

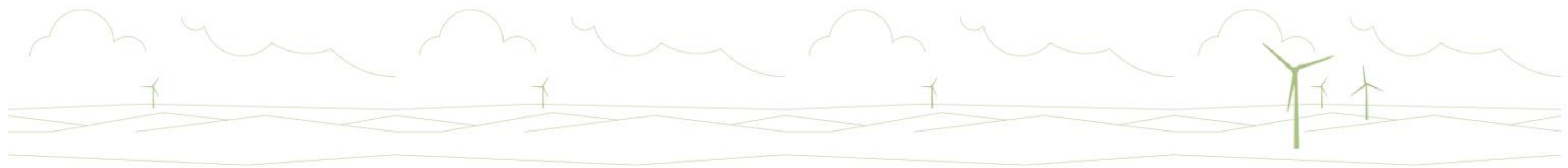


# Technical Appendix 6.5

## Initial Borrow Pit Assessment

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# 1 Introduction

1. This report forms an appendix to the Environmental Impact Assessment Report **Chapter 6: Geology, Hydrology, Hydrogeology and Peat** and should be read with reference to this chapter and associated figures.
2. The Proposed Development comprises eight wind turbines and associated infrastructure, including access tracks, borrow pits and cable route. The Proposed Development is located approximately 13km north of Dumfries, entirely within the Dumfries and Galloway Council area, and is described more fully in **Chapter 6: Geology, Hydrology, Hydrogeology and Peat** of the EIA Report.
3. To minimise the volume of material imported to the Site and any subsequent environmental impact, site-won aggregate will be used for construction. Aggregate will be required for the construction of access tracks, turbine base back-fill, compounds, hardstanding areas and concrete. It has been calculated that the cut and fill track construction method alone will 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 assessment for the Proposed Development, in which three potential borrow pit search areas (hereafter referred to as BP01, BP02 and BP03) were evaluated. These locations are illustrated in **EIA Report Figure 4.1 Site Layout Plan**.

# 2 Aims

5. The aims of this assessment were to provide:
  - preliminary assessment of the suitability of the bedrock as a road building material;
  - 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 re-instatement and rehabilitation proposals.
6. This document outlines the method for borrow pit assessment along with the analysis undertaken; conclusions drawn and recommendations for borrow pit search areas.
7. It should be noted that all borrow pit 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 search areas were identified across the Site and identified for further investigation during the site visit.
10. A site visit was undertaken in July 2020. 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. This section details:
  - bedrock geology (**EIA Report Figure 6.2 Bedrock Geology**);
  - superficial geology (**EIA Report Figure 6.3 Superficial Geology**); and
  - other geological faults or features found within and immediately surrounding the Site.

### 4.1.1 Bedrock Geology

12. On-site access tracks and part of the southern access track to the Site are underlain by sedimentary rocks from the Silurian age Queensberry, Selcoth and Glendearg formations of the Gala and Ettrick groups. These formations comprise interbedded turbidite (wacke) sandstone and mudstone/siltstone in variable proportions.
13. The southern section of the southern access track is underlain by the Permian age Hartfield and Corncockle Sandstone formations of the Stewartry Group. The Hartfield Formation comprises sandstone interbedded with pebbly sandstone and angular pebble grade conglomerate, while the Corncockle Sandstone Formation comprises fine- to medium-grained, well sorted, red quartz sandstone.
14. BGS Geological mapping (2020) (**EIA Report Figure 6.2 Bedrock Geology**) indicates the formations noted within the Site from north to south east:
  - Queensberry Formation - sandstone, typically medium to coarse-grained, but ranging from fine to very coarse-grained, locally pebbly. Generally medium- to very thick-bedded or massive over thicknesses of tens of metres, units up to few metres thin-bedded;
  - Locherben Breccia Formation - well sorted sandy breccia with clasts of bladed greywacke, argillite and purple amygdaloidal basalt;
  - Carron Basalt Formation - olivine basalt lava flows interbedded with thin breccias and sandstones;
  - Selcoth Formation - sandstone, typically fine to medium-grained but ranging from very fine to coarse-grained. Generally medium- to thick-bedded over thicknesses of tens of metres interspersed with units up to few metres very thin to thin-bedded;
  - North Britain Siluro-Devonian Calc-Alkaline Dyke Suite – small area south of Whitefauld Hill;
  - Moffat Shale Group - black shale, grey shale, bentonite, tuff;
  - Glendearg Formation - sandstone, typically fine- to medium-grained but ranging from very fine- to coarse-grained. Generally medium- to thick-bedded over thicknesses of tens of metres interspersed with units up to few metres very thin to thin-bedded;
  - Hartfield Formation - Red, laminated and cross-laminated silty sandstone interbedded with pebbly sandstone and lenses of breccio-conglomerate. The sandstone is medium- to thick-bedded, silty, medium- to fine-grained with small [ $<0.5\text{mm}$ ] detrital mica flakes and including many frosted and rounded quartz grains;
  - Carghidown Formation - greywacke beds dominantly less than 0.5m thick, with interbedded mudstones including some red mudstone beds; and
  - Corncockle Sandstone Formation - fine to medium-grained, well sorted, red quartz sandstone with large scale aeolian cross-bedding.



15. The Site is largely formed from sedimentary rocks of the Gala and Ettrick Groups.

#### 4.1.2 Structural Geology

16. BGS Geology mapping, shown in **Figure 6.3 Superficial Geology**, indicates that in the wider region, the noted geological formations are heavily faulted. The faults follow the same orientation as the bedrock geology, from north east to south west. A fault is noted 20m to the east of Turbine 6 and 160m to the east of Turbine 8.

## 4.2 Hydrogeology

17. The sandstones of the Queensberry, Selcoth and Glendearg Formations (Gala Group) which underlie the majority of the Site are classified as low productivity aquifers, with highly indurated greywackes with limited groundwater in the near surface weathered zone and secondary fractures. These formations may support small private water supplies. For further details regarding private water supplies within the Site, see **Appendix 6.4 Private Water Supply Assessment**.
18. The sandstones of the Hartfield and Corncockle (Stewartry Group) in the south east of the Site forms a Highly productive aquifer, which can be up to 1500m thick with sandstones and breccias yielding up to 40l/s.
19. The wacke and mudstones of the Carghidown Formation (Hawick Group) in the southern extent of the Site are classified as low productivity aquifers, with highly indurated greywackes with limited groundwater in the near surface weathered zone and secondary fractures.

## 4.3 Peat Stability

20. A Peat Stability Assessment has been prepared for this project, assessing peat depths and peat stability issues in infrastructure areas across the Proposed Development, provided as **Appendix 6.1 Peat Stability Assessment**. No peat stability issues have been identified within the proposed borrow pit search areas.
21. Based on the peat probes undertaken within BP01, the depth of peat varied from 0.0 to 0.94 m; depth results within BP02 were 0.1 and 0.5m; and within BP03 0.2 and 0.5m.

## 4.4 Suitability of Bedrock as Aggregate

22. A volume of approximately 36,222.45m<sup>3</sup> of aggregate is expected to be required for construction of access tracks (base and capping), crane hardstandings and control building foundation.
23. The bedrock across the Site is indicated to be sedimentary in nature, consisting of mainly sandstone and siltstones of the Selcoth and Queensberry Formations.
24. The bedrock identified at this stage, determine that the quality of aggregate won from the Site is likely to be reasonably good. Sandstone aggregate could be used to provide a sub-base underlying a hard wearing hard (basalt) course.

## 5 Potential Borrow Pits

25. Three potential borrow pit search areas were identified (BP1, BP2 & BP3) based on topographical information, vicinity to access tracks and expected shallow bedrock geology, taking account of environmental constraints. These locations are presented in **EIA Report Figure 4.1 Site Layout Plan**.
26. An engineering geology walkover survey of the search area BP1, BP2 & BP3 was conducted on 31 July 2020. Visual inspections, photographs and detailed field notes were taken reporting the geological aspects of the vicinity. A hand-held GPS unit was used to obtain locations to obtain a 5m accuracy.

### 5.1 Borrow Pit BP01



Photograph 1: Photograph taken at NGR: 302416 593813, looking north east across existing quarry and proposed borrow pit BP01.

27. Borrow Pit BP01 is located to the north of Whitefauld Hill within the Forest of Ae, centred at NGR 302437, 593874. It is located at the site of a quarry, likely used to extract aggregate for the existing tracks. **Photograph 1** and **2** show the current area where proposed excavation would take place.





Photograph 2: Photograph from NGR: 30247 59378, showing view from side of quarry, looking north. Proposed borrow pit BP01 will continue quarry into hillside to the right.

28. Bedrock is clearly exposed in the quarry. The lithology is:
- reddish brown and grey;
  - medium strong to strong;
  - fine to medium grained;
  - thin to thickly bedded; and
  - interbedded sandstone and siltstone.
29. There is a high proportion of fine-grained siltstone which is more susceptible to weathering once exposed at the surface. **Photograph 3** shows a closer view of the quarry face; a lot of weathered fine material is evident.



Photograph 3: Photograph from NGR: 30246 59386, showing view of quarry face, looking south.

30. Geological mapping and onsite peat probing surveys indicate that superficial deposits on the ground above the quarry consist of peat, with depths ranging from 0 – 0.9m, resulting in an average of 0.3m. The surface elevation in this area is approximately 340 to 360m AOD.
31. Bedrock in the area above the quarry is generally not visible, being covered by superficial deposits and vegetation. The geological mapping indicates no change in the rock type so it can be assumed to be the same as the quarry.

## 5.2 Borrow Pit BP02



Photograph 4: Photograph taken at NGR: 30143 59250, looking north. Proposed BP02 would extend into the forest in the foreground.

32. Proposed Borrow Pit BP02 is located on the west slope of Pumro Fell within the Forest of Ae, centred at NGR 301446, 592335. It is located approximately 300m east of the Glenkiln Burn. **Photograph 4** and **5** show the current area where proposed excavation would take place.





Photograph 5: Photograph taken at NGR: 30143 59250, looking south. Proposed BP02 would extend into the forest in the foreground.

33. Geological mapping indicates that superficial deposits consist of Glacial Till. Onsite peat probing surveys have confirmed this is overlain by peat, with depths ranging from 0.1 – 0.5m, resulting in an average of 0.3m. The surface elevation in this area is approximately 320 to 380mAOD.
34. Bedrock is generally not visible, being covered by superficial deposits and vegetation, however the geological mapping indicates this is the same rock strata as seen in the quarry. Boulders seen beside the track and in cuttings are of the same rock type.

5.3 Borrow Pit BP03



Photograph 6: Photograph taken at NGR: 30056 59200, looking north. Proposed BP03 would be on the hillside to the right and extend into the forest in the background.

35. Proposed Borrow Pit BP03 is located on the north east of Brownmoor Hill within the Forest of Ae, centred at NGR 300629, 592257. It is approximately 1km west of BP02. **Photograph 6** shows the current area where proposed excavation would take place.
36. Geological mapping and onsite peat probing surveys indicate that superficial deposits are peat, with depths ranging from 0.2 – 0.5m, resulting in an average of 0.4m. The surface elevation in this area is approximately 260 to 320mAOD.
37. Bedrock is generally not visible, being covered by superficial deposits and vegetation. The geological mapping indicates this is of a different geological unit to BP01 and BP02 although the rock type is the same; they are both sandstone bedded with siltstone and mudstone. Sandstone and siltstone can be seen in boulders seen beside the track and in cuttings but there is not enough exposure to note any difference between this locality and the others.

6 Assessment of Potential Borrow Pit Locations

38. The required aggregate volume of 36,222m<sup>3</sup> for aggregate requirements for the construction of access tracks, turbine base back-fill, compounds and hard-standing areas at the Site has been calculated. 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 requirements, resulting in a required borrow pit volume of 45,278m<sup>3</sup>.
39. **Table 1** illustrates the proposed borrow pit dimensions for the identified location. The volume given has been calculated from indicative 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.

ID	Location	Approx. footprint dimensions (m)	Approx. footprint area (m <sup>2</sup> )	Max. depth (m)	Approx. Volume (m <sup>3</sup> )	Probable extraction method
BP 01	NGR 302437, 593874.	592.7	21,576.1	21.3	194,850	Hammer (and blasting) and Ripping.
BP 02	NGR 301446, 592335	752.8	26,817.2	21.6	203,200	Hammer (and blasting) and Ripping.
BP 03	NGR 300629, 592257	870.3	31,143.7	19.9	230,250	Hammer (and blasting) and Ripping.
					Total Estimated Volume (m <sup>3</sup> )	628,300

Table 1: Indicative Borrow Pit Dimensions and Extraction Volumes

40. Volumes are a preliminary assessment only and have been calculated directly from cross sections with no bulking factors added. Strong thickly bedded bedrock would be expected to have a high bulking factor, increasing the as dug volumes. A percentage of the material may also be unusable as aggregate due to its fine-grained nature. All volumes provided are be subject to more detailed refinement at a later stage.
41. It is anticipated that, upon completion, the borrow pits would be at least partially reinstated. 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. There may also be the potential for environmental enhancement by creating a small wetland or other desirable habitats.



42. An assessment of the effects of the borrow pit on the local hydrology and hydrogeology has been undertaken and incorporated into the EIA Report (**Chapter 6: Hydrology, Hydrogeology, Geology and Soils**). 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

43. Based upon the evidence available on Site, the three borrow pit search areas are suitable, with BP01 deemed as the most suitable location. The estimated required aggregate volume for the Site could be obtained from any of the individual borrow pit search areas.
44. BP01 has a known rock type, access is already established, and the overburden material has been shown to be generally shallow.
45. It should be noted that all borrow pit information provided within this report is indicative only and is based on a desk study and reconnaissance survey alone. Aside from peat probing, no intrusive investigation has been carried out, and consequently the suitability of the rock is a broad estimate and should be treated as such.
46. It is strongly recommended that detailed ground investigations, slope stability assessments and geotechnical testing be undertaken to inform the detailed design of the borrow pit and to confirm suitability as source of aggregate for track and turbine base construction.

## 8 Geotechnical Risk Register

47. A review of the geotechnical risks associated with the scheme has been undertaken and is presented in **Table 3** in accordance with the guidelines set out in CD 622 'Managing Geotechnical Risk'. 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 2**.

PROBABILITY (P)			IMPACT (I)			
			TIME		COST	
Very High	Very likely >75%	5	Very High	5	>50%	>20%
High	Probable 40-75%	4	High	4	25-50%	10-20%
Medium	Possible 10-40%	3	Medium	3	10-25%	5-10%
Low	Unlikely 2-10%	2	Low	2	2-10%	1-5%
Very Low	Negligible <2%	1	Very Low	1	<2%	<1%

Probability

	5	4	3	2	1
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

X

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Risk ratings:

1 to 4  
5 to 10  
12 to 16  
20+

Low Risk  
Medium Risk  
High Risk  
Critical Risk

Probability and impact nomenclature and scorings are based on a number of sources including CD622 'Managing Geotechnical Risk' (Highways England). Probability frequencies and the % increase of costs are WSP derived values

Table 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.	2	4	8	Requires extra GI to mitigate this risk.
2	Rock mass properties and geological background (presence of faults which may cause changes in lithology)	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.

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	
	based on site observations may be different than in reality.										
5	Borrow pits may not have suitable yield, may have low excavatability or may have unfavourable joint orientation.	Delays in construction works. Additional fill requirements.	None.	4	4	16	Carry out detailed design Ground Investigation to determine the rock properties and quantity of rock that can be yielded.	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 3: Geotechnical Risk Register

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