PRINCES CHANNEL DEVELOPMENT

Placement of Dredged Sand in the North Edinburgh Channel

Environmental Characterisation Report

EXECUTIVE SUMMARY

The Port of London Authority proposes to deepen the Princes Channel, the southern approach to the Port of London, to remove the navigational risk associated with the existing situation. Estimates of likely increases in ship numbers have indicated that the development of the Princes Channel should be complete by the end of 2006.

The dredge will produce up to 2.5Mm^3 of predominantly fine sands. The PLA is committed to finding beneficial use for as much of the material as possible, and indeed, has successfully found a use for dredged material generated during an earlier dredge. However, the PLA recognises the practical difficulties associated with aligning the timescales of major projects and, should beneficial use not be available, it is proposed to recycle the sand within the sedimentary system. A sand placement site has been identified in the North Edinburgh Channel, in consultation with the local fishing industry.

An environmental characterisation exercise has been undertaken and is discussed in this report. A range of surveys have been undertaken to define the baseline environment including biological, sediment quality, current speeds, bathymetry and archaeological surveys. The North Edinburgh Channel is characterised by a dynamic mobile sandy environment and the channel is migrating eastwards. The biological communities are, therefore, representative of an unstable environment and the Channel does not provide specific spawning or nursery habitat for fish, other than as part of the wider Thames Estuary. There are no conservation sites within 15km of the Channel although feeding grounds for birds are widely distributed across Estuary.

The placement of sand in the North Edinburgh channel is considered to mimic the natural dynamic processes and the environment is, therefore, adapted to this regime. The environmental assessment does not predict any effects over those already occurring naturally.

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1 INTRODUCTION

1.1 Background

The PLA has a statutory responsibility for maintaining safe navigation within its port limits, as shown in Figure 1. In practice this responsibility is met by a navigational Safety Management System, which includes state of the art Vessel Traffic Services (VTS), Port Control Centres, hydrographic surveys, chart production, the provision of pilotage, and where necessary, the maintenance of sufficient channel depth to permit safe access.

The Thames Estuary is a dynamic environment with sand banks formed of mobile sand. The PLA manages navigation in this environment by monitoring and moving the buoys that mark the channels and providing up to date information to pilots, ships' masters and berth operators. However there will inevitably be situations where depths in the channels have reduced to an extent where dredging is required to restore navigational safety. Occasionally, in cases where hydrodynamic processes lead to the accumulation of sufficient material in an existing channel, it may be necessary to seek an alternative route for vessels by opening up a new approach channel. In the case of the southern access routes to the port, the shallowing of the North Edinburgh Channel and, more recently, the potential instability in the Fisherman's Gat, together with navigational safety considerations, have led the PLA to consider providing improved access to the Port of London, from the south, via the more stable yet shallower Princes Channel.

1.2 Project Overview

1.2.1 Princes Channel Development

Princes Channel forms part of the southern approaches to the Port of London. Figure 1 shows the main approaches to the Port. Following recommendations from a navigational risk assessment that studied these approaches, the PLA is proposing to deepen part of Princes Channel to a depth of -8.0m CD. The deepening is proceeding in two phases with Phase I, undertaken as a trial, now complete. The objective of the trial was to deepen a narrow part of the western section of the Channel to approximately –7.0m CD, which is marginally below the regime depth at this location, and then to study the channel stability and rate of infill. Phase I was carried out in summer 2003 and frequent bathymetric surveys have been undertaken to monitor the response of the channel. These surveys have demonstrated that the deepened channel is sustainable and, as a result, it is the PLA's intention to proceed to deepen the channel to the target depth of –8.0m below CD, thus providing an alternative but safer and more stable access from the south than is presently available.

The PLA has been advised that the southern approach should be operational prior to any further significant increase in shipping traffic at the Port of London or the Port of Medway. On this basis, the Princes Channel development should be complete by the end of 2006.

In line with Government regulations, and in accordance with the London Convention and OSPAR requirements, all the dredged material from Phase I, some 350,000m^3, has been used beneficially in a construction scheme on the east coast. Despite the difficulties in coordinating the timescales of disparate projects the PLA is continuing to seek beneficial uses for the material from Phase II of the project but it recognises that this may not be achievable. Beneficial use can include such schemes as reclamation, maritime construction, coastal protection and environmental enhancement.

However, in the event of the PLA being unable to secure beneficial use within the identified timescale, it will be considered necessary to place the dredged material at a marine disposal site. The nearest existing site to the Thames Estuary is South Falls but the PLA has suggested the designation of a new sand placement site, in the North Edinburgh Channel, within the dynamic regime of the estuary. This report details the characterisation process for the proposed sand placement site.

A detailed description of the project is given in Section 2.

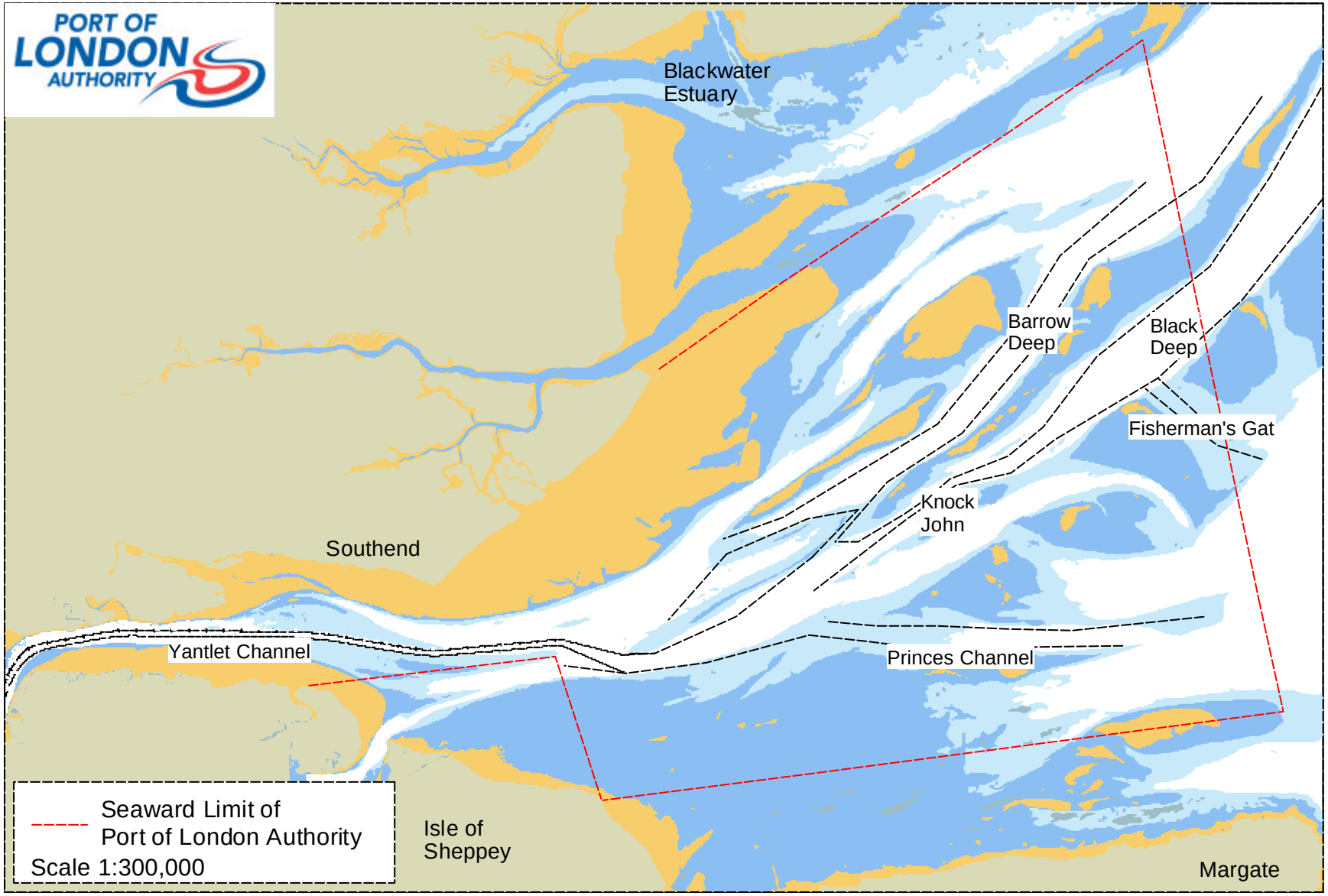

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Figure 1: Approaches to the Port of London

1.3 Study Area

1.3.1 The Thames Estuary

The Thames Estuary is a dynamic environment with highly mobile sandbanks intersected by deep channels. Numerous studies that have been carried out on the movement of the sandbanks and historical charts show clearly how the banks and channels have moved over time. The main channels are generally oriented in the direction of the prevailing currents (with speeds of $1ms^{-1}$) and are thus relatively stable. There exist, however, many "swatchways" which run across the prevailing currents and are thus very unstable. These "swatchways" are formed, in part, by the complex interaction of tides from both the North Sea and the English Channel. Seabed sediments vary from fine sand and silt to coarse gravel depending on the energy levels in any individual location.

Despite the dynamic regime, the Thames Estuary hosts important shellfisheries including cockles, flat oysters and mussels and the area is designated as Shellfish Waters. Figure 2 shows the environmental designations in the outer Thames estuary. The area also provides shelter for juvenile fish and is a recognized spawning ground for commercial species such as sole and herring. Consultation with local fishermen and their representatives has indicated that Princes Channel and North Edinburgh Channel are not important fishing grounds but that banks and channels nearby are trawled for sole.

Much of the Essex and north Kent coasts are designated as Sites of Special Scientific Interest (SSSI), Special Protection Areas (SPA) and Ramsar sites for their bird interest but the protected areas do not extend significantly offshore (see Figure 2). To the north, the designation of the Essex Estuaries SAC protects eelgrass and sandflat habitats. There are presently no designated conservation sites in the subtidal parts of the estuary.

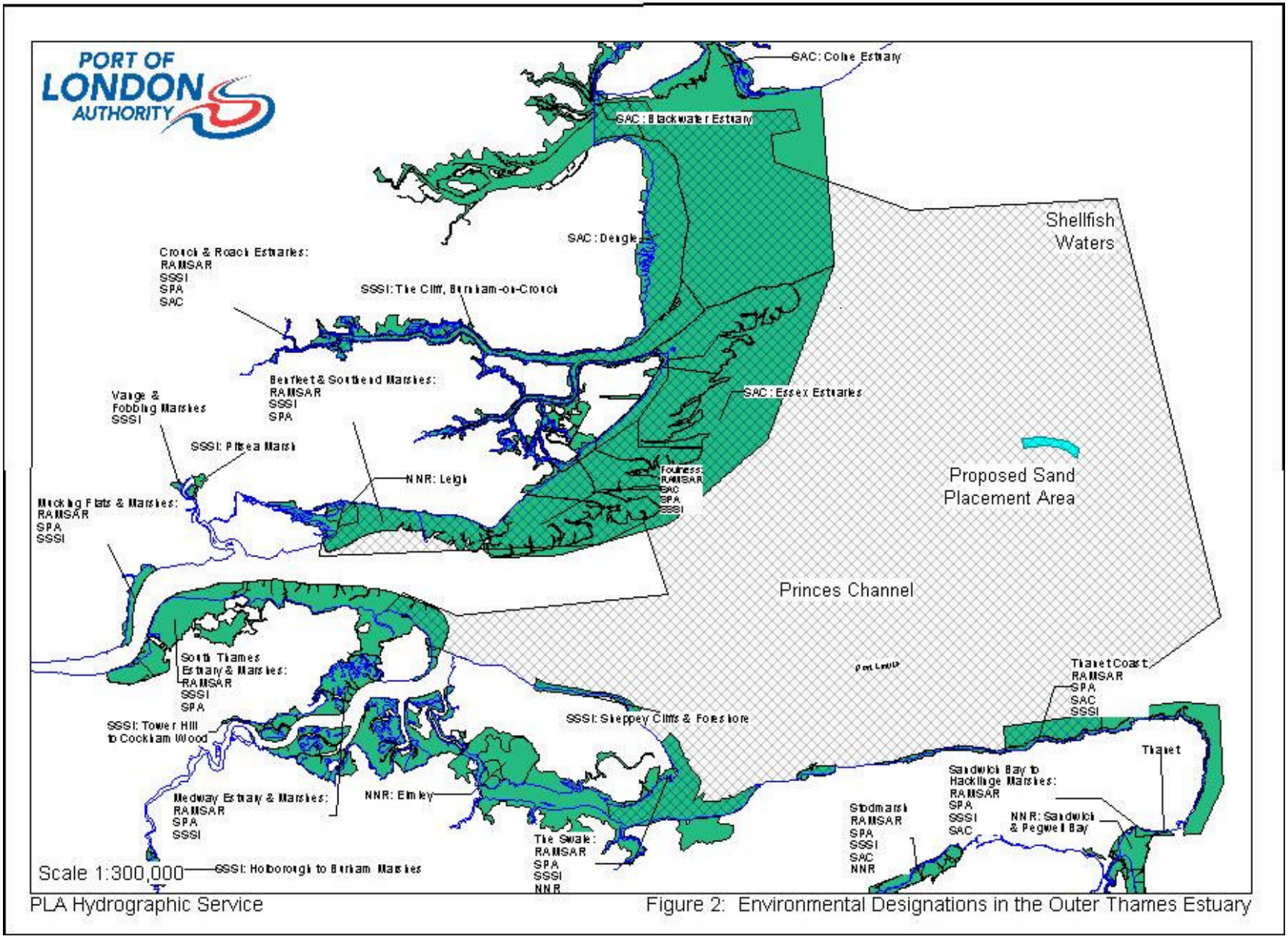

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Figure 2: Environmental Designations in the Outer Thames Estuary

1.3.2 Navigation

The Port of London is in the top three ports in the country in terms of tonnage and the Thames estuary correspondingly has a very high density of shipping with more than 30,000 movements per annum. Of these movements, 60% are via Princes Channel and include arrivals and departures to both London and the Medway ports; (Polaris, Drewry 2003). Deep draught vessels, such as VLCC and large container vessels, use Black Deep (the main deep water channel). The diversity of shipping using the port is wide and, in addition to the two types previously mentioned, includes oil tankers, Ro-Ro, aggregate dredgers and many more. Vessel movements in Princes Channel are predominantly general cargo ships, RoRo ferries and small tankers. Many of these vessels have draughts in excess of 5m and thus are only able to use the Princes Channel at higher states of the tide. Those so constrained must either wait for the tide to rise, or divert via the Fisherman's Gat with its inherently more complex vessel traffic problems, or increase significantly their journey length and enter from the north via the Black Deep and Knock John Channel.

Recreational navigation is also an important activity in the study area as evidenced by the many sailing and yacht clubs on the Essex and Kent estuarial coastlines. Other waterborne activities including windsurfing and personal water craft (PWC) are confined to designated inshore waters.

The archaeological heritage of the Thames Estuary is of great importance in terms of the hundreds of shipwrecks giving further evidence to both the challenging navigational environment and previous maritime conflict. It is also important because in the past much of the Estuary was dry land and probably inhabited, thereby providing the potential for artefacts and remains of early human activity.

1.3.3 Dredge Area

Princes Channel is located in the southern part of the Thames Estuary approximately 13km off the north Kent coast. Princes Channel is oriented in an east-west direction and runs parallel to the coast between Margate and Herne Bay. The Channel is bordered by drying sand banks and shallow waters typical of the Thames Estuary. Existing water depths in Princes Channel range from more than -20.0m in the east to the much shallower western section with ruling depths of -5.0 to -6.0m. The proposed Phase II dredging is to deepen further the shallow western section of the Channel and over a wider area than Phase I.

1.3.4 Sand Placement Area

The proposed sand placement site is located in the north-western part of the North Edinburgh Channel, as shown on Figure 2. The North Edinburgh Channel is in one of the most dynamic areas in the Thames Estuary and borders the large sandbank known as

Long Sand. Seabed sediments comprise mobile sands with low levels of fine sediment with biological communities representative of seabed disturbance (EMU, 2004).

1.4 Report Structure

This report presents the conclusions of the environmental characterisation of a sand placement site in the North Edinburgh Channel. The report comprises 17 sections. Sections 1 and 2 introduce the project and set the context for the development. Section 3 outlines the characterisation process and the legislative framework applicable to the project. Sections 4 to 15 describe the existing environment and discuss the predicted impacts upon the features listed in List 1. Section 16 considers the cumulative and in-combination effects of the placement site with the dredging of Princes Channel and other developments in the Thames Estuary. Finally, Section 17 provides a summary of the conclusions, impacts and mitigation measures.

List 1 Topics Considered in the Characterisation Process

- Section 4 Coastal Processes
- Section 5 Sediment Quality
- Section 6 Water Quality
- Section 7 Marine Biology
- Section 8 Natural Fisheries and Marine Mammals
- Section 9 Birds
- Section 10 Designated Conservation Sites
- Section 11 Marine Archaeology
- Section 12 Commercial Fishing
- Section 13 Navigation
- Section 14 Recreational Activity
- Section 15 Other Seabed Uses

2 PRINCES CHANNEL DEVELOPMENT

2.1 Navigational Need

Southern access to the Port of London has, for many years, been provided by the North Edinburgh Channel, Princes Channel and, more recently, the Fisherman's Gat. The seabed of the Thames Estuary in these areas is in constant flux, and water depths and channel centrelines are continually changing. Historically, there has always been a southern access route to the main entrance channel of the Thames with a minimum channel depth in the region of -7.0 to -8.0m. Currently, this is provided by the Fisherman's Gat, but there are signs that this access route is unstable, and recent traffic risk assessment studies (Marico, 2002) have highlighted the added risk inherent in having to cross busy shipping lanes when entering from this channel. To address this issue, it has been recommended, on safety grounds, that alternative routes are developed which remove the double-crossing situation that exists at the lower end of the Knock John Channel and Black Deep at its confluence with Fisherman's Gat.

2.2 The Dredging Operation

Phase II of the Princes Channel Development will develop part of Princes Channel to provide a 300m channel with maintenance dredging zones of 75m to either side (see Figure 3). The maintenance dredging zones will facilitate maintenance requirements by providing uninterrupted passage to ships. Approximately 2.5Mm^3 of predominantly fine sand will be dredged. An environmental assessment of the dredging operation has been undertaken and is reported separately.

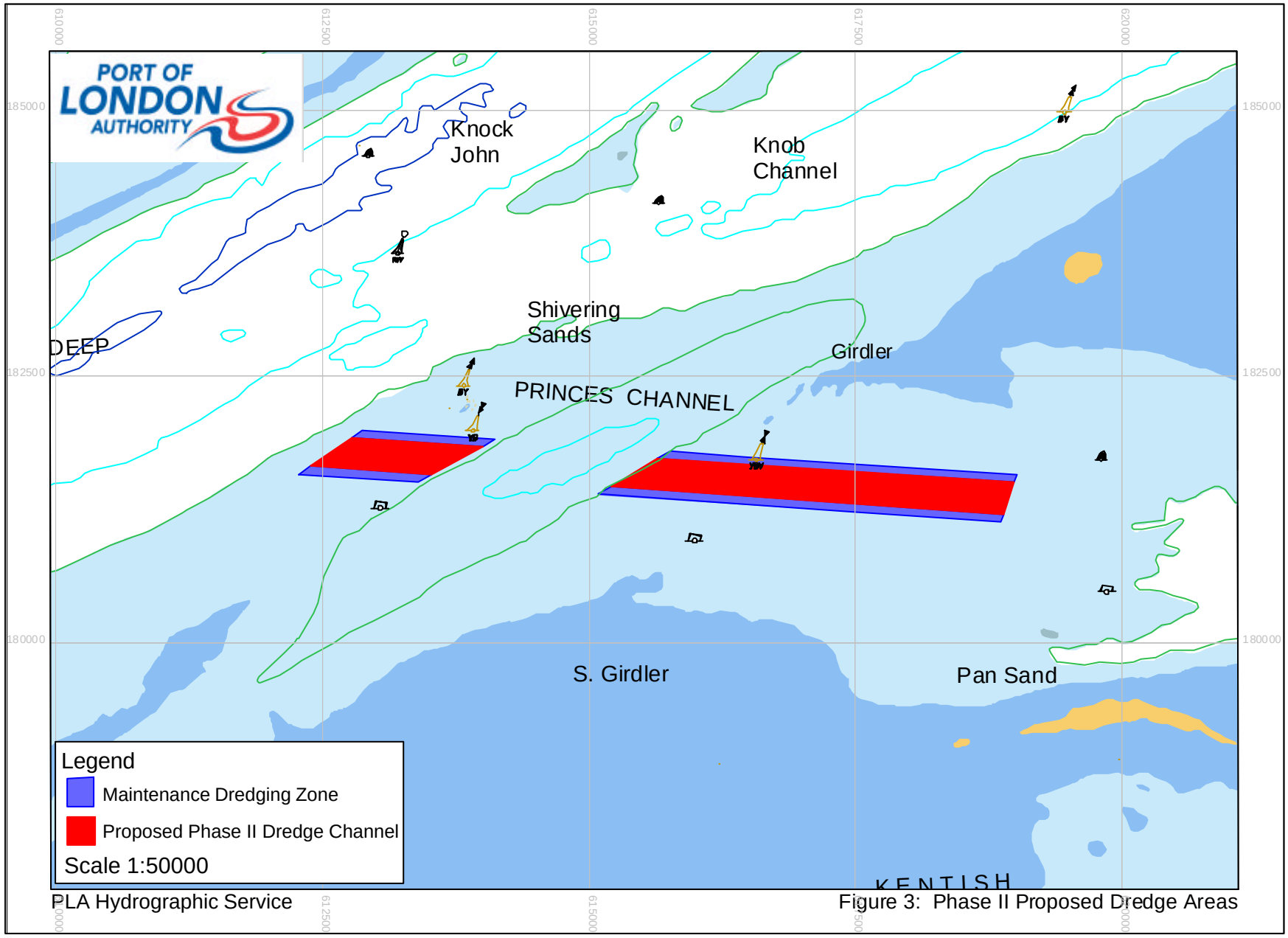

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Figure 3: Phase II Proposed Dredge Areas

2.2.1 Material Composition

A vibrocore survey has been undertaken to provide information on the composition of the seabed in the Phase II dredge area. Figure 4 shows the average particle size distribution in one metre slices to –8.00mCD and for the slice between –8.00 and –10.00mCD. A summary of the composition is provided in Table 1.

Table 1 Summary of Dredged Material Composition

MATERIAL TYPE	APPROXIMATE QUANTITIES (M^3)		
	-6m to –7mCD	-7m to –8mCD	-8m to –10mCD
Clay (stiff)	0	0	350,000
Silts and weak clays	97,500	272,000	1,100,000
Sand	526,500	1,292,000	4,176,000
Gravel	26,000	136,000	174,000
Total	650,000	1,700,000	5,800,000

From Table 1 it can be seen that the total quantity of material in the vibrocore survey area amounts to some 8.15 Mm^3 at -10mCD depth and comprises a silty fine sand inter-bedded with thin layers of soft sandy clays with bands of fine sand. When dredged, a large proportion of the silts and weak clays will be winnowed out, leaving a predominantly fine sand with a modest gravel content. Some bands of stiff clays are encountered in the eastern end of the Girdler area of the Channel but are found at depths of below –8.00mCD.

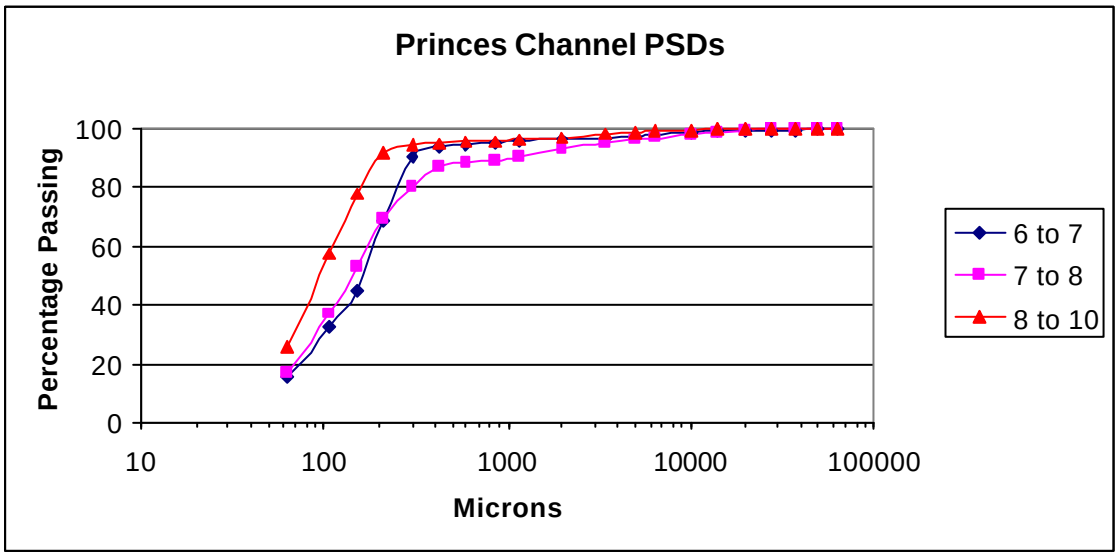

Figure 4 Composition of Seabed Sediment

2.3 Beneficial Use of Dredged Material

The PLA is committed to using dredged material beneficially where possible, in accordance with Government guidance and International requirements, including the London Convention and OSPAR. Investigations are ongoing to identify uses for dredged material from Phase II and all potential uses will be considered, including construction projects, habitat creation, coastal defences and recycling within the estuary system. Offshore disposal at a licensed marine disposal site, e.g. South Falls will be considered a last resort and only when beneficial use is not available, or for material that is physically unsuitable for beneficial use.

The PLA requests that the investigation it has undertaken into beneficial use options should be considered as an alternative in the consideration of the fate of the dredged material. The PLA's current understanding of beneficial use projects is summarised in Table 2.

Table 2 Status of Beneficial Use Projects

BENEFICIAL USE TYPE	PRESENT STATUS
Construction Projects	A number of projects requiring general infill material exist in the vicinity of the Thames Estuary. These are expected to commence in early 2005.
Habitat Creation	Wallasea Island requires a large quantity of dredged material for creation of saltmarsh but the timescale may be beyond the PLA's 2006 deadline. The PLA is in contact with English Nature Conservation Officers for Kent and Essex and the RSPB but no requirements have been identified to date.
Flood Defence	The PLA is in discussion with the EA about the use of dredged material for projects identified in the CHaMPs process. However there are no projects identified to date and the future developments are uncertain.
Other Opportunities	Possible uses for Interreg projects run by Estuary Partnerships but the Thames is not in the project area. Liaison is ongoing.
Beach Replenishment	Beaches in the area are replenished using shingle and the fine sand from Princes Channel is not considered an appropriate beach material.

In recognition of the difficulties associated with aligning the timescale of two or more developments, the PLA is proposing the designation of a sand placement site in the outer Thames Estuary. Sediment would be retained within the sedimentary system by relocating the sand from the western part of Princes Channel to a local area in deeper waters. This proposal is described in detail in Section 2.4.

2.4 Dredged Material Placement

There is a possibility that beneficial use may not be found in the relevant timescale (see Section 2.5) or that some of the dredged material may not be suitable for beneficial use. Should these circumstances occur, then an alternative solution will be required. Ideally, this alternative should permit the dredged material to be put in the same sedimentary cell that contains the channel. Princes Channel is part of the complex area of channels and banks over which water flows when it is leaving or entering the Thames Estuary from the East and South. It is well known that these channels (Princes, Fishermen's Gat, the Edinburghs etc.) change depth fairly regularly, as do the sand banks that separate and surround them (D'Olier, 1998). The seabed in this area is, thus, known to be mobile. Opportunities therefore exist to relocate dredged material to suitable zones in this area, where the material can then be re-cycled within the sedimentary system.

2.4.1 Consideration of Alternatives

A number of potential sand relocation areas were considered and one was selected as the preferred area. Figure 5 shows these areas. The preferred option is located in the North Edinburgh Channel. In addition the option of using the existing disposal site at South Falls has been considered.

Alternative Sites in the Thames Estuary

Five alternative areas and two different deposition methods (bottom placement and thin layer spreading) were considered as shown in Figure 5. These areas were initially selected based on hydrodynamic parameters and water depths. The hydrodynamic parameters included the current velocities and direction and, due to the aim of entraining the sediment within the system, areas with low current velocities were excluded. The main current direction in the outer Thames Estuary is east-west as shown by the orientation of the sandbanks. The interaction of both North Sea and English Channel currents provides complexity and channels across the sandbanks are caused by the differentials in water depths to either side of the banks (pers. comm. Brian D'Olier, 2004).

The Thames Estuary hosts the largest cockle fishery in the UK and the extensive intertidal mud and sand banks provide the cockle habitat. Shellfish beds are also found on sandbanks in the outer estuary. It is widely accepted that shellfish are particularly sensitive to sedimentation thus shallow sandbanks were ruled out of the consideration of sand placement sites. The edges of these sandbanks are, however, subject to frequent and large movements of sand and these areas and the adjacent channels were considered further.

Commercial fishing is an important economic activity in the Thames Estuary with trawling occurring in some of the channels and drift-netting on some banks. Extensive studies of the commercial fishery were undertaken for the London Gateway Port Development and a baseline understanding of the fisheries was prepared by MacAlister Elliot and Partners Ltd.

Navigation requirements for minimum channel depths influenced the selection of only those areas with depths of >10m at low water.

Options 5, 6, 7 and 8 were quickly discounted due to the relative importance of these areas for fishing and the proximity to the proposed London Gateway dredging areas (and hence the inherent potential for cumulative effects). Options 2 and 3 were discounted during discussions with the fishing industry as being important fishing grounds for vessels from Whitstable and nearby ports. Following a meeting and discussions with representatives of Kent and Essex Sea Fisheries Committee (KESFC) and local fishing associations, a preferred option was selected by the fishing industry. This option is the North Edinburgh Channel (Option 4, see Figure 5). The fishing industry representatives also confirmed that no fishing activity occurs in Princes Channel East (Option 1) but that the adjacent banks are fished.

Given the above, the PLA has taken the advice of the fishing industry and selected the North Edinburgh Channel as its preferred option, subject to the findings of the environmental characterisation. Princes Channel East is considered potentially viable but will not be pursued further at this stage.

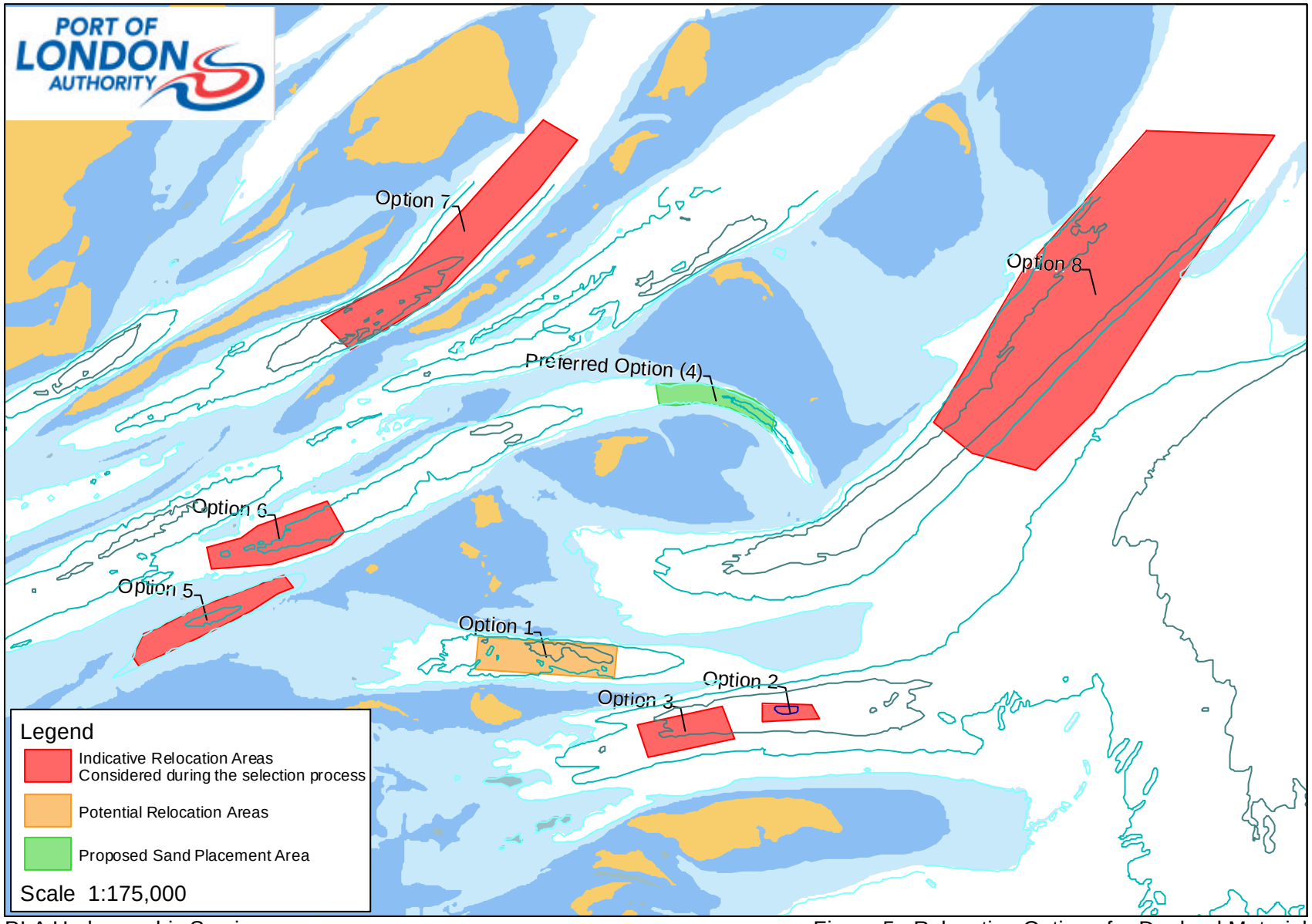

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Figure 5: Relocation Options for Dredged Material

South Falls Disposal Site

The nearest licensed marine disposal site to the Thames Estuary is South Falls off North Foreland. South Falls is approximately 55km from Princes Channel. The site is used for both maintenance and capital dredged material predominantly from the Medway Estuary but with occasional use by operators in the Thames Estuary. Currently the site has 1 active licence permitting a total quantity of 280,000 tonnes.

The advantage of using South Falls is that it is an already impacted area and would prevent the need for another area of seabed to be potentially adversely impacted. However, the great distance from the dredge site to South Falls places a significantly increased cost on the development (approximately 50%). The PLA's proposal is to place sand at a location where there are presently large movements of sand and to essentially blend the placement operation in with those natural processes. Section 7 presents data that shows the lack of stable biological habitats in the placement site due to the sand movements and compares the effect on marine biology and natural fisheries of the placement operation at North Edinburgh with the effects of a similar operation at South Falls.

It is, however, anticipated that a small amount of clay will be encountered during the dredging process, for example in a pocket at the eastern end of the dredge area. This material (<50,000m^3) would be unsuitable for placement at a dispersive sand site and, subject to obtaining the appropriate consent, would be transported to South Falls.

Placement Methodology

Two types of potential placement options were considered: bottom placement and thin layer spreading. Bottom-placement involves the release of dredged material from a hopper at an identified location and can be carried out in a number of ways, for example, whole hopper loads infilling a grid system or discharge spread over the disposal area by the dredger steaming through the site. Dredged material can also be placed just above the seabed by discharge via the dredge pipe. Dispersion of dredged material would be by both bedload movement and entrainment by tidal currents.

Thin-layer spreading would comprise the discharge of dredged material at the water surface or into the shallow water layers. The dredged material would then be distributed by the hydrodynamic processes operating in this part of the water column. Material dispersed by this route may travel further and wider than material placed near the seabed. As a result there is a greater potential for sedimentation occurring on the sensitive sandbanks and in the frequently fished channels.

Following discussion with the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), the method of thin layer spreading (dispersion of dredged material into the water column to form a thin layer on the seabed) was discounted due to the difficulties in demonstrating the effects of such a technique. CEFAS advised that, without prejudice to the outcome of an environmental characterisation, there is an

advantage in confining impacts because monitoring can be carried out to show the effects.

A form of bottom placement has been selected as the appropriate placement methodology. Further to the initial environmental considerations, the environmental characterisation has considered the effects of this methodology on the various environmental features in the study area.

2.4.2 North Edinburgh Channel Placement Site

The North Edinburgh Channel is the preferred option for the PLA due to its relative proximity to the dredged area and the advice from the fishing industry that the area is not heavily fished. In addition, the existing dynamic nature of the channel and its adjacent sandbanks support the concept of recycling the dredged material within the sedimentary cell.

The dredging will be carried out using a trailer suction hopper dredger (TSHD) and placement at the relocation area would be by bottom dumping in a grid system. The material would be placed in such a way to ensure that the majority of the hopper load travelled directly to the seabed and did not become entrained in the ambient currents. Loads would be of the order of 3,000 to 5,000 m^3 per cycle initially, but could be increased in size if the dredger capacity was increased once the depths at the dredging site allowed. The loads would be placed accurately using GPS to ensure that a notional –10.00m CD channel depth was not infringed at any time.

Although the PLA hopes to find beneficial use for the majority of the dredged material there is a possibility that no such use will arise in the timescale. With this in mind, the environmental characterisation and assessment of the North Edinburgh placement site is based on it receiving the total quantity for Phase II of up to 2.5Mm^3 (with the exception of 50,000m^3 of cohesive clay).

An assessment of the site's capacity to receive periodic maintenance dredging has also been undertaken and is reported in Section 2.4.3 and Section 17.

2.4.3 Maintenance Dredging Requirements

Bathymetric monitoring along a series of survey lines has been carried out over the 12 months since the Phase I dredge of Princes Channel. The monitoring indicates that, due to the lack of accretion in the ten months since the Phase I dredge, maintenance dredging requirements will be low (PLA, 2004). However, given the dynamic nature of the area it would be appropriate to plan for such a low level maintenance dredging campaign (i.e. 100,000m^3) once every five years.

2.5 Programme

It is important that the PLA meets the recommendation for improving the safety of navigation in the southern approaches in as short a timescale as possible. However, given the current traffic levels and the high quality of vessel traffic management exercised by the PLA, the requirement is not yet essential, although it is becoming increasingly urgent. The PLA would wish to complete the development of Princes Channel, from a navigation point of view, within the next two and a half years e.g. by the end of 2006. Should this not prove feasible and dredging has to continue beyond this period, close liaison will be maintained with the developers of London Gateway in order to co-ordinate dredging operations, and thus avoid potential conflict and possible in-combination effects.

This programme provides for the commitment of the PLA to identify beneficial use for as much as possible of the material from the Phase II dredge. The PLA has been in discussion with those involved in potential beneficial use projects and has based the programme on their advice, within the constraints of the overall timescale. Consideration has also been given to other projects that are likely to commence within the project timescale and these issues are discussed in Section 16.

3 ENVIRONMENTAL CHARACTERISATION PROCESS

This section describes the legislation that is applicable to the placement of material at sea, the environmental scoping process and the environmental characterisation process.

3.1 Legislative Context

A number of pieces of national and European legislation are applicable to the placement of dredged material in the marine environment including the following:

- Food and Environment Protection Act, 1985.
- Conservation (Natural Habitats &c.) Regulations 1994;
- Countryside and Rights of Way Act (CRoW) 2000;
- Environmental Impact Assessment (EIA) Directive (97/11/EC);
- Shellfish Waters Directive (79/923/EEC); and
- Surface Waters (Dangerous Substances) (Classification) Regulations 1997 & 1998.

The Shellfish Waters Directive and the Surface Waters Regulations are soon to superseded by the Water Framework Directive and its implementing regulations.

3.1.1 Deposits At Sea

Placement of sand below mean high water springs is considered a deposit at sea, which is regulated by the Department for Environment, Food and Rural Affairs (Defra) under the Food and Environment Protection Act (FEPA) 1985. Under Section 5 of Part II a license is required for the disposal of dredged material at sea.

It is often the case that marine disposal takes place at existing licensed sites but there are examples of placement sites that have been licensed for short term or project-specific operations.

The PLA is proposing the recycling of sand within the estuary system and believes that this is more akin to using dredged material beneficially rather than disposing of it. However, the same licensing requirements apply to both beneficial placement and disposal in the marine environment.

3.1.2 Conservation (Natural Habitats &c.) Regulations 1994

These regulations transpose the 1992 EC Habitats Directive into legislation in England and Wales. There is a requirement to consider if a project is likely to have a significant effect on a designated European site and, if this is the case, to undertake an appropriate assessment to determine the effects of the project on the integrity of the site. In the UK, English Nature (EN) provides advice to government on the likely effects of projects on designated sites.

The CRoW Act contains similar provisions to the above Conservation Regulations in that it provides protection for conservation sites designated under national legislation.

3.1.3 EIA Directive and Implementing Regulations

The EIA Directive has been implemented for works in harbours through the Harbour Works (EIA) Regulations 1999. These regulations are operated by the DfT through the CPA consent process. However, there are currently no specific regulations that apply the EIA Directive to applications under FEPA, although these are in preparation. In the absence of such regulations, the PLA is preparing an environmental characterisation based on the requirements for the provision of environmental information in the FEPA.

3.1.4 Shellfish Waters Directive

The Shellfish Waters Directive (SWD) applies to coastal or brackish waters which need "protection or improvement in order to support shellfish (bivalve and gastropod molluscs) life and growth and thus to contribute to the high quality of shellfish products directly edible by man". The Directive sets water quality standards which must not be exceeded by pipeline discharges and defines sampling and monitoring requirements for compliance.

Part of the Thames Estuary is one of more than 100 designated Shellfish Waters in the UK (Figure 2). Others include Southampton Water and the Solent, the Humber Estuary, Liverpool Bay, Swansea Bay, Milford Haven and Morecambe Bay. Poole Harbour, Portsmouth Harbour and the Fal estuary, and many other areas of importance for port and recreational navigation also have designated waters.

Sea disposal activities are not subject to consideration under the Shellfish Water Directive although, during their scientific assessment of the proposals, CEFAS consider the effects on shellfish and the food chain.

3.1.5 Water Framework Directive

In December 2003, the EC Water Framework Directive was transposed into national law by means of the Water Environment (Water Framework Directive) (England and Wales) Regulations, 2003. These Regulations provide for the implementation process of the WFD from designation of all surface waters as water bodies to achieving good ecological status in 2015. Presently, there is little guidance on the application of the Regulations to existing activities such as disposal at sea. Further, the WFD is limited to activities within 1nm of the coast. Although boundary lines have not yet been seen the North Edinburgh Channel is certainly more than 1nm from the shoreline.

3.2 Environmental Characterisation

3.2.1 Scoping Study

An Environmental Scoping Report was prepared with the aim of identifying the key issues to be assessed during the characterisation process. The Report set out the existing environmental data and outlined the additional survey requirements (Appendix A on the accompanying CD-ROM). The Report was submitted to Defra as the Regulator and the relevant environmental consultees. Responses were received from the majority of consultees and any additional issues raised were taken forward as part of the characterisation process. Table 3 summaries the responses to the Scoping Report and the full responses are contained in Appendix B.

Table 3 Summary of Consultation Responses

CONSULTEE	SUMMARY OF RESPONSE
Defra	1. Discussion of choice of disposal site 2. Fisheries/shellfisheries, commercial fishing 3. Fate of dredged material 4. Future maintenance dredging 5. Sediment quality 6. Cumulative effects 7. Use of South Falls
KESFC	No comments on Scoping Report
Environment Agency	1. Post-disposal marine biological survey 2. Shellfishery assessment 3. Consideration of suspended solids
RYA	1. Notice to Mariners 2. Vessels marked
RSPB	1. Designated conservation sites & interest features 2. Disturbance to birds 3. Effects from sediment movement (smothering, erosion. accretion etc.) 4. Keep material within the system 5. Birds outside designated sites
English Nature	1. Welcomes retaining material within system 2. Consider placement/beneficial use options 3. Confirms issues in Scoping Report 4. *Sabellaria* reefs in benthic surveys 5. Possible future offshore sites

3.2.2 Existing Marine Surveys and Datasets

During the preparation for Phase I of the Princes Channel Development, the PLA carried out a number of surveys to provide information on the geological, physical, chemical and biological characteristics of the study area, focussing mainly on the Princes Channel area. These surveys are described briefly in Appendix C.

Following the Scoping Study, further surveys were carried out in the North Edinburgh Channel. Table 4 summaries these surveys and studies.

Table 4 North Edinburgh Surveys and Studies

SURVEY/WORK DESCRIPTION	COMMENT
Dredged material characterisation	Surface and depth samples were taken during a vibrocore survey and analysed for a suite of heavy metals, TBT and particle size.
Placement site seabed characterisation	Surface samples were collected and analysed for a suite of heavy metals, TBT, organics, pesticides and microbiological parameters.
Current profiling	ADCP survey on track shown in Figure 7.
Fate of deposited material	Process modelling of the dredging operations. Conventional sediment bed-load transport techniques to assess rate of movement along the bed. Dynamic plume modelling was originally proposed but was discounted due to lack of fines in the material to be placed.
Marine biological survey	Survey comprising grabs and trawl sampling to complement existing data. Survey covered area shown within red outline on Figure 14.
Morphological change	Desk study of existing literature.
Archaeological assessment	Assessment covered Thames Estuary and focussed on North Edinburgh Channel.
Ordnance	Desk study of existing literature.

3.2.3 Environmental Characterisation Process

The consultation responses, baseline surveys and data collection described above provided the inputs into the environmental characterisation process. The environmental characterisation comprised identification and evaluation of possible impacts, discussion of possible mitigation and/or monitoring requirements, and reporting. The results of the

characterisation are set out in Sections 4-15 using, where appropriate, the following structure for each topic area:

- Existing Environment
- Impact Title
- Impact Description
- Mitigation Measures
- Residual Impact
- Impact Summary Table
- Monitoring Requirements

The characterisation process has considered the spatial and temporal extent of impacts and any potential in-combination and cumulative effects. Potential direct and indirect, permanent or temporary impacts have been assessed.

Significance Criteria
The significance of an impact upon a feature has been considered using the significance criteria (outlined in Table 5) as a guide. Significance levels may be adverse or beneficial.

Table 5 Environmental Significance Criteria

	MAGNITUDE (DIRECT/INDIRECT, GEOGRAPHIC EXTENT, TIMESCALE ETC)				
Value (including designations, rarity etc)		***High***	***Medium***	***Low***	***Very Low***
	High	Major	Major/moderate	Minor	Negligible
	Medium	Moderate	Moderate/minor	Minor	Negligible
	Low	Moderate	Minor	Negligible	Negligible

4 COASTAL PROCESSES

This section describes the existing environment in the outer Thames Estuary with emphasis on the North Edinburgh Channel area, details the sand placement process and discusses the likely changes on hydrodynamic parameters that may occur as a result of the placement operation.

4.1 Existing Environment

The North Edinburgh Channel is one of a number of dynamic channels in a complex sandbank system of the Outer Thames Estuary. It is thought that sand enters the outer estuary as sand ribbons and waves moving from the north east and joins the north western tip of the Long Sand. This sandbank feature is considered to control water movement in the outer Estuary and thus the movement of sand (pers. comm.. B D'Olier, 2004). The interaction of the tidal currents from the North Sea and the English Channel result in the sand being moved westwards through a series of deposition zones to the eventual deposition site on the Maplin Sands (pers. comm.. B D'Olier, 2004). It is reasonable to assume that the Outer Thames Estuary forms a single sedimentary system and the Princes Channel and the North Edinburgh Channel, being a few km apart, are part of this system. Studies of historical charts demonstrate that the forms of the various sandbanks have changed over time and the PLA's ongoing hydrographic surveys continue to find changes in depth and form. Within the context of these large scale movements, smaller scale changes are observed such as those in the North Edinburgh Channel.

4.1.1 North Edinburgh Channel

Bathymetry

Water depths in the proposed placement site in the North Edinburgh Channel vary from approximately 10m along the boundary of the site to more than 16m in the Channel centre. Beyond the site's boundaries depths gradually shallow up to the very shallow and in some places drying sandbanks. These depths are representative of low water conditions and at high water an additional 4.5m of water is available with the resulting depths being 14m to 20m. For the purposes of this assessment low water depths have been used.

Morphology

Bathymetric data relating to the North Edinburgh Channel can be found on PLA Chart 203MS, which was last subject to a full main survey in 1997. More recently a survey was carried out by PLA in 2004. These data show the channel to have moved some 220 metres eastwards between the two surveys as well as becoming considerably shallower overall. Rough computations, using the approximate channel geometries, indicate that a total of around 24 Mm^3 of sand would have to be eroded from a 4 km strip on the east side of the channel to allow this to happen (pers. comm. DRL, 2004). An equivalent, or possibly greater, amount of sand would have to be deposited on the west side of the channel to complete the geometrical shift and shoaling. It can be seen from these figures

that on average in excess of $6Mm^3$ of sand is moving annually to make these geomorphological changes. However, this is only the resultant, or residual, movement of material occurring over a 12-month period (pers. comm. DRL, 2004). In practice, the gross amount of material moved in any direction would probably be an order of magnitude higher than this. The proposed placement operation is assessed within this context. Figure 6 shows a comparison between surveys from 1997 and 2004 and it can be seen that over this period depth changes of 10m occurred in some places.

Tidal Currents

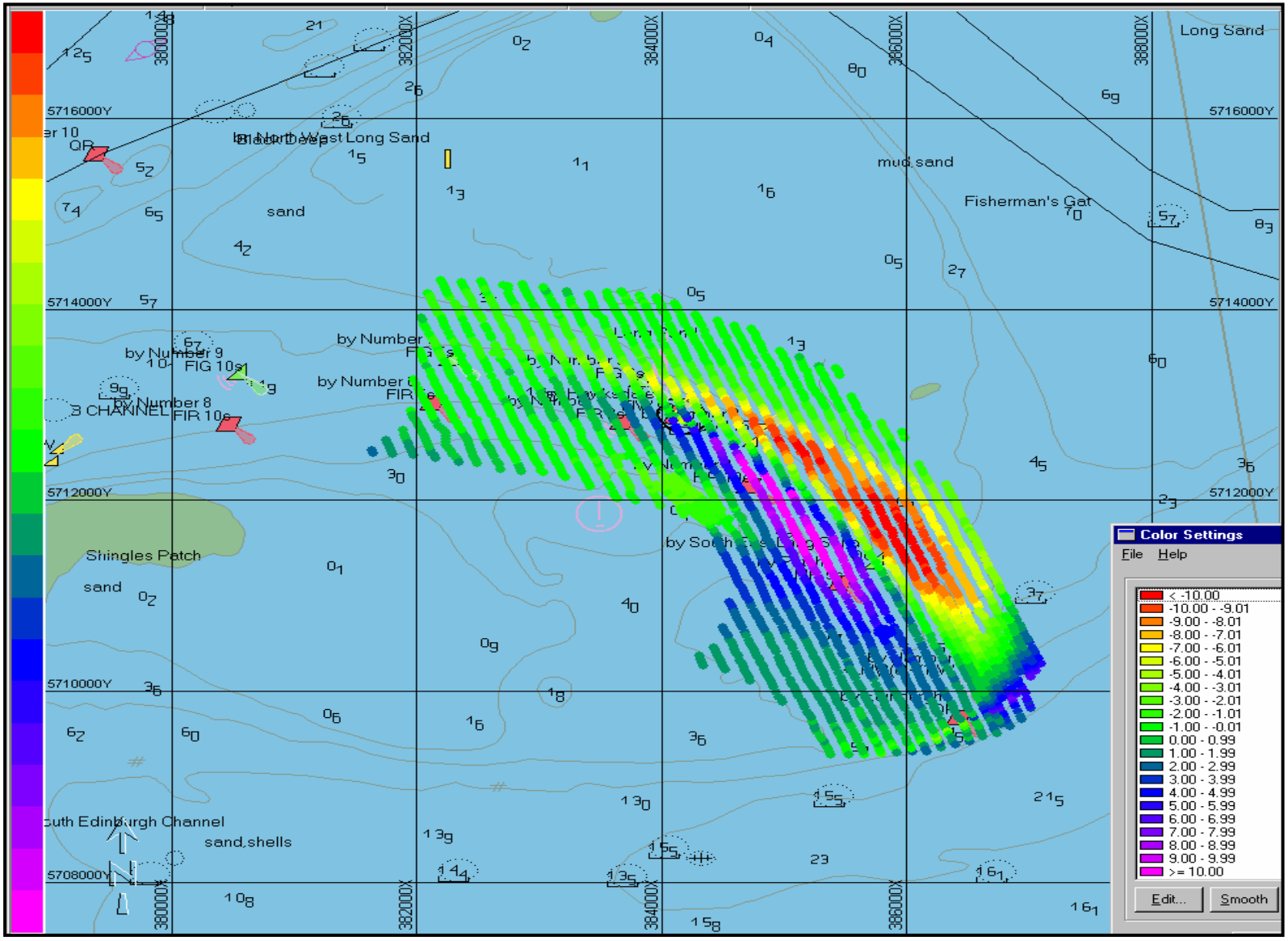
A survey of tidal currents was carried out in the North Edinburgh channel in February 2004 and a vessel-mounted ADCP was used to collect water velocity data along the four transects shown on Figure 7. The data was used to refine the existing mathematical model for the outer Thames Estuary and to inform an assessment of sand movement away from the placement site. In the deeper water in the centre of the Channel and towards the northern side of the Channel, peak water speeds are approximately $1ms^{-1}$ while in the shallow water speeds are in the range of $0.5ms^{-1}$ to $0.9ms^{-1}$. At one location in the deep water in the centre of the Channel the current speed reached $1.5ms^{-1}$ but this isolated reading is not considered representative (DRL, 2004).

Seabed Sediments

During the marine biological survey, sediment samples were taken at 22 locations and analysed for their constituent fractions of silt, sand and gravel. Figure 8 shows the sediment composition for the survey area.

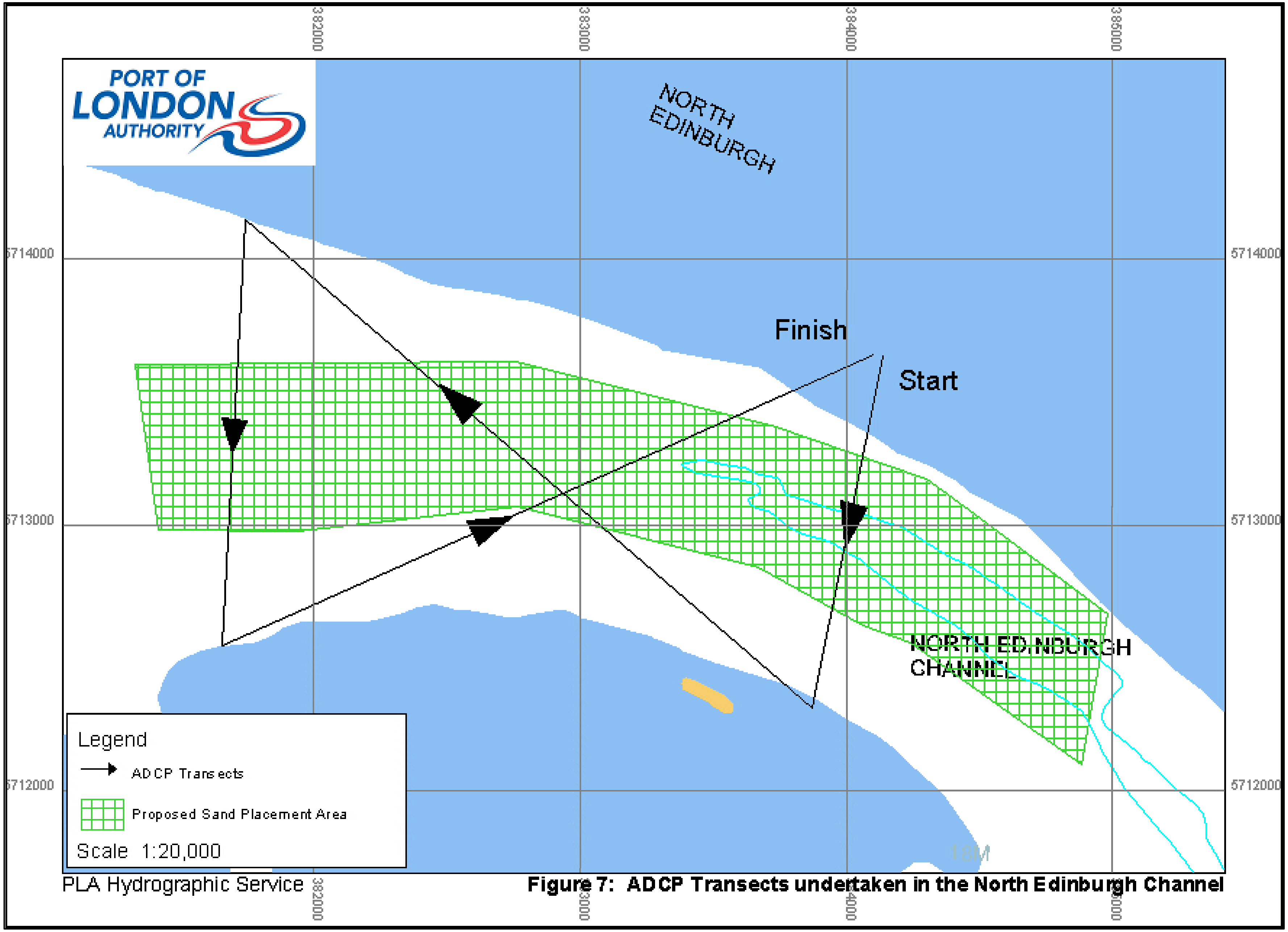
All of the 22 locations comprise sand, the majority comprise between 95 and 100% sand. Gravel fractions are identified in only three samples, two are located in the deep water of the Knock Deep (samples 20 and 2) to the south of the Long Sand and the third (sample 13) is located on the Kentish Flats to the southeast of Princes Channel. Many of the samples contain a very small component of fine material with the greatest proportion in sample 15 in the Black Deep (near to the historic disposal site) and sample 2 in the Knock Deep.

The five samples within the proposed placement site all have a sand content of greater than 90%. The seabed in the placement site and much of the surrounding area is described as heterogeneous, poorly sorted, mixed sediments with variables levels of silt and gravel fraction (EMU, 2004). On the western edge of the proposed placement site is a localised area of homogeneous moderate to well sorted sands (EMU, 2004).



PLA Hydrographic Service

Figure 6: Net Change in Sediment Movement in North Edinburgh Channel 1997 – 2004



PLA Hydrographic Service

Figure 7: ADCP Transects undertaken in the North Edinburgh Channel

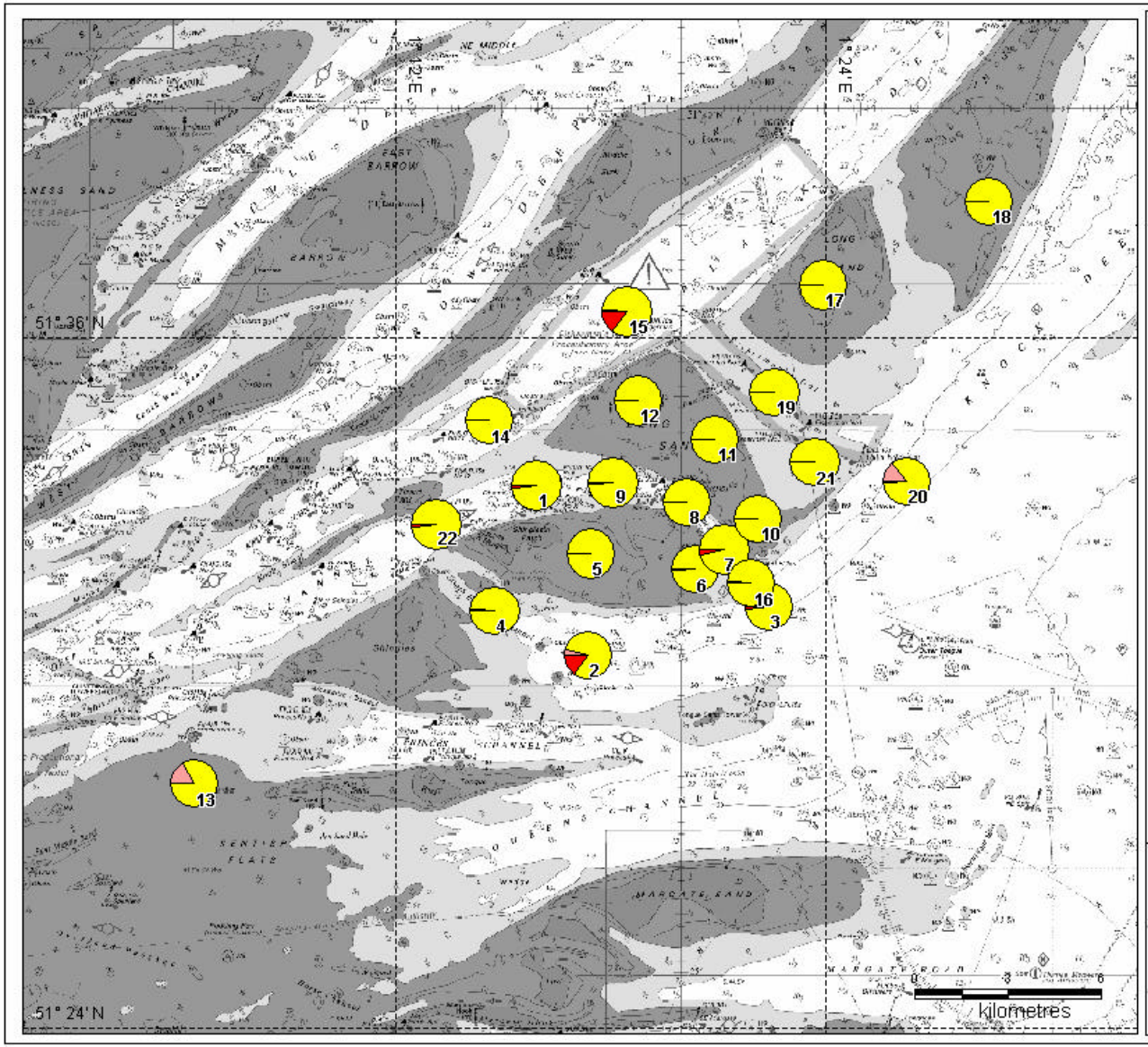


Figure 8:
Surface Sediment Characteristics

Key

Sediment Characteristics

- Gravel
- Sand
- Fines

Based on Emu 2004

PORT OF LONDON AUTHORITY

4.1.2 South Falls Disposal Site

The nearest existing marine disposal site is South Falls, located some 55km from Princes Channel. This site has been in use for many years and receives both capital and maintenance dredged material. The site is located in water depths of approximately 40m and is subject to tidal currents of approximately $1ms^{-1}$ (Defra GIS, 2004). Given the strength of the tidal currents it is probable that dispersive material and fine sand will be transported away from the site in the form of plumes and bedload transport. Larger material (gravel, rocks, clay etc.) would remain at the site and be subject to winnowing and erosion over time. The seabed is described as fine sand however it is also likely to contain debris from capital dredging operations and may not be a smooth sandy seabed.

The site is presently used for the disposal of maintenance dredged silts and sands from the River Medway with a total permitted quantity 280,000 tonnes (approximately $147,500m^3$). One operator on the Thames uses the site on a periodic basis (about once every three years) for coarse sand that cannot be moved by water injection dredging, and the quantity can be up to 70,000 tonnes (approximately $40,000m^3$). In 1993/4 the Port of Ramsgate was licensed to dispose of up to 700,000 tonnes of capital material and in 2000 and 2001, Medway Port Authority held a licence for up to 800,000 tonnes of material from its channel deepening project (Defra Public Register, 2004).

4.2 The Sand Placement Operation

The placement operation will occur from a stationary trailer dredger in a series of pre-defined placement cells and the actual placement operation by bottom discharge will occur within approximately one minute (out of a round trip time of three hours). The assessment of effects on coastal processes is based on placement of the entire $2.5Mm^3$ on a continuous basis. In such an operation, approximately $210,000m^3$ would be placed at the site each week over a 12 week period. In practise this is very unlikely to occur given the PLA's commitment to find beneficial use for the majority of the dredged material.

The processes which operate during disposal by bottom-discharge from barges or trailer dredgers can be divided into three phases (Bokuniewicz *et al.*, 1978); convective descent, impact (or dynamic collapse) and passive diffusion.

On release, the material descends rapidly as a well-defined turbulent jet at a speed far in excess of the settling velocity of the component soil particles. During descent, the material is diluted due to axial spreading of the jet and entrainment of ambient water. The degree of dilution is largely a function of the geometry of the dumping situation. It increases as the water depth increases and as the speed of discharge from the vessel decreases.

A proportion of the material is stripped from the descending jet to form a passive sediment plume in the water column. Depending on the water depth and hydrodynamic conditions at the dump site, the suspended material may be transported considerable

distances by water currents. The amount of material stripped from the jet will be greater in deep water than in shallow water but for this operation would be in the region of 3%. The size of barge or dredger bottom-openings through which the material is discharged is also a factor. In percentage terms, stripping losses will generally decrease as the size of the discharging vessel increases.

In very deep water, the dilution eventually reaches the stage where dynamic collapse occurs; the density of the jet is reduced to a density similar to that of the surrounding seawater and the material becomes subject to passive advection and diffusion. Unless very small vessels are used, and discharge speeds are slow, dynamic collapse is unlikely to occur in water depths of less than 100 metres. Instead, the dumped material will impact the seabed at speed and spread radially from the impact point as a density current, eventually coming to rest, assuming a level seabed, when all of the kinetic energy has been dissipated through friction.

4.3 Changes to Bathymetry

4.3.1 Effect description

As Port Authority the PLA is concerned to ensure that the placement operation does not compromise the future use of the North Edinburgh or other channels in the vicinity because further natural bathymetric changes may allow these channels to be re-opened. The site has been chosen to reflect an area with depths of greater than -10mCD at low tide.

The placement operation will result in a number of individual mounds of sand distributed over the seabed. If the total quantity of 2.5Mm^3 is distributed evenly over the disposal area, a mound of 1.25m would be formed. In practice, following each placement operation, the sand will impact on the seabed and spread laterally under its own momentum and gravity (DRL, 2004). Assuming a medium sized dredger (4-8,000m3 hopper capacity) each placement will initially form a mound of approximately 2m in height. Slumping and reworking by tidal currents would reduce the mounds to approximately 1.5m. The remaining sand would then form part of the seabed for uptake in bedload sediment transport (see Section 4.6).

The result of the placement of 2.5Mm^3 in the placement site would result in a depth reduction of 1.5m following initial slumping and levelling off.

4.3.2 Mitigation

To ensure the navigational constraint of -10mCD is maintained, it is proposed that placement activities are restricted to water depths of -12mCD or greater. Figure 9 shows the revised placement area.

The significance of the effect for other environmental features is discussed in the relevant section.

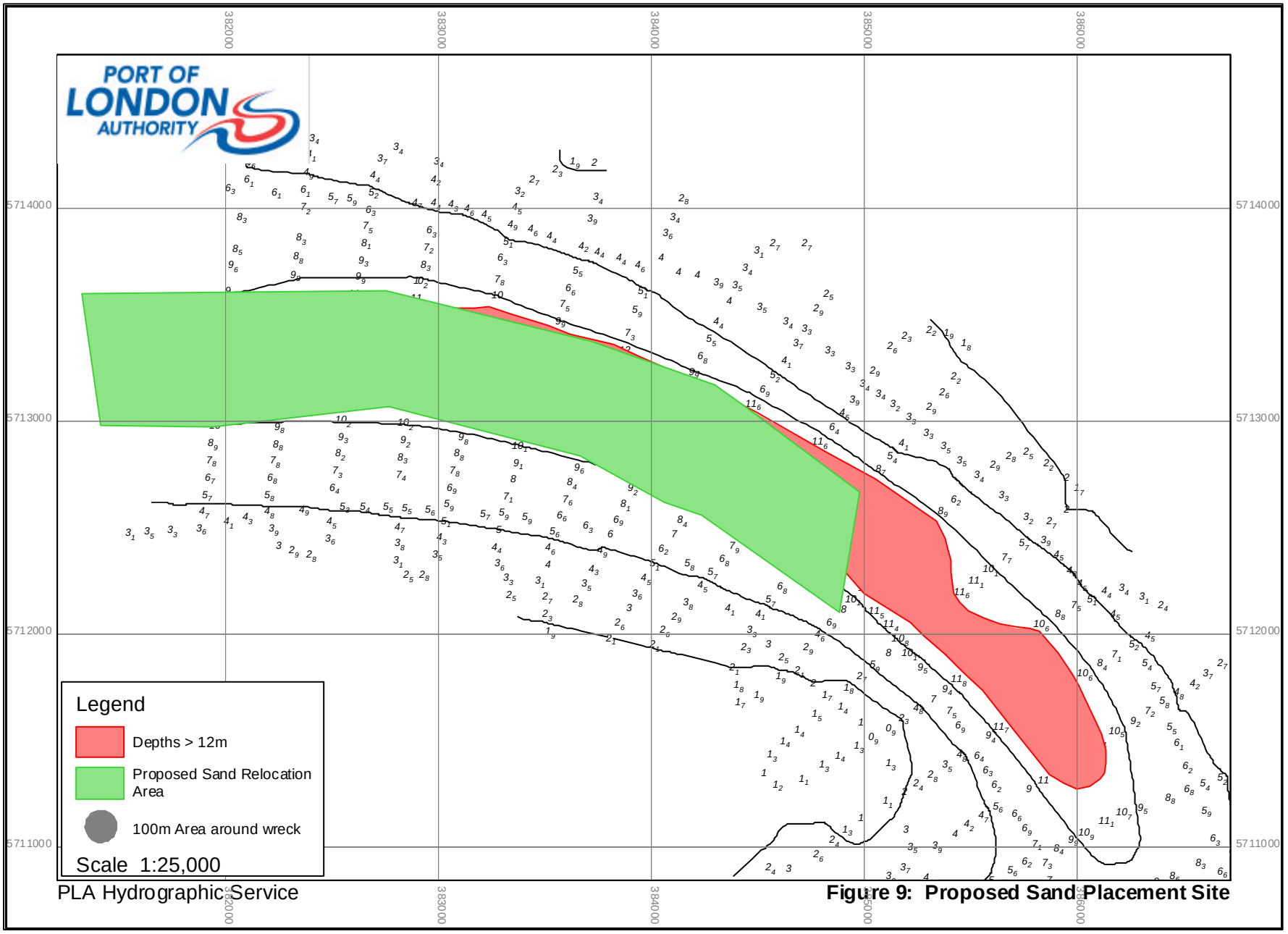


Figure 9: Proposed Sand Placement Site

4.4 Changes to Current Speed

4.4.1 Effect Description

Changes to water depths can result in changes to current speeds and subsequently sedimentation and erosion patterns. It is important to be aware that the North Edinburgh Channel is frequently subject to dramatic depths changes caused both by extreme events and the ongoing migration of the channel. For example, the eastwards movement described in Section 4.1 would have involved depth changes of up to 10 metres at any individual point. It can be concluded, therefore, that the North Edinburgh Channel is subject to changes in current speeds as a result of natural processes.

The reduction in depth of between 1.5 and 2m would result in an increase in local tidal current speeds of up to 25% across each mound of sand. At peak tidal flows this could result in localised increases in water speed of up to $0.25ms^{-1}$ (DRL, 2004). The effect of this increase will be enhanced erosion over the mounds and the dispersal of the sand into the sediment transport processes (see Section 4.6). Increases in tidal currents are predicted to remain local to each individual mound and will not affect current speeds outside of the immediate vicinity. As each mound decreases, the increase in current speed will also decrease, therefore, the 25% increase is considered a maximum short-lived effect. It should be noted that these predictions are based on low tide depths and the additional 4.5m at high tide will result in lower current speed increases. Assuming the worst case scenario of placement of $2.5Mm^3$ of sand, in the large scale outer Thames Estuary, no significant change to tidal flows or the sediment regime is predicted.

4.4.2 Mitigation

Given the above, consideration has been given to designing the placement methodology to have the least effect on current speed. It is therefore proposed to carry out placement along longitudinal strips parallel to the current flow. This will ensure that there are no blocking effects to current speeds across the channel, however, this will have the effect of slower dispersal of the sand away from the placement site.

The significance of these effects for environmental features are considered in Sections 5 to 16.

4.5 Changes to Wave Action

The wave climate local to the sand placement site has been derived using HR Wallingford's HINDWAVE and TELURAY models. The local conditions at the site are dependent on swell waves (generated in the North Sea) and wind sea waves generated within the Outer Thames Estuary by local wind action. In this case, HINDWAVE was run (with over 15 years of wind data) in order to predict the locally generated waves and TELURAY used to transform waves generated in the North Sea to the North Edinburgh Channel taking account of the modification to the offshore spectra resulting from refraction and shoaling. The dominant factor in the vicinity of the North Edinburgh

channel relates to the large surrounding drying banks which limit the height of the waves by depth induced breaking. In this context, the very local change in depth within the deposition area is such as to have a negligible impact on wave height distribution.

4.6 Changes to Sediment Transport Patterns

4.6.1 Effect description

The introduction of sand to the North Edinburgh Channel will increase the amount of sand available for onward sediment transport. As noted in Section 4.4 the initial effect of the placement will be to increase sediment transport processes local to each placement mound. This will result in increased erosion of the mounds with deposition of sand into the hollows between each mound until a more level seabed is achieved and sediment transport patterns return to those existing at present (DRL, 2004). Evolution of the North Edinburgh Channel is considered to be driven primarily by extreme events, i.e. storm action, and the placement of this material is considered to mimicking a smaller storm event.

It is not predicted that there will be any increased erosion of the adjacent sandbanks, rather the changes will be restricted to the locality of the placement site, which is approximately 360m from the 2m contour.

4.7 Fate of the Placed Sand

The material proposed for placement into the North Edinburgh Channel is fine sand and has very similar characteristics to the existing seabed material. Although the seabed material in the Princes Channel has a higher *in situ* fines content, use of DRL's Dredging Process model predicts that much of this material will be dispersed into the immediate area during the dredging process. The fines content of the material remaining in the hopper of the dredger is comparable to the fines content of the North Edinburgh seabed sediment. Figure 10 shows the relative properties of the two; dredged material and the seabed sediment at the placement site.

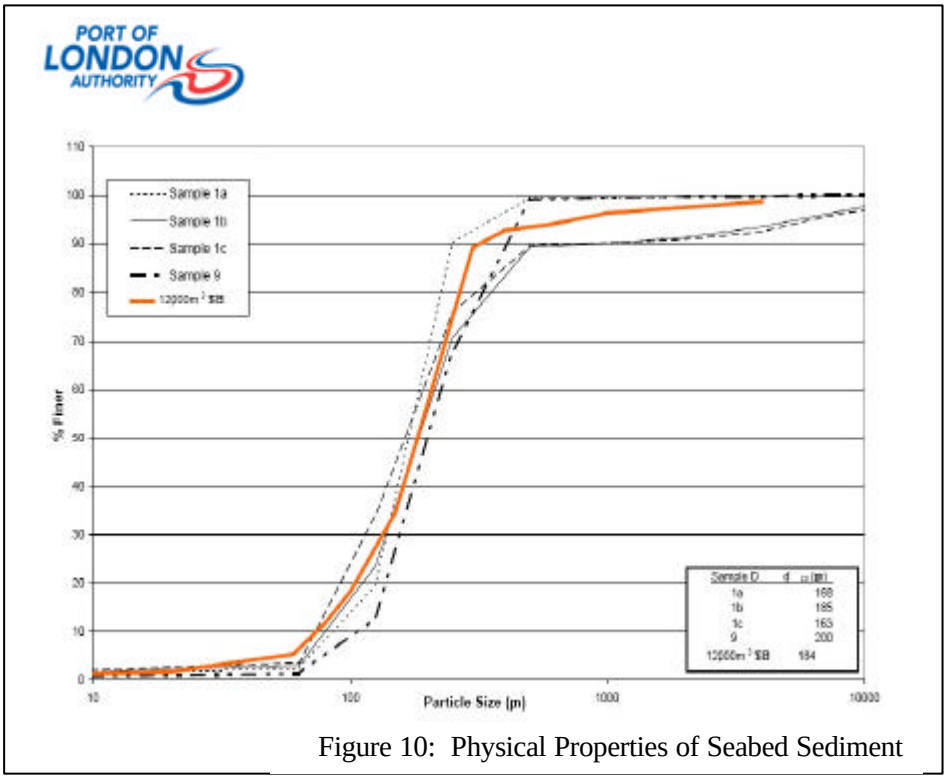


Figure 10: Physical Properties of Seabed Sediment

It is likely that there will be a small proportion of London Clay in one section of the Princes Channel dredge area. This area has been identified from the vibrocore survey and, if encountered, permission would be sought to dispose of this clay to South Falls, the existing marine disposal site for capital material.

Apart from the clay, given the similarity in properties, it can be predicted that the two sediments will behave in a similar way when subjected to tidal currents and wave action. The approach taken to assess the mobility of the sand involves calculations of shear stress required to initiate movement in the North Edinburgh Channel. The calculations found that the shear stress required to initiate movement ranged from a current speed of $0.38ms^{-1}$ to $0.43ms^{-1}$. Assuming that the current speed varies sinusoidally with the tide, with a peak speed of $1ms^{-1}$ (from ADCP data), it can be see that the shear stress will be exceeded for between 75% and 72% of the tidal cycle (DRL, 2004). The peak water speed could mobilise sand grains up to a diameter of 2.5-3mm, therefore, even the coarser sand will be mobilised on a spring tide.

Assessment of the eventual fate of placed material is notoriously complicated as many factors affect bedload movement, such as currents, storm surges, storm waves and swell, strong winds etc. The placed material will be mobilised for the majority of each tidal cycle and will be transported in the direction of the tidal flow. On the flood tide the material will move towards the inner estuary for a distance of a few km, over slack water the sand will be deposited on the seabed before being picked up again as speeds increase on the ebb. Material that is moved initially on the flood is expected to move up and

down over a number of tides before being deposited in a lower estuary depositional environment, on a sandbank or coastal fringes.

In the North Edinburgh Channel, the ebb tide is dominant and sand will be transported further distances to the east, moving over the bank at the eastern end of the Channel and fanning out into the deeper water of the Knock Channel. Figure 6 indicates shows the most dynamic part of the channel and the initial placement operations will be targeted in this area. The deposited sand will act as the top mobile layer and will move in place of the sand that was previously forming the seabed surface. The placement operation will not, therefore, cause a significant increase in the material being transported out of the North Edinburgh Channel on each tide as the original seabed material would be buried and, therefore, not available for transport.

4.8 Comparison with South Falls

The South Falls disposal site has received a maximum of 800,000 tonnes in an annual period and only on three or four occasions. Ongoing use of the site is relatively small scale and amounts so to 2-300,000 tonnes per year. The capacity of the site to receive 2.5Mm^3 (equivalent to approximately 4.75M tonnes) of sand on a continuous basis has not, therefore, previously been assessed. It is probable, however, that the period of deposition would be more than double that for placement at North Edinburgh due to the significantly increased cycle time from Princes Channel to South Falls. A period of 30 weeks is thus more likely.

South Falls, with water depths of up to 40m clearly has the bathymetric capacity to receive the sediment, however, it is not in a sandbank system such as the Thames Estuary, rather it is in an area of deep water with no obvious sources of mobile sand. The current speeds at the South Falls site are similar to North Edinburgh. However, the influences of surges, storms and waves etc. at this depth are greatly reduced and thus most movement that occurs will be in the dominant current directions, which are 032º and 209º. The result of the deposition of this quantity of sand at South Falls over the given timescale would be to provide an increased quantity of mobile sand for onward transport. The assessment of the likely significance of this effect on marine biology, fisheries and fishing activity is considered in Sections 7, 8 and 12 respectively.

4.9 Summary of Potential Effects

The assessment of impacts on the environmental features in Sections 5 to 16 is based on the following effects on coastal processes:

- 2.5Mm^3 placed over a 12 week period (the "worst-case scenario");
- Local increase in current speeds around each disposal mound;
- Sediment properties of placed material are equivalent to existing seabed material;
- Sediment will move away from the site as bedload transport in place of existing seabed sediment;
- There will be no obvious disposal plume due to low fines content; and
- There is no predicted change to wave action.

4.10 Monitoring

The rate of movement of placed material away from the site will be monitored by weekly bathymetric surveys during the placement operation. The surveys will extend away from the placement site in the direction of the tidal cycle to provide information on any local accumulations of material. A pre-placement survey will be undertaken and this, along with existing survey data, will form the baseline situation. Following the completion of the placement operations, monthly survey will be undertaken for a period of six months with further surveys undertaken on a six month basis until the site is considered have returned to its former regime. Figure 11 shows the proposed bathymetric survey area.

4.11 Sand Placement Management Plan

A Sand Placement Management Plan will be prepared for the dredging contractor to ensure that the placement operation is carried out in accordance with the assessment. The placement site will be divided into a grid with a series of cells, approximately 100m x 100m. Sand placement will occur cell by cell in longitudinal strips parallel with the tidal flow.

Environmental mitigation measures will also be contained within the plan as will monitoring requirements.

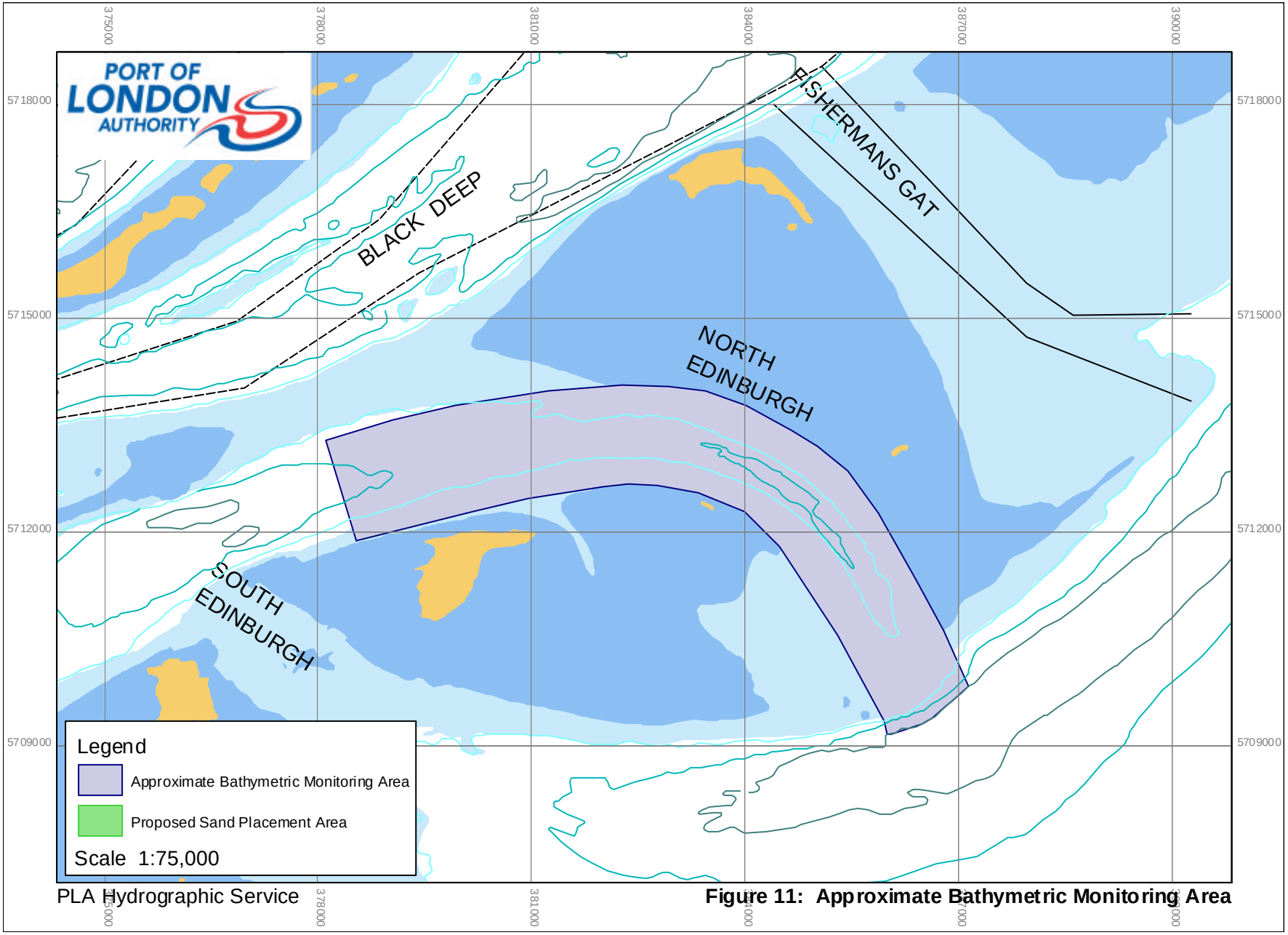


Figure 11: Approximate Bathymetric Monitoring Area

5 SEDIMENT QUALITY

This section discusses the quality of seabed sediment in the proposed placement site in the North Edinburgh channel and considers the impacts on sediment quality of introducing sediment from Princes Channel. Effects on water quality from the placement operation are considered in Section 6.

5.1 Existing Environment

The North Edinburgh Channel forms part of the dynamic system of channels and sandbanks in this part of the Outer Thames Estuary. The proposed placement site is 18km from the nearest coast and therefore is unlikely to be affected by anthropogenic inputs of contaminants, for example there are no long sea outfalls in the vicinity. Present day inputs may include waste from commercial and recreational vessels.

Historically, a waste disposal site was located in the Black Deep, approximately 9km to the north east of the placement site. Dredged material from the River Thames and its dock system (both capital and maintenance), and sewage sludge was placed at this site until its closure in the late 1960s (CEFAS, 1994, O'Donnell, 1976). In addition, a sewage sludge site was located in the Barrow Deep, approximately 12km to the north of the North Edinburgh Channel. This site received sewage sludge from 1967 to the late 1990s when the disposal of sewage sludge at sea was banned (CEFAS, 1994). As part of the monitoring of licensed disposal sites, CEFAS undertook a sediment sampling survey in 1992. This survey covered a wide area slightly to the north of the North Edinburgh Channel and found that the heavy metals associated with sewage sludge disposal had dispersed away for the disposal site to form part of the background load of metals in the sediments in the Thames Estuary (CEFAS, 1994). The metals data is summarised in Table 6. A survey of marine derived litter was carried out by CEFAS in 1992-3 and found that the sewage sludge sites in the Thames Estuary were in the top three most contaminated sites (CEFAS, 1994).

Table 6 CEFAS 1992 Sediment Quality Data

PARAMETER*	MINIMUM CONCENTRATION ($mgkg^{-1}$)	MAXIMUM CONCENTRATION ($mgkg^{-1}$)	MEAN CONCENTRATION ($mgkg^{-1}$)
Lead	26	104	51.5
Zinc	78	225	126.3
Copper	25	107	45.6
Mercury	0.08	2.4	0.29

*Samples were taken from 48 locations.

As part of the baseline studies to characterise the North Edinburgh placement site, a sediment quality survey was undertaken (during the marine biological survey).

Sediments were taken from sites within the North Edinburgh Channel and at sites across a wider area. Only one of these sites is comparable with the earlier CEFAS samples. The samples were collected from surface sediments using a grab sampler and were analysed for a suite of parameters previously agreed with CEFAS and the EA (see Appendix D). The parameters included metals, organics and microbiological parameters, and were analysed in recognition of the status of the Thames estuary as designated Shellfish Waters. Particle size analysis (PSA) was also carried out. A summary of the sediment quality data is provided in Table 7 and the full report is available as Appendix E on the accompanying CD-ROM.

In addition, as part of the FEPA application, samples were collected from the North Edinburgh and Princes Channel and analysed by CEFAS but the results are not yet available from CEFAS.

Table 7 Sediment Quality in the North Edinburgh Channel and Adjacent Areas

PARAMETER*	MINIMUM CONCENTRATION ($mgkg^{-1}$ dry wt)	MAXIMUM CONCENTRATION ($mgkg^{-1}$ dry wt)	MEAN CONCENTRATION ($mgkg^{-1}$ dry wt)
Lead (16 sites)	1	75	18.5
Zinc (16 sites)	6	160	44.4
Copper (4 sites)	2	5	3.5
Mercury	All below detection limit of $0.13mgkg^{-1}$		
Arsenic (16 sites)	4	73	23.7
Cadmium	All below detection limit of $0.7mgkg^{-1}$		
Nickel (16 sites)	2	56	10.4
Chromium	5	150	28
Silver (13 sites)	0	45	10.2
Tributyl Tin	One conc. of 40 μgkg^{-1}. Others below detection limit of $<10\mu gkg^{-1}$		
PAHs	All below detection limits (see Appendix E).		
PCBs	All below detection limits (see Appendix E).		
Pesticides	All below detection limits (see Appendix E).		

*Samples were taken from 22 locations – where below detection limit or no value, average has been taken over remaining sites. Detection limits were set in accordance with Canadian ISQG values. Results are corrected for % organic carbon.

Particle size analysis carried out for each sample classifies the great majority of the samples as sand. Figure 8 shows the sediment characteristics across the survey area.

5.1.1 Sediment Quality Assessment

Currently, there are no published national guidelines for marine sediment quality. CEFAS (who are responsible for providing scientific advice to Defra on the sea disposal of dredged material) have internal guidelines for evaluating the results of sediment contamination testing. These internal CEFAS guidelines comprise two Action Levels

(AL), which are used as part of a weight-of-evidence approach to assessment on a case by case basis. In general terms, however, if contamination levels are below AL 1 then the materials are likely to be considered chemically 'clean'. Between AL 1 and 2, further testing may be required to identify any management techniques which may be required before sea disposal can be authorised and at levels above AL2, material may be considered too contaminated for sea disposal or require specialised dredging/disposal techniques.

An alternative or additional approach to assessing sediment quality is the use of the Interim Sediment Quality Guidelines (ISQGs) for the protection of marine aquatic ecosystems. The ISQGs have been acknowledged by English Nature as being appropriate for use in the UK given the lack of national standards. The ISQGs comprise two levels, the first (and lower level) being the ISQG, the level below which no effects would be expected on marine aquatic life. The second level is the Probable Effects Level (PEL) and sediments containing contamination at this level would be expected to cause effects in 50% of organisms. Between the two levels further assessment would be necessary to identify any necessary management actions in the same way as for CEFAS' Action Levels. As CEFAS Action Levels are unpublished and are based on wet weights, ISQG levels have been used as the first assessment in this report.

Metals

The sediment quality analysis demonstrated a variation between levels of metals that were at or below detection limits and levels that are above ISQG and PEL levels. Of particular note are the levels of arsenic, which are elevated above the ISQG at the majority of sites while levels at four sites are above the PEL. The maximum concentration of 75mgkg^{-1} is significantly greater than the PEL of 41.6mgkg^{-1}. Levels of lead and zinc at some sites are also elevated with concentrations between ISQG and PEL levels. Although arsenic was not analysed in the CEFAS survey in 1992, the lead and zinc levels are comparable with those recorded from that survey. This suggests that the previous use of the Black Deep and Barrow Deep disposal sites continues to effect sediments in the outer Thames Estuary.

There are no obvious spatial distribution patterns within the sample locations and the samples are representative of surface sediments only. However, the sediment is fine sand which has been observed to move considerably over relatively short periods and so there is the possibility for release by redistribution of older more contaminated material (PLA survey data, 2004). Elevated sediment concentrations are found in samples both in deeper water and on the drying banks leaving no indication of any distribution associated with dominant water movements.

Further, there is no clear association of elevated levels of contaminants with those samples with a higher fines content, for example, the highest zinc level is recorded at sample location 5 which comprises almost 100% sand. Site 5 also has high arsenic, chromium and nickel, although these elevated levels are in part a product of the standardisation technique applied to the data i.e. the low organic carbon levels at the site.

Tributyl Tin
The results for tributyl tin (a biocide and component of antifouling paints that is presently being phased out of use) showed that, with the exception of one sample, the levels in all samples were below the detection limit of 10µgkg^{-1}. TBT was recorded at site 7 with a level of 40µgkg^{-1}, but this was below the relevant guideline level and CEFAS advised that this isolated peak was not considered significant (EMU, 2004).

Non-Metallic Parameters
The majority of non-metallic parameters analysed for during the survey were found to be below the detection limit and therefore below the ISGC thresholds and CEFAS Action Levels. These included all pesticides and organic compounds with the exception of Total Petroleum Hydrocarbons (TPH) (EMU, 2004). Although TPH was recorded, levels were considered very low across the area and well below the CEFAS Action Level.

Microbiological Parameters
Neither faecal Coliforms nor faecal Streptococci were detected across the study area. Clostridum perfringens was detected but levels were found to be low compared to other benthic surveys carried out in the vicinity of North Edinburgh Channel some of which surveys were specifically associated with sewage discharge (EMU, 2004).

5.2 Change in Sediment Quality in North Edinburgh Channel

5.2.1 Impact Description

The sediment quality in the North Edinburgh Channel reflects an area that has, in the past, been subject to inputs of anthropogenic contamination with levels of trace metals being elevated compared to natural background for an area such as the Thames Estuary (with no mineralisation or geological inputs). In order to ascertain the effects on sediment quality from the introduction of sand from Princes Channel, a detailed survey of sediment quality in Princes Channel was undertaken. A previous survey of sediment quality has found elevated levels of some metals in Princes Channel seabed sediments but no organic contamination. This survey was not considered to reflect the current situation given the Phase I dredge has been completed and the Phase II dredge will cover an increased area and depth.

The sediment quality survey comprised 43 vibrocores on three transects spaced 300m x 175m across the channel. Figure 12 shows the distribution of the vibrocores and the data is contained in Appendix F on the accompanying CD-ROM. Vibrocores were sunk to a depth of more than 4m, well below the maximum dredge level of 2m. At a representative selection of sites samples were taken from the surface sediments and at various depths throughout the sediment column and analysed for a suite of trace metals, organics, TBT

and microbiological parameters. The samples were divided into three groups; those provided to CEFAS for analysis, those analysed for all parameters (Suite A) and those analysed for metals only but at 0.5.m intervals throughout the sediment column (Suite B) Each sample was also analysed for particle size.

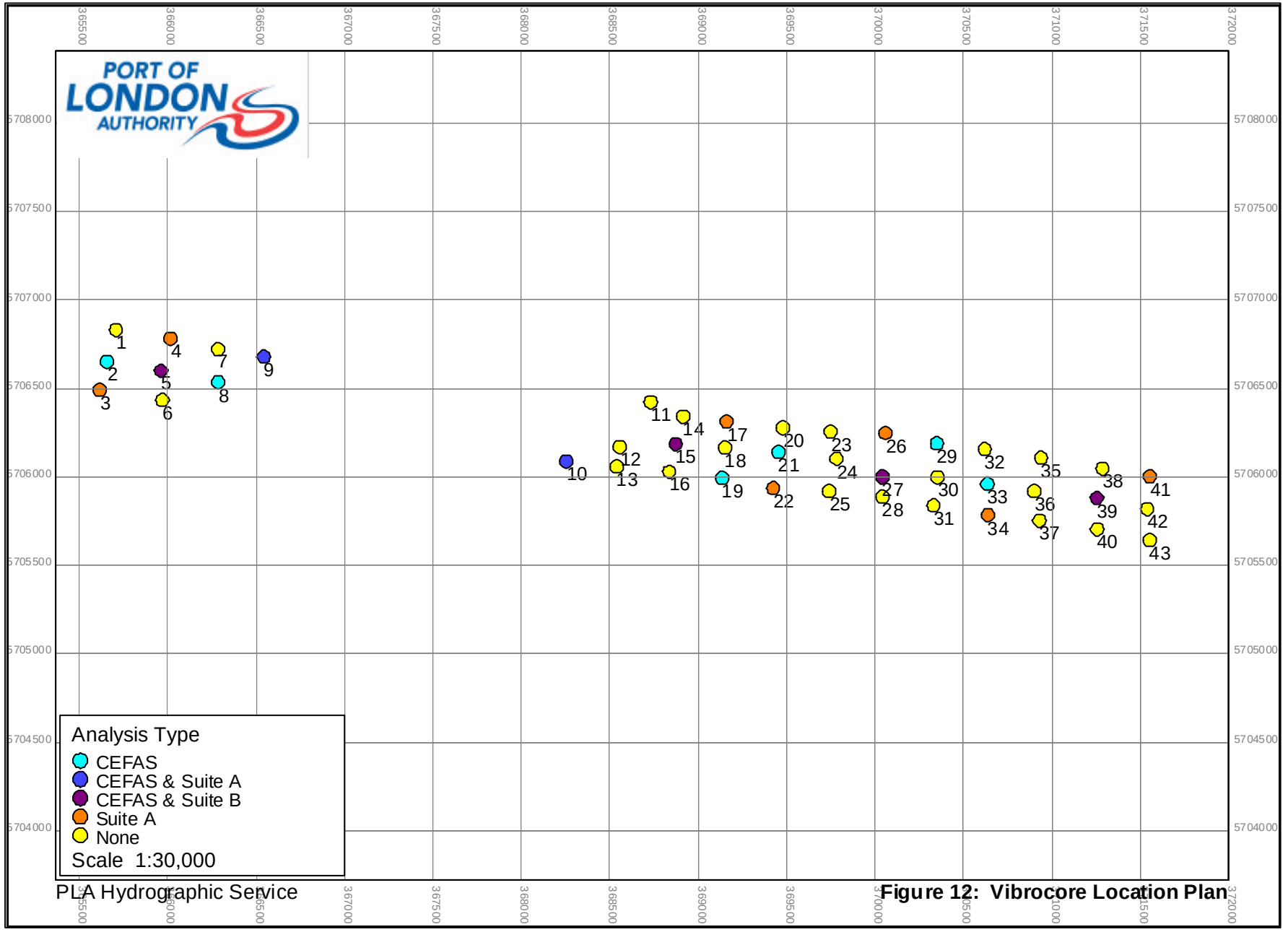


Figure 12: Vibrocore Location Plan

As with the samples from the North Edinburgh Channel, the Canadian ISQG levels were used as a guide to sediment quality. Analytical detection limits were set in accordance with these levels.

Microbiological Parameters

Samples were analysed for Clostridia, E Coli, faecal Streptococci and total coliforms. No microbiological parameters were recorded at any of the stations in either surface samples or at depths in the sediment column. The results from the Princes channel and North Edinburgh Channel are very similar with the exception that *Clostridium perfringens* was recorded at two sites in the North Edinburgh Channel at values slightly above the detection limit used for the Princes Channel analysis. It is considered that the proposed placement operation will have **no change** on the microbiological quality of the North Edinburgh channel.

Non-Metallic Parameters

As was found in the earlier survey, levels of organic parameters (PCBs, PAHs and pesticides) were very low with almost all parameters of concern undetectable. The full dataset can be found in Appendix F on the accompanying CD-ROM. The sediment in the North Edinburgh Channel also contains undetectable levels of organic parameters. It is therefore considered that there will be **no change** in the levels of organic parameters resulting from the placement of sand from Princes Channel at the proposed placement site in the North Edinburgh Channel.

Tributyl Tin

For the large majority of samples, TBT levels were found to be below the detection limit of 1 μgkg^{-1}. TBT was recorded at a small number of samples but the levels were significantly below CEFAS Action Level of 100μgkg^{-1} (there is no ISGQ level for TBT). The TBT levels are comparable with the levels of TBT recorded in the North Edinburgh Channel and it is therefore considered that there will be **no change** in the levels of TBT resulting from the placement of sand from Princes Channel at the proposed placement site in the North Edinburgh Channel.

Trace Metals

The metals data demonstrates the sediment quality throughout the Princes Channel area, both surface and through the sediment column is good with levels at or below the precautionary ISQG level. Table 8 provides a summary of the metals data for surface sediments.

Table 8 Metal Levels in Princes Channel Surface Sediments

PARAMETER	MINIMUM CONCENTRATION ($mgkg^{-1}$ dry wt)	MAXIMUM CONCENTRATION ($mgkg^{-1}$ dry wt)
Arsenic	7.1	36.7
Cadmium	<0.1	<0.1
Chromium	9.7	15
Lead	3.3	18
Mercury	<0.1	<0.1
Copper	1.2	5.8
Nickel	23.3	27.3
Zinc	8.8	29.5
Silver	<0.1	<0.1

There are two exceptions to the general low levels noted above; as follows:

1. Arsenic levels are considered slightly elevated at most sites in surface samples. The concentrations decrease with depth to what could be described as background at depths of greater than 2.5m (~4.5$mgkg^{-1}$). Although slightly elevated above the ISQG, the majority of concentrations are well below the relevant PEL value of 41.6 $mgkg^{-1}$ with a mean concentration of 11.4 $mgkg^{-1}$.

   At five sites (comprising six samples) concentrations of arsenic of more than 25$mgkg^{-1}$ have been recorded. Figure 13 shows the sites and the arsenic concentrations. In all but one of the sites the arsenic is contained in the first 60cm of sediment. The exception is site 3 where arsenic increases with depth from 17.3 $mgkg^{-1}$ at the surface to 26 $mgkg^{-1}$ at approximately 2m depth. A review of the associated particle size data indicates that there is no correlation between the higher levels and the finer sediments. In fact, the reverse appears to be the case with the coarser samples containing the higher arsenic levels. The unpublished CEFAS Action Levels for disposal of dredged material at sea are 10$mgkg^{-1}$ (AL1) and 25-50$mgkg^{-1}$ (AL2) (CEFAS, 2000). These levels are wet weight and using 50% as an approximate conversion to dry weight gives 20$mgkg^{-1}$ (AL1) and 50-100$mgkg^{-1}$ (AL2). Given that the arsenic concentrations for the majority of the samples are below AL1, these few elevated levels are not considered significant.

2. Site 39 (see Figure 12) shows a slight elevation of chromium, nickel, zinc and cadmium relative to all the other sites. Whilst the difference is of interest, the concentrations remain below their relevant ISQG levels.

In general the metals content in the North Edinburgh Channel sediments are significantly higher than the concentrations in Princes Channel. Table 9 compares the maximum and mean concentrations for each metal. Given that the particle size data suggests that the seabed sediments are physically similar, it is likely that the difference relates to the relative proximity of North Edinburgh Channel to the disused sewage sludge disposal sites.

Table 9 Comparison of Summary Metals data for Princes and North Edinburgh Channels

PARAMETER	MINIMUM CONC ($mgkg^{-1}$ dry wt) NORTH EDINBURGH	MINIMUM CONC ($mgkg^{-1}$ dry wt) PRINCES CHANNEL	MAXIMUM CONC ($mgkg^{-1}$ dry wt) NORTH EDINBURGH	MAXIMUM CONC ($mgkg^{-1}$ dry wt) PRINCES CHANNEL
Arsenic	4	7.1	73	36.7
Cadmium	<0.7	<0.1	<0.7	<0.1
Chromium	5	9.7	150	15
Lead	1	3.3	75	18
Mercury	<0.13	<0.1	<0.13	<0.1
Copper	2	1.2	5	5.8
Nickel	2	23.3	56	27.3
Zinc	6	8.8	160	29.5
Silver	0	<0.1	45	<0.1

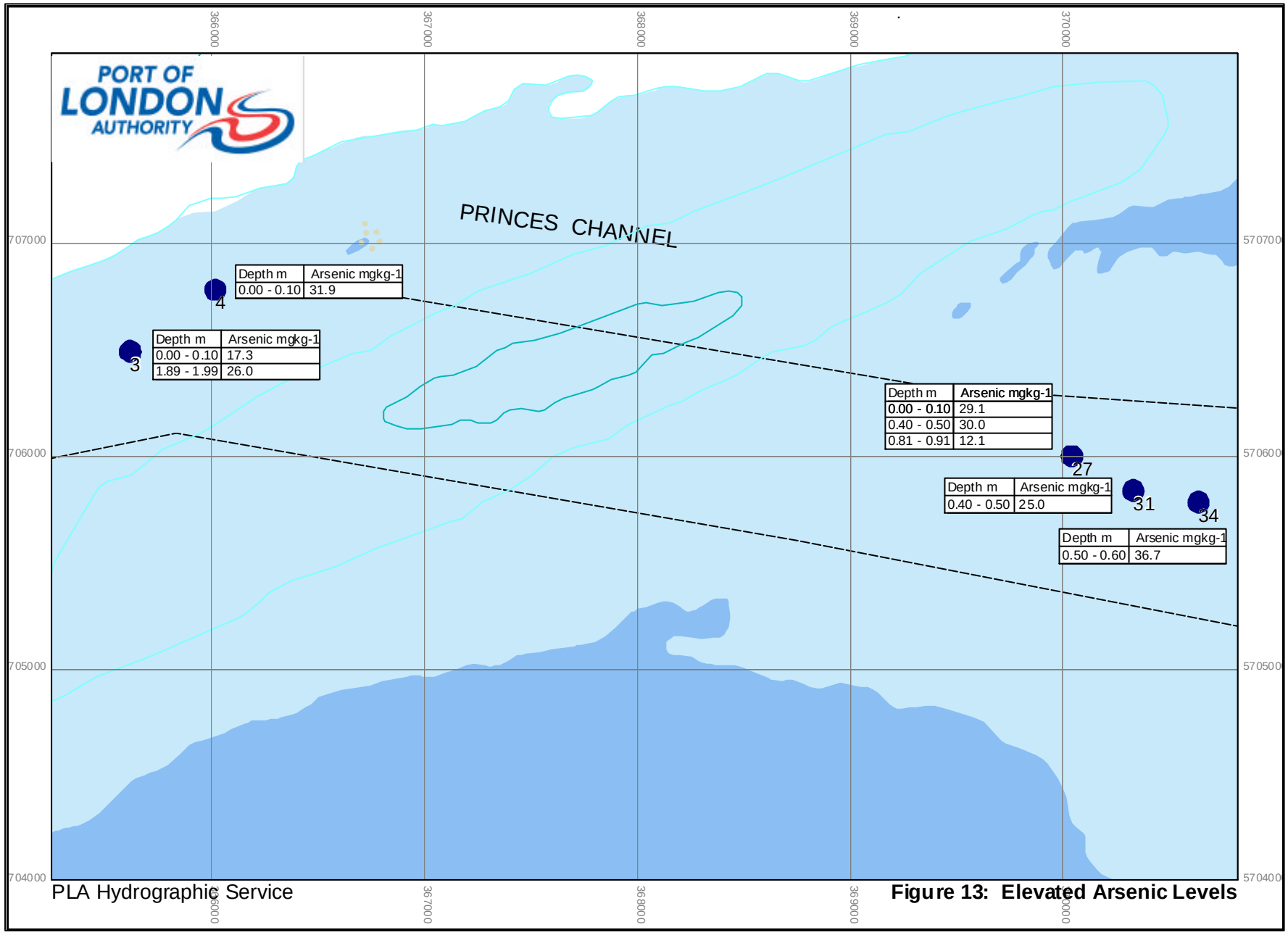
The placement of sand from Princes Channel into the North Edinburgh Channel will have the effect of improving sediment quality at the placement site. This improvement is considered to be of **minor beneficial significance**.

5.2.2 Mitigation

No mitigation is required

5.2.3 Residual Impact

The residual impact for change in sediment quality at the North Edinburgh Channel placement site is **minor beneficial significance**.



PLA Hydrographic Service

Figure 13: Elevated Arsenic Levels

5.3 Summary of Potential Impacts

Table 10 summarises the predicted potential impacts, any mitigation measures and the residual impact.

Table 10 Summary of Potential Impacts on Sediment Quality

IMPACT TITLE	SIGNIFICANCE LEVEL	MITIGATION	RESIDUAL IMPACT
Change in sediment quality in North Edinburgh Channel	Microbiology: no change Non-Metallic: no change TBT: no change Trace Metals: minor beneficial	None required	**None** **None** **None** **Minor beneficial**

No cumulative impacts are on sediment quality are predicted.

6 WATER QUALITY

This section considers the impacts of the placement operation on water quality.

6.1 Existing Environment

The outer Thames Estuary is designated as Shellfish Waters under the SWD. The SWD sets water quality standards for a range of parameters including metals, microbiological contaminants and chemicophysical parameters such as List I and List II substances, dissolved oxygen (DO) and suspended solids (SS). The EA monitors the quality of the Shellfish Waters at one or more fixed monitoring points. Nowhere in the vicinity of the North Edinburgh Channel has been selected for monitoring. The levels of the majority of List I and List II substances are below their relevant EQS levels, but the EA monitoring at inner estuary sites has found exceedences for some parameters including TBT, copper and zinc. These exceedences are likely to be due to the proximity of the sampling point to a fixed source, for example, an outfall.

To some extent, the quality of the surface sediments is an indication of the quality of the overlying waters as these waters are the main pathway of contaminants into the sediment. The sediment quality analysis in both the area to be dredged and the North Edinburgh Channel did not identify significant levels of contamination in the sediment (with the exception of arsenic) and thus it would be reasonable to assume that the water quality in the outer Thames Estuary is similarly acceptable.

Water sampling was undertaken prior to and during the Phase I dredge in Princes Channel and suggested that background suspended solids levels (1m above the bed) vary between approximately $30mgl^{-1}$ to approximately $100mg^{-1}$. These levels were representative of background conditions during a quiet period with little or no storm activity. Dissolved oxygen levels were generally above $10mgl^{-1}$. Given that the North Edinburgh Channel is relatively close to Princes Channel, this data is likely to be representative of the general area, although, with the addition of the mobile sand and the channel movements recorded on the hydrographic survey it is likely that the lower water column in the North Edinburgh Channel may be subject to periods with significantly greater concentrations of suspended solids.

6.2 Increase in Suspended Sediment in the Water Column

The Dredging Process model developed by DRL has shown that the fines content of the material in the hopper will be in the region of 5.5 to 8.5%, depending on dredger size. This material will be mixed with the coarser sediment and will fall through the water column as part of the dynamic plume. It is estimated that approximately 3% of the hopper total load of dredged material is released into the water column as the material falls to the seabed. This material will be a mixture of both coarser and fine sediment. However, the material will enter the water column at a depth of between 6-10m below the

water surface thus limiting the potential for any effects in the first 10m of the water column. The material lost to the water column will spread laterally and move in the direction of the tide as it continues to fall. Assuming an average hopper capacity of 6,000m^3, approximately 10 to 15m^3 of fines would move into the surrounding water. This quantity can be compared with the figure of around 8,000m^3 of residual movement in the North Edinburgh Channel on each tide and a considerably larger figure for absolute movement. With the three hour round trip between the placement site and the dredged area, it is predicted that any temporary increase in suspended sediment at depth in the water column will be well within background levels before the next placement operation. As a result, **no impacts** on water quality from increases in suspended solids are predicted.

6.3 Input of Contaminants to the Water Column

The sediment quality survey found that levels of all contaminants in the material to be dredged are below guideline values for disposal at sea. These values are established to consider effects on the water column as a result of the disposal process. Given the low levels of contaminants, the limited fines content of the dredged material and the wide dilution of the Outer Thames Estuary there is **no risk** of input contaminants to the water column. Mobilisation of the existing bed material, with its higher levels of certain trace metals, during each tidal cycle has more potential to input contaminants into the water column. It is therefore not considered necessary to undertake any further investigation into losses of contaminants.

6.4 Input of Microbiological Parameters to the Water Column

There are no microbiological contaminants in the material to be placed in the North Edinburgh Channel site and there is, therefore, **no risk** of such contaminants being lost to the water column.

6.5 Decrease in Dissolved Oxygen Levels

Monitoring of a number of different types of dredging operations on the Thames (including Phase I of the Princes Channel Development) has indicated that there is no effect on dissolved oxygen levels as a result of dredging. The material to be deposited has low organic content and, therefore, a low biochemical oxygen demand. There will no measurable lateral plume from the placement operation. **No impact** on dissolved oxygen levels is predicted.

6.6 Summary of Impacts

No impacts are predicted on water quality as a result of the proposed placement operation.

6.7 Monitoring

As no impacts are predicted, no monitoring is proposed in this offshore area.

7 MARINE BIOLOGY

This section describes the ecological quality of the proposed placement site and the surrounding area and considers the impacts of the placement operation on the ecology.

7.1 Existing Environment

A marine biological survey was carried out in early October 2003 to provide information of the numbers and types of species within the North Edinburgh Channel and surrounding area. The design of the survey was informed by the results of previous marine biological surveys undertaken in Princes Channel and for the proposed London Gateway Development. These previous surveys also provided information on seasonality as they covered differing times of the year. The survey comprised the collection of seabed material using Mini-Hamon and Shipek grab samples from 22 stations including two reference sites located beyond the limits of the tidal excursion. Replicates were collected from a number of sites to provide a total of 142 samples for analysis. Otter trawl tows were also carried out to assess the epifaunal communities and demersal fish within the survey area. The survey design and sampling locations were agreed in advance with CEFAS and the Environment Agency. The survey area and sample locations are shown on Figure 14. A detailed description of the survey methodology can be found in Appendix G on the accompanying CD-ROM.

7.1.1 Macrobenthic Conditions

A total of 109 species were recorded during the survey with only three of these being represented by sessile epifaunal taxa. The benthic macrofauna of the Edinburgh Channel survey area may be regarded as relatively typical of shallow water, gravely sand and silty sand substrates around the UK and particularly of the North Sea. The top ranking macrobenthic species recorded from the grab samples included species that are amongst the 30 most frequently recorded species in the North Sea as identified by Heip & Craeymeersch, 1995; including *Spiophanes bombyx, Scoloplos armiger, Goniada maculate, Mysella bidenta, Bathyporeia elegans, Magelona johnstoni .and Notomastus latericeus* (EMU, 2004). Species identified across the area comprised a mixture of sand-dwellers such as the polychaetes *Nephtys cirrosa* (and other Nephtyidea species), *Ophelia borealis, Urothoes* species and *Bathyporeia* species, and those species indicative of relatively stable substrate affected by mobile sediments such as the Sand Mason worm *Lanice conchilega.*

The Ross Worm *Sabellaria spinulosa* was recorded from the survey area but only occurred at 2 sites (samples locations 1 and 13). Numbers were extremely low and are not indicative of reef formations (EMU, 2004). *S. spinulosa* is naturally common around the British Isles with a wide distribution and in the majority of its range it does not form reefs but it mostly solitary living attached to small pebbles etc. No rare or protected macrobenthic species were noted during this study (EMU, 2004).

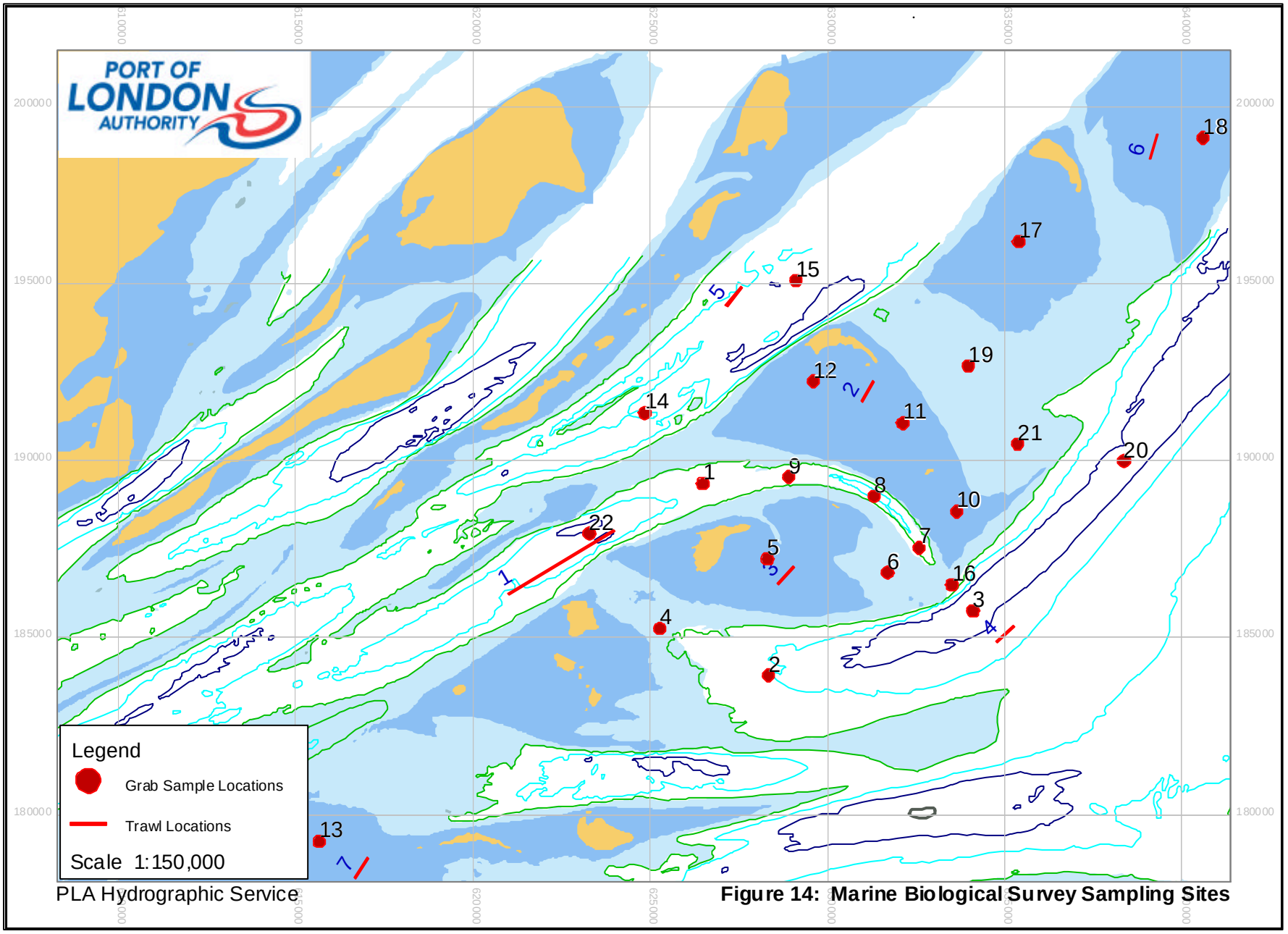


Figure 14: Marine Biological Survey Sampling Sites

The similarity analysis of the macrobenthic data identified three main sample groupings (Clusters A and B and C) which exhibited biological differences. However, given that all three clusters supported a number of similar species, it would be more appropriate to describe these groupings as local faunal/sediment associations, rather than distinct communities (EMU, 2004).

Cluster A represented a patchy, gravely sand association, characterised by a relatively diverse macrobenthic community with high biomass. This Cluster contrasted with the more impoverished, mobile sand association of Cluster C, where the numbers of species, abundance and biomass were all low in comparison. Cluster B was indicative of a highly patchy silt and sand community with gravel influences, where the number of species was high in comparison to the clean mobile sand, but the abundance and biomass of these species was low suggesting the seabed environment was mobile in nature. The identity of dominant species within all clusters are recognised as mobile sand tolerant species (EMU, 2004).

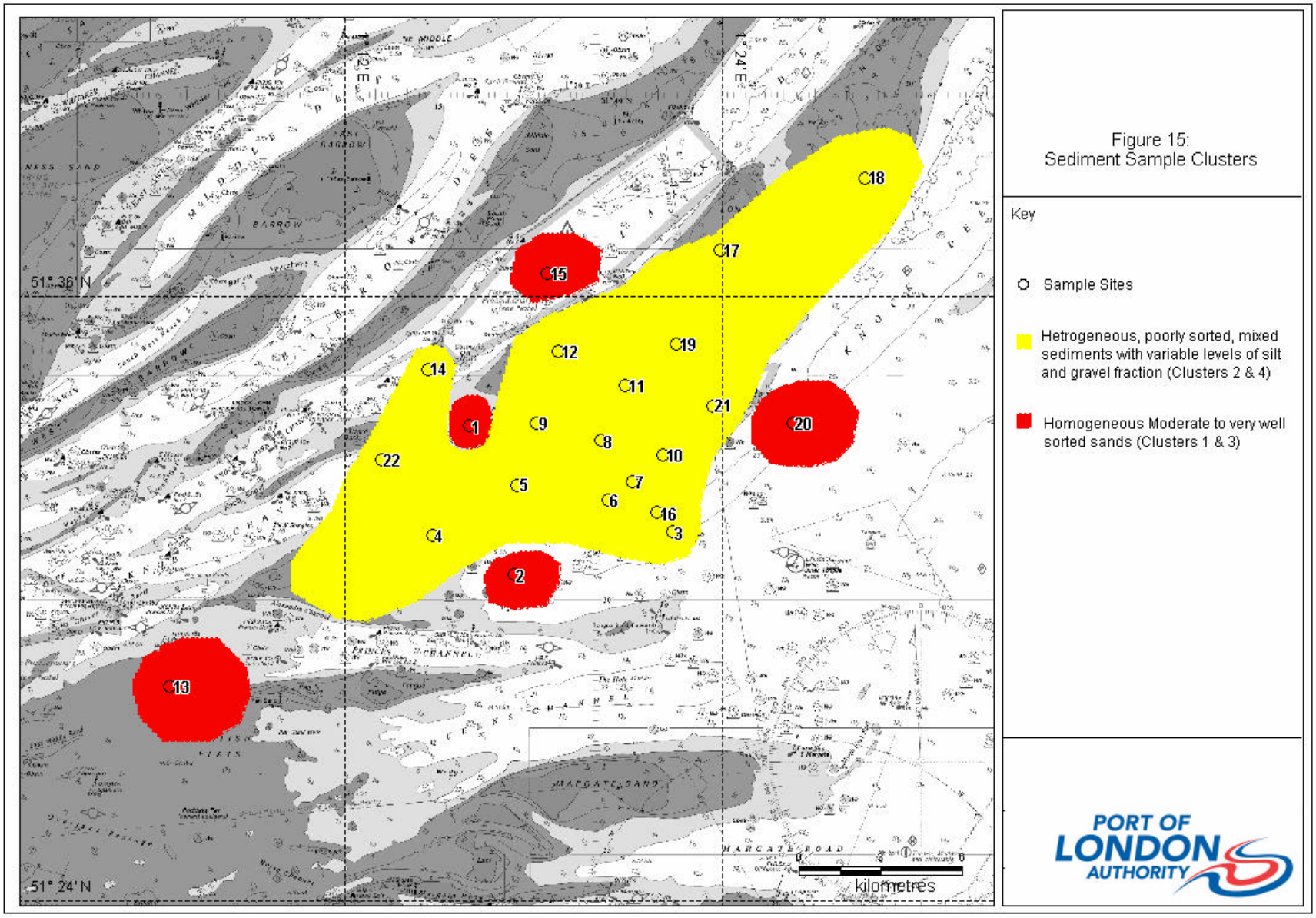
The seabed at the proposed sand placement site formed part of Cluster C, impoverished mobile sand (see Figure 15). However, sample 1 located outside the western end of the proposed site was identified as Cluster A, with its higher diversity and biomass associated with a gravely sand seabed.

7.1.2 Epifaunal Species

Fauna caught within the Otter trawls were broadly characteristic of the estuarine assemblage described by Rees *et al* (1999). The Otter trawl exercises revealed a number of other species that are capable of surviving the rigours of mobile sand banks in the survey area. These included larger epibenthic species, such as brown shrimps, hermit crabs and other crab species. These types of species may possibly avoid the compaction forces of the mobile sand sediments by living in the sediment surface rather than within the substrate (EMU, 20040.

Epibenthic species, which live on the seabed surface, were relatively typical of the estuarine and east coast gravely assemblages described by Rees et al (1999) and a reflection of the habitats evident from the grab samples within the vicinity of each trawl line. Generally, these assemblages were characterised by the brown shrimp, *Crangon crangon*, sessile epifauna, *Electra pilosa* (seamat). Hydroid turf (sea firs), hermit crabs (Paguridae), *Macropodia* spp, *Alcyonium diaphinum*, *Vesiculosa spinosa*, *Hydrallmania falcate*, *Flustra foliacea* and Gobies (Gobiidae spp.). This type of assemblage has been previously recorded from the Thames Estuary area and is considered typical for the region (EMU, 2004). Other epifaunal species, which are characteristic of the study area, included the swimming crab *Liocarcinus depurator* and the hydroid *Obelia bidenta.*

A detailed description of the ecological conditions in the survey area is contained in Appendix G on the accompanying CD-ROM.


51° 36' N
51° 24' N
2° 18' E
2° 24' E
18
17
15
12
19
14
11
21
20
1
9
8
10
22
5
7
6
16
3
4
2
13
kilometres
Figure 15:
Sediment Sample Clusters
Key
Sample Sites
Hetrogeneous, poorly sorted, mixed sediments with variable levels of silt and gravel fraction (Clusters 2 & 4)
Homogeneous Moderate to very well sorted sands (Clusters 1 & 3)
PORT OF LONDON AUTHORITY

7.2 Change to Seabed Habitat

7.2.1 Impact Description

The seabed habitat in the vicinity of the disposal site is described as impoverished mobile sand with both infauna and epifauna characteristic of this type of habitat in the North Sea. The placement operation will result in a layer of mobile fine sand upon the existing mobile fine sand layer thus providing the same habitat to the species in the area. Dispersion of sand from the site will occur in the same manner as the present situation and local areas of accumulation outside of the placement site are not predicted. It is considered that there will be no change to the seabed habitat following the sand placement operation.

The presence of the more biologically diverse pocket of heterogeneous sand adjacent to the western boundary of the site cannot be easily explained as the particle size data indicates the sediment is the same as that found in immediately adjacent areas. Further, the area is subjected to the same tidal current and wave actions.

It is considered that placement of sand on this biologically diverse area would be of **moderate adverse significance**.

7.2.2 Mitigation

Direct impacts on the more diverse area will be avoided and the sand placement will take place at a minimum distance of 100m from the area. The existence of this localised diverse site will be noted in the Sand Placement Management Plan.

7.2.3 Residual Impact

The residual impact is considered to be of **minor adverse significance** due to the proximity of the area to the western boundary of the placement area.

7.3 Smothering of Epibenthos and Epifauna

Epibenthos and epifauna living on or within the sand in the North Edinburgh placement site will be smothered during the sand placement operation. Placement will occur for one minute, once every three hours and will affect only a small area of the placement site on each occasion. It is unlikely that species will be able to form escape tunnels through the 1.5m of sand although movement may be possible through the sides of the mound.

As the seabed habitat will not be changed by the operation, it is considered that epifauna and epibenthos will quickly recolonise each mound by moving from adjacent areas. The initial smothering of species is considered of **minor adverse significance** due to the impoverished nature of the habitat, the small area affected on each occasion and the short term duration of the effect.

7.3.1 Mitigation

It is not considered possible to mitigate for this impact.

7.3.2 Residual Impact

The residual impact of smothering epibenthos is of **minor adverse significance**.

7.4 Impact to Protected Species

No rare or protected species were recorded during the survey. The Ross Worm was observed in extremely low numbers at only two sites, one of which was on the Long Sand to the north east of the placement site and the other is located just outside the western boundary of the placement site. The findings are not considered indicative of reef formations but represent the common distribution of the Ross Worm. **No impacts** are predicted to rare or protected species.

7.5 South Falls Disposal Site

There is no available information on the marine biology of the South Falls site, however, as it is on a more stable seabed it may be expected to have a higher species diversity than the North Edinburgh Channel. Species diversity, abundance and biomass may be affected, to some extent, by the disposal activities but the site is not subject to a high degree of usage and such activities may provide crevices and other habitats. The placement of 2.5Mm^3 of sand at the South Falls sites would blanket the existing habitats and smother species that may not be adapted to living in mobile sand conditions. However, the site is a recognised disposal area and such impacts within the site may be considered acceptable.

7.6 Summary of Predicted Impacts

Table 11 summaries the predicted potential impacts, any mitigation measures and the residual impact.

Table 11 Summary of Potential Impacts on Marine Biology

IMPACT TITLE	SIGNIFICANCE LEVEL	MITIGATION	RESIDUAL IMPACT	COMMENTS
Change in Seabed habitat	Moderate Adverse	Avoid biologically diverse area.	**Minor Adverse**	Applies only to 1 localised site
Smothering of Epibenthos/Epifauna	Minor Adverse	None	**Minor Adverse**	-
Impact to Protected Species	None	None Required	**None**	-

Given that the residual impacts of all impacts are considered to be minor adverse, no significant cumulative effects from the individual impacts are predicted.

7.7 Monitoring

As agreed with the Environment Agency, a repeat marine biological survey will be undertaken on completion of the placement operations to assess any changes in the study area. The survey design and specification will be based on the existing survey and details will be agreed with the Environment Agency and CEFAS in due course.

8 NATURAL FISHERIES AND MARINE MAMMALS

This section describes the fisheries and mammal interest within the study area and considers the potential effects of the proposed placement operation.

8.1 Existing Environment

The Thames Estuary is recognised for its important for both shellfish and other fish species. The shallow waters provide nursery grounds for species such as bass, herring and sole while the banks host cockles and oysters. The Estuary is an important area for spawning sole and there is a localised herring spawning ground. Other commercial species such as cod, sprat and whiting are also found.

8.1.1 Fish

As part of the marine biological survey, a beam trawl was used to provided an idea of fish species present in the area at the time (early October, 2003). The beam trawl identified 20 fish species within the study area, nine of which may be considered commercially important fin fish. These are herring, sprat, whiting, dab, Dover sole, sand eels, thornback ray, bass and brill (EMU, 2004).

Herring and sprat were the most abundant commercially exploitable fish within the study area. Notably, all individuals of herring caught were likely juveniles owing to the size range measured, indicating that the survey area and, in particular, the top of the sand bank features may serve as nursery areas for this species, although both these species have a widespread distribution (EMU, 2004).

The flat fish dab and Dover sole were among the most abundant commercially exploitable fish within the study area. This observation most likely reflects the importance of the wider Thames to flatfish. These species demonstrated a wide distribution throughout the survey area where they were noted in five out of the seven Otter trawls undertaken. Few (<10) individuals of sole caught were considered juveniles (<5cm). No juvenile dab were caught (EMU, 2004).

Other fish species commonly trawled from the survey area included Poor Cod, Pogge, Horse Mackerel, Bull Huss and Red Mullet. The current list of fish species is not exhaustive since many fish would appear in the outer Thames Estuary on a seasonal basis (EMU, 2004). Figure 16 shows the fish species found during the trawl survey.

A review of young fish data for 2003 found juvenile sole, plaice, dab, bass, flounder, five bearded rockling, thornback ray, solenette, goby, whiting, pogge, Nelson's pipefish and sprat. The majority of the sole were 2+ year group with relatively low number 0-Group fish. The juvenile sole were distributed throughout the estuary but with apparent concentration in the outer estuary and coastal waters, although accumulations were also

found in the inner estuary (CEFAS, 2004). The overall catches of juvenile fish decreased since 2002.

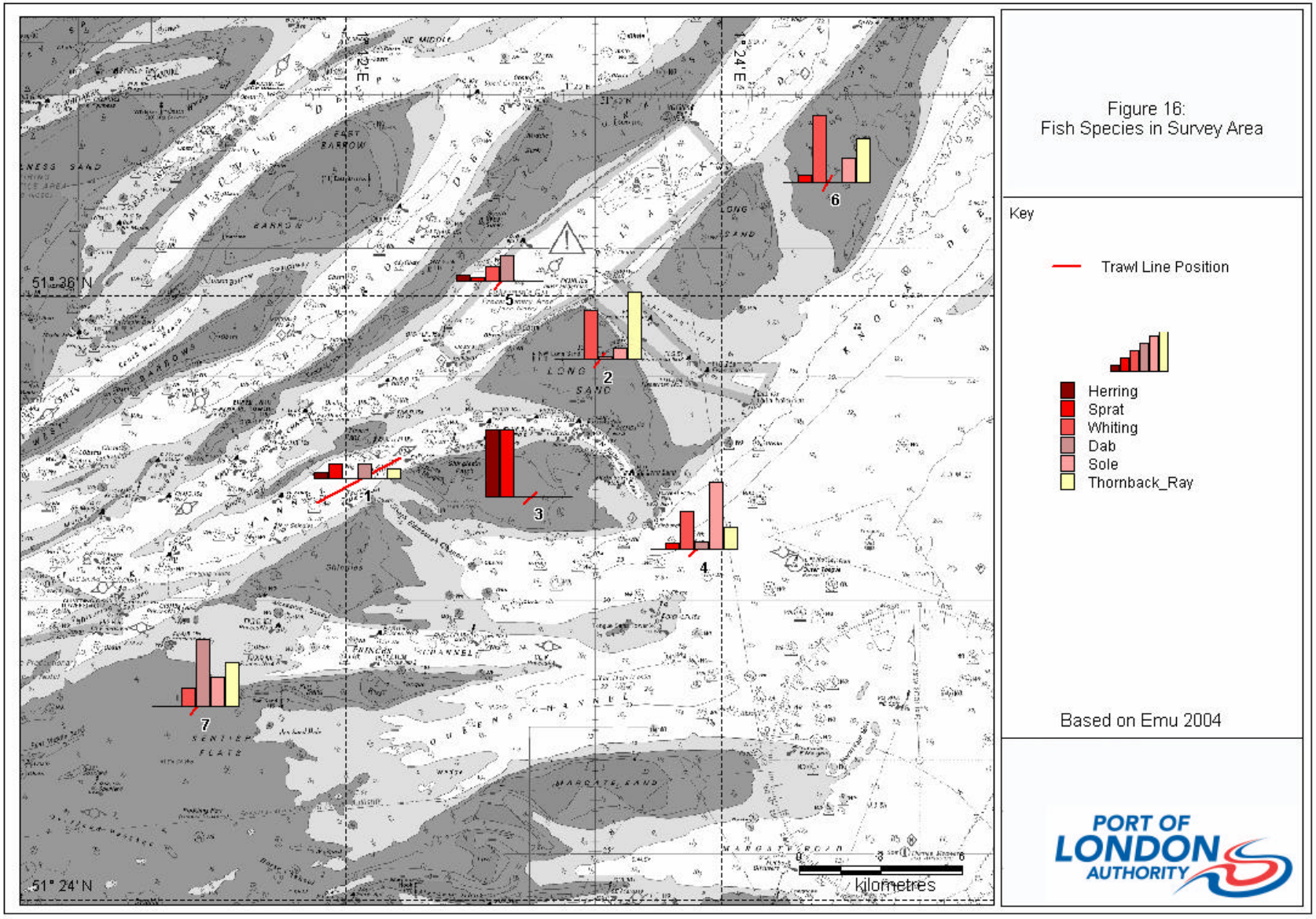


Figure 16:
Fish Species in Survey Area
Key
Trawl Line Position
Herring
Sprat
Whiting
Dab
Sole
Thornback_Ray
Based on Emu 2004
PORT OF LONDON AUTHORITY
51° 36' N
51° 24' N
2° 12' E
2° 24' E
kilometres
1
2
3
4
5
6
7

8.1.2 Shellfish

The Thames estuary cockle fishery is the largest in the UK. Shellfish beds are located on the intertidal flats and drying banks throughout the estuary. The location of the shellfish beds was a key factor in determining an appropriate sand placement site. The nearest shellfish beds to the North Edinburgh Channel are on the Sunk Sand approximately 8km to the north of the proposed placement site (these are described as frequently fished cockle grounds by KESFC); and on the West Shingles Bank, approximately 6km to the southwest of the proposed placement site (these beds are described as occasionally fished cockle grounds).

8.2 Smothering of Shellfish Beds

The North Edinburgh Channel was chosen due to its relative distance from any commercial shellfish beds. As discussed in Sections 4 (Coastal Processes) and 6 (Water Quality) the dredged material will enter the water column at between 6-10m depth. There will be no deposition in water depths of less than 12m. The deposited material will be entrained by the tidal currents in the same way as the present mobile seabed. Given this and the distance of the site for the shellfish beds, it is considered that there is no mechanism for large quantities of sand to smother the shellfish beds noted in Section 8.1.2. The potential impact on the shellfish beds is considered to be of **negligible significance**. Using the same basis of assessment, there is considered to be a negligible impact on cockle spat.

8.2.1 Mitigation

Mitigation has been built into the choice of the proposed placement site by avoiding areas adjacent to shellfish beds.

8.2.2 Residual Impacts

The residual impact on the shellfish beds is **negligible significance**.

8.3 Spawning Fish

The Thames Estuary is recognised as a spawning area for a number of fish species, of which sole is considered to be the most important. The PLA has made a commitment to manage the dredging of Princes Channel to avoid the sole spawning period of March to May, where possible. It therefore follows that placement operations are not likely to take place during this period. However, sole spawning is thought to be concentrated in the shallow coastal areas and it is considered unlikely that the placement operation, being in the deeper offshore part of the estuary, would have an adverse effect on spawning sole.

8.4 Nursery Area

Many species of fish use the outer Thames Estuary as a nursery area and the North Edinburgh Channel may form part of that area, although few juvenile fish were identified during the survey in early October. Juvenile fish would usually be found in the shallower waters over the banks and surface waters of the channel, therefore, direct effects from the placement operation would be unlikely. The site was chosen in consultation with KESFC who have not advised of any special importance for spawning fish or as a nursery area. Any juvenile fish in the vicinity of the Channel during a placement operation would be disturbed and displaced or caught within the falling sand and smothered. The placement operation will last 10 minutes (with release of material taking only one minute) so the risk is short-lived. The potential impact of the placement operation on juvenile fish is considered to be of **minor adverse significance**.

8.4.1 Mitigation

No mitigation is considered necessary.

8.4.2 Residual Impact

The residual impact on the fish nursery area is **minor adverse significance**.

8.5 Interference to Adult Fish Behaviour

Adult fish use the Thames Estuary as a feeding area, for example, as they pass through on migration. The low diversity and low abundance of the seabed suggests that the North Edinburgh Channel does not provide an important feeding area in its own right but forms part of the wider North Sea habitats. The placement operation is predicted to temporarily smother seabed habitats but recolonisation is expected to be rapid as placement will occur in localised mounds. An impact of minor adverse significance is predicted on the feeding ground.

There will be no discernable lateral plume from the placement operation but there will be a localised barrier through the water column for a short duration. It is anticipated that adult fish will simply move away from the falling sand. At no point will the sand affect more than a small proportion of the channel width. An impact of **negligible significance** is predicted on adult fish movement.

8.5.1 Mitigation

No mitigation is considered necessary.

8.5.2 Residual Impact

The residual impact on loss of feeding habitat is **minor adverse significance** and the residual impact on adult fish movement is **negligible significance**.

8.6 Interference to Marine Mammals

Marine mammals including porpoise and seals are occasionally recorded in the outer Thames Estuary. The sandbanks adjacent to the proposed placement site are not known for providing haul out environments for seals. Due to their limited presence in the Estuary and the intelligence and swimming ability of these species **no impacts** are predicted upon these species which will avoid the periodic sand placement operation.

8.7 South Falls Disposal Site

The South Falls disposal site is also located within spawning and nursery areas for various fish species. There is no available information on the value of the actual placement site as a spawning or nursery area. It is, therefore, assumed that any impacts would be comparable with those predicted at the North Edinburgh site.

8.8 Summary of Potential Impacts

Table 12 summarises the predicted potential impacts, any mitigation measures and the residual impact.

Table 12 Summary of Potential Impacts on Natural Fisheries and Marine Mammals

IMPACT TITLE	SIGNIFICANCE LEVEL	MITIGATION	RESIDUAL IMPACT	COMMENTS
Smothering of shellfish beds	Negligible	None	**Negligible**	-
Spawning Fish	None	None	**None**	-
Nursery Area	Minor Adverse	None	**Minor Adverse**	
Interference with adult fish behaviour	Feeding: Minor Adverse Movement: Negligible	None None	**Minor Adverse** **None**	-
Interference to marine mammals	None	None	**None**	-

Given that the residual impacts of all impacts are considered to be negligible or minor adverse significance, no significant cumulative effects from the individual impacts are predicted.

9 BIRDS

This section discusses the potential effects on birds using the outer Thames Estuary. The potential effects on birds at the designated coastal conservation sites are discussed in Section 10.

9.1 Existing Environment

The mud and sand flats that form the borders of the Kent and Essex coasts of the Thames Estuary are recognised for their international importance to bird populations. The intertidal muds and sands provide productive feeding areas for migrating and over-wintering birds during the months of October to late March. Both bird assemblages and individual species occur in numbers that exceed the threshold for Special Protection Area status under the Birds Directive 1979.

Offshore, the sandbanks, which either dry or are covered by shallow water at low tide also provide feeding grounds for divers and other birds. In addition, the sporadic appearance of large shoals of fish attracts divers to the estuary.

Aerial surveys undertaken by JNCC and the Wildfowl and Wetland trust for a number of proposed offshore windfarm developments found that the outer Thames Estuary supports a large population of divers (particularly red-throated diver) with common scoter, eider, grebes and other bird species also observed possibly on migration to or from the coastal SPAs (Gill et al., 2004). The aerial survey data show the following bird species on the sandbanks adjacent to the proposed placement site in the North Edinburgh Channel (Gill et al., 2004):

- Red-throated diver;
- Unidentified diver;
- Common tern;
- Cormorant; and
- Auk.

No accumulations of any bird species were recorded in the North Edinburgh Channel placement site itself during the two years of surveying, although individual and small numbers of birds (particularly red-throated divers and auks) were recorded on the channel edges and adjacent sandbanks. It is to be expected, however, that bird use of the estuary is geographically variable and dependent upon the abundance of food sources (for example, fish & shellfish) in an area at any time. Therefore, the assessment has assumed that, during the autumn and winter months, a larger number of divers could be present in the channel and that other bird species may use the adjacent banks as feeding habitat.

9.2 Displacement Caused by Presence of Dredger

9.2.1 Impact Description

Dredgers and other vessels have the potential to disturb and displace birds as a result of movement or noise during vessel operation and it has been observed during the boat based surveys for offshore windfarms that birds resting or feeding on the water surface will move off in response to the approach of a vessel (Gill et al., 2004). Dredgers are, however, generally quieter than survey vessels. The North Edinburgh Channel has been closed to shipping for a number of years and is now only occasionally used by recreational vessels. The nature of the present usage includes vessels moving under power and under sail although it is likely that the majority of such passages would occur in the summer months when the bird usage is lowest.

Given the PLA's commitment to find beneficial use, the placement operation may occur at any period during the year although the weather conditions of the winter months make these periods less favourable. During the placement operation the dredger would enter the North Edinburgh Channel from the western approach, move to the placement zone and discharge the sand before returning to the dredge site in Princes Channel via the Knob Channel, the route by which it came. The dredger would be in the channel for a maximum of ten minutes of which one to two minutes would comprise the placement operation. Any birds on the water (e.g. divers) are likely to be displaced, but given the distance from the sandbanks to the placement site (>360m), birds feeding on the adjacent sandbanks are unlikely to be disturbed. The WWT aerial surveys recorded birds throughout the estuary both on sandbanks and in the navigation channels, indicating that the presence of a moving vessel (including vessels significantly larger than a dredger) does not prevent birds from feeding and resting. The additional presence of one dredger moving to and from Princes Channel and the North Edinburgh Channel is considered to be of potentially **minor adverse significance**, although the nature of such disturbance would be temporary and short-lived.

9.2.2 Mitigation

Within operational constraints, should numbers of divers be observed in the North Edinburgh Channel placement site, placement will be directed to an available cell remote from the bird activity.

9.2.3 Residual Impact

The residual impact for displacement of birds is **negligible**.

9.3 Loss or Change to Feeding Habitat on Sandbanks

9.3.1 Impact Description

The shellfish and benthic fauna on the extensive sandbanks in the Thames Estuary provide a rich feeding ground for birds. One of the main factors in the decision of the location of the proposed placement site was the need to avoid any impacts on the shellfish beds. In practice this means avoiding increases in suspended sediment over the sandbanks and ensuring that material is not deposited directly or indirectly onto the sandbanks. The placement operation is described in Section 4.2. In addition, the placement site is in water depths of >12m and so there is no potential for a direct effect upon the adjacent sandbanks. Indirect effects could occur if significant quantities of silt were removed from the sand as it fell through the water column. Studies of disposal operations have shown that only 3% of material will be lost (see Section 6.2). Further, the placement operation will commence from about 6-10m below the water surface and so at most states of the tide, the sand will already be below the level of the adjacent banks before it starts to move to the seabed.

The dredging and placement operation will be constrained by weather although trailer suction hopper dredgers can work in swells of up to 3m (pers. comm.. Nick Bray, DRL, 2004). Wave action in such conditions affects the water column with effects reducing exponentially with depth. Given that the sand is released at 6-10m below the water surface the effects of wave action on the dynamic plume will be limited. It is considered that the potential for loss or change to feeding habitats on the adjacent sandbanks is of **negligible significance**.

9.3.2 Mitigation

There is no requirement for mitigation.

9.3.3 Residual Impact

The residual impact on the feeding habitat on the adjacent sandbanks is **negligible significance.**

9.4 Reduction in Visibility of Prey Items in the Water Column

9.4.1 Impact Description

The placement site has been chosen in discussion with local fishermen and KESFC as it is not presently considered a productive fishing ground. This may be related to the dynamic nature of the sands that form the channel, which prevent the establishment of stable biological communities (see Section 7). The placement site is considered of low value as a feeding ground for fish and thus birds, but there is the potential for a shoal of fish to move through the channel and to attract feeding divers. Effects will include temporary increases in suspended sediment as the material falls to the seabed. However,

given that the placement operation will commence about 6-10m below the surface water level and that the dredged material is sand with a very low fines content there will not be a plume of material remaining in the upper water column. It is predicted that the placement operation will affect turbidity in the lower water column for approximately 30 minutes before turbidity returns to previous levels. Red-throated divers can feed in water depths of up to 9m (pers. comm. English Nature, 2004). It is likely that fish would take avoiding action and move away from the disposal operation into clear water. The potential for impact relies on a shoal of fish and feeding divers coinciding with a placement operation and any impact would be temporary and short-lived. The reduction of water column visibility is considered to be of **minor adverse significance** and the likelihood of occurrence is very low.

9.4.2 Mitigation

Mitigation has been built into the choice of placement area due to the limited importance of North Edinburgh Channel as a fishing ground. Within operational constraints, should divers be observed in the North Edinburgh Channel placement site, placement will be directed to an available cell remote from the bird activity.

9.4.3 Residual Impact

The residual impact for reduction in water column visibility is **negligible.**

9.5 Summary of Impacts

Table 13 summarises the predicted potential impacts, any mitigation measures and the residual impact.

Table 13 Summary of Potential Impacts on Birds

IMPACT TITLE	SIGNIFICANCE LEVEL	MITIGATION	RESIDUAL IMPACT	COMMENTS
Displacement	Minor Adverse	Within operational constraints avoid areas of diver activity	**Negligible**	Applies to October to March
Loss or change to feeding Habitats	Negligible	Built into choice of site.	**Negligible**	-
Reduction in visibility of prey	Minor Adverse	Built into choice of site. Within operational constraints avoid areas of diver activity	**Negligible**	Applies October to March

Given that the residual impacts of all impacts are considered to be negligible no significant cumulative effects from the individual impacts are predicted.

10 DESIGNATED CONSERVATION SITES AND SPECIES

This section considers the effects from the project on the coastal designated conservation sites. Any potential in-combination impacts are discussed in Section 16.

10.1 Existing Environment

The coastal areas of Kent and Essex are designated as SSSIs and SPAs for the bird interest supported by the existence of extensive intertidal mud and sandflats. These areas are known as European Marine Sites (EMSs). In the Thames Estuary, EMSs are located in the middle to outer estuary area and include the following sites (as shown on Figure 2):

- Thames Estuary and Marshes SPA;
- Benfleet and Southend Marshes SPA; and
- Essex Estuaries EMS (comprising SAC and several SPAs).

The Thames Estuary is thought to host conservation fish species including twaite shad, allis shad and lamprey. However, conservation is related to protection of spawning sites which may be upriver in the Thames but this has not been established.

10.1.1 Thames Estuary and Marshes SPA

The Thames Estuary and Marshes SPA includes constituent SSSIs on both the Kent and Essex sides of the Estuary and is designated for its ornithological interest including the following:

- Internationally important populations of regularly occurring Annex 1 species (Article 4.1 of the EU Birds Directive).
- Internationally important populations of regularly occurring migratory species; and
- An internationally important assemblage of waterfowl (Article 4.2 of the EU Birds Directive).

A detailed description of the conservation interest can be found in the Regulation 33 advice prepared by English Nature and the key sub-features are as follows:

- Intertidal mudflats;
- Intertidal saltmarsh; and
- Intertidal shingle.

10.1.2 Benfleet and Southend Marshes SPA

The Benfleet and Southend Marshes SPA is designated for its ornithological interest and qualifies under Article 4.2 of the EU Birds Directive by regularly supporting at least 20,000 waterfowl. In addition it qualifies for supporting populations of European importance of the following migratory species:

- Ringed Plover (on passage);
- Dark-bellied Brent Goose (over winter);
- Grey Plover (over winter); and
- Knot (over winter).

Further details on the interest features can be found in the relevant Regulation 33 advice prepared by English Nature.

10.1.3 Essex Estuaries SAC

The Essex Estuaries SAC is designated for the following interest features:

- *Salicornia* and other annuals colonising mud and sand;
- *Spartina* swards;
- Atlantic salt meadows
- Meditteranean and therm-Atlantic halophilous scrubs;
- Estuaries; and
- Mudflats and sandflats not covered by seawater at low tide.

A number of sub-features have been identified relating to each of the above interest features and further information can be found in the relevant Regulation 33 advice. The SAC forms part of a wider EMS, which includes the five estuaries on the Essex coast that are designated as SPAs.

10.2 Change in Extent or Nature of Coastal Habitat

Impacts on designated sites are considered against the conservation objectives for that site. In essence, the conservation objectives generally require maintenance of favourable condition, for example, by maintaining geographical extent of the habitats etc. The effects of the proposed placement have been considered against the relevant conservation objectives and no impacts are predicted on the extent of nature of the habitats at the designated conservation sites due to the following factors:

- The geographical distances from the designated sites to the North Edinburgh placement site;
- No significant changes are predicted to sediment transport and erosion patters outside the placement site boundary;
- The sediment to be placed is chemically cleaner than the existing seabed material; and
- No impacts are predicted on water quality.

10.3 Interference with Birds on Route to the Coastal Sites

Birds on route to and from the coastal conservation sites may fly over the North Edinburgh Channel. The only visible sign of the placement operation will be the dredger. The dredger will be one of a large number of vessels on the water in the Thames Estuary and will not create any cause for interference to migrating birds. **No impact** is predicted.

10.4 Interference with Conservation Fish Species

There is no evidence to suggest that there are spawning populations of conservation species in the outer Thames Estuary. **No impact** is predicted on these species.

10.5 Subtidal Sandbanks and Reefs

The JNCC and English Nature are presently considering the designation of subtidal sandbanks as SACs under the Habitats Directive. It is assumed that such designation would reflect areas of high biological diversity or the presence of *Sabellaria* reef structures. The marine biological survey found that the majority of the survey areas was impoverished and characterised by mobile sands. Evidence of *Sabellaria* was found at two sites only, in extremely low numbers and there was no evidence to suggest that reef structures are present. Based on the survey data, the North Edinburgh Channel placement area and its environs are not considered likely to fulfil the requirements for designation under the Habitats Directive.

10.6 Summary of Impacts

No impacts are predicted on the coastal conservation sites or conservation species as a result of the sand placement operation.

11 MARINE ARCHAEOLOGY

This section considers the effects of the proposed placement operation on marine archaeology.

11.1 Existing Environment

The Thames Estuary has great archaeological potential and significance from both its maritime history and the evidence of early human activity from periods when much of the present seabed was dry land. Appendix H provides a detailed discussion of the archaeological evolution and potential of the Thames Estuary and this is summarised below.

11.1.1 Prehistoric Activity

The Thames Estuary area was dry land above sea level at several times during the history of human occupation of Britain. Wenban-Smith has recently noted that with sea level being at least 50m below that of today, for 40% of the Lower Palaeolithic "humans would probably have been occupying the offshore landscape for the majority of the time during its regular exposure by lower sea levels" (Wenban-Smith 2001: 11). It has also been demonstrated that the last inundation of the placement area occurred between the Later Mesolithic and Neolithic period (6-4,000BC) (Wessex Archaeology, 2004).

Any archaeological artefacts dating from the Lower and Middle Palaeolithic are likely to survive as derived objects within the sand and gravel associated with the palaeo-channels of the Thames-Medway Rivers and their tributaries. For later periods, from the Upper Palaeolithic to the Neolithic, there is potential for survival of both artefacts and sites within the sediment filled palaeo-channels of the Thames and the peat deposits identified in the Estuary (Wessex Archaeology, 2004).

There are currently just three known submerged archaeological sites of Mesolithic date in the UK, and none of Palaeolithic date. As such, on the basis of their age and rarity, any such site would be of high, possibility national archaeological importance (Wessex Archaeology, 2004).

11.1.2 Maritime Activity

The long history of shipping within the study area is demonstrated by Mesolithic or Neolithic logboats, possible Bronze Age and Roman wrecks. These known sites, in addition to what is known about communities within the study area, demonstrates that there is potential for wrecks, dating back as far as the Mesolithic, to exist within the Thames Estuary. Any such finds would probably be of national importance, based on their rarity (Wessex Archaeology, 2004).

There are 160 known maritime sites with the area selected as the Marine Study Area comprising both documented wrecks and seabed features. Of these, and of particular interest is a wreck of mid 14th century date and two of 17th century date (see Appendix H for figures). Wrecks of medieval date are very rare in Britain, and should a site of this date be discovered, it would almost certainly be of national importance (Wessex Archaeology, 2004).

The two casualties of 17th century date would also be of archaeological interest, although fourteen wrecks of this date are protected under the Protection of Wrecks Act 1973 (Wessex Archaeology, 2004).

It should be noted that the obstructions on the edge of the placement area (2150, 2142, 2151) may have the greatest archaeological potential from the limited reports that are available of their character and extent (Wessex Archaeological, 2004).

More research into named craft may reveal particular technological innovations that would raise their individual importance. At present, their main interest lies in them being characteristic of a particular point in naval history. For example, the wreck Hawksdale (2072) dates from a period of major change in ship building technology, from which there are few known surviving examples. The Hawksdale is one of two wrecks that are known to lie within the proposed placement area, with a third less than 50m outside the proposed placement area.

11.2 Change in Sedimentation and Erosion Patterns

Buried archaeological sites may be exposed or subject to erosion while exposed sites may be buried if the sedimentation and erosion patterns changed. Section 4 details the predicted change to sedimentation and erosion patterns which is considered to be localised around each individual mound of sand. No significant change is predicted to tidal currents or wave action outside of the North Edinburgh Placement site and changes within the site will gradually return to normal as the placed sediment is mobilised and the seabed levels. The archaeological sites within the placement site will be subject to a temporary change in sedimentation but the effect is considered to be within the envelope of natural change that occurs in the North Edinburgh channel. All three of these sites will have been subject to depth changes of up to and in some cases greater than 10m over the previous 10 years due to the eastward migration of the channel. It is considered that the effect of the short-term and localised change in sedimentation and erosion patterns will be of **minor adverse significance.**

11.2.1 Mitigation

It is not possible to directly mitigate the effect. The PLA is compiling an Archaeological Strategy to provide information and direction for the management of the archaeological resources within the Port of London. These sites will be included within this strategy.

11.2.2 Residual Impact

The residual impact of the temporary change in sedimentation and erosion patterns is **minor adverse** significance

11.3 Increase in Burial Depth

The sand deposition process will increase the burial depth over any archaeological features within the placement area. This will have the effect of providing protection from erosive forces and increasing the depth of the anaerobic conditions that contribute to the preservation of archaeological material. The sand is the same material as the existing seabed, therefore, no changes in seabed chemistry or the resulting biological communities are predicted. Archaeological features outside the placement site will not be subject to an increase in burial depth. The effect of increasing burial depth is considered to be of **minor beneficial** significance.

11.3.1 Mitigation

No mitigation is considered necessary.

11.3.2 Residual Impact

The residual impact of increasing burial depth is **minor beneficial significance**.

11.4 Direct damage to Archaeological Site

One known archaeological site lies within the placement area as defined by the 12m contour. This wreck, the Hawksdale, may be damaged should sand be deposited from directly above the wreck. The Hawksdale is considered to be of archaeological importance as once of the few remaining examples of this type of ship. Notwithstanding that the Hawksdale will be subject to large movements of sand during extreme storm events, deposition of sand directly onto the Hawksdale is considered to be of **moderate adverse significance.**

11.4.1 Mitigation Measures

An exclusion zone of 100m will be placed around the Hawksdale. No sand will be deposited within this 100m zone.

11.4.2 Residual Impact

The residual impact of damage to the Hawksdale is **minor adverse significance**.

11.5 Summary of Predicted Impacts

Table 14 summarises the predicted potential impacts, any mitigation measures and the residual impact.

Table 14 Summary of Potential Impacts on Marine Archaeology

IMPACT TITLE	SIGNIFICANCE LEVEL	MITIGATION	RESIDUAL IMPACT	COMMENTS
Change in sedimentation and erosion patterns	Minor Adverse	PLA Archaeological Strategy	**Minor Adverse**	Temporary.
Increase in Burial Depth	Minor Beneficial	None	**Minor Beneficial**	
Direct Damage to Archaeological site	Moderate Adverse	100m Exclusion Zone	**Minor Adverse**	Refers to Hawksdale.

Given that the residual impacts of all impacts are considered to be minor adverse, no significant cumulative effects from the individual impacts are predicted.

11.6 Monitoring

The weekly bathymetric monitoring undertaken as part of the Sand Placement Management Plan will also inform of any effects on the Hawksdale. Further, on completion of the placement operations, a sidescan sonar or multibeam survey will be run over the wreck site.

12 COMMERCIAL FISHING

This section considers the effect of the proposed placement activities on the commercial fishing industry. Any in-combination effects are discussed in Section 16.

12.1 Existing Environment

The Thames Estuary is an important commercial fishery for both fish and shellfish. Fishing methods include trawling, gillnetting, potting, dredging, long-lining and rod and line fishing. Sole and cockles are believed to be the two most important fisheries.

The North Edinburgh Placement site was selected in discussion with representative of KESFC and local fishermen. The boundaries of the site were delineated by KESFC. The site was chosen as there is no fishing within the North Edinburgh Channel or on the banks directly adjacent to the Channel. Nearby channels are trawled for sole and sandbanks are drift-netted, also for sole. The nearest commercial shellfish beds are approximately 6km from the placement site, see Section 8.1.2.

12.2 Interference with fishing activity

The placement site was chosen in discussion with the fishermen as the area that would have the least interference with fishermen from either Kent or Essex. The fishermen will be kept informed of operations via KESFC. Trawling for sole in the deeper channels occurs in April and early May, after which the sole move up onto the banks. Placement operations will not be taking place between March and May due to the PLA's commitment to, where possible, avoid dredging the Princes Channel during this period. An effect of **negligible significance** is predicted on the fishing industry.

12.3 Sand Blanketing Nearby Fishing Grounds

Section 4 explains the coastal process mechanisms and the predicted fate of the placed sand. It is predicted that the placed sand will replace the existing seabed as the mobile layer and, given the similarity between the two materials, future sand distribution from the North Edinburgh Channel is predicted to follow current pathways. A **negligible impact** is predicted on fishing grounds and this will be confirmed by the bathymetric monitoring.

12.4 South Falls Disposal Site

Fishing off the south Kent coast comprises various forms of netting and potting for lobsters and crabs. There is no available information on the importance of the area around the South Falls disposal site for fishing activity. It can be surmised that given the area is not within a sandbank system there will be less sand moving around than in the North Edinburgh Channel. Any static fisheries may therefore be more sensitive to large

inputs of sand (as proposed in this project) than the North Edinburgh Channel. However, the site is a licensed disposal area and has previously received smaller quantities of sand.

12.5 Summary of Impacts

The North Edinburgh Placement site was specifically chosen to avoid impacts on the fishing industry.

13 NAVIGATION

This section describes the impacts on commercial navigation from the proposed placement operations.

13.1 Existing Environment

The North Edinburgh Channel was, until recently, one of the main approach channels to the Port of London for ships travelling to and from the south. In 2000 the development of a bar across the entrance to the Channel shallowed sufficiently to prevent further navigation. The bar has continued to accumulate and presently has depths of approximately -3mCD. At the same time as the shallowing of the North Edinburgh Channel, the entrance to the Fisherman's Gat deepened. The PLA took a decision to close the North Edinburgh and move shipping to Fisherman's Gat, thus avoiding the need for maintenance dredging (which would have been uneconomic and unsustainable in such a dynamic environment). The buoys marking the North Edinburgh Channel have now been removed and commercial shipping no longer uses the channel.

13.2 Interference with Commercial Navigation

The proposals to place material in the deep section of the North Edinburgh Channel are required to facilitate the development of the southern approach channel in light of the findings of a navigational risk assessment. It is therefore ultimately beneficial for commercial shipping for the North Edinburgh placement site to be available. The Channel is no longer used by commercial traffic and therefore there is **no predicted impact** on commercial navigation from the use of the placement site. The dredger will travel to and from the disposal site using recognised shipping channels under the control of the PLA Harbour Master. Information will be provided to ships by way of Notices To Mariners, as considered necessary by the PLA Harbour Master.

14 RECREATIONAL ACTIVITY

This section consider the effects of the proposed placement operation on recreational activity in the North Edinburgh Channel.

14.1 Existing Environment

The outer Thames Estuary is a popular area for leisure craft, particularly during the spring and summer months. However the North Edinburgh Channel is used only by the occasional recreational vessel and there is no other recreational activity (pers. comm.. PLA Harbour Master). Yachts and leisure cruisers cross the sandbanks by way of the buoyed channels, such as Foulger's Gat.

There is the potential for amateur archaeologists to dive on the Hawksdale wreck in the centre of the North Edinburgh Channel, however, this wreck is becoming progressively covered by sand and is, therefore, not presently of interest to divers.

14.2 Interference with Recreational Activity

The limited recreational activity in the North Edinburgh Channel limits the potential for interference. The RYA has been consulted and advises that, subject to the issuing of Notices To Mariners, they do not anticipate any problems. The dredger will travel to and from the site using the main navigational channels and this information will be included in the Notice To Mariners. Post-placement depths for the Channel have been agreed with the PLA Harbour Master and will not prevent any future navigation by recreational craft. It is considered that there is a potential **negligible impact** on recreational activity.

15 OTHER SEABED USES

This section considers the potential interference and effects on other seabed uses from the proposed placement operations. Any in-combination effects for the various projects are discussed in Section 16.

15.1 Existing Environment

The Thames Estuary is heavily used by a variety of marine industries including shipping, aggregate extraction, cables, fishing and, more recently, the renewable energy industry. Two windfarms have been consented on banks near to the Essex and Kent coasts and the Thames Estuary has been identified as a Strategic Area for Round 2 of the Offshore Windfarm Development Programme.

The following projects have been identified as potentially ongoing during the timescale of the placement operations (end 2006):

- Kentish Flats Windfarm: construction commencing 2004;
- London Gateway Development: outcome of the HEO Public Inquiry and FEPA licence applications awaited;
- Two marine cables: timescale not known, EIA underway;
- Round 2 windfarms: at scoping and survey stage.

15.2 Kentish Flats Windfarm

The Kentish Flats windfarm is located some 14km from the North Edinburgh Channel and no interference is anticipated between the two projects.

15.3 Round 2 Windfarms

The Round 2 windfarms are in early stages, but the information that is available suggests that should not be any interference between the projects. The developers have been made aware of the North Edinburgh Channel and will need to take account of it in their EIAs. A copy of this report will be provided to the developers to assist them in informing the relevant parts of their studies.

15.4 Subsea Cables

Based on the available knowledge it does not appear that the routes of the two proposed subsea cables pass through or near the North Edinburgh Channel.

15.5 London Gateway

The London Gateway Development comprises a reclamation and a channel dredge. Part of the proposed dredged area lies in the Black Deep to the north east of the proposed placement site. The Environmental Statement for London Gateway indicates that the

dredging is to be carried out using a single TSHD and that all material is to be placed into the reclamation site. There is a commitment to maintain the cross sectional area of the inner estuary thus requiring the initial period of dredging to be undertaken in the channel adjacent to London Gateway. The timescale for a decision is not known but in the event that consent is given, dredging is unlikely to commence before mid-2005. As the dredging is planned to take place over five years and given the requirement to dredge the inner estuary in line with the reclamation, it is considered very unlikely that the Black Deep area will be dredged before the end of 2006. The possibility of sediment from the placement site accumulating in the area to be dredged by P&O has been considered but given the presence of a sandbank between the two and the direction of the tidal current there is no obvious mechanism by which sediment could be transported to the Black Deep. Bathymetric monitoring will confirm the lack of any effects. There is, therefore, unlikely to be any interference between the two projects.

15.6 Summary of Potential Interference

No interference is predicted between the proposed placement site and the other projects that may or may not occur in the Thames Estuary.

16 IN-COMBINATION EFFECTS

This section considers the potential in-combination effects from the various projects proposed or existing in the Thames Estuary.

16.1 Introduction

For the purposes of this assessment, in-combination effects has been taken to mean effects on environmental features caused by the use of the North Edinburgh Placement Site in combination with the effects of other projects. Cumulative effects on environmental features resulting solely from this project have been discussed in the relevant sections.

The other projects that have been identified as possibly operating before the end of 2006 are as follows:

- Kentish Flats Windfarm: construction commencing 2004;
- London Gateway Development: outcome of the HEO Public Inquiry and FEPA licence applications awaited;
- Two marine cables: timescale not known, EIA underway;
- Round 2 windfarms: at scoping and survey stage of EIA.

In addition, the effects of the Phase II Princes Channel dredge must be considered. Figure 17 shows the approximate location and extent of direct effects of each of these projects.

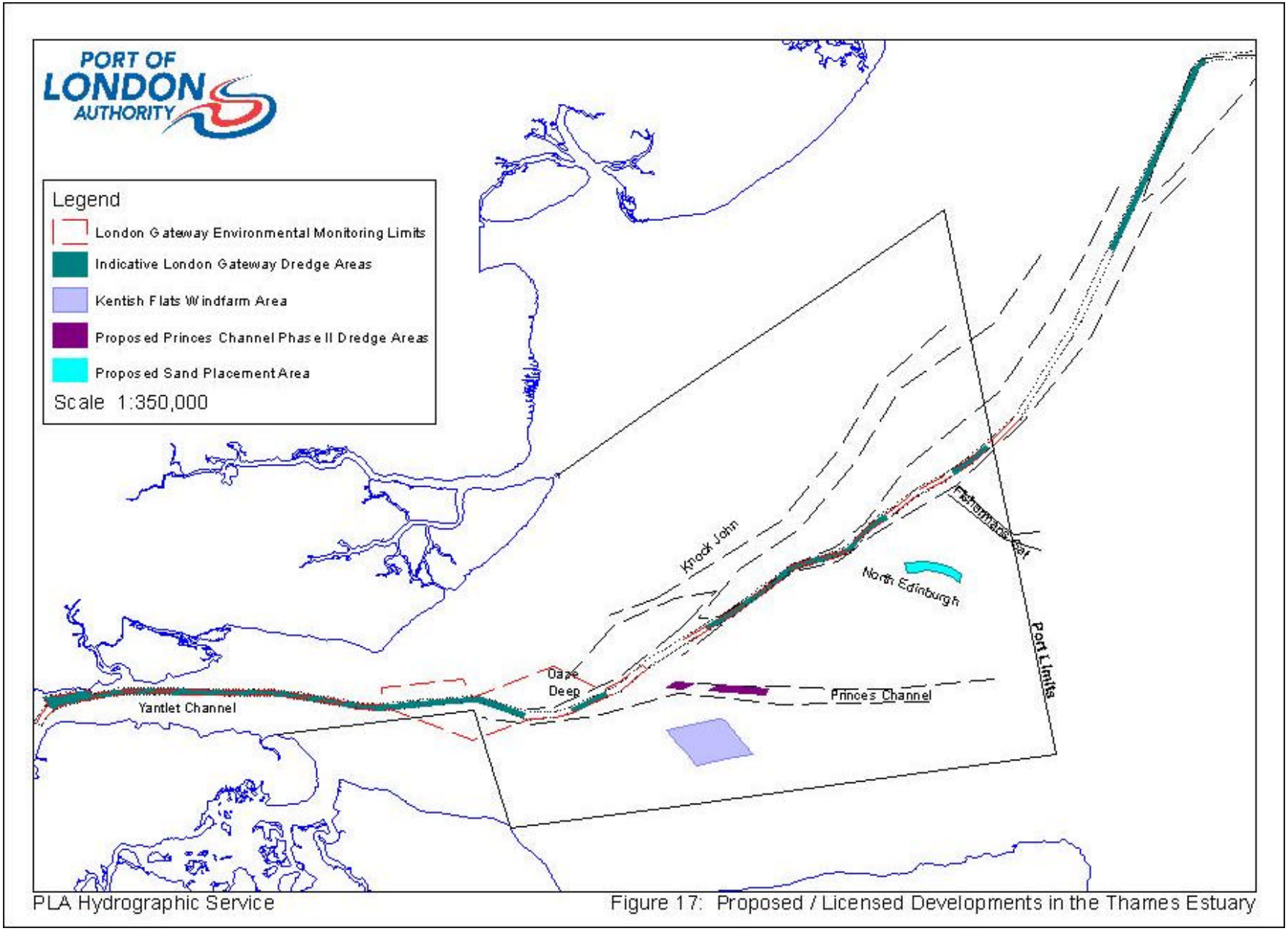


Figure 17: Proposed / Licensed Developments in the Thames Estuary

16.2 In-Combination effects

An initial screening of the environmental features suggests that, in respect of the effects of this project, in-combination effects should be considered for the following features:

- Designated conservation sites;
- Birds;
- Marine Biology;
- Fish; and
- Fishing Activity.

The distance between the various projects indicates that for other, geographically localised effects, an assessment of in-combination is not necessary,

An assessment of in-combination effects must draw upon available environmental data, for example, in the form of published Environmental Statements. These exist for the Kentish Flats Windfarm and the proposed London Gateway Development. Applications for the Round 2 windfarms are not expected until early 2005, long after a decision is expected to have been made on the FEPA application for the designation of the North Edinburgh Channel placement site. It will, therefore, be the responsibility of the windfarm developers to take into account the effects of the activities in the North Edinburgh Channel as part of their consideration of in-combination effects. The same reasoning applies to the marine cable developers who have not yet produced Environmental Statements.

The assessment of in-combination effects, therefore, includes the Princes Channel dredge, the proposed London Gateway Development and the Kentish Flats windfarm. Figure 17 shows the extent of direct effects from each of these developments; including sediment plumes from the dredging operations exceeding 100mgl^{-1}. It can be seen that there is no geographical overlap between any of the direct effects. Consideration, therefore, should be given to the effects on mobile species and the additive loss of marine biological habitat (for the London Gateway Development only the outer estuary effects on marine biology are to be considered).

16.3 Designated Conservation Sites

No significant impacts are predicted on designated conservation sites as a result of the Princes Channel dredge, Kentish Flats Windfarm or North Edinburgh Placement site. There are, therefore, no additional impacts on those features to those that may be caused should the London Gateway Development proceed. No in-combination effects are predicted.

16.4 Birds

The effects on birds as a result of the presence of a dredger (London Gateway, Princes Channel and North Edinburgh) are not considered to be significant, and will not, therefore, add to any effects on birds from the operation of the Kentish Flats Windfarm. Figure 17 demonstrates the limited geographic area affected by the projects and indicates that there will remain a large amount of clear water (for feeding divers), should the dredging projects be underway at the same time.

16.5 Marine Biology

Each project will result in the loss or change of seabed habitat. However, in the context of the outer Estuary the area to be effected is approximately 21km^2 out of a total of approximately 1,226.5km^2 and the only area permanently lost relates to the turbine locations for the windfarm that has been consented and is, therefore, considered acceptable. The seabed habitats affected by the two capital dredges will gradually recolonise, while following the placement operations at the North Edinburgh Channel there will be a more rapid recolonisation. Further, as discussed in Section 15.5 the two dredging projects in the outer Estuary are likely to take place subsequent to each other rather than concurrently thus removing the potential for in-combination effects.

16.6 Fish

As discussed in Section 16.4, should the projects proceed concurrently there will remain large expanses of unaffected water. However, it is possible that the dredging of the inner estuary for the London Gateway Development (assuming consent is achieved) would displace sole, either further into the River or out into the estuary. To avoid any in-combination effects on sole during the sensitive spawning period, the PLA is committed to managing the dredging and placement operations associated with the Princes Channel Development to avoid the spawning period of March to May. Whilst the numerous operations may displace adult fish the geographical extent of the effects on water quality from the Princes Channel dredge and North Edinburgh placement operations are minimal, as shown by Figure 17. Further the cycle time for the operations means that any effects would have disappeared before the next cycle commences.

16.7 Fishing Activity

Neither the area to be dredged in the Princes Channel nor the North Edinburgh Channel are fishing grounds and the projects will not, therefore, add to any displacement effects caused by the Kentish Flats Windfarm or proposed London Gateway Development.

16.8 Conclusion

With the exception of spawning sole, there are no predicted in-combination effects of the North Edinburgh Channel and the other developments that are ongoing or proposed for the Thames Estuary. To remove this potential impact, the PLA will seek to manage the

Princes Channel dredge, where possible, to avoid the sole spawning period of March to May. This commitment will be included in the Sand Placement Management Plan.

17 CONCLUSIONS

An environmental characterisation assessment has been undertaken to consider the potential use of a site within the North Edinburgh Channel for the placement of sandy dredged material. The site was chosen in consultation with the local fishing industry, who were considered key stakeholders in this offshore location.

A series of baseline surveys were carried out to provide information on marine biology, sediment quality, fish, bathymetry and hydrodynamic parameters. Desk-based studies were undertaken to consider the archaeological potential of the site and to predict the fate of the placed sand.

The conclusions of the assessment are presented as follows and a table summarising the impacts and mitigation measures is contained in Appendix J:

1. The placement operation will cause localised changes to hydrodynamic properties in the placement site. These changes will gradually return to the previous regime as the sand is transported away from the site. No significant effects are predicted outside of the area surrounding each mound of sand.

2. The sediment quality of the material to be placed has been compared to the existing seabed condition in the North Edinburgh channel. The dredged sand is considered chemically cleaner than the existing seabed sediment in the North Edinburgh, perhaps due to its relative distance from the historic sewage sludge disposal sites. The placement operation is predicted to improve sediment quality at the placement site.

3. There are no predicted impacts on water quality parameters due to the low levels of contaminant and organic material and the small proportion of fine material in the dredged sand.

4. The marine biology within the proposed placement site is impoverished and representative of communities inhabiting mobile sand environments. There were no species of conservation importance identified in the survey. The placement operation will initially smother the existing community but it is predicted that recovery will be relatively rapid as the placement operation is essentially similar to the effects of a natural extreme event to which the biology will be adapted.

5. The Thames estuary is of importance to fisheries as both spawning and nursery areas for a variety of fish. There is no evidence to suggest that the placement site is of any specific importance. However, in recognition of the increased sensitivity during the important sole spawning period, the PLA has committed, where possible, to avoid both dredging and placement activities doing this time.

6. Bird usage of the Thames Estuary is geographically widespread and variable from year to year. Red-throated divers are of particular importance in the estuary and should such birds be observed in the placement site, placement operations will be directed to a site remote from the diver activity.
7. There are no designated conservation sites within 15km of the proposed placement site and no impacts are predicted on these designated areas.

8. An archaeological assessment of the proposed placement site found evidence for a number of maritime and prehistoric sites in the wider estuary. Within the placement site lies the wreck of the Hawksdale and an exclusion zone of 100m will be established around this wreck to prevent direct coverage. It is thought however that the wreck is presently buried.

9. The site was established following discussion with the commercial fisherman and, therefore, negligible effects are expected on fishing activity.

10. Commercial and recreational navigation will be managed by the PLA harbour master to avoid any interference from the placement activities.

11. There are a number of other projects ongoing or predicted in the Thames Estuary, but due to the geographical separation between the projects, no interference is predicted.

12. Further, the geographical separation limits the potential for in-combination effects. There is the potential for mobile species to be affected by the projects and the PLA has undertaken to manage the placement operations, where possible, to avoid the sole spawning area.

17.1 South Falls Marine Disposal Site

The South Falls disposal site is the closest licensed site to the Princes Channel, but the distance is considerable at 55km. The characterisation process has considered the impact of placing the material at South Falls with the following conclusions:

1. The cost of the operation would be expected to double due to the significant increase in transit time compared to the North Edinburgh channel.
2. The sand would be moved to a location outside of the sedimentary regime of the Thames Estuary.
3. South Falls has not previously received such a large quantity of sand over the proposed time period and further assessment would be required to consider the effects of the rate of input.
4. South Falls is not in a dynamic sandbank system and the marine ecology may not be as well adapted to mobile sand as the North Edinburgh site.

Notwithstanding the above, the South Falls site is a designated disposal site where adverse impacts are to some extent considered acceptable. However, the placement of

sand in the North Edinburgh Channel is considered akin to mimicking the natural processes and recycling sediment rather than disposing of material.

17.2 Maintenance dredging

There may be a small future maintenance dredging requirement and the characterisation assessment has indicated that the site would be able to receive this ongoing input without adverse effects. Such placement would form a small fraction of the ongoing movement of sand in this dynamic area. This prediction will be confirmed by the bathymetric monitoring proposed for the main placement operation.

17.3 Conclusion

In summary, there are no predicted long-term significant adverse effects on any of the environmental sensitivities considered in the characterisation assessment. It is considered that the potential for in-combination effects can be managed with the commitment from the PLA to avoid the sole spawning period. The preparation of a Sand Placement Management Plan will ensure that the dredging contractor builds the proposed mitigation measures into his project plan. Liaison with the fishing industry and navigation sector will occur throughout the project via the PLA Harbour Master.

It is considered that the lack of significant environmental effects associated with the proposed sand placement operation and the significant cost reduction achieved by using the North Edinburgh outweighs the benefits of using the South Falls disposal site.

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