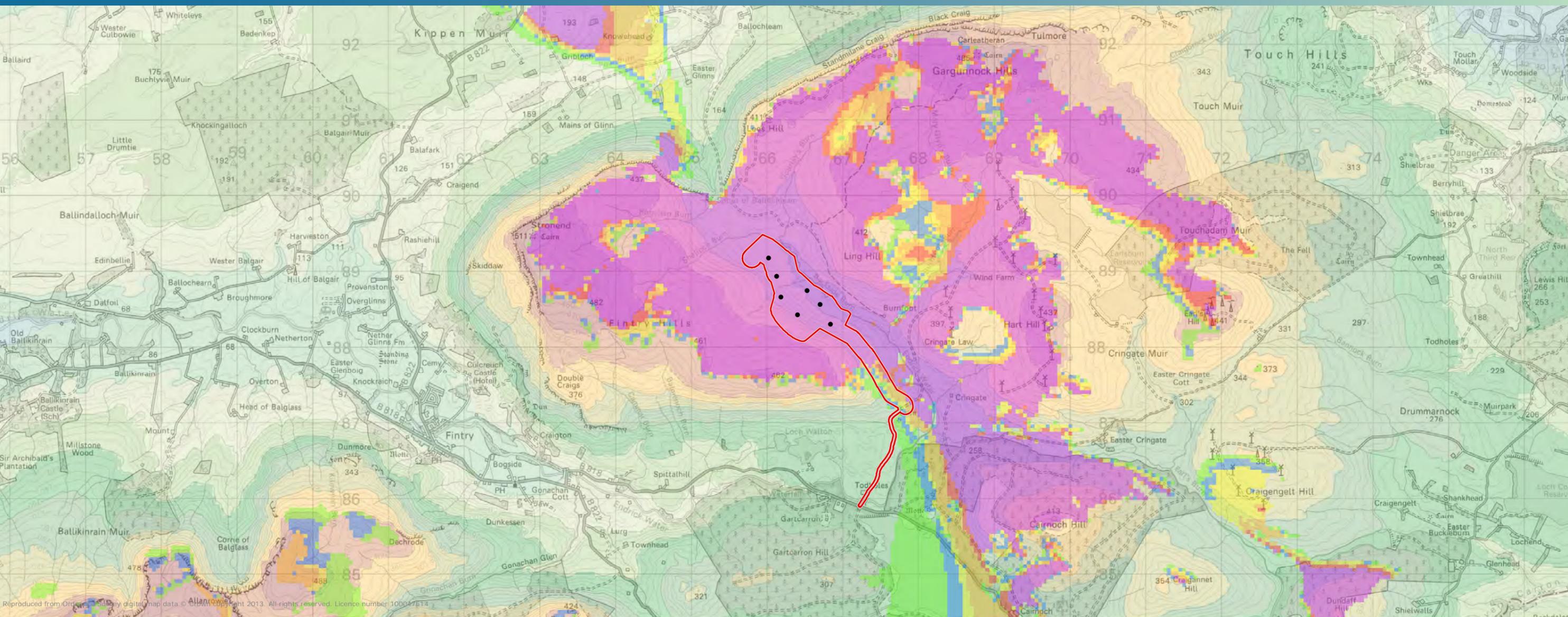


Craigton and Spittalhill Wind Farm Environmental Statement

Volume II: Appendices

November 2013



**Craigton and Spittalhill Wind Farm
Environmental Statement**

**Prepared by LUC
on behalf of
Force 9 Energy**

November 2013



Preface

This Environmental Statement (ES) has been prepared in support of an application for planning permission to construct and operate the seven turbine Craigton and Spittalhill Wind Farm. The Development is located approximately 12km south-west of Stirling and 7.5km to the east of Balfroon, and lies wholly within the Stirling Council area.

The ES comprises the following documents:

- Volume I: Main Text and Figures
- Volume II: Appendices

The ES has been prepared by LUC and supporting sub-consultants. In addition, the ES is accompanied by a Non-Technical Summary, Planning Statement, Design and Access Statement and Pre-Application Consultation (PAC) Report.

Copies of the full ES and accompanying documents, or further information on the Development may be obtained from:

Force 9 Energy LLP and EDF Energy ER

c/o 272 Bath Street

Glasgow

G2 4JR

The Non-Technical Summary is available free of charge. A hard copy of the ES and accompanying documents costs £250. In addition, all documents are available in an electronic format (as PDFs for screen viewing only) on CD/DVD for £2.

The ES and accompanying documents are available for viewing by the public during normal opening hours at the following locations:

Fintry Sports and Recreation Club Kippen Road Fintry Glasgow G63 0YA	Planning and Building Standards Stirling Council Municipal Buildings 8-10 Corn Exchange Road Stirling FK8 2HU	Howietown Fishery Stirling FK7 9QH
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The documents will also be made available on-line at <http://pabs.stirling.gov.uk/online-applications/>

Comments in relation to the Planning Application should be forwarded to the Stirling Council Planning Environment Services department at the address above. Alternatively, comments can be made via Stirling Council's online planning portal.

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Craigton and Spittalhill Wind Farm: Technical Appendix Borrow Pit Assessment

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1 Introduction

This report forms a Technical Appendix to Chapter 4: Development Description of the Environmental Statement for Craigton and Spittalhill Wind Farm (Mouchel, 2013) and should be read with reference to this chapter.

To minimise the volume of imported material brought onto the site and any consequent environmental impact, a borrow pit will be located within the site to source the necessary material for track construction. It has been calculated that approximately 37,500m³ of aggregate material will be required for the construction of access tracks, turbine base back-fill, compounds and hardstanding areas.

Mouchel Ltd was commissioned to undertake a borrow pit assessment for this development site. The aims of this assessment were to provide:

- Preliminary indication of the suitability of the bedrock as a road building material;
- Potential borrow pit locations;
- Indicative borrow pit dimensions;
- Indicative extraction volumes;
- Estimates of overburden at borrow pit locations;
- Indication of potential extraction methods;
- Recommendations for geotechnical testing;
- Preliminary borrow pit re-instatement and rehabilitation proposals.

This document outlines Mouchel's method for borrow pit assessment along with the analysis undertaken; conclusions drawn and recommendations for borrow pit design and location.

It should be noted that all borrow pit information provided within this report is indicative only, and is based on desk study and reconnaissance survey alone. No intrusive investigation has been carried out, and consequently the suitability of the rock, suggested extraction methods and volumes are broad estimates and should be treated as such.

2 Project Method

The project involved a desk study and an engineering geology walkover survey.

The desk study consisted of a review of information with regard to Craigton and Spittalhill which included examining available geological and hydrogeological data together with additional information relating to the site. These included:

- Ordnance Survey Landranger 57 (Stirling and the Trossachs), 1:50,000 scale;
- Ordnance Survey Explorer 348 (Campsie Fells), 1:25,000 scale;
- Ordnance Survey digital raster mapping, 1:50,000, 1:25,000 and 1:10,000 scale;
- Ordnance Survey Landform Profile 10m Digital Elevation Model data;
- British Geological Survey DiGMapGB-50 1:50,000 digital geological mapping, bedrock, superficial and linear geology;
- British Geological Survey Hydrogeological Map of Scotland, 1:625,000 scale;
- Available satellite imagery.

During the desk study potential sites for borrow pits were identified across the site, for further investigation during the site visit.

The study area for this assessment consisted of the area enclosed by the site boundary plus a buffer of at least 250m; areas further from the Site were considered where they provided additional valuable information.

A site visit was undertaken on 27 June 2013 by Mouchel personnel. The site visit consisted of a walkover survey including a visual inspection of the potential borrow pit locations.

3 Desk Study

3.1 Geology

The predominant igneous geology is that of the Clyde Plateau Volcanic Formation, a volcanic high Chadian to Asbian in age, of the larger Strathclyde group. A smaller single Midland Valley carboniferous to early Permian alkaline basic dyke suite is found within site.

Much of the Clyde Plateau Volcanic Formation consists of lavas, tuffs and volcanoclastic sedimentary rocks (Browne et al., 1999). The igneous geology of the site can be differentiated on mineralogy and varying microstructure. The dominant Plagioclase-macrophyric basaltic rock covers much of the site and surrounding Fintry Hills. Within the central area of the site there are several thinner units of Microporphyritic basalt, trending NW to SE in mid to lower slopes of the site. The north western section of the site is underlain by plagioclase-microphyric basaltic with a thinner trachybasalt unit succeeding to the south west.

The proposed site access track crosses an area of volcanoclastic sandstone and conglomerate and subordinate argillaceous rocks, found in the lower slopes where the Burnfoot Burn and Backside Burn converge. A single mafite suite unit is found in the centre of the site with several other suite units found in the lower slopes.

Superficial geology is dominated by peat deposits in the mid and upper slopes of the Fintry Hills. Devensian till is found in the mid slopes and surrounds areas of exposed bedrock with hummocky glacial deposits in lower slopes of the upper Endrick valley. In the immediate vicinity of the Backside Burn alluvial deposits are present, characterising the northern border of the site.

Two fault lines found in the centre of the site trend from north to south for approximately 0.7km and offset the plagioclase-macrophyric geology with the thinner microporphyritic units.

Maps of the bedrock and superficial geology are included in Chapter 8: Geology, Hydrology and Hydrogeology of ES as Figures 8.4 and 8.5 respectively.

3.2 Hydrogeology

The Strathclyde group and its dominant igneous geology forms an aquifer of low productivity. Faulting and weathering in upper strata and near surface bedrock may yield a more productive aquifer however this is still likely to produce low levels of water in rare springs at approximately 2l/s (BGS,2013).

The peat deposits are almost entirely saturated and therefore water is likely to be at the near surface, with further rainfall likely to result in rapid surface runoff. Runoff rates and volumes are likely to be influenced by the topography and the influence of the less permeable bedrock geology. The smaller deposits of diamicton till are highly variable in composition and may support water tables dependant on density and composition of the material. These are likely to be discontinuous and limited in extent and as such can have limited groundwater potential.

3.3 Initial Search Areas

At the early stages of the desk based study, two potential Borrow Pit Search (BPS) locations were identified, as reasonably large areas indicating where potential borrow pits would be preferably located, based on local outcrop and slope angles, plus reasonable distance from watercourse pathways. These were BPS1 (centred at NS 6629 8832) and BPS2 (centred at NS: 6744 8768). Due to access restrictions, BPS2 was not visited and therefore not included in further detailed assessment. However, geological mapping indicates that plagioclase-macrophyric basalt of the Clyde Plateau Volcanic Formation is present at the location and may potentially be a source of good aggregate.

3.4 Suitability of Bedrock as Aggregate

The varying compositions of bedrock in the Clyde Plateau Volcanic Formation mean that their suitability as aggregates is dependent on mineralogy and composition.

Smith & Collis (2001) indicated that much of the aggregate in Britain produced from igneous geology is usually fine to medium grained basic geology. The extrusive nature of the Clyde Plateau Formation at the site indicates that the geology may be suitable for aggregate. The grain size and silica content is an indication of the suitability, with coarser grained aggregates likely to have less strength. The porphyry, porphyrite and trachybasic (intermediate silica, medium to fine grained in composition) identified at this stage, determine that the quality of aggregate won from the site is likely to be reasonably good.. Basalt aggregate could be used to provide a wearing course over sandstone sub-base.

4 Engineering Geology Walkover Survey

A walkover survey of the search area BPS1 was conducted on 27 June 2013. Visual inspections, photographs and detailed field notes were taken reporting the geological and hydrogeological aspects of each of the pre-identified locations from the desk study stage. A hand-held GPS unit was used to obtain locations to better than 30m accuracy.

One potential borrow pit location was identified as being a good representative location within BPS1, this was found to be suitable for aggregate sourcing. This position was determined based on close proximity to turbine infrastructure, whilst ensuring a stand off from watercourses, this is identified as borrow pit BP01.

The chosen location lies entirely within the site boundary. The following sections give specific information about the selected borrow pit location and are accompanied by an A3 technical drawing presented in Figure BP01.

4.1 Borrow Pit BP01



Photograph 1: Photograph taken at NGR: 6646 8842, looking west across proposed borrow pit BP01

Borrow Pit BP01 is located on the north eastern slope of the Fintry Hills, centred at NGR: NS 6634 8836, approximately 500m south west of the Backside Burn. Several areas of exposed bedrock are present in the vicinity of the borrow pit. The main axis would run approximately north east to south west. Photograph 1 and 2 show the current area where proposed excavation would take place.



Photograph 2: Photograph from NGR:6628 8837, showing view from top of proposed borrow pit BP01, looking north east

The lithology is:

- dark brown to black;
- strong to very strong;
- intermediate to fine grained;
- porphyritic;
- extrusive igneous;
- basalt.

Geological mapping indicates that superficial deposits consist of peat with depths likely to be between 0 and 1m deep. The surface elevation in this area is approximately 350 to 365mAOD.

Bedrock is generally not visible, being covered by superficial deposits and vegetation, however there are numerous outcrops located on the upper slopes. Slope characteristics are gentle and generally uniform along the borrow pit axis. Appropriate benches may need to be added to the face of excavation to minimise slope instability.

5 Assessment of Potential Borrow Pits

The client provided Mouchel with a required aggregate volume of 30,000m³ for aggregate requirements for the construction of access tracks, turbine base back-fill, compounds and hard-standing areas at the site. As there has been no detailed ground investigations carried out, a contingency of 25% has been added to this value for the indicative borrow pit design requirement, resulting in an aggregate requirement of 37,500m³.

The main part of the borrow pit assessment is in the form of a technical drawing, presented in Figure BP01. The technical drawing includes a location map for the borrow pit within the site, a photograph of the potential borrow pit area, a location plan showing the proposed borrow pit footprint and a schematic cross-section. It should be noted that the borrow pit footprint and cross-section illustrated in Appendix A have been produced using available DTM data and consequently they are not detailed designs but are indicative only.

Table 1 illustrates the proposed borrow pit dimensions for the identified location. The volume given has been calculated from the borrow pit cross-section, taking into account the benches and gradients of the extraction face, and not from the borrow pit footprint dimensions and depth approximations shown.

It should be noted that the given borrow pit dimensions and volume are estimates. Detailed ground investigations and geotechnical testing will be required to inform detailed design of the borrow pits.

ID	Location	Approx. footprint dimensions (m)	Approx. footprint area (m ²)	Max. depth (m)	Approx. Volume (m ³)	Probable extraction method
BP01	NS 6634 8836	56m x 147m	6300	12	37,500	Drilling and Blasting
Total Estimated Volume (m³)					37,500	

Table 1. Indicative borrow pit dimensions & extraction volumes

As borrow pit BP01 is located within a hard and fairly resistant rock type it is likely that drilling and blasting will be required for excavation.

It is anticipated that, upon completion, the borrow pit will be at least partially reinstated. This will involve the reworking of faces to stabilise them, partial infilling with excavated material not needed for construction or of unsuitable grade, and landscaping. There may be the potential for environmental enhancement by creating a small wetland or other desirable habitats.

There remains the potential to open a second borrow pit (within BPS2) to provide sufficient aggregate for the main site access and to provide tracks to the main wind farm infrastructure. Opening of another borrow pit would be expected to decrease the required volume from BP01.

An assessment of the effects of the borrow pit on the local hydrology and hydrogeology has been undertaken and incorporated into the Environmental statement (Chapter 8: Geology, Hydrology and Hydrogeology). This includes:

- Limiting entry of surface run-off into borrow pits;
- Limiting entry of groundwater into borrow pits;
- Drainage and treatment of water collecting in borrow pits;
- Storage of excavated material for post-use restoration and rehabilitation.

6 Conclusions and Recommendations

Engineering geology walkover and supporting field surveys carried out on site initially identified two potential borrow pit search areas (BPS1 and BPS2). After consideration of environmental and access constraints, one specific location within BPS1 was considered most suitable for more detailed assessment. The surveys suggest that the area of greatest potential in terms of suitability for bedrock excavation, in terms of aggregate quality, overburden depth and slope angle, whilst minimising environmental impact is BP01. The peat depths at BP01 are generally shallow and predominantly <1m, considered representative of the wider BPS1 search area.

Using the information gathered, an assessment of the selected borrow pit location was carried out. BP01 has been designed to enable extraction of the required aggregate volume for the construction of this project (37,500m³, including 25% contingency), with borrow pit dimensions estimated and probable extraction methods identified.

Detailed ground investigations, slope stability assessments and geotechnical testing will be required to inform the detailed design of the borrow pit(s) and to confirm suitability as sources of aggregate for track and turbine base construction.

7 References

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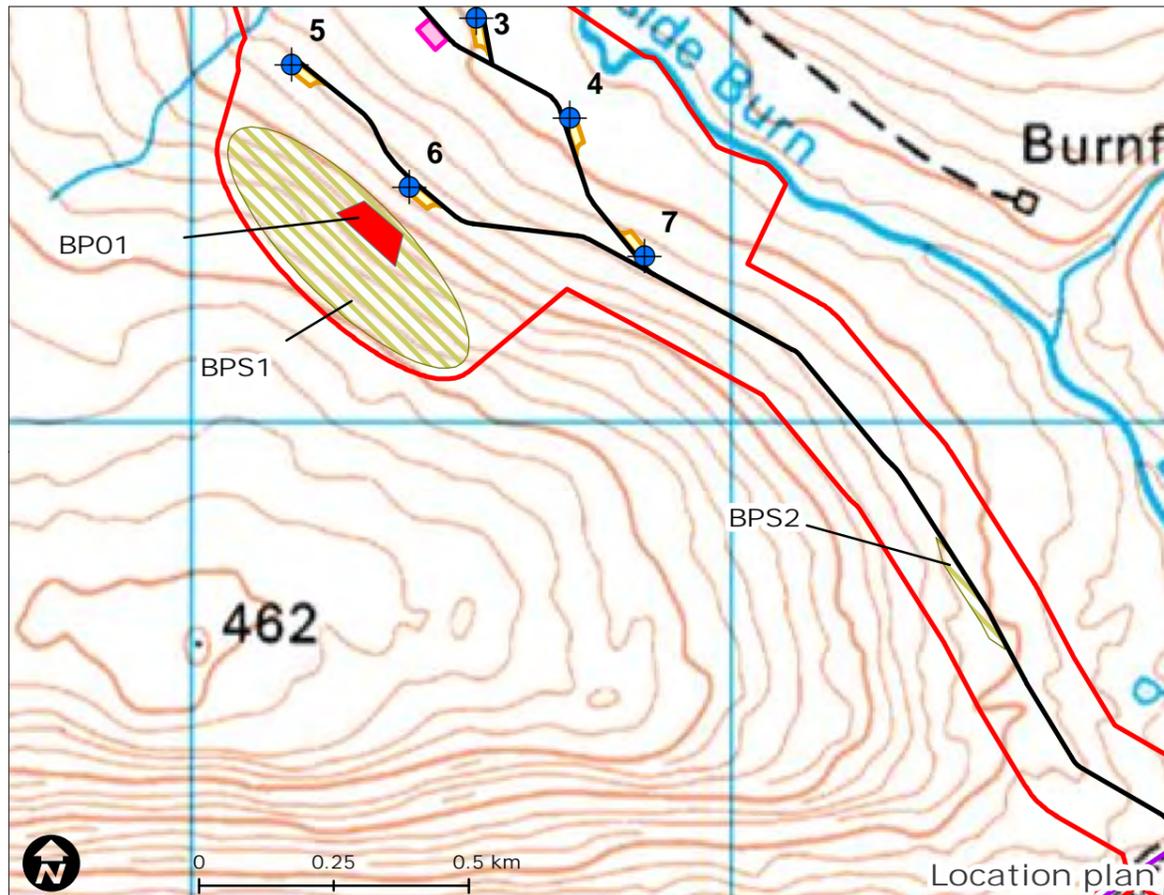
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Appendix A

Figure BP01

Borrow Pit Design (BP01)



Borrow Pit Design

Borrow Pit ID:
BP01

NGR:
NS 6634 8836

Approximate footprint area:
6300 sq m

Approximate maximum depth of BP:
12m

Indicative BP volume:
37,500 cubic m

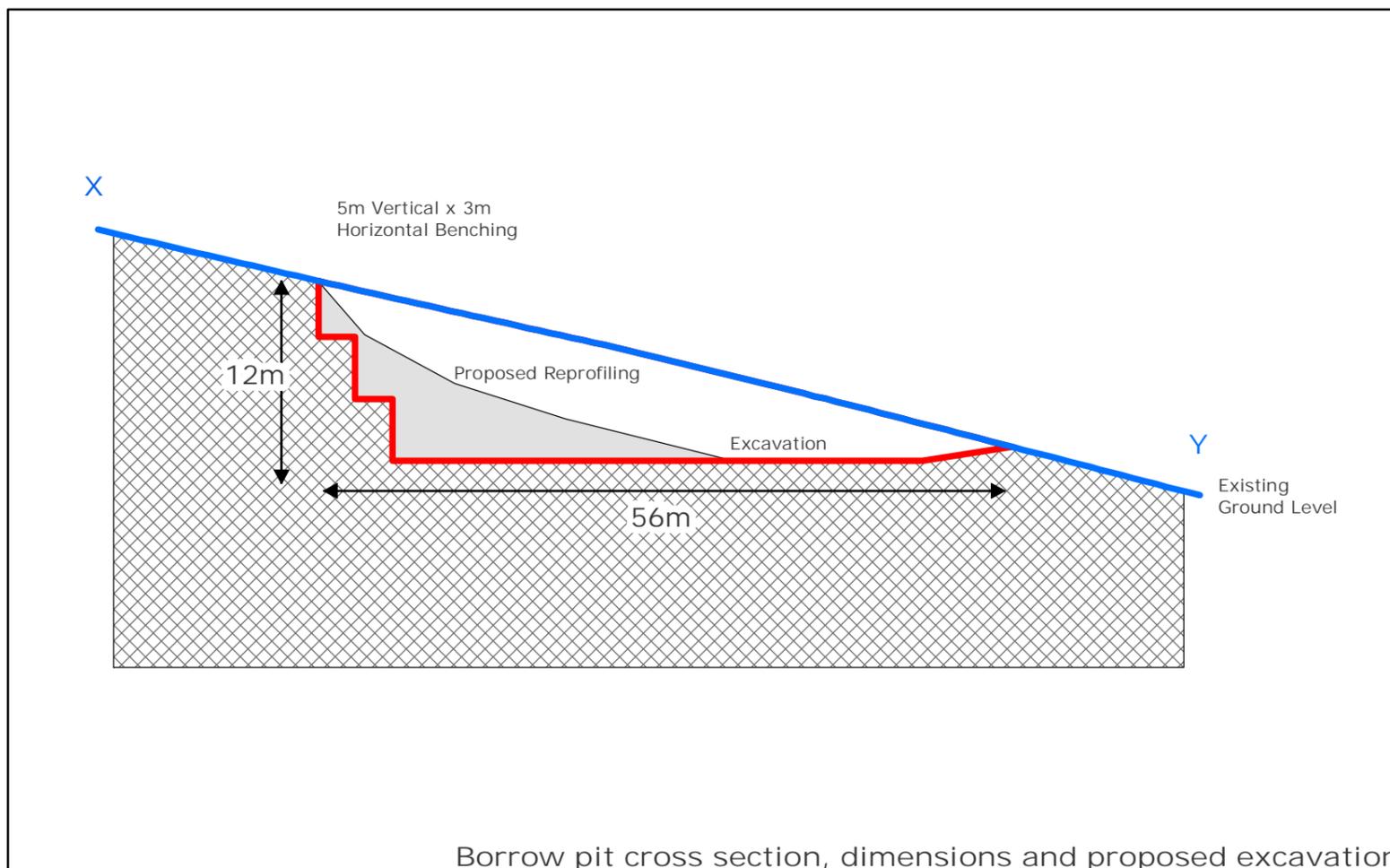
Lithology:
Dark brown to black
Strong to very strong
Intermediate to fine grained
Porphyritic
Extrusive igneous
Basalt

Terrain:
Site lies on a NE facing
slope with gentle sloping
along a NE to SW axis and
more varied geomorphology in a SE
to NW axis. Some bedrock
exposure is visible but
location is primarily covered
by vegetation.

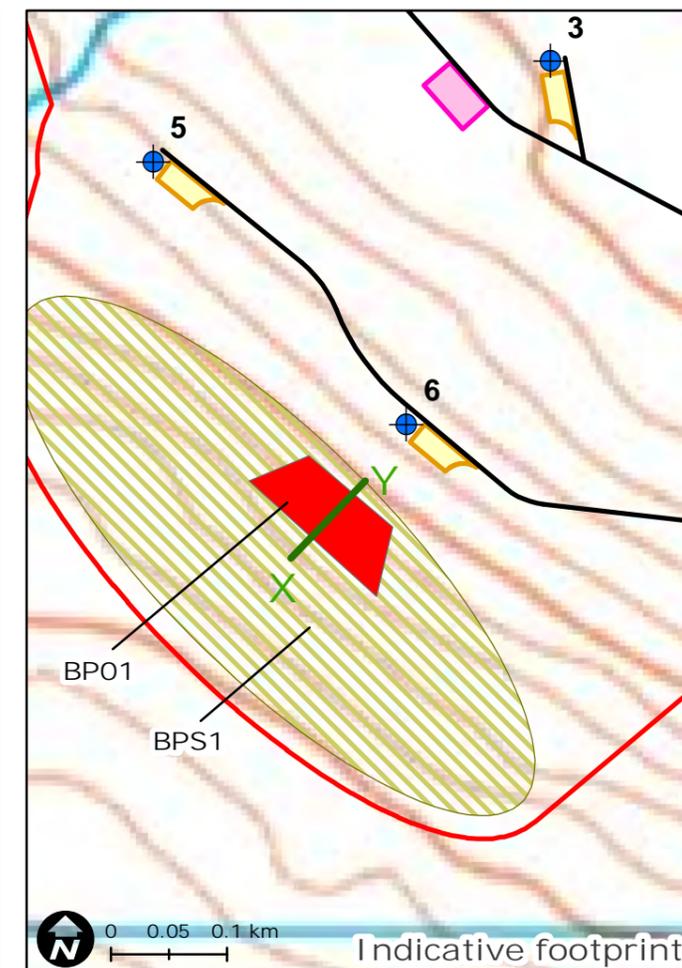
Excavation required:
Mechanical excavation
some blasting may be required

Restoration:
Profile is indicative only

Figure BP01



Borrow pit cross section, dimensions and proposed excavation



Indicative footprint

Appendix 4.2: Outline Soil and Peat Management Plan

Craigton and Spittalhill Wind Farm: Technical Appendix Outline Soil and Peat Management Plan

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1 Introduction

This report forms a Technical Appendix to Chapter 4: Development Description of the Environmental Statement for Craigton and Spittalhill Wind Farm (LUC 2013) and should be read with reference to this chapter.

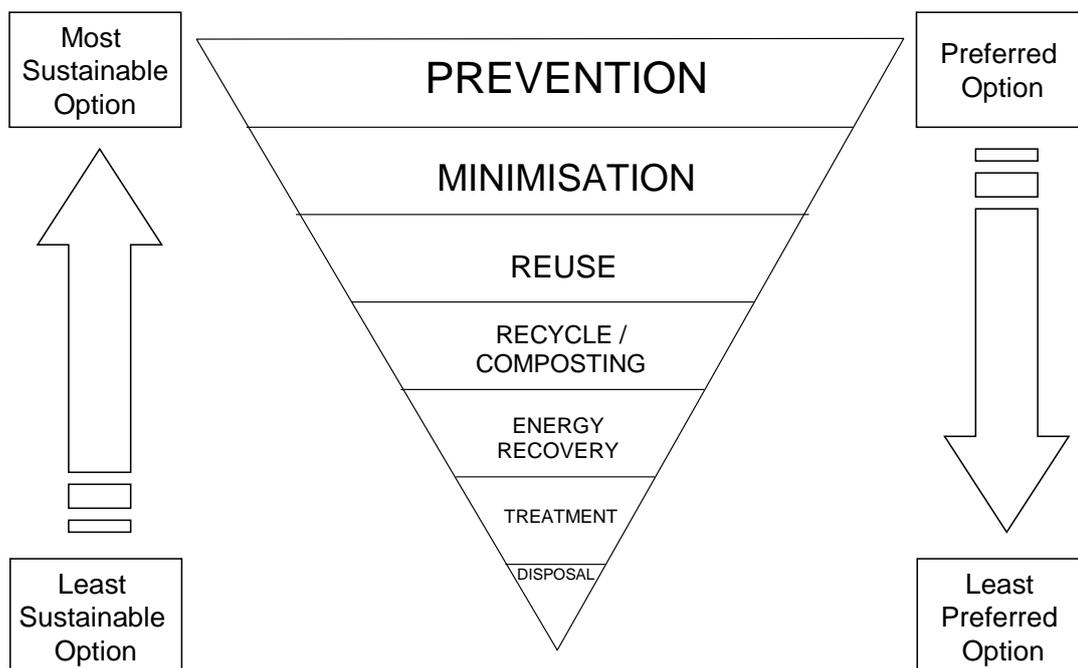
Permission is being sought for the erection of seven three bladed horizontal axis turbines (individual maximum capacity up to 3MW) at a site named Craigton and Spittalhill. This site is located on an area of open moorland and rough grazing in the eastern Fintry Hills, approximately 4km to the north-east of Fintry, 15km south-west of Stirling. During initial investigations it was established that peat was present on the site and that further work was commissioned to establish peat characteristics, depths and extent.

In the Scottish Environment Protection Agency's regulatory position statement *Developments on Peat* (SEPA, 2010), SEPA state that "developments on peat should seek to minimise peat excavation and disturbance to prevent the unnecessary production of waste soils and peat". This report examines likely soil and peat excavation requirements during the construction process and the potential for minimising excavation and maximising reuse of materials. It is recognised that while reuse of any peat and soil during the construction process represents the preferred option, any such use should be carefully considered regarding risks to the environment or human health.

Furthermore, under the Environmental Protection Act 1990, producers of waste have a 'Duty of Care' to ensure that waste is properly managed. The 'waste hierarchy' (SEPA, 2013) identifies options from 'preferred' to 'least preferred', shown in Illustration 1. As in all matters concerning waste, the legislative requirements and the 'waste hierarchy' have been used as the primary benchmarks when considering options for dealing with construction waste. Likewise, this has been recognised, for the purpose of this review, as an appropriate approach to be adopted. The types and quantities of waste produced will be dependent on design practices, local conditions, scale and type of the development.

Excavated material, such as peat from turbine foundations and spoil from borrow pits, can often be used for reinstatement and restoration, thereby minimising the volume of waste material. This can also effectively reduce the need for imported material for use in reinstatement. There are now a significant number of wind farms in Scotland that have been through the planning process and are under construction or in operation. As a result, many of the issues regarding such material have been considered against the best practicable environmental option criteria.

Illustration 1. The Waste Hierarchy



2 Scope of Work

This report evaluates opportunities to minimise excavated volumes and examines potential reuse strategies for excavated material. While there may be minor amendments to the site layout throughout the planning process and due to micrositing during construction, evaluating the likely excavation and reuse factors at this stage encourages the development of good practice in terms of pre-construction strategy and subsequent site environmental management.

It is a prudent course of action to consider these issues at this stage to ensure appropriate plans for excavation, storage, reuse, and (if necessary) disposal of soil / peat have been considered in advance of the construction phase of the project.

This report provides details on peat depth records for key items of proposed infrastructure in order to inform recommendations, with reference to the approach outlined in the 'waste hierarchy' (Illustration 1).

3 Method

During the construction phase of the project there will be a need to excavate soil / peat for the installation of infrastructure, such as access tracks and turbine bases.

This report reviews site soil / peat data, then considers project activities and good practice, including layout design, infrastructure excavation and restoration opportunities, storage methods and finally disposal options, where reuse is not possible.

Reference is made to the guidance document "*Promoting the sustainable reuse of greenfield soils in construction*" (Scottish Government, 2010).

4 Site Soil / Peat Depth Data

As detailed in ES Chapter 8 (Mouchel, 2013a) the site is located almost entirely within an area classified as Soil Unit 4 of the Organic Soils Association, derived from Macaulay Land Use Research Institute (MLURI) (1982) which includes Blanket Peat as a component soil.

Peat probing was undertaken across the site during a number of site visits between October 2012 to June 2013, with 620 records gathered in total, of these 82% were less than 1.0m and 58% of all probing points were less than 0.5m (i.e. not generally considered as peat), with a single location in excess of 2.5m (at 2.56m). Further details on peat depth records and techniques, including maps are provided in the *Peat Stability Assessment, Technical Appendix* of the Environmental Statement for Craigton and Spittalhill Wind Farm (Mouchel 2013b).

The Soil Survey of Scotland (MLURI, 1982) and Peat Landslide Hazard And Risk Assessments - Best Practice Guide For Proposed Electricity Generation Developments (Scottish Government, 2006), both indicate a minimum depth for soil to be defined as peat of 0.5m. It is important to recognise that peat probing is an exercise that determines the depth of soils through which a probing rod will travel, which may not always represent peat.

Peat is primarily present at the valley floor adjacent to Backside Burn, where the deeper records and wetter conditions were recorded. There was very little peat evidence on the upper slopes, based on observations and data obtained during site visits, where occasional exposed banks provided evidence of very shallow peaty surface horizons with deeper material consisting of glacial till (boulder clay). During the Peat Stability Assessment (Mouchel, 2013b) a number of soil cores were recorded as primarily sampling such clay material.

Therefore, the likelihood of excavating peat is different in these two zones; known as the 'slope zone' and 'valley floor zone', with turbine and track details for each zone provided in the following sections with data limited to that in the immediate vicinity (within 25m) of infrastructure locations.

Peat is a soft to very soft, highly compressible, highly porous organic material which can consist of up to 90% water by volume. Unmodified peat typically has two layers, a surface layer or acrotelm which is usually 0.1 to 0.3 m thick, highly permeable and receptive to rainfall. The acrotelm layer generally has a high proportion of fibrous material and often forms a crust under dry conditions. The second layer, or catotelm, lies beneath the acrotelm and forms a stable colloidal substance which is generally impermeable. As a result, the catotelm usually remains saturated with little groundwater flow. Acrotelmic peat is generally considered more robust and more readily restored, with catotelmic peat more difficult to re-establish following disturbance.

With the peat depths at infrastructure locations generally very shallow, it is judged that the conditions necessary for catotelmic peat to be present and encountered in any notable quantities during construction are very unlikely to occur. The field surveys and core data gathered during the Peat Stability Assessment (Mouchel, 2013b) found little evidence of deep peat.

All of the excavated soil / peat material will require careful management, whether peat or other soil material. However, a proportion of the non-peat soils may be suitable as a base on which to lay aggregate for construction of hardstandings and access tracks, thus reducing the requirement to excavate material.

5 Layout Design

Peat probing data was used to develop a constraints map identifying locations of deep peat, which would also be the most likely areas to contain catotelmic peat. This process initially covered a wide development area, with subsequent field surveys focussed upon planned infrastructure locations.

This constraints map was used as part of the iterative design process to avoid deeper peat areas and to minimise the excavation requirement for soil / peat. Furthermore, it is intended to microsite infrastructure, where practicable, to further minimise excavation as additional information becomes available at the detailed engineering design and construction stages.

6 Infrastructure Excavation and Reuse

The construction process for the proposed development will necessitate extraction of soil / peat to facilitate the construction of access tracks, site compound, turbine bases and areas of hardstanding.

The design of various infrastructure features has been provided by the civil engineering consultants for this project. The layout of the wind farm and dimensions of infrastructure are taken from *Development Description*, Chapter 4 of the Environmental Statement for Craigton and Spittalhill Wind Farm (LUC, 2013).

6.1 Access Tracks

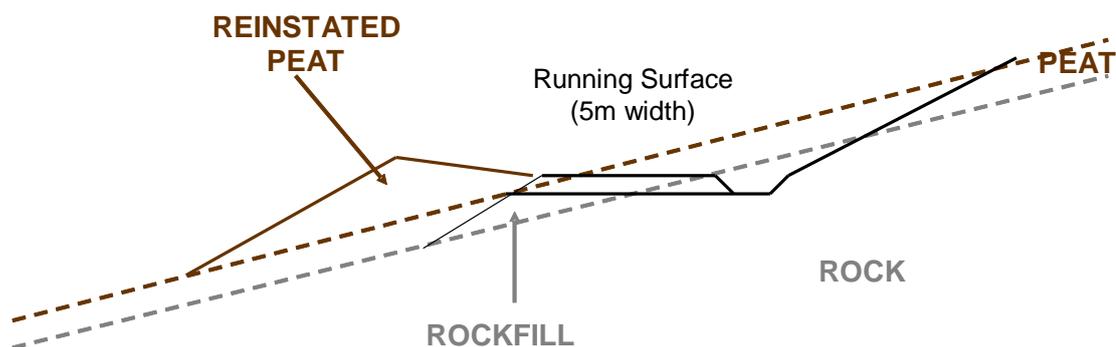
All new access tracks, comprising 5km of new track, are planned as cut and fill construction. This technique was chosen due to the typically shallow soil depth recorded. This requires excavation of surface deposits and backfilling with aggregate to produce a final track level at, or close to, the existing surface level.

The standard running width of the new tracks will be 5m (LUC, 2013), with the overall dimensions of this track varying depending on the terrain crossed, i.e. some cross-slope locations will have wider shoulders.

The track positioning has taken account of the constraints map, avoiding areas of deeper peat, wherever practicable. To provide additional depth information, specific to the track location, analysis was undertaken to identify the average peat depth within 25m of the planned track route. From 223 records the average depth is 0.62m. To refine the site data, peat depths have also been calculated for the individual slope and valley floor zones, with an average of 0.35m (from 103 records) within 25m of track route in the slope zone and a valley floor zone average of 0.85m (from 120 records). This breakdown illustrates that the soil on the sloping area of the site is generally <0.5m, and not considered as peat.

There is the opportunity to use excavated material on the trackside bankings, with trackside banking of 0.5m by 1.0m on both sides considered a conservative initial assumption, demonstrating minimal reuse. The use of excavated material for reinstatement and/or landscaping will not be uniform across the site, and experience of other similar projects has shown that substantial volumes of excavated material may be necessary for reinstatement and/or landscaping for banking downslope of cut and fill tracks where these traverse a hillside, as is often the case on this site, as shown on Illustration 2.

Illustration 2. Cross-gradient cut and fill track construction



Some non-peat soils will potentially provide suitably supportive geotechnical qualities to be utilised in the construction of access tracks. It is anticipated that the 'slope zone' track locations, from the existing access track has the greatest potential for this purpose, with subsequent geotechnical investigations required to confirm. Locations where existing soil can be left *in situ* shall be identified pre-construction and excavation avoided.

In the 'valley floor' zone, micro-siting of the track could further reduce peat excavation requirements.

6.2 Turbine Bases

Construction of the seven turbine bases will require excavation. The ES Chapter 4 (Land Use Consultants, 2013) identifies the turbine base area as 16m x 16m, with the associated excavation area slightly larger.

The initial excavation estimate uses actual probing data, giving an average depth at the turbine bases of 0.6m. As for the tracks, the turbines can be considered to be placed in slope or valley floor zones, with the average depths in each zone notably different, as detailed in Table 1.

The majority of turbine bases are at locations with soil / peat depths of less than 0.5m, therefore not considered as peat. Where practicable, the remaining turbine locations (T1, T4 and T5) will be micro-sited to minimise the excavation requirements.

There is the potential to backfill turbine foundations to the existing ground level and also to cover turbine bases with excavated material, this shall be done to match local depth conditions.

Table 1 Measured soil / peat depths at turbine locations

Turbine ID	Location, Zone	Depth (m)
1	NS 6603 8918, valley floor	1.1
2	NS 6613 8893, valley floor	0.3
3	NS 6653 8875, valley floor	0.4
4	NS 6670 8856, valley floor	1.2
5	NS 6619 8866, slope	0.6
6	NS 6641 8844, slope	0.2
7	NS 6684 8831, slope	0.1
Turbine base average depth (m)		0.6
Slope zone turbines, average depth (m)		0.3
Valley floor zone turbines, average depth (m)		0.8

6.3 Crane Hardstandings

The crane hardstandings associated with the turbine bases are required for supporting lifting equipment. These are created by excavation to rock and backfilling the excavation with aggregate to form a stable surface from which construction activities can be carried out.

The proposed dimensions for each hardstanding is 30m x 40m, as stated in ES Chapter 4 (LUC, 2013). It is expected that all hardstandings will be excavated. The hardstanding areas are co-located with turbines and will exhibit similar depth characteristics to the turbines, as discussed in the previous section.

Batter areas around hardstandings will be backfilled with excavated material. Where practicable, micro-siting will be considered in the local area to reduce excavation requirements. Also soil characteristics at the hardstanding location will be investigated, as should these be considered 'fit for purpose', there is the potential to reduce excavation.

In addition, it is considered that there is the potential, post-construction, to place an impermeable geotextile membrane across the majority of each hardstanding (75% of each area). This geotextile membrane will serve as a separation layer to avoid unwanted mixing of aggregate and soil/peat, to prevent the underlying aggregate acting as a drainage layer. Above this geotextile, reinstatement could be undertaken to a depth of 0.5m using local soil / peat material, thus retaining a small hardstanding maintenance area adjacent to the turbine. Although major maintenance of a turbine may deem it necessary to remove the covering material during the operational phase of the wind farm, this is considered to have a relatively low likelihood and will be subject to a method statement to mitigate any environmental risks and ensure that activities are carried out in accordance with good practice. This approach may also provide useful soil habitat, rather than areas of hardstanding for the duration of the operational phase.

6.4 Borrow Pit

Details of the proposed borrow pit location are provided in *Borrow Pit Assessment, Technical Appendix 4.1* of the Environmental Statement for Craigton and Spittalhill Wind Farm (Mouchel 2013c). Two potential borrow pit search locations were initially identified, however, following assessment the borrow pit options were reduced to a single borrow pit to minimise environment effects.

The borrow pit is located in an area with shallow surface deposits. A conservative average depth of overburden of 0.4m has been assumed, based on an average of peat depth records within the borrow pit search area.

The proposed borrow pit has an indicative footprint of 6,300m² and a maximum excavation depth of approximately 12m, thus, allowing the potential for reuse of excavated material for restoration. Restoring the borrow pit footprint with excavated material provides a reuse purpose. If reinstated to a depth of 0.4m (equivalent to the removed overburden) this would balance the excavated volume at the borrow pit, with any deeper reinstatement providing the potential to usefully reuse additional soil / peat material, such as for habitat creation. Any reinstatement depths greater than 1m would involve discussion of rationale and engineering techniques with SEPA.

6.5 Compound and Control Building

The construction compound comprises the control building and a fenced hardstanding area to accommodate vehicle access and parking. The control building is anticipated being 16.6m x 10.6m, with the excavation expected to be 33m x 17m in size, including the fenced hardstanding (LUC, 2013).

For the purposes of the report it has been assumed that all peat / soil will be excavated at the control building location. Peat probing at the location of the control building provides an average soil / peat depth of 0.3m.

Where practicable, micro-siting will be considered in the local area to reduce excavation requirements to shallower soil depth. Also, soil characteristics will be investigated, as aforementioned for site tracks, to establish potential use, *in situ*, to reduce excavation.

Following construction, as for the crane hardstandings, consideration shall be given to covering parts of this installation that are not required during the operation phase with soil / peat material to local depth characteristics.

6.6 Meteorological Mast

The earthworks associated with the met mast are assumed to be essentially neutral in terms of excavation and reuse of material following installation.

7 Storage and Soil Management

Storage considerations include both the short term storage and segregation of excavated material identified for reuse or disposal and the potential need to retain sufficient material for reuse during decommissioning of the wind farm, anticipated to be 25 years in the future. At all times the volume and duration of storage must be minimised.

This section focuses on temporary storage of peat and soil on site during the construction phase and discusses the potential longer term storage of peat for restoration on decommissioning.

7.1 Management of Excavated Peat and Soils

It is expected that prior to construction commencing, the contractor will provide a plan detailing potential locations for temporary storage and an outline programme indicating the duration and quantity of stored peat and measures to mitigate and/or capture sediment runoff from stored material. At all times the primary objectives shall be to minimise both the time and volume of temporary storage and to prevent sedimentation of any watercourse or waterbody.

Erosion control is recognised as being more effective than sediment control in preventing water pollution, i.e. minimising generation of sediment and control at source. This 'prevention-led'

philosophy shall be applied during all phases of this project. Careful construction project programming will take account of interactions between construction, erosion and sedimentation, thus reducing the potential for impact.

All construction work will be undertaken to meet current good practice standards, including recommendations in CIRIA guidance documents such as *Control of water from linear construction projects* (CIRIA, 2006) and *Handbook for construction of SUDS* (CIRIA, 2007).

Soil removed during excavation activities will be stored nearby and battered or otherwise protected such that it will not dry out or be liable to erosion, and can be used subsequently to reinstate the excavated area. Protective coverings (such as jute, coir or geotextiles) will be considered as temporary measures to protect the stockpiles from rainfall and wind erosion. There is less potential for erosion where bare ground has purposefully rough surface characteristics, as this will reduce the velocity of overland water and will encourage faster revegetation. This approach is likely to be most applicable to areas adjacent to track construction (CIRIA, 2006) whereas individual stockpiles adjacent to turbines or borrow pits may be more suitable for covering.

Excavated material or other forms of loading will not be placed on or close to breaks in slope or other potentially unstable slopes.

Catclimic peat should always be reinstated quickly and locally, as if not used within an appropriate timeframe, it is likely to lose structure and be susceptible to structural failure or become subject to wind or water erosive forces.

Good practice methods would include careful removal of vegetated turves, short time scales between lifting and replacement of turves (with a 6 week reinstatement objective), minimal distance of travel and ensuring stored turves are kept in good condition (including watering when weather conditions could lead to desiccation). Revegetation of bare soil with native vegetation would be encouraged.

Care will be taken to avoid mixing of soils and aggregate materials, this will enable potential removal of aggregates during decommissioning for other uses whilst retaining local soil characteristics, such as at crane hardstandings.

7.2 Decommissioning

To date, no evaluation of the requirement of peat for restoration on decommissioning has been made. However, it seems likely that some material will be required for reinstatement when wind farm infrastructure is decommissioned. An appropriate volume of planned site storage of excavated soil and peat would cover the eventuality of material being required for decommissioning of wind farm infrastructure.

The main areas in which peat is likely to be required for restoration on decommissioning are the turbine bases, permanent hardstandings and control building. This assumes that tracks remain *in situ* at the decommissioning stage.

As discussed in the hardstanding section, post-construction covering of 75% of the hardstandings will retain a local source of restoration material for these locations. .

The material for these purposes would be better sourced on site than transported from elsewhere, thus the creation of a series of small storage areas, carefully sized and designed to resemble the existing terrain where possible, potentially serving long term storage solutions, is proposed.

8 Other Reuse Options

The Aggregain website (Aggregain, 2013), provides information on sustainable construction aggregate, including details on suitable materials for reuse and appropriate treatment methods, along with UK case studies. It is recommended that this resource is reviewed for applicable good practice. It is anticipated that by applying the discussed measures at appropriate locations all of the excavated material could potentially be reused on site.

However, in the event that there is still an excess of excavated material, off site reuse options shall be explored. Feasible opportunities include providing material for soil conditioning, habitat enhancement or topsoil requirements in the local area. Local forestry enterprises may provide a local receptor for good quality material for the aforementioned uses.

9 Disposal

Where there is not a defined use for soil / peat material, excess material will be considered as waste and will require to be disposed of in accordance with regulatory requirements, this is becoming increasingly controlled in order to minimise useful material, such as soil / peat being sent to landfill.

Disposal of soil / peat as waste will be considered as the final, least preferred, option, in line with the 'waste hierarchy'.

10 Summary and Recommendations

This report identifies a number of areas where excavation is anticipated and where there is potential for reinstatement of soil / peat. Using the approach outlined in the 'waste hierarchy' (Illustration 1), the initial stage was to undertake fieldwork and create constraint maps to avoid placing infrastructure in deep peat locations, following this consideration has been given to the practices involved in construction and installation of infrastructure, summarised under four main categories:

- Excavation at the location of site infrastructure, including tracks, turbine bases, hardstandings and site compounds, minimising the material excavated;
- Re-use of material, considering options for reuse of excavated material both on site and off site;
- Storage and soil management, of excavated material to minimise degradation in soil quality and avoid sedimentation of watercourses, including consideration of storage to facilitate restoration at decommissioning;
- Disposal where there is an excess of excavated material over reasonable opportunities for reuse, there may be a need for disposal of this material to a licensed waste facility.

The average soil / peat depth within 25m of the planned track is 0.62m, with the average depth on the slopes of the site notably shallower at 0.35m. Where deeper peat occurs, on the valley floor, depths average 0.85m and micro-siting will be employed to minimise excavation volumes. It is likely that the excavated material will be reuseable on site and is anticipated to consist mainly of glacial till and peat-containing soils, rather than peat.

The concerns associated with the damage to catotelmic peat with regard to excavation, storage, transport and restoration are considered to be minimal on this site. However, should catotelmic peat be encountered during excavation, this material shall be reported on site and provisions made to micro-site or to reuse this material rapidly and appropriately.

All appointed subcontractors will be fully briefed regarding the general site waste management strategy and applicable site-specific waste management measures.

Prior to construction, a Site Waste Management Plan (SWMP) shall be prepared. Although SWMPs are not currently legally required in Scotland, these have been a regulatory requirement in England and Wales since April 2008 for large projects. The development and use of these plans is regarded as good practice (IEMA, 2008). This plan would quantify various material streams and reuse options, with soil / peat an integral element of this process. There are a number of publications, including the *Simple Guide to Site Waste Management Plans* (NetRegs, 2013) and *Waste Management* (IEMA, 2008), which may assist in the establishment of a SWMP document. During the preparation of the SWMP, at the pre-construction stage, discussions would be held with local waste management stakeholders including SEPA, Stirling Council and Waste Aware Scotland to gain advice on good practice and local schemes to minimise requirements for off site transport. This consultation will enable the discussion and inclusion of additional features within the SWMP, where practicable.

11 References

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Appendix 6.1: Landscape Baseline

Appendix 6.1: Landscape Baseline

Introduction

- 6.1 This Appendix sets out the Landscape Character Types (LCTs) that occur within the 35km study area for the Development.
- 6.2 The LCTs within 35km of the Development are illustrated on **Figure 6.4** and listed in **Appendix Table 6.1: Landscape Character Types considered as Landscape Receptors**. The theoretical inter-visibility with the Development (ZTV coverage), as shown on **Figure 6.1** is described in the table, and used as a means of identifying which LCTs require further assessment, and which LCTs can be scoped out because they are unlikely to be affected by the Development. This assessment focused on LCTs with potential inter-visibility with the Development, within 15 km of the site.

Appendix Table 6.1: Landscape Character Types considered as Landscape Receptors

Landscape Character Type ¹	Theoretical visibility of Development (ZTV coverage)
Central Region LCA (1999)	
LH 10, Lowland Hills – Fintry, Gargunnoch and Touch Hills	Yes, considered in the assessment
LH 11, Lowland Hills – Campsie Fells	Yes, considered in the assessment
LHF 14, Lowland Hill Fringes – Mugdock	No theoretical visibility, not considered further
LHF 15, Lowland Hill Fringes – East Touch Fringe	Very limited, no potential for significant effects, not considered further
LHF 17, Lowland Hill Fringes – Denny Muir	Very limited, no potential for significant effects, not considered further
LP 18, Lowland Plateaux – Kippen Muir	Yes, considered in the assessment
LRV 20, Lowland River Valleys – Teith	No theoretical visibility, not considered further
LRV 21, Lowland River Valleys – Carse of Forth	No theoretical visibility, not considered further
LRV 23, Lowland River Valleys – Lower Devon Carselands	No theoretical visibility, not considered further
LRV 25, Lowland River Valleys – Strath Blane	No theoretical visibility, not considered further
LRV 26, Lowland River Valleys – Endrick Water/Blane Water	No theoretical visibility, not considered further
LRV 27, Lowland River Valleys – Middle Endrick Water	No theoretical visibility, not considered further
LRV 28, Lowland River Valleys – Upper Carron	Yes, considered in the assessment
LRV 29, Lowland River Valleys – Middle Carron	No theoretical visibility, not considered further
LRV 30, Lowland River Valleys – Falkirk/Denny Urban Fringe	No theoretical visibility, not considered further
LRV 31, Lowland Valley Fringes – Forth/Teith	No theoretical visibility, not considered further
LRV 32, Lowland Valley Fringes – Teith/Forth/Allan	No theoretical visibility, not considered further

Landscape Character Type ¹	Theoretical visibility of Development (ZTV coverage)
LRV 34, Lowland Valley Fringes –Forth/ Kippen Muir	Very limited, no potential for significant effects, not considered further
Glasgow and the Clyde Valley LCA (1999)	
1, Raised Beach	No theoretical visibility, not considered further
2, Floodplain	No theoretical visibility, not considered further
3, Urban Greenspace	No theoretical visibility, not considered further
4, Rolling Farmland	No theoretical visibility, not considered further
5, Plateau Farmland	No theoretical visibility, not considered further
6, Rugged Upland Farmland	No theoretical visibility, not considered further
7, Fragmented Farmland	No theoretical visibility, not considered further
8, Incised River Valleys	No theoretical visibility, not considered further
9, Green Corridors	No theoretical visibility, not considered further
10, Broad Valley Lowland	No theoretical visibility, not considered further
11, Broad Urban Valley	No theoretical visibility, not considered further
12, Upland River Valleys	No theoretical visibility, not considered further
16, Drumlin Foothills	No theoretical visibility, not considered further
18, Plateau Moorlands	Very Limited, no potential for significant effects, as beyond 15km, not considered further
20, Rugged Moorland Hills	Yes, considered in the assessment
Loch Lomond and the Trossachs National Park LCA (2009)	
Rolling Farmland with Estates	Yes, but a very limited area over 10km away
Moss Farmland with Estates	Yes, but a very limited area over 10km away
Natural and Restored Moss	Yes, but a very limited area over 10km away
Forested Moorland	Yes, but a very limited area over 10km away
Loch Island	Yes, but a very limited area over 10km away
Lowland Lochs	Yes, but a very limited area over 10km away
Stirling Proposed SPG (2012)	
L2-L3, Flat Valley Floor	Yes, considered in the assessment
L6-L7, Rolling Valley Farmland	Yes, considered in the assessment
L14, Farmed Valley or Hill Fringe	Yes, considered in the assessment
L21, Lowland Valley Fringes	No theoretical visibility, not considered further

¹ Codes used are those published in the source Landscape Character Assessments

Landscape Character Type ¹	Theoretical visibility of Development (ZTV coverage)
Tayside (1999)	
1b, Mid Highland Glens	No theoretical visibility, not considered further
1c, Lower Highland Glens	No theoretical visibility, not considered further
3, Highland Summits and Plateaux	Very Limited, no potential for significant effects, as beyond 15km, not considered further
6, Lowland Hills	Very Limited, no potential for significant effects, as beyond 15km, not considered further
8. Igneous Hills	No theoretical visibility, not considered further
10, Broad Valley Lowland	No theoretical visibility, not considered further
15, Lowland Loch Basin	No theoretical visibility, not considered further
Argyll and the Firth of Clyde (1996)	
5, Open Ridgeland	No theoretical visibility, not considered further
13, Rolling Farmland with Estates	No theoretical visibility, not considered further
Lothians (1998)	
4, Lowland Hills and Ridges	Very Limited, no potential for significant effects, as beyond 30km, not considered further
5, Lowland Plateaux	Very Limited, no potential for significant effects, as beyond 30km, not considered further
7, Coastal Margins	Very Limited, no potential for significant effects, as beyond 30 km, not considered further
Fife (1999)	
5, Lowland Hills and Valleys	No theoretical visibility, not considered further
11, Coastal Hills	No theoretical visibility, not considered further
4, Coastal Braes	No theoretical visibility, not considered further
15, Coastal Flats	No theoretical visibility, not considered further

6.3 There is a gap in the SNH dataset for LCTs, where the boundaries of LCAs do not meet. This area extends from the National Park boundary to Thornhill, Kippen Station and along the A811 to Balfron Station and part way to Drymen. This area is covered by the draft LCA contained in Stirling Council's unapproved SPG¹. For this assessment, the following LCTs contained in the draft SPG are used:

- Flat Valley Floor:
 - L2, Carse West of Stirling – ZTV coverage;
 - L3, Flanders Moss West – ZTV coverage;
- Rolling Valley Farmland:
 - L6, Dyke Head – ZTV coverage;
 - L7, Garden/Gartinstarry – No ZTV coverage, not considered further;
- Farmed Valley or Hill Fringe:
 - L14, Forth/Teith Valley Fringe – ZTV coverage;

- Moorland Hill Fringe:
 - L21, Bat a'Charchel – No ZTV coverage, not considered further.

Key characteristics of the LCTs

6.4 The LCTs taken forward to assessment are described in **Appendix Table 6.2: Key Characteristics of Landscape Character Types within 15km of the site.**

Appendix Table 6.2: Key Characteristics of Landscape Character Types within 15km of the site²

LCT	Key Characteristics	Sensitivity
Central Region LCA		
Lowland Hills - 10, Fintry, Gargunnoch and Touch Hills - 11, Campsie Fells	<ul style="list-style-type: none"> • Rounded hill plateaux, unity of the hills is accentuated by encircling and enclosing river valleys • Northern and western edges of the hills are dramatically defined by steep, precipitous slopes, topped by exposed rock • Rolling expanses of uninterrupted grass and heather moorland • Hill tops seem remote, emphasised by the simple expanse of moorland and general lack of human influence • Sweeping views of the carselands and the hills to the north can be obtained from higher ground • Less unified as Touch Hills drop down towards the east • Small to medium reservoirs in hills with forestry plantations • Few dwellings 	<ul style="list-style-type: none"> • The hills form distinctive skylines when viewed from the north • Earlsburn and Craigengelt Wind Farms exist within the LCT • Covered by local designations <p>Sensitivity is judged to be medium</p>
Lowland Plateaux - 18, Kippen Muir	<ul style="list-style-type: none"> • Gently rolling plateau of Kippen, Buchlyvie and Ballindalloch Muirs stretches north-westwards from the fringes of the Fintry Hills • Mosaic of heather and grass moorland is the dominant land cover • An intermediate landscape 	<ul style="list-style-type: none"> • Simple landform that does not form distinctive skylines • Not designated <p>Sensitivity is judged to be low</p>
Lowland River Valleys - 28, Upper Carron	<ul style="list-style-type: none"> • Dominated by Carron Valley Reservoir • Enclosed by hills covered in coniferous plantations • Few houses and farmsteads • Forest walks are a popular recreational resource • The simple composition of water and afforested hillside, combined with a lack of settlement and the position of the reservoir within the hills, creates a moderately remote atmosphere 	<ul style="list-style-type: none"> • Reservoir enclosed by forested hills • Earlsburn and Craigengelt Wind Farms are present on the skyline • Covered by local designations, and of recreational value <p>Sensitivity is judged to be medium</p>

² Text in italics is quoted from relevant Landscape Character Assessment.

LCT	Key Characteristics	Sensitivity
Glasgow and the Clyde Valley LCA (referred to as Strathclyde 'STR') in the SNH dataset)		
20, Rugged Moorland Hills	<ul style="list-style-type: none"> "Distinctive upland character created by combination of the elevation, exposure, rugged landform, moorland vegetation and the predominant lack of modern development These areas share a sense of apparent naturalness and remoteness which contrasts strongly with the farmed and developed lowland areas Presence of archaeological sites on hilltops and sides" 	<p>"Particular concerns relate to windfarm development on these hills. The limited extent of the hills, their remote and apparently 'natural' character, and the sensitivity of their hill slopes and skylines, mean that it is very likely that a windfarm development in any of the three areas would have a significant and adverse effect on the local landscape character" (Page 209)</p> <p>The Development will not be located within this LCT, and the sensitivity to wind farms outside the LCT is judged to be medium</p>
Stirling Proposed SPG		
Flat Valley Floor - L2, Carse West of Stirling - L3, Flanders Moss West	<ul style="list-style-type: none"> L2: Area considered forms the westernmost end of the LCT, described as: <i>The broad, flat valley floor of the River Forth, known as the 'Carse of Forth' or 'Carse of Stirling', is in marked contrast to rising ground to the north and south and the volcanic crags of Stirling Castle, Craigforth and Abbey Craig rising abruptly from the plain in the east. The breadth of the valley floor, relative paucity of tree cover and panoramic views from within and across the carse, create a strong impression of an open, flat landscape despite the presence of the enclosing hills. This character area terminates in the west near Parks of Garden, where the valley floor narrows between deposits of glacial moraine</i> L3: <i>The Carse of Stirling narrows between deposits of glacial moraine near the Parks of Garden, but the flat valley floor opens out again to the west before terminating in the rising ground of Loch Ard Forest. Farmland on the eastern and southern margins of this area share characteristics with the carse further east, but elsewhere the poorer soils are unable to support such rich agriculture, commercial conifer woodland has a strong presence and there is a greater feeling of isolation.</i> 	<ul style="list-style-type: none"> Flat topography means that features are visible from surrounding higher ground Turbines and masts visible on the surrounding higher ground (present in backdrop) Not designated for landscape value, but Flanders Moss NNR is visited <p>Sensitivity to further development of surrounding skylines is judged to be medium</p>
Rolling Valley Farmland - L6, Dyke Head	<ul style="list-style-type: none"> A belt of glacial deposits on a north-south alignment cuts across the Carse of Stirling to the west of Flanders Moss National Nature Reserve. The River Forth has cut a way through these deposits near Parks of Garden, so that a narrow strip of flat land links the Carse West of Stirling and Flanders Moss West, with higher land to either side. The small but distinctive 	<ul style="list-style-type: none"> Undulating landform means that views are generally short and contained by landform and tree cover Turbines and masts visible on the surrounding higher ground (present in backdrop) Not designated <p>Sensitivity to development</p>

LCT	Key Characteristics	Sensitivity
	<p>landscape of Dykehead is the northern of the two areas of gently rolling farmland established on the remnant end moraines, lying east and south of the Lake of Menteith. In terms of landform, land cover and settlement history it differs markedly from the adjacent carselands</p>	<p>outside the LCT is judged to be low</p>
Farmed Valley or Hill Fringe - L14, Forth/Teith Valley Fringe	<ul style="list-style-type: none"> A broad spur of undulating land extending eastwards from the Menteith Hills separates the valley of the River Teith to the north from the wide Carse of Forth to the south. The south facing slopes of this spur comprise the Forth/Teith Farmed Valley Fringe, a broad tract of rolling farmland elevated above and generally sloping towards the Carse of Stirling. 	<ul style="list-style-type: none"> Low ridge forms an intermediate horizon in views north from the Carselands Not designated <p>The Development will not be located within this LCT, and the sensitivity to wind farms outside the LCT is judged to be low</p>

Landscape Designations

6.5 There are numerous designated landscapes across the 35km radius study area, as show on **Figure 6.5**. These are set out below in **Appendix Table 6.3: Designated Landscapes within 35km of the site:** and include:

- National Scenic Areas (NSAs);
- Special Landscape Areas (SLAs);
- Areas of Great Landscape Value (AGLVs);
- Regional Scenic Areas (RSAs);
- Sites of Special Landscape Importance (SSLIs);
- National Park;
- Country Parks.

Appendix Table 6.3: Designated Landscapes within 35km of the site

Designated Landscape	Theoretical visibility of Development (ZTV coverage)
National Designations	
Loch Lomond and the Trossachs National Park	Limited, implications considered in the assessment
Loch Lomond NSA	None, not considered further
Trossachs NSA	Very limited, implications considered in the assessment
River Earn NSA	None, not considered further
Regional/Local Designations	
Fintry, Gargunnock and Touch Hills AGLV ³ (Stirling)	Yes, implications considered in the assessment
Western Ochils AGLV ⁴ (Stirling)	Very limited, implications considered in the assessment

³ Will be replaced by the Southern Hills Local Landscape Area (LLA5) when emerging Local Development Plan is adopted.

⁴ Will be replaced by the Western Ochils Local Landscape Area (LLA3) when emerging Local Development Plan is adopted.

Designated Landscape	Theoretical visibility of Development (ZTV coverage)
Trossachs and Breadalbane AGLV (Stirling)	Very limited, not considered further (see implications of Loch Lomond and The Trossachs National Park)
Campsie Fells RSA (Glasgow and Clyde Valley Joint Structure Plan)	Limited, implications considered in the assessment
Kilsyth Hills RSA (Kilsyth Local Plan)	Yes, implications considered in the assessment
Kilpatrick Hills RSA (West Dunbartonshire)	None, not considered further
Denny Hills AGLV (Falkirk)	Very limited, not considered further
Ochil Hills AGLV (Clackmannanshire)	Limited, implications considered in the assessment
Gartmorn AGLV (Clackmannanshire)	None, not considered further
River Devon AGLV (Perth & Kinross)	None, not considered further
Slamannan Plateau AGLV (Falkirk)	Very limited, not considered further
Avon Valley AGLV (Falkirk)	None, not considered further
Bo-ness AGLV (Falkirk)	Yes, but over 30km away, not considered further
Cleish Hills AGLV	None, not considered further
Upper Forth SLA	None, not considered further
Lower Clyde and Calderglen SLA	None, not considered further
Middle Clyde Valley	None, not considered further
Other Designations (which include landscape or scenic value as part of the reasons for designation)	
Balloch Castle Country Park	None, not considered further
Calder Glen Country Park	None, not considered further
Drumpellier Country Park	None, not considered further
Gartmorn Country Park	None, not considered further
Gleniffer Braes Country Park	None, not considered further
Mugdock Country Park	None, not considered further
Muiravonside Country Park	None, not considered further
Palacerigg Country Park	None, not considered further
Polkemmet Country Park	None, not considered further
Pollock Country Park	None, not considered further
Strathclyde Country Park	None, not considered further
Plean Country Park	None, not considered further
Cathkin Braes Country Park	None, not considered further
Dams to Darnley Country Park	None, not considered further

ⁱ Stirling Council. (2012). Proposed Supplementary Guidance SG28: Landscape Character Assessment.

Appendix 6.2: Visualisation Methodology

Appendix 6.2: Visualisation Methodology

Introduction

- 6.1 This Appendix sets out the approach to the production of visualisation which accompany the Landscape and Visual Impact Assessment (LVIA) and Cumulative Landscape and Visual Impact Assessment (CLVIA).

Visualisations and Modelling

Zone of Theoretical Visibility (ZTV) Mapping

- 6.2 Evaluation of the theoretical extent to which the wind farm would be visible across the study area was undertaken by establishing a Zone of Theoretical Visibility (ZTV) using specific computer software designed to calculate the theoretical intervisibility between the wind farm and its surroundings. ReSoft Windfarm© and Arcmap© GIS software was used to generate the ZTV. These programmes calculate areas from which the turbines are potentially visible. This is performed on a 'bare ground' computer generated terrain model, which does not take account of potential screening by buildings or vegetation. The model uses a 50m x 50m grid which means that the computer calculates the number of turbines visible from the centre point of each 50m x 50m square. It should be noted that the programmes use point height data, rather than continuous data, and assumes straight line topography between data points, and is therefore not able to take account of small scale topographic features. As it uses a 'bare ground' model, it is considered to over emphasise the extent of potential visibility of the wind farm and therefore represents a 'maximum potential visibility' scenario.
- 6.3 The ZTV was calculated to show the number of turbines visible to blade tip or hub height. The ZTV calculated to blade tip height is shown in **Figure 6.1** and **Figure 6.1a-i**, the hub height ZTV is shown in **Figure 6.2**. Subsequent figures make use of the ZTV to tip height.
- 6.4 Cumulative Zones of Theoretical Visibility (CZTVs) are used to show the number of wind farms (rather than the number of turbines) visible, and are constructed to illustrate the combined visibility of the Development with other wind farms considered in the CLVIA. The ZTV to tip height of each wind farm was generated in accordance with SNH guidanceⁱ, and then combined with the Development ZTV (35km radius). Combined CZTVs were set up to show the number of wind farms (rather than the number of turbines) visible. The combined CZTVs were colour coded to distinguish between areas where the Development is predicted to be visible (either on its own, or in conjunction with a number of other wind farms), and areas where other wind farms would be visible but the Development would not. The CZTVs do not identify which other wind farms would be visible.
- 6.5 Paired CZTVs were constructed to illustrate the combined visibility of the Development with other specific wind farms within 20km and highlight key cumulative relationships between the proposed Development and other wind farms which were considered likely to occur. The ZTV to tip height of each wind farm was generated in accordance with SNH guidance, and then paired with the Development ZTV (35 km radius). The paired CZTV was set up to show where each wind farm within the indicated paired CZTV would be visible. Paired CZTVs were colour coded to distinguish between the Development and each individual wind farm, indicating where the Development is predicted to be visible (either on its own, or in conjunction with other specific wind farms included within the paired CZTV), and areas where each other wind farm would be visible but the Development would not.

Viewpoint Photography

- 6.6 Photographs were taken by LUC during 2012, following good practice guidelines.
- 6.7 The camera LUC used for the photography was a Nikon D700 Full frame sensor digital SLR with a fixed 50mm focal length lens. The methodology for photography is in accordance with guidance from the Landscape Institute regarding photographyⁱⁱ. The focal length used is in accordance with recommendations contained in guidance.
- 6.8 A tripod with vertical and horizontal spirit levels was used to provide stability and to ensure a level set of adjoining images. A panoramic head was used to ensure the camera rotated about the no-parallax point

of the lens in order to eliminate parallax errors between the successive images and enable accurate stitching of the images. The camera was moved through increments of 15 degrees and rotated through a full 360 degrees at each viewpoint. Twenty four photographs were taken for each 360 degree view.

- 6.9 The location of each viewpoint and information about the conditions was recorded in the field in accordance with SNH and Landscape Institute guidance.
- 6.10 Weather conditions and visibility were considered an important aspect of the field visits for the photography. Where possible, visits were planned around clear days with good visibility. Viewpoint locations were visited at times of day to ensure, as far as possible, that the sun lit the scene from behind, or to one side of the photographer. South facing viewpoints can present problems particularly in winter when the sun is low in the sky. Photographs facing into the sun were avoided where possible to prevent the wind turbines appearing as silhouettes.

Photograph Stitching, Wireframes and Photomontages

- 6.11 Photograph stitching software (The Panorama Factory©) was used to stitch together the adjoining images.
- 6.12 The software package ReSoft© Wind Farm version 4.2 was used to view the wind farm from selected viewpoints in wireframe format. OS Landform Panorama data (equivalent to 1:50,000 scale mapping with 10m contour intervals) was used to model the landform seen in the wireframe view. Turbine locations, type and size, and viewpoint location coordinates were entered. Photomontages have been constructed to show the candidate turbine with the specified tip height, hub height and rotor diameter. The ReSoft© software includes a default viewer height of 2m above ground level. The pre-prepared 90 degree photos were imported into the ReSoft© software and the wireframe views overlaid onto the photographs.
- 6.13 The presentation of fully rendered photomontages involved a number of additional stages as follows.
- 6.14 The ReSoft© software was used to render the turbines, taking account of the sunlight conditions and the position of the sun in the sky at the time the photograph was taken. Blade angle and orientation adjustments were also made to represent a realistic situation¹. Fixed features on the ground, for example buildings and roads, were located in the wireframe model and used as markers to help line up the wireframe ground model with the photograph.
- 6.15 The final stage required the rendered turbines to be blended into the actual view. This was carried out using Photoshop© software and allowed the turbines to be located behind foreground elements that appeared in the original photograph.
- 6.16 Adjustments to lighting of the turbines were made in the rendering software to make the turbines appear realistic in the view under the particular lighting and atmospheric conditions present at that time.
- 6.17 Autodesk AutoCAD© software was used to present the figures. For each view the first figure page shows a location plan indicating the viewpoint location and view direction. To provide context for the actual photomontage, the second figure page presents an original photograph from the viewpoint above a wireframe image, both above a photomontage, and all showing 90 degrees (included angle) of view. The third figure page contains a 50 degree wireframe and 50 degree photograph, at image heights and viewing distances above the minimum recommended by SNHⁱⁱⁱ. The fourth figure page shows a photomontage only, at 50 degrees included angle of view. Cumulative wireframes representing the CLVIA are included for 11 of the 15 assessment viewpoints (Viewpoints 1-10 and 12). Each cumulative wireframe is shown at 90 degree included angle, with multiple wireframes where views in other directions are required to illustrate wind farms theoretically visible. Three additional cumulative photomontages showing 90 degrees (included angle) of view and 50 degrees (included angle) of view are also included for three of the assessment viewpoints (Viewpoints 5, 7 and 8).

ⁱ Scottish Natural Heritage (SNH). (2006). Visual Representation of Windfarms: Good Practice Guidance.

ⁱⁱ Landscape Institute. (2011). Practice Advice Note, Photography and photomontage in landscape and visual impact assessment. Advice Note 01/11.

ⁱⁱⁱ SNH. (2006). Visual Representation of Windfarms. pages 72-75.

¹ The depicted rotation of the blades in wireframes was set with one blade vertically upwards to illustrate full tip height, but was set at random for photomontages to represent a more realistic image. The orientation of rotors was set to be perpendicular to the direction of view at the centre of the wind farm for wireframes. For photomontages, the orientation of the rotors was set as for the wireframes (perpendicular to the centred direction of view), except where there were other operational wind farms in the view, in which case rotor orientation was set to mimic the orientation of the existing turbines, and therefore the wind direction at the time of photography.

Appendix 7.1: Noise Prediction Methodology

Appendix 7.1 – Noise Prediction Methodology

Noise Prediction Methodology

Noise predictions were carried out using International Standard ISO 9613, *Acoustics – Attenuation of Sound During Propagation Outdoors* (ISO 9613-2). The propagation model described in Part 2 of this standard provides for the prediction of sound pressure levels based on either short-term downwind (i.e. worst case) conditions or long-term overall averages. Only the downwind condition has been considered in this assessment; that is, for wind blowing from the proposed turbines towards the nearby houses. When the wind is blowing in the opposite direction noise levels will be significantly lower, especially if there is any shielding between the site and the houses.

- 1.1 The ISO propagation model calculates the predicted sound pressure level by taking the source sound power level for each turbine in separate octave bands and subtracting a number of attenuation factors according to the following:

$$\text{Predicted Octave Band Noise Level} = L_w + D - A_{geo} - A_{atm} - A_{gr} - A_{bar} - A_{misc}$$

These terms are defined below.

- 1.2 The predicted octave band levels from each of the turbines are summed together to give the overall 'A' weighted predicted sound level from all the turbines acting together. These factors are discussed in detail below.

L_w - Source Sound Power Level

- 1.3 The sound power level of a noise source is normally expressed in dB re: 1pW. Noise predictions have been based on warranted sound power levels the Vestas V90 3 MW wind turbine as candidate model with a hub height of 80m. The noise levels for different wind speeds are shown in Table 0.1. The Vestas V90 3MW turbine was chosen for the predictions as it represents a wind turbine that fits the dimensions of the scheme and has relatively high warranted sound levels. It should be noted that 2 dB has been added to the warranted noise levels to account for any uncertainty in the sources data. This turbine is considered to represent a realistic worst case scenario.

Table 0.1: V90 Turbine Warranted Sound Power Levels

Standardised 10 metre height Wind Speed (m/s)	Sound Power Level (dB L_{wd})
4	99.9
5	102.9
6	106.2
7	108.1
8	109.0
9	108.9
10	107.6
11	107.2
12	107.3

- 1.4 The noise spectrum used, shown in Table 0.2 below, has been taken from measurement of a Vestas V90 3MW turbine and have been normalised to the relevant overall noise level. They are shown for an overall sound power level of 109.0 dB L_{WA} .

Table 0.2: Turbine Octave Band Noise Data

Octave Band Centre Frequency (Hz)	Assumed Octave Band Levels (dB L_{Aeq})
63	95.8
125	98.2
250	101.6
500	102.7
1k	103.6
2k	99.7
4k	95.4
8k	87.8

D – Directivity factor

- 1.5 The directivity factor allows for an adjustment to be made where the sound radiated in the direction of interest is higher than that for which the sound power level is specified. In this case the sound power level is measured in a down-wind direction, corresponding to the worst case propagation conditions considered here and needs no further adjustment.

A_{geo} – Geometrical divergence

- 1.6 The geometrical divergence accounts for spherical spreading in the free-field from a point sound source resulting in attenuation depending on distance according to:

$$A_{geo} = 20 \times \log(d) + 11$$

where d = distance from the turbine

- 1.7 Each of the wind turbines may be considered as a point source beyond distances corresponding to one rotor diameter.

A_{atm} - Atmospheric absorption

- 1.8 Sound propagation through the atmosphere is attenuated by the conversion of the sound energy into heat. This attenuation is dependent on the temperature and relative humidity of the air through which the sound is travelling and is frequency dependent with increasing attenuation towards higher frequencies. The attenuation depends on distance according to:

$$A_{atm} = d \times \alpha$$

where d = distance from the turbine

α = atmospheric absorption coefficient in dB/m

- 1.9 Published values of ' α ' from ISO 9613 Part 1, corresponding to a temperature of 10°C and a relative humidity of 70%, have been used for these predictions. These are the values specified in the IoA GPG (*A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise*), which give relatively low levels of atmospheric attenuation, and subsequently worst case noise predictions as given in Table 0.3 below.

Table 0.3: Frequency Dependent Atmospheric Absorption Coefficients

Octave Band Centre Frequency (Hz)	Atmospheric Absorption Coefficient (dB/m)
63	0.00012
125	0.00041
250	0.00104
500	0.00193
1k	0.00366
2k	0.00966
4k	0.0328
8k	0.117

A_{gr} - Ground effect

1.10 Ground effect is the interference of sound reflected by the ground with the sound propagating directly from source to receiver. The prediction of ground effects is frequency dependant and inherently complex and depends on the source height, receiver height, propagation height between the source and receiver and the ground conditions. The ground conditions are described according to a variable G, which varies between 0 for 'hard' ground (includes paving, water, ice, concrete & any sites with low porosity) and 1 for 'soft' ground (includes ground covered by grass, trees or other vegetation). Predictions have been carried out using a source height corresponding to the proposed height of the turbine nacelle, a receiver height of 4 m and an assumed ground factor G = 0.5 for mixed ground. The IoA GPG states that use of G = 0.5 and a receptor height of 4 m should be used to predict the resultant turbine noise level at dwellings neighbouring a proposed development provided that an appropriate allowance for measurement uncertainty is accounted for within the stated source noise levels. Therefore, predictions in this report are based on G = 0.5 with a receptor height of 4 m and, due to the confidence associated with the use of the declared apparent sound power levels (or based on warranted noise level plus 2 dB), these predictions are considered to be conservative.

A_{bar} - Barrier attenuation

1.11 The effect of any barrier between the noise source and the receiver position is that noise will be reduced according to the relative heights of the source, receiver and barrier and the frequency spectrum of the noise. The barrier attenuations predicted by the ISO 9613 model have, however, been shown to be significantly greater than that measured in practice under downwind conditions. The results of a study of propagation of noise from wind farm sites carried out for ETSU concludes that an attenuation of just 2 dB(A) should be allowed where the direct line of site between the source and receiver is just interrupted and that 10 dB(A) should be allowed where a barrier lies within 5 m of a receiver and provides a significant interruption to the line of site. The GPG states that '*Topographic screening effects of the terrain (ISO 9631-2, Equation 2) should be limited to a reduction of no more than 2 dB, and then only if there is no direct line of sight between the highest point on the turbine rotor and the receiver location*'. There are no significant topographical barriers surrounding the proposed site. As a result, this has not been accounted for within the predictions.

A_{misc} - Miscellaneous other effects

1.12 ISO 9613 includes effects of propagation through foliage, industrial plants and housing as additional attenuation effects. These have not been included here and any such effects are unlikely to significantly reduce noise levels below those predicted.

Cumulative Noise Assessment Noise Data

1.13 Table 0.4 below shows the octave band noise data used in the noise predictions for the sites included in the cumulative noise assessment. The levels presented here have been normalised to the overall sound power level at a standardised 10 metre height wind speed of 8 m/s.

Table 0.4: Turbine Octave Band Noise Data

Octave Band Centre Frequency (Hz)	Assumed Octave Band Levels (dB L _{Aeq})			
	Earlsburn, Fintry Community Turbine	Earlsburn North, Craigengelt,	Carron Valley, Craigton and Spittalhil;	Balafark Farm
	Nordex N80	Nordex N90	Vestas V90 3MW	Endurance E-3120
63	92.0	90.3	95.8	72.2
125	98.6	94.1	98.2	80.6
250	99.4	100.3	101.6	85.6
500	97.2	102.3	102.7	84.5
1k	96.9	102.2	103.6	85.8
2k	96.0	99.7	99.7	88.7
4k	92.4	96.8	95.4	86.4
8k	84.5	86.9	87.8	73.4
Overall	105.3	108.0	109.0	93.7

Appendix 7.2: Calculation of Confidence Level

 Hayes McKenzie Partnership Ltd	Best Practice Guide for the use of Wind Turbine Noise Data	Public document
	Calculation of Confidence Level	Rev: 2 Date: 21/06/2012 Prepared: SB Approved: ARM/ MDH

Aim: Explain how to use wind turbine data based on measurement report(s), warranted or unwarranted data provided by the manufacturer.

Action: Contact wind turbine manufacturer and ask for as many turbine test reports in accordance with IEC 61400-11 [1] as available.

Calculate the K value in accordance with IEC 61400-14 [2] with the amount of measurement reports available. The methods are detailed in the order of preference.

How WT noise data are declared:

1. At least 3 measurement reports available

Check hub heights in measurement report. If they are for different hub heights, carry out a hub height conversion according to [2] Annex A first. Data can only be averaged for the same hub height unless it is the sound power level at rated power. Results suitable for deriving the declared sound power level need to have been obtained from measurements of the same wind turbine type with the same hub height and operational mode, and components from the same blade and gear-box manufacturer.

Declaration of apparent sound power level:

For wind turbines of the same type, tower (steel or concrete, tubular or lattice) and same hub height, the mean value is calculated with

$$\bar{L}_W = \frac{1}{n} \sum_{i=1}^n L_i \quad (1)$$

\bar{L}_W : mean sound power level of n measurement results on n individual wind turbines

n : number of individual measurement results

L_i : individual sound power level

The standard deviation of the average is calculated with equation (2).

$$s = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (L_i - \bar{L}_W)^2} \quad (2)$$

s : standard deviation

The standard deviation σ used for the declaration is determined by

$$\sigma = \sqrt{\frac{1+n}{n} (\sigma_R^2 + \sigma_P^2)} \quad (3)$$

σ : standard deviation of declaration

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σ_p : standard deviation of production (here $\sigma_p = s$)

σ_R : standard deviation of reproducibility (here $\sigma_R = 0.9$ dB)

An estimate of σ_R is 0.9 dB as suggested in [2], based on typical uncertainties given in [1] Annex D.

σ_p is taken to be equal to the standard deviation s .

Declared sound power level L_{Wd} :

$$L_{Wd} = \bar{L}_W + K = \bar{L}_W + 1.645 \cdot \sigma \quad (4)$$

L_{Wd} : declared sound power level

K : confidence level (using $K=1.645 \cdot \sigma$ represents a probability of 95% that results from sound power level measurements performed in accordance with [2] do not exceed the declared sound power level L_{Wd}).

($K=1.28 \cdot \sigma$ for a 90% probability)

Declaration of Tonality:

Results of the tonality assessment cannot be declared in the same way as the sound power level. Tonality and the frequency at which the tone occurs have to be reported for each measurement.

2. Only 1 or 2 measurement report(s) available

If only one or two measurement reports are available, the confidence level is estimated using the following procedure:

- a typical standard deviation of reproducibility of $\sigma_R = 0.9$ dB and
- an average maximum standard deviation of production of $\sigma_p = 1$ dB, derived from a number of calculations carried out under paragraph 1 above for various turbine types.
Using the average maximum standard deviation is a conservative assumption to allow for the uncertainty when there is only one or two measurement reports available. This value is subject to change if more measurement reports become available.

Thus it follows that:

$\sigma (n=1) = 1.9$ dB and $K(95\%) = 3.1$ dB

$\sigma (n=2) = 1.6$ dB and $K(95\%) = 2.7$ dB.

$K(95\%)$ is added to the measured sound power level as stated in the acoustic performance test.

Declaration of Tonality:

Results of the tonality assessment cannot be declared in the same way as the sound power level. Tonality and the frequency at which the tone occurs have to be reported for each measurement.

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3. **No measurement report available but Manufacturer's Warranty**

If warranted data is available, use the warranted data plus the uncertainty as declared by the manufacturer to allow for measurement uncertainty and production variability. In the absence of a statement about uncertainty, use 2 dB. This is to allow for the usual practice of a wind turbine manufacturer subtracting the measurement uncertainty from the measured sound power level when assessing compliance with the warranty.

4. **No measurement report available**

If no warranty is issued, use data supplied by the manufacturer for predictions plus an uncertainty margin of 3.1 dB as derived above, treating it as if one acoustic performance test is available.

Preferred Method:

To determine the declared sound power level it is preferred to use method 1. If an insufficient number of measurement reports are available, the further approach is detailed in the order of preference above.

Update:

-

Additional Information:

-

Reference:

- [1] BS EN 61400-11:2003 Incorporating Amendment A1:2006 -*Wind turbine generator systems - Part 11: Acoustic noise measurement techniques*, International Electrotechnical Commission
- [2] IEC/TS 61400-14:2005 *Wind turbine - Part 14: Declaration of apparent sound power level and tonality values*, International Electrotechnical Commission
- [3] pr EN 50376:2001 *Declaration of sound power level and tonality values of wind turbines*, European Committee for Electrotechnical Standardization

Appendix 8.1: Geology, Hydrology and Hydrogeology of the Wind Farm Area

Appendix 8.1: Geology, Hydrology and Hydrogeology of the Wind Farm Area

Diagram 8.1 Graph Illustrating Average Monthly Rainfall Data for Paisley (Met Office), Stirling and Callander Weather Stations

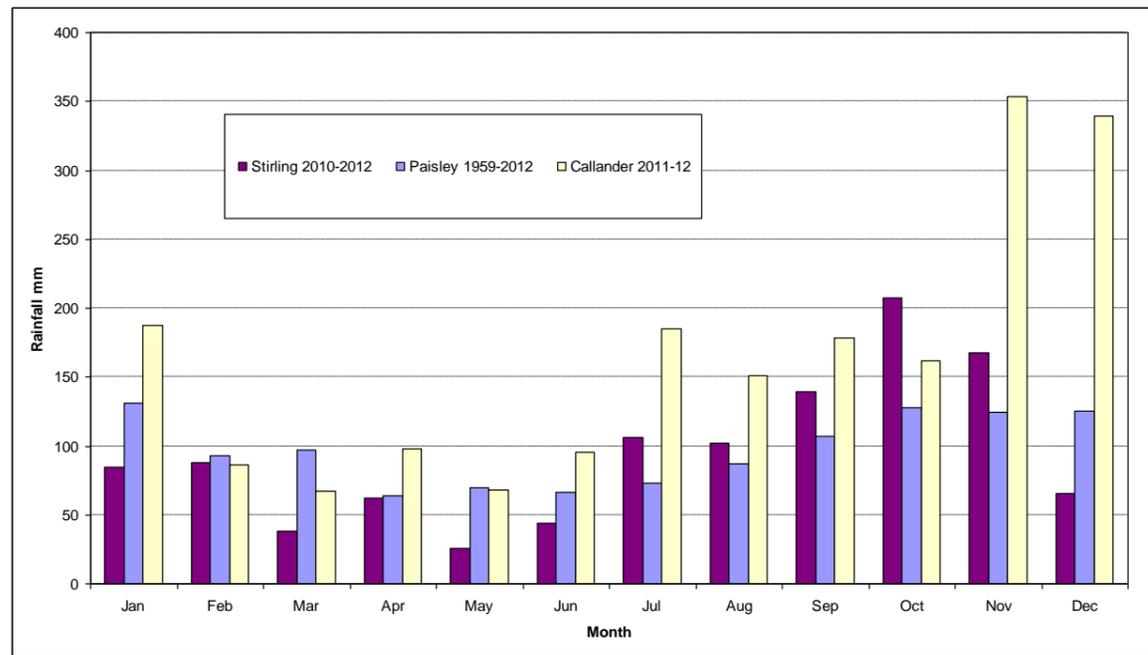


Diagram 8.2 Cross-section From Fintry Hill Ridge To Backside Burn (south-west to north east)

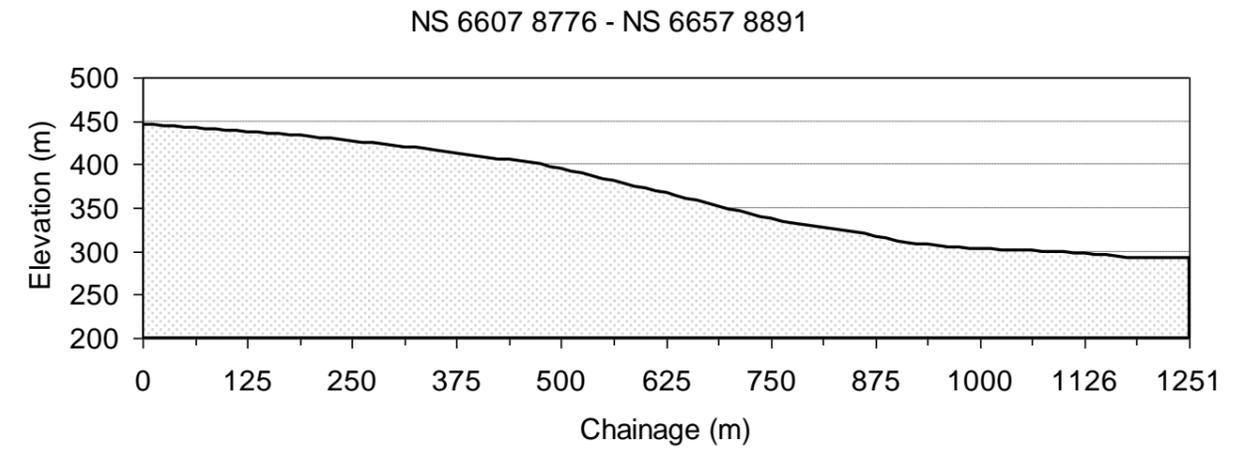
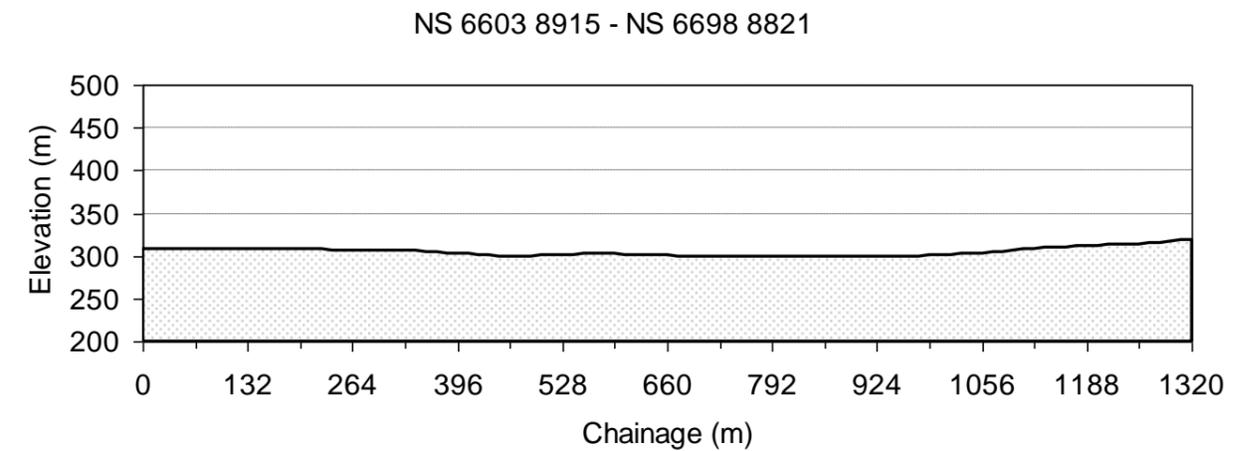


Diagram 8.3 Cross-section along Backside Burn valley side (north-west to south-east)



Photograph 8.1 Exposed solid geology, taken at NS 664 884



Photograph 8.3 Looking south-east, across the site from Backside Burn, taken at NS 660 892



Photograph 8.2 Looking north-west, across the site from lower slopes of the Fintry Hills, taken at NS 668 882



Photograph 8.4 Exposed soil horizons at stream bank, taken at NS 661 884, peat probe marked in 0.1m gradations for scale



Photograph 8.5 Backside Burn looking east and downstream, taken at NS 668 886



Photograph 8.7 Typical flush zone found onsite looking north-west and downstream, taken at NS 661 891



Photograph 8.6 Unnamed tributary of the Backside Burn, shown on OS 1:50,000 mapping, looking south-west and upstream to waterfall, taken at NS 661 886



Appendix 8.2: Peat Stability Assessment

Craigton and Spittalhill Wind Farm: Technical Appendix Peat Stability Assessment

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Laboratory Core Results

Appendix C GIS Images and Photographs for Identified Peat Stability Risk Areas

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1 Introduction

This report forms a Technical Appendix to Chapter 8 (Geology, Hydrology and Hydrogeology) of the Environmental Statement for Craigton and Spittalhill Wind Farm (Mouchel, 2013) and should be read with reference to this chapter.

Force9 Energy is currently progressing proposals for a 7 turbine wind farm north-east of Fintry, Stirlingshire. The proposed wind farm is located on an area of upland moorland on the northern slopes of the Fintry Hills, with the Backside Burn forming the northern site boundary. Access would be from the south east, linking to the existing access track for the operational Earlsburn Wind Farm, from which a new section of track would be constructed to give access to the proposed Craigton and Spittalhill site.

Mouchel was commissioned in 2012 to undertake a peat stability assessment for the Craigton and Spittalhill Wind Farm site, in conjunction with the soil and water element of the Environmental Impact Assessment.

This document presents Mouchel's method for initial peat stability assessment, the analyses performed and results obtained.

1.1 Aims

The aims of this Peat Stability Assessment are to:

- Undertake a review of available relevant site information;
- Undertake site survey work to characterise the prevailing ground conditions and identify existing or potential peat instability;
- Detail the findings of the above, reporting on any existing or potential instability, the likely causes and contributory factors;
- Assess the risk of instability; and
- Provide recommendations on further work, mitigation measures and specific construction methods that should be implemented pre-construction to minimise the risk of peat instability at the development site.

1.2 Method

The method adopted by Mouchel for the peat stability assessment of the Craigton and Spittalhill site has involved the following stages:

- Desk study;
- Site reconnaissance;
- Peat depth survey;
- Preliminary stability analysis;
- Ground investigation; and
- Mitigation.

Further detail on each of these stages is provided in the following sections.

Peat stability assessment work involved a phased approach, with initial findings feeding back into layout design and the Environmental Impact Assessment.

The desk study, site reconnaissance, preliminary peat depth survey and preliminary stability analysis were carried out in relation to the conceptual wind farm layout. Following the evaluation, recommendations on further work were made leading to additional peat probing and a revision to the wind farm layout. This document provides an assessment of the finalised layout, including suggested mitigation/good practice measures including provision of guidance relating to areas of potentially deep or unstable peat that should be avoided where practical.

2 Desk and Field Study

2.1 Information Sources

A desk study was undertaken, reviewing available information on the ground conditions at the Craigton and Spittalhill Wind Farm site. Sources included:

- Ordnance Survey digital raster mapping, 1:50,000 and 1:10,000 scale;
- Ordnance Survey Landform Profile 10m Digital Terrain Model (DTM) data (OS Open Data);
- Flash Earth satellite imagery;
- British Geological Survey DiGMap-GB 1:50,000 digital geological mapping, bedrock, superficial and linear geology;
- British Geological Survey Hydrogeological Map of Scotland, 1:625,000 scale;
- Soil Survey of Scotland 1:250,000 Sheet 6, mapping of soil types.

2.2 Context

The Craigton and Spittalhill site is located in the Fintry Hills, 4km north-east of Fintry, 15km south-west of Stirling. This is an upland moorland site with blanket peat evident and the current land use is rough grazing. The site is located on a north facing hillside, which is drained by the Backside Burn, one of the headwaters of the Endrick Water which flows into Loch Lomond.

2.3 Historical Information

There are no historical records of peat instability in the vicinity of the site. Small-scale slope failures were observed on and close to the site, in all cases these are considered to have been caused by the erosive processes of incised watercourses on steep slopes due to removal of slope support. These failures are more associated with underlying geology than peat.

2.4 Baseline Conditions

Baseline conditions at the wind farm site are discussed in detail within Chapter 8, Geology, Hydrology and Hydrogeology, of the Environmental Statement (Mouchel, 2013). This chapter should be referred to for this information.

2.5 Site Reconnaissance

Subsequent to the desk study, walkover and peat probing surveys were carried out between October 2012 and June 2013. These surveys focused on gaining a good overall understanding of the site and collecting peat depth data along track routes and at turbine locations, as were current at the time of each visit. The weather during the site visits was generally good, however the visit in December 2012 had a number of peat results annulled due to concern over frozen ground, with probe results at such locations removed from the dataset.

Figures 1 to 6 provide photographs and descriptive text of a representative sample of the wind farm site area, detailing the range of landforms, vegetation and erosion patterns encountered.

2.6 Peat Depth Survey

2.6.1 Fieldwork

The peat depth survey for Craigton and Spittalhill Wind Farm was undertaken in a number of phases. Initially, peat probing was undertaken in early October 2012 across the landholding to the north-east of Spittalhill Farm, to gather a representative dataset for peat depths on steep slopes, gentle slopes, stream valleys and the Backside Burn's wide valley base. The client provided provisional turbine coordinates which were also probed.

Following data gathering and processing of the peat depths results, areas of deeper peat were identified and initial observations relating to peat stability were made (using the factor of safety technique detailed later in this report but with the abbreviated dataset available at this stage).

Following this feedback, plus input from other disciplines, a number of small changes were suggested for the design. The site was revisited in late October 2012 and further data gathered to refine our knowledge of conditions in specific areas, with this information fed into the final design.

Upon provision of the final design, the complete layout was reviewed to identify locations where further data was required, the finalised turbine, track, crane hardstanding, compound, met mast and control building locations were then visited in mid-June 2013. The tracks were probed at 50m intervals, with 2 sets of parallel routes either side of the track centreline probed to identify any variability in peat depths. Turbines were probed on a 30m x 30m grid pattern, originating from the centre point probe, with probes 15m N, S, E, W plus NE, NW, SE, SW for a total of 9 records. Hardstanding areas were also probed to give representative data at each. During this visit peat probe records were also gathered at locations highlighted as potentially unstable, both at locations of planned infrastructure and further removed, within the site boundary.

Note that more limited data is available for the area south east of T7, where it is intended to connect the Craigton and Spittalhill Wind Farm to Earlsburn Wind Farm's existing access track. This was due to access restrictions, with permission granted to visit during early December 2012. The limited data held for this area is considered representative, with consistent peat depths on this slope, with probing approximately every 50m.

The peat depths were initially measured using two 2m long, 12mm diameter steel rods, connected together into a 4m length where necessary and marked in 0.1 m intervals. This equipment was superseded in April 2013 with Van Valt peat probing rods, consisting of multiple connecting 0.94m fibreglass sections, with depths measured via tape measure to an accuracy of $\pm 0.05\text{m}$. The rods were pushed into the ground until they could be pushed no further, when the depth was recorded. There were 620 peat depths recorded on the site, no results exceeded the depth of peat probes, with the deepest record being 2.6m, located on the low lying ground close to the Backside Burn.

Figure 1. Looking north-west across the site, from T7 area



NGR: NS 6687 8814

View north-west across the site from 350m AOD, south and above T7.

The site is within a single valley, on the northern slopes of the Fintry Hills and including the valley floor south of the Backside Burn, which forms the northern boundary.

Steeper slopes shallow out to a wide valley floor. This upper area has very limited peat or soil deposits with occasional bedrock outcrop.

The vegetation on the slopes is generally a short grassy sward, grazed by sheep, with isolated areas of heather.

Figure 2. Typical bedrock outcrop on slope



NGR: NS 6632 8827

At an altitude of between 340m-400m AOD on the north-facing slope of the Fintry Hills, numerous exposures of bedrock are evident on the site.

The intended borrow pit will be placed in such a location to minimise over-burden above rock, which tends to be 0.5m and primarily boulder clay and glacial till.

Figure 3. Exposed peat bank at top of slope



NGR: NS 6621 8831

Exposed peat bank towards top of slope, at 385m AOD.

This eroded peat bank shows approximately 0.4m of peat, overlying boulder clay and glacial till material.

This situation is considered typical, based on depth records and a number of exposures on the slopes of the site.

Figure 4. Small gorge on unnamed site stream, looking south-west



NGR: NS 6613 8869

This small stream has a misfit gorge, located west of T5. This feature is likely to be due to a change in underlying geological conditions leading to increased erosion. This was the only gorge within the site, atypical of local stream morphology on the site. However, similar features were identified on the southern slopes of the Fintry Hills.

Bedrock is exposed at the surface in this area at 330m AOD.

Figure 5. Small watercourse channels, looking south-west



NGR: NS 6612 8899

There are a number of small streams formed on the steeper slopes, when reaching shallower slopes these often have been straightened, particularly in the more waterlogged floodplain area prior to meeting the Backside Burn.

The artificial and modified channels show no signs of recent maintenance or repair work, with many moss-filled.

Vegetation at the lower level is dominated by tall sedges. Heather rarely occurs on the Backside Burn floodplain. Mosses are found in the mid-level flush zones where the steeper slopes level off. Photograph taken on the floodplain at 310m AOD.

Figure 6. Exposed stream bank in flood plain



NGR: NS 6643 8883

Exposed stream bank, unnamed stream on Backside Burn floodplain, at 300m AOD.

Showing peat depth of approximately 0.4m, overlying deeper boulder clay layer, down to a mineral soil layer at approximately 2m below ground level.

This exposure is due to water erosion.

The underlying substrate can be estimated from the feel of the rod reaching total depth; for example, the rod suddenly hitting a solid surface with a ringing sensation would suggest bedrock, a 'gritty' feel at total depth suggests sandy or gravelly material, and a gradually increasing difficulty in pushing in the rod suggests clayey material underlying the peat.

The collected data from the initial peat probing survey are summarised in Table 1, 82% of the 620 points probed had a peat depth result of less than 1.0m, with 93% of the results less than 1.5m. The peat probing results are displayed on Figure PS01 (PS01a and PS01b – Appendix A). Locations with deeper peat tend to coincide with flat valley floors and plateaux with low slope angles, generally around watercourse headwater areas. No peat haggling or peat erosion was noted on the site or adjacent areas. Much of the site is confirmed to have generally shallow peat, generally becoming deeper on the shallow sloping, lower altitude ground approaching the Backside Burn. The peat probing results also serve to demonstrate that peat depths can vary substantially over very short distances at the base of the steeper slope and peat deeper than 2m is very localised.

It is considered that the depth probed often included entry into clay material underlying surface peat, particularly on steeper sloping ground, therefore our results (which include clay depth) are likely to be over-estimates of peat depth, leading to conservative depth and subsequent stability estimations.

Table 1. Results of peat probing survey

Peat Depth Range (m)	No. of Points	% of Points	Average depth in range (m)
<0.5	358	57.7	0.27
0.5 to <1.0	151	24.4	0.65
1.0 to <1.5	67	10.8	1.21
1.5 to <2.5	43	6.9	1.79
2.5 to <4.0	1	0.2	2.56
4.0 +	0	0.0	-
Total	620	100	0.57

2.6.2 Indicative Peat Depth Mapping

The use of a regular grid for terrain analyses of this type is a standard recognised GIS technique and is widely applied in a range of situations. A grid system allows the application of a systematic process across the landscape, where a set of relevant properties need to be assigned to each particular location. In this analysis, these properties include slope angle and peat depth.

The resolution of DTM and base mapping must be taken into account, as using a very fine grid with a resolution identical to or finer than the DTM will return spurious results with a false indication of accuracy. For Craigton and Spittalhill Wind Farm a 50m grid was used in line with Mouchel's standard peat stability analysis method as this is a fine enough scale to provide an appropriate level of detail for analysis but also sufficiently large to gain meaningful results from the 10m resolution DTM and derived slope model.

To inform the refinement of the infrastructure layout, the results of the initial peat probing survey were used to produce an extrapolated indicative peat depth map for the study area. A grid of 50m x 50m cells was overlaid across the site and a peat depth range assigned to each. The peat depth ranges used are detailed in Table 2.

Table 2. Indicative peat depth categories

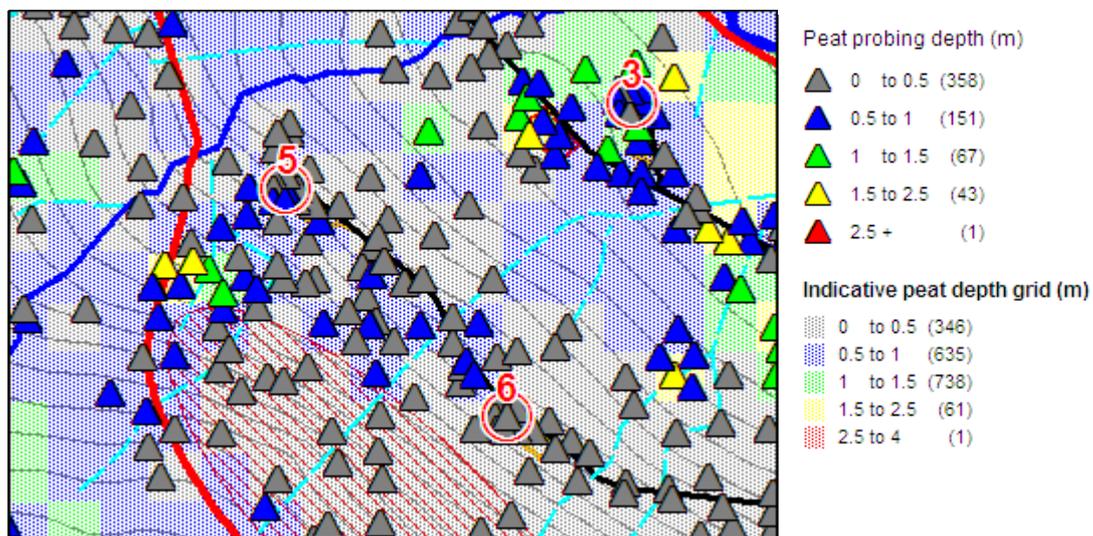
Peat Depth Range (m)	Peat Depth Category Number	Peat Depth Category
<0.5	1	No Peat
0.5 to <1.0	2	Shallow
1.0 to <1.5	3	Moderate
1.5 to <2.5	4	Deep
2.5 +	5	Very Deep

Blanket peat tends to form in areas with high rainfall and low temperatures. In the Scottish context, blanket peat can be 5m or more in thickness, especially in hollows or valleys, but is generally not much more than 3m deep and often much less. Peat depth category names and ranges were chosen in the context of wind farm construction; for example, the cut-off between cut-and-fill and floating track construction is typically around 1.0m or 1.5m peat depth. Equally, the practicalities of constructing turbine foundations in peat more than 2.5m deep makes this a less attractive option. The cut-off for very shallow peat of 0.5m is based on the Soil Survey of Scotland definition (MLURI, 1982), as used in the Scottish Government guidelines (Scottish Executive, 2006).

Figure 7 shows an enlarged portion of the peat depth mapping. Each cell is 50m x 50m with areas of no peat coloured grey, shallow peat coloured blue, moderate depth peat coloured green, deep peat in yellow and very deep peat coloured red. This section of map does not include any areas of very deep peat.

The full indicative peat depth map is included in Drawing PS01 (Appendix A).

Figure 7. Sample of indicative peat depth map, also showing infrastructure and watercourses



From observation it is clear that both slope and elevation have an influence on the development of peat, although the exact mechanism is not well understood and there is no mathematical growth/decay model for the development and depth of peat. However, slope and elevation factors may be used intuitively when extrapolating from peat sampling data in the creation of an indicative peat depth map. It can be seen that the deeper peat is to be found in flatter areas such as valleys, plateaux and hollows. Flat areas on hill summits tend to have relatively little peat; this is possibly due to a combination of exposure and slow growth rate as well as better

drainage. Steep slopes also generally have less peat, owing for the most part to their better drainage and more rapid runoff.

As can be seen from Figure 7 and Drawing PS01, where a cluster of peat probing points is all within the same peat depth category this has been taken as a good indication of the general peat depth in the surrounding area and the indicative peat depth map has been coloured accordingly. However, where clusters of peat probing points have returned depths in a wide range of depth categories a cautious approach has been taken, with the indicative peat depth map being classified in line with the deepest category of peat found in the area. This leads to a conservative indicative peat depth map. The peat depth category breakdown for both the actual probing data and the extrapolated grid is given in Table 3.

Table 3. Peat depth category breakdown

Peat Depth Category (m)		<0.5	0.5 - <1.0	1.0 - <1.5	1.5 - <2.5	2.5 +	Total
Actual Probing Data	No. of points	358	151	67	43	1	620
	% of points	57.7	24.4	10.8	6.9	0.2	100
Indicative Peat Depth Grid	No. of cells	346	635	738	61	1	1781
	% of cells	19.4	35.7	41.4	3.4	0.1	100

The initial indicative peat depth map was used to inform the design of the wind farm layout. The areas identified as having deep peat were avoided as far as practicable for placing new infrastructure.

2.7 Preliminary Stability Analysis

Using the collated data a preliminary analysis of slope stability can be carried out using the infinite slope model. The stability of a slope can be assessed by calculating the factor of safety F which is the ratio of the sum of resisting forces (shear strength) and the sum of the destabilising forces (shear strength):

$$F = \frac{c' + (\gamma - m\gamma_w)z \cos^2 \beta \tan \phi'}{\gamma z \sin \beta \cos \beta}$$

Where c' is the effective cohesion, γ is the unit weight of saturated peat, γ_w is the unit weight of water, m is the height of the water table as a fraction of the peat depth, z is the peat depth in the direction of normal stress, β is the angle of the slope to the horizontal and ϕ' is the effective angle of internal friction.

The Factor of Safety (FoS), F , represents the ratio of the forces resisting a slide to the forces causing the material to slide. Clearly, if $F > 1$ then the slope is stable and normally if $F > 1.4$ then there is a degree of comfort that the slope will not fail. The boundary value of 1.4 is in agreement with the current recommendations of Eurocode 7 (BSI, 2004 & 2007).

To get an indication of the stability of the peat at the proposed wind farm infrastructure locations, the factor of safety can be calculated for each peat probing location. In addition, to gain a better view of peat stability in the areas surrounding the infrastructure, factor of safety calculations can be carried out for the grid cells of the indicative peat depth map in the vicinity of the infrastructure.

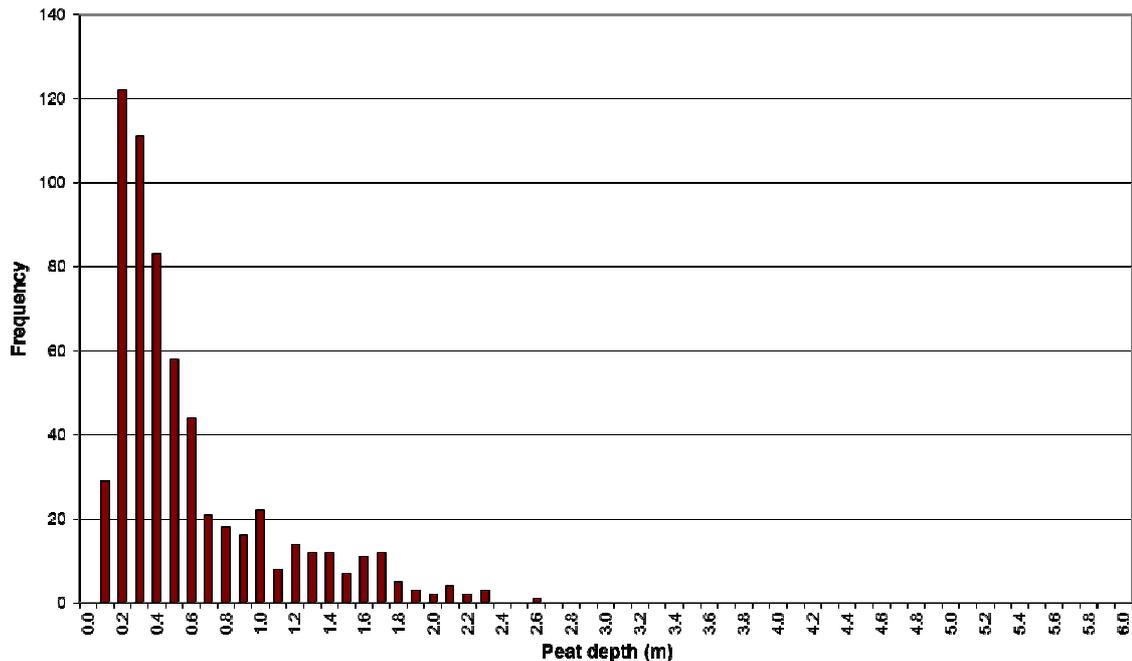
In order to do this we must know, or be able reasonably to, infer the parameters for the FoS equation for each probing location and grid cell under construction.

The slope angle, β , can be derived from the DTM for the site. With the peat probing locations, a single slope angle value is generated for each point, whilst the DTM is interrogated for

maximum, minimum and average slope values for each grid cell. The average slope angle has been used in the grid FoS calculations, although the other statistics provide useful supporting information on the variability of slope within the cells.

The actual peat depth measurements recorded for each probing location are used in calculating the point FoS values. For the grid-based FoS assessment it is necessary to convert the indicative peat depth ranges into a specific figure for each range for use within the calculation. Taking a conservative approach, the upper bound of each range has been used, where actual data is not held. Measured peat depths are presented as a histogram in Figure 8.

Figure 8. Peat depth histogram



The unit weight of water, γ_w , is known to be 1.0 Mg/m^3 .

The bulk density of peat is known to vary with the level of decomposition. A literature review has found quoted *in situ* undrained bulk densities ranging from 0.5 to 1.4 Mg/m^3 . Laboratory analyses undertaken on samples collected by or on behalf of Mouchel have returned bulk density values between 0.8 and 1.4 , with an average of 1.2 Mg/m^3 over a range of Scottish peatland sites. This average bulk density has been used in the preliminary FoS calculations.

If it is assumed that the site is covered with active blanket bog, it follows that the peat must be completely saturated, with a water table at or close to the surface. On-site observations indicate that this assumption is only valid for lower-lying parts of the site close to the Backside Burn, where ground conditions were fairly wet underfoot. Consequently, a water table ratio, m , of 1.0 has been chosen, which is considered conservative given most of the site exhibits drier conditions.

The angle of internal friction in peat also varies, decreasing with increasing decomposition and moisture content. In some instances, although not at this site, 'quaking bog' has been observed where the peat takes the form of a slurry beneath a surface mat of vegetation. In such a situation the angle of internal friction will be very low. For the FoS calculations, a ϕ' value of 5° has been selected in line with the conservative approach.

Finally, a value for the effective cohesion, c' , must be derived. Literature values for c' in peat vary widely, ranging from 4.5 to 60 kN/m^2 . To provide an indication of the cohesive strength of the peat at Craigton and Spittalhill a back-calculation using the FoS equation and actual peat

depth probing data for the site has been completed. The techniques involved are discussed below.

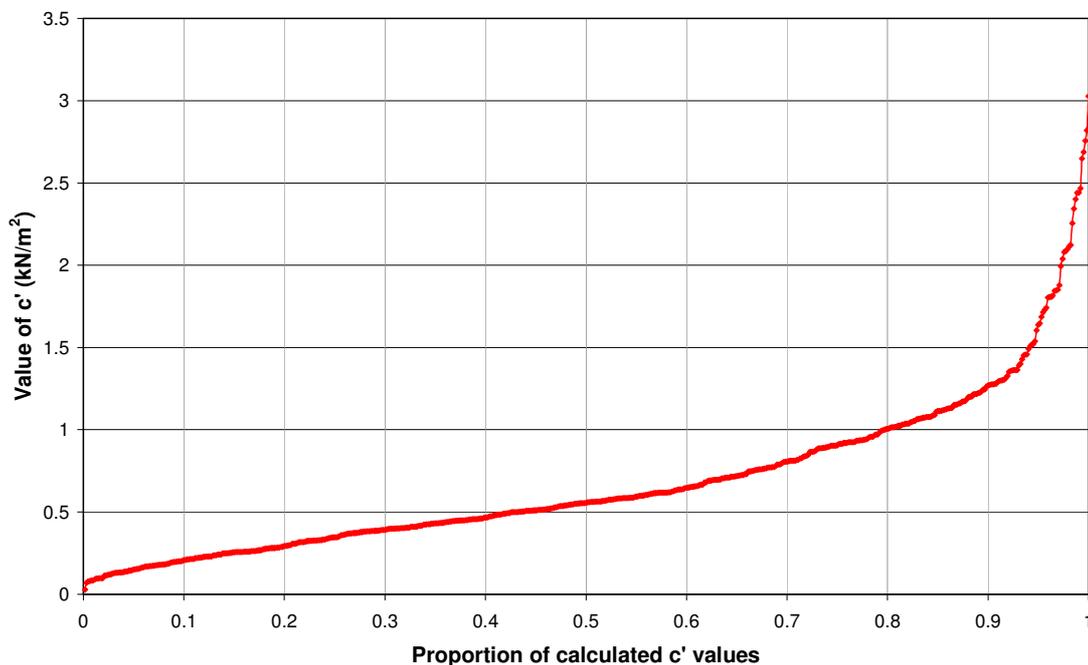
2.7.1 Estimation of Cohesive Strength

A range of field and laboratory tests can be carried out to determine the effective cohesion of a material. However, owing to its fibrous and thixotropic nature and the variation in strength with decomposition, peat is a particularly difficult material to analyse both in the field and in the laboratory. An alternative approach to assessing the strength of the peat is to rearrange the FoS equation to calculate a value of c' at actual peat probing locations. Essentially, this approach assumes that if the hillside is stable then the material must have at least a certain minimum strength.

Each peat probing location visited, is known to have been stable at the time of the visit, and therefore must have a FoS of at least 1. If we assume conservatively that $F=1$ and use values for the other parameters as discussed above, the FoS equation can be rearranged to allow derivation of a value for c' at each probing location. Slope angles for the probing points are generated from the DTM. It is important to note that the value of c' calculated for each location represents the *minimum* cohesive strength necessary for the peat to be stable at that location. In fact, the shear strength may be, and in most cases probably is, considerably higher.

At Craigton and Spittalhill, 620 locations have been probed during the different phases of fieldwork. c' values for each of these have been calculated and the distribution of these values is shown in Figure 9. For example, reading from the graph, 0.8 (or 80%) of the probing locations required a c' value of 1.0kN/m² or less to be stable and retain peat on the slope.

Figure 9. Estimate of minimum cohesive strength, c'



From this work it is possible to state, with confidence, that across the site as a whole the shear strength of the peat is unlikely to be less than 2.68kN/m² as this is the value of the 99.5th percentile point on the graph. The basis for making this statement depends upon:

- The deliberate choice of conservative values for assumed parameters such as bulk density and water table level, coupled with the assumption of an FoS of 1 when back-calculating c' values;

- Recognition of what the calculations are stating, which is that these are the minimum strengths that would be required, not the actual *in situ* strengths. Therefore, where slopes are gentle and the peat shallow, very little shear strength is required to ensure stability of the slope. This accounts for the vast majority of the lower values;
- Assuming a reasonable degree of homogeneity for peat properties, in particular strength, across the site. This seems reasonable, except for very shallow peat where the acrotelm, which is more fibrous, represents a significant proportion of the total depth. Such areas are, in any case, unlikely to be areas of concern;
- Given the above considerations, it is the higher strength values that are relevant. If this were not the case then one would expect large areas of the site to be denuded of peat as it would not have the strength to adhere to the hillsides.

For the purposes of the Factor of Safety Assessment a c' value of 2.68kN/m^2 has been used. This value is very conservative in comparison with estimates derived from other sites around Scotland, largely due to the relatively shallow peat found on most site slopes. The actual effective cohesion of the peat at Craigton and Spittalhill is therefore likely to be higher than 2.68kN/m^2 ; however, this value has been chosen to ensure a conservative desktop assessment whilst also using data from the site.

2.8 Preliminary Stability Analysis Results

Having assigned measured or inferred values to each parameter in the FoS equation it is now possible to calculate an FoS value for each probing location coinciding with proposed infrastructure and for each cell of the indicative peat depth grid in the vicinity of the infrastructure. The results of the FoS assessment for the probing points and site grid are summarised in Table 4. The FoS assessment maps generated with these values are shown on Drawing PS02 (Appendix A).

Table 4. Summary of Factor of Safety assessment

Factor of Safety	<1.0	1.0 - <1.4	1.4 - <3.0	3.0 +	No peat in Grid (less than 0.5 m)	Total
No. of points	4	14	165	437	-	620
% of points	0.6	2.3	26.6	70.5	-	100
No. of cells	7	103	948	377	346	1781
% of cells	0.4	5.8	53.2	21.2	19.4	100

In selecting the 99.5th percentile value of the back-calculated c' strengths, one is implicitly condemning 0.5% of the sample locations to failure, plus any similar cells across the site as a whole. As can be seen, there are a very small number of cells with an FoS value of less than 1; in theory these should either have failed or currently be failing. In reality this is unlikely to be the case and these results are a consequence of the conservative approach adopted, these should be considered as representing the least stable locations on this specific site. A larger number of points and cells have a FoS between 1.0 and 1.4, where stability can be considered marginal.

The cells that fall into both these categories are scattered in clusters across the site, the majority are a reasonable distance from site infrastructure and therefore based upon conservatively estimated, rather than actual, peat depths. To summarise, 93.8% of the site has a FoS of 1.4 or greater, where stability can be assumed with a degree of comfort.

Note that where peat depth is less than 0.5m, these cells were not considered as peat and are removed from further stability investigation (known as 'no peat' locations).

The results demonstrate that the vast majority of the wind farm infrastructure will be built in areas where there is a degree of comfort in inferring stability. The cells identified as having marginal stability are generally clustered into areas where deeper peat and moderate or steep

slopes occur within the same grid cell. Such areas, where close to planned infrastructure, have been considered further as potential peat stability risk areas.

3 Ground Investigation

Following the desktop factor of safety assessment seven areas were highlighted as having potential risk of peat landslide. To assess the risk of peat landslide in these areas more fully Mouchel staff undertook some basic ground investigation work during the June 2013 site visit.

3.1 Methodology

At each location measurements were made or samples taken to determine the following parameters:

- Peat probing to maximum depth, to improve definition of peat depth characteristics at each location;
- Peat cores gained by Russian corer to base of peat, for laboratory analysis of bulk density and moisture content;
- Von Post classification of peat core, for level of decomposition of organic material and hence likely cohesion level;
- *In-situ* shear strength at shallow depth, for comparison against theoretical cohesive strength;
- Description of peat core and photograph of core;
- Topographic description of area, including water conditions and evidence of instability, including appropriate photographs.

Coring was undertaken using a Russian corer, using 1 m extension rods to reach peat base. Following photographing the extracted core, a 0.2m length of undisturbed core was carefully removed into a marked plastic bag, which was sealed and then transported for laboratory analysis for bulk density and moisture content, the laboratory were provided with the cross-sectional dimensions of the semi-cylindrical corer. Samples were collected on the 26th June 2013 and delivered to the laboratory on 28th June 2013, for analysis.

Von Post classification was evaluated immediately after core extraction and lab sample bag transfer, using the remaining core material. This process involved evaluating water expression and colour of any water expressed, peat expression and noting plant material extracted in the core.

Shear strength tests were undertaken using an Impact Shear Vane SL810, this equipment was last calibrated on 31st January 2013, with annual calibration the minimum frequency. The 0.3m extension was used with the 33mm blade vane. The shear strength constant of the 33 mm blade was 0.3598, translating from a 30 division site result to a shear strength of 11kPa (equivalent to 11 kN/m²). Shear strength tests were undertaken at a depth of 0.3m, with 3 tests within 10m of the core location, enabling minimum, mean and maximum data at each location.

3.2 Results

The weather conditions during this work were dry and clear. The locations and results are detailed in Table 5.

Core locations are shown on Drawing PS03 (Appendix A). At a number of planned coring locations the peat was too shallow and no core information was obtained, of the 11 intended cores, eight were successful. It was noted that two of these eight cores were considered to be clay rather than peat.

Table 5. Ground investigation data

Location ID	Core NGR	Comment
C01	NS 66006 89144	Core taken for Lab bulk density / moisture analysis at 2.56m Von Post of Core – H9-H10 (Almost completely - completely decomposed) Bulk Density Core – 1.044Mg/m ³ Shallow Shear Vane at 0.3m - 12Kn/m ² (lowest shear result) Additional peat probing in area <i>Considered primarily clay rather than peat</i>
C02	NS 66428 88715	Core taken for Lab bulk density / moisture analysis at 1.47m Von Post of Core – H4 (Weakly decomposed) Bulk Density Core – 1.066Mg/m ³ Shallow hand shear vane at 0.3m – 14kN/m ² (lowest shear result) Additional peat probing in area
C03	NS 66571 88477	Core taken for Lab bulk density / moisture analysis at 1.58m Von Post of Core – H5 (Moderately decomposed) Bulk Density Core – 1.109Mg/m ³ Shallow hand shear vane at 0.3m – 14kN/m ² (lowest shear result) Additional peat probing in area
C04	NS 66704 88563	Core taken for Lab bulk density / moisture analysis at 1.19m Von Post of Core – H4 (Weakly decomposed) Bulk Density Core – 0.964Mg/m ³ Shallow hand shear vane at 0.3m – 14kN/m ² (lowest shear result) Additional peat probing in area
C05	NS 66823 88426	Core taken for Lab bulk density / moisture analysis at 1.94m Von Post of Core – High clay content identified, N/A to von post Bulk Density Core – 1.067Mg/m ³ Shallow hand shear vane at 0.3m – 13kN/m ² (lowest shear result) Additional peat probing in area <i>Considered primarily clay rather than peat</i>
C06	NS 66925 88225	No core taken, depth too shallow Additional peat probing in area
C07	NS 66631 88273	No core taken, depth too shallow Additional peat probing in area
C08	NS 66269 88256	Core taken for Lab bulk density / moisture analysis at 0.68m Von Post of Core – H3-H4 (Very weakly-weakly decomposed) Bulk Density Core – 1.031Mg/m ³ Shallow hand shear vane at 0.3m – 16kN/m ² (lowest shear result) Additional peat probing in area
C09	NS 66374 88475	No core taken, depth too shallow Additional peat probing in area

Location ID	Core NGR	Comment
C10	NS 66272 88576	Core taken for Lab bulk density / moisture analysis at 0.79m Von Post of Core – High Clay Content, N/A to Von Post Bulk Density Core – 1.578Mg/m ³ (considered to be clay not peat) Shallow hand shear vane at 0.3m – 19kN/m ² (lowest shear result) Additional peat probing in area <i>Considered primarily clay rather than peat</i>
C11	NS 66069 88586	Core taken for Lab bulk density / moisture analysis at 1.92m Von Post of Core – H4 (Weakly decomposed) Bulk Density Core- 1.074Mg/m ³ Shallow hand shear vane at 0.3m – 19kN/m ² (lowest shear result) Additional peat probing in area

Slope angle data is derived from OS Profile DTM 10 m resolution digital terrain model for this area.

3.3 Interpretation

Bulk density measurements were taken from eight peat cores. These returned bulk density results between 0.964 and 1.578Mg/m³, with an average value of 1.12Mg/m³. However, removing the maximum bulk density core result from consideration, as this core was noted as primarily clay in field notes, the range becomes reduced to 0.964 to 1.067Mg/m³, with the average thereby reduced to a value of 1.05Mg/m³ for samples considered as peat. This is comparable with the value of 1.20Mg/m³ used in the initial FoS calculations (with no results exceeding the theoretical value of 1.20Mg/m³), which shows the method applied as being reasonably conservative. Full details of the cores and lab results are provided in Appendix B.

At previous sites there has been a distinct correlation between the von Post classification of the peat and the depth of the sample. This relationship was not as distinct at Craigton and Spittalhill, with the five peat-containing samples returning a range of von Post classifications between H3 (very weakly undecomposed) and H5 (moderately decomposed). The typical decomposition was H4 (weakly decomposed) at this site, with three of five peat cores thus classified.

The recorded peak shear strengths were all taken at shallow depth (0.3m), with three tests taken within 10m of one another at applicable locations. Results varied between 12.0 and 22.0kN/m², with an overall average value of 16.7kN/m², the lowest mean shear value at any single location was 13.3kN/m². Generally, high shear strengths would be expected to be recorded in this upper 0.3m of peat owing to the more fibrous nature of the peat often encountered at this depth. In previous studies it has been found that minimum strength tends to be recorded in the central part of the peat column where shear strength was measured at three or more depths, with a slight increase close to the total depth. As shear vane values at Craigton and Spittalhill were limited to shallow depth there is no trend apparent at this site. However, it would be expected that there would be a general correlation with depth, similar to that observed at other sites.

All measured shear strengths from the hand vane shear tests are substantially higher than the value used in the initial desktop FoS analysis (which used 2.68kN/m² as the 99.5th percentile value), with the lowest and average site test results also substantially higher than the maximum back-calculated shear strength, which was 3.03kN/m². This is in line with expectations and confirms the conservative nature of Mouchel's analysis method.

4 Assessment

Drawing PS02 shows the planned infrastructure layout overlaid on the Factor of Safety (FoS) mapping, from which it is clear to see areas which have been identified as at higher risk of instability as red or yellow cells. The cells cluster into seven small areas, each of which has been allocated an identification letter and are shown on Drawing PS03 (which includes core locations). For perspective, 93.8% of the grid cells on the site have FoS values commensurate with low or negligible risk.

For each area of concern, the impact and possible mitigation have been considered and are set out in Table 6. Additional GIS images and photographs for each identified risk area are provided in Appendix C.

The images provided display the FoS class for each grid cell (each measuring 50 m x 50 m), as discussed in Section 2.8, with cells highlighted of concern in descending order from those of most concern, coloured red (FoS <1, high risk), followed by yellow (FoS 1 to 1.4, moderate risk), green (FoS 1.4 to 3, low risk) and blue (FoS >3, negligible risk). Grey cells represent areas without peat (depth shallower than 0.5 m, no risk). The probe location triangles are coloured as for the above FoS ranges, but are labelled with peat depth values. Core locations are shown as a pink rhombus with core identifier (e.g. C01). The site boundary is shown as a solid red line. Most of these areas contain only moderate risk cells (yellow, representing FoS values between 1 and 1.4), although two areas include high risk cells (red, representing FoS less than 1).

It is anticipated that, with careful design and construction, no peatslides will occur. It is, however, possible to assess the potential impact should slides occur at highlighted locations, considered most at risk. One measure of impact is to estimate slide volume and travel distances (*i.e.* how much peat could slide) and identify the receiving environment (sensitive receptors).

To estimate the impact of a peatslide in each area, the surrounding topography and measured/indicative peat depths have been examined and an estimate made of the likely distance the slide would travel, if it were to occur. Also considered is the possibility of the slide destabilising material up-slope from the original failure. These distances are shown in the table as 'Down' and 'Up' slide distances. The indicative peat depth map and actual peat probing data have been examined to estimate the depth of peat that could slide, shown in the 'Estimated Peat Depth' column. Using these depths, along with an approximate width for each slide, it has been possible to estimate the volume of peat that could potentially be mobilised. This ranges from approximately 400m³ at Area F (south west of Turbine 5) up to 5,250m³ at Area B (south of Turbine 7).

The review of these areas included identification of the receptor where any slide debris would possibly terminate. In all cases this would be into small unnamed watercourses draining site slopes. The secondary receptor is the Backside Burn, for which these smaller streams and ditches form tributaries.

The column marked 'Track Orientation' gives an indication of the access track orientation with respect to the contours. This has been considered in three broad categories - 'parallel', 'diagonal' and 'perpendicular'. The reason for indicating this is that roads cutting parallel to the contours are most at risk of removing the toe support from the uphill side of the road, particularly where cut-and-fill road construction methods are used. As stated elsewhere all these sections of access track will require detailed and conservative design, but this becomes less of an issue as the orientation tends to the perpendicular. The 'Initial Risk' column provides an indication of the risk level ('High' or 'Moderate') based on peat probing data fed into the desktop FoS assessment.

The 'Comments' column discusses specific data for each area, including re-calculated values for FoS taking account of site-specific shear strength and bulk density data. This section also puts the area into context, with regard to slope angle and peat depth, as often deep peat in a

particular area is not coincident with the steeper slopes present in the same locality. Deep peat may also be present in a small well-defined area, in an area of highly variable peat depth.

The 'Actions and Potential Mitigation' column details specific measures which should be considered at the particular locations. However, there are also a number of generic good practice measures that should be deployed across the wind farm site. These are discussed in more detail in Section 5.

The 'Residual Risk' column reflects the risk level judged following consideration of specific characteristics for each area, using applicable ground investigation information and the identification and application of any appropriate mitigation measures during design, construction and operation.

Table 6. Risk Assessment for Identified Peat Stability Risk Areas

Area Identifier, NGR	Infrastructure	Peat Probing (m)	Max. Slope (°)	Av. Slope (°)	FoS Range for Peat Probes Lowest FoS for Grid Cells	Track Orientation (relative to contours)	Estimated Potential Peat Slide Parameters					Initial Receptor	Secondary Receptor	Initial Desktop Risk	Comments	Actions and Potential Mitigation	Residual Risk
							Est Average Peat Depth (m)	Width (m)	Down slide Distance (m)	Up slide Distance (m)	Volume (m ³)						
Area A, NS 6699 8819	Main access track	21 probing points (as per labels on image). Range: 0.1 – 1.2 m Average depth in area: 0.6 m	16.1	11.7	0.95 – 9.49 0.95	Parallel	1.0	50	25	50	3,750	Unnamed small tributary stream	Backside Burn	High	<p>Within this area the track contours around this relatively steep slope, 100 m south east of T7, crossing pockets of peat up to 1.2 m depth.</p> <p>No instability was evident, potential for peat movement likely to be restricted by surrounding shallow peat and close to surface bedrock. See photograph in Appendix C.</p> <p>This location proved too shallow to successfully core at C06, nearby cores on this slope suggest a shallow peat layer with clay below and bedrock typically at around 1.0 m depth.</p> <p>Re-running the FoS calculation for the lowest FoS value cell (i.e. highest risk), using lowest shear vane value and highest bulk density from the site (12.0 and 1.578) results in a cell FoS of 3.16, instead of 0.95.</p> <p>Considered a stable location with isolated, constrained pockets of slightly deeper peat, potential small scale movement.</p>	<p>Continue to monitor and reappraise risk assessment during detailed design and construction.</p> <p>Follow good construction practice.</p>	Low

Area Identifier, NGR Infrastructure	Peat Probing (m)	Max. Slope (°)	Av. Slope (°)	FoS Range for Peat Probes Lowest FoS for Grid Cells	Track Orientation (relative to contours)	Estimated Potential Peat Slide Parameters					Initial Receptor	Secondary Receptor	Initial Desktop Risk	Comments	Actions and Potential Mitigation	Residual Risk
						Est Average Peat Depth (m)	Width (m)	Down slide Distance (m)	Up slide Distance (m)	Volume (m ³)						
Area B, NS 6683 8842 Area downhill of T7 and access track to T4	14 probing points (as per labels on image). Range: 0.1 – 2.3 m Average depth in area: 1.2 m	9.8	6.0	1.23 – 23.37 1.13	Diagonal	2.1	25	50	50	5,250	Unnamed small tributary stream	Backside Burn	Moderate	Base of slope zone, including flush zone and wetland area. Track passes south-west / uphill of Area B on shallower peat. Turbine 7 is located south / uphill on shallower peat. No instability was evident, potential for peat movement likely to be restricted by surrounding shallow peat, particularly between Area B and the planned infrastructure. Photograph of Area in Appendix C. Core C05 had a high clay content, suggesting a shallow peat layer, with clay below. Re-running the FoS calculation for the lowest FoS value cell (i.e. highest risk), using lowest shear vane value and bulk density data from this area (13.0 and 1.067) results in a cell FoS value of 5.42, instead of 1.13. Considered a stable location with deeper peat at base of the slope, unlikely to be disturbed by infrastructure on shallower peat to the south and west.	Continue to monitor and reappraise risk assessment during detailed design and construction. Follow good construction practice.	Low

Area Identifier, NGR Infrastructure	Peat Probing (m)	Max. Slope (°)	Av. Slope (°)	FoS Range for Peat Probes Lowest FoS for Grid Cells	Track Orientation (relative to contours)	Estimated Potential Peat Slide Parameters					Initial Receptor	Secondary Receptor	Initial Desktop Risk	Comments	Actions and Potential Mitigation	Residual Risk
						Est Average Peat Depth (m)	Width (m)	Down slide Distance (m)	Up slide Distance (m)	Volume (m³)						
Area C, NS 6657 8847 Area between access track spurs	10 probing points (as per labels on image). Range: 0.2 – 1.6 m Average depth in area: 0.6 m	11.9	8.5	1.11 – 9.42 1.11	Parallel / Diagonal	1.0	25	25	25	1,250	Unnamed small tributary stream	Backside Burn	Moderate	<p>This area lies between the 2 spurs of access track servicing T4 and T6. A single peat depth of over 1.5 m led to stability concern.</p> <p>No instability was evident, potential for peat movement likely to be restricted by surrounding shallow peat and close to surface bedrock. Photograph of Area in Appendix C.</p> <p>Core C03 provided evidence of moderately decomposed peat (Von Post H5 result) in this deeper pocket.</p> <p>Re-calculating the FoS calculation for the lowest FoS value cell (i.e. highest risk), using lowest shear vane value and bulk density data from this area (14.0 and 1.109) results in a cell FoS value of 5.77, instead of 1.11.</p> <p>Considered a stable location with isolated, constrained pockets of deeper peat within.</p>	<p>Continue to monitor and reappraise risk assessment during detailed design and construction.</p> <p>Follow good construction practice.</p>	Low

Area Identifier, NGR Infrastructure	Peat Probing (m)	Max. Slope (°)	Av. Slope (°)	FoS Range for Peat Probes Lowest FoS for Grid Cells	Track Orientation (relative to contours)	Estimated Potential Peat Slide Parameters					Initial Receptor	Secondary Receptor	Initial Desktop Risk	Comments	Actions and Potential Mitigation	Residual Risk
						Est Average Peat Depth (m)	Width (m)	Down slide Distance (m)	Up slide Distance (m)	Volume (m ³)						
Area D, NS 6603 8914 T1 and access track to south of T1	22 probing points (as per labels on image). Range: 0.4 – 2.6 m Average depth in area: 1.4 m	5.9	3.4	1.44 – 13.53 1.36	Parallel	1.0	50	25	25	2,500	Unnamed small tributary stream and drains	Backside Burn	Moderate	<p>In this area, a section of track crosses a gentle slope on approach to T1, crossing pockets of peat up to 2.6m depth at the base of the steeper slope to the south east. T1 is located on much shallower peat (approximately 1.1 m).</p> <p>No instability was evident, potential for peat movement likely to be restricted by the low slope angles. Photograph of Area in Appendix C. This was the location where the deepest peat was found on the site. However, it is unlikely, given shallow slope, that peat would slide from base, hence predicted only upper 1.0 m. No individual probing locations resulted in FoS scores of concern (i.e. none less than 1.4), within the grid cell of concern the steeper slopes are not coincident with deeper peat. Re-running the FoS calculation for the lowest FoS value cell (i.e. highest risk), using lowest shear vane value and bulk density data from this area, C01, (12.0 and 1.044) results in a cell FoS value of 6.08, instead of 1.36.</p> <p>Considered a stable location of deeper peat.</p>	<p>The track SE of T1 should be considered for micro-siting to shallower peat in this area, if possible. Continue to monitor and reappraise risk assessment during detailed design and construction.</p> <p>Follow good construction practice.</p>	Low

Area Identifier, NGR Infrastructure	Peat Probing (m)	Max. Slope (°)	Av. Slope (°)	FoS Range for Peat Probes Lowest FoS for Grid Cells	Track Orientation (relative to contours)	Estimated Potential Peat Slide Parameters					Initial Receptor	Secondary Receptor	Initial Desktop Risk	Comments	Actions and Potential Mitigation	Residual Risk
						Est Average Peat Depth (m)	Width (m)	Down slide Distance (m)	Up slide Distance (m)	Volume (m ³)						
Area E, NS 6663 8828 Located south of the access track servicing T6	14 probing points (as per labels on image). Range: 0.2 – 1.0 m Average depth in area: 0.4 m	15.7	12.8	1.09 – 6.34 1.09	Diagonal	0.6	25	25	25	750	Unnamed small tributary stream	Backside Burn	Moderate	<p>This area is located 60 m south / uphill of the track section contouring along this relatively steep slope, 200 m south west of T7. A single peat depth of 1.0 m led to stability concern.</p> <p>No instability was evident, potential for peat movement likely to be restricted by surrounding shallow peat and close to surface bedrock. Photograph of Area in Appendix C.</p> <p>This location proved too shallow to successfully core at C07, nearby cores on this slope suggest a shallow peat layer, with clay below. Bedrock generally within 1 m of surface.</p> <p>Re-calculating FoS calculation for the lowest FoS value cell (i.e. highest risk), using lowest shear vane value and highest peat bulk density from site (12.0 and 1.578) results in a cell FoS value of 3.62, instead of 1.09.</p> <p>Considered a stable location, with infrastructure location on very shallow peat downslope unlikely to disturb stability.</p>	<p>Continue to monitor and reappraise risk assessment during detailed design and construction.</p> <p>Follow good construction practice.</p>	Low

Area Identifier, NGR Infrastructure	Peat Probing (m)	Max. Slope (°)	Av. Slope (°)	FoS Range for Peat Probes Lowest FoS for Grid Cells	Track Orientation (relative to contours)	Estimated Potential Peat Slide Parameters					Initial Receptor	Secondary Receptor	Initial Desktop Risk	Comments	Actions and Potential Mitigation	Residual Risk
						Est Average Peat Depth (m)	Width (m)	Down slide Distance (m)	Up slide Distance (m)	Volume (m ³)						
Area F, NS 6628 8854 Access track to T5	13 probing points (as per labels on image). Range: 0.1 – 0.9 m Average depth in area: 0.4 m	16.1	11.9	1.32 – 12.66 1.32	Parallel	0.5	20	20	20	400	Unnamed small tributary stream	Backside Burn	Moderate	<p>In this area the track contours around this relatively steep slope, 100 m SE of T5. The BPS1 borrow pit search area is located south / uphill of this area. A single peat depth of 0.9 m led to stability concern.</p> <p>No instability was evident, potential for peat movement likely to be restricted by surrounding shallow peat and close to surface bedrock. Photograph of Area in Appendix C.</p> <p>The C10 core suggests very shallow peat with a high bulk density value (1.578), observed as clay. Bedrock generally within 1 m of surface.</p> <p>Re-calculating FoS for the lowest FoS value cell (i.e. highest risk), using lowest shear vane value and bulk density data from this area (19.0 and 1.578) results in a cell FoS value of 6.91, instead of 1.32.</p> <p>Considered a stable location, with infrastructure location on very shallow peat downslope unlikely to disturb stability.</p>	<p>Continue to monitor and reappraise risk assessment during detailed design and construction.</p> <p>Follow good construction practice.</p>	Low

Area Identifier, NGR Infrastructure	Peat Probing (m)	Max. Slope (°)	Av. Slope (°)	FoS Range for Peat Probes Lowest FoS for Grid Cells	Track Orientation (relative to contours)	Estimated Potential Peat Slide Parameters					Initial Receptor	Secondary Receptor	Initial Desktop Risk	Comments	Actions and Potential Mitigation	Residual Risk
						Est Average Peat Depth (m)	Width (m)	Down slide Distance (m)	Up slide Distance (m)	Volume (m ³)						
Area G, NS 6611 8857 South of T5	16 probing points (as per labels on image). Range: 0.2 – 1.9 m Average depth in area: 0.8 m	14.0	11.0	0.90 – 5.60 0.83	Parallel	1.5	50	25	25	3,750	Unnamed small tributary stream	Backside Burn	High	<p>This area is located south west of T5, adjacent to the western edge of the BPS1 borrow pit search area. A number of deeper peat results were identified in a hollow where the slope levelled out for a short distance above T5.</p> <p>No instability was evident, potential for peat movement likely to be restricted by surrounding shallow peat and close to surface bedrock. Photograph of Area in Appendix C.</p> <p>The C11 core suggests weakly decomposed peat in the well defined hollow.</p> <p>Re-calculating FoS for the lowest FoS value cell (i.e. highest risk), using lowest shear vane value and bulk density data from this area (19.0 and 1.074) results in a cell FoS value of 5.88, instead of 0.83.</p> <p>Not considered a development risk given T5 is located 110 m north east, on shallower peat, and subject to slope support being retained.</p>	<p>Borrow pit activities to stay at least 100 m south east of this area.</p> <p>Continue to monitor and reappraise risk assessment during detailed design and construction.</p> <p>Follow good construction practice.</p>	Low

5 Mitigation & Good Practice Measures

The purpose of the peat stability risk assessment is to identify areas of the site which are potentially at most risk of peat instability and thereafter assess construction impacts. Where avoidance is not possible mitigation measures require to be implemented.

In addition to specific mitigation measures which may be deployed at particular locations there are a number of generic construction good practice measures that should be considered. A number of these are set out in Table 7 below (NB the list is not exhaustive).

Table 7. Mitigation and good practice measures

Potential Actions	Good Practice	Mitigation Measure
1. Geotechnical specialist on-site during the construction phase to undertake advance inspection, carry out regular monitoring and provide advice	✓	✓
2. Maintain and update geotechnical risk register or similar management system	✓	✓
3. Construction staff should be made aware of peatslide indicators and emergency procedures (<i>see below</i>)	✓	✓
4. Emergency procedures should include steps to be taken on detection of an incipient peatslide or of the event occurring	✓	
5. Microsite the turbine base or access track in order to avoid the problem area (subject to non-violation of other constraints)	✓	
6. Ensure that good ground- and surface water control, such as moor gripping or drainage ditches, is in place in advance of construction activities	✓	
7. Installation of stand pipes / piezometers to monitor ground water levels and pore pressures		✓
8. Ensure artificial drainage does not concentrate flows onto slopes or into excavations	✓	
9. Ensure that sediment control measures are incorporated into all artificial drainage measures	✓	
10. Earthmoving activities should be restricted during and immediately after heavy and/or prolonged rainfall events	✓	
11. The construction plan should minimise the extent and duration of open excavations and bare ground	✓	
12. Avoid placing excavated material or other forms of loading on breaks-in-slope or other potentially unstable slopes	✓	
13. Avoid removing slope support, particularly where slope stability has been highlighted as of concern.	✓	✓
14. Establish / re-establish vegetation as soon as possible to improve slope stability and provide sediment transport control	✓	
15. Modify slope geometry to provide a 'weighted toe'		✓
16. Use of retaining structures, such as gabions for terracing		✓
17. In worst case, debris nets and/or deflection systems to protect installations		✓

Many of the activities listed serving to mitigate and reduce the likelihood of a peat slide occurring are also recognised as good construction practice.

Good practice guidance documents, such as *Managing Geotechnical Risk* (Clayton, 2001) and *Peat landslide hazard and risk assessments: best practice guide for proposed electricity generation developments* (Scottish Executive, 2006) should be consulted to inform the design and construction processes. All site investigation work will be undertaken in compliance with relevant British Standards, including BS 5930: 1999 and BS 6031: 2009.

On-site staff who are close to the project are often the best placed to provide advance notification of potential problems, provided they are trained to do so and there is a reporting mechanism in place. There are a number of recognised indicators for slope failures and these may indicate a potential peat slide or the commencement of a peat slide event. The suspected identification of any of these indicators should be assessed by specialist geotechnical personnel. The factors discussed below are particularly applicable to low velocity peat slides:

- The development of tension fracture cracking across the slope or in semicircular patterns;
- Boggy ground or new springs appearing at the base of slopes;
- Sudden reactivation of spring lines;
- Creep and bulging of ground;
- Displacement and leaning of trees, fence posts, dykes etc.;
- Breaking of underground services.

6 Summary & Recommendations

The proposed wind farm site and infrastructure locations have been assessed for their risk of slope instability using a quantitative assessment method based on plane failure analysis. The areas of the site highlighted as having low Factors of Safety (i.e. of stability concern) coincident with or adjacent to proposed infrastructure have been considered in detail.

The conservative nature of the methodology applied leads to identification of the least stable areas on any specific site, meaning that on very stable sites, such as Craigton and Spittalhill, the procedure will still identify locations initially considered of high or moderate risk, with this risk relative to the remainder of the site. Five areas with 'Moderate' risk and two areas with 'High' risk were initially highlighted in Section 4 (Assessment), based on peat probing and desktop factor of safety calculations specific to this site. For each area, the potential effect of wind farm construction was considered and re-assessed based on specific characteristics of each location including ground investigation data, with appropriate mitigation measures recommended, where necessary, to then arrive at a residual risk level. No locations hold a residual risk level above 'Low', when taking account of site-specific geotechnical data and suggested mitigation. Local control measures will be required at such locations to aid constructability and to ensure that the risk of slope instability is kept to a minimum.

This report is based on the available data from the finalised track layout and turbine grid or data derived from back-analysis of shear strengths from topographic features. Further peat depth measurement, geotechnical assessment and testing will be necessary in certain localised areas to provide more specific data on physical parameters and to allow for appropriate micro-siting and mitigation. The need for this should be targeted to the areas identified in Table 6.

The need for risk management has been emphasised throughout this report and should include the development and regular review of a geotechnical risk register, supported by appropriate actions within the Construction Method Statement (CMS) when that stage is reached. It would also be considered useful to undertake shear vane measurements at mid and full depth of peat for highlighted locations where peat depths were greater than 1.0m.

This document lists a number of design and mitigation measures along with good practice guidelines. Whilst this list is not exhaustive, it is expected that a competent design consultancy and contractor will adopt these and other techniques as appropriate.

7 References

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Mouchel (2013). *Soil & Water*. Chapter 8 of the Environmental Statement for Craigton and Spittalhill Wind Farm.

Scottish Executive (2006). *Peat landslide hazard and risk assessments: best practice guide for proposed electricity generation developments*. Halcrow Group for the Scottish Executive.

Appendices

Appendix A

Drawings

PS01 Indicative Peat Depth Grid and Peat Depth Point Data

PS02 Factor of Safety Grid and FoS Point Data

PS03 Stability Risk Areas and Coring Locations

Appendix B

Laboratory Results

Laboratory Core Results

Appendix C

GIS Images and Photographs of Identified Peat Stability Risk Areas

Area A

Area B

Area C

Area D

Area E

Area F

Area G

Appendix A

Drawings

Peat Stability Assessment
Peat Depths North West

Infrastructure

- Turbine Location
- MetMast
- Access Track
- Existing Track
- Site Boundary
- Crane Hardstanding
- Control Building
- Construction Compound
- Borrow Pit Search Area

Hydrology

- Watercourses (Shown on OS 10K)
- Additional Watercourses (Not Shown on OS 10K)
- Water Bodies

Peat Depth

Measured Peat Depths (m)

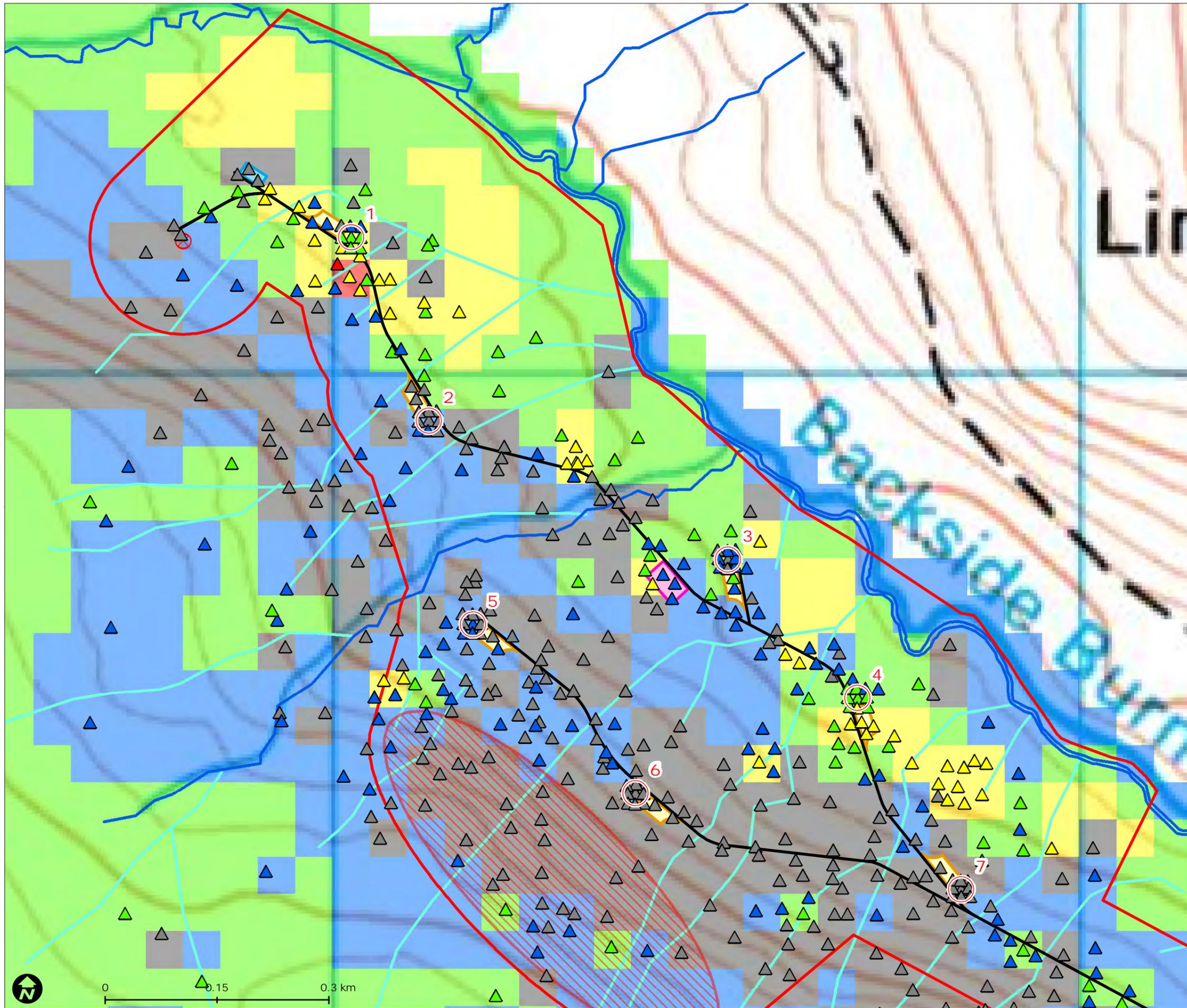
- 0 < 0.5 (358)
- 0.5 < 1 (151)
- 1 < 1.5 (67)
- 1.5 < 2.5 (43)
- 2.5 + (1)

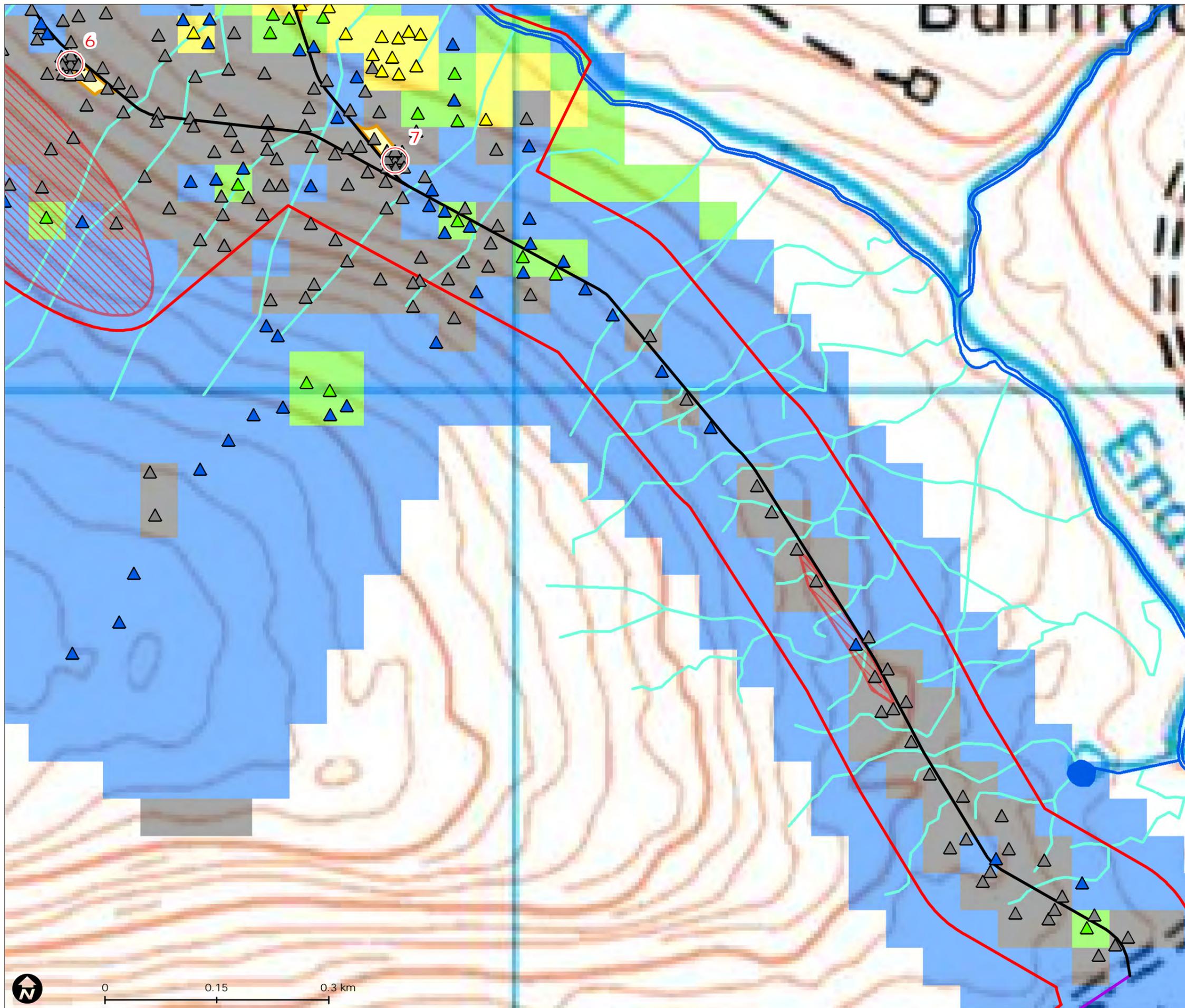
Indicative Peat Depth (m)
Grid of 50x50m Cells

- 0 to < 0.5 (346)
- 0.5 to < 1.0 (635)
- 1.0 to < 1.5 (738)
- 1.5 to < 2.5 (61)
- 2.5 + (1)

Figure PS01a

Map Scale @ A3:1:5,000





Peat Stability Assessment
Peat Depths South East

Infrastructure

-  Turbine Location
-  MetMast
-  Access Track
-  Existing Track
-  Site Boundary
-  Crane Hardstanding
-  Control Building
-  Construction Compound
-  Borrow Pit Search Area

Hydrology

-  Watercourses (Shown on OS 10K)
-  Additional Watercourses (Not Shown on OS 10K)
-  Water Bodies

Peat Depth

Measured Peat Depths (m)

-  0 < 0.5 (358)
-  0.5 < 1 (151)
-  1 < 1.5 (67)
-  1.5 < 2.5 (43)
-  2.5 + (1)

Indicative Peat Depth (m)
Grid of 50x50m Cells

-  0 to < 0.5 (346)
-  0.5 to < 1.0 (635)
-  1.0 to < 1.5 (738)
-  1.5 to < 2.5 (61)
-  2.5 + (1)

Figure PS01b

Map Scale @ A3:1:5,000

Peat Stability Assessment
Factor of Safety North West

Infrastructure

- Turbine Location
- MetMast
- Access Track
- Existing Track
- Site Boundary
- Crane Hardstanding
- Control Building
- Construction Compound
- Borrow Pit Search Area

Hydrology

- Watercourses (Shown on OS 10K)
- Additional Watercourses (Not Shown on OS 10K)
- Water Bodies

Peat Stability

Factor of Safety (FoS)

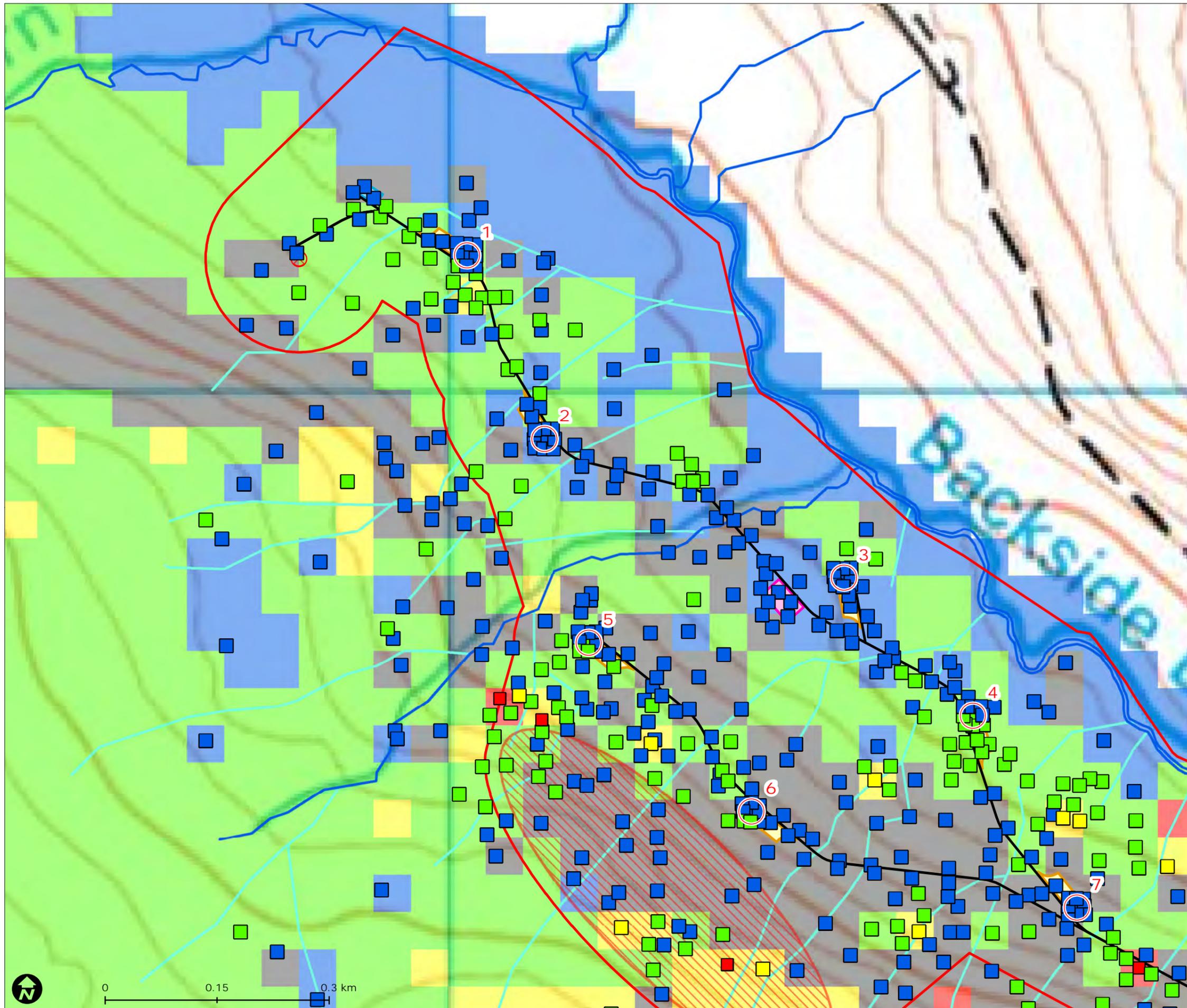
- | | | |
|--|------------|-------|
| | <1 | (4) |
| | 1 to < 1.4 | (14) |
| | 1.4 to < 3 | (165) |
| | 3 + | (437) |

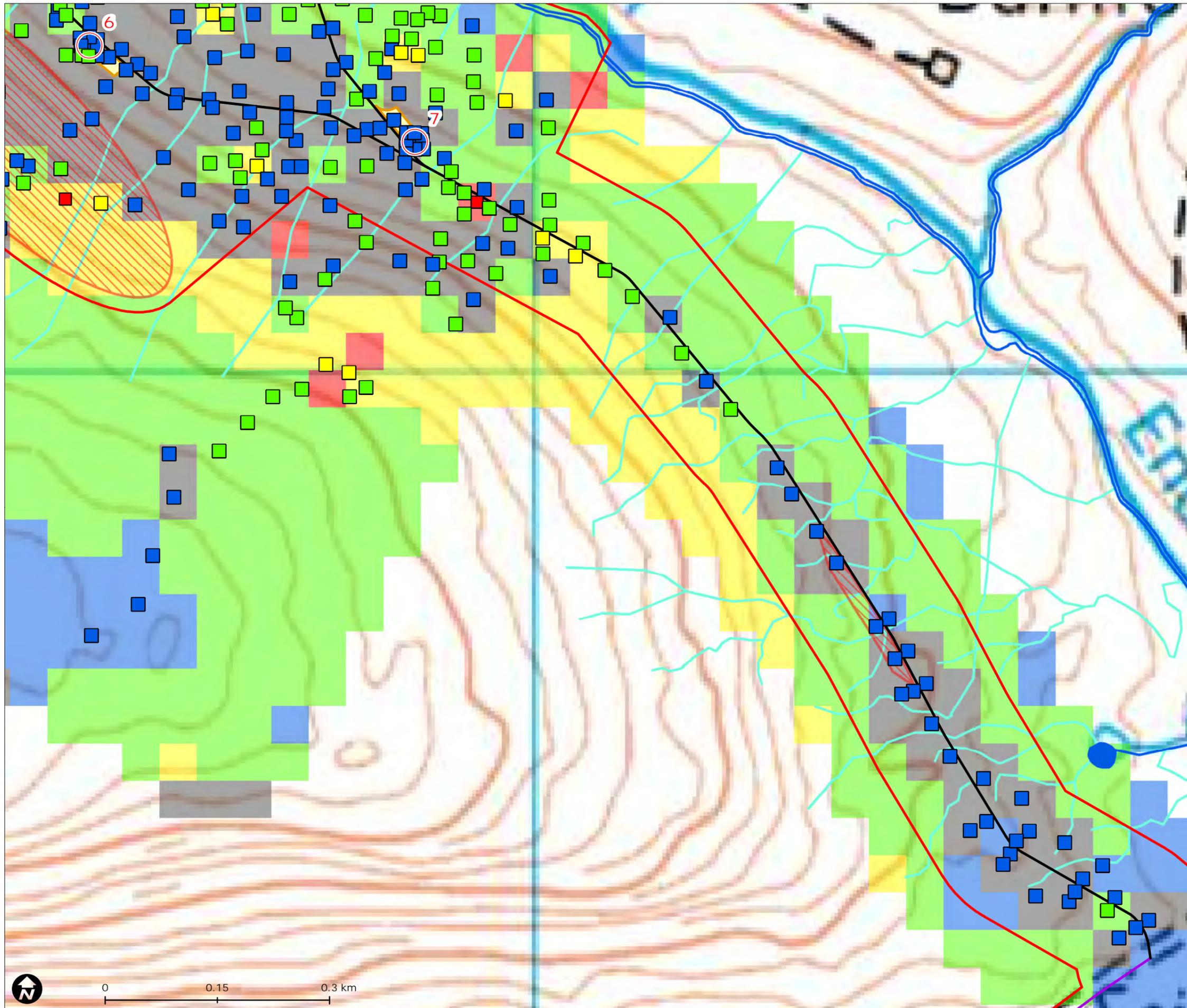
Factor of Safety.
50x50m Grid cells

- | | | |
|--|---------------------------------------|-------|
| | <1 | (7) |
| | 1 to <1.4 | (103) |
| | 1.4 to < 3 | (948) |
| | 3 + | (377) |
| | Not Applicable as
<0.5m Peat Depth | (346) |

Figure PS02a

Map Scale @ A3:1:5,000





Peat Stability Assessment
Factor of Safety South East

- Infrastructure
-  Turbine Location
 -  MetMast
 -  Access Track
 -  Existing Track
 -  Site Boundary
 -  Crane Hardstanding
 -  Control Building
 -  Construction Compound
 -  Borrow Pit Search Area

- Hydrology
-  Watercourses (Shown on OS 10K)
 -  Additional Watercourses (Not Shown on OS 10K)
 -  Water Bodies

Peat Stability

Factor of Safety (FoS)

	< 1	(4)
	1 to < 1.4	(14)
	1.4 to < 3	(165)
	3 +	(437)

Factor of Safety.
50x50m Grid cells

	< 1	(7)
	1 to < 1.4	(103)
	1.4 to < 3	(948)
	3 +	(377)
	Not Applicable as < 0.5m Peat Depth	(346)

Figure PS02b
Map Scale @ A3: 1:5,000

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Figure PS02b Map created 23/10/2013

Peat Stability Assessment
Detailed Assessment

Infrastructure

- Turbine Location
- MetMast
- Access Track
- Existing Track
- Site Boundary
- Crane Hardstanding
- Control Building
- Construction Compound
- Borrow Pit Search Area

Hydrology

- Watercourses (Shown on OS 10K)
- Additional Watercourses (Not Shown on OS 10K)
- Water Bodies

Detailed Assessment

- Core Locations
- Peat Stability Risk Area

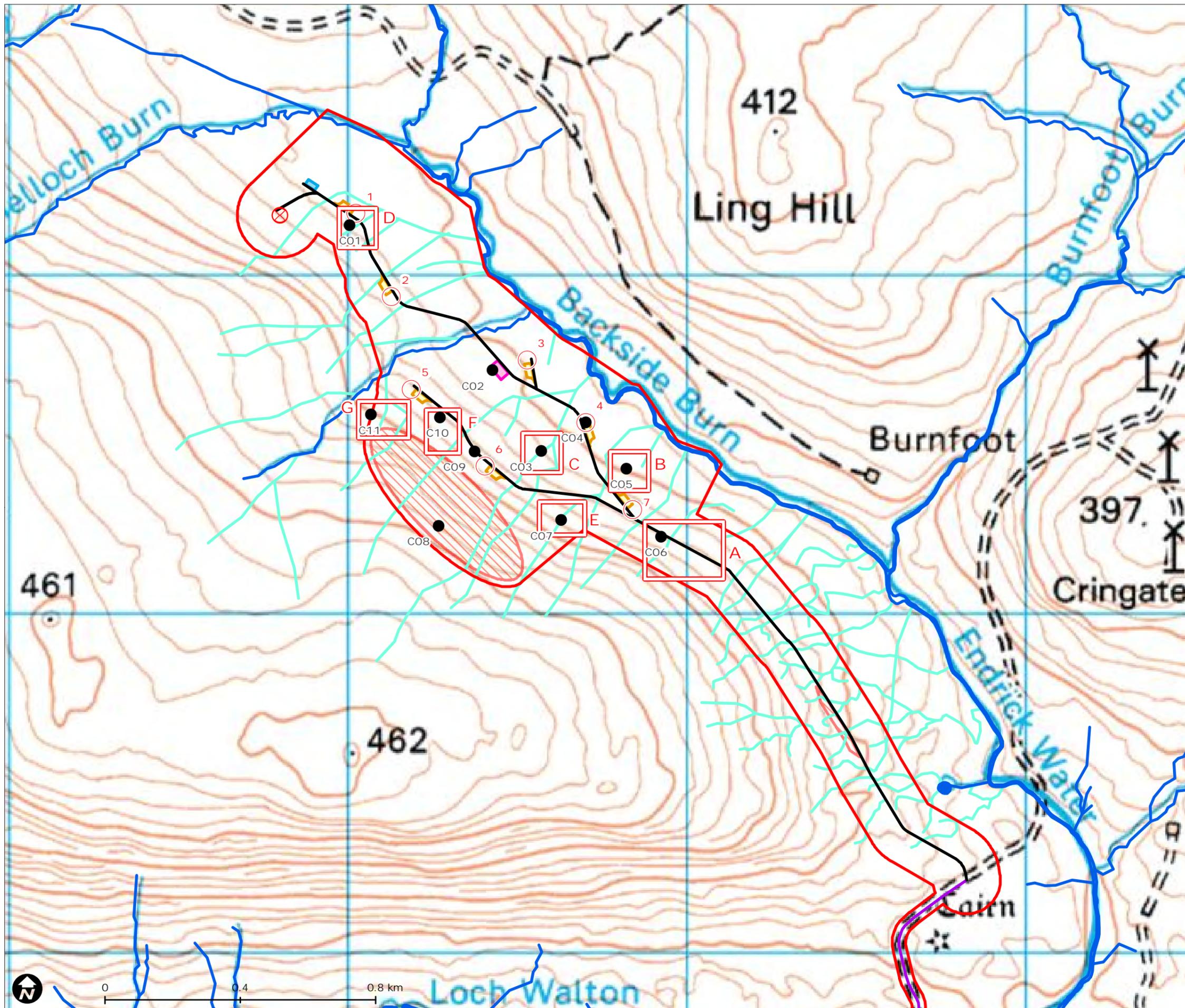


Figure PS03

Map Scale @ A3:1:11,000

Appendix B

Laboratory Results

Mouchel Peat Testing

Client: Mouchel Scotland

Job No: 4506-104

Consultant:

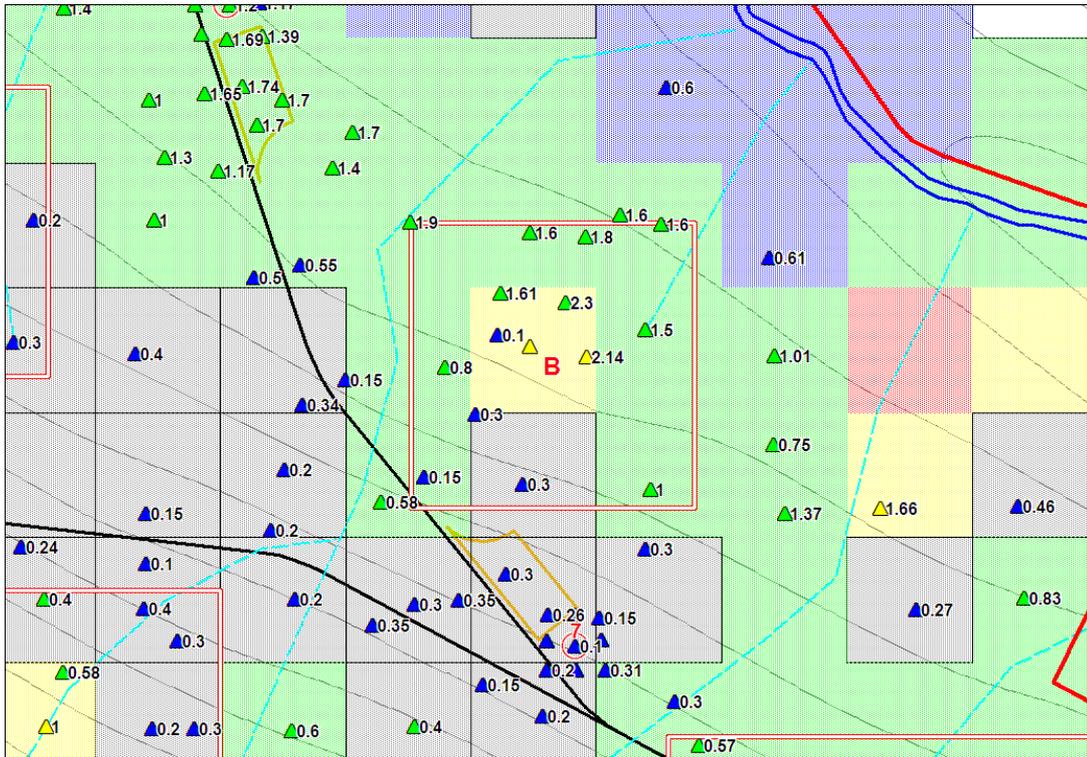
Test Method - BS 1377:1990:Part 2:Method 7.2

Sample Identification				Moisture Content (%)	Bulk Density (Mg/m ³)	Dry Density (Mg/m ³)
Hole ID	Type	Number	Depth			
C5C01	B	297208	m	422.0	1.044	0.2
C5C03	B	297209	m	289.0	1.109	0.285
C5C04	B	297210	m	827.0	0.964	0.104
C5C08	B	297212	m	435.0	1.031	0.193
C5C10	B	297213	m	65.0	1.578	0.956
C5C11	B	297214	m	342.0	1.074	0.243
C5CO2	B	297207	m	572.0	1.066	0.159
C5CO5	B	297211	m	240.0	1.067	0.314

Appendix C

GIS Images and Photographs of Identified Peat Stability Risk Areas

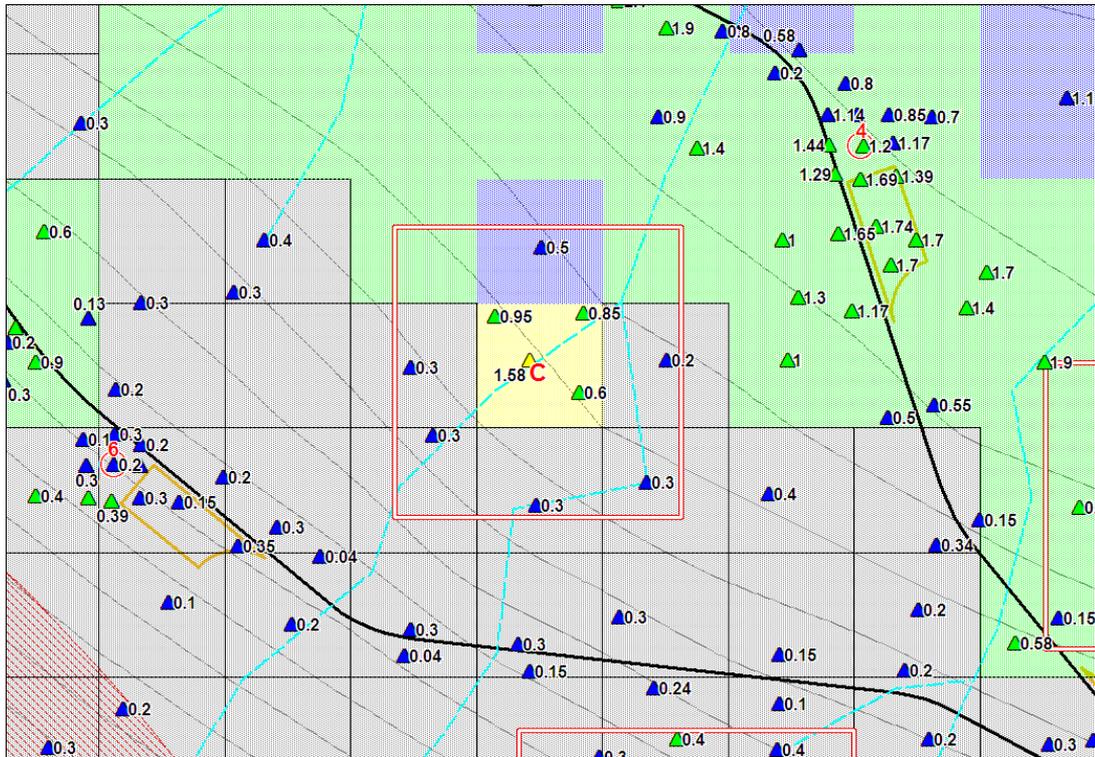
Area B



Photograph of Area B, at base of slope, looking south from NS 6680 8857, near Backside Burn



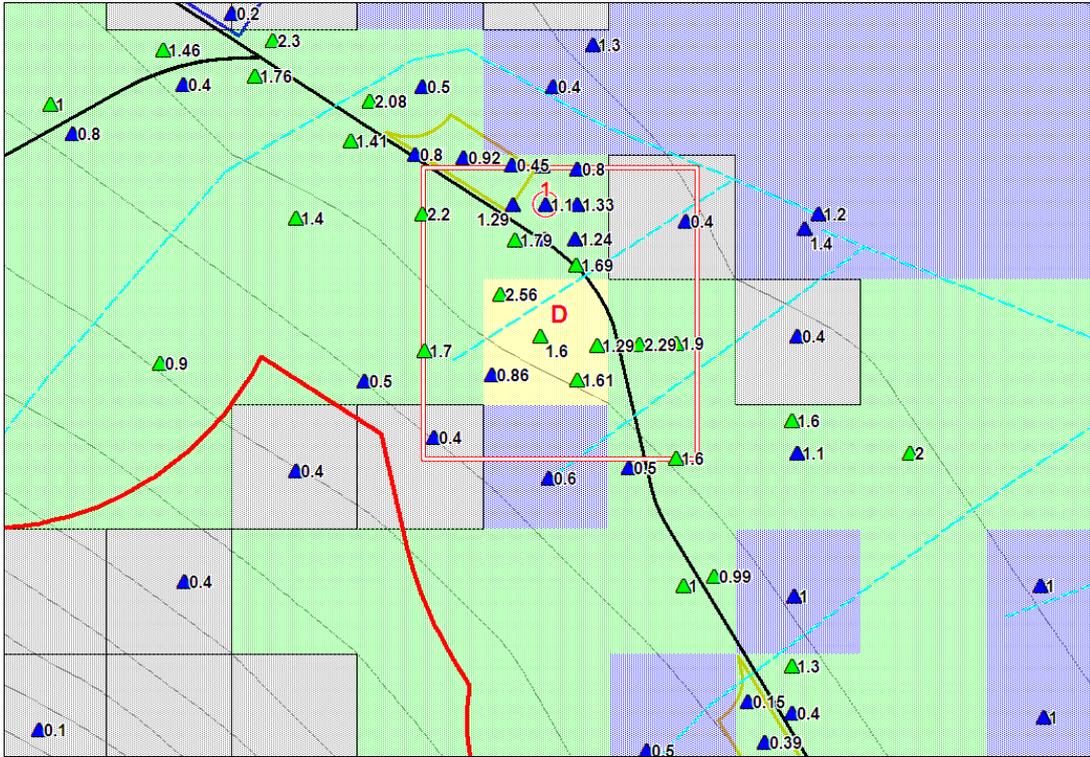
Area C



Photograph of Area C, towards base of slope, looking east from NS 6647 8841



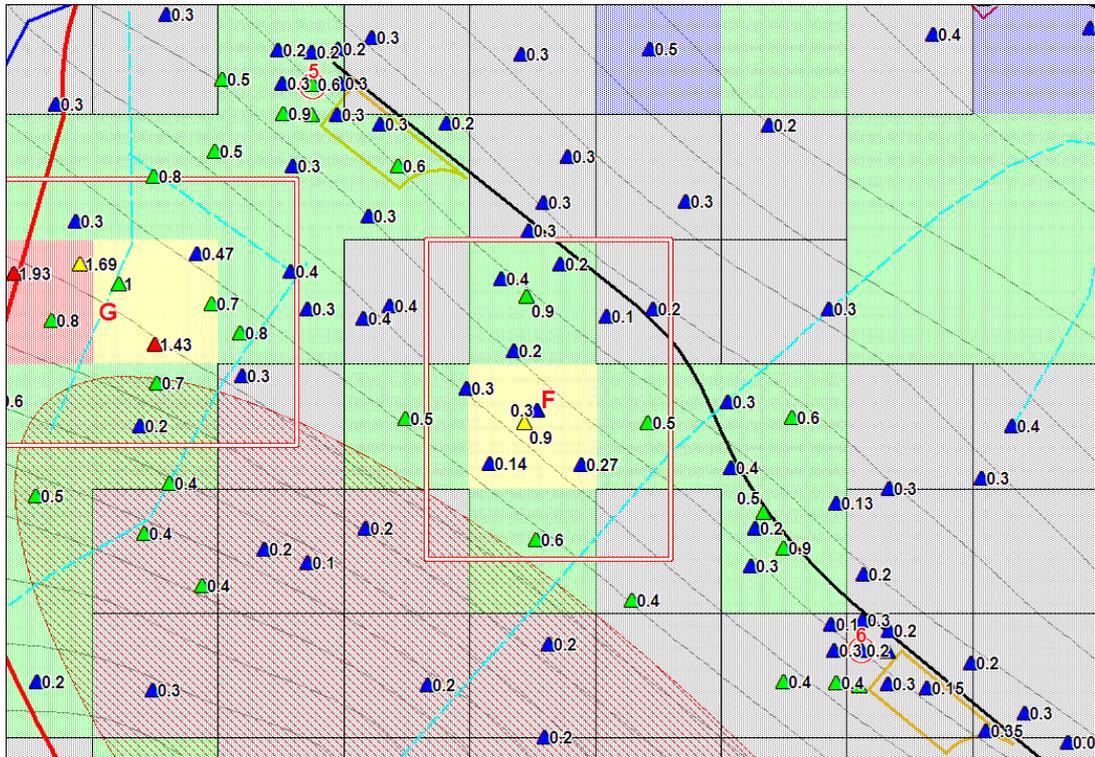
Area D



Photograph of Area D, looking south from NS 6602 8918 (T1)



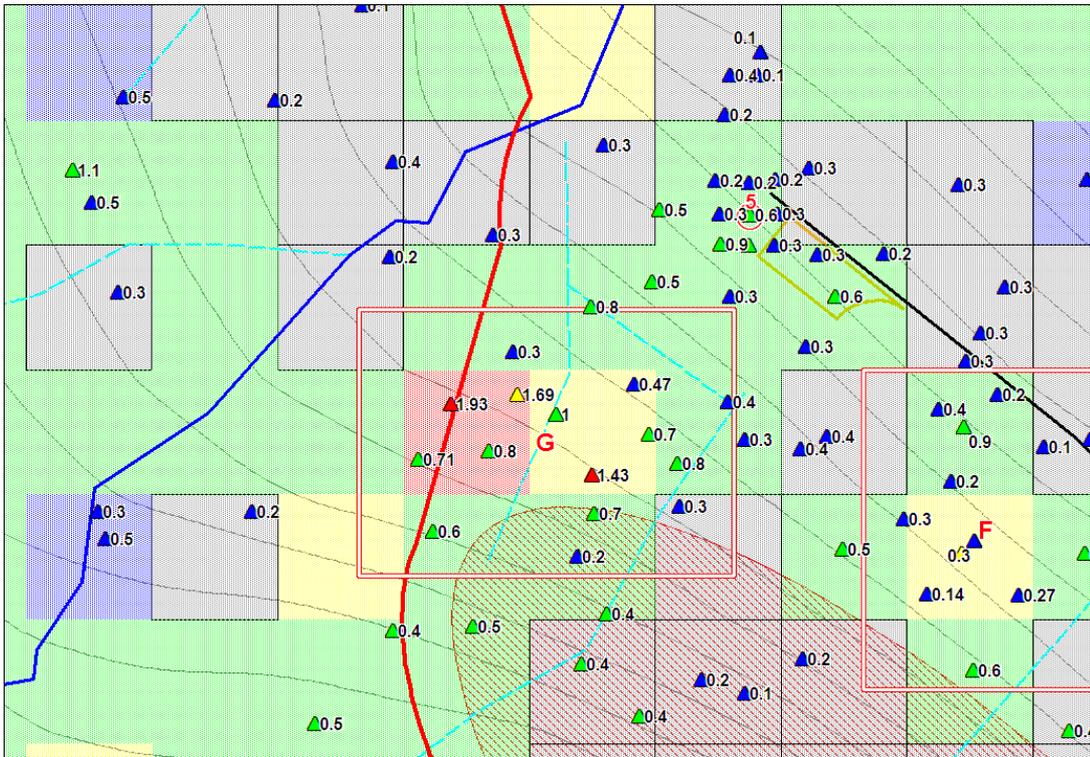
Area F



Photograph of Area F, looking south east from NS 6615 8863, 50 m south west of T5



Area G



Photograph of Area G, looking west from NS 6616 8854, 120 m south of T5



Appendix 9.1: Extended Phase 1 Habitat Survey



MacArthur Green Ltd

Craigton and Spittalhill Windfarm

Extended Phase 1 Habitat Survey

Technical Appendix 9.1

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EXECUTIVE SUMMARY

MacArthur Green Ltd was commissioned by Force 9 to complete an Extended Phase 1 Habitat Survey at the proposed Craigton and Spittalhill Windfarm Site (hereafter referred to as 'the site').

The surveys were carried out in addition to, and subsequently informed, dedicated protected species and National Vegetation Classification (NVC) surveys on site.

Surveying was conducted on 25th July 2012 during still and dry weather conditions.

The survey revealed a dominance of wet modified bog with a smaller portion of the site supporting marshy grassland and semi-improved acid grassland, with the most botanically diverse areas being confined to the marshy grassland areas.

Evidence of protected species presence was confined to two separate otter spraints recorded from the Backside Burn. No further protected species were recorded although some areas were deemed suitable for water vole presence.

1. INTRODUCTION

MacArthur Green Ltd was commissioned by Force 9 to undertake an Extended Phase 1 Habitat Survey (Ex. P1) at the proposed Craigton and Spittalhill Windfarm Site near Fintry, Stirlingshire (hereafter referred to as the 'site' - Figure 9.1).

The aim of this Ex. P1 is to detail those habitats present on site together with any other features of ecological interest in order to fully inform an ecological impact assessment of the proposed Windfarm.

The site extends throughout land to the north of the Craigton and Spittalhill farms, including the Fintry Hills and up to the Backside Burn. The north-east of the site is bordered by the Earlsburn Windfarm. Access to the site is via Todholes farm in the south east of the site.

2. METHODOLOGIES

2.1 Desk-based Study

A desk-based study was undertaken to inform subsequent field survey and assessment with regards the presence of designated sites and species of interest within the site and its environs. This study consisted data gathering exercise from the online resources NBN Gateway (www.searchnbn.co.uk) and SNH Sitelink (www.gateway.snh.gov.uk) (undertaken during September 2012).

2.2 Field Survey

Field surveys were completed in accordance with standard Ex. P1 guidelines (JNCC, 1993) and involved surveyors completing a walkover of the site, recording the habitats present onto a 1:10,000 map. Linear and point features (such as fencelines and single trees) were also mapped. Ex. P1 is a standard technique for classifying and mapping British habitats, with the aim of providing an inventory of those areas of greatest ecological importance. In addition to the recording of habitats, all other features of ecological interest, especially those pertaining to the presence or likely presence of protected species were also noted via the inclusion of 'Target Notes' (TNs). Each TN includes a brief description of the feature together with a grid reference – additional information such as a diagram and/or photograph is also provided depending on the feature.

Higher plant identification and nomenclature follow Stace (1995).

3. SURVEY CONSTRAINTS

Surveys were carried out during a suitable time of year and in suitable weather conditions, with all vegetation in leaf and identifiable to species level. All areas of the site were accessible.

4. SURVEY RESULTS

4.1 Desk-based Study

The desk-based study revealed the presence of the following designated sites within 5 km of the site:

- The Double Craigs SSSI lies within 2.5km of the site boundary to the south-west. It is designated due to the relatively undisturbed, upland grassland vegetation communities present as well as the igneous petrology geological features.
- The Endrick Water SSSI and SAC lies within 2.5km of the site boundary to the south. As well as being the largest river that flows in to Loch Lomond it is important nationally and internationally for its populations of Atlantic salmon, river lamprey and brook lamprey. The site also supports the only British records of the Scottish dock, a rare aquatic plant.

4.2 Field Survey

Field surveys were undertaken on the 25th July 2012 by four suitably qualified surveyors with a combined 15 years experience of habitat survey across Scotland. The following habitats were recorded (in order of greatest coverage). Figure 9.1 illustrates these findings:

4.2.1 Wet Modified Bog (E1.7)

Wet modified bog habitat covers the majority of the site with the only notable exceptions being two areas of marshy grassland within the central and northern parts of the site, and the proposed access route which is grassland dominated.

The bog habitat is heavily degraded throughout and has a subsequently reduced species diversity and notable absence of key blanket bog indicator species such as *Sphagnum papillosum* and *S. magellanicum* mosses and shrubs such as cross-leaved heath *Erica tetralix* and cranberry *Vaccinium oxycoccus*. The habitat supports a frequent coverage of hare's-tail cottongrass *Eriophorum vaginatum*, beneath the vascular plants, *Sphagnum fallax* dominates, with non-*Sphagnum* mosses such as *Polytrichum commune* also present. In places, a more herb-rich community is present which suggests a shift away from purely ombrotrophic¹ conditions. Heath bedstraw *Galium saxatile*, buttercup *Ranunculus* sp, common sorrel *Rumex acetosa* and cuckoo flower *Cardamine pratensis* are all frequent amongst a dominant hare's-tail cottongrass and *S. fallax* presence.

The northern side of the site, adjacent to the Backside Burn supports a purple moor grass *Molinia caerulea* mire habitat within which hare's-tail cottongrass and *Sphagnum capillifolium* are locally abundant.

A number of drainage ditches and very minor flush features bisect the bog habitat and are likely to have heavily influenced the current conditions observed within this habitat by virtue of long term drying effect. These features vary in their relative levels of activity, with some of the drains having seemingly infilled and therefore exhibiting no obvious water movement. Soft rush *Juncus effusus* is abundant within these channels.

¹ Defined as receiving all water and nutrients from rainwater

4.2.2 Acid Grassland (Semi-improved) (B1.2)

Semi-improved (SI) acid grassland extends throughout the majority of the eastern parts of the site, primarily on the proposed access route where the ground is heavily grazed. In some areas the sward is greatly influenced by grazing pressure from sheep and cattle with much-reduced sward length, and a reduced species diversity. These areas are dominated by Yorkshire fog *Holcus lanatus*, sheep's fescue *Festuca ovina* and sweet-vernal grass *Anthoxanthum odoratum*.

There are also pockets of semi-improved grassland in the north-west of the site, on the areas of lower ground. These areas lack *Sphagnum* species and have both wavy hair grass *Deschampsia flexuosa* and tufted hair grass *Deschampsia cespitosa* present amongst more common grasses such as sweet-vernal grass and Yorkshire fog.

The semi-improved grassland habitat is interspersed with (in places densely) scattered flushes, including those supporting a relatively diverse and interesting flora (e.g. TN 15). In such areas, basic conditions are prevalent and reflected in a community in which hairy stonecrop *Sedum villosum*, yellow sedge *Carex viridula* and marsh lousewort *Pedicularis palustris* are present.

4.2.3 Marshy Grassland (B5)

Marshy grassland extends across two large areas in the centre and north-west of the site and is scattered elsewhere alongside the Backside Burn and amongst grassland within the access track corridor. The habitat is generally dominated by rush species, most notably soft rush and sharp-flowered rush *Juncus acutiflorus* and also has a fair density of herbs such as cuckoo flower, marsh willowherb *Epilobium palustre*, marsh thistle *Cirsium palustre* and common sorrel. Bryophytes are notably absent.

In places, the sward takes on a more 'improved' appearance, with Yorkshire fog and sweet vernal grass becoming abundant, especially in those areas adjacent to semi-improved grassland.

4.2.4 Acid Fen (E3)

Acid fen habitat is confined to a single patch adjacent to where the proposed access route joins the main site. The habitat here shows marked similarities with the marshy grassland described above but has a rich *Sphagnum* layer present in which *S. fallax* is almost exclusively dominant. In addition to the herb species described above, this habitat also supports meadowsweet *Filipendula ulmaria*, marsh marigold *caltha palustre* and northern marsh orchid *Dactylorhiza purpurella*.

4.2.5 Running Water (G2)

The Backside Burn (TN 21) borders parts of the site and drains the whole area. The watercourse varies between around 0.5m and 2m in width, with a depth of up to around 0.5m over a mainly cobble/gravel substrate. In many places the banks are heavily affected by livestock, with poaching and a greatly-reduced sward length evident along much of its course. The Backside Burn is fed by several small burns on site and flows towards the Carron Valley reservoir.

The Backside Burn is fed by the Shelloch Burn (TNs 1 and 5) and an additional un-named burn to the south (TNs 9 and 11). Both of these watercourses are typical upland burns, flowing over bedrock for much of their length here. The widths varied from between 0.75m to 2m with an average depth of around 0.3m.

In addition, flushes and drainage ditches are abundant on the slopes of the Fintry Hills (TNs 2-4, 6-8, 10, 12-15, 17, 19 and 20). Many of these appear to have regular flow, and are likely to play an important role in draining the site. Elsewhere, the channels are vegetated to the extent that flow has

been much reduced. Some of these areas represent the most ecologically interesting habitats on the site, with locally basic conditions reflected in the vegetation present (e.g. TN 15).

4.2.6 Wet Dwarf Shrub Heath (D2)

A very small patch of wet dwarf shrub heath is present at the eastern end of the access route. Deergrass *Trichophorum cespitosum* and cross-leaved heath are dominant here, with bilberry *Vaccinium myrtillus* also present.

4.2.7 Standing Water (Dystrophic) (G1.4)

A single medium sized waterbody (TN 18) with 90% coverage of pond weed is found on the proposed access route in the east of the site. The pond appeared to be used utilised for drinking by livestock.

4.3 Faunal Interest

Faunal interest was recorded through the identification of signs of animal presence e.g. sightings, tracks, droppings etc., together with potentially suitable habitats. In each case, this interest was target noted, with a grid reference and photograph taken as appropriate. This study does not aim to confirm the presence/absence of any protected species on Site and indeed the absence of any such evidence does not preclude their presence.

Additional protected species surveys were undertaken (Technical Appendices 9.3 and 9.4), which detail the results of dedicated surveys undertaken on site for badger, bat, fish and water vole; however the following points were noted during the Ex.P1.

4.3.1 Otter

Signs of otter *Lutra lutra* were not recorded during the Ex.P1 survey though were recorded in the subsequent protective species surveys. The watercourses on site are considered suitable to provide foraging resources, given the food supply (salmonids) observed within the Backside Burn. During bird survey work otters were spotted on the nearby Loch Walton (approximately 1km south of the site).

4.3.2 Water Vole

No water vole *Arvicola amphibious* evidence was recorded on Site, although a number of suitable habitats were identified within the following areas:

- Alongside the tributaries/flushes feeding the Backside Burn from the south-east;
- Backside Burn

4.3.3 Reptiles

Much of the drier habitat on Site (especially on the south side of Fintry Hills and beyond) is suitable for reptiles, especially those heath/modified bog areas in the middle of the site. Common (viviparous) lizard *Zootoca vivipara* was recorded from a number of locations across the Site.

5. CONCLUSIONS

The habitats on the site reflect a landscape that has been heavily influenced by man over the recent and historic past with a muchdried habitat recorded over much of the site. The access route shows greater levels of more specific management, with an active grazing regime and more grassland-dominated habitats present. The most botanically diverse areas are confined to those habitats

where water levels have been retained i.e. upland basic flushes and marshy grassland/acid fen within the immediate vicinity of the watercourses on the site.

Protected species presence was confirmed on the site through the recording of two otter spraints along the Backside Burn and is considered likely that this watercourse and those that feed it are utilised by the species as a foraging and commuting resource. Although no evidence of water vole presence on site was recorded, a number of suitable areas were identified with an abundant food resource (rushes and sedges) together with a suitable substrate for burrowing.

6. REFERENCES

Joint Nature Conservancy Council, 1990. *Handbook for phase 1 habitat survey – a technique for environmental audit*. Revised reprint 2003. JNCC

Rose, F. (1981). *A Wild Flower Key, for the British Isles and North West Europe*. Revised reprint 2006. Warne, London.

Stace, C., 1997. *New Flora of the British Isles* (2nd Edition), Cambridge University Press.

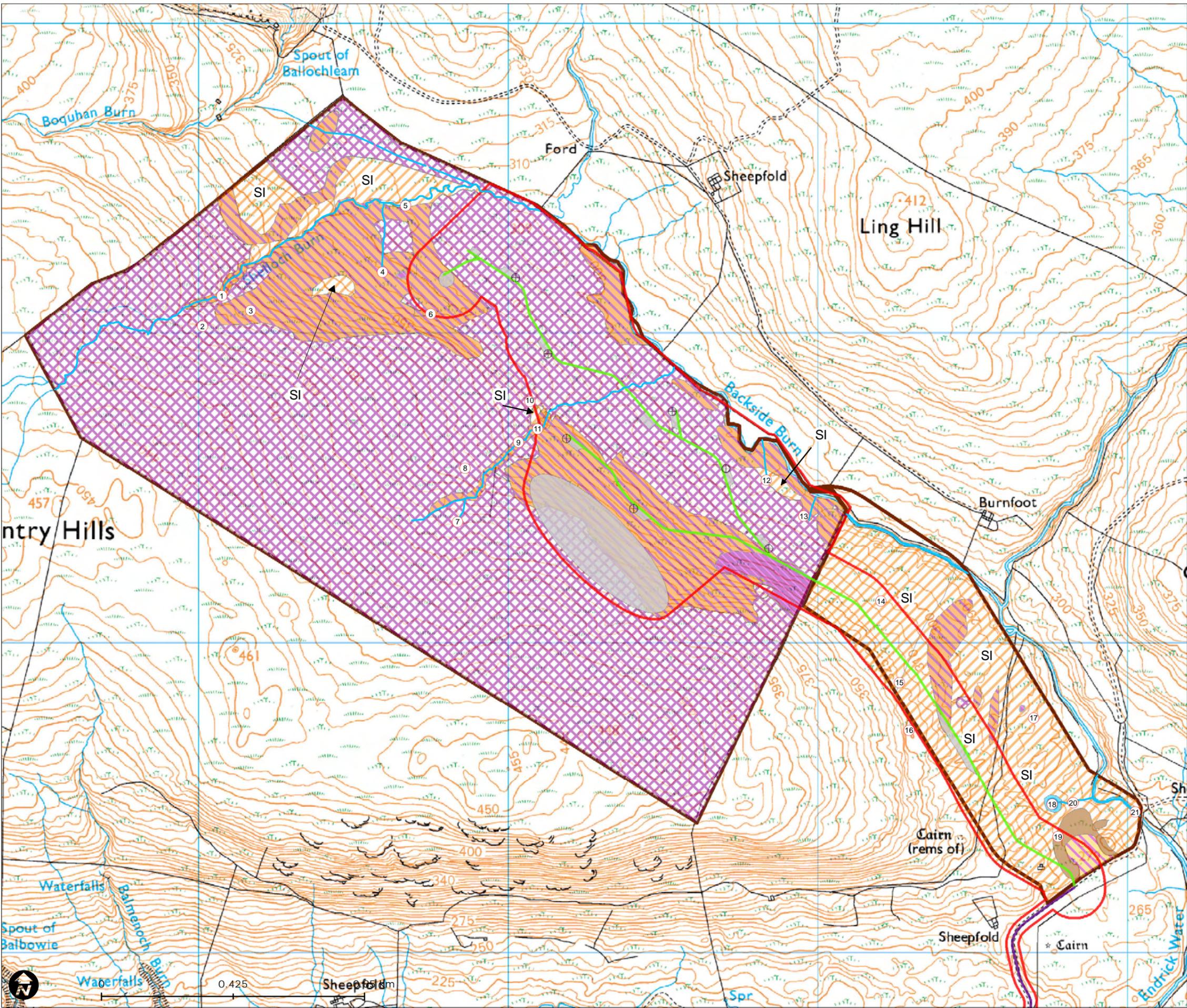
Websites:

NBN Gateway – www.nbn.org.uk

SNH Sitelink – www.gateway.snh.gov.uk

ANNEX 1 – FIGURE 9.1

Extended Phase 1 Survey Results
2012



- Phase 1 habitats**
- Semi-improved acid grassland
 - Marshy grassland
 - Continuous bracken
 - Wet dwarf-shrub heath
 - Wet modified bog
 - Acid fen
 - Standing water
 - Running water
- Wind farm infrastructure**
- Infrastructure
 - Proposed turbine locations
 - Existing tracks
 - Site tracks
- Boundaries**
- Survey boundary*
 - Site boundary

* The survey boundary was based off a preliminary site boundary.

Figure 9.1
Map Scale @ A3: 1:12,000

ANNEX 2 – TARGET NOTES

TN	Grid ref	Description
1	NS 65074 89122	Shelloch Burn - moderate sized burn with a width of 0.5-2m and a depth of 0.3-0.7m. Burn has a moderate flow over a cobble/boulder substrate with variable banks of common grasses, marshy grassland and patches of heath.
2	NS 65084 89107	Small burn with average width of 0.5m and a depth of 0.3-0.6m. Burn has a moderate flow over a cobble/boulder substrate with variable banks of marshy grassland, boulders, common grasses and patches of heath.
3	NS 65168 89074	Very small burn/drain with an average width of 0.3m and a depth of <0.5m. Burn has a moderate flow over a gravel based substrate, with small banks of marshy grassland.
4	NS 65594 89199	Small soft rush dominated ditch snaking through area of marshy grassland.
5	NS 65668 89413	Shelloch Burn – moderate sized burn with a width of 0.3-1m and depth of 0.25-0.5m. Burn has a moderate flow over a cobble/boulder substrate, with banks of common grasses and marshy grassland. Burn was assessed as having low to moderate water vole potential.
6	NS 65750 89063	Very small burn/drain with an average width of 0.3m and a depth of <0.5m. Burn has a moderate flow over a gravel based substrate, with small banks of marshy grassland.
7	NS 65836 88393	Small burn with average width of <0.4m and depth of <0.3m. Burn has swift flow over cobble/boulder substrate, with banks of marshy grassland. Was assessed as having low to moderate water vole potential.
8	NS 65861 88565	Small burn with average width of <0.4m and depth of <0.3m. Burn has swift flow over gravel substrate, with banks of marshy grassland.
9	NS 66033 88649	Small burn with a width of 0.5-1.5m and depth of <0.7m. Burn has a fast flow over a cobble/boulder substrate with steep banks of marshygrassland with areas of heath and ferns scattered throughout. Sections of the banks are rocky with rowan trees scattered along them.
10	NS 66070 88781	Small burn with an average width of 0.5m and depth of <0.5m. Burn has a moderate flow over a gravel based substrate, with low banks of marshy grassland.
11	NS 66095 88692	Waterfall on burn. Section of bare cliffs with moderate bat roost potential.
12	NS 66833 88526	Burn flowing downslope into Backside Burn. Burn has a width of 0.5m and a depth of <0.25m, with banks of grasses and rushes

13	NS 66954 88411	Very minor watercourse surrounded by tufted hair grass, soft rush and bent spp. Burn has an average width of 0.25m and a depth of <0.1m.
14	NS 67203 88136	Small burn within general acid fen habitat. Burn is 0.3m wide and <0.1m deep.
15	NS 67263 87874	Basic flush with sharp-flowered rush, hairy stonecrop, yellow sedge, marsh lousewort, and crested dog's tail grass. Flush has a very shallow area of flowing water.
16	NS 67294 87719	Boulders at foot of crags. May offer decent reptile shelter.
17	NS 67711 86487	Minor burn with an average width of 0.4m and depth of <0.25m. Burn has a moderate flow over a pebble substrate with banks of soft rush and continuous bracken. Burn was assessed as having low to moderate water vole potential.
18	NS 67757 87480	Medium-sized pond with 90% coverage of pondweed and 40% horsetail.
19	NS 67776 87376	Small drainage ditch with soft rush and <i>Sphagnum fallax</i> . Was assessed as having low to moderate water vole potential.
20	NS 67791 86487	Outflow from pond, feeding Backside Burn with species including water forget-me-not, marsh thistle and marsh willowherb.
21	NS 68025 87455	Backside Burn - moderate-sized watercourse to 2.5m width and >0.75m depth. Run and riffle flow dominating over boulders and cobbles. Drains the entire site.

Appendix 9.2: NVC Survey



MacArthur Green Ltd

Craigton and Spitalhill Windfarm

NVC Survey

Technical Appendix 9.2

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EXECUTIVE SUMMARY

MacArthur Green Ltd was commissioned by Force 9 Energy to undertake a National Vegetation Classification (NVC) survey at the proposed Craigton and Spitalhill Windfarm site at Craigton and Spitalhill farms near Fintry, Stirlingshire (hereafter referred to as the 'site' – Figures 9.2a to 9.2b).

The aim of this NVC survey was to further qualify those vegetation communities identified during Extended Phase 1 Habitat Surveys in order to inform the Windfarm design process.

In total 13 NVC communities were recorded at the site, however only a small number of communities accounted for the majority of the site area. The most common and widespread community is the M20 *Eriophorum vaginatum* blanket mire which dominates the higher slopes of the main site, but is also scattered throughout the lower slopes. Where the community is not dominant it forms a significant component of an extensive mosaic with other mire communities (M6 *Carex echinata-Sphagnum recurvum/cuspidatum* mire (sub-communities b and c), M19 *Calluna vulgaris – Eriophorum vaginatum* blanket mire, and M23 *Juncus effusus/acutiflorus – Galium palustre* rush-pasture (sub-communities a and b)), rush pasture communities (MG10 *Holcus lanatus-Juncus effusus* rush-pasture) and grassland communities (MG9 *Holcus lanatus-Deschampsia cespitosa* grassland, U4 *Festuca ovina – Agrostis capillaris – Galium saxatile* grassland and U6 *Juncus squarrosus - Festuca ovina* grassland). The next most dominant community is the U4 grassland which is the dominant community across the access track area and is scattered throughout areas of mire and rush pasture within the main site area. U6 was the only other calcifugous grassland community recorded on site, and forms a minor component of an extensive mosaic with mire communities that dominate the higher slopes of the main site.

The lower ground that borders the Backside Burn in the northern section of the site is dominated by the M25 *Molinia caerulea - Potentilla erecta* mire community.

The area around the steeper slopes and remaining non-mire habitat across the main site is generally an extensive and complex mosaic dominated by M23, with MG10 and U4 communities also prominent in places. These communities also form a significant component of the bankside vegetation along the majority of watercourses across the site. The MG9 community is restricted exclusively to a section of the Shelloch Burn where it often merges with surrounding areas of M23 and U4.

M6 mire is a prominent feature of the extensive mire habitat across the higher slopes of the main site but also snakes through the areas of MG10, M23 and U4 further down the slopes. The community forms an extensive network of drainage channels across this general area that drains the local mire habitats.

1. INTRODUCTION

MacArthur Green Ltd was commissioned by ScottishPower Renewables (SPR) to undertake a National Vegetation Classification (NVC) survey at the proposed Craigton and Spitalhill Windfarm site approximately 3.5km north-east of the town of Fintry in Stirlingshire (hereafter referred to as the 'site' - Figure 9.2a to 9.2b).

The site is approximately 370 hectares in size and reaches an elevation of 480m a.s.l. near the summit of the Fintry Hills.

The site can effectively be split into three main sections based upon the dominant community types recorded in these areas. The access route is dominated almost exclusively by grassland communities, with additional mire communities scattered throughout. The majority of the main site area is dominated by an extensive blanket of mire communities while the steeper middle section of the main site consists of a distinct mosaic of rush pasture, mire and grassland communities. The site has been impacted by man over time in a number of ways, with areas of open grassland heavily influenced by grazing and areas of mire influenced by both grazing and localised drainage management.

The aim of this NVC survey was to identify, and map, the vegetation communities present within the site boundary in order to identify those areas of greatest ecological interest (i.e. Annex I habitats¹; Groundwater Dependent Terrestrial Ecosystems (GWDTE)² habitats which would satisfy the criteria for SSSI selection; and those habitats listed under local and national Biodiversity Action Plans (BAPs)).

This report details the findings of the NVC surveys together with an evaluation of those communities described.

2. METHODS

The vegetation was surveyed by suitably qualified and experienced botanical surveyors using the National Vegetation Classification (NVC) (Rodwell, 1991 – 2000, 5 volumes) and in accordance with NVC survey guidelines (Rodwell, 2006). The NVC scheme provides a standardised system for classifying and mapping semi-natural habitats, and ensures that surveys are carried out to a consistent level of detail and accuracy.

Homogenous stands and mosaics of vegetation were identified and mapped by eye, drawn as polygons on field maps; these polygons were surveyed qualitatively to record dominant and constant species, sub-dominant species and others species present. In practice the vegetation was mapped progressively across the Site to ensure that no areas were missed and that mapping was accurate. An aerial photograph of the Site was also used to aid accurate mapping of vegetation boundaries. NVC communities were attributed to the mapped polygons using surveyor experience and matching field data against published floristic tables (Rodwell 1991 – 2000). Stands were classified to sub-community where possible.

¹ As defined by the Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora – the 'Habitats Directive'

² As defined within SEPA. (2011). Guidance Note 4 - Planning Advice on Windfarm Developments;

Quadrat sampling was not used in this survey as it is not always necessary if vegetation types can be reliably identified in the field using sufficient qualitative data as most NVC communities and sub-communities are defined by inter-stand frequency, not by the abundance of the constituent species. It is better in many cases to record several qualitative samples than one quantitative sample; furthermore qualitative information can be vital for understanding the dynamics and trends in vegetation patterns (Rodwell, 2006).

Due to vegetative and habitat variability across the Site, and the numerous transitional zones between similar NVC communities, a number of polygons represent complex mosaics of the NVC communities attributed to that respective polygon. Where polygons have been mapped as mosaics an attempt was made to give approximate percentage coverage of each NVC community within the polygon so that the dominant community could still be ascertained.

It should be noted that the results from this survey, and the matches made in describing communities, represent a current community evaluation as opposed to one seeking to describe what the community was before any human interference or may become in the future. In light of this, a clear constraint of the process is that it offers only a snapshot of the vegetation communities present and is thus subject to scrutiny if the results are relied upon for long term accuracy.

3. SURVEY CONSTRAINTS

Surveys were undertaken on 25-26th July 2012 when vegetation was readily identifiable to species level. All areas were easily accessible and were covered during the course of the surveys.

4. RESULTS

4.1 NVC categories

The categories of vegetation on site include the following NVC communities recorded during the survey:

- Blanket bogs and mire: M19, M20, M25;
- Heaths: M15;
- Flushes: M6b, M6c, M23a, M23b;
- Grassland: U6, U4, MG10, MG9; and
- Scrub: U20.

The following sections describe these communities in more detail in relation to the site and its flora. The broad habitat types, and the NVC communities within them, are described generally in order of relative abundance on site.

4.2 Mires and wet heaths

A significant portion of the main site area consists of an extensive mosaic of mire communities. This general habitat is dominant across all areas of the main Site except upon the steeper slopes.

4.2.1 M20 *Eriophorum vaginatum* blanket mire

The M20 *Eriophorum vaginatum* blanket mire community is characteristic of ombrogenous peats on bogs where certain treatments have greatly affected the vegetation; grazing and burning have been of greatest significance, but drainage has also played a part in the development of M20 (Ecklington *et al.*, 2001). These factors have led to floristic impoverishment.

The M20 community is the most dominant community type recorded on the site, covering extensive areas across the higher slopes of the site, but also found scattered in patches on the lower, steeper slopes as well. The community is the dominant feature across the majority of its extent but in places the habitat also forms a significant component of an extensive mosaic with other mire communities (M6, M19, and M23), rush pasture communities (MG10), and grasslands (MG9, and U4). The community is also present as a small patch within the otherwise grassland dominated ground of the access track area.

The community has a generally distinct species composition which varies across the site in regards to the relative abundance of its dominant plant species. The community consists of a co-dominance of *Eriophorum vaginatum*, and *Deschampsia flexuosa* with additional constants consisting of *Narthecium ossifragum*, *Vaccinium myrtillus*, *Juncus squarrosus*, *Eriophorum angustifolium* and *Molinia caerulea*. Additional species present to varying extents include *Nardus stricta*, *Galium saxatile*, *Anthoxanthum odoratum*, *Dactylorhiza maculata*, *Agrostis canina* and *Empetrum nigrum*. *Vaccinium oxycoccos* was recorded in one isolated stand within the access track area.

Certain patches of this community are notable for a reduction in the cover of *Eriophorum vaginatum* and the emergence of *Trichophorum cespitosum* as the dominant vegetative feature. A typical feature of this community is the patchy *Sphagnum* carpet that extends across most of the recorded habitat. *Sphagnum fallax*, *S. capillifolium* and *S. palustre* dominate the bryophyte layer while *S. papillosum* was occasionally recorded, though never in sufficient abundance to warrant a change in community classification toward a potential M17 *Scirpus cespitosus* – *Eriophorum vaginatum* blanket mire community. Non-*Sphagnum* mosses are also present but almost exclusively dominated by *Polytrichum commune*, with *Rhytidiadelphus squarrosus* scattered.

The habitat grades into nearby M19 communities where *Calluna vulgaris* emerges to become a prominent feature of the vegetation.

Elsewhere the community is found in zonations and successions with rush pasture communities including the M23 *Juncus effusus/acutiflorus* – *Galium palustre* community. A thinning of the peat cover is generally marked by a transition towards the nearby rush pasture habitat.

4.2.2 M25 *Molinia caerulea* – *Potentilla erecta* mire

The M25 *Molinia caerulea* – *Potentilla erecta* mire community is abundant on the site but is restricted exclusively to the lower ground where it forms a large belt that hugs the eastern site boundary. Here the community borders the Backside Burn that runs from south-east to north-west along the edge of the site, occasionally forming mosaics with other mire (M23), grassland (U4 and U6), and rush pasture (MG10) communities.

The community has a typical species composition consisting of an overwhelming dominance of *Molinia caerulea* alongside occasional areas of *Deschampsia flexuosa*, and *Agrostis* spp. In wetter patches the community tends to grade into nearby M23 and other rush pasture communities, as evidenced by the emergence of species such as *Juncus acutiflorus*, *Deschampsia cespitosa* and various herb species typical of rush pastures. A species poor herb layer is dominated by *Potentilla erecta* with few associates.

M25 tends to develop on slightly more aerated peats or peaty soils and the presence of this community on site is likely a consequence of grazing and drainage over ground that would naturally carry some other kind of mire or wet heath vegetation.

4.2.3 M19 *Calluna vulgaris* – *Eriophorum vaginatum* blanket mire

The M19 community is rare across the site, mainly restricted to scattered patches throughout the extensive M20 dominated mosaic in the higher areas of the main site. Elsewhere the community forms three small distinct patches lower down amongst the M25 dominated landscape.

The species composition of the community closely mirrors that of the M20 community recorded across the site with the main exception being the presence of *Calluna vulgaris*. The general species composition is typical of blanket bog vegetation of high-altitude ombrogenous peats present in the wet and cold climate of the uplands of northern Britain (Elkington *et al.*, 2001).

Constants include *Eriophorum vaginatum*, *E. angustifolium* and *Deschampsia flexuosa*. A typical *Sphagnum* carpet is present, dominated by *S. fallax*, *S. palustre* and *S. capillifolium*. *Calluna vulgaris* appears to be degraded in one particular area of this habitat in the south-eastern end of the main site. This degradation is reflected in the significantly reduced sward height relative to vegetation recorded elsewhere.

Much of the M19 *Calluna vulgaris* – *Eriophorum vaginatum* blanket mire on site often grades into other similar NVC communities creating overlap, transitional areas, and mosaics of communities. The site is/was being heavily drained, as evidenced by the considerable drainage network through the higher areas of the Site. The influence of this drainage management and the potential influence of grazing may affect the presence and proportions of many plant species leading to a blurring of vegetative boundaries.

4.2.4 M23 *Juncus effusus/acuteiflorus* – *Galium palustre* rush-pasture (sub-communities a and b)

The M23 *Juncus effusus/acuteiflorus* – *Galium palustre* rush-pasture community occurs over a variety of moist, moderately acid to neutral, peaty and mineral soils (Ecklington *et al.*, 2001).

The habitat is a prominent feature of the lower sections of the main site, especially along the steeper slopes leading down to the Backside Burn. Here the habitat forms several large areas of flush but otherwise forms a significant component of an extensive and complex mosaic with other mire (M6 and M20), rush pasture (MG10), and grassland (MG9 and U4) communities. The community also forms a significant component of the bankside vegetation along the majority of the minor watercourses across the site and the Backside Burn.

This community has a distinct general character but includes a wide variation in species composition. Vegetation is ill-defined and quite diverse, characterised by the abundance of either *Juncus effusus* or *J. acuteiflorus*, sometimes both, over a herbaceous layer common to wet grasslands. *Sphagnum* spp. do not form part of the M23 community.

Aside from a dominance of *Juncus effusus* and *J. acuteiflorus* a grass layer is also present including *Holcus lanatus*, *Agrostis canina*, and *Deschampsia flexuosa*. This upper layer lies over a herb-rich under-storey with species such as *Galium saxatile*, *Rumex obtusifolius*, *Cirsium palustre*, *Caltha palustris*, *Ranunculus repens*, *Epilobium palustre*, and *Rumex acetosa*. Additional species recorded in occasional stands include *Carex rostrata*, *C. panicea*, *Viola palustris*, *Dactylorhiza maculate*, *Myosotis scorpioides*, *Ajuga reptans* and *Cynosurus cristatus*.

An additional species of note was *Sedum villosum* which was recorded in a particularly herb-rich area along a section of the access track.

Although the grass layer is a sub-dominant component of this community across much of its extent, grasses such as *Holcus lanatus* and *Deschampsia cespitosa* attain a higher abundance where the community merges with nearby areas of MG10 and MG9 communities.

Furthermore, the community also shares many similarities with the M6 *Carex echinata-Sphagnum recurvum/ cuspidatum* mire on site and often transitions or forms mosaics with this community; differentiation often being based upon *Sphagna* in the basal layer.

M23 is mainly maintained by grazing.

4.2.5 M15 *Scirpus cespitosus* – *Erica tetralix* wet heath (sub-community b)

The M15 *Scirpus cespitosus* – *Erica tetralix* wet heath community is restricted to a small area along the south-eastern end of the access track where the habitat forms a mosaic with M20.

This community is characteristic of moist and generally acid and oligotrophic peats and peaty mineral soils in the wetter western and northern parts of Britain. It is also associated with thinner or better drained areas of ombrogenous peat (Elkington *et al.*, 2001). Although typically a diverse habitat this particular community has a relatively constant species composition across its recorded area.

The community consists of a dominance of *Trichophorum cespitosum* over a carpet of *Vaccinium myrtillus*. In contrast to more typical examples of this community, *Calluna vulgaris* is greatly reduced here and is somewhat degraded in vegetative character, reflected in a very short plant height. Heavy localised grazing is likely to be a significant factor in this degradation of the vegetation.

4.2.6 M6 *Carex echinata-Sphagnum recurvum/ cuspidatum* mire (sub-communities b and c)

This community has a distinct general character but includes a wide variation in composition, expressed as two separate sub-communities across the Site. It is a poor-fen with small sedges or rushes dominating over a carpet of base-intolerant *Sphagnum* spp. (Ecklington *et al.*, 2001).

The community is abundant across the site, forming an extensive network of small flushes and drains across the highest parts of the site as well as the steep slopes across the central areas. Across its extent the habitat forms a small but significant component of an extensive mosaic with other mire communities (M23, M20 and M19), rush pasture communities (MG10 and MG9) and grassland communities (U4).

The M6 habitats on site for the most part appear as linear features where there is an obvious channelling of water, and also border sections of several of the unmarked burns that bisect the site.

Two of the M6 sub-communities are represented on site; the M6b *Carex nigra* – *Nardus stricta* sub-community and M6c *Juncus effusus* sub-community. Of these sub-communities M6c is the most common with M6b only occasional in small patches.

M6b sub-community consists of a dominance of sedge species, (*Carex nigra* generally dominant with occasional areas of *C. rostrata*, and *C. panicea*) while the M6c community is dominated by *Juncus effusus*. Both sub-communities share a generally species poor herb layer consisting of a

mixture of constants including *Ranunculus repens*, *Rumex acetosa*, and *Cirsium palustre*, alongside scattered areas of *Galium saxatile* and grass species including *Agrostis canina* and *Deschampsia flexuosa*.

Certain patches of the community have a more diverse herb layer where additional species were recorded including *Cardamine pratensis* and *Caltha palustris*.

Both sub-communities share an extensive *Sphagnum* carpet dominated by *S. fallax*, *S. palustre* and *S. capillifolium*. Non-*Sphagnum* mosses are sparse in general but *Polytrichum commune* is frequent, particularly in stands of M6c *Juncus effusus* sub-community.

Occasionally the M6 community overlaps, and forms a mosaic with, the M23 *Juncus effusus/acuteiflorus* – *Galium palustre* rush-pasture (see 4.2.7) with a large similarity in species composition except for the presence or absence of *Sphagnum* spp. which largely became the differentiating factor in separation of the communities.

4.3 Grasslands

Grasslands are a dominant feature of the access track and form a significant component of an extensive mosaic with mire habitat across much of the main site.

4.3.1 MG10 *Holcus lanatus*-*Juncus effusus* rush-pasture

MG10 is a rush-pasture found on pre-dominantly moist soils across most of the British lowlands, with the typical sub-community being particularly prominent towards the north and west. Although found on various soil types including brown earth and calcareous earth throughout its range, this habitat can also have close associations with various types of mire vegetation and can form significant parts of rush-dominated mire communities in areas of suitably moist soil levels (Rodwell et al. 1991-2000).

The community is a prominent feature of the lower, steeper slopes of the main site but is more restricted in its extent compared to the extensive stands of M23 in this area. However, the community still forms a significant component of an extensive mosaic with the M20, M6, M23 and U4 across large areas of the main site. Elsewhere the community forms a minor component of the bankside vegetation along several of the minor watercourses across the site.

The community has a typical species composition, consisting of a co-dominance of *Holcus lanatus* and other grasses including *Agrostis* spp, along with prominent tussocks of *Juncus effusus*. Additional species present to varying extents include *Deschampsia cespitosa*, and *Anthoxanthum odoratum*. *Deschampsia cespitosa* emerges as a dominant vegetative component where the community grades into nearby MG9. The community has a generally species poor herb layer which includes *Cirsium palustre*, *Potentilla erecta*, and *Galium saxatile*, but additional species typical of the M23 community such as *Rumex obtusifolius*, and *Caltha palustris* emerge where these two communities merge.

4.3.2 MG9 *Holcus lanatus*-*Deschampsia cespitosa* grassland

The MG9 *Holcus lanatus*-*Deschampsia cespitosa* grassland community is a type of grassland found mainly on permanently moist and periodically inundated circumneutral soils across large areas of the British lowlands. Where recorded, it exists on level to moderately steep sloping ground in areas of pasture or meadow but can also be found along woodland rides and fen margins (Rodwell et al., 1991-2000).

The community is restricted exclusively to a thin strip that borders the Shelloch Burn in the northern end of the site. Here the community occurs in isolated stands alongside areas of M23 and U4, but also forms small mosaics with U6 and M25 communities.

Species composition is very similar to that of MG10 with the notable exception of *Juncus effusus* which is almost completely absent in this community. This community has a dominant upper layer of *Holcus lanatus*, *Deschampsia cespitosa* and *Agrostis* sp with occasional *Anthoxanthum odoratum* also present. Similar to MG10, the community has a generally species poor herb under-storey consisting of a mixture of species including *Ranunculus repens*, *Galium saxatile*, *Cirsium palustre* and *Rumex acetosa*. Where the habitat is nestled within larger areas of mire community and M23, species typical of these communities begin to emerge amongst the more typical MG9 vegetation. These species include *Polytrichum commune*, and *Juncus effusus*.

4.3.3 U4 *Festuca ovina* – *Agrostis capillaris* – *Galium saxatile* grassland

The U4 *Festuca-Agrostis-Galium* grassland is a form of pasture grassland, usually found on well-drained, more base-poor mineral soils throughout the wet and cool regions of north-west Britain, where it dominates extensive areas of pastureland. Throughout this geographic range the community can often be found forming a distinctive component of a larger mosaic consisting of a diverse network of other grasslands, heaths, and mires (Ecklington *et al.*, 2001).

U4 grassland is abundant across the site forming the dominant community of the access track area and forming a sub-dominant component of an extensive mosaic with MG10, M23, M20, and M6 communities across the main site area. Elsewhere, the community forms a minor component of the bankside vegetation of many of the burns across the site.

The species composition of the community shows a distinct shift between the grazed hillside along the access track, and the main site area. Throughout the access track area and along sections of bankside vegetation the community is generally dominated by a species poor combination of *Holcus lanatus*, *Festuca ovina*, and *Anthoxanthum odoratum* with scattered *Juncus effusus*. Across the majority of the access track the sward length is very low, evidently as a result of an intense grazing regime here.

Across the main site the species composition shifts toward a dominance of *Deschampsia flexuosa*, with additional constants including *Anthoxanthum odoratum*, and *Agrostis canina*. Additional species present to varying extents include *Deschampsia cespitosa* and *Molinia caerulea*. This community variant has a relatively species rich herb layer consisting of *Galium saxatile*, *Ranunculus repens*, *Rumex acetosa* and *Urtica dioica*. As a result of the extensive mosaic with mire habitats, species typical of such mire communities including *Eriophorum vaginatum* and *Molinia caerulea* occasionally emerge within the vegetation.

4.3.4 U6 *Juncus squarrosus* - *Festuca ovina* grassland

U6 is characteristic of moist peats and peaty mineral soils (Cooper, 1997). The U6 community is abundant but restricted to the higher slopes of the main site, and occasional patches further down the slopes. For the most part the community forms an extensive mosaic with the mire communities that dominate the higher areas of the site (M20, M6, and M19). Elsewhere the community sits within a large area of MG10 near the Backside Burn in the northern end of the site.

The U6 in the main site is of a more transitional form bridging the boundary between distinct areas of mire.

Juncus squarrosus is present but rather sparse as can sometimes be the case, while *Agrostis* spp. dominate alongside *Deschampsia flexuosa*. Additional species present to varying extents include *Anthoxanthum odoratum*, *Molinia caerulea*, and *Vaccinium myrtillus*. There is an increase in bryophytes compared to U4 above with *Polytrichum commune* becoming more prominent and *Hypnum jutlanticum* also present in patches.

4.4 Scrubland

4.4.1 U20 *Pteridium aquilinum*-*Galium saxatile* community

This community is restricted exclusively to a small patch in the very southern edge of the access track area. Here the community forms a broad band within an area otherwise dominated by U4. As is typical of the community, *Pteridium aquilinum* is wholly dominant and unbroken across the entire extent of the community.

5. SUMMARY

In total 13 NVC communities were recorded at the site, however only a small number of communities accounted for the majority of the site area. The most common and widespread community is the M20 blanket mire which dominates the higher slopes of the main site, but is also scattered throughout the lower slopes. Where the community is not dominant it forms a significant component of an extensive mosaic with other mire communities (M6, M19, and M23), rush pasture (MG10) and grasslands (MG9, U4 and U6). The next most dominant community is the U4 grassland which is the dominant community across the access track area and is scattered throughout areas of mire and rush pasture within the main site area. U6 was the only other calcifugous grassland community recorded on Site, and forms a minor component of an extensive mosaic with mire communities that dominate the higher slopes of the main Site.

The lower ground that borders the Backside Burn in the northern section of the Site is dominated by the M25 *Molinia caerulea* *Potentilla erecta* mire community.

The area around the steeper slopes and remaining non-mire habitat across the main site is generally dominated by an extensive and complex mosaic dominated by M23, with MG10 and U4 communities also prominent in places. These communities also form a significant component of the bankside vegetation along the majority of watercourses across the Site. The MG9 community is restricted exclusively to a section of the Shelloch Burn where it often merges with surrounding areas of M23 and U4.

M6 mire is a prominent feature of the extensive mire habitat across the higher slopes of the main site but also snakes through the areas of MG10, M23 and U4 further down the slopes. The community forms an extensive network of drainage channels across this general area that drains the local mire habitats.

Much of the mire habitat recorded across the site appears to be in a state of moderate degradation with anthropogenic interaction likely to be the main cause. *Calluna vulgaris* is rare and where present, the vegetation height is very low which is indicative of heavy grazing. In addition, an extensive drainage network exists across the site area which drains the mire habitat. This heavy drainage regime is likely to have affected the historic communities through changes to water regimes and alterations to the structure and composition of the flora. This is likely to have contributed to the extensive areas of M20 community across much of the main site.

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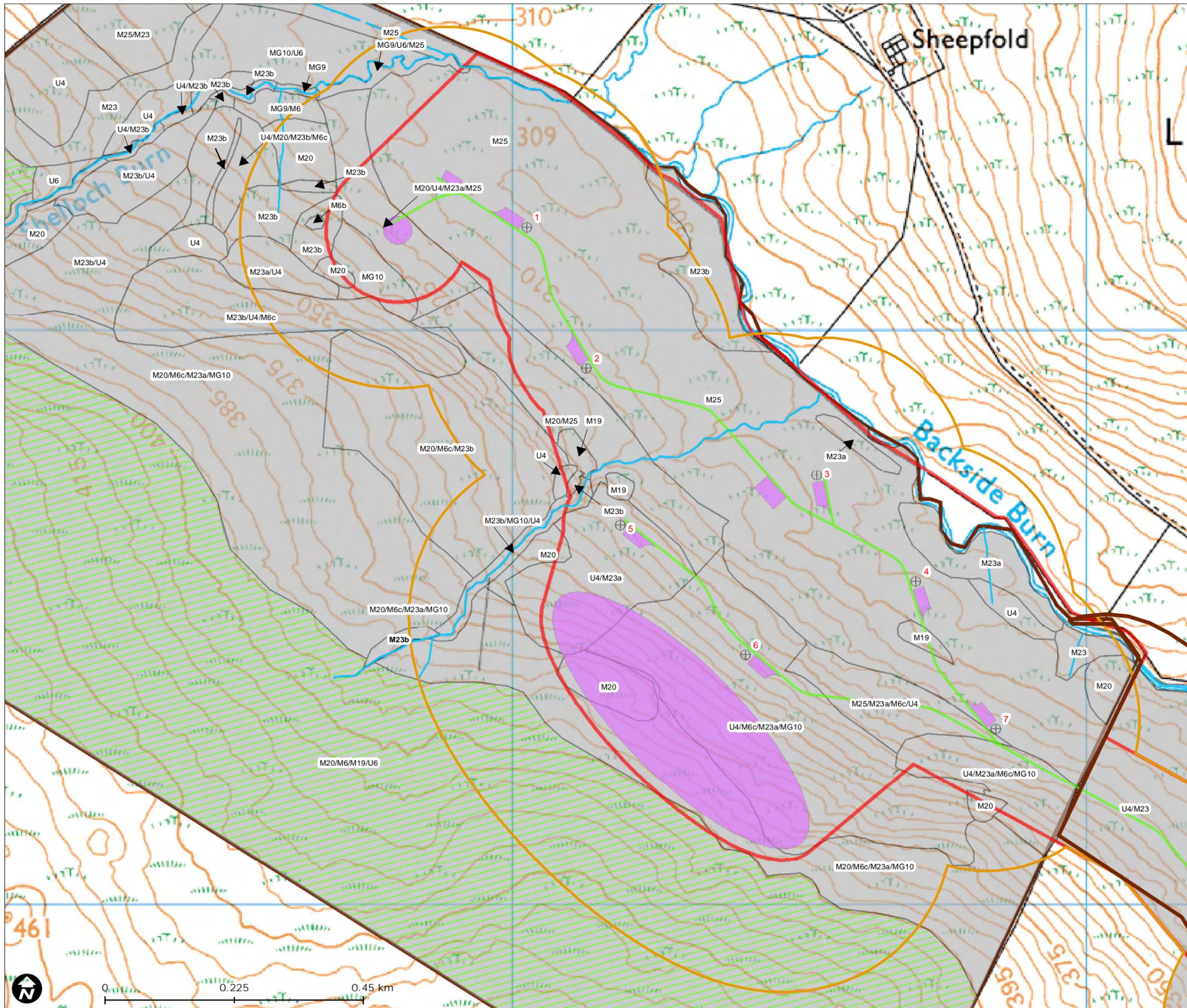
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ANNEX 1 – FIGURES 9.2a to 9.2b



NVC Survey Results
2012

NVC survey results

- NVC habitat
- * M6 flushes running throughout area
- Running water

Wind farm infrastructure

- Infrastructure
- ⊕ Proposed turbine locations
- Existing tracks
- Site tracks

Boundaries

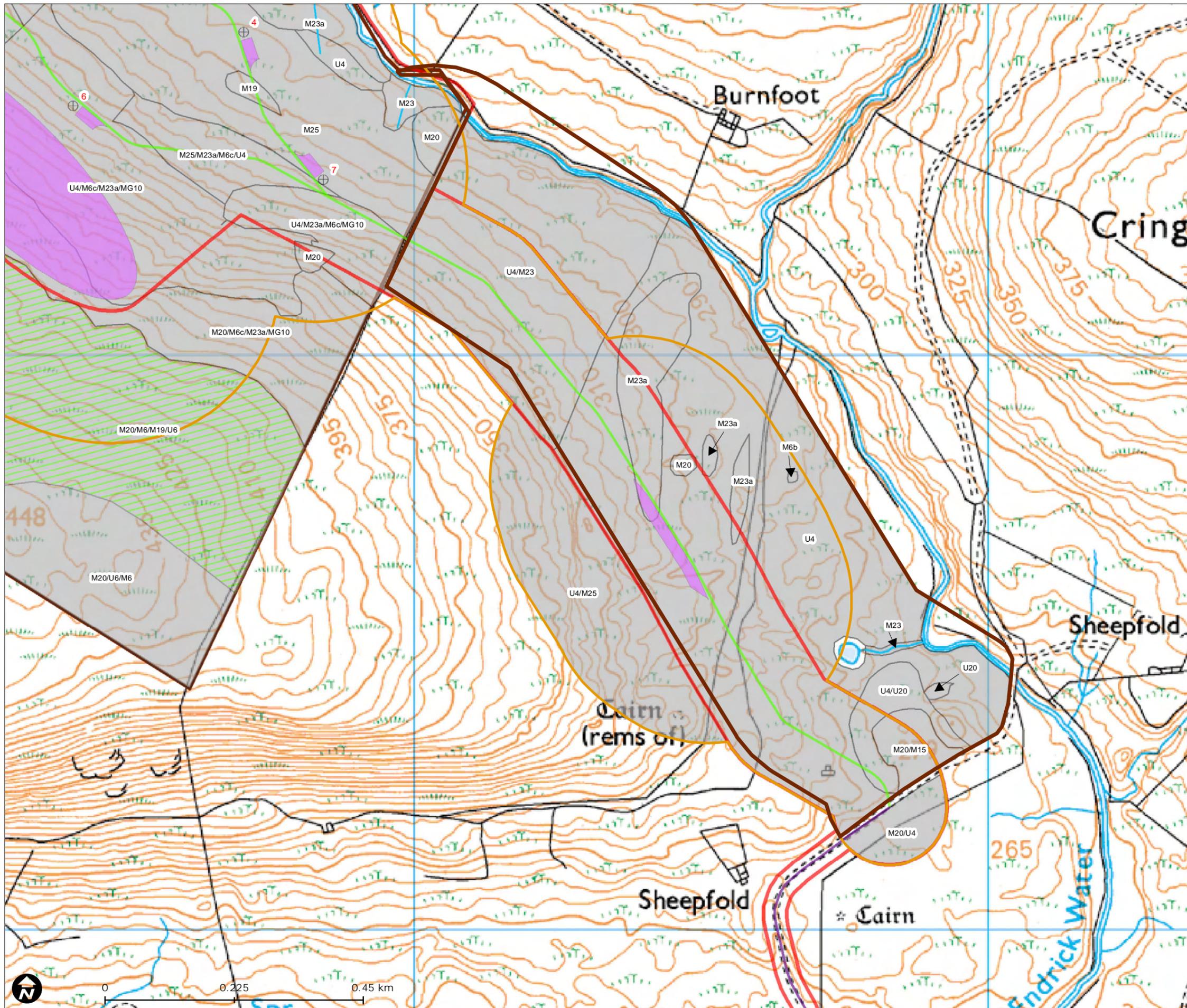
- Survey boundary*
- Infrastructure influence area**
- Site boundary

* The survey boundary was based off a pre-liminary site boundary.

** 250m buffer for general infrastructure and 100m buffer for Site tracks

Figure 9.2a

Map Scale @ A3: 1:6,500

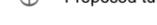


NVC Survey Results
2012

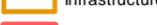
NVC survey results

-  NVC habitat
-  * M6 flushes running throughout area
-  Running water

Wind farm infrastructure

-  Infrastructure
-  Proposed turbine locations
-  Existing tracks
-  Site tracks

Boundaries

-  Survey boundary*
-  Infrastructure influence area **
-  Site boundary

* The survey boundary was based off a pre-liminary site boundary.

** 250m buffer for general infrastructure and 100m buffer for Site tracks

Figure 9.2b

Map Scale @ A3: 1:6,500

Appendix 9.3: Protected Species Survey



MacArthur Green Ltd

Craigton and Spitalhill Wind Farm

Protected Species Survey

Technical Report 9.3

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EXECUTIVE SUMMARY

MacArthur Green Ltd was commissioned by Force 9 to complete protected species surveys for otter, water vole and badger at the Craigton and Spitalhill Wind Farm site (hereafter referred to as 'the site').

These surveys were required to inform an Ecological Impact Assessment for the wind farm.

Surveys were conducted on the 25th July 2012 during still and dry weather conditions. Rainfall levels during the preceding days were low resulting in normal flow conditions of all watercourses surveyed.

The surveys found evidence of otter along the Backside Burn. No evidence of water vole presence was recorded, although suitable habitat was identified, and no evidence or suitable habitat for badgers was recorded.

1 INTRODUCTION

MacArthur Green Ltd was commissioned by Force 9 to carry out otter *Lutra lutra*, water vole *Arvicola amphibious* and badger *Meles meles* surveys at the Craigton and Spitalhill Wind Farm site (hereafter referred to as 'the site', see Figure 9.3).

These surveys were required to inform the subsequent Ecological Impact Assessment for the development.

The site extends across land to the immediate west of Craigton and Spitalhill, approximately 5 miles east of Fintry, Stirlingshire

Details pertaining to the legal status of those species surveyed are included within Annex 2.

2 METHODS

Surveys to record the presence or absence of otter, water vole and badger were carried out at the site on 25th July 2012 during dry and clear weather conditions. Surveys were undertaken by four suitably qualified surveyors, with a combined 15 years experience of protected species survey across Scotland.

The survey methods used are described below.

2.1 Badger

Land with the potential to support badger within the site was searched for field signs with particular attention given to areas around woodland and areas underlain by mineral soils as opposed to peat. Field signs of badger are described in Neal and Cheeseman (1996), Bang and Dahlstrøm (2001), and SNH (2001). Field evidence searched for included:

Holes (i.e. setts, single and groups of burrows);

Prints;

Latrines (and dung pits used as territorial markers): These are small excavated pits in which droppings are deposited;

Hairs: Tufts of hair can often be found on fences;

Feeding signs (snuffle holes): Small scrapes where badgers have searched for insects and plant tubers; and

Paths.

A walkover survey for the above signs was undertaken to determine current presence or absence of badger. The signs found also indicate type and intensity of activity and consequently help in the assessment of the importance of a particular area for badger.

2.2 Otter

Otter surveys were undertaken along the Backside Burn, Boquhan Burn, Burnfoot Burn, Gourlay's Burn, Shelloch Burn and those un-named ditches/burns on the site, and for a distance of approximately 250m upstream and downstream. Surveying involved a walkover of the survey area,

recording signs of otter presence as described in Bang & Dahlstrøm (2001), Sargent & Morris (2003) and Chanin (2003), including:

- **Holts:** Underground features where otters live. They can be tunnels within bank sides, underneath root-plates or boulder piles, and even man-made structures such as disused drains. Holts are used by otters to rest up during the day, and are the usual site of natal or breeding sites. Otters may use holts permanently or temporarily;
- **Couches:** These are above ground resting-up sites. They may be partially sheltered, or fully exposed. Couches may be regularly used, especially in reed beds and on in-stream islands. They have been known to be used as natal and breeding sites. Couches can be very difficult to identify, and may consist of an area of flattened grass or earth. Where rocks or rock armour are used as couches, these can be almost impossible to identify without observing the otter in-situ;
- **Prints:** Otters have characteristic footprints that can be found in soft ground and muddy areas;
- **Sprints:** Otter faeces may be used to mark territories, often on in-stream boulders. They can be present within or outside the entrances of holts and couches. Sprints have a characteristic smell and often contain fish remains;
- **Feeding signs:** The remains of prey items may be found at preferred feeding stations. Remains of fish, crabs or skinned amphibians can indicate the presence of otter;
- **Paths:** These are terrestrial routes that otters take when moving between resting-up sites and watercourses, or at high flow conditions when they will travel along bank sides in preference to swimming; and
- **Slides and play areas:** Slides are typically worn areas on steep slopes where otters slide on their bellies, often found between holts/couches and watercourses. Play areas are used by juvenile otters in play, and are often evident by trampled vegetation and the presence of slides. These are often positioned in sheltered areas adjacent to the natal Holt.

Any of the above signs are diagnostic of the presence of otter. However, it is often not possible to identify couches with confidence unless other field signs are also present. Sprinting is the most reliably identifiable evidence of the presence of this species.

2.3 Water Vole

Water vole surveys were undertaken along the Backside Burn, Boquhan Burn, Burnfoot Burn, Gourlay's Burn, Shelloch Burn and those un-named ditches/burns on the site, and for a distance of approximately 250m upstream and downstream. Surveying involved a walkover of the survey area, following the methodology prescribed in Strachan & Moorhouse (2006). This involved searching for the following field signs:

- **Faeces:** Recognisable by their size, shape, and content. If not too dried-out these are also distinguishable from rat droppings by their smell;
- **Latrines:** Faeces, often deposited at discrete locations known as latrines;
- **Feeding stations:** Food items are often brought to feeding stations along pathways and hauled onto platforms. Recognisable as neat piles of chewed vegetation up to 10cm long;

- **Burrows:** Appear as a series of holes along the water's edge distinguishable from rat burrows by size and position;
- **Lawns:** May appear as grazed areas around land holes;
- **Nests:** Where the water table is high above ground woven nests may be found;
- **Footprints:** Tracks may occur at the water's edge and lead into bank side vegetation. May be distinguishable from rat footprints by size; and
- **Runways in vegetation:** Low tunnels pushed through vegetation near the water's edge; these are less obvious than rat runs.

3 RESULTS

The surveys revealed the presence of otters on the site. No evidence of water vole or badger presence was found during the surveys. These findings are illustrated on Figure 9.3, with detailed features of interested detailed within the Target Note table (Appendix 3) and referenced within this report (TNs).

3.1 Otter

Evidence of otter activity was found along the Backside Burn, with two separate sprainting locations identified (TNs 1-2) at which relatively old (greater than one week old) spraints were identified. No further signs of otter presence (including holts and couches) were recorded from the site, with much of the prevailing habitats being generally unsuitable for holts/couches by virtue of the high levels of disturbance/grazing pressure in many areas. The habitat is more suited to foraging and commuting animals and those migrating through the wider area, especially from more optimal feeding grounds such as around the Endrick Water and River Carron (approximately 1km south of the site) and those standing waterbodies nearby (such as Loch Walton and Carron Reservoir both 1-2km to the south of the site).

Otters have been recorded in Loch Walton by bird surveyors while travelling on site to complete bird surveys during 2012.

3.2 Water Vole

No evidence of water vole presence was recorded during the survey, with the prevailing habitats generally considered suitable for the species by virtue of the abundant rush-dominated minor channels/flushes which are present across the north-eastern areas of the site. Many of these features have well-defined channel profiles, with peat-dominated banks that offer suitable burrowing opportunities, especially in combination with the dense vegetative cover.

3.3 Badger

The surveys revealed no presence of badgers across the site. The habitat is generally sub-optimal, with little suitable foraging and shelter/cover. The areas of semi-improved grassland habitat in the south of the site are of greatest suitability in this regard.

4 CONCLUSIONS

The site appears to be of use to an otter population for foraging and commuting purposes. The Backside Burn forms part of the Carron Valley Reservoir catchment and is known to support

salmonids (see Technical Appendix 9.5), which will be an important food source to the local otter population. It is unlikely that otters will establish holts/couches on the site whilst the land management remains as it is (i.e. for use by livestock, resulting in high levels of localised disturbance).

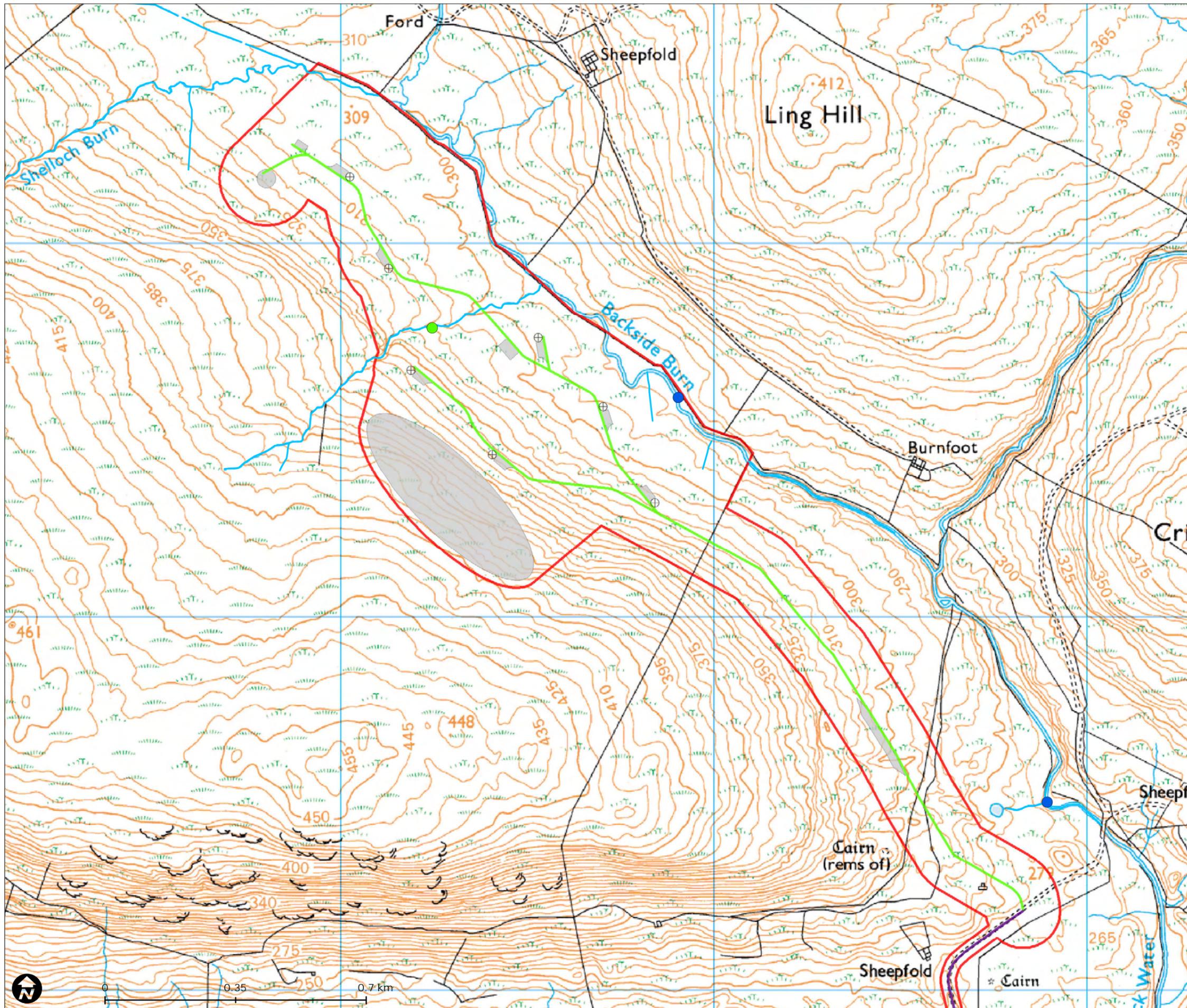
The site does not support any water voles at present; however potentially suitable habitat was identified during the surveys.

No signs of badger were recorded from the site.

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ANNEX 1 – SITE SURVEY FIGURE 9.3



Protected Species Survey Results
2012

Protected species signs

- Location of otter spraints
- Location of reptile sightings
- Running water

Wind farm infrastructure

- Infrastructure
- ⊕ Proposed turbine locations
- Existing tracks
- Site tracks
- Site boundary

Figure 9.3

Map Scale @ A3: 1:10,000

ANNEX 2 – LEGAL PROTECTION

Otters

Conservation (Natural Habitats, &c.) Regulations 1994 (as amended)

Under Regulation 39 (1) it is an offence to:

- (a) deliberately or recklessly to capture, injure or kill a wild animal of a European protected species;
- (b) deliberately or recklessly:
 - (i) to harass a wild animal or group of wild animals of a European protected species;
 - (ii) to disturb such an animal while it is occupying a structure or place which it uses for shelter or protection;
 - (iii) to disturb such an animal while it is rearing or otherwise caring for its young;
 - (iv) to obstruct access to a breeding site or resting place of such an animal, or otherwise to deny the animal use of the breeding site or resting place;
 - (v) to disturb such an animal in a manner that is, or in circumstances which are, likely to significantly affect the local distribution or abundance of the species to which it belongs; or
 - (vi) to disturb such an animal in a manner that is, or in circumstances which are, likely to impair its ability to survive, breed or reproduce, or rear or otherwise care for its young;
- (c) deliberately or recklessly to take or destroy the eggs of such an animal; or
- (d) to damage or destroy a breeding site or resting place of such an animal.

Regulation 44 (2e) allows a licence to be granted for the activities noted in Regulation 39 such that:

Preserving public health or public safety or other imperative reasons of overriding public interest including those of a social or economic nature and beneficial consequences of primary importance for the environment.

Otter is also listed on Appendix I of CITES, Appendix II of the Bern Convention and Annexes II and IV of the Habitats Directive (1994). It is also listed as globally threatened on the IUCN/WCMC Red Data List.

The **water vole** is not protected by Section 9, subsection 1 of the Wildlife and Countryside Act but is covered by Section 9, subsection 4 and Section 10¹.

Wildlife and Countryside Act (1981)
Nature Conservation (Scotland) Act 2004

Under Section 9, Subsection 4, Paragraphs (a) and (b)⁴, a person is guilty of an offence if intentionally or recklessly:

- a) he damages or destroys any structure or place which any wild animal included in Schedule 5 uses for shelter or protection;
- b) he disturbs any such animal while it is occupying a structure or place which it uses for shelter or protection; or
- c) he obstructs access to any structure or place which any such animal uses for shelter or protection.

Under Section 10, Subsection 3, Paragraph (c)⁴, a person shall not be guilty of an offence by reason of:

- c) any act made unlawful by that section if he shows:
 - (i) that each of the conditions specified in subsection (3A) was satisfied in relation to the carrying out of the unlawful act; or
 - (ii) That the unlawful act was carried out in relation to an animal bred and, at the time the act was carried out, lawfully held in captivity.
- Section 3a states those conditions referred to in Subsection 3c are:
 - a) That the unlawful act was the incidental result of a lawful operation or other activity;
 - b) That the person who carried out the lawful operation or other activity:
 - (i) took reasonable precautions for the purpose of avoiding carrying out the unlawful act; or
 - (ii) did not foresee, and could not reasonably have foreseen, that the unlawful act would be an incidental result of the carrying out of the lawful operation or other activity; and
 - c) That the person who carried out the unlawful act took, immediately upon the consequence of that act becoming apparent to the person, such steps as were reasonably practicable in the circumstances to minimise the damage or disturbance to the wild animal, or the damage or obstruction to the structure or place, in relation to which the unlawful act was carried out.

¹ as amended by the Nature Conservation (Scotland) Act 2004

ANNEX 2 – LEGAL PROTECTION

Badgers are protected under the **Protection of Badgers Act 1992** (as amended by the **Nature Conservation (Scotland) Act 2000 (as amended)**).

The following applies under this legislation:

Part 1.–

(1) A person is guilty of an offence if, except as permitted by or under this Act, he wilfully kills, injures or takes, or attempts to kill, injure or take, a badger.

(2) If, in any proceedings for an offence under subsection (1) above consisting of attempting to kill, injure or take a badger, there is evidence from which it could reasonably be concluded that at the material time the accused was attempting to kill, injure or take a badger, he shall be presumed to have been attempting to kill, injure or take a badger unless the contrary is shown.

(3) A person is guilty of an offence if, except as permitted by or under this Act, he has in his possession or under his control any dead badger or any part of, or anything derived from, a dead badger.

Part 3. –

(1) A person is guilty of an offence if, except as permitted by or under this Act, he interferes with a badger sett by doing any of the following things–

- (a) damaging a badger sett or any part of it;
- (b) destroying a badger sett;
- (c) obstructing access to, or any entrance of, a badger sett;
- (d) causing a dog to enter a badger sett; or
- (e) disturbing a badger when it is occupying a badger sett.

intending to do any of those things or being reckless as to whether his actions would have any of those consequences.

(2) A person is guilty of an offence if, except as permitted by or under this Act, he knowingly causes or permits to be done an act which is made unlawful by subsection (1) above.

ANNEX 3 – TARGET NOTES

Target Note (TN)	Grid Reference	Description
1	NS 67897 87498	Old otter spraint upon mid-channel boulder
2	NS 66937 88544	Spraint on rock at side of burn

Appendix 9.4: Bat Report

Contract Bat Consultancy

Craigton and Spittalhill

Fintry, Stirlingshire, G63 0XH

Central OS Grid Ref: NS 657 881

Contract Reference: MAG04.11.546



TECHNICAL APPENDIX 9.4

Dated: 24 November 2011

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Survey Report Reference MAG04.11.546
Signed on behalf of Echoes Ecology Ltd:



Laura Davis MIEEM
(Team Manager and Senior Ecologist)

Date: 24 November 2011



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Overview

The site, Craigton and Spittalhill, is situated approximately 5km east of Fintry, Stirlingshire, G63 0XH, central OS Grid Reference NS 657 881. It is the intention, subject to planning permission being approved, to install eight wind turbines and associated access roads. For a plan of the site please refer to Appendix I.

Echoes Ecology Ltd were appointed by MacArthur Green Ltd to carry out an assessment of Craigton and Spittalhill to determine the potential for roosting, foraging and commuting by bats, and to identify any potential conflicts between bats and proposed wind turbine locations at the site. It is the intention, subject to planning permission being approved, to install eight wind turbines and associated access roads within the Spittalhill (east) side of the site. A survey boundary of at least 300m around the turbines was established. No land outside this survey boundary was surveyed.

A survey programme relating to bats took place during the period 12.04.11 to 05.09.11. Although small numbers of bats were found to be active (foraging and commuting) within the site boundary, no roosting potential existed within the survey boundary for bats and therefore no evidence of roosting bats was established.

Any construction works at the site should take account of the mitigation measures (Section 4) drawn from this report.

Section 1 - Introduction

1.1 Contract Overview

- 1.1.1 Echoes Ecology Ltd were appointed by MacArthur Green Ltd to carry out an assessment of the site to determine the potential for roosting, foraging and commuting by bats, and to identify potential conflicts between bats and proposed wind turbine locations at the site.
- 1.1.2 The site, Craigton and Spittalhill, is situated approximately 5km east of Fintry, Stirlingshire, G63 0XH, central OS Grid Reference NS 657 881. It is the intention, subject to planning permission being approved, to install eight wind turbines and associated access roads within the Spittalhill (east) side of the site. A survey boundary of at least 300m from each turbine was established. No land outside this survey boundary was surveyed. For a plan of the site please refer to Appendix I.
- 1.1.3 The survey area lies at an altitude ranging from approximately 300m to 420m above sea level, and the habitat is mainly rough grassland.
- 1.1.4 For the purposes of this report the site as a whole is referred to as Spittalhill.
- 1.1.5 The survey work reported upon within this document was carried out during the period 12.04.11 to 05.09.11.

1.2 Bats in the UK

- 1.2.1 There are 18 species of bat found in the UK, 10 of which have been recorded in Scotland (see Appendix II). All bats occurring in the UK are nocturnal and insectivorous (Altringham, 2003). A single pipistrelle bat can consume up to 3,000 insects in a night (Bat Conservation Trust, 2008), thus demonstrating the valuable contribution that bats make to the environment.
- 1.2.2 In order to interact naturally with their environment, maintain viable populations and indeed survive it is important that bats have access to roosting sites and foraging areas. Linear features are also important for many UK bat species (Middleton, 2004) which have been shown to rely upon these as commuting corridors or as points of reference in the dark (see Appendix III).
- 1.2.3 Bats roost in groups or as individuals. In the course of a year bats will use a number of different roosts for different purposes according to the season (see Table 1.1). These roosts can be in the same location or a good distance apart. Due to bats regularly switching roosts (e.g. according to season), the absence of bats in any one particular location at any one time does not necessarily mean that bats do not roost there at other times. Bats tend to be faithful to their roosts and as such return to them, year after year. This is one of the reasons why a bat roost is always protected even if the bats are not present at any given time.
- 1.2.4 Bats and their roosts can be very difficult to detect. This is because the bat species which occur in the UK have evolved over millions of years (Altringham, 2003) to seek safe shelter in dark enclosed areas, away from disturbance and out of sight from potential predators (e.g. birds of prey). Common roosting locations for UK bats within buildings include: beneath slates or tiles; in crevices between stonework (particularly where these extend to rubble fill or a wall cavity); in mortise joints; around window frames; behind barge/soffit boards and areas where timber (e.g. rafters) creates corners, crevices or cavities (Scottish Natural Heritage, 2007). Further, many bat species can also be found roosting in trees, utilising cracks, crevices, holes and loose bark for this purpose. Note that this list is by no means exhaustive and bats can be found in a variety of other roosting places such as caves, tunnels, bridges, mines and historic buildings.
- 1.2.5 In order to help study bats and locate roosts, bat ecologists undertake a range of methods and techniques (Mitchell-Jones and McLeish, 2004). These include searching for signs of bats (e.g. droppings, corpses, feeding remains) and activity surveys (e.g. watching for bats leaving a structure at dusk or re-entering at dawn) using ultrasonic bat detectors in order to understand their behaviour.

Table 1.1 - Typical Annual Cycle of Bat Roosting within the UK

Season	Type of Roosts Formed	Roosting Behaviour
Spring	Spring transitional	Bats come out of hibernation and move into transitional spring roosts.
	Male roosts	For many species males usually roost separately to females.
	Night roosts	Night roosts used by bats taking a rest during the night rather than returning to their normal day roost.
	Maternity roosts	Females of most species begin to form maternity colonies.
Summer	Maternity roosts Nursery roosts	For some species of bat maternity roosts can typically hold many hundreds of adult females waiting to give birth. Damage or disturbance to any roosting colonies at this time could have a potentially significant adverse effect on the species population for that area. Once the females give birth the roost location is known as a nursery roost.
	Male roosts	Male bats tend to roost separately to females, individually or in smaller numbers.
	Night roosts	Night roosts used by bats taking a rest during the night rather than returning to their normal day roost.
Autumn	Nursery Roosts	Nursery roosts are vacated as the females and immature bats find alternative roosting areas.
	Harems/Breeding Roosts	Male bats set up breeding roosts. Approach differs according to species. The autumn breeding season takes place.
	Non-breeding roosts	Bats not actively involved with breeding may be found separately at other roosting locations.
	Night roosts	Night roosts used by bats taking a rest during the night rather than returning to their normal day roost.
Winter	Hibernacula	Bats hibernate during the winter to conserve energy. At this stage in their life cycle damaging or obstructing a roost or disturbing bats may affect their survival as they would struggle to replenish the energy used in waking up at a time of year when food was scarce.

1.3 Bats and the UK Biodiversity Action Plan (UKBAP)

1.3.1 In 1992, 150 government leaders from around the world (including the UK) signed the Convention on Biological Diversity at the United Nations Conference on Environment and Development (also known as The Rio Earth Summit). By doing so, the signatory nations were committing to promoting sustainable development, and at a national level implementing plans to do so.

In the UK, the governmental response to the Convention on Biological Diversity is the UK Biodiversity Action Plan (UKBAP), which depicts the biological resources of the UK and the detailed plans to protect them. These plans are presented in the form of 1,150 Species Action Plans (SAPs), 65 Habitat Action Plans (HAPs) and 190 Local Biodiversity Action Plans (LBAPs). Seven bat species have SAPs within the UKBAP, of which the following three are found in Scotland:

- Brown long-eared (*Plecotus auritus*)
- Noctule (*Nyctalus noctula*)
- Soprano pipistrelle (*Pipistrellus pygmaeus*)

1.4 Legal Considerations – A General Overview

- 1.4.1 All bats and their roosts are protected under UK and European Legislation, including, amongst others, the following:
- The Wildlife and Countryside Act 1981
 - The Nature Conservation (Scotland) Act 2004
 - The Wildlife and Natural Environment (Scotland) Act 2011
 - The Conservation (Natural Habitats, &c.) Regulations 1994
 - The Conservation (Natural Habitats, &c.) Amendment (Scotland) Regulations 2007
 - The Conservation (Natural Habitats, &c.) Amendment (No. 2) (Scotland) Regulations 2008
 - The Conservation of Habitats and Species Regulations 2010 (replaces the Conservation (Natural Habitats, &c.) Regulations 1994 and amendments in England and Wales and in Scotland with regards to reserved matters).
- 1.4.2 It is an offence to deliberately or recklessly disturb a bat (including injuring, capturing and/or killing), or damage, obstruct, alter or destroy a bat roost.
- 1.4.3 A bat roost is protected at all times irrespective as to whether any bats are using the roost at a given time. Scottish Natural Heritage should always be consulted by planning authorities if any proposed work could affect bats or their roosts. Developers, planners and contractors (as well as everyone else involved) must make every effort to safeguard bats, their roosts and their commuting and foraging habitat.
- 1.4.4 Within Scotland, a consolidated Scottish Planning Policy (SPP) document provides statements of Government policy on nationally important land use and other planning matters and gives guidance on how the Government's policies for the conservation and enhancement of Scotland's natural heritage should be reflected in land use planning. The presence of protected species is a material consideration to be taken account of by planning authorities.
- 1.4.5 Local Planning Authorities are required to take account of the presence of bats as a material consideration when processing planning applications. It is therefore advisable for developers and the like to investigate for the presence of bats, and other protected species, at as early a stage in the process as possible.
- 1.4.6 If the work proposed affects bats or their roosts, a Habitats Regulations licence, issued by Scottish Natural Heritage (SNH) will be required. In the event that a Habitats Regulations licence is required there are three tests that must be satisfied before it will be granted (refer to Table 1.2), in addition to which mitigation and/or compensation will almost certainly be required. If an application for a licence is required to be made it should be noted that this will usually take a minimum of 6 weeks to come to a conclusion and there are no guarantees that such an application will be successful.

Table 1.2 - The Conservation (Natural Habitats, &c.) Regulations 1994

<p>THE CONSERVATION (NATURAL HABITATS, &c.) REGULATIONS 1994</p> <p>Under the 1994 Regulations it is an offence to kill, capture or disturb European Protected Species, and/or damage or destroy a breeding site or resting place of such an animal.</p> <p>Habitats Regulations licences can be granted under Regulation 44 for certain purposes including preserving public health or public safety or other imperative reasons of overriding public interest including those of a social or economic nature and beneficial consequences of primary importance for the environment (<i>Test 1</i>).</p> <p>Licences will only be granted under the Conservation (Natural Habitats, &c.) Regulations 1994 if SNH are satisfied that:</p> <ul style="list-style-type: none"> • There is no satisfactory alternative (<i>Test 2</i>) and • The action authorised will not be detrimental to the maintenance of the population of the species at a favourable conservation status in their natural range (<i>Test 3</i>)

- 1.4.7 Due to the specialist knowledge required by ecologists with relation to bats, developers are advised to engage the services of an experienced bat consultant with matters of this nature. In addition, it is recommended that the consultant should be a licensed bat worker, because if a roost is found and information needs to be gathered legally in order to obtain the details required for a Habitats Regulations licence application, then only persons licensed to do so may disturb bats in a roost.

1.5 Bats and Wind Farms

- 1.5.1 There are a number of factors thought to contribute to bat mortality rates at wind farm sites (Kunz *et al.*, 2007). One study, an investigation into patterns of bat fatalities at wind farm sites in North America, showed the number of fatalities to be heavily skewed towards migratory species (Arnett *et al.*, 2008). A previous study, again on North American bats, by Kunz *et al.* (2007) identified seasonal variation in the numbers of bat fatalities at wind farm sites. The highest numbers of fatalities were observed during late summer and early autumn and this was linked to the timing of bat migrations. Although in the UK there do not appear to be migrations over large distances as there is in North America, it is known that British bat species do migrate on a smaller scale when moving between summer roosts and hibernacula sites (Betts, 2006) and could therefore be negatively impacted upon if wind farms were positioned on routes between these sites.
- 1.5.2 A study by Horn *et al.* (2008) into the causal effect of bat mortality discovered that when bats approached both rotating and non-rotating blades they appeared to inspect the structures, suggesting this may be because the structures appeared to offer potential roost sites. One of the consequences of going near the blades is that bats then become trapped in the vortex caused by the movement of the blade through the air. The bats were also observed colliding directly with either the blades or the monopole. Another indirect negative effect identified was the creation of linear foraging habitat through the building of access roads; this had the effect of bringing bats into closer contact with wind farms.
- 1.5.3 Studies of bat carcasses found beneath turbines have revealed the bats to have signs of internal haemorrhaging often with no visible external injuries (Baerwald *et al.*, 2008). This type of fatal injury is thought to have been caused by sudden drops in air pressure resulting from the movement of the turbine blades, and is known as barotrauma.
- 1.5.4 In the UK, guidelines have been produced with regards to assessing the ecological impact upon bats from wind farm developments. These guidelines aid in producing mitigation and compensation strategies to minimise any negative impact upon local bat populations.
- 1.5.5 Bats and Onshore Wind Turbines: Interim Guidance (Anon, 2009a, and Anon, 2009b): This documents the considered opinion as to which species of bat (at individual and population level) are likely to be impacted upon by wind farms, and to what extent. In addition, it provides useful guidance relating to the positioning of turbines within certain habitat types. Bat species (individuals and populations) are assigned to 'Low', 'Medium' and 'High' risk categories as described below within Tables 1.3 and 1.4.

Table 1.3 - Individual Bats Likely to be at Risk from Wind Turbines (Adapted from Anon, 2009a)

Low Risk	Medium Risk	High Risk
<i>Myotis</i> species	Common pipistrelle	Noctule
Long-eared bats	Soprano pipistrelle	Leisler's
Horseshoe bats	Serotine	Nathusius' pipistrelle
	Barbastelle	

Table 1.4 - Bat Populations Likely to be at Risk from Wind Turbines (Adapted from Anon, 2009a)

Low Risk	Medium Risk	High Risk
<i>Myotis</i> species	Serotine	Noctule
Long-eared bats	Barbastelle	Leisler's
Common pipistrelle		Nathusius' pipistrelle
Soprano pipistrelle		
Horseshoe bats		

- 1.5.6 Bat Surveys, Good Practice Guidelines (Bat Conservation Trust, 2007): This document provides an outline of the best practice methods when assessing bats relative to development. It provides strong guidance as to survey effort levels and the like, albeit at its time of publication it was not thorough in its conclusions regarding wind farm development within the UK. As a result of this a further, more specific, set of guidelines for wind farm development in the UK, was published in 2011 (as described below).
- 1.5.7 Surveying for Onshore Wind Farms (Bat Conservation Trust, 2011): This recently published document provides clear guidance as to the survey methods that should be adopted within the UK relative to wind farm development. This document will eventually be included as a chapter within the proposed 2nd edition of 'Bat Surveys, Good Practice Guidelines'. When making reference to the Natural England Interim Guidance, this Bat Conservation Trust guidance discusses that certain bat species (e.g. Soprano pipistrelle and Common pipistrelle) may need to be considered at greater risk than originally thought, when it comes to their positioning within the 'High', 'Medium' or 'Low' risk categories (see Tables 1.3 and 1.4 above). It does however state that local abundance of these species, and the design and location of wind turbines should always be considered when estimating the potential risk to bat populations of any species in an area.

Section 2 - Survey Methodology

2.1 Desk Study Methods

No desk study was carried out as part of this study.

2.2 Proposed Wind Farm Description

2.2.1 Eight wind turbines are proposed for the eastern side of the site. This information was used when determining the survey effort required at the site. For a plan of the site including the proposed turbine locations, refer to Appendix I.

2.3 Field Survey Methods

2.3.1 The relevant, most recently published, guidelines (as discussed in Section 1.5) were not in place at the time that the survey methods for this case were agreed, however within this report these guidelines are referred to, and referenced against the survey methodology adopted. The level of survey effort was established based upon the species likely to be affected at an individual and a population level, and the number of turbines proposed for the site (see Tables 2.1 and 2.2).

2.3.2 The survey effort scale concluded that a low amount of survey effort (see Table 2.2) would be required for this site. The methods employed are described below within Table 2.4

- Survey period: The survey period was April to September 2011 and included dusk and dawn transect surveys coupled with automated detector surveys to gain an accurate representation of the species assemblage present at the site.
- Survey area: The transect surveys covered an area of approximately 45 hectares.
- Ground Level Manual Surveys: One visit per transect (one transect for this site) each month between April to September was made. The guidelines would suggest one visit per season, therefore in this respect the guidelines have been exceeded.
- Ground Level Static Surveys: Anabat remote detecting systems were positioned at two allocated survey points each month between April to September, for a minimum of three nights, totalling 44 survey nights (see Table 2.3).
- Static Surveys at tree top (i.e. canopy) height: There are no trees within the turbine envelope and so there was no need for static surveys at canopy height. Further, it was not anticipated that high flying, high risk bats (e.g. Noctule) would feature at this site.

Due to the nature of the site and anticipated bat activity, it was felt that the overall approach demonstrated above would allow a rigorous assessment of the site's importance to bats to be made.

Table 2.1 - Potential Risks to Bats (Individuals and Populations). (Adapted from Anon, 2009a).
Highlighted areas in green show the species potentially active in or around this site

Risk	Low	Medium	High
Bats likely to be at individual risk from wind turbines	<i>Myotis</i> (Daubenton's and Natterer's) Long-eared bats Horseshoe bats	Soprano pipistrelle* Common pipistrelle* Serotine* Barbastelle	Noctule Leisler's Nathusius' pipistrelle
Bat populations likely to be threatened due to the impacts from wind turbines	<i>Myotis</i> (Daubenton's and Natterer's) Long-eared bats Horseshoe species Soprano pipistrelle* Common pipistrelle*	Serotine* Barbastelle	Noctule Leisler's Nathusius' pipistrelle
* On a case by case basis, these species may require to be raised to a higher level of risk dependent upon their geographic distribution, local abundance, locality of known roosts, as well as the proposed wind turbine dimensions and overall wind farm site design			

Table 2.2 - Minimum Survey Standards (adapted from Bat Conservation Trust, 2011)

	Bat Species/Bat Populations Risk Levels (see Table 2.1)		
	Low	Medium	High
Survey Period	As a minimum, surveys should provide data for one complete season, represent species assemblage present, and account for nocturnal and seasonal activity patterns		
Survey Area	50m plus rotor radius from proposed area of development	50m plus rotor radius from proposed area of development	100m plus rotor radius from proposed area of development
Ground Level Manual Surveys	One visit per transect per season (spring, summer, autumn)	One visit per transect each month (Apr - Oct)	Two visits per transect each month (Apr - Oct)
Ground Level Static Surveys	For sites with 1 - 4 turbines		
	5 consecutive nights for each turbine per season	5 consecutive nights for each turbine per month	2 sets of 5 consecutive nights for each turbine per month
	For sites with 5 - 10 turbines		
	Minimum 4 locations for 5 consecutive nights per season	Minimum 4 locations for 5 consecutive nights per month	Minimum 4 locations for 2 sets of 5 consecutive nights per month
	For sites with over 10 turbines		
	Minimum 5 locations for 3 consecutive nights per season	Minimum 5 locations for 3 consecutive nights per month	Minimum 5 locations for 2 sets of 3 consecutive nights per month
	Where turbine positioning is undetermined, survey locations should be spread across the development area.		
Static Surveys at Height	Particularly woodland sites where key holing is proposed or sites where high flying bats are likely to be present		

Table 2.3 - Monthly Ground Level Static Surveys Carried out at Site

Survey Point (Habitat)	Number of Nights per Month						
	April	May	June	July	August	September	Total
Open	5	3	4	3	4	3	22
Stream	5	3	4	3	4	3	22
Total	10	6	8	6	8	6	44

Table 2.4 - Overview of Survey Methods Adopted

Number and Type of Surveys	1 x Daytime Assessment 6 x Ground Level Manual Surveys (3 dusk, 3 dawn) 6 x Ground Level Static Surveys at 2 habitat type locations (44 survey nights in total)	Surveyors	Neil Middleton Laura Davis Aaron Middleton Julie Smith Jenny Diack Jason Ryan Rhiannon Cowan Daniel Lynch
Daytime Assessment	12.04.11		
Ground Level Manual Survey Dates	21.04.11 (dusk), 06.05.11 (dawn), 06.06.11 (dusk) 08.07.11 (dawn), 04.08.11 (dusk), 02.09.11 (dawn)		
Ground Level Static Survey Dates	12.04.11 to 17.04.11 (2 detectors x 5 nights) 07.05.11 to 10.05.11 (2 detectors x 3 nights) 06.06.11 to 10.06.11 (2 detectors x 4 nights) 08.07.11 to 11.07.11 (2 detector x 3 nights) 04.08.11 to 08.08.11 (2 detectors x 4 nights) 02.09.11 to 05.09.11 (2 detectors x 3 nights)		
Methods Used	<p>(a) Daytime Assessment An overview inspection of the site as a whole in order to ascertain roosting potential within the site boundary. The site was walked over in order to form a view as to the best approach regarding survey methods.</p> <p>(b) Ground Level Manual Surveys (Dusk) One transect route (see Appendix IV) was established covering the proposed turbine locations. Typically the transect surveys commenced at least 15 minutes prior to sunset and concluded at least 120 minutes after sunset. Stopping points were surveyed along the route for five minute intervals. The starting point of the transect, and the direction the transect was walked (i.e. clockwise or anti-clockwise) was changed from month to month.</p> <p>Survey Equipment Used: Bat detector systems (Frequency Division), MP3 recording devices, GPS, torch</p> <p>(c) Ground Level Manual Surveys (Dawn) The dawn surveys commenced approximately 120 minutes before sunrise and ended 15 minutes after sunrise at the earliest. During each transect, stopping points were surveyed for five minute intervals. The starting point of the transect, and the direction the transect was walked (i.e. clockwise or anti-clockwise) was changed from month to month.</p> <p>Survey Equipment Used: Bat detector systems (Frequency Division), MP3 recording devices, GPS, torch</p>		

(d) Ground Level Static Surveys

This involved leaving static Anabat detectors *in situ* in order to record activity overnight and over prolonged periods of time. The detectors were placed at the two different habitat locations (open and stream) present within the site boundary. The devices recorded all bat activity in the vicinity between sunset and sunrise for a minimum of three nights.

Survey Equipment Used: Anabat SD2 bat detecting system

All bat data gathered will be assigned to a habitat type (open or stream) and species group, in order to populate a 'Bat Activity Index' which will provide data showing bat passes per hour per habitat type etc.

Section 3 - Overview of Activity Survey Results

3.1 Daytime Assessment

- 3.1.1 The daytime assessment was undertaken by two suitably qualified and experienced surveyors on 12.04.11. The site boundary encompasses two areas: Craigton at the west, and Spittalhill at the east. It is proposed to locate turbines within the Spittalhill area (east side) of the site. An area of at least 300m around the proposed turbine locations was surveyed (the survey area). The closest buildings to the turbines are at Spittalhill Farm, and as these buildings are approximately 2.4km away, they were not surveyed. There are no apparent suitable roosting locations (e.g. trees, structures, etc.) within the survey boundary (i.e. within 300m of the turbine locations).

3.2 Activity Surveys (Combined Transect and Static Detector)

- 3.2.1 Six transect surveys (3 dusk and 3 dawn) were undertaken by two surveyors during the period 21.04.11 to 02.09.11 as described within Section 2 of this report. Two Anabat systems were deployed on 6 occasions during the period 12.04.11 to 05.09.11, covering a total of 44 overnight surveys (i.e. dusk to dawn). For full supporting data relating to the activity survey results please refer to Appendix IV.
- 3.2.2 Within Table 3.1 below, the total bat passes recorded for each species are shown, as collected on transect and static detector surveys. Within the transect surveys, only Soprano pipistrelle and unidentified pipistrelle were encountered. During the static detector surveys in addition to these, Common pipistrelle and *Myotis* bats were also recorded. As expected, *Nyctalus* and Brown long-eared bats were not encountered during the survey programme. In total, 324 bat passes were recorded during the survey programme. By far the most frequently encountered species was Soprano pipistrelle, representing almost 77% of all bat encounters. Unidentified pipistrelle (either Soprano or Common calling at around 50kHz, therefore not able to be allocated definitively to either species group) was the next most frequently encountered species (12.04%), followed by Common pipistrelle (7.41%) and then *Myotis* species (3.70%).
- 3.2.3 Upon the completion of the survey programme the levels of bat activity were allocated to species level, bat activity (i.e. passes) per hour and habitat type. In total 24,432 minutes (407.2 hours) of surveying took place, covering the two habitat types (open and stream) present within the survey boundary. The following table (Table 3.1) shows the overall results for transect and static detector surveys. Overall, in terms of bat passes per hour (BPpH) the majority of bat activity occurred within stream habitat, with 1.35 BPpH recorded compared to 0.28 BPpH within open habitat. This was reflected during both the transect surveys (1.47 BPpH in stream habitat, compared to 0.59 BPpH in the open), and the static detector surveys (1.35 BPpH in stream habitat compared to 0.25 BPpH in the open). Overall, an average bat activity of 0.8 BPpH was recorded. Consideration should be made to the different survey methods used to obtain this data when drawing conclusions from these final figures and this is discussed further in Section 4.

Table 3.1 - Overview of Transect and Static Detector Survey Results (Total Bat Passes per Hour)

Habitat Types	Transect		Static Detector		Total		Total All Habitat Locations
	Open	Stream	Open	Stream	Open	Stream	
Survey Minutes	811	41	11,790	11,790	12,601	11,831	24,432
Minutes converted to Hours	13.52	0.68	196.50	196.50	210.02	197.18	407.2
<i>Nyctalus</i> species	0	0	0	0	0	0	0 (0%)
Soprano pipistrelle	6	1	18	224	24	225	249 (76.85%)
Common pipistrelle	0	0	7	17	7	17	24 (7.41%)
Unidentified pipistrelle	2	0	14	23	16	23	39 (12.04%)
<i>Myotis</i> species	0	0	11	1	11	1	12 (3.70%)
Brown long-eared	0	0	0	0	0	0	0 (0%)
Total Bat Passes	8	1	50	265	58	266	324 (100%)
Bat Passes per Hour	0.59	1.47	0.25	1.35	0.28	1.35	0.80

3.3 Risk to Individual Bats

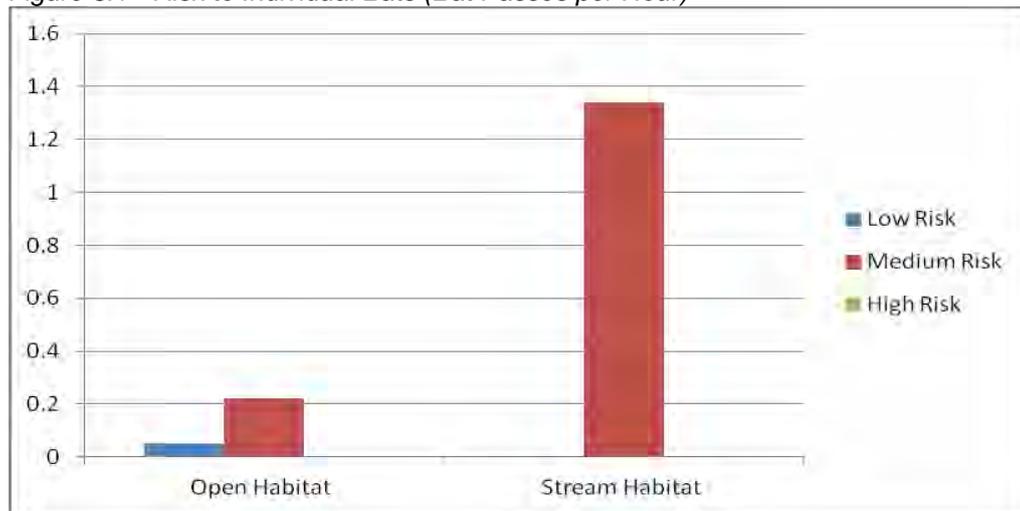
- 3.3.1 Soprano pipistrelle, Common pipistrelle and *Myotis* bats were encountered within the Spittalhill site. The presence of these species is now examined to investigate the likelihood of risk for each species group as described at the beginning of each table taken from Bats and Onshore Wind Turbines: Interim Guidance (Anon, 2009), noting higher, medium and lower risk species groups (refer to Section 2, Table 2.1).
- 3.3.2 Within the assemblage of species found to occur at the site no high risk species (e.g. *Nyctalus* species) were encountered during the survey period. Soprano pipistrelle and Common pipistrelle were encountered and are deemed to be at medium risk, from an individual bat perspective. *Myotis* bats were encountered and are classed as low risk. Table 3.2 and Figure 3.1 describe BPpH for each risk group within each habitat type. The medium risk group were more active than the low risk group within both habitat types.

Table 3.2 - Risk to Individual Bats (Bat Passes per Hour)

	Low Risk	Medium Risk	High Risk
Open Habitat	0.05	0.22	0
Stream Habitat	0.005	1.34	0
Total BPpH	0.029	0.77	0

Note: The Total BPpH is not the total of the figures shown in the corresponding columns above, but is a figure that is calculated from the total bat passes as they relate to total survey effort, as shown within Table 3.1

Figure 3.1 - Risk to Individual Bats (Bat Passes per Hour)



3.4 Risk to Bat Populations

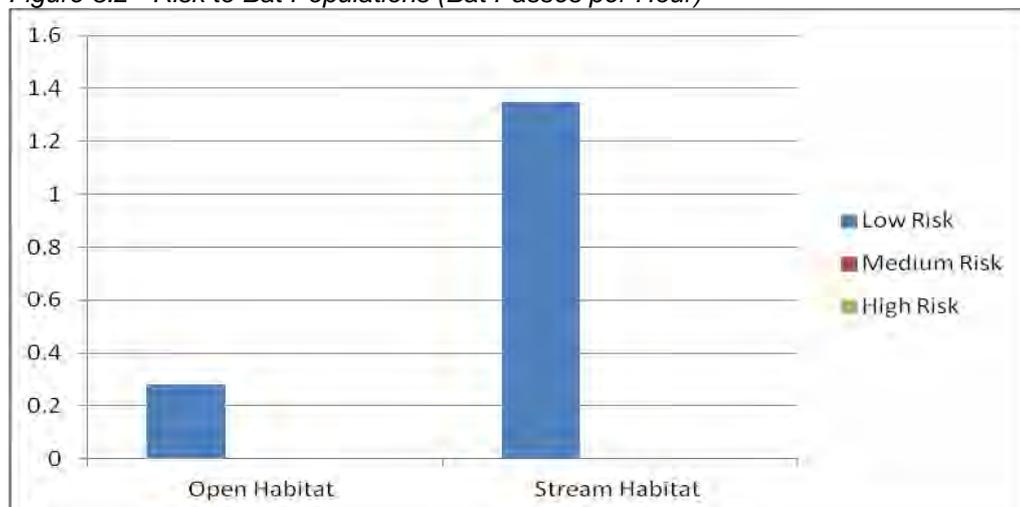
3.4.1 Within the assemblage of species found to occur at the site no high risk species (e.g. *Nyctalus* species) were encountered during the survey period. Soprano pipistrelle, Common pipistrelle and *Myotis* bats were present and are all deemed to be low risk from a bat population perspective. Table 3.3 and Figure 3.2 describe BPpH for each risk group at each habitat type. As seen previously bat activity was highest within stream habitat and lowest within open habitat.

Table 3.3 - Risk to Bat Populations (Bat Passes per Hour)

	Low Risk	Medium Risk	High Risk
Open Habitat	0.28	0	0
Stream Habitat	1.35	0	0
Total Passes	0.80	0	0

Note: The Total BPpH is not the total of the figures shown in the corresponding columns above, but is a figure that is calculated from the total bat passes as they relate to total survey effort, as shown within Table 3.1

Figure 3.2 - Risk to Bat Populations (Bat Passes per Hour)



3.5 Relative Frequency of Site Use, Split by Month and Species

3.5.1 A comparison of bat activity on a species by species, month by month basis was made using the bat activity index (BPpH). The results from both the transect surveys and Anabat surveys were used when making this comparison. The results of this comparison are shown within Figures 3.3 to 3.6 below. As discussed previously, Soprano pipistrelle was the dominant species encountered during all the survey months, and during April and September Soprano pipistrelle was the only bat species encountered. Soprano pipistrelle activity peaked during August, to 3.31 BPpH (compared to 0.06 BPpH in April and September, 0.08 BPpH in June and 0.31 BPpH in July). Common pipistrelle was encountered during in June, July and August, and *Myotis* bats were encountered only in June and August. No bat activity was recorded in May.

Figure 3.3 - April Activity, noting Bat Passes per Hour, split by species

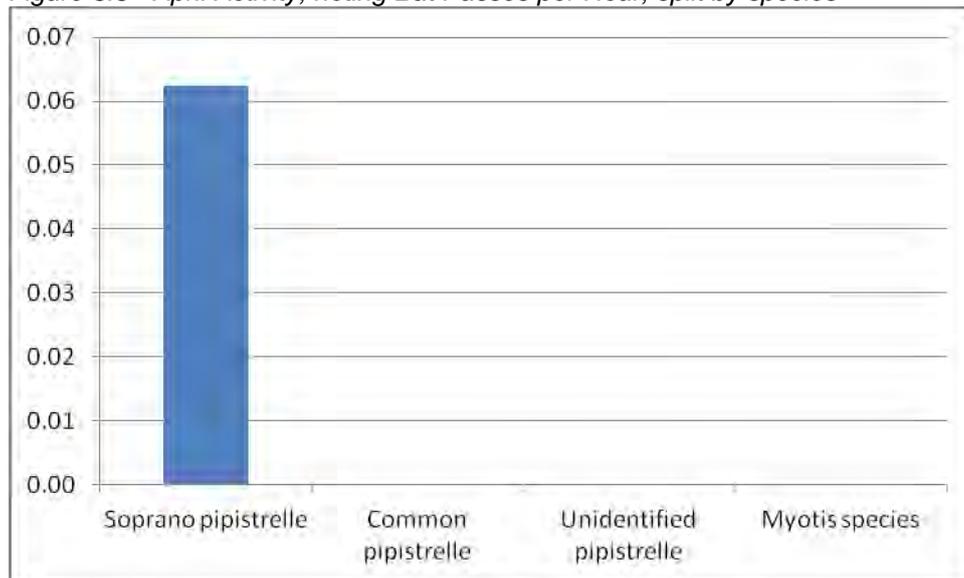


Figure 3.4 - May Activity, noting Bat Passes per Hour, split by species

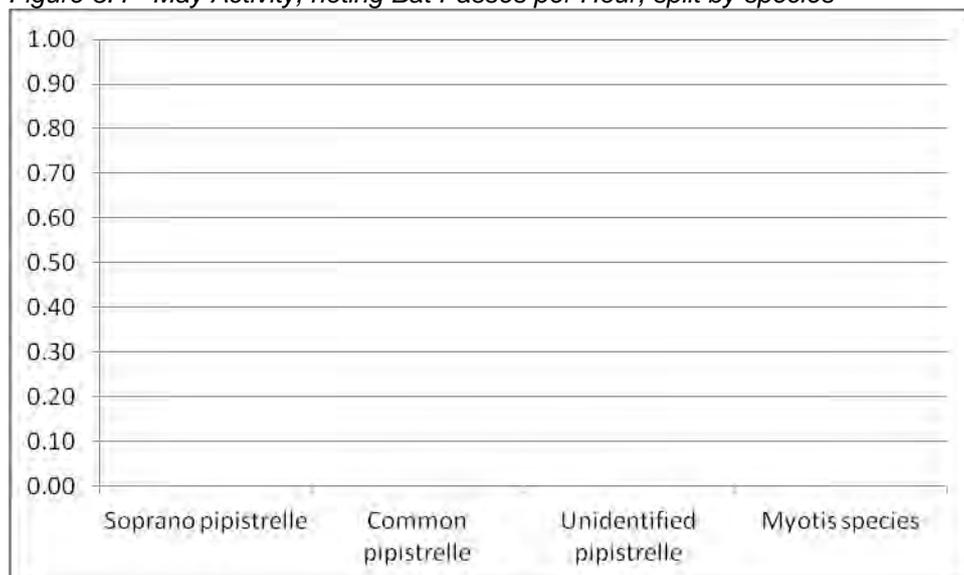


Figure 3.5 - June Activity, noting Bat Passes per Hour, split by species

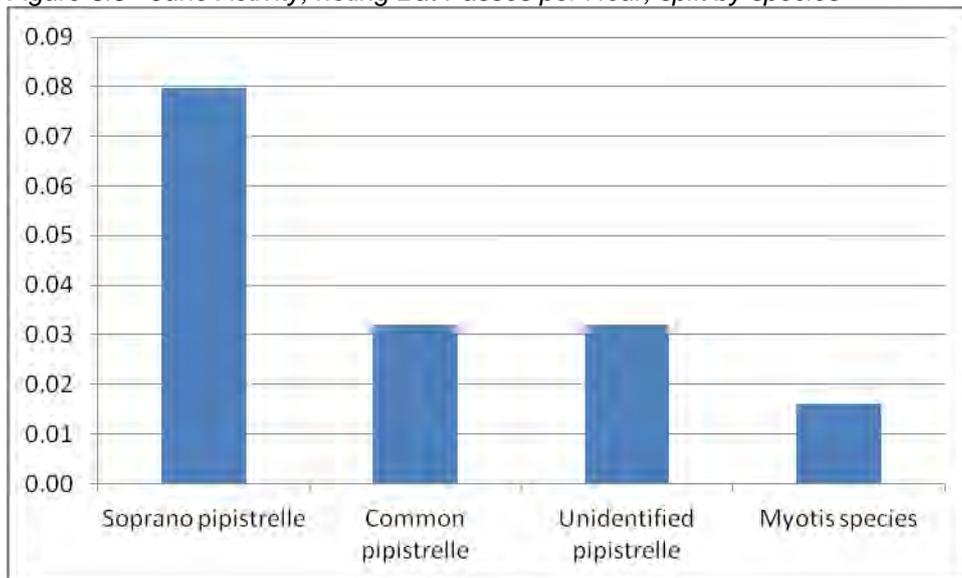


Figure 3.6 - July Activity, noting Bat Passes per Hour, split by species

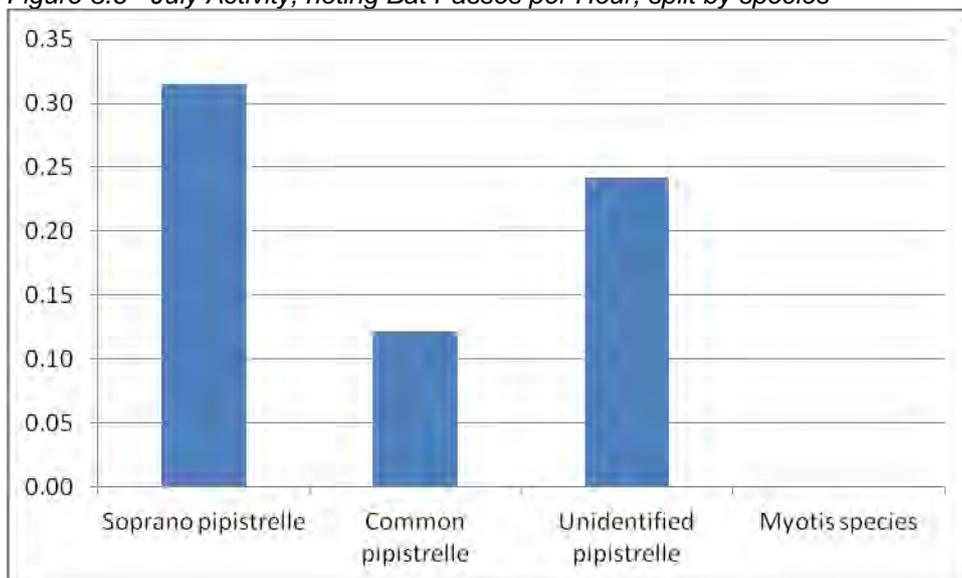


Figure 3.7 - August Activity, noting Bat Passes per Hour, split by species

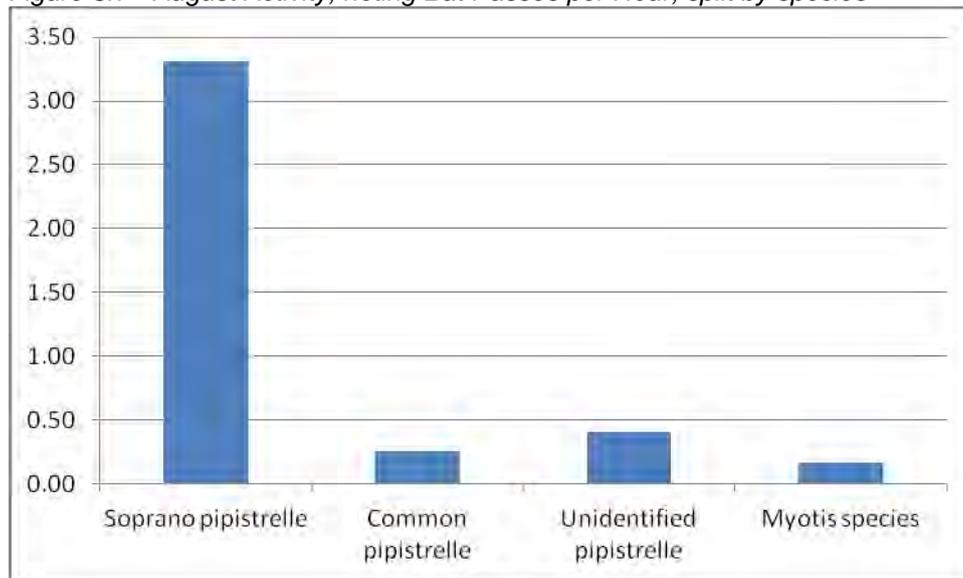
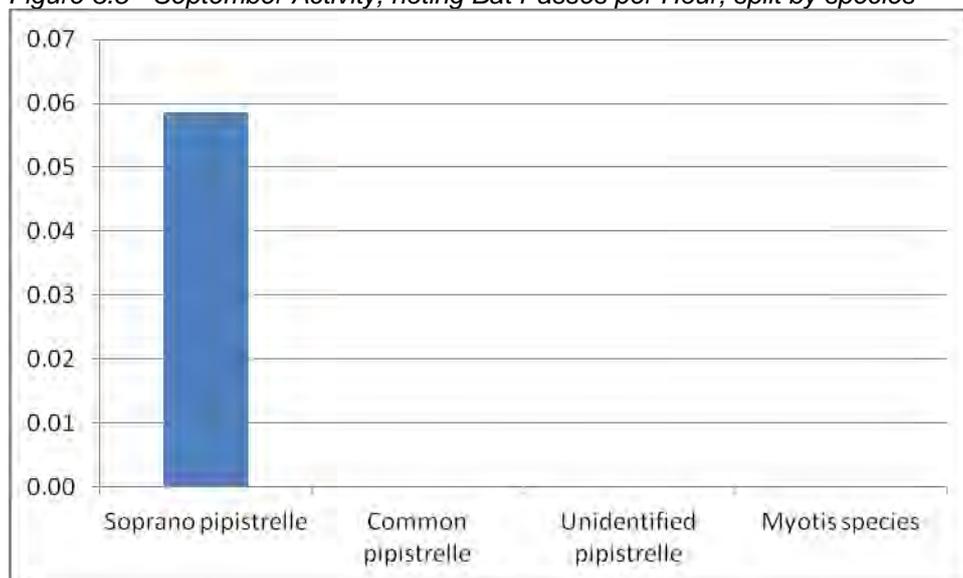


Figure 3.8 - September Activity, noting Bat Passes per Hour, split by species



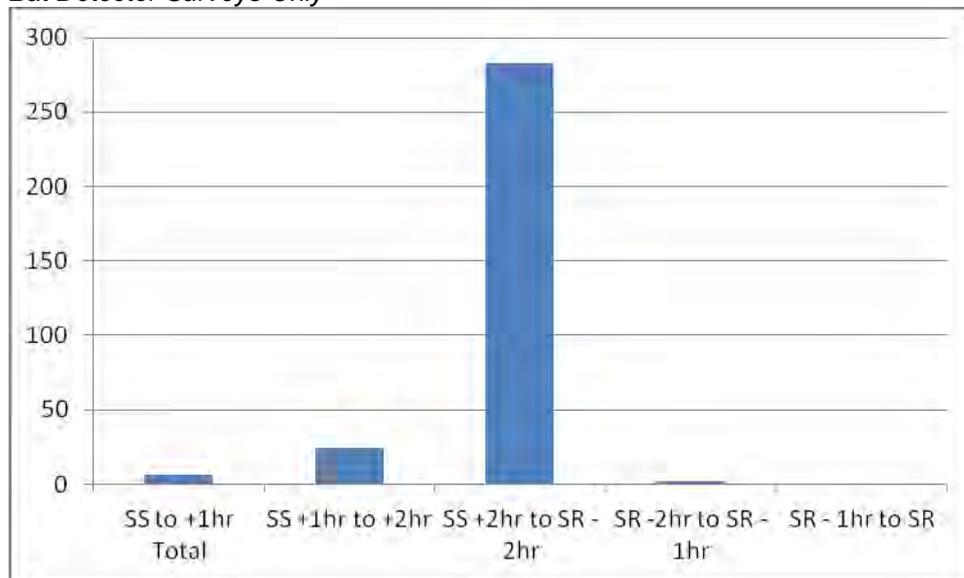
3.6 Temporal Distribution of Activity for Different Species

- 3.6.1 The Anabat static bat detector data was analysed in isolation, to obtain a description of temporal distribution of bat activity over a survey night (e.g. between Sunset to Sunrise). Table 3.4 and Figure 3.9 below describe temporal variation of bat activity based on the activity of the all species present and shows there to be a peak in activity in the middle of the night (the period between 2 hours after sunset and 2 hours before sunrise). When considering the temporal variation of activity for each species individually, this also followed the trend of heightened activity during the middle of the night.

Table 3.4 - Summary of all Activity (Bat Passes) Relative to Sunset (SS)/Sunrise (SR) - Static Bat Detector Surveys Only

Totals All Nights	Soprano pipistrelle	Common pipistrelle	Unidentified pipistrelle	Myotis bats	Total
SS to +1hr Total	1	0	5	0	6
SS +1hr to +2hr	15	4	5	0	24
SS +2hr to SR -2hr	225	19	27	12	283
SR -2hr to SR -1hr	1	1	0	0	2
SR - 1hr to SR	0	0	0	0	0
Grand Total	242	24	37	12	315

Figure 3.9 - Summary of all Activity (Bat Passes) Relative to Sunset (SS) / Sunrise (SR) - Static Bat Detector Surveys Only



Section 4 - Discussion

4.1 Limitations to Survey Work

Surveying for bats is not the easiest of tasks. They hide themselves away in roosts during daylight hours and are active during darkness. The survey methods adopted for any site usually must be regarded as only a sample of the patterns of behaviour by bats. The more survey resource that is adopted (e.g. more survey visits, greater number of surveyors, better use of technology) the more likely the results will give an accurate reflection of the situation. However, even with the maximum amount of effort, the nature of bats is such that things can be wrongly interpreted (e.g. a small number of bats may use a site during a different time of the year in which the surveys took place).

In this case the recommended survey guidelines, as existed at the commencement of the project, were followed and adapted as to the correct level of survey resource required. The overall approach is considered suitable to allow a rigorous assessment of the site's importance to bats to be made.

The results can only be interpreted as far as they show what evidence regarding roosting existed and what bat activity was occurring at the time of the surveys. The surveys took place at a time of year when bats are active and in good weather conditions.

4.2 Roosting, Foraging and Commuting Behaviour by Bats

When establishing the conservation needs of bats there are three important aspects that should be considered when making changes to the local habitat or features. These are roosting sites, foraging areas and commuting/navigational corridors or features (Entwistle *et al.*, 2001; Middleton, 2004). Within the context of the work proposed the survey results can be considered as follows.

4.2.1 Roosting Sites

Throughout the year, during periods of inactivity, all bats require safe and sheltered roosting sites.

No features within the survey boundary appeared to be suitable for roosting purposes, and as such no bats were found to be roosting within the site boundary. However, the potential for roosting within the structures and/or mature trees close to the site, at lower altitudes on its southern boundary, does exist.

In Section 3 (Table 3.4) temporal variation in bat activity overnight showed there to be a peak in bat activity during the middle of the night. The delay, and early reduction, in bat activity may indicate that the majority of bats are coming into the site from roost sites further afield, though this is not conclusive evidence.

4.2.2 Foraging Habitat and Commuting Corridors

Bats, represented by at least three species, were found foraging and commuting over the survey area.

With regards to the potential foraging areas and insect abundance within the site it is concluded that the proposed changes are unlikely to affect the foraging prospects of the bats which appear to use the site in this respect. If the development was to proceed in the anticipated manner, the site and surrounding habitat is such that foraging areas will still be available to local bat populations during the works and this will continue to be the case post development.

Bats require linear features in order to orientate themselves in the dark and to act as commuting corridors between their roosts and their foraging areas. The proposed changes to the site are unlikely to impact upon bats in this respect. Linear features within and leading to and from areas of interest for bats at the site (e.g. foraging areas) will still be available during and after the

proposed works. The structure of the habitat is such that local bat populations will still be able to commute effectively within and in the vicinity of the site.

When assessing the potential conflict between the turbine and foraging and commuting bats, it should be noted that the highest bat activity (1.35 BPpH) was observed in stream habitat. Activity was lowest (0.28 BPpH) in the open areas, which form the vast majority of the survey area. Although only the stream in the centre of the area, flowing south-west to north-east into the Backside Burn, was covered in surveys, the increased levels of bat activity would also be expected at the Shelloch Burn, at the north-west of the site (which also flows south-west to north-east into the Backside Burn) and the Backside Burn (which forms the north-east site boundary).

There are a number of reasons why bat activity within the areas of stream habitat may have been higher compared to open habitat. Firstly, within the survey area the watercourses are the only obvious linear features which bats have available to commute along, and so rather than fly over open areas, bats may use these features in order to navigate within and through the site. Secondly, it is likely that insect numbers and/or densities are greater in the vicinity of water habitat than in open areas and so provide more opportune feeding environs.

4.2.3 Bat Activity Levels at the Site

In order to draw conclusions as to the relative level of bat activity at the site it is useful to compare the results from the current study to data for similar bat surveys carried out at other sites within Scotland during the past 24 months. Table 4.1 provides data from three other sites surveyed by Echoes Ecology Ltd using similar methods to those carried out for this site. Based on this data overall, bat activity levels at this site would be deemed to be low.

Table 4.1 - Comparison of Bat Passes per Hour (BPpH) recorded during other Wind Farm Bat Surveys within Central Scotland during the period 2009 to 2010.

Habitat Type	Open Habitat (BPpH)	Edge Plantation Woodland (BPpH)	Stream Habitat (BPpH)	Bat Passes Overall
Site Reference				
Survey Site - Spittalhill	0.28	N/A	1.35	0.8
Site A - Upland with Plantation Woodland on boundary	2.76	8.06	N/A	6.78
Site B - Lowland Farm with Plantation and Broadleaved Woodland	6.76	7.61	N/A	9.18
Site C - Lowland Farm	N/A	22.19	10.57	18.39

4.2.4 Risk to Bats at the Site

This study has shown that bats, represented by commonly occurring and widespread species, are present in the area, commuting and foraging. Within the species assemblage found to be present at the site, as shown within Table 3.1 in Section 3, with regards to Soprano and Common pipistrelle, the risk to individual bats of these species would be viewed as medium, whereas the population risk would be deemed as low. *Myotis* bat species are listed as being at low risk on both an individual and population level. As anticipated, no high risk species, such as *Nyctalus* bats, were found to be present during the surveys.

4.3 Mitigation Measures

Bat activity within open areas was lower than within stream habitat. If the turbines are to be positioned within open habitat, away from streams, the results suggest that the risk to bats would be, relatively speaking, low compared to other areas within the survey boundary.

At the time of reporting it is not clear where the access roads are to be located should the development proceed.

The following measures are designed to anticipate potential actions that may be required.

4.3.1 Design Measures

There appears to be steps that could be taken in the design of the project which could reduce the risk of bats coming into conflict with the proposed turbines. It is important to minimise the risk to bats and therefore, in accordance with guidelines (Anon, 2009a), consider the maintenance of a 50m buffer around any feature (e.g. tree lines, forest edge, water course) shown to be particularly attractive to bats. The preferred approach would be to position the turbine well away from streams within the site as bat activity was shown to be greatest here. In effect, this means that the edge of the rotor-swept area needs to be at least 50m from the nearest of the habitat feature. In order to calculate the correct buffer distance (*b*) from the turbine base to a habitat feature at ground level, allowing for the rotor sweep, the guidelines suggest a calculation, as shown below, which considers the recommended minimum buffer (50m), the blade length (*bl*), the hub height (*hh*) and the feature height (*fh*).

$$b = \sqrt{(50m + bl)^2 - (hh - fh)^2}$$

For example, estimating blade length as 45 metres and hub height as 80 metres, a buffer distance of 51.23 metres is recommended from a watercourse at ground level. Currently, the nearest proposed turbine to a water course is approximately 75 metres, so based on the above calculations, this distance is adequate. Obviously the greater the distance between turbines and water courses then the lower the potential impacts upon bats.

The turbines generally should, as far as possible, avoid connectivity with natural linear features (e.g. tree lines and hedgerows). The creation of new edge habitat should be kept to a minimum so as prevent bats being led into the site and towards turbines, and this should be taken into consideration when deciding on the proposed access road route.

4.3.2 Pre Construction Measures

Once the route of the access roads has been established, any trees within a 20 metre buffer zone of this route should be assessed for bat roosting potential (BRP) immediately prior to works commencing, using tree climbers experienced in bat roosting ecology if aerial surveys are necessary. If, during the BRP survey, bat roosts are found within any of the trees being assessed, the appropriate licence(s) will need to be applied for and granted from Scottish Natural Heritage prior to any activities commencing that may result in the disturbance to or destruction of these roosts.

4.3.3 Summary of Proposed Mitigation Recommendations

The following table (Table 4.2) summarises the various mitigation measures discussed earlier in this section.

Table 4.2 - Summary of Proposed Mitigation Measures

Item No	Mitigation
1	Access Road Bat Roost Potential (BRP) Survey Once the access road route is established any mature trees within a 20 metre buffer of the route must be assessed for bat roosting potential. Although there are no trees within the survey area, there may be trees outwith this area along the route of the proposed track which require surveying. All trees identified as having bat roosting potential that are to be felled, worked upon, or disturbed as part of the construction phase of works must be fully inspected, using specialist tree climbers experienced in surveying for bats if necessary, immediately prior to works commencing
2	Bat Roost Trees If during Item 1 any bat roosts are found within trees that are due to be felled, worked upon or disturbed as part of the proposed works, the appropriate licence(s) will need to be applied for and granted from Scottish Natural Heritage before works can proceed

3	Edge Habitat Consideration should be taken when routing the access road to minimise the creation of new edge habitat leading into the turbine area
4	Positioning of Turbines away from Streams It is important to minimise the risk to bats and therefore, in accordance with guidelines (Anon, 2009a), consider the maintenance of a 50m buffer around any feature (e.g. tree lines, forest edge, water course) shown to be particularly attractive to bats. The preferred approach would be to position the turbine well away from streams within the site as bat activity was shown to be greatest here. In effect, this means that the edge of the rotor-swept area needs to be at least 50m from the nearest of the habitat feature

Section 5 - Conclusions

5.1 Conclusions

During the surveys at Spittalhill, bats were recorded commuting and foraging in small numbers. No evidence of roosting bats was established within the survey boundary. With regards to the bats encountered, no species deemed to be at high risk were recorded. The bat activity in the area amounted to 324 bat passes recorded over approximately 407 hours of survey effort, with an overall bat activity rate of 0.8 BPpH. This is deemed as a low level of activity. The results are not surprising bearing in mind the altitude of the site and the fact that it is very exposed and open with few linear features or sheltered areas, and no areas of roosting potential.

Bat activity was highest around stream habitat as opposed to open habitat (an average of 1.35 BPpH compared to 0.28 BPpH) and as such, the positioning of turbines well away (i.e. more than 50m) from water courses is recommended, so as to reduce the potential conflict between wind turbines and bats foraging and commuting in their vicinity. In addition, any potential conflicts arising due to the creation of access roads should be considered. However, with the appropriate design measures discussed (see Section 5) the risks can be managed and reduced.

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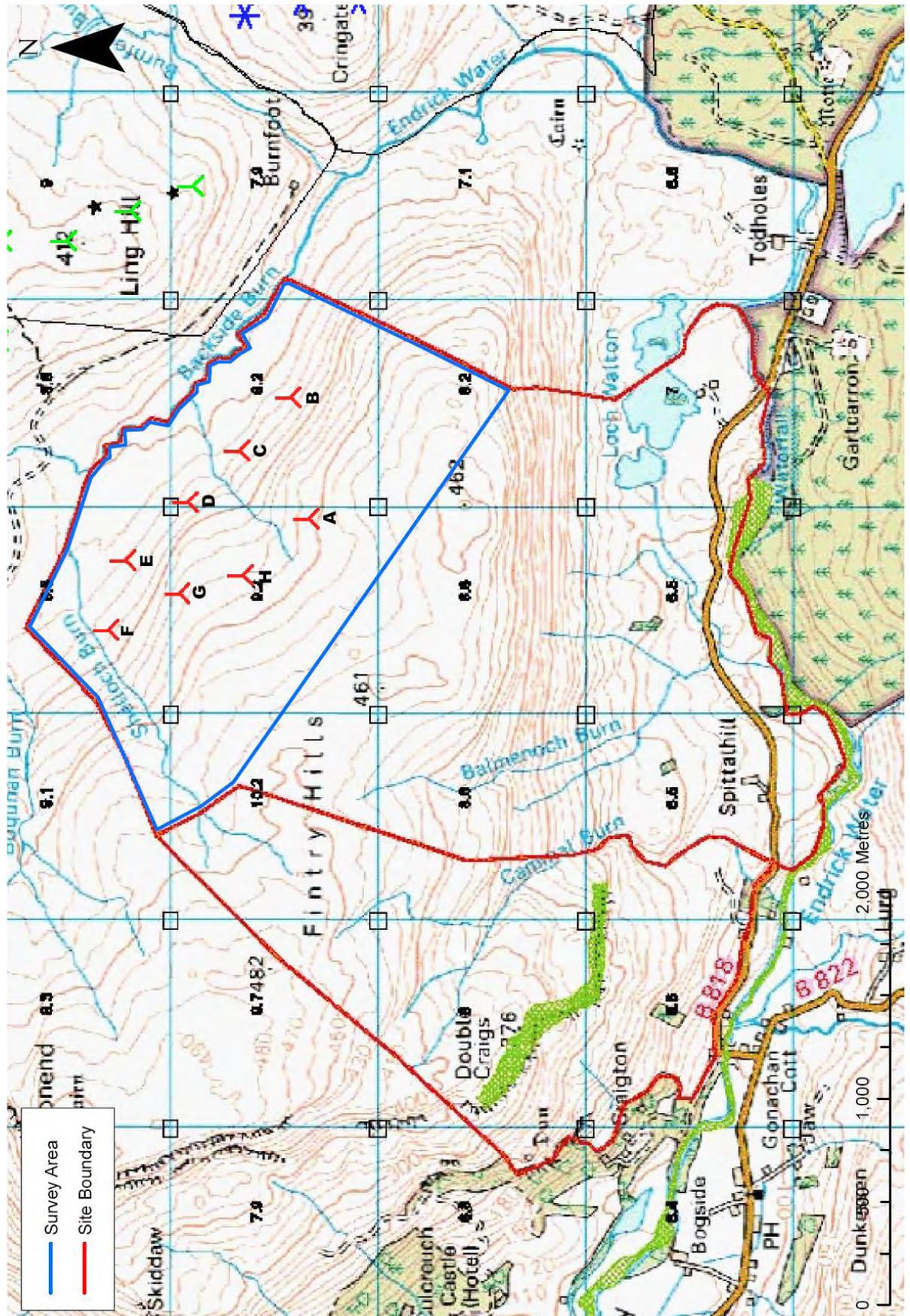
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Appendix I: Site Plan

Figure I.1 - Plan showing Site and Survey Boundaries (Craigton is smaller area at west, Spittalhill is larger area at east). Turbines proposed for Spittalhill are indicated with red, lettered, symbols.



Appendix II: Conservation Status of Bats in Stirlingshire

Bat Populations and Distribution in Scotland

All bats in Scotland are insectivorous and nocturnal (Altringham, 2003). It is widely accepted that 18 species of bat occur within the UK, up to 10 of which may occur within Scotland (Richardson, 2000). The species of bat potentially occurring in Scotland, their local status and roosting/foraging habitat preferences are described in Table II.1. The data within the table is of a general nature and it should be borne in mind that exceptions to the described behaviours have been recorded.

Table II.1: Bat populations and habitat preferences within Scotland and Stirlingshire

Species Common Name (Scientific Name)	Estimated Population in Scotland* (% of GB*)	Frequency Of Occurrence (Scotland)	Status within Stirlingshire	Main Roosting Sites	Main Foraging Sites
Bandit pipistrelle (<i>Pipistrellus pipistrellus</i>)	220,000** (17.2%)	Common (widespread)	Common	Buildings Trees	Generalist All habitat types
Soprano pipistrelle (<i>Pipistrellus pygmaeus</i>)	330,000** (45.8%)	Common (widespread)	Common	Buildings Trees	Riparian associated habitats
Nathusius pipistrelle (<i>Pipistrellus nathusii</i>)	Only a small number of records to date	Rare May breed but no breeding records so far	Rare	Buildings Trees	Woodland Riparian
Brown long-eared bat (<i>Plecotus auritus</i>)	27,500 (13.8%)	Less Common (widespread)	Less Common	Buildings Trees	Woodland Parkland
Daubenton's bat (<i>Myotis daubentonii</i>)	40,000 (26.7%)	Less Common (widespread as far north as Sutherland)	Less Common	Buildings Structures Caves Trees	Riparian Woodland
Natterer's bat (<i>Myotis nattereri</i>)	17,500 (17.5%)	Uncommon (widespread as far north as Inverness)	Uncommon	Buildings Structures Caves Trees	Woodland Riparian
Whiskered bat (<i>Myotis mystacinus</i>)	1,500*** (3.8%)	Rare (southern and Central Scotland)	Rare	Buildings Structures Caves	Woodland Riparian
Brandt's bat (<i>Myotis brandtii</i>)	500*** (1.7%)	Rare (may occur in southern Scotland)	Not recorded in this area	Buildings Structures Caves	Woodland Riparian
Noctule bat (<i>Nyctalus noctula</i>)	250**** (0.5%)	Rare (localised: southern Scotland)	Not recorded in this area	Trees	Woodland Parkland Riparian
Leisler's bat (<i>Nyctalus leisleri</i>)	250 (2.5%)	Rare (localised: south west Scotland)	Not recorded in this area	Buildings Structures Trees	Woodland Parkland Riparian

The 'Species' boxes are colour coded to reflect current thinking (Macdonald and Baker, 2005) as to how population trends are performing against recent benchmarks (**RED**: in decline, **AMBER**: stable or unknown, **GREEN**: on increase).

* All figures taken from Battersby & Tracking Mammals Partnership (2005).

** Due to these species previously being regarded as one, Harris *et al.*, 1995 gave an estimate for both together at 550,000. There are currently no population figures splitting them by species for Scotland. For the purposes of this document and until such time as data to the contrary is available we have guessed a 60/40 split, however the relative abundance of each species does vary considerably in some parts of Scotland.

*** There have been a few historical records of Brandt's bat for Scotland (Richardson, 2000), however due to the difficulty in separating it in the field from Whiskered bat the assumption is that Brandt's bat may occur in southern Scotland.

****It is generally accepted that this figure for Noctule bat is no longer accurate as more and more records for this species are being noted from throughout southern Scotland. As such, although this species is rare/absent in many parts of Scotland, it is not regarded as rare within its established range within southern Scotland.

Appendix III: Habitat Use Model

This appendix contains a copy of a fact sheet relating to the use of habitat by bats in the UK.

BaTML Factsheet: A simple habitat use model for bats in the UK

Author: Neil E Middleton*

Dated: 1st August 2004

*Correspondence details: email: middleneil@msn.com

Introduction

In order to interact naturally with their surroundings, establish viable populations and indeed survive, bats need all of the following occurring within their immediate environment:

(1) Roosts

A choice of different roosts (including alternatives) for different times of the year, unseasonable changes in weather conditions, disturbance and depending on whether they are male or female. The following examples of roosting requirements are typical for most bat species in the UK:

- Maternity roosts
- Male roosts
- Harems / breeding sites
- Spring and autumn transitional roosts
- Hibernacula

Depending upon the species involved a number of these requirements could potentially occur at one site. In reality, however, more often they tend to be separate to each other, albeit in the same locality.

(2) Commuting Corridors / Flyways

Bats need to find their way to/from their roosts to feeding sites and other roosting sites. This is greatly aided by the presence of linear features along which bats can navigate and orientate themselves in the dark. This is especially true for smaller species and it has been suggested that a gap of as little as 30m in such a feature could act as a barrier to movement for some species. In addition to this, these features also can provide a degree of protection from potential predators, and can act as valuable feeding corridors allowing bats

to catch prey whilst travelling to specific foraging areas. On windy nights the leeward side of these features may not only be more attractive to bats because it saves them energy by avoiding the windy conditions, but also they can find more insect food which will also be taking shelter for the same reason. The following are examples of features used by bats whilst commuting:

- Tree lines / woodland edge
- Hedgerows
- Waterways (i.e. rivers/canals/lake shores)
- Walls
- Woodland tracks

(3) Foraging Sites

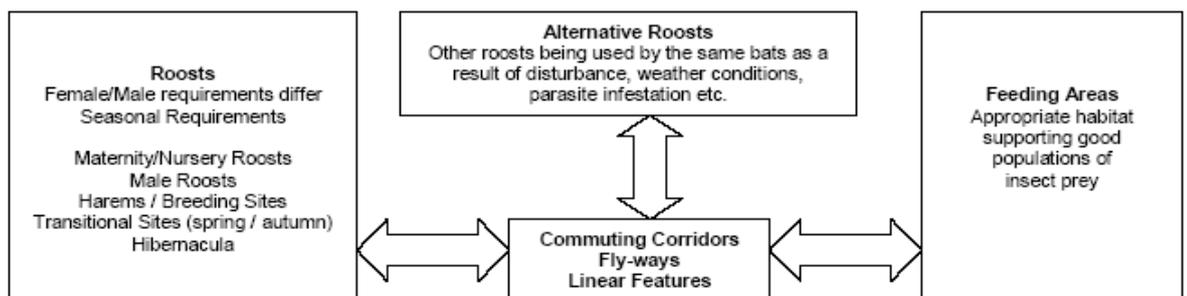
Finally bats need a healthy supply of food (insects) in order to survive. As such it is important that good healthy insect populations thrive in the environment throughout the period when bats are active and bats are able to access these.

Conclusion

If any of the above features are not available or removed from the equation then potentially bat populations will struggle to be successful. Therefore all aspects relating to these features need to be considered when the conservation of bats is on the agenda.

Habitat Use Model – Bats in the UK

The simple model shown below demonstrates the interaction between the required features. Consider all of the things that could potentially impact upon this model and hence influence the success/failure of bats within the environment.



Appendix IV: Raw Survey Data

Activity Surveys

The following pages provide full details relating to the bat surveys carried out at the site during the period 12.04.11 to 05.09.11.

Figure IV.1 - Transect Route at Spittalhill

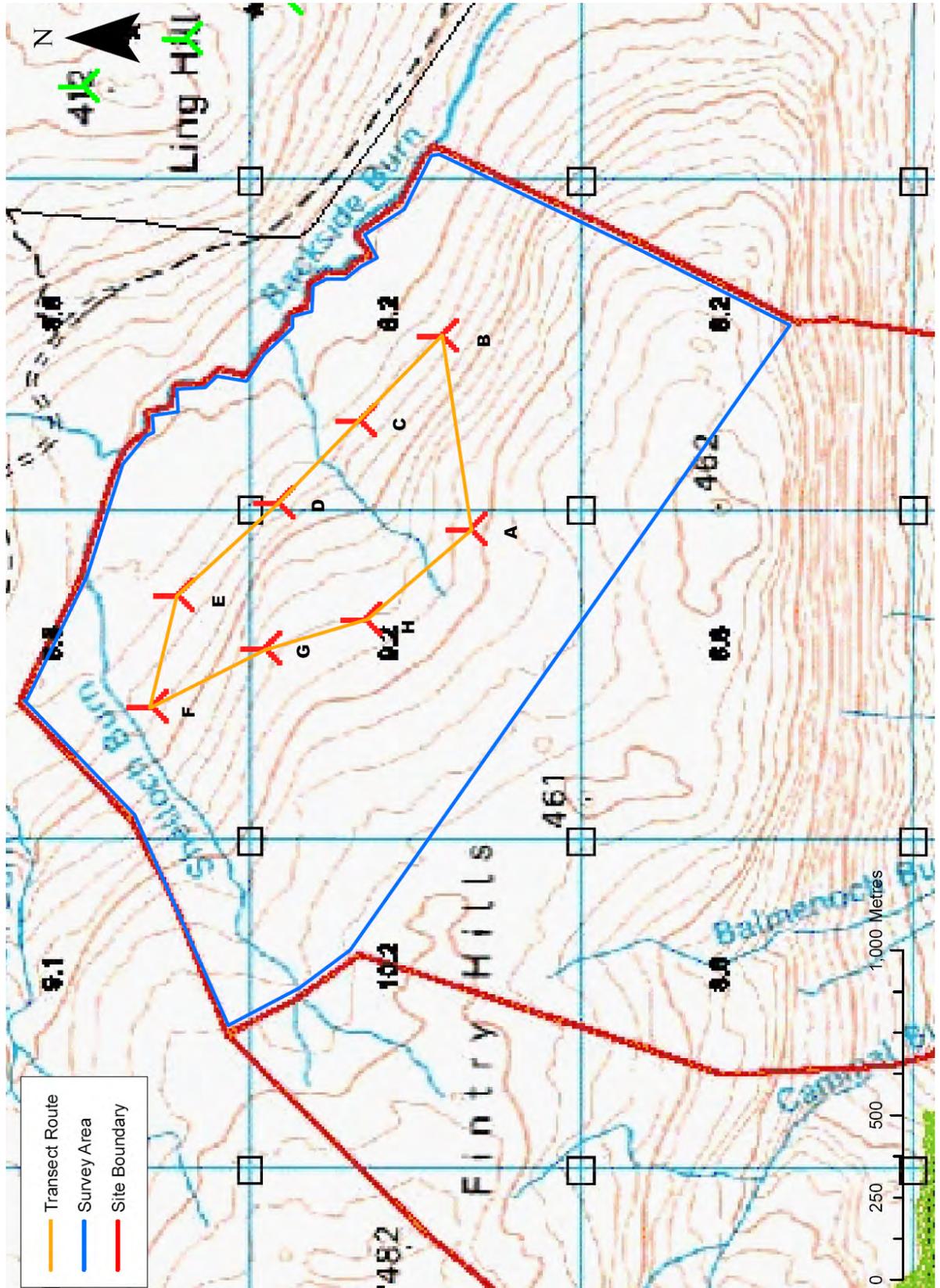
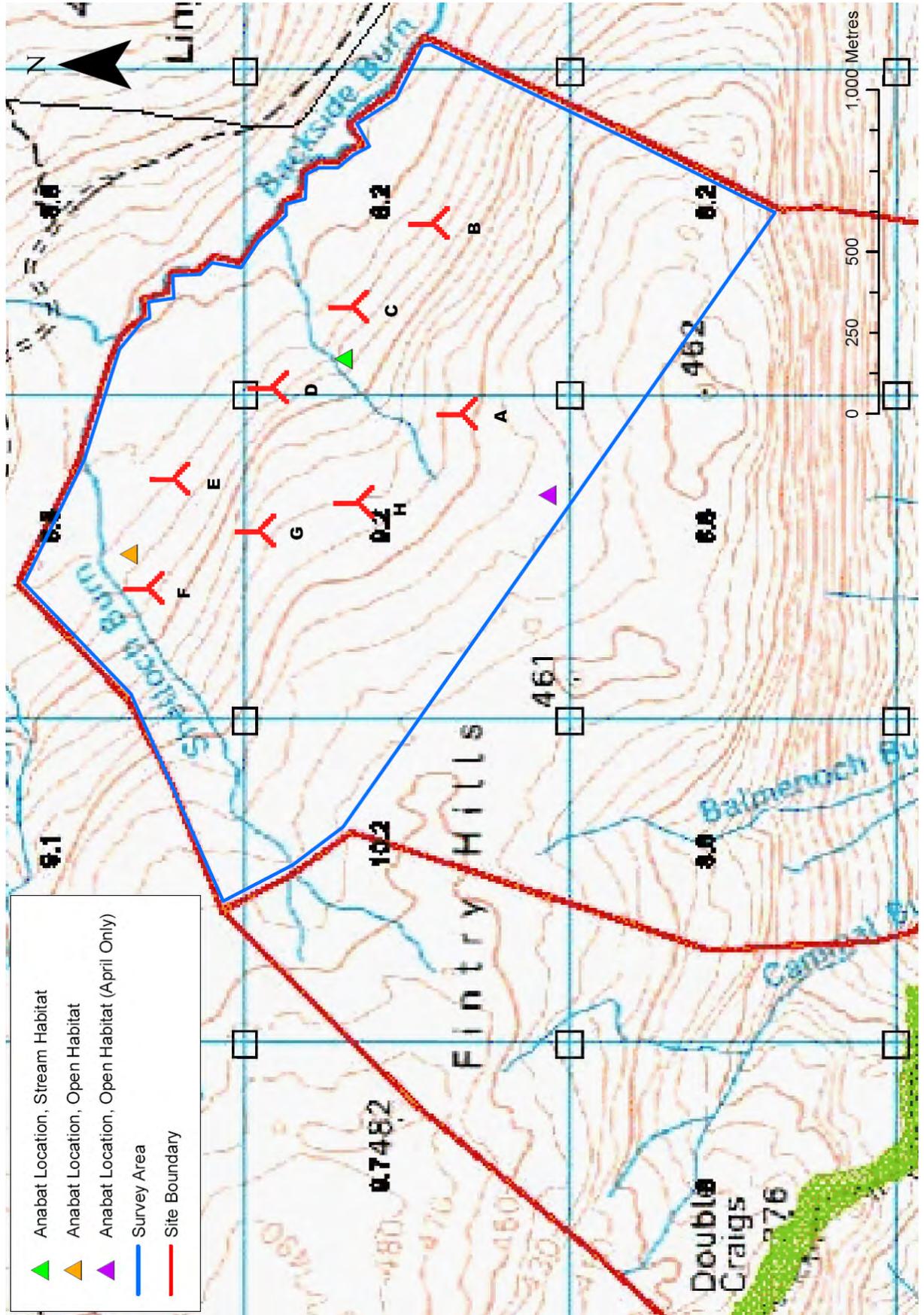


Figure IV.2 - Locations of AnaBat Detector Surveys at Spittalhill



Spittalhill Survey Form 1 (Transect Survey, Dusk of 21.04.11)

Site Name	Date	Survey Type	Temperature °C	Surveyor(s) (Location Ref)
Spittalhill	21/04/2011	Dusk Transect	min: 6	A Middleton
Survey Timespan		Precipitation	Wind (F)	L Davis
15mins before Sunset until 124mins after Sunset		Dry	30%	Waning Gibbous
Time Slot (SS - Sunset / SR - Sunrise)	Time	Species	Max Number of Individual Bats Present	Behaviour
SS-15 to SS+30	20:18			
	20:18 - 21:03			
SS+31 to SS+60	21:03 - 21:15			
	21:15 - 21:20			
	21:20 - 21:26			
	21:26 - 21:31			
	21:31 - 21:34			
SS+61 to SS+90	21:34 - 21:39			
	21:39 - 22:41			
	21:40			
	21:41 - 21:46			
	21:42			
	21:46 - 21:55			
	21:48			
	21:55 - 22:00			
SS+91 to SS+120	22:00 - 22:04			
	22:04 - 22:06			
	22:06 - 22:11			
	22:11 - 22:20			
	22:20 - 22:25			
	22:25 - 22:28			
	22:28 - 22:32			
	22:32 - 22:37			
	22:37			
Total Survey Time (mins)		Overall Activity Totals	5	6
Habitat Time Split		Open	6	
		Stream	0	
Results Summary and Conclusions: Five commuting Soprano pipistrelles were recorded whilst between turbines C and E. No bats were recorded at other point on the transect.				

Spittalhill Survey Form 3 (Transect Survey, Dusk of 06.06.11)

Site Name	Date	Survey Type	Temperature °C	Surveyor(s) (Location Ref)
Spittalhill	06/06/2011	Dusk Transect	min: 7	J Diack
Survey Timespan		Precipitation	Wind (F)	D Lynch
11mins after Sunset until 168mins after Sunset (SS - Sunset / SR - Sunrise)		Sporadic light rain	1 to 2	
Time	Habitat Type	Species	Behaviour	Additional Notes
Location (T - Turbine)	Habitat Mins	Max Number of Individual Bats Present		
SS-15 to SS+30	Open	90%	1 to 2	
TH: NS 6567 8864	19	Waxing crescent		
SS+31 to SS+60	Open			
Between TH and TA	8			
22:07 - 22:26	Stream			
22:26 - 22:34	1			
Between TH and TA	3			
22:34 - 22:35	Open			
Between TH and TA	5			
22:35 - 22:38	Open			
Between TH and TA	13			
TA: NS 6594 8833	6			
22:38 - 22:43	Open			
Between TA and TB	5			
22:43 - 22:56	Open			
Between TA and TB	12			
SS+61 to SS+90	Open			
Between TA and TB	5			
22:56 - 23:02	Open			
Between TA and TB	2			
TB: NS 6653 8841	2			
23:02 - 23:07	Open			
Between TB and TC	5			
23:07 - 23:19	Open			
Between TB and TC	9			
23:10	Open			
23:13	Open			
23:19 - 23:24	Open			
TC: NS 6629 8866	2			
Between TC and TD	2			
23:24 - 23:26	Open			
Between TC and TD	5			
23:26 - 23:28	Stream			
Between TC and TD	2			
23:28 - 23:33	Open			
Between TC and TD	1			
23:33 - 23:35	Stream			
Between TC and TD	2			
23:35 - 23:36	Open			
Between TC and TD	5			
23:36 - 23:38	Open			
Between TC and TD	9			
23:38 - 23:43	Open			
TD: NS 6602 8891	5			
23:40	Open			
23:43 - 23:52	Open			
Between TD and TE	5			
23:52 - 23:57	Open			
TE: NS 6574 8921	9			
Between TE and TF	5			
23:57 - 00:06	Open			
TF: NS 6540 8928	5			
00:06 - 00:11	Open			
Between TF and TG	13			
00:11 - 00:24	Open			
TG: NS 6557 8895	5			
00:24 - 00:29	Open			
Between TG and end	6			
00:29 - 00:35	Open			
Between TG and end	2			
00:35 - 00:37	Stream			
Between TG and end	7			
00:37 - 00:44	Open			
Between TG and end				
Survey End Time 00:44				
Total Survey Time (mins) 157	Overall Activity Totals	3		
Habitat Time Split	Open	3		
148	Bat Pass Split	3		
9	Stream	0		

Results Summary and Conclusions: Three commuting pipistrelle bats were recorded during the transect, two whilst between Turbines B and C, and one at Turbine D.

Spittalhill Survey Form 4 (Transect Survey, Dawn of 08.07.11)

Site Name	Date	Survey Type	Sunrise	OS Grid Ref	Temperature °C	Surveyor(s) (Location Ref)
Spittalhill	08/07/2011	Dawn Transect	04:40	NS 657 881	min: 13	D Lynch
Survey Timespan		Precipitation	Cloud Cover	Moon Phase	Wind (F)	R McLeod
Approx 120mins before Sunrise until approx 15mins after Sunrise		Dry	30%	First Quarter	2 to 3	
Time Slot (SS - Sunset / SR - Sunrise)	Time	Species	Max Number of Individual Bats Present	Bat Passes (Max of 5 per single bat)	Behaviour	Additional Notes
SR-120 to SR-91	02:38					
TA: NS 6594 8833	02:38 - 02:43	Open		NIL		
Between TA and TB	02:43 - 02:57	Open		NIL		
TB: NS 6653 8841	02:57 - 03:02	Open		NIL		
Between TB and TC	03:02 - 03:09	Open		NIL		
Between TB and TC	03:09 - 03:12	Open		NIL		
TC: NS 6629 8866	03:12 - 03:17	Open		NIL		
Between TC and TD	03:17 - 03:27	Open		NIL		
Between TC and TD	03:27 - 03:38	Stream		NIL		
SR-60 to SR-31	03:38 - 03:43	Open		NIL		
TD: NS 6602 8891	03:43 - 03:53	Open		NIL		
Between TD and TE	03:53 - 03:58	Open		NIL		
TE: NS 6574 8921	03:58 - 04:07	Open		NIL		
Between TE and TF	04:07 - 04:12	Open		NIL		
SR-30 to SR+15	04:12 - 04:23	Open		NIL		
TF: NS 6540 8928	04:23 - 04:28	Open		NIL		
Between TF and TG	04:28 - 04:34	Open		NIL		
TG: NS 6557 8895	04:34 - 04:54	Open		NIL		
Between TG and TH						
TH: NS 6567 8864						
Survey End Time		Survey End Time		Survey End Time		
	04:54					
Total Survey Time (mins)		Overall Activity Totals		Total Survey Time (mins)		
	136	0		0		
Habitat Time Split		Habitat Time Split		Habitat Time Split		
	125	Open		Bat Pass Split		
	11	Stream		0		
Results Summary and Conclusions: No bats were recorded during the transect.						

Spittalhill Survey Form 5 (Transect Survey, Dusk of 04.08.10)

Site Name	Date	Survey Timespan	Survey Type	Sunset	OS Grid Ref	Temperature °C	Surveyor(s) (Location Ref)
Spittalhill	04/08/2011		Dusk Transect	21:20	NS 657 881	min: 13	R McLeod
			Precipitation	Cloud Cover	Moon Phase	Wind (F)	J.Ryan
			Species	Max Number of Individual Bats Present	Bat Passes (Max of 5 per single bat)	Behaviour	Additional Notes
Approx 30mins before Sunset until 122mins after Sunset			Mainly dry	100%	Waxing crescent	F2	
Time Slot (SS - Sunset / SR - Sunrise)	Location (T - Turbine)	Survey Start Time	Habitat Type	Habitat Mins			
SS-15 to SS+30		20:51					
	TH: NS 6567 8864	20:51 - 21:36	Open	45			
	Between TH and TG	21:36 - 21:44	Open	8			
	TG: NS 6557 8895	21:44 - 21:49	Open	5			
SS+31 to SS+60		21:49 - 21:55	Open	6			
	Between TG and TF	21:55 - 22:00	Open	5			
	TF: NS 6540 8928	22:00 - 22:10	Open	10			
	Between TF and TE	22:10 - 22:15	Open	5			
	TE: NS 6574 8921	22:15 - 22:20	Open	5			
	Between TE and TD	22:20 - 22:25	Open	5			
SS+61 to SS+90		22:25 - 22:30	Open	5			
	Between TE and TD	22:30 - 22:36	Open	6			
	Between TD and TC	22:36 - 22:38	Stream	2			
	Between TD and TC	22:38 - 22:41	Open	3			
	TC: NS 6629 8866	22:41 - 22:46	Open	5			
	Between TC and TB	22:46 - 22:51	Open	5			
SS+91 to SS+120		22:51 - 23:01	Open	10			
	Between TC and TB	23:01 - 23:06	Open	5			
	TB: NS 6653 8841	23:06 - 23:16	Open	10			
	Between TB and TA	23:16 - 23:21	Open	5			
	TA: NS 6594 8833						
		Survey End Time					
		Total Survey Time (mins)		150			
		Overall Activity Totals		0			
		Habitat Time Split		148			
			Open			Bat Pass Split	
			Stream			0	
Results Summary and Conclusions: No bat passes were recorded during the transect.							

Spittalhill Survey Form 6 (Transect Survey, Dawn of 02.09.11)

Site Name	Date	Surveyor(s) (Location Ref)	Temperature °C	OS Grid Ref	Sunrise	Survey Type	Habitat Type	Habitat Mins	Species	Cloud Cover	Moon Phase	Wind (F)
Spittalhill	02/09/2011	D Lynch	min: 10	NS 657 881	06:22	Dawn Transect						
Survey Timespan												
Approx 120mins before Sunrise until 15mins after Sunrise												
Time Slot (SS - Sunset / SR - Sunrise)	Location (T - Turbine)	Survey Start Time	Time	Habitat Type	Habitat Mins	Species	Max Number of Individual Bats Present	Bat Passes (Max of 5 per single bat)	Behaviour	Additional Notes		
SR-120 to SR-91	TA: NS 6594 8833	04:21	04:21 - 04:26	Open	5			NIL				
	Between TA and TH		04:26 - 04:37	Open	11			NIL				
	TH: NS 6567 8864		04:37 - 04:42	Open	5			NIL				
	Between TH and TG		04:42 - 04:50	Open	8			NIL				
SR-90 to SR-61	TG: NS 6557 8895		04:50 - 04:55	Open	5			NIL				
	Between TG and TF		04:55 - 05:04	Open	9			NIL				
	TF: NS 6540 8928		05:04 - 05:09	Open	5			NIL				
	Between TF and TE		05:09 - 05:21	Open	12			NIL				
SR-60 to SR-31	TE: NS 6574 8921		05:21 - 05:26	Open	5			NIL				
	Between TE and TD		05:26 - 05:38	Open	12			NIL				
	TD: NS 6602 8891		05:38 - 05:43	Open	5			NIL				
	Between TD and TC		05:43 - 05:47	Open	4			NIL				
	Between TD and TC		05:47 - 05:49	Stream	2			NIL				
	Between TD and TC		05:49 - 05:51	Open	2			NIL				
SR-30 to SR+15	Between TD and TC		05:51 - 05:57	Open	6			NIL				
	TC: NS 6629 8866		05:57 - 06:02	Open	5			NIL				
	Between TC and TB		06:02 - 06:10	Open	8			NIL				
	TB: NS 6653 8841		06:10 - 06:15	Open	5			NIL				
	Between TB and TA		06:15 - 06:30	Open	15			NIL				
	TA: NS 6594 8833		06:30 - 06:37	Open	7			NIL				
Survey End Time 06:37												
Total Survey Time (mins)					136	Overall Activity Totals		0				
Habitat Time Split					134	Open	Bat Pass Split	0				
					2	Stream		0				
Results Summary and Conclusions: No bats were recorded during the transect.												

Spittalhill Static Survey Form 1 (AnaBat Survey - Stream, 12.04.10 to 17.04.10)

Automated Bat Detector Survey Results Form

Site Spittal Hill MAG546 Detector Name/Grid Ref: AB11 / NS 6611 8869

Habitat Type Stream

Dates 12.04.11 dusk to 17.04.11 dawn 5 nights

Time On 19.45 Time Off 07.00

Time	Date	12.04.11	13.04.11	14.04.11	15.04.11	16.12	06:15	20:19	06:15	20:21	06:12	15.04.11	Sunset	20:23	06:10				
		Sunrise	Sunrise	Sunrise	Sunrise	Sunrise	Sunrise	Sunrise	Sunrise	Sunrise	Sunrise	Sunrise	Sunrise	Sunrise	Sunrise				
		Temp °C	Temp °C	Temp °C	Temp °C	Temp °C	Temp °C	Temp °C	Temp °C	Temp °C	Temp °C	Temp °C	Temp °C	Temp °C	Temp °C				
		U pip	U pip	U pip	U pip	U pip	U pip	U pip	U pip	U pip	U pip	U pip	U pip	U pip	U pip				
		MV	MV	MV	MV	MV	MV	MV	MV	MV	MV	MV	MV	MV	MV				
		BLE	BLE	BLE	BLE	BLE	BLE	BLE	BLE	BLE	BLE	BLE	BLE	BLE	BLE				
		Nyc	Nyc	Nyc	Nyc	Nyc	Nyc	Nyc	Nyc	Nyc	Nyc	Nyc	Nyc	Nyc	Nyc				
		S pip	S pip	S pip	S pip	S pip	S pip	S pip	S pip	S pip	S pip	S pip	S pip	S pip	S pip				
		C pip	C pip	C pip	C pip	C pip	C pip	C pip	C pip	C pip	C pip	C pip	C pip	C pip	C pip				
30 min slots																			
SS to +30mins																			
31 to +60mins																			
Sub Total		0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Total All Nights		0	0	0	0	0	0	0	0	0	0	0	0	0	0				
61 to +90mins																			
91 to +120mins																			
Sub Total		0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Total All Nights		1	0	0	0	0	0	0	0	0	0	0	0	0	0				
SS+121mins to SR-121mins																			
Sub Total		0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Total All Nights		0	0	0	0	0	0	0	0	0	0	0	0	0	0				
120 to -91mins																			
90 to -61mins																			
Sub Total		0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Total All Nights		0	0	0	0	0	0	0	0	0	0	0	0	0	0				
60 to -31mins																			
30 to SR																			
Sub Total		0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Total All Nights		0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Totals All Nights		S pip	C pip	U pip	MV	BLE	Nyc	S pip	C pip	U pip	MV	BLE	Nyc	S pip	C pip	U pip	MV	BLE	Nyc
SS to +1hr Total		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SS +1hr to +2hr		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SS +2hr to SR-2hr		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR-2hr to SR-1hr		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR-1hr to SR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Totals All Nights	S pip	C pip	U pip	MV	BLE	Nyc	Total
SS to +1hr Total	0	0	0	0	0	0	0
SS +1hr to +2hr	1	0	0	0	0	0	1
SS +2hr to SR-2hr	0	0	0	0	0	0	0
SR-2hr to SR-1hr	0	0	0	0	0	0	0
SR-1hr to SR	0	0	0	0	0	0	0
Grand Total	1	0	0	0	0	0	1

Survey Effort (mins) 660 x 5 nights = 3300

Stream

Spittalhill Static Survey Form 2 (AnaBat Survey - Stream, 07.05.10 to 10.05.10)

Automated Bat Detector Survey Results Form

Site Spittal Hill MAG546 Detector Name/Grid Ref: AB10 / NS 6611 8869
Habitat Type Stream

Dates 07.05.11 dusk to 10.05.11 dawn 3 nights
Time On 20:40 Time Off 05:45

Time	Date	07.05.11	Sunset	21:08	Sunrise	05:18	Date	08.05.11	Sunset	21:10	Sunrise	05:16	Date	09.05.11	Sunset	21:12	Sunrise	05:14	Date	10.05.11	Sunset	21:14	Sunrise	05:12
30 min slots	S pip	C pip	U pip	My	BLE	Nyc	S pip	C pip	U pip	My	BLE	Nyc	S pip	C pip	U pip	My	BLE	Nyc	S pip	C pip	U pip	My	BLE	Nyc
SS to +30mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31 to +60mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61 to +90mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91 to +120mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SS+12mins to SR-12mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120 to -91mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90 to -61mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60 to -31mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 to SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals All Nights	S pip	C pip	U pip	My	BLE	Nyc	S pip	C pip	U pip	My	BLE	Nyc	S pip	C pip	U pip	My	BLE	Nyc	S pip	C pip	U pip	My	BLE	Nyc
SS to +1hr Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SS +1hr to +2hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SS +2hr to SR -2hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR -2hr to SR -1hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR -1hr to SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Survey Effort (mins) 540 x 3 nights = 1620
Stream

Spittalhill Static Survey Form 4 (AnaBat Survey - Stream, 08.07.11 to 11.07.11)

Automated Bat Detector Survey Results Form

Site Spittal Hill MAG546 Detector Name/Grid Ref: AB11 / NS 6611 8869

Habitat Type Stream

Dates 08.07.11 dusk to 11.07.11 dawn 3 nights

Time On 21:30 Time Off 05:15

Time	08.07.11			09.07.11			10.07.11			11.07.11			04:45					
	Date	Sunset Temp °C U pip C pip	Sunrise Temp °C U pip My BLE Nyc	Date	Sunset Temp °C U pip C pip	Sunrise Temp °C U pip My BLE Nyc	Date	Sunset Temp °C U pip C pip	Sunrise Temp °C U pip My BLE Nyc	Date	Sunset Temp °C U pip C pip	Sunrise Temp °C U pip My BLE Nyc	S pip	C pip	U pip	My	BLE	Nyc
30 min slots																		
SS to +30mins																		
31 to +60mins																		
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61 to +90mins																		
91 to +120mins																		
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SS+121mins to SR-121mins																		
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120 to -91mins																		
90 to -61mins																		
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60 to -31mins																		
30 to SR																		
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Totals All Nights	S pip	C pip	U pip	My	BLE	Nyc	Total
SS to +1hr Total	0	0	0	0	0	0	0
SS +1hr to +2hr	0	0	0	0	0	0	0
SS +2hr to SR -2hr	0	0	0	0	0	0	0
SR -2hr to SR -1hr	0	0	0	0	0	0	0
SR -1hr to SR	0	0	0	0	0	0	0
Grand Total	0	0	0	0	0	0	0

Survey Effort (mins) 390 x 3 nights = 1170

Spittalhill Static Survey Form 5 (AnaBat Survey - Stream, 04.08.11 to 08.08.11)

Automated Bat Detector Survey Results Form

Site Spittal Hill MAG546 Detector Name/Grid Ref: AB11 / NS 6611 8869

Habitat Type Stream

Dates 04.08.11 dusk to 08.08.11 dawn 4 nights

Time On 21:00 Time Off 06:00

Time	Date	04:08:11	Sunset	21:19	Sunrise	05:27	Date	05:08:11	Sunset	21:17	Sunrise	05:29	Date	06:08:11	Sunset	21:15	Sunrise	05:31	Date	07:08:11	Sunset	21:13	Sunrise	05:33
30 min slots	S pip	C pip	U pip	My	BLE	Nyc	S pip	C pip	U pip	My	BLE	Nyc	S pip	C pip	U pip	My	BLE	Nyc	S pip	C pip	U pip	My	BLE	Nyc
55 to +30mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31 to +60mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61 to +90mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91 to +120mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55+121mins to SR-121mins	0	0	0	0	0	0	217	16	23	1	0	0	217	16	23	1	0	0	0	0	0	0	0	0
Sub Total	0	0	0	0	0	0	217	16	23	1	0	0	217	16	23	1	0	0	0	0	0	0	0	0
Total All Nights	217	16	23	1	0	0	217	16	23	1	0	0	217	16	23	1	0	0	0	0	0	0	0	0
120 to -91mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90 to -61mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60 to -31mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 to SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	218	16	23	1	0	0	258	16	23	1	0	0	258	16	23	1	0	0	0	0	0	0	0	0

Totals All Nights	S pip	C pip	U pip	My	BLE	Nyc	Total
SS to +1hr Total	0	0	0	0	0	0	0
SS +1hr to +2hr	0	0	0	0	0	0	0
SS +2hr to SR -2hr	217	16	23	1	0	0	257
SR -2hr to SR -1hr	1	0	0	0	0	0	1
SR -1hr to SR	0	0	0	0	0	0	0
Grand Total	218	16	23	1	0	0	258

Survey Effort (mins) 480 x 4 nights = 1920

Spittalhill Static Survey Form 7 (AnaBat Survey - Open, 12.04.10 to 17.04.10)

Automated Bat Detector Survey Results Form

Site Spittal Hill MAG546 Detector Name/Grid Ref: AB10 / NS 6569 8806

Habitat Type Open Moor

Dates 12.04.11 dusk to 17.04.11 dawn 5 nights
 Time On 19:45 Time Off 07:00

	Date	12.04.11	Sunset	20:17	Sunrise	06:17	Date	13.04.11	Sunset	20:19	Sunrise	06:15	Date	14.04.11	Sunset	20:21	Sunrise	06:12	Date	15.04.11	Sunset	20:23	Sunrise	06:10					
Time	S pip	C pip	U pip	Temp °C	My	BLE	Nyc	S pip	C pip	U pip	Temp °C	My	BLE	Nyc	S pip	C pip	U pip	Temp °C	My	BLE	Nyc	S pip	C pip	U pip	Temp °C	My	BLE	Nyc	
30 min slots	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55 to +30mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31 to +60mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61 to +90mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91 to +120mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55+121mins to SR-121mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120 to -91mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90 to -61mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60 to -31mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 to SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals All Nights	S pip	C pip	U pip	My	BLE	Nyc	Total	S pip	C pip	U pip	My	BLE	Nyc	Total	S pip	C pip	U pip	My	BLE	Nyc	Total	S pip	C pip	U pip	My	BLE	Nyc	Total	
55 to +1hr Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55 +1hr to +2hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55 +2hr to SR -2hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR -2hr to SR -1hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SR -1hr to SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Survey Effort (mins) Mins 6600 x 5 nights = 3300
 Open Moor

Spittalhill Static Survey Form 8 (AnaBat Survey - Open, 07.05.10 to 10.05.10)

Automated Bat Detector Survey Results Form

Site Spittal Hill MAG546 Detector Name/Grid Ref: AB11 / N5 6551.8935

Habitat Type Open

Dates 07.05.11 dusk to 10.05.11 dawn 3 nights

Time On 20:40 Time Off 05:45

Time	Date	07.05.11	Sunset	21:08	Sunrise	05:18	Date	08.05.11	Sunset	21:10	Sunrise	05:16	Date	09.05.11	Sunset	21:12	Sunrise	05:14	Date	10.05.11	Sunset	21:14	Sunrise	05:12	
	S pip	C pip	U pip	My	BLE	Nyc	S pip	C pip	U pip	My	BLE	Nyc	S pip	C pip	U pip	My	BLE	Nyc	S pip	C pip	U pip	My	BLE	Nyc	
30 min slots																									
SS to +30mins																									
31 to +60mins																									
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
61 to +90mins																									
91 to +120mins																									
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
SS+121mins to SR-121mins																									
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
120 to -91mins																									
90 to -61mins																									
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
60 to -31mins																									
30 to SR																									
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
S pip	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
C pip	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
U pip	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
My	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
BLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Nyc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
SS to +1hr Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
SS +1hr to +2hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
SS +2hr to SR -2hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
SR -2hr to SR -1hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
SR -1hr to SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Grand Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Survey Effort (mins) [Mins]

Spittalhill Static Survey Form 9 (AnaBat Survey - Open, 06.06.11 to 10.06.11)

Automated Bat Detector Survey Results Form

Site Spittal Hill MAG546 Detector Name/Grid Ref: AB10 / NS 6551.8935

Habitat Type Open

Dates 06.06.11 dusk to 10.06.11 dawn 4 nights

Time On 21:30 Time Off 05:00

Time	Date	06.06.11	Sunset	21:57	Sunrise	04:33	Date	07.06.11	Sunset	21:58	Sunrise	04:33	Date	08.06.11	Sunset	21:59	Sunrise	04:32	Date	09.06.11	Sunset	22:00	Sunrise	04:32
30 min slots	S pip	C pip	U pip	My	BLE	Nyc	S pip	C pip	U pip	My	BLE	Nyc	S pip	C pip	U pip	My	BLE	Nyc	S pip	C pip	U pip	My	BLE	Nyc
SS to +30mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31 to +60mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61 to +90mins	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91 to +120mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SS+121mins to SR-121mins	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub Total	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120 to -91mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90 to -61mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60 to -31mins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 to SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	3	1	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Totals All Nights	S pip	C pip	U pip	My	BLE	Nyc	Total
SS to +1hr Total	0	0	0	0	0	0	0
SS +1hr to +2hr	1	0	0	0	0	0	1
SS +2hr to SR-2hr	2	0	0	0	1	0	3
SR-2hr to SR-1hr	0	1	0	0	0	0	1
SR-1hr to SR	0	0	0	0	0	0	0
Grand Total	3	1	0	0	1	0	5

Survey Effort (mins) Mins 450 x 4 nights = 1800
Open

Spittalhill Static Survey Form 10 (AnaBat Survey - Open, 08.07.11 to 11.07.11)

Automated Bat Detector Survey Results Form

Site Spittal Hill MAG546 Detector Name/Grid Ref: AB10 / NS 6551.8935

Habitat Type Open

Dates 08.07.11 dusk to 11.07.11 dawn 3 nights
Time On 21:30 Time Off 05:15

Time	08.07.11			09.07.11			10.07.11			11.07.11			04:44			04:45			
	Date	Sunset Temp °C	Sunrise Temp °C	S pip	C pip	U pip	S pip	C pip	U pip										
30 min slots																			
55 to +30mins																			
31 to +60mins																			
Sub Total	0	0	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	1	0	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
61 to +90mins																			
91 to +120mins																			
Sub Total	6	2	4				1												
Total All Nights	3	2	4				1												
Sub Total	9	4	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	10	4	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
55+121mins to SR-121mins																			
Sub Total	2	1																	
Total All Nights	2	1																	
120 to -91mins																			
90 to -61mins																			
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60 to -31mins																			
30 to SR																			
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals All Nights	S pip	C pip	U pip	My	BLE	Nyc	S pip	C pip	U pip	My	BLE	Nyc	S pip	C pip	U pip	My	BLE	Nyc	S pip
55 to +1hr Total	1	0	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
55 +1hr to +2hr	10	4	5	0	0	0	19												
55 +2hr to SR -2hr	2	1	0	0	0	0	3												
SR -2hr to SR -1hr	0	0	0	0	0	0	0												
SR -1hr to SR	0	0	0	0	0	0	0												
Grand Total	13	5	10	0	0	0	28												

Totals All Nights	S pip	C pip	U pip	My	BLE	Nyc	Total
55 to +1hr Total	1	0	5	0	0	0	6
55 +1hr to +2hr	10	4	5	0	0	0	19
55 +2hr to SR -2hr	2	1	0	0	0	0	3
SR -2hr to SR -1hr	0	0	0	0	0	0	0
SR -1hr to SR	0	0	0	0	0	0	0
Grand Total	13	5	10	0	0	0	28

Survey Effort (mins) Mins 390 x 3 nights = 1170
Open

Spittalhill Static Survey Form 11 (AnaBat Survey - Open, 04.08.11 to 08.08.11)

Automated Bat Detector Survey Results Form

Site Spittal Hill MAG546 Detector Name/Grid Ref: AB10 / NS 6551 8935

Habitat Type	Open
Dates	04.08.11 dusk to 08.08.11 dawn 4 nights
	Time On 21:00 Time Off 06:00

Time	Date	04.08.11	Sunset	21:19	Sunrise	05:27	Date	05.08.11	Sunset	21:17	Sunrise	05:29	Date	06.08.11	Sunset	21:15	Sunrise	05:31	Date	07.08.11	Sunset	21:13	Sunrise	05:33	
		S pip	C pip	U pip	My	BLE	Nyc		Temp °C	U pip	My	BLE	Nyc		Temp °C	U pip	My	BLE	Nyc		Temp °C	U pip	My	BLE	Nyc
30 min slots		0	0	0	0	0	0																		
SS to +30mins		0	0	0	0	0	0																		
31 to +60mins		0	0	0	0	0	0																		
Sub Total		0	0	0	0	0	0																		
Total All Nights		0	0	0	0	0	0																		
61 to +90mins																									
91 to +120mins																									
Sub Total		0	0	0	0	0	0																		
Total All Nights		0	0	0	0	0	0																		
SS+121mins to SR-121mins																									
Sub Total		2	1	4	6	0	0		2	1	4	4	0		0	0	0	0	0		0	0	0	0	0
Total All Nights		2	1	4	10	0	0																		
120 to -91mins																									
90 to -61mins																									
Sub Total		0	0	0	0	0	0																		
Total All Nights		0	0	0	0	0	0																		
60 to -31mins																									
30 to SR																									
Sub Total		0	0	0	0	0	0																		
Total All Nights		0	0	0	0	0	0																		
Grand Total		2	1	4	10	0	0																		

Totals All Nights	S pip	C pip	U pip	My	BLE	Nyc	Total
SS to +1hr Total	0	0	0	0	0	0	0
SS +1hr to +2hr	0	0	0	0	0	0	0
SS +2hr to SR -2hr	2	1	4	10	0	0	17
SR -2hr to SR -1hr	0	0	0	0	0	0	0
SR -1hr to SR	0	0	0	0	0	0	0
Grand Total	2	1	4	10	0	0	17

Survey Effort (mins)	480
Open	480 x 4 nights = 1920

Spittalhill Static Survey Form 12 (AnaBat Survey - Open, 02.09.11 to 05.09.11)

Automated Bat Detector Survey Results Form

Site Spittal Hill MAG546 Detector Name/Grid Ref: AB10 / NS 6551 8935

Habitat Type Open

Dates 02.09.11 dusk to 05.09.11 dawn 3 nights

Time On 19:45 Time Off 06:50

Time	Date	02.09.11	03.09.11	04.09.11	05.09.11	06.24	06.26	20:07	20:05	06:28	Sunrise	
	S pip	C pip	U pip	Temp °C	My	BLE	Nyc	S pip	C pip	U pip	Temp °C	Sunrise
30 min slots												
SS to +30mins												
31 to +60mins												
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0
61 to +90mins												
91 to +120mins												
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0
SS+121mins to SR-121mins												
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0
120 to -91mins												
90 to -61mins												
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0
60 to -31mins												
30 to SR												
Sub Total	0	0	0	0	0	0	0	0	0	0	0	0
Total All Nights	0	0	0	0	0	0	0	0	0	0	0	0

Totals All Nights	S pip	C pip	U pip	Temp °C	My	BLE	Nyc	Total
SS to +1hr Total	0	0	0	0	0	0	0	0
SS +4hr to +2hr	0	0	0	0	0	0	0	0
SS +2hr to SR -2hr	0	0	0	0	0	0	0	0
SR -2hr to SR -1hr	0	0	0	0	0	0	0	0
SR -1hr to SR	0	0	0	0	0	0	0	0
Grand Total	0	0	0	0	0	0	0	0

Survey Effort (mins)	Mins
Open	660 x 3 nights = 1980

Appendix 9.5: Electrofishing Survey

Electrofishing Survey at Craigton and Spittalhill Wind Farm Site

TECHNICAL APPENDIX 9.5

Report prepared by Dr Joanna Girvan

River Forth Fisheries Trust

October 2012



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1. Summary

- An electrofishing survey was carried out at the proposed Craigton wind farm site near Fintry, Stirlingshire during October 2012.
- The substrate and flows of the surveyed burns were found to be suitable for salmonid fish species to inhabit and to spawn in.
- Very low densities of brown trout (*Salmo trutta*) were found at three of the four survey sites. The remaining site had no fish of any species present.
- No Atlantic salmon (*S. salar*), lamprey or non-salmonid fish species were found at any of the survey sites.

2. Background

The River Forth Fisheries Trust (RFFT) was commissioned by MacArthur Green Ltd to carry out an electrofishing survey of burns associated with the proposed Craigton wind farm site. This report details the baseline conditions for salmonid fish, lamprey and other fish species present at the site and assesses the suitability of the habitat available for salmon and trout.

3. Introduction

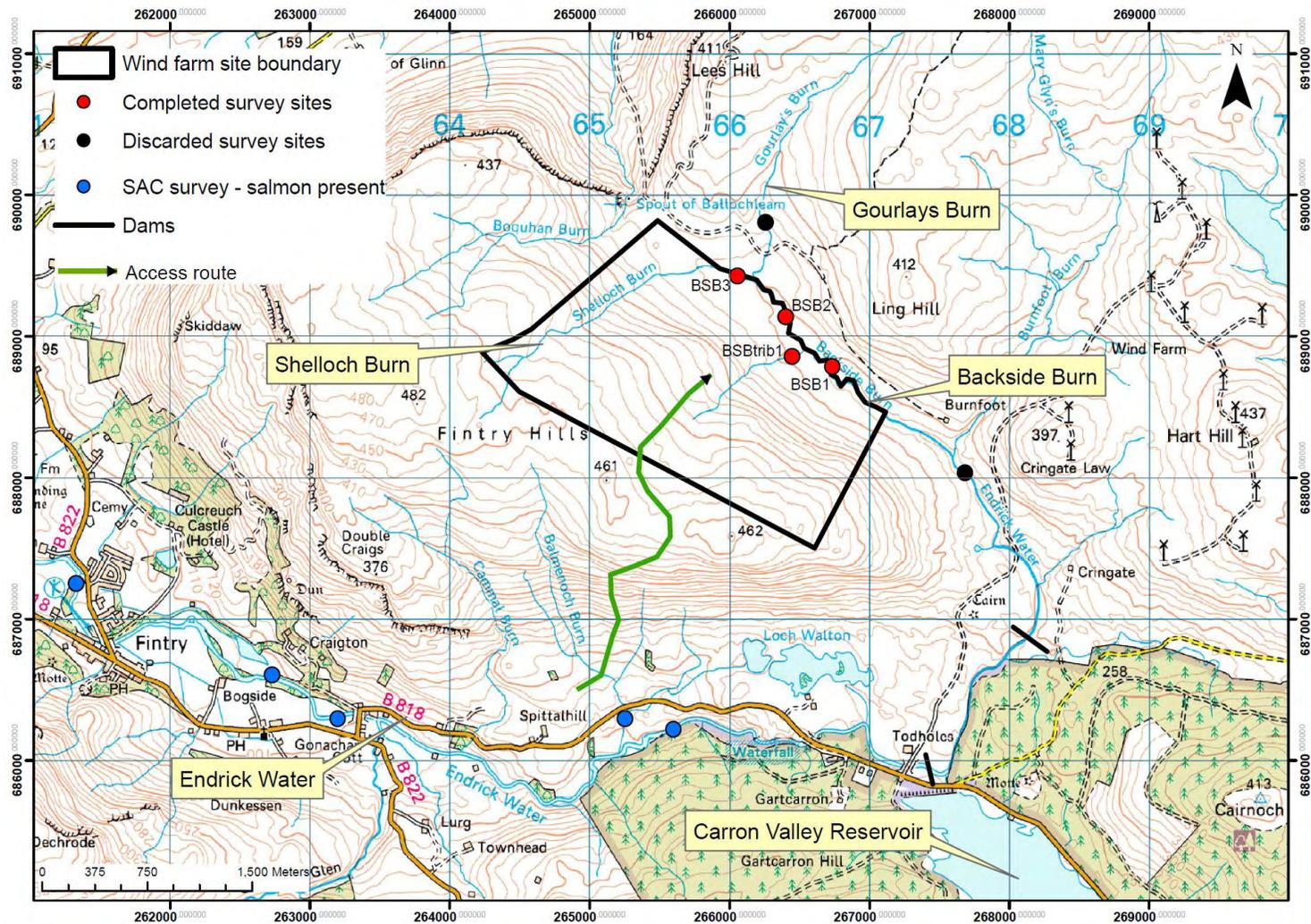
The proposed wind farm site at Craigton lies ca. 4.5km to the north-east of the town of Fintry in Stirlingshire. The site lies in a valley of the Fintry Hills, and the land use comprises rough pasture grazed by sheep, with wetter areas on the valley floor, dominated by rushes (Photo 1). At the top of the valley, the Shelloch Burn and Gourlay's Burn join to form the Backside Burn (Map 1), which is the main burn in the valley. Several small tributaries flow into the Backside Burn as it flows along the valley floor. Approximately 0.5km downstream of the site boundary, it joins with the Burnfoot Burn to form the headwaters of the Endrick Water which is a designated Special Area of Conservation (SAC) that ultimately flows into Loch Lomond.

Migratory salmonids such as Atlantic salmon and sea trout are not able to reach the burns of the Craigton wind farm site as there are natural and artificial barriers to upstream migration on the Endrick Water. There are two dams on the Endrick Water (Map 1), located near the Carron Valley Reservoir. Natural falls are interspersed along the same stretch. A survey of Atlantic salmon in the Endrick Water, carried out in 2011 in support of its SAC designation, showed that salmon are present almost as far upstream as the first dam (Map 1). Of the 5 SAC survey sites on the Endrick Water shown on Map 1, salmon were present at all of them, and each juvenile year class was present, indicating successful spawning and survival. No migratory salmonids are likely to be present upstream of the dams, or within the wind farm site.



Photo 1 Un-named burn (foreground) and Backside Burn (on far valley floor)

Map 1 - Craighton wind farm site showing the site boundary, survey access route, survey sites, watercourses, Carron Valley Reservoir and the locations of two dams on the Endrick Water



4. Methods

RFFT was commissioned to carry out an electrofishing survey at the proposed Craighton wind farm site. The survey was carried out for the purposes of establishing baseline conditions to inform an Environmental Impact Assessment. The survey was carried out on 5th October 2012. All fish species, including lamprey, were included.

Initially, six survey sites were identified from the map and agreed with the client. Four survey sites were within the wind farm site boundary, on the Shelloch Burn and the Backside Burn (Map 1), one was a control site on Gourlay's Burn upstream of the boundary and one was downstream of the boundary on the Endrick Water. However, following consultation with the client, it became apparent that access to the burns was more difficult than expected. Ultimately, access was achieved by quad bike (Photo 2) and on foot, but the access difficulties meant that only the four survey sites within the wind farm boundary were included in the final survey. Despite this, the survey effort is considered appropriate, with this limitation not having a material effect on the integrity of the overall survey.

Map 1 shows the locations of the completed survey sites (in red) as well as the discarded survey site locations (in black). A Garmin GPS was used to determine the grid references of each survey site and these are shown in Table 1.



Photo 2 Quad bike access to the un-named burn

All electrofishing methods used follow the recommendations of the Scottish Fisheries Coordination Centre (SFCC) (see SFCC website at: <http://www.scotland.gov.uk/Topics/marine/science/sfcc/Protocols/ElectrofishingSurveys>).

Insufficient fish were caught at any of the sites to allow an estimate of total population to be made and so the data was used instead to produce a lower precision estimate of minimum population (also known as semi-quantitative survey).

The equipment used was an Electracatch backpack powered by two 12 volt lead acid batteries. The conductivity of the water at each site was measured using a YSI portable conductivity meter. In general, conductivity was low (around $20 \mu\text{Scm}^{-1}$) and so both smooth and pulsed current was used to maximise the effectiveness of the fishing.

Water levels were low and clarity was good during the survey, although there was some peat staining. The water temperature was around 9°C (above the recommended lower limit for electrofishing) and the pH was circumneutral ranging from 7.1 to 8.4 (i.e. not harmful to aquatic life).

Captured fish were maintained in large buckets with portable aerators to ensure that oxygen levels remained high. All fish were anaesthetised using a dilute solution of Benzocaine dissolved in acetone. SFCC recording sheets were used to capture species, lengths and habitat data. Fish were allowed to recover fully in fresh water before being returned to the burns once all fishing had been completed at that site.

4.1 Survey team

The survey team consisted of two members. The team leader was the RFFT biologist who has completed the 'Managing Electrofishing Operations' course administered by the SFCC. The other team member belonged to Stirling Council Fisheries team, was trained in electrofishing, experienced in quad bike handling and trained in emergency first aid.

4.2 Constraints

Difficulty of access, by off road quad biking and on foot, meant that the most downstream proposed survey site could not be reached. Access was not permitted to the control site on Gourlay's Burn. The total number of sites was therefore reduced from six to four, all of which were within the wind farm boundary.

5. Results

Extremely low densities of brown trout were found at three of the survey sites. At the fourth site, on the Shelloch Burn, no fish were caught, although one trout parr was observed but not caught.

The catches at each survey site are shown in Table 1. The site codes corresponding to each of the four sites are shown on Map 1. All fish were caught on the first run. Further runs were not carried out due to insufficient fish numbers.

Table 1 – Grid references for each electrofishing site, with number of adult and juvenile brown trout caught and length ranges

Site code	Grid reference	Fish caught	Length range (mm)	Fish observed but not caught
BSB1	NS66728 88797	1 juvenile trout	75	1
BSB2	NS66394 89164	1 adult trout	130	0
BSB3	NS66049 89420	None	n/a	1
BSBtrib1	NS66417 88841	2 juvenile trout	95 - 110	0

5.1 Population estimates

Insufficient numbers of fish were captured at the sites to produce mean population estimates, and only minimum population could be estimated in each case. Estimated minimum populations of brown trout, survey site area and trout densities are shown in Table 2.

Table 2 – Estimated minimum populations, survey areas and trout densities at each site

Site Code	Estimated minimum populations in surveyed reach	Area of surveyed site (m ²)	Density of trout (trout per m ²)
BSB1	1	63	0.016
BSB2	1	54	0.019
BSB3	0	54	0.000
BSBtrib1	2	27	0.074

5.2 Habitat

The Backside Burn, Shelloch Burn and the un-named tributary that were covered by the survey all contained habitat that was good or excellent quality for both trout and salmon. The substrate was clean of excess silt and was comprised of gravels, cobble and boulders. Water was shallow and fast flowing in riffle sections that were suitable to give cover to juveniles, while there were also deeper, slower moving sections and pools, providing cover for adults. The main channel of the Backside Burn was approximately 3 – 5 meters in width, while the smaller tributaries were less than 1m across. pH was circumneutral, and there were no visible signs indicating problems with water quality other than very small areas of filamentous algae on the substrate.

6. Discussion

In total, one adult brown trout and 3 juveniles were caught during this survey. Trout were the only fish species present at any of the four survey sites, and densities were extremely low despite the presence of good quality salmonid habitat i.e. silt-free rocky substrate, fast flowing, shallow water, deeper glides and pools. No clear cut explanation for the low population densities was immediately evident from observation of the site. No land use impacts on water quality were observed - the area consists of rough pasture grazed by sheep. The banks of the Backside Burn appeared to be stable, and the erosive/depositional functioning of the river appeared as expected. Small amounts of filamentous algae were visible on the substrate, indicating some enrichment, however, the coverage was restricted and did not suggest water quality problems sufficient to decimate a trout population. It is possible that predation pressure is high enough to depress the population to such low levels. While the banks were often undercut, there were no trees or shrubs overhanging the banks, and so refuge from predation may be limited at this site.

While the local brown trout population is relatively sparse, care should nevertheless be taken to mitigate any potential impacts on fish e.g. sedimentation, to avoid the complete loss of the population from the Backside Burn. Of particular note is the fact that the Backside Burn flows into, and becomes the Endrick Water (SAC) less than a kilometre downstream of the lower wind farm site boundary. Atlantic salmon have been recorded spawning and surviving successfully in the Endrick Water approximately 6km downstream of the wind farm boundary, and this should be considered when identifying mitigation measures to protect fish populations.

Appendix 10.1: Ornithological Study and Annex A: Legal Protection



CRAIGTON AND SPITTALHILL WINDFARM

ORNITHOLOGICAL STUDY

Technical Report 10.1

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Figure 10.1 – Site Area & Survey Boundaries

Figure 10.2 – Designated Sites

Figure 10.3 – Vantage Point Viewshed

Figure 10.4 – Collision Risk Analysis Area

Figure 10.5 – Target Species Flight Lines

Figure 10.6 – Breeding Season Flight Lines 2011

Figure 10.7 – Breeding Season Flight Lines at PCH 2011

Figure 10.8 – Non-Breeding Season Flight Lines 2011/2012

Figure 10.9 – Non-Breeding Season Flight Lines at PCH 2011/2012

Figure 10.10 – Breeding Season Flight Lines 2012

Figure 10.11 – Breeding Season Flight Lines at PCH 2012

Figure 10.12 – Breeding Bird Survey Results 2011

Figure 10.13 – Breeding Bird Survey Results 2012

Figure 10.14 – Raptor Survey Results 2011

Figure 10.15 – Raptor Survey Results 2012

Figure 10.16 – Black Grouse Survey Results

EXECUTIVE SUMMARY

MacArthur Green Ltd was commissioned by Force 9 to complete ornithological surveys at the proposed Craigton and Spittalhill Windfarm site, Stirlingshire (referred to hereafter as 'the Site').

These surveys were required to inform an assessment into the likely impacts of the development on bird populations occupying the site area and its surrounds.

Surveys informing this report were conducted between March 2011 and August 2012 during weather conditions conducive to a range of bird survey methods.

The surveys revealed the presence of the following Target Species within the site area and its surrounds:

- Black grouse
- Geese spp;
- Hen harrier;
- Osprey; and
- Red kite.

This technical report details the surveys and methods that have been employed on the site together with the results of the bird surveys. Detailed legislation information, methodologies, survey data and collision risk modelling are included within Annexes A-E; this report is accompanied by Figures 10.1 to 10.16.

1 INTRODUCTION

MacArthur Green Ltd was commissioned by Force 9 to carry out bird surveys at the proposed Craigton and Spittalhill Windfarm site (hereafter referred to as 'the site'). The Development covers an area of approximately 562ha and is situated approximately 4km north-west of Fintry, Stirlingshire (Figure 10.1).

The surveys were commissioned to inform an assessment into the likely ornithological impacts that would arise should the development progress through the planning process. A range of survey methods were employed in order to establish a thorough baseline dataset on important bird species at the site.

This technical report summarises the methods employed and the results of the field surveys and is supported by the following Annexes:

Annex A:	Legal Protection of Birds;
Annex B:	Methods;
Annex C:	Survey Effort;
Annex D:	Results; and
Annex E:	Collision Risk Modelling.

2 LEGAL PROTECTION

All wild birds and their eggs are protected by law. Specific levels of protection are determined by a species' inclusion on certain lists. Annex A to this report details the various levels of legal protection afforded to UK bird species.

3 METHODOLOGIES

3.1 Consultations and Desk-Based Study

The following resources were consulted with regards the ornithological interests on and adjacent to the Site area:

- Scottish Natural Heritage (SNH) Site Link (www.snh.gov.uk/sitelink) – Data on designated sites;
- NBN Gateway (www.searchnbn.net) – Information relating to Schedule 1, Annex 1 and Red and Amber List bird species in OS Tile NS68;
- BTO Bird Track for OS Tile NS68; and
- SNH.

3.2 Field Survey

The following surveys were undertaken at the site. These follow recommended survey guidelines and are described in detail within Annex B:

- Flight Activity Vantage Point Survey (VP) (2 breeding seasons and 1 non-breeding season);
- Breeding Bird Survey (BBS) (2 breeding seasons);
- Winter walkover (WWO) (1 non-breeding season);

- Breeding Raptor Survey (2 breeding seasons); and
- Black Grouse Survey (1 breeding season).

Each survey was carried out beyond the site boundary within a distance specific to that method – e.g. 2km buffer for the breeding raptor survey. Details of these boundaries are listed within Annex B and illustrated within Figure 10.1. These boundaries are hereafter referred to as the ‘survey area’ within this report.

The relative importance of the data collected was determined by the specific level of protection assigned to those species recorded, coupled with their perceived susceptibility to impacts by the Windfarm. The resulting ‘Target Species’ and ‘Secondary Species’ lists are a standard assessment tool for Windfarm ornithological studies (see Annex B).

3.3 Survey Constraints

No constraints were experienced during surveying.

4 RESULTS

4.1 Consultations and Desk-Based Study

SNH SiteLink (<http://gateway.snh.gov.uk/sitelink/>) revealed the presence of the following designated sites within 20km of the site; Table 1 and Figure 10.2. Only designated sites with an ornithological qualifying feature are listed (furthermore other non-ornithological qualifying features within these sites are not listed).

Table 1, Designated sites within 20km of the Site and associated ornithological qualifying features

Distance from the Site	Site	Qualifying Features
< 1 km	None	n/a
< 5 km	None	n/a
< 10km	None	n/a
< 15 km	Lake of Menteith SSSI	<u>Non-breeding birds</u> Pink-footed goose
< 20 km	Loch Lomond SPA	<u>Non-breeding birds</u> Greenland white-fronted goose <u>Breeding birds</u> Capercaillie
	Loch Lomond RAMSAR	<u>Non-breeding birds</u> Greenland white-fronted goose
	Firth of Forth SSSI	<u>Breeding birds</u> Eider, Ringed plover, Shelduck, Sandwich tern (passage) <u>Non-breeding birds</u> Bar-tailed godwit, Common scoter, Cormorant, Curlew, Dunlin, Eider, Golden plover, Goldeneye, Great-crested grebe, Grey plover, Knot, Long-tailed duck, Mallard, Oystercatcher, Pink-footed goose, Red-breasted merganser, Redshank, Red-throated diver, Ringed plover, Scaup, Shelduck, Slavonian grebe, Turnstone, Velvet scoter, Wigeon, and Lapwing.
	Firth of Forth RAMSAR	<u>Non-breeding birds</u> Sandwich tern (passage), Slavonian grebe, waterfowl assemblage, Bar-tailed godwit, Goldeneye, Knot, Pink-footed goose, Redshank, Shelduck, and Turnstone.
	Firth of Forth SPA	<u>Non-breeding birds</u>

Distance from the Site	Site	Qualifying Features
		Oystercatcher, Ringed plover, Shelduck, Velvet scoter, Bar-tailed godwit, Common scoter, Cormorant, Curlew, Dunlin, Eider, Golden plover, Goldeneye, Great-crested grebe, Grey plover, Knot, Lapwing, Long-tailed duck, Mallard, Pink-footed goose, Red-breasted merganser, Redshank, Red-throated diver, Sandwich tern, Scaup, Slavonian grebe, Turnstone, Wigeon, and waterfowl assemblage.
	Slamannan Plateau SPA	<u>Non-breeding birds</u> Taiga bean goose
	Slamannan Plateau SSSI	<u>Non-breeding birds</u> Taiga bean goose
	Endrick Mouth & Islands SSSI	<u>Non-breeding birds</u> Greenland white-fronted goose, greylag goose <u>Breeding birds</u> Breeding bird assemblage
	Loch Mahaick SSSI	<u>Non-breeding birds</u> Pink-footed goose
	West Fannyside Moss	<u>Non-breeding birds</u> Taiga bean goose

The NBN Gateway and BTO BirdTrack database included records for the following Target Species within the OS tile NS68 for the site;

- Barn owl
- Barnacle goose
- Black grouse
- Common crossbill
- Cuckoo
- Dunlin
- Fieldfare
- Grasshopper warbler
- Hen harrier
- Herring gull
- Lapwing
- Lesser redpoll
- Linnet
- Pink-footed goose
- Greylag goose
- Golden plover
- Merlin
- Osprey
- Peregrine falcon
- Redshank
- Redwing
- Song thrush
- Skylark
- Starling
- Short-eared owl
- Tree pipit
- Whooper swan
- Yellowhammer

SNH was consulted as detailed below:

- SNH Scoping Response 22/10/2012.

4.2 Field Survey

Survey work commenced on the 25th March 2011 and continued until 13th August 2012. All surveys were undertaken by suitably qualified and experienced surveyors and carried out during suitable weather conditions (as described within Annex B – Survey Methodologies). The Schedule 1/Annex 1 surveys were carried out by appropriately licensed surveyors.

A total of 37 bird species were recorded within, or adjacent, the site during the various ornithological surveys carried out. Survey effort and results of the field surveys are detailed within Annexes C & D; survey results are also illustrated within Figures 10.5 – 10.16. The following sections summarise the results from each survey undertaken. All Target Species identified by the survey work, their Nature Conservation Importance and Conservation Status are noted below in Table 2.

Table 2, Target Species Recorded & Nature Conservation Importance

Target Species	Nature Conservation Importance	Reason for Conservation Importance	Conservation Status Information for UK (BOCC3 listing)	Conservation Status in Scotland & SPA where Relevant
Greylag goose	High	Endrick Mouth & Islands SSSI qualifying species	Amber List	Greylag goose is a common resident bird in much of Scotland and also a winter visitor from Iceland. Numbers of resident greylag geese were reduced by exploitation and their distribution shrank to NW Scotland and especially the Outer Hebrides by the 1960s. Since the 1940s, greylag geese have been reintroduced to many areas of Scotland and populations have increased. There are now about 20,000 greylag geese in NW Scotland and at least 5000 in the rest of Scotland. In autumn, tens of thousands arrive from Iceland to overwinter in lowland Scotland, though since the 1960s the numbers wintering in Scotland have decreased considerably as many now remain in Iceland in winter. Many of those wintering in Scotland now occupy pastures in Orkney rather than the central belt.
Black grouse	Moderate	Annex 1 and BOCC Red Listed	Red List	Breeding numbers in the UK declined by 80% between 1991 and 2004. Sim et al. (2008) estimated there to be 5,078 male black grouse in the UK, with approximately two-thirds of these occurring in Scotland. However, Forrester et al. (2007) estimate that in Scotland there are now around 3,550 to 5,750 lekking males, representing about 71% of the British population. In Scotland the breeding range is contracting and numbers are declining, though the rate of decline varies regionally, being highest in southern Scotland. Numbers declined by 49% in SW Scotland between 1995 and 2005.
Grasshopper warbler	Moderate	BOCC Red Listed	Red List	Although red listed in the UK due to large declines in breeding numbers in England in the 1970s, Breeding Bird Survey data show a recovery in breeding numbers between 1994 and 2004 in the UK. There are thought to have been around 900 to 3,700 pairs in Scotland in 1990 (BTO 2nd Atlas data). Data for Scotland are limited, but suggest that numbers have been increasing in Scotland in recent years and that this species is doing better in Scotland than in England.
Hen harrier	Moderate	Annex 1, Schedule 1 & Red List	Red List	Historic decline and Species of European Conservation Concern (SPEC) (Birdlife International 2004) listed. 633 pairs in Scotland.
Herring gull	Moderate	BOCC Red Listed	Red List	About 72,100 pairs nest in Scotland and around 100,000 birds are present in winter. The species is red listed due to steep decline in breeding numbers (by more than 50%) from the 1960s to the present, and a similar decline in wintering numbers.
Lapwing	Moderate	BOCC Red Listed	Red List	RSPB estimate 156,000 pairs in UK. Numbers have declined considerably in England and Wales, by 80% since 1960, the decrease being related to agricultural impacts. In Scotland, there are now 71,500 to 105,600 breeding pairs, with trends in breeding numbers in Scotland much less evident than in England. Breeding numbers in Scotland may have declined slightly, but far less than in England.
Linnet	Moderate	BOCC Red Listed	Red List	The linnet is divided into six subspecies. Of these, the subspecies autochthona is endemic to Scotland, with linnets in England and Wales classified as the nominate subspecies cannabina. The Scottish subspecies is, however, only marginally distinct from the nominate form found south of the border. There are around 70,000 to 90,000 pairs of linnets in Scotland. It is likely that numbers have declined in Scotland, as they certainly have in England where BTO data indicate a 50% drop in numbers between the 1970s and 2000 (Forrester et al. 2007). The decline has been attributed to agricultural change and particularly the switch from spring-sown to autumn-sown grain. Increases in cultivation of oil-seed rape and linseed may be responsible for an apparent increase in linnet numbers in Scotland of 23% from 1994 to 2003 (Forrester et al. 2007).
Osprey	Moderate	Annex 1 and Schedule 1	Amber List	Breeding numbers in Scotland (182-200 pairs) represent 97% of the UK population, and have been increasing since natural re-colonisation in the 1950s. Breeding distribution in Scotland has spread from initial colonisation in Speyside to almost the whole of Scotland occupied by breeding Ospreys now, though there is scope for further increases in areas such as southern Scotland. Some Scandinavian migrants pass through Scotland in spring and autumn.

Target Species	Nature Conservation Importance	Reason for Conservation Importance	Conservation Status Information for UK (BOCC3 listing)	Conservation Status in Scotland & SPA where Relevant
Peregrine falcon	Moderate	Annex 1 and Schedule 1	Green List	The Scottish breeding population of around 600 pairs represents about 42% of the UK total. Numbers have increased in Scotland since the 1960s; though have been approximately stable or slightly reduced since peaking in 1990.
Red kite	Moderate	Annex 1 and Schedule 1	Amber List	Red kite became extinct in Scotland in the late 19th century. Re-introduced since 1989 to the Black Isle, Stirlingshire, Dumfries and most recently Aberdeenshire, numbers are now increasing and breeding range very slowly spreading from these release centres. RSPB report 180 breeding pairs in 2010 in Scotland, with similar numbers in Black Isle, central Scotland and Dumfries & Galloway. Britain now holds nearly 10% of the red kite population with over 1800 pairs. Further increases in Scotland have occurred in 2011 and 2012 and these populations can be expected to spread over much of Scotland in coming years. Due to its strongly social nature, the spread will probably be slow, with highest concentrations of numbers remaining in areas where releases took place.
Skylark	Moderate	BOCC Red Listed	Red List	There has been a very well publicised decline in the UK breeding population of skylarks (for example by 55% between 1975 and 1994, but this has been mainly in England. BBS data show an 8% increase in Scotland between 1995 and 2008. The Scottish population is estimated at 290,000-557,000 pairs, and is thought to be broadly stable at present (Forrester et al. 2007), so while Red List status is appropriate for the species in England, it is a misleading designation for Scotland.

4.2.1 Flight Activity Vantage Points (VPs)

The VP surveys recorded all flight activity within the site and beyond, with this data sorted to provide data for the 'Collision Risk Analysis Area' (CRAA) [i.e., the area to be occupied by operational turbines, together with a 250m buffer area to allow for surveyor error (Figure 10.4)], together with all flight activity outside of this area. One VP was used during all VP surveys which gave full coverage of the CRAA (see Figure 10.3).

A total of 17 species were recorded during the VP surveys, of which six were Target Species (further details within Annex D; Figures 10.5 to 10.11 details all flight lines observed). The Target Species recorded during VPs and the total number of flights is noted below in Table 3.

Table 3, Target Species Recorded and Total Number of Flights Recorded

Target Species	Total Number of Flight Lines Recorded
Black grouse	1
Grey goose ¹	1
Greylag goose	7
Hen harrier	1
Osprey	9
Red kite	4

*The figures in this table give the total number of flight lines for that species recorded whilst undertaking VP watches from March 2011 to August 2012.

Table 4 shows the total number of survey hours per season for each VP.

Table 4, Summary of total hours for VP1 in each survey season

Season	VP1
Summer (2011) (mid-March to August)	54
Winter (2011-2012) (September to mid-March)	36
Summer (2012) (mid-March to August)	36

The Target Species observed were Black grouse (one flight), Greylag goose (seven flights), Grey goose¹ (one flight), Hen harrier (one flight), Osprey (nine flights) and Red kite (four flights) (Figures 10.5 – 10.11). A brief description of Target Species observations is provided below. Only flight observations recorded within the Collision Risk Analysis Area are considered in the following discussion. Full survey results detailing the findings from each survey visit (including those out with the Collision Risk Analysis Area and Secondary Species information) can be found within Annex D.

- A single Black grouse flight was recorded within the CRAA during VPs on 13/08/2012. The total flight time for Black grouse in the CRAA was 25 seconds (i.e., five birds flying for five

¹ 'Grey geese' is the term applied to those grey geese (greylag/pink-footed) for whom identification to species level was not possible.

seconds). All flight activity was below Potential Collision Height (PCH). A Black grouse lek was identified during other surveys (see below).

- A total of seven Greylag goose flights were observed in the CRAA during VPs between summer 2011 and summer 2012. These occurred in the 2011 breeding season (5 flights), the 2011/2012 non-breeding season (1 flight), and the 2012 breeding season (1 flight). All breeding season flights were recorded in the migratory period for geese i.e. October, April and May. The total flight time for Greylag geese in the CRAA during the 2011 breeding season was 227.5 seconds of which 61.8% was at PCH. The total flight time for Greylag geese in the CRAA during the 2011/2012 non-breeding season was 192.6 seconds of which 100% was at PCH. The total flight time for Greylag geese in the CRAA during the 2012 breeding season was 62.3 seconds of which 100% was at PCH.
- A solitary Hen harrier flight was observed in the CRAA during the 2011 breeding season (4th May 2011). The flight time for Hen harrier in the CRAA during the 2011 breeding season was 67.6 seconds of which 59.2% was at PCH. The flight line was along the north eastern edge of the site (Figure 10.6).
- Seven Osprey flights were observed in the CRAA during VPs between summer 2011 and summer 2012. These occurred in the 2011 breeding season (1 flight) and the 2012 breeding season (6 flights). The total flight time for Osprey in the CRAA during the 2011 breeding season was 58.3 seconds of which 79.8% was at PCH. The total flight time for Osprey in the CRAA during the 2012 breeding season was 114 seconds of which 61.9% was at PCH.
- No Red kite flights were recorded in the CRAA during VPs but were recorded out with this area [four flights with three being on the same day (14/06/2011)].

Tables 5 to 10 below provide details of the number and proportion of flight activity within each flight category for each of the above species observed in the Collision Risk Analysis Area (data provided in Annex D).

4.2.2 Breeding Raptor Survey including Barn Owl

Raptor searches to locate breeding raptors and their nest sites were carried out in the 2011 and 2012 breeding seasons. The raptor survey area encompassed a 2km buffer area around the site (Figure 10.1). Records of Buzzard, Kestrel and Sparrowhawk were made during raptor searches in 2011 with no nest sites found. Records of Hen harrier, Osprey, Peregrine, Buzzard, and Kestrel were made during raptor searches in 2012 with a single Buzzard territory located within the survey area, although it is very likely that most of the other species, including the Osprey, also bred in the wider area (Osprey observed carrying fish). Full details of raptor surveys are provided within Annex C and D and locations of observations provided within Figures 10.14 and 10.15.

4.2.3 Breeding Bird Survey

The upland BBS recorded sixteen breeding species. Wader territories in 2011 included Curlew (3 territories) and Snipe (1 territory); surveys in 2012 recorded Curlew (5 territories) (see Figures 10.12 and 10.13, respectively).

4.2.4 Winter Walkover

The winter walkover surveys recorded nine bird species. Of particular note were observations of two Black grouse, 25 Greylag geese and 20 Linnets. Full details of the results are presented in Annex D.

4.2.5 Black Grouse

One Black grouse lek was identified during dedicated Black grouse surveys in the 2012 breeding season; this lek consisted of 4 lekking males within the site boundary (see Figure 10.16).

Black grouse were also observed on one occasion during Vantage Point surveys and two Black grouse were also observed during a winter walkover survey in January 2012.

4.2.6 Flight lines within the Collision Risk Analysis Area

Flight lines are presented in Figures 10.5 to 10.11.

Table 5, Target Species Bird Seconds within the Collision Risk Analysis Area during the 2011 Breeding Season

Bird Seconds within Height Bands (Breeding Season*)					
Species	Flights	<20	20-125	125 >	Total
Greylag Goose	5	86.9	140.6	0.0	227.5
Hen Harrier	1	27.6	40.1	0.0	67.6
Osprey	1	11.8	46.5	0.0	58.3

Table 6, Percentage of Target Species Bird Seconds within the Collision Risk Analysis Area during the 2011 Breeding Season

% of Bird Seconds within Height Bands (Breeding Season)					
Species	Flights	<20	20-125	125 >	Total
Greylag Goose	5	38.2	61.8	0.0	100.0
Hen Harrier	1	40.8	59.2	0.0	100.0
Osprey	1	20.2	79.8	0.0	100.0

Table 7, Target Species Bird Seconds within the Collision Risk Analysis Area during the 2011/2012 Non-breeding Season

Bird Seconds within Height Bands (Non-breeding Season*)					
Species	Flights	<20	20-125	125 >	Total
Greylag Goose	1	0.0	192.6	0.0	192.6

Table 8, Percentage of Target Species Bird Seconds within the Collision Risk Analysis Area during the 2011/2012 Non-breeding Season

% of Bird Seconds within Height Bands (Non-breeding Season)					
Species	Flights	<20	20-125	125 >	Total
Greylag Goose	1	0.0	100.0	0.0	100.0

Table 9, Target Species Bird Seconds within the Collision Risk Analysis Area during the 2012 Breeding Season

Bird Seconds within Height Bands (Breeding Season*)					
Species	Flights	<20	20-125	125 >	Total
Black Grouse	1	25.0	0.0	0.0	25.0
Greylag Goose	1	0.0	62.3	0.0	62.3
Osprey	6	0.0	70.5	43.5	114.0

Table 10, Percentage of Target Species Bird Seconds within the Collision Risk Analysis Area during the 2012 Breeding Season

% of Bird Seconds within Height Bands (Breeding Season)					
Species	Flights	<20	20-125	125 >	Total
Black Grouse	1	100.0	0.0	0.0	100.0
Greylag Goose	1	0.0	100.0	0.0	100.0
Osprey	6	0.0	61.9	38.1	100.0

4.2.7 Flight line Information

Table 11 below is to be read in conjunction with Figure 10.5. Figure 10.5 shows all flight lines recorded during vantage point surveys and are numerically labelled; each flight line number corresponds to the data presented in Table 11.

Table 11, Flight line data for all flight lines

Date	Labelled Flight Line No.	VP Start Time	VP Finish Time	Start Time	BTO Spp Code	No. Of Birds	Duration (s)	Total bird second duration	< Buffer: Sec. <20m	< Buffer: Sec.20 to 125m	< Buffer: Sec. >125	> Buffer: Sec. <20m	> Buffer: Sec.20 to 125m	> Buffer: Sec. >125
06/04/2011	2	1710	2010	1841	GJ	2	45	90	0	50.4	0	0	39.6	0
15/04/2011	1	945	1245	946	GJ	2	20	40	27.6	0	0	12.4	0	0
27/04/2011	3	930	1230	937	GJ	2	65	130	0	41.6	0	0	88.4	0
04/05/2011	6	1455	1755	1527	OP	1	94	94	11.78	46.5	0	7.22	28.5	0
04/05/2011	5	1455	1755	1712	HH	1	76	76	27.59	40.05	0	3.41	4.95	0
04/05/2011	4	1805	2105	1811	GJ	3	34	102	6.48	48.6	0	5.52	41.4	0
04/05/2011	23	1805	2105	1908	GJ	4	22	88	52.8	0	0	35.2	0	0
14/06/2011	7	825	1125	1034	KT	2	110	220	0	0	0	220	0	0
14/06/2011	8	1135	1435	1219	KT	1	85	85	0	0	0	0	45	40
14/06/2011	9	1135	1435	1222	KT	1	38	38	0	0	0	0	0	38
05/09/2011	10	945	1245	1141	KT	2	125	250	0	0	0	0	250	0
20/10/2011	11	900	1200	909	GG	50	45	2250	0	0	0	0	0	2250
06/01/2012	12	955	1355	1030	GJ	16	86	1376	0	192.64	0	0	1183.36	0
30/04/2012	13	940	1240	1118	GJ	2	38	76	0	62.32	0	0	13.68	0
28/05/2012	14	1430	1730	1634	OP	1	45	45	0	8.55	0	0	36.45	0
28/05/2012	15	1740	2040	1828	OP	1	20	20	0	0	0	0	0	20
28/05/2012	16	1740	2040	2016	OP	1	48	48	0	28.8	0	0	19.2	0

Date	Labelled Flight Line No.	VP Start Time	VP Finish Time	Start Time	BTO Spp Code	No. Of Birds	Duration (s)	Total bird second duration	< Buffer: Sec. <20m	< Buffer: Sec.20 to 125m	< Buffer: Sec. >125	> Buffer: Sec. <20m	> Buffer: Sec.20 to 125m	> Buffer: Sec. >125
27/06/2012	17	1000	1300	1229	OP	1	12	12	0	7.08	0	0	4.92	0
27/06/2012	18	1000	1300	1331	OP	1	28	28	0	0	0	0	28	0
20/07/2012	19	440	740	652	OP	1	25	25	0	3.5	0	0	21.5	0
13/08/2012	20	1440	1740	1511	OP	1	25	25	0	12.25	0	0	12.75	0
13/08/2012	21	1440	1740	1556	OP	1	78	78	0	10.35	43.47	0	4.65	19.53
13/08/2012	22	1440	1740	1650	BK	5	5	25	25	0	0	0	0	0

5 REFERENCES

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ANNEX A LEGAL PROTECTION

In Scotland, all wild birds are protected under the Wildlife and Countryside Act 1981, as amended by the Nature Conservation (Scotland) Act 2004. This protection also extends to their eggs and nests, with it being an offence to*:

- intentionally or recklessly kill, injure or take any wild bird;
- intentionally or recklessly damage or destroy the nest of any wild bird while it is being built or used;
- intentionally or recklessly take or destroy an egg of any wild bird, or to cause or permit any of these acts; and
- have in possession or control any live or dead wild bird or any part thereof; or any egg or part of an egg of any wild bird.

Further special protection under this legislation is afforded to those species listed on Schedule 1 of the Act. For these species, it is an offence to:

- intentionally or recklessly disturb any wild bird listed on Schedule 1 while it is nest building, or at a nest containing eggs or young, or disturb the dependent young of such a bird;
- intentionally or recklessly disturb any wild birds included on Schedule 1 which leks, while it is doing so. In Scotland the Capercaillie is the only bird this offence applies to;
- intentionally or recklessly harass any wild bird included in Schedule 1A. In this case a White-tailed Eagle is the only bird listed though more may be added; and
- intentionally or recklessly take, damage, destroy or otherwise interfere with any nest habitually used by bird on Schedule A1 at any time. The White-tailed Eagle is also the only bird on Schedule A1 at this time.

Further protection is described under the EU Birds Directive which requires member states to maintain wild bird species in favourable conservation status** and promote the conservation of bird species listed within Annex 1 through the protection of their habitat. This is achieved via the designation of Special Protection Areas (SPAs).

Red List bird species are those deemed to be globally threatened and to be suffering population declines within the UK. Although not legally enforceable, the conservation of Red List bird species represents a material consideration, in planning terms.

*Exceptions to these offences exist under various circumstances (e.g. controlling pest species; taking birds during specific seasons; and killing sick or injured birds, etc.)

**While the term 'favourable conservation status' is not used in the Birds Directive, EU court cases over recent years have progressively interpreted the concept as meaningful in a Birds Directive context (SNH, 2006).

Appendix 10.1 Annex B: Bird Survey Methodologies

ANNEX B: BIRD SURVEY METHODOLOGIES

A range of ornithological surveys have been carried out at the proposed Craigton and Spittalhill Wind Farm. The methodologies used in these surveys are summarised in the sections below; more detailed descriptions can be consulted in the SNH Guidance (2010).

The survey boundaries for all ornithological surveys carried out were based on a preliminary development area, provided during the early stages of planning (Figure 10.1). The development area is a boundary defined by the maximum area likely to be occupied by the development infrastructure. Once the design of the Wind Farm was frozen, the final area relevant to the Collision Risk Analysis was identified, the Collision Risk Analysis Area (CRAA). This area was defined by buffering all turbine locations by 250 metres (to allow for observer error) (Figure 10.4). Target Species flight activity within this area was used to inform the Collision Risk Analysis.

Survey areas for Vantage Point surveys, breeding bird surveys, winter walkover surveys, black grouse surveys, and breeding raptor surveys remained constant during the entire survey period (Figure 10.1).

B1. Flight Activity Vantage Point Surveys

The aims of these surveys are: (1) to record flight activity within the vicinity of the proposed development in order to identify areas of importance to birds; and (2) to quantify flight activity within 250m of the proposed turbine in order to estimate the likelihood of collision (SNH, 2010. P.13).

Timing

- A survey period of 36 hours is recommended as the minimum level of sampling intensity at each VP for each season (breeding, non-breeding, migratory) (SNH, 2010. P.15);
- Watches were spread as evenly throughout the year as possible to ensure that temporally representative data is collected. Specific consideration was given to the period around dawn and twilight for breeding waders and to changing raptor behaviour across seasons (SNH, 2010. P.16 and P.19);
- During the breeding period (mid-March to August) a total of **at least 36 hours** from the vantage point was collected;
- During the winter season (December to mid-March) and migration seasons (March to mid-May; and September to October) a total of **at least 36 hours** from the vantage point was collected;
- Watches were suspended and resumed to take account of changes in visibility (e.g. fluctuations in cloud base). Watches were undertaken in conditions of good ground visibility when the cloud base was higher than the most elevated ground being observed; and
- Watches were conducted in a range of weather conditions and were spread throughout the day (see Annex A and Annex D).

Field methods

- Reconnaissance surveys were undertaken to establish potential VP locations;

- View-shed analysis was then conducted using Arc GIS to confirm suitable VP locations and their associated visible areas;
- The VP location and associated view shed are detailed in Figure 10.3;
- Care was taken to maximize the area visible whilst minimising disturbance to birds;
- The VP location was selected with the aim of achieving coverage of the whole potential turbine envelope and the survey area such that no point was greater than 2km from a VP. This objective was achieved for the Collision Risk Analysis Area (CRAA) (Figure 10.3);
- A maximum 180° view arc was scanned. This rule did not however apply when tracking migratory waterfowl, divers or raptors across the CRAA;
- Although all points within the survey area were required to be within the 2km of the VP, observations from the VP were not constrained to a 2km radius (i.e. birds are recorded regardless of their distance from the VP) (SNH, 2010. P.46); and
- Each watch lasted a maximum of three hours but was suspended and then resumed to take account of changes in visibility (e.g. fluctuations in the cloud base).

For species of high nature conservation importance (target species) the following data was recorded (SNH, 2010. P.44):

- The flight lines by individual birds;
- The time spent flying over a defined survey area;
- The proportion of flying time spent at approximate rotor height (20-125m);
- In the case of Hen Harriers, the locations of any display flights observed were recorded, together with details of the duration of display, number of oscillations and the estimated maximum and minimum flying height;
- Time the target bird was detected and flight duration were recorded;
- The route followed was plotted in the field onto 1:25,000 scale maps;
- The birds flight height was recorded at the point of detection and at 15 second intervals thereafter;
- Flight heights were classified in bands depending on rotor blade dimensions and rotor hub height (<20, 20-125, and >125m);
- For secondary species, activity summaries were sub-divided into 5 minute periods at the end of which the number and activity of all secondary species were recorded;
- If a target species was being tracked during a 5 minute period, then the activity summary for that period was and a new one started once observations of the target species had ended;

- Observation of target species took priority over recording secondary species;
- The number of birds recorded were the minimum number of individuals that could account for the activity observed; and
- Observers only recorded perched birds and birds on water-bodies once only on arrival at the VP. Thereafter only flying birds and newly noticed perched/swimming birds were included in the activity summaries.

B2. Upland Breeding Bird Surveys

Upland breeding bird survey methodology was employed as detailed within SNH Guidance (SNH, 2010. P.15, 16). In summary, this involved the following:

- Open upland (including hedgerows, scrub, isolated trees and copses) was surveyed using an intensive version of the Brown and Shepherd (1993) method for upland bird survey;
- The objectives were to map the distribution of breeding bird territories and estimate the approximate size of breeding bird populations;
- The survey covered all areas **within 500m** of the Development Area (Figure 10.1); and
- All upland wader species were recorded during the breeding bird survey.

Timing

- The area was surveyed three times in 2011 (May-July) and four times in 2012 (April-July);
- Fieldwork was undertaken between sunrise and sunrise + 6 hrs; and
- Fieldwork was not undertaken in conditions considered likely to affect bird detection rates, for example strong winds (greater than Beaufort Scale Force 4), persistent precipitation, poor visibility (less than 300m), or in unusually hot weather.

Field methods

- Walk-routes were used that optimised ground visibility;
- Surveyors paused at appropriate vantage and listening points;
- Isolated trees, copses and patches of scrub were approached and examined;
- Streams, ditches and hedgerows were walked;
- All other areas were approached to within 100m; and
- Registrations were mapped at the first location that behaviour indicative of breeding was observed. BTO activity codes were used.

B3. Diurnal Breeding Raptor Survey

The aims are to determine the distribution of occupied nests within 2km of the development area and record breeding success (SNH, 2010. P.17). Species such as buzzard, sparrowhawk and kestrel were included in a survey within 1 km of the development. Survey areas are detailed in Figure 10.1.

Surveys were undertaken by experienced and licensed field ornithologists. Extreme care was taken to avoid unnecessary disturbance to breeding birds.

These methods are summarised in SNH guidance (SNH, 2010. P16-18).

Hen Harrier

- Areas of suitable habitat were observed during the period 20 March – 30 April and behaviour indicative of breeding recorded; and
- Unsuitable areas include land above 600m; improved pasture and arable land; extensive areas of degraded land with no heather cover and low vegetation; the vicinity of cliffs, rocky outcrops, boulder fields and scree; areas within 100m of hill farms and occupied dwellings;

Merlin

- Areas of suitable nesting habitat (including forest edge where trees >5m high) were closely observed during the period 20 March - 30 April;
- Boulders, fence lines, isolated posts, stone dykes, grouse butts, hummocks, stream banks, crags, trees and recently burnt areas of heather were checked for signs of occupation (e.g. plucked prey, moulted feathers, pellets and faeces);
- If Merlin were observed, or signs found, areas were visited at least twice to verify occupation of the site; and
- Potential nest areas were watched for 4-6 hours if necessary.

Peregrine

- Potential nest sites were visited and checked for evidence of occupation in March and April;
- Sites checked included crags and steep banks identified from OS maps and searches of the survey area;
- Surveyors checked for signs of occupation (e.g. faecal splash, fresh plucked prey);
- If occupied sites were found they were re-visited to verify incubation; and
- Searches were made for eyries. Where this was not possible sites were watched from a suitable vantage point for 3-4 hours or until a nest was located.

Barn Owl

- The surveys used the methodology outlined in Gilbert et al (1998), as mentioned in SNH Guidance (SNH, 2010. P26-27).
- Surveys were undertaken within 1km of the Development.
- Surveyors checked for signs of occupation (moulted feathers, pellets) in all suitable buildings within this 1km buffer.

B4. Black Grouse

The survey methodology used is detailed in SNH Guidance (SNH, 2010. P24). A summary is provided below.

- Breeding Black Grouse were surveyed within 1.5km of the development area by counting total numbers of males and females at leks, most lekking activity taking place at or soon after dawn in spring.
- Known lek sites and other areas of suitable habitat which can host leks were identified and visited during April within 2 hours of dawn on calm dry days with good visibility;
- Visits involved listening and scanning for lekking Black Grouse from strategic VPs (avoiding disturbance of leks) and during walks between these VPs ensuring that all potential habitat was covered;
- The maximum count of males in the 2 hours around dawn gives the standard count estimate but the maximum number of females seen was also presented; and
- Leks that were at least 200m apart were treated as separate leks.

B5. Winter Walkover Survey

The aim is to formally record bird activity over large areas of ground relatively quickly during the non-breeding season. The method involves a series of shortened (1 hr) vantage point watches linked by a walk route designed to maximise coverage of the survey area. VPs other than those selected for observations of flight activity may be used. The recording of birds in woodland habitats in the non-breeding season will be included in these surveys.

Timing

- Surveys were undertaken three times during the non-breeding season; and
- Surveys were undertaken in conditions of good ground visibility (at least 3km) when the cloud base is higher than the most elevated ground being observed.

Field methods

- Walk routes will meander in order to closely examine as much ground as practicable;
- Routes linking the Vantage Points will vary between visits in order that coverage of the site is maximised over time;
- All water bodies will be scanned thoroughly. Other features of potential ornithological importance (e.g. mires, areas of scrub, woodland edge, hedgerows, etc.) will be closely approached;
- Emphasis will be given to recording birds of high nature conservation importance;
- One hour watches will be undertaken as part of walkover/scan surveys;
- During vantage point watches, data will be collected during timed watches using the standard method (see above); and
- During the walk route, observers will pause frequently to scan skylines for raptors and other birds. In the case of target species, the location and flight route (if applicable) of each individual will be mapped. For other species, an inventory of the numbers encountered during the walkover will be recorded together with observations of any notable concentrations or behaviour.

REFERENCES

Brown, A. F. & Shepherd, K. B. (1993) *A method for censusing upland breeding waders*. *Bird Study*, 40: 189-195.

Gilbert, G., Gibbons, D. W. & Evans, J. (1998) *Bird Monitoring Methods*. RSPB, Sandy.

Scottish Natural Heritage (2005 – revised December 2010) *Survey Methods for Use in Assessing the Impacts of Onshore Windfarms on Bird Communities*.

**Appendix 10.1 Annex C: Survey Effort and General Information
and Annex D: Survey Results**

ANNEX C: SURVEY EFFORT AND GENERAL INFORMATION

C1. Vantage Point Surveys

A series of vantage point (VP) surveys were undertaken following the methodology set out in Scottish Natural Heritage (SNH) Guidance (2010) but tailored to be more appropriate for a site of this small size, following consultation with SNH (see Annex B). The VP surveys set out to record the presence and activity of pre-defined Target Species and Secondary Species. The details of the VP watches undertaken are detailed below.

Table C.1 Details of generic VP watches

Date	VP	VP Start	VP Finish	VP Hours
25/03/2011	1	0630	0930	3
25/03/2011	1	0940	1240	3
06/04/2011	1	1400	1700	3
06/04/2011	1	1710	2010	3
15/04/2011	1	0945	1245	3
15/04/2011	1	1255	1555	3
27/04/2011	1	0930	1230	3
27/04/2011	1	1240	1540	3
04/05/2011	1	1455	1755	3
04/05/2011	1	1805	2105	3
20/05/2011	1	0515	0815	3
20/05/2011	1	0825	1125	3
14/06/2011	1	0825	1125	3
14/06/2011	1	1135	1435	3
04/07/2011	1	1500	1800	3
04/07/2011	1	1815	2115	3
12/08/2011	1	0610	0910	3
12/08/2011	1	0920	1220	3
05/09/2011	1	0630	0930	3
05/09/2011	1	0945	1245	3
20/10/2011	1	0900	1200	3
20/10/2011	1	1215	1515	3
28/10/2011	1	1130	1400	2.5
28/10/2011	1	1415	1645	2.5
06/12/2011	1	1230	1430	2
12/12/2011	1	1130	1430	3
21/12/2011	1	0945	1145	2
21/12/2011	1	1200	1400	2
06/01/2012	1	0955	1355	4
13/01/2012	1	0915	1115	2
13/01/2012	1	1125	1325	2

25/01/2012	1	1030	1230	2
19/03/2012	1	0840	1140	3
19/03/2012	1	1200	1500	3
30/04/2012	1	0630	0930	3
30/04/2012	1	0940	1240	3
28/05/2012	1	1430	1730	3
28/05/2012	1	1740	2040	3
27/06/2012	1	1000	1300	3
27/06/2012	1	1310	1610	3
20/07/2012	1	0440	0740	3
20/07/2012	1	0750	1050	3
13/08/2012	1	1440	1740	3
13/08/2012	1	1755	2055	3

Table C.3 Meteorological conditions recorded during generic VP watches (conditions per hour of survey)

Date	VP	Start	Finish	Survey Hour	Wind Speed	Wind Direction	Rain	Cloud Cover	Cloud Height	Visibility	Frost	Snow
25/03/2011	1	0630	0930	1	1	N/A	0	8	2	2	0	0
25/03/2011	1	0630	0930	2	1	N/A	0	7	2	2	0	0
25/03/2011	1	0630	0930	3	1	N/A	0	3	2	2	0	0
25/03/2011	1	0940	1240	1	2	S	0	1	2	2	0	0
25/03/2011	1	0940	1240	2	1	S	0	3	2	2	0	0
25/03/2011	1	0940	1240	3	3	S	0	7	2	2	0	0
06/04/2011	1	1400	1700	1	7	N	1	8	1	1	0	0
06/04/2011	1	1400	1700	2	6	N	0	8	1	2	0	0
06/04/2011	1	1400	1700	3	6	N	0	7	1	2	0	0
06/04/2011	1	1710	2010	1	7	NE	0	7	1	2	0	0
06/04/2011	1	1710	2010	2	6	NE	0	7	1	2	0	0
06/04/2011	1	1710	2010	3	7	NE	0	7	1	2	0	0
15/04/2011	1	0945	1245	1	2	E	0	7	2	2	0	0
15/04/2011	1	0945	1245	2	3	E	0	8	2	2	0	0
15/04/2011	1	0945	1245	3	3	E	0	8	2	2	0	0
15/04/2011	1	1255	1555	1	3	NE	0	8	2	2	0	0
15/04/2011	1	1255	1555	2	4	NE	0	6	2	2	0	0
15/04/2011	1	1255	1555	3	4	NE	0	6	2	2	0	0
27/04/2011	1	0930	1230	1	3	N	0	5	2	2	0	0
27/04/2011	1	0930	1230	2	2	N	0	3	2	2	0	0
27/04/2011	1	0930	1230	3	3	N	0	2	2	2	0	0
27/04/2011	1	1240	1540	1	2	N	0	1	2	2	0	0
27/04/2011	1	1240	1540	2	2	N	0	1	2	2	0	0
27/04/2011	1	1240	1540	3	2	N	0	1	2	2	0	0
04/05/2011	1	1455	1755	1	3	WNW	0	7	2	2	0	0
04/05/2011	1	1455	1755	2	4	NW	0	6	2	2	0	0

Date	VP	Start	Finish	Survey Hour	Wind Speed	Wind Direction	Rain	Cloud Cover	Cloud Height	Visibility	Frost	Snow
04/05/2011	1	1455	1755	3	3	WNW	0	4	2	2	0	0
04/05/2011	1	1805	2105	1	3	WNW	0	6	2	2	0	0
04/05/2011	1	1805	2105	2	3	WNW	0	6	2	2	0	0
04/05/2011	1	1805	2105	3	2	WNW	0	5	2	2	0	0
20/05/2011	1	0515	0815	1	6	NE	1	8	1	1	0	0
20/05/2011	1	0515	0815	2	6	NE	1	8	1	2	0	0
20/05/2011	1	0515	0815	3	5	NE	2	8	1	1	0	0
20/05/2011	1	0825	1125	1	3	NE	1	8	1	2	0	0
20/05/2011	1	0825	1125	2	3	NE	1	7	2	2	0	0
20/05/2011	1	0825	1125	3	2	NE	0	6	2	2	0	0
14/06/2011	1	0825	1125	1	2	E	0	3	2	2	0	0
14/06/2011	1	0825	1125	2	3	E	0	3	2	2	0	0
14/06/2011	1	0825	1125	3	2	E	0	4	2	2	0	0
14/06/2011	1	1135	1435	1	3	E	0	5	2	2	0	0
14/06/2011	1	1135	1435	2	3	E	0	4	2	2	0	0
14/06/2011	1	1135	1435	3	2	E	0	4	2	2	0	0
04/07/2011	1	1500	1800	1	3	NW	0	4	2	2	0	0
04/07/2011	1	1500	1800	2	2	NW	0	3	2	2	0	0
04/07/2011	1	1500	1800	3	2	NW	0	4	2	2	0	0
04/07/2011	1	1815	2115	1	3	NW	0	6	2	2	0	0
04/07/2011	1	1815	2115	2	2	NW	0	4	2	2	0	0
04/07/2011	1	1815	2115	3	2	NW	0	4	2	2	0	0
12/08/2011	1	0610	0910	1	1	S	1	8	0	0	0	0
12/08/2011	1	0610	0910	2	1	S	2	8	0	0	0	0
12/08/2011	1	0610	0910	3	1	S	2	8	0	0	0	0
12/08/2011	1	0920	1220	1	1	S	2	8	0	1	0	0
12/08/2011	1	0920	1220	2	1	S	2	8	0	0	0	0

Date	VP	Start	Finish	Survey Hour	Wind Speed	Wind Direction	Rain	Cloud Cover	Cloud Height	Visibility	Frost	Snow
12/08/2011	1	0920	1220	3	1	S	2	8	0	1	0	0
05/09/2011	1	0630	0930	1	0	0	0	0	0	2	0	0
05/09/2011	1	0630	0930	2	0	0	0	1	2	2	0	0
05/09/2011	1	0630	0930	3	1	W	0	2	2	2	0	0
05/09/2011	1	0945	1245	1	2	W	0	3	2	2	0	0
05/09/2011	1	0945	1245	2	3	W	0	3	2	2	0	0
05/09/2011	1	0945	1245	3	2	W	0	4	2	2	0	0
20/10/2011	1	0900	1200	1	2	NE	0	7	2	2	1	0
20/10/2011	1	0900	1200	2	3	NE	1	8	1	1	0	0
20/10/2011	1	0900	1200	3	3	NE	2	8	1	1	0	0
20/10/2011	1	1215	1515	1	4	NE	2	8	1	1	0	0
20/10/2011	1	1215	1515	2	3	NE	2	8	1	1	0	0
20/10/2011	1	1215	1515	3	4	NE	2	8	1	1	0	0
28/10/2011	1	1130	1400	1	5	N	0	7	2	2	0	0
28/10/2011	1	1130	1400	2	5	N	0	6	2	2	0	0
28/10/2011	1	1130	1400	3	5	N	0	6	2	2	0	0
28/10/2011	1	1415	1645	1	5	N	0	7	2	2	0	0
28/10/2011	1	1415	1645	2	5	N	0	7	2	2	0	0
06/12/2011	1	1230	1430	1	4	WNW	0	6	2	2	0	1
06/12/2011	1	1230	1430	2	4	WNW	0	8	1	1	0	1
12/12/2011	1	1130	1430	1	4	WSW	0	4	2	2	0	2
12/12/2011	1	1130	1430	2	5	WSW	0	7	2	2	0	2
12/12/2011	1	1130	1430	3	5	WSW	0	8	1	2	0	2
21/12/2011	1	0945	1145	1	3	E	1	8	0	0	0	0
21/12/2011	1	0945	1145	2	4	E	2	8	0	0	0	0
21/12/2011	1	1200	1400	1	4	E	2	8	0	0	0	0
21/12/2011	1	1200	1400	2	4	E	2	8	0	0	0	0

Date	VP	Start	Finish	Survey Hour	Wind Speed	Wind Direction	Rain	Cloud Cover	Cloud Height	Visibility	Frost	Snow
06/01/2012	1	0955	1355	1	5	SW	0	4	2	2	1	2
06/01/2012	1	0955	1355	2	5	SW	0	4	2	2	1	2
06/01/2012	1	0955	1355	3	3	SW	1	8	2	2	1	2
06/01/2012	1	0955	1355	4	3	SW	1	8	2	2	1	2
25/01/2012	1	1030	1230	1	7	S	1	8	2	2	0	0
25/01/2012	1	1030	1230	2	7	S	0	8	2	2	0	0
13/01/2012	1	0915	1115	1	0	0	0	2	2	2	1	1
13/01/2012	1	0915	1115	2	0	0	0	2	2	2	1	1
13/01/2012	1	1125	1325	1	0	0	0	2	2	2	1	1
13/01/2012	1	1125	1325	2	0	0	0	2	2	2	1	1
19/03/2012	1	0840	1140	1	5	N	0	8	2	2	0	0
19/03/2012	1	0840	1140	2	5	N	0	8	2	2	0	0
19/03/2012	1	0840	1140	3	5	N	0	8	2	2	0	0
19/03/2012	1	1200	1500	1	5	N	0	8	2	2	0	0
19/03/2012	1	1200	1500	2	5	N	0	8	2	2	0	0
19/03/2012	1	1200	1500	3	5	N	2	8	2	2	0	0
30/04/2012	1	0630	0930	1	5	S	1	8	1	1	0	0
30/04/2012	1	0630	0930	2	5	S	0	8	1	1	0	0
30/04/2012	1	0630	0930	3	5	S	0	8	1	1	0	0
30/04/2012	1	0940	1240	1	4	S	0	8	1	1	0	0
30/04/2012	1	0940	1240	2	4	S	0	8	2	2	0	0
30/04/2012	1	0940	1240	3	4	S	0	8	2	2	0	0
28/05/2012	1	1430	1730	1	3	NE	0	2	2	2	0	0
28/05/2012	1	1430	1730	2	5	NE	0	2	2	2	0	0
28/05/2012	1	1430	1730	3	5	NE	0	2	2	2	0	0
28/05/2012	1	1740	2040	1	5	NE	0	2	2	2	0	0
28/05/2012	1	1740	2040	2	5	NE	0	2	2	2	0	0

Date	VP	Start	Finish	Survey Hour	Wind Speed	Wind Direction	Rain	Cloud Cover	Cloud Height	Visibility	Frost	Snow
28/05/2012	1	1740	2040	3	5	NE	0	6	2	1	0	0
27/06/2012	1	1000	1300	1	2	NE	1	8	0	1	0	0
27/06/2012	1	1000	1300	2	1	0	1	8	0	1	0	0
27/06/2012	1	1000	1300	3	1	0	1	8	0	1	0	0
27/06/2012	1	1310	1610	1	0	0	0	8	0	2	0	0
27/06/2012	1	1310	1610	2	0	0	2	8	0	2	0	0
27/06/2012	1	1310	1610	3	0	0	3	8	0	1	0	0
20/07/2012	1	0440	0740	1	1	0	0	7	2	2	0	0
20/07/2012	1	0440	0740	2	1	0	0	7	2	2	0	0
20/07/2012	1	0440	0740	3	1	0	0	7	2	2	0	0
20/07/2012	1	0750	1050	1	1	0	0	7	2	2	0	0
20/07/2012	1	0750	1050	2	1	0	0	7	2	2	0	0
20/07/2012	1	0750	1050	3	1	0	0	7	2	2	0	0
13/08/2012	1	1440	1740	1	4	W	1	8	1	2	0	0
13/08/2012	1	1440	1740	2	4	W	0	8	1	2	0	0
13/08/2012	1	1440	1740	3	4	W	3	8	1	2	0	0
13/08/2012	1	1755	2055	1	4	W	3	8	1	2	0	0
13/08/2012	1	1755	2055	2	4	W	1	8	1	2	0	0
13/08/2012	1	1755	2055	3	4	W	0	8	2	2	0	0

Table C.4 Meteorological conditions recorded during raptor watches (conditions per hour of survey)

Day	Month	Year	Observer	Survey Start Time	Survey Finish Time	Hour	Wind speed	Wind direction	Rain	Cloud cover	Cloud height	Visibility	Frost	Snow
7	4	2011	LB	900	1600	1	4	SW	1	8	1	1	0	0
7	4	2011	LB	900	1600	2	4	SW	1	8	1	1	0	0
7	4	2011	LB	900	1600	3	4	SW	0	8	2	2	0	0
7	4	2011	LB	900	1600	4	4	SW	0	8	2	2	0	0
7	4	2011	LB	900	1600	5	4	SW	0	8	2	2	0	0
7	4	2011	LB	900	1600	6	4	SW	0	8	2	2	0	0
7	4	2011	LB	900	1600	7	4	SW	0	8	2	2	0	0
8	4	2011	LB	845	1600	1	2	SW	0	3	2	2	0	0
8	4	2011	LB	845	1600	2	2	SW	0	3	2	2	0	0
8	4	2011	LB	845	1600	3	2	SW	0	3	2	2	0	0
8	4	2011	LB	845	1600	4	2	SW	0	3	2	2	0	0
8	4	2011	LB	845	1600	5	2	SW	0	3	2	2	0	0
8	4	2011	LB	845	1600	6	2	SW	0	3	2	2	0	0
8	4	2011	LB	845	1600	7	2	SW	0	3	2	2	0	0
18	5	2011	LB	830	1445	Throughout	5	SW	3	7	2	2	0	0
27	6	2011	LB	1000	1700	Throughout	2	SSE	0	4	2	2	0	0
28	6	2011	LB	730	1330	Throughout	2	SSE	0	3	2	2	0	0
4	4	2012	KJ	900	1400	1	4	NE	0	3	2	2	2	1
4	4	2012	KJ	900	1400	2	4	NE	0	4	2	2	2	1
4	4	2012	KJ	900	1400	3	4	NE	0	5	2	2	2	1
4	4	2012	KJ	900	1400	4	4	NE	0	5	2	2	2	1
4	4	2012	KJ	900	1400	5	4	NE	0	5	2	2	2	1
18	5	2012	KJ/RW/RC	830	1330	Throughout	5	E	1	8	2	2	0	0
18	5	2012	KJ/RW/RC	830	1330	Throughout	5	E	1	8	2	2	0	0
29	6	2012	KJ/RW/RC	600	1200	1	3	NW	1	8	1	1	0	0

Day	Month	Year	Observer	Survey Start Time	Survey Finish Time	Hour	Wind speed	Wind direction	Rain	Cloud cover	Cloud height	Visibility	Frost	Snow
29	6	2012	KJ/RW/RC	600	1200	2	3	NW	2	8	1	1	0	0
29	6	2012	KJ/RW/RC	600	1200	3	3	NW	2	8	1	1	0	0
29	6	2012	KJ/RW/RC	600	1200	4	3	NW	2	8	1	1	0	0
29	6	2012	KJ/RW/RC	600	1200	5	3	NW	1	7	1	1	0	0
29	6	2012	KJ/RW/RC	600	1200	6	3	NW	1	8	1	1	0	0

Table C.5 Meteorological conditions recorded during black grouse surveys

Day	Month	Year	Observer	Survey Start Time	Survey Finish Time	Hour	Wind speed	Wind direction	Rain	Cloud cover	Cloud height	Visibility	Frost	Snow
4	4	2012	KJ	600	900	1	4	NE	0	3	2	2	2	1
4	4	2012	KJ	600	900	2	4	NE	0	4	2	2	2	1
4	4	2012	KJ	600	900	3	4	NE	0	5	2	2	2	1
27	4	2012	KJ	530	700	1	4	E	0	3	2	2	1	0
27	4	2012	KJ	530	700	2	4	E	0	3	2	2	1	0

Table C.6 Meteorological conditions recorded during breeding bird surveys

Date	Observer	Survey Start Time	Survey Finish Time	Wind Speed	Wind Direction	Rain	Cloud Cover	Cloud Height	Visibility	Frost	Snow
09/05/2011	LB	830	1530	3	SSE	0	7	2	2	0	0
03/07/2011	KJ	900	1500	2	NW	0	3	2	2	0	0
14/07/2011	LB	730	1420	2	SW	0	4	2	2	0	0
27/04/2012	KJ	700	1400	4	E	0	3	2	2	1	0
14/05/2012	ZS	800	1500	6	NW	0	6	2	2	0	0
04/06/2012	KJ	730	1430	4	SW	0	5	2	2	0	0
11/07/2012	KJ	730	1430	2	NE	0	5	2	2	0	0

Table C.7 Meteorological conditions recorded during winter walkover surveys

Date	Surveyor	Survey Start Time	Survey Finish Time	Hour	Wind	Wind Direction	Rain	Cloud Cover	Cloud Height	Visibility	Frost	Snow
06/12/2011	LB	900	1230	1	4	WNW	0	6	2	2	0	1
06/12/2011	LB	900	1230	2	4	WNW	0	6	2	2	0	1
06/12/2011	LB	900	1230	3	4	WNW	0	6	2	2	0	1
12/12/2011	LB	830	1130	1	4	WSW	0	3	2	2	0	2
12/12/2011	LB	830	1130	2	4	WSW	0	3	2	2	0	2
12/12/2011	LB	830	1130	3	4	WSW	0	3	2	2	0	2
23/12/2011	KJ	845	1500	All Day	5	E	2	6	2	2	0	0
06/01/2012	KJ	755	955	1	5	SW	0	4	2	2	1	2
06/01/2012	KJ	755	955	2	5	SW	1	8	2	2	1	2
25/01/2012	KJ	900	1300	1	8	S	0	8	2	2	0	0
25/01/2012	KJ	900	1300	2	7	S	1	8	2	2	0	0
25/01/2012	KJ	900	1300	3	7	S	1	8	2	2	0	0
25/01/2012	KJ	900	1300	4	7	S	0	8	2	2	0	0

In accordance with SNH Guidance (2010), target species are those which may be considered to be at risk from the potential effects of wind farms. For example, large raptors or wildfowl, whose typical behaviour may put them at risk of either collision with turbines, or being displaced by the presence of the turbines. Particular emphasis is placed upon those species which are afforded legislative protection or represent a qualifying interest of a protected site. The species considered Target Species and Secondary Species observed during the surveys are listed below.

List of Target Species

Black Grouse
Grey Goose spp.
Greylag Goose
Hen Harrier
Osprey
Red Kite

List of Secondary Species

Black-headed Gull	Kestrel
Buzzard	Red Grouse
Carrion Crow	Raven
Mallard	Curlew
Gull spp.	Mute Swan
Herring Gull	Snipe

ANNEX D: SURVEY RESULTS

D1a. Target Species Recorded During VP Watches

All flights of Target Species within the Site and the surrounding area were mapped and details of each flight recorded. Observations of Target Species were recorded on data sheets and maps. Information on species, time of observation, flight height (in bands), location, and the length of each observation was recorded. The details are given below. The buffer area referred to in the table refers to the Collision Risk Analysis Area (CRAA); which specifically is the final turbine development area encompassed by a 250m buffer to allow for observer error in flight line mapping (see Annex B for further details). All flight lines of Target Species are displayed in Figures 10.5 to 10.11.

Table D.1 Details of Target Species recorded during VP surveys

Date	VP	Observer	VP Start Time	VP Finish Time	Start Time	Spp Code	No. Of Birds	Duration (s)	Total bird second duration	< Buffer: Sec. <20m	< Buffer: Sec.20 to 125m	< Buffer: Sec. >125	> Buffer: Sec. <20m	> Buffer: Sec.20 to 125m	> Buffer: Sec. >125
06/04/2011	1	KJ	1710	2010	1841	GJ	2	45	90	0	50.4	0	0	39.6	0
15/04/2011	1	KJ	945	1245	946	GJ	2	20	40	27.6	0	0	12.4	0	0
27/04/2011	1	KJ	930	1230	937	GJ	2	65	130	0	41.6	0	0	88.4	0
04/05/2011	1	KJ	1455	1755	1527	OP	1	94	94	11.78	46.5	0	7.22	28.5	0
04/05/2011	1	KJ	1455	1755	1712	HH	1	76	76	27.59	40.05	0	3.41	4.95	0
04/05/2011	1	KJ	1805	2105	1811	GJ	3	34	102	6.48	48.6	0	5.52	41.4	0
04/05/2011	1	KJ	1805	2105	1908	GJ	4	22	88	52.8	0	0	35.2	0	0
14/06/2011	1	KJ	825	1125	1034	KT	2	110	220	0	0	0	220	0	0
14/06/2011	1	KJ	1135	1435	1219	KT	1	85	85	0	0	0	0	45	40
14/06/2011	1	KJ	1135	1435	1222	KT	1	38	38	0	0	0	0	0	38
05/09/2011	1	KJ	945	1245	1141	KT	2	125	250	0	0	0	0	250	0
20/10/2011	1	KJ	900	1200	909	GG	50	45	2250	0	0	0	0	0	2250

Date	VP	Observer	VP Start Time	VP Finish Time	Start Time	Spp Code	No. Of Birds	Duration (s)	Total bird second duration	< Buffer: Sec. <20m	< Buffer: Sec.20 to 125m	< Buffer: Sec. >125	> Buffer: Sec. <20m	> Buffer: Sec.20 to 125m	> Buffer: Sec. >125
06/01/2012	1	KJ	955	1355	1030	GJ	16	86	1376	0	192.64	0	0	1183.36	0
30/04/2012	1	KJ	940	1240	1118	GJ	2	38	76	0	62.32	0	0	13.68	0
28/05/2012	1	KJ	1430	1730	1634	OP	1	45	45	0	8.55	0	0	36.45	0
28/05/2012	1	KJ	1740	2040	1828	OP	1	20	20	0	0	0	0	0	20
28/05/2012	1	KJ	1740	2040	2016	OP	1	48	48	0	28.8	0	0	19.2	0
27/06/2012	1	KJ	1000	1300	1229	OP	1	12	12	0	7.08	0	0	4.92	0
27/06/2012	1	KJ	1000	1300	1331	OP	1	28	28	0	0	0	0	28	0
20/07/2012	1	KJ	440	740	652	OP	1	25	25	0	3.5	0	0	21.5	0
13/08/2012	1	KJ	1440	1740	1511	OP	1	25	25	0	12.25	0	0	12.75	0
13/08/2012	1	KJ	1440	1740	1556	OP	1	78	78	0	10.35	43.47	0	4.65	19.53
13/08/2012	1	KJ	1440	1740	1650	BK	5	5	25	25	0	0	0	0	0

Species codes used above:

- BK** Black grouse
- GJ** Greylag goose
- GG** Grey goose spp.
- HH** Hen harrier
- KT** Red kite
- OP** Osprey

D2. Secondary Species

Secondary Species were recorded to give an indication of the use of the Site by these species and to allow 5 minute activity summaries to be calculated. Details of the VP, species, minimum number present, the flight height (in bands: 1 = <20m, 2 = 20-125m, 3 = >125m; where several height bands were recorded or ambiguity existed the worst case scenario was adopted i.e. height band 2), and location in relation to the Site were all recorded (i.e. within the Site Boundary, within the 250m Site buffer area, or outside the buffer area). The data collected in the course of undertaking VP watches is provided below.

Table D.2 Details of Secondary Species recorded during VP surveys

Date	VP	Observer	VP Start Time	VP Finish Time	5 Min Rec block	Start Time	End Time	Spp Code	Min Number	Height	On Site	Buffer	Beyond
25/03/2011	1	KJ	630	930	630	630	635	CU	2	1		1	1
25/03/2011	1	KJ	630	930	710	710	715	BZ	1	2			1
25/03/2011	1	KJ	630	930	725	725	730	C.	2	1		1	
25/03/2011	1	KJ	630	930	730	730	735	C.	2	2	1	1	1
25/03/2011	1	KJ	630	930	730	730	735	C.	1	2	1	1	
25/03/2011	1	KJ	630	930	745	745	750	C.	1	2	1	1	
25/03/2011	1	KJ	630	930	815	815	820	RG	1	1	1		
25/03/2011	1	KJ	630	930	825	825	830	CU	1	2	1	1	1
25/03/2011	1	KJ	630	930	840	840	845	C.	2	1	1	1	
25/03/2011	1	KJ	630	930	850	850	855	C.	2	1	1	1	
25/03/2011	1	KJ	630	930	905	905	910	C.	2	1	1	1	
25/03/2011	1	KJ	630	930	910	910	915	C.	1	1	1	1	
25/03/2011	1	KJ	940	1240	1010	1010	1015	RG	1	1	1	1	
25/03/2011	1	KJ	940	1240	1040	1040	1045	BZ	1	1	1	1	
25/03/2011	1	KJ	940	1240	1155	1155	1200	BZ	1	3			1
25/03/2011	1	KJ	940	1240	1205	1205	1210	RN	1	1	1	1	
25/03/2011	1	KJ	940	1240	1215	1215	1220	BZ	1	3	1	1	
25/03/2011	1	KJ	940	1240	1220	1220	1225	CU	1	2	1	1	
06/04/2011	1	KJ	1400	1700	1420	1420	1425	CU	1	1			1

Date	VP	Observer	VP Start Time	VP Finish Time	5 Min Rec block	Start Time	End Time	Spp Code	Min Number	Height	On Site	Buffer	Beyond
06/04/2011	1	KJ	1400	1700	1435	1435	1440	CU	2	1			1
06/04/2011	1	KJ	1400	1700	1500	1500	1505	CU	1	1			1
06/04/2011	1	KJ	1710	2010	1745	1745	1750	CU	2	1			1
06/04/2011	1	KJ	1710	2010	1815	1815	1820	CU	3	1			1
15/04/2011	1	KJ	945	1245	945	945	950	CU	2	1	1	1	1
15/04/2011	1	KJ	945	1245	945	945	950	RG	1	1	1	1	
15/04/2011	1	KJ	945	1245	1000	1000	1005	MS	3	2	1	1	1
15/04/2011	1	KJ	945	1245	1100	1100	1105	CU	1	2		1	1
15/04/2011	1	KJ	945	1245	1115	1115	1120	CU	1	2	1	1	1
15/04/2011	1	KJ	1255	1555	1255	1255	1300	BZ	4	2		1	1
15/04/2011	1	KJ	1255	1555	1255	1255	1300	K.	1	1	1	1	1
15/04/2011	1	KJ	1255	1555	1335	1335	1340	C.	1	1	1	1	
27/04/2011	1	KJ	930	1230	945	945	950	CU	1	1	1	1	
27/04/2011	1	KJ	930	1230	950	950	955	BZ	1	3	1	1	
27/04/2011	1	KJ	930	1230	1010	1010	1015	BZ	1	3	1	1	
27/04/2011	1	KJ	930	1230	1020	1020	1025	CU	1	1	1	1	
27/04/2011	1	KJ	930	1230	1025	1025	1030	CU	1	1	1	1	
27/04/2011	1	KJ	930	1230	1045	1045	1050	CU	1	1	1	1	
27/04/2011	1	KJ	930	1230	1055	1055	1060	CU	1	1	1	1	
27/04/2011	1	KJ	930	1230	1115	1115	1120	CU	1	1	1	1	
27/04/2011	1	KJ	1240	1540	1240	1240	1245	CU	2	1	1	1	
27/04/2011	1	KJ	1240	1540	1300	1300	1305	CU	1	1	1	1	
27/04/2011	1	KJ	1240	1540	1340	1340	1345	CU	2	1	1	1	
27/04/2011	1	KJ	1240	1540	1420	1420	1425	CU	1	1	1	1	
04/05/2011	1	KJ	1455	1755	1455	1455	1500	BZ	1	3			1
04/05/2011	1	KJ	1455	1755	1455	1455	1500	C.	1	3			1

Date	VP	Observer	VP Start Time	VP Finish Time	5 Min Rec block	Start Time	End Time	Spp Code	Min Number	Height	On Site	Buffer	Beyond
04/05/2011	1	KJ	1455	1755	1545	1545	1550	BZ	3	2		1	1
04/05/2011	1	KJ	1455	1755	1610	1610	1615	HG	2	2	1	1	
04/05/2011	1	KJ	1455	1755	1620	1620	1625	CU	1	1	1		
04/05/2011	1	KJ	1805	2105	1815	1815	1820	CU	1	2	1	1	
04/05/2011	1	KJ	1805	2105	1920	1920	1925	RG	1	1	1	1	
20/05/2011	1	KJ	515	815	555	555	600	GULL	2	1	1	1	
20/05/2011	1	KJ	825	1125	825	825	830	SN	2	2	1		
20/05/2011	1	KJ	825	1125	840	840	845	RG	1	1	1		
20/05/2011	1	KJ	825	1125	905	905	910	CU	1	2	1		
20/05/2011	1	KJ	825	1125	935	935	940	MA	2	1	1		
14/06/2011	1	KJ	825	1125	835	835	840	C.	1	2	1		
14/06/2011	1	KJ	825	1125	900	900	905	CU	2	2	1	1	
14/06/2011	1	KJ	825	1125	920	920	925	GULL	2	2		1	1
14/06/2011	1	KJ	825	1125	1030	1030	1035	C.	5	1	1	1	
14/06/2011	1	KJ	825	1125	1120	1120	1125	GULL	1	1		1	
14/06/2011	1	KJ	1135	1435	1215	1215	1220	K.	1	3	1	1	
14/06/2011	1	KJ	1135	1435	1220	1220	1225	BZ	2	3	1	1	1
14/06/2011	1	KJ	1135	1435	1305	1305	1310	BZ	2	3		1	1
14/06/2011	1	KJ	1135	1435	1310	1310	1315	C.	1	2		1	1
14/06/2011	1	KJ	1135	1435	1405	1405	1410	C.	1	2		1	1
04/07/2011	1	KJ	1500	1800	1530	1530	1535	C.	2	2	1	1	
04/07/2011	1	KJ	1500	1800	1545	1545	1550	C.	1	2	1	1	
12/08/2011	1	KJ	610	910	755	755	800	C.	1	2	1		
12/08/2011	1	KJ	610	910	845	845	850	HG	1	2	1	1	
12/08/2011	1	KJ	920	1220	925	925	930	C.	1	2	1	1	
05/09/2011	1	KJ	630	930	810	810	815	RN	1	2	1	1	

Date	VP	Observer	VP Start Time	VP Finish Time	5 Min Rec block	Start Time	End Time	Spp Code	Min Number	Height	On Site	Buffer	Beyond
05/09/2011	1	KJ	630	930	920	920	925	RG	1	2	1	1	
05/09/2011	1	KJ	945	1245	1000	1000	1005	BZ	1	3		1	1
05/09/2011	1	KJ	945	1245	1220	1220	1225	K.	1	2	1	1	
20/10/2011	1	KJ	900	1200	900	900	905	RG	2	1	1	1	
20/10/2011	1	KJ	900	1200	905	905	910	RG	2	1	1	1	
20/10/2011	1	KJ	900	1200	950	950	955	RG	1	1	1	1	
20/10/2011	1	KJ	900	1200	1035	1035	1040	RG	1	1	1	1	
28/10/2011	1	KJ	1415	1645	1340	1340	1345	RN	2	2	1	1	1
28/10/2011	1	KJ	1415	1645	1420	1420	1425	RG	4	1	1		
06/12/2011	1	LB	1230	1430	1305	1305	1310	RN	1	2	1		
21/12/2011	1	KJ	945	1145	1010	1010	1015	RG	1	2	1	1	
21/12/2011	1	KJ	945	1145	1125	1125	1130	RG	1	1	1	1	
21/12/2011	1	KJ	1200	1400	1315	1315	1320	RG	1	1	1	1	
06/01/2012	1	KJ	955	1355	1010	1010	1015	RG	1	1	1	1	
06/01/2012	1	KJ	955	1355	1015	1015	1020	RG	1	1	1	1	
06/01/2012	1	KJ	955	1355	1205	1205	1210	RG	1	1	1	1	
06/01/2012	1	KJ	955	1355	1300	1300	1305	RG	1	1	1	1	
13/01/2012	1	KJ	915	1115	935	935	940	RG	1	1	1		
13/01/2012	1	KJ	915	1115	1015	1015	1020	RG	3	1	1		
13/01/2012	1	KJ	1125	1325	1105	1105	1110	RN	1	1	1	1	
19/03/2012	1	KJ	840	1140	940	940	945	RN	1	1	1	1	
30/04/2012	1	KJ	630	930	705	705	710	CU	1	1	1	1	1
30/04/2012	1	KJ	630	930	710	710	715	RG	1	1	1	1	1
30/04/2012	1	KJ	630	930	935	935	940	CU	1	1	1	1	1
28/05/2012	1	KJ	1430	1730	1500	1500	1505	BZ	2	2	1	1	
28/05/2012	1	KJ	1740	2040	1745	1745	1750	BH	2	2	1	1	

Date	VP	Observer	VP Start Time	VP Finish Time	5 Min Rec block	Start Time	End Time	Spp Code	Min Number	Height	On Site	Buffer	Beyond
28/05/2012	1	KJ	1740	2040	1750	1750	1755	CU	1	1			1
28/05/2012	1	KJ	1740	2040	1825	1825	1830	BH	1	2	1	1	
27/06/2012	1	KJ	1000	1300	1030	1030	1035	CU	1	2	1		
27/06/2012	1	KJ	1000	1300	1055	1055	1100	CU	1	2	1		
27/06/2012	1	KJ	1000	1300	1125	1125	1130	SN	1	1	1		
20/07/2012	1	KJ	750	1050	750	750	755	HG	1	2	1	1	
13/08/2012	1	KJ	1440	1740	1645	1645	1650	RN	1	1	1	1	

Species codes as used in Annex D2 above:

BTO Code	Species
BH	Black-headed gull
BZ	Buzzard
C.	Carrion crow
CU	Curlew
GULL	Unidentifiable gull species
HG	Herring gull
K.	Kestrel
MA	Mallard
MS	Mute swan
RG	Red grouse
RN	Raven
SN	Snipe

D3. Upland Breeding Bird Survey

Upland breeding bird surveys were undertaken following the methodology described by Brown & Shepherd (1993). Three surveys were carried out during 2011, (9th May and 3rd, 14th July), and four surveys were undertaken in 2012 (27th April, 14th May, 4th June and 12th July);

Table D.3 Moorland Breeding Bird Survey results by species (number of pairs) 2011

Species	Estimated number of breeding pairs (derived from final map)
Curlew	3
Snipe	1
Red grouse	1

Table D.3 Moorland Breeding Bird Survey results by species (number of pairs) 2012

Species	Estimated number of breeding pairs (derived from final map)
Curlew	5
Red grouse	4

Territories were plotted according to Brown & Shepherd (1993) and are detailed within Figures 10.12 and 10.13.

D4. Winter walkover

A series of winter walkover surveys were conducted on the 6th and 12th December 2011 (visit 1), 23rd December 2011 (visit 2) and 6th and 25th January 2012 (visit 3). The numbers of each species seen are presented below.

Table D.4 Results of winter walk over surveys 2011 - 2012

Visit 1		Visit 2		Visit 3	
Species	No.	Species	No.	Species	No.
Carrion Crow	2	Greylag Goose	25	Black Grouse	2
Linnet	3	Linnet	20	Grey Heron	1
Pied Wagtail	2	Red Grouse	7	Red Grouse	7
Raven	3				
Red Grouse	3				
Woodcock	4				

D5. Raptor Survey

During 2011 three monthly visits were undertaken (8th April, 18th May and 27th/28th June). No nests were located. Buzzard, Kestrel and Sparrowhawk were recorded during the surveys inside the 2km buffer (Figure 10.14)

During 2012 three monthly visits were undertaken (4th April, 18th May, and 29th June). Records were made of Hen harrier, Osprey, Peregrine, Buzzard and Kestrel within the 2km survey buffer (Figure 10.15). Only Buzzard was considered breeding within the survey area, the other species are likely to be breeding in the wider area. Osprey were observed carrying fish on one occasion in the vicinity of Carron Valley Reservoir and Loch Walton.

D6. Black Grouse Survey

During 2012, two black grouse visits were undertaken (4th April and 27th April). On the 4th of April, a lek with 4 males was located in the north east of the Site (Figure 10.16).

D7. Bird Species Index

A total of 37 bird species were recorded at, or adjacent, to the Site during the undertaking of various ornithological surveys. The table below comprises a list of all these species.

Table D.5 Bird species recorded at Craigton and Spittalhill (25/03/2011 – 13/08/2012)

Black grouse	Mallard
Black-headed gull	Meadow pipit
Buzzard	Mute swan
Carrion crow	Osprey
Curlew	Oystercatcher
Dipper	Peregrine falcon
Grasshopper Warbler	Pied wagtail
Great black-backed gull	Raven
Greylag goose	Red grouse
Grey goose species	Red kite
Gull species	Skylark
Hen harrier	Snipe
Herring gull	Sparrowhawk
Heron	Stock Dove
House martin	Swallow
Kestrel	Wheatear
Lapwing	Woodcock
Lesser black-backed gull	Wren
Linnet	

Appendix 10.1 Annex E: Collision Risk Assessment

ANNEX E: COLLISION RISK ASSESSMENTS

Table E1 presents the parameters which apply to each Collision Risk Model (CRM)

Table E1

WIND FARM PARAMETERS		
Size of wind farm envelope	96.27	hectares
Number of turbines	7	turbines
Rotor diameter	90	metres
Hub height	80	metres
Max. rotor depth	1.9	metres
Max. chord	3.5	metres
Pitch	15	degrees
Rotation period	4.03	seconds
Turbine operation time	87%	%

Outputs for the CRM for the following species are presented in the following order below:

- Greylag goose; and
- Osprey.

E2 Greylag goose

Table E2.1

BIRD PARAMETERS		
Length (l)	0.825	metres
Wingspan	1.64	metres
Assumed flight speed (v)	18	ms ¹
Number of days birds potentially present (1 st Oct-15 th May)	227	per year
Number of hours birds potentially present	10.241	per day
Avoidance rate	99.8%	%
Non-avoidance rate	0.2%	%
Risk height Highest	125	metres
Risk height Lowest	35	metres

Table E2.2

WATCH DATA		
VP	Area (ha)	Time (hrs)
1	93.61	72.00
Totals	93.61	72.00

* These relate to surveys conducted during goose period (taken as 1st October to 15th May)

Table E2.3

BIRD FLIGHT DATA	
VP	Seconds at Risk Ht.
1	395.56

Table E2.4

FLIGHT ACTIVITY PER UNIT TIME & AREA			
VP	Observation Effort (HaHr)	Flying Time at Risk Height (Hahr ⁻¹)	
1	6739.92	0.00001630	
			%
Totals	6739.92	0.00001630	0.156944%
			0.156944%
Mean Activity hr⁻¹ in wind farm			
	Risk height		0.156944%
	Rotor height		0.156944%

Tale E2.5

Weighted flying time ha ⁻¹ hr ⁻¹			
VP	Weighting	Flying time at Risk Height (Hahr ⁻¹)	
1	1.000	0.156944%	
Totals	1.000	0.156944%	
Mean Activity hr⁻¹ in wind farm			
			%
	Risk height	0.156944%	0.156944%
	Rotor height	0.156944%	0.156944%

Table E2.6

OUTPUT FROM COLLISION MODEL	
% Transits to Collide	8.67%
% Transits to Collide * correction for ops	7.54457%

Table E2.7

MORTALITY ESTIMATE (UNWEIGHTED)		
Flight risk volum (Vw)	86643000.0	m ³
Rotor radius ²	2025.0	m ²
Combined Rotor Swept Volume (Vr)	44532.08	m ³
Total Combined Rotor Swept Volume (Vr*(d+l))	121349.91	m ³
Bird occupancy (n)	3.65	hrs/yr
Bird occupancy of rotor swept volume (b)	18.40	bird-sec
Bird transit time (t)	0.151	secs
No. of transits through rotors	121.515	per year
Estimated collisions (m)	10.5377	per year
Estimated collisions after correction for operation(m ^o)	9.1678	per year
Estimated collisions after avoidance factor (m*)	0.0183	per year
Equivalent to 1 bird every	54.539	Years
Number of predicted collisions over 25 years	0.458	Collisions

Table E2.8

MORTALITY ESTIMATE (WEIGHTED)		
Flight risk volum (Vw)	86643000	m ³
Rotor radius ²	2025	m ²
Combined Rotor Swept Volume (Vr)	44532.076	m ³
Vr*(d+l)	121349.907	m ³
Bird occupancy	3.648	hrs/yr
Bird occupancy of rotor swept volume (b)	18.396	bird-sec
Bird transit time	0.151	secs
No. of transits through rotors	121.515	per year
Estimated collisions (m)	10.538	per year
Estimated collisions after correction for operation (m ^o)	9.168	per year
Estimated collisions after avoidance factor (m*)	0.018	per year
Equivalent to 1 bird every	54.539	Years
Number of predicted collisions over 25 years	0.458	Collisions

Table E2.9, Stage 2

K: [1D or [3D] (0 or 1)		Calculation of alpha and p(collision) as a function of radius										
NoBlades		Upwind:					Downwind:					
MaxChord		r/R	c/C	α	collide	contribution	collide	contribution	collide	contribution		
Pitch (degrees)		radius	chord	alpha	length	p(collision)	length	p(collision)	length	p(collision)		
						from radius r				from radius r		
BirdLength	1	0.825	m	0.025	0.575	10.26	37.30	1.00	0.00125	36.26	1.00	0.00125
Wingspan	3	1.64	m	0.075	0.575	3.42	12.78	0.53	0.00396	11.74	0.49	0.00364
F: Flapping (0) or gliding (+1)	0			0.125	0.702	2.05	8.87	0.37	0.00458	7.60	0.31	0.00393
				0.175	0.860	1.47	7.45	0.31	0.00539	5.89	0.24	0.00426
Bird speed	18	m/sec	0.225	0.994	1.14	6.60	0.27	0.00615	4.80	0.20	0.00447	
RotorDiam	90	m	0.275	0.947	0.93	5.37	0.22	0.00611	3.66	0.15	0.00416	
RotationPeriod	4.03	sec	0.325	0.899	0.79	4.51	0.19	0.00606	2.88	0.12	0.00387	
			0.375	0.851	0.68	3.86	0.16	0.00599	2.32	0.10	0.00360	
			0.425	0.804	0.60	3.36	0.14	0.00590	1.90	0.08	0.00334	
			0.475	0.756	0.54	2.95	0.12	0.00580	1.58	0.07	0.00311	
Bird aspect ratio: β	0.50		0.525	0.708	0.49	2.64	0.11	0.00572	1.35	0.06	0.00294	
			0.575	0.660	0.45	2.42	0.10	0.00575	1.22	0.05	0.00291	
			0.625	0.613	0.41	2.23	0.09	0.00577	1.12	0.05	0.00290	
			0.675	0.565	0.38	2.06	0.09	0.00576	1.04	0.04	0.00290	
			0.725	0.517	0.35	1.91	0.08	0.00573	0.98	0.04	0.00292	
			0.775	0.470	0.33	1.78	0.07	0.00569	0.93	0.04	0.00297	
			0.825	0.422	0.31	1.65	0.07	0.00563	0.89	0.04	0.00302	
			0.875	0.374	0.29	1.54	0.06	0.00555	0.86	0.04	0.00310	
			0.925	0.327	0.28	1.43	0.06	0.00546	0.84	0.03	0.00320	
			0.975	0.279	0.26	1.33	0.05	0.00535	0.83	0.03	0.00334	
Overall p(collision) =					Upwind	10.8%	Downwind	6.6%				
					Average	8.7%						

E3. Osprey

Table E3.1

BIRD PARAMETERS		
Length (l)	0.57	metres
Wingspan	1.575	metres
Assumed flight speed (v)	13.3	ms ¹
Number of days birds potentially present	168	per year
Number of hours birds potentially present	15.78	per day
Avoidance rate	98%	%
Non-avoidance rate	2%	%
Risk height Highest	125	metres
Risk height Lowest	35	metres

Table E3.2

WATCH DATA		
VP	Area (ha)	Time (hrs)
1	93.61	90.00
Totals	93.61	90.00

Table E3.3

BIRD FLIGHT DATA	
VP	Seconds at Risk Ht.
1	117.03

Table E3.4

FLIGHT ACTIVITY PER UNIT TIME & AREA			
VP	Observation Effort (HaHr)	Flying Time at Risk Height (Hahr ⁻¹)	
1	8424.9	0.00000386	
			%
Totals	8424.9	3.8586E-06	0.037147%
			0.037147%
Mean Activity hr⁻¹ in wind farm			
	Risk height	0.000371	
	Rotor height	0.000371	

Tale E3.5

Weighted flying time ha ⁻¹ hr ⁻¹			
VP	Weighting	Flying time at Risk Height (Hahr ⁻¹)	
1	1.000	0.00000386	
Totals	1.000	0.000	
Mean Activity hr⁻¹ in wind farm			
			%
	Risk height	0.000371468	0.037147%
	Rotor height	0.000371468	0.037147%

Table E3.6

OUTPUT FROM COLLISION MODEL	
% Transits to Collide	8.59%
% Transits to Collide * correction for ops	7.30430%

Table E3.7

MORTALITY ESTIMATE (UNWEIGHTED)		
Flight risk volum (Vw)	86643000.00	m ³
Rotor radius ²	2025.00	m ²
Combined Rotor Swept Volume (Vr)	44532.08	m ³
Total Combined Rotor Swept Volume (Vr*(d+l))	109994.23	m ³
Bird occupancy (n)	0.985	hrs/yr
Bird occupancy of rotor swept volume (b)	4.501	bird-sec
Bird transit time (t)	0.186	secs
No. of transits through rotors	24.234	per year
Estimated collisions (m)	2.083	per year
Estimated collisions after correction for operation(m ^o)	1.770	per year
Estimated collisions after avoidance factor (m*)	0.035	per year
Equivalent to 1 bird every	28.246	Years
Number of predicted collisions over 25 years	0.885	Collisions

Table E3.8

MORTALITY ESTIMATE (WEIGHTED)		
Flight risk volum (Vw)	86643000	m ³
Rotor radius ²	2025	m ²
Combined Rotor Swept Volume (Vr)	44532.076	m ³
Vr*(d+l)	109994.227	m ³
Bird occupancy	0.985	hrs/yr
Bird occupancy of rotor swept volume (b)	4.501	bird-sec
Bird transit time	0.186	secs
No. of transits through rotors	24.234	per year
Estimated collisions (m)	2.083	per year
Estimated collisions after correction for operation (m ^o)	1.770	per year
Estimated collisions after avoidance factor (m*)	0.035	per year
Equivalent to 1 bird every	28.246	Years
Number of predicted collisions over 25 years	0.885	Collisions

Table E3.9, Stage 2

K: [1D or [3D] (0 or 1)		Calculation of alpha and p(collision) as a function of radius									
NoBlades		Upwind:					Downwind:				
MaxChord		r/R	c/C	α	collide	contribution	collide	contribution	collide	contribution	
Pitch (degrees)		radius	chord	alpha	length	p(collision)	length	p(collision)	length	p(collision)	
							from radius r			from radius r	
BirdLength	0.57	m	0.025	0.575	7.58	27.20	1.00	0.00125	26.16	1.00	0.00125
Wingspan	1.575	m	0.075	0.575	2.53	9.42	0.53	0.00395	8.37	0.47	0.00352
F: Flapping (0) or gliding (+1)	0		0.125	0.702	1.52	6.62	0.37	0.00463	5.35	0.30	0.00374
			0.175	0.860	1.08	5.64	0.32	0.00552	4.08	0.23	0.00399
Bird speed	13.3	m/sec	0.225	0.994	0.84	5.06	0.28	0.00637	3.26	0.18	0.00410
RotorDiam	90	m	0.275	0.947	0.69	4.15	0.23	0.00639	2.43	0.14	0.00375
RotationPeriod	4.03	sec	0.325	0.899	0.58	3.51	0.20	0.00638	1.88	0.11	0.00341
			0.375	0.851	0.51	3.02	0.17	0.00634	1.48	0.08	0.00311
			0.425	0.804	0.45	2.64	0.15	0.00629	1.19	0.07	0.00282
			0.475	0.756	0.40	2.33	0.13	0.00620	0.96	0.05	0.00256
Bird aspect ratio: β	0.36		0.525	0.708	0.36	2.08	0.12	0.00610	0.79	0.04	0.00233
			0.575	0.660	0.33	1.90	0.11	0.00613	0.71	0.04	0.00228
			0.625	0.613	0.30	1.75	0.10	0.00613	0.64	0.04	0.00225
			0.675	0.565	0.28	1.62	0.09	0.00611	0.59	0.03	0.00225
			0.725	0.517	0.26	1.50	0.08	0.00607	0.58	0.03	0.00236
			0.775	0.470	0.24	1.38	0.08	0.00600	0.61	0.03	0.00263
			0.825	0.422	0.23	1.28	0.07	0.00591	0.62	0.03	0.00288
			0.875	0.374	0.22	1.18	0.07	0.00579	0.63	0.04	0.00311
			0.925	0.327	0.20	1.09	0.06	0.00565	0.64	0.04	0.00331
			0.975	0.279	0.19	1.01	0.06	0.00549	0.64	0.04	0.00349
Overall p(collision) =					Upwind	11.3%			Downwind	5.9%	
					Average	8.6%					

Appendix 11.1: Lists of Cultural Heritage Assets

Appendix 11.1: Lists of Cultural Heritage Assets

Table A11.1: Gazetteer of undesignated cultural heritage assets mentioned in the text

CgMs Reference	S&CSMR Reference	Brief Description
CH1	3072 & 3065	A group recorded on the S&CSMR and NMRS consisting of: a head dyke, two sheepfolds, one of which is attached to the head dyke, and five enclosures, three of which are attached to one of the sheepfolds, and depicted on the First Edition OS 6 inch map of 1864. Recorded in the NMRS as NS68NE15. In the same approximate location as Roy's 'Newfield'. A building within the inner study area is not shown on first edition Ordnance Survey mapping (1864) or subsequent editions (1922 & 1952) nor is it identifiable on historic or modern aerial photographs. It appears on Ordnance Survey mapping in 1978 and may be a modern feature.
CH2	3761, 5546 & 5547	The tumbled remains of a sheep shelter (3761) at the base of the east slope of a knoll, on a relict river terrace above the Endrick Water. The shelter comprises a drystone wall, 0.5m wide and surviving up to 0.5m high with tumbled stone present to either side. Adjacent area of rig and furrow (5546) noted during field survey by SUAT in 2006. The area measured 50m northwest-south east and 21.5m southwest-northeast, with prominent furrows an average of 1m deep and 0.2m wide running in parallel 5m apart. Also a dyke a short distance to the north (5547).
CH3	N/A	Drystone wall running along the north-west bank of an unnamed tributary of the Backside Burn. Around 400m long, 0.5m wide and up to 0.5m high. Follows a sinuous course that ends at a small waterfall and cliff-face in the south-west and peters out to the north-east. Three possible twinning pens were noted, each measuring approximately 2x1m and adjoining the wall to the north-west. None of the features are shown on mapping.
CH4	4111	Amorphous remains of a possible hut circle, consisting of a small curved section of an earth and stone bank 0.3m high by 10m long, with a probable diameter of about 11m.
CH5	4540	Vague traces of a hut circle, 9m in diameter, visible on the top of a slight knoll. The bank attains a maximum height of 0.3m in places.
CH6	4544	The remains of a hut circle measuring about 6m in diameter with a wall spread up to 2m thick and the turf-covered walls up to 0.3m high.

CgMs Reference	S&CSMR Reference	Brief Description
CH7	4541	By 1965 only slight traces of a bank, 0.2m high, and 5m long, survived of this hut circle which was described by RCAHMS in 1952. During construction of the Earlsburn Wind Farm it was tested by excavation but results inconclusive as to whether the feature was natural or archaeological (NMRS NS68 NE5; Earlsburn Wind Farm Site 23).
CH8	1921	Post-medieval settlement and agricultural remains at Burnfoot. Mapped on first edition Ordnance Survey (1864)
CH9	3134	Post-medieval settlement at Backside. Noted as ruinous on first edition Ordnance Survey (1864).
CH10	3754	Post-medieval settlement at Cringate. Mapped on first edition Ordnance Survey (1864)
CH11	4052	Stock enclosure.
CH12	3793	Shieling hut.
CH13	4542	Shieling hut.
CH14	-	Circular enclosure recorded on site walkover.
CH15	-	Group of enclosures recorded on site walkover.
Ch16	-	Unmapped stretch of drystone dyke recorded on site walkover

Table A11.2: Scheduled Monuments in the Middle Study Area

AM	NAME	LINK
608	Double Craigs, hut circle	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2300:35:::::P35_SELECTED_MONUMENT:00608
701	Endrick Water, low bridge 1830m ESE of Fintry	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2300:35:::::P35_SELECTED_MONUMENT:00701
2229	Fintry, motte 400m WSW of Fintry Bridge	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2300:35:::::P35_SELECTED_MONUMENT:02229
2492	Todholes, cairn 1000m NNE of	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2300:35:::::P35_SELECTED_MONUMENT:02492
2547	Brokencastle, dun 600m NE of Dasher	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2300:35:::::P35_SELECTED_MONUMENT:02547

AM	NAME	LINK
2556	Craigton, dun 460m N of	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2300:35:::::P35_SELECTED_MONUMENT:02556
2561	Keir Knowe, motte 460m W of Easter Glinns	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2300:35:::::P35_SELECTED_MONUMENT:02561
2575	Dunmore, fort	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2300:35:::::P35_SELECTED_MONUMENT:02575
2696	Knochraich, standi ng stone 340m NW of	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2300:35:::::P35_SELECTED_MONUMENT:02696
2719	Waterhead, two standing stones 800m ENE of	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2300:35:::::P35_SELECTED_MONUMENT:02719
3394	Harvieston, desert ed village E of	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2300:35:::::P35_SELECTED_MONUMENT:03394
4278	Sir John de Graham's Castle	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2300:35:::::P35_SELECTED_MONUMENT:04278
4491	Todholes, cairn 1300m NNW of	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2300:35:::::P35_SELECTED_MONUMENT:04491
5681	Dunbeg, fort 700m W of Fintry Bridge	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2300:35:::::P35_SELECTED_MONUMENT:05681
7005	Stronend, cairn at summit, Gargunnock Hills	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2300:35:::::P35_SELECTED_MONUMENT:07005
7010	Carleatheran, cairn at summit, Gargunnock Hills	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2300:35:::::P35_SELECTED_MONUMENT:07010
7030	Stronend, cairn 300m SSW of summit, Gargunnock Hills	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2300:35:::::P35_SELECTED_MONUMENT:07030
7085	Fintry Castle, remains of	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2300:35:::::P35_SELECTED_MONUMENT:07085
7009	Dasher, fort 600m ENE of	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2300:35:::::P35_SELECTED_MONUMENT:07009

Table A11.3: Listed Buildings within Middle Study Area

HBNUM	ADDRESS	CATEGORY	LB_DOC
8191	GRIBLOCH HOUSE AND SWIMMING POOL	A	http://hsewsf.sedsh.gov.uk/hslive/portal.hsstart?P_HBNUM=8191
8191	GRIBLOCH HOUSE AND SWIMMING POOL	A	http://hsewsf.sedsh.gov.uk/hslive/portal.hsstart?P_HBNUM=8191
10467	CULCREUCH CASTLE	A	http://hsewsf.sedsh.gov.uk/hslive/portal.hsstart?P_HBNUM=10467
4203	MAINS OF GLINN	B	http://hsewsf.sedsh.gov.uk/hslive/portal.hsstart?P_HBNUM=4203
8155	WRIGHTPARK	B	http://hsewsf.sedsh.gov.uk/hslive/portal.hsstart?P_HBNUM=8155
8192	GRIBLOCH HOUSE GARAGE AND STAFF ACCOMMODATION	B	http://hsewsf.sedsh.gov.uk/hslive/portal.hsstart?P_HBNUM=8192
8193	GRIBLOCH HOUSE LODGE	B	http://hsewsf.sedsh.gov.uk/hslive/portal.hsstart?P_HBNUM=8193
10444	AULDHALL	B	http://hsewsf.sedsh.gov.uk/hslive/portal.hsstart?P_HBNUM=10444
10465	PARISH CHURCH	B	http://hsewsf.sedsh.gov.uk/hslive/portal.hsstart?P_HBNUM=10465
10466	OLD MANSE (DUNMORE COTTAGE)	B	http://hsewsf.sedsh.gov.uk/hslive/portal.hsstart?P_HBNUM=10466
10468	FINTRY BRIDGE	B	http://hsewsf.sedsh.gov.uk/hslive/portal.hsstart?P_HBNUM=10468
10469	LOW BRIDGE OF GONACHAN	B	http://hsewsf.sedsh.gov.uk/hslive/portal.hsstart?P_HBNUM=10469
12513	FINTRY, MAIN STREET, K6 TELEPHONE KIOSK	B	http://hsewsf.sedsh.gov.uk/hslive/portal.hsstart?P_HBNUM=12513
8156	BAILIE BOWS BRIDGE	C	http://hsewsf.sedsh.gov.uk/hslive/portal.hsstart?P_HBNUM=8156
8175	MRS BUCHANAN MAIN STREET (NORTH SIDE)	C	http://hsewsf.sedsh.gov.uk/hslive/portal.hsstart?P_HBNUM=8175
12514	KIPPEN, MAIN STREET, POST OFFICE AND GROCER WITH PILLAR BOX AND BUCHANAN HOUSE	C	http://hsewsf.sedsh.gov.uk/hslive/portal.hsstart?P_HBNUM=12514

HBNUM	ADDRESS	CATEGORY	LB_DOC
45586	GLENTIRRANMUIR, BOCHASTLE AND GLENTIRRAN COTTAGES	C	http://hsewsf.sedsh.gov.uk/hslive/portal.hsstart?P_HBNUM=45586
45586	GLENTIRRANMUIR, BOCHASTLE AND GLENTIRRAN COTTAGES	C	http://hsewsf.sedsh.gov.uk/hslive/portal.hsstart?P_HBNUM=45586
49005	TO SOUTH WEST OF BALAFARK, BRIDGE OVER LERNOCK BURN AT NS 6102 8999	C	http://hsewsf.sedsh.gov.uk/hslive/portal.hsstart?P_HBNUM=49005

Table A11.4: Inventory Gardens & Designed Landscapes in the Outer Study Area

Site Name	Link
CARDROSS HOUSE	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2400:15:0::::GARDEN:GDL00086
GARGUNNOCK HOUSE	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2400:15:0::::GARDEN:GDL00188
TOUCH	http://data.historic-scotland.gov.uk/pls/htmldb/f?p=2400:15:0::::GARDEN:GDL00377

Appendix 11.2: Aerial Photographs

Appendix 11.2: Aerial Photographs

Table A11.5: Aerial Photographs inspected

Sortie	Frames	Date
106G/UK/0085	4430-4422, 3423-3431, 3255-3245, 4081-4089	1946
B.0072	3071-3079	1946
B.0422	0135-0143	1956
B.0460	0112-0120	1959
B.0626	0101-0109	1954
B.0454	0144-0152	1958

Appendix 12.1: Site Access Route Review

Force 9 Energy

Craigton and Spittalhill Wind Farm

Appendix 12.1 Site Access Route Review

July 2011

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Appendix A: Site Access Route
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1 INTRODUCTION

1.1 Background

In April 2011 Grontmij were commissioned by Force 9 Energy to provide a high level review on the viability of site access routes, via the public highway corridor and private land, to a proposed wind farm development site at Craigton / Spittalhill, near Earlsburn, Stirling.

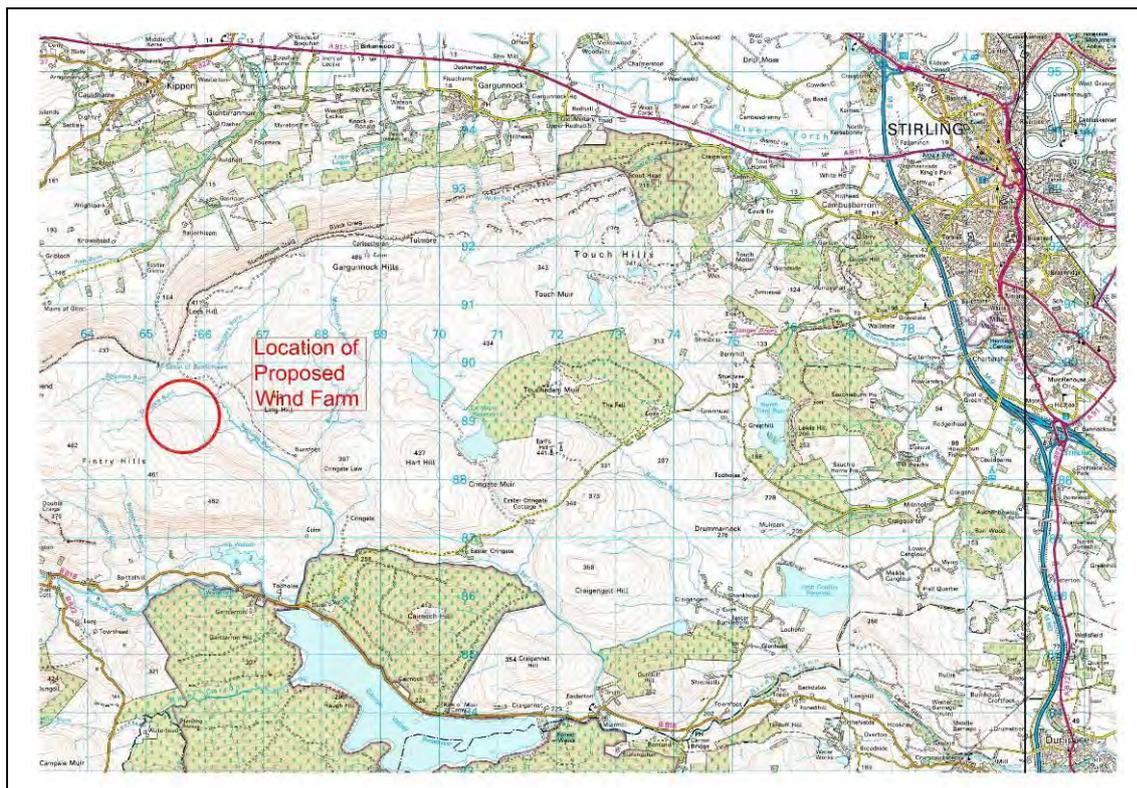
The findings of this report will be used to outline the key constraints, any areas where significant engineering works may be required and recommendations for future works for each of the identified routes.

1.2 Site Location

The proposed development site is located near the Carron Reservoir on the B818 road between Carron Bridge and Fintry, Stirling. The site is approximately 14km South West of Stirling, Scotland. **Figure 1.1** illustrates the site location.

The National Grid Reference for the site centre is approximately 264850E, 689500N.

Figure 1.1 Site Location



1.3 Client Supplied Information

The following information was supplied by the client to assist with the required access study:

- Identified route (labelled 'Route 1' in this report).
- Land Ownership Plan
- Wind Turbine Selection (quoted as Nordex N80/2500 – 40m turbine blade)

2 ROUTE REVIEW METHODOLOGY

2.1 Introduction

This chapter describes the methods and concepts used when examining the potential access routes to the boundary of the proposed wind farm site. The impact on the immediate surrounding environment (i.e. public highway corridor or adjacent land) was considered when reviewing the access route. It should be noted that this is a 'high level' report and it is recommended that where there is a likely requirement for additional works a topographical survey, or drive through by an experienced haulage contractor is undertaken to enable a more detailed review.

The Grontmij brief included the following work items, all of which will be addressed in this report:

- Examine site access route as identified by client and identify constraints along this route.
- Examine proposed access to site from the existing tracks serving the Earlsburn Wind Farm.

2.2 Methodology

The strategic route review involved a detailed site visit along the client identified delivery route in order to identify the geometric and topographical constraints that would impact on the manoeuvring of the turbine delivery vehicles. A further review was also completed to examine access to the proposed turbine locations across the open hillside via the existing access tracks constructed for the established Earlsburn Wind Farm. The routes are shown on drawing **106008/CGT/001** and in more detail on drawings **106008/CGT/002-009**.

2.3 Abnormal Loads and Construction Access

Wind turbine components are considered to be abnormal loads due to their size, weight and vehicle movement geometry. These loads are typically transported on specialist delivery vehicles by specialist delivery contractors. In Grontmij's experience the wind turbine blades typically prove to be the most onerous with regard to horizontal geometry and as such Grontmij have used this component when running swept path analysis models. On this basis the vehicle swept path analysis was completed using the following modelled vehicles:

- Typical delivery vehicle transporting a 40m long turbine blade.

It is recognised that actual delivery vehicles used by the appointed turbine component haulage contractor may vary from the modelled vehicles. Recommendation is therefore given that further modelling is undertaken by the haulage contractor upon appointment.

Where there is insufficient space, within the public road corridor and the modelled turbine blade delivery vehicle requires additional land take it is noted that further discussion may be required with 3rd party landowners.

The brief excluded modelling of the any construction plant however from our experience it is recognised that the turbine blade delivery is the most challenging, in terms of vehicle swept path analysis. In this instance no modelling of any construction plant has been undertaken.

The effect on public utilities and any required discussions were outwith the scope of this report. However where it is apparent (i.e. where overhead cables were visually noted present at the identified 'pinch' points) comments have been expanded to include likely works.

In order to minimise disruption to the road network the Highways Agency recommend that, where possible, abnormal loads are directed from the nearest suitable port facility. Presently no indication has been given on the receiving port. Given this the point of origin for the route review commences from the Bannockburn Junction on the M9 motorway. This has been acknowledged by the client as the point of access from the existing trunk road network.

A check was undertaken on the vehicle swept path, at identified 'pinch' points along the route, to ensure turbines blades could also be removed from the site. The results of this are presented in Section 3 of this report.

The swept path analysis undertaken was prepared using Ordnance Survey mapping. The accuracy of this mapping information cannot be guaranteed and recommendation is given that localised topographical surveys are completed on the identified constraint points along the delivery routes.

3 SITE DELIVERY ROUTES

3.1 Access Route 1 – Client Identified Route

This is the route suggested by Force 9 Energy for the initial assessment and is shown on drawing **106008/CGT/001** (included in **Appendix A**).

The route assessed is as follows:

- Commences at the Bannockburn Junction (Jcn 9) on the M9 motorway.
- Heading south, on the A872 towards Denny.
- Right turn at the junction of the A833 / A872 in Denny (heading south west).
- Right turn at junction of the A833 / B878 (heading west)
- Follow B878 west until Todholes Farm.
- Right turn at Todholes Farm.

The delivery vehicle swept path modelling has indicated areas where works may be required to facilitate safe, unhindered access. These areas are examined further in this report and are presented in the drawings included in **Appendix B**. The comments noted in this section of the report are based on the delivery of a 40 metre long turbine blade.

3.1.1 Bannockburn Junction on M9

As stated previously it has been assumed that the origin for the route noted as 'Access Route 1' will be junction 9 on the M9 trunk road at Stirling Services, shown on **plate 1**.



The direction of delivery is unknown at present and as a result the turbine delivery vehicle modelling exercise undertaken was completed from both the East and West approaches. Irrespective of this, the swept path analysis undertaken indicates that the modelled vehicle can safely negotiate this junction (access slip and roundabout) without any carriageway widening works being required. This is shown on drawing number **106008/CGT/002** attached in **Appendix B**.

3.1.2 M9 Junction 9 to Denny (A872)

Travelling south along the A872 you progress towards the town of Denny. From the drive through it would appear that there are no permanent obstructions that would impact on the component deliveries. Obstruction may be caused by parked cars along the side of the A872 (Stirling Street) and it is recommended that contact is made with the local Transport Authority and Central Scotland Police to check the requirement for any 'Temporary Transport Regulation Order' that may be required.

There are two right turns to be performed in Denny. The first of these is from the A872 onto the A883, as shown on **plates 2 & 3**. The swept path analysis undertaken on this junction would indicate that whilst the wheel path of the modelled delivery vehicle remains within the road corridor, with no requirement for carriageway widening, some vehicle overhang occurs over the kerb line. The overhang is greater to the east side of this junction where the existing boundary wall is located (**see plate 4**). This is shown on drawing number **106008/CGT/003** included in **Appendix B**. There may be a requirement for the temporary removal of an existing street sign however a drive through by the appointed delivery contractor may show that by utilising rear wheel steering there is no requirement for the street sign to be removed / relocated.



Plate 2: Looking South Towards the Junction of the A872 & A833.



Plate 3: Looking South West at Junction of A872 & A833.



Plate 4: Looking North East Towards Junction of A872 & A833

Upon completing the right turn at the aforementioned junction the delivery route continues in a westerly direction for approximately 450 metres where the second right turn, onto the B818, is performed (**see plates 5 and 6**).



Plate 5: Looking South West Towards Junction of A872 & B818.



Plate 6: Looking West at Junction of A872 & B818.

The swept path analysis completed at this location, as shown on drawing number **106008/CGT/004** included in **Appendix B**, would suggest that the turbine component delivery vehicle can negotiate the junction without the requirement for any works. There is however an existing 'Give Way' sign on the north side of the junction (**see plate 7**). This may impact on the vehicle overhang and would result in the sign requiring to be relocated or temporarily removed.



Plate 7: Looking East Towards Junction of A872 & B818.

3.1.3 Denny to Todholes Farm on B818 (Exit from Public Highway)

The last, and longest, section of the access route that follows the public highway is from the junction of the A872 / B818 to Todholes Farm. The delivery vehicles would head in a westerly direction following the B818 until Todholes Farm is reached at which point the vehicles would leave the public highway by performing a right turn.

Given that this replicates the route used for deliveries to the neighbouring Earlsburn Wind Farm it is anticipated that there will be limited, if any, works required to this section of public highway. In the areas where previous widening was undertaken these areas may require improvement / reinstatement.

The areas where works may be required, along this length of carriageway, are shown on drawing **106008/CGT/001** with individual areas included in drawings **106008/CGT/005 – 008**. These drawings are attached in **Appendix B**.

Upon negotiating the right turn the first section of carriageway that has evidence of previous works is the double bend located between Frankerton and Crummocksteps (**see plate 8**). The swept path analysis, as shown on drawing number **106008/CGT/005**, indicates that whilst the delivery vehicle can negotiate these bends some temporary downtakings of the existing post and wire fence may be required. This is more evident with the fence on the right side of the road (**as shown in plate 8**).

There is also evidence of damage to the carriageway edge at this location (**plate 9**). This effectively reduces the carriageway width and is likely to impact on the space available for the delivery vehicle. It is likely that the Local Authority Highways Department will request on works being completed to the damaged section of the road edge at some point in the contract duration.

Recommendation is given that a further check is undertaken in this location by completing a localised topographic survey and further vehicle swept path. Should any work be required to the carriageway edge in this location then agreement will be required from the Local Authority Highways Department to agree the scope of these works.



Plate 8: Looking West Along B818.

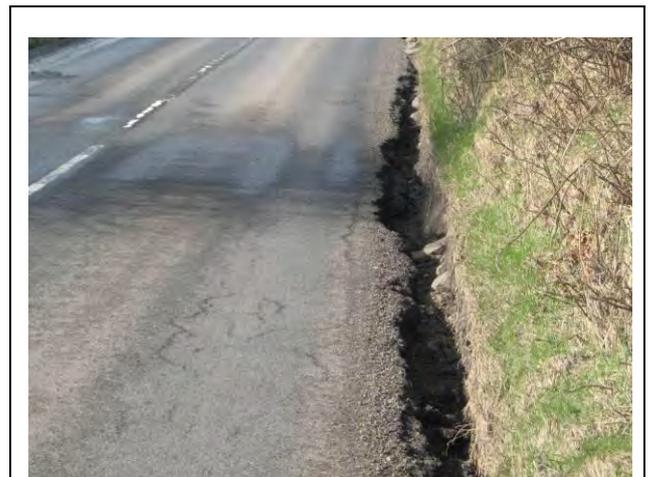


Plate 9: Damage / Erosion to Edge of Carriageway at Crummocksteps)

As this route progresses west the next area where there is evidence of previous works is on the approach to the masonry arch bridge at Crummocksteps (**see plate 10**) where the previous widening works can be seen on the left approach to the bridge (**see plate 11**). The swept path exercise undertaken at this location, as shown on drawing number **106008/CGT/006** attached in **Appendix B**, indicates that carriageway widening would be required however it is acknowledged that this route was used for transporting components to Earslburn Wind Farm and as such it is likely that through passage can be achieved by using rear wheel steer on the delivery vehicles. It is recommended that this is confirmed by appointing a haulage contractor to complete a drive through.



Plate 10: Looking West Along B818 on Approach to Masonry Bridge.

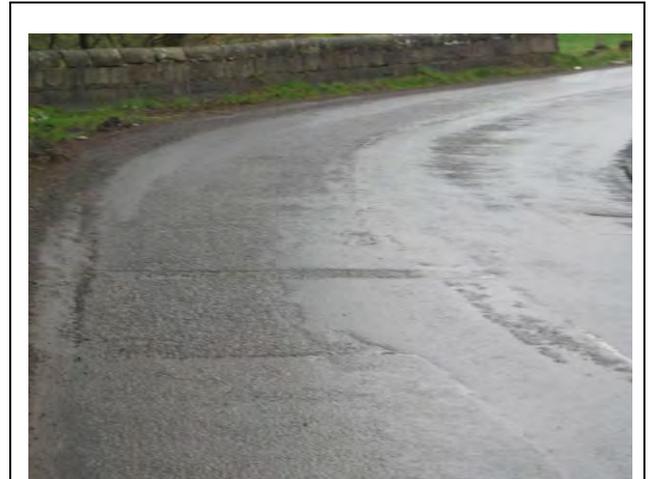


Plate 11: Carriageway Widening on Left Side Approach to Masonry Arch Bridge.

Progressing west along the B818 you encounter another masonry arch bridge, 'Townfoot Bridge' (**see plate 12 and drawing number 106008/CGT/007 attached in appendix B**). Again previous evidence of widening works is present on the left verge. The vehicle swept path modelling indicates that this widening is required to enable the turbine component delivery vehicle to negotiate the right turn onto, and over the bridge. The previous widening works undertaken show signs of deterioration and recommendation is given that the widening is reinstated to a suitable condition.



Plate 12: Approach to Townfoot Bridge Showing Previous Widening.

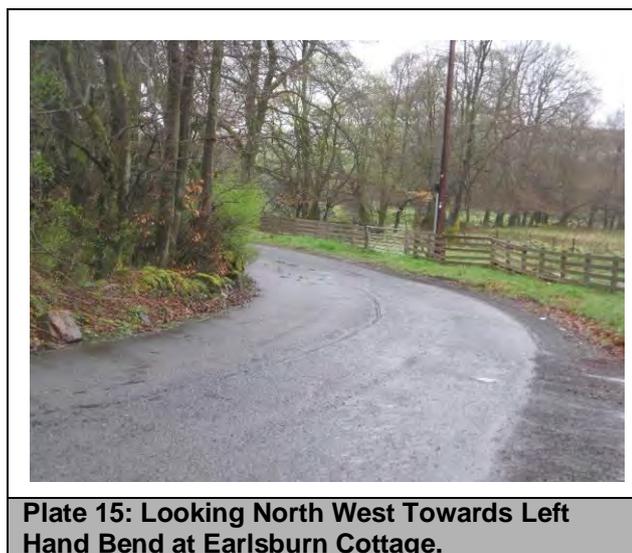


Plate 13: Looking South East Towards Townfoot Bridge (vehicles travel towards camera).

The swept path modelling completed at the 'Townfoot Bridge' also indicates that vehicle overhang occurs on the right side during approach at the existing stone wall and bridge parapet (**see plate 14**). It is recommended that this area is also checked by appointing a haulage contractor to complete a drive through. The proximity of the existing telegraph pole should also be checked during the drive through.



The last section of public highway that swept path analysis was undertaken was on the left hand bend at Earlsburn Cottage (**see plate 15**). There is evidence of previous work at this location with carriageway widening, fence relocation and localised diversion of the existing overhead cables. The swept path analysis completed, as shown on drawing number **106008/CGT/008** attached in **Appendix B**, indicates that the modelled delivery vehicle can negotiate this bend without the requirement for any works.



It should be noted that during the route inspection there was a contractor undertaking works on the existing carriageway in the vicinity of the Todholes Farm access. It would appear that the contractor was undertaking localised carriageway pothole repairs ('Jetpatching') along the length of the B818. Given that there were potholes along the length of the carriageway it is recommended that a full visual condition survey of the B818 is completed and submitted to the Local Authority Roads Department prior to any construction works / deliveries. This may limit any liability for carriageway repairs should the Local Authority try and apportion repair costs based on the abnormal vehicle loadings of the construction plant.

3.2 Todholes Farm to Site Access from Earlsburn Wind Farm Track

3.2.1 Junction on B818 at Todholes Farm

The exit from the public highway to the existing access tracks serving Earlsburn Wind Farm is situated at Todholes Farm (see plate 16). To enable construction at Earlsburn the access was widened to accommodate the turbine component delivery vehicles. The previous works undertaken on this access still exist thus ensuring access is still available with no works required.



Plate 16: Looking North West Towards Site Entrance at Todholes Farm.

3.2.2 Proposed New Access from Existing Access Track

Upon entering the existing Earlsburn Wind Farm site, and using the existing tracks, you progress in a northerly direction. Given that the proposed wind farm is on the south side of the 'Backside Burn', it is anticipated that the new access tracks required will be constructed on the south side of the watercourse running in a north westerly direction until reaching the area where the new wind turbines are proposed (as shown on drawing number **106008/CGT/009** attached in **appendix B**).

Upon reviewing the existing access tracks it was anticipated that the best location to branch off the existing Earlsburn track would be on the approach to the bridge crossing (**see plate 17**). This suits not only the existing track layout but is also best placed due to the topography in the area although it is likely that some 'cut' will be required for the first 30m of new access track construction.



Plate 17: Looking North Towards Proposed Access from Existing Earlsburn Track.



Plate 18: Existing Drainage Channels at Location of Proposed Access Tracks

Upon leaving the existing access tracks the proposed new tracks would progress in a north westerly direction over the existing moorland. It was noted from the site walkover that the ground conditions, adjacent to the existing Earlsburns' access tracks, indicate that there may be peat present in this location with the ground being considerably wetter (**see plate 18**) than the ground nearer the proposed turbine positions. Further investigative works are recommended in this area to confirm ground conditions thus confirming the type of track construction required.

During the site walkover it was also apparent that there are various areas where rock outcrops at ground level (**see plate 19**). It is recommended that a further investigation is undertaken to assess the suitability of this rock for site access track construction.

From the site walkover there would be areas where the tracks would cross small channels / water streams that would likely require culverting. This is in addition to the new bridge structure(s) that would be required to cross the un-named tributary of the Backside Burn (**see plate 20**). The location of the proposed crossing is shown on drawing number **106008/CGT/009** attached in **appendix B**. It is recommended that a catchment assessment is undertaken to ensure adequate sizing of the required culverts and bridge structures.



Plate 19: Looking North Towards Proposed Access from Existing Earlsburn Track.



Plate 20: Existing Un-named Tributary of Backside Burn. Bridge Crossing(s) Required.

3.3 Alternative Access West of Todholes Access

As an alternative location for site access the area west of the existing Todholes Farm access was reviewed for suitability.

Immediately west of the Todholes Farm access there is a masonry arch bridge (**see plate 20**) that would likely cause an obstruction to the through passage of component delivery vehicles due to the vertical alignment. Coupled with the poor horizontal geometry of this section of carriageway it would be unlikely that component delivery vehicles could negotiate this section of public highway without completing significant civil engineering works.

It is also noted that to gain access to the windfarm site the new access track would be required to cross the Fintry Hills. The topography of the southern side is such that the slope gradients would be excessive with access highly unlikely.

As a result of the above it was agreed that no further investigative works would be undertaken on a potential access west of the Todholes Farm / Earlsburn access.



4 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

From the investigations completed, and given that this route was previously used for turbine component deliveries to the adjacent Earlsburn Wind Farm, it is acknowledged the proposed site access route is suitable for deliveries to the proposed windfarm development at Craigton / Spittalhill. This is based on the assumption that a similar specification of turbine is proposed for this development. However it should be noted that as a result of the poor condition of the road, particularly along the section West of Fankerton, this may result in remedial works being required / requested by the Local Roads Authority.

Some minor works will be required to provide the required, reinstated carriageway widening, specifically at Townfoot Bridge.

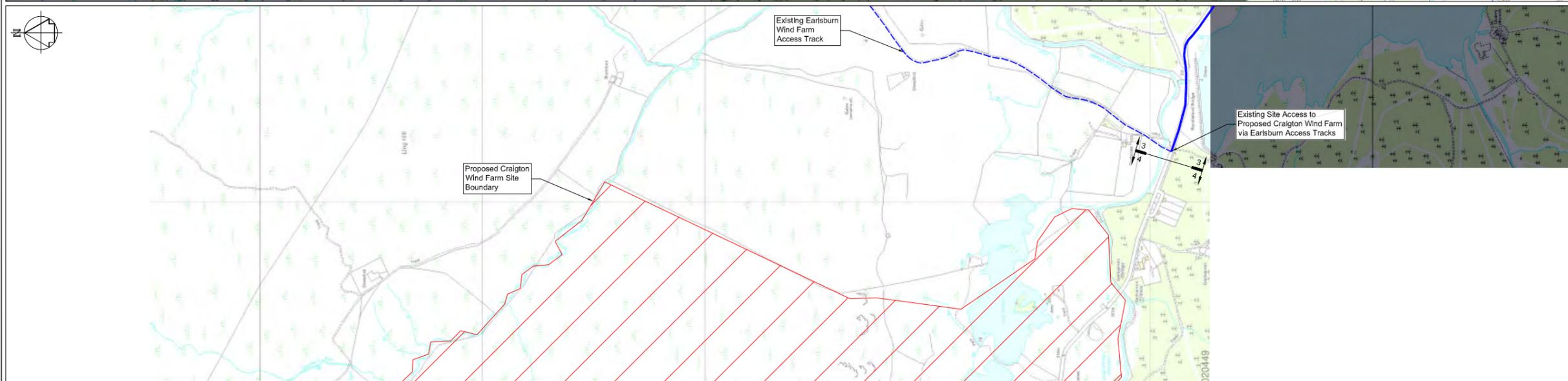
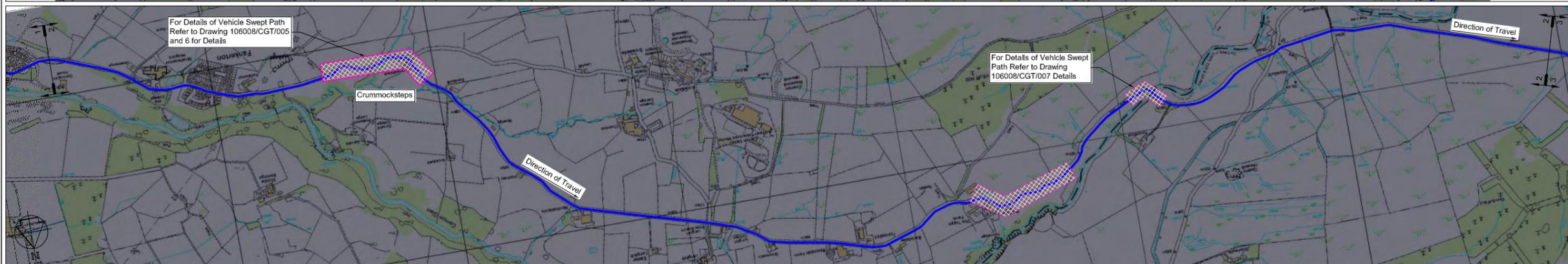
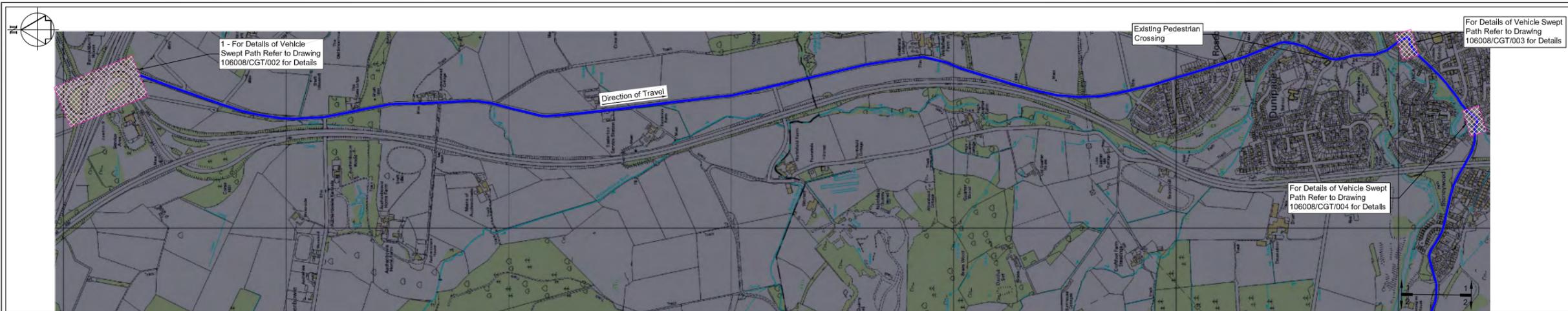
The scope of this report excluded any structural assessments of any bridge crossings.

4.2 Recommendations

Due to the variety of obstacles identified on the proposed delivery route(s) and the limitations this places on the final proposals for developing this site the following recommendations are made:

- Consultation with Local Authority (Transportation and Planning) to confirm acceptance of delivery route including load bearing capacity of bridge crossings and any downtakings required to existing walls.
- Completion of a full conditional survey of the existing adopted carriageway with submission / consultation with Local Authority Highways Authority. This will establish if any reinstatement works will be requested on sections of public highways that are currently in poor condition.
- Discussions with turbine suppliers are held to check the limitations of the actual delivery vehicles.
- Consultation with utility companies to ascertain extent of any diversionary works
- Consultation with other, interested 3rd party landowners.
- Drive through, by haulage contractor, along the proposed delivery route to check through passage.
- Delivery vehicle modelling to be re-visited by appointed haulage contractor.
- Further site investigative work (site walkover by Grontmij Geologist to assess suitability of on site rock for re-use in proposed site access tracks.

APPENDIX A
Site Access Route



- NOTES**
- All dimensions in millimetres and all levels in metres AOD unless shown otherwise.
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 - Grontmij recommend that discussions are held with the Local Authority Transport Department to agree proposed route and also check load capacity of existing bridge crossings.
 - For vehicle swept path details refer to drawings 106008/CGT/002 to 007
- Legend**
- Client Identified Site Delivery Route
 - Location of Proposed Craighton Wind Farm
 - Areas Where Delivery Vehicle Modelling Completed. Refer to Quoted Drawing No.106008/CGT/002 to 007 For More Details

IMPORTANT
HEALTH, SAFETY & ENVIRONMENTAL INFORMATION

IN ADDITION TO THE HAZARDS AND RISKS NORMALLY ASSOCIATED WITH THE TYPE OF WORK DETAILED ON THIS DRAWING, PLEASE NOTE THE FOLLOWING ADDITIONAL RISKS TO HEALTH AND SAFETY:-

DESIGNER'S RISK ASSESSMENT REFERENCE GIVING FULL DETAILS:-
IP09-F01 Design Risk Assessment - Rev 5

CONSTRUCTION PHASE:-

IT IS ASSUMED THAT ALL WORKS WILL BE CARRIED OUT BY A COMPETENT CONTRACTOR WORKING, WHERE APPROPRIATE, TO AN APPROVED METHOD STATEMENT.

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CLIENT
Force 9 Energy

PROJECT
Craighton Wind Farm Access Review

TITLE
Site Access Route

STATUS
Draft

ORIGINATED	DRAWN	CHECKED	APPROVED
AM	BH	AM	MT
DATE 23/05/11	DATE 23/05/11	DATE 23/05/11	DATE 23/05/11
DRAWING SCALE 1:10,000		ORIGINAL DRAWING SIZE A1 - 841x594	
DRAWING No. 106008/CGT/001			REV. 0

APPENDIX B

Vehicle Swept Path Analysis Drawings



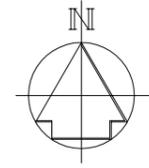
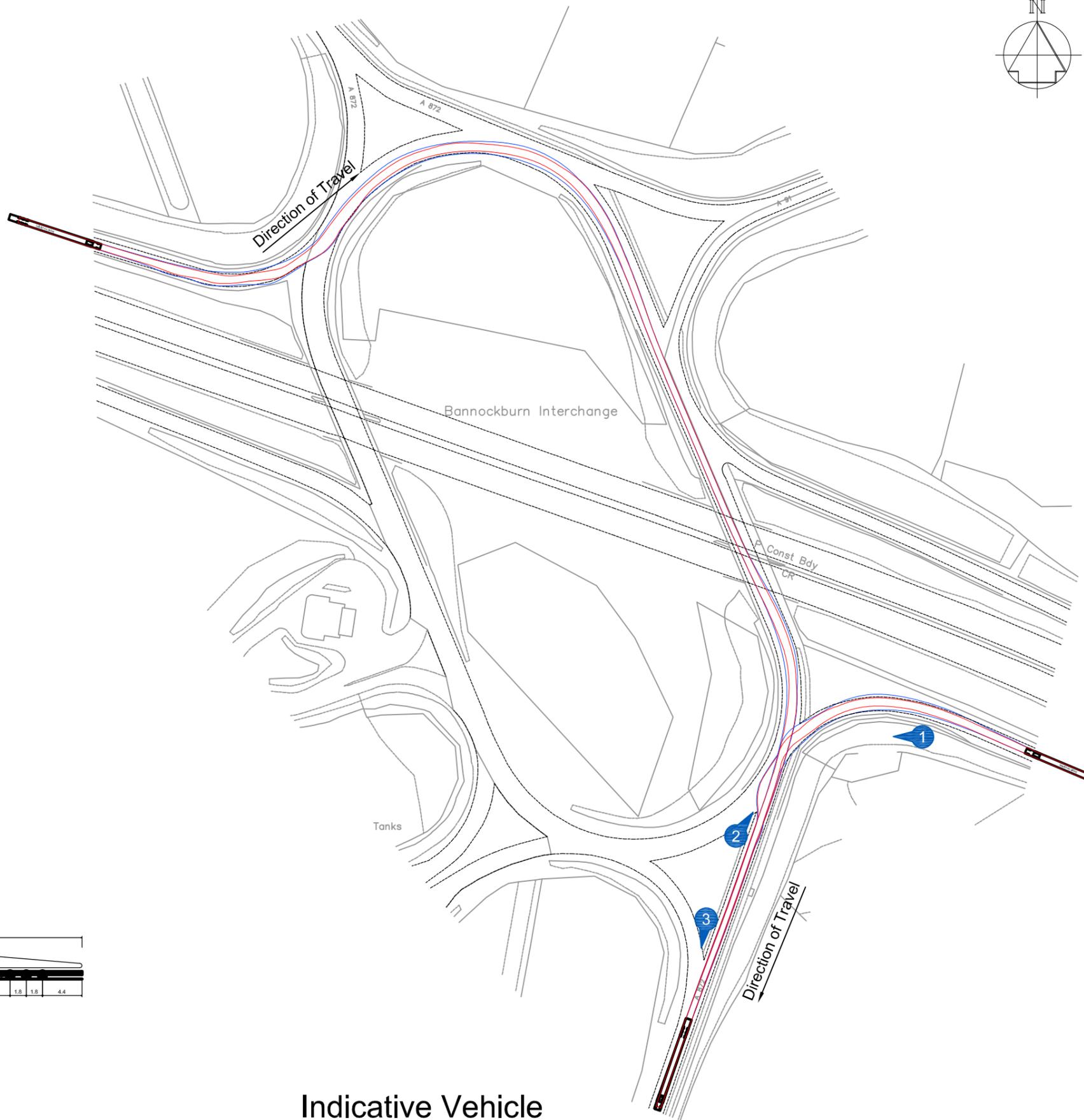
Plate 1: Looking west towards Bannockburn Interchange from M9 Jct 9 west bound off-slip



Plate 2: Looking north towards Bannockburn Interchange from A872



Plate 3: Looking south along A872



NOTES

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 - Refer to drawing number 106008/CGT/001 for location of works

Legend:

- Modelled Vehicle Wheel Base
- Modelled Vehicle Blade Overhang
- Photograph Direction and reference

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DESIGNER'S RISK ASSESSMENT REFERENCE GIVING FULL DETAILS:-
IP09-F01 Design Risk Assessment

CONSTRUCTION PHASE:-
• Delivery vehicle overhang conflicting with existing features (ie road signs etc).

IT IS ASSUMED THAT ALL WORKS WILL BE CARRIED OUT BY A COMPETENT CONTRACTOR WORKING, WHERE APPROPRIATE, TO AN APPROVED METHOD STATEMENT.

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CLIENT
Force 9 Energy

PROJECT
**Craigton Wind Farm
Access Review**

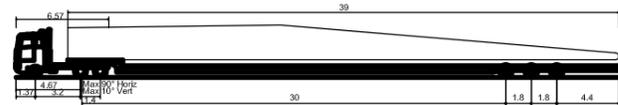
TITLE
**Swept Path
Sheet 1 of 7
(Bannockburn Jct)**

STATUS
DRAFT

ORIGINATED AM	DRAWN BH	CHECKED AM	APPROVED MJT
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DRAWING No. 106008/CGT/002 REV. 0

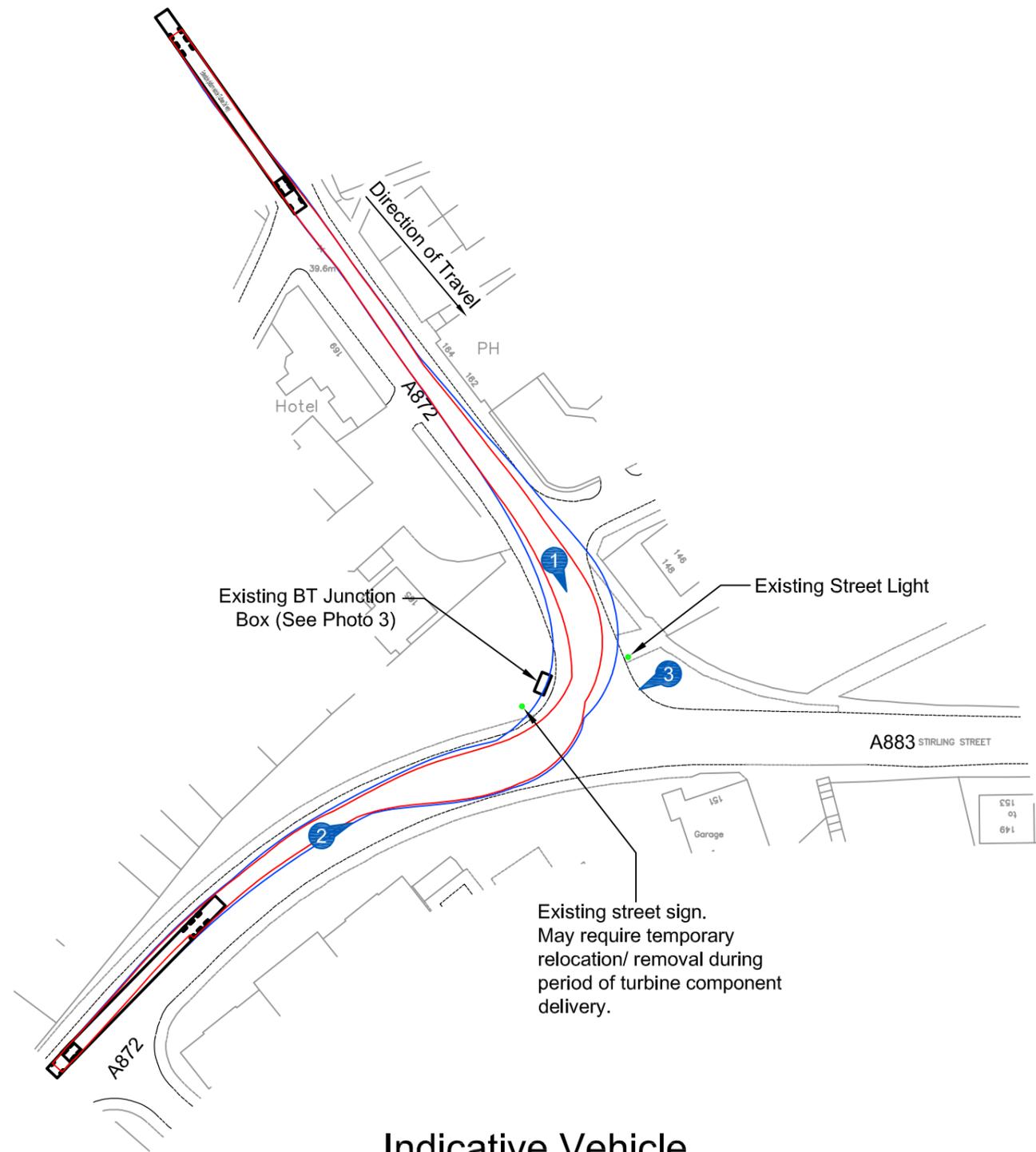
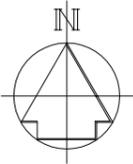


Extendible platform vehicle (Turbine Delivery)
Overall Length 42.670m
Overall Width 2.600m
Overall Body Height 3.396m
Min Body Ground Clearance 0.320m
Max Track Width 2.600m
Lock to Lock Time 6.00 sec
Wall to Wall Turning Radius 16.500m

SCALE 1 : 2000



Indicative Vehicle Swept Path
Scale 1:2000



Indicative Vehicle Swept Path

Scale 1:1000



SCALE 1 : 1000



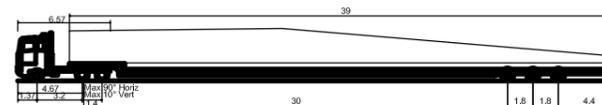
Plate 1: Looking south towards A872/A883 Junction



Plate 2: Looking east along A872 towards A872/A883 junction



Plate 3: Looking west across A872/A883 junction



Extendible platform vehicle (Turbine Delivery)
 Overall Length 42.670m
 Overall Width 2.600m
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 - Accuracy of Map Image Not Guaranteed Due to Reproduction Methods.
 - Refer to drawing number 106008/CGT/001 for location of works
 - Public utility information shown is approximate only. A full search is recommended to determine full scope of any required diversion / protection works.
 - Swept path is based on the vehicle shown in the 'Modelled Delivery Vehicle Dimensions and Information' Diagram. **Haulage contractor to confirm proposed works are adequate to accommodate their loaded delivery vehicles prior to delivery of turbine components.**

Legend:

- Modelled Vehicle Wheel Base
- Modelled Vehicle Blade Overhang
- Photograph Direction and reference

IMPORTANT

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IP09-F01 Design Risk Assessment

CONSTRUCTION PHASE:-

- Delivery vehicle overhang conflicting with existing features (ie road signs etc)

IT IS ASSUMED THAT ALL WORKS WILL BE CARRIED OUT BY A COMPETENT CONTRACTOR WORKING, WHERE APPROPRIATE, TO AN APPROVED METHOD STATEMENT.

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Force 9 Energy

PROJECT
**Craigton Wind Farm
 Access Review**

TITLE
**Swept Path
 Sheet 2 of 7
 (A872/A883 Junction)**

STATUS
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DATE 24/05/11	DATE 24/05/11	DATE 24/05/11	DATE 24/05/11

DRAWING SCALE 1:1000 ORIGINAL DRAWING SIZE A3 - 420x297

DRAWING No. **106008/CGT/003** REV. **0**

Appendix 14.1: Carbon Report

Craigton and Spittalhill Wind Farm: Technical Appendix Carbon Report

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Document Control Sheet

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Report Title	Carbon Report
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Status	Final
Control Date	30 October 2013

Record of Issue

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2	Final	P. Jenn	25/10/13	S. Bone	25/10/13	S. Bone	30/10/13

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Force9 Energy	Andrew Smith	1
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1 Introduction

The UK and Scottish Governments, in common with the majority of governments across the world, recognise the impacts of rising atmospheric levels of CO₂ and other greenhouse gases on global warming. In order to reduce the volume of CO₂ emitted, they have introduced or supported a number of measures. Under the *Climate Change Act 2008* (UK Government, 2008), the UK Government has set a target of reducing CO₂ emissions (based on a 1990 baseline) by 80% by 2050, with an interim target of 34% reduction by 2020. The Scottish Government has set a more ambitious target, with an interim emissions reduction target of 42% by 2020, as stated in *Low Carbon Scotland: Meeting the Emissions Reduction Targets 2010-2022* (Scottish Government, 2011a). In terms of energy production, the UK target is 15% of energy consumption from renewable sources by 2020 within the current EU target of 20% supply from renewable sources by 2020. *The Scottish government 2011 renewable energy policy* (Scottish Government, 2011b) has set a target of the equivalent of 100% of annual electricity demand generated from renewable sources by 2020.

The proposed Craigton and Spittalhill Wind Farm will generate renewable energy that will contribute to national targets for reduction of carbon emissions into the atmosphere and for the amount of electricity supplied from renewable energy. However, it is recognised that the construction and, to a lesser extent, the operation of the wind farm will encompass activities that either directly or indirectly result in CO₂ emissions. Additionally, as this wind farm is proposed in an area with peat deposits, there are potential losses of CO₂ from carbon stored in the peat and there is a potential loss of habitat that can capture and store carbon.

In recognising that development of renewable sources of energy could contribute to carbon emissions in the short term, the Scottish Government funded research to revise and update Scottish Natural Heritage (SNH) technical guidance note "*Windfarms and Carbon Savings*" (SNH, 2003). The output of this research, started in 2007, was a spreadsheet tool to facilitate calculation of greenhouse gas emissions and carbon payback times. This spreadsheet tool, described in the report "*Calculating Carbon Savings From Wind Farms On Scottish Peat Lands - A New Approach*" (Nayak et al, 2008) has been updated several times in the intervening period, with the final corrected report dated 29th June 2010. A full report on version 2 of the calculator, titled "*Carbon Implications Of Windfarms Located On Peatlands – Update Of The Scottish Government Carbon Calculator Tool*" (Smith et al, 2011) was published in 2011. The calculator is also supported by two other documents: "*Calculating Potential Carbon Losses & Savings from Wind Farms on Scottish Peatlands Technical Note – Version 2.0.1.*", Scottish Government, 2011" (Scottish Government, 2011c); and "*Carbon Payback Calculator: Guidance on how to use the spreadsheet*" (Scottish Government, 2011d)". The current version of the tool, version 2.7.0 (Scottish Government, 2012) has been used in evaluating carbon payback for the Craigton and Spittalhill Wind Farm (site).

Although there is currently no requirement to use this tool as part of the planning or consenting process for developments of less than 50MW generating capacity, it is encouraged by a number of key stakeholders and is considered to be good practice. This report will provide an estimate of the CO₂ emissions related to the proposed construction, operation and decommissioning of the Site and will compare these with the estimated CO₂ emissions related to the production of electricity from wind rather than from fossil fuels, to provide an overall estimate of the payback time for the development.

This report provides an estimate of the CO₂ emissions related to the proposed construction, operation and decommissioning of the site and will compare these with the estimated CO₂ emissions related to the production of electricity from wind rather than from fossil fuels, to provide an overall estimate of the payback time for the development.

2 Site Description

The proposed Craigton and Spittalhill site is located in the Fintry Hills, 4km north-east of Fintry, 15km south-west of Stirling. This is an upland moorland site with blanket peat evident and the current land use is rough grazing (land capability class 6₃). In such areas, the vegetation is dominated by plant communities with low grazing values, particularly heather moor, bog heather moor and blanket bog. The site is located on a north-east facing hillside, which is drained by the Backside Burn, one of the headwaters of the Endrick Water which flows into Loch Lomond.

There are no sites designated for nature conservation within the Craigton and Spittalhill Wind Farm site boundary, however there are several sites present in the surrounding region. There is one site of European importance within a 5km radius of the site centre, Endrick Water SSSI and SAC, and the nationally designated Double Craigs SSSI.

3 Methodology

The methodology used for calculating the impact of the wind farm development on the carbon balance was that outlined in the stated literature (Nayak et al (2008); Smith et al (2011); Scottish Government (2011c); Scottish Government (2011d)) to facilitate the completion of the Carbon Calculator Excel Spreadsheet version 2.7.0.

In a number of cases, the methods suggested in the guidance require measurement around the constructed feature. Clearly, this is not possible for a project still at the planning stage, such as this site. Therefore, where practical, actual data has been used in the assessment, however, where real data was not obtainable, either standard (default) data or, in some cases, an estimate has been used. In each case, an explanation of the values used and their source is provided. The following section provides a more detailed explanation of the data used and respective source(s).

4 Input Parameters for Carbon calculator

In order to calculate the carbon balance for the site, a range of data was collated regarding the wind farm characteristics and infrastructure, construction data, the local ecology, potential restoration and the benefits of replacing fossil fuel generated electricity with renewables. Of particular note is the potential for loss of stored carbon from peatlands.

4.1 Wind Farm Characteristics

4.1.1 *Number of Turbines and Project Timescale*

The current proposal for the site is described in Chapter 4: Development Description of the Craigton and Spittalhill Environmental Statement (ES) (LUC, 2013). This identifies that planning consent will be sought for seven wind turbines with a likely operational life of 25 years. These figures have therefore been included in the carbon calculator.

4.1.2 *Performance*

The capacity factor for a wind farm is obtained by dividing the annual generated output with the installed capacity, multiplied by the number of operational hours per year. The annual output is a function of a wind turbine's power curve and the prevailing wind resource at the site.

The turbine specifications defined in ES Chapter 4 (LUC, 2013) indicate a nominal 3MW capacity, a hub height of 80m, blade tip height of 125m and rotor diameter of 45m.

The most recent average annual capacity factors reported by the Department of Energy and Climate Change in the *Digest of UK Energy Statistics, (DUKES) Table 6.5: Load factors for renewable electricity generation* (DECC, 2013a) are shown below in Table 1. However, the average capacity factor for Scotland (1998 – 2004) is quoted in Nayak et al (2008) as 30%. Nayak also recommends that the likely range of results is calculated using the best (34%) and worst (27%) case capacity factors for Scotland.

Table 1 shows a sharp decrease in capacity factor for onshore wind during 2010. *DUKES Chapter 6 Renewable Sources of Energy* (DECC, 2013b) identifies the reason for this drop as unusually low levels of wind in the UK during 2010, with 10 of the 12 months having below average windspeeds.

Table 1: Annual UK Onshore Wind Capacity Factor

Year	2007	2008	2009	2010	2011	2012
Capacity Factor (%)	27.5	27.0	27.4	21.7	27.3	26.2

Measured windspeed data for the site was not yet available during the preparation of this report. Estimations were therefore used by the client in order to provide a capacity factor for the purpose of carbon calculations. Using an estimated windspeed of 9.5 ms^{-1} from the UK NOABL wind speed database extrapolated to the hub height and other appropriate factors, a capacity factor of 35.6% was derived (Andrew Smith, pers. comm., 2013).

From Table 1, the average capacity factor, disregarding the 2010 anomaly, is 27.1% (26.2 including 2010). The worst (27%) case value proposed by Nayak et al (2008) is used to represent the minimum value. With the client supplied value, in this case, being greater than the maximum proposed by Nayak et al (2008) it is considered appropriate to use this figure of 35.6% as a maximum value and the 30% value to represent the expected capacity factor.

4.1.3 Backup

Due to the inherent variability of wind generated electricity, it is recognised that backup power generation facilities are required to stabilise supply. Nayak (2008) identifies that the extra capacity required is estimated as 5% of the rated capacity of the wind farm. It is also stated that backup generation capacity is only necessary where wind power contributes more than 20% to the national grid.

It is assumed that the backup power is from fossil fuel and also that where backup power is required there will be additional emissions of 10% due to reduced thermal efficiency of the reserve generation.

DUKES Table 6.4 (DECC, 2013b) indicates that the installed onshore wind capacity in the UK in 2012 was 5.893GW, and installed offshore wind capacity 2.995GW, giving a total of 8.888GW. The RenewableUK website, accessed on 2nd September 2013 (RenewableUK, 2013) identifies installed UK wind capacity as 10.027GW, amounting to approximately 11.2% of total generation capacity (89.241GW in 2012 (DECC, 2013c)). It is assumed that, when electricity generated from wind energy forms 20% of national electricity generation, it will be necessary to implement additional backup capacity, suggested to be 5% of the actual output of the wind farm.

Comparing the electricity generated in the UK during 2012 of 360,869GWh (DECC (2013d)) with that generated from wind of 16,884GWh), wind energy accounts for 4.68% of total

generation. Therefore, at current levels, additional backup capacity is not required as it can be assumed to be obtained from within the spare generating capacity of other power sectors.

Nayak (2008) identifies, based on 2006 figures, that the contribution of wind power to the national grid will not reach 20% until 2038. On the basis of a 25 year lease for Craigton and Spittalhill Wind Farm, from 2015 to 2040, this would result in backup power being required for the final 2 years of the planned operational period of the wind farm.

The timescale of 2038 for achieving 20% of production from wind is subject to a number of assumptions. Therefore, to provide a comparison, the “expected value” of the carbon calculator has been populated based on two options, depending on whether or not it has been assumed that backup generation capacity will be required through the operational period.

The minimum value used for backup is 0% (with 0% additional emissions due to thermal inefficiency) and the maximum value 5% (with 10% (Scottish Government, 2011c) additional emissions due to thermal inefficiency of the backup).

4.1.4 *Carbon Dioxide Emissions from Turbine Life*

Carbon dioxide emissions during the life of a wind turbine include those that occur during production, transportation, erection, operation, dismantling and removal of turbines and foundations. Where possible, the best option for this factor is to have an actual calculation determining the total emissions for the wind farm based on generating capacity. In the absence of this information, emissions are estimated based on turbine capacity and previously identified emission values. This calculation is embedded in the calculator spreadsheet. In this case, the latter approach has been taken as detailed data on emissions from turbine life are not available.

4.1.5 *Characteristics of Peatland before Wind Farm Development*

As described above in Section 2, the vast majority of the site is typical of land suitable only for rough grazing, with heather moor, bog heather moor and blanket bog habitats evident across much of the area. It is largely wet underfoot with variations occurring; higher ground being drier and lower ground near the Backside Burn being waterlogged, with flushes common on the lower slopes. There is evidence of artificial channels throughout the site and peat bodies are variable in their degree of quality with several areas shallow and dehydrated.

4.1.6 *Type of Peatland*

The calculator offers two options for this item: Fen or Acid Bog. The peat deposits on this site are consistent with the Acid Bog option.

4.1.7 *Average Air Temperature at Site*

The closest Met office station to the site is Springburn Met Office, with an annual average (climate period 1981 – 2010) of diurnal maximum and minimum temperatures of 12.2°C and 5.5°C respectively (Met office website, 2013a), giving a mean temperature of 8.9°C.

Based on the information from Springburn Met Office a mean annual temperature of 8.9°C is proposed, with maximum and minimum values of 12.2°C and 5.5°C, reflecting the extremes of the stated mean Met office temperature ranges.

4.1.8 *Average Depth of Peat at Site*

Extensive peat probing has been carried out, initially at representative locations across the site and latterly in the vicinity of proposed infrastructure. In total, 620 peat probes have been taken. Results of peat depth probing are summarised in ES Chapter 8 (Mouchel, 2013a). Average peat depth across all probe points is 0.57m, with over 82% of probed locations having a peat depth

of <1.0m. The large number of probing points taken provides a robust base for the averages used for the purpose of this assessment.

4.1.9 *Carbon Content of Dry Peat*

Actual figures were not available for this parameter. In the absence of site specific data, values for carbon content in the peat component of the principal soil units on the site (soil unit 4, 149, and 163) covering the entire site were obtained from the Macaulay Land Use Research Institute (MLURI) Soil Indicators For Scottish Soils (SIFSS) website (MLURI, 2013). This provided a median value for carbon content (as C) of 55%. The website also yielded \pm one standard deviation values for carbon content of blanket peat of 63% and 47% respectively. These figures have been adopted as the maximum and minimum input values for the carbon calculator, with 55% used as the expected value.

4.1.10 *Average Extent of Drainage around Development Features at Site*

The extent of drainage around construction strongly influences the total volume of peat impacted by the construction of the wind farm. Thus, the extent of drainage has a significant impact on the calculated carbon payback time for the development.

A review of the available literature (Nayak et al, 2008) found that the extent of drainage effects are reported as being anything from 2m to 50m horizontally around the site of disturbance. Research into the effects of artificial drainage and water table data from other sites yielded a horizontal draw down distance typically of about 2m. It is thought that in extreme cases, this may extend as far as 15 – 30m, though this would be exceptional - and is why most grips are about 15m apart.

Smith et al (2011) identified the average extent of drainage impact at three sites (Cross Lochs, Farr windfarm and Exe Head) as ranging from 3 m to 9 m. The actual extent of drainage at any given location will be dependant on local conditions including topography.

The site is patterned with drainage channels. Visual examination indicates that these are historic in nature and that several demonstrate varying degrees of revegetation with Sphagnum, grasses and other bog plants.

The photographs below show differing examples of drainage on the site. Illustration 1 features a distinct channel flowing to the east, to the confluence with Backside Burn. In Illustration 2, the historic drainage ditch is extensively revegetated with Sphagnum and grasses. A second ditch can be seen running in parallel in the distance. Here there is little evidence of changes in vegetation, suggesting that changes in hydrology are limited.

Illustration 1: Photograph showing view upstream of channel in a central area of the site flowing east towards confluence with Backside Burn (NS 6637 8878)



Illustration 2: Revegetated drainage ditch with second ditch visible in distance (NS 6597 8912)



Based on the above, it is proposed that the expected value for extent of drainage is 10m, at the upper end of the measured values quoted above by Smith et al (2011). Further, it is proposed that maximum and minimum values of 15m and 5m respectively are used.

It should be noted that the area where peat is removed is not included when estimating the extent of drainage because carbon loss from removed peat has already been counted in direct losses.

4.1.11 Average Water Table Depth at Site

Drainage channels in the north of the site are generally revegetated, with water levels close to surface, noted wet underfoot in the lowest areas of the site. The “*Guidance on how to use the Calculator*” (Scottish Government, 2011d) indicates that on intact sites, the depth to water table may be <100mm (0.10m), with up to 300mm (0.3m) to water table on eroded sites. The site is considered to be partially intact, given that only the lowest parts are wet underfoot and strictly classed as acid peat bog. Many of the drainage ditches in these areas are however, historic and are revegetated. In keeping with the conservative approach taken in this assessment it is deemed appropriate that the expected depth to water table used is 0.1m, with maximum and minimum values of 0.3m and 0.0m respectively included in the carbon calculator.

4.1.12 Dry Soil Bulk Density

As part of the ground investigation peat samples, taken by Russian corer, were analysed for dry bulk density (Mouchel, 2013b). The maximum and minimum values reported were 0.956Mgm^{-3} and 0.104Mgm^{-3} , with a mean value of 0.307Mgm^{-3} .

For the purposes of the calculations, a dry soil bulk density of 0.307Mgm^{-3} , equivalent to the mean of measured values, has been assumed as the expected value. The highest and lowest individual measured values of 0.956Mgm^{-3} and 0.104Mgm^{-3} respectively are included as the maximum and minimum values.

Field notes obtained for the sample location for the high outlier value of 0.956Mgm^{-3} (see Appendix A) indicate that the core sample measured was clay throughout, rather than peat. This clearly presents a potentially significant influence on the results for this assessment given that the carbon calculator is designed to assess the carbon losses and gains associated with developments on peat. The data has however been retained within the calculations as the maximum value but is expected to skew the results to a very conservative maximum value.

4.2 Characteristics of Bog Plants

4.2.1 Time Required for Regeneration of Bog Plants after Restoration (years)

The expected value used here is 5 years. This is a judgement made by Mouchel based on their experience of other wind farms and evidence of repopulation / regrowth within drainage channels on the site. This figure assumes the use of best practice during restoration.

Values of 3 years and 10 years are proposed for the minimum and maximum values to be used for the calculator.

4.2.2 Carbon Accumulation due to C Fixation by Bog Plants

There are a number of factors controlling the carbon (C) cycle in peatlands, including plant community, temperature, drainage, water table depth and peat chemistry. The estimated global average for apparent C accumulation rate in peatland ranges from 0.12 to $0.31\text{tCha}^{-1}\text{yr}^{-1}$ (Turunen et al., 2001; Botch et al., 1995). However, the accumulation of C in peat is highly site specific. The SNH Guidance (SNH, 2003) proposes an average value of $0.25\text{tCha}^{-1}\text{yr}^{-1}$, which is within the range of the quoted. This value has been used as the expected value for the site. The accumulation rates of $0.12\text{tCha}^{-1}\text{yr}^{-1}$ and $0.31\text{tCha}^{-1}\text{yr}^{-1}$ noted above are proposed as the minimum and maximum values entered into the carbon calculator respectively.

4.3 Forestry Plantation Characteristics

The presence of extensive areas of forestry on and in the vicinity of a site can significantly reduce the yield of wind energy, so it has often been the practice to clear existing forestry prior

to wind farm development. However, there are no areas of forestry plantation on or around this site, therefore there will be no felling of forestry plantation necessary. Entries for this section of the carbon calculator are zero.

4.4 Counterfactual Emission Factors

These figures represent the estimated average emission of CO₂ resulting from generation of energy from different sources. Figures, shown below in Table 2 taken from the *Digest of the United Kingdom Energy Statistics 2012 Chapter 5 – Electricity Table 5C*. (DECC, 2013e).

Table 2: Carbon Dioxide emissions from electricity generation (tCO₂MWh⁻¹)

Fuel source	2010	2011	2012	Average (2010 – 2012)
Coal	0.906	0.906	0.895	0.902
All Fossil Fuels	0.594	0.614	0.700	0.636
Grid Mix	0.457	0.440	0.483	0.460

In each case, the mean of the three annual estimates has been used as the expected value in the carbon calculator, with the minimum and maximum individual annual values used as the minimum and maximum entry into the calculator.

4.5 Development Infrastructure

4.5.1 Borrow Pits

One potential borrow pit location (BP01) has been identified. The location and estimated dimensions of this is provided in the Borrow Pit Assessment Technical Appendix of the Craigton and Spittalhill Wind Farm Environmental Statement Chapter 4: Development Description.

Dimensions of the identified borrow pit are provided below in Table 3. The nominal footprint dimensions represent the maximum width and length of the proposed borrow pit. The calculator requires entry of an average length and width for the borrow pit. The average surface area of the borrow pit is 6300m², which equates to a square of side 79.37m. This is used as the expected value for both the average length and width of the borrow pit. The actual dimensions of the borrow pit will vary depending on the quality of rock, local geology and topography and windfarm design. An error of ± 10% in surface area is proposed to reflect the maximum and minimum values. This equates to a square of side 83.25m and of 75.30m for the maximum and minimum respectively. For area of borrow pit to be restored (ha) the same ± 10% error is applied giving 0.69ha and 0.57ha for maximum and minimum respectively.

Table 3: Site Borrow Pit Dimensions

Borrow Pit ID	Maximum Depth of overburden (m)	Nominal Footprint Dimensions (m)	Nominal Footprint Area (m ²)
BP01	1.1	56 x 147	6300

Measured peat depths indicate that surface soils are limited in the vicinity of the borrow pit and are generally not peat, with outcrops often present. Therefore, an average depth of 0.6m is proposed as the expected value, with a maximum of 1.1m and minimum of 0.1m.

4.5.2 *Wind Turbine Foundations*

The turbine foundations at the site are expected to be rectangular with vertical walls. The dimensions of the wind turbine foundations are estimated to be 16m x 16m with the excavations for these estimated at 30m x 30m. Excess excavated peat will be used for reinstatement of the foundation excavation post construction. Therefore, the foundation area represents the volume of peat lost. The minimum and maximum likely dimensions are 16m x 16m and 30m x 30m respectively (ES Chapter 4) (LUC, 2013).

Based on the peat probing undertaken, the average peat depth in the vicinity of the turbines is conservatively estimated to be 0.61m from averages of surrounding measured peat depths (within a 25m radius circular buffer of each turbine; thus completely covering the estimated dimensions of 30m x 30m working area) across the seven turbine locations. Maximum and minimum values for calculator purposes are estimated as $\pm 10\%$ of the expected value of 0.61 m, giving 0.67 m and 0.55 m respectively.

4.5.3 *Hard-standing Area Associated with each Turbine*

The average dimensions of the excavations for crane hard-standings will be 30m x 40m. Assuming that actual dimensions may vary by up to $\pm 5\%$, the maximum and minimum dimensions are 31.5m x 42m and 28.5m x 38m respectively.

Based on the peat probing undertaken, the average peat depth in the vicinity of the turbines, is 0.61m. For the purposes of the calculator, a maximum and minimum of $\pm 10\%$ is assumed, giving peat depths of 0.67m and 0.55m respectively.

4.6 **Access Tracks**

4.6.1 *Access Track Lengths*

The total length of existing track which is deemed already fit for purpose is 1.53km. The total length of access track to be constructed is estimated to be approximately 5km. This includes: site access, all spurs to turbines and borrow pits and the main site access tracks. As the design and construction process progresses, there may be small changes in track length as a result of micro-siting etc. It is considered unlikely that the total track length will change by more than $\pm 5\%$, giving a maximum length of 5.25 km and minimum of 4.75 km.

4.6.2 *Length of Access Track - Floating Track*

There are no plans for floating track reported in ES Chapter 4 Development Description. All values required by the carbon calculator for this section are therefore zero.

4.6.3 *Length of Access Track - Excavated Track*

A cut track design is proposed for the site due to the limited presence of peat onsite. The estimated length of access track using cut and fill construction is therefore approximately 5km.

For convenience in populating the calculator, all cut and fill construction track is considered to be single track. Although this may slightly underestimate the excavation volume, this is offset by the assumption that all excavated material will be peat, which is not the case.

It is unlikely that the total length of cut and fill track will vary by more than $\pm 5\%$, giving a maximum of 5.25km and minimum of 4.75km.

The width of cut and fill track is therefore estimated at 8m including running width (5m), track shoulder (2 x 0.5m) and drainage (2 x 1m) with an average excavated depth of 0.62m, based on measured peat depths within 25m of the proposed access track routes.

The total excavation width will vary with peat depth and local topography, but it is considered unlikely that total track width will vary on average by more than $\pm 0.5\text{m}$, giving a maximum width of 8.5m and minimum of 7.5m.

The average peat depth (0.62m) for cut and fill sections of track, based on peat probing results, is considered to be robust, being based on some 224 measured peat depths within 25m of the new track. Indeed, this is a conservative approach as it assumes all probed material is peat, which will not be the case in practice (*Peat Stability Assessment Technical Appendix* of the Craigton and Spittalhill Wind Farm Environmental Statement) (Mouchel, 2013b). It is recognised that minor changes in access track routing will result in a change in the average depth of peat excavated therefore an error of $\pm 10\%$ is applied to derive the maximum and minimum values for the calculator, giving depths of 0.68m and 0.56m.

4.6.4 *Length of Access Track – Rock Filled Road*

There are no sections of track that are planned to be rock filled.

4.6.5 *Cable Trenches*

It is intended that all cable trenches will follow the route of access tracks.

4.7 **Peat Landslide Hazard**

A peatslide risk assessment has been carried out and this is detailed in the Peat Stability Assessment (Mouchel, 2013b). The majority of the site was considered to have a low risk of peatslide however a higher level of risk was identified in seven locations. Detailed consideration of these locations has resulted in a lowering of the level of risk to 'low' in all locations. For these locations in particular, and all locations in general, following recommended mitigation measures and application of good construction practices will minimise the risk of a peatslide.

Consequently, all entries for this section of the calculator are zero.

4.8 **Improvement of C Sequestration at Site**

Any local improvements to carbon sequestration, for example by blocking of drains or habitat restoration, will result in a reduction in the net carbon emissions from the development.

4.8.1 *Improvement of Degraded Bog*

Peatlands on the site, although in places crossed by historic drainage ditches, appear generally to be in good condition. It has therefore been assumed that there will be no improvement of degraded bog.

4.8.2 *Improvement of Felled Plantation Land*

As there is no felling necessary for construction, there will be no opportunity for improvement of felled plantation land. The area of felled plantation to be improved has therefore been assumed to be zero.

4.8.3 *Restoration of Peat Removed from Borrow Pits*

Peat coverage at the proposed borrow pit location is minimal, with the maximum recorded depth of overburden 1.1 m (Mouchel, 2013c). An Outline Peat Management Plan has been provided as part of this project (Mouchel, 2013d), within which it is considered that peat and any other superficial soils will be removed and stockpiled adjacent to the borrow pit and when construction is complete this material will be utilised to landscape the sides and floor of the excavation. Due

to the shallow nature of surface deposits at the borrow pit location, it is proposed to utilise peat excavated elsewhere on site for restoration, to an appropriate depth.

The surface area of the borrow pit, given in Table 3, is estimated to be 6,300m² in total. As detailed in section 4.5.1, it is estimated that footprint may vary by $\pm 10\%$, giving a maximum of 6,930m² and minimum of 5,670m².

For calculation purposes, It has been assumed that restoration of the borrow pits will be carried out using good practice and that the post-restoration water table in the borrow pits will be similar to the water table across the site. In section 4.1.11, this was estimated to be 0.1m, with maximum and minimum values of 0.3m and 0.0m respectively.

Peat deposits can take many years to develop. The plant communities found on peat bogs are typically slow growing and may take a number of years to become established. In the absence of measured data or detailed study, it has conservatively been estimated that recovery will take 10 years, with a maximum time to recovery of 20 years and minimum of 5 years.

4.8.4 *Removal of Drainage from Foundations and Hardstandings*

It has been assumed that drainage around foundations and hardstandings will be temporary, only necessary during construction. Therefore, the area can be assumed to be drained only up to the time of completion of backfilling, removal of any temporary surface drains, and full restoration of the hydrology. Subsequently, the water table level is assumed to return to its original value of 0.1m. A conservative timescale of six years has been assumed, based on the findings of Isselin-Nondedeu et al (2007) “*Long-term vegetation monitoring to assess the restoration success of a vacuum-mined peatland (Québec, Canada)*”, who report 90% vegetation cover after 6 years. Maximum and minimum time to recovery is estimated to be 10 years and 2 years respectively.

4.9 **Restoration of Site after Decommissioning**

Restoration following decommissioning is likely to reduce the total carbon loss. By restoring the hydrology and returning remaining stored carbon to anaerobic conditions, further oxidative loss will be arrested. Restoration of habitats presents an opportunity for additional carbon sequestration. In the absence of restoration after decommissioning, the model assumes 100% loss of carbon from the drained volume of soil. For the site, good practice will be employed during construction to minimise disruption to peatland hydrology. It is considered likely that access tracks will not be restored. They will remain in situ for use by the landowner or covered in topsoil following wind farm decommissioning.

4.9.1 *Blocking of gullies*

In the event that any gullies in the peat have formed due to erosion during the wind farm operation, these will be blocked using good practice techniques such as plastic piling to promote restoration of the local hydrology. In this case, it has been assumed that the site will be restored on decommissioning.

4.9.2 *Blocking of artificial drainage ditches*

Given that it has been assumed that access tracks will remain in situ post-decommissioning, drainage associated with the access tracks will not be blocked. As good practices will be followed during construction, it is expected that with appropriate maintenance, disruption of local hydrology due to artificial drainage will be minimised.

4.9.3 *Restoration of site habitat*

The site is currently used for rough grazing. It has been assumed that during the operational phase and post decommissioning of the wind farm the current use will continue. Disruption to the site habitat is expected to be minimal.

4.9.4 *Management to favour species reintroduction*

Where there is evidence of degradation of peat bodies, positive action will be taken to restore these. This will include as necessary, programmed planting or seeding of selected plant communities to facilitate restoration of degraded areas. This situation does not apply to this site.

4.10 **Choice of Methodology for Calculating Emission Factors**

There are two choices for methodology. The IPCC method is an internationally accepted standard. However, the values used are rough estimates and an improved estimate can be obtained (IPCC 1997) using site specific values and the site specific estimates generated by the Ecosse project (Smith et al, 2007). Accordingly, the site specific option is chosen as being most appropriate.

4.11 **Summary of Input Data**

The values entered into the carbon calculator are summarised below in Table 4.

Table 4: Summary Calculator Data Values

Input data	Possible range of values		
	Expected value	Minimum value	Maximum value
Windfarm characteristics			
<u>Dimensions</u>			
No. of turbines	7	7	7
Lifetime of windfarm (years)	25	25	25
<u>Performance</u>			
Power rating of turbines (turbine capacity) (MW)	3	3	3
Capacity factor	Direct Entry	Direct Entry	Direct Entry
Estimated Capacity Factor (percentage efficiency)	30.0	27	35.6
<u>Backup</u>			
Extra capacity required for backup (%)	5 (0)	0	5
Additional emissions due to reduced thermal efficiency of the reserve generation (%)	10 (0)	0	10
<u>Carbon dioxide emissions from turbine life -</u> (eg. manufacture, construction, decommissioning)	Calculate wrt installed capacity	Calculate wrt installed capacity	Calculate wrt installed capacity
Characteristics of peatland before windfarm development			
Type of peatland	Acid bog	Acid bog	Acid bog
Average annual air temperature at site (°C)	8.9	5.5	12.2
C Content of dry peat (% by weight)	55	47	63
Average extent of drainage around drainage features at site (m)	10.00	5.00	15.00
Average water table depth at site (m)	0.10	0.00	0.30
Dry soil bulk density (g cm ⁻³)	0.31	0.10	0.96
Characteristics of bog plants			
Time required for regeneration of bog plants after restoration (years)	5	3	10
Carbon accumulation due to C fixation by bog plants in undrained peats (tC ha ⁻¹ yr ⁻¹)	0.25	0.12	0.31
Forestry Plantation Characteristics			
Method used to calculate CO ₂ loss from forest felling	Enter simple data	Enter simple data	Enter simple data
Area of forestry plantation to be felled	0	0	0
Average rate of carbon sequestration in timber (tCha-1yr-1)	0.00	0.00	0.00
Counterfactual emission factors			
To update counterfactual emission factors from the web			
Coal-fired plant emission factor (t CO ₂ MWh ⁻¹)	0.902	0.895	0.906
Grid-mix emission factor (t CO ₂ MWh ⁻¹)	0.46	0.44	0.483
Fossil fuel-mix emission factor (t CO ₂ MWh ⁻¹)	0.636	0.594	0.7
Borrow pits			
Number of borrow pits	1	0	1
Average length of pits (m)	79.37	75.3	83.25
Average width of pits (m)	79.37	75.3	83.25
Average depth of peat removed from pit (m)	0.60	0.10	1.10

Foundations and hard-standing area associated with each turbine			
Method used to calculate CO ₂ loss from foundations and hard-standing	Rectangular with vertical walls	Rectangular with vertical walls	Rectangular with vertical walls
Average length of turbine foundations (m)	16	16	30
Average width of turbine foundations (m)	16	16	30
Average depth of peat removed from turbine foundations (m)	0.61	0.55	0.67
Average length of hardstanding (m)	30	28.5	31.5
Average width of hardstanding (m)	40	38	42
Average depth of peat removed from hard-standing (m)	0.61	0.55	0.67
Access tracks			
Total length of access track (m)	5000	4750	5250
Existing track length (m)	1530	1530	1530
<u>Length of access track that is floating road (m)</u>	0	0	0
Floating road width (m)	0	0	0
Floating road depth (m)	0.00	0.00	0.00
Length of floating road that is drained (m)	0	0	0
Average depth of drains associated with floating roads (m)	0.00	0.00	0.00
<u>Length of access track that is excavated road (m)</u>	5000	4750	5250
Excavated road width (m)	8	7.5	8.5
Average depth of peat excavated for road (m)	0.62	0.56	0.68
<u>Length of access track that is rock filled road (m)</u>	0	0	0
Rock filled road width (m)	0	0	0
Rock filled road depth (m)	0	0	0
Length of rock filled road that is drained (m)	0	0	0
Average depth of drains associated with rock filled roads (m)	0.00	0.00	0.00
Cable Trenches			
Length of any cable trench on peat that does not follow access tracks and is lined with a permeable medium (eg. sand) (m)	0	0	0
Average depth of peat cut for cable trenches (m)	0.00	0.00	0.00
Additional peat excavated (not already accounted for above)			
Volume of additional peat excavated (m ³)	0	0	0
Area of additional peat excavated (m ²)	0.0	0.0	0.0
Peat Landslide Hazard			
Weblink: Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments	0	0	0
Improvement of C sequestration at site by blocking drains, restoration of habitat etc			
<u>Improvement of degraded bog</u>			
Area of degraded bog to be improved (ha)	0	0	0
Water table depth in degraded bog before improvement (m)	0.00	0.00	0.00
Water table depth in degraded bog after improvement (m)	0.00	0.00	0.00

Time required for hydrology and habitat of bog to return to its previous state on improvement (years)	0	0.00	0.00
<u>Improvement of felled plantation land</u>			
Area of felled plantation to be improved (ha)	0	0	0
Water table depth in felled area before improvement (m)	0.00	0.00	0.00
Water table depth in felled area after improvement (m)	0.00	0.00	0.00
Time required for hydrology and habitat of felled plantation to return to its previous state on improvement (years)	0	0	0
<u>Restoration of peat removed from borrow pits</u>			
Area of borrow pits to be restored (ha)	0.63	0.57	0.69
Water table depth in borrow pit before restoration (m)	0.1	0	0.3
Water table depth in borrow pit after restoration (m)	0.10	0.00	0.30
Time required for hydrology and habitat of borrow pit to return to its previous state on restoration (years)	10.0	5.0	20.0
<u>Removal of drainage from foundations and hardstanding</u>			
Water table depth around foundations and hardstanding before restoration (m)	0.10	0.00	0.30
Water table depth around foundations and hardstanding after restoration (m)	0.10	0.00	0.30
Time to completion of backfilling, removal of any surface drains, and full restoration of the hydrology (years)	6	2	10
Restoration of site after decommissioning			
Will the hydrology of the site be restored on decommissioning?	Yes	Yes	Yes
Will you attempt to block any gullies that have formed due to the windfarm?	Yes	Yes	Yes
Will you attempt to block all artificial ditches and facilitate rewetting?	No	No	No
Will the habitat of the site be restored on decommissioning?	Yes	Yes	Yes
Will the habitat of the site be restored on decommissioning?	Yes	Yes	Yes
Will you control grazing on degraded areas?	No	No	No
Will you manage areas to favour reintroduction of species	Yes	Yes	Yes
Choice of methodology for calculating emission factors	Site Specific		

5 Output from carbon calculator

Based on the figures input to the carbon calculator as described in section 4, the total carbon losses associated with the wind farm development and predicted payback time for the wind farm are detailed in Tables 5 and 6, below.

Table 5: Total Carbon Losses Due To Wind Farm

Source of Losses	Carbon losses (tCO ₂ yr ⁻¹)		
	Expected Value*	Minimum Value	Maximum Value
Turbine life cycle	16,349	16,349	16,349
Backup generation	14,625 (0)	0	16,097
Reduction in carbon fixing potential	487	123	1,054
Soil organic matter	37,351	4,376	188,546
DOC & POC leaching	0	1	0
Felling of forestry	0	0	0
Total	68,812 (54,187)	20,848	222,044

* Numbers in brackets reflect carbon losses for the scenario where no backup generation capacity is required.

With the exception of the backup generation (assumed to be from fossil fuel sources), the carbon losses are independent of the generation mix used to calculate the overall carbon balance. Assuming a requirement for backup generation capacity, the calculator model indicates that based on expected values, over 23.8% of the carbon losses are from turbine life cycle, with approximately 54.3% due to losses of soil organic matter, as demonstrated in Table 5.

Over 21% of the potential carbon losses are due to the requirement for backup power generation. As discussed in section 4.1.3, it is likely that the need for backup power generation will be much smaller, perhaps for 10% or less of the wind farm's proposed operational period of 25 years. Should no backup generation capacity be required, emissions from turbine life cycle and soil organic matter losses account for over 99% of carbon emissions.

Table 6: Payback Time Table

Generation Source	Counterfactual emission factors (tCO ₂ MWh ⁻¹)	Carbon Payback time (years)			
		Expected Value		Minimum Value	Maximum Value
		0% Backup	5% Backup		
Coal fired	0.902	1.1	1.4	0.3	5.0
Grid Mix	0.460	2.1	2.7	0.6	10.2
Fossil Fuel Mix	0.636	1.5	2.0	0.4	7.5

Given that the “Grid-mix” will involve renewable energy developments that are operational, the “Fossil fuel-mix” represents the most likely scenario in terms of the existing capacity to be replaced by electricity generated from the site.

Therefore, with the figures used as described in section 4 and assuming a requirement for backup generation capacity of 5%, the expected payback time is calculated to be approximately 2 years or 24 months. With a 25 year operational life, this would mean that this development would save over twelve times the carbon emissions generated. Based on the worst case scenario, represented by the maximum values entered in the calculator, payback time is calculated to be 7.5 years, or 90 months.

The more likely scenario is that there will be little or no requirement for backup generation capacity, based on predictions for the growth in the contribution of wind energy to the national grid. With no requirement for backup capacity, the carbon payback period is reduced to 1.5 years (18 months) based on the “Fossil Fuel-mix”, equating to carbon emission savings of over sixteen times those generated for a 25 year operational period.

6 Conclusions

Use of the carbon calculator with best estimate values, based on available information, indicates that the site will pay back the carbon emissions associated with its construction and operation in 2 years. Assuming a 25 year wind farm life, this equates to an overall carbon saving of over twelve times the carbon emitted.

Outputs from the carbon calculator demonstrate some key points, summarised below:

- There are two principal sources of carbon emission covering the life of the wind farm. These are emissions due to turbine life cycle and emissions due to losses of soil organic matter. Between them, these account for over 78% of the carbon losses due to the development (over 99% in the scenario where backup generation is not required).
- A third potential source of carbon loss is from the need for backup power generation due to the inherent variability of wind. This has been conservatively estimated to contribute over 21% of total carbon emissions. It is not anticipated that backup power generation will be required until the latter few years of the wind farms proposed 25 year operational period.
- In compiling carbon data, a conservative approach has been taken, therefore little allowance has been made for CO₂ gains due to onsite improvements
- The large range between expected and maximum soil organic matter (SOM) has been attributed to the dry bulk density mean and maximum values obtained from all 8 core samples analysed. As discussed in section 4.1.12, the maximum dry bulk density value obtained (0.956Mgm⁻³) was identified as clay and therefore has had a skewing effect on the results. It is noted that, as the calculator is designed to assess CO₂ losses and gains for development on peat, the high density is assumed to be predominantly organic material resulting in this magnified loss of CO₂ through SOM. In reality, this is known to be incorrect considering the presence of clay. This is a clear demonstration of the very conservative approach taken for this assessment. If the outlier in this case is replaced by the second highest value of 0.314Mgm⁻³, the SOM maximum value of loss reduces from 188,546tCO₂yr⁻¹ to 60,901tCO₂yr⁻¹. Furthermore, the mean value of the reduced dataset reduces to 0.214Mgm⁻³, with the associated expected value reducing from 37,351 to 25,860.
- In further demonstration of the conservative approach taken it is worth considering the shallow depth of water table which has been consistently applied throughout the assessment

for the entire site, when in actuality this is only correct for a small number of turbine base locations on the lower ground, near the Backside Burn.

Although it is possible that some combination of changes could have an impact greater than the sum of their individual effects on payback, the sensitivity analysis embedded within the carbon calculator demonstrates that, even using conservative values for all of the factors contributing to the overall estimation of carbon payback, the carbon savings of the wind farm will still be significantly greater than the carbon emissions attributable to the development.

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Appendix A

Natural bulk density laboratory results

Natural bulk density laboratory results

Sample Identification				Moisture Content (%)	Bulk Density (Mg/m ³)	Dry Density (Mg/m ³)
Hole ID	Type	Number	Depth			
C5C01	B	297208	m	422.0	1.044	0.2
C5C03	B	297209	m	289.0	1.109	0.286
C5C04	B	297210	m	827.0	0.964	0.104
C5C08	B	297212	m	435.0	1.031	0.193
C5C10	B	297213	m	65.0	1.578	0.956
C5C11	B	297214	m	342.0	1.074	0.243
C5C02	B	297207	m	572.0	1.066	0.159
C5C05	B	297211	m	240.0	1.067	0.314