PRINCES CHANNEL DEVELOPMENT

Phase II Dredging

Environmental Assessment 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.

Phase I of the dredging was completed in August 2003 and produced 350,000m^3 of sand. Phase II of the development 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 the earlier Phase I 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 (subject to receiving the appropriate consents). A sand placement site has been identified in the North Edinburgh Channel, in consultation with the local fishing industry.

An environmental assessment of the likely effects of the Phase II dredge has been undertaken and is discussed in this report. A range of surveys were undertaken prior to the Phase I dredge to define the baseline environment including biological, sediment quality, current speeds, bathymetry and archaeological surveys. These surveys have been supplemented by a detailed site investigation and an archaeological assessment. The Princes Channel is characterised by a sandy seabed in a relatively stable channel morphology. The biological communities are representative of the wider Thames Estuary and the channel does not provide specific spawning or nursery habitat for fish, other than as part of the wider Estuary. There are no conservation sites within 20km of the Channel although feeding grounds for birds are widely distributed across Estuary.

The environmental assessment does not predict any significant long term effects on the natural environment of the Princes Channel. The main impact of the project is the necessary removal of a historically important 16th Century wreck that is located in the centre of the Channel. This impact has been mitigated by the development of an appropriate mitigation strategy with English Heritage.

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1 INTRODUCTION

This section introduces the Princes Channel Development.

1.1 Background

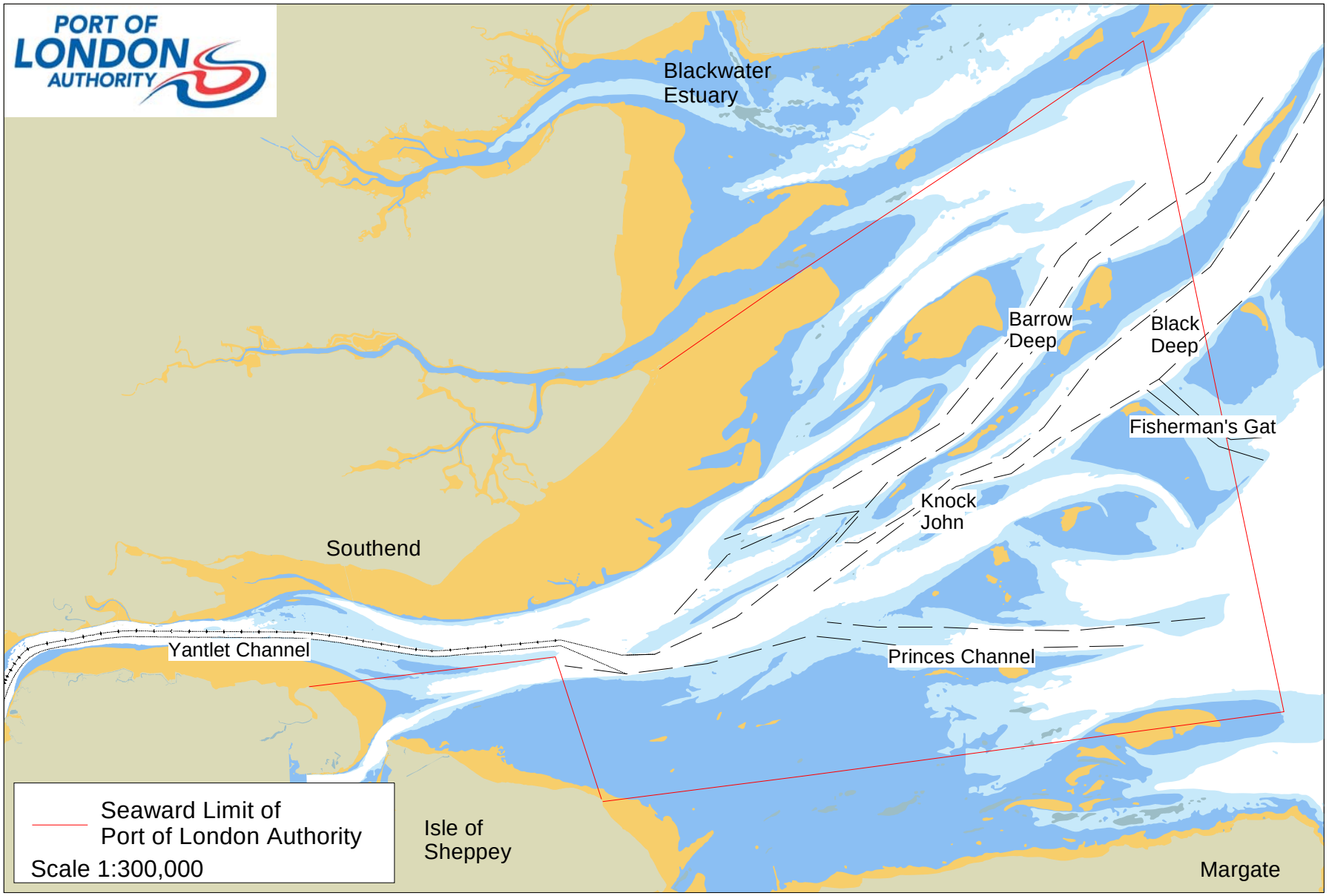
The PLA has a statutory responsibility for maintaining safe navigation within its port limits, as shown in Figure 1. In practice this responsibility is met by a navigational Safety Management System, which includes state of the art Vessel Traffic Services (VTS), Port Control Centres, hydrographic surveys, 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 closure of the North Edinburgh Channel and, more recently, instability in the area of Fisherman's Gat, together with navigational safety considerations, have led the PLA to consider the provision of improved access to the Port of London, via Princes Channel, for smaller vessels approaching from the south.

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.



PLA Hydrographic Service

Figure 1: Approaches to the Port of London

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. An environmental characterisation of the suitability of the site has been undertaken and submitted to the Department of Environment, Food and Rural Affairs (Defra) with an application for consent under the Food and Environment Protection Act (1985).

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

1.3 Study 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 CD in the east to the much shallower western section with ruling depths of -5.3m CD (around a wreck). The proposed Phase II dredging is to deepen further the shallow western section of the Channel and over a wider area than Phase I.

The Port of London is one of 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-draughted 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.

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 itself is not an important fishing ground but that the nearby banks are trawled for sole.

Much of the north Kent Coast is designated as a Site of Special Scientific Interest (SSSI), Special Protection Area (SPA) and Ramsar site for its bird interest but the protected areas do not extend significantly offshore (see Figure 2).

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.

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

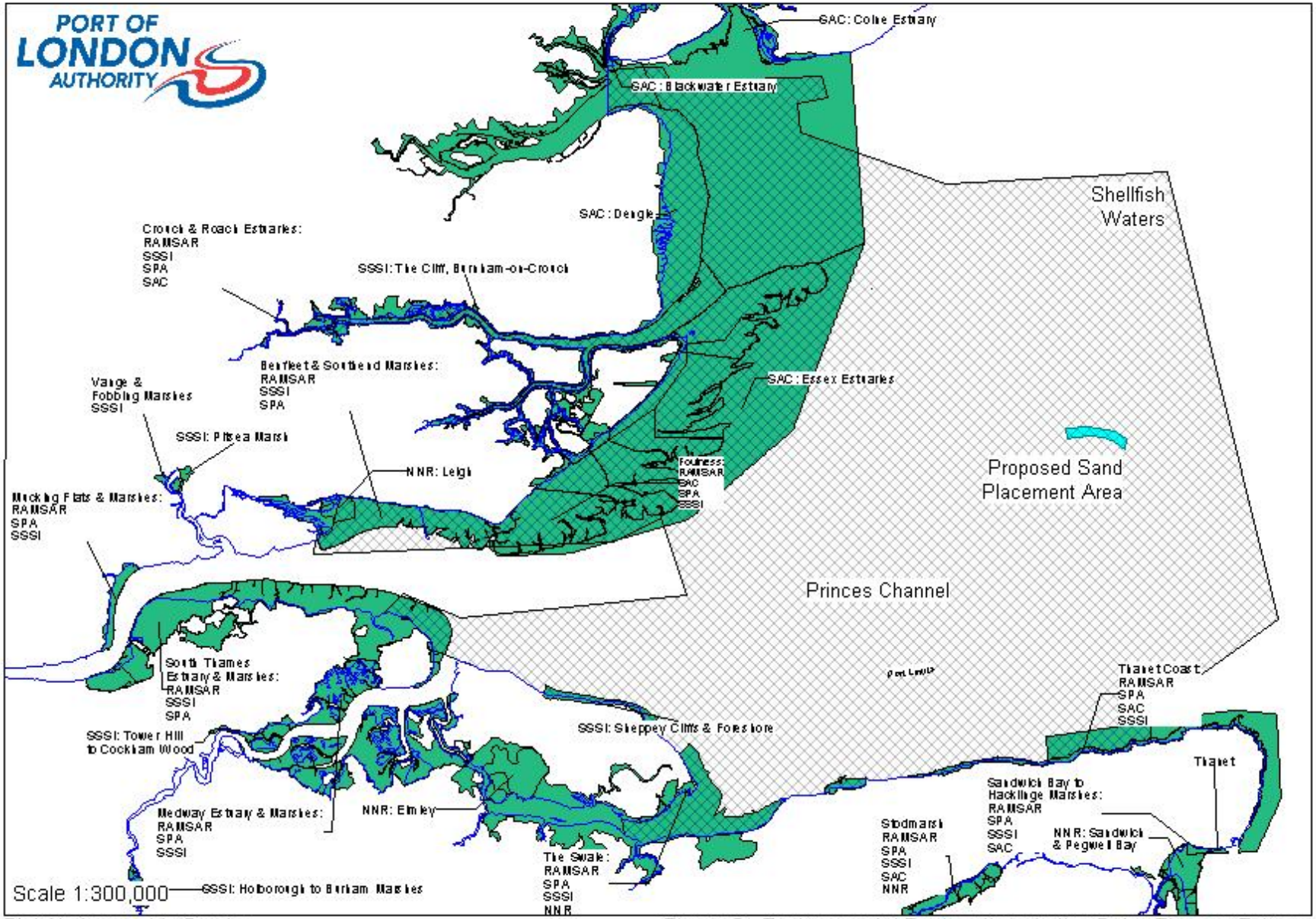


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Figure 2: Environmental Designations in the Outer Thames Estuary

1.4 Report Structure

This report presents the conclusions of an environmental assessment of the impacts of Phase II of the Princes Channel Development. The report draws upon and updates the Environmental Review completed prior to the Phase I works and fulfils the recommendations for further work set out within that report.

The report comprises 17 sections. Sections 1 and 2 introduce the project and set the context for the development. Section 3 outlines the environmental assessment 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 in-combination effects of the Princes Channel Development and other developments in the Thames Estuary. Finally, Section 17 provides a summary of the conclusions.

List 1 Topics Considered in Environmental Assessment

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

2 PRINCES CHANNEL DEEPENING

This section provides further details on the Princes Channel Development.

2.1 Navigational Need

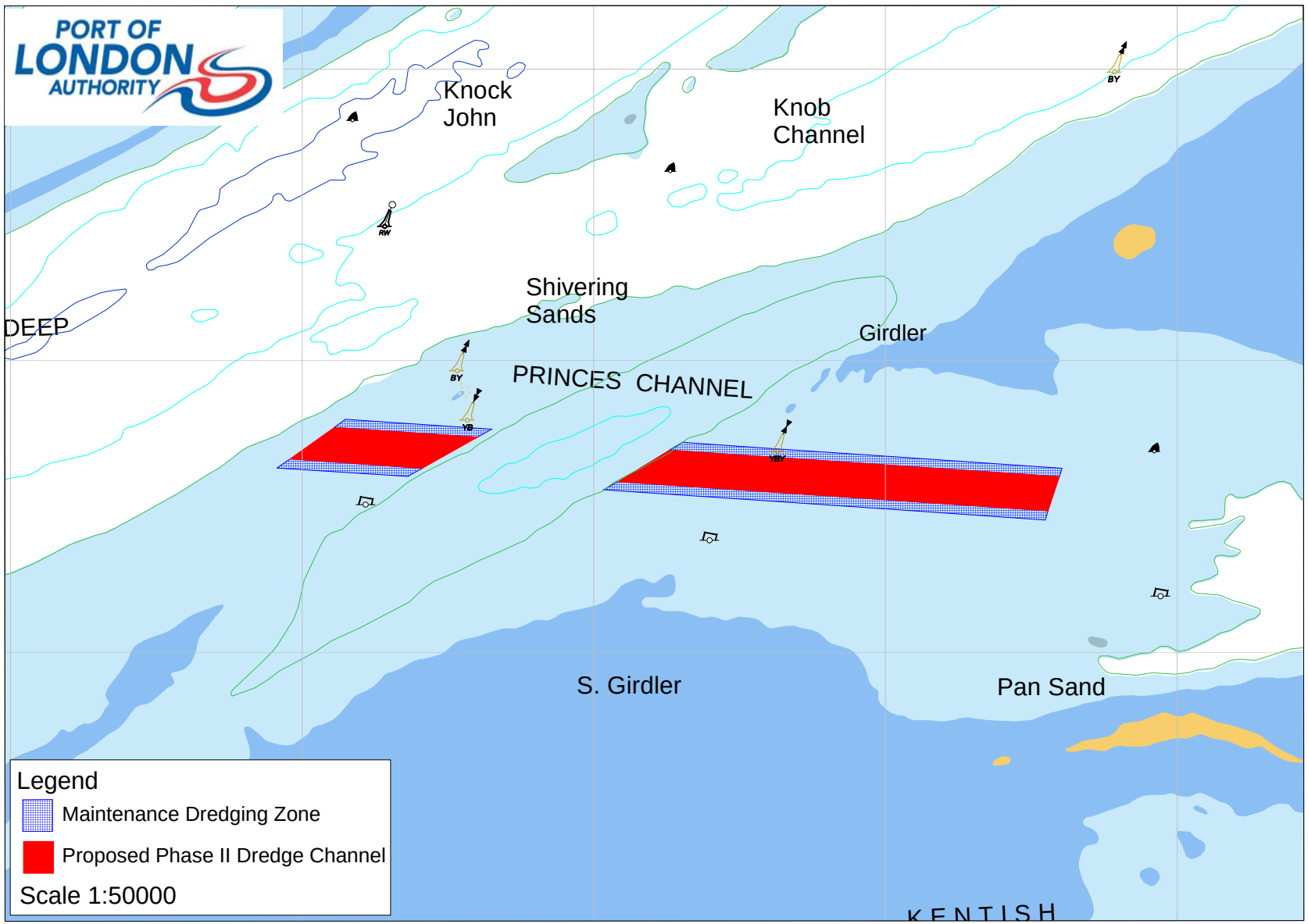
Southern access to the Port of London has, for many years, been provided by the North Edinburgh Channel, Princes Channel and, more recently, the Fisherman's Gat. The seabed of the Thames Estuary in these areas is in constant flux, and water depths and channel centrelines are continually changing. Historically, 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 is unstable, and recent traffic risk assessment studies (Marico, 2002) have shown that the necessity for vessels to cross busy shipping lanes when entering from this point introduces additional risk. To address this issue, the PLA has been recommended to consider greater flexibility for access by smaller vessels to the Port and to develop alternative routes to remove the double-crossing situation that exists at the upper end of the Knock John Channel and Black Deep at its confluence with Fisherman's Gat.

Princes Channel is up to 1km wide in places and the proposed development will affect only a small part of the overall channel width. Much of the existing Princes Channel is already relatively deep with water depths of, typically, -11.0m to -14.0m CD and as much as -20.0m CD in places. However, towards the western end of Princes Channel, depths are more typically between -6.5m and -8.0m CD, and it is in this area that further dredging will be required to achieve the target depth of -8.0m CD throughout. Further, immediately to the west of this, dredging through a part of Shivering Sands (currently at around -6.2m to -8.0m CD) will also be required.

The dredging completed during Phase I, the trial dredge, resulted in depths of approximately -7.0m CD over a channel width of 300m. One exception is the area surrounding a wreck where depths are presently -6.4mCD

The aim of Phase II is to further deepen this 300m channel to -8.0m but also to provide a maintenance dredging zone of 75m to either side of the channel. This will allow for continued ship movement through Princes Channel in the event of any maintenance requirements. Figure 3 shows a the additional areas to be dredged during Phase II.

At the far western end of the Princes Channel, dredging through Shivering Sands will mostly be limited to less than 1m increasing to 1.6m in the maintenance zone. South of the Girdler, most of the dredging will be less than 1m but, as with Shivering Sands, in the maintenance zone up to 2.5m will be removed. No dredging is required between these two areas or to the east of the Girdler in the main body of Princes Channel as the depths are already at or below -8.0m CD.



PLA Hydrographic Service

Figure 3: Phase II Proposed Dredge Areas

2.2 Sustainability Assessment of Phase I

The aim of Phase I was to gain an understanding of the sustainability of the dredged channel as recommended by the hydrodynamic studies. In practice, assessing the sustainability was achieved by undertaking a pre- and post- dredge survey and subsequently running a series of monitoring surveys. The initial post-dredge survey was completed in July 2003 and monitoring surveys have been undertaken as follows:

- 11th September 2003
- 28th October 2003
- 11th February 2004
- 16th February 2004
- 26th April 2004
- 7th June 2004
- 2nd September 2004

Analysis of the survey data indicates that general depth improvements of 1 to 1.5m were achieved and that these depths have been sustained for ten months. Immediately post-dredge, the survey showed an uneven seabed with peaks and troughs characteristic of dredging activity. By September 2003 these peaks and troughs had, through natural processes, levelled to about half of the original dimensions. This trend continued into the October survey but no further changes were seen in the February survey following the winter storms. The surveys of April, June and September confirmed that there is no indication of any deposition. From the survey data it can be concluded that there are no discernable trends to be seen in the dredged areas.

2.2.1 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 wider area it would be appropriate to plan for such a low level maintenance dredging campaign (i.e. 100,000m^3) once every five years.

2.3 Phase II

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. The maintenance dredging zones will facilitate maintenance requirements by providing uninterrupted passage to ships. Approximately 2.5Mm^3 of fine sand will be dredged.

2.4 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 1.

Table 1 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 the subject of a separate Environmental Characterisation Report.

2.5 Dredging Scenarios

Due to the different types of dredging plant available, there is the potential for a number of different dredging scenarios for the Princes Channel Development. The environmental assessment has taken account of these different scenarios in order to prevent a potential requirement for additional work at a later date.

The Phase I studies considered the effects of the plume dispersion caused by a specified dredging scenario. The Phase II studies assessed only the plume dispersion effects of dredging scenarios that are considered significantly different from that previously modelled. Table 2 sets out the different scenarios that have been included as part of the environmental assessment.

Table 2 Potential Dredging Scenarios

DREDGING SCENARIO	DESCRIPTION
1	TSHD up to 12,000m^3 capacity commencing dredging 1 hour before high tide.
2	Jumbo–dredger part-loading (for later projects once depths are greater).
3	Limiting depth at receiving end (e.g. Wallasea Island). Small dredger (4,400m^3) working at any time of the tidal cycle.
4	Multiple TSHD working as Scenario 1
5	Multiple small THSD dredgers working as Scenario 3
6	Medium TSHD (6,400m^3) dredging and disposing at North Edinburgh at any time in the tidal cycle.
7	Multiple medium TSHD (6,400m3) working as Scenario 6.
8	Stationary dredger (CSD) discharging into a hopper. Overflow from hopper.

Scenarios 2 and 5 have been discounted as while they are technically possible they are not considered to be economically viable. Scenario 8 is also considered unlikely. Further plume dispersion modelling has been carried out to consider Scenarios 1, 3, 6 and 7. The effects of multiple dredgers have also been considered (Section 4.7.5).

It is probable that the dredging will be undertaken using a Trailer Hopper Suction Dredger as there are navigational constraints associated with the use of stationary dredgers. In the ideal scenario of the material being used beneficially, the choice of dredger type will be determined by that use with the PLA ensuring that the methodology is appropriate for any environmental sensitivities identified in the environmental assessment.

2.6 Consideration of Alternatives

2.6.1 Other Ways of Meeting the Navigational Need

The development of the Princes Channel has been selected as the only practical and sustainable solution to the navigational risk identified at the junction of Fishermen's Gat with the Black Deep. A number of alternatives were considered and discarded as follows:

Close Fisherman's Gat and route all deeper draughted traffic round the Long Sand Head and down the main channel (Black Deep): this would significantly increase the transit time and cost for vessels approaching from the south and would make the Port of London uncompetitive for such ships. It would also increase congestion in the Sunk boarding and landing area off Harwich

Dredge an alternative channel to the north of Fisherman's Gat: All channels running across the main tidal flows in this area, including Fisherman's Gat, are inherently unstable and may not be navigable over the medium term. Any alternative to Fisherman's Gat would necessitate cutting a new channel through the Long Sand with significantly more dredging than that required to deepen the Princes Channel.

Continue with the present 'waiting for tide' system with its attendant congestion implications: such measures are not compatible with the increasing volume of shipping in the area and would create their own safety issues.

2.6.2 Channel Alignments

Two potential channel alignments were investigated. The first alignment was chosen to avoid potentially unstable bed depths between Girdler and West Shingles whilst taking full advantage of maximum natural depths without the need for bends in the channel. The second channel was chosen to be hydraulically less intrusive to the estuary regime as it minimised the dredging commitment in the vicinity of Shivering Sand. However, to achieve the latter, there was a need to introduce a series of bends around the seaward end of Shivering Sand. A consequence of the latter was the necessity that vessels would have

to navigate across the main current and potential wave activity. Numerical modelling confirmed that the impacts of either alignment were insignificant and therefore the navigationally preferential straight line channel was chosen for development.

2.7 Dredged Material Placement

The PLA is committed to finding beneficial use for as much of the dredged material as practicable and is currently holding discussions with interested parties. 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. The designation of this site is subject to a FEPA licence. The Environmental Characterisation report is available from the PLA.

2.8 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 ASSESSMENT PROCESS

This section describes the legislation that is applicable to navigation dredging and the environmental assessment process.

3.1 Legislative Context

The PLA is a self-funding public body with a range of statutory powers and duties. The Secretary of State appoints the Chairman and the Non-executive Board Members. The following extract from the PLA's Environmental Policy sets out its approach towards environmental issues:

"The PLA as a statutory harbour authority has environmental duties under the Harbours Act 1964. The PLA is also a competent authority under the Conservation (Natural Habitats &c.) Regulations 1994 and the Countryside and Rights of Way Act 2000. It is therefore a requirement for the PLA to ensure continuing compliance with environmental legislation (including the relevant EC Directives) and to take the environment into account in its actions and decisions.

The Government's policy paper, "Modern Ports", states that it is necessary to maintain an appropriate balance between the long-term protection of the environment and the securing of sustainable economic growth.

Whilst ensuring continuing compliance with environmental legislation (including the relevant EC Directives) and taking the environment into account in its actions and decisions, the PLA must also give weight to appropriate and proportionate development plans and opportunities.

The PLA recognises that a well-researched baseline understanding of the estuarine regime is necessary to provide the basis for effective, objective and scientific decision taking."

3.1.1 Regulation of Dredging

The general position elsewhere around the coast of England and Wales is for dredging undertaken for navigational purposes to be regulated by the Department for Transport (DfT) (via the Marine Consents and Environment Unit) under Section 34 of the Coast Protection Act 1949 (CPA).

However, within PLA port limits (see Figure 1) the situation is different. The PLA has the powers both to carry out and to license dredging. These were given to the PLA under successive Port of London Acts (most recently PoLA 1968 s.60 and 73), and therefore dredging on the Thames is exempt from the provisions of s.34 of the CPA under s.35 of the same Act.

3.1.2 Harbours Act 1964

Section 48A of the Harbours Act 1964 (an amendment dating from 1992) requires the PLA to "have regard to" a number of environmental issues when fulfilling its functions, such as authorising dredging operations, and is drawn in wide terms:

" a) the conservation of the natural beauty of the countryside and of flora, fauna and geological or physiographical features of special interest;

b) the desirability of preserving for the public any freedom of access to places of natural beauty; and

c) the desirability of maintaining the availability to the public of any facility for visiting or inspecting any building, site or object of archaeological, architectural or historic interest. "

In addition, the PLA, as a public body, must comply with the following environmental legislative requirements when carrying out or licensing dredging operations:

- Conservation (Natural Habitats &c.) Regulations 1994;
- Countryside and Rights of Way Act 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. Further, there are separate legislative requirements associated with other parts of the PLA's functions, for example, oil spill management.

The main environmental legislation relevant to the Princes Channel project is described further below.

3.1.3 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 test is passed, 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.

3.1.4 EIA Directive

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. As the PLA does not require development consent, the EIA Regulations do not apply. Notwithstanding this, in recognition of its environmental responsibilities, it is PLA policy to carry out an Environmental Assessment to comply with the spirit of the Regulations, and indeed, to carry out a full EIA if significant impacts are anticipated. The Environmental Assessment is considered necessary by the PLA to contribute to its own internal audit processes and to demonstrate environmental transparency and accountability to stakeholders.

3.1.5 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.

The PLA has taken legal advice about the applicability of the SWD to mobile dredging operations and has been advised that its applicability is far from certain in law. Notwithstanding those doubts, the PLA apply the full spirit of the SWD by seeking to ensure that dredging is carried out, as far as practicable, in a manner that does not adversely affect shellfish beds or other interests (e.g. cockle spat in the water column). This approach has been applied in Section 5 of this Environmental Review.

3.1.6 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 navigation dredging. Further, the WFD is limited to activities within 1nm of the coast. Although boundary lines have not yet been seen the Princes Channel is certainly more than 1nm from the shoreline.

3.2 Environmental Assessment

This report considers the effects of Phase II of the Princes Channel development and updates the conclusions and findings of the Environment Review prepared for the Phase I works. The Environmental Review (PLA, 2003) made a number of recommendations about additional studies required to inform the assessment of the larger Phase II project and these studies are listed in Table 3. In addition to the studies in Table 3 additional numerical modelling has been undertaken to consider the effects of the channel and the maintenance dredging zones on hydrodynamic processes.

Table 3 Summary of Phase II Requirements

TOPIC OR ISSUE	PHASE II REQUIREMENT
Physical seabed characterisation	Geotechnical investigation of footprint of dredged channel
Plume dispersion from dredger	Numerical modeling.
Sediment quality	Sampling and chemical analysis of surface and depth samples.
Water quality	Suspended solids monitoring to complete baseline dataset.
Fishing activity	Continued liaison with fishing industry.
Archaeology	Archaeological review and development of reporting procedure.
Ordnance	Additional surveys as necessary to inform risk assessment.
In-combination and cumulative effects	Consideration of combined impacts with windfarms and other projects as necessary.

The Phase II assessment has also been informed by the results of the water quality monitoring undertaken during the dredging in 2003 and by a plume dispersion study carried out in 2004.

3.2.1 Environmental Assessment Process

The baseline surveys and data collection described above provided the inputs into the environmental assessment process. The environmental assessment 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 assessment 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 4) as a guide. Significance levels may be adverse or beneficial.

Table 4 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 Princes Channel area, details the likely dredging process and discusses the likely changes on hydrodynamic parameters that may occur as a result of the dredging operations. A series of modelling studies were undertaken for the Phase I works and these studies have been updated for the Phase II development.

4.1 Existing Environment

4.1.1 Geology and Bathymetry

Princes Channel forms part of the deep buried channel of the Palaeo-Swale river (D'Olier, 1998). Much of this ancient river is infilled but marine erosion over many decades has exposed sections that can be seen in the deeper parts of Princes Channel. Princes Channel is one of several channels that provide deep water access through the dynamic sandbanks of the Thames estuary. Water depths in the deeper eastern section of the channel are greater than -20m CD with shallower depths of -6-7m CD in the recently dredged western section. The eroded sections of the ancient river channel are being slowly refilled from the east and south-east, and also from the north due to the southerly migration of the Shingles Patch. Figure 3 shows the areas within the channel where depths are less than -8m CD.

The drying sandbanks to the north and south of Princes Channel are formed by long-term slow erosion of exposed areas of bedrock (D'Olier, 1998). This slow process is an indication of the relatively stable nature of the Princes Channel and its environs with processes occurring over many decades. A further example of the relatively stable nature of the sand transport is further shown by the initiation, opening and closing of the Alexandra Channel (that runs north-east from Princes Channel) over a period of 200 years. This can be compared with the evolution of the Edinburgh Channels which are continually changing.

A historical chart review confirmed that landward of the west Shingle and Girdler Banks, the seabed has been much more stable than further seaward (e.g. the Alexandra and Edinburgh Channels).

4.1.2 Seabed Sediment

The seabed of Princes Channel comprises fine silty to coarse sand with a high percentage of shell fragments. Evidence from geophysical surveys suggests no obvious widespread sedimentary bedforms although visual inspection by divers did find some evidence of ripples. The sediment at depth is also fine silty to coarse sand with varying shell content and the occasional thin silt/clay layer.

The geological review (summarised above) indicates the presence of mobile sediment in the wider area surrounding Princes Channel. For example, sediment pathways have been

identified on Shivering Sands in a north-east direction with a return sand flow identified on the south-western end of the sands. The Red Sands Channel is another area of active deposition and contains soft silty sands and clays but also has a non-depositional or erosional area along its eastern flank (D'Olier, 1998). The Girdler and Alexandra Channels also show signs of a dominant north-east sand transport pathway.

Material Composition

A vibrocore survey comprising 43 sites on three transects spaced 300m x 175m across the channel has been undertaken to provide information on the composition of the seabed in the Phase II dredge area (See Figure 3). The vibrocores were sunk to a depth of up to 4m below existing bed level (approximately -10mCD). 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 5.

Table 5 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 5 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 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 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 –8.0mCD.

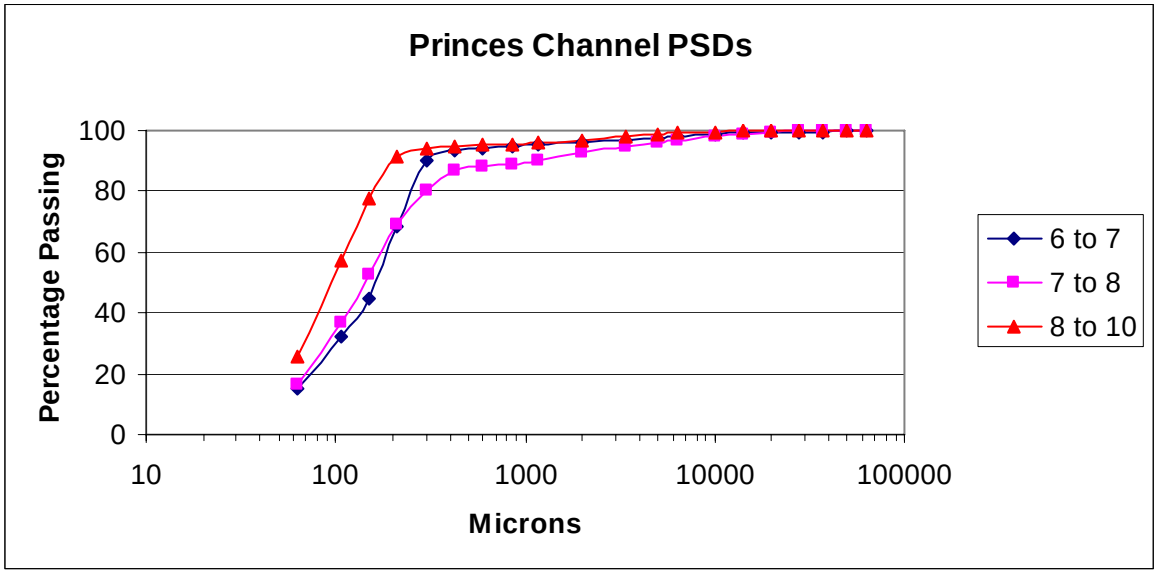


Figure 4 Composition of Seabed Sediment

The detailed results of the vibrocore surveys are available in Appendix A on the accompanying CD-ROM.

4.1.3 Hydrodynamic Conditions

Tidal flow atlases of the Outer Thames Estuary provide evidence to suggest that the alignment of the channels to the north of the Long Sand/Shingles boundary is controlled by the exchange of tidal waters between the estuary and the southern North Sea on the ebb tide (HR Wallingford, 1999). HR Wallingford also indicated that to the south of this boundary, the channels are aligned in accordance with the flood tides from the English Channel. Current meter readings collected by the PLA show the tidal direction supports the overall north-east south-west movement indicated by the sedimentary bedforms. Current velocity measurements indicated that the maximum current strength at mid flood tide was in the order of 1.0ms^{-1} and that the maximum current strength at mid ebb was in excess of 1.5ms^{-1}. During the early and mid-ebb tide, the surface flows were almost twice those near to the bed (HR Wallingford, 1999). Further details are provided in HR Wallingford Report EX 3974 (1999).

4.2 The Dredging Operation

The dredging method likely to be selected for Phase II is a trailer suction hopper dredger (TSHD). A TSHD, or “trailer”, is a mobile, sea-going dredger that draws material from the seabed up through a suction pipe and loads its own hopper. If the material being taken up is not of a sufficient density then the water is discharge via an overflow. When the hopper is full the dredger sails to the discharge point and pumps the material ashore. Because trailers are moving vessels and do not operate on mooring wires, they are not a

hindrance to shipping. A TSHD can dredge most materials with the exception of stiff clay and rock.

4.3 Changes to bathymetry

4.3.1 Effect Description

The dredging operation will deepen the western section of the Princes Channel to -8.0mCD. This will remove between 1 and 2.5m of sediment from the seabed along a channel length of approximately 4.3km. Although not an impact in itself, such changes to bathymetry can have effects on current speed and consequentially sediment transport and erosion patterns. To predict such changes the TELEMAC model used for the Phase I studies was set up and updated with the post-Phase I bathymetry. The results are discussed in Section 4.5.

4.4 Changes to Current Speed and Direction

4.4.1 Effect Description

The TELEMAC model was used to predict any changes to hydrodynamic conditions. The bathymetry of the calibrated model was adjusted to incorporate the Phase II dredged channel with bed levels of –8.0m CD. The flow model was run to simulate conditions between 10 February 2004 and 13 February 2004 as the model has been validated with data from ADCP measurements collected during this period. Comparisons of the current speed within the channel are shown in Figure 5. It can be seen that current within the channel increases with channel depth at Points A, B and C. Outside of the channel (Points D and E) there is no change in current (HR Wallingford, 2004). The following describes the results of the spring tide modelling and further details and figures are available in Appendix B on the accompanying CD.

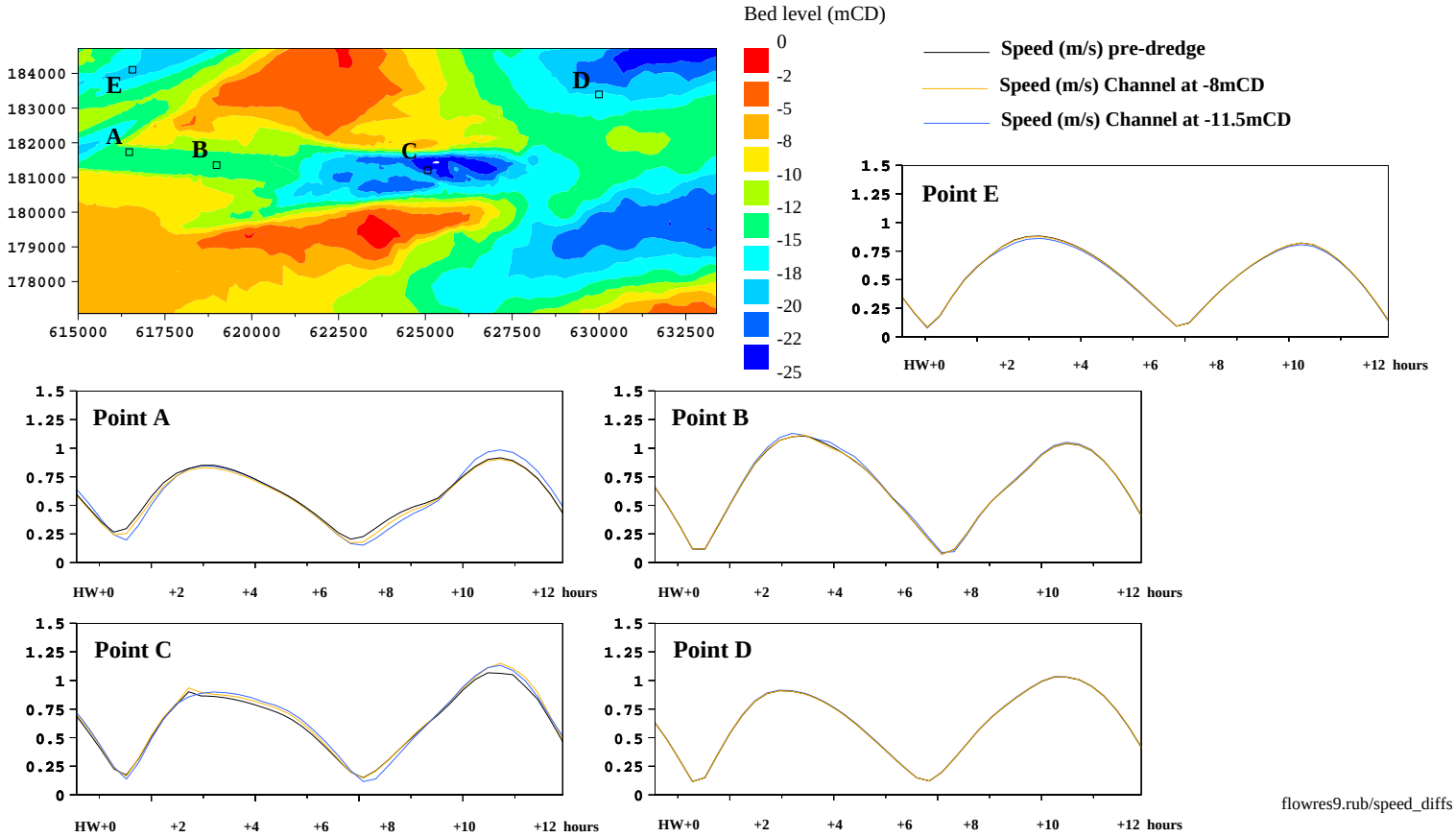


Figure 5 Predicted Current Speed Changes Post Phase II Dredging

Changes to current speed

Figures 6 and 7 indicate the extent and magnitude of change to peak ebb and flood current speeds for the Phase II channel. As can be seen from the data presented on these figures the channel has no discernible impact on current speed (HR Wallingford, 2004).

Current velocity

The similarity of the flow vectors between the existing situation and the modelled channel confirms that the changes to current speeds described above are of small magnitude. The modelling also shows that there will be little change to the flow direction either in the vicinity of the proposed works or elsewhere as a consequence of the deepening of Princes Channel (HR Wallingford, 2004).

Neap tides

The work described in previous sections was for a spring tide. The impact of the proposed works upon the flow regime on a neap tide was not examined but it can be expected that the impact to upon both speed and direction will be much smaller in magnitude.

In conclusion, the impact of the proposed Princes Channel dredging works will have little impact upon the hydrodynamic flow regime in the Outer Thames Estuary (HR Wallingford, 2004).

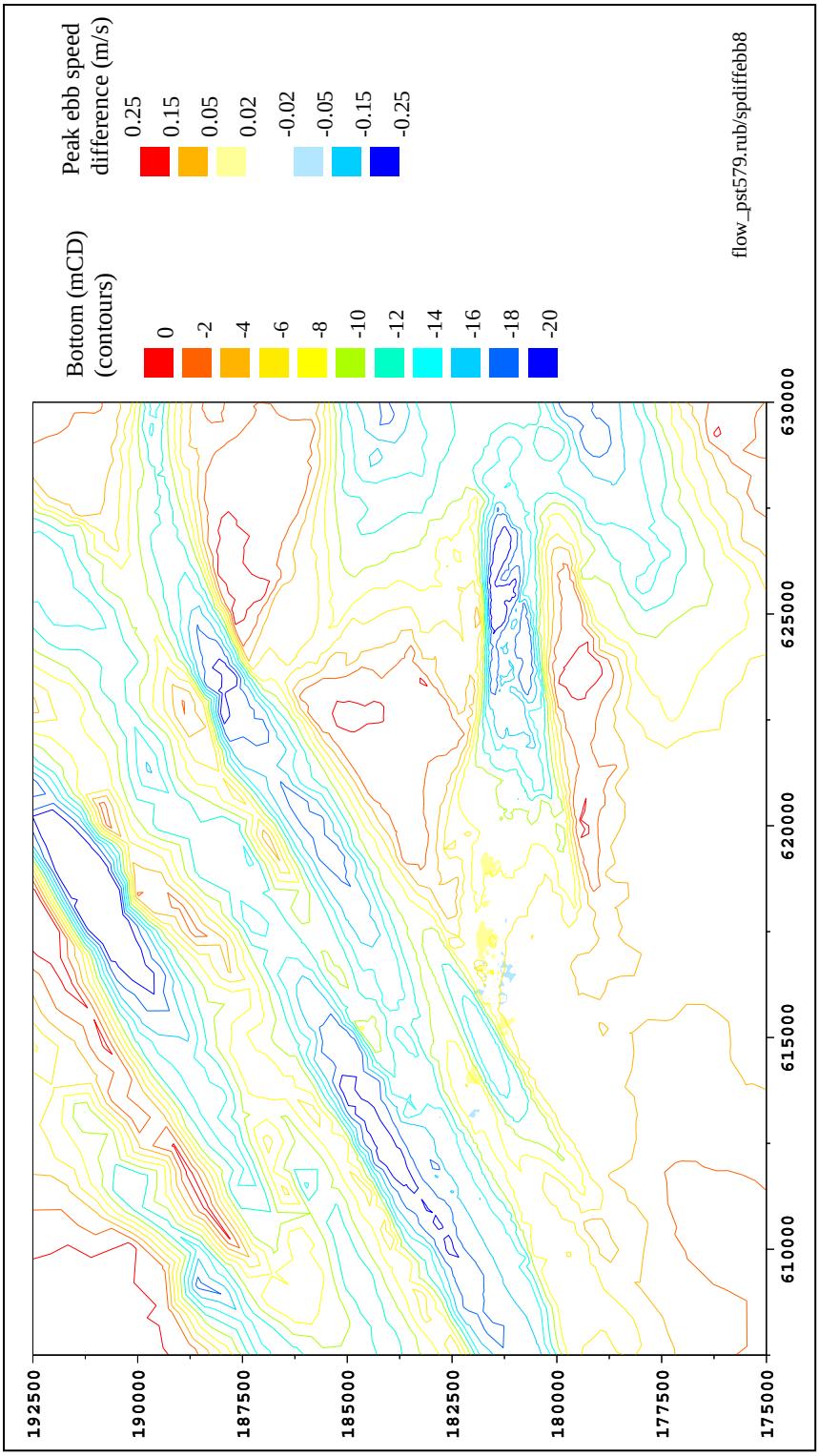


Figure 6 Current speed change with –8 m CD channel (peak ebb tide)

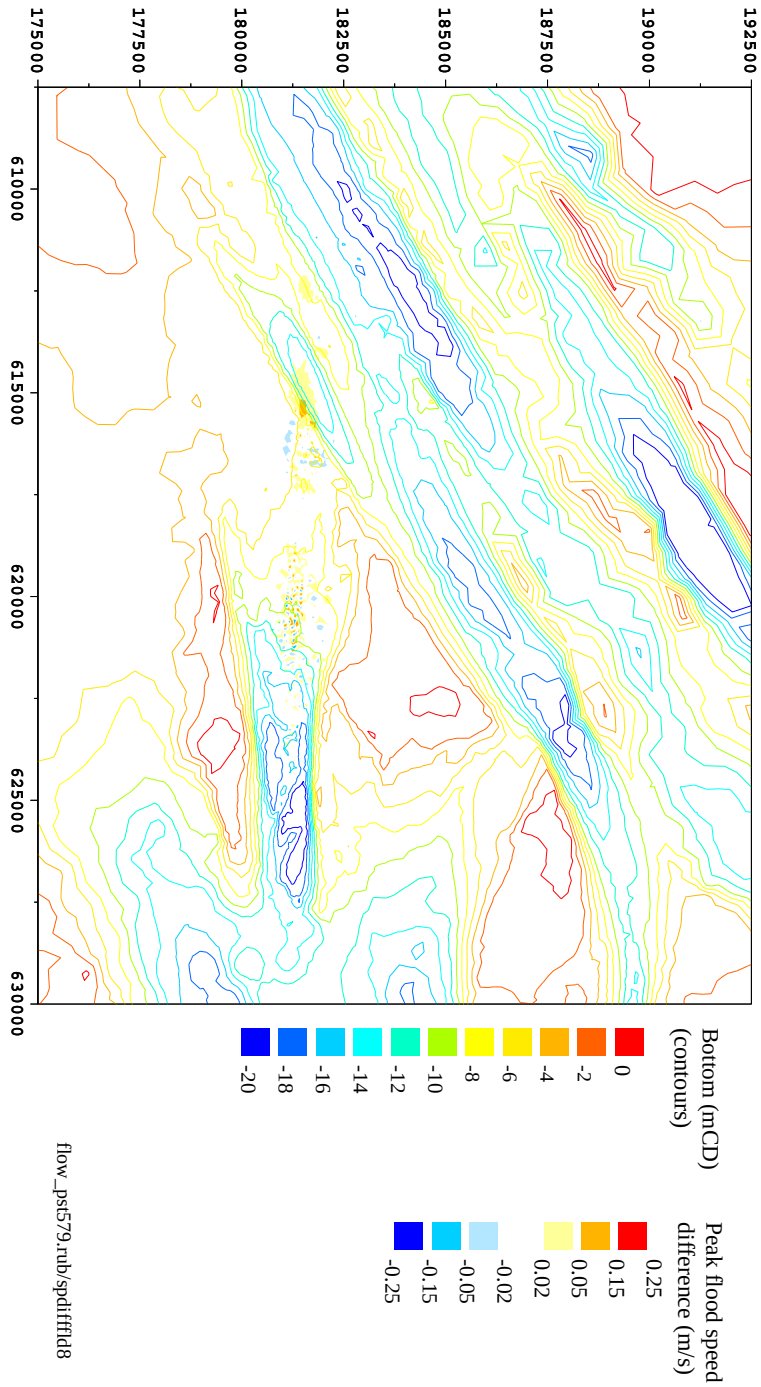


Figure 7 Current speed change with –8 m CD channel (peak flood tide)

4.5 Changes to Wave Action

4.5.1 Effect description

Wave modelling was undertaken to predict the extent of any changes to the local wave conditions as a result of the proposed Phase II dredge. As part of the Phase I studies HR Wallingford has assessed wave conditions in this area using the SWAN (**S**imulating **WA**ves **N**earshore) model. SWAN was developed by the Technical University of Delft in the Netherlands. It is a 3rd generation wave model and is a state-of-the-art tool for coastal wave studies. For this assessment the model used in the earlier Phase I study was reinstated. The bathymetry used in the model was amended to include the proposed dredged channel and the model was re-run for selected incident conditions. Based on the results of the earlier study, winds and waves from the 30°N and 60°N offshore direction sectors were determined to give the most severe conditions in the estuary. The updated model was run for a total of five conditions. The selected incident conditions applied at the boundary of the SWAN model are presented in the technical report on the accompanying CD-ROM.

The results of the new runs were then compared against the corresponding 'baseline' runs (HR Wallingford, 2004).

The wave study concluded that the proposed dredging of the Princes Channel will have little effect on the overall wave climate. For 1 in 1 year conditions, localised wave heights in the immediate vicinity of the dredging may increase by up to about 5%. However, this effect is quickly dissipated over a wide area and by the time waves reach the North Kent coast the effect is negligible (HR Wallingford, 2004). The full report is contained in Appendix B on the accompanying CD.

4.6 Changes to Sediment Transport Patterns

4.6.1 Effect Description

The flow and wave modelling studies have shown that there will be little discernable effect on these parameters outside of the channel itself. It is therefore reasonable to conclude that there is no mechanism for a resulting change in sediment transport or erosion patterns. The periodic bathymetric surveys of the area carried out by the Port of London Authority will provide information to validate this prediction.

4.7 Plume Dispersion

4.7.1 Effect Description

The dredging at Princes Channel will be carried out using a TSHD. A TSHD takes both water and sediment into its hopper and overflows the excess water through an overflow pipe. This water will inevitably contain fine sediment with the quantity dependant upon

the nature of the material being dredged. The overflowed water and sediment create a plume of material which is moved and dispersed by the tidal currents.

The characteristics of a plume also differ depending upon the characteristics of the dredger carrying out the work. The PLA commissioned HR Wallingford to undertake plume dispersion modelling for a range of dredger sizes that could undertake the work (based on the scenarios outlined in Table 2). The full results are reported in Appendix B on the accompanying CD. The model was also revised to take account of the modelling and calibration work undertaken by the PLA in princes Channel. This work comprised water quality monitoring during the Phase I dredge and a plume tracking research project.

4.7.2 Phase I Dredge Monitoring

Water quality monitoring was undertaken during the Phase I dredge to validate the predictions that impacts on water quality and shellfish would be low. Monitoring instruments (OBS and ABS) were placed on frames sited 1m above the seabed at four stations considered representative of either sensitive areas or the predicted direction of the plume. An explanation of the monitoring results is given in Section 6, but in summary, while peaks of suspended sediment were recorded, few of these correlated with any dredging activity. At one monitoring station which contained two OBS meters mounted on the same frame, one meter recorded peaks while the other did not. This indicated that the peaks were not representing real increases in suspended solids but could actually be a result of fouling or fish movement. The suspended solids levels recorded at the monitoring stations during the dredging operations were comparative with the background levels.

4.7.3 Plume Tracking

Although four water quality monitors were placed around the dredge area at locations based on the modelling predictions, it was possible that the plume had moved in a different direction or at a different depth in the water column. To provide further information on this a plume tracking exercise was undertaken involving the PLA, DRL and HR Wallingford. A dredger (of similar size and characteristics to that which carried out the Phase I dredge) filled its hopper with a load of sand with overflow operating in the normal manner. A survey vessel deploying ADCP tracked the dredger to pick up the plume. Water samples were also taken. The survey indicated that, while there was an increase in turbidity of the water in the vicinity of the dredger, this did not translate into a sediment plume.

4.7.4 Implications for the SEDPLUME Model

The results of the two monitoring surveys were provided to HR Wallingford to assist them in calibrating the SEDPLUME model. HR Wallingford advised that the data suggested that a dynamic plume effect was occurring due to the presence of a central spillway on the dredger. This meant that the overflow material resulted in a body of water which is denser than the surrounding water and which descends towards the

seabed. The plume may then impact the seabed and behave as a density current, spreading out radially (HR Wallingford, 2004). This action will decay over time as sediment settles out onto the seabed. In reality, this suggests that the majority of the material overflowed during the dredging of Princes Channel falls back to the seabed either within the channel or in the immediate vicinity. There is, therefore, only a limited amount of material forming the passive plume which would move with the tidal currents.

The SEDPLUME model for the Phase II dredge has been run both with and without the dynamic plume effect. The results presented below are only those with the dynamic plume included.

4.7.5 SEDPLUME Results for Phase II

The plume modelling used HR Wallingford's SEDPLUME model with input source terms being provided by the output from the TELEMAC-2D model and a dredger simulation model run by Dredging Research Ltd (DRL). SEDPLUME only considers fine sediment (<63 microns) as the majority of the coarser material would be expected to remain in the hopper or settle out close to the dredger. In this instance the dynamic plume effect was also included in the modelling. The model was run over five tides.

Scenario 1

Scenario 1 comprised a large dredger (12,000m^3) commencing dredging one hour before high tide. The results of the modelling show that peak suspended solids will not exceed 50mgl^{-1} above background at the edge of the channel with peak concentration increases of 20-50mg^{-l} above background extending up to 5km from the channel in the direction of the tidal flow (HR Wallingford, 2004). However these concentrations would last for a short period of no more than 30 minutes before decaying to within normal background ranges well within a tidal cycle. The dredging will be carried out only once every twelve hours, hence individual plumes will not interact. Figure 8 shows the envelope of maximum intensity and peak deposition patterns and Figure 9 shows the decay of the plume over time. No permanent deposition is predicted. Further details and figures are available in Appendix B on the accompanying CD-ROM.

Scenario 3

Scenario 3 comprised a small dredger (4,400m^3) dredging in the same manner as Scenario 1. The results are similar in that the peak suspended solids at the channel edge are below 30mgl^{-1} with peak concentration increases of 20-30mgl^{-1} above background extending away from the dredger in the direction of the tidal flow.

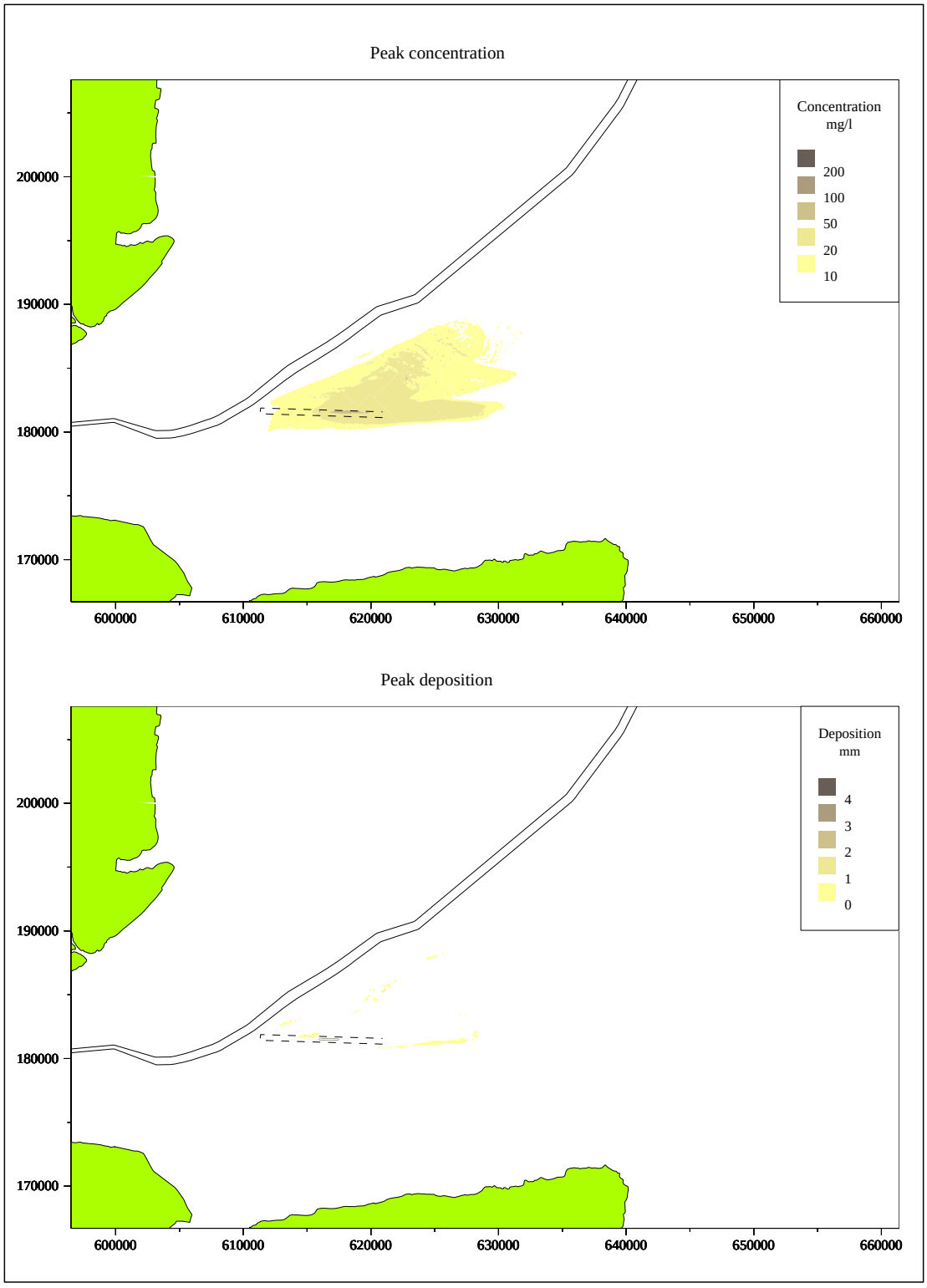


Figure 8 Predicted depth averaged concentration increases (above background) and slack water deposition arising from dredging by 12,000 m^3 dredger, with dynamic plume effect included.

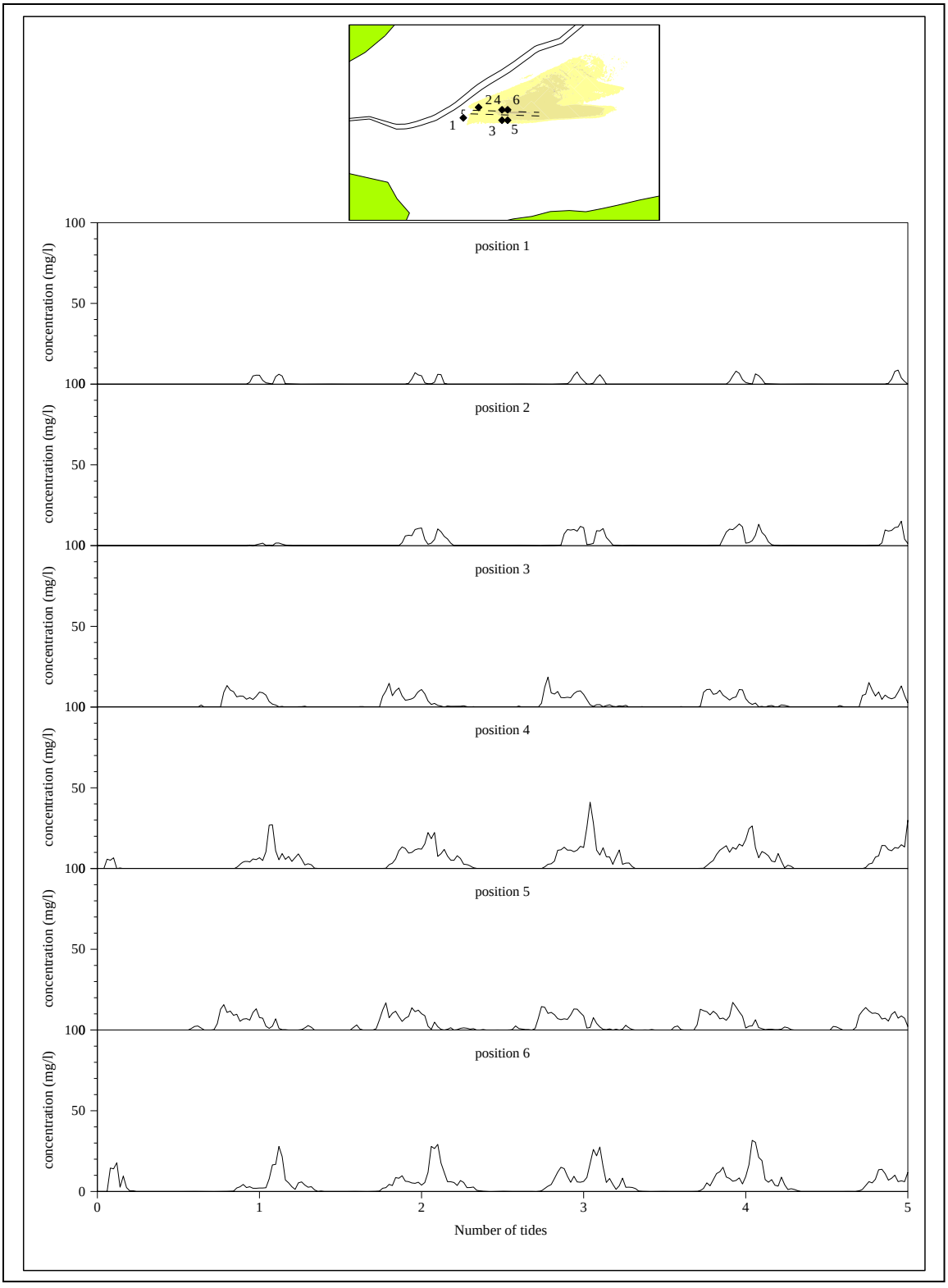


Figure 9 Time series of predicted depth averaged concentration increases (above background) at the channel edge arising from dredging by 12,000 m^3 dredger, with dynamic plume effect included.

Scenario 6

Scenario 6 is considered the most likely scenario and comprised a medium TSHD of 6,400m^3 capacity. The results of the modelling of this dredger are almost identical to the larger 12,000m^3 dredger. This is likely to be as a result of the increased settling effect in the larger dredger which will counteract the increased volume of the discharge. The dredging process model run by DRL predicted a lesser loss rate from the larger dredger.

Scenario 7

Scenario 7 considers the possibility that two dredgers may be working in the area over the same period. Such an operation would be managed by ensuring that the two dredgers were separated to different parts of the dredge area. Each dredger would then produce a plume as described above with increases of < 50mgl^{-1} above background at the channel edge and increases of 20-50mgl^{-1} extending away from the channel in the direction of the tidal flow. It should be noted that these are peak increases which will quickly decay to within normal background levels. Multiple dredgers will have the result of affecting a wider geographic area than a single dredger but should the plumes interact they will not result in increases above the levels mentioned for a single dredger. Additional increases would only occur if one dredger overflowed directly into the plume of the other dredger, thus the overflow would be entering an environment of already increased background levels. Dredging operations will be managed to ensure that a dredger does not overflow into an existing plume.

4.8 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:

- Change in bathymetry to -8.0mCD within the dredged areas.
- No change to current speed, velocity or direction.
- No change to sediment transport or erosional processes.
- Little effect on the overall wave climate.
- Suspended solids will be increased by up to 50mgl^{-1} above background at the edge of the channel.
- Suspended solids may increase by 20-50mgl^{-1} for a duration of up to 30 minutes and at distance of up to 4km away from the channel in the direction of the tidal flow.

4.9 Mitigation

Two management measures will be required to ensure the impacts of the dredging are as assessed. These measures are as follows:

The dredger should have a central spillway rather than a ship side spillway; and
If more than one dredger operates in the area the dredgers should be sufficiently separate to ensure that one overflow does not enter directly into the plume created by the other vessel.

4.10 Monitoring

Bathymetric monitoring of the channel and it environs will continue on a monthly basis (when weather conditions allow) until the stability of the final channel is confirmed to the satisfaction of the PLA Port Hydrographer.

5 SEDIMENT QUALITY

This section discusses the quality of seabed sediment in the Princes Channel. Effects on water quality from the dredging operation are considered in Section 6.

5.1 Existing Environment

Sediment quality was analysed in two surveys prior to the Phase I dredge and this provided information on sediment quality at the surface and at depth within the sediment column. The results did not show any significant contamination by metals, organic or microbiological contaminants. However, the depth sampling was limited and did not include sufficient samples from within the footprint of the channel to cover Phase II. Therefore, a further sediment sampling campaign was carried out to provide definitive information on sediment quality. The majority of the samples were taken from areas that were previously sub-surface and would not be expected to contain any effects of anthropogenic contamination.

The sediment quality survey comprised 43 vibrocores on three transects spaced 300m x 175m across the channel. Figure 10 shows the distribution of the vibrocores and the data is contained in Appendix A 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.

As with the earlier surveys, the Canadian Interim Sediment Quality Guideline levels were used as a guide to sediment quality. Analytical detection limits were set in accordance with these levels.

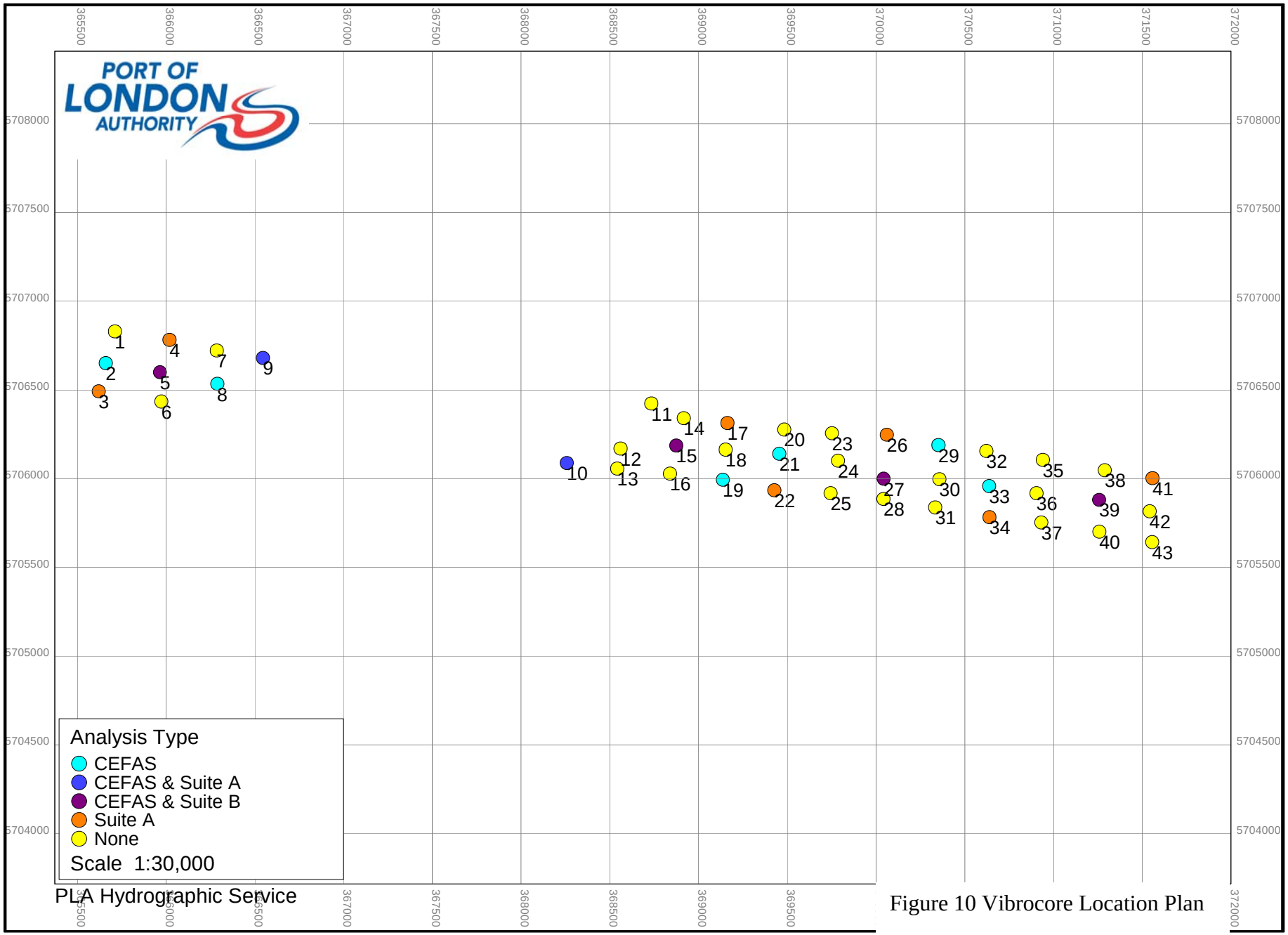


Figure 10 Vibrocore Location Plan

5.2 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.

5.2.1 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.

5.2.2 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 A on the accompanying CD-ROM.

5.2.3 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).

5.2.4 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 6 provides a summary of the metals data for surface sediments.

Table 6 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:

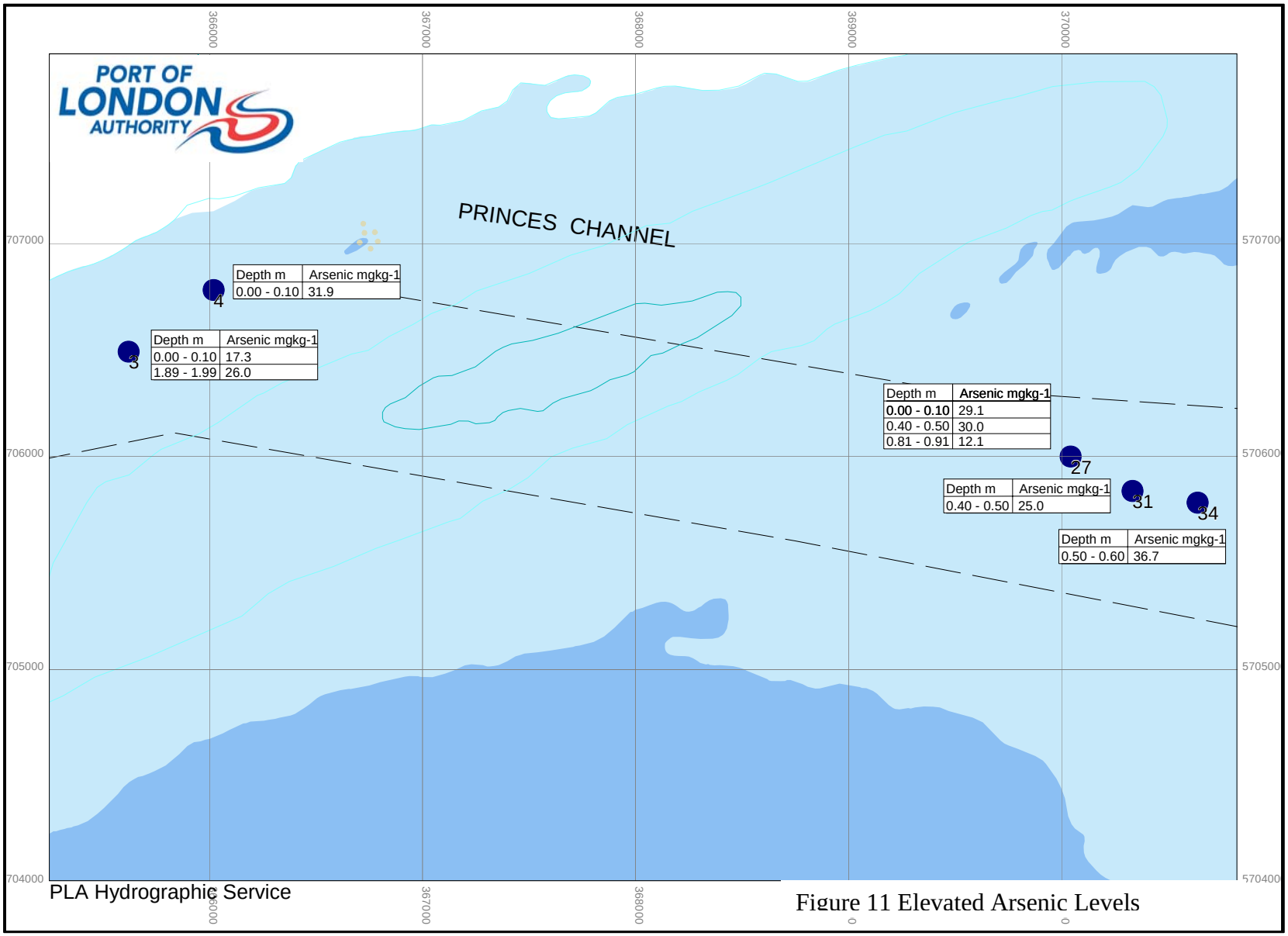
- Arsenic levels are considered slightly elevated at most sites in surface samples. The concentrations decrease with depth to what could be described as background at depths of greater than 2.5m (~$4.5 mgkg^{-1}$). Although slightly elevated above the ISQG, the majority of concentrations are well below 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 11 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.

- Site 39 (see Figure 10) 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.

5.3 Conclusion

The sediment quality survey found low or undetectable levels of all parameters. There were no parameters found at levels that would preclude sea disposal of dredged material. The fate of the dredged material from Princes Channel will ideally be for use in construction projects and the sediment quality data will be made available to those involved in such projects. Should beneficial use not be available then the PLA hopes to place the sand in the North Edinburgh Channel and a FEPA application has been made to Defra on this basis. The supporting Environmental Characterisation report compares the sediment quality in the material to be dredged with that present in the North Edinburgh Channel.



PLA Hydrographic Service

Figure 11 Elevated Arsenic Levels

6 WATER QUALITY

This section considers the impacts of the dredging 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 Princes 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 the Princes Channel did not identify significant levels of contamination in the sediment 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 $10mgl^{-1}$.

6.2 Phase I Monitoring Results

The water quality monitoring was carried out in Princes Channel for five distinct periods, as shown in the Table 7

Table 7 Monitoring periods

TYPE AND LOCATION OF MONITORING	START DATE	FINISH DATE
a) Background monitoring – location 3	21/2/03	24/3/03
b) Background monitoring – location 3	26/3/03	24/4/03
c) Monitoring during dredging – locations 1, 2, 3, and 4	10/6/03	24/6/03
d) Monitoring during dredging – locations 1, 2, 3, and 4	27/6/03	18/7/03
e) Background monitoring – location 3	22/7/03	19/8/03

The minimum amount of instrumentation at each monitoring location consisted of the following:

- An Aquadopp current meter;
- An Optical Backscatter Sensor (OBS);
- A Dissolved Oxygen (DO) sensor; and
- A Diver locator beacon.

Additional instrumentation was included at some of the locations to detect movement of the frame (altimeter) or to back up instrumentation (an additional OBS sensor). The backscattered sound from the Aquadopp current meter was also recorded and calibrated to give turbidity measurements (ABS). Temperature and salinity were also monitored.

The detailed results from the water quality monitoring operations are appended as Appendix C and an overview of the data is also provided.

As outlined in Seciton 4.7.2 the monitoring did not detect the plume from the dredging operations. This is thought to be because the original SEDPLUME monitoring did not take account of the dynamic plume effect from dredgers with central spillways. With such a dredger, the passive plume (that floats with the tide) is significantly reduced.

Further, no changes to dissolved oxygen levels attributable to dredging operations were observed.

6.4 Input of Contaminants to the Water Column

6.4.1 Impact Description

The sediment quality assessment has not identified contaminants present at levels that may cause impacts on marine aquatic life. Microbiological parameters are also not present. Given this, it is reasonable to assume that the potential for impact on water quality is of **negligible significance** and the potential for the dredging of Phase I of Princes Channel to affect the Shellfish Waters monitoring points is negligible.

6.5 Increase in Suspended Solids Levels

6.5.1 Impact Description

As discussed in Section 4.7.5, the dredging has the potential to cause short term increases in SS levels close to the dredger and extending to the channel edge. The SS levels are predicted to peak at $50mg1^{-1}$ at the channel edge for a period of less than 30 minutes. Peaks of between $20\text{-}50mg^{-1}$ may be seen extending in the direction of the tidal flow. Increases of such low magnitude are considered to be well within the natural background levels of variation and therefore of **negligible significance**. In addition, the plumes from each dredging run will not overlap and will have decayed to within background levels

prior to the dredger returning. **No cumulative effects are therefore predicted**. Once again, it is not predicted that SS levels at or near the Shellfish Waters monitoring points will be affected.

6.6 Increase in Dissolved Oxygen Levels

6.6.1 Impact description

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 dredged has a low organic content and, therefore, a low biochemical oxygen demand. **No impact** on dissolved oxygen levels is predicted.

6.7 Monitoring

A single water quality monitoring station is proposed to be located at Station 3. This monitoring will validate the predicted assessment relating to suspended sediment levels and dissolved oxygen.

6.8 Conclusion

The monitoring of Phase I demonstrated that there were no observable impacts to water quality for the dredging operation. Although the Phase II dredge is of a greater magnitude there are no contaminants present I the sediment at levels of concern and the plume dispersion modelling has shown that the effects are likely to be within natural background variations.

7 MARINE BIOLOGY

This section introduces the biological environment of the study area and summarises the results of the surveys carried out to provide information on predicted effects and impacts. Further information on these studies is provided in each of the referenced reports.

7.1 Existing Environment

A marine biological survey was undertaken to inform the Phase I dredge. Since the survey the area has been dredged so there will have been a loss of biodiversity within the dredged areas, however, for completeness the results of the survey are summarised in this section. The survey was agreed in advance with CEFAS and the EA and comprised a series of 45 benthic grab samples and epibenthic trawl samples at eight trawl sites carried out in February 2002.

The trawl surveys were subsequently repeated in April and August 2002 to provide an understanding of the seasonal changes of the resource. The key findings of the surveys are summarised as follows. A total of 138 taxa of benthic invertebrates were recorded from the survey area as a whole; this is considered typical of shallow water sandy deposits elsewhere in the coastal waters of the southern North Sea. The survey did not identify any communities of special conservation significance or species that are not widespread elsewhere. The only species of potential conservation significance was the occasional specimen of the reef-building worm *Sabellaria spinulosa*. However Marine Ecological Surveys (MES) advise that there is no evidence from this or other surveys that major sub-tidal reef structures of this species occur off the North Kent coast.

The trawl surveys recorded a wide range of invertebrates and fish that are typical of the outer Thames Estuary. In all a total of 21 macro-invertebrates and 19 fish species were recorded in February 2002. The results of the April and August surveys show that the species composition of the fish and epibenthos were essentially similar, although there was a continuing increase in population density of both invertebrate and fish components with August showing major increases over the previous surveys. This increase was entirely consistent with the expectations of those undertaking the survey, but even with these increases, MES report that the population densities are not high compared with those recorded in similar surveys at sites in the inner estuary.

7.2 Direct Removal of Benthos and Loss of Habitat

7.2.1 Impact Description

The Phase I dredge removed approximately 1m of sediment from the majority of the areas to be dredged in Phase II. The dredging process will also have removed the biological habitats and communities within the area. As these communities are impoverished and representative of a sandy substrate that is widespread in the Thames the impacts are considered to be of **minor adverse significance**. The Phase II dredge will repeat the process. Once this dredge is complete recovery will commence.

7.2.2 Mitigation

Mitigation is not considered necessary as recovery will occur naturally.

7.2.3 Residual Impact

The residual impact of the direct removal of benthos and habitat is minor adverse significance.

7.3 Change to Seabed Habitat

7.3.1 Impact Description

The dredge is not predicted to change the seabed sediment which will remain sandy and thus provide for the same communities that existed prior to the Phase I dredge.

7.4 Impact to Protected Species

7.4.1 Impact Description

No rare or protected species were recorded during the survey. The Ross Worm was observed but 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.

8 NATURAL FISHERIES

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

There are no frequently fished cockle grounds in the vicinity of Princes Channel, the nearest being some 7.5km to the south west on the Red Sand and Middle Sand. To the south east are the beds on the Margate Sands which are only occasionally fished. There are also some occasionally fished beds on the Girdler/West Shingles Bank. Discussions with KESFC have not raised any concerns about proximal shellfish beds.

Also of importance is the feature of the Thames Estuary as a spawning ground for sole. Other species also spawn in the area, e.g. there is a localised herring spawning area inshore of Princes Channel. However the number of juveniles taken in the MES surveys suggest that the area is not of importance as a nursery ground for fish, with the possible exception of Dab.

Information on fisheries resources has been obtained from the marine biological surveys and discussions with CEFAS, the EA and KESFC. The consistent view from KESFC representatives has been that Princes Channel itself is of limited importance for fisheries and that the surrounding banks and sands are of greater importance for fishing. The area is also not considered to be of importance for juvenile fish.

Full details on the fish species present, their seasonal distribution and biomass can be found in the in Appendix D on the accompanying CD-ROM.

8.2 Smothering of Shellfish Beds

8.2.1 Impact Description

As noted in Section 8.1, there are no actively fished cockle beds in the vicinity of Princes Channel. With one exception, the beds identified as actively or occasionally fished do not lie within the predicted dispersion pattern of the dredging plume. The exception is the occasionally fished beds on the Girdler/West Shingles Bank. These areas lie 2km from the edge of the channel and, according to the modelling results, should not be subject to either high suspended solid levels or deposition. This was confirmed by the water quality monitoring during the Phase I dredge.

Cockles are also extremely sensitive to falls in DO, particularly in April to June but the dredging is not predicted to have an effect on DO levels.

The impacts of the Phase II dredge on shellfish are considered to be **negligible**.

8.3 Spawning Fish

8.3.1 Impact Description

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. Although Princes Channel is not within the area shown as being important for sole spawning it is possible that some sole also spawn in the channel and surrounding banks. In any case, sole eggs and larvae will be present in the water column with their location dependant on tidal action. 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. However, sole spawning is thought to be concentrated in the shallow coastal areas and it is considered unlikely that the dredging operation, being in the deeper offshore part of the estuary, would have an adverse effect on spawning sole.

8.3.2 Mitigation

Where possible, the dredging will not be carried out during the sole spawning period of March to May.

8.3.3 Residual Impact

The residual impact on spawning sole is considered to be **negligible**.

8.4 Nursery Area

8.4.1 Impact Description

Many species of fish use the outer Thames Estuary as a nursery area and the North Princes Channel may form part of that area. Juvenile fish would usually be found in the shallower waters over the banks and surface waters of the channel, therefore, direct effects from the dredging operation would be unlikely. KESFC 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 dredging operation would be disturbed and displaced or entrained. The potential impact of the dredging operation on juvenile fish is considered to be of **minor adverse significance**.

8.4.2 Mitigation

No mitigation is considered necessary.

8.4.3 Residual Impact

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

8.5 Interference to Adult Fish Behaviour

8.5.1 Impact description

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 Princes Channel does not provide an important feeding area in its own right but forms part of the wider North Sea habitats. The dredging operation is predicted to remove seabed habitat but recolonisation will gradually occur. An impact of **minor adverse significance** is predicted on the feeding ground.

There will be no significant lateral plume from the dredging operation but there may be an area of increased suspended sediments through the water column for a short duration. It is anticipated that adult fish will simply move away from this area. Some fish, sole for example, travel at night and thus would not be affected by decreases in visibility caused by increases in SS levels. An impact of **negligible significance** is predicted on adult fish movement.

8.5.2 Mitigation

No mitigation is considered necessary.

8.5.3 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

8.6.1 Impact Description

Marine mammals including porpoise and seals are occasionally recorded in the outer Thames Estuary. The sandbanks adjacent to the Princes Channel 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 dredging operation.

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 dredge site in Princes Channel (Gill et al., 2004):

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

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 Princes Channel is the main approach to the Port of London from the south and is heavily used by ships. Many of these ships would be noisier than a dredger. The additional presence of one dredger in Princes Channel is considered to be of **negligible** significance.

9.2.2 Mitigation

No mitigation is considered necessary.

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. The dredging operation will affect only the seabed in water depths of greater than -6.0mCD. There will be no direct impacts to sandbanks. The limited passive plume and low increases in suspended solids levels indicate that there is no mechanism for any indirect effects on the sandbanks. 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 Princes Channel 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 overflow from the dredging will enter the water column nearer the seabed than the water surface there will not be a plume of material remaining in the upper water column. It is likely that fish would take avoiding action and move away from the dredging operation into clear water. The

potential for impact relies on a shoal of fish and feeding divers coinciding with a dredging 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

No mitigation is considered necessary.

9.4.3 Residual Impact

The residual impact for reduction in water column visibility is considered to be of **minor adverse significance.**

10 DESIGNATED CONSERVATION SITES

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 nearest conservation sites to Princes Channel are approximately 20km away on the North Kent Coast (see Figure 2). More specifically, the closest points are the eastern extremity of the Thames Estuary and Marshes SPA and the westernmost point of the Thanet Coast European Marine Site.

The Thames Estuary and Marshes SPA is designated for the following interest features:

- Internationally important populations of regularly occurring Annex 1 species;
- Internationally important populations of regularly occurring migratory species; and
- An internationally important assemblage of waterfowl.

The Thanet Coast cSAC is designated for the following interest features:

- Reefs; and
- Submerged or partially submerged sea caves.

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.

10.2 Change in Extent or Nature of Coastal Habitat

10.2.1 Impact Description

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 dredging operation have been considered against the relevant conservation objectives and no impacts are predicted on the extent or nature of the habitats at the designated conservation sites due to the following factors:

- The geographical distances from the designated sites to the Princes Channel;
- No significant changes are predicted to the hydrodynamic conditions outside of the channel boundary;
- No significant changes are predicted to sediment transport and erosion patters outside the channel boundary; and
- No impacts are predicted on water quality.

10.3 Interference with Birds on Route to the Coastal Sites

10.3.1 Impact Description

Birds on route to and from the coastal conservation sites may fly over the Princes Channel. The only visible sign of the dredging 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

10.4.1 Impact Description

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

10.5.1 Impact Description

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 but there was no evidence to suggest that reef structures are present. Based on the survey data, the Princes Channel 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 dredging operations.

11 MARINE ARCHAEOLOGY

This section considers the effects of the proposed dredging 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 E 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). In the middle of the Mesolithic period sea level rose to15m below current sea level and shallow marshland and intertidal flats were formed. Such areas have been identified in the Thames Estuary approximately 40km to the north east of the Princes Channel (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). Throughout the Palaeolithic and Mesolithic periods, the well-drained sand and gravel terraces around the estuary were favoured locations for the activities of early humans. Terraces of Shepperton gravel and Kempton Par/East Tilbury Gravel are noted to the north of the Princes Channel following the edge of the Thames palaeo-channel. Hence, it is reasonable to assume that such terraces also exist in the vicinity of the areas to be dredged (Wessex Archaeology, 2004).

There are currently just three known submerged archaeological sites of Mesolithic date in the UK, and none of Palaeolithic date. There are no known sites within, or near to, the areas to be dredged. 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 are 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).

The Thames Estuary region has the heaviest concentration of occupation during the Bronze Age and bonze hoards have been found along the Kent and Essex coasts. Bronze objects have been found at Pan Shoal to the south of Princes Channel. Iron Age and Roman finds have also been recorded on the foreshore.

It seems likely that the proposed dredging area was navigable during the later prehistoric and Roman period. The mobile sand banks are well documented as presenting navigational problems to mariners throughout the Post-Mediaeval period, and it would not be unlikely that a number of prehistoric or Roman vessels foundered in a similar way navigating through Princes Channel.

There are 62 known maritime sites with the area selected as the Marine Study Area comprising both documented wrecks and seabed features. None of the wrecks are designated by the Ministry of Defence under the Protection of Military Remains Act 1986. The wrecks range in date from the 18th Century to 1941 but over half of the wrecks have not been dated at all. One wreck within the Princes Channel (discovered as a result of this project) has recently been dated to the 16th Century and is, therefore, of considerable interest. Despite studies of records an identity has not yet been found for this wreck.

There are no recorded obstructions within the proposed dredging areas. A number of magnetic anomalies were recorded within the dredged area but no corresponding records indicated any archaeological interest. These anomalies were removed during the Phase I dredge.

11.2 Damage to Palaeoland surfaces

11.2.1 Impact Description

Indications of palaeoland surfaces may be found as organic layers in borehole surveys. Two geotechnical investigations have been carried out in the Princes Channel, the second comprising 43 vibrocores all located within the areas to be dredged. No organic material was found within the vibrocores at depths of up to -8.0m CD, although material was found at greater depths. The Princes Channel Development will not therefore directly damage any buried palaeoland surfaces and the impact is considered to be of **negligible significance**.

11.3 Removal of 16th Century Wreck

11.3.1 Impact Description

The wreck identified as 16th Century (timbers have been dated to 1574) is located directly in the middle of the Princes Channel. Detailed diving and desk-based work has been undertaken to characterise the wreck prior to deciding on a mitigation strategy. Consideration has also been giving to moving the Channel but there is no safe and viable route. Any new route is also likely to impact on wreck sites of potentially equal importance. The wreck must, therefore, be removed and such removal would constitute **a major adverse impact**.

11.3.2 Mitigation

Discussions have been ongoing between the PLA (advised by their consultants Wessex Archaeology) and English Heritage to agree a suitable mitigation strategy. The agreed mitigation strategy comprises the following:

- Archaeological investigation and recording (both in situ and once lifted on land) of the wreck site and the ship. An outline of the wok is included as Appendix E.
- Implementation of an Archaeological Strategy for the area within the PLA's jurisdiction. This includes reviewing and assessing the importance of wrecks and features contained on the various databases.

11.3.3 Residual Impact

Without mitigation the impact of removal of this historic wreck is considered to be **major adverse**. Even with mitigation the residual impact is still considered to be **moderate/major adverse** due to the physical loss of what is considered a rare and unique feature.

11.4 Impacts on Other Archaeological features

No other archaeological features have been identified within the proposed dredge areas. There will be no change in hydrodynamic processes outside of the channel and thus no changes to erosion rates in areas containing features of potential archaeological interest. There is, therefore, a **negligible** potential for impact.

12 COMMERCIAL FISHING

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

12.1 Existing Environment

Discussions with fishermen have indicated that there is limited fishing in Princes Channel itself but that fishing is carried out for sole on the surrounding banks and, further afield, for cockles. During the Phase I dredge it is understood that one fishing vessel reported the presence of the dredger to KESC but that no complaints or concerns were raised.

Discussion of the impacts on fish is included in Section 8.

12.2 Interference with Fishing Vessels

12.2.1 Impact Description

Fishermen and their representatives have raised concerns about increases in shipping using Princes Channel affecting their ability to fish in the area. There has been no increase in shipping traffic as a result of the Phase I dredge. Once the Phase II dredge is complete, the effect will be to spread the current shipping over a wider tidal range, thereby avoiding the existing high densities of vessel traffic using the channel over the high tide. There will also be a small overall increase in shipping using the channel because ships which have previously, for draught reasons, had to use alternative access routes will be able to access via their chosen route. Give the wider accessibility provided by the Phase II dredge, this is not anticipated to increase traffic density to the detriment of fishing activity.

13 NAVIGATION

13.1 Existing Environment

At the present time, the channel depth in Princes Channel is limited by the Princes Channel bar. This area of shallower water effectively precludes access by deeper-drafted vessels (i.e. up to 7-7-8m) over the low water period. Further, the highly mobile and dynamic area around the North Edinburgh Channel and Fisherman's Gat has led to sediment accumulation and reduction of depths to the point where the Edinburgh Channels are no longer viable for navigation and channel buoyage has been removed for safety reasons. Further information on shipping has previously been given in Sections 1 and 2.

13.2 Interference with Commercial Navigation

13.2.1 Impact Description

The Princes Channel deepening is being carried out to reduce risk and to meet a navigational need. A stable southern approach route into the Port of London capable of meeting the time and draught constraints of contemporary commercial trade is an essential requirement. During the dredging operation, navigation will, as usual, be under the control of the PLA Harbour Master who will issue Notices to Mariners and manage vessel traffic as necessary to ensure safety. There is no predicted impact on commercial navigation.

14 RECREATIONAL ACTIVITY

This section considers the effects of the proposed dredging operations on recreational activity in the North Edinburgh Channel.

14.1 Existing Environment

The outer Thames Estuary is an important area for recreational sailing, and the southern section of the estuary is used by many craft as a route between the Thames and Medway and near-continental ports. One diving site has been identified at the Pan Sand to the south of Princes Channel.

14.2 Interference with Recreational Activity

14.2.1 Impact Description

River users including recreational sailors and diving teams will be notified of the presence of the dredger in the usual way, i.e. a Notice to Marines will be issued by the PLA Harbour Master. All navigation is under the control of the Harbour Master who is responsible for navigational safety. 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 dredging 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 Princes Channel Development (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 1.5km from the Princes Channel and no interference is anticipated between the two projects. The Phase II dredge will not affect the windfarm due to the limited extent of changes to hydrodynamic conditions. Effects on waves were considered further and are described below.

15.2.1 Change in Wave Height

The potential effect of the Phase II dredge on the Kentish Flats windfarm was considered and changes to wave height modelled. The effect of the dredging is to marginally increase wave penetration into the wind farm area and to slightly change the pattern of wave heights in the immediate vicinity of the channel. However, by the time waves reach the analysis cross sections at the coast and across the river mouth, the effect is so diffuse as to be undetectable (HR Wallingford, 2004). The wave modelling report is included as Appendix B on the accompanying CD-ROM.

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 Princes Channel Development and will need to take account of it in their

EIAs. A copy of this report will be provided to the developers, on request, to assist them in informing the relevant parts of their studies.

15.4 Subsea Cables

The PLA is in consultation with the relevant cable developers to ensure that the cables do not pass through navigation channels unless sufficiently buried.

15.5 London Gateway

The London Gateway Development comprises a reclamation and a channel dredge. The nearest part of the project is the dredging in the Knock John Channel some 5km from the Princes Channel. 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 Knock John area will be dredged before the end of 2006. 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 dredging operation and the other projects that may or may not occur in the Thames Estuary.

15.7 Presence of Ordnance

A desk study was undertaken by BAE Systems Environmental with a view to assess the presence of potential unexploded ordnance in the Princes Channel. No records of finally abandoned bombs or ordnance disposal activities on or in the immediate vicinity of the site were identified. However, because the Thames Estuary was an important shipping channel for both merchant and naval shipping during both WWI and WWII it was considered that there was a significant potential for items of ordnance to be present. Additionally, non-intrusive surveys in the trial dredging area identified small items of ordnance. As a consequence of the likely presence of ordnance, the dredging contract will address the issue accordingly.

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 Princes Channel deepening 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; and
- Round 2 windfarms: at scoping and survey stage of EIA.

In addition, the effects of the potential sand placement site in the North Edinburgh Channel must be considered. Figure 12 shows the approximate location and extent of direct effects of each of these projects.

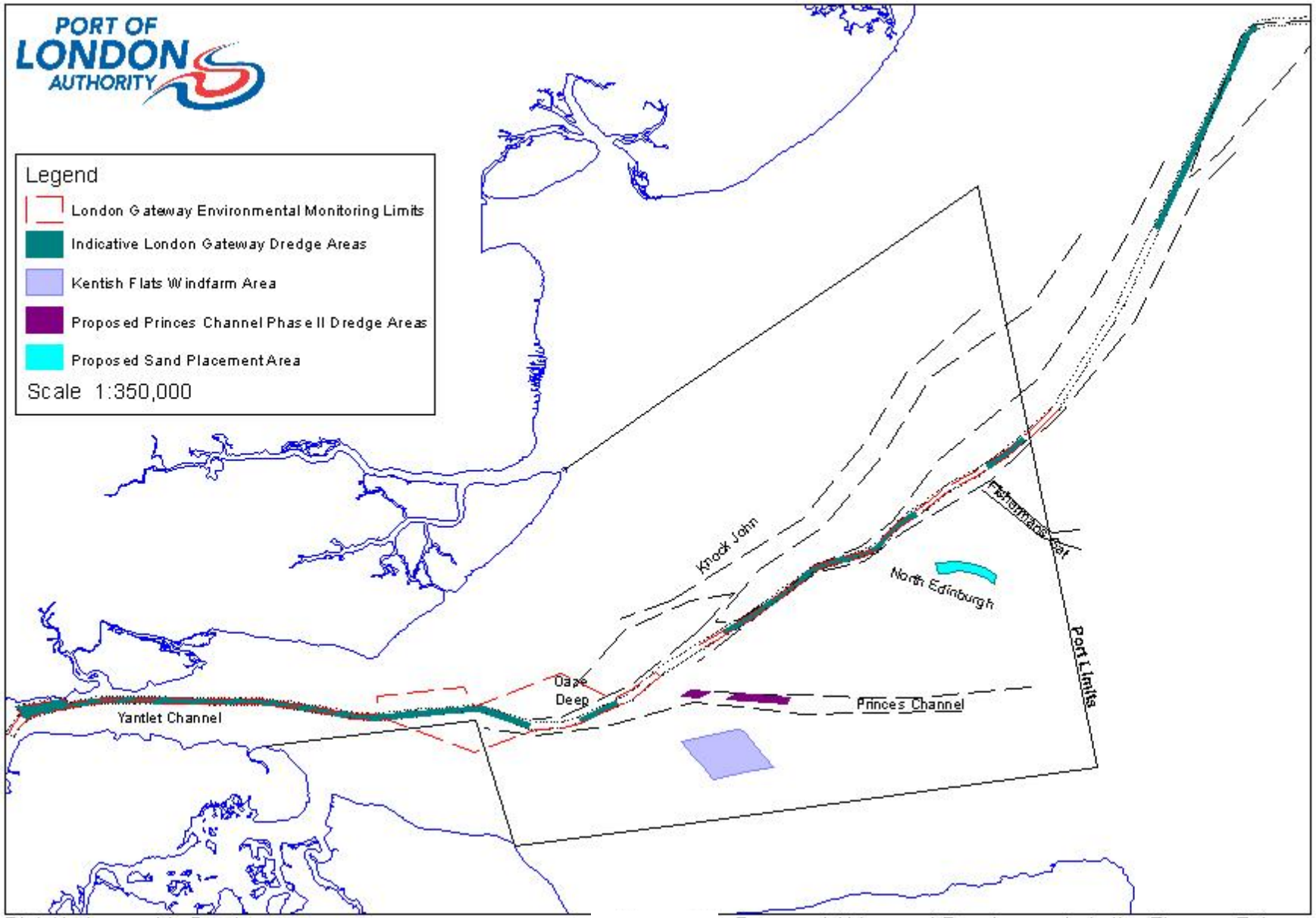

PORT OF LONDON AUTHORITY
Legend
London Gateway Environmental Monitoring Limits
Indicative London Gateway Dredge Areas
Kentish Flats Windfarm Area
Proposed Princes Channel Phase II Dredge Areas
Proposed Sand Placement Area
Scale 1:350,000
Knock John
North Edinburgh
Port Limits
Oaze Deep
Princes Channel
Yantlet Channel
PLA Hydrographic Service
Proposed / Licensed Developments in the Thames Estuary

Figure 12

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 and the commencement of dredging in the Princes Channel. It will, therefore, be the responsibility of the windfarm developers to take into account the effects of the activities in the Princes and North Edinburgh Channels 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 North Edinburgh Placement Site, the proposed London Gateway Development and the Kentish Flats windfarm. Figure 12 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 12 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, 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 16.5, 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 12. 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.

17 CONCLUSIONS

An environmental assessment has been undertaken to consider the impacts of Phase II of the Princes Channel Development. The initial, Phase I, dredge was completed in August 2003.

A series of baseline surveys were carried out prior to the Phase I dredge to provide information on marine biology, sediment quality, fish, bathymetry and hydrodynamic parameters. A further detailed vibrocore survey of sediment type and quality was undertaken prior to the Phase II dredge. Desk-based studies were undertaken to consider the archaeological potential of the site.

The conclusions of the assessment are presented as follows:

1. The dredging operation will cause localised changes to hydrodynamic properties in the Princes Channel but the changes will not affect areas outside of the Princes Channel area. There will be no observable changes to sediment transport or erosion patterns.

2. The seabed sediment has been analysed for common contaminants and is considered chemically clean. It is therefore considered to be suitable for placement at sea, for which application has been made to CEFAS. .

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 dredge site is impoverished and representative of communities inhabiting sand environments. There were no species of conservation importance identified in the survey. The Phase I dredge will have removed much of the previous biological community and recovery will commence on completion of the Phase II operations.

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 dredge site is of any specific importance. However, in recognition of the increased sensitivity during the important sole spawning period, the PLA will, where possible, avoid dredging activities during this time.

6. Bird usage of the Thames Estuary is geographically widespread and variable from year to year. The presence of dredging vessels is a buy shipping channel is not considered likely to affect bird activity.

7. There are no designated conservation sites within 20km of the areas to be dredged and no impacts are predicted on these designated areas.

8. An archaeological assessment of the proposed dredge site found evidence for a historically important wreck site within the Princes Channel. This being investigated and lifted in accordance with a mitigation strategy agreed with English Heritage.

9. The local commercial fisherman have indicated that the Princes Channel is of limited importance for fishing, therefore, negligible effects are expected on fishing activity.

10. Commercial and recreational navigation will be managed by the PLA Harbour Master to avoid any potential interference from the dredging 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 dredging operations, where possible, to avoid the sole spawning area.

17.1 Conclusion

In conclusion, the Phase II dredging is not predicted to have any significant effects on the natural environment in the vicinity of the Princes Channel. The loss of the limited biological community will be temporary as recovery will commence on completion of the dredging. The dredge will result in the removal of a historically important wreck but this impact has been mitigated by the agreement of a detailed mitigation strategy with English Heritage.

The project will result in the improvement of navigational accessibility and safety in the wider area. Liaison with the fishing industry and navigation sector will occur throughout the project via the PLA Harbour Master.

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