Annex 9.3

Assessment of proposed reclamation impact on recirculation at E-ON intake/outfall

(HR Wallingford)

HR Wallingford
Working with water

EX 6503

Able Marine Energy Park near Immingham

Assessment of proposed reclamation impact on recirculation at E.ON intake/outfall

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Prepared Graham Watt

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Authorised T E Jones

Summary

Able Marine Energy Park near Immingham

Assessment of proposed reclamation impact on recirculation at E.ON intake / outfall

Report EX6503
March 2011

Able UK Ltd proposes to construct a Marine Energy Park (MEP) near Immingham on the southern bank of the Humber estuary. The MEP will be a facility for the construction of offshore wind turbines and other activities associated with sources of renewable energy and will consist of a large reclamation approximately 1300 m long along the shore and up to 400 m wide in the offshore direction.

Immediately to the north of the reclamation there are two existing outfalls for two gas-fired power stations, which are located some 2 km inland of the proposed reclamation. One plant is operated by Centrica and the other by E.ON. These outfalls discharge cooling water from the power stations. This report describes thermal dispersion modelling of the cooling water discharges, and predicts the effects on thermal recirculation to the E.ON intake.

Under existing conditions, the plume from the E.ON outfall is rapidly dispersed, so that the water abstracted at the E.ON intake is likely to be less than 0.1°C above the ambient temperature.

The presence of the quay will affect the behaviour of the plume from the E.ON outfall. Instead of dispersing in the direction of the main estuarine flow, the plume will be forced offshore parallel to the side of the quay in the direction of the intake. The warm water will remain for a longer period of time close to the outfall due to the presence of eddies, particularly on the flood tide.

With the proposed quay in place, the seawater temperatures at the E.ON intake are predicted to be up to 0.75°C above the ambient value. At the level of the intake, the excess temperatures at the intake are predicted to be greater than 0.25°C for up to 4 hours per day and greater than 0.5°C for less than 1 hour a day.

Final design (Appendix 2)

Since the modelling described in this report was carried out, the reclamation layout has been amended; Appendix 2 shows the final design. Based on a brief, non-quantitative review of this design, HR Wallingford expects the recirculation temperature predictions described in this report to be somewhat higher than predictions using the final design.

Contents

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1. Introduction

Able UK Ltd proposes to construct a Marine Energy Park (MEP) near Immingham on the southern bank of the Humber estuary. The site location is shown in Figure 1.1. The MEP will be a facility for the construction of offshore wind turbines and other activities associated with sources of renewable energy.

The MEP will consist of a large reclamation approximately 1300 m long along the shore and up to 400 m wide in the offshore direction. Immediately to the north of the reclamation there are two existing outfalls for two gas-fired power stations, which are located some 2 km inland of the proposed reclamation. One plant is operated by Centrica and the other by E.ON. These outfalls discharge cooling water from the power stations. HR Wallingford has already undertaken an initial assessment of the issues associated with the cooling water discharges [1]. This report describes thermal dispersion modelling of the cooling water discharges, and predicts the effects on thermal recirculation to the E.ON intake.

1.1 COORDINATE SYSTEM

The coordinate system used in the model and this report is British National Grid (OSGB36). Vertical positions have been related primarily to Ordnance Datum Newlyn (ODN). Units are metres in both horizontal and vertical directions.

Some levels have been provided relative to Chart Datum (CD) which is roughly the level of lowest astronomical tide. At Immingham, CD is 3.90 m below ODN.

1.2 REPORT STRUCTURE

Chapter 2 describes the setup and validation of HR Wallingford's hydrodynamic model used in this study, and Chapter 3 discusses the thermal dispersion predictions based upon it. Chapter 4 draws conclusions from the assessment.

2. Hydrodynamic modelling

A new hydrodynamic model has been set up for this study, based on a model previously used by JBA Consulting (JBA) [2]. HR Wallingford's model used the TELEMAC system, which was developed by EDF-LNHE, Paris and is now under the directorship of a consortium of organisations including EDF-LNHE, HR Wallingford, Sogreah-Artelia, BAW and CETMEF. A kernel of developers from these organisations carries out the software developments together with contributions from many universities and other organisations.

In a TELEMAC model, the area to be studied is represented on a mesh of triangular elements of variable size. Very small elements can be used in the vicinity of a discharge and the resulting plume, while larger elements can be used further away. With this efficient combination of detail and area covered, one model can represent mid- and far-field effects. The model calculates water level and profiles of velocity, temperature and salt concentration at each corner of each triangle in the mesh and stores these at intervals through the simulation. The 3D model is divided into a number of horizontal planes through the depth, as appropriate to specific applications. For thermal plume applications, the effect of surface cooling is included.

HR Wallingford has wide experience of using TELEMAC-3D for a range of types of effluent plume, including thermal plumes from power stations. We have undertaken such studies at many locations in the UK and worldwide including UAE, Qatar, Bahrain, Saudi Arabia, India and Malaysia.

2.1 MODEL SETUP

The model was set up using bathymetry information from JBA. It covers the majority of the Humber Estuary, extending from the Humber Bridge to Spurn Head. Close to the outfalls and intakes, the grid resolution is around 10 m; this grows gradually upstream and downstream, to some 200 m at Humber Bridge and some 600 m at the seaward boundary.

The model coverage, resolution and bathymetry are shown in Figures 2.1 and 2.2.

Boundary conditions were also supplied by JBA. These were applied as prescribed water levels at both the upstream and downstream boundaries.

2.2 MODEL VALIDATION

The model was run for spring tides, using the JBA boundary level data, and the model physical and numerical parameters were adjusted until good agreement was obtained with the behaviour predicted by the JBA model. (This had previously been validated against survey measurements.)

A comparison between the two models is shown in Figures 2.3 and 2.4, and demonstrates that the predicted behaviour is in very good agreement. These comparisons are given at the site of one of the current meters (ADCP 1) used in JBA’s original model calibration. Since the TELEMAC model predicts similar variations in water depth, current speed and current direction, it is considered to be an appropriate starting point for the following thermal dispersion study.

3. *Thermal dispersion modelling*

Intake and outfall flows from the two power stations have been introduced into the model, and the dispersion of the thermal plumes has been simulated over several tidal cycles, for four combinations of tidal and wind conditions. These simulations considered both the existing condition, and developed condition including the proposed reclamation.

Figure 3.1 shows the existing and developed condition layouts.

3.1 INTAKE AND OUTFALL PARAMETERS

Data provided by the power station operators suggests the ambient water temperature is around 18°C in summer around 10°C in winter.

The E.ON outfall temperature is about 27°C in summer which implies the discharge has excess temperature around 9°C; in winter, the outfall temperature is around 21°C which implies the discharge has excess temperature around 11°C. For this study, we have assumed a constant value of 10°C.

Less definite information has been supplied about the Centrica discharge, but its behaviour seems broadly similar; therefore this has also been assumed to have a constant excess temperature of 10°C.

These parameters are summarised, together with the relevant flow rates, in Table 3.1.

Table 3.1 Intake and outfall parameters

	E.ON	**Centrica**
Intake flow rate (m^3/s)	0.7	0.4
Outfall flow rate (m^3/s)	0.7	0.3
Outfall excess temperature (°C)	10	10

3.2 ENVIRONMENTAL CONDITIONS

The thermal dispersion simulations were run for spring tides and neap tides, under calm conditions, and assuming a constant wind blowing from the west at 7 m/s.

Calm conditions were used because they often give the most adverse predictions for the accumulation of heated water in the vicinity of a discharge. The wind condition was selected because the Admiralty Pilot suggests that this is the most commonly occurring wind.

Figures 3.2a and 3.2b show predicted current patterns and speeds under existing and developed conditions, respectively.

3.3 RESULTS

Figures 3.3 to 3.6 show dispersion plume patterns from the simulations, at the sea surface and sea bed, at times corresponding approximately to High Water (HW) and Low Water (LW) slack.

Under existing conditions (Figures 3.3 and 3.4), excess temperatures above 0.5°C are predicted only close to the outfalls around high and low water. The thermal plumes from both outfalls are dispersed rapidly.

The presence of the quay (Figures 3.5 and 3.6) causes an eddy to form in the vicinity of the two intakes/outfalls. A weaker eddy forms close to the quay wall. The E.ON outfall is located within 50 m of the edge of the quay and is located in this weaker eddy. The plume from the E.ON outfall therefore shows complex behaviour due to this eddy and the proximity of the wall. Instead of dispersing in the direction of the main estuarine flow, the E.ON plume will be forced offshore parallel to the side of the quay, in the direction of the intake. The warm water will remain for a longer period of time close to the outfall due to the presence of eddies particularly on the flood tide.

Although the plume from the Centrica outfall is predicted to give excess temperatures greater than 0.1°C for longer periods than in the existing case, it is still dispersed rapidly. The Centrica plume tends to spread more or less in line with the main direction of flow along the estuary.

3.4 PREDICTED IMPACTS AT E.ON INTAKE

Figures 3.7 to 3.10 show the predicted variation in excess temperature at the E.ON intake over two tides for each of the tidal and wind conditions tested, for the exiting case. Under all four tide and wind conditions, the temperature at the E.ON intake is predicted to be less than 0.1°C above the ambient temperature.

With the proposed quay in place, higher excess temperatures are predicted at the E.ON intake (Figures 3.11 to 3.14). Under spring tides, two peaks of around 30 minutes each appear about 1 hour after LW and 30 minutes after HW. Under calm conditions, the surface temperature is predicted to be peak at 0.6°C above the ambient near high and low water, while the near-bed value is 0.3°C. With a constant wind applied, the excess temperature at the bed is also predicted to be 0.6°C. A smaller peak is predicted during the flood tide; the surface temperature is predicted to be between 0.25°C and 0.3°C in both calm and wind cases, while at the bed the excess temperature is predicted to be less than 0.2°C.

Similar patterns are predicted for the neap tide, although the peak during the flood is higher, exceeding 0.5°C at the surface (0.25°C near the bed). The peak excess temperatures at low water are similar to those for a spring tide. At high water the excess temperature peak is around 0.6°C at the surface with an imposed wind but is much lower (around 0.3°C) under calm conditions. The presence of the constant wind from the west tends to encourage the plume to remain closer to the quay wall than in the case with no wind.

During the ebb tide under all conditions tested, the surface and mid-depth excess temperature at the E.ON intake drops rapidly to the value predicted for the existing case.

The excess temperatures are predicted to be greater than 0.5°C for no more than 1 hour per day during spring tides through the depth under westerly wind conditions and for up to 2 hours per day at the surface during neap tides. At the bed and at mid-depth, the excess temperature is predicted to be greater than 0.5°C for less than 30 minutes per day during neap tides.

4. *Conclusions*

Thermal dispersion of the cooling water from the E.ON and Centrica power stations has been simulated, using a new TELEMAC-3D model based on JBA’s previous model of the Humber Estuary.

Under existing conditions, the plume from the E.ON outfall is rapidly dispersed, so that the water abstracted at the E.ON intake is likely to be less than 0.1°C above the ambient temperature.

The presence of the quay will affect the behaviour of the plume from the E.ON outfall. Instead of dispersing in the direction of the main estuarine flow, the plume will be forced offshore parallel to the side of the quay in the direction of the intake. The warm water will remain for a longer period of time close to the outfall due to the presence of eddies, particularly on the flood tide.

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Final design (Appendix 2)

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5. References

[1] HR Wallingford, Able Marine Energy Park near Immingham: Initial assessment of impact of proposed reclamation on existing cooling water discharges, in, 2010.

[2] JBA. Consulting, South Humber Channel Marine Studies: Hydrodynamic, Wave and Sediment Study, in, 2010.

Figures

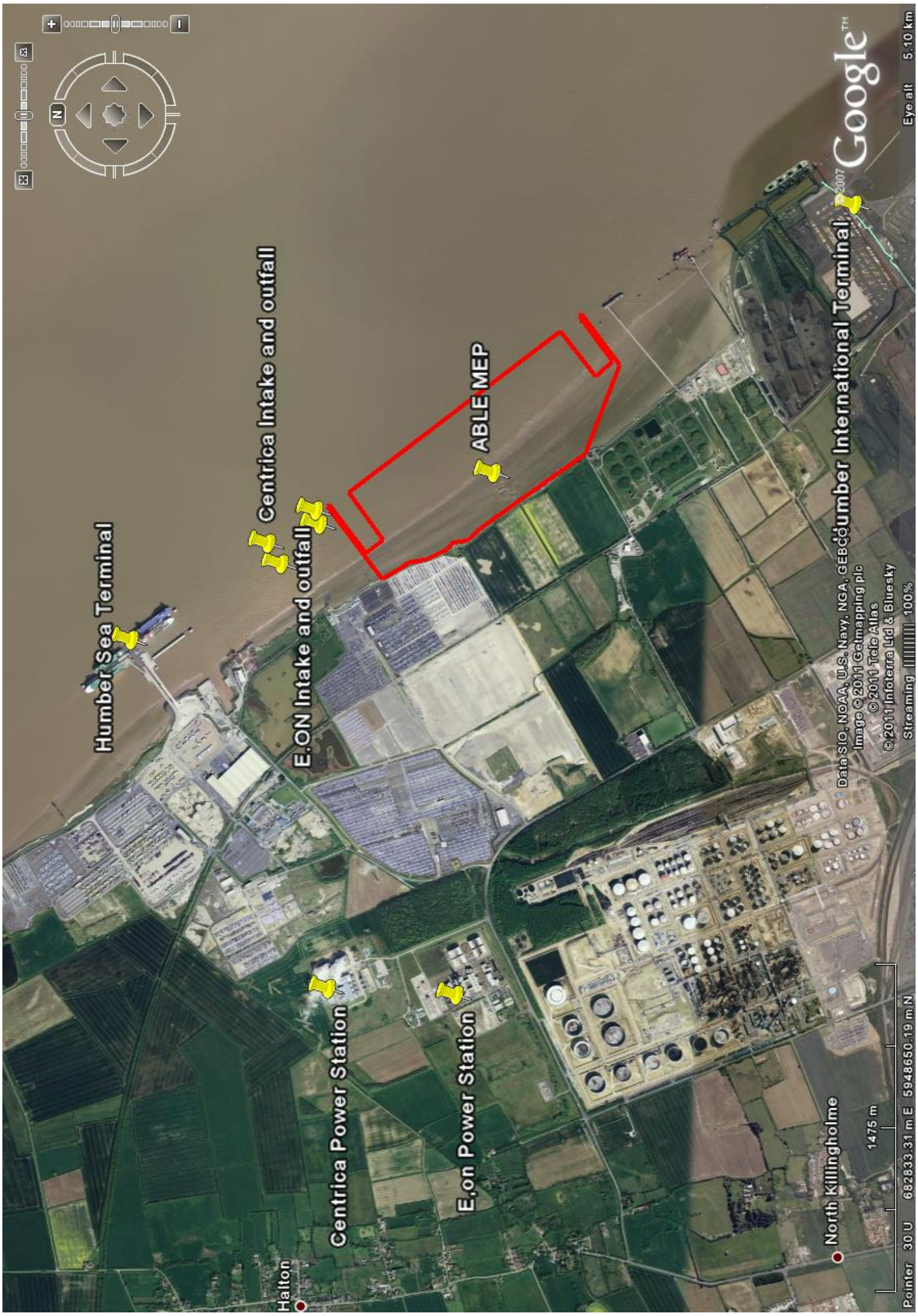

Figure 1.1 Site location

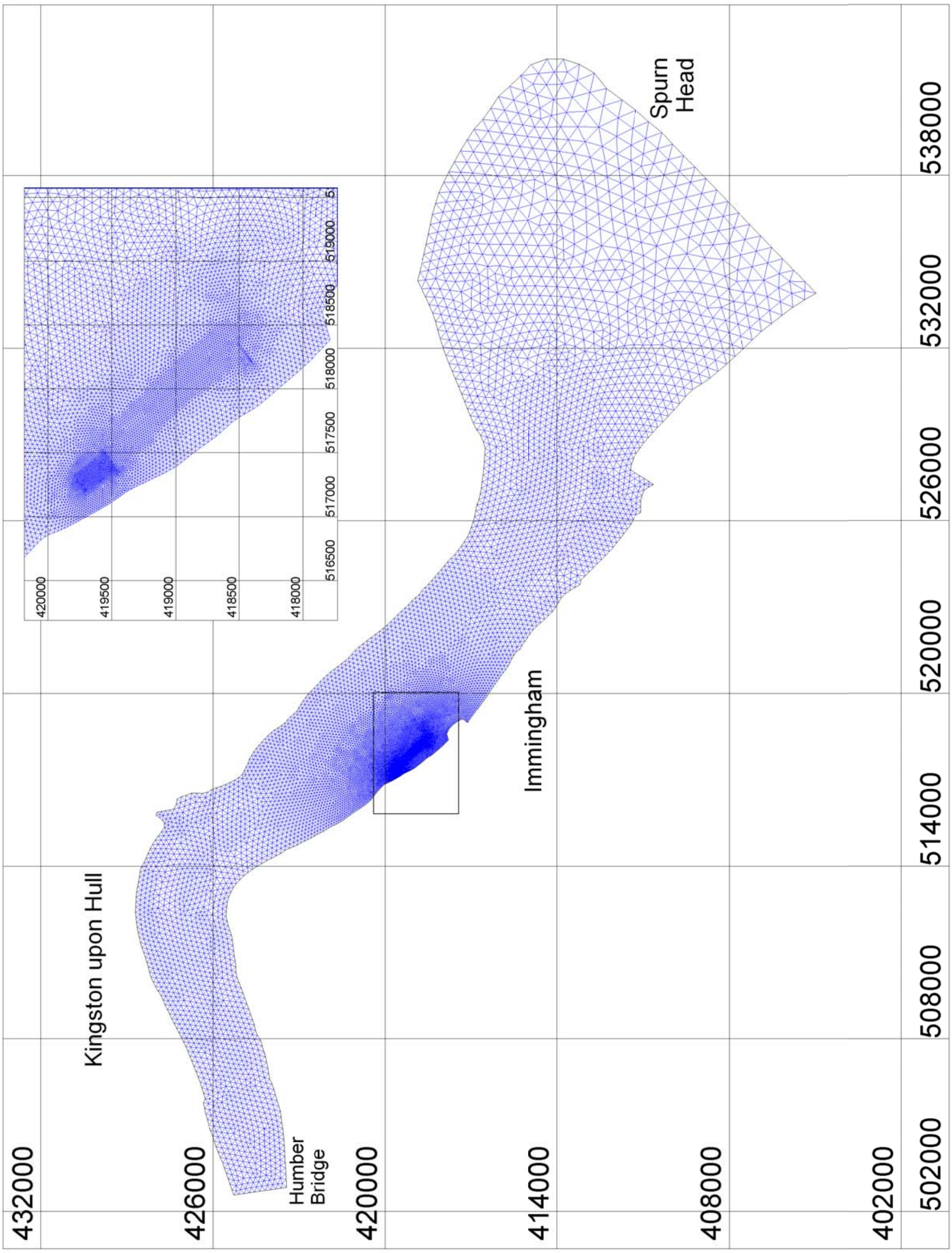

Figure 2.1 Model mesh

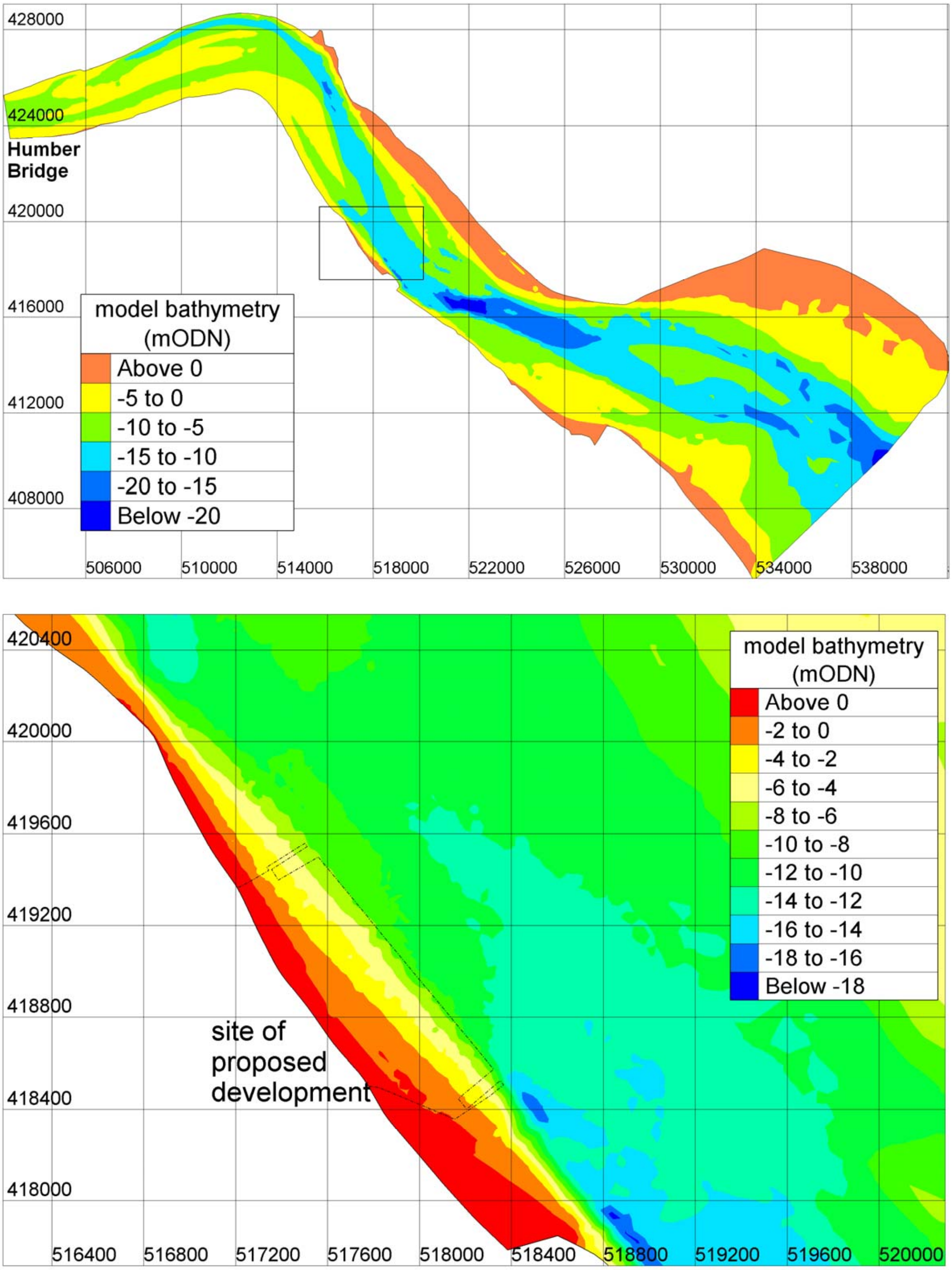

Figure 2.2 Model bathymetry

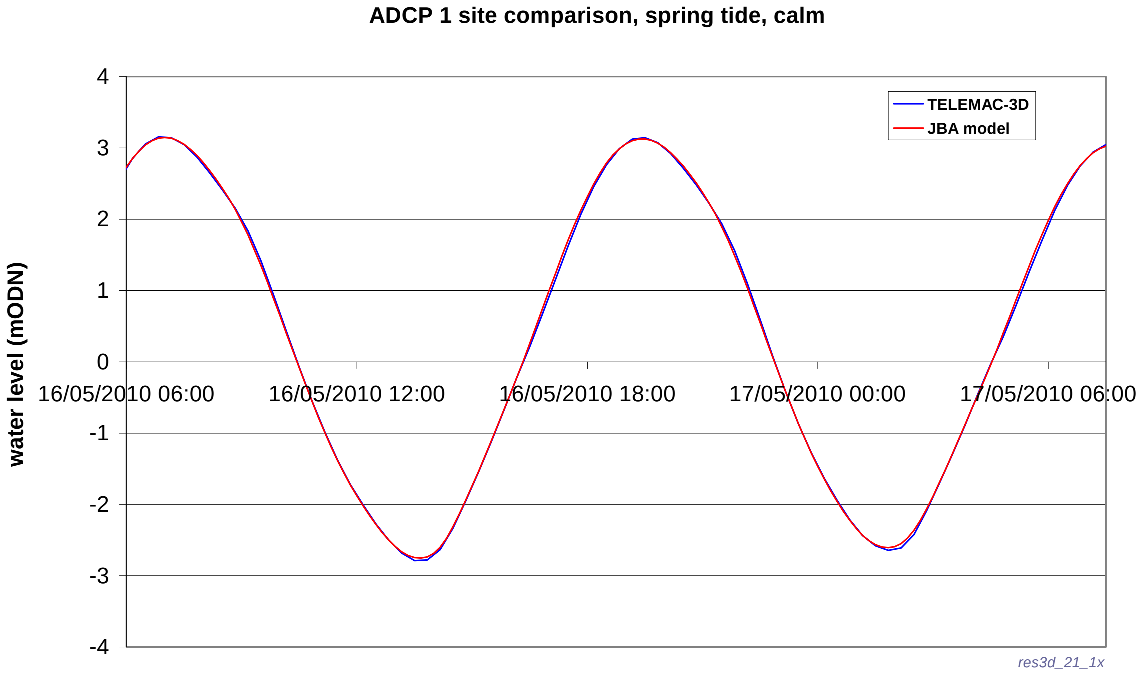

Figure 2.3 Predicted water level variation at ADCP1

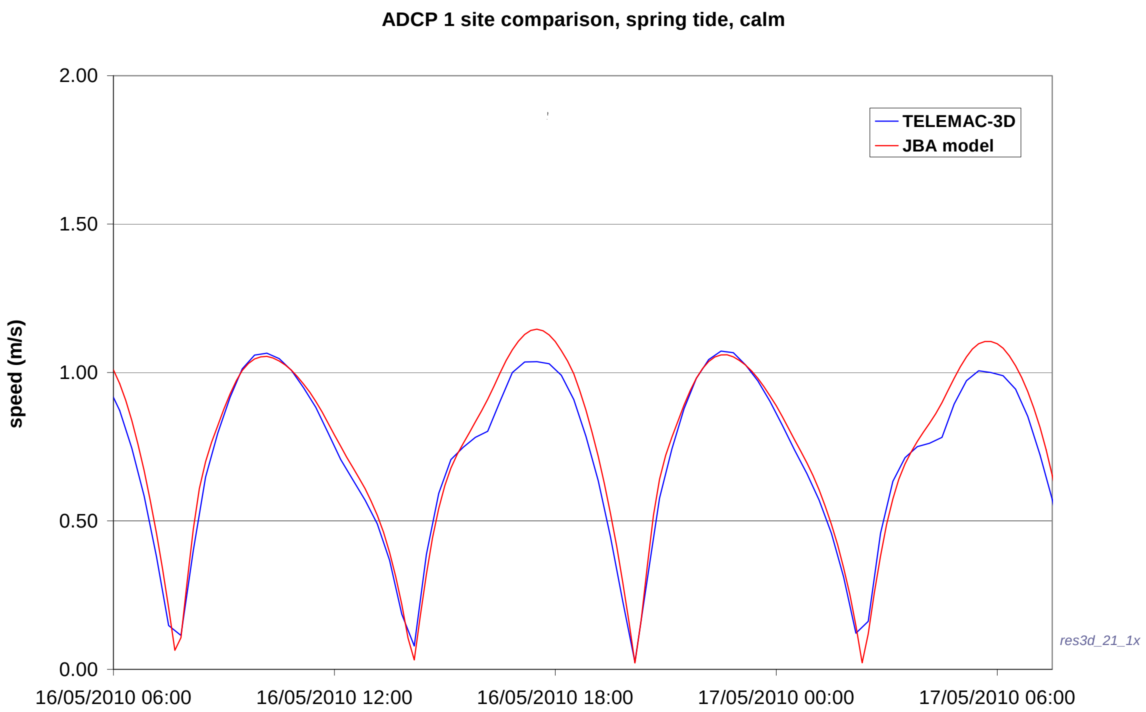

Figure 2.4 Predicted current speed and direction variation at ADCP 1

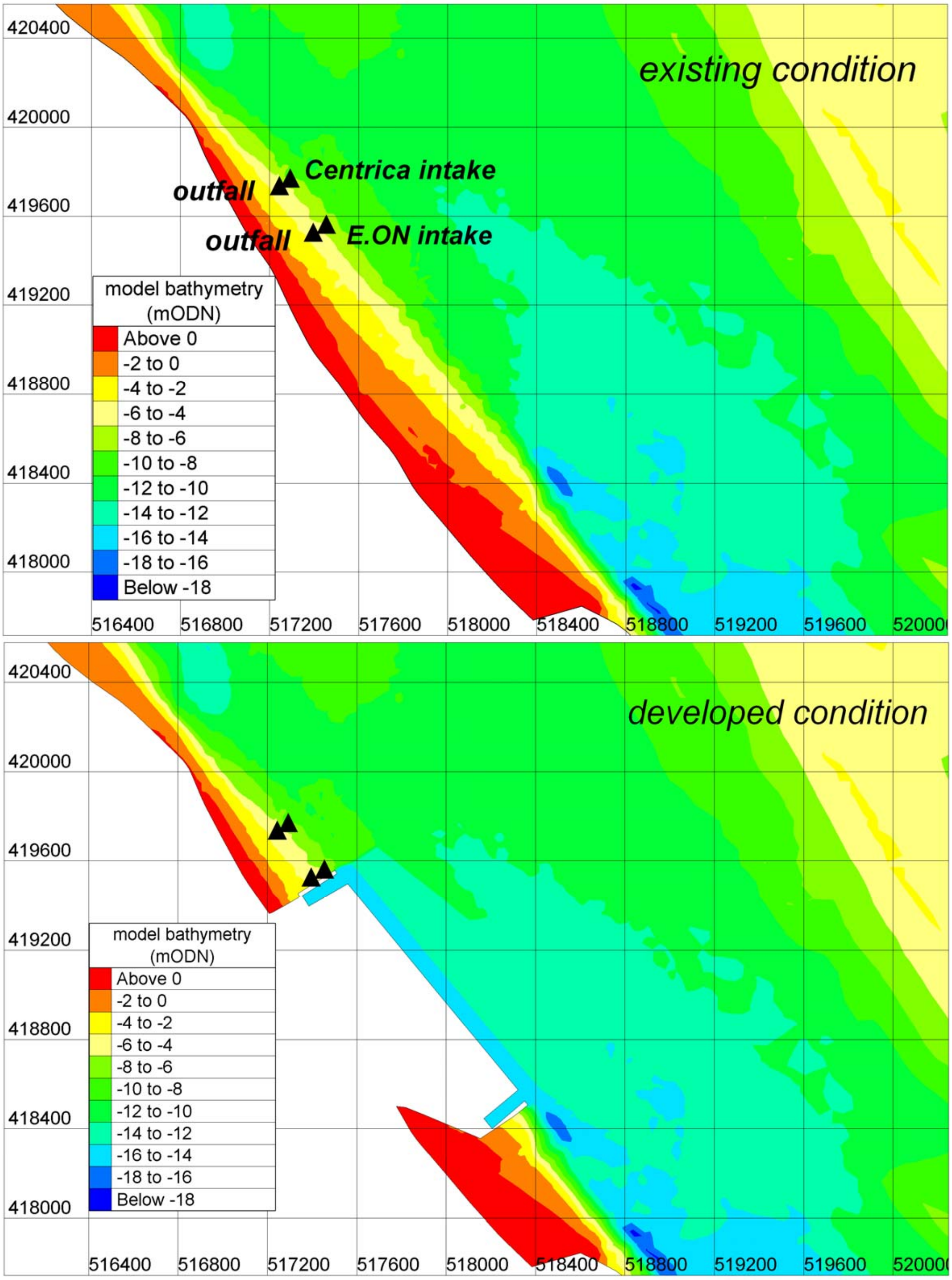

Figure 3.1 Site layouts, existing and proposed developed case

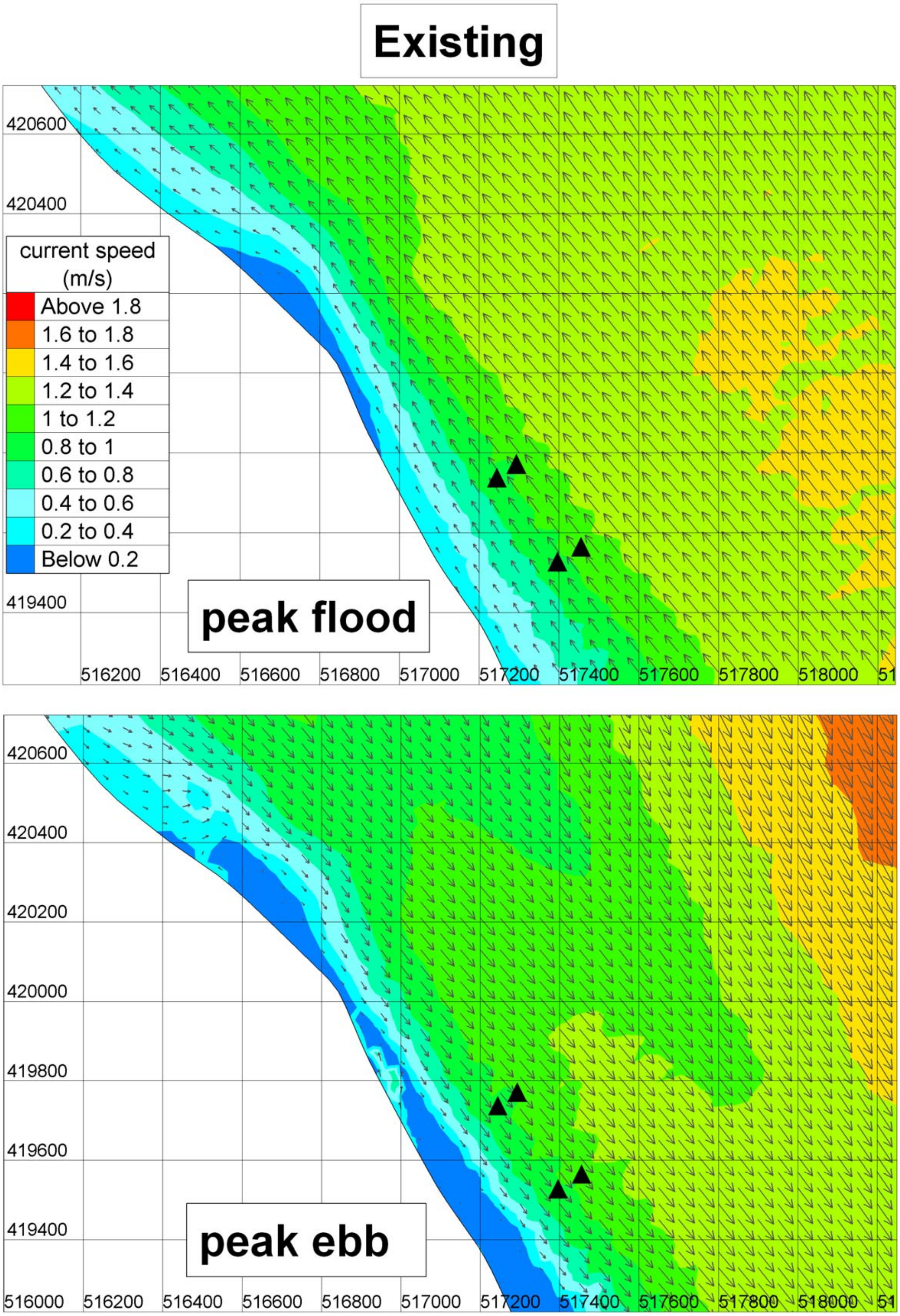

Figure 3.2a Predicted current patterns, spring tide, existing condition

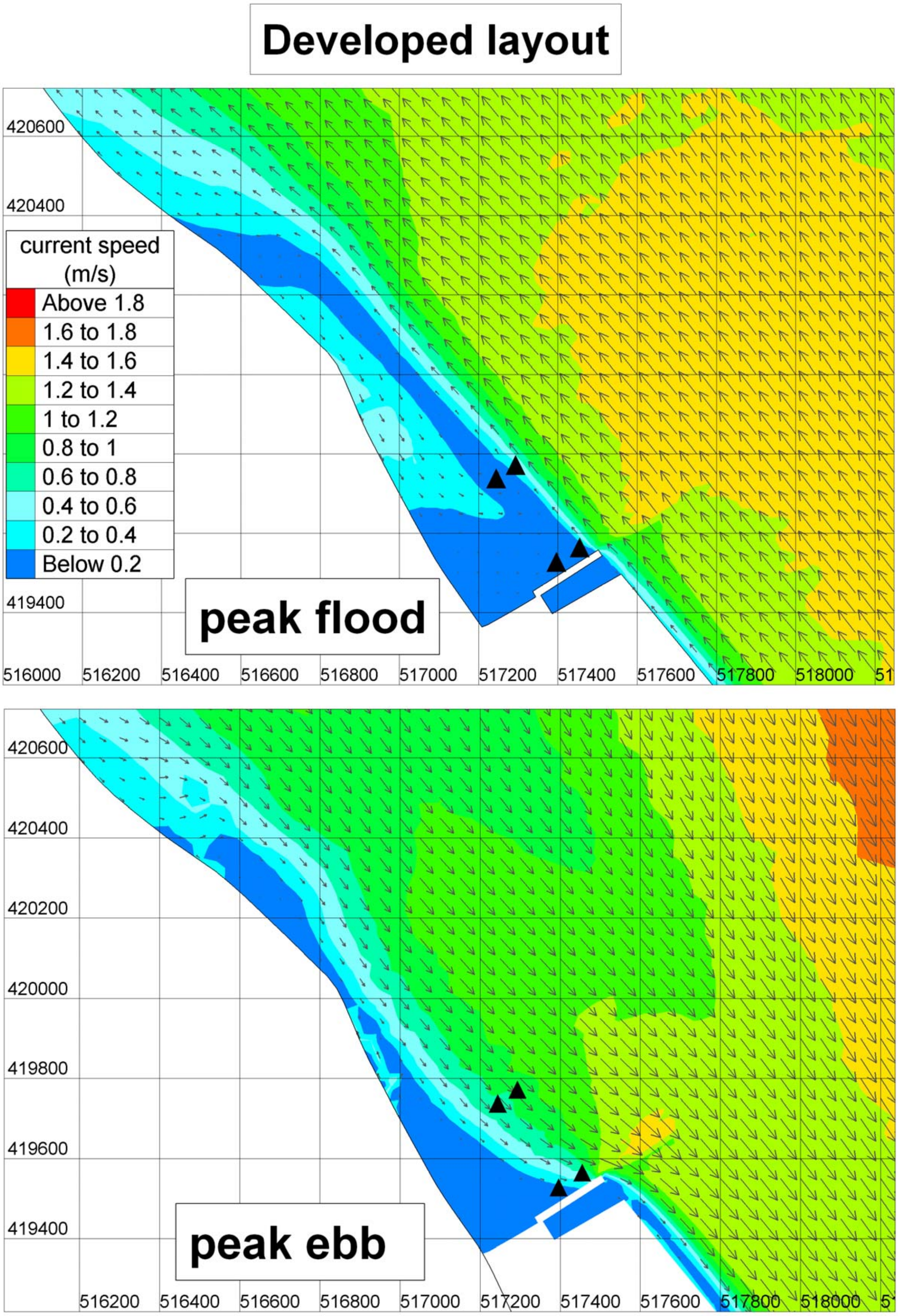

Figure 3.2b Predicted current patterns, spring tide, proposed developed condition

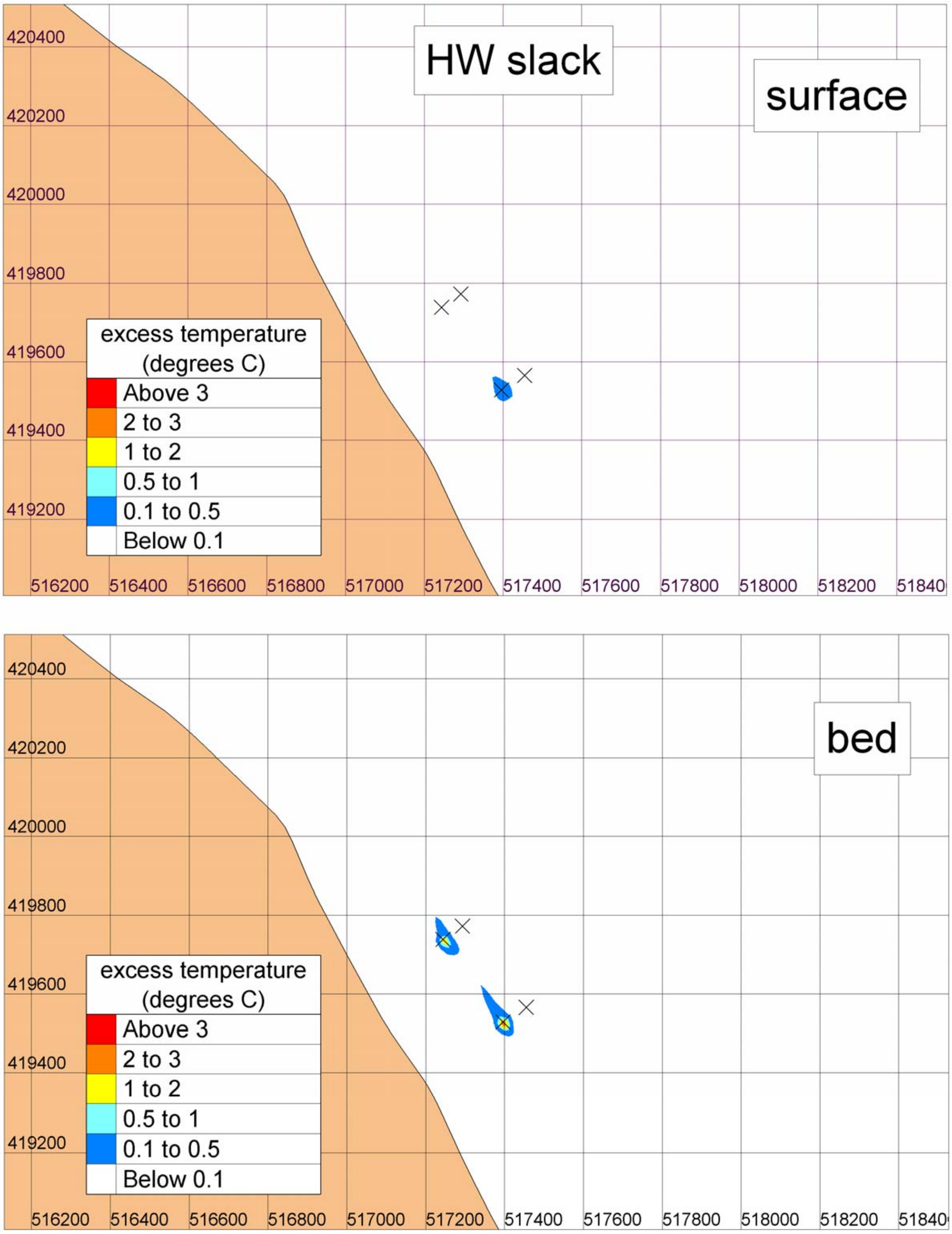

Figure 3.3 Predicted thermal dispersion patterns at High Water, existing layout, spring tide, calm conditions

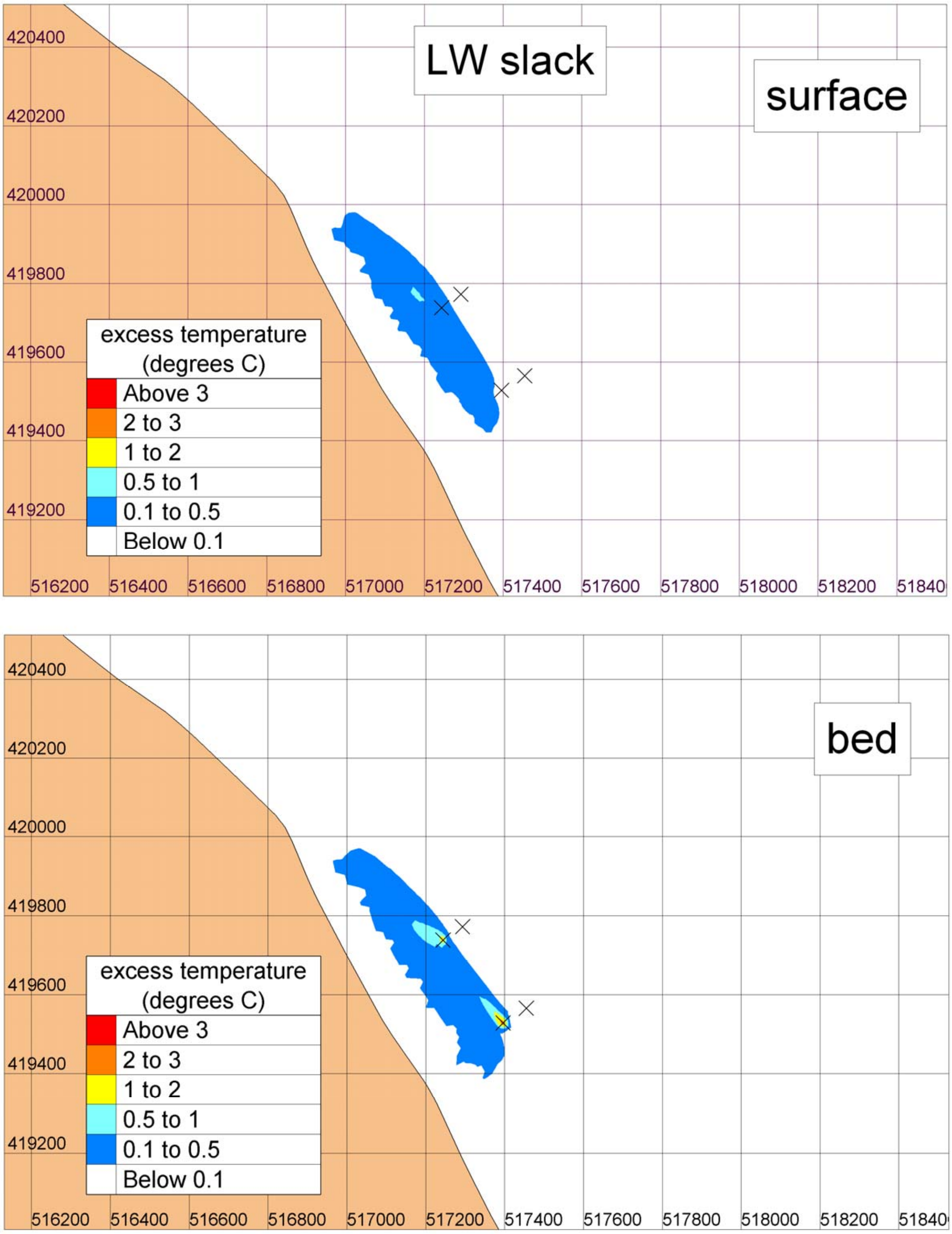

Figure 3.4 Predicted thermal dispersion patterns at Low Water, existing layout, spring tide, calm conditions

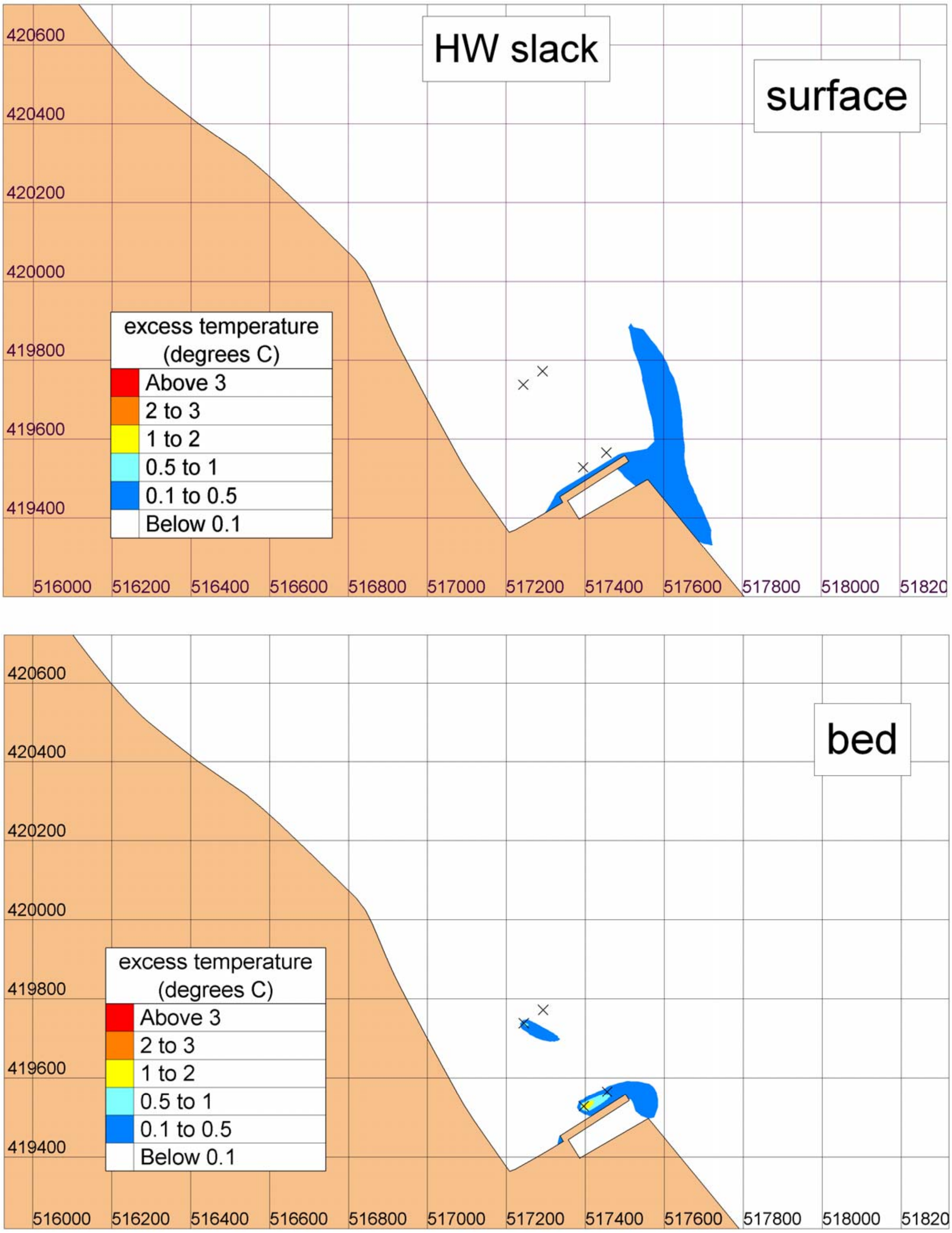

Figure 3.5 Predicted thermal dispersion patterns at High Water, developed layout, spring tide, calm conditions

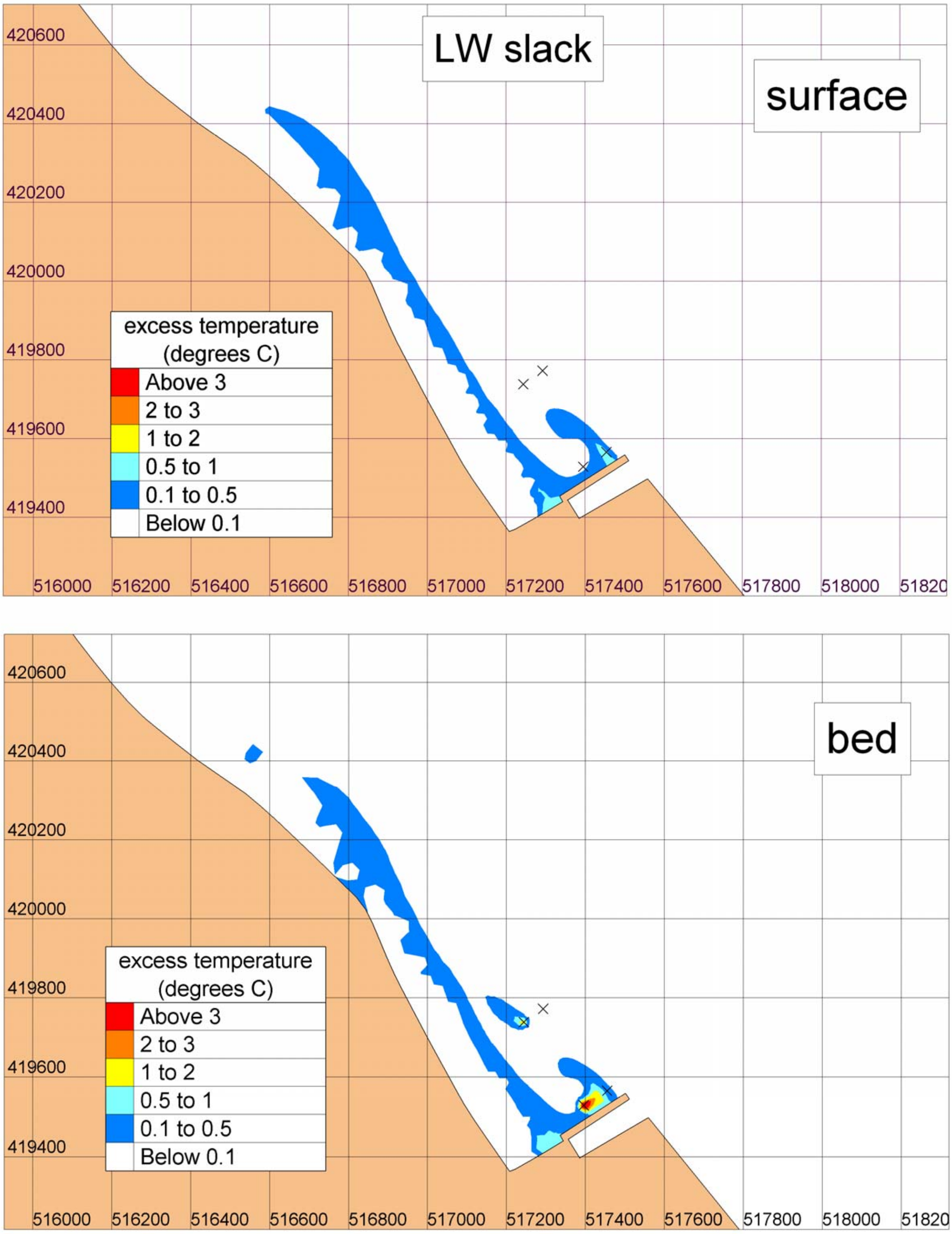

Figure 3.6 Predicted thermal dispersion patterns at Low Water, developed layout, spring tide, calm conditions

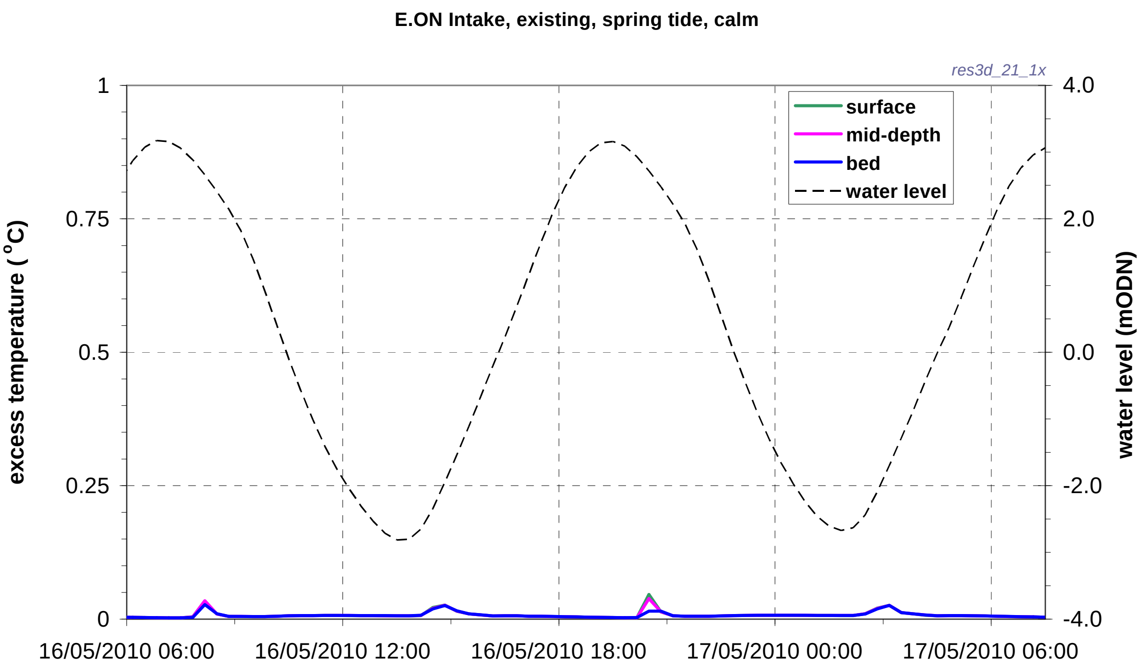

Figure 3.7 Predicted excess temperature variation at the E.ON intake, existing layout, spring tide, calm conditions

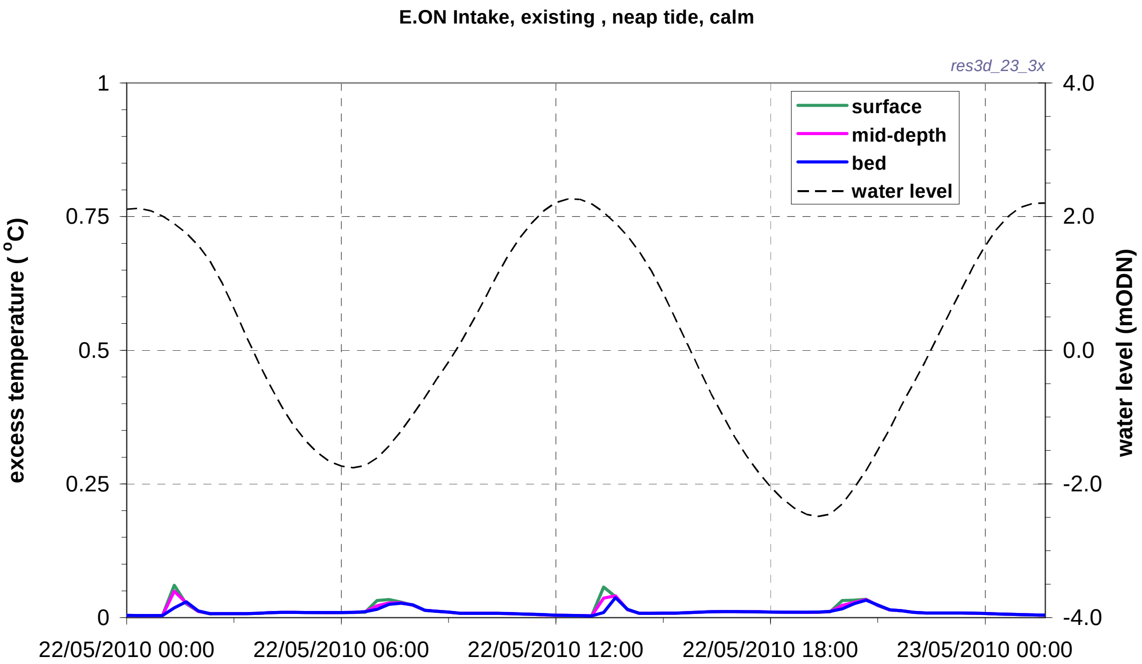

Figure 3.8 Predicted excess temperature variation at the E.ON intake, existing layout, neap tide, calm conditions

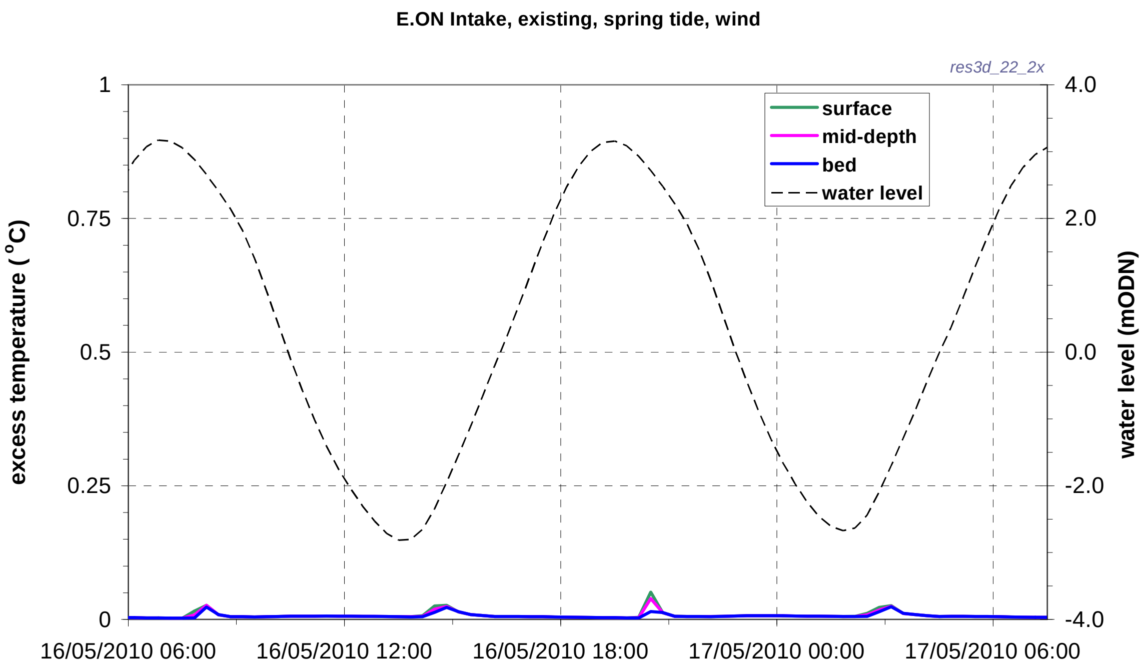

Figure 3.9 Predicted excess temperature variation at the E.ON intake, existing layout, spring tide, constant wind

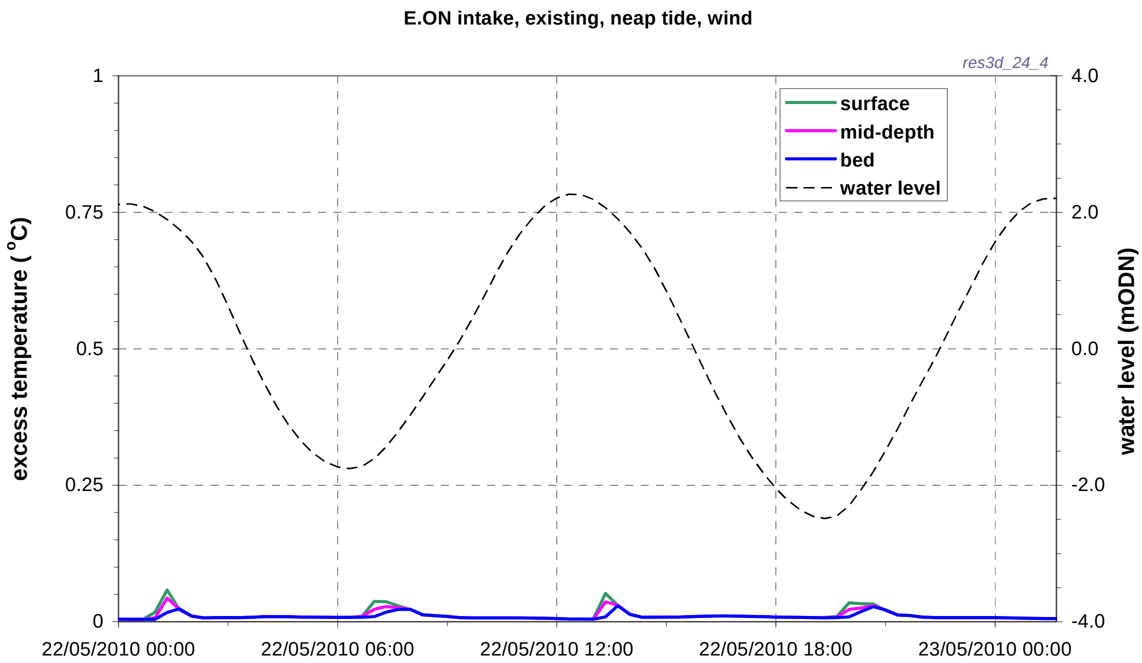

Figure 3.10 Predicted excess temperature variation at the E.ON intake, existing layout, neap tide, constant wind

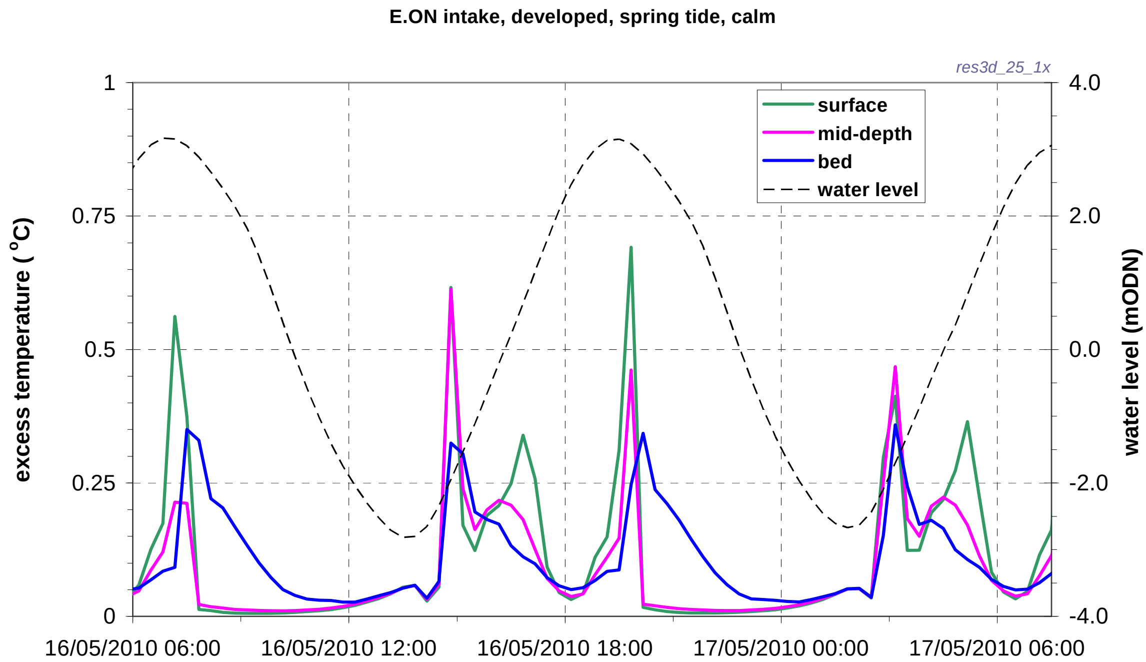

Figure 3.11 Predicted excess temperature variation at the E.ON intake, developed layout, spring tide, calm

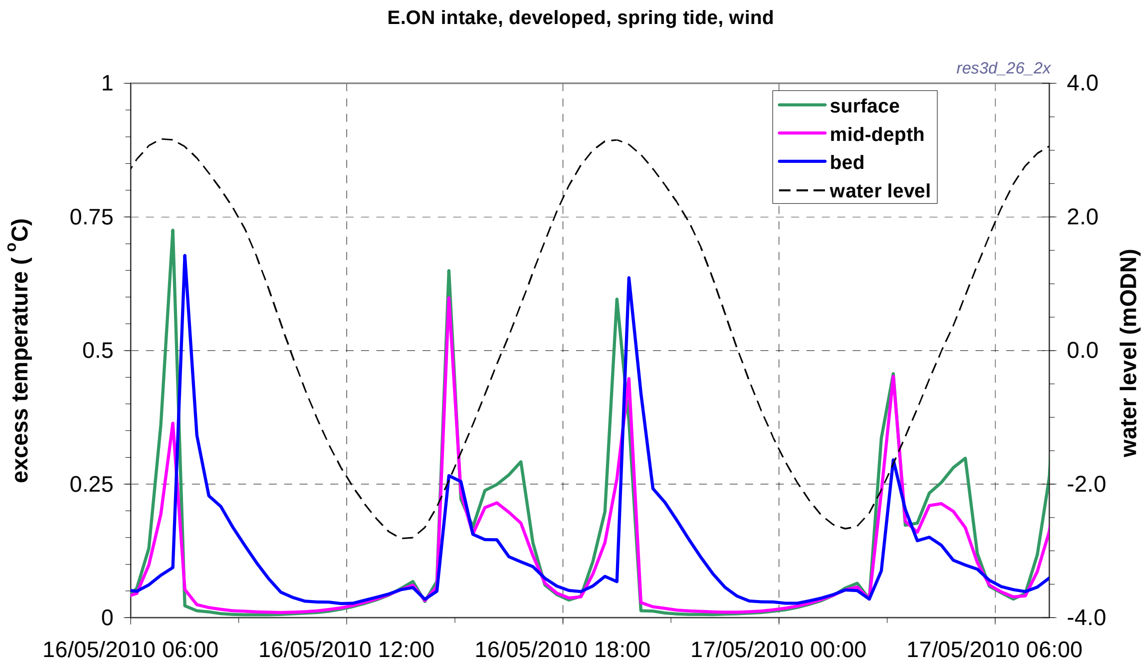

Figure 3.12 Predicted excess temperature variation at the E.ON intake, developed layout, spring tide, constant wind

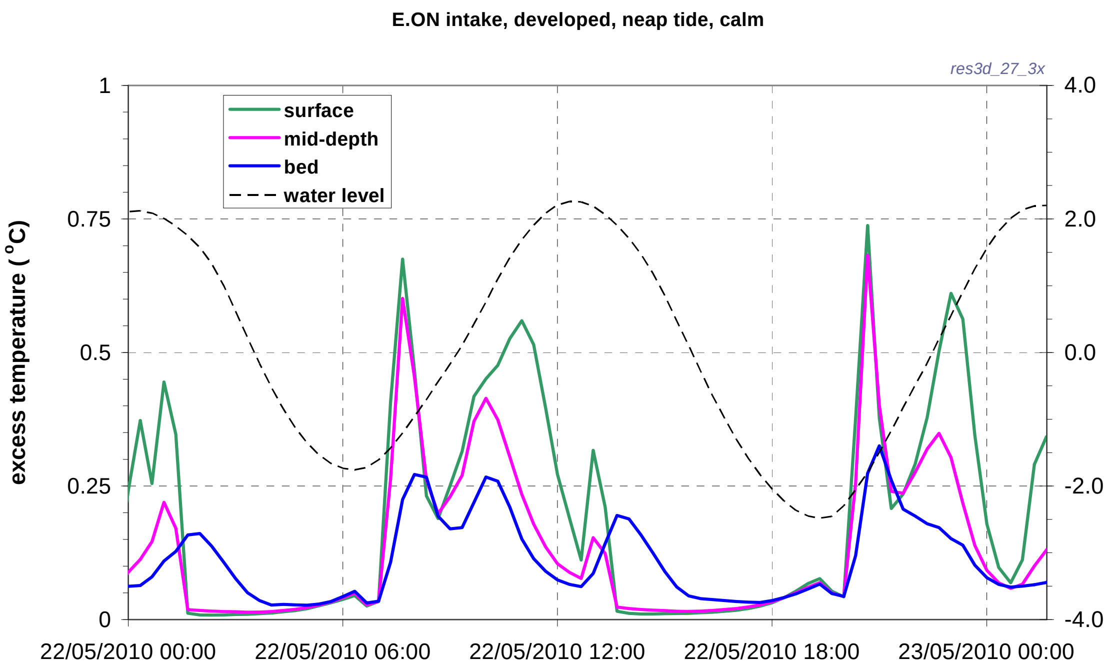

Figure 3.13 Predicted excess temperature variation at the E.ON intake, developed layout, neap tide, calm

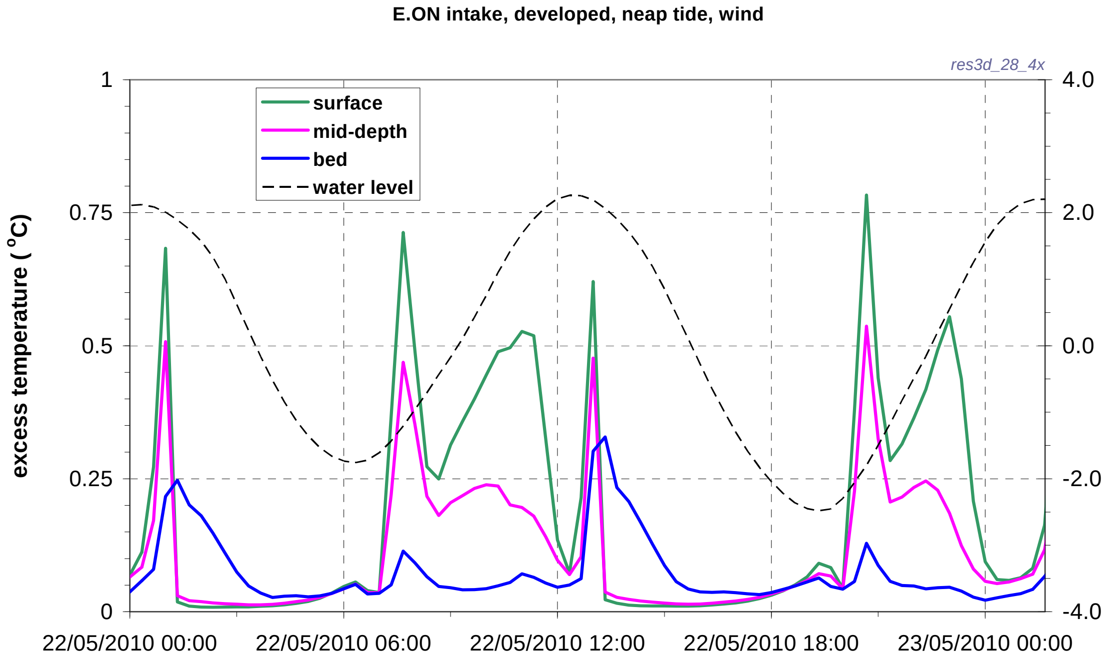

Figure 3.14 Predicted excess temperature variation at the E.ON intake, developed layout, neap tide, constant wind

Appendices

Appendix 1 Construction Design and Management Regulations (CDM 2007)

The Construction (Design and Management) Regulations 2007 (CDM 2007) require a designer to avoid foreseeable risks to those involved in construction and future use of the structure, and in doing so, they should eliminate hazards (so far as is reasonably practicable, taking into account other design considerations) and reduce risks associated with those hazards which remain. It is essential that a competent designer and principal contractor are selected to fulfil their respective duties under the CDM 2007. It is also essential to highlight and record the impacts of the works on health, safety and welfare which should feed into both the Health and Safety Plan and Health and Safety File. Further details of the requirements of CDM 2007 can be found on:

http://www.hse.gov.uk/construction/cdm.htm

This project consists of desk assessments and or modelling work which may be used by others in the design process. No design work, as defined in the CDM 2007, has been undertaken by HR Wallingford and we have not identified any particular issues that should be drawn to the attention of a competent designer and principal contractor in any ultimate construction work which may be undertaken. It is assumed that the appointed designer will review the information produced in this study when discharging his duties under the CDM 2007.

Appendix 2 Amended layout

KEY

- Limit of deviation for siting of building up to 50m high, car parking and on plot landscaping.
- Limit of deviation for siting of building up to 25m high, car parking and on plot landscaping.
- Limit of deviation for siting of building up to 15m high, car parking and on plot landscaping.
- 48 — 48 Space Car Park
- Stone Surfacing
- Concrete Surfacing
- Rock Revetment
- Existing Lighting Column (21-30m High)
- Proposed Lighting Column (55m High)
- Existing Cooling Water Intake
- Existing Cooling Water Outfall
- Existing Mooring Dolphin
- Existing Building
- Building
- Electric Substation
- HMRC Office
- Berthing Pocket

Rev	Date	Comments	Drw	Chk	App
C	04/11/11	General Amendments	JH	RC	RC
B	30/08/11	General Amendments	JH	RC	RC
A	16/06/11	Preliminary Issue	JH	RC	RC

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Project: ABLE Marine Energy Park

Client: ABLE UK Ltd

Title: Figure 4.2
Indicative Site Plan For AMEP

PRELIMINARY

Scale:	Drawn	Checked	Approved
1:5,000@A1	J Harris	R Cram	R Cram
Date	16/06/2011	16/06/2011	16/06/2011

Drawing No. Figure 4.2 — Revision: C