Appendix B

Dredge Material Characterisation
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Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ABP</td>
<td>Associated British Ports</td>
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<tr>
<td>BGS</td>
<td>British Geological Society</td>
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<tr>
<td>CD</td>
<td>Chart Datum</td>
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<tr>
<td>CPT</td>
<td>Cone Penetration Test</td>
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<tr>
<td>FES</td>
<td>Fugro Engineering Services</td>
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<tr>
<td>GIS</td>
<td>Geographical Information System</td>
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<tr>
<td>NEDECO</td>
<td>Netherlands Engineering Consultants</td>
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<td>NERC</td>
<td>Natural Environment Research Council</td>
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<tr>
<td>OSPAR</td>
<td>Oslo and Paris Conventions</td>
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<tr>
<td>STL</td>
<td>Southern Testing Laboratories</td>
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<tr>
<td>SPT</td>
<td>Standard Penetration Test</td>
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</tbody>
</table>

%    percent
µm   micrometre(s)
mm   millimetre(s)
m    metre(s)
m²   square metre(s)
m³   cubic metre(s)
kg   kilogram(s)
kPa  kilopascal(s)
t    tonne(s)
°    degree(s)

B1. Introduction

A literature review and search for geotechnical and geophysical data has been undertaken to develop an understanding of the geological structure of the proposed dredge areas and help characterise the material that requires to be dredged. The data sources used in this review include:

- ABP Research (1994) - File Note - Analysis of Geotechnical Data for Dredgeability - R/2888/05/n/ga/PAW.
- ABP Research (1994) - File Note - ABP Southampton - Proposed Channel Deepening - R/2888/05/n/ga/D.
- BGS (1990) - Sea Bed Sediments and Quaternary Geology WIGHT Sheet 50°N 02°W 1:250,000 series.
A review of these studies identified gaps in the knowledge on the material types and a Geographical Information System (GIS) presentation of the main data sets was used to identify to locations where further information was required with the aim of completing the determination of:

- Volumes of different material types to be dredged;
- The sediment properties for dredge, disposal and beneficial use purposes;
- Definition of inputs parameters for the modelling investigations;
- Possible contamination of the dredged sediments;
- Probable stability of side slopes; and
- Any palaeo-environmental features.

These requirements were used to define a project-specific site investigation to provide additional information that would integrate well with the existing data. This work was undertaken by Fugro Alluvial Offshore Ltd between February and April 2008.
In addition, laboratory testing was undertaken on samples of the different material types encountered from all types of investigations to determine the engineering, rheological and chemical properties of the materials. In accordance with the OSPAR guidelines for the characterisation of dredge material for possible disposal within the marine environment, the samples used for chemical analysis were obtained at a range of depths and locations distributed throughout all areas to be dredged. The results of these analyses are presented and discussed in the Sediment Quality Chapter (Chapter 9).

From these datasets, a detailed analysis of the geological strata encountered in the area to be dredged was undertaken. This took the form of a series of interpreted profiles in the areas of most significant dredging, along with a general description of the material characteristics at those locations. This analysis is presented in the following section and forms the core data that defines the potential dredge methodology and the time required to complete the dredge. The characteristics of the disturbed sediment and character of the material at the point of disposal/use is also used to inform the numerical modelling (Chapter 8), and determination for any likely beneficial use of the dredged material(s) (Chapter 3).

B2. Spatial Characteristics of Material to be Dredged

The different zones of dredging defined in the previous section were in part based on the changes the geological structure of the bed in the different areas. Within these zones, and at the depths to be dredged, five different material types can be identified from the borehole, vibrocore and CPT records. In some cases, however, the differences between the material types are subtle. Table B.1 summarises the volumes of each material type, allowing for a 0.3m overdredge. Please note all depths quoted are the channel design depths, i.e. not including the overdredge allowance. The following sections describe the sediment structure, then the general characteristics of the different material types to enable their dredgeability and the likely character of the material at the time of disposal to be determined.

Table B.1 Volumes of different sediment types to be dredged

<table>
<thead>
<tr>
<th>Location</th>
<th>Material Type</th>
<th>Volume to be Dredged (m$^3$ in situ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Channel (Marchwood)</td>
<td>Firm-very stiff silty/sandy CLAY and very dense SAND</td>
<td>247,000</td>
</tr>
<tr>
<td></td>
<td>GRAVEL (Pleistocene)</td>
<td>23,000</td>
</tr>
<tr>
<td></td>
<td>Soft-very soft CLAY (alluvium)</td>
<td>180,000</td>
</tr>
<tr>
<td></td>
<td><strong>Total volume</strong></td>
<td><strong>450,000</strong></td>
</tr>
</tbody>
</table>

Figure B.1 shows a mixture of sediments will be dredged. At the shallowest depths (approaching Chart Datum) a layer of the order of 1m thick of very soft organic clay or alluvium covers about 2m of gravel. As the existing bed depths increase, down estuary, the gravel layer disappears, but the thickness of the soft organic alluvial silty sandy clays increases to over 2m. At depths below –6m CD the majority of material will comprise firm to stiff, laminated green/grey to brown sandy clay. A pocket of very dense fine to medium sand with some lignite (not Greensand) will also need to be dredged.
B3. Physical Characteristics of Material to be Dredged

In broad terms, three main types of material will require to be dredged. Whilst some have similar general descriptions they come from different geological strata with different physical characteristics, which can affect the dredging and disposal method and their potential for environmental effects. They are:

- Eocene - Bracklesham and Barton Beds (with several sub-types);
- Pleistocene (and Eocene) Gravel/sands;
- Holocene Clay.

B3.1 Eocene - Bracklesham and Barton Beds

The particle size grading that typifies this material is show in Figure B.2. The components of this material are now described.

- **Very stiff (in places hard silty/sandy CLAY)**. This material is typically described as stiff to very stiff (sometimes hard) greenish grey laminated slightly sandy clay, sometimes with organic matter. The median size (D50) from the particle size envelope is in the range 5–9µm and all material being less than 200µm in diameter. Bulk densities are generally in the range of 2–2.2 t/m³. The clays are generally fissured and the clay mineralogy changes in different beds. Measured un-drained shear strengths with moisture contents of 26–29 % are in the range 118–178 kPa. Laboratory testing to determine the Atterberg limits show a liquid limit for the clay in the range of 59–66%, a plastic limit of 24–29% and a plasticity index in the range 35–37%.

- **Stiff clayey silt/sand** has a D50 value in the range 60–75µm, a bulk density in the range 1.97–2.0 t/m³, and an un-drained shear strength between 130 to 150 kPa for a moisture content of 27–35%. The clay within the material has a plastic limit of between 13–18%, a liquid limit of 34–53% and a plasticity index of 21–35%.

- **Stiff silty/sandy clay**. The sediment is generally described as firm to stiff light brown/olive grey sandy clay, often thinly laminated sand/silt partings. It has a bimodal size distribution with D50 values in the range 12–50µm and 80–200µm, a bulk density in the range 1.92–1.98 t/m³ with a moisture content 25–37%, and an un-drained shear strength of around 100 kPa which increases with depth. The clay within the material has a plastic limit of between 13–18%, a liquid limit of 34–53% and a plasticity index of 21–35%.

- **Very dense SAND**. The sediment is generally described as very dense grey, locally stained black, silty fine/medium sand with partings/laminae of firm grey clay. The material comprises around 10–30% silt and a small proportion of gravel. It is characterised by D50 values in the range 220–280µm and a D90 exceeding 600µm. The bulk density is around 2.0 t/m³.

B3.2 Pleistocene (and Eocene) Gravel/sands

The particle size grading that typifies this material is show in Figure B.3. The sediments are described as medium to dense brown grey slightly silty sandy gravel. The material has a D50 of 8–16mm, a D90 of over 25mm and D10 values in the range 300–500µm, with generally less than 5% silts and clays. Particles are sub-angular to sub-rounded fine to coarse with occasional flint. The bulk density is variable from about 1,600-2,000 kg/m³ with SPT n values up to about 70 blows, increasing with depth.
B3.3 Holocene Clay

The Holocene clay is recently deposited material (less than 10,000 years ago) that forms a shallow surface layer of soft sediments of variable thickness, up to approximately 3.5 m in areas not previously dredged. The material varies from soft to very stiff in places, particularly at the base of the layer. The silty clay sediments are dark grey to black, fine grained, organically rich, and interspersed with pockets of clayey sand. Small lenses of peat and gravelly material are also present particularly in areas not previously dredged. At surface, whether on the side slopes or the channel base, the alluvial material is generally much finer. Although within the channel most of the material exposed is stiff or very stiff, it is likely that the sediments in the widening and side slope areas will be soft to firm. The particle size distribution for the recent alluvium at the base of the channel has a D50 of 8–60µm (predominantly the finer), a D90 of 80–200µm with 20–25% of the material clay size. Typical bulk densities are in the range 1.5–1.8 t/m³. From the widening and side slope area the material is sandier with the D50 increasing to 24–200µm and the coarser fraction over 2mm. Shear strengths near the surface are generally less than 10kPa.

B.4 Dredgeability Summary

All sands, clays and alluvial clays will be dredgeable by a trailer suction hopper dredger. Although from different geological times, the stiff to very stiff clays and silts and other dense materials are generally similar with respect to their dredgeability. Whilst some could be dredged by a trailer suction hopper dredger this would be inefficient. All these materials can be dredged by a cutter suction or bucket wheel dredger, or large backhoe dredger. To minimise environmental impacts, however, backhoe dredging would be the preferred option. The different sediment layers will not be easy to separate and little benefit is likely to be derived from doing so.
Turning_Dredge_Depth

- **GRAVEL**: Predominantly SAND and GRAVEL - 45%
- **PET**: Peat Pocket - 17%
- **Soft to Very Soft CLAY**: Predominantly stiff - very stiff Sandy CLAY - 2%
- **Firm to Stiff Sandy CLAY**: Predominantly soft sandy CLAY - 23%
- **Fine - Medium Dense SAND**: Predominantly firm - stiff Sandy CLAY - 12%
- **GRUNESAND**: Predominantly Greensand

**Peat**

- Predominantly soft sandy CLAY - 23%

**Channels**

- **CHANNEL DREDGE DEPTH 13.0M**

**Berth Dredge Depth**

- DEPTH 16.0M

**Metro**

- **METRES RELATIVE TO CHART DATUM**
- **DISTANCE (METRES FROM QUAYLINE)**

**Figure B1**

**Geological Profile From Centre of 201/202 Quay Through Turning Area and Corner Widening**
Very stiff clay and stiff silty sandy clay of Bracklesham and Barton Beds.

Figure B2

Particle size envelope
Stiff Clay/Sandy Clay
Figure B3

Particle size envelope
Holocene alluvium and
Pleistocene/Eocene Sand and Gravel