9 Hydrology, Hydrogeology, Geology & Soils

9.1 Introduction

9.1.1 This chapter of the Environmental Impact Assessment Report (EIA Report) assesses the impacts on the geological, hydrological and hydrogeological environment at Bloch Wind Farm, the 'proposed development', and the likely significant environmental effects resulting from the construction and operation of the proposed wind turbines and associated infrastructure. The specific objectives of the chapter are to:

- describe the current baseline;
- describe the assessment methodology and significance criteria used in completing the impact assessment;
- describe the potential effects, including direct, indirect and cumulative effects;
- describe the mitigation measures proposed to address any potentially significant effects; and
- assess the residual effects remaining following the implementation of mitigation measures.

9.1.2 The assessment and associated Technical Appendices were undertaken by Natural Power, of Natural Power Consultants Ltd. Natural Power has an established reputation in providing assessment of geological, hydrological and hydrogeological considerations discussed in this chapter.

9.1.3 The chapter is supported by the following technical appendices:

- Technical Appendix 9.1: Schedule of Watercourse Crossings;
- Technical Appendix 9.2: Peat Management Plan;
- Technical Appendix 9.3: Peat Slide Risk Assessment;
- Technical Appendix 9.4: Private Water Supply Risk Assessment;
- Technical Appendix 9.5: Groundwater Dependant Terrestrial Ecosystems Assessment;
- Technical Appendix 9.6: Watercourse Assessment; and
- Technical Appendix 9.7: Carbon Balance Assessment.

9.1.4 Figures 9.1 – 9.12 are referenced in the text where relevant:

- Figure 9.1: Hydrology Overview;
- Figure 9.2: Flow Accumulation;
- Figure 9.3: Topographic Wetness Index;
- Figure 9.4: Predominant Soils;
- Figure 9.5: Carbon and Peatland Soils;
- Figure 9.6: Peat Depth Interpolation;
- Figure 9.7: Peat Slide Risk:
- Figure 9.8a: Potential GWDTE Dependency;
- Figure 9.8b: Actual GWDTE Dependency;
- Figure 9.9: Bedrock Geology;
- Figure 9.10: Superficial Geology;
- Figure 9.11: Slope Angle; and
- Figure 9.12: Artificial and Natural Drainage Networks.

9.2 Legislation, Policy and Guidance

9.2.1 The assessment takes account of:

- Water Framework Directive (2000/60/EC);
- Water Environment and Water Services (Scotland) Act 2003;
- Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended);
- Water Environment (Miscellaneous) (Scotland) Regulations 2017;
- Flood Risk Management (Scotland) Act 2009;
- The Public Water Supplies (Scotland) Regulations 2014;
- Private Water Supplies (Scotland) Regulations 2006;
- The Water Intended for Human Consumption (Private Supplies) (Scotland) Regulations 2017;
- Part IIA of the Environment Protection Act 1990;
- Waste Management Licensing (Scotland) amendment Regulations 2016
- Pollution Prevention and Control (Scotland) Regulations 2012;
- SEPA Technical Flood Risk Guidance for Stakeholders – Version 12, May 2019. SS-NFR-P-002;
- SEPA Land Protection. Reference EP054;
- SEPA Policy No. 19 Groundwater Protection Policy for Scotland;
- SEPA Policy No. 41 Development at Risk of Flooding: Advice and Consultation; and
- SEPA Policy No. 61 Control of Priority & Dangerous Substances & Specific Pollutants in the Water Environment.

9.2.2 The following development plan policies were also taken account of during the assessment:

- Dumfries and Galloway Council Local Development Plan 2 (LDP2) 2019:
  - OP1: Development Considerations;
  - OP2: Design Quality and Placemaking;
  - OP3: Developer Contributions;
  - NE11: Supporting the Water Environment;
  - NE12: Protection of Water Margins;
  - NE14: Carbon Rich Soil;
  - NE15: Protection and Restoration of Peat Deposits as Carbon Sinks;
  - IN1: Renewable Energy;
  - IN2: Wind Energy;
  - IN7: Flooding and Development; and
  - IN8: Surface Water Drainage and Sustainable Drainage Systems (SuDS).

9.2.3 Table 9.1 lists other key guidance and good practice documentation which have been considered as part of this assessment.

Table 9.1: Guidance and Good Practice

Topic	Source of Information
Scottish Government Planning Advice Notes (PANs)	PAN 50: Controlling the Environmental Effects of Surface Mineral Workings PAN 51: Planning (revised 2006), Environmental Protection and Regulation PAN 1/2013: Environmental Impact Assessment PAN 61: Sustainable Urban Drainage Systems Flood Risk: planning advice PAN 79: Water and Drainage Onshore Wind Turbine: planning advice Wind farm developments on peat land: planning advice
SEPA Guidance for Pollution Prevention (GPPs) and Pollution Prevention Guidelines (PPGs)	PPG 1: Understanding your Environmental Responsibilities - Good Environmental Practices GPP 2: Above Ground Oil Storage Tanks GPP 4: Treatment and Disposal of Wastewater Where there is no Connection to the Public Foul Sewer GPP 5: Works and Maintenance in or Near Water PPG 6: Working at Construction and Demolition Sites PPG 7: Safe Storage - The Safe Operation of Refuelling Facilities GPP 8: Safe Storage and Disposal of Used Oils GPP 13: Vehicle Washing and Cleaning GPP 21: Pollution Incident Response Planning GPP 22: Dealing with Spills GPP 26: Safe Storage - Drums and Intermediate Bulk Containers
SEPA Position Statements (Published)	WAT-PS-06-02: SEPA (2015), Culverting of Watercourses, Version 2 WAT-PS-07-02: SEPA (2012), Bank Protection, Version 2 WAT-SG- 78: SEPA (2012), Sediment Management Authorisation, Version 1 WAT-SG-23: SEPA (2008), Engineering in the Water Environment, Good Practice Guide - Bank Protection Rivers and Lochs, Version 1 WAT-SG-25: SEPA (2010), Engineering in the Water Environment, Good Practice Guide, Construction of River Crossings, Version 2 WAT-SG-26: SEPA (2010), Engineering in the Water Environment, Good Practice Guide, Sediment Management, Version 1 WAT-SG-75: SEPA (2011), Water Run-Off from Construction Sites September 2021 WAT-SG-31: SEPA, (2006) Special Requirements for Civil Engineering Contracts for the Prevention of Pollution, Version 2
Construction Industry Research and Information Association (CIRIA)	CIRIA C692 Environmental Good Practice on Site (third edition) CIRIA C753 SuDS Manual (2015) CIRIA C532 Control of Water Pollution from Construction Sites CIRIA C648 Control of Water Pollution from Linear Construction Projects CIRIA C689 Culvert Design and Operation Guide
Other Guidelines	SNH and Scottish Renewables Joint Publication, (2019) Good Practice During Wind Farm Construction Version 4 FCE, SNH, (2010), Floating Roads on Peat; Scottish Renewables, Joint Publication (2012), Development of Peatland: Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimization of Waste SEPA, The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended), A Practical Guide, Version 9.1, March 2022 Scottish Government, Scottish Natural Heritage, SEPA (2017) Peatland Survey Guidance on Developments on Peatland, on-line version only SEPA Land Use Planning Guidance CC1 (LUPS-CC1) (2019). Climate change allowances for flood risk assessment in land use planning. Issue 1. SEPA Land Use Planning Guidance Note 4 (2017): Planning Guidance on On-Shore Windfarm Developments, Version 9 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 SNIFFER. 2009. WFD95 A Functional Typology for Scotland

9.3 Consultation

9.3.1 Table 9.2 summarises the consultation responses relating to the geological, hydrological and hydrogeological environment.

Table 9.2: Relevant Consultation Responses

Organisation	Relevant Response	Comments
Scottish Water	A review of our records indicates that the proposed activity falls partly within a drinking water catchment where a Scottish Water abstraction is located. Winterhope Reservoir supplies Winterhope Water Treatment Works (WTW) and it is essential that water quality and water quantity in the area are protected. It appears that this activity may slightly encroach within the catchment, but should be of low risk to water quality. However we ask that water quality protection measures are still implemented.	Winterhope Reservoir has been scoped out of further consideration within the chapter as it is not hydrologically connected to the proposed development (further details provided in Section 9.4)
Scottish Ministers	Request that the Company investigates the presence of any private water supplies which may be impacted by the development. The EIA report should include details of any supplies identified by this investigation, and if any supplies are identified, the Company should provide an assessment of the potential impacts, risks, and any mitigation which would be provided. Recommend that the Company discuss and agree Baseline Fish Surveys with the local District Salmon Fishery Board and Fisheries Trust. Where there is a demonstrable requirement for peat landslide hazard and risk assessment (PLHRA), the assessment should be undertaken as part of the EIA process to provide Ministers with a clear understanding of whether the risks are acceptable and capable of being controlled by mitigation measures. The Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (Second Edition), published at http://www.gov.scot/Publications/2017/04/8868, should be followed in the preparation of the EIA report, which should contain such an assessment and details of mitigation measures.	See Technical Appendix 9.4: Private Water Supply Risk Assessment. Galloway Fisheries Trust have been engaged to undertaken baseline fishery surveys on the site, and the findings will be written up and included in Technical Appendix 7.4 See Technical Appendix 9.3: Peat Slide Risk Assessment.
Marine Scotland Science (MSS)	MSS provide generic scoping guidelines for onshore wind farm and overhead line development https://www2.gov.scot/Topics/marine/Salmon-TroutCoarse/Freshwater/Research/onshoreren) which outline how fish populations can be impacted during the construction, operation and decommissioning of a wind farm or overhead line development and informs developers as to what should be considered, in relation to freshwater and diadromous fish and fisheries, during the EIA process. In addition to identifying the main watercourses and waterbodies within and downstream of the proposed development area, developers should identify and consider, at this early stage, any areas of Special Areas of Conservation where fish are a qualifying feature and proposed felling operations particularly in acid sensitive areas. MSS also provide standing advice for onshore wind farm or overhead line development (which has been appended at Annex B) which outlines what information, relating to freshwater and diadromous fish and fisheries, is expected in the EIA report. Use of the checklist, provided in Annex 1 of the standing advice, should ensure that the EIA report contains the required information; the absence of such information may necessitate requesting additional information which may delay the process. Developers are required to submit the completed checklist in advance of their application submission.	Galloway Fisheries Trust have been engaged to undertaken baseline fishery surveys on the site, and the findings will be written up and included in Technical Appendix 7.4. The MSS checklist has been completed.
NatureScot	Peat in the Scottish soil classification is soil with more than 60% organic carbon and exceeding 50cm in thickness. We advise that the proposed development should avoid or minimise impacts on areas of peat that exceed 50cm in thickness. If this development involves forestry activities in close proximity to watercourses, we advise that the proposed development adhere to the UK Forestry Standards Forests and Water guidelines. We advise that a Pollution Prevention Plan be put in place, particularly to manage the risk of sedimentation and chemical pollution to the watercourses on and around the proposed development site.	See Technical Appendix 9.2: Peat Management Plan. No forestry activities are proposed for this development. See Technical Appendix 2.3: Outline Pollution Prevention Plan (PPP).

Organisation	Relevant Response	Comments
SEPA	In line with our scoping advice, the site should be designed to avoid sensitive receptors (i.e. peat, GWDTE, water features, private water supplies) and incorporate appropriate buffer distances. We note a number of turbines are currently proposed directly on water features (T3, T7, T17 & T19). These turbines should be relocated incorporating a 50m buffer from watercourses and waterbodies as per Section 10.2.10 of the Scoping Report. Please refer the applicant to our attached scoping advice for wind farms which sets out our full requirements for the EIA. a) Map and assessment of all engineering works within and near the water environment including buffers, details of any flood risk assessment and details of any related applications made under the Controlled Activities Regulations (CAR). With relation to flood risk, if, having considered the site and potential for flood risk, it appears that the only apparent issue could relate to design of watercourse crossing, then provided crossings are designed to accommodate the 1 in 200 year event and other infrastructure is located well away from watercourses it is unlikely that there will be a need for detailed information on flood risk b) b) Map and assessment of impacts upon Groundwater Dependent Terrestrial Ecosystems and buffers. Where it is clear that much of the site is likely to be peatland and/or wetland, we suggest you may wish to go straight to carrying out NVC survey without carrying out Phase 1 and Sniffer assessments (see appendix for details). c) c) Map and assessment of impacts upon groundwater abstractions and buffers. Where there are no abstractions within 250 m of excavations then this should be confirmed in the EIA Report. d) Peat depth survey and table detailing re-use proposals. Where much of the site is on peat, we expect the application to be supported by a comprehensive site specific Peat Management Plan. e) Map and table detailing forest removal if on afforested area. Note that habitat survey information is not required for areas which are heavily forested or recently felled. f) Map and site layout of borrow pits. g) Schedule of mitigation including pollution prevention measures. h) Quarry or Borrow Pit Site Management Plan of pollution prevention measures. i) Map of proposed waste water drainage layout. j) Map of proposed surface water drainage layout. k) Map of proposed water abstractions including details of the proposed operating regime. l) Decommissioning statement. Appendix 1: Detailed scoping requirements also included	Preapplication consultation with SEPA has been undertaken to demonstrate that drainage ditches at wind turbines T3, T7, T17 and T19 are mapped as watercourses. Further details are presented in Technical Appendix 9.6: Watercourse Assessment. Other responses addressed throughout this chapter, supporting figures and associated Technical Appendices.
Galloway Fisheries Trust	We wish to make the following specific comments / observations: · The proposed development site does cover a number of important fish supporting water courses including the Bigholms Burn, Wauchope Water, Collin Burn and Back Burn. The Border Esk supports an important salmon and sea trout fishery. The river and its burns also support a range of protected fish species including Atlantic salmon, sea trout, European eels and Lamprey species. · It is disappointing at the very limited mention of fish in the scoping report. This is not acceptable. · A baseline fish survey should be undertaken to understand what fish species are present and their densities. This information should follow the 2021 Marine Scotland guidance titled 'Monitoring watercourses in relation to onshore wind farm developments: generic monitoring programme' (https://www.gov.scot/publications/monitoring-watercourses-in-relation-toonshore-wind-farm-developments-generic-monitoring-programme/). This guidance states the need for fish surveys and aquatic invertebrates and provides guidance and minimum standards. · The baseline fish survey is important for the EIA. It will highlight sensitivities that should be considered when designing roads, silt control methods, water quality monitoring points, water crossing designs, timing of works, etc. Importantly it will also inform the production of a 'Fish Monitoring Plan' which should cover pre, during and post construction phases. · Any new water course crossing must ensure fish access is protected. If instream works are planned in a watercourse supporting trout/salmon then such works should avoid taking place between October – May to protect spawning redds. Also a fish rescue by electrofishing should take place prior to instream works in fish supporting water courses. · We would appreciate the opportunity to comment in due course on any proposed Habitat Management Plan for the site. We feel there would be opportunities to improve the habitat for aquatic ecology especially fish. Riparian tree planting, using native deciduous species, could help to address future concerns with climate change driven increases in water temperatures. The following have the potential to impact fish species and their habitats. These points/potential issues are of general concern and interest to us: • Access track layout in relation to the proximity to sensitive fish habitat (e.g. spawning habitat);	Galloway Fisheries Trust have been engaged to undertaken baseline fishery surveys on the site, and the findings will be written up and included in Technical Appendix 7.4

Organisation	Relevant Response	Comments
	• The number of watercourse crossings (new and upgraded); • The location of new and upgraded watercourse crossings; • New and upgraded watercourse crossing type, design, and structure, including information relating to the installation of each crossing point (e.g. maintaining the existing gradient, maintaining fish access at all water heights etc.); • Construction information for new tracks (including layby locations), trackside drainage plans and designs especially in relation to increased run off rates; • Turbine base locations; • Turbine base excavation and associated run off from loose ground; • Peat depth information in relation to water quality, peat slides or ground slips; • Borrow pit locations; • Changes to instream hydrological conditions and flush zones; • Exacerbated erosion and/or elevated levels of suspended silt to watercourses during construction activities; • Water quality monitoring information; • Pollution to watercourses in the form of silt pollution; • Pollution to watercourses in the form of chemical pollution; • Reduction in quantity and quality of instream habitat; • Adverse changes to instream morphology; • Direct mortality of fish species; • Mitigation measures to protect fish population and their habitats from the impact from all of the above; • Timings of specific works such as new track building, new watercourse crossing installation, upgrading of existing watercourse crossings; • Mitigation measures to protect watercourses, fish and their habitats – that which is built into the design of the development and any additional mitigation measures which will be employed if required.	See Technical Appendix 9.1: Schedule of Watercourse Crossings See Technical Appendix 9.6: Watercourse Assessment See Technical Appendix 9.3 Peat Landslide Hazard Risk Assessment
Middlebie & Waterbeck Community Council	Ecosystems - The destruction of peat environments and the associated carbon sink capacity is clearly detrimental. Furthermore, the disruption of natural drainage systems and the water table will have wider effects beyond the site itself, on the balance of the wider area's moorland and wetland habitats. The inevitable damage of fragile flora, fauna and ecosystems is indefensible. The permanence of the infrastructure of these turbines will require that immense quantities of aggregate/concrete foundations will remain, long after the turbines have been decommissioned, leaving a lasting scar on the land and ecosystem. There does not appear to be any clear plan, or statement of responsibility regarding decommissioning and removal or the turbine equipment in the plans.	See Technical Appendix 9.2: Peat Management Plan See Technical Appendix 9.7: Carbon Balance Assessment See Technical Appendix 7.6: Outline Habitat Management Plan See Chapter 2: Description of the Proposed Development.
Natural England	The development site is within or may impact on the following European/internationally designated nature conservation site(s): • Solway Firth SPA (Special Protected Area) • Solway Flats & Marshes Ramsar The development site is within or may impact on the following Site of Special Scientific Interest: • Upper Solway Flats & Marshes SSSI The following issues should be considered and, where appropriate, included as part of the Environmental Statement (ES): • The degree to which soils would be disturbed or damaged as part of the development • The extent to which agricultural land would be disturbed or lost as part of this development, including whether any best and most versatile (BMV) agricultural land would be impacted. This may require a detailed Agricultural Land Classification (ALC) survey if one is not already available. The ES needs to take account of any strategic solutions for nutrient neutrality or Diffuse Water Pollution Plans, which may be being developed or implemented to mitigate and address the impacts of elevated nutrient levels. Further information can be obtained from the Local Planning Authority.	See Chapter 7: Terrestrial Ecology See Technical Appendix 9.2: Peat Management Plan

9.4 Methodology

Scope of Assessment

Effects Scoped out of the Assessment

9.4.1 Pre-application consultation with Scottish Water, confirmed the Scottish Water WTW, reservoir and its catchment are not hydrologically connected to the site. As such, Public Water Supplies will not be considered further in this assessment. Winterhope Reservoir is situated in a separate hydrological catchment from the proposed development, it is part of the Kirtle Water catchment which is located west of the proposed development. Winterhope Reservoir is located upgradient of the proposed development and is 3.4km from the nearest proposed site infrastructure (T5).

Effects to be Scoped into the Assessment

9.4.2 The greatest risk of the proposed development affecting the geological, hydrological 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 proposed development:

- changes to existing drainage patterns;
- effects on baseflow;
- effects on run-off rates;
- effects on erosion and sedimentation;
- effects on groundwater levels;
- effects on water resources;
- effects on impediments to flow;
- on-site and downstream flood risk;
- pollution risk;
- effects on local geology;
- effects on hydrological integrity of peat bodies; and
- effects on groundwater and surface water quality.

Overview

9.4.3 The assessment has involved the following:

- detailed desk studies and site visits to establish baseline conditions of the area;
- evaluation of the likely significant environmental effects of the proposed development and the impacts that these could have on the current site conditions;
- identification of embedded good practice mitigation 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 mitigation measures.

Baseline Characterisation

Study Area

9.4.4 The hydrological study area is larger in extent than the actual site and includes the upper and lower reaches of watercourse catchments that are present within the site. The extent of the catchments is shown in Figure 9.1 which outlines the extent of the study area and totals an area of 27.3km^2. Designated sites and relevant developments are considered from the perspective of assessing any potential hydrological linkages or cumulative effects.

Desk Study / Field Survey

9.4.5 Table 9.3 outlines the information sources used to characterise baseline conditions at the site and in the surrounding area.

Table 9.3: Baseline Information Sources

Topic	Source of Information
Topography	5m contour data derived from Digital Terrain Model (DTM) data and Ordnance Survey (OS) mapping
Climate	Met Office, https://www.metoffice.gov.uk/public/weather/climate/gcv3mcrf9 Flood Estimation Handbook (FEH): FEH Web Service, https://fehweb.ceh.ac.uk/
Designated Nature and Conservation Sites	NatureScot, https://map.environment.gov.scot/sewebmap/ Magic Map, DEFRA, https://magic.defra.gov.uk/magicmap.aspx
Surface Water Hydrology	1:10,000, 1:25,000 & 1:50,000 OS Vector & Raster Data

Topic	Source of Information
	Flood Estimation Handbook (FEH): FEH Web Service, https://fehweb.ceh.ac.uk/
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/ Scotland's Soils Interactive Map, Carbon and Peatland 2016 and National Soil Map of Scotland, http://soils.environment.gov.scot/
Flooding	1:10,000, 1:25,000 & 1:50,000 OS Raster Data Flood Estimation Handbook (FEH): FEH Web Service, https://fehweb.ceh.ac.uk/ Flood Modeller Suite, https://www.floodmodeller.com/ Indicative River and Coastal Flood Map (SEPA) http://map.sepa.org.uk/floodmap/map.htm
Water Quality	SEPA, River Basin Management Plans, Web Mapping Application, https://informatics.sepa.org.uk/RBMP3/
Water Resources	Private water supply (PWS) information provided by Dumfries and Galloway Council (DGC) and consultation with OS mapping. Responses to PWS questionnaires sent to local residents included on the PWS database provided by the Council. Abstraction and discharge license information obtained from SEPA
Hydrogeology	Scotland's Environment Web Interactive Map, https://map.environment.gov.scot/sewebmap/ BGS Geology of Britain Viewer, https://www.bgs.ac.uk/map-viewers/bgs-geology-viewer/ SEPA, River Basin Management Plans, Web Mapping Application, http://gis.sepa.org.uk/rbmp/ BGS Groundwater Vulnerability (Scotland), Version 2 https://nora.nerc.ac.uk/id/eprint/17084/1/OR11064.pdf

Sensitivity Criteria

9.4.6 Table 9.4 defines the sensitivity of the receiving environment i.e., its baseline quality as well as its ability to absorb the effect without perceptible change.

Table 9.4: Definition of Sensitivity of the Receiving Environment

Sensitivity	Definition
High	National importance. Receptor with a high quality and rarity, local scale and limited potential for substitution/replacement or receptor with a medium quality and rarity, regional or national scale and limited potential for substitution / replacement.
Medium	Regional importance. Receptor with a medium quality and rarity, local scale and limited potential for substitution/replacement or receptor with a low quality and rarity, regional or national scale and limited potential for substitution / replacement.
Low	Local importance. Receptor with a low quality and rarity, local scale. Environmental equilibrium is stable and is resilient to changes that are greater than natural fluctuations, without detriment to its present character.

Magnitude of Effect

9.4.7 For the purposes of this assessment the magnitude of effect criteria is defined in Table 9.5 and includes the timing, scale, size and duration of the likely significant environmental effects.

Table 9.5: Magnitude of Effect

Sensitivity	Criteria	Definition
High	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.
Medium	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.
Low	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.

Significance Criteria

9.4.8 The likely significant environmental effects of the proposed development have been defined by taking account of two main factors;

- the sensitivity of the receiving environment; and
- the potential magnitude should that effect occur.

9.4.9 Table 9.6 defines the significance of the effect assuming the successful implementation of industry good practice and embedded design mitigation measures.

Table 9.6: Significance Assessment Matrix

	Sensitivity		
Magnitude	**High**	**Medium**	**Low**
High	Major	Moderate/Major	Minor/Moderate
Medium	Moderate/Major	Moderate	Minor
Low	Moderate	Minor	Negligible/Minor
Negligible	Negligible	Negligible	Negligible

9.4.10 Potential effects are therefore concluded to be Major, Moderate, Minor or Negligible. Effects considered as being Major or Moderate/Major are considered **significant** for the purposes of the EIA Report.

9.4.11 Any likely effects of the proposed development on geology or the water environment identified by the assessment have been addressed and mitigated by the design and the application of good practice guidance to be implemented as standard during construction, operation, and decommissioning to prevent, reduce, or offset effects where possible. Where appropriate, furthermore tailored mitigation measures have been identified prior to determining the likely significance of residual effects.

Assessment of Residual Effects of Significance

9.4.12 A statement of residual effects, following consideration of any further specific mitigation measures where identified, is then given.

9.5 Baseline

Current Baseline

9.5.1 This subsection presents the information gathered on the current environmental baseline conditions within the site and its immediate surroundings.

Topography

9.5.2 The proposed development is in Dumfries and Galloway, approximately 5.5km[1] south-west of Langholm in an area of open moorland. A topographic high is reached on the northern boundary of the proposed development at Bloch Hill of 271m Above Ordnance Datum (AOD).

Climate

9.5.3 The standard average annual rainfall (SAAR) for the site has been derived from the FEH Web Service as ranging from 1132-1325mm based on the site catchments. To put this into context, rainfall in Scotland varies from under 800mm per year on mainland eastern Scotland in areas such as Fife, to over 3000mm on the mainland Western Highlands.

9.5.4 The Met Office 1991-2020 annual rainfall total from the Eskdalemuir climate station is 1,827mm with 194 days of rainfall greater than 1mm recorded. This climate station is located approximately 20km north-west of the proposed development at an elevation of 242m AOD. According to the 1991-2020 average for Eskdalemuir climate station, the highest rainfall totals are recorded during the winter months from October through to January as shown in Chart 9.1.

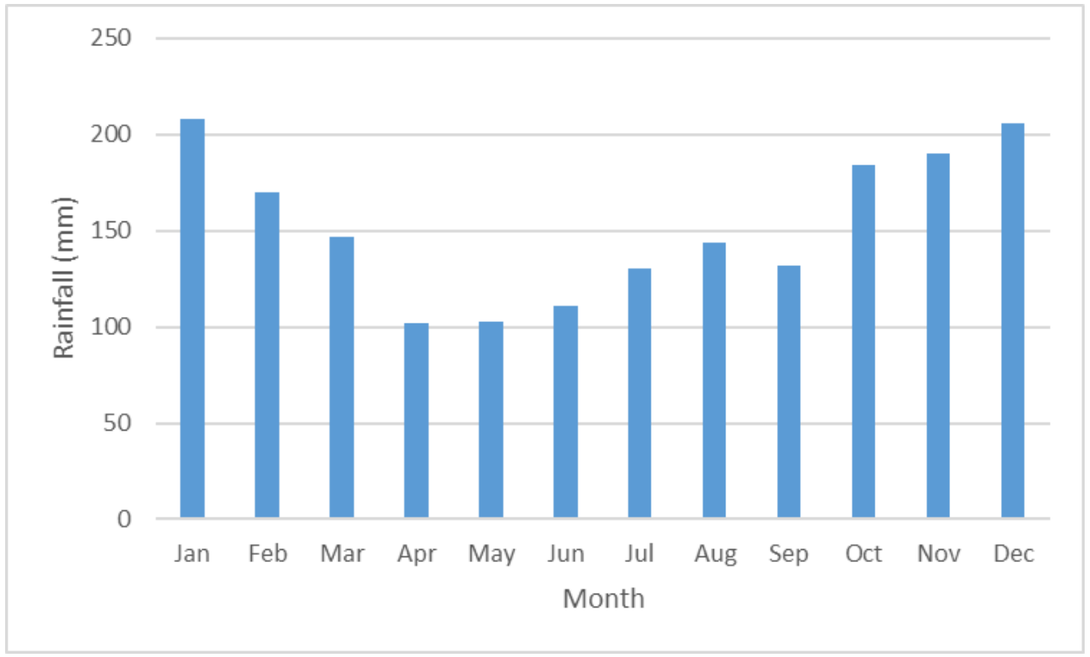

Chart 9.1: Average monthly rainfall data for climate period 1991-2020 for Eskdalemuir Climate Station

[1] This distance is given to the approximate centre point of the site boundary.

Designated Sites

9.5.5 A review of NatureScot and DEFRA records indicates that are no statutory designated sites within the site. There are a few designations which lie outside of the site but within 5km of the site boundary. A summary of the designated sites can be found in Table 9.7.

Table 9.7: Designated sites in proximity of the site boundary

Designated Site	Location	Reason for Designation	Hydrological connection to Proposed Development
Bigholms Burn SSSI	Located north of B7068 adjacent to central section of site boundary.	Geological	The Collin Burn joins the Bigholms Burn upstream of the designation. Therefore, the SSSI will be considered further in Section 9.7 of the EIA Report.
Langholm – Newcastleton Hills SSSI and SPA	Located approximately 3km north-east of proposed development, separated from site by A7 and River Esk.	Mixed and Biological	Not hydrologically connected to the proposed development. Can be scoped out and will not be considered further in this section of the EIA Report.
River Esk, Glencartholm SSSI	Section of River Esk located approximately 3.3km east of proposed development is designated.	Geological	Not hydrologically connected to the proposed development. Can be scoped out and will not be considered further in this section of the EIA Report.
Bell's Flow SSSI	Located approximately 3km south of proposed development.	Biological	Not hydrologically connected to the proposed development. Can be scoped out and will not be considered further in this section of the EIA Report.

Surface Water Hydrology

9.5.6 Hydrologically, the proposed development lies in the watershed of the River Esk which discharges into the Solway Firth and therefore falls within the Solway-Tweed River Basin District which is jointly managed by SEPA and the Environment Agency. Figure 9.1 shows a hydrological overview of the proposed development.

9.5.7 Watercourses or their tributary catchments within the site, which are sub-catchments to the River Esk are the Collin Burn, Back Burn, Cow Sike, Bloch Burn, Hall Burn and Kerr Burn. In addition to the natural watercourses, there is an extensive network of artificial ditches (also known as drains or grips). Some of these man-made features are also shown as watercourses on OS mapping. Further information on these artificial ditches in relation to natural watercourses is presented in Technical Appendix 9.6: Watercourse Assessment.

9.5.8 The headwaters of the **Collin Burn** are sourced from the Collin Hags (255m AOD) at the western edge of the site. The Muir Burn converges with the Collin Burn at E330247, N581209 before joining the Bigholms Burn at E330665, N581439.

9.5.9 The valley forms a shallow vee, and the catchment drains predominately from open moorland (Photograph 9.1).

Photograph 9.1: Collin Burn at E329922, N580842

9.5.10 The headwaters of the **Back Burn** are sourced from Lang Grain Head (219m AOD) at the western/central section of the site. The Back Burn is sourced from the Hope Burn, Lang Grain, Peat Sike and several other small unnamed tributaries. The Back Burn joins the Bigholms Burn 1.2km downstream from the Collin Burn join at E331626, N581100.

9.5.11 The valley forms a shallow vee, and the catchment drains predominately from open moorland. The meandering and incised channel is 0.8m in width (Photograph 9.2). Artificial ditches and peatland hags were evident on the hydrological walkover within this catchment.

Photograph 9.2: Back Burn at E330962, N580234

9.5.12 The **Cow Sike** is a singular tributary, 1.5km in length situated west of Bloch Farm in the central section of site (Photograph 9.3). Cow Sike joins the Bigholms Burn 1.3km downstream from the Back Burn join at E332629, N581781.

Photograph 9.3: Cow Sike at E332587, N580845

9.5.13 The headwaters of the **Bloch Burn** are sourced from the western side of Bloch Hill (271m AOD), Graham's Knowes (215m AOD) and the northern section of the Bloch Plantation (188m AOD). The Bloch Burn is sourced from Upper Woodie Sike, Nether Woodie Sike, Yellow Sike, Farfold Sike and several other small unnamed tributaries. Photograph 9.4 shows the Bloch Burn downstream of these main tributaries joining. The Bloch Burn joins the Wauchope Water at E333569, N582616. The Wauchhope Water flows east joining the River Esk at Langholm.

9.5.14 The Bloch Burn drains predominately from open moorland but includes a small section of plantation forestry (Bloch plantation) within the catchment area. It was noted on the hydrological walkover that artificial ditches were particularly prevalent in the eastern section of this catchment.

Photograph 9.4: Bloch Burn at E333282, N581957

9.5.15 The headwaters of the **Hall Burn** are sourced from Bloch Flow (199m AOD) at the south of the site. The Hall Burn discharges into River Sark flowing south into the River Esk at Gretna.

9.5.16 The headwaters of the Hall Burn, namely the Blough Sike are contained within the southern section of the site in an area of moorland (Photograph 9.5).

Photograph 9.5: Blough Sike, upland tributary of Hall Burn at E331822, N580242

9.5.17 The headwaters of the **Kerr Burn** are sourced from the Bloch plantation and Kerr Height forming the Glenzier Burn which flows south-east discharging into the River Esk at Netherby.

9.5.18 The Kerr plantation is visible within the catchment in Photograph 9.6.

Photograph 9.6: Kerr Burn at E333422, N579442

Hydrological Regime

9.5.19 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 9.8. Catchment descriptors were derived from the FEH Web Service and used for calculating peak flows for the identified catchments above. Catchment boundaries have been used in their entirety, as opposed to their delineation along the site boundary area, which would otherwise generate potentially unrepresentative results. The annual median flood flow (QMED) is also presented.

9.5.20 As per SEPA Land Use Planning Guidance CC1 (LUPS-CC1), it is predicted that there will be increases in rainfall intensity due to climate change which will increase the severity and frequency of flooding on small watercourses. This will subsequently increase the peak runoff flows in these small catchments. The climate change uplift required for the Solway River Basin region for total change to the year 2100 is a 53% increase in peak river flows and a 38% increase in peak rainfall intensity.

Table 9.8: Estimated peak runoff for site catchments calculated using the methodology prescribed by the FEH RR and IHI24 methods

Catchment	Area (km^2)	Method	Estimated peak runoff ($m^3 s^{-1}$) for stated return period						
			2 (QMED)	5	10	30	50	100	200
Collin Burn	3.0	FEH RR	3.31	4.52	5.38	6.85	7.61	8.78	10.18
		IHI24	3.38	4.50	5.22	6.55	6.84	7.49	8.17
Back Burn	2.1	FEH RR	2.39	3.27	3.91	4.98	5.53	6.37	7.36
		IHI24	2.1	2.61	3.18	5.22	5.19	6.22	7.54
Hall Burn	3.1	FEH RR	2.65	3.57	4.23	5.33	5.90	6.77	7.80
		IHI24	3.1	2.79	3.40	5.58	5.55	6.65	8.06
Bloch Burn	2.4	FEH RR	2.47	3.41	4.08	5.20	5.77	6.65	7.67
		IHI24	2.4	2.75	3.35	5.50	5.47	6.55	7.94
Glenzier Burn	16.6	FEH RR	8.48	11.07	12.94	16.04	17.65	20.07	23.03
		IHI24	16.6	7.75	9.45	15.50	15.42	18.48	22.40

9.5.21 Base Flow Index (BFI) and Standard Percentage Runoff (SPR) data for the catchments covering the proposed development 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 catchments to 0.99 in highly permeable catchments. The SPR values represent the percentage of rainfall that is likely to contribute to runoff.

9.5.22 The BFI for the site catchments ranges from 0.236 to 0.335 Hydrology Of Soil Types (HOST) classification indicating that around a quarter of the catchment's long-term runoff is derived from stored sources. The SPR for the site catchments ranges from 44.52% to 58.75% indicating that around half of the rainfall during a rainfall event contributes to runoff. The BFI and SPR values show that the site is located on moderately impermeable catchments indicating the infiltration capacity of the catchments is low and that rainfall is likely to be quickly reflected in surface water discharge.

9.5.23 Figure 9.2 provides information on the flow direction of the surface runoff within the site. Flow accumulation is based on the 5m resolution DTM of the area occupied by the proposed development. The flow accumulation represents the volume of water that would flow into each 5m cell of the DTM, assuming that all water becomes runoff and there was no interception, evapotranspiration or infiltration. The volume of accumulation is represented in greyscale with higher flow accumulations being darker in shade to areas with lower flow accumulation. This figure illustrates the influence of topography on the accumulation and direction of surface water runoff across the site.

9.5.24 Figure 9.3 provides information on how the topography influences the surface saturation of the peat and soils across the site. The analysis of the DTM derived a topographic wetness index (TWI). The TWI is a dimensionless index, defined by the equation: ln (a/tan b) where a = area draining through a point from an upslope contributing area and tan b = the local slope angle. The index provides results on the hydrological similarity of peat. All points with the same value of the index are assumed to respond in a similar hydrological manner. High index values will tend to saturate first and will therefore indicate potential subsurface or high surface runoff areas.

9.5.25 As shown in Figure 9.3, the TWI for the site has identified those areas where water will accumulate on-site and result in saturation of the surrounding peat. The highest values (25 plus) in the TWI form linear channels or where areas have a tendency to become saturated, are shown in blue and drier areas where there may be less tendency for the ground to saturate, are shown in yellow and orange. The dark blue linear channels are considered to show achievable flow rates that are likely to occur throughout the year or during extreme rainfall events. The lighter blue is likely to represent areas of the site where the topography allows the accumulation and saturation of peat and soils from subsurface or surface during prolonged and/or intense rainfall events. Whilst it is recognised that other areas of the proposed development are likely to become saturated, it is expected that any saturation will be dependent upon climatic conditions such as the intensity and duration of rainfall. Figure 9.3 suggests that away from the watercourses and riparian corridors, that the site is generally quite dry with TWI at the lower end of the range.

Flood Risk

9.5.26 The assessment has been carried out in accordance with Scottish Planning Policy (SPP) (Scottish Government, 2014). 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."*

9.5.27 The Flood Risk Management (Scotland) Act sets in place a statutory framework for delivering a sustainable and risk-based approach to managing flooding (Scottish Government, 2009). 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.

9.5.28 Local Planning Policy IN7: Flooding and Development states that "the avoidance principle is the most sustainable form of flood management but where a proposed development could lead to an unacceptable flood risk, it may be that a Flood Risk Assessment (FRA) is able to clarify to the satisfaction of the Council and SEPA that the level of risk both on and off-site would be acceptable."

9.5.29 The following paragraphs outline the results of the assessment for determining flood risk.

Fluvial Flooding Sources

9.5.30 Flood information available on the SEPA Flood Map indicates that the Wauchope Water and the Kerr Burn/Glenzier Burn and the lower catchment of the River Sark have a high likelihood of fluvial (watercourse) flooding in any given year. The areas indicated do not extend much beyond the riparian corridor. No other tributaries of the catchments shown on Figure 9.1 have been highlighted as being at a risk of fluvial flooding.

9.5.31 All the catchments within the site discharge into the River Esk. Downstream of the site, where the Wauchope Water joins the River Esk at Langholm, the High Street is indicated as at risk for flooding encompassing residential and commercial areas.

9.5.32 The overall fluvial derived flood risk within the site boundary is considered low.

Pluvial Flooding Sources

9.5.33 Flood information available on the SEPA Flood Map indicates that small, isolated areas have been highlighted as having a medium to high likelihood of pluvial (surface water) flooding.

9.5.34 The potential for flooded areas remains within the watercourse channels throughout the site.

9.5.35 The most significant area at risk of pluvial flooding outside the site boundary encompasses the valley floor at Langholm High Street and is predominately classified at high risk, although the extent of the area at risk is reduced when compared to fluvial flooding risk extent.

Coastal Flooding Sources

9.5.36 The proposed development is located approximately 20km from the nearest coast and due to this distance along with the topographical position, the proposed development will not be affected by coastal flooding.

Groundwater Flooding Sources

9.5.37 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 mid or late winter).

9.5.38 Groundwater flooding is often associated with the shallow unconsolidated sedimentary aquifers that overlie sediments with no / very low permeability. Such aquifers are susceptible to flooding as the storage capacity within these deposits is often low, which combined with high direct rainfall recharge, can subsequently increase the water levels within the groundwater and providing a good hydraulic connection with adjacent river networks.

9.5.39 Flood information available on the SEPA website indicates that the Bloch Burn located at the east of the site and within the site boundary is at low risk of groundwater flooding. This includes the Wauchope Water downstream of the Bloch Burn joining and the River Esk. This is part of the Dumfries Nith (Potentially Vulnerable Area 14/05).

9.5.40 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. The SEPA website indicates that the remainder of the site is not at risk of groundwater flooding.

Flooding from Artificial Drainage Systems

9.5.41 There is extensive evidence of artificial drainage associated with the upland moorland habitat management which appears to be predominately managed for sheep grazing (see Photograph 9.7). There is the potential that this artificial drainage could cause some localised flooding by increasing runoff rates to the natural watercourses within the catchments. At the time of the site visits there was no flows observed within the artificial drainage channels and very little standing water was observed across the site.

Photograph 9.7: Drainage ditch near T4 (western section of site at E330683, N580198) [left] and artificial drainage channels evident in area of deeper peat which could benefit from ditch blocking near T7 (central section of site E332022, N580542) [right]

Cumulative Flood Risk

9.5.42 Without appropriate drainage mitigation being in place the proposed infrastructure has the potential to increase flood risk especially to vulnerable areas downstream of the proposed development by altering existing runoff and flow regimes.

Water Quality

9.5.43 Several waterbodies within the vicinity of the site have been classified under SEPA's River Basin Management Plans (RBMP). The RBMP are one of the requirements of the Water Framework Directive (WFD) (2000/60/EC) and are the plans designed for protecting and improving the water environment. Table 9.9 details the classified watercourses, water bodies and groundwater bodies associated with the proposed development.

Table 9.9: RBMP classification of surface and ground waterbodies within the vicinity of the Proposed Development

Water Body	Catchment	Current Overall Status (2020)	Reason for Classification	Target Status 2027	Target Status Long Term
Wauchope/Logan Water (ID: 10684)	River Esk	Moderate	Unknown pressure on water animals and plants	Good	Good
Glenzier Burn (ID: 10759)	River Esk	Moderate	Water quality impacted by diffuse source pressures from rural sources	Moderate	Good
East Dumfrieshire groundwater (ID: 150690)	Solway	Good	Overall status Good	Good	Good

9.5.44 Other watercourses within the proposed development are not classified within the RBMP.

Fisheries and Recreation

9.5.45 The watercourses within the proposed development (Collin Burn, Back Burn, Bloch Burn) all drain into the River Esk and represent important fish supporting watercourses. The Border Esk supports an important salmon and sea trout fishery. The river and its burns also support a range of protected fish species including Atlantic salmon, sea trout, European eels and Lamprey species.

9.5.46 Further information on fish populations and monitoring can be found in Chapter 7: Terrestrial Ecology of this EIA Report, and Technical Appendix 7.4.

Water Resources

Water Use Authorisations

9.5.47 Following consultation, no abstractions or discharges were identified as being potentially hydrologically connected with the site.

Private Water Supplies

9.5.48 DGC provided information on PWS abstractions, both domestic and commercial, within 3km of the proposed development. There are nine PWS sources within the 3km search area serving 15 properties. The locations are presented in Figure 9.1. Bigholms Cottages (ID A), Bloch Farm (ID I) and Bloch Steading (ID E) are situated between 0.2-0.7km downgradient and within the same catchment as the proposed development. All other identified PWS sources are considered at negligible risk and were screened out from the assessment because they were hydrologically unconnected to the proposed development. Further information on PWS and PWS mitigation is available in Technical Appendix 9.4: Private Water Supply Risk Assessment.

Peat and Soils

9.5.49 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 provided by Scotland's Environment which brings together data from public organisations across Scotland including BGS, JHI, NatureScot and SEPA.

9.5.50 The generalised soil type according to the National Soil Map of Scotland within the site is peaty gleys of the Canonbie Association comprising of soils developed on drifts derived from Permian and Carboniferous sandstones and shales (Figure 9.4).

9.5.51 The Carbon and Peatland Map presented in Figure 9.5 shows a dominance of Class 3 (predominately peaty soil with some peat soil) across most of the site. Class 3 soils are not priority peatland habitat as only occasionally are peatland habitats found. There are some areas identified as consisting of Class 1 soils which are considered to be of national importance. Class 1 is found on Collin Hags, Whaup Knowe/Healy Hill and Bloch Hill. The remaining areas are comprised of smaller sections of Class 4 (Predominately mineral soil with some peat soil) and Class 5 (No peatland vegetation).

Peat Survey Results

9.5.52 Peat survey data has been collected in line with the recommended statutory approach, comprising of initial Phase 1 (100m grid) surveys followed by more detailed Phase 2 (targeted) surveys. The peat depth locations and interpreted peat depths are presented in Figure 9.6.

9.5.53 On-site peat surveys undertaken by Natural Power have demonstrated that there is sufficient capacity for excavated peat to be re-used as part of infrastructure dressing and reinstatement on the proposed development. Further details on the peat survey results collected can be found in Technical Appendix 9.2: Peat Management Plan and Technical Appendix 9.3: Peat Slide Risk Assessment.

Effects of Forestry

9.5.54 There is no forestry contained wholly within the site, however there is a very small section of forestry within the central section of site (Bloch Plantation). No forestry activities are proposed that are associated with the proposed development.

Hydrogeology

9.5.55 The British Geological Survey GeoIndex Onshore 1:625,000 scale online mapping indicates that the site is underlain by aquifers with moderate productivity (yields up to 10L/s). Flow is virtually all through fractures and other discontinuities. Secondary B aquifers are mainly lower permeability layers that may store and yield limited amounts of groundwater through fissures and openings or eroded layers.

9.5.56 The Bedrock Geology (BGS, 1:50,000 scale) of the proposed development (Figure 9.9) is split into three separate units all formed during the Carboniferous period and comprised of sedimentary rocks that are fluvial in origin. To the north and west of the site, Ballagan Formation - Sandstone, siltstone and dolomitic limestone. To the south of the site, Border Group – Sandstone, siltstone and mudstone. To the north-east of the site, Whita Sandstone Beds – Sandstone.

9.5.57 There are some undefined faults that are predominately found to strike at a north-west to south-easterly direction.

9.5.58 Overlying the bedrock, the Superficial Deposits (BGS, 1:50,000 scale) of the proposed development (Figure 9.10) are comprised of Quaternary tills with interspersed areas of peat, alluvium and sedimentary deposits (clay, silt, sand, gravel, boulders).

9.5.59 The peat and alluvium may host a shallow superficial aquifer. Alluvium with a high content of sand and gravel deposited by glacial meltwater rivers of post-glacial riverine processes, will have highest permeability. The alluvium and peat make up a very small part of the superficial deposits compared to the till, with the alluvium found near existing water channels and the peat found in small, isolated patches across the site. Conversely, the till will comprise of finer grained, lower permeability sediments such as silts and clays, and therefore water transmission will be more limited. The hill tops and steeper sections across the site are recorded as having no superficial deposits.

9.5.60 In lower lying areas of lesser relief, the water table generally occurs just below the surface. However, the proposed development is primarily located on moderately impermeable catchments with a high density of drainage ditches identified across the site. These were used as part of historical land improvement measures (further details provided in Technical Appendix 9.6: Watercourse Assessment).

Groundwater Dependant Terrestrial Ecosystems

9.5.61 SEPA's wind farm planning guidance (SEPA, 2017) states a National Vegetation Classification (NVC) survey should be undertaken to identify wetland areas that might be dependent on groundwater. If potential GWDTE are identified within (a) 100m of proposed excavations less than 1m deep (e.g. roads, tracks and trenches), or (b) within 250m of excavations deeper than 1m (e.g. excavated tracks, borrow pits and foundations), then it is necessary to assess how the potential GWDTE may be affected by the proposed development.

9.5.62 SEPAs wind farm planning guidance (SEPA, 2017) has been used to inform the design of the proposed development. For details see Chapter 3: Design Evolution and Alternatives where areas of potential GWDTE have been identified and assessed accordingly. In line with SEPA guidance, an NVC survey data has been used to identify areas of possible GWDTE and site works have then been completed to assess whether the potential GWDTE is actually sustained by groundwater or not.

9.5.63 A description of the NVC mapping is given in Chapter 7: Terrestrial Ecology. Figure 9.8a shows areas of potential GWDTE, the proposed site infrastructure, and 100m / 250m buffers to the infrastructure as stipulated in SEPA guidance. Figure 9.8b shows areas of actual GWDTE with further details available in Technical Appendix 9.5: Groundwater Dependant Terrestrial Ecosystems Assessment.

Modifying Influences

9.5.64 Information regarding climate change was obtained from the UK Climate Projections (UKCP18) website (Met Office, 2020). 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 (25km), Global (60km), Regional (12km) and Local (2.2km) projections.

9.5.65 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.

9.5.66 It is suggested that increased temperatures in the summer could also increase evapotranspiration and potentially cause desiccation of peat (Scottish Government, 2008). 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. This should be considered when working around the areas where peat is recorded.

Future Baseline

9.5.67 The widespread occurrence of artificial ditches and the reduced permeability of the degraded bog habitats mean that potential increases in rainfall as depicted in Modifying Influences (as a result of climate change), could continue to increase soil erosion and place additional stresses upon nearby water resources. The outline Habitat Management Plan (see Technical Appendix 7.6) proposes that some artificial ditches affected by past drainage will be blocked to encourage re-wetting with the aim of enhancing peatland habitats and provide an improved source of invertebrate food for breeding waders and other ground-nesting birds.

9.5.68 Riparian tree planting, using native deciduous species will take place as part of a program of environmental betterment, which without the proposed development is unlikely to otherwise occur.

9.5.69 It is considered that the environmental benefit afforded through associated habitat and NFM proposals will be more favourable than those which could be provided as part of any alternative development proposals or just leaving the site boundary in its current state. Further details are provided in Technical Appendix 7.6: Outline Habitat Management Plan.

9.6 Assessment of Potential Effects

Receptor Sensitivity

9.6.1 On the basis of the baseline surveys and available information, Table 9.10 below presents the sensitivity of the identified receptors based on the criteria outlined earlier in Table 9.4.

Table 9.10: Justification for Receptor Sensitivity

Receptor	Sensitivity	Reason for Sensitivity
Surface Water Quality		
On-site Watercourses	Medium	None of the on-site watercourses are designated under RBMP, however receiving watercourses downstream are classified as having Moderate status. The Wauchope/Logan Water and Glenzier Burn are designated under RBMP. From the on-site watercourses, the Collin Burn, Back Burn and Bloch Burn drain into the Wauchope/Logan Water. The Kerr Burn drains into the Glenzier Burn. The watercourses draining the proposed development support water quality in downstream fisheries.
Flood Risk		
The proposed development	Low	Only very limited areas of the proposed development fall within the flood inundation envelope (i.e. only at lower catchment watercourse crossing locations).

Receptor	Sensitivity	Reason for Sensitivity
Watercourses 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.
Water Resources		
Private Water Supplies	High	Private Water Supplies are of low regional importance, but high in a local context from the perspective of the PWS User.
Fisheries and Recreation	Medium	The River Esk represents an important fish supporting watercourse.
Soils & Peat		
Site soils and peat < 0.5m depth	Low	Over half of the surveyed soils (55%) are less than 0.5m deep and therefore not classified as peat.
Site soils and peat > 0.5m depth	High	There are several small areas of deeper peat which are also identified as consisting of Class 1 soils which are considered to be of national importance.
Geology		
Geology	Low	Geology is typical of wider area with no designated sites of geological interest located within the proposed development or in a location downstream that could be impacted by the proposed development.
Designations	Medium	Off-site area near Bigholms Burn designated as Geological SSSI.
Hydrogeology		
Groundwater within Peat	Medium	Owing to the medium permeability of the underlying bedrock across most of the proposed development, the peat may host a shallow superficial aquifer which is vulnerable to pollutants that are not readily absorbed or transformed.
Underlying Groundwater	Medium	Groundwater is likely to be of limited resource potential but on account of geological conditions may be vulnerable to pollution due to limited attenuation capacity
GWDTE	Medium	Available information does not suggest a strong GW component associated with identified possible GWDTE within the site. Notwithstanding, localised hydrogeological conditions may partially nourish some of the identified habitats in combination with surface waters. Whilst not of national or regional importance, such habitats are still protected under the WFD.

Construction Effects

9.6.2 The potential for 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 potential effects associated with the construction of the proposed development is discussed and assessed in the following sections.

9.6.3 The evaluation of construction effects is provided in Table 9.11. The assessment results assume the successful implementation of the embedded good practice mitigation measures provided in Section 9.6.

Pollution Incidents

9.6.4 During the construction phase, a number of potential pollutants will be present on-site, including oil, fuels, chemicals, unset cement and concrete, waste and wastewater from construction activities and staff welfare facilities. The majority of these potential pollutants will be located or stored within the construction compound located within the Kerr Burn catchment. 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 & Sedimentation

9.6.5 Soil and sediment generation may occur in areas where the ground has been disturbed, particularly where surface run-off has been concentrated. Drainage ditches are particularly prone to this problem, 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.

9.6.6 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.

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

Changes in Water Quality

9.6.8 Excavation and disturbance of soils, subsoils and peat could result in changes in the chemistry of surface water run-off including colour, dissolved organic carbon (DOC), turbidity and dissolved metals. As with erosion and sedimentation, this can have implications on both the quality of the aquatic habitat and also the resource potential of the water itself.

9.6.9 Potential pollutants coming into contact with bedrock or the superficial sediments also have the potential to alter the quality of the groundwater resource. Such alterations including changes in pH or addition of chemicals, could be difficult to rectify and due to the fractured nature of the bedrock and limited extent of any superficial aquifer would attenuate very slowly.

Increases in Run-off

9.6.10 Wind turbine foundations, hardstands and access tracks will act as impermeable areas, restricting the natural movement of water within the hydrological environment, potentially resulting in increased rates of run-off into the on-site and downstream catchments.

9.6.11 Localised increases in run-off 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.

9.6.12 The relatively impermeable nature of the underlying bedrock and medium permeability of the overlying peat and glacial till within the site will naturally encourage higher rainfall run-off rates. Therefore, the addition of the proposed development infrastructure will not significantly alter the existing baseline hydrological regime and is likely to have a minimal effect on the existing rainfall run-off scenario.

Modification of Surface Drainage Patterns

9.6.13 The interception of diffuse overland flow by the proposed development infrastructure 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 for water quality or quantity (including PWS) and on flood issues downstream of the proposed development.

9.6.14 The high density of artificial drainage ditches currently present on the site is likely to have already significantly modified natural drainage patterns from the proposed development.

Impediments to Surface Water Flow

9.6.15 Watercourse crossings if not properly installed have the potential to impede fish and mammal movement in the riparian corridor.

Modification of Groundwater Flows and Levels

9.6.16 Deep excavations, such as those required for the wind turbine foundations could disrupt the shallow groundwater systems and bedrock geology. The installation of cut-off drains has the potential to lower local groundwater levels within surrounding peat dominated soils.

9.6.17 The majority of temporary and permanent infrastructure (apart from foundations) would be permeable to some extent, however these may locally reduce infiltration capacity.

9.6.18 Access tracks and other linear infrastructure elements such as cable trenches have the potential to disrupt flow pathways as granular backfill may create preferential infiltration and throughflow pathways. These may interrupt shallow groundwater flow or alter the hydrological regime impacting baseflow to watercourses, GWDTE and PWS.

Compaction of Soils

9.6.19 The movement of construction traffic within the proposed development 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 may damage the vegetation and result in a reduction in the soil permeability and rainfall infiltration, thereby increasing the potential for flood risk and erosion as well as altering groundwater flows and levels.

Assessment of Construction Effects

9.6.20 Table 9.11 identifies the likely construction effects on the identified receptors and their significance assuming the successful implementation of good practice and embedded mitigation measures (Section 9.7).

Table 9.11: Assessment of Construction Effects

Potential effects	Identified receptor(s)	Sensitivity	Magnitude of effect	Significance of effects post mitigation
Water quality effects including: • pollution incidents; • erosion and sedimentation; • acidification; • increase in runoff; • modifications to surface drainage pattern; and • impediments to surface water flow.	Collin Burn	High	Negligible	Negligible
	Black Burn	Medium	Negligible	Negligible
	Cow Sike	Medium	Negligible	Negligible
	Hall Burn	Medium	Negligible	Negligible
	Bloch Burn	Medium	Negligible	Negligible
	Kerr Burn	Medium	Negligible	Negligible
Flooding effects including: • increase in runoff; • modifications to surface drainage patterns; • impediments to surface water flow; and • compaction of soil.	The proposed development	Low	Low	Minor/Negligible
	Downstream of the proposed development	Medium	Low	Minor
Water resource effects including: • pollution incidents; • modifications to surface drainage patterns; • impediments to surface water flow; • modification of groundwater flows and levels; and • compaction of soils.	PWS abstractions that are hydrologically unconnected to site.	High	Negligible	Negligible
	PWS abstractions that are located within catchment of site.	High	Low	Moderate
	PWS abstractions that are located within same aquifer as site.	High	Low	Moderate
Fisheries and recreation effects including: • pollution incidents; • erosion and sedimentation; • acidification; • increase in runoff; • modifications to surface drainage pattern; and • impediments to surface water flow.	River Esk (on-site catchments)	Medium	Low	Minor
Effects to soil including: • pollution incidents; • modifications to surface drainage patterns; • modification of groundwater flows and levels; and • compaction of soils.	Site soils and peat <0.5 m depth	Low	Low	Negligible/Minor
	Site soils and peat >0.5 m depth	High	Low	Moderate
Disruption to local geological features from deep wind turbine excavation and other excavation required for construction.	On-site geology	Low	Low	Negligible/Minor
	Designated geology	Medium	Low	Minor
Hydrogeological effects including: • pollution incidents; and • modification of groundwater flows and levels.	Underlying groundwater aquifers	Medium	Low	Minor
	Groundwater within peat	Medium	Low	Minor
	GWDTE	Medium	Low	Minor

Operational Effects

9.6.21 The effects of the proposed development will be substantially lower during the operational phase. The following paragraphs discuss and assess the potential effects that are predicted to occur during the operational phase of the proposed development.

Pollution Incidents

9.6.22 The potential risk of pollution is substantially lower during operation than during construction because of the reduced levels of activity in the operational phase. Most potential pollutants will have been removed when construction was completed; however, lubricants for wind turbine gearboxes, and transformer oils may be stored on-site and there is the risk of possible fuel leaks from maintenance vehicles whilst on-site.

Erosion & Sedimentation

9.6.23 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 are still possible on the access tracks and drainage ditches as a result of scouring during extreme rainfall events. Similarly, there could be some short term increases to erosion and sedimentation around new stream crossings as watercourses reach new equilibrium primarily within the construction and early in the operational phases of the proposed development.

Changes in Water Quality

9.6.24 During the operation phase there will be no continued construction works associated with excavation and exposure of soils, peat and sediments. Opportunities for erosion and transportation of materials will be considerably reduced during the operational phase as previously exposed surfaces become vegetated.

Increases in Runoff

9.6.25 Some of the drainage management features such as silt ponds and silt fencing will be dismantled, with retained features designed to blend into the landscape, but also provide protection against erosion. A reduction in the number of drainage management features overall is likely to reduce the rate of runoff compared to the construction phase with permeant drainage designed to mimic greenfield hydrological regimes.

Modification of surface drainage patterns

9.6.26 Modification of surface runoff will occur as a result of the construction of the new infrastructure associated with the proposed development. The operational effects could result in changes to volume and/or changes to runoff rate, however the permeant drainage will be designed to avoid this.

Impediments to Surface Water Flow

9.6.27 During the operational phase impediments to flows can generally occur as a result from blockages to watercourse crossings, ditches and watercourses themselves, resulting from vegetation and erosion debris. The cost of maintaining the mitigation measure shall be met by the Operator through the lifetime of the planning permission.

Modification of Groundwater Flows and Levels

9.6.28 Cut tracks and their drainage as well as wind turbine foundations and hardstands will potentially alter the water table within the upslope and downslope peat and bedrock groundwater, which can also have implications for the long-term functionality of peatland environments.

Compaction of Soils

9.6.29 The compaction of soils/peat will be significantly reduced during the operational phase as a result of settlement of infrastructure following initial construction and significantly reduced traffic movements.

Assessment of Predicted Operation Effects

9.6.30 Table 9.12 identifies the likely operational effects on the identified receptors and their significance based on the successful implementation of good practice and embedded mitigation measures (Section 9.7).

Table 9.12: Assessment of Operational Effects

Potential effects	Identified receptor(s)	Sensitivity	Magnitude of effect	Significance of effects post mitigation
Water quality effects including: • pollution incidents; • erosion and sedimentation; • acidification; • increase in runoff; • modifications to surface drainage pattern; and • impediments to surface water flow.	Collin Burn	High	Negligible	Negligible
	Black Burn	Medium	Negligible	Negligible
	Cow Sike	Medium	Negligible	Negligible
	Hall Burn	Medium	Negligible	Negligible
	Bloch Burn	Medium	Negligible	Negligible
	Kerr Burn	Medium	Negligible	Negligible
Flooding effects including: • increase in runoff; • modifications to surface drainage patterns; • impediments to surface water flow; and • compaction of soil.	The proposed development	Low	Negligible	Negligible
	Downstream of the proposed development	Medium	Negligible	Negligible
Water resource effects including: • pollution incidents; • modifications to surface drainage patterns; • impediments to surface water flow; • modification of groundwater flows and levels; and • compaction of soils.	PWS abstractions that are hydrologically unconnected to site.	High	Negligible	Negligible
	PWS abstractions that are located within catchment of site.	High	Negligible	Negligible
	PWS abstractions that are located within same aquifer as site.	High	Negligible	Negligible
Fisheries and recreation effects including: • pollution incidents; • erosion and sedimentation; • acidification; • increase in runoff; • modifications to surface drainage pattern; and • impediments to surface water flow.	River Esk (on-site catchments)	Medium	Negligible	Negligible
Effects to soil including: • pollution incidents; • modifications to surface drainage patterns; • modification of groundwater flows and levels; and • compaction of soils.	Site soils and peat <0.5 m depth	Low	Negligible	Negligible
	Site soils and peat >0.5 m depth	High	Negligible	Negligible
Disruption to local geological features from deep wind turbine excavation and other excavation required for construction.	On-site geology	Low	Negligible	Negligible
	Designated geology	Medium	Negligible	Negligible
Hydrogeological effects including: • pollution incidents; and • modification of groundwater flows and levels.	Underlying groundwater aquifers	Medium	Negligible	Negligible
	Groundwater within peat	Medium	Negligible	Negligible
	GWDTE	Medium	Negligible	Negligible

Decommissioning Effects

9.6.31 During decommissioning of the proposed development, potential impacts on the geological, hydrological and hydrogeological, 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.

9.6.32 The decommissioning of the proposed development will adhere to the latest legislative and guidance requirements at the time.

9.7 Mitigation

Mitigation by Design

9.7.1 The distribution of the proposed development infrastructure has evolved as additional site-specific information on peat and water resources became available through consultation and on-site survey works. Hydrological receptors and peat soils were identified as key constraints from the outset, and the design has evolved to minimise impacts on these receptors as far as possible. A summary of the hydrological influences on the project layout are given below with full details of the project design evolution provided in see Chapter 3: Design Evolution and Alternatives of the EIA Report.

9.7.2 The findings of the peat depth survey show that the infrastructure has, as far as possible, when taking into account other environmental and engineering constraints, been sited outside areas of deep peat (>1.0m thickness).

9.7.3 To facilitate the reduction of potential impacts on the hydrological environment a series of set-back distances have been adopted and have been designed proportionately to allow greater protection in more sensitive areas:

- Watercourses mapped on a 1:25,000 scale OS map found across the site were allocated a 50m buffer.

9.7.4 Other embedded mitigation integrated as part of the design of the proposed development is as follows:

- Borrow pits and their search areas associated with the proposed development, have been located across the site to minimise transportation movements of stone. They are located close to the proposed infrastructure and will be restored after use. All of the proposed borrow pits and search areas are located out with 50m from all watercourses marked on a 1:25,000 scale OS map;
- The layout of the access tracks has been designed to minimise impacts on the hydrological environment and as far as possible avoid sensitive receptors such as watercourses, GWDTE and deep peat;
- Four new watercourse crossing locations will be required for the proposed development (Technical Appendix 9.1: Schedule of Watercourse Crossings). The layout of the access tracks has been optimised to reduce the number of new watercourse crossings as far as possible. As identified in Section 9.5, there are a high number of artificial ditches found across the proposed development. As part of the construction program, it is envisaged some of these artificial ditches will be blocked to provide environmental betterment; and
- The detailed design of linear infrastructure elements will be done so to avoid modifying surface water and groundwater flow pathways. This includes the use of permeable materials for access track construction, adoption of a site-wide drainage strategy integrating the use of regular cross drains and soakaways, and the use of regular clay plugs within buried structures such as cable trenches.

Standard Good Practice Mitigation

9.7.5 A number of planning, design and construction proposals have been identified during the assessment. Full details of the good practice construction management and mitigation measures to be implemented will be outlined in a site-specific Construction Environment Management Plan (CEMP) which will be prepared post consent as part of the conditions discharge process. An outline CEMP is provided as Technical Appendix 2.1.

Additional Mitigation and Monitoring

9.7.6 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 standard good practice and embedded mitigation to further reduce measurable impacts. The recommendations outlined will be incorporated into the CEMP post-consent.

9.7.7 Site-specific mitigation will be undertaken at the some of the PWS situated adjacent to or within the site, as outlined in Technical Appendix 9.4: Private Water Supply Risk Assessment. This will include the implementation of a series of additional measures for the Bigholms Cottages, Bloch Farm and Bloch Steading PWS:

- Further investigation by the Principal Contractor prior to construction;
- Demarcation of supply and infrastructure and appropriate design of standard good practice mitigation to avoid potential for impact; and
- Establishment of a programme of inspection and monitoring.

9.7.8 A programme of surface water quality monitoring will be finalised post consent, prior to construction. An overview of the proposed monitoring methods is provided below and considers the sensitivities of the on-site and downstream receptors.

9.7.9 The details of any required surface water quality monitoring should be discussed and agreed with SEPA, Marine Scotland and DGC prior to commencement. The extent and the frequency of the monitoring will be proportionate to the level of activity on-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;
- Reduce or remove any impacts on the water environment; and
- Understand the long-term effects of the proposed development on the natural environment.

9.7.10 A baseline surface water quality 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 surface 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 are also established at the same time.

9.7.11 A suitably qualified Environmental Clerk of Works (ECoW) will be employed throughout the construction of the proposed development. The appointed ECoW can provide advice to the Principal Contractor about how environmental effects can be minimised, and what methods can be employed to reduce effects on water quality, soils and associated habitats.

9.7.12 Monitoring will 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.

9.7.13 All construction management and water management techniques are agreed prior to construction. The techniques will be agreed following consultation with SEPA, and DGC. 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 the Controlled Activities Regulations (CAR) with respect to GBR 10 and in particular; clauses d, g and h. In addition to this, if deemed necessary, then PWS monitoring can be undertaken if required.

9.7.14 SEPA requirements under CAR brought in by the Water Environment (Miscellaneous) (Scotland) Regulations 2017 impose the need for individual sites to require a site-specific site license 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 >5km or which includes any area >1 hectare or >500m on ground with slope >25º.

9.7.15 Information that can be used to support license applications under CAR would be taken from this chapter of the EIA Report as well as Technical Appendix 2.3 Outline PPP. Further information on the final drainage design would also be required, which would be available post-consent.

9.8 Assessment of Residual Effects

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

9.8.2 This has identified that there will be no significant effects from the proposed development on the geological, hydrological and hydrogeological environment and therefore it can be concluded that no residual effects will take place.

9.9 Assessment of Cumulative Effects

Predicted Cumulative Effects

9.9.1 A cumulative impact is considered to be the impact on a hydrological, hydrogeological or geological receptor arising from the proposed development in combination with other developments which are likely to affect surface water, groundwater or geology. Developments (operational, consented and in planning) within the same catchment as the proposed development and within a distance of 2km from the proposed development have been considered. Cumulative impacts are considered using the same methodology as for impacts of the proposed development in isolation.

9.9.2 Solwaybank Wind Farm is an operational wind farm located adjacent to the proposed development. The on-site catchments are hydrologically unconnected to the proposed development but do drain into the same wider catchment areas, the Kirtle Water (empties into estuary of the Border Esk) and the River Sark (flows into estuary of River Esk).

9.9.3 Off-site cumulative hydrological effects are primary related to changes in water quality and increases in flood risk. Mitigation has been presented in Section 9.6 to adequately protect hydrological receptors and therefore will be suitable to ensure the protection of those situated downstream, and should not contribute to or exacerbate any effects arising from other developments, land uses or activities. With regards to flood risk specifically, the design of the drainage will mimic the existing hydrological and greenfield regime of the site, as outlined in Section 9.6.

9.9.4 It is concluded that following the successful implementation of the mitigation outlined in Section 9.7 and Technical Appendix 2.1: Outline CEMP, cumulative impacts of the proposed development during construction, operation and decommissioning will be **negligible**.

9.10 Summary

9.10.1 An assessment has been carried out of the likely impacts of the proposed development on the geological, hydrological, hydrogeological, geological environment. The assessment has considered site preparation, construction and operation of the proposed development.

9.10.2 The potential effects have considered:

- Pollution incidents;
- Erosion and sedimentation;
- Changes in water quality;
- Changes to water resources i.e. PWS;
- Modification of surface water and groundwater flows;
- Modification of natural drainage patterns;
- Impediments to flow and flood risk;
- Peat instability; and
- Compaction of soils.

9.10.3 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. An outline version of the CEMP supports this application in Technical Appendix 2.1 which will be built upon as more site-specific information and ground investigation results are provided post-consent.

9.10.4 The impact assessment has taken into account the hydrological regime, highlighting that the principal effects will occur during the construction phase. Following the successful design and implementation of mitigation measures the significance of construction effects on all identified receptors are not defined as significant. The assessment of predicted operational effects has determined that the significance of effects on all receptors to be of no significance. Table 9.13 summarises the likely significant environmental effects of the proposed development.

9.10.5 Good practice design and construction of the proposed development delivered through a skilled team of competent workers, with mitigation and compliance monitored in collaboration with SEPA, DGC and other engaged stakeholders, will result in a risk that is considered to be **not significant** in terms of the EIA Regulations.

Table 9.13: Summary of Residual Effects

Likely Significant Effect	Mitigation	Means of Implementation	Residual Effect
Construction effects including: • detrimental impacts to on-site and downstream water quality; • 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); • impacts to PWS on and near the proposed development; and • peaty gleys as a result if interrupting surface and sub-surface drainage pathways.	Appropriate drainage design that incorporates sediment management measures to attenuate and treat runoff from construction activities. Measures will be designed to encourage water retention within peat/soils. Appropriate storage and handling of potential pollutants. Refuelling of construction plant in designated areas. Adoption and agreement on emergency measures should significant effects occur. Appropriate design of watercourse crossings to prevent increased flood risk downstream and allow free passage of fish and mammals. Identification of subsurface hydrological pathways prior to construction.	Hydrological elements of the CEMP can include, but not limited to the following: • A Drainage Management Plan; • Pollution Prevention Plan; • Watercourse crossing assessment (detailed design prior to construction); and • Water quality monitoring programme.	Moderate, Negligible / Minor
Detrimental impacts to on-site and downstream water quality 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) Impacts to PWS on and near to the proposed development Peaty gley soils as a result of interrupting surface and sub-surface drainage pathways	Appropriate drainage design that incorporates sediment management measures to attenuate and treat runoff from construction activities. Measures will be designed to encourage water retention within peat/soils. Appropriate storage and handling of potential pollutants. Refuelling of construction plant in designated areas. Adoption and agreement on emergency measures should significant effects occur. Appropriate design of watercourse crossings to prevent increased flood risk downstream and allow free passage of fish and mammals. Identification of subsurface hydrological pathways prior to construction.	Preparation of site-specific CEMP prior to construction. Hydrological elements of the CEMP can include, but not limited to the following: • A Drainage Management Plan; • Pollution Prevention Plan; • Watercourse crossing assessment (detailed design prior to construction); and • Water quality monitoring programme.	Negligible
Operational effects including: • detrimental impacts to on-site and downstream water quality 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); and • increases to on-site and downstream flood risk as a result of degradation of infrastructure and/or poor.	Appropriate drainage design that incorporates sediment management measures to attenuate and treat runoff from Wind Farm infrastructure. Appropriate storage and handling of potential pollutants. 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). Plan can detail the appropriate monitoring methods, including: Visual monitoring and completion of checklists signed off by SEPA; Regular water quality monitoring for a period post construction to determine potential long terms effects of the proposed development on water quality.	Negligible