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Supplementary Environmental Information

Medium and Long Term Quantum of Habitat Loss

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Able UK

ABLE MARINE ENERGY PARK

MEDIUM AND LONG TERM QUANTUM OF HABITAT LOSS

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EXPLANATORY NOTE

INTRODUCTION

1. The development of Able Marine Energy Park (AMEP) includes for the reclamation of 45 ha of the Humber Estuary SPA/SAC; the area lost by the reclamation is habitat of community interest. Whilst, temporary construction impacts are being mitigated to avoid any additional impact on the protected habitat, once the development is operational, activity within the site may cause intermittent disturbance to the intertidal mudflats to the north and south of the quay. The intertidal area to the south of AMEP is currently used as a feeding resource by birds that are part of the SPA assemblage. Operations on the quay have the potential to reduce the functional value of the mudflat resource to the south of the quay and this potential functional loss is also a direct effect of the development.

2. The area of mudflat that may be disturbed by operations has been assessed, on a precautionary basis, to extend 275 m from the operational limit of the quay to the south.

3. The area of mudflat to the south of the quay will also be cut through by a new drainage channel that will be formed by the discharge of surface water from the industrial site associated with the development. The drainage water will discharge via a pumping station that will be located on land immediately to the south of the quay. This will be a functional change to the habitat within the disturbance zone. The new channel is illustrated on drawing AME-06077-A, refer to Appendix A.

MEDIUM TERM IMPACTS

4. Over the medium term (0-30 years) the reclamation is likely to cause a significant change in estuary processes in the upstream and downstream lee of the development, resulting in local change to the existing sub-tidal and intertidal habitats.

5. Upstream of the quay, the prediction of local effects can be informed by the changes that have been observed upstream of the Humber International Terminal (HIT), following its construction at the Port of Immingham in 2000. The changes to the Killingholme Marshes foreshore over the 10 year period between 2001 and 2010, are reported in Supplementary Report EX8.9, *'AMEP Assessment of changes to Morphology (Particularly Intertidal) Between the Humber International Terminal (HIT) and Humber Sea terminal (HST)'*, (HR Wallingford, 2012).

6. Briefly, the HIT reclamation has resulted in a change to the sedimentary regime upstream of that reclamation, with accretion occurring over a significant area and bed levels being raised by up to 3.5m over a period of 10 years, refer to Figure 1.

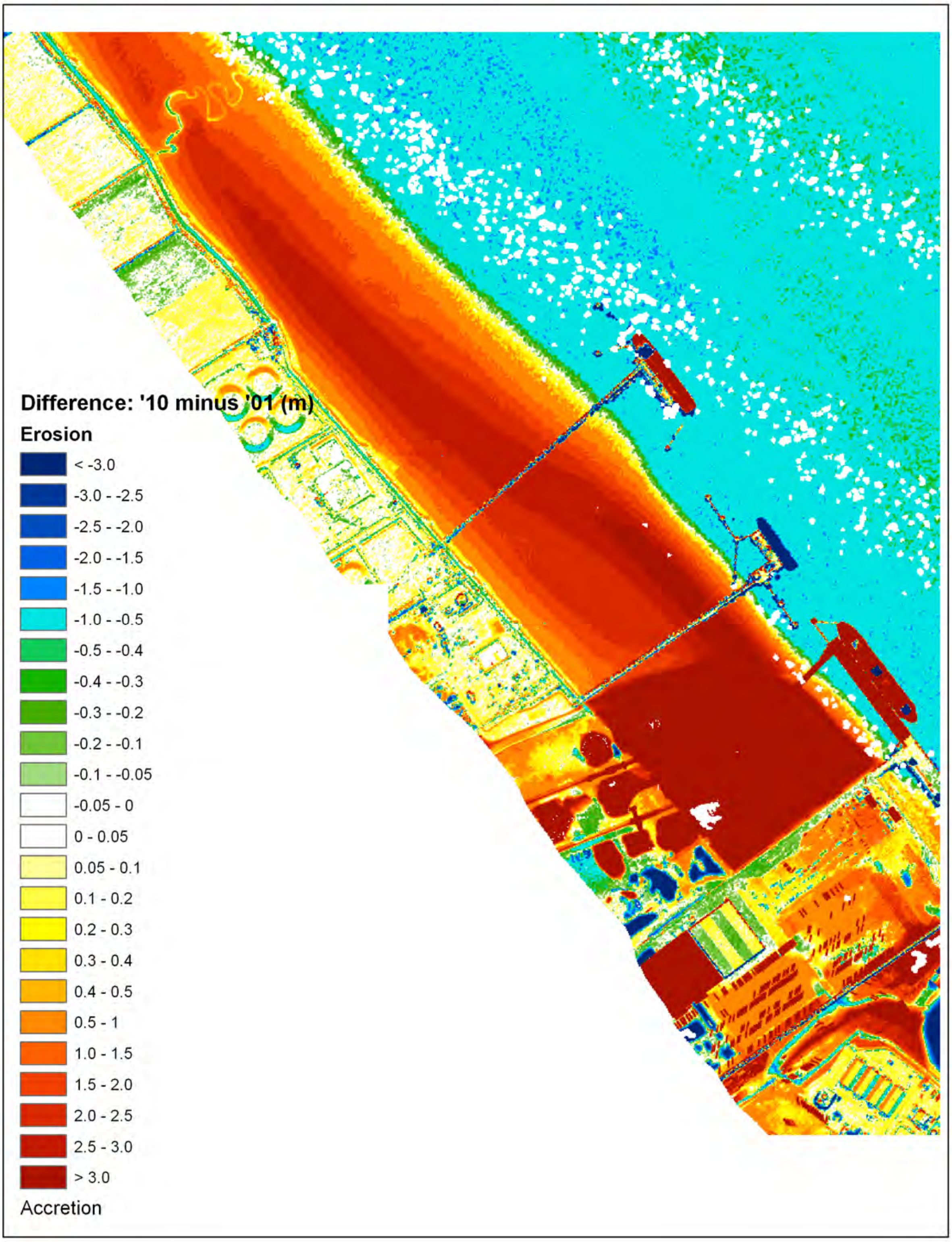


Figure 1: Accretion on Killingholme Marshes Foreshore Post-HIT (2001-10)

7. The rate of accretion in recent years appears unabated compared to earlier periods, indicating that this is a decadal scale process that is not yet complete. The MHWS contour lies along the face of the flood defence wall and is therefore constrained. Of potential significance however, is the increasing area of intertidal habitat that is lying between MHWN (+1.9 mAOD) and MHWS (+3.4 mAOD); between these levels, saltmarsh can become established (though elevation within the tidal range is only one relevant factor in saltmarsh development). Drawing AME-06090, also included in Appendix A, shows the creep into the estuary of the MHWN contour between 2001 and 2010. As a consequence of this process, over the last 10 years the intertidal area that lies between the MHWN and MHWS elevations has increased from 3.27 ha to 18.95 ha, an increase of 15.68 ha. Many confounding variables influence habitat development, which means that even in the absence of AMEP, the long term evolution of habitat on this dynamic foreshore is uncertain. All that is known for certain is that the Killingholme Marshes foreshore is undergoing a process of change and that saltmarsh is beginning to establish quite extensively; refer to Photographs 1 to 4.

8. With the development of AMEP, a wide embayment will be created to the south of the quay: AMEP's southern revetment; the flood defence wall and HIT will form an enclosure around approximately 27 ha of the estuary. Long term morphological change within this embayment has been modelled and is reported in Supplementary Report EX8.10, *'AMEP 3D Mud Modelling Morphological Assessment of Changes South-East of the Development'*. The computer modelling predicts deposition of sediment between the -5m ODN and -10m ODN, but not further inshore. The absence of accretion within the embayment is not however considered entirely credible over decadal timescales. It is more credible that the existing accretionary trend in this area will continue to progress and be exacerbated by AMEP, causing more of the intertidal zone to be raised (than would be caused by HIT alone) and to lie within the range MHWN and MHWS. A new MHWN contour is therefore postulated to develop between the northern edge of the HIT reclamation and the southern edge of the AMEP reclamation, refer to drawing AME-06033-G in Appendix A.

9. Whilst upstream of AMEP, the sedimentary regime will be affected in a similar way to the upstream changes observed at HIT, the presence of Humber Sea Terminal's dredged berths will influence the extent to which sediment is allowed to accrete. Long term morphological change to the north of the quay has been assessed and is reported in Supplementary Report EX8.8, *'AMEP Update to Longer term Morphology Predictions in the Region of the Centrica and E.ON Outfalls'*. Using this assessment, and knowledge of the intertidal changes north of HIT, then a new MHWN contour is postulated between the northern edge of AMEP and the HST berthing pockets, refer again to drawing AME-06033-G.

Photograph 1: Saltmarsh development at Immingham Gas Jetty (IGT)

Photograph 2: Looking north along flood defence bank north of HIT.

Photograph 3: Intertidal area looking south toward HIT.

Photograph 4: Intertidal area between SKOJ and IGT

LONG TERM IMPACTS

10. Over longer timescales (0-100 years) it is possible that the development will result in a change to the intertidal areas within the estuary as a whole, as a result of potentially millimetric changes to the high and low water levels as well as changes to sedimentation patterns within the estuary affecting natural geomorphological change. The Environment Agency has sought expert opinion on this matter from Deltares, and their advice is reproduced in Appendix B. In summary it suggests that the inter-tidal area within the estuary could reduce by 5 ha over 100 years as a result of the project.

11. The Deltares assessment infers morphological change from studies undertaken on set-back sites within the estuary, assuming that the quantum of habitat change resulting from previous modelled reclamation works will be pro-rata, and opposite to, the quantum of habitat change due to a substantial (808 ha) set back site on Sunk Island. The original work is reported in, *'Impacts of Setbacks on Estuarine Morphology'*, (Jueken et al 2007), refer to Appendix C.

12. Using the information for the modelled Sunk Island set-back contained in Jeuken et al 2007: where area changes over time are shown in Figure 11, the change in seaward loss is about 13 ha, initial landward loss is perhaps 4ha after 5 years which after 50 years changes into a gain of 2 ha with a further perhaps 3 ha loss in the rivers. There is a gain of 30 ha in the setback area from 814 to 844 ha. Taken together this gives a gain of (30+2-13-3), or 16 ha which equates to about 2% of the Sunk Island intertidal area and not the 5% indicated by Deltares in Appendix C.

13. Modelling of morphological change carries high levels of uncertainty. Long term change in the estuary will be dictated by sea level rise (SLR). Over one hundred years, using UKCP09 95% medium emission scenario, SLR will amount to around 1055 mm between 2015 and 2115. On the same basis, over the first 50 years SLR is predicted to be 380 mm. The Humber CHaMP uses an assumption that sea levels will rise by 6mm/year between 2000 and 2050 and that this will give rise to a need for 600 ha of new intertidal habitat in order to maintain the habitat at its current quanta. (In other words, 1mm SLR has been assessed to give rise to a loss of 2ha of intertidal habitat throughout the estuary)

14. Deltares predictions are based on modelling of setbacks in combination with SLR of 1.8mm/year, whilst in the future SLR is now predicted to be 4mm/year until 2025 and then 7mm/year until 2050.

15. By contrast to the above effects, the changes in water levels due to AMEP are reported to be sub-millimetric, or virtually negligible, throughout most of the estuary and cannot be distinguished from model error (Report EX8.7), suggesting that any intertidal/subtidal change will be very small indeed.

16. In the long term, sea level rise will cause the loss of intertidal foreshore at Killingholme Marshes whether or not AMEP is consented. The area lost due to the reclamation amounts to approximately 1.2% of the whole of the middle estuary intertidal habitat (CHaMP, 2005). By 2050, the CHaMP predicts that 360 ha of intertidal will be lost in the middle estuary due to SLR. Adopting a simple pro-rata approach would suggest that, in the long term 4.32 ha of the existing intertidal at Killingholme Marshes will become sub-tidal due to SLR by 2050, and more thereafter. The long term baseline is therefore quite different to the existing baseline.

DEALING WITH UNCERTAINTY

17. Whilst the quantum of immediate direct change due to the reclamation works is measurable and therefore known with a degree of certainty, the medium and longer term impacts are less certain and that uncertainty needs to be addressed when assessing the quantum of compensatory habitat to be provided. The indirect effects also mean that the impacts of the development change over time. Initially the losses are limited to the direct habitat loss due to the reclamation works and the functional habitat loss caused by disturbance, but over decadal timescales, the indirect changes will modify the impact of the project on the estuary and this change is summarised in Table 1 below.

Table 1: Habitat Impacts of AMEP Over Time

Timescale	Impacts on the Humber Estuary SPA/SAC
Immediate	Mudflat loss = 29.5 ha Estuary habitat loss = 13.5 ha sub-tidal + 2 ha saltmarsh Σ (sub-tidal + intertidal) losses = 45 ha Functional loss of intertidal SPA habitat = 11.6 ha
Medium term 0-30 years	Sediment will accrete on the intertidal areas to the north and south of AMEP. Sediment that accretes below the existing MLWS contour will create a band of new sustainable mudflat both north and south of the quay. Sediment that accretes nearer the shore will lead to the development of a greater area of intertidal habitat lying between MHWN (+1.9 mAOD) and MHWS (+3.4 mAOD); between these levels saltmarsh is likely to develop. There is evidence of this transformation occurring in the upstream lee of HIT, 10 years after its construction. The foreshore within the area of functional loss due to AMEP is demonstrably accreting now, and is therefore likely to lose some of its functionality (due to saltmarsh development) even in the absence of AMEP. The medium term baseline is therefore different to the existing baseline. Indirect physical habitat impacts do not result in any new loss of habitat, only a **change** of habitat type within the estuary. Therefore, over 0-30 years the impacts of AMEP on habitat will **change**; the net loss of intertidal mud is likely to reduce whilst the net loss of sub-tidal habitat is likely to increase (but only to the same extent of the intertidal gain).

	In summary, over 0-30 years: Intertidal mud losses = <29.5 ha Estuary habitat losses = >15.5 ha, but Σ (sub-tidal + intertidal) losses remains 45 ha. Functional loss of SPA habitat <11.6 ha
Long term 0-100 years	Sea level rise will naturally result in some intertidal along Killingholme foreshore becoming sub-tidal. A reasonable estimate of this is around 4.32 ha. Geomorphological change caused by AMEP has been assessed by, Deltares, to give rise to a potential loss of 2-5 ha of intertidal habitat within the estuary; this would be accompanied by a sub-tidal gain. The prediction relies upon modelling of set-back sites in combination with 1.8mm/year of SLR. The relative impact of the set back may be less with the higher rate of SLR currently predicted A review of the project specific modelling of water level changes within the estuary due to AMEP shows them to be millimetric local to the development and negligible over the vast majority of the estuary. On this basis the estuary wide impacts can be estimated to be very small. Using, for the time being, a figure of 1 ha of intertidal loss and sub-tidal gain (as 4.32 ha would occur in any event), then In summary, Over 0-100 years: Intertidal losses < (29.5 ha + 1ha) mud Estuary habitat losses >(15.5 ha - 1 ha) But; Σ (sub-tidal + intertidal) losses remains 45 ha Functional loss of SPA habitat <11.6 ha

REQUIREMENT FOR COMPENSATORY HABITAT

18. It has been agreed with Natural England that the direct and indirect habitat losses affect four habitat types of community interest, none of which is a priority habitat:

    a. 1130 Estuaries

    b. 1140 Mudflats and sandflats not covered by seawater at low tide

    c. 1310 *Salicornia* and other annuals colonising mud and sand.

    d. 1330 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)

19. It has further been agreed with Natural England that where losses are assessed to have an adverse effect on the integrity of the Humber Estuary SPA/SAC then compensation should be provided in the following ratios:

    a. For habitat type 1140, initially in the ratio of 2:1 (compensation:loss) due to uncertainty with regard to the effectiveness of the scheme. The compensatory habitat must be sustainable in the ratio of 1:1.

    b. For habitat types 1130, 1310 and 1330, in the ratio of 1:1 due to the certainty that this type of habitat will be created within the scheme.

20. On this basis, the quantum of habitat to be provided to compensate for the short, medium and long term effects of AMEP are summarised in Table 2 below.

Table 2: Habitat Compensation Requirements Over Time (Ignoring Saltmarsh Development)

	Habitat Type and Gain/Loss (ha)			**TOTAL COMPENSATION AREA REQUIRED (ha)**
Timescale	**1130**	**1140**	**1310/1330**	
Immediate Impact	13.5	41.1	2	97.7
Compensation	**13.5**	**82.2**	**2**	
Medium Term Impact Sub-tidal to mudflat (0-30 years)	>13.5	<41.1	2	>47 <97.7
Compensation	**<45** **>13.5**	**>0** **<82.2**	**2**	
Long Term Impact (0-100 years, 1 ha habitat change)	<(45-1) >(13.5-1)	>1 <(41.1+1)	2	>48 <98.7
Compensation	**<44** **>12.5**	**>2** **<84.2**	**2**	

CONFOUNDING VARIABLES

The Baseline

21. The impact of AMEP needs to be assessed against a baseline, but in this case the baseline itself is evolving due to the HIT development and due to SLR.

22. Assessing the true medium term impact of AMEP is therefore complicated by the fact that two predictions need to be made, *viz.*

- The medium/long term development of the Killingholme foreshore subject to HIT alone, and,
- The **extra** medium/long term development of the Killingholme foreshore post-AMEP.

The difference between these two predictions is the impact of AMEP on the foreshore.

23. As it is known that the foreshore is continuing to accrete, so it is conservative to address this particular uncertainty by assuming that the 2010 levels do actually provide a stable baseline and to accept the existing foreshore levels as the medium term levels.

24. The long term baseline will be characterised by a greater quantum of sub-tidal habitat and an equal reduction in intertidal habitat. This uncertainty can be addressed by, again, conservatively assuming that there is no change from the existing baseline.

25. Using the above assumptions ensures a precautionary approach.

Development of new Intertidal Habitat in the Medium Term

26. In Annex 8.2 (Figure 9a) of the ES, the evolution of the foreshore post-AMEP is postulated and from that, the quantum of sub-tidal habitat predicted to change to mudflat was estimated to be 7.88 ha. This assessment preceded the more recent Wallingford reports (EX8.8. EX8.9 and EX8.10) which enable a more informed assessment.

27. To the south of AMEP, there is a broad expanse of intertidal mudflat that extends from the flood defence, to the MLWS contour which lies just inshore of the two jetty berths (SKOJ and IGT). Between AMEP and HIT there cannot therefore be any significant increase in the area of intertidal habitat as that will be constrained by the location of the deep water channel along the jetty line; a small increase in area is therefore postulated on Drawing AME-06033-G, refer to Appendix A. Accretion over existing intertidal areas south of the quay will almost certainly continue however and bring more habitat above the level of MHWN. The flood defence wall has appeared to limit the upper level of mudflat in this area however, so the existing foreshore slope is expected to simply flatten over time.

28. To the north of AMEP the intertidal area is less extensive and accretion is likely to create new mudflat where it occurs below existing MLWS. However the areal extent of undisturbed accretion will be limited by the presence of nearby berthing pockets and the associated approach channels for HST. Any sediment accreting in those areas will be dredged before they become significant and the potential for sedimentation north of HST, whilst possible, seems unlikely.

29. Putting quantities to these impacts is, realistically, a matter of professional judgement, taking into consideration all of the information available. The extent of new intertidal habitat that is predicted to the north and south of the quay is indicated on drawing AME-06033-G which is reproduced in Appendix A.

Development of Saltmarsh in the Medium Term

30. The existing intertidal habitat on the Killingholme Marshes foreshore is mostly mudflat with a small area of mature saltmarsh in the downstream lee of Humber Work Boats' premises. The development of HIT has led to a significant response in the local sedimentary regime with accretion becoming dominant and around 40 ha of existing intertidal being raised in level. This process is continuing and over the long term saltmarsh will develop in some elevated intertidal areas whether or not AMEP is constructed.

31. Attempting to quantify the area of saltmarsh that that would evolve in the absence of AMEP and the additional saltmarsh that would develop if AMEP is constructed is a matter of judgement. The DEFRA publication, *'Suitability Criteria For Habitat Creation – Report 1 : Reviews of Present practices and Scientific Literature Relevant to Site Selection Criteria',* (EA, 2004), provides an extensive review of the habitat requirements for saltmarsh development. In summary there are numerous factors that influence its development to a greater or lesser extent, including:

- Elevation
- Frequency of inundation
- Estuary size
- Tidal range
- Site gradient
- Drainage
- Sediment characteristics, both physical and chemical
- Salinity

32. The DEFRA report provides two formulae for the lower limit of *Spartina* (a pioneer species) and *Puccinellia maritime* (a low-mid marsh species) on the south and west coast of Britain, viz.

$$LL = -0.805 + 0.366SR + 0.053F + 0.135\mathrm{Log}_e A \qquad \textbf{(1)}$$

Where, LL = lower limit of *Spartina* (mODN)

SR = spring tidal range (m)

F = fetch length in the direction of the transect (km),

A = Estuary area (km^2), Humber estuary =

And, $$LL = 0.23 + 1.39*MHWN \qquad \textbf{(2)}$$

Where, LL = lower limit of *Puccinellia maritima*

33. Using the formulae yields the values 2.54 mODN (SR=6.4, F=4.5, A=286) and 2.87 mODN for formulae (1) and (2) respectively. Whilst these formula are not directly relevant to the Humber they nevertheless provide a guide to the most significant factors in the suitability of a site for saltmarsh development. Essentially, in larger estuaries with a high tidal range, saltmarsh will colonise at higher levels.

34. In terms of tidal inundations, the DEFRA report states that, 'sites with elevations that will experience less than about 450 tidal inundations would be expected to develop salt marsh, whereas mudflat will develop at levels that experience greater than 500 inundations per year (Burd 1995)'. Annex 32.5 of the ES provides the percentage of tides at Immingham that are above various levels, the relevant table is reproduced below. Given that there are 704 high tides per year, then there are 418 high tides that exceed 2.5 mAOD every year. At a level of 2.25 mAOD, the number of annual tidal inundations increases to around 500.

Table 1 Frequency of occurrence of high tides at Immingham 1996, 2008-2011

Level mAOD	1996	2008	2009	2010	2011	Average (5 years)	Average (3 years) 1996, 2008, 2010
Percent >2.5	64.0	55.5	56.7	58.6	59.6	58.9	59.4
Percent ≥ 3.0	41.2	32.3		34.8			36.1
Percent ≥ 3.4	15.4	9.6	10.8	11.2	11.9	11.8	12.1
Percent ≥ 3.8	2.5	0.4	1.3	2.6	2.8	1.9	1.8
Percent ≥ 4.0	0.3	0.0		0.7			0.3

35. Also in Annex 32.5, the development of saltmarsh at Paull Holme Strays is reported in relation to site level, again the relevant table is reproduced below.

Table 6 Saltmarsh ground cover at Paull Holme Strays

Level group (in 2005)	Average ground coverage with saltmarsh (percent)					
	Sept 03	Sept 04	Sept 05	Sept 06	Sept 07	Sept 08
2.0-2.3	0.0	0.0	0.0	0.0	0.8	1.5
>2.3-2.6	0.0	0.0	0.1	1.3	9.1	34.2
>2.6-3.0	0.0	3.8	14.7	44.1	57.3	76.8
>3.0-3.5	0.0	40.9	55.0	74.4	67.5	74.8

Note: From Tables 4.2 from Brown (2009).

36. The evidence therefore indicates that saltmarsh development is relatively constrained below about 2.3 mAOD and that this is consistent with accepted habitat development criteria.

37. On the basis of the above, it is predicted that the foreshore will reach equilibrium with an upper level at the toe of the sea wall and that it will slope very gently towards the MHWN contour which will, over time, creep towards the berthing line of AMEP. Approximately half of the area of intertidal in the lee of AMEP will therefore have the potential to develop into saltmarsh. Some of the area to the north of HIT already has the potential to develop into saltmarsh and there is some evidence of that occurring now. The habitat changes that might occur over the medium term are detailed on drawing AME-06033.

38. Tables 3 to 5 below provide a quantitative assessment of medium and long term habitat gain and loss.

	HABITAT TYPE			
	Saltmarsh	Intertidal Mudflat	Sub-tidal (Estuary)	
IMMEDIATE IMPACTS				
Direct	-2	-31.5 2	-13.5	
Functional Loss		-11.6		
TOTAL	-2	-41.1	-13.5	
Direct Compensation	2	82.2	13.5	97.7

Table 3: Short Term Impacts of AMEP on SPA Habitat

	HABITAT TYPE			
	Saltmarsh	Intertidal Mudflat	Sub-tidal (Estuary)	
MEDIUM TERM (0-30 YEARS)				
Direct	-2	-31.5	-13.5	
		2		
Functional Loss Due to AMEP		-8.9		
TOTAL	-2	-38.4	-13.5	
Compensation	2	76.8	13.5	
Local Functional Mudflat creation - North		0	0	
Local Functional Mudflat creation - South		0.5	-0.5	
TOTAL	-2	-37.9	-14	
Direct Compensation + reduction by Indirect mudflat creation	2	75.8	14	
Local Functional Mudflat Conversion to Saltmarsh - North	0	0		
Local Functional Mudflat Conversion to Saltmarsh - South	1.1	-1.1		
Creation of saltmarsh in the disturbance zone	4.7			
TOTAL	3.8	-39	-14	
Direct Compensation + reduction by Indirect mudflat creation + Indirect mudflat conversion to saltmarsh	0	78	10.2	88.2

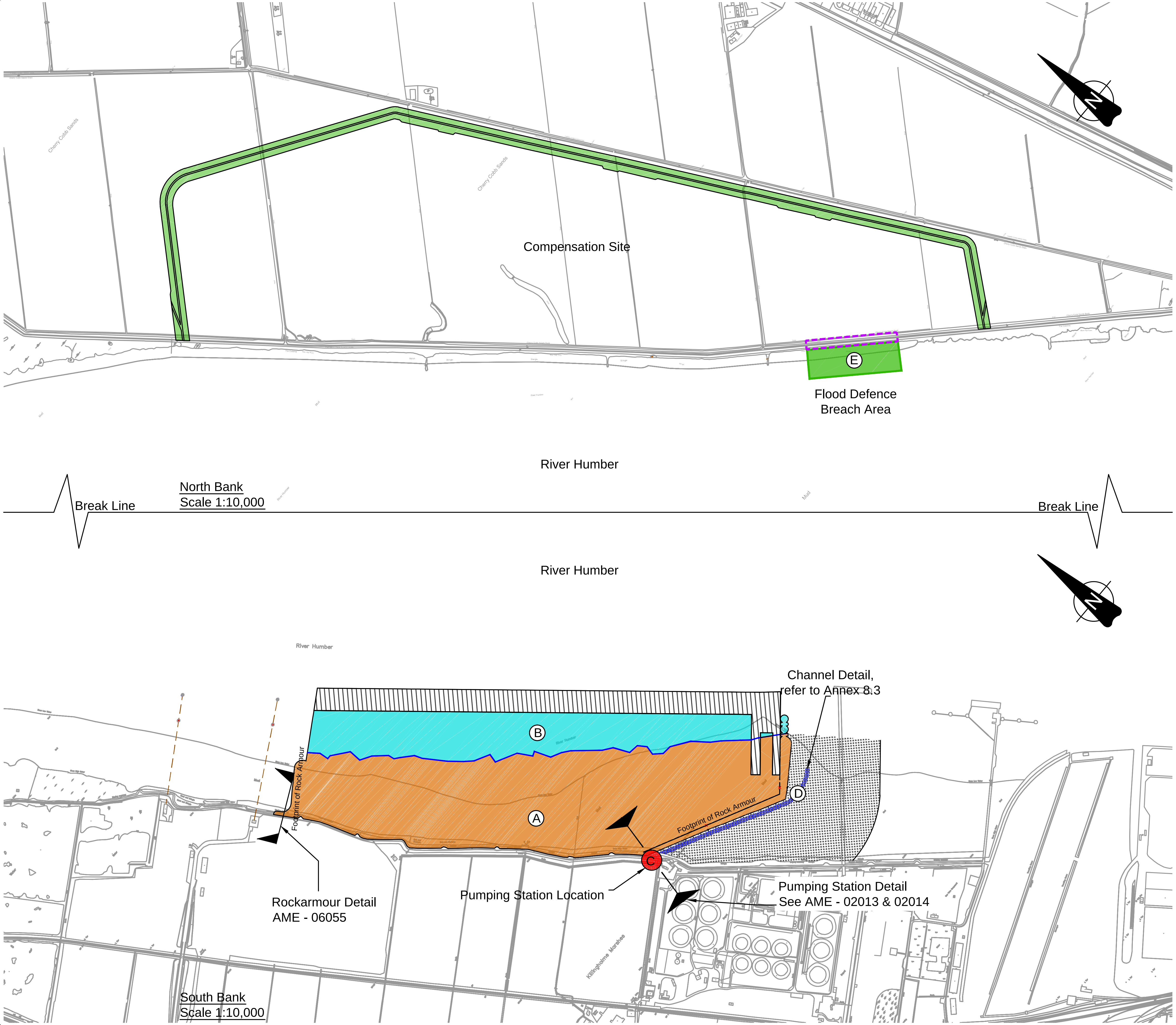
Table 4: Medium Term Impacts of AMEP on SPA Habitat

	HABITAT TYPE			
	Saltmarsh	Intertidal Mudflat	Sub-tidal (Estuary)	
LONG TERM IMPACTS				
Direct	-2	-31.5	-13.5	
		2		
Functional Loss Due to AMEP		-8.9		
TOTAL	-2	-38.4	-13.5	
Compensation	2	76.8	13.5	
Local Functional Mudflat creation - North		0	0	
Local Functional Mudflat creation - South		0.5	-0.5	
TOTAL	-2	-37.9	-14	
Direct Compensation + reduction by Indirect mudflat creation	2	75.8	14	
Local Functional Mudflat Conversion to Saltmarsh - North	0	0		
Local Functional Mudflat Conversion to Saltmarsh - South	1.1	-1.1		
Creation of saltmarsh in the disturbance zone	4.7			
TOTAL	3.8	-39	-14	
Direct Compensation + reduction by Indirect mudflat creation + Indirect mudflat conversion to saltmarsh	0	78	10.2	
LONG TERM (0-100 YEARS)				
Indirect - WL Change		-1	1	
TOTAL	3.8	-40	-13	
Direct + Indirect + EA Compensation	0	80	9.2	89.2

Table 5: Long Term Impacts of AMEP on SPA Habitat

39. The size of compensatory habitat proposed is 100 ha which is sufficient to address the changing impacts of the scheme on the habitat types within the designated site over the short, medium and long term. It also caters for the associated uncertainty of the indirect effects both local to the quay and estuary wide.

APPENDIX A – Drawings



KEY

- Berthing Pocket
- A Intertidal Habitat Loss - 31.50ha
- B Subtidal Habitat Loss - 13.50ha
- C Limit of Operational Disturbance - 11.6ha
- D Drainage Channel & Pumping Station
- E Flood Defence Breach Area - 1.8ha
- Mean Low Water Spring
- Limit of Operational Boundary

Notes:

1. Limit of disturbance is defined by 150m offset from a point source (+).

Rev	Date	Comments	Drw	Chk	App
B	17/05/12	North Bank Added	RK	JD	RC
A	13/04/12	Preliminary Issue	JH	RC	RC

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Project: ABLE Marine Energy Park

Client: ABLE UK Ltd

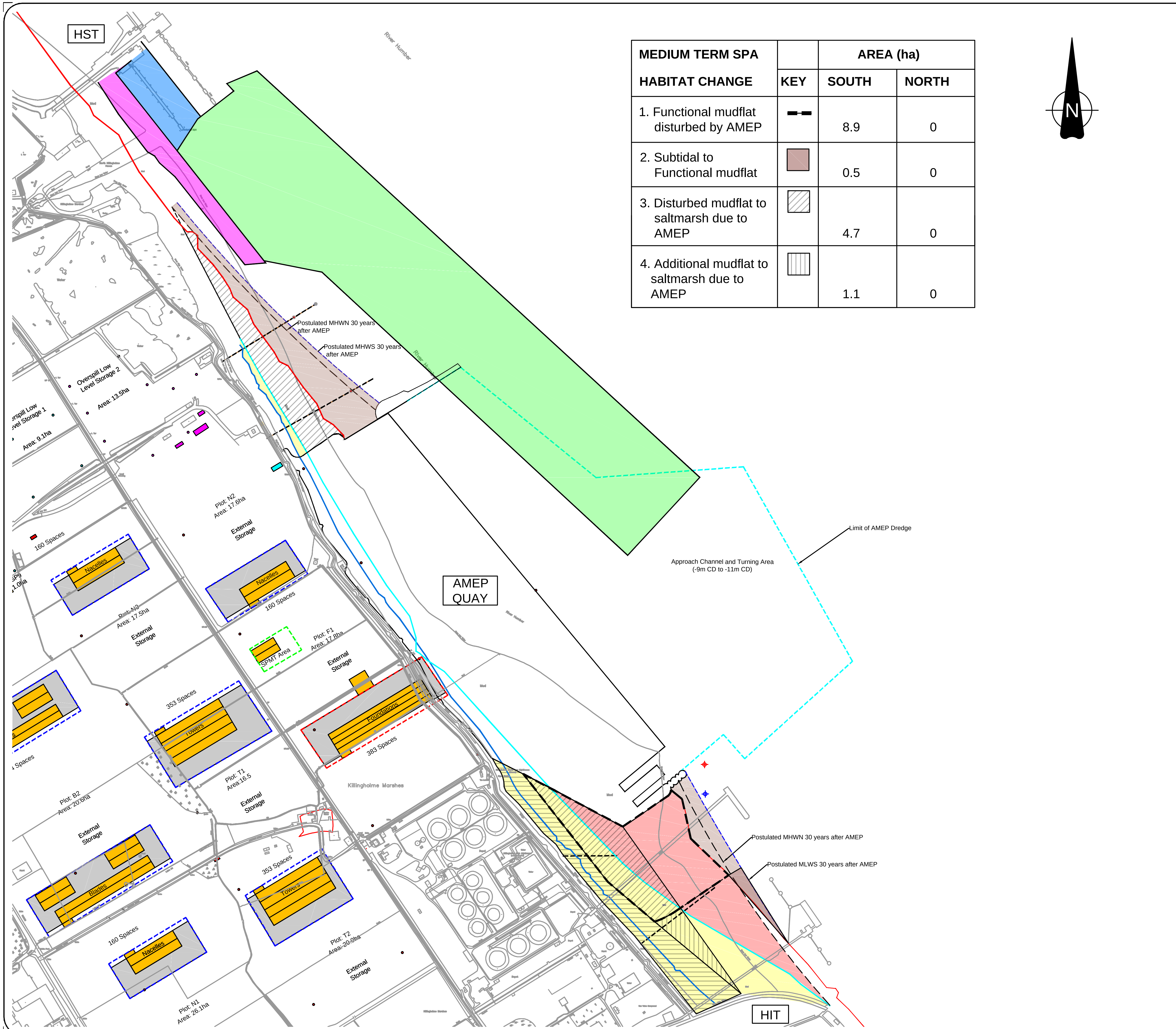
Title: Habitat Impacts

PRELIMINARY

Scale:	Drawn	Checked	Approved
As Shown@A3	J Harris	R Cram	R Cram
Date	13/04/2012	13/04/2012	13/04/2012

Drawing No.: AME - 06077

Revision: B



MEDIUM TERM SPA HABITAT CHANGE	KEY	AREA (ha) SOUTH	NORTH
1. Functional mudflat disturbed by AMEP		8.9	0
2. Subtidal to Functional mudflat		0.5	0
3. Disturbed mudflat to saltmarsh due to AMEP		4.7	0
4. Additional mudflat to saltmarsh due to AMEP		1.1	0

KEY

- Existing MLWS
- Existing Outfall
- IUS Dolphin
- US Dolphin Constructed 2011
- HST Consented to Dredge to 9.35m CD
- HST Consented to Dredge to 7.2m CD
- HST Consented to Dredge to 6.2m CD
- 2001 MHWN 1.9m ODN
- 2010 MHWN 1.9m ODN
- Intertidal habitat above MHWN 2010
- Existing mudflat that will accrete above MHWN post AMEP
- Predicted saltmarsh development without AMEP
- Additional saltmarsh development with AMEP
- Existing sub-tidal accreting to mudflat post AMEP
- Limit of Operational Disturbance Medium Term

Rev	Date	Comments	Drw	Chk	App
H	12/06/12	Table Ammended	FM	RC	RC
G	08/06/12	2001 MHWN Added	FM	RC	RC
F	07/06/12	mage Added & Ti le Ammended	FM	RC	RC
E	26/04/12	Image Added	JH	RC	RC
D	09/03/12	Dolphins & Outfalls Added	JH	RC	RC
C	29/09/11	Bird Disturbance Added	JH	RC	RC
B	13/04/11	Dredge Quantities Added	JH	RC	RC
A	07/04/11	Preliminary Issue	JH	RC	RC

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Project: ABLE Marine Energy Park

Client: ABLE UK Ltd

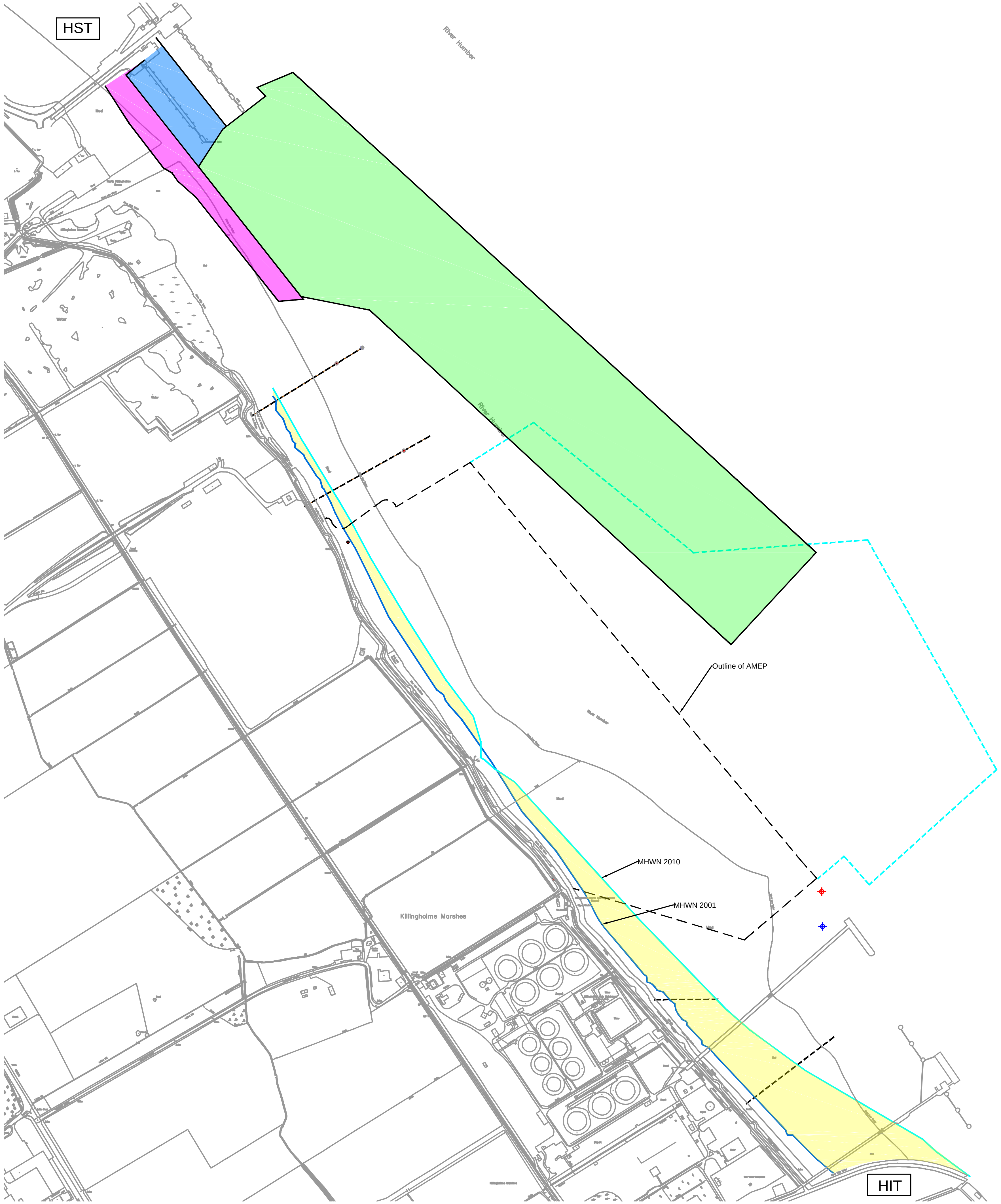
Title: Medium Term SPA (0-30yr) Habitat Change Post-AMEP

PRELIMINARY

Scale:	Drawn	Checked	Approved
1:10,000@A1	J Harris	R Cram	R Cram
Date	07/04/2011	07/04/2011	07/04/2011

Drawing No. AME - 06033

Revision: G



KEY

- Existing Outfall
- IUS Dolphin
- US Dolphin Constructed 2011
- Turning Circle
- MHWN1.9m ODN
- 2001 MHWN 1.9m ODN
- HST Consented to Dredge to 9.35m CD
- HST Consented to Dredge to 7.2m CD
- HST Consented to Dredge to 6.2m CD
- Intertidal level change Post-HIT from <MHWN to >MHWN (2001 - 2010) 13.9ha

Rev	Date	Comments	Drw	Chk	App
A	08/06/12	Preliminary Issue	FM	RC	RC

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Project: ABLE Marine Energy Park

Client: ABLE UK Ltd

Title: 2001- 2010 Habitat Change North of HIT

PRELIMINARY

Scale:	Drawn	Checked	Approved
1:10,000@A1	F Maddison	R Cram	R Cram
Date	08/06/2012	08/06/2012	08/06/2012

Drawing No.: AME - 06090

Revision: A

APPENDIX B – Deltares Report for The Environment Agency

Background

Two port developments on the north and south banks of the Humber Estuary are going through the planning process. Associated British Ports (ABP) are progressing a major north bank scheme (Green Port Hull, abbreviated as GPH). Able UK is promoting a south bank scheme (Able Marine Energy Park abbreviated as AMEP). EIA studies are available for both developments, both considering the cumulative environmental effects of the combined developments. Herein disagreement exists about whether or not the south bank scheme (AMEP) will have detrimental effects on estuarine functioning and result in further indirect losses taking place. The Environment Agency (EA) is responsible for meeting coastal squeeze losses. For this reason EA commissioned Deltares to provide an independent assessment of the claims being made.

This memo reports the results of the first part of the work, which is a desk assessment of the correspondence EA has received and of the Environmental Statements. The first section below summarizes our conclusions and gives some recommendations. The subsequent sections substantiate the conclusions by first summarising the relevant findings from the assessments of the two studies, followed by a more detailed evaluation of the impacts of the developments on the estuarine processes, i.e. the hydrodynamics, sediment transports and morphology.

Conclusions and Recommendations

For both developments, GPH and AMEP, extensive and detailed studies have been carried out for making the Environmental Statements. The relevant parts of the documents reporting the studies have been assessed in a short desk study. The conclusion from this first assessment is that both studies are sound in assessing the environmental impacts for the development they consider. Each of the studies supply detailed assessments of the impacts of its own development. We did not find indications pointing at underestimated effects in the EIA studies.

As required, both studies address the combined and cumulative effects by considering the other ongoing and planned developments. For this purpose the study on GPH has considered the impacts of AMEP, and vice versa. However, both studies lack details of the other development, apparently because of the insufficient availability of information. Therefore the evaluations of the combined and cumulative effects are precautious, as they should.

As repeatedly stated in the EIA documents for the GPH development, the assessment of the effects of AMEP is based on results of preliminary modelling because the results of detailed modelling study were not available. The statements on the effects of AMEP are meant for a precautionary evaluation of the combined and cumulative effects in the EIA of GPH. Therefore EA is advised to interpret those statements strictly in this manner.

As follow up we recommend the EA to ask the consortium who carried out the study for AMEP to present the results of the TELEMAC model concerning the impacts of the AMEP scheme to the water levels and tidal currents. This will help to answer questions that emerged from our assessment of the EIA documents for the AMEP development (see following Section). It would also be desirable to carry out the sand transport modelling using the TELEMAC model and compare the results with those from the CMS – model. It would be ideal if both developments would be simulated with a same model with comparable resolutions of the computational grid at both sites.

AMEP documents

The following documents from the study on the AMEP development have been received from EA and assessed:

08 - Hydrodynamic and Sedimentary Regime.pdf

09 - Water and Sediment Quality.pdf

13.1 - Flood Risk Assessment and Drainage Strategy.pdf

32 - Hydrodynamic and Sedimentary Regime.pdf

32.1 Compensation site geomorphology.pdf

32.2 Hydraulic model set up report.pdf

32.3 Compensation site breach design report.pdf

32.4 Compensation site model test report.pdf

32.5 - Compensation site sedimentation and erosion.pdf

32.6 - 110ha Compensation site model test report.pdf

33 - Water and Sediment Quality.pdf

36 - Drainage and Flood Risk.pdf

44 - In-Combination.pdf

8.1 - AMEP Estuary Modelling Studies Report.pdf

8.2 - Geomorphological Review of the Humber.pdf

8.3 - Assessment of the Effects on Fine Sediments.pdf

8.4 - Dredging Plume Dispersion.pdf

9.1 - Bathymetry Hydrography Survey.pdf

9.4 - Water Framework Directive Assessment.pdf

9.5 - Anglian Water Letter.pdf

9.6 - Assessment of relocation EON outfall.pdf

92-ASS~1.PDF (draft internal document for review)

93-ASS~1.PDF (draft internal document for review)

Our assessment focused on those parts concerning the effects on estuarine processes, i.e impacts on the hydrodynamics, sediment transports and morphology. Relevant findings from the assessment of these documents are summarised as follows:

- Two different numerical models have been applied for evaluating the various effects of the AMEP scheme:
  - A 2DH hydrodynamic model based on CMS – Flow is used for the effect on water levels and currents and bed shear stresses. The results of this model are also used for the effect on short-term sediment transport processes and suspended sediment concentrations.
  - A 3D hydrodynamic model based on TELEMAC is set up and used in combination with DELWAQ for the effects on fine sediments.
- The results of the TELEMAC hydrodynamic model for the effects on water levels, currents and bed shear stresses are not presented. This is a pity as the results could be compared with those from the CMS model in relation to the next observation.
- The proposed development consists of: i) a quay, ii) an area of dredged depths comprising the berthing areas and approach channels, and iii) an area of compensation land exposed to the Estuary on the north bank. The hydrodynamic modelling results are from model runs without taking into account of the compensation area on the north bank (5.6 of document 8.1 AMEP Estuary Modelling Study Report). The quay has the effect that it decreases the tidal storage (volume between HW and LW) and the volume under LW, whereas the dredging increases the volume under LW. The combined effect on the volume under LW is an increase (5.8 of document 8.1 AMEP Estuary Modelling Study Report). In terms of hydrodynamics it means a decrease of the storage width and an increase of the cross-sectional area for flow. Based on the experience of earlier studies (Wang and Jeuken, 2004; Jeuken et al., 2007) initially a (small) increase of the tidal range through the estuary would be expected. However, the presented results show the opposite, a reduction in tidal range. A possible explanation is that the detailed model simulates circulations at the two (especially the north) ends which effectively decrease the local flow carrying cross-sectional area while the storage width remains the same. Another, additional explanation could be that the dredging in front of the quay is not fully implemented in the simulation. The following observation triggers this suspicion:
- The model results show increased peak flow velocities in the majority of the dredged area. Only in a small strip directly next to the quay, a reduction in peak velocities is simulated.
- The results of the short-term sediment transport simulations (Figure 27 in document 8.1 AMEP Estuary Modelling Study Report) point at additional sedimentation, which is remarkable given the predicted pattern of the change in flow velocity field.

GPH documents

The following documents from the study on the GPH development are received from EA and assessed:

0326_001.pdf (draft internal document for review)

10 Water Quality, Drainage and Flood Risk FINAL.pdf

1203-0099-m-Review EIA documents GPH & AMEP.doc (draft internal document for review)

1203-0100-vdraft-m-Review EIA documents GPH & AMEP.doc (draft internal document for review)

2 Need and Alternatives FINAL.pdf

21 Cumulative and Combined Effects FINAL.pdf

9 Coastal and Estuarine Processes FINAL.pdf

Appendix 10C FINAL.pdf

Appendix 9A FINAL.pdf

Chapter 10 Figures FINAL.pdf

Chapter 2 Figures FINAL.pdf

Chapter 21 Figures FINAL.pdf

Chapter 9 Figures FINAL.pdf

Compensation. PDF (re-issued as ABPmer Report R1975 260412.pdf)

Environment Agency Response 23.02.12.pdf

GPH IROPI hcc draft 23 Mar 12.doc

Green Port Hull habitat regs step guide.doc

hcc aa 23 3 12.doc

In combination update -ABPmer 22-3-12 (2).pdf

Our assessment focused on those parts concerning the effects on estuarine processes. Relevant findings from the assessment of these documents are summarised as follows:

- The EIA for GPH concerning coastal and estuarine processes is based on the 1D and 2DH numerical modelling of the consented Quay 2005 development. This is why no model simulation including AMEP is carried out in the study for evaluating the combined and cumulative effects. Evaluation for AMEP is based on preliminary modelling results from the AMEP-study.
- In their report "21 Cumulative and Combined Effects FINAL.pdf" they refer to the study "JBA (2011) South Humber Channel Marine Studies: Hydrodynamic, Wave and Sediment Study. Report to Yorkshire Forward". This latter study does not seem to be the same study as the one assessed in this desk study, i.e. "8.1 - AMEP Estuary Modelling Studies Report.pdf". This may explain why the effects of AMEP on the currents reported in paragraphs 21.152 and 21.153 of the GHP study "21 Cumulative and Combined Effects FINAL.pdf" are larger than those reported in the AMEP study. All the other statements saying that the effects of the AMEP development would be substantial are related to these larger effects on the currents.
- Obviously, a different set of models is used than the models used in the AMEP-study.
- Infilling of the dock and reclamation will require sediment dredged elsewhere. The dredging of the infilling material is not considered in the GPH study, probably because the dredging will take place outside the estuary, except that the dredged material from the IOTA development may be used for this purpose.
- It is proper to use the worst scenario for combined and cumulative impact as long as it is meant for evaluating the impact of the development under consideration. Presumably, this is not meant for judging the other developments, especially when no detailed information of another development is used.

Impact on estuarine processes

The results from the Geo Studies in the Humber Estuary Shoreline Realignment Project may be used as reference for evaluating the developments under consideration (See Wang and Jeuken, 2004; Jeuken et al., 2007). In that study various set backs along the shorelines of the Humber Estuary have been considered. The set backs have the effect that the size of the estuary, especially the intertidal zone, is increased. This is opposite than the effect of the developments of GPH and AMEP. Nevertheless, the experience obtained in that study is still relevant. Both the GPH and the AMEP developments are relatively small compared with the set backs considered in that study. Therefore, the impacts of both developments, especially concerning the large-scale and long-term effects, will be limited (see the appendix for a more quantitative consideration of effects).

It is obvious that the effects of a development depend on the size of the development, the larger the size, the more serious the effects. The size of a development should be measured with the volumes of the development in the intertidal zone and in the sub-tidal zone. The AMEP development is much larger than the GPH development. However, the difference in size between the two developments seems not sufficient to explain the reported differences in the impacts on current field by the GPH-document "21 Cumulative and Combined Effects FINAL.pdf".

As a matter of fact the reclamation for a development will simply block the local current field. This means that the maximum reduction of the current by a development is simply the maximum magnitude of the current along the edges of the development. However, this is a local effect and it should be clearly distinguished from the larger scale effects in the discussion. Whether local or large scale effect is considered depends on the model used. That different models are used in the two studies is the most logical explanation of the exaggerated differences between the effects of the two developments reported by the GPH-study.

It is noted that the local effects on the current field of a development determined by a numerical model can be dependent on the resolution of the model grid. Sufficient resolution of the model grid is needed for correctly modelling the local effects on the current field. Furthermore, one of the local effects is the generation of a circulation zone behind the development, as shown in the numerical modelling study for the AMEP development. For a correct representation of this circulation zone the horizontal eddy viscosity is an important model parameter. However, the setting of this parameter is usually considered not important in 2DH flow models as usually only the large–scale effects are considered. It is noted that validation of the models concerning the local effects is not given for any of the models used in the two studies for GPH and AMEP developments respectively. It is important to use the same or at least comparable models concerning model grid resolution and parameter setting when the local effects of the developments are compared with each other.

Another issue is the disposal of the material from capital dredging. In the GPH documents it is mentioned that the large amount of the material dredged during the AMEP development will cause problems at the disposal sites, which will not have sufficient space to accommodate all the dredging material from the various developments. This issue is not considered in detail here as detailed information about the disposal sites is not available and needs to be checked by the AMEP consortium.

References

Wang Z.B. and M.C.J.L. Jeuken, 2004, Long-term morphologic modelling of the Humber Estuary with ESTMORPH, The future morphologic evolution and the impact of set backs, Report Z3451/Z3521, WL | Delft Hydraulics.

M.C.J.L. Jeuken, Z.B. Wang and D. Keiller, 2007, Impact of setbacks on the estuarine morphology, In Dohmen-Jansen, C.M. and S.J.M.H. Hulscher (eds.), River, Coastal and Estuarine Morphodynamics, RCEM2007, Taylor & Francis, 2008, London, pp1125-1134.

Appendix - Effects on intertidal area

Basically, a realignment development (reclamation or setback) in an estuary may affect the intertidal area in three ways (Jeuken et al., 2007): (1) its direct effect, (2) change due to change of tidal range, (3) morphological change due to sedimentation and erosion. Effect (1) is local at the realignment site and it is a sudden change in time, i.e. takes place immediately after the realignment and can be considered to remain constant in time. Effect (2) is in principle through the whole estuary and it takes place immediately after the realignment and will change in time due to effect (3). Effect (3) is a gradual change in time and can in principle occur through the whole estuary. A realignment development causes thus an initial change (effects 1 & 2) as well as a change in time (effects 2 & 3) for the intertidal area. The change in time causes a long-term effect, which can be a gain or a loss of intertidal area depending on the type as well as the location of the development.

The AMEP development consists of a reclamation on the south bank of the estuary and a setback as compensation on the north bank, both in the mid – estuary zone. The reclamation has a size of 45 Ha of which 31.5 Ha in the intertidal zone and 13.5 Ha in the subtidal zone. The setback has a size of about 100 Ha, at an elevation of about ODN + 2.5 m which is around the MHW. Effect (1) for the intertidal area is thus -31.5 + 100 = + 68.5 Ha. Additionally, there is a direct functional loss [1]of 6 ha (in sector E), resulting in a total direct loss of inter-tidal area of 37.5 ha. The initial compensation ratio for the intertidal area is 100:37.5 = 2.7. The compensation ratio for the entire reclamation is 100:45 = 2.2

The combined effect of the reclamation and the compensation site on the tidal prism is a decrease, even for spring tide. MHWS = 3.4 m and MLWS = - 3 m, so the increase of tidal prism due to the compensation site is about (100 Ha * 0.9 m) 0.9 million m^3. The sub-tidal part of the reclamation causes a decrease of the tidal prism of 6.4 m * 13.5 Ha = 0.9 million m^3. The intertidal part of the reclamation will also cause about 1 million m^3 (31.5 Ha * 0.5 * 6.4 m) decrease of the tidal prism during spring tide. During neap tide the compensation site will not be flooded. Therefore the combined effect on the tidal prism is always a decrease. The dredging causes an increase of the sub-tidal water volume of the estuary which is larger than the decrease resulting from the reclamation, causing an increase of the tidal range. Therefore, the initial part of effect (2) is an extra (small) gain in intertidal area because of the expected increase of the tidal range.

For the long-term morphological development it is expected that sedimentation will take place seaward of the development and erosion landward of the development. For the evaluation of this part of the effect reference is made to the development of Sunk Island setback (because of comparable location along the estuary) reported by Jeuken et al. (2007). The trend of the development will be opposite, i.e. a long-term loss due to the AMEP development instead of the long-term gain reported in Jeuken et al. (2007) for the Sunk Island setback case. The long-term gain for the Sunk Island setback case is about 5% of the size of the development after 50 years. If this relative number is applied to the AMEP case it will mean a loss of intertidal area of about 3 Ha (68.5 * 0.05) after 50 years and an equally large gain of sub-tidal area (i.e. intertidal area changed into subtidal area). For the change after 100 years the loss is estimated to be about 5 Ha (the rate of change decreases in time, although no more reference to the

[1] It is assumed, that functional loss implies a loss in e.g. ecological value without affecting the intertidal character of Sector E.

earlier study can be made). To deal with uncertainties we may take a factor 2 for the lower and the upper limits of the changes, resulting in 2 to 7 Ha loss after 50 years and 3 to 10 Ha after 100 years.

For the worst scenario after 100 years we take the upper limit of the long-term loss and ignore the initial part of effect (2), the remaining total gain of intertidal area will be about 58 Ha, i.e. 10 Ha has changed into sub-tidal area. The compensation ratio for the intertidal area is then about 1.8 (58:31.5). Taking the functional loss of 6 Ha into account as well, the compensation ratio for the intertidal area is 1.6 (58:37.5). The compensation-ratio for the entire reclamation will stay the same (i.e. 2.2) as intertidal losses will result in sub-tidal gains.

The GPH development will influence the estuary by reclamation of 7.5 Ha, 4.5 Ha in the intertidal zone and 3 Ha in the sub-tidal zone. This concerns a very small development, and it is a consented development. The long-term development will cause a similar relative loss as discussed above. For the worst case scenario this will be about 0.6 Ha ($\approx 10*4.5/68.5$) after 100 years. This is calculated with the same rule as in the AMEP case. Note that the 4.5 Ha initial change is a loss instead of gain in the AMEP case. Motivation that the long-term effect will be a loss is that the reclamation will cause a small increase of the tidal range in the estuary. The long-term increase in tidal range will be associated with increasing current velocities and erosion. During this erosion process intertidal area will be transformed into subtidal area. Thus the estimated loss of about 0.6 ha of intertidal area implies an equal gain for the sub-tidal zone.