

8.1 INTRODUCTION

8.1.1 This chapter examines the likely significant effects of AMEP on the hydrodynamic and sedimentary regime of the Humber Estuary. The development of AMEP will cause an alteration of the local estuary shoreline and bathymetry, which may lead to changes to existing estuarine processes both in close proximity to AMEP and potentially remotely. This chapter evaluates the potential effects of AMEP in terms of physical processes (for example changes to hydrodynamics, sediment transport, waves and geomorphology) and its findings have been used to inform the impact assessment that is reported in other chapters of the ES.

8.1.2 The Humber Estuary is a dynamic estuarine environment with complex hydrodynamic processes controlling local and wider scale sediment transport processes. The nature of these hydrodynamic processes is determined by a range of factors including the local and general estuary morphology, wave climate, tidal range and freshwater inputs. Additionally, the Humber Estuary contains numerous man-made structures that change the flow and sediment patterns. The components of AMEP comprise a solid reclamation and quay that will protrude from the flood defence wall into the intertidal and sub-tidal area, and dredging of the surrounding bathymetry for shipping access. The development will therefore result in an alteration of the local estuary morphology at Killingholme.

8.1.3 Impacts of the associated Compensation Site on the hydrodynamic and sedimentary regime are not included in this chapter as these are addressed in *Chapter 32*.

8.1.4 This chapter has been informed by four technical assessments including numerical modelling studies:

- Annex 8.1 AMEP Estuary Modelling Studies (*JBA Consulting, 2011a*)
- Annex 8.2 Review of Geomorphological Dynamics of the Humber Estuary (*JBA Consulting, 2011b*);
- Annex 8.3 Able Marine Energy Park 3D Mud Modelling (*HR Wallingford, 2011a*)

- Annex 8.4 Able Marine Energy Park – Dredging Plume Dispersion Arising From Capital Works (*HR Wallingford, 2011b*)

8.1.5 During the course of undertaking these studies, the design of the AMEP has evolved (as described in *Annex 4.4*). The impacts presented in this chapter are informed by hydrodynamic and sediment modelling results for different iterations of the scheme. In all cases where the impacts are based upon an earlier layout for AMEP, these relate to a larger scheme set forward further into the estuary. For clarity, the different layouts are shown in *Figure 8.1*. *Table 8.1* lists the model layouts used to inform the various impacts presented in this chapter.

Figure 8.1 *AMEP Layouts (including original (or preliminary) design, an intermediate layout (Layout 1b) and the final layout) used in the modelling of impacts*

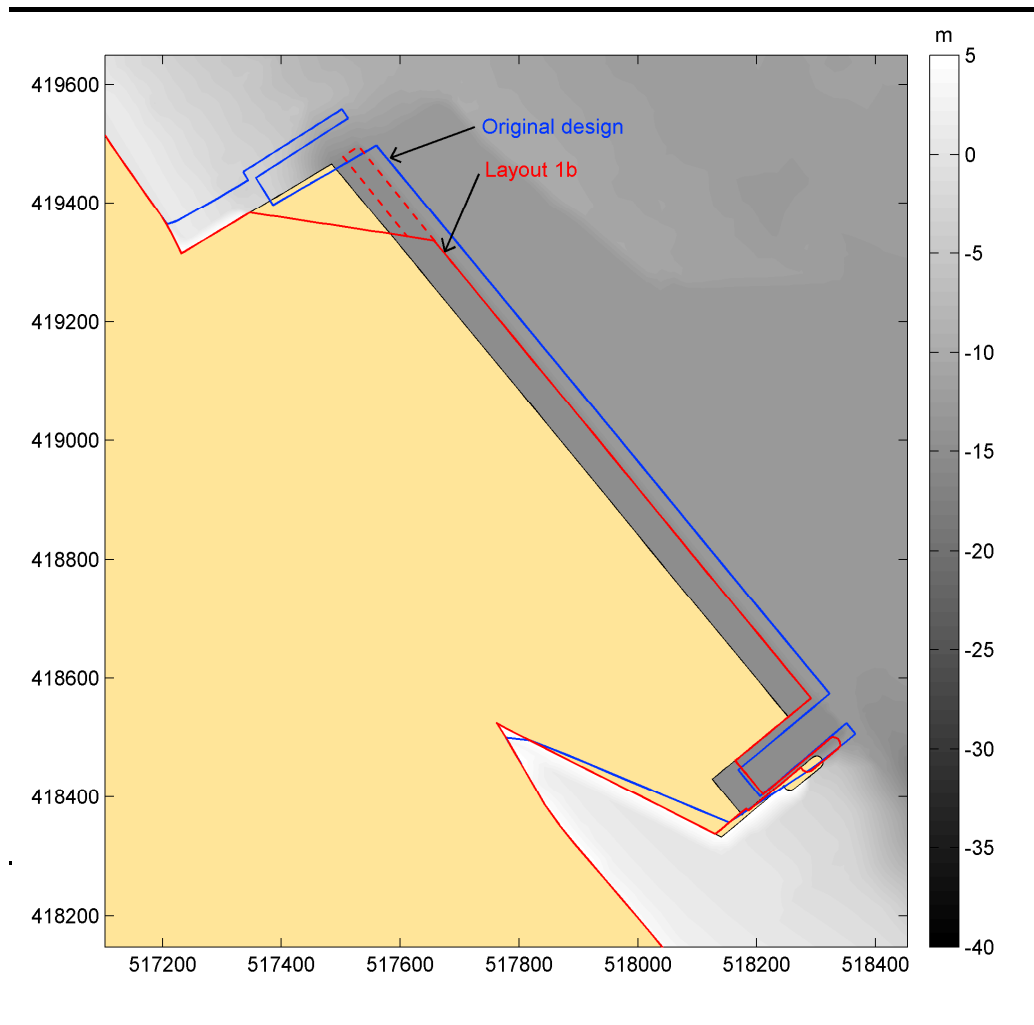


Table 8.1 *AMEP layouts modelled for the assessment of impacts*

Annex	Impact	Model Layout
8.1	Tidal levels	Original
8.1	Tidal currents	Original
8.1	Waves	Original
8.1	Sand transport	Original
8.1	Plume dispersal from dredge disposal site	Original
8.2	Estuary geomorphology	Original
8.3	Fine sediment transport	Final
8.3	Infill / sedimentation	Final
8.3	Longer term change to morphology	Layout 1b
8.3	Drainage channel formation on intertidal	Final
8.4	Plume dispersal from construction activities at the AMEP	Layout 1b*

* Impacts were revised to relate to the dredged quantities for the final AMEP layout but the model used Layout 1b.

8.2 *LEGISLATION, POLICY AND GUIDANCE*

8.2.1 There are no specific Directives or legislation governing solely the areas of hydrodynamics or the sedimentary regime. Legislation, guidance and policy documents are generally directed towards either the ecological, chemical or human environment. Changes to the hydrodynamic and sedimentary regime have the potential to impact on these other receptors, and these effects are addressed in other chapters in this report, for example *Chapter 10* on Aquatic Ecology and *Chapter 14* on Commercial and Recreational Navigation. However, the Water Framework Directive recognises the link between hydromorphological characteristics and ecological quality by defining a series of hydromorphological quality elements that support the biological quality elements. These hydromorphological quality elements include parameters reflecting morphological conditions and tidal regime and, to comply with the Water Framework Directive, it is necessary for each parameter to achieve good status. Further information on the requirements of the Water Framework Directive can be found in *Chapter 9* on Water and Sediment Quality and in the supporting Water Framework Directive Assessment in *Annex 9.4*.

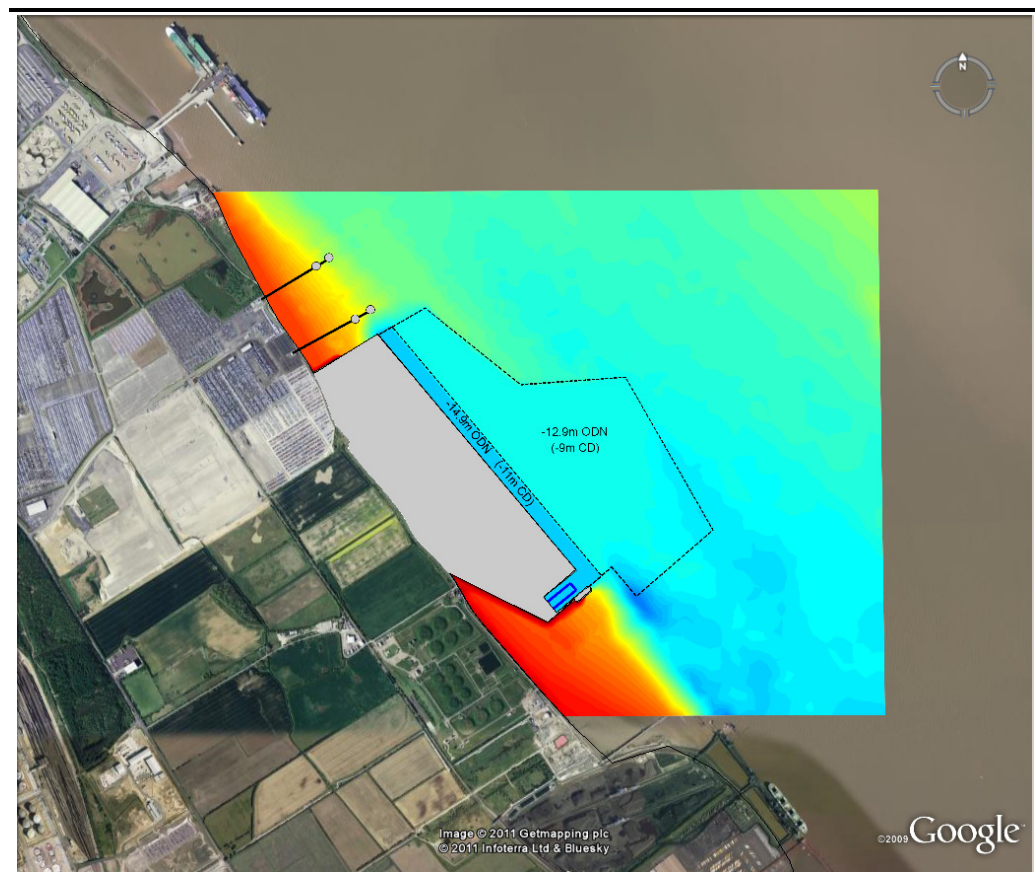
8.2.2 There are a number of plans and guidance documents that are of some relevance to the hydrodynamic and sedimentary regime; these are detailed below, and where appropriate are taken into account in this chapter.

- 8.2.3 The *Humber Estuary Management Scheme Annex D* (Environment Agency, 2004) provides guidance on the noted effects of dredging and their significance in the estuary.
- 8.2.4 The *Humber Maintenance Dredging Baseline Document* (ABP Humber Estuary Services, 2008) provides information on the current maintenance dredging regime including quantities and locations of disposed material in the estuary.
- 8.2.5 The *Humber Estuary Coastal Habitat Management Plan (CHaMP)* (Environment Agency, 2005) provides mechanisms for delivering flood and coastal defence schemes which comply with the requirements of the Habitats Directive.
- 8.2.6 The *Humber Flood Risk Management Strategy: Planning for the Rising Tides* (Environment Agency, 2008) sets out the Environment Agency's strategy for managing the flood defences of the Humber Estuary over the next 100 years.
- 8.2.7 The *Humber Estuary Coastal Authorities Group Flamborough Head to Gibraltar Point Shoreline Management Plan: Consultation Draft* (Scott Wilson, 2009) provides a plan for managing flood and erosion risk for the area of coastline encompassing the outer Humber Estuary. This plan details the development of a sustainable management approach and looks at the short, medium and long term.
- 8.2.8 The *East Riding of Yorkshire Biodiversity Action Plan*, the *Lincolnshire Biodiversity Action Plan* and the *Hull Biodiversity Action Plan* all aim to actively conserve priority habitats and species locally.
- 8.2.9 Guidance and best practice for the calibration and validation of hydrodynamic models used to simulate estuarine processes is provided by the Environment Agency technical report, *Quality Control Manual for Computational Estuarine Modelling* (Bartlett, 1998).
- 8.2.10 Guidance and best practice for predicting morphological change in estuaries is provided in the EA / Defra / Natural England report, *A Guide to the Prediction of Morphological Change within Estuarine Systems* (Emphasys Consortium, 2000).

Overview

- 8.3.1 An assessment of the effects of AMEP on hydrodynamic and sedimentary processes has been carried out using appropriate numerical modelling tools. This section provides an overview of the modelling techniques utilised, which include hydrodynamic modelling, sediment transport modelling, sediment plume modelling and nearshore wave transformation modelling. The modelling has been used to simulate the baseline conditions in hydrodynamic and sedimentary processes in the Humber Estuary, and subsequently to determine and quantify the predicted effects of AMEP on these baseline conditions. Detailed descriptions of the development of the models are provided in JBA Consulting (2011a & b) and HR Wallingford (2011a & b), *Annexes 8.1, 8.2, 8.3 and 8.4*. The final layout of the AMEP is shown in *Figure 8.2*. As noted in *Paragraph 8.1.5* above, this layout was developed after several iterations at different stages of the studies. Although the studies relate to different layouts, the final proposal mitigates impacts when compared with the larger earlier layouts.

Figure 8.2 *Representation of AMEP in the cohesive sediment modelling (Annex 8.3), showing main features, dredged areas, and locations of intakes/ outfalls.*



- 8.3.2 For the purpose of reporting, the impact assessment is activity led and has been divided into activities that will occur during construction and operation of the AMEP.

Construction Phase

Impact assessment of dredge disposal

- 8.3.3 The construction of the AMEP requires capital dredging and reclamation. In order to examine the likely fate of any sediment plumes resulting from the dredging, reclamation and disposal, a Particle Tracking Model (PTM) was used. The model contains algorithms that appropriately represent transport, settling, deposition, mixing, and re-suspension processes in nearshore conditions. The model tracks the fate of sediment in a specified hydrodynamic flow field after being released from a source. The model was used to assess the effects of disposal of dredged materials at the HU080 disposal ground, see *Figure 8.3*.

Impact assessment of dredging and reclamation works

- 8.3.4 Construction will require the following activities: dredging of alluvium from the reclamation area; excavation of flap anchor trench; combi-piling of the reclamation site; rainbowing of selected fill over the flap anchors and hydraulic fill of the reclamation site; dredging of the berth pocket and turning area. Further details may be found in the Dredging Strategy, *Annex 7.6*.
- 8.3.5 Construction impacts will include changes to water levels, flow speeds, morphology, and suspended sediment concentrations. Changes to flow speeds and water levels during construction will be less than when the AMEP is operational (as will direct impacts on morphology) and so no further assessment is required. Indirect construction impacts on morphology and impacts on suspended sediment concentrations do require assessment. The main elements of the required assessment are outlined below.
- 8.3.6 Impacts of construction activities around the proposed reclamation site have been assessed through plume dispersion modelling. The assessment focusses on the potential (temporary) elevation of suspended sediment concentrations arising from the proposed dredging and reclamation activities.

Operational Phase

Hydrodynamic Modelling

- 8.3.7 An investigation of the impacts of the AMEP on hydrodynamic processes within the Humber Estuary has been carried out using computer modelling techniques (*Annexes 8.1, 8.2 and 8.3*).
- 8.3.8 Two and three dimensional (2D and 3D) hydrodynamic numerical models were constructed, calibrated and validated in order to simulate baseline flows within the estuary. The model grid extends from Spurn Head to Trent Falls.
- 8.3.9 Alterations to the model grid were made to incorporate the changes represented by the AMEP. Comparisons between the results of model simulations using this grid with those of the baseline model reveal the predicted effects of the scheme on estuarine hydrodynamic processes.

Wave Modelling

- 8.3.10 Simulation of waves within the Humber Estuary was performed using a phase-averaged, 2D wave spectral transformation model. The model calculates the shallow water wave transformation processes of depth-induced wave refraction and shoaling, current induced refraction and shoaling, depth and steepness-induced wave breaking, wind-wave growth, wave-wave interaction, and white-capping. Diffraction and wave reflection processes are approximated by the model, as opposed to being explicitly simulated.

Sediment Transport Modelling

- 8.3.11 Simulations of both sandy and muddy material were undertaken with sediment transport models. Initially a non-cohesive Sediment Transport (ST) model was used (*Annex 8.1*) to simulate patterns of sediment erosion and deposition within the Humber Estuary. This model was used to investigate the potential impacts of the AMEP as previously defined in the PEIR (original layout) on morphological patterns driven by non-cohesive processes. The ST model was also used to provide initial estimates of the maintenance dredging requirements for the AMEP berth, and potential changes to third party maintenance dredging requirements in the vicinity of the AMEP. Subsequent to this assessment the AMEP quay was set back 80 m towards the land.
- 8.3.12 After the non-cohesive modelling was complete, a 3D mud (cohesive) transport model was used (*Annex 8.3*), together with desk assessments,

to predict likely changes to sedimentation patterns around the AMEP development. This further modelling complemented the initial non-cohesive modelling undertaken by JBA Consulting and expert geomorphological assessment is used in this chapter to interpret the overall conclusions.

- 8.3.13 It should be noted that all sediment transport models involve a high level of uncertainty, particularly when used for the purposes of estimating morphological change.

Morphological Assessment

- 8.3.14 The sediment transport models have been used to inform predictions of future changes to morphology as a consequence of the AMEP. This has been supported by the use of expert geomorphological assessment (*Annexes 8.1, 8.2 and 8.3*).

Sensitive Receptors

- 8.3.15 There are a number of receptors that may be affected by changes to the hydrodynamic and sedimentary regime. These include sensitive environmental receptors such as intertidal mudflat and saltmarsh habitats, and operational receptors including vessels navigating in the vicinity of AMEP, nearby port facilities (Humber Sea Terminal, Humber Work Boats, South Killingholme Oil Jetty, Immingham Gas Jetty, Humber International Terminal, Immingham Bulk Terminal, Immingham Docks), and Centrica and E.ON power station intakes and outfalls.

Significance Criteria

- 8.3.16 This chapter defines the predicted changes to the hydrodynamic and sedimentary regime of the Humber Estuary resulting from the AMEP. As these are changes to processes rather than impacts on receptors it is not appropriate to assign significance levels. The approach adopted in this chapter is to describe and, where possible, quantify any predicted changes. The implications of the predicted changes to the hydrodynamic and sedimentary regime are assessed in terms of the significance of the potential impacts on various environmental parameters (e.g. aquatic ecology, water quality, commercial fisheries, etc.) in the relevant chapters of this ES. Similarly, any measures that may be required in order to mitigate a potential impact on a receptor arising from a predicted effect on the hydrodynamic and sedimentary regime of the estuary are described in the relevant chapters.

8.4 CONSULTATION

- 8.4.1 *Annex 2.2* summarises the responses from the consultation including those that are of relevance to the hydrodynamic and sedimentary regime, and explains how these matters have been addressed in this chapter.
- 8.4.2 Further consultation responses were received on earlier versions of *Annexes 8.1* and *8.2*. These comments were addressed in the present versions of these Annexes and a response log is provided in *Annex 8.1*.

8.5 BASELINE

Hydrodynamic Regime

Water levels

- 8.5.1 The Humber Estuary is a macro-tidal estuary with a spring tidal range of 6.0 - 7.0m at the site of the proposed AMEP. High water levels increase further upstream as tidal flows are constricted by the narrowing estuary. Mean High Water Spring levels at Goole are 1.3m above levels at the estuary mouth at Spurn Head. UKCP09 guidance on relative sea level rise at AMEP ranges from 0.22m (Low Emissions Scenario 5th percentile) to 0.90m (High Emissions Scenarion 95th percentile). Although this is the latest climate change guidance, this assessment used the more conservative recommendations in PPS 25 (revised Mar 2010) as advised by the EA.

Currents

- 8.5.2 Currents within the estuary are dominated by the tide. Upstream, the monthly average freshwater flow rate at Trent Falls of 250 m³/s has been estimated from Environment Agency data, with a variability of ± 110 m³/s (Townend and Whitehead, 2003). Observations of currents near to Killingholme used to calibrate the hydrodynamic model show that magnitudes can reach approximately 1.5 m/s offshore and 1.1 m/s in the nearshore zone during a modest spring tide (15th May 2010). Predictions of currents provided by the United Kingdom Hydrographic Office Admiralty TotalTide software, suggest ebb-flow dominance of current magnitudes throughout the middle estuary. Peak flows occur within the deeper channels of the estuary, with the greatest flow speeds of over 2.0 m/s occurring in Halton Middle, upstream of Killingholme between Halton Flats and Paull Sand.

Waves

- 8.5.3 The wave climate at South Killingholme is dictated by the local fetch lengths over which the wave-generating force of wind stress can act. Fetch lengths to the north bank are the shortest, with longer lengths upstream and downstream, leading to larger waves from these directions.
- 8.5.4 A still water level/wave height joint probability analysis study provides details of the prevailing wave climate at South Killingholme (ABPmer, 2007). An analysis of wave heights over a multi-year period highlighted the dominance of south-easterly waves, followed by waves propagating from the north-west in the direction of Hull.
- 8.5.5 Wave overtopping calculations were performed using values for water level, wave height and wave period specified in ABPmer (2007). Calculations were carried out for a range of return periods (1:2-year, 1:5-year, 1:10-year and 1:200-year) joint probability events, with 100 years of projected climate change added (i.e. 100 years of sea level rise and increased wave heights) in accordance with PPS25.

Bed shear stresses

- 8.5.6 The shear stresses experienced on the bed of the Humber Estuary determine the evolution of the morphology. Bed shear stresses are a result of both wave and current forcing, primarily through the friction they exert on the bed. The total bed shear stress consists of skin friction, form drag and the effects of sediment transport (via momentum transfer between grains). The stresses due to wave action are irregular and determined mainly by wind variability but also locally by ship wake. However the tidal currents within the estuary are far more predictable and regular. The large magnitudes of the currents in the deep channels of the estuary mean that their contribution to the bed shear stress dominates here. Wave-related bed shear stress is more significant in the shallower sub-tidal and inter-tidal areas.

Estuary Morphology

- 8.5.7 The sub-tidal bed of the Humber Estuary consists of silt, sand, gravel and boulder clay at different locations. In shallow subtidal and intertidal areas along the banks of the estuary the bed consists mostly of silt and fine sand. Particle size analysis of intertidal and sub-tidal bed material around the AMEP site has generally revealed surface sediments to comprise: muds on the upper intertidal areas; sandy muds

on the lower intertidal areas, and; sandy muds, muddy sands or slightly gravelly muddy sands on the subtidal areas (IECS, 2010a).

8.5.8 A recent site investigation involved the collection of multiple vibrocore samples from the site of the proposed scheme (Buro Happold, 2010). These showed a surface alluvium layer consisting of varied grain sizes, with median values equally distributed in the range 0.01mm to 0.3mm. A thin layer of sand and gravels was intermittently observed below this, with a thicker layer of stiff glacial till underneath, though this structure shows significant variation with location.

8.5.9 For the most part, the sub-tidal areas of the Outer Estuary (generally considered as the Estuary downstream of Grimsby) are predominantly sand. Further upstream more mixed sediments are typically found, often consisting of silty sand. On the lower intertidal the sediments generally consist of sandy silt, fining to silt at the higher levels.

Sedimentary regime

8.5.10 The water within the Humber Estuary contains very high concentrations of fine suspended sediment. On a given tide up to 1.2×10^6 T of sediment may be in the water column (Townend and Whitehead, 2003). Fluvial input amounts, on average, to 335 T of sediment per tide compared to the average tidal exchange of 1.2×10^5 T per tide at the mouth. Around 430 T per tide is deposited in the estuary with a net marine import of around 100 T per tide.

8.5.11 The sedimentation patterns are therefore dominated by tidal flow, with approximately only 3 percent of sediment entering the estuary originating from upstream. Much of the sediment entering the estuary from the mouth is returned to the sea on the ebb tide. However, a considerable amount is deposited across intertidal areas or shifted around sub tidally. An annual rate of infilling of between 2.6 and 6.6×10^5 m³ has been estimated (ABP Research, 1999).

8.5.12 There is a large degree of variability in the suspended sediment concentration (SSC) throughout the estuary. The position of the turbidity maximum varies seasonally between Hull and Selby depending on the balance of freshwater/tidal water flows (Uncles et al, 1998) and the availability of sediment is governed by the hydrodynamic and sediment transport processes, including wave dynamics, tidal asymmetry and salinity-induced circulation. British Transport Docks Board measurements (BTDB, 1970) report a range within the middle and outer estuary between 300 mg/l and 1 900 mg/l. Further upstream in the Upper Estuary concentrations regularly reach 5 000 mg/l (Uncles

et al., 1998). At times concentrations of up to 20 000 mg/l have been recorded in the system (ABPHES, 2008).

- 8.5.13 Maintenance dredge volumes in the Humber Estuary vary considerably from year to year. Between 1985 and 2007 the total mass of material dredged from and disposed into the estuary was in the range 9 to 17 million wet tonnes per annum (ABPHES, 2008). The Sunk Deep Channel (SDC) was originally dredged to allow deep-draughted vessels to use deep-water terminals at Immingham. It experiences significant annual variation in accumulated sediment, requiring an annual maintenance dredging ranging from none to 9 million tonnes per annum between 1985 and 2007. Maintenance dredge material at the 'Humber 3A' disposal site is mainly from material arising from dredging of Immingham Docks, jetties and terminals. Records show significant variation here also, with disposals in the range 1-7 million tonnes from 1985 to 2007. The Humber Maintenance Dredging Baseline Document (ABP Humber Estuary Services, 2008) states that there is no apparent trend in dredge volumes at Immingham.

8.6 *IMPACTS*

- 8.6.1 This section describes the predicted changes to the hydrodynamic and sedimentary regime as a result of the construction and operation of the AMEP. Impacts are divided into construction and operational phases, and are further broken down into hydrodynamic impacts and sedimentary impacts.

Construction Phase

- 8.6.2 The potential impacts on the hydrodynamic and sedimentary processes during the construction of AMEP are associated with the dispersion and deposition of material from dredging, disposal and reclamation activities.

Dispersion of sediment during capital dredging and reclamation

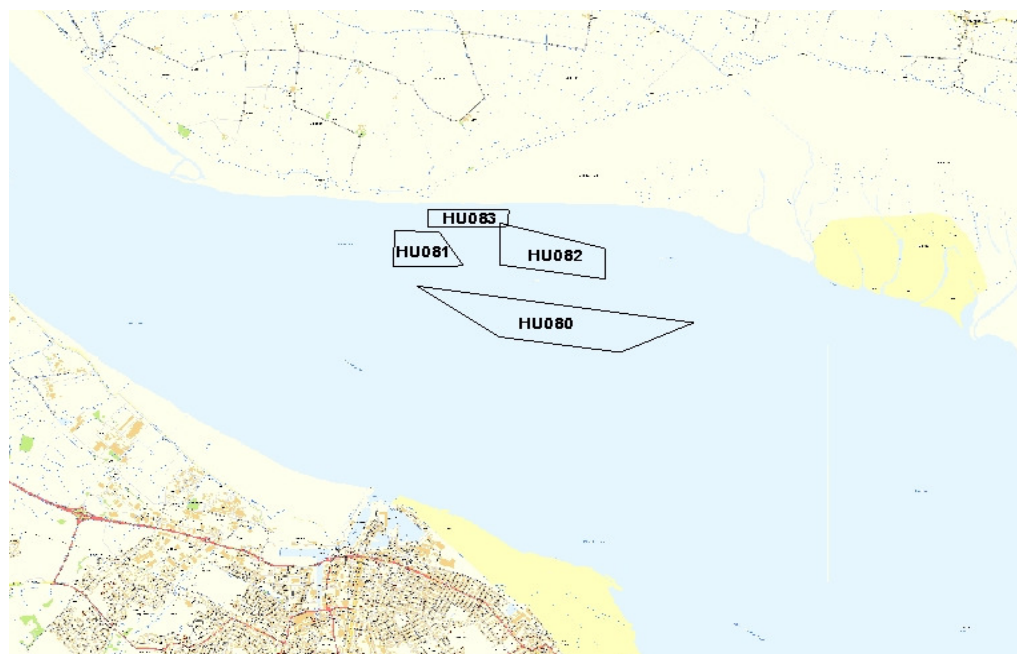
- 8.6.3 The construction of the AMEP requires a significant capital dredging operation. In total, and including the reclamation area, flap anchor trench, berths, approach channel, and turning area 1 935 500 m³ will be extracted from the estuary bed (*Annex 7.6*) and some material may be released back into the water column during the process. Therefore the dredging programme will lead to a temporary increase in sediment in the water column, which may travel from the dredging site to other areas of the estuary.

- 8.6.4 Various dredging methods will be applied to carry out the capital dredging and create the reclamation area for the AMEP. The erodible material is to be excavated using Trailing Suction Hopper Dredgers (TSHDs). Within the dredge area, the TSHD suction pipe is lowered to the seabed, the dredge pump is started and dredging commences. After dredging, the TSHD will sail to the licensed disposal area to discharge the load of dredged material by opening the bottom doors. Disposal of the dredged material will be carried out under the terms of the relevant marine licence(s).
- 8.6.5 The unerodible glacial till is to be dredged using a Backhoe Dredger (BHD), producing large lumps of stiff clay. These will be disposed of at sites to the north of the SDC.
- 8.6.6 In order to source material for the reclamation area, a TSHD will sail to a licensed marine aggregate area and dredge suitable material. For discharging the dredged material from a TSHD into the reclamation, several options are possible. For this project the following options are being proposed:
- Dumping the load by opening the bottom doors;
 - Rainbowing by means of pumping the load over the bow, through a nozzle;
 - Pumping the load through a floating and/or sinker pipeline to a reclamation area. Once above the low water mark, the sand is spread out using land based equipment
- 8.6.7 Full details of the proposed capital dredging programme can be found in the Dredging Strategy (*Annex 7.6*).

Dispersion of sediment during dredged material disposal

- 8.6.8 The material is to be disposed of in the estuary at specific disposal sites. The dredged material consists of erodible (soft clay, silt, sands and gravels, with an estimated total volume of 981 150 m³, *Annex 7.6*) and unerodible (glacial till) material with an estimated total volume of 954 350 m³ (*Annex 7.6*), which will be dumped at separate sites. Site HU080 (Middle Shoal) has been proposed as the disposal ground for the erodible material, whereas the sites HU081, HU082 and/or HU083 have been proposed as the unerodible material disposal site. The unerodible sites are to the north of the SDC and the erodible site, Middle Shoal, (HU080) is to the south see *Figure 8.3*.

Figure 8.3 *Proposed disposal sites in the Humber Estuary (©OS OpenData™), reproduced from Annex 8.1 (JBA, 2011)*



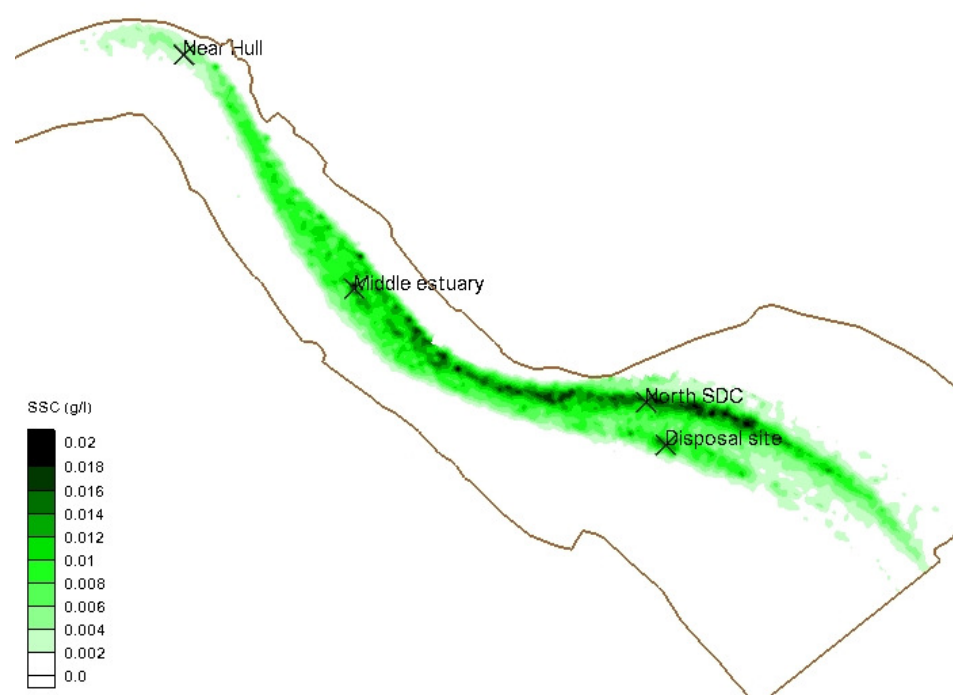
8.6.9 The unerodible glacial till is to be excavated using a backhoe dredger, producing large lumps of stiff clay. These will be disposed of at the sites to the north of the SDC. The disposal of the stiff glacial till clay at these sites is highly unlikely to add significantly to background SSCs due to the strongly cohesive nature of the material. The Environmental Statement prepared for the Hull Riverside Bulk Terminal proposal reported on monitoring of similar material disposed of at the site during the Immingham Outer Harbour dredge (ABPmer, 2010). This monitoring showed that little material had been lost over time. Moreover a multibeam survey showed the outlines of individual barge loads to be still in place. Therefore it can be assumed that disposal of glacial till from the AMEP scheme capital dredge will add negligible material to the background SSCs.

8.6.10 For the erodible material disposal, the majority of material will be contained within the dynamic plume that will settle on the bed of the estuary. Upon disposal, the majority of material will fall to the bed, but a proportion of the finer material will be entrained in a plume that will move away from the disposal site with the tides, and disperse. The plume will therefore add to background SSCs and an assessment has been performed to examine the significance of this likely impact.

8.6.11 The preliminary dredge programme reports that a TSHD will pick up 630 m³ of sediment from the AMEP site and dump it at the disposal site over a period of 15 minutes. The total cycle time for this procedure would be 142 minutes. For the dredging of 250 000 m³ of surface alluvium this would necessitate 400 round trips. The surface alluvium is not compacted and therefore a density of 1 250 kg/m³ is assumed, which is typical of superficial sediment in the estuary (ABPHES, 2008). Therefore approximately 788 tonnes of material will be disposed of during each return trip. Based upon core samples, an assumption was made that 25% of the total disposed load would form a plume. (*Annex 8.1*).

8.6.12 *Figure 8.4* shows the resulting average SSCs (that are attributable to the dredge disposal operation alone) over the last day of sediment release throughout the Humber Estuary. This shows that the model predicts that the enhanced SSCs will travel back and forth with the tidal currents up to Hull and down to the estuary mouth. The sediment plume is largely confined to the deeper channels in the short term, with dispersion around the estuary likely over the longer term. The largest concentrations occur in the shallower areas, with the average SSC during day 14 of up to 20 mg/l above ambient.

Figure 8.4 *Average SSCs during last day of 14-day period of intermittent sediment release at Middle Shoal disposal site (from Annex 8.1, JBA 2011)*



8.6.13 Away from the disposal site, the modelled plume exhibits largest concentrations in the shallower water to the north of the SDC. Changes

to SSCs are cyclical, peaking at 40 mg/l – 50mg/l above ambient here, with slightly lower concentrations further away from the disposal site in the Middle Estuary. Though the passive plume reaches Hull, SSCs here are much reduced to typically 10-20 mg/l above ambient. Upon cessation of sediment release SSCs quickly decrease as the sediment disperses within the estuary. *Annex 8.1* describes how the model possibly underestimates SSCs, and recommends that “*using judgement, the peak increase in SSCs after 44 days of disposal can be estimated to be of the order of 80-100 mg/l to the north of the SDC, reducing elsewhere within the estuary.*”

- 8.6.14 The initial TSHD dredging programme is assumed to continue for approximately 48 days in total. For the first 8 days SSCs gradually increase at all locations. After approximately 8 days the SSCs due to the disposal start to exhibit a regular cyclical pattern that peaks at approximately 40-50 mg/l to the north of the SDC, with smaller values elsewhere in the estuary.
- 8.6.15 A sensitivity test was performed to examine the likely increase in SSCs due to a larger (40%) proportion of the disposed sediment directly entering the passive plume. In this scenario the short-lived (<2 hours) peaks in SSCs at the disposal site can reach 300-400 mg/l above ambient. The longer term values experienced at the North SDC location appear to reach an equilibrium of 60 mg/l above ambient after 14 days.
- 8.6.16 The dispersion of the sediment extends along the coastline from the Humber Bridge to past the estuary mouth. This large area means that any accumulation of the disposed sediment on inter-tidal areas will be negligible compared with accumulation due to natural processes and present maintenance dredging requirements.
- 8.6.17 After the preliminary dredge of 250 000 m³, the remaining ~730 000 m³ will be dredged with a large TSHD such as the Barent Zanen (8 000 m³ capacity). No quantitative assessment has been undertaken of dispersal from the disposal site for this dredger. However, if the proposed cycle times are similar to those for the smaller TSHD, then an estimation of these impacts can be made based upon the work described above. Assuming that the dispersal primarily relates to placed sediment into the water column, elevations in ambient concentrations of 5-6 times those reported in *Paragraph 8.6.13* may be expected for the duration (26 days) of these operations.

- 8.6.18 Sediment plume dispersion studies were undertaken to evaluate the impacts of dredging on the sediment regime at the dredge site (*Annex 8.4*).
- 8.6.19 The capital dredging was characterised as use of a trailer suction hopper dredger (TSHD) to dredge 750 000 m³ alluvium/clay and 230 000m³ sand/gravel and use of a backhoe to dredge 955 000 m³ glacial till.
- 8.6.20 The proposed dredging of alluvium (without overflow) by TSHD will cause increases in suspended sediment concentrations at the E.ON intake of up to 180mg/l (near bed) and at the Centrica intake of up to 60mg/l (near bed) for a period of around three weeks. Should overflowing be utilised during the dredging of alluvium the predicted increases in suspended sediment concentration above background and the deposition of fine sediment arising from this dredging will be considerably larger. Overflowing for ten minutes on every load would result in increases in suspended sediment concentration of up to 800mg/l (near bed) at the Centrica intake and up to 1600mg/l (near bed) at the E.ON intake for a period of up to three weeks. Whilst this may represent a significant increase in the background levels of suspended sediment concentration it is noted that this increase will occur for a limited period of time given that overflowing would only occur for 10 minutes in every 150 minutes.
- 8.6.21 The proposed dredging of sand/gravel by TSHD will cause increases in suspended sediment concentrations at the Centrica intake of up to 200 mg/l (near bed) and at the E.ON intake of up to 400 mg/l (near bed) for a period of up to a week.
- 8.6.22 Whilst this may represent a significant increase in the background levels of suspended sediment concentration it is noted again that this increase will occur for a limited period of time.
- 8.6.23 The predicted infill into other nearby berths arising from the capital works is small (*Annex 8.4*). The additional infill is at most estimated to be in the order of several thousand cubic metres at the South Killhome Oil Jetty, Immingham Gas Terminal, Humber International Terminal and the Immingham Bulk Terminal and approximately one hundred cubic metres at the Humber Sea Terminal. These increases should be compared with the annual maintenance dredging requirements at these berths which are of the order of many tens of thousands or hundreds of thousands of cubic metres per year.

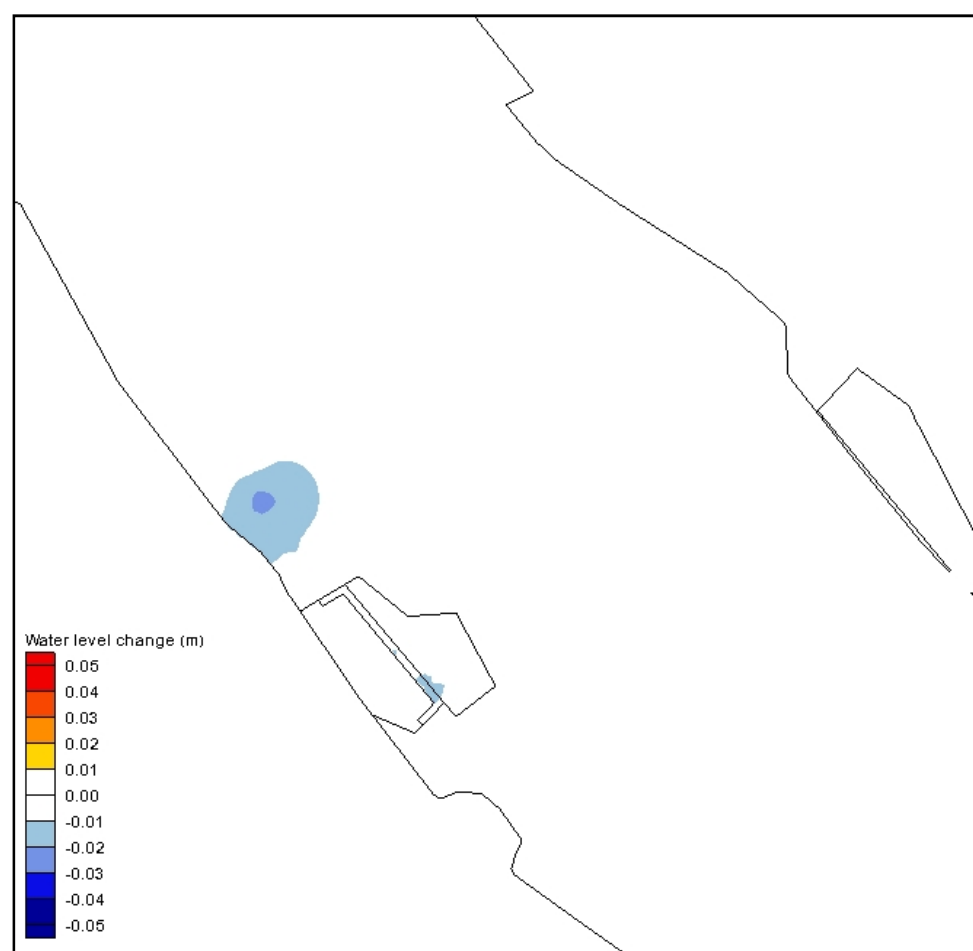
Operational Phase

- 8.6.24 Potential impacts during operation of the AMEP are associated with the effects of the reclamation on the hydrodynamic regime and, in particular, the resulting changes to local estuary morphology and deposition patterns. Potential impacts may also arise due to dispersion and deposition of sediment associated with maintenance dredging activities.

Hydrodynamic Impacts – Impacts on tidal levels

- 8.6.25 The combined impacts on water levels of the AMEP, dredged berths and the Compensation Site have been assessed using a numerical hydrodynamic model (*Annex 8.1*). Simulations of a mean high water spring tide were performed for the AMEP and Baseline scenarios. The maximum and minimum water levels were calculated from the simulations in order to investigate any absolute changes in levels during times of high and low water.

Figure 8.5 *Modelled changes to High Water levels (AMEP minus baseline – negative shows a reduction in water High Water level). From Annex 8.1 (JBA, 2011).*



8.6.26 *Figure 8.5 shows the modelled impacts on High Water levels. The hydrodynamic modelling predicted changes to High Water levels of less than 1cm everywhere except at Humber Sea Terminal (HST) where a reduction in High Water of 2cm is predicted, and at a location fronting the AMEP Quay where a reduction of 1cm is predicted. A small decrease in Low Water levels is predicted (<0.5cm).*

Hydrodynamic Impacts – Impacts on flows

8.6.27 *Figures 8.6 and 8.7 show modelled changes to peak flood and ebb flows (respectively) for a mean spring tide. During both flood and ebb flows, significant reductions in flow speeds are predicted upstream and downstream of the AMEP, with reductions of more than 0.1 m/s extending approximately 1 km at peak flood (0.6 km during peak ebb) in an upstream and downstream direction (Annex 8.1), and with greater reductions closer to the AMEP.*

8.6.28 Although the development shown in *Figures 8.5 to 8.7* is superseded, there is no need to reassess the impacts because the footprint of AMEP is now smaller, and impacts on flows and tide levels may have reduced but will not have worsened. The model results may therefore be seen as conservative.

Figure 8.6 *Modelled changes to peak mean spring tide flood flows (AMEP minus baseline). From Annex 8.1 (JBA, 2011).*

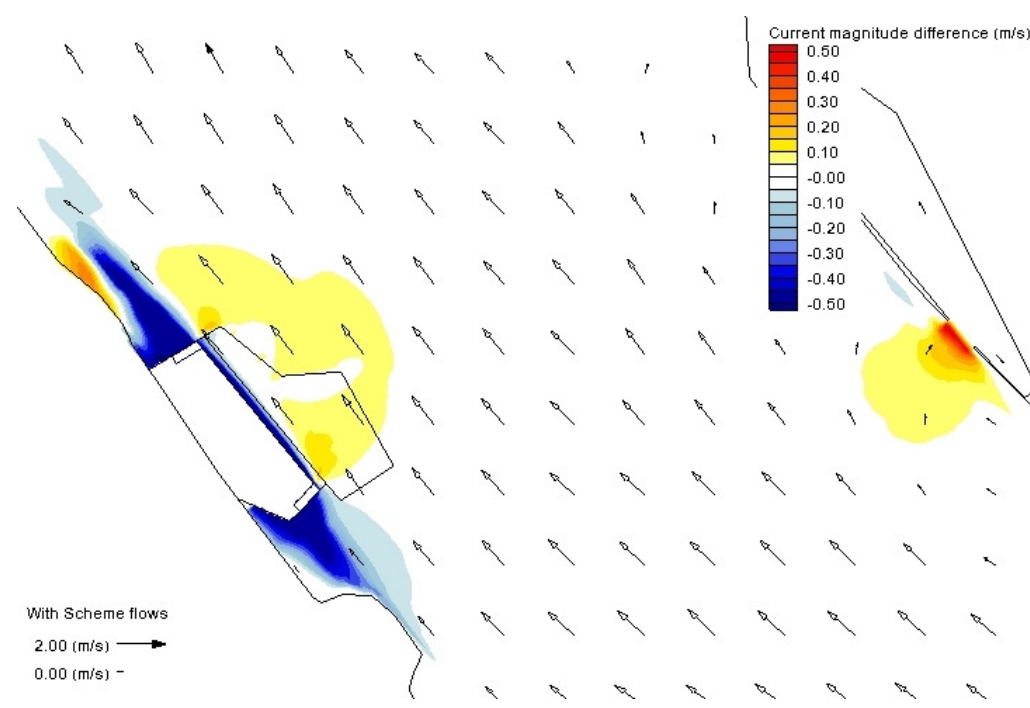
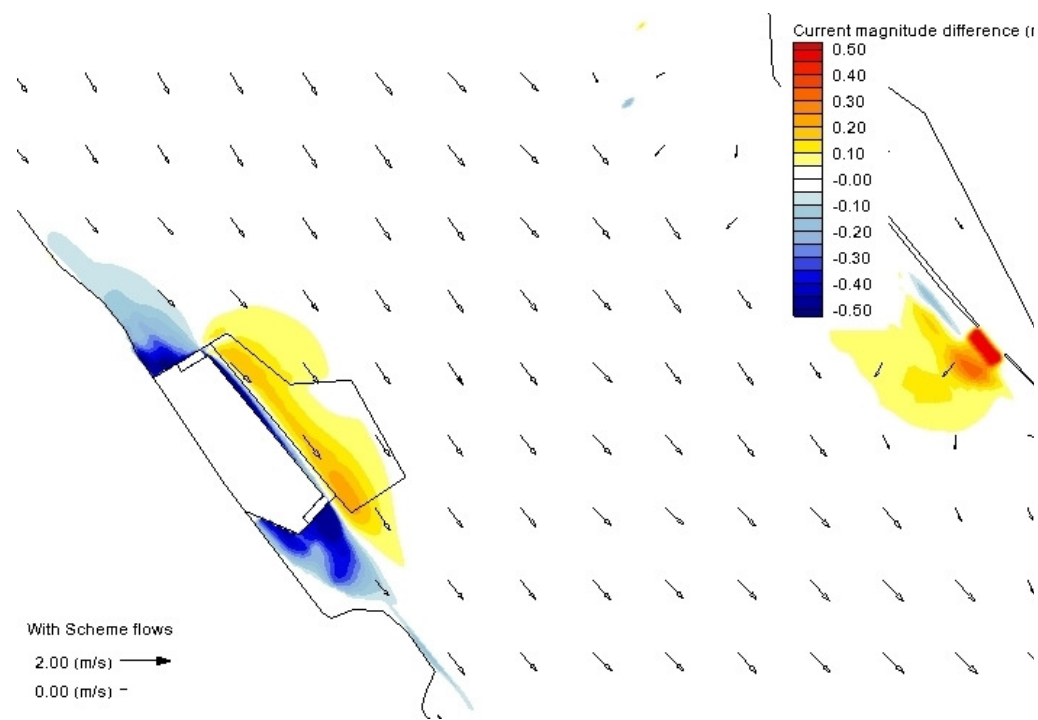


Figure 8.7 *Modelled changes to peak mean spring tide ebb flows (AMEP minus baseline). From Annex 8.1 (JBA, 2011).*



8.6.29 Offshore of the AMEP berthing pocket, flows are predicted to increase through the turning area by up to 0.25 m/s during peak ebb and up to 0.15 m/s during peak flood. Smaller increases of more than 0.05 m/s are predicted to extend up to 0.6 km upstream and downstream of the AMEP.

8.6.30 Although the hydrodynamic model included the Compensation Site, these effects are not reported in this chapter (they are considered in detail in *Chapter 32*). The in-combination assessments described later in this document show that inclusion of the Compensation Site does not alter the conclusions in terms of the effects on flows and tide levels predicted as a consequence of the AMEP.

Impacts on Bed Shear Stress (due to changes in tidal flows)

8.6.31 The changes to the local hydrodynamics (flows) result in changes to patterns of bed shear stress (which in turn affect patterns of sedimentation and erosion discussed later in this Chapter). *Figures 8.8 and 8.9* show predicted changes to bed shear stress in response to the AMEP.

Figure 8.8 *Modelled changes to peak mean spring tide bed shear stress, flood tide (AMEP minus baseline). From Annex 8.1 (JBA, 2011).*

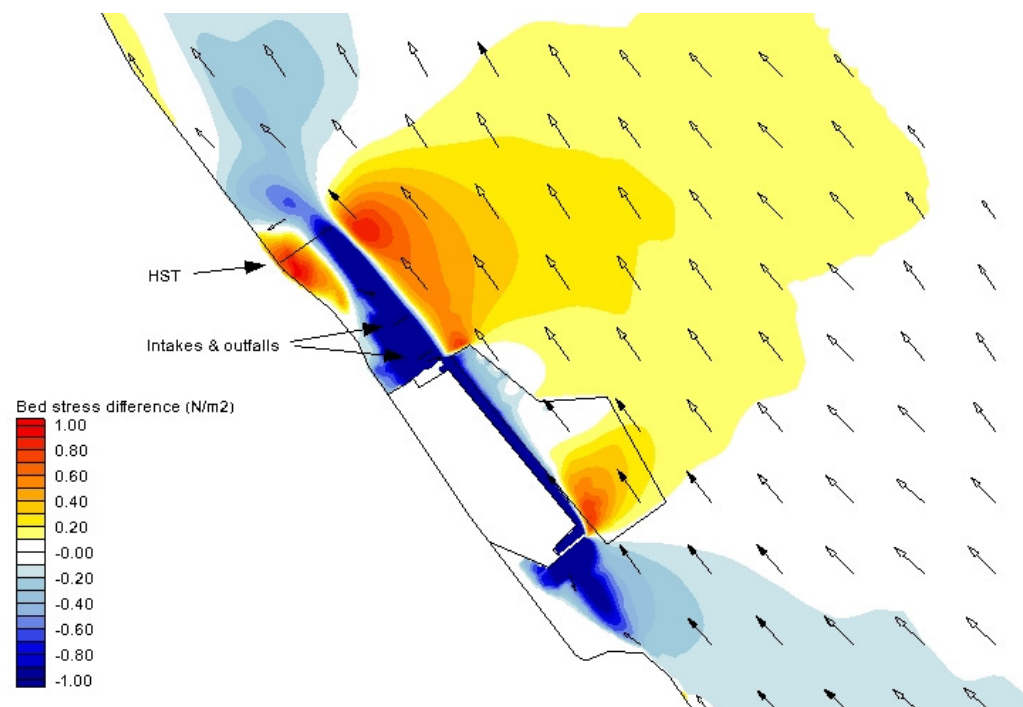
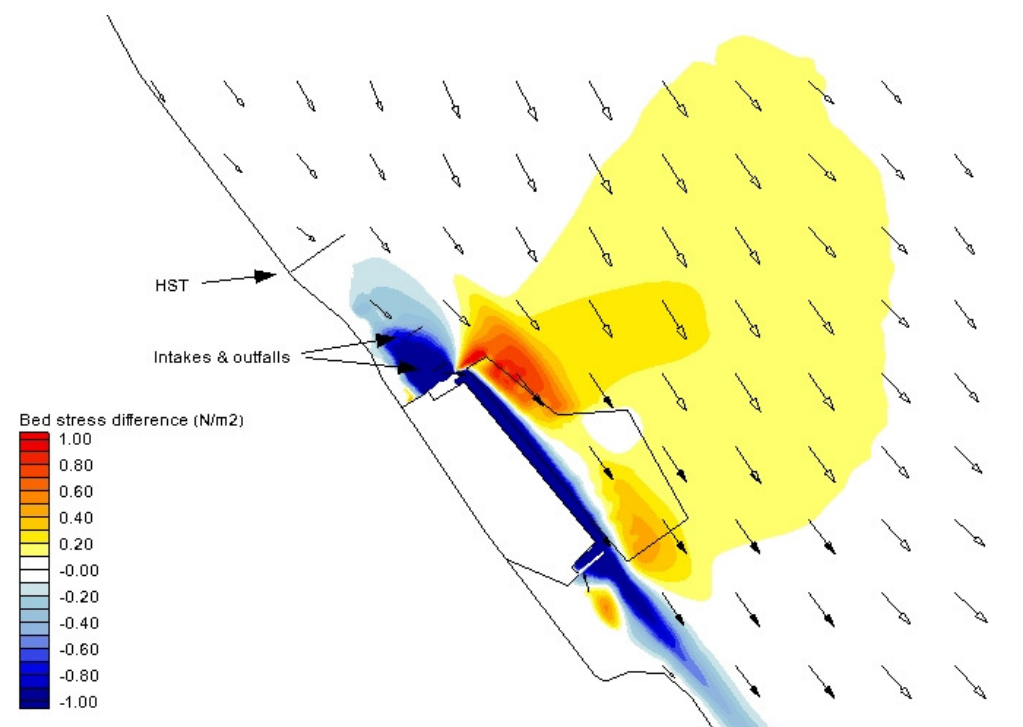


Figure 8.9 *Modelled changes to peak mean spring tide bed shear stress, ebb tide (AMEP minus baseline). From Annex 8.1 (JBA, 2011).*



- 8.6.32 Bed shear stress increases in the proposed dredged approach area are approximately 20% of the baseline stress. Further towards the middle of the estuary the increases represent a much smaller proportion of the larger bed stresses experienced here. During each phase of the tide, flow is suppressed at the sides of the AMEP, leading to decreased bed shear stresses. A hydrodynamic wake is predicted to occur, reducing the flow in the lee of the AMEP, again leading to decreased bed shear stresses in these areas. The berthing areas along the AMEP frontage will also experience reduced flow due to the increase in depth as a result of the capital dredging.
- 8.6.33 The predicted reduction in the baseline bed shear stresses to the north-west and south-east of the AMEP is likely to lead to increased accumulation of sediments in these areas, while the predicted increase in bed shear stress off the North Killingholme Pits could lead to potential increases in erosion. The results of both sand and mud transport modelling are discussed later in this chapter including predicted patterns of increased erosion or deposition, and so this is not considered further in this Section.

Impacts on waves and overtopping

- 8.6.34 *Figures 8.10 and 8.11* show model predicted changes to an extreme 200 year joint wave/water level condition, including for 1.19 m of sea level rise corresponding to earlier more conservative (than the latest UKCP09 guidance) Defra (2006) guidance for sea level rise from 2007 (base wave data) to 2114 (end of the proposed 100 year life of the AMEP). For both directions, a wave height of 1.6m was used in conjunction with a water level of 5.66m AOD. The model predicted changes include for reflections off the AMEP.
- 8.6.35 Immediately in front of the AMEP quay, increases in wave height of up to 0.4 m are predicted. 750 m offshore (for the easterly extreme condition) the predicted increase has reduced to 0.2 m. In terms of wave impacts on the shoreline, for the easterly extreme an increase is predicted along the shoreline between the southern end of the AMEP and the northwestern flank of HIT (~0.1 m increase in wave height) and for the northerly extreme condition, an increase in overtopping risk is predicted where the AMEP meets the shoreline at the northwestern end (~0.4m increase in wave height focussed on this corner).
- 8.6.36 Depending upon the nature of management of the predicted siltation at this location, the predicted increase in overtopping risk may be to some degree mitigated by sedimentation onto the intertidal area. Detailed

reporting of an assessment of overtopping risk is presented in *Annex 8.1*.

8.6.36 Wave reflection from the AMEP (as previously represented in the PEIR) quay walls was predicted to result in an increase in the overtopping risk along the sea defences to the north of the quay for approximately 200 m (the 30 m closest to the quay edge being most susceptible). To the south of the AMEP, no increase in overtopping risk is predicted (*Annex 8.1*). For the final layout, the mitigating effects of a reduction in the size of AMEP together with a revised 1 in 4 slope rubble mound (to enhance wave dissipation) have been assessed by JBA Consulting (*Appendix F of Annex 8.1*). The revised length of sea defences to the north of the quay affected by wave reflection impacts is 60m.

Figure 8.10 *Modelled increase in wave heights for a 1:200-year water level/wave height event in 2114 for waves from the east (AMEP minus future 2114 'baseline'). From Annex 8.1 (JBA, 2011)*

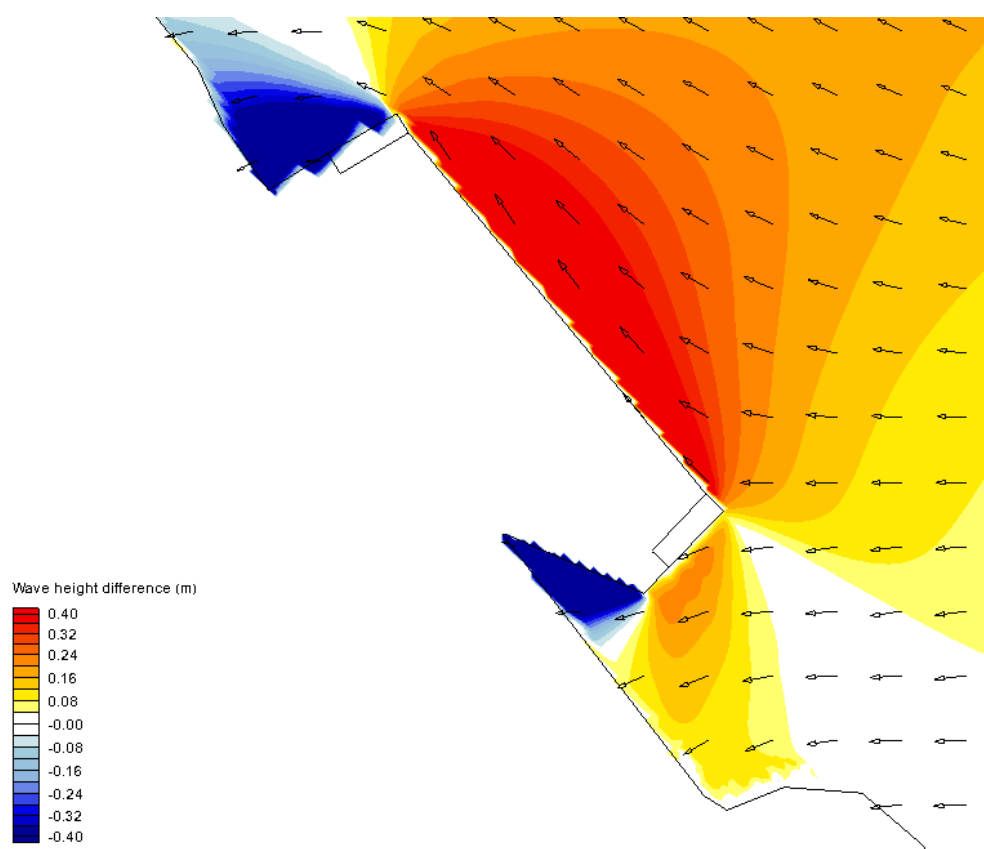
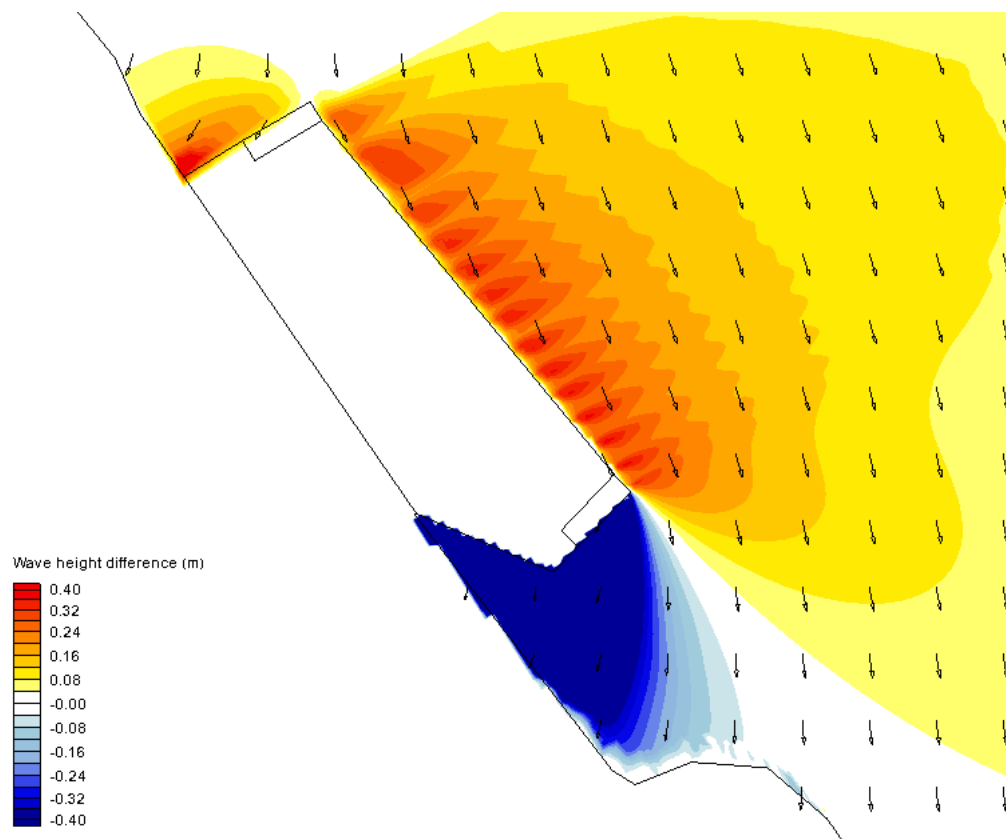


Figure 8.11 *Modelled increase in wave heights for a 1:200-year water level/wave height event in 2114 for waves from the north (Original AMEP Layout minus future 2114 'baseline'). From Annex 8.1 (JBA, 2011)*



Impacts on sediments

- 8.6.38 The sediment on the bed in the vicinity of the proposed quay varies between mud, sandy mud, and muddy sand (see *Paragraph 8.5.7*). For this reason impacts on sediment transport were assessed through the use of 2D sand transport (*Annex 8.1*) and 3D mud transport models (*Annex 8.3*). The 3D model was used to investigate the likely effects of the scheme on suspended sediments and morphology along the intake/outfall lines and sedimentation onto designated intertidal areas and into the existing adjacent downstream berths.
- 8.6.39 The 3D mud transport modelling simulated the effects of the final AMEP quay whilst the sand transport model was undertaken for an alternative (earlier) design option with a quay set forward a further 80 m, refer to *Figure 8.1*.
- 8.6.40 Impacts on suspended fine sediment concentrations were assessed at the locations of the Centrica and E.ON intakes (*Annex 8.3*). Modelled effects show, during a spring neap cycle and importantly before the

formation of significant areas of deposition, slight reductions in peak suspended sediment concentrations on the flood tide (up to 15%) and little change (0-4% reduction) on the ebb tide. This is likely to be associated with the AMEP berthing pockets which lead to increased sedimentation. In the longer term, the development of significant levels of accretion at the northwestern end of the AMEP will lead to an increased risk of periodically enhanced suspended sediment concentrations from wave agitation acting on these new deposits.

8.6.41 The results of the sand transport modelling for the original (preliminary) layout are provided in *Annex 8.1*. The spatial extent of the patterns of erosion and deposition have changed substantially as a result of the quay face for the final AMEP layout being set back 80m towards the land.

8.6.42 *Figure 8.12* presents the results of the 3D mud transport modelling of the AMEP for the present layout showing predicted patterns of changes to potential erosion and deposition of fine sediments. Details are provided in *Annex 8.3*, including sensitivity tests to waves from the northwest and southeast.

Figure 8.12 *Predicted increases to deposition or erosion after a spring-neap cycle (14-15 days, AMEP minus baseline).*



8.6.43 *Figure 8.12* shows deposition into the AMEP berth pocket and extending upstream and downstream of the AMEP. For the chosen

AMEP design no increased deposition is predicted into the existing neighbouring berth pockets (e.g., HST, South Killingholme Oil Jetty, Immingham Gas Terminal, and HIT). Increased potential erosion of soft deposits is seen in the areas flanking the approach channel.

Impacts on Existing and Future Maintenance Dredging Requirements

- 8.6.44 Annualised sedimentation values are presented in *Table 8.2* below. To convert from masses in the 3D model to volumes, a dry density of 500 kg/m³ was assumed.

Table 8.2 *Annualised changes to deposition and erosion derived from the 3D mud and 2D sand transport modelling*

Area	Predicted Annual Increase in Deposition (m3/Year) Original Layout	Predicted Annual Increase in Deposition (m3/Year) Layout with chamfered quay and suspended deck (Layout 1b)	Predicted Annual Increase in Deposition (m3/Year) AMEP (80m set back quay)
	2D sand transport model*	3D mud transport model	3D mud transport model
Humber Sea Terminal	20,000 to 320,000	14,000 to 36,000	-20,000 to -50,000
South Killingholme Oil Jetty	0	100,000 to 266,000	-36,000 to -92,000
Immingham Gas Terminal	600 to 26,000	74,000 to 186,000	-4,000 to -8,000
Humber International Terminal	100 to 17,000	241,000 to 624,000	-38,000 to -96,000
Immingham Bulk Terminal	700 to 16,000	-58,000 to -110,000	-60,000 to -148,000
AMEP	280,000 to 1,300,000	687,000 to 1,842,000	502,000 to 1,254,000
Inshore of E.ON and Centrica Intakes	Not analysed	338,000 to 882,000	188,000 to 468,000

* The lower figure assumes a 0.3mm median grain size and the higher figure a 0.075mm median grain size for the estuary bed as a whole.

- 8.6.45 The modelling (both sand transport and 3D mud modelling) of alternative layouts that project further into the estuary than the final scheme, showed an impact in terms of increased maintenance dredging requirements at adjacent berths. However, 3D mud modelling of the present AMEP shows no such impact. 3D mud modelling predicted annual infill is generally 2-3 times higher than observed rates (*Annex 8.3*). The reasons for this difference include (amongst others) the inherent simplification in a simple linear scaling of the spring-neap cycle simulated, the absence of extreme (storm) tide conditions and storm waves, the motion of ships into and out of the berths and berth occupancy, assumptions on densities, actual frequency and locations of maintenance dredging, and natural variability in suspended sediment

concentrations in the Humber Estuary. Considering only the last item reveals year on year differences in maintenance dredging requirements of a similar order.

- 8.6.46 Given the level of uncertainty in modelled infill predictions, the predicted future changes to maintenance dredging requirements are presented as a range. It should be noted that this is good practice in sediment transport modelling and that a model predicted infill rate within a factor of 2-5 of the observed figures is not unreasonable.

Morphological assessment

- 8.6.47 For the proposed scheme no increase in maintenance dredging requirements at adjacent berths is predicted. Assessment of the longer term development of the intertidal morphology to the northwest of the AMEP was undertaken using both computational modelling and consideration of the observed effects of the Humber International Terminal (HIT) reclamation.

- 8.6.48 Analysis of pre- and post-HIT Admiralty Charts shows, in the area of the pink oval marked on *Figure 8.12*, an apparent effect extending for approximately 600 m alongshore, and with an increase to intertidal levels of approximately 1.5 m at an equivalent location to the Centrica and E.ON outfalls. This observation, combined with the sediment modelling results described in *Paragraph 8.6.52* below, indicates a likely requirement for maintenance at these locations.

- 8.6.49 For an alternative assessment into the potential longer term development of the intertidal profile along the intake-outfall lines, the 3D mud model was run for an extended duration, updating the model bathymetry before each re-running of both the 3D flow and mud transport models. This work was done for Layout 1b which had the quay face located 50m seawards of the final AMEP layout. To infer longer term changes for the final AMEP layout, results were extracted from the Layout 1b modelling. The sedimentation effects were abstracted from the Layout 1b model at the locations of the intakes and outfalls, and also at points 30m and 50m seaward of these locations. Examining these results allowed longer term changes to be inferred at the intakes and outfalls as a consequence of the AMEP layout from the longer term modelling undertaken for Layout 1b.

- 8.6.50 The long-term sediment transport assessment, in combination with the desk assessment undertaken into changes observed northwest of the Humber International Terminal, gives an indication of the possible longer term changes to morphology that will be experienced to the northwest of the AMEP. Overall, the inferred longer term morphology

changes show little risk of sedimentation at the intakes, but a risk of significant sedimentation at the outfalls. Inferred changes from Layout 1b show longer term risk of sedimentation of 1-2m at the Centrica Outfall and 3-3.5m at the E.ON Outfall (*Annex 8.3*). It should be noted that because these are indicative results inferred from modelling undertaken for a previous layout (Layout 1b), this adds to the uncertainty.

8.6.51 Without any intervention or management, the area of intertidal affected by an increase in levels towards the northwest of the development is likely to be approximately 12 hectares. It is quite possible that areas to the south may also be affected, although as the existing intertidal is generally higher and wider to the south of the AMEP, the areas affected are likely to be smaller.

8.6.52 In addition to the assessments described above, a drainage channel is proposed as part of the AMEP. *Annex 8.3* presents an assessment of the effects of this element of the AMEP for which excavation and maintenance of a channel through the intertidal will be required at the southeastern flank of the AMEP. It is estimated that a further 1ha of intertidal will be affected.

8.7 MITIGATION MEASURES

Construction Phase

8.7.1 Best practice guidelines will be used, and a monitoring programme is proposed with regards to the operation of the intakes, with monitored suspended sediment concentrations triggering temporary cessation of works or a warning that temporary cessation of works may be imminent. Stop/caution thresholds will be agreed with the operators. Monitoring might include the deployment of monitoring buoys to provide real time feedback of suspended sediment concentrations adjacent to the intakes.

Operational Phase

8.7.2 After completion of studies to assess the predicted changes to deposition and erosion arising from AMEP, the quay face has been positioned to avoid any adverse effects on maintenance dredging requirements at adjacent berths.

8.7.3 The model results have shown the potential for accumulations of sediment inshore of the Centrica and E.ON intake/outfall lines and this will need to be monitored and, if necessary, managed (mitigated) through dredging (e.g. ploughing, see the Dredging Strategy, *Annex*

7.6). A new outfall will be built into the new quay to allow for the diversion of the outfalls if maintenance dredging proves unduly onerous. An assessment of the thermal plume dispersion that would arise from a new outfall built into the quay is included in *Annex 9.6*. The assessment demonstrates that such an outfall would not interfere with the operation of the intakes. There is a lower risk that a similar diversion may also be required for the Centrica outfall.

8.8 RESIDUAL IMPACTS

Construction Phase

- 8.8.1 The residual impacts remain as per the impacts described in this chapter with the exception of approximately 12 hectares of intertidal affected to the northwest of the AMEP. If dredging is adopted to manage the sedimentation in the area around the cooling water infrastructure, then the area of intertidal affected (raised) will reduce.

Operational Phase

- 8.8.2 The predicted annual maintenance requirement arising from operations will be in the range 250 000-630 000 dry tonnes from the dredging of the AMEP Berthing Pocket and Dock. This is likely to require dredging by TSHD and disposal at the Sunk Deep Channel disposal site HU080, refer to *Annex 7.6*.
- 8.8.3 A further quantity of dredging may arise (depending on the mitigation approach selected – see *Paragraph 8.7.3*) from use of dredging techniques to manage the expected accretion inshore of Centrica and E.ON Intake/Outfall Lines. However, any dredging used to manage this accretion would use water injection or ploughing techniques and would not require offshore disposal.

8.9 IN COMBINATION IMPACTS

Construction Phase

- 8.9.1 Some of the dredge arisings from the projects listed below will be disposed of within the same areas as those proposed by AMEP. *Table 8.3* details the estimated dredge quantities for each project, as set out in the relevant promoter's Environmental Statement, for those disposal sites that are common to the AMEP Proposal. Able has consulted with MMO who confirmed that suitable capacity exists (*Annex 7.6*).

Table 8.3 *Summary of Capital Dredge Quantities for other Approved Projects also using the AMEP Disposal Sites*

Project	SDC Window Sites (HU081, 82, 83)	Middle Shoal (Humber HU080)
AMEP	954 350m ³	981 150m ³
Hull Riverside Bulk Terminal	548 000m ³	0m ³
Quay 2005 (Green Port Hull)	0m ³	0m ³
Grimsby Ro-Ro	45 000m ³	0m ³
IOT (SDC Channel Deepening)	375 000m ³	1 597 000m ³
Total	1 888 000m ³	2 287 000m ³

Operational Phase

Water Levels

- 8.9.2 An in combination modelling assessment was undertaken (*Annex 8.1*) and found that predicted impacts at HST (lowering of High Water by 2 cm) were unaffected by other developments. The model predicts a decrease in High Water near to Quay 2005 of up to 2cm.

Flows

- 8.9.3 An in combination modelling assessment was undertaken (*Annex 8.1*) and found that changes to flow patterns were distinct and separate for the various developments. The patterns of change around the AMEP quay were the same as for the scheme when considered without other future developments.

Waves

- 8.9.4 There are no in combination effects on waves.

Bed shear stress

- 8.9.5 The in combination impacts on current speeds found that there will be negligible changes just upstream and downstream of the scheme, with local changes entirely due to the scheme. As stated in *Paragraph 8.9.4* there will be no in combination impacts on waves. Therefore the in combination impacts on bed shear stresses exhibit negligible differences to those due to the scheme alone.

- 8.9.6 *Table 8.2 shows the model predicted likely range of potential changes to the maintenance dredging requirements at adjacent berths. In practice the changes to requirements will also depend on a number of uncertainties and practicalities highlighted in Section 8.6.47.*

8.10 SUMMARY AND CONCLUSIONS

- 8.10.1 This chapter has investigated the impacts of the AMEP on the hydrodynamic and sedimentary regime and has concluded the following.

Water Levels

- 8.10.2 Changes to Low water everywhere of less than 0.5 cm are predicted. A 2 cm lowering of High Water is predicted at the Humber Sea Terminal. An assessment of in combination effects shows a decrease in High Water of up to 2cm at Quay 2005 along a length of shoreline approximately 400m long (equating to a reduction of < 0.001 hectares of intertidal).

Flows

- 8.10.3 Flow speeds are reduced upstream and downstream of the AMEP during flood and ebb tides and over a distance of 0.6 km to 1 km from the AMEP. Flow speeds are initially increased seawards of the quay. The scale of changes remained the same when tested in combination with other developments.

Bed Shear Stress

- 8.10.4 Significant reductions in bed shear stress are predicted upstream and downstream of the AMEP, with increases seawards of the AMEP. The changes to bed shear stresses give an indication of changes to sedimentation and erosion that have been assessed using sand and mud transport models.

Waves

- 8.10.5 Immediately in front of the AMEP quay, increases in wave height of up to 0.4 m are predicted. 750 m offshore (for the easterly extreme condition) the predicted increase has reduced to 0.2 m. In terms of wave impacts on the shoreline, slight increases in the wave height

corresponding to 200 year event are predicted along the adjacent shoreline, with the largest increase predicted immediately adjacent to the AMEP and to the north (~0.4m). The latest design of the AMEP (encroaching 80m less into the estuary) plus planned mitigation through use of rock armour on the northern flank, will reduce this effect.

Sediments and Maintenance Dredging Requirements

- 8.10.6 Predicted increases in sedimentation into the AMEP dredged areas and shorewards of the Centrica and E.ON intakes indicate a need for significant maintenance dredging. No increases to maintenance dredging requirements are predicted for Humber Sea Terminal, South Killingholme Jetty, Immingham Oil Terminal, Humber International Terminal, or Immingham Bulk Terminal.
- 8.10.7 In the absence of sediment management activities discussed in *Section 8.7.3*, bed levels across approximately 12 hectares of intertidal would rise to the north of the AMEP to form a similar response to that which is seen north of the HIT reclamation. To the south of the AMEP less change is predicted on the upper intertidal areas as a result of the intertidal levels already being higher in response to the HIT development.
- 8.10.8 An estimated 1ha of intertidal to the south of the AMEP is likely to be affected by construction, maintenance, and evolution of a drainage channel from the proposed drainage outfall (*Annex 8.3*).
- 8.10.9 In terms of dispersal of sediments from the disposal site, the peak increase in SSCs after 44 days of disposal by the smaller TSHD can be estimated to be of the order of 80-100 mg/l to the north of the SDC, reducing elsewhere within the estuary. For the larger TSHD, concentrations of 5-6 times higher might be expected (for up to 26 days).
- 8.10.10 The proposed dredging of alluvium (without overflow) by TSHD will cause increases in suspended sediment concentrations at the E.ON intake of up to 180mg/l (near bed) and at the Centrica intake of up to 60mg/l (near bed) for a period of around three weeks. Should overflowing be utilised during the dredging of alluvium the predicted increases in suspended sediment concentration above background would be up to 800mg/l (near bed) at the Centrica intake and up to 1600mg/l (near bed) at the E.ON intake for a period of up to three weeks. This increase will occur for a limited period of time given that overflowing would only occur for 10 minutes in every 150 minutes.

- 8.10.11 The proposed dredging of sand/ gravel by TSHD will cause increases in suspended sediment concentrations at the Centrica intake of up to 200 mg/l (near bed) and at the E.ON intake of up to 400 mg/l (near bed) for a period of up to a week.
- 8.10.12 The predicted infill into other nearby berths arising from the capital works is small (*Annex 8.4*)