Chapter 10

Hydrology, hydrogeology, geology and soils

SCOTTISHPOWER RENEWABLES

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10.1 Introduction

1. This Chapter assesses the impacts of the proposed Development on soils, geology and the water environment (hydrology and hydrogeology). The assessment of impacts has been made on the basis of the proposed turbine and infrastructure layout as fully described in **Chapter 3: Description of the Development**.

2. The Chapter details the assessment undertaken to determine the potential effects of construction and operation of the proposed Development on the current baseline environment of soils, geology and hydrological and hydrogeological regimes (forming the water environment). It outlines the embedded good practice methods which have been incorporated into the design and would be used during the construction and operation of the proposed Development to prevent or reduce identified effects and risks.

3. Further mitigation methods to address any potential effects are proposed, where appropriate, and residual effects assessed.

4. In addition, the assessment uses information and findings presented in **Chapter 8: Ecology** to inform the assessment of potential effects on possible areas of Groundwater Dependent Terrestrial Ecosystems (GWDTEs) which are presented in this Chapter.

5. This Chapter presents summary information from the following Technical Appendices:

- Technical Appendix 10.1 Peat Landslide Hazard and Risk Assessment (PLHRA);
- Technical Appendix 10.2 Peat Management Plan (PMP);
- Technical Appendix 10.3 Private Water Supply Risk Assessment;
- Technical Appendix 10.4 Schedule of Watercourse Crossings;
- Technical Appendix 10.5 Borrow Pit Screening Assessment Report;
- Technical Appendix 10.6 Phase 1 Peat Report; and
- Technical Appendix 10.7 Phase 2 Peat Report.

6. This Chapter has been prepared by SLR Consulting Ltd, who has also undertaken the assessment.

10.2 Approach to assessment and methods

7. The potential effects from the proposed Development on soils, geology and the water environment have been assessed by completing an initial desk study followed by an impact assessment.

10.2.1 Study area

8. The study area includes all of the proposed Site infrastructure. In addition, details of local water use and quality within a buffer of at least 1 km from the proposed new and upgraded infrastructure have been considered. The study area encompasses the Site as well as bodies of water and their catchments which could potentially be affected by the construction and operation of the proposed Development.

9. The Site is drained by two main catchment areas: the River Stinchar (and its tributaries the Cross Water, Duisk River and Water of Tig) and the River Cree. The River Stinchar drains the majority of the Site and the entire area of proposed new and upgraded infrastructure while the River Cree catchment serves the existing access track from the A714 public road. Full details of the study area hydrology is provided in Section 10.3.5.

10. The study area for hydrogeology is the same as the hydrological study area defined above, as the extent of any potential effects are controlled by the watershed. This does not apply for geology where the study area is defined by the proposed Development.

11. The study area for public and private water supplies is the same as the hydrological and hydrogeological study area; it encompasses the surface watercourses and groundwater bodies from which the supplies may abstract.

12. The study area for potential cumulative effects uses the catchments within the study area, with a maximum downstream distance of 5 km from the proposed infrastructure.

13. This assessment has been undertaken with regard to environmental legislation, planning policy and general guidance, including the following. Planning policies of relevance to this assessment are outlined in **Chapter 4: Renewable Energy and Planning Policy**.

10.2.2 Legislation and guidance

14. Legislation, policy and guidance relevant to this assessment is provided in **Technical Appendix 4.1**.

10.2.3 Temporal scope

15. Due to the consent in perpetuity which is proposed, the temporal scope requires consideration of the potential for climate change to impact on future baseline conditions. Climate change studies predict a decrease in summer precipitation and an increase in winter precipitation alongside slightly higher average temperatures. This suggests that there may be greater pressures on water supplies and water levels in summer months in the future. In addition, summer storms are predicted to be of greater intensity. Therefore, peak fluvial flows associated with extreme storm events may also increase in volume and velocity.

10.2.4 Effects assessed in full

16. The following potential impacts have been assessed in full in relation to the proposed Development:

- pollution risk, including potential impact on surface water and groundwater quality and public and private water supplies during forest felling, and construction and operation;
- erosion and sedimentation which could give rise to potential impact on surface water and groundwater quality, and private water supplies during forest felling, construction and operation;
- fluvial flood risk resulting from changes to runoff volumes and rates and modifications to natural and man-made drainage patterns during operation;
- potential impact upon the linkage between groundwater and surface water during construction and operation;
- potential impact on areas of peat during construction and operation;
- potential impact on areas of GWDTE during construction and operation; and
- potential cumulative impact during construction and operation.

10.2.5 Effects scoped out

17. On the basis of the desk based and survey work undertaken, policy, guidance and standards, the professional judgement of the EIA team, feedback from consultees and experience from other relevant projects, the following topic areas have been 'scoped out':

- potential effects on geology during both construction and operation as there are no protected geological features within the Site. Furthermore, the nature of the activities during construction and operation of the proposed Development would be unlikely to alter the geology of the Site. Potential cumulative effects on geology have also been scoped out on this basis. For context, information on the geology of the Site is presented in the 'Baseline Conditions' and **Technical Appendix: 10.1 Peat Landslide Hazard and Risk Assessment (PLHRA)** and **Technical Appendix: 10.2 Peat Management Plan (PMP**);

- increased flood risk caused by blockages to flow in watercourses during operation and maintenance of the proposed Development. These crossings would be subject to maintenance requirements under the Controlled Activities Regulations (CAR), flood risk onsite is negligible and the Development design ensures no critical infrastructure is located near watercourses;
- changes to public/private water supply yield as a consequence of changes to runoff rates and volumes during operation and maintenance of the proposed Development as no significant alterations to runoff rates/infiltration or drawdown of the water table are anticipated during or as a consequence of construction;
- potential cumulative effects in relation to public/private water supply yields during the operational phase as water requirements are low during operation and any change would not be discernible at the catchment level; and
- potential effects associated with forest felling on surface water quality and runoff as all forest felling would be undertaken in accordance with good practice guidelines published by Scottish Forestry (formerly Forestry Commission Scotland). Details of forestry felling for the construction of the proposed Development are given in **Technical Appendix 3.2: Forestry**. It is proposed that the wind farm infrastructure would be 'key holed' into the existing forest crop and only tress required for the infrastructure and an immediate buffer would be felled and cleared ahead of the current forest plan. The Forestry Commission (Forestry Commission, 2014) report that research shows that the effects on harvesting on surface water acidity are difficult to discern when 20% or less of a catchment is felled within any three year period. Consequently, where the rate of felling exceeds this figure it may be necessary to carry out a site impact assessment to determine if the watercourse is at risk; this includes felling for habitat restoration or windfarm development. The proportion of proposed felling is much less than 20% and thus it can be expected that acidification of the watercourses would not occur as a consequence of felling to establish the wind farm.

10.2.6 Baseline determination

10.2.6.1 Data sources

18. An initial desk study has been undertaken to determine and confirm the baseline characteristics by reviewing available information on soils, geology, hydrology and hydrogeology such as: groundwater resources, licensed and unlicensed groundwater and surface water abstractions, public and private water supplies, surface water flows, flooding, rainfall data, water quality and soil data. This has also included a review of published geological maps, OS maps, aerial photographs and Site specific data such as site investigation data, geological and hydrogeological reports, digital terrain models (slope plans) and geological literature.

19. The following sources of information, including good practice guidance and legislation have been consulted in order to characterise and assess the soils, geology, hydrogeology and hydrology of the area within and surrounding the Site:

- Ordnance Survey (OS) 1:50,000 and 1:10,000 scale mapping data;
- Flood Estimation Handbook (FEH) web service (available online at https://fehweb.ceh.ac.uk/);
- British Geological Survey (BGS) 1:50,000 scale data - superficial deposits, bedrock, linear features, mass movement and artificial ground (available online at http://mapapps2.bgs.ac.uk/geoindex/home.html);
- BGS Hydrogeological Map of UK, 2019;
- James Hutton Institute The Soil map of Scotland (partial cover) (1:25,000) (available online at http://soils.environment.gov.scot/maps/);
- BGS Hydrogeological Maps of Scotland (groundwater vulnerability and aquifer productivity) 1:100,000 scale;
- The SEPA flood maps (available online at https://www.sepa.org.uk/environment/water/flooding/flood-maps/ and http://map.sepa.org.uk/reservoirsfloodmap/Map.htm);
- SEPA Water Environment Hub (SEPA, 2017b) for water body classifications (available online at https://www.sepa.org.uk/data-visualisation/water-classification-hub/);
- Scottish Natural Heritage (SNH) Sitelink Online Information Service (available online at https://gateway.snh.gov.uk/sitelink/searchmap.jsp);
- Natural England Magic Map (available online at http://magic.defra.gov.uk/MagicMap.aspx);
- Data requests with SEPA regarding details of registered/licensed abstractions and discharges (September 2018); and
- Data requests with SAC environmental health department regarding details of historic flooding records and private water abstractions (August 2018).

20. Several previous EIAs have been reviewed to inform this assessment and include the existing Arecleoch Windfarm EIA (2008), the original Kilgallioch Windfarm EIA submission (2010) and its Addendum (2011), the Mark Hill Windfarm EIA submission (2005) and the Altercannoch Windfarm EIA submission (2015) and additional PWS information submission (2016).

10.2.6.2 Field survey

21. The project hydrologists, geologists and ecologists have worked closely on this assessment to ensure that appropriate information is gathered to allow a comprehensive impact assessment to be completed.

22. Detailed Site visits and walkover surveys have been undertaken by SLR Consulting Ltd and MacArthur Green on the following dates:

- 24 August 2018, initial Site reconnaissance;
- 5 November to 24 November 2018, peat depth probing and peat characterisation (refer to **Technical Appendix 10.6**);
- 23 January 2019 borrow pit assessment and track layout planning;
- 11 February to 16 February 2019, further peat probing around finalised infrastructure locations (refer to **Technical Appendix 10.7**); and
- 5 February to 6 February and 12 April 2019, private water supply survey, GWDTE assessment and watercourse crossing survey.

23. The scope of the private water supply survey was also informed by data received from SAC and a review of the EIAs of neighbouring developments along with OS mapping and aerial photography as detailed within **Technical Appendix 10.3: Private Water Supply Risk Assessment**. To complete the Private Water Supply Risk Assessment properties which may have or have a recorded private water supply downstream of the site were visited and where possible the source of the water supply was verified and confirmed. Where this was not possible a questionnaire was left with the occupiers of the property and they were asked to provide details of their water supply. This has ensured a thorough assessment of Private Water Supplies has been completed.

24. The field work has been undertaken in order to:

- verify the information collected during the desk and baseline study;
- undertake a visual assessment of the main surface waters and identify and verify private water supplies;
- identify drainage patterns, areas vulnerable to erosion or sediment deposition, and any pollution risks;
- visit any identified potential GWTDEs (in consultation with the project ecologist);
- visit any potential watercourse crossings and prepare a schedule of potential watercourse crossings;
- inspect rock exposures and establish by probing, an estimate of overburden thicknesses, peat depth and stability;
- confirm underlying substrate, based on the type of refusal of a peat probe and by coring; and
- allow appreciation of the Site, determine gradients, potential borrow pit locations, access routes, ground conditions, etc., and to assess the relative location of all the components of the proposed Development.

25. The desk study and field surveys have been used to identify potential development constraints and have been used as part of the iterative design process. The peat probing completed as part of the initial field surveys has been developed further as part of the assessment of effects. This assessment is reported in **Technical Appendix: 10.1: PLHRA** with a summary provided in this Chapter. In conjunction with the project ecologists and hydrologists, an assessment of the condition of the peat has been undertaken. This has included details related to the characteristics of the soils, classification of vegetation cover, assessment of current land use impacts, assessment of drainage paths and channels, evidence of peat erosion and coring to further characterise the peat. This is also reported in **Technical Appendix: 10.2: PMP.**

26. The data obtained as part of the desk study and collected as part of the field work has been processed and interpreted to complete the impact assessment and recommend mitigation measures where appropriate.

10.2.7 Consultation

27. The scope of the study has been determined through a combination of professional judgement, reference to relevant guidance documents and consultation with stakeholders.

28. Consultation for the proposed Development was undertaken with statutory and non-statutory bodies during 2018 and 2019 as set out in **Chapter 6: Scoping and Consultation**. The outcome of the relevant consultations with regard to soils, geology and the water environment is summarised in **Table 10.1**.

Consultee	Summary of Consultation	Comment / Action
South Ayrshire Council (SAC) 9th November 2018	Prior to the commencement of works on the site, a water management plan covering water control and the means of drainage from all hard surfaces and structures within the site shall be submitted for approval of the planning authority and following approval shall be implemented by the company. For the purposes of this condition "hard surfaces" includes internal access tracks, construction and lay-down areas, turbine pads and crane pads. The details to be submitted shall include the means of protecting surface water and ground water and controlling surface water run-off. The management plan as approved shall then be implemented in full. The applicant shall submit to the planning authority a site specific hydrogeological report which contains a review of the risks to all private water sources and supplies that have the potential to be affected by the development. Work shall not commence on site prior to the written approval of the Planning Authority being obtained. The report should include an assessment of all private water sources and supplies and focus on the effects of the development on the quality and quantity of water supplied to all private water users both within and out-with the boundary of the proposed site that have the potential to be affected by the development. A conceptual site model should be included as this is key to developing a robust assessment of all risks to all potentially affected private water supplies. Attention should also be given to possible leachate generation at any Borrow Pit excavations.	Water management plan would form part of the site CEMP, see Section 10.4. Hydrogeological and hydrological site setting discussed in Section 10.3 and private water supply risk assessment presented as **Technical Appendix 10.3.**
Dumfries & Galloway Council (D&GC) Date not given	No comment with respect to soils, geology, hydrology or hydrogeology	
SEPA 10th December 2018	We consider that the following key issues must be addressed in the Environmental Impact Assessment process. • Map and assessment of all engineering activities in or impacting on the water environment including proposed buffers, details of any flood risk assessment and details of any related CAR applications. • Map and assessment of impacts upon Groundwater Dependent Terrestrial Ecosystems (GWDTE) and buffers. • Map and assessment of impacts upon groundwater abstractions and buffers. • Peat depth survey and table detailing re-use proposals. • Map and table detailing forest removal. • Map and site layout of borrow pits. • Schedule of mitigation including pollution prevention measures. • Borrow Pit Site Management Plan of pollution prevention measures. • Map of proposed waste water drainage layout. • Map of proposed surface water drainage layout. • Map of proposed water abstractions including details of the proposed operating regime. • Decommissioning statement.	See **Figure 10.1** for details of proposed development. See **Figure 10.7** and Section 10.3.4.3 for details of GWDTE and potential impacts. No licensed groundwater abstractions identified. See **Technical Appendix 10.1** and **10.2** for peat assessment. Forest waste proposals presented in Forestry **Technical Appendix 3.2**. See **Technical Appendix 10.5** for details of proposed borrow pits.
		Water management plan would form part of the site CEMP, see Section 10.4.
SNH 29th November 2018	We note that electrofishing surveys were undertaken in 2017 at eight sites within or downstream from the proposed development. It would have been useful to know the location of these survey sites and the ES should include a map of fisheries survey locations with the wind farm boundary, proposed turbines, tracks and infrastructure layout overlapping. The electrofishing surveys recorded salmon, trout, eel and lamprey. Therefore we support the proposals to consult with the Stinchar River Salmon Fisheries Board and Ayrshire Rivers Trust prior to EIA submission. The ES should include a map of the 2015 and 2018 NVC habitat survey results with the wind farm boundary, proposed turbines, tracks and infrastructure layout overlapping. The habitat description within the scoping report indicates commercial conifer plantation is the main habitat type on site, with clear felled areas widespread. Small areas of blanket bog (M19) have also been recorded and we recommend that these should be retained and managed to improve the condition of the peatland habitat. Class 1 areas are nationally important carbon-rich soils, deep peat and priority peatland habitat and are likely to be of high conservation value. The scoping report states that this priority habitat will not be considered as part of the "developable area" and we support this mitigation measure. The scoping report also confirms that peat probing was undertaken as part of the initial field surveys and further peat surveys work will be undertaken before EIA submission. We advise that detailed peat surveys of the site, measuring the peat deposit to full depth, should be undertaken in accordance with Scottish Government guidance. The results should also be used to inform a peat slide assessment. We recommend that peat survey results should be used to inform the design and layout process, so that the development avoids, where possible, fragile and priority habitats and other sensitive areas (e.g. blanket bog and peat). Where this is not possible, suitable restoration and/or compensation measures should be presented in the ES in the form of a draft Habitat Management Plan (HMPs). An assessment of impacts of hydrological changes (particularly related to groundwater) on habitats should also be included. In addition to turbine foundations access tracks are the elements that will result in the greatest land-take, habitat fragmentation and hydrological disruption. It is important that the track construction methods for any new track to be constructed are clearly described in the ES, along with the rationale for their type and location, and all direct and indirect impacts assessed.	See **Chapter 8: Ecology** for details of fisheries surveys completed and NVC habitat surveys. See **Technical Appendix 10.1 and 10.2** for peat assessments. Water management plan would form part of the site CEMP, see Section 10.4.
Scottish Water 2nd November 2018	A review of our records indicates that there are no Scottish Water drinking water catchments or water abstraction sources, which are designated as Drinking Water Protected Areas under the Water Framework Directive, in the area that may be affected by the proposed development.	Noted.
Fisheries Management Scotland	The proposed development falls within the district of the Stinchar District Salmon Fishery Board, and the catchments relating to the	See **Chapter 8: Ecology**.

31st October 2018	Ayrshire Fisheries Trust. It is important that the proposals are conducted in full consultation with these organisations.	
Marine Scotland Science 26th November 2018	MSS suggests that the developer considers water quality within the Environmental Impact Assessment (EIA), particularly as the proposed development area suffers from acidification problems and modified drainage related to forestry practices. Furthermore the potential impact on water quality and aquatic biota associated with the proposed felling should also be assessed. MSS recommends that the developer establishes an integrated water quality (hydrochemical and macroinvertebrate) and fish population monitoring programme before, during and after construction to monitor watercourses which could potentially be impacted and control sites. MSS recommends that the developer discusses the potential cumulative impact of adjacent wind farms on water quality and fish populations	Baseline fisheries and water quality monitoring has been proposed. See **Chapter 8: Ecology** and Section 10.4 of this Chapter.
Ayrshire Rivers Trust (ART)	The Ayrshire Fisheries Trust (ART) has completed a number of baseline surveys to characterise baseline conditions (see **Chapter 8: Ecology**) and recommended that these survey locations are re-surveyed prior to any construction works commencing including the provision of access roads for site traffic.	Baseline fisheries and water quality monitoring has been proposed. See **Chapter 8: Ecology** and Section 10.4 of this Chapter.
River Stinchar Salmon Fisheries board	No response received	
Forestry Commission Scotland 21st January 2019	It should be made clear that both felling operations and compensatory planting (if relevant) must be carried out in accordance to good forestry practice as defined in the UK Forestry Standard (UKFS). The UKFS, supported by a series of guidelines, is the reference standard for sustainable forest management in the UK and provides a basis for regulation and monitoring. The Scottish Government expects all forestry plans and operations in Scotland to comply with the standards.	See Forestry report provided in **Technical Appendix 3.2**
Scottish Wildlife Trust	No response received	

Table 10.1: Consultation responses

10.2.8 Good practice measures and mitigation

29. Any potential effects of the proposed Development on soils, geology and the water environment identified by the assessment have been addressed and mitigated by the conceptual Site design and the application of good practice guidance implemented as standard during construction and operation to prevent, reduce or offset effects where possible. As such a number of measures would form an integral part of the design/construction process and these have been taken into account prior to assessing the likely effects of the proposed Development. Where appropriate, furthermore tailored mitigation measures have been identified prior to determining the likely significance of residual effects.

30. Good practice measures would be applied in relation to pollution risk, sediment management, peat management and management of surface runoff rates and volumes. This would form part of the Construction Environment Management Plan (CEMP) to be implemented for the proposed Development and would be prepared prior to construction, an outline of which is provided in **Technical Appendix 3.1: outline Construction Environmental Management Plan**.

31. As the CEMP develops it would include details and responsibilities for environmental management onsite for Site environmental aspects and would outline the necessary surface water management, oil and chemical delivery and storage requirements, waste management, traffic and transport management and would specify monitoring requirements for waste water, water supply including an Environmental Incident Response Plan (EIRP) and all appropriate method statements and risk assessments for the construction of the proposed Development.

10.2.9 Approach to assessment of effects

10.2.9.1 Significance of effect

32. The significance of potential effects of the proposed Development has been assessed by considering two factors: the sensitivity of the receiving environment and the potential magnitude of impact, should that effect occur. The assessment methodology has also been informed by the assessor's experience of carrying out such assessments for a range of windfarm and other developments, a knowledge of soils, geology and the water environment characteristics in Scotland and cognisance of good practice.

33. This approach provides a mechanism for identifying the areas where mitigation measures are required and for identifying mitigation measures appropriate to the significance of potential effects presented by the proposed Development.

34. Criteria for determining the significance of effect are provided in **Table 10.2, Table 10.3 and Table 10.4.**

10.2.9.2 Sensitivity

35. The sensitivity of the receiving environment (i.e. the baseline quality of the receiving environment) is defined as its ability to absorb an effect without a detectable change and can be considered through a combination of professional judgement and a set of pre-defined criteria which is set out in **Table 10.2**. Receptors in the receiving environment only need to meet one of the defined criteria to be categorised at the associated level of sensitivity.

Sensitivity	Definition
High	▪ SEPA Water Framework Directive Water Body Classification: High-Good or is close to the boundary of a classification: Moderate to Good or Good to High; ▪ receptor is of high ecological importance or National or International value (e.g. Site of Special Scientific Interest (SSSI), Special Area of Conservation (SAC), habitat for protected species) which may be dependent upon the hydrology of the Development Area; ▪ receptor is at high risk from flooding above 0.5% Annual Exceedance Probability (AEP) and/or water body acts as an active floodplain or flood defence; ▪ receptor is used for public and/or private water supply (including Drinking Water Protected Areas; ▪ groundwater vulnerability is classified as high; ▪ if a Groundwater Dependent Terrestrial Ecosystem is present and identified as being of high sensitivity; and ▪ soil type and associated land use is highly sensitive (e.g. unmodified blanket bog peatland).
Moderate	▪ SEPA Water Framework Directive Water Body Classification: Moderate or is close to the boundary of a classification: Low to Moderate; ▪ receptor is at moderate risk from flooding (0.1% AEP to 0.5% AEP) but does not act as an active floodplain or flood defence; ▪ moderate classification of groundwater aquifer vulnerability; and soil type and associated land use moderately sensitive (e.g. arable, commercial forestry).
Low	▪ SEPA Water Framework Directive Water Body Classification: Poor or Bad; ▪ receptor is at low risk from flooding (less than 0.1% AEP); ▪ receptor not used for water supplies (public or private); and soil type and associated land use not sensitive to change in hydrological regime and associated land use (e.g. intensive grazing of sheep and cattle)
Not Sensitive	▪ receptor would not be effected by the proposed development e.g. lies within a different and unconnected hydrological / hydrogeological catchments.

Table 10.2: Criteria for assessing sensitivity of receptor

10.2.9.3 Magnitude

36. The potential magnitude of impact would depend upon whether the potential effect would cause a fundamental, material or detectable change. In addition the timing, scale, size and duration of the potential effect resulting from the proposed Development are also determining factors. The criteria that have been used to assess the magnitude of impact are defined in **Table 10.3**.

Magnitude	Criteria	Definition
Major	Results in loss of attribute	Fundamental (long term or permanent) changes to the baseline geology, hydrology, hydrogeology and water quality such as: ▪ permanent degradation and total loss of the soils habitat; ▪ loss of important geological structure/features; ▪ wholesale changes to watercourse channel, route, hydrology or hydrodynamics; ▪ changes to the site resulting in an increase in runoff with flood potential and also significant changes to erosion and sedimentation patterns; ▪ major changes to the water chemistry and ▪ major changes to groundwater levels, flow regime and risk of groundwater flooding.
Medium	Results in impact on integrity of attribute or loss of part of attribute	Material but non-fundamental and short to medium term changes to baseline geology, hydrology, hydrogeology and water quality, such as: ▪ loss of extensive areas of soils habitat, damage to important geological structures/features; ▪ some fundamental changes to watercourses, hydrology or hydrodynamics. Changes to site resulting in an increase in runoff within system capacity; ▪ moderate changes to erosion and sedimentation patterns; ▪ moderate changes to the water chemistry of surface runoff and groundwater; and ▪ moderate changes to groundwater levels, flow regime and risk of groundwater flooding.
Low	Results in minor impact on attribute	Detectable but non-material and transitory changes to the baseline geology, hydrology, hydrogeology and water quality, such as: ▪ minor or slight loss of soils or slight damage to geological structures / feature; ▪ minor or slight changes to the watercourse, hydrology or hydrodynamics; ▪ changes to site resulting in slight increase in runoff well within the drainage system capacity; ▪ minor changes to erosion and sedimentation patterns; ▪ minor changes to the water chemistry of surface runoff and groundwater; and ▪ minor changes to groundwater levels, flow regime and risk of groundwater flooding.
Negligible	Results in an impact on attribute but of insufficient magnitude to affect the use/integrity	No perceptible changes to the baseline soils, geology, hydrology, hydrogeology and water quality such as: ▪ no impact or alteration to existing important geological environs; ▪ no alteration or very minor changes with no impact to watercourses, hydrology, hydrodynamics, erosion and sedimentation patterns; ▪ no pollution or change in water chemistry to either groundwater or surface water; and ▪ no alteration to groundwater recharge or flow mechanisms.

Table 10.3: Criteria for assessing magnitude of impact

10.2.9.4 Significance of effect

37. The sensitivity of the receiving environment together with the magnitude of the impact determines the significance of the effect, which can be categorised into level of significance as identified in **Table 10.4**. This also takes into account good practice measures implemented and embedded as part of the design and construction of the proposed Development and use of professional judgement where appropriate.

38. The table provides a guide to assist in decision making. However, it should not be considered as a substitute for professional judgment and interpretation. In some cases, the potential sensitivity of the receiving environment or the magnitude of potential impact cannot be quantified with certainty and therefore professional judgement remains the most robust method for identifying the predicted significance of a potential effect.

Magnitude of Impact	Sensitivity			
	High	Moderate	Low	Not Sensitive
Major	**Major**	**Major**	**Moderate**	Negligible
Medium	**Moderate**	**Moderate**	Minor	Negligible
Low	**Moderate**	Minor	Minor	Negligible
Negligible	Negligible	Negligible	Negligible	Negligible

Table 10.4: Significance of effect

39. The characteristics of the impacts are described in terms of direct/indirect, temporary (revisable)/permanent (irreversible), together with timescales (short, medium, long term).

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

10.2.9.5 Cumulative effects

41. The assessment also considers potential cumulative effects associated with other windfarm developments within the same surface water catchments.

42. A cumulative effect is considered to be the effect on a hydrological or hydrogeological receptor arising from the proposed Development in combination with other proposed developments which are likely to affect surface water and groundwater.

43. Proposed developments within the same catchment as the Site and within a distance of 5 km from the proposed Development have been considered.

44. Cumulative effects are considered using the same methodology as for effects of the proposed Development in isolation.

10.2.9.6 Statement of significance

45. The soils, geology and water environment assessment concludes with a statement of significance associated with the proposed Development. Effects of ‘major’ and ‘moderate’ significance are considered to be ‘significant’ in terms of the EIA Regulations.

10.2.10 Limitations to the assessment

46. The assessment uses site investigation and survey data and publicly available data sources, including but not limited to SEPA, Met Office, Local Authority and commercial data supply companies, as well as additional information supplied from stakeholders during the scoping and consultation stages.

47. As a consequence it is considered that the data and information used to complete this assessment is robust and that there are no significant data gaps or limitations.

10.3 Baseline conditions

48. This section presents information gathered regarding the existing geological, hydrogeological and hydrological conditions at the Site and its immediate surroundings.

10.3.1 Site setting

49. The proposed Development Site is located approximately 3 km south west of Barrhill, South Ayrshire and is centred at National Grid Reference (NGR) NX 20068 80045. The proposed Development occupies an area of 1,446.6 ha although only a small proportion of this would be occupied by the new infrastructure of the proposed Development.

50. An extract of Ordnance Survey (OS) mapping for the Site is presented in **Figure 10.1**.

51. Ground elevations within the proposed Development range between approximately 60 m Above Ordnance Datum (AOD) in the north where Site access is granted from the A714 near Bents Farm, and 250 m AOD near the summit of Loch Hill in the west of the Site. Ground levels generally decrease towards the north and east of the Site.

52. The standard average annual rainfall (SAAR) for the surface water catchments that serve the Site, based on data obtained from the Flood Estimation Handbook (FEH) Web Service (CEH, 2018) confirms a wet climate:

- 1,526 mm for the Cross Water catchment; and
- 1,547 mm for the Water of Tig catchment.

53. The existing land use across the proposed Development is commercial coniferous plantation forestry, managed by Forestry and Land Scotland. Arecleoch Windfarm, an operational facility comprising 60 wind turbine generators (WTG) and operated by ScottishPower Renewables (SPR), is also situated adjacent to the proposed Development.

54. The proposed Development has been designed to use existing access tracks onsite, wherever possible. The existing access track includes 24 watercourse crossings, eight of which are scheduled for upgrade and two new watercourse crossings are proposed (**Figure 10.1**). An audit of existing watercourse crossings scheduled for upgrade and details of watercourses at locations of proposed new watercourse crossings is presented in **Technical Appendix 10.4: Schedule of Watercourse Crossings**.

10.3.2 Statutory designated sites

55. A review of the Scottish Natural Heritage (SNH) Sitelink (SNH, 2018) and Magic Map (DEFRA, 2018) webpage highlights that the proposed Development does not contain statutory designated sites.

56. The locations of nearby statutory designated sites are shown on **Figure 10.1** and **Figure 2.1** available in Volume 2 of the submission and are summarised below.

57. Glen App and Galloway Moors Site of Special Scientific Interest (SSSI) and Special Protection Area (SPA), a 8942 ha site, is located approximately 2 km to the west of the Site boundary, extending southwest to Loch Ryan. SSSI qualifying features include the hen harrier (*Circus cyaneus*). Part of the Glen App and Galloway Moors SSSI and SPA is located within the Water of Tig catchment area of, however within its sub-catchment of Dunnack Burn where no infrastructure of the proposed Development exists (i.e. it is not in hydrological connectivity with the Proposed Development) and is therefore not considered further within this Chapter;

58. Craig Wood SSSI, a 23 ha site, exists downstream of the proposed Development along the banks of the Water of Tig in Glen Tig. SSSI qualifying features include upland oak woodland classified by SNH as favourably maintained in 2009. The Site comprises a wide range of habitats from acid, sessile oak woodland on dry talus slopes through to base-rich, mixed ash-elm-oak woodland on the riverside flats and lower valley slopes. Craig Wood SSSI is over 4.5 km downstream of the application boundary and on the northern banks of the watercourse extending upgradient. This SSSI is within sub-catchments that are delineated by the hills of Cairn Hill, Bencummin and Knockdhu to the north and not the Water of Tig itself and therefore not in hydrological connection to the proposed Development and not considered further in this assessment.

59. Feoch Meadows SSSI, a 82 ha site, exists to the north of the proposed Development in the Duisk River catchment. SSSI qualifying features include fen meadow and lowland neutral grassland. This site lies within the Feoch Burn sub-catchment that lies upgradient on the Duisk River in the north (i.e. it is not in hydrological connectivity with the proposed Development) and is therefore not considered further within this Chapter;

60. The Wood of Cree SSSI and Galloway Oakwoods SAC occupy the same area of land on the east of the River Cree between the streams of Ballocharus Burn and Coldstream. The Wood of Cree SSSI (143 ha) is recognised for features of upland oak woodlands and oligotrophic loch both favourably maintained (2000 and 2004 respectively). The SSSI includes areas of open water with lily beds, mires within the flood plain, reedbeds, willow carr and meadows developing to strands of hazel on alkaline rich slopes. The site contains three lochs that are examples of oligotrophic water lily pools with locally uncommon characteristic species of pondweed (*Potamogeton obtusifolius* and *P. alpinus*) and a stonewort. The sedge *Carex aquatilis* and *Hypericum elodes*, marsh St Johns' wort, both of which are present in the swamp and fen fringes of the lochs, are also uncommon species. Wood of Cree forms part of the Galloway Oakwoods Special Area of Conservation (SAC) (355 ha) designated for Western acidic oak woodland, containing examples of old sessile oak woods that are diverse in mosses, liverworts, lichens and ferns. These sites are more than 14 km downstream of the watercourse crossings of the River Cree at the site access from the A714 public road (WX20) and its tributary Corwar Burn (WX19) where no new development is proposed; therefore these sites are not considered further in this Chapter.

10.3.3 Geology

10.3.3.1 Soils and superficial deposits

61. An extract of the 1:25,000 Soil Survey of Scotland (James Hutton Institute, 2019) mapping is presented as **Figure 10.2**, available in Volume 2 of the submission.

62. The principal soil type underlying is peat with areas of peaty gleys and brown soils along many of the watercourse valleys. Rare units of peaty gleyed podzols exist within the application boundary, most notably at the watercourse crossing of Cross Water (WX01). Mineral gleys and Brown soils have been recorded along the existing access track to the A714, west of Barrhill. Along the larger watercourses at lower altitudes (Water of Tig and River Cree) alluvial soils are observed within and along watercourses.

63. An extract of the 1:50,000 BGS superficial deposits data is presented as **Figure 10.3**, review of this and of the BGS Onshore Geoindex 1:50,000 data (BGS, 2019) shows that almost the entire Site is underlain by peat, while alluvium is shown to bound the Water of Tig, Pollingowan Burn and River Cree. The smaller hills and hummocky features along both Access Tracks from the A714 have been identified by the BGS as underlain by Glacial Till (diamicton). Superficial deposits are noted as absent on some hill tops.

64. As part of the baseline assessment a comprehensive peat probing exercise has been conducted and informs the **Peat Landslide Hazard Risk Assessment (Technical Appendix 10.1**). In summary:

- the presence and depth of peat was assessed at more than 1,500 locations;
- the areas of thickest peat are generally located towards the north of the proposed Development Site and coincide with the flatter gradients;
- the steeper slopes, where the majority of the turbines are located have significantly less peat and in general comprise mainly peaty soils (<0.5 m depth); and
- a hazard impact assessment has been completed, which has concluded that subject to the employment of appropriate mitigation measures, the presence of peat and potential peat slide instability are not development constraints.

10.3.3.2 Bedrock geology and linear features

65. An extract of the 1:50,000 BGS bedrock and linear features data is presented as **Figure 10.4**, available in Volume 2 of the submission.

66. There are three bedrock geological units within the study area:

- Kirkholm Formation, a sedimentary wacke is the dominant geological unit that almost entirely underlies the Site;
- Gladenoch Formation, also a of sedimentary wacke which is present as narrow bands that lie in a general south west to north east trend;
- Dalreoch Formation that exists to the immediate west of the Site boundary; and
- North Britain Palaeogene Dyke Suite of Microgabbro as two minor intrusions in the very west of the Site.

67. All of the proposed turbines are underlain by the Kirkholm Formation.

68. The BGS have mapped an inferred fault with unknown displacement separating the Kirkholm Formation and Dalreoch Formation geological units mapped in the very west of the study area.

10.3.4 Hydrogeology

10.3.4.1 Aquifer characteristics and groundwater vulnerability

69. BGS mapping of Scotland (**Figure 10.5**) shows that the bedrock deposits beneath the Site are considered low productivity aquifers, all of which are defined as highly indurated greywackes with limited groundwater in near surface weathered zone and secondary fractures.

70. A description and hydrogeological classification of the geological units at the Site is presented in **Table 10.5**. This is based on BGS aquifer productivity and groundwater vulnerability maps (BGS, 2019).

Period	Geological U-unit	Hydrogeological characteristics	Hydrogeological classification and groundwater Vulnerability
Pleistocene to Recent	Alluvium	Local differences in the aquifer thickness, the material and its sorting can realise a considerable range in hydraulic conductivity. Commonly in hydraulic continuity with nearby watercourses and can support locally important potable water supplies.	Intergranular Flow Considered to be highly vulnerable due to potential rapid groundwater movement and shallow depth to groundwater.
Pleistocene to Recent	Glacial Till	Sand and gravel horizons within this unit are capable of storing groundwater, although their lateral and vertical extent realises a variable and often small groundwater yield. Intergranular flow mechanisms dominate. Clay within this unit acts as an aquitard to the more permeable sand and gravel lenses and will hinder/prevent large scale groundwater movement. Regionally, groundwater flow will be limited by the variability of these deposits and consequently any groundwater yields are normally low.	Not classified. Not considered to be vulnerable to pollution as a consequence of predominance of clay in the Till.
--	Kirkholm Formation, Gladenoch Formation and Dalreoch Formation	Generally without groundwater except at shallow depth. Limited groundwater in near surface weathered zone and secondary fractures or rare springs. Low Productivity aquifers.	Where not overlain by superficial deposits vulnerable to pollution due to potential rapid groundwater movement and shallow depth to groundwater. Afforded protection when overlain by Glacial Till.

Table 10.5: Hydrogeological characteristics of geological units at the Site

71. The BGS groundwater vulnerability data (**Figure 10.6**) classifies the underlying aquifer (superficial and bedrock) according to the predominant groundwater flow mechanism (fracture or intergranular) and the estimated groundwater productivity. Groundwater vulnerability is divided into five classes (1 to 5) with 1 being least vulnerable and 5 being most vulnerable. The vulnerability map shows that the groundwater underlying the Site is generally of high vulnerability (Class 4a and 4b), due to the dominance of fracture flow and generally thin superficial cover. Groundwater in the east of the Site at the bridge of River Cree and where the access track crosses Crowar Burn is of slightly higher vulnerability (Class 5) due to the absence of superficial deposits.

10.3.4.2 Groundwater levels and quality

72. Baseline factors that would inhibit groundwater recharge at Site include the following:

- steeper topographic gradients present in parts of the site would encourage the formation of surface water runoff;
- the underlying Glacial Till deposits would inhibit infiltration owing to its characteristic low bulk permeability; and
- the underlying bedrock (where it is not weathered or fractured) generally displays a low permeability that would limit groundwater recharge.

73. SEPA has confirmed they have no information regarding groundwater levels and quality within the Site.

74. In the absence of published information or data held by SEPA, it is inferred that groundwater will be present as perched groundwater within more permeable horizons (sand and gravels) of the Glacial Till deposits, within the Alluvium, and within weathered zones, fractures or fault zones within the bedrock deposits.

75. All of Scotland's groundwater bodies have been designated as Drinking Water Protected Areas under the Water Environment (Drinking Water Protected Area) (Scotland) Order 2013 and require protection for their current use or future potential as drinking water resources.

76. The current status of groundwater bodies in Scotland has been classified by SEPA (SEPA, 2017) in accordance with the requirements of the Water Framework Directive (WFD). SEPA identify two groundwater bodies that underlie the Site:

- Galloway (SEPA ID 150694), classified in 2017 with and Overall Status of Good and no pressures are identified; and
- South Ayrshire Hills (SEPA ID 150660), classified in 2017 with an Overall Status of Good and no pressures are identified.

10.3.4.3 Groundwater Dependent Terrestrial Ecosystems

77. A habitat mapping exercise was conducted in 2018 as part of the ecology baseline assessment, to identify potential Groundwater Dependent Terrestrial Ecosystems (GWDTEs) within the Site. The results of the habitat mapping exercise are discussed in detail within **Chapter 8 (Ecology)** and areas of potential GWDTE are shown on **Figure 10.7**. An assessment of the GWDTE, and in particular whether the habitats are sustained by ground or surface water, is summarised below:

- all potentially moderately and highly dependent GWDTE habitats presented in the NVC mapping are associated along forest rides and watercourse banks;
- the Site has been proven to be underlain by peat and Glacial Till, both of which are characterised by low bulk permeability which hinders the movement of groundwater;
- the underlying bedrock also contains little groundwater;
- hand dug trial pits in areas mapped as GWDTE typically were dry or where water was encountered was witnessed to seep into to the pit from the surface acrotelm layer of the peat;
- often the areas of potential GWDTE were recorded at the time of the Site survey to be dry underfoot; and
- surface gradients are typically shallow and given the low permeability soils and geology rainfall will preferentially pond on the ground surface and form surface water runoff.

78. Following review of the Site setting and the findings of field investigations it is concluded that the areas mapped as potential GWDTE are not sustained by groundwater but rather are sustained by incident rainfall and surface water runoff.

10.3.5 Hydrology

10.3.5.1 Local hydrology

79. The Site is drained by two main catchment areas: the River Stinchar and the River Cree. The River Stinchar drains the majority of the Site and the entire area of proposed new and upgraded infrastructure while the River Cree catchment serves the existing access track from the A714 public road at the bridge of River Cree. The catchment areas are shown in **Figure 10.1** (Volume 2) and described below.

10.3.5.2 River Stinchar

80. The River Stinchar has an overall catchment size of 343 km^2 and discharges to the North Channel at Ballantrae to the west of the Site. Within the study area, the River Stinchar is served by two large sub-catchments: the Water of Tig (discharging to the River Stinchar at Balnowart) and the Duisk River (that discharges to the River Stinchar at Pinwherry). The Water of Tig serves the north and west half of the turbine area while the Cross Water, a tributary that lies within the Duisk River catchment, serves the southern and eastern half of the turbine area. The majority of the existing access tracks from the A714 public road are served by several tributaries of the Duisk River including Burn of Lig, Alty Burn, Pollgowan Burn (upstream recognised as Laggish Burn, Haw Burn and Pullower Burn) and Lavery Burn.

10.3.5.3 Water of Tig

81. Within the Water of Tig catchment the existing track scheduled for upgrade passes adjacent to an unnamed waterbody (Photograph 10.3-1). This waterbody appears to be a flooded borrow pit with no significant outflow found.

Photograph 10.3-1: Existing access track and unnamed waterbody to the south west of proposed WTG 4

82. The Water of Tig is crossed by the existing access track watercourse crossing WX09 that is scheduled for upgrade. The Water of Tig here is approximately 3 m wide and 0.2 m deep showing no evidence of excessive erosion or aggrading (Photograph 10.3.-2). The Water of Tig catchment is almost entirely forested while some sections are currently undergoing clear felling (10.3-3).

Photograph 10.3-2: Water of Tig immediately upstream of existing watercourse crossing WX09

Photograph 10.3-3: Area of recent clear felling immediately upgradient of existing watercourse crossing WX05

10.3.5.4 Cross Water

83. The Cross Water catchment within the proposed Development includes many unnamed watercourses and as well as a watercourse named White Loan. The catchment has almost entirely been forested in the past however much has been clear felled and reforested (Photograph 10.3-4).

Photograph 10.3-4: Cross Water catchment, looking towards the existing access track crossing of railway and Cross Water

84. In the west of the catchment several coupes of forestry have been recently clear felled and show some local surface water ponding (Photograph 10.3-5).

Photograph 10.3-5: Recently clear felled catchment upgradient of proposed new watercourse crossing WX06

85. In the vicinity of proposed WTG 10, approximately 100 m to the north and 80m to the south of the WTG lies a small narrow watercourse (Photograph 10.3-6 and Photograph 10.3-7 respectively) which is crossed by the proposed new access track at watercourse crossing WX03 and at the existing access track at watercourse crossing WX02 that is scheduled for upgrade.

Photograph 10.3-6: Small unnamed OS watercourse to the north of proposed WTG 10

Photograph 10.3-7: Small unnamed OS watercourse to the south of proposed WTG 10

86. The White Loan tributary of Cross Water has a very similar catchment to the wider Cross Water catchment where previous forestry has been clear felled (see Photograph 10.3-8). The existing railway line crosses the White Loan watercourse to the east of proposed WTG 12, which is culverted beneath.

Photograph 10.3-8: White Loan flowing north through clear felled land towards the railway line

10.3.5.5 River Cree

87. The River Cree has an overall catchment size of 368 km^2 and discharges to Wigtown Bay to the south east of the Site. Within the study area, the access track crosses the River Cree itself at the existing forestry bridge immediately off the A714 public road at the bridge of River Cree and Corwar Burn, identified downstream of Loch Dornal as Carrick Burn.

10.3.5.6 Surface water flow

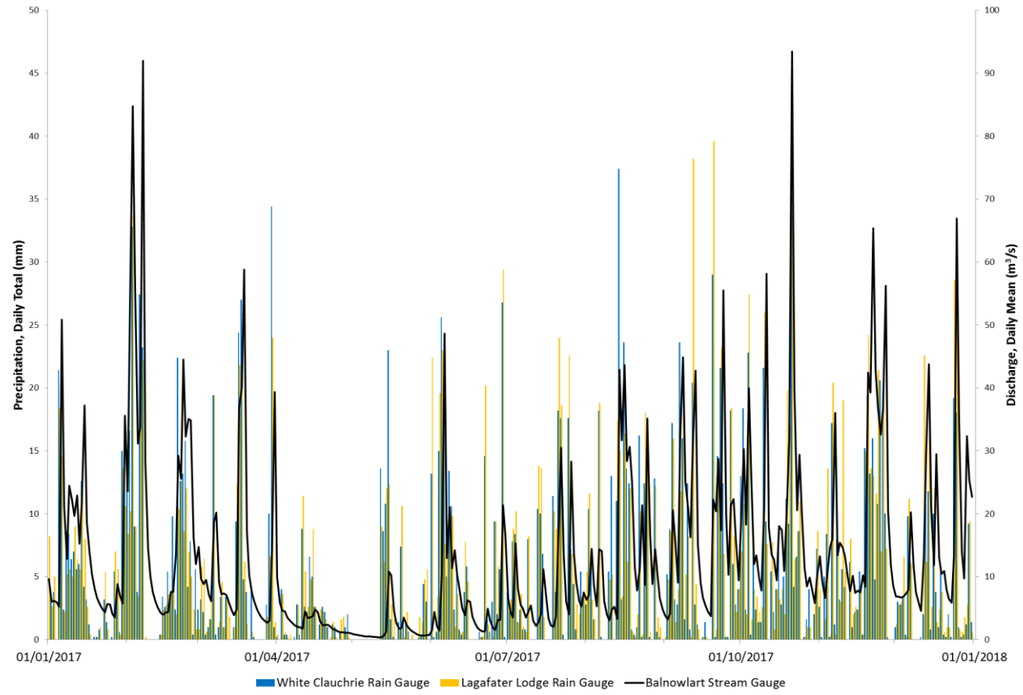
88. **Table 10.6** presents catchment areas and the key catchment descriptors from the FEH Web Service (CEH, 2019) for the Water of Tig and Cross Water catchments, which can be used to describe the catchments' anticipated response to rainfall.

Watercourse	Downstream Point (NGR)	Area (km^2)	SAAR (mm)	ALTBAR (mASL)	DPSBAR (m/km)	LDP (km)	BFIHOST (dim)
Water of Tig	NX 16450 82600	15.78	1,508	210	73.90	11.00	0.2790
Cross Water	NX 23350 82450	11.96	1,526	180	46.70	9.20	0.2630

Table 10.6: Surface water catchment descriptors

Notes: Grid reference of downstream maximum extent of catchment as denoted by ether the Proposed Development Site boundary or confluence with another watercourse; SAAR – surface average annual rainfall between 1961 and 1990; ALTBAR – mean catchment altitude (metres above sea level); DPSBAR – index of catchment steepness; and LDP – longest drainage path; BFIHOST - base flow index is a measure of catchment responsiveness to precipitation.

89. SEPA provided precipitation data for the two nearest rain gauges to the proposed Development (White Clauchrie at NGR NX 29459 86266 and Lagafater Lodge at NGR NX 13933 75968) and the closest stream gauge on the River Stinchar at Balnowlart (NGR NX 10749 83222). Daily precipitation totals for the two gauges and mean daily discharge for 2017 are presented in **Graph 10.1**.



Graph 10.1: SEPA precipitation and stream flow data for River Stinchar.

90. In 2017 a total of 2,011.2 and 2,043.4 mm were recorded at White Clauchrie and Lagafater Lodge rain gauges, notably higher than the SAAR data provided by the FEH web service while the mean daily discharge recorded at Balnowlart was 13.7 m^3/s. Review of **Graph 10.1** highlights that autumn to spring records significantly higher and more variation in precipitation and flows.

10.3.5.7 Surface water quality

91. Water quality of the Water of Tig, Cross Water, Duisk River, Lavery Burn, Corwar Burn and River Cree is monitored by SEPA and classified annually in accordance with the requirements of the Water Framework Directive (WFD). **Table 10.7** provides summary details of the SEPA classifications reported in 2017 (SEPA, 2017). It should be noted that smaller watercourses within the proposed Development are not monitored nor classified by SEPA.

Watercourse (SEPA ID)	Overall status	Overall ecology	Physico-chemical status	Hydromorphology
Water of Tig (10468)	Good	Good	Good	Good
Cross Water (10472)	Moderate	Moderate	Moderate	Good
Duisk River – upstream of Muck Water Confluence (10470)	Good	Good	Good	Good
Lavery Burn (10474)	Good	Good	Good	Good
Carrick Burn (Corwar Burn (10525)	Moderate	Moderate	High	Good
River Cree – upstream of Carrick Burn (10522)	Bad	Bad	High	Good

Table 10.7: SEPA waterbody classification (2017)

92. Pressures identified by SEPA for the monitored waterbodies include the following:

- Carrick Burn/Corwar Burn – unknown pressures on aquatic life and vegetation that have been identified as not in good condition however SEPA have not identified the cause; and
- River Cree – water quality pressures from acid rain impacts resulting in soil damage and increase of more acidic runoff. SEPA have identified forest restructuring and regulation as the methods to deal with the issue.

93. Although not an issue identified as a pressure by SEPA, it is noted that the Cross Water achieved a status of Fail for iron and a status of Moderate for reactive phosphorus in 2017.

10.3.6 Fisheries

94. Fisheries for watercourses that are downstream of the proposed Development are managed by the Ayrshire Rivers Trust (ART) in partnership with the River Stinchar District Salmon Fishery Board. It is noted that ART have prepared a fisheries management plan (FMP) and have reported that they are conducting conservation work within the River Stinchar catchment regarding acidification, flooding and excessive erosion and deposition from forestry practices (ART, 2009). Fishery interests are discussed in detail and assessed within **Chapter 8: Ecology**.

10.3.7 Flood risk

95. SEPA has developed national flood maps (SEPA, 2018a) that present modelled flood extents for river, coastal, surface water and groundwater flooding. The river, coastal, surface water and groundwater maps were developed using a consistent methodology to produce outputs for the whole of Scotland, supplemented with more detailed, local assessments where available and suitable for use. Flood extents are presented in three likelihoods:

- high likelihood: A flood event is likely to occur in the defined area on average more than once in every ten years (1:10). Or a 10% chance of happening in any one year.
- medium likelihood: A flood event is likely to occur in the defined area on average more than once in every two hundred years (1:200). Or a 0.5% chance of happening in any one year.
- low likelihood: A flood event is likely to occur in the defined area on average more than once in every thousand years (1:1000). Or a 0.1% chance of happening in any one year.

96. The flood risk from each of these potential sources is discussed below. Consultation with SAC and SEPA has been conducted and used to inform this assessment. SAC confirm they hold no historical records of flooding within 5 km of the main turbine area and SEPA confirmed details presented within their online Flood Maps service.

10.3.7.1 Flooding from the sea or tidal flooding

97. The SEPA coastal flood maps confirm that the Site is distant from coastal flooding extents. The lowest elevations within the proposed Development are approximately 60 m AOD.

10.3.7.2 Flooding from rivers or fluvial flooding

98. SEPA mapping has identified that the main Water of Tig and Cross Water floodplain extents are local, never extending far from the watercourse.

99. Approximately 200 m downstream of the existing access track watercourse crossing WX09 scheduled for upgrade within the forest clearing the Water of Tig flood extent is shown to fill the clearing, narrowing again immediately downstream of here (see Photograph 10.3-9).

Photograph 10.3-9: Water of Tig forest clearing downstream of watercourse crossing WX09, looking north

100. Approximately 150 m upstream of the existing access track watercourse crossing scheduled for upgrade for the Cross Water (WX01) where the Cross Water joins the White Loan and another unnamed tributary (Photograph 10.3-10), the SEPA High likelihood flood extent is seen to envelop the railway line (see Photograph 10.3-10).

Photograph 10.3-10 Cross Water Immediately Upstream of Watercourse Crossing WX01, Looking South west

101. SEPA has also identified the watercourses of Laggish Burn (watercourse crossing WX10), Lavery Burn (watercourse crossing WX17) and the River Cree (watercourse crossing WX20) with limited floodplains.

10.3.7.3 Flooding from surface water

102. SEPA has modelled many small surface water flood extents within the Site, largely coinciding with existing forestry tracks (i.e. at Knockshin Hill) and along watercourse channels (i.e. Cross Water and Laggish Burn) and waterbodies (i.e. Loch Long and Black Loch near existing watercourse crossing WX14), it is noted however, that the flood extents are minor and localised, never forming large linked areas or flowpaths.

10.3.7.4 Flooding from groundwater

103. The SEPA groundwater flood map illustrates that the Site is not at risk from predicted groundwater flooding. This concurs with the desk based assessment which has shown that there is little potential for significant groundwater at the Site.

10.3.7.5 Flooding from infrastructure failure

104. SEPA has produced reservoir inundation maps (SEPA, 2018b) for those sites currently regulated under the Reservoirs Act 1975. Review of the SEPA Inundation Mapping highlights that there is no risk of reservoir inundation within the proposed Development Site.

10.3.7.6 Historical flooding records

105. Consultation with SAC highlighted that they hold no records of historical flooding within 5 km of the proposed Development Site centre.

10.3.7.7 Private Water Supplies and licenced sites

106. Private water supplies (PWS) are regulated by The Water Intended for Human Consumption (Private Supplies) (Scotland) Regulations 2017. The regulatory objective is to ensure the provision of clean and wholesome drinking water and the delivery of significant health benefits to those using such supplies.

107. As part of this assessment, data requests were made to SAC who provided details of 19 properties and PWS sources within 5 km of the main turbine area centre. This data was supplemented with data from the EIAs of neighbouring developments (existing Arecleoch Windfarm, Kilgallioch Windfarm, Altercannoch Windfarm and Mark Hill Windfarm) and PWS surveys conducted onsite on 06/02/2019 and 12/04/2019, which then informed the **Private Water Supply Risk Assessment (Technical Appendix 10.3)**.

108. As requested by SAC, the Private Water Supply Risk assessment presents a conceptual site model. The location of the PWS sources in relation to the proposed windfarm infrastructure are detailed and the potential hydrological and hydrogeological linkages between the PWS sources and the proposed infrastructure are considered prior to assessing the risk the development poses to each of the PWS sources.

109. In summary, the Private Water Supply Risk Assessment shows:

- 35 properties were determined to be within 5km and potentially be downgradient of the proposed Development; and
- of these, 5 properties, which are connected to at 4 PWS sources, have been assessed without mitigation or monitoring as potentially at risk of impact from the proposed Development.

110. No new development is proposed in the catchments of three of the PWS sources identified as potentially at risk. However, existing access tracks, which will be used to access the proposed Development, have been identified as upstream of the PWS sources. The properties that had been assessed as potentially at risk are (illustrated in **Figure 10.1**) and include:

- PWS02 Arnimean (PWS source located 10m west of existing access track);
- PWS04 Burnside (PWS source is located 200m west of existing access track);
- PWS10 Laggish Farm (PWS source is located 1km north east of existing access track); and
- PWS14 which includes Barrhill Train station and Ferngate Cottage (PWS source is located 400m north of a proposed upgraded access track and catchment area includes a number of proposed watercourse crossings turbines).

111. With good practice and site specific mitigation measures presented in the Private Water Supply Risk Assessment the PWS sources can be safeguarded.

112. There is no evidence to suggest that the bedrock deposits present at Site produce leachant (currently or when exposed) in water that passes through the rock**.** This has been confirmed by the existing borrow pits on Site and from the quality of drainage witnessed from the site won aggregate used to construct the existing site access tracks.

113. It is proposed that routine monitoring would be completed prior to and during the proposed Development which would be used to confirm the PWS sources 02, 04, 10 and 14 are not impaired, see **Private Water Supply Risk Assessment (Technical Appendix 10.3)** for further details.

114. SEPA provided details of CAR registrations/licences within 5 km of the of the main turbine area; these are shown on **Figure 10.1** and summarised as follows:

- 24 discharges of sewage (private) primary (19 of which to groundwater, 5 to watercourses);
- 4 discharges of sewage (private) secondary to watercourses;
- 1 discharge of sewage (private) tertiary to watercourse (Barrhill Holiday Park); and
- discharges from one combined sewer overflow and one sewage (public) secondary belonging to the Barrhill Sewage Purification Works.

115. SEPA hold no records of registered or licenced abstractions within 5 km of the centre of the main turbine area. There are no licensed sites within 1 km of the existing access track and it is assessed that the registrations along the route are attributed to the registration of watercourse crossings and sewage discharges from properties.

10.3.8 Summary of sensitive water environment receptors

116. **Table 10.8** outlines the receptors identified as part of the baseline study, and their sensitivity based upon the criteria contained in **Table 10.2**. These receptors form the basis of the assessment, and as per the previously introduced methodology, are used in conjunction with an estimate of the magnitude of an effect to determine significance.

117. While a catchment carries a high sensitivity if private water supplies are present, the risk to private water supplies is assessed at an individual source level. This allows for a more detailed risk assessment of individual sources based upon the proposed design layout. All private or water supplies carry a ‘high’ sensitivity designation. See **Private Water Supply Risk Assessment (Technical Appendix: 10.3)**.

118. **Table 10.8** outlines the receptors identified as part of the baseline study, together with a description of their sensitivity to potential impacts associated with windfarm development.

Receptor	Sensitivity	Reason for Sensitivity
Statutory Designated Sites	Not Sensitive	No statutory designated sites are hydrologically connected to the proposed Development.
Geology	High	Sensitive peat soils have been recorded within the proposed Development.
Groundwater	High	Groundwater has been classed by SEPA as Good and vulnerability is classified as High.
Surface water	High	Surface water watercourses have been classified by SEPA as Good and no pressures identified for the catchments serving the main turbine area.
Flooding	Moderate	Several watercourses that are crossed by existing access track and the Cross Water at the watercourse crossing scheduled for upgrade are identified at risk from flooding but do not act as an active floodplain or flood defence.
Private Water Supplies	High	Five properties (using four water sources) have been identified to be served by a PWS that are downgradient of the proposed Development.
Licenced sites	Negligible	No licenced abstractions or sensitive discharges are recorded.

Table 10.8: Sensitivity of receptors

10.4 Assessment of effects

10.4.1 Potential effects

10.4.1.1 Embedded measures

119. The assessment of effects is based on the proposed Development description outlined in **Chapter 3: Description of the Development** and is structured as follows:

- construction effects of the proposed Development;
- operational effects of the proposed Development; and
- cumulative effects of the proposed Development, Arecleoch Windfarm and other proposed windfarms in the study area (no other types of development were identified as relevant to the assessment when screening for cumulative effects).

120. The proposed Development has undergone design iterations and evolution in response to the constraints identified as part of the baseline studies and field studies so as to avoid and/or minimise potential effects on receptors where possible. This has included geological, hydrological and hydrogeological constraints which include slope stability, watercourse locations, areas of potential flooding, and groundwater dependent terrestrial ecosystems.

10.4.1.1.1 Buffer to watercourses

121. In accordance with SEPA's PPG5, a buffer distance between watercourses and any proposed construction activities or infrastructure was applied to those watercourses within the Site. The 50 m buffer applied is in excess of the PPG guidance.

122. Whilst all key infrastructure and hardstanding areas have been designed to be located out with these areas, the access track has had to impinge on the buffer where it crosses watercourses (as presented in **Technical Appendix 10.4: Schedule of Watercourse Crossings**). The layout of the access tracks was designed to minimise the number of watercourse crossings across the Site. The location of the two proposed new crossings is shown in **Figure 10.1**.

123. It is also noted that it has been necessary for the new access tracks to WTG 4 and between WTG 7 and 8 to be within the 50 m buffer to watercourses however the watercourses are not crossed.

10.4.1.1.2 Peat

124. The potential presence of peat within the Site formed a key consideration in the design of the proposed Development. Informed by the extensive programme of peat probing undertaken across the Site, the design has avoided areas of deeper peat and limited development to small areas of shallow peat or where peat is absent.

10.4.1.1.3 Groundwater dependent habitats

125. SEPA's windfarm planning guidance (SEPA, 2017) states a National Vegetation Classification (NVC) survey should be undertaken to identify wetland areas that might be dependent on groundwater. If potential GWDTEs are identified within (a) 100 m of roads, tracks and trenches, or (b) within 250 m of borrow pits and foundations, then it is necessary to assess how the potential GWDTEs may be affected by the proposed Development.

126. This guidance has been used to inform the Site design and the proposed turbines and associated infrastructure has been located so as to minimise potential effects on areas of possible GWDTE. A summary of the habitat surveys completed at Site is provided in **Chapter 8: Ecology** along with a detailed NVC habitat plan. An assessment of GWDTEs is presented in Section 10.3.4.3.

127. **Figure 10.7** shows area of potential GWDTE and the proposed Development.

128. As discussed in Section 10.3.4.3, further field investigation onsite, which included a programme of trial pitting has concluded that areas of potential moderately or highly GWDTE habitat are likely to be sustained by incident rainfall and local surface water runoff rather than by groundwater.

129. Measures have been proposed to safeguard existing water flow paths and maintain existing water quality. It is considered therefore that the water dependent habitats identified by the NVC mapping can be therefore sustained. This would be confirmed, in accordance with good practice, by the Ecological Clerk of Works (ECoW) at the time of the construction of the proposed Development.

10.4.1.2 Good practice measures

Measures would be adhered to during the construction and operation of the proposed Development. Good practice measures would be applied in relation to pollution risk, sediment management and management of surface runoff rates and volumes. This would form part of the CEMP (**Technical Appendix 3.1: Outline CEMP**) to be implemented for the proposed Development.

130. SPR is committed to implementing good practice measures as a matter of course during the construction of the proposed Development and these are not considered to be mitigation measures but form an integral part of the design/construction process. Key good practice measures are stated below and the assessment incorporates these measures as part of the proposed Development. Any further specific mitigation which may be required to reduce the significance of a potential effect is identified in the assessment of likely effects during the construction and operation phases.

10.4.1.2.1 General measures

131. As a principle, preventing the release of any pollution/sediment is preferable to dealing with the consequences of any release. There are several general measures which cover all effects assessed within this Chapter, details are given below.

132. Prior to construction, section specific drainage plans would be produced. These would take into account any existing local drainage which may not be mapped and incorporate any section specific mitigation measures identified during the assessment.

133. Measures would be included in the final CEMP for dealing with pollution/sedimentation/flood risk incidents and would be developed prior to construction. This would be adhered to should any incident occur, reducing the effect as far as practicable.

134. The final CEMP would contain details on the location of spill kits, would identify 'hotspots' where pollution may be more likely to originate from, provide details to Site personnel on how to identify the source of any spill and state procedures to be

adopted in the case of a spill event. As identified in the outline CEMP, a specialist spill response contractor would be identified to deal with any major environment incidents.

135. A wet weather protocol would be developed. This would detail the procedures to be adopted by all staff during periods of heavy rainfall. Tool box talks would be given to engineering/construction/supervising personnel. Roles would be assigned to different engineering/construction/supervising personnel and the inspection and maintenance regimes of sediment and runoff control measures would be adopted during these periods.

136. In extreme cases, the above protocol would dictate that work onsite may have to be temporarily suspended until weather/ground conditions allow.

10.4.1.2.2 Water quality monitoring

137. The catchments of the Water of Tig, Cross Water, Pollgowan Burn, Lavery Burn and River Cree have been highlighted as being at risk of potential construction effects due to the nature of works within the catchments as well as the high sensitivity receptors within the catchments. Water quality monitoring before and during the construction phase would be undertaken, to ensure that the tributaries of the main channels and sensitive receptors (PWS) identified at risk from the proposed Development have no significant impacts to water quality and/or quantity. Monitoring would be carried out at a specified frequency (depending upon the construction phase) on these catchments.

138. This monitoring would continue throughout the construction phase and immediately post construction. Monitoring would be used to allow a rapid response to any pollution incident as well as assess the impact of good practice or remedial measures. Monitoring frequency would increase during the construction phase if remedial measures to improve water quality were implemented. Water quality monitoring plans would be developed during detailed design (SEPA, SAC, D&GC and the ART would be consulted on the plan) and would be contained within the Construction Management Plan.

139. The performance of the good practice measures would be kept under constant review by the water monitoring schedule, based on a comparison of data taken during construction with a baseline data set, sampled prior to the construction period.

10.4.1.2.3 Pollution risk

140. Good practice measures in relation to pollution prevention would include the following:

- refuelling would take place at least 50 m from watercourses and where possible it would not occur when there is risk that oil from a spill could directly enter the water environment. For example, periods of heavy rainfall or when standing water is present would be avoided;
- foul water generated onsite would be managed in accordance with PPG4;
- a vehicle management plan and speed limit (15 mph) would be strictly enforced onsite to minimise the potential for accidents to occur;
- drip trays would be placed under stationary vehicles which could potentially leak fuel/oils;
- areas would be designated for washout of vehicles which are a minimum distance of 50 m from a watercourse;
- washout water would also be stored in the washout area before being treated and disposed of;
- if any water is contaminated with silt or chemicals, runoff would not enter a watercourse directly or indirectly prior to treatment;
- water would be prevented as far as possible, from entering excavations such as borrow pits;
- procedures would be adhered to for storage of fuels and other potentially contaminative materials in line with the Controlled Activity Regulations, to minimise the potential for accidental spillage (e.g. stored in 110% bunded storage facilities); and
- a plan for dealing with spillage incidents would be designed prior to construction, and this would be adhered to should any incident occur, reducing the effect as far as practicable. This would be included in the final CEMP for the Development.

10.4.1.2.4 Erosion and sedimentation

141. Good practice measures for the management or erosion and sedimentation would include the following:

- all stockpiled materials would be located out with a 50 m buffer from watercourses;
- where possible, stockpiled material would either be seeded or appropriately covered;
- water would be prevented as far as possible, from entering excavations such borrow pits through the use of appropriate cut-off drainage;
- where the above is not possible, water that enters a borrow pit would pass through a number of settlement lagoons and silt/sediment traps to remove silt prior to discharge into the surrounding drainage system. Detailed assessment of ground conditions would be required to identify locations where settlement lagoons would be feasible;
- clean and dirty water onsite would be separated and dirty water would be filtered before entering the water environment;
- if the material is stockpiled on a slope, silt fences would be located at the toe of the slope to reduce sediment transport;
- the amount of ground exposed, and time period during which it is exposed, would be kept to a minimum and appropriate drainage would be in place to prevent surface water entering deep excavations, specifically borrow pit excavations;
- a design of drainage systems and associated measures to minimise sedimentation into natural watercourses would be developed - this may include silt traps, check dams and/ or diffuse drainage;
- silt/sediment traps, single size aggregate, geotextiles or straw bales would be used to filter any coarse material and prevent increased levels of sediment. Further to this, activities involving the movement or use of fine sediment would avoid periods of heavy rainfall where possible; and
- SPR construction personnel and the Principal Contractor would carry out regular visual inspections of watercourses to check for suspended solids in watercourses downstream of work areas.

10.4.1.2.5 Fluvial flood risk

142. It is proposed to adopt Sustainable Drainage Systems (SuDS) as part of the proposed Development. SuDS techniques aim to mimic pre-development runoff conditions and balance or throttle flows to the rate of runoff that might have been experienced at Site prior to development. Good practice in relation to the management of surface water runoff rates and volumes and potential for localised fluvial flood risk would include the following:

- drainage systems would be designed to ensure that any sediment, pollutants or foreign materials which may cause blockages are removed before water is discharged into a watercourse;
- onsite drainage would be subject to routine checks to ensure that there is no build-up of sediment or foreign materials which may reduce the efficiency of the original drainage design causing localised flooding.
- appropriate drainage would attenuate runoff rates and reduce runoff volumes to ensure minimal effect upon flood risk;
- where necessary, check dams would be used within cable trenches in order to prevent trenches developing into preferential flow pathways; and
- as per good practice for pollution and sediment management, prior to construction, section specific drainage plans would be developed and construction personnel made familiar with the implementation of these.

143. Further information on ground conditions and drainage designs would be provided in the final CEMP.

10.4.1.2.6 Water abstractions

144. Abstraction of water for construction activities is proposed from a suitable source yet to be identified. An application for a CAR Licence would be made to SEPA and managed through the regulation of the CAR Licence. Should a suitable source not be identified, a water bowser would be used.

145. Good practice that would be followed in addition to the CAR Licence regulations includes:

- water use would be planned so as to minimise abstraction volumes;
- water would be re-used where possible;
- abstraction volumes would be recorded; and
- abstraction rates would be controlled to prevent significant water depletion in a source.

10.4.1.2.7 Watercourse crossings

146. Two new and eight upgraded water crossings are required during the construction phase and would remain in place during the operational phase.

147. The upgraded crossings would have the same design as the existing crossings and at least the same hydraulic conveyance capacity of the existing crossings.

148. Good practice in relation to new water crossings involves the following aspects:

- the appropriate crossing type would be identified from SEPA's good practice guidance and would take into account any ecological and hydrological constraints; and

- the crossing would be sized and designed so as to minimise effect upon flood risk (sized to accommodate at least the 200 year flow).

10.4.1.2.8 Peat management

149. A detailed review of the distribution and depth of peat at the Site is contained in **Technical Appendix 10.1 PLHRA**.

150. As shown in **Technical Appendix 10.2: PMP**, the Site design has avoided areas of deep peat and only very limited amounts of peat would be encountered by the proposed Development which can be readily managed and accommodated within the Site layout without significant environmental impact. No surplus peat would be generated and the limited volumes of peat generated from the proposed excavations can be used to reinstate track verges, turbine bases, cane hardstandings and restoration of on-site borrow pits.

10.4.1.2.9 Peat landslide hazard

151. A Design and Geotechnical Risk Register would be compiled to include risks relating to peat instability, as this would be beneficial to both SPR and the Contractor in identifying potential risks that may be involved during construction.

152. Good construction practice and methodologies to prevent peat instability within areas that contain peat deposits are identified in the PLHRA. These include:

- measures to ensure a well-maintained drainage system, to include the identification and demarcation of zones of sensitive drainage or hydrology in areas of construction;
- minimisation of 'undercutting' of peat slopes, but where this is necessary, a more detailed assessment of the area of concern would be required;
- careful micro-siting of turbine bases, crane hardstandings and access track alignments to minimise effects on the prevailing surface and sub-surface hydrology;
- raising peat stability awareness for construction staff by incorporating the issue into the Site Induction (e.g. peat instability indicators and good practice);
- introducing a 'Peat Hazard Emergency Plan' to provide instructions for Site staff in the event of a peat slide or discovery of peat instability indicators;
- developing methodologies to ensure that degradation and erosion of exposed peat deposits does not occur as the break-up of the peat top mat has significant implications for the morphology, and thus hydrology, of the peat (e.g. minimisation of off-track plant movements within areas of peat);
- developing robust drainage systems that would require minimal maintenance; and
- developing drainage systems that would not create areas of concentrated flow or cause over-, or under-saturation of peat habitats.

153. Notwithstanding any of the above good construction practices and methodologies, detailed design and construction practices would need to take into account the particular ground conditions and the specific works at each location throughout the construction period. An experienced and qualified engineering geologist / geotechnical engineer would be appointed as a supervisor, to provide advice during the setting out, micro-siting and construction phases of the proposed Development.

10.4.2 Potential construction effects

10.4.2.1 Pollution risk

154. During the construction phase, there is the potential for a pollution event to affect surface water and local groundwater bodies impacting on their water quality. This would have a negative effect on the receptor and the resulting degradation of the water quality would impact on any aquatic life and private water supplies abstracting from the watercourse/aquifer.

155. Potential effects on the identified private water supplies in **Figure 10.1** are assessed at an individual source level in **Technical Appendix 10.3: Private Water Supply Risk Assessment**. Five private water supplies (served by four water sources) have been identified as potentially being at risk either during construction or operation.

156. Pollution may occur from excavated and stockpiled materials during Site preparation and excavation of borrow pits. Contamination of surface water runoff from machinery, leakage and spills of chemicals from vehicle use and the construction of hardstanding also have the potential to affect surface water bodies. Potential pollutants include sediment, oil, fuels and cement.

157. The risk of a pollution incident occurring would be managed using good practice measures as detailed above. Many of these practices are concerned with undertaking construction activities away from watercourses and identifying safe areas for stockpiling or storage of potential pollutants that could otherwise lead to the pollution of watercourses.

158. As detailed within Technical Appendix 10.3, Site specific mitigation would be implemented to protect downgradient PWS sources:

- although no upgrade to the existing access track form the A714 public road at the bridge of the River Cree is required, an audit of the drainage features that serve the track would be conducted to ensure the efficacy of SuDS features and that there is no direct discharge of track drainage to the water environment;
- no refuelling/vehicle maintenance/parking zones would be implemented upgradient of the PWS at Arnimean (PWS02), Burnside (PWS04) and Laggish Farm (PWS10);
- silt fences would be established along the minor crossing of the access track immediately upstream of the PWS abstraction of Burnside (PWS04) to prevent silt entering the watercourse directly;
- oil booms would be deployed on watercourses downgradient of watercourse crossings within the Cross Water catchment; and
- monitoring of these PWS sources for suspended solids, major anions and cations, and Total Petroleum Hydrocarbons would form part of the water quality monitoring plan, which would be agreed with SEPA, SAC and D&GC.

159. The baseline assessment has shown that the majority of the proposed Development would be located in the catchments of the Water of Tig and Cross Water. Fisheries data has shown the presence of salmon, trout, eel and lamprey in the catchments downstream of the study area. Private water supplies from surface and groundwater have been shown to be located within 1 km of the Site. Therefore the watercourses onsite, and immediately downstream, and local groundwater have ecological and amenity interests.

160. After consideration of good practice measures the magnitude of a pollution event within the Water of Tig and Cross Water catchments is considered **Negligible** following adherence to good practice and Site specific mitigation measures.

161. No new development is proposed in the Pollgowan Burn, Lavery Burn and River Cree catchments, however Site traffic would use the existing windfarm access track that passes through these catchments. The magnitude of a pollution event is considered **Negligible** following adherence to good practice and Site specific mitigation measures.

162. The potential effect of a Negligible magnitude event on those hydrological receptors of High sensitivity would be of **Negligible** significance. No further mitigation measures are required.

163. The groundwater bodies extending beyond the study area are very large when compared to the area of proposed Development. Any effects are judged not to be detectable beyond the study area. Potential pollution events occurring during the construction of the turbines or any hardstanding would be **Negligible** magnitude as they would be controlled by good practice measures and would be subject to some attenuation in the soils before reaching groundwater. Should pollutants reach the groundwater the scale of the effect would be low in relation to the overall groundwater body. The effect to groundwater, which has been assigned a High sensitivity, is therefore assessed as having **Negligible** significance. No further mitigation measures are required.

10.4.2.2 Erosion and sedimentation

164. Site traffic during the construction phase has the potential to cause erosion and increase in sedimentation loading during earthworks, and due to increased areas of hard-standing and such features as stockpiles, tracks and borrow pits, etc., which could be washed by rainfall or overwhelmed Site mitigation, into surface water features. This has the potential to reduce the surface water quality, increase turbidity levels, reduce light and oxygen levels and effect ecology including fish populations.

165. Excavation of borrow pits, construction of hardstanding, diversion of drainage channels and construction of water crossings are the key sources of sediment generation. Adherence to good practice measures would ensure that any material generated is not transported into nearby watercourses.

166. Location specific good practice measures would be in place for sediment control for each of the borrow pits to control the amount of fine sediment that could potentially enter a watercourse if not managed appropriately. These measures would be

dependent upon the final borrow pit designs and stone quality, but would potentially include cut-off drainage, sediment traps, sediment lagoons and flocculation stations.

167. Similar good practice measures to those applied at the borrow pit locations would be required around the track construction activities.

168. After consideration of good practice measures, the magnitude of impact to the receptors is assessed as Negligible and therefore with the High sensitivity receptors described above, the significance of effect without mitigation is assessed as **Negligible** and no further mitigation measures are required.

10.4.2.3 Fluvial flood risk

169. Construction of hardstanding including the construction compound and turbine bases would create impermeable surface areas. This would lead to a relatively small increase in the total impermeable surface area of the Site causing **Negligible** increases in runoff rates and volumes within the Water of Tig and Cross Water catchments.

170. The permanent effect of the increase in impermeable surface area is assessed during the operational phase to avoid any double counting of effects. The construction phase includes the effects of temporary increases in impermeable area and temporary drainage diversions during the construction phase.

171. The proposed access track crosses two tributaries of the Cross Water. Details of the proposed water crossing are shown in **Technical Appendix 10.4: Schedule of Watercourse Crossings**. The greatest risk of localised flooding would be at these locations where any blockage would reduce the ability of the channel to convey water leading to short duration, localised flooding.

172. The drainage design would ensure management of any increase in runoff volumes for a 1 in 200 year return period at the detailed design stage. During the construction phase, the good practice measures would be in place to prevent materials entering watercourses and to ensure that man-made drains and blockages do not lead to bank erosion and localised flooding.

173. Adherence with good practice measures including appropriate drainage design and compliance with the final CEMP would limit potential effects to being local and short duration and so of **Negligible** magnitude.

174. The Forestry Commission (Forestry Commission, 2011) report forest establishment and growth appear to have a small effect (decrease) on peak flows, with the impact of clear felling (increase) often being difficult to detect. Overall, research suggests that the contrasting effects of the different stages of the forest cycle (cultivation, drainage, road construction, forest growth and harvesting) would even out at the catchment scale, especially as forest areas become more diverse in age. As a result, upland forests are unlikely to adversely affect downstream flood risk. Therefore this has not been assessed for the proposed Development.

175. Rainwater and limited groundwater ingress that collects in the turbine excavations during construction would be stored and attenuated prior to controlled discharge to ground adjacent to the excavation.

176. Attenuation of runoff generated within the proposed turbine excavations would allow settlement of suspended solids within the runoff prior to discharge in accordance with ‘Site control’ component of the SuDS ‘management train.

177. Where possible, it is proposed to develop the borrow pits with a fall on the floor of the pits which falls away from the edge of the pit. This would ensure that all surface water runoff generated on the floor of the pit during construction would be contained within the pit prior to controlled disposal by pump or gravity (in a cut trench with granular fill) under supervision of the ECoW.

178. If necessary a shallow open drain would be developed around the pit rim to prevent surface water inflow to the borrow pits. This drain would route the drainage around the pit and thus maintain the pre-development drainage paths.

179. Water in the borrow pits would be managed in accordance with SuDS techniques. Attenuating runoff within the borrow pits would provide an opportunity for any suspended solids within the runoff to settle within the pit prior to controlled and pumped discharge from the pit.

180. The potential effect of a short term increase in runoff on the hydrological receptors is therefore assessed of **Negligible** significance. No further mitigation is therefore required.

181. The magnitude of the increase in impermeable area is not sufficient to have a measurable effect on groundwater levels, therefore, groundwater flood risk is not considered in this assessment.

10.4.2.4 Infrastructure and man-made drainage

182. During the construction period, drainage would be required to ensure construction areas are workable and not saturated. In particular, drainage, some of which would be temporary, would be required around turbine working areas, the construction compound and borrow pits to manage surface flows. Excavation of turbine foundations may require temporary de-watering for the period of the foundation build. These drainage activities may lead to temporary changes in the water table surrounding these construction activities (where de-watering is required below the level of the natural water-table).

183. As construction of proposed infrastructure is required through the buffers associated with GWDTEs, there is potential to disrupt water contributions to these habitats. It has been shown that areas of potential GWDTE are sustained by surface water rather than groundwater and that the construction of the proposed Development would have no long term effect on any potential GWDTE habitat.

184. Excavations associated with constructions works (e.g. cut tracks, turbine bases foundations, cable trenches, borrow pits etc.) can result in local lowering of the water table. This is important in areas of peat deposits, where the water table is characteristically near the ground surface (e.g. where the excavations are likely to intercept the groundwater table) and/or areas where there are groundwater dependent water supplies.

185. Dewatering associated with construction of turbine foundations is commonly temporary and dewatering following construction would not be required. Cable laying, without appropriate mitigation measures, can also lower high groundwater levels and provide a preferential drainage route for groundwater movement that can lead to local and permanent drying of soils/superficial deposits and / or water supplies.

186. The design of the proposed Development has avoided areas of ecological or habitat interest wherever possible. Furthermore, the bedrock has little groundwater and therefore limited or little dewatering is likely to be required. There remains potential however, for local dewatering of soils near cable trenches, turbine bases and borrow pits, without incorporation of mitigation measures.

187. The sensitivity of the receptor (groundwater and habitat that may be dependent on groundwater) has been assessed as being Moderate. Without mitigation the magnitude of impact is assessed as **Negligible** and therefore the potential significance of effect of changing groundwater levels and flow due to dewatering is considered **Negligible** significance and requires no further mitigation.

188. The potential effect of the proposed Development on groundwater and areas of GWDTE is not considered to change during the operation of the proposed Development and therefore has not been considered under operational effects.

10.4.2.5 Water abstraction

189. During the construction of the proposed Development, water may be required for uses such as dust suppression and vehicle washing. The volume of water and mitigation required would be regulated through the CAR and therefore the magnitude of an effect on groundwater-surface water interactions is considered Negligible. The significance of effect is therefore **Negligible**.

10.4.2.6 Peat landslide hazard

190. A detailed review of potential peat slide risk and appropriate mitigation is presented in **Technical Appendix 10.1 (PLHRA)**.

191. During the construction phase there is potential from the siting of turbines and other Site infrastructure for the instability, removal or loss of soils. The magnitude of impact is **Negligible** due to the careful micro-siting that has occurred during the Site design and therefore the significance of effect to potential groundwater and surface water receptors is assessed as **Negligible** and requires no further mitigation.

10.4.2.7 Proposed mitigation

192. As there are no predicated significant effects under the terms of the EIA Regulations, other than the good practice measures that SPR implement as standard (and as described above), no specific mitigation, during construction, is required.

10.4.2.8 Residual effects

193. No significant residual effects on surface water or groundwater receptors are predicted during the construction period of the proposed Development.

10.4.3 Potential operational effects

194. During the operational phase of the proposed Development, it is anticipated that routine maintenance of infrastructure and tracks would be required across the Site. This may include work such as maintaining windfarm tracks and drainage and turbine maintenance.

195. Should any maintenance be required onsite during the operational life of the project which would involve construction type activities; mitigation measures would be adhered to along with the measures in the CEMP to avoid potential effects.

10.4.3.1 Pollution risk

196. The possibility of a pollution event occurring during operation is very unlikely. There would be a limited number of vehicles required onsite for routine maintenance and SPR's operational presence. Storage of fuels/oils onsite would be limited to the hydraulic oil required in turbine gearboxes and this is bunded to (110% bund capacity) to prevent fluid escaping.

197. Based upon this, the potential risk associated with frequency, duration and likelihood of a pollution event is low. It is therefore anticipated that the magnitude of a pollution event during the operational phase of the Development would be **Negligible**, as no detectable change would likely occur. Therefore, the significance of effect for a pollution event during the operational phase of the Development is predicted to be **Negligible** for all receptors. No mitigation is therefore required.

10.4.3.2 Erosion and sedimentation

198. During the operation of the Development, it is not anticipated that there would be any excavation or stockpiled material, reducing the potential for erosion and sedimentation effects.

199. Immediately post-construction, newly excavated drains and track dressings may be prone to erosion as any vegetation would not have matured. Appropriate design of the drainage system, incorporating sediment traps, would reduce the potential for the increased delivery of sediment to natural watercourses. Potential effects from sedimentation or erosion during the operational phase are considered to come from linear features on steeper slopes, where velocities in drainage channels are higher. Immediately post-construction, flow attenuation measures would remain and be maintained to slow runoff velocities and prevent erosion until vegetation becomes established.

200. The likelihood, magnitude and duration of a potential erosion and sedimentation event occurring within the surface water catchments would be **Negligible** following adherence to good practice measures. Therefore, the potential significance of effect on these high sensitivity receptors is of **Negligible** significance. No mitigation is therefore required.

201. Should any non-routine maintenance be required at the sections of track crossing wet areas (defined visually onsite by a contractor or operational personnel) there would be potential for erosion and sedimentation effects to occur due to the existence of disturbed material. Should this type of activity be required, then the good practice measures as detailed for the construction phase would be required on a case by case basis. Extensive work at water crossings/adjacent to the water environment may require approval from SEPA under the CAR (depending upon the nature of the activity).

10.4.3.3 Fluvial flood risk

202. The risk of an effect on fluvial flood risk arises as a result of a potential restriction of flow at a permanent water crossing following intense rainfall. In accordance with good practice routine inspection of the culverts at Site would be undertaken, reducing the likelihood of a blockage occurring. In the unlikely event of a blockage any flooding would be localised and the magnitude of impact is assessed as **Negligible**, and thus the significance of effect is assessed as **Negligible**, and no further mitigation is required.

10.4.3.4 Infrastructure and man-made drainage

203. Operation of the proposed Development requires limited activities relative to the construction phase. The presence of access tracks and hardstanding, as opposed to their construction, may affect the potential infiltration and groundwater conditions as well as the sub-surface flow paths around the infrastructure. In addition, cabling and crane hardstanding would also remain in situ to serve the proposed Development.

204. Drainage would be required to service new sections of access track. This could also potentially alter groundwater levels and recharge. The dispersed nature of new drainage, coupled with good practice, means that the magnitude of the predicted effect of an alteration to drainage on groundwater levels and recharge of the groundwater body can be considered **Negligible**. This magnitude level has been determined principally through the fact that any change is unlikely to be detectable through monitoring and the associated track drainage remaining during operation is likely to be less than 1 m deep.

205. The magnitude of a potential effect on groundwater and sub-surface flows as a result of permanent hardstanding and associated drainage would be **Negligible** on the overall groundwater body due to the dispersed nature of the proposed hardstanding. The significance of effect is **Negligible**. No further mitigation is required.

10.4.3.5 Proposed mitigation

206. As there are no predicated significant effects under the terms of the EIA Regulations, other than the good practice measures that SPR implement as standard, no specific mitigation, during operation, is required.

10.4.3.6 Residual effects

207. No significant residual effects on surface water or groundwater receptors are predicted during the operational period of the proposed Development.

10.4.3.7 Cumulative effects assessment

208. This section considers the potential cumulative hydrological effect of the proposed Development taking into consideration other windfarm developments within the same hydrological catchments as the proposed Development and within 5 km up/downstream of any proposed infrastructure. Any developments which are out with the study area are not considered.

209. Windfarms within the catchments of the River Stinchar and River Cree within 5 km of the application boundary include:

- River Stinchar
  - Arecleoch Windfarm (operational);
  - Kilgallioch Windfarm (operational);
  - Chirmorie Windfarm (consented);
  - Mark Hill Windfarm (operational);
  - Arnsheen Windfarm (scoping); and
  - Strannoch Windfarm (consented, with a further application to vary)

- River Cree
  - Bargrennan Windfarm (scoping);

210. The surface water catchments are considered to be of high sensitivity. The magnitude of a potential pollution event at each of the developments is **Negligible** following good practice measures as discussed above. This would result in a cumulative effect which is **Negligible** and therefore not significant. The probability of a pollution event occurring at more than one development at one time is judged to be low.

211. The magnitude of a potential sedimentation and erosion event at each development is also **Negligible** following good practice measures as discussed above. As with a pollution event, the probability of a sedimentation event occurring at more than one development at one time is judged to be low.

212. The potential increase in peak runoff from each development should be mitigated through the detailed design of the drainage systems at each development. The developments should be managed to ensure there is no increased downstream fluvial flood risk.

213. The developments should not have a significant effect on the wider groundwater bodies but if a localised area of groundwater is thought to be at risk of alteration, it should be mitigated on a case by case basis dependant on the sensitivity of the receiving GWDTE. Assuming such mitigation is applied, there would be no cumulative effect.

214. It is concluded that there would be a **Negligible** cumulative effect on hydrological receptors from both the construction and operating phases of the proposed Development.

10.4.4 Further survey requirements and monitoring

215. This Chapter has demonstrated that the effects of the proposed Development that have been assessed are not likely to have significant effects on the study area's hydrological receptors. The lack of significant effects relates primarily to the proposed 'Good Practice Measures', proposed water quality monitoring and the iterative design process (**Chapter 2: Site Description and Design Evolution**), which effectively act as 'designed-in' mitigation. No other further surveys or monitoring is considered necessary to complete this assessment.

216. It has been recognised in this assessment that a programme of water monitoring would be required prior to any construction activity and during construction of the wind farm. The monitoring programme would be agreed with SAC, SEPA and ART, and it is expected to include monitoring PWS sources and watercourses identified at potentially at risk without incorporation of best practice construction and mitigation techniques. An example water monitoring schedule is shown in **Technical Appendix 10.3: Private Water Supply Risk Assessment**.

10.5 Summary and statement of significance

217. A summary of proposed mitigation measures required to reduce the potential effects to acceptable levels are identified in **Table 10.9**.

Potential effect	Significance of effect before mitigation	Proposed mitigation / enhancements	Significance of residual effect
Construction			
Pollution, Erosion and Sedimentation	Negligible	• good practice techniques • confirmatory water quality monitoring	Negligible
Operation			
No additional mitigation measures required.			
Cumulative			
There are no predicted cumulative effects of the Development within the hydrological study area.			

Table 10.9: Summary of residual effect after mitigation

10.6 References

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