LYNN AND INNER DOWSING OFFSHORE WIND FARMS

STAGE 1 BOREHOLE ASSESSMENT

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1. INTRODUCTION

1.1.1. Wessex Archaeology was commissioned by AMEC Wind Energy to undertake an archaeological assessment of borehole logs collected in connection with the construction of the proposed Lynn and Inner Dowsing Offshore Wind Farms.

1.1.2. This report comprises a Stage 1 assessment of the existing borehole data within the following stage structure:

Stage 1: Planning

1.1.3. Desk-based archaeological assessment of core logs generated by geotechnical contractors. This assessment will establish the likely presence of horizons of archaeological interest and broadly characterise them, as a basis for deciding what Stage 2 archaeological recording is required. The Stage 1 report will state the scale of Stage 2 work proposed.

Stage 2: Coring and Recording

1.1.4. Archaeological recording of selected retained or new cores. This will entail the splitting of the cores, with half of each core being cleaned and recorded. The Stage 2 report will state the results of the archaeological recording and will indicate whether any Stage 3 work is warranted.

Stage 3: Sampling and Assessment

1.1.5. Sub-sampling and palaeo-environmental assessment (pollen, diatoms and foraminifera). Sub-samples will be taken from one core-half, with the other core-half retained intact should further sub-sampling be required. Assessment will comprise laboratory analysis of the samples to a level sufficient to enable the value of the palaeo-environmental material surviving within the cores to be identified. Sub-samples will also be taken and retained at this stage in case radiocarbon dating is required during Stage 4. The Stage 3 report will set out the results of each laboratory assessment together with an outline of the archaeological implications of the combined results, and will indicate whether any Stage 4 work is warranted.

Stage 4: Analysis and Dating

1.1.6. Full analysis of pollen, diatoms and/or foraminifera assessed during Stage 3. Typically, Stage 4 will be supported by radiocarbon dating of suitable sub-samples. Stage 4 will result in an account of the successive environments within the coring area, a model of environmental change over time, and an outline of the archaeological implications of the analysis.

1.1.7. The information provided for this assessment was as follows:

- Borehole logs of 29 boreholes, as detailed in Table 1;
- Vibrocore logs of 24 cores, taken along the cable route.

1.1.8. All boreholes were plotted in the Ground Investigation Report (Fugro Engineering Services Ltd, 2004). Boreholes BHID1 to BHID30 are located within the Inner Dowsing Wind Farm area. Boreholes BHL2 to BHL 30 were drilled within the Lynn Wind Farm area. All vibrocores were extracted along the marine feeder cable route.

1.1.9. Water depths within the Inner Dowsing area range from six to nine metres below Lowest Astronomical Tide (LAT). Within the Lynn area depths range from six to 13 metres below LAT.

1.1.10. According to the Fugro Report (Fugro Engineering Services Ltd, 2004), the strata encountered are Holocene sediments, sediments of the Devensian Bolders Bank Formation and bedrock (Cretaceous chalk). The distribution of these strata is outlined in Table 1 below:

Borehole	Holocene Sediments		Bolders Bank Formation		Cretaceous Chalk	
	Depth to top of stratum (m)	Thickness (m)	Depth to top of stratum (m)	Thickness (m)	Depth to top of stratum (m)	Thickness (m)
BHID1	0	1.0	1.0	9.5	10.5	38.7
BHID3	-	-	0	10.0	10.0	30.5
BHID6	-	-	0	7.0	7.0	43.2
BHID8	0	0.2	0.2	7.6	7.8	31.5
BHID10	-	-	0	7.5	7.5	42.75
BHID11	-	-	0	9.5	9.5	29.75
BHID13	-	-	0	8	8	41.55
BHID15	-	-	0	7.9	7.9	31.7
BHID18	-	-	0	7.4	7.4	42.6
BHID21	-	-	0	7.0	7.0	42.50
BHID23	-	-	0	8.0	8.0	27.30
BHID25	0	0.2	0.2	8.7	8.7	40.95
BHID27	0	0.2	0.2	8.5	8.5	32.0
BHID30	-	-	0	8.1	8.1	42.8
BHL2	0	0.3?	0.3	3.8	4.1	46.15
BHL4	0	0.3?	0.3	6.3	6.6	43.85
BHL6	0	0.5	0.5	5.5	6.0	34.5
BHL8	-	-	0	5.5	5.5	34.5
BHL10	-	-	0	6.0	6.0	34.5
BHL11	-	-	0	4.5	4.5	46.0
BHL13	-	-	0	3.4	3.4	46.55
BHL15	0	0	0.4	3.8	4.2	46.55
BHL17	-	-	0	6.0	6.0	34.45
BHL19	-	-	0	7.8	7.8	32.8
BHL21	0	0	-	-	3.1	34.9
BHL24	-	-	0	3.8	3.8	46.3
BHL26	0	0	0.9	1.0	1.0	49.5
BHL28	0	0	0.2	5.5	5.7	34.0
BHL30	-	-	0	4.0	4.0	46.65

Table 1: Distribution of strata in Boreholes from Fugro Report (Fugro Engineering Services Ltd, 2004)

2. CHARACTERISTICS OF THE SEDIMENT UNITS

2.1.1. An assessment of the descriptions provided in the borehole logs and the geotechnical report enabled the identification of four broad sedimentary units:

- Unit 1: Brown gravely sand or sandy gravel with shell inclusions and flint content;
- Unit 2: Firm to stiff brown, sometimes speckled white, slightly sandy or gravely clay;
- Unit 3: Variation of sometimes clayey, sometimes silty sand and gravel layers;
- Unit 4: Chalk.

3. RESULTS

3.1. UNIT 1

Brown gravely-sand or sandy-gravel with shell inclusions

3.1.1. The Unit 1 sediment was identified as Holocene stratum in the Fugro report (Fugro Engineering Services Ltd, 2004), and where present forms the uppermost layer in all cores. In most cases only very little of this layer remains (0.2 – 1.0 metres). Only core BHL21 contains a significant depth (3.1 metres) of this sediment. In some cases, the sediment was only observed by the drill operator and did not survive in the core.

3.2. UNIT 2

Firm to stiff brown (sometimes speckled white) slightly sandy - slightly gravely clay

3.2.1. In all of the borehole logs the Unit 1 sediment, if present, overlay a stiff sandy or gravely clay – Unit 2 sediment. The only exception is core BHL 21, where the substantial Unit 1 sediment directly overlay the chalk bedrock.

3.2.2. In the Fugro report (Fugro Engineering Services Ltd, 2004) this layer has been assigned to the Bolders Bank Formation. This is a composite of sub-glacial and supra-glacial deposits dating to the end of the Devensian glaciation.

3.2.3. However, the core log descriptions of the deposit indicate the presence of significant elements of clay within this sedimentary unit. Clay deposits are usually formed in low energy environments, thus they may represent material deposited during transgression in sheltered parts of the Holocene coastline, or material re-deposited by the Devensian glaciers. Low energy deposition is characteristic of Holocene estuaries, and can be associated with peat formation.

3.2.4. In core BHL28, there is a 2.5 metre thick silt inclusion within the clay. The silt in the lowermost part of this inclusion is recorded as having an organic odour. Silt is generally formed in higher energy environments than clay. However, the organic odour could be indicative of the presence of peat within this element of the sequence,

and thus may suggest that the deposit formed in what was still a relatively low energy environment.

3.3. UNIT 3

Variation on Unit 2 - sometimes clayey, sometimes silty-sand and gravel layers

3.3.1. This layer lies below Unit 2. It has also been identified by Fugro (Fugro Engineering Services Ltd, 2004) as part of the Bolders Bank formation. The layer represents a variation on the typical description of Unit 2. Where present, it directly overlays the chalk bedrock.

3.3.2. In core BHID3 the sand and gravel layers were overlay a stiff clay, that in turn overlay the bedrock. In core BHID15 gravely clay, rather than sand or gravel, was observed. The sand in core BHL6 contained shell fragments that may be indicative of a marine environment. Silt inclusions were observed in cores BHID27 and BHL17. This layer was not observed in cores BHL24, 28 and 30.

3.3.3. In core BHID6 possible organic content was detected in a clay inclusion. This may suggest the possible presence of peat deposits that are indicative of the survival of palaeo-landsurfaces. Due to the level of information available in the borehole logs and the resolution at which the descriptions were provided it is not possible to determine the exact nature of the organic remains.

3.4. CHALK

3.4.1. The chalk layer, typically encountered at about four to 10 metres below the seabed in all cores is the local bedrock. This layer has no palaeo-environmental potential.

3.5. ARCHAEOLOGICAL POTENTIAL

Unit 1

3.5.1. This layer has been interpreted as the modern (i.e. post transgression) marine seabed sediment, and is largely made up of sand and gravel. If this interpretation is found to be accurate then the palaeo-environmental potential is likely to be low. However, there is some potential for the presence of pre-transgression deposits in the lower reaches of this deposit, and if present any such deposits would have a high palaeo-environmental and archaeological potential.

Unit 2

3.5.2. Due to the level of information available in the borehole logs and the resolution at which the descriptions were provided it is not possible to determine the exact nature of this deposit. Fugro have identified this deposit as being part of the Devensian Bolders Bank formation (Fugro Engineering Services Ltd, 2004), however it is possible that the deposit is in fact more complex, and detailed archaeological recording and assessment may identify elements of the deposit that are of specific archaeological interest.

3.5.3. In general the layers with highest palaeo-environmental and archaeological potential are likely to lie directly below the modern mobile marine sediments and above the glacially deposited Bolders Bank layer. The deposits with the highest potential are

peat and fine-grained sediment formations that allow for the preservation of organic remains. From the descriptions provided it is not possible to determine conclusively whether the upper reaches of Unit 2 contain any such deposits, but if present they would have high palaeo-environmental and archaeological potential.

Unit 3

3.5.4. Due to its position within the sequence (i.e. directly above the bedrock) this deposit may be part of the Bolders Bank formation (as suggested by Fugro) or it may be part of a formation deposited prior to the Devensian glaciation. As with Unit 2, if present any peat or fine-grained deposits within of Unit would have high palaeo-environmental and archaeological potential.

4. RECOMENDATIONS

4.1.1. Based on the results of this assessment of the borehole sample descriptions in the geotechnical report (Fugro Engineering Services Ltd, 2004), the following course of action is suggested: A Stage 2 borehole assessment comprising the archaeological recording of six cores (two from Lynn OWF, two from Inner Dowsing OWF and two from the marine feeder cable route).

4.1.2. The Stage 2 assessment would involve splitting the cores, with half of each core being cleaned and subject to archaeological recording. This approach would allow for an archaeological assessment of typical elements of the broad sedimentary sequence as identified in the Fugro report (Fugro Engineering Services Ltd, 2004). It would allow for an informed assessment of the palaeo-environmental and archaeological potential of the sedimentary sequence likely to be impacted by the development. The report would indicate the requirement for any further, Stage 3, archaeological works.

4.1.3. Sub bottom profiler (hereafter seismic) marine geophysical data has not been assessed archaeologically, either during the desk-based assessment (Wessex Archaeology 2002) or as part of this assessment. The assessment of this data would help to determine whether the area to be impacted by the wind farms contains any submerged river valleys and/or pre-transgression deposits. These areas are generally considered to contain the greatest potential for the presence of palaeo-environmental evidence, and their identification would greatly aid this aspect of the archaeological research into the site.

5. REFERENCES

Fugro Engineering Services Ltd., 2004, 'Lynn And Inner Dowsing Wind Farm Developments. Geotechnical Investigations. Final Report on Ground Investigation', Unpublished 'report ref NEA041005.

Wessex Archaeology, 2002, 'Lynn and Inner Dowsing Offshore Wind Farms: Maritime Archaeological Assessment Technical Report', Unpublished Report ref: 51145.02.