Planning Act 2008
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009
Regulation 5(2) [a]
Document reference: TR030001/APP/14b

Supplementary Environmental Information

Morphological Assessment of Changes south-east of Development

Explanatory Note EX 8.10

June 2012
Revision: 0
HR Wallingford

Able Marine Energy Park 3D Mud Modelling

Morphological assessment of changes south-east of development

Technical Note DDR4808-02

Address and Registered Office: HR Wallingford Ltd**. Howbery Park, Wallingford, OXON OX10 8BA**
Tel: +44 (0) 1491 835381 Fax: +44 (0) 1491 832233

Document information

Project	Able Marine Energy Park 3D Mud Modelling
Technical subject	Morphological assessment of changes south-east of development
Client	Able UK Ltd
Client Representative	Richard Cram
Project No.	DDR4808
Technical Note No.	DDR4808-02
Project Manager	Graham Siggers
Project Director	John Harris

Document history

Date	Release	Prepared	Approved	Authorised	Notes
19/04/12	1.0	KRO	GBS	JMH	Draft for Able UK Review
24/05/12	2.0	KRO	GBS	JMH	Responded to Able UK comments
06/06/12	3.0	KRO	GBS	JMH	Final
18/06/12	4.0	KRO	GBS	JMH	Dolphin location revised

Prepared [redacted]

Approved [redacted]

Authorised [redacted]

Contents

1. Introduction

1.1 BACKGROUND

Able UK proposes to construct Able Marine Energy Park (AMEP) near Immingham on the southern bank of the Humber Estuary. AMEP will be a facility for the construction of offshore wind turbines and other activities associated with sources of renewable marine energy. AMEP will consist of a large reclamation approximately 1,300 m in length along the shore and extending 300 – 400 m out into the estuary (Figure 1).

Two intakes/outfalls lie in the area immediately southeast of the reclamation (Figure 2). One of these is connected to fire fighting ponds at the South Killingholme Tank Farm and is reported by the owner, The Oil pipelines Agency (OPA), to have been smothered following the construction of the Humber International Terminal (HIT). The other is operated by Associated Petroleum Terminals (Immingham) Limited, (APT); it is reported to be operational and used on a weekly basis to discharge around 600 m^3 of effluent over a three hour window.

In addition, there are two mooring dolphins associated with the South Killingholme Oil Jetty and concerns have been raised about potential accretion around these structures that might restrict vessel access which is essential for their operation. The more northerly dolphin has recently been replaced, following impact damage, and the new dolphin is slightly inshore of the original structure.

1.2 OBJECTIVE

Predictions of longer term changes to morphology in (HR Wallingford, 2011) have been derived from a desk-based assessment of charted morphology changes to the northwest of the Humber International Terminal (HIT) before and after construction, and from longer term morphology modelling undertaken for an earlier layout of the AMEP and re-interpreted for the present layout. The desk-based assessment has subsequently been extended to consider high resolution LiDAR data, showing detailed changes to the intertidal between 2001 and 2010 (HR Wallingford, 2012a).

This technical note uses a desk assessment approach, drawing on previous morphological modelling (HR Wallingford, 2012b), to look at the potential sedimentation impacts on the two intakes/outfalls and mooring dolphins southeast of the development in more detail.

Figure 1 shows the proposed location of AMEP. Figure 2 shows the area southeast of the development, showing the locations of the two intake/outfalls, the two functional SKOJ mooring dolphins and location of the demolished structure.

Appendix 1 shows detailed outfall drawings supplied by Able UK. APT’s outfall appears to have been installed in the 1980’s prior to the development of HIT. The outfall was installed at a level of -1.1 mAOD (MLWN is at -1.3 mAOD), and is located 250m from the toe of the existing flood defence wall. According to the drawings, at the time that the outfall was installed it projected approximately 1m above the surrounding estuary bed. Since the development of HIT, this area of foreshore has been subject to accretion as a result of the change in sedimentation caused by the reclamation of the estuary for the HIT development. Currently, based on 2010 LIDAR data, the outfall is effectively buried with the surrounding bed level over 1m above the outfall. There is therefore an existing maintenance concern for APT. Nevertheless, the outfall is currently operational and this is probably because its use is sufficiently frequent, and the flow sufficiently strong, to flush the outfall of sediment during each discharge.

2. Longer-term morphological predictions

2.1 METHODOLOGY

To gain an insight into the potential longer term development, the model was run for an extended duration, updating the model bathymetry before each re-running of both the 3D flow and mud transport models (HR Wallingford, 2012b). Initially, four iterations of the flow and mud transport models were undertaken. Before each subsequent iteration of the flow and sediment models, the model bathymetry was updated based on the results of the last run. After reviewing the results of the fourth iteration, it was decided to run one further (fifth) iteration of the models to provide further insight into the longer term changes.

Allowing for some consolidation of materials over time, the linear scaling of results for each iteration translates into a time period of approximately six weeks. That is, after five iterations of the models, the predictions are broadly representative of deposition after an elapsed time of 30 weeks.

2.2 RESULTS OF LONGER-TERM PREDICTIONS

Figures 3 to 7 show the longer-term bed changes predicted using the DELWAQ model for the prediction periods: 0-6 weeks, 6-12 weeks, 12-18 weeks, 18-24 weeks, and 24-30 weeks. Figure 8 shows the total bed change predicted between 0 and 30 weeks. These figures are the difference from the baseline situation (i.e. accretion shown is in addition to any baseline accretion). The changes are summarised in Table 1.

Table 1 Summary of model predicted morphology changes

Iteration	Main changes
1	Initial deposition of up to 1.5 m immediately southeast of the AMEP and below the -5 m contour, with some erosion predicted below the -10 m contour (ODN).
2	Further accretion of up to 1 m immediately southeast of the AMEP and also between the -5 m ODN and -10 m ODN contours. The erosion below the -10 m contour is predicted to continue at a lower rate.
3	Similar to iteration 2, with deposition of between 0.5 m and 1 m immediately southeast of the proposed structure and between the -5 m ODN and -10 m ODN contours. The 0 m ODN and 5 m ODN contours are predicted to move seaward as a result of this increased deposition.
4 & 5	Deposition predicted to continue to the south of the structure and between the -5 m ODN and -10 m ODN contours. Erosion below the -10 m ODN contour progressively decreased with each iteration.

Figure 8 shows the total morphological change over the 5 iterations. Overall the model predicts up to 4 m accretion immediately south of the proposed development and up to 3.5 m accretion between the -5 m ODN and -10 m ODN contours. Up to 2.5 m of erosion is predicted below the -10m ODN contour adjacent to the development. Figure 9 (a&b) shows the initial and final bathymetry over the simulation period.

The total volume of sediment deposited by the model within the "embayment area" enclosed by AMEP and HIT was 171,000 m^3 after five model iterations. There was no apparent slowing down of model predicted deposition over this duration.

2.3 EMPIRICAL CHECK OF PREDICTED DEPOSITION VOLUME

The potential sedimentation in an embayment or basin can be estimated based on the ambient concentrations and the flow velocity past the opening (Winterwerp and Kesteren, 2004). For this analysis the area between the proposed development and the HIT was assumed to be an embayment (albeit with a wide mouth). The potential sedimentation was estimated using:

$$S = Q_e c_a$$

$$Q_e = f_e A U_r$$

Where c_a is the ambient sediment concentration, f_e is the exchange coefficient (usually between 0.01 and 0.03), A is the area for exchange (i.e length of opening by depth) and U_r is the velocity passing the opening.

This equation is sensitive to the location used for c_a and U_r, but yielded accretion volumes broadly similar to the morphological modelling, suggesting that the modelled accretion rates are reasonable in this "embayment" area.

2.4 PREDICTED DEPOSITION DISTRIBUTION

The modelling results suggest that much of the deposition resulting from the development occurs immediately adjacent to the structure or subtidally, between the -5 m and -10 m ODN contours. Although this is a modelled best estimate, and for the model scenarios considered, it is considered possible that in the longer term some of this predicted deposition may also occur further inshore. One reason why more deposition might occur further landward is that the model only uses a single sediment grain (floc) size, whilst in reality, sediment particles/flocs will cover a range of sizes, with smaller ones tending to be carried further landward before settling out of the water column.

To gain an upper estimate of possible deposition rates further inshore, the model predicted deposition into the "embayment" zone bounded by AMEP and HIT was summed volumetrically and then assumed to be spread over the region below the 2m ODN contour (approximately MHWN).

The predicted upper estimate of deposition at the two intakes/outfalls was 0.6m after five iterations (~30 weeks), with no apparent decreasing trend at this stage. This finding needs to be set against the observed existing accretionary trend discussed further below.

3. Discussion and interpretation

An assessment of recent changes in intertidal level is reported in HR Wallingford (2012a). Figure 10 shows the changes in intertidal level at the locations of the two intake/outfalls, derived from an assessment of EA LiDAR data. The Figure shows 2.4-2.8 m accretion between 2001 and 2010. This corresponds to an annual accretion rate of 0.1-0.3 m/year from 2001 to 2005, and 0.4 m/year more recently. Although this accretion in response to construction of the HIT will ultimately slow down, there is no sign of this yet occurring in Figure 10.

Interpreting the modelling results presented above against this background trend, it is predicted that a post-AMEP accretionary rate of 0-1 m/year may occur at the locations of these two outfalls.

In terms of how this will alter the existing maintenance concern for the operators (currently 0.4 m/year accretion – towards the centre of the future projected range of accretion), it is recommended that this should be the subject of continued ongoing monitoring, e.g. using LiDAR data, to further extend the findings shown in Figure 10, post-development.

It should be further noted that the location of the OPA outfall is in proximity to the proposed AMEP drainage outfall, which may result in significant scour, depending on the composition of the bed materials (see HR Wallingford, 2011).

Around the South Killingholme Oil Jetty, there are existing and proposed mooring dolphins located to the northwest of the jetty head (Table 2). The existing seaward US dolphin has been removed (status as of 13 May, 2012). This was replaced with a new US dolphin located shoreward and closer to the proposed AMEP. The location of the proposed dolphin was originally supplied as shown in Figure A.1, but subsequently confirmed to be at the coordinates given in Table 2 below (and shown on Figure 2).

The new US dolphin is located in the region of potential erosion in the model (sedimentation at this location is not predicted). The existing IUS dolphin however is within the predicted area of deposition and the model results suggest that 1 to 2 m of deposition could occur after 30 weeks.

The new US dolphin will, however, also be located in close proximity to the side slopes of the AMEP dredged areas (Figure A.3). Given this close proximity and the uncertainty in actual side slopes, there is a need to consider the feasibility of its operation in the presence of the AMEP dredged areas and associated side slopes.

Table 2 Details of mooring dolphins located north of the South Killingholme Oil Jetty

Dolphin name	Position (BNG)	Approximate distance from AMEP (m)
IUS	518373, 418412	75
US (to be demolished)	518377, 418495	80
US (new location)	518361, 418485	30

4. Summary

The morphological model predictions suggest that the AMEP will lead to accretion immediately to the southeast of the proposed structure and between the -5 m ODN and -10 m ODN contours (approximately 1-6 m below Chart Datum).

The model predicted no accretion onto the locations of the two intake/outfalls southeast of the AMEP. However, allowing for the possibility that more of the model predicted accretion into this “embayment” area could occur further landward, an upper estimate of 0.6 m of accretion at the two intake/outfall structures was predicted after 30 weeks (up to 1 m/year). It is recommended that the existing trends in intertidal levels (currently increasing by ~0.4m per year as the intertidal profile continues to rise and push outwards in response to HIT) continue to be monitored after construction of AMEP.

The model predictions suggest that some sedimentation is likely at the existing South Killingholme Oil Jetty IUS dolphin (Figure A.2). Depending on the composition of bed materials, erosion may occur at the newly installed US dolphin. The dolphin will also be in close proximity to the side slopes of the AMEP dredged areas.

The IUS dolphin is located within and at the edge of a predicted zone of sedimentation. Sedimentation should therefore be treated as a risk. In practice sedimentation will depend on the dredged areas, side slopes, vessel activities and the broader range of environmental conditions experienced at this location.

5. References

HR Wallingford (2011). Able Marine Energy Park: 3D mud modelling. Report EX6603 for Able UK, December.

HR Wallingford (2012a). Able Marine Energy Park: Update to longer term morphology predictions in the region of the Centrica and E.ON intakes and outfalls. Technical Note DHR4808-01.

HR Wallingford (2012b). Able Marine Energy Park: Detailed assessment of recent trends in intertidal and subtidal morphology (In progress).

Winterwerp, J.C. and van Kesteren, W.G.M. (2004). Introduction to the physics of cohesive sediment in the marine environment. Developments in Sedimentology 56, T van Loon (ed.). Elsevier, Amsterdam, The Netherlands, 466 pp. (+ appendices).

Figures

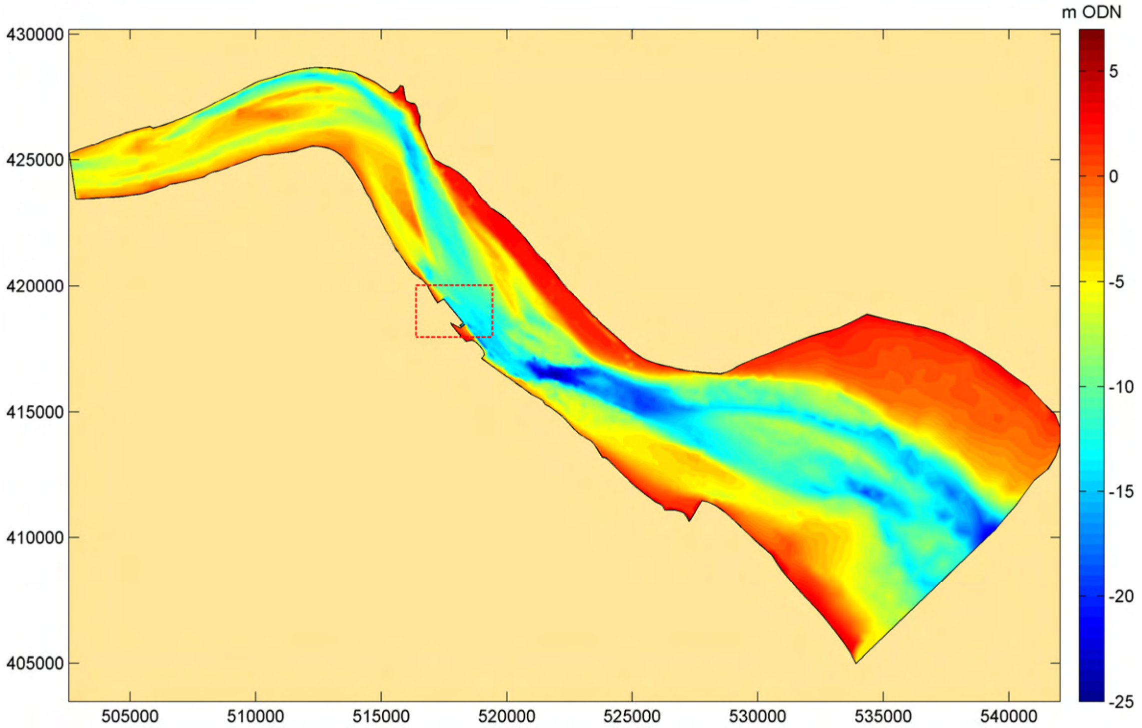

Figure 1 Proposed location of AMEP

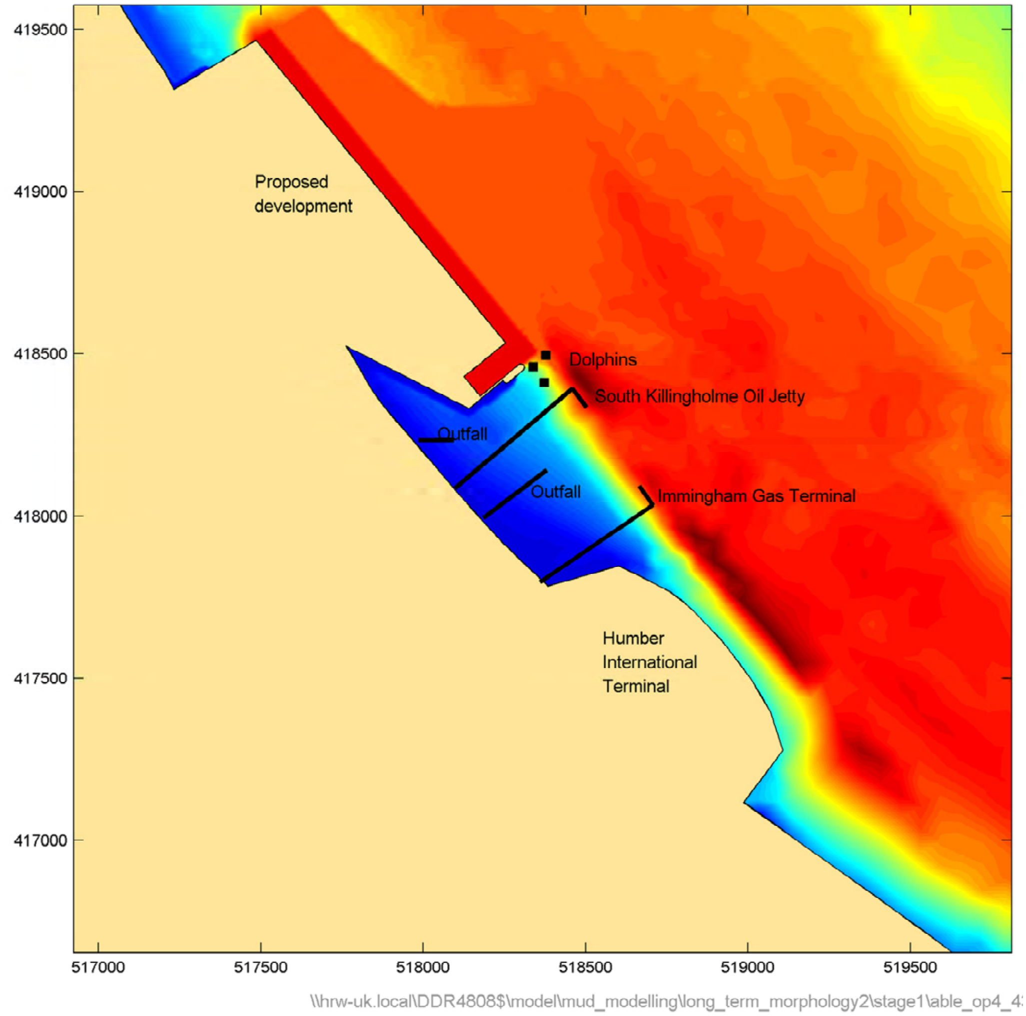

Figure 2 Region of the proposed development and embayment to south east, showing jetties, intakes/outfalls and dolphins

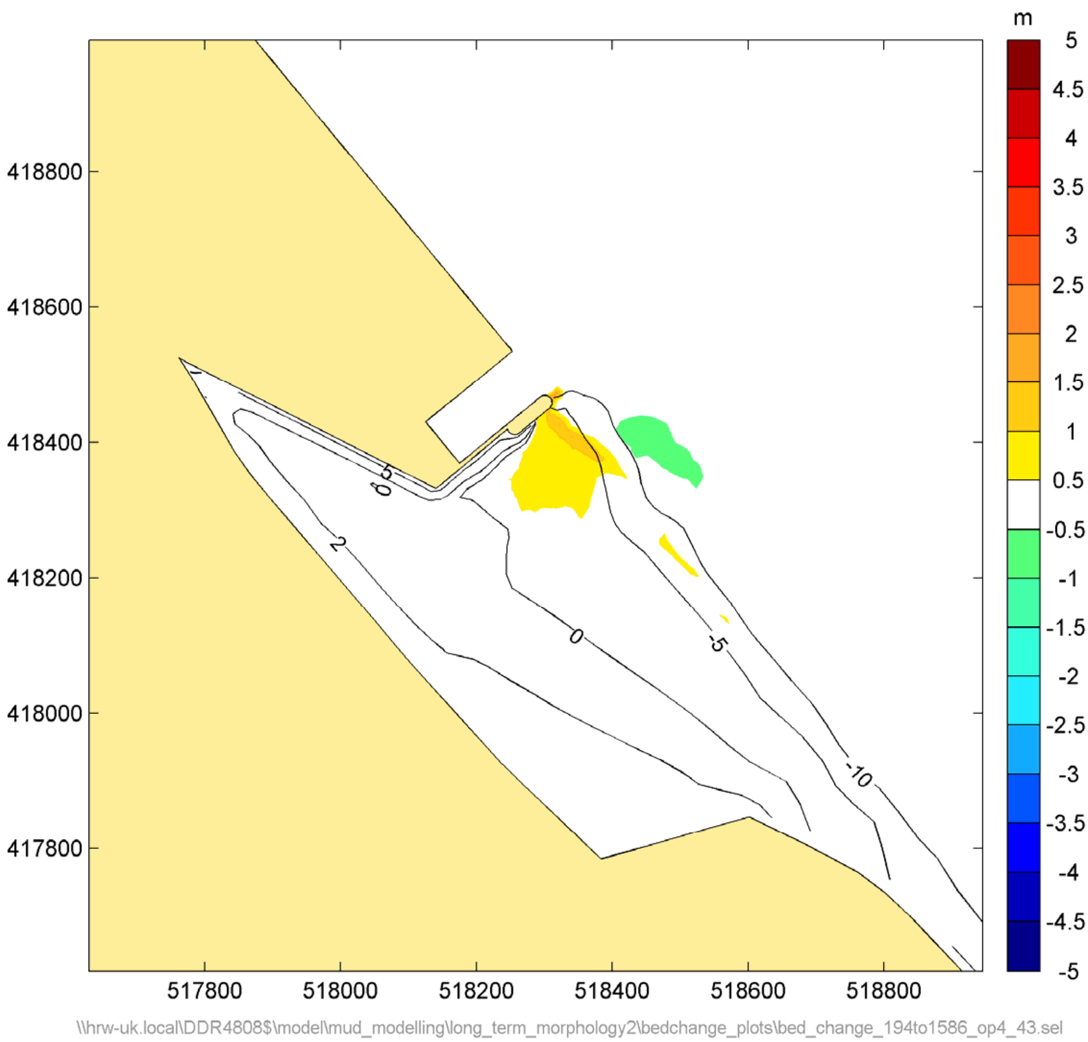

Figure 3 **Long term morphological prediction (Iteration 1 – bed difference after elapsed time of six weeks)**

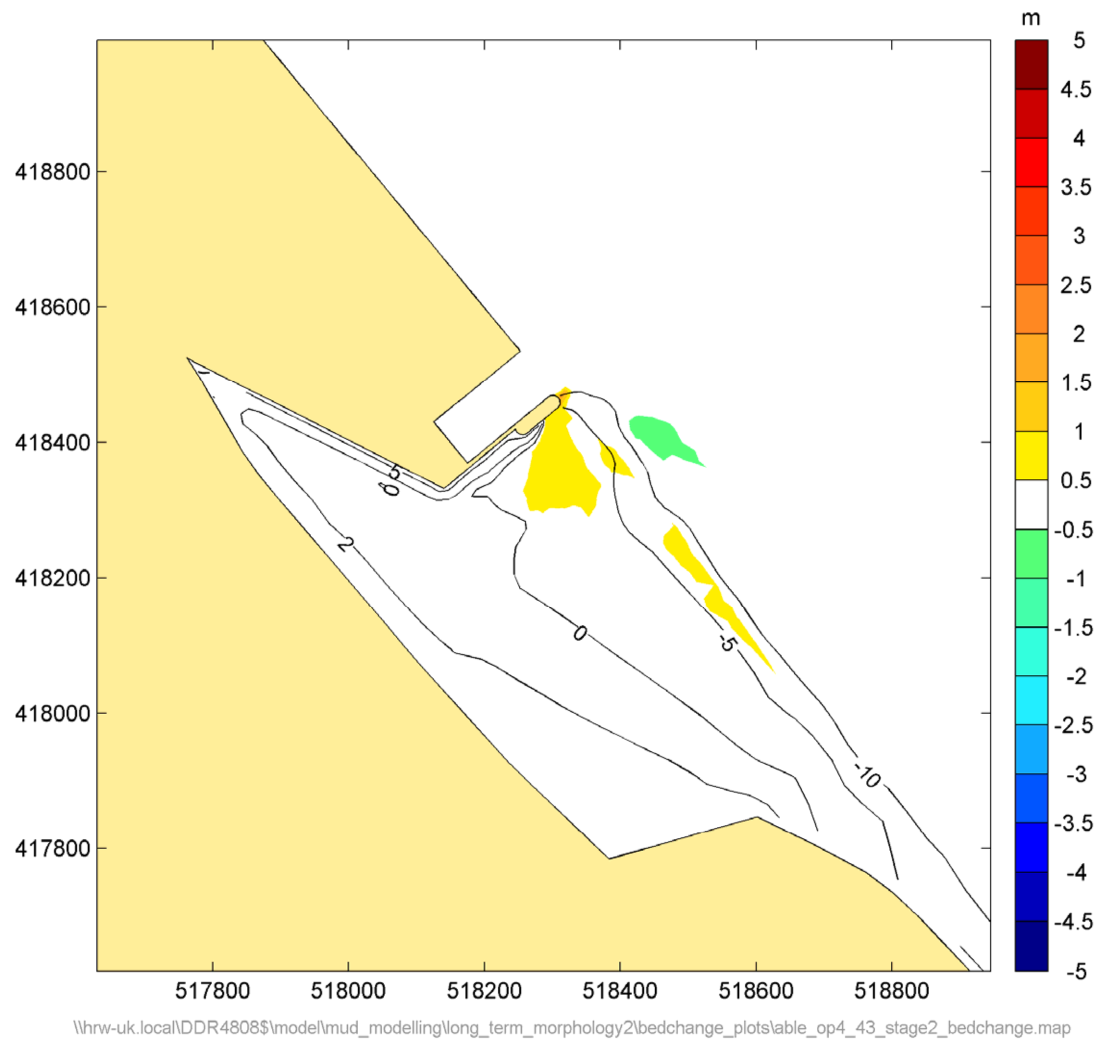

Figure 4 Long term morphological prediction (Iteration 2 – bed difference between six and twelve weeks elapsed time)

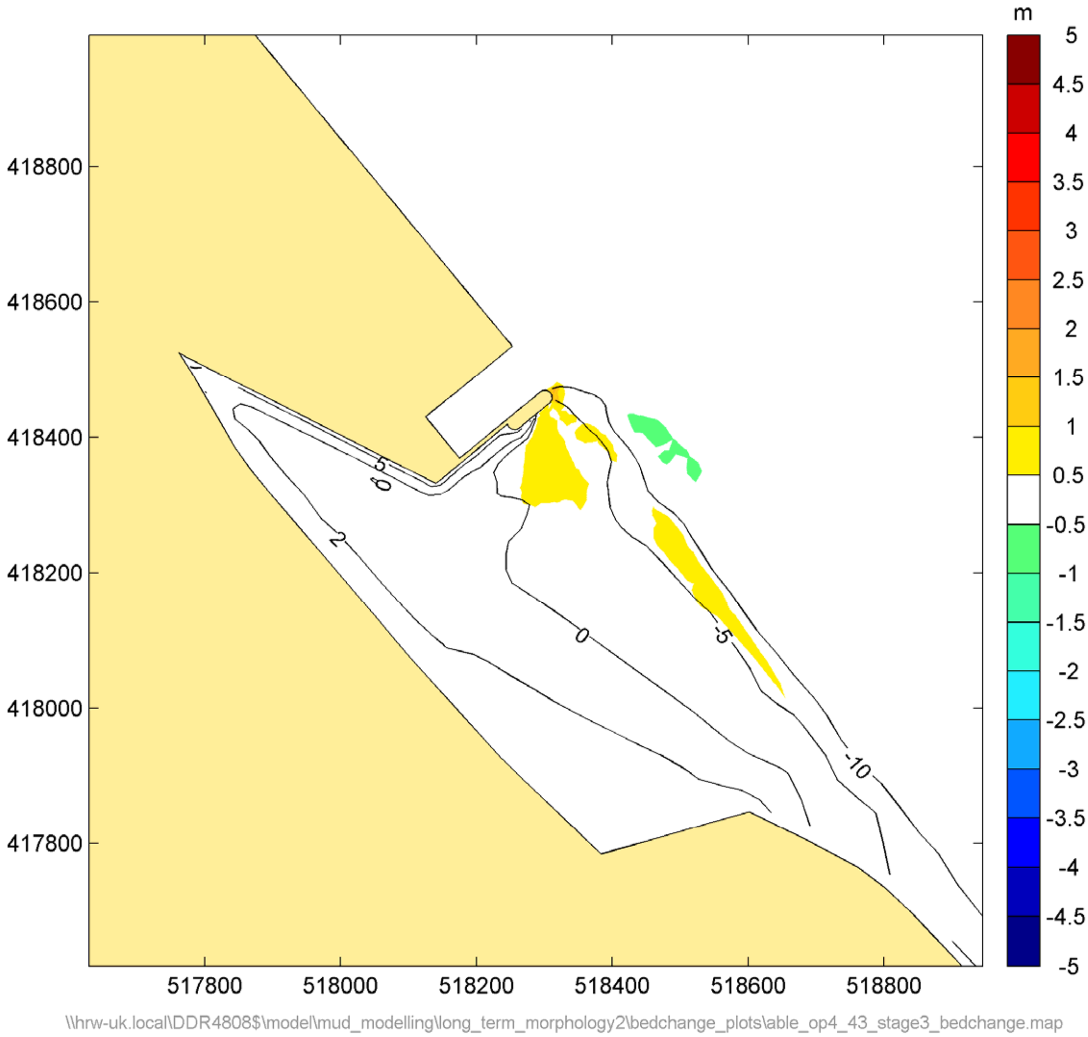

Figure 5 Long term morphological prediction (Iteration 3 – bed difference between twelve and eighteen weeks elapsed time)

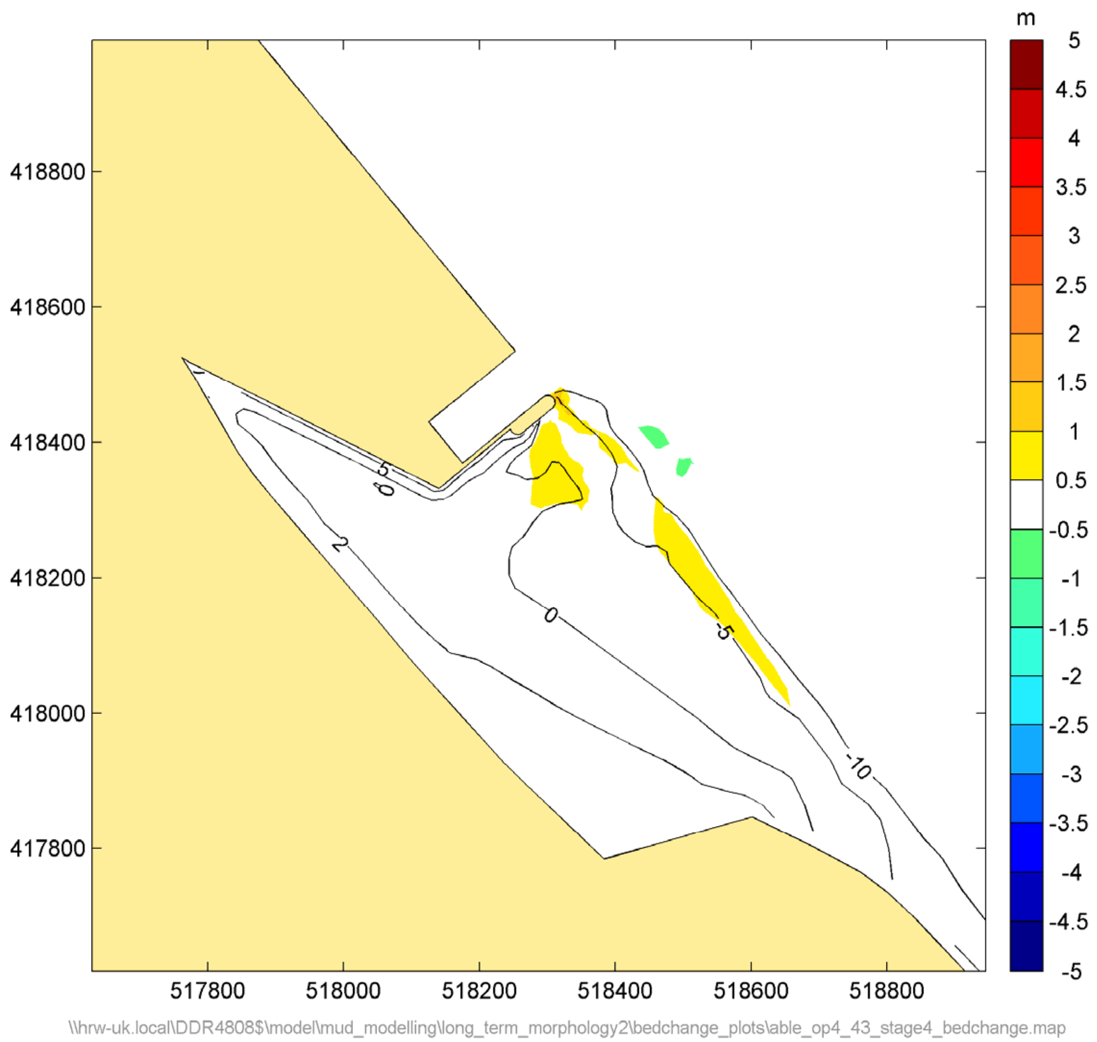

Figure 6 Long term morphological prediction (Iteration 4 – bed difference between eighteen and twenty-four weeks elapsed time)

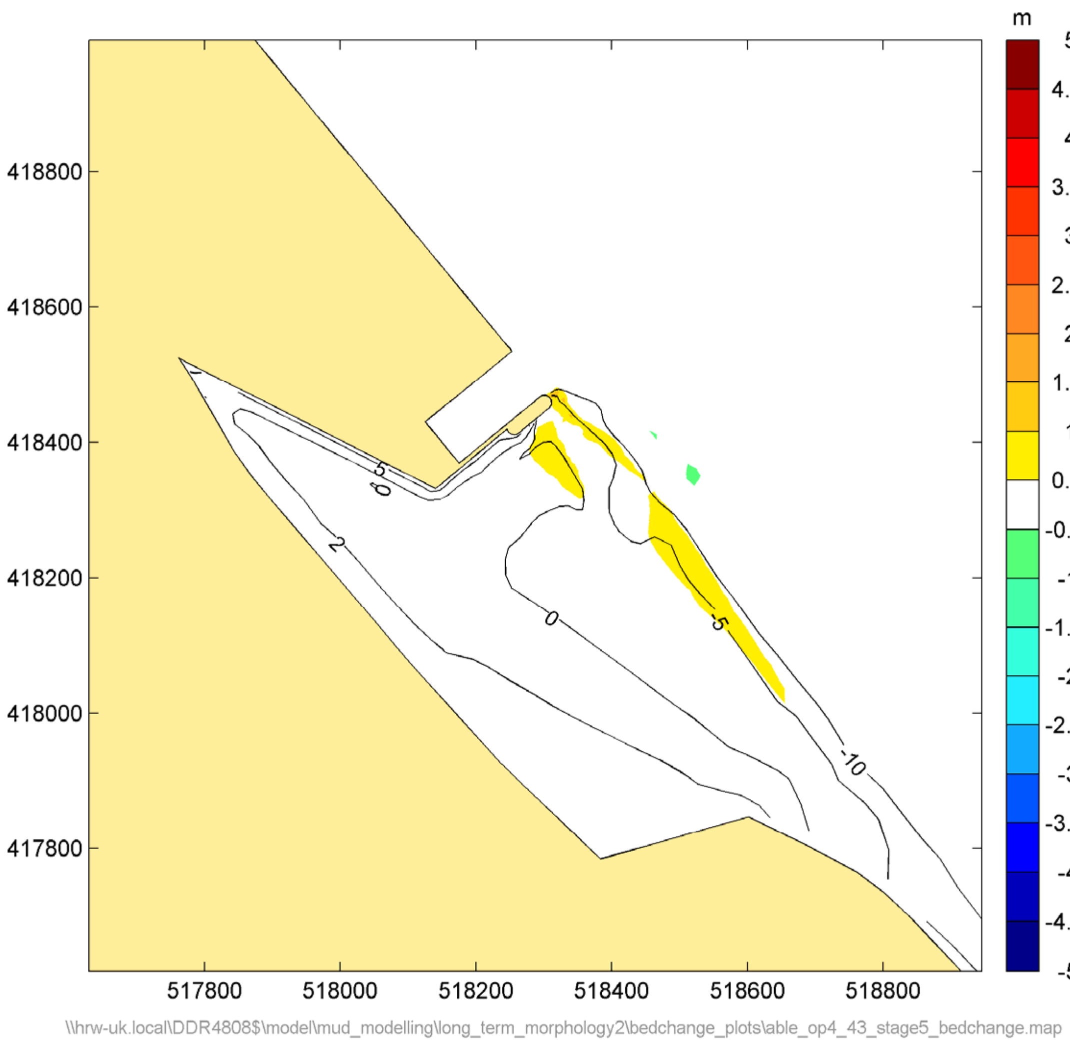

Figure 7 Long term morphological prediction (Iteration 5 – bed difference between twenty-four and thirty weeks elapsed time)

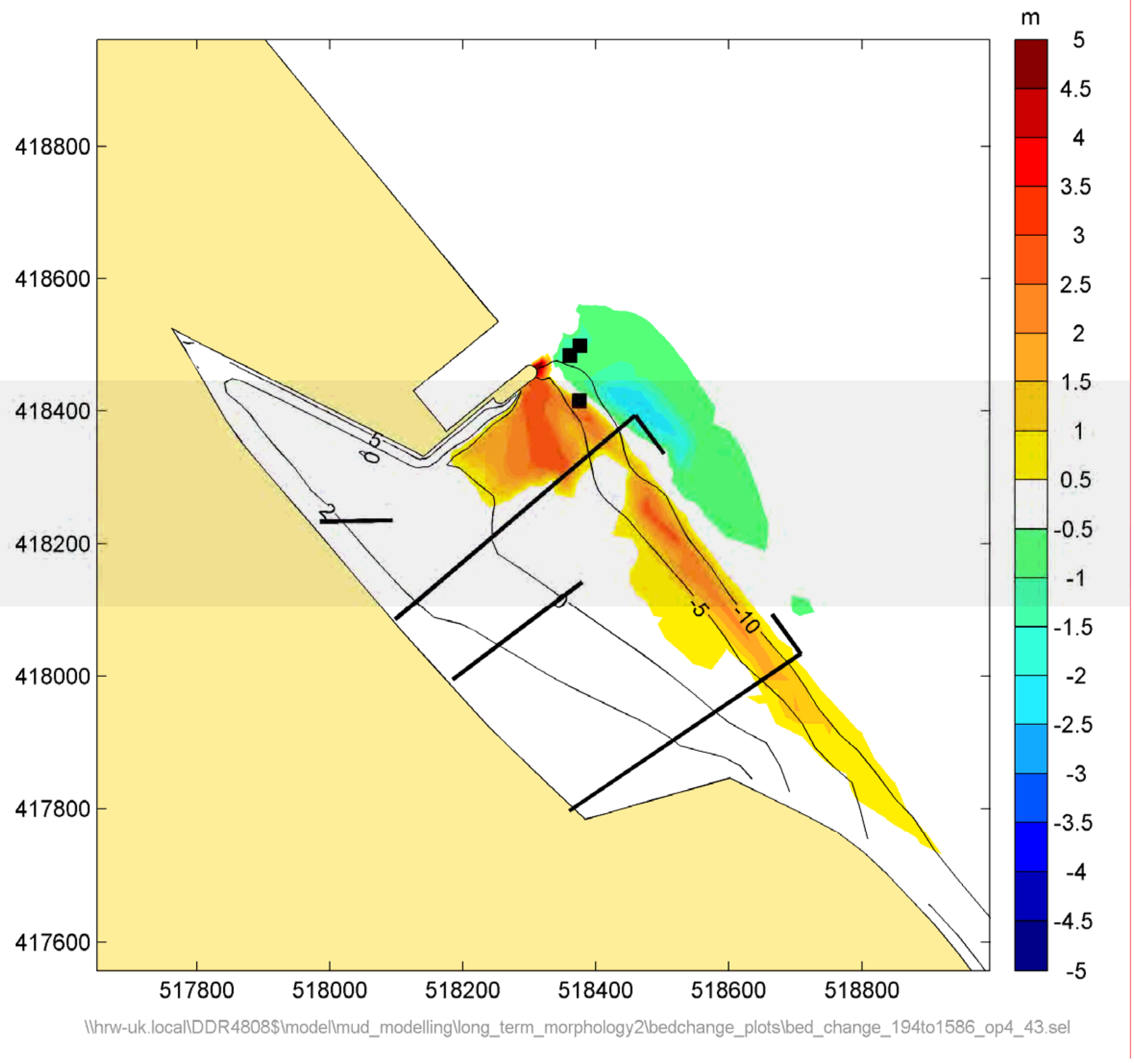

Figure 8 Long term morphological prediction (bed difference between initial and thirty weeks elapsed time, contours show initial bathymetry)

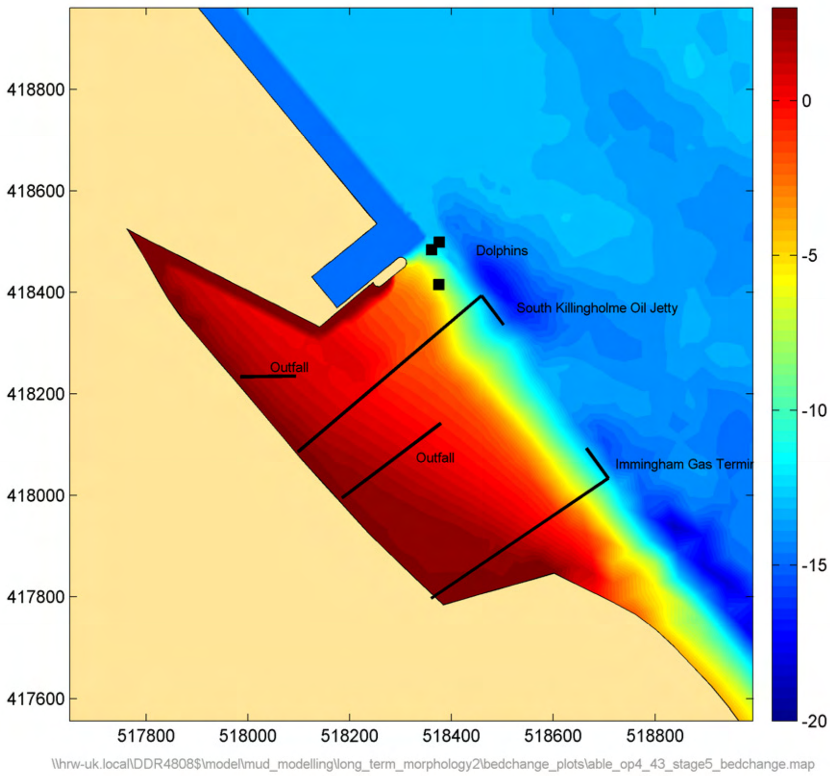

Figure 9a Initial model bathymetry (week 0, metres ODN)

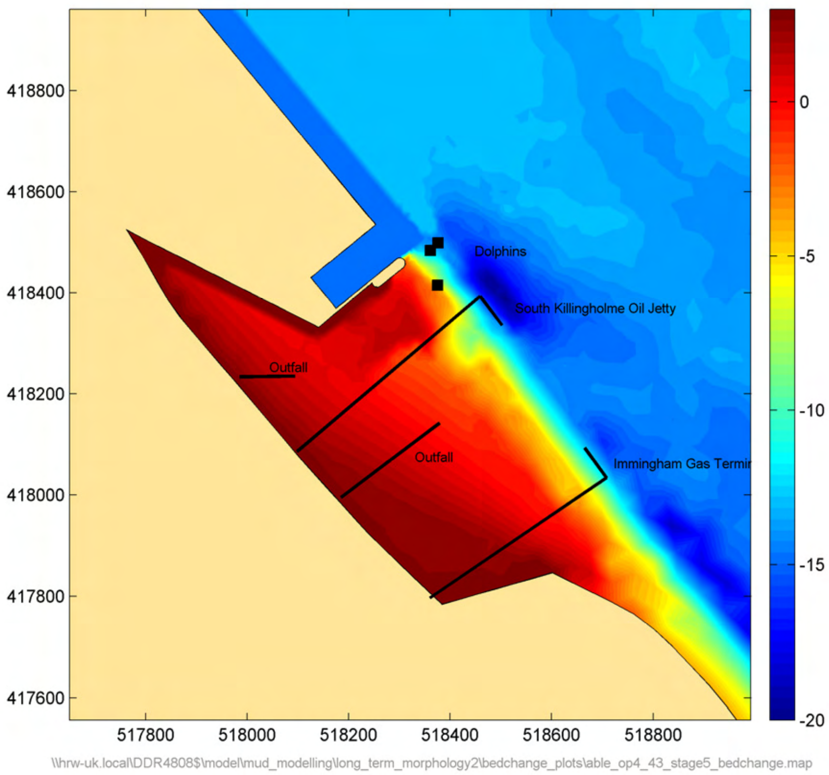

Figure 9b Final model predicted bathymetry (~week 30, metres ODN)

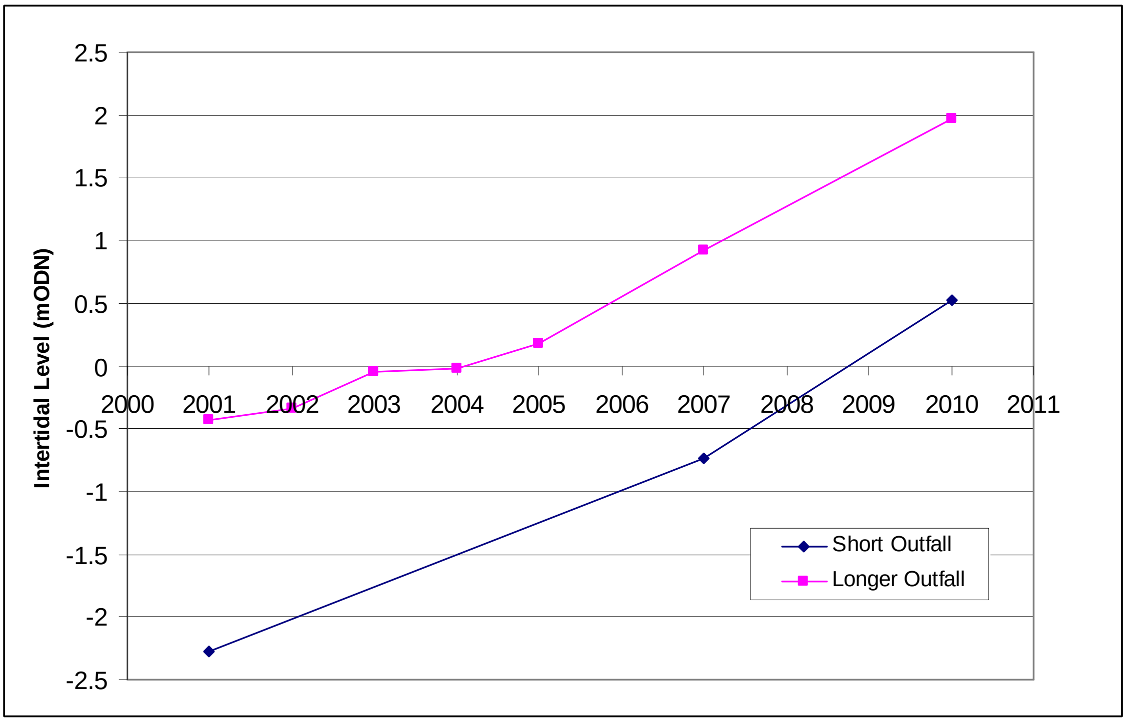

Figure 10 Intertidal levels in proximity to the two outfalls (from EA LiDAR data)

Appendix A Detailed drawings of outfall structures and SKOJ dolphins

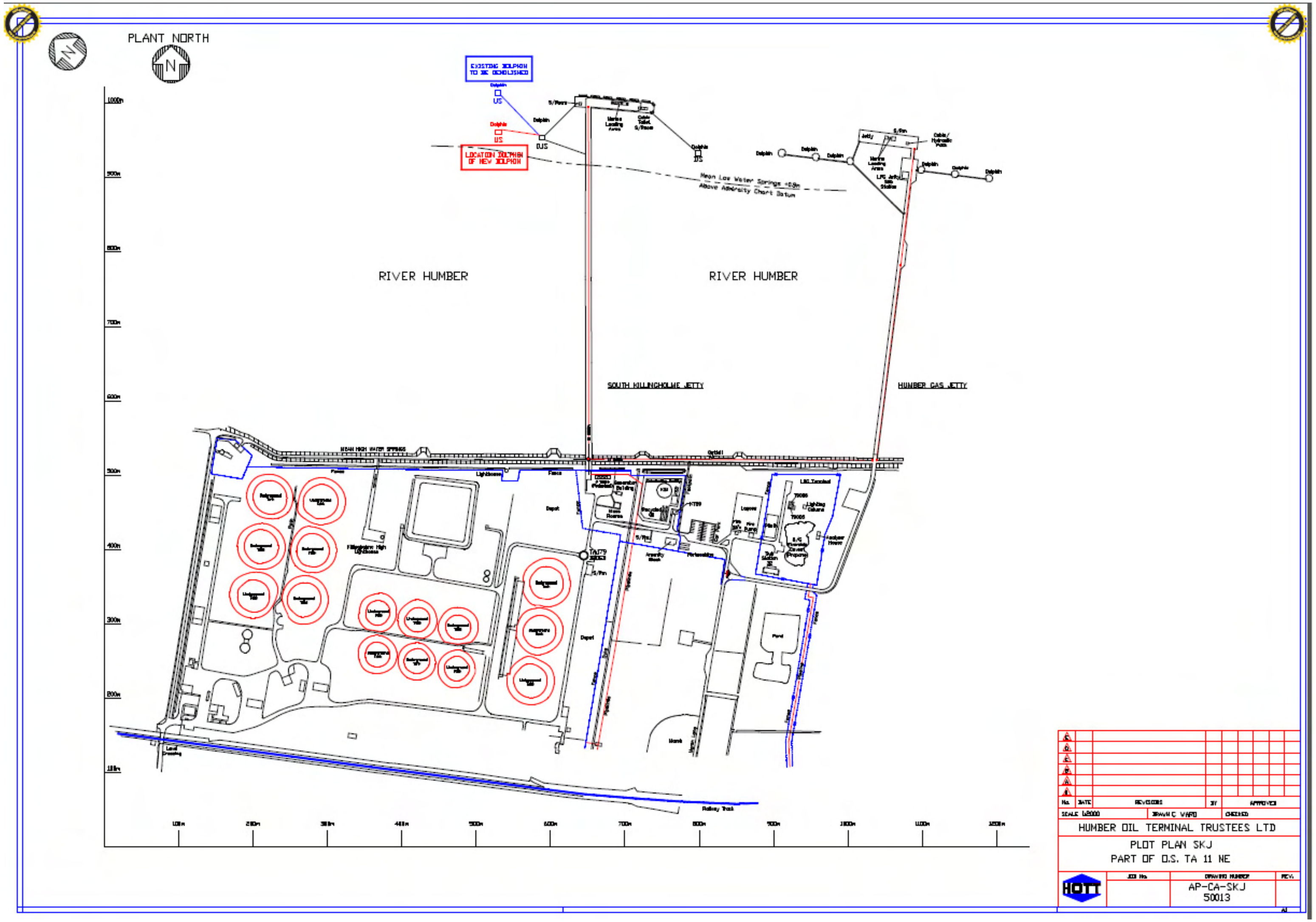

Figure A.1 South Killingholme Oil Jetty Mooring Dolphin Drawing (Note that the location of New Dolphin as shown in this drawing is not consistent with the supplied installed coordinates. The New Dolphin is closer to the Old Dolphin than shown in this drawing)

Figure A.2 APT Outfall

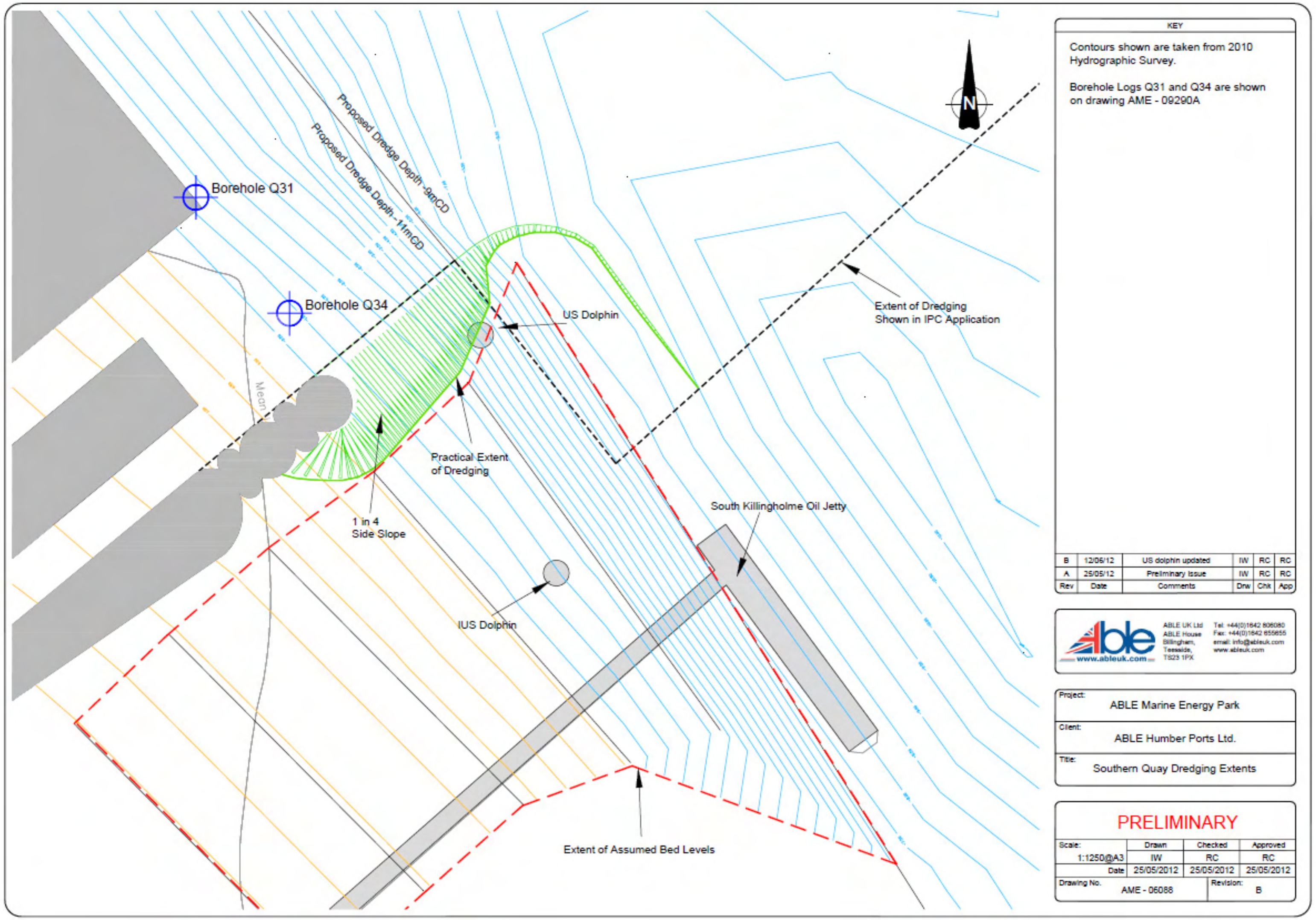

Figure A.3 Dredge and side slopes in vicinity of South Killingholme Oil Jetty (Not to Scale - from Able UK, 2012)