Appendix B

Dredge Material Characterisation
Appendix B.  Dredge Material Characterisation

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 Dredgability - 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.
- J D Nul, 1996 - Southampton Site Investigation - Vibrocore logs.


Note. West, I.M. at Southampton University has access to over 1,400 boreholes from around the Solent, which can be looked at by the University. Many of these are owned by different companies and are confidential.

A review of these studies identified gaps in the knowledge on the material types, particularly in the areas outside Southampton Water and for the areas to be widened within the estuary. 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 soil's properties for dredge, disposal and beneficial use purposes;
- Parameters on inputs to the modelling investigations;
- Possible contamination within the dredged sediments;
- Probable stability of side slopes; and
- Any palaeo-environmental features.

This information was used to define a project specific site investigation to integrate with the existing data. This was undertaken by Fugro Alluvial Offshore Ltd between February and April 2008.

The combined site investigations provide the following additional data over all the areas to be dredged:

- 14 Cone Penetration Tests (CPT) logs;
- 53 interpreted Vibrocores logs;
- 27 grab samples; and
- 5 interpreted borehole logs.

In addition, laboratory testing was undertaken on samples of the different material types encountered from all types of investigation to determine the engineering, rheological and chemical properties of the materials. The samples for chemical analysis were distributed throughout all areas to be dredged and with depth, in accordance with the OSPAR guidelines for the characterisation of dredge material for possible disposal within the marine environment. The results of this analysis are presented and discussed in the Sediment Quality Chapter (Chapter 9).

To complement this dataset, sidescan sonar/geophysical surveys were undertaken in the main widening areas, where peat layers were known to occur, to enable archaeological analysis. Boreholes were also logged through the complete depth of the dredge in these areas and samples made available to the archaeologists.

In addition, separate sampling for benthic invertebrate analysis, which included particle size distribution analysis, was undertaken from the areas to be dredged and locations where sediments may disperse to during the dredging works, as well as in and around the Nab licensed deposit ground, where much of the dredged material is likely to be deposited. These data sets are reported in the Sediment Quality and, Marine and Coastal Ecology Chapters (Chapters 9 and 11).
From these datasets, a detailed analysis of the geological strata encountered in the areas to be dredged was undertaken, in the form of a series of interpreted profiles in the areas of most significant dredging, along with a general description of the material characteristics that are to be dredged from the different channel locations. This analysis is presented in the following sections and forms the core data that defines the likely dredge methodology and timescale to undertake 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 (Appendix C), 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 the depths to be dredged ten different material types can be determined from the borehole, vibrocore and CPT records. In some cases, however, the difference between the material types is subtle. Where required, each zone has been split into sub areas, which are shown in Figure 2.3 of the main Environmental Statement (ES) document. Table B.1 summarises the volumes of each material type for each defined area of the dredge, 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 within the different areas, 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 by area

<table>
<thead>
<tr>
<th>Zone</th>
<th>Sub Area</th>
<th>Material Type</th>
<th>Volume to be Dredged (m³ in situ)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1a - Container Port</td>
<td>Very dense silty SAND (Greensand)</td>
<td>178,900</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stiff silty/sandy CLAY</td>
<td>47,500</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soft-very soft CLAY (alluvium)</td>
<td>67,800</td>
<td></td>
</tr>
<tr>
<td>A1b - Upper Swinging Ground</td>
<td>Very Stiff (in places hard) silty sandy CLAY</td>
<td>71,900</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very dense silty SAND (Greensand)</td>
<td>176,900</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stiff silty/sandy CLAY</td>
<td>61,700</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very dense SAND (with silty layers)</td>
<td>5000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GRAVEL (Pleistocene)</td>
<td>1400</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soft-very soft CLAY (alluvium)</td>
<td>21,000</td>
<td></td>
</tr>
<tr>
<td>207 Berth to Dock Head</td>
<td>Very Stiff (in places hard) silty sandy CLAY</td>
<td>46,100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very dense silty SAND (Greensand)</td>
<td>211,600</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stiff silty/sandy CLAY</td>
<td>348,200</td>
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<tr>
<td></td>
<td>Very dense SAND (with silty layers)</td>
<td>106,100</td>
<td></td>
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<tr>
<td></td>
<td>GRAVEL (Pleistocene)</td>
<td>25,700</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soft-very soft CLAY (alluvium)</td>
<td>306,000</td>
<td></td>
</tr>
<tr>
<td>A2 - Western Docks (including 105/106 widening and Marchwood Turning Area widening)</td>
<td>Very dense silty SAND (Greensand)</td>
<td>429,100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stiff silty/sandy CLAY</td>
<td>114,000</td>
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</tr>
<tr>
<td></td>
<td>Stiff clayey SILT (sometimes firm)</td>
<td>117,807</td>
<td></td>
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<tr>
<td></td>
<td>GRAVEL (Pleistocene)</td>
<td>44,910</td>
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<tr>
<td></td>
<td>Soft-very soft CLAY (alluvium)</td>
<td>33,317</td>
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</tr>
<tr>
<td></td>
<td>Very Stiff (in places hard) silty sandy CLAY</td>
<td>127,700</td>
<td></td>
</tr>
<tr>
<td>B - Marchwood to Dock Head (Junction Channel and Lower Swinging Ground)</td>
<td>Stiff silty/sandy CLAY</td>
<td>127,700</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stiff clayey SILT (sometimes firm)</td>
<td>357,500</td>
<td></td>
</tr>
<tr>
<td>C - North Section - Dock Head to northwest Netley</td>
<td>Stiff clayey SILT (sometimes firm)</td>
<td>357,500</td>
<td></td>
</tr>
</tbody>
</table>
Zone 1 - 207 Berth to Dock Head

Sub Area A1a - Container Port

This comprises the section from Berths 207-203 in the Container Port and the outer section of the Bury Swinging Ground. The base of the dredge channel will be deepened to -13.6m below CD from the present advertised depth of -12.6m CD. Since no widening is to take place in this area the maximum depth of dredging is about 1m with some areas significantly less.

Material from base of dredge will comprise of stiff to very stiff (sometimes hard) silty/sandy clay throughout the length of the dredge opposite 207 Berth then predominantly dense to very dense silty fine to medium sand (Greensand) through to 203 Berth and Slowhill Copse. These materials, which extend through to approximately Dock Head, belong to the Bracklesham Beds of the Eocene era. These undisturbed geological strata could be covered with up to about 0.3 m of recently deposited soft alluvial clay sediments. The side slopes within the Bury Swinging Ground will be a relatively narrow band of very mixed materials composed of soft silt recent alluvium, possibly small volumes of peat and gravel' in addition to the stiff clays and Greensand.

Although different material types exist in this section they are mostly described as stiff to very stiff, sometimes hard or very dense. From previous knowledge these will require similar methods of dredging, either a cutter suction, bucket wheel or large backhoe or dipper dredger, and it is very unlikely the material types can be separated.
Sub Area A1b - Upper Swinging Ground

This section comprises predominantly the area of the Upper Swinging Ground and a short section of the Western Docks (see Figure 2.3 of the main ES). A geological section has been constructed from the site investigation data through this area perpendicular to and from the Berth 201/202 Quay line, crossing the Upper Swinging Ground and passing through the area where widening will occur, to ease turning opposite the Mayflower Cruise Terminal (Figure B.1).

Figure B.1 shows that in the existing Upper Swinging Ground the material to be dredged will comprise about 5% soft clay alluvium deposited since the previous dredge, 50% Greensand and the remaining 45% stiff to very stiff laminated clay.

Sub Area A2 - Western Docks

Sub area A2 extends from the Upper Swinging Ground to Mayflower Park (Western Docks) and includes the widening opposite 105/106 Berths and the extension to the Middle Swinging Ground in the vicinity of the Marchwood Military Port.

Within the main channel the maximum depth of dredging for the most part is less than 1m. The material to be dredged will be alternate bands of stiff silty clay and sandy silt (about 55%), Greensand (40%) with the remainder soft alluvial clay, predominantly at the edges. The majority of the clay comprises the west half of the channel with the Greensand predominating closest to the quay line.

In the area of the widening opposite Berths 105/106, 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 peat covers about 2m of gravel. As the existing bed depths increase, down estuary, the gravel and peat layers disappear, but the thickness of the soft organic alluvial silty sandy clays increase 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 from this area of widening.

Analysis of the vibrocores in the area of the Middle Swinging Ground to be widened down to the 10.2m proposed dredge depth is shown to comprise almost entirely of very soft sandy clay (alluvium) with a very low bulk density. Whilst these materials could be removed with a Trailer Suction Hopper Dredger (TSHD), it is likely they will be removed by mechanical methods along with the denser clays and Greensand from the base of the channel.

Sub Area B (Marchwood to Dock Head) - Junction Channel

The deepening will be undertaken into the very dense laminated Greensand down estuary of Town quay and a mixture of Greensand to the west and very stiff to stiff green/grey clay, which, in places, is also described as very dense silt, in front of Mayflower Park. The exception is a small area of gravel indicated on the west side of the channel opposite Dock Head and a thin covering of soft alluvial clay up to about 0.4m in places.

It is estimated that about 5% of the dredge from the base of the channel will be soft silt (alluvium), 60% the dense sand, about 5% gravel and the remaining 30% the clay/silt.
The side slope will comprise soft alluvial silt, possibly including peat over soft to firm silt/clay at the up estuary (Marchwood) end of the section before gravel over the stiff silt/clay and Greensand that needs to be dredged from the main channel. Moving towards Dock Head, the soft silt/clay band is replaced by a thickening band of gravel, which encroaches into the channel opposite Dock Head. Thus, within the side slope, there is again a very mixed type of sediment. It is estimated that the stiff clay/dense silt and Greensand at the base represents about 70% of the slope volume, gravel 25% and the remaining being predominantly soft to firm silts and clay with a small proportion of peat (1%).

As with all areas up estuary the dredging is likely to be undertaken by mechanical plant in all areas, most likely a large backhoe dredger.

Zone 2 - Dock Head to Fawley Natural Deep

Sub Area C - North Section - Dock Head to North West Netley

In this area and Sub area D the channel will be both deepened and widened (to 300m), on the northeast (Netley) side. Figure B.2 shows a geological profile through the strata that will require to be dredged from the area of widening in both sub areas C and D. This section indicates that the depth of required dredging ranges from less than 1m in the existing channel to over 9m within the widening area in the vicinity of the MOD moorings off Netley.

In the area just down estuary of Dock Head the geological sequence changes from the Eocene Bracklesham Beds to the Barton Clays and Sands. These layers dip down and, at the depths to be dredged, are covered by the Holocene alluvial materials laid down on the Barton Beds, about halfway (3.4 km) from Dock Head (end of sub area C).

Within the existing channel section, the material to be dredged will comprise almost entirely of Barton Sand (very dense sand with frequently silty beds) for about the first 500m down estuary of Dock Head. At this point stiff to very stiff green sandy/silty clay (Barton Clay) starts to feed into the channel from the southwest side, progressing across the full channel width at about 800m from Dock Head. This clay is then uniform across the bed for about another 2,200m, although a thin veneer of gravel may remain at locations beneath any alluvial sediment deposited since the last dredge.

From this point (about 3000m from Dock Head) dense gravel (and sand) begins to overlay the clays at the dredge depth and by the end of sub area C (3,400m from Dock Head) the deepening will be almost entirely be into sand and gravels. Throughout this section of changing bed materials about 20% will be very dense sand (at the up estuary end), about 75% stiff green clay in the middle section and about 5% gravel with sand overlying the clay in the last 400m of the section.

Sub area C has the most complicated strata formations both along its length but also vertically and is one of the areas where the most widening will take place. In the area of widening the materials at the base of the dredge will comprise at the base of the dredge a layer of the very dense Barton Sand (2 - 2.5 m thick down to the maximum dredge level). About 500m from Dock Head the dense fine sand changes relatively abruptly to stiff to very stiff clay, the surface of which appears to dip to the southwest effectively reducing the amount of clay to be dredged with distance down estuary.
Lying above the stiff clay and dense sand is medium to dense flinty Pleistocene gravel, which has a thickness of the order of 2m throughout the widening area over the complete length of the section. The top of this layer is at a depth of about -8m CD near Dock Head dipping to around -11m CD at the end of the sub area C. This gravel generally becomes finer down estuary and is predominantly sand near to the base of the dredge. Overlying the gravel is a layer of soft (Holocene) alluvial sandy/silty clay, which also includes some organic content and in places pockets of gas. This layer both dips downwards and thins from Dock Head down the channel from 2 - 3m to around 1m at the end of the sub area as existing depths deepen. Within this layer substantial pockets of peat occur up to around 2m thick, however they do not occur over the complete width of the widening.

Taking these divisions into account gives rise to the following proportions of material types within the widened area are estimated:

- Very soft silt/clay material 17%
- Peat with some silt/clay 18%
- Gravel/ Medium to dense fine sand 35%
- Dense fine sand 5%
- Stiff clay and silts 10%
- Stiff and dense layered silt and sand 10%
- Very stiff silty sandy clay 5%

Of these material types the soft clays, peat and gravel will be able to be dredge by a TSHD but a mechanical dredger, such as a backhoe will be required to remove the remaining sands and clays of the Barton Beds.

Sub Area D - South Section - North West Netley to Fawley Natural Deep

For sub area D the material to be dredged from the base of the existing channel for the first circa 750m will consist of very stiff silty clay; this however will only about 0.3m thick. The majority of the material will consist of Pleistocene gravel, with some fine sand, again with a thickness of about 2m, with a small outcrop of peat extending up to 500m along the channel, centred about 4.75 km down estuary of Dock Head. It is estimated that from the base about 17% will be the stiff to very stiff sandy clay, about 3% peat and the remaining 80%, gravel.

For the side slope/widening area comprise predominantly of the gravel for about 2m at the base of the dredge covered by up to about 2m of soft to firm silt/clay material down to an average level of about -11m CD. The pocket of peat noted at the base of the channel extends into the area of the widening and forms a layer up to 1m thick between the gravel and overlying soft alluvial material. It should be noted that the boreholes suggest the peat pocket does not extend to the full width of the widening. In proportional terms, including the new side slopes, the soft/firm silts are likely to represent 27% of the dredge, peat 10%, stiff to very stiff clay 3% and the remaining 60% gravel.

Within this sub area it is expected that nearly all the material will be dredged by a TSHD accept possibly for the clay at the base of the channel.
Sub Area E - Fawley Maintained Area and Natural Deep

This area comprises the existing maintained areas around the Fawley Marine Terminal and BP Hamble Jetty, the natural deep area, where little dredging is required, and the additional widening area off ExxonMobil Berth No 1. The vibrocores and CPT information for these areas show that the sediments to be dredged from the widening area are gravel covered by alluvial soft clay in approximately equal proportions. For the maintained area the gravel layer changes to dense sand beneath the clay. South of Fawley towards Calshot represents the area of the Natural Deep where the site investigations show the small amount of material to be dredged will comprise almost entirely soft to firm Holocene clay. These materials will all be able to be dredged by TSHD.

Zone 3 - Fawley Natural Deep to Calshot Turn (including Hook to Hamble Spit Widening)

Hook to Hamble Spit Widening

For the widening of the ‘Natural Deep’ between Hook and the BP Jetty, the material to be dredged is shown in the first half of the geological section, shown in Figure B.3. This shows that in the shallowest areas, at the eastern edge of the widening, towards Calshot approximately 1m of Solent Marine Shingle (sand and gravel) lies above soft Holocene clays down to about -9m CD. At depths below this level the surface material is generally the soft to very soft sandy clay, varying in thickness from about 1.5m thick down to 0.5m at the deeper depths. Opposite the Fawley Power Station entrance channel the bottom 1 - 1.5m of the dredge will be into firmer clay with pockets of peat and fine medium dense sand, the latter being opposite the Hamble Entrance. It is estimated that the volume to be dredged from this widening area including the new side slope will comprise approximately 28% firm to stiff sandy clay, 10% dense sand, 4% peat, 8% sand and gravel with the remainder being soft Holocene sandy clay.

It is considered that all this material could be removed with a TSHD.

Calshot Turn

The geological structure of the material to be dredged from the base of the channel in the Calshot Turn is shown on the second part of Figure B.3. This shows the depth to be removed ranges from about 0.5 - 1m. In the northern part the material will be predominantly stiff sandy clay. Moving south this material changes to the Solent Marine Shingle (sand and gravel), about 0.75m thick, overlying stiff to very stiff sandy clay for the bottom circa 0.3m of the dredge. The side slopes are likely to be a mixture of gravel and muddy sand.

It is estimated that about 25% of the dredge volume will be stiff clay from the Eocene (pre Pleistocene) era probably from the Barton Beds, about 10% soft Holocene clay and 65% Holocene Solent Marine Shingle (sands and gravels).
Zone 4 - Bramble Turn

A geological section of the materials to be dredged down the Thorn Channel are shown in Figure B.4. The first part shows the strata for the widest section of the Calshot Turn (see last section). The section shows that about 1km in the centre of the Thorn Channel is already below the required dredge depth of -13.8m CD. In the area of the Bramble Turn up to 1.5m of sediments will require to be dredged. The strata is similar to the Calshot Turn along the profile line with stiff sandy clay outcropping near the base of the dredge, but the majority of material to be dredged is described as the Solent Marine Shingle where the majority is gravel. It should be noted that the distribution of CPT and vibrocores indicate that the stiff clay only occurs at the depth to be dredged down the western side of the Thorn Channel and dips below where the turning area widens to the east.

Of the volume to be dredged about 5% will be soft to firm silty/sandy clay, 15% stiff to very stiff sandy clay at the base with the remaining 80% sands and gravels, predominantly gravel. All the gravels will be able to be dredged by a TSHD and possibly the clays, however, the stiff clays at the base will be near the limit for a TSHD and mechanical dredge methods, e.g. a backhoe dredger may be required for this material.

Zone 5 - Nab Channel

The Nab Channel cuts across the alignment of the Solent River Channel. The depth of the sub-Pleistocene surface indicates that most, if not all dredging should be into Pleistocene Holocene sediments. Figure B.5 shows the geological profile along the length of the channel interpreted from the vibrocore site investigation. This shows the material to be dredged will be entirely sand and gravels predominantly belonging to the Solent Marine Shingle (Holocene). At the northern a thin veneer of gravel is present over a fine to medium size sand, which is well sorted and uniform in character. At this end the channel will require deepening in the order of 2.5 m. In the southern half of the channel the sand changes from a dark grey colour to a light olive brown and changes to gravel down the western side. The depth required to be dredged also reduces towards the south. All material will be able to be dredged by a TSHD.

Solent (Nab End to West Bramble)

Within the Solent a small isolated patch is indicated by a bathymetric survey to require a small amount of dredging in the vicinity of Ryde Middle. A vibrocore targeted on this area failed to find the shallower depths. Around the location the bed generally consists of soft clay.

It should also be noted that two small patches require removal at the southern end of the channel. It is thought these are chalk outcrops.

B3. Physical Characteristics of Material to be Dredged

In broad terms, ten 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 deposit methodologies and potential for environmental effects.
Eocene - Bracklesham and Barton Beds

- **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 particle size envelope is shown on Figure B.6 and shows the median size ($D_{50}$) to be 5 - 9µm, nearly all material being less than 200µm. 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. Undrained shear strengths have been measured in the range 118 - 178 kPa with moisture contents of 26 - 29%. 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%.

- **Very dense silty SAND (Greensand),** is typically described as very dense grey green becoming green clayey glauconitic fine and medium sand, often interbedded with stiff grey clay sometimes with shell fragments. Typically the particle size distribution comprises 75 - 85% < 63µm with up to 25% in the silt and clay fractions. The median particle size ($D_{50}$) is generally in the range of 80 - 120µm with a $D_{90}$ of 180 - 250µm. A typical particle size distribution is shown on Figure B.7. The bulk density is generally in the range of 1.94 - 2.4 t/m³ with a moisture content ranging from 20 - 40% at different locations. The relatively high proportion of clay means the material has Atterberg limits with the liquid limit in the range of 27 - 31%, plastic limit of 16 - 17% and a plasticity index between 15 - 20%. An undrained shear strength in excess of 300 kPa has been measured for the material, with typical SPT penetration being 150 - 250mm for 50 blows.

- **Stiff clayey silt/sand,** the bulk density 1.97-2.0 t/m³, moisture content 27 - 35%, undrained shear strength around 130 - 150 kPa, and a $D_{50}$ 60 - 75µm. The clay within the material gives rise to a plastic limit of between 13 - 18%, a liquid limit of 34 - 53% and a plasticity index of 21 - 35%. This material and the next are not distinctly different in dredging terms and merge into each other at different locations.

- **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. The bulk density has been measured in the range of 1.92 - 1.98 t/m³ with a moisture content 25 - 37% and an undrained shear strength about 100 kPa increasing with depth. The atterberg limits have been recorded as 61 - 63% for the liquid limit, 17 - 23% for the plastic limit and 40 - 42% for the plasticity index. The median particle size is around 12 - 50µm and a $D_{90}$ of 80 - 200µm.

- **Very dense SAND,** generally described as very dense grey, locally stained black, silty fine/medium sand with partings/laminae of firm grey clay. The bulk density is generally in the order of 2.0 t/m³ with a median particle size of 220 - 280µm and a $D_{90}$ exceeding 600µm. The material generally can comprise 10 - 30% silt and a small proportion of gravel. The particle size grading that typifies this material is show in Figure B.8.
Pleistocene (and Eocene) Sands and Gravels

- The gravels are generally described as medium to dense brown grey slightly silty sandy gravel. Particles are subangular to subrounded fine to coarse with occasional flint. For the most part they become sandier with depth particularly about half way along the Dock Head to Fawley widening, where the material is described as sand. 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. The gravel has a $D_{50}$ of 8-16mm, a $D_{90}$ of over 25mm and a $D_{10}$ of 300 - 500µm, with generally less than 5% silts and clays. The typical particle size gradings are shown on Figure B.9.

Holocene

- **Peat**, brown to very dark brown in colour with white shelly sand and plant roots. The particle size varies from that of coarse silt to fine gravel where it occurs on its own. Often however, it merges with soft grey organic clay, which contains pseudofibrous and amorphous plant material, has a strong organic odour and pockets of gas. The bulk density is variable from 1.1 t/m³ in the pure peat - 1.6 t/m³ in the clay, with a typical moisture content of 50 - 70% and an undrained shear strength of 25 - 30 kPa.

- **Clay**, 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, dark grey to black fine grained, organically rich, silty clay sediments interspersed with pockets of clayey sand. Small lenses of peat and gravelly material are also present particularly where it has previously not been dredged. At the very surface, whether on the side slopes or the channel base the alluvial material is generally much finer. Within the channel most of the material exposed will be stiff or very stiff, but is likely to be soft to firm in the widening and side slope areas. Typical bulk densities are in the range 1.5 - 1.8 t/m³. The particle size distribution for the recent alluvium at the base of the channel has a median particle size ($D_{50}$) of 8 - 60µm (predominantly the finer), a $D_{90}$ of 80 – 200µm with 20 - 25% of the material clay size. From the widening and side slope area the material is sandier with the $D_{50}$ increasing to 24 - 200µm and the coarser fraction over 2mm. Shear strengths near the surface are generally less than 10kPa.

- **Solent Marine Shingle**, is generally composed of sands and gravel, both of which will require dredging from the Thorn and Nab Channels. Where the bed has not been previously disturbed, the deeper the bed the coarser the sediment tends to be. The sand from the Calshot Turn has a $D_{50}$ in the range of 60 - 70µm increasing to 90µm at the Bramble Turn. The $D_{90}$ is in the range of 96 - 120µm again increasing to around 150µm in the area of the Bramble Turn. The gravels have a median particle size between 2.7 - 12 mm with the $D_{90}$ generally in the range of 14 - 39 mm.

At the Nab the sands and gravel are more uniform in size. The sand has a median size of between 130 - 220µm with the $D_{90}$ not much coarser (170 - 260µm) with little or no silt or clay material. The gravel is generally finer than within Southampton Water and the Thorn Channel with a median particle size of 3 - 4.5 mm.
Bulk densities for all the sands and gravels vary in the range 1.7 - 2.3 t/m³ but most are in excess of 2.0 t/m³.

**B4. Dredgability Summary**

All sands and gravels (Pleistocene or Solent Marine Shingle) alluvial clays and peat will be dredgeable by a trailer suction dredger, however teeth and jets are likely to be required particularly for the glacial gravels.

The stiff to very stiff clays and silts and dense Greensand although from different geological times 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, however for predominantly environmental reasons the latter is likely to be used. The different layers will not be easily separated and little benefit is likely to be derived from doing so. Most material of this type will be dredged from just down estuary of Dock Head up to the Container Port, similar materials will need dredging from the Calshot and Bramble Turns near to the base of the dredge.

Table B.2 summarises the volumes of material types for the dredge as whole taking account of likely method and differences in relative production.

**Table B.2. Quantities to be dredged by material type (defined by relative dredgability)**

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Dredge Volume (m³ in situ) (including an overdredge allowance of 0.3m)</th>
<th>Dredge Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very dense silty SAND (Greensand)/ Very stiff silty sandy CLAY</td>
<td>1,985,800</td>
<td>Mechanical (probably backhoe)</td>
</tr>
<tr>
<td>Stiff silty/sandy clay or clayey silt (Eocene deposits)</td>
<td>1,894,100</td>
<td>Mechanical (probably backhoe)</td>
</tr>
<tr>
<td>Very dense SAND (with silty layers) (Eocene deposits)</td>
<td>480,800</td>
<td>Mechanical (probably backhoe)</td>
</tr>
<tr>
<td>Pleistocene (glacial) GRAVEL</td>
<td>1,741,800</td>
<td>TSHD</td>
</tr>
<tr>
<td>PEAT/ organic clay</td>
<td>490,000</td>
<td>TSHD</td>
</tr>
<tr>
<td>Soft -very soft CLAY (alluvium)</td>
<td>1,882,400</td>
<td>TSHD</td>
</tr>
<tr>
<td>Post glacial SANDS and GRAVELS (Solent Marine Shingle)</td>
<td>3,173,500</td>
<td>TSHD</td>
</tr>
<tr>
<td><strong>Total Volume</strong></td>
<td><strong>11,648,400</strong></td>
<td></td>
</tr>
</tbody>
</table>

Dredge volume includes an overdredge allowance of 0.3m
Geological Profile From Centre of 201/202 Quay Through Turning Area and Corner Widening

Figure B1

- TURNING AREA
- WIDENING AREA
- BERTH
- SDN8
- SDN9
- CPT
- TURNING_Dredge_Depth
- CHANNEL Dredge
- PEAT
- Soft to Very Soft CLAY
- Firm to Stiff Sandy CLAY
- Fine - Medium Dense SAND
- GREENSAND
- Predominantly soft sandy CLAY - 23%
- Predominantly firm - stiff Sandy CLAY - 12%
- Stiff - Very Stiff CLAY
- Predominantly stiff - very stiff Sandy CLAY - 2%
- Predominantly SAND and GRAVEL - 45%
- Peat Pocket - 17%
Geological Profile along Dock Head to Fawley widening

Figure B2

- PEAT
- Predominantly soft sandy CLAY - 23%
- Predominantly firm - stiff Sandy CLAY - 12%
- Predominantly SAND and GRAVEL - 45%
- Predominantly stiff - very stiff Sandy CLAY - 2%
- Soft to Very Soft CLAY
- Predominantly SAND and GRAVEL
- Fine - medium dense SAND
- STIFF - VERY STIFF CLAY

Material to be dredged:

This area already removed from main channel.

New Depth

Widening area

Old nominal bed

APPROXIMATE DISTANCE FROM DOCK HEAD (m)

DEPTH (METRES) BELOW CHART DATUM

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Scale 1:26,000

OSGB 1936
Geological Profile From Hook Widening to Calshot Turn

Figure B3

DATE
Sep 08

BY
MCE

SIZE
A3

VERSION
1A

3742 - Fig_Profile_Lines_4.mxd

SCALE
1:30,000

Projection
OSGB 1936

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HO 1095/070712/18

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Fawley to Calshot

Offshore to East

CALSHOT TURN

LOCATIONS AT SHALLOW EDGE OF HOOK WIDENING

DISTANCE FROM POSITION A

DEPTH (METRES) BELOW CHART DATUM

-13.8m DREDGE LEVEL

PEAT
Very soft - soft CLAY
Firm - stiff Sandy CLAY
Fine - medium dense SAND

GRAVEL
Stiff - very stiff CLAY
Predominantly soft sandy CLAY
Predominantly firm-stiff sandy CLAY

Medium dense-dense Gravelly SAND

Predominantly SAND and GRAVEL
Predominantly stiff-very stiff sandy CLAY
PEAT Pocket

West of Line

NORTH W

SOUTH E

B

A

0
1000
2000
3000
4000
5000
0
10
20
30
40
50
60
70
80
90
100
DISTANCE FROM POSITION A

PEAT
Very soft - soft CLAY
Firm - stiff Sandy CLAY
Fine - medium dense SAND

GRAVEL
Stiff - very stiff CLAY
Predominantly soft sandy CLAY
Predominantly firm-stiff sandy CLAY

Medium dense-dense Gravelly SAND

Predominantly SAND and GRAVEL
Predominantly stiff-very stiff sandy CLAY
PEAT Pocket
Geological Profile along Thorn Channel

**Date:** Sep 08  
**By:** MCE  
**Size:** A3  
**Version:** 1A

3742 - Fig_Profile_Lines_5.mxd

Scale: 1:30,000

**Projection:** OSGB 1936

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**Figure B4**

- Depth (metres) below chart datum
  - 14.0
  - 13.0
  - 12.0
  - 11.0
  - 10.0
  - 9.0

- Distance from position C

0 - 1000 - 2000 - 3000 - 4000 - 5000

C NORTH

D SOUTH

-13.8m DREDGE LEVEL

Firm - stiff Sandy CLAY
Fine - medium dense SAND
GRAVEL
Stiff - very stiff CLAY
Predominantly firm - stiff Sandy CLAY
Predominantly SAND and GRAVEL
Predominantly stiff - very stiff Sandy CLAY

73V 75V 77V 78V 79V 80V 82C 83C 84V

81V 85 (OFFLINE TO EAST)
Figure B.6
Particle size envelope
Stiff Clay/Sandy Clay

Very stiff clay and stiff silty sandy clay of Bracklesham and Barton Beds

Reference
3742 - Bracklesham.xls
Produced by ABPmer Ltd.
Particle size envelope
Greensand

Figure B.7
Figure B.8

Particle size envelope for Sand and Gravel from Thorn and Nab Channels
Particle size envelope
Holocene alluvium and
Pleistocene/Eocene Sand
and Gravel

Figure B.9