

European Offshore Wind Deployment Centre

Environmental Statement

Chapter 6: Geology and Bathymetry



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6 GEOLOGY AND BATHYMETRY

6.1 Introduction

- 1 A review of the offshore sediments and geology in Aberdeen Bay indicates that the seabed sediments are defined as non-solid sediments laid down by the actions of the sea during the early Holocene. The sediments in this region reflect its glacial history and hydrodynamic regime. There is little input of sediment from land with most inputs being derived from peat deposits. The sediments off Aberdeen consist predominantly of sand and slightly gravelly sand (DTI, 2004).
- 2 Below the seabed, Pleistocene deposits off the Aberdeenshire coast vary from soft red-brown, grey-brown and pink-grey muds to compact grey clays with scattered pebbles that are interpreted as glacial till. The soft muds probably date from late Devensian to Early Flandrian, being deposited during the retreat of the last ice sheet. The underlying bedrock along the coast between Aberdeen and Stonehaven comprises sandstones, conglomerates, mudstones and cherts.
- 3 Forvie is designated as a geological conservation statutory review site. This is a non statutory designation which reflects the area's earth science interest in relation to coastal geomorphology.
- 4 Surveys that obtained bathymetric, seabed and sub-bottom data are critical to the project, providing a basis for the foundation design work, and informing the coastal process modelling and marine ecological and archaeological impact assessments.

6.1.1 Key Guidance Documents

- 5 There are no formal guidance documents to inform the geology assessment, but several project reports have been used to provide baseline information.

6.1.2 Data Information and Sources

6.1.2.1 Surveys

- 6 Site specific studies were undertaken that collected on-site survey data and also incorporated more general information from background literature such as British Geological Survey charts.
- 7 In 2007, EMU Ltd. was commissioned to undertake a geophysical and seabed habitat survey of the site as proposed at that time (Layout 011, see Frame 4, Figure 2.3). The survey included swath bathymetry data, sidescan sonar imaging, shallow seismic profiling, magnetometer readings and use of an Acoustic Ground Discrimination System (AGDS) with video ground-truthing (EMU Ltd, 2008). The survey was completed using the vessel *FPV Morven* between 12th and 18th September 2007.
- 8 Following a change in site location as outlined in Chapter 3 Site Selection, Osiris Hydrographic & Geophysical Projects Ltd (Osiris Projects) was commissioned to undertake a geophysical and benthic sampling survey of the current site (Layout 039, see Figure 3.2) and potential cable corridor area.

9 This second survey area slightly overlapped with the previous survey area to enable comparison between the two surveys and ensure consistency of data. The survey was completed using the vessel *MV Lia* between 3rd September and 26th October 2010.

10 The areas of both surveys can be seen on Figure 6.1.

6.1.2.2 Project Reports

11 In addition to the surveys, a geotechnical desk study was undertaken to determine the soil properties within the site.

12 These studies are reported in the following documents:

- EMU Ltd (2008b) Geophysical and Seabed Habitat Assessment of the Proposed Aberdeen Offshore Wind Farm
- Osiris Ltd (2011) Aberdeen Offshore Wind Farm Geophysical Survey Report – Volumes 2a and 2b
- Setech Ltd (2009) Geotechnical Desktop Study

6.2 Baseline Assessment

6.2.1 General Description

13 The geological succession in the area has been charted as:

- Superficial sediments
- Quaternary sediments
 - Forth Formation – St Andrews Bay Member
 - Forth Formation – Largo Bay Member
 - Wee Bankie Formation
- Bedrock
 - Devonian Sandstone
 - Ultrabasic and other coarse grained igneous rocks related to the Belhelvie gabbro mass

14 BGS described the superficial sediments as gravelly shelly sands ranging in thickness from less than 0.5 m to 2.0 m in thickness.

15 Underlying these are the Quaternary sediments. The fine to coarse sands (St Andrews Bay Member) are anticipated to be up to 20 m thick, underlain by silty clays and gravelly clays (Largo Bay Member). Beneath these is the glacial till deposit of the Wee Bankie Formation. This comprises sandy gravelly clays with frequent cobbles, occasional boulders and thin layers of sand and silty clay, together with coarser sand and gravel deposits.

16 The bedrock beneath the Quaternary deposits consists of Upper Devonian sandstones and conglomerates. However, the BGS data indicate that ultrabasic rocks are present at the central inshore section of the site (Osiris, 2010). These are rich in ferromagnesian minerals.

17 There is no evidence at this stage to suggest that shallow gas will be present at the proposed site.

18 The UK is an area of low seismicity and the risk to offshore structures is considered to be correspondingly low. The Dee Valley Fault strikes

diagonally across Aberdeen Harbour, however it is unlikely to affect ground conditions below the project area (Setech, 2009).

6.2.2 Geophysical and Seabed Habitat Survey Results

- 19 The survey reports include presentations of the data for:
- depth: swath bathymetry
 - seabed features: AGDS, drop-down video, sidescan data and magnetometer contacts
 - sub-seabed geology: sediment isopach charts and geological cross sections
- 20 **Bathymetry:** The seabed slopes consistently offshore, deepening to the east-north-east. This even increase in water depth was apparent in both geophysical surveys. The depths within the 2010 survey area range from 0.8 m to 35.1 m below Lowest Astronomical Tide (LAT) (Osiris, 2011).
- 21 In the shallow inshore section, depths increase from 0.8 m to 6 m in an irregular channel. To the east of this channel, there is a series of linked narrow bank features running parallel to the shore. In places, the depth decreases to 2m below LAT. These banks are asymmetrical, with the steeper side facing west. The seabed then slopes east-south-east with decreasing gradient between 1 in 110 and 1 in 140 to the 25 m contour, continuing to decrease further offshore at a gradient of 1 in 300.
- 22 The depths within The Crown Estate lease boundary range from 11 m to 35 m below Chart Datum (CD). The data from both surveys are shown in Figure 6.2.
- 23 **Seabed features:** The sidescan sonar showed the sediments over most of the survey area were predominantly slightly silty sands, which are frequently shelly (see Figure 6.3). Along the western border of the survey areas there are outcrops of glacial (clayey) till. There are also patches of gravel to the north. The till and gravel are exposed due to erosional forces of the tides and waves preventing net deposition. This means the gravels are reworked during storm periods changing the nature of the sediment morphology (Osiris, 2011).
- 24 Depositional ripple features are apparent towards the intertidal area (Emu, 2008), with megaripples within the gravel areas and other features in the silty sand up to 1,500 m from the shoreline (Osiris, 2011).
- 25 Several trawl scars were visible in the sonar data, plus numerous targets, most of which are interpreted as boulders. A wreck and possible area of associated debris have been identified near the proposed site of Wind Turbine 8 (see Chapter 18 Archaeology for more details).
- 26 The 2007 data identified 59 magnetic targets, being dominated by several large readings in the north-west of the survey area. These were the result of submerged geological features.
- 27 In the 2010 data, there was a total of 262 anomalies in the magnetometer readings. These included three outfall pipes running out from shore and the route of a disused telecoms cable. There was also an area of high magnetic readings in the west of the site, associated with submerged geology as described in the 2007 data. An igneous intrusion probably related to the Belhelvie gabbro mass was highlighted.

- 28 Only one medium-sized magnetic anomaly was considered to be of anthropogenic origin and of concern; this is located adjacent to Wind Turbine 3 and could be the remains of an unknown wreck or aircraft crash."
- 29 There were numerous small magnetic anomalies across the site. Given the possibility of ordnance in the area these may indicate small metallic objects such as unexploded ordnance (UXO).
- 30 The drop-down video confirmed that silty sand was common across the area, with ripple marks of 20-40 cm wavelength. Inshore, there was a lower mud content than offshore. There were occasional patches of shelly fragments.
- 31 **Sub-seabed geology:** The surveys confirmed a surface veneer of sandy sediments, which is absent in some locations nearshore (where the till outcrops at the surface) increasing to over 10 m thickness offshore. Nearshore, this is thickest in the sand bar features described above. In the north-west there may also be layers of peat near the surface.
- 32 These surficial sediments overlie a sequence of glacial (Quaternary) sediments with evidence of erosional surfaces and variable lithology (Emu, 2008). At the top of this sequence is the fine to coarse shelly sand of the Forth Formation. This is not present across the whole site, as patches of till outcrop at the surface; its deepest extent is 36 m below seabed in the north-west corner of the survey area (Osiris, 2011). Beneath this is the glacial till of the Wee Bankie Formation. There is a ridge feature extending west-north-west/east-south-east across the central eastern section of the proposed site. This is approximately 2 km long and 150 m wide, possibly representing a terminal or recessional moraine (Osiris, 2011). In the west, distinct lenses of sediment are apparent lying directly on the rockhead. These coincide with the high magnetometer readings and are interpreted as reworked local igneous material contained within the till deposit. This means the geology will be of variable engineering strength (Emu, 2008).
- 33 The rockhead is expected to be Devonian Old Red Sandstone which occurs at a depth of 5-10 m below the seabed in the west, deepening to over 30 m below seabed at the eastern boundary.
- 34 Further information on the habitat can be found in Chapter 9 Marine Ecology, Intertidal Ecology, Sediment and Water Quality.

6.2.3 Geotechnical Study Results

- 35 Setech (Geotechnical Engineers) Ltd. conducted a geotechnical desk study in early 2009. This used the Emu survey data plus existing borehole information from the BGS. The comparison of these datasets confirmed that the presence of Holocene sediments underlain by glacial Wee Bankie Formation, which rests directly on the Devonian Old Red Sandstone.
- 36 There is limited geotechnical information available, and therefore only general assumptions can be made regarding strength. The Wee Bankie Formation is described as soft to very stiff clay (increasing with depth), with borehole logs indicating C_u (undrained shear strength) values of 30 to >150 Kn/m². However, verification of the strength of both this and the bedrock is needed to determine engineering parameters for foundations.

6.3 Impact Assessment

6.3.1 Impact Assessment Methodology

- 37 From the geophysical and geotechnical studies undertaken, the only environmental impact anticipated on the geology and bathymetry is potential scour, which is considered in Chapter 8 Coastal Processes, or removal of material directly where the foundations are installed. Consequently, a formal impact assessment is not considered appropriate here.

6.3.2 Impact Assessment

- 38 Construction would not alter the geology of the site other than in localised areas directly impacted by the installation of wind turbine foundations. This is dependent upon the size of the foundation used, but is not considered to be significant for any of the options under consideration. It is anticipated that during decommissioning, foundations would be removed to below the seabed surface.

6.3.3 Summary

- 39 The geology of the site comprises silty sand at the surface, lying above glacial till, which in turn lies on Devonian Old Red Sandstone.
- 40 The only anticipated impacts would be potential scour due to the turbine foundations, which is considered in Chapter 8 Coastal Processes and direct loss of sediment where the foundations are installed. This would be dependent on the type and size of foundations used but is not considered to be significant.
- 41 However, to inform the engineering considerations, further geological work would be undertaken for the project. Following the recommendations by Setech (2009), a full site investigation would be conducted to obtain site specific data on soil conditions. This would confirm the potential strength parameters of the Wee Bankie Formation, and would also verify the bedrock composition, competency and strength as an addition to the geophysical survey and the desktop study. This survey would be conducted as part of the pre-construction survey.

6.4 References

DTI (2004) SEA 5: Strategic Environmental Assessment of Parts of the Northern and Central North Sea to the East of the Scottish Mainland, Orkney and Shetland. Department of Trade and Industry.

EMU Ltd (2008) Geophysical and Seabed Habitat Assessment of the Proposed Aberdeen Offshore Wind Farm. Report No. 07/J/1/02/1136/0716. February 2008.

Osiris Ltd (2011) Aberdeen Offshore Wind Farm Geophysical Survey Report – Volumes 2a and 2b C10023. February 2011.

Setech Ltd (2009) Geotechnical Desktop Study. Report No. 8733-0-0. January 2009.