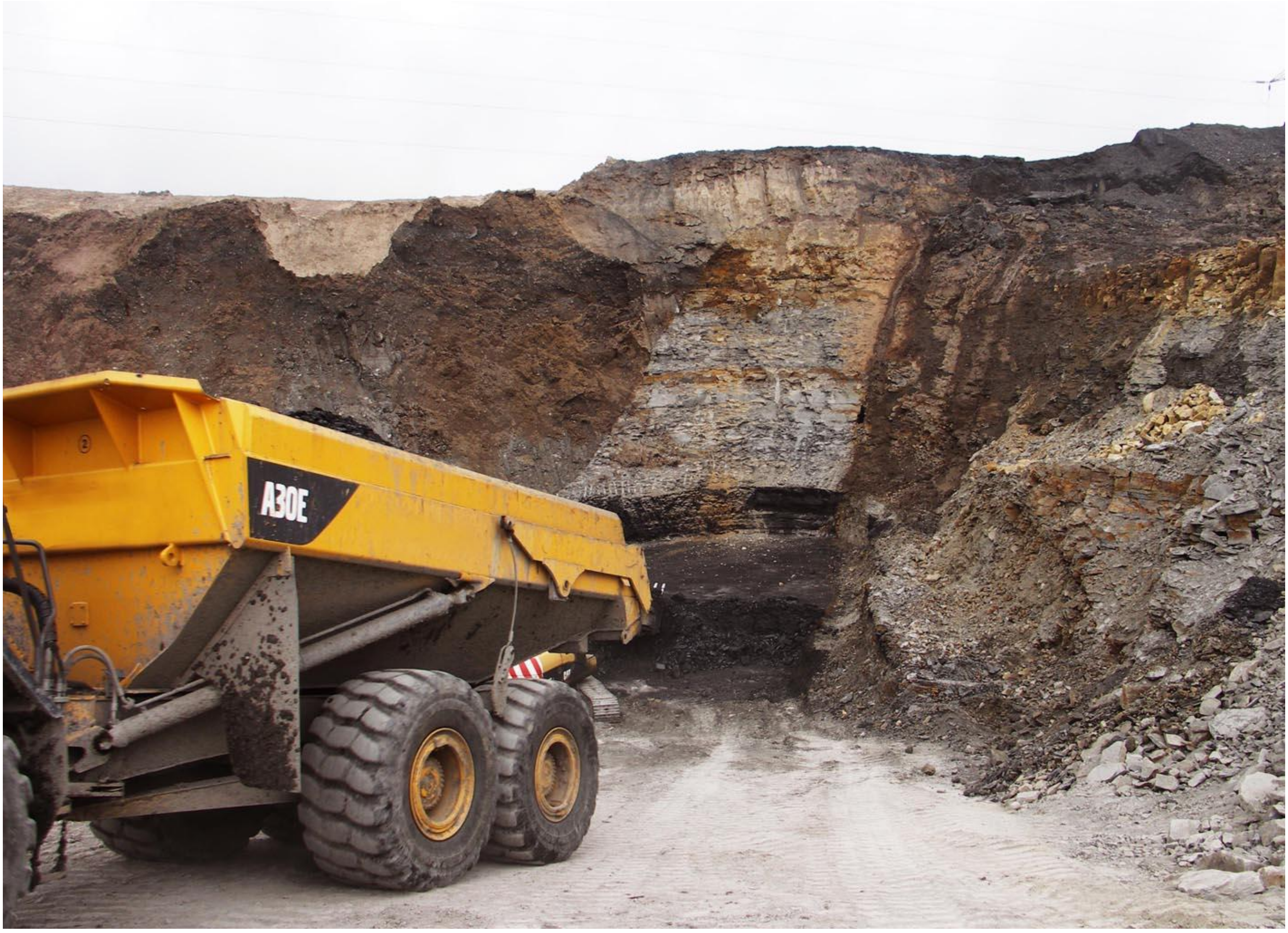

Kirkan Wind Farm Limited

Kirkan Wind Farm: Borrow Pit Assessment

Technical Appendix 9.3

650395-P9.3 (02)

MARCH 2019

RSK GENERAL NOTES

Project No.: 650395-P9.3 (02)

Title: Kirkan Wind Farm: Borrow Pit Assessment

Client: Kirkan Wind Farm Limited

Date: 19th March 2019

Office: Stirling

Status: Final

Author	Catherine Isherwood	**Technical reviewer**	Andrew Gunning
Date:	19/03/2019	Date:	19/03/2019

Project manager	Joe Somerville
Date:	25/03/2019

CONTENTS

TABLES

FIGURES

1 INTRODUCTION

1.1 This report provides a Borrow Pit Assessment for Kirkan Wind Farm and associated development infrastructure.

1.2 The report forms a Technical Appendix to the Environmental Impact Assessment Report for Kirkan Wind Farm and should be read in conjunction with this document. It has been produced to address the requirement for aggregate for the project to supply the construction needs for access tracks and hardstanding areas, including ongoing supply for track maintenance during the operation of the project.

1.3 This report quantifies the aggregate requirement, appropriate locations within the project area from which this material can be sourced and addresses the suitability of the material for the required purpose. Potential impacts from aggregate extraction, processing and transportation are considered and assessed. Design and mitigation measures to avoid or minimise these impacts are set out, along with a number of good construction practices that would be employed during all site works.

Site location

1.4 The project area is located on Strathvaich Estate, in the Garve District of the Ross and Cromarty Region of the Highlands. The project area lies to the south of the A835 trunk road from Garve to Ullapool, and to the east of the operational Corriemoillie and Lochluichart wind farms.

1.5 The project area is approximately 5.3 km north-west of the village of Garve and approximately 19 km west-north-west of Dingwall. Ullapool is approximately 32 km to the north-west. The Aultguish Inn lies 490 m north-west of the project area's northern boundary.

Development proposals

1.6 The Kirkan Wind Farm proposal includes the following key elements:

- 17 turbines, of approximately up to 4.8 MW each and a maximum tip height of 175 m;
- Hardstanding areas at the base of each turbine, with a maximum total area of 1,850 m^2;
- Up to 2 permanent meteorological masts and associated hardstanding areas;
- 10,835 m of access track with associated watercourse crossings, of which 9,975 m is new access track, and 860 m is upgrade to existing track;
- An operations control building with parking and temporary welfare facilities;
- A substation compound;
- A substation construction compound, providing space for a prospective modular energy storage facility;
- Telecommunications equipment, including masts;
- Up to three temporary construction compounds;

- Two borrow pits, to provide suitable rock for access tracks, turbine bases and hard standings; and
- Underground cabling linking the turbines with the substation.

1.7 Full details of the project design are provided in Chapter 2 of the EIAR.

Aims

1.8 This report aims to undertake a review of available relevant site information, including all track design specifications, to produce borrow pit designs and development plans in order to address the aggregate need for the site construction and operational maintenance. Recommendations will be made for mitigation measures and reinstatement to minimise potential landscape, visual, hydrological and hydrogeological impacts from the excavations. Potential impacts from noise, dust and vibration are also considered.

Assessment method

1.9 The assessment has involved the following stages:

- Desk study;
- Site reconnaissance;
- Borrow pit design;
- Discussion.

2 DESK STUDY

Information sources

2.1 The desk study involved a review of available relevant information sources on the ground conditions in the project area. Information sources included:

- Ordnance Survey mapping at 1:50,000, 1:25,000 and VectorMap Local raster mapping, Terrain 50 digital terrain model contours and OpenData mapping;
- Ordnance Survey MasterMap high-resolution orthorectified aerial imagery;
- British Geological Survey online geological mapping, 1:50,000 scale;
- Scotland's Soils digital soil mapping, 1:250,000 scale;
- Data provided by the client, including turbine foundation and track design specifications;
- Archive and extensive site data held by RSK Group.

Geology

2.2 Geological information is derived from the BGS GeoIndex online geological mapping (BGS, 2018) and the Ben Wyvis Geological Map (BGS, 2004) with supporting information from Trewin (2002) and Johnstone and Mykura (1989).

Bedrock geology

2.3 The bedrock in the Kirkan area is largely Pre-Cambrian in age. The western part belongs to the Crom Psammite Formation, part of the Moine Supergroup. This is described as a well-bedded, flaggy to massive, white to pale grey or buff psammite. The lower sections include garnet-bearing semipelite bands and the upper part is locally pebbly.

2.4 The eastern part of the project area is underlain by the Inchbae augen gneiss, a granitic gneiss forming part of the Carn Chuinneag Complex. This distinctive rock is described as a coarse biotite-granite gneiss with abundant feldspar augen ('eyes').

2.5 A small area around Beinn nan Cabag, in the south of the project area, is underlain by the Ousdale Arkose Formation, part of the Devonian-age Old Red Sandstone system. The rock is described as a red feldspar-rich conglomerate.

2.6 A major regional fault, the Strathconon Fault, runs through the project area from just west of Beinn nan Cabag to Black Bridge (BGS, 2018; Johnstone and Mykura, 1989). There are no records of recent or historical activity along the fault within the project area and immediate surroundings (BGS, 2019).

Superficial geology

2.7 Much of the project area is overlain by a blanket of glacial deposits, described as diamicton, gravel, sand and silt. Diamicton is a very variable glacial sediment consisting of unsorted material ranging in size from clay to boulders, usually with a matrix of clay to sand. It was formerly known as till or boulder clay.

2.8 The river valleys have deposits of alluvium, a mixture of clay, silt, sand and gravel. These are confined to the River Glascarnoch/Black Water channel and the lower reaches of the main site watercourses and tend to be ribbon-like in form.

2.9 The south-western part of the project area is shown to have peat deposits. These extend from the upper reaches of Allt Giubhais Beag, skirting the western and southern slopes of Sìthean nan Cearc, to the upper reaches of Allt Bad an t-Seabhaig. Some outlying areas are indicated along the Allt Glac an t-Sìthein.

Rock volumes

2.10 Calculation of aggregate requirement has been undertaken using details of the track and infrastructure design provided by Kirkan Wind Farm Limited. The access track route has been planned to make use of existing infrastructure where this is available, to help to minimise the requirement for new aggregate. A contingency allowance of 25% has been included in the volume estimates to allow for under-estimation in the requirements and for some of the excavated material being unsuitable for construction use.

2.11 The calculated aggregate requirement is provided in Table 9.3.1.

Table 9.3.1: Aggregate volumes for construction

Infrastructure	Area (m^2)	Depth (m)	Volume (m^3)
Turbines (17 no)	702	0.75	8,954
Turbine hardstandings (17 no)	1,984	0.75	25,299
Access track (10,835 m length) inc. turning heads & passing places	114,555	0.75	85,916
Met masts (2 no)	132	0.75	198
Compounds (5 no)	20,740	0.75	15,555
		Total (m^3):	135,922
		Total including contingency (m^3):	**170,000**

2.12 It is anticipated that the initial section of track would be constructed with imported stone until the first of the internal borrow pit locations is reached. The turbine foundations, hardstanding areas and all internal access tracks after the first borrow pit are anticipated to be constructed using rock sourced from the site.

2.13 The volumes of material to be supplied from each source are provided in Table 9.3.2.

Table 9.3.2: Aggregate volumes by source

Aggregate source	Volume (m^3)
Import from commercial source	25,700
Site borrow pits (2 no)	144,300
Total (m^3):	**170,000**

Design optimisation

2.14 Design optimisation considers alternative directions and modes of working. The optimised borrow pit designs provide in the first instance for the rock requirement whilst also considering, in line with PAN 50, potential impacts on:

- Landscape;
- Ecology;
- Hydrology;
- Hydrogeology.

2.15 Potential impacts on human beings relate principally to operational factors and include:

- Noise;
- Vibration;
- Dust;
- Visibility.

2.16 The physical constraints of rock suitability and topography, and the requirement to plan for a suitable restoration scheme, have been primary considerations in the borrow pit design. The preferred option has been to open two borrow pits, both to supply rock aggregate, within the main wind farm area and to create the access to the first borrow pit site through imported rock material from a commercial source. The rock at both borrow pit locations has been assessed visually by an experienced geotechnical specialist as potentially suitable for track and hardstanding construction. The location of both pits is adjacent to the site access tracks and has been designed to minimise visibility from key viewpoints.

3 BORROW PIT METHOD OF WORKING

The Quarries Regulations 1999

3.1 The principles of the *Quarries Regulations 1999* would be followed by the contractor appointed by Kirkan Wind Farm Limited to provide a safe working environment during the development of the site borrow pits. The excavation designs have to provide, in the first instance, safe and stable slopes which encompass the principle of '*design for closure*'. Haul and access roads should be of adequate width for the plant used on site and allow for the provision of edge protection in all locations where applicable.

The Water Environment (Controlled Activities) (Scotland) Regulations 2011

3.2 The *Water Environment (Controlled Activities) (Scotland) Regulations 2011* as amended set out good practice guidelines to prevent pollution of the groundwater environment. These guidelines reflect good operational practices and would be implemented at the site.

3.3 Where authorisations are required for process plant operation or consents to discharge (under the *Water Environment (Controlled Activities) (Scotland) Regulations 2011* as amended and the *Pollution Prevention and Control (Scotland) Regulations 2012*) these would be obtained in advance from the Scottish Environment Protection Agency (SEPA).

Borrow Pit 1: Development

3.4 Figure 9.3.1 below shows a view across the area of Borrow Pit 1 (BP1), together with a close-up view of the bedrock present at the site.

Figure 9.3.1: (a) View south across BP1. (b) Close-up of augen gneiss bedrock.

3.5 The existing topography of the proposed borrow pit BP1 area is illustrated on Figure 9.3.3. Figure 9.3.4 shows the borrow pit development plan and Figure 9.3.5 shows the indicative restoration plan. Cross sections through the existing and development topographies of the borrow pit area are provided in Figure 9.3.6.

Topsoil stripping and storage

3.6 The peat depth reconnaissance surveys confirm that the proposed borrow pit area has no peat cover. Soil is present across the area at depths of up to 0.4 m, with some limited areas of bedrock exposure. It has been assumed that the average depth of soil across the borrow pit footprint is 0.35 m, based on site measurements. The site has a relatively uniform slope with localised undulations and is currently rough open moorland.

3.7 The borrow pit would be worked in strips, to ensure that only enough aggregate for the development is obtained and to limit the impacts of the borrow pit to as confined an area as possible.

3.8 Topsoil would be removed in strips from the initial excavation area and would be stored in a temporary storage area. The topsoil storage mound would not exceed 2 m in height, to minimise compaction of the soil, and would be shaped to promote shedding of water. Some limited blading would be undertaken on the soil mound surface to assist in shedding of water and to minimise surface erosion in wet conditions. Mounds would not be compacted.

3.9 As the borrow pit excavation develops, the topsoil would be removed in advance of the active excavation and would be progressively restored over the worked-out areas of the borrow pit where possible, to minimise duration of soil storage. All removed topsoil, plus rock material unsuitable for use as aggregate or fill, would be used in the final restoration of the borrow pit.

Extraction of rock

3.10 The augen gneiss rock would be obtained by blasting. The blast techniques to be used would depend on the depth of rock to the borrow pit floor level at 307 m AOD. Pattern blasting is recommended for the initial opening-up of the borrow pit, blasting at shallow depths initially at the borrow pit entrance and gradually increasing in depth as the land rises to the west.

3.11 Pattern blasting involves the drilling of blast holes on a grid layout, normally to a depth of up to 6 m, and is mostly used where no pre-existing natural face is present. Once the fragmented rock is removed, blasting can continue from the rock faces created, using continued pattern blasting or face blasting as appropriate. Face blasting typically involves one or two rows of blast holes drilled to the target depth parallel to and behind an existing face.

3.12 The proposed site of the borrow pit is on rising and slightly undulating ground. The borrow pit has been designed to have two main working faces and four subsidiary faces, with an intermediate bench at 317 m AOD and a gently sloping floor level at 307 m AOD. Faces would be up to 10 m in height, blasted at an angle of 75° from the horizontal. The general direction of working would be to the west-north-west, with blasted rock removed and transported to the relevant area of construction.

3.13 Drainage would be directed to the south-east corner, where water treatment would be provided for the borrow pit and for the adjacent Turbine 3 and hardstanding area. The borrow pit floor would have a gentle slope during rock extraction, to allow for free drainage out of the borrow pit. This may be modified as part of the restoration process, depending on the ecological outcomes desired following restoration.

3.14 The borrow pit would be accessed directly from the Turbine 3 hardstanding.

3.15 Operational effects from noise and dust would be minimised by keeping the use of processing plant to a minimum. The blast pattern would be kept tight to maximise fragmentation, although some processing is likely to be required to produce aggregate of suitable grade for track construction. Blast design, including charge weights and delays, is the responsibility of the contractor. Processing plant would be operated only for short periods of time, as necessary to provide the aggregate requirement for construction works.

Drainage

3.16 Natural slope runoff would be diverted around the active excavation area by construction of a low soil bund (0.5 m high) around the outer edge of the excavation, to ensure that runoff is prevented from flowing directly into the excavation. Blind ditches would be created as necessary to control water flow.

3.17 During blasting operations, joints and fractures in the sub-drill zone below the target extraction level are opened up by the expansion of gases generated by the explosives. In consequence, incident rainfall into the operational area would mostly infiltrate into the borrow pit floor. Any excess runoff would be diverted towards a constructed water collection sump, from where collected water would be allowed to discharge slowly onto vegetated ground below the borrow pit.

Restoration

3.18 Figure 9.3.5 illustrates the restoration plan for BP1. The excavation edges would be softened with respect to the immediately adjacent hillside by earthworks and/or restoration blasting as appropriate. Any unusable material from the excavation would be used in restoration of the borrow pit. Restored faces would have a maximum slope of 27° and stored topsoil would be replaced over the restored faces to facilitate re-vegetation and the final restoration of the borrow pit. Excavated peat would be used within the lower part of the borrow pit to create an area of peatland habitat.

3.19 Borrow pit floors would be ripped or routed to break up the surface and soils and turf material would be replaced over the area. Locally sourced heather brash may be used to help in the restoration process. The site soils would contain a natural rough moorland seedbank and it is anticipated that natural vegetation would re-establish over time. Additional seeding may be required; this would be assessed by the Environmental Clerk of Works at the point of restoration and a suitable upland grass seed mix would be identified for this process.

3.20 Part of the borrow pit would be kept available for track and hardstanding maintenance work during the lifetime of the wind farm. Once the wind farm ceases operation, the borrow pit would be fully restored.

Borrow Pit 2: Development

3.21 Figure 9.3.2 below shows a view across the area of Borrow Pit 2 (BP2), together with a close-up view of the bedrock present at the site.

3.22 The existing topography of the proposed borrow pit BP2 area is illustrated on Figure 9.3.3. Figure 9.3.4 shows the borrow pit development plan and Figure 9.3.5 shows the indicative restoration plan. Cross sections through the existing and development topographies of the borrow pit area are provided in Figure 9.3.6.

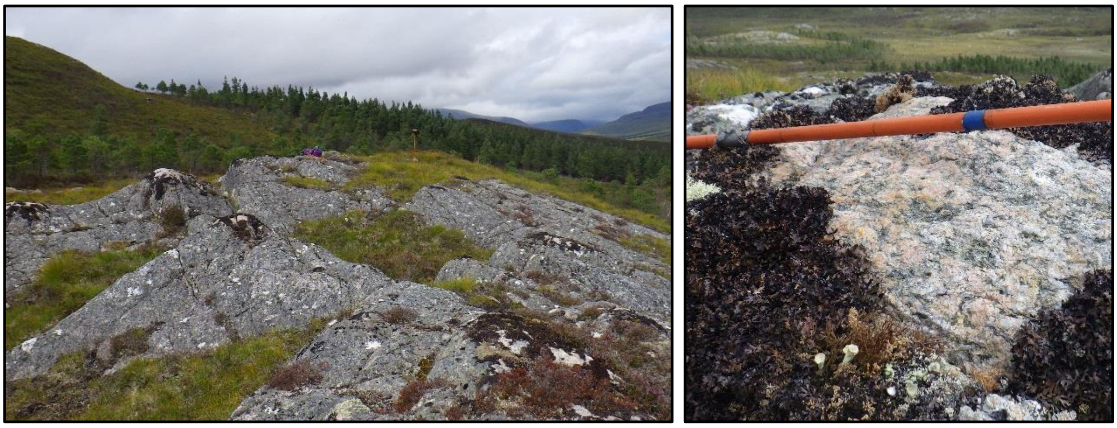

Figure 9.3.2: (a) View north-west across BP2. (b) Close-up of augen gneiss bedrock (marks on probe at 10 cm interval).

Topsoil stripping and storage

3.23 The peat depth reconnaissance surveys confirm that the proposed borrow pit area has limited peat cover, with a small pocket towards the northern margin having peat up to 0.9 m in depth. Most of the site has no peat and soil is present across the area at depths of up to 0.45 m, with fairly extensive areas of bedrock exposure. It has been assumed that the average depth of peat and soil across the borrow pit footprint is 0.35 m, based on site measurements. The site has a relatively uniform slope, steepening to the west, with localised undulations and is under a mix of native woodland, mainly Scots pine, and rough open moorland.

3.24 The borrow pit would be worked in strips, to ensure that only enough aggregate for the development is obtained and to limit the impacts of the borrow pit to as confined an area as possible. If ground conditions make it possible, the area of peat would be avoided during the borrow pit excavation works.

3.25 Topsoil and, where required, peat acrotelm, would be removed in strips from the initial excavation area and would be stored in a temporary storage area. Topsoil and peat would be stored in separate mounds. The storage mounds would not exceed 2 m in height, to minimise compaction of the soil and peat, and would be shaped to promote shedding of water. Some limited blading would be undertaken on the soil mound surface to assist in shedding of water and to minimise surface erosion in wet conditions. Mounds would not be compacted.

3.26 As the borrow pit excavation develops, the topsoil and/or peat acrotelm would be removed in advance of the active excavation and would be progressively restored over the worked-out areas of the borrow pit where possible, to minimise duration of soil and peat storage. All removed topsoil, plus rock material unsuitable for use as aggregate or fill, would be used in the final restoration of the borrow pit.

Extraction of rock

3.27 The augen gneiss rock would be obtained by blasting. The blast techniques to be used would depend on the depth of rock to the borrow pit floor level at 320 m AOD. Pattern blasting is recommended for the initial opening-up of the borrow pit, blasting at shallow depths initially at the borrow pit entrance and gradually increasing in depth as the land rises to the west. Face blasting is expected to form the main method of extraction once a rock face has been established.

3.28 The proposed site of the borrow pit is on rising and slightly undulating ground. The borrow pit has been designed to have two main working faces and four subsidiary faces, with an intermediate bench at 333 m AOD and a gently sloping floor level at 320 m AOD. Faces would be up to 13 m in height, blasted at an angle of 75° from the horizontal. The general direction of working would be to the west, with blasted rock removed and transported to the relevant area of construction.

3.29 Drainage would be directed to the south-east corner, where water treatment would be provided for the borrow pit area. The borrow pit floor would have a gentle slope during rock extraction, to allow for free drainage out of the borrow pit. This may be modified as part of the restoration process, depending on the ecological outcomes desired following restoration.

3.30 The borrow pit would be accessed directly from a short approach track from Turbine 12.

3.31 Operational effects from noise and dust would be minimised by keeping the use of processing plant to a minimum. The blast pattern would be kept tight to maximise fragmentation, although some processing is likely to be required to produce aggregate of suitable grade for track construction. Blast design, including charge weights and delays, is the responsibility of the contractor. Processing plant would be operated only for short periods of time, as necessary to provide the aggregate requirement for construction works.

Drainage

3.32 Natural slope runoff would be diverted around the active excavation area by construction of a low soil bund (0.5 m high) around the outer edge of the excavation, to ensure that runoff is prevented from flowing directly into the excavation. Blind ditches would be created as necessary to control water flow.

3.33 During blasting operations, joints and fractures in the sub-drill zone below the target extraction level are opened up by the expansion of gases generated by the explosives. In consequence, incident rainfall into the operational area would mostly infiltrate into the borrow pit floor. Any excess runoff would be diverted towards a constructed water collection sump, from where collected water would be allowed to discharge slowly onto vegetated ground below the borrow pit.

Restoration

3.34 Figure 9.3.5 illustrates the restoration plan for BP2. The excavation edges would be softened with respect to the immediately adjacent hillside by earthworks and/or restoration blasting. Any unusable material from the excavation would be used in restoration of the borrow pit. Restored faces would have a maximum slope of 27° and stored topsoil would be replaced over the restored faces to facilitate re-vegetation and the final restoration of the borrow pit. Excavated peat would be used within the lower part of the borrow pit to create an area of peatland habitat.

3.35 Borrow pit floors would be ripped or routed to break up the surface and soils and turf material would be replaced over the area. Locally sourced heather brash may be used to help in the restoration process. The site soils would contain a natural rough moorland seedbank and it is anticipated that natural vegetation would re-establish over time. Additional seeding may be required; this would be assessed by the Environmental Clerk of Works at the point of restoration and a suitable upland grass seed mix would be identified for this process.

3.36 Part of the borrow pit would be kept available for track and hardstanding maintenance work during the lifetime of the wind farm. Once the wind farm ceases operation, the borrow pit would be fully restored.

4 ENVIRONMENTAL REVIEW

4.1 Most potential environmental effects associated with borrow pit development have been considered within the relevant EIAR chapters. As a result, this section provides a brief review of environmental issues not addressed elsewhere.

Dust

4.2 Borrow pit operations are small-scale, owing to the small aggregate volume requirement for the wind farm track and hardstanding construction.

4.3 Dust emissions can arise from blasting, processing, loading-out and stockpiled material. They are sensitive to weather conditions, typically being worst in dry and windy weather. Water sprays would be available on site for use in dust suppression in dry and windy conditions, to control and minimise dust emissions. Any processing plant brought to site would have integral dust suppression systems to control dust emissions during processing. Effects from dust would be limited to active excavation at the borrow pits, notably during blasting, processing and loading-out of blasted and processed material. With appropriate controls in place, effects from dust emissions would be negligible.

Lighting

4.4 Any lighting associated with the borrow pits should have a clearly defined purpose and be directed to where it is required in order to provide a safe working environment. Lighting would only be used when necessary and would be switched off when not required.

Site stability

4.5 Site stability has been assessed as part of the survey and design work for the borrow pits and has been incorporated into the design as part of a safe working environment. The proposed restoration scheme takes into consideration the requirement for long-term safety with respect to future landuse.

5 CONCLUSIONS

5.1 This report sets out details with respect to the operational design for the borrow pits for Kirkan Wind Farm, in order to supply the need for the proposed access track, turbine foundations and hardstanding requirements for the development. The borrow pit design and recommended method of operation are in line with the *Quarries Regulations, Approved Code of Practice, 1999* (as amended) to provide a safe working environment and minimise risk of instability.

5.2 An Environmental Review of potential effects from the borrow pit operation has been undertaken. Use of best practice working methods and other mitigation methods as appropriate would be put in place during all borrow pit operations. It is concluded that residual effects would be short-term, temporary and minor adverse during borrow pit operation, decreasing to negligible following full restoration of the borrow pit areas.

6 REFERENCES

BGS (2004). Ben Wyvis: Bedrock and superficial geology. British Geological Survey, Geological Survey of Scotland 1:63,360/1:50,000 geological map series. Available to view at http://www.bgs.ac.uk/data/maps/maps.cfc?method=viewRecord&mapId=11135, accessed December 2018.

BGS (2018). GeoIndex online geological mapping. British Geological Survey. http://mapapps2.bgs.ac.uk/geoindex/home.html, accessed December 2018.

BGS (2019). Geology of Britain viewer. British Geological Survey. Available at http://mapapps.bgs.ac.uk/geologyofbritain/home.html?mode=earthquakes, accessed January 2019.

HSE (2013). Health and Safety at Quarries: The Quarries Regulations 1999, Approved Code of Practice and Guidance, 2nd Edition. HSE Books. Available at http://www.hse.gov.uk/pubns/books/l118.htm, accessed December 2018.

Johnstone, G.S., & Mykura, W. (1989). *The Northern Highlands of Scotland*, 4th Edition. Volume 2 of British Regional Geology Guides. British Geological Survey, Nottingham.

Trewin, N.H. (2002). *The Geology of Scotland*, 4th Edition. The Geological Society, London.