- to draw material to areas accessible for trailing suction hopper dredgers;
- to create access for a trailing suction hopper dredger into shallow water.

NOTE Rakes and ploughs can be used to remove light debris that might interfere with dredging activities prior to the commencement of works.

7.3.7 Trenching equipment

To protect offshore pipelines and cables, trenching techniques should be adopted as necessary to avoid ship, anchor and trawl impact, to reduce spanning, to avoid currents and sediment movement, such as:

- direct dredging;
- dredging and side casting;
- ploughs;
- jetting and burial machines.

NOTE Pipeline protection can be effected using equipment such as:

- *side dump barges;*
- *fall pipes;*
- *rock placement fall pipes.*

Particular care should be taken to avoid excessive fall velocities that can displace and damage pipelines and cause seabed instability.

For pipelines and cable landfalls the appropriate equipment should be selected to ensure effective production in shallow water and possible surf conditions.

7.3.8 Barges

The appropriate method of dredged material transport should be selected to suit the dredger and site conditions.

*NOTE Hydraulic dredgers, which typically discharge through floating pipelines giving high productivity, are covered in **7.2**.*

For mechanical dredgers, a variety of barges are used to support dredging operations, namely hopper, split hopper, and side dump. Specialist deep placement barges should be deployed, particularly where accurate placement is required at depth, such as when placing rockfill scour protection round seabed facilities. Self-propelled barges should be adopted:

- for the efficient transport of material over greater distances;
- in areas of adverse sea conditions where dumb barges handled by tugs, are slow and susceptible to sea conditions.

7.4 Dredger selection

Preliminary guidance on the selection of the more common items of dredging plant is given in Table 11 to Table 13. More definitive advice should be sought from dredging practitioners and professionals before committing to a particular method or plant. The tables assume knowledge of various site conditions. This knowledge should be used to determine the general suitability of each type of plant in relation to the site characteristics.

It is intended that these tables provide only a general guide to plant suitability. The tables are not definitive, and actual selection should be based on the particular plant, sea, ground and project conditions. The simplistic approach does not take account of all factors, but normally provides a reasonable indication of the optimum plant type(s) for a particular task.

Table 11 **Guidance on the selection of plant for maintenance dredging**

Site conditions	Trailing suction			Cutter suction	Grab pontoon	Backhoe	Barge unloader
	<5 000 m^3	> Capacity <	>15 000 m^3				
Bed material							
Loose silt	1	1	1	1	2	2	1
Cohesive silt	2	1	1	1	1	1	2
Fine sand	1	1	1	1	2	2	1
Medium sand	1	1	1	1	2	2	1
Coarse sand	1	1	1	1	2	1	1
Sea conditions							
Enclosed water	2	3	N	1	1	1	2
Sheltered water	1	1	1	1	1	1	1
Exposed water	2	1	1	3	3	3	N
Disposal to:							
Shore	1	1	1	1	32	3	1
Tide	1	1	1	1	N	N	N
Sea bed	1	1	1	3	1	1	N
Quantities							
< 100 000 m^3	1	2	3	1	1	1	1
< 250 000 m^3	2	1	2	1	2	1	1
< 500 000 m^3	2	1	2	1	3	3	1
> 500 000 m^3	3	1	1	1	3	3	1
Heavy traffic	1	1	1	2	2	1	1
Confined working	2	3	3	1	1	1	2

Key
1 = Most suitable; 2 = Acceptable; 3 = Marginal; N = Not usually suitable.

NOTE Other factors not referred to can influence the choice of dredger. The table provides only a general guide.

Table 12 **Guidance on the selection of plant for capital dredging**

Site conditions	**Trailing suction**			**Cutter suction**	**Grab pontoon**	**Backhoe**
	<5 000 m³	**> Capacity <**	**>15 000 m³**			
Bed material						
Loose silt	1	1	1	1	2	2
Cohesive silt	1	1	1	1	1	1
Fine sand	1	1	1	1	2	2
Medium/Coarse sand	1	1	1	1	2	2
Gravel	1	1	1	1	1	1
Soft clay	1	1	1	2	1	1
Medium clay	2	2	2	2	2	1
Stiff clay	3	3	3	3	3	1
Cobbles	3	3	2	2	1	1
Boulders	N	N	N	3	2	1
Very weak rock	N	3	3	1	3	1
Weak rock	N	N	3	1	N	1
Moderately weak rock	N	N	3	1	N	2
Pre-treated rock	2	2	1	1	2	1
Sea conditions						
Enclosed water	2	3	N	1	1	1
Sheltered water	1	1	1	1	1	1
Exposed water	2	1	1	3	3	3
Disposal to:						
Shore	1	1	1	1	3	3
Tide	1	1	1	1	N	N
Sea bed	1	1	1	3	1	1
Quantities						
< 100 000 m³	1	2	3	1	1	1
< 250 000 m³	1	1	2	1	2	1
< 500 000 m³	2	1	2	1	3	2
> 500 000 m³	3	1	1	1	3	3
Heavy traffic	1	1	1	3	3	2
Confined working	2	3	3	2	1	1

Key
1 = Most suitable; 2 = Acceptable; 3 = Marginal; N = Not usually suitable.

NOTE Other factors not referred to can influence the choice of dredger. The table provides only a general guide.

Table 13 **Guidance on the selection of plant for land reclamation[A)] and beach recharge**

Site conditions	Trailing suction [A)]			Cutter suction	Grab pontoon	Backhoe
	<5 000 m³	> Capacity <	>15 000 m³			
Bed material						
Fine sand	1	1	1	1	3	3
Medium sand	1	1	1	1	3	3
Coarse sand	1	1	1	1	3	3
Gravel	2	1	1	1	3	3
Cobbles	3	2	2	2	3	3
Boulders	N	N	N	N	3	3
Very weak rock	N	3	3	1	3	3
Weak rock	N	N	N	1	N	3
Sea conditions						
Enclosed water	2	3	N	1	1	1
Sheltered water	1	1	1	1	1	1
Exposed water	2	1	1	3	3	2
Placing by:						
Direct dumping	2	3	3	N	2	2
Direct pumping	2	N	N	1	N	N
Transport and pump	1	1	1	N	N	N
Barge and dump	3	3	3	3	1	1
Quantities						
< 100 000 m³	1	2	3	1	1	1
< 250 000 m³	1	1	2	1	2	1
< 500 000 m³	2	1	2	1	3	2
> 500 000 m³	3	1	1	1	3	3
Heavy traffic	1	1	1	3	3	2
Confined working	3	3	N	2	1	1

Key
1 = Most suitable; 2 = Acceptable; 3 = Marginal; N = Not usually suitable.

NOTE Other factors not referred to can influence the choice of dredger. The table provides only a general guide.

A) Guidance on reclamation with dredged hydraulic fill in given in in prEN 16907-6.

8 Maintenance dredging

*COMMENTARY ON CLAUSE **8***

Many aspects of maintenance dredging are covered in other clauses and consequently only particular aspects are discussed here.

Maintenance dredging generally involves the removal (or relocation) of soils recently deposited, usually comprising relatively fine sediments (sand and finer). Normally, the material to be removed is of small thickness and low strength. When dredging alongside quays or jetties, particularly in industrial areas, the sediments can contain materials such as spilled cargo, cables, ropes and jetsam.

In maintenance dredging the strength of the soil to be dredged is generally low and it is unnecessary for dredging plant employed to have a powerful cutting or dredging action. In many instances, particularly where dredging volumes are small, relatively lightweight equipment is adequate for the task.

*Most kinds of dredging equipment can be used for maintenance dredging. The types most commonly used are trailing suction hopper dredgers, small cutter suction dredgers, grab dredgers, backhoe dredgers, ploughs and water injection dredgers (see Clause **7** and Table 10).*

8.1 General

Dredged areas should be designed such that operational needs are met and the rate of infill into the areas is minimized. Applicability of channel/berth design techniques such as over-dredging and the use of sediment traps should be assessed in situations where accumulation rates are predicted to be high. Channel/berth design with respect to dredging is a technical activity and should be undertaken by a competent person.

The interval between maintenance dredging programmes can be as little as a few weeks or as long as a few years, and should be determined on a case-by-case (need) basis but with adequate forward planning.

8.2 Plant for maintenance dredging

Maintenance dredging (see Table 11) normally involves the removal of recently deposited fine sediments. Consequently, operators should take into account the reduced need for exceptionally powerful or heavily built equipment. If the distance to the disposal area is long, the operators should ensure that the maximum sailing speed and design of the hopper or dredger is suitable for the efficient loading and transport of fine materials.

The operational factors required when setting maintenance dredging strategy should be determined in accordance with BS 6349-1-1.

NOTE For regular maintenance dredging, the ranges of quantity to be dredged that are listed in Table 10 are for each separate campaign.

8.3 Infill calculation

Infill calculations should utilize bathymetric survey data collected over the area to be subject to maintenance dredging (see Clause **6**). Measurement of bed level before, during and after maintenance dredging should be undertaken in a careful and consistent way, with particular attention being paid to echo-sounder acoustic frequency (see Clause **6**).

To maximize the value of the surveys and the confidence in the infill calculations, consistent methods should be used for the surveys in question. If it is suspected that fluid mud might exist in an area then a dual frequency echo-sounder should be used with acoustic frequencies approximating 33 kHz and 210 kHz.

8.4 Design and planning of maintenance dredging

In the design and planning of maintenance dredging, early attention should be given to environmental aspects (see Clause **5**), including sampling and testing of the materials to be dredged for contaminants and particle size, as this informs the dredging methodology and choice of dredging plant.

NOTE 1 The number of sediment samples required for testing, and the suite of contaminants that are to be analysed, are usually informed by the relevant regulatory body (requirements can vary according to region).

The planning process should include the investigation of available options for the placement or use of the dredged material. Rather than placing dredged material at a marine disposal site, thereby removing it from the sediment budget of the estuary or coastal zone, beneficial use options should be preferentially employed where practicable, whereby some or all of the material is retained in the system. For example, there might be options available for sediment to be placed within an estuary to feed intertidal areas or for use in other forms of coastal defence or sediment cycling. Where the material is of appropriate quality, options for its use in engineering works (such as reclamations or general construction) should be investigated.

The planning of maintenance dredging operations should also take into account the port usage and in particular the anticipated vessel traffic type and density of movements.

NOTE 2 Certain vessels, such as LNG tankers, require that an exclusion, or buffer, zone is maintained around them. The exclusion zone is an area of water where access is restricted such that other vessels cannot enter, berth, moor or anchor. Unauthorized entry into the zone, which extends below the water level to the seabed and under any wharf adjacent to the zone, is classed as an offence. Such exclusion zones can have significant implications for the planning of dredging operations.

NOTE 3 Attention is drawn to the following legislation in respect of dredging activities in general, and licensing and environmental impact assessments in particular:

- *Marine and Coastal Access Act 2009 [11];*
- *Marine Works (Environmental Impact Assessment) Regulations 2007 [12];*
- *Conservation of Habitats and Species Regulations 2010 [13];*
- *Offshore Marine Conservation (Natural Habitats, etc.) Regulations 2007 [14].*

8.5 Methodology

The method of dredging and the particular type of plant to be employed should be determined on the basis of the specific dredging requirement and the particular characteristics of the site (see Clause **7**).

If the planning and design of dredging shows that the release of sediment to the environment needs to be strictly minimized then the viability of using plant with low release rates (e.g. backhoe dredgers and grabs with visors) should be assessed, along with the use of techniques such as placement via barges, without overflow (see Clause **7**).

When routinely using water injection dredging for maintenance activities, planning should include provision for coarsening of the bed sediments at the site over time, as this can be a consequence of the use of the technique (ultimately a trailing suction hopper dredger might need to be employed periodically to remove the coarse lag sediments; see Clause **7**).

Those involved in designing and planning maintenance dredging should bear in mind that at certain sites such as quays and jetties it might be possible and advantageous to position dredging plant on land.

Where dredging close to structures, dredging methodologies should clearly set out how removal of material close to the structure is to be achieved, without damage being inflicted on the structure. The regime for monitoring the integrity of the structure should also be agreed and set out.

*NOTE A guide to the selection of plant for particular types of maintenance dredging activity is given in Clause **7** and Table 10.*

8.6 Frequency of maintenance dredging

A maintenance dredging strategy should be developed taking into account the practical constraints on navigation, dredging equipment, efficiency, availability, weather, operational and environmental windows, to determine the economic and environmentally preferred, or otherwise optimal, dredging method and frequency.

The frequency of a maintenance dredging programme should be assessed taking into account:

- the rate of sediment accumulation in the areas to be dredged;
- the operational requirements of the waterway (i.e. shipping for a navigation channel, flow rates for a river channel).

The optimum timing of dredging (e.g. with respect to seasonal and tidal variations) should be assessed, as dredging might not be possible or permitted (via licences) under certain conditions, while its efficiency and benefit (with respect to retention of materials in the sediment transport system) might be increased under others. Numerical modelling should be used to inform such assessments for projects of an appropriate scale.

8.7 Soil density and maintenance dredging

*COMMENTARY ON **8.7***

Some waterway bed sediments are of a semi-fluid nature, consisting of very fine particles in a dense solution (referred to as fluid mud). Where such materials have been shown to exist consistently and have been extensively investigated in terms of their characteristics, ports sometimes operate a policy whereby vessels knowingly navigate through such fluid muds. Operation of such a system is sometimes referred to as the "nautical bottom approach". The density of fluid mud deposits is at a minimum at the upper surface and increases with depth. In these situations, the position of the bed is difficult to define and therefore difficult to measure. Determination of water depth purely on the basis of the record produced by a high frequency echosounder (e.g. 200 kHz or higher) can occasionally result in dredging being carried out at intervals that are shorter than is strictly necessary to preserve safe and proper navigation depths.

Fluid mud is particularly likely during and immediately after dredging in some environments. The materials can then consolidate and/or be subject to transport beyond the dredging location.

The existence of fluid mud does not necessarily mean that the material is safe to navigate through. The density of fluid mud is often used operationally (measured) to provide a guide to its navigability (or otherwise). However, the relationship between navigability and density varies between ports, demonstrating that it is not simply density which governs navigability. The rheological properties of fluid mud are important to navigability, as are the characteristics and operation of the vessels making passage.

For the adoption of the nautical bottom approach, the density and rheological properties of fluid mud at the bed of a waterway should be established, with due attention being paid to the way in which these properties vary spatially and temporally (particularly tidally and seasonally) and the way in which the properties are measured (rheology can be altered by sediment sampling and transport).

Specialist advice should be sought with respect to the collection and interpretation of rheology and density data in terms of vessel navigability/manoeuvrability, bearing in mind that once data analysis and interpretation has been undertaken it might be decided that a full scale trial is needed using an agreed vessel. Following conclusion of the investigation, if it is decided to use a nautical depth approach then fluid mud density and/or rheology measurements should be used operationally in order to inform the need for maintenance dredging. The optimum method of dredging in relation to the allowable draught should be established through assessment and experience built up at the site. The likely efficiency of water injection dredging should be assessed; at some sites this is used to reduce the density of fluid mud and enhance its navigability and propensity for transport.

8.8 Alternative and supplementary strategies

*COMMENTARY ON **8.8***

Hard engineering structures such as training walls and current deflecting walls are sometimes used in order to try to reduce maintenance dredging requirements.

The use of training walls for this purpose is now relatively rare in the UK and many other locations due to factors such as cost, performance of the structures and unintended side effects arising from rigid structures.

Sediment traps are sometimes included in the design of dredged areas to increase the interval between maintenance dredges. The purpose of a sediment trap is to accommodate infill material that would otherwise have accumulated in a navigation or berth area. The use of sediment traps does not negate the need for maintenance dredging altogether, as the traps themselves require dredging in order to remain functional. As traps fill and become less efficient, the infill rate of the navigation area/berth can be expected to increase.

Specialist advice should be sought if alternative and supplementary measures to maintenance dredging are being considered. The design of any alternative or supplementary strategy should be subject to detailed study prior to its implementation and can include numerical modelling. These studies should focus not only on the effectiveness, cost and potential benefits but also on the potential for negative impacts on the surrounding environment and infrastructure.

8.9 Disposal of material

The disposal of dredged materials should be undertaken in accordance with Clause **12**.

9 Capital dredging

*COMMENTARY ON CLAUSE **9***

Capital dredging occurs where an area is dredged for the first time or to a greater depth than previously dredged.

9.1 General

The project site should be characterized by the investigation methods in Clause **6** relating to:

- site bathymetry;
- soil conditions;
- metocean and sea conditions;
- environmental surveys.

The dredging scheme should be designed to meet the respective performance criteria in Clause **4.4** and the environmental design criteria in Clause **5**.

9.2 Capital dredging plant

*COMMENTARY ON **9.2***

In many cases, capital dredging involves dredging a range of different materials. The unpredictability can be reduced by a good quality soils investigation. The requirements of the work can also be very varied. Consequently, versatility can be important, in respect of both the ability to tackle a wide range of ground conditions and the ability to work in a variety of ways, e.g. employing varying methods of spoil disposal.

*A guide to the selection of plant is given in Clause **7** and more specifically the plant commonly employed is given in Table 12.*

Generally, plant to be employed upon capital works should be of more rugged construction and greater power than plant of the same type designed specifically for maintenance work, as the material is undisturbed with consequently stronger in-situ strengths and higher densities.

9.3 Debris

Areas that are likely to contain appreciable quantities of debris, such as at fitting-out, scrap and river berths, can be difficult to dredge with trailing suction-type dredgers or cutter suction dredgers, and should be fully evaluated so that the area can be cleared before capital dredging, by suitable equipment such as grab or backhoe dredgers or cleared by means of a bottom rake or plough (see **7.3.6**).

NOTE Attention is drawn to the legal requirements in connection with the disposal of debris.

9.4 Particular geotechnical conditions

9.4.1 General

The soil conditions illustrated in Table 11 to Table 13 can all affect capital dredging works and should be taken into account during design, plant selection and operations, as described in **9.4.2** to **9.4.6**.

9.4.2 Clays

NOTE 1 Certain clays of high plasticity adhere to the buckets of any bucket-type dredger. As a result, the material can be difficult to discharge from the bucket and subsequently can be difficult to discharge from the hopper into which it is loaded. Special jetting facilities might be required to assist the release of dredged clays.

When the presence of highly plastic clays is suspected, hoppers should be employed that have a regular internal construction with an unobstructed opening for spoil placement to allow rapid discharge.

The appropriate plant should be selected for dredging the clays at the dredging location (Clause **7** and Table 11 to Table 13).

NOTE 2 Selection of the incorrect plant can lead to production being substantially reduced in areas of stiff and hard clays and where boulders are present.

9.4.3 Peat

Special measures should be applied as necessary when dredging peat due to its low density, possible gas content and tendency to swell rapidly upon the removal of any overburden.

If pumped onshore, the containment areas should have sufficient excess capacity to cope with the high bulking that commonly occurs.

Suction methods should be avoided if possible.

NOTE When loaded into hoppers by pumping, the maximum load is governed by the concentration of the peat in the incoming mixture. No increase in hopper load is achieved by continued pumping after the hopper is filled with mixture.

9.4.4 Flints

The selection of plant should account for the highly abrasive nature of flint that can cause exceptional wear rates in pumps and pipelines, especially where high concentrations of flint cobbles or nodules are found, often on the surface of weathered chalk deposits.

NOTE Dredging might be most economical using a bucket-type dredger.

9.4.5 Vegetation

Appropriate provision should be made in areas of heavy vegetation, such as seaweed, reeds, rushes, mangrove, etc., which can cause serious problems for suction-type dredgers.

Care should be taken to avoid vegetation causing pump blockage and engine overheating on blockage of the cooling system of the dredgers or other craft on the site.

NOTE Where high concentrations of weed are known to occur, it might be preferable to employ bucket-type dredgers or to employ separate plant to clear the weed in advance of dredging.

9.4.6 Dredging of cobbles and boulders

*COMMENTARY ON **9.4.6***

Cobbles and boulders do not usually occur in large volumes on their own. When they do, appropriate plant can be selected. However, they are commonly found in glaciated or volcanic regions, usually as a constituent of glacial tills or agglomerates, in which identification of the boulders can be extremely difficult. It is as a constituent of these materials that they pose the greatest problem in dredging.