

GUNFLEET SANDS 2 OFFSHORE WINDFARM, ESSEX

Desk-Based Assessment (Stage 1)



Oxford Archaeology North

DONG
energy

Gunfleet Sands
Offshore Wind Farm

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CONTENTS

SUMMARY	2
1. INTRODUCTION	3
1.1 Circumstances of the Project	3
2. METHODOLOGY	4
2.1 Project Design	4
2.2 Stage 1: Desk-Based Assessment	4
2.3 Archive	4
3. BACKGROUND	5
3.1 Location, Topography, Geology and Archaeology.....	5
4. ARCHAEOLOGICAL ASSESSMENT RESULTS	6
4.1 Introduction.....	6
4.2 Core BHSS.....	6
4.3 Core BHFS.....	6
4.4 Core BHF9	6
4.5 Interpretation of the Data	7
5. CONCLUSION	8
5.1 Discussion	8
5.2 Recommendations.....	8
6. BIBLIOGRAPHY.....	9
6.1 Primary and Cartographic Sources	9
6.2 Secondary Sources	9
6.3 Internet Sources	9
7. ILLUSTRATIONS.....	10
7.1 List of Figures	10
APPENDIX 1: PROJECT DESIGN.....	11
APPENDIX 2: GUNFLEET SANDS 2 LOG DATA	17

SUMMARY

Following proposals for the construction of an offshore windfarm at Gunfleet Sands, Essex (NGR centred TM 622200), Gunfleet Sands Limited, commissioned Oxford Archaeology North (OA North) to undertake an archaeological assessment of the marine deposits impacted upon by the second phase of development.

The proposed assessment will be undertaken in a phased manner, each stage informing the work required for the next. The work undertaken in this phase forms Stage 1, which was an initial desk-based assessment of three logs provided by the geotechnical contractor, Structural Soils, which were recorded in August and September 2007. The aim was to broadly characterise the sediments and identify their archaeological potential in relation to evidence for former land surfaces and deposits “such as peat”. From the results, recommendations will be made for Stage 2, archaeological recording of the existing retained cores.

The sediments recorded in all three cores represent bands of clays, silts, sands, gravels and silty peats (in one borehole) deposited under either fluvial or estuarine conditions. It is possible that the deposits recorded from Gunfleet Sands represent a seaward extension of the infilled drainage system of the former Thames-Medway Rivers and their tributaries. On these grounds, it is recommended that the programme of work progresses to Stage 2.

1. INTRODUCTION

1.1 CIRCUMSTANCES OF THE PROJECT

- 1.1.1 Gunfleet Sands 2 Ltd has applied for consent for an extension of the Gunfleet Sands 1 offshore wind farm, Essex (NGR centered at approximately TM 622200) known as the Gunfleet Sands 2. NIRAS, Denmark (hereafter the 'client'), acting on behalf of Dong Energy, requested that Oxford Archaeology North (OA North) submit a project design (*Appendix 1*) for an archaeological assessment of the marine deposits to be impacted upon by a second phase of development on the site. This phase of the development will consist of 22 wind turbines over an area of 7.5km².
- 1.1.2 The Gunfleet Sands project consists of an already consented project Gunfleet I (GS1) (*Figure 1*), which has consent to construct up to 30 turbines, each of a maximum capacity of 3.6MW, thus yielding a total capacity of 108MW and a proposed extension Gunfleet Sands 2. The Environmental Statement for the proposed extension was submitted to BERR on 18th June 2007. The Gunfleet Sands 2 development will consist of 22 wind turbines over an area of 7.5 km². Gunfleet Sands Ltd requested that OA North undertook an archaeological assessment of 3 geotechnical cores from the proposed development area of Gunfleet Sands 2 Offshore Wind Farm.
- 1.1.3 Gunfleet Sands Ltd has received a Coast Protection Act 1949 (CPA): Section 34 for Ground Investigations, and it has been requested that "*Geotechnical works should be analysed for archaeological interests*". This should include "*In particular, analysis of the geotechnical survey data ...to determine the presence of deposits such as peat beds that may contain material of archaeological significance.*" The Archaeological Protocol for Gunfleet Sands 1 Offshore Windfarm, the first phase of the development, which was prepared by Wessex Archaeology, also recommends an archaeological assessment of the geotechnical data.
- 1.1.4 The project design submitted by OA North followed the Archaeological Protocol provided by the client, which stipulates that 'The programme of work is to be taken in four stages: Stage 1, a desk-based assessment; Stage 2, Coring and recording; Stage 3, Sampling and assessment; and Stage 4, Analysis and dating'. OA North were subsequently commissioned to undertake the work and this report presents the results of the data generated at Stage 1. This initial stage consists of a desk-based archaeological assessment of three core logs provided by Gunfleet Sands Ltd, with the principle aim being to assess the logs for their archaeological potential, primarily in relation to any evidence for former land surfaces and peat deposit. The results generated from this report also provided the basis with which to recommend any future stages of work.

2. METHODOLOGY

2.1 PROJECT DESIGN

- 2.1.1 The project design submitted by OA North followed the Archaeological Protocol provided by the client. The methodology for Stage 1, outlined in the project design (*Appendix 1*) was adhered to.

2.2 STAGE 1: DESK-BASED ASSESSMENT

- 2.2.1 A geoarchaeological specialist inspected the three logs in order to assess the nature of the sedimentary sequences present below the seabed at each borehole location. It is acknowledged that any interpretation made at this stage of the investigations may be limited and dependent on the available geotechnical records. However, attempts were made to interpret the data and assess their archaeological potential by referring to the results of previous geoarchaeological and palaeoenvironmental investigations carried out in the area. In particular, geoarchaeological and archaeological work carried out at Cudmore Grove and Clacton-on-Sea was referred to (Roe 1995; Bridgland *et al* 1999). In addition, the Quaternary Research Association's Field Guide for the Lower Thames Valley (Bridgland *et al* 1995) provided valuable information.

2.3 ARCHIVE

- 2.3.1 A full archive has been prepared to a professional standard in accordance with current United Kingdom Institute for Conservation (UKIC 1990) and English Heritage guidelines (English Heritage 1991).

3. BACKGROUND

3.1 LOCATION, TOPOGRAPHY, GEOLOGY AND ARCHAEOLOGY

- 3.1.1 The site of the proposed development lies roughly 7km south-east of Clacton-on-Sea, Essex (NGR centred at TM 622200), situated on one of many sand bars, which are a prevalent feature of the marine-dominated outer estuary of the Lower Thames Valley (Bates and Whittaker 2004).
- 3.1.2 The Thames Valley is a significant regions in British Pleistocene geology, and its terrace sequence, with surviving deposits of interglacial sediments, has provided the basis for a British Palaeolithic sequence of palaeoenvironmental changes in relation to climatic and sea level fluctuations. Reconstruction of the Pleistocene drainage evolution of the lower Thames (Bridgland *et al* 1995) has shown that prior to the Anglian glaciation (*c* 480,000-375,000 BP) the course of the Thames was further north, and its convergence with the River Medway was near to Clacton-on-Sea. During the Anglian period, the Thames was blocked by ice and diverted southwards near to its current position.
- 3.1.3 Although the northward alignment of the former post-diversion route of the Thames is no longer evident, its drowned extension and tributaries now lie offshore, submerged by the Holocene marine transgression. Several major climatic episodes and marine fluctuations have affected the area since the Anglian glaciation, leading to the development of a complex sequence of estuarine and fluvial deposits. The number of glacial and interglacial episodes represented in the sequence is still open to debate, and crucial to this understanding are the thick channel infills present on the coast and further offshore. Upper Pleistocene freshwater sediments have been recorded at -35m OD (Ordnance Datum) in the Channel (West 1972), and interglacial channel fills have been exposed at Cudmore Grove (NGR TM 067144; Roe 1995) and at Clacton-on-Sea (Pike and Godwin 1952, Bridgland *et al* 1999).
- 3.1.4 The deposits of clays and silts recorded at both Clacton-on-Sea and Cudmore Grove contain rich assemblages of vertebrate remains, molluscs, and ostracods (Roe 1995; Bridgland *et al* 1999). In addition, the organic clays recorded at both sites contain well-preserved pollen (Pike and Godwin 1952; Roe 1995). Both channel fills contain fauna and flora interpreted as being Hoxnian in age (dated to *c* 424,000-380,000 BP).
- 3.1.5 The Lower Thames Valley is also renowned for its important archaeological sites and associated Clactonian-type palaeolithic industry, which is fundamental to the understanding of both Britain's and Europe's earliest populations. Although few sites with *in situ* archaeological material have been discovered in the Lower Thames Valley, the importance of the buried deposits, with or without cultural material, in providing a broader understanding of the chronological sequence of events in relation to climate change and early human occupation cannot be underestimated.

4. ARCHAEOLOGICAL ASSESSMENT RESULTS

4.1 INTRODUCTION

- 4.1.1 The core logs obtained from Gunfleet Sands 2 and provided by Structural Soils, contain information relating to the sedimentary nature of the deposits at three locations located 7km south-east of Clacton-on-Sea, Essex (Fig 1). The sediment cores (BHSS, BHFS and BHF9, see *Appendix 2*) were obtained using a Beretta T41 rotary corer and sampled with thin-walled Shelby tubes. The three cores extended to 50.35m, 51.50m and 48.85m below the seabed respectively. The co-ordinates and the ground levels (Ordnance Datum) of each of the cores were not available at this stage.

4.2 CORE BHSS

- 4.2.1 Core BHSS commenced at a depth of 14m and was terminated at 50.35m depth. The surface of the underlying geology, described as London Clay, was encountered at 36m depth. The log indicates that the London Clay in core BHSS is overlain by gravel of various lithological sizes to a depth of 34.6m, which, in turn, is overlain by a fine to medium sand to a depth of 32.4m.
- 4.2.2 The sand is overlain by a deposit of firm grey calcareous clay-silt with occasional inclusions of black peaty organic silt with subangular fine gravel of flint, which is recorded between 32.4m and 30.6m depth (a thickness of 1.8m). A deposit of gravel to 30.5m depth, and then clay to 27.5m depth overlies this organic silt. Silty or clayey-sand is recorded from 27.5m to 14m depth (the top of the core).

4.3 CORE BHFS

- 4.3.1 Core BHFS commenced at a depth of 16.3m and was terminated at 51.5m depth. The surface of the underlying geology, described as London Clay, was encountered at 33.1m depth. The log indicates that the London Clay in core BHFS is overlain by gravel of various lithological sizes to a depth of 30.15m, which, in turn, is overlain by a deposit of clay to 23.95m, and silty-sand to 21m depth.
- 4.3.2 The silty sand is overlain by a deposit of sandy-gravelly organic silt-clay with some fine shell fragments, which is recorded between 21m and 19m depth (with a thickness of 2m), and this is sealed by gravelly-clayey sand to the top of the core (at 16.3m depth).

4.4 CORE BHF9

- 4.4.1 Core BHF9 commenced at a depth of 14.1m and was terminated at 48.85m depth. The surface of the underlying geology, described as the Reading Formation, was encountered at 42.3m depth. The log indicates that the

Reading Formation is overlain here by a complex sequence of silt-sand, sand, clay-silt and clay deposits to the top of the core. Some black fine organic sediment was recorded in the uppermost deposit of sand (between 22.7m and 14.1m depth).

4.5 INTERPRETATION OF THE DATA

- 4.5.1 The sediment sequence recorded in the three cores can be closely correlated with the foreshore deposits at Cudmore Grove and Clacton-on-Sea (*see Sections 3.1.3 and 3.1.4*). The sediments at both sites represent the fills of deep channels cut into the London Clay, which form the base of the Pleistocene sequences.
- 4.5.2 At both Cudmore Grove and Clacton-on-Sea the basal deposits consist of up to 7m of sands and gravels; At Cudmore Grove this is overlain by up to 10m of deep grey silty-clay, and then 2.5m of organic clay rich in wood fragments. These deposits contained rich diatom, mollusc, and ostracod assemblages indicative of a tidally influenced river channel and later a lagoonal environment. The deposits also contained abundant pollen, indicative of warm temperate conditions, which, on biostratigraphical grounds, have been assigned to the Hoxnian interglacial.
- 4.5.3 The basal gravel and overlying loamy sands and clays recorded at Clacton-on-Sea, known as the ‘freshwater beds’, also yielded rich mollusc, ostracod, and pollen assemblages (Bridgland *et al* 1999). The results of the pollen work by Bridgland *et al* (1999) has been directly compared to Pike and Godwin’s (1952) earlier pollen diagram also from Clacton-on-Sea, which, rich in temperate trees such as oak, alder, elm and lime, has also been assigned to the Hoxnian interglacial period. Of added significance at Clacton-on-Sea were the rich mammalian remains and large assemblage of Clactonian artefacts discovered in the lower ‘freshwater beds’ (Bridgland *et al* 1999). The upper deposits at Cudmore Grove and Clacton-on-Sea consist of gravel or sands, which, at the latter site, contain shell fragments and are interpreted as estuarine in origin (Roe 1995; Bridgland *et al* 1999).
- 4.5.4 The sediments recorded in cores BHSS and BHFS from Gunfleet Sands have similar sequences to those recorded at Cudmore Grove and Clacton-on-Sea. Both cores show a basal deposit of London Clay overlain by sand and gravel, which, in turn, is overlain by clays and sands with organic remains. In addition, both cores also contain upper deposits of sand/gravel, which contained shell fragments in core BHFS. Core BHF9 varies slightly, with differing underlying geology and the absence of basal gravel. However, some organic material is recorded in the upper part of the sequence.

5. CONCLUSION

5.1 DISCUSSION

- 5.1.1 Although the data generated at this stage of the investigations are limited, they suggest that the three cores contain silty peats, fluvial or marine sediments in which organic remains are likely to be preserved, which may potentially be archaeologically significant.
- 5.1.2 It is possible that the deposits recorded in the three cores from Gunfleet Sands represent the seaward extension of similar deposits recorded nearer the shore at Cudmore Grove and Clacton-on-Sea. The deposits at these two sites have been interpreted as the infills of the former channels of the Thames-Medway Rivers, and contain interglacial faunal and floral assemblages, which have been assigned to the Hoxnian interglacial period (dated to 424,000-380,000 BP). In conclusion, the data provided by the sediment logs from Gunfleet Sands suggest that more detailed examination of the sediments would prove to be beneficial.

5.2 RECOMMENDATIONS

- 5.2.1 Given the importance of the Pleistocene history of the Lower Thames Valley and the similarity of the recorded deposits from the three cores with significant interglacial sites further towards the coast, it is recommended that Stage 2 should proceed (*Appendix 1*). This would involve the detailed inspection and recording of selected or new cores taken from the development area.

6. BIBLIOGRAPHY

6.1 PRIMARY AND CARTOGRAPHIC SOURCES

Ordnance Survey, 1972, 1:25 000, Sheet TM 11/21, Pathfinder 1101

6.2 SECONDARY SOURCES

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Pike, K, and Godwin, H, 1952 The Interglacial at Clacton-on-Sea. *Quarterly Journal of the Geological Society*, 108, 261-272

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UKIC, 1990 *Guidelines for the Preparation of Archives for Long-Term Storage*, London

West, RG, 1972, Relative land-sea-level changes in southeastern England during the Pleistocene. *Philosophical Transactions of the Royal Society, London, A*, **272**, 87-98

6.3 INTERNET SOURCES

<http://www.gunfleetsands.co.uk/front+page.htm>

7. ILLUSTRATIONS

7.1 LIST OF FIGURES

Figure 1: Location map of Gunfleet Sands and the development area.

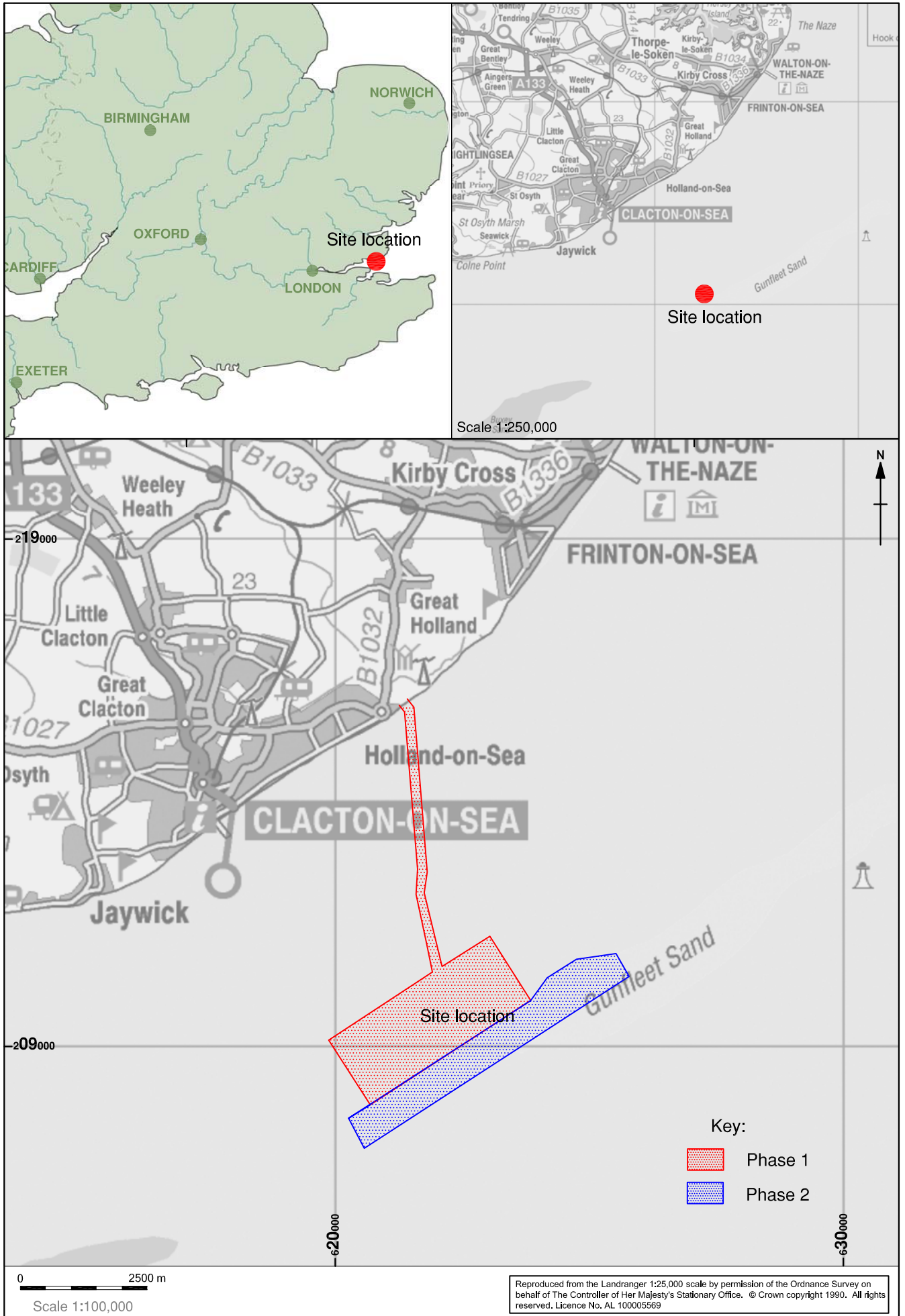


Figure 1: Location map of Gunfleet Sands Phases 1 and 2

APPENDIX 1: PROJECT DESIGN

1 INTRODUCTION

1.1 PROJECT BACKGROUND

- 1.1.1 NIRAS, Denmark (hereafter the ‘client’) has requested that Oxford Archaeology North (OA North) submit proposals for an Archaeological Assessment of three bore cores from a Marine Geotechnical Survey ahead of the construction of Gunfleet Sands 2 Offshore Windfarm, Essex, being planned by DONG Energy (UK) Ltd, a subsidiary of Danish Oil and Natural Gas (DONG). The site of Gunfleet Sands 2, lies 7km south east of Clacton-on-Sea, Essex.

1.2 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

- 1.2.1 Gunfleet Sands Ltd has received a Coast Protection Act 1949 (CPA): Section 34 for Ground Investigations at Gunfleet Sands Ltd Two Offshore Windfarm and it has been requested that “*Geotechnical works should be analysed for archaeological interests*”. The Archaeological Protocol for Gunfleet Sands 1 Offshore Windfarm, which was prepared by Wessex Archaeology, recommends an archaeological assessment of the geotechnical data. The Scope of work for marine archaeology was submitted to OA North by NIRAS and will not be repeated here.

1.3 OXFORD ARCHAEOLOGY NORTH

- 1.3.1 The company, both as Oxford Archaeology North, and under the former guise of Lancaster University Archaeological Unit (LUAU), has considerable experience of sites of all periods, having undertaken a great number of small and large scale projects throughout Northern England during the past 25 years and latterly in Southern England. Evaluations, assessments, watching briefs and excavations have taken place within the planning process, to fulfil the requirements of clients and planning authorities, to very rigorous timetables.
- 1.3.2 OA North has the professional expertise and resources to undertake the project detailed below to a high level of quality and efficiency. OA North is an Institute of Field Archaeologists (IFA) registered organisation, registration number 17, and all its members of staff operate subject to the IFA Code of Conduct.

2 OBJECTIVES

- 2.1 The following programme has been designed following the Archaeological Protocol provided by NIRAS and will be undertaken in 4 stages.
- Stage 1: Desk-based assessment
 - Stage 2: Coring and recording
 - Stage 3: Sampling and assessment
 - Stage 4: Analysis and dating
- 2.2 Stage 1: Desk-based assessment: Desk-based Archaeological assessment of three core logs already 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 if any Stage 2 recording is required. A written report detailing the results of Stage 1 will be produced.
- 2.3 Stage 2: Coring and recording: Archaeological recording of selected retained or new cores. Again, a written report will be produced, which will indicate if any Stage 3 work is warranted.

- 2.4 **Stage 3: Sampling and assessment:** To assess the palaeoenvironmental potential of the selected core(s) for further analysis. A written report will be produced giving the results of the assessment, an outline of the archaeological implications of the combined work and an indication if any Stage 4 work is warranted.
- 2.5 **Stage 4: analysis and Dating:** This stage will comprise full analysis of pollen, diatoms and/or foraminifera and it will be supported by a programme of scientific dating. An account of successive environments within the coring area, a model of environmental change over time and an outline of archaeological implications will be given.
- 2.6 **Report and archive:** a written report will be produced at each stage to assess the significance of the data generated by the programme within a local and regional context. It will present the results of the assessments from each stage.

3 METHOD STATEMENT

3.1 ARCHAEOLOGICAL ASSESSMENT

- 3.1.1 **Stage 1:** desk-based assessment. The three core logs generated by the geotechnical contractors will be assessed to establish whether there are horizons of archaeological interest for example buried land surfaces. These will be broadly characterised. This data will be the basis as to whether it is necessary to proceed to Stage 2 of the archaeological recording. The results of this exercise will be summarised in a written report.
- 3.1.2 **Stage 2:** coring and recording. Selected cores, either those from the initial geotechnical work or new ones will be split, and half the core will be cleaned and recorded on *pro-forma* sheets following the English Heritage guidelines for Geoarchaeology (English Heritage 2004). The data will be used to produce lithology diagrams and a written report, which will include the methodology, results, interpretation, and potential of the cores for further analysis with appropriate diagrams and maps.
- 3.1.3 **Stage 3:** sampling and assessment. One half of the selected core(s) will be subsampled and samples taken for environmental assessment (pollen, diatoms and/or foraminifera) and scientific dating. The subsamples will be assessed in the laboratory for pollen, diatoms and/or foraminifera either by the OA North in house specialist (pollen) or sent to the appropriate specialists.
- 3.1.4 **Pollen:** The pollen in the sediment will be assessed to help understand the nature and processes of accumulation of the waterlogged deposits and also the local environment. The pollen assessment method to be used is in the following paragraph.
- 3.1.5 Sub-samples, 10-20ml in volume, will prepared for pollen analysis using a standard chemical procedure (method B of Berglund & Ralska – Jasiewiczowa (1986), using HCl, NaOH, sieving, HF, and Erdtman's acetolysis, to remove carbonates, humic acids, particles > 170 microns, silicates, and cellulose, respectively. The samples were then stained with safranin, dehydrated in tertiary butyl alcohol, and the residues mounted in 2000 cs silicone oil. Slides will be examined at a magnification of 400x (1000x for critical examination) by equally-spaced traverses across at least two slides to reduce the possible effects of differential dispersal on the slide (Brooks & Thomas, 1967). For the assessment a pollen count for each sample of at least 100 land pollen and spores will be reached. *Lycopodium* tablets (Stockmarr, 1971) will be added to a known volume of sediment at the beginning of the preparation so that pollen concentrations could be calculated. Pollen identification will be made using the keys of Moore *et al.* (1991), Faegri & Iversen (1989), and a small modern pollen reference collection. Andersen (1979) will be followed for identification of cereal-type grains. Indeterminable grains will also be recorded as an indication of the state of the pollen preservation. Plant nomenclature will follow Stace, 1997.
- 3.1.6 The data will be presented in tables as either percentage values or actual numbers of pollen grains and spores. The interpretation of the data may help in our understanding of the nature in which the waterlogged deposits accumulated and also of the local environment.

- 3.1.7 **Diatoms:** The sediments will be assessed for the presence and absence of diatoms. If present the diatoms will be identified and quantified. Small sub-samples of the sediment samples will be submitted to the relevant specialists (Drs Philip Barker and Lydia King), who will prepare 10ml samples following the standard hydrogen peroxide and hydrochloric acid procedure (Batterbee 1986).
- 3.1.8 Diatoms are freshwater or marine algae with a silica frustule or chamber, which is resistant to decay. They are habitat specific and are therefore a good indicators of such characteristics as salinity and water quality (English Heritage, 2002).
- 3.1.9 **Foraminifera:** The samples will be assessed in the first instance for the presence or absence of foraminifera by Dr John Whittaker of the Natural History Museum. Subsamples will be prepared as follows. They will be placed in a ceramic bowl and dried in an oven at a low temperature, then a teaspoon of sodium bicarbonate will be added (to assist clay breakdown), hot water will poured on and the samples left to soak overnight. Each will then washed through a 75 micron sieve with hot water, the residue being decanted back into the bowl and left, again, to dry in the oven. The dried samples were then put into labelled plastic bags.
- 3.1.10 Sorting will be carried out under a binocular microscope, the sample being first dried sieved through a nest of sieves (>500 microns, >250 microns, >150microns, and pan), and then a portion of each sieve-size, one at a time, being sprinkled onto a grid-lined picking-tray. Microfossils will be picked out with a small brush onto a 3x1" faunal slide for reference purposes. At this assessment stage recording was merely on a presence/absence basis. Other organic matter of interest (plant debris, seeds, insects, ostracods and diatoms) will also noted.
- 3.1.11 The data from the pollen, diatom and foraminifera assessment will be presented in a written report with an outline of the archaeological implications. Proposals will be made for further analysis if warranted and the methodology for this analysis will also be included.
- 3.1.12 **Stage 4:** analysis and dating. If the environmental assessment demonstrates the potential for further research of the pollen, and/or diatom and foraminifera, a programme of full analysis from all or part of the borehole sequence will be undertaken. The details of the methodology will be outlined in the Stage 3 report. This programme of analysis will supported by a programme of scientific dating and the advice of the English Heritage dating team will be sort because of the possible influence of old carbon in marine sediment. It may be necessary to consider using some other dating techniques instead of radiocarbon.

3.2 REPORT AND ARCHIVE

- 3.2.1 **Report:** one bound and one unbound copy of the final report will be submitted to the client within three weeks of the completion of Stages 1-3 of the project. Three copies of the final report will be submitted to the client on completion of the project. The report will include:
- a site location plan related to the national grid;
 - a front cover to include the planning application number and the NGR;
 - the dates on which each phase of the programme of work was undertaken;
 - a concise, non-technical summary of the results;
 - an explanation to any agreed variations to the brief, including any justification for any analyses not undertaken;
 - a description of the methodology employed, work undertaken and results obtained;
 - plans and sections at an appropriate scale showing the location and position of deposits and finds located as well as sites identified during the desk-based assessment;

- monochrome and colour photographs as appropriate
 - a description of the sediments in the borehole selected for all stages of the project;
 - a list of scientific dates;
 - a description of any environmental or other specialist work undertaken and the results obtained;
 - a summary of the impact of the development on any archaeological remains and, where possible, a model of potential archaeological deposits within as-yet unexplored areas of the development site;
 - a copy of this project design, and indications of any agreed departure from that design;
 - the report will also include a complete bibliography of sources from which data has been derived.
- 3.2.2 This report will be in the same basic format as this project design; a copy of the report can be provided on CD, if required. Recommendations concerning any subsequent mitigation strategies and/or further archaeological work following the results of the field evaluation will be provided in a separate communication.
- 3.2.3 **Confidentiality:** all internal reports to the client are designed as documents for the specific use of the client, for the particular purpose as defined in the project brief and project design, and should be treated as such. They are not suitable for publication as academic documents or otherwise without amendment or revision.
- 3.2.4 **Archive:** the results of all archaeological work carried out will form the basis for a full archive to professional standards, in accordance with current English Heritage guidelines (*Management of Archaeological Projects*, 2nd edition, 1991, English Heritage Guidelines for Geoarchaeology, 2004 and The English Heritage Guidelines for Environmental Archaeology, 2002). The project archive will include summary processing and analysis of all features, finds, or palaeoenvironmental data recovered during fieldwork, which will be catalogued by context.
- 3.2.5 The deposition of a properly ordered and indexed project archive in an appropriate repository is essential and archive will be provided in the English Heritage Centre for Archaeology format and a synthesis will be submitted to the Essex HER (the index to the archive and a copy of the report). OA North practice is to deposit the original record archive of projects with the appropriate Record Office.
- 3.2.6 All artefacts will be processed to MAP2 standards and will be assessed by our in-house finds specialists. The deposition and disposal of any artefacts recovered in the evaluation will be agreed with the legal owner and an appropriate recipient museum. Discussion regarding the museum's requirement for the transfer and storage of finds will be conducted prior to the commencement of the project, and Essex HER will be notified of the arrangements made.
4. HEALTH AND SAFETY
- 4.1 OA North provides a Health and Safety Statement for all projects and maintains a Unit Safety policy. All site procedures are in accordance with the guidance set out in the Health and Safety Manual compiled by the Standing Conference of Archaeological Unit Managers (1997). A written risk assessment will be undertaken in advance of project commencement and copies will be made available on request to all interested parties.
- 4.2 Full regard will, of course, be given to all constraints (services etc) during the fieldwork as well as to all Health and Safety considerations.

5 PROJECT MONITORING

- 5.1 work and its results, and will be notified a week in advance of the commencement of the fieldwork. Any proposed changes to the project design will be agreed with Essex HER in consultation with the client.

6 STAFFING

- 6.1 The project will be under the direct management of an OA North Project Manager.
- 6.2 All environmental sampling and assessment will be undertaken under the auspices of **Elizabeth Huckerby** (OA North Environmental Manager) who has unparalleled experience of palaeoenvironmental work in the North West and who heads a team of environmental archaeologists. **Denise Druce**, who has considerable experience of working in the North West and also on the Severn estuary, will describe the sediments and assess their geoarchaeological potential. **Lucy Verrill and Sylvia Peglar**, who are both experienced as a pollen analysts, may also assist with the project. **Sylvia** has previously analysed samples for pollen from East Anglia and has experience of marine cores taken in advance of the construction of the channel tunnel.
- 6.3 All diatom work will be undertaken under the supervision of Dr Philip Barker and Dr Lydia King of the Geography Department of the University of Lancaster.
- 6.4 The foraminifera will be examined by Dr John Whittaker of the Natural History Museum, London

7 INSURANCE

- 7.1 OA North has a professional indemnity cover to a value of £2,000,000; proof of which can be supplied as required.

8 REFERENCES

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APPENDIX 2: GUNFLEET SANDS 2 LOG DATA



Contract Gunfleet Sands		Client Geo@Sea		Borehole No BHSS
Job No 720506	Start 30.08.07 End 02.09.07	Ground Level (m CD) ---	Local Grid Co-Ordinates ---	Sheet 1 of 3


Drilling Records				Instrumentation	Water	Description of Strata	Depth (Thickness)	Legend
Depth	No	Test / Result	Drilling Time					
14.00-15.50	1	B						
14.00-16.00	2					Grey-brown organic fine to medium SAND with possible lenses of soft dark grey clay. Rare gravel of subrounded coarse coal. (Superficial Deposits) ... (Flush returns: Fine grey silty organic SAND).	(2.40)	
16.40-18.15	3	U				Dark grey fine slightly silty organic SAND. (Superficial Deposits) ... (Flush returns: Dark grey slightly silty fine SAND).	16.40	
18.15	4	D						
18.16-19.66	5	B						
19.66-21.00	6	D					(6.00)	

Drilling Progress and Water Observations						General Remarks	
Date	Time	Borehole Depth	Casing Depth	Casing Diameter	Water Depth		
30/08/07	11:31	13.45	14.00	260		1. Air and water flush used, sand surging up casing due to pressure difference therefore no air flush used below 18.00m depth. 2. Window sampling, thin walled Shelby tubes and rotary coring used to obtain samples. 3. No recovery in WS at 32.40m and 34.20m or U70 at 45.19m. 4. Tricone, claw and drag bits used for open holing. 5. Deck level 30/08/07 = 48.86mOD, spud legs 0.40m below sea bed. 6. Deck level 31/08/07 = 50.20mOD, spud legs total 1.10m into sea bed. Change in	
30/08/07	13:00	16.40	16.40	200			
30/08/07	16:50	18.16	19.66	200			
31/08/07	10:00	23.00	23.00	200			
31/08/07	13:20	27.35	26.00	200			
31/08/07	15:35	30.50	29.06	200			
31/08/07	17:50	30.50	30.75	150			
01/09/07	05:00	33.50	34.02	150			
All dimensions in metres		Method Beretta T41 rig		Drilled By CA/WM	Logged By MG	Checked By	
Scale 1:111							



Contract Gunfleet Sands		Client Geo@Sea		Borehole No BHSS
Job No 720506	Start 30.08.07 End 02.09.07	Ground Level (m CD) ---	Local Grid Co-Ordinates ---	Sheet 2 of 3


Drilling Records				Instrumentation	Water	Description of Strata	Depth (Thickness)	Legend
Depth	No	Test / Result	Drilling Time					
						Dark grey fine slightly silty organic SAND. (Superficial Deposits) (<i>stratum layer from previous sheet</i>)	22.40	
22.40-23.00	7	D				Grey silty fine SAND. (Flush returns)	23.00	
23.00-24.20	8	U				(Superficial Deposits) Dark grey and black clayey/silty fine SAND with thin lenses of clay. (Superficial Deposits)	(3.00)	
24.20-26.00	9	B				... (Flush returns: Dark grey clayey/silty fine SAND).	26.00	
26.00-27.50	10	B				Grey fine SAND. (Flush returns) (Superficial Deposits)	(1.50)	
27.35-27.90	11	TW				Very soft dark grey CLAY. (Superficial Deposits) ... (Flush returns: Dark grey CLAY).	(2.95)	
30.50	12	D				Soft dark grey and black slightly gravelly CLAY with some fine shells and shell fragments. Gravel is subangular to rounded fine flint. (Superficial Deposits)	30.50	
30.50-31.90	13	U				Grey clayey subrounded medium to coarse flint GRAVEL (Possibly driven down from sand layers above) (Superficial Deposits)	30.60 (1.80)	
31.90	14	D				Firm grey calcareous CLAY/SILT with occasional inclusions of black peaty/organic silt and some subangular fine gravel of flint. (Superficial Deposits)	32.40	
31.90		$c_u=44$... (No return in flush from 30.90-32.40m depth).	34.60	
32.40-34.20	15	B				Brown fine to medium SAND. (Water flush unable to lift gravels). (Superficial Deposits) ... (No recovery from window sample).	(1.40)	
34.60-36.00	16	B				Grey subangular to rounded fine to medium GRAVEL of various lithologies, dominantly flint. (Flush returns). (Superficial Deposits)	36.00	
36.00	17	D				Stiff dark grey CLAY. (London Clay Formation)	(3.00)	
36.00-36.54	18	TW					39.00	
36.00		$c_u=75$						
36.54		$c_u=125$						
39.00-39.50	19	TW				Very stiff dark grey fissured CLAY. (London Clay Formation)		
39.00		$c_u=40/40/40$						

Drilling Progress and Water Observations						General Remarks					
Date	Time	Borehole Depth	Casing Depth	Casing Diameter	Water Depth						
01/09/07	10:20	34.20	34.60	150		elevation of +1.34m.					
01/09/07	11:20	45.22	37.20	150							
01/09/07	11:55	36.00	37.20	150							
01/09/07	15:00	39.00	37.20	150							
01/09/07	17:40	42.50	37.20	150							
01/09/07	20:20	45.00	37.20	150							
02/09/07	03:00	46.50	37.20	150							
02/09/07	05:00	48.24	37.20	150							
All dimensions in metres				Method		Drilled By		Logged By		Checked By	
Scale 1:111		Beretta T41 rig		CA/WM		MG					



Contract Gunfleet Sands		Client Geo@Sea		Borehole No BHSS
Job No 720506	Start 30.08.07 End 02.09.07	Ground Level (m CD) ---	Local Grid Co-Ordinates ---	Sheet 3 of 3

Drilling Records				Instrumentation	Water	Description of Strata	Depth (Thickness)	Legend
Depth	No	Test / Result	Drilling Time					
39.50		$c_u=32$ $c_u=240/250/250$				Very stiff dark grey fissured CLAY. (London Clay Formation) (<i>stratum layer from previous sheet</i>)	(3.00)	
42.00-42.50	20	TW				Very stiff/hard grey fissured CLAY. (London Clay Formation)	(3.20)	
45.00-45.50	21	TW					(45.20)	
45.19-45.22	22	D				Dark grey MUDSTONE. (London Clay Formation)	(45.50)	
45.22-46.50	23	C				Very stiff dark grey CLAY. (London Clay Formation)	(2.50)	
48.00-48.24	24	TW					(48.00)	
48.24-49.90	25	D				Firm to stiff dark grey CLAY with some fine sand. (London Clay Formation) ... (Flush returns: Dark grey CLAY with some fine to medium sand).	(2.35)	
49.90-50.35	26	TW				... very stiff below ~49.90m depth. Borehole terminated at 50.35m depth.	(50.35)	

Drilling Progress and Water Observations						General Remarks			
Date	Time	Borehole Depth	Casing Depth	Casing Diameter	Water Depth				
02/09/07	09:15	50.35	37.20	150					
All dimensions in metres Scale 1:111		Method Beretta T41 rig		Drilled By CA/WM	Logged By MG	Checked By			



Contract Gunfleet Sands		Client Geo@Sea		Borehole No BHF3
Job No 720506	Start 02.09.07 End 03.09.07	Ground Level (m CD) ---	Local Grid Co-Ordinates ---	Sheet 1 of 3

Drilling Records				Instrumentation	Water	Description of Strata	Depth (Thickness)	Legend
Depth	No	Test / Result	Drilling Time					
16.30-17.80	1	B				Dark grey, locally black, slightly gravelly clayey fine SAND. Gravel is subangular fine flint. (Sample includes soft upper layer of sea bed - very poor recovery). (Superficial Deposits) ... (Flush returns: Dark grey clayey fine SAND).	(2.70)	
19.35-20.40	2	D				<i>Description on next sheet</i> ... (Flush returns: Dark grey sandy SILT/CLAY).	(2.00)	

Drilling Progress and Water Observations						General Remarks			
Date	Time	Borehole Depth	Casing Depth	Casing Diameter	Water Depth				
02/09/07	15:00	16.30	19.00	260		1. Air flush used in gravels, water flush used in all other material. 2. Window sampling, thin walled Shelby tubes and rotary coring used to obtain samples. 3. No recovery in Shelby at 21.00m or WS at 29.30m depth. 4. Tricone and drag bits used for open holing. 5. Deck level 02/09/07 = 8.219mCD, spud legs approx 2.00m into sea bed (including soft upper layer).			
02/09/07	15:45	16.30	19.70	200					
02/09/07	17:30	20.40	21.40	200					
02/09/07	18:10	20.70	22.65	200					
02/09/07	21:00	24.15	24.15	200					
02/09/07	22:30	25.65	25.65	200					
03/09/07	02:40	29.30	25.70	200					
03/09/07	05:15	30.15	30.20	150					
All dimensions in metres			Method		Drilled By				
Scale 1:111			Beretta T41 rig		CA/WM	MG			



Contract Gunfleet Sands		Client Geo@Sea		Borehole No BHF3
Job No 720506	Start 02.09.07 End 03.09.07	Ground Level (m CD) ---	Local Grid Co-Ordinates ---	Sheet 2 of 3

Drilling Records				Instrumentation	Water	Description of Strata	Depth (Thickness)	Legend
Depth	No	Test / Result	Drilling Time					
21.00-22.65	3	B				Dark grey slightly sandy slightly gravelly organic SILT/CLAY with some fine shell fragments. Gravel is subangular fine flint. (Superficial Deposits) (<i>stratum layer from previous sheet</i>) Dark grey slightly silty fine SAND. (Flush returns). (Superficial Deposits)	21.00 (2.95)	
22.65-24.15	4	U $c_u=40$				Dark grey slightly sandy slightly gravelly CLAY. Gravel is subangular to angular fine to medium flint. (Superficial Deposits)	23.95 (3.20)	
27.15-27.40	5	TW				Firm dark grey CLAY. (Superficial Deposits)	27.15 (3.00)	
29.30-30.15	6	U+				Brown subangular to rounded fine to medium, occasionally coarse, flint GRAVEL. (Flush returns, fines possibly washed out). (Superficial Deposits)	30.15 (1.75)	
31.35-31.90	7	B				Brown very sandy subrounded to rounded fine to medium flint GRAVEL. (Flush returns). (Superficial Deposits)	31.90 (1.20)	
31.90-33.40	8a	B				Very stiff dark grey fissured CLAY. (Flush returns). (London Clay Formation)	33.10 (8.90)	
31.90-33.40	8b					... Becoming hard with depth. ... (Flush returns: Dark grey CLAY).		
33.40-34.10	9	D				... (Flush returns: Dark grey CLAY).		
34.80-35.34	10	TW						
37.60-38.90	11	C						
38.90-39.10	12	D						

Drilling Progress and Water Observations						General Remarks			
Date	Time	Borehole Depth	Casing Depth	Casing Diameter	Water Depth				
03/09/07	05:45	29.30	30.40	150					
03/09/07	08:30	31.90	33.00	150					
03/09/07	10:45	34.80	33.40	150					
All dimensions in metres		Method		Drilled By	Logged By	Checked By			
Scale 1:111		Beretta T41 rig		CA/WM	MG				




STRUCTURAL SOILS

DRAFT
ROTARY OPENHOLE LOG

Contract Gunfleet Sands		Client Geo@Sea		Borehole No BHF3
Job No 720506	Start 02.09.07 End 03.09.07	Ground Level (m CD) ---	Local Grid Co-Ordinates ---	Sheet 3 of 3

Drilling Records				Instrumentation	Water	Description of Strata	Depth (Thickness)	Legend
Depth	No	Test / Result	Drilling Time					
42.00-42.50	13	TW $c_u=12$ $c_u=25$				Very stiff dark grey fissured CLAY. (Flush returns). (London Clay Formation) (<i>stratum layer from previous sheet</i>) ... (Flush returns: Dark grey CLAY). Firm dark grey CLAY. (London Clay Formation)	42.00 (3.00) 45.00	
45.00-45.60	14	U $c_u=20$ $c_u=160/200/200$				Very stiff/hard dark grey fissured CLAY. (London Clay Formation) ... (Flush returns: Dark grey CLAY).	(6.50)	
48.50-50.00	15	C				... (Flush returns: Dark grey CLAY).		
50.00-51.50	16	C					51.50	
Borehole terminated at 51.50m depth.								

Drilling Progress and Water Observations						General Remarks			
Date	Time	Borehole Depth	Casing Depth	Casing Diameter	Water Depth				
All dimensions in metres Scale 1:111			Method Beretta T41 rig		Drilled By CA/WM	Logged By MG	Checked By		



Contract Gunfleet Sands		Client Geo@Sea		Borehole No BHF9
Job No 720506	Start 04.09.07 End 05.09.07	Ground Level (m CD) ---	Local Grid Co-Ordinates ---	Sheet 1 of 3

Drilling Records				Instrumentation	Water	Description of Strata	Depth (Thickness)	Legend
Depth	No	Test / Result	Drilling Time					
14.10-16.50	1	D				Dark grey very silty/clayey fine SAND and very sandy SILT/CLAY with some black fine organic sediment. (Flush returns). (Superficial Deposits)		
16.50-18.00	2	D				... (Flush returns: Dark grey very silty/clayey fine SAND and very sandy SILT/CLAY)	(8.60)	

Drilling Progress and Water Observations						General Remarks			
Date	Time	Borehole Depth	Casing Depth	Casing Diameter	Water Depth				
04/09/07	11:00	14.10	15.00	260		1. Water flush used. 2. Window sampling, U100 and U70 tubes used to obtain samples. 3. Insufficient flush return for sampling from 25.80m to 27.00m. 4. No recovery in U70 at 19.70m or WS at 36.00m. 5. Wing/claw and drag bits used for open holing. 6. Deck level 04/09/07 = 8.545mCD.			
04/09/07	11:45	14.10	19.70	200					
04/09/07	14:50	21.10	22.70	200					
04/09/07	17:10	24.00	25.70	200					
04/09/07	18:00	24.00	25.70	150					
04/09/07	18:45	25.80	27.15	150					
05/09/07	06:45	35.60	33.16	127					
05/09/07	08:15	35.60	36.26	127					
All dimensions in metres		Method		Drilled By	Logged By	Checked By			
Scale 1:111		Beretta T41 rig		CA/WM	MG				



Contract Gunfleet Sands		Client Geo@Sea		Borehole No BHF9
Job No 720506	Start 04.09.07 End 05.09.07	Ground Level (m CD) ---	Local Grid Co-Ordinates ---	Sheet 2 of 3

Drilling Records				Instrumentation	Water	Description of Strata	Depth (Thickness)	Legend
Depth	No	Test / Result	Drilling Time					
20.50-22.70	3	D				Dark grey very silty/clayey fine SAND and very sandy SILT/CLAY with some black fine organic sediment. (Flush returns). (Superficial Deposits) (<i>stratum layer from previous sheet</i>) ... (Flush returns: Dark grey very silty/clayey fine SAND and very sandy SILT/CLAY)	22.70	
22.70-23.80	4	U				Brown medium to coarse SAND. (Fines possibly flushed out). (Superficial Deposits)	23.10 (0.90)	
24.00-25.70	5	D				Dark grey silty fine SAND. (Superficial Deposits) Dark grey slightly sandy CLAY/SILT. (Flush returns). (Superficial Deposits)	24.00 (2.00)	
27.00-27.32	6	U				... (Flush returns: Dark grey slightly sandy CLAY/SILT). Brown slightly clayey fine to medium SAND. (Flush returns). (Superficial Deposits)	26.00 (1.00)	
27.32	7	D				Firm brown slightly sandy slightly gravelly CLAY. Gravel is angular to subangular fine to coarse sandstone and flint. (Superficial Deposits)	27.00 (3.00)	
30.00-30.25	8	U				Very stiff grey slightly sandy CLAY. (Superficial Deposits)	(0.80)	
30.25	9	D				... (Flush returns: Grey-brown clayey SAND). Grey-brown clayey SAND. (Flush returns). (Superficial Deposits)	30.80 (2.20)	
30.25-30.80	10	U				... (Flush returns: Grey-brown clayey SAND).	33.00	
30.80-31.50	11	D				Grey brown slightly clayey SAND. (Superficial Deposits)	33.38	
31.10-33.00	12	D				Grey-brown slightly clayey slightly gravelly SAND. Gravel is angular to subangular fine to medium flint. (Superficial Deposits)	33.50 (2.25)	
33.00-33.38	13	U				Very stiff slightly sandy CLAY. (Superficial Deposits)	36.00	
33.38-33.75	14	U				Brown slightly clayey SAND. (Flush returns). (Superficial Deposits)	(1.50)	
33.75-36.00	15	D				Dark grey very sandy SILT/very silty fine SAND. (Flush returns). (Superficial Deposits)	37.50 (1.50)	
36.00-37.60	16	D				Stiff grey CLAY with thin bands of pale brown weakly cemented silt/very weak siltstone. (Superficial Deposits)	37.90	
37.50-38.05	17	U				Dark grey very sandy SILT/silty fine SAND. (Superficial Deposits)	(3.10)	
37.90-39.20	18	D				Description on next sheet		
39.20-40.70	19	D						

Drilling Progress and Water Observations						General Remarks
Date	Time	Borehole Depth	Casing Depth	Casing Diameter	Water Depth	
05/09/07	09:00	37.60	37.90	127		
05/09/07	09:30	38.05	40.70	127		
05/09/07	10:20	40.70	42.20	127		
All dimensions in metres Scale 1:111		Method Beretta T41 rig		Drilled By CA/WM	Logged By MG	Checked By



Contract Gunfleet Sands		Client Geo@Sea		Borehole No BHF9
Job No 720506	Start 04.09.07 End 05.09.07	Ground Level (m CD) ---	Local Grid Co-Ordinates ---	Sheet 3 of 3

Drilling Records				Instrumentation	Water	Description of Strata	Depth (Thickness)	Legend
Depth	No	Test / Result	Drilling Time					
40.70-42.10	20	D				... (Flush returns: Dark grey sandy CLAY/very clayey fine SAND). Dark grey very sandy SILT/silty fine SAND. (Superficial Deposits) (<i>stratum layer from previous sheet</i>) ... (Flush returns: Dark grey sandy CLAY/SILT).	41.00 (1.30)	
42.10-42.50	21	U				Firm to stiff dark grey gravelly CLAY with some shell fragments. Gravel is subangular to rounded medium to coarse flint. (Superficial Deposits)	42.30	
42.10-42.50	22	D				... (Flush returns: Pale brown CLAY). Very stiff grey mottled orange-brown, locally red, CLAY. (Reading Formation)	(2.70)	
45.00-45.35	23	U				Hard grey mottled orange-brown CLAY. (Reading Formation)	45.00 (3.50)	
47.20-47.80	24	U				... (Flush returns: Grey-green CLAY).	48.50	
48.50-48.85	25	U				Hard grey mottled orange-brown slightly gravelly CLAY. Gravel is angular fine to medium mudstone, with rare subangular coarse calcareous limestone (possibly from layer above?). (Reading Formation) Borehole terminated at 48.85m depth.	48.85	

Drilling Progress and Water Observations						General Remarks			
Date	Time	Borehole Depth	Casing Depth	Casing Diameter	Water Depth				
All dimensions in metres			Method		Drilled By	Logged By	Checked By		
Scale 1:111			Beretta T41 rig		CA/WM	MG			