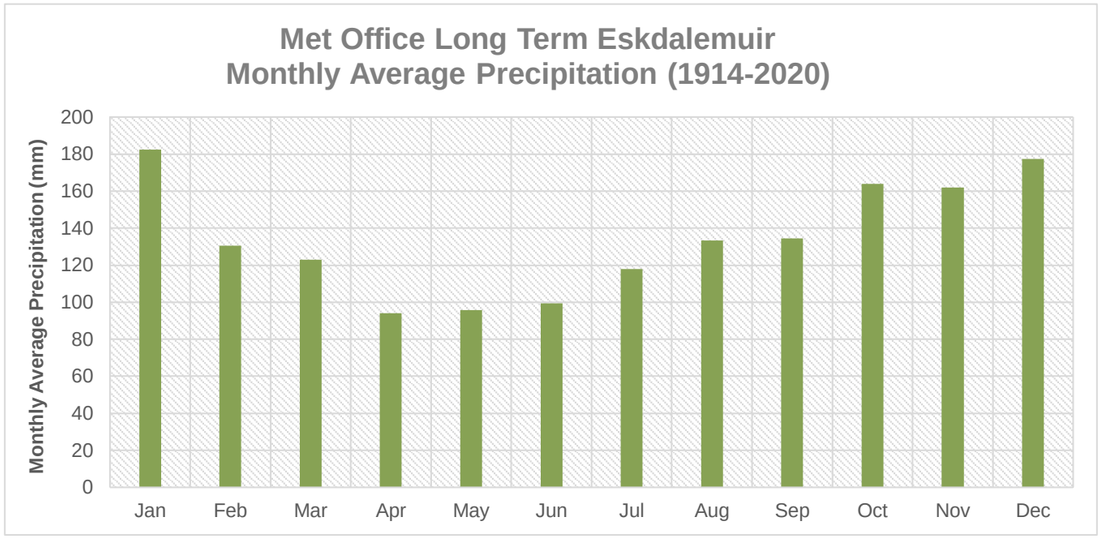


Plate 6.1: Long Term Monthly Average Rainfall Data at the Eskdalemuir Met Office Station

35. This precipitation data provides an understanding of seasonal variations that will be anticipated in the region area, with Eskdalemuir Met Office station at an altitude within the range across the Site.

36. Longer-term trends for Scotland indicate that weather may become more variable leading to hotter and drier summers and milder and wetter autumn/winters. It is also anticipated that there will be an increase in extreme temperatures and drought in summer and an increase in frequency and intensity of precipitation events.

6.5.4 Geomorphology

37. This section details:

- the geomorphological characteristics of the Site; and
- topographic cross-sections of the Site.

6.5.4.1 Geomorphological Characteristics

38. There are a number of identified hill peaks within and surrounding the Site, with the undulating terrain typically gently sloping. The steeper slopes within the Site are generally related to incised watercourse valleys, some of which have extremely steep slopes, such as the Tairlaw Burn and Dalquhairn Burn.

39. The Site is largely afforested peatland and till, reaching its peak at Garleffin Fell, 430m AOD, at the westernmost section of the Site Boundary. Other hills include Stob Hill, 335m AOD and Eldrick Hill, 328m AOD. The western section of the Site is drained by the Palmullan Burn and its tributaries. The eastern section of the Site is drained by the Tairlaw Burn.

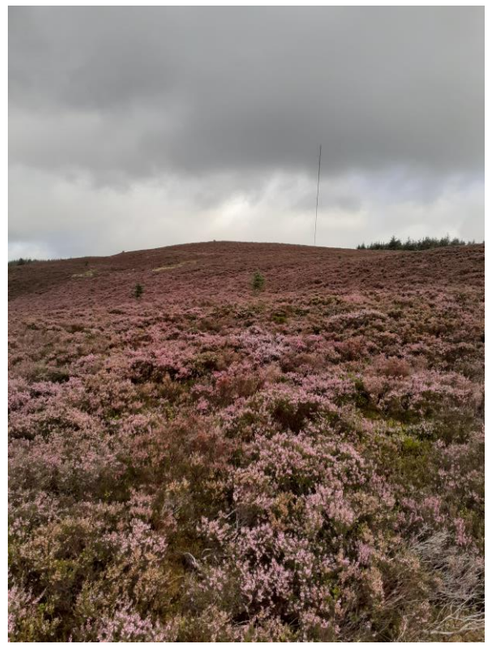
40. Elevation data is provided in **Figure 6.1 Elevation**. Transect locations of cross-sections are detailed in **Plates 6.2** and **6.3** alongside photographs of Site features.

41. **Photograph 6.1** and **Photograph 6.2** show the Site from two viewpoints, giving a good impression of current Site conditions.

42. Topographic cross sections of the Site taken from west to east, and north west to the south east across the Site are provided in **Plate 6.2** and **Plate 6.3,** respectively. They were generated using digital terrain model data. Site elevation data, including cross-section positions are shown in **Figure 6.1 Elevation**.

43. The slope angles exhibited on the Site are very steep in localised places, with slope angles in excess of 20˚ found along the valleys of Palmullan Burn, Tairlaw Burn and tributaries of the Dalquhairn Burn.

44. Where steeper slopes and watercourse channels are coincident, some accelerated bankside erosion was noted on both sides.



Photograph 6.1: (left image) Looking north, between the lower slopes of Stob Hill and Linfern Loch, taken at NGR 235223, 598204

Photograph 6.2: (right image) Looking east, between the lower slopes of Black Hill of Garleffin and Garleffin Fell, taken at NGR 234298, 599022

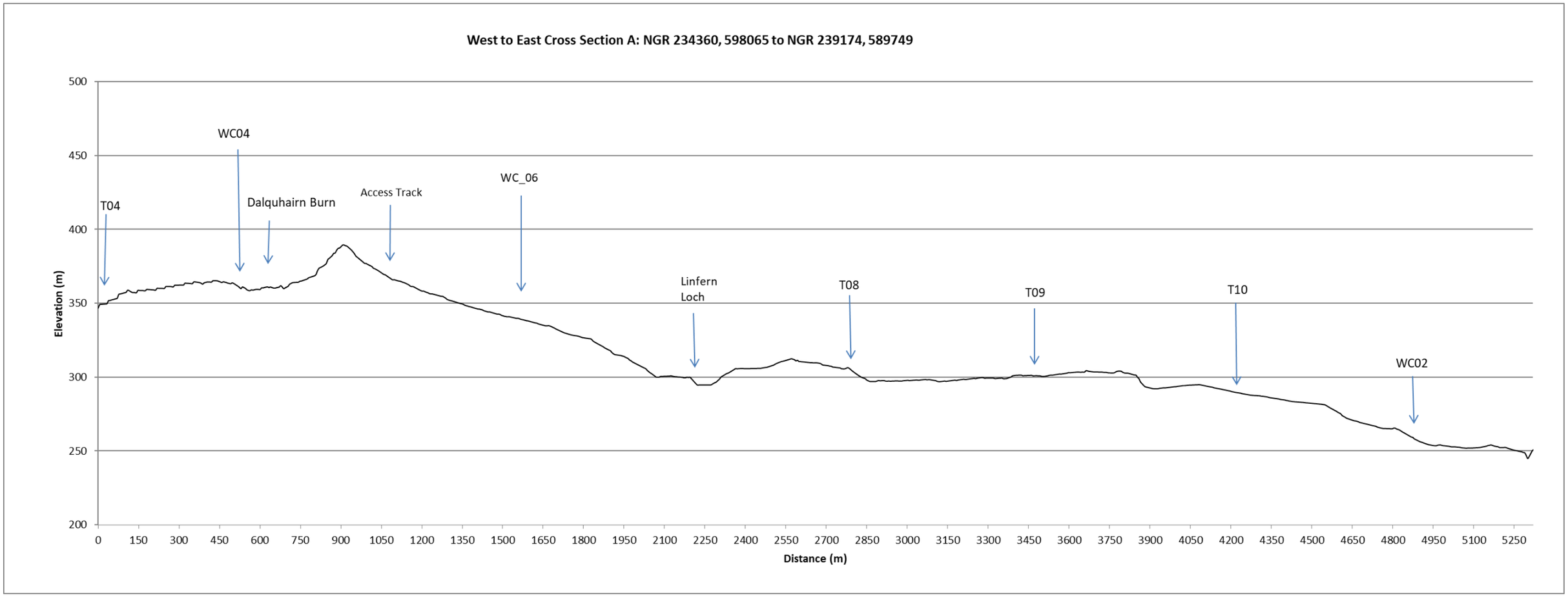


Plate 6.2: Cross Section A: NGR 234360, 598065 to NGR 239174, 589749 Showing Landforms From West to East

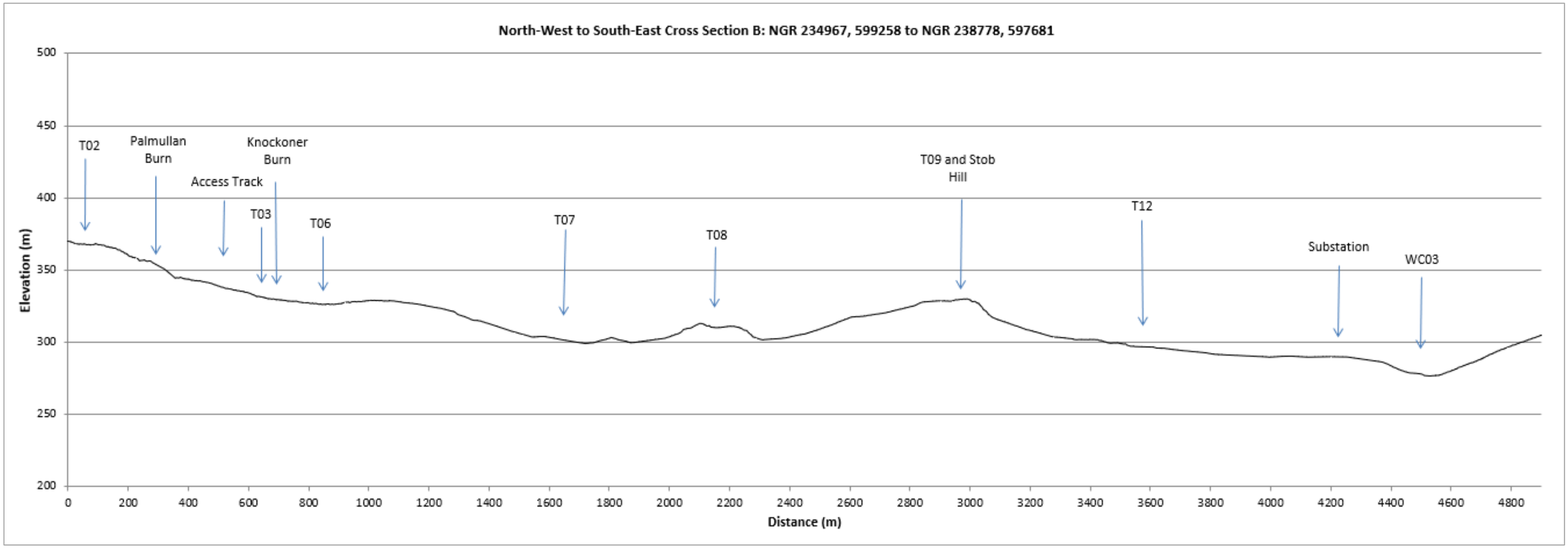


Plate 6.3: Cross Section B: NGR 234967, 599258 to NGR 238778, 597681 Showing Landforms From North West to South East Extents

6.5.4.2 Geology

45. This section details:

- bedrock geology (**Figure 6.2 Bedrock Geology**);
- superficial geology (**Figure 6.3 Superficial Geology**); and
- other geological faults or features found within and immediately surrounding the Site (**Figure 6.2 Bedrock Geology**).

6.5.4.3 Bedrock Geology

46. BGS Geological mapping (2019) (**Figure 6.2 Bedrock Geology**), indicates the formations noted within the Site from west to east:

- Swanshaw Sandstone Formation – red-brown, grey-green and chocolate-brown, medium and coarse-grained terrestrial sandstones with subordinate pebble beds and conglomerates, minor fine-grained sandstones, siltstones and mudstones. Estimated to be at least 750m thick;
- Duneaton Volcanic Formation – mainly andesitic and basaltic lavas, commonly amygdaloidal, including olivine basalts, pyroxene andesites and feldsparphyric lavas with subordinate volcanic breccias, tuffs and minor sandstone interbeds. Estimated to be from 440m in the reference section in the Duneaton Water tributary to at least 1200m thick;
- Southern Midland Valley Felsite Sills – Andesitic Rock. These igneous rocks are magmatic (intrusive) in origin. Poor in silica, they form intruded batholiths, plutons, dykes and sills;
- Greywacke Conglomerate Formation – conglomerate of cobbles and boulders up to 250mm diameter but most clasts are less than 70mm, mostly subrounded, consisting of greywacke, minor chert and quartzite, with a few sandstone beds;
- Dalreoch Formation – Sandy and pebbly greywacke. They are detrital and comprise coarse- to fine-grained slurries of debris. Approximately 1000m thick; and
- Kirkcolm Formation – Sedimentary Bedrock. Sandstone/siltstone turbidite sequence. They are detrital and comprise coarse- to fine-grained slurries of debris. Estimated thickness of c.4,500m.

There are small pockets of:

- Maybole-Straiton-Dalmellington Mafic Intrusions. These igneous rocks are magmatic (intrusive) in origin. Poor in silica, they form intruded batholiths, plutons, dykes and sills;
- Inverclyde Group – Sandstones containing pedogenic limestone and dolomite nodules ('cornstones'), fine-grained carbonate as beds, nodules and pebbles, and grey and brown mudstones containing thin beds of limestone and dolomite ('cementstones'); subordinate siltstone and mudstone. Thickness up to c.1,500m;
- Benan Conglomerate Formation – boulder conglomerate. Locally erosive contact with Stinchar Limestone Formation, basal beds are laterally equivalent to the Superstes Mudstone Formation. Thickness 50m-750m;
- Unnamed Igneous Intrusion, Late Silurian to Early Devonian – diorite, granite, granitic-rock, microdiorite, porphyritic microgranite and porphyritic microgranodiorite with subsidiary trachytic-rock and trace felsite and microgranodiorite. Igneous intrusive bedrock; and
- North Britain Siluro-Devonian Calc-Alkaline Dyke Suite.

6.5.4.4 Superficial Geology

47. Superficial geology mapping (**Figure 6.3 Superficial Geology**) indicates that the majority of the Site is underlain by till (Diamicton), areas of peat and small pockets of alluvium (silt and clay). Hummocky (moundy) glacial deposits (Diamicton, Sand and Gravel) are also noted.

6.5.4.5 Other Structural Geological Features

48. BGS geology mapping (**Figure 6.2 Bedrock Geology**) indicates that in the wider region, the noted geological Formations are heavily faulted.

6.5.4.6 Soils and Peat

49. This section details:

- soils and soil characteristics;
- carbon-rich soil, deep peat and priority peatland habitats;
- peat characteristics and depth; and
- peat stability.

50. The following information is summarised from The James Hutton Institute soil mapping, using the National soil map of Scotland (1:250,000 scale), with reference to information gathered onsite. Soils present within the Site are shown in **Figure 6.4 Soils.**

6.5.4.7 Soils and Soil Characteristics

51. The distribution of soils within the Site is dependent on the geology, topography and drainage regime of the area.

52. The Site consists of brown forest soils, podzols, gleys, noncalcerous gleys, blanket peat; units of Organic Soil, Linfern, Blair, Darleith and Ettrick Association. The soil units present are detailed in order of dominance onsite in **Table 6.5**.

Soil Association Parent Materials	Soil Unit	Component Soils	Landforms	Typical Associated Vegetation	Site Presence
Organic Soils Organic Deposits.	4	Dystrophic blanket peat.	Mainly on gentle slopes, but sometimes on steeper areas in the uplands and hills.	Rough grazing of poor quality from blanket, flying bent bog and upland and mountain blanket bog communities. Many areas ploughed, surface drained and planted with conifers.	Most predominant soil type, distributed throughout the whole Site.
Linfern Moranic drifts derived from greywackes and shales of Silurian and Ordovician ages and sandstones of Old Red Sandstone age.	379	Complex soil pattern of peaty podzols and brown forest soils.	On morainic mounds and blanket peat in intervening hollows.	Formally open moorland with moist Atlantic heather moor, blanket bog and acid bent-fescue grassland as the principal plant communities. Most of the land has been planted in recent years with coniferous trees.	Presence in the east of Site.
Blair Till derived from greywackes with lavas, sandstones and felsites of Old Red Sandstone age.	69	Noncalcareous gleys, peaty gleys and peat.	Undulating uplands with gentle and strong slopes.	Unimproved and sharp-flowered rush pasture, flying bent grassland and bog heather moor, and semi natural vegetation of sedge mires.	Sporadic presence of this soil throughout the Site, at the south-western extent, north of Stob Hill and north of Pulreoch Burn.

Soil Association Parent Materials	Soil Unit	Component Soils	Landforms	Typical Associated Vegetation	Site Presence
Darleith Drifts derived from basalts and intrusive basic igneous rocks.	159	Peaty podsols, Brown forest soils, and peaty gleys.	These soils are developed on stony loamy drifts on slightly rocky hill slopes.	The dry and moist Atlantic heather moors and acid bent-fescue grassland provide rough grazing of moderate quality and in some favoured areas sward improvement is possible.	Presence in the north-east of the Site.
Ettrick Drifts derived from greywackes and shales of Silurian and Ordovician ages.	230	Peaty podzols, peaty gleys; some peat and rankers.	Hills with complex strong and steep slopes: non-rocky.	Permanent pasture, forestry and recreation.	Present in the south west of the Site.

Table 6.4: Soil Units with Associated Landforms, in Order of Dominance Onsite

53. The high rainfall, slowly permeable clay loam till and topographic position on concave and gentle slopes all contribute to the wet conditions characteristic of this land.

54. A brief description of the characteristics and formation of component soil groupings is included below.

- Blanket peat: most common form of peat in Scotland, formed under cool maritime conditions. It is found in areas of high rainfall, often with low temperatures. Dead plant material builds up faster than it can be broken down by soil organisms. They contain a large store of carbon and are considered very important for nature conservation;
- Podzols: these typically form in acid, coarse textured, well drained materials. Surface vegetation is usually coniferous woodland or heather moorland. Podzols are generally nutrient deficient and heavily leached in the upper horizons resulting in a bleached appearance, with an accumulation of thin layers of iron/aluminium oxides ('ironpan') or organic material at lower levels within the soil profile, with an orange-brown or black colour, respectively. Humus-iron podzols have a surface horizon of humified (or decomposed) organic material. In areas with low slope angles, waterlogging may occur above the ironpan; this can produce a soil intermediate between a podzol and a gley;
- Gleys: naturally poorly drained soils that develop under conditions of intermittent or permanent waterlogging. Soils are typically greyish or blue with orange mottling. Peaty gleys have a peat-rich surface horizon. They are highly extensive soils, particularly in northern and western districts and listed among principal soils, generally together with peat, in a large number of map units. Non-calcareous gleys are naturally poorly drained soils that develop under conditions of intermittent or permanent waterlogging;
- Brown forest soils: Fertile, often deep soils, rich in nutrients and organic matter. Soil is free draining and often not very distinctive visually, although usually lightens in colour with depth as organic content decreases. Texture and level of fertility depend on parent material and degree of alteration that the soil has undergone; and
- Noncalcareous gleys: naturally poorly drained soils that develop under conditions of intermittent or permanent waterlogging. Soils are typically greyish or blue-grey with orange mottling. Humic gleys are loamy or clayey with a surface horizon of decomposed organic material, while peaty gleys have a peat-rich surface horizon.

6.5.4.8 Carbon-rich Soil, Deep Peat and Priority Peatland Habitats

55. The Carbon and Peatland Map (SNH, 2016), a Geographic Information System (GIS) vector dataset covering Scotland, presents the importance of environmental interests. They 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).

56. With reference to Scottish Planning Policy (2014), carbon-rich soils, deep peat and priority peatland habitat importance categories 1 and 2 from the Carbon and Peatland Map are within Group 2 ('areas of significant protection'), and the development should demonstrate that effects on this type of peat can be substantially overcome by siting, design or other mitigation. The mapping indicates that approximately 0.3% of the Site area is within Class 1 peat (SNH, 2016). This class is a small isolated area noted approximately 90m east of wind turbine 5, on the plateau of Glester Cairn. No Class 2 is noted within the Site.

57. The mapping indicates approximately 10.0% of the Site is within Class 4, and approximately 84.2% is within Class 5. These classes do not indicate peatland habitat. As shown within **Table 6.6**, Class 5 predominates throughout the Site and Class 0 around the Tairlaw Burn and steeper slopes. A summary description of the classes present within the Site is also provided in **Table 6.6**.

Class	Area (km^2)	%	Description	Site Presence
5	6.97	84.2	Soil information takes precedence over vegetation data. No peatland habitat recorded. May also include areas of bare soil. Soils are carbon-rich and deep peat.	Extensive presence throughout the Site.
4	0.83	10.0	Area unlikely to be associated with peatland habitats or wet and acidic type. Area unlikely to include carbon-rich soils.	Small areas located throughout the Site.
0	0.45	5.4	Mineral soil - Peatland habitats are not typically found on such soils.	Presence throughout the Site. It is noted surrounding steeper slopes and the Tairlaw Burn.
1	0.02	0.3	Nationally important carbon-rich soils, deep peat and priority peatland habitat. Areas likely to be of high conservation value.	Small area located adajcent to the track leading to wind turbine 5 and its hardstanding, on the plateau of Glester Cairn, in the western extent of the Site.
3	0.005	0.1	Dominant vegetation cover is not priority peatland habitat but is associated with wet and acidic type. Occasional peatland habitats can be found. Most soils are carbon-rich soils, with some areas of deep peat.	Small isolated area north of Linfern Loch.

Table 6.5: Summary of Carbon and Peatland Classes Present Within the Site in Order of Dominance Onsite

58. The depths measured during the peat surveys are summarised in **Table 6.7**. Peat/Soil Depths and fully detailed in **Appendix 6.2 Soil and Peat Management Plan**, provide site-specific peat depth information which supersedes the higher-level characterisation from the SNH Carbon and Peatland Map dataset.

Peat/Soil Depth Range (m)	Number of Locations Surveyed	Percentage of Locations Surveyed	Average Depth in Range (m)
0.0 to <0.5	651	35.8%	0.25
≥0.5 to <1.0	483	26.6%	0.71
≥1.0 to <1.5	260	14.3%	1.24
≥1.5 to <2.0	187	10.3%	1.71
≥2.0 to <2.5	105	5.8%	2.21
≥2.5 to <4.0	116	6.4%	2.97
≥4.0	16	0.9%	4.65
Total/Aggregate	1,818	100.0%	0.99

Table 6.6: Peat/Soil Depths

6.5.4.9 Peat Characteristics and Depth

59. Peat is a soft to very soft, highly compressible, highly porous organic material which can consist of up to 90% water by volume. Unmodified peat typically has two layers, a surface layer or acrotelm which is often around 0.30m thick (but can vary widely in depth depending on local conditions), highly permeable and receptive to rainfall. The acrotelm layer generally has a high proportion of fibrous material and often forms a crust under dry conditions. The second layer, or catotelm, lies beneath the acrotelm and forms a stable colloidal substance which is generally impermeable. As a result, the catotelm usually remains saturated with little groundwater flow. Peat is thixotropic, meaning that its viscosity decreases under applied stress. This property may be considered less important where the peat has been modified through artificial drainage and is drier but will be significant when the peat body is saturated.

60. Given the presence of peat, as aforementioned, further peat-specific work was undertaken, including peat probing for use in a site-specific peat stability assessment, soil and peat management plan and carbon emission evaluation. Soil and peat depths were sampled at representative locations across the Site, with latter focus upon infrastructure locations.

61. The Scottish Government guidance document on peat landslide hazard and risk assessments defines peat as a soil greater than 0.50m in depth, with an organic matter content of more than 60%. It is noted that, approximately 35.8% of the measured depths are less than 0.50m and are therefore not formally considered as peat.

62. **Table 6.7** shows the range of results gathered during peat depth surveys. A total of 1,818 soil and peat depth records were gathered at the Site, with measured depths averaging 0.99m.

63. Of the measured peat depths, 62.4% were less than 1.00m and 87.0% less than 2.00m. Peat is present within the forestry as well as in open areas, such as forestry rides, clearings and in the vicinity of surface water bodies.

1. The results of the peat depth survey were extrapolated to produce an indicative peat depth map as a 50m x 50m grid for the Site. This map and the results of the peat depth survey are shown in **Figure 6.5 Peat Overview**.
2. Peat typically has two layers, a surface layer or acrotelm which is often considered to be 0.10-0.30m deep, and catotelm, which lies beneath the acrotelm and forms a stable colloidal substance which is generally saturated and acts as an impermeable layer. Within the catotelmic peat, there can be a sub-divide, with a more structured and fibrous upper material and underlying amorphous material with a higher water content.
3. There are a number of infrastructure locations where amorphous catotelmic peat is likely to be present on the Site. This is based on the application of a 1.30m threshold depth, as advised by peat core data obtained at various onsite locations.
4. The key locations identified are listed below and described further in **Appendix 6.2 Soil and Peat Management Plan**:

- Wind turbines 1 and 2;
- Wind turbine 3;
- Wind turbine 7;
- Wind turbine 10; and
- Wind turbine 13.

64. Due to the iterative design process, using peat depth constraints as a key component for new infrastructure locations, the deeper peat locations where more sensitive amorphous catotelmic material is predicted have been avoided, where practicable. The infrastructure likely to lead to excavation of amorphous catotelmic peat, at a threshold depth of 1.30m or greater, are generally related to the ancillary infrastructure around wind turbine locations such as the blade laydown areas, crane hardstandings, turning heads and crane boom assembly areas, as well as specific access track sections; for which opportunities to avoid or reduce excavation have been noted within **Appendix 6.1 Peat Landslide Hazard and Risk Assessment**.

6.5.4.10 Peat Stability

65. Due to the presence of areas of peat on the Site, a peat landslide hazard and risk assessment has been undertaken and a soil and peat management plan prepared.

66. The peat landslide hazard and risk assessment applies a combined qualitative (contributory factor) and quantitative (factor of safety) approach to determine the likelihood of peat landslides and then compares areas with the highest likelihoods with receptors to identify risks and determine appropriate mitigation measures. Further details on the methodology, interpretation and results are provided in **Appendix 6.1 Peat Landslide Hazard and Risk Assessment**.

67. A peat management plan has been prepared that uses peat depth data to calculate likely excavation volumes during construction, identifies pragmatic options for reuse of excavated material, including in restoration of degraded areas across the Site, and provides guidance on good practice storage and management of excavated material. Further details are provided in **Appendix 6.2 Soil and Peat Management Plan**.

6.5.5 Hydrogeology

68. This section details:

- hydrogeological features present at the Site and their characteristics;
- groundwater vulnerability;
- groundwater body characterisation and water quality; and
- GWDTE.

6.5.5.1 Hydrogeological features

69. The majority of the Site is underlain from north to south by Southern Midland Valley Felsite Sills and Duneaton Volcanic Formation, and are classified as low productive aquifers. These formations may support small PWS.

70. There are also small pockets of Inverclyde Group (sandstones containing pedogenic limestone and dolomite nodules, fine-grained carbonate as beds, nodules and pebbles, and grey and brown mudstones containing thin beds of limestone and dolomite; subordinate siltstone and mudstone).

6.5.5.2 Groundwater Vulnerability

71. Groundwater vulnerability to pollution is predominantly Class 4, which is defined as ‘Vulnerable to those pollutants not readily adsorbed or transformed’.

6.5.5.3 Groundwater Body Characterisation and Water Quality

72. The WFD came into force in December 2003 and is implemented in Scotland through the Water Environment and Water Services (Scotland) Act 2003. A key objective of this Directive is the achievement of 'good condition' (as a minimum) of all natural water bodies by 2027.

73. Under the terms of the WFD, all river basin districts require to be characterised. The characterisation process required SEPA to produce an initial assessment of the impact of all significant pressures acting on the water environment. Groundwater bodies have been identified to reflect the main aquifer types (bedrock and superficial). For areas above low productivity aquifers, groundwater bodies have been defined by SEPA using surface water sub-catchments as a surrogate. Areas above high productivity aquifers have been defined using geological and major catchment boundaries. The main purpose of identifying water bodies is to enable their status to be described accurately and compared with environmental objectives.

74. SEPA classify groundwater bodies using two classes: 'Good' and 'Poor'. The classifications take into account pressures and their potential effects, compared to near natural conditions for the respective water body (SEPA, 2019). This risk-based system highlights groundwater issues such as over abstraction, in addition to chemical groundwater quality. There are two groundwater bodies within the Site; Girvan (ID: 150607) and South Ayrshire Hills (ID: 150606). The classification results of these water bodies are summarised in **Table 6.8.**

Name (WFD SEPA ID)	Area (km^2)	Classification (2019)	Anticipated Classification (2021)	Summary of Pressures
Girvan (ID: 150617)	139.6	Overall: Good Quantitative status: Good Chemical status: Good	Overall: Good Quantitative status: Good Chemical status: Good	No existing pressures
South Ayrshire Hills (ID: 150606)	367.6	Overall: Good Quantitative status: Good Chemical status: Good	Overall: Good Quantitative status: Good Chemical status: Good	No existing pressures

Table 6.7: WFD Groundwater Classification

6.5.5.4 Groundwater Dependent Terrestrial Ecosystems

75. Regions of the Site have been surveyed using the NVC system and an associated map produced, see **Chapter 7: Ecology and Biodiversity**. This map was reviewed for GWDTE in accordance with SEPA guidance (2017). This was used to determine which NVC areas could potentially be GWDTE-applicable.

76. The NVC surveys targeted areas across the Site (see **Appendix 7.2 Habitats Baseline Report**). The vegetation is a matrix of species including those which are identified as GWDTE, including NVC M15, M23, M23a, M23b, M25, M25a, M6d, and MG10a. Further details of each community are detailed below:

- M15 *Trichophorum-Erica* wet heath is widespread in the north and west of Great Britain. It is most common in the western Highlands. It is a community of shallow, wet or intermittently waterlogged, acid peat or peaty mineral soils on hillsides, over moraines, and within tracts of blanket mire (JNCC, 2004);
- M23 *Juncus effuses/acutiflorus-Galium palustre* rush-pasture community and sub-communities (M23a and M23b), occur over a variety of moist, moderately acid to neutral, peaty and mineral soils in the cool and rainy lowlands of western Britain. It is a community of gently-sloping ground around the margins of soligenous flushes, as a zone around topogenous mires and wet heaths, and especially widespread in ill-drained, comparatively unimproved or reverted pasture (JNCC, 2001);
- M25 *Molinia caerulea-Potentilla erecta* mire and sub-community M25a, is a community of moist, but well aerated, acid to neutral peats and peaty mineral soils in the wet and cool western lowlands of Britain. It occurs over gently-sloping ground, marking out seepage zones and flushed margins of sluggish streams, water-tracks and topogenous mires, but also extends onto the fringes of ombrogenous mires (JNCC, 2004);
- M6 *Carex echinate-Sphagnum fallax/denticulatum* mire and M6d sub-community are common throughout the uplands from Cornwall north to Shetland. They are the most widespread soligenous mires in the British uplands. These mires appear in wet hollows, gullies and along streams (JNCC, 2004); and
- MG10 *Holcus lanatus-Juncus effusus* rush-pasture and sub-community (MG10a) is a vegetation type of damp acid to neutral soils on level to gently sloping ground in enclosed pastures, and in neglected situations such as ditches, pond sides and roadside verges. This community is widespread in lowland Great Britain, and it also occurs at low altitudes in most upland areas (JNCC, 2004).

77. The majority of these communities, where present, are associated with surface water moving from the surrounding hills downslope to eventually form or join surface water channels. As a result, surface water and hill runoff are likely to be the dominant soil water factors and the groundwater dependency of these habitats is considered Low. Further details are included in **Figure 6.6 GWDTE Overview** and **Appendix 6.3 GWDTE** .

6.5.6 Hydrology

78. This section details:

- hydrological characteristics of the Site and downstream area;
- surface water flows and flooding;
- water quality;
- water supplies; and
- fisheries.

79. By evaluating the hydrology of the Site using a catchment-based system, assumptions can be made regarding potential influences that site activities may have downstream and on other water bodies within the catchment. Figures displaying the hydrological overview and more detailed site-specific hydrology are provided in **Figure 6.7 Hydrology Overview**.

6.5.6.1 Hydrological Characteristics

80. The Site is located across the catchments of the Water of Girvan and the River Stinchar. The Water of Girvan catchment has an area of approximately 250km^2 and the River Stinchar has a catchment areas of approximately 253km^2.

81. The northern part of the Site is drained by the Water of Girvan catchment and its tributaries, including Palmullan Burn (6.5km^2 catchment area) shown in **Photograph 6.3**, which drains northern and western extents of the Site, flowing in a north easterly direction to join the Water of Girvan, approximately 4.7km downstream. Other tributaries of the Water of Girvan, in the north-western part of the Site, include the Knockoner Burn (1.0km^2 catchment area).

Photograph 6.3: Looking upstream at Palmullan Burn from the existing forestry track crossing, taken at NGR 234520, 599024

82. Southern extents of the Site are drained by the River Stinchar and its tributaries, including Linfern Loch Burn (4.1km^2 catchment area) and Dalquhairn Burn (2.1km^2 catchment area).

83. The eastern extent of the Site is drained by the Tairlaw Burn (7.1km^2), as shown in **Photograph 6.4**, and its tributaries, including Pulreoch Burn (0.8km^2 catchment area), flowing in a north east direction to join Water of Girvan.

Photograph 6.4: Looking upstream at Tairlaw Burn from the existing forestry track crossing, taken at NGR 239189, 597349

84. Linfern Loch (0.26km^2) is located immediately south of the Site. It drains several small channels and outflows via Linfern Loch Burn to the River Stinchar. Loch Bradan is approximately 650m to the east of the Site and is a Scottish Water public water supply source. The loch outflows via the Water of Girvan to the north and then flows generally north west and converges with the aforementioned tributaries draining the Site. Therefore, there is no hydrological connection from the Site to Loch Bradan.

85. Within the Site there are numerous small artificial channels, as shown in **Photograph 6.5**, which are associated with conifer plantation. These channels generally have an ephemeral nature and are anticipated to require a culvert.

Photograph 6.5: Looking upstream at a forestry ditch at the proposed access track to wind turbine 7, taken at NGR 236488, 598764

6.5.6.2 Surface Water Flows and Flooding

86. Theoretical runoff rates have been estimated for a selection of representative Site watercourses at proposed watercourse crossing locations. Peak flows have been estimated using the Flood Estimation Handbook catchment characteristics, with the 'FEH Rainfall-Runoff' method used to derive a range of peak flow return periods. Low flow measurements have been determined by the 'Low Flow' method and are quoted as Q_{95} (i.e. the flow exceeded 95% of the time). These data are shown in **Table 6.9**.

Catchment (Upstream of Grid Reference)	Area (km^2)	Mean Annual Flow (m^3/s)	Low Flow Q95 (m^3/s)	Estimated Peak Runoff (m^3/s) for each return period (years)				
				5	10	25	50	100
Tairlaw Burn, Tributary of the Water of Girvan NGR 239869, 598070	2.77	0.122	0.014	6.45	7.84	9.81	11.45	13.37
Tairlaw Burn, Tributary of the Water of Girvan NGR 239134, 598209	0.89	0.014	0.004	2.14	2.61	3.26	3.81	4.44

Table 6.8: Estimated Surface Water Flow Characteristics

87. The Hydrology of Soil Types (HOST) is a hydrologically-based classification of soils on the basis of their physical properties and their effects on the storage and transmission of water. It makes use of the fact that the physical properties of soils have a major influence on the hydrological response of a catchment. Other parameters can then be derived from the HOST classification (Institute of Hydrology, 1995). For the purposes of hydrological assessment, the Baseflow Index (BFI) and Standard Percentage Runoff (SPR) are the most useful parameters. BFI is the long-term ratio of baseflow to total stream flow, where baseflow represents the contribution to total flow from groundwater (University of Newcastle, 2008). BFI values range from 0.1 in relatively impermeable clay catchments to 0.99 in highly permeable chalk catchments. A very low BFI of 0.15 represents a flashy catchment with minimal storage, low BFI values (e.g. 0.3) indicate a catchment with little storage and active runoff, a BFI of 0.7 (or greater) indicates a significant contribution to flow from a major aquifer.

88. SPR is the average percentage of rainfall that causes the short-term increase in flow seen at a catchment outflow following a storm event (NSRI, 2008).

89. Using FEH to derive catchment descriptors, Tairlaw Burn has a BFI-HOST value of 0.26 indicating catchments with little storage and active runoff. This value would be expected given the low aquifer productivity across the majority of the Site. Local watercourses would quickly respond to rainfall events, with a short lag time between rainfall occurring and increased stream flow values. The SPR values range between 56.35-55.66%, indicating a moderately flashy response to rainfall, attenuated by local conditions. Additionally, the steep characteristics of site valleys would further contribute to this high level of runoff.

90. Flood risk data provided by SEPA (2020) shows flooding risk limited to the immediate area adjacent to the River Stinchar, Tairlaw Burn, near crossing location WC01, Palmullan Burn and Water of Girvan. Small Discrete locations of surface water flooding are noted adjacent to the small tributaries of the River Stinchar and Water of Girvan.

91. As discussed in the ‘Groundwater Body Characterisation‘ and ‘Water Quality‘ sections, the WFD is a risk-based classification system. This highlights such issues as watercourse morphology and existing artificial structures in addition to chemical water quality and ecological diversity.

92. As for the Groundwater Body Characterisation and Water Quality section, SEPA has characterised surface water quality under the WFD.

93. The WFD applies to all surface waters, but for practical purposes, SEPA has defined a size threshold above which a river or loch qualifies automatically for characterisation. For lochs, the threshold is a surface area of $0.5km^2$ and rivers must have a catchment area of $10km^2$ or more. In addition to these larger water bodies, smaller waters have been characterised where there is justification by conservation interests and to meet the requirements of regulatory legislation, such as for drinking water supplies. **Table 6.10** summarises the WFD classification for the relevant water bodies.

Catchment	Name (WFD SEPA ID)	Overall Classification (2019)	Anticipated Classification (2021)	Summary of Pressures
River Stinchar	River Stinchar (u/s Water of Gregg) (ID: 10467)	Moderate	Good	None
	Dalquhairn Burn (ID: 10477)	High	High	None
	Palmullan Burn (ID: 10463)	High	High	None
Water of Girvan	Water of Girvan (d/s Loch Bradan to Palmullan Burn) (ID: 10456)	Good ecological potential	High	None

Table 6.9: WFD Surface Water Classification

94. For water bodies that have not been classified, the normal convention is to assume a classification based on downstream or adjacent water bodies unless there are specific indications to the contrary.

95. In relation to this assessment it is considered that the higher the WFD status, the higher the sensitivity of the water body. To prevent any deviation from ‘good status’ for receiving watercourses, the objective is to keep construction phase and post-development runoff to pre-development levels, in terms of both quality and quantity, whilst recognising that natural variability in flow values and water quality do occur. Measures to ensure this are discussed in the assessment sections below.

6.5.6.3 Water Supplies

96. Information on public water supplies was sought from Scottish Water. This confirmed that the Proposed Development is located within a Drinking Water Protected Area, due to the presence of a Scottish Water abstraction. It has been identified that the Stinchar Aqueduct supplies Afton, Bradan, Penwhapple and Camphill Water Treatment Works.

97. Further information of Scottish Water Assets has been provided by FLS. The public water catchment area covers a large part of the south and south east areas within the Site Boundary and an associated pipeline runs south of the Site adjacent to the C46w public road at the eastern extent, before it meets Loch Bradan. This pipeline is shown in **Figure 3.1 Environmental Designations** in **Chapter 3: Site Selection and Design.** There is no hydrological connection between the Proposed Development and the start of the pipeline in the south west of the Site. There is also no hydrological linkage between the Proposed Development and Loch Bradan.

98. PWS information was obtained from the South Ayrshire Council, who provided a record of properties and supplies within 10km of the Site Boundary. Further information was obtained from the DWQR (2019) online map, before all PWS sources were screened for those to be consdered as part of this assessment. The remaining PWS for consideration are located within a 5km radius of the Site.

99. **Figure 6.7 Hydrology Overview** shows the location of local PWS sources that were identified within the 5km buffer.

100. There are two categories of PWS provided within the data:

- type A supplies: supply more than $10m^3$ per day or serve at least 50 people or supply a commercial or public activity (regardless of volume); and
- type B supplies: categorise the remaining supplies which do not meet the Type A criteria.

101. There are seven Type B supplies within the 5km buffer, which generally supply individual properties, which are either residential or farms. These have been considered in more detail, taking account of source type and location, distance from Site and intervening topography, and water features, to determine if there were potential pollutant source-pathway-receptor relationships.

102. Further details are covered in the 'Mitigation by Design' and 'Embedded Mitigation' sections of this chapter. Information on those considered to be potentially affected by the Proposed Development is also available in this section.

6.5.6.4 Fisheries

103. The River Stinchar, Dalquhairn Burn, Pallmullan Burn, Tairlaw Burn and Pulreoch Burn are recognised as having potential to support fish populations (including salmonids). Fish populations could also be present in minor watercourses, and tributaries of the noted watercourses. Further details and species information is available in **Appendix 7.5 Aquatic Ecology Report**.

104. Further details regarding the good practice measures to avoid sedimentaton of watercourses, that could potentially have adverse effects on fisheries are outlined in the 'Erosion and Sedimentation' sections in this chapter. Implementation of these good practice measures will also ensure the conservation of the local fish populations in accordance with the provisions of Schedule 9 of the Electricity Act 1989.

6.6 Potential Effects

105. The assessment of effects is based on the project description as outlined in **Chapter 4: Development Description**. Unless otherwise stated, potential effects identified are considered to be negative and adverse. The assessments are based on the criteria for sensitivity, magnitude, probability and significance provided in the Significance Criteria section of this chapter, including **Tables 6.2** to **6.4**.

106. The assessment assumes the integral good practice measures described in **Appendix 4.2 Outline Construction Environmental Management Plan (CEMP)** have been incorporated into the Proposed Development's design and these do not form mitigation measures.

107. 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.

6.6.1 Mitigation by Design and Embedded Mitigation

108. Detailed constraints advice was provided during the iterative layout design process for the wind turbines and associated infrastructure. At various stages during the determination of the design, fieldwork was undertaken to provide feedback to the design team. This approach identified Site constraints in order to minimise a number of potential effects (such as minimising development infrastructure close to or crossing water features and undertaking initial peat depth and stability studies to avoid deeper peat areas). Due to the iterative design process using peat depth constraints as a key component for new infrastructure locations, the deeper peat locations where more sensitive amorphous catotelmic material is predicted were avoided, where practicable. These are discussed further in **Appendix 6.2 Soil and Peat Management Plan** and **Chapter 3: Site Selection and Design**.

109. Forestry felling, extraction and associated activities would require specific management and control measures in order to reduce environmental impact. However, although the baseline condition is that the existing plantation forests will require harvesting in due course, this activity may be hastened by the Proposed Development. Felling contractors would be expected to conduct felling, harvesting and associated activities in accordance with forestry good practice measures, provided in **Appendix 13.1 Forestry Assessment**.

110. During the detailed design and construction phases, wind turbines and hardstandings could be microsited to avoid deeper peat. Sections of track would be surveyed and microsited, within 50m, to optimise the distances from the waterbodies and peat, taking into account local topography and local characteristics. For instance, this type of micrositing approach would be beneficial to:

- the small area of peat class 1 located adjacent to the track leading to wind turbine 5 and its hardstanding, therefore minimising the disturbance of this deep peat area;
- the new track routes, for instance, the new track route between wind turbines 1 and 2, to minimise disturbance of peat and maximise spacing from break of slope to north;
- the ancillary infrastructure around wind turbine positions, to minimise disturbance of peat and particularly amorphous catotelmic peat; and
- wind turbines 1, 3, 8 and 13, where the average peat depths are deeper than 1.50m, therefore allowing these areas of deep peat to be avoided, where possible.

111. Further examples of where and why micrositing will be beneficial throughout the Site are provided in **Appendix 6.1 Peat Landslide Hazard and Risk Assessment** and **Appendix 6.2 Soil and Peat Management Plan.**

112. As part of the layout design strategy, watercourse crossings were minimised. Where access necessitates watercourse crossings, construction features have been limited in these buffers as far as possible, for example minimising access tracks running parallel to watercourses and trying to avoid track junctions being constructed in these zones. A total of seven watercourse crossings have been identified. These watercourse crossings are discussed further in **Appendix 6.5 Watercourse Crossings Report**, including local channel characteristics and suitability for migratory fish, shown in **Figure 6.7 Hydrology Overview**. These crossings are mapped on OS 1:50,000 scale map and therefore subject to CAR. It has been assumed that five of these existing locations have structures in place that require upgrading. The watercourse crossing upgrading will be required if the crossing falls within a track section that requires upgrading. It has been assumed that the crossing type for the new and upgraded crossings will consist of a circular culvert structure; however, this will be investigated further during detailed design stage.

113. Hydromorphological processes such as erosion and deposition have been identified and presented in **Appendix 6.5 Watercourse Crossings Report,** with recommendations made to minimise adverse effects relating to construction of crossing structures.

Water Crossing	Easting	Northing	Description
WC01	239869	598070	Tairlaw Burn, tributary of the Water of Girvan
WC02	239134	598209	Unnamed Tributary of Tairlaw Burn, tributary of the Water of Girvan
WC03	239189	597349	Tairlaw Burn, tributary of the Water of Girvan
WC04	234948	598251	Dalquhairn Burn, tributary of the River Stinchar
WC05	234512	599022	Unnamed tributary of Palmullan Burn, tributary of Water of Girvan
WC06	235641	598350	Unammed Tributary of Linfern Loch, tributary of the River Stinchar
WC07	238407	597303	Tairlaw Burn, tributary of the Water of Girvan

Table 6.11: Summary of CAR Applicable Watercourse Crossing Locations

Infrastructure	Crossing Type	Watercourse Size			
		Large	Medium	Small	Total
Track	Bridge	-		-	
	Rectangular culvert / arch	-	-	-	-
	Open base arch structure	-	-	-	-
	Circular culvert	WC01	WC02, WC04, WC06, WC07	WC03, WC05	7
	Circular pipe	-	-		
	Drainage layer	-	-	-	-
Total new crossings		-	1	1	2
Existing crossings potentially requiring an upgrade		1	3	1	5
Total (new and upgraded)		1	4	2	7

Table 6.12: Summary of Types and Sizes of CAR-Applicable Watercourse Crossings

114. All engineering activities in such locations are subject to CAR, and subject to SEPA approval. Post-consent, detailed design information would be provided to support this process.

115. A number of additional, smaller watercourse crossings have also been identified during fieldwork, these watercourses are not mapped on OS 1:50,000 scale mapping and comprise crossings of flush zones and small headwater channels. These crossings would have structures installed appropriate to local conditions and would be anticipated to be designed as over-sized circular culverts or layers of pipes for flush zones. **Table 6.11** and **Table 6.12** summarise the CAR watercourse crossings, with further details and a full inventory of crossings in **Appendix 6.5 Watercourse Crossings Report** and shown in **Figure 6.7 Hydrology Overview**.

116. The following mitigation measures are proposed to reduce potential alterations to sub-surface flows and groundwater levels by the works and, as result, reduce potential effects on GWDTE:

- development and implementation of a drainage system, encouraging the infiltration of surface water runoff via SuDS arising from the infrastructure;
- the access tracks will be micro-sited, where possible, to avoid areas of potential GWDTE;
- use of permeable fill in the construction of the access tracks to maintain flow and inclusion of cross-formation drains to maintain groundwater flows, where practicable; and
- consideration shall be given to peat storage and reuse in areas of GWDTE, to avoid causing long-term alterations in local hydrological conditions.

6.1.1 Receptor Sensitivity

117. Receptor sensitivity has been determined using the criteria provided in **Table 6.2**.

118. All watercourses and groundwater bodies including Dalquhairn Burn and Palmullan Burn have been rated as having High sensitivity, with the exception of River Stinchar (u/s Water of Gregg) that has Medium sensitivity.

119. Local PWS identified of concern are generally considered of Medium sensitivity value, based on the number of properties they serve.

120. Carbon and Peatland Map Class 1 and Class 2 (SNH, 2016) have been identified within the Site. An extensive peat depth survey was undertaken, with an average peat depth of 0.99m, while 62.4% of peat depth records were less than 1.00m. Peat depths and peatland characteristics varied across the Site. However, a high degree of soil modification due to widespread forestry practices was generally evident, with soils and peat rated as of Medium sensitivity, based on soil characteristics and carbon-rich status across the Site.

121. Groundwater levels and sub-surface flows have a relationship with the peatland habitats present and the associated sensitivity for this Site is considered as High. GWDTE have been assessed and are not considered as predominantly groundwater fed, therefore are rated as Low sensitivity.

6.6.2 Construction

6.6.2.1 Private and Public Water Supplies

122. The PWS locations were evaluated based on their position relative to the Site and on the potential of the Proposed Development to affect the PWS, in order to determine if there could be potential pollutant source-pathway-receptor relationships. This took into account source type and location, distance from Proposed Development infrastructure, groundwater pathways, intervening topography, and other surface water features. Potential effects on water supply and on infrastructure of the PWS were also considered.

123. South Ayrshire Council provided data of PWS within 10km of the Site centre point. This data specifies whether each supply represents a small domestic supply (known as Type B) or a supply to a larger population and/or for commercial purposes (known as Type A).

124. Groundwater sources within a 1km Study Area and surface water sources within the 5km Study Area were considered. In addition, sources within a 100m buffer around access tracks and other infrastructure, and those within a 250m buffer around wind turbines and borrow pits, were considered further as per SEPA (2017) Land Use Planning System Guidance Note 31 (LUPS-GU31) with regards to potential groundwater monitoring. All other PWS were scoped out, as were judged unlikely to be hydrologically connected to the Proposed Development.

125. Further details of the PWS screening process is provided in **Appendix 6.4 PWS Assessment**. This process did not identify any PWS considered to be at risk of adverse effects, resulting from the Proposed Development and have therefore been scoped out of this assessment.

6.6.2.2 Pollution Incidents

126. During the construction phase a number of potential pollutants would be present onsite to facilitate forestry clearance and civil engineering activities, including oil, fuels, chemicals, unset cement and concrete, and waste and wastewater from construction activities. With chemicals and oil being stored and used onsite, along with concrete batching, there is the potential for an incident. Any pollution incident occurring on the Site could have a detrimental effect on the water quality of the nearby surface waters, groundwater and/or soil, thereby also indirectly affecting ecology.

127. Requirements for soil excavation, transport and storage may lead to additional sedimentation issues at locations where new track, widened existing track, crane hardstandings or foundation construction activities are necessary. Borrow pits have the potential to release sediment-laden runoff if measures are not taken to minimise surface water input into such areas and to adequately treat flows from the borrow pits.

128. The adoption of the applicable good practice measures as provided in **Appendix 4.2 Outline CEMP** would reduce the probability of an incident occurring and also reduce the magnitude of any incident due to a combination of good Site environmental management procedures, including minimised storage volumes, staff training, contingency equipment and emergency plans. Key measures identified to reduce potential for pollution include:

- application of a 50m buffer zone from OS 1:10,000 watercourses, except where access is required;
- secure oil and chemical storage in over-ground bunded areas, limited to the minimum volume required to serve immediate needs with specified delivery and refuelling areas;
- emergency spill kits retained onsite at sensitive locations;
- special measures at concrete batching plants with pre-cast structures used where appropriate;

- cessation of work and development of measures to contain and/or remove pollutant should an incident be identified; and
- a surface water quality monitoring programme is recommended, to commence 12 months prior to construction and continue into early operational period. During construction, this would include an adaptive monitoring system enabling early investigation of parameters outwith expected ranges, with prompt alerts to the construction team to amend any work activities causing an adverse effect.

129. In addition, the substantial dilution factor when comparing site watercourse flows with downstream flow characteristics, taking account of enlarged catchment areas and confluences, would be expected to further reduce any potential effect downstream. This would be particularly notable for the large hydrological systems of the Water of Girvan and the River Stinchar catchment.

130. This site will require a Construction Site Licence, this pre-construction application process will involve descriptions of pollution control methods and specific detailed design features to gain SEPA approval. Taking into account the design and embedded mitigation, the effects are assessed as follows:

- the magnitude of pollution effect on surface waters is considered Moderate and of Low probability to occur, giving an overall significance of **Minor**;
- the magnitude of pollution effect on groundwater is considered Minor and of Low probability to occur, giving an overall significance of **Minor**;
- the magnitude of pollution effect on soil is considered Minor and of Low probability to occur, giving an overall significance of **Minor**.

6.6.2.3 Erosion and Sedimentation

131. Soil erosion, loss of soil and sediment generation may occur in areas where the ground has been disturbed during construction, including in situations where: engineering activities occur close to watercourses, such as at watercourse crossings; where higher velocity surface water flows may occur due to local slopes and drainage design; and where forestry felling is occurring. Surface water passing through the drainage network, efficiently draining the new infrastructure, could exhibit high localised flows, increasing the potential for bank erosion.

132. Sediment transport in watercourses can result in high turbidity levels which affect the ecology, particularly fish stocks, by reducing the light and oxygen levels in the water. Sediment deposition can further effect watercourses by potentially smothering plant life, invertebrates and spawning grounds and can reduce the flood storage capacity of channels and block culverts, resulting in an increased flood risk. It is recognised that extensive felling of forestry can lead to long-term increases in run-off from previously afforested slopes and shorter term increases in sediment loading. There is also potential for acidification and nutrient loading as a result of deforestation and post-felling forestry waste management.

133. Requirements for soil excavation, transport and storage may lead to additional sedimentation issues at locations where new track, widened existing track, crane hardstandings or foundation construction activities are necessary. Borrow pits have the potential to release sediment-laden runoff if measures are not taken to minimise surface water input into such areas and to adequately treat flows from the borrow pits.

134. The adoption of the applicable good practice measures as summarised in the **Appendix 4.2 Outline CEMP** and **Appendix 6.6 Inital Borrow Pit Assessment** would reduce the probability of an incident occurring and also reduce the magnitude of any incident due to a combination of good site environmental management procedures, including additional precautions when operating machinery close to watercourses, soil management, staff training, contingency equipment and emergency plans. Key measures identified to reduce erosion and sedimentation include:

- existing forestry tracks would be used where applicable to reduce earthworks;
- vegetation clearance would be scheduled only as needed, buffer strips would be retained as vegetated features and revegetation encouraged with native species;
- forestry clearance activities to follow good practice and take account of sediment and nutrient management;
- silt traps would be employed and maintained in appropriate locations;
- temporary interception bunds and drainage ditches would be constructed upslope of excavations such as borrow pits to minimise surface runoff ingress and in advance of excavation activities;
- borrow pits would have appropriate and specific drainage, likely to include a series of settlement lagoons to reduce sediment load and would be monitored prior to discharge;
- excavation and earthworks would be suspended during and immediately following periods of heavy rainfall in order to minimise sediment generation and soil damage; and
- a surface water quality monitoring programme is recommended, to commence 12 months prior to construction and continue into early operational period. During construction, this would include an adaptive monitoring system enabling early investigation of parameters outwith expected ranges, with prompt alerts to the construction team to amend any work activities causing an adverse effect.

135. In the case of pollution incident effects, good practice site environmental management measures and the dilution factor involved would be expected to reduce any potential sedimentation effect downstream.

136. Taking into account the design and embedded mitigation, the effects are assessed as follows:

- the magnitude of the effect of erosion or loss of soil adjacent to surface watercourses is considered to be Minor and of Medium probability to occur, giving an overall significance of **Minor**;
- the magnitude of sedimentation effect on surface water is considered to be Minor and of Medium probability to occur, giving an overall significance of **Minor**; and
- the magnitude of sedimentation effect on groundwater PWS is considered Minor and of Low probability to occur, giving an overall significance of **Negligible**.

6.6.2.4 Modification of Surface Water Drainage Patterns

137. Surface flows could be impeded by construction activity in or adjacent to stream channels, poor choice of watercourse crossing locations or inadequately designed crossing structures. Blockages could be caused by inadequate control of earthmoving plant, sedimentation and poor waste management, all of which could lead to flooding upstream. There are a number of flood-sensitive locations such as River Stinchar, Tairlaw Burn, and Palmullan Burn which run across the Site, as discussed in the Baseline Conditions.

138. Wind turbine bases and other constructed impermeable surfaces would restrict the infiltration of rainfall into the soil and underlying superficial deposits, resulting in localised increased volumes of surface runoff. The interception of diffuse overland flow by new access tracks and their drains could disrupt the natural drainage regime of the Site by concentrating flows and influencing drainage in soils.

139. The local watercourses on the Site have been identified as having a moderately flashy response to rainfall events, as demonstrated by rapid response times and peak flows. Forestry felling may lead to increased surface water flows due to less interception and uptake from trees. The increases in flows could have a detrimental effect on the populations of fish, freshwater invertebrates and species dependent on the water environment.

140. The track design includes an upgrade to five existing crossing structures, for watercourses that are subject to CAR regulation (as shown on OS 1:50,000 mapping). **Table 6.11** summarises these watercourse crossings, with further details in **Appendix 6.5 Watercourse Crossings Report**.

141. There would be a requirement for minor watercourse crossings (i.e. representing minor watercourses not shown on OS 1:50,000 mapping), typical crossing locations and suggested structures are also provided in **Appendix 6.5 Watercourse Crossings Report**.

142. The adoption of the applicable good practice measures in the **Appendix 4.2 Outline CEMP** would reduce the impact of modification to surface water drainage patterns, with artificial drainage installed only where necessary and would, wherever practical, be installed in advance of ground being cleared of vegetation. All structures would be designed and constructed following good practice techniques and would be of sufficient capacity to receive storm flows with an allowance for increased flows due to climate change. Key measures identified to minimise alterations to surface water drainage patterns include:

- minimising the number of watercourse crossings, using and upgrading existing structures where applicable;

- application of sustainable drainage techniques to increase peak lag time and implementation of cross-drains at appropriate intervals and frequent discharge points to reduce scour potential;
- minimising the size and duration of in-channel works; and
- appropriate design of crossing structures to ensure sufficient capacity to convey 1:200-year storm flows and enable mammal and fish passage.

143. The area of impermeable surface created would be very small in comparison with sub-catchment areas, as only the wind turbine, hardstandings and control building bases would be designed as impermeable, with the unbound tracks likely to act as semi-permeable features with limited infiltration potential.

144. Taking into account the design and embedded mitigation, the effect is assessed as follows:

- the magnitude of effect on surface water drainage patterns is considered Minor and of Medium probability to occur, giving an overall significance of **Minor**.

6.6.2.5 Modification of Groundwater Levels and Flows

145. Deep excavations, such as those required for the wind turbine foundations and borrow pits could disrupt shallow groundwater systems. Groundwater controls, such as physical cut-offs or dewatering, would be utilised to prevent the excavations filling with water. This would result in the lowering of groundwater levels in the immediate vicinity of the excavations and alterations to flow paths during dewatering activities. access tracks could interrupt shallow groundwater flow. There may be some infiltration of water through the access tracks, but the majority of the water would enter the surface water drainage system and would be discharged downslope of the access track at discrete points.

146. Cable trenches, particularly if backfilled with more permeable material than surrounding soil, can create preferential pathways for groundwater flow, resulting in local lowering of groundwater level.

147. Soil water conditions at the Site are likely to be primarily influenced by surface water and direct rainfall, with groundwater having minimal influence, and this influence decreasing at higher altitude.

148. It is possible that there would be local lowering of the water table close to track corridors, resulting in a localised corridor of altered vegetation and ecology. Wind turbine foundations and borrow pit excavations would permanently alter groundwater flows at the coincident locations, however it would be expected that natural conditions of groundwater level and flow would recur close to these locations. In contrast, forestry felling could result in a rise in groundwater levels in the short term until restocked trees are established.

149. The adoption of the applicable good practice measures as provided in the Outline CEMP would reduce potential for lowering effects upon groundwater systems, with the effects of dewatering likely to be local and temporary, with groundwater expected to return to former levels quickly following cessation of construction activities. The key concerns for good groundwater management involve careful decisions involving locations of drainage and dewatering activity and ensuring such activities are undertaken sympathetically and minimised in terms of extent and time to avoid excessive influence on groundwater levels and flows. Key measures identified to minimise alterations to groundwater levels and flows include:

- drainage systems, typically consisting of french drains (using a gravel layer as water conduit, rather than pipework, running downhill to a soakaway zone designed to enable water to percolate back into soil), would be installed at hardstanding locations where applicable;
- dewatering activity would be limited to the minimum necessary duration; and
- access tracks crossing GWDTE would have appropriate drainage measures applied to maintain current groundwater conditions.

150. Taking into account the design and embedded mitigation, the effect is assessed as follows:

- the magnitude of effect on groundwater levels and flows is considered Minor and of Medium probability to occur, giving an overall significance of **Minor**;
- the magnitude of effect of alterations to groundwater levels and flows on PWS is considered Minor and of Low probability to occur, giving an overall significance of **Negligible**; and
- the magnitude of effect on GWDTE is considered Minor and of Medium probability to occur, giving an overall significance of **Negligible**.

6.6.2.6 Loss and Compaction of Soils and Peat

151. In its regulatory position statement, SEPA (2010) states that “developments on peat should seek to minimise peat excavation and disturbance to prevent the unnecessary production of waste soils and peat”. The key items of infrastructure which influence this effect are the dimensions, location and type of new access tracks, wind turbine foundations and crane hardstandings. Other features which would also be considered for excavation requirements include borrow pits, substation and construction compounds; one of which may be retained (in part or in whole) for use as a car park during the operational life of the windfarm for the benefit of recreational users in order to provide a safe parking area for visitors to the Carrick Forest.

152. Modifications made during the layout design process has led to an avoidance of areas where deeper peat has been identified, the volume of excavated material for Site infrastructure results in 214,900m^3 of material requiring to be excavated. **Appendix 6.2 Soil and Peat Management Plan** evaluates the likely volumes of soil and peat excavated during construction and opportunities for reuse of this material. It also identifies measures for the management of peat throughout the construction process. It is recognised that the initial priority is to reduce the volume of peat excavated, followed by appropriate reuse of any peat and soil excavated, as per the principle of the ‘waste hierarchy’. The extensive dataset of peat depth data collected for the peat stability study has been used to inform this assessment.

153. Three sub-categories of peat have been distinguished, with estimated quantities for acrotelmic, fibrous catotelmic and amorphous catotelmic peat at defined threshold depths, with a total anticipated peat excavation volume of 184,700m^3. Due to the iterative design process using peat depth constraints as a key component for new infrastructure locations, the deeper peat locations where more sensitive amorphous catotelmic material is predicted have been avoided, where practicable. A precautionary threshold depth of 1.30m has been applied for this material, based on Site peat core data, with an anticipated excavation volume of 15,900m^3. The infrastructure likely to lead to excavation of amorphous catotelmic peat, at a threshold depth of 1.30m or greater, are generally related to the ancillary infrastructure around wind turbine locations such as the blade laydown areas, crane hardstandings, turning heads and crane boom assembly areas, as well as specific access track sections; for which opportunities to avoid or reduce excavation have been noted within **Appendix 6.2 Soil and Peat Management Plan**.

154. Compaction may also damage the vegetation and result in a reduction in soil permeability and rainfall infiltration, particularly on peat, thereby increasing the potential for longer-term erosion from surface water runoff. This would be most likely caused by tracking of heavy plant machinery.

155. Stockpiled and unvegetated/exposed areas of soils are also at risk of desiccation and wind and water erosion, also potentially causing soil loss.

156. The design principles and adoption of the applicable good practice measures summarised in **Appendix 4.2 Outline CEMP** and **Appendix 6.2 Soil and Peat Management Plan** would reduce the soil losses and compaction of soil effects, with the combination of planning infrastructure on very shallow soils, minimising excavation, promoting local reuse of suitable material, identifying catotelmic/amorphous peat in-situ and the majority of vehicle movements being restricted to existing or new access tracks or clearly demarcated construction areas. This combination of measures resulting in any notable effect being very localised and temporary in nature. Site monitoring would identify any areas where soil effects are noted and enable a fast response to minimise effect. Key measures identified to minimise loss and compaction of soils and peat include:

- reducing excavation depth and footprint required for Site infrastructure by careful placement;
- limiting storage of soil and peat to a maximum height of 2m;
- appropriate re-use of excavated material for reinstatement and profiling of track verges on disturbed ground;
- appropriate re-use of excavated material to reinstate and/or reprofile borrow pits to an average 1.90m depth; and
- limiting movements to specific corridors avoiding sensitive receptors such as deep peat.

157. With peat excavation and reuse opportunities refined, based on pragmatic good practice measures, the reuse potential exceeds the revised excavation volume by 2,100m^3 (**Appendix 6.2 Soil and Peat Management Plan**).

158. Taking into account the design and embedded mitigation resulting in an excess of material excavated, the effect of loss and compaction of soils is assessed as follows:

- the magnitude of effect of soil loss is considered Moderate and of High probability to occur, giving an overall significance of **Moderate**; and
- the magnitude of effect of compaction of soil is considered Minor and of Low probability to occur, giving an overall significance of **Negligible**.

159. As there is a significant effect identified, mitigation measures have been provided in the **Section 6.7 Mitigation**.

6.6.2.7 Peat Stability

160. Peat slides are a natural occurrence that can occur without human interference, but issues such as removal of slope support or increased loading upon slopes can either increase the likelihood of an event occurring or can increase the scale of any failure that does occur.

161. Peat slides affect soil (and associated habitats) and potentially downstream surface water systems where soil inundation can lead to sedimentation reducing water quality and modification to drainage patterns. The various receptors of a peat stability failure have been separated for this evaluation.

162. The Site is underlain by peat of varying depths of blanket peat and peaty podzols, with an average depth across the Study Area of 0.99m. There are a number of steep slopes in the central and western parts of the Site, where deeper peat coincides with these slopes, especially at convex break of slope positions, the likelihood of peatslide increases. Areas identified as of higher likelihood for instability were primarily related to locations at or below convex breaks of slope or due to isolated deeper peat deposits recorded.

163. The conservative nature of the methodology applied leads to initial risk identification, based on factor of safety analysis, of the least stable areas on any specific site. No areas with initial 'High' or 'Moderate' risk were identified within 500m of infrastructure planned for the Proposed Development, with locations of concern avoided as part of the design process. In order to verify these initial risk findings, two areas were identified from the factor of safety analysis outcomes and visited as part of the Detailed Assessment.

164. The methods involved in this initial risk assessment are purposefully cautious, in order to highlight areas of concern, with the expectation that additional data collated as part of the revised risk assessment and pre-construction investigations would reduce concern.

165. The review of aerial photography within the peat stability assessment process identified a potential occurrence of slope instability within the Site, with this location being within the incised stream valley of a headwater of the Palmullan Burn, where fluvial erosion is considered the causal factor of a suspected peaty debris slide. Although not confirmed during site visits due to the distance from the Proposed Development, this instability is unlikely to be caused by peat conditions.

166. The inherent design principles and adoption of the applicable good practice measures summarised in the Outline CEMP would reduce the effect of peat instability. Key measures identified to minimise peat stability risk include:

- avoidance of removal of slope support;
- avoidance of heavy loading on slopes;
- forestry clearance activities to follow good practice and take account of slope stability;
- good drainage practice to ensure flows not concentrated onto slopes or into excavations;
- restricting earthmoving activities during and immediately after intense and prolonged rainfall events; and
- creating and managing of geotechnical risk register or similar management system throughout the detailed design and construction phases.

167. Following site visit, taking account of good practice measures, the revised risk was confirmed as no higher than 'Low' risk across the Site (**Appendix 6.1 Peat Landslide Hazard and Risk Assessment**).

168. Taking into account the design and embedded mitigation, the effect on peat stability is assessed as follows (with the peat stability risk value considered broadly equivalent to the probability in the Environmental Impact Asssessmen Report (EIAR):

- the magnitude of effect of a peat stability failure on soil loss is considered Minor and of Low probability to occur, giving an overall significance of **Negligible**;
- the magnitude of effect of a peat stability failure on surface water sedimentation is considered Moderate and of Low probability to occur, giving an overall significance of **Minor**; and
- the magnitude of effect of a peat stability failure on surface water drainage patterns is considered to be Moderate and of Low probability to occur, giving an overall significance of **Minor**.

169. Although there is no significant effect identified, specific mitigation measures have been provided in the **Section 6.7 Mitigation** in order to ensure stability concerns in relation to potential magnitude and watercourse receptors within localised areas (Peat Stability Areas A and B, **Appendix 6.1 Peat Landslide Hazard and Risk Assessment**) are adequately managed.

6.6.3 Operation

170. Many of the effects identified during construction would not be expected to lead to significant effects during the operational phase. Furthermore, good practice design and construction management would be anticipated to reduce potential operational adverse effects.

171. This section sets out the likely operational effects of the Proposed Development.

6.6.3.1 Modification of Groundwater Levels and Flows

172. Groundwater levels may be influenced by the drainage features of the Proposed Development and may also be influenced by local alterations in groundwater regime, such as where foundations or track construction leads to changes in level or flow. Such issues are more likely to become apparent in the operation phase than during construction, where corridors of altered vegetation may occur adjacent to access tracks and other locations where the natural regime has changed.

173. However, the adoption of the applicable good practice measures would incorporate a sustainable drainage strategy that minimises disturbance of natural groundwater systems to reduce adverse effect on groundwater levels and flows. Good practice sustainable drainage measures would minimise any effect upon GWDTE.

174. Taking into account the design and embedded mitigation, the effect is assessed as follows: the magnitude of effect on groundwater levels and flows is considered Minor and of Medium probability to occur, giving an overall significance of **Minor**.

6.7 Mitigation

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

176. The majority of effects have been assessed as **Not Significant**, with the exception of loss and compaction of soils and peat. No significant effect was identified for peat stability; however, specific mitigation measures have been provided to ensure stability concerns are adequately managed.

6.7.1 Loss and Compaction of Soils and Peat

177. As there was an excess of excavated material identified in **Appendix 6.2 Soil and Peat Management Plan**, further opportunities for re-use of material were investigated at the existing quarries/borrow pits to the east of Borrow Pit (BP) 02 and north of BP03. These locations have a combined surface area of approximately 8,662m^2. Restoring

these existing borrow pit footprints to an average depth of 1.90m, creates the potential to re-use 16,500m^3 of material.

178. With peat excavation and reuse opportunities refined, including the mitigation identified above, the potential estimated reuse volume exceeds the revised excavated volume by 2,100m^3, demonstrating that it is reasonably practicable to anticipate the reuse of all excavated material onsite (**Appendix 6.2 Soil and Peat Management Plan**), subject to landowner agreement. No material is planned to be transported into the Site for restoration purposes.

179. Micrositing of infrastructure should be considered, taking account of other design constraints, to minimise disturbance of soils and peat. Reinstatement of infrastructure post-construction should also be considered.

6.7.2 Peat Stability

180. Two locations were identified as requiring further investigation, known as 'Detailed Assessment' in **Appendix 6.1 Peat Landslide Hazard and Risk Assessment**. Following a site visit and interpretation of the additional site data, location-specific peat stability measures were identified, including:

- additional site investigation pre-construction, including post-felling surveys, with any additional areas of concern identified and assessed (and specific mitigation implemented, as applicable);
- micrositing to avoid/minimise disturbance of deeper peat and coincident breaks of slope;
- slope management measures for particular slopes;
- appropriate borrow pit excavation methodology at the proposed borrow pit BP04; and
- specific drainage designs including routes, scour prevention and discharge locations to be implemented to reduce potential adverse effect on slope stability during construction.

181. On the basis of the additional information and application of the identified mitigation, both of these locations were confirmed as at revised 'Low' risk in **Appendix 6.1 Peat Landslide Hazard and Risk Assessment**.

6.8 Residual Effects

182. The residual effects during construction and operation phases following mitigation are outlined in **Table 6.13 Summary of Significant and Residual Effects**. As specific mitigation is only proposed for loss and compaction of soils and peat plus peat stability effects, all other construction phase effects would remain as per the above section.

6.7.3 Loss and Compaction of Soils and Peat

183. Taking into account the design, the proposed peat disturbance methods and the mitigation of restoring two existing borrow pits (**Appendix 6.2 Soil and Peat Management Plan**), the effect on loss and compaction of soils is assessed as follows:

- the magnitude of effect of soil loss is considered Minor and of High probability to occur, giving an overall significance of **Minor**; and
- the magnitude of effect of compaction of soil is considered Minor and of Low probability to occur, giving an overall significance of **Negligible**.

6.7.4 Peat Stability

184. Following the application of mitigation measures that have been identified to minimise localised peat stability concerns, primarily in relation to surface water sedimentation and drainage patterns, as detailed in **Appendix 6.1 Peat Landslide Hazard and Risk Assessment**:

- the magnitude of effect of a peat stability failure on soil loss is considered to remain Minor and Low probability to occur, giving an overall significance of **Negligible**;
- the magnitude of effect of a peat stability failure on surface water sedimentation is considered to be reduced to Minor and remain as Low probability to occur, giving an overall significance of **Minor**; and
- the magnitude of effect of a peat stability failure on surface water drainage patterns is considered to be reduced to Minor and remain as Low probability to occur, giving an overall significance of **Minor**.

Description of Effect	Pre-mitigation Effect		Mitigation Measure	Residual Effect	
	Magnitude	Significance		Magnitude	Significance
Construction					
Pollution of surface waters	Moderate	Minor Adverse	N/A	Moderate	Minor Adverse
Pollution of groundwater	Minor	Minor Adverse	N/A	Minor	Minor Adverse
Pollution effect on soil	Minor	Minor Adverse	N/A	Minor	Minor Adverse
Erosion causing loss of soil	Minor	Minor Adverse	N/A	Minor	Minor Adverse
Sedimentation of surface water	Minor	Minor Adverse	N/A	Minor	Minor Adverse
Surface water drainage patters	Minor	Minor Adverse	N/A	Minor	Minor Adverse
Modification of groundwater levels and flows	Minor	Minor Adverse	N/A	Minor	Minor Adverse
Modification of groundwater levels and flows on groundwater and GWDTE	Minor	Negligible	N/A	Minor	Negligible
Loss of soil	Moderate	Moderate Adverse	Restoration of existing quarries adjacent to BP02 and BP03 Micrositing of infrastructure	Minor	Minor Adverse
Compaction of soil	Minor	Negligible	N/A	Minor	Negligible
Peat stability failure on soil loss	Minor	Negligible	Additional site investigation, including post-felling Micrositing Slope management Specific drainage design Borrow pit methodology	Minor	Negligible
Peat stability failure causing surface water sedimentation	Moderate	Minor Adverse	Additional site investigation, including post-felling Micrositing Slope management Specific drainage design Borrow pit methodology	Minor	Minor Adverse

Description of Effect	Pre-mitigation Effect		Mitigation Measure	Residual Effect	
	Magnitude	Significance		Magnitude	Significance
Peat stability failure modifying surface water drainage patterns	Moderate	Minor Adverse	Additional site investigation, including post-felling Micrositing Slope management Specific drainage design Borrow pit methodology	Minor	Minor Adverse
Operation					
Modification of Groundwater Levels and Flows	Minor	Minor Adverse	N/A	Minor	Minor Adverse

Table 6.13: Summary of Significant and Residual Effects

6.8 Cumulative Assessment

185. Cumulative effects are additional effects as a result of the Proposed Development in combination with other developments currently at the planning, consented, or construction stages.

186. Soil and geology cumulative effects are considered to be limited to the Site; however, surface water and groundwater pathways have the potential to cause or exacerbate a wider cumulative effect.

187. Other windfarms were identified and have been considered for the assessment of cumulative effects. Knockcronal Windfarm is at Scoping stage and is located approximately 100m from the Site Boundary. Craiginmoddie Windfarm is at Application stage and is located approximately 2.8km west from the Site Boundary, Tralorg Windfarm is operational and is located approximately 10.7km west from the Site Boundary, and Kirk Hill Windfarm has been consented and lies approximatelty 7.3km north west from the Site Boundary.

188. As the Proposed Development is located within headwaters of a number of watercourses, there would not be expected to be any cumulative effect from upstream development. However, runoff from the Proposed Development in combination with other developments could contribute to effects on overall water quality and flow within the channels. There is the potential for flow levels or sediment to be elevated downstream due to cumulative construction activities, particularly if there were coincident construction phases. However, effective 'source' controls would limit each individual development's effects on respective catchments, and it would be anticipated that other sites or activities involving groundworks would follow a similar good practice methodology to that for the Proposed Development. Furthermore, the differing construction programming and activities that would be anticipated to occur across various developments reduces the probability that water quality and flow issues would be coincident across a number of intra-catchment sites in a manner that would lead to a notable cumulative effect downstream, particularly when taking account of the higher flow/dilution available within the downstream channels.

189. Taking account of the above factors, cumulative effects during construction on pollution of surface water and groundwater, sedimentation of surface water and modifications to surface water drainage patterns are considered likely to be not significant in Environmental Impact Assessment (EIA) terms. This outcome has resulted from the basis of large intervening distances, substantial dilution factor, effective 'source' controls and differing construction programmes at various sites to manage water quality and drainage patterns.

6.9 Summary

190. The effects detailed in **Table 6.13** are with reference to the criteria identified in **Tables 6.2, 6.3** and **6.4** and the mitigation measures from the applicable sections of text above. Following the implementation of good practice measures and specific mitigation measures outlined, no significant effects are predicted for the hydrology, hydrogeology, geology and soils receptors.

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