Chapter 9: Hydrology, Hydrogeology, Geology and Peat

Contents

9. Hydrology, Hydrogeology, Geology and Peat

9.1 Introduction

9.1.1 This chapter considers the potential effects of the Revised Larbrax Wind Farm (the Proposed Development) on Geology, Hydrology, Hydrogeology and Peat. It details the findings of the assessment of likely significant effects associated with the construction and operation of the Proposed Development.

9.1.2 This chapter should be read alongside **Chapter 7: Ecology** due to interactions between both disciplines in terms of the potential effects on water quality and potential effects on Ground Water Dependent Terrestrial Ecosystems (GWDTEs). Potential effects on any GWDTEs are considered within this chapter. The assessment is based on the project description and construction methods described in **Chapter 4: Development Description**.

9.1.3 This chapter has been prepared by Kaya Consulting Limited. Details of experience and expertise of the author is provided in **Technical Appendix 1.1: Statement of Expertise**.

9.1.4 This chapter is supported by a number of figures which are referenced throughout the text, and which can be found at **Volume 3a: Figures**:

- **Figure 9.1: Site location, showing hydrological features, topography, private water supplies and abstractions;**
- **Figure 9.2: Watercourses, buffers, main catchments and watercourse crossings;**
- **Figure 9.3: Ground Water Dependent Terrestrial Ecosystems (GWDTE), groundwater abstractions and private water supplies;**
- **Figure 9.4: Solid Geology and Superficial Geology;**
- **Figure 9.5: Soils;**
- **Figure 9.6: Carbon and Peatlands Classification;**
- **Figure 9.7: Peat Depths (combined Phase 1 and Phase 2).**

9.1.5 The following appendices are also referred to throughout the chapter and can be found in **Volume 4: Technical Appendices**:

- **Technical Appendix 9.1: Watercourse Crossings;**
- **Technical Appendix 9.2: Peat Survey Report;**
- **Technical Appendix 9.3: Groundwater Dependent Terrestrial Ecosystems (GWDTE);**
- **Technical Appendix 9.4: Flood Risk Assessment;**
- **Technical Appendix 9.5: Outline Peat Management Plan;** and
- **Technical Appendix 9.6: Peat Landslide Hazard and Risk Assessment.**

9.1.6 The following abbreviations will be referred to throughout this chapter. The associated meaning is set out in the Glossary at the end of this chapter.

- DGC – Dumfries and Galloway Council;
- GWDTE – Groundwater Dependent Terrestrial Ecosystems;
- PWS – Private Water Supply;
- DWPA - Drinking Water Protection Area;
- SEPA – Scottish Environment Protection Agency.

9.2 Assessment Methodology

Legislation, Policy and Guidance

Legislation

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

- The Flood Risk Management (Scotland) Act, 2009;
- The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) (CAR);
- The Water Framework Directive (2000/60/EC) (WFD), and Water Environment and Water (Scotland) Act (WEWS Act), 2003;
- The Pollution Prevention and Control (Scotland) Regulations, 2012;
- The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017 ('the EIA Regulations');
- The Control of Pollution Act 1974 (as amended) Part II: Pollution of Water;
- The Scotland River Basin District (Standards) Directions, 2014;
- The Scotland River Basin District (Status) Directions, 2014
- The Public Water Supplies (Scotland) Regulations, 2014;
- The European Drinking Water Directive (Council Directive 98/83/EC);
- The Private Water Supplies (Scotland) Regulations, 2006;
- The Water Intended for Human Consumption (Private Supplies) (Scotland) Regulations, 2017;
- The Water Environment (Drinking Water Protected Areas) (Scotland) Order, 2013; and
- The Waste Management Licensing (Scotland) Regulations, 2011.

Policy

9.2.2 The following policies of relevance to the assessment have been considered:

- SEPA: Policy No. 19, Groundwater protection policy for Scotland, 2009;
- Scottish Government: National Planning Framework 4, 2023; and
- Dumfries and Galloway Council: Local Development Plan 2, 2019.

Guidance

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

- The Scottish Environment Protection Agency (SEPA)'s Guidance for Pollution Prevention (GPPs) and Pollution Prevention Guidelines (PPGs), including:
  - GPP1: Understanding your environmental responsibilities – good environmental practices;
  - GPP2: Above ground oil storage tanks;
  - GPP4: Treatment and disposal of wastewater where there is no connection to the public foul sewer;
  - GPP5: Works and maintenance in or near water;
  - GPP6: Working at construction and demolition sites;
  - GPP8: Safe storage and disposal of used oils;
  - GPP21: Pollution incident response planning;
  - GPP22: Dealing with spills; and

  - GPP26: Safe storage – drums and intermediate bulk containers.
- Scottish Government Planning Advice Notes (PANs) and Guidance (including PAN 51 Planning, Environmental Protection and Regulation; PAN 1/2013 Environmental Impact Assessment, as amended; and PAN 79 Water and Drainage);
- Scottish Executive: River crossings & migratory fish: Design guidance, 2012;
- SEPA: Technical Flood Risk Guidance for Stakeholders, version 13, June 2022;
- SEPA: Water Environment (Controlled Activities) (Scotland) Regulations 2011 – A Practical Guide, Version 9.4 July 2024;
- SEPA: Position Statement to support the implementation of the Water Environment (Controlled Activities) (Scotland) Regulations 2005, WAT-PS-06-02: Culverting of Watercourses – Position Statement and Supporting Guidance, Version 2, June 2015.
- SEPA: Engineering in the Water Environment Good Practice Guide – River Crossings, WAT-SG-25, 2010;
- SEPA: Engineering in the Water Environment Good Practice Guide – Temporary Construction Methods, WAT-SG-29, 2009;
- SEPA: Sector Specific Guidance: Construction Sites, WAT-SG-75, 2021;
- SEPA: Special requirements for civil engineering contracts for the prevention of pollution, WAT-SG-31, 2006;
- SEPA: Land Use Planning System, SEPA Guidance Note 31 (LUPS-31): Guidance on Assessing the Impacts of Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems, 2017;
- SEPA: Flood Risk and Land Use Vulnerability Guidance, version 4, July 2018;
- SEPA: Climate change allowances for flood risk assessment in land use planning, Land Use Planning System SEPA Guidance. Version 3, 4 April 2023;
- SEPA: Regulatory Position Statement – Developments on Peat, 2010;
- Scottish Water standards and policies, including Sewers for Scotland 3rd edition, 2015 and Water for Scotland 3rd edition, 2015;
- CIRIA: The SuDS Manual (C753), 2015;
- CIRIA: Control of water pollution from construction Sites: Guidance for consultants and contractors (C532), 2001;
- CIRIA: Groundwater Control – design and practice (C515), 2016;
- Scottish Government, Scottish Natural Heritage & SEPA: Peatland Survey – Guidance on Developments on Peatland, 2017;
- Scottish Renewables, SNH, SEPA & Forestry Commission Scotland: Good Practice during Wind Farm Construction, 2019;
- Scottish Government: Peat Landslide Hazard and Risk Assessments, Best Practice Guide for Proposed Electricity Generation Developments (Second Edition), Scottish Government, 2017;
- DEFRA: Code of Practice for the sustainable use of soils on construction sites, 2009; and
- Scottish Government & Marine Scotland: Freshwater and diadromous fish and fisheries associated with onshore wind farm and transmission line developments: generic scoping guidelines, April 2022.

Consultation

9.2.4 At the time of writing DGC has not provided their Scoping Opinion and there have been no site-specific scoping consultation responses received from other consultees. In the absence of site-specific consultation and for completeness, details of SEPA's standard scoping appendix for wind farm applications are included below for completeness.

Table 9.1: Consultation Responses

Consultee and Date	Scoping/Other Consultation	Issue Raised	Response/Action Taken
SEPA	Other – Standard Scoping Response for Onshore Windfarms (Appendix 1)	SEPA consider that the following key issues must be addressed in the Environmental Impact Assessment process. To avoid delay and potential objection, the information outlined below (and detailed further in the appendix of the response from SEPA) must be submitted in support of the application:	The information requested is provided in this EIA Report, as described below (with justification for any exclusions at this stage):
		a) Map and assessment of all engineering works within and near the water environment including buffers, details of any flood risk assessment and details of any related CAR applications.	a) Map of all engineering activities is provided in **Figure 9.1** and buffers are shown in **Figure 9.2**. A Flood Risk Assessment was undertaken for the Proposed Development at the Green Burn crossing of the access track. Details of the assessment can be found in **Technical Appendix 9.4**. Flood risk is also described in the baseline and assessment. CAR requirements are also covered in the assessment and **Technical Appendix 9.4**.
		b) Map and assessment of impacts upon Groundwater Dependent Terrestrial Ecosystems and buffers.	b) A map and assessment of impacts upon GWDTE and buffers is included in **Figure 9.3** and **Technical Appendix 9.3**.
		c) Map and assessment of impacts upon groundwater abstractions and buffers.	c) A map and assessment of impacts upon groundwater abstractions and buffers are included in **Figure 9.1** and discussed in the effects assessment.
		d) Peat depth survey and table detailing re-use proposals.	d) A peat depth survey is provided in **Technical Appendix 9.2** and re-use proposals described in **Technical Appendix 9.5**. A Phase 1 peat survey was carried out in August 2023, supplemented by a Phase 1 survey conducted in 2013 by AECOM for the Consented Larbrax Wind Farm. The Phase 1 Peat Survey report was appended to the Scoping report, dated September 2023. The data was used to inform the design to avoid deeper peat.
		e) Map and table detailing forest removal.	e) There is no forest removal required for the Proposed Development. There will be some scrub removal along the access track. A map of

Consultee and Date	Scoping/Other Consultation	Issue Raised	Response/Action Taken
			the area to be cleared is included in **Figure 9.1**.
		f) Map and site layout of borrow pits.	f) There is one temporary borrow pit proposed as shown in **Figure 9.1**. The temporary borrow pit proposed for the extraction of stone will be located east of T2. An indicative plan and cross-section of the proposed borrow pit is shown in **Figure 4.13: Indicative Borrow Pit Search Area**.
		g) Schedule of mitigation including pollution prevention measures.	g) Pollution prevention measures are described in the Mitigation section within this chapter. A Schedule of Mitigation, Good Practice, Enhancement and Monitoring is provided in **Technical Appendix 2.1**.
		h) Borrow Pit Site Management Plan of pollution prevention measures.	h) A Borrow Pit Site Management Plan will support the Construction Environmental Management Plan (CEMP).
		i) Map of proposed waste water drainage layout.	i) The Proposed Development will not generate wastewater and therefore no waste water drainage layout is provided.
		j) Map of proposed surface water drainage layout.	j) A detailed surface water drainage layout plan will be developed post consent and prior to construction and will form part of the track Construction Method Statement.
		k) Map of proposed water abstractions including details of the proposed operating regime.	k) There is no water abstraction proposed for the Proposed Development.
		l) Decommissioning statement.	l) A decommissioning strategy will be submitted by the Applicant to DGC for agreement prior to the decommissioning works taking place, and this is likely to form a condition to the consent. Decommissioning effects for this chapter are scoped out of detailed assessment.
		SEPA expect to see a 50 m buffer applied to all watercourses. If a minimum buffer of 50 m cannot be achieved each breach must be numbered on a plan with an associated photograph of the location, dimensions of the loch or watercourse and drawings of what	A 50 m buffer was applied to all watercourses, including those identified during surveys. Locations where the 50 m water feature buffer is encroached are identified and justified in **Technical Appendix 9.1**. Site specific additional mitigation, if required, is outlined in

Consultee and Date	Scoping/Other Consultation	Issue Raised	Response/Action Taken
		is proposed in terms of engineering works.	the appendix and also in the schedule of mitigation.
		SEPA recommend that all small-scale watercourse crossings should be designed as oversized bottomless arched culverts or traditional style bridges.	Noted. Details of watercourse crossings are provided in **Technical Appendix 9.1**.
		SEPA note the following Regulatory Requirements: • Proposed engineering works within the water environment will require authorisation under The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended). • Management of surplus peat or soils may require an exemption under The Waste Management Licensing (Scotland) Regulations 2011. • Proposed crushing or screening will require a permit under The Pollution Prevention and Control (Scotland) Regulations 2012. Consider if other environmental licences may be required for any installations or processes.	Engineering in the water environment has been minimised. **Technical Appendix 9.1** and **Figure 9.1** provides information on new and existing watercourse crossings and comments on the level of CAR authorisation required. An Outline Peat Management Plan (**Technical Appendix 9.5**) has been prepared which identifies the volumes of peat to be excavated in association with proposed infrastructure and provides suitable reuse recommendations and mitigation measures. Relevant permits for the proposed crushing or screening (at the borrow pits) will be sought when required. A CAR construction site licence will be required for the Proposed Development. This will be applied for in advance of construction in line with SEPA's Sector Specific Guidance: Construction Sites (WAT-SG-75).
Dumfries and Galloway Council (DGC) 20th June 2023	Response to PWS data request	DGC provided its register of known Private Water Supply (PWS) sources and supplies in the form of a shapefile. DGC noted that the register contains details of the private water supplies that they are aware of, however there is likely to be a number of water supplies that have not been notified to the Council.	The PWS data provided was reviewed and mapped to inform the baseline. Local residents were contacted via questionnaires and site visits to inform whether their properties are supplied by a PWS. There are no PWS within the Site boundary and four PWS within 1 km of the Site boundary.
SEPA 4th September 2023	Response to data request for information on groundwater abstractions	SEPA confirmed that there are no licensed abstractions showing from a search of 1 km from Site boundary. SEPA noted that private drinking water supply abstractions of 10 m^3 or less are covered by a General Binding Rule (GBR) and they do not hold a record of these. It is the responsibility of the local	The data was used to inform the baseline - there are no SEPA groundwater abstractions within a 1 km buffer of the Site boundary. DGC was contacted to obtain the council data on PWS (see above).

Consultee and Date	Scoping/Other Consultation	Issue Raised	Response/Action Taken
		authority to maintain a register of private drinking water supplies, and it is suggested that contact is made with DGC for this information.	

Study Area

9.2.5 The study area for the hydrology and hydrogeology assessment covers the Site itself and watercourses/waterbodies which drain the Site. The study area for geology and peat encompasses the locations of proposed infrastructure within the Site. The peat and hydrology survey extents are shown in **Figure 9.1**.

9.2.6 The study area for detailed assessment of groundwater abstractions, including private water supplies and GWDTE, is within a 250 m buffer zone from the permanent infrastructure, as per SEPA guidance. However, a wider search area of 1 km from the Site boundary for private water supplies and groundwater abstractions was undertaken for the assessment.

Desk Based Research and Data Sources

9.2.7 The following data sources have informed the assessment:

- Ordnance Survey mapping at 1:25,000 and 1:50,000 scales;
- British Geological Survey (BGS) online digital mapping at 1:50,000 and 1:625,000 scales;
- Scottish Soil mapping at 1:250,000 scale;
- NatureScot (formerly SNH) Carbon and Peatland 2016 mapping at 1:250,000 scale;
- Aerial imagery of the Site and surrounding area;
- The Flood Estimation Handbook (FEH) Web-service[1];
- SEPA Flood Maps[2];
- SEPA Water classification Hub[3];
- Ordnance Survey (OS) Terrain 5 Topographic Data (5 m resolution);
- LiDAR Phase 3 DTM data downloaded from the Scottish Remote Sensing Portal[4];
- Scotland's Environment Website and Interactive Map[5];
- NatureScot Site Link Interactive Map[6];
- Scottish Water Asset Plans of the Site, viewed online on the Scottish Water GIS Extranet[7];
- Private Water Supply Data provided by DGC;
- Private Water Supply Data obtained from questionnaires sent to local properties and 'door knocking' consultation with residents;
- Licenced Abstraction Data provided by SEPA; and
- AECOM (2015) Larbrax Wind Farm: Environmental Statement, including an initial Phase 1 peat depth survey, which was undertaken in 2013 by AECOM, covering the eastern part of the Site.

[1] https://fehweb.ceh.ac.uk/Map
[2] https://scottishepa.maps.arcgis.com/
[3] https://www.sepa.org.uk/data-visualisation/water-classification-hub/
[4] https://remotesensingdata.gov.scot/data#/map
[5] https://map.environment.gov.scot/sewebmap/
[6] https://sitelink.nature.scot/map
[7] https://sw.cloud.esriuk.com/portal/apps/webappviewer/index.html?id=ee4bc6712ce64290b41b2d998ec7a749

Field Survey

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

- Phase 1 peat depth survey and initial hydrology walkover – 26th to 27th July 2023 (main area of proposed infrastructure). Peat surveys were carried out following the Scottish Government, Scottish Natural Heritage & SEPA (2017) guidance[8]. Further details of methodology are described in **Technical Appendix 9.2**. The weather conditions during the Phase 1 peat depth survey were mixed, with dry, sunny weather on the 26th morning, followed by a prolonged period of rainfall throughout the afternoon and evening. The 27th followed with sun and no rain.
- Phase 2 peat depth survey – 1st to 2nd May 2024; 16th May and 30th May. The weather was sunny and warm the first two days and overcast was some rain on the following visits.
- GWDTE and PWS surveys – 31st August to 1st September 2023 to ground truth potential GWDTEs identified based on vegetation to assess hydrological setting and actual groundwater dependence and visit local properties to determine PWS source locations. Weather was dry and overcast.
- Hydrology and watercourse crossing assessment – 26th to 27th July 2023 and 1st to 2nd May 2024. Weather conditions were the same as the Phase 1 and 2 peat survey weather as above.
- The weather conditions experienced over the survey periods did not limit survey quality.

Assessing Significance

Sensitivity

9.2.9 Sensitivity of receptors has been determined on the basis of the following criteria shown in **Table 9.2**.

Table 9.2: Criteria to Assess the Sensitivity of Receptor

Sensitivity of Receptor	Typical Indicators
High	Receptor is of national or international value (i.e., Site of Special Scientific Interest (SSSI), Special Area of Conservation (SAC), Special Protection Area (SPA), and RAMSAR). Overall water quality classified by SEPA as high and salmonid spawning grounds present. Abstractions for public water supply. Groundwater classified under the WFD as 'good' or groundwater resource with numerous sensitive users/receptors. The flooding of property (or public roads) that has been susceptible to flooding in the past. Watercourse floodplain/hydrological feature that provides critical flood alleviation benefits. Natural channel and of high morphological diversity. Receptor supports GWTDE confirmed as highly groundwater dependent. Class 1 or 2 priority peatland.
Medium	Receptor is of regional or local value (e.g. Local Nature Reserve). Overall water quality classified by SEPA as good or moderate, salmonid species may be present and may be locally important for fisheries.

[8] Scottish Government, Scottish Natural Heritage & SEPA (2017) Peatland Survey - Guidance on Developments on Peatland

Sensitivity of Receptor	Typical Indicators
	Smaller watercourse lying upstream of larger river that is an SSSI, SAC SPA or RAMSAR. May be subject to improvement plans by SEPA. Abstractions for private water supplies. Groundwater resource with sensitive users/receptors. Environmental equilibrium copes well with natural fluctuations but cannot absorb some changes greater than this without altering part of its present character. The flooding of property (or public roads) that may be susceptible to flooding. Watercourse/floodplain/hydrological feature that provide some flood alleviation benefits. Semi-natural channel, with morphological diversity. May have some minor morphological constraints. Receptor supports GWTDE confirmed as moderately groundwater dependent. Unmodified active peatland. Deeper peat (>1.0 m depth) unless minor area.
Low	Receptor is of low environmental importance (e.g., water quality classified by SEPA as bad or poor, fish sporadically present or restricted). Not subject to water quality improvement plans by SEPA. Environmental equilibrium is stable and is resilient to changes which are considerably greater than natural fluctuations, without detriment to its present character. No abstractions for public or private water supplies. No significant groundwater resource and no identified sensitive users/receptors. No flooding of property or public roads. Watercourse/floodplain/hydrological feature that provides minimal flood alleviation benefits. Heavily engineered or artificially modified watercourse and may dry up during summer months. No GWDTE confirmed as either moderately or highly groundwater dependent. No or shallow peat (0.5 m to <1.0 m depth) and/or modified peat.

Magnitude

9.2.10 The magnitude of change has been assessed based on the criteria presented in **Table 9.3**.

Table 9.3: Criteria for estimating the Magnitude of Effect

Magnitude	Description/ Typical Example
Substantial	Fundamental changes to the hydrology, water quality, geology, or hydrogeology (in terms of quantity, quality, and morphology). A >10% change in average or >5% change in flood flows.

Magnitude	Description/ Typical Example
	The extent of flood risk areas (as classified by NPF4 – i.e. land or built form with an annual probability of being flooded of greater than 0.5% including an appropriate allowance for future climate change) will be significantly increased. Change that would render water supply unusable for longer than one month. Change resulting in total loss of feature or integrity of feature or use.
Moderate	Material but non-fundamental changes to the hydrology, water quality, geology, or hydrogeology (in terms of quantity, quality, and morphology). A >5% change in average and minimal change in flood flows. Extent of flood high risk areas will be moderately increased/or decreased. Change that would render water supply unusable for days or weeks with no alternative.
Slight	Detectable but non-material changes to the hydrology, water quality, geology, or hydrogeology (in terms of quantity, quality, and morphology). A ≥1% and ≤5% change in average flows and no increase in flood flows. Change that would render water supply unusable for short period (days) or for longer period if alternative supply put in place.
Negligible	No perceptible changes to the hydrology, water quality, geology, or hydrogeology (in terms of quantity, quality, and morphology). A <1% change in average and no change in flood flows. No change in water supply or minor change (days) where alternative is put in place.
None	No change to baseline.

Significance

9.2.11 The predicted significance of the effect was determined through a standard method of assessment based on professional judgement, considering both sensitivity and magnitude of change as detailed in **Table 9.4** below. **Major** and **moderate** effects are considered **significant** in the context of the EIA Regulations. Where two outcomes are possible through application of the matrix i.e. major/moderate effect, professional judgment supported by reasoned justification, has been used to determine the level of significance.

Table 9.4: Significance criteria

Receptor Sensitivity	Magnitude of Change				
	Substantial	Moderate	Slight	Negligible	None
High	Major	Major/Moderate	Minor	Minor	None
Medium	Major/Moderate	Moderate	Minor	Minor/Negligible	None
Low	Moderate	Minor	Minor/Negligible	Negligible	None

Assessment Assumptions

9.2.12 The following assumptions have been made when undertaking the assessment of effects:

- The assessment was based on existing, available data, supplemented by hydrology and peat depth surveys of the Site. 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 geology, hydrology, hydrogeology and peat.

- The assessment of effects has been undertaken assuming that the good practice and embedded mitigation measures described in **Section 9.6** and **Section 9.7** will be implemented. Additional mitigation is identified during the assessment to address localised site or issue specific likely significant adverse effects and is described within the 'Committed Additional Mitigation' section.

Assessment Limitations

9.2.13 The following limitations were considered when undertaking the assessment of effects:

- It is noted that a section of the access track is not fully covered by the Phase 2 peat depth data due to dense *Rhododendron* scrub obstructing access (**Image 9.1**). The peat depth data that exists is considered sufficient to inform the assessment.
- An artificial drain depicted on the 1:25,000 OS map in the east of the Site could not be accessed, also due the *Rhododendron* scrub. The artificial drain is discussed in more detail in **Technical Appendix 9.1** and the data that exists is considered sufficient to inform the assessment.

Image 9.1: Dense Rhododendron scrub obstructing access to a section of the access track for peat probing

9.3 Existing Conditions

Climate

9.3.1 The average annual temperature in this part of south-west Scotland is 12.88 °C (Met Office[9]). The average annual rainfall on the Site is 1043 mm (FEH[10]).

Topography

9.3.2 The Site is located in a varied topographic setting where ground levels within the Site generally slope downhill to the west towards the North Channel (**Image 9.2** and **Figure 9.2**). Larbrax Moor is generally flat, sloping down to the east towards the Green Burn. Galdenoch Moor is gently undulating, punctuated by Hind Hill (82 m Above Ordnance Datum [AOD]). **Figure 9.2** shows the topography of the Site and surrounds with the main hydrology features, including the catchment divide between the Green Burn catchment in the eastern part of the Site and the westerly drainage to the North channel. The highest elevation is 83 m AOD at the southern end of the Site on Larbrax Moor, with the south-eastern side of the hill steeply sloping towards a small unnamed watercourse. Coastal cliffs line the western edge of the Site boundary.

Image 9.2: Typical pasture across most of the Site, looking west towards the North Channel

Watercourses, Surface Water and Drainage

9.3.3 The western part of the Site is comprised of several small unnamed watercourses which generally drain west directly into the North Channel (**Figure 9.2**). T1 to T4, along with the substation and borrow pit, are located within the catchments of these smaller unnamed watercourses.

9.3.4 The eastern part of the Site drains towards the Green Burn (**Image 9.3** and **Figure 9.2**), via several small, unnamed watercourses. The Green Burn flows north adjacent to the eastern Site boundary. The Green Burn is known as the Galdenoch Burn downstream of its confluence with Mill Isle Burn north of the Site. The Galdenoch Burn then flows

[9] https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/
[10] https://fehweb.ceh.ac.uk/map

west towards the coast to enter the North Channel. The temporary construction compound and part of the access track where it connects with the B738 are located within the Green Burn / Galdenoch Burn catchment.

Image 9.3: The Green Burn flowing along the eastern Site boundary, looking upstream

9.3.5 There are several small surface waterbodies within the Site, including Loch More and Loch Beg.

9.3.6 Galdenoch Moor has artificial drainage both within the moor and around the periphery. Larbrax Moor has limited artificial drainage around the periphery.

Watercourse Crossings

9.3.7 There are a number of existing farm tracks already onsite with existing watercourse crossings. These tracks are between Meikle Galdenoch to the north of the Site and Meikle Larbrax to the south of the Site.

9.3.8 New watercourse crossings were reduced as far as practicable by using existing tracks where possible and minimising the number of crossings during initial design iterations. The Proposed Development will use four existing crossings, all requiring upgrading, and proposes four new crossings. Details and photographs of all watercourse crossings (existing and proposed) are provided in **Technical Appendix 9.1** with the locations shown on **Figure 9.2**.

9.3.9 There is a water flow pathway with boggy ground (crossing NC1) in the vicinity of T2 that will require to be crossed by new wind farm tracks. Two new crossings are also required along a section of new track to the south of Loch More: crossing NC2 is a flow outlet from the loch; crossing NC3 is a shallow drain. The fourth new crossing spans the Green Burn as part of the new access track (crossing NC4). The track crosses approximately 30 m of the Green Burn floodplain to the west of the river. A Flood Risk Assessment (FRA) has been provided for the Green Burn at **Technical Appendix 9.4**.

Hydrology and Flood Risk

9.3.10 The SEPA flood maps show the likely extent of flooding for high, medium, and low likelihood for fluvial (river), pluvial (surface water) and tidal flows.

9.3.11 The SEPA flood map indicates that there are some areas identified to be at risk of fluvial flooding for a 1 in 200-year event (including an allowance for climate change) within the Site. The areas identified as being at fluvial flood risk fringe the eastern extent and northern tip of the Site along the Green Burn / Galdenoch Burn, with the largest area of flood risk noted at the north-east Site boundary (**Figure 9.2**). This area is a floodplain to the west of the Green Burn through which approximately 30 m of access track crosses. More detail can be found in the Flood Risk Assessment (**Technical Appendix 9.4**).

9.3.12 The SEPA flood map predicts small areas of medium to high risk of pluvial (surface water) flooding around Loch More, the pond in the south-east Site corner, Loch Beg and Green Burn. There is no proposed infrastructure within the predicted pluvial floodplain extent.

9.3.13 The coastal flood risk area fringes the coastline to the west of the Site but does not encroach into the Site due to the steep nature of the terrain along the western Site boundary.

Water Supplies, Discharges, Abstractions and Services

9.3.14 DGC was consulted in June 2023 and provided their database of private water supplies (PWS). It is noted the council data can be incomplete and provides the supplied property location (and not the PWS source). Therefore, questionnaires were also sent out to properties within 1 km of the Site boundary which had the potential to be hydrologically connected to proposed infrastructure. The Scottish Water asset plans online were consulted to eliminate properties connected to the mains. Based on council data, questionnaire responses, and direct consultation with residents, it was found that there are no PWS sources within the Site boundary and six PWS properties within 1 km of the Site boundary (**Table 9.5** and **Figure 9.1**). The closest PWS source to any proposed infrastructure is the source that supplies Larbrax Lodge, which is located approximately 450 m upslope of the Site entrance.

9.3.15 The resident at Larbrax Lodge provided two source locations for their PWS source – one close to the Green Burn east of the property and one approximately 2 km south near Pinewood. Both source locations are listed in **Table 9.5**. There was no questionnaire response from Meikle Galdenoch property, however the surrounding properties, Drumwhistley and Greenburn, are connected to the mains, so it can be inferred that Meikle Galdenoch is also on the mains.

9.3.16 Due to PWS sources being at least 450 m away from proposed infrastructure and none being hydrologically connected to the Proposed Development, effects on PWS have been scoped out.

9.3.17 There are no Surface Drinking Water Protected Areas (DWPA) within the Site. There is a Surface DWPA approximately 1.5 km east of the Site (ID 100590 - Lochnaw Loch); this is in the upper catchment of the Mill Isle Burn, which is a tributary of the Galdenoch Burn, and will not be affected by the Proposed Development.

9.3.18 A review of Scottish Water asset plans online does not show any infrastructure within the Site.

9.3.19 Consultation with SEPA has confirmed that there are no licensed abstractions within a 1 km buffer of the Site boundary.

Table 9.5: Private Water Supplies (PWS) within 1 km of the Site Boundary

Data Source	Property Name	Property Location	PWS Source location	Source Type	Number of Properties Supplied	Distance from Nearest Proposed Infrastructure	Scoped in/out
Questionnaire response	Meikle Larbrax Cottages	NW 97777 60981	NW 97763 61015	Spring	1	The source is 918 m south-east of T1. Source is located north of Larbrax Cottages next to the small drain adjacent to the road. There is no infrastructure located upgradient within the catchment of the PWS source and it is not hydrologically connected to the Proposed Development.	Scoped out

Data Source	Property Name	Property Location	PWS Source location	Source Type	Number of Properties Supplied	Distance from Nearest Proposed Infrastructure	Scoped in/out
Questionnaire response	Larbrax Lodge	NW 98227 61557	NW 98374 61699 and NW 98767 59589	Well	1	The source is 450 m south-east of the access track entrance. The source is a well located immediately south of the Green Burn. There is no infrastructure upgradient within the catchment of the PWS source and it is not hydrologically connected to the Proposed Development. The second source is over 2 km south of the Site near Pinewood and will not be impacted.	Scoped out
Council data (no response was obtained from PWS questionnaire)	Glen-vallagh Cottage	NW 98204 62896	None provided	Unknown	Unknown	The property is 996 m north of the access track entrance. The property is located north of the Mill Isle Burn (**Figure 9.1**) in a different catchment to the Proposed Development. The source location is unknown but given the property location it will not be hydrologically connected to the Proposed Development	Scoped out
Questionnaire response	Galdenoch Mill Cottage	NW 97344 63473	NW 97351 63489	Spring	1	The source is 1,370 m north-east of T4. The source is located on the other side of Galdenoch Moor from the proposed infrastructure. There is no infrastructure	Scoped out

Data Source	Property Name	Property Location	PWS Source location	Source Type	Number of Properties Supplied	Distance from Nearest Proposed Infrastructure	Scoped in/out
						upgradient within the catchment of the PWS source and it is not hydrologically connected to the Proposed Development.	
Council data (no response was obtained from PWS questionnaire or site visit)	Larbrax School House	NW 98416 61041	None provided	Unknown	Unknown	The property is 1480 m south-east of T1 and 982 m south of the access track. The property is on the other side of a small watercourse. There is no infrastructure upgradient of the PWS and it is not hydrologically connected to the Proposed Development.	Scoped out
Council data (no response was obtained from PWS questionnaire or site visit)	Balgracie Farm	NW 98700 60700	None provided	Unknown	Unknown	The property is 1860 m south-east of T1 and 1400 m south of the access track. The property is upgradient from the Proposed Development and on the other side of the B738. The PWS property (and source) is not hydrologically connected to the Proposed Development.	Scoped out

Water Quality and Protected Areas

9.3.20 SEPA has characterised surface water quality status under the terms of the Water Framework Directive. Classification by SEPA considers water quality, hydromorphology, biological elements including fish, plant life and invertebrates, and specific pollutants known to be problematic. The classification grades through High, Good,

Moderate, Poor, and Bad status. This provides a holistic assessment of ecological health. There are two waterbodies within the Site which are large enough to be classified by SEPA[11]:

- The Galdenoch Burn (Waterbody ID: 10482) was classified as 'Moderate Ecological Potential' in 2022. The Galdenoch Burn has been designated as a heavily modified water body on account of physical alterations that cannot be addressed without affecting water storage in an upstream reservoir (for public drinking water). The reservoir (Lochnaw Loch) is in the upper catchment of the Mill Isle Burn, a tributary of the Galdenoch Burn, and will not be affected by the Proposed Development. Levels of specific pollutants and ammonium have been designated a 'Fail' since 2019.
- Mull of Galloway to Corsewall Point (Coastal Waterbody ID: 200012) was classified as 'Good' in 2022.

9.3.21 An area of coastline along the south-west of the Site lies within the Salt Pans Bay Site of Special Scientific Interest (SSSI). This is designated on the basis of its Maritime Cliff Geology and subsequent rare coastal heath habitat. Areas around T1 and T2 drain towards the SSSI (**Figure 9.1**).

Geology and Soils

9.3.22 The solid geology of the Site (**Figure 9.4**) is comprised of deep-sea sedimentary rock (Kirkcolm Formation Wacke). These detrital sedimentary rocks dominate the Site with the exception of a small area in the north of the Site which is comprised of Galdenoch Formation Wacke. The Kirkcolm Formation Wacke are derived from continental shelf origins, with graded bedding from coarse-grained to fine-grained sedimentary debris slurries.

9.3.23 Superficial deposits within the Site (**Figure 9.4**) are mainly composed of Glaciofluvial deposits (gravel, sand and silt).

9.3.24 Scottish Soil mapping (**Figure 9.5**) shows that the majority of the Site is underlain by mineral podzols with dystrophic basin peat on Larbrax and Galdenoch Moor. The northern part of the Site is underlain by brown forest soils and there is an area of peaty podzols in the north.

9.3.25 The NatureScot 2016 Carbon and Peatland Map indicates various classifications of peat across the Site. Parts of the areas of higher ground of Larbrax Moor and Galdenoch Moor (**Image 9.4**) in the east of the Site comprise of Class 1 peat, as shown in **Figure 9.6**. In the north of the Site, there is an area of Class 3 peat and there are smaller areas of Class 5 peat throughout the Site. The rest of the Site, particularly the western coastal area is classed as mineral soils (Class 0), with no peat indicated (**Image 9.8**). The relevant class descriptions are below:

- Class 1- Nationally important carbon-rich soils, deep peat and priority peatland habitat. Areas likely to be of high conservation value.
- Class 3 - Dominant vegetation cover is not priority peatland habitat but is associated with wet and acidic type. Occasional peatland habitats can be found. Most soils are carbon-rich soils, with some areas of deep peat.
- Class 4 - Area unlikely to be associated with peatland habitat or wet and acidic type. Area unlikely to include carbon-rich soils.
- Class 5 - Soil information takes precedence over vegetation data. No peatland habitat recorded. May also include areas of bare soil. Soils are carbon-rich and deep peat.

[11] https://www.sepa.org.uk/data-visualisation/water-classification-hub/

Image 9.4: Galdenoch Moor

Image 9.5: Exposed soil horizon in the area of proposed infrastructure

Peat

9.3.26 Detailed peat depth surveys were undertaken within the Site. The results of the peat survey are shown in **Figure 9.7** and presented in full in **Technical Appendix 9.2**.

9.3.27 A total of 1,358 peat depth probes were collected over the Phase 1 and Phase 2 peat surveys. Of these:

- 69.1% of probes were recorded as having a depth of less than 25 centimetres (cm). These probes are not peat.
- 16.9% of probes were recorded as having a peat depth of between 25 – 50 cm. These probes are classified as organo-mineral soils and not formally considered to be peat.

- 8.5% of probes were recorded as having a peat depth of between 50 – 100 cm.
- 5.4% of the probes were recorded as having a peat depth of over 100 cm. The deepest peat depth recorded on the Site was 540 cm.

9.3.28 A total of 9 cores were taken across the Site at the locations shown in **Figure 9.7**. The cores are described in detail in **Technical Appendix 9.2**. The coring determined that the acrotelm layer was up to 25 cm. Clay was the dominant source of base material across the cored locations.

9.3.29 The majority of the peat present in the Site was on Galdenoch Moor (**Image 9.7**) and on Larbrax Moor. There was limited peat found in the western part of the Site.

9.3.30 The results from the Phase 1 peat survey were used to feed into the design (deeper peat was avoided where possible) and the spatial extent of the Phase 2 peat survey. The Phase 1 and Phase 2 peat survey results were used to inform the Outline Peat Management Plan (**Technical Appendix 9.5**) and Peat Landslide Hazard and Risk Assessment (**Appendix 9.6**).

Groundwater

9.3.31 The groundwater body underlying the Site is The Rhins (Waterbody ID: 150641) in the Solway Sub Basin District and is classified by SEPA as having an overall classification of 'Good'.

9.3.32 The Site is underlain by highly indurated greywackes which are classified as having low aquifer productivities. As a Class 2c aquifer, flow is virtually all through fractures and other discontinuities. There is limited groundwater in the near surface weathered zone and secondary features.

9.3.33 SEPA groundwater flood maps indicate the western half of the Site sloping down towards the sea is in a Potentially Vulnerable Area for groundwater flooding.

Groundwater Dependant Terrestrial Ecosystems (GWDTEs)

9.3.34 Areas of potential Groundwater Dependent Terrestrial Ecosystems (GWDTEs) were identified during the ecology NVC surveys and are shown and described in **Chapter 7** and **Technical Appendix 7.1**.

9.3.35 A walkover survey of potential GWDTE polygons within the Site was undertaken by a team of two hydrologists. Further details of the GWDTEs onsite are contained in **Technical Appendix 9.3**. Based on field observations, two GWDTEs (GWDTE 1 and GWDTE 2) were considered to have a groundwater contribution, one being moderately dependent and one highly dependent. Other areas that were classified based on NVC surveys as potentially groundwater dependent were confirmed to be mostly fed by surface water and are not GWDTE.

9.3.36 These moderately (GWDTE 1) and highly (GWDTE 2) dependent GWDTEs are shown on **Figure 9.3** with recommended buffers from infrastructure as per SEPA guidance. These were avoided during early iterations of the design, where possible. However, GWDTE 1 is still within the 250 m buffer from proposed turbines (>1 m excavation); the impact on GWDTE 1 from the Proposed Development is assessed in detail in **Technical Appendix 9.3**.

9.4 Implications of Climate Change for Existing Conditions

9.4.1 Climate change projections for the area are described in **Chapter 12: Climate Change.** In summary, the projections highlight that summer and winter temperatures are likely to be greater that the current baseline, with winter rainfall increasing and summer rainfall decreasing. Increased rainfall will result in higher peak flows in the watercourses in the future. In addition, there may be more drought periods in the summer months, with drier, hotter conditions predicted resulting in lower flows during the summer months.

9.4.2 The National Planning Framework 4 (NPF4) notes "*Development proposals will be sited and designed to adapt to current and future risks from climate change*".

9.4.3 SEPA published guidance[12] on climate change in Scotland which provides a regional based approach to estimate uplift in future river flows in Scotland. For river catchments under 30 km^2, the peak (200-year) rainfall intensity allowance should be increased by 38% in the Solway River Basin to account for projected climate change increases

[12] SEPA (2023) Climate change allowances for flood risk assessment in land use planning, Version 4, 8 November 2023

to the year 2100. Thus, the part of Scotland which includes the Site, is likely to get wetter with higher peak flows in the watercourses in the future.

9.4.4 Hydrological implications of the UKCP18 predictions and the SEPA guidance are that river flows will increase as weather events grow more extreme. Baseline hydrological conditions for flood events are likely to become flashier and more intense. This is accounted for when applying SEPA climate change uplifts to hydrological estimates and drainage / watercourse crossing design and adhering to SEPA guidance on watercourse buffers.

9.4.5 Increased temperatures and disruption to seasonal rainfall are likely to lead to increased peatland degradation as localised water table decreases are exacerbated. Micrositing of proposed turbine locations to avoid areas of deep peat has been incorporated to help mitigate peatland degradation.

9.4.6 Site drainage and watercourse crossing designs will consider future estimates of increased precipitation and flows and will follow an adaptive approach, as per relevant guidance documents from SEPA and DGC.

9.5 Future Baseline in the Absence of the Proposed Development

9.5.1 Without the Proposed Development, the main change to the future baseline would be as a result of climate change.

9.6 Embedded Design Mitigation

9.6.1 A 50 m infrastructure buffer from all blue-line watercourses and water features shown on 1:25,000 Ordnance survey maps was applied at the early project design phase. Ordnance Survey water feature data was obtained for the Site area and buffered accordingly. Smaller watercourses and drains identified during the survey work were considered and buffered wherever possible. Locations where the recommended buffers could not be met are assessed in **Technical Appendix 9.1** and summarised in the 'Assessment of Effects' section within this chapter.

9.6.2 From the outset of the project, deeper areas of peat (>1 m) have been treated as a key constraint to siting wind farm infrastructure. Details of the iterative design approach are provided in **Chapter 3** and this forms the first tier of the peat management strategy ('prevent') at the Proposed Development. The second tier of the strategy is to reuse excavated peat, and the approach to reuse is described in the Outline Peat Management Plan (**Technical Appendix 9.3**). Only a small volume of peat will be excavated as part of construction (c. 1,577 m^3) of which a small volume will be reinstated in temporary infrastructure locations. The remaining 1,440 m^3 will be used to reinstate an area of historic cutting opposite the temporary construction compound. No need has been identified for recycling or disposal of excavated materials.

9.6.3 Through careful design, including consideration of early PLHRA likelihood results, the vast majority of proposed infrastructure has been sited or routed away from areas of Moderate peat landslide likelihood or Factor of Safety <1.4 (using best estimate parameters). One potential source zone has been identified on the access track on the north side of Larbrax Moor associated with a section of cut-track at the margin between soils (<0.5 m) and peat. Risks are calculated to be Low to Negligible in this area.

9.6.4 Watercourse crossings were avoided as much as possible during early iterations of the turbine and track layouts. The existing track was used where possible, to reduce the number of new crossings. New and existing crossings are described in **Technical Appendix 9.1**.

9.6.5 A 100 m buffer was maintained between all confirmed GWDTE from proposed infrastructure with excavations < 1 m deep (e.g. tracks). For excavations > 1 m deep (e.g. turbine foundations) a buffer of 250 m from GWDTE was applied where possible following SEPA (2017) guidance[13]. A detailed GWDTE Assessment is included at **Technical Appendix 9.3**.

9.6.6 Additional design measures that will be incorporated into the construction of the Proposed Development will include:

- SuDS to minimise/attenuate surface runoff from new hardstanding and tracks;
- SuDS to reduce sedimentation and erosion;
- SuDS to reduce pollution and accidental spillage;

[13] SEPA: Land Use Planning System, SEPA Guidance Note 31 (LUPS-31): Guidance on Assessing the Impacts of Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems, 2017

- Pollution control measures to be put in place at watercourse crossings; and
- Peat management measures.

9.6.1 Drainage measures for new access tracks and infrastructure include (but are not limited to):

- Appropriately sized culverts passing under the tracks that do not restrict flow and allow small watercourses, intercepted field drains and ephemeral streams/surface water flow pathways to pass under the tracks.
- Interceptor drainage ditches on the upgradient side of all proposed infrastructure to intercept and divert 'clean' surface water runoff draining towards the construction areas.
- Installation and maintenance of swales and track drains to intercept, collect and treat runoff from access tracks and hardstanding areas of the Site and channel runoff to stilling ponds for sediment settling.

9.7 Good Practice Measures

9.7.1 A number of good practice pollution prevention and control measures will be put in place during the construction phase. These will reflect best practice guidance and recognised industry standards, as well as the Applicant's experience of constructing wind farms. Good practice measures will be contained within the Construction Environmental Management Plan (CEMP).

9.7.2 As a minimum, the contractor will be required to follow the guidance contained in SEPA Guidance for Pollution Prevention (GPPs) and to follow SEPA's general binding rules (GBR) under the Water Environment (Controlled Activities) (Scotland) Regulations 2011, as amended (CAR Regulations).

9.7.3 Engineering activities on minor watercourses do not normally require authorisation under the SEPA CAR Regulations. SEPA defines minor watercourses as those not shown on the 1:50,000 scale Ordnance Survey maps. Of the four new crossings proposed, three are on minor watercourses and therefore fall under GBR 6 and GBR 9. These crossings will not require registration or a licence under CAR; however, the work will follow general good construction practice and GBR 6 and GBR 9.

9.7.4 One of the proposed new crossings (NC4 in **Technical Appendix 9.1**) will require a simple licence under CAR and will require specific mitigation measures.

9.7.5 Bridging solutions will be designed to avoid affecting the bed and banks of watercourses. Fording of watercourse will be avoided. Design and implementation of crossings will follow best practice, including recommendations by SEPA (2010)[14], Scottish Renewables et al. (2019)[15] and SNH (2015)[16].

9.7.6 During construction, temporary construction SuDS will be put in place at each watercourse crossing to ensure no sedimentation from construction works or pollution from plant or machinery can enter the watercourse. The temporary construction SuDS could be a series of settlement ponds or settlement tanks and silt fences.

9.7.7 A Construction Site Licence (CSL) will be obtained from SEPA under the CAR Regulations in advance of the construction works. This will include a Pollution Prevention Plan (PPP) to ensure that any discharges of water runoff from the Site to the water environment do not cause pollution. This will be prepared in advance of construction and authorisation from SEPA is required before construction commences.

9.7.8 Prior to construction and on completion of ground investigations and micro-siting, a Site Waste Management Plan (SWMP) shall be produced; including site soil and peat management good practice. Any excavated peat will be appropriately managed and re-used. This is detailed further in the Outline Peat Management Plan (**Technical Appendix 9.5**).

9.7.9 A detailed CEMP will be developed and agreed with DGC and SEPA in advance of the works. The CEMP will establish a framework to ensure that health and safety and environmental best practice are adopted throughout the works and will include:

[14] SEPA (2010) Engineering in the Water Environment Good Practice Guide - River Crossings
[15] Scottish Renewables et al. (2019) Good Practice during Windfarm Construction
[16] SNH (2015) Constructed tracks in the Scottish Uplands

- A Surface Water Management Plan, or similar, which will detail proposed surface drainage measures to treat and deal with all the surface runoff from the Site, will be designed in accordance with SuDS principles and all best practice guides and recognised industry standards.
- The approved PPP, which will detail the proposed mitigation measures to address each identified pollution risk.
- A plan to monitor and plan the timing of works to avoid construction during periods of heavy rainfall.
- A plan to detail emergency procedures in the event of spillages or any other breach.
- A Site Waste Management Plan to detail proposals for managing the extraction and storage of waste.
- A Peat Management Plan (see **Technical Appendix 9.5**)

9.7.10 The assessment of effects that follows has been undertaken assuming that the good practice and embedded mitigation identified will be implemented. Additional mitigation is identified during the assessment to address localised site or issue specific likely significant adverse effects and is described within the 'Committed Additional Mitigation' sections.

9.8 Micrositing

9.8.1 A 100 m micrositing allowance will be used for the Proposed Development's infrastructure (refer to **Chapter 3**), i.e. a 100 m radius from infrastructure. However, it should be noted that micrositing of infrastructure closer to watercourses or GWDTEs, within the watercourse and GWDTE buffers will not be undertaken. Where micrositing is required, it will move infrastructure further away from sensitive water features, GWDTEs and deeper peat, where possible. Any proposed micrositing will be overseen by an Ecological Clerk of Works (EcoW).

9.9 Scope of the Assessment

Effects Assessed in Full

9.9.1 This assessment concentrates on the effects of construction and operation of the Proposed Development upon receptors identified during the review of desk-based information and field surveys.

9.9.2 The following potential effects were identified for consideration in this assessment:

- Direct effects during construction on:
  - Surface and ground water quality;
  - GWDTEs;
  - Hydrology (flood risk);
  - Channel morphology; and
  - Peat.
- Direct effects during operation on hydrology (flood risk).

Effects Scoped Out

9.9.3 On the basis of the desk-based and field survey work undertaken, the professional judgement of the EIA team, experience from other relevant projects and policy guidance or standards, and feedback received from consultees, the following effects have been 'scoped out' of detailed assessment:

- Effects on bedrock geology during both construction and operation;
- Effects on Private Water Supplies; and
- Cumulative effects during construction and operation on surface and ground water quality, hydrology and peat. There are no proposed developments within the same catchment as the Site, and assuming that any future nearby wind farm schemes are designed and constructed in line with NPF4 and national guidelines with respect to SuDS and GPPs, there will be no cumulative effect on the downstream catchments.

9.10 Assessment of Effects

9.10.1 The assessment of effects is based on the project description as outlined in **Chapter 4: Development Description** and the embedded mitigation by design and good practice measures described above. Unless otherwise stated, potential effects identified are considered to be negative.

Construction Effects

Predicted Construction Effects

9.10.2 The sensitivity of the identified receptors has been assessed in **Table 9.6**, using the criteria in **Table 9.2**.

Table 9.6: Sensitivity of Receptors

Receptor	Sensitivity	Comment
Watercourses and waterbodies Green Burn / Galdenoch Burn Smaller unnamed watercourses and drainage features within the Site Loch More Loch Beg	Water quality – Medium Flood Risk – Medium Morphology – Low	The east of the Site lies within the Green Burn catchment, which is classified by SEPA as having 'Moderate ecological potential' and 'Poor' overall ecology. SEPA classified the Green Burn's morphology as 'Poor' and 'Fail' for specific pollutants and ammonium. The majority of watercourses within the Site are too small to be classified by SEPA. There are no properties downstream of the project infrastructure that are currently at flood risk on the named and unnamed watercourses within the Site. The B738 close to the access entrance may be susceptible to flooding from the Green Burn.
Peat	High	Both Class 1 and Class 5 peat is present onsite. Open areas of Class 1 peatland are located close to the access track of the Proposed Development on Larbrax Moor but have largely been avoided. Deeper peat (>1 m) has been avoided, where possible, in the design process.
Groundwater	Low	The Proposed Development is located on low productivity aquifers. The groundwater body is classified by SEPA as 'Good'. There are no groundwater abstractions or PWS within the Site. The closest PWS is 450 m away from infrastructure. The area is a within Drinking Water Protection Area (DWPA) for groundwater (as is all of Scotland). However, there is no significant groundwater resource and no identified sensitive users/receptors.
Groundwater Dependent Terrestrial Ecosystems (GWDTE)	Medium to High	There is 1 highly dependent and 1 moderately dependent GWTDE confirmed (see **Technical Appendix 9.3** for more details)
Salt Pans Bay SSSI	High	T1 and T2 drain towards the coastal SSSI.

9.10.3 The main environmental effects are predicted to occur during construction. The activities that will occur during construction that may have an effect on the water environment and peat, include site clearance and vegetation removal; use of heavy plant machinery; increase of hardstanding areas; construction of wind farm tracks and upgrading of access track; watercourse crossings; associated earthworks/excavation/re-profiling and construction traffic on access tracks.

9.10.4 There are four turbines (the foundations of which will require excavation of approximately 3.5 m deep over a foundation diameter of 25 m), and associated crane hardstandings, one substation, one borrow pit and a construction compound. All the permanent turbine hardstandings are located on mineral soil (<0.5 m deep). There is 1.9 km of proposed new wind farm tracks, and the Proposed Development will use 1.05 km of existing tracks (including some widening/upgrading). The majority of the tracks do not cross peat, except an 80 m section of access track on the northern margin of Larbrax Moor and a 60 m section on the approach to the B738 in the east of the Site. According to the peat depth data in these areas, the peat is expected to be c. 0.5 m in the former and c. 1.25 m adjacent to the B738.

9.10.5 During the initial design stage, a buffer of 50 m was applied to all watercourses and water features identified from Ordnance Survey mapping. A 50 m buffer was achieved for most mapped watercourses and water bodies. Except for the existing and proposed watercourse crossings, there were three instances in which the 50 m buffer was encroached upon (labelled A to C on **Figure 9.2** and described in detail in **Technical Appendix 9.1**):

- A – the access track encroaches to within ~22 m of an unnamed drain.
- B – the access track encroaches to within ~5 m from an unnamed drain marked on the OS map. Confirmation of the drain was not possible as it could not be accessed due to Rhododendron scrub. However, there was no indication of a channel, flow pathway or water at the closest point downgradient of the drain.
- C – upgrades to the existing track will encroach to within ~24 m of Loch More.

9.10.6 Existing access tracks were used as much as possible to avoid new watercourse crossings and land take. There are eight watercourse crossings required for the Proposed Development (**Technical Appendix 9.1**); of which four are existing crossings using the existing farm tracks.

9.10.7 Four new crossings are required along the new sections of track to be built, three of which are small, minor drains or flow pathways. The construction of these crossings will be covered by SEPA's General Binding Rules. These crossings will not require registration or a licence under CAR; however, the work will follow general good construction practice and GBR 6 and GBR 9.

9.10.8 The new crossing NC4 over the Green Burn will require authorisation under the CAR Regulations (either registration or a simple licence depending on the crossing design). Full details of crossings and CAR requirements are provided in Table 1 in **Technical Appendix 9.1** and further details of the crossing design is provided in **Technical Appendix 9.4** and **Figure 4.11b**.

Effects During Construction on Surface and Ground Water Quality

9.10.9 The potential effects on surface water quality during construction are:

- Pollution of surface waters caused by the release of sediment to watercourses from excavated material during construction, heavy plant movement on the access tracks and construction compounds and the felling of trees/vegetation.
- Pollution of surface water caused by the release of hydrocarbon pollution resulting from accidental oil or fuel leaks or spillages. There is also a risk posed by concrete (and other construction material) spillages during the formation of hardstanding areas at the turbine bases.
- Pollution/sediment runoff during construction of new watercourse crossings for new tracks.

9.10.10 The potential effects on groundwater quality include:

- The risk of hydrocarbon pollution of groundwater resulting from accidental oil or fuel leaks from construction traffic and construction works. There is also potential pollution effects caused by silt and sediment disturbed during construction infiltrating into the groundwater and pollution from concrete spillages.

9.10.11 Risks to surface water quality will be greatest during construction when works involve the exposure of bare earth which could result in increased erosion and sedimentation. Without embedded and good practice mitigation, the

increase in sediment concentration in runoff from construction areas and access tracks may result in excessive levels of suspended sediment in watercourses. This can have an indirect effect on watercourse ecology and fish (see **Chapter 7**).

9.10.12 Scrub removal can result in increased surface water runoff and sediment runoff. Direct removal for construction of an area of 0.34 ha of scrub is required for the access track (see **Figure 4.1**).

9.10.13 Pollutants can enter the watercourses in the event of accidental spills or leaks from machinery and vehicles and in the event of an accidental release of concrete or other building materials. Pollutants and silt/sediment could enter watercourses directly, or via overland flow pathways. Shallow groundwater could also be affected.

9.10.14 An assessment of the potential effects on watercourses and water features at locations where the 50 m buffer could not be achieved (**Figure 9.2**) is set out in **Table 2** of **Technical Appendix 9.1** and summarised below. Details of additional mitigation for each is described in the appendix and summarised in the committed additional mitigation section of this chapter.

- A – the access track encroaches to within ~22 m of an unnamed drain. Flow path analysis indicates that surface water runoff paths are from the proposed track towards the drain. At the closest point, the proposed track is ~4m higher than the drain. There is a risk of sediment/pollution entering the water environment during construction. Embedded and good practice mitigation will be included in the design, so surface water runoff will be treated and attenuated. It is considered that the buffer width is considered adequate for the size of water feature, however additional site-specific mitigation is recommended.
- B – the access track encroaches to within ~5 m from an unnamed drain marked on the OS map. The presence of the drain could not be confirmed during the site visits. However, given that it is upgradient of the new track, there is low risk that sediment/pollution will enter into the drain. The mapped drain sits ~4 m higher than the proposed access track. Further investigation to locate this drain will be carried out prior to construction and additional mitigation installed if required.
- C – upgrades to the existing track will encroach to within ~24 m of Loch More. The loch is ~2-3 m higher and upgradient of the track so there is unlikely to be a direct effect resulting from the construction and operation of the track, as surface water flow paths from the track will be away from the loch. It is considered that the buffer width is considered adequate, and no additional mitigation is required.

9.10.15 With the embedded mitigation measures described above in place, including buffers, following good practice construction and site drainage management guidance from relevant bodies (e.g. SEPA, CIRIA), the magnitude of the effect of increased sediment/silt runoff causing a deterioration in surface water quality in waterbodies and watercourses within and downstream of the Site during construction is considered to be **negligible** and of short duration. The sensitivity of all downstream receptors is **high** (the coastal SSSI) and the significance of the effect is considered to be **minor**.

9.10.16 Good practice measures to minimise the risk of pollution and accidental spillage will minimise the likelihood and severity of such incidents happening, however, there is still a residual risk. The magnitude of effect of pollution of surface water and groundwater caused by the release of hydrocarbon pollution and concrete resulting from accidental oil or fuel leaks or spillages is considered to be of short duration and **negligible**. However, given the **high sensitivity** of the downstream water environment, the significance of the effect is considered to be **minor**.

9.10.17 There are no groundwater abstractions within the Site; no significant groundwater resource and no identified users/receptors.

Effects on channel morphology (bank erosion and channel form) during construction

9.10.18 For all watercourses, the effect on channel morphology (bank erosion and channel form) during construction is assessed to be of **negligible** magnitude, as embedded mitigation measures, including a minimum 50 m buffer zone (where possible) and environmentally sensitive bridge/culvert design, have been incorporated into the project design. The new crossings and upgrades to existing crossings will be bottomless culverts and will not affect the bed or banks of the channel.

9.10.19 The watercourses in the Site are considered to be of **low** sensitivity in terms of morphology. Any effect on channel morphology is considered to be short-lived, localised and of **negligible** magnitude and the effect is considered to be of **negligible** significance.

Effects during construction on runoff rates, flood risk and ground-water levels/recharge

9.10.20 In accordance with NPF4, there should be no new development in flood risk areas. NPF4 defines a flood risk area as one that lies within the 200-year floodplain, including an appropriate allowance for future climate change. The SEPA future flood map shows flooding just downstream of the proposed access track crossing of the Green Burn. SEPA flood maps do not consider catchments <3 km^2, hence the flood risk area at the proposed access track crossing is not shown on the SEPA flood maps.

9.10.21 Based onsite observations and a review of the LiDAR topographic data, the access track crosses part of the Green Burn floodplain. A flood risk assessment (FRA) was completed to ascertain the extent of the flood risk area at this location and to assess the effect of the track and new crossing on flood risk. The results show a minor increase in peak flood water level for both option scenarios which were modelled (0.02 – 0.07 m increase). The models did not predict an increase in flooding on the B738. Other than the access track itself, there are no properties downstream which are predicted to flood in the 200 year + climate change event, meaning that receptors are considered to be of **low** sensitivity. There will be a **negligible** magnitude of change in flood levels under the modelled scenario and the overall effect is considered to be **negligible**.

9.10.22 A 50 m buffer from watercourses and surface water bodies has been achieved for most of the proposed infrastructure, apart from the exceptions described above and in Table 2 of **Technical Appendix 9.1**.

9.10.23 New and upgraded watercourse crossings will be designed to maintain and not reduce the existing capacity of the channel. It is considered that this is an appropriate approach to take in a rural environment. The crossing of the Green Burn will be designed to pass the 200 year + climate change flow in order not to increase flood risk on the B738 road.

9.10.24 Compaction of soils and increased areas of hardstanding reduces the infiltration rate and can lead to a greater rate and volume of surface water runoff. Clearance of vegetation can also lead to an increase in surface water runoff rates. This results in a 'flashier' catchment response and could increase flood risk downstream. However, the magnitude of the change is **negligible** due to the small area of hardstanding or semi-permeable surfaces (**Table 9.8**) compared to the total catchment area.

Table 9.8: Areas of land take for the Proposed Development within the Green Burn Catchment (in m^2)

	Green Burn (at NW 97350 63050 just downstream of the Site)
Catchment area (m^2)	4,190,000
Land take within catchment*(m^2)	8,045
% of catchment area	0.19%

** This includes all proposed hardstanding (temporary and permanent), construction compound, earthworks and proposed track extents within the catchment.*

9.10.25 The catchment area of the Green Burn downstream of the Proposed Development is provided in **Table 9.8**. The total area of proposed new hardstanding or semi-permeable surfaces represents 0.19% of the total catchment area of the Green Burn. The rest of the Site drains directly into the sea and, with no receptors downstream of the Site, and will not increase fluvial or coastal flood risk downstream.

9.10.26 The construction of infrastructure, such as tracks, could affect (block or realign) natural flow pathways, resulting in changes to the local runoff rate and volume and change in contributing catchment areas. This would also have an effect on the rate and volume of water reaching receiving watercourses and other downstream receptors.

9.10.27 Changes to the rate and volume of infiltration due to the construction of infrastructure could also affect recharge rates to the groundwater body. Excavations for turbine foundations and in the borrow pit during construction could also result in minor, local changes to groundwater levels, as water will tend to fill up the excavated areas.

9.10.28 The Proposed Development incorporates SuDS and other embedded good practice mitigation measures to minimise the risk of increased runoff and flood risk (see Embedded Design Mitigation and Good Practice Measures above)

and the discharge of attenuated surface water runoff from the working areas and access tracks into the watercourses will be limited to greenfield runoff rates entering each watercourse from the Site at present.

9.10.29 Based on the small percentage of the total catchment area affected by temporary and permanent hardstanding, the effect of construction on runoff rates and flood risk is considered to be of **negligible** magnitude and the significance will be **negligible** on watercourses and waterbodies downstream of the Proposed Development.

9.10.30 Excavations for turbine foundations and borrow pit could temporarily affect local groundwater recharge levels. The effect is considered to be of short duration, localised and reversible and is considered to be of **negligible** magnitude and **negligible** significance on the groundwater body.

Effects During Construction on GWDTEs

9.10.31 There is one moderately dependent GWDTE within 250 m of proposed infrastructure, as T3 is located within the 250 m buffer. This is shown in **Figure 9.3** and assessed in detail in **Technical Appendix 9.3**. The assessment methodology and results are summarised below.

9.10.32 A site-specific qualitative risk assessment of the GWDTE location was carried out based on the available data on local geology, hydrology, ecology and hydrogeological regime. There is no available data on sub-surface flows and in the absence of data, it is considered that the movement of sub-surface water is primarily driven by topography.

9.10.33 Flow routing analysis was carried out in QGIS software using OS 5m terrain data. In the absence of data on ground water levels and flow paths, analysis of topography and surface water flows paths was used to infer hydrological and hydrogeological connectivity to the project infrastructure.

9.10.34 The assessment of effect on a groundwater flow path is made with reference to distance, slope, aspect, typical water table levels and features such as watercourses. The assessment is made with imperfect knowledge of the exact extent that a particular effect may have and imperfect knowledge of specific sub-surface flow paths. As such, it takes a precautionary approach using the available information.

9.10.35 In summary the results of the GWDTE assessment are:

- GWDTE 1 (fracture fed seep and moderately dependent GWDTE)
  - T3 is located approximately 227 m north-east of the GWDTE and is approximately 10 m higher than the GWDTE. Surface water flow paths, based on the topography data (**Technical Appendix 9.3**), indicate that there are no direct hydrological connections between the proposed turbine infrastructure and the GWDTE. The turbine and associated compound are within the 250 m GWDTE buffer for a length of around 55 m and will not affect flow paths to the GWDTE, as the turbine area is not hydrologically connected to the GWDTE. Therefore, it is considered that the Proposed Development will not change groundwater flows or quality at the GWDTE during construction. Similarly, there is not expected to be any long-term effect on hydrology and sub-surface flows during operation. The effect on the GWDTE is considered to be **none.**

Direct and Indirect Disturbance of Peat During Construction

9.10.36 Construction work on peat has the potential to cause peat instability, which may affect peat soils (and their inherent carbon stores), peatland habitats and nearby watercourses, infrastructure or land uses. A PLHRA has been undertaken and is documented in **Technical Appendix 9.6**. The PLHRA included detailed site mapping and field walkover, qualitative and quantitative assessment of peat stability, identification of on- and offsite receptors and calculation of risk associated with peat landslides.

9.10.37 The PLHRA indicates that the vast majority of the Site has a Low or Very low baseline likelihood of peat instability, with only one localised area of Moderate likelihood on the edge of Larbrax Moor overlapping with the proposed access track. The peat depths are c. 0.5 m in this location, and due to very gentle slopes below the potential source zone in this location, calculated risks are Low to Negligible and manageable by good practice during construction.

9.10.38 The alteration of the geological environment by the excavation of the subsoil and peat required to build the infrastructure such as turbine bases, construction compounds, tracks and borrow pits will result in some alteration of the geological environment. In particular, any underlying topsoil and peat may be temporarily or permanently removed to be re-instated or re-used elsewhere and will need to be stored and managed appropriately. Activities, or effects of activities, which have the potential to alter the geological environment include:

- earthworks and site drainage;

- reduction in water table levels resulting in the drying out, oxidation and potential erosion of peat;
- excavation and removal of peat; and
- the disturbance and loading of peat by vehicle tracking.

9.10.39 The Outline PMP (**Technical Appendix 9.5**) considers the excavation and reuse of peat based on a peat depth model interpolated from the collected peat depth data across the Site. Excavation calculations have been undertaken for all site infrastructure, including permanent excavations (turbine foundations and the main hardstandings, the main compound with substation, and all tracks of cut and fill construction) and temporary excavations (secondary crane hardstandings and laydowns, the new construction compound and borrow pits). Excavation calculations treat all soils ≥0.5 m as peat, with the uppermost 0.3 m as acrotelm, and all soils <0.5 m as organic soils. All peat and soils that are temporarily excavated will be stored locally and directly reinstated at their point of origin following construction. All permanently excavated peat and soils require alternative uses, ideally as restoration materials.

9.10.40 Based on the approach described above, up to 1,577 m^3 of peat will be excavated, the majority being used to reinstate an area of historical cutting adjacent to an upgraded track and opposite the temporary construction compound. Approximately 7,630 m^3 of soil will be excavated, and all of this will be used in dressing cut and fill earthworks surrounding infrastructure.

9.10.41 Therefore, based on the calculations described within the Outline PMP, there are sufficient opportunities to reuse peat across the Site without generating a surplus. Assuming embedded mitigation measures detailed above are incorporated into project design and are effective, the magnitude of the effect on peat is **slight**. Overall, the effect on peat is **minor**.

Committed Additional Mitigation

9.10.42 The PPP will contain details of location specific additional mitigation for relevant infrastructure and the contractor will be legally obliged to comply with the pollution control and drainage measures agreed in the PPP and CSL. An ECoW will be present onsite during construction to monitor and assess the works and check the mitigations outlined in the PPP are adhered to and function properly. If monitoring or assessment identifies non-compliance, ineffective mitigations, or impacts beyond those predicted in the EIA Report, this will be raised with the Contractor who will be required to demonstrate and deliver compliance.

9.10.43 Additional mitigation and SuDS (e.g. silt fences, settlement ponds) will be installed around the following working areas, crossings and access tracks during construction to reduce the risk of sediment/silt runoff to the water environment during construction:

- Watercourse crossings of the proposed and existing tracks – NC 1-4 and UC 1-4;
- Buffer encroachment A – proposed new access track (if required following further investigation of the presence of the drain prior to construction); and
- Buffer encroachment B – proposed new access track.

9.10.44 The bed and banks of watercourses adjacent to crossing locations will be restored immediately after construction.

9.10.45 No construction materials will be placed within the flood risk area of the Green Burn during construction of the access track, and the contractor will sign up to SEPA's flood warning service and follow weather forecasts in order to receive advance warning of flood events. Construction works of the access track crossing will cease during flood events.

9.10.46 Any excavated peat will be stored appropriately nearby and re-used as soon as possible for reinstatement purposes.

9.10.47 Further minimisation of peat landslide risk may be achieved through careful construction management and through such mitigation, landslide risks are interpreted to be negligible post-mitigation.

9.10.48 An ECoW will be onsite throughout the construction to monitor the effectiveness of the embedded and additional mitigation measures.

Residual Construction Effects

9.10.49 With embedded mitigation and additional mitigation in place the residual construction effects are either **minor**, **negligible** or **none** and are summarised in **Table 9.9**.

Operational Effects

Predicted Operational Effects

9.10.50 Following construction of the Proposed Development, all infrastructure will be left in situ to permit maintenance.

9.10.51 The predicted operational impacts of the Proposed Development are associated with the permanent Site infrastructure, including the tracks, turbine bases, substation and hardstanding areas and any required maintenance work during operation.

9.10.52 The assessment of operational effects considers that the pollution prevention controls, and permanent drainage installed during construction will remain in place during operation.

9.10.53 During operation, the increase in hardstanding areas (turbine bases, substation, and tracks) could result in a negligible increase in the rate and volume of surface water runoff, leading to an increase in flood risk downstream. However, given the permanent SuDS drainage measures and the size of the areas of hardstanding compared to the catchment area of the downstream watercourse, the magnitude of the effect on increased runoff increasing flood risk downstream is considered to be **negligible** and thus is assessed to have an effect significance of **negligible**.

9.10.54 An FRA was completed to ascertain the effect of the access track and new crossing of the Green Burn (NC4) on flood risk close to the B738 road. The modelling did not predict an increase in flooding on the B738 with the crossing in place (see **Technical Appendix 9.3**). Other than the access track itself, there are no properties downstream which are predicted to flood in the 200 year + climate change event, meaning that receptors are considered to be of **low** sensitivity. There will be a **negligible** magnitude of change in flood levels with the new access track crossing and the overall effect is considered to be **negligible**.

9.11 Interrelationship Between Effects

9.11.1 Excessive levels of suspended sediment in watercourses as a result of construction activities can have an effect on watercourse ecology and fish (see **Chapter 7**). However, with embedded, good practice and additional site-specific mitigation (e.g. adherence to GPP, SuDS, buffers etc) there is considered to be no significant residual effect on water quality of the downstream watercourses.

9.12 Further Survey Requirements and Monitoring

9.12.1 Mitigation of residual peat instability risks will be supported by good practice construction measures and by monitoring both during and after construction. Further details are provided in **Technical Appendix 9.4**.

9.12.2 Satisfactory implementation of the PMP in order to mitigate peat loss / disturbance will be assured by monitoring both during and after construction. Further details are provided in **Technical Appendix 9.5**, Section 9.6.

9.12.3 Circa 15 peat probing points were inaccessible along a section of track near the Site entrance due to dense scrub. Additional peat probing will be undertaken following scrub removal and prior to construction to ensure that the track is in an optimum location.

9.12.4 An ECoW (or equivalent) will be onsite throughout the construction to monitor the effectiveness of the embedded and additional mitigation measures.

9.13 Summary of Significant Effects

9.13.1 There are no significant effects of the Proposed Development on Geology, Hydrology, Hydrogeology and Peat prior to additional mitigation. Most of the likely effects prior to mitigation were either **none, negligible or minor** significance, assuming embedded design and good practice mitigation measures are in place during construction.

Glossary/Abbreviations

Table 9.9: Glossary

Term in Full	Abbreviation	Meaning
Groundwater Dependent Terrestrial Ecosystem	GWDTE	GWDTE are habitats that are dependent on groundwater. They are specifically protected under the Water Framework Directive.
General Binding Rule	GBR	GBRs are statutory rules by SEPA that control low-risk activities that may affect Scotland's water environment.
Private Water Supply	PWS	PWS are any water supplies to residents and their land that are not supplied through the mains system – these can be surface water or groundwater fed.
Scottish Environment Protection Agency	SEPA	SEPA is Scotland's principal environmental regulator, protecting and improving Scotland's environment.
Site of Special Scientific Interest	SSSI	Statutory Designation.