8 Geology, Hydrology & Hydrogeology

8.1 Introduction

The EIA will consider the potential issues arising from the construction, operation and decommissioning of the proposed development in relation to existing and future potential geological, hydrogeological and hydrological impacts.

It will assess the potential effects on surface and ground waters, (including Ground Water Dependant Terrestrial Ecosystems (GWDTE) and Private Water Supplies) and ground conditions. The assessment will provide baseline information; discuss potential mitigation and management and assess the significance of residual impacts assuming the proposed mitigation is implemented.

8.2 The Existing Environment

8.2.1 Surface Water Features

There are numerous small water courses throughout the site, most of which are small, fast flowing streams. There are a couple of named watercourses within the site (Allt Achadh a Choire and Alltan Fraoich) and several small unnamed watercourses which feed Clachaig Water. In the south of the site are Allt Criche and Loch Mor, which drain south to Barr Water. Various areas (predominantly adjacent to watercourses) have been designated as bogs or blanket bogs.

The site contains several small lochs including Loch na Creige in the crags on the eastern ridge part of the site, Loch Mor and Dubh Loch to the south. Loch na Naich is located outside of the site but is immediately adjacent, between the northern boundary of the land available for associated infrastructure and the existing FCS access tracks.

The main catchment area is local to the site and drains via a single large valley where Clachaig Water forms and flows west to meet the sea.

Figure 8 presents a location plan of the identified surface water features.

8.2.2 Flood Risk

The Scottish Environment Protection Agency (SEPA) indicative flood map only shows a risk of minor flooding locally to the channel, which is likely to be confined well within the 50m watercourse buffer that is being observed at the site. However, there appears to be a minor risk of flooding downstream at Killean and Muasdale so it will be essential to ensure the development does not increase this risk, particularly from the removal of interception storage due to deforestation.

Potential flood risk (both rivurine and pluvial) will be considered for any new or upgraded watercourse crossings and in a preliminary drainage assessment. Watercourse crossings will be designed in accordance with SEPA's Engineering in the Water Environment Good Practice Guide; Construction of River Crossings (WAT-SG-25).

8.2.3 Water Resources

There are several properties downstream of the land available for turbine and associated development that may be reliant upon the catchment for potable water supply and other water requirements. These abstractions are likely to be either surface water or localised shallow groundwater through boreholes.

Under the *Private Water Supplies (Scotland) Regulations 2006*, councils have a duty to prepare and maintain a database of private water supplies and monitor the quality of the supplies. Argyll and Bute Council will be contacted regarding the presence of private water supplies either within or close to the site.

8.2.4 Geology

The desk based assessment for High Clachaig has indicated that peat is not present at the site, with glacial till (boulder clay) shown, with bedrock at or near surface in the eastern area of the site (the ridge running SSW from Cruach Mhic-an t-Saoir) and in other localised areas within the site.

From west to east (Claichaig Glen, and ridge, to Cruach Mhic-an t-Saoir ridge) the following bedrock is indicated:

- Stonefield Schist Formation: Semipelite.
- Loch Tay Limestone Formation: Metalimestone.
- Glen Sluan Schist Formation: Psammite and Semi Pelite.
- Green Beds Formation: Metavolcaniclastic sedimentary rock.
- Southern Highland Group (south-east corner): Metavolcaniclastic igneous rocks.
- Neoprotozoic Basic minor intrusions are present within the above four rock formations.
- Beinn Bheula Schist Formation: Gritty Psammite and Pelite.

8.2.5 Ground Contamination

Given the historical use as a commercial forestry and absence of development, it is unlikely that the developable area is contaminated. However information regarding pollution incidents and previous uses will be collated and considered as part of the EIA.

8.2.6 Deforestation

The proposed development would involve felling of trees to allow installation of new access roads and wind turbines, which has the potential to affect the surface water and groundwater environment. The potential effect of deforestation associated with the proposed development will be considered with any appropriate mitigation measures. Particular attention will be paid to the effect of deforestation on downstream flood risk.

8.3 Methods

8.3.1 Study Area

The study area is the land available for turbine and associated development plus a 1km buffer. This will focus largely on the potential effects on the peat resource upslope from and outside of the associated infrastructure boundary will be considered.

8.3.2 Desk Based Studies

It is recognised that a variety of data is available from third parties (i.e. Envirocheck, SEPA and FCS). It is therefore proposed that the following tasks will be undertaken to ensure the baseline data informs the impact assessment:

- Review of Ordnance Survey (OS) maps to identify surface water features;
- Review of the River Basin Management Plan;
- Identification of the locations and characteristics of catchments, surface water features and springs within the land available for associated infrastructure, and in the study area from desk-based data;
- Identification of Water Framework Directive (WFD) classifications and objectives, obtained from the SEPA website for watercourses within the study area;
- Collation of data and location of abstractions and discharges consents within the study area;
- Collation of information on climate, surface hydrology, water quality and flood risk;

- Identification of hydrogeological conditions and groundwater resources;
- Review of solid and drift geology maps; and
- Review of soil maps.

The data review will include a search for Regionally Important Geological Sites (RIGS) or protected geo-morphological features within the vicinity of the site. There are records of historical coal mine workings in the vicinity of the site and these will be investigated and considered in the EIA.

8.3.3 Site Walkover Survey

Following a review of the desk-based assessment, a site walkover survey will be undertaken around the land available for turbine and associated development. The depth and variability of drift deposits including the possibility of peat and soft or waterlogged ground and shallow rock will be determined based on existing quarries, cuttings, exposures and stream beds and surface (peat) features.

8.3.4 Peat Risk Assessment

The indicated absence of peat within the land available for turbine and associated development suggests that a peat risk assessment (including phase 1 and 2 peat probing) will not be required. However, should peat be identified during the site walkover survey then a revised approach would be derived to include the following elements (as appropriate):

- Phase 1 Peat Investigation;
- Phase 2 Peat Investigation;
- Peat Risk Slide Assessment; and
- Carbon Calculation.

8.3.5 Hydrology & Hydrogeology Assessment

A qualitative assessment will be undertaken using a combination of professional judgment, legislation and other statutory policy and guidance. Key acts of legislation, policy and guidance which will be considered in the preparation of this assessment include:

- *Water Framework Directive (2000/60/EC)*;
- *Water Environment and Water Services (Scotland) Act 2003*;
- *The Water Environment (Register of Protected Areas) (Scotland) Regulations 2004*;
- *Water Environment (Controlled Activities) (Scotland) Regulations 2005*;
- Scottish Natural Heritage *et al* (2010) *Good practice during wind farm construction*;
- SEPA (2008). *Engineering in the Water Environment Good Practice Guide – Bank Protection*;
- SEPA (2008). *Engineering in the Water Environment Good Practice Guide - Construction of River Crossings*;
- SEPA (2010). Engineering in the Water Environment Good Practice Guide – Sediment Management;
- CIRIA Report C502: Environmental Good Practice on Site;
- CIRIA Report C532: Control of Water Pollution from Construction Sites;
- Scottish Planning Policy;
- SEPA Position Statement 06 – Culverting of Watercourses; and

- SEPA Pollution Prevention Guidelines (PPGs).

The assessment will identify potential effects mainly due to construction and decommissioning of the forest roads, watercourse crossings, turbine foundations, cable trenches, compound and storage areas etc. Some of the activities have the potential to continue having an effect during the operational stage. The potential effects identified include the following:

- Increased run-off on exposed ground causing pollution or leading to increased flood risk;
- Disturbance or erosion of bed and banks of watercourses and land drains;
- Increased run-off from hardstanding areas causing pollution;
- Dewatering of groundwater and peat during foundation construction;
- Pollution from accidental spillages;
- Cutting off natural surface and groundwater pathways; and
- Leaching of concrete into groundwater and peat.

Mitigation measures will be proposed where appropriate to avoid, reduce or offset predicted negative effects and these will feed into the scheme layout and design detail.

8.3.6 Assessment Methods and Guidance

The assessment method is based on guidance given in the IEMA publication Guidelines for Environmental Impact Assessment (2004) and the Design Manual for Roads and Bridges (DMRB), Volume 11, Part 10, HD 45/09 Road Drainage and the Water Environment (Highways Agency 2009).

In assessing the significance of potential effects of the proposed wind farm, three key factors have been taken into account:

- The likelihood of that effect occurring based on a scale of certain, likely or unlikely;
- The sensitivity and/or importance of the receiving environment; and
- The potential magnitude of the effect.

8.3.7 Determining Significance

The assessment of the significance of individual effects on the receiving environment will be based on criteria for the sensitivity or importance of the resource and the magnitude of the effect, as defined in the following tables. The importance of the resource is classified according to the highest individual defining feature, for example a resource will be defined as having Very High Importance if it is designated as a SAC regardless of its social / economic use or quality of groundwater.

Table 8.1: Sensitivity Definition

Importance	Criteria	Defining Features
Very High	Attribute has a rarity on international scale	Feature of international importance, for example a Special Area of Conservation (SAC). Critical social or economic uses such as for water supply, navigation or

Table 8.1: Sensitivity Definition		
Importance	**Criteria**	**Defining Features**
		mineral extraction. Groundwater is a valuable resource because of its high quality and yield, or is known to be extensively exploited for water supply. Alternatively, groundwater is critical to designated sites of nature conservation.
High	Attribute has a rarity on national scale	Feature of national importance, for example a Special Area of Conservation (SSSI) High classification for water quality (i.e. A1 Excellent or A2 Good or Sensitive habitats of national importance. Groundwater is a locally valuable resource because of its moderate quality and/or yield, or is known to be locally exploited for water supply.
Medium	Attribute has a rarity on county/ regional/ local scale	Feature of regional or local importance. Moderate water quality (i.e. B Moderate). Sensitive habitats of regional importance. Limited social or economic uses. Groundwater of limited value because its quality does not allow potable or other quality sensitive uses. Exploitation of local groundwater is not extensive and/or local areas of nature conservation known to be sensitive to groundwater impacts.
Low	Attribute has no rarity on county/ regional/ local scale	Heavily modified with poor water quality (i.e. C Poor or D Seriously Polluted). Minimal economic or social uses. Poor groundwater quality and/or very low permeabilities make exploitation unfeasible. Changes to groundwater not expected to impact on local ecology. Associated habitats less than local importance.
Negligible	Attribute has no rarity on county/ regional/ local scale	Very poor groundwater quality (i.e. D Seriously Polluted) and/or very low permeability make exploitation of groundwater unfeasible. Private water supplies are abandoned. Changes to groundwater are irrelevant to local ecology.

The magnitude of effect considers the scale of the predicted change to baseline conditions resulting from a given potential effect and takes into account the duration of an effect i.e. temporary or permanent and whether it is direct or indirect. The magnitude of an effect is independent of the importance/sensitivity of a receptor. Definitions are described in Table 8.2.

Table 8.2: Effect Magnitude Definition	
Magnitude	**Criteria**

High	Fundamental change to a water body, water quality or water body characteristics.
Medium	Measurable change to a water body, water quality or water body characteristics.
Low	Minor change to a water body, water quality or water body characteristics.
Negligible	Very slight change to a water body, water quality or water body characteristics.

The significance of effect will then be determined using the matrix presented in Table 8.3. The significance of a given impact or effect is based on a combination of the sensitivity or importance of the receptor and the magnitude of potential effect. The effects can be beneficial, adverse or negligible and their significance major, moderate, minor or negligible.

Table 8.3: Approach to Assessment of Effects

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

Note: Shaded boxes indicate a significant effect in terms of EIA.

The EIA will consider mitigation measures as appropriate to reduce the impact of any of the potential effects.

8.4 Aspects to be Scoped Out

8.4.1 Operational Phase

Operational effects on the water environment will be addressed through design at the construction stage. It is therefore proposed that the operational effects will be fully considered and are scoped out of the assessment.

8.4.2 Contaminated Land Assessment

It is not proposed to undertake a contaminated land assessment due to the limited land use history of commercial forestry and absence of other potentially contaminative development. Therefore the likelihood of encountering contamination is low.

8.4.3 Peat Testing/Sampling

It is not proposed to undertake any sampling or testing of the peat material and values for the carbon content of peat will be taken from published literature.

8.5 Conclusions and Summary

The EIA will assess the geological, hydrogeological and hydrological impacts of the proposed development including the potential effects on aquifers, surface waters, water dependant habitats (including Ground Water Dependent Terrestrial Ecosystems GWDTE) and human use of water resources. Consultation with SEPA will be sought on the level of flood risk assessment that will be required. The effects of the development will be assessed for the construction, operational and decommissioning phases of the development.

The EIA will also include a ground conditions review and a review of the sites historic uses to confirm the assumption that the probability of encountering any contaminated land is low.

8.6 References

CIRIA, (1999) *Report C502: Environmental Good Practice on Site*

CIRIA, (2001) *Report C532: Control of Water Pollution from Construction Sites*

SEPA (Scottish Environment Protection Agency), (2008) *Engineering in the Water Environment Good Practice Guide – Bank Protection*

SEPA (Scottish Environment Protection Agency), (2008) *Engineering in the Water Environment Good Practice Guide - Construction of River Crossings*

SEPA (Scottish Environment Protection Agency), (2010) *Engineering in the Water Environment Good Practice Guide – Sediment Management*

SEPA (Scottish Environment Protection Agency), (2006) *Position Statement 06 – Culverting of Watercourses*

SNH (Scottish Natural Heritage) *et al*, (2010) *Good practice during wind farm construction*