7 Hydrology, Hydrogeology, Geology and Soils

Introduction

7.1 This chapter presents the findings of the assessment of potential effects of the Development on hydrology, hydrogeology, geology and soils. It details each of these items in turn, including a baseline description, followed by the identification and assessment of effects on each receptor and where relevant, identification of measures proposed to mitigate potentially significant effects.

7.2 This chapter is supported by the following Appendices, provided as part of the ES:

- **Appendix 7.1: Accompanying Photographs and Diagrams**;
- **Appendix 7.2: Peat Stability Assessment**;
- **Appendix 7.3: Mining Desk Study;**
- **Appendix 7.4: Soil and Water Sampling;**
- **Appendix 7.5: Groundwater Dependant Terrestrial Ecosystems;**
- **Appendix 7.6: Private Water Supplies;** and
- **Appendix 7.7: Watercourse Crossings**.

7.3 A Landslide Susceptibility Report was also prepared, as a supporting document during the preparation of **Appendix 7.2: Peat Stability Assessment**, where it is presented as an addendum.

7.4 Closely associated with this chapter are the following appendices:

- **Appendix 4.1: Borrow Pit Report;**
- **Appendix 4.3: Outline Construction and Decommissioning Environmental Management Plan (CDEMP);**
- **Appendix 4.4: Soil and Peat Management Plan**;
- **Appendix 14.1: Carbon Report.**

7.5 Planning policies of relevance to this assessment are provided in **Chapter 5: Policy Context**.

7.6 Interrelationships of effects with **Chapter 8: Ecology** are also presented within the chapter.

7.7 The assessment was undertaken by the Environment Team at Mouchel, based in Glasgow.

Scope of the Assessment

Effects Assessed in Full

7.8 The following effects have been assessed in full, on the basis that following collation of desk and field based baseline data, modifications to the design and implementation of good practice measures, they were considered to have the potential to be significant:

- Direct effects during construction from chemical or hydrocarbon pollution to surface water, groundwater or soils reducing quality and resource value;
- Indirect effects during construction on surface water quality, groundwater quality or soils due to mobilisation of heavy metals;
- Direct effects during construction from sedimentation upon surface water quality;
- Direct effects during construction that modify surface water drainage patterns, altering hydrological regime, hydromorphology and flood risk;
- Direct effects during construction on groundwater flows and levels, including groundwater dependent terrestrial ecosystems;
- Direct effects during construction on private water supplies, taking account of water quality and yield;
- Direct effects during construction on soils, including loss and compaction; and
- Indirect effects during construction on surface water quality, surface water drainage patterns or soil due to peat instability.

Effects Scoped Out

7.9 Informed by the feedback received at the scoping stage and further consultation undertaken as part of the EIA, collation of desk and field survey information, modifications to the layout design, and application of the good practice measures (detailed in **Appendix 4.2**), professional judgement was applied with reference to the significance criteria, consultation responses and experience from other relevant projects and policy guidance or standards to scope out a number of potential effects from detailed assessment. After taking account of the above factors, the following effects were considered to be not likely to be significant and have thus been scoped out from detailed assessment:

- Direct or indirect effects during construction or operation on any designated sites with hydrological, hydrogeological, geological or soils features identified within designation citation, on the basis that there are no sites designated within the study area for such features with the potential to be adversely effected by the Development due to lack of hydrological connectivity;
- Direct effects during operation from chemical, hydrocarbon or sediment pollution to surface water, groundwater or soil, reducing quality and resource value, on the basis that these are effects more applicable to the construction phase;
- Indirect effects during operation on surface water or groundwater quality due to mobilisation of heavy metals and peat instability, on the basis that these are effects more applicable to the construction phase;
- Direct effects during operation that modify surface water drainage patterns, altering hydrological regime and flood risk, taking account of design considerations and good practice;
- Direct effects during operation on groundwater flows and levels and groundwater dependent terrestrial ecosystems, on the basis that these effects are more applicable to the construction phase plus taking account of design considerations and good practice;
- Direct effects during operation on private water supplies, on the basis that these effects would be more applicable at the construction phase; and
- Indirect effects during operation on surface water quality due to peat instability, on the basis that these effects are more applicable to the construction phase.

Cumulative Effects

7.10 Cumulative effects are additional effects as a result of this Development in combination with other developments currently at the planning, consented, construction or operational stages. Developments within the River Nith catchment (which the Development is solely within) were identified via consultation and have been considered for the assessment of cumulative effects. Geology and soil cumulative effects are considered to be limited to the Development area, however surface water and groundwater pathways have the potential to cause or exacerbate a wider cumulative effect.

7.11 Other developments considered within the upper River Nith catchment (upstream of Thornhill):

- Glenmuckloch (10km);
- Sandy Knowe (10km);
- Twenty Shilling Hill (10km);
- Ulzieside (10km);
- Sanquhar (11km);
- Whiteside (11km);
- Sanquhar Six (14km);

- Hare Hill Phase 1 (15km);
- Hare Hill Phase 2 (15km); and
- Afton (18km).

7.12 It is acknowledged that within the upper River Nith catchment there will be activities in alternative sectors, such as the pumped hydropower scheme at Glenmuckloch, forestry and agriculture, all of which have the potential to cause similar effects to this development, particularly in relation to surface water quality and surface water flow patterns.

7.13 As the Development sits within headwaters of a number of watercourses, there would not be expected to be any cumulative effect from upstream development. However, runoff from this and other developments could contribute to overall water quality and flow within the downstream Crawick Water and Mennock Water or the larger River Nith catchment. There is the potential for flow levels, sediment or mobilised heavy metal levels to be elevated downstream due to cumulative construction activities, particularly if there were coincident construction phases or felling activities.

7.14 Effective 'source' controls will limit each individual development's effects on the upper Nith catchment and it would be anticipated that other sites or activities involving groundworks would follow similar good practice methodology. All other development sites are at least 10km from the Development and thus, dilution and attenuation in the River Nith system will reduce any cumulative effect. Furthermore, the differing construction programming and activities that would be anticipated to occur across various sites reduces the probability that water quality and flow issues would be coincident across a number of intra-catchment sites in a manner that would lead to a notable cumulative effect downstream, particularly when taking account of the higher flow / dilution available within the River Nith.

7.15 After taking account of the above factors, the following cumulative effects were considered to be not likely to be significant and have thus been scoped out from detailed assessment:

- Cumulative effects during construction on pollution of surface water and groundwater, sedimentation of surface water, mobilisation of heavy metals and modifications to surface water drainage patterns, on the basis of large intervening distances, substantial dilution factor, effective 'source' controls and differing construction programmes at various sites to manage water quality and drainage patterns; and
- Cumulative effects during operation on pollution of surface water and groundwater, sedimentation of surface water, mobilisation of heavy metals and modifications to surface water drainage patterns, on the basis that of large intervening distances, substantial dilution factor and effective 'source' controls at various sites to manage drainage patterns.

Assessment Methodology

Legislation and Guidance

Legislation

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

- Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000, as amended;
- Water Environment and Water Services (Scotland) Act 2003;
- Water Environment (Controlled Activities) (Scotland) Regulations 2011, as amended;
- Private Water Supplies (Scotland) Regulations 2006; and
- Electricity Act 1989.

Guidance

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

- CIRIA Report C532, Control of water pollution from construction sites: Guidance for consultants and contractors;
- CIRIA Report C648, Control of water pollution from linear construction projects: Technical guidance;
- CIRIA Report C649, Control of water pollution from linear construction sites: Site guide;
- CIRIA Report C753, The SUDS Manual;
- Forestry Commission (2011) Forests & water guidelines, 5th Edition;
- Scottish Executive (2012) River crossings & migratory fish: Design guidance;
- Scottish Executive (2006) Peat landslide hazard and risk assessments: Best practice guide for proposed electricity generation developments;
- Scottish Natural Heritage (2014) Siting and Designing Wind Farms in the Landscape;
- Scottish Natural Heritage (2014) A handbook on environmental impact assessment;
- Scottish Natural Heritage (2001) Guidelines on the environmental impacts of windfarms and small scale hydroelectric schemes;
- Scottish Natural Heritage and Forestry Commission (2010) Floating roads on peat;
- Scottish Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) A Practical Guide;
- Scottish Environment Protection Agency Policy No. 19, Groundwater protection policy for Scotland;
- Scottish Environment Protection Agency Position Statement WAT-PS-06-02, Culverting of watercourses;
- Scottish Environment Protection Agency WAT-SG-25, Good practice guide - river crossings;
- Scottish Environment Protection Agency WAT-SG-31, Special requirements for civil engineering contracts for the prevention of pollution;
- Scottish Environment Protection Agency (2010) Regulatory Position Statement – Developments on Peat;
- Scottish Environment Protection Agency (2014) Land Use Planning System SEPA Guidance Note 31, Guidance on Assessing the Impacts of Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems;
- Scottish Renewables / Scottish Environment Protection Agency (2012) Developments on Peatland: Guidance on the assessment of peat volumes, reuse of excavated peat and the minimisation of waste; and
- Scottish Renewables (2015) Good Practice during Windfarm Construction (co-authored by Scottish Natural Heritage, Scottish Environment Protection Agency, Forestry Commission Scotland, and Historic Environment Scotland).

7.18 The following Scottish Environment Protection Agency (SEPA) (jointly with the Environment Agency and the Northern Ireland Environment Agency) Pollution Prevention Guidelines have also been considered:

- PPG1 General guide to the prevention of pollution;
- PPG2 Above ground oil storage;
- PPG3 The use and design of oil separators in surface water drainage systems;
- PPG4 Treatment and disposal of sewage where no foul sewer is available;
- PPG5 Works and maintenance in or near water;
- PPG6 Working at construction and demolition sites;
- PPG7 Safe operation of refuelling facilities;
- PPG8 Storage and disposal of used oils;
- PPG13 Vehicle washing and cleaning;
- PPG18 Managing fire water and major spillages;
- PPG21 Pollution incident response planning;
- PPG22 Incident response - dealing with spills; and
- PPG26 Safe Storage – Drum and intermediate bulk containers.

Consultation

7.19 **Table 7.1** summarises the consultation undertaken as part of assessment. The response/action taken to points raised by consultees is shown within the table, showing where the issue has been assessed, or where the Development has been altered in relation to the issue.

Table 7.1: Consultation Responses

Consultee and Date	Scoping/ Other Consultation	Issue Raised	Response/Action Taken
Scottish Government Local Energy and Consents Unit (LECU) 17th May 2016	Scoping	The extent of former underground mine workings and mine wastes should be considered, and that the application should include a detailed study of site geology to assess the impact of excavation on underlying geology.	A Mining Desk Study is presented as **Appendix 7.3**.
		Special consideration to be given to any possible impacts on identified private water supplies (PWS), Groundwater dependent terrestrial ecosystems (GWDTE) and the wider water environment.	PWS, GWTDE and the wider water environment are identified and assessed in the Existing Conditions and Assessment of Effects sections of this chapter and **Appendices 7.5 and 7.6**.
Dumfries and Galloway Council (D&GC) Environmental Health Officer (EHO) 25th February 2016	Scoping via LECU	Requested that a Construction Method Statement (CMS) be included in EIA.	This is provided as **Appendix 4.3: CDEMP**.
South Lanarkshire Council (SLC) Planning Services 4th March 2016	Scoping via LECU	ES should contain comprehensive surveys regarding the hydrological impacts on peatland environment within South Lanarkshire to determine effects on the peatland resource in South Lanarkshire.	Peat survey undertaken to locate infrastructure away from disturbing deeper peat and hydrological effects on peatland environment are identified and assessed in the Existing Conditions and Assessment of Effects sections of this chapter GWDTE are identified and assessed in the Existing Conditions and Assessment of Effects sections of this chapter. A Peat Stability Assessment is provided as **Appendix 7.2**. A Soil and Peat Management Plan is provided as **Appendix 4.2**.
SEPA 23rd February 2016	Scoping via LECU	ES should address concerns regarding that large scale deep construction work may release further metal loadings into the catchments of Wanlock Water and Crawick Water, impacting water quality.	A Mining Desk Study is presented as **Appendix 7.3**, with soil and water sampling results provided in **Appendix 7.4**. Pollution prevention good practice measures, mitigation and drainage measures are outlined in **Appendix 4.3**.
		ES should include a summary demonstrating how the Development has been designed with regards to layout and mitigation to minimise release of CO_2 and preventative/mitigation measures for construction within peat environments.	This is included in **Appendix 14.1**.
		Phase 1 Habitat Survey to be conducted, including micro-siting distances, in order to assess the potential risk to GWDTE and groundwater abstractions (Public and PWS) at the following distances: a) within 100m radius of all excavations shallower than 1m b) within 250m of all excavations deeper than 1m	A National Vegetation Classification (NVC) Survey is included within **Chapter 8: Ecology**. GWDTE are identified and assessed in the Existing Conditions and Assessment of Effects sections of this chapter. Groundwater abstractions (public and private water supplies) are identified and assessed in the Existing Conditions and Assessment of Effects sections of this chapter plus **Appendix 7.6**.
		ES should include detailed risk assessments for the following higher risk GWDTE and groundwater abstractions (Public and PWS): a) Proposed infrastructure within 250m of GWDTE and groundwater abstractions, where the infrastructure excavation deeper than 1m b) For excavations within 100m of GWDTE and groundwater abstractions but shallower than 1m if the applicant will not accept a detailed long term monitoring planning condition	GWDTE are identified and assessed in the Existing Conditions and Assessment of Effects sections of this chapter and **Appendix 7.5**, in accordance with SEPA guidance, with appropriate mitigation and/or monitoring measures identified. Groundwater abstractions (public and private water supplies) are considered in the Existing Conditions and Assessment of Effects sections of this chapter and **Appendix 7.6**, in accordance with SEPA guidance, with appropriate mitigation and/or monitoring measures identified.
		ES should include a detailed peat depth map with infrastructure overlain and a table which contains details of proposed peat quantities and depths to be excavated and reused.	Outputs of peat surveys are provided in the Existing Conditions section of this chapter, with further details included as part of **Appendix 4.2**.
		Production of a Peat Management Plan should be considered.	Provided as **Appendix 4.2**.
		ES should include details of any forestry felling, including how it will be undertaken and managed. ES to assess fell to waste not relate to the improvement in peatland habitats.	Details of forestry felling are included in **Chapter 4: Scheme Description** of the ES and **Appendix 4.2 Forestry**. A Carbon Balance Report taking into account environmental effects from felling for the Development is included as **Appendix 14.1**.
		Details of Public or PWS water abstractions should be obtained and assessed.	Public water supply information was requested from Scottish Water. Private water supply information was obtained from Dumfries and Galloway Council and South Lanarkshire Council and are considered in the Existing Conditions and Assessment of Effects sections of this chapter and **Appendix 7.6**. Abstraction data will include details of the source location, source type, location relative to infrastructure, potential linkage between source and development and appropriate alternative supply, mitigation and/or monitoring (as applicable).

Consultee and Date	Scoping/ Other Consultation	Issue Raised	Response/Action Taken
		Engineering activities such as culverts, bridges, watercourse diversions, bank modifications or dams should be avoided unless there is no practicable alternative. Photographs and details of engineering works, including justification for such activities and proposed mitigation should be included.	Site infrastructure developed with the intention of minimising construction activities within 50m of watercourses and only planning watercourse crossing structures at locations where there are no practical, alternative options available. Details of watercourse crossings are provided in **Appendix 7.7**.
		A Flood Risk Assessment should be submitted with the application if engineering works are likely to lead to increased flood risk to property or people.	Flood risk is considered in the Existing Conditions section of this chapter. Appropriate infrastructure design and good practice drainage measures are considered to attenuate any increases in runoff in local watercourses leading to downstream receptors. Therefore a flood risk assessment is not anticipated to be necessary.
		Draft Schedule of Mitigation recommended to accompany the ES detailing pollution prevention and mitigation measures identified to avoid or minimise environmental effects. Principles of a CDEMP should also be set out in the ES and should outline the way in which the Schedule of Mitigation will be implemented.	**Appendix 4.3** is an Outline Construction and Decommissioning Environment Management Plan. **Appendix 4.3** detailing pollution prevention and mitigation measures included to avoid or minimise environmental effects.
		ES should justify the use of borrow pits in line with SPP paragraph 243 and should provide a map and site specific plan of all those proposed onsite.	Borrow pit locations selected on the basis of providing suitable material, close to demand, and taking account of minimising potential environmental effect. Further details are provided in **Appendix 4.1**.
		The ES should include an assessment of cumulative effects on the water environment.	Other developments in the Development's hydrological catchment were considered and on the basis of intervening distances and good practice measures, cumulative effects have been scoped out.
		Recommended consulting with DGC EHO.	Dumfries and Galloway EHO (and South Lanarkshire Council EHO) contacted and data requested for private water supply information.
SEPA 20th September 2016	Response to suggested approach for establishing soil and water baseline values for heavy metals	SEPA has concerns that large scale deep construction work may release further metal loadings into the catchment unless proper comprehensive pre-development studies are undertaken to understand the geology at the turbine locations/construction areas and whether disturbance of soils, peat and/or bedrock may exacerbate an existing problem. The current desk study which has been undertaken does not take into account the potential for elevated concentrations of heavy metals to be present in the natural soils/bedrock and therefore will not provide a full understanding of the geology at the turbine locations/construction areas. Should the project go ahead, excavations and earthworks will be required and sufficient investigation and assessment of soils across the site is likely to be required in order to ensure that such works do not pose a risk to the water environment through leaching or sediment transportation.	Additional sampling of soils was undertaken across the wider development area to help establish the natural baseline of elevated levels of heavy metal content. This issue is discussed in the Existing Conditions and Assessment of Effects sections of this chapter, with a Mining Desk Study is presented as **Appendix 7.3**, with soil and water sampling results provided in **Appendix 7.4**.

Consultee and Date	Scoping/ Other Consultation	Issue Raised	Response/Action Taken
SEPA 8th March 2017	Response to **Appendix 7.3: Mining Desk Study** and **Appendix 7.4: Soil and Water Sampling Results**	The avoidance of Access C has taken infrastructure away from the area identified as being of high risk from mining activities, infrastructure should also avoid the moderate risk area identified south of Highmill Knowe. Clarification sought that additional characterisation would be undertaken on all excavated soils, not confined to those considered to be in high/moderate risk areas. Suggestion that a metal loading study of local soils and watercourses, under natural conditions would be beneficial. An updated conceptual site model should reflect further data collected. Comparison with Environmental Quality Standards is considered adequate but consideration of bioavailability levels for metals would enhance understanding of likely effect. The use of site-won material for access tracks should be carefully considered and monitored to ensure that metal-rich material, with high leachability potential, is not distributed across the entire site. Groundwater dependent terrestrial ecosystems and private water supplies to be identified and assessed. Abstractions >10m^3/day shall require authorisation, with concerns identified over groundwater abstractions in formerly mined areas due to potential pollution.	Design has avoided crossing moderate risk area, although approximately 100m of track across the ridge of Green Hill runs adjacent to a moderate risk area, where slope constraints prevent an alternative route. Commitment that prior to construction additional baseline soil analysis including rock analysis from borrow pits, revised conceptual model, metal loading study, bioavailability tests and soil characterisation shall be provided as part of the ground investigation process. Groundwater dependent terrestrial ecosystems have been identified and assessed in terms of hydrological linkage using data provided in **Chapter 8: Ecology,** provided in Baseline Conditions and Assessment of Effects sections of this chapter and **Appendix 7.5**. Groundwater abstractions are not planned, with surface water abstractions discussed in the Project Design Considerations section of this chapter. Private water supplies are detailed in **Appendix 7.6**.
Scottish Water 22nd February 2016	Scoping via LECU	No Scottish Water drinking water abstraction sources or wider drinking water catchments in the area, however Scottish Water infrastructure located at the periphery of the site boundary near Sanquhar and at Wanlockhead, and in proximity to the roads proposed to be used for access to the site.	Public water supplies considered in the Existing Conditions section of this chapter. The design has evolved and no site access is now planned in close proximity to either Sanquhar or Wanlockhead settlements where Scottish Water infrastructure is present.

Consultee and Date	Scoping/ Other Consultation	Issue Raised	Response/Action Taken
Marine Scotland 23rd February 2016	Scoping via LECU	ES should include details of all water quality, macroinvertebrate and fish population surveys and proposed monitoring programmes. Cumulative effects on water quality should be considered (felling, lead mining, hydroelectric schemes and windfarm developments).	Macroinvertebrates and fish populations are considered in **Chapter 8: Ecology** of the ES. Aquatic ecology is cross-referenced from **Chapter 8: Ecology** in **Appendix 7.7**. Commencing 1 year prior to construction, monthly monitoring of watercourses shall be undertaken to provide seasonal baseline data to include peak flow and low flow conditions. Details are provided in the Further Survey Requirements and Monitoring section of this chapter. Other developments in the Development's hydrological catchment were considered and on the basis of intervening distances and good practice measures, cumulative effects have been scoped out. Pollution prevention good practice measures, mitigation and drainage measures are outlined in **Appendix 4.3**.
Leadhills Community Council 23rd February 2016	Scoping via LECU	ES should consider the effects of lead pollution should the Development lead to deposits being disturbed.	A Mining Desk Study is presented as **Appendix 7.3**, with soil and water sampling results provided in **Appendix 7.4**.
		ES should include details of how siting infrastructure on peat has been avoided.	The Development has been located outwith areas of peat, where possible. Outputs of peat surveys are provided in the Existing Conditions section of this chapter, with further details and mapping included as part of **Appendix 4.2**.
Wanlockhead Village Council 24th February 2016	Scoping via LECU	Extensive studies should be undertaken to ensure that any area of ground that will be disturbed by the creation of infrastructure, borrow pits, compounds and sub stations does not re-mobilise existing lead.	Site soil surveys have been undertaken to establish baseline conditions and mitigation measures have been identified to minimise potential for mobilisation of lead or other heavy metals. Soil and water sampling results are provided in **Appendix 7.4**.
		ES and design of the Development should take into account old mine workings and effects in relation to mine disturbance should be considered.	The Development has been located outwith areas of previous mine workings. A Mining Desk Study outlining areas of mining history is presented as **Appendix 7.3**. Pollution prevention good practice measures, mitigation and drainage measures are outlined in **Appendix 4.3**.

Consultee and Date	Scoping/ Other Consultation	Issue Raised	Response/Action Taken
		Turbines 27/28/29/30/31 - in the centre of this group there is a planned substation and two borrow pits. Water flow is of concern, with the Glenbuie Burn directly in the path of the development and any additional run off caused by this construction will flow directly into the Mennock Water exacerbating the issue with Archaeology in the area.	The Development design in this central area has evolved, now containing a single borrow pit plus substation and turbines outlined. It is considered that runoff from this area of the Development will flow via local watercourses, including the Glenbuie Burn and Clackleith Burn, to the Crawick Burn, rather than the Mennock Water. Pollution prevention good practice measures, mitigation and drainage measures are outlined **Appendix 4.3**.
		ES should assess the effects of peat disturbance.	Outputs of peat surveys are provided in the Existing Conditions section of this Chapter, with further details and mapping included as part of **Appendix 4.2**. A Peat Stability Assessment is provided as **Appendix 7.2**.
		Turbines 19/20/21 - Turbine 19 and there is also a spring in this vicinity. Damage to the watercourses will feed into the Crawick Water and Glensalloch Burn.	Identification of local hydrology and hydrogeology receptors has formed part of the assessment process. A 50m buffer has been applied for infrastructure based on water features shown on OS 1:10,000 mapping, additionally limiting locations where crossing structures required and planning appropriate type and size of crossing structure. Pollution prevention good practice measures, mitigation and drainage measures are outlined in **Appendix 4.3**.
		Turbine 18 - Borrow pit planned for this area. Run-off of water from Glensalloch Burn to Crawick Water in terms of contamination is also a concern.	The Development design has evolved, no borrow pit planned close to Turbine 18, primarily due to close proximity to Southern Upland Way. A 50m buffer has been applied for infrastructure based on water features shown on OS 1:10,000 mapping, additionally limiting locations where crossing structures required and planning appropriate type and size of crossing structure. Pollution prevention good practice measures, mitigation and drainage measures are outlined in **Appendix 4.3**.
		Turbine 15 - Envisaged that by developing this area there will be additional run off of water from Glensalloch Burn which feeds into Crawick Water, placing these watercourses in danger of further contamination.	A 50m buffer has been applied for infrastructure based on water features shown on OS 1:10,000 mapping, additionally limiting locations where crossing structures required and planning appropriate type and size of crossing structure. Pollution prevention good practice measures, mitigation and drainage measures are outlined in **Appendix 4.3**.
		Suggested that The National Association of Mining History Organisations (NAMHO) be consulted.	NAMHO promotes mining history. Information requested from Coal Authority and The Museum of Lead Mining, Wanlockhead, referenced in **Appendix 7.3**.
		Turbines 1 and 2 - There is the potential for run off of water going into the Glendyne and Sheil Burns, which run into the Mennock Water causing further contamination on an already contaminated river source.	A 50m buffer has been applied for infrastructure based on water features shown on OS 1:10,000 mapping, additionally limiting locations where crossing structures required and planning appropriate type and size of crossing structure. A Mining Desk Study is presented as **Appendix 7.3**, with soil and water sampling results provided in **Appendix 7.4**. Water quality is considered in the Existing Conditions section of this chapter. Pollution prevention good practice measures, mitigation and drainage measures are outlined in **Appendix 4.3**.
The Coal Authority	Data Request	Data obtained on the previous mining in area surrounding Leadhills and Wanlockhead.	Data and reports obtained used to inform this assessment and related appendices.
Dumfries and Galloway Council, Environmental Health 20th July 2016	Data Request	Private water supplies request for 10km area surrounding site centre point of NGR 282900 615000	Data obtained used to inform this assessment and related appendices.
South Lanarkshire Council, Environmental Health 20th July 2016	Data Request	Private water supplies request for 10km area surrounding site centre point of NGR 282900 615000	Data obtained used to inform this assessment and related appendices.

Study Area

7.20 The main study area is based upon the Development Area, with a wider study area of 5 kilometres (km) downstream of the Development Area for surface water derived receptors (following pathways) and 1km from the Development Area for groundwater derived receptors. Although the boundary of the Development Area has been applied to define the study area, planned infrastructure is generally located well within this boundary.locations.

7.21 The wider study area was used to assess potential effects on private water supplies and designations. All other surveys related to this assessment were conducted within the Development Area.

7.22 These study areas are based upon professional judgement and experience of assessing similar developments in upland environments.

7.23 In terms of chemical and sedimentation effects, it is considered that at distances in excess of 5km that the Development is unlikely to have a hydrological effect, as attenuation and dilution of substances is likely to occur.

7.24 The Proposed Development Layout is provided as **Figure 4.1** and an aerial photograph of the Development Area is provided as **Figure 7.1: Aerial Photography**.

Desk Based Research and Data Sources

7.25 The following data sources have been used during this assessment:

- Ordnance Survey (OS) (2016) digital mapping, 1:50,000 and 1:25,000 scale;
- OS (2016) Terrain 5 Digital Terrain Model (DTM) data;
- British Geological Survey (BGS) Geoindex Onshore Bedrock and Superficial Deposits 1:50,000 (interactive web map)[i];
- BGS Hydrogeological Map of Scotland, 1:625,000 scale[ii];
- SNIFFER (Scotland and Northern Ireland Forum for Environmental Research) (2004) Map of Vulnerability of Groundwater in the Uppermost Aquifer, Scotland[iii];
- Soil Survey of Scotland 1:250,000 Sheet 6, mapping of soil types and land capability for agriculture[iv];
- Centre for Ecology & Hydrology (CEH) Flood Estimation Handbook (FEH) Web Service[v];
- Wallingford HydroSolutions LowFlows 2[vi];
- National River Flow Archive (NRFA) (interactive web map)[vii];
- SEPA Flood Risk Map of Scotland (interactive web map)[viii];
- SEPA Water Environment Hub (River Basin Management Planning interactive web map)[ix];
- NVC survey, undertaken by MacArthur Green (2017); and
- SNH (2016) Sitelink Website[x].

7.26 Additional references are included in individual appendices.

Field Surveys

7.27 Field surveys were undertaken by teams with the appropriate experience of assessing hydrology, hydrogeology, geology, soil and peat issues for onshore windfarms in upland environments. These visits were undertaken between June 2016 and February 2017. The weather conditions for the site visits undertaken during 2016 were predominantly dry and mild, with some precipitation. The weather conditions for the site visits undertaken during 2017 were cold with heavy persistent showers, with some snowfall. All visits were undertaken operating under safe working practices.

7.28 The visits focused on gaining a good overall understanding of the hydrological and geological regime of the area, undertaking initial peat probing to feed into the layout constraints for both peat depth and stability, plus verifying details of private water supplies and soil and water sampling. Site walkover activities and local research in relation to historic mining activities involved staff with experience in this specific discipline.

7.29 Peat depth surveys for the Development were undertaken over a number of phases, and are fully detailed in **Appendix 7.2**. Initial peat probing was undertaken in early June 2016 focussing on ridgelines across the Development Area as this was identified as the most likely location for infrastructure to be located. This produced a representative dataset of peat depths across a variety of slope angles, adjacent to stream channels, adjacent to existing tracks and along ridges where potential new tracks will be required. A provisional turbine layout was provided by NLEI Ltd and probed where accessible.

7.30 Following data gathering and processing of the peat depth results, areas of confirmed or likely deeper peat were identified and initial observations relating to peat stability were made (using the factor of safety technique detailed in **Appendix 7.2** but with the abbreviated dataset available at this stage).

7.31 Following this feedback, and additional input from other disciplines, a number of modifications were made to the layout design and the Development Area was revisited in September 2016 and further peat data gathered to refine knowledge of conditions in specific areas. This information informed subsequent modifications to the layout design.

7.32 In December 2016 a specialist geotechnical team visited the Development Area to review landslide susceptibility, visiting areas identified from desktop review using BGS GeoSure landslide digital mapping.

7.33 Upon finalisation of the layout design, the entire infrastructure layout was reviewed to identify locations where further data was required to inform the assessment and these areas were visited in January and February 2017. Access to turbines and associated infrastructure, such as tracks and hardstandings, was restricted in limited areas by dense forestry cover. During this visit, further peat probe records were also gathered at locations close to infrastructure where initial stability concerns were based on indicative rather than actual peat depth results.

7.34 Field techniques used for the peat probing were in accordance with the Scottish Government's Peat Landslide Hazard and Risk Assessment Best Practice Guide[xi] and Floating Road on Peat guidance[xii].

Assessing Significance

7.35 The predicted significance of the effect was determined through a standard method of assessment based on professional judgement, taking into account three key factors:

- Sensitivity of the receiving environment;
- Potential magnitude of the effect; and
- Probability of the effect occurring.

Sensitivity

7.36 The receptor sensitivity represents its ability to absorb the anticipated effect without perceptible change resulting. Three levels of sensitivity have been used, as shown in **Table 7.2**. Evaluation of sensitivity of hydrology, hydrogeology, geology and soils requires a considerable degree of professional judgement, based on defined characteristics and values and calling on experience, which is accordingly applied during evaluation.

Table 7.2: Sensitivity

Sensitivity	Definition
High	• Receptor has 'High' or 'Good' WFD overall status and/or water quality status for surface water or groundwater body; • Receptor is a designated site protected under national or international legislation, such as Sites of Special Scientific Interest (SSSI), Special Area of conservation (SAC), and Special Protection Areas (SPA), for the disciplines assessed in this chapter; • Receptor contains Geological Conservation Review (GCR) sites designated as SSSIs or Candidate SSSIs; • Receptor contains areas of regionally important economic mineral deposits; • Receptor supports significant species and habitats sensitive to changes in suspended sediment concentrations and turbidity, such as salmon or freshwater pearl mussels; • Receptor supports GWTDE confirmed as highly groundwater dependent; • Receptor contains a range of hydromorphological features with very little modification; • Receptor is a watercourse or floodplain, with a possibility of direct flood risk to populated areas, which are sensitive to increased flood risk by the possible increase in water levels; • Receptor provides clear flood alleviation benefits; • Receptor used for abstraction or storage for public water supply or large private water supply serving ≥10 properties; • Class 1 or 2 priority peatland, carbon-rich and peaty soils cover ≥20% of the Development Area; • Receptor is classed a high productivity aquifer; and • Receptor groundwater vulnerability contains classes 5, 4a and 4b.
Medium	• Receptor has 'Moderate' WFD overall status and/or water quality status for surface water or groundwater body; • Receptor contains GCR sites with Local Geodiversity Site (LGS) status; • Receptor contains areas of locally important economic mineral deposits; • Receptor supports GWTDE confirmed as moderately groundwater dependent; • Receptor contains limited hydromorphological features and a limited range of fluvial processes, such areas may have been subject to past modification such as straightening, bank protection and culverting or other anthropogenic pressures; • Receptor is a watercourse or floodplain, with a possibility of direct flood risk to high value agricultural areas, which are moderately sensitive to increased flood risk by the possible increase in water levels; • Receptor provides limited flood alleviation benefits; • Receptor used for abstraction or storage for private water supply serving <10 properties or for agricultural/industrial use; • Class 1 or 2 priority peatland, carbon-rich and peaty soils cover <20% of the Development Area, or Class 3 and 5 peatland areas, carbon rich and peaty soils; • Receptor is classed a moderate or low productivity aquifer; and • Receptor groundwater vulnerability contains classes 2 and 3.
Low	• Receptor has 'Poor' or 'Bad' WFD overall status and/or water quality status for surface water or groundwater body; • Receptor contains GCR sites without SSSI (or Candidate SSSI) designation or LGS status, and non GCR sites with potential geodiversity interest;

Sensitivity	Definition
	• Receptor supports no significant species and habitats sensitive to changes in suspended sediment concentrations and turbidity; • Receptor supports GWTDE based on NVC mapping, with local water sources not considered as predominantly groundwater; • Receptor contains no hydromorphological diversity and/or are identified as 'heavily modified waterbodies' or 'artificial waterbodies'; • Receptor is a watercourse or floodplain which passes through low value agricultural areas, which are less sensitive to increased flood risk by the possible increase in water levels; • Receptor provides limited flood alleviation benefits; • Receptor does not support any water abstractions; • Receptor contains Class -2, -1, 0, and 4 non-peatland areas, with no carbon-rich and peaty soils; • Receptor is classed a very low productivity aquifer; and • Receptor groundwater vulnerability contains classes 0 and 1.

Magnitude

7.37 The magnitude of the effect takes into account the timing, scale, size and duration of the potential effect. Four levels of magnitude have been adopted, as shown in **Table 7.3**.

Table 7.3: Magnitude of Effect

Magnitude	Definition
Major	• Long-term (≥12 months) or permanent change in surface water quality, resulting in a permanent change in WFD status and/or prevention of attainment of target status of 'Good'; • Results in loss of feature(s) and failure of hydromorphological elements (morphology, quantity and dynamics of flow) resulting from the works. Loss or damage to existing habitats. Replacement of natural bed and/or banks with artificial materials. Extensive change to channel planform; • Loss of floodplain due to construction within flood risk area; • Permanent loss of water supply; • Major or total loss of a geological site or mineral deposit, where the value of the site would be severely affected; • Major or total loss of soils or peatland deposits or where the value of the site would be severely affected; • Long-term (≥12 months) or permanent change in groundwater quality, resulting in a permanent change in WFD status and/or prevention of attainment of target status of 'Good'; • Major loss of an aquifer in terms of water level or yield, with total loss of or major changes to dependent abstractions/habitats; and • Major change or total loss of a GWDTE, where the value of the site would be severely affected.
Moderate	• Mid-term (≥6 months) change in local surface water quality, potentially resulting in a temporary change of WFD status (or equivalent status at local scale) or preventing attainment of target overall status of 'Good' during this period; • Results in adverse impact on integrity of feature(s) or loss of part of feature / moderate shift away from baseline conditions. Failure of one or more hydromorphological elements (morphology, quantity and dynamics of flow) resulting from the works. Some damage or loss to habitat due to the modifications. Replacement of the natural bed and/or banks with artificial material; • Floodplain impacts due to extensive increases in impermeable area within catchment and/or drainage design which would result in an increase in peak flood level; • Temporary loss of water supply; • Partial loss of a geological site or mineral deposit, with major effects to the settings, or where the value of the site would be affected; • Partial loss of soils or peatland deposits or where the value of the site would be affected; • Mid-term (≥6 months) change in local groundwater quality, not affecting overall WFD status; • Changes to an aquifer in terms of water level or yield, with small changes to nearby dependent abstractions/habitats; and • Partial change or loss of a GWDTE, where the value of the site would be affected.
Minor	• Short-term (≥1 month) change in local surface water quality, resulting in minor temporary changes such that ecology is affected for short-term. Equivalent to a temporary minor, but measurable, change within WFD status class; • Potential failure in one of hydromorphological elements (morphology, quantity and dynamics of flow) resulting from the works. Results in minor adverse impact on feature / minimal shift away from baseline conditions or partial loss or damage to habitat due to modifications; • Floodplain impacts due to limited increases in impermeable area within catchment and/or drainage design which would result in a minor increase in peak flood level; • Temporarily reduced quality and quantity of water supply; • Small effect on a geological site or mineral deposit, such that the value of the site would not be affected; • Small loss of soils or peatland, or where soils will be disturbed but the value not impacted; • Short-term (≥1 month) change in local groundwater quality;
Negligible	• Small change to an aquifer in terms of water level or yield, with little discernible change to dependent abstractions/habitats; and • Small change to or loss of a GWDTE, where the value of the site would not be affected.
Negligible	• Negligible change to surface water quality, very slight temporary change in water quality with no discernible effect on watercourse ecology; • No alteration to hydromorphological elements. Some impact on feature(s), but of insufficient magnitude to affect the use / integrity, approximating to a 'no change' situation; • Floodplain impacts of negligible change; • No anticipated effect on water supply; • Minimal or no change to a geological site or mineral deposit; • Minimal or no change to soils or peatland deposits; • Negligible change to groundwater quality, very slight temporary change in local water quality; • Minimal or no change to an aquifer in terms of water level or yield, with no discernible change to dependent abstractions/habitats; and • Minimal or no change to or loss of a GWDTE.

Probability

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

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

Significance

7.40 The application of the three criteria considered in the evaluation of the effects have been used via a matrix for each potential effect (see **Table 7.4**) to form a judgement on the significance of the effect.

7.41 Potential effects are concluded to be of major, moderate, minor or negligible significance.

7.42 Major and moderate effects are considered to be significant in the context of the EIA Regulations.

Assessment Limitations

7.43 The fieldwork followed standard 'reconnaissance' field methods in which watercourses were visited close to planned access routes and peat probing was completed on a representative sampling basis initially. Following the provision of the infrastructure design, specific infrastructure locations were visited for peat probe survey and stability assessment, wherever accessible. Some areas of plantation forestry were densely planted and difficult to establish an accurate position using mapping or hand-held GPS units. Hand held GPS units were noted to be only accurate to 15m in such areas.

7.44 Private water supply information was provided by Dumfries and Galloway Council and South Lanarkshire Council. It is recognised that council information may be incomplete and that information on supplies serving abandoned properties and livestock welfare may not be available. However, it is considered unlikely that such types of supply exist at the Development Area.

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

Table 7.4: Significance Matrix

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

Existing Conditions

7.46 The current land use within the Development Area comprises a mix of coniferous woodland plantation at lower altitudes, and open land for rough grazing at higher altitudes. The Development Area covers a number of hills and valleys, including the summits of Glenrae Dod at 411m above ordnance datum (mAOD) in the north, Glengaber Hill at 515mAOD in the central region and Bail Hill at 540mAOD, in the south-east.

7.47 There are numerous relatively small upland streams draining the Development Area. These are the Wanlock Water and its tributaries which drain the northern and eastern areas of the Development Area, flowing north to join Crawick Water/Spango Water at NGR 282345 617865. The Crawick Water/Spango Water and its tributaries drain the northern and western sections of the Development Area, flowing south to the confluence with the River Nith at NGR 277115 610335. The Mennock Water and its tributaries drain the southern sections of the Development Area, flowing south to the confluence with the River Nith at NGR 280740 607850. Open ground is typically covered by a mixture of upland moorland vegetation, with craggy rock outcrops.

Designated Sites

7.48 This section details sites designated in relation to hydrology, geology or soils which are of regional, national or international importance identified with reference to the SNH Sitelink Website[x] and which have potential linkages to the Development Area.

7.49 These are summarised in **Table 7.5** including linkage to the Development Area, where relevant.

7.50 Following review, the designated sites shown in **Table 7.5** are not considered to be at risk of adverse effect with respect to the disciplines being assessed within this chapter, and as a result are scoped out.

Table 7.5: Summary of Designated Sites

Designation Name	Designation	Feature related to chapters disciplines	Location Relative to Development Area and linkage, where relevant
Leadhills – Wanlockhead	SSSI	Mineralogy of Scotland (lead-zinc geology deposits)	Approximately 200m downstream of the eastern boundary of the Development Area, at its nearest point. No influence on geology of external sites anticipated and not considered further.
North Lowther Uplands	SSSI	Mineralogy of Scotland (Bail Hill) Upland Habitats (blanket bog, wet and dry heaths and acid grassland)	Approximately 50m from the north-western boundary of the Development Area, to the west of the Crawick Water. Considered to be hydrological disconnected from the Development, as upstream and within separate surface water catchments. No influence on geology or soils of external sites anticipated and not considered further.

Climate

7.51 This section details:

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

7.52 The Development Area is within the Met Office's Western Scotland climatic region[xiii]. Areas of higher ground, which include the Development Area, are likely to experience a higher level of precipitation compared with lower areas nearby to the west of the Development Area, with air cooling at altitude causing more cloud and precipitation. Much of Western Scotland includes high ground exposed to rain-bearing westerly winds.

7.53 The standard average annual rainfall (SAAR) has been estimated from the Flood Estimation Handbook, FEH[v], as varying between 1430 millimetres (mm) and 1456mm across the Development Area. To put this in perspective, annual average rainfall across Scotland varies from over 4000mm in the North-West Highlands, to less than 700mm along the Fife coast.

7.54 The long term average monthly rainfall is shown on **Diagram 7.1** in **Appendix 7.1** using details from the Camps Reservoir Met Office station[xiv] (with an elevation of 295mAOD and located approximately 15km north-east of the Development Area at NGR 299815 622611).

7.55 The elevation of the Development Area ranges from approximately 588mAOD at the highest point at Green Hill in the east of the Development Area, to 200mAOD and 160mAOD at the lowest points, on the banks of the Crawick Water and Mennock Water, respectively. The Camps Reservoir Met Office station elevation falls within this range and has an annual average rainfall of 1311mm, between 1981 and 2010.

7.56 Climate change projections for 2050 suggest that a medium emissions scenario would yield an increase in temperatures within Western Scotland of up to approximately 2.4°C, with a 15% increase in autumn and winter precipitation, potentially increasing flood risk and frequency[xv].

Geomorphology

7.57 This section details:

- Geomorphological characteristics of the Development Area; and
- Topographic cross-sections of the Development Area.

7.58 The Development Area is located in the Lowther Hills, between the villages of Sanquhar, to the south, and Wanlockhead, to the east. The Development Area consists of steep sided hills and valleys with a number of hills greater than 500mAOD. These hills connect to form steep sided ridges separated by incised watercourse valleys which drain the area. The ridges and valleys decrease in height from Wanlockhead to the western and southern sections of the Development Area. The north-eastern boundary of the Development is upon the ridge of Sowen Dod, Snarhead Hill, Reecleuch Hill and Slough Hill; rising to greater than 500mAOD to the south and reducing in height to the north-west. The western boundary of the Development follows Crawick Water between Spango, in the north, and Knockenhair, in the south. The southern and south-eastern boundary of the Development follows the Mennock Water.

7.59 The majority of the Development Area consists of open moorland that is predominantly used for livestock grazing (sheep). Areas of commercial forestry are located in the north-western area of the Development Area.

7.60 **Photographs 7.1** to **7.8** show the typical upland landscape character of the Development Area, including steep sided valleys, conifer plantations and open moorland (**Appendix 7.1**).

7.61 A number of areas of instability have been observed in the form of land slip on the steeper slopes and erosion at watercourse headwaters (**Photographs 7.6**, **7.7**, and **7.8**, **Appendix 7.1**). Further site photographs related to landform and slope stability are provided in **Appendix 7.2** and the associated addendum reporting Landslide Susceptibility.

7.62 **Figure 7.2: Elevation** shows Development Area elevation data, including four cross section transects, with **Diagrams 7.2**, **7.3**, **7.4** and **7.5** (**Appendix 7.1**) providing elevation details of these cross sections.

Geology

7.63 This section details:

- Bedrock geology;
- Superficial geology; and
- Other geological faults or features found within and immediately surrounding the Development Area.

7.64 Geological mapping, shown in **Figure 7.3: Bedrock Geology**, indicates the underlying bedrock geology consists of the following strata, all of Silurian-Ordovician age, described in stratigraphic order from oldest to youngest:

- **Crawford Group** – consists of chert with lava, tuff and mudstone successions. This strata outcrops as an inlier within the Kirkcolm Formation as a result of thrust faulting.
- **Moffat Shale Group** – lies conformably over the Crawford Group and is a mudstone with black and grey shale, bentonite and tuff. This Group outcrops with the Crawford Group as an inlier within the Kirkcolm Formation. Black shales within this group may contain pyrite (iron sulphide) which can result in the generation of acid rock drainage, should the pyrite be exposed to the atmosphere.
- **Kirkcolm Formation** – a greywacke sandstone, medium to thin bedded. Contains quartzose with some thick siltstone intercalations, chert beds and conglomerate.
- **Portpatrick Formation** – a greywacke sandstone and siltstone turbidite succession. This formation forms the host rock for the mineralisation present in the Development Area, which was mined at Wanlockhead.

7.65 A number of igneous intrusions have been mapped across the Development Area, including felsite and alkali dolerite dykes, and are largely focused in the south-eastern section of the Development.

7.66 Superficial geology mapping, shown in **Figure 7.4: Superficial Geology**, indicates a variety of deposits present within the Development Area. It is noted that there are large areas of higher ground with no superficial cover present, where bedrock is considered to be at, or near to, the surface. Superficial deposits include:

- **Glacial Till** – Till deposits are found within the valley floors and sides, the material laid down by glacial ice. They usually consist of a variety of sediments, usually sandy silty clay with pebbles but can contain gravel-rich or laminated sand layers.
- **Alluvium** – Deposits of gravel, sand and silt deposited in river valleys. Analysis of sediment samples from Wanlock Water indicate that mine waste material is present, washed into the river from the various tips and settlement ponds located in the area[xvi].
- **Peat** – Peat, formed from an accumulation of plant remains in anaerobic conditions is shown on the geology maps predominantly located on higher, flatter ground such as plateaus and ridge areas, on the northern and north-western slopes of the hills.

7.67 The strata have undergone significant folding, typically dipping between 50° and 90°. A large thrust fault (Leadhills Fault) crosses the area in a north-east to south-west orientation and has brought older rocks (Crawford Group and Moffat Shale Group) to the surface in some areas. The Leadhills Fault has a reverse structure dipping to the north-west at c.45° with an ignimbrite feature behind, due to additional associated thrust faults. Approximately 3km to the south-east of the Leadhills Fault, and running parallel, is the Fardingmullach Fault.

7.68 Numerous mineral lodes[1] (over 70) exist in the Wanlockhead and Leadhills area within the eastern section of the Development Area. These lodes that have been historically mined for the minerals galena (lead) and sphalerite (zinc). Many other minor minerals are also present. The lodes are situated between the Fardingmullach Fault to the south-east and the Leadhills Fault to the north-west and are related to the Caledonian Orogeny. The majority of the lodes terminate against the Leadhills Fault, however, in the Wanlockhead area some lodes are mapped on both sides of the Leadhills Fault, terminating at other faults within the fault zone. The lodes typically trend in a north-south direction dipping steeply to the east with a few later lodes having a north-west to south-east trend, dipping steeply to the south-west.

Mine Workings

7.69 Wanlockhead and Leadhills, east of the Development, were historically the centres for lead mining in Scotland. This area has been extensively mined, exploiting mineral lodes for lead, zinc and silver. Mining has taken place since the 13th Century but the majority occurred from the 18th Century to the mid-20th Century. During this time it has been estimated that 400,000 tonnes of lead, 10,000 tonnes of zinc and 25 tonnes of silver were produced. A legacy of this mining is the discharge of heavy metals (lead, zinc, cadmium and copper) contaminating groundwater and the Wanlock Water valley downstream of Wanlockhead, as a result of minewater discharges and runoff passing through/over mine waste material. This is considered to have been a key contributor to the pollution of the Wanlock Water, as identified in this watercourse's overall status, detailed in the Water Quality section of this chapter.

7.70 Information obtained to inform the EIA has identified the mining and geological risks that are present within and close to the Development Area boundary and highlighted the areas where any proposed development would be considered to be of moderate or high risk of exacerbating or generating pollution, or is at risk of subsidence due to the presence of mining voids. Full details and drawings are provided in **Appendix 7.3.**

7.71 Sources of contamination leading to areas identified as 'high risk' include the Glencrieff tips, shallow mine workings (surface and underground), tailings ponds, former ore processing areas, crushing mill,

[1] Lode: A vein of minerals within a fissure

contaminated fluvial sediments and mine water discharging from the underground workings, with these sources located within and along the flanks of the Wanlock Water valley where the majority of mining activity occurred. This Wanlock Water valley area is considered to be of high risk, and any development within this area will have a high potential of creating pollutant linkages exacerbating the current pollution issues observed within the valley. Potential subsidence related issues associated with shallow underground voids as a result of the mine workings are also present.

7.72 The moderate risk area takes into account the wider mining area where deeper mine workings, shafts and/or associated waste material may be present. It also includes the mapped mineral lodes which, if excavated during construction, could expose metal sulphide minerals to oxygen leaving soluble hydrated metal sulphate minerals that could be leached out, thereby resulting in increased metal pollution entering the soil and water environment. The geological maps show that the Moffat Shale, including black shale, is only found in localised areas, as a result of the thrust faulting that has occurred.

7.73 Targeted soil and water sampling in proximity to the high and moderate risk areas was undertaken by trained Mouchel staff on 29th September 2016, with an additional soil sampling visit undertaken from the 5th to 7th December 2016 to provide wider site coverage. Soil leachate analysis was undertaken on soil samples to identify the leachability of contaminants of concern from these soils. Details on methodology, rationale, location and results of 22 soil samples and 6 surface water samples are provided in **Appendix 7.4**. Analytical results have been compared against a number of guideline values to provide context, including reference to the recent Coal Authority study on the Wanlock Water[xvi].

7.74 Soil samples across the Development Area typically displayed high levels of heavy metals; cadmium, lead, zinc, chromium and copper, but it is recognised that the Southern Uplands generally have relatively high values of these elements, due to underlying geology. Therefore the relatively consistent exceedances across the Development Area suggest a natural, background geology-related cause as would be expected with the underlying geology in the Southern Uplands.

7.75 All surface water samples displayed high values of chromium and a number have high copper values. The sample from the Wanlock Water recorded high levels of chromium, cadmium, copper, lead and zinc, these results are considered to reflect the historic mine water discharging into this channel. This mining legacy is also noted by SEPA, as detailed in the Water Quality section of this chapter.

7.76 The key findings of the desk study were:

- The mine workings and associated ore processing area is predominantly confined to 3km of the Wanlock Water valley immediately downstream of Wanlockhead (shown in **Appendix 7.3** and associated drawings), with these areas identified as of high mining risk and shown on **Figure 7.3**;
- A wider area has been identified as being of moderate mining risk, where deeper mine workings, shafts and/or associated waste material may be present and also includes mapped mineral lodes which, if exposed, could lead to pollution of soil or water;
- Adits draining the mine workings are discharging water with elevated concentrations of lead, zinc, cadmium and copper into the Wanlock Water;
- The ore processing areas, waste tips, tailings and settlement ponds also provide a source of heavy metal contamination to the environment with large quantities of waste mine material present likely to contain heavy metals that can be mobilised and released into the environment; and
- The sources of mining contamination have led to water quality in the Wanlock Water exceeding the relevant Environmental Quality Standards (EQS) for lead, cadmium, zinc and copper and resulted in downgraded WFD surface water status. Groundwater WFD status is similarly downgraded due to mining history.

7.77 The Development does not interact with the high or moderate risk areas identified (with the exception of approximately 100m of track located along the edge of a moderate area). Baseline results from all soil samples collected within the Development Area do not indicate any particular areas of high metal content or a specific geological strata, such as black shale, which could be defined as a potential source of heavy metal pollution.

Soils and Peat

7.78 This section details:

- Soils present at the Development Area and their characteristics, including peat; and
- Peat stability.

7.79 The following information is summarised from Macaulay Land Use Research Institute (MLURI) soil mapping[iv], soil handbook[xvii] and Scotland's soils website[xviii], with reference to information gathered on-site.

7.80 **Table 7.6** identifies the soil units present within the Development Area, many of which include peat in their composition. The descriptions are general and do not provide information on soil depths and engineering properties.

7.81 As shown in **Table 7.6**, the majority of the Development Area is covered by Component Soil Unit 226 with Component Soil Units 228 and 229 also covering large areas of the Development Area.

7.82 A brief description of the characteristics and formation of component soil groupings is included below:

- Blanket Peat is an undecomposed organic material that has remained wet to the surface. Deep peat (>1m[xix]) is formed under cool, wet climatic conditions, which, in combination with high acidity and nutrient deficiency, depress microbiological activity.
- Podzols: typically form in acid, coarse textured, well drained materials. Surface vegetation is usually coniferous woodland or heather moorland. Podzols are generally nutrient deficient and heavily leached in the upper horizons resulting in a bleached appearance, with an accumulation of thin layers of iron/aluminium oxides or organic material at lower levels within the soil profile, with an orange-brown or black colour respectively. Peaty podzols have a peat-rich surface horizon; Humus-iron podzols have a surface horizon of humified (or decomposed) organic material. In areas with low slope angles, waterlogging may occur above the ironpan; this can produce a soil intermediate between a podzol and a gley.
- Gleys: naturally poorly drained soils that develop under conditions of intermittent or permanent waterlogging. Soils are typically greyish or blue with orange mottling. Peaty gleys have a peat-rich surface horizon. They are highly extensive soils, particularly in northern and western districts and listed among principal soils, generally together with peat, in a large number of map units. Non-calcareous gleys are naturally poorly drained soils that develop under conditions of intermittent or permanent waterlogging.
- Brown forest soils: fertile, often deep soils, rich in nutrients and organic matter. Soil is free draining and often not very distinctive visually, although usually lightens in colour with depth as organic content decreases. Texture and level of fertility depend on parent material and degree of alteration that the soil has undergone.

Table 7.6: Summary of Associated Soils and their Properties within the Development Area

Soil Association/ Parent Materials	Component Soil Unit	Component Soils	Landforms	Typical Associated Vegetation	Site Presence
Organic Soils Derived from organic deposits	4	Blanket Peat	Uplands and northern lowlands with gentle and strong slopes	Blanket and flying bent bog; Swamp, sedge mires and rush pastures.	Small sections south-west of Wedder Dod Hill and large area between Slough Hill and Snarhead Hill in east of Development Area.
Ettrick Derived from Lower Paleozoic greywackes and shales	210	Noncalcareous gleys; some brown forest soils with gleying	Foothills and depressions with gentle slopes.	Sharp-flowered rush pasture; Tussock-grass pasture; Arable and Permanent pasture.	Small area in the north-west of the Development Area, west of Whiteside Hill.
	221	Brown forest soils	Hills and valley sides with steep and strong slopes.	Acid bent-fescue grassland; Dry Atlantic heather moor; Oak and birchwood.	Small area at southernmost part of the Development Area around Mill Hill.
	226	Peaty podzols, brown forest soils	Hills with simple convex steep and strong slopes.	Moist Atlantic heather moor; White Bent grassland; Acid bent-fescue grassland.	Covers the majority of the Development Area between Crawick Water and Mennock Water.
	228	Peaty podzols; some humus-iron podzols	Hills with simple convex strong and steep slopes.	Dry and moist Atlantic heather moor, locally Boreal; White bent grassland	Eastern Development Area, west of Wanlockhead.
	229	Peaty podzols; some peaty gleys, peat	Hills with simple convex steep and strong slopes.	Moist Atlantic heather moor; Heath-rush – fescue grassland; Blanket and flying bent bog	Large areas of the Development Area, north of Wedder Dod and south-east of Spango Hill.
	233	Peaty gleys, noncalcareous gleys	Valleys and depressions amongst hills and uplands with gentle slopes.	Rush pastures and sedge mires; Moist Atlantic heather moor; Flying bent grassland.	Small area south of Spango Hill.
Rowanhill/ Giffnock/ Winton Derived from Carboniferous sandstones, shales and limestones	446	Noncalcareous gleys; some brown forest soils with gleying and peaty gleys	Undulating lowlands with gentle and strong slopes	Rush pastures and sedge mires; Arable and permanent pastures; Broad-leaved woodland.	Small area east of the Fingland Burn.
	450	Peaty gleys; some peat and non-calcareous gleys	Undulating foothills with gentle and strong slopes	Flying bent grassland and bog; Blanket bog; Moist Atlantic heather moor.	Area west of Brown Hill and south of Conrig Hill.

Carbon-rich Soils, Deep Peat and Priority Peatland Habitats

7.83 The Carbon and Peatland Map (SNH, 2016), a GIS vector dataset covering Scotland, presents the importance of environmental interests[xx]. They have been derived using a matrix of soil carbon categories (derived from Soil Survey of Scotland maps) and peatland habitat types (derived from Land Cover of Scotland 1988 map).

7.84 With regard to Scottish Planning Policy 2014[xxi], carbon-rich soils, deep peat and priority peatland habitat importance categories 1 and 2 from the Carbon and Peatland Map are within Group 2 (‘areas of significant protection’), where development should demonstrate that effects can be substantially overcome by siting, design or other mitigation. Approximately 2% of the Development Area is within importance category 1, with no category 2 locations recorded. The importance category 1 locations are on the ridges of Willowgrain Hill, Stood Hill, Green Hill, Slough Hill and Reecleugh Hill, shown on **Figure 7.4: Superficial Geology**. These areas were taken account of during the early design stages and also informed the more detailed scope of the peat probing undertaken to inform the design and EIA.

7.85 Thus, the vast majority of the Development Area would be considered as Group 3 (‘areas with potential for windfarm development’, in relation to carbon-rich soils).

7.86 The outcomes of the more detailed peat survey, summarised below and fully detailed in **Appendix 7.2**, provide site-specific peat depth information which supercedes the higher level characterisation from the SNH Carbon and Peatland Map dataset. This more detailed peat information was used to inform the design of the layout of the Development and the subsequent assessment of effects.

Peat

7.87 Peat is a soft to very soft, highly compressible and highly porous organic material which can consist of up to 90% water by volume. Unmodified peat typically has two layers:

- Acrotelm (surface layer) which is often around 0.3m thick (but can vary widely in depth depending on local conditions), highly permeable and receptive to rainfall. It generally has a high proportion of fibrous material and often forms a crust under dry conditions.
- Catotelm (base layer) lies beneath the acrotelm and forms a stable colloidal substance which is generally impermeable. As a result, the catotelm usually remains saturated with little groundwater flow.

7.88 Peat is thixotropic, meaning that its viscosity decreases under applied stress. This property may be considered less important where the peat has been modified through artificial drainage and is drier, but will be significant when the peat body is saturated.

7.89 Given the desk based indicative presence of peat, or peat containing soils, as aforementioned (based on the SNH data), further peat-specific work, including peat probing was undertaken to inform the layout design and for subsequent use in a site-specific peat stability assessment, soil and peat management plan and carbon emission evaluation. Soil and peat were also sampled at representative locations across the Development Area to establish chemical status, with results and interpretation of data provided in **Appendix 7.4**.

7.90 **Table 7.7** shows the range of results gathered during peat depth surveys. A total of 2,607 soil and peat depth records were gathered within the Development Area, providing representative data across the general area and increasingly focused on planned infrastructure locations as these evolved during the iterative design process.

7.91 Measured depths average 0.44m, with 94% of recordings less than 1.0m and 98% less than 1.5m. Peat or organic soil deposits deeper than 1.5m were rare on this site, with these generally located on saddles/bealach on ridges or in ‘bowl’ depressions in valleys.

7.92 The results of the peat depth surveys were extrapolated to produce an indicative peat depth map as a 50m x 50m grid for the Development. This is shown on **Figure 7.5 (a-d): Peat Depths**. Further details on the peat depth survey methodology are provided in **Appendix 7.2**.

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

7.94 The Scottish Executive (now Scottish Government) guidance document on peat landslide hazard and risk assessments[xxii] defines peat as a soil greater than 0.5m in depth, with an organic matter content of more than 60%. The probing data records that the majority (over 64%) of the sampled points are shallower than 0.5m in depth and are not therefore not formally considered as peat.

7.95 Additional information on peat characteristics, including catotelmic peat distribution at this site, is also provided in **Appendix 4.2**.

Table 7.7: Peat/Soil Depths

Peat/Soil Depth Range (m)	Number of locations surveyed	Percentage of locations surveyed	Average depth in range (m)
0.0 to <0.5	1677	64.33%	0.26
0.5 to <1.0	769	29.50%	0.62
1.0 to <1.5	113	4.33%	1.19
1.5 to <2.5	39	1.50%	1.75
2.5 to <4.0	8	0.31%	2.70
≥4.0	1	0.03%	4.02
Total / Aggregate	**2607**	**100%**	**0.44**

Peat Stability, Soil and Peat Management and Carbon Reporting

7.96 Due to the presence of areas of peat within the Development Area, a peat stability assessment, soil and peat management plan and carbon report have all been undertaken.

7.97 The peat stability assessment uses peat depth data in combination with slope information to initially determine areas considered of greatest risk of slope failure, based on factor of safety slope stability calculations. Further details on peat stability methodology, interpretation and results are provided in **Appendix 7.2**.

7.98 The soil and peat management plan uses peat depth data to calculate likely excavation volumes across various items of infrastructure, identifies pragmatic options for reuse of excavated material and provides guidance on good practice storage and management of excavated material, including peat. Further details are provided in **Appendix 4.2**.

Hydrogeology

7.99 This section details:

- Hydrogeological features present across the Development Area and their characteristics;
- Groundwater vulnerability;
- Groundwater body characterisation and water quality; and
- Groundwater dependent terrestrial ecosystems (GWDTE).

7.100 In 2015 the BGS and SEPA reviewed and re-defined Scotland's aquifers[xxiii]. The Development Area lies within the Silurian-Ordovician aquifer and is described as a fracture flow, low productivity bedrock aquifer. The geology in the area consists of mudstone and greywackes; these strata are generally of low permeability with little groundwater storage. Where groundwater is present it is usually confined to fault zones and areas of surface weathering. Springs emerge from the hillsides to form numerous burns, typically issuing at higher elevations near the top of the hills, the water is weakly mineralised except where contact is made with sulphide rich black shales[ii]. These springs are unlikely to flow all year round and will be dependent on the preceding precipitation. Rainfall in the region is likely to be between 1300-1500mm/year (based on FEH estimation and Camps Reservoir rainfall data) but based on the geology, topography and baseflow, infiltration has been estimated to be less than 100mm/year.

7.101 The presence of mine workings will locally affect the natural groundwater drainage due to the presence of shafts, levels, adits and worked stopes (stepped excavations) providing high permeability pathways for groundwater to flow through.

Groundwater Vulnerability

7.102 The majority of the Development Area has been classified as being of Vulnerability Class 5[iii], i.e. vulnerable to most pollutants, with rapid impact in many scenarios. This is likely to be due to the limited amount of superficial and soil cover over the majority of the area.

Groundwater Body Characterisation and Water Quality

7.103 The Water Framework Directive (WFD) (EU, 2000) came into force in December 2003 and is implemented in Scotland through the Water Environment and Water Services (Scotland) Act 2003 (Scottish Executive, 2003). A key objective of this Directive is the achievement of 'good condition' (as a minimum) of all natural waterbodies by 2027. SEPA classify surface waterbodies using two classes: 'Good' and 'Poor'. The classifications take into account pressures and their potential effects, compared to near natural conditions for the respective waterbody (SEPA, 2017[xxiv]). This risk-based system highlights groundwater issues such as over abstraction, in addition to chemical groundwater quality.

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

7.105 The Development Area falls within one groundwater body; the Upper Nithsdale groundwater body (Waterbody ID: 150663). SEPA provide a confidence rating for each classification result which gives an indication of the robustness of the monitoring data upon which the classification status is based[xxv]. The classification results of this waterbody are summarised in **Table 7.8**.

Table 7.8: Water Framework Directive Groundwater Classification

Groundwater Body	Groundwater Body SEPA ID	Classification (2014)	Anticipated Classifications (2021)	Relevant Associated Surface Waterbody	Summary of Pressures
Upper Nithsdale	150663	Overall: Poor Water quality: Poor	Overall: Poor Water quality: Poor	Wanlock Water Crawick Water / Spango Water Mennock Water	Water quality – legacy pollution due to mining or quarrying

Groundwater Dependent Terrestrial Ecosystems

7.106 The Development Area was surveyed against the National Vegetation Classification (NVC) system. The NVC data was used to inform the layout design and assessment and the survey findings are presented in **Chapter 8 - Ecology**.

7.107 The NVC information was reviewed for GWDTE using SEPA guidance[xxvi] which indicates which NVC habitats could potentially be highly or moderately groundwater dependent, based solely on vegetation communities present. The findings are outlined in **Table 7.9**.

7.108 The Development Area comprises a range of NVC communities, including those indicative of potentially moderate or high groundwater dependence, combined to cover approximately 24% of the area surveyed, with 7% being considered to be of potential high dependence.

7.109 The distribution of GWDTE is presented in **Figure 7.8: Potential High Dependency Groundwater Dependant Terrestrial Ecosystems**, in accordance with SEPA LUPS-GU4 based on their groundwater dependency classification under SEPA guidelines.

7.110 A brief description of the NVC communities of the potential high dependency GWTDE present within the Development Area are:

- M6 (*Carex echinata-Sphagnum recurvum/auriculatum*) - Occurs on peats and peaty gleys irrigated by base poor waters in the sub-montane zone. Tends to be acidic (pH between 4.5 and 5);
- M6c (*Juncus effusus*) – M6 sub-community found throughout M6. It is most abundant when vegetation dominated by rushes upon extensive *Sphagnum* carpet;

- M6d (*Juncus acutiflorus*) - M6 sub-community found throughout M6. It tends to be dominant over extensive *Sphagnum* carpet when *Molinia caerulea* becomes more frequent[xxvii];
- M23 (*Juncus effusus/acutiflorus - Galium palustre*) - Occurs on moist, moderately acid to neutral, peaty and mineral soils in lowland areas. It is found on areas that are moist to wet for the majority of the year;
- M23a (*Juncus acutiflorus*) – M23 sub-community very common in Scotland; and
- M23b (*Juncus effusus*) - M23 sub-community found throughout M23.

7.111 GWTDE areas of potential high groundwater dependency and hydrological dependency are considered further in **Appendix 7.5**.

Table 7.9: Groundwater Dependent Area Screening (Potential High or Moderate Dependency Based Solely on Vegetation Communities)

Groundwater Dependency	Area (km^2)	Area as Approximate Percentage of Development Area	LUPS dominant NVC communities	Location
High (Dominant community)	1.05	2.3%	M6 M6c M6d M23 M23a M23b	South of Cogshead, on the slopes of Wether Hill and Brown Hill, south of Lowmill Knowe, west of Glengaber Hill, along the Black Burn, Reeves Burn, Clackleith Burn, along the slopes of Glenrae Dod, north-western slopes of Clackleith Hill and forest rides east of Craignorth Hill.
High (Subdominant community)	2.51	5.5%	M23 M23a M23b	Large areas on the slopes of the Dod, lower slopes of Tongue Hill, southern slope of Conrig Hill, slopes of Willowgrain Hill, southern slopes of Brown Hill, southern slopes of Snarhead Hill, large areas east of Well Hill, along the Glengalloch Burn, along the slopes of Wedder Dod and the south-western slopes of Slough Hill.
Moderate (Dominant community)	6.13	13.5%	M15b M15d M23a M25 MG10 MG10a U6	Large areas on the upper slopes of Slough Hill, Clackleith Hill, Duntercleuch Rig, Craignorth Hill, Wedder Dod, Well Hill, Tongue Hill, The Dod, Fingland Rig, Glengaber Hill, Lowmill Knowe and smaller areas to the south at Brown Hill, Wether Hill, and White Dod.
Moderate (Subdominant community)	2.38	5.3%	M15 M15b M25 MG10 MG10a U6	Glenrae Dod, Clackleith Hill, Craignorth Hill, Reecleuch Hill, Wedder Dod, Snarhead Hill, Well Hill, Tongue Hill, The Dod, Conrig Hill, Willowgrain Hill, Brown Hill, Wether Hill, White Dod and Bail Hill.

Hydrology

7.112 This section details:

- Hydrological characteristics of the Development Area and downstream area;
- Surface water flows and flooding;
- Water quality; and
- Water supplies.

7.113 By evaluating the hydrology of the Development Area using a catchment-based system, judgements can be made regarding potential influences that site activities may have downstream and on other waterbodies within the catchment. Maps displaying the hydrological overview and more detailed site-specific hydrology are provided as **Figure 7.6: Hydrology Overview** and **Figure 7.7: Site Hydrology**, respectively.

Hydrological Description

7.114 The majority of the Development is situated across the watershed of both the Mennock Water and Crawick Water, both tributaries of the River Nith.

7.115 Hydrology within the Development Area can be broadly split into four main watercourse catchments which nominally drain the northern, central, southern and western areas within the Development Area. These are, the Wanlock Water, Cog Burn, Glendyne Burn and Loch Burn, respectively. Smaller watercourses in the southern and western extents of the Development Area drain directly to the Mennock Water and Crawick Water.

7.116 To the north of the Development Area, between Sowen Dod and Slough Hill, watercourses drain to the adjacent Snar Water, a moderately sized tributary of the Duneaton Water, which in turn drains to the River Clyde. No infrastructure is located within these catchments.

Crawick Water and its Tributaries

7.117 The Crawick Water drains the western fringes of the Development Area and forms the western boundary. The catchment consists of upland moor with parcels of commercial conifer tree plantation. The Crawick Water has an approximate catchment area of 78.5km^2, upstream of Spoth Bridge (NGR 279396 614013).

7.118 The Wanlock Water has a catchment area of approximately 16km^2 and rises at approximately 430mAOD within the small village of Wanlockhead. The watercourse flows predominantly north-west through a 'V' shaped valley with a moderate floodplain width at its base, estimated to be approximately 50 to 60m. This floodplain narrows in its lower course, with the watercourse becoming deeply incised, draining very steep slopes, notably south-west of Glenrae Dod. The watercourse predominantly drains upland moorland, with historic mine workings found in its upper catchment between Glendorch Rig and Glengarber Hill. Numerous watercourses, with steep, deeply incised channels converge with the main channel along its course. These include the Glendorch Burn (at Glendorch Rig) and Glenbuie Burn, the latter of which has a catchment area of approximately 2.5km^2, the largest of the Wanlock Water tributaries. The watercourse converges with the Spango Water at Spango Bridge (NGR 282340 617870) to become the Crawick Water.

7.119 The Cog Burn has a catchment area of approximately 9.8km^2 and forms from the convergence of numerous small upland watercourses at Cogshead (NGR 283092 613002), approximately 294mAOD. The watercourse flows predominantly north-west through a deeply incised, terraced valley, draining upland moorland and conifer forestry plantation (see **Appendix 7.1, Photograph 7.1**). The watercourse shows a moderate degree of sinuosity in its upper and lower courses with some riffle-pool sequences and bifurcation. Two notable tributaries, the Glendorch Burn (at Conrig Hill) and Glensalloch Burn converge with the watercourse at NGR 282230 613906 and NGR 281781 614751, respectively. The watercourse drains to the Crawick water at Nether Cog (NGR 280623 615271).

Mennock Water and its Tributaries

7.120 The Mennock Water forms the southern Development Area boundary and collects numerous small watercourses which originate within the Development Area, notably the Glendyne Burn, Glenclach Burn and Glendauchan Burn. This watercourse covers a total catchment area of approximately 38km^2.

7.121 The head of the Glendyne Burn rises at NGR 285937 612126 at an elevation of 444mAOD between Bail Hill, Green Hill and Stood Hill and has an approximate catchment of 7.9km^2. The watercourse flows west along a deeply incised 'V' shaped valley (mapped as Glendyne), before orientating south-west, north of Brown Hill and collecting numerous smaller tributaries including the Shiel Burn and Coal Burn, before discharging to the Mennock Water at NGR 281839 608691.

7.122 The Loch Burn forms from the runoff and convergence of Bogs Burn and Fingland Burn at NGR 280497 612138 at an elevation of 253mAOD. It has a catchment size of approximately 7.5km^2 and flows predominantly south-east, draining open moorland and agricultural grazing land before discharging into the Mennock Water at NGR 280920 608111, which in turn then joins the River Nith, a further 370m downstream of this confluence.

7.123 Photographs of a variety of representative water features are provided in **Appendix 1**, as **Photographs: 7.1.** Cog Burn, **7.9.** Crawick Water, **7.10.** Glendorch Burn, **7.11.** Wanlock Water and **7.12.** Glenbuie Burn.

Surface Water Flows and Flooding

7.124 Theoretical runoff rates have been estimated for a varied selection of watercourses found downstream of the Development Area. Catchment characteristics have been used with the 'FEH Rainfall-Runoff' method to derive a range of peak flow return periods[xxviii]. Low flow measurements have been determined by the 'Low Flow' method[vi] and are quoted as Q_{95} (representing the exceeded 95% of the time). This data is shown in **Table 7.10**.

7.125 Flood risk data published by SEPA[viii] shows fluvial flood risk limited to the immediate area adjacent to the Wanlock Water, Glendyne Burn, Mennock Water and the Cog Burn watercourse channels. There are a number of localised small areas of surface water flooding adjacent to most watercourses within the Development Area, as is typically indicated for upland moorland areas on this strategic-level dataset. No new Development infrastructure is located in areas classed as a medium to high risk for fluvial flooding.

7.126 SEPA Flood Maps show High (average 1 in 10 years or 10% chance) or Medium Likelihood (0.5% chance) river flooding from the Wanlock Water immediately adjacent to the main channel, with wider areas of flooding adjacent to the properties at Meadowfoot (NGR 286356 613682) and its confluences with the Glendorch Burn and Spango Burn (NGR 282790 617875).

7.127 SEPA Flood Maps show Medium likelihood of river flooding along the majority of the extent of the Crawick Water. These areas generally widen at its confluences with the Wanlock Water and Cog Burn. Further Medium to Low risk areas (1 in 1000 or 0.1% chance) occur where its floodplain widens, south of Corsebank at NGR 280750 616240 and south of Carco at NGR 278500 613770.

7.128 Downstream of the Development Area, at the confluence with the Crawick Water and at Sanquhar, the River Nith has an extensive, Medium likelihood flood plain and further extensive flooding zones are noted where the River Nith flows past Thornhill and Dumfries.

7.129 The Hydrology of Soil Types (HOST) is a hydrologically-based classification of soils on the basis of their physical properties and their effects on the storage and transmission of water[xxix]. It makes use of the fact that the physical properties of soils have a major influence on the hydrological response of a catchment. Other parameters can then be derived from the HOST classification. For the purposes of hydrological assessment the Baseflow Index (BFI) and Standard Percentage Runoff (SPR) are the most useful parameters.

7.130 BFI is the long-term ratio of baseflow to total stream flow, where baseflow represents the contribution to total flow from groundwater[xxx]. BFI values range from 0.1 in relatively impermeable clay catchments to 0.99 in highly permeable chalk catchments. A very low BFI of 0.15 represents a flashy catchment with minimal storage, low BFI values (e.g. 0.3) indicate a catchment with little storage and active runoff, a BFI of 0.7 (or greater) indicates a significant contribution to flow from a major aquifer.

7.131 The SPR is the average percentage of rainfall that causes the short-term increase in flow seen at a catchment outflow following a storm event[xxxi].

7.132 Using FEH to derive catchment descriptors for watercourse reaches relevant to the Development Area, the Cog Burn, Glendyne Burn, Wanlock Water, Craigy Burn, Loch Burn, Glenclach Burn, Mennock Water, Burgess' Grain, Crawick Water, Glensalloch Burn, and the Glenbuie Burn have BFI-HOST values of 0.31 - 0.42, indicating little contribution from stored water sources. These values would be expected given the underlying geological conditions with little groundwater infiltration leading to low aquifer productivity. Local watercourses will respond quickly to rainfall events, with a short lag time between rainfall occurring and increased stream flow values. The SPR values range between 43-50%, indicating a moderately flashy response to rainfall, attenuated by local conditions, potentially including forestry cover. Additionally the steep characteristics of site valleys would further contribute to this high level of runoff.

Table 7.10: Estimated Surface Water Flow Characteristics

Catchment (Upstream of Grid Ref)	Area (km^2)	Mean Annual Flow (m^3/s)	Low Flow Q95 (m^3/s)	Estimated Peak Runoff (m^3/s) for each return period (years)						
				5	10	25	50	100	200	200 + CC
Cog Burn at Nether Cog	9.8	0.352	0.040	13.247	16.068	20.667	24.555	28.412	33.055	39.666
Glendyne Burn at Brown Hill	3.5	0.125	0.014	5.686	6.853	8.840	10.602	12.349	14.460	17.352
Wanlock Water at Glenrae Brae	16.2	0.584	0.066	20.423	25.081	32.039	37.970	43.855	50.936	61.123
Wanlock Water at Glendorch Rig	6.7	0.252	0.029	11.102	13.383	17.288	20.687	24.061	28.133	33.760
Craigy Burn at Lochburn	0.5	0.017	0.002	0.994	1.203	1.518	1.835	2.142	2.512	3.014
Loch Burn at Meadowbank	5.5	0.182	0.021	6.404	7.805	9.992	11.847	13.685	15.896	19.075
Glenclach Burn at Moor End	2.2	0.082	0.009	4.115	5.012	6.385	7.774	9.133	10.780	12.936
Mennock Water at Mill Hill	20.6	0.705	0.080	24.105	29.135	37.810	45.119	52.393	61.182	73.418
Burgess' Grain at Cogshead	3.4	0.124	0.014	6.222	7.522	9.605	11.543	13.453	15.757	18.908
Crawick Water at Spoth Bridge	78.9	2.822	0.316	76.033	92.092	115.465	135.298	154.842	178.188	213.826
Glensalloch Burn at Bank Wood	2.1	0.071	0.008	3.552	4.298	5.471	6.601	7.711	9.05	10.860
Glenbuie Burn at Sheepfold	2.5	0.088	0.010	4.221	5.087	6.560	7.856	9.141	10.692	12.830

Water Quality

7.133 As discussed in the groundwater quality section, the Water Framework Directive (WFD) is a risk-based classification system. This highlights such issues as stream morphology and existing artificial structures in addition to chemical water quality and ecological diversity. Heavily modified waterbodies, which can no longer be considered to be natural, are classified on the basis of 'ecological potential'.

7.134 As for the groundwater section, SEPA has characterised surface water quality under the WFD.

7.135 The WFD applies to all surface waters, but for practical purposes, SEPA has defined a size threshold above which a river or loch qualifies automatically for characterisation. For lochs, the threshold is a surface area of $0.5km^2$ and rivers must have a catchment area of $10km^2$ or more. In addition to these larger waterbodies, smaller waters have been characterised where there is justification by conservation interests and to meet the requirements of regulatory legislation such as for drinking water supplies. **Table 7.11** summarises the WFD classification for the Wanlock Water, Crawick Water/Spango Water, Mennock Water and River Nith[ix].

Table 7.11: WFD Surface Water Classification

Name (SEPA ID)	Waterbody Type (River Length)	Classification (2014)	Anticipated Classification (2021)	Summary of Pressures
Wanlock Water (10619)	Surface water (8.3km length)	Overall: Moderate Water Quality: Moderate	Overall: Moderate Water Quality: Moderate	Legacy pollution (mining or quarrying) – Elevated concentrations of cadmium in watercourse.
Crawick Water/ Spango Water (10618)	Surface water (25.7km length)	Overall: Good Water Quality: Good	Overall: Good Water Quality: Good	No pressures exist on this waterbody.
Mennock Water (10620)	Surface water (11.1km length)	Overall: Good Water Quality: Good	Overall: Good Water Quality: Good	No pressures exist on this waterbody.
River Nith (10610)	Surface water (49.3km length)	Overall: Moderate Water Quality: Moderate	Overall: Moderate Water Quality: Moderate	Physical condition – Modifications to bed, banks and shores. Water Quality – Diffuse source.

7.136 For waterbodies that have not been classified, the normal convention is to assume a classification based on downstream or adjacent waterbodies unless there are specific indications to the contrary. Given the location of the Development Area and the status of nearby watercourses, all waterbodies within the Development Area are considered to have an overall Good status as they have no existing pressures and were outwith areas with previous history of mining.

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

7.138 Targeted watercourse chemistry sampling was undertaken in September 2016, with the results provided in **Appendix 7.4.**

Water Supplies

7.139 The Development Area is not a source zone for public water supply, with a number of water supplies within the area provided by private abstraction. No public water supply infrastructure is located within the Development Area as confirmed by Scottish Water, where nearest assets were identified in the settlements of Sanquhar and Wanlockhead. Therefore, public water supplies are not considered further.

7.140 Private water supply information was sought from both Dumfries and Galloway Council and South Lanarkshire Council, who both provided a list of registered private water supplies within the Sanquhar, Wanlockhead and Leadhills area. **Figure 7.6: Hydrology Overview** shows the location of local private water supply sources.

7.141 There are two categories of private water supply:

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

7.142 Following a review of supply source locations relative to the Development, taking account of local catchments and intervening distances, a number of supplies were not considered to have hydrological connectivity with the Development and therefore not considered further. These were as follows (identification codes matching those shown on **Figure 7.6: Hydrology Overview**):

- Knockenhair (1);
- Radar Station (3);
- Ardoch (4);
- Blackgannoch (6);
- Carco (7);
- Carcoside (8);
- Chapel Farm (9);
- Glenanners and Corsebank (12);
- Dalveen (Care Centre and Shepherds Cottage) (13);
- Fingland (14);
- Gareland (15);
- Kirkbride (18);
- Knockenjig (19);
- Meikle Carco (20);
- Spango Bridge (24);
- Spoth (25);
- Low Todholes (26);
- High Todholes (27);
- Twenty Shillings (28);
- Upper Dalveen Cottage (29); and
- The Hass (30).

7.143 Of these properties, Glenanners and Corsebank were visited as control locations to confirm if the properties were fed by private water supply, and to determine if the properties were hydrologically linked to the Development. These properties supplies were found to be abstracted from Castle Hill, to the west of the Development, in catchments hydrologically unconnected to the Development. It was considered that these supplies were representative of a number properties listed above and located to the south-west of the Development. As a result, the above supplies were scoped out and not considered further.

7.144 The remaining supplies, where it was judged that there were potential hydrological linkages to the Development, warranted further assessment. This consisted of a series of site visits between October 2016 and February 2017 to obtain details on the:

- Source type of supply (stream, borehole, spring collector etc.);
- Location of supply (including photographs, where possible);
- Number of properties served (including name of properties);
- Changes in quality and quantity seasonally;
- Quality of water; and
- Source protection.

7.145 Where a resident was not available, a contact letter was left at the property, for the resident to arrange a time suitable to for a site visit, or provide details by telephone or email.

7.146 The properties considered to have a potential hydrological connection included :

- Nether Cog, referred to as its local name Cogsfoot (2);
- Auchengruith (5);
- Clackleith (10);
- Clenries (11);
- Glenim Cottage (16);
- Howatsburnfoot (17);
- Mennock Pass Cottage (21);

- Mossend (22);
- Spango Bank, Spango Farm and Spango View (23); and
- Auchentaggart / Brandleys (31).

7.147 Mossend, known as Mossholm on OS mapping, has been confirmed to be on mains water supply, Auchentaggart / Brandleys is also confirmed as being on mains water supply, as a result these supplies are not considered further.

7.148 Full details of the remaining private water supplies are provided in **Appendix 7.6**.

7.149 Nether Cog and Clenries private water supplies were considered to be the only ones from the above list to be hydrologically connected to the Development, as per information in **Appendix 7.6**, as a result these are assessed in the Assessment of Effects section of this chapter. All other private water supplies were scoped out and are not considered further.

The 'Do Nothing' Scenario

7.150 Should the proposed development not proceed, the majority of the Development Area will continue as commercial forestry and rough grazing.

7.151 In due course, there are relatively small areas of plantation forestry which will require to be felled, with the requirement for associated forestry operations and machinery in the Development Area. At this time, there is a heightened potential for adverse effect to the local soil and water features; primarily due to soil loss, potential peat instability and associated sedimentation of site watercourses during and following the felling operation. With reduced forestry cover, there is also a potential increase in soil water content, which could lead to increased surface water flows from deforested slopes.

NLEI Design Considerations

7.152 Detailed constraints advice was provided during the iterative layout design process for both the turbine and associated infrastructure features. At a number of stages during the iterative design process, fieldwork was undertaken to provide further localised feedback to the Development design team. This approach minimised a number of potential effects. The hydrology and ground condition constraints that were taken into account in the design of the Development are listed below:

- Identification of areas of historic mine workings to avoid infrastructure placement in potentially contaminated land (high and moderate risk areas);
- Identification of mapped mineral lode and black shale areas, where high metal content is likely in the geology – to avoid borrow pit placement and reduce opportunity for disturbance of high metal load sediments and mobilisation of metals into water environment;
- 50m buffer around water features shown on OS 1:10,000 mapping (other than where access tracks required incursion) – to protect from physical damage, pollution or flood inundation;
- Minimisation of watercourse crossing structures and identification of best locations for necessary crossings – to protect from physical damage or pollution;
- Identification of private water supply source locations – to protect from physical damage or pollution;
- Identification of areas where peat depths anticipated to be 1.5m or deeper – to protect from physical damage, minimise excavation and transportation of peat, reduce potential for peat instability and minimise potential soil carbon loss;
- Identification of areas with peat depths greater than 1.0m, with floating track techniques employed to reduce excavation;
- Identification of areas with slope angles greater than 8°- to minimise soil loss and potential instability;
- Identification of areas where initial peat stability concern was identified (factor of safety values less than 1.4) – to minimise incursion into areas with possible instability issues and associated indirect effects on surface water and inform design iterations; and
- Landslide Susceptibility Assessment process - to evaluate geotechnical issues at infrastructure and inform design iterations.

7.153 The data gathered with regard to historic mining and soil and water analysis informed the design process and infrastructure has not been planned in areas of either moderate or high risk, including removal of a potential access track link to the B979, south of Wanlockhead, formerly known as Access C. The new track approach to Turbine 14 is located immediately adjacent to an area of moderate risk (approximately 100m in length), however, this route corridor is restricted by steep slopes on either side and was designed to approach from the north to avoid construction in an area of high risk identified on Black Hill.

7.154 Aggregate material will be won on site from five borrow pits, with borrow pit locations and excavation design detailed in **Appendix 4.1**, site-won material will be supplemented by material brought into the Development Area by road. Borrow pits are not planned where mineral lodes or black shales are considered likely to be present. If black shales are encountered during development, excavations in these areas should be minimised to reduce the risk of generating acid rock drainage due to the presence of pyrite.

7.155 As part of the layout design strategy, watercourse crossings were minimised. Where access necessitates watercourse crossings, construction features have been limited as far as possible, for example minimising tracks running parallel to streams and avoiding track junctions being constructed in these zones.

7.156 The final infrastructure design indicates the requirement for four new watercourse crossing structures and an upgrade to eight existing crossing structures for watercourses that are subject to CAR (as shown on OS 1:50 000 mapping). **Table 7.12** summarises these watercourse crossings, with further details and an inventory of crossings in **Appendix 7.7**. Locations of watercourse crossings are shown on **Figure 7.7: Site Hydrology**.

7.157 There will also be a requirement for minor watercourse crossings (i.e. representing minor watercourses not shown on OS 1:50 000 mapping), and typical crossing locations and suggested structures have also been provided in **Appendix 7.7**.

7.158 During the detailed design and construction phases, sections of track will be surveyed and microsited to optimise the distances from the waterbodies, taking into account local micro-topography and local characteristics.

Table 7.12 Summary of CAR Watercourse Crossings including Individual Identification Code

Track Crossing Type	Watercourse Size			
	Large	Medium	Small	Total
Bridge	WC01*, WC02*, WC08	-	-	**3**
Rectangular culvert/arch	-	-	-	**-**
Open base arch structure	-	WC04*	WC05*, WC07	**3**
Circular culvert	-	WC10	WC03*, WC06, WC09*, WC11*, WC12*	**6**
Circular Pipe	-	-	-	**-**
Drainage layer	-	-	-	**-**
Total new crossings	**1**	**1**	**2**	**4**
Total existing crossings, potentially requiring upgrade	**2**	**1**	**5**	**8**
TOTAL (new + upgraded)	**3**	**2**	**7**	**12**

*Existing crossing

7.159 In relation to concrete batching on site, if it is assumed that each turbine foundation requires approximately 150m^3 of water for concrete production (including for washdown etc) and that one turbine foundation will be poured every 3 days, with water abstracted continuously and stored for use during

batching operations in a lagoon or storage vessel, a constant abstraction rate of 50 m^3/day (or 0.0006 m^3/s or 0.6 l/s) applies over this 3 day period. Specific abstraction information is provided as follows:

- The local watercourse to the potential batching site at BP02, is the Clackleith Burn, located 100m south. This has an upstream catchment area of 0.68km^2, with mean flow and low flow (Q_{95}) values of 0.024 m^3/s and 0.003 m3/s, respectively - calculated using LowFlows 2 software. The second concrete batching location is at BP03, with the local watercourse being the Winter Cleuch, located 100m south. This has an upstream catchment area of 0.14km^2, with mean flow and low flow values of 0.005m^3/s and <0.001 m^3/s, respectively. Both of these watercourses drain the local area and would include surface flows intercepted by any cut-off drainage installed upslope of borrow pits.
- To provide context, the above watercourses flow into the Crawick Water, which has a much larger catchment and mean and low flow values of 2.766 m^3/s and 0.281 m^3/s, respectively.
- Comparing the mean flow and low flow rates for the Clackleith Burn, the suggested maximum abstraction of 50 m^3/day equates to 2.5% of the mean flow value and 20% of the low flow value. For the Winter Cleuch, the same abstraction rate represents 12% of the mean flow, rising to effectively 100% abstraction during low flow conditions. The equivalent percentages for the same abstraction rate on the Crawick Water are 0.02% of mean flow and 0.2% of low flow.
- It is considered that the Clackleith Burn is feasible for abstraction for concrete batching at BP02, using the Crawick Water as a contingency abstraction location in low flow conditions. The Winter Cleuch is not considered feasible, due to flow values, with the Crawick Water to be used for abstractions needed for concrete batching at BP03.

7.160 Land, flooding and drainage related aspects within Scottish Planning Policy (2014) were considered, including risk-based assessment of individual catchments with regard to SEPA Flood Mapping, use of sustainable drainage techniques and appropriate design of watercourse crossing structures.

Assessment of Effects

7.161 The assessment of effects is based on the project description as outlined in **Chapter 4.** Unless otherwise stated, potential effects identified are considered to be negative and adverse. The assessments are based on the criteria for sensitivity, magnitude, probability and significance provided in the Assessing Significance section of this chapter, including **Tables 7.2-7.4**.

7.162 The assessment assumes the integral good practice measures described in **Chapter 4 (Appendix 4.3: CDEMP)** have been incorporated into the design and these do not form mitigation measures.

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

Summary of Appendices

7.164 A section of overview photographs from field surveys and diagrams are located in **Appendix 7.1: Accompanying Photograms and Diagrams**. These typically show a variety of representative features across the Development Area.

7.165 The Peat Stability Assessment is located in **Appendix 7.2: Peat Stability Assessment**. Potential effects are outlined within the Peat Stability section of this assessment. Due to the previous mining history in the locality, **Appendix 7.3: Mining Desk Study** and the associated **Appendix 7.4: Water and Soil Sampling Results** were prepared. Potential effects are outlined within the Mobilisation of Metals section of this assessment.

7.166 Additional details on GWTDE assessed to inform this chapter are presented in **Appendix 7.5: Groundwater Dependant Terrestrial Ecosystems**. Potential effects are considered within the Modification of Groundwater Levels and Flows, including Groundwater Dependent Terrestrial Ecosystems section of this assessment.

7.167 Additional details on the private water supplies assessed to inform this chapter are presented in **Appendix 7.6: Private Water Supplies**. Potential effects are considered within the Pollution Incidents section of this assessment.

7.168 The details on watercourse course crossings and an inventory of CAR watercourse crossings for the Development Area is located in **Appendix 7.7: Watercourse Crossings.** Potential effects are outlined within the Modifications to Surface Water Drainage Patterns section of this assessment.

7.169 The Borrow Pit Report is located in **Appendix 4.1: Borrow Pit Report.** Potential effects from borrow pits are outlined within the relevant sections of this assessment.

7.170 The Soil and Peat Management Plan is located in **Appendix 4.4: Soil and Peat Management Plan.** Potential effects are outlined within the Erosion and Sedimentation section of this assessment.

Additional Effects Scoped Out Following Baseline Studies

7.171 Following the collection and interpretation of data to establish the existing conditions for the Development, a number of additional effects have been scoped out.

Effects on Groundwater Dependent Terrestrial Ecosystems

7.172 Groundwater dependent terrestrial ecosystems (GWDTE) may be adversely affected by local changes in the groundwater regime, potentially resulting in altered vegetation in corridors close to infrastructure. As stated in the baseline section, approximately 7% of the NVC survey area, (see **Chapter 8: Ecology)**, comprises areas identified as GWDTE which have the potential (based on vegetation communities present) to be highly dependent on groundwater sources, based on SEPA Guidance[xxxiii]. These are 25 clusters of habitats, located within 100m of tracks and construction compounds and/or within 250m of foundations (including turbines, substation control building and borrow pits). A description of each of these areas is provided in **Appendix 7.5** and are illustrated in **Figure 7.8**, showing all GWDTE areas within the study area

7.173 These locations have been considered further, taking account of local topography, geology, hydrogeology and hydrology to determine likely primary sources of water for each area. Underlying bedrock geology (Kirkcolm & Portpatrick Formation Greywacke) is classed as a low productivity aquifer with limited groundwater presence in surface weathered zones and secondary fractures. Underlying superficial geology across the Development Area primarily consists of impermeable till (Devensian) and shallow peat. These GWDTE areas are typically identified as adjacent to watercourse channels or on flush zones on slopes, with primary water sources likely to be surface water and rainfall. Further details are provided in **Appendix 7.5**.

7.174 Following investigation of the areas with potentially high dependency, GWDTE Areas 1-25 have all been assessed as low groundwater dependency GWDTE, due to the lack of underlying or surrounding likely groundwater components.

7.175 Therefore, all initially identified areas are now considered to be of low groundwater dependency and thus of low sensitivity to changes in groundwater levels or flows and the Development is not considered likely to lead to a significant effect when taking account of standard good practice measures. All identified potential GWDTE areas are considered to be allocated against SEPA LUPS Guidance Note 31 Option 2; as these areas are judged not to be groundwater dependent[xxvi]. GWDTE have therefore been scoped out of detailed assessment, based on the findings of the baseline study.

Operational Effects

7.176 The risk of pollution, mobilisation of metals and effects of peat instability to surface water, groundwater, soil and related receptors are all substantially lower during operation than during construction due to the decreased levels of site activity and reduced sources of pollution.

7.177 As the man-made impermeable areas are small in comparison with the catchment area, no appreciable increase in runoff volumes is expected, even at site catchment scale. Watercourse crossing structures will be designed to meet 1:200 annual return period flow capacity.

7.178 Taking account of the design principles adopted during construction in tandem with the applicable good practice measures (provided in **Appendix 4.3: CDEMP**) during operation will reduce the probability of an incident occurring and also reduce the magnitude of any incident, due to a combination of good drainage design, staff training, contingency equipment and emergency plans. Accordingly, these effects during operation are reduced from those assessed for construction and are scoped out.

Receptor Sensitivity

7.179 Receptor sensitivity has been determined using the criteria provided on **Table 7.2**.

7.180 All watercourses and groundwater receptors have been rated as of **high** sensitivity, given water quality, groundwater vulnerability classifications and direct hydrological linkage to River Nith with salmonid and flooding concerns.

7.181 Local private water supplies are considered of **medium** sensitivity value, based on these being supplies to individual or small number of properties. It is recognised that these receptors will be an important issue for the specific properties.

7.182 Peat-containing soils are found across the Development Area, however, mapping of blanket peat and Class 1-2 priority peatland and carbon-rich soils identified that more sensitive peatland areas are very limited within the Development Area, restricted to distinct upland areas on Wedder Hill, Well Hill and Highmill Knowe in the central part of the Development Area, Slough Hill and Reecleuch Hill in the east and Stood Hill and Willowgrain Hill in the south. Site peat surveys have confirmed that the Development Area as a whole has very shallow peat, with average peat/soil depth measured at 0.44m, with isolated clusters of peat depths greater than 1.0m in parts of the areas noted from mapping data above. Soil samples recorded that clay is often found underlying a shallow surface peat layer (as detailed in **Appendix 7.4**). Accordingly, soil and peat receptors are considered of **medium** sensitivity.

Construction Effects

Pollution Incidents

7.183 During the construction phase a number of potential pollutants will be present on site to facilitate civil engineering activities and forestry clearance, including oil, fuels, chemicals, unset cement and concrete and waste and wastewater from construction activities. With chemicals and oil being stored and used on site and concrete batching anticipated in defined areas, there is the potential for a pollution incident.

7.184 Any pollution incident occurring within the Development Area may have a detrimental effect on the water quality of the nearby surface waters, groundwater and/or soil, thereby also indirectly affecting ecology.

7.185 Concrete batching is recognised as having the potential for causing a pollution incident. Two concrete batching locations at this pre-detailed design stage are proposed at borrow pits BP02 and BP03, which are located close to site entry points and anticipated to avoid transporting concrete on public roads. At the detailed design stage it may become apparent that off-site batching is more appropriate (or partial off-site batching) but there remains the potential for concrete batching on site and this scenario is considered in this assessment and good practice measures are detailed in **Appendix 4.3: CDEMP**. Abstraction issues for concrete batching are discussed separately but suitability of locally abstracted water would require confirmation by the concrete batching contractor in due course. If a requirement is determined to use potable (drinking) water for concrete batching then this material will be treated for storage and use as per other site chemicals, as it is recognised that chlorine and other chemical additives introduced to potable water may have adverse effect on natural water systems.

7.186 The adoption of the applicable good practice measures (provided in **Appendix 4.3: CDEMP**) will reduce the probability of an incident occurring and also reduce the magnitude of any incident that does occur, due to a combination of good site environmental management procedures, including good practice storage of potential polluting materials, staff training, contingency equipment and emergency plans.

7.187 In addition, the substantial dilution factor when comparing site watercourse flows with the confluence locations where the Crawick Water and Mennock Water meet the River Nith, would be expected to further reduce any potential pollutant effect to the downstream River Nith.

7.188 The following effects take account of the inherent design principles and good practice measures discussed above and identified in **Appendix 4.3: CDEMP**:

- As a **high** sensitivity receptor, the magnitude of pollution effect on surface waters is considered **moderate** and of **low** probability to occur, giving an overall significance of **minor**.
- As a **high** sensitivity receptor, the magnitude of pollution effect on groundwater is considered **moderate** and of **low** probability to occur, giving an overall significance of **minor**.
- As a **medium** sensitivity receptor, the magnitude of pollution effect on soil is considered **moderate** and of **low** probability to occur, giving an overall significance of **minor**.

Mobilisation of Heavy Metals

7.189 The legacy of mining in the wider area has resulted in elevated concentrations of heavy metals, in particular lead, zinc and cadmium currently being mobilised/released into the environment and adversely effecting local soil, groundwater and surface water quality. The proposed infrastructure is all located outside of the former mining area of high risk and consequently their construction are not considered likely to exacerbate the pollution already caused by the historic mining in the Wanlockhead area or be affected by the presence of mining associated voids. A conceptual site model was prepared as part of **Appendix 7.3**, which details potential source-pathway-receptor linkages.

7.190 Heavy metals have also been identified as being in elevated concentrations in local soils, with detailed soil and water sample information is provided in **Appendix 7.4**. The conclusion of this study is that elevated levels of heavy metals are present in soil and water samples across this site, irrespective of proximity to historic mine workings, these are considered to represent naturally elevated levels determined by the local underlying geology and not linked to historic mining activity.

7.191 Consequently, there is potential for excavation, construction and drainage associated with the proposed development of turbines and the associated infrastructure such as substations, access tracks and borrow pits to exacerbate the mobilisation of material in this naturally elevated situation. The potential additional mobilisation of heavy metals from natural background, in particular when dealing with peat, during earthworks and when managing runoff and drainage was an important aspect in the development process and design.

7.192 With elevated levels of metals, there is the potential for mobilisation of heavy metals which could occur during transfer of soil or aggregate into other areas of the Development Area. There is also the potential for mobilisation of heavy metals from soils into the water environment, exacerbating the existing elevated heavy metal loading in groundwater and watercourses, such as the Wanlock Water, which has led to downgraded water quality status under the Water Framework Directive, due to mining legacy.

7.193 Due to the avoidance of areas identified as being of high and medium risk due to historical mining and mineral lodes, the Development is unlikely to interact with any existing mine waste and expose reactive sulphide minerals to the atmosphere, however, there is a possibility that excavations could intercept unmapped natural mineral veins, exposing reactive minerals in the excavations. These minerals could be taken into solution on exposure to water and washed into nearby watercourses or into the ground via historic mine workings or bedrock fractures. It is considered that the 'saddle' between Green Hill and Black Hill is the area where this risk is most likely to occur given the regional presence of historic mine workings and the location of mineral lodes outcropping at surface. In addition to the presence of mineral lodes, geological descriptions of the Moffat Shale formation state that this formation includes the presence of black shales. Black shales often contain pyrite (iron sulphide) which can result in the generation of acid rock drainage should the pyrite be exposed to the atmosphere.

7.194 The Development design has avoided areas with historic mining impacts and by implementing good practice for material handling on site and drainage design identified in **Appendix 4.3: CDEMP** will limit additional mobilisation of heavy metals from naturally elevated baseline conditions.

7.195 Taking account of the above information, design iterations and commitment to further studies to determine appropriate site management measures:

- As a **high** sensitivity receptor, the magnitude of the effect of mobilisation of heavy metals on surface water is considered to be **moderate** and of **medium** probability to occur, giving an overall significance of **moderate (significant)**.
- As a **high** sensitivity receptor, the magnitude of the effect of mobilisation of heavy metals on groundwater is considered to be **minor** and of **medium** probability to occur, giving an overall significance of **minor**.
- As a **medium** sensitivity receptor, the magnitude of the effect of mobilisation of heavy metals on soils is considered **minor** and of **medium** probability to occur, giving an overall significance of **minor**.

7.196 As there is a significant effect identified, mitigation measures have been provided in sections 7.236 to 7.241.

Erosion and Sedimentation

7.197 Soil erosion and sediment generation may occur in areas where the ground has been disturbed, including during forestry clearance and log transit. It is of particular concern where engineering activities occur close to watercourses, such as at watercourse crossings and where higher velocity surface water flows may occur due to local slopes and drainage design. Surface water passing through the drainage network, efficiently draining the new infrastructure, can exhibit high localised flows, increasing the potential for bank erosion.

7.198 Sediment transport in watercourses can result in high turbidity levels which affect the ecology, particularly fish stocks, by reducing the light and oxygen levels in the water. Sediment deposition can further affect watercourses by potentially smothering plant life, invertebrates and spawning grounds and can reduce the flood storage capacity of channels and block culverts, resulting in an increased flood risk.

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

7.200 The design principles and adoption of the applicable good practice measures (provided in **Appendix 4.3: CDEMP**) will reduce the probability of an incident occurring and also reduce the magnitude of any incident due to a combination of good site environmental management procedures, including additional precautions when operating machinery close to watercourses, soil management, staff training, contingency equipment and emergency plans.

- As a **high** sensitivity receptor, the magnitude of sedimentation effect on surface water quality is considered to be **minor** and of **medium** probability to occur, giving an overall significance of **minor**.

Modification of Surface Water Drainage Patterns

7.201 Watercourses within the Development Area and the Development's receiving watercourses have been identified as having a moderately flashy response to rainfall events, as demonstrated by rapid response times and high peak flows. In addition, very low flows may be recorded in watercourses during dry periods, such as in summer months. It is recognised that changes in river siltation, land drainage, water quality, the presence of river obstructions and river flow reductions can have a detrimental effect on the populations of fish, freshwater invertebrates and species dependent on the water environment.

7.202 Forestry clearance and log transit activities can lead to flow impediments in watercourse channels. Turbine bases and other constructed impermeable surfaces will restrict the infiltration of rainfall into the soil and underlying superficial deposits, resulting in localised increased volumes of surface runoff.

7.203 The interception of diffuse overland flow by new tracks and their drains may disrupt the natural drainage regime of the Development Area by concentrating flows and influencing drainage in soils. This effect will be incremental during the construction phase and the main effect may only become apparent during the operational phase of the Development.

7.204 Surface flows can be impeded by construction activity in or adjacent to stream channels, poor choice of crossing locations and inadequately designed crossing structures. Blockages can be caused by inadequate control of earthmoving plant, sedimentation and poor waste management, all of which could lead to flooding upstream. Downstream of the Development Area, there are a number of locations considered to be flood-sensitive (based on SEPA Flood Risk mapping), such as at the Wanlock Water confluence of the Crawick Water and the River Nith at Sanquhar, plus further downstream adjacent to the River Nith at Thornhill and Dumfries.

7.205 It may be possible to abstract the quantities of water required for concrete batching from a nearby drainage channel (such as cut-off channels diverting surface flows from hillside above BP02 or BP03) and/or local watercourses. However, this will be subject to assessment of low flow conditions in the watercourses at the detailed design stage, consideration of water quality and the approval of SEPA under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended), known as CAR. As discussed above, detailed calculations of low flows and water demand will be carried out at the detailed design stage however some estimates, based on reasonable site assumptions, have been calculated to gain a broad insight into the likely abstraction volumes and rates required. These are discussed in detail in Project Design Considerations section of this chapter. It is considered that water can be abstracted in accordance with regulatory requirements from the Clackleith Burn and the Crawick Water.

7.206 The adoption of the applicable good practice measures (provided in **Appendix 4.3: CDEMP**) will reduce the effect of modification to surface water drainage patterns, with artificial drainage installed only where necessary and shall, wherever practical, be installed in advance of ground being cleared of vegetation. All structures will be designed and constructed following good practice techniques and will be of sufficient capacity to receive 1:200 annual exceedance probability flow event, with an allowance for increased flows due to climate change. Engineering works in or adjacent to watercourses will be minimised in terms of hydromorphology effects, with CAR criteria followed and appropriate applications made pre-construction.

7.207 The area of impermeable surface created will be very small in comparison with local catchment areas, as only the turbine, substation and construction compound bases will be designed as impermeable, with the unbound tracks likely to act as semi-permeable features with limited infiltration potential. The drainage shall be designed to encourage infiltration into soils and sustainable drainage design. These measures will reduce the potential for site flooding and increases of peak surface water flows from the Development Area which could exacerbate existing flood risk issues on the downstream River Nith.

7.208 The additional infrastructure added in these catchments, taking account of these measures, will not alter the existing characteristics of the Development Area, with steep slopes and underlying geology encouraging a rapid/flashy response in watercourse levels during/following rainfall events.

7.209 The following effect takes account of the inherent design and good practice measures discussed above and identified in **Appendix 4.3: CDEMP**:

- As a **high** sensitivity receptor, the magnitude of effect on surface water drainage patterns is considered **minor** and of **medium** probability to occur, giving an overall significance of **minor**.

Modification of Groundwater Levels and Flows

7.210 Deep excavations, such as those required for the turbine foundations, can disrupt shallow groundwater systems. Groundwater controls, such as physical cut-offs or dewatering, will be utilised to prevent the excavations filling with water. This is likely to result in the lowering of groundwater levels in the immediate vicinity of the excavations and alterations to flow paths during dewatering activities.

7.211 Access tracks may interrupt shallow groundwater flow. There may be some infiltration of water through the access tracks, but the majority of the water will enter the surface water drainage system and will be discharged downslope of the access track at discrete points.

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

7.213 However, local soil water conditions across the Development Area are considered to be primarily influenced by surface water and direct rainfall, with groundwater having minimal influence, with this influence decreasing at higher altitude. The underlying geology at the site is generally considered as low permeability with limited groundwater storage, with potential groundwater present in near-surface weathered zones and fractures, as per the hydrogeological baseline information, which corroborates this judgement. Springs issue from hillsides at higher elevations, further reducing groundwater influence. The typically shallow peat depths to underlying geology, averaging 0.44m from all peat probes, also suggests limited potential for influence on groundwater from construction activities.

7.214 The adoption of the applicable good practice measures (provided in **Appendix 4.3: CDEMP**) will reduce effects upon groundwater systems, with the effects of dewatering likely to be local and temporary with groundwater expected to return to former levels quickly following cessation of construction activities. The key concerns for good groundwater management involve careful decisions involving locations of drainage and dewatering activity and ensuring such activities are undertaken sympathetically and minimised in terms of extent and time to avoid excessive influence on groundwater levels and flows.

7.215 It is possible that there will be local lowering of the water table close to track corridors, resulting in a localised corridor of altered vegetation and ecology. Turbine foundations and borrow pit excavations will permanently alter groundwater flows at the coincident locations, however it would be expected that natural conditions of groundwater level and flow will recur close to these locations.

7.216 The following effect takes account of the inherent design and good practice measures discussed above and identified in **Appendix 4.3: CDEMP**:

- As a **high** sensitivity receptor, the magnitude of effect on groundwater levels and flows is considered **minor** and of **low** probability to occur, giving an overall significance of **minor**.

Private Water Supplies

7.217 Details are provided in **Appendix 7.6** of local private water supplies, following investigation into the sources of the private water supplies two properties are considered to be potentially adversely effected by the Development; Nether Cog and Clenries. These private water supplies are considered to be hydrologically connected to the Development, each of which use groundwater sources located

hydrologically downgradient of the Development however clear flowpath information is not known at this stage, i.e. the direction of groundwater flow.

7.218 Nether Cog (also known as Cogs Foot) has a spring supply which is located in close proximity to Access B. The supply is located 20m upslope of the existing track requiring upgrade, but also 120m downslope as the new track loops behind this supply approaching the sheepfold. There is also an unused borehole at Nether Cog, located 90m downslope of the existing track requiring upgrade.

7.219 The Clenries property has a spring supply located 1km downslope of Turbines 2 and 3 and the associated infrastructure.

7.220 Potential effects on private water supplies relate to construction pollution, mobilisation of heavy metals and/or changes to groundwater levels or flows. Temporary loss of supply would constitute a moderate magnitude effect as per **Table 7.3**.

- As a **medium** sensitivity receptor, the magnitude of construction pollution effect on private water supplies is considered **moderate** and of **medium** probability to occur, giving an overall significance of **minor**.
- As a **medium** sensitivity receptor, the magnitude of the effect of mobilisation of heavy metals on private water supplies is considered **minor** and of **medium** probability to occur, giving an overall significance of **minor**.
- As a **medium** sensitivity receptor, the magnitude of effect on groundwater levels and flows causing an indirect effect on private water supplies is considered **moderate** and of **medium** probability to occur, giving an overall significance of **minor**.

7.221 In order to protect individual private waters supplies, specific mitigation measures have been provided in sections 7.242 to 7.245.

Loss of Soils and Compaction of Soils

7.222 In its regulatory position statement[xxxiv], SEPA states that "developments on peat should seek to minimise peat excavation and disturbance to prevent the unnecessary production of waste soils and peat". The key items of infrastructure which influence this effect are the dimensions, location and type of new access tracks, turbine base foundations and crane hardstandings. Other features which should also be considered for excavation requirements include borrow pits, substation and temporary construction compound facilities.

7.223 Although this site has typically shallow soils and modifications made during the layout design process has led to an avoidance of most areas where deeper peat has been identified, the aggregated volume of excavated material for site infrastructure results in 181,500m^3 of material requiring to be excavated. **Appendix 4.2** evaluates the likely volumes of soil and peat excavated during construction and opportunities for reuse of this material. It also identifies measures for the management of peat throughout the construction process. It is recognised that the initial priority is to reduce the volume of peat excavated, followed by appropriate reuse of any peat and soil excavated, as per the principle of the 'waste hierarchy'. The extensive dataset of peat depth data collected for the peat stability study has been used to inform this assessment.

7.224 With peat excavation and reuse opportunities refined, based on pragmatic good practice measures, the revised reuse potential exceeds the estimated excavated volume, i.e. demonstrating that it is reasonably practicable to anticipate the reuse of all excavated material on site (**Appendix 4.2**).

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

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

7.227 The design principles and adoption of the applicable good practice measures (provided in **Appendix 4.3: CDEMP** and **Appendix 4.2**) will reduce the soil losses and compaction of soil effects, with the combination of planning infrastructure on very shallow soils, minimising excavation, promoting local reuse of suitable material, identifying catotelmic / amorphous peat *in-situ* and the majority of vehicle movements being restricted to existing or new site tracks or clearly demarcated construction areas. This combination of measures resulting in any notable effect being very localised and temporary in nature.

Site monitoring will identify any areas where soil effects are noted and enable a fast response to minimise effect.

- As a **medium** sensitivity receptor, the magnitude of effect of soil loss is considered **moderate** and of **low** probability to occur, giving an overall significance of **minor**.
- As a **medium** sensitivity receptor, the magnitude of effect of compaction of soil is considered **minor** and of **low** probability to occur, giving an overall significance of **negligible**.

Peat Stability

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

7.229 With peat present within the Development Area, a Peat Stability Assessment was conducted and presented in **Appendix 7.2**, in accordance with the Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments[xxxv]. This is required for projects with a generating capacity of 50MW or above, falling under Section 36 of the Electricity Act 1989.

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

7.231 The concerns in the Development Area are primarily determined by steep slopes, with some locations showing visual evidence of historic and active slope instability. Peat depths are typically shallow, generally less than 1.0m, and the instability issues are on slopes with shallow peat or non-peat soils. The Development design has taken account of these factors, with infrastructure set back from particular locations following constraint inputs based on peat depth, slope angle and landslide susceptibility.

7.232 **Appendix 7.2** has highlighted 15 localised areas of initial stability concern (five High risk and 10 Moderate risk), with the methodology, data, location maps and interpretation of individual locations provided within this document. The methods involved in this investigation are purposefully cautious, in order to highlight initial areas of concern, with the expectation that additional data collated pre-construction will reduce concern.

7.233 The inherent design principles and adoption of the applicable good practice measures (provided in **Appendix 4.3: CDEMP** and **Appendix 7.2**) will reduce the effect of peat instability, with steep slopes and deep peat generally avoided and awareness to avoid loading materials on or at top of slopes and that slope support is not removed during construction activities.

- As a **medium** sensitivity receptor, the magnitude of effect of a peat stability failure on soil loss is considered **moderate** and of **medium** probability to occur, giving an overall significance of **minor**.
- As a **high** sensitivity receptor, the magnitude of effect of a peat stability failure on surface water sedimentation is considered **moderate** and of **medium** probability to occur, giving an overall significance of **moderate (significant)**.
- As a **high** sensitivity receptor, the magnitude of effect of a peat stability failure on surface water drainage patterns is considered to be **minor** and of **low** probability to occur, giving an overall significance of **minor**.

7.234 As there is a significant effect identified, mitigation measures have been provided in sections 7.246 to 7.248.

Proposed Mitigation

7.235 In addition to the good practice measures outlined in **Chapter 4**, **Appendix 4.3**, further mitigation has been identified specifically in relation to the mobilisation of heavy metals and peat stability following the identification of potentially significant effects, and in relation to PWS to protect supplies to the properties.

Mobilisation of Heavy Metals

7.236 With regards to the mobilisation of heavy metals, reports prepared by Mouchel (**Appendices 7.3** and **7.4**) have been presented to SEPA, as noted in **Table 7.1**, which presented the methodology, results and interpretation of data collated during the EIA. Whilst the siting and design of the infrastructure has avoided the area of historic mine workings, further soil and water sampling, prior to construction, is proposed to identify the range of natural baseline values across the Development Area and enable

appropriate soil and water management measures to be established to minimise potential leaching of metallic content. This is primarily in relation to the potential risk of mobilisation of metal contaminants into the water environment, as identified in **Appendices 7.3** and **7.4**. The conceptual site model will be updated as further data is collected, to inform the soil management and pollution prevention strategy pre-construction, in consultation with SEPA.

7.237 As part of the geotechnical site investigation prior to construction, a more detailed baseline description of soil metal content will be prepared to quantify the current metal loading released from the Development Area, i.e. under natural conditions, and how this affects the metal loadings of the receiving watercourses. Further soil sampling will be undertaken to determine natural variations in heavy metals present or any evidence of contaminated land from historic mineworkings within the Development Area. Sampling will include data collection at borrow pits, each turbine foundation, the substation and at regular intervals along new track routes where turbines are absent, including the 'saddle' area between Green Hill and Black Hill and the western flanks of Glengaber Hill, with a total of 50-60 additional samples anticipated. This data will enable establishment of the range of natural elevated levels across the Development Area and agreement on threshold values for additional mitigation. The methodology for establishing bioavailability of metals will be determined and agreed with SEPA to enable a better understanding of potential biological effect on watercourses.

7.238 Where suitably high groundwater conditions occur, to further reduce potential for peat or excavated soils drying out and oxidising, mitigation will involve placing extracted peat material below the water table, or to have smaller artificial peat bogs to optimise metal absorption from surface run-off. Drainage design will take account of the benefits of local water storage and discharging into peatland to reduce quantity of elevated metal content runoff discharging into local watercourses.

7.239 At this stage, i.e. prior to intrusive ground investigation undertaken prior to construction, there is no intrusive geotechnical information available to determine whether black shales of this formation exist within the Development Area, however, should any be identified samples will be taken for analysis of sulphate content to determine pyrite content. If pyrite is found to be present, this material will not be excavated and/or used for infrastructure including tracks, thereby reducing the risk of generating acid rock drainage. Locations where infrastructure is located on Moffat Shale deposits will be tested and any instances of black shale exposure during excavations shall be identified and reported in order to seek guidance before construction proceeds, which could include floating track techniques to avoid excavating such material.

7.240 Any areas identified as containing particularly high metal levels in soil, relative to the Development Area in general and following agreement of threshold values with SEPA, shall have specific methodologies prepared for vehicle movements, soil disturbance and soil transfer activities, to reduce the potential of releasing such sediments into the environment. A CAR application will be prepared, specifically regarding management of site runoff and management of sediment containing elevated levels of metals, as requested in SEPA correspondence.

7.241 The above combination of targeted soil measurements and associated site management of highlighted areas pre-construction, in adherence with SEPA advice, is reflected in the residual effect assessment.

Private Water Supplies

7.242 Prior to construction, the Nether Cog and Clenries private water supplies will require further investigation and monitoring in accordance with SEPA Guidance[xxvi] and the Private Water Supplies (Scotland) Regulations 2006[xxxvi] in terms of both water quality and yield. Other local properties will also be contacted to confirm latest water supply status. Monitoring will involve assessing both water quality and water yield.

7.243 Discussions will also be held with property owners/occupiers to establish and plan for appropriate temporary replacement sources as contingency measures, with this most applicable for Nether Cog where track infrastructure is close to source area and associated pipework. An example of such contingency would be the planned provision of mobile water bowsers during periods of construction works in close proximity to private water supply locations.

7.244 It is not considered likely that any permanent replacement supplies will be necessary, however, should further data suggest this is required, replacement supply options will be discussed with owner/occupiers.

7.245 The above mitigation measures are reflected in the residual effect assessment.

Peat Stability

7.246 The peat stability mitigation measures are very location-specific and are fully detailed within **Appendix 7.2**. 15 locations are identified within **Appendix 7.2** that were considered of initial high or moderate risk and required further investigation, following review of individual location characteristics a total of nine locations are considered to remain as being of moderate risk, to highlight concern and ensure suitable and sufficient pre-construction activities are undertaken. These are identified in **Appendix 7.2** and shown on **Figure 7.2.4** as locations; A, B, E, F, N, G, K, L and O, with these areas located on the slopes of Slough Hill, Reecleuch Hill, Highmill Knowe, Willowgrain Hill, White Dod and Wether Hill.

7.247 Additional site investigation will be undertaken following forest clearance at Turbine 17, further peat data to be gathered from the moderate risk locations, plus consideration of micrositing of turbine and crane hardstanding infrastructure to reduce the probability for peat instability to occur. Peat and slope instability in all initially 15 identified areas shall be included in the project Geotechnical Risk Register, with ongoing mitigation on a location-specific basis; including the monitoring of slopes for both peat and on-peat instability, installation of piezometers to assess groundwater levels, plus consideration of slope support.

7.248 This moderate risk relates to a peat stability failure event occurring, this event having an indirect effect on surface water quality would be reduced and this is reflected in the magnitude and probability factors identified in the residual assessment.

Residual Construction Effects

7.249 As specific mitigation is only proposed for the mobilisation of heavy metals, private water supplies and peat stability effects, all other construction phase effects will remain as per the above section.

7.250 Following site-wide and location-specific mitigation measures discussed above and detailed in **Appendices 7.3** and **7.4** in relation to mobilisation of heavy metals:

- As a **high** sensitivity receptor, the magnitude of effect of the mobilisation of heavy metals on surface water quality is considered to be *reduced* to **minor**, retaining a **medium** probability to occur, giving an overall significance of **minor**.

7.251 Following location-specific mitigation measures discussed above and detailed in **Appendix 7.2** in relation to private water supplies (and including for specific mitigation in relation to mobilisation of heavy metals):

- As a **medium** sensitivity receptor, the magnitude of construction pollution effect on private water supplies is considered to remain **moderate** but *reduced* to **low** probability to occur, giving an overall significance of **minor**.
- As a **medium** sensitivity receptor, the magnitude of the effect of mobilisation of heavy metals on private water supplies is considered to remain **minor** but *reduced* to a **low** probability to occur, giving an overall significance of **negligible**.
- As a **medium** sensitivity receptor, the magnitude of effect on groundwater levels and flows causing an indirect effect on private water supplies is considered to remain **moderate** but *reduced* to **low** probability to occur, giving an overall significance of **minor**.

7.252 Following location-specific mitigation measures discussed above and detailed in **Appendix 7.2** in relation to peat stability:

- As a **high** sensitivity receptor, the magnitude of effect of a peat stability failure causing sedimentation to surface water quality is considered to remain **moderate** but *reduced* to a **low** probability to occur, giving an overall significance of **minor**.

Interrelationship between Effects

7.253 There are clear linkages and relationships between effects discussed within this chapter and **Chapter 8: Ecology**, particularly with regard to GWDTE, peatland habitats, aquatic habitats and the receptor species therein.

Further Survey Requirements and Monitoring

7.254 Surface water quality monitoring shall be undertaken from site watercourses, including those sampled during baseline assessment and detailed in **Appendix 7.4**. The parameters and locations shall be agreed with stakeholders and monthly testing, to include peak flow and low flow conditions, would be expected to commence 12 months prior to construction and include pH, turbidity and heavy metal loadings to establish pre-construction natural seasonal levels. During construction, water quality monitoring shall also be undertaken, adjacent to and downstream of construction activities liable to effect water quality or drainage patterns.

7.255 Private water supply monitoring will be conducted at the two identified supplies of ongoing concern (Nether Cog and Clenries), including monitoring of water quality and water yield at both source and property, where possible. This will include monitoring of interim locations between infrastructure and these receptors. This will follow appropriate SEPA monitoring guidance[xxvi].

7.256 Soil sampling will be undertaken to establish levels of heavy metals in soils within the Development Area, the specific parameters and locations of sampling will be agreed with SEPA and a threshold value for typical metal levels established. This will also be undertaken at locations planned for borrow pits prior to extraction and transfer of aggregate.

7.257 Slope stability monitoring will occur during pre-construction and construction phases of work, including for both peat stability and non-peat related stability. These would focus on locations highlighted as being of concern, as per **Appendix 7.2**. Further peat probing and stability assessments shall be undertaken post-forestry clearance such as at Turbine 17, to confirm indicative peat depths and stability assessment on the felled area, any additional areas of stability concern identified shall be added to the Geotechnical Risk Register.

Summary of Significant Effects

7.258 Significance has been determined with reference to the criteria identified in **Table 7.2**, **Table 7.3** and **Table 7.4**, following application of project design considerations and good practice measures, then subsequently assessed taking account of site-specific mitigation measures. Effects are considered adverse, unless stated otherwise.

7.259 Potentially significant effects prior to mitigation have been identified during the construction phase only in relation to mobilisation of heavy metals and peat instability. These are presented in **Table 7.13**.

7.260 Following the implementation of the specific mitigation measures outlined above in relation to these two construction phase effects, no significant adverse effects are predicted during the construction of the Development. No potentially significant effects are predicted during operation and cumulatively with other developments.

Table 7.13: Summary of Significant of Effects

Phase **Predicted Effect**	**Significance of Effect, Taking Account of Design and Good Practice Measures**	**Site-Specific Mitigation Measures**	**Significance of Residual Effect**
Construction Mobilisation of heavy metals; elevating metal levels in surface water quality	High sensitivity Moderate magnitude Medium probability Resulting in moderate effect **Significant**	*Competent environmental supervision during construction activities, particularly close to watercourses.* *Site-specific mitigation, as per detail in **Appendices 7.3 and 7.4**, including:* • *Soil testing to establish natural baseline range in advance of construction including leachate testing, bioavailability assessment and updating of conceptual site model;* • *Characterisation of all soils and aggregate planned for excavation across the site;* • *Ongoing dialogue with SEPA regarding threshold values and selection of appropriate mitigation and monitoring measures;* • *Increased control methods for excavating at locations with values beyond agreed threshold value;* • *Micrositing of infrastructure; and* • *Site awareness of potential of interaction with mine workings material, mineral lodes or black shale and ensuring appropriate training and supervision.*	High sensitivity Minor magnitude Medium probability Resulting in minor effect **Not significant**
Construction Peat stability failure; causing sedimentation to surface water quality	High sensitivity Moderate magnitude Medium probability Resulting in moderate effect **Significant**	*Competent environmental supervision during construction activities, particularly close to watercourses.* *Site-specific mitigation at locations of concern, detailed in **Appendix 7.2**, which will include additional investigation during geotechnical site investigation undertaken prior to construction.* *Additional site investigation following forestry removal.* *Micrositing of infrastructure.* *Ongoing slope stability monitoring.*	High sensitivity Moderate magnitude Low probability Resulting in minor effect **Not significant**

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