1 Summary

1.1 A wind energy project is proposed for a moorland plateau between Cannich and Drumnadrochit near Inverness. The project consists of five wind turbines, an upgraded access track and a switchgear building, all to be owned by local companies.

1.2 As part of the planning process, studies relating to the possible effects of the wind turbine development on the geology, superficial deposits, hydrogeology and hydrology beneath and across the site have been undertaken.

1.3 The site and route of the access track have been surveyed over two years as part of the project ecological assessment, with any hydrological features noted and mapped. The project layout has evolved over the assessment period, and as the project has been designed to have minimum ecological impact, care has been taken to avoid areas of sensitive habitats. In addition, a walkover survey was completed, identifying any surface water features, including sources, drains and burns.

1.4 The bedrock in the area is uniform metamorphic quartz-feldspar granulites of Precambrian age. Folding of the rock is not significant, and rocky outcrops are present throughout the site, particularly along the western slope of the hill.

1.5 The project has evolved to take into account ground conditions. In particular care has been taken to avoid areas of peat or blanket bog, with the project infrastructure positioned in area away from deep peat or bog. Water crossings have also been avoided, with one new bridge required to cross the upper reaches of the River Enrick. The main superficial deposit on the site is a thin draping of peat over part of the hill proposed for the development. The deepest peat has been avoided by ensuring the access track travels between all five turbines in a circuit; maximum recorded peat depth on the turbine sites and along the route of the access track was around 0.5m.

1.6 Assessment of the risk of possible ice and snow effects has been completed, with a low probability of icing, and in any event the turbine site is well away from housing, public roads and powerlines; the turbines are a minimum of 300m away from the track to east of the site. Consequently ice throw is not predicted to be a significant issue for the Glenurquhart & Strathglass Wind Energy Project.

1.7 Hydrological management and pollution prevention measures are discussed, with a series of recommendations presented.
2 Landscape and Geomorphology

2.1 The project is located on Sliabh an Ruighe Dhuibh, a minor hill at the head of River Enrick, in a remote and isolated moorland area between Glen Affric, Glen Moriston and Loch Ness. Access to the site follows an existing track through Corrimony farm, and an underground cable will be routed over to the Fasnakyle Power Station at Cannich, with a switchgear house located near the power station, Figure 1.

2.2 The general area is defined as Rocky Moorland Plateau in the South Inverness Landscape Character Assessment, and consists of a high rocky plateau, rising to the more mountainous areas in the west, and bordering the Great Glen to the east. This landscape type is characterised by small rocky hills which rise out of open, gently rolling moorland plateaux. These plateaux possess distinct edges which isolate them from adjacent areas which are generally not visible from their interior, creating an impression of being within a remote upland moor. Rocky heather moorland dominates the hilltops and upper slopes, and numerous small lochans and areas of bog occupy depressions. Regenerating woodland concentrates along river valleys and form sporadic patches on hillsides.

2.3 The geomorphology of the site is to a large degree controlled by the underlying geology. The underlying rocks are made up of hard, metamorphosed sediments, which have been cut by glaciers to create ranges of rugged, irregular mountains, covered in numerous rocky outcrops, lochans and scattered glacial debris. Throughout these uplands, the routes of glaciers have also emphasised fault weaknesses to create long, steep-sided glens which sub-divide the mountains into a series of distinct ranges. Peat covers much of the area, draping the bedrock with varying depths of superficial deposits.

2.4 Anthropological influences in recent years have altered the landscape. The boggy floors of the straths were drained in the 18th century, converted into rich meadows and eliminating the need to move cattle to high ground during the summer months. As a result the character of many of the straths and glens changed radically; older traditional landuse has disappeared, replaced by a more regular pattern of pastoral and arable fields along the lower slopes, and large farmhouses surrounded by pastoral meadows along the drained strath floors. Although the straths and glens have changed, the upper hills and more remote moorland areas have not seen the effects of agricultural improvement, and animal stock levels are low, with only limited anthropological impact.
3 General Geology

3.1 This is a relatively homogenous area from a geological perspective, dominated by metamorphic bedrock that was originally an area of sand and mud deposited 1000M years ago. The establishment of the Moine thrust zone and the subsequent creation of the Caledonian mountain range around 400M years ago resulted in deformation and metamorphosis over a wide area. The Great Glen fault to the east of Corrimony is a significant boundary, and is a major strike/slip fault that defines the boundary between the older Northern Highlands to the west, and the Grampian Highlands to the east.

3.2 An assessment of the geology and the hydrogeological features of the area was conducted with reference to maps produced by the British Geological Survey [2,3,4]. These maps identified the extent of superficial deposits in the area, mainly peat and glacial till soils, along with alluvial silt along the glens and straths to the north and west of the site. The bedrock geology in this part of the Highlands is mainly quartz-feldspar granulites of Moine age (1000–873 Ma), Figure 4. Around 10km to the north east, the Glen Urquhart Complex is a small intrusion of serpentinite that includes schist, gneiss and bands of limestone.

3.3 The elevated plateau landforms present throughout this part of the Highlands are a consequence of the extensive glaciation that has occurred, with major ice sheets developing around 850,000 years ago. The last ice sheet disappeared around 15,000 years ago, and the passage of these ice sheets resulted in heavily glaciated valleys cut into the gneiss and Moine rocks, giving a landscape which is rugged and boggy with steep wooded valley sides and bare rocky hills.

3.4 The turbines are to be positioned on an area of hard bedrock on Sliabh an Ruighe Dhuibh, with glacial till deposits giving rise to hummocky terrain. The topsoil varies across the site with topography and aspect, with the upper River Enrick valley floor dominated by brown earth soil, along with deep peat where drainage is poor. There is a thin draping of peat on the upper slopes of the hill, with peaty podzols, peaty soils and peaty gleys.
4 Hydrology and Hydrogeological Features

4.1 A soil and hydrological investigation of the access route and the turbine site has been completed, with reference to the following resources:

- Soil Survey of Scotland, 1: 50000 Scale Map number 73
- Land Use Capability, 1:50000 Scale Map number 73.
- OS 1:25000 Explorer Map number 415
- River Enrick Flood Risk Assessment; Glen Urquhart Land Use Partnership.
- The Design of Field Drainage Pipe Systems; MAFF Ref. 345.
- The Climate of the Agricultural Areas of Scotland; Met. Office.
- FEH CD-ROM 1999; CEH Institute of Hydrology, Wallingford.
- CIRIA C521; Sustainable urban drainage – design manual for Scotland and Northern Ireland
- CIRIA C697; The SUDS Manual

4.2 The River Enrick is approximately 26km long, and runs from the elevated landscape around Sliabh an Ruighe Dhuibh, to join Loch Ness at Drumnadrochit. There have been six major flooding events in recent years over the last two decades, resulting in a detailed assessment of flood risks along Glen Urquhart.

4.3 Annual rainfall has been measured at the Mill of Tore Gauging Station, on the River Enrick downstream of Corrimony; average annual rainfall for the last decade has been 1378mm. Rainfall levels in the area are moderate for the Highlands, largely due to the rainshadow effect of the mountains to the south and west.

4.4 At Corrimony the river has a raised bed, with an extensive flood plain. River flows have been managed to a certain extent, with embankments and barriers controlling local floods. The source of the Erick is upstream of Corrimony, with two branches of the river either side of the elevated turbine site, Figure 2. To the east of Sliabh an Ruighe Dhuibh the river follows a steep and narrow route, with a series of small waterfalls. To the west, the river flows more slowly along the valley floor; the source of the river is a series of small lochans, the main one being Loch na n Eun. It should be noted that one of the sources of the Enrick River is Loch a’Mhuilinn, one of two mill lochs in the area, indicating that these hills have been used for renewable energy production in the past.

4.5 There are no other significant hydrological features to consider; the site access tracks have avoided water crossings. There will be the need to cross the western tributary of the river, and although there is a bridge in place at present, this will require replacement
before any work can commence on the site; a simple slab and pier structure will be put in place. The cable to Fasnakyle goes underneath two water courses; this should be done using either directional drilling or by installing ducting in the river beds.

4.6 It is recommended that care should be taken to avoid pollution on the upper reaches of the Enrick, and it is suggested that SEPA’s Pollution Prevention Guidelines PPG1, PPG5, PPG6, PPG8 and PPG21 should be adopted by the project. To combat the potential risk of run-off from the track, it is recommended that mechanisms used to construct Sustainable Urban Drainage systems be adopted, using a permeable surface on the access track to allow water to pass through the upper layer, along with filter strips and bunds of vegetated land to provide filtering and flow attenuation of water run-off.

5 Superficial deposits and topsoil stability; Peat Slide

5.1 Peat is a biogenic superficial deposit which when saturated consists of about 90-95% water. The organic content of the solid part of peat is very high, and is made up of the decayed remains of vegetation which has accumulated over a timescale of 100s of years.

5.2 Site assessment confirmed that there are very few major peat deposits in the area, mainly around Loch ma Stac, 4km to the south of the turbines. These peat deposits follow the shape of the bedrock, draping over the land in a blanket covering. The slope of the hill is around 5° at the steepest, flattening out at the upper parts of the site.

5.3 Peat of varying depth and wetness underlies all of the moorland and the drained and planted areas, with the most extensive deeper peat lying at the centre of the part of Sliabh an Ruighe Dhuibh proposed for the development, Figure 3. The hill slopes around the site have not been subject to peat cutting and there is only very limited artificial drainage, close to the existing track in places.

5.4 Deep peat is not present at the locations chosen for the turbines, with only a thin layer of around 0.5m present at the turbine positions and along the route of the access track. The top of the hill is fairly level and mostly clothed in deep peat of a depth of around 1m, with clusters of bog pools, particularly in the wetter central section. The steep slope to the west has a thinner covering of peat with occasional outcrops of rock, and the route of the access track has been designed to avoid areas of deep peat.

5.5 Despite avoiding areas of deep peat, around 5000m³ will be removed, based on the peat depth measurements made along the track and on the spur, and the dimensions of the
infrastructure elements. Where required some of this would be used at the point of removal to form sloping verges around the turbine hardstandings and along the sides of the uppermost access route. The remainder of the peat would be partly or wholly used in reinstatement of the turbine hardstandings, and to infill the borrow pits plus an existing pit further up along the track. The borrow pits would be filled to a depth of 1 to 1.5m, allowing for reinstatement of the vegetation as blanket bog.

5.6 Landslides, bog flows and bog bursts are widespread in the uplands of the British Isles\[6\], and these movements are usually triggered by heavy or prolonged rainfall. Peat slide involves instability of peat deposits over a rock or mineral subsurface, resulting in slab-like failure\[7\]. Bog burst involve the rupture of peat surfaces due to internal swelling, resulting in disruption of the surface\[8\].

5.7 Landslide and peat movement share several common characteristics, all relating to hill slope hydrological processes:
   a. A superficial layer overlying an impervious rock, clay or mineral base;
   b. A convex slope or a slope with a break of slope at the head;
   c. Proximity to local drainage either from seepage or groundwater flow;
   d. A connection between surface drainage and the soil/rock interface.

5.8 Although peatslide is not fully understood, the hydrological process which triggers the event is likely to be an increase in water flow at the interface between the peat layer and the underlying impermeable base. Analysis of recorded peat movements in the British Isles indicated that more than half occurred in the late summer months of October and August \[7\], suggesting that summer storms and periods of above average rainfall can trigger slides. Slope form is also likely to influence hillside hydrology and stability. Peat slides often occur on convex slopes, however slope angle can vary considerably; a study of 18 occurrences of peat instability in the Pennines recorded slope angles of 4° to 24°\[7\].

5.9 There is little risk of peat slide at Corrimony. Drainage conditions and topography have been considered and neither the access track nor the hardstanding areas have the characteristics of an area at risk of landslide. The access track will be constructed to ensure that water cannot drain into the interface between superficial layers and the bedrock. The access track to the site will be aligned to ensure the track does not cut across the slope, and the construction process will ensure that water does not drain into the peat/rock interface, again to minimise the potential risk of peat slide.
6 Ice and Snow Effects

6.1 The Corrimony area has a moderate average rainfall of around 1400mm per annum, and consequently snow volumes are low due to rainshadow effects [9].

6.2 The climate around this part of the Highlands is essentially mild in the summer and typically cold in winter. Heavy snow fall is rare, and on average, the number of days with snow falling is typically around 30 per winter; the winter of 2009/2010 was an exceptionally unusual.

6.3 A European study has been completed into the likelihood of icing conditions occurring, and the areas most likely to have blade icing include Germany, Austria, Switzerland, France and the Spanish border region [10]. The Wind Energy Production in Cold Climates Study (WECO) describes Scotland as a whole as having occasional to light icing conditions, and it is predicted that the Glenurquhart & Strathglass turbines will be subject to icing effects due to the relevant ice and snow conditions on perhaps three days in the year.

6.4 When considering the possibility of ice throw from a turbine, the same WECO project has the following statement:

“Ice throw is an essential problem when the site of the wind energy power plant is planned to be close to public roads, housing, power lines etc. According to the data and models developed and verified within the project it can be recommended for sites with high probability of icing to keep a distance between the turbines and nearest objects of about (hub height + diameter), or it can be recommended to stop the turbine automatically during the icing period and wind coming from unfavourable directions, if the public safety might be affected by ice throw.”

The Glenurquhart & Strathglass turbines have a low probability of icing, and in any event the turbine site is well away from housing, public roads and powerlines; the turbines are a minimum of 300m away from the track to east of the site. Consequently ice throw is not predicted to be a significant issue for the Glenurquhart & Strathglass Wind Energy Project.
7 Hydrological management and pollution prevention

7.1 The construction of wind turbine foundations involves pouring fresh concrete. The nearest watercourses are the burns feeding into River Enrick, approximately 800m from the turbine site, and to reduce the risk of pollution run-off it is recommended that all concrete will be brought onto site as a dry mix to minimise the risk of spills. Cleaning of shutters and the washing of equipment should only be done away from the site.

7.2 Track construction will be achieved by excavating down to bedrock, then to mitigate any surface run-off problems the track will only be constructed in dry conditions, with a layer of stone immediately placed on the exposed bedrock as the construction progresses, with crushed rock aggregate sub-bottoming placed on top of the as-dug rock. All displaced soil will be relocated into depressions and other areas in the turbine field.

7.3 Track construction will follow the general SUDS guidelines published by SEPA, with a porous construction and a free-draining sub layer. The access track will have a filter strip adjoining the peaty soils to ensure that any water is routed to the upper layers of the adjacent soil.

7.4 To minimise risk of pollution from oils and fuels during project construction, all work should be to COSHH regulations and any machinery, equipment or construction material should be located on areas of hardstanding away from water courses. Any waste should be transported away from the work area and disposed of using standard waste handling procedures.

7.5 Fuel or oil pollution would have a drastic affect on water quality should it enter any water courses, and accordingly refuelling activities for construction vehicles and equipment should be restricted to bunded and contained areas of hard standing at fuel storage areas. Good site management should be established:

- Fuel storage should be in double-skinned tanks
- No-refuelling should take place within 100m of a watercourse
- Equipment should be regularly inspected for leaks and spillages
- The site compound should have a full set of absorbent pad spill kits
- Any static plant at the substation compound should be bunded
- Self-contained portaloos and washing facilities should only be located at hardstanding areas.
References and bibliography

1. SNH Publications, Scottish Natural Heritage: *South Inverness Landscape Character Assessment*.


9. SEPA: Rainfall levels and Hydrological Summary for Mill of Tore, River Enrick.


Appendix:

Figures
Figure 1: Site Overview
Figure 2: Main Hydrological Features

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Figure 3: Peat Depths
Figure 4: Bedrock and Superficial Deposits

Bedrock

Quartz feldspar metamorphic
Devonian sedimentary
Igneous intrusion

Superficial Deposits

Alluvial
Peat deposits