Able Marine Energy Park

Marine Environmental Management and Monitoring Plan

April 2013

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1. INTRODUCTION

1.1 Background and Aims of the Marine EMMP (MEMMP)

1. The development of the Able Marine Energy Park (AMEP) east of North Killingholme on the Lincolnshire Coast will partly affect the Humber Estuary Special Area of Conservation (SAC) and the Special Protection Area (SPA) / Ramsar site. Measures to both compensate and mitigate for the effects of AMEP on these habitats and species have been identified, and will be implemented as part of any future development.
2. This Marine Environmental Management and Monitoring Plan (MEMPP) has been drawn-up taking account of guidance on management planning produced by the Conservation Management System (CMS) Consortium (www.cmsconsortium.org). It describes the mitigation measures that are required and lists specific objectives which are fundamental to their delivery. Further, it includes targets and management actions which support the objectives and the monitoring which will be undertaken to confirm progress towards the objectives, and ultimately confirming that they have been achieved. Limits of acceptable change are defined where appropriate and any necessary remedial actions which will be undertaken should the monitoring show that these limits have not been met.

1.2 Process of Finalising Outstanding Targets

3. The mitigation proposals for AMEP are complex, and the objectives and targets / management options included in this version of the MEMMP have been subject to extensive discussions with stakeholders. Prior to the Deemed Marine Licence (DML) being granted, the MEMMP will be further refined through stakeholder discussion regarding targets / management actions and subsequent monitoring requirements, and this process is currently still ongoing.
4. The MEMMP will continue to be a live working document which will be in place for as long as it is deemed necessary to achieve the agreed objectives set out in it. Updates to it will be overseen by the Steering Group, whose role is explained below and includes undertaking a complete review of the MEMMP every five years.

1.3 The Steering Group

5. Able Humber Ports Limited (AHPL) will have overall responsibility for the implementation of the MEMMP. However, the involvement of other stakeholders is essential for the effective working of the MEMMP, and hence AHPL will establish a Steering Group whose members and terms of reference are set out in a '*Deed in Relation to the Able Marine Energy Park'*, between Able Humber Ports Limited and Natural England (NE).

6. An agenda will be drawn up in advance of each Steering Group meeting by AHPL and minutes will be produced after the meeting by them for agreement.
7. Unless otherwise stated, the default duration for the ecological survey work (e.g. saltmarsh, intertidal and subtidal benthos and fish communities) described within this document is 10 years. Continuance of any of these components beyond that period will be determined through discussion on findings etc by the Steering Group. It is expected that some components of the compensation and the mitigation will require ongoing management to ensure that the objectives continue to be met.

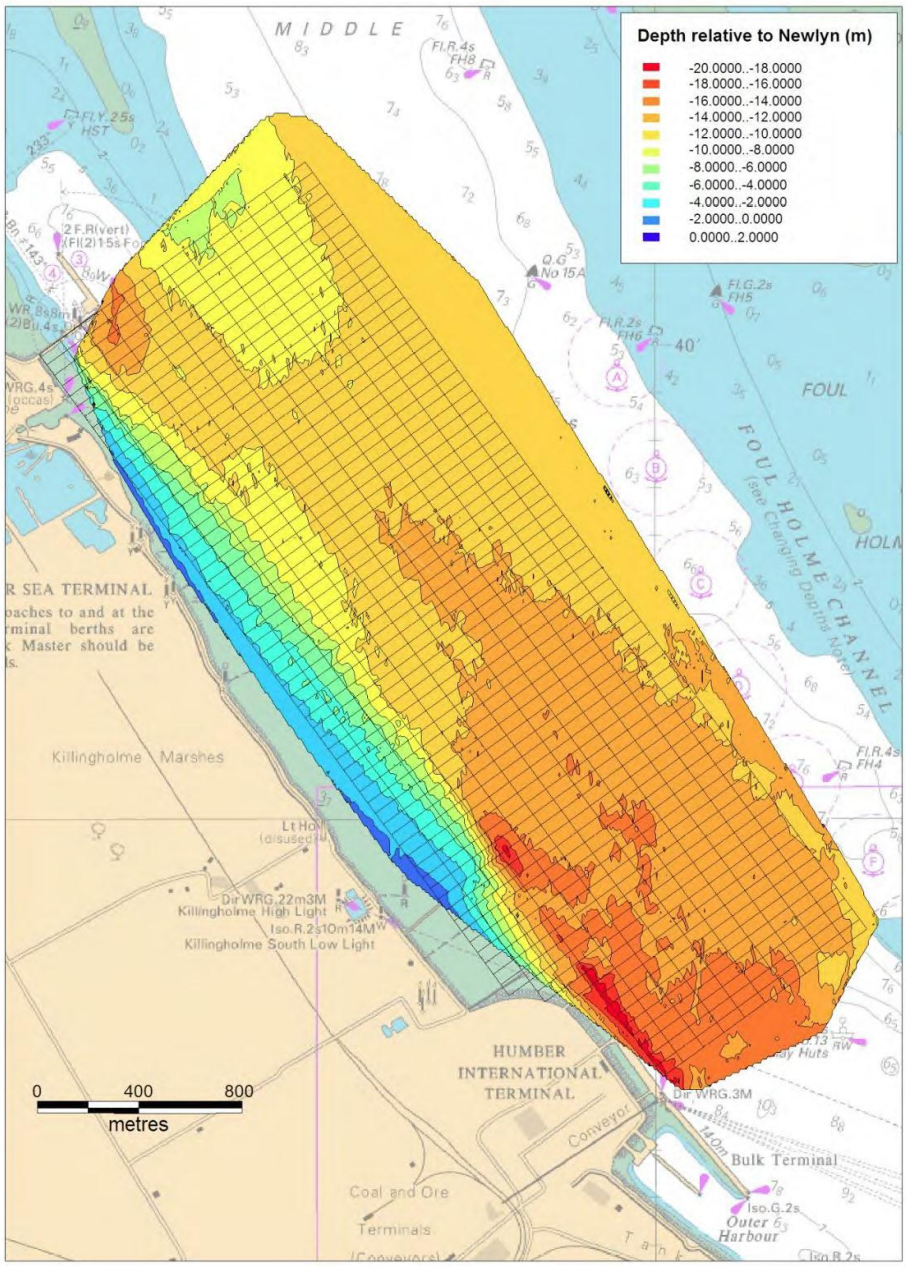
2. ENVIRONMENTAL BASELINE AND IDENTFIED IMPACTS

8. The following main environmental topic sections provide an overview of relevant headline environmental baseline data gathered from the Environmental Statement (ES) and associated documents submitted to the Planning Inspectorate in relation to AMEP.
9. Where these data form specific monitoring and management target(s) then these are identified. Document references are provided for additional context and information where necessary.
10. Impacts raised by the relevant Defra agencies are summarised in relation to the environmental topic sections.

2.1 Bathymetry/Topography and Sediment Parameters

2.1.1 BASELINE

11. A survey of subtidal bathymetry was undertaken in March 2010; this is graphically summarised in Figure 1. Further information (including figures of changes to intertidal profiles since 2000) is available in EX 28.3 Prt 2 (Baseline of North Killingholme Foreshore) and in Annex 9.1 of the ES.



Note: The lower extent of the intertidal zone is denoted by the seaward extent of the 2m to -4mAOD contour range (-4mAOD = -0.1mCD)

Figure 1: Subtidal Bathymetry (2010)

12. The topography of the intertidal reach around AMEP has been routinely covered by LiDAR surveys. The baseline LiDAR output from 2010 and the change in topography between 2001 and 2010 is shown in Figure 2.

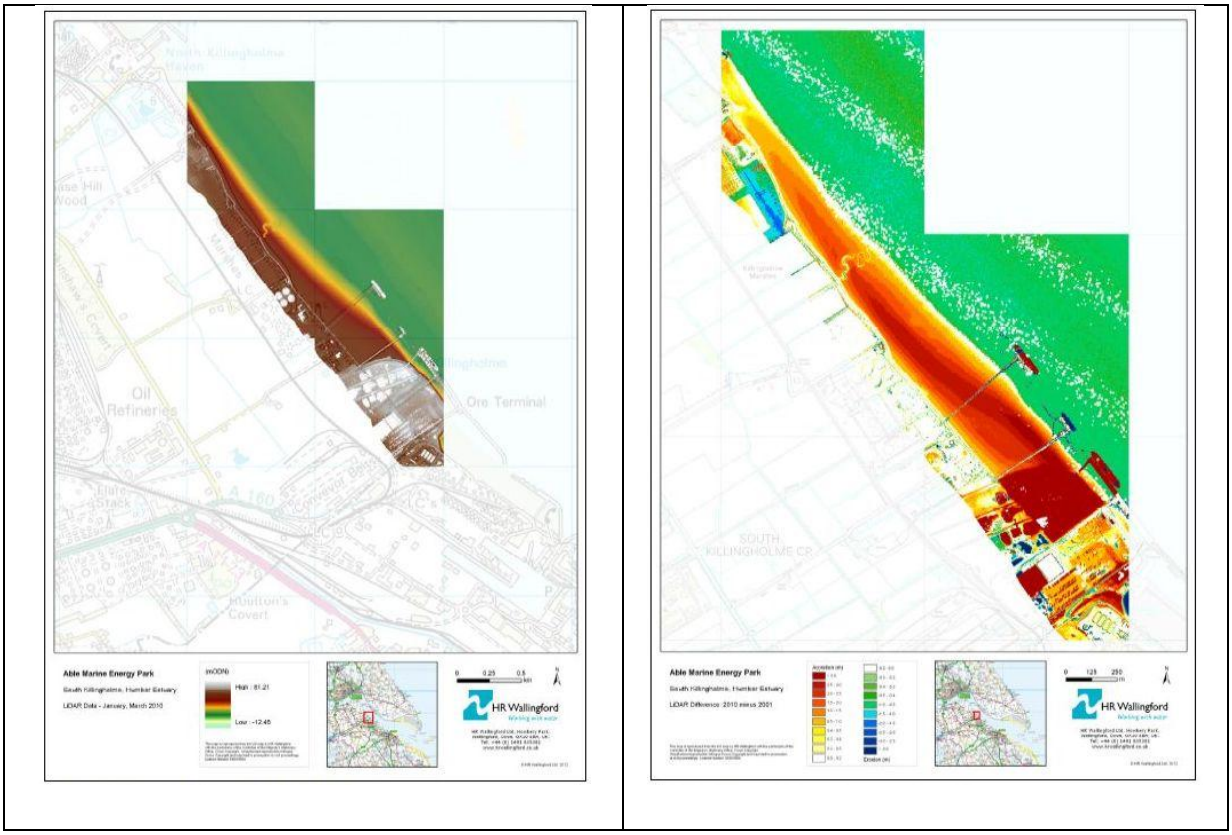


Figure 2: Intertidal Topography (2010) and change 2001 to 2010

13. Figure 2 indicates a general accretion of the mudflat between 2001 and 2010 of between 0.5m and 3.0m over a 2km length of intertidal between Humber International Terminals (HIT) and C.RO Port (Killingholme) Ltd (CPK). The largest amount of accretion has occurred adjacent to the HIT on the lower intertidal area, extending north-westwards along the foreshore. Figure 3 shows the LiDAR information for 2010 translated into a series of contours.

14. The review of topographic change provided in EX8.9 identifies an ongoing trend of accretion in the zone, leading to both increases in elevation, but also extension downshore. This is expected to be ongoing.

15. Further details are provided in EX8.9 which concludes that as changes to the intertidal zone from HIT have continued for 9-10 years and are predicted to be ongoing. Expert predictions are that it is likely that a stable landform upstream from the AMEP would not be reached for many years, but would take the form of a new low water line coming off the end of the quay/dredged side-slopes and extending approximately parallel and seawards of the current low water line up to CPK.

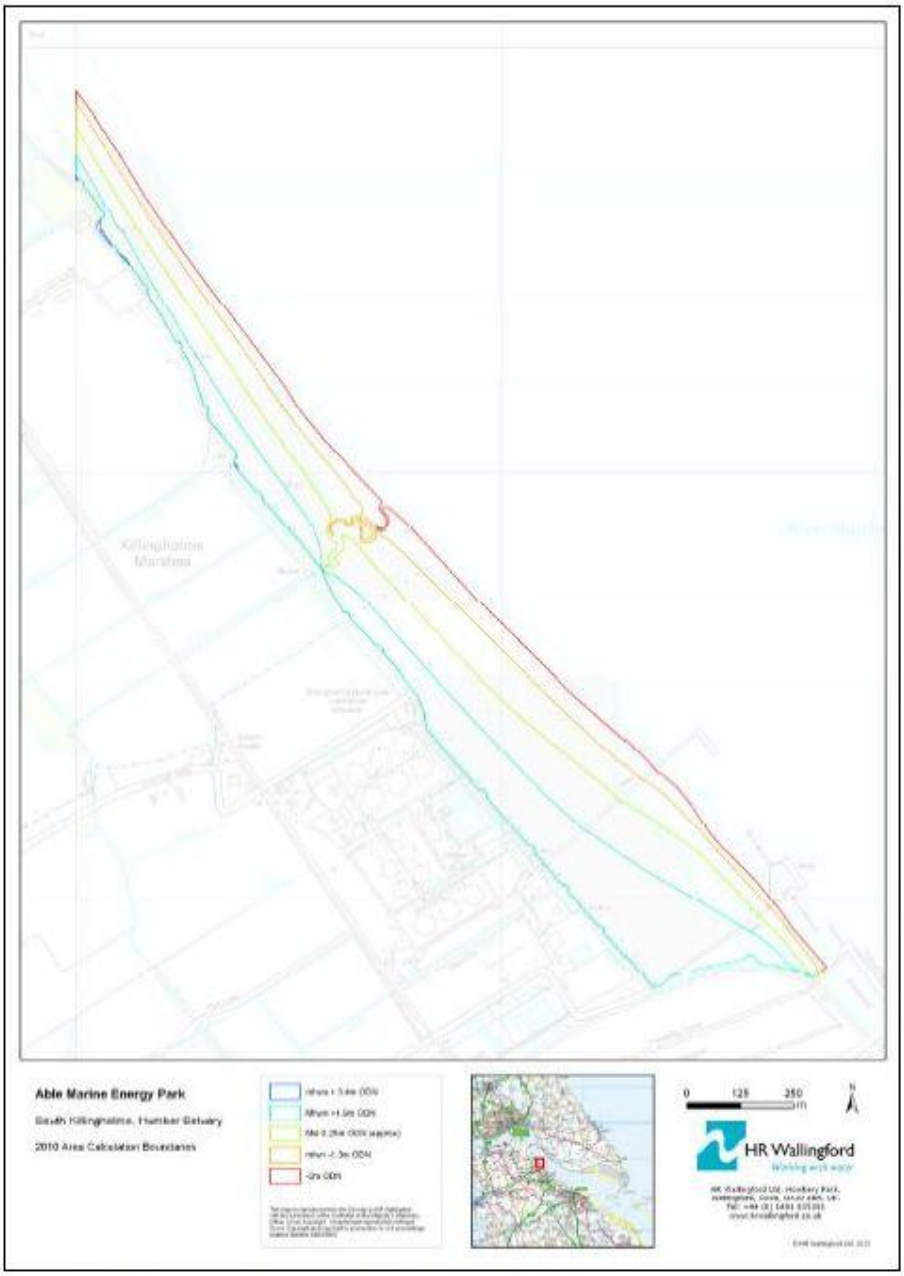


Figure 3: Intertidal contours based on 2010 LiDAR data

16. Analysis of sediment particle size was undertaken on samples taken at the same locations as the benthic intertidal and subtidal samples during the 2010 study (see Annex 7.2 to the ES). The baseline findings are given here for the intertidal zone locations (Table 1) and subtidal zone locations (Table 2) (see paragraphs 29 et seq).

Table 1: Intertidal Sediment Particle Size Data (2010)

Transect	Shore position	Mean φ	Mean µm	% Gravel	% Sand	% Mud	Sediment name	Textural group
1	Upper	5.880	16.98	0.0%	14.5%	85.5%	Very Fine Sandy Very Coarse Silt	Sandy Mud
1	Middle	6.255	13.10	0.0%	10.5%	89.5%	Very Fine Sandy Fine Silt	Sandy Mud
1	Lower	5.772	18.31	0.0%	19.0%	81.0%	Very Fine Sandy Very Coarse Silt	Sandy Mud
2	Upper	6.379	12.02	0.0%	7.5%	92.5%	Medium Silt	Mud
2	Middle	6.326	12.47	0.0%	6.9%	93.1%	Medium Silt	Mud
2	Lower	4.617	40.74	0.0%	48.5%	51.5%	Very Fine Sandy Very Coarse Silt	Sandy Mud
3	Upper	6.774	9.139	0.0%	4.5%	95.5%	Fine Silt	Mud
3	Middle	5.461	22.70	0.0%	20.6%	79.4%	Very Fine Sandy Very Coarse Silt	Sandy Mud
3	Lower	5.893	16.83	0.0%	14.5%	85.5%	Very Fine Sandy Coarse Silt	Sandy Mud
4	Upper	6.616	10.20	0.0%	5.5%	94.5%	Medium Silt	Mud
4	Middle	5.864	17.17	0.0%	15.5%	84.5%	Very Fine Sandy Very Coarse Silt	Sandy Mud
4	Lower	5.908	16.65	0.0%	12.4%	87.6%	Very Fine Sandy Coarse Silt	Sandy Mud
5	Upper	6.416	11.71	0.0%	7.5%	92.5%	Medium Silt	Mud
5	Middle	5.847	17.38	0.0%	16.0%	84.0%	Very Fine Sandy Very Coarse Silt	Sandy Mud
5	Lower	5.839	17.47	0.0%	17.3%	82.7%	Very Fine Sandy Very Coarse Silt	Sandy Mud
6	Upper	6.654	9.930	0.0%	5.2%	94.8%	Medium Silt	Mud
6	Middle	5.608	20.51	0.0%	20.3%	79.7%	Very Fine Sandy Very Coarse Silt	Sandy Mud
6	Lower	5.618	20.36	0.0%	23.8%	76.2%	Very Fine Sandy Very Coarse Silt	Sandy Mud
7	Upper	6.122	14.36	0.0%	8.4%	91.6%	Coarse Silt	Mud
7	Middle	4.828	35.22	0.0%	42.4%	57.6%	Very Fine Sandy Very Coarse Silt	Sandy Mud
7	Lower	5.878	17.01	0.0%	16.8%	83.2%	Very Fine Sandy Medium Silt	Sandy Mud
8	Upper	6.459	11.37	0.0%	6.9%	93.1%	Medium Silt	Mud
8	Middle	5.605	20.54	0.0%	19.9%	80.1%	Very Fine Sandy Very Coarse Silt	Sandy Mud
8	Lower	6.050	15.09	0.0%	11.5%	88.5%	Very Fine Sandy Coarse Silt	Sandy Mud
9	Upper	6.249	13.15	0.0%	8.7%	91.3%	Medium Silt	Mud
9	Middle	5.764	18.41	0.0%	17.3%	82.7%	Very Fine Sandy Very Coarse Silt	Sandy Mud
9	Lower	6.148	14.10	0.0%	10.4%	89.6%	Very Fine Sandy Coarse Silt	Sandy Mud
10	Upper	6.120	14.37	0.0%	13.3%	86.7%	Very Fine Sandy Fine Silt	Sandy Mud
10	Middle	6.087	14.71	0.0%	13.3%	86.7%	Very Fine Sandy Medium Silt	Sandy Mud
10	Lower	5.133	28.49	0.0%	29.3%	70.7%	Very Fine Sandy Very Coarse Silt	Sandy Mud
11	Upper	5.541	21.48	0.0%	19.3%	80.7%	Very Fine Sandy Very Coarse Silt	Sandy Mud
11	Middle	5.158	28.00	0.0%	29.8%	70.2%	Very Fine Sandy Very Coarse Silt	Sandy Mud
11	Lower	6.041	15.19	0.0%	12.6%	87.4%	Very Fine Sandy Coarse Silt	Sandy Mud
12	Upper	6.687	9.708	0.0%	6.7%	93.3%	Fine Silt	Mud
12	Middle	5.397	23.73	0.0%	23.2%	76.8%	Very Fine Sandy Very Coarse Silt	Sandy Mud
12	Lower	5.879	16.99	0.0%	14.1%	85.9%	Very Fine Sandy Very Coarse Silt	Sandy Mud

17. The baseline bathymetry and hydrography study (Annex 9.1 to the ES) indicates that typical suspended sediment concentrations near to AMEP measured in September 2010 range from 100mg/l at slack water on a neap tide to 400-500mg/l during the neap tide ebb flow. Concentrations during the spring tides reached 1,600mg/l during peak flood flow and were in excess of 800mg/l on the ebb flow. Again, these values will vary on an intra-annual basis due to natural processes.

Table 2: Subtidal Sediment Particle Size Data (2010)

Station No.	Mean φ	Mean µm	% Gravel	% Sand	% Mud	Sediment name	Textural group
1	2.492	177.8	0.0%	95.9%	4.1%	Moderately Sorted Fine Sand	Sand
2	5.849	17.35	0.0%	21.2%	78.8%	Very Fine Sandy Medium Silt	Sandy Mud
3	4.907	33.34	0.0%	43.5%	56.5%	Very Fine Sandy Medium Silt	Sandy Mud
4	3.797	71.95	0.0%	70.9%	29.1%	Very Coarse Silty Fine Sand	Muddy Sand
5	6.236	13.26	0.0%	14.4%	85.6%	Very Fine Sandy Fine Silt	Sandy Mud
6	2.944	130.0	0.0%	77.5%	22.5%	Fine Silty Medium Sand	Muddy Sand
7	4.274	51.68	0.0%	60.4%	39.6%	Very Coarse Silty Very Fine Sand	Muddy Sand
8	5.910	16.64	0.0%	18.8%	81.2%	Very Fine Sandy Fine Silt	Sandy Mud
9	5.770	18.33	0.0%	20.3%	79.7%	Very Fine Sandy Fine Silt	Sandy Mud
10	5.014	30.96	0.0%	41.0%	59.0%	Very Fine Sandy Fine Silt	Sandy Mud
11	6.056	15.03	0.0%	15.0%	85.0%	Very Fine Sandy Fine Silt	Sandy Mud
12	1.879	271.8	1.6%	83.8%	14.6%	Slightly Very Fine Gravelly Fine Silty Medium Sand	Slightly Gravelly Muddy Sand
13	3.305	101.2	0.0%	70.5%	29.5%	Fine Silty Medium Sand	Muddy Sand
14	6.071	14.88	0.0%	14.2%	85.8%	Very Fine Sandy Fine Silt	Sandy Mud
15	3.181	110.3	0.2%	71.1%	28.7%	Slightly Very Fine Gravelly Fine Silty Medium Sand	Slightly Gravelly Muddy Sand
16	3.366	97.02	2.2%	60.5%	37.3%	Slightly Very Fine Gravelly Fine Silty Medium Sand	Slightly Gravelly Muddy Sand
17	4.474	44.99	0.7%	44.5%	54.9%	Slightly Very Fine Gravelly Medium Sandy Medium Silt	Slightly Gravelly Sandy Mud
18	3.405	94.39	0.0%	69.9%	30.1%	Fine Silty Medium Sand	Muddy Sand
19	2.909	133.2	3.0%	69.6%	27.3%	Slightly Very Fine Gravelly Fine Silty Medium Sand	Slightly Gravelly Muddy Sand
20	3.296	101.8	0.9%	68.2%	30.9%	Slightly Very Fine Gravelly Fine Silty Medium Sand	Slightly Gravelly Muddy Sand
21	3.734	75.15	0.0%	59.8%	40.2%	Fine Silty Medium Sand	Muddy Sand
22	2.681	155.9	0.5%	78.7%	20.8%	Slightly Very Fine Gravelly Fine Silty Medium Sand	Slightly Gravelly Muddy Sand
23	3.122	114.9	2.9%	65.0%	32.0%	Slightly Very Fine Gravelly Very Coarse Silty Medium Sand	Slightly Gravelly Muddy Sand
24	2.315	201.0	0.0%	83.6%	16.4%	Fine Silty Medium Sand	Muddy Sand
25	4.969	31.92	0.0%	43.2%	56.8%	Very Fine Sandy Very Coarse Silt	Sandy Mud
26	2.490	177.9	6.7%	72.2%	21.1%	Very Fine Gravelly Fine Silty Medium Sand	Gravelly Muddy Sand
27	3.671	78.50	7.6%	52.3%	40.1%	Medium Gravelly Fine Silty Medium Sand	Gravelly Muddy Sand
28	4.338	49.45	0.0%	47.5%	52.5%	Medium Sandy Very Coarse Silt	Sandy Mud
29	0.220	858.5	46.7%	31.0%	22.3%	Fine Silty Sandy Coarse Gravel	Muddy Sandy Gravel
30	0.162	893.7	22.7%	70.6%	6.7%	Fine Gravelly Coarse Sand	Gravelly Sand

2.1.2 IMPACTS

18. The following potential impacts have been identified:

NE (sHRA)

- Capital and maintenance dredging indirectly impacting on intertidal and subtidal habitats and associated benthic communities through sediment particle size changes.

MMO

- Capital and maintenance dredging leading to changes in sediment conditions.

EA

- Capital and maintenance dredging leading to a reduction of Ecological Potential under WFD.
- Capital and maintenance dredging resulting in a reduction in flood protection standards. Understood to be addressed within a separate Flood Risk Management Plan.

Other

- Capital and maintenance dredging deleteriously affecting the operation of the E.ON and Centrica intake and outfall operation.

2.1.3 PRE-CONSTRUCTION BASELINE AND BACI-TYPE ASSESSMENT (2013 ONWARDS)

19. Whilst no dedicated pre-construction seabed sediment survey is anticipated, as part of the pre-construction intertidal and subtidal benthic biological surveys, details of bathymetry and sediment characteristics will be sampled. Details of these surveys are given in Appendix 3
20. In addition, bathymetric surveys will be undertaken to assess the effects of dredging work in the subtidal (Appendix 1) as well as LiDAR for the intertidal (Appendix 2), whilst suspended sediment will be monitored via a buoy-mounted sonde.
21. Subsequent surveys will be undertaken to allow construction and operation impacts to be assessed. Details and duration are given in the Objectives section onwards and Appendices in this document.

2.2 Intertidal Estuarine Habitat (Saltmarsh)

2.2.1 BASELINE (2010 CHARACTERISATION)

22. Small areas of saltmarsh were identified adjacent to the proposed AMEP site (Figure 4). Further information on these can be found in EX 28.3 Prt 2 and in Annex 11.2 to the ES.

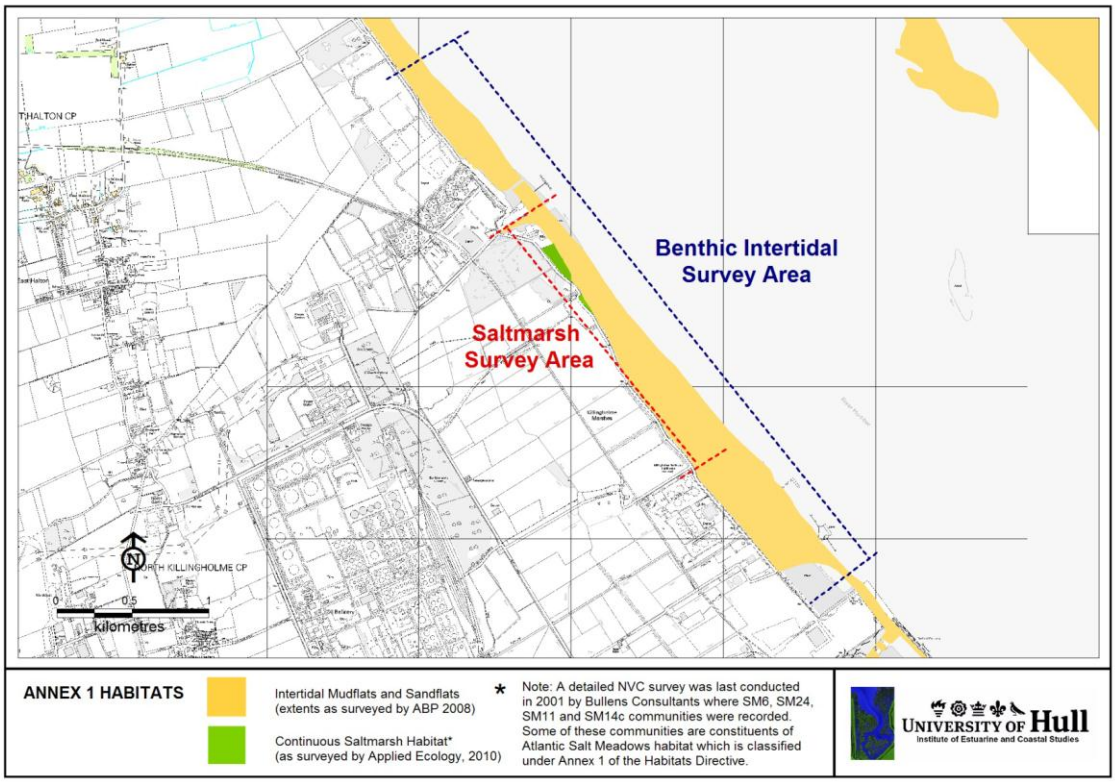


Figure 4: Saltmarsh Area (2010 Survey)

23. In the vicinity of the AMEP site a very small patch of saltmarsh was recorded on the seaward side of the seawall, close to the mouth of the main drain onto the foreshore and also adjacent to the North Killingholme Haven Pits. During the Phase 2 Survey undertaken in 2006, a number of different saltmarsh communities were identified within this area including sea couch (*Elymus pycnanthus*), saltmarsh rush (*Juncus gerardii*) and couch (*Elymus repens*).

24. Killingholme Marshes foreshore is undergoing a process of change and patches of saltmarsh are beginning to establish in certain areas due to the foreshore rising within the tidal range (EX8.9).

25. Given the potential for further change to saltmarsh extent and associated changes/impacts to adjacent habitat status, a pre-construction baseline survey of saltmarsh extent and composition will be undertaken. Details are given in paragraphs 91 onwards and Appendix

3. These data will also be assessed in the context of adjacent mudflat change (topography and extent) with details in Appendix 1.

2.2.2 IMPACTS

26. The following potential impacts have been identified:

NE (sHRA)

- No direct impacts identified. However, changes to saltmarsh extent will need to be characterised to address impacts to other habitats e.g. mudflat.

MMO

- No direct impacts identified.

EA

- Capital and maintenance dredging leading to a reduction of Ecological Potential under WFD. Characterisation of saltmarsh extent and composition required as well as the need to address changes with respect to other habitats for WFD needs.

2.2.3 PRE-CONSTRUCTION BASELINE AND BACI-TYPE ASSESSMENT (2013 ONWARDS)

27. In order to characterise the extent and composition of the saltmarsh community present, as well as any changes over time and effects on adjacent habitat status (mudflat in particular), pre-construction surveys will be undertaken, and carried forward. For saltmarsh, these will include field survey and aerial photography following EA guidance for WFD compliant methods (see Appendix 3), whilst LiDAR will be used to map mudflat extent and topography (Appendix 1).

28. Subsequent surveys will be undertaken to allow construction and operation impacts to be assessed. Details and duration are given in the Objectives section onwards and Appendices in this document.

2.3 Intertidal Estuarine Habitat (Benthos)

2.3.1 BASELINE (2010 CHARACTERISATION)

29. Baseline data are available from a site characterisation study undertaken at the AMEP site in May 2010. A total of 36 intertidal samples were taken along 12 intertidal transects with one sample taken using a 0.01m^2 corer at each of three stations along each transect. The location of sampling stations is shown in Figure 5; and the data are presented as Tables 3 and 4.

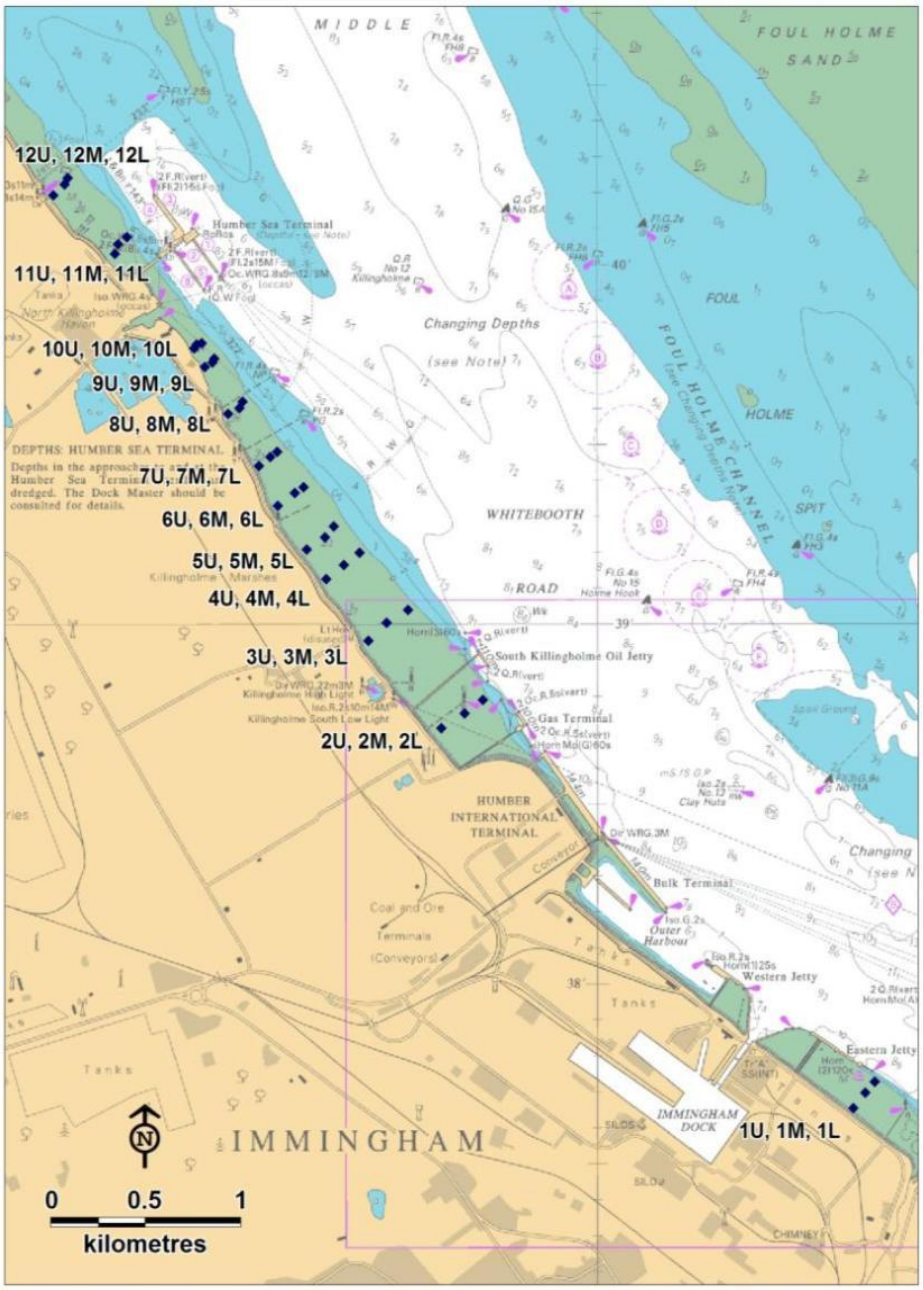


Figure 5: Intertidal benthic invertebrate sampling stations (Characterisation Study 2010)

30. The most commonly occurring species in the intertidal samples were the oligochaete *T. benedii*, Nematoda, the polychaete *Streblospio shrubsolii* and the amphipod crustacean *Corophium volutator*. These species were present in most of the samples and were present at higher abundances than all other species throughout the survey area. The bivalve *M. balthica* was widespread and the polychaete *H. diversicolor* was present at most of the upper shore stations.
31. *T. benedii* was the dominant species at the upper and mid shore intertidal stations. *S. shrubsolii* was dominant at the lower shore intertidal stations where the sediments were presumably sandier.
32. Species richness (number of species recorded) ranged from 2-9 species/sample (mean = 5.8). Abundance (number of individuals/sample) ranged from 5-197 (mean = 46.4) and biomass ranged from <0.001 to 1.37 g/sample (mean = 0.18 g/sample) and was generally higher at stations where *H. diversicolor* was found.

    All species found were typical for the intertidal area of the middle region of the Humber Estuary, with moderate abundance and diversity of mostly common species. There were no species of particular conservation importance although those present were key prey species for birds.
33. It should be noted that for the purposes of setting baseline benthic conditions against which any impacts might be assessed, a new, more detailed baseline survey will be undertaken in the spring of 2013. Details of methods are provided in Appendix 3.
34. Furthermore, for the purposes of target setting benthic community attributes to be used in assessing the delivery of compensatory function within the Compensation Site, a further dedicated intertidal benthic 'target setting' survey will be undertaken in the late summer/early autumn of 2013 (timed for the last week of August/first week of September). Details of the methods, and the protocols to develop targets are provided within the CEMMP.

Table 3: Biomass data (g.m^{-2}) from North Killingholme intertidal monitoring (2010)

Biomass values per m2				1			2			3			4			5			6		
MCS Code		Taxon	Taxon Qualifier	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower
F	2	TURBELLARIA														0.0700					
HD	1	NEMATODA		0.0100	0.0700	0.0100		0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100			0.0100	0.0100
P	117/118	*Eteone flava/longa*																			
P	462	*Hediste diversicolor*		28.0000						136.0000						26.4000					
P	499	*Nephtys hombergii*																			
P	672	*Scoloplos armiger*							0.0100												
P	776	*Pygospio elegans*							0.0100		0.0100					0.0100				0.0100	
P	799	*Streblospio shrubsolii*		0.2900	0.1500		0.0100	0.0400		0.1400	0.0100	0.2100	0.0200	0.0500	0.0100	0.1400	0.0100	0.0100	0.1400	0.0200	0.4100
P		*Tharyx*	Sp. A														0.0100			0.0200	
P	846	*Tharyx killariensis*																			0.0100
P	907	*Capitella capitata*	Sp. Complex		0.0100																
P	931	*Arenicola*	Juvenile												0.0100			0.0100			
P	1294	*Manayunkia aestuarina*		0.0100	0.0100					0.0600						0.0100					
P	1420	*Paranais litoralis*						0.0500	0.0100	0.0100			0.0100			0.0200					
P	1479	*Heterochaeta costata*					0.0100									0.0900					
P	1490	*Tubificoides benedii*		2.7700	12.4400	0.0100	0.0500	0.2700	0.0100	0.9000	0.2000	0.0100	4.3600	0.5200	0.0100	2.1900	0.0500	0.0100	3.3900	0.3200	0.0100
P	1500	*Tubificoides swirencoides*									0.0100	0.3200		0.0100	0.0100						
P	1501	Enchytraeidae																			
S	605	*Corophium*	Juvenile								0.0100										
S	616	*Corophium volutator*					1.7800			0.1200	8.6000		8.4100	3.0000			9.0000		0.0100	1.3700	
S	1253	*Diastylis rathkei*																			
W	385	*Hydrobia ulvae*		0.3100	1.5800		0.1000														
W	1695	*Mytilus edulis*																		0.0100	
W	1906	*Mysella bidentata*																			6.0700
W	2007	TELLINACEA	Juvenile	0.1100	0.0100		0.0100		0.0100									0.0100	0.0100		
W	2029	*Macoma balthica*		9.2500	11.5300	2.7100		9.5700	8.4200		38.7300	2.5100	3.5800	0.8000						0.5100	0.0100
W	2064	*Abra tenuis*		0.0600	0.1000	0.0100															
Total Biomass				40.8100	25.9000	2.7400	1.9600	9.9400	8.4800	137.2400	47.5800	3.0600	16.3900	4.3900	0.0500	28.9400	9.0800	0.0400	3.5500	2.2700	6.5200
Quantitative Species Diversity				9	9	4	6	5	7	7	8	5	6	6	5	9	5	4	4	8	6
Qualitative Species Diversity				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Species Diversity				9	9	4	6	5	7	7	8	5	6	6	5	9	5	4	4	8	6

Table 3 (continued): Biomass data (g.m^{-2}) from North Killingholme intertidal monitoring (2010)

Biomass values per m2				7			8			9			10			11			12		
MCS Code		Taxon	Taxon Qualifier	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower
F	2	TURBELLARIA																			
HD	1	NEMATODA		0.0100	0.0100		0.0100	0.0100	0.0100	0.0100	0.0100	0.0100		0.0100	0.0100	0.0100		0.0100	0.0100	0.0100	0.0100
P	117/118	*Eteone flava/longa*			0.2300																
P	462	*Hediste diversicolor*					34.0000			3.4100					6.7900	15.0000			42.7000		
P	499	*Nephtys hombergii*																0.0100			
P	672	*Scoloplos armiger*																			
P	776	*Pygospio elegans*									0.0100										0.0100
P	799	*Streblospio shrubsolii*		0.1400	0.2700	0.3000		0.0100	0.7300		0.0500	0.0100	0.0100	0.0100	0.2100	0.3200	0.2100	0.1400	0.0100	0.0100	0.7500
P		*Tharyx*	Sp. A		0.1300			0.0100													
P	846	*Tharyx killariensis*																			
P	907	*Capitella capitata*	Sp. Complex																		
P	931	*Arenicola*	Juvenile																		
P	1294	*Manayunkia aestuarina*		0.0100												0.0100			0.0100		
P	1420	*Paranais litoralis*		0.0100																	
P	1479	*Heterochaeta costata*					0.0100									0.0100					
P	1490	*Tubificoides benedii*		2.8400	0.7500	0.0100	0.5100	3.9700	0.1100	0.0100	0.2300			0.1500	0.1800	0.3100	0.1800			1.1000	0.2100
P	1500	*Tubificoides swirencoides*									0.0100										
P	1501	Enchytraeidae														0.0100			0.0100		
S	605	*Corophium*	Juvenile																		
S	616	*Corophium volutator*		5.2600	0.1000		2.8900	2.9300		18.6300	0.4600	0.2300		0.7500	1.6100	0.5700	15.0000		4.0300	3.2900	11.2000
S	1253	*Diastylis rathkei*																0.1400			
W	385	*Hydrobia ulvae*																			
W	1695	*Mytilus edulis*																			
W	1906	*Mysella bidentata*																			
W	2007	TELLINACEA	Juvenile												0.0100					0.0100	
W	2029	*Macoma balthica*		10.9300	16.1300		0.6200	3.2800	0.0100	0.3800	0.2900	0.0100	1.4400	1.4800		0.6500	50.7400	6.9200		22.4200	
W	2064	*Abra tenuis*																			
			Total Biomass	19.2000	17.6200	0.3100	38.0400	10.2100	0.8600	22.4400	1.0600	0.2600	1.4500	2.4000	8.8100	16.8900	66.1300	7.2200	46.7700	26.8400	12.1800
			Quantitative Species Diversity	7	7	2	6	6	4	5	7	4	2	5	6	9	4	5	6	6	5
			Qualitative Species Diversity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Total Species Diversity	7	7	2	6	6	4	5	7	4	2	5	6	9	4	5	6	6	5

Table 4: Abundance data (individuals.m^{-2}) from North Killingholme intertidal monitoring (2010)

Abundance values per m2				1			2			3			4			5			6		
MCS Code		Taxon	Taxon Qualifier	Upp	Mid	Low	Upp	Mid	Low	Upp	Mid	Low	Upp	Mid	Low	Upp	Mid	Low	Upp	Mid	Low
F	2	TURBELLARIA														1					
HD	1	NEMATODA		500	3500	100	0	1000	500	600	800	100	300	300	100	200	700			1100	300
P	117/118	*Eteone flava/longa*																			
P	462	*Hediste diversicolor*		1200						2600						500					
P	499	*Nephtys hombergii*																			
P	672	*Scoloplos armiger*							100												
P	776	*Pygospio elegans*							100		300					100				100	
P	799	*Streblospio shrubsolii*		600	900		100	400		600	400	600	200	400	200	300	200	200	400	600	1500
P		*Tharyx*	Sp. A														400			200	
P	846	*Tharyx killariensis*																			100
P	907	*Capitella capitata*	Sp. Complex		100																
P	931	*Arenicola*	Juvenile												100			100			
P	1294	*Manayunkia aestuarina*		100	100					3200						200					
P	1420	*Paranais litoralis*						600	100	500			900			600					
P	1479	*Heterochaeta costata*					200									100					
P	1490	*Tubificoides benedii*		3800	13600	100	200	1200	100	4300	400	200	5500	500	100	3800	400	100	5000	1000	100
P	1500	*Tubificoides swirencoides*									100	1500		100	100						
P	1501	Enchytraeidae																			
S	605	*Corophium*	Juvenile								100										
S	616	*Corophium volutator*					300			200	3400		1200	1000			3200		100	1000	
S	1253	*Diastylis rathkei*																			
W	385	*Hydrobia ulvae*		400	600		100														
W	1695	*Mytilus edulis*																		100	
W	1906	*Mysella bidentata*																			100
W	2007	TELLINACEA	Juvenile	1300	100		100		100									100	200		
W	2029	*Macoma balthica*		200	500	200		400	400		900	200	100	200						400	100
W	2064	*Abra tenuis*		300	300	100															
Total Abundance				8400	19700	500	1000	3600	1400	12000	6400	2600	8200	2500	600	5801	4900	500	5700	4500	2200
Quantitative Species Diversity				9	9	4	6	5	7	7	8	5	6	6	5	9	5	4	4	8	6
Qualitative Species Diversity				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Species Diversity				9	9	4	6	5	7	7	8	5	6	6	5	9	5	4	4	8	6

Table 4 (continued): Abundance data (individuals.m^{-2}) from North Killingholme intertidal monitoring (2010)

Abundance values per m2				7			8			9			10			11			12		
MCS Code		Taxon	Taxon Qualifier	Upp	Mid	Low	Upp	Mid	Low	Upp	Mid	Low	Upp	Mid	Low	Upp	Mid	Low	Upp	Mid	Low
F	2	TURBELLARIA																			
HD	1	NEMATODA		200	200		200	500	100	600	300	100		400	400	2000		100	300	500	300
P	117/118	*Eteone flava/longa*			100																
P	462	*Hediste diversicolor*					2400			400					300	1300			3000		
P	499	*Nephtys hombergii*																100			
P	672	*Scoloplos armiger*																			
P	776	*Pygospio elegans*									100										200
P	799	*Streblospio shrubsolii*		1200	600	900		100	1500		500	400	600	200	600	900	600	500	100	100	2700
P		*Tharyx*	Sp. A		200			200													
P	846	*Tharyx killariensis*																			
P	907	*Capitella capitata*	Sp. Complex																		
P	931	*Arenicola*	Juvenile																		
P	1294	*Manayunkia aestuarina*		100												500			100		
P	1420	*Paranais litoralis*		500																	
P	1479	*Heterochaeta costata*					100									300					
P	1490	*Tubificoides benedii*		3000	1600	100	600	5600	100	100	300			400	300	500	200			1900	300
P	1500	*Tubificoides swirencoides*									100										
P	1501	Enchytraeidae														200			100		
S	605	*Corophium*	Juvenile																		
S	616	*Corophium volutator*		1000	100		1300	1200		5200	400	200		200	1500	300	7000		1300	2700	7100
S	1253	*Diastylis rathkei*																100			
W	385	*Hydrobia ulvae*																			
W	1695	*Mytilus edulis*																			
W	1906	*Mysella bidentata*																			
W	2007	TELLINACEA	Juvenile												100					100	
W	2029	*Macoma balthica*		300	300		100	300	100	200	200	100	300	100		100	600	300		800	
W	2064	*Abra tenuis*																			
Total Abundance				6300	3100	1000	4700	7900	1800	6500	1900	800	900	1300	3200	6100	8400	1100	4900	6100	10600
Quantitative Species Diversity				7	7	2	6	6	4	5	7	4	2	5	6	9	4	5	6	6	5
Qualitative Species Diversity				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Species Diversity				7	7	2	6	6	4	5	7	4	2	5	6	9	4	5	6	6	5

35. Figure 6 (below) indicates the intertidal (and subtidal) biotopes and their likely spatial extent based on the sediment, benthic community and bathymetric data for the area derived from the 2010 survey. Further details are provided in document EX11.14.

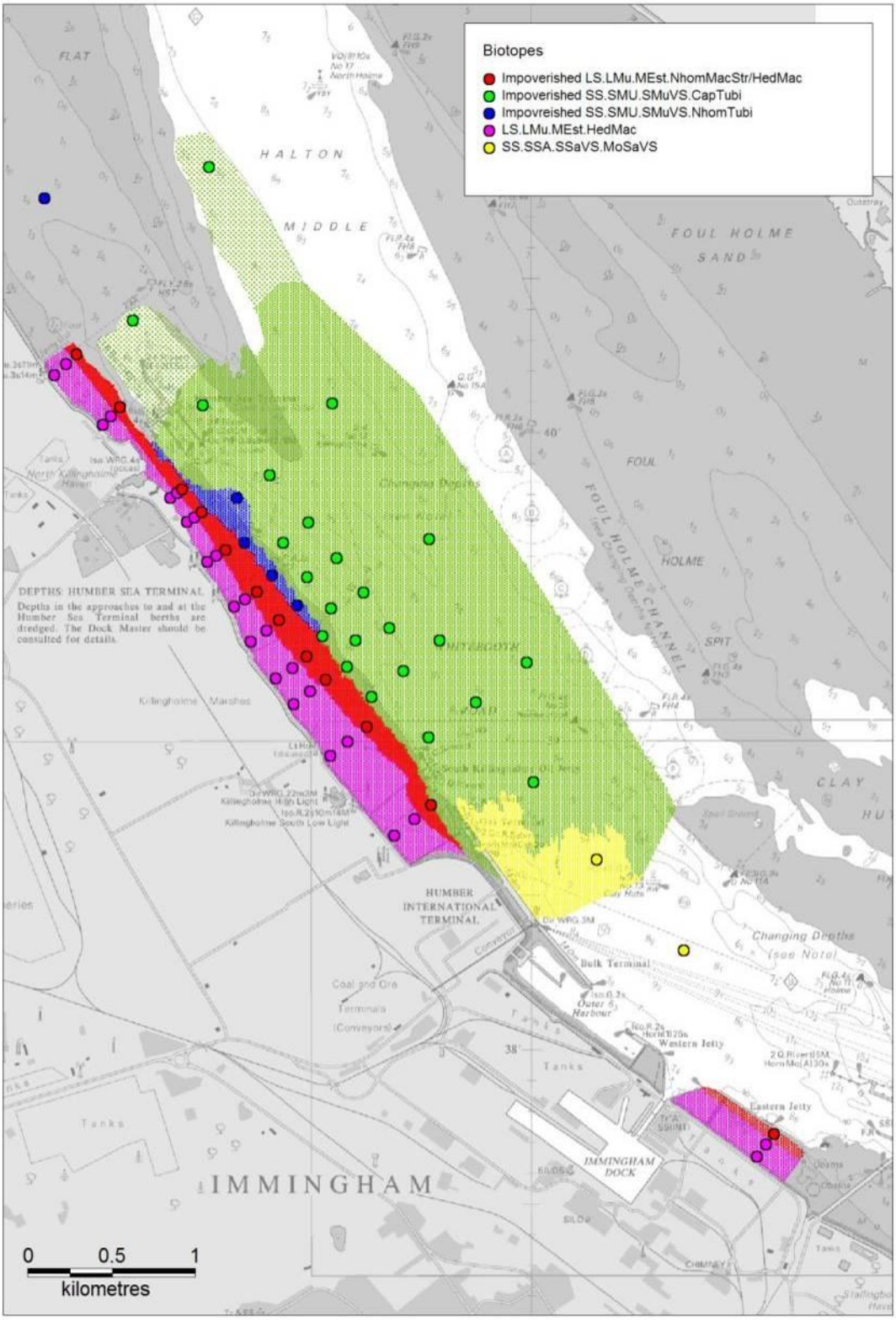


Figure 6: Biotope Location (2010 Survey) and Possible Extent based on Bathymetry

2.3.2 IMPACTS

36. The following potential impacts have been identified:

NE (sHRA)

- Medium to longer term changes to habitat arising from the quay presence (transformation of intertidal mudflat to saltmarsh).
- Permanent loss of intertidal habitat (31.5ha). Addressed within the CEMMP.
- All requirements in relation to SPA birds are addressed within the CEMMP and TEMMP.

MMO

- Capital and maintenance dredging leading to smothering of intertidal benthos.

EA

- Capital and maintenance dredging leading to a reduction of Ecological Potential under WFD.

2.3.3 PRE-CONSTRUCTION BASELINE AND BACI-TYPE ASSESSMENT (2013 ONWARDS)

37. AHPL will undertake a pre-construction baseline benthic survey of the intertidal area. This baseline survey has been designed to incorporate aspects of the characterisation survey in order to allow an initial indication of inter-annual variability, as well as additional components to provide a robust Before-After Control-Impact (BACI-type) methodology against which the impacts of the AMEP can be assessed.
38. This survey will use a three replicate coring methodology and follow standard methods (e.g. Ware and Kenny 2011; the Marine Monitoring Handbook, Davies et al 2001). However, importantly, reference where appropriate has been made to the operational instructions for sampling and sample processing for macrobenthic invertebrates in TraC waters in order to collect data that can be used for WFD assessment purposes.
39. Monitoring and assessment will take into account adjacent habitats (e.g. in particular the subtidal zone) in order to provide a waterbody approach that meets WFD assessment needs. For the AMEP development this will be the Humber Lower waterbody.
40. Subsequent surveys will be undertaken to allow construction and operation impacts to be assessed. Details and duration are given in the Objectives section onwards and Appendices in this document.
41. An additional ‘target setting’ survey will be undertaken at the site in the late summer/early autumn to define bird prey targets (primarily for Black-tailed Godwit) for the Compensation Site. Further details are provided in the CEMMP.

2.4 Subtidal Estuarine Habitat (Benthos)

2.4.1 BASELINE (2010 CHARACTERISATION)

42. A total of thirty subtidal benthic samples were taken across the area that will be developed as the berthing pocket, approach channel and turning circle during May 2010 using a 0.1m^2 Hamon grab (details of methods and results are provided in Annex 10.1 to the ES).

43. The sampling positions are shown in Figure 7 and co-ordinates are provided in Table 5.

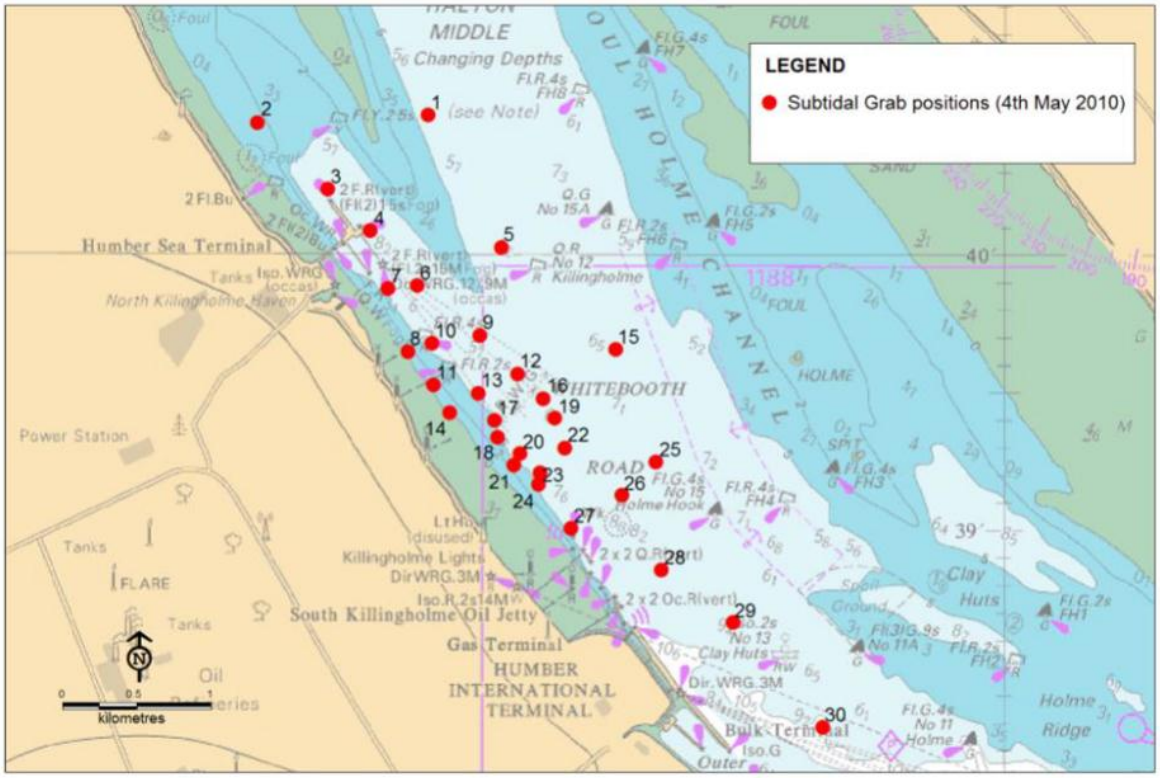


Figure 7: Subtidal Benthic Invertebrate Sampling Stations (2010)

Table 5: Subtidal Benthic Sampling Position Co-ordinates (2010)

Station No.	Date	Time	Sea State	Attempt	Depth (m)	Position (WGS 84)		Description
						Lat	Long	
1	04/05/2010	11:36	Calm	1st	10.4	53.67483	0.22367	Muddy sand
2	04/05/2010	11:44	Calm	1st	7.9	53.67433	0.24100	Mud
3	04/05/2010	11:58	Calm	2nd	14.1	53.67033	0.23383	Mud
4	04/05/2010	12:05	Calm	1st	12.6	53.66783	0.22950	Muddy sand
5	04/05/2010	12:13	Calm	1st	12.6	53.66683	0.21617	Mud & clay
6	04/05/2010	12:18	Calm	1st	11.3	53.66450	0.22467	Muddy sand
7	04/05/2010	12:25	Calm	1st	11.5	53.66433	0.22767	Mud
8	04/05/2010	12:28	Calm	1st	7.7	53.66050	0.22567	Mud
9	04/05/2010	12:43	Calm	1st	12.2	53.66100	0.22317	Clay with surface layer of sand
10*	04/05/2010	12:40	Calm	1st	12.3	53.66150	0.21833	Sandy mud
11*	04/05/2010	13:40	Calm	1st	13.6	53.65917	0.21450	Sandy mud
12*	04/05/2010	12:50	Calm	1st	10.9	53.65800	0.21850	Medium sand
13	04/05/2010	13:07	Calm	1st	8.5	53.65850	0.22300	Muddy sand
14	04/05/2010	13:22	Calm	1st	7	53.65683	0.22133	Mud
15	04/05/2010	13:44	Calm	1st	11	53.65633	0.21683	Medium sand
16	04/05/2010	13:37	Calm	1st	12.8	53.65767	0.21183	Sand with compacted clay
17*	04/05/2010	13:28	Calm	1st	11.6	53.66067	0.20450	Muddy sand
18*	04/05/2010	14:20	Calm	3rd	10.6	53.65650	0.21067	Medium sand
19*	04/05/2010	13:56	Calm	1st	10.5	53.65433	0.21417	Muddy sand
20	04/05/2010	14:09	Calm	1st	10	53.65533	0.21650	Medium sand
21	04/05/2010	14:29	Calm	3rd	9.4	53.65367	0.21483	Muddy sand
22	04/05/2010	15:02	Calm	1st	10.2	53.65250	0.21233	Sand with compacted clay
23	04/05/2010	14:58	Calm	1st	10.9	53.65317	0.21217	Muddy sand with coal fragments
24	04/05/2010	14:53	Calm	3rd	11.3	53.65467	0.20967	Muddy sand with coal fragments
25	04/05/2010	15:14	Calm	2nd	11.2	53.65383	0.20033	Sandy mud
26	04/05/2010	15:18	Calm	1st	12.5	53.65183	0.20383	Sand with coal fragments
27	04/05/2010	15:29	Calm	1st	12.9	53.64983	0.20900	Sand with coal fragments
28	04/05/2010	15:36	Calm	2nd	12.1	53.64733	0.19983	Clay with a surface layer of sand
29	04/05/2010	15:44	Calm	1st	12.9	53.64417	0.19250	Clay with a surface layer of sand
30	04/05/2010	16:03	Calm	4th	11.6	53.63783	0.18333	Sand with shell & coal fragments

* Sample collected from contaminant analysis

44. Details of the findings are given in Annex 10.1 to the ES. However Tables 6 to 8 provide abundance and biomass data for quick reference.

45. In summary, the survey results indicate a species richness that ranged from 0-17 (including colonial taxa) (mean = 4) with values of five or less being recorded from all but two stations. The most widespread species (occurring in the greatest number of samples) was the polychaete *Capitella capitata*. Although the barnacles *Balanus improvisus* and *Elminius modestus* were the most abundant species recorded from a sample, these were only present at one station, presumably from occasional hard substratum e.g. boulders, and as such this abundance dominance is not characteristic of the survey area in general.

Table 6: Abundance data from North Killingholme subtidal monitoring (2010) (per m^2)

MCS Code		TAXON	TAXON Qualifier	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
D	158	Tubulariidae																								P							
D	433	*Sertularia*		P	P																					P	P		P				
D	510	*Hartlaubella gelatinosa*		P																		P		P			P						
D	662	ACTINIARIA																						30									10
F	1	PLATYHELMINTHES																	10										20			60	20
HD	1	NEMATODA			60						30		10	50			10				30			40			20						
K	45	*Pedicellina*																										P					
P	117/118	*Eteone flava/longa*	aggregate	10																													
P	499	*Nephtys hombergii*								10	10																						
P	672	*Scoloplos armiger*																			50												
P	753	*Polydora cornuta*																						130									
P	799	*Streblospio shrubsolii*			30					30	110			220			50				10												
P	845	*Tharyx*	species A								10																						
P	907	*Capitella capitata*	species complex	20		30	10					10			20	10		10		20	60		20	70		20	90	140	80	40			
P	919	*Mediomastus fragilis*			10																												
P	931	*Arenicola marina*		90		40	420			20														30				70	10	10			
P	1083	*Protodriloides chaetifer*																															10
P	1490	*Tubificoides benedii*					10			10	10			90																			
P	1498	*Tubificoides pseudogaster*																						10									
P	1500	*Tubificoides swirencoides*												30			10																
Q	53	ACARI																								10							
R	14	CIRRIPEDIA	indeterminate																														10
R	68	*Elminius modestus*																						140									
R	78	*Balanus improvisus*																						1240									
R	142	COPEPODA	indeterminate												10								10	10	30		20	100	10	10	20		
S	76	*Neomysis integer*																														10	
S	86	*Schistomysis kervillei*							10																								
S	471	*Gammarus*	juvenile																					10									
S	481	*Gammarus salinus*																											20				
S	616	*Corophium volutator*															10																
S	1197	*Bodotria scorpioides*																						10	10								
S	1253	*Diastylis rathkei typica*																						10									
W	1696	*Mytilus edulis*	juvenile							20														110				10					
W	2007	TELLINACEA	juvenile												10																		
W	2029	*Macoma balthica*				10	10				10						10																
Y	112	*Walkeria uva*																									P						
Y	137	*Bowerbankia*																								P		P	P				
Y	176	*Electra crustulenta*																						P					P				
Y	177	*Electra monostachys*		P									P	P	P			P						P		P	P	P					
Y	187	*Flustra foliacea*																						P						P			
Y	222	*Amphiblestrum auritum*		P																													
Y	255	*Bicellariella ciliata*								p			p																P				
Quantitative				**3**	**3**	**3**	**4**	**0**	**1**	**5**	**6**	**1**	**1**	**4**	**3**	**1**	**5**	**1**	**1**	**1**	**4**	**0**	**2**	**13**	**2**	**2**	**3**	**4**	**5**	**3**	**1**	**2**	**4**
Colonial				**4**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**2**	**1**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**4**	**0**	**4**	**4**	**3**	**4**	**1**	**0**	**0**	**0**
Total Taxa				**7**	**4**	**3**	**4**	**0**	**1**	**6**	**6**	**1**	**3**	**5**	**4**	**1**	**5**	**2**	**1**	**1**	**4**	**1**	**2**	**17**	**2**	**6**	**7**	**7**	**9**	**4**	**1**	**2**	**4**
Total Abundance				**120**	**100**	**80**	**450**	**0**	**10**	**90**	**180**	**10**	**10**	**390**	**40**	**10**	**90**	**10**	**10**	**20**	**150**	**0**	**30**	**1840**	**40**	**30**	**130**	**320**	**140**	**60**	**20**	**70**	**50**

Table 7: Biomass data from North Killingholme subtidal monitoring (2010) (per m^2)

MCS Code		TAXON	TAXON Qualifier	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
D	158	Tubulariidae																															
D	433	*Sertularia*																															
D	510	*Hartlaubella gelatinosa*																															
D	662	ACTINIARIA																						37.5000									0.0010
F	1	PLATYHELMINTHES																	0.0010										0.0010			0.0010	0.0010
HD	1	NEMATODA			0.0010						0.0010		0.0010	0.0010			0.0010					0.0010		0.0010			0.0010						
K	45	*Pedicellina*																															
P	117/118	*Eteone flava/longa*	aggregate	0.0080																													
P	499	*Nephtys hombergii*								0.1540	0.0300																						
P	672	*Scoloplos armiger*																			0.3010												
P	753	*Polydora cornuta*																						0.0260									
P	799	*Streblospio shrubsolii*			0.0010					0.0120	0.0280			0.0720			0.0100				0.0010												
P	845	*Tharyx*	species A								0.0010																						
P	907	*Capitella capitata*	species complex	0.0050		0.0010	0.0010					0.0010			0.0300	0.0010		0.0010		0.0230	0.0130		0.0180	0.0800		0.0100	0.0650	0.2730	0.0100	0.0310			
P	919	*Mediomastus fragilis*			0.0010																												
P	931	*Arenicola marina*		0.0410		0.0240	0.1180			0.0010														0.0010				11.0000	0.0010	0.0010			
P	1083	*Protodriloides chaetifer*																															0.0010
P	1490	*Tubificoides benedii*					0.0010			0.0010	0.0010			0.0680																			
P	1498	*Tubificoides pseudogaster*																						0.0010									
P	1500	*Tubificoides swirencoides*												0.0010			0.0010																
Q	53	ACARI																								0.0010							
R	14	CIRRIPEDIA	indeterminate																														0.0010
R	68	*Elminius modestus*																						13.6780									
R	78	*Balanus improvisus*																						101.3450									
R	142	COPEPODA	indeterminate												0.0010								0.0010	0.0010	0.0010		0.0010	0.0010	0.0010	0.0010	0.0010		
S	76	*Neomysis integer*																														0.0850	
S	86	*Schistomysis kervillei*							0.1800																								
S	471	*Gammarus*	juvenile																					0.0010									
S	481	*Gammarus salinus*																											0.6660				
S	616	*Corophium volutator*															0.0080																
S	1197	*Bodotria scorpioides*																						0.0010	0.0010								
S	1253	*Diastylis rathkei typica*																						0.0320									
W	1696	*Mytilus edulis*	juvenile							0.0010														0.1870				0.0010					
W	2007	TELLINACEA	juvenile												0.0010																		
W	2029	*Macoma balthica*				0.0430	0.0610				0.4350						0.0010																
Y	112	*Walkeria uva*																															
Y	137	*Bowerbankia*																															
Y	176	*Electra crustulenta*																															
Y	177	*Electra monostachys*																															
Y	187	*Flustra foliacea*																															
Y	222	*Amphiblestrum auritum*																															
Y	255	*Bicellariella ciliata*																															
Quantitative				**3**	**3**	**3**	**4**	**0**	**1**	**5**	**6**	**1**	**1**	**4**	**3**	**1**	**5**	**1**	**1**	**1**	**4**	**0**	**2**	**13**	**2**	**2**	**3**	**4**	**5**	**3**	**1**	**2**	**4**
Colonial				**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total Taxa				**3**	**3**	**3**	**4**	**0**	**1**	**5**	**6**	**1**	**1**	**4**	**3**	**1**	**5**	**1**	**1**	**1**	**4**	**0**	**2**	**13**	**2**	**2**	**3**	**4**	**5**	**3**	**1**	**2**	**4**
Total Biomass				**0.054**	**0.003**	**0.068**	**0.181**	**0.000**	**0.180**	**0.169**	**0.496**	**0.001**	**0.001**	**0.142**	**0.032**	**0.001**	**0.021**	**0.001**	**0.001**	**0.023**	**0.316**	**0.000**	**0.019**	**152.854**	**0.002**	**0.011**	**0.067**	**11.275**	**0.679**	**0.033**	**0.001**	**0.086**	**0.004**

Table 8: % Dominance, abundance and biomass (subtidal survey, 2010)

MCS Code		TAXON	TAXON Qualifier	Total Abundance	%
R	78	*Balanus improvisus*		124	28
P	931	*Arenicola marina*		69	15
P	907	*Capitella capitata*	species complex	65	14
P	799	*Streblospio shrubsolii*		45	10
HD	1	NEMATODA		25	6
R	142	COPEPODA	indeterminate	22	5
R	68	*Elminius modestus*		14	3
W	1696	*Mytilus edulis*	juvenile	14	3
P	753	*Polydora cornuta*		13	3
P	1490	*Tubificoides benedii*		12	3
F	1	PLATYHELMINTHES		11	2
P	672	*Scoloplos armiger*		5	1
D	662	ACTINIARIA		4	1
P	1500	*Tubificoides swirencoides*		4	1
W	2029	*Macoma balthica*		4	1
P	499	*Nephtys hombergii*		2	0
S	481	*Gammarus salinus*		2	0
S	1197	*Bodotria scorpioides*		2	0
P	117/118	*Eteone flava/longa*	aggregate	1	0
P	845	*Tharyx*	species A	1	0
P	919	*Mediomastus fragilis*		1	0
P	1083	*Protodriloides chaetifer*		1	0
P	1498	*Tubificoides pseudogaster*		1	0
Q	53	ACARI		1	0
R	14	CIRRIPEDIA	indeterminate	1	0
S	76	*Neomysis integer*		1	0
S	86	*Schistomysis kervillei*		1	0
S	471	*Gammarus*	juvenile	1	0
S	616	*Corophium volutator*		1	0
S	1253	*Diastylis rathkei typica*		1	0
W	2007	TELLINACEA	juvenile	1	0
D	158	Tubulariidae		0	0
D	433	*Sertularia*		0	0
D	510	*Hartlaubella gelatinosa*		0	0
K	45	*Pedicellina*		0	0
Y	112	*Walkeria uva*		0	0
Y	137	*Bowerbankia*		0	0
Y	176	*Electra crustulenta*		0	0
Y	177	*Electra monostachys*		0	0
Y	187	*Flustra foliacea*		0	0
Y	222	*Amphiblestrum auritum*		0	0
Y	255	*Bicellariella ciliata*		0	0
			Total Abundance	**450**	**100**
			Total Quantitative Species	**31**	

% dominance, total abundance from the subtidal surveys (quantitative species only)

MCS Code		TAXON	TAXON Qualifier	Total Biomass	%
R	78	*Balanus improvisus*		10.135	60.79
D	662	ACTINIARIA		3.750	22.49
R	68	*Elminius modestus*		1.368	8.20
P	931	*Arenicola marina*		1.119	6.71
S	481	*Gammarus salinus*		0.067	0.40
P	907	*Capitella capitata*	species complex	0.056	0.34
W	2029	*Macoma balthica*		0.054	0.32
P	672	*Scoloplos armiger*		0.030	0.18
W	1696	*Mytilus edulis*	juvenile	0.019	0.11
P	499	*Nephtys hombergii*		0.018	0.11
S	86	*Schistomysis kervillei*		0.018	0.11
P	799	*Streblospio shrubsolii*		0.012	0.07
S	76	*Neomysis integer*		0.009	0.05
P	1490	*Tubificoides benedii*		0.007	0.04
S	1253	*Diastylis rathkei typica*		0.003	0.02
P	753	*Polydora cornuta*		0.003	0.02
R	142	COPEPODA	indeterminate	0.001	0.01
HD	1	NEMATODA		0.001	0.00
P	117/118	*Eteone flava/longa*	aggregate	0.001	0.00
S	616	*Corophium volutator*		0.001	0.00
F	1	PLATYHELMINTHES		0.000	0.00
P	1500	*Tubificoides swirencoides*		0.000	0.00
S	1197	*Bodotria scorpioides*		0.000	0.00
P	845	*Tharyx*	species A	0.000	0.00
P	919	*Mediomastus fragilis*		0.000	0.00
P	1083	*Protodriloides chaetifer*		0.000	0.00
P	1498	*Tubificoides pseudogaster*		0.000	0.00
Q	53	ACARI		0.000	0.00
R	14	CIRRIPEDIA	indeterminate	0.000	0.00
S	471	*Gammarus*	juvenile	0.000	0.00
W	2007	TELLINACEA	juvenile	0.000	0.00
D	158	Tubulariidae		0.000	0.00
D	433	*Sertularia*		0.000	0.00
D	510	*Hartlaubella gelatinosa*		0.000	0.00
K	45	*Pedicellina*		0.000	0.00
Y	112	*Walkeria uva*		0.000	0.00
Y	137	*Bowerbankia*		0.000	0.00
Y	176	*Electra crustulenta*		0.000	0.00
Y	177	*Electra monostachys*		0.000	0.00
Y	187	*Flustra foliacea*		0.000	0.00
Y	222	*Amphiblestrum auritum*		0.000	0.00
Y	255	*Bicellariella ciliata*		0.000	0.00
			Total Biomass	**16.672**	**100**
			Total Quantitative Species	**31**	

% dominance, total biomass from the subtidal surveys (quantitative species only)

46. Overall abundance ranged from 0-184 individuals/sample (mean = 15) with abundance in most samples being less than 20 individuals. Excluding barnacle records, peak abundance reduced to a maximum of 46 individuals (Station 21). Biomass ranged from <0.001 to 15.5 g/sample (mean = 0.56) with the barnacle component of Station 21 contributing 11.5g of the 15.5g total and with values at most stations being <0.05g.

47. The subtidal biotope extent and distribution around the development area (from the 2010 survey) is given in Figure 4.

2.4.2 IMPACTS

48. The following potential impacts have been identified:

NE (sHRA)

- The effects of capital and maintenance dredging and disposal on subtidal habitat and benthic communities.

- Loss of 13.5ha of subtidal habitat. Addressed within the Compensation EMMP (CEMMP).

MMO

- Capital and maintenance dredging leading to smothering of subtidal benthos.

EA

- Capital and maintenance dredging leading to a reduction of Ecological Potential under WFD.

2.4.3 PRE-CONSTRUCTION BASELINE AND BACI-TYPE ASSESSMENT (2013 ONWARDS)

49. AHPL will undertake a pre-construction baseline benthic survey of the subtidal area. This baseline survey has been designed to incorporate aspects of the characterisation survey in order to allow an initial indication of inter-annual variability, as well as additional components to provide a robust Before-After Control-Impact (BACI-type) methodology against which the impacts of the AMEP can be assessed.

50. This survey will use a three replicate Day grab methodology and follow standard methods e.g. Ware and Kenny 2011; the Marine Monitoring Handbook, Davies et al 2001). However, importantly, reference where appropriate has been made to the operational instructions for sampling and sample processing for macrobenthic invertebrates in TraC waters in order to collect data that can be used for WFD assessment purposes.

51. Furthermore, monitoring and assessment will need to take into account information from adjacent habitats (e.g. in particular the intertidal zone) in order to provide a waterbody approach that addresses WFD assessment needs. For the AMEP development this will be the Humber Lower waterbody.

52. Subsequent surveys will be undertaken to allow construction and operation impacts to be assessed. Details and duration are given in the Objectives section onwards and Appendices in this document.

2.5 Fish Communities

2.5.1 BASELINE (2010 CHARACTERISATION)

Intertidal

53. Two intertidal fish and shellfish surveys were conducted in the immediate area around the project site in May/June and October/November 2010, each comprising four fixed fyke net positions in the intertidal and eight 2m beam trawls over subtidal habitat (details of methods and results are provided in Annex 10.1 to the ES).

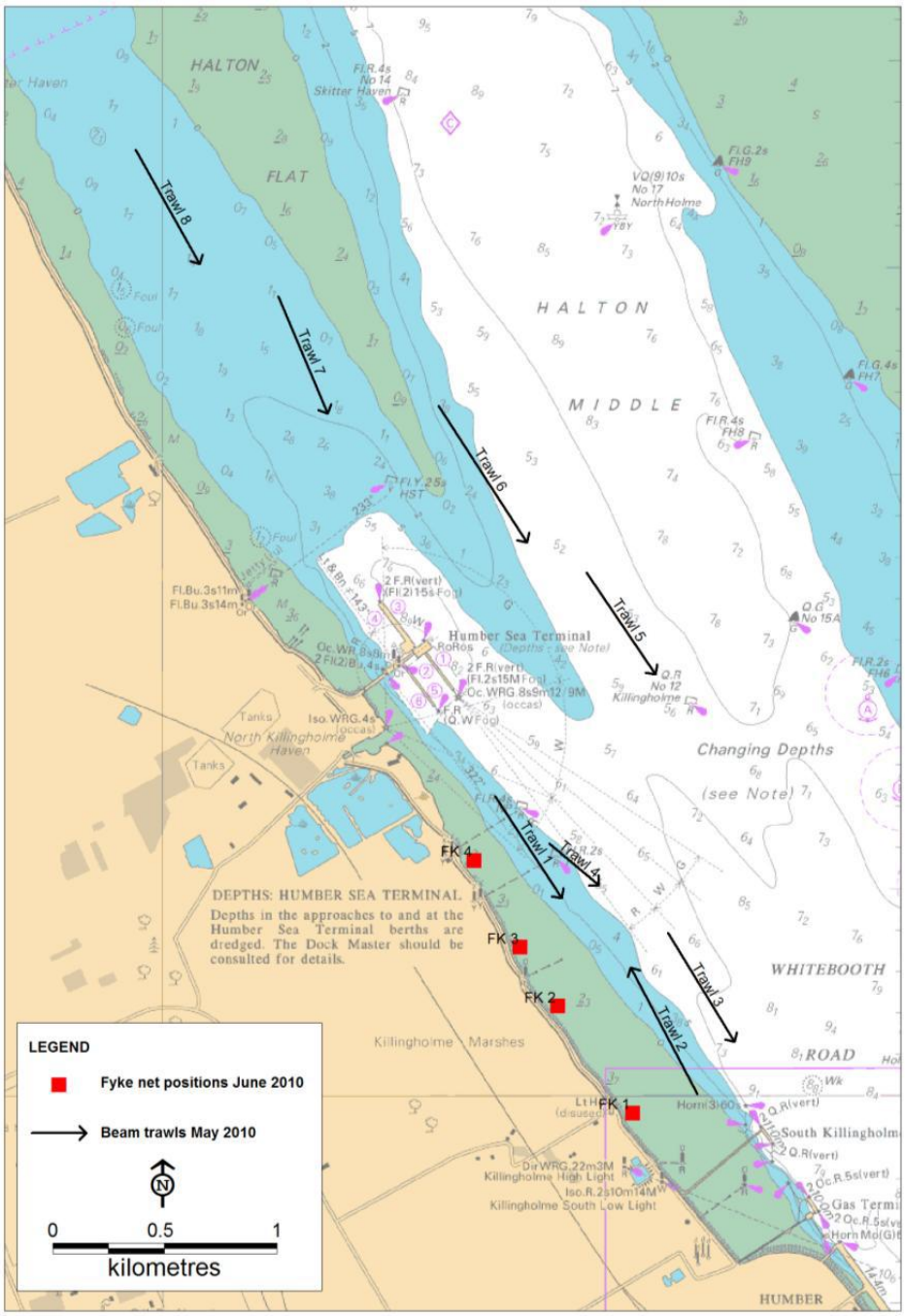


Figure 8: Location of the Intertidal and Subtidal Fish Sampling Positions (2010)

Table 9: Intertidal and Subtidal Sampling Locations (2010)

Site No.	Position (WGS 84)		Deployment		Retrieval		
	Lat (N)	Long (W)	Date	Time	Date	Time	
FK 1	53.64932	0.2182	08/06/2010	17:00	09/06/2010	17:30	Intertidal sampling locations
FK 2	53.65362	0.22324	08/06/2010	17:41	09/06/2010	18:15	
FK 3	53.65599	0.22579	08/06/2010	18:30	09/06/2010	19:00	
FK 4	53.65948	0.22891	08/06/2010	19:16	09/06/2010	19:48	
Weather conditions: Overcast and breezy with showers							

Trawl No.	Start Position		End Position		Date	Time in	Time Out	Water depth (m)	Sea state	
	Lat	Long	Lat	Long						
T 1	53.66217	0.22750	53.65800	0.22300	05/05/2010	09:00	09:10	12	Calm	Subtidal sampling locations
T 2	53.65017	0.21383	53.65517	0.21833	05/05/2010	09:17	09:30	11.3	Calm	
T 3	53.65667	0.21583	53.65217	0.21133	05/05/2010	09:42	09:53	10.2	Calm	
T 4	53.66017	0.22383	53.65850	0.22050	05/05/2010	10:01	10:13	12.1	Calm	
T 5	53.67117	0.22133	53.66700	0.21667	05/05/2010	10:26	10:36	12.2	Calm	
T 6	53.67233	0.22533	53.67783	0.23133	05/05/2010	10:45	10:55	10	Calm	
T 7	53.68217	0.24217	53.67750	0.23883	05/05/2010	11:01	11:10	8.9	Calm	
T 8	53.68817	0.25183	53.68350	0.24750	05/05/2010	11:20	11:29	8.3	Calm	
Weather conditions: Dry with sunny spells and light breeze										

54. Figure 8 and Table 9 provide details of the fish community sampling locations with further details provided in Annex 10.1 to the ES.

55. The summer catch was dominated by benthic flatfishes (flounder and sole) most probably year class 1+ flounder (born the year before) and mostly year class 0+ sole (born in present year), which highlights the role of the area (typical mudflat) as a flatfish nursery. Sand goby was recorded but due to the small size of this fish it is normally misrepresented in fyke net catches.

56. Whiting, common sole, five-bearded rockling and flounder dominated the fyke net catches (intertidal) during the autumn survey. Common sole juveniles and whiting were also present.

57. Given the background information available for the Humber Estuary and adjacent coastal area, and the gear selectivity profile of fyke nets, the fish and shellfish assemblage found during the surveys was considered normal. However, the summer abundance was low compared to previous survey programs.

Subtidal

58. Two subtidal beam trawl surveys were conducted in the subtidal area in the vicinity of the project site in May/June 2010 and October/November 2010.

59. Sole caught in the summer subtidal assessment were substantially larger that those found in the fyke nets, showing a segregation of sole year classes and indicating a distinct habitat dependency between 0+ sole and older juveniles. This segregation was not observed in autumn, although juvenile sole were present.

Similar to the intertidal assessment, the subtidal assemblage is consistent with previous results for the area with a real dominance of sand goby in both the summer and autumn surveys. Interestingly flounder (the more abundant species in the intertidal catch) was

recorded only once in the summer survey and six times in the autumn survey. This observation suggests the greater importance of the intertidal zone for flounder. Whiting were also common in the autumn survey, although not so in the summer survey. Common sole juveniles and whiting were also present.

2.5.2 IMPACTS

60. The following potential impacts have been identified:

NE (sHRA)

- Lamprey movements concluded to not be impacted so not included specifically in this document.

MMO

- Capital and maintenance dredging leading to smothering of subtidal benthos.

EA

- Capital and maintenance dredging leading to a reduction of Ecological Potential under WFD.

2.5.3 PRE-CONSTRUCTION BASELINE AND BACI-TYPE ASSESSMENT (2013 ONWARDS)

61. AHPL will undertake a pre-construction baseline fish survey across both the intertidal and subtidal environments.
62. The baseline survey has been designed to incorporate aspects of the characterisation survey in order to allow an initial indication of inter-annual variability, as well as additional components to provide a robust Before-After Control-Impact (BACI-type) methodology against which the impacts of the AMEP can be assessed.
63. This survey will use a suite of gear to cover the main aspects of fish ecology in the area and will incorporate features identified within the EA's guidance for WFD monitoring. Surveys will be undertaken in both the spring and autumn to capture seasonal variability in assemblage etc, and the biological data will be augmented by a suite of environmental parameters including dissolved oxygen, temperature and salinity.
64. Subsequent surveys will be undertaken to allow construction and operation impacts to be assessed. In addition, sub-surface monitors will be deployed to provide data on temperature, DO and underwater noise. Details and duration are given in the Objectives section onwards and Appendices in this document.

2.6 Temperature, DO and Suspended Sediments

2.6.1 BASELINE

65. No baseline data were collected, but there is provision for specific impact monitoring (see Objectives section). Some relevant baseline information is available relating to a series of water quality parameters.
66. A survey of water quality to inform the EIA process was conducted in May-July 2010 within the Humber Estuary with sampling locations across the intertidal and subtidal zone in the vicinity of the AMEP development (presented as Annex 7.2 to the Environmental Statement).
67. Data were collected throughout the day covering the full range of tidal conditions, ebb, flood and slack water.
68. Derived temperature data showed little variability e.g. with surficial temperature sampled in mid July 2010 showing a variation of less than 1 C (17.8–18.7°C). However, the proximity of the E.ON and Centrica discharges to the sampling area may have produced elevated surficial temperature readings as a continuous reading near-bed monitor deployed in the vicinity of the AMEP site in May 2010 indicated a temperature range of c. 11-16°C, the location of the monitor being c. 100m south-south-west (inshore) of the discharge point. As such, it is probable that the AMEP development and adjacent waters may fall within the mixing zone of these outfalls. Temperature will also vary naturally over the year outwith these parameters.
69. The baseline bathymetry and hydrography study (Annex 9.1 to the Environmental Statement) indicates that typical suspended sediment concentrations near to AMEP measured in September 2010 range from 100 mg/l at slack water on a neap tide to 400-500 mg/l during the neap tide ebb flow. Concentrations during the spring tides reached 1,600 mg/l during peak flood flow and were in excess of 800 mg/l on the ebb flow. Again, these values will vary on an intra-annual basis due to natural processes.

2.6.2 MONITORING

70. Temperature and DO data will be monitored in relation to DML requirements and particularly concerning percussive piling activity mitigation for fish (no adverse effect on fish with agreed mitigation measures, as specified in the DML, applied). There is an additional suspended sediments monitoring requirement in relation to potential impacts on local water intakes/outfalls, and these data will also be available to assist in the assessment of the continuing suitability of the area for utilisation by the fish community.
71. It will be necessary for compliance to specific condition criteria provided in the DML to be reported and addressed as necessary.

72. There is a requirement for recording to be provided on a continuous basis during the percussive piling phase, and a second monitoring device will be employed to ensure data availability were equipment failure to occur.

2.6.3 BASELINE & COMPLIANCE SURVEYS (2013 ONWARDS)

73. AHPL will undertake surveys as required within the DML, and as such, these will include aspects associated specifically with the percussive piling operation, as well as in relation to intake and discharge infrastructure.

3. OBJECTIVES

3.1 Introduction

74. Objectives and targets have been derived with reference to a number of information sources, including the SoCG, the DCO/DML and dialogue with the Regulatory Authorities and tables to action these are presented in the following text. See the Target Setting and Triggers section for further detail.

3.2 Sediment Parameters

3.2.1 RATIONALE & OBJECTIVES

75. Rationale: Monitoring is necessary to ensure that elevated levels of suspended solids arising from the capital and maintenance dredging activities are identified within the EX8.10, as these have the potential to affect subtidal and intertidal conditions and communities (e.g. mudflat elevation), as well as fish utilisation (e.g. barrier effects, behavioural responses).
76. They also have the potential to impact on the operation and maintenance of the adjacent E.ON and Centrica cooling water intake and outfall. Accretion rates along the pipeline relating to elevated suspended solids will also require monitoring.
77. Legal Requirement (1): E.ON and Centrica have cooling water intake and discharge points immediately north of the proposed quay and have expressed concerns regarding the level of suspended sediment caused by the development which may have an impact upon the operation of their cooling water pipelines and systems. The requirement to monitor suspended solids is included within Schedule 11 to the DCO, necessitating that a monitoring scheme be established for monitoring sedimentation along the lines of and in front of the E.ON and Centrica cooling water intake and outfall facilities.
78. Legal Requirement (2): There are requirements under WFD compliance monitoring as well as the Humber Estuary EMS Conservation Objectives relating to changes to subtidal and intertidal conditions and communities (e.g. mudflat elevation) as well as fish utilisation.
79. Objective(s): During dredging ensure sediment levels remain within limits agreed with Centrica and E.ON. Provide suitable data to ensure predictions within the EIA process regarding Humber Estuary EMS Conservation Objectives and WFD requirements (e.g. relating to changes to subtidal and intertidal conditions and communities (e.g. mudflat elevation) as well as fish utilisation) are correct.

3.2.2 MONITORING

Suspended Solids and Accretion Monitoring (E.ON and Centrica Requirements)

80. Suspended solids monitoring will be undertaken using automatic monitoring equipment installed on the same specialised 1250mm diameter buoy as used for the water quality monitoring.
81. Turbidity (suspended solids) monitoring will be carried out using a YSI 6600 multi sonde which will also be used to monitor temperature & dissolved oxygen (as above).
82. The sensor within the sonde can monitor turbidity within a range from -0 to 1000 NTU with an accuracy of. ± 2% of reading or 0.3 NTU whichever is greater.
83. Suspended solids monitoring will be carried out for a prolonged period prior to the start of dredging and percussive piling works to give sufficient time to ascertain suspended solids levels and from which to agree trigger levels with both E.ON and Centrica. The monitoring will continue up to and including first maintenance dredging or 12 months after completion of the marine piling works.
84. A specific sedimentation monitoring scheme will be drafted for this purpose and will be submitted in writing to the Marine Management Organisation for approval, in consultation with the Environment Agency, Centrica and E.ON UK plc.
85. Depending on the outcomes of the monitoring programme, agreed triggers will determine any requirement for remedial actions to be initiated in relation to the E.ON and Centrica cooling water intake and outfall facilities.

Suspended Solids and Accretion Monitoring (Humber Estuary EMS and WFD requirements)

86. Suspended solids information as described above will be utilised to assess the continuing suitability of conditions for fish utilisation around the AMEP site.
87. Accretion monitoring will also be undertaken to identify change in the intertidal mudflat elevation, with a monitoring scheme to be established for the monitoring of the foreshore and sediment levels around the quay. A default duration for this monitoring will be 10 years, with any requirement for subsequent continuance to be discussed and agreed by the Steering Group.
88. It should be noted that a monitoring scheme specific to the requirements of E.ON UK plc & Centrica (and subject to the approval of the MMO and EA) will be submitted to the MMO as above. However, in principle it is anticipated that the monitoring for Humber Estuary EMS and WFD requirements will primarily be based around bi-annual LiDAR surveys of the area, as these will provide the best coverage at a suitable accuracy.

89. In terms of Humber Estuary EMS and WFD requirements, the purpose of such surveys will not be to identify remedial actions on the NKM site, as gross changes in mudflat elevation would be difficult to address. Rather the surveys will inform the Steering Group of any elevation change, with the information also being incorporated into analysis of change from other components e.g. benthos.

Elevation Change Monitoring

90. Elevation changes in the intertidal zone are covered under the Intertidal Habitat (Saltmarsh) objectives section.

Bathymetric Change Monitoring

91. EA requirements associated with changes to the bathymetry and associated sediment characteristics are covered in the Subtidal Benthos objectives section.

3.3 Intertidal Habitat (Saltmarsh)

3.3.1 RATIONALE & OBJECTIVES

92. Rationale: Monitoring is necessary to identify any changes to saltmarsh community and extent in the wider AMEP area of impact. Impacts may arise from modification to erosion and deposition patterns on the intertidal zone relating to the influence of the quay and from capital and maintenance dredging.
    In particular, extension of saltmarsh area into existing mudflat habitat will be of interest/concern as this will impact on other ecological aspects such as carrying capacity for waterbirds.
93. Legal Requirement: WFD compliance and the Humber Estuary EMS Conservation Objectives.
94. Objective(s): To record changes in extent and composition of saltmarsh in association with other adjacent habitat e.g. mudflat.

3.3.2 MONITORING

Survey

95. A suite of field and aerial photography techniques will be used to address saltmarsh status (detailed further in Appendix 3), whilst mudflat status (extent and topography) will be surveyed using LiDAR (Appendix 1), together with quality (benthos) through invertebrate coring (Appendix 3).
96. Saltmarsh extent, community, zonation and diversity will be ascertained following EA WFD guidance e.g. OI 200_07 or any subsequent relevant revisions.

97. In advance of each annual survey the most recent available aerial images will be requested from the EA. Where the data are current then depending on coverage, it may be unnecessary to undertake an additional survey flight.
98. When such images are unavailable, then a survey flight will be undertaken, with aerial colour images captured. These images will be:
    - of resolution of at least 25cm
    - 3 band red green blue (RGB) imagery
    - taken in daylight at low water around a spring tide
    - taken under stable lighting conditions (little or no cloud shadow)
    - taken between June and September each year, with timing to be standardised to a single month per year where possible
    - taken on an annual basis for a minimum of 10 years, the requirements for subsequent surveys to be determined by the Steering Group
99. Detailed ground-truthing will be undertaken on-foot within the saltmarsh using transects and quadrats to determine community zonation and taxa diversity as well as DGPS to ascertain location.
100. Each transect will cover both the seaward and landward extent of the saltmarsh and transition points between zones will be mapped with two quadrat samples taken to characterise the major community changes, recording species, cover, sward height etc following OI 200_07 procedures.

Analysis

101. The saltmarsh will then be assessed for the following metrics in accordance with the WFD Saltmarsh Index Tool:
    - saltmarsh extent as proportion of “historic saltmarsh”
    - saltmarsh extent as proportion of the intertidal
    - change in saltmarsh extent over two or more time periods
    - proportion of saltmarsh zones present (out of five)
    - proportion of saltmarsh area covered by the dominant saltmarsh zone
    - proportion of observed taxa to historical reference value **or** proportion of observed taxa to 15 taxa
102. Analysis of LiDAR output and integration with saltmarsh findings including aerial photographs to characterise mudflat change along the remaining NKM frontage.

3.4 Intertidal Habitat (Benthos)

3.4.1 RATIONALE & OBJECTIVES

103. Rationale: Monitoring is necessary at North Killingholme Marshes (NKM) to identify any changes to the intertidal area and extent in the wider AMEP area of impact, and in particular, the associated benthic community as defined during the characterisation and baseline surveys. Direct loss from the AMEP footprint is addressed in the CEMMP, however indirect impacts may arise from modification to erosion and deposition patterns on the intertidal zone relating to the influence of the quay and from capital and maintenance dredging. These impacts may take the form of actual habitat loss through erosion (or accretion to a level that the zone becomes saltmarsh), but may also occur in the form of a substantial shift in community attributes (both physical and biological), above natural variation. Further monitoring will be necessary on Cherry Cobb Sands (CCS), around the location of the breach for the compensation scheme, as variation in flow and other factors have the potential to alter the current benthic community in this area.
104. Legal Requirement: WFD compliance and the Humber Estuary EMS Conservation Objectives.
105. Objective(s): To identify deleterious change to intertidal benthic invertebrate fauna.
106. It should be noted that a comprehensive Black-tailed Godwit prey survey will also be undertaken pre-construction, and the metrics associated with this study used to update the characterisation data and to populate specific monitoring metrics for the CEMMP. This survey will focus on foraging potential on NKM pre construction e.g. a maximum of two surveys, one in 2013 and one in 2014 (the latter only initiated if development has not yet commenced), and timed for the last week in August or first week in September in order to characterise prey availability during the peak period of importance for Black-tailed Godwit foraging in the vicinity of the AMEP development.

3.4.2 MONITORING

General

107. Samples taken to support the intertidal benthic invertebrate monitoring programme will be collected by means of hand coring.
108. Guidelines used in the design and subsequent reporting of benthic monitoring for the AMEP development have included *Guidelines for the Conduct of Benthic Studies at Marine Aggregate Extraction Sites* (Ware and Kenny, 2011), the Marine Monitoring Handbook (Davies *et al*, 2001) and the Environment Agency's Operational Instructions for sampling and sample processing for macrobenthic invertebrates in TraC waters, the latter to ensure that methods and derived data are suitable for WFD assessment purposes.

Survey Methods (BACI-Type Methods for North Killingholme Marshes and Cherry Cobb Sands)

109. The intertidal areas that remain to the north and to the south of the quay development (i.e. at Killingholme Marshes foreshore adjacent to North Killingholme Haven Pits and the foreshore near to South Killingholme Haven) will comprise the survey area; effectively Sectors A and E (as monitored for the baseline assessments); and a non-impacted south bank control area will also be surveyed (e.g. within 2 km of the quay development).
110. A further intertidal benthic survey will be undertaken on the Cherry Cobb Sands in the vicinity of the compensation site breach.
111. The survey details for the NKM site are summarised in Table 10 and the sample locations shown in Appendix 3.
112. Ongoing BACI-type monitoring surveys of the intertidal benthos will be carried out at the same time of year as the baseline survey (at NKM). If the same month cannot be accommodated then sampling in the same season will at least be ensured.
113. The intertidal survey at CCS will be undertaken at around the same time as the NKM survey, survey timing designed to be within the acceptable period defined for WFD compliance. Sampling and analysis methods employed for the CCS survey programme will be the same as those for the NKM survey.

Table 10: NKM Intertidal Invertebrate Sample Summary

				Number of replicate benthic		
Survey areas		**area code**	**Transect**	**Upper**	**Mid**	**Lower**
Impact	Under direct footprint of quay development	**DI**	DI.1	3	3	3
			DI.2	3	3	3
			DI.3	3	3	3
	Under the area of indirect impact north of the quay development	**IIN**	IIN.1	3	3	3
			IIN.2	3	3	3
			IIN.3	3	3	3
	Under the area of indirect impact south of the quay development	**IIS**	IIS.1	3	3	3
			IIS.2	3	3	3
			IIS.3	3	3	3
Control	Control area north of NKM	**CN**	CN.1	3	3	3
			CN.2	3	3	3
			CN.3	3	3	3
	Control area south of NKM	**CS**	CS.1	3	3	3
			CS.2	3	3	3
			CS.3	3	3	3

114. As part of the overall quality assurance strategy the continued validity of stations selected as representative of impacted and reference conditions will be ensured through regular evaluations. Therefore, some allowance will be made for the possible modification in locations in response to unanticipated anthropogenic or natural influences.
115. All surveys will be logged in a pre-designed field log or electronic datasheet. Each log-sheet will be clearly laid out, providing prompts for all the information required.
116. For each area, sampling will be undertaken at three stations along transects across the foreshore, effectively covering the upper, mid- and lower-intertidal. Three transects will be surveyed within each impact zone (direct impact, secondary impact and control areas), with a total of nine sampling stations surveyed within each zone.
117. Four replicate samples will be taken at each station, three of which will be subsequently analysed for species composition, abundance, size class and biomass etc with the fourth being used for an assessment of sediment particle size and organic content.
118. Sampling will be carried out using hand-held corers (e.g. 0.01m^2 sampling area) to a depth of c.15cm. Sample locations along transects will be recorded using DGPS to allow for greater station fidelity between years.
119. In addition to core sampling, observational monitoring will be conducted at each sampling station:

- Recording obvious sediment surface conditions (e.g. algae coverage, evidence of drying, casts, etc.);
- Recording the character and composition of surface sediments; and
- Providing a photographic record of the sampling station.

120. All sites will be monitored on an annual basis; with monitoring in the spring to comply with WFD requirements
121. An additional baseline intertidal invertebrate survey will be undertaken in the last week of August or first week in September at the NKM site (pre-construction) to quantify the prey characteristics for Black-tailed Godwit using the AMEP area. This survey will incorporate a modified methodology to address this specific foraging issue and the derived data will be used to set invertebrate community targets for the CEMMP. Details of the methods for this survey are provided in Appendix 3.
122. A full (spring) pre-construction baseline survey of the Cherry Cobb Sands intertidal area will also be carried out using a similar methodology to augment existing baseline characterisation data. Station locations are shown in Appendix 3.
123. Monitoring will continue at the NKM and CCS sites using the same baseline methods for a period of at least ten years following completion of the works.
124. Further details of the methodologies to be employed for the North Killingholme Marshes and Cherry Cobb Sands BACI-type intertidal invertebrate surveys are given in Appendix 3, together with a methodology to identify the prey characteristics for Black-tailed Godwit at North Killingholme Marshes.

Analysis

125. In order to provide analytical quality assurance, invertebrate identification, biomass and particle size analysis will be performed by laboratories that are members of the NMBAQC scheme.
126. Laboratory analyses will include species (identified to highest taxonomic detail), abundance, and wet weight tissue blotted (WWTB) biomass.
127. Sediment particle size analysis and organic content will also be measured.
128. In line with WFD requirements, the IQI (infaunal quality index) will be calculated for benthic samples, the three parameters which feed into this are:
    - number of taxa;
    - AZTI* Marine Biotic Index (AMBI); and
    - Simpson's Evenness.
129. Analysis of variance will be applied at univariate and multivariate level (Permanova routine can be used in both cases, using a pseudo-F statistic and permutations, thus avoiding assumptions of the parametric F-statistics) to assess the significance of possible impacts. The analysis will be carried out on univariate descriptors of the community (e.g., abundance, biomass, species richness, diversity) as well as on the multivariate structure of the assemblages. The main aim of the analysis is to test for interactions between periods (before and afters) and treatment (controls and impacts) in order to assess whether temporal

changes in the impacted areas are in line with changes at control areas (if not, i.e. an interaction exists, then an impact is assumed). Contrast between levels of the factors (e.g. impact sites and control sites) will be assessed. The interaction of these factors with shore location will be taken into account to highlight possible impacts that might manifest only at certain shore levels.

130. Analysis will also be integrated with the findings of the intertidal LiDAR surveys described in the relevant Objectives section, as elevation change can influence benthic community structure.
131. Furthermore, in order to provide an approach to address waterbody effects in compliance with the WFD approach (Humber Lower waterbody), findings from the intertidal survey programmes will be assessed in the context of those from the subtidal survey programme described below.
132. The analysis methods described above will be used for both the NKM an CCS BACI-type survey programmes (see Appendix 3 for details). In addition, further analysis will be undertaken as part of the prey characterisation survey in order to inform the setting of benthic targets for the compensation site (see CEMMP for details).

3.5 Subtidal Habitat (Benthos)

3.5.1 RATIONALE & OBJECTIVES

133. Rationale: Monitoring is necessary to identify any changes to the subtidal area and extent in the wider AMEP area of impact, and in particular, the associated benthic community as defined during the characterisation and baseline surveys. Direct loss from the AMEP footprint is addressed in the CEMMP, however indirect impacts may arise from modification to erosion and deposition patterns on the subtidal zone relating to the influence of the quay and from capital and maintenance dredging. These impacts may take the form of actual habitat loss through erosion but may also occur in the form of a substantial shift in community attributes (both physical and biological), above natural variation.
134. Legal Requirement: WFD compliance monitoring and Humber Estuary EMS Conservation Objectives.
135. Objective(s): To identify deleterious change to subtidal benthic invertebrate fauna due to dredging and dredge disposal e.g. including WFD compliance. To derive baselines for dredging and disposal impacts and to validate boundaries of disposal grounds.

3.5.2 MONITORING

General

136. The subtidal benthic monitoring will be carried out using the same framework as defined for benthic intertidal samples in the relevant Objectives section.
137. Guidelines to be used in the design and subsequent reporting of benthic monitoring are the *Guidelines for the Conduct of Benthic Studies at Marine Aggregate Extraction Sites* (Ware and Kenny, 2011), the Marine Monitoring Handbook (Davies *et al*, 2001) and the Environment Agency's Operational Instructions for sampling and sample processing for macrobenthic invertebrates in TraC waters, the latter to ensure that methods and derived data are suitable for WFD assessment purposes.
138. As such, samples for the subtidal invertebrate monitoring will be taken using a $0.1m^2$ Day grab where possible. However, in locations where an adequate sample cannot be gained using the Day grab e.g. gravel/cobble ground, then a $0.1m^2$ Hamon grab should be employed instead (with appropriate notes made on the station(s) of this deployment if required.

Survey

139. The initial impact of operational dredging on the subtidal benthic invertebrate assemblages within the berthing pocket, approach channel and turning circle will be monitored.
140. A total of 30 stations will be monitored in the vicinity of the development, with stratification of the design based on impact zones (impact and control areas) and on depth levels..
141. Details on the survey design and an example of the location of the sampling stations are shown in Appendix 3.
142. Samples will be collected using a $0.1m^2$ Day grab or a $0.1m^2$ Hamon grab if sufficient sediment cannot be gained from the Day grab.
143. Three replicate benthic samples will be collected from each station for subsequent invertebrate analysis, with a further replicate for particle size analysis and organic content. Each sample will be analysed for species composition, abundance and biomass together with an assessment of sediment particle size and organic content. Dedicated sediment particle size and organic content will be carried out on the fourth replicate.
144. Monitoring of subtidal benthos will only cover the first round of maintenance dredging. Any longer-term monitoring requirements will be determined by the Steering Group.
145. In addition, and prior to the commencement of any marine disposal activities, in order to be meet WFD compliance, a scheme for the protection and enhancement of benthic invertebrates through the monitoring and management of disposal activities within, and

immediately surrounding, the disposal sites of the Lower Humber water body, will be submitted to and agreed in writing with the EA. The scheme will include the following:

- A timetable for when monitoring shall be undertaken;
- A detailed monitoring methodology;
- An evaluation of the contribution the disposal activities make to the overall ecological potential of the Lower Humber water bodies.

Analysis

146. In order to provide analytical quality assurance, invertebrate identification, biomass and particle size analysis will be performed by laboratories that are members of the NMBAQC scheme.
147. Laboratory analyses will include species (identified to highest taxonomic detail), abundance, and biomass (WWTB). Sediment particle size analysis and organic content will also be measured.
148. Standard univariate statistical analyses, either parametric (e.g., ANOVA, t-test) or non-parametric (e.g., Kruskal-Wallis test, Mann-Whitney test, PERMANOVA) will then be applied to the data of abundance, richness, biomass, eveness, diversity and biomass-to-abundance ratio.
149. In line with WFD requirements, the IQI (infaunal quality index) will be calculated for benthic samples, the three parameters which feed into this are:
    - number of taxa;
    - AZTI* Marine Biotic Index (AMBI); and
    - Simpson's Evenness.
150. Analysis of variance will be applied at univariate and multivariate level (Permanova routine can be used in both cases, using a pseudo-F statistic and permutations, thus avoiding assumptions of the parametric F-statistics) to assess the significance of possible impacts. The analysis will be carried out on univariate descriptors of the community (e.g., abundance, biomass, species richness, diversity) as well as on the multivariate structure of the assemblages. The main aim of the analysis is to test for interactions between periods (before and afters) and treatment (controls and impacts) in order to assess whether temporal changes in the impacted areas are in line with changes at control areas (if not, i.e. an interaction exists, then an impact is assumed). Contrast between levels of the factors (e.g. impact sites and control sites) will be assessed. The interaction of these factors with depth level will be taken into account to highlight possible impacts that might manifest only at certain depth levels.

151. Multivariate analysis will be also carried out using cluster analysis (combined with similarity profile routine, SIMPROF) and ordination techniques (e.g., MDS, PCO) in order to identify different community types and gradients in the assemblage distribution/variation, as well as applying the SIMPER routine to identify the species which contribute most to the differentiations between groups. Multivariate statistical analysis (e.g., ANOSIM, PERMANOVA) will be applied to detect changes in community structure and composition. Bio-Env routine and linkage trees (BEST) in Primer will be used to explore the relationship between biotic (community) patterns and substrate characteristics.

Bathymetric Survey

152. Additional bathymetric surveys will be taken to assess potential impacts at dredge disposal sites and across the wider estuary. These will be as laid out in the Environment Agency's proposals (reproduced as Appendix 1 to this document) with the surveys to ensure WFD compliance.

3.6 Fish Communities

3.6.1 RATIONALE & OBJECTIVES

153. Rationale: Monitoring is necessary to identify any changes to the fish communities in the vicinity of the AMEP. Impacts may arise from percussive piling during construction, from capital and maintenance dredging, changes to habitat type and elevation relating to the presence of the quay. These impacts may take the form of a change in community attributes (e.g. species composition and size class abundance), above natural variation.
154. Legal Requirement: WFD compliance monitoring and Humber Estuary EMS Conservation Objectives. Also Section 6 of the Environment Act 1995 (transferring from the Salmon and Freshwater Fisheries Act, 1975) in order to 'maintain, improve and develop' salmon fisheries, trout fisheries, freshwater fisheries and eel fisheries in England and Wales.
155. Objective(s): That there is no significant change to baseline community attributes resulting from the AMEP development within a degree of natural variability.

3.6.2 MONITORING

General

156. Fish sampling on the intertidal will be undertaken by seine netting and beam trawling whilst subtidal fish sampling will be by means of otter trawling. In both instances WFD compliant methods will be employed as detailed in the Environment Agency's Operational Instructions for WFD transitional fish surveillance monitoring to ensure that methods and derived data are suitable for WFD assessment purposes. Below a general description of the survey

monitoring design and methods is provided, whereas further details are provided in Appendix 3.

157. Additional monitoring is required in relation to potential impacts from percussive piling. These methods utilise a fixed sonde with permanent noise recording during the piling phase. Methods are detailed in the DML.

Intertidal

158. Bi-annual (six-monthly) seine net and beam trawl surveys of the intertidal mudflat will be undertaken. This monitoring will continue for an initial period of ten years.
159. For each survey seine net will be deployed at low slack tide at each of four sites (2 in the impact area, 2 in the control area north of the development site), with each deployment including two hauls. Also a 1.5m beam trawl will be deployed at high slack tide (to allow boat access to the intertidal area), taking into account all the health and safety issues deriving from operating this net from a boat on intertidal areas. Each trawl will be deemed to commence from the point at which the gear reaches the seabed after the warp length is paid out and the winch is locked. Trawling will be conducted with a warp length of three times the depth at constant speed (3 knots) following a straight path (towards or away from the station fix) to a predetermined finish point to allow a towing length of 200m.
160. Following retrieval of the nets, the catch will be collected and processed on site (identification, enumeration and measurement), with only fishes that are not identifiable in the field (e.g., juveniles) being preserved in 60% Ethanol for identification in the laboratory using appropriate keys.
161. Monitoring will be undertaken during the spring and autumn, but with consideration to key periods of waterbird sensitivity (i.e. avoiding the main winter period and the autumn passage as a minimum).

Subtidal

162. Subtidal fish monitoring will be undertaken annually (autumn) by means of a 8m-wide otter trawl fitted with a 10mm cod end sleeve.
163. Sampling locations will utilise those used in the baseline study, but will be extended to also cover nearby WFD sampling locations in the Humber Lower waterbody.
164. Each trawl will be deemed to commence from the point at which the gear reaches the seabed after the warp length is paid out and the winch is locked. Trawling will be conducted with a warp length of three times the depth at constant speed (2 knots) following a straight path (towards or away from the station fix) against the rising tide, with towing duration of 30 minutes.

165. All relevant details (including, for each tow: station and tow number; start & end times and positions; shooting & hauling times and positions; any significant changes in tow direction; depth; length of warp; speed over ground; tidal state; weather and sea conditions; and shipping activity, together with date and gear type) will be recorded. Positions to be recorded using DGPS.
166. After the completion of the sampling run, the trawl will be quickly hauled to the vessel's deck and the sample will be recovered into a container. The net will then be checked for any remaining epifauna and fish, before the cod end is refastened, prior to redeployment at the next station.
167. After completion of the sampling run and hauling up to survey vessel's deck, samples will be cleared of large debris and the total catch shall be photographed. Fish species will be sorted from epifaunal invertebrates, divided into species groups, counted and measured (total length) to the closest millimetre.
168. Any species not identified on board will be coded and preserved in 10% buffered formaldehyde solution in seawater or frozen and identified on return to the laboratory.
169. Analysis of variance will be applied at univariate and multivariate level (Permanova routine can be used in both cases, using a pseudo-F statistic and permutations, thus avoiding assumptions of the parametric F-statistics) to assess the significance of possible impacts. The analysis will be carried out on univariate descriptors of the community (e.g., abundance, biomass, species richness, diversity) as well as on the multivariate structure of the assemblages. The main aim of the analysis is to test for interactions between periods (before and afters) and treatment (controls and impacts) in order to assess whether temporal changes in the impacted areas are in line with changes at control areas (if not, i.e. an interaction exists, then an impact is assumed). Contrast between levels of the factors (e.g. impact sites and control sites) will be assessed.
170. Due to the difference sampling gear (with different selectivity) used in the intertidal and subtidal zones, the data collected in the two zones will be analysed separately and the patterns in the results will be compared.

Underwater Percussive Piling Noise

171. A series of timing and other restrictions for percussive piling are identified within the DML.
172. Underwater noise levels will be monitored by an automatic monitoring buoy to demonstrate that restrictions on percussive piling laid out with the DML are complied with.
173. Noise monitoring will be carried out using a sensor an Ic-Listen-LF smart hydrophone with a bandwidth of 0.1 to 1600 Hz installed on a specialised 1250mm diameter buoy. The buoy will be anchored to the river bed and connected via a chain of approximately 15m in length (to allow for tidal movement and wave height).

174. The location of the monitoring buoy in relation to the intake and outfall locations and the AMEP development is provided in Figure 9.

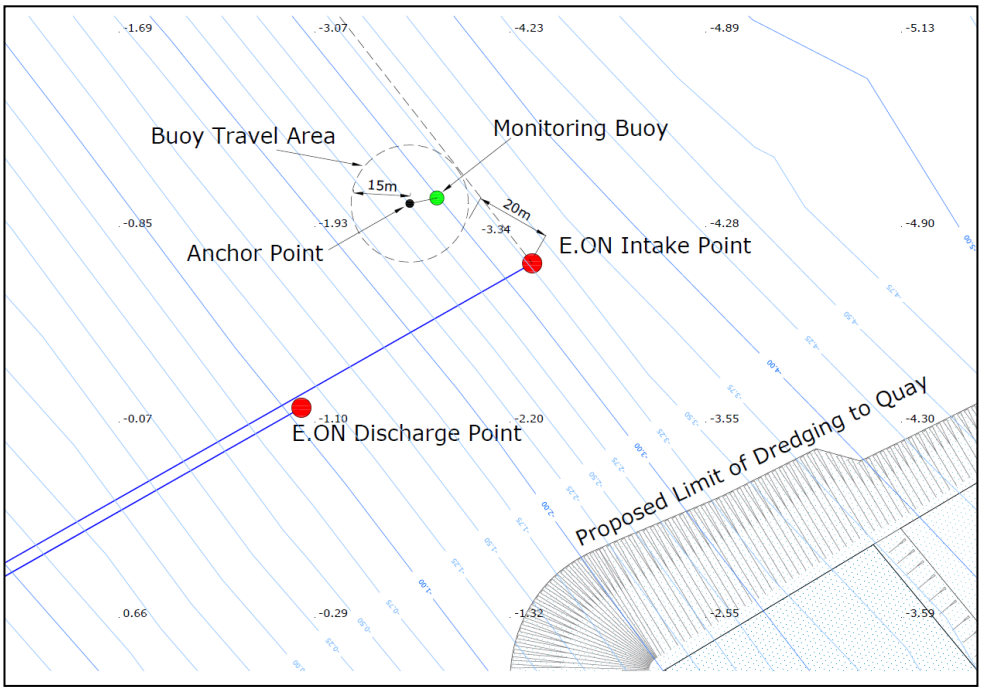


Figure 9: Proposed Monitoring Buoy Location

175. An additional noise monitor will be deployed to ensure that were the first monitor to fail, noise monitoring would continue be achieved. The location of this second monitor will be downstream of the proposed site, but with the location to be determined taking into account logistical constraints whilst still ensuring suitable recording veracity.
176. Able will carry out noise monitoring approximately two weeks prior to commencement of the percussive piling and dredging works and throughout the duration of the works.
177. Additional monitoring of parameters relating to the conditions of the DML will be undertaken with automatic monitoring equipment installed on the same 1250mm diameter buoy (see below).

Temperature Monitoring

178. Temperature monitoring will be carried out using a YSI 6600 multi sonde installed onto the buoy.
179. The sensor within the sonde can monitor temperatures within a range from -5^{o}C to +50^{o}C with an accuracy of $\pm$0.15^{o}C.
180. Temperature monitoring will be carried out by default when the suspended solids are monitored.

Dissolved Oxygen Monitoring

181. Dissolved oxygen monitoring will be carried out by installation of an additional sensor onto the YSI 6600 multi sonde which is used to monitor temperature and suspended solids.
182. The sensor within the sonde can monitor dissolved oxygen within a range from -0 to 50mg/L with an accuracy of. ± 0.2mg/L or 2% of reading whichever is greater for 0 to 20mg/L range and ±6% of reading for 20 to 50mg/L range.
183. Able propose to carry out dissolved oxygen monitoring approximately two weeks prior to commencement of the percussive piling and dredging works and throughout the duration of the works.

3.7 Marine Mammals

3.7.1 RATIONALE & OBJECTIVES

184. Although no baseline data were collected, potential impacts to marine mammals from percussive piling activity on the AMEP were identified, although with no adverse effect with mitigation measures applied.
185. Legal Requirement: Percussive piling conditions are identified within the DML, with a requirement to undertake 'soft start' piling techniques. Furthermore, there is a requirement for a qualified Marine Mammal Observer to be present.
186. Objectives(s): Ensure compliance with percussive piling restrictions and to restrict or remove potential impacts on sensitive marine mammal receptors.

3.7.2 MONITORING

187. As per the percussive piling conditions detailed within the DML, 'soft start' techniques will be employed.
188. A Marine Mammal Observer will be present (within 100 metres of the pile being driven) during marine percussive piling works.
189. The Marine Mammal Observer will operate standard protocols to ensure that percussive piling work is not undertaken when a marine mammal is in the vicinity of the works.

3.8 Waterbirds

3.8.1 RATIONALE & OBJECTIVES

190. As part of the assessment of percussive piling impacts, it was identified that disturbance to waterbirds could occur from percussive piling which would have an elevated impact during periods of extended cold weather.

191. Legal Requirement: Percussive piling conditions are identified within the DML, with a requirement to ensure that this activity is not carried out during periods of extended cold weather.
192. Objectives(s): Ensure compliance with percussive piling restrictions to restrict or remove potential impacts on sensitive bird receptors.

3.8.2 MONITORING

193. Air temperature will be monitored at three points within the Humber Estuary. Percussive piling will not be permitted during extended periods of cold weather.
194. The details of the location of the monitoring points have yet to be finalised. However the threshold details for the necessary temporary cessation of piling are provided in the DCO.
195. These primarily require temporary cessation following 7 consecutive days of zero or sub-zero temperature, but with additional detail as provided in the DCO.

3.9 Target Setting and Triggers

196. As noted above, objectives and targets have been derived with reference to a number of information sources, including the SoCG, the DCO/DML and dialogue with the Regulatory Authorities and tables to action these are presented in the following text.
197. However, where objectives, targets and/or remedial actions have yet to be agreed in full, then these are identified in the following tables with an asterisk (*) and will be developed through subsequent dialogue with the appropriate Regulatory Authorities.
198. Whilst the agreement on many of these can be formed through bilateral discussion, the cross cutting nature of some of these may require multi-lateral discussion.

4. TABULATED ACTION PLANS

199. For the broad Objectives identified in the preceding text, the following Action Plans summarise Targets, Actions (or Monitoring) to achieve those Targets and the Responsible Body to undertake the Actions (or Monitoring). Timing for the Action (or Monitoring) is provided, as well as Limits of Acceptable Change (LACs) against which any change from baseline conditions can be identified. Finally, potential types of Intervention are identified where LACs have been exceeded.

200. Importantly given the status of this plan, items within the plan that have yet to be agreed and thus require further consultation with regulators are marked with an asterisk (*) at the initial Objective headline.

201. As described within the Steering Group section earlier in text, the findings from the monitoring programmes will be submitted to the Steering Group, and required actions will be identified where necessary, based on baseline data and compliance with agreed targets and triggers.

TOPIC: SEDIMENT PARAMETERS

Objective M1: During dredging ensure sediment levels remain within limits agreed under the DML in relation to Centrica and E.ON intake/outfall operation *

Target	Ensure sediment levels remain within ranges identified and agreed through pre-construction monitoring at automatic monitoring buoy. NB existing baseline data suggest typical range of 100-1600 mg/l within the Humber Estuary
Management	n/a
Monitoring	Automatic monitoring buoy equipped with YSI 6600 multi Sonde
Who	AHPL
When	Continuous monitoring: initial pre-construction monitoring will be used to develop new baseline; monitoring will continue up to, and including, the first maintenance dredging
Limits of Acceptable Change	To be agreed following collection of baseline data and included within the monitoring scheme submitted to, and approved by, the MMO, in consultation with the EA, Centrica and E.ON
Remedial Action	As set out in the DML, to be agreed and included within the monitoring scheme submitted to, and approved by, the MMO, in consultation with the EA, Centrica and E.ON
Notes	Details of scheme to be developed and agreed prior to development commencing

Objective M2: To corroborate predictions on intertidal accretion/erosion from EX11.24

Target	No target – impact verification
Management	n/a
Monitoring	LiDAR
Who	AHPL appointed consultant/contractor
When	Detail of monitoring dates laid out in Appendix 1; to include pre- and post-construction for a period of at least ten years
Limits of Acceptable Change	n/a
Remedial Action	Dredging if required, specifically in relation to the ongoing operational requirements of the Centrica and E.ON intakes/outfalls. Wider changes to mudflat elevation across the NKM will not require dredging work
Notes	Wider elevation changes referred to above relate to Humber Estuary EMS and WFD issues

TOPIC: INTERTIDAL ESTUARINE HABITAT (SALTMARSH) - WFD / HUMBER ESTUARY EMS MONITORING

Objective M3: To record changes in extent and composition of saltmarsh

Target	No target; ongoing monitoring to address WFD and Humber Estuary EMS Conservation Objectives issues
Management	n/a
Monitoring	Methods to be WFD compliant following EA Guidance OI 200_07. Aerial RGB photographic survey (potential to utilise EA images if timing is appropriate). Field survey using transects and quadrats following OI200_07. Subsequent analysis in accordance with the WFD saltmarsh index tool.
Who	Environmental Manager and suitably qualified surveyor in consultation with the Environment Agency
When	Annually during June to September (ideally July); for at least ten years
Limits of Acceptable Change	No deleterious change to WFD/EMS status.
Remedial Action	n/a
Notes	

TOPIC - INTERTIDAL ESTUARINE HABITAT (BENTHOS)

Objective M4: To identify deleterious change to intertidal benthic invertebrate fauna *

Target	No impact on WFD status (status currently assessed as Moderate for Humber Lower, and predicted as being Moderate in 2015 for Humber Lower; no assessments for Humber Middle) – WFD assessments include number of taxa; AZTI* Marine Biotic Index (AMBI); and Simpson's Evenness Quantitative targets to be defined and agreed following completion of full baseline (pre-construction) surveys. BACI-type surveys at NKM and CCS.
Management	refer to CEMMP for details of targets etc
Monitoring	Intertidal survey using hand-held corers (standard methods – including species and community analysis, particle size analysis, organic content)
Who	AHPL appointed consultant/contractor
When	Annual (spring) BACI-type surveys beginning with establishing new baseline pre-construction and continuing for ten years post-construction. One-off late summer/autumn bird prey characterisation survey at NKM.
Limits of Acceptable Change	To be based on uni- and multi-variate statistical analysis of temporal and spatial community variability and change
Remedial Action	n/a (provided by CEMMP)
Notes	Full targets to be defined and agreed following agreement of analysis methods and completion of full baseline (pre-construction) surveys

Objective M5: To record and identify changes in intertidal topography & extent

Target	To meet EA monitoring requirements and to validate model predictions of changes in topography to the south-east of the AMEP quay as described in EX 8.9. Also to inform NE of any topographic or extent changes to intertidal mudflat.
Management	n/a
Monitoring	LiDAR survey of intertidal between the flood defence wall and MLWN or -2m ODN (whichever is the greater) and between CPK and HIT (area shown in Appendix 2).
Who	AHPL appointed consultant/contractor
When	• Once during month prior to commencement of construction works; • Biannual surveys for ten years post-construction
Limits of Acceptable Change	n/a
Remedial Action	n/a
Notes	Further details as per Environment Agency monitoring requirements attached as Appendix 1

TOPIC - SUBTIDAL ESTUARINE HABITAT (BENTHOS)

Objective M6: To identify deleterious change to subtidal benthic invertebrate fauna due to dredging and dredge disposal e.g. including WFD Compliance *

Target	To identify potential impact on WFD status (status currently assessed as Moderate for Humber Lower, and predicted as being Moderate in 2015 for Humber Lower; no assessments for Humber Middle) – WFD assessments includes number of taxa; AZTI* Marine Biotic Index (AMBI); and Simpson's Evenness Quantitative targets to be defined and agreed following completion of full baseline (pre-construction) surveys. Possible metrics to include: • Abundance and biomass dominance; • Overall benthic invertebrate biomass (wet weight / m^2) to exceed agreed thresholds; • Biotope composition and extent to remain unaffected.
Management	n/a
Monitoring	Subtidal benthic invertebrate survey of (maintenance) dredge areas using Hamon grab (standard methods – including species and community analysis, particle size analysis, organic content); Subtidal benthic invertebrate survey of areas within, and immediately surrounding, dredge disposal sites.
Who	AHPL appointed consultant/contractor
When	Dredge sites: annual (spring) surveys beginning with establishing new baseline pre-construction and continuing for ten years post-construction Disposal sites: scheme for monitoring and management of disposal activities to be submitted to, and agreed with, the EA; the scheme shall include: • timetable for when monitoring shall be undertaken; • detailed monitoring methodology; • evaluation of the contribution the disposal activities make to the overall ecological potential of the Humber Lower water body
Limits of Acceptable Change	To be based on uni- and multi-variate statistical analysis of temporal and spatial community variability and change
Remedial Action	n/a
Notes	Full targets to be defined and agreed following completion of full baseline (pre-construction) surveys. Further details regarding disposal site monitoring as per Environment Agency monitoring requirements attached as Appendix 1

Objective M7: To derive baselines for dredging and disposal impacts and to validate boundaries of disposal grounds

Target	Derive baselines for dredging/disposal impacts and to validate assumptions on boundaries of disposal grounds
Management	n/a
Monitoring	Bathymetric survey of dredge areas and disposal sites and of the intertidal area between CPK and HIT
Who	AHPL appointed consultant/contractor
When	Once during month prior to commencement of construction works; Fortnightly during capital dredging and the month following; Annual surveys for ten years post-construction
Limits of Acceptable Change	Sedimentation patterns indicating greater levels of erosion in comparison to those defined in Chapter 8 of ES or subsequent revision
Remedial Action	As noted below, the annual surveys will provide the information needed to either validate the boundaries of the deposit grounds, or trigger the need for them to be amended, and will also allow ongoing management of the dredge and disposal.
Notes	• The first surveys shall provide the baseline for determining the impacts of dredge and disposal works, and should allow natural variability to be accounted for in any assessment. • The subsequent surveys shall provide the information needed to either validate the boundaries of the deposit grounds, or trigger the need for them to be amended. It shall also allow ongoing management of the dredge and disposal. • Surveys will be undertaken on similar tidal ranges and state of tide wherever possible. This will allow volumetric differences to be roughly compared, meaning the approximate portion of sediment retained and dispersed may be deducted. Further details as per Environment Agency monitoring requirements attached as Appendix 1

TOPIC – FISH COMMUNITIES

Objective M8: To identify deleterious change to intertidal fish populations *

Target	To identify potential impact on WFD status (status currently assessed as Good for Humber Middle and Lower, and predicted as being Good in 2015 for Humber Middle and Lower) and Humber Estuary EMS Conservation Objectives
Management	n/a
Monitoring	Intertidal seine net and beam trawl surveys
Who	AHPL appointed consultant/contractor
When	By-annual (Spring and Autumn), beginning with establishing new baseline pre-construction and continuing for ten years post-construction
Limits of Acceptable Change	To be based on uni- and multivariate statistical analysis of temporal and spatial community variability and change
Remedial Action	n/a
Notes	

Objective M9: To identify deleterious change to subtidal fish populations *

Target	To identify potential impact on WFD status (status currently assessed as Good for Humber Middle and Lower, and predicted as being Good in 2015 for Humber Middle and Lower) and Humber Estuary EMS Conservation Objectives
Management	n/a
Monitoring	Subtidal otter trawl surveys
Who	AHPL appointed consultant/contractor
When	Annual (Autumn), beginning with establishing new baseline pre-construction and continuing for ten years post-construction
Limits of Acceptable Change	To be based on uni- and multivariate statistical analysis of temporal and spatial community variability and change
Remedial Action	n/a
Notes	

Objective M10: Ensure compliance with percussive piling restrictions to restrict or remove potential impacts on sensitive fish receptors

Target	Percussive piling only to take place when dissolved oxygen levels are above defined threshold value as specified within the DCO
Management	n/a
Monitoring	Automatic monitoring buoy equipped with YSI 6600 multi Sonde
Who	AHPL
When	Continuous monitoring: to include pre-construction monitoring and subsequent monitoring throughout construction phase
Limits of Acceptable Change	Dissolved oxygen to be at, or in excess of, 5 mg/l
Remedial Action	No percussive piling to take place whilst dissolved oxygen is below 5 mg/l
Notes	All details as per DML

Objective M11: Ensure compliance with percussive piling restrictions to restrict or remove potential impacts on sensitive fish receptors

Target	Percussive piling only to take place when water temperature is below the threshold value as specified within the DCO
Management	n/a
Monitoring	Automatic monitoring buoy equipped with YSI 6600 multi Sonde
Who	AHPL
When	Continuous monitoring: to include pre-construction monitoring and subsequent monitoring throughout construction phase
Limits of Acceptable Change	Water temperature to be at, or below, 21.5 °C
Remedial Action	No percussive piling to take place whilst water temperature exceeds 21.5 °C
Notes	All details as per DML

Objective M12: Ensure compliance with percussive piling restrictions to restrict or remove potential impacts on sensitive fish receptors

Target	Piling only to take place at times specified within the DCO
Management	n/a
Monitoring	Deployment of two automatic monitoring buoy equipped with Ic-Listen-LF smart hydrophone (second hydrophone to provide surety of 24 hour recording in case of unforeseen outage of the first hydrophone)
Who	AHPL
When	Continuous monitoring: to include pre-construction monitoring and subsequent monitoring throughout construction phase
Limits of Acceptable Change	No percussive piling shall take place between 7 April and 1 June inclusive in any calendar year. No percussive piling shall take place before 0600hrs or after 2200hrs on any day. Percussive piling shall be restricted at other times as follows: • from 2 June to 22 July inclusive in any year, the maximum amount of percussive piling permitted within any four-week period shall not exceed: o 101 hours where a single piling rig is in operation, or o a total of 168 hours where two or more rigs are in operation; • from 23 July to 10 September inclusive in any year, the maximum amount of percussive piling permitted within any week-long period shall not exceed: o 25 hours where a single piling rig is in operation, or o a total of 42 hours where two or more rigs are in operation; • from 11 September to 31 October inclusive in any year, the maximum amount of percussive piling permitted within any four-week period shall not exceed: o 134 hours where a single piling rig is in operation, or • a total of 224 hours where two or more rigs are in operation. • from 1 November in any year to 6 April in the following year inclusive, the maximum amount of percussive piling permitted within any eight-week period shall not exceed: o 336 hours where a single piling rig is in operation, or o a total of 560 hours where two or more rigs are in operation. o The measurement of time during each work-block shall begin at the start of each timeframe, roll throughout it, then cease at the end, where measurement will begin again at the start of the next timeframe, such process to be repeated until the end of piling works.
Remedial Action	Piling to cease outside of permitted times.
Notes	All details as per DML

TOPIC: MARINE MAMMALS

Objective M13: Ensure compliance with percussive piling restrictions to restrict or remove potential impacts on sensitive marine mammal receptors

Target	To ensure no marine mammal presence in vicinity of percussive piling activity when it commences
Management	Soft start percussive piling as detailed in the DML
Monitoring	Direct observation by Marine Mammal Observer using standard protocols (e.g. JNCC guidance, 2009)
Who	AHPL appointed consultant/contractor
When	Whenever percussive piling is being undertaken
Limits of Acceptable Change	No marine mammal within 100 metres of the pile being driven
Remedial Action	No percussive piling to commence if marine mammals are within 100 metres of the pile being driven
Notes	All details as per DML

TOPIC: WATERBIRDS

Objective M14: Ensure compliance with percussive piling restrictions to restrict or remove potential impacts on sensitive bird receptors

Target	To ensure no percussive piling activity during extended periods of cold weather
Management	n/a
Monitoring	Temperature monitoring at sites to be agreed
Who	AHPL appointed consultant/contractor
When	Whenever percussive piling is being undertaken
Limits of Acceptable Change	Range of temperature-based restrictions set out in DCO
Remedial Action	Cessation of piling when cold-weather thresholds are breached
Notes	No operations consisting of piling shall commence until a cold weather piling restriction strategy is submitted and agreed with the MMO, following consultation with Natural England. A finalised strategy has yet to be produced.

TOPIC: SUBTIDAL – FLOOD RISK ASSESSMENT

Objective M15: To assess longer-term impacts of AMEP within the wider estuary on standard of protection of EA defences

Target	Validation of predicted changes in sedimentation patterns, as defined in Chapter 8 of ES or subsequent revision
Management	n/a
Monitoring	Bathymetric and LiDAR surveys within the area shown in Appendix 2.
Who	AHPL appointed consultant/contractor
When	Once during month prior to commencement of construction works; Annual surveys post-construction to 2033 (Humber Strategy Period)
Limits of Acceptable Change	Sedimentation patterns indicating greater levels of erosion in comparison to those defined in Chapter 8 of ES or subsequent revision
Remedial Action	Monitoring frequency increased to biannual until either: • there are two confirmed surveys indicating erosion - which will trigger a Standard of Protection (SoP) Review to be undertaken for affected locations; or • there is no further evidence of erosion and a pattern of stabilisation can be detected; at which point the monitoring may return to annual frequency
Notes	Understood to be addressed within a separate Flood Risk Management Plan; Further details as per Environment Agency monitoring requirements attached as Appendix 1

TOPIC: SUBTIDAL – FLOOD RISK ASSESSMENT

Objective M16: To assess longer-term impacts of AMEP within the wider estuary on standard of protection of EA defences

Target	Validation of predicted changes in sedimentation patterns, as defined in Chapter 8 of ES or subsequent revision
Management	n/a
Monitoring	Bathymetric and LiDAR surveys within the area shown in Appendix 2.
Who	AHPL appointed consultant/contractor
When	Once during month prior to commencement of construction works; Annual surveys post-construction to 2033 (Humber Strategy Period)
Limits of Acceptable Change	Sedimentation patterns indicating greater levels of erosion in comparison to those defined in Chapter 8 of ES or subsequent revision
Remedial Action	Monitoring frequency increased to biannual until either: • there are two confirmed surveys indicating erosion - which will trigger a Standard of Protection (SoP) Review to be undertaken for affected locations; or • there is no further evidence of erosion and a pattern of stabilisation can be detected; at which point the monitoring may return to annual frequency
Notes	Understood to be addressed within a separate Flood Risk Management Plan; Further details as per Environment Agency monitoring requirements attached as Appendix 1

5. REFERENCES

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6. APPENDICES

Appendix 1: Agreed Monitoring for Able Marine Energy Park (AMEP) Capital Dredging and Disposal Activities

A. Bathymetric Monitoring

Able shall undertake bathymetric surveys (as defined in Section E) at the following locations and for at least 500 metres up and down the estuary, at not greater than 50 metre line spacing:-

1. AMEP berth pocket dredge (bounded by co-ordinates (517488.989E, 419460.856N), (517454.211W, 419439.954N), (517435.893E, 419475.602N), (517531.037E, 419519.186N), (518378.171E, 418490.982N) and (518328.443E, 418441.438N));
2. AMEP approach channel dredge (bounded by co-ordinates (517531.037E, 419519.186N), (517698.908E, 419600.314N), (518741.000E, 418726.000N), (518446.000E, 418462.000N) and (518378.171E, 418490.982N));
3. AMEP turning area dredge (bounded by co-ordinates (518069.000E, 419289.000N), (518475.000E, 419314.000N), (518779.000E, 418761.000N) and (518741.000E, 418726.000N));
4. HU080 Disposal site down estuary (bounded by co-ordinates (53° 36.5520 N, 00° 00.4320 E), (53° 36.3000 N 00° 00.6180 W), (53° 36.4680 N, 00° 02.3220 W), (53°36.9481 N, 00° 03.4680 W) and (53° 36.5520 N, 00° 00.4320)) ;
5. HU082 Disposal down estuary (bounded by co-ordinates (53° 37.5000 N, 00° 02.2698 W), (53° 37.2480 N, 00° 00.7980 W), (53° 36.9702 N, 00° 00.8100 W), (53° 37.1220 N, 00° 02.2920 W) and (53° 37.5000 N, 00° 02.2698 W))

The first surveys shall be undertaken and completed within the month prior to the commencement of any marine construction, dredge or disposal works. Surveys shall thereafter be repeated no less than once a fortnight unless otherwise agreed, during the capital dredge programme (as defined in the dredge and disposal strategy, clause 32 (1) Schedule 8 of the draft Development Consent Order dated 23 November 2012). Upon completion of the capital dredge programme, surveying shall continue at the agreed frequency for one month.

Within 2 weeks of the completion of each survey, Able shall:-

- Supply the results of each report to the EA via email to humber.strategy@environment-agency.gov.uk, unless otherwise advised in writing by the EA.

Able shall notify the EA of the commencement of monitoring and produce a report collating and analysing the monitoring undertaken to date:-

- Every 6 months from the commencement of monitoring; and
- Supply a copy of each report to the EA via email to humber.strategy@environment-agency.gov.uk, unless otherwise advised in writing by the EA.

Note:

- The first surveys shall provide the baseline for determining the impacts of dredge and disposal works, and should allow natural variability to be accounted for in any assessment.
- The subsequent surveys shall provide the information needed to either validate the boundaries of the deposit grounds, or trigger the need for them to be amended. It shall also allow ongoing management of the dredge and disposal.

- Surveys shall be undertaken on similar tidal ranges and state of tide wherever possible. This shall allow volumetric differences to be roughly compared, meaning the approximate portion of sediment retained and dispersed may be deducted.

B. LiDAR Monitoring Upstream and Downstream of AMEP

Able shall undertake LiDAR surveys (as defined in Section E) at the following locations, at not greater than 50 metre line spacing:-

6. Between the top of the flood defence wall and MLWN or -2m ODN (whichever is the greater) upstream of AMEP, from quay wall to CPK (as defined in drawing AME-06114 revC);
7. Between the top of the flood defence wall and MLWN or -2m ODN (whichever is the greater) downstream of AMEP, from quay wall to HIT (as defined in drawing AME-06114 revC);

Able shall survey locations 6 and 7 as defined above and identified with green diagonal lines in drawing AME-06 114 rev C in the month prior to the commencement of any marine construction, dredge or disposal works under the Development Consent and thereafter one month from completion of the quay construction. These surveys shall be repeated at six month intervals unless otherwise agreed, for a period of 10 years in order to record the level of sedimentation taking place upstream and downstream of the quay.

Within 2 weeks of the completion of each survey, Able shall:-

- Supply the results of each report to the EA via email to humber.strategy@environment-agency.gov.uk, unless otherwise advised in writing by the EA.

Able shall produce a report collating and analysing the monitoring undertaken to date:-

- Every 12 months from the commencement of monitoring; and
- Within 6 weeks of each six month survey; and
- Compare the results to the modelling results presented in Chapter 8 of the ES and all technical appendices and subsequent supplementary information submitted with the application; and
- Supply a copy of each report to the EA via email to humber.strategy@environment-agency.gov.uk, unless otherwise advised in writing by the EA.

If sedimentation differs to that predicted in the ES, in location 6 or 7, and such change, if it continues over 2 consecutive surveys, and is likely to impede any existing surface water outfall or increase the risk of overtopping, Able shall increase the frequency of monitoring to every 12 weeks until such time that a pattern of stabilisation can be detected. In that event, the monitoring may return to the 6 monthly frequency identified above.

If sedimentation that is attributable to AMEP interferes with any surface water outfalls within locations 6 and 7, Able shall undertake appropriate remedial action.

If there is any indication of significant erosion of sediment attributable to AMEP (which shall be defined as a level change of more than 500mm from the baseline survey recorded in the month prior to the commencement of marine works) or sedimentation differs in either location 6 or 7 and there is a credible risk of the Flood Defences being overtopped, Able shall:

Increase the frequency of monitoring to every 12 weeks until such time that either:

- there is no further evidence of erosion and a pattern of stabilisation can be detected; at which point the monitoring may return to the 6 monthly frequency identified above; OR
- there are two confirmed surveys indicating erosion in which event Able shall carry out within 14 days of the later survey a Standard of Protection Review, at Able's cost, which shall be completed as soon as reasonably practicable for all flood defences identified in the monitoring results showing a change in sedimentation patterns. The Standard of Protection that is provided by the current defence line against flooding from the sea shall be reviewed at Able's cost using those parameters in use by the EA and which have been notified to Able in writing by the EA. If the results show a reduction in the Standard of Protection, Able shall, at its own cost, undertake improvement works to restore the affected lengths of defence to the Standard of Protection. The Standard of Protection Review shall extend over the entire area of locations 6 and 7 as defined above. Prior to any improvement works being undertaken by Able, the methodology shall be agreed in writing with the EA.

If there is any indication of significant erosion of the estuary bed at the toe of the flood defences attributable to AMEP (which shall be defined as a level change of more than 300mm from the baseline survey recorded in the month prior to the commencement of marine works) in either location (6 or 7) and there is a risk of the Flood Defences being undermined, Able shall, at its own cost:

- Prepare a design for improvement works to protect the toes of the flood defences from scour.
- Obtain EA approval for the scheme.
- Undertake the improvement works to restore the affected lengths of defence.

C. <u>Longer term Monitoring of Impacts of AMEP within the Wider Estuary on Standard of Protection of EA Defences</u>

Able shall undertake the following surveys;-

Bathymetric surveys (as defined in Section E) at not greater than 500 metre line spacing:-

- In the area upstream and adjacent to AMEP as highlighted yellow and defined in drawing AME-06114 revB, across the width of the estuary up to MLWN; and
- In the area upstream and downstream of the disposal grounds as highlighted yellow and defined in drawing AME-06115 revB, across the estuary from MLWN at the north bank to the northern edge of the Sunken Dredged Channel

LiDAR surveys (as defined in Section E in this Schedule) at not greater than 50 metre line spacing:-

- In the areas upstream and opposite to AMEP as highlighted with red lines and defined in drawing AME-06114 revB, between the top of the flood defence wall and MLWN or -2m ODN (whichever is the greater) at both the north and south river banks; and
- In the area upstream and downstream of the disposal grounds as highlighted with red lines and defined in drawing AME-06115 revB, , between the top of the flood defence wall and MLWN or -2m ODN (whichever is the greater) at the north river bank

These surveys shall be undertaken on a 12 monthly basis for 10 years, commencing one month after completion of the marine and capital dredging works under the Development Consent. At the end of

the 10 year period the EA shall review the results; which may include a Standard of Protection review (as defined in Section B in this Schedule) at Able's cost if there is a significant change in the surveyed levels (which shall be defined as a level change of more than 500mm from the baseline survey recorded) which demonstrates that erosion is occurring that will impact upon the flood defences and such erosion is attributable to AMEP. If the EA shall so request, Able shall carry out monitoring for a further 10 years if the EA considers this to be reasonably necessary and justifiable following the SoP review.

Within 2 weeks of the completion of each survey, Able shall:-

- Supply the results of each report to the EA via email to humber.strategy@environment-agency.gov.uk, unless otherwise advised in writing by the EA.

Able shall produce a report collating and analysing the monitoring undertaken so far:-

- Every 12 months from the commencement of monitoring; and
- Within 6 weeks of the each annual survey; and
- Compare the results to the modelling results presented in Chapter 8 of the ES and all technical appendices and supplementary information submitted with the application; and
- Supply a copy of each report to the EA via email to humber.strategy@environment-agency.gov.uk, unless otherwise advised in writing by the EA.

If sedimentation differs to that predicted in the ES, and such sedimentation, if it continues, is likely to impede any existing surface water outfall, Able shall increase the frequency of monitoring to every 12 weeks until such time that there is no further evidence of sedimentation or a pattern of stabilisation can be detected. In that event, the monitoring may return to the 6 monthly frequency identified above.

If sedimentation that is attributable to AMEP interferes with any surface water outfalls within locations 6 and 7 or within the areas marked pink on drawings AME – 06114 revC and AME – 06115 revB, Able shall reinstate the effective discharge of water into the estuary

If there is any indication of significant erosion of the estuary bed at the toe of the flood defences attributable to AMEP (which shall be defined as a level change of more than 300mm from the baseline survey recorded in the month prior to the commencement of marine works) in either location (6 or 7, or the areas marked pink on drawings AME -06114 revC or AME – 06115 revB) and there is a risk of the Flood Defences being undermined or the erosion protection in front of the flood defences being impacted, Able shall, at its own cost:

- Prepare a design for improvement works to protect the toes of the flood defences from scour.
- Obtain EA approval for the scheme.
- Undertake the improvement works to restore the affected lengths of defence.

D. Benthic Invertebrates

Prior to the commencement of any marine disposal activities, a scheme for the protection and enhancement of benthic invertebrates through the monitoring and management of disposal activities within, and immediately surrounding, the disposal sites of the Lower Humber water body ('the BI Scheme'), shall be submitted to and agreed in writing with the EA. The BI Scheme shall include the following:-

i. A timetable for when monitoring shall be undertaken, including monitoring before, during and after marine disposal activities are undertaken;
ii. A detailed methodology for the monitoring;
iii. An evaluation of the contribution the marine disposal activities make to the overall ecological potential of the Humber Lower water body as assessed by the biological elements, supporting elements, supporting conditions and ecological potential assessment as set out in Annex B of the Humber River Basin Management Plan;

If the evaluation of i)-iii) shows that marine disposal activities contribute to, or are likely to contribute to, a failure of the water body in achieving its Water Framework Directive objectives, ABLE shall submit a Remedial Action Plan to the EA that details measures to ensure marine disposal activities are amended such that, as far as is reasonably practicable, they do not contribute towards a deterioration of the Humber Lower water body status (including deterioration within existing status class), should such arise. The Remedial Action Plan may include variations to marine disposal activities to reduce their impact and/or specific measures to protect and enhance benthic invertebrates.

Within 2 weeks of the completion of each piece of monitoring, Able shall:-

- Supply the results of each report to the EA via email to humber.strategy@environment-agency.gov.uk, unless otherwise advised in writing by the EA.

Able shall notify the EA of the commencement of monitoring and shall produce a report collating and analysing the monitoring undertaken to date:-

- Every 6 months from the commencement of monitoring; and
- Within 6 weeks of each annual survey; and
- Supply a copy of each report to the EA via email to humber.strategy@environment-agency.gov.uk, unless otherwise advised in writing by the EA.

Should a Remedial Action Plan be deemed necessary as a result of the BI Scheme, Able shall:-

- As soon as reasonably practicable, submit a Remedial Action Plan to the EA for approval,
- As soon as reasonably practicable following the approval of the Remedial Action Plan, implement any actions agreed in it together with any other remedial actions which the EA shall reasonably require

Definitions

MHWS- Mean High Water Springs

MHWN- Mean High Water Neaps

MLWS- Mean Low Water Springs

MLWN – Mean Low Water Neaps

Bathymetric Survey

All survey work shall be undertaken in accordance with the EA survey specification v3.1, relating directly to Section VII (Hydrographic Surveys of River channels and other Water Areas using Swathe Bathymetry), or shall be provided in accordance with an agreed alternative method.

A multibeam echo sounder should be used. The system measures water depths across a wide swathe perpendicular to the vessel track, thus giving greater coverage of bed features along the line than traditional single beam. The additional horizontal coverage shall vary depending upon the water depths, but should approximate between 3 to 8 times the water depth, and produce wide channels of data capture, and ultimately complete coverage of the river channel.

The results need to include the methodology used to collect the data; the equipment deployed, including but not limited to Echo Sounder, Motion Sensor, Sound Velocimeter; position fixing equipment and processing. The software used to collect and process the data and the software used to produce charts and digital x,y,z outputs.

All surveys are to be referenced to UK National Grid, and any vertical datum shall be referenced to Ordnance Datum Newlyn.

The following data shall be supplied.

i) ASCII raster format *.asc 1m gridded data set supplied per OS Grid Square

ii) XYZ data *.txt 1m gridded data set per study reach

iii) Survey report.

Following the initial baseline survey, all subsequent data shall be compared to the baseline for the identification of river bed and bank movement.

LiDAR Survey

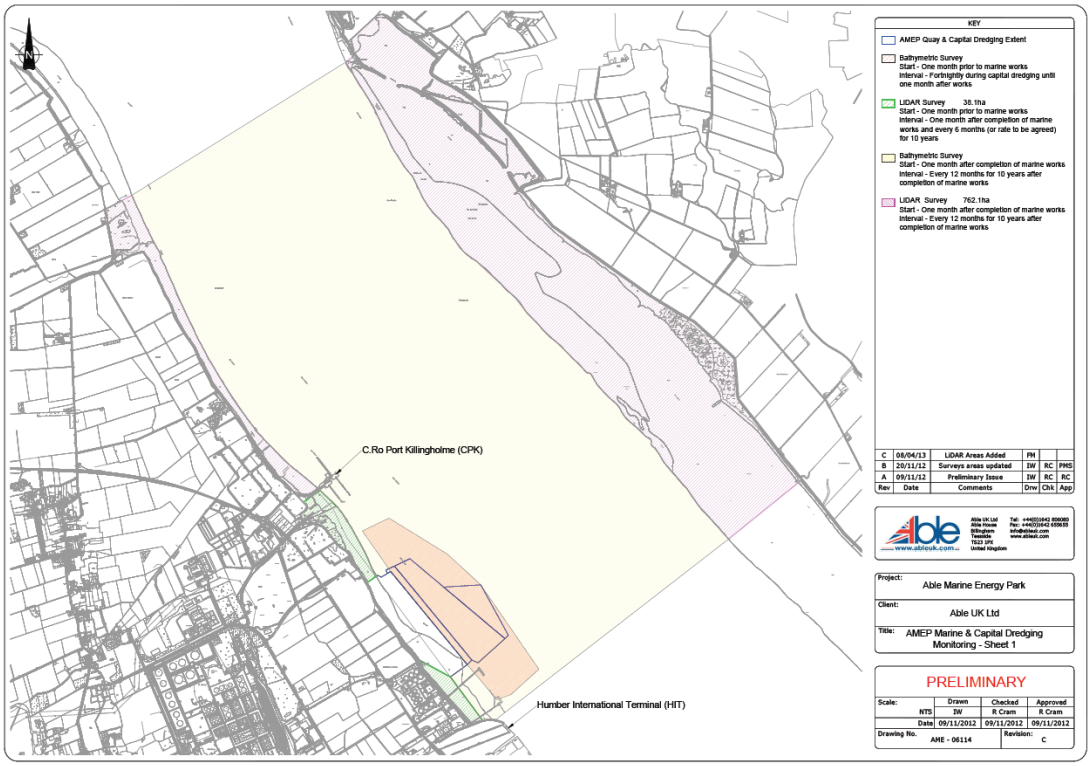
A LIDAR Digital Surface Model (DSM) and Digital Terrain Model (DTM) in ArcView ASCII Grid file in 0.25m x 0.25m and 0.5m x 0.5m file sizes for each polygon defined. Also supplied shall be last return XYZI point cloud data in LAS format and DSM XYZ ASCII TXT.
Data shall be collected during tidal windows in the order of 1 hour either side of Low Water, or suitable agreed time period.

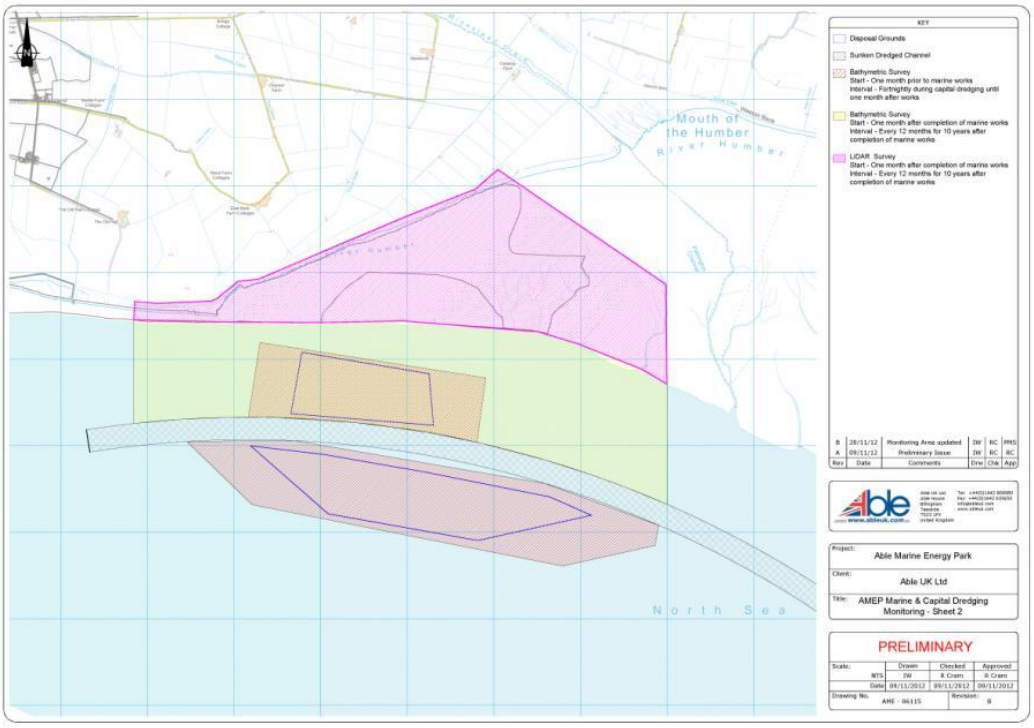
The error specification for LIDAR surveys shall be an RMSE of +/- 15cm.
Ground truth surveys for the checking of LIDAR height accuracy shall be carried out within each polygon.

A full quality control report shall be supplied to the EA on completion of each survey. This shall include at least the following:

- A plot of all data indicating polygon coverage and aircraft navigation lines.
- A copy of the flight log for all polygons.
- Data processing procedures.
- A report on the comparison of these data with available ground truth data.

Appendix 2: LiDAR and Bathymetric Survey Locations





Appendix 3: Saltmarsh, Benthic Invertebrate and Fish Sampling Methods

1. Baseline and ongoing impact audit survey methods for the saltmarsh component of NKM, inc. WFD compliance

Saltmarsh extent, community, zonation and diversity will be ascertained following EA WFD guidance e.g. OI 200_07 or any subsequent relevant revisions.

In advance of each annual survey the most recent available aerial images will be requested from the EA (although it is noted that not every year will be updated by the EA), this information providing additional data and informing the survey process. Where the data are current (e.g. the year of image is current to the year of survey, then depending on coverage, it may be unnecessary to undertake an additional survey flight.

When such images are unavailable, then a survey flight will be undertaken, with aerial colour images captured. These images will be:

- of resolution of at least 25cm
- 3 band red green blue (RGB) imagery
- taken in daylight at low water around a spring tide
- taken under stable lighting conditions (little or no cloud shadow)
- taken between June and September each year, with timing to be standardised to a single month per year where possible
- taken on an annual basis for a minimum of 10 years, the requirements for subsequent surveys to be determined by the Steering Group

In addition to the annual aerial image survey, field survey of the saltmarsh habitat will be undertaken on an annual basis, again following guidelines in the EA's OI 200_07

This will include a series of transects of sufficient frequency to adequately describe the communities, their zonation and extent (see OI 200_07 for details). Each transect will cover both the seaward and landward extent of the saltmarsh. Transition points will be mapped and two quadrat samples taken to characterise the major community changes, recording species, cover, sward height etc following OI 200_07 procedures. Analysis will include zonal area and diversity as well as NVC community, with the field survey data collated with the aerial imagery.

The saltmarsh will then be therefore assessed for the following metrics in accordance with the WFD Saltmarsh Index Tool:

- saltmarsh extent as proportion of "historic saltmarsh"
- saltmarsh extent as proportion of the intertidal
- change in saltmarsh extent over two or more time periods
- proportion of saltmarsh zones present (out of five)
- proportion of saltmarsh area covered by the dominant saltmarsh zone
- proportion of observed taxa to historical reference value **or** proportion of observed taxa to 15 taxa

2. Baseline and ongoing impact audit survey methods for the intertidal benthos component of NKM, inc. WFD compliance

Survey rationale: the survey is designed primarily to allow detection of possible impacts on intertidal benthic infauna by comparison of impact monitoring with baseline data. The characterisation of the baseline (pre-construction) benthic community in the intertidal area will allow also possible wider comparison with data collected during a previous characterisation survey (May 2010) in order to highlight natural temporal variability in benthic assemblages in the area.

The survey design and methods have been devised based on existing guidelines (Guidelines for the Conduct of Benthic Studies at Marine Aggregate Extraction Sites - Ware and Kenny 2011; the Marine Monitoring Handbook, Davies et al 2001). Also the operational instructions for sampling and sample processing for macrobenthic invertebrates in TraC waters have been taken into account in order to collect data that can be used for WFD assessment purposes.

Sampling method: hand held corer (0.01 m^2), sediment sampled to a depth of c.15 cm.

Sampling period: monitoring to be carried out annually, in Spring (possibly May, to allow better comparison with previous data; in any case, between February and June), during pre-construction (1 or 2 years, depending on when the construction works will start), construction (where sampling sites can be still accessible in safe conditions) and for 10 years post-construction.

Sampling design: A beyond BACI (Before-After Control-Impact) gradient design is suggested. The BACI gradient design will take into account the existence of different zones of impact (namely, primary (or direct) impact, under the direct footprint of the quay development, and secondary (or indirect) impact) as well as control (i.e., no impact) zone.

Also, a stratification of the design by shore level (upper, middle and lower shore strata) is suggested to account for the variability of communities that occur at different shore levels (hence the variability of possible impacts, due, e.g., to different sensitivity of species), hence reducing the degree of unexplained variance (with consequent increase in the power of the analysis).

If possible, multiple control areas should be chosen to represent the mudflat benthic assemblages in natural conditions. The criteria below should be followed in the choice of control areas:

- Mudflats outside the influence of impacts from the proposed development or other anthropogenic activities, in order to reflect natural conditions;
- Mudflats located in the vicinity of the impact area (e.g., along the southern bank of the estuary and within 2 km from the development area), in order to limit the natural variability of mudflat assemblages and to increase the probability that the communities surveyed under “control” conditions are similar to those naturally present in the impact area (before construction).

It is of note that, under these conditions and based on the information available to date, only one control area could be identified *a priori* for intertidal mudflats. In fact, suitable natural mudflats are too far from NKM (hence more likely to show naturally different environmental

conditions and communities) or those within the 2 km range are likely to be under the influence of other anthropogenic activities (hence unlikely to represent natural conditions).

However, considering the benefit of including multiple control sites to allow assessment of impacts at NKM, it is noted that two control areas for mudflat communities will be surveyed during the pre-construction baseline monitoring at CCS (see section 3 of this Appendix). The information available to date does not allow the determination as to whether these control sites would be suitable controls for the mudflats at NKM. It is proposed that, if the data obtained during the pre-construction baseline at CCS confirms the suitability of these control areas for the mudflat at NKM (i.e. similar communities present), then these will be included in the impact assessment design for intertidal mudflat at NKM.

The proposed survey design is summarised in the table below. It should be noted that additional control areas (not included in the table and figure below) might be included in the survey design, provided their availability and suitability as controls, as mentioned above.

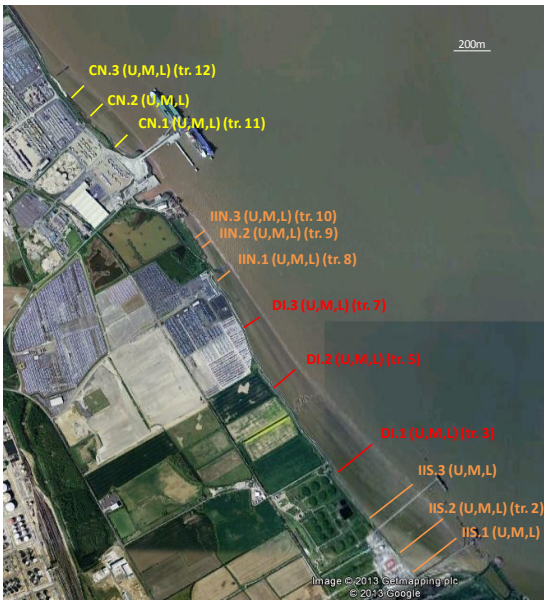
				Number of replicate benthic		
Survey areas		**area code**	**Transect**	**Upper**	**Mid**	**Lower**
Impact	Under direct footprint of quay development	**DI**	DI.1	3	3	3
			DI.2	3	3	3
			DI.3	3	3	3
	Under the area of indirect impact north of the quay development	**IIN**	IIN.1	3	3	3
			IIN.2	3	3	3
			IIN.3	3	3	3
	Under the area of indirect impact south of the quay development	**IIS**	IIS.1	3	3	3
			IIS.2	3	3	3
			IIS.3	3	3	3
Control	Control area north of NKM	**CN**	CN.1	3	3	3
			CN.2	3	3	3
			CN.3	3	3	3
			12 transects			
			3 locations x transect = 36 locations			
			3 repl x location = 108 samples = n			

It is of note that the area under the direct footprint of the quay development (DI) would be lost, hence would not be included in the post-construction monitoring and in the BACI-type design. Nevertheless, a baseline characterisation of its assemblages is considered relevant (i) to confirm previous observations (2010) and the temporal (inter-annual) natural variability of invertebrate communities in this area; (ii) to identify (statistically) similarities with communities nearby (in remaining impact areas and control areas); (iii) to assess seasonal variability of communities in the area by comparison with data from autumn survey (for transects overlapping with "bird food" survey design).

Sampling stations (i.e., locations at different transects and shore levels) are to be intended as boxes (10 x 10m) with 3 replicate samples collected randomly within each box. Multiple locations are selected for each stratum, as defined by the treatment (controls/impacts) and the shore position. In addition to replication of locations within each stratum, also replication within each location (triplicate samples) is proposed in order to reduce the residual variance of the data and increase the power of the analysis. Randomization will be applied to the selection of replicates (core samples) at each location, thus limiting the pseudo-replication. Re-sampling of the same locations is suggested as it increases the power compared to the

collection of the same number of samples reallocating sites every year (Green, 1989[1]). It is of note that modifications in the shore profile over the years might lead to changes in the shore level of a certain location. Re-sampling the same location each year would allow to assess changes in the benthic community also due to this factor. In addition to the 3 replicate samples collected at each station for benthic invertebrate analysis, a fourth sample will be collected at each station to characterise sediment (PSA and organic matter).

The characterisation survey carried out in May 2010 should be used to inform suitable sample locations, within the constraints of the sampling design proposed here. An example of the possible position of sampling stations is shown in the following map, where impact and control areas are identified by different colours and the possible overlapping with transects surveyed in 2010 (e.g., tr. 2, tr. 3) is indicated (possible additional control areas that might be identified at CCS are shown in Section 3 of the present Annex).



Sample locations along transects will be recorded using DGPS to allow for greater station fidelity between years.

In fact, it is suggested that post-construction monitoring will use a “resampling of sites” approach, rather than a “reallocation of sites” approach, as it will allow a higher power of the analysis (Green 1989). However, it is acknowledged that possible small-scale morphological modifications might occur in the site in response to unanticipated anthropogenic or natural influences and this might lead to changes in the representativeness of the station of a particular stratum (e.g., a station located at mid shore one year could be located at low shore another year due to changes in the foreshore profile). In these cases, some allowance will be made for small-scale changes in the station location in order to maintain its representativeness of the shore level stratum.

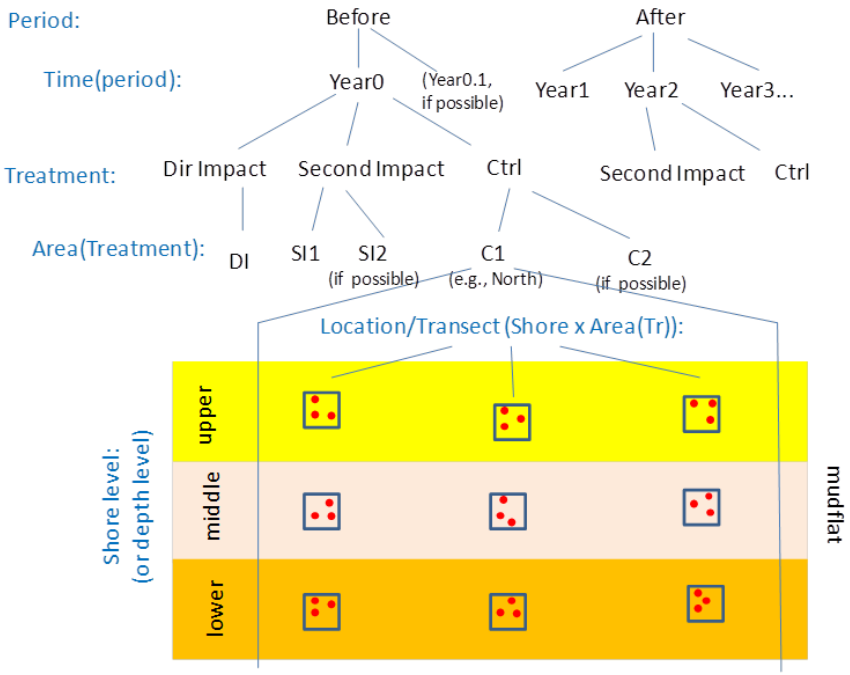
[1] Green RH, 1989. Power analysis and practical strategies for environmental monitoring. Environmental Research 50, 195-205.

Sample processing: Samples from different replicates should be kept separate. Benthic samples are to be sieved through a 0.5mm sieve. Laboratory analysis will include species (identified to highest taxonomic detail), abundance and biomass.

Supporting parameters: Sediment particle size analysis and organic content will also be measured in the additional sediment sample. Additional supporting parameters recorded on site will include the recording of the character and composition of surface sediments (type, colour, smell), depth of RPD layer, texture and presence of surface features. A photographic record of the sampling station and of the sediment will be also collected.

Data analysis: Analysis of variance will be applied at univariate and multivariate level (Permanova routine can be used in both cases, using a pseudo-F statistic and permutations, thus avoiding assumptions of the parametric F-statistics) to assess the significance of possible impacts. The analysis will be carried out on univariate descriptors of the community (e.g., benthic abundance, biomass, species richness, diversity) as well as on the multivariate structure of the assemblages.

A schematisation of the analysis design, with indication of all the factors involved, is provided below:



The main aim of the analysis is to test for interactions between periods (before and afters) and treatment (controls and impacts) in order to assess whether temporal changes in the impacted areas are in line with changes at control areas (if not, i.e. an interaction exists, then an impact is assumed). Contrast between levels of the factors (e.g. secondary impact sites and control sites). The interaction of these factors with shore location/depth level will be taken into account to highlight possible impacts that might manifest only at certain shore/depth levels.

It is of note that the primary impact intertidal area will be sampled only before the construction as it will be lost under the quay footprint – therefore in this case the statistical analysis over time (before/after) will involve the testing changes only at control and secondary impact areas.

In addition, modifications in the shore profile over the years might lead to changes in the shore level of a certain location, hence leading to the need of re-allocating the location to the proper a different stratum if a relevant change in the beach morphology has occurred, in order to correctly account for the shore level stratification in the analysis.

3. Baseline and ongoing impact audit survey methods for the intertidal benthic component of CCS area around the compensation site

Survey rationale: the general survey rationale is similar to that one for the baseline survey and ongoing impact audit at NKM, with the impact in this case being ascribed to the opening of the breach at the RTE/CCSWG site.

Sampling method: hand held corer (0.01 m^2), sediment sampled to a depth of c.15 cm.

Sampling period: monitoring to be carried out annually, in Spring (possibly May, to allow better comparison with previous data; in any case, between February and June) during pre-construction (1 or 2 years, depending on when the construction works will start), construction (where sampling sites can be still accessible in safe conditions) and for 10 years post-construction.

Sampling design: Similarly to the intertidal survey at NKM, a beyond BACI design is suggested, with stratification by shore level (the same considerations on control areas, locations and replication as from the intertidal survey at NKM apply here). In this case the impact zone has been identified in correspondence of the breaching area whereas two control areas have been identified South and North of the impact zone. It is of note that a third control site might be available at NKM, if deemed suitable for inclusion of the impact assessment at CCS (i.e., data collected during the pre-construction baseline surveys at both NKM and CCS confirm the similarity of communities). The proposed survey design is summarised in the table below.

				Number of replicate benthic cores by shore level stations		
Survey areas	**Area location**	**area code**	**Transect**	**Upper**	**Mid**	**Lower**
Impact	Under direct footprint	**I**	I.1	3	3	3
			I.2	3	3	3
			I.3	3	3	3
Control	North	**CN**	CN.1	3	3	3
			CN.2	3	3	3
			CN.3	3	3	3
	South	**CS**	CS.1	3	3	3
			CS.2	3	3	3
			CS.3	3	3	3

9 transects
3 locations x transect = 27 locations
3 repl x locations = 81 samples

In addition to the 3 replicate samples collected at each station for benthic invertebrate analysis, a fourth sample will be collected at each station to characterise sediment (PSA and organic matter).

An example of the possible position of the sampling stations is shown in the following map (impact and control areas are indicated; names of transects are as per table above).

Considerations on re-sampling of same locations as per description provided for the intertidal design at NKM apply here.

Sample processing / supporting parameters / data analysis: as for intertidal survey at NKM.

4. Baseline and ongoing impact audit survey methods for the subtidal benthos of NKM, inc. WFD compliance

Survey rationale: the rationale of the survey is similar to that of the baseline intertidal survey at NKM, aiming at allowing detection of possible impacts on subtidal benthic infauna following dredging activities at the quay development area. Also the operational instructions for sampling and sample processing for macrobenthic invertebrates in TraC waters have been taken into account to allow for WFD compliance.

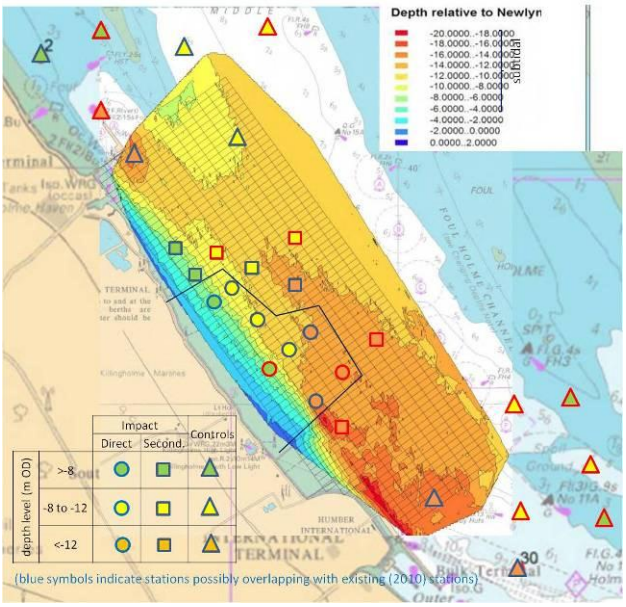
Sampling method: 0.1 m2 Day grab; although this method is suited to survey estuarine sediments (WFD compliant method), it is of note that it would not as efficient where sediments are coarser/more compact. With limitation to only these cases, it is suggested the use of a 0.1m2 Hamon grab. Sample acceptance criteria will be used as defined in WFD operational instructions (i.e., sediment depth in the grab >7cm for mud, >5cm for coarser sediments).

Sampling period: monitoring to be carried out annually, in Spring (possibly May, to allow better comparison with previous data; in any case, between February and June) during pre-construction (1 or 2 years, depending on when the construction works will start), construction (where sampling sites can be still accessible in safe conditions) and for 10 years post-construction.

Sampling design: Similarly to the intertidal benthic survey at NKM (described in previous sections), a beyond BACI gradient design is suggested. The BACI-type gradient design will take into account the existence of different zones of impact (namely, primary (or direct) impact, within the combined area of the proposed berthing pocket, approach channel and

turning circle, and secondary (or indirect) impact) as well as control (i.e., no impact) zone. In this case, a stratification of the design by depth level is suggested to account for the variability of communities with habitat, as described by depth, hence reducing the degree of unexplained variance (with consequent increase in the power of the analysis).

The location of proposed stations has been selected also trying to matching (as much as possible) the location of existing stations (2010 survey) to allow a temporal comparison. The resulting proposed design is summarised in the map (with indicative station's location) and table below.



Number of grab locations:

depth level (m OD)	Impact		Control		Total
	Primary	Second.	North	South	
>-8	2	2	2	2	8
-8 to -12	3	3	3	3	12
<-12	3	3	2	2	10
Total	8	8	7	7	30

4 areas (2 impacts + 2 ctrls)
3 depth levels per area = 12 levels
2-3 locations per level = 30 locations
3 repl per location = 90 samples

In each station, 3 replicate grab samples will be collected for benthic invertebrate analysis to allow statistical comparison within the BACI-type design. A small subsample of the retrieved sediments sub-sample will be obtained from the faunal samples for PSA and organic content analysis, as recommended by Cefas.

Sample processing: Samples from different replicates should be kept separate. Benthic samples are to be sieved through a 0.5mm sieve. Laboratory analysis will include species (identified to highest taxonomic detail), abundance and biomass.

Supporting parameters: Sediment particle size analysis and organic content will also be measured in the additional sediment sample. Additional supporting parameters recorded on site will include the recording of the character and composition of surface sediments (type, colour, smell), depth of RPD layer, texture and presence of surface features. A photographic record of the sampling station and of the sediment will be also collected.

Data analysis: Analysis of variance will be applied at univariate and multivariate level (Permanova routine can be used in both cases, using a pseudo-F statistic and permutations, thus avoiding assumptions of the parametric F-statistics) to assess the significance of possible impacts. The analysis will be carried out on univariate descriptors of the community (e.g., benthic abundance, biomass, species richness, diversity) as well as on the multivariate structure of the assemblages.

The main aim of the analysis is to test for interactions between periods (before and afters) and treatment (controls and impacts) in order to assess whether temporal changes in the

impacted areas are in line with changes at control areas (if not, i.e. an interaction exists, then an impact is assumed). Contrast between levels of the factors (e.g., secondary impact sites and control sites). The interaction of these factors with depth level will be taken into account to highlight possible impacts that might manifest only at certain depth levels.

5. Baseline and ongoing impact audit survey methods for the fish component of NKM, inc. WFD compliance

Survey rationale: the survey is designed primarily to allow detection of possible impacts on fish fauna by comparison of impact monitoring with baseline data. The characterisation of the baseline (pre-construction) fish community will allow also possible wider comparison with data collected during a previous characterisation survey (2010) in order to highlight natural temporal variability in fish assemblages in the area. The survey design and methods have been amended following the operational instructions on data requirements for WFD transitional fish surveillance monitoring in order to collect data that can be used for WFD assessment purposes.

Sampling method: A combination of gear types and replicated sampling locations are included in the design and follows the methods developed by the EA for the WFD TraC fish monitoring. Seine net and 1.5m beam trawl will be used in the intertidal area, and otter trawl in the subtidal area. The seine net will be deployed at low slack tide, whereas the beam trawl will be towed for 200m at high slack tide to allow boat access to the intertidal area. The otter trawl will be deployed in the subtidal area, with tows of 30 min. carried out against the rising tide.

Sampling period: Spring (May/June) and Autumn (September/October) in the intertidal area; Autumn only in the subtidal area.

Sampling design: Survey design is based on a beyond BACI (Before-After Control-Impact) approach, while also considering the characterisation survey carried out in 2010 to inform suitable sample locations.

A stratified design is devised, with strata defined based on intertidal/subtidal area and impact areas (impact zone around the development and control areas). The impact area is located in the intertidal and subtidal zone between the Humber Sea Terminal (North) and the Humber International Terminal (South).

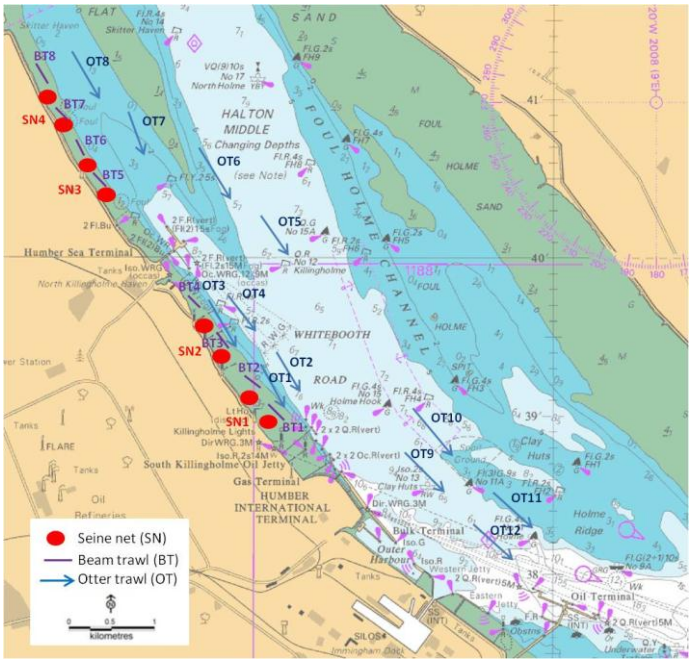
If possible, at least two control areas should be chosen to represent the fish assemblages in natural conditions. The criteria below should be followed in the choice of control areas:

- Intertidal and subtidal areas outside the influence of impacts from the proposed development or other anthropogenic activities, in order to reflect natural conditions;
- Intertidal and subtidal areas possibly along the southern bank of the estuary and within 2 km from the development area, in order to limit the natural variability of fish assemblages and to increase the probability that the communities surveyed under “control” conditions are similar to those naturally present in the impact area (before construction).

As highlighted for the intertidal benthic survey at NKM, due to local constraints, only one control area (north of the development site) can be identified in the intertidal mudflats around the development site.

At each area, two sites will be surveyed with seine net (with two hauls undertaken per site) and 4 sites with beam trawl in the intertidal area, and 4 sites with otter trawl in the subtidal area.

The location of proposed stations should be selected also trying to matching (where possible) the location of existing stations (2010 survey) to allow a temporal comparison, although a certain variability is allowed, considering also the mobility of fish fauna. An example of the possible position of sampling stations is shown in the following map (site labels are also shown) and the proposed survey design is summarised in the table below, showing the number of hauls per sampling area and method. A control area south of the development site could not be identified in the intertidal area given the criteria described above, therefore subtidal stations are only shown for that area.



Number of hauls:

		Impact area				
method	**zone**	**Impact**	**Control**	**Control S**	**Season**	**Total/year**
Seine net	intertidal	4	4		Spring and Autumn	16
Beam trawl	intertidal	4	4		Spring and Autumn	16
Otter trawl	subtidal	4	4	4	Autumn only	12
	Total	12	12	4		44

It should be noted that the haul locations in the map are only indicative as their final position will be adjusted on site also based on health and safety issues. In addition, overlapping with WFD sampling stations in the Lower Humber water body will be allowed wherever possible. With the purpose of allowing assessment of any change to the ecological status of the water body, it is suggested that 3 additional subtidal stations are included in the design, covering WFD biology sampling stations in the water body.

The proportion of samples obtained with the different methods in the impact and control areas has been devised also based on the WFD guidelines. Sample locations will be recorded using DGPS to allow for greater station fidelity between years.

Sample processing: Field notes, haul information and species identification, abundance, size and weight records will be noted on site. Following EA Transitional Waters Guidelines,

for each sample, up to 50 individuals of each fish species will be measured (total length, nearest mm), with the remainder identified and counted. However, fishes that are not identifiable in the field (e.g., 0+ fishes) will be preserved in 60% Ethanol for identification in the laboratory using appropriate keys.

Supporting parameters: Discrete water-quality measurements (water temperature, dissolved oxygen, and salinity) will be taken at each sampling event. Also qualitative appraisals of substratum composition, vegetation and other proximate structures, and a location (DGPS coordinates) of each sample will be taken.

Data analysis: Analysis of variance will be applied at univariate and multivariate level (Permanova routine can be used in both cases, using a pseudo-F statistic and permutations, thus avoiding assumptions of the parametric F-statistics) to assess the significance of possible impacts. The analysis will be carried out on univariate descriptors of the community (e.g., fish abundance, species richness, diversity, fish size) as well as on the multivariate structure of the assemblages.

The main aim of the analysis is to test for interactions between periods (before and afters) and treatment (controls and impacts) in order to assess whether temporal changes in the impacted areas are in line with changes at control areas (if not, i.e. an interaction exists, then an impact is assumed). Contrast between levels of the factors (e.g., impact sites and control sites). Due to the difference sampling gear (with different selectivity) used in the intertidal and subtidal zones, the data collected in the two zones will be analysed separately and the patterns in the results will be compared.

6. 'Bird food' benthic target survey of NKM

Survey rationale: this survey has a completely different rational compared to the previously described surveys. The primary aim of this survey, in fact is not to allow the impact assessment of the development, but it is to quantify the benthic invertebrate food availability at the main bird feeding areas (particularly for Black-tailed Godwit) within the development area at NKM in order to set a benthic target for the compensation area.

The survey has been designed with three main objectives:

Obj. 1- To allow identification of an average benthic target for the compensation site reflecting the overall bird food availability at the mudflat area that will be lost or possibly affected by indirect impacts following the quay development at NKM.

Obj. 2- To better characterise higher value feeding grounds for Black-tailed Godwit (i.e. supporting higher numbers of feeding birds, according to the bird monitoring survey) present in sectors C and D at NKM, hence allowing the weighting of benthic targets based on hot spot feeding areas.

Obj. 3- To take into account natural inter-annual variability in food resources, in order to allow temporal adjustment of the target.

Sampling method: hand held corer (0.01 m^2), with sediment sampled to a depth of c.15 cm. Four replicate samples are collected at each station, 3 for benthic invertebrate analysis and 1 to characterise sediment (PSA and organic matter).

Sampling period: monitoring to be carried out annually, in late summer-early autumn (possibly between the last week of August and first week of September, just before the October peak use of the site by Black-tailed Godwit for feeding) during pre-construction (1 or 2 years, depending on when the construction works will start), construction (in control sites) and for 10 years post-construction (in control sites).

Sampling design: A stratified systematic design is suggested in order to take account of different shore elevation (upper, mid and low shore strata). Systematic design is devised as the best way to estimate population size of clustered (patchy) populations, allowing also to obtain data better suited for spatial analysis (Ware and Kenny 2011[2], Mier and Picquelle 2008[3] and references therein). In order to capture the patchiness of the benthic distribution in intertidal mudflats at NKM (target setting survey), the survey design aims at optimising the spatial resolution of the sampling, whereas replication at a single location is considered less important in this instance (*sensu* Ware and Kenny 2011). The survey has been designed considering the three objectives highlighted above:

Obj. 1 – Stations are located on a regular grid on the mudflat area under the direct footprint of the developments and in adjacent areas possibly affected by it (sectors A to E). Nine transects are regularly spaced over the area (ca. 250m apart), and 9 stations are sampled at each transect (covering the high, mid and low shore levels) (tot. 81 stations). This design allows partial overlapping of stations with the baseline (spring) intertidal survey at NKM, thus allowing also the identification of seasonal variability in benthic assemblages. The availability of baseline spring and autumn data could be used to obtain not only standing stock data (B) but also a rough estimate of benthic secondary production (P) and productivity (P/B ratio) for target species (albeit it would be referred only to season between the two surveys), which characterise the functioning (dynamic) of the feeding area. However, in order to allow a better understanding of baseline seasonal variability, additional transects might need to be added to the whole design to grant complete overlapping with existing transects from the spring baseline. In addition, post-construction monitoring of the remaining stations that will not be lost under the footprint of the quay development would allow to identify changes in the benthic food availability in secondary feeding grounds and to relate them to any change in bird usage that might be observed during post-construction monitoring, thus supporting also the validation of predictions in the ES with regards to changes in sediment/benthos etc.

Obj. 2 – Four additional transects will be surveyed in sectors C and D, with stations distributed across three shore levels, as described above (tot. 36 stations). This would lead to a finer-meshed sampling grid in this area (with transects 125m apart, and a total of 117 stations surveyed over the whole NKM mudflat) for a more detailed characterisation of the spatial distribution and variability of benthic prey in this main feeding ground.

Obj. 3 – three transects regularly spaced (ca. 150m apart) will be surveyed in the control area located on the foreshore north of North Killingholme Haven Pits, with stations distributed across three shore levels, as described above (tot. 27 stations). This is also an area where Black-tailed Godwit have been seen feeding (Nick Cutts, pers. obs.) and the

[2] Ware and Kenny 2011. Guidelines for the Conduct of Benthic Studies at Marine Aggregate Extraction Sites.

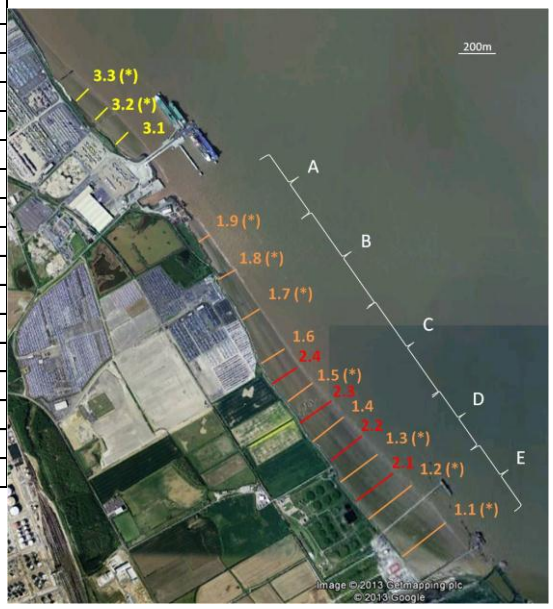
[3] Mier KL and Picquelle SJ, 2008. Estimating abundance of spatially aggregated populations: comparing adaptive sampling with other survey designs. Can. J. Fish. Aquat. Sci. 65, 176-197.

assessment of bird food availability in this feeding area during the 2013 survey and the monitoring of this area over the years (post-construction) would allow to identify natural background inter-annual fluctuations in benthic populations hence could be used to derive a correction factor for the target values to take into account this source of temporal variability. Similarly, control areas that would allow for the assessment of the temporal variability of mudflat benthic communities in the middle estuary are identified at CCS, these stations being included as reference stations in the monitoring of the compensation site (see Compensation EMMP).

The proposed survey design is summarised in the table below and the indicative position of the sampling transects is shown in the map (asterisk indicates possible overlap with spring baseline survey; white letters indicate the bird sectors). Control stations at CCS are not shown here, but their indicative location would be along the control transects identified in the intertidal impact assessment monitoring at CCS (with autumn monitoring, in this case).

	Number of stations by shore level stations				
Transect	**Upper**	**Mid**	**Lower**	**Survey Objective**	**2010 monitoring zone**
1.1	3	3	3	1	**E**
1.2	3	3	3	1 and 2	**D**
1.3	3	3	3	1 and 2	**D**
1.4	3	3	3	1 and 2	**C**
1.5	3	3	3	1 and 2	**C**
1.6	3	3	3	1	**B**
1.7	3	3	3	1	**B**
1.8	3	3	3	1	**B**
1.9	3	3	3	1	**A**
2.1	3	3	3	2	**D**
2.2	3	3	3	2	**C**
2.3	3	3	3	2	**C**
2.4	3	3	3	2	**C**
3.1	3	3	3	3	**na**
3.2	3	3	3	3	**na**
3.3	3	3	3	3	**na**

16 transects
3 strata (shore level) per transect = 48 sections
3 stations per section = 144 stations
1 sample per station = 144 samples



One sediment sample will be taken at each station for faunal analysis and an additional sample will be collected for PSA and organic matter analysis. Sample locations along transects will be recorded using DGPS.

Sample processing: Samples from different replicates should be kept separate. Benthic samples are to be sieved through a 0.5mm sieve. Laboratory analyses will include species (identified to highest taxonomic detail), abundance, size class and biomass (WWTB), with standard AFDW conversion factors applied (using, for example, Rumohr et al., 1987; Ricciardi and Bourget, 1998; and Eleftheriou and Basford, 1989).

Supporting parameters: Sediment particle size analysis and organic content will also be measured in the additional sediment sample. Additional supporting parameters recorded on site will include the recording of the character and composition of surface sediments (type, colour, smell), depth of RPD layer, texture and presence of surface features. A photographic record of the sampling station and of the sediment will be also collected.

Data analysis: Standard univariate statistical analyses, either parametric (e.g., ANOVA, t-test) or non-parametric (e.g., Kruskal-Wallis test, Mann-Whitney test, PERMANOVA) will then be applied to the data of abundance, richness, biomass, evenness, diversity and biomass-to-abundance ratio.

Multivariate analysis will be also carried out using cluster analysis (combined with similarity profile routine, SIMPROF) and ordination techniques (e.g., MDS, PCO) in order to identify different community types and gradients in the assemblage distribution/variation, as well as applying the SIMPER routine to identify the species which contribute most to the differentiations between groups. Multivariate statistical analysis (e.g., ANOSIM, PERMANOVA) will be applied to detect changes in community structure and composition. Bio-Env routine and linkage trees (BEST) in Primer will be used to explore the relationship between biotic (community) patterns and substrate characteristics. Based on these analyses, the main biotope(s) present in the site will be identified and their distribution over the NKM area will be presented in a biotope map to highlight the broad scale homogeneity in terms of MNCR biotopes. Also GIS methods will be used to present maps of the distribution of biomass/abundance/species diversity (e.g., using kernel density interpolation) in order to provide information on the spatial extent of what may be the hotspots of each parameter (biomass etc). Analysis will also be integrated with the findings of the intertidal LiDAR surveys as elevation change can influence benthic community structure hence food availability to bird species.

Additional details on suggested methods to set and assess the targets are provided in Annex 3 of the CEMMP.

Appendix 4: Calendar of Key Survey Activities within the Marine EMMP

2013

Pre-construction Surveys (baseline / target setting)			Year 1 Pre-Constr.											Year 2 Pre-Constr.										
Site	**Component**	**Monitoring type**	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
NKM	saltmarsh	impact assessment, BACI																								
NKM	intertidal benthos and sediment	impact assessment, BACI																								
CCS	intertidal benthos and sediment	impact assessment, BACI																								
NKM	subtidal benthos and sediment	impact assessment, BACI																								
NKM	fish	impact assessment, BACI																								
NKM	intertidal benthos and sediment	target setting (NKM)																								
		target revision (control)																								

The possibility of carrying out more than 1 pre-construction survey would be dependent on when the construction works will be initiated

2013

Construction Surveys (baseline / impact assessment / target revision)			Year 1 Constr.											Year 2 Constr.										
Site	**Component**	**Monitoring type**	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
NKM	saltmarsh	impact assessment, BACI																								
NKM	intertidal benthos and sediment	impact assessment, BACI																								
CCS	intertidal benthos and sediment	impact assessment, BACI																								
NKM	subtidal benthos and sediment	impact assessment, BACI																								
NKM	fish	impact assessment, BACI																								
NKM	intertidal benthos and sediment	target setting (NKM)																								
		target revision (control)																								

Possible scenario of construction activities

2013

Post-construction Surveys (impact assessment / target revision)			Year 1 Post-Constr.											Year 2 Post-Constr.											Year 3 Post-Constr. ...										
Site	**Component**	**Monitoring type**	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
NKM	saltmarsh	impact assessment, BACI																																				
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NKM	fish	impact assessment, BACI																																				
NKM	intertidal benthos and sediment	target setting (NKM)																																				
		target revision (control)																																				

Monitoring continued to Year 10 Post-Constr.

Monitoring continued to Year 10 Post-Constr., with review of targets/survey design in Year 5 Post-Constr.

Note: light blue indicates the the survey season (WFD-compliant); the darker blue indicates the preferred survey time (ideally May, to allow comparison also with 2010 data)