# Craiginmoddie Wind Farm

## Environmental Statement
## Chapter 12: Hydrology, Hydrogeology and Geology

December 2020

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**FIGURES**



**FIGURES**

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# 12 HYDROLOGY, HYDROGEOLOGY AND GEOLOGY

## Introduction

12.1 This chapter of the Environmental Impact Assessment Report (EIAR) assesses the impacts on the hydrological, hydrogeological and geological environment at Craiginmoddie Wind Farm, the "Proposed Development" and the likely significant environmental effects resulting from the construction and operation of the proposed turbines and associated infrastructure. The red-line plan is referred to as "the Site".

12.2 The assessment is also supported by the following Technical Appendices:

- Technical Appendix 12.1: Water Crossing Assessment;
- Technical Appendix 12.2: Peat Management Plan; and
- Technical Appendix 12.3: Peat Slide Risk Assessment.

12.3 The assessment is supported by the following figures provided in Volume II of the EIAR:

- Figure 12.1: Hydrology Overview;
- Figure 12.2: Private Water Supply Users;
- Figure 12.3: Predominant Soils;
- Figure 12.4: Carbon and Peatland;
- Figure 12.5: Interpolated Peat Depths;
- Figure 12.6: Superficial Geology;
- Figure 12.7: Bedrock Geology Main Site: and
- Figure 12.8: Bedrock Geology Off-site Access Track.

12.4 This assessment and associated Technical Appendices were undertaken by Natural Power Consultants (Natural Power). Natural Power has an established reputation in providing assessment of hydrological, hydrogeological and geological considerations discussed in this chapter.

## Legislation and Policy Context

### *Policy Context*

12.5 The assessment takes account of the requirements of the Water Framework Directive (2000/60/EC) (WFD). The WFD aims to protect and enhance the quality of surface freshwater (including lakes, rivers and streams), groundwater, groundwater dependent terrestrial ecosystems (GWDTE), estuaries and coastal waters. The key objectives of the WFD relevant to this assessment are:

- To prevent deterioration and enhance aquatic ecosystems; and
- To establish a framework of protection of surface freshwater and groundwater.

12.6 The WFD resulted in The Water Environment and Water Services (Scotland) Act 2003, which gave Scottish Ministers powers to introduce regulatory controls over water activities in order to protect, improve and promote sustainable use of Scotland's water environment. These regulatory controls in the form of The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) or CAR, made it an offence to undertake the following activities without a CAR authorisation:

- Discharges to all wetlands, surface waters and groundwaters (replacing the Control of Pollution Act 1974);
- Disposal to land (replacing the Groundwater Regulations 1998);
- Abstractions from all wetlands, surface waters and groundwaters;
- Impoundments (dams and weirs) of rivers, lochs, wetlands and transitional waters; and
- Engineering works in inland waters and wetlands.

## *National Legislation and Policy*

12.7 The assessment takes account of the following legislation and policy:

- The Water Environment and Water Services (Scotland) Act 2003;
- The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended);
- The Water Environment (Miscellaneous) (Scotland) Regulations 2017;
- Flood Risk Management (Scotland) Act 2009;
- The Private Water Supplies (Scotland) Regulations 2006;
- Water Intended for Human Consumption (Private Water Supplies (Scotland) Regulations 2017;
- Part IIA of the Environment Protection Act 1990;
- Waste Management Licensing Regulations 1994;
- Pollution Prevention and Control (Scotland) Regulations 2012;
- Scottish Planning Policy (SPP) (2014);
- SEPA Policy No. 19 Groundwater Protection Policy for Scotland;
- SEPA Policy No. 22 Flood Risk Assessment Strategy;
- SEPA Policy No. 41 Development at Risk of Flooding: Advice and Consultation;
- SEPA Policy No. 54 Land Protection Policy; and
- SEPA Policy No. 61 Control of Priority & Dangerous Substances & Specific Pollutants in the Water Environment.

## *Regional Policy*

12.8 The assessment takes account of the following policy:

- South Ayrshire Council (herein referred to as SAC) Local Development Plan 2014 (LDP1);
- SAC Modified Proposed Local Development Plan 2 2020 (once adopted will replace LDP1):

  - STRATEGIC POLICY1: Sustainable Development;
  - LDP policy: water environment;
  - LDP policy: wind energy;
  - LDP policy: flood and development;
  - LDP policy: minerals and aggregates;
  - LDP policy: natural heritage; and
  - LDP policy: waste management.

- SAC Supplementary Guidance: Wind Energy 2015.

## *Other Guidance and Best Practice*

12.9 Table 12-1 below lists other key guidance and good practice documentation which has been considered as part of this assessment.

**Table 12-1: Guidance and good practice**

| Topic | Source of information |
|---|---|
| Scottish Government Planning Advice Notes (PAN's) | ▪ PAN 50 Controlling the Environmental Effects of Surface Mineral Workings<br>▪ PAN 51 Planning (revised 2006), Environmental Protection and Regulation<br>▪ PAN 1/2013 Environmental Impact Assessment<br>▪ PAN 61 Planning and Sustainable Urban Drainage Systems<br>▪ PAN 79 Water and Drainage |
| Scottish Environment Protection Agency (SEPA) Guidance for Pollution Prevention (GPPs) and Pollution Prevention Guidelines (PPGs) | ▪ PPG 1: Understanding your Environmental Responsibilities - Good Environmental Practice<br>▪ GPP 2: Above Ground Oil Storage Tanks<br>▪ GPP 4: Treatment and Disposal of Wastewater Where there is no Connection to the Public Foul Sewer<br>▪ GPP 5: Works and Maintenance in or Near Water<br>▪ PPG 6: Working at Construction and Demolition Sites<br>▪ PPG 7: Safe Storage - The Safe Operation of Refuelling Facilities<br>▪ GPP 8: Safe Storage and Disposal of Used Oils<br>▪ GPP 13: Vehicle Washing and Cleaning<br>▪ GPP 21: Pollution incident response planning<br>▪ GPP 22: Dealing with Spills<br>▪ GPP 26: Safe Storage - Drums and Intermediate Bulk Containers |
| SEPA Position Statements (Published) | ▪ WAT-PS-06-02: SEPA (2015), Culverting of Watercourses, Version 2<br>▪ WAT-PS-07-02: SEPA (2012), Bank Protection, Version 2<br>▪ WAT-SG-23: SEPA (2008), Engineering in the Water Environment, Good Practice Guide - Bank Protection Rivers and Lochs, Version 1<br>▪ WAT-SG-25: SEPA (2010), Engineering in the Water Environment, Good Practice Guide, Construction of River Crossings, Version 2 |

| Topic | Source of information |
|---|---|
| | ▪ WAT-SG-26: SEPA (2010), Engineering in the Water Environment, Good Practice Guide, Sediment Management, Version 1<br>▪ WAT-SG-31: SEPA, (2006) Special Requirements for Civil Engineering Contracts for the Prevention of Pollution, Version 2<br>▪ WAT-SG- 78: SEPA (2012), Sediment Management Authorisation, Version 1 |
| Construction Industry Research and Information Association (CIRIA) | ▪ CIRIA C692 Environmental Good Practice on Site (third edition)<br>▪ CIRIA C753 SuDS Manual (2015)<br>▪ CIRIA C532 Control of Water Pollution from Construction Sites;<br>▪ CIRIA C648 Control of Water Pollution from Linear Construction Projects<br>▪ CIRIA C689 Culvert Design and Operation Guide |
| Other Guidelines | ▪ SNH and Scottish Renewables Joint Publication, (2019) Good Practice During Wind Farm Construction Version 4<br>▪ FCE, SNH, (2010), Floating Roads on Peat<br>▪ Scottish Renewables, Joint Publication (2012), Development of Peatland: Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste<br>▪ SEPA, The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended), A Practical Guide, Version 8.4, October 2019<br>▪ River Crossings and Migratory Fish: Design Guidance, A Consultation Paper, The Scottish Executive<br>▪ SEPA Land Use Planning Guidance Note 4 (2017): Planning Guidance on On-Shore Windfarm Developments, Version 9<br>▪ SEPA Land Use Planning Guidance Note 31 (2017): Guidance on Assessing the Impacts of Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems, Version 3 |

## Stakeholder Consultation

12.10 The scoping and consultation responses relating to the hydrological, hydrogeological and geological environment are summarised in Table 12-2. Please note that the scoping response was based on the Scoping Layout which provided initial turbine positions only and did not provide details of any infrastructure including track alignment, borrow pit locations etc.

**Table 12-2: Consultation responses relating to hydrology, hydrogeological and geology**

| Organisation | Summary of Relevant Response | Comment |
|---|---|---|
| SEPA | Application must be supported by:<br>a) Map and assessment of all engineering activities in or impacting on the water environment included proposed buffers, details of any flood risk assessment and details of any related CAR applications;<br>b) Map and assessment of impacts upon GWDTE and buffers;<br>c) Map and assessment of impacts upon groundwater abstractions and buffers;<br>d) Peat depth survey and table detailing re-use proposals;<br>e) Map and table detailing forest removal;<br>f) Map and site layout of borrow pits;<br>g) Schedule of mitigation including pollution prevention measures;<br>h) Borrow Pit Site Management Plan of pollution prevention measures;<br>i) Map of proposed waste water drainage layout (if applicable0;<br>j) Map of Proposed surface water drainage layout;<br>k) Map of proposed water abstractions including details of the proposed operating regime; and<br>l) Decommissioning statement | ▪ a) Flood risk considered in paragraph 12.53 to 12.63;<br>▪ Figure 12.1 demonstrates hydrological watercourse buffers;<br>▪ Watercourse crossing details provided in Technical Appendix 12.1: Water Crossing Assessment;<br>▪ b) See Chapter 9: Ecology of the EIAR;<br>▪ c) See Chapter 9: Ecology of the EIAR;<br>▪ d) See Technical Appendix 12.2: Peat Management Plan;<br>▪ e) See Chapter 13: Forestry of the EIAR;<br>▪ f) See Site Layout Figure 12.1 and Chapter 3: Project Description of the EIAR;<br>▪ g) Mitigation outlined in chapter, further details to be included and considered within the Construction Environmental Management Plan (CEMP); and<br>▪ h-l) To be included and considered within the CEMP. Details provided in paragraph 12.132. |
| SEPA | The submission must include:<br>a) all proposed temporary or permanent infrastructure overlain with all lochs and watercourse;<br>b) a minimum buffer of 50m around each loch or watercourse. If this minimum buffer cannot be achieved each breach must be numbered on plan with an associated photograph of the location, dimensions of the loch or watercourses and drawings of what is proposed in terms of engineering works; and<br>c) Detailed layout of all proposed mitigation including all cut off drains, location, number and size of settlement ponds | ▪ a-b) Figure 12.1 demonstrates proposed infrastructure and hydrological watercourse buffers.<br>▪ See Technical Appendix 12.1: Water Crossing Assessment; and<br>▪ c) Mitigation outlined in chapter, further details to be included and considered within the CEMP. |
| SEPA | The submission must include:<br>a) detailed map of peat depths with all the built elements (including peat storage areas) overlain to demonstrate how the development avoids area so deep peat and other sensitive receptors such as GWDTE | ▪ a-b) See Technical Appendix 12.2: Peat Management Plan for quantities and outline sustainable measures to excavate, store and use peat to support infrastructure construction. Refer to Figure 12.5: Interpolated Peat Depths; and |

| Organisation | Summary of Relevant Response | Comment |
|---|---|---|
| | b) Table which details the quantities of acrotelmic, catotelmic and amorphous peat will be excavated for each element and where it will be re-used during reinstatement. Details of proposed widths and depths of peat to be re-used and how it will be kept wet permanently. | ▪ Technical Appendix 9.1 provides further detail on the assessment of habitats. |
| SEPA | A map demonstrating that all GWDTE are out with a 100m radius of all excavations shallower than 1m and out with 250m of all excavations deeper than 1m and proposed groundwater abstractions. | ▪ The data and assessment of GWDTE is detailed in Chapter 9: Ecology of the EIAR and Technical Appendix 9.1: Phase 1, NVC & GWDTE Report;<br>▪ Compliance with the buffers are shown in Figure 12.1: Hydrological Overview; and<br>▪ Paragraph 12.72 provides details on information provided by SEPA on the presence of licenced abstractions. |
| SEPA | Forestry felling, consideration of impacts on water quality and forestry waste | ▪ The impacts of forestry works have been considered as part of this chapter of the EIAR; and<br>▪ See Chapter 13: Forestry of the EIAR for further details. |
| SEPA | Detailed borrow pit management plan | ▪ Borrow pit search areas have been delineated in outline with baseline desk study information provided in relation to the underlying soils and geology. Borrow pit search areas have been included within the detailed peat surveys being undertaken for the development;<br>▪ See Technical Appendix 12.3: Peat Slide Risk Assessment for further details; and<br>▪ Specific and detailed borrow pit designs would be progressed post-consent following completion of ground investigations. |
| SEPA | Detailed schedule of mitigation | ▪ Proposals for mitigation and pollution prevention are included within paragraph 12.123 to 12.181. |
| SEPA | Proposals for decommissioning must demonstrate accordance with SEPA Guidance (decommissioning of onshore wind farms). | ▪ Proposals for mitigation and pollution prevention are included within paragraph 12.123 to 12.181; and<br>▪ Detailed decommissioning statements would be progressed post-consent. |
| SEPA | Require the submission of a Biosecurity Plan as part of the EIAR, or clear justification as to how other measures will ensure that this risk is mitigated. | ▪ See Chapter 9: Ecology. |

| Organisation | Summary of Relevant Response | Comment |
|---|---|---|
| | The site is close to areas where American Signal Crayfish are present. The applicant will therefore need to demonstrate compliance with the Scottish Government's Code of Practice on NNS and INNS. | |
| SAC | The development should not adversely affect the private water supplies in the area.<br><br>There is no clear indication of proposed sites for borrow pits (quarries), or for water crossings that could have potential impact in catchment areas for private water supplies situated just out with the marked boundary on the provided map. | ▪ See paragraph 12.73 to 12.78 and Table 12-9 for an assessment of private water supplies;<br>▪ Figure 12.1 provides an indication of the hydrological context of the Proposed Development;<br>▪ Mitigation proposals are included in paragraph 12.123 to 12.181 as part of the EIAR to protect supplies and commitments to undertake further investigations;<br><br>▪ Borrow pit search areas have been delineated in outline with baseline desk study information provided in relation to the underlying soils and geology. Borrow pit search areas have been included within the detailed peat surveys being undertaken for the development; and<br>▪ Specific and detailed borrow pit designs would be progressed post-consent following completion of ground investigations. |
| SAC | Details on access into site from roads to be provided.<br><br>Details on internal access roads to be provided. | ▪ Chapter 3: Project Description of the EIAR provides details on the Site infrastructure; and.<br>▪ Further details are also provided in Technical Appendix 12.2: Peat Management Plan |
| SAC | Require proof that problems will not occur, or be further compounded by the proximity to further or existing windfarms such as Carrick, Hadyard Hill, etc. | ▪ An assessment of cumulative effects has been considered in paragraph 12.208 to 12.211. |
| NatureScot | a) Site includes an area mapped as Class 1 on SNH's Carbon and Peatland map 2016. The proposal will need to demonstrate that any significant effects on the qualities of these areas can be substantially overcome by siting, design or other mitigation;<br>b) Advise that detailed peat surveys, measuring the peat deposit to full depth should be undertaken in accordance with Scottish | ▪ a) See Figure 12.4: Carbon and Peatland and Figure 12.5 which is more accurately based off site specific survey data for placement of infrastructure in relation to peat depth;<br>▪ b) Refer to Technical Appendix 12.2: Peat Management Plan and Technical Appendix 12.3: Peat Slide Risk Assessment for results; and |

| Organisation | Summary of Relevant Response | Comment |
|---|---|---|
| | Government Guidance. The probing results should be used to inform a peat Stability Risk Assessment;<br>c) Peat survey results should also be used to inform the design and layout process, so that development avoids, where possible, fragile and priority habitat and other sensitive areas e.g. blanket bog and peat. Suitable restoration and/or compensation measures should be presented in the EIA Report in the form of a draft Habitat Management Plan. | ▪ c) Site Layout has been informed by peats surveys (See Figure 12.5). Further details in relation to habitat is available in Chapter 9: Ecology of the EIAR. |
| Dailly Community Council | Detailed consideration of private water supplies. Measure to protect supplies must be included and considered appropriately within the assessment. | ▪ See paragraph 12.73 to 12.78 and Table 12-9 for an assessment of private water supplies; and<br>▪ Mitigation proposals are included in paragraph 12.123 to 12.181 as part of the EIAR to protect supplies and commitments to undertake further investigations. |
| Marine Scotland | Site characterisation surveys to be undertaken with impacts of the Proposed Development on fish species to be included.<br><br>Site specific mitigation plans, including an integrated water quality and fish monitoring plan to be included<br><br>Acidification problems in the area to be included in the assessment.<br><br>Consideration of the potential cumulative impact on the water quality and Marine Scotland fish populations as a result of other developments which are in hydrological connectivity with the present proposal. | ▪ Assessment of effects on aquatic species included in Chapter 9: Ecology of the EIAR;<br>▪ Mitigation details provided in paragraph 12.123 to 12.181; and<br>▪ Assessment of cumulative effects provided in paragraph 12.208 to 12.211. |
| Ayrshire Rivers Trust | The following potential effects from site preparation and construction and operational activities should be assessed:<br><br>▪ Forest felling and subsequent effects of this activity on the hydrological environment;<br>▪ Construction activities – impediment to fish movement. Construction activities should not impede movement of all migratory and resident fish populations; and<br>▪ Construction/operation activities – increased silt loading to watercourses. | ▪ Assessment of effects provided in Table 12-14 and Table 12-15; and<br>▪ Further details on watercourse crossings are available in Technical Appendix 12.1: Watercourse Crossing Assessment. |

| Organisation | Summary of Relevant Response | Comment |
|---|---|---|
| | A comprehensive mitigation and monitoring plan should be included that will address the above potential negative impacts on watercourses. | |

## Assessment Methodology and Significance Criteria

### *Effects to be assessed*

12.11 The greatest risk of the Proposed Development affecting the hydrological, geological and hydrogeological environment will occur during the construction phase, with effects reduced during the operational and decommissioning phase. Taking this into account the following issues will be addressed during all phases of development of the Site:

- Changes to existing drainage patterns;
- Effects on baseflow;
- Effects on run-off rates;
- Effects on erosion and sedimentation;
- Effects on groundwater and surface water quality (including Groundwater Dependent Terrestrial Ecosystems (GWDTEs));
- Effects on groundwater levels;
- Effects on water resources;
- Effects on impediments to flow;
- Flood risk;
- Pollution risk;
- Mining considerations;
- Effects on local geology; and
- Effects on hydrological integrity of peat bodies.

### *Methodology*

#### *Overview*

12.12 The assessment has involved the following:

- Detailed desk studies and site visits to establish baseline conditions of the area;
- Evaluation of the environmental impacts of the Proposed Development and the likely significant effects that these could have on the current site conditions;
- Identification of embedded good practice measures to avoid and mitigate against any identified adverse effects resulting from the Proposed Development;
- Evaluation of the likely significant environmental effects with consideration of the potential embedded mitigation measures, taking account of the sensitivity of the baseline features the potential magnitude of these effects and the probability of these effects occurring; and
- The residual significance of the environmental effects following the consideration of additional mitigation measures.

*Baseline Assessment*

12.13 A desktop survey to establish the baseline conditions was undertaken in order to:

- Describe surface water hydrology, including watercourses, springs and waterbodies;
- Identify existing catchment pressures (e.g. point source and diffuse pollution issues);
- Identify all private drinking water abstractions and public water supplies within 5 km of the Site;
- Identify all flooding risks;
- Describe the hydromorphological conditions of watercourses;
- Collect information relating to recreational and fisheries resources;
- Collate hydrological flow and flooding data for the immediate area and main downstream watercourses;
- Collect soil, geological and hydrogeological information;
- Confirm surface water catchment areas and watersheds; and
- Confirm the extent and nature of peat deposits across the Site.

12.14 Published information consulted for the baseline is outlined in Table 12-3 below.

**Table 12-3: Baseline information sources**

| Topic | Sources of Information |
|---|---|
| Topography | 10 m contour data derived from Digital Terrain Model (DTM) data |
| Designated Nature and Conservation Sites | In-house Designated Site Database. Scottish Natural Heritage, SiteLink website, http://gateway.snh.gov.uk/sitelink/searchmap.jsp |
| Solid and Superficial Geology | BGS Geology of Britain Viewer, http://mapapps.bgs.ac.uk/geologyofbritain3d/index.html |
| Soils and Peat | James Hutton Institute (JHI), Soil Information For Scottish Soils (SIFSS), http://sifss.hutton.ac.uk/<br>Scotland's Soils Interactive Map, Carbon and Peatland 2016 and National Soil Map of Scotland, http://soils.environment.gov.scot/ |
| Climate | Met Office, https://www.metoffice.gov.uk/public/weather/climate/gcv3mcrf9<br>Flood Estimation Handbook (FEH): FEH Web Service, https://fehweb.ceh.ac.uk/<br>Flood Modeller Suite, https://www.floodmodeller.com/ |
| Surface Water Hydrology | 1:10,000 OS Raster Data<br>1:50,000 OS Raster Data<br>Flood Estimation Handbook (FEH): FEH Web Service, https://fehweb.ceh.ac.uk/<br>Flood Modeller Suite, https://www.floodmodeller.com/ |
| Flooding | Flood Risk Management Map (SEPA) http://map.sepa.org.uk/floodmap/map.htm |

| Topic | Sources of Information |
|---|---|
| Water Quality | SEPA, WFD Classification, Web Mapping Application,<br>SEPA, Water Classification Hub, https://www.sepa.org.uk/data-visualisation/water-classification-hub<br>SAC, State of the Environment Report 2018 – 2020<br>https://www.south-ayrshire.gov.uk/sustainable-development/publications.aspx |
| Water Resources | Private water supply information provided by SAC |
| Hydrogeology | Scotland's Environment Web Interactive Map, https://map.environment.gov.scot/sewebmap/<br>BGS Geology of Britain Viewer, http://mapapps.bgs.ac.uk/geologyofbritain3d/index.html<br>BGS Geoindex Onshore<br>https://mapapps2.bgs.ac.uk/geoindex/home.html<br>SEPA, River Basin Management Plans, Web Mapping Application, http://gis.sepa.org.uk/rbmp/ |

*Effects Evaluation*

12.15 The likely significant environmental effects of the Proposed Development have been defined by taking account of the two main factors; the sensitivity of the receiving environment and the potential magnitude should that effect occur. The sensitivity of the receiving environment i.e. its baseline quality as well as its ability to absorb the effect without perceptible change is defined in Table 12-4 below.

**Table 12-4: Definition of sensitivity of the receiving environment.**

| Sensitivity | Definition |
|---|---|
| High | The receptor/resource has little ability to absorb change without fundamentally altering its present character or is of international or national importance. |
| Medium | The receptor/resource has moderate capacity to absorb change without significantly altering its present character; or is of medium/regional importance. |
| Low | The receptor/resource is tolerant of change without detriment to its character, is of low or local importance. |

12.16 The magnitude of impact includes the timing, scale, size and duration of the likely significant environmental effects. For the purposes of this assessment the magnitude of impact criteria area defined in Table 12-5 below.

**Table 12-5: Magnitude of impact.**

| Magnitude | Criteria | Definition |
|---|---|---|
| Substantial | Total loss of or major/substantial alteration to key elements/features of the baseline (pre-development) conditions such that the post development character/composition/attributes will be fundamentally changed. | Fundamental (long term or permanent) changes to geology, hydrology, water quality and hydrogeology. |

| | | |
|---|---|---|
| Moderate | Loss or alteration to one or more key elements/features of the baseline conditions such that post development character/composition/attributes of the baseline will be materially changed. | Material but non-fundamental and short to medium term changes to the geology, hydrology, water quality and hydrogeology. |
| Slight | A minor shift away from baseline conditions. Change arising from the loss/alteration will be discernible/detectable but not material. The underlying character/composition/attributes of the baseline condition will be similar to the pre-development circumstances/situation. | Detectable but non-material and transitory changes to the geology, hydrology, water quality and hydrogeology. |
| Negligible | Very little change from baseline conditions. Change barely distinguishable, approximating to a 'no change' situation. | No perceptible changes to the geology, hydrology, water quality and hydrogeology. |

12.17 Assuming the successful implementation of good practice and design mitigation measures, the sensitivity of the receiving environment together with the magnitude of the effect defines the significance of the effect as outlined in Table 12-6 below.

**Table 12-6: Significance Matrix**

| | | **Magnitude of change** | | | |
|---|---|---|---|---|---|
| | | Substantial | Moderate | Slight | Negligible |
| **Sensitivity** | High | Major | Major/ Moderate | Moderate | Moderate/ Minor |
| | Medium | Major/ Moderate | Moderate | Moderate/ Minor | Minor |
| | Low | Moderate | Moderate/ Minor | Minor | Minor/ Negligible |

12.18 Potential effects are therefore concluded to be Major, Moderate, Minor or Negligible. Effects considered as being Major or Moderate/Major are considered significant in terms of The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017.

## Assumptions and Limitations

12.19 The fieldwork carried out was a standard reconnaissance level walkover survey covering the main hydrological features within the Site. Representative locations and features such as watercourses, peat bodies and geological information were assessed, and this information is interpreted for any areas not visited.

12.20 Private water supply information within 5 km of the Site has been provided by SAC. Additional on-site private water supply sources were not encountered during the site investigations and are considered unlikely due to the remoteness of the Proposed Development. However, it is possible that there are non-potable supplies, such as for livestock, which were not identified in the SAC register.

12.21 The information presented in this assessment is based on desk studies and site investigations on the Proposed Development layout. There is the potential that further constraints may

be identified during the pre-construction detailed design stage. Should further constraints be identified these will be assessed and appropriately mitigated prior to construction.

## Baseline Conditions

12.22 This subsection presents the information gathered on the existing topographical, hydrological, hydrogeological and geological conditions within the Site and the study area. The study area is defined in Figure 12.1 provided in Volume II of the EIAR.

### *Site Area*

12.23 The Proposed Development will be located approximately 4 km north-east of Barr and 4 km south of Dailly in South Ayrshire, Scotland. The Proposed Development will be in an upland area consisting predominantly of open moorland and extensive areas of plantation forestry.

12.24 The Proposed Development will consist of the erection, 35-year operation, and subsequent decommissioning of up to 14 wind turbines, with tip heights of 200 m. The Proposed Development includes associated turbine foundations and transformers, battery storage, hardstanding areas for erecting cranes at each turbine location, a series of on-site tracks connecting each turbine, underground cables linking the turbines to the grid connection, an on-site substation, a construction compound, two borrow pit search areas and a new access into the Site. Off-site access works are proposed to facilitate turbine component delivery. These are detailed in Chapter 3 Project Description and Chapter 11 Traffic and Transport.

12.25 A topographic high is reached in the north east of the Site at Craiginmoddie summit of 382 m Above Ordnance Datum (AOD). All areas of the infrastructure are noted to be above 250 m AOD.

12.26 The hydrological study area is larger in extent than the actual Site and includes the lower reaches of watercourse catchments that are present within the Site. The extent of the catchments are shown in Figure 12.1 in Volume II which outline the extent of the study area. Designated sites and relevant developments are considered from the perspective of assessing any potential hydrological linkages or cumulative effects.

### *Site Investigations*

12.27 The phase 1 peat depth survey and hydrological walkover were undertaken in July 2020. Weather conditions were dry, cool and occasionally showery. The phase 2 peat survey and further hydrological surveys, including watercourse crossing assessment, were undertaken in November 2020. Weather conditions were predominately cold and occasionally wet.

## Climate

12.28 The standard average annual rainfall (SAAR) for the Site has been derived from the FEH Web Service[1] as ranging from 1411 - 1656 mm based on the Site catchments. To put this into context, rainfall in Scotland varies from under 800 mm a year on mainland eastern Scotland in areas such as Fife to over 3000 mm on the mainland Western Highlands.

12.29 The Met Office 1981-2010 annual rainfall total from the Girvan Climate Station (9 m AOD) is 1063 mm with 164.4 days of rainfall days greater than 1 mm recorded[2], compared to 1787 mm and 191.1 days for the Scotland West region.

12.30 The Girvan Climate Station is positioned approximately 11 km west of the Proposed Development and at a lower elevation compared to the Proposed Development. However, the comparison with the regional Met Office and FEH data provides a good indication of both rainfall totals and patterns expected at the Site.

12.31 The highest rainfall totals as shown in Figure 12.A are typically experienced during the winter months through October to January. The lowest totals rainfall is typically recorded during the Spring months from April to May.

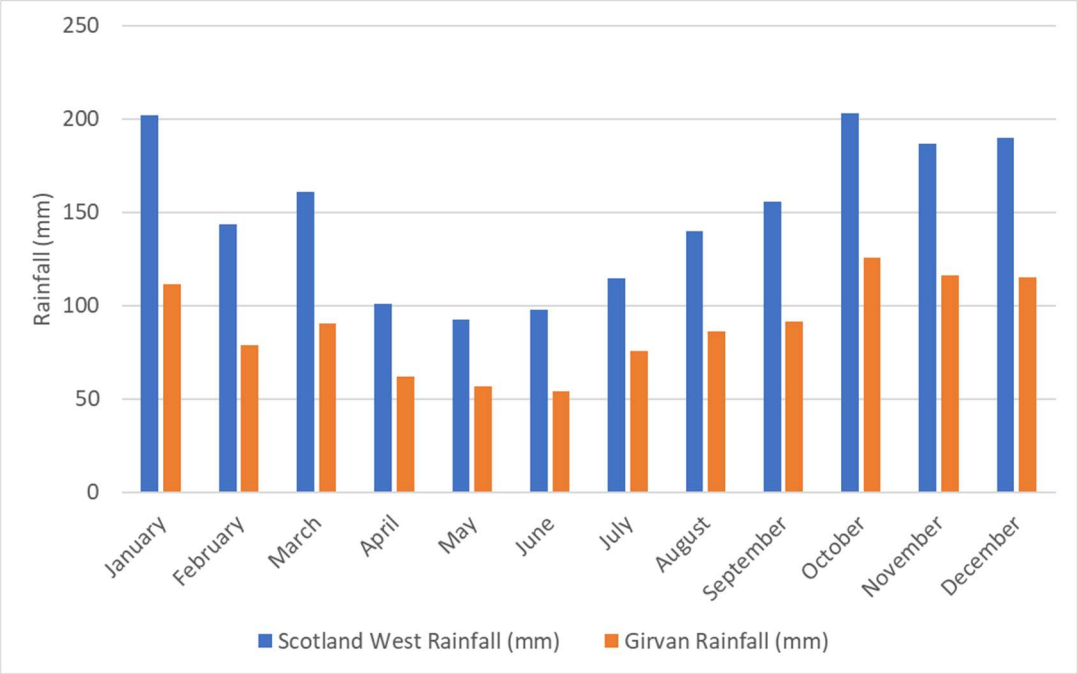


**Figure 12.A: Average monthly rainfall data for climate period 1981-2010**

## Designated Sites

12.32 There are no designated sites of hydrological importance within the study area.

[1] FEH Web Service, https://fehweb.ceh.ac.uk/, accessed 10/11/2020

[2] Met Office, Girvan Climate, https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gcuurcfer, accessed 10/11/2020

12.33 There are three Sites of Special Scientific Interest (SSSI) within 5 km of the Site. Blair Farm SSSI and Knockgardner SSSI are designed for geological interests and are located 2.1 km and 4.4 km, respectively to the north east of the Site. Auchalton SSSI is designated for biological interests as it comprises an area of dry and wet grassland on the site of a former lime works. The base-rich soil supports dry grassland plant communities that are species rich and are the best example of their type in the local area. The three SSSI are not hydrologically connected to the Proposed Development and therefore will not be considered further.

## *Surface Water Hydrology*

12.34 Hydrologically, the Site lies within the catchments of the River Stinchar and Water of Girvan. Figure 12.1: Hydrology Overview in Volume II shows distribution of hydrological features across and adjacent to the Proposed Development. There are several burns which supply these networks situated in and around the Site.

### *River Stinchar Catchment*

12.35 The headwaters of the River Stinchar are located within the Carrick Forest. The River Stinchar has a catchment area of 314 km$^2$ and the watercourse flows north initially from its source then flows south west for the majority of its 45 km course before discharging into the Firth of Clyde of Ballantrae. The Milton Burn and the Dalquhairn Burn are the two main tributaries of the River Stinchar that discharge from the Site.

12.36 Milton Burn and its tributaries drain the south western section of the Site. The tributaries vary from flush areas with both defined and undefined channels at higher elevations to distinct channelised areas along the lower reaches of the Milton Burn.

12.37 Along the reach of the Milton Burn there is a combination of surface pooling with no flow or defined small channels ranging from 0.2 m to 0.4 m wide with a water depth of less than 0.1 m and bank height of 0.3 m. Silty material, reeds and moss species make up the channel banks and are present within the channels and surface pools. A number of the tributaries are fed by water originating in Daljedburgh Forest, a coniferous plantation, which is subject to flow via forestry ditches. The Milton Burn has an incised channel with a width varying from 1.5 m to 3 m and a water depth of 0.2 m to 0.7 m. Pools and stepping over bedrock are present with gravel and cobbles making up the bed load. Milton Burn has an incised v-shaped valley in its upper reaches, which becomes gentler in downstream reaches. Figure 12.B shows the Milton Burn channel in a headwater tributary, and on the main stem.

Source: Google Maps (2020)[3]

**Figure 12.B: Milton Burn tributary (view downstream from NX 29679 97825) [left], and Milton Burn main stem (view downstream from NX 29568 97300) [right]**

12.38 The catchment of the Dalquhairn Burn drains the southern and eastern areas of the Site and is comprised of coniferous woodland and open moorland (as shown in Figure 12.1 in Volume II). Doughty Hill lies within the west of the catchment, reaching an elevation of 380 m Above Ordnance Datum (AOD). Slopes surrounding Doughty Hill are of moderate gradient with steeper sections and v-shaped valleys along and in the vicinity of the Auchengairn and Dalquhairn Burns.

12.39 The Auchengairn Burn is a tributary of the Dalquhairn Burn and flows in a south easterly direction through coniferous forestry and open moorland before joining the Ferly Burn at NGR NX 32597 97438). Drainage ditches are present on the hillside of Doughty Hill within the headwaters of Auchengairn Burn and appear to have diverted runoff away from original natural headwater channels (see Figure 12.C). The main stem of Auchengairn Burn is well defined (Figure 12.C), flowing through a v-shaped valley with a bed material mainly comprised of cobbles. The banks are stable and vegetated with no significant evidence of bank instability of erosion.

[3] Google Maps, 2020, Street View, https://www.google.co.uk/maps/, accessed 20/11/2020

**Figure 12.C: Boggy land with drainage ditches surrounding Auchengairn Burn headwaters [left], and main stem of Auchengairn Burn (view downstream) [right]**

12.40 Ferly Burn is a tributary of the Dalquhairn Burn and is a meandering channel in a U-shaped valley flowing from north to south into the Dalquhairn Burn and then into the River Stinchar. Areas of deposition on the insides of the meander bends and undercutting of banks on the outside, which reach heights of two metres, provide evidence of higher flows (as shown in Figure 12.D). Similarly to other watercourses in the catchment, banks are vegetated, and bed material varies in size from gravels to boulders.

**Figure 12.D: Ferly Burn**

*Water of Girvan Catchment*

12.41 The catchment of the Water of Girvan is approximately 250 km$^2$ and flows west for approximately 45 km from its source at Loch Girvan Eye through Straiton and Dailly before discharging into the Firth of Clyde at Girvan. The Site is located within the catchment of the Lindsayston Burn, which discharges into the Water of Girvan at NGR NS 27267 01776.

12.42 The headwaters of the Lindsayston Burn comprise of the watercourses that make up the catchments of the Delamford Burn and Dobbingston Burn, which drain the northern and western areas of the Site. The majority of the catchment is comprised of open moorland, with the headwaters dominated by commercial coniferous forestry plantation. No evidence of significant instability was noted with deciduous forestry occupying the riparian corridor of the lower reaches of the Lindsayston Burn. An example of the Lindsayston Burn channel is shown in Figure 12.E.

**Figure 12.E: Lindsayston Burn**

## *Hydrological Regime*

### *Effects of Forestry*

12.43 The majority of the Site is dominated by commercial forestry, with lower reaches of the main catchments dominated mostly by open moorland, and some recent afforestation.

12.44 Areas of existing mature commercial forestry help to attenuate peak flows due to the interception of precipitation by the closed canopy. Research into the effects on the hydrological regime of catchments suggests that forestry practices can have impacts on peak flows, and water quality.

12.45 The existing commercial forestry across the Site was planted between 1972 and 1987, and there are large areas of closed canopy which currently help attenuate peak flows and reduce downstream flood risk in the wider catchment[4]. It can be concluded that due to the age (48 - 33 years) and density of the existing forestry, flows are likely to have reduced since the initial installation of the drainage channels and subsequent maturation of the forestry[5].

12.46 In addition to the existing commercia forestry, new planting has been undertaken across the south eastern slopes of Doughty Hill (Figure 12.F) and around Auchengairn. During late 2020, planting was also being undertaken on the south western slopes of Daljedburgh Hill. This new afforestation will impact the Auchengairn Burn, Dalquhairn Burn and two unnamed tributaries of the River Stinchar. This afforestation will reduce peak storm flows within these watercourses, due to greater interception and uptake of rainfall by trees,

[4] Forestry Commission (2011), Forests and Water, UK Forestry Standard Guidelines, https://www.confor.org.uk/media/246145/forest-and-water-guidelines.pdf, accessed 20/11/2020

[5] Holden et al (2004), Artificial drainage of peatlands: hydrological and hydrochemical process and wetland restoration, Progress in Physical Geography: Earth and Environment, Volume: 28, Issue 1, https://doi.org/10.1191%2F0309133304pp403ra, accessed 20/11/2020

combined with attenuation of overland flows through increased infiltration rates. Research suggests that there may be a 1.5 – 2 % reduction of potential water yield for every 10 % of a catchment under mature conifer forest[4].

12.47 Other effects of afforestation relate to water quality. Scavenging of atmospheric nitrogen and sulphur by trees can contribute to water course acidification[6]. This may have a negative impact on downstream WFD classified rivers - the River Stinchar and the Dalquhairn Burn.

**Figure 12.F: Newly planted trees within open ground on Doughty Hill, photo taken in November 2020 (from NX 32282 98918)**

12.48 In areas to be felled as part of the Proposed Development, a reduction in existing forestry cover will lead to a reduction in interception of precipitation, increases in runoff and subsequently flood risk. Harvesting would be expected to increase sediment runoff, and clear felling may elevate phosphates and nitrates within watercourses[6].

*Flow Estimation*

12.49 Peak flows have been estimated for the key catchments described above using the FEH Rainfall Runoff (FEH RR) and Institute of Hydrology Report 124 (IH124) methodologies for a range of return periods, with the results presented in Table 12-7 below. Catchment

[6] Environment Agency (2011), Woodland for Water: Woodland measures for meeting Water Framework Directive objectives, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/291522/scho0711btyr-e-e.pdf, accessed 20/11/2020

descriptors were derived from the FEH Web Service and used for calculating peak flows for the identified catchments above.

12.50 Table 12-7 presents flows for the Site catchments. The Q200+Climate Change (CC) is the 200-year return period flow plus a 20 % mark up for CC as per SEPA Land Use Planning Guidance CC1 (LUPS-CC1) (2019) climate change allowances for flood risk assessment in land use planning.

**Table 12-7: Estimated peak runoff for the Site catchments calculated using the methodology prescribed by the FEH RR and IoH Report No. 124.**

| Catchment | Area ($km^2$) | Method | Estimated peak runoff ($m^3/s$) for stated return periods | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 | 5 | 10 | 25 | 50 | 100 | 200 | 200 + CC |
| Milton Burn | 4.3 | FEH RR | 3.82 | 5.63 | 6.79 | 8.46 | 10.02 | 11.72 | 13.76 | 16.52 |
| | | IH124 | 4.24 | 5.17 | 6.62 | 8.43 | 10.11 | 12.25 | 14.82 | 17.78 |
| Dalquhairn Burn | 11 | FEH RR | 9.20 | 13.45 | 16.17 | 20.09 | 24.01 | 27.91 | 32.64 | 39.16 |
| | | IH124 | 11.94 | 14.56 | 18.63 | 23.74 | 28.47 | 34.50 | 41.72 | 50.06 |
| Lindsayston Burn | 12.6 | FEH RR | 7.83 | 11.31 | 13.52 | 16.69 | 20.04 | 23.23 | 27.10 | 32.53 |
| | | IH124 | 8.76 | 10.69 | 13.67 | 17.43 | 20.90 | 25.32 | 30.62 | 36.75 |

### *Catchment Characteristics*

12.51 Base Flow Index (BFI) and Standard Percentage Runoff (SPR) data for the Site catchments was also taken from the FEH Web Service. The BFI is a measure of the proportion of a catchment's long-term runoff that derives from stored sources, with the BFI ranging from 0.1 in relatively impermeable clay catchments to 0.99 in highly permeable catchments. The SPR values represent the percentage of rainfall that is likely to contribute to runoff.

12.52 The BFI for the Site catchments ranges from 0.301to 0.319 indicating that around a third of the catchment's long-term runoff is derived from stored sources. The SPR for the site catchments ranges from 46.82 % to 52.42 % indicating that around a half of the rainfall during a rainfall event contributes to runoff. The BFI and SPR values show that the Site is located on moderately permeable catchments.

## *Flood Risk*

12.53 The assessment has been carried out in accordance with SPP[7]. The document states that:

> *'Planning authorities must take the probability of flooding from all sources – (coastal, fluvial (watercourse), pluvial (surface water), groundwater, sewers and blocked culverts) and the risks involved into account when preparing development plans and determining planning application.' (SPP, page 58)*

[7] Scottish Government (2014), Scottish Planning Policy

12.54 The Flood Risk Management (Scotland) Act[8] sets in place a statutory framework for delivering a sustainable and risk-based approach to managing flooding. The main elements of flood risk management relevant to the Proposed Development is assessment of flood risk as well as undertaking structural and non-structural flood management measures.

12.55 As outlined in the following paragraphs the relevant factors for assessing flood risk have been taken into account, measures to mitigate and sustainably manage the flood risk within the Site are provided in paragraph 12.162 to 12.176.

12.56 As highlighted above, all potential sources of flooding must be considered for the Site. A summary of the potential sources of flooding is presented below.

*Fluvial flooding sources*

12.57 Areas identified at risk of fluvial flooding are limited to the watercourses forming the south eastern boundary of the Site. Flood information available on the SEPA Flood Risk Management Map[9] indicates that the Auchengairn Burn and Dalquhairn Burn are at a medium (1 in 200) to high – 10% (1 in 10) likelihood of fluvial (watercourse) flooding in any given year. On the Auchengairn Burn the risk aeras are generally contained in the river channel extent. The risk areas on the Dalquhairn Burn occupy the wider U-shaped valley near Dalquhairn and Dalwayne, which lies outside the Site approaching the confluence with River Stinchar. The SEPA Flood Risk Management Map does not indicate any risk of fluvial flooding on watercourses situated within the Site.

*Pluvial flooding sources*

12.58 A review of SEPA Flood Risk Management Map indicates that small pockets of land surrounding the Auchengairn Burn, Ferly Burn, and within forestry across the northern half of the Proposed Development are at risk of pluvial (surface-water) flooding. These small areas are at a medium (1 in 200) to high – 10% (1 in 10) likelihood of pluvial flooding in any given year.

*Coastal flooding sources*

12.59 The Site is located approximately 12 km from the nearest coast and due to this distance along with the topographical position of site infrastructure, approximately 250 m AOD within the Site, it is presumed that it will not be affected by tidal flooding.

*Groundwater flooding sources*

12.60 Flooding can also result from high groundwater levels if the water table rises above the surface level. Groundwater flooding can occur in a variety of geological settings including river valleys with thick deposits of alluvium and river gravels. Groundwater flooding happens in response to a combination of already high groundwater levels (usually during

[8] Scottish Government (2009), The Flood Risk Management (Scotland) Act 2009

[9] Scottish Environment Protection Agency (2020), Flood Risk Management Map, https://map.sepa.org.uk/floodmap/map.htm, accessed 20/11/2020

mid or late winter) and intense or unusually lengthy storm events. Such flooding also often lasts much longer than flooding caused by a river over-flowing its banks.

12.61 Groundwater flooding is difficult to predict as it rarely follows a consistent pattern. The response time between rainfall and groundwater flooding is also relatively long.

12.62 Groundwater flooding is often associated with the shallow unconsolidated sedimentary aquifers that overlie non-aquifers. Such aquifers are susceptible to flooding as the storage capacity within these deposits is often limited and direct rainfall recharge can be relatively high, subsequently increasing the water levels within the groundwater and providing a good hydraulic connection with adjacent river networks. The SEPA Flood Risk Management Map does not indicate any areas within the Site at risk of groundwater flooding.

*Flooding from artificial drainage systems*

12.63 There is evidence of artificial drainage associated with the commercial forestry works within the upper reaches of all site catchments within the Site. There is the potential that this could cause some localised flooding by increasing runoff rates to the main watercourses within the catchments. However, given the limited spatial coverage and extent of this area, the risks are assumed to be low. As discussed in paragraph 12.45, existing mature forestry is likely to attenuate peak flows and may result in reduced flood risk within the wider catchment.

## Water Quality

*Water quality WFD Classification*

12.64 Two waterbodies within the Site are classified under the Scottish Government's Water Framework Directive (WFD) (2000/60/EC) classification directions; The Scotland River Basin District (Standards) Directions 2014, and The Scotland River Basin District (Status) Directions 2014. These classified waterbodies are summarised in Table 12-8 below. WFD classifications discussed below are derived from SEPA's Water Classification Hub[10].

**Table 12-8: WFD classification of surface waterbodies within the vicinity of the Proposed Development**

| Water Body | Waterbody ID | Current Overall Status (2018) | Overall Ecology (2018) | Overall Hydrology (2018) | Projected Overall Status (2021) | Projected Overall Status (2027) |
|---|---|---|---|---|---|---|
| Dobbingstone Burn/Lindsayston Burn | 10459 | High | High | High | High | High |
| Dalquhairn Burn | 10477 | High | High | High | High | High |

[10] Scottish Environment Protection Agency (2020), Water Classification Hub, https://www.sepa.org.uk/data-visualisation/water-classification-hub/, accessed 18/11/2020

12.65 WFD classified waterbodies are considered in the River Basin Management Plan (RBMP) for the Scotland river basin district: 2015-2027[11]. The RBMPs are designed to protect and improve the water environment.

12.66 The two waterbodies described in Table 12-8 drain into larger WFD classified waterbodies; the River Stinchar (Waterbody ID 10467), and Water of Girvan (Waterbody ID 10757). Both Water of Girvan and the River Stinchar have an Overall WFD Status of Moderate[10].

12.67 Old mine workings at Dailly are an existing pollution hazard on Water of Girvan and were the cause of a significant pollution event in 1979. Water quality has since considerably improved and current pressures on Water of Girvan water quality are sewage discharges[12].

12.68 Water quality is generally very good within the River Stinchar, and pollution is generally limited to siltation from bank erosion due to livestock[12]. However, It is possible that the failure of the River Stinchar to achieve High WFD status for acidity (in 2018)[10] may in part be due to afforestation within the Duisk River catchment[13]. Afforestation on the eastern slopes of Doughty Hill and around Auchengairn may jeopardise the current Good WFD status for acidity held by the River Stinchar through excessive deposition of acidifying compounds (paragraph 12.47). This could contribute to critical load exceedance within downstream watercourses. The risk of critical load exceedance will principally depend on extent of afforestation across the catchment area, and the existing acid neutralising capacity of downstream watercourses[14]. Due to this existing acidification risk, the River Stinchar could be considered an acid sensitive catchment as defined by Forestry and Land Scotland guidance[14].

## *Water Resources*

### *Water Resources WFD Classification*

12.69 The two classified waterbodies within the Site (Dobbingstone Burn/Lindsayton Burn, and Dalquhairn Burn) both have a WFD classification of High for overall hydrology (Table 12-8), indicating that there are no abstractions within their catchment, and flows within these watercourses are considered natural.

### *Public Water Supply*

12.70 The Site drains land which is part of a surface drinking water protection area (DWPA) associated with the wider River Stinchar catchment. This surface DWPA (Scottish Government ID DWPA13_491)[15] includes land drained by the upper headwaters of the Milton Burn, and several unnamed tributaries of the River Stinchar originating on the

[11] Scottish Government (2015), The river basin management plan for the Scotland river basin district: 2015-2027, https://www.sepa.org.uk/media/163445/the-river-basin-management-plan-for-the-scotland-river-basin-district-2015-2027.pdf, accessed 18/11/2020

[12] South Ayrshire Council (2018), State of the Environment Report 2018 – 2020, https://www.south-ayrshire.gov.uk/sustainable-development/publications.aspx, accessed 19/11/2020

[13] Ayrshire Rivers Trust (2020), River Stinchar, http://www.ayrshireriverstrust.org/river-stinchar/, accessed 19/11/2020

[14] Forestry and Land Scotland (2014), Managing forests in acid sensitive water catchments, file:///C:/Users/findlayc/Downloads/FCPG023.pdf, accessed 23/11/2020

[15] Scotland's Environment (2020), Scotland's environment map, https://map.environment.gov.scot/Soil_maps/?layer=1 accessed 19/11/2020

southern slopes of Daljedburgh Hill. The Site is also underlain by the Girvan and Lendalfoot groundwater body DWPAs[15].

12.71 Penwhapple Reservoir is approximately 3 km west of the Site. This reservoir is situated within a different surface water catchment from the Proposed Development and there is not considered to be any hydrological or hydrogeological connectivity between this reservoir and the Site.

*Water Use Authorisations*

12.72 SEPA were contacted to establish if there are any abstractions or discharges within 5 km of the Proposed Development. A response was received that indicated thirteen licensed sites with use limited to sewage release only. There are no CAR authorised abstractions or impoundments within 5 km of the Proposed Development.

*Private Water Supply*

12.73 SAC was consulted regarding the presence of private water supplies (PWS), both domestic and commercial within a 5 km search area from the Site boundary. Information on 39 Users served by a PWS were identified. These PWS Users are premises which are served by a PWS and were assigned a PWS ID number (1 to 39).

12.74 PWS can be impacted by chemical pollution, damage to PWS infrastructure (e.g. water transfer pipes, intakes) and reduced recharge volumes through disruption of natural flow pathways. The risk posed to a PWS will principally depend on the degree of hydrogeological/hydrological connectivity between PWS source and infrastructure associated with the Site.

12.75 To determine whether the Proposed Development poses a risk to any PWS, a high level screening risk assessment of the 39 PWS was undertaken. This considered local topography and surface water catchments to determine Users of PWS which could not reasonably be impacted by the Proposed Development owing to lack of hydrological and hydrogeological connectivity. The results of this assessment identified seven PWS which may be hydrologically connected to the Proposed Development. These PWS are listed in Table 12-9 below and provided in Figure 12.2 in Volume II of the EIAR.

12.76 Consultation with the PWS Users in Table 12-9 was undertaken via submission of a questionnaire requesting details concerning the supply location, the location of delivery infrastructure and general anecdotal information on temporal changes in water quality and quantity. This information will be used to undertake further assessment of these PWS to determine any possible impacts arising from the construction and operation of the Proposed Development. Responses were received from PWS Users Lindsayston Farm, Knockrochar Farm, Dalquhairn Farm and Corphin Cottage.

**Table 12-9: PWS Users**

| PWS User ID | PWS User name | PWS ID | PWS Type | PWS source distance from nearest infrastructure (Km) | Source within SEPA LUPS-GU31 buffer? |
|---|---|---|---|---|---|
| 9 | Lindsayston Farm | A | Groundwater Spring | 0.5 | Source – No Infrastructure - Yes |
| 12 | Knockrochar Farm | B | Groundwater Spring | 1.4 | No |
| 25 | Dalwayne Cottage | C | Groundwater Spring | Unconfirmed | Unconfirmed |
| 26 | Dalquhairn Farm | D | Surface Water | 1.7 | No |
| 30 | Corphin Cottage | E | Groundwater Spring | 1.8 (Holding tank) | No (Holding tank, source unknown) |
| 38 | Delamford Farm | F | Groundwater Spring | Unconfirmed | Unconfirmed |
| 39 | Dobbingstone Farm | G | Groundwater Spring | Unconfirmed | Unconfirmed |

12.77 With regards to PWS User Lindsayston Farm, consultation with the owner indicates that the spring source (PWS ID A) lies on the north eastern slopes of Craig Hill, upgradient of the proposed offsite access track. Water is piped downhill under gravity to a holding tank, a settling tank, and then into the household. The situation of these two tanks indicates that water transfer pipes will intersect the proposed offsite access track. It is recommended that a site inspection to confirm the location and nature of the infrastructure and layout of PWS A is undertaken to allow for mitigation measures to be considered to adequately protect the supply from any impact (as outlined paragraph 12.181) .

12.78 There is a holding tank between the spring source (PWS ID B) and the Knockrochar Farm property. The spring source is indicated by the resident on the south western slopes of Barony Hill (319 m AOD). The source is not hydrologically and hydrogeologically connected to the Site.

12.79 The source supplying PWS User Dalwayne Cottage has not been confirmed, however should the supply be sourced from Daljedburgh Hill, similar to Dalquhairn Farm, the source will not be hydrologically and hydrogeologically connected to the Site. The source of PWS User Dalquhairn Farm was confirmed by the owner to be a surface water intake (PWS ID D) situated approximately 250 m uphill of the household, on the lower south eastern sloped of Daljedburgh Hill. This source location is situated within a separate surface water catchment from infrastructure associated with the Site. Therefore, there is not considered to be any risk posed from the Proposed Development. No further consideration of this PWS is required.

12.80 PWS User Corphin Cottage and the likely source location is downstream and within a shared catchment of the proposed site infrastructure. A site visit is recommended to ascertain the source location of PWS E given resident owners uncertainty in the source location.

12.81 The PWS sources for PWS Users Delamford Farm and Dobbingstone Farm have not been confirmed. It is reasonable to conclude that these two PWS sources are situated downgradient from infrastructure associated with the Proposed Development and therefore at risk of being impacted.

## *Fisheries and Recreation*

12.82 Watercourses draining from the Site are part of the wider River Stinchar, and Water of Girvan catchments. The following information has been obtained from the Ayrshire Rivers Trust website which provides information on fish populations in the Water of Girvan and the River Stinchar [16].

12.83 The River Stinchar is considered a renowned salmon fishery. This river hosts salmon, trout, eels, minnows, sticklebacks and lampreys. The quality of the River Stinchar as a fishery is primarily a result of a natural catchment with limited impacts on water quality and quantity, although acidity arising from Duisk River is a concern.

12.84 The Water of Girvan is also considered a good salmon and trout fishery. Other species present include eels, minnows, stone loach, sticklebacks, lampreys and grey mullet within the tidal areas. Current impacts of concern to fisheries on the Water of Girvan include diffuse pollution, bankside erosion, and canalisation.

## *Soils and Peat*

12.85 The distribution of soils across the Site is dependent upon land use, geology, topography and hydrological regime of the area. Information on the Site soils has been obtained from Scotland's Environment Website[15] which brings together data from public organisations across Scotland including the British Geological Society (BGS), James Hutton Institute (JHI), NatureScot and SEPA.

12.86 Figure 12.3 in Volume II shows the distribution of soils across the Site according to the National Soil Map of Scotland. Soil types expected to occur within the Site primarily include blanket peats, peat, peaty gleys, and mineral gleys.

12.87 Mineral gleys are formed in frequently waterlogged areas and are mapped on the south eastern slopes of Doughty Hill, and the south eastern slopes of Craiginmoddie. Peaty gleys are the result of particularly frequent waterlogging and are mapped on the south western slopes of Green Larg. Blanket peat is expected to be found across the more poorly drained plateau areas around the summits of Doughty Hill, Craiginmoddie, and Green Larg.

12.88 On steeper areas, particularly on the northern slopes of Doughty Hill and southern slopes of Delamford Hill, peaty podzols and brown soils are expected to be present. Podzol soils often have a thin iron-pan which restricts the flow of water deeper into the soil.

12.89 The Carbon and Peatland 2016**Error! Bookmark not defined.** map provides information on the likely presence and nature of peat within the Site. Figure 12.4 in Volume II shows that the Site is

[16] Ayrshire Rivers Trust (2020), River Girvan, http://www.ayrshireriverstrust.org/river-girvan/, accessed 19/11/2020

dominated by Class 5 (no peatland habitat); this is peat soils with no peatland vegetation cover. Class 5 soils are mapped across the gently sloping plateaus around the summits of Doughty Hill, Craiginmoddie, and Green Lairg. On steeper sloping areas, Class 4 (unlikely peatland habitat) are present, with more isolated patches of Class 3 (occasional peatland habitat) dispersed across the Site.

12.90 A small area of Class 1 (nationally important) peat soil is mapped on the gently sloping land north east of Doughty Hill. This indicates a possible area of deep carbon rich peat of national importance and high conservation value.

12.91 Peat is a soft to very soft, highly compressible, highly porous organic material that can consist of up to 90 – 95% water, with 5 – 10% solid material[17]. Unmodified peat consists of two layers; a surface acrotelm which is usually 10 – 30 cm thick, highly permeable and receptive to rainfall. Decomposition of organic matter within the acrotelm occurs aerobically and rapidly. The acrotelm generally has a high proportion of fibrous material and often forms a crust in dry conditions.

12.92 A 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 the viscosity of the material decreases when stress is applied. The thixotropic nature of peat may be considered less important where the peat has been modified through artificial drainage or natural erosion and is drier but will be significant when the peat body is saturated.

*Peat Survey Results*

12.93 Due to the likely distribution of peat and peaty soils underlying the Site, a phase 1 peat depth survey, followed by phase 2 detailed probing have been carried out to thoroughly understand the peat and its locality within the Site. Technical Appendix 12.2: Peat Management Plan outlines approximate volumes of peat that will be excavated and reinstated, based on the survey results and the infrastructure.

12.94 The phase 1 (100 m grid) peat depth walkover survey at the Site was undertaken in July 2020 in line with Scottish Government guidance. The detailed Phase 2 peat depth survey targeting proposed infrastructure was undertaken in November 2020. The interpolated peat depths are provided in Figure 12.5 in in Volume II.

12.95 A breakdown of points in each category of peat depth is provided in Table 12-10 below.

[17] J. Warburton, J. Holden and A.J. Mills, (2004), Hydrological controls of surficial mass movements in peat, Earth-Science Reviews, 67, 139 – 156

**Table 12-10: Total number of peat depths surveyed within each category**

| Peat Depth Range (m) | Results | % of Points surveyed |
|---|---|---|
| ≤0.5 | 543 | 46 |
| >0.5 – 1.0 | 464 | 39 |
| >1.0 – 1.5 | 96 | 8 |
| >1.5 – 3.0 | 62 | 5 |
| >3.0 | 28 | 2 |
| **Total** | **1193** | **100** |

12.96 The highest proportion (46%) of recorded peat depths were shallow (≤0.5 m). Areas of deepest peat (greater than 3 m deep) were located on the gently sloping plateau extending north west of the summit of Doughty Hill (380 m AOD). Other areas of particularly deep peat are located on the south west slope of Doughty Hill, and at the north eastern tip of the Site.

12.97 Generally, areas indicated to be Class 5 unexpectedly coincide with peat depth measurements greater than 0.5 m. However, areas mapped as Class 3 do not coincide with peat depths deeper than 0.5 m.

12.98 The small area identified as Class 1 east of Doughty Hill coincides with peat recorded to be deeper than 0.5 m. However, this area of land has been recently impacted by afforestation. Over time tree growth will remove and modify any pre-existing natural peatland habitat in this area.

12.99 In summary, desk study and survey evidence indicate the Site does contain peat and peaty soils acting as a carbon store beneath commercial forestry, confirming the presence of predominantly Class 5 peat soil across the Site. It is possible that deep peat on Doughty Hill cannot be considered to be actual Class 1 due to recent afforestation. There is however reasonable potential for future peatland habitat restoration considering the extent of peat deeper than 0.5 m across the Site.

## *Geology*

12.100 The following information regarding the underlying geology of the Site has been obtained from digital data available from the British Geological Survey online geology mapping[18].

12.101 As shown in Figure 12.6 in Volume II, superficial deposits are entirely composed of till, which can be expected to be present within river valleys and areas away from higher elevations and summits. These quaternary till formations are sedimentary in origin and were deposited through the action of meltwater and ice.

12.102 Within areas where no superficial deposits are mapped, including higher elevations and summits, it is expected that there will be a layer of weathered bedrock overlain by soil or peat.

[18] British Geological Survey (2020), Geology of Britain Viewer, https://mapapps.bgs.ac.uk/geologyofbritain/home.html, accessed 19/11/2020

12.103 The south western area of the Site is underlain by an area of Devonian and Silurian microgabbro (Bedrock Geology provided in Figure 12.7 and 12.8 in Volume II). This igneous intrusion is immediately surrounded by a Greywacke Conglomerate formation. Within the north east area of the Site, bedrock is dominated by the Devonian and Silurian Swanshaw sandstone formation. The sandstones and conglomerate formations within the Site are sedimentary rocks of fluvial origin formed during the Devonian and Silurian periods. There is also a fault line running through the north eastern tip of the Site. A small area of Early Devonian Duneaton volcanic formations encroach onto the Site are at the north east boundary.

12.104 South Ayrshire has a history of coal extraction[12]. Consultation with the online Coal Authority Interactive Map shows no evidence of known historic coal mining within the Site. However, an area of known historic coal mining is associated with the Water of Girvan around Dailly approximately 3 km north west of the Site.

## *Hydrogeology*

12.105 The following information was obtained from digital data available from the British Geological Survey GeoIndex Onshore 1:625,000 scale online mapping[19].

12.106 The sandstone and conglomerate formations underlying the majority of the Site are considered to be a moderately productive aquifer (yields up to 12 L/s) with flow through fractures and discontinuities.

12.107 The microgabbro formation in the south west area of the Site, and the small areas of volcanic formations at the north east boundary are low productivity aquifers. Groundwater in these formations will be limited to secondary fractures.

12.108 Considering the likely presence of silts and clays within till deposits, it is not expected that there exists any significant superficial aquifer. However, groundwater may be present in limited quantities within peat, till, and weathered bedrock.

12.109 Information regarding groundwater WFD classification was obtained from SEPA's Water Classification Hub[10]. The Site is primarily underlain by the Girvan groundwater body (waterbody ID 150607), which has an overall WFD classification of Good (2018). The south western tip of the Site is underlain by the Lendalfoot groundwater body (waterbody ID 150617), which also has an overall classification of Good (2018). These two groundwater bodies have classifications of Good for both Quantitative status (groundwater water level) and chemical status (groundwater quality).

12.110 According to The Groundwater Vulnerability Map of Scotland[20], aquifers underlying the Site are considered vulnerable to pollutants that are not readily absorbed or transformed (Classes 4a & 4b). The most vulnerable aquifer will be the moderately productive sandstone and conglomerate formations, particularly on higher elevations and summits, where no superficial till is mapped. Where bedrock aquifers are overlain by thick till and

[19] British Geological Survey (2020), GeoIndex Onshore, https://mapapps2.bgs.ac.uk/geoindex/home.html, accessed 19/11/2020

[20] British Geological Survey (2011), User Guide: Groundwater Vulnerability (Scotland) GIS dataset, Version 2, http://nora.nerc.ac.uk/id/eprint/17084/1/OR11064.pdf, accessed 19/11/2020

peat deposits, groundwater vulnerability will be reduced owing to increased potential for contaminant attenuation.

12.111 It is expected that groundwater within the Site flows from high to low elevation, with the water table predominantly below ground level, and reflecting the shape of the topography. Where topography is relatively flat and overlain by peat deposits, piping may be present where water flows through eroded conduits at the interface between peat and weathered bedrock.

## *Groundwater Dependent Terrestrial Ecosystems*

12.112 The methodology, survey data and assessment of potential and actual GWDTE has been considered in full in Technical Appendix 9:1: Phase 1, NVC and GWDTE Report and within Chapter 9: Ecology of the EIAR.

12.113 In summary, as presented in Figure 9.5a and 9.5b in Volume II of the EIAR, three areas of moderately dependent GWDTE were identified within a 150 m survey buffer of the Site. None of the GWDTE sample points cross areas of infrastructure.

12.114 The GWDTE sample points identified have been defined in Table 12-11. One area of M15 (wet heath) identified to the south of the entrance track and two further areas of M25/M17 (blanket mire) and M17/M25 (mire mosaic) were identified along the west boundary of the Site. The blanket bog encountered on the Site has been subject to modification from forestry drainage, anthropological peat drainage and overgrazing.

**Table 12-11: GWDTE Assessment**

| GWDTE Sample Point | Potential GWDTE habitats as per LUPS-GU31 | Bedrock Geology | Superficial Geology | Hydrogeology | Potential Dependency (as per LUPS-GU31) | Actual Groundwater Dependency |
|---|---|---|---|---|---|---|
| 13 | M15 | Benan Conglomerate Formation - Conglomerate(west) and Greywacke Conglomerate Formation – Sandstone (east) | Till, Devensian – Diamicton | Low productivity aquifer (west) Moderately productive aquifer (east) | Moderate | Moderate |
| 17 | M17/M25 | Swanshaw Sandstone Formation – Sandstone | Till, Devensian – Diamicton | Moderately productive aquifer | Moderate | Moderate |
| 18 | M25/M17 | Swanshaw Sandstone Formation – Sandstone | Till, Devensian – Diamicton | Moderately productive aquifer | Moderate | Moderate |

12.115 The points identified as moderate groundwater dependant are in proximity to watercourses. Areas of the Site are mapped as moderately productive aquifers where flow is virtually all through fractures and other discontinuities. The low productivity aquifers to the east of GWDTE sample point 13 are indicated as low aquifer productivity and are unlikely to support any significant volumes of groundwater.

12.116 A search distance of 250 m from all proposed new site infrastructure was adopted for all elements deemed to require excavations >1 m, which included turbine foundations and borrow pit search areas. A 100 m search distance was applied to all access tracks, including existing tracks which may be subject to local widening and typically may require excavations <1 m. None of the GWDTE sample points were located within this buffer distance.

### *Modifying Influences*

12.117 Information regarding climate change was obtained from the UK Climate Projections (UKCP18) website[21]. The UKCP18 is a climate analysis tool which features comprehensive projections for different regions of the UK. General climate change trends projected over UK land for the 21st century show an increased chance of warmer, wetter winters and hotter, drier summers along with an increase in the frequency and intensity of weather extremes. This is seen in the Probabilistic (25 km), Global (60 km), Regional (12 km) and Local (2.2 km) projections.

12.118 Warmer and wetter winters suggest less snow and more rain. This will create increased risk for flood events, and issues with water quality as less precipitation will be held in its frozen state during the winter season. If climate predictions are correct, summer months will become drier. This will create pressure on the needs of water abstractions and on sensitive ecosystems that rely on aquatic habitats. Evidence also suggests that although the summer months will have an average decrease in rainfall, summer storms will be more frequent and intense. This may lead to more extreme flow values during and immediately following such events, with consequential flooding and water quality issues. This is of key importance for the hydrological environment during summer construction periods.

12.119 It is suggested that increased temperatures in the summer could also increase evapotranspiration and potentially cause desiccation of peat[22]. The desiccation could result in the peat being more susceptible to erosion due to increased intensity in summer storms and increased rainfall during the winter months. As peat and peat dominant soils are composed of vegetation remains, they contain a high proportion of carbon compared to other soils.

## Identification and Evaluation of Effects

### *Proposed Development Interactions*

12.120 The Proposed Development will introduce physical changes which have the potential to alter the hydrological characteristics within the Site. During the construction phase and to a lesser extent during the operational phase potential sources of pollution will be present. Hydrological surveys have been undertaken to establish the existing on-site baseline conditions and associated areas downstream to assess the likely significant environmental effects of the Proposed Development on the identified receptors, the significance of these

[21] Met Office (2020), UK Climate Projections (UKCP), https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index, accessed 20/11/2020

[22] Scottish Government (2008), The Scottish Soil Framework: a consultation document, June 2008, https://www.scotlink.org/files/policy/ConsultationResponses/LINKatfConsultSoilFrame08.pdf, accessed 20/11/2020

effects on the receptors and the potential for mitigation to reduce the significance of the identified effects.

## Effects Evaluation

### *Basis of Assessment*

12.121 The Proposed Development will consist of the erection, 35 year operation, and subsequent decommissioning of up to 14 wind turbines, with tip heights of up to 200 m. The Proposed Development includes associated turbine foundations and transformers, battery storage, hardstanding areas for erecting cranes at each turbine location, a series of on-site tracks connecting each turbine, underground cables linking the turbines to the grid connection, an on-site substation, a construction compound, two borrow pit search areas, a new access into Site and an off-site access track.

12.122 Typically, the construction phase will involve a period of earthworks inclusive of felling, track construction and excavations for forming turbine bases. Following this, the turbine bases and infrastructure will be installed and finally the turbines will be transported to Site and erected.

### *Mitigation by Design*

12.123 A summary of the hydrological influences on the Proposed Development layout are given below with full details of the Proposed Development's design provided in Chapter 4: Design Evolution, of the EIAR. Due to the nature of the environment occupied by the Proposed Development it is important that the design and infrastructure helps maintain or even improve the local hydrology. Poor design of development infrastructure can result in significant implications to the hydrological environment, soils and ecology.

12.124 The findings of the peat depth survey (paragraph 12.93 to 12.99 and Figure 12.5 in Volume II) show that the infrastructure has, as far as possible, taken into account other constraints and have been sited outside areas of deeper peat. The peat depths within the Site are predominantly shown to be in a shallow range (≤0.5 m) when considering the discrete turbine and access track areas.

12.125 The hydrological desktop study and site visits have identified a typical upland hydrological environment which include hydrological pathways and features associated with it. A series of buffer distances have been adopted to help reduce effects of the Proposed Development on the hydrological environment. A 50 m buffer was implemented for all identified natural hydrological features.

12.126 Table 12-12 confirms that all turbines and infrastructure associated with the Proposed Development are located outside the buffer limits. Distances were calculated using the functionalities provided within the Quantum Geographic Information System (QGIS) package. Watercourses are linear features that were identified from the OS 1:10,000 raster data.

**Table 12-12: Distance from Turbine to nearest watercourse.**

| Turbine ID | Turbine distance from watercourse (inclusive of 50 m buffer) |
|---|---|
| Turbine 1 | 123 |
| Turbine 2 | 53 |
| Turbine 3 | 115 |
| Turbine 4 | 191 |
| Turbine 5 | 178 |
| Turbine 6 | 223 |
| Turbine 7 | 158 |
| Turbine 8 | 227 |
| Turbine 9 | 339 |
| Turbine 10 | 90 |
| Turbine 11 | 55 |
| Turbine 12 | 124 |
| Turbine 13 | 132 |
| Turbine 14 | 127 |

12.127 Where access necessitates essential watercourse crossing, construction features have been limited in these buffers as far as possible, for example, minimising tracks running parallel to watercourses and trying to avoid track junctions being constructed in these zones. The exceptions to this are where access tracks have to cross watercourses or when other constraints have resulted in the tracks having to infringe upon the edges of the buffers of ephemeral headwater drainage channels.

12.128 New and upgrading of existing watercourse crossing locations will be required for the Proposed Development (Technical Appendix 12.1: Water Crossing Assessment). The crossings should be constructed in a manner that minimises the impact of hydrological disturbance on the Site and allows free passage of aquatic species.

## *Receptor Sensitivity*

12.129 On the basis of the baseline surveys and available information, Table 12-4 above identifies the criteria for assigning the sensitivity of receptors as outlined in Table 12-13 below with justification for their categorisation.

**Table 12-13: Receptor sensitivity**

| Receptor | Sensitivity | Comment |
|---|---|---|
| Surface water | | |
| River Stinchar | High | The River Stinchar is designated as having "Moderate" status under the SEPA RBMP and is also a designated surface water (Drinking Water Protected Area). Pressures preventing the River Stinchar achieving "High" status potentially due to catchment being an acid sensitive catchment. |

| Receptor | Sensitivity | Comment |
|---|---|---|
| Water of Girvan | High | The Water of Girvan is designated as having "Moderate" status under the SEPA RBMP. |
| Milton Burn | Medium | The upper Stinchar catchment of the Dalquhairn Burn are designated as having "High" status under the SEPA RBMP. The Milton Burn is not designated under the SEPA RBMP. |
| Dalquhairn Burn | Medium | |
| Lindsayton Burn | Medium | Tributary catchment of the Water of Girvan, which is designated as having "High" status under the RBMP. |
| Fisheries and Recreation | High | The River Stinchar and Water of Girvan catchments are important fisheries with existing pressures on both catchments, including acidification diffuse pollution and bankside erosion |
| Flood Risk | | |
| The Proposed Development | Low | Only very limited areas of the Proposed Development fall within the flood inundation envelope for fluvial flooding (i.e. only at lower catchment watercourse crossing locations). |
| Downstream of the Proposed Development | Medium | Downstream watercourses are at potential risk of flooding and any changes to the hydrological environmental that results in additional flow could exacerbate the likelihood of flooding. However, the impermeable nature of the bedrock and low permeability of the overlying peat and glacial till will naturally encourage high rainfall-runoff rates. The addition of the Proposed Development will not significantly alter the existing baseline hydrological regime and is likely to have a minimal effect on the existing rainfall-runoff scenario. |
| Water Resources (Private Water Supplies) | | |
| Lindsayston Farm (PW9)) | Medium | Consultation response received from residents confirming supply details. Potential for supply be disrupted due to construction of off-site access track. |
| Knockrochar Farm (PWS12) | Medium | Consultation response received. The source is not hydrologically and hydrogeologically connected to the Site. However, property is within shared hydrological catchment as infrastructure. |
| Dalwayne Cottage (PWS25) | Medium | Consultation response not received. Source location unconfirmed. Topographic relationship between Proposed Development and property indicates limited hydrological/hydrogeological connectivity. |
| Dalquhairn Farm (PWS26) | Medium | Consultation response received. Source location on the southern flanks of Daljedburgh Hill with no hydrological connectivity to the Proposed Development. |
| Corphin Cottage(PWS30) | Medium | Consultation response received. Likely source location is downstream and within a shared catchment to proposed site infrastructure. |
| Delamford Farm (PWS38) | Medium | Consultation response not received. Source location unconfirmed. Topographic relationship between Proposed Development and property indicates hydrological/hydrogeological connectivity. |
| Dobbingstone Farm (PWS39) | Medium | Consultation response not received. Source location unconfirmed. Topographic relationship between |

| Receptor | Sensitivity | Comment |
|---|---|---|
| | | Proposed Development and property indicates hydrological/hydrogeological connectivity. |
| Soils & Peat | | |
| Site soils and peat < 0.5 m depth | Low | 46% of the recorded peat depths are less than 0.5 m deep and therefore not classified as peat. |
| Site soils and peat > 0.5 m depth | High | Class 1 peat has been avoided as part of the design of the Proposed Development. 54% of the recorded peat depths are greater than 0.5 m deep and therefore classed as deep peat. |
| Geology | | |
| Geology | Low | Geology is typical of wider area with no designated sites of geological interest located within the study area. |
| Hydrogeology | | |
| Groundwater within peat | Medium | Owing to the low permeability of the underlying bedrock across the Site, the peat may host a shallow superficial aquifer which is vulnerable to pollutants that are not readily absorbed or transformed. |
| Underlying Groundwater | Medium | Moderately productive aquifer underlying the majority of the Site. Potential for bedrock groundwater to support baseflow to streams, however BFI & SPR values indicate surface water runoff as the predominant component of streamflow. |
| GWDTE | Medium | Predominantly ombrotrophic or surface water fed habitats associated with modified bog, wet heath or acid / neutral flush but supported occasionally by shallow/diffuse groundwater seepage. |

## Mitigation Measures

12.130 A number of planning, design and construction proposals have been identified during the assessment. Full details of the industry good practice construction management and mitigation measures will be provided in a Construction Environmental Management Plan (CEMP) which would be prepared post consent as part of a planning condition. A summary of the measures included within the CEMP are described below and have been assumed to be part of the proposals when the residual effects and their significance are reported. Any additional mitigation, specific to the Proposed Development, but still considered good practice is also provided in further detail in paragraph 12.179 to 12.197.

12.131 A number of the mitigation measures described in the following paragraphs can also be adopted during the operational phase of the Proposed Development. To avoid duplication of text, the reference to what stage the measures can be adopted is provided.

### *Outline Construction and Environment Management Procedures*

12.132 A site-specific CEMP will provide details on industry good practice measures to be put in place to manage activities in such a manner as to prevent or minimise effects on the surface and groundwater environment. The CEMP will be prepared prior to commencement of construction but will include information as follows:

- *Drainage* – all runoff derived from construction activities and site infrastructure will not be allowed to directly enter the natural drainage network. All runoff will be adequately treated via a suitably designed drainage scheme with appropriate sediment and pollution management measures. The Proposed Development is situated in an upland hydrological area and it is imperative that the drainage infrastructure is designed to accommodate storm flows based on a 1 in 200-year event (plus climate change) to help maintain the existing hydrological regime;
- *Storage* – all soil/peat stockpiles as well as equipment, materials and chemicals will be stored well away from any watercourses. Chemical, fuel and oil stores will be sited on impervious bases with a secured bund;
- *Vehicles and Refuelling* – standing machinery will have drip trays placed underneath to prevent oil and fuel leaks causing pollution. Where practicable, refuelling of vehicles and machinery will be carried out in designated areas, on an impermeable surface, and well away from any watercourse;
- *Maintenance* – only emergency maintenance to construction plant will be carried out within the Site, in designated areas, on an impermeable surface well away from any watercourse or drainage, unless vehicles have broken down necessitating maintenance at the point of breakdown, where special precautions will be taken;
- *Welfare Facilities* – on-site welfare facilities will be adequately designed and maintained to allow for sewage to be disposed of appropriately. This may take the form of an on-site septic tank with soakaway, or tankering and off-site disposal depending on the suitability of the Site for a soakaway and prior agreement with SEPA;
- *Cement and Concrete* – fresh concrete and cement are very alkaline and corrosive and can be lethal to aquatic life. The use of wet concrete in and around watercourses will be avoided and carefully controlled;
- *Monitoring Plan* – to provide environmental compliance, activities undertaken as part of the Proposed Development will be monitored throughout the construction phase. Water quality monitoring will also occur throughout each phase of the Proposed Development and will help to maximise the effectiveness of mitigation measures whilst monitoring effects on the hydrological environment;
- *Contingency Plans* – plans will provide information on emergency equipment and where it is available on the Site i.e. spill kits and absorbent materials, advice on action to be taken and who should be informed in the event of a pollution incident; and
- *Training* – All relevant staff personnel will be trained in both normal operating and emergency procedures and be made aware of highly sensitive areas on the Site.

12.133 Further details regarding the pollution prevention and mitigation measures that will be adopted during the construction and operation of the Proposed Development are detailed in the following paragraphs.

## *Runoff and Sediment Management*

12.134 The following measures will be adopted to appropriately attenuate and treat runoff during construction and operation of the Proposed Development.

12.135 The Site drainage system will convey water away from construction activities as well as the Proposed Development infrastructure. However, due to the nature of the works on the Site

and the negligible infiltration and storage capacity of the underlying peat and bedrock there is significant potential for sediment and other pollutants to become entrained in the surface runoff.

12.136 To reduce this potential, prior to the commencement of work and during construction, plans showing the Site drainage and hydrologically sensitive areas should be regularly checked to review potential for runoff and ponding of water within the Site to make sure that runoff patterns are well known.

12.137 The drainage systems installed within the Site will also have sediment management measures incorporated into their design to help reduce or wholly mitigate effects on the hydrological environment. The type of sediment management will depend on the volume of construction activities occurring in particular areas within the Site. For all of the suggested control measures regular inspection and maintenance is necessary, particularly after prolonged heavy rainfall.

12.138 Silt traps will be installed within the Site drainage system. Silt traps could take the form of terram fences or clean stone. However, the ability of the silt traps to successfully treat runoff will be dependent upon the permeability of the terram geotextile material and the size and source of the clean stone.

12.139 The ability of the silt traps to effectively treat runoff will depend upon the volume of runoff within the drainage channel, the type of material used and the frequency of monitoring and replacement of the measures.

12.140 If required, flocculents could also be used to treat runoff. Flocculents are very effective at removing suspended sediment from water but they can also have effects on water chemistry. As such, SEPA will be consulted prior to the use of flocculents and only considered as a last resort. If their use is proposed, SEPA will be consulted and a method statement agreed prior to use. This method statement must detail the type of floc, how dosing is controlled, record keeping (dates used, location, volume/weight used etc) and how the precipitated silt will be disposed of.

12.141 Access tracks crossing slopes will disrupt surface flow that consequently will collect in drains constructed upslope of the tracks. Cross-drains will be constructed at regular intervals to conduct this surface flow below or across the track where it will be discharged back into the drainage system, although all efforts will be made to segregate this runoff from more silty runoff originating from track surfaces and other exposed construction areas, thus reducing the silt load and volume discharging to all silt treatment areas. Regular discharge points will limit the concentration of surface runoff and the diversion of flows between catchments. Such cross drains need to be strong enough to withstand the expected traffic loadings[23].

12.142 During storm events there is likely to be some ponding on the uphill side of tracks, as percolation alone is unlikely to be able to accommodate surface flows. To minimise this ponding, small diameter cross drains or perforated pipes (similar to plastic pipe field drains)

[23] Forestry Civil Engineering and Scottish Natural Heritage (2010), Floating Roads on Peat: A Report into Good Practice in Design, Construction and Use of Floating Roads on Peat with particular reference to Wind Farm Developments in Scotland

would be incorporated into the track base at regular intervals to allow more flow to pass through the track and maintain the current flow regime. It is recommended that such pipes are surrounded by free draining material that is wrapped in a separator geotextile. The number of pipes and associated dimensions will be dependent upon the width of the flush/boggy area and the hydrological regime.

12.143 Prior to track construction, site operatives and the Environmental Clerk of Works (ECoW) will identify flush areas, depressions or zones which may concentrate water flow. These sections will be spanned with plastic pipes to help maintain hydraulic conductivity under the road and reduce water flow over the road surface during heavy precipitation.

12.144 The constructed drainage system will not discharge directly to any natural watercourse, but will discharge to buffer strips, trenches or SUDS measures, preferably on flatter, lower lying ground. These buffers will act as filters and will minimise sediment transport, attenuate flows prior to discharge and maximise infiltration back into the soils and peat.

12.145 Drainage from the construction compound, welfare facilities, borrow pits and concrete wash out areas will be collected and treated separately from the Site drainage, as the runoff from these areas is more likely to be contaminated and therefore will require treatment. Appropriate treatment, such as oil interceptors and treatment for high alkalinity, will be installed.

12.146 Watercourse crossings will be appropriately designed so that they do not alter the natural drainage, hinder the passage of aquatic fauna and can accommodate flow for a 1:200 year plus climate change event. All watercourse crossings will be designed with edge upstands or bunds e.g. straw bales, sandbags or silt fences to prevent sediment laden runoff from construction plant movement from directly entering watercourses. Relevant CAR Authorisation from SEPA will be sought for construction of the crossings that are required over watercourses that are displayed on the 1:50,000 OS Landranger maps.

### *Pumping and Dewatering of Excavations*

12.147 All pumping operations e.g. removal of water from turbine base excavations, will be carried out in line with good practice and where necessary in line with the requirements of The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended)[24] prior to the works being undertaken. Suitable measures to minimise the impact of the pumped water on the hydrological environment shall be taken. These measures shall include, but are not limited to, the following techniques:

12.148 Due to the expected low permeability of the Site soils it is expected that the potential for groundwater ingress would be low. The ingress of surface water into the excavations will be minimised through the use of upgradient drainage measures e.g. cut-off ditches. It is recognised that water can still enter the excavation and would need to be removed. This can be achieved by allowing the water to gravity drain to a designated area before being pumped from the excavation to a predesigned settlement lagoon or other suitable silt

[24] Scottish Environment Protection Agency (2018), The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended): A Practical Guide, Version 8

treatment area. The settlement lagoons would attenuate and treat runoff before discharging back into the natural drainage network.

12.149 Due to peaty soils on Site the throughput rate of runoff within the settlement treatment areas would be reduced to give longer settlement time within the excavations and settlement tanks. If required, a series of settlement lagoons or other silt treatment measures can be deployed to allow maximum settlement of sediment during the construction period.

12.150 The treated water from the settlement lagoons or other silt treatment measures will not be discharged directly into watercourses but directed onto vegetated surfaces where appropriate. Any sediment within the treated water will be deposited amongst the rough surface vegetation, away from sensitive habitats or watercourses.

12.151 To reduce the likelihood of erosion channels being formed by the discharge from the sediment treatment outfalls it is recommended that the water is discharged at a slow rate or spread evenly across a surface. For discharge onto rough vegetation to be effective the discharge must be spread efficiently, and the vegetation, soils and topography be carefully considered to determine an appropriate discharge location.

12.152 To maximise the efficiency of the settlement measures or other holding lagoons or tanks, the sediment sludge that collects at the base will be removed as required.

### *Storage of Fuels/Chemicals and Bunding Arrangements*

12.153 Throughout the construction and to a lesser extent during the operational phase of the Proposed Development a number of oils and chemicals will be used. Such materials will be used and stored in a safe manner to so that the surface and groundwater environment is not adversely affected.

12.154 The following measures will be adopted to protect the surface and groundwater environment from the inappropriate storage and use of substances hazardous to the environment:

- All equipment, materials and chemicals to be stored away from any watercourses. Chemicals, fuel and oil will be stored in tanks of sufficient strength and structural integrity to minimise the likelihood of bursts or leak in ordinary use. They will also be sited on impervious bases within a secured bund of 110 % of the storage capacity;
- Where oil is stored in a bunded area, oil residue can build up. This residue build up will reduce the storage capacity of the bund and will be removed regularly. The residue will be disposed of by a specialist contractor;
- Locks shall be fitted to all fuel storage tanks or containers and there shall be a nominated trained person to oversee the refuelling and delivery to prevent spillages; and
- Standing machinery to have drip trays placed underneath to prevent oil and fuel leaks causing pollution. Where practicable refuelling of vehicles and machinery will be carried out at a central designated area, on an impermeable surface, which will be located at least 50 m away from any watercoursesRefuelling

12.155 A fuel bowser will be used for refuelling on the access tracks or hardstanding. The bowser driver shall be responsible for ensuring that refuelling of mobile plant does not take place within 50 m of a watercourse. The bowser driver will receive extra training on spill prevention and response.

12.156 The refuelling bowser shall be equipped with a mobile spillage control kit containing oil absorbent booms and mats. All site personnel will be trained in their use as part of the Site induction training or toolbox talks. Special attention will be paid to spillage control at watercourses.

### *Vehicle Maintenance and Management*

12.157 All plant used during the construction of the Proposed Development will be in suitable condition and fit for purpose to carry out the works and will be maintained as per manufacturers guidelines.

12.158 Maintenance of construction plant to be carried out in designated areas, on an impermeable surface away from any watercourse or drainage. Only if vehicles have broken down will maintenance be permitted out with a designated area, and this would only be carried out after implementing special precautions. Such precautions include, but are not limited to:

- Drip trays will be placed underneath vehicles during maintenance;
- As a precautionary measure, straw bales or entrapment matting can be placed downstream of the maintenance area;
- All heavy construction plant will be inspected daily by the operating personnel and any defects or issues resolved immediately prior to starting works. All heavy construction plant shall be issued with spill-kits. Should a spillage occur, larger spill kits shall also be positioned at various areas within the Site which will be highlighted to all operatives during the Site induction; and
- Standing machinery and plant will have drip trays placed underneath to prevent oil and fuel leaks causing pollution. Where practicable refuelling of vehicles and machinery will be carried out at a central designated area, on an impermeable surface, which will be located at least 50 m away from any watercourses.

### *Concrete Works*

12.159 Concrete would be required for the construction of the wind turbine foundations. The following section provides good practice measures that are required to be implemented to prevent detrimental effects to the hydrological environment.

12.160 Care will be taken during the transportation of concrete to the turbine and building foundations using good practice measures. Freshly mixed concrete and/or dry cement powder will not be allowed to enter any watercourse. This will be implemented by:

- Locating turbines, concrete batching (if considered) or wash out areas at least 50 m from watercourses;

- Concrete wagons will only be permitted to wash-out into specifically designed wash-out areas and predetermined at agreed locations Site wide;
- The drivers will be informed at their Site induction of the location of the designated wash-out areas and issued with a location map;
- Loads will be managed and assessed with regards to the size of vehicle and ground conditions whilst keeping at appropriate speed limits to avoid spillage.
- Tools and equipment will not be cleaned in watercourses. Should it be necessary to clean tools and equipment on the Site, this will be done in the predetermined wash-out areas;
- A designated concrete wash out will be constructed within the Site at a location agreed with the relevant consultees to protect the watercourses. The design and construction of these wash out areas will be agreed with SEPA; and
- Wash out areas will be continually monitored, and findings recorded to prevent a rise in effluent levels and avoid a spill over into the environment.

### *Welfare Facilities/Foul Water*

12.161 The following measures will be adopted for the design of the foul water drainage system:

- Any sewage associated with the temporary construction compound and welfare facilities will be collected in appropriately sized interceptor tanks and shall be located at the construction compound. All wash basins, toilets and shower areas shall also be connected to an interceptor tank; and
- The interceptor tanks and the tanks within any Site portable toilets, which shall be situated not less than 50 m from any watercourse, will be emptied regularly by a suitably licensed contractor. Sewerage from these facilities will be disposed offsite in accordance with waste management legislation.

### *Site Drainage*

12.162 The following section discusses the conventional Site drainage measures that can be installed during the construction and operation of the Proposed Development.

12.163 Surface drainage ditches will be installed alongside tracks only where necessary. The length, depth and gradient of individual drains will be minimised to avoid intercepting large volumes of diffuse overland flow and generating high velocity flows during storm events. Sediment traps, settlement ponds and buffer strips will be incorporated into the drainage system as necessary and will serve the dual purpose of attenuating peak flows, by slowing the flow of runoff through the drainage system and allowing sediment to settle before water is discharged from the drainage system.

12.164 As well as utilising sediment traps, structures such as v-notched weirs and/or check dams will be installed within the drainage channels. Such structures will throttle the flow within the channel, thus reducing erosive potential of any runoff and allowing sediment and/or pollutants to settle.

12.165 To reduce the impact of the Proposed Development on the natural hydrological regime, the Site drainage will mimic greenfield runoff response through the use of sustainable drainage practices.

12.166 Sustainable Drainage Systems (SuDS) will be taken into consideration as part of the water management and details of the proposed SuDS regime would be included in the CEMP that will be produced post-consent to discharge planning conditions and the Pollution Prevention Plan (PPP) that will be produced as part of the application that would be made to SEPA for a construction site licence (CSL).

12.167 SuDS are used to attenuate rates of runoff from development sites and can also have water purification benefits. The implementation of SuDS as opposed to conventional drainage systems provides several benefits by:

- Reducing peak flows to watercourses and potentially reducing risk of flooding downstream;
- Reducing the volumes and frequency of water flowing directly to watercourses;
- Improving water quality by removing pollutants;
- Reducing potable water demand through rainwater harvesting; and
- Replicating natural drainage patterns, including the recharge of groundwater so that base flows are maintained.

12.168 Whilst it is understood that the scope for SuDS measures is limited as a result of the hydrological environment, it is recommended that the installed drainage measures adopt the principles highlighted above.

12.169 Access tracks crossing slopes will disrupt surface flow that consequently will collect in drains constructed upslope of the tracks. Cross-drains and/or water bars will be constructed at regular intervals to conduct this surface flow below or across the track where it will be discharged back into the drainage system, although all efforts will be made to segregate this runoff from more-silty runoff originating from track surfaces and other exposed construction areas, thus reducing the silt load and volume discharging to all silt treatment areas. Regular discharge points will limit the concentration of surface runoff and the diversion of flows between catchments. Such cross drains need to be strong enough to withstand the expected traffic loadings.

12.170 During storm events there is likely to be some ponding on the uphill side of tracks, as percolation alone is unlikely to be able to accommodate surface flows. To minimise this ponding, small diameter cross drains or perforated pipes (similar to plastic pipe field drains) would be incorporated into the track base at regular intervals to allow more flow to pass through the track and maintain the current flow regime. It is recommended that such pipes are surrounded by free draining material that is wrapped in a separator geotextile. The number of pipes and associated dimensions will be dependent upon the width of the flush/boggy area, proximity to GWDTE and the hydrological regime.

12.171 Prior to track construction, site operatives will identify flush areas, depressions or zones which may concentrate water flow. These sections will be spanned with plastic pipes to

help maintain hydraulic conductivity under the road and reduce water flow over the road surface during heavy precipitation.

12.172 Due to the poor permeability of the surrounding peat, peaty soils and bedrock, it is also recommended that drains and/or cut-off drains are installed on the upstream/upgradient sides of the turbine foundations, crane hardstands, and other excavations required across the Proposed Development. The purpose of this will be to help reduce the volume of surface water runoff entering the excavations and minimise any subsequent contamination.

12.173 The constructed drainage system will not discharge directly to any natural watercourse, but will discharge to buffer strips, trenches or SuDS measures, preferably on flatter, lower lying ground. These buffers will act as filters and will minimise sediment transport, attenuate flows prior to discharge and maximise infiltration of water back into the soils and peat.

12.174 Drainage from the construction compounds, welfare facilities, borrow pits and concrete wash out areas will be collected and treated separately from the main Site drainage, as the runoff from these areas is more likely to be contaminated and therefore will require treatment. Appropriate treatment, such as oil interceptors and treatment for high alkalinity, will be installed.

12.175 Mitigation will follow industry good practice. All mitigation and drainage will be subject to detailed design and approved by Scottish Water and SEPA prior to construction with the ECoW ensuring compliance. The Proposed Development will also be subject to a CSL. Further suggested measures include ensuring the detailed design includes buffer areas indicating "no construction zones" whereby the micrositing of infrastructure is not permitted. This will also include construction activities, including stockpile storage areas, refuelling areas are not located within buffers of watercourses or the catchments of private water supplies.

12.176 New watercourse crossings will be required, along with upgrading of some of the existing watercourse crossings, as part of the access tracks associated with the Proposed Development (see Technical Appendix 12.1: Watercourse Crossing Assessment). The crossings will be appropriately designed so that they do not alter the natural drainage, hinder the passage of aquatic fauna and can accommodate flow at a minimum of 1:200yr + CC event. All watercourse crossings will be designed with edge upstands or bunds e.g. straw bales, booms, sandbags or silt fences to prevent sediment laden runoff from construction plant movement from directly entering watercourses. Relevant CAR Authorisation from SEPA will be sought for construction of the crossings that are required over watercourses that are displayed on the 1:50,000 OS Landranger maps.

### *Emergency Water Management Measures*

12.177 A large volume of oils and chemicals will be stored on Site during the construction phase and to a lesser extent the operational phase. Site traffic will also be present in significant numbers during the construction phase of the Proposed Development, with traffic volumes significantly reduced during Wind Farm operation.

12.178 The appropriate storage of oils, chemicals and maintenance of Site plant has been discussed above. However, despite these measures, accidents can happen, and these can have significant impacts upon the quality of the surface and groundwater environment. The following emergency procedures can be implemented to allow protection of the surface and groundwater environment during the construction and operation of the Proposed Development:

- All relevant on-site staff to be trained in both normal operating and emergency procedures and be made aware of highly sensitive areas on Site. The staff training and implementation of Site procedures will be overseen by the Infrastructure Contractor. These measures should be carried out effectively to minimise the risk of a pollution incident;
- Contingency plans should provide information on where emergency equipment is available on site (i.e. spill kits and absorbent materials), and that provide advice on actions to be taken and who would be informed, in the event of a pollution incident;
- Contingency planning procedures must be regularly reviewed to include changes to site operations that were not foreseen during design;
- The procedures set out in Site contingency plans need to be prepared in conjunction with the assessment of the risk of a pollution incident occurring and the measures to be taken to minimise pollution. The location of the procedures will be publicised, and it is essential that they are set out clearly so that they can easily be understood and acted upon; and
- The emergency procedures can include the following:
  - Containment measures;
  - Emergency discharge routes;
  - List of appropriate equipment and clean-up materials;
  - Maintenance schedule for equipment;
  - Details of trained staff, location, and provision for 24-hour cover;
  - Details of staff responsibilities;
  - Notification procedures to inform the relevant environment protection authority;
  - Audit and review schedule;
  - Telephone numbers of statutory and local water company; and
  - List of specialist pollution clean-up companies and their telephone numbers.

## *Additional Mitigation Recommendations*

12.179 Where specific risks exist for individual receptors as a result of the construction and operation of the Proposed Development, additional mitigation will also be used alongside embedded mitigation to further reduce measurable impacts. The recommendations outlined will be incorporated into the CEMP post-consent.

12.180 The use of general site pollution control and other mitigation measures outlined in this chapter apply to the entire Site area. Site specific mitigation including that which has been presented above will be developed as part of the detailed design in the CEMP post consent. The establishment of communication channels for risk management and monitoring are an essential component of the CEMP.

12.181 Site-specific mitigation will be undertaken at all PWS identified within the study area owing to their proximity to the Site. This will include:

- Post consent a site-specific hydrogeological report will be provided based on the results of detailed site investigations and further consultation with residents where a response to questionnaires has not been received. The hydrogeological report will provide a conceptual ground model to provide details on the likely controls to groundwater movement between the Proposed Development and supply sources. The report will contain a review of the risks to all private water sources, their catchment areas, and the supplies, that have the potential to be affected by the Proposed Development and will be submitted to SAC for approval prior to commencement of work on the Site.
- The report will consider the following mitigation measures should there be a risk to the quality and quantity of water serving the supplies:
  - Buffer areas indicating "no construction zones" whereby the micrositing of infrastructure is not permitted. This will also include construction activities, including but not limited to ensuring that stockpile storage areas, and refuelling areas are not located within buffers of watercourses or the catchments of private water supplies or on GWDTE.
  - ECoW to carry out regular inspections to maximise the effectiveness of the mitigation and make recommendations for improvements as required. Photographic evidence shall be included;
  - Demarcation of the area of the source and avoid movements/works in peripheral upgradient areas;
  - Avoid refuelling and the storage of fuels and oils within the catchments of supplies;
  - All pipework associated with any PWS shall be demarcated. Consultation with the residents has confirmed the Lindsayston PWS (PWS A) source to be upgradient of the off-site access track. The pipework for any supply will be afforded additional protection if it is bisected by the access track, including:
    - Metal plates on the running surface over the crossing point;
    - Excavation of the track and installation of local protection measures around pipework, concrete slabs placed under the pipe, track make up material then placed over the top;
    - Provision of a temporary supply that can be deployed immediately in the unlikely event that the supply pipe is disrupted; and
  - The exact details of the mitigation to be used will be responsibility of the appointed construction contractor. A programme of water quality and quantity monitoring will be developed to monitor this supply.

## *Predicted Construction Effects*

12.182 The potential for significant environmental effects on the hydrological environment is greatest during the construction phase due to the high levels of activity on-site and when there is greatest change to the existing environment. The construction of the Proposed

Development is discussed in the following paragraphs, this information is considered in the mitigation and management measures outlined in the mitigation measure section below.

12.183 The evaluation of construction effects is provided in Table 12-14 below. The table assumes the successful implementation of the mitigation measures provided in paragraph 12.123 to 12.181.

*Pollution incidents*

12.184 During the construction phase, a number of potential pollutants will be present onsite, including oil, fuels, chemicals, unset cement and concrete, waste and waste water from construction activities and staff welfare facilities. Most potential pollutants will be located or stored within the construction compound. In addition, there is the potential for contamination of the hydrological and terrestrial environment caused by spillages along the access tracks and construction areas.

*Erosion and sedimentation*

12.185 Soil and sediment generation may occur in areas where the ground has been disturbed, particularly where surface runoff has been concentrated. Drainage ditches are particularly prone to this, due to the high velocities of surface water runoff passing through the drainage network. Considerable sediment generation is expected where the ground has been excavated for the Proposed Development infrastructure.

12.186 Sediment transport in watercourses can result in high turbidity levels which can impact on the water quality, particularly affecting the ecological potential of the watercourses. High turbidity in watercourses can reduce the light and oxygen levels in the watercourses, while sediment deposition can smother plant life and spawning grounds. Sediment deposition can also reduce the flood storage capacity of the watercourses and block culverts, resulting in an increased flood risk.

12.187 Felling would be required in a small section of the forestry to allow for the construction of the access tracks. Forestry felling has the potential to expose soils within the catchments of the Milton Burn, Dalquhairn Burn and Lindsayston Burn. The removal of closed canopy will result in reduced levels of interception and transpiration of precipitation. As such, felling has the potential to increase the volume of runoff entering watercourses, with increased soil erosion and sedimentation.

12.188 As a result of the construction operations, all catchments with new and upgraded infrastructure present are vulnerable to erosion and sedimentation.

*Acidification*

12.189 Tree removal also can increase nitrogen mineralisation and nitrification, which can promote nitrate leaching and enhance acidity in waters draining some soils. The effect can last between two to five years after felling, depending upon the rate at which vegetation re-establishes. The filling of trenches with fresh brash could accentuate the effect by promoting leaching below the rooting zone.

*Increase in runoff*

12.190 Turbine bases, hardstanding areas and access tracks will act as impermeable areas, restricting the natural movement of water within the hydrological environment, potentially resulting in increased rates of runoff into the onsite catchments.

12.191 In the areas which are to be felled, localised runoff responses have the potential to increase due to the reduction in precipitation being intercepted by the closed canopy forestry. The effects on runoff will be dependent upon the extent of forestry management and the felling techniques adopted. Felling and extraction would also be planned to minimise the number of drain crossings and reduce any increases in runoff.

12.192 Localised increases could cause issues for downstream flood storage capacity and/or pollution incidents. Increases in the volume of runoff entering watercourses could also cause erosion and sedimentation, therefore having detrimental effects on surface water hydrology.

*Modification of surface drainage patterns*

12.193 The interception of diffuse overland flow by the Proposed Development and associated drainage may disrupt the natural drainage regime of the area, concentrating flows and potentially diverting flows from one catchment to another. This may have implications on flood issues downstream of the Proposed Development.

*Impediments to surface water flow*

12.194 The construction of watercourse crossings may restrict flow in the various channels and reduce hydraulic capacity, resulting in an increase in flood risk, and promotion of erosion and sedimentation. In addition, poorly designed watercourse crossings may impede the migration of fish and mammal movement in the riparian corridor.

*Modification of groundwater flows and levels*

12.195 Deep excavations, such as those required for the turbine foundations are likely to disrupt the shallow groundwater systems and bedrock geology. Surface water ingress will be minimised utilising upgradient cut-off drains or other drainage measures. The installation of cut-off drains as well as dewatering excavations has the potential to lower local groundwater levels within surrounding peat and peat dominated soils.

12.196 Access tracks have the potential to disrupt flow pathways, such as interrupting shallow groundwater flow or altering the hydrological regime.

- Actual GWDTE habitats have been assessed as having a moderate dependency on groundwater. Construction of the Proposed Development may have the following potential effects on the quantity and quality of groundwater supplying GWDTE habitats:
  - Turbine foundations, borrow pits and hardstand areas located up-gradient from GWDTE could disrupt shallow groundwater flow from dewatering and diversion of flow paths;

- Turbine foundations, borrow pits and hardstand areas located down-gradient from GWDTE could cause temporary lowering of the water table from dewatering;
- Access tracks, drainage ditches and cable trenches located up-gradient from GWDTE could disrupt and divert shallow groundwater flow-paths;
- Infrastructure located directly over GWDTE habitats could contaminate and lower the quality of groundwater supplying GWDTE through pollution and sedimentation; and
- Runoff from construction areas up-gradient of GWDTE may infiltrate into shallow groundwater aquifers and contaminate and lower the quality of groundwater supplying GWDTE through pollution and sedimentation.

*Compaction of soils*

12.197 The movement of construction traffic within the Site is likely to cause localised compaction of the ground surface, leading to changes in both the hydrological and hydrogeological regime. The impacts of compaction are likely to be highly localised but will damage the vegetation and result in a reduction in the soil permeability and rainfall infiltration, thereby increasing the potential for flood risk and erosion.

## *Assessment of Construction Effects*

12.198 Table 12-14 identifies the likely construction effects on the identified receptors and their significance assuming the successful implementation of good practice and mitigation measures. The assessment is based on the criteria outlined in paragraph 12.15 to 12.18.

**Table 12-14: Assessment of construction effects.**

| Potential Effect | Identified Receptor(s) | Sensitivity | Magnitude of Effect | Significance of Effect Post-Embedded Mitigation | Significance of Effect Post-Additional Mitigation |
|---|---|---|---|---|---|
| Surface Waters (Water Quality) | | | | | |
| ▪ Pollution incidents<br>▪ Erosion and sedimentation<br>▪ Acidification<br>▪ Increase in Runoff<br>▪ Modifications to Surface Drainage Pattern<br>▪ Impediments to Surface Water Flow | River Stinchar | High | Slight | Moderate | - |
| | Water of Girvan | High | Slight | Moderate | - |
| | Milton Burn | Medium | Slight | Moderate/ Minor | - |
| | Dalquhairn Burn | Medium | Slight | Moderate/ Minor | - |
| | Lindsayston Burn | Medium | Slight | Moderate/ Minor | - |
| | Fisheries and Recreation | High | Slight | Moderate | - |
| Flood Risk | | | | | |
| ▪ Increase in runoff<br>▪ Modifications to Surface Drainage Patterns<br>▪ Impediments to Surface Water Flow<br>▪ Compaction of Soil | The Proposed Development | Low | Slight | Minor | - |
| | Downstream of the Proposed Development | Medium | Slight | Moderate/ Minor | - |
| Water Resources (Private Water Supplies) | | | | | |
| ▪ Pollution incidents<br>▪ Erosion and sedimentation<br>▪ Changes in Water Quality | Lindsayston Farm (PW9)) | Medium | Moderate | Moderate | Moderate/ Minor |
| | Knockrochar Farm (PWS12) | Medium | Negligible | Minor | - |
| | Dalwayne Cottage (PWS25) | Medium | Negligible | Minor | - |

| Potential Effect | Identified Receptor(s) | Sensitivity | Magnitude of Effect | Significance of Effect Post-Embedded Mitigation | Significance of Effect Post-Additional Mitigation |
|---|---|---|---|---|---|
| ▪ Increase in Runoff<br>▪ Modifications to Surface Drainage Pattern<br>▪ Impediments to Surface Water Flow<br>▪ Modification of Groundwater Flows and Levels<br>▪ Compaction of Soils | Dalquhairn Farm (PWS26) | Medium | Negligible | Minor | - |
| | Corphin Cottage (PWS30) | Medium | Moderate | Moderate | Moderate/ Minor |
| | Delamford Farm (PWS38) | Medium | Moderate | Moderate | Moderate/ Minor |
| | Dobbingstone Farm (PWS39) | Medium | Moderate | Moderate | Moderate/ Minor |
| <u>Soils and Peat</u> | | | | | |
| ▪ Pollution incidents<br>▪ Modifications to Surface Drainage Patterns<br>▪ Modification of Groundwater Flows and Levels<br>▪ Compaction of Soils | Site soils and peat < 0.5 m depth | Low | Slight | Minor | - |
| | Site soils and peat > 0.5 m depth | High | Slight | Moderate | - |
| <u>Geology</u> | | | | | |
| ▪ Excavation and removal required for construction | Geology | Low | Slight | Minor | - |
| <u>Hydrogeology</u> | | | | | |
| ▪ Pollution incidents<br>▪ Modification of groundwater flows and levels | Groundwater within peat | Medium | Slight | Moderate/ Minor | - |
| | Underlying Groundwater | Medium | Slight | Moderate/ Minor | - |
| | GWDTE | Medium | Slight | Moderate/ Minor | - |

| Potential Effect | Identified Receptor(s) | Sensitivity | Magnitude of Effect | Significance of Effect Post-Embedded Mitigation | Significance of Effect Post-Additional Mitigation |
|---|---|---|---|---|---|
| ▪ Compaction of Soils | | | | | |

## Potential Operational Effects

12.199 The effects of the Proposed Development are expected to be substantially lower during the operational phase. The following paragraphs discuss the potential effects that may occur during the operational phase of the Proposed Development.

*Pollution incidents*

12.200 The potential risk of pollution is substantially lower during operation than during construction because of the decreased levels of activity in the operational phase. The majority of potential pollutants will have been removed when construction is complete; however, lubricants for turbine gearboxes, transformer oils and possible fuel leaks from maintenance vehicles will remain.

*Erosion and sedimentation*

12.201 Levels of erosion and sedimentation during operation will be much lower than construction as there will be no excavations or bare exposed ground. Some erosion and sedimentation is still possible on site tracks and drainage ditches as a result of scouring during extreme rainfall events. Similarly, there could be some erosion and sedimentation around new stream crossings as watercourses reach new equilibrium.

*Modification of surface drainage patterns*

12.202 Modification of surface runoff will occur as a result of the construction of the new infrastructure associated with the Proposed Development. The operational effects are likely to result in changes to volume and/or changes to runoff rate.

12.203 Poorly designed site tracks and associated drainage could allow surface water to travel through a catchment much faster than if it were to travel as diffuse overland flow. This could result in an increase in runoff rates, peak flows and influence response times during storm events. The utilisation of many of the existing tracks reduces the magnitude of the changes expected to the drainage regime.

*Impediments to surface water flows*

12.204 During the operational phase impediments to flows can generally occur as a result from blockages to watercourse crossing, ditches and watercourses resulting from vegetation and erosion debris.

*Modification of groundwater flow and levels*

12.205 Tracks and their drainage as well as turbine foundations and hardstandings will potentially alter the water table within the upslope and downslope peat and upper bedrock aquifers, which can also have implications for the long term functionality of peatland environments. Backfilled cable trenches can also provide preferential flow pathways for groundwater.

*Compaction of soils*

12.206 The compaction of soils/peat is likely to be significantly reduced during the operational phase as a result of less heavy traffic movement.

## Assessment of Predicted Operational Effects

12.207 Table 12-15 below identifies the likely operational and ongoing effects on the identified receptors and their significance assuming the successful implementation of good practice and mitigation measures. The assessment is based on the criteria outlined in paragraph 12.15 to 12.18.

**Table 12-15: Assessment of operational and ongoing effects**

| Potential Effect | Identified Receptor(s) | Sensitivity | Magnitude of Effect | Significance of Effect Post-Mitigation | Significance of Effect Post-Additional Mitigation |
|---|---|---|---|---|---|
| Surface Waters (Water Quality) | | | | | |
| ▪ Pollution incidents<br>▪ Erosion and sedimentation<br>▪ Acidification<br>▪ Increase in Runoff<br>▪ Modifications to Surface Drainage Pattern<br>▪ Impediments to Surface Water Flow | River Stinchar | High | Negligible | Moderate/ Minor | - |
| | Water of Girvan | High | Negligible | Moderate/ Minor | - |
| | Milton Burn | Medium | Negligible | Minor | - |
| | Dalquhairn Burn | Medium | Negligible | Minor | - |
| | Lindsayston Burn | Medium | Negligible | Minor | - |
| | Fisheries and Recreation | High | Negligible | Moderate/ Minor | - |
| Flood Risk | | | | | |
| ▪ Increase in runoff<br>▪ Modifications to Surface Drainage Patterns | The Proposed Development | Low | Negligible | Minor/ Negligible | - |
| | Downstream of the | Medium | Negligible | Minor | - |

| Potential Effect | Identified Receptor(s) | Sensitivity | Magnitude of Effect | Significance of Effect Post-Mitigation | Significance of Effect Post-Additional Mitigation |
|---|---|---|---|---|---|
| ▪ Impediments to Surface Water Flow<br>▪ Compaction of Soil | Proposed Development | | | | |
| Water Resources (Private Water Supplies) | | | | | |
| ▪ Pollution incidents<br>▪ Erosion and sedimentation<br>▪ Changes in Water Quality<br>▪ Increase in Runoff<br>▪ Modifications to Surface Drainage Pattern<br>▪ Impediments to Surface Water Flow<br>▪ Modification of Groundwater Flows and Levels<br>▪ Compaction of Soils | Lindsayston Farm (PW9)) | Medium | Moderate | Moderate | Moderate/Minor |
| | Knockrochar Farm (PWS12) | Medium | Negligible | Minor | - |
| | Dalwayne Cottage (PWS25) | Medium | Negligible | Minor | - |
| | Dalquhairn Farm (PWS26) | Medium | Negligible | Minor | - |
| | Corphin Cottage (PWS30) | Medium | Negligible | Minor | - |
| | Delamford Farm (PWS38) | Medium | Moderate | Moderate | Moderate/Minor |
| | Dobbingstone Farm (PWS39) | Medium | Moderate | Moderate | Moderate/Minor |
| Soils and Peat | | | | | |
| ▪ Pollution incidents<br>▪ Modifications to Surface Drainage Patterns<br>▪ Modification of Groundwater Flows and Levels | Site soils and peat < 0.5 m depth | Low | Negligible | Minor/ Negligible | - |
| | Site soils and peat > 0.5 m depth | High | Negligible | Moderate/ Minor | - |

| Potential Effect | Identified Receptor(s) | Sensitivity | Magnitude of Effect | Significance of Effect Post-Mitigation | Significance of Effect Post-Additional Mitigation |
|---|---|---|---|---|---|
| ▪ Excavation of soils/peat<br>▪ Compaction of Soils | | | | | |
| Geology | | | | | |
| ▪ Excavation and removal required for construction | Geology | Low | Negligible | Minor/ Negligible | - |
| Hydrogeology | | | | | |
| ▪ Pollution incidents<br>▪ Modification of groundwater flows and levels<br>▪ Compaction of Soils | Groundwater within peat | Medium | Negligible | Minor | - |
| | Underlying Groundwater | Medium | Negligible | Minor | - |
| | GWDTE | Medium | Negligible | Minor | - |

## *Cumulative Effects and Interaction of Effects*

12.208 The application of a hydrological catchment methodology enables a logical evaluation of the potential for cumulative effects of the hydrological environment.

12.209 There are a number of wind farm developments within 10 km of the Proposed Development and within the catchments of the River Stinchar and Water of Girvan. These include four operational sites (Hadyard Hill, Tralorg, Dersalloch and Mark Hill), one in planning (Clauchrie) and one currently going through scoping (Carrick).

12.210 The construction and subsequent operation of the schemes within the 10 km radius as well as the Proposed Development has the potential to cumulatively affect the water quality, flooding and fisheries interests associated with the River Stinchar and Water of Girvan catchments. There is also the potential for cumulative impacts on private water supplies and public water supplies.

12.211 However, taking into account that four of the wind farms are already operational and the other two are in various planning stages and that construction of these developments, as well as the Proposed Development, would not be concurrent and assuming the successful implementation of detailed mitigation (following industry good practice) and monitoring

plans it is expected that any cumulative effects would be of minor significance and not Significant in EIA terms.

## *Monitoring*

12.212 A programme of surface water quality monitoring will be finalised post consent, prior to construction. A breakdown of the proposed monitoring methodologies has been provided to take into account sensitivities of the on-site and downstream environments.

12.213 The details of any required monitoring should be discussed and agreed with SEPA, and SAC prior to commencement. The extent and the frequency of the monitoring will be proportionate to the level of activity on the Site during the construction, operation and decommissioning of the Proposed Development. Appropriate monitoring is important to:

- Provide reassurance that established in-place mitigation measures are effective and that the Proposed Development is not having any significant adverse impact upon the environment;
- Indicate whether further investigation is required and, where pollution is identified, the need for additional mitigation measures to prevent, reduce or remove any impacts on the water environment; and
- Understand the long-term effects of the Proposed Development on the natural environment.

12.214 A baseline surface water monitoring programme will be undertaken prior to the commencement of construction works. The establishment of a baseline is very important as it provides a suite of parameters against which to compare samples taken during the Proposed Development's lifetime, and with which to assess any impacts and the requirement for any appropriate remedial measures. However, due to the variance in climatic conditions, recording like for like water quality prior to and during construction is likely to be unusual. Therefore, it is also recommended that control sites, situated outside the area affected by the Proposed Development infrastructure are also established at the time.

12.215 It is also recommended that a suitably qualified ECoW is employed throughout the construction of the Proposed Development. The appointed consultant can provide advice to the contractors about how environmental effects can be minimised, and what methods can be employed to reduce effects on water quality, soils and associated habitats.

12.216 Monitoring should be undertaken throughout construction of the Proposed Development. The monitoring will help to identify areas where infrastructure is having a negative effect on peaty soils and utilise the appropriate methods to prevent further deterioration and/or promote further enhancement.

12.217 It is also recommended that all construction management and water management techniques are agreed prior to construction. The techniques would be agreed following consultation with SEPA, and SAC. In conjunction with this, there should be a programme of visual monitoring to ensure that the designed drainage system is compliant with the requirements under CAR with respect to GBR 10 and in particular clauses d, g and h.

*Licencing Requirements*

12.218 SEPA amended the requirements under CAR brought in by the Water Environment (Miscellaneous) (Scotland) Regulations 2017 to impose the need for individual sites to require a site-specific licence relating to surface water drainage, rather than individual activities required to adhere to the regulations. This requirement is linked to specific criteria for a construction site, including access tracks, of >4 hectares, or >5 km or which includes any area >1 hectare or >500 m on ground with slope >25°.

12.219 It is acknowledged that to support the licence application further information on the drainage and environmental management requirements is likely to be required. It should be acknowledged within this chapter of the assessment that the information relating to good practice has been provided, but that the level of detail to support a CAR licence application is not required to support the planning application.

## *Residual Effects*

12.220 The residual effects represent the overall likely significant effect of the development on the environment taking account of practical and available mitigation measures.

12.221 This has identified that there will be no significant environmental effects from the Proposed Development on the hydrological, hydrogeological and geological environment and therefore it can be concluded that no residual effects will take place.

## Decommissioning

12.222 During decommissioning of the Proposed Development, potential impacts on the hydrological, hydrogeological and geological environment are expected to be less than those encountered during the construction phase and therefore "not significant". No specific mitigation measures are therefore identified.

12.223 The decommissioning of the Proposed Development would adhere to the latest legislative and guidance requirements at the time.

## Future Baseline

12.224 Without the Proposed Development, the recorded baseline scenario for the hydrological, geological and hydrogeological of the Site would be unlikely to significantly change. However the widespread occurrence of artificial drainage ditches and the reduced permeability of the degraded bog habitats mean that potential increases in rainfall as depicted in Modifying Influences (paragraph 12.117 to 12.119) as a result of climate change could continue to increase soil erosion and place additional stresses upon nearby water resources. This could also be exacerbated by the cycling of afforestation and harvesting of timber resources within the Site, which also has the potential to increase the risk of acidification of the catchments. There is also the potential that the landowners may choose to pursue alternative development opportunities which cover a greater footprint of the site area than current proposals.

12.225 It is considered that alternative development proposals or continuation of current land-uses would not favour the habitat and peatland restoration potential. The adoption of permeant drainage as part of the Proposed Development will also seek to mitigate pressures on the water environment through the incorporation of sustainable design features as well as impacts of peatland habitat improvement which will have been proven to attenuate peak flows and improve water quality.

## Summary

12.226 An assessment has been carried out of the likely significant effects of the Proposed Development on the hydrological, hydrogeological and geological environment. The assessment has considered the Site preparation, construction and operation of The Proposed Development.

12.227 The potential effects on the hydrological, geological and hydrogeological environment have considered:

- Pollution Incidents;
- Erosion and sedimentation;
- Changes to water resources i.e. private water supplies;
- Modification of surface water and groundwater flows;
- Modification of natural drainage patterns;
- Impediments to flow and flood risk;
- Excavation of material, including rock, soils and peat;
- Peat instability; and
- Compaction of soils.

12.228 Following the identification and assessment of the key receptors, taking into account the potential effects listed above, a comprehensive suite of mitigation and good practice measures has been incorporated into the design, including extensive buffer areas. In addition, a site specific CEMP as well as detailed design of infrastructure and associated mitigation will be implemented to protect the groundwater and surface water resources from pollution and minimise changes to the hydrological environment.

12.229 The impact assessment has taken into account the hydrological regime, highlighting that the principal effects will occur during the construction. Assuming the successful design and implementation of mitigation measures the significance of construction effects on all identified receptors is considered to be of minor or no significance. The assessment of predicted ongoing and operational effects has also determined that the significance of effects on all receptors to be of **minor/moderate minor or negligible significance**. The assessment of predicted ongoing and operational effects has also determined that the significance of effects on all receptors to be of **minor or negligible significance**.

12.230 Table 12-16 summarises the environmental effects of the Proposed Development.

**Table 12-16: Summary of likely significant environmental effect of the Proposed Development**

| Likely Significant Impact | Mitigation Proposed | Means of Implementation | Outcome / Residual Impact |
|---|---|---|---|
| **Construction** | | | |
| Detrimental impacts to on-site and downstream water quality | Appropriate drainage design that incorporates sediment management measures to attenuate and treat runoff from construction activities.<br>Appropriate storage and handling of potential pollutants.<br>Refuelling of construction plant in designated areas.<br>Adoption and agreement on emergency measures should significant effects occur.<br>Completion of hydrogeological risk assessment. Develop conceptual ground model to identify risk to PWS | Preparation of site specific CEMP prior to construction. Hydrological elements of the CEMP can include, but not limited to the following:<br>▪ A Drainage Management Plan;<br>▪ Pollution Prevention and Incident Response Plan<br>▪ Watercourse crossing assessment (detailed design prior to construction);<br>▪ Water quality monitoring programme<br><br>Development of mitigation measures following completion of hydrogeological risk assessment to protect PWS | **Minor/Negligible** |
| Detrimental effects to on-site and downstream fisheries as a result of changes to water quality | | | |
| Increases to on-site and downstream flood risk as a result of poor construction practices (including poor construction of watercourse crossings) | | | |
| Modifications of groundwater flows and levels with consequential impacts on GWDTE | | | |
| Impacts on quality and quantity of water to PWS on and near to the Proposed Development | | | **Moderate, Moderate/Minor, Minor** |
| Impacts on peat and peaty soils as a result of direct excavation and poor handling and use of excavated material as well interrupting surface and sub-surface drainage pathways | Appropriate storage and sustainable reuse of peat and peaty soils.<br>Appropriate drainage design that incorporates sediment management measures to attenuate and treat runoff from construction activities. | Preparation of site specific CEMP prior to construction. Hydrological elements of the CEMP can include, but not limited to the following:<br>▪ Drainage Management Plan (designed to maintain drainage pathways); | **Minor/Negligible** |

| Likely Significant Impact | Mitigation Proposed | Means of Implementation | Outcome / Residual Impact |
|---|---|---|---|
| | Measures will be designed to encourage water retention within peat/soils.<br>Identification of subsurface hydrological pathways prior to construction.<br>Appropriate design of watercourse crossings in areas of flushes<br>. | ▪ Water quality monitoring programme. | |
| **Operation** | | | |
| Detrimental impacts to on-site and downstream water quality through degradation of The Proposed Development infrastructure and poor storage of materials | Appropriate drainage design that incorporates sediment management measures to attenuate and treat runoff from Wind Farm infrastructure.<br>Appropriate storage and handling of potential pollutants.<br>Adoption of a long term monitoring programme to monitor degradation of infrastructure (including the removal of blockages from watercourse crossings). | Operational drainage and monitoring plan (designed prior to construction).<br>Plan can detail the appropriate monitoring methods, including:<br>▪ Visual monitoring and completion of checklists signed off by SEPA;<br>▪ Regular water quality monitoring for a period post construction to determine potential long terms effects of Wind Farm on water quality. | **Minor** |
| Detrimental impacts to private water supplies through degradation of The Proposed Development infrastructure and poor storage of materials | | | |
| Detrimental effects to on-site and downstream fisheries as a result of changes to water quality (as described above) | | | |
| Increases to on-site and downstream flood risk as a result of degradation of infrastructure and/or poor maintenance/monitoring of infrastructure | | | |

12.231 The significance of effects on the site hydrological, hydrogeological and geological conditions are **not significant** under the terms of The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017.