The Potential Alternative Uses Of Dredged Material in the Humber Estuary

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Abstract

The Humber Estuary handles around 16% of the UK's maritime trade. It is important for economic reasons with a number ports and wharves as well as for the environment, with local, national and international designations applied to numerous species and habitats. Associated British Ports (ABP) (as well as other port operators) routinely dredges parts of the estuary for the safe navigation of vessels. Occasionally developer's capitals dredge new areas to create new or deeper channels or berth pockets in order to remain economically competitive.

This study has investigated the alternative uses of the maintenance and capital dredged material which is usually disposed of within the estuary, to alternative suitable locations within the Humber Estuary whilst taking into account the sediment composition and hydrodynamics, as well as the local need, economics and adherence to the 7 tenets of sustainable development.

The potential use locations were based primarily on the sites that have been identified by the Environment Agency (EA) has having flood defences in less than favourable condition. These locations were characterised by the sediment type, quantity of material needed to ensure protection, average flow velocities at the sites and distance from the dredge site.

By disposing of this sediment within the estuary, it keeps it available to maintain the equilibrium; however this material could potentially be used as a resource to reduce erosion and protect the flood defences behind along the banks of the Humber.

Maintenance dredging involves the removal of the recently settled sediment that contributes to the sediment budget (sediment within a system at one time including the sources, sinks and processes). Therefore only those options that allow the sediment to remain part of the budget have been considered. After taking into account the considerations identified above, this study has indicated that the maintenance dredge arising's could potentially be used for the creation of berm breakwaters within the estuary in order to protect the shore and flood defences behind from erosion and the continuation of disposal within the estuary.

Capital dredging occurs rarely in order to create new channels or berths for new or expanding ports. As capital dredge arising's do not contribute to the sediment budget more options were available to investigate. Dependant on the material type, quantity and distance between the dredge and disposal sites, the alternative uses include the construction of berm breakwaters, intertidal enhancement and also the continuation of disposal within the estuary.

Potential alternative uses for the maintenance and the proposed capital dredge arising's from the Humber Estuary have been identified taking the considerations above into account. The organisations that carry out the dredging operations however are different to those who would require the material for the potential uses identified; therefore there would be difficulties in combining the projects. From this study it appears that due to the designations of the estuary and the characteristics of the dredged material, the continuation of within estuary disposal is the most suitable method of disposal at this time. As it has fewer constraints associated with it, requires less monitoring and also appears to have more neutral than detrimental effects on the estuary than other identified potential uses. From monitoring past published charts and the

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dynamics of the estuary, historically there is no evidence to prove that this method of disposal negatively affects the estuary's functioning.

Further work including a detailed field investigation to determine the local and estuary wide effects of the proposed potential uses identified in this study on the environmental, hydrographical, sediment transport and economic aspects. This study is time and site specific for the identified potential uses on the Humber Estuary however the criteria used can be applied to future projects and on other estuaries.

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Abbreviations and Acronyms

ABP- Associated British Ports
ABPmer- Associated British Ports Marine Environmental Research
AMEP- Able Marine Energy Park
CD- Chart Datum
CDM- Contaminated dredged material
Cefas- Centre for Environment, Fisheries and Aquaculture Science
C_{org}- Organic carbon
Cu- Copper
DEFRA- Department for the Environment, Food and Rural Affairs
DfT- Department for Transport
DM- Dredged material
DPSIR- Drivers, Pressures, State, Impact, Response
EA-Environment Agency
EIA- Environmental Impact Assessment
EQS- Environmental Quality Standards
ES- Environmental Statement
EU- European Union
FEPA- Food and Environmental Protection Act
GEP- Good Ecological Potential
GES- Good Ecological Status
GPH- Green Port Hull
Ha- Hectare
HES- Humber Estuary Services
HFRMS- Humber Flood Risk Management Strategy
HMBD- Humber Maintenance Dredge Baseline Document
HMWB- Heavily Modified Water Body
HRBT- Hull Riverside Bulk Terminal
IOH- Immingham Oil Harbour
IOT- Immingham Oil Terminal
IOTA- Immingham Oil Terminal Approach
IPC- Infrastructure Planning Commission
MCZ- Marine Conservation Zone
MMO- Marine Management Organisation
MRMoToWFO- Managed Realignment Moving towards Water Framework Objectives
nm- Nautical miles
NE- Natural England
N_{org} – Organic nitrogen
OPSAR- Administration of the Oslo and Paris Conventions for the Protection of the Marine Environment of the North East Atlantic.
Pb- Lead
PPT- Parts per Thousand
PSU-Practical Salinity Unit
Pub charts- Published Charts. Charts produced by HES to monitor the estuary and aid in navigation.
Ro/Ro- Roll-on/ Roll-off

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SAC- Special Area of Conservation
SDC- Sunk Dredged Channel
SLR- Sea Level Rise
SPA- Special Protection Area
SPM- Suspended Particulate Matter
SSC- Suspended Sediment Concentration
SSSI- Site of Specific Scientific Interest
TIDE- Tidal River Development
UKD- UK Dredging
WFD- Water Framework Directive
Zn- Zinc

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1 Introduction

1.1 Background to Estuaries, Port Activity and Navigation

1.1.1 Estuaries

Estuaries, the region where the freshwater from rivers and streams meet the saltwater of the sea, are important for many reasons. They act as sea-river corridors for sediment and nutrient transfer and contaminant dilution as well as for migration routes, shelter, nursery and spawning grounds, resting sites and as permanent habitat sites for both birds and fish species (Edwards and Winn, 2006, Elliott and Whitfield, 2011). Not only are estuaries important for biodiversity but they are of economic importance for industries, recreation and tourism (Table 1.1) (Broome et al., 1988, Micallef and Williams, 2002, Cave et al., 2003, Edwards and Winn, 2006).

The Humber Estuary is a large area that covers 30,551 ha (Hemingway et al., 2008b) and accommodates a variety of niches and land uses that deliver many ecological and economical goods and services (Mazik et al., 2007).

The aim of this study is to analyse the current dredging and disposal strategies of the maintenance and proposed capital dredge projects within the Humber Estuary, and to identify potential beneficial uses whilst taking into consideration the economic and environmental implications.

1.1.2 Port Activity and Navigation

Waterways and ports have considerable socio-economic value by providing employment and recreational facilities, as well as being vitally important for transporting goods by sea (Burt and Murray, 2004) (Table 1.1).

There are four major ports located on the Humber Estuary (Brett, 1992) along with many other smaller ports and wharves including those on the Rivers Trent and Ouse (Figures A3 and A4). The Humber Estuary (including the Rivers Trent and Ouse) support a large number of domestic and foreign traffic that require navigable channels to be maintained (Figure 1.1).

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Table 1.1 The general and specific land uses (for the Humber Estuary) that occur within and adjacent to estuary's.

Land Use Type	**Specific Land Uses for the Humber Estuary**
Industrial	Cooling water for power stations e.g. Ferrybridge and Drax Disposal of effluent
Shipping Companies and Ports and associated industries	Commercial fisheries Navigation of vessels Maintenance dredging Safe anchorage for vessels Landing bulk and liquid cargoes
Capital Dredging	Expansion of ports and Marinas
Aggregate Removal	Removal of aggregate for use in construction
Agriculture	Grazing Crop growing
Nature Conservation	Protection of species of national importance Protection of areas and habitats of national importance
Land reclamation	Flood defence Habitat recreation Compensation for habitats Storage of flood water
Provide water to Residences	Water is abstracted up estuary and treated to provide drinking water
Recreation	Recreational vessels e.g. sailing Divers in the North Sea Visual aesthetic qualities for walkers

Comparison between the total domestic and foreign traffic for the Humber Estuary, England and the UK (Figure 1.1) shows that the traffic for the Humber Estuary has decreased in the years 2008 and 2009 due to the economic recession. The percentage of traffic for the Humber Estuary, however when compared with England and the UK has increased from 19.8% to 22.6% and 12.8 to 15.3% respectively. These figures show that the Humber Estuary has become increasingly more important for the sea trade since 1997.

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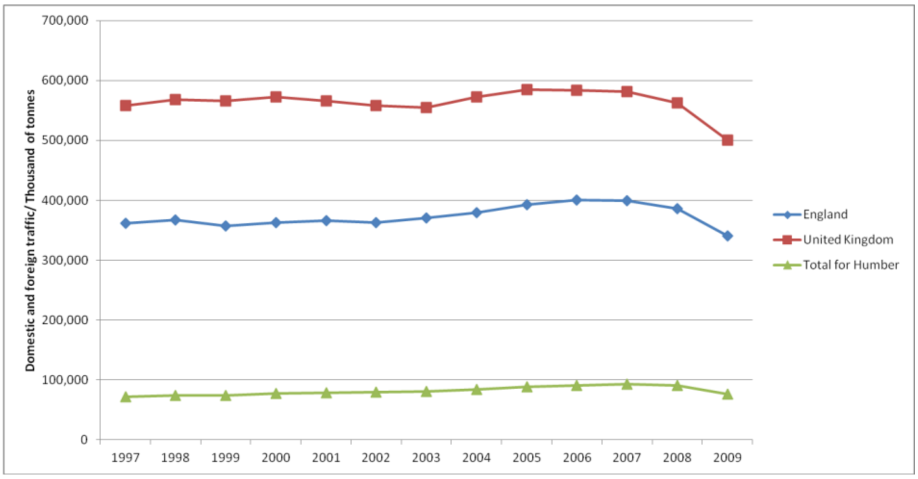

Figure 1.1 The total domestic and foreign traffic for the ports of the Humber, England and the UK (Department for Transport, 2011).

1.1.3 The Study

Dredging is necessary to allow access for vessels to safely navigate the coastlines and estuaries and support the economy. Annually, approximately 40 million wet tonnes of sediment are disposed of in approximately 150 licensed disposal sites around the coast of England (Bolam *et al.*, 2011)., Due to the introduction of landfill tax (Mitchell, 2007) and the obligation under the Marine and Coastal Access Act, 2009, some ports such as Harwich Haven and Port of London Authority are investigating alternative potential uses in order to reduce the costs for landfill tax and comply with the Marine and Coastal Access Act (section 3.8.2) (UK Marine Special Area of Conservation Project, 2001, Royal Haskoning, 2007).

This study will look at the potential alternative uses of dredged material in the Humber Estuary by carrying out a literature review (chapter 2) of past beneficial use options, sites, both in the UK and globally. These will be compared with the Humber Estuary (Chapter 3) to determine if there are any potential uses that could be implemented and if so, where (Chapters 4 and 5)?

As the government has a policy to work towards sustainable development (Office of the Deputy Prime Minister, 2005) developers are looking to reduce the costs associated, many ports are investigating the use of dredged material in beneficial ways (section 2.3) (McFarland *et al*., 1994, Ray *et al.*, 1994, Yozzo *et al.*, 2004, Bolam and Whomersley, 2003). This use of dredge material in alternative ways can not only be beneficial in terms of the environment and ecology but could also provide some benefit the populations that reside near the estuary e.g. for flood defence. (ABP Research, 1998, Bolam and Whomersley, 2003, Yozzo *et al*., 2004, Edwards and Winn, 2006, French and Burningham, 2009, van der Waal *et al*. 2011, Simpson *et al*., 2005).

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1.2 Aims, Objectives and Research Questions

The aim of this study is to investigate the potential uses of both maintenance dredge and the proposed capital dredge material in the management of the Humber Estuary. For both the maintenance and capital dredge projects, the port authority or developer must gain permission from the Marine Management Organisation (MMO) under the Marine and Coastal Access Act 2009 (sections 3.8.1 and 3.8.2).

In their guidance, the MMO state that "*the applicant must consider alternative means of disposal of dredged material before applying for a licence to dispose of dredged material at sea. . . disposal at sea should be a last resort, where no other viable options for dealing with the dredged material are available*" (MMO, 2011*a*: 28, Simpson *et al*., 2005).

The same guidance note states that reuse of the dredged material can include beach nourishment, intertidal feeding (nourishment) or creation and are discussed in Chapter 2. Disposal of dredged material in the estuary is considered a beneficial use in keeping the sediment budget balanced (Section 3.5)

Under the Marine and Coastal Access Act, 2009 and international law such as the Waste Framework Directive (2008/98/EC) however, this type of disposal is still considered as "waste". Therefore in the terms of the Marine and Coastal Access Act, it cannot be considered as beneficial re-use (MMO, 2001*a,* Dubois *et al*., 2009).

For this study however, within estuary disposal will be considered as a beneficial use option. Other alternative options that may be of more benefit to the ecology or the populations of the Humber will be considered in the first instance and within estuary disposal considered as a secondary measure if no other suitable alternative options can be identified.

The evaluation of the suitability of the dredged material for beneficial uses is re-assessed when an applicant is required to re-new their licence i.e. for maintenance dredge activities (Tom Jeynes, ABP, *pers. Comm.*, 18/04/12). This is to ensure that any changes in the activities or functioning of the estuary are assessed to determine the most suitable disposal method and location.

If the disposal (be it disposal within estuary or an alternative beneficial disposal) occurs near to or in a designated area such as an SPA or SAC (section 3.7), then in order to grant consent, the MMO (and other statutory bodies (section 3.8.1) must be satisfied that the project adheres to the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) (commonly and hereafter referred to as the Habitats Regulations) and must be confident that the project will not adversely affect the integrity of the site (MMO, 2011*a*). For this study it is assumed that the projects (maintenance or capital dredging) are granted permission and adhere to the Habitats Regulations or will do, (as some are currently under consideration) and therefore no further consideration on the Habitat Regulations will be given (section 3.8.3).

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The objectives of this study are to:

- to research the Humber Estuary to identify suitable locations for both maintenance and proposed capital- dredged material;
- consider the cost benefit dredge strategy of relocating dredged material within the Humber Estuary sediment budget for the dredge contractors, and
- consider the environmental impacts of both the extraction and deposition of the dredged material.

The research questions of this study are:

1. Where are the proposed capital and maintenance- dredged material being taken from within the Humber Estuary?
2. What are the amounts, type and characteristics of the material being dredged?
3. What can potentially be done with the dredged material with regards to the function of the potential use e.g. flood defence or habitat enhancement, the location of disposal and taking sediment characteristics into account?
4. What are the constraints of potential uses of dredged material?
5. From past studies, what are the most appropriate monitoring strategies that can used to determine if a project of beneficial use of dredged material is a success?

The term “beneficial” is a subjective term and may have different definitions for different people or organisations. Therefore, for the avoidance of doubt, the term “beneficial use” in this study will be defined as “those methods that maintain or enhance the local environment and that can also allow humans to benefit from the alternative disposal method”.

1.3 Methodology

1.3.1 General

This study has been primarily completed by desk based research with correspondence to regulators, ports and dredging contractors to determine the baseline of maintenance dredging that currently occurs. It has also ascertained the sediment types and quantities of the material that is routinely dredged by maintenance. When information has been used within this study that was delivered via correspondence the correspondents name is referenced and will be quoted as *personal communications* or as *pers. Comm* (provided in Appendix H).

This study has used environmental statements (ES) that are in the public domain i.e. have been submitted to Local Authorities or Regulators and that have either been consented or pending consent. This is to ensure that all relevant factors are taken into consideration such as the types and volumes of sediment that are to be dredged and the areas of disposal, therefore any proposed developments not in the public domain will not be considered further in

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this study. Due to the amount of the legislation that is required for the consent of a project, the necessity to adhere to the Habitats Regulations (due to the designated features of the estuary (sections 3.8.3 and 3.7)), and the time restrictions of this study, it will be assumed that all projects have been granted or will be granted consent and adhere to the all of the relevant legislation (section 3.8.2).

The scope of this study is to carry out desk based research to determine if there any alternative beneficial uses for the use of dredged material in addition to the disposal strategies already being carried out on the Humber. There have been areas identified in this study where there is limited or in some cases no information or data to increase the certainty in the findings. The additional work that would be needed to collect the “missing” data and information is beyond the scope of this study due to time constraints. Where these limitations have been identified they are discussed in Chapter 7.

1.3.2 Calculating Distances between Dredge and Disposal Sites

When calculating the distances between the dredge areas and disposal sites an online resource (www.gridreferencefinder.com) has been used, using the co-ordinates provided by ABP (*pers. Comm.)*, ABP *(in prep.a),* Environmental Statements (URS Scott Wilson, 2010, ABPmer and Scott Wilson, 2010*b*, ABPmer, 2009*a* and 2009*b*) and ABPmer (*pers. Comm.*). The shortest and most direct line has been used i.e. shipping lanes were not considered. Examples of which are shown in Figures 1.2 and 1.3. The co-ordinates are given in appendices B and C for the dredge and disposal locations respectively.

For the areas that are under threat from erosion (section 3.10) the locations were provided by the EA (Susan Manson, *pers. Comm.*) and the co-ordinates were identified from an online resource (www.gridreferencefinder.com). For those areas that cover a large extent (e.g. South Ferriby) two points were taken; the most westerly and the most easterly points. For those areas that cover a lesser extent, one central point was taken.

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Figure1.2- The method of calculating distances that do not involve meanders of the estuary.

Key:

1- Port of Hull (Alexandra Dock, King George Dock and Queen Elizabeth Dock)

2- Sunk Dredged Channel

3- River Trent

4- Spurn Point

– - Direct line of transport for the dredger from the Port of Hull to the closest point at Sunk Dredged Channel

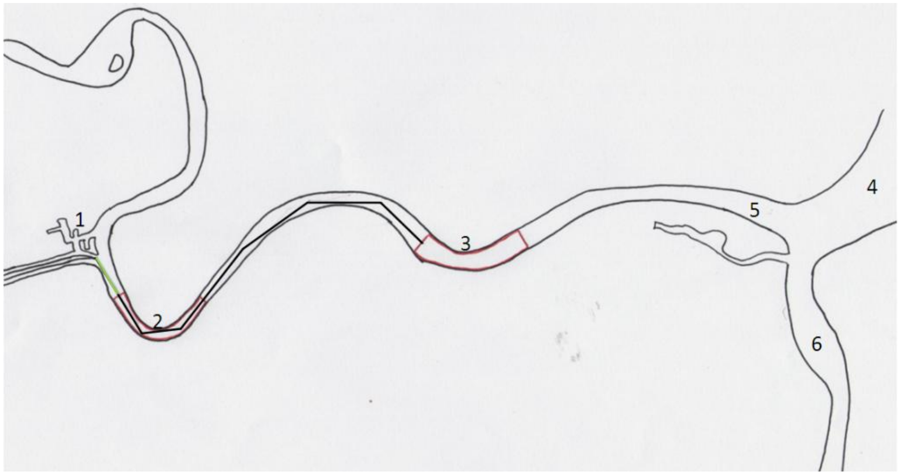

Figure 1.3- The method of calculating distance when meanders are present.

Key:

1- Port of Goole

2- Goole Reach disposal site

3- Whitgift Bight disposal site

4- Confluence of the Humber Estuary and Rivers Trent and Ouse

5- River Ouse

6- River Trent

– -Direct line of transport for the dredger from the Port of Goole to the closest point of Goole Reach disposal site

– - Direct line of transport for the dredger from the Port of Goole to the closest point of Whitgift Bight disposal site

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1.3.3 Generation of Plans in Appendix A

The plans generated in Appendix A were done so by the use of ArcGIS version 10, by using the co-ordinates provided in Appendices B and C (coordinates for dredge and disposal sites respectively). ESRI shapes were also downloaded from the Joint Nature Conservation committee (JNCC) and Natural England's (NE) website for the designated sites. All plans are based on the British National Grid co-ordinate system.

1.4 Economics of Transporting the Dredged Material to an Alternative Site

Dredging contractors and port authorities, including those operating on the Humber, were consulted asking for an indication of costing for extending the distance between dredge and disposal sites. No response was received for the costing, however Peter Crawley of Forth Ports stated that the distance is a cost consideration in dredging (*pers. Comm.,* 30/01/12, Captain Phil Cowing, Humber Estuary Services, *pers. Comm.,* 30/09/12, Sheenan *et al*., 2009).

As monetary values could not be assigned to the current and proposed strategies an assessment was made by taking into account the potential increase in cost for the additional fuel, labour and maintenance of the vessel. This was done by analysing the current dredge and disposal strategies and determining a conservative distance to ensure that the potential uses and sites are not unviable due to excess costs. This will be termed the "cost benefit dredge strategy" from here on in.

The study will use 10 nautical miles (nm) as a conservative distance based on the current and proposed dredge and disposal sites. All of the distances (between the maintenance and proposed capital dredge sites to the corresponding disposal sites) were below 6.5nm (those that had clay as part of the capital dredge arisings, however increased to 12.67nm but this is due to the clay disposal sites only being located in the outer estuary (Section 3.1, Figures A3 and A8)).

1.5 Using the Dredged Material as Construction Material as a Potential Alternative Use

Maintenance dredge would not be considered in any instance due to the need to keep this material available to the estuary for the maintenance of the sediment budget (see section 3.5 and Chapter 4).

The Green Port Hull (Appendix K) development has proposed part of the capital dredge arisings from the IOTA deepening (primarily sand and gravel) to be used for construction purposes as infill for part of the GPH project (URS Scott-Wilson, 2011). No other Humber development has considered the use of dredged material for infill and as the reclamations will require different load bearings depending on the use of the quay, the inference on whether a sediment type would be suitable or not will not be made (Sheenan and Harrington, 2009).

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Correspondence was sent to aggregate companies that operate on the Humber Estuary to research which, if any of the sediments that are proposed to be capital- dredged could be used for terrestrial construction purposes No response however was received to determine which sediment type could be used as a construction material by these companies.

Therefore this option will not be considered further in this study. It should still however be considered for future developments and investigations of the alternative uses of dredged material Dubois *et al*., 2009).

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2 Literature Review

2.1 Dredging

Dredging is defined as the removal of any material (suspended or not) from the sea or seabed and transferring to another location (Marine Management Organisation, 2011*a*) (the different types of dredgers are described in detail in Appendix F).

Dredging can be defined as maintenance or capital (explained and discussed in chapters 4 and 5 respectively). The main reasons for dredging are (CEDA, 2005):

- navigation to allow vessels to reach ports or for the passage of recreational vessels;
- maintain an operational depth within in the ports and berths;
- flood control by making storage areas for flood waters;
- construction and reclamation to build additional land and/or berths for expanding ports and/ or cities;
- beach nourishment to help re-establish eroding beaches and foreshores;
- environmental to re-establish habitats and species in a given area: or
- mining to excavate aggregates for construction, including for infill.

2.1.1 The Maintenance Dredge Protocol

Defra, the Marine Fisheries Agency (now MMO), English Nature (now Natural England) and the Ports Industry collaborated to establish the Maintenance Dredge Protocol. This would provide assistance to those wishing to seek approval for maintenance dredge applications that could potentially affect the European Designated sites around the coast of the UK.

The Maintenance Dredge Protocol recommends that the Statutory Harbour Authority assemble and update a document known as a “Baseline Document” (MMO, 2011*a*). This document should evidence the current and historic dredging activities of the area with an assessment of the potential effects that dredging may have on the conservation features (MMO, 2011*a*).

By providing information such as the historic and current dredging volumes, dredger types, disposal quantities, sediment type and sites, chemical status, monitoring and any other relevant information, it allows the competent authorities to assess the proposed dredging applications against the baseline dredging activities.

The Harbour Authority will seek Natural England’s endorsement of the assessment. If Natural England do not endorse the assessments/ findings the Harbour Authority will need to re-assess or expand parts/all of the Baseline Document. Once endorsed, the Harbour Authority will publish and make the Baseline Document available to the competent authorities, relevant authorities and the Estuary Management Committee.

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The Baseline document should be reviewed every 5-6 years to ensure that it reflects current best practice (MMO, 2011*a*). When applying for a marine licence to carry out maintenance dredging, the Baseline Document should either be included in the application or be made readily available for relevant assessments to be made.

2.2 Effects of Dredging

Dredging and disposal of dredged material is essential for aiding vessel navigation (see chapter 4) but is considered to have detrimental effects such as affecting hydrodynamic regimes and the hydromorphology of a system, which may in turn cause a shift in the equilibrium. According to Pethick (2002) the Humber Estuary is close to its theoretical equilibrium, and therefore this needs to be taken into consideration when planning new projects which include a dredging component.

The effects on the hydrodynamics and hydromorphology can cause a number of negative impacts listed below but the extent is dependant on many factors such as habitat type (and relationships summarised in Figures 2.1and 2.2) (Johnson, 1981, Day *et al*., 1989, Mitchell *et al.*, 1998, McLusky and Elliott, 2004, Bolam *et* al., 2006Harbasins, 2008):

- increased turbidity leading to;
- reduced light penetration and;
- altered behaviour in fish;
- altered tidal exchange, mixing and circulation;
- reduced nutrient outflow from marshes and swamps;
- increased saltwater intrusion;
- altered dissolved oxygen levels, and
- modifies the ratio of intertidal and subtidal, and therefore alters the area of exposed mud available for feeding birds.

The primary effects of dredging are bed alteration, bathymetric changes and resuspension of sediments which together can alter the hydrology of the area. The two major effects of dredging are of conservation and socio-economic in nature (Figures 2.1 and 2.2).

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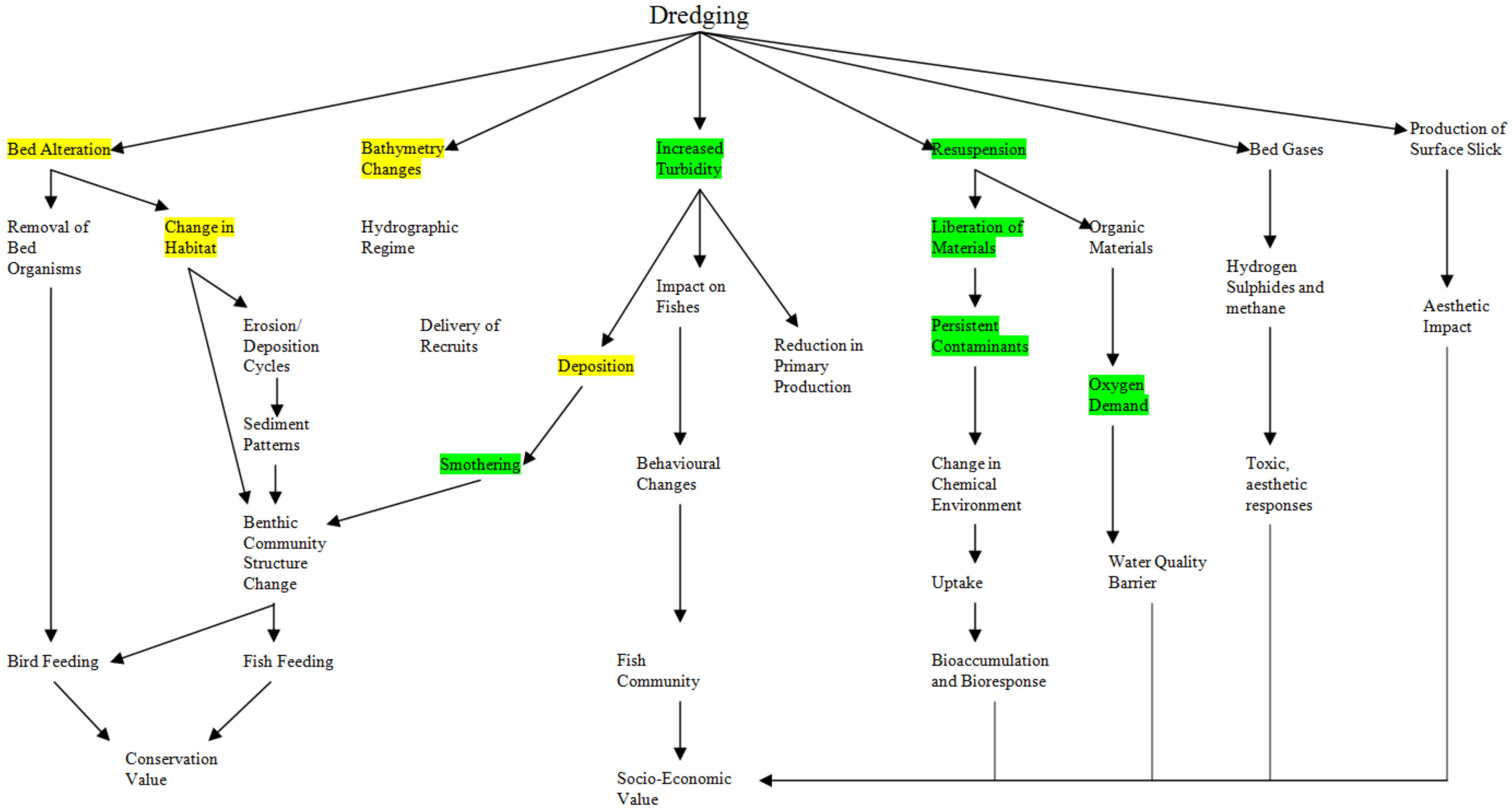

Figure 2.1 The potential environmental impacts of dredging (modified from McLusky and Elliott, 2004)

[yellow] - what man can control to reduce the effects e.g. by mitigation

[green] - what man can control to an extent but must also monitor to ensure that the activity is not having a detrimental effect.

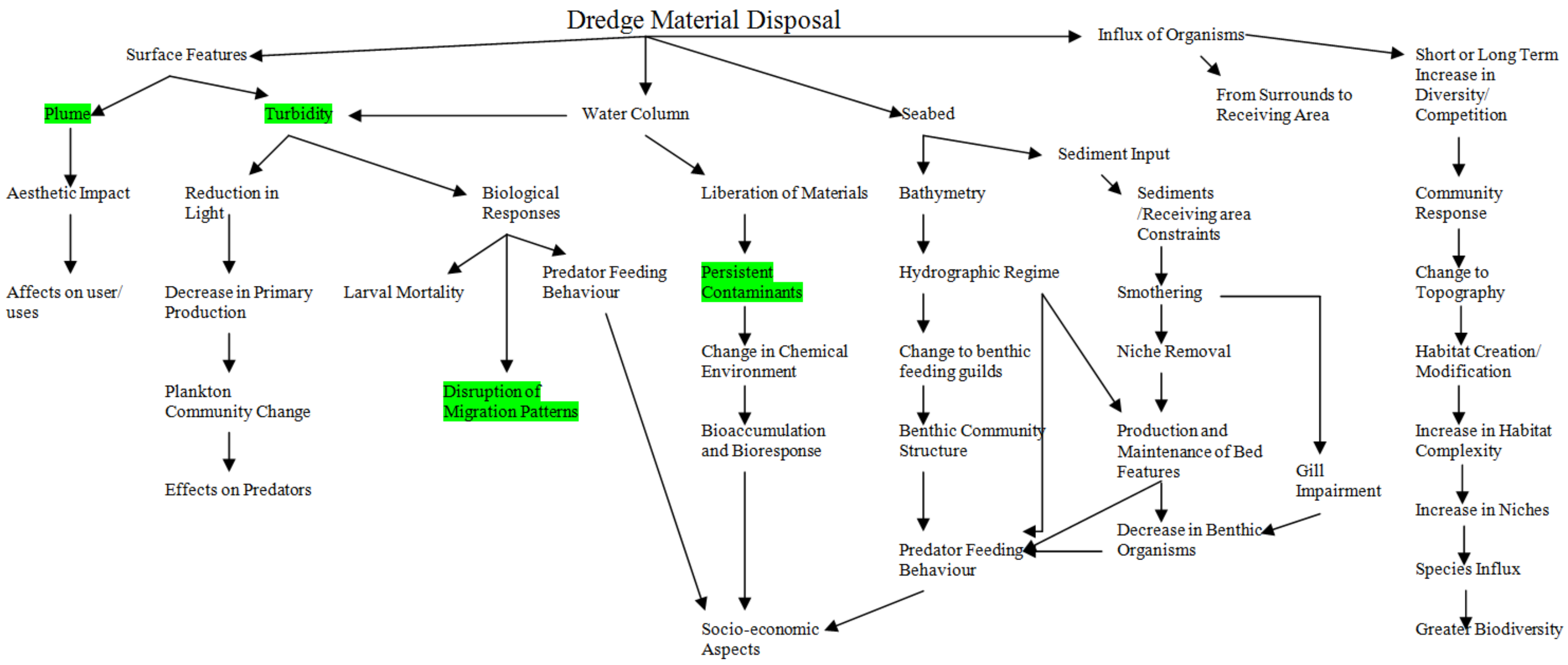

Figure 2.2 The potential environmental impacts of disposal (modified from McLusky and Elliott, 2004)

- what man cannot control but can monitor to ensure the activity is not having a detrimental effect

Depositing the dredge arisings on intertidal mudflats or in the subtidal environment can lead to the resident invertebrates being smothered. Recovery occurs by a combination of vertical migration or by settlement by both juveniles and adults (Figure 2.3) (Bolam and Whomersley, 2005).

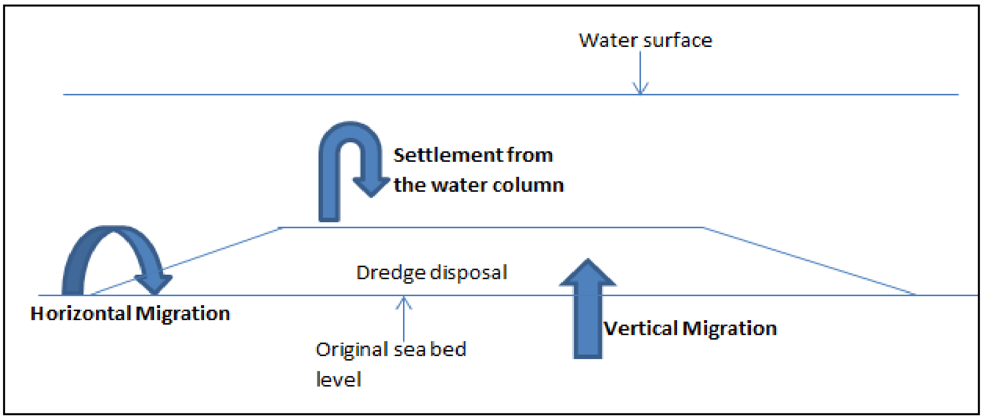

Figure 2.3 The varying migration methods that benthic invertebrates use to recolonize a dredge disposal site (adapted from Bolam and Whomersley, 2005, Mitchell, 2007).

These impacts will differ from place to place depending on factors such as geography, geology, hydrography, bathymetry, ecology and the types of commercialisation, industrialisation and urbanisation (Gupta *et al*., 2005).

The immediate effect of dredging and/or disposal however is the plume and temporary increased turbidity as finer sediments are washed downstream. Management techniques can be used to reduce the effects of plumes and turbidity clouds by using a suction dredger, dewatering of fins through sediment traps, no dredging during storms and monitoring. The amount of sediment lost through the dredging process is commonly referred to as the dredgers 's' value (the 's' values of specific dredgers are discussed in detail in Appendix F).

OPSAR (2009) advises the use of excavation tools, minimise overflow, use specially designed dredgers when dredging contaminated sediments. The use of such dredgers that introduce small amounts of sediment into the water column reduce the chances and/or effects of turbidity.

Dredging can alter the morphological equilibrium of the estuary (the balance between erosion and accretion or sources and sinks of sediments) (see section 3.5). The sediment budget is defined as "*A sediment budget is a balance of the quantity of sediment entering and leaving a selected segment of coast or estuary*" (Townend and Whitehead, 2003:756). It is important to ensure that the sediment budget is not altered i.e. more sediment is released from sources or trapped in sinks as for example, the continuous removal of sediment can reduce the flow speeds (due to the greater depth) and increase accretion at this location leading to positive feedback system (CEDA, 2005). At an intertidal level e.g. mudflats, dredging will cause the intertidal profile to slope towards the deepest part of the channel, therefore the slope will be exaggerated and will become unstable (Figures 2.4a, b and c). Where the sediment is deposited, and the depth is reduced, the flow is greater and therefore erosion can occur at this location, again leading to a positive feedback mechanism showing the importance of monitoring any sediment disposed by within estuary disposal to determine any effects.

Figure 2.4a The natural channel before capital dredging occurs

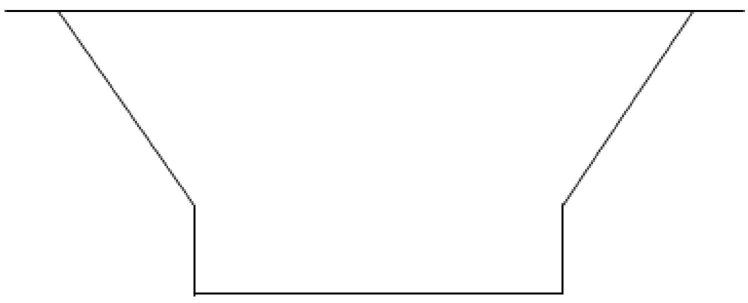

Figure 2.4b The channel post capital dredging

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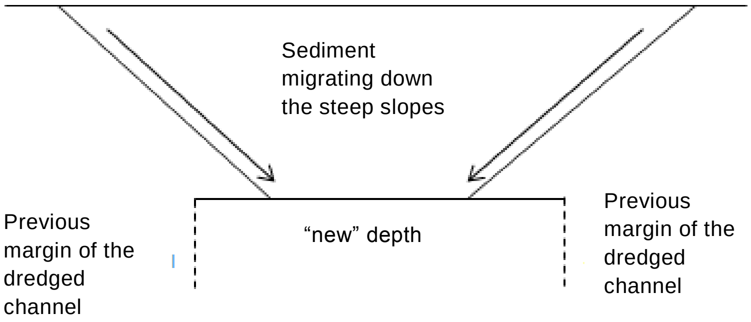

Figure 2.4c The movement of sediment down the steep slopes to produce more gradual slopes and as a result, a shallower depth.

2. 3 Science of Beneficial Use

The introduction of landfill tax within the UK legislation increased the costs for the companies that need to dispose of the dredged arisings and disposing of the material at sea is becoming more constrained by national and international legislation (Mitchell, 2007, Dubois *et al.*, 2009, French and Burningham, 2009). Therefore alternative methods were sought to keep operations economically viable (Mitchell, 2007).

There have been many studies and investigations into the beneficial use of dredged material including intertidal enhancement, berm breakwaters and beach nourishment that show varied results (McFarland *et al.*, 1994, Ray *et al.*, 1994, Colenutt, 2001, Yozzo *et al.*, 2004, Bolam and Whomersley, 2003, 2005). The differences in results may not occur purely due to the presence of the sediment being disposed of at these locations; rather there are site specific variations that must be accounted for such as the prevailing conditions and the physicochemical conditions of the sediment (Bolam and Whomersley, 2005, Bolam *et al.*, 2006).

A survey carried out by Sheenan *et al* (2009:8) found the main reasons why beneficial use practices did not occur were because of the "*engineering aspects of the material, economic viability, transports logistics, environmental constraints and the length of time involved in instigating such a process, owing to the licenses and permits required*".

It is generally accepted that capital- dredged material is more suitable for beneficial use because as it is generally coarser and in a consolidated state, it is therefore more stable and predictable whereas material that is maintenance dredged is more fine and more mobile. Maintenance dredging involves taking the top layer of sediment off which has recently settled out of suspension and forms part of the sediment budget (section 3.5). Capital dredging

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however will take deeper more consolidated material, that is not part of the sediment budget, and can therefore be taken further afield and even onshore for potential use.

The end use of the material depends on the characteristics of the dredged sediment itself (Table 2.1). Coarser sediments (i.e. those most likely to be removed during capital dredging) are more suited to protect the coastline from erosion due to their consolidated state and larger mass (Colenutt, 2001). Finer sediments (i.e. those most likely to be removed during maintenance dredging) are more suited to habitat enhancement (Table 2.1) (Colenutt, 2001). Typically fine-grained dredged material (silts and clays) is more desirable for wetland vegetation restoration than sandy materials (Colenutt, 2001, Comoss *et al.,* 2002) (section 2.5).

With all of these uses in mind, it is important to consider, the most economical and environmentally viable uses of dredged material considering characteristics whilst ensuring that the relevant stakeholders' objectives are not compromised (Sheenan and Harrington, 2009).

Table 2.1 The potential beneficial uses of dredged material depending on the sediment type (Website 24). Not all of these potential uses are applicable to the Humber Estuary i.e. aquaculture and fisheries for example, but have been included for completeness (OPSAR (2009) and Nicholson *et al.* (2010)). This list however is not exhaustive and the specific use depends on the local environment, sediment qualities and characteristics.

	Dredged Material Sediment Type				
Beneficial Use Options	Rock	Gravel and Sand	Consolidated Clay	Silt/ Soft Clay	Mixture
Engineered Uses					
Land Creation	X	X	X	X	X
Land improvement	X	X	X	X	X
Berm breakwater creation	X	X	X		X
Shore protection	X	X	X		
Replacement fill	X	X			X
Beach nourishment		X			
Capping		X	X		X
Feeder Berm breakwaters		X		X	
Keep in sediment budget		X		X	X
Agricultural/Product Uses					
Construction materials	X	X	X	X	X
Aquaculture			X	X	X
Topsoil				X	X
Environmental Enhancements					
Wildlife habitats	X	X	X	X	X
Fisheries improvement	X	X	X	X	X
Wetland restoration			X	X	X

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2.4 Potential Uses

2.4.1 Intertidal Enhancement

One solution for the potential use of dredged material is the use of dredge arisings to enhance habitats that are typical of estuaries including intertidal mudflats and saltmarshes, by raising the surface elevation (Broome *et al*., 1988). These not only act as important habitat and feeding grounds for invertebrate, over winter birds and wildfowl, but also play a part in shoreline stabilisation thereby reducing erosion (Broome *et al*., 1988, Atkinson *et al.*, 2001*a* ,Yozzo *et al.*, 2004).

The physical characteristics of the sediment used for habitat restoration relate to the successful colonisation of wetland vegetation. Typically fine-grained dredged material (silts and clays) is more desirable for wetland vegetation restoration than sandy materials (Colenutt, 2001). This vegetation will help to prevent erosion as the binding actions of the roots stabilise the sediments, as well as the vegetation itself reducing the wave energy (Pethick, 2002, Comoss *et al.,* 2002, French and Burningham, 2009). Due to the complex relationships however between physical, biological and chemical processes of saltmarshes, it is difficult to predict how the vegetation and marsh will develop over time and therefore monitoring would be required to determine the success (Atkinson *et al.*, 2001*a*).

Ray (2000) described the study of constructing two mudflats near Jonesport, Maine where 53,500m^3 of muddy dredged material was placed in shallow water surrounded by rock to help protect and stabilise the sediment. After 2 years of monitoring it showed that there was an additional 1.2ha of intertidal habitat created.

This is supported by McFarland *et al.* (1994) who found that that using a mixture of fine and coarse material was not appropriate and led to the sediment becoming highly compacted and dense and leading to process called cliffing (Figures 2.5 a and b), whereby the looser sediment at the front falls away leaving a relatively short but sudden drop on the foreshore. These studies show the importance of sediment type, sorting and grain size when determining the potential uses and will be reflected in this study.

Gray and Elliott (2009) explained that the grain size and degree of sorting influence the community structure because:

- fauna have a particular grain size preference;
- sediments are rarely uniform and vary over small distances;
- species can be specific or general;
- macroinfaunal diversity increases with increasingly poorly sorted sediment as this will have pore spaces to allow movement, aeration and the accumulation of detritus; and
- the heterogeneous sediments increase the available niches.

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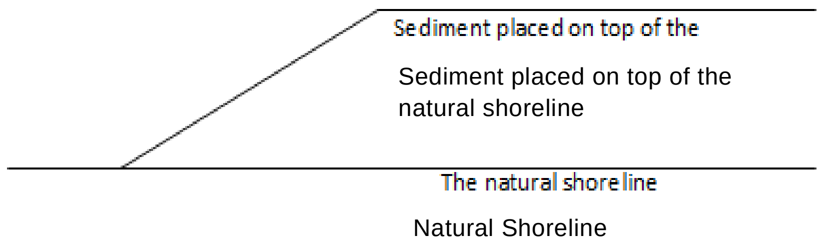

Figure 2.5a The shoreline after mixed sediment has been placed onto the shore.

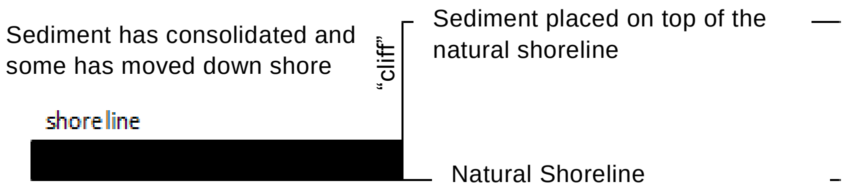

Figure 2.5b The shoreline after the fore part of the slope has migrated down onto the shoreline.

The EA has a proposal to deliver a managed realignment site at Donna Nook (EA, 2009). The silt from some of the proposed capital projects could be used to improve the likelihood of the colonisation of saltmarsh habitats and species by raising the elevation to allow saltmarsh to colonise (Colenutt, 2001).

The Humber however, due its high turbidity, accretes rapidly (Black, 1999, Boyes and Mazik, 2004, Mazik *et al.,* 2007, 2010). Therefore raising the levels could accelerate the site to terrestrial ecology, thereby not achieving the primary goals set, or achieving the goals on a short term basis.

Even though the beneficial use option is not applicable at present the Humber, the option shall be investigated in this study. The approaches used could be used in the future to determine if it should be considered in the future if erosion occurs or the accretion slows.

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2.4.2 Beach Nourishment

Beach replenishment is important in retaining the beach profile and grain size (Figures 2.6a and b). It involves rebuilding a beach to a width that provides some protection while adding more recreational and amenity benefits (Cooper and Harlow, 1998, McFarland *et al*., 1994, Colenutt, 2001, Comoss *et al.,* 2002, Bolam and Whomersley 2005, 2003). In order to do this there are different approaches as described and summarised below (Greene, 2002, McLusky and Elliott, 2004, Mitchell, 2007);

1. estimate the beach profile and place the sediment accordingly along the width of the foreshore ;
2. allow the coastal area to return back to equilibrium by replacing the sediment that is lost due to erosion with feeder Berm breakwaters;
3. overestimate the upper beach levels and allow waves to draw material down to form the natural profile;
4. using nourished sand to build a wider and higher Berm breakwater above the mean water level;
5. placing the sediment offshore to produce a Berm breakwater, this also acts to reduce erosion; or
6. placing the sediment directly on the area or spray/ pumping the sediment onto the area from an offshore rainbow dredger.

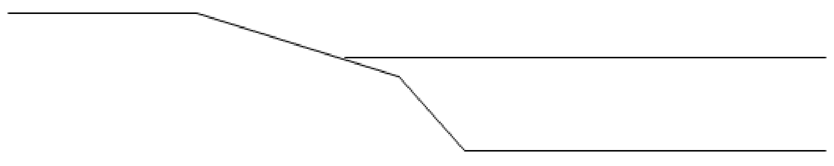

Figure 2.6a The shoreline prior to nourishment.

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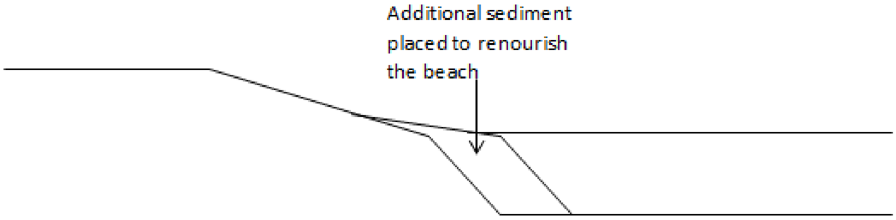

Figure 2.6b Shoreline post nourishment.

Atkinson *et al.* (2001*a*) describe how fine-grained cohesive beaches and sediments are more complex to replenish than sand or shingle beaches. As described, coarse sediments form well drained deposits on placement whereas fine grained sediments take longer to reach equilibrium it generally involves complex de-watering and consolidation processes to occur as well as biological processes on deposited (French and Burningham, 2009). Fine grained sediments can also be lost due to gravitational movement down slope if the sediment is placed on high elevation grounds. For example, French and Burningham (2009) described a beach nourishment investigation on the Orwell Estuary whereby the gravel had migrated landward and the newly created had reduced in width by approximately 60%. By recharging the area in 2000 and 2003 the area now boasts 80% of the area being colonizes by a diverse community of saltmarsh halophytes. This study again emphasises the need to monitor and the possibility of recharge.

The majority of intertidal areas on the Humber Estuary are designated primarily for the protection of species and habitats (under the SAC and SSSI) designations. There are some tourist beaches such as Cleethorpes (South East of Grimsby) that could potentially benefit from beach nourishment.

Cleethorpes however is currently accreting mud. This is leading to an increase in the colonisation in saltmarsh which in turn is stabilising the beach (Mike Sleight, NELC, *pers. Comm.*, 05/03/12). This accretion cannot be reduced due to the dynamics of the estuary in the area and the capital- dredged sand cannot be placed into the mud or saltmarsh due to the SAC designation.

This could potentially become an issue in the future as Cleethorpes may lose its tourist industry if the beach fully transforms into saltmarsh, thereby affecting the local economy. Due to the designations, the impact on socio-economy and the lack of information such as the area

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that would need material, this discussion is beyond the scope of this project but should be considered in future studies or investigations.

2.4.3 Managed Realignment

Managed realignment sites are those that have been deliberately breached, migrating the old flood defence landwards to combat sea level rise (SLR) and to compensate for the intertidal habitats being lost due to coastal squeeze under the Habitats Directive (Andrews *et al.*, 2006). An example of which on the Humber Estuary are Alkborough flats shown in Figure 2.7a and b (location shown on Figure A45). The site was breached adjacent to the Humber Estuary in 2006 and now has an area of approximately 170 ha of mudflats and saltmarsh developing. These sites increase the area of intertidal habitats for species that are anticipated to be lost due to coastal squeeze. It will also aid in realising objectives to meet good ecological status under the WFD (considered within the MRMoToWFO project as described in section 3.8.5).

Figure 2.7a The Alkborough Flats Managed Realignment site prior to the breach of the flood defences (Defra *et al.*, 2009).

Figure 2.7b The Alkborough Flats Managed Realignment site after the breach of the flood defences (WildlifeExtra, 2008).

Saltmarshes that develop at the managed realignment sites are important in coastal flood defence as they reduce erosion by attenuating wave energy and, therefore protect the sea walls from erosion, and consolidate the sediment. The restoration of a small area can lead to a substantial cost savings and a sustainable coastal defence solution by reducing erosion and increasing sedimentation (Mazik *et al.*, 2010).

Saltmarsh however can be also lost due to wave action and an increase in tidal action, therefore berm breakwaters (discussed in section 2.4.3) could be used in conjunction with saltmarsh restoration as well as vegetation planting to decrease the wave energy and therefore increasing and maintaining the flood defences in the area.

2.4.4 Within Estuary Disposal

Depositing the material at licensed disposal sites within the estuary is the current beneficial use that is employed by Humber Estuary Services. By using the sediment within a similar habitat and ensures that the biodiversity of the estuary can be maintained and the dynamics of the estuary are not altered i.e. sediments from the inner estuary should be deposited in the inner estuary (Table 2.2).

Placing sediments at the subtidal locations not only changes the species present but also changes the bathymetry at the site and can alter local hydrodynamics. This could cause sediment to migrate into shipping lanes. Humber Estuary Services (HES) monitor these sites regularly to ensure that the navigation channels are free and safe for vessels to navigate.

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The disposal itself has been shown to have environmental implications for smothering benthic fauna (Van Dolah, *et al.*, 1984, Bolam and Rees, 2003, Bolam *et al.*, 2006)

Although it has been shown that species found at dredged and disposal sites are generally more “r” species (those that are short lived and colonise a habitat quickly due to high reproductive rate) and those found in areas that are not dredged or used as disposal grounds are generally “k” species (those that are long lived and generally take longer to colonise) (Gray and Elliott, 2009). This is not unexpected as “r” species are generally colonisers and “k” species prefer a more stable and well established environment.

Bolam and Whomersley (2005) found that generally, species and individual numbers recovered after approximately 6-12 months. This is supported by Bolam and Whomersley (2003) who found on three locations of an estuary in Essex, that the macro fauna recovered slowly and after 18 months. Neither study however, found the same communities within the reference and study site. It was proposed that this may be due to the increased tidal elevation or some other, as yet unidentified variables.

A similar study was considered by van der Wal *et al.* (2011) who studied the disposal of dredged material seawards of an intertidal flat in order to modify and over all, improve the ecological productivity found after 5 years of monitoring they found that part of the sediment had moved towards the flat as intended, however the beneficial habitat was not successful, but also it did not adversely affect the site. Factors that may have contributed to the unsuccessful habitat creation could include the thickness of the disposal. If the dredged material placed is too thick, vertical migration will not occur and colonisation will rely mainly on adult and juvenile resettlement as described above.

Disposal within the estuary also ensures that the sediment that contributes to the sediment budget is kept in this balance and the estuary near its theoretical equilibrium (section 3.6). This allows that estuary to keep its functionality and ensure that no areas become erosion or accretion dominant.

Within estuary disposal is considered a beneficial use in environmental terms (for biodiversity and keeping the sediment in the sediment budget (see section 3.5)) however this study will look at alternative methods of disposal that could also benefit humans in terms of protection from erosion or for shore expansion. Therefore, the term “beneficial use” in this study will be defined as defined in section 1.2 Within estuary disposal will still be considered a beneficial use in this study as it is important in maintaining the sediment budget and the continuation of dredging but as it is not directly affecting the populations around the Humber it will be considered as a “last resort” option.

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2.4.5 Reefs

Yozzo *et al.* (2004) suggested that habitat enhancement could be accomplished by creating artificial reefs. Artificial Reefs are defined by Rousseau (2008) as "…*approved structures [that] have been intentionally placed or constructed for the purpose of enhancing benthic relief. Structures may be designed to provide and/or improve opportunities for recreational and commercial fishing, aid in the management or enrichment of fishery resources and ecosystem services, or to achieve a combination of these objectives".*

Artificial Reefs have already been constructed in New Jersey, Massachusetts, San Diego and North Caroline (Yozzo *et al.,* 2004, Rosseau, 2008). Rousseau (2004) described the benefits and risks of carrying out artificial reef creation using dredged material. These are described below:

- Benefits;
  - Mitigate effects of habitat loss by providing a new habitat for marine life in the form of a reef;
  - Water quality improvement from filter feeders as the development of fast growing, highly productive fouling communities feed on plankton and detritus;
  - Reefs close to ports to reduce fuel and time in relation to the disposal of the material; and/ or
  - Increase habitat for recreation. By creating a new habitat that can attract marine life, it may provide a recreational area for fishing and recreational diving;
- Risks
  - The use of inappropriate materials may lead to the migration of the material into shipping lanes or may not be suitable for the marine life it is intended to attract to the area;;
  - inappropriate site selection may decrease the success of marine life. This could be due to there being less shelter or more adverse environmental conditions;
  - movement by currents/ wave action into areas where it may conflict with other maritime or coastal interests e.g. beaches; and/ or
  - costs associated with travel to dispose of the material and monitor its success.

The US Army Corps of Engineers (2004) carried out monitoring of the Massachusetts Bay Rock Reef Site (MBRRS) where rock from the Third Harbour Tunnel Project in Boston and dredging in Weymouth Fore River and deposited at MBRRS between 1992 and 1993. Table 2.2 shows where the dredged material was taken from and how much material was placed within the MBRRS reef during the two years to give an indication of the volumes involved. The rock was placed in an area of homogenous silty sand to increase the habitat diversity. There

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was an increase in species diversity but a reduction in the abundance of epifaunal organisms associated with deep water habitats.

Table 2.2 The volume of dredged material taken from the Third Harbour Tunnel Project and Weymouth Fore River that was placed within the MBRRS site during 1992 and 1993 (US Army Corps of Engineers, 2004).

Year	**Project**	**Volume/ m^3**
1992	Third Harbour Tunnel Project	280,685
	Weymouth Fore River	1,530
	1992 Total	282,215
1993	Third Harbour Tunnel Project	242,860
	Weymouth Fore River	20,644
	1993 Total	263,504
Total Estimated		545,719

Rousseau (2008) stated that the use of dredged material should not be mitigated for dissimilar habitat types e.g. creating reefs to compensate for the loss of mudflats and these artificial reefs should not be created for the primary purpose of disposing of solid waste as artificial reefs require different criteria to disposal. This option therefore has been discounted for the Humber Estuary and will not be considered further in this study.

2.4.6 Berm breakwaters

Berm breakwaters are manmade revetments (mounds of material) that can be placed under water to attenuate wave energy and slow the flow behind the berm breakwater to allow sedimentation to occur, thereby allowing more intertidal areas to develop. Alternatively they can be constructed onshore to physically protect the land behind from over topping of waves and erosion (Sigurdarson *et al.*, 1998).

Berm breakwaters are a useful tool as they can reduce the amount of primary resources that are used. If placed onshore, they can act as a natural flood defence, and contribute to the foreshore by being eroded over time. These berm breakwaters can also reduce the amount spent on flood defences because if the material was deposited at sites or areas where erosion is a problem, placing armour will reduce erosion and protect the defences from further deterioration.

Berm breakwaters are considered more cost effective than providing a new revetment ($125,000 as opposed to $500,000) but do however require maintenance (Komar and Allan, 2009).

Fine sediment would be eroded too quickly to be effective and would therefore serve no purpose for enhancing or protecting the intertidal area. Constructing with more non erodible material such as clay to reduce the wave energy reaching the intertidal area would be more

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appropriate as it would resist erosion for longer (requiring less maintenance and increasing efficacy) but this would only be available with capital dredge material. Maintenance dredging can dredge mixed sediments consisting of gravel, at present it is unclear as to whether this sediment would be effective as berm breakwaters so will still be considered in this study. Maintenance dredge arisings for silt for the potential use as berm breakwaters will not be considered, whereas mixed sediment will, although a pilot project would need to be carried out to determine their effectiveness (Sheenan and Harrington, 2012).

According the Marine Board (1994), berm breakwaters require waters that are between 12 and 14 meters deep. In 1990 approximately 13 million m^{-3} of material was placed parallel to Dauphin Island. The full Berm breakwater measured 6m x 1609m x 4023m and was considered a success. It stabilised the shore and reduced the energy from waves including storm waves, but it also had no adverse impact on the biology. Fish were found to use the Berm breakwater as both a refuge and feeding resource (Marine Board, 1994).

Douglass (1994) in a later study however found that although the berm breakwater had migrated as intended it was also trapping sand in its lee. . Although the effects of this trapping are unknown, this demonstrates the importance of long term monitoring for any beneficial as well as detrimental effects not only on the biology but also the hydrodynamics of the system.

The berm breakwater constructed at Dauphin Island could not be constructed in the Humber Estuary as at its widest it is 14km with an average width of 4.2km and an average depth of 6.5m. Even at its widest part, constructing a berm breakwater with a width of 1609m would result in over 10% of the estuary being obstructed by this berm breakwater. This is not practical on the Humber Estuary due to the extent of the shipping that occurs on the Estuary that requires deep, wide navigation channels.

In order to determine the effectiveness of the Berm breakwaters within the Humber Estuary on a smaller scale a pilot project would need to be carried out to determine if they are effective and can withstand the erosion (Sheenan and Harrington, 2012). Due to this uncertainty about the effectiveness of berm breakwaters, the option will be investigated in this study for capital dredge arisings (for boulder clay) and mixed sediment dredged material, but will not investigate maintenance dredge arisings or capital- dredged alluvium. Alluvium is generally of a fine, silty composition. It is believed that whilst some of the sediment that is released during the deposition of dredged material may reach the estuary bed, the silt is broadly dispersed into the water column due to the high water velocities (Captain Phil Cowing, Harbour Master Humber, *Pers. Comm.*, 30-08-12). This indicates that if any fine material were to be placed to act as berm breakwaters they would be ineffective as the sediment would be eroded quickly.

It is considered that loose gravel, in its dredged state, would also be ineffective as berm breakwaters, however the sediment could be placed into geotextile bags to increase their effectiveness. This practice, of placing loose gravel in geotextile bags, is currently used on the Humber to protect exposed pipelines on the estuary bed (Captain Phil Cowing, Harbour Master Humber, *Pers. Comm.*, 30-08-12).

Geotextile bags and gravel have been used at Feint Harbour whereby by the geotubes retained the sediment but allowed water to escape (Sheenan *et al*., 2009). It was shown that the beneficial use was economically beneficial as it reduced the amount of material needed from quarries and a consequent reduction in the transportation which in turn supported environmental benefits. This study shall investigate the use of gravel as berm breakwaters but within geotextile bags, not as loose material.

It should be noted however that even these filled geotextile bags can be displaced and split, thereby reducing their effectiveness, therefore whilst gravel is being considered as a use in this study, it is highly recommended that a pilot project and monitoring be undertaken to ensure the site is suitable for such a use (Sheenan and Harrington, 2012, Captain Phil Cowing, Harbour Master Humber, *Pers. Comm.*, 30-08-12).

2.5 Monitoring

From the study carried out by the Dredging and Dredged Material Disposal Monitoring Task Team (DMDMTT) the most appropriate monitoring should consider the following (MEMG, 2003):

- the sequence of the monitoring;
- review against the environmental quality objectives (Table 2.3);
- the indicators of the favourable conditions;
    - Area;
    - Substratum;
    - Species of fauna and birds of area;
    - Depth and tidal elevation;
    - Water characterisation;
    - Hydro physical regime;
    - Habitat mosaic;
- the baseline condition;
- time-scale;
- spatial area; and
- determination and significance of the effect.

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Table 2.3 The environmental Quality Objectives (DMDMTT, 2003)

Use	Objective
Amenity	Maintenance of environmental quality so as to reduce the impacts to the public.
Commercial harvesting of fish and shellfish for public consumption	Maintenance of environment so as the fish and shellfish are suitable for human consumption
Protection of commercial species	Preserve the wellbeing of commercially exploited species
General ecosystem conservation	Maintenance of the environment so as to prevent the degradation of aquatic life and species dependant on the aquatic ecosystem
Preservation of the natural environment	Impacts shall be restricted to the designated disposal zone.

These should be incorporated with the monitoring strategy identified by the EA (section 3.8.5), however these should be defined and specified for the specific project being applied to (table 7.2).

2.6 Main Findings

Dredging is a necessary activity to ensure that the ports on the estuaries can remain economically viable. The effects of dredging can be reduced by carrying out dredging on an ad hoc basis (currently the practice on the Humber Estuary), and the disposal can be done in such a way as to have beneficial uses for the economy, sediment budget, ecology and in accordance with sustainable development policies.

Even though dredging needs to take place and has its own impacts, the disposal of material has multiple options available for investigation to reduce the impacts of disposal and perhaps to increase the benefit, whether economical or otherwise, to the stakeholders of the Estuary.

The constraints of both intertidal enhancement and within estuary disposal involve an in-depth investigation of all the variables to deem both the dredged material and the receiving coastal area are of similar qualities. These variables include the re-colonisation potential, consolidation, particle size, consistency and contamination levels (Mitchell, 2007).

Once the sediment has been deemed fit for purpose, monitoring should be carried out to ensure it is successful and to determine the frequency of additional works, with a consideration on the variables if the monitoring shows a drastic change in the system (Colenutt, 2001, DMDMTT, 2003,Bolam and Whomersley 2003, 2005, 2006, JNCC, 2004).

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3. Site Description

3.1 Introduction to the Humber Estuary

The Humber Estuary is located on the East Coast of the United Kingdom and forms at the confluence of the River Ouse and River Trent, and flows easterly to Kingston-Upon-Hull (Hull) where it then flows south eastwards, and enters the North Sea between Spurn Point and Grimsby (Figure A2). The Humber provides 250 $m^3 s^{-1}$ of freshwater to the North Sea, a large contribution of freshwater, especially when compared to the Thames, which discharges 69$m^3 s^{-1}$ (Freestone *et al.*, 1987, Jarvie *et al*., 1997, Cave *et al*., 2003, Hemingway *et al.*, 2008*b*).

The Humber Estuary is divided into 4 regions depending on their characteristics. These were originally identified by the EA as part of their flood defence works. These regions are divided and characterised as shown in Table 3.1 (Figure A3).

Table 3.1 The different habitats and the dominant taxa that are present. The parts of the estuary are explained in section 3.1 (Natural England).

Part of the Estuary	**Location**	**Habitat**	**Dominant Taxa**
Tidal Rivers	Both the Rivers Trent and Ouse are deemed tidal rivers and are fully canalised with extensive erosion protection works on the banks.	Data not available	
Inner	This region lies between the Humber Bridge and the confluence of the River Trent and River Ouse. This area is under tidal influence but no dredging takes place in this region	Impoverished sand/muddy sand	No one dominant taxa. Mysid present
Middle	This region lies between Grimsby and the Humber Bridge. The foreshore at the outer part is currently considered to be eroding	Mainly transitional sand/muddy sand	Polychaetes, mysid and gammarid crustaceans
Outer	This region lies between the estuary mouth (Spurn Point) and Grimsby. Most exposed to wave action	Mobile marine sands, stable marine sands and muddy sands	Polychaetes

3.2 Land Uses of the Humber Estuary

The land surrounding the Humber Estuary is used for urban, industrial, recreational and agricultural purposes, as well as receiving waste from this use (r) s (section 1.1). When considering a new proposal for depositing dredged material, it is important to consider this different use (r) s whilst also ensuring that the local and national governances are met.

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The Humber Estuary supports 4 major ports; the Port of Goole, the Port of Hull, the Port of Immingham and the Port of Grimsby (ordered from west of the Humber to the east and shown on Figure A4) as well as a number of smaller ports and wharves (these are listed with their main statistics in Appendix D and the locations can also be seen on Figure A4 and A5) (Brett, 1992).

This is typical of estuaries for example the Medway River supports two major ports at its entrance plus a number of smaller ports and marinas as well as two power stations. The Outer estuary is also ecologically important due to being designated as SAC's and Ramsar sites (Kirby, 2012).

3.3 Hydrology of the Humber Estuary

There are numerous factors that can influence an estuary and there are numerous impacts that these factors can have on the hydromorphology (Figures 2.1 and 2.2). These factors include those at a global, national, estuary wide and local scale and demonstrates how complex an estuary system is and how one factor can influence many aspects of an estuary, both biotically and abiotically.

Past published charts (pub charts) (ABP, *pers. Comm.)* show how the bathymetry within the estuary near the Port of Hull and more specifically deposit site Hull Middle (HU020) has changed. From 1999 to 2009 the deposit ground, Hull Middle has extended eastwards. It appears that accretion has occurred during this period by developing more sediment and raising the bed levels as expected. This is shown on the pub charts by a shallower depth.

The accretion pattern for Hull Middle and Halton Flat, and the erosion pattern for Skitter Sand may be due to the hydrology as the water velocity increases on the south bank and decreases on the north bank, and decreases still into Halton Flats where sediment can deposit.

Paull Sand appears to have been unaltered by either accretion or erosion; this may be due to the protection that Paull offers Paull Sands on the longer ebb flow or the increased velocity on the flood flow.

From past published charts it is also recognised that above the Humber Bridge (inner estuary) is highly dynamic whereas below the Humber bridge (middle to outer estuary) the estuary is relatively stable (Captain Phil Cowing, Harbour Master Humber, pers. Comm., 30/08/12).

3.4 Tides of the Humber Estuary

The Humber Estuary has a large tidal range, with the mean being 5.7m at Spurn, increasing to 7.4m at Saltend, 6.4m at Hessle and 5.6m at Trent Falls (Hemingway *et al.*, 2008*b*). Due to its spring-neap tidal range being over 4m, the Humber Estuary is considered a

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macrotidal estuary (Masselink and Anthony, 2000, Pontee *et al*., 2004). The tidal waters within the system extend from the outer estuary at Spurn Point to Cromwell Weir on the River Trent and Naburn on the River Ouse (Harris, 2003, Pontee *et al.*, 2004, Tappin *et al.*, 2003). In comparison, the tidal ranges for Tamar Estuary (Plymouth) are 2.1m on the neap tide and 4.5m on the spring tide.

Tides not only range along the Humber estuary, but also in their symmetry. At Spurn the tide is approximately sinusoidal i.e. the flood and ebb both take approximately 6.25 hours. At Brough the flood lasts 4.5 hours and the ebb for 8 hours while at Gainsborough the figures are 2 hours and 10 hours respectively. The asymmetry has a marked effect on the current velocities in the upper estuary which are more pronounced on the flood tide, thus creating a marked imbalance in the transport of sediments into, rather, than out of the estuary (Freestone *et al.*, 1987, JBA Consultants, 2011*a*).

In the upper reaches of the estuary, the tidal asymmetry has a major impact, as the sediments tend to be pushed landwards on the flood. During the ebb tide as water levels drop, the freshwater flows are often sufficient enough to scour through the accumulation of sediments leaving the silts and clays on banks but eroding the bed down to harder deposits.

JBA (2011b) show that the flood tide flows can reach 2 ms-1 at just south of Paull and along the foreshore from Victoria Dock Village to the Humber Bridge. Elsewhere, the flows remain between 1.1-1.4 ms-1 with the flows near Hawkins Point slowing down to 0.5 ms-1.

On the ebb tide, the flows are increased towards the outer estuary with the flow of 2.0ms-1 extending from south of Paull, down the centre of the estuary to Immingham where the flows are approximately 1.5ms-1. The peak bed shear stresses follow similar patterns to the flood and ebb tide flows i.e. the higher the flow the higher the bed shear stress. In order to determine if the sediments can be placed at the areas identified as sites of potential use, the average flow speeds at these areas will be compared with the Hjulstrom graph (an adaptation of which is shown in Figure 3.1) to determine if the sediment is likely to be transported, eroded or left in place.

These variations of the tides on a daily basis show how difficult it is to have certainty in the conclusions and recommendations when no site specific data has been collected and analysed.

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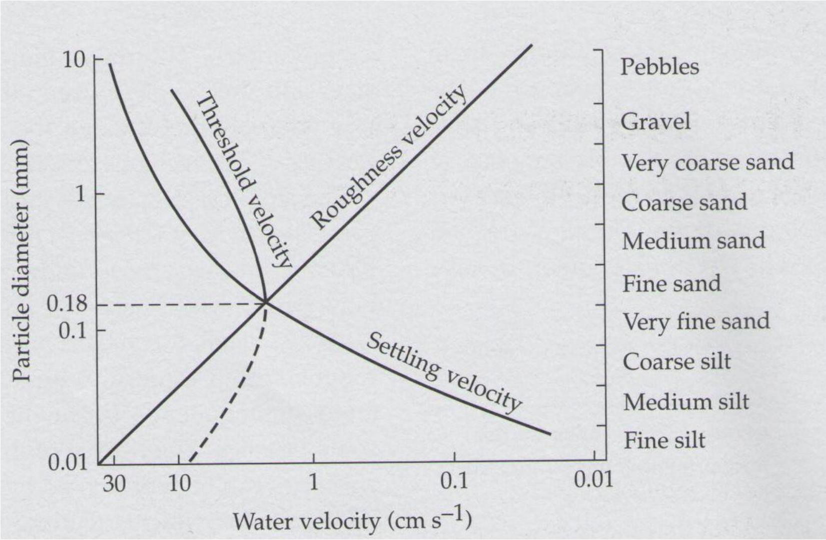

Figure 3.1 The Hjulstrom graph that determines the velocity at which particles of certain sizes deposit, erode or transport (taken from Gray and Elliott, 2009: 23)

3.5 Sediment Budget of the Humber Estuary

A sediment budget is a balance of the quantity of sediment entering and leaving an area of the coast or estuary (Townend and Whitehead, 2003). The budget is based on quantifying (in terms of sinks, processes and sources) sediment transport, erosion and deposition within a given control volume (Townend and Whitehead, 2003). In the case of the Humber Estuary, the sources include freshwater flow from rivers, outfalls, the sea, transfers from the intertidal zones and wetlands and erosion from subtidal areas and sea cliffs (Paipai, 2003, Townend and Whitehead, 2003) (Figure 3.2). An important consideration is the sediment that is stored in suspension (Townend and Whitehead, 2003). Black (1999) found that the suspended particle matter for the Humber during the flood tidal bore was 1.2 gl^{-1}. As the water level increase, this decreases to 0.55-0.6 gl^{-1}. Within the turbidity maximum, this can reach 20 gl^{-1} (Edwards and Winn, 2006).

The sediment budget is important to ensure that the hydrodynamics of the estuary are not adversely affected. Townend (2004) explained that activities such as reclamation, dredging and the removal of flood storage areas can alter the dynamics of the system. Therefore, depending on the local hydrodynamics, the area may become erosion dominated (increasing the risk of flooding by degrading the flood defences) or becoming accretion dominant (increasing the risk to navigational safety and therefore requiring more maintenance dredging and having a financial implication).

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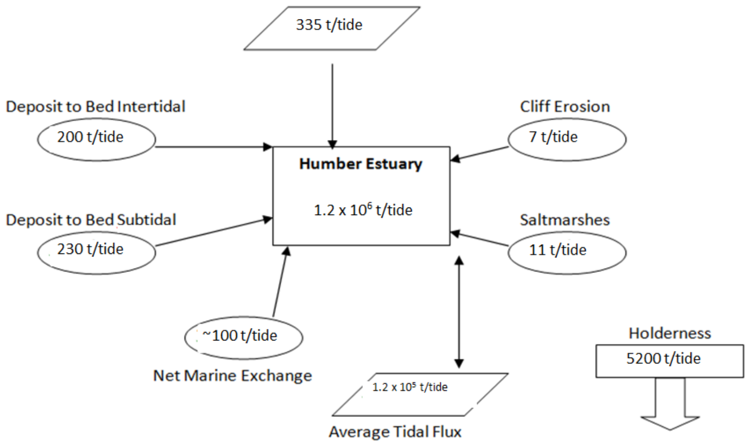

Figure 3.2 A schematic view of the sediment budget for the Humber Estuary (Townend and Whitehead, 2003: 765).

It is often difficult to estimate the sediment budget and the implications that dredging may have especially for an estuary such as the Humber due to its large extent. There are a number of factors that interact with each other over different spatial and temporal scales (see Figures 2.1 and 2.2) (Townend and Whitehead, 2003) .

The Humber Estuary's sediment budget is important in preventing a eutrophic environment as the sediments take up many of the nutrients that enter the system through run-off, discharges and other sources (SedNet, 2006). The fine sediments that are in suspension may influence nutrient and contaminant dynamics and therefore improving the water quality for the species present. The sediments that are deposited on the intertidal areas are also important. The nutrients that will have been absorbed will be released into the soils and promote plant growth, and in turn will consolidate the material and aid in erosion protection (although may take a time to establish).

The Humber Estuary is thought to be near its theoretical equilibrium and therefore it is important to ensure that the sediment budget is not altered and is taken into consideration when proposing new projects or dredging practices. It is because of this equilibrium that Natural England are concerned that the maintenance dredge arisings are kept within the sediment budget to avoid disturbing this equilibrium and thus disturbing the functionality of the estuary and therefore will be taken into consideration when investigating the potential uses (Pethick, 2002).

3.6 Turbidity Maximum of the Humber Estuary and the Rivers Trent and Ouse

The turbidity maximum is an important feature of the estuary due its influence on primary production, pollutant flushing, fish migration and dredging (Mitchell *et al.,* 1998). The turbidity maximum is characterised as a region of high suspended sediment concentration (SSC). This

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usually occurs in the upper estuary and the concentrations of the suspended sediments are higher than those found in the rivers and the sea (Dyer, 1990).

The turbidity maximum is observed upstream of the fresh-salt water interface. The turbidity maximum is usually found 90km down river from the River Ouse's Tidal Limit (Uncles *et al.*, 1998). The mean positions for the freshwater-saltwater interface and turbidity maximum are 47 and 52km upstream respectively of the tidal limit(Uncles *et al.*, 1998). Pontee *et al.* (2004) found this can vary by 20 km along the Humber Estuary and River Ouse due to seasonal variations and the freshwater discharge from the Rivers Trent and Ouse.

The dynamics of the estuary are influenced by river flow, tidal range, channel morphology, wind strength and direction, and sediment availability for example under low freshwater flow conditions, the tidal asymmetry moves the sediment landward (Mitchell *et al.*, 1998, Uncles *et al.*, 1998, Dyer, 1990). Seasonal variations can bring about changes in the rivers and in the estuary including bed levels due to accretion and erosion. Pontee *et al.* (2004) found that in the Outer Humber siltation rates are generally inversely proportional to freshwater discharges as greater freshwater discharges in the winter can flush out sediments from the estuarine system. Due to this relationship, areas in the outer estuary such as around the Sunk Dredged Channel, requiring maintenance dredging to maintain the navigational routes through the estuary. In contrast to this the lower Trent shows no relationship between the freshwater discharge levels and the bed level (Pontee *et al.*, 2004). In winter, the freshwater-saltwater interface was further downstream from the tidal limit and was relatively weak. The reverse is true for the summer months (Uncles *et al.,* 1998).

The turbidity maximum on the Tamar Estuary also occurs in the low salinity upper reaches and has been shown to also be associated with the salt-fresh water interface and the changes in river flow (Black and Veatch, 2011). It has been shown that during the summer it is normally 0-10km downstream, whereas in winter it moves downstream 15-25km (Black and Veatch, 2011).

3.7 Designations of the Humber Estuary

The Humber Estuary has a number of national and international nature conservation designations. The details of the statutory designated sites are provided below (locations on Figures A6 and A7) (note that they some do share the same boundaries in some instances):

- **The Humber Estuary Special Protection Area (SPA)** is designated under the EC Birds Directive (79/409/EEC) in order to support bird populations of European importance that are included in Annex I and Annex II;
- **The Humber Estuary Ramsar Site** is designated for its estuarine habitats;
- **The Humber Estuary Special Area of Conservation (SAC)** qualifies under the EC Habitats Directive (92/43/EEC) for its Annex I habitats and Annex II species, and

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- **The Humber Estuary Site of Special Scientific Interest (SSSI)** is designated under the Wildlife and Countryside Act 1981 for its nationally important habitat, geological interest, importance to breeding, wintering and passage birds, breeding grey seal and the presence of river and sea lamprey.

3.8 Governance

Due to the effects that dredging could potentially have on the environment (section 2.2), developers should ensure that their project adheres to the governance (governance is a term that summarises the regulators and legislation) to ensure that the project is: (modified from Micallef and Williams (2002) and Atkins *et al.*, (2011))

- environmentally sustainable with ecological integration into the project;
- technologically feasible;
- economically viable including vessel traffic assessments;
- socially acceptable and tolerable with use/ user integration;
- legally permissible;
- administratively achievable including dredge contractors, port authorities and existing management, and
- politically expedient including planning and regulatory controls.

(these are termed the 7 tenets from here on in as defined by Atkins *et al.*, 2011).

3.8.1 Regulatory Bodies

The regulators for England, and the Humber specifically, and their respective roles are as follows:

- **The Environment Agency's** role is to protect or enhance the environment and seek sustainable development including balancing factors such as costs. Their functions include the supervision and administration of flood defences, fisheries regulation, navigation, and harbour and conservancy duties and to prevent, minimise, remedy or mitigate effects of pollution;
- **Natural England's** key responsibilities are for nature conservation, species and habitat protection, protection of geological features and landscape protection;
- **Associated British Ports as the Harbour Authority** have the responsibility to maintain clear and safe navigation for commercial and recreational vessels;

- **The Marine Management Organisation** is responsible for marine planning up to the mean high water (MHW) mark and extends out up to the seaward limits of the terrestrial sea as set out in the Marine and Coastal Access Act, 2009 (DEFRA, 2010) ;
- **The local authorities** (Kingston Upon Hull City Council, North Lincolnshire Council, North East Lincolnshire Council or East Riding of Yorkshire Council depending on the location of the project), or
- **The Infrastructure Planning Commission** (IPC) was a system that allowed large developments (such as Able MEP) to conduct all of the consultations prior to application and have all their mitigation and compensation sorted prior to application so that the IPC can solely grant consent. The IPC however, was abolished in April 2012 and in place a National Infrastructure Planning Commission has been formed. This directorate will make recommendations to the Secretary of State who will be the sole decision-maker.

3.8.2 Legislation

The legislation relevant to the dredging and disposal of dredged material are as follows:

- **Humber Conservancy Act 1905** allows the Harbour authority (in the case of the Humber Estuary this is ABP) the powers to carry out maintenance dredging on the Humber Estuary for navigation;
- **Coastal Protection Act 1949**, under this act, permission must be obtained before any structure is placed on the river bed or dredge arisings are deposited;
- **Harbours Act 1964** ensures that the Harbour Authorities have a general duty to exercise their functions with regard to nature conservation and other related environmental considerations;
- **Food and Environment Protection Act 1985** (superseded by the Marine and Coastal Access Act, 2009) this act sets out the requirement for licences for the deposit of substances and articles in the sea;
- **Marine Works (EIA) Regulations 2007** determines whether a marine plan/ project requires an EIA, the procedure that should be followed and the contents of an EIA as well as the offences of falsely or not providing information, and
- **Marine and Coastal Access Act 2009** supersedes the FEPA 1985 and includes marine planning, marine licensing, marine conservation zones and coastal access.

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3.8.3 Directives

The most relevant directives for the proposed plans and projects in England are:

- **Environmental Impact Assessment (85/337/EEC and 97/11/EC)** states that an EIA must be carried out to assess the effects of a project on 1) humans, fauna and flora; 2) soil, water, air, climate and the landscape and the interactions between these;
- **Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC)** was created to protect the designated SAC features;
- **Water Framework Directive** became a part of the UK law in 2003 to ensure that all water bodies are of good ecological standard (discussed in more detail in section 3.8.4); and
- **Wild Birds Directive (Directive 2009/147/EC)** was created to protect SPA sites that comprise the most suitable territories for endangered and migratory species of birds.

3.8.4 Water Framework Directive and Contamination within the Humber Estuary

The Water Framework Directive (WFD) came into force in December 2000 and applies to waters out to one nautical mile from which the territorial waters are drawn. The ultimate aim of the WFD, as outlined in Article 1, paragraph 27 (Official Journal of the European Commission, 2000), is to achieve “concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances”.

For natural systems, the aim to reach Good Ecological Status (GES), however for those water bodies that would fail GES due to the hydromorphological changes these are classed as Heavily Modified Water Bodies (HMWB). HMWB’s are defined as water bodies whereby if you were to alter the hydromorphological regime to reach GES, it would have significant effects on (Borja and Elliott, 2007):

i) “The wider environment;

ii) Navigation, including port facilities, or recreation;

iii) Activities for the purposes of which water is stored, such as drinking water supply, power generation or irrigation;

iv) Water regulation, flood protection, land drainage; or

v) Other equally important sustainable human development activities”.

The Humber Estuary is defined as a HMWB and the “traditional” method of assessing Good Ecological Potential (GEP) would be to identify the criteria for Maximum Ecological Potential (MEP) by relating it to the biological quality after all possible mitigation has been implemented (Kampa and Laaser, 2009). The Prague approach however defines GEP on the identification of mitigation measures. Any mitigation measures that would have a significant

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adverse effect, be too costly or that would in combination result only in a slight ecological improvement are discounted. GEP is defined on biological values that are expected from implementing remaining mitigation measures (Kampa and Laaser, 2009).

The Humber catchment is post-industrial meaning that the sediments that acted as a sink of contaminants during the mining and industrial periods can now act as a source during the maintenance and capital dredging that has to be carried out (Cave *et al.,* 2005). Dredging and reclamation can negatively affect the WFD as they can cause:

- the formation of sediment plumes;
- degradation of marine resources;
- suspension and settlement of sediments; and
- contaminant release and uptake by organisms.

The Centre for Environment, Fisheries and Aquaculture Science (Cefas), an executive agency of DEFRA, currently undertake a physical and chemical characterisation of the dredged material on behalf of the MMO provide advice to those wishing to dredge (MMO, 2011*a*).

The Port of Goole showed to have higher concentrations of contaminants than other ports as shown by ABPmer (2008*c*) who carried out a study on the contaminants within the Port of Goole and the Albert and William Wright Docks of the Port of Hull (the action levels for contaminants within a water body are shown in Appendix E). The Port of Hull docks reached action level 1 in both docks whereas action level 2 for certain contaminants in the William Wright Dock. The majority of the contaminants were at the extremities. ABPmer (2008*c*) suggested that this was because this is where the vessels are moored. This could also be because the flow slows in William Wright Dock where the finer sediments (which carry contaminants more effectively) can settle out of suspension.

In the Port of Goole the heavy metal contaminants reaches action level 1 in most samples in the West Dock, Stanhope and Railway docks. Action level 2 was reached in West Dock. Lead, nickel and zinc were most significant within West dock and sample 3 (in the SW corner) showed the highest levels of arsenic, boron, chromium, copper, lead, nickel and selenium. ABPmer again suggested that these high levels were because this is where the vessels are moored.

Consideration of the treatment of contaminated sediments is not considered as part of this study due to the various treatment methods and the varying factors that need to be taken into considered. Due to this contamination issue at the Port of Goole, the maintenance dredged arisings from the Port of Goole will not be assessed for the beneficial uses. The study will assume that all other sediment will be free of contamination so can be utilised for the alternative potential uses identified in this study.

3.8.5 Managed Realignment Moving Towards Water Framework Objectives (MRMoToWFO)

In order to comply with the WFD, the EA investigated the use of Managed Realignment sites to increase the Humber Estuary's potential. This project was referred to as Managed Realignment Moving Towards Water framework Objectives (MRMoToWFO). MRMoToWFO was an EU funded project whose aims were (EA, 2010*a,* 2010*b*):

- to identify the means where by managed realignment sites can meet the demands of both the habitats regulations and the WFD, and
- inform future design, implementation and monitoring of managed realignment sites to facilitate progress towards achievement of the WFD.

The managed realignment sites were designed to provide habitats that are being lost due to developments and coastal squeeze and to store flood water and provide flood defence. They were developed to meet the requirements of the Wild Birds and Habitats Directives but they may help towards achieving GEP under the WFD (EA, 2010*a,* 2010*b*).

The MRMoToWFO project found that the development of intertidal fauna is most rapid and successful at sites where there is a combination of frequent inundation, development of sediment and sources of material for colonisation. The size and extent of the breaches are important to the rate of colonisation and speed of ecological developments (EA, 2010*a,* 2010*b*). Differences were found between the new and old estuarine habitats. This was attributed to the agriculture surrounding the realignment sites and the fact that many of the sites were of agricultural nature prior to becoming a managed realignment site (MMO, 2011*c*).

The disadvantages of managed realignment sites were effects on navigation, impact on flood defences and changes in sediment transportation (EA, 2010*a*, 2010*b)*. This is due to the fact that alterations to the estuary, including land reclamation for habitat loss and or enhancement, can alter the tidal regimes and therefore the transport of sediments and sedimentation within the estuary.

The Environment Agency recommends the following be key parameters in all management realignment monitoring programmes (as set out in Environment Agency, 2010*b*):

- original ground levels;
- frequency of tidal inundation on all parts of the new intertidal areas;
- sedimentation at fixed monitoring points;
- changes in ground level across the site;
- the nature of sediments in terms of particle size, organic content and moisture content;
- invertebrate colonisation of the intertidal sediments and water column;
- fisheries;
- use of the site by birds; and

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- colonisation of bare substrates by vegetation including both algae and higher plants.

The EA also recommended and concluded that:

- the authorities need more consistent monitoring and data and to be shared across the EU by a central repository;
- the project demonstrated that managed realignment sites maintain and improve biodiversity across target species and habitats, and
- the EA has committed to continue the monitoring of these sites beyond the MrMOTOFOW project and to input into new sites and to help continue to grow and inform future projects.

MRMoToWFO is not discussed further for the study, however the lessons learnt from the project can be applied to both this study and any future projects should the potential uses identified in this study be explored further in the field.

3.9 Disposal Sites within the Humber Estuary

As discussed, the current disposal strategy in the Humber is within estuary disposal. There are currently 16 open and licensed disposal sites within the Humber Estuary (Figure A8)). These are listed (in location of east to west) with their main composition of sediments given (Table 3.2). There are a number of different dredgers that can be used to dredge and dispose of the sediment. The type of dredger is based primarily on the sediment type and the dredge depths. The specific dredgers for the maintenance and capital dredge projects are given in Tables 4.1 and 5.4 respectively (and are discussed in more detail in Appendix K).

It is important to consider the sediment composition of both the dredged material and the disposal site as the sediments should be of similar composition (Captain Phil Cowing, Harbour Master Humber, *pers. Comm.,* 30/08/12). This is to reduce adversely affecting the dynamics of the estuary, as well as the economics factors. This will be taken in to consideration in both the maintenance and capital dredge chapters (4 and 5 respectively) when considering alternative uses (Table 2.1).

Table 3.2 The disposal sites of the Humber Estuary and the River Ouse with the sediment types.

Disposal Name	Alternate Name	Sediment Type
Goole Bight		Silt
Whitgift Reach		Silt
Hull Middle	HU30	Silt
Humber Hook Extension	HU20	Fine Silts
Holme Channel Deep		mobile sand, soft clay and silt

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Clay Huts	HU060	Silts
Holme ridge North		Silts
Burcom Sand	HU90	Soft Clays
Burcom Sand Extension		Soft Clays
Sunk Dredged Channel- Western Site		Mobile Sand
Sunk Dredged Channel- Central Site and Hawke Channel		Soft clay and silt
Sunk Dredged Channel- Window Site A		Clay lumps
Sunk Dredged Channel- Window Site B		Clay lumps
Sunk Dredged Channel- Window Site C		Clay in slurry Form
Middle Shoal	HU080	soft clay, silt, sand and gravel
Haille Channel	HU110	Sand and silt
Bull Sand Fort	HU111	Mobile sand but is not routinely used. Clay lumps are used for scour holes and capped by sand. Soft clays and silts.
Bull Sand Fort Extension		Fine to medium sand
Chequer Shoal and western parts of Eastern approaches		Sandy substratum
Eastern parts of the eastern approaches		Coarse Sediments

3.10 Areas under Threat of Erosion within the Humber Estuary

Within the Humber Estuary there are a number of areas that the Environment Agency has identified as the flood defences being in less than favourable condition (see Environment Agency (2010*a* and *b*) for more information on the classification of the flood defences) (Table 3.3).

Each location will be considered for the beneficial use of the different maintenance and capital dredge arisings in their respective chapters (4 and 5). Considerations of each location will include;

- distance involved;
- local hydrodynamics;
- depth at the location;
- amount of sediment required at the location;
- amount of sediment being dredged, and
- sediment at the location.

These areas could have their protection from erosion increased by the placement of berm breakwaters within the estuary to reduce the wave energy reaching the foreshore or the

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sediment could be placed onto the intertidal to protect the flood defences. These two options in the Humber Estuary require different sediments to be successful. Berm breakwaters require non erodible material such as boulder clay and till whereas alluvial materials such as silts would be transported relatively quickly to have little or no effect on the erosion rates of the area (Captain Phil Cowing, Harbour Master Humber, *pers. Comm.,* 30/08/12). This silt however could potentially be used for the intertidal enhancement to either create additional habitat or to protect the land behind from erosion French and Burningham, 2009, Bolam and Whomersley, 2003, Comoss *et al.,* 2002, Colenutt, 2001.

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Table 3.3 Summary of the areas under threat from erosion within the Humber Estuary and the River Ouse, with the EA's concerns and the geology of the area. The locations shown on FigureA9.

Area Under Threat	Concern for the EA	Geology of the Land	Sediment at Site	Length of defences/ km	Average depth at site (mAODN)	Average Flow Velocity ms^{-1}
Swinefleet	Stability of the defences. The embankment revetment is damaged by erosion.	Mud, silt and sand	Unavailable	2	-1	unavailable
Saltmarshe	Stability of the defences	Mud, silt and sand	Unavailable	1	0	Unavailable
Reedness	Stability of the defences	Mud, silt and sand	Unavailable	1	1	unavailable
Whitgift Bank		Silt and Alluvium	Unavailable	2.5	1	Unavailable
Whitton Ness	Foreshore eroding and concerned with stability of defences	Mainly silt and some lias to the west	Unavailable	4.5	-3.5	Unavailable
Winteringham Haven	Foreshore eroding and concerned with stability of defences	Alluvium	Unavailable	4.5	0	Unavailable
A1077/ South Ferriby	Foreshore eroding and concerned with stability of defences	Alluvium with some Jurassic clays to the SE	Fine and coarse sands	8	1	Unavailable
East Clough	Foreshore eroding	Boulder clay, chalk with alluvium to the east	Fine and coarse sands	4.5	-1	Unavailable
Paull	The toes of the present defences	Alluvium with some gravel	Silty clay	2.5	-3	2
Halton Marshes	Foreshore eroding	Alluvium	Fine and coarse sands	4	1	2.1
Stallingborough	Foreshore eroding	Alluvium	Silty clay	4	1	2.2
Hawkins Point	The toes of the present defences	Alluvium	Silty clay	12	-1.5	0.5

(Sources of information; JBA ,2011*a*, EA, 2008 and De Boer, 1979, Pub Charts).

By using the Hjulstrom's Curve (Figure 3.1) against the average flow velocities given (Table 3.3) it appears that only the very fine material ($0.01ms^{-1}$), being unconsolidated clay would be transported away from the area of disposal at sites Paull, Halton Marshes, Stallingborough and Hawkins Point. For those sites that where the average flow velocities are unavailable for this study, they will still be investigated on the grounds of distance, sediment

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type, quantity etc but if shore protection in the form of berm breakwaters were to be investigated further in the future it is essential that the flow velocities be taken from these sites.

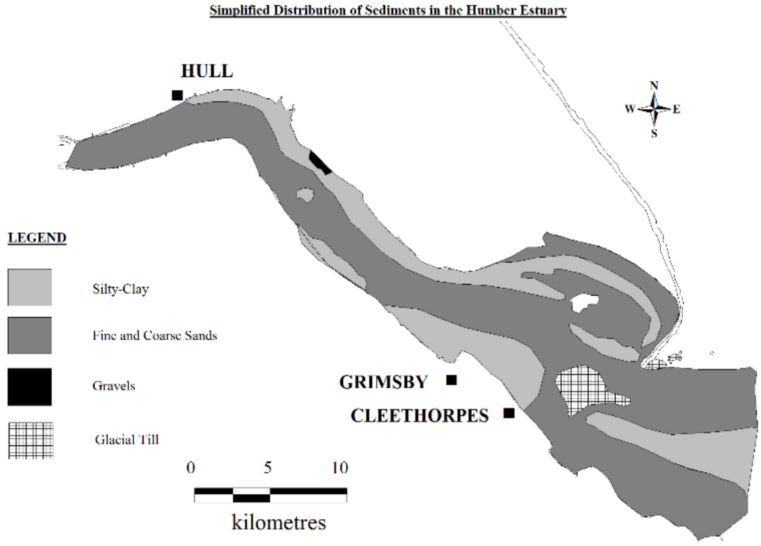

Figure 3.3 The sediment of the Humber Estuary bed (IECS *Pers. Comm., 17/01/*12).

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3.11 Main Findings

The Humber Estuary is important, not just for ecological reasons with various designations, habitats and species, but also for economic reasons as it handles 15% of the UK's traffic. In order to compete with other ports, both within and outside of the Humber Estuary, a safe navigational depth must be maintained by dredging and to expand in order to accommodate the new generations of larger vessels.

The Humber Estuary is a dynamic system, as shown in the differences of the past published charts created by HES, and due to these dynamics many areas around the Humber Estuary are under threat from less than favourable flood defences and as a result under threat from flooding. These areas have been identified in section 3.10 and the potential uses identified in Chapter 2 will be investigated in Chapters 4 and 5.

Due to the large area that the Humber covers the EA divided the Humber into 4 areas of which are varying characteristics, and have different users and uses of the sites. It is important to consider the different aspects of the zones of the estuary when investigating alternative uses and therefore aspects such as the sediment budget, designations and the zones will be taken in to consideration. It is also important that any activity is carried out with consideration for the 7 tenets of sustainable development (section 3.8) and in accordance with legislation (section 3.8.2).

The current baseline of the Humber dredging activities are that the maintenance and capital dredging are carried out on an ad hoc basis and that all of this material is currently disposed of within the estuary based on distance and sediment composition. The Environment Agency have identified areas under threat where this material could potentially be used to benefit those living around the Humber and possibly for managed realignment sites such as Donna Nook.

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4 Maintenance Dredging

Historically, maintenance dredge arisings from the Humber Estuary have been disposed of in various licensed subtidal disposal sites within the estuary (listed in section 3.9 and the locations are shown on Figure A8).

Historically, the disposal sites that are in use today very much resemble the disposal sites that were first used when the docks were opened in the latter half of the 19th century. Since monitoring the sites and the Humber Estuary, it can be determined that the disposal of the sediment at these sites has shown no significant change from the Humber's natural variability with regards to dynamics (Captain Phil Cowing, Harbour Master Humber, *pers. Comm..,* 30-08-12).

The regulators have agreed this approach as this disposal strategy allows the sediment to be remobilised and is free for the estuary to "use", in accordance with the prevailing conditions at that time. By keeping the estuary near its theoretical equilibrium, for this reason it is considered a beneficial use (Tim Page, NE, *pers. Comm.*, 13/10/11). NE have no formal position on the use of dredged material beneficially but are looking at potential alternative methods of disposal of dredged material providing the uses are acceptable under the Habitats Regulations (Tim Page, NE, *pers. Comm.*, 17/01/12).

Using maintenance- dredged material for intertidal enhancement is a possibility as this has been done elsewhere in the UK such as the Stour, Orwell and Thames Estuary (UK Marine Special Areas of Conservation Projects, 2001, Royal Haskoning, 2007, Frenchman and Burningham, 2009). On the Thames Estuary, the material that is dredged conventionally i.e. by TSHD, is placed at Rainham Marshes and Cliffe Pools, both of which are RSPB reserves. The Baseline Document for the Thames Estuary states that *"As a consequence of the costs associated with transporting dredged material over this distance* [dredged area to South Falls] *it is relatively unusual for sediment dredged from the Thames to for maintenance to be taken to sea disposal"* (Royal Haskoning, 2007:8). The RSPB sites use the dredged sand and in agreement with the port. The sites are mutually managed to provide enhanced habitats for bird species.

On the Stour and Orwell Estuaries however, the dredged material from the Harwich Haven Approach Channel Deepening was used beneficially to recharge the beach between Naze and Stone Point (Figure 4.1) and maintenance dredge arisings to create mudflat and saltmarsh habitat on the Shotley foreshore (Figure 4.1) (French and Burningham, 2009). These areas are of international importance as being designated as both Ramsar sites and also as SAC's (Figure 4.1). This shows that the dredged material could potentially be used on designated mud and sandflats for beneficial use.

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Results published by French and Burningham (2009) show that 80% of the mud area of North Shotley has been colonised by a diverse community of saltmarsh halophytes. This area did however need recharging (additional material to be placed on the area after the original disposal) in 2000 and 2003. Previous to this placement, the North Shotley foreshore was eroding however there has been a marked reduction in the erosion damage to the flood defence infrastructure and increase in habitat restoration over decadal timescale (French and Burningham, 2009).

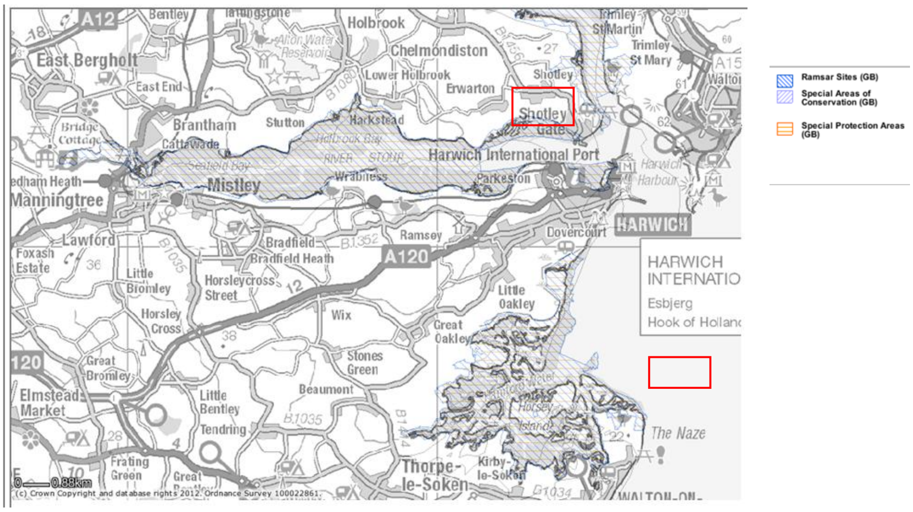

Figure 4.1 Designations of the Stour and Orwell Estuaries with the areas of beneficial use marked (website 25)

Carrying out such a strategy on the Humber Estuary would be required to pass stringent tests in order to comply with the statutory designations that are applied to the Humber Estuary. It would also need to have extensive pre-disposal studies and be monitored both locally and estuary wide as Natural England have expressed a concern that the existing intertidal mudflat sediments have already been sorted. To put dredged material onto this may lead to inappropriate material being disposed of in the “wrong place” and by the estuary’s processes, being relocated elsewhere. This could then affect the erosion or accretion in other unforeseen areas of the estuary (Tim Page, NE, *pers. Comm*., 13/10/11).

As also indicated by NE (Tim Page, *pers. Comm*., 13/10/11) the Humber Maintenance Dredge Baseline Document (HMBD) would also need to be updated. It would need to accommodate these new uses for the maintenance dredge arisings to allow regulators to make informed decisions when considering new plans or projects within the estuary.

NE summarised their (regional) view as “keeping the sediment within the sediment budget” could constitute as subtidal or intertidal disposal (Tim Page (NE), *pers. Comm*., 13/10/11). Subtidal disposal has however been used historically in the Humber Estuary and as discussed, any intertidal use would need to pass stringent tests to comply with the

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designations and have extensive pre-disposal and post-disposal monitoring to ensure that the estuary was not adversely affected therefore intertidal enhancement is not considered for maintenance dredge arising's.

4.1 Reasons for Maintenance Dredging

Maintenance dredging is needed to ensure recreational and commercial vessels can safely navigate through the estuary to the ports, wharves and marinas. This is important for the local, regional and national economy to ensure that each approach and berth is maintained at a certain depth to accommodate the vessels.

Beneficial use schemes may involve the inclusion of third parties e.g. on the Thames. In order to ensure that the construction programmes, of both the dredging company and the company using the sediment, will not be affected by delays in the other, it is important to have plans in place in case a delay is incurred

Maintenance dredging is undertaken by the Harbour Authority as it is their responsibility to maintain clear and safe navigation for commercial and recreational vessels (for the Humber this is ABP), by contracting a dredging contractor (primarily UK Dredging (UKD) for the Humber) (ABP, *in prep.a*) (the dredgers that UKD employ are summarised in Table F2 and described in more detail in Appendix F).

Table 4.1 shows the maintenance dredge sites within the Humber, the frequency and the type of dredgers that are used. Tables 4.2 and 4.3 show the amount of material dredged at specific port locations with the Humber estuary (from ABP *in prep.a*). The locations are shown on Figures A10 to A14.

4.2 Areas of Maintenance Dredge and Disposal

The majority of sedimentation in the Ports that are owned by ABP occurs at the lock entrances both inside and outside of the lock gates and at the extremities where the flow slows enough for the sediment to settle out of suspension (Appendix G). Saltend jetties have sediment that settles down estuary of the jetties. This is because at this part of the estuary, the tides are ebb dominant i.e. the ebb tide last longer than the flood tide and also have lower flow velocities (section 3.4).

The maintenance dredging activities within the Humber Estuary can vary depending on local conditions and necessity (Figures 4.2-4.9). It appears that in 2008 the Port of Immingham and HST dredged 3 and 1.4 Mm^3 of material respectively (both are located in close vicinity to each other) and have both continued to have large amounts of material dredged in 2009 and 2010).although decreasing (Figure 4.5). The Port of Hull (Figure 4.7), although there is an

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overall decrease in the amount of sediment to be dredged annually from 2004, it has remained relatively constant. The SDC (Figure 4.3) however, previously requiring nearly 1.2 Mm^3 of material to be dredged in 2004, has not needed to be dredged in the years 2007-2010. This demonstrates that the maintenance dredging only takes place on an ad hoc basis and emphasises the importance of monitoring (ABP *pers. Comm.*).

These figures (4.2-4.9) show how even in a semi enclosed system such as the Humber Estuary, there still remains local variations between sites, and these differences need to be taken into account when determining the dredge material and the potential use need of the estuary as a whole.

The dredged material is often deposited near to the dredge site itself (Tables 4.1 and 4.2). This is to keep the sediment within the local sediment budget and to reduce costs and keep the dredging activities economically sustainable for both the port authorities and the dredging contractors (Figures A10 to A14).

4.3 Characteristics of Maintenance Dredge Material

Out of the 13 maintenance dredge sites, 8 are of silty composition and 3 are of a mixture of silts and clay (Table 4.1). Other than Immingham to Burcom Sands and Middle Shoal (4.62 and 5.52 nm respectively) and Goole to Goole reach (4.03 nm), all have direct distances i.e. the shortest route from dredge to disposal (not taking into account shipping lanes) below 2.7nm.

This small distance between the dredge and disposal site is a key factor for the port authorities and dredging contractors in order to reduce costs (section 1.4). The disposal sites also reflect the sediment composition being dredged e.g. all the docks of the Port of Hull (Albert, Alexandra and King George Dock) deposit at Hull Middle and Hull Middle Hook as both the dredged material and disposal sites are mainly of silt composition.

The Grimsby docks have maintenance dredge consists of silt, gravel and boulder clay dredged but the majority of the maintenance- dredged areas are made up of silt sediments (Table 4.1). Since there is a distinct difference between the two compositions, this study shall focus on the potential uses of silt sediments and mixed sediments from maintenance dredge locations to specific potential areas of disposal.

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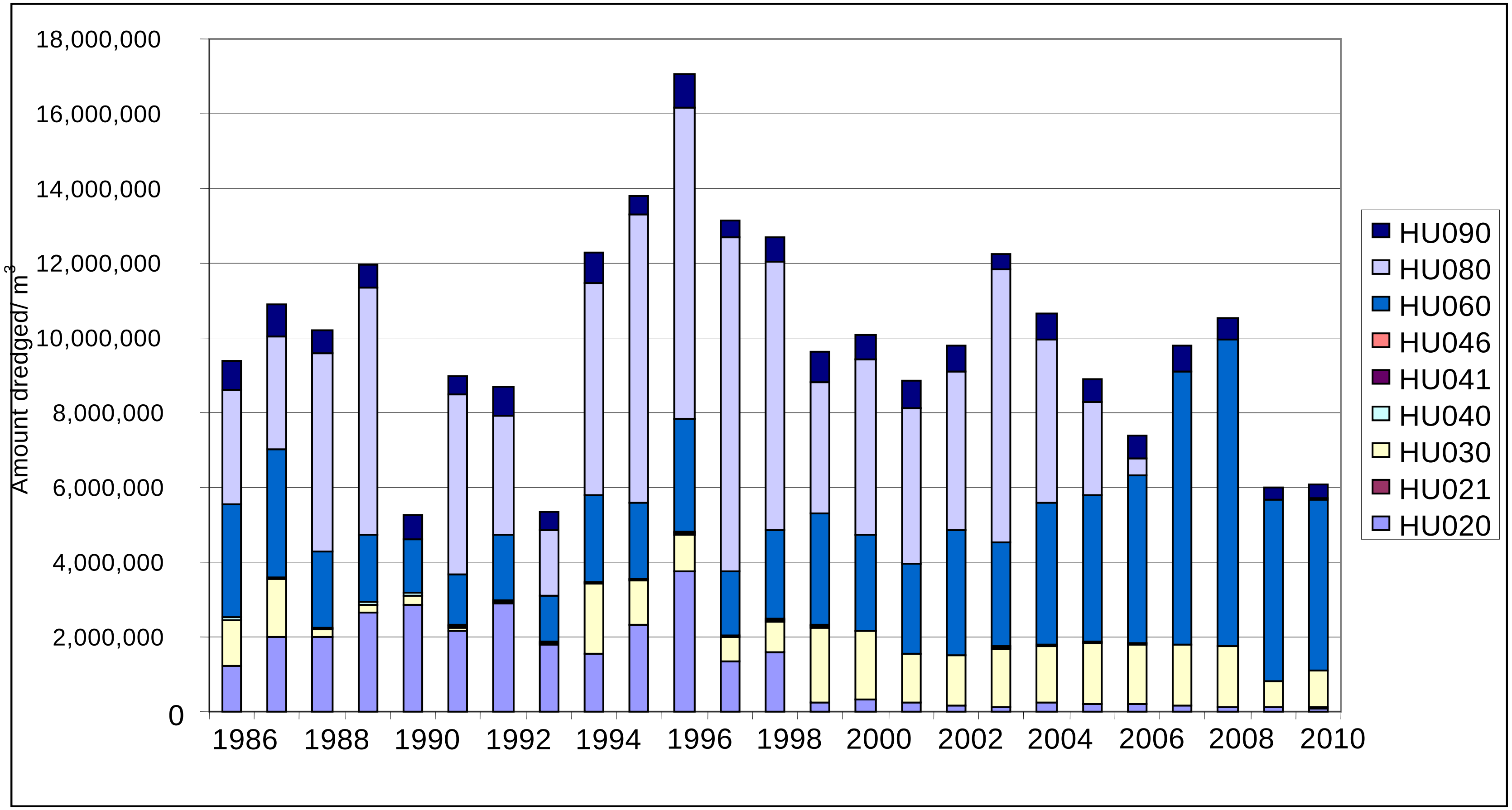

Figure 4.2 The amount of dredged material placed at the different disposal sites within the Humber from 1986-2010 (ABP, *in prep.a*).

Table 4.1 The maintenance dredge areas within the Humber, the licence details and the dredger types (Collation of data provided courtesy of MMO *pers. comm.*, Cefas *pers. comm.* and ABP, *in prep.a*).

Dredge Area	Specific Dredge Area	Tonnage Licensed	Licence Length	Disposal Site	Distance/ km	Composition	Main Dredger	Purpose
North Killingholme	Berths 3 and 4	3,300,000	3 Years	Clay Huts	1.62	Silt	Cutter Suction	Maintain berth depth
	Berths 5 and 6	1,800,000	3 Years	Clay Huts	1.62	Silt	Cutter Suction	Maintain berth depth
	Berths 1 and 2	1,494,000	3 Years	Clay Huts	1.62	Silt	Cutter Suction	Maintain berth depth
Humber Estuary	Immingham Docks and waterfront berths	37,950,000	3 Years	Clay Huts	1.39	Silt	Grab & Trailer Suction	Maintain berth depth
				Foul Holme Spit	N/A			
				Burcom Sand	8.57			
				Middle Shoal	10.23			
	Hull - Alexandra Dock	3,500,000		Hook	0.8	Fine silts	TSHD	
				Hull Middle	1		Grab	
	Hull- King George Dock			Hook	1.3	Silts and clay	TSHD	
				Hull Middle	0.96		Grab	
	Hull- Albert Dock			Hook	3.5	Silt, clay and sand	Grab	
				Hull Middle	3.5		TSHD	
	Immingham Bulk Terminal	1,425,000	3 Years	Clay Huts	1.13	Silt	Grab & TSHD	Maintain area depth
Grimsby Docks	Royal Dock Lock	388,125	1 year	Burcom Sand	1.69	Silt/ gravel/ alluvium clay	Backhoe	Maintain dock depth

	No1 Dock				1.8			
Goole Docks	Ocean Lock	98,000	2 years	Goole Reach	7.47	Silt	Grab	Maintain dock depth
				Whitgift Bight	0.95			
	Victoria Dock			Goole Reach	7.47			
				Whitgift Bight	1.32			
SDC		N/A	N/A	Middle Shoal	0.35	Sand/ silt	TSHD	Maintain depth

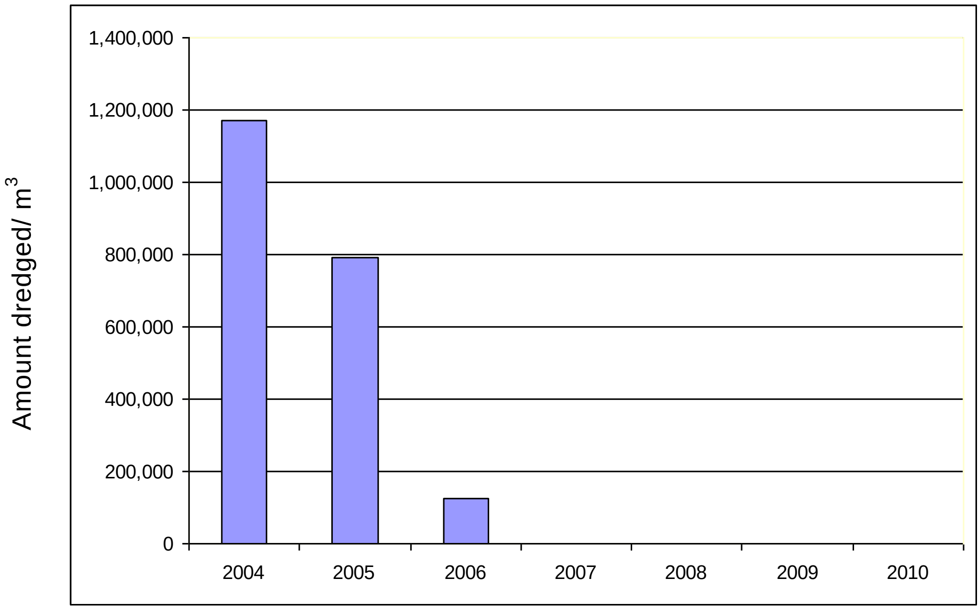

Figure 4.3 The maintenance dredge arisings from the Sunk Dredged Channel between 2004 and 2010 (ABP, *in prep.a*).

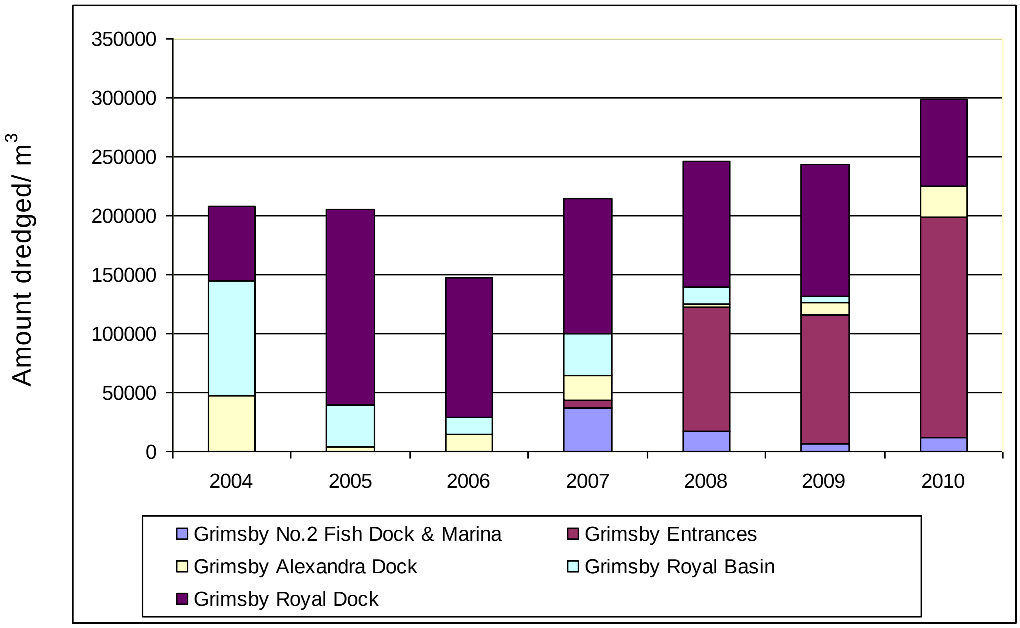

Figure 4.4 The maintenance dredge arisings from the Port of Grimsby between 2004 and 2010 (ABP, *in prep.a*).

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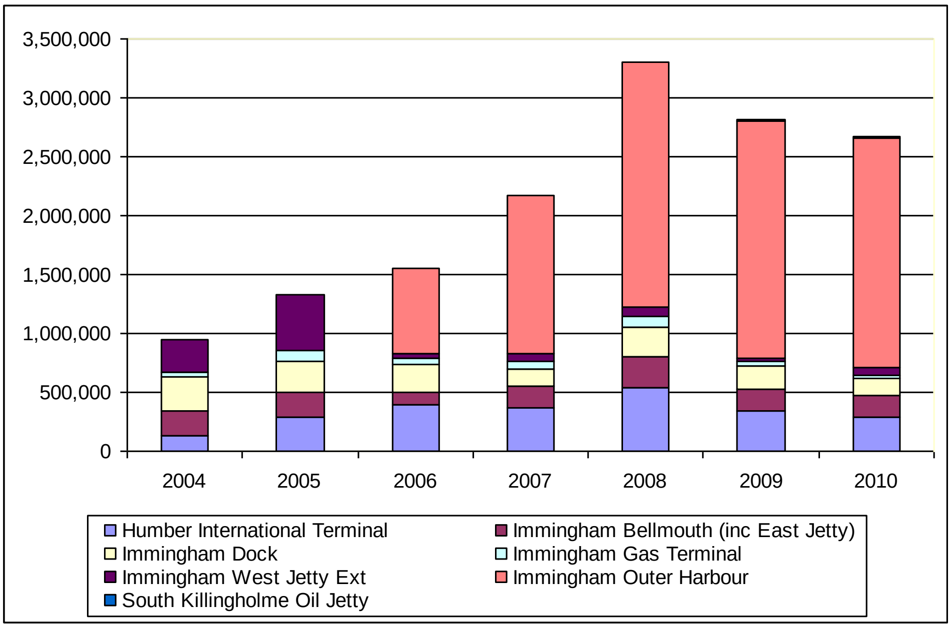

Figure 4.5 The maintenance dredge arisings from the Port of Immingham between 2004 and 2010 (ABP, *in prep.a*).

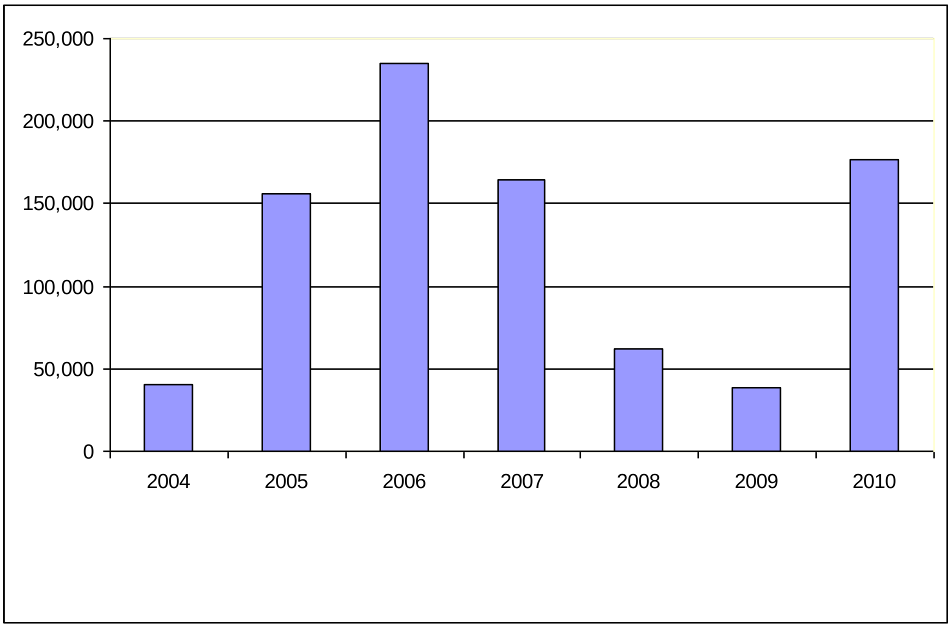

Figure 4.6 The maintenance dredge arisings from the Saltend Jetty between 2004 and 2010 (ABP, *in prep.a*).

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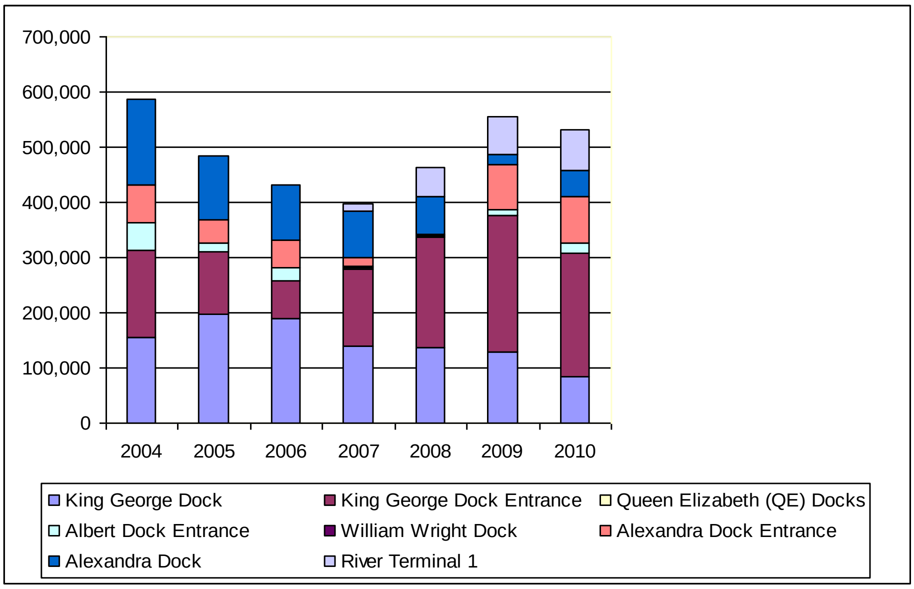

Figure 4.7 The maintenance dredge arisings from the Port of Hull between 2004 and 2010 (ABP, *in prep.a*).

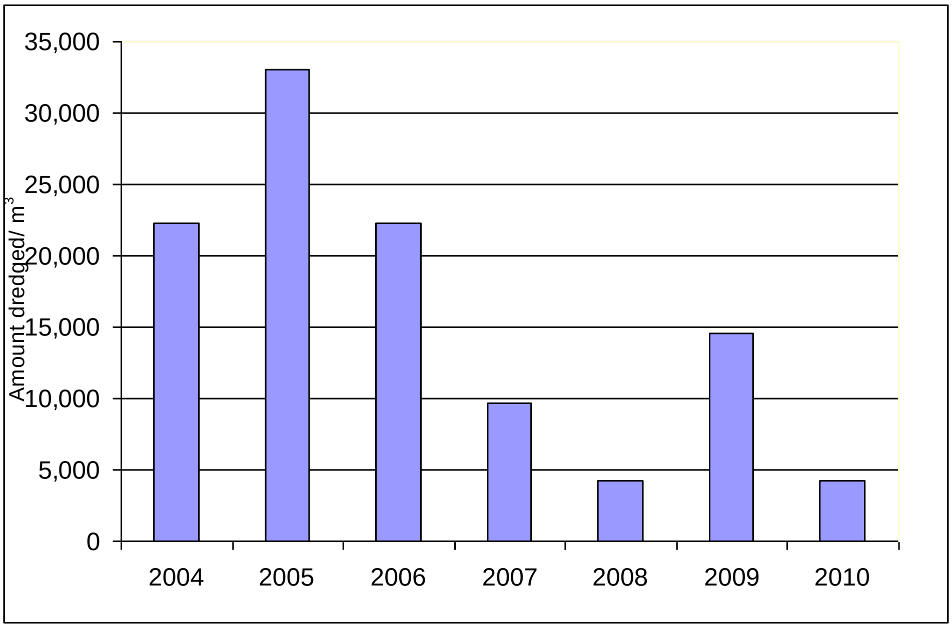

Figure 4.8 The maintenance dredge arisings from the Port of Goole between 2004 and 2010 (ABP, *in prep.a*).

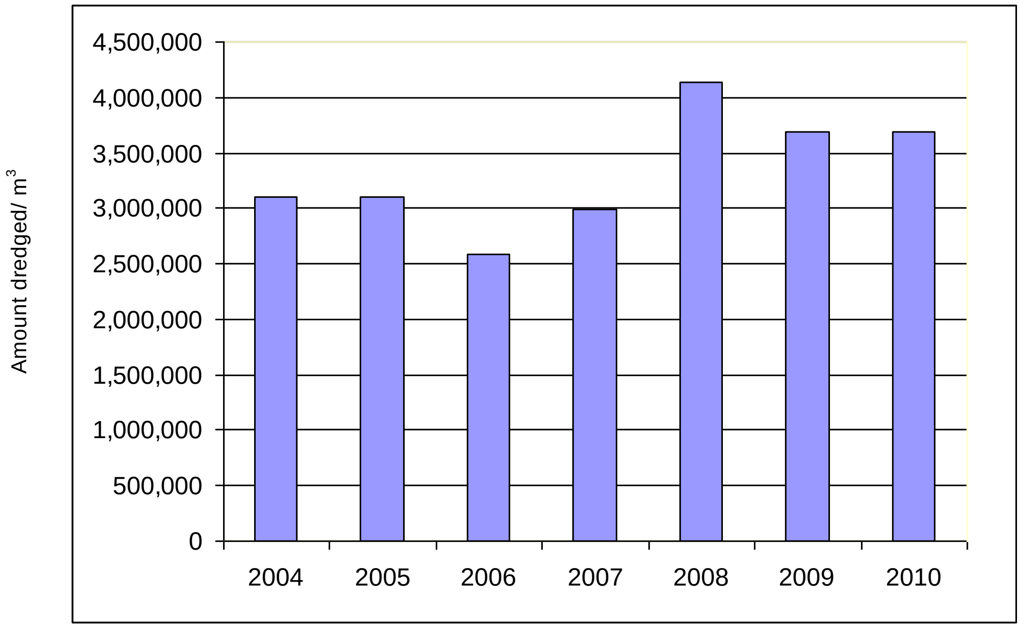

Figure 4.9 The total maintenance dredge arisings from the ABP ports on the Humber from 2004-2010 (ABP, *in prep.a*).

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Table 4.2 The amount of dredged material disposed of at their corresponding disposal sites (1985-1996) (Data from ABP *in prep.a*).

	Wet Tonnes												
Site	**Dredged Area**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
HU020	Hull	1687688	1241897	2003313	1983780	2673175	2887975	2154130	2940236	1784060	1569023	2344045	3735181
HU030	Hull	1667548	1222536	1536421	205360	196990	249730	99580	24000	20930	1866497	1146331	985788
	Hull total	**3355836**	**2464433**	**3539734**	**2189140**	**2870165**	**3137705**	**2253710**	**2964236**	**1804990**	**3435520**	**3490376**	**4720969**
HU040	Goole	53265	74210	63035	54420	78890	52240	49715	41010	45890	43620	50455	55576
HU041	Goole	0	0	0	0	0	19345	13880	7855	6945	5740	19255	31310
	Goole Total	**53265**	**74210**	**63035**	**54420**	**78890**	**71585**	**63595**	**48865**	**52835**	**49360**	**69710**	**86886**
HU060	Immingham	3190805	3016875	3432605	2047285	1798265	1407085	1347612	1764605	1245246	2326894	2030341	3010452
HU080	SDC	2356900	3057600	2995200	5293600	6592300	7113600	7251400	3190200	1758540	5651604	7729597	8332745
HU090	Grimsby	821572	776870	864350	632235	612330	670455	519925	740310	482740	837926	568775	917795
Total		**9777778**	**9389988**	**10894924**	**10216680**	**11951950**	**12400430**	**11436242**	**8708216**	**5344451**	**12301304**	**13888799**	**17068847**

Table 4.3 The amount of dredged material disposed of at their corresponding disposal sites (1997-2008) (Data from ABP *in prep.a*).

	Wet Tonnes													
Site	**Dredged Area**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
HU020	Hull	1353613	1576273	235314	331415	252833	166580	141965	264945	197235	216905	156460	114390	127685
HU030	Hull	649011	848355	2009174	1828187	12589602	1343826	1543189	1470914	1635917	1594512	1620639	1624536	679197
	Hull total	**2002624**	**2424628**	**2244488**	**2159602**	**1542435**	**1510406**	**1685154**	**1735859**	**1833152**	**1811417**	**1777099**	**1738926**	**806882**
HU040	Goole	32425	43310	38180	6575	5575	0	1115	3345	15565	10035	10105	3380	5765
HU041	Goole	17480	17385	42040	6690	9720	10220	33451	18500	21855	14565	28125	8305	17010
	Goole Total	**49905**	**60695**	**80220**	**13265**	**15295**	**10220**	**33566**	**21845**	**37420**	**24600**	**38230**	**11685**	**22775**
HU060	Immingham	1697240	2371148	3783405	2547476	2531003	3600106	2953055	4098315	3935056	4483622	7346646	8606826	4851564
HU080	SDC	8945818	7170342	3506220	4719030	4190217	4241355	7307587	4366425	2801211	448446	0	0	0
HU090	Grimsby	462266	676375	809118	639142	713975	708221	423099	681309	610587	626677	928871	641382	363051
Total		**13157853**	**12703188**	**10429451**	**10078515**	**8992925**	**10070308**	**12403461**	**10903753**	**9217696**	**7394762**	**10090846**	**10998819**	**6044272**

4.4 Potential Uses

4.4.1 Silt

4.4.1.1 Areas of Silt Dredge and Disposal

The main areas of silt accretion that need to be routinely dredged and the sites where this sediment is disposed of are shown in Table 4.1. In order to assess how much maintenance dredge arisings are produced a year, an average has been taken. For Hull, Goole and Immingham the average has been taken from Tables 4.2 and 4.3. For North Killingholme Berths and Immingham Bulk Terminal, their tonnage licence (Table 4.1) was divided by their licence length (Table 4.1). The resulting annual averages are presented in Table 4.4.

e.g. For King George Dock;

Average = (3,500,000/ 3)/3

Tonnage

For the three docks the tonnage is licensed for (King George Dock, Albert Dock and Alexandra Dock)

Number of years the licence is valid for

Table 4.4 The average amount of sediment consisting mainly of silt dredged from ABP owned ports on the Humber Estuary

Dredge Area	**Annual Average/ m^3**
King George Dock, Port of Hull	388,888
Alexandra Dock, Port of Hull	388,888
Albert Dock, Port of Hull	388,888
Port of Grimsby	190,063
Port of Goole	49,000
Port of Immingham	6,562,500

4.4.1.2 Potential Uses

The potential uses for silt that contributes to the sediment budget (Table 2.1) are:

- shore Protection such as Berm breakwaters constructed within the estuary, or
- within estuary disposal.

Construction and intertidal habitat enhancement will not be considered in this section as maintenance dredge arisings need to be kept in the sediment budget.

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4.4.1.2.1 Shore Protection- Berm breakwaters

As stated in section 2.4.3, Berm breakwaters constructed at the locations identified in table 3.3 would require non erodible material such as boulder clay or geotextile bagged gravel (French and Burningham, 2009). The silt material that is maintenance- dredged would be eroded and transported too quickly to be effective at protecting the land behind, therefore this option is not considered for maintenance- dredged silt in the Humber (Captain Phil Cowing, Harbour Master Humber, *Pers. Comm.*, 30/08/12).

4.4.1.2.2 Within estuary disposal

The material could be disposed of within the estuary for sedimentary budget reasons and is currently the only option being utilised on the Humber Estuary for the maintenance dredge arisings.

The benefits of disposing either all (if no beneficial use schemes are available at the time of dredging) or part (if not all of the sediment is needed beneficially) of material at these licensed disposal sites is that the sites are considered based on their distance from the dredge site and also on the sediment composition already present at the site. The silt is placed in disposal sites such as Hull Middle or Burcom Sands where the sediment composition is already silt. Keeping the sediment within the same estuary area allows the biodiversity and hydrodynamics to remain relatively unchanged (Table 3.1).

Since the material has been deposited at these sites historically and has shown no significant change from the Humber's natural variability with regards to dynamics (Captain Phil Cowing, Harbour Master Humber, *pers. Comm.,* 30-08-12, as discussed in section 4.1, it is assumed that this method of beneficial use will still be permitted and allows the benefits of within estuary disposal to be continued.

4.4.2 Mixed Sediment

4.4.2.1 Areas of Mixed Sediment Dredge and Disposal

The areas that consist mainly of mixed sediments are SDC, Albert Dock and the Port of Grimsby. In order to assess how much maintenance dredge arisings are produced a year an average has been calculated (the same method as in section 4.4.1.1 and the results are presented in Table 4.5).

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Table 4.5 The average maintenance dredge arisings for King George Dock, Alexandra Dock and the Port of Grimsby

Dredge Area	Annual Average/ m^3
SDC	4,360,797
Albert Dock	388,888
Port of Grimsby	190,063

4.4.2.2 Potential Uses

Mixed sediments are dredged from Albert Dock, Grimsby Docks and SDC. This could be used for shore protection at the locations set out in section 3.10 and detailed below by using for within estuary berm breakwaters. Construction and intertidal habitat enhancement will not be considered in this section as maintenance dredge arisings need to be kept in the sediment budget.

4.4.2.2.1 Shore Protection by Constructing Within Estuary Berm Breakwaters

The areas that have been identified by the EA as under threat from possible flooding and would benefit from increased protection from erosion (Table 3.3) (and an increase in flood risk) and are less than 10nm additional sailing time from the original deposit sites of the maintenance dredge arisings (Table 4.6).

Table 4.6 The potential use sites where the maintenance dredge material could be utilised based on the amount of mixed sediment to be dredged (sufficient to construct a berm breakwater) and the distance between the dredge and disposal site (within 10 nm) The locations are shown on Figures A15 to A18.

Potential Uses Site	Volume Needed/ m^3	Number of Trips	Area to be Dredged			
			King George Dock	Alexandra Dock	Port of Grimsby	Sunk Dredged Channel
			Amount to be dredged/ m^3			
			388,888	388,888	190,063	41,360, 797
Swinefleet	8,420	10				
Saltmarshe	4,210	5				
Reedness	4,210	5				
Whitgift Bank	10,525	13				
Whitton Ness	70,650	88				
Winteringham Haven	18,945	24		✓		
A1077/ South Ferriby	33,680	42	✓	✓		
East Clough	18,945	34	✓	✓		
Paull	33,750	42	✓	✓	✓	✓
Halton Marshes	16,840	21	✓	✓	✓	✓
Stallingborough	16,840	21	✓	✓	✓	✓
Hawkins Point	79,560	99	✓	✓	✓	✓
Donna Nook					✓	✓

The maintenance dredge arisings of mixed sediment could potentially be used to construct the berm breakwaters (Colenutt, 2001, French and Burningham, 2009). For those areas where the information was not available to determine the average flow velocities

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however, further survey work would need to be undertaken to ensure that the sediment would remain in situ or be transported (Table 4.1). It should be noted however that maintenance dredge is carried out on an ad hoc basis and therefore it is not always the guarantee that if the berm breakwater needs replenishment, the sediment would be there to maintain the minimum flood protection needed. This option will keep the sediment within the sediment budget for the estuary to utilise and keep the estuary near its theoretical equilibrium. By using within 10nm, it reduces the economic impact on the ports and allows the dynamics of the Humber to be relatively unchanged.

The flow velocities at the sites appear to be low enough to allow the sediment to remain at the site within geotextile bags (Table 3.2). Site specific investigations will be required however and a pilot project will be needed to ensure that the sites are suitable for these during these average velocities.

The increase in vessel movements from delivering the dredge material to the sites of potential usage is well within the capacity of the Humber Estuary (tables 4.6 and 4.7). The maximum number of trips for one barge for any one project would be 44 trips (or 88 movements or 0.25% increase) (table 4.6). The Humber Estuary in 2001-2007 accommodated over 35,000 vessels (table 4.7) on the Humber Estuary therefore it is assumed that the 44 trips made by one dredger would be able to safely navigate to the dredge and disposal sites without compromising the navigational safety of the estuary.

Table 4.7 Humber shipping traffic summary (URS Scott-Wilson, 2011: 15-5)

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total	36,054	36,780	36,580	37,260	37,203	36,400	35,664	33,578	33,580	29,453

4.4.2.2.2 Within estuary disposal

Disposing of the sediment by within estuary disposal will maintain the environmental conditions of the estuary, , has proven not to affect the Humber's functioning above the Humber's natural variability, are based on distance and sediment composition and will keep the sediment within the sediment budget. Therefore, if no alternatives can be found that could also benefit the residents of the estuary i.e. by protecting land from erosion, then within estuary disposal should still be carried out.

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4.5 Main Findings

This chapter has identified the most suitable sites for the dredged sediment taking into consideration the distance involved, the quantity and type of sediment. These are summarised and presented in Table 4.8 but does not include within estuary disposal as this has been historically and is currently carried out on the Humber Estuary.

From this chapter, the identified beneficial uses for the maintenance- dredged silt are the continuation of within estuary disposal. Silt would not be appropriate for berm breakwater construction as it would be eroded and transported from the site too quickly to be effective to protect the land behind.

Mixed sediment has been identified as potentially being used for within estuary disposal and potentially as berm breakwaters, however a pilot study and monitor work would be needed to ensure the berm breakwaters are effective and do not negatively affect the functioning of the estuary (Sheenan and Harrington, 2012).

There are constraints the potential uses, such as (Colenutt, 2001, CEDA, 2005):

- site specific investigative studies should be carried out prior to disposal;
- a pilot project should be carried out to ensure the disposal does not affect the Estuary;
- considerations such as local hydrodynamics, biodiversity and sediment characteristics should be taken in to account;
- post disposal monitoring should be carried out, and
- plans in place should be agreed prior to dredging in case the dredged material is not available for the beneficial use.

These potential uses which have been identified will be tested for the adherence to the 7 tenets of sustainable development in chapter 6.

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Table 4.8 Summary of the maintenance dredge sites and the potential sites where these maintenance dredge arisings could potentially be utilised (based on distance (within 10 nm), sediment type and quantity).

			Maintenance									
			Silt						Mixed			
			KGD	Alex	Albert	Port of Grimsby	Port of Goole	Port of Immingham	KGD	Alex	Port of Grimsby	SDC
			388,888	388,888	388,888	190,063	49,000	6,562, 500	388,888	388,888	190,063	41,360, 797
	Sediment at Site	**Sediment Needed**										
Swinefleet	Unavailable	8,420										
Saltmarshe	Unavailable	4,210										
Reedness	Unavailable	4,210										
Whitgift Bank	Unavailable	10,525										
Whitton Ness	Unavailable	70,650										
Winteringham Haven	Unavailable	18,945								✓		
A1077/ South Ferriby	Fine and coarse sands	33,680							✓	✓		
East Clough	Fine and coarse sands	18,945							✓	✓		✓
Paull	Silty clay	33,750							✓	✓	✓	✓
Halton Marshes	Fine and coarse sands	16,840							✓	✓	✓	✓
Stallingborough	Silty clay	16,840							✓	✓	✓	✓
Hawkins Point	Silty clay	79,560							✓	✓	✓	✓
Donna Nook												

5 Capital Dredging

Capital- dredging involves removing sediment that has not been disturbed in the last 10 years (Gupta *et al.*, 2005) or historically. Even though it may not contribute to the daily, annual or even decadal sediment budget it can still be considered as part of the sediment budget in centenary terms. Capital dredge projects are those that generally involve a new marine facility such as a jetty or quay and the deepening of the approaches leading to new facilities. As described in chapters 2 and 4 (Literature Review and Maintenance Dredging respectively) there is a responsibility on the developer to keep the readily mobile alluvial (top layer of) sediments within the sediment budget. For the proposed capital dredge projects, there will be an element of sediment that needs to be kept in the sediment budget and an element that will not i.e. the deeper more compacted sediment that does not contribute to the sediment budget. As there is little or no mention of this top layer of sediment that contributes to the sediment budget, in the ES's or publicly available documents, this study will assume that the developer/ contractor has agreed that the top layer of sediment that does contribute to the sediment budget will first be maintenance- dredged, leaving the more compacted sediment below to be potentially used in alternative ways.

Capital dredge projects are carried out in strict accordance with timelines to either be economically competitive if the industry is aimed at particular cargo or vessel type, or because there is an interested customer who have their own commercial timelines to keep. It is therefore in the developer's interest to ensure the construction programmes are followed to ensure that the port can remain economically sustainable. By having a third party involved e.g. for the beneficial disposal at a certain site(s), it puts additional pressure on the developers of both sites to ensure that the projects are synchronised.

Table 5.1 shows the projects that are proposed for the Humber Estuary that involve capital dredging and the associated sediment types, the amount of the dredged material and the proposed disposal sites (the locations are shown in Figures A19-A23 and Figures A20-23, A46 and a brief summary of each capital dredge project are provided in Appendix K). Table 5.1 also summarises the different types of dredgers that are proposed for the capital dredge projects within the Humber Estuary (Appendix F).

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Table 5.1 The types and amounts of sediment to be dredged from the capital projects and the proposed disposal sites. Figure A1 shows the location of the proposed dredge and disposal sites.

Project	Area to be Dredged	Sediment Type	Dredge Volume	Amount/ m^3	Disposal	Distance/ km	Dredger
HRBT	Approach and berth	Alluvial clays	112,000	112,000	Hull Middle Hook	0.406	TSHD
		glacial gravel	37,000	37,000	SDC A and B	20.11	TSHD/ Backhoe or CSD
		glacial clay	511,000	511,000	SDC A and B	B= 19.62 A= 21.33	TSHD/ Backhoe or CSD
	Halton Middle	Fine sand and silts	450,000	450,000	Foul Holme Spit		TSHD
IOTA	Stallingborough Emergency Turning Area	Soft clay, Silt and Sand	65,000	22000	Holme Channel Deep	2.14	TSHD
				43000	HU080	1.29	TSHD
	SDC	Soft clays and silt	1985000	311000	Holme Channel Deep	7.32	TSHD
				659000	Middle Shoal	2.77	TSHD
		Fine Sand		895000	Middle Shoal	2.77	TSHD
		Firm Glacial Clay		120,000	SDC C	1.32	Backhoe
	Hawke Channel	Soft clays and silt	565,000	565,000	Bull Sand Fort	11.89	TSHD
	Chequer Shoal	Fine to medium sand	865,000	865000	Bull Sand Fort extension	4.98	TSHD
	Eastern approaches	Fine to medium sand	170,000	170,000	Bull Sand Fort extension	4.96	TSHD
		Stiff glacial clay	255,000	120,000	SDC A and B	A= 13.46 B= 15.10	Backhoe
				135,000	Bull Sand Fort	4.96	Backhoe
Grimsby	Berth Pocket	Soft clay and silt	160,000	115,000	Middle shoal	4.1	backhoe
		Firm/ Stiff Clay		45,000	SDC A	3.99	Backhoe
					SDC B	3.86	Backhoe
	Turning Area	Soft Clays/ alluvium	38,000	38,000	Burcom Sand	1.55	TSHD
	Approach	Soft Clays/ alluvium*	12,000	12,000	Burcom Sand	1.77	TSHD
AMEP	Approach, Turning Area and berth pocket	Alluvium clays, silts, sand and gravel	981,150	981,150	Middle Shoal	11.54	TSHD
		Glacial Till	945,350	945,350	SDC A and C	13.20	TSHD
							Backhoe
GPH	Two consented berths	Soft Silt and fine sands	9,500	9,500	Infill	0.3	TSHD
		Boulder clay and glacial till	109,700	109,700	Infill	0.3	Backhoe
	Third berths and widening of the berths	Soft silt and fine sands	12,300	12,300	Hull Middle	1.26	TSHD
		Boulder clay and glacial till	135,850	135,850	SDC A and B	23.45/ 22.29	Backhoe

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5.1 Alluvium and Fine to Medium Sand

Alluvium (a mix of silt and mud) and sand generally makes up the top layers of the estuary bed. The potential uses for alluvium and sand are similar (Table 2.1) and are as follows:

- shore Protection by constructing onshore or berm breakwaters constructed within the estuary;
- intertidal enhancement, or
- within estuary disposal.

Construction has not been considered due to the absence of responses from such companies (section 1.5), therefore this potential use cannot be considered further in this study. It should still be considered in the future (Sheenan and Harrington, 2012,Wang *et al.*, 2012).

5.1.1 Potential Uses

5.1.1.1 Shore Protection by Constructing within Estuary Berm Breakwaters

As discussed in section 2.4.3, alluvium and fine to medium sand will not be appropriate for use as berm breakwaters to protect the land from erosion (French and Burningham, 2009, Captain Phil Cowing, Harbour Master Humber, *pers. Comm.,* 30/08/12)). The material would be eroded too quickly to be effective within the estuary and would be transported elsewhere. Therefore the option will not be considered for capital- dredged alluvium and fine to medium sand.

5.1.1.2 Intertidal Enhancement

The EA has a proposal to deliver a managed realignment site at Donna Nook (EA, 2009). The silt from some of the proposed capital projects could be used to improve the likelihood of the colonisation of saltmarsh habitats and species, and possible enhancement of the proposed earth embankment for flood defence. As discussed, it is important to consider the sediments chemical and physical characteristics as even though sand is easier to plant, the alluvium generally has a higher organic matter content (Broome *et al.,* 1988).

As discussed in section 2.4.1, the placement of sediment at Donna Nook would most likely develop the site to saltmarsh colonisation in the short term with the site progressing to a terrestrial ecology due to the high accretion rates (Boyes and Mazik, 2004, Mazik *et al*., 2007, 2010). With this in mind, it is not considered that the placement of material will be used at Donna Nook for enhancement but the option will be considered for future use.

The sand dredged for example from the IOTA chequer shoal and eastern approaches sites could be used to create the earth embankment at Donna Nook as the earth embankment will join the already existing sand dunes at the east of the site (EA, 2009). This would allow for

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the new embankment to be in keeping with the existing landscape and be able to enhance biodiversity of the dune habitat (Colenutt, 2001). This option would need to be determined as suitable by ensuring the sediment characteristics are suitable for placement on intertidal areas.

AMEP could provide all of the material required to enhance Donna Nook (Table 5.2). It is unlikely however that the EA would require sediment for the entire 111ha site to create the site as the site would most likely be designed to accommodate multiple niches and habitats. Therefore all of the proposed projects could deliver some material to raise ground levels for saltmarsh and enhance intertidal habitats. The exception is GPH which is further than 10nm than the proposed Donna Nook and has therefore been discounted.

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Table 5.2 The proposed capital projects that are within 10nm additional sailing distance (from the proposed disposal sites) of the proposed managed realignment site. The locations are shown on Figures A24 to A27 and A48.

Capital Dredge Area	**Sediment to be dredged**	**Amount to be dredged/ m^3**	**Additional Sailing Distance/ nm**	**Amount of sediment required/ m^3***	**Can Capital deal with this**
Grimsby Ro-Ro Berth	Soft silt and clay	115,000	9.6	1,110,000	In part or combination
Grimsby Ro-Ro Turning Area	Soft clays and alluvium	38,000	10.4	1,110,000	In part or combination
Grimsby Ro-Ro Approach	Soft clays and alluvium	12,000	9.3	1,110,000	In part or combination
AMEP	Alluvium clays and silt	60,000	11.23	1,110,000	In part or combination
IOT Turning Areas	Soft clay, silt and sand	65,000	12	1,110,000	In part or combination
IOT SDC	Soft clays and silt and fine sand	2,880,000	9	1,110,000	Yes
IOT Hawke	Soft clays and silt	565,000	3.8	1,110,000	In part or combination
IOT Chequer Shoal	Fine to medium sand	865,000	1.5	1,110,000	In part or combination
IOT Eastern Approaches	Fine to medium sand	170,000	2.5	1,110,000	In part or combination
GPH	Fine silts and sand	12,300	22.91	1,110,000	No

* The total area of 111ha has been used to provide a worst case scenario (it is unlikely the EA will require such quantities of dredged material as once breached the area will develop towards an estuarine habitat).

5.1.1.3 Within estuary disposal

As discussed in section 2.4.4, there are benefits to disposing of the material in these sites including ecological, hydrodynamical and economical. Within estuary disposal therefore should be continued to be the method of disposal if no alternative disposal methods can be identified that would either enhance the environmental or ecological conditions or provide additional benefits to the local populations of the estuary.

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5.2 Clay

Glacial clay is generally dredged from the lower depths and due to being under greater pressure, is more consolidated and therefore more resistant to erosion. The potential uses of clay are:

- land and shore protection by berm breakwaters, or
- construction materials

Construction has not been considered due to the absence of responses from such companies, therefore this potential use cannot be considered further in this study but should be considered in the future (section 1.5) (Dubois *et al*., 2009).

5.2.1 Potential Uses

5.2.1.1 Shore Protection By Constructing Within Estuary Berm Breakwaters

The potential for enhancing the shore protection along the Humber Estuary and therefore increasing the protection to flood risk could be accomplished by the construction of berm breakwaters (either onshore (which would require an additional consent for the placement of material on an SAC) or within the estuary depending on the location). The areas on the Humber Estuary that have been identified as being under threat to erosion and are within or less than 10nm less additional sailing distance (from the proposed disposal sites) (Table 5.3).

A decision would have to be made however, on the sediment type of the berm breakwaters constructed within the estuary as capital clay cannot be placed on the alluvium that contributes to sediment budget as this would “trap” the alluvium from the sediment budget (Section 5.1). To avoid “trapping” the sediment from the budget the developer could agree to a “maintenance” dredge to remove this top layer of sediment from the site. This would require another additional consent from the MMO for the dredging.

The additional barge trips to deliver the dredge material to the sites of potential usage are well within the capacity of the Humber Estuary. The maximum number of trips for one barge for any one project would be 99 trips (or 198 movements or 0.28% increase) (Table 4.7). It is assumed that the 99 trips made by one dredger would be able to safely navigate to the dredge and disposal sites without compromising the navigational safety of the estuary. The routes the dredger would take are shown on Figures A38 to A44 and A48.

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Table 5.3 The areas of the Humber Estuary that are under threat of erosion and the sediment that would be required to ensure a level of protection to the defences behind any berm breakwaters to be constructed. The capital projects that could provide this level of sediment and the number of dredger trips that would be required. The locations are shown on Figures A24 to A27 and A46.

Area under threat of erosion	**Length of defences/ km**	**Depth/m**	**Base/ m**	**Total Sediment Required/m^3**	**Possible Capital project**	**Number of Dredger Trips***
Winteringham Haven	4.5	1	9	18,945	AMEP HRBT	24
A1077/ South Ferriby	8	1	9	33,680	IOT (SDC) IOT (EA) HRBT AMEP GPH	42
East Clough	4.5	1	9	18, 945	AMEP GPH IOT HRBT	24
Paull	2.5	3	9	33,750	IOT GPH HRBT AMEP Grimsby Ro-Ro	42
Halton Marsh	4	1	9	16,840	IOT GPH HRBT AMEP Grimsby Ro-Ro	21
Stallingborough	4	1	9	16,840	IOT GPH HRBT AMEP Grimsby Ro-Ro	21
Hawkins Point	12	1.5	9	79,560	IOT GPH HRBT AMEP Grimsby Ro-Ro	99

*Number of backhoe trips (for movements double) based on a hopper capacity of 1000m^3 and allowing for variation of density in situ and within the barge.

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5.2.1.2 Within Estuary Disposal

The major scour holes identified within the Humber Estuary are the SDC windows (A, B and C) and Bull Sand Fort (ABP, *pers. Comm.*). The reason that the proposed dredged clay will be disposed in the SDC windows or Bull Sand Fort is to protect the areas from further erosion (Table 5.1) (Captain Phil Cowing, Harbour Master Humber*, pers. Comm.,* 30/08/12)*)*. It is therefore concluded that any clay that could not be used in constructing berm breakwaters (for economic, quantity reasons or other) that excess clay should be disposed of in the SDC windows or at Bull Sand Fort as was originally proposed to protect landscape and cultural heritage sites (see Table 5.1).

5.3 Glacial Gravels

The glacial gravels are to be dredged from the HRBT approach and berth and some from the AMEP project. However, since these volumes are not great, it is recommended that the sediment either be utilised in combination with clay in the construction of Berm breakwaters or for the developer to continue the disposal of the sediment at the proposed licensed sites within the estuary.

Intertidal enhancement is not considered for glacial gravels as the intertidal areas consist of fine grained silts and muds to support the protected species of the estuary whereas gravel would not be suitable for this purpose.

5.4 Main Findings

The potential uses identified in this chapter show that the capital dredge arising's could be used for intertidal enhancement, berm breakwater construction or the continuation of within estuary disposal (summarised in Table 5.4). These have shown to be viable options for the capital dredge arisings based on the sediment type and distance between these proposed sites and the areas of dredging. Capital dredge works however are normally carried out on a strict timeline, any potential use identified would have to have the same or similar time line for construction to ensure that the sediment is not dredged and then left unused. These additional consents and legal agreements that would be required can add high costs and extended time periods to the construction phase. These could prove uneconomically for the developer to pursue an alternative beneficial use.

The using of capital dredge arisings can potentially be used as flood defence by constructing berm breakwaters (whether onshore or within the estuary), however as a capital dredge project is done once, the material will only be available for a short period of time and no more will be available after (unless another capital dredge project is granted consent which will

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dredge similar sediments). In order to overcome this, the EA will need plans in places in order to address this concern.

These potential uses which have been identified will be tested for the adherence to the 7 tenets of sustainable development in chapter 6.

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Table 5.4 Summary of the capital dredge sites and the potential sites where these dredge arisings could potentially be utilised (based on distance (within 10 nm), sediment type and quantity

			HRBT				IOTA												Grimsby					AMEP		GPH	
			Approach and berth			Halton Middle	Stallingborough Emergency Turning Area		SDC				Hawke Channel	Chequer Shoal	Eastern approaches			Berth Pocket		Turning Area		Approach				
			Alluvial clays	glacial gravel	glacial clay	Fine sand and silts	Soft clay, Silt and Sand	Soft clay, Silt and Sand	Soft clays and silt	Soft clays and silt	Fine Sand	Firm Glacial Clay	Soft clays and silt	Fine to medium sand	Fine to medium sand	Stiff glacial clay	Stiff glacial clay	Soft clay and silt	Firm/ Stiff Clay	Soft Clays/ alluvium	Soft Clays/ alluvium*	Alluvium clays and silts*	Sands and gravels*	Glacial Till	silt	glacial till
			112,000	37,000	511,000	450,000	22,000	43,000	311,000	659,000	895,000	120,000	565,000	865,000	170,000	120,000	135,000	115,000	45,000	38,000	12,000	60,000	250,000	1,023,000	12,300	135,850
	Sediment at Site	**Sediment Needed**																								
Swinefleet	N/A	8,420																								
Saltmarshe	N/A	4,210																								
Reedness	N/A	4,210																								
Whitgift Bank	N/A	10,525																								
Whitton Ness	N/A	70,650																								
Winteringham Haven	N/A	18,945			✓																			✓		
A1077/ South Ferriby	Fine and coarse sands	33,680			✓							✓				✓	✓	✓						✓		✓
East Clough	Fine and coarse sands	18,945			✓							✓				✓	✓	✓						✓		✓
Paull	Silty clay	33,750			✓							✓				✓	✓	✓	✓	✓	✓			✓		✓
Halton Marshes	Fine and coarse sands	16,840			✓							✓				✓	✓	✓	✓	✓	✓			✓		✓
Stallingborough	Silty clay	16,840			✓							✓				✓	✓	✓	✓	✓	✓			✓		✓
Hawkins Point	Silty clay	79,560			✓							✓				✓	✓	✓	✓	✓	✓			✓		✓
Donna Nook									✓	✓	✓		~	~	~			~		~	~	~	~			

6 The 7 Tenets

This section will determine if the different potential alternative uses of the proposed capital dredged material and the maintenance dredged material adheres to the 7 tenets of sustainable management (as discussed in 3.8). Each potential use will be investigated separately with each of the tenets, although no discrimination of the capital and maintenance dredging has been made in this chapter as the it is the beneficial use options being tested rather that the specific cases investigated in this study.

This study has identified that certain tenets have a higher degree of confidence when being applied to the different proposals. The tenet for being "Environmentally and ecologically sustainable" can be defined as ensuring the environment and ecology remains functional, diverse and productive. This tenet can be regarded with high confidence due to number of past studies and the studies on to the effects of dredging and disposal (Van Dolah, *et al.*, 1984, McFarland *et al*., 1994, Ray *et al.*, 1994, Bolam and Rees, 2003, Bolam and Whomersley, 2003, Yozzo *et al.*, 2004, Bolam *et al.*, 2006). There is however, a certain degree of uncertainty due to the lack of site specific data that can be tested against and should therefore be regarded with caution.

The tenet for "Technologically Feasible" refers to the viability of the scheme based on the technology at present. This tenet can also be regarded with high confidence due to the knowledge that HES, EA and the dredge contractors use the appropriate technology at present. The availability however, would be unknown until the consent has been granted for the dredging equipment. Therefore although the technology does exist there is some uncertainty over whether the technology would be available at the time of dredging and disposal.

The tenet for "Economically Viable" means that it would be unjust to have an obligation on the developer to carryout the most environmentally sustainable option if the costs are so onerous it would make the scheme unviable. It has a low degree of confidence associated with it as no monetary values were assigned to any aspect of the dredging activities or potential uses. The assessment was carried out using only a cost benefit dredge strategy based on assumptions that were based on the baseline of present day disposal strategies (Section 1.4).

The tenet for "Socially Acceptable/ Tolerable" refers to the public's perception and if the public and society in general what the scheme. This tenet has a low degree of confidence associated with it. It is unknown how the public would react to new disposal strategies specific to the potential use sites and what their worries and concerns would be.

The tenet for "Legally Permissible" refers to the current legislation. A project cannot be carried out if any aspect is not lawful. This tenet again has a certain degree of uncertainty associated with it. Past studies have shown that dredged material can be used in alternative,

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beneficial ways successfully and that the MMO do state on their licences that beneficial uses should be considered even after the licence is granted (Tom Jeynes, ABP, *Pers. Comm.,* Van Dolah, *et al.*, 1984, McFarland *et al*., 1994, Ray *et al.*, 1994, Bolam and Whomersley, 2003, Bolam and Rees, 2003, Yozzo *et al.*, 2004, Bolam *et al.*, 2006). The uncertainty however is if the MMO would grant consent for the alternative uses on the Humber Estuary given that the current method of disposal is firstly considered a beneficial use in its own right and secondly, has shown to have no long term adverse effects on the estuary functioning.

The tenet for "Administratively Achievable" refers to the organisations that are responsible to the consenting, implementation and regulation of the activities and whether these already exist to regulate the scheme. This tenet again has a certain degree of uncertainty with it. There are bodies that exist to ensure that all consideration and constraints are taken account of before consent is given and detailed monitoring could be conditioned, however it is unclear as to whether these bodies would allow the alternative disposal in "new" sites in the Estuary.

The tenet for "Politically Expedient" cannot be assessed with any confidence because politics take into consideration the economics and the benefits that the dredging activities can contribute to the local economy, whereas the environmental implications may not be taken into equal consideration. This tenet therefore will not be assessed further.

6.1 Within Estuary Disposal

The consideration of the 7 tenets given to within estuary disposal (i.e. distance involved and sediment already present) is already considered by the ports, developers and regulators.

It is important to note, as discussed in section 4.1 that historically, the disposal sites that are in use today very much resemble the disposal sites that were first used when the docks were opened in the latter half of the 19th century. The sites were first considered due to their proximity to the dredge area. As described by Captain Phil Cowing (Harbour Master Humber, *pers. Comm.,* 30/08/12) port operators must take into account not only the distance from the port based on the steaming time but also how far away to remove the sediment. This is important because the port operators would want to move the sediment far enough away not to instantly "refill" the dredge area as soon as the tide comes in but also not too far away so as to be economically unviable.

In more recent years, there has been an increased legislative presence especially in terms of environmentally sustainability however, the current sites on the Humber have continued to address the recent concerns due to their:

- Keeping the estuary within the sediment budget;
- Being far enough away to prevent continuous dredging;

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- Not being too far away as to be considered economically onerous;
- Sites are considered on a "like for like" basis; and
- Are monitored to ensure the disposal do not become full or alter the dynamics of the system.

(Captain Phil Cowing, *pers. Comm.,* 30/08/12).

Environmentally Sustainable with Ecological Integration into the Project

By choosing disposal sites that are in close proximity to the dredge sites (tables 4.1 and 5.1), as already carried out by the maintenance dredge activities and the capital dredge operations, it reduces the carbon footprint of the operation by using less fuel and therefore emitting fewer emissions. This reduction in travelling distance reduces the impact that the vessel will have on aquatic species through noise and local water quality variations.

The sediment is disposed of in licensed disposal sites that are of similar sediment characteristics as that of the dredged material. With relatively small distances it ensures that the sediment will remain within the same estuary area (Section 3.1) and the biodiversity and hydrodynamics will remain relatively unchanged (Table 3.1). The disposal will have some effects on the local environment but these are temporary and historical records have shown no negative effects from this method of disposal and are routinely monitored.

Technically Feasible

The technology already exists to dredge and dispose of the material at the licensed sites in the form of TSHD's and backhoe dredgers. HES already have sonar equipment to monitor as they use to survey the Humber Estuary to ensure the safe navigation of vessels therefore all of the necessary equipment required to carry out such an exercise already exists and is therefore technically feasible.

There also already exists the mitigation technology to reduce the effects of dredging on the environment and therefore this option is technically feasible whilst ensuring environmental sustainability (Appendix K).

Economically Viable Including Vessel Traffic Assessments

The disposal sites of dredged material are generally decided on two main points; 1) the composition of the dredged material; and 2) the distance between the licensed disposal site with this composition and the dredge site. The developer/ dredging contractor try to ensure that the licensed disposal sites are with relatively close distance to the dredge site to reduce costs.

Within estuary disposal has been carried out on the estuary for a number of years and therefore the developers, port operators and dredging contractors have a sound knowledge of the licensing procedure, length of procedure and how long these licenses last. Having this

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knowledge is vitally important as it ensures the developer/ port operator/ dredging contractor can avoid being fined for using an expired license or having to cease shipping activity due to an expired license by planning their applications carefully.

Since the dredging contractors, port authorities and developers already use these sites and there are multiple sites throughout the estuary with varying sediment compositions it would appear to be an economically viable option to continue to dispose at the licensed disposal sites.

Within estuary disposal however can incur additional costs for the port operator if not monitored and managed accordingly.. An increase in distance may also increase the costs of hiring the dredger to compensate for the increase in fuel costs, labour and maintenance of the vessel.

This therefore shows the importance of detailed investigative studies to determine the likelihood of this scenario and the costs and benefits of disposing at various distances.

Socially Acceptable/ Tolerable

To apply for any marine licence (new or renewal) there is an obligation to advertise the proposed works in two local newspapers (MMO, 2011*e,* Marine EIA Regs*, 2007: paragraph 16 (ai)*). This allows the public to become aware of the proposed works and find out more about them.

There is also a Humber Maintenance Dredge Baseline Document (in review at present) that is in the public domain. It demonstrates the quantities of sediment that are dredged, where the sediment is disposed of and the reasons behind their disposal strategies.

This document is important for capital dredge projects, because the Humber Estuary has international designations it allows the regulators to understand the current levels of dredging and disposal activity on the estuary when determining a new application.

Since within estuary disposal has been carried out on the estuary historically (ABP, *in prep.a*) it would appear that this method is generally accepted and tolerated by the public and stakeholders and by the regulators who grant consent. The HMDP is a way in which to communicate the management of the Humber Estuary and to understand the driving forces behind the decisions.

Beneficial use of the dredged material is still a relatively new concept but is gaining more publicity with the wider public becoming more aware of “sustainable development” with many local authorities are trying to use this resource in alternative ways to meet this sustainable development target. Due to this growing interest, stakeholders and developers are also looking into alternative uses of the dredge material. If at the time of dredging however there are no potential alternative uses for the material, within estuary disposal is the preferred option because, as discussed earlier, it allows sediment to remain in and be used by the estuary and

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has to present shown no permanent adverse effects on the system. This would allow the developer to maintain their construction programme.

Legally Permissible

Disposing of the dredged material within the estuary system is legally permissible under The Marine and Coastal Access Act, 2009 and is granted by the MMO under this legislation. Since this has been and still is the preferred method of disposal in the Humber Estuary and the MMO continue to grant licenses for within estuary disposal this method of disposal is legally permissible.

Administratively Achievable Including Dredge Contractors, Port Authorities and Existing Management

Within estuary disposal is administratively achievable as the ports that operate within the estuary carry out dredging and disposal at these sites on a regular basis (see chapter 4 Maintenance Dredging). Therefore the companies, strategies and technology all exist to carry out such operations and can apply the same methods, dependant on the material and location, to capital dredge projects.

The disposal of the sediment within the estuary have satisfied the NE, EA, ABP (as the Harbour Authority), MMO and the local authorities in the past and therefore it appears that this option is administratively achievable. It is regulated by the MMO and is monitored by the Harbour Authority to ensure the vessels can navigate the channels safely.

6.2 Berm Breakwaters

As discussed in section 2.4.3, maintenance- dredged silt will not be considered for berm breakwaters due to the sediment type being ineffective for berm breakwater creation and therefore the 7 tenets refer to the capital dredge arisings only and maintenance mixed arisings.

Environmentally Sustainable with Ecological Integration into the Project

It is considered that the construction of these berm breakwaters would be environmentally sustainable as, in time, they would allow colonization of infaunal invertebrates and the intertidal behind the berm breakwater to accrete (Rousseau, 2008) . This would provide more intertidal habitat for invertebrates, vegetation and as a feeding resource for birds, therefore increasing the biodiversity of the estuary (Rousseau, 2008).

These berm breakwaters would erode and overtime would add to the sediment budget or the intertidal area, depending on the prevailing conditions at the time (French and Burningham, 2009). This erosion however would also reduce the berm breakwaters functionality and would therefore need maintenance (Comoss *et al.*, 2002, French and Burningham, 2009). As capital

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dredging is carried out only once this loss in functionality may become a concern, as this may result in the berm breakwaters eroding to a point to allow erosion to occur behind. This can be avoided however by careful monitoring and by the EA ensuring a suitable plan is in place prior to disposal. If after the pilot project it was determined that mixed sediments from maintenance dredging were effective as Berm breakwater material, this could be used to replenish the berm breakwaters as and when maintenance dredging is carried out.

By using a secondary resource such as dredged material, it provides less opportunity for the need to purchase primary resources in the refurbishment or maintenance of the flood defences already present around the estuary.

Technically Feasible

The technology already exists to dredge and dispose of the material at the licensed sites in the form of TSHD's and Backhoe dredgers. HES and the EA have the necessary equipment to monitor the subtidal and intertidal dynamics to determine the success/ effectiveness of the berm breakwater and are therefore technically feasible and provide a cost effective way of monitoring.

More localised details monitoring would be required. The technologies for these measurements do exist although this may add costs to the monitoring strategy e.g. for the hiring of this equipment or the use of man hours. This may be of interest if in the future this method of disposal is proven effective, the EA can reduce the costs they spend on the flood defences.

Economically Viable Including Vessel Traffic Assessments

As discussed in section 1.3.2, by identifying sites of potential use that are within a relatively close distance (10nm), it allows resources to be kept to a minimum for the dredging contractor.

The use of capital and maintenance dredge arisings to create a protective barrier to the areas under threat of erosion, ensures that a cost effective alternative in comparison to having to purchase primary resources to maintain or refurbish the defences that are providing a less than adequate flood protection.

Using this disposal strategy would require the same technology i.e. dredgers as those that were carrying out the dredging activity therefore no new equipment would need to be hired in. As HES and EA already have the technology available to monitor the subtidal and intertidal habitats to determine the effectiveness of the berm breakwaters. This appears to be cost effective however this strategy could see the parties involved incur additional costs from monitoring but they would also have to invest in a detailed pilot project to determine the site specific effects (Fettweis *et al*., 2011, Sheenan and Harrington, 2012).

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As discussed above, the berm breakwaters may require additional sediment however by careful monitoring, especially before a maintenance dredge is to be carried out, the sediment from the next maintenance dredge can be utilised (depending on sediment type and quality), thereby ensuring the project remains economically viable.

Socially Acceptable/ Tolerable

It is unknown at this stage whether berm breakwaters would be accepted by the users and stakeholders or not. It is therefore imperative that the developers consult with the public to ensure any concerns are considered and the reasons for the approach explained in order to educate the public as to the reasoning behind this approach such as the potential threats of sea levels rise on the ecology and the on the flood protection. This is important as public representatives are taken into account when determining the project for consent (Marine EIA Regs 2007, Paragraph 21).

As this kind of potential use of dredged material has not been considered before on the Humber Estuary, if consent was granted and programmes allowed the project to be taken forward, it is advised that an in depth study of the local area be monitored. The results should be shared for other projects and other estuaries to learn from such projects and the potential uses of dredged material could also be considered elsewhere.

Legally Permissible

As all of the beneficial uses described in this study have previously been carried out on other estuaries in the UK (Colenutt, 2001; Atkinson *et al.*, 2001*a;* Greene, 2002; US Army Corps of Engineers, 2004;Yozzo *et al.*, 2004; Rousseau, 2004; McLusky and Elliott, 2004; Bolam and Whomersley, 2005, 2003; Bolam *et al.*, 2006, Somerfield *et al.,* 2006; Nicholson *et al.* 2010; van der Wal *et al.,* 2011) it is assumed that as long as the developer can prove no adverse or significant environmental effects or impacts from the "new" use, these are legally permissible.

According to the Marine and Coastal Access Act (2009) regulation 66 (1), a licensable marine activity is:

> *7. To deposit any substance or object within the UK marine licensing area, either in the sea or on under the sea bed from-*
> *(a) any vehicle, vessel, aircraft or marine structure. .*
> *8. To construct, alter or improve any works within the UK marine licensing area either-*
> *(a) In or over the sea, or*
> *(b) On or under the sea bed.*

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These regulations, even though are explicit regarding the location of the material i.e. on the sea bed are not explicit as to the purpose of the disposal and therefore the regulations do not prohibit the granting of a licence for a use such as berm breakwater construction. It is therefore assumed that provided all of the tests are passed and detailed monitoring is proposed, there appears to be no legal reason for the MMO not to withhold consent for berm breakwater construction within the estuary.

Administratively Achievable Including Dredge Contractors, Port Authorities and Existing Management

Theoretically, constructing berm breakwaters with the capital dredge arisings could be achieved; however permissions would need to be sought for the disposal of the material within the identified areas. This could be a lengthy process. If construction of the projects (Table 5.1) were to commence (due to commercial reasons) before the permissions were granted for the disposal of the sediments, then the dredged material would have to be disposed of at the originally proposed disposal sites in the Humber Estuary to keep the construction programmes on schedule.

The use of the sediment for the construction of berm breakwaters within the estuary would have to satisfy NE, EA, ABP (as the Harbour Authority), MMO and the local authorities due to their role in the management of the estuary and their responsibilities.

If the permissions were granted in time for the capital projects to commence, then this option could be pursued as (stated above) it requires no additional technology or contractors to be brought in to dispose of it.

6.3 Intertidal Enhancement

As stated in section 5.2.1.1, maintenance dredge arisings cannot be used as intertidal enhancement as this sediment needs to be available to the sediment budget of the estuary to ensure it remains functional. Therefore this section only refers to the alluvium that would be capital- dredged.

Environmentally Sustainable with Ecological Integration into the Project

By identifying sites that are within 10nm of the original proposed disposal sites, it ensures that the dredger uses less fuel (than if it were to travel a greater distance for a similar potential use) thereby reducing their economic resources and carbon footprint.

By ensuring the dredger has a 10nm radius it limits the areas of the estuary where the sediment can be disposed of thereby reducing the effects the dredger may have on aquatic species such as migrating Salmon (of economic importance) or Lamprey (of conservation

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importance). This is accomplished by the reduction in the effects of noise and local water quality variations.

By using the capital- dredged silt material as intertidal enhancement it provides a previously terrestrial ecology with estuarine sediment thereby increasing the chances of the area developing successfully into the desired intertidal habitat. This potential use ensures that as sea levels rise there will still be some intertidal areas in the future for protected species such as Dunlin. By increasing the intertidal area that could be lost to coastal squeeze, the species can be protected and will also help maintain the current flood defences by attenuating wave energy.

Intertidal enhancement should not need additional sediment to be placed on the area in the future as in theory the area should favour sedimentation (due to lower water velocities etc) (although monitoring is strongly advised in case the site varies). This option is therefore considered environmentally sustainable as the area should develop independently once created.

Technically Feasible

Intertidal enhancement has been carried out by other developers on other estuaries such as PLA and Harwich Harbour (Buro Happold, 2010, Royal Haskoning, 2007). It uses a TSHD to dredge the material and either a pipe or a rainbow spray dredger to get the material on land, therefore the technology does exist. This technology however may need either modifying (using a pipe) or the sediment may need transferring into a rainbow dredger to complete the disposal. There is also existing technology for the mitigation of the effects of the TSHD in order to reduce the effects that dredging may have on the extraction and disposal of material.

Economically Viable Including Vessel Traffic Assessments

By identifying sites of potential use that are within 10nm additional sailing time of the proposed managed realignment site, it reduces the need for using economic resources and environmental impacts that may be caused due to an increase in distance.

By using capital dredge arisings to add to the existing levels of the intertidal area, it will help to develop intertidal flats and saltmarsh. This would help ensure that the EA do not have to spend large amounts of resources purchasing highly sought primary material from marine won sources elsewhere, to replace the habitat being lost to coastal squeeze under the Habitat Regulations.

This disposal strategy would require the same technology as what was already being brought into the estuary to carry out the capital dredge works although they may require a rainbow dredger. HES already carryout surveys on the Humber Estuary and the EA use LiDAR to study managed realignment sites thereby providing a cost effective way to monitor the site.

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Some monitoring of the development intertidal development is advised to inform further works either on this development or in other estuaries.

Intertidal enhancement should not need additional sediment to be placed on the area in the future as in theory the area should favour sedimentation. This option therefore is economically viable as the area should develop independently once created and should not require additional costs apart from that for monitoring.

Socially Acceptable/ Tolerable

Donna Nook Managed Realignment site has been granted consent therefore the public will have been consulted on the project however they will not have been consulted on the use of capital- dredged material at this site therefore it is unknown at this stage whether this approach would be accepted and further consultation would therefore need to be carried out before consent could be granted.

As this kind of potential use of dredged material has not been considered before on the Humber Estuary it is advised that an in depth study of the local area be monitored and the results shared for other projects and other estuaries so potential uses of dredged material could also be considered elsewhere.

Legally Permissible

As all of the beneficial uses described in this study have previously been carried out on other estuaries in the UK (McFarland *et al.,*1994; Ray, 2000; UK Marine Special Areas of Conservation Projects, 2001; Colenutt, 2001; Atkinson *et al.*, 2001*a;* Greene, 2002; Yozzo *et al.*, 2004; McLusky and Elliott, 2004; Bolam and Whomersley, 2005, 2003; Bolam *et al.*, 2006; Nicholson *et al.* 2010; van der Wal *et al.,* 2011), it is assumed that as long as the developer can prove no adverse environmental effects or impacts from the "new" use, these are legally permissible, although would have to pass stringent tests (Tim Page, (NE), *pers. Comm.*).

As discussed in 6.2, the Marine and Coastal Access Act (2009) provides no legal reason for the MMO to refuse consent of the use of dredged material for intertidal enhancement (provided similar caveats are applied).

Administratively Achievable Including Dredge Contractors, Port Authorities and Existing Management

Intertidal enhancement is administratively achievable as there are regulators in place and who are functional in the task of regulating and monitoring dredging activities and the effects on the intertidal habitat. However, to carry out such an operation is dependent on many factors, namely timing of the projects (the intertidal enhancement must be an already proposed project as the intertidal mudflats are EU protected under the SAC and are protected under the

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SSSI therefore no sediment can be placed on these without an in-depth study again being extremely timely and costly to the developer). Proposing a Managed Realignment site is considered a plan or project in itself which may require a separate EIA due to the designations of the Humber Estuary.

The use of the sediment for the creation of intertidal enhancement would have to satisfy NE, EA, ABP (as the Harbour Authority), MMO and the local authorities due to their role in the management of the estuary.

6.4 Main Findings

From this test it appears that within estuary disposal would satisfy all 7 tenets with a higher degree of certainty for both maintenance and capital- dredged material.

The alternative options (berm breakwater creation and intertidal enhancement) do appear to satisfy the 7 tenets although with less certainty due to these not being tested before on the Humber Estuary. In order to raise confidence in these areas, in depth, site specific studies and pilot projects should be carried out to determine their effectiveness (Sheenan and Harrington, 2012).

The major concerns identified were the cost implications if permissions were delayed therefore delaying the project(s) and potentially affecting the local economy. These permissions should however not be rushed as all potential impacts should be fully assessed so as not to adversely affect the estuary functioning when disposing at the potential use sites and is therefore a necessary precaution.

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Table 6.1 Summary of the alternative potential uses for the different sediments that adhere to the 7 tenets of sustainable development. This table has been constructed using the information and conditions provided in this study.

	Sediment	Potential Use	Tenets						
			Environmentally Sustainable	Technically Feasible	Economically Viable	Socially Acceptable	Legally Permissible	Administratively Achievable	Politically Expedient
Maintenance	Silt	Shore Protection	✓	✓	~	~	✓	~	✓
		Habitat Creation							
		Disposal	✓	✓	✓	✓	✓	✓	✓
	Mixed Sediment	Shore Protection							
		Disposal	✓	✓	✓	✓	✓	✓	✓
Capital	Alluvium and fine – medium sand	Shore Protection	✓	✓	✓	~			✓
		Intertidal Enhancement	✓	✓	✓	~	~	~	✓
		Disposal	✓	✓	✓	✓	✓	✓	✓
	Clay	Shore Protection	✓	✓	✓	~	✓	✓	✓
	Gravels	No Potential Use Identified	-	-	-	-	-	-	-

✓- adheres to the corresponding tenet
~- option will adhere to the tenet depending on the economic situation, social acceptance and gaining the relevant permissions.
-- no potential use was identified to check against the 7 tenets of sustainable development.

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7 Discussion

7.1 Main Findings

The Humber Estuary is important because of its ecological international designations, recreation and also for economic reasons. Due to the shipping industry and the advances in the markets, the port operators and developers need to dredge the estuary to remain economically competitive and viable (Section 1).

Dredging ensures that the Humber channels and berths are kept clear and at a safe depth to allow vessels to navigate to the ports and wharves safely. Historically, within estuary disposal has been the preferred option of disposal. This is because of the sediment types, economics including distances from the dredge and disposal sites, the environmental impacts and the recognised importance of retaining the sediment in the sediment budget of the estuary (Section 3.5).

7.1.1 Maintenance Dredging

This study has indicated that the maintenance- dredged alluvium material would only be appropriate for the continuation of within estuary disposal due to the sediment and the Humber Estuary's characteristics, such as the high water velocities. Silt would be inappropriate for berm breakwater construction (section 2.4.6) as silt would be eroded and transported from the site too quickly to be effective to protect the land behind.

The maintenance- dredged mixed sediment, could potentially be used as berm breakwaters, however a pilot project should be carried out to determine if the berm breakwaters are an effective solution and do not negatively affect the functioning of the estuary (Sheenan and Harrington, 2012, Captain Phil Cowing, Harbour Master Humber, *pers. Comm.,* 30/08/12). Komar and Allan (2009) suggest that these types of structures would require maintenance and therefore ongoing costs to maintain the defences. As the EA maintain the defences an assessment would need to be carried out to determine if the maintenance of a berm breakwater is more or less costly than the maintenance of the current flood walls.

Due to lack of site specific data it is unknown at this stage whether the berm breakwaters would be effective or not. If these options are to be investigated further. As discussed by Bolam and whomersley (2003, 2005), the site specific variations, prevailing conditions and physiochemical characteristics of the sediments must be taken into consideration.

There are constraints to some of the potential uses of maintenance dredged material. Berm breakwaters constructed within the estuary would need to be monitored to ensure that the navigation channels were not compromised (due to water moving the berm breakwaters)

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and to ensure the berm breakwater still provided a safe level of protection from erosion to the land behind.

Due to the importance to the sediment budget and the theoretical equilibrium of the estuary, it is important that this material is retained. The PLA and Harwich Harbour however beneficially utilise the maintenance dredge material outside of the sediment budget (UK Marine Special Area of Conservation Project, 2001, Royal Haskoning, 2007). Therefore the option remains a possibility in the future but currently maintenance dredge disposal must remain within the sediment budget of the Humber Estuary as confirmed by Natural England (Tim Page, NE, *pers. Comm.*, 13/10/11).

7.1.2 Capital Dredging

As discussed in chapter 5, the capital- dredged silt and sand could be used for intertidal enhancement at areas such as at Donna Nook, as it has been shown by other studies that the sediment can be colonised relatively quickly (Bolam and Whomersley, 2003, 2005). Colenutt (2001) however states that typically fine grained material is more desirable for wetland vegetation than sandy materials.

This option would require consideration of the timing of the dredging and the disposal of the material due to the construction programmes of both developments and could lead to multiple consents being applied for. This is especially necessary for the Donna Nook Managed Realignment site, as the site already has consent to proceed.

Capital clay could potentially be used for the construction of berm breakwaters within the estuary. Clay is more consolidated and therefore it will require higher water velocities to transport the "lumps" of clay. It would take a considerably longer time to erode or transport than that of alluvium. Permissions would need to be sought for the disposal of the material within the identified areas. This could be a lengthy process and again the problem of synchronising construction programmes becomes an issue. .

This clay could not be considered for construction due to the lack of responses from companies but should still be considered in future studies (section 1.5). As discussed capital-dredged alluvium would not be used for berm breakwaters due to the sediment and Humber's characteristics.

These potential uses should be subject to pre and post disposal monitoring to ensure that placing different material in the subtidal areas is not detrimental to the local and estuary wide environment (Fettweis *et al*., 2011).

The using of capital dredge arisings has been identified potentially to be used as flood defence by constructing Berm breakwaters, however as a capital dredge project is done once, the material will only be available for a short period of time and no more will be available after (unless another capital dredge project is granted consent which will dredge similar sediments).

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In order to overcome this, the EA will need plans in place in order to address this concern, which would have to be in place prior to disposal.

7.1.3 Overview

The main legislative, regulations and directives that apply in the Humber Estuary when dredging have been identified and the potential problems in terms of cost and time that these regulations may have on the projects (Section 3.8). It was assumed that all of the regulators would be satisfied and that all the legislation would be met. It is important that when considering potential uses that the regulations, especially the Habitats Regulations are adhered to, to maintain the coherence of the *Natura* 2000 site.

The study has assessed the potential uses of both maintenance dredge and the proposed capital dredge material in the management of the Humber Estuary. Suitable locations have been identified after taking in to consideration the ecological considerations and the cost benefit dredge strategy (Table 4.8 and 5.5). This was accomplished taking into account the considerations such as sediment type, characteristics and distance between the dredge and proposed disposal sites, whilst adhering the 7 tenets of sustainable development (Table 6.1).

The potential beneficial and adverse effects for the implementation of the potential alternative uses as well as the monitoring and maintenance of the alternative uses have been identified (Table 7.1 and 7.2). Potentially the most environmentally sustainable options would be intertidal enhancement whereas within estuary disposal appears to be the most neutral. It has some beneficial effects, some detrimental effects but appears have “no effect” on a number of aspects overall such as it does not require maintenance and would not impede vessel movement. Nor would it require additional vessels to be present than current presence, whereas intertidal enhancement and berm breakwaters have a number of detrimental effects associated with them.

The construction of berm breakwaters appear to be largely beneficial although if a pilot project is not considered on a smaller scale first to determine the best methods of disposal i.e. depth, slope, length etc, the effects could be detrimental (Sheenan and Harrington, 2012).

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Table 7.1 The beneficial and detrimental effects of the potential use options on various aspects of the Humber Estuary.

	Combat Coastal Squeeze	Increase Habitat for Birds	Prevent Erosion	Increase Biodiversity	Aid in Flood Defence	Retain Equilibrium	Use sediment within same zone	Decrease Erosion	Increase Intertidal Area	Sediment Sorting	Sediment Type	Organisms-smothering	Organisms-different	Alter Equilibrium	Requires Maintenance	Depth	Flow	Vessel Movement	Additional Vessel Movements
Intertidal Enhancement	Green	Green	Green	Green	Green	Yellow	Green	Yellow	Green	Red	Red	Red	Red	Orange	Yellow	Orange	Orange	Black	Black
Managed Realignment	Green	Green	Green	Green	Green	Yellow	Green	Yellow	Green	Red	Red	Red	Red	Orange	Yellow	Orange	Orange	Black	Black
Within Estuary Disposal	Black	Black	Blue	Green	Yellow	Green	Green	Yellow	Black	Red	Red	Red	Red	Orange	Black	Orange	Orange	Yellow	Black
Shore Protection-Berm breakwaters	Red	Green	Green	Green	Green	Yellow	Green	Green	Blue	Red	Red	Red	Red	Orange	Red	Red	Red	Yellow	Black

Key:

Red	Detrimental Effect of the Option (if not properly planned for)
Orange	Effect Could be detrimental
Yellow	Unknown if the option would be detrimental, beneficial or no effect.
Blue	Option could be beneficial
Green	Benefits of the option
Black	No effect of the potential use option on this aspect

A schedule of recommended monitoring has been identified based on past studies in order to ensure the potential use is successful in terms of function, economics and local and estuary wide environmental impacts (Table 7.2) (Colenutt, 2001, Bolam and Whomersley, 2003, 2005, 2006, DMDMTT, 2003, JNCC, 2004, Mazik *et al*., 2007). As discussed by Atkinson *et al.* (2001*a*), it is important to monitor the site post disposal as the complex relationships between and within the abiotic and biotic factors.

In order to set targets for monitoring and determining the success of the beneficial use option, they should be based on the baseline conditions and reference sites (Bolam and Whomersley, 2003, 2005, 2006). It is important to consider timing, scale, amount and type of recharge as well as the elevation, dynamics and biodiversity in terms on total individuals, species, diversity, evenness and biomass (Bolam and Whomersley, 2003, 2005, 2006, Fettweis *et al*., 2011).

It can be difficult to predict how the site will react to the disposed sediment. Within estuary disposal will require fewer variables to be monitored during the post-disposal period where as berm breakwaters will require the most monitoring post disposal (Table 7.2). These should be considered when determining the most viable potential use option for the dredged material as any additional monitoring, especially monitoring that requires additional labour or equipment will increase the costs of pursuing these uses.

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Table 7.2 The required aspects that would need to be monitored for the different potential uses in the Humber Estuary (not exhaustive).

	Intertidal Enhancement	Berm breakwaters	Within Estuary Disposal
Sediment Type	✓	✓	✓
Sediment Quantity	✓	✓	✓
Slope	✓	✓	x
Bathymetry	x	✓	✓
Area	✓	✓	✓
Sedimentation	✓	✓	✓
Fish species biodiversity	✓	✓	~
Infaunal species biodiversity	✓	✓	✓
Flora species biodiversity	✓	✓	~
Bird species biodiversity	✓	✓	x
Oxygen levels	~	✓	~
Water temperature	~	✓	~
Flow velocities	✓	✓	✓
Erosion	✓	✓	✓
Sediment particle size	✓	✓	✓
Sediment organic matter	✓	✓	~
Sediment oxygen content	✓	✓	~
Sediment water content	✓	✓	~
Heavy metal content	✓	✓	✓
Inundation	✓	x	x
Ground levels	✓	x	x
Migration of sediment	~	✓	✓
Nutrient levels	✓	✓	x

Key
✓- will need to be monitored
~- may need to be monitored
x- will not need to be monitored

7.3 Constraints of Beneficial Use

There are constraints to using the sediment beneficially and these should be taken into consideration when investigating the scope of the potential uses (Table 7.3). Firstly each potential use for a project is dependent on the prevailing conditions e.g. the volumes and types of sediment being dredged, the location and the condition in the Humber Estuary (Table 7.3). Therefore even though the potential uses identified in this study may not be able to be directly applied to other projects, the characteristics used may be used to determine the most suitable use and location for the dredged material.

A decision would have to be made however, on the sediment type of the berm breakwaters constructed within the estuary as capital clay cannot be placed on the alluvium that contributes to the sediment budget as this would “trap” the alluvium from the sediment budget.

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This study has also indicated that the sediment from the maintenance and capital projects are different and should be treated as such. Maintenance dredging is carried out on an ad hoc basis. Capital dredge arisings involve an extraction of a large amount of material at one specific time to increase the depth previous, meaning that if the potential use sites required maintenance i.e. replenish with additional material either on regular intervals or on an ad hoc basis, there may not be the guarantee that the sediment will be available to maintain the defences or the intertidal habitat.

Even though beyond the scope this study, developers should also take in to consideration the ecological carrying capacity of the Humber Estuary.

Table 7.3 The constraints of the different potential use schemes for the Humber Estuary

	Intertidal Enhancement	**Berm breakwaters**	**Within Estuary Disposal**
Sediment Type	✓	✓	✓
Sediment Quantity to be Dredged	✓	✓	✓
Local Hydrodynamics	✓	✓	✓
Gaining Permission	✓	✓	✓
Planning of Programmes	✓	✓	x
Additional consents	✓	~	x
Location of Dredge	✓	✓	✓
Location of Disposal	✓	✓	✓
Location of Potential Use Site	✓	✓	✓
Timing	✓	✓	✓
Method of Dredging in Relation to Disposal/ Potential Use	✓	✓	✓
Legislation	✓	✓	✓
Distance involved	✓	✓	✓
Bathymetry	✓	✓	✓
Contamination	✓	✓	✓
Quantity of sediment needed at potential use site	✓	✓	x

Key
✓- is considered a constraint
~- may be considered a constraint
x- is not considered a constraint

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Unfortunately no monetary values were available to be assigned to the different options and techniques. This is because the economics of calculating such a value is dependent on many factors and to determine this figure is beyond the scope of this study. In order to assign a monetary value to the activities it would be necessary to ascertain monetary values for the activities that currently occur within the estuary. This would include gaining costs for the maintenance dredge and disposal activities for the difference dredge and corresponding disposal sites. For capital dredge projects, an average could be calculated for the average cost for the dredge and transport per tonne for example. In order to compare with the beneficial uses that have been identified, costs from past projects could be used such as for the intertidal enhancement use, costs could be ascertained from the developer for the dredge and disposal of the sediment and compare with the current costs that are incurred.

As no monetary value could be assigned, an attempt has therefore been made to incorporate the economic implications of the potential uses based on conservative assumptions. The uses identified could still prove useful in the project planning process by investigating the sites or uses identified (dependant on the project).

The objectives of this study included assessing the environmental impacts of both extraction and deposition of the dredged material. Whilst the study has included within it the general effects of dredging and deposition of the material on the environment, the actual effects will be site dependant. With no site specific field data of the turbidity, biota present etc, this would have proven inconclusive and therefore would need to be investigated during the project planning process if viable to do so.

By producing a cost benefit analysis of implementing the potential uses it shows that regardless of the use, there are associated costs and benefits (Table 7.4). The costs are mainly the monetary costs associated with the identified alternative uses whereas the benefits include the increase in protection for flood defence and also the environmental benefits by improving the habitats for ecology.

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Table 7.4 Cost-benefit analysis of the potential use of dredged material.

Costs of Implementing Potential Uses	**Benefits of Potential Uses**
Increased distance to disposal site	Potential use sites identified within 10 additional nautical miles of proposed disposal site
Further site investigation to ensure sediment is suitable for identified location	Reduce costs for importing primary resources for the flood defences, intertidal enhancement for example.
May require further tests to be passed and permissions to be gained to use the sediment at the identified location	Reduce maintenance costs of some of the flood defence sections
Costs may be incurred due to delays in consenting process	Reduce the pressure off of the EA to purchase primary construction material for the areas under threat of erosion for a time.
Monitoring -, before and post disposal of multiple variables.	Enhance biodiversity at the areas of potential use, especially by using more natural resources and encouraging intertidal mudflats and saltmarsh to develop
	Reduce the costs of re-building the A1077 by reduce the erosion at that site by using berm breakwaters etc.

The disposal of the material may cause smothering of some species (section 2.2). Disposing by within estuary berm breakwaters in the subtidal at the areas that are under threat of erosion only represent a small amount of the subtidal habitat and communities plus the berm breakwaters can become recolonized after disposal.

Even though the government has a policy of sustainable development, the sediment characteristics and the stakeholders' objectives must be taken into consideration, if the sediment does not have the correct characteristics for a potential site, it should be disposed of within the estuary. Waiting for an appropriate beneficial use would be costly (in terms of money and time) to those developers and contractors involved and may require additional licenses. These additional licenses may be needed because if the two developments are not synchronised and the material is dredged before the need, then the dredge operator has two options; 1) dispose of the material within the estuary (requiring a license) or 2) store the material on land until the need is met (which also requires a license from the Environment Agency). By applying for two licenses to dispose (for the beneficial use and for an alternative site in case the site is not ready for the material at the ime of dredging) it reduces the risk of dredging and not having a place to put it therefore reducing the risk of delaying the project. The application for multiple licenses however can be costly in terms of money and time, as

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each application has its own fee band depending on the size of the project (Tom Jeynes, ABP, *pers. Comm.*).

7.3.1 Constraints of Combining Projects

The most likely potential uses of dredged material involve the combining of two or more projects, so the sediment from one project can utilised in another. As outlined within this study however there are difficulties with combining projects, these include:

- Customer- having to take the customer into consideration with commercial developments (Chapter 5) e.g. HRBT was halted as there was no customer to sustain the development, this would have impacted on any development that would have been proposed to use the dredged sediment beneficially (ABP, *pers. Comm.*);
- Construction programmes - the construction programme of both the projects would need to synchronise at the point of the material being dredged to be used immediately by the receiving party (Chapter 5). This would rarely occur due to planning circumstances and general construction problems e.g. a different substratum or quantity than previously anticipated. This would mean that either the receiving construction party would have to halt their operations (costly) or the dredged material would need storing, requiring an additional licence to do so.

- In some instances only limited information is available on proposed developments therefore this assessment is based on the best available knowledge at the time (Chapter 5).

Combining projects is possible however, as demonstrated by Harwich Harbour who overcame these difficulties. Harwich Harbour was responsible for the intertidal recharge of Stour, Orwell and Blackwater Estuaries as well as Horsey Island (UK Marine Special Areas of Conservation Projects, (2001) (section 4). It must be taken into consideration that such combinations require a lot of forethought and planning, and both parties should consider their plans in place in case either ones programmes (planning or construction) do not go to schedule.

7.4 Critique of Study

- The study is temporally and spatially specific in relation to the projects and sites investigated, therefore even though the conclusions for the potential uses and sites may not be directly applied the criteria and methods used to investigate the potential uses and sites can be applied to other projects and locations.
- The criteria used to determine the most suitable sites were selected on two main focuses being the areas under threat of erosion and a consented managed realignment site. These

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were two specific problems to overcome with specific criteria to fulfil these; however alternative sites can be investigated once the issues have been identified and the criteria for the solution have been selected.

- The criteria to determine the most suitable dredged material was based on the dredge location, distance and sediment characteristics mainly. The flow velocities were considered however these were based on velocities made available on published charts and are therefore based on velocities for navigational aid rather than sediment transport. The criteria identified however can give suitable sites the most suitable material for the purpose.
- On objective of the study was to investigate the environmental impacts of dredging and disposal of the dredged material. Even though detailed environmental implications have not been assessed, the general implications have. It has also been emphasised that the sediment should be used in the same estuary zone, and sediment type where possible.
- The study has also identified the aspects that should be monitored if a pilot project is carried out or if the potential uses are implemented. These are based on past studies and projects and have been differentiated for each use.
- The assessment of cost benefit dredge strategy and the analysis of the current and proposed dredging strategies allowed a conservative 10nm distance to be applied.

Limitations

- A major limitation was the lack of data available in order to give the conclusions a high degree of certainty.
- This lack of information also meant that some potential uses could not be considered such as using the dredged material as construction material as there was limited information as to the type of material construction companies require.
- Due to the commercial sensitivity of the port operators, no monetary values could be ascertained to determine the relative costs of transporting the sediment to the potential use sites identified. This therefore meant that only the cost benefit dredge strategy could be considered rather than an investigation to the monetary costs and benefits of carrying out the beneficial disposal.

7.5 Suggestions for further work and use of conclusions

The study aimed to carry out desk based research to determine if there are any alternative beneficial uses for dredged material in addition to the disposal strategies already being carried out on the Humber.

There have been areas identified where there is limited or in some cases no information or data that would otherwise have improved the confidence of the findings. Additional work

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has been identified for the issues that were beyond the scope of this study but could be investigated in further work. Those issues that were not considered but have been identified as importance considerations for future studies on the beneficial use of dredged material. Each aspect that was beyond the scope of this project but would need full consideration in any further work is discussed below.

Sufficient Capacity of the Disposal Sites

An aspect that has not been considered in this study but is crucial to the future of the continued dredging and disposal activities on the Humber is the capacity of the disposal sites to be able to accommodate future volumes of the dredged material.

Maintenance- dredged material is to a point, less of an issue as this is the relocation of the readily mobile sediment and can be dispersed almost immediately after been disposed of depending on the prevailing local conditions (section 2.4.6). The disposal of capital dredge arisings however poses the question of how much more material can the disposal sites accommodate? This is especially true of the SDC windows A, B and C that are used to dispose of the more non erodible cohesive material such as clay. As the clay takes longer to be eroded, it can be in-situ for considerably longer, meaning that the disposal site remains at a greater capacity for longer. In the future, if developers are proposing to capital dredge more clay than the disposal site can accommodate the question of whether the clay can be beneficially reused will in fact become “now the disposal sites are full, what are our options?”

This concern will need to be addressed by either licensing a new disposal site within the estuary or by considering the beneficial use schemes. Both options will require in-depth investigations and modelling to understand the implications of either option at a number of locations and will also have to pass the tests of the Habitats Regulations. At this point it would the developer’s responsibility to prove there would be no negative effects on the estuary in order to continue with their plan or project.

This study can aid in that decision-making process as although with no site specific data, possible potential use sites have been identified and the methods used could be applied to alternative locations, projects and uses. A completed pilot project would also be of importance to the decision making process to determine the effectiveness of the potential use and the local and estuary wide effects.

Pilot Project

A pilot project could be carried out to determine the effectiveness of any or all of the potential uses identified within this study (Sheenan and Harrington, 2012). It would require a detailed investigation to determine the most appropriate site for the potential use based on the site specific data such as flow velocities, shipping lanes, land use etc and the sediment to be

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dredged. This may require mathematical modelling to be carried out to determine the likelihood of the sediment staying in place or being transported elsewhere in the estuary and predict the efficacy of the uses.

The project would also need to monitor the local area and wider estuary to determine if the placement of material has an effect on the hydrology (Fettweis *et al*., 2011). This is addition to the biodiversity and water quality as the alternative use has to be, at the least, neutral on the environment.

The pilot project would aid in understanding the effects of sediment placement at potential sites within the estuary. This could be applied to other estuaries and shorelines to help combat erosion, habitat loss and work towards sustainable development.

Within Estuary Disposal

Within estuary disposal has been identified as the most appropriate method of disposal of the dredged material in the Humber Estuary as it has fewer detrimental effects, fewer constraints and fewer variables to monitor compared to other potential uses. The method can however be improved upon because even though it was not considered as part of the study, mathematical modelling could be used to determine the most appropriate location for the sediment .

Section 2.4.3 concluded that the dredged material could be placed at the disposal grounds on specific tides to encourage certain sediments to be transported in certain directions. For example, ABPmer (2009*c*) proposed that for the IOTA dredge arisings, it was proposed that the finer silt material should be deposited at Middle Shoal between low water (-1 hour) and high water (- 1 hour), this would ensure that the tides would transport the sediment up estuary which is silt dominant (ABPmer, 2009*c)*. Whereas the sand material should be deposited at Middle shoal during the rest of the tide to distribute the sands down estuary where they are most abundant (AMPmer, 2009*c*).

This method could again be improved further by using mathematical models to determine if the disposal of any of the material at any of the disposal sites could be beneficial in such a way that it would feed natural dispersion patterns and perhaps encourage the desired accretion of a preferred sediment at a particular location. This mathematical modelling would require a large time input and further survey work to determine the hydromorphology of the estuary to produce accurate predictions of the likelihood of the output occurring.

Habitats Regulations Assessment

This study assumed that the proposed capital dredge projects were assumed to adhere to the Habitats Regulations by having no adverse effect on the integrity of the site or the conservation objectives of the Humber, or being able to mitigate or compensate the effects.

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The assessments of the projects under the Habitats Regulations Assessment would require each project to be studied in depth with specific information to determine the likely effects that each component of the project could have on the designated sites. These assessments are lengthy for each project and therefore could not be included in this study.

This therefore would require specifics such as exact locations, dimensions, timing, sediment type and quantity, designated features and the reasons for their designation. Such specific data such as exact locations for the "ideal" site and the local hydrodynamics or the designated features of the site were not available for the study at this time and therefore detailed assessments under the Habitats Regulations were not carried out here.

If a pilot study were to be carried out to determine the effectiveness of the potential uses identified, the placement of the material either in the subtidal or intertidal habitat that is designated would need to be assessed under the Habitats Regulations to comply with EC Directive 92/43/EEC. It is important to note that under the Habitats Directive, socio-economic factors are not considered when preparing an assessment (European Commission, 2000)

Scour Holes

The potential use of shore protection by infilling scour holes (other than disposal at the SDC windows and Bull Sand Fort) could not be considered in detail due to a lack of information, specifically on the sites affected by scour However the option could still be pursued in the future however but would require detailed site specific data and mathematical modelling to determine if the sediment would be effective at these locations.

Construction

Utilising the dredged material as construction material was not considered as part of this study however construction could still be considered for future developments and investigations of the alternative uses of capital- dredged material.

This could also lead to an investigation to determine which is more environmentally friendly: using capital dredge material as construction or using marine won aggregates when the projects in their entireties are taken into consideration.

Treatment of Contaminated Sediments

The treatment type also depends on the contaminant and therefore other treatments will cost more than others. This cost has to be considered otherwise developers will not agree to the beneficial use of the material.

The consideration of the treatment and therefore potential use of contaminated sediments was not considered as there are numerous treatment options that are dependent on a variety of factors. If the dredged material were to be used for an alternative use, the economics of treating and disposing at the identified sites or other disposal options would have to be compared.

Surge Storms and Flood Events

Storm surges and high water springs were not considered but should be considered in future investigations as during these events the flow velocities may increase and transport the sediment elsewhere and may, in some cases, increase the risk of flooding. This may occur if the flood defences have not been maintained due the presence of a berm breakwater., If for example, flow velocities increase and move the Berm breakwater, or advance the area behind is at risk from flooding.

The risk of flooding should also be taken into account by working with the EA to determine the likelihood of flooding (with sea level rise) and the areas appropriate for the sediment to be placed.

Consultation

Consultation with the public and stakeholders is a valued and worthwhile part of the process but can be a lengthy process for large plans such as the introduction of beneficial uses of dredged material in an area which has not had to consider the plans before. During the study, consultation has been carried out with a number of organisations although the correspondence was mainly on specific matters regarding to the overall project and was with those who have a knowledge of the estuary, port operations or the local issues and therefore the public were not involved due to time constraints. It is therefore unknown what the public's perception of the identified uses would be and how they would react to such proposals being brought forward.

Further work could include carrying out a survey to determine what the public's perception of the different potential uses of dredged material are and the reasons for their opinions. This would help not only the developer in understanding the opinions but would also help decision makers if a proposal ever came forward to be determined about the most appropriate course of action.

Consultation also allows opportunities for the developers to educate the public and stakeholders on the reasons behind the proposals and what they mean for the future.

Economics

The economics of any development is based on many factors. For dredging operations these would also include weather and tidal conditions to be able to access some of the areas. Further studies could include assigning monetary values to the different options and techniques identified in this study based on average or actual costs.

Even though potential sites have been identified in this study and the methods used could be used to identify sites in the future and on other estuaries, the application of monetary values to the activities associated with the dredging and beneficial disposal would aid developers in determining the most practical and most economical, as well as environmentally sound method of disposing of their dredged material.

The economic view could also include aspects from other areas identified in this section such as the costs of treating contaminated sediment compared to other options available to contaminated sediment.

Having an economic view of these could also aid in the consultation process if monetary values could be assigned to the maintenance of flood defences and the construction and maintenance of Berm breakwaters for example, or the costs that would be incurred if some areas of the estuary were allowed to continue to erode.

Applying monetary values is a useful analysis because it allows a value to be quantified in such a way that the public and stakeholders can understand rather than using complicated mathematic models or statistics in order to make a point.

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8. Conclusions

This study set out to investigate the potential beneficial uses of dredged material in the Humber Estuary and identify locations where these uses could be implemented. The beneficial uses and sites identified are based on criteria such as sediment type, quantity and distance; and were assessed by discriminating between maintenance and capital dredged material. This discrimination was to ensure that the functioning of the estuary and the ecology were taken into consideration whilst ensuring that any potential use identified took economics into consideration by way of the cost benefit dredge strategy as developers and dredge contractors would be less willing to consider beneficial uses if they incurred more costs than present.

As some of the beneficial uses have not been considered in the area before, once the sediment has been placed in the areas, monitoring should be carried out not only at the site but both upstream and downstream of the site as well as the estuary to ensure that down drift is not affected and that the sediment budget is maintained. This is important as these impacts will differ from place to place depending on factors such as geography, geology, hydrography, bathymetry, ecology and the types on commercialisation, industrialisation and urbanisation within the area. The beneficial uses would also need to pass stringent tests under the Habitats Directive to ensure that integrity of the site was not affected negatively. It is important to note that under the Habitats Directive, socio-economic factors are not considered when preparing an assessment (European Commission, 2000).

With the beneficial uses, constraints have also been identified which include the additional costs incurred and the timing and the owners of separate projects aiming to dredge and use the dredged material. The benefits and the detrimental effects have also been assessed to determine the either the most beneficial alternative use or the least detrimental one.

All of the potential uses appear to satisfy the 7 tenets. It appears that the continuation of within estuary disposal is the most suitable method of disposal at this time as it has fewer constraints associated with it, requires less monitoring and also appears to have more neutral than detrimental effects on the estuary than the other identified potential uses. Within estuary disposal has been carried out historically and there is no evidence to prove that this method of disposal affects the estuary’s functioning above the natural variation of the estuary. Alternative uses however also include constructing berm breakwaters and the possibility of intertidal enhancement with the caveats noted above.

Further work however should be carried out including a detailed field investigation, even if on a relatively small scale, to determine the local and estuary wide effects of the proposed potential uses identified in this study on the environmental, hydrographical, sediment transport and economic aspects.

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The Interreg IVB North Sea Region Programme

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Appendix A Plans

For all of the plans the following Key applies:

Magenta	Proposed Capital Dredge Site
Green	Proposed Potential Use Site
Lilac	Port
Cyan	Disposal Site
Red	Towns

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The Interreg IVB North Sea Region Programme

Number	Title
A1	The Urban Areas and the Maintenance, Proposed Capital Disposal and Potential Use Sites within the Humber Estuary
A2	The Major Urban Areas of the Humber Estuary
A3	The Zones of the Humber Estuary
A4	The Ports of the Humber Estuary
A5	The Ports and Wharves of the Rivers Trent and Ouse
A6	The Designations of the Humber Estuary
A7	The Designated Mudflats of the Humber Estuary
A8	The Disposal Sites of the Humber Estuary
A9	The Areas of Potential Use of Dredged Material in the Humber Estuary
A10	The Maintenance and Disposal Sites for the Alexandra Dock, Port of Hull
A11	The Maintenance and Disposal Sites for the Port of Goole
A12	The Maintenance and Disposal Sites for the Port of Immingham
A13	The Maintenance and Disposal Sites for the King George Dock, Port of Hull
A14	The Maintenance and Disposal Sites for the William Wright and Albert Docks, Port of Hull
A15	The Maintenance, Disposal and Potential Use Sites for the Alexandra Dock, Port of Hull
A16	The Maintenance, Disposal and Potential Use Sites for the Port of Immingham
A17	The Maintenance, Disposal and Potential Use Sites for the King George Dock, Port of Hull
A18	The Maintenance, Disposal and Potential Use Sites for the William Wright and Albert Docks, Port of Hull
A19	The Proposed Capital Dredge Sites of the Humber Estuary
A20	The Proposed Capital Dredge and Disposal Sites for AMEP
A21	The Proposed Capital Dredge and Disposal Sites for the Grimsby Ro/Ro
A22	The Proposed HRBT Dredge and Disposal Site
A23	The Proposed IOTA Dredge and Disposal Site
A24	The Proposed Capital Dredge, Disposal and Potential Use Sites for AMEP

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A25	The Proposed Capital Dredge, Disposal and Potential Use Sites for the Grimsby Ro/Ro
A26	The Proposed HRBT Dredge, Disposal and Potential Use Sites
A27	The Proposed IOTA Dredge, Disposal and Potential Use Sites
A28	The 10 Nautical Mile Radii for the Maintenance Dredge Sites
A29	The 10 Nautical Mile Radii for the Proposed AMEP Site
A30	The 10 Nautical Mile Radii for the Proposed Grimsby Capital Dredge Areas
A31	The 10 Nautical Mile Radii for the Proposed HRBT Site
A32	The 10 Nautical Mile Radii for the Proposed Chequer shoal Site
A33	The 10 Nautical Mile Radii for the Eastern Approach Sites
A34	The 10 Nautical Mile Radii for the Proposed Halton Middle Deepening
A35	The 10 Nautical Mile Radii for the Proposed SDC Deepening
A36	The 10 Nautical Mile Radii for the North stallingborough Turning Area Deepening
A37	The 10 Nautical Mile Radii for the South stallingborough Turning Area Deepening
A38	The Direct Routes for the Dredger from AMEP to the Potential Use Sites (Within 10 nautical miles)
A39	The Direct Routes for the Dredger from Grimsby Capital Dredge to the Proposed Disposal Sites
A40	The Direct Routes for the Dredger from Grimsby Dredge Areas to the Potential Use Sites (Within 10 nautical miles)
A41	The Direct Routes for the Dredger from HRBT to the Proposed Disposal Sites
A42	The Direct Routes for the Dredger from HRBT to the Potential Use Sites (Within 10 nautical miles)
A43	The Direct Routes for the Dredger from IOTA Deepening’s to the Proposed Disposal Sites
A44	The Direct Routes for the Dredger from IOTA Deepening’s to the Potential Use Sites (Within 10 nautical miles)
A45	The Location of Alkborough Flats Managed Realignment Site
A46	The Proposed Capital Dredge and Disposal Sites for the GPH Development
A47	The 10 Nautical Mile Radius for the Proposed GPH Development
A48	The Direct Routes for the Dredger from the GPH Site to the Potential Use Sites (within 10 nautical miles)

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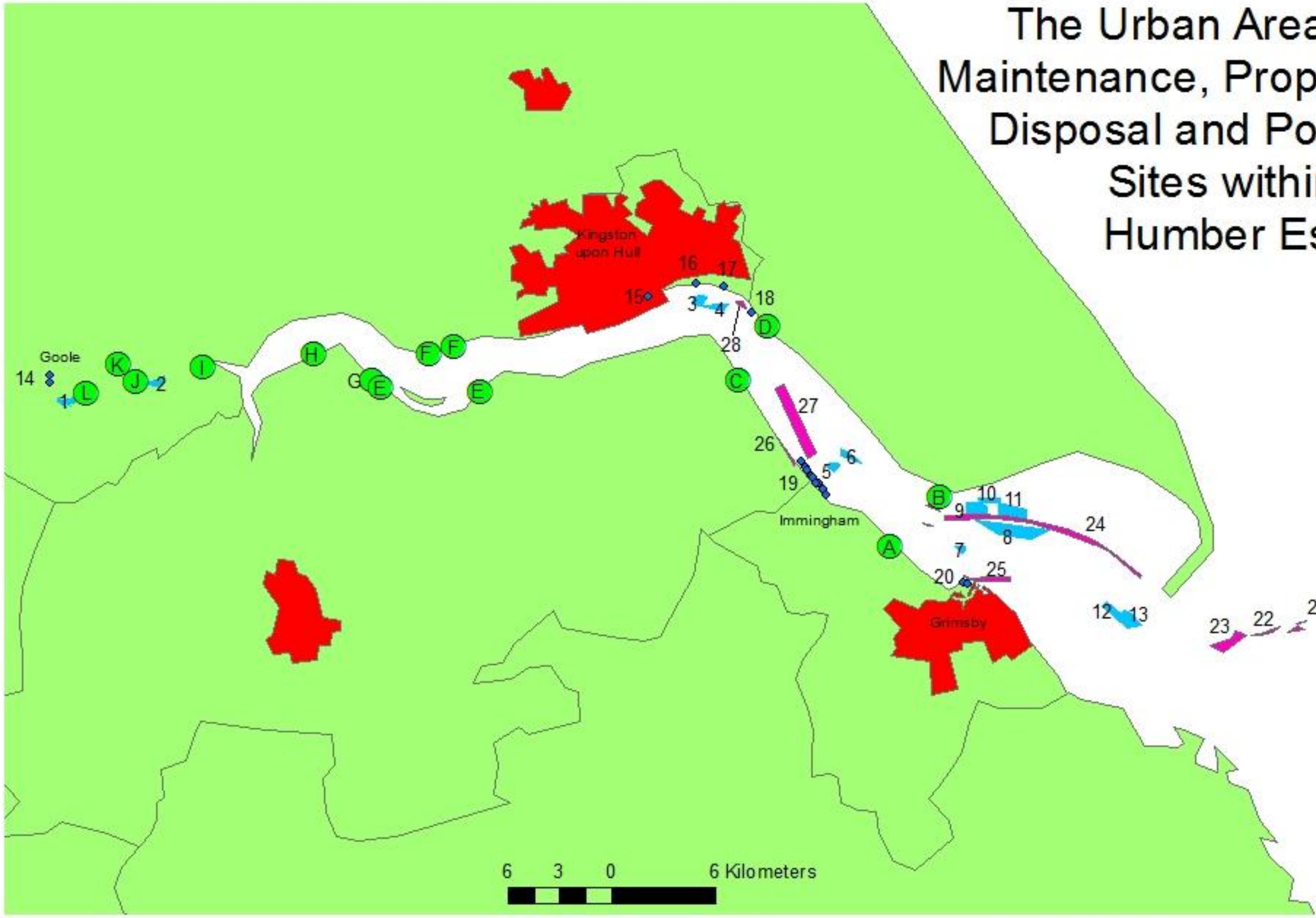
The Interreg IVB North Sea Region Programme

Figure A1
The Urban Areas and the Maintenance, Proposed Capital, Disposal and Potential Use Sites within the Humber Estuary



Disposal Sites
1- Whitgift Bight
2- Goole Reach
3- Hull Middle
4- Hull Middle Hook and Extension
5- Clay Huts
6- Holme Channel Deep
7- Burcom Sand
8- SDC
9- SDC B
10- SDC C
11- SDC A
12- Bull Sand Fort
13- Bull Sand Fort Extension

Maintenance Dredge Sites
14-Port of Goole
15-Port of Hull- William Wright and Albert Docks
16-
17-Port of Hull- Alexandra Dock
18-Port of Hull- King George Dock
19- Port of Immingham
20- Port of Grimsby

Proposed Capital Dredge Sites
21- Eastern Approach 1
22- Eastern Approach 2
23- Eastern Approach 3
24- Sunk Dredged Channel
25- Grimsby Turning Area and Berth Pocket
26- Able Marine Energy Park
27- Halton Middle
28- Hull Riverside Bulk Terminal Berth Pocket

Potential Use Sites
A- Stallingborough
B- Hawkins Point
C- Halton Marsh
D- Paull
E- South Ferriby
F- East Clough
G- Winteringham Haven
H- Whitton Ness
I- Whitgift Bank
J-Reedness
K- Saltmarshe
L-Saltmarshe

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The Interreg IVB North Sea Region Programme

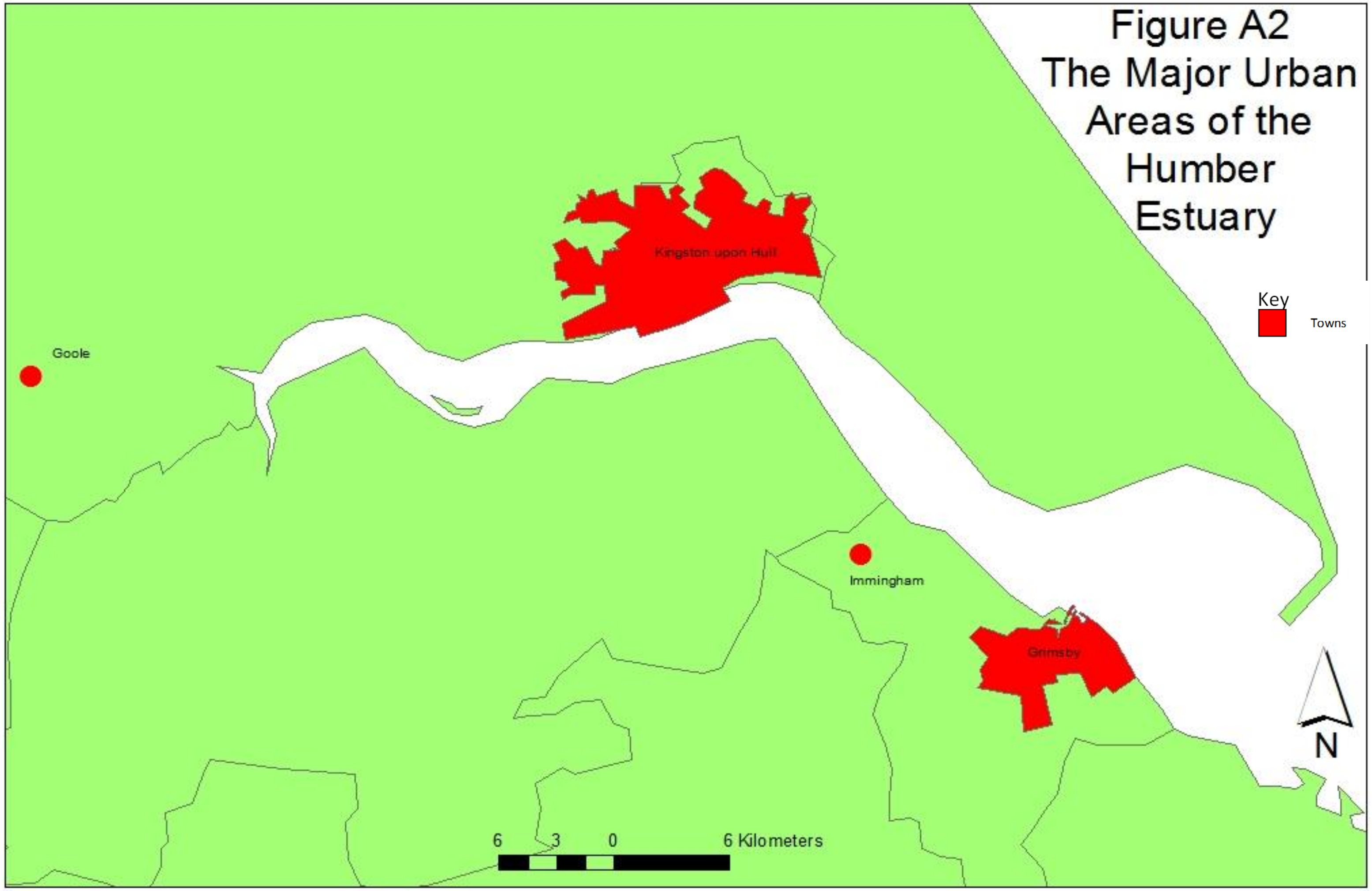


Figure A2
The Major Urban Areas of the Humber Estuary

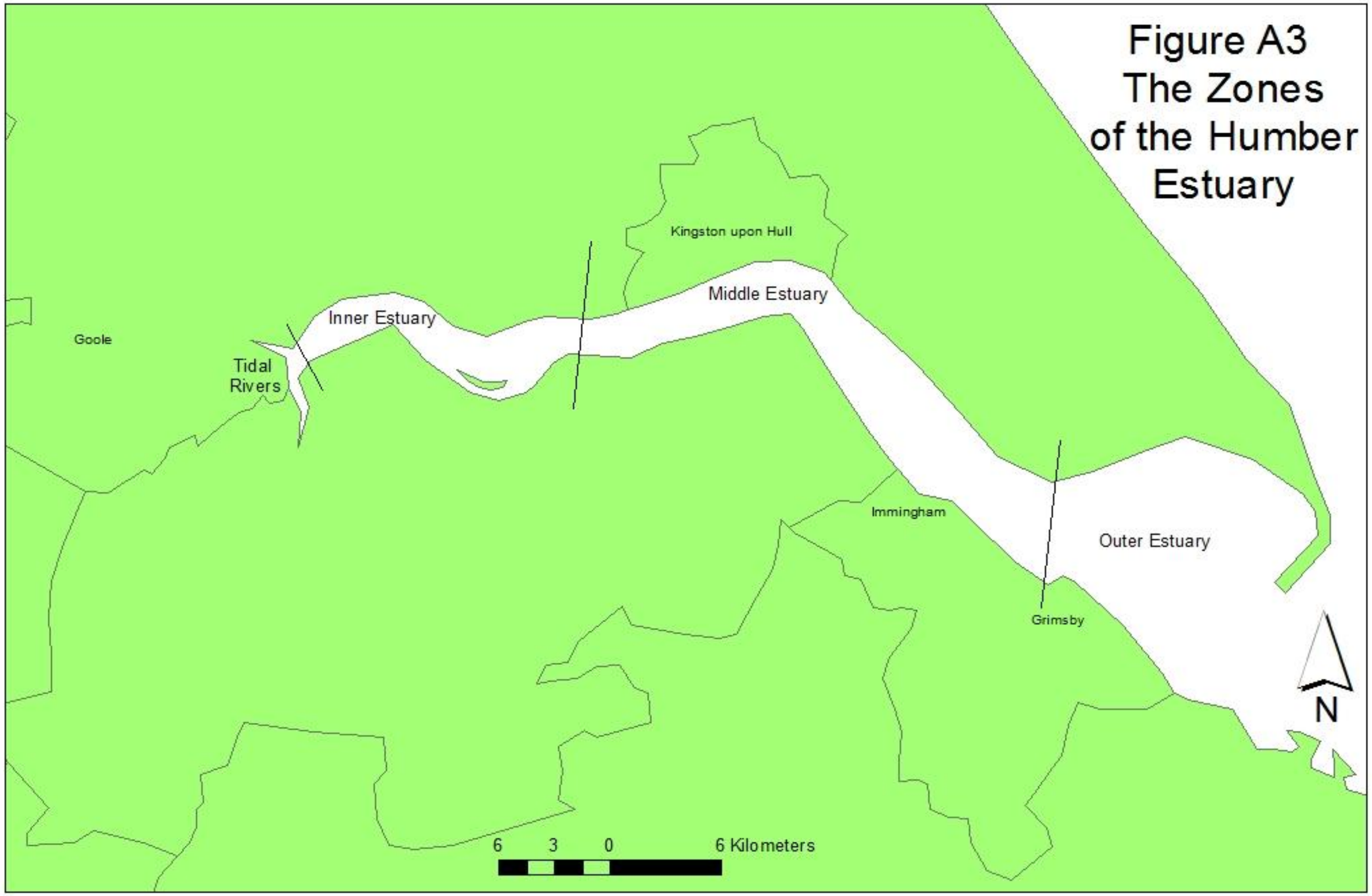


Figure A3
The Zones
of the Humber
Estuary
Kingston upon Hull
Middle Estuary
Inner Estuary
Goole
Tidal
Rivers
Immingham
Outer Estuary
Grimsby
N
6
3
0
6 Kilometers

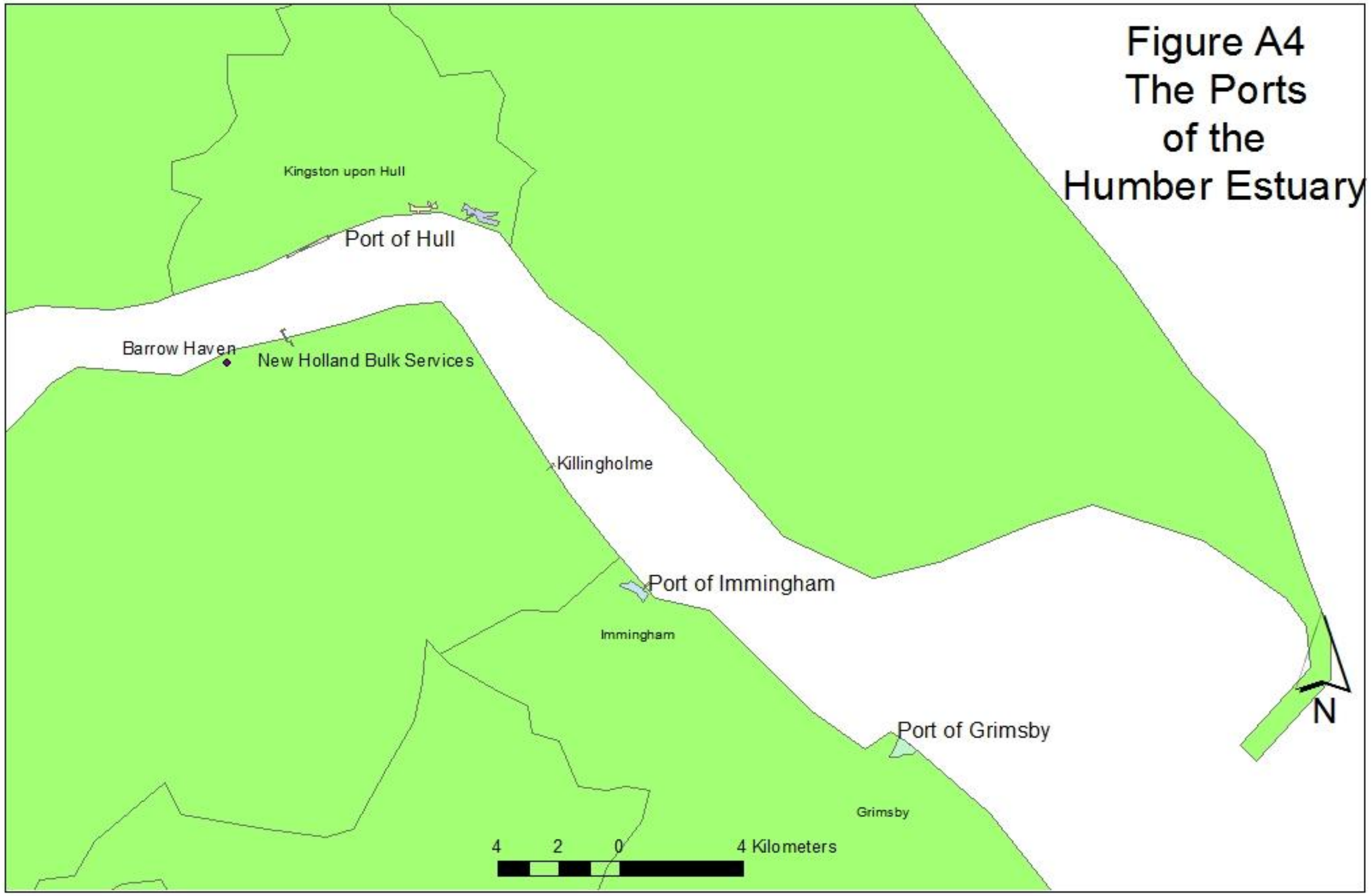
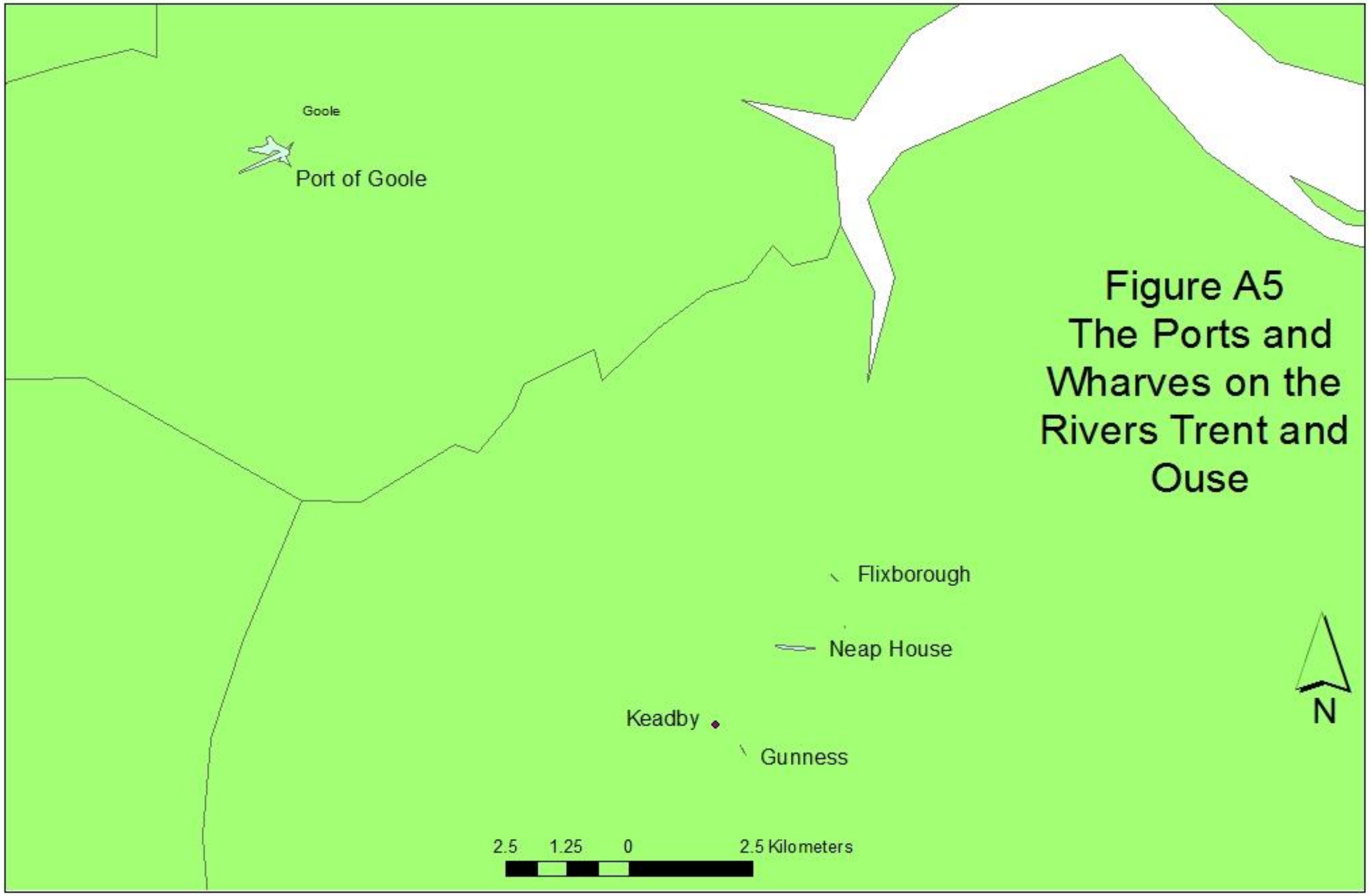


Figure A4
The Ports
of the
Humber Estuary
Kingston upon Hull
Port of Hull
Barrow Haven
New Holland Bulk Services
Killingholme
Port of Immingham
Immingham
Port of Grimsby
Grimsby
N
4
2
0
4 Kilometers


Goole
Port of Goole
Figure A5
The Ports and Wharves on the Rivers Trent and Ouse
Flixborough
Neap House
Keadby
Gunness
N
2.5
1.25
0
2.5 Kilometers

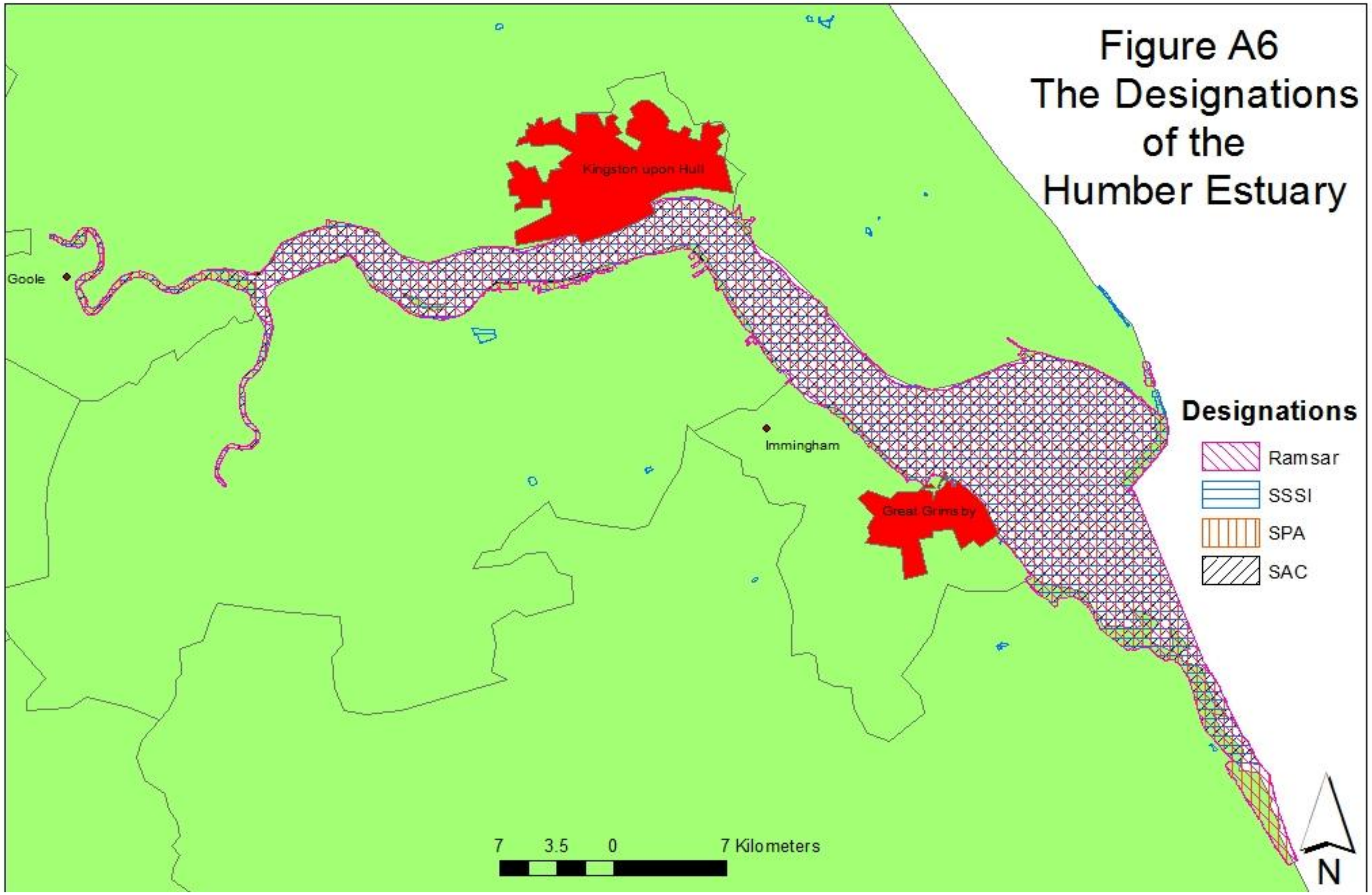


Figure A6
The Designations
of the
Humber Estuary
Kingston upon Hull
Goole
Immingham
Great Grimsby
Designations
Ramsar
SSSI
SPA
SAC
7 3.5 0 7 Kilometers
N

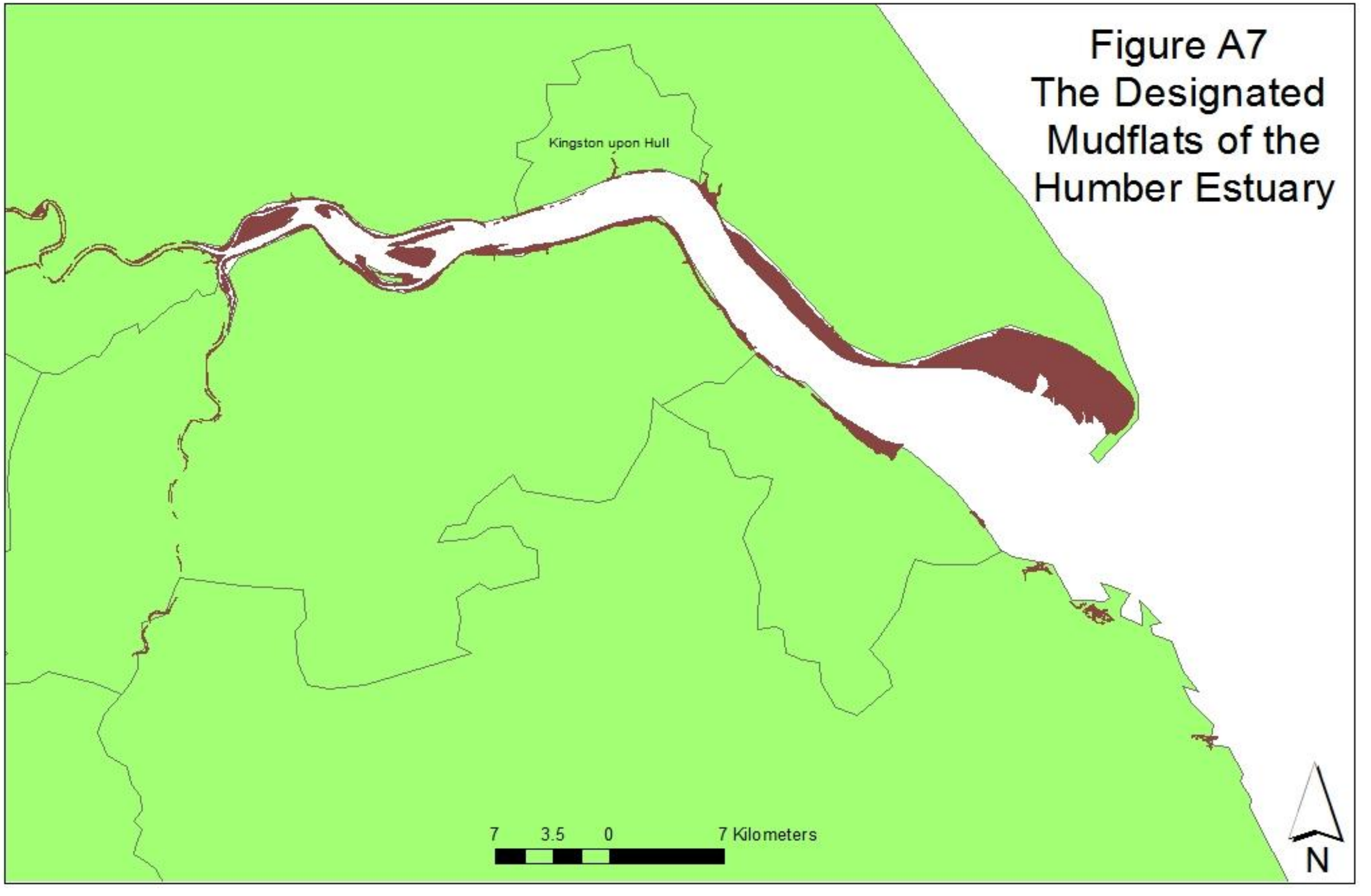
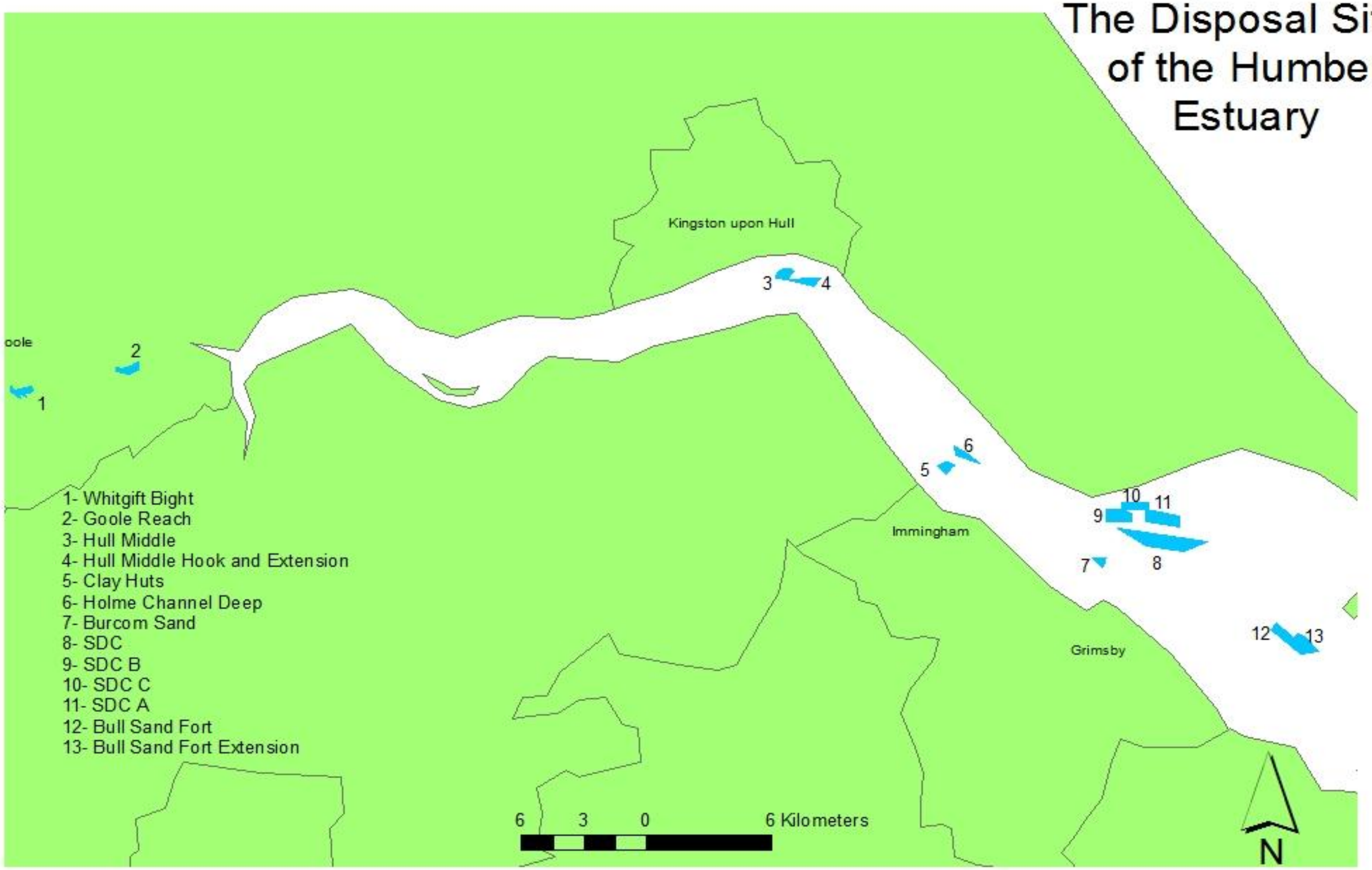


Figure A7
The Designated
Mudflats of the
Humber Estuary
Kingston upon Hull
7 3.5 0 7 Kilometers
N

Figure A8
The Disposal Sites of the Humber Estuary



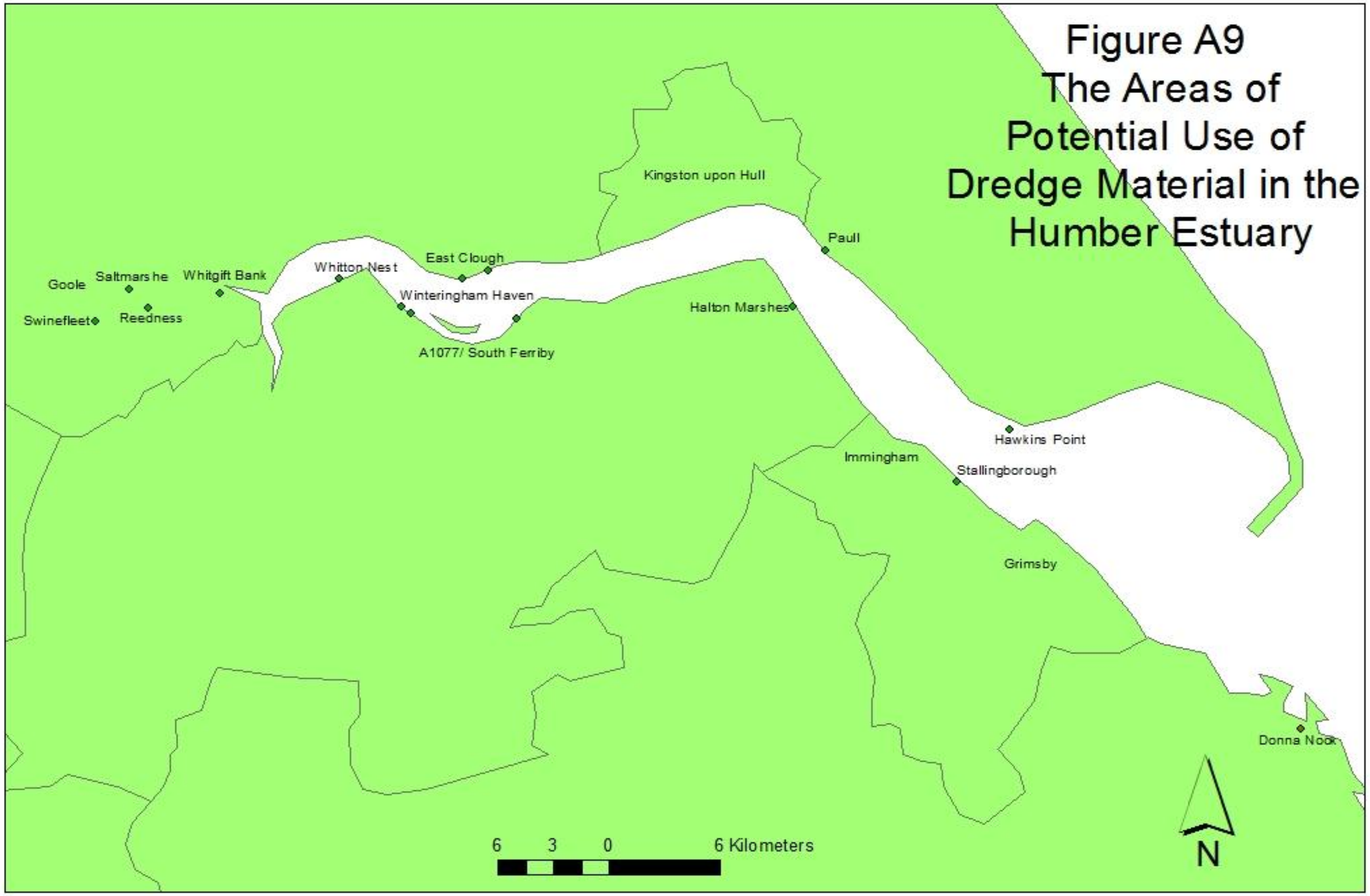


Figure A9
The Areas of
Potential Use of
Dredge Material in the
Humber Estuary
Kingston upon Hull
Paull
East Clough
Whitton Nest
Whitgift Bank
Saltmarshe
Goole
Swinefleet
Reedness
Winteringham Haven
A1077/ South Ferriby
Halton Marshes
Hawkins Point
Immingham
Stallingborough
Grimsby
Donna Nook
6 3 0 6 Kilometers
N

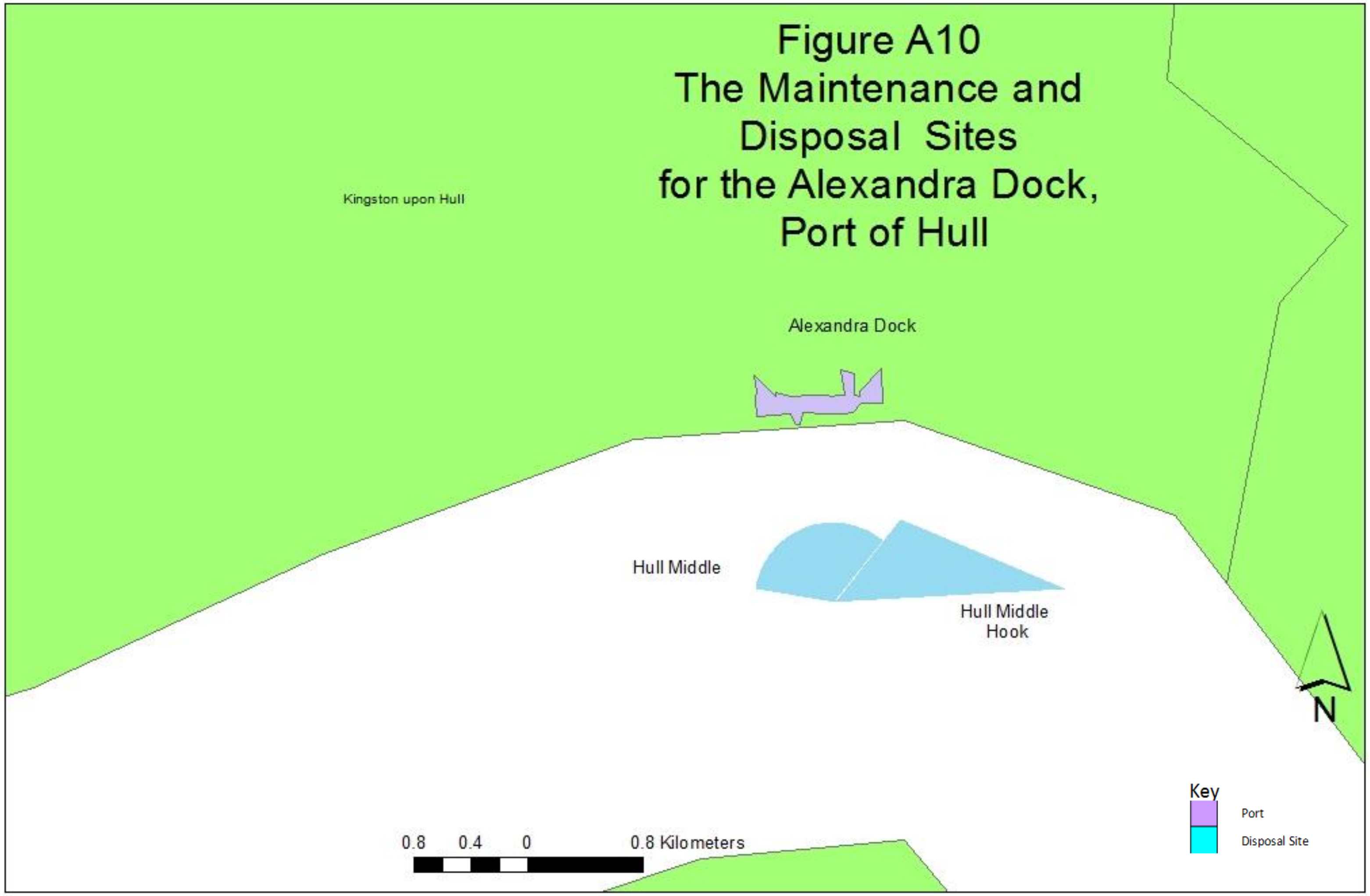


Figure A10
The Maintenance and
Disposal Sites
for the Alexandra Dock,
Port of Hull
Kingston upon Hull
Alexandra Dock
Hull Middle
Hull Middle
Hook
N
Key
Port
Disposal Site
0.8 0.4 0 0.8 Kilometers

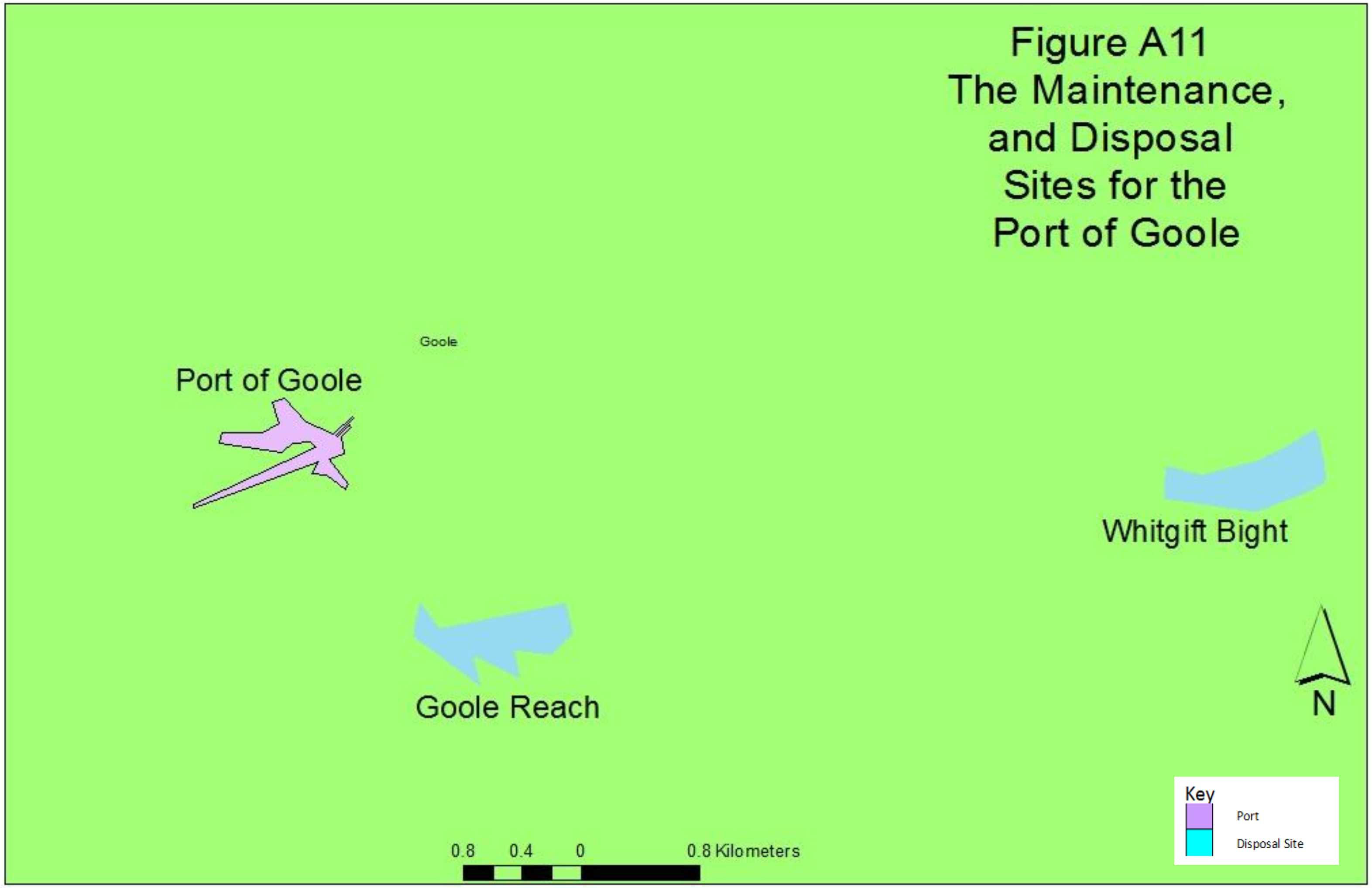


Figure A11
The Maintenance,
and Disposal
Sites for the
Port of Goole
Goole
Port of Goole
Whitgift Bight
Goole Reach
N
Key
Port
Disposal Site
0.8 0.4 0 0.8 Kilometers

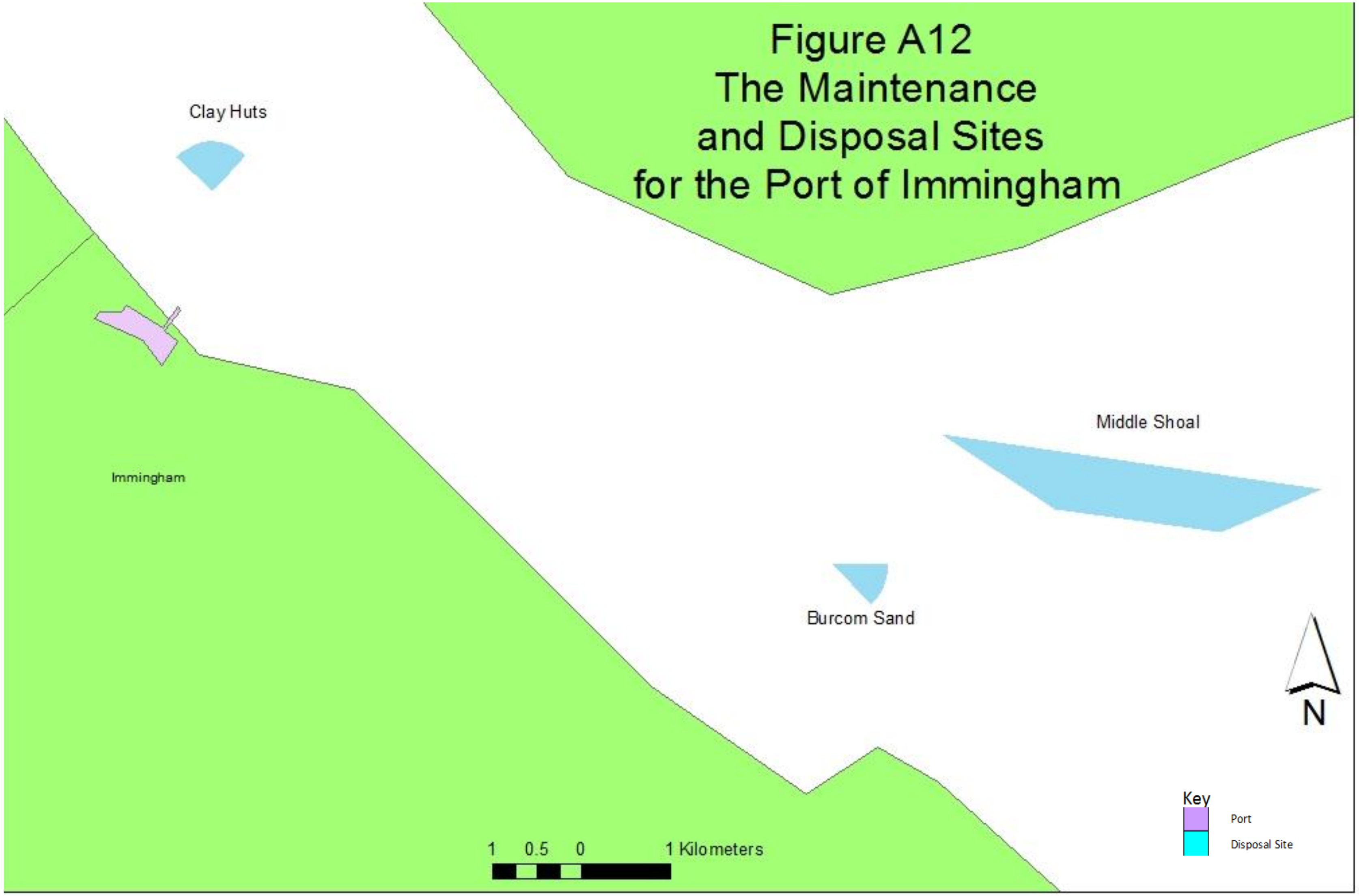


Figure A12
The Maintenance
and Disposal Sites
for the Port of Immingham
Clay Huts
Immingham
Middle Shoal
Burcom Sand
N
1 0.5 0 1 Kilometers
Key
Port
Disposal Site

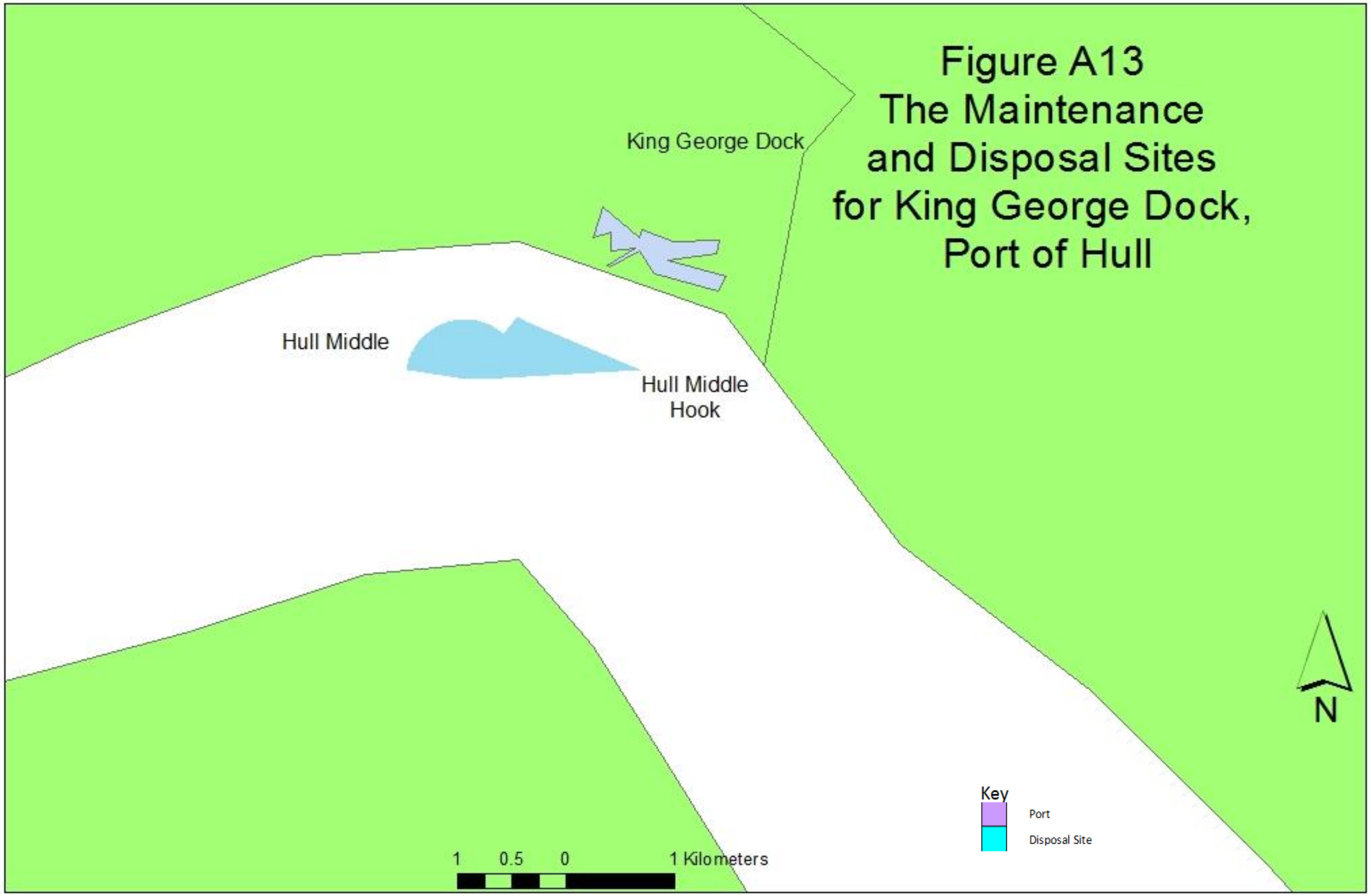


Figure A13
The Maintenance
and Disposal Sites
for King George Dock,
Port of Hull
King George Dock
Hull Middle
Hull Middle
Hook
N
Key
Port
Disposal Site
1 0.5 0 1 Kilometers

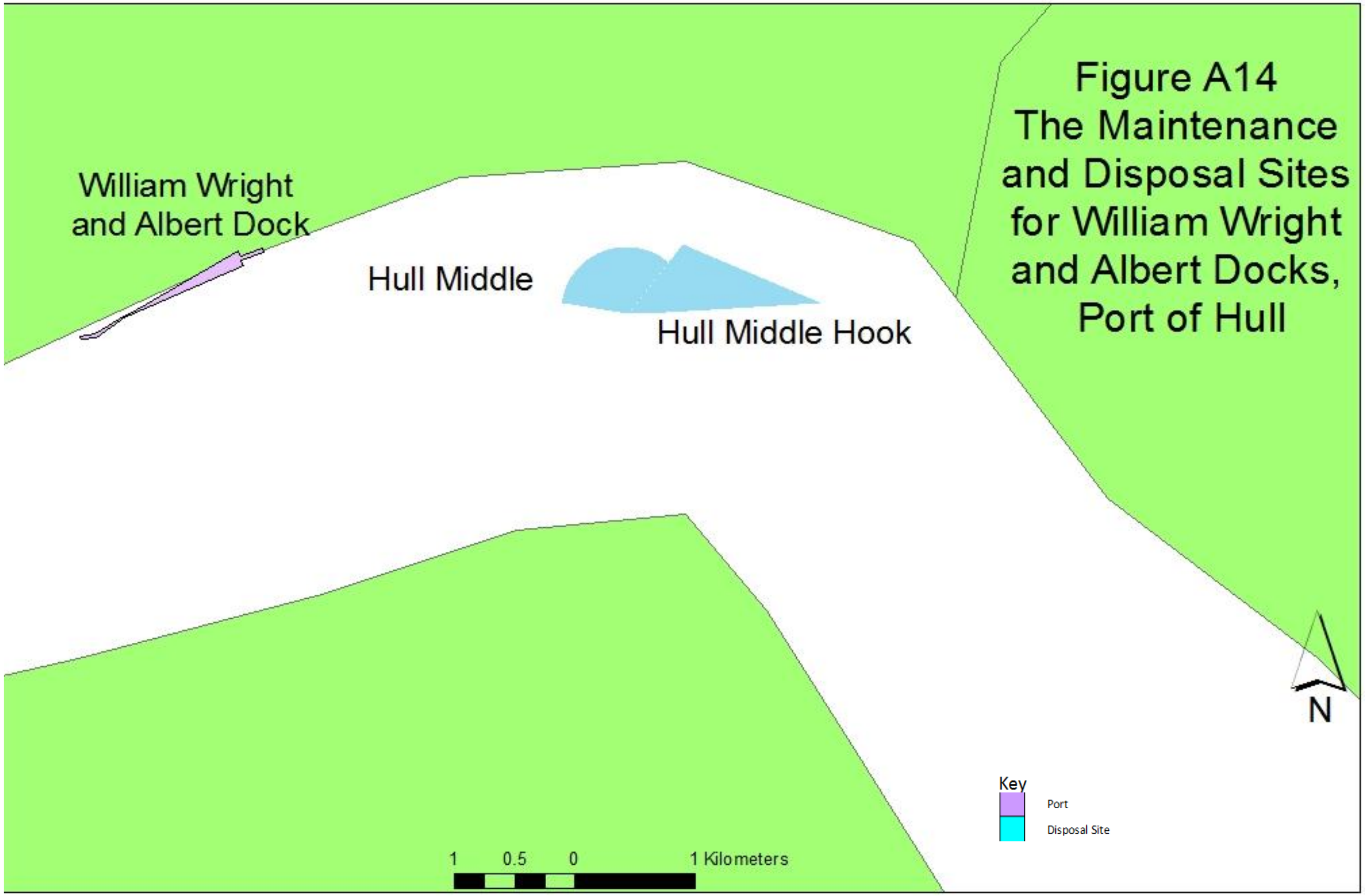


Figure A14
The Maintenance and Disposal Sites for William Wright and Albert Docks, Port of Hull
William Wright and Albert Dock
Hull Middle
Hull Middle Hook
N
Key
Port
Disposal Site
1 0.5 0 1 Kilometers

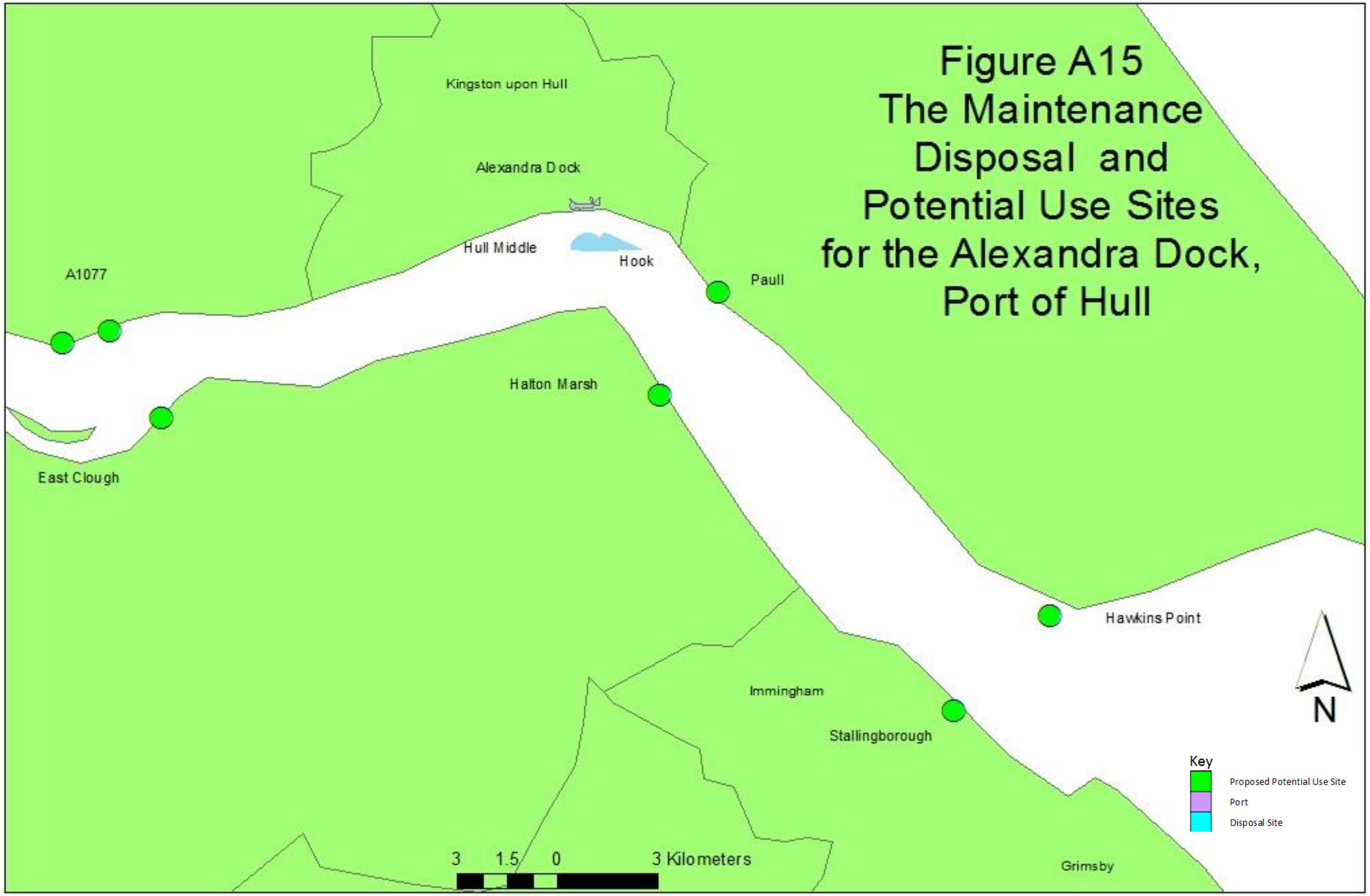


Figure A15
The Maintenance Disposal and Potential Use Sites for the Alexandra Dock, Port of Hull
Kingston upon Hull
Alexandra Dock
Hull Middle
Hook
Paull
A1077
Halton Marsh
East Clough
Hawkins Point
Immingham
Stallingborough
Grimsby
N
Key
Proposed Potential Use Site
Port
Disposal Site
3 1.5 0 3 Kilometers

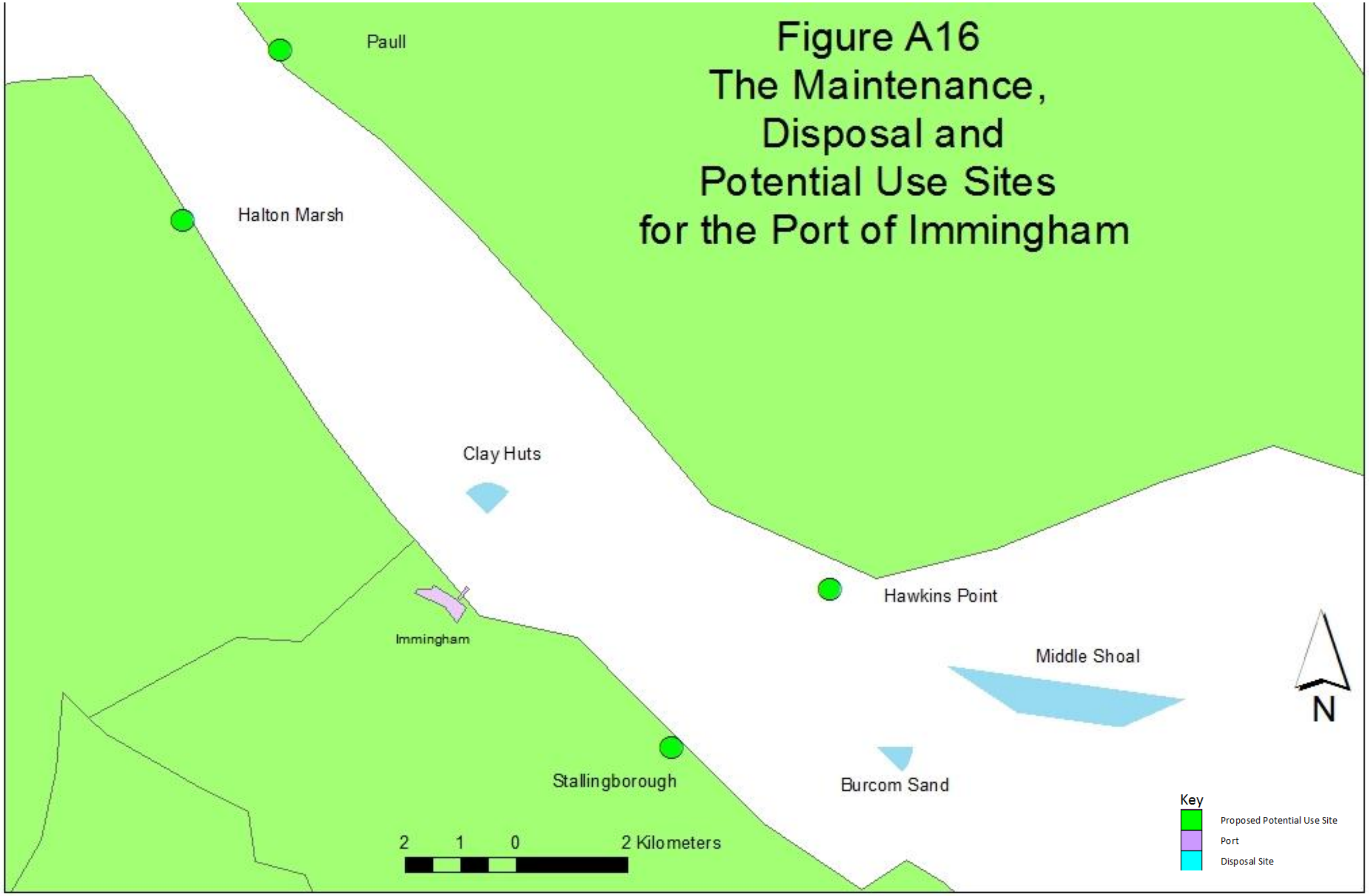


Figure A16
The Maintenance, Disposal and Potential Use Sites for the Port of Immingham

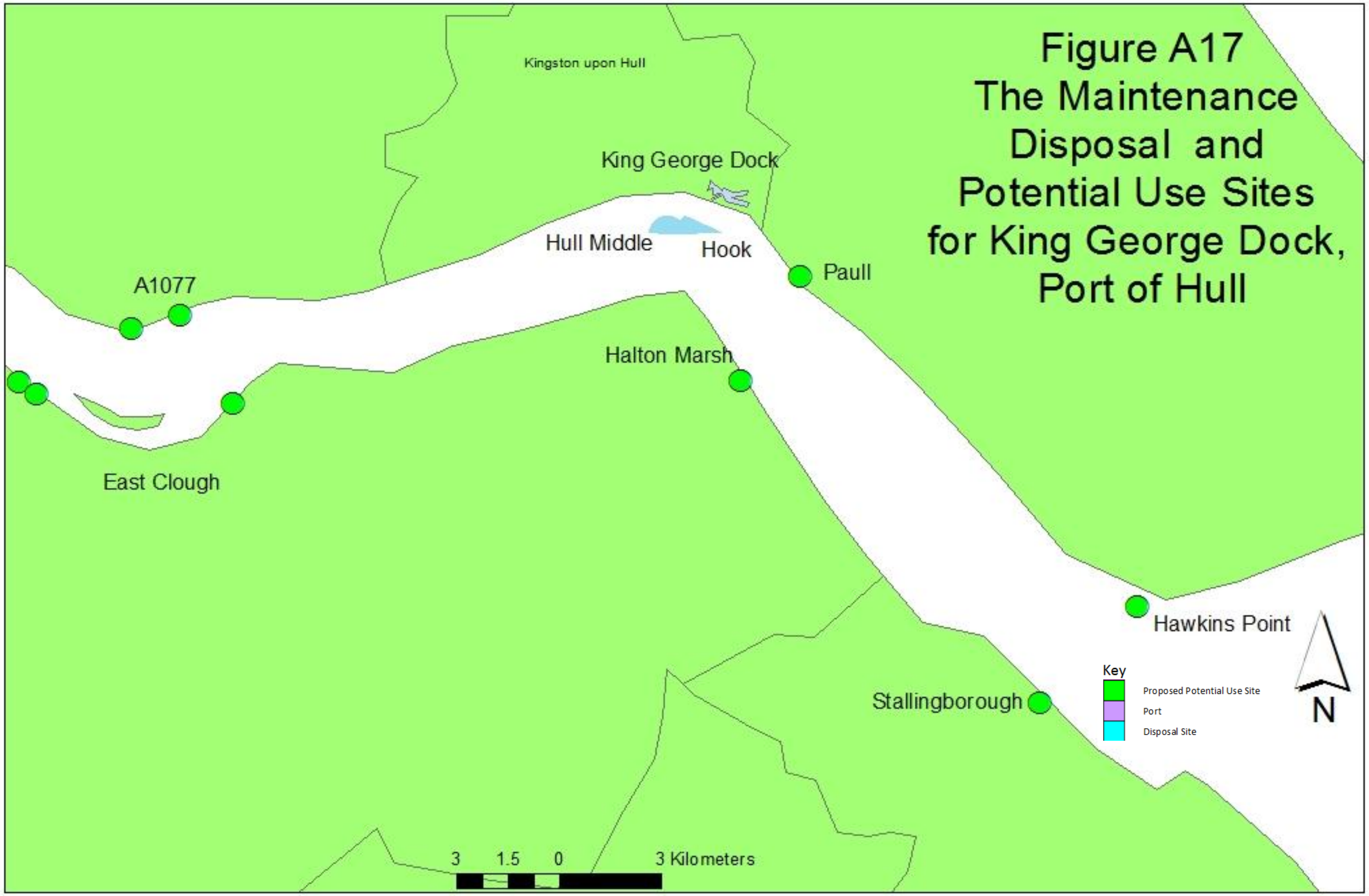


Figure A17
The Maintenance
Disposal and
Potential Use Sites
for King George Dock,
Port of Hull
Kingston upon Hull
King George Dock
Hull Middle
Hook
Paull
A1077
Halton Marsh
East Clough
Hawkins Point
Stallingborough
Key
Proposed Potential Use Site
Port
Disposal Site
N
3 1.5 0 3 Kilometers

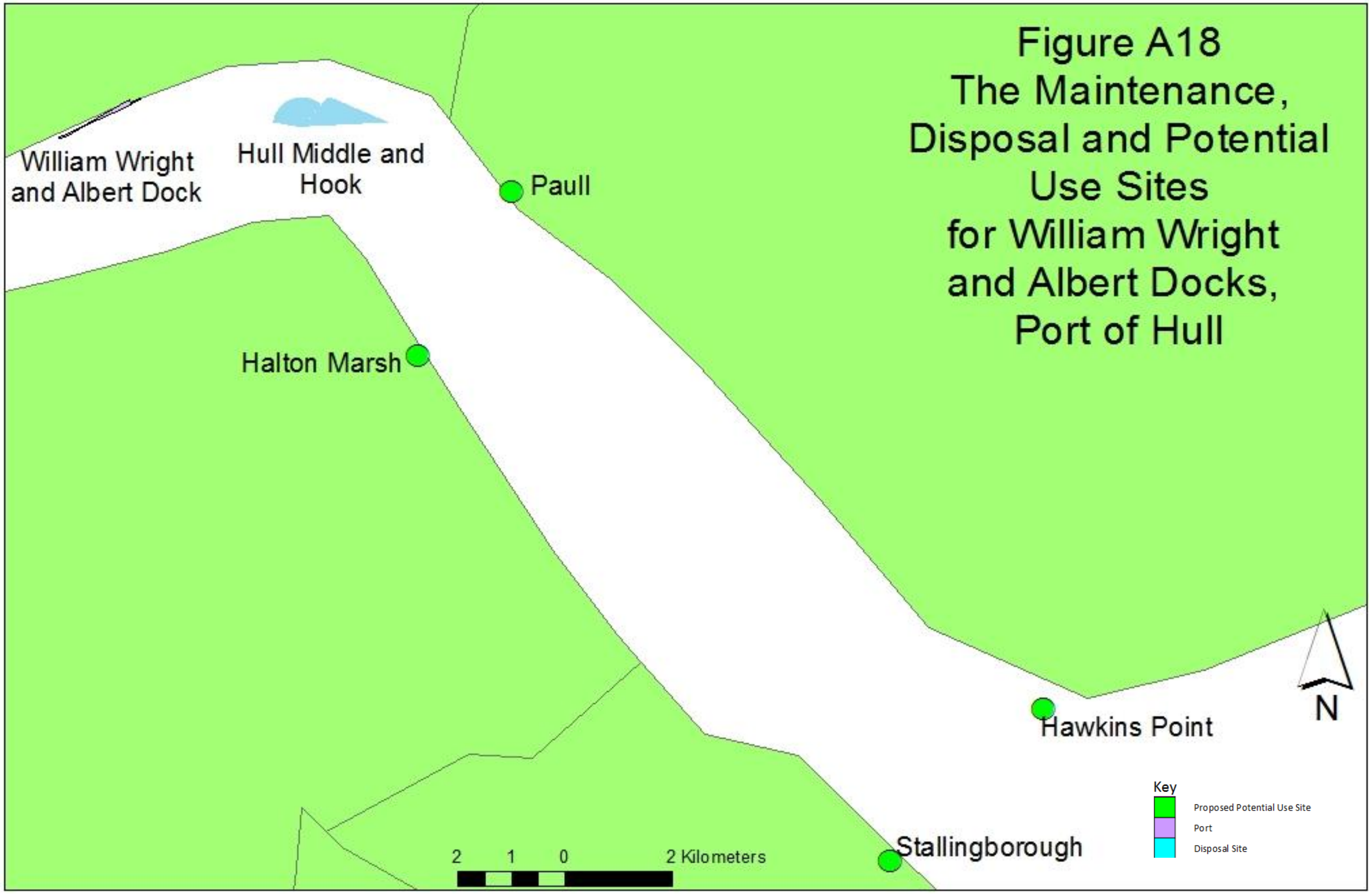


Figure A18
The Maintenance,
Disposal and Potential
Use Sites
for William Wright
and Albert Docks,
Port of Hull
William Wright
and Albert Dock
Hull Middle and
Hook
Paull
Halton Marsh
Hawkins Point
Stallingborough
N
2 1 0 2 Kilometers
Key
Proposed Potential Use Site
Port
Disposal Site

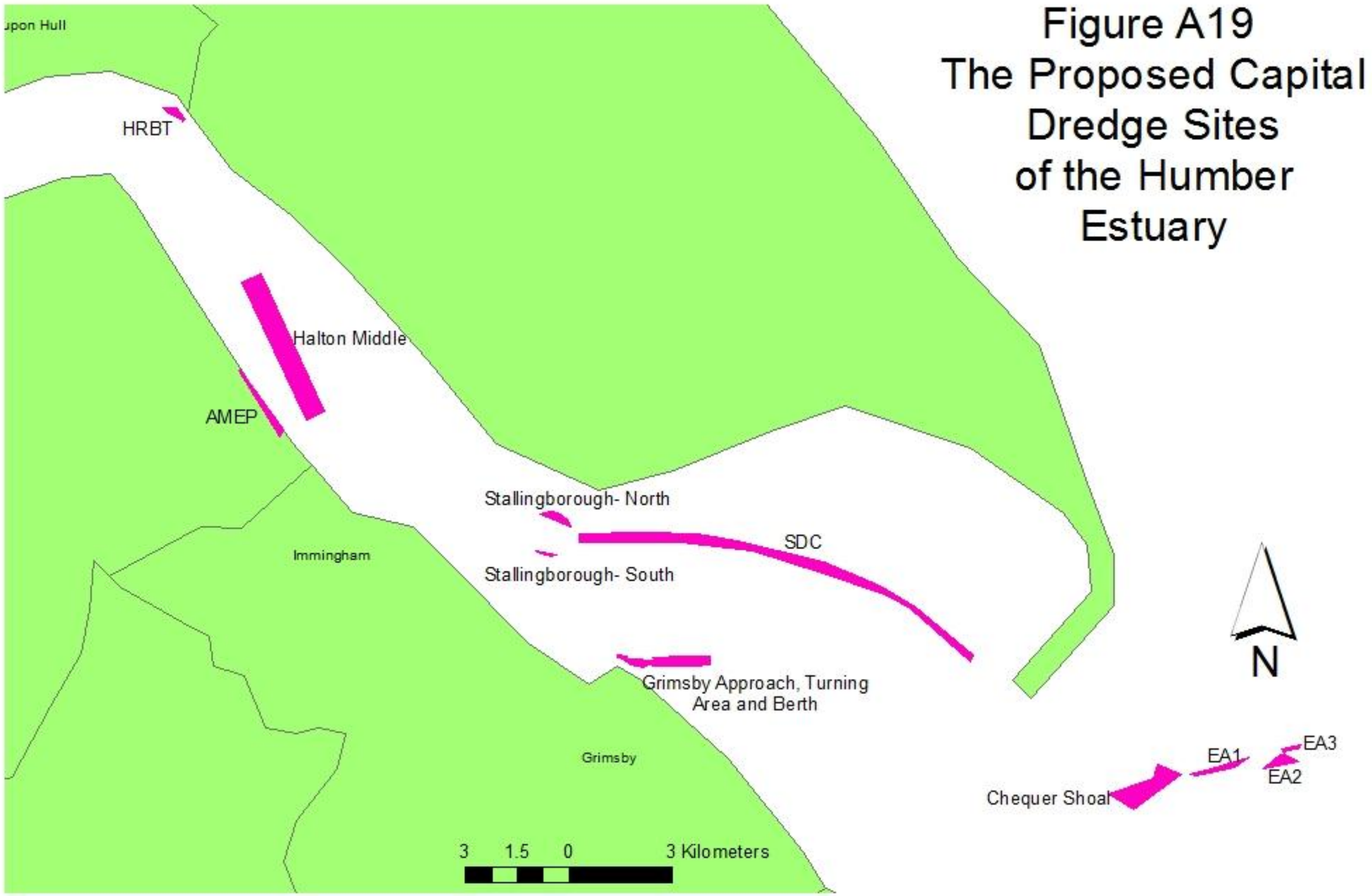


Figure A19
The Proposed Capital
Dredge Sites
of the Humber
Estuary
upon Hull
HRBT
Halton Middle
AMEP
Immingham
Stallingborough- North
Stallingborough- South
SDC
Grimsby Approach, Turning
Area and Berth
Grimsby
Chequer Shoal
EA1
EA2
EA3
N
3 1.5 0 3 Kilometers

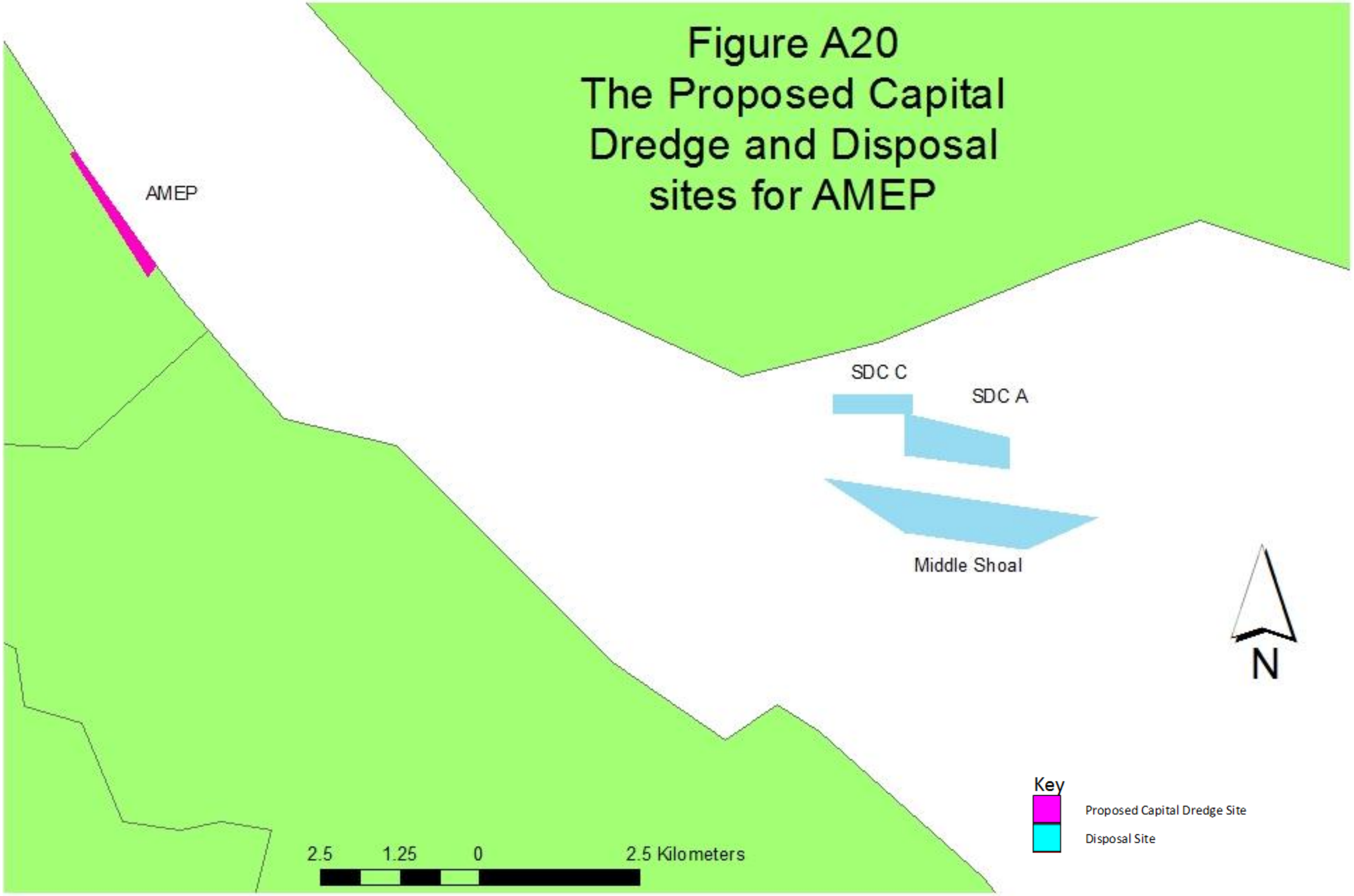


Figure A20
The Proposed Capital Dredge and Disposal sites for AMEP
AMEP
SDC C
SDC A
Middle Shoal
N
Key
Proposed Capital Dredge Site
Disposal Site
2.5
1.25
0
2.5 Kilometers

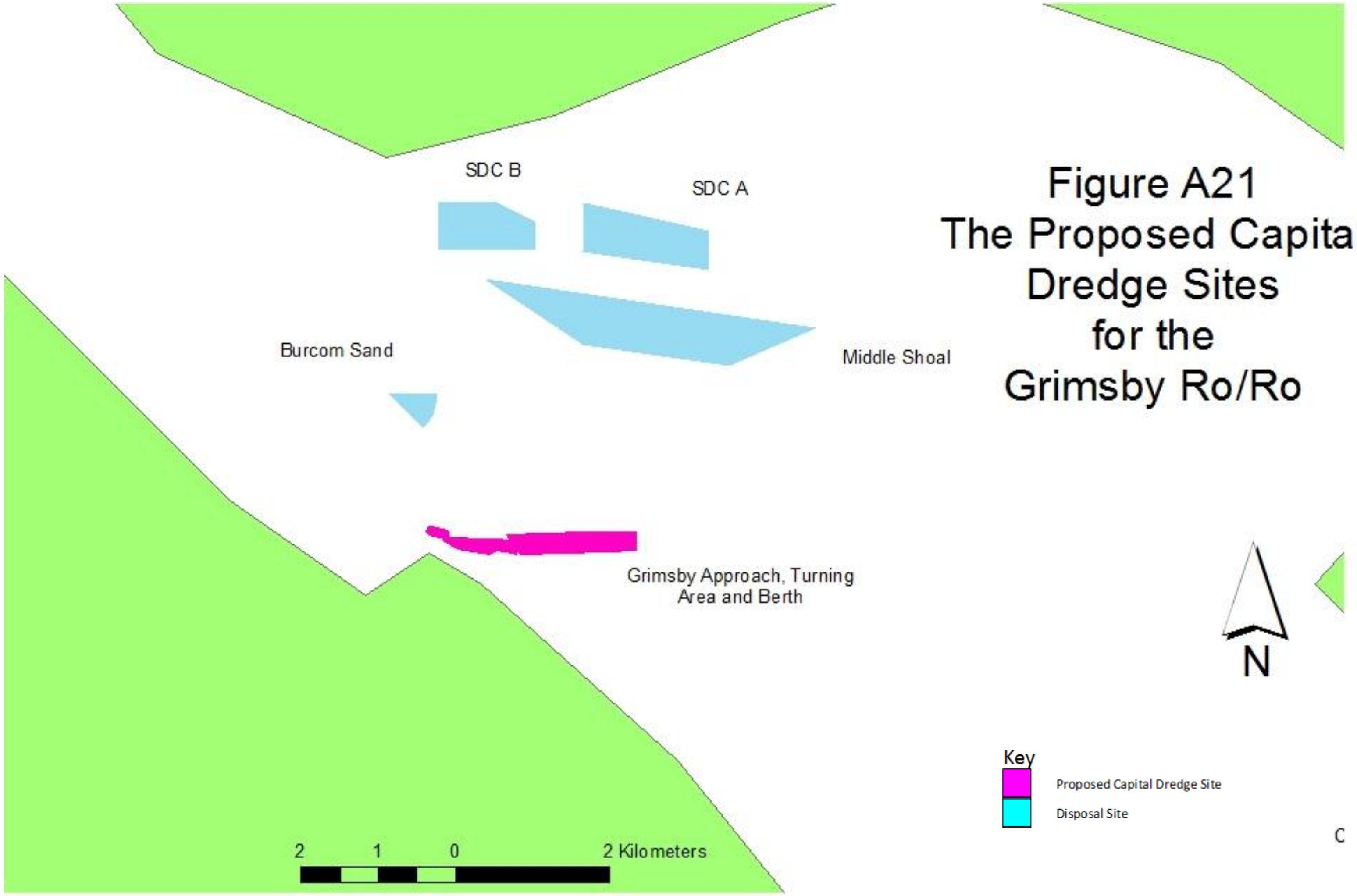


Figure A21
The Proposed Capital
Dredge Sites
for the
Grimsby Ro/Ro

Figure A22 The Proposed HRBT Dredge and Disposal Site

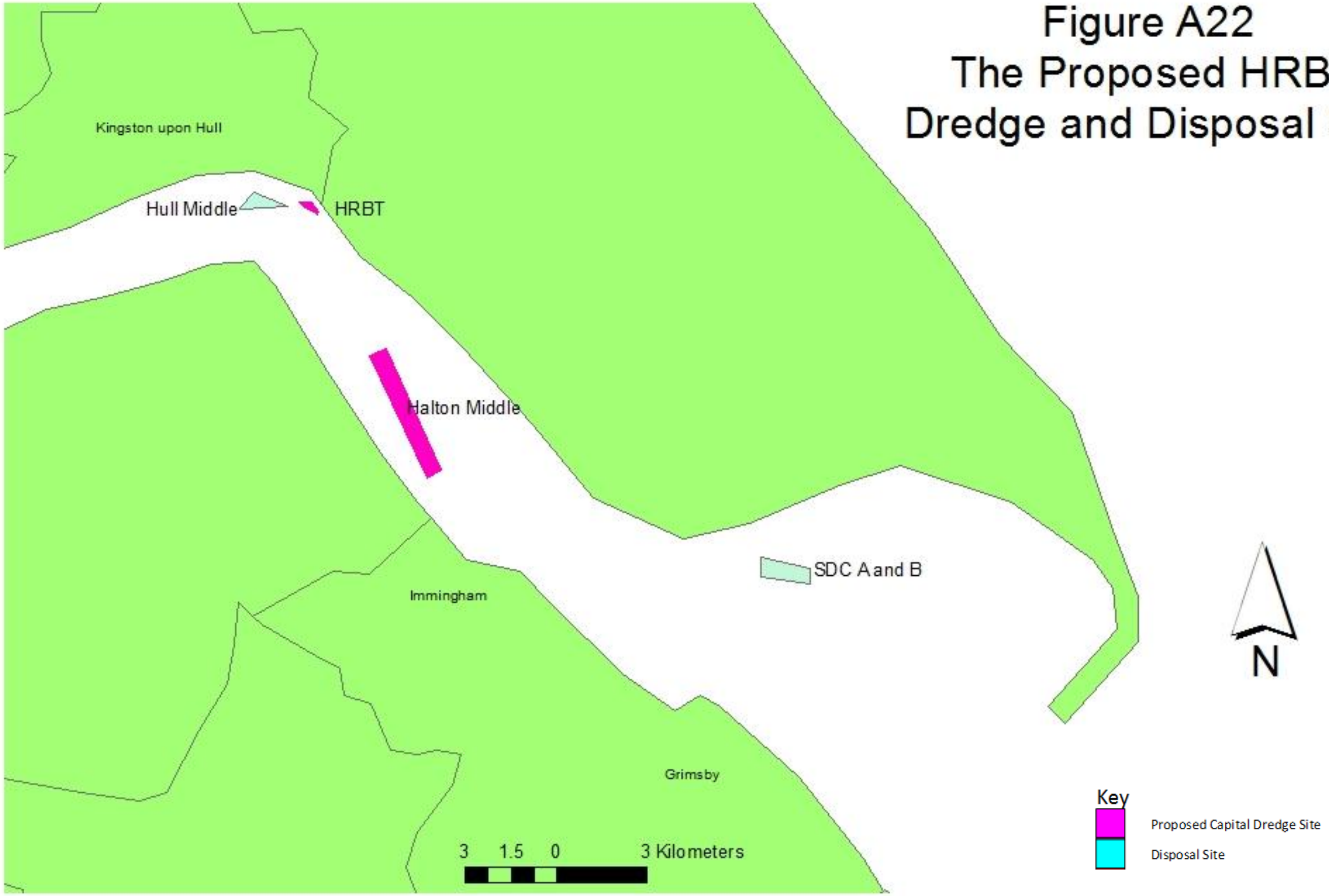
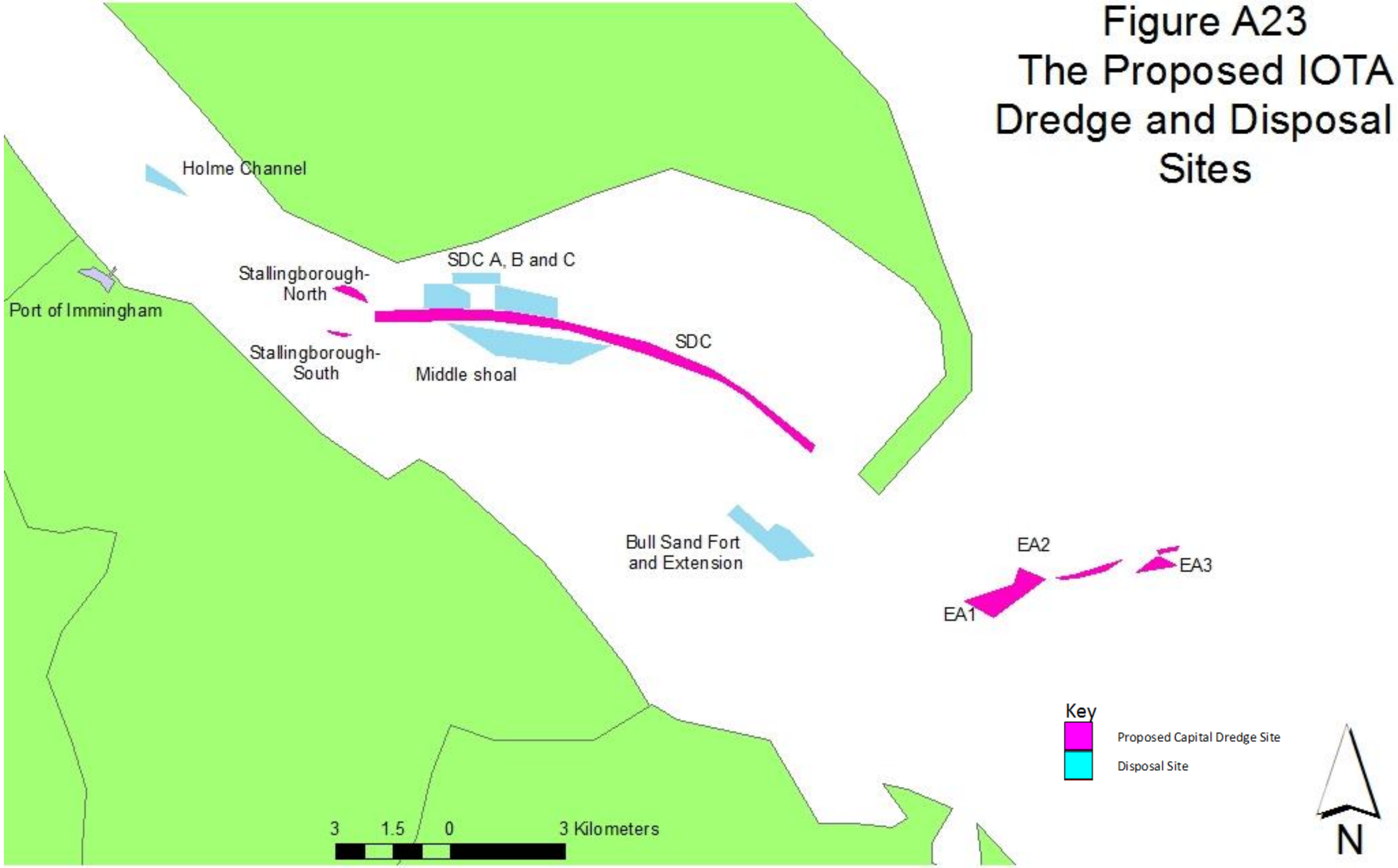


Figure A23
The Proposed IOTA Dredge and Disposal Sites



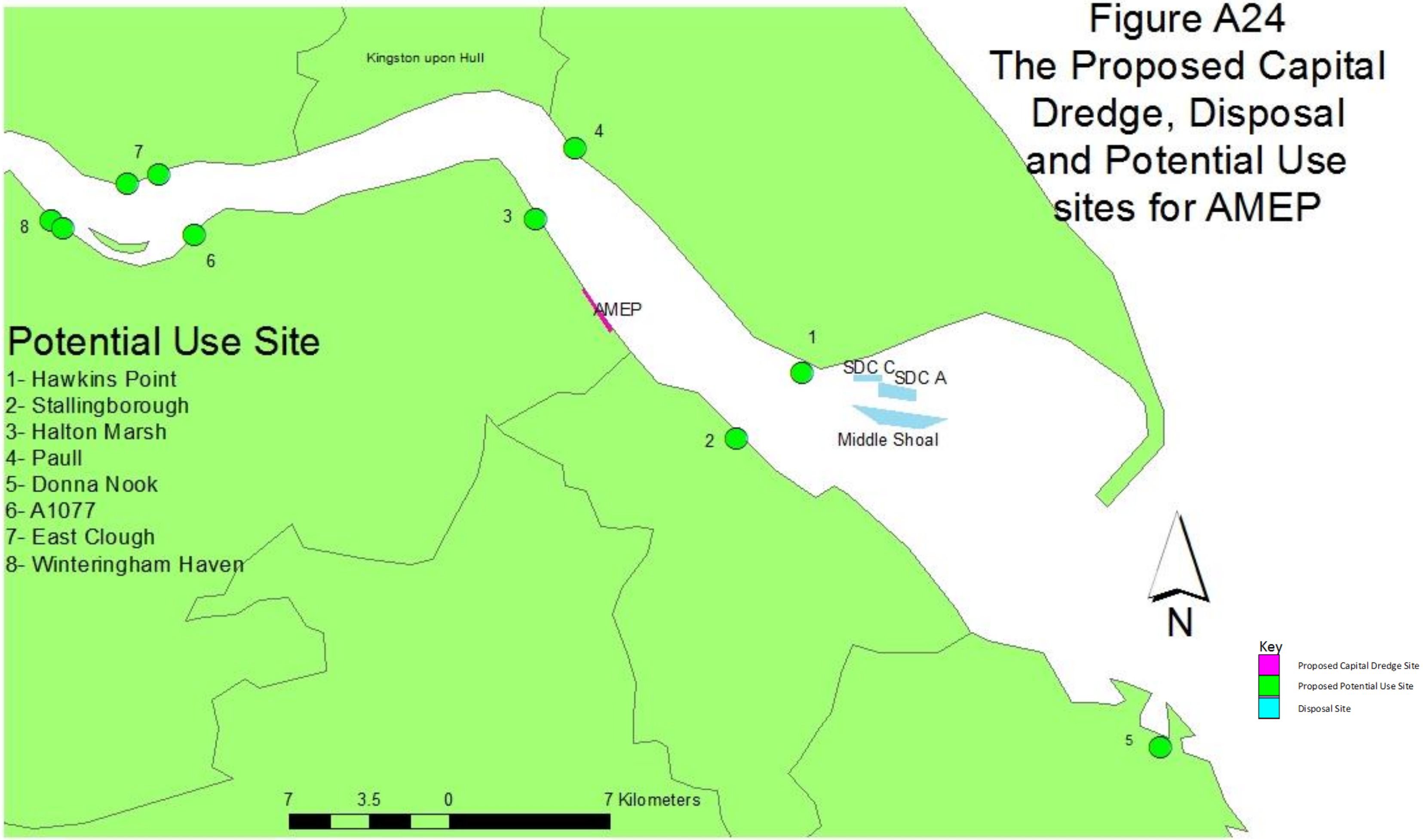


Figure A24
The Proposed Capital Dredge, Disposal and Potential Use sites for AMEP

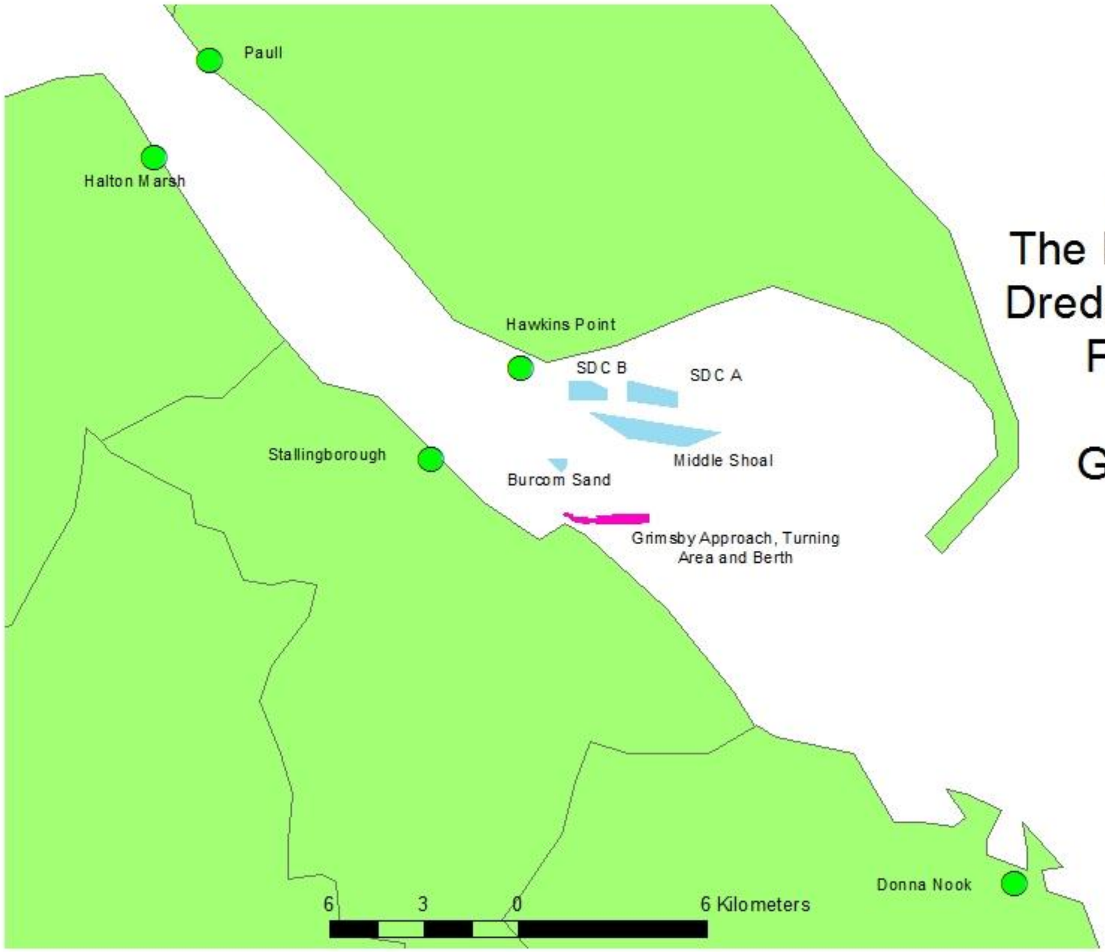


Figure A25
The Proposed Capital Dredge, Disposal and Potential Uses for the Grimsby Ro/Ro

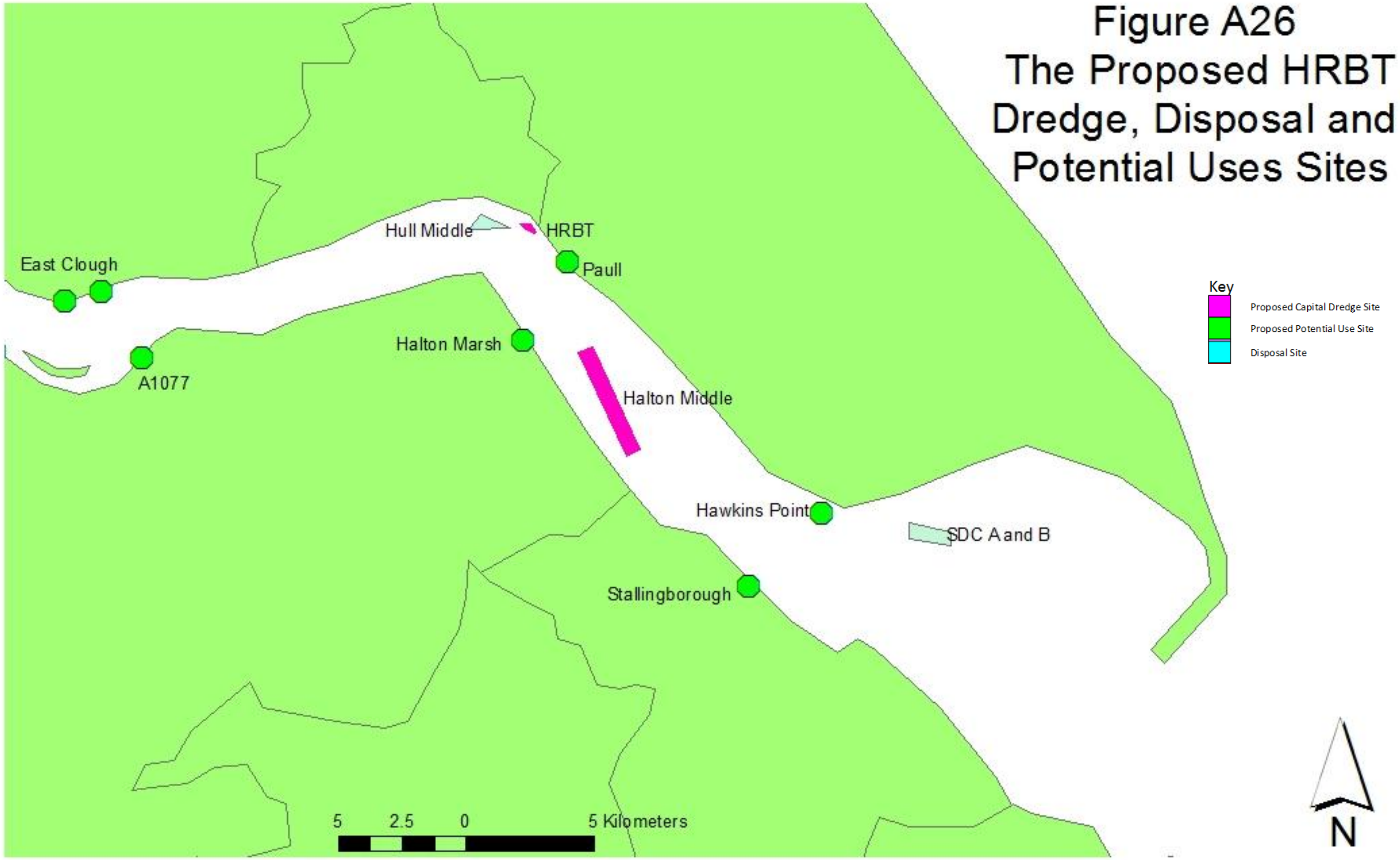
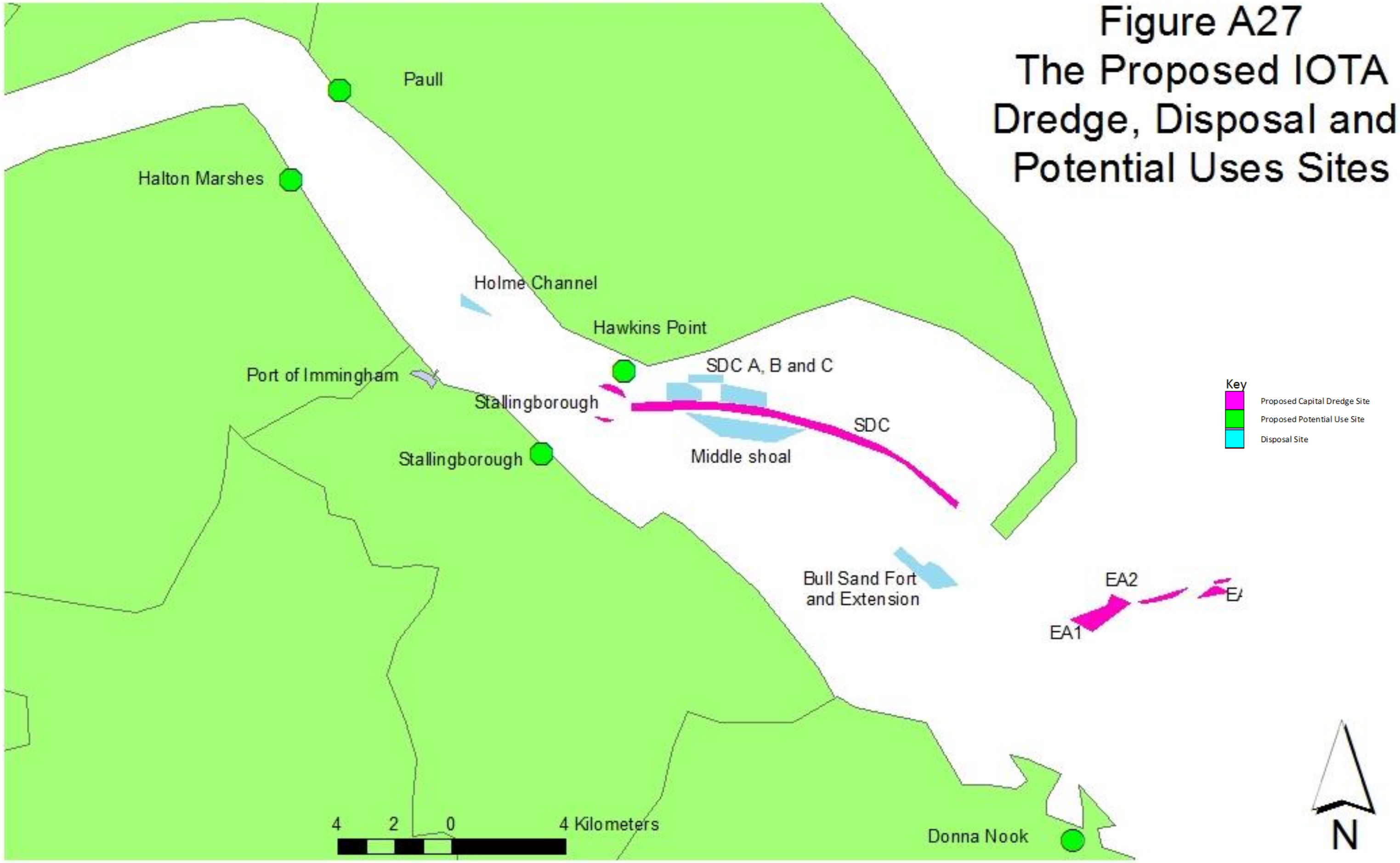


Figure A26
The Proposed HRBT Dredge, Disposal and Potential Uses Sites

Figure A27 The Proposed IOTA Dredge, Disposal and Potential Uses Sites



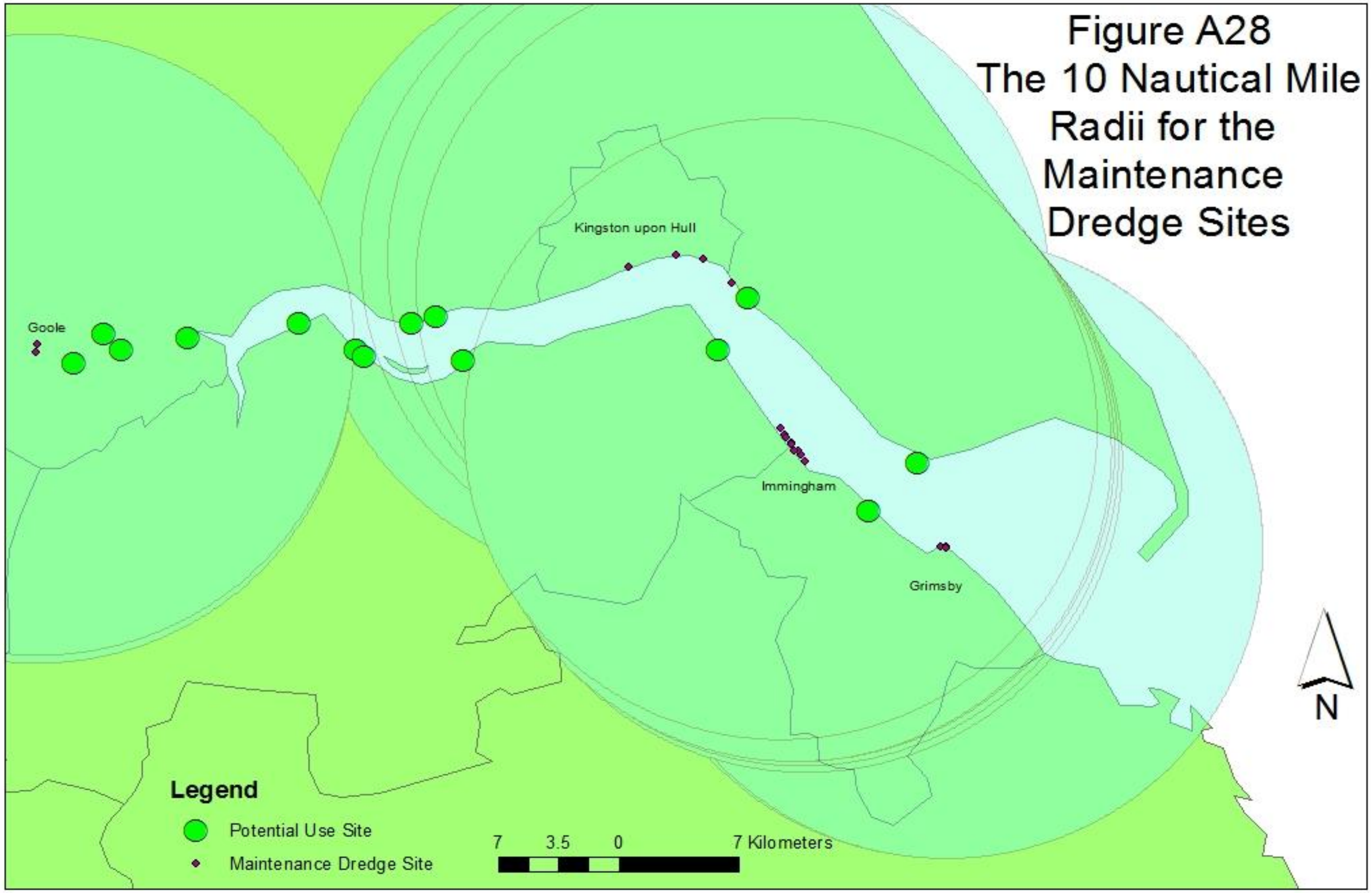


Figure A28
The 10 Nautical Mile
Radii for the
Maintenance
Dredge Sites
Kingston upon Hull
Goole
Immingham
Grimsby
N
Legend
Potential Use Site
Maintenance Dredge Site
7 3.5 0 7 Kilometers

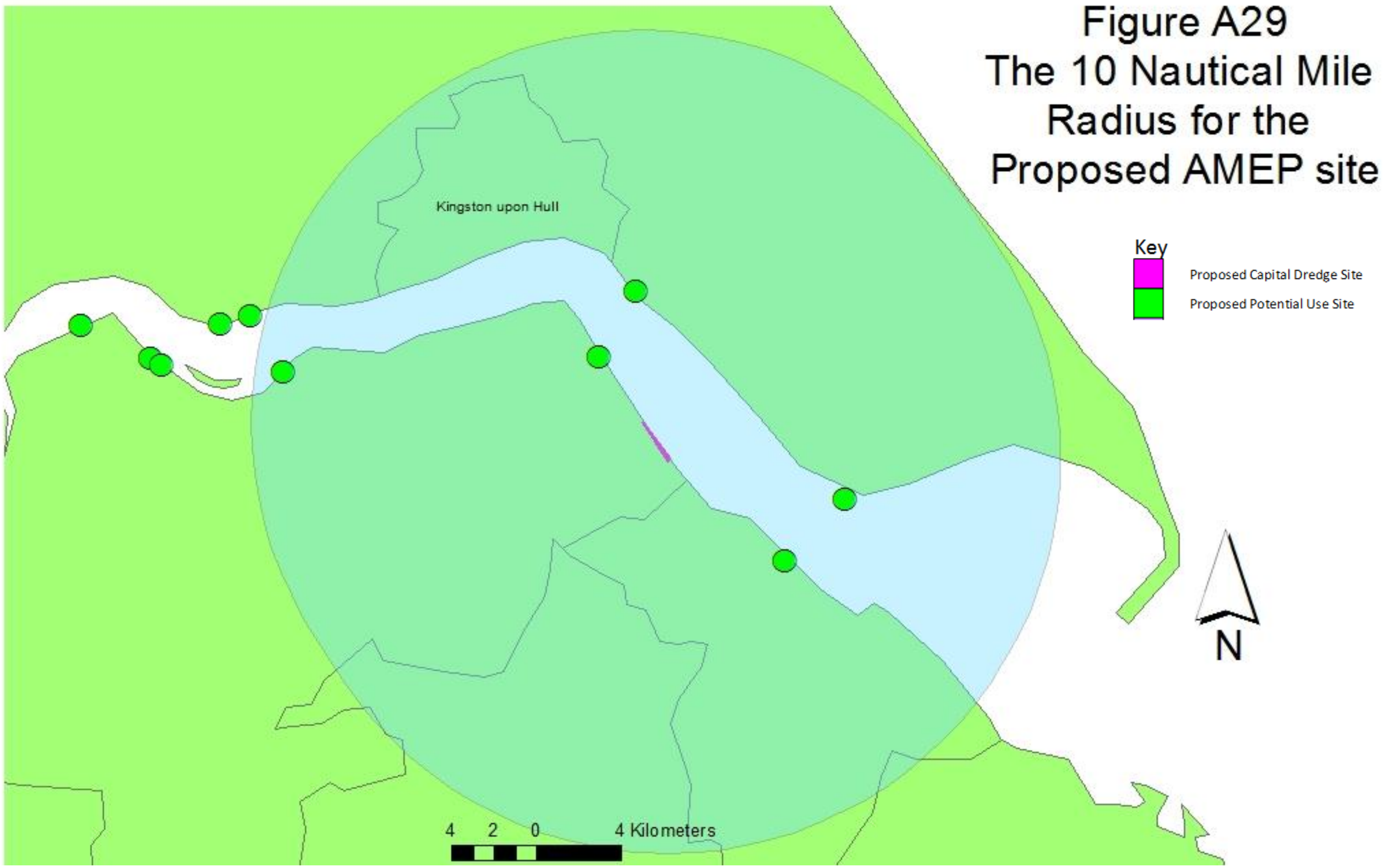
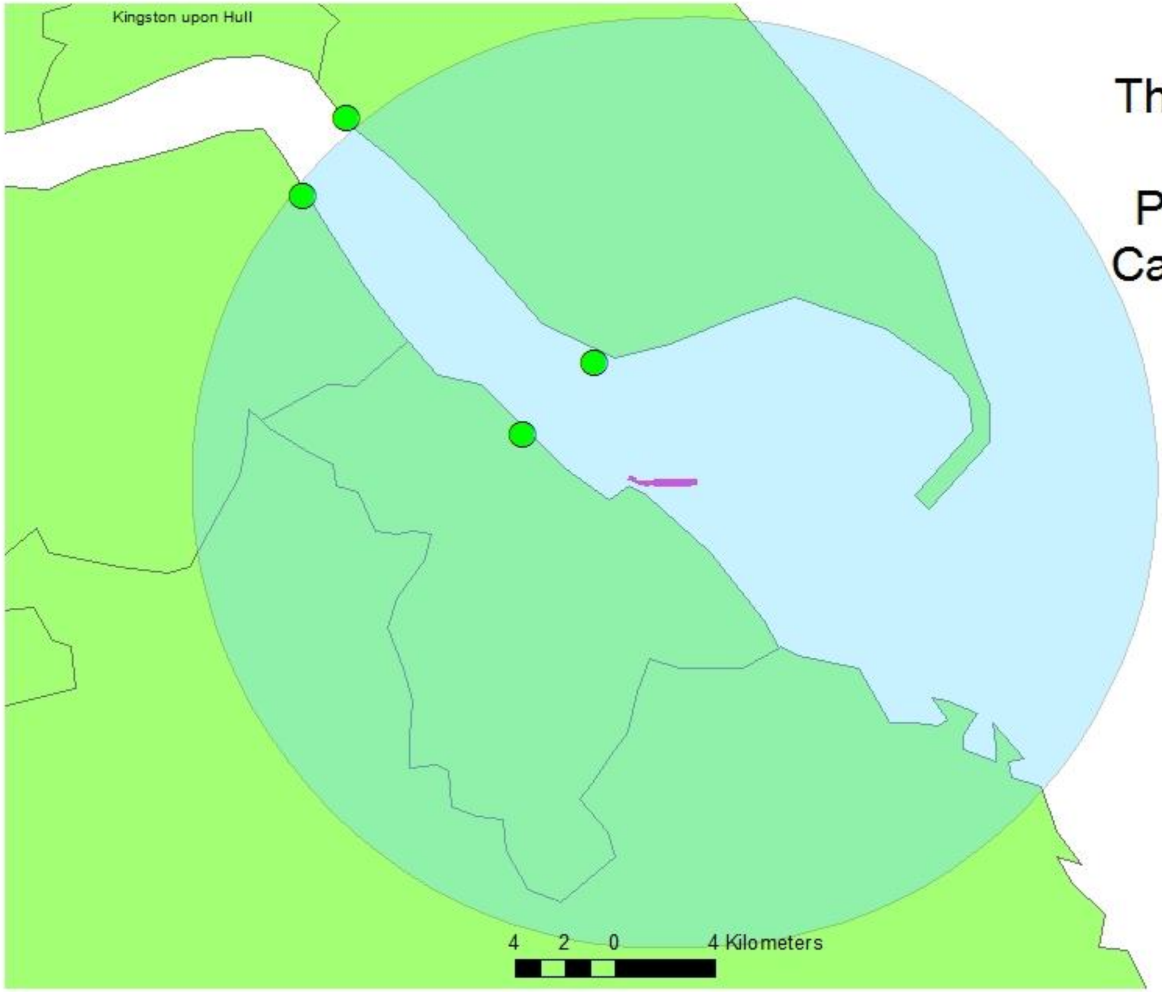


Figure A29
The 10 Nautical Mile
Radius for the
Proposed AMEP site
Kingston upon Hull
Key
Proposed Capital Dredge Site
Proposed Potential Use Site
N
4 2 0 4 Kilometers

Figure A30
The 10 Nautical Mile Radius for the Proposed Grimsby Capital Dredge Areas



Key
Proposed Capital Dredge Site
Proposed Potential Use Site

N

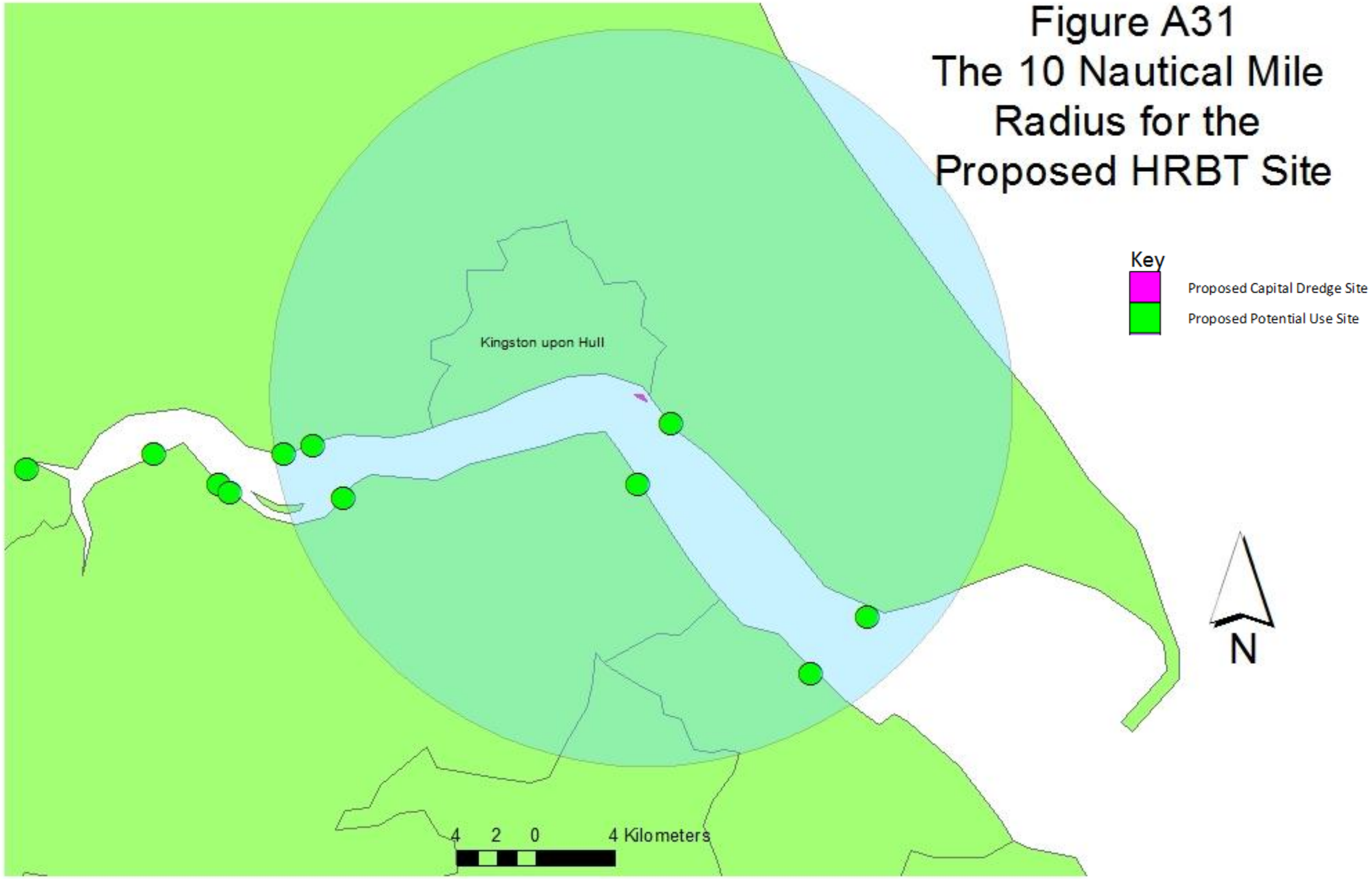


Figure A31
The 10 Nautical Mile
Radius for the
Proposed HRBT Site

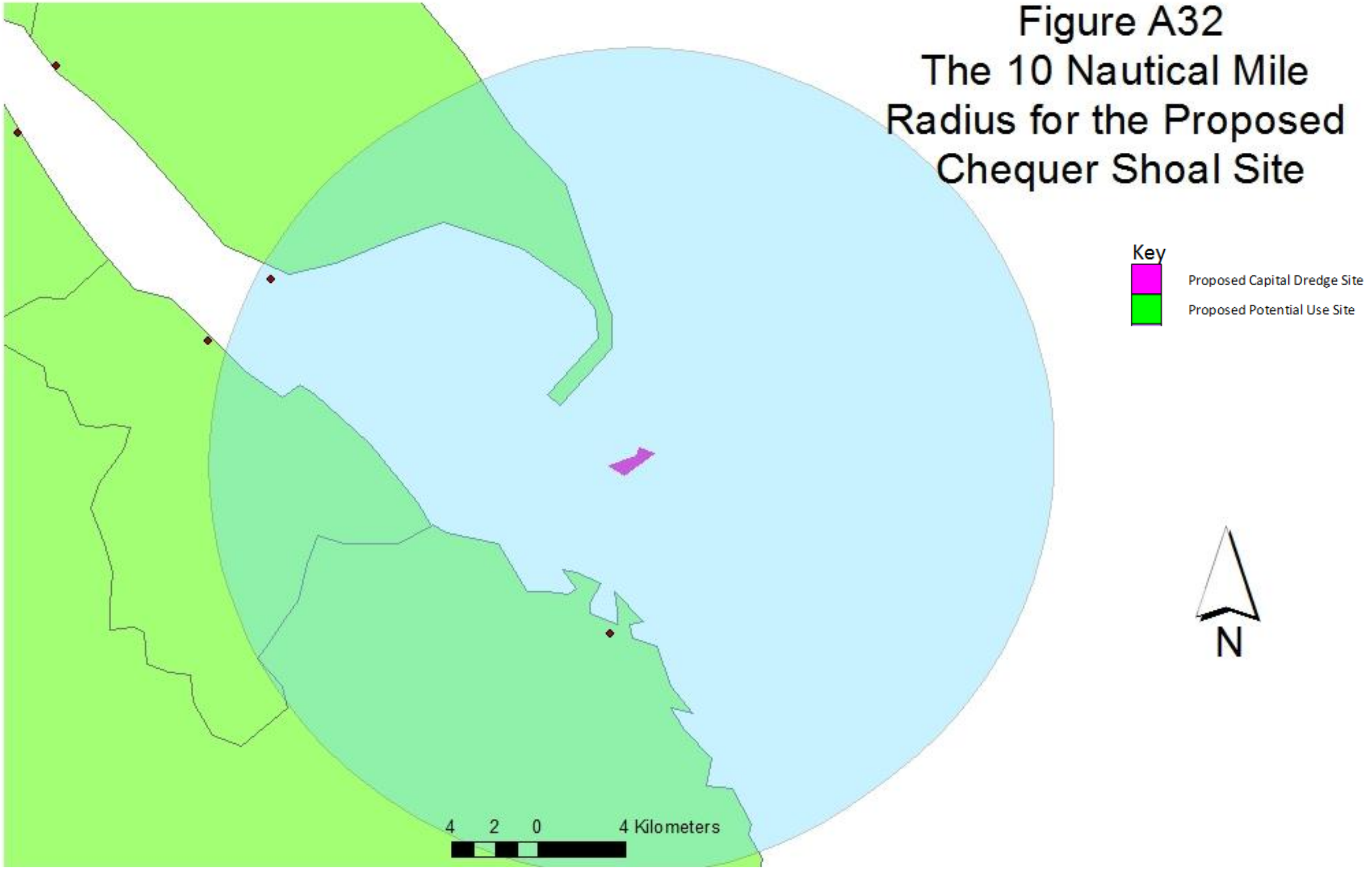


Figure A32
The 10 Nautical Mile Radius for the Proposed Chequer Shoal Site

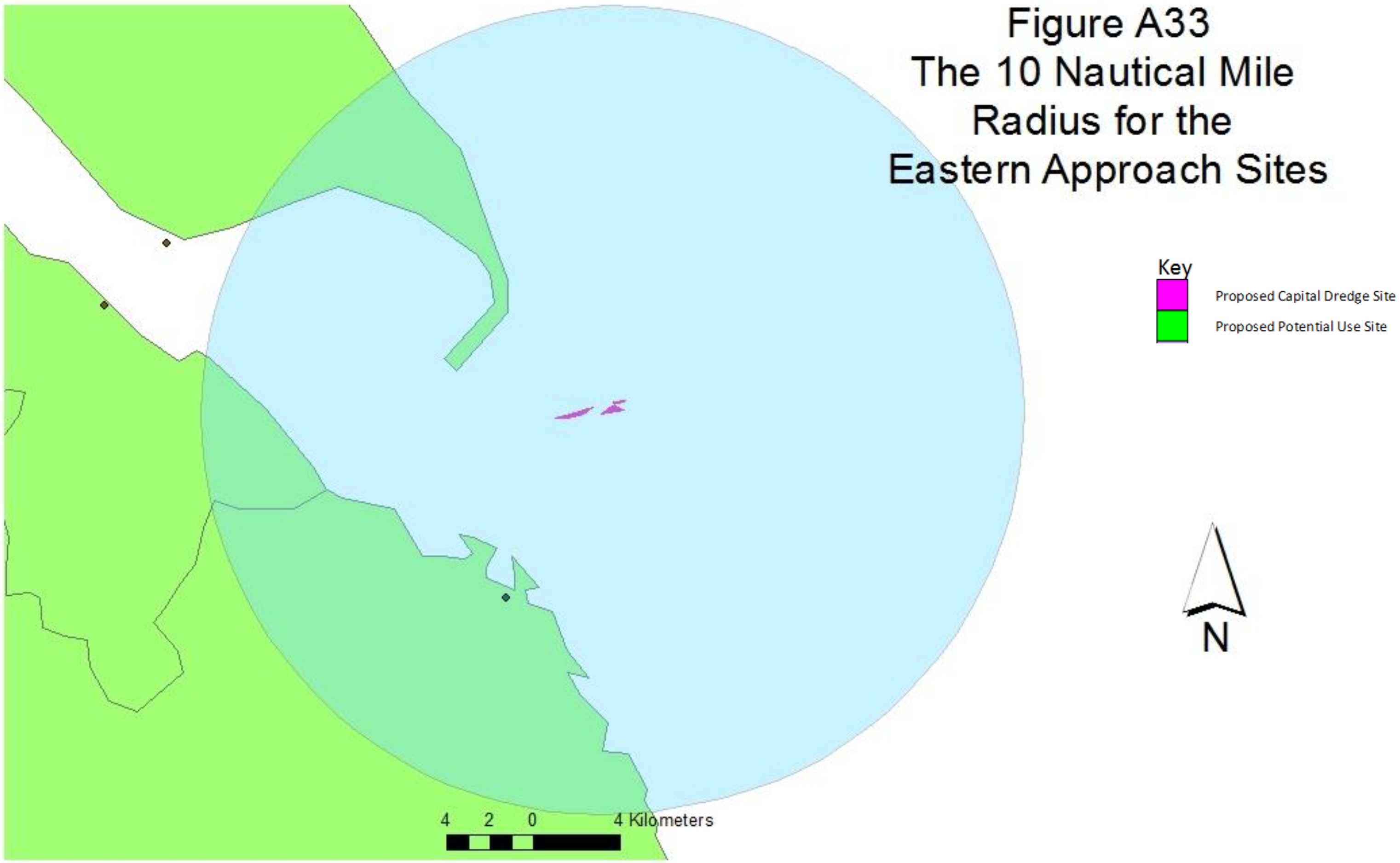


Figure A33
The 10 Nautical Mile
Radius for the
Eastern Approach Sites
Key
Proposed Capital Dredge Site
Proposed Potential Use Site
N
4 2 0 4 Kilometers

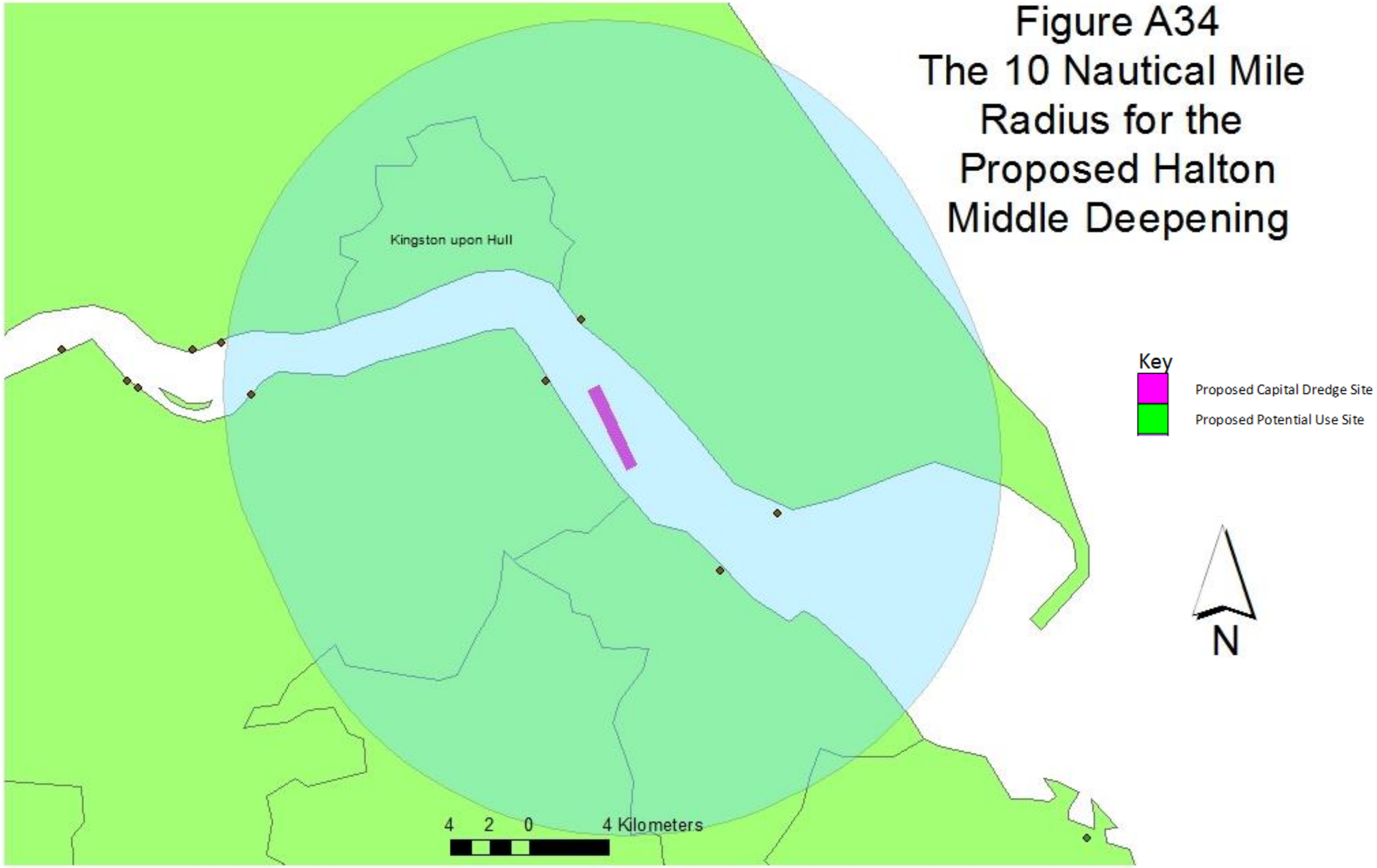
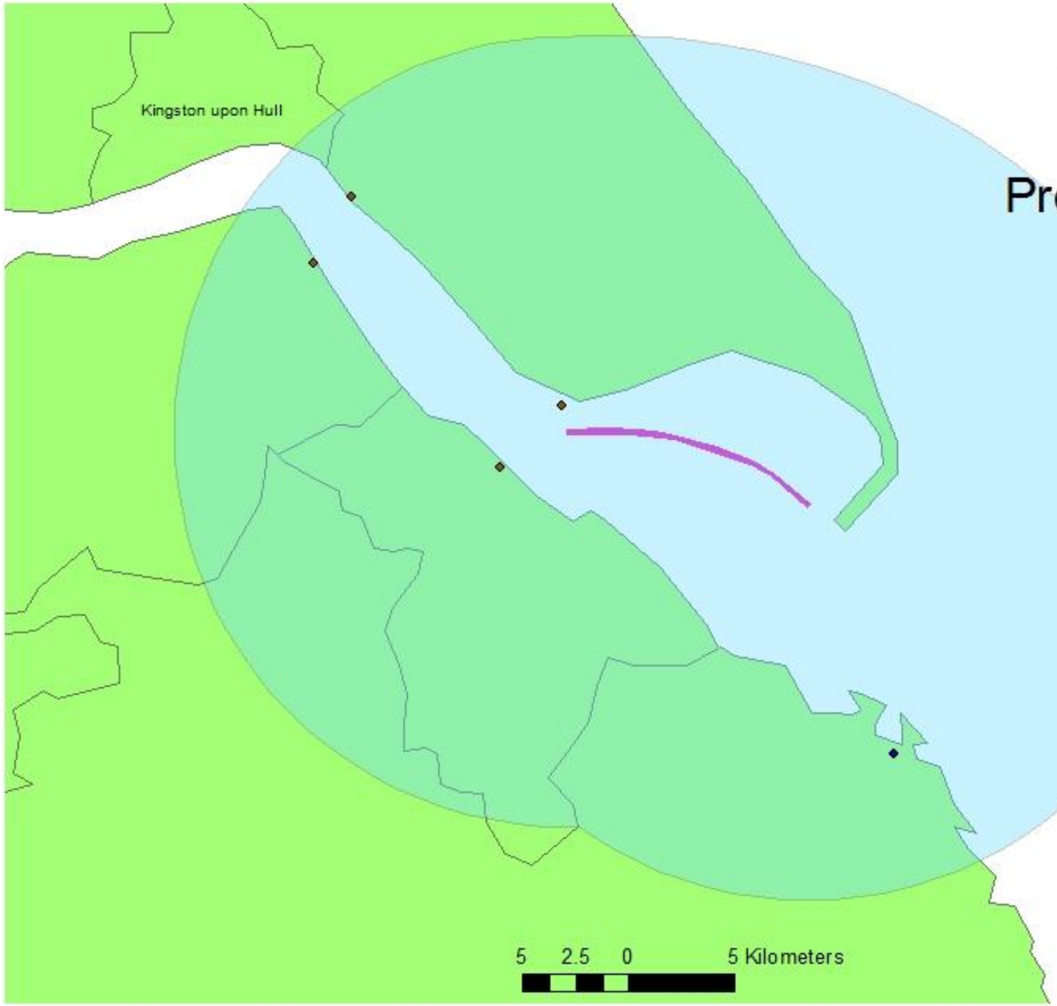


Figure A34
The 10 Nautical Mile Radius for the Proposed Halton Middle Deepening

TIDE
Tidal River Development

Figure A35
The 10 Nautical Mile Radius for the Proposed SDC Deepening



Key
Proposed Capital Dredge Site
Proposed Potential Use Site

N

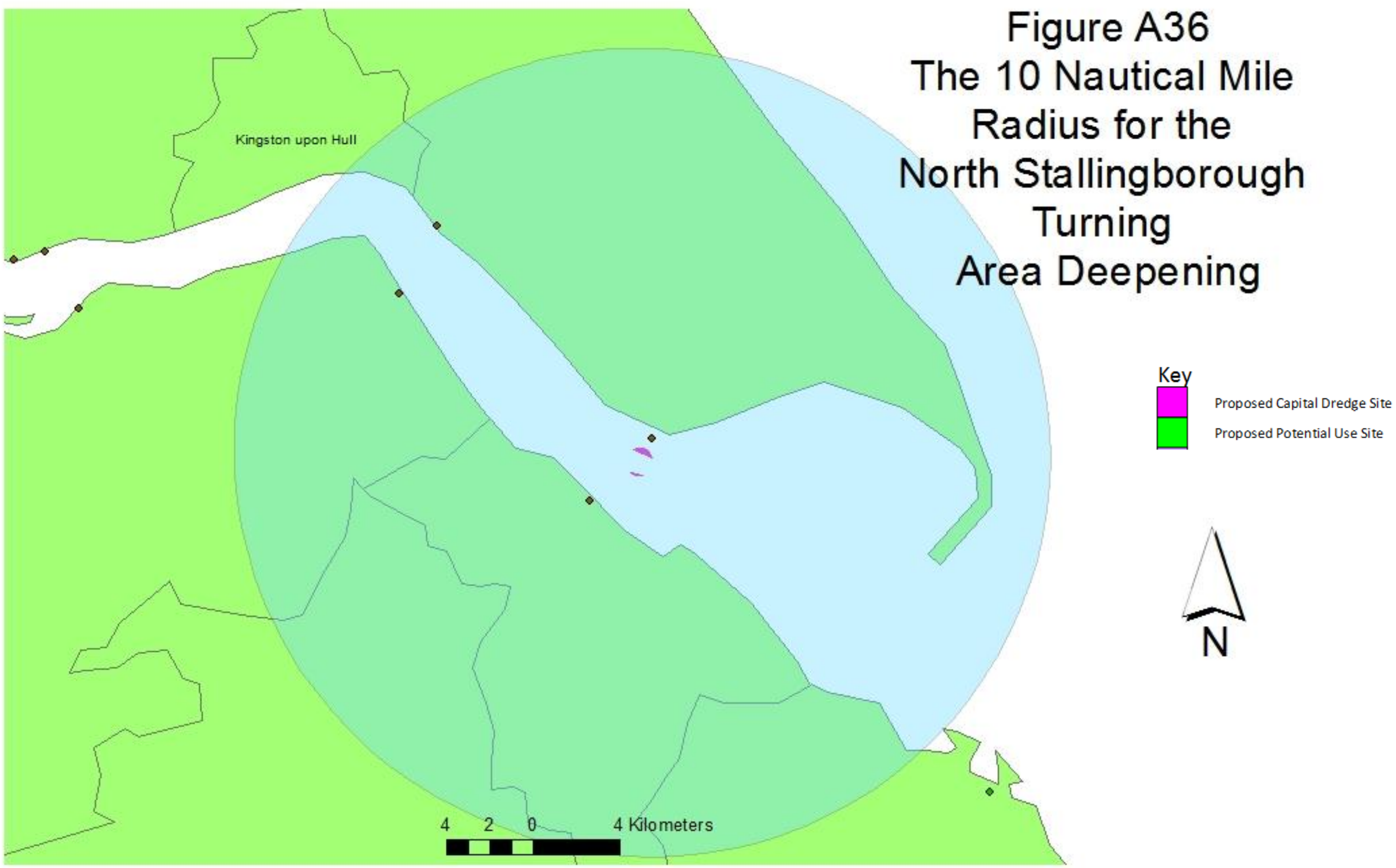
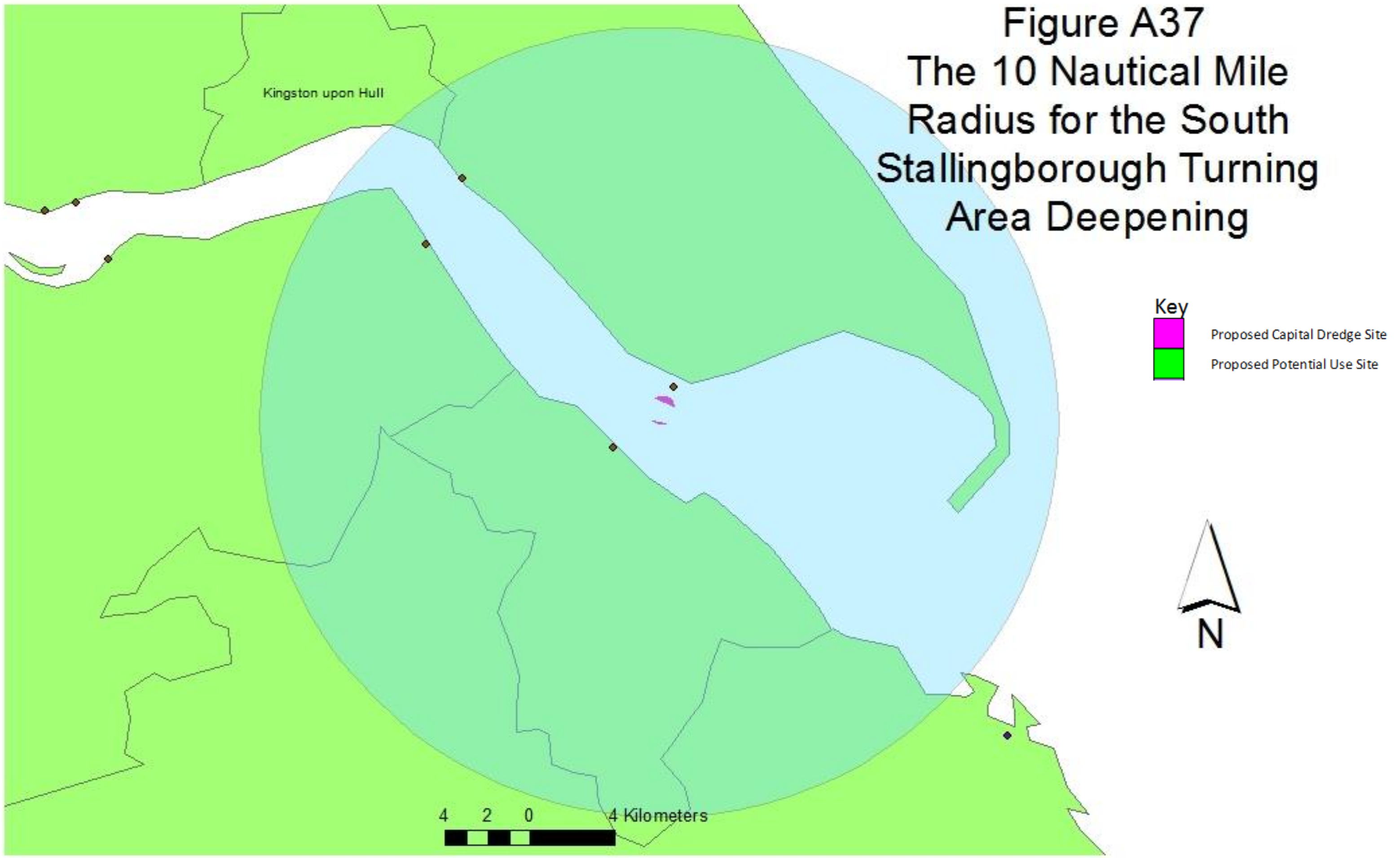


Figure A36
The 10 Nautical Mile
Radius for the
North Stallingborough
Turning
Area Deepening
Kingston upon Hull
Key
Proposed Capital Dredge Site
Proposed Potential Use Site
N
4 2 0 4 Kilometers

Figure A37
The 10 Nautical Mile Radius for the South Stallingborough Turning Area Deepening



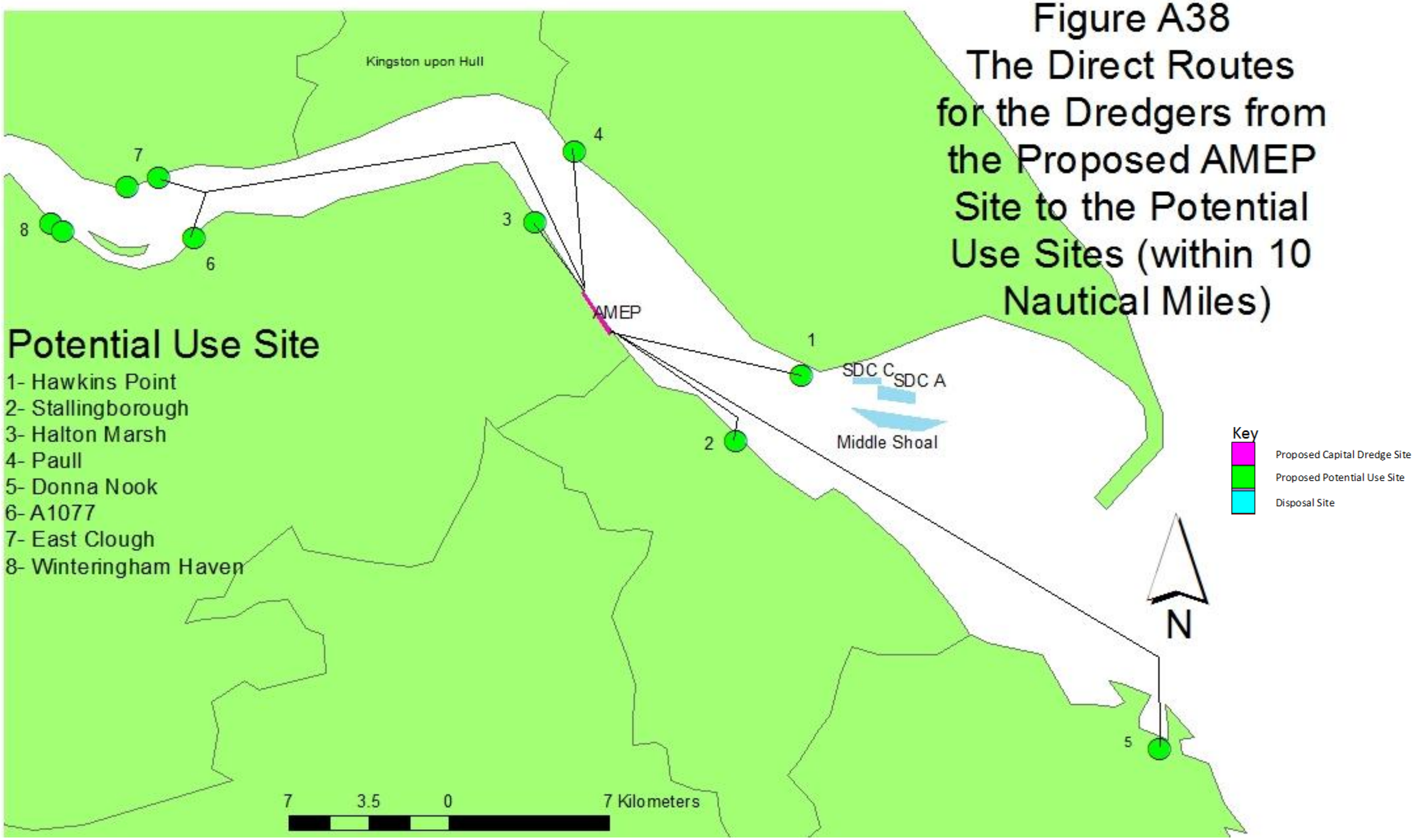


Figure A38 The Direct Routes for the Dredgers from the Proposed AMEP Site to the Potential Use Sites (within 10 Nautical Miles)

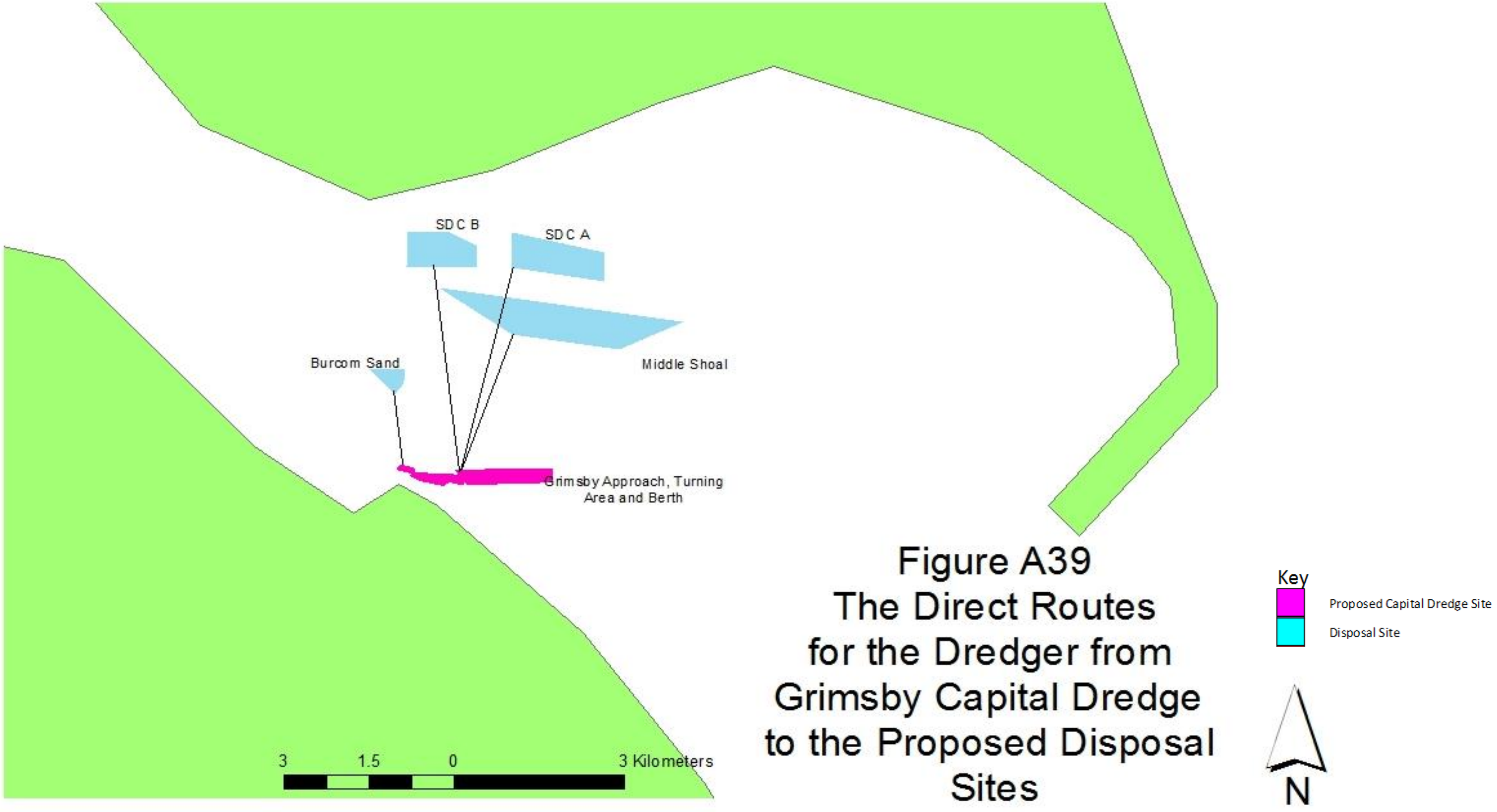


Figure A39
The Direct Routes for the Dredger from Grimsby Capital Dredge to the Proposed Disposal Sites

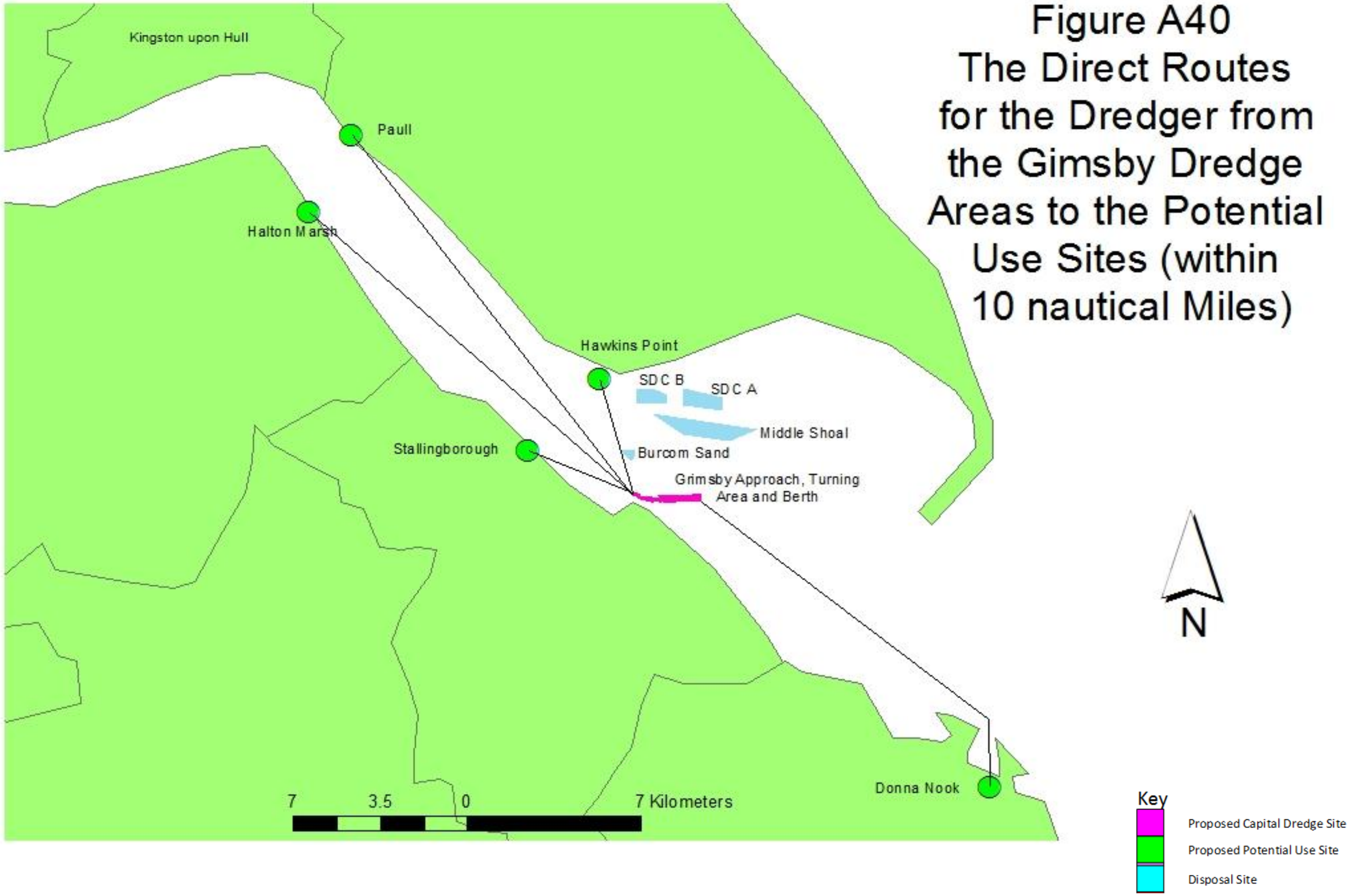


Figure A40
The Direct Routes for the Dredger from the Gimsby Dredge Areas to the Potential Use Sites (within 10 nautical Miles)

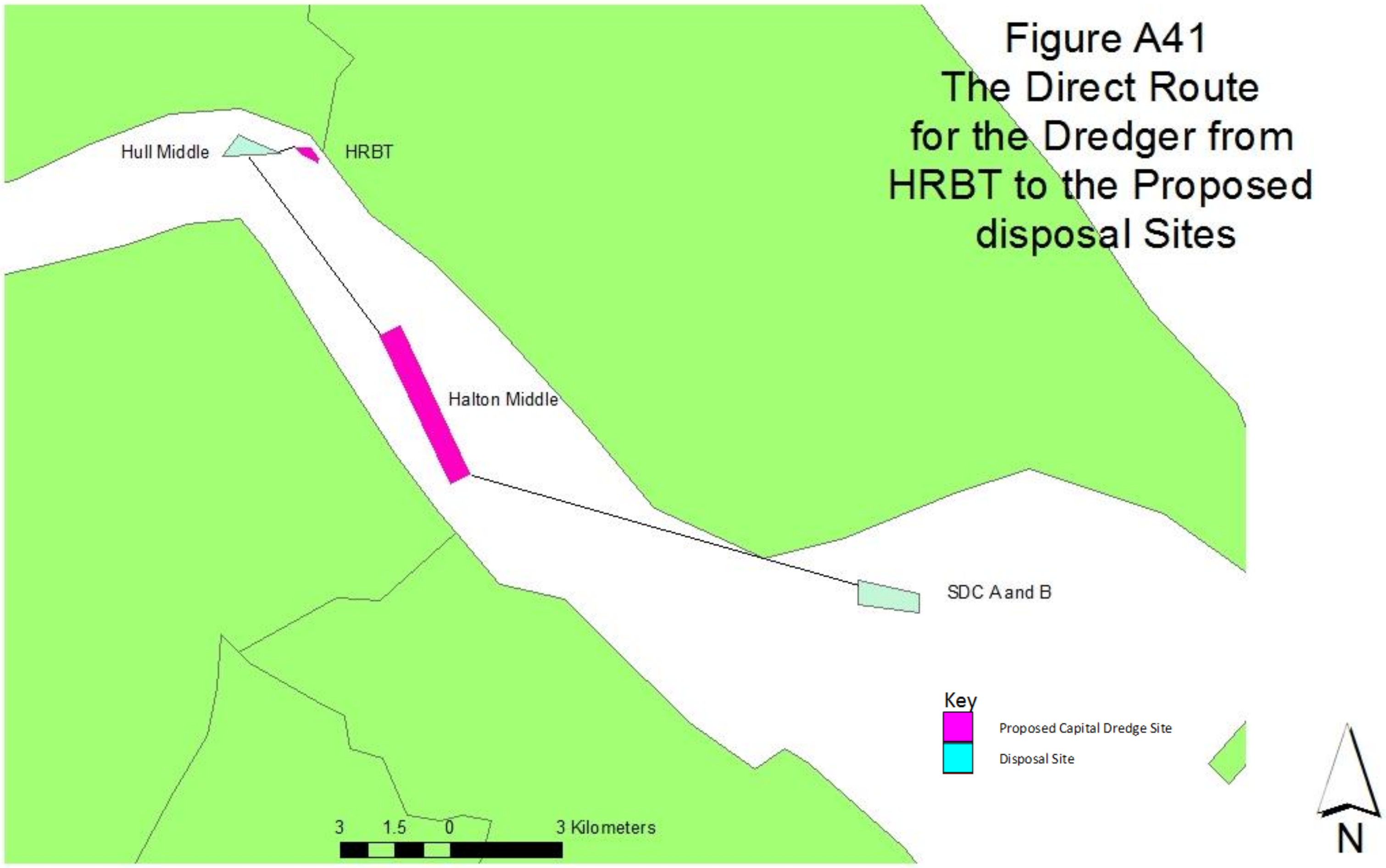


Figure A41
The Direct Route
for the Dredger from
HRBT to the Proposed
disposal Sites
Hull Middle
HRBT
Halton Middle
SDC A and B
Key
Proposed Capital Dredge Site
Disposal Site
3 1.5 0 3 Kilometers
N

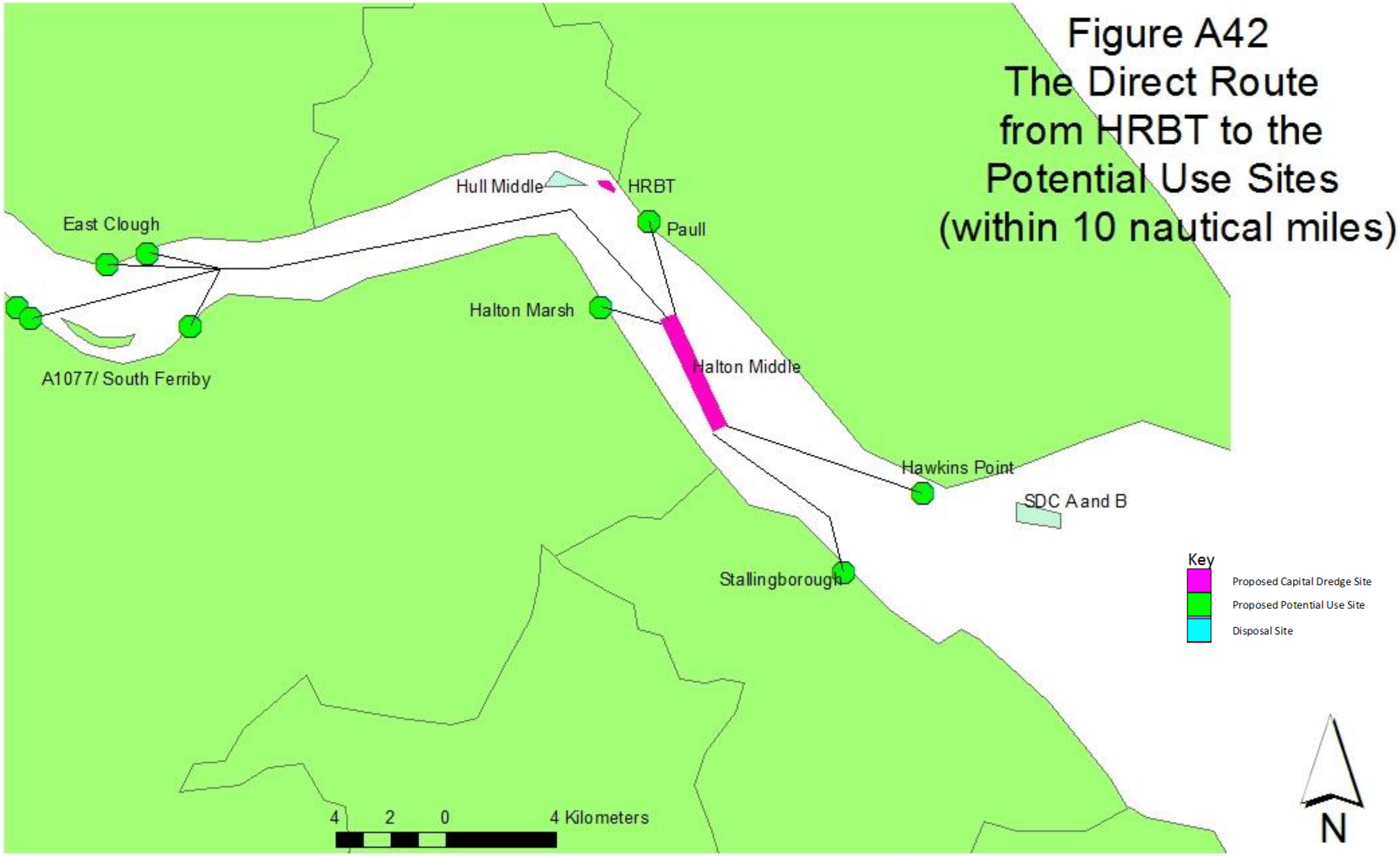


Figure A42
The Direct Route
from HRBT to the
Potential Use Sites
(within 10 nautical miles)
Hull Middle
HRBT
Paull
East Clough
Halton Marsh
Halton Middle
A1077/ South Ferriby
Hawkins Point
SDC A and B
Stallingborough
Key
Proposed Capital Dredge Site
Proposed Potential Use Site
Disposal Site
4
2
0
4 Kilometers
N

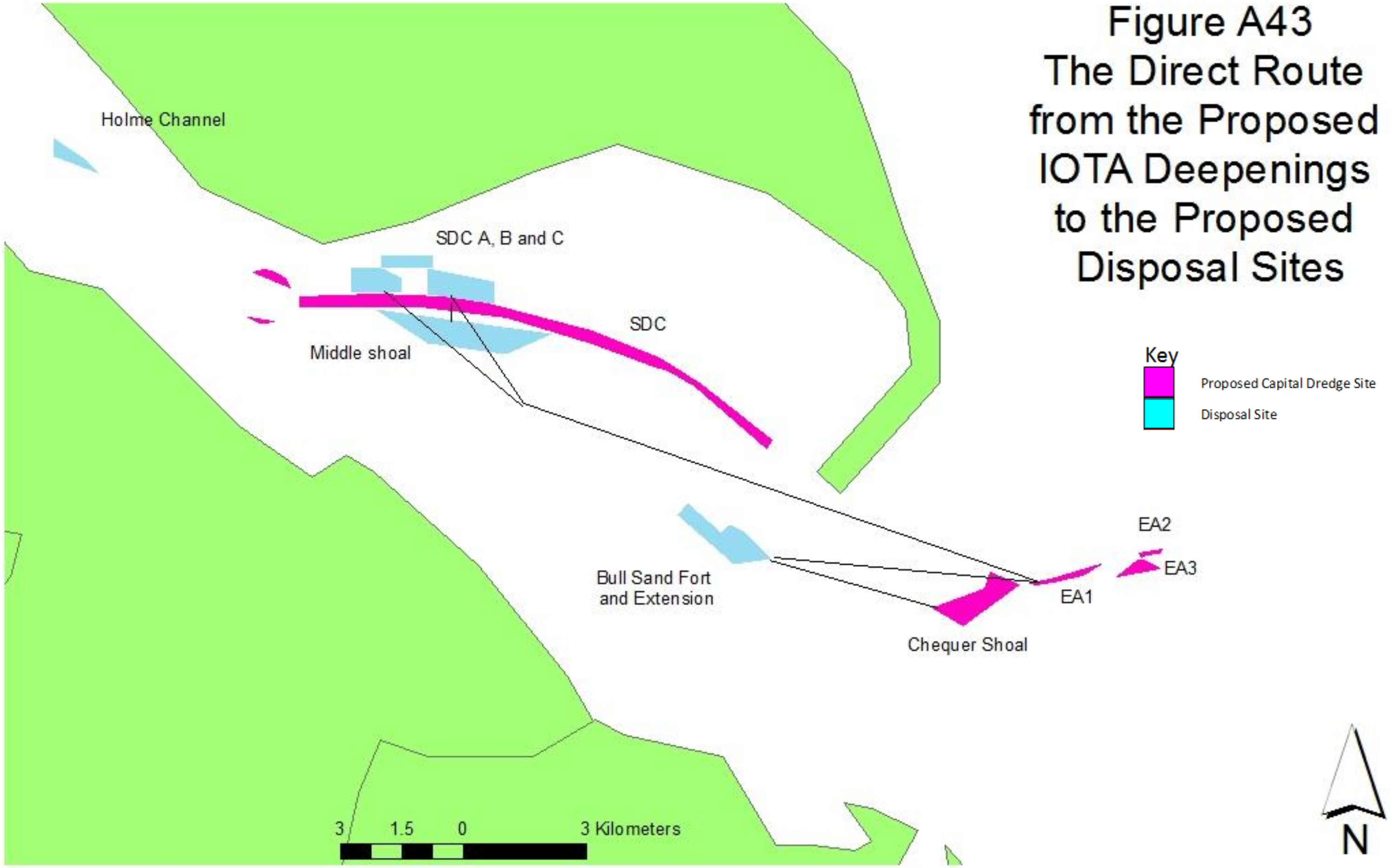


Figure A43
The Direct Route
from the Proposed
IOTA Deepenings
to the Proposed
Disposal Sites

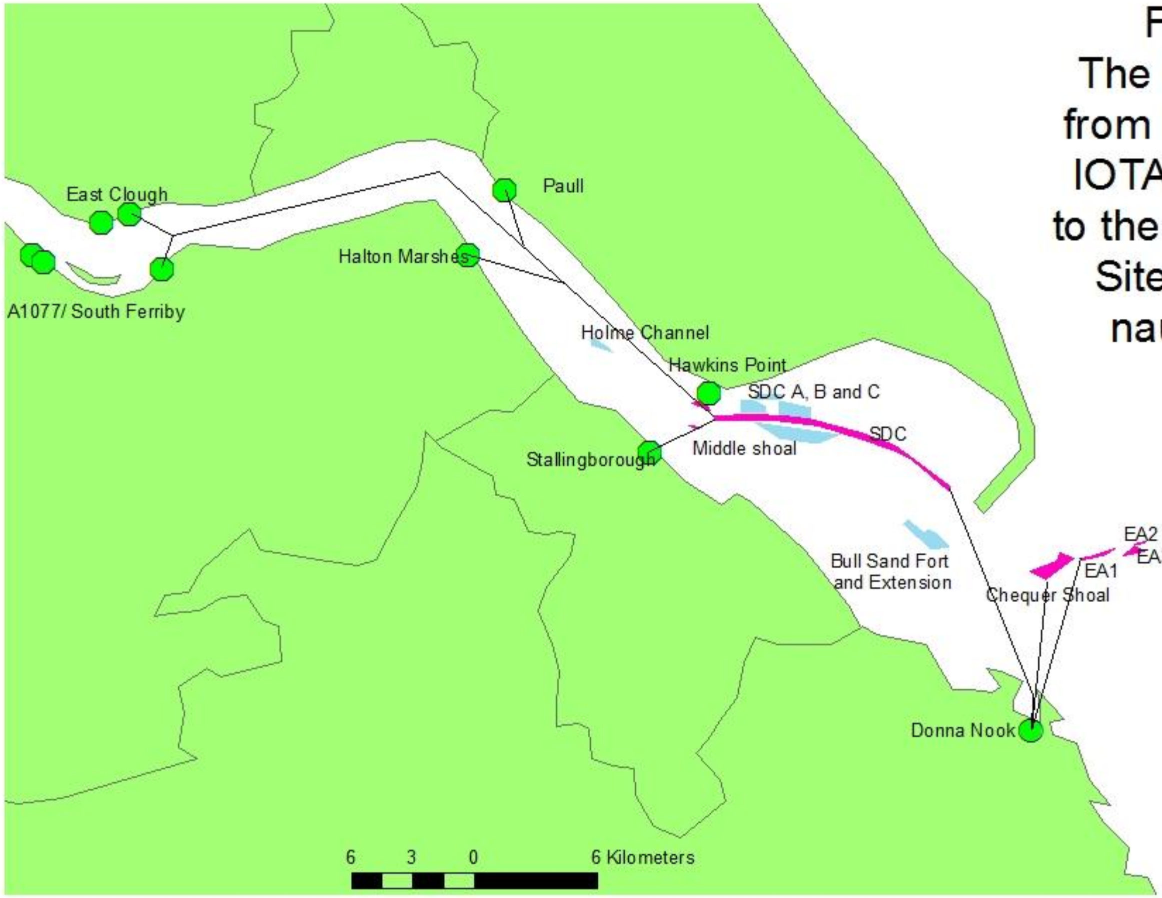


Figure A44
The Direct Route
from the Proposed
IOTA Deepenings
to the Potential Use
Sites (within 10
nautical miles)

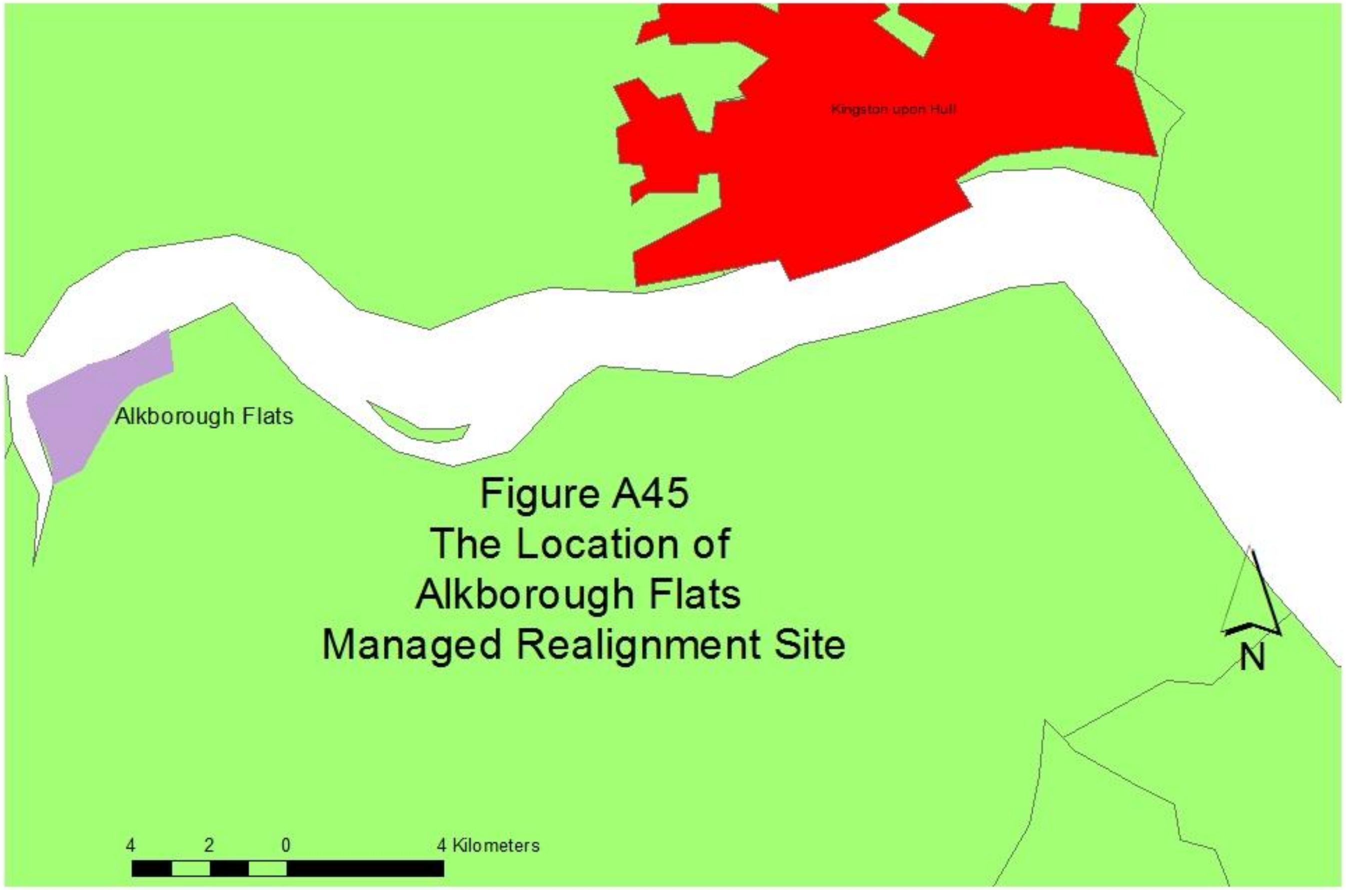


Figure A45
The Location of
Alkborough Flats
Managed Realignment Site

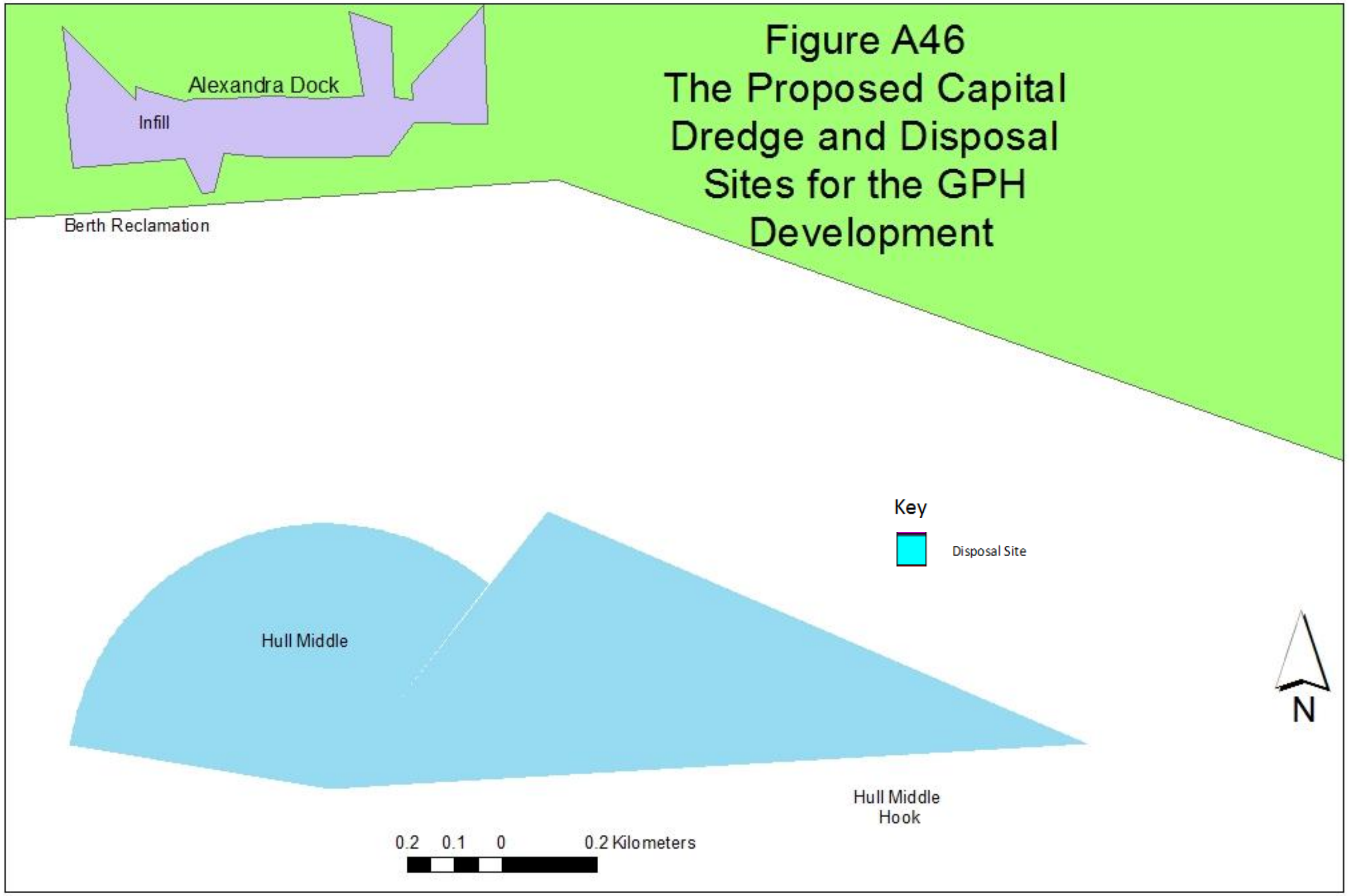


Figure A46
The Proposed Capital
Dredge and Disposal
Sites for the GPH
Development
Alexandra Dock
Infill
Berth Reclamation
Key
Disposal Site
Hull Middle
Hull Middle
Hook
N
0.2 0.1 0 0.2 Kilometers

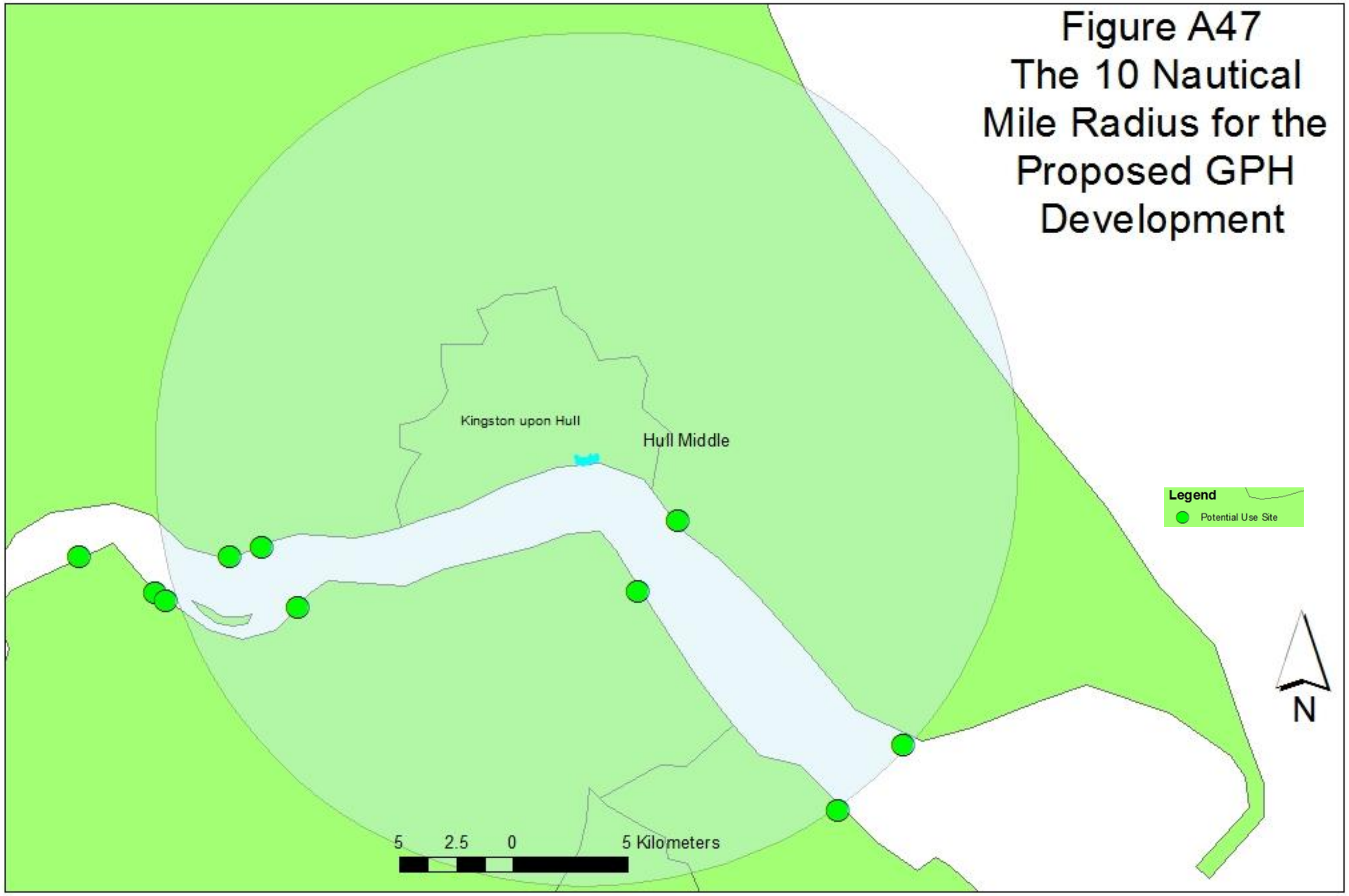


Figure A47
The 10 Nautical Mile Radius for the Proposed GPH Development
Kingston upon Hull
Hull Middle
Legend
Potential Use Site
N
5 2.5 0 5 Kilometers

Key

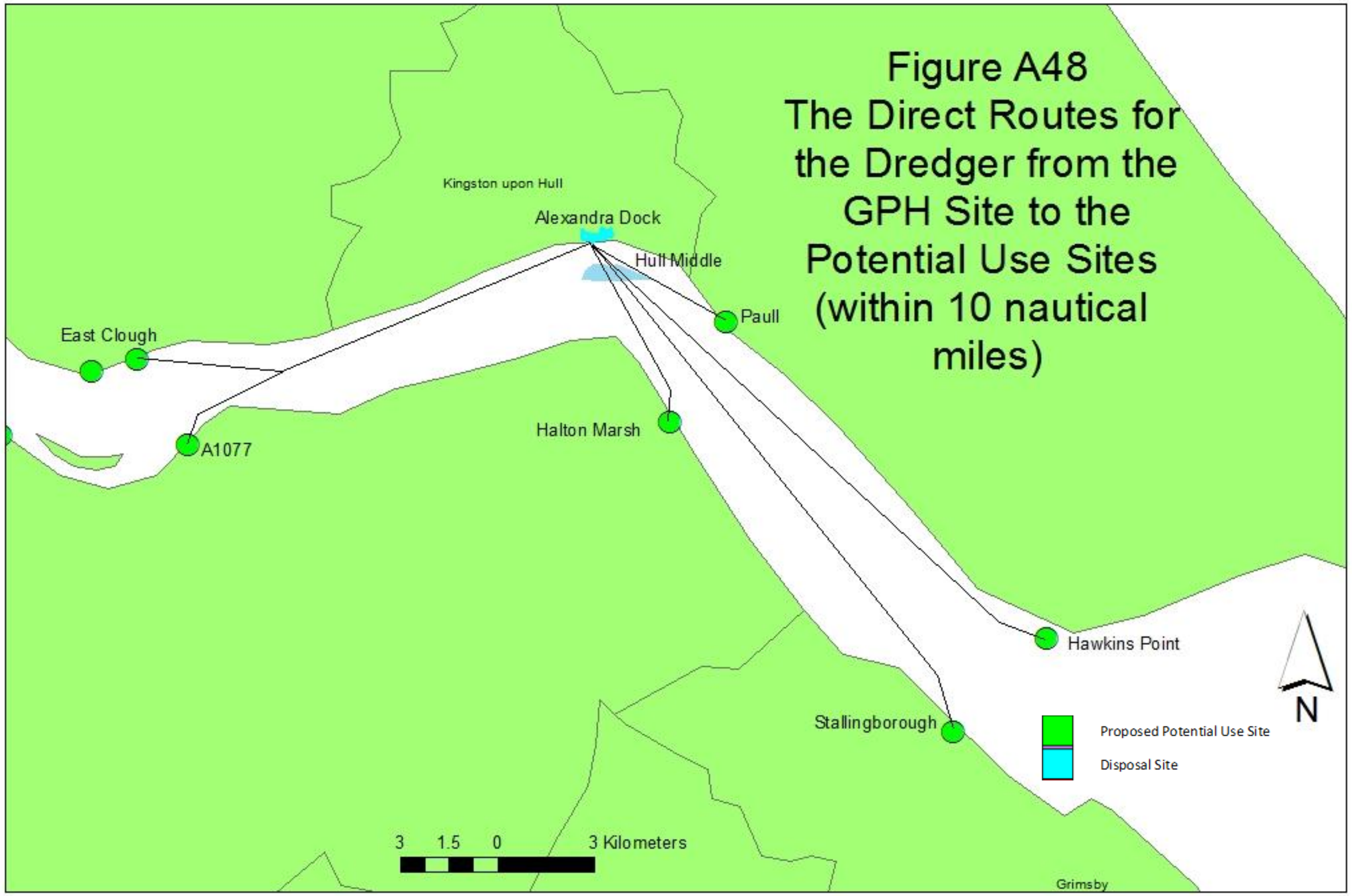


Figure A48
The Direct Routes for the Dredger from the GPH Site to the Potential Use Sites (within 10 nautical miles)
Kingston upon Hull
Alexandra Dock
Hull Middle
Paull
East Clough
A1077
Halton Marsh
Hawkins Point
Stallingborough
Proposed Potential Use Site
Disposal Site
N
3 1.5 0 3 Kilometers
Grimsby

Appendix B Coordinates for Dredge Sites

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Appendix B Coordinates for Dredge Sites

Name	X	Y	Project
Halton Middle and future maintenance dredge at Whitebooth Road	516940	422639	HRBT
	517494	422880	HRBT
	519337	418867	HRBT
	518831	418602	HRBT
HRBT Potential Area	515220	427301	HRBT
	515196	427314	HRBT
	514781	427545	HRBT
	514642	427698	HRBT
	515051	427700	HRBT
	515287	427383	HRBT
	515234	427318	HRBT
Stallingborough Emergency Turning Area North	526511	415523	IOTA
	525623	415892	IOTA
	525883	415957	IOTA
	526153	415905	IOTA
	526407	415716	IOTA
	526511	415523	IOTA
Stallingborough Emergency Turning Area South	526106	414690	IOTA
	525489	414803	IOTA
	525601	414729	IOTA
	525754	414673	IOTA
	525932	414657	IOTA
	526106	414690	IOTA
SDC/ Hawke Channel	526746	415290	IOTA
	526738	415051	IOTA
	529692	415071	IOTA
	531781	414808	IOTA
	533839	414168	IOTA
	535382	413613	IOTA
	538113	411601	IOTA
	538225	411794	IOTA
	536513	413160	IOTA
	536355	413124	IOTA
	535703	413501	IOTA
	535505	413786	IOTA
	533853	414468	IOTA
	531317	415111	IOTA
	530191	415289	IOTA
	528619	415355	IOTA
	526746	415209	IOTA

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Chequer Shoal	542886	407296	IOTA
	542152	407731	IOTA
	543425	408175	IOTA
	543566	408581	IOTA
	544250	408291	IOTA
	542886	407296	IOTA
Eastern Approaches 1	544512	408324	IOTA
	546233	408797	IOTA
	545801	408523	IOTA
	545088	408345	IOTA
	545005	408411	IOTA
	544677	408287	IOTA
	544512	408324	IOTA
Eastern Approaches 2	547668	408673	IOTA
	546627	408486	IOTA
	547128	408867	IOTA
	547269	408872	IOTA
	547668	408673	IOTA
Eastern Approaches 3	547170	409042	IOTA
	547746	409154	IOTA
	547659	409062	IOTA
	547336	409008	IOTA
	547232	408938	IOTA
	547170	409042	IOTA

Grimsby Berth Pocket	527840	411731	Grimsby Ro/Ro
Grimsby Berth Pocket	527848	411706	Grimsby Ro/Ro
	527867	411694	Grimsby Ro/Ro
	528077	411644	Grimsby Ro/Ro
	528104	411646	Grimsby Ro/Ro
	528121	411668	Grimsby Ro/Ro
	528130	411707	Grimsby Ro/Ro
	528128	411730	Grimsby Ro/Ro
	528104	411749	Grimsby Ro/Ro
	527894	411799	Grimsby Ro/Ro
	527869	411798	Grimsby Ro/Ro
	527850	411775	Grimsby Ro/Ro

Grimsby Turning Area	529049	411614	Grimsby Ro/Ro
Grimsby Turning Area	528228	411518	Grimsby Ro/Ro
	528647	411434	Grimsby Ro/Ro
	528995	411438	Grimsby Ro/Ro
	528952	411454	Grimsby Ro/Ro
	528749	411497	Grimsby Ro/Ro
	528149	411661	Grimsby Ro/Ro

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	528049	411613	Grimsby Ro/Ro

Grimsby Approach Channel	528865	411699	Grimsby Ro/Ro
Grimsby Approach Channel	529058	411445	Grimsby Ro/Ro
	530159	411474	Grimsby Ro/Ro
	530557	411487	Grimsby Ro/Ro
	530555	411732	Grimsby Ro/Ro
	529877	411725	Grimsby Ro/Ro
	528867	411697	Grimsby Ro/Ro

Port of Hull- Albert Entrance	509608	427991	Maintenance
Port of Hull- Albert Dock	509608	427991	Maintenance
Port of Hull- Queen Elizabeth Dock	513969	428518	Maintenance
Port of Hull-King George Dock	513969	428518	Maintenance
Port of Hull- King George Entrance	513969	428518	Maintenance
Port of Hull- Saltend	515625	427060	Maintenance
Port of Hull- Alexandra Dock	512386	428716	Maintenance
Port of Goole- Ocean Lock	474855	422944	Maintenance
Port of Goole- Victoria Dock	474923	423420	Maintenance
Port of Grimsby- Alexandra Dock	527828	411360	Maintenance
Port of Grimsby- Royal Basin	527828	411360	Maintenance
Port of Grimsby- Royal Dock	527828	411360	Maintenance
Port of Grimsby- Marina	528152	411318	Maintenance
Port of Immingham- Bellmouth	519927	416436	Maintenance
Port of Immingham- Dock	519927	416436	Maintenance
Port of Immingham- Gas Terminal	518708	418048	Maintenance
Port of Immingham- West Jetty	519699	416815	Maintenance
Humber International Sea Terminal- East	519085	417516	Maintenance
Humber International Sea Terminal- West	518812	417889	Maintenance
Port of Immingham- Bulk Terminal- East	519471	417090	Maintenance
Port of Immingham- Bulk Terminal- West	519132	417455	Maintenance
Port of Immingham- Outer Harbour	519283	417088	Maintenance
South Killingholme Jetty	518447	418387	Maintenance
Port of Grimsby- No. 1 Dock	528143	411298	Maintenance
AMEP eastern side	518045	418130	Capital
AMEP western side	516882	419919	Capital

Sources

ABP Humber, Humber Estuary Services, (*in prep. a*), Humber Estuary: Maintenance Dredge Protocol and Water Framework Directive Compliance Baseline Document.

ABPmer, (2011), Addendum to Immingham Oil Terminal Approaches Environmental Statement - Investigation into Beneficial Use, Report R.1809.

ABPmer, Scott Wilson, (2010*b*), Hull Riverside Bulk Terminal Environmental Statement, Report Number C122173.

ABPmer, (2009*a*), Grimsby Ro-Ro Berth: Environmental Statement, Report Number R.1506

ABPmer, (2009*b*), Immingham Oil Terminal Approach Channel Dredging Environmental Statement, Report Number R.1416.

ABPmer *pers. Comm.*

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Environmental Resource Management, (2011), Able UK Marine Energy Park Preliminary Environmental Report (PEIR).

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Appendix C Coordinates for Disposal Sites

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The Interreg IVB North Sea Region Programme

Appendix C Coordinates for Disposal Sites

Name	Code	X	Y	Project
Whitgift Bight (River Ouse)	HU040	481530	422978	Maintenance for the Port of Goole
	HU040	481378	422888	
	HU040	481051	422759	
	HU040	481049	422767	
	HU040	481051	422759	
	HU040	480433	422858	
	HU040	480433	422869	
	HU040	480432	422896	
	HU040	480432	422923	
	HU040	480433	422951	
	HU040	480434	422978	
	HU040	480435	423005	
	HU040	480437	423032	
	HU040	480440	423059	
	HU040	480442	423086	
	HU040	480678	423023	
	HU040	481091	423127	
	HU040	481114	423143	
	HU040	481136	423154	
	HU040	481232	423207	
	HU040	481452	423344	
	HU040	481457	423346	
	HU040	481465	423322	
	HU040	481473	423297	
	HU040	481480	423273	
	HU040	481487	423247	
	HU040	481493	423222	
	HU040	481499	423196	
	HU040	481504	423170	
	HU040	481509	423144	
	HU040	481514	423118	
	HU040	481518	423091	
	HU040	481522	423064	
	HU040	481525	423037	
	HU040	481527	423010	
Goole Reach	HU041	475335	421896	Maintenance for the Port of Goole
	HU041	475337	421917	
	HU041	475341	421944	
	HU041	475345	421970	
	HU041	475349	421996	
	HU041	475354	422022	
	HU041	475359	422048	
	HU041	475365	422074	
	HU041	475371	422099	

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	HU041	475377	422124	
	HU041	475382	422139	
	HU041	475503	421955	
	HU041	475739	421767	
	HU041	476016	421805	
	HU041	476351	422125	
	HU041	476365	422139	
	HU041	476369	422127	
	HU041	476376	422102	
	HU041	476382	422077	
	HU041	476389	422052	
	HU041	476394	422026	
	HU041	476400	422000	
	HU041	476405	421974	
	HU041	476409	421948	
	HU041	476413	421921	
	HU041	476414	421917	
	HU041	476266	421770	
	HU041	476060	421605	
	HU041	475788	421548	
	HU041	475370	421870	
Hull Middle/Humber 4	HU030	512655	427460	Maintenance from The Port of Hull namely Alexandra Dock, King George Dock and Albert Dock
	HU030	512105	427552	
	HU030	512106	427560	
	HU030	512107	427567	
	HU030	512108	427574	
	HU030	512110	427582	
	HU030	512111	427589	
	HU030	512113	427596	
	HU030	512115	427603	
	HU030	512116	427611	
	HU030	512118	427618	
	HU030	512120	427625	
	HU030	512122	427632	
	HU030	512125	427639	
	HU030	512127	427646	
	HU030	512129	427653	
	HU030	512132	427660	
	HU030	512134	427667	
	HU030	512137	427674	
	HU030	512140	427681	
	HU030	512143	427688	
	HU030	512146	427695	
	HU030	512149	427702	
	HU030	512152	427709	
	HU030	512155	427715	
	HU030	512158	427722	

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	HU030	512162	427729	
	HU030	512165	427735	
	HU030	512169	427742	
	HU030	512173	427748	
	HU030	512176	427755	
	HU030	512180	427761	
	HU030	512184	427767	
	HU030	512188	427774	
	HU030	512192	427780	
	HU030	512197	427786	
	HU030	512201	427792	
	HU030	512205	427798	
	HU030	512210	427804	
	HU030	512214	427810	
	HU030	512219	427816	
	HU030	512224	427821	
	HU030	512228	427827	
	HU030	512233	427833	
	HU030	512238	427838	
	HU030	512243	427844	
	HU030	512248	427849	
	HU030	512254	427855	
	HU030	512259	427860	
	HU030	512264	427865	
	HU030	512269	427870	
	HU030	512275	427876	
	HU030	512280	427881	
	HU030	512286	427885	
	HU030	512292	427890	
	HU030	512297	427895	
	HU030	512303	427900	
	HU030	512309	427904	
	HU030	512315	427909	
	HU030	512321	427913	
	HU030	512327	427918	
	HU030	512333	427922	
	HU030	512339	427926	
	HU030	512345	427930	
	HU030	512352	427934	
	HU030	512358	427938	
	HU030	512364	427942	
	HU030	512371	427946	
	HU030	512377	427950	
	HU030	512384	427953	
	HU030	512390	427957	
	HU030	512397	427960	
	HU030	512404	427964	
	HU030	512410	427967	

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HU030	512417	427970
HU030	512424	427973
HU030	512431	427976
HU030	512438	427979
HU030	512445	427982
HU030	512452	427984
HU030	512458	427987
HU030	512466	427989
HU030	512473	427992
HU030	512480	427994
HU030	512487	427996
HU030	512494	427998
HU030	512501	428000
HU030	512508	428002
HU030	512516	428004
HU030	512523	428006
HU030	512530	428007
HU030	512537	428009
HU030	512545	428010
HU030	512552	428011
HU030	512559	428013
HU030	512567	428014
HU030	512574	428015
HU030	512582	428016
HU030	512589	428016
HU030	512596	428017
HU030	512604	428018
HU030	512611	428018
HU030	512619	428019
HU030	512626	428019
HU030	512634	428019
HU030	512641	428019
HU030	512649	428019
HU030	512656	428019
HU030	512663	428019
HU030	512671	428018
HU030	512678	428018
HU030	512686	428017
HU030	512693	428017
HU030	512701	428016
HU030	512708	428015
HU030	512715	428014
HU030	512723	428013
HU030	512730	428012
HU030	512737	428011
HU030	512745	428010
HU030	512752	428008
HU030	512759	428007

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	HU030	512767	428005	
	HU030	512774	428003	
	HU030	512781	428001	
	HU030	512788	427999	
	HU030	512795	427997	
	HU030	512803	427995	
	HU030	512810	427993	
	HU030	512817	427991	
	HU030	512824	427988	
	HU030	512831	427986	
	HU030	512838	427983	
	HU030	512845	427980	
	HU030	512852	427978	
	HU030	512859	427975	
	HU030	512865	427972	
	HU030	512872	427969	
	HU030	512879	427965	
	HU030	512886	427962	
	HU030	512892	427959	
	HU030	512899	427955	
	HU030	512905	427952	
	HU030	512912	427948	
	HU030	512918	427944	
	HU030	512925	427941	
	HU030	512931	427937	
	HU030	512937	427933	
	HU030	512944	427929	
	HU030	512950	427924	
	HU030	512956	427920	
	HU030	512962	427916	
	HU030	512968	427911	
	HU030	512974	427907	
	HU030	512980	427902	
	HU030	512986	427898	
	HU030	512991	427893	
	HU030	512680	427492	
Hull Middle / Humber 4B/ Hook	HU020	512655	427460	Maintenance from Port of Hull, namely Alexandra Dock, King George Dock and Albert Dock. Capital from HRBT,
	HU020	512693	427509	
	HU020	513114	428046	
	HU020	513209	428005	
	HU020	514259	427554	
	HU020	512781	427467	
Clay Huts /Humber 3A	HU060	520316	417765	Maintenance dredge from North Killingholme and Immingham docks and Immingham Bulk Terminal
	HU060	520271	417807	
	HU060	519911	418151	
	HU060	519911	418151	

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HU060	519913	418154
HU060	519915	418156
HU060	519918	418158
HU060	519920	418161
HU060	519922	418163
HU060	519924	418166
HU060	519927	418168
HU060	519929	418170
HU060	519931	418173
HU060	519934	418175
HU060	519936	418177
HU060	519938	418179
HU060	519941	418182
HU060	519943	418184
HU060	519946	418186
HU060	519948	418188
HU060	519951	418191
HU060	519953	418193
HU060	519955	418195
HU060	519958	418197
HU060	519960	418199
HU060	519963	418201
HU060	519965	418204
HU060	519968	418206
HU060	519971	418208
HU060	519973	418210
HU060	519976	418212
HU060	519978	418214
HU060	519981	418216
HU060	519983	418218
HU060	519986	418220
HU060	519989	418222
HU060	519991	418224
HU060	519994	418226
HU060	519997	418228
HU060	519999	418230
HU060	520002	418232
HU060	520005	418233
HU060	520007	418235
HU060	520010	418237
HU060	520013	418239
HU060	520016	418241
HU060	520018	418243
HU060	520021	418244
HU060	520024	418246
HU060	520027	418248
HU060	520030	418250
HU060	520032	418251

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	HU060	520035	418253	
	HU060	520038	418255	
	HU060	520041	418256	
	HU060	520044	418258	
	HU060	520047	418260	
	HU060	520049	418261	
	HU060	520052	418263	
	HU060	520055	418264	
	HU060	520058	418266	
	HU060	520061	418267	
	HU060	520064	418269	
	HU060	520067	418270	
	HU060	520070	418272	
	HU060	520073	418273	
	HU060	520076	418275	
	HU060	520079	418276	
	HU060	520082	418278	
	HU060	520085	418279	
	HU060	520088	418280	
	HU060	520091	418282	
	HU060	520094	418283	
	HU060	520097	418284	
	HU060	520100	418286	
	HU060	520103	418287	
	HU060	520106	418288	
	HU060	520109	418290	
	HU060	520112	418291	
	HU060	520115	418292	
	HU060	520118	418293	
	HU060	520121	418294	
	HU060	520124	418295	
	HU060	520127	418297	
	HU060	520130	418298	
	HU060	520133	418299	
	HU060	520137	418300	
	HU060	520140	418301	
	HU060	520143	418302	
	HU060	520146	418303	
	HU060	520149	418304	
	HU060	520152	418305	
	HU060	520155	418306	
	HU060	520159	418307	
	HU060	520162	418308	
	HU060	520165	418309	
	HU060	520168	418310	
	HU060	520171	418310	
	HU060	520174	418311	
	HU060	520178	418312	

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HU060	520181	418313
HU060	520184	418314
HU060	520187	418314
HU060	520190	418315
HU060	520194	418316
HU060	520197	418317
HU060	520200	418317
HU060	520203	418318
HU060	520206	418319
HU060	520210	418319
HU060	520213	418320
HU060	520216	418320
HU060	520219	418321
HU060	520223	418322
HU060	520225	418322
HU060	520226	418322
HU060	520229	418323
HU060	520232	418323
HU060	520236	418324
HU060	520239	418324
HU060	520242	418324
HU060	520245	418325
HU060	520249	418325
HU060	520252	418326
HU060	520255	418326
HU060	520259	418326
HU060	520262	418327
HU060	520265	418327
HU060	520268	418327
HU060	520272	418327
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HU060	520278	418328
HU060	520282	418328
HU060	520285	418328
HU060	520288	418328
HU060	520291	418329
HU060	520295	418329
HU060	520298	418329
HU060	520301	418329
HU060	520305	418329
HU060	520308	418329
HU060	520311	418329
HU060	520314	418329
HU060	520318	418329
HU060	520321	418329
HU060	520324	418329
HU060	520328	418329
HU060	520331	418329

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HU060	520334	418328
HU060	520337	418328
HU060	520341	418328
HU060	520344	418328
HU060	520347	418328
HU060	520351	418327
HU060	520354	418327
HU060	520357	418327
HU060	520360	418327
HU060	520364	418326
HU060	520367	418326
HU060	520370	418326
HU060	520374	418325
HU060	520377	418325
HU060	520380	418324
HU060	520383	418324
HU060	520387	418324
HU060	520390	418323
HU060	520393	418323
HU060	520396	418322
HU060	520400	418322
HU060	520403	418321
HU060	520406	418320
HU060	520409	418320
HU060	520413	418319
HU060	520416	418319
HU060	520419	418318
HU060	520422	418317
HU060	520425	418317
HU060	520429	418316
HU060	520432	418315
HU060	520435	418314
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HU060	520441	418313
HU060	520445	418312
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HU060	520451	418310
HU060	520454	418310
HU060	520457	418309
HU060	520461	418308
HU060	520464	418307
HU060	520467	418306
HU060	520470	418305
HU060	520473	418304
HU060	520476	418303
HU060	520479	418302
HU060	520483	418301
HU060	520486	418300

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HU060	520489	418299
HU060	520492	418298
HU060	520495	418297
HU060	520498	418295
HU060	520501	418294
HU060	520504	418293
HU060	520507	418292
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HU060	520513	418290
HU060	520516	418288
HU060	520520	418287
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HU060	520526	418284
HU060	520529	418283
HU060	520532	418282
HU060	520535	418280
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HU060	520541	418278
HU060	520544	418276
HU060	520547	418275
HU060	520549	418273
HU060	520552	418272
HU060	520555	418270
HU060	520558	418269
HU060	520561	418267
HU060	520564	418266
HU060	520567	418264
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HU060	520601	418244
HU060	520604	418243
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HU060	520609	418239
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HU060	520615	418235
HU060	520618	418233
HU060	520620	418232
HU060	520623	418230
HU060	520626	418228

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	HU060	520628	418226	
	HU060	520631	418224	
	HU060	520634	418222	
	HU060	520636	418220	
	HU060	520639	418218	
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	HU060	520657	418204	
	HU060	520659	418201	
	HU060	520662	418199	
	HU060	520664	418197	
	HU060	520667	418195	
	HU060	520669	418193	
	HU060	520672	418191	
	HU060	520674	418188	
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	HU060	520679	418184	
	HU060	520681	418182	
	HU060	520684	418179	
	HU060	520685	418179	
	HU060	520686	418177	
	HU060	520689	418175	
	HU060	520691	418173	
	HU060	520693	418171	
	HU060	520656	418131	
	HU060	520363	417815	
	HU060	520367	417809	
	HU060	520319	417762	
Humber 4b/Hook Extension	HU021	514273	427555	
	HU021	514186	427468	
	HU021	513911	427117	
	HU021	512668	427456	
	HU021	514006	427539	
	HU021	514253	427553	

Middle Shoal/ Humber 1A	HU080	528571	415006	Maintenance from Immingham Docks and waterfront berths and SDC

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	HU080	532891	414384	Capital from IOTA-Stallingborough Emergency Turning Area,
	HU080	531746	413888	
	HU080	529863	414151	

SDC B		527998	415380	Capital from HRBT. Capital from IOTA Eastern Approaches
		528003	416011	
		528754	415995	
		529246	415748	
		529245	415377	

SDC C		528745	416291	Capital from IOTA SDC
		530003	416289	
		529999	416010	
		528754	415995	

SDC A		529867	416007	Capital from HRBT, Capital from IOTA Eastern Approaches
		531499	415644	
		531502	415124	
		529863	415357	

Holme Channel Deep		520718	419167	Capital from IOTA-Stallingborough Emergency Turning Area, SDC
		521898	418298	
		520752	418706	
		521433	418706	

Bull Sand Fort		535931	409992	Capital from IOTA- Hawke Channel and Eastern Approaches
		536177	410276	
		537571	409052	
		537325	408767	

Bull Sand Fort Extension		537001	409560	Capital from IOTA- Chequer Shoal and Eastern Approaches
		537193	409758	
		538220	408900	
		537325	408767	
		537571	409571	

Burcom Sand		527358	413522	Maintenance from Grimsby Docks and Immingham Docks and Waterfront berths
		527976	413528	
		527968	413400	
		527921	413254	
		527838	413124	
		527784	413073	

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Appendix C2 Co-ordinates of the Areas Under Threat from Erosion on the Humber Estuary and River Ouse

Area under threat of erosion	Easting	Northing
Swinefleet	477052	422339
Saltmarshe	478871	424066
Reedness	479874	423076
Whitgift Bank	483782	423857
Whitton Nest	490239	424655
Winteringham Haven	493580	423092
A1077/ South Ferriby-Western Point	494097	422720
A1077/ South Ferriby-Eastern Point	499864	422429
East Clough- Western Point	496887	424669
East Clough- Eastern Point	498312	425066
Paull	516555	426230
Halton Marshes	514807	423121
Stallingborough	523622	413502
Hawkins Point	526499	416390

Sources

ABP Humber, Humber Estuary Services, (*in prep. a*), Humber Estuary: Maintenance Dredge Protocol and Water Framework Directive Compliance Baseline Document.

ABPmer, (2011), Addendum to Immingham Oil Terminal Approaches Environmental Statement - Investigation into Beneficial Use, Report R.1809.

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ABPmer, (2009*a*), Grimsby Ro-Ro Berth: Environmental Statement, Report Number R.1506

ABPmer, (2009*b*), Immingham Oil Terminal Approach Channel Dredging Environmental Statement, Report Number R.1416.

ABPmer *pers. Comm*

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Appendix D The Main Statistics of the Major and Minor Ports and Wharves within the Humber

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Table D1 Main Statistics of the Major and Minor Ports and Wharves within the Humber Estuary and Rivers Ouse and Trent

Port	Operator	Location	Dock/Quay	Maximum Size of Vessel				Commodities
				Length	Beam	Draught	DWT	
Goole	ABP	River Ouse	Any	100 m	24 m	6 m	4,500	Containers, dry bulk, forest products, liquid bulk, steel, rail traffic and project cargo
Grimsby	ABP	South Bank, Humber Estuary	Commercial Docks	145 m	20.5 m	5.8 m	6,000	Dry bulk, steel, minerals and ores, fresh fruit and perishables and Ro-Ro traffic.
			Fish Docks	73 m	12.8 m	5.8 m		
Hull	ABP	North Bank, Humber Estuary	Saltend Jetty No.1	214 m	40 m	10.4 m	40,000	Containers, dry bulk (aggregates, agriculture, cement, chemicals, coal and cocoa), forest products, liquid bulk, steel, fresh fruit and perishables, minerals and ore, Ro-Ro traffic and Passengers.
			Saltend Jetty No.3	214 m	40 m	10.4 m	40,000	
			King George & Queen Elizabeth Docks	199 m	25.5 m	10.4 m	34,000	
			River Terminal 1	215 m	32 m	6.5 m	12,000	
			Alexandra Dock	153 m	23.7 m	7.9 m	9,000	
			Alexandra Dock extension	122 m	19.7 m	7.9 m	6,000	
			Riverside Quay		30 m	4.5 m	4,500	
			Albert & Wm Wright Docks	122 m	22 m	7 m	5,000	
Immingham	ABP	South Bank Humber Estuary	Enclosed dock	198 m	26.2 m	10.36 m	38,000	Dry bulk, forest products, fresh fruit and perishables, general cargos, liquid bulk, Ro-Ro, minerals and ores and steel
			Humber International Terminal	289 m	45 m	12.8 - 14.2 m	200,000	
			Eastern and Western Jetties	213 m	No restriction	10.4 m	50,000	
			Immingham Oil Terminal	366 m	No restriction	13.1 m	290,000	
			Immingham Bulk Terminal	303 m	45 m	14 m	200,000	
			Immingham Gas Jetty	280 m	No restriction	11 m	50,000	
			Immingham Outer Harbour	240 m	35 m	11 m	18,500	
Killingholme- Humber Sea Terminal	Simon Groups Plc	South Bank Humber Estuary	Any	210 m	not specified	7 m	35,000	Majority Ro/Ro cargo
New Holland Bulk Services	New Holland Bulk Services Ltd.	South Bank Humber Estuary	Any	100 m	No restriction	7 m	5,000	Agribulk, biomass and industrial minerals
New Holland Dock Wharfingers Ltd	The Howarth Timber Group Ltd	South Bank Humber Estuary	Any	115 m	not specified	6.2 m	4,500	Timber and steel

Barrow Haven (Old ferry wharf timber terminal)	William Foster and Sons (Barrow Haven) Ltd	South Bank Humber Estuary	Any	95 m	not specified	5.3 m	3,000	Bulk, steel and coils, tiles and bricks, timber
Hessle Haven	Waverly Shipping	North Bank, Humber Estuary	Any	110 m	No restriction	4.5 m	not specified	Not specified
Flixborough	RMS Group	River Trent	Any	103 m	not specified	5.5 m	3,500	Paper, aluminium, steel, dry bulk and project cargos
Gunness	RMS Group	River Trent	Any	100 m	No restriction	5.5 m	4,500	Steel, timber and bulk including coal, fertiliser, minerals and ores.
Keadby	Associated Waterway services ltd	River Trent	Any	88 m	Not specified	5.2 m	3,000	Paper, steel, timber
Grove Wharf	J. Wharton	River Trent	Any	93 m	No restriction	5.3 m	3,500	Steel, timber and bulk including coal, fertiliser, minerals and ores.
Neap House	J. Wharton	River Trent	Any	90 m	not specified	5.2 m	3,500	Timber
Howdendyke	pd ports	River Ouse	Any	88 m	not specified	5.3 m	3,000	Steel, forest products and bulk cargo
Kings Ferry Wharf	Charles Willy Group	River Trent	Any	115 m	No restriction	5.2 m	3,500	Timber

Sources

Brett, S., (1992), A report on all non ABP port/wharf installations in the Rivers Hull, Humber, Ouse and Trent, Updated by Hutty, S., (1998), *Unpublished.*

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Website 4- www.newhollandbulkservices.co.uk (Accessed 28-7-2011).

Website 5- www.oldferrywharf.com (Accessed 28-7-2011).

Website 6- www.rms-humber.co.uk (Accessed 28-7-2011).

Website 7- www.pdports.co.uk (Accessed 28-7-2011).

Website 8- www.whartongrovewharf.co.uk (Accessed 28-7-2011).

Appendix E Action Levels for Contaminants

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Appendix E Action Levels for Contamination

	Action Level 1	**Action Level 2**
Contaminant / Compound	**mg/kg Dry Weight (ppm)**	**mg/kg Dry Weight (ppm)**
Arsenic	20	100
Mercury	0.3	3
Cadmium	0.4	5
Chromium	40	400
Copper	40	400
Nickel	20	200
Lead	50	500
Zinc	130	800
Orgotins; TBT DBT MBT	0.1	1
PCB's, sum of ICES 7	0.01	none
PCB's, sum of 25 congeners	0.02	0.2
*DDT	*0.001	
*Dieldrin	*0.005	

Source

Marine Management Organisation: Marine licensing guidance 3: Dredging, disposal and aggregate dredging, (2011*a*) (Available online at: marinemanagement.org.uk/licensing/documents/guidance/03.pdf [Accessed 25/10/11]).

Appendix F Dredgers

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Appendix F Different Types of Dredgers

Dredging

Dredging is the removal of any material (suspended or not) from the sea or seabed and transferring to another location (Marine Management Organisation, 2011*a*). There are two main dredging activities, capital dredging for creating a greater depth than previous; and maintenance dredging which is used to keep waterways open for navigation to ensure vessels do not run aground (Gupta *et al.*, 2005).

Where maintenance dredging is considered to have a potential affect the integrity of *Natura 2000* sites these should be considered as a "plan or project" and assessed in accordance with the EC Habitats Directive (ABP Humber (*in prep.a*)).

Methods and Types of Dredging.

There are two main methods of dredging mechanical and hydraulic dredgers. Mechanical dredgers are used for excavation by dislodging the material and rising to the surface using scoops or buckets. This material will then transported as large pieces. Hydraulic dredgers suck/ absorb from the bottom and use hydraulic centrifugal pumps to provide the dislodging and lifting force and remove material in a slurry form.

UK dredging (UKD) is a fleet owned by ABP that carries out the capital and maintenance dredges for ABP. UKD have a fleet of seven summarised in table F2.

The types of dredgers include (images of which follow below in figures F1 to F7):

- Grab
- Backhoe
- Ladder bucket

} Mechanical dredgers

- Cutter Suction (CSD)
- Trailing Suction

} Hydraulic dredgers

- Stationary Suction
- Water jet
- Offshore Rainbow

Below are descriptions of the different types of dredgers:

- **Grab** dredgers are dredgers that have a large bucket that opens and closes that allows sediment to be "grabbed".
- **Backhoe** dredgers have a large bucket attached to an arm to the dredger that "scoops" the sediment up.
- **Ladder Bucket** dredgers are dredgers that have multiple buckets on a conveyor so sediment can be brought up to the surface on an almost continuous basis.
- **Cutter Suction** dredger uses a cutter head to loosen material on the sea floor before pumping material through a pipe on to a barge or marine disposal, discharge site.

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- **Trailer Suction Hopper** dredger sucks material into the hopper of the dredger. Heavier materials such as rocks, gravel and sand sink while the finer sediments rise to the surface. The hopper is filled; water is discharged through an overflow pipe below the water line, taking finer materials with it.

- **Stationary Suction** dredger;

- **Water jet** dredger involves pumping water into the sediment to make the sediment. This can either be used to mobilise the sediment and have the currents disperse the sediment (as the Port of London Authority do) or can be used to make the sediment into a slurry to make dredging and transporting easier.

- **Offshore Rainbow** dredger pumps the dredged material onshore by spray. This means that the dredgers do not have to come too close to the shore for fear of grounding.

Dredgers and 'S' Values

The 'S' value approximates the amount of sediment (in Kilograms per cubic metre (kg/ m^3)) dredged which is lost outside of the immediate vicinity of the dredger due to dredgers inefficiencies (DOER, 1999, Poiner and Kennedy, 1984). Loose clays will result in higher concentrations, whereas, stiff clays with high density will result in lower suspensions. Greater impact of the bucket on the bottom results in higher sediment release to the water column. Closed buckets generally result in lower suspended sediment concentrations than those generated with open buckets.

The amount of sediment released into suspension depends on a number of factors including the amount of energy input, method of excavation, material transport, the sediment type being dredged, the type of dredge and the manner in which it is operated. If the sediment is primarily fine grained it will remain in suspension for an extended period of time whereas coarser materials such as sand will be released into the water column but will quickly settle.

Loose clays will result in higher concentrations, whereas, stiff clays with high density will result in lower suspensions. Greater impact of the bucket on the bottom results in higher sediment release to the water column. Closed buckets generally result in lower suspended sediment concentrations than those generated with open buckets.

Table F1 shows the 'S' values associated with the dredger and sediment type. These values have been averaged from the DOER (1999), Pennekamp *et al.* (1996) and Kirby and Land (1990) to give typical 'S' values for the types of dredger taking into account different sizes of dredger types.

From Table F1 we can see that the different dredger types produce varying 'S' values. Table F1 shows the mechanical dredgers such as mechanical grab and mechanical bucket dredgers produce considerably high and consistent 'S' values. The Hydraulic Cutterhead and Hopper dredgers produce lower 'S' values this may be because of the actual method of dredging involved differs between the two types of dredgers. Mechanical dredgers do not have a fully enclosed system from which to remove the sediment, they have to disturb large quantities before the grab or bucket is closed leading to high levels of resuspended sediments. Hydraulic dredgers on the other hand use systems that ensure as much of the dredge process is enclosed throughout as the suction pipe of the TSHD's or the cutter head of the CSD's are either close to the bed or within the bed itself.

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The different sediment types also influence the ‘S’ values. Taking averages for each sediment type given in Table F1, it can be seen that mud typically produces the least amount of resuspended sediment within the vicinity of the dredger head. Silt and sand also produce low levels of resuspended sediment within the vicinity of the dredger head. Silty clay and clay produce the highest levels of resuspended sediment. This supports the hypothesis set by Kirby and Land (1990) that mechanical dredgers that are used to dredge harder substrates such as silty clays and clays produce higher levels of resuspended sediment and hydraulic dredgers that are used for softer substrates produce lower levels of resuspended sediment.

Table F1 the ‘S’ values associated with the dredger and sediment type (DOER, 1999, Pennekamp *et al.*, 1996, Kirby and Land, 1990).

Dredge Type	**Sediment Type**	**Average s value/ value**
Hydraulic Cutterhead	Silty Clay	12.57
	Clay	40.80
	Sandy Loam	2.82
	Mud	4.50
Hopper	Silty Clay	7.10
	Silt	25.20
	Mud	6.50
Mechanical Grab	Silty Clay	89.00
	Clay	84.20
	Silty Loam	14.93
	Sand	36.70
	Mud	12.11
Mechanical bucket	Sand	36.70
	Mud	21.67
Backhoe	Mud	12.67

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Table F2 The characteristics of the dredger fleet of UKD (ABP, 2010).

	Bluefin	Marlin	Dolphin	Cherry Sand	Seahorse	Sea lion	Orca
Description	Twin pipe TSHD	Twin pipe TSHD	Single TSHD	Self-propelled grab hopper dredger	Multicat dredging support. 10m plough for bed levelling with a submersible dredge pump	Sister of Seahorse	New TSHD for 2010
Length (m)	98	85	79	62.5	25.97	25.97	78.0
Breadth (m)	18	16	14	12.04	10.06	10.06	15.85
Draught Loaded	6.7	5.6	4.5	4.02	2.55	2.55	5.6
Gross tonnage (tonnes)	4171	2692	1742	1080	206	210	3,087
Hopper capacity (m3)	3900	2968	2189	765	10m x 8 tonnes	10m x 8 tonnes	2,373
Pump ashore	Yes	Yes	Yes	Yes			

Figure F1 Grab dredger (Website 11)

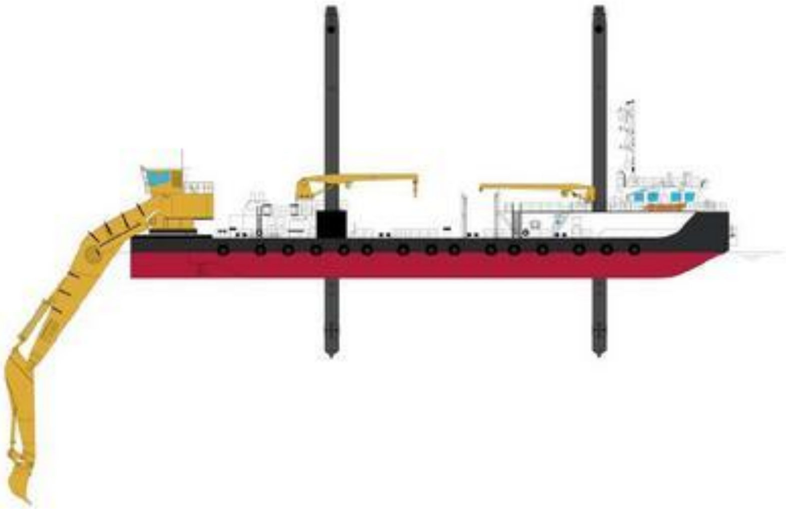

Figure F2 A backhoe dredger (Website 18).

Figure F3 Bucket Ladder (Website 12)

Figure F4 A cutter suction dredger (Website 19).

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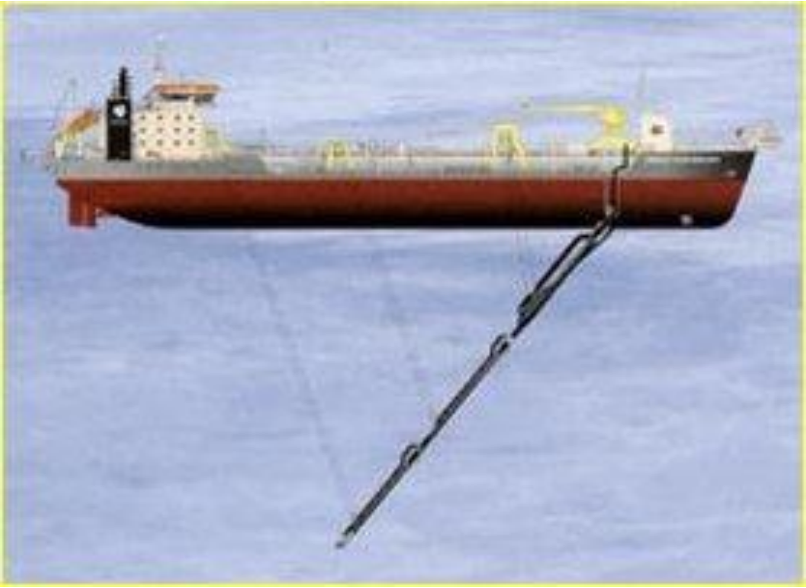

Figure F5 A trailing suction hopper dredger (Website 20).

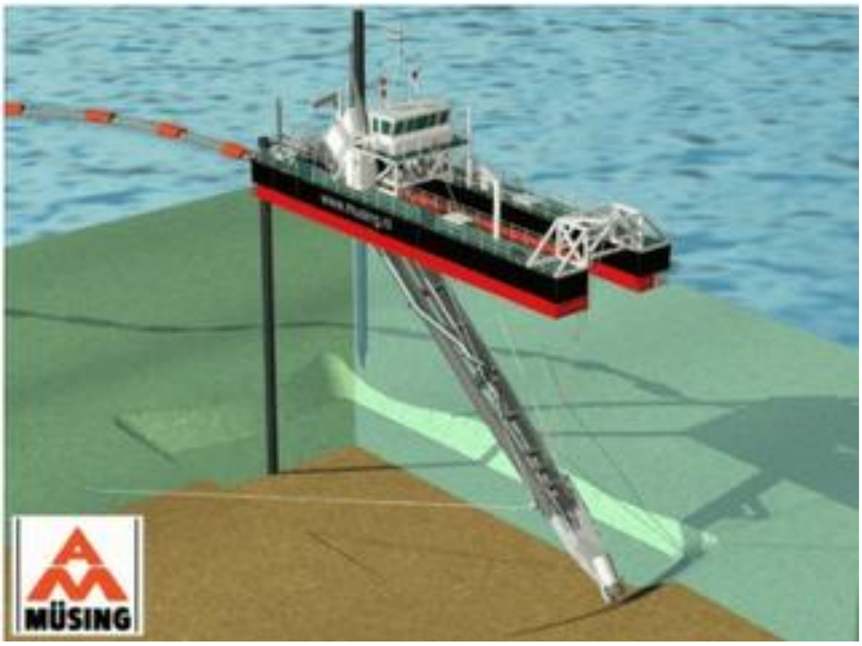

Figure F6 Stationary suction dredger from (Website 21)

Figure F7 An offshore rainbow dredger replenishing Pevensey Bayin East Sussex (Website 22)

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Website 18-http://www.imcbrokers.com/blog/overview/p/detail/jan-de-nul-ahead-
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Website 22- http://www.maritimejournal.com/features101/marine-civils/dredging/the_best_environmental_project_award_for_ppp_flood_defence (Accessed 22/06/11).

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Appendix G Areas of Sedimentation within the Port of Hull Docks

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Appendix G Areas of Sedimentation with the Port of Hulls Docks (from ABP, *in prep. a*)

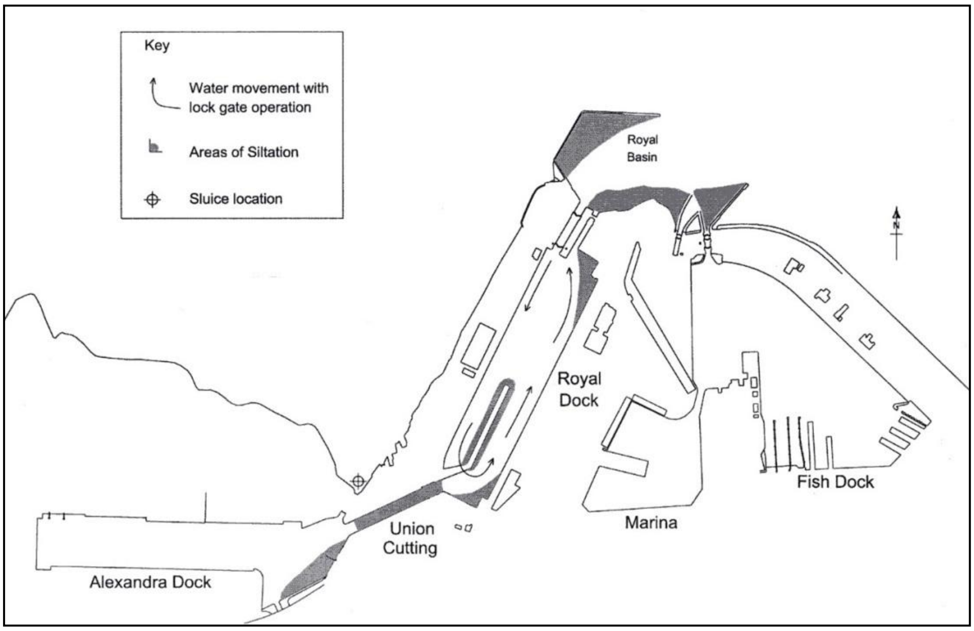

Figure G1 Areas of sedimentation at the Port of Grimsby

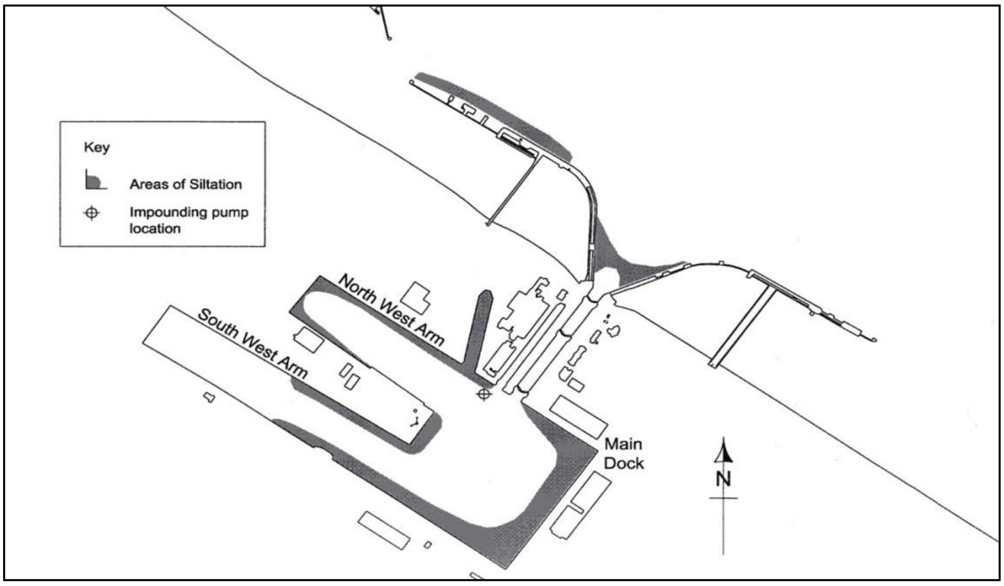

Figure G2 Areas of sedimentation at the Port of Immingham.

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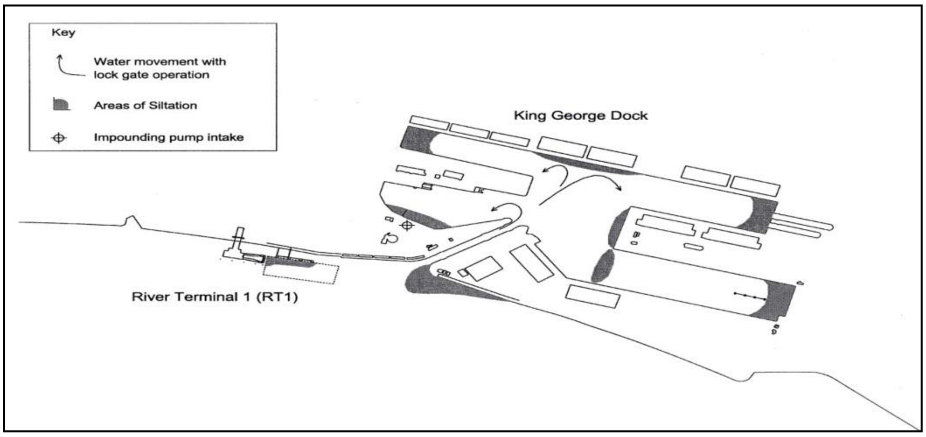

Figure G3 Areas of sedimentation at King George Dock, Port of Hull.

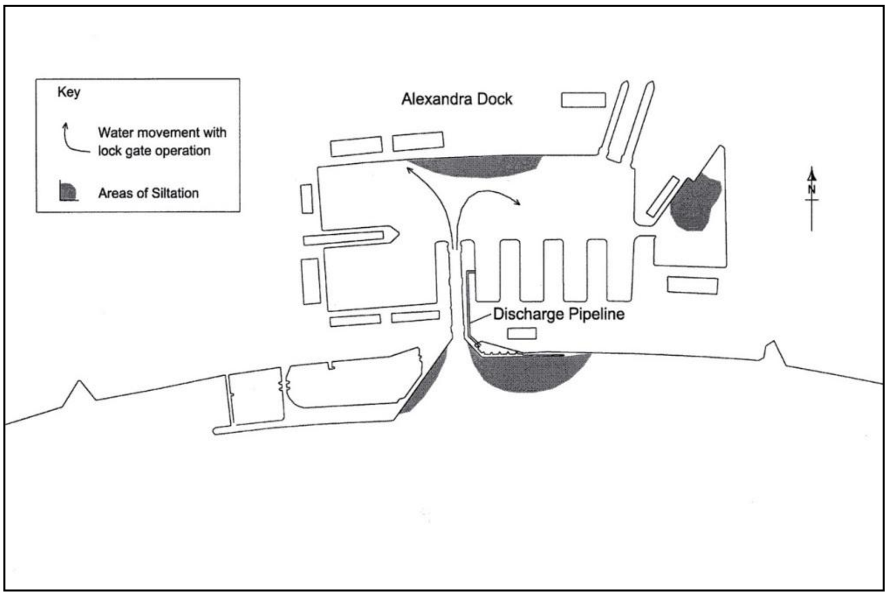

Figure G4 Areas of sedimentation at Alexandra Dock, Port of Hull.

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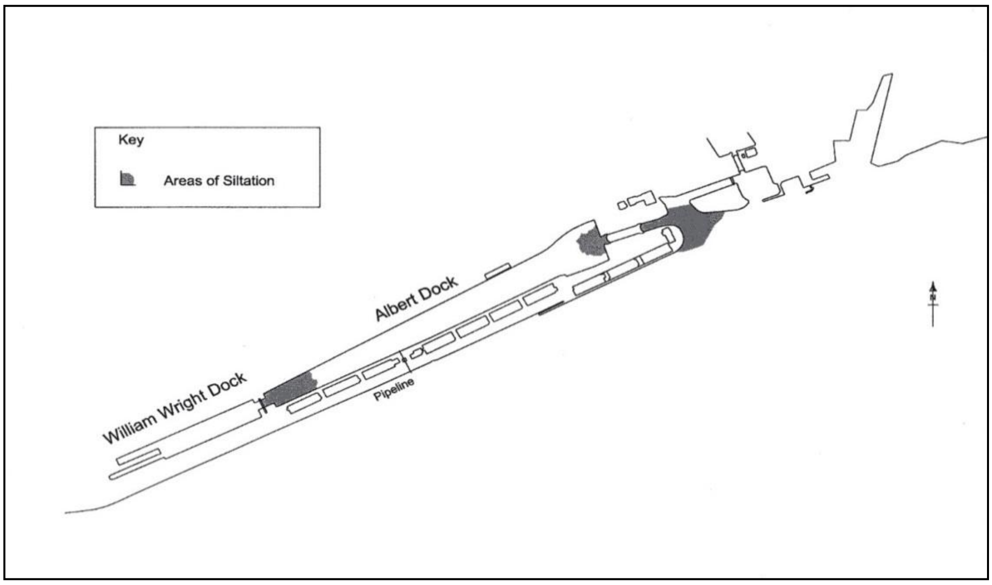

Figure G5 Areas of sedimentation at William Wright and Albert Docks, Port of Hull.

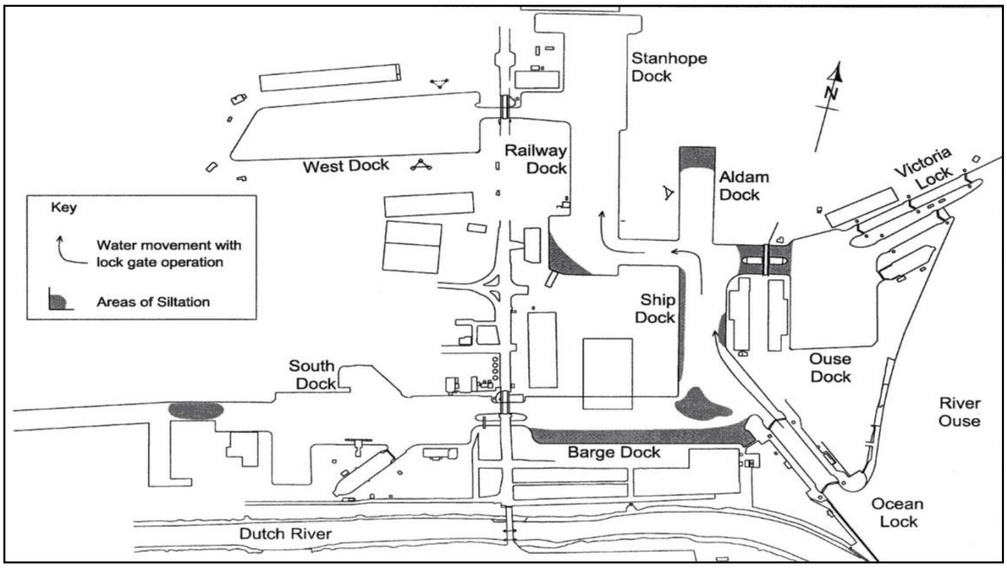

Figure G6 Areas of sedimentation at Port of Goole.

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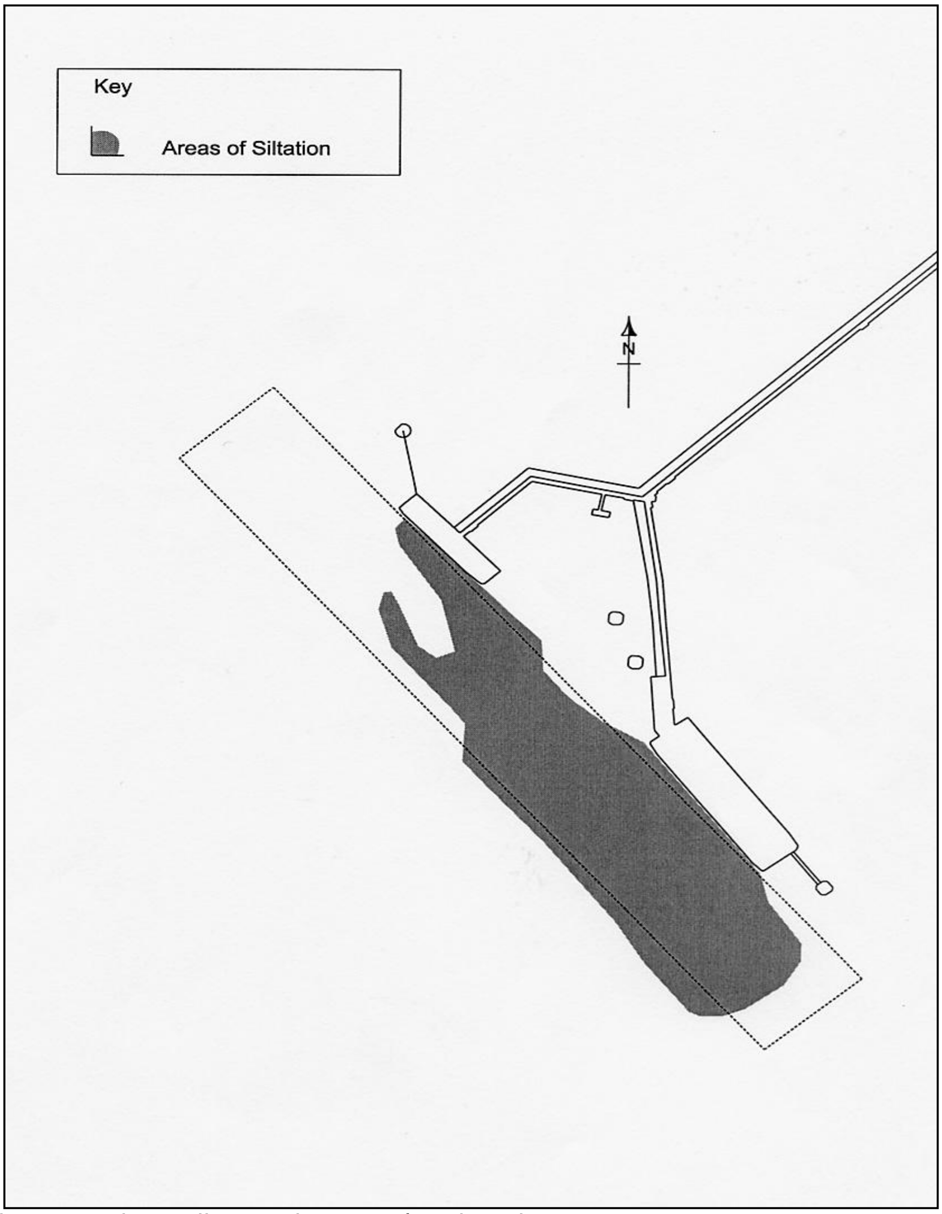

Figure G7 the sedimentation at Saltend Jetties.

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Appendix H Collection of Correspondence.

Project part-financed by the European Union (European Regional Development Fund)

From: "Watson, Andrew (MMO)" <Andrew.Watson@marinemanagement.org.uk>
To: jemmaanne.lonsdale@yahoo.com
Sent: Thursday, August 11, 2011 2:24 PM
Subject: RE: Environmetal Statements
Jemma,

Thank you for your email.

I have today posted a DVD containing some of the Environmental Statements (ES) requested. These are Hull Riverside Bulk Terminal, Grimsby Ro-Ro, and The Immingham Oil Terminal Approach.

I think you may be able to obtain copies of the ES for Quay 2005 and the Humber Sea Terminal from the Ports Division at the Department for Transport who would have determined the harbour revision order applications at the time. In respect of the Northern Humber Port Facility, I think this application may well be with the IPC for consideration and as such you may be able to obtain a copy from them.

I hope this is helpful.

Kind Regards

Andrew Watson
Marine Consents Officer
Major Infrastructure Projects Team

PO Box 1275
Newcastle Upon Tyne
NE99 5BN
0191 376 2524
andrew.watson@marinemanagement.org.uk

From: Jemma-Anne Lonsdale [mailto:jemmaanne.lonsdale@yahoo.com]
Sent: 11 August 2011 12:05
To: SH - MFA Marine Consents (MMO)
Subject: Environmetal Statements

36 Sunny Bank
High Green
Sheffield
S35 4NP
10-08-11

Dear Sir/ Madam,

I was wondering if you send me copies of the Environmental Statements and/ or any (other) information on the following projects please:

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- Hull Riverside Bulk Terminal;
- Hull Riverside Container Terminal aka Quay 2005;
- Grimsby RO-RO;
- Hydrogen Pipeline Project;
- Northern Humber Port Facility;
- Humber Sea Terminal; and
- The Immingham Oil Terminal Approach.

If you have also have any other information on any other projects that have been proposed/ consented within the Humber Estuary, this would also be greatly appreciated.

Many thanks and best regards
Jemma Lonsdale

The Marine Management Organisation (MMO)

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From: Page, Tim (NE) [mailto:Tim.Page@naturalengland.org.uk]
Sent: Thu 13/10/2011 18:19
To: Jemma-Anne Lonsdale
Subject: RE: Maintenance Dredging

Jemma-Anne,

Many apologies for not responding to you before now.

Interesting in your original e-mail.

As you suggest we have tended to reflect the approach that for an estuary like the Humber it is important to retain dredged sediment in the system and for it not to be lost to the overall sediment budget. An earlier manifestation of this sort of thinking can be seen in the discussions that English Nature had back in 2003 with the MCEU (one of the predecessors to the MMO) over the setting up of a standardised approach to maintenance dredging licences:

"Maintenance dredging is the natural follow-on to capital dredging that is known to affect estuarine morphology and morphological evolution. In essence, maintenance dredging returns part of the system to the condition it was in at the time of the capital dredge, and means that the natural process of readjustment is interrupted. Sediment draw-down continues and depending upon the disposal site it may be lost from the system altogether.
The maintenance of a positive sediment budget for UK estuaries is an important aspect of maintaining their favourable condition. Sediment is required to allow mudflats and saltmarshes to accrete and keep pace with sea level rise, and to provide natural habitat and energy attenuation. Should sites fail to keep pace with the impacts of sea level rise as a result of net export of sediment through anthropogenic impacts, it is possible that their condition may become unfavourable. In the case of sites designated under the Birds Directive (79/409/EC) or the Habitats Directive (92/43/EC) the impacts of such anthropogenic activities may, in some cases, be construed as having an adverse affect on their integrity for the purposes of Regulation 48[5] of the Habitats Regulations (1994). However, there are models of good practice, including sediment feeding, that mitigate the effects wholly or partly of maintenance dredging."

In the Humber we have tended to interpret this in a fairly straightforward way. Keeping the sediment in the system for us has meant simply disposing of it in various designated subtidal disposal sites. We haven't really tried to do anything more sophisticated. One basic but logical argument to support this approach is that disposal within the subtidal environment allows sediment to be remobilised (assuming it is that sort of material) and the estuary system is then free to "use" the sediment according to prevailing conditions. In a dynamic system which we may not fully understand it may be sensible to keep intervention to a minimum and to allow that system to find its own equilibrium (or equilibriums). Also there may be significant differences between dredged material and (for example) existing intertidal material. The existing intertidal material has already been sorted by estuary process. To put dredged material straight onto intertidal mud is to short circuit that process and potentially put inappropriate material in the wrong place with the result that the process just removes it and puts it elsewhere or that the estuary then starts to erode/accrete in other unforeseen areas.

Another big issue to consider is the relevant legislative framework. As you know the Humber holds a whole variety of statutory designations. Any new proposals would have to be considered with this legislation and the associated regulatory process in mind. This doesn't shut the door but it does mean that stringent tests would probably have to be passed.

Also there is the Humber maintenance dredging baseline document (one of a number of similar documents around the country) which represents an attempt to streamline the consideration of

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maintenance dredging proposals where there is this significant regulatory environment. As I understand it, historically Humber dredged material has been disposed of at subtidal disposal sites within the estuary system. This situation
has seen itself transfer into the basic approach of the baseline document. A different approach would need a new baseline document.

Having said all that, other estuaries have done more in terms of intervention. Here are a few examples from a colleague talking about the Stour and Orwell;

"Capital dredging produces especially stiff clays, rocks , gravel and sand (sometimes in large volumes). It was not possible to find a use for the bulk of stiff clay, which was therefore sent to offshore disposal sites, along with a proportion of rock and gravel which was spread as a veneer on the clays to produced fish/lobster habitat... a significant proportion of sand was used beneficially on shore to sustain retreating beaches and low sand dunes (south of the dredged channel and thus effectively sediment bypass), with recreational, sea defence, and nature conservation benefits.
Sand ... produced (by maintenance dredging) is used beneficially on shore as above....
Placement (of silt) has been by both subtidal placement and release into the water column: each has benefits and drawbacks – bulk placement obliterates existing benthos, but acts as a source of trickle feed to the intertidals; release into the column is immediately introduced into the natural process pathways, but can create turbidity issues, and at least in the lower estuary can simply be washed out of the estuary without settling on the intertidal (the lower 2/3 of the Stour estuary is ebb dominant).
A smaller proportion of the maintenance silt have been used more directly for habitat creation/enhancement. Some is pumped into new realignment sites (eg.. Trimley) to boost the initial sediment input and help raise the bed levels to the point at which intertidal flats and saltmarshes can form, thus promoting more rapid attainment of mitigation/compensation objectives (especially where – as is often the case – historic land claim for agriculture has created a land surface which is now well below tide heights)
And we have also seen silts placed beneficially upon severely eroded salt marsh surfaces (eg. Horsey Island), with mixed but largely positive results."

As implied above, the principle of keeping sediment "in the system" does not necessarily come with a requirement for a specific subtidal or intertidal disposal site(s). Both can count as being "within the system".

These are just my own thoughts off the top of my head, taken from my own experience. I've asked a colleague in one of our national teams for a more general NE view. I'll let you know what she comes up with.

Tim P

From: Jemma-Anne Lonsdale [mailto:J.Lonsdale@2007.hull.ac.uk]
Sent: 16 September 2011 19:13
To: Page, Tim (NE)
Subject: Maintenance Dredging

Hi Tim,

Just to clarify this is the Jemma who works for ABP on the GPH project, however I am also doing a MSc research degree and my thesis is on the potential uses of dredge material within

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the Humber Estuary. At the minute I am looking at the potential uses of maintenance dredge arisings and wondered if you could help me.

If we maintenance dredge a channel/ berth can that sediment be used for intertidal enhancement? I am not sure what constitues as "keeping the sediment in the sediment budget" as, at the moment I think it can be argued both ways but if I could get Natural Englands view on this I would take that as my position.

Thank you in advance for taking time out for this and any steer on this would be extremely appreciated.

Many thanks and best regards
Jemma Lonsdale

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From: Balson, Peter S. [mailto:psba@bgs.ac.uk]
Sent: Wed 04/01/2012 14:21
To: Jemma-Anne Lonsdale
Subject: RE: Humber Bed Sediments: IDA 202735

Hi Jemma-Anne

Your enquiry has recently been passed to me. BGS does hold extensive data on the bottom sediments, sediment thickness and geology of the Humber Estuary. Most of this data was obtained in the late 1960s and early 1970s on behalf of the British Transport Docks Board who were modelling sediment movement in the estuary. The data is therefore quite dated now and given the amount of dredging which has taken place over the past 50 years may not be an accurate reflection of the present situation. You are very welcome to see this data if you think it would be of use. In the 1990s the NERC- funded LOIS programme was focussed on the sediments and changes within the Humber Estuary and involved a number of researchers from the University of Hull. Most of our work during this project concerned the accumulated sediments on the floodplains of the Humber and the estuary's long-term Holocene evolution. Subsequently there have been further studies on sediment transport funded by the Environment Agency for the Humber Estuary Management Plan but this was mostly based around modelling studies with relatively little new data as far as I remember. More recent data on the dredging of sediments and their disposition may be available from ABP.

Please let me know if you need any further information or if you would like to see any of the BGS data.

Regards

Peter Balson

--

From: Page, Tim (NE) [mailto:Tim.Page@naturalengland.org.uk]
Sent: Tue 10/01/2012 09:42
To: Jemma-Anne Lonsdale
Subject: RE: Msc on Dredging

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Jemma,

Happy new year etc. Sorry not to have responded before now.

Your paper seems good to me. Though I was n't quite sure what you meant by, *"... NE have expressed a concern that the existing intertidal mudflat has already been sorted."*

By way of background explanation it may be worth adding that the "estuary" itself is a feature of the SAC. This fact (and the accompanying conservation objectives for the designated site) are the basis of NE's considerations as to what to do with dredged material. Any decisions which do not conflict with this situation and affect the favourable conservation status of the designated site are acceptable. Up to now we have taken the view that the easiest way to proceed is to simply retain the dredged material in the system as a whole via disposal in subtidal areas. As you will see below there is no objection in principle to other forms of disposal/use. It just has n't really been done on the Humber to my knowledge.

Below is a response I got from one of our national specialists on beneficial use of dredged material. It's rather brief and the Defra paper mentioned was not actually attached. I'll chase this up and send it on.

"We do not have a formal position on this – Nicki Hiorns was working on a position paper before she went on maternity leave – unfinished as yet. However in general material should be kept within the system (with the proviso that it is uncontaminated) wherever possible and should generally be regarded as a resource for other schemes such as beach replenishment, salt marsh feeding/creation etc if not (again contaminant dependent as well as grain size). NE are working with other Defra agencies on this and I have attached a paper. << File: Dredged Material as a Resource.pdf >>"

More soon I hope.

Tim P

From: Jemma-Anne Lonsdale [mailto:J.Lonsdale@2007.hull.ac.uk]
Sent: 25 November 2011 07:30
To: Page, Tim (NE)
Subject: Msc on Dredging

Hi Tim,

Please find attached the page from my MSc where I reference your email dated 13/10/11. If I have mis-interpreted or have anything incorrect please do let me know.

Thanks again for your help.

Kind regards
Jemma Lonsdale

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From: Shona Thomson
Sent: Tue 17/01/2012 11:14
To: Jemma-Anne Lonsdale
Subject: RE: Email address

This is a section from the Harbasins project. Front cover also attached for referencing.

S

Shona Thomson

GIS Specialist
Institute of Estuarine and Coastal Studies
University of Hull

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From: Jemma-Anne Lonsdale
Sent: 17 January 2012 10:43
To: Shona Thomson
Subject: RE: Email address

Thanks Shona.

Jemma

From: Shona Thomson
Sent: Tue 17/01/2012 10:31
To: Jemma-Anne Lonsdale
Subject: RE: Email address

Hi Jemma,

Strangely we haven't got much on sediments in the Humber. Attached is what we do have. Very simplified and really old. They only go up as far as trent falls but the rest you may be able to get on a council GIS?

Shona

Shona Thomson

GIS Specialist
Institute of Estuarine and Coastal Studies
University of Hull

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From: Jemma-Anne Lonsdale
Sent: 17 January 2012 07:38
To: Shona Thomson
Subject: RE: Email address

Hi Shona,

Mike said you may be able to help. I need to find out what sediments are at the following locations (on maps attached):

Hawkins Point;
stallingborough;
Halton Marsh;
Paull;
A1077;
East Clough;
Winteringham Haven;
Swinefleet;
Whitton Ness;
Whitgift Bank; and
Saltmarshe.

Preferably I would like the sediment for the intertidal and adjacent subtidal and terrestrial areas. Have you got this information please?

Thanks
Jemma

From: Shona Thomson
Sent: Mon 16/01/2012 16:57
To: Jemma-Anne Lonsdale
Subject: RE: Email address

Hey Jemma,

Whats up?

Shona

Shona Thomson

Project part-financed by the European Union (European Regional Development Fund)

GIS Specialist
Institute of Estuarine and Coastal Studies
University of Hull

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From: Mike Elliott
Sent: 16 January 2012 16:54
To: Jemma-Anne Lonsdale
Cc: Shona Thomson
Subject: RE: Email address

Hi Jemma

I'll copy this to her.

Hope all is OK.

Mike

Professor Mike Elliott,
Chair in Estuarine & Coastal Sciences, Department of Biological Sciences,
Director of the Institute of Estuarine & Coastal Studies (IECS),
The University of Hull, HULL, HU6 7RX, UK
Tel. +44 (0)1482 465503/464558
Fax. +44 (0)1482 464130
URL http://www.hull.ac.uk/iecs
Email Mike.Elliott@hull.ac.uk

From: Jemma-Anne Lonsdale
Sent: 16 January 2012 16:45
To: Mike Elliott
Subject: Email address

Hi Mike,

Can you please send me shona's (not sure if I spelt her name correctly) email address please?

Thanks
Jemma

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From: Peter Crawley [mailto:peter.crawley@forthports.co.uk]
Sent: Tue 17/01/2012 11:45
To: Jemma-Anne Lonsdale
Subject: FW: Scottish Ports Equiry Form: General Enquiries

Good Morning Jemma,

Your email has been passed to me from our general admin office. Can you let me know exactly what information you require? I should be able to provide you with dredged areas and disposal site coords and quantities for each.

Regards

Peter Crawley.
Dredging & Conservancy Supt.
Forth Ports Limited
01324 498542
07711 152653

-----Original Message-----
From: Lyndsey Higgins
Sent: 17 January 2012 09:45
To: Peter Crawley
Subject: FW: Scottish Ports Equiry Form: General Enquiries

Peter

As per the email below, do you respond to enquiries such as this?

Regards

Lyndsey Higgins
Administrator

Tel - 01324 668429
Fax - 01324 668484

-----Original Message-----
From: j.lonsdale@2007.hull.ac.uk [mailto:j.lonsdale@2007.hull.ac.uk]
Sent: 10 January 2012 14:48
To: marketing
Subject: Scottish Ports Equiry Form: General Enquiries

-
You have received an e-mail via the Scottish Ports - Contact Us Equiry

Project part-financed by the European Union (European Regional Development Fund)

Form

-

Type: General Enquiries
Email: j.lonsdale@2007.hull.ac.uk
Enquiry: Dear Sir/ Madam,

I am a MSc research student at the University of Hull and I am currently writing a dissertation on the "Potential Alternative Beneficial Uses of Dredged Material within the Humber Estuary" and was wondering if you could please send me any information on your maintenance dredging activities. This is so I can compare the Humber's maintenance dredging and diposal activities against other estuaries.

Of particular interest are the dredge and disposal sites themselves (with distances or co-ordinates if possible).

Many Thanks
Jemma Lonsdale

-

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Attachement: Grangemouth Dredge Areas; Oxcar Spoil Ground Coords; Leith Dredging Areas 2011; Narrow Deep Spoilground Coords 2011; Rosyth Dredge Area 2011; Boness Coordinates

From: Peter Crawley [mailto:peter.crawley@forthports.co.uk]
Sent: Wed 18/01/2012 13:17
To: Jemma-Anne Lonsdale
Subject: RE: Scottish Ports Equiry Form: General Enquiries

Jemma,

We run 3 main dredging operations on the Forth, Grangemouth to Bo'ness spoilground, Leith to Narrow Deep spoilground and Rosyth to Oxcars spoilground. Each requires a separate dredging\disposal licence. Our disposal licences allow us to deposit 1 million cubic metres from Grangemouth per annum, 200,000 cubic metres from Rosyth per annum and 100,000 cubic metres from Leith per annum. Obviously annual quantities vary but we are usually fairly close to our maximums.

Attached are coordinate lists for the dredge areas and disposal sites. Distances are approximately 3miles from Grangemouth to Bo'ness, 4 miles from Leith to the Narrow Deep and 6 miles from Rosyth to the Oxcars.

As part of the dredge licence application you have to produce a Best Practical Environmental Option (BPEO) and in that document you have to consider other uses for the dredged spoil. Other uses may include topsoil, building block manufacture, beach replenishment etc. Because our dredged material is fine silt, it does not lend itself to any practical beneficial use. You also have to consider that in a maintenance dredging operation the dredging will be a repeat operation. At Grangemouth it is a monthly operation. This means you must have an ongoing disposal operation. The dredge licencing regimes differ in England and Scotland and between capital and maintenance dredging. Sediment type and quantity form part of the BPEO assessment and dredged samples are taken for analysis by the regulator.

Let me know if you need more info.

Regards

Peter Crawley.
Dredging & Conservancy Supt.
Forth Ports Limited
01324 498542
07711 152653

From: Jemma-Anne Lonsdale [mailto:J.Lonsdale@2007.hull.ac.uk]
Sent: 17 January 2012 12:40
To: Peter Crawley
Subject: RE: Scottish Ports Equiry Form: General Enquiries

Peter,

Project part-financed by the European Union (European Regional Development Fund)

Thank you for your reply. I would like the co-ordinates of the dredge and disposal sites so can I can compare the different strategies between the Humber and the Forth especially the distances involved and the sediment quantities.

Could you also give an indication of the sediment types and whether the disposal of the sediment considers the sediment type at the disposal site as well?

And lastly, do any of the ports on the Forth consider beneficial use of dredged material and if so/ not what considerations do you take into account.

Thank you for you time
Best regards
Jemma Lonsdale

From: Peter Crawley [mailto:peter.crawley@forthports.co.uk]
Sent: Tue 17/01/2012 11:45
To: Jemma-Anne Lonsdale
Subject: FW: Scottish Ports Equiry Form: General Enquiries

Good Morning Jemma,

Your email has been passed to me from our general admin office. Can you let me know exactly what information you require? I should be able to provide you with dredged areas and disposal site coords and quantities for each.

Regards

Peter Crawley.
Dredging & Conservancy Supt.
Forth Ports Limited
01324 498542
07711 152653

-----Original Message-----
From: Lyndsey Higgins
Sent: 17 January 2012 09:45
To: Peter Crawley
Subject: FW: Scottish Ports Equiry Form: General Enquiries

Peter

As per the email below, do you respond to enquiries such as this?

Regards

Lyndsey Higgins
Administrator

Tel - 01324 668429
Fax - 01324 668484

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-----Original Message-----
From: j.lonsdale@2007.hull.ac.uk [mailto:j.lonsdale@2007.hull.ac.uk]
Sent: 10 January 2012 14:48
To: marketing
Subject: Scottish Ports Equiry Form: General Enquiries

-
You have received an e-mail via the Scottish Ports - Contact Us Equiry Form
----
-

Type: General Enquiries
Email: j.lonsdale@2007.hull.ac.uk
Enquiry: Dear Sir/ Madam,

I am a MSc research student at the University of Hull and I am currently writing a dissertation on the "Potential Alternative Beneficial Uses of Dredged Material within the Humber Estuary" and was wondering if you could please send me any information on your maintenance dredging activities. This is so I can compare the Humber's maintenance dredging and diposal activities against other estuaries.

Of particular interest are the dredge and disposal sites themselves (with distances or co-ordinates if possible).

Many Thanks
Jemma Lonsdale

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in Scotland No 76746 Forth Properties Limited, Registered Office: 1 Prince of Wales Dock, Edinburgh, EH6 7DX, Registered in Scotland No 124730 Forth Property Developments Limited, Registered Office: 1 Prince of Wales Dock, Edinburgh, EH6 7DX, Registered in Scotland No 223863 Forth Property Holdings Limited, Registered Office: 1 Prince of Wales Dock, Edinburgh, EH6 7DX, Registered in Scotland No 223868 Forth Property Investments Limited, Registered Office: 1 Prince of Wales Dock, Edinburgh, EH6 7DX, Registered in Scotland No 102967 Ocean Terminal Limited, Registered Office: 1 Prince of Wales Dock, Edinburgh, EH6 7DX, Registered in Scotland No 178696 Nordic Limited, Leslie Ford House, Tilbury Freeport, Essex RM18 7EH Registered in England No 5396187 Nordic Holdings Limited, Leslie Ford House, Tilbury Freeport, Essex RM18 7EH Registered in England No 3118969 Nordic Recycling (Lincoln) Limited, Leslie Ford House, Tilbury Freeport, Essex RM18 7EH Registered in England No 06232146 Nordic Recycling Limited, Leslie Ford House, Tilbury Freeport, Essex RM18 7EH Registered in England No 2963790 Nordic Forest Terminals Limited, Leslie Ford House, Tilbury Freeport, Essex RM18 7EH Registered in England No 03112560 Nordic Data Management Limited, Leslie Ford House, Tilbury Freeport, Essex RM18 7EH Registered in England No 3033517

From: Peter Crawley [mailto:peter.crawley@forthports.co.uk]
Sent: Mon 30/01/2012 11:08
To: Jemma-Anne Lonsdale
Subject: RE: Scottish Ports Equiry Form: General Enquiries

Morning Jemma,

Distances are in nautical miles to the centre of the spoilground. However, the spoilgrounds cover a wide area. The Bo'ness spoilground is 3nm long by 1nm wide at it's maximum.

No studies have been carried out to determine if any dredged material finds it's way back to the dredged area. Marine Scotland, who issue our disposal licences, have had a policy in the Forth for many years of the spoilgrounds being close to the dredging areas. I believe this is so that any contamination, which may exist, is not distributed to a wider area. However, if the spoil is too badly contaminated, it is not suitable for sea disposal anyway. The distance to the spoilground is a major cost consideration in any dredging operation.

Regards

Peter Crawley.
Dredging & Conservancy Supt.
Forth Ports Limited
01324 498542
07711 152653

From: Jemma-Anne Lonsdale [mailto:J.Lonsdale@2007.hull.ac.uk]
Sent: 30 January 2012 08:24
To: Peter Crawley
Subject: RE: Scottish Ports Equiry Form: General Enquiries

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Peter,

Sorry for taking so long to reply. firstly thank you for taking the time to send this information through. I just have a couple more questions, firstly the distances you gave are these miles or nautical miles?

Also, the distances all seem relatively close from dredge to disposal area has any work been carried out to determine if this leads to an increase in accretion at the dredge site or if it would be an unnoticeable difference between the diposal sites used and those further afield.

Thanks again
Jemma

From: Peter Crawley [mailto:peter.crawley@forthports.co.uk]
Sent: Wed 18/01/2012 13:17
To: Jemma-Anne Lonsdale
Subject: RE: Scottish Ports Equiry Form: General Enquiries

Jemma,

We run 3 main dredging operations on the Forth, Grangemouth to Bo'ness spoilground, Leith to Narrow Deep spoilground and Rosyth to Oxcars spoilground. Each requires a separate dredging\disposal licence. Our disposal licences allow us to deposit 1 million cubic metres from Grangemouth per annum, 200,000 cubic metres from Rosyth per annum and 100,000 cubic metres from Leith per annum. Obviously annual quantities vary but we are usually fairly close to our maximums.

Attached are coordinate lists for the dredge areas and disposal sites. Distances are approximately 3miles from Grangemouth to Bo'ness, 4 miles from Leith to the Narrow Deep and 6 miles from Rosyth to the Oxcars.

As part of the dredge licence application you have to produce a Best Practical Environmental Option (BPEO) and in that document you have to consider other uses for the dredged spoil. Other uses may include topsoil, building block manufacture, beach replenishment etc. Because our dredged material is fine silt, it does not lend itself to any practical beneficial use. You also have to consider that in a maintenance dredging operation the dredging will be a repeat operation. At Grangemouth it is a monthly operation. This means you must have an ongoing disposal operation. The dredge licencing regimes differ in England and Scotland and between capital and maintenance dredging. Sediment type and quantity form part of the BPEO assessment and dredged samples are taken for analysis by the regulator.

Let me know if you need more info.

Regards

Peter Crawley.
Dredging & Conservancy Supt.
Forth Ports Limited
01324 498542
07711 152653

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From: Jemma-Anne Lonsdale [mailto:J.Lonsdale@2007.hull.ac.uk]
Sent: 17 January 2012 12:40
To: Peter Crawley
Subject: RE: Scottish Ports Equiry Form: General Enquiries

Peter,

Thank you for your reply. I would like the co-ordinates of the dredge and disposal sites so can I can compare the different strategies between the Humber and the Forth especially the distances involved and the sediment quantities.

Could you also give an indication of the sediment types and whether the disposal of the sediment considers the sediment type at the disposal site as well?

And lastly, do any of the ports on the Forth consider beneficial use of dredged material and if so/ not what considerations do you take into account.

Thank you for you time
Best regards
Jemma Lonsdale

From: Peter Crawley [mailto:peter.crawley@forthports.co.uk]
Sent: Tue 17/01/2012 11:45
To: Jemma-Anne Lonsdale
Subject: FW: Scottish Ports Equiry Form: General Enquiries

Good Morning Jemma,

Your email has been passed to me from our general admin office. Can you let me know exactly what information you require? I should be able to provide you with dredged areas and disposal site coords and quantities for each.

Regards

Peter Crawley.
Dredging & Conservancy Supt.
Forth Ports Limited
01324 498542
07711 152653

-----Original Message-----
From: Lyndsey Higgins
Sent: 17 January 2012 09:45
To: Peter Crawley
Subject: FW: Scottish Ports Equiry Form: General Enquiries

Peter

As per the email below, do you respond to enquiries such as this?

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Regards

Lyndsey Higgins
Administrator

Tel - 01324 668429
Fax - 01324 668484

-----Original Message-----
From: j.lonsdale@2007.hull.ac.uk [mailto:j.lonsdale@2007.hull.ac.uk]
Sent: 10 January 2012 14:48
To: marketing
Subject: Scottish Ports Equiry Form: General Enquiries

-
You have received an e-mail via the Scottish Ports - Contact Us Equiry Form
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-

Type: General Enquiries
Email: j.lonsdale@2007.hull.ac.uk
Enquiry: Dear Sir/ Madam,

I am a MSc research student at the University of Hull and I am currently writing a dissertation on the "Potential Alternative Beneficial Uses of Dredged Material within the Humber Estuary" and was wondering if you could please send me any information on your maintenance dredging activities. This is so I can compare the Humber's maintenance dredging and diposal activities against other estuaries.

Of particular interest are the dredge and disposal sites themselves (with distances or co-ordinates if possible).

Many Thanks
Jemma Lonsdale

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You replied on 05/03/2012 15:05.

Jemma-Anne Lonsdale

From: Sleight, Mike [Mike.Sleight@Nelincs.gov.uk] **Sent:** Mon 05/03/2012 15:00
To: Jemma-Anne Lonsdale
Cc:
Subject: RE: Cleethorpes Beach
Attachments:

Jemma

The beach is mainly accreting with the mud then the saltmash colonises the mud and stabilises the beach. Although we are now controlling the saltmarsh, but we still have a muddy beach. I personally have concerns about the mud a creaks forming in the area. Due to not many people other than me explore the beach and see these things there isn't many concerns. However due to the dynamics of the estuary there is very little we can do about the situation.

I hope this helps.

Mike

From: Jemma-Anne Lonsdale [mailto:J.Lonsdale@2007.hull.ac.uk]
Sent: 05 March 2012 11:52
To: Sleight, Mike
Subject: RE: Cleethorpes Beach

Hi Mike,

Thanks for this. I am sure it wil be very useful.

I wonder if I could also pick your brain on a few more things as well that I thought of after my previoud email. Can I also ask if the beach has been eroding at all or is it just "atrracting" mud? Of this, is the mud causing the Council any particular concerns? And if so what are you plans for dealing with it please?

Many Thanks

Jemma Lonsdale

From: Sleight, Mike [mailto:Mike.Sleight@Nelincs.gov.uk]
Sent: Mon 05/03/2012 09:40
To: Jemma-Anne Lonsdale
Subject: Cleethorpes Beach

Jemma

As you may know we are working with Hull University with several surveys on Cleethorpes Beach this includes the saltmarch and mud on the beach. We do have

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two areas that seem to attracting mud and development of creaks one is TA30943 08778 this is between the pair and Brighton street slip. The other area is TA 31393 08 08150 again with creaks. I suspect that the tide is coming round the sand backs depositing some sediment and the outgoing tide is carving the creaks out.

I hope this helps with your work and please contact me if you think I can help.

Mike Sleight

Highgate

Cleethorpes

North East Lincolnshire.

DN35 8NX

01472 323436

Mobile 07730014661

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From: Tom Jeynes
Sent: 18 April 2012 10:10
To: Jemma-Anne Lonsdale
Subject: RE: Question for my MSc
Most licences will say that you should re-evaluate re-use if you apply for a renewal.

From: Jemma-Anne Lonsdale
Sent: 18 April 2012 09:52
To: Tom Jeynes
Subject: RE: Question for my MSc
Thanks Tom. One more question, how often do you have to re-evaluate the uses of dredged material is it every renewal of an application or annually?
Thanks again
Jemma

From: Tom Jeynes
Sent: 18 April 2012 09:42
To: Jemma-Anne Lonsdale
Subject: RE: Question for my MSc
Page 19 onwards

From: Jemma-Anne Lonsdale
Sent: 18 April 2012 08:45
To: Tom Jeynes
Subject: Question for my MSc
Hi Tom,
Just a quick question (when you have time); I know that the MMO say that those wanting to dredge have to consider alternative/ beneficial uses for the dredged material but where does this come from? I have looked at the MCAA, Marine EIA works regs and marine licenses and can't seem to find a written reference that says developers have to consider alternative uses.
Any help to point me in the right direction would be HUGELY appreciated.
Many thanks
Jemma
Jemma-Anne Lonsdale | Projects Assistant | ABP Hull & Goole
| PO Box 1 | Port House | Northern Gateway | Hull | HU9 5PQ | UK
| Tel: 01482 608457 | Email: jlonsdale@abports.co.uk

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Meeting with Captain Phil Cowing, Harbour Master Humber, 30-9-12

Attendees: Captain Phil Cowing, Harbour Master Humber
Jemma Lonsdale

PC explained that there are three main reasons why dredged material is disposed of within the estuary being:

1. for sedimentary budget reasons. HES aim to deposit the sediment back to its place of origin.
2. sites are based on a like for like basis ie sandy dredged material is placed in a location that is predominantly sand
3. for economic and resource reasons. Aim is to keep sediment away from the dredged areas but not too far away so as to mean that there is more time spent steaming than dredging/ dumping of the material.

JL asked PC how long it takes for the silty material to disperse from the disposal site and how much silt actually reaches the estuary bed. PC explained that most of the silt would be in the water column and would be broadly dispersed with some depositing on the bed although no one knows the quantities of these. PC explained that from surveys the disposal sites remain relatively deep which support the hypothesis that the majority of the fine sediments are broadly dispersed.

JL asked PC if the Humber experience any plumes when disposing of the sediment. PC responded by saying that due to the Humber's turbidity, no plume is visible and therefore the distance that the disposed dredged material travels on disposal is unknown. PC explained that the rate of dispersal is probably a quick dispersal due to the Humber's currents.

JL then asked PC if the SDC windows and Bull Sand Fort disposal sites were chosen specifically for clay to address the scour. PC explained that the SDC windows were identified because they have natural depressions and by depositing material here it would level out the estuary bed. PC went on to explain that the deposition of material here would have a secondary beneficial effect of acting as a training wall to direct the SDC.

PC went on to explain that the Bull Sand Fort disposal sites were temporary disposal sites for clay to reduce natural scour that occurred around the base. The material for this was taken from primarily SDC dredging but also others.

JL asked PC what his thoughts were on loose gravel being pumped on shore and whether the loose gravel would be transported or stay in-situ. PC explained that loose gravel would be transported due to the fast currents of the Humber Estuary. PC offered the advice that the loose gravel could be placed in geotextile bags to offer rigidity. PC explained that on the Humber geotextile bagged gravel is used to protect exposed pipelines on the estuary bed but added caution that these bags of gravel can still be displaced and can split open.

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Appendix I Additional Distances from the Capital Dredge Sites to the Sites of Potential Uses

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Appendix I Additional Distances from the Capital Dredge Sites to the Sites of Potential Uses

Project	Closest Deposit site	Distance	Area under Threat of erosion	Distance	Difference/ km	Difference/ nm
HRBT Approach and berth	Hull Middle	0.406	Swinefleet	40.7	-40.29	-21.76
			Saltmarshe	38.02	-37.61	-20.31
			Reedness	36.53	-36.12	-19.51
			Whitgift Bank	32.37	-31.96	-17.26
			Whitton Ness	25.73	-25.32	-13.67
			Winteringham haven	19.43	-19.02	-10.27
			A1077/ South Ferriby- western point	16.36	-15.95	-8.61
			A1077/ South Ferriby- eastern point	10.14	-9.73	-5.26
			East Clough- Western Point	12.96	-12.55	-6.78
			East Clough- Eastern Point	10.66	-10.25	-5.54
			Paull	1.75	-1.34	-0.73
			Halton Marshes	4.19	-3.78	-2.04
			Stallingborough	17.1	-16.69	-9.01
			Hawkins Point	18.99	-18.58	-10.03
			Donna Nook	40.9	-40.49	-21.87
IOTA Turning Areas	HU080	1.29	Swinefleet	56.39	-55.10	-29.75
			Saltmarshe	53.71	-52.42	-28.30
			Reedness	52.22	-50.93	-27.50
			Whitgift Bank	48.06	-46.77	-25.25
			Whitton Ness	41.42	-40.13	-21.67
			Winteringham haven	35.12	-33.83	-18.27
			A1077/ South Ferriby- western point	32.05	-30.76	-16.61
			A1077/ South Ferriby- eastern point	25.83	-24.54	-13.25

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			East Clough- Western Point	28.65	-27.36	-14.77
			East Clough- Eastern Point	26.35	-25.06	-13.53
			Paull	14.51	-13.22	-7.14
			Halton Marshes	13.6	-12.31	-6.65
			Stallingborough	2.42	-1.13	-0.61
			Hawkins Point	0.7	0.59	0.32
			Donna Nook	23.54	-22.25	-12.01
IOTA SDC	SDC C	1.32	Swinefleet	60.51	-59.19	-31.96
			Saltmarshe	57.83	-56.51	-30.51
			Reedness	56.34	-55.02	-29.71
			Whitgift Bank	52.18	-50.86	-27.46
			Whitton Ness	45.54	-44.22	-23.88
			Winteringham haven	39.24	-37.92	-20.48
			A1077/ South Ferriby- western point	36.17	-34.85	-18.82
			A1077/ South Ferriby- eastern point	29.95	-28.63	-15.46
			East Clough- Western Point	32.77	-31.45	-16.98
			East Clough- Eastern Point	30.47	-29.15	-15.74
			Paull	17.68	-16.36	-8.83
			Halton Marshes	14.2	-12.88	-6.95
			Stallingborough	6.23	-4.91	-2.65
			Hawkins Point	2.11	-0.79	-0.43
			Donna Nook	18.98	-17.66	-9.54
IOTA Hawke Channel	Bull Sand Fort	11.89	Swinefleet	60.51	-48.62	-26.25
			Saltmarshe	57.83	-45.94	-24.81
			Reedness	56.34	-44.45	-24.00
			Whitgift Bank	52.18	-40.29	-21.75
			Whitton Ness	45.54	-33.65	-18.17
			Winteringham haven	39.24	-27.35	-14.77
			A1077/ South	36.17	-24.28	-13.11

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			Ferriby- western point			
			A1077/ South Ferriby- eastern point	29.95	-18.06	-9.75
			East Clough- Western Point	32.77	-20.88	-11.27
			East Clough- Eastern Point	30.47	-18.58	-10.03
			Paull	17.68	-5.79	-3.13
			Halton Marshes	14.2	-2.31	-1.25
			Stallingborough	6.23	5.66	3.06
			Hawkins Point	2.11	9.78	5.28
			Donna Nook	18.98	-7.09	-3.83
IOTA Chequer Shoal	Bull Sand Fort Extension	4.98	Swinefleet	75.19	-70.21	-37.91
			Saltmarshe	72.51	-67.53	-36.46
			Reedness	71.02	-66.04	-35.66
			Whitgift Bank	66.86	-61.88	-33.41
			Whitton Ness	60.22	-55.24	-29.83
			Winteringham haven	53.92	-48.94	-26.43
			A1077/ South Ferriby- western point	50.85	-45.87	-24.77
			A1077/ South Ferriby- eastern point	44.63	-39.65	-21.41
			East Clough- Western Point	47.45	-42.47	-22.93
			East Clough- Eastern Point	45.15	-40.17	-21.69
			Paull	35.83	-30.85	-16.66
			Halton Marshes	31.73	-26.75	-14.44
			Stallingborough	19.46	-14.48	-7.82
			Hawkins Point	17.92	-12.94	-6.99
			Donna Nook	7.81	-2.83	-1.53
IOTA Eastern Approaches (2)	Bull sand Fort	4.96	Swinefleet	79.7	-74.74	-40.36

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			Saltmarshe	77.02	-72.06	-38.91
			Reedness	75.53	-70.57	-38.10
			Whitgift Bank	71.37	-66.41	-35.86
			Whitton Ness	64.73	-59.77	-32.27
			Winteringham haven	58.43	-53.47	-28.87
			A1077/ South Ferriby- western point	55.36	-50.40	-27.21
			A1077/ South Ferriby- eastern point	49.14	-44.18	-23.86
			East Clough- Western Point	51.96	-47.00	-25.38
			East Clough- Eastern Point	49.66	-44.70	-24.14
			Paull	40.42	-35.46	-19.15
			Halton Marshes	36.27	-31.31	-16.91
			Stallingborough	24.04	-19.08	-10.30
			Hawkins Point	22.44	-17.48	-9.44
			Donna Nook	9.58	-4.62	-2.49
Grimsby Berth	SDC B	3.86	Swinefleet	60.5	-56.64	-30.58
			Saltmarshe	57.82	-53.96	-29.14
			Reedness	56.33	-52.47	-28.33
			Whitgift Bank	52.17	-48.31	-26.09
			Whitton Ness	45.53	-41.67	-22.50
			Winteringham haven	39.23	-35.37	-19.10
			A1077/ South Ferriby- western point	36.16	-32.30	-17.44
			A1077/ South Ferriby- eastern point	29.94	-26.08	-14.08
			East Clough- Western Point	32.76	-28.90	-15.60
			East Clough- Eastern Point	30.46	-26.60	-14.36
			Paull	17.95	-14.09	-7.61
			Halton Marshes	16.86	-13.00	-7.02
			Stallingborough	3.89	-0.03	-0.02
			Hawkins Point	4.91	-1.05	-0.57

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			Donna Nook	21.63	-17.77	-9.60
Grimsby Turning Area	Burcom Sand	1.55	Swinefleet	61.443	-59.89	-32.34
			Saltmarshe	58.763	-57.21	-30.89
			Reedness	57.273	-55.72	-30.09
			Whitgift Bank	53.113	-51.56	-27.84
			Whitton Ness	46.473	-44.92	-24.26
			Winteringham haven	40.173	-38.62	-20.85
			A1077/ South Ferriby- western point	37.103	-35.55	-19.20
			A1077/ South Ferriby- eastern point	30.883	-29.33	-15.84
			East Clough- Western Point	33.703	-32.15	-17.36
			East Clough- Eastern Point	31.403	-29.85	-16.12
			Paull	19	-17.45	-9.42
			Halton Marshes	4.84	-3.29	-1.78
			Stallingborough	4.83	-3.28	-1.77
			Hawkins Point	4.99	-3.44	-1.86
			Donna Nook	20.81	-19.26	-10.40
Grimsby Approach	Burcom Sand	1.77	Swinefleet	62.263	-60.49	-32.66
			Saltmarshe	59.583	-57.81	-31.22
			Reedness	58.093	-56.32	-30.41
			Whitgift Bank	53.933	-52.16	-28.17
			Whitton Ness	47.293	-45.52	-24.58
			Winteringham haven	40.993	-39.22	-21.18
			A1077/ South Ferriby- western point	37.923	-36.15	-19.52
			A1077/ South Ferriby- eastern point	31.703	-29.93	-16.16
			East Clough- Western Point	34.523	-32.75	-17.69
			East Clough-	32.223	-30.45	-16.44

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			Eastern Point			
			Paull	19.92	-18.15	-9.80
			Halton Marshes	20.05	-18.28	-9.87
			Stallingborough	5.85	-4.08	-2.20
			Hawkins Point	5.38	-3.61	-1.95
			Donna Nook	18.93	-17.16	-9.27
Able	Middle Shoal	12.63	Swinefleet	47.96	-35.33	-19.08
			Saltmarshe	45.24	-32.61	-17.61
			Reedness	43.84	-31.21	-16.85
			Whitgift Bank	40.44	-27.81	-15.02
			Whitton Ness	33.2	-20.57	-11.11
			Winteringham haven	29.35	-16.72	-9.03
			A1077/ South Ferriby- Western point	28.94	-16.31	-8.81
			A1077/ South Ferriby- Eastern point	24.43	-11.80	-6.37
			East Clough- Western Point	24.91	-12.28	-6.63
			East Clough- Eastern Point	26.09	-13.46	-7.27
			Paull	8.08	4.55	2.46
			Halton Marshes	5.2	7.43	4.01
			Stallingborough	9.37	3.26	1.76
			Hawkins Point	10.75	1.88	1.02
			Donna Nook	33.43	-20.80	-11.23
			Cherry Cobb Sands	4.6	8.03	4.34
GPH	Hull Middle	1.26	Swinefleet	38.89	37.63	20.32
			Saltmarshe	36.39	35.13	18.97
			Reedness	34.19	32.93	17.78
			Whitgift Bank	33.25	31.99	17.27
			Whitton Ness	24.65	23.39	12.63
			Winteringham haven	19.92	18.66	10.08
			A1077/ South Ferriby- Western point	19.52	18.26	9.86
			A1077/ South	14.81	13.55	7.32

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			Ferriby- Eastern point			
			East Clough- Western Point	16.63	15.37	8.30
			East Clough- Eastern Point	15.47	14.21	7.67
			Paull	4.8	3.54	1.91
			Halton Marshes	6	4.74	2.56
			Stallingborough	19.42	18.16	9.81
			Hawkins Point	20.81	19.55	10.56
			Donna Nook	43.68	42.42	22.91

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Appendix J Additional Distances from the Maintenance Dredge Sites to the Sites of Potential Uses

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Appendix J Additional Distances from the Maintenance Dredge Sites to the Sites of Potential Uses

Maintenance Area	Closest Disposal	Distance/ km	Area under Threat of erosion	Distance	Difference/ km	Difference/ nm
North Killingholme	Clay Huts	1.62	Swinefleet	52.16	-20.54	-27.29
			Saltmarshe	48.18	-47.19	-25.48
			Reedness	47.3	-45.68	-24.67
			Whitgift Bank	42.8	-41.18	-22.24
			Whitton Ness	35.88	-34.26	-18.50
			Winteringham haven	31.79	-30.17	-16.29
			A1077/ South Ferriby- western point	28.62	-27	-14.58
			A1077/ South Ferriby- eastern point	28	-26.38	-14.24
			East Clough- Western Point	27.18	-25.56	-13.80
			East Clough- Eastern Point	26.69	-25.07	-13.54
			Paull	10.89	-9.27	-5.01
			Halton Marshes	7.98	-6.36	-3.43
			Stallingborough	7.97	-6.35	-3.43
			Hawkins Point	8.05	-6.43	-3.47
			Donna Nook	31.5	-29.88	-16.13
Port of Hull Alex Dock	Hull Middle Hook	0.8	Swinefleet	39.29	-38.49	-20.78
			Saltmarshe	36.7	-35.9	-19.38
			Reedness	35.7	-34.9	-18.84
			Whitgift Bank	31.9	-31.1	-16.79
			Whitton Ness	25.01	-24.21	-13.07
			Winteringham haven	20.65	-19.85	-10.72
			A1077/ South Ferriby- western point	20.16	-19.36	-10.45
			A1077/ South Ferriby- eastern point	15.72	-14.92	-8.06
			East Clough- Western Point	17.29	-16.49	-8.90
			East Clough- Eastern Point	16.18	-15.38	-8.30
			Paull	4.86	-4.06	-2.19
			Halton Marshes	6.75	-5.95	-3.21
			Stallingborough	19.26	-18.46	-9.97
			Hawkins Point	20.6	-19.8	-10.69
			Donna Nook	42.71	-41.91	-22.63

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Port of Hull KGD	Hull Middle	0.96	Swinefleet	48.4	-47.44	-25.62
			Saltmarshe	45.8	-44.84	-24.21
			Reedness	44.5	-43.54	-23.51
			Whitgift Bank	32.05	-31.09	-16.79
			Whitton Ness	27.32	-26.36	-14.23
			Winteringham haven	23.76	-22.8	-12.31
			A1077/ South Ferriby- western point	22.37	-21.41	-11.56
			A1077/ South Ferriby- eastern point	16.43	-15.47	-8.35
			East Clough- Western Point	17.85	-16.89	-9.12
			East Clough- Eastern Point	16.43	-15.47	-8.35
			Paull	3.6	-2.64	-1.43
			Halton Marshes	5.7	-4.74	-2.56
			Stallingborough	18.52	-17.56	-9.48
			Hawkins Point	19.86	-18.9	-10.21
			Donna Nook	27.17	-26.21	-14.15
Port of Hull Albert Dock	Hull Middle	3.5	Swinefleet	37.21	-33.71	-18.20
			Saltmarshe	34.78	-31.28	-16.89
			Reedness	33.37	-29.87	-16.13
			Whitgift Bank	29.21	-25.71	-13.88
			Whitton Ness	22.97	-19.47	-10.51
			Winteringham haven	17.91	-14.41	-7.78
			A1077/ South Ferriby- western point	17.47	-13.97	-7.54
			A1077/ South Ferriby- eastern point	13.73	-10.23	-5.52
			East Clough- Western Point	14.52	-11.02	-5.95
			East Clough- Eastern Point	13.31	-9.81	-5.30
			Paull	7.31	-3.81	-2.06
			Halton Marshes	8.37	-4.87	-2.63
			Stallingborough	21.1	-17.6	-9.50
			Hawkins Point	22.52	-19.02	-10.27
			Donna Nook	46.53	-43.03	-23.23
Immingham Bulk Terminal East	Clay Huts	1.13	Swinefleet	51.93	-50.8	-27.43

			Saltmarshe	48.58	-47.45	-25.62
			Reedness	47.07	-45.94	-24.81
			Whitgift Bank	42.57	-41.44	-22.38
			Whitton Ness	35.65	-34.52	-18.64
			Winteringham haven	31.56	-30.43	-16.43
			A1077/ South Ferriby- western point	28.39	-27.26	-14.72
			A1077/ South Ferriby- eastern point	27.77	-26.64	-14.38
			East Clough- Western Point	26.95	-25.82	-13.94
			East Clough- Eastern Point	26.46	-25.33	-13.68
			Paull	10.66	-9.53	-5.15
			Halton Marshes	7.75	-6.62	-3.57
			Stallingborough	7.74	-6.61	-3.57
			Hawkins Point	7.82	-6.69	-3.61
			Donna Nook	31.27	-30.14	-16.27
Port Of Grimsby Royal Dock Lock	Burcom Sand	1.69	Swinefleet	69.09	-67.4	-36.39
			Saltmarshe	66.49	-64.8	-34.99
			Reedness	65.08	-63.39	-34.23
			Whitgift Bank	53.46	-51.77	-27.95
			Whitton Ness	46.02	-44.33	-23.94
			Winteringham haven	41.7	-40.01	-21.60
			A1077/ South Ferriby- western point	41.29	-39.6	-21.38
			A1077/ South Ferriby- eastern point	36.91	-35.22	-19.02
			East Clough- Western Point	38.36	-36.67	-19.80
			East Clough- Eastern Point	37.08	-35.39	-19.11
			Paull	13.35	-11.66	-6.30
			Halton Marshes	19.04	-17.35	-9.37
			Stallingborough	5.72	-4.03	-2.18
			Hawkins Point	5.67	-3.98	-2.15
			Donna Nook	21.13	-19.44	-10.50
Port of Grimsby No 1 Dock	Burcom Sand	1.8	Swinefleet	69.65	-67.85	-36.64
			Saltmarshe	67.05	-65.25	-35.23
			Reedness	65.64	-63.84	-34.47

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			Whitgift Bank	54.02	-52.22	-28.20
			Whitton Ness	46.58	-44.78	-24.18
			Winteringham haven	42.26	-40.46	-21.85
			A1077/ South Ferriby- western point	41.85	-40.05	-21.63
			A1077/ South Ferriby- eastern point	37.47	-35.67	-19.26
			East Clough- Western Point	38.92	-37.12	-20.04
			East Clough- Eastern Point	37.64	-35.84	-19.35
			Paull	13.91	-12.11	-6.54
			Halton Marshes	19.6	-17.8	-9.61
			Stallingborough	6.28	-4.48	-2.42
			Hawkins Point	6.23	-4.43	-2.39
			Donna Nook	21.69	-19.89	-10.74
Port of Goole Ocean Lock	Whitgift Bight	0.95	Swinefleet	3.17	-2.22	-1.20
			Saltmarshe	5.68	-4.73	-2.55
			Reedness	7.12	-6.17	-3.33
			Whitgift Bank	11.07	-10.12	-5.46
			Whitton Ness	17.86	-16.91	-9.13
			Winteringham haven	23.64	-22.69	-12.25
			A1077/ South Ferriby- western point	29.85	-28.9	-15.60
			A1077/ South Ferriby- eastern point	30.97	-30.02	-16.21
			East Clough- Western Point	34.28	-33.33	-18.00
			East Clough- Eastern Point	33.04	-32.09	-17.33
			Paull	51.38	-50.43	-27.23
			Halton Marshes	52.61	-51.66	-27.89
			Stallingborough	65.37	-64.42	-34.78
			Hawkins Point	66.78	-65.83	-35.55
			Donna Nook	89.82	-88.87	-47.99
Port of Goole Victoria Lock	Whitgift Bight	1.32	Swinefleet	3.6	-2.28	-1.23
			Saltmarshe	6.11	-4.79	-2.59
			Reedness	7.55	-6.23	-3.36
			Whitgift Bank	11.5	-10.18	-5.50
			Whitton Ness	18.29	-16.97	-9.16
			Winteringham	24.07	-22.75	-12.28

			haven			
			A1077/ South Ferriby- western point	30.28	-28.96	-15.64
			A1077/ South Ferriby- eastern point	31.4	-30.08	-16.24
			East Clough- Western Point	34.71	-33.39	-18.03
			East Clough- Eastern Point	33.47	-32.15	-17.36
			Paull	51.81	-50.49	-27.26
			Halton Marshes	53.04	-51.72	-27.93
			Stallingborough	65.8	-64.48	-34.82
			Hawkins Point	67.21	-65.89	-35.58
			Donna Nook	90.25	-88.93	-48.02
Port of Immingham Dock	Clay Huts	1.39	Swinefleet	51.93	-50.54	-27.29
			Saltmarshe	48.58	-47.19	-25.48
			Reedness	47.07	-45.68	-24.67
			Whitgift Bank	42.57	-41.18	-22.24
			Whitton Ness	35.65	-34.26	-18.50
			Winteringham haven	31.56	-30.17	-16.29
			A1077/ South Ferriby- western point	28.39	-27	-14.58
			A1077/ South Ferriby- eastern point	27.77	-26.38	-14.24
			East Clough- Western Point	26.95	-25.56	-13.80
			East Clough- Eastern Point	26.46	-25.07	-13.54
			Paull	10.66	-9.27	-5.01
			Halton Marshes	7.75	-6.36	-3.43
			Stallingborough	7.74	-6.35	-3.43
			Hawkins Point	7.82	-6.43	-3.47
			Donna Nook	31.27	-29.88	-16.13

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Tidal River Development

Appendix K Summary of the Proposed Developments on the Humber Estuary that Include Capital Dredging.

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Appendix K Summary of the Proposed Developments on the Humber Estuary that Include Capital Dredging.

This appendix gives a brief summary of the proposed developments on the Humber Estuary that will result in capital dredging. The locations of these developments are shown in figure A18.

Hull Riverside Bulk Terminal (HRBT)

Associated British Ports (ABP) identified the need to build a new facility for receiving and handling of dry bulk cargoes such as coal and biomass, for use in power stations, at the Port of Hull. It would involve dredging at the approach Halton Middle and the dredging of the proposed berth pocket for vessels with draughts of 10-14m to berth. It will be located to the east of King George and Queen Elizabeth Docks.

This application has been submitted but has been deferred as the customer that required this project has gone elsewhere, therefore at the present this study cannot presume the combination of this project with any other current project that is either under application or consented. Instead, this study will assess the likelihood of the potential use of dredged material in isolation.

Immingham Oil Terminal Approach (IOTA)

ABP have identified the need to deepen the approaches to the Immingham Oil Terminal (IOT) as at present the access to IOT is limited to vessels with a 13.2m draught due to the SDC. With the proposed deepening of the approaches, the IOT would be able to accommodate vessels with 15m draughts, thereby enhancing the ports ability to actively compete within the market.

Grimsby Ro/Ro Jetty

ABP have identified the need to construct a roll-on roll-off (Ro-Ro) berth at the Port of Grimsby to accommodate larger vessels that cannot be accommodated within the dock due to the restrictions of the lock. Dredging will take place at the berth, approaches and turning areas in order to allow the vessels to remain berthed at low water without grounding.

Able Marine Energy Park

Able UK has identified the need for an offshore wind turbine manufacturing and export facility on the south bank of the Humber Estuary. This development is known as the Able UK Marine Energy Park (AMEP) and will incorporate a 245ha of reclaimed land for the manufacture of wind turbine components including the foundations and an area of 55 ha of reclaimed estuary for a quay measuring over 1200m and that extends for approximately 400m into the estuary for the import of wind turbine components and the export of partially or fully erected wind turbines for transport to the offshore wind farms.
Capital dredging will occur for the new quay, berths, approach and turning circles to ensure the large wind installation vessels can safely navigate to the quay and remain there during low tides.

Green Port Hull

ABP and Siemens Ltd have identified the need for an offshore wind turbine manufacturing facility at Alexandra Dock at the Port of Hull. This development is known as Green Port Hull and was submitted to the Kingston Upon Hull City council in December 2011. The development will incorporate approximately 56ha of the dock to be redeveloped for Siemens. All buildings will be demolished and part of the dock will be infilled to create additional storage space for the

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wind turbines and components. In place of the buildings there will be a factory (for the production of nacelles), offices, vessel crew facility, security buildings and associated infrastructure.

In addition, ABP already have consent for a new in river quay and two berths for a container terminal but need permission to do so. They are also applying for the widening of the berths and an additional berth to be able to accommodate three wind installation vessels. The in river berths are important as these cannot fit through the locks at the Port of Hull.

Capital dredging will be needed for the new quay and the three berths, although some of the dredged material from the two consented berths will be used as infill for the infill of Alexandra Dock.

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