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Our ref: AN/2012/113982/01-L12
Your ref: IPC-Pro-11

Date: 9 November 2012

Dear Mr Cram

Able Marine Energy Park, Killingholme Marshes, North Lincolnshire Supplementary Information

Thank you for the supplementary information in respect of the above proposal, which was received on 16 October 2012.

Given the substantial amount of information received, it has been difficult to fully consider it in the time available but we have reviewed it so far as possible. We have the following comments to make on the Chapters of it that are relevant to issues within our remit:

1.0 EX 7.8 Dredging Strategy

1.1 We are satisfied with the information included within this strategy and have no comments to make on it.

2.0 EX8.7A, Modelling of the Final Quay Design (Supplement to Annex 8.1 of the ES) (Superseding Supplementary Environmental Information EX8.7)

2.1 We would like to draw your attention to the fact that we agreed to define the 1:200 year joint probability wave height/ water level storm event in 2033 for the defences to the north and south of the Able Marine Energy Park (AMEP) quay, due to our plans for this area. This agreed period (2033) did not apply estuary wide or to the north bank of the estuary. We acknowledge the potential uncertainty in the wave modelling results within this JBA report (EX8.7A), and that caution needs to be applied to any outputs showing changes in wave height between 0.05-0.1m. It is due to this potential uncertainty in model outputs, as shown in Figure 3.5 (section 3.3.1), where there are potential changes in wave height on the north bank of the estuary for storms with a northerly or easterly wave direction, that we require Able to accept a legal obligation to monitor this potential change (for a period of at least 10 years), rather than request up front

mitigation for this potential impact. (See Appendices A and B attached, which represents the Appendix that we require attaching to the legal agreement – refer to Section C & Plan 6 respectively). Able has, to date, not accepted such an obligation in the draft legal agreement which is currently passing between us.

2.2 3.3.4 - We note the insertion of the potential impacts of the Regulated Tidal Exchange (RTE) design on the estuary as a whole. The inclusion of a potential impact of 0.005m (+ /-0.01m) at High Water in the Middle Estuary is of concern to us. Firstly, there is an order of magnitude difference in the impact and the error margin associated with the model outputs. In addition, this change is over and above the change in high water, which we had previously understood to take place as a result of this development. There is a major change in our understanding of losses within the Humber Estuary since the Humber Flood Risk Management Strategy (HFRMS) was published in 2008.

2.3 The greatest concentration of losses is within the Middle and Outer South part of the estuary. At present we are undertaking work to look at how much of this change is natural change and how much is influenced by anthropogenic processes. Our understanding of the current rates of loss per sector within the estuary are summarised in Table 1. The identification and delivery of suitable managed realignment sites in the estuary is already extremely challenging and complex. For any development to exacerbate the rates of habitat loss, no matter how small, without being required to secure suitable compensation for themselves, could seriously jeopardise our ability to meet these responsibilities as well as adding to both the cost and complexity of what needs to be delivered. This additional change has not been incorporated into the agreed habitat changes as presented in the Shadow Habitats Regulation Assessment Statement of Common Ground (sHRA SoCG), Annex B. A change of 5mm in high water levels within the middle estuary would be a greater change in the intertidal area than arises from one year of change resulting from coastal squeeze (9.81 ha in the middle estuary).

Table 1: A summary of nodal trend as reported in the CHaMP, showing the 95% prediction error bands within the estuary. The large difference in the Inner estuary is reflective of the poor predictive capability of the regression equation.

Estuary Section	Statistical trend	Loss/ gain between 2000-2056 (ha)
Inner	5.9 ha yr^{-1} ± 4.7 ha yr^{-1}	330
Middle	-9.1 ha yr^{-1} ± 2.8 ha yr^{-1}	-510
Outer North	1.1 ha yr^{-1} ± 1.3 ha yr^{-1}	62
Outer South	-3.0 ha yr^{-1} ±1.4 ha yr^{-1}	-168
Whole Estuary	-5.1 ha yr^{-1} ±5.8 ha yr^{-1}	-286

2.4 We have reviewed section 4.0 of the report and we agree with the methodology applied, and acknowledge the potential uncertainty with some of the model outputs. In section 4.4.1 we note there is a potential change in wave height of 2% over a 2km stretch of the north shore of the estuary. We also note the potential change at Mean Low Water Springs (MLWS) of up to 4% in wave height. We believe the Environment Agency is being reasonable in its response to this matter, by requesting a legal agreement which would secure monitoring of these areas by Able to ensure that the Standard of Protection of these defences is not compromised by the proposed capital disposal, whilst acknowledging potential model uncertainty. We have defined our requirements in Section C

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(see Appendix A attached) and Plan 6, (see Appendix B attached). We would like to have seen an assessment of the frequency with which the wave heights that had the potential to impact on the north shore to have been included. This would have enabled an assessment of the potential impact on the intertidal area of these increases in wave height to have been assessed. As such, including the change in water level outlined in 3.3.4, we are no longer confident that the impact on the intertidal area has been adequately assessed.

2.5 We now require confirmation whether the assessment outlined in 5.3, bullet point 1 (in-combination hydrodynamic and sedimentary modelling assessment), includes the RTE and Cherry Cobb Sands (CCS) Managed Realignment (MR). As currently written, it appears this assessment has not included this element of the AMEP development. The EA has no option but to reserve comment on this matter until it is in receipt of confirmation as to whether the assessment included the RTE and MR at CCS.

3.0 EX 8.12A, Water Framework Directive Assessment

3.1 Section 3.2 - morphology sensitive exemption. We do not believe this removes the need for mitigation measures to improve the Ecological Potential. Annex B merely indicates that this exemption applies to 2015, meaning the mitigation measures do not need to be in place in advance of 2015, but the AMEP project extends beyond the 2015 date and the implications from the project may not be realised for 10 years plus. We would expect you to have assessed that the activities undertaken do not jeopardise the achievement of good ecological potential, which consists of adherence to plausible mitigation measures for the activities being undertaken.

3.2 Table 4 - intertidal zone structure. The assessment indicates that the existing disposal sites are sub-tidal and are not located on the intertidal area or within 10m of MLWS. We would draw your attention to your own modelling work, as presented in EX8.7A, which indicates that impacts from the disposal of the capital dredged material extends into the intertidal zone. This should be assessed within the WFD Assessment.

3.3 We would ask you to provide an explanation to confirm that the assumption made in Specific Pollutants and Priority Substances: Cherry Cobb Sands Intertidal Compensation Site, regarding the dry weight of the chemical substances is valid.

3.4.3 - Benthic invertebrate fauna (Pg 18)

3.4 The following statement needs to be amended.
'Analysis of the Environment Agency's the latest monitoring data (provided by Environment Agency, Pers. Comm. June 2012) indicates that the diversity and abundance of the sub tidal benthic invertebrates of the Humber Lower water body are related to a number of factors including natural factors such as particle size and the mobility of sediment in the areas as well as anthropogenic factors such as disturbance and pollution'

3.5 The diversity and abundance of benthic invertebrates will indeed be affected by environmental factors such as sediment grain size (and mobility of sediments) but this variation is factored into the reference conditions set for classification using the Infaunal Quality Index tool. As a result of the setting of reference conditions with in-depth consideration of the influence of grain size (and salinity) any change in classification should only reflect changing levels of impact associated with anthropogenic pressures.

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3.6 The remainder of the paragraph will also need reviewing in light of the information provided above.

3.4.3 - Reclamation dredging and disposal (pg 21)

3.7 1) The assertion that ecological status close to the proposed AMEP is Poor and Moderate is not supported by the data provided in Figure 2. There are not enough data points in 'the vicinity' of the proposed development to infer the ecological status at the AMEP.

3.8 We would draw your attention to the fact that whilst the nearest monitoring station is Poor the next nearest is Good and that High and Moderate stations are approximately equidistant away. A more acceptable statement would indicate that monitoring points close to the AMEP range from Poor to High ecological status.

3.9 2) The assertion that 2.52 km² (or 252 ha) of sub-tidal habitat loss will occur should be studied closely. If this is the level of expected sub-tidal habitat loss then compensation (of another estuary feature) should be provided at a ratio of 1:1. The proposed mitigation site at Cherry Cobb Sands is 105 ha.

3.10 It is our understanding that CCS will mitigate for inter-tidal habitat loss at a ratio of 2:1.

3.11 The HRA (5.4.14) states that 13.5 ha of sub-tidal loss can be offset by any other estuary feature. Please clarify where habitat loss (Quay foot print and berthing pocket) which will require compensation occurs and where impacts which may be temporary will occur.

3.12 We would also direct you to 3.4.5 and 3.4.6 which contradict the overall message taken from this section of the document.

3.13 3) Whilst there are monitoring stations 'near' to the dredge dispersal ground which are at High status there are many more at Moderate status (Figure 2). (see also point 3.4.3 - 1) above)

Fish Fauna

3.14 The classification for fish in transitional waters under WFD is carried out using the Transitional Fish Classification Tool (TFCI). This is not covered by, and is not part of, the Freshwater Fish Directive (FFD). The FFD is applicable to lakes and rivers and is not applicable to transitional water bodies, including the Humber Lower, under WFD legislation. Please revise this section accordingly.

3.15 Section 3.4.5 – We would like to seek further clarification of the argument presented on the realignment site contributing to the mitigation measures on the Humber Lower Waterbody. It is our understanding that the further development of the RTE MR site design means that it will be necessary to maintain the existing flood defences in situ in order to form the back of the RTE fields. We accept that managed realignment is one of the necessary mitigation measures required, but this is being provided, whilst the defence line on the south bank is being extended, and hence is increasing the hard defences on the south bank of the Humber Lower Waterbody.

3.16 A further point in Section 3.4.5 is that the paragraph referring to AMEP not affecting any actual projects the Environment Agency may have to alter its flood

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defences, would depend on whether Able is required to deliver its over-compensation proposal (EX28.3 Part 8). If the wet-grassland is required at the East Halton site, it has implications for the Environment Agency; these implications are outlined in paragraphs 13.1 to 13.7 below.

3.17 Section 3.4.6 - The WFD does not at present appear to adequately take account of the RTE design development in its reflection of ecological impacts on fish. The EA would advise that this should be adequately assessed in sections 3.4.3 (fish fauna), 3.4.6, and 5.0.

3.4.7 - Assessing future maintenance dredging using the principles set out in the Clearing the Waters guidance

3.18 If the frequency of maintenance dredging does prevent the recovery of benthic invertebrates to pre-impact (baseline) levels then the impact on this biological quality element will be non-temporary. If the effect is non-temporary and recovery never occurs there is a high possibility that deterioration will be observed at the water body level and that the environmental objective of not preventing deterioration in the status of a water body is not achieved. The Examining Authority as the Competent Authority determining this application, for the purposes of the Water Framework Directive, will need to either ensure that deterioration does not occur or that the application meets the criteria set out in Article 4.7 of the Water Framework Directive. It would therefore be advisable for you to provide the Competent Authority with the necessary information in order for them to be able to make an assessment. If the final decision on this application was that development could be permitted on the basis that the conditions set out under Article 4.7 have been met, the Competent Authority would have to inform the Environment Agency that deterioration in the water body has been allowed under Article 4.7 and the reasons for doing so as the Environment Agency have the responsibility to record use of Article 4.7 and the reasons for doing so in the relevant River Basin Management Plan.

3.19 We welcome the opportunity to feed in to the measures that will be put in place to prevent the exacerbation of the local accumulation of sediment on the estuary side of the sluice at Stone Creek, and advise these may be best placed within the Environmental Management and Monitoring Plans.

4.0 EX10.8, Disposal Site Characterisation and Impact Assessment

4.1 Changes to the benthic ecosystem will occur as a result of the disposal of gravel to HU080 and its subsequent migration up stream of the disposal site. The majority (49%) of the gravel is in the 2-6mm fraction, 29% is in the 6-20mm and 22% in the 20-60mm fraction.

4.2 2.6.2 - The gravel will persist in the sediments and will result in changes to the habitat available to invertebrate fauna. Changes to the sedimentary habitat will be patchy and this potential variability has been acknowledged. However, the assertion that the gravel fraction will be of negligible thickness (at 8mm or 0.008m) cannot be supported by the data presented. 22% of the gravel to be disposed has a larger diameter (minimum 20mm) than the estimated thickness of the gravel layer, and of the 29% in the 6-20mm fraction a large proportion can be estimated to be 8mm and larger. We appreciate that this point is raised in 2.7.1 and in Appendix A but feel some adjustment to predicted impacts may be necessary.

4.3 Deterioration of the benthic invertebrate biological quality element will not necessarily follow changes to the proportion of gravel in sediments. There is the possibility that communities will recover to pre-disposal assemblages. However, some shift in community structure and composition of benthic invertebrate communities inhabiting the impacted area is probable. Classification of the IQI is against reference conditions calculated for the specific sedimentary environment encountered. It should be noted however, that reference conditions for gravel habitats do not have the high degree of confidence associated with muddy and sandy sediments.

4.4 The summary provided within Appendix A needs to be read within the context of the material being modelled. It is not possible for the thickness of the material to be only 4mm when 22% of the material being modelled has a grain size in excess of 20mm. The final average thickness of not exceeding 0.02m as quoted within the report does not reflect that 22% area the material is distributed over will be 0.02m or higher. The Appendix acknowledges this point at the end of section 4.0, but this is not translated to paragraphs 2.8-2.8.2 of the main report. The potential uncertainty within the model outputs should be reflected in the discussion in paragraphs 2.6-2.8.2, at present this is not the case. We request that the model errors are reported within the Appendix for us to be able to determine the likely uncertainty in the results presented. If the error bands are within the same order of magnitude, it may be possible to address this point relatively quickly. If the error bands are of a different order of magnitude this needs to be explicitly reported within the interpretation of the impacts on the benthic environment (see paragraphs 4.1-4.3).

5.0 EX10.9, Environmental Management and Monitoring Plan 1. Marine Works (Draft)

5.1 We are disappointed with the format of the Marine Environmental Management and Monitoring Plan (EMMP) as it currently stands. We provided advice to you in an email of 29 August 2012 of the type of monitoring we required to be undertaken for the protection of flood risk as a consequence of the AMEP (and associated) development. We have sought to secure this monitoring via a legal agreement, but would have anticipated that you would have acknowledged this within the EMMP when referring to wave height and water levels (Section 6.3.2). At present, the indication of appropriate monitoring that should be undertaken does not reflect the work that either party have undertaken to try to reach agreement on this matter.

5.2 Section 2 of the EMMP does not, in all places, reflect our latest understanding of the development. For example, Section 2.4.2.1 refers to the negligible impact of the development when compared to natural change. We have worked with you to reach an agreement on what compensation will be delivered for this longer-term impact, and we are still working with you with respect to the WFD. The Marine EMMP also states in 2.4.2.1 that "*cumulative effects with other projects will not occur as impacts to aquatic ecology from AMEP site are localised to AMEP site*". This does not reflect our comments of 7th September regarding the in-combination assessment, nor does it reflect your own documents in EX8.7A and EX10.8 where dredge disposal from AMEP and other projects are discussed in greater detail.

5.3 We request that this document is updated to reflect the latest status of the application and all associated supplementary information as soon as possible. In addition, we believe it would have been sensible to include within this document

all Requirements, as defined within the DCO and DML, which are relevant to the Marine environment.

5.4 For example our Requirement 13 in Schedule 11 in respect of river basin management:

The monitoring and management strategy document shall in particular consider the spatial and temporal extent of the impact of the approved scheme on—
(a) those "biological elements" and "ecological potential elements" as defined in the Humber River Basin Management Plan for the Humber Middle and Humber Lower Water Bodies (GB53040269201 and GB30402609202), to include, but not limited to: macro algae, angiosperms, macrophytes, benthic/macro invertebrates, fish, and
(b) those biological and ecological elements defined as "water-dependent habitats or species for which the Protected Area was designated" as defined in Annex D of the Humber River Basin Management Plan.
(3) The authorised scheme shall be constructed and managed in accordance with the approved strategy document and the monitoring detailed in the approved strategy document shall be implemented.

5.5 At present the Marine EMMP does not make direct reference to these Requirements, or the WFD, this needs amending. Please find attached advice on monitoring in order to be compliant with the WFD (Appendix C). We would expect to agree triggers with regard to this requirement that would result in remedial action.

5.6 We need to agree the exact wording to be inserted into the EMMPs before the close of the examination.

5.7 We would draw your attention to the fact that monitoring will need to commence prior to the quay construction and dredging works, and continue for a minimum of 6 years post breach of Cherry Cobb Sand and completion of the marine works.

5.8 The WFD Monitoring Parameters to be included are:

- Fish
- Benthic invertebrates
- Vegetation (saltmarsh)

5.9 Section 2.2.2.2 – Quay Construction – Noise
The 11th bullet point states that the hours are to be restricted "within each four-week work-block". This wording is incorrect and needs amending to read "within each week-long work-block" as per the Tri-agency letter of 31st July 2012.

5.10 The 13th bullet point is similar and needs correcting to read "within each eight-week work-block".

5.11 6.3.3 - It is acknowledged that mitigation has been agreed to minimise underwater noise impacts from piling. However, we believe that it would be useful to inform future developments if underwater noise level monitoring could be undertaken during construction works.

5.12 Section 6 – Monitoring. We have previously sent advice to you (email to Mr Jonathan Monk on 12th October 2012) in respect of fish monitoring but this was

not provided in time to be incorporated into this draft of the EMMP. For completeness, the advice is repeated below:

The survey shall be undertaken in at all specified locations related to the AMEP application boundary in both Autumn and Spring, and will included data such as the type, abundance, richness, age, weight and size of the species inhabiting these intertidal areas.

The surveys should be undertaken using methods such as beam trawling or fyke netting in order to monitor demersal fish populations; and seine netting or otter trawling in order to monitor the pelagic fish populations.

There are particular and unique challenges that these surveys may encounter in the Humber estuary, such as the high amplitude of the tides, fast currents and large amounts of debris. Survey techniques should be chosen with these constraints in mind.

All survey work undertaken will be in compliance with the EA's WFD fish survey methods. Fact sheets specific to WFD monitoring in estuarine environments are attached.

In addition to the above, we would also request the inclusion of the following: *Surveys undertaken should record and specify the proportional area of creeks sampled to enable the scaling up of community data.*

5.13 It would also be helpful if the plan could include the number and location of monitoring buoys that will be used to monitor temperature and dissolved oxygen in the estuary during construction.

6.0 EX28.3, Part 1 Non-Technical Summary

6.1 Paragraph 1.6.2.4 – we request clarification of the size of the wind powered pumps that will drive the irrigation systems.

7.0 EX28.3, Part 2 Baseline of North Killingholme Foreshore

7.1 Paragraph 1.5.1–1.5.2 - We would request an explanation for the basis of the robust and reasonable assessment of coastal squeeze losses in these paragraphs. The assumption of losses in the middle estuary was based on the 2005 Coastal Habitat Management Plan (CHaMP) (paragraph 1.5.1). We have provided you with the most up to date understanding of losses within the middle estuary in our approved Habitats Regulations Assessment for the Humber Flood Risk Management Strategy (2011), which supersedes the 2005 CHaMP and reflects the change in sea level rise predictions and understanding of rates of loss in the middle estuary. Your assumptions on losses in the middle estuary should reflect this understanding and not the earlier 2005 position.

7.2 We provided you with the most up to date understanding of estuary losses in our oral submission on 11-13th September and in our written submission of 3rd August (paragraph 4.31). We are providing this advice based on the following two assumptions made by Able:

- Losses are evenly distributed within the Middle estuary;
- The foreshore at Killingholme Marshes is 1.2% of the Middle Estuary extent.

7.3 If these two assumptions are valid, it is our opinion that you should reflect this newer understanding of the estuary losses (HFRMS HRA, 2011) within your documentation, and not the earlier CHaMP (2005). As such, we do not think that your estimate in 1.5.1 "*remains robust and reasonable*" (Paragraph 1.5.2).

8.0 EX28.3, Part 3 Development and Operation of the Intertidal Habitat Site

8.1 4.5.6-7 - We strongly recommend, as we have previously, that robust erosion protection is provided along the entire length of the new flood embankment. The exposed length has actually reduced due to the introduction of the Regulated Tidal Exchange (RTE) solution. Therefore, we recommend that, to reduce uncertainty over erosion, the armorflex-type erosion protection is extended and, as suggested in paragraph 4.5.7, the toe design is given careful consideration.

8.2 4.9.1-3 - We welcome the inclusion of discussion on reservoir classification in this section. Further clarity could be provided on the likely range of volumes in the RTE fields and how this compares with the Reservoir Act provisions.

8.3 There is still no discussion of the environmental impact and contingency should the old flood embankment fail and the RTE fields flood. However, we do acknowledge that a separate document on Embankment Inspection and Maintenance has been submitted. It would have been helpful if somewhere in Part 3 there was a cross-reference to this document.

8.4 5.3.9 – We note the increase in predicted erosion in the Cherry Cobb Sands Creek as highlighted in this paragraph. This shows an increase of 20%, with up to 1.8m of erosion a year when compared to the original design. The EA considers this change quite significant to the local area and would like further explanation as to where this eroded material is likely to be deposited. This area is obviously very sensitive due to tidal flood risk, land drainage issues and sedimentation in the Stone Creek area. This information suggests that there is likely to be an impact in the Stone Creek area, particularly in the early years of operation.

8.5 We also note that the revised document does not appear to take account of the discussions at the hearings on 5th September and the 11th and 12th September regarding the potential impact of the RTE MR site on discharge from Keyingham Drain. We would be grateful if you could indicate where this work has been carried out in order that we can assess the potential impacts to our flood defence structures. It would be helpful if you can present the assessment of the potential impact to the length of time the tidal outfall at Keyingham Drain will be able to operate, in order that we can assess the potential change in head that will be applied to the doors on a regular basis.

8.6 5.3.10 – This paragraph indicates that the duration of the low tide period when discharge from the Environment Agency tidal outfall is possible is slightly shorter, but with no quantification of this period. This point requires clarification so that we can ensure the proposal does not impact on our operating regime and infrastructure.

8.7 This is further emphasised in paragraph 8.17 where there is no quantification of time or magnitude of the impact of drainage on Stone Creek, and more specifically Keyingham Drain. We would also draw your attention to paragraph 11.5.1 which implies that any enlarging of Cherry Cobb Sands Creek, as a consequence of the RTE MR, is likely to result into drainage from Foul Holme

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Sands to be via the Creek following this enlargement. We acknowledge that there is some uncertainty associated with this potential impact, but require some expert judgement to be applied as to the likely consequence of this change on to the duration to which Keyingham Drain tidal outfall will be able to discharge.

8.8 We have some general concerns regarding the information provided in this report with respect to the principles of sustainability and the delivery of this RTE. It is our opinion that sustainability needs to be at the heart of the compensation that is delivered and that work should be invested ahead of delivery to ensure that anything delivered can achieve appropriate self-management that is sustainable with limited intervention. The RTE, as presented, requires significant on-site intervention, as indicated in paragraph 6.1.4 "*in practice the site managers would adjust the sluice settings and depth of inundation to best achieve these objectives in the light of their developing operation experience*". As indicated in paragraph 4.6.9, the site is designed for a 100 year design life, and as such requiring such frequent adjustments to the sluices (which will potentially need replacing twice following initial construction [paragraph 4.6.9 "*mechanical items will be designed for a 30 year design life*"]), leaves us with serious concerns about the long-term sustainability of the site as currently presented.

8.9 The above point is further illustrated via paragraph 6.2.4 where you explain the site design in further detail. This states that the minimum depths of water within the RTE close to the inlet will be between 16-7mm on the lowest tides. This gives the impression of a very artificial habitat lacking sustainability as a core principle to deliver compensatory habitat for a SAC and SPA. We will have to draw this to the attention of the Examining Authority during next week's Hearings. The Environment Agency's core purposes are to protect and improve the environment and promote sustainable development. We have concerns at present with how the RTE meets the objective of sustainable development, requiring such active intervention in an artificial manner, whilst trying to replicate a naturally occurring habitat.

8.10 8.2.7 –We require further clarification in respect of the detailed design of the RTE fields. It is unclear from this paragraph whether the final design layout, including flood defences, as shown in Figure 8.1 is the final layout, or whether there may still be further changes to the flood defence size and gradients. In addition, it is unclear from this paragraph what the impact of the further detailed design would be on the total habitat compensation provided. As shown in Table 8.2 at present the total compensation area below 3.4 mAOD is 105.4 ha, but it is unclear whether any of this area includes the banks within and around the site that are below the 3.4 mAOD threshold. We would request further clarification as to how the 105.4ha has been derived.

8.11 As mentioned in Paragraph 8.1 above, we would also advise you that due to the increases in velocities and shear stresses within the site (paragraphs 5.3.3 (periods in excess of 2 hours where velocities are in the region of 1 $m^{-1}s^{-1}$, and 5.3.6)), it would be our advice that the Armourflex 180 be applied to the full flood defence bank that runs parallel to the creek within the site as defined on Figure 8.2.

9.0 EX28.3, Part 4 Development of Wet Grassland and Roosting Site

9.1 5.4.3 – 5.4.4 These paragraphs discuss salinity in Keyingham Drain and suggest works will be carried out to minimise saline incursion on tides.

9.2 The Environment Agency has recently carried out works to replace the canopy timbers on the existing tidal control structure. This work has reduced the amount of sea water that is able to ingress into the upstream section of Keyingham Drain. No further works are planned. This structure is primarily a flood defence asset to prevent tidal flooding of local communities rather than to regulate water chemistry. It works by allowing freshwater flows out through hinged timber pointing doors, which, on the rising limb of tides are pushed closed when the downstream tidal level exceeds the freshwater level upstream. There is inevitably a period where mixing goes on to differing extents except when the doors are fully shut.

9.3 The Environment Agency has a current water sampling point at Sands Bridge which crosses Keyingham Drain, some 4 kilometres upstream of the tidal outfall. A formal information request could be made to find out more about the sampling regime and results if required by emailing neyorkshire@environment-agency.gov.uk.

9.4 6.2.16 - This paragraph describes the widening of the existing western embankment of Keyingham Drain, using spoil generated from wetland creation. This existing embankment is not classed as a formal flood defence raised embankment by the Environment Agency, nor do we routinely access along the bank for maintenance purposes. Therefore, we have no objections to the widening of the bank in this location but would ask that the current height is maintained rather than increased (so as not to alter the characteristics of the floodplain), which is suggested in 6.2.16, albeit to a limited extent.

9.5 Those works carried out within 8 metres of the top edge of the drain bank will require the prior written Consent from the Environment Agency, under the Yorkshire Land Drainage Byelaws.

9.6 6.2.31 - Any pumps erected within 8 metres of Keyingham Drain, or encroaching in the channel or bank sides will need prior written Consent from the Environment Agency, under the Water Resources Act and Yorkshire Land Drainage Byelaws. It will need to be demonstrated at design stage that any such structures will not have any detrimental effect on wildlife or associated habitats.

10.0 EX28.3, Part 5 Assessment of Functionality

10.1 1.4.7 –The Environment Agency has already carried out works to reduce saline intrusion into Keyingham Drain. We do not intend to carry out further works. Please refer to the explanation given with reference to paragraph 5.4.3-4 from Part 4 above.

10.2 Our main concern arising from this document is the potential reliance on the over-compensation at East Halton, which is discussed in EX28.3, Part 8. We have significant concerns over the deliverability of this over-compensation as outlined in paragraphs 13.1 to 13.7 below. Should the Secretary of State deem that over-compensation is a necessary part of the compensation package in order to meet the Habitat Regulations, we will be requesting that the issues as presented in paragraphs 13.1 to 13.7 are a material consideration to the decision.

11.0 EX28.3 Part 6 EIA Review

11.1 This Chapter includes reference to two proposed wind pumps at the RTE scheme (as shown on Figure 3.3). It appears from Figure 3.3 that these could be

sited on the flood embankment. We would request further information on these, such as the proposed location, size and potential impacts on the compensation site.

12.0 EX28.3, Part 7 Compensation Site Environmental Management & Monitoring Plan

12.1 We are disappointed that the Compensation Site EMMP has not at present been populated with baseline data, numerical objectives, or reflects our comments in relation to the Requirements we have requested within the DCO and our legal agreements, and how any remedial actions that may be required will be implemented and secured. This is essential, if the EMMP is to be completed to a state where it can be agreed before the close of the examination. At present the EMMP reflects too much of the Environmental Statement, and does not include all our relevant advice that has been provided. For example, we note in section 6.5 (paragraph 135) your views are repeated on the potential impacts to fish from the AMEP construction and associated development. We would like to remind you of our differing opinion with regard to potential impacts on fish as outlined in paragraphs 4.48 to 4.73 of our Written Representations (29 June 2012) and Paragraphs 3.1-3.16 of our submission of 3 August 2012.

12.2 Paragraph 136 – In addition to surveying around the RTE intertidal mudflat habitat and the intertidal managed realignment area, it would also be useful to survey the area around the inundation site. This should be both pre and post development, with a small beam trawl to determine if the site is having any localised effects on the neighbouring environments.

12.3 It would be helpful if the EMMP agreed baselines could be provided in tabulated format, or succinct bullet format to enable ease of comparison in the future when the Advisory Group (as defined in Schedule 3, EX28.3, Part 10) come to review the performance of the site against the baselines and agreed target objectives.

12.4 At present it is difficult for us to provide any advice on the target objectives as they are not easy to decipher from the text, they do not reflect our WFD Requirements or methods (DCO Schedule 11, Requirement 13, and Appendix C attached). Without very clearly defined targets and objectives it will be very difficult for the Advisory Group to assess the performance of the site and whether the site is meeting its extent and functional requirements (SAC and SPA) and hence whether the coherence of the Natura 2000 network has been maintained and you have met all your legal requirements (Habitat Regulations, WFD, marine licence etc).

12.5 We look forward to receiving an updated and amended version of the Compensation EMMP and we will endeavour to provide what advice is possible in the time remaining within the Examination timetable. It is our opinion that without the above improvements to the EMMP, it will not be possible for us to inform the Examining Authority that the EMMP is agreed in advance of the close of the Examination of this proposal.

13.0 EX28.3, Part 8 Over-compensation site proposal

13.1 Chapter 2 – the area for proposed grassland lies within the boundary of a site, which is currently pending planning consent from North Lincolnshire Council (PA/2009/0600) for the Able Humber Ports Facility: Northern Area (often referred to as the Able Logistics Park - ALP). The site is currently protected by a tidal flood defence. The Environment Agency does not plan to continue to maintain

this line as a flood defence, as outlined in the Humber Flood Risk Management Strategy. However, we have been in discussions with Able for several years regarding the wording of a legal agreement, which would require urgent improvements, continued monitoring and future improvements to this area, should you wish to develop it.

13.2 Chapter 3 - We have reviewed the information in respect of geology and hydrogeology, which appears to be correct. However, there is the probable presence of two historical boreholes, i.e. a well near the mouth of East Halton Beck associated with the coast guard station and a wind pump in the middle of the proposed area. Both of these locations have borehole records on British Geological Survey (BGS) Index.

13.3 We recommend that a survey is undertaken to identify these boreholes on the ground and if no longer in use they should be decommissioned if this has not already been done.

13.4 Chapter 5 - If the legal agreement in respect of tidal flood defences at ALP is signed by all parties (Associated British Ports hold a land interest where the improved defence line would encroach and therefore will need to be party to the agreement) then it is still highly unlikely that you could meet your legal obligations to improve the defence line by only working between the months of April to July. The duration of necessary works has been a point of continued discussion between our organisations for some considerable time.

13.5 If the legal agreement in relation to ALP is not concluded, then the condition and continued deterioration of this defence will necessitate the Environment Agency having to proceed with its preferred option of building a cross bank. Either way, heavy plant and construction activity are likely to impact on the site between April to the end of September. Therefore, the expected disturbance described in section 5.3 is not accurate. Evidence included at Appendix D shows some of the deterioration along the defence line in Flood Cell 23, where we were forced to undertake emergency repairs this summer, whilst trying to reach a satisfactory legal agreement with you.

13.6 If the cross bank option proceeds and the defence continues to deteriorate, it is worthy of note that the land level is generally below the Mean High Water Springs and failure of the defence would lead to saline intrusion onto the site and likely habitat adaptation to a salt marsh or inter-tidal mud. There is a potential risk, as outlined above, of the over-compensation proposal being unable to meet the Habitat Regulations requirements.

13.7 We are of the opinion that this wet grassland proposal will also need to be subject to a WFD assessment. The Humber Flood Risk Management Strategy helped to inform the River Basin Management Plan for the Humber transitional waters. We do not intend to maintain this line of defence (Appendix E), and as such the continuation of hard defences in this location would be a change to the plans. This would need to be assessed against the mitigation measures not yet in place in the Humber Lower Waterbody, especially:

- *Removal of hard bank reinforcement / revetment, or replacement with soft engineering solution;*

- *Managed realignment of flood defence.*

14.0 EX28.3, Part 9 Land Ownership and Funding

Cont/d..

14.1 Could you please clarify what the length of time over which the £90 000 maintenance costs (paragraph 8) have been assessed. As EX28.3 Part 3 paragraph 4.6.9 refers to a design life of 100 years, with the mechanical items having a design life of 30 years, plus the requirement of a site manager for the RTE site, a budget of £90, 000 seems very small if this is spread over the lifetime of the development. If we were to assume this to be £90 000 per annum, it would equate to 9 million pounds over the 100 year lifetime, and so significantly more than the "*less than 1% of the total project costs*" as expressed in this paragraph. We look forward to receiving a full explanation as to how these costings have been derived.

15.0 EX28.3, Part 10 Final Compensation Proposals - Draft Legal Agreement

15.1 We are not currently in a position to make comment on whether or not the Environment Agency will be a party to this agreement. We hope to be able to indicate our intentions during next week's Hearing.

16.0 EX31.5A Factual Report on Geo-Environmental Ground Investigation, Cherry Cobb Sands (Final)

16.1 This report does not contain a controlled waters risk assessment. We do not require this risk assessment pre-consent as Schedule 11, Requirement 33 will ensure that this is carried out prior to the commencement of development. However, we would like to highlight the following points, which will need to be addressed in order to satisfy Requirement 33.

16.2 Evidence of contamination was encountered in the following trial pits and trial trenches, but there appears to have been no chemical sampling of the soil at these locations:

1. TP34 (TR125): Trial pit log indicates evidence of hydrocarbons and bright blue discolouration of the ground.
2. TP35 (TR126): Trial pit log indicates evidence of hydrocarbons and bright blue discolouration of the ground.
3. TR119: Trial trench log indicates presence of both demolition and pharmaceutical wastes. Oily latex smell present.
4. TR120: Trial trench log indicates presence of both demolition and pharmaceutical wastes. Oily latex smell present.
5. TR121: Trial trench log indicates presence of both demolition and pharmaceutical wastes. Oily latex smell present.
6. TR122: Trial trench log indicates presence of both demolition and pharmaceutical wastes. Oily latex smell present.
7. TR123: Trial trench log indicates presence of both demolition and pharmaceutical wastes. Oily latex smell present.
8. TR124: Trial trench log indicates presence of both possible furnace waste and pharmaceutical wastes. Oily smell present.

16.3 We request an explanation as to why these were not sampled given this is where both visual and olfactory evidence of contamination was encountered. These areas should have been tested as they possibly relate to former creeks that were infilled with potentially contaminated material, as identified in the initial preliminary risk assessment. Although it may be that you intend to remove any contaminated areas as part of a remediation programme we would still request an explanation as to why they have not been sampled to date.

16.4 Hydrocarbon contamination was identified in TR116 though we note that only a total hydrocarbon concentration was recorded in the sampling results. Ideally a full speciated Total Petroleum Hydrocarbon suite (including BTEX) should be tested for the above locations, especially for any subsequent quantitative risk assessment work where individual TPH fractions could be are required.

16.5 TR116 has also identified very high concentrations of polychlorinated biphenyls (PCBs). It is likely that these may also be present in the above locations and should be sampled for unless there are other reasons as to why this was not /will not be done.

17.0 EX36.4 Embankment Inspection and Maintenance Report

17.1 We request further explanation as to how the performance of the RTE site will be impacted by the reduction in the Standard of Protection along the existing flood defence line that will occur over time. In paragraph 3.4 (b) it implies that the failure of the embankment would result in limited impacts "*any adverse impact to the compensation site and flood defence is likely to be short duration and relatively minor*". We would query this view, as you are going to considerable length and expense to design and create the RTE element of the compensation package, and yet any failure to the existing defence would result in inundation directly from the estuary to the RTE fields.

17.2 We would seek further clarification as to the impact on the RTE fields in the future as the likelihood of overtopping of the existing flood defences, providing part of the RTE structure increases in frequency. Table 3.5, section 5 indicates it would be uneconomic for the applicant to raise this embankment in the future, and hence we ask for further clarification as to the long-term future for the RTE compensation site. We have expressed concerns regarding the sustainability of the site (Paragraphs 8.8 – 8.9 above), and seek confirmation as to how the significant structures that are required for the RTE to function will be safeguarded into the longer-term future. Paragraph 4.2 provides no evidence that a Standard of Protection of 1 in 18 will be sufficient to prevent any significant adverse impact to the compensation site. We request sight of the evidence on which this judgement has been based, particularly when you have indicated that the site will be fully functioning by 2018 (Table 5.1, EX28.3, Part 5), and as such if the development had a 100 year life we would have expected to see an assessment of risk in 2118 and not 2108.

17.3 We would advise you to undertake a walkover inspection of the existing defence line in order to establish the extent and level of stone erosion protection that currently is required (section 5 (b)). We have to make a regular significant investment on our flood defences on this north shore of the estuary on erosion protection to safeguard the longer-term functioning and integrity of our defences. It is our opinion that you have not demonstrated a full-understanding of this potential investment requirement in EX36.4.

17.4 We support the conclusion that the breached embankment integrity needs to be retained. Previously, we have recommended that the ends of the breach in the bank have erosion protection. This document suggests protection as an option. We recommend it should be a certainty and should be carried out at site development stage, when access is more available.

18.0 EX44.2, Addendum to EX44.1

18.1 We have reviewed EX44.2, but it appears that our points as outlined in Section 10 of our 3rd August submission and In-Combination effects section of our submission of 7th September have not been addressed. The points are reproduced below for your information:

• Clear logical arguments to be presented with the appropriate cross referencing to alternative documents where necessary, when the justification for the view taken is not presented;
• Capital and maintenance dredging and dredge disposal;
• Hydrodynamic and morphological change.

18.2 We wish to understand how you have arrived at the Figure of +513 ha of habitat creation in Table 4.6. The HFRMS losses and gains are set out in our HRA (2011, see paragraphs 7.1-7.3 for full definition). This table takes no account of the losses taking place within the estuary as a consequence of coastal squeeze and that these habitat creation schemes within the HFRMS are about replacement of lost habitat. The total losses arising from the HRFMS for the first 50 years, as defined in the HRA (Table B1 (as provided in our response of 29th June), are approximately 400 ha, which requires a replacement of approximately 517ha, due to the distribution of losses within the estuary. This table appears to be a misrepresentation of the HFRMS HRA, and we welcome a response from you on this matter.

19.0 Comments on Able's comments to responses to Examining Authority's 2nd Questions

19.1 5.10 and 5.12 The reports mentioned in these paragraphs should then have been used to inform the assessment in EX44.1 and have not been.

19.2 5.2 We accept your response to Table 3.1 of the sHRA SoCG. However, we would draw your attention to the fact that you did not carry an explanation forward into Table 3.2 as to why there either is, or is not, a Likely Significant Effect for the Berthing Pocket (Table 3.1, item 3).

Plainly given that the examination of this application is due to close on 24 November the information requested above is of the utmost urgency if we are to have any opportunity of considering it properly and advise the Examining Authority accordingly. I look forward to hearing from you as soon as possible.

Yours sincerely

Annette Hewitson
Principal Planning Advisor

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Direct fax 01522 785040
Direct e-mail annette.hewitson@environment-agency.gov.uk

c.c. The Planning Inspectorate

APPENDIX A

Legal Agreement Monitoring Requirements proposed by the Environment Agency

APPENDIX ONE

Monitoring for Able Marine Energy Park (AMEP) Capital Dredging and Disposal Activities

A. Bathymetric Monitoring

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

1) AMEP berth pocket dredge (as defined in Drawing AME-06093, bounded by co-ordinates (53°39.55'N, 00°13.48'W), (53°39.57'N, 00°13.43'W), (53°38.94'N, 00°12.60'W) and (53°39.92'N, 00°12.64'W));
2) AMEP approach channel dredge (as defined in Drawing AME-06033, bounded by co-ordinates (53°39.57'N, 00°13.43'W), (53°39.61'N, 00°13.30'W), (53°39.40'N, 00°12.90'W), (53°39.03'N, 00°12.41'W) and (53°38.94'N, 00°12.60'W));
3) AMEP turning area dredge (as defined in Drawing AME-06033, bounded by co-ordinates (53°39.40'N, 00°12.90'W), (53°39.41'N, 00°12.53'W), (53°39.11'N, 00°12.26'W) and (53°39.03'N, 00°12.41'W));
4) HU080 Disposal site down estuary (as defined in Plan 6, bounded by co-ordinates (53°36.95'N, 00°03.47'W), (53°36.55'N, 00°00.42'E), (53°36.30'N, 00°00.62'W) and (53°36.47'N, 00°02.32'W)) ;
5) HU082 Disposal down estuary (as defined in Plan 6, bounded by co-ordinates (53°37.47'N, 00°02.27'W), (53°37.25'N, 00°00.80'W), (53°36.97'N, 00°00.81'W) and (53°37.12'N, 00°02.29'W));
6) Between the flood defence wall and MLWN or -2m ODN (whichever is the greater) upstream of AMEP, from quay wall to HST (as defined in Plan 6);
7) Between the flood defence wall and MLWN or -2m ODN (whichever is the greater) downstream of AMEP, from quay wall to HIT (as defined in Plan 6);

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 during the capital dredge programme (as defined in the dredge and disposal strategy, clause 32 (1) Schedule 8 of the Development Consent Order). Upon completion of the capital dredge programme, surveying shall continue at this frequency for at least one month, but may thereafter revert to being undertaken at 12 monthly intervals. This monitoring shall continue for a minimum of 10 years.

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 6 months from the commencement of monitoring; and
- Within 6 weeks of the 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.

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. Bathymetric and LiDAR Monitoring Upstream and Downstream of AMEP

Able shall survey locations 6 and 7 (bathymetric and LiDAR as defined below) in the month prior to the commencement of works seaward of the EA flood defences, including 500m up and down the estuary at not greater than 50m line spacing, as shown in Plan 6. These surveys shall be repeated at six month intervals for a minimum 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 the each annual survey; and
- Compare the results to the modelling results presented in Chapter 8 of the ES and all technical appendices 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 the predicted sedimentation does not materialise as predicted in the ES, or there is a loss of sedimentation, or there is any indication of erosion of sediment in either location (6 or 7), Able shall:

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

- there are two confirmed surveys indicating erosion. This shall trigger a Standard of Protection (SoP) Review, at Able's cost, for all 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 using those parameters in use by the EA and which have been notified to Able in writing by the EA at Able's request. If the results show a reduction in SoP Able shall, at its own expense, undertake improvement works to restore the affected lengths of defence to the original SoP. The original SoP, shall be agreed by both parties prior to the Commencement. This SoP review shall extend from Humber Sea Terminal (HST) to Humber International Terminal (HIT) and shall be undertaken at Able's own cost. Prior to any improvement works being undertaken by Able, the methodology shall be agreed in writing with the EA; OR
- 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.

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

Bathymetric Surveys and LiDAR (as defined below) shall be undertaken within the area marked on Plan 6. These surveys shall be undertaken on a 12 monthly basis for a minimum of 10 years. At the

end of the 10 year period the EA shall review the results, this may include a SoP review (as defined Section B) at Able's expense if necessary. The EA may require monitoring to be undertaken for a further 10 years if it considers this to be reasonably necessary. The survey work to be undertaken shall be:

- Bathymetric surveys at a minimum of 500 m intervals within AMEP monitoring 1 polygon on Plan 6, across the width of the estuary to include flood defences, MLWN, MLWS, MHWN and MHWS, as defined below
- Bathymetric surveys at a minimum of 500 m intervals within AMEP monitoring 2 polygon on Plan 6, across the width of the estuary to include flood defences, MLWN, MLWS, MHWN and MHWS, as defined below
- LiDAR to include the polygons marked on Able Plan 1 to be flow at MLWS

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 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 at any point during the monitoring period there is a change in the sedimentation patterns defined in the baseline assessment (based on Chapter 8 or the ES subject to suitable revisions of this chapter by Able) Able shall:

Increase the frequency of monitoring to every 6 months until such time that either:

- there are two confirmed surveys indicating erosion which will trigger a Standard of Protection (SoP) Review to be undertaken by Able for those locations identified to be affected (following methodology defined in Section B). If there is a reduction in SoP, improvement works shall be required at Able's expense to maintain the SoP (as confirmed prior to the commencement of construction works of AMEP at Able's expense). The methodology for improvement works shall be agreed, in advance of work being undertaken, in writing with the EA; OR
- there is no further evidence of erosion and a pattern of stabilisation can be detected; at which point the monitoring may return to the 12 monthly frequency identified above.

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, shall be submitted to and agreed in writing with the EA. The Scheme shall include the following:-

i. A timetable for when monitoring shall be undertaken, including monitoring before, during and after disposal activities are undertaken;
ii. A detailed methodology for the monitoring;
iii. An evaluation of the contribution the 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 works contribute to, or are likely to contribute to, a failure of the water body in achieving its WFD objectives, a Remedial Action Plan shall be submitted to the EA that detail measures to ensure 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 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 produce a report collating and analysing the monitoring undertaken so far:-

- Every 6 months from the commencement of monitoring; and
- Within 6 weeks of the 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 Scheme, Able shall:-

- As soon as reasonably practicable, submit a Remedial Action Plan to the EA for their approval,
- As soon as reasonably practicable following the approval of the Remedial Action Plan, implement any actions agreed in the plan

Definitions

MHWS- Mean High Water Springs
MHWN- Mean High Water Neaps
MLWS- Mean Low Water Springs
MLWN – Mean Low Water Neaps

Bathymetric Definition

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)

Echo sounder

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.

It is important that the surveys are referenced to UK National Grid, and that any vertical datum is 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 Definition

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 above. 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.

Data Accuracy

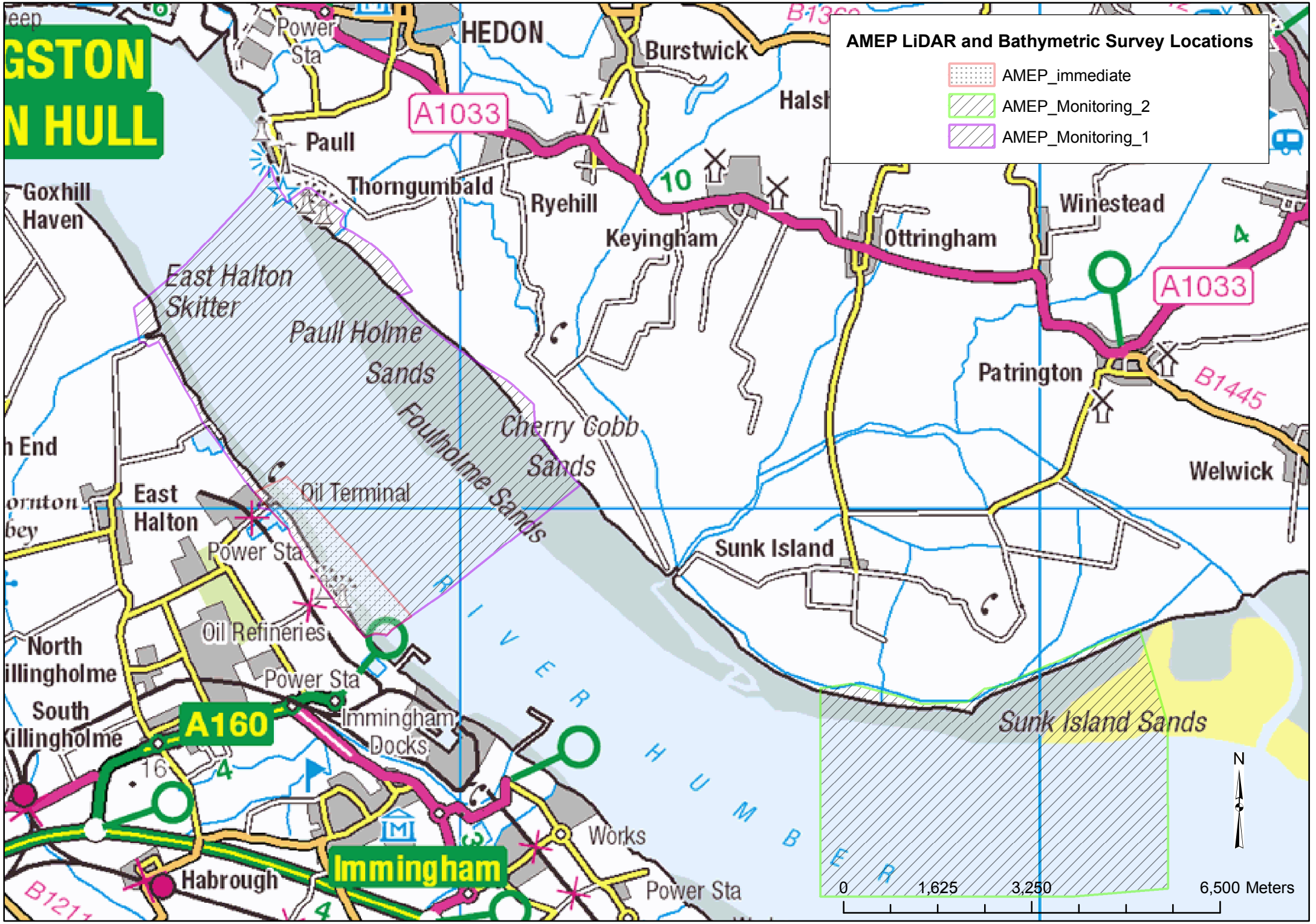
The error specification for LIDAR surveys is an RMSE of +/- 15cm.
Ground truth surveys for the checking of LIDAR height accuracy shall be carried out within each polygon.

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 B

Legal Agreement Monitoring Plan 6 proposed by the Environment Agency


AMEP LiDAR and Bathymetric Survey Locations
AMEP_immediate
AMEP_Monitoring_2
AMEP_Monitoring_1
A1033
A160
A1033
B1445
B1211
Power Sta
HEDON
Burstwick
Paull
Thorngumbald
Ryehill
Keyingham
Ottringham
Winestead
Goxhill Haven
East Halton Skitter
Paull Holme Sands
Foulholme Sands
Cherry Cobb Sands
Oil Terminal
East Halton
Power Sta
Oil Refineries
Power Sta
Immingham Docks
Immingham
Habrough
Works
Power Sta
Sunk Island
Sunk Island Sands
Patrington
Welwick
RIVER HUMBER
N
0
1,625
3,250
6,500 Meters

APPENDIX C

Water Framework Directive Guidance

Collecting and handling marine phytoplankton samples for Water Framework Directive and OSPAR

Collect from sample site

Rule	You must collect chlorophyll samples alongside each phytoplankton sample.
Collection frequency	Samples are collected every month for WFD and in the months May to September inclusive for OSPAR purposes. Samples not taken in a month can be collected up to, but not exceeding, seven days before or seven days after (known as 'catch ups') that month end. There must be at least a 10-day interval between sampling occasions at each site. **Note:** There is no value in taking 'catchups' beyond this period as the classification tool requires data to be representative of the phytoplankton throughout the year.
Method	**In waters of less than five metres depth** Take phytoplankton samples from just below the water surface avoiding the surface film and without disturbing bottom sediments. **In waters greater than five metres in depth** To obtain an integrated sample, use a hose across a wider depth range. For information on the equipment required and how to do this, see Taking an integrated water sample using a hose.
Bottles	Use plastic sample bottles of at least 200 ml capacity. 300 ml is the maximum volume to make transport easier and to minimise laboratory storage space and transport costs.

Add Lugols iodine

Competence of samplers

All samplers must be familiar with the COSHH assessment for Lugols. They must wear chemical resistant gloves and safety goggles/face shield when adding concentrated Lugols to a sample.

Actions

Follow the steps in the table below to add Lugols iodine to preserve the sample.

Step	Action
1	Obtain the Lugols iodine as a pre-prepared solution only.
2	Use only a few drops of Lugols solution to avoid overdosing. Figure 1 below indicates the colour required for good quality preservation while ensuring identification of cells is still possible. Insufficient dosing will cause deterioration in the sample. **Note:** The preservative can reduce over time, resulting in a paler solution. Ensure that samples stored for extended periods are regularly checked and further Lugols added as appropriate.
3	Check for samples containing large amounts of organic matter between 24 and 48 hours after collection. Add additional preservative to maintain the colour, if needed.

Figure 1

The photo below shows examples of phytoplankton sample preservation with Lugols iodine. The dark, straw coloured sample in the centre is the aim.

Label and complete logs

How to label samples

The steps in the table below describe how to label samples.

Step	Action
1	Label each sample clearly with waterproof writing. Use labels that match the sample tracking sheet information.
2	If salinity is low (<5 ppm), it is helpful to indicate this on the tracking sheet in the comments. It enables analysts to determine the likelihood of freshwater taxa being present.

Complete the sample log sheet

Follow the steps below to complete the log.

Step	Action
1	The following must be duplicated on the phytoplankton sample log sheet: ▪ sample location; ▪ survey; ▪ sampler name; ▪ time information. Include any exceptional information in the comments. **Example:** A highly turbid site, previous high rainfall or low salinity. It is important to complete all this information on the sample log sheet. This becomes part of a master sample-tracking sheet for use by the laboratory, the contract manager and the data entry officers.
2	Ensure that each container of samples has a sample log sheet with details of the samples that are in that container.

Storage and transport

Storage requirements

You must ensure the following storage requirements are met:

- samples must be stored in the dark;
- samples preserved in Lugols iodine can be kept at room temperature, provided they are analysed within three weeks;
- keep samples not preserved **between 1 and 4^{o}C**;
- log sheets must accompany each container of samples.

Retention periods

! Important Do not keep samples for prolonged periods. Analysis and quality of samples are affected if kept in storage for long periods (over a month), before reaching the laboratory.

Note: If there are only two or three samples then there is an allowance to keep samples for longer (up to four weeks) in order to send a bigger batch.

Additional samples

Full speciation is required for all WFD and OSPAR samples.

If any additional samples require ID, then it may be possible to analyse these on the national contract. You **must** contact the analytical contract manager (Luke Martina) to arrange this.

Taking an integrated water sample using a hose

Actions

The table below describes the equipment and technique needed to take an integrated water sample using a hose.

Step	Action
1	Ensure the bung is not in the tube end.
2	With the free end of the line attached to the vessel, lower the weighted end of the line vertically into the water.
3	Once the tube is down to correct depth (see Collection frequency), firmly secure the bung into the top of the tubing and carefully pull in the line.
4	Once the tube is above the surface, hold the end and direct the tube into the sampling can or bucket.
5	Release the bung. Then hold the tubing over your head while running hand-over-hand from the top end of the tube to the bottom end. This will ensure all the layers of water are included in the bulk sample.
6	Transfer the sample in the bucket to the sample bottle.

Water Framework Directive (WFD) saltmarsh monitoring

Introduction

Background information

The Water Framework Directive (WFD) requires the assessment of the ecological status of saltmarsh using the following three criteria:

- extent of saltmarsh;
- zonation of saltmarsh, that is pioneer, low, mid and upper marsh;
- species diversity of saltmarsh.

We monitor these three criteria through field survey and aerial surveillance from 1st June to 30th September.

The key pressure being assessed is that of morphological alteration to the saltmarsh.

Definitions

Position average

Fixing a point on a GPS, based on multiple point recordings over a set period of time.

Major community

A dominant community of an area. It may have smaller scale 'minor' communities within it, such as *Atriplex* along creek edges, but beyond the creek edges the major expanse is of a *Puccinellia* dominated plant community.

Minor community

A smaller scale change in community type found within a major community type e.g.*Atriplex* along narrow creek edges or grasses associated with a small elevated mound.

Important H&S note on walking across saltmarshes

Creeks and gullies start very small, becoming wider and deeper while heading seaward. There are two particular hazards to be aware of.

Narrow gullies

Narrow gullies can be indistinguishable under vegetation cover. Take care to check the ground ahead to avoid tripping or stepping into a gully and risking injuries to ankles and knees.

Walking across larger gullies

When crossing gullies/creeks, avoid walking across larger gullies/creeks if possible (by pre-planning the route using aerial photography). If entering a gully is unavoidable, ensure that:

- it is safe to stand in and that you have a ready route out either side;
- you have left sufficient time to walk off the marsh and cross the gulley/creek before the flood tide encroaches on the marsh.

Be aware of the tidal state and your safe egress route at all times.

Dynamic risk assessment

Carry out a dynamic risk assessment whenever conditions change, whether that is conditions underfoot or the weather (for example, fog can cause disorientation and block visual references). Before setting out on the marsh, confirm the route and direction (as bearings) you should take to exit the marsh safely in preparation for a change in conditions.

Summary of surveying methods

Field survey

The field survey method is designed primarily to provide the information necessary for diversity assessment of the marsh and secondarily to assist in the photointerpretation of the marsh. The field survey data informs photo-interpreters on the zones within a saltmarsh (through the plant communities identified) and the diversity of the saltmarsh (through the species found).

Field surveys are carried out along transects. The species and their percentage abundance is recorded in two $4m^2$ quadrats (2m x 2m), at sites along the transect. The percentage cover of species indicates the plant community. We also use the field visit to confirm the saltmarsh boundary.

Aerial survey

Aerial imagery is used for two purposes:

Pre-planning saltmarsh surveys

Photo-interpretation of saltmarsh extent and zones for classification

Field survey requirements

Access and timing

The pre-planning of the survey must identify and address health and safety issues particular to the site and the survey time.

Step	Action
1	Seek all necessary permissions to access the marsh from the appropriate authorities e.g. Conservation Agency, National Trust, MOD, private landowners and/or farmers;
2	Collate this information and keep it for future reference, updating it as necessary.
3	The survey window is from 1st June to 30th September. This is when saltmarsh plants are at their most floristic, most visually obvious and easiest to identify.
4	Plan surveys to take place during daylight on a falling tide. A rising tide is only acceptable if there is a known and tested safe route back at all states of the tide, taking into account inundation of creeks.

Transect location and intervals

The location of new transects must be done in advance to ensure they are located in safe and appropriate locations, avoiding major creeks. This planning requires access to recent or new aerial imagery.

Each transect must cover the seaward and landward extents of the saltmarsh. They must also be placed to cross over areas of the marsh which encompass the most communities possible (see Figure 1) usually by covering the elevational gradient. In most cases, this will be perpendicular to the coastline.

Ensuring that transects cut along this gradient requires pre-survey planning, using the most recent aerial imagery. However, transects should be placed primarily to address H&S issues such as avoiding large creeks, having to cross a lot of creeks or any other hazards identified in the pre-survey planning.

Figure 1

Example of where you might place transects (white line), approximately every 0.5km (green) along a marsh, avoiding large creeks, but capturing as many plant communities as possible.

Equipment list

This list is not intended to be exhaustive but lists important items for carrying out saltmarsh field work. Use this with the equipment list in the Intertidal soft sediment operational instruction.

- standard lifejacket;
- EGNOS-enabled GPS and compass;
- digital camera;
- spare batteries;
- whistle;
- reliable mode of communication with StaffCall and Emergency Services (fully charged);
- ordnance survey map;
- print of aerial imagery (laminated or in plastic sleeve);
- plant ID guides;
- tape measure/poles for marking out quadrats;
- saltmarsh field recording sheets which can be found in the
- weather-proof clip board;
- range-finder such as a laser range finder – useful for projected distances.

Field sampling protocol

For field data requirements, there are four categories of information that need to be recorded along a transect. The methodology for each of the categories in this list is described below.

Category of information	What is required
The most landward and seaward saltmarsh points	GPS position average fix, target notes
Major community transition points*	GPS position average fix, target notes
Quadrat sample sites in major communities	GPS position average fix, quadrat data, target notes, sward height, bearings to features, photo – always taken seaward
Additional species diversity information	GPS fix, target notes

Landward and seaward points

The landward and seaward points represent the maximum extent of the saltmarsh at either end of the transect. These positions mark the top of the upper zone landward and the end of the saltmarsh seaward for each transect.

Action in the upper zone

The upper zone demarcation represents the end of saltmarsh plants, often at the foot of a seawall, or the transition from saltmarsh plants to terrestrial plants. Where a transition with terrestrial plants exists, mark the position at which saltmarsh plants become less than 5% of the predominantly terrestrial community. You can determine this by using the quadrat.

Action at the seaward end

At the seaward end of the transect, the final demarcation will be where the saltmarsh vegetation cover has become so sparse it covers ≤5%. Again this can be determined using the quadrat. Only mark and record the edge of the pioneer zone *in situ* where it is safe to do so. Take a projected position in circumstances where it is unsafe to walk to the end point of the marsh.

* Please note that this was formerly down in this table as “minor” transitions. This should have been major and is updated as such in this version.

Defining major community transitions

When plant communities have changed distinctly from the previously sampled community, consider this a major community transition point to sample. Along a transect line, you should sample every major community. If you are uncertain as to whether an area is another distinct community, sample the vegetation using a quadrat. Move well into the distinct community, then make your quadrat recordings.

Example of marking a transition point: Where a homogenous area of *Atriplex* dominated marsh fades into a *Spartina* dominated marsh.

Locating major transition points to survey, can be a difficult task and may not always be easy to pinpoint because of the fuzziness of community transitions. A 'best guess' of the midpoint of the transition is acceptable and will aid in the mapping of the vegetation. If the mosaic nature of the marsh means that changes are consistently taking place, then one GPS position average fix, along with a target note describing the consistent changes, will suffice.

Avoid transition zones between major saltmarsh communities when sampling. However a GPS position average fix and description is still required, see below for more detail.

For new transects: As a guide, sample a minimum of four sites along every transect. This relates to an expectation that there will be a pioneer, low, mid and upper zone, and as such, at least four distinct plant communities should be present. More commonly, transects will contain more than four sample sites, they may contain less.

Whether quadrat record is needed

A quadrat record is associated with, 'a major community change'. View community changes at the appropriate scale for sampling.

Example: In many marshes, a small-scale localised community may be found repeatedly at creeks, such as *Atriplex*, in a few centimetre border along the edge, while the remaining dominant vegetation over 30m^2 is *Spartina*. For this, you would only record the distinct large-scale *Spartina* community and just note any community changes at the smaller scale, *Atriplex*.

Quadrat sampling methodology

Move well into the distinct community, then make your quadrat recordings.

Samples are the percentage of species within a 4m^2 quadrat. Percent cover may be rounded to the nearest 5%. Where a species present is less than 5% cover, it should be round down to 1% cover.

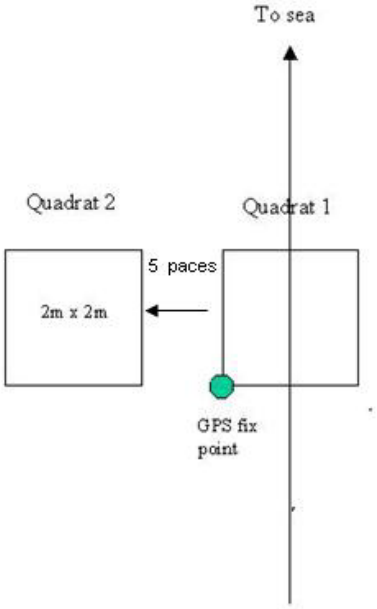
The total percentage can be greater than 100% where the plant community is canopied.

Example: Finding *Bostrychia scorpioides* at the base of *Atriplex portulacoides*.

Step	Action
1	Assess two 4m^2 replicate quadrats at each sample site (see Figure

	2).
2	Mark out each quadrat area and assess each in turn. Use a tape measure and mark out the $4m^2$ area or use pole(s). Fibreglass tent poles have proved very useful and can be collapsed and packed away in rucksacks when not in use. For consistency, number the replicates in the order given in Figure 2.
3	Take a GPS position fix average for at least one minute. When taking position fixes, place the GPS on the ground, away from obstructions including your own body so that as many satellites as possible can be picked up and the accuracy of the fix maximised. Ideally, take position fixes close to the bottom left hand corner of the first quadrat, the top of this quadrat being seaward. **Note:** No position fixes are required for the second quadrat.
4	Place the replicate quadrat either side of the first quadrat, and about five paces away from the edge of it.
5	Record each species present and its percentage cover to the nearest 5% (any result <5% can be recorded as 1%).
6	Take at least one digital photograph of the quadrat and log this for future reference and quality assurance. Always take photos facing seaward.
7	To aid the photo-interpreter and maximise the site position accuracy, record any additional positional information. In the notes section of the field recording sheet, describe the position of the site in relation to features of the marsh using a compass bearing. **Example**: Quadrat 1 at waypoint X is positioned approximately 3m southwest of a large creek cutting across the marsh from north to southeast. Other features that can be used as a reference are a distinct area of particular vegetation cover, for example *Spartina*, or man-made features such as a sea wall, old defences or gates. Repeat for every site.
8	Record sward height at each site. Take at least 3 readings to within 5cm accuracy and provide the average.
9	Only visit the low marsh if it is safe to do so. In circumstances where it is not possible, describe the site using binoculars and a range-finding device from which the co-ordinates of the projected position can be calculated. If this is done, note that the position was not fixed and is only a cursory point.

Figure 2 Representation of the position of quadrats at a sample site on the transect and the position from which to make a GPS fix.


To sea
Quadrat 2
Quadrat 1
5 paces
2m x 2m
GPS fix
point

Species diversity

The table below describes what to do to identify species diversity. In late 2011 a revised species list, which will reduce the number of species that need to be identified, is expected. Until this time the original provided list should be used. Surveyors should be aware of the species encountered in previous surveys and only identify down to a level they are confident. Take a specimen back for further ID if necessary.

Step	Action
1	As you walk along each transect, note additional species which have not been recorded in the quadrats sampled so far. The total list of saltmarsh species found on the marsh while walking the transects will be used in the species diversity assessment.
2	You must include further species identified while walking between the transects.
3	If you cannot identify plants, take photographs and make notes of the position they were found on the marsh.
4	Take a sample of the plant (if it is plentiful) and place in a plastic bag.
5	Ask a botanist working in your area , for their help in identifying the plant species.
6	Additionally, at each site sampled, note any evidence of possible negative indicators, such as: ▪ banks; ▪ walls; ▪ grazing; ▪ vehicle track damage; ▪ bare areas due to trampling; ▪ artificial drainage channels; ▪ turf cutting; ▪ evidence of accretion or erosion; ▪ *Spartina anglica* swaths; ▪ *Enteromorpha* mats; ▪ signs of pollution.

GPS protocol

To undertake a precise transect, use the project waypoint feature in your GPS. To do this use the compass bearing you want to take across the marsh and the distance (range) you want to walk. With this information, the GPS can display a line for you to keep to that will help you to walk the transect as accurately and efficiently as possible. Determine the range and bearing using maps and aerial surveillance imagery, programme it into your GPS during survey planning. It is usually best to enter an over-estimate of the range; however the bearing must be precise.

Alternatively, you can enter a start and end-point if both are known, removing the need to create a projected point.

Keeping to a programmed line will avoid the risk of meandering, which can occur when a bearing alone or 'go to' GPS function is relied upon. Take care to look out for hazards.

Aerial survey information

Collection of aerial survey data

The specification for aerial survey data to be collected includes:

- resolution of at least 25cm;
- red green blue (RGB);
- imagery taken in daylight, at low water, preferably on a spring tide, in order to capture the full extent of the saltmarsh;
- stable lighting conditions throughout the period of photography, meaning there should be little or no cloud shadow.

It may be necessary to use data that does not meet this specification, but such data will be in the minority.

Analysis

How we use data

MMS will determine the extent of each saltmarsh from the aerial photography and the fieldwork information available.

The plant communities in each quadrat will be derived from the species and percentage cover records. These will be used to help map the pioneer, lower, mid and upper zones of the marsh. The zone areas will be calculated and an assessment made of whether sufficient zones are present. The National Vegetation Classification (NVC) scheme will be referenced for plant community identiification and this will feed into determining zones.

The diversity of the marsh will be derived from the species information gathered during the field survey.

Other organisation such as CCW and Natural England will use this data for their own Protected Site condition assessments and may even collect their own data. It is therefore opportune to integrate your field surveys with any locally planned by these organisations. Making these teams aware of your survey plan can provide additional WFD data or resource efficiencies for both you and them.

Sampling macrobenthic invertebrates in Water Framework Directive (WFD) Transitional and Coastal Waters

Sampling must be carried out by /or under the supervision of fully competent staff.

The technical lead must also understand the survey design requirements of the classification tool.

Collect samples during Spring (1 February – 31 May). If sampling encompasses CSEMP sites then align time of sampling with the collection of the Clean Seas Environment Monitoring Programme (CSEMP, previously called NMMP) benthic invertebrate samples.

The methods are based on collecting a number of single samples from soft sediments within a waterbody.

Prior to any field sampling, undertake a desk study to identify indicative sampling points within a waterbody. Ecological judgement in the field will ensure that the indicative points are suitable for assessment.

If a waterbody has previously been sampled for WFD, use the information gathered previously and make use of the positions, there is no need to do a desk study from scratch again. Ensure the number of samples collected is in line with what is specified in the WFD transitional and coastal waters monitoring programme as it may differ from previous year.

Waterbody information

Collect information for the water-body (WB).

Stage	Description
1	Identify WB boundaries and pressures – through the risk assessment or local knowledge.
2	Identify ‘allowable zones of effect’ for point source pressures.
3	Identify any protected areas/habitats within the WB, which must be avoided when using destructive sampling methods.
4	For transitional waters, establish indicative salinity zones (oligohaline, mesohaline, polyhaline) using any historic bottom salinity data, WB salinity models and where necessary, any anecdotal evidence.
5	Overlay any sediment information for the WB (particle size analysis (PSA) data, navigational charts, habitat maps, sediment maps (for example, MESH)
6	Identify any established benthic invertebrate sampling points in the WB (for example, CSEMP).

Suitable sediment

Select suitable sediments.

Stage	Description
1	Establish where the soft sediment habitats are.
2	Consider the pressures acting in the WB that would act on the benthic invertebrate community. Are any of the defined habitats in the WB especially sensitive to the impacts from these pressures? (Refer to information available on MARLIN website.)

Indicative sampling points

Select indicative sampling points.

Stage	Description
1	Monitoring is primarily aimed at surveillance monitoring but must also consider operational pressures where they have been identified in the WB. Therefore place samples near but outside, any 'allowable zone of effect' for licensed pressures in the WB that would act on the benthic invertebrate.
2	Aim to spread sampling points as widely as possible. Expert judgement must be used to balance the spatial spread of samples (surveillance) with targeting around identified pressures (operational).
3	Samples should have as broad and even spatial spread as logistically possible within a waterbody.
4	Where possible select existing sample point locations
5	If sampling inter-tidally select mid-shore locations in order to standardise emersion/immersion times.
6	Where a coastal survey vessel (CSV) is being used for a sampling platform, send indicative positions (NGR) to the relevant survey officer.
7	Sampling points are only indicative until confirmed by field sampling.
8	If sampling is carried out in a conservation area, the relevant groups (Natural England or Countryside Council for Wales) must be notified of the survey plan and their comments incorporated into the survey design.

WFD field method

Step	Action
1	Take two samples at each station, one for benthic invertebrate abundance analysis and one for PSA
2	For WFD monitoring (surveillance and operational) only benthic invertebrate abundance is required, biomass is NOT required. Where a sample is used for both WFD and CSEMP assessment, it must be assessed primarily as a CSEMP sample to ensure the measurement of biomass.
3	You must sieve benthic invertebrate samples to: ▪ 1mm in coastal WBs 0.5mm in transitional WBs.
4	Start sampling at indicative stations identified in the desk study. Locations may need to be moved if the habitat is inappropriate
5	Label samples in consecutive order, and sample labels must match survey log labels (avoiding any requirement for re-labelling samples, which can introduce errors in to the datasets).
6	Collect PSA samples from a separate grab/core at the sample location, and process them according to standard methods (depth integrated sample from zone inhabited by invertebrate community, 300 - 500ml material required, PSIZC pot as of 1 April 2008). Ensure that the PSA sample is consistent with the biological sample..
7	Supporting parameters must be recorded as for the benthic invertebrate sample.

Inter-tidal sampling

- To obtain a sufficient volume of material when using an inter-tidal hand corer (0.01m^2), take three cores at each station for the benthic invertebrate sample. Combine these in the field to form a single sample at the station.
- You can use rubble sacks (strong plastic bags), fastened using a cable tie, to transport samples to a suitable sieving station.
- Ensure that a waterproof sample label is included.
- Take samples at a consistent tidal height (mid shore position maintained).
- Take a digital image of the sediment surface prior to coring.

Supporting parameters

Record the following information for each sample:

- station code;
- NGR Easting (six digits, including leading zeros);
- NGR Northing (six digits, including leading zeros);
- sampling date;
- sampling time (GMT);
- water depth (m) (insitu) at time of sampling;
- depth relative to Chart Datum (+/- m, drying areas are denoted by a negative value);
- salinity (insitu) [bottom measurement] at each invertebrate sample site (transitional waters only) – for intertidal sampling measure interstitial salinity using a hand-held refractometer, record refractometer salinity against det code– 4760;
- Follow quality control measures for salinity measurements taken by probe or refractometer. Use a salinity standard to test the equipment.
- time of high water, the time of the previous high tide
- time of sampling relative to previous high water (hrs) (relates to number of hours and minutes after high water when sampling occurred);
- sediment description (include EUNIS description if known);
- depth of sediment in grab/core (cm);
- depth of RPD layer (cm);
- digital image of sediment in grab/sediment surface (image ID code = station code and date (use a,b,c if multiple photos taken), include sample label in image;
- where time allows, record images of the sample following sieving as this allows information for the cost quotation and rapid assessment of samples (may be needed for first level reporting if data is not available), include sample label in image.

Quality assurance

For sample analysis, all contractors must demonstrate a high level of internal analytical quality control (AQC) of samples..

Technical reference material: mapping marine plants for Water Framework Directive (WFD)

Operational instruction **Issued** 05/07/07 **Review due by** 05/07/08

1 Background

1.1 This document provides generic guidance on survey planning and sampling, for the WFD surveillance programme marine plants mapping surveys. It supports individual instructions provided for each of the marine plants tools. This information is common to each of the tools and consequently has been produced as a separate cross-cutting document.

1.2 This document assists decision-making on the design of the surveys, implementation of field and aerial surveillance and generic information on undertaking field surveys. This is done by providing options for survey design and implementation. When this document is read with the specific tools guidance, it will ensure appropriate and consistent survey methods will be applied.

1.3 This guidance supports more detailed instructions on what to measure and how, as given in the individual documents for each plant group. It applies to all staff (including external contractors) undertaking mapping surveys in Transitional and Coastal (TraC) water bodies for the surveillance of:

- Opportunistic Macroalgal beds
- Intertidal Seagrass beds (to be published)
- Saltmarshes

1.4 Information from these surveys is used to assess the impact of nutrient enrichment, and changes to the shoreline in transitional and coastal waters. These assessments are used to classify waterbodies and will help determine where mitigating action is needed.

1.5 These marine plant categories have a number of monitoring requirements in common. They all are found in the intertidal zone (with similar resources and H&S issues), they all require a measure of extent and diversity, and they all can make use of aerial mapping techniques.

1.6 **2007 Aerial flight Programme**

The National Marine Monitoring team (NMMT) has collated the major aerial monitoring programmes going on in 2007 for the Agency, for the purposes of linking with aerial surveillance needs for saltmarsh assessment. The programme of flights for saltmarsh surveys will therefore be assured at a national level.

There may be the opportunity to use this programme of flights to provide aerial information on macroalgal or seagrass extent. Those responsible for delivering these surveys for WFD should contact Sarah Peaty or Niall Phelan on 7 50 4332.

Document details

Related documents

Feedback

Contact for queries

Sarah Peaty
7 50 4332

2 Key Safety and competency requirements

2.1 Field surveyors should be competent in the use of GPS and understand the sources of error and bias in the techniques they use.

2.2 Field surveyors should be familiar with the Intertidal GRA and Instruction on Soft sediment work if undertaking work in soft sediment environments. The control measures must be followed.

2.3 Field surveyors should be able to demonstrate an understanding of tides and tide tables – this can be achieved through e-Learning course – Understanding Tides and Tide Tables.

2.4 Surveys should always be planned in advance to ensure a safe survey method, time, site location and tide state, and adapted as necessary according to the conditions on the day.

2.5 Ensuring you are in a safe location when the tide begins to flood is essential.

2.6 You must ensure you are aware of your safe egress route at all times.

2.7 Use of crafts such as small boats should be considered if this provides a safer means of site access.

3 General sampling requirements

3.1 The plant groups listed in paragraph 1.3, all require a measure of total bed/marsh extent and a measure of species present.

3.2 There is also a measure of percent cover for seagrass and macroalgae and zone extent for saltmarsh.

3.3 Various supporting data is required which, alongside much of the diversity and percent cover information, can only be obtained with the use of field surveys.

3.4 Aerial mapping provides a means of obtaining information (particularly on extent) from a larger scale and from terrain difficult to reach by foot.

3.5 All aerial surveillance requires ground-truthing of the data.

3.6 Therefore a combination of aerial and field surveys are required, but a full field survey may replace the need for an aerial survey if local circumstances permit full access to the site.

4 Survey preparation and preliminary site visit

4.1 Follow the decision-tree given in Figure 1, which provides assistance in planning your survey. The steps are elaborated in the points given below.

4.2 For each identified water body, gather information on location and extent of bed/habitat to inform the preliminary site visit. This may be from historical information in Urban Waste Water Treatment Directive reports, aerial photographs, satellite or similar images, or other historical data of affected areas.

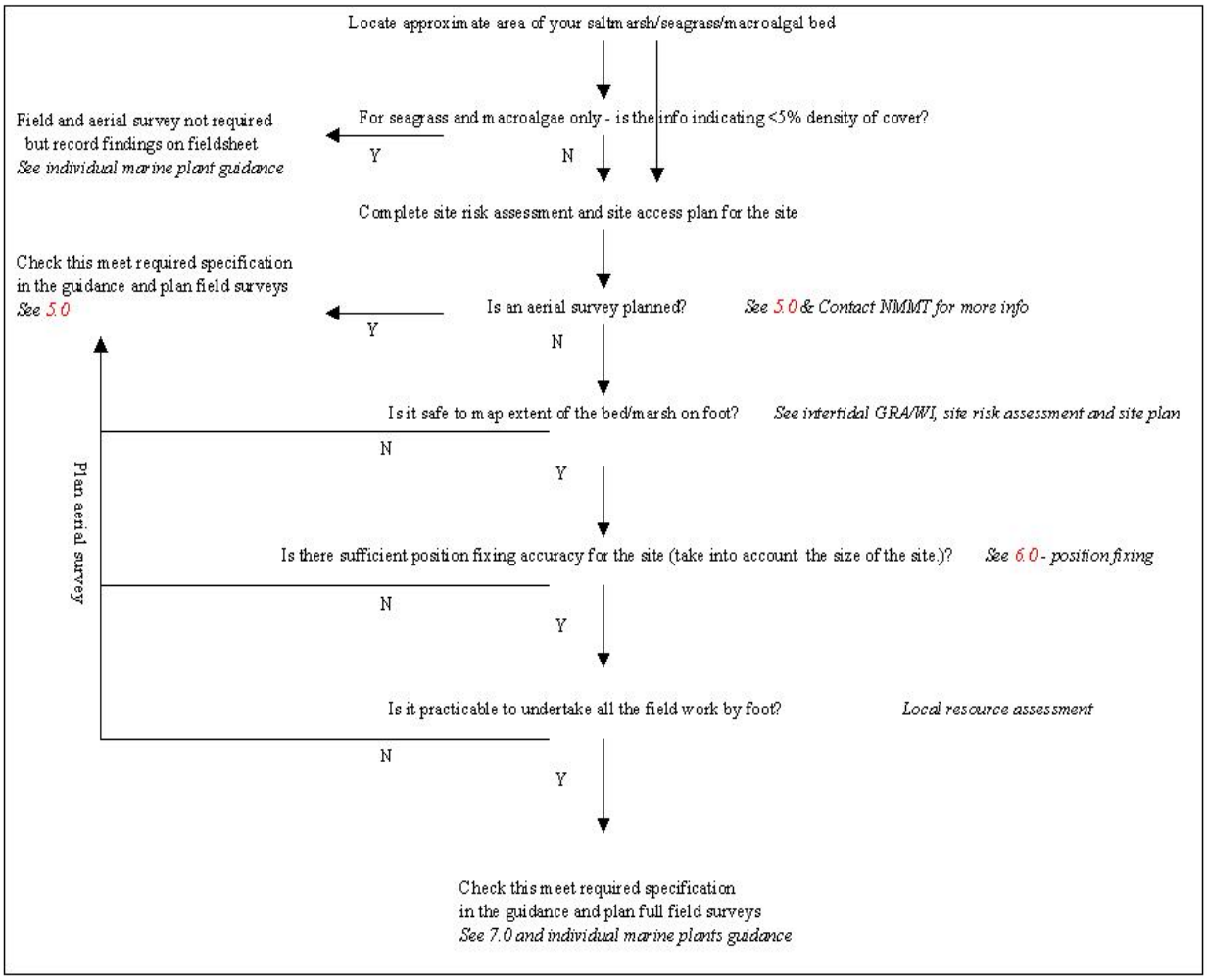
4.3 Confirm compliance with the Generic Risk Assessments for Working in or near water, Inter-tidal soft sediment (if applicable), lone or remote working and their related instructions. Carry out site and task risk assessments for Health & Safety, and implement any necessary H&S measures.

4.4 Undertaking a full survey on foot (or with partial access by vessels), must be decided taking into account the size of the area to be surveyed; the H&S risks for that entire area and the available resources.

4.5 A preliminary site visit should be made to establish, semi-quantitatively, if the percentage of macroalgae or seagrass cover is significant (see individual guidance). Conduct a general visual assessment establishing the approximate perimeter of the

cover. This will also help determine the best way to monitor the site (e.g. field survey, aerial, optical etc) for any more intensive survey.

Figure 1: Flowchart of decisions when planning a mapping survey



4.6 As a general guide, beds smaller than 10 hectares should not be measured without other methods in place to improve the field position accuracy to within +/- 5%. This is because the error as a percentage of the whole bed is very high when using simple handheld devices. See section 6 for more information on position fixing.

4.7 Such accuracy is not considered sufficient for CASI ground-truthing where a fixed base station may be necessary to improve the station accuracy to match a pixel resolution.

4.8 For very small sites that are readily accessible and can be covered by foot using few resources, remote-sensing work is not considered a mandatory requirement. Since, as a guide, sites smaller than 1 hectare could be comprehensively assessed by foot with limited resources and then transferred to GIS format. This GIS transfer step still depends on getting good position fixes of the survey area. How GPS accuracy can vary and be improved with different techniques is covered in section 6.

4.9 Based on the preliminary site visit the more intensive survey (if required) can be planned, including: amount of fieldwork required to safely survey the area during one low-tide exposure; number of transects, quadrats, etc required to satisfactorily survey the site.

4.10 See individual guidance for intertidal seagrass (to be published), opportunistic macroalgae and saltmarsh assessments to establish detailed needs of each survey.

5 Aerial survey/remote sensing techniques

5.1 Various techniques may be used to obtain views or images of intertidal beds from a distance. Some of the advantages and disadvantages and their applicability to WFD surveys are summarised in table 1 on the next page. Decisions about which technique is most appropriate will depend on what other information is available, the accessibility of a site, and the funding / manpower available. Further information on each technique follows below.

5.2 Aerial photography

5.2.1 Digital vertical aerial photography is slightly more cost-effective than traditional print photography as it omits the stage of scanning prints and any associated loss of resolution. It is important to ensure adequate resolution is achieved. The following need to be standardised:

- Height at which survey is flown (e.g. 1,500 metres)
- Scale of photography (e.g. 1:3,000)
- Photos to incorporate fiducial (position reference) marks
- GPS location to be given for plane at time of photography
- Photos to be taken at time of low tide +/- 2 hours, preferably a spring tide
- Photos to be taken at similar time of year, generally to cover time of peak biomass,
- Geocorrection – this should be carried out by qualified personnel
- Guidelines for drawing around algal mats – where ground-truthing data exists, this can be done for different percentage cover bands (as specified earlier). If done purely from images, there is clearly a lower degree of accuracy, but this will give some idea of the density of the mats.

5.2.2 Oblique aerial photography introduces further variables into the approach since it is difficult to provide sufficient data for each image to allow for accurate geocorrection.

5.2.3 Also the correction needed (either by eye or electronically) is more extreme and therefore has a greater inaccuracy associated with the final result. Vertical photography should always be preferred over oblique photography

Table 1 : Summary of remote sensing techniques relevant to the mapping of marine plants.

Method	Comments	Potential Accuracy	Aerial only cost (estimates)	Applicability
Standard colour (RGB) Vertical Aerial survey using standard or digital camera	Simple technique; important to ensure adequate resolution is achieved. Weather dependent. Separate ortho-rectification (OR) and data analysis stage. Ground-truthing required.	High	Low/ Medium	Highly appropriate for quality WFD mapping across a range of habitats
Standard colour (RGB), Oblique aerial photography	Technique suited to coverage of smaller locations. Weather dependent. Separate OR and data analysis stage. Ground-truthing required. Quality of final data when compared to vertical photography depends on variation from the horizontal and ability of OR process.	Medium	Low	Appropriate when lower mapping accuracy is acceptable. Can provide high quality WFD data only when provided alongside full ground surveys or if stage can demonstrate appropriate quality of data is achieved.
False colour imagery (FCIR)	Capable of giving high quality data if undertaken in conjunction with appropriate ground-truthing. Requires expert interpretation. Weather dependent	High	Medium	Appropriate for a range of habitats but better for saltmarsh than macroalgal communities
Compact Airborne Spectral Imager (CASI)	Highly weather dependent. Data interpretation can be provided from survey outputs. Specific and often intensive ground-truthing needs with high GPS accuracy requirements	High	Medium/ High	Highly appropriate for all mapping work
Satellite	Spatial resolution 0.6-4 m Swath width <30 km Kelp, *Zostera*, *Fucus* and *Cladophora* give similar signal. Need to process images & requires ground-truthing. Time restricted	High	Medium / high	Quality of data limited. Difficult to differentiate plant types, therefore only acceptable when used with extensive ground surveys, or where site is known to be dominated by single plant species or genera.
Telescopic surveys	Rapid assessment of sites where access is restricted. Ideally needs concurrent ground-truthing survey	Low	Low	Poor quality in terms of mapping, but useful for initial ground survey assessment e.g. where are beds? Are they <15%?

5.3 Infra-red

5.3.1 This technique is capable of giving high quality data if undertaken in conjunction with appropriate ground-truthing.

5.3.2 False colour infrared aerial photography at 1:10,000 and 1:3,000 scale have been used in the Solent region in order to detect temporal and spatial changes. The survey involved the production of a topographic and vegetation map of the harbour at 1:5,000 scale. In all, 20 species groups were mapped, including *Zostera*.

5.3.3 Technical details are similar for aerial photography and include:

- Images will have 60% fore and aft overlap and 25% lateral overlap
- The surveys must be undertaken around LW during the spring tides at the period of peak plant blooms. Flights at or near dawn or dusk should be avoided.
- Surveys should be restricted to 1 hour before and 2 hours after low water.
- The effects of cloud cover and shadow must be minimised.
- A combination of FCIR and full colour Red-green-blue (RGB) photography is a useful combination to assist validation of the FCIR results.

5.4 CASI (Compact Airborne Spectrographic Imager)

5.4.1 Guidelines for the conduct of CASI surveys and associated ground-truthing can be found on the Easinet, Science enterprise Centre - CASI and in Ground Data Requirements for CASI Remote Sensing Surveys.

5.4.2 CASI is capable of giving high quality data if undertaken in conjunction with an appropriate amount of ground-truthing. Clear conditions are essential for CASI flights. Ground-truthing is done following the CASI survey, and the amount and location is directed by the CASI validation needs. The window of time to carry out ground-truthing is limited as ground-truthing is needed soon after the survey, therefore those carrying out the ground-truthing need to be flexible in case flight times change.

5.5 Satellite imagery

5.5.1 Satellite imagery, e.g. Quickbird, IKONOS, has a coarser resolution than photography or CASI, but ground truthing requirements are similar, with some optical measurements also necessary. Image capture requires cloud-free conditions, with image collection limited to the short period of time the satellite passes. The resolution is not always as good as for techniques using aerial flights.

5.6 Constraints affecting all aerial remote sensing methods

- Cloud cover - makes interpretation of images more difficult and in particularly cloudy circumstances, impossible.
- For temporal assessments, images should be taken at a similar time of year covering the time of peak biomass, unless local knowledge shows a different pattern of growth, e.g. there can be a bi-modal occurrence with biomass peaks in spring and late summer.
- Images need to be collected at a time when the habitat is exposed by the tide, which may require a low spring tide.
- All methods require ground-truthing

5.7 Telescopic method

5.7.1 Nedwell *et al*. (2002) surveyed opportunistic macroalgal blooms in the Deben estuary using a telescope (x 50 magnification) from the opposite shore. Several

fields of view observations were made along transects down the intertidal. Presence or absence was determined, but not density. It may be possible to adapt this method to field surveys of areas of limited access; e.g. very soft sediment.

5.7.2 This approach could be most useful as a screening survey – where the presence of the marine plant is minimal (<5%), but needs confirmation.

6 Position-fixing on site

6.1.1 It is a requirement of WFD to be able to provide a measure of risk of misclassification i.e. uncertainty in the results. For this, we must know the accuracy of the approach at each stage, and to improve this if necessary.

6.1.2 Position fixing during the field surveys is critical to the overall accuracy of the data. Any global positioning system (GPS) should be set-up correctly (see manufacturers instructions) and the accuracy limit noted whilst on site.

6.1.3 Past experience has been to either use a simple hand held GPS or to use a base station with a GPS. The second approach is a requirement for ground-truthing CASI surveys.

6.1.4 A GPS is required in all of the WFD marine plants work. The WFD surveys relevant to this document include saltmarsh surveys, nuisance macroalgal, seagrass surveys.

6.1.5 A GPS system measures the distance from at least three satellites to the receiver by timing how long it takes a radio signal to reach the receiver, then calculating the distance from that travel time. The known location of satellites along with a triangulation function enable the location of a GPS receiver to be calculated within the handheld. A very useful tutorial on GPS may be found at: http://trimble.com/gps/whatgps.shtml .

6.1.6 The factors that must be considered to ensure that an acceptable level of accuracy is maintained in WFD field surveys are discussed below.

6.2 Basic considerations for maximising GPS accuracy in the field

6.2.1 There are several factors that must be considered in field surveys in order to maximise the accuracy of a GPS during these surveys. All of the WFD surveys require accuracy when position-fixing on site of at least 10m, therefore it is crucial that field surveyors consider all factors listed in this document to achieve the required accuracy for the survey type in question.

6.2.2 The local environment strongly influences GPS accuracy. Forested areas or surveying amongst tall buildings will result in greater inaccuracies in GPS fixing. Most TraC waterbody surveys however will take place in open, uncanopied spaces so this will not be an issue.

6.2.3 Users in Europe now have available a geostationary satellite that corrects the accuracy. This is called EGNOS and most new GPS have this service. EGNOS enabled GPS ensure accuracy <10m variation, which is a critical level for any WFD survey work.

6.3 Accuracy of readings on a GPS

The declaration of the accuracy by GPS receivers can lead to confusion. On an average reading, you may find an accuracy of 4 m. This readout refers to the 50% CEP (Circular Error Probable) which means that 50% of all measurements are within a radius of 4m. On the other hand, 50% of all measured positions are outside of this radius. Furthermore, 95% of all measured positions are within a circle of twice this radius and 98.9% of all positions are within a circle of 2.55 the radius. In this example, nearly all positions are within a circle with a radius of 10 m. The determined position is in the worst case accurate to 10m.

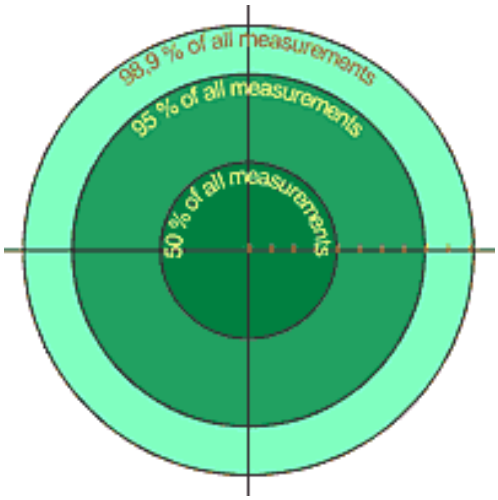


Figure 2: This picture explains what the accuracy on a GPS receiver indicates

6.4 Core considerations for maximising the accuracy of the GPS

- Use an EGNOS-capable GPS and ensure the EGNOS enabling is switched on.
- Confirm differential reception on the satellite signal strength (letter 'd' on a Garmin device)
- Position average (at least for 1 minute) - this option is available on all new GPS devices – at fixed points.
- Use other readings to further improve position fixing such as taking bearings and distance readings from key features

7 Ground-truthing

7.1 Ground-truthing provides a check on the mapping assessment to ensure the interpretation of the aerial data is accurate and reflects the true conditions on the ground.

7.2 Ground-truthing is always required to validate any aerial survey data. This is done in addition or alongside any other field survey.

7.3 Ground-truthing for CASI surveys meets a specific need driven by results from the aerial survey data. The requirements for ground-truthing for CASI are given in the document Ground Data Requirements for CASI Remote Sensing Surveys.

7.4 For other techniques, ground-truthing confirms what the human eye is seeing prior to any image analysis. In these cases, the surveyor may assess suitable locations for ground-truthing directly from recent photographs.

7.5 In these cases, it may be possible to use photographs from the year before to make this assessment of locations, if the photographs from that survey year are not available soon after the flights has been completed. If this is done, then a check on the images taken for that year must be made to ensure all appropriate locations across the current extent of the bed were covered.

7.6 Ground-truthing for aerial surveys can be incorporated into the design of the overall field survey for the collection of additional diversity and on-site density information.

7.7 The Ground-truthing survey must include a range of locations within the bed, across a range of community (for saltmarsh) or density (for macroalgae & seagrass) values. For CASI surveys this is defined by the mapping outputs. For all other work, the survey design must be at least randomly stratified. Fully random is not always logistically

possible although it provides greater validity. See sections on quadrat survey and transect surveys for more information.

7.8 Where ground-truthing is not possible, photographs of the chosen quadrat area should be taken and linked to the aerial photographs or remote images as an alternative. However, this should only be used where access is restricted for health and safety reasons and not considered as a means of providing appropriate quality data routinely.

7.9 Ground-truthing must also check where the perimeter of the bed or patch is and also identify any zone boundaries (saltmarsh).

7.10 The precise edge of a bed can be indistinct and in some instances fragmented patches or habitat mosaics may exist. In such cases a subjective decision needs to be made, supported by descriptive notes and photographs

Note: Past data using aerial surveys with insufficient or incorrect ground-truthing has resulted in widely changing estimates of bed extent or community-type which has led to large errors in maps.

8 Full field surveys – general considerations

8.1 Field surveys on the ground provide a source of data that cannot be obtained from remote sensing e.g. biomass measurements of macroalgae.

8.2 They are also the alternative survey approach instead of using remote sensing techniques. In this case, a full field survey is required.

8.3 When mapping full extent, the precise edge of a bed can be indistinct and in some instances fragmented patches or habitat mosaics may exist. In such cases a subjective decision needs to be made, supported by descriptive notes and photographs

8.4 The use of quadrats is common to all the marine plants mapping. They are used to define a known area for detailed assessment.

8.5 When doing a full field survey to assess percent cover and biomass, you need to ensure you select a range of different cover. As for the ground-truthing field work, the survey design must be at least randomly stratified. Fully random is not always logistically possible although it provides maximum validity.

8.6 Quadrat size, number and location must be appropriate to enable estimates of the real variance in cover and density. See individual marine plants guidance for details.

9 Related documents

- 426_05 Working in or near water
- 193_06 GRA – Intertidal Soft Sediment
- 13_07 Intertidal Soft Sediment
- eLearning – Understanding Tides and Tide Tables
- 138_07 Ground data requirements for CASI remote sensing surveys
- Science enterprise Centre - CASI
- GPS tutorial
- 200_07 WFD Saltmarsh Monitoring
- 201_07 Opportunistic Macroalgal Bloom assessment for WFD in Transitional and Coastal Waters
- Surveying Intertidal Seagrass for WFD (to be published)

WFD Fish Methodology

It is suggested that a team of two field staff are deployed for one day at each of the four sites to observe inundation of the developing saltmarsh during the incoming tide. Surveyors will record the grid references of suitable access points and creeks where fyke nets can be positioned to catch fish on the flood and ebb tides. The survey will also facilitate an on-site risk assessment to identify the main health and safety issues of concern including water depths and velocities, access points, inaccessible areas and areas of soft sediment. This baseline appraisal will then be used to inform and specify any measures required to optimise safety. While the main focus of this initial reconnaissance visit should be site safety, it is further proposed that if opportunity allows, some initial fisheries data are collected using a 10 by 3 metre micromesh seine net. Where feasible, samples will be taken within ponded water remaining in depressions on the salt marsh during low tide. Such a strategy was found to compliment the main survey design at Freiston MR with the catches providing a good representative of the range of species entering and leaving the site with the tide (Brown, Pinder et al., 2007).

A summary report detailing the findings of the site visits (including field maps or sketches and photographs where appropriate) and a full method statement will be produced. Tide Plotter software will be used to attain the timings of spring tides and thus report the most appropriate survey windows. Results will also be used to inform the production of risk statements for future survey work.

The knowledge attained during the proposed site reconnaissance visit will allow an optimised survey design to be executed. Thus, the proposals presented below are indicative only and may be subject to change based on the outputs of deliverable one.

It is proposed that the sampling strategy will follow the best practice Water Framework Directive (WFD) „multi-method" approach, utilising a combination of static fyke nets and marginally deployed seine nets combined with (where applicable) physical observation and dip net samples.

To distinguish between fish entering and leaving the site during the respective flood and ebb tides, paired multi-directional fyke nets (6 pairs) will be set within the developing creeks during low tide. Previous experience has shown that feeding crabs can decimate catches if left too long, therefore, as soon as the tide has retreated sufficiently to allow access, the fyke nets will be retrieved immediately and the catches processed. Fykes will fish over a single tidal cycle and net wetting times will be recorded to inform catch per unit effort (CPUE) to allow the calculation of temporal and spatial variations in fish abundance.

While the fyke nets are in place, a 10 by 3 metre micromesh seine net will be deployed at the top of the shore at high tide. A 10m seine to have substantial benefits over larger nets due to the increased number of samples which can be collected during a limited window of the tide. Indeed, the use of a smaller net, means that the field team can be more mobile, thus increasing the spatial resolution of data collection and also minimising ecological damage by avoiding very large catches which cannot be processed without avoiding some degree of mortality. Nets will be deployed by wading in a semicircle from the bank and as many samples as possible will be taken during the tidal window of opportunity. It is considered that slack water at high tide may last ~30 minutes and therefore a minimum of approximately five or six seine net samples should be possible during high water.

In addition, as MR sites will not be fully inundated on all tides (i.e. neaps) the formation of pools and ponded areas may be of prime importance for fish as they can form a permanent refuge at low tide. Additional seine and dip net samples may be possible at low tide if areas of ponded water remain in ditches/depressions.

The WFD transitional waters fish sampling methodologies were developed for subtidal and intertidal estuarine conditions. There is no requirement under the Directive to develop a fish classification tool which can be applied to high intertidal habitats such as saltmarsh. As a result, standard sampling methodologies have not been established yet for high intertidal habitats such as saltmarsh (and managed realignments). Of the WFD monitoring factsheets, only seine netting & fyke netting could be employed safely & effectively within MR sites on the Humber.

Some of the pioneering work in the UK in the field of fish sampling in saltmarshes and managed realignments is described in Colclough et al., 2005. It is proposed that the monitoring regime for this study would be enhanced significantly by the inclusion of additional monitoring techniques described in the 2005 paper (site conditions will dictate the actual suite of techniques). This could involve:-

- Rectangular Static nets (2.5m x 500mm x 400mm), with 4mm knotless mesh, 1mm knotless codend,
- 4mm knotless inscale with twin 5m wings (30cm high).
- 35m x 2m knotless seine net with 5mm centre and 10mm wings.
- 10 x 1m knotless seine net (5mm mesh).
- Standard Freshwater Biological Association kick net with 1mm mesh deployed around high intertidal vegetation for 1 minute.
- Passive samplers, with 1mm mesh, deployed in focussed tidal flows.
- Minnow or bottle traps.
- 3m x 1m push net.
- Visual observations of fish movement & behaviour.

The WFD compliant sampling window of autumn (Sept to Nov) and spring (April to June)

Water-quality data logger systems will be set inside each realignment and at a reference site outside during the entire fyke deployment period. The device will record water depth, temperature and salinity at 15-minute intervals. In addition, discrete water-quality measurements (water temperature, dissolved oxygen, and salinity) will be taken. We will also record qualitative appraisals of substrata composition, vegetation and other proximate structures, and a location (DGPS coordinates) of each sample. Field notes, haul information and species identification, abundance, size and weight records will be noted on site and compiled on return to the laboratory. 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. Consortium staff are highly experienced at identifying 0+ fishes in the field so, whenever possible, all fishes will be released at their site of capture following data collection. Fishes that are not identifiable in the field will be preserved in 60% Ethanol for identification in the laboratory using appropriate keys. All field data will be checked for mistakes and consistency.

Coates, S. (2009). UKTAG Transitional water assessment methods, fish fauna. Transitional fish classification index (TFCI). WFD-UKTAG, SNIFFER, Edinburgh.

Coates, S., Waugh, A., Anwar, A., Robson, M., (2007). Efficacy of a multi-metric fish index as an analysis tool for the transitional fish component of the water framework directive. Marine Pollution Bulletin 55, 225–240.
Coates, S., Colclough, S.R., Robson, M.A., Harrison, T.D. (2004). Development of an estuarine classification scheme for the Water Framework Directive. Phases 1& 2 – transitional fish component. R&D Technical Report E1-131/TR.: Environment Agency, Bristol.

APPENDIX D

Photographic evidence of the deterioration of flood defences

Flood Cell 23

Halton Marsh toe beam failure, bay number 61

8th December, 2011


Halton Marsh toe beam failure, bay number 61
8th December, 2011


East Halton toe beam bay north of 61
8th May, 2012


East Halton toe beam
8th May, 2012


East Halton toe beam
8th May, 2012


East Halton toe beam
8th May, 2012

APPENDIX E

Humber Flood Risk Management Strategy Extract

Flood Cell 23

Flood Area 23
Halton and Killingholme Marshes

Key information	
Size of flood area	876 ha
Number of properties in floodplain	26
Area of agricultural land	871 ha
Length of defences	7.3 km
Current standard of protection	Varies, 2% to 0.67% (1 in 50 to 1 in 150)
Remaining life of defence	Varies, 5 to 15 years
Defences managed by	Environment Agency, Associated British Ports

The areas of Halton and Killingholme Marshes lie within the proposed South Humber Bank development site which has been allocated for estuary related industry or commercial activities. Most of the properties at risk fall into this category, including wharf facilities and a major petro-chemical plant. There is also a significant area of high-grade agricultural land. The local authorities have prepared a Strategic Flood Risk Assessment to inform their planning decisions and the future development of the area. The land drainage is designed to cater for these developments and releases surface water into the estuary through a combination of pumped systems and gravity.

Existing flood defences

The foreshore is being worn away, which is weakening the defences along the whole frontage, particularly at Halton Marshes. If they are not repaired these defences are likely to fail within the next five years.

We are currently planning to improve the standard of protection in 10 to 20 years, although the timing will depend on the rate of sea level rise.

Key

- Flood area boundary
- Flood defence line
- Floodable area
- Urban area
- Power line
- Railway line
- Road
- River
- Planned flood storage area for extreme events

Proposed management approach

We will continue to protect most of this area and will work with the local and regional authorities, property owners and developers to make sure flood risk is taken into account at all stages of the planning process. We will also work with the local planning authorities to avoid any permanent buildings being located immediately behind the defences.

We will improve the defences that protect existing development but plan to stop maintaining those that protect currently undeveloped areas. The work will be expensive so we will seek to supplement public funds with contributions from major beneficiaries and from developers, who will be expected to pay the full cost of any new works needed to protect their development.