Appendix 6.6

Initial Borrow Pit Assessment

SCOTTISHPOWER RENEWABLES

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1 Introduction

1. This report forms an appendix to the **Chapter 6: Hydrology, Hydrogeology, Geology and Soils** of the Environmental Impact Assessment Report (EIAR) and should be read with reference to this chapter and associated figures.

2. The Proposed Development comprises up to 13 wind turbines and associated infrastructure, including proposed access tracks, Substation Compound, temporary construction compounds and borrow pits. The Proposed Development is located approximately six kilometres (km) south of Straiton, entirely within the South Ayrshire Council area, and is described more fully in **Chapter 6: Hydrology, Hydrogeology, Geology and Soils** of the EIAR.

3. To minimise the volume of material imported to the Site and any subsequent environmental impact, site-won aggregate is proposed for construction and understood to be available in sufficient quantities. Aggregate would be required for the construction of access tracks, wind turbine foundations back-fill, compounds, hardstanding areas and concrete. It has been calculated that the cut and fill track construction method alone would not generate sufficient aggregate. Therefore, there is a need for additional excavation of aggregate material.

4. This appendix presents the findings of a borrow pit search area assessment for the Proposed Development, in which four potential borrow pit search areas (hereafter referred to as BP01, BP02, BP03 and BP04) were evaluated. Borrow pit search areas are proposed to be a potential source of windfarm earthworks and granular pavement construction materials. These locations are illustrated in **Figure 4.1 Site Layout** of the EIAR.

2 Aims

5. The aims of this assessment were to provide:

   - preliminary assessment of the suitability of the bedrock for construction purposes;
   - indicative borrow pit search area dimensions;
   - indicative extraction volumes;
   - estimates of overburden at the borrow pit search areas;
   - indication of potential extraction methods;
   - recommendations for geotechnical testing; and
   - preliminary borrow pit search areas re-instatement and rehabilitation proposals.

6. This report outlines WSP's method for borrow pit search area assessment along with the analysis undertaken; conclusions drawn and recommendations for borrow pit search areas.

7. It should be noted that all borrow pit search area information provided within this report is indicative only and is based on available desk study and reconnaissance survey information 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.

3 Project Method

8. Desk study and a walkover survey were undertaken by an Engineering Geologist. The desk study consisted of a review of available information with regard to the identified Site. The information reviewed includes:
   - British Geological Survey (BGS) Solid Geology Map 1:50,000, geological mapping, bedrock, linear geology;
   - BGS GeoIndex online database, 2020;
   - BGS Digital Hydrogeological Map of Scotland, 1:625,000 scale; and
   - BGS soils map viewer, 2020.

9. During the desk study, potential sites for borrow pit search areas were identified across the Site and identified for further investigation during the site visit. Peat probing surveys results were consulted to assess the overburden depth for the borrow pit search areas.

10. Site visits were undertaken in August and September 2020 by WSP personnel. The site visit consisted of a walkover survey of the area, including a visual inspection of the potential borrow pit search areas.

4 Desk Study

4.1 Geology

11. The drift and solid geology across the Site extents have been assessed using geological maps for the area obtained from the British Geological Survey (BGS):

    - Geological Survey of Scotland (1981), 1:50,000 geological map series, Drift, Sheet 8W;
    - Geological Survey of Scotland (1995), 1:50,000 geological map series, Solid, Sheet 8W; and
    - publicly available geological information from the BGS online aid GeoIndex (2020).

12. Maps of the bedrock and superficial geology are included in **Chapter 6: Hydrology, Hydrogeology, Geology and Soils** of the EIAR as **Figure 6.2 Bedrock Geology** and **Figure 6.3 Superficial Geology** of the EIAR, respectively.

4.1.1 Drift Geology

13. Superficial geology is indicated to be limited in the proposed borrow pit search areas i.e. bedrock is expected at or near the surface. Where encountered, the superficial deposits are expected to consist of shallow deposits of peat or Diamicton Till (of glacial deposition).

4.1.2 Bedrock Geology

14. The predominant rock type expected at the proposed borrow pit search areas (BP01-BP04) is Felsite Porphyry from the Southern Midland Valley Felsite Sills. The porphyry is described by the BGS solid geology map as *fine-grained felsic rock composed of phenocrysts of alkali feldspar with or without biotite in a fine-grained quartzo-feldspathic groundmass; usually very altered; mainly in sills.* It should be noted that BP01 and BP04 are located close to the contact between the Felsite Porphyry unit and basalt and basic andesite lavas. Due to the scale of the geological map there is therefore the potential for the borrow pits at these two locations to be of either or both geological units.

4.1.3 Structural Geology

15. One fault runs through the location of BP04 trending from north west to south east for approximately 2.5km and offset the Felsite Porphyry geology with basalt and basic andesite lava units of the Duneaton Volcanic Formation. Two large faults are also recorded to the south of BP01.

4.2 Hydrogeology

16. The Southern Midland Valley Felsite Sill complex 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.

17. The peat deposits are almost entirely saturated and therefore water is likely to be at or near the 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 dependent 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.

4.3 Peat Stability

18. A Peat Stability Assessment has been prepared, assessing peat depths and peat stability issues in infrastructure areas across the Site, provided as **Appendix 6.1 Peat Landslide and Hazard Risk Assessment** of the EIAR.

19. Based on the peat probes undertaken in the vicinity of the four borrow pit search area locations (**Appendix 6.1 Peat Landslide and Hazard Risk Assessment** of the EIAR), the average value for soil depth at the borrow pits is 0.47 metres (m).

4.4 Suitability of Bedrock as Aggregate

20. An approximate minimum volume of 128,000m^3 of aggregate is expected to be required for on-site construction activities e.g. access tracks (base and capping), hardstanding and foundations (including concrete requirements).

21. A concrete batching plant would be located within the main temporary construction compound and would comprise aggregate and cement hoppers, water bowsers/tanks, a mixer and a control cubicle. The wind turbines would typically have gravity base foundations approximately 30m in diameter and would be constructed using reinforced concrete, which will have an impact on the quantity of aggregate required.

22. The suitability of the Southern Midland Valley Felsite Sill complex as proposed infrastructure aggregate is dependent on mineralogy and composition.

23. Smith & Collis (2001) indicated that much of the aggregate in Britain produced from igneous geology is usually fine- to medium- grained basic geology. The igneous nature of the Southern Midland Valley Felsite Sills indicates that the geology may be suitable for aggregate. The grain size and silica content are an indication of the suitability, with coarser grained aggregates likely to have less strength. The porphyry with its fine-grained structure identified at this stage, determine that the quality of aggregate won from the Site is likely to be reasonably good.

5 Engineering Geology Walkover Survey

24. Potential borrow pit search areas were identified based on topographical information, vicinity to access tracks and expected shallow bedrock geology.

25. Walkover surveys of four potential borrow pit search area locations (BP01, BP02, BP03 and BP04) were undertaken on 20 August 2020 and 17 September 2020. Visual inspections, photographs and detailed field notes were taken reporting the geological and hydrogeological aspects of the vicinity. A smartphone with global positioning system (GPS) software was used to obtain photographs, notes and locations to better than 20m accuracy.

5.1 Borrow Pit Search Area BP01

26. Borrow pit search area BP01 is located close to the route of the proposed access track for the Proposed Development. The slopes within BP01 range from low to moderate. Bedrock was not noted to outcrop directly in the area of BP01. One felsite outcrop was noted approximately 180m to the north west, however, given the distance from the proposed access track it was not deemed to be a suitable location. Geological mapping of the area of BP01 suggests there is the potential for two types of bedrock to be present.

27. The area of BP01 was tree covered and had an artificial forestry drainage channel, which looked to carry a reasonable volume of water. The forestry drains will be avoided pre-construction during the positioning of the borrow pit within the search area.

28. Probing in this area indicated soft material (potentially peat) depths of up to 0.60m. Slope angles range from 2 to 13 degrees. A break of slope is noted across BP01 going from west to north east, however, no peat stability risks have been identified within or in the vicinity of BP01.

Photograph 1 Rock outcrop approximately 180m north east of BP01 (facing north west, from NGR 237791, 598137).

5.2 Borrow Pit Search Area BP02

29. BP02 has been located to extend an existing previous borrow pit to the south and west, approximately 60m south of wind turbine 8. The area is currently afforested, with gentle to moderate slopes. This borrow pit search area is positioned off an existing forestry track.

30. Bedrock is clearly exposed in the quarry. The lithology is:

- pinkish grey;

- strong to very strong;
- intermediate to fine grained;
- porphyritic;
- phenocrysts of felspar;
- felsitic;
- strong;
- intermediate to fine grained;
- veined; and
- phenocrysts of felspar.

31. **Photograph 3** shows a closer view of the existing borrow pit face; a lot of weathered, broken and fine material is evident.

32. Probing indicated soft deposits (peat) depths ranging from 0.10m to 0.84m, with an isolated peat depth of 2.62m at the eastern extent, which is likely to be associated to banking of the existing forestry track. Slope angles range from 1 to 14 degrees. A break of slope is noted across BP02 running from south east to north west, however, no peat stability risks have been identified within or in the vicinity of BP02.

Photograph 2. Cut face at the area of BP02 (facing southwest, from NGR 237124, 598479)

Photograph 3. Rock seen in the existing borrow pit at BP02

5.3 Borrow Pit Search Area BP03

33. BP03 has been located adjacent to two existing FLS borrow pit locations, on the eastern slopes of Garleffin Fell, approximately 130m east of wind turbine 6. The slopes angles range from low to moderate.

34. **Photograph 4** indicates that bedrock has been exposed following the overturning of a tree, indicating the presence of extremely shallow bedrock (<1m).

35. Bedrock is clearly exposed in the quarry. The lithology is:

- reddish pink;
- strong to very strong;
- intermediate to fine grained;
- porphyritic;
- phenocrysts of felspar and biotite;
- intrusive igneous; and
- felsitic.

36. **Photograph 5** shows a closer view of the existing borrow pit face; a lot of weathered, broken and fine material is evident.

37. Probing indicated soft deposits (peat) depths ranging from 0.10m to 0.43m, with an isolated peat depth of 1.54m at the western extent. Slope angles range from 0.4 to 24 degrees. A break of slope is noted at the northern extent of BP03 running from north to south, however, no peat stability risks have been identified within or in the vicinity of BP03.

Photograph 4. Shallow bedrock can be seen in an area exposed by a fallen tree in the area of BP03 (taken at NGR 399362, 6124109)

Photograph 5. Cut wall in existing borrow pit at BP03 (facing south, from NGR 399386, 6124137)

Photograph 6. Rock sample recovered from area of BP03

5.4 Borrow Pit Search Area BP04

38. No rock outcrop was noted in the area of BP04; however, probes recorded depths to refusal less than 1m.

39. The proposed location consists of a tree and vegetation covered hillside (**Photograph 7**). Slopes are generally dipping approximately 30 degrees towards the access track (north east).

40. Numerous drainage channels are present between the rows of trees, indicating that surface run-off is potentially high in this area and could cause issues if this area was excavated for a borrow pit. A detailed drainage design would be undertaken and submitted to the Scottish Ministers, in consultation with the Scottish Environmental Protection Agency (SEPA), for approval prior to construction.

41. Geological mapping of the area of BP04 suggests there is the potential for two types of bedrock to be present and the possibility for Glacial Till to overlie the bedrock. Field observations were unable to confirm this, and intrusive investigation is required to get a full understanding of ground conditions.

42. Probing indicated soft deposits (peat) depths ranging from 0.10m to 0.86m. Slope angles range from 11 to 18 degrees. A break of slope is noted across BP04 running from north west to south east, however, no peat stability risks have been identified within or in the vicinity of BP04.

Photograph 7. Typical setting of BP04 (Facing northwest, from NGR 399386, 6124137)

6 Assessment of Potential Borrow Pit Search Area Locations

43. The required aggregate volume for two scenarios for the construction of access tracks, wind turbine foundations back-fill, compounds and hard-standing areas were calculated, at the Site. Scenario 1; all onsite tracks require to be completely rebuilt in addition to new access tracks being constructed, 143,548.65m^3. Scenario 2; all existing onsite forestry tracks only require upgrading in addition to new access tracks being constructed, 127,771.65m^3.

44. **Table 6.6.1** illustrates the proposed borrow pit search areas dimensions for the identified location. The volume given has been calculated from the borrow pit search area cross-section area, taking into account the benches and gradients of the extraction face, and the length of the proposed borrow pit search area. It should be noted that the borrow pit search area footprint and cross-section have been produced using available digital terrain model (DTM) data and consequently they are not detailed designs but are indicative only.

ID	Location	Approx. footprint area (m^2)	Max. depth (m)	Approx. Volume (m^3) *	Probable extraction method
BP01	237662, 597950	167,056	4.0	41,016	Blasting, hammer (and blasting) and Ripping
BP02	237098, 598458	26,299	5.7	20,060	Blasting, hammer (and blasting) and Ripping
BP03	235821, 598504	27,986	5.5	47,190	Blasting, hammer (and blasting) and Ripping
BP04	235307, 599005	33,586	22.9	231,000	Blasting, hammer (and blasting) and Ripping
Total Estimated Volume (m^3)					339,266

Table 6.6.1 Indicative Dimensions and Extraction Volumes

* Volume has been calculated multiplying the cross section areas by the approximate length. Please note lengths will differ from the ones extracted from the GIS files due to shape of the areas and conservative estimates for side slopes.

45. Volumes are a preliminary assessment only and have been calculated directly from cross sections with no bulking factors added, due to lack of information at this stage (i.e. without site investigation) regarding minerology. Strong bedrock would be expected to have a high bulking factor, increasing the as dug volumes. All volumes provided are subject to more detailed refinement at a later stage.

46. The igneous rock types described on the geological maps and seen onsite have the potential to be suitable for use as an aggregate, depending on the confirmed mineralogy and strength. Since several of the proposed locations consist of previously used borrow pits it is likely to be the case that the rock is suitable for use as an aggregate.

47. As the borrow pits are located within a hard and fairly resistant rock type it is likely that drilling and blasting would be required for excavation. However, due to the highly fractured nature of the rock seen in existing borrow pits in the area, it is possible that ripping may be sufficient for a proportion of the material.

48. It is understood that selected borrow pit(s) might be left open after completion of the windfarm construction for ongoing track maintenance requirements and/or used as storage areas for excess site-won aggregate. It is anticipated that, if this is not the case, that the borrow pits would be at least partially reinstated (subject to landowner agreement). This would involve the reworking of faces to stabilise them, partial infilling with excavated material not needed for construction or of unsuitable grade, and landscaping. The restored landscaping would be suitable for tree planting with a minimum free rooting soil of 1m.

49. An assessment of the effects of the borrow pit on the local hydrology and hydrogeology has been undertaken and incorporated into **Chapter 6: Hydrology, Hydrogeology, Geology and Soils** of the EIAR. 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; and
- storage of excavated material for post-use restoration and rehabilitation.

7 Conclusions and Recommendations

50. The surveys suggest that the area of borrow pits BP02 and BP03 have good potential in terms of suitability for bedrock excavation, in terms of aggregate quality, overburden depth and slope angle, whilst minimising environmental impact.

51. Borrow pit search areas BP01 and BP04 would require intrusive investigation to confirm the type of igneous bedrock present and depths of superficial deposits.

52. The required aggregate volume for the worst case scenario is 143,548.65m^3, which accounts for approximately 42% of the total estimated potential volume of aggregate (339,266m^3).

53. 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. Aside from probing, 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.

54. It is strongly recommended that detailed ground investigations, slope stability assessments and geotechnical testing would be undertaken to inform the detailed design of the borrow pit and to confirm suitability as source of aggregate for track and wind turbine foundations construction.

8 Geotechnical Risk Register

55. A review of the geotechnical risks associated with the scheme has been undertaken and is presented in **Table 6.6.3** in accordance with the guidelines set out in CD 622. The risk register lists the anticipated geotechnical risks associated with the borrow pit design. The risk before control of the hazard has been assessed quantitatively and following the specific response to each risk. The values assigned to impact for these hazards should be considered as quantitative as detailed in **Table 6.6.2.**

PROBABILITY (P)		
Very High	Very likely >75%	**5**
High	Probable 40-75%	**4**
Medium	Possible 10-40%	**3**
Low	Unlikely 2-10%	**2**
Very Low	Negligible <2%	**1**

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IMPACT (I)			
		TIME	**COST**
Very High	**5**	>50%	>20%
High	**4**	25-50%	10-20%
Medium	**3**	10-25%	5-10%
Low	**2**	2-10%	1-5%
Very Low	**1**	<2%	<1%

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		Impact				
		5	**4**	**3**	**2**	**1**
Probability	**5**	**25**	**20**	**15**	**10**	**5**
	4	**20**	**16**	**12**	**8**	**4**
	3	**15**	**12**	**9**	**6**	**3**
	2	**10**	**8**	**6**	**4**	**2**
	1	**5**	**4**	**3**	**2**	**1**

Risk Ratings

1 to 4	Low Risk
5 to 10	Medium Risk
12 to 16	High Risk
20+	Critical Risk

Sources: Probability and impact nomenclature and scorings are based on a number of sources including -
HD22 /02 Managing Geotechnical Risk
Describing probability: The limitations of natural language (Hillson)
Probability frequencies and the % increase of costs are WSP derived values

Table 6.6.2 Geotechnical Risk Evaluation Matrices

No	Hazard	Risk	Risk Management Measures undertaken to date	Risk rating following risk management measures undertaken to date			Proposed Risk Management Measures	Anticipated risk rating following proposed risk management			Comments or further information
				P	I	R		P	I	R	
1	Depths of superficial deposits may vary from the depths assessed by probing of soft deposits.	Inappropriate borrow pit design and potential instability in superficial deposits. Additional cost and delays to programme.	Peat probing.	3	4	12	Carry out detailed design Ground Investigation to determine the depth of superficial deposits.	1	4	**4**	Requires extra GI to mitigate this risk.
2	Rock mass properties and geological background (presence of faults which may cause changes in lithology) based onsite observations may be different than in reality.	Inappropriate borrow pit design and unsuitable aggregate material. Additional cost and delays to programme.	Site observation where rock is exposed.	4	4	16	Carry out detailed design Ground Investigation to determine the rock mass properties, geological background and aggregate suitability.	1	4	**4**	Requires extra GI to mitigate this risk.
3	Borrow pit yield differs to that estimated.	Additional fill requirements over and above the borrow pits currently proposed.	Site observation where rock is exposed.	4	4	16	Carry out detailed design Ground Investigation to determine the quantity of material that can be yielded at each location including aggregate suitability as discussed in Risk no. 1 & 2.	1	4	**4**	Requires extra GI to mitigate this risk.

No	Hazard	Risk	Risk Management Measures undertaken to date	Risk rating following risk management measures undertaken to date			Proposed Risk Management Measures	Anticipated risk rating following proposed risk management			Comments or further information
4	Borrow pit yield differs to that estimated – unfavourable joint orientation requiring reduced face angles and/or increased bench widths reducing volume of material excavated from the pits.	Additional fill requirements over and above the borrow pits currently proposed.	Site observation where rock is exposed.	4	4	16	Carry out detailed design Ground Investigation to determine the quantity of material that can be yielded at each location including aggregate suitability as discussed in Risk no. 2.	1	4	**4**	Requires extra GI to mitigate this risk.
5	Excavatability of rock mass estimated by empirical method may differ from the reality.	Delays in construction works. Having to revise design proposals (if needed volume of the rock mass is not possible to excavate).	None.	4	4	16	Carry out detailed design Ground Investigation to determine the rock properties.	1	4	**4**	Requires extra GI to mitigate this risk.
6	Groundwater conditions not known.	Inappropriate borrow pit design. Additional cost and delays to programme.	None.	4	4	16	Carry out detailed design Ground Investigation to determine the groundwater conditions. BP base may need to be inclined when potential of groundwater seepage is found. Drainage measures implemented above rock face.	1	4	**4**	Requires extra GI to mitigate this risk.
7	Rock slope stability properties not known.	Inappropriate borrow pit design. Unsuitable bench width. Additional cost and delays to programme.	None.	4	4	16	Carry out detailed design Ground Investigation to determine the rock slope stability properties.	1	4	**4**	Requires extra GI to mitigate this risk.

Table 6.6.3 Geotechnical Risk Register

9 References

Highways England, Design Manual for Roads and Bridges, CD622, Managing geotechnical risk.

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