Hampshire Water Transfer and Water Recycling Project

Environmental Statement – Appendix 19.5 Eastney Long Sea Outfall Solent dispersion modelling

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1 Introduction

1.1 Purpose of document

The purpose of this document is to summarise the results of dispersion modelling undertaken to inform the environmental assessments associated with the proposed Hampshire Water Transfer and Water Recycling Project. Specifically, this report will support the Marine Biodiversity and Water Environmental Impact Assessment (EIA) chapters, including supporting assessments such as the Water Environment Regulations (WER) assessment.

This report provides an update of a previous report (Royal HaskoningDHV, 2022) to reflect recent WRP design changes, as set out in **Section 1.4**.

1.2 Requirement for dispersion modelling

No physical modifications are anticipated to the Eastney LSO, however operation of the WRP will require use of the Eastney LSO to discharge reject water changing the existing permitted Budds Farm discharge conditions. Dispersion modelling has therefore been completed to understand what effects the reduction in treated wastewater discharge flows and addition of the reject water to the discharge may have on the marine environment. Parameters modelled were informed by the results of work undertaken to produce the '*Water for Life Hampshire: Water Resources Project: Budds Farm Final Effluent Environmental Permit: WRP Discharge Position Statement*' issued in March 2022 (subsequently updated on 2023), which identified the potential for changes to the following parameters:

- Biological oxygen demand (BOD);
- Chemical oxygen demand (COD);
- Suspended solids concentrations;
- Salinity;
- Iron; and
- Total nitrogen.

The previous modelling report (Royal HaskoningDHV 2022), considered that the WRP could be delivered in two separate phases. Since this report was finalised the design and requirements for the proposed WRP in the context of the urgent need case for the project has changed, so that the proposed WRP would be delivered in one single phase providing at peak output 60Ml/d of recycled water. This report has therefore been updated to reflect a single phase of operation.

The location of the existing Eastney LSO is shown in **Figure 1-1**.

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Figure 1-1: Location of the existing Eastney LSO

The modelling approach is described in **Section 2** and the discharge conditions are described in **Section 3**. The hydrodynamic model build and calibration process is described in **Section 4** and the dispersion model and results in **Section5**, followed by the conclusions in **Section 6**.

Natural England, the Environment Agency and the Marine Management Organisation were consulted on the model calibration process as part of the previous 2022 modelling work.

2 Approach

Previous work undertaken by Southern Water to support the options appraisal process for RAPID Gate 2 included model runs for different flows; 15Ml/d (Business as usual (BAU) and 75Ml/d (maximum design flow) discharge scenarios using a 2-dimensional MIKE21 model. However, this MIKE21 model was built in the rectangular-mesh version of MIKE21 (shown in Figure 2-1) and was last calibrated and validated in 1981, although currently operated by Southern Water in the 2011 version of MIKE21. Considering that Southern Water's 2-dimensional model was developed over 10 years ago and the rectangular-mesh version of MIKE21 is no longer supported by the model developer, an existing Solent and Isle of Wight 3-dimensional model (referred to as the "Isle of Wight and Solent model") developed by Royal HaskoningDHV was used.

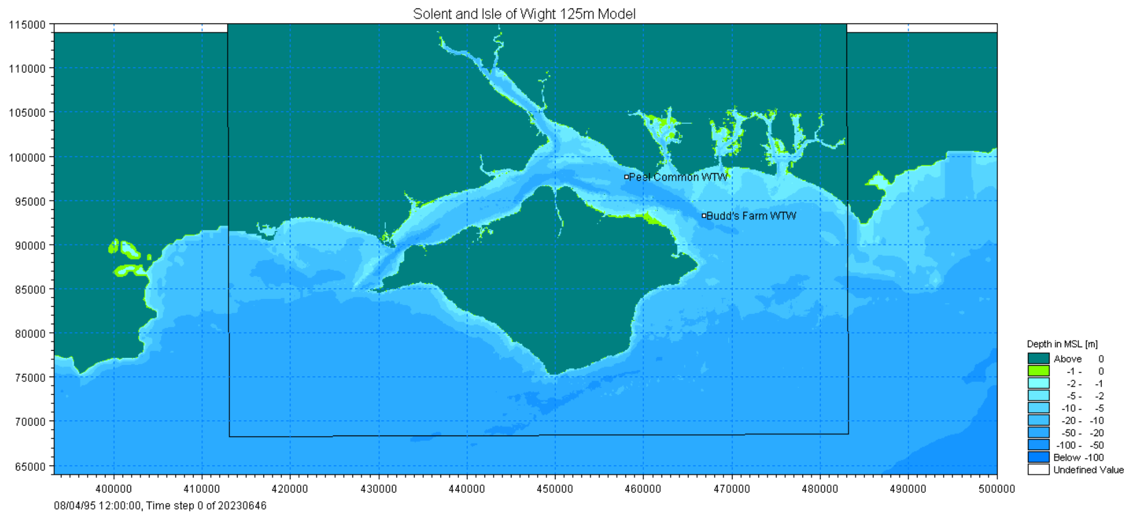

Figure 2-1: Southern Water's 125m resolution Mike21 model extent – Christchurch to Selsey Bill

For this study, the Isle of Wight and Solent model has been previously calibrated and validated by measured tidal data collected in the area south of the Isle of Wight (see Figure 2-2). The model boundary conditions were taken from Royal HaskoningDHV's English Channel Regional Model. Further details on bathymetry and model extent are provided in **Section 4.1** and **4.2**, respectively.

Figure 2-2: Locations of ADCP data and tidal gauge data (Ventnor) used for RHDHV's model calibration

Following a desk-based review of available sources of calibration data, it was determined that the measured tidal data in Portsmouth Harbour and the data collected in April and May of 2006 for the "Portsmouth Approaches and Harbour Deepening: Baseline Modelling" project delivered by ABP Marine Environmental Research Ltd. (Ref. R/3616/3, Doc. No. R.1348, February 2008) were the latest openly available data for this area. Therefore, the Isle of Wight and Solent model has been re-calibrated and validated against that data. Further details on model re-calibration and validation are provided in **Section 4.3**.

The model simulations were set to a duration of one month, to cover several tidal cycles (to assess potential accumulation of the discharged pollutants) and various wind conditions were included in sensitivity tests to identify the worst wind condition. This is discussed in **Section 5.1** and **5.2**.

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3 Discharge conditions

To model the potential impact in marine water quality caused by the changes in the existing treated wastewater discharge (reduction in flows) and addition of the WRP reject stream, a mass balance calculation was conducted by Southern Water for the identified parameters (see **Section 1.4**) to determine changes in discharge concentration for the 60Ml/day operational flow scenario.

Table 3.1 presents the discharge conditions (salinity, flow and load) provided by Southern Water for the existing 'baseline' scenario (i.e. no changes to the current discharge) and the potential WRP flow scenario (60Ml/day). Similarly, **Table 3.2** shows the concentrations of water quality parameters, also provided by Southern Water for the same two scenarios. No change to ambient water temperature was assumed for both the existing wastewater discharge and the WRP reject stream.

Table 3.1: Proposed discharge conditions – salinity, flow, and load (based on "Mass Balance Inputs to Tool v1.3.xlsx")

Scenario	Existing			Future (60Ml/D)		
	Salinity (PSU)	Salinity (PSU)	Salinity (PSU)	Salinity (PSU)	Flow (m^3/s)	Flow (Ml/day)
Budd's Farm	2.56	2.56	2.56	2.56	0.40	34.08
WRP	N/A	9.56	9.56	9.56	0.20	21.52
Total to Solent (Budds Farm + WRP)	2.56	5.27	5.27	5.27	0.60	55.60

Table 3.2: Proposed concentrations (mg/l) of the considered parameters (based on "Mass Balance Inputs to Tool v1.3.xlsx")

Concentration (mg/l)	BIOCHEMICAL OXYGEN DEMAND	CHEMICAL OXYGEN DEMAND	IRON	SOLIDS (SUSPENDED AT 105°C)	SALINITY (AT 105°C)	TOTAL NITROGEN
Existing	4.32	63.36	0.11	16.51	2.56	8.18
60Ml/d	11.96	133.77	0.22	39.16	5.27	16.10

Table 3.3: Calculated discharge loads of pollutants (g/s) based on values presented in Table 3.1 and Table 3.2

Concentration (mg/l)	BIOCHEMICAL OXYGEN DEMAND	CHEMICAL OXYGEN DEMAND	IRON	SOLIDS (SUSPENDED AT 105°C)	SALINITY (AT 105°C)	TOTAL NITROGEN
Existing	6.22	91.15	0.16	23.75	3,689	11.77
60Ml/d	7.70	86.08	0.14	25.20	3,393	10.36

Table 3.3 presents calculated discharge loads of pollutants, which shows small increase in BOD and decrease in COD, Iron, salinity and Total Nitrogen for the 60Ml/d scenario.

It should be noted that the model does not simulate the absolute concentration of the water quality parameters i.e. does not combine the discharged concentrations with background concentrations in the water column, apart from salinity that was specified for the ambient water. Instead, the modelled output is presented as either an increase or decrease above a baseline of 0. Modelling of the existing discharge scenario can therefore be used as a baseline to calculate the difference in the water quality parameters between conditions now and each future flow scenarios. Furthermore, no decay or chemical or bio-chemical processes were considered, and all parameters were assumed to be fully dissolved except Total Suspended Solid which was assumed in suspension permanently (i.e. no settling).

4 Hydrodynamic model

4.1 Bathymetry

The Isle of Wight and Solent model was updated with Marine Themes Digital Elevation Model (DEM) bathymetry data from OceanWise Ltd. (supplied by Southern Water), as shown in **Figure 4-1** below. The DEM was created using data from the UK Hydrographic Office and other agencies. Data derived from Electronic Navigational Charts (ENCs) was also used by OceanWise to provide additional coverage.

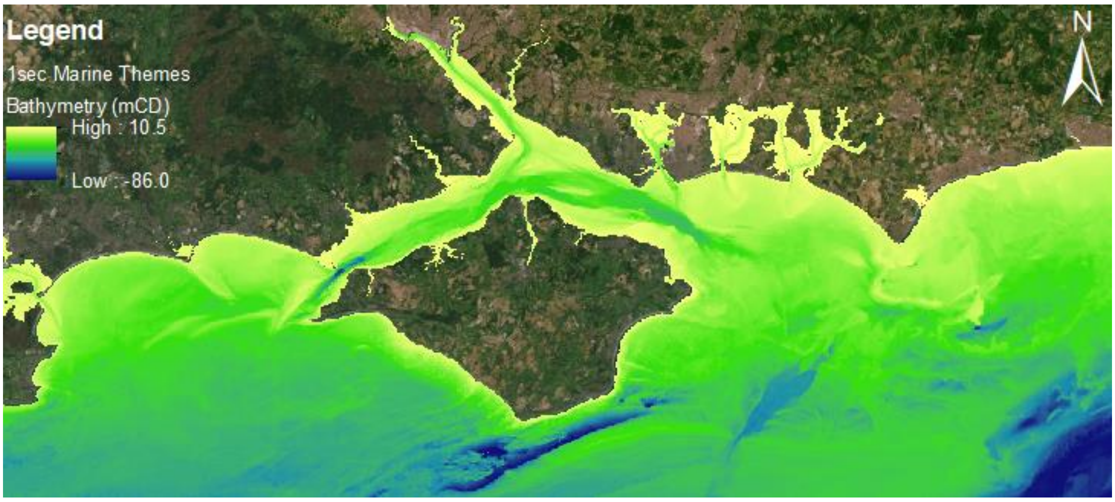

Figure 4-1: OceanWise Marine Themes DEM bathymetry data

4.2 Model mesh

The extent and bathymetry of the Regional English Channel model used for boundary conditions for the Isle of Wight and Solent model, is shown in **Figure 4-2**.

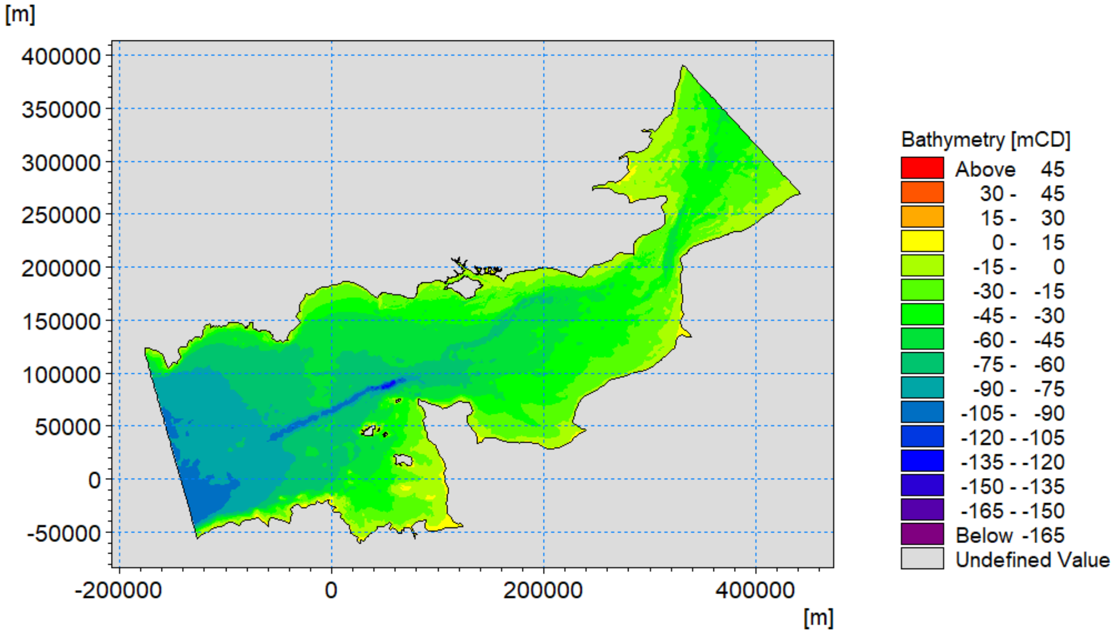

Figure 4-2: Regional English Channel model extent and bathymetry

The Isle of Wight and Solent model extent was updated to match the existing MIKE21 Southern Water model, as shown in **Figure 4-3**. The model mesh was refined within the Solent and the finest mesh was set within the Portsmouth harbour, where one of the calibration points was located, as presented in **Figure 4-4**. Following model calibration, further mesh refinement around the Eastney LSO location was also applied.

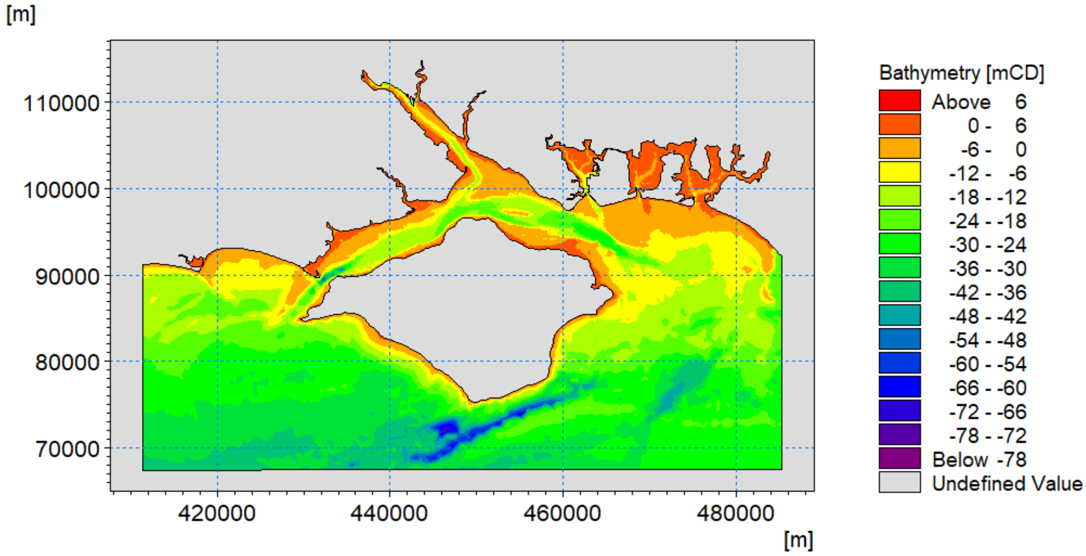

Figure 4-3: Isle of Wight and Solent model extent and bathymetry

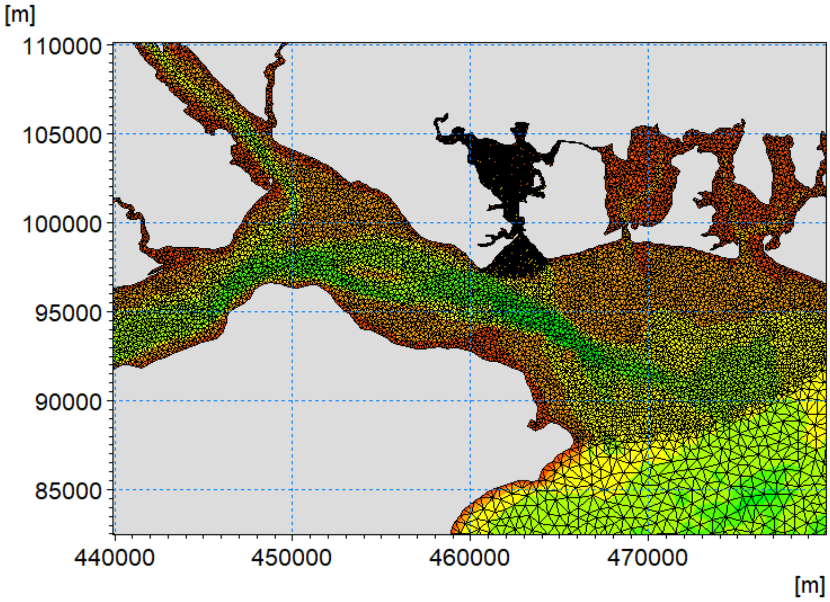

Figure 4-4: Isle of Wight and Solent model mesh refinement

4.3 Model calibration

For the Isle of Wight and Solent model calibration, the boundary conditions were extracted from the Regional English Channel model for a period between 1st of April and 30th of May 2006. This matches the period of data collected for the "Portsmouth Approaches and Harbour Deepening: Baseline Modelling" project.

The calibration/validation data consisted of measured water levels, current speed and direction at a location within Portsmouth Harbour (Points B in **Figure 4-5**) and predicted data at several locations within the Solent (Points I, J, K, L and N in **Figure 4-5**). The astronomic predictions of water levels and currents were obtained from the TotalTide software developed by the UK Hydrographic Office. The predicted data were used in lieu of measurements.

The collected data were not available in digital format but in images, therefore a visual comparison was made based on timeseries plots of water level, current speed and direction (see Figure 4-7- Figure 4-11 in which modelled and measured are presented in separate graphs).

It should be noted that the focus of model calibration was on the data points located with Solent (mainly Points L, J and K, see Figure 4-5) as the closest locations to the Eastney LSO discharge location.

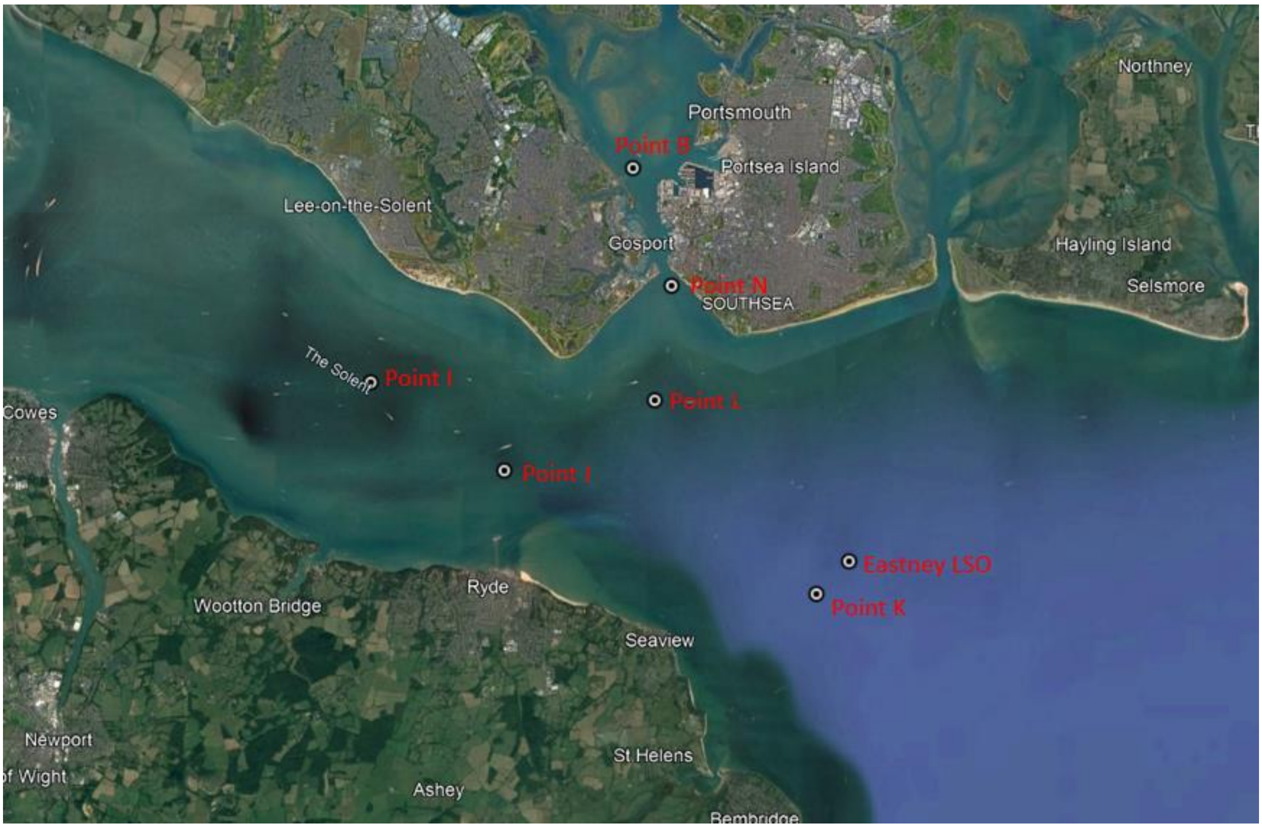

Figure 4-5: Locations of the calibration/validation data points

2D depth-averaged model results were considered in the model calibration, as the measured data in the 'Portsmouth Approaches and Harbour Deepening: Baseline Modelling' project report, are only presented as depth-averaged values.

Results of the water level model calibration at Portsmouth tide gauge are presented in **Figure 4-6** showing relatively good agreement between the predicted and modelled water levels. The model slightly underpredicts high water levels during the spring tide (less than 10%) but gives a very good match at neap tide. Such small differences between modelled and predicted water levels are not significant and therefore, it is assumed that the model is able to represent the water levels within Solent and Portsmouth harbour.

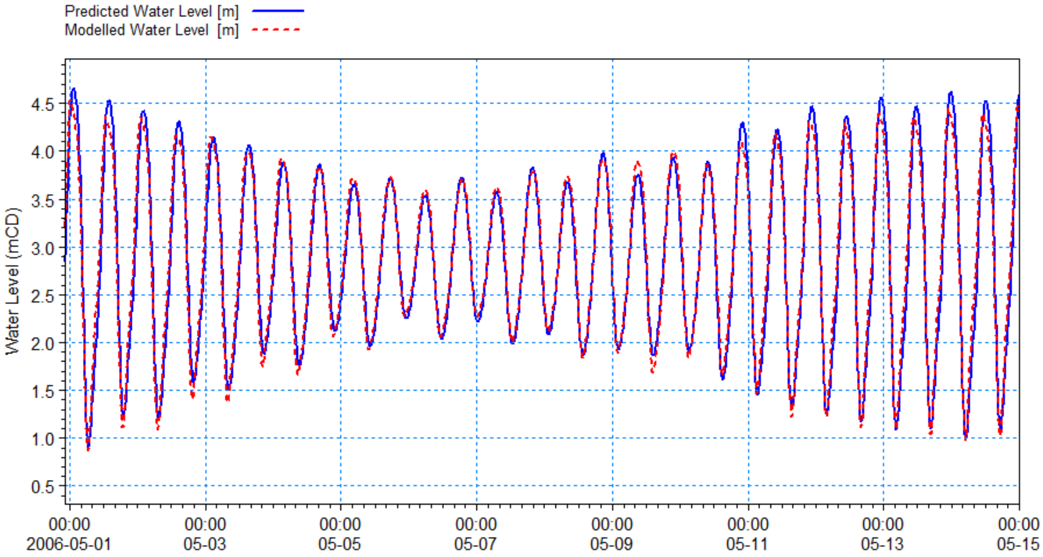

Figure 4-6: Water level model calibration results at Portsmouth tide gauge

Calibration of tidal currents at Point B (**Figure 4-5**) within Portsmouth Harbour proved more challenging than other calibration points. The model results show an underprediction of current speeds when compared to the measured current speeds, see "Inner AWAC" illustrated in **Figure 4-7**. Upper Panel shows the modelled results, whereas Lower Panel shows a snapshot of the measured and modelled results taken from the "Portsmouth Approaches and Harbour Deepening: Baseline Modelling" project report by ABPmer.

Figure 4-7 shows that, similarly to water levels, a better agreement between modelled and measured current speeds is achieved for neap tides, whereas for spring tides the discrepancy is greater.

However, it should be noted that the Isle of Wight and Solent model was built with the latest bathymetry data, whereas the measured current speeds were collected in 2006. Therefore, there is the potential that local bathymetry may have changed over the years, which could have impacted local current speeds. This was confirmed with a series of model tests with manually adjusted bed levels within the harbour, and showed significant sensitivity of current speed to local bathymetry changes.

Since Portsmouth Harbour was not considered as a key location for this study (the main impacts being likely at the discharge location in the Solent), further changes to model were not made, but rather model calibration was focused on achieving good agreement for locations within Solent, i.e. Points I, J, K and L.

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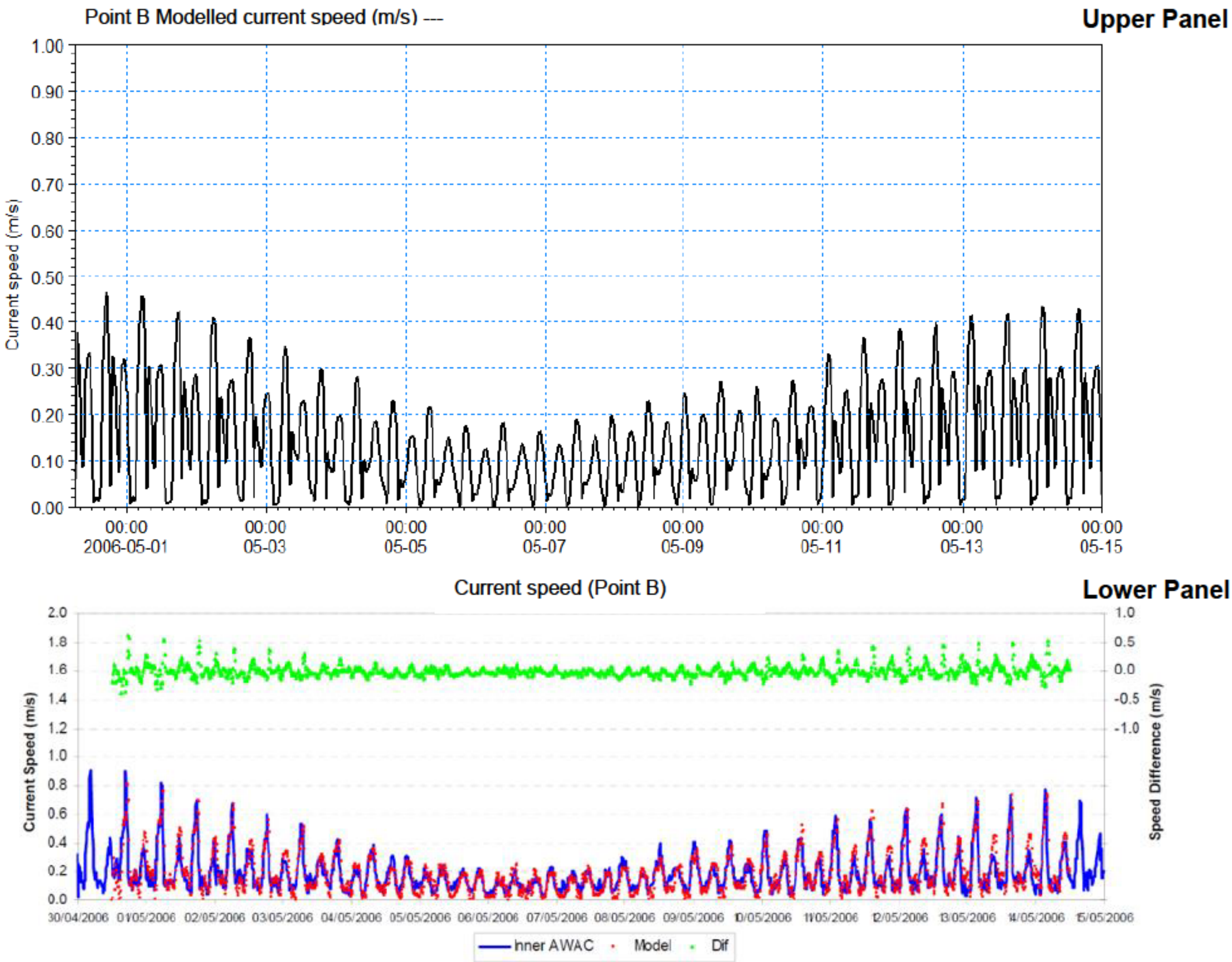

Figure 4-7: Comparison of modelled (Upper Panel) and measured (Lower Panel) current speeds at Point B within Portsmouth Harbour (red and green dots in Lower Panel were related to modelled data by ABPmer)

Figure 4-8 and **Figure 4-9** show comparison of modelled (Upper Panel) and measured (Lower Panel) current speeds at Points J and K within Solent, respectively. Additional figures for all considered Points (I, J, K and L) are provided in Appendix A.

Results in **Figure 4-8** and **Figure 4-9** show good agreement between the modelled (Upper Panel) and measured (Lower Panel) current speeds at Point J and Point K within Solent, with peak speeds at spring tide around 0.8m/s and around 0.4 m/s for neap tides.

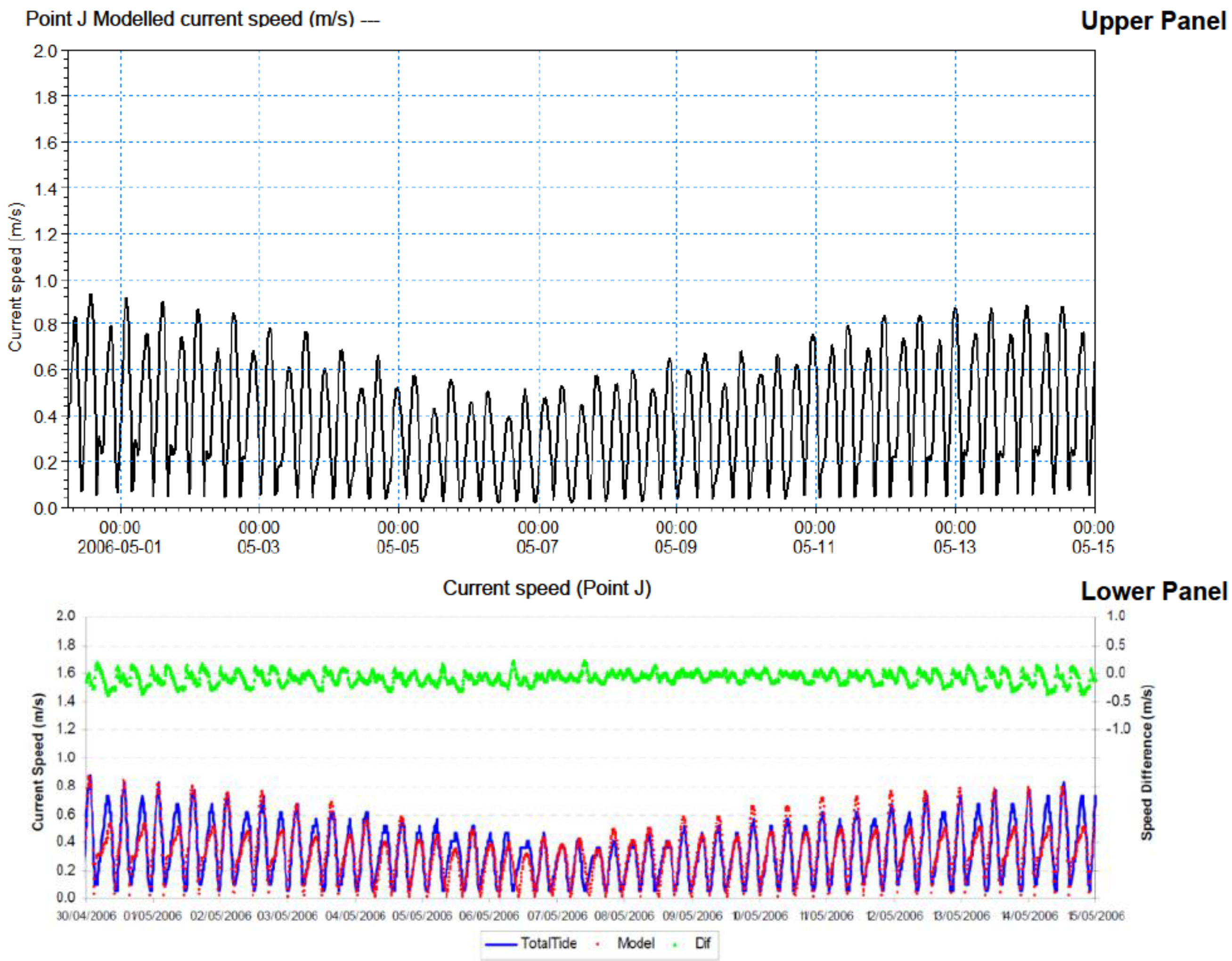

Figure 4-8: Comparison of modelled (Upper Panel) and measured (lower Panel) current speeds at Point J within Solent (red and green dots in Lower Panel were related to modelled data by ABPmer)

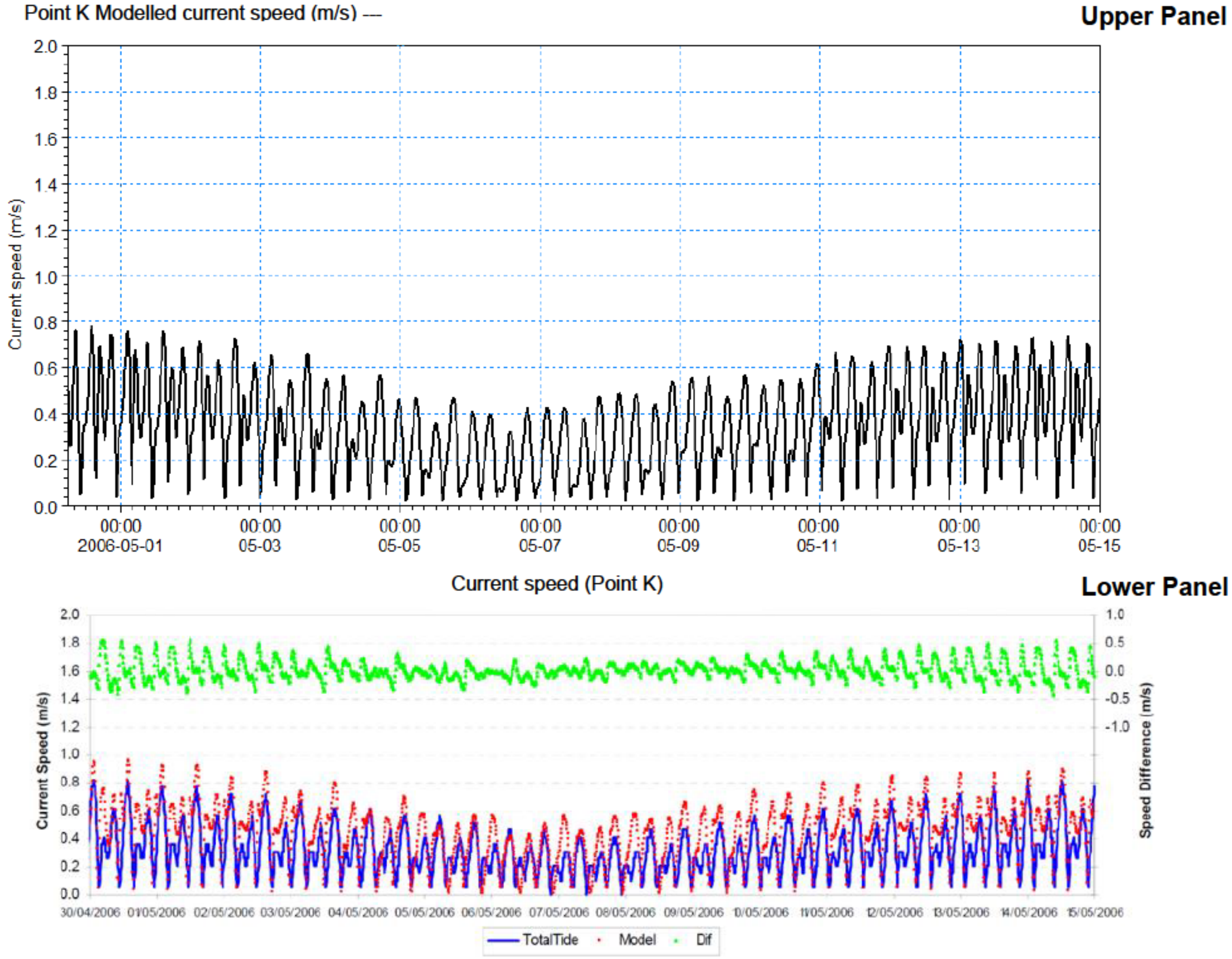

Figure 4-9: Comparison of modelled (Upper Panel) and measured (Lower Panel) current speeds at Point K within Solent (red and green dots in Lower Panel were related to modelled data by ABPmer)

Figure 4-10 and **Figure 4-11** show comparison of modelled (Upper Panel) and measured (Lower Panel) current direction at Points J and K within Solent, respectively. Additional figures for all Points (I, J, K and L) are provided in Appendix A.

Results in **Figure 4-10** and **Figure 4-11** show good agreement between the modelled (Upper Panel) and measured (Lower Panel) current direction at Point J and Point K within Solent. General current direction at flood tide is around 115degN and 135degN for Points J and K respectively at flood tides, and around 280degN and 300degN at ebb tides. The current direction in the plots shown in this report refers to “flowing going to”.

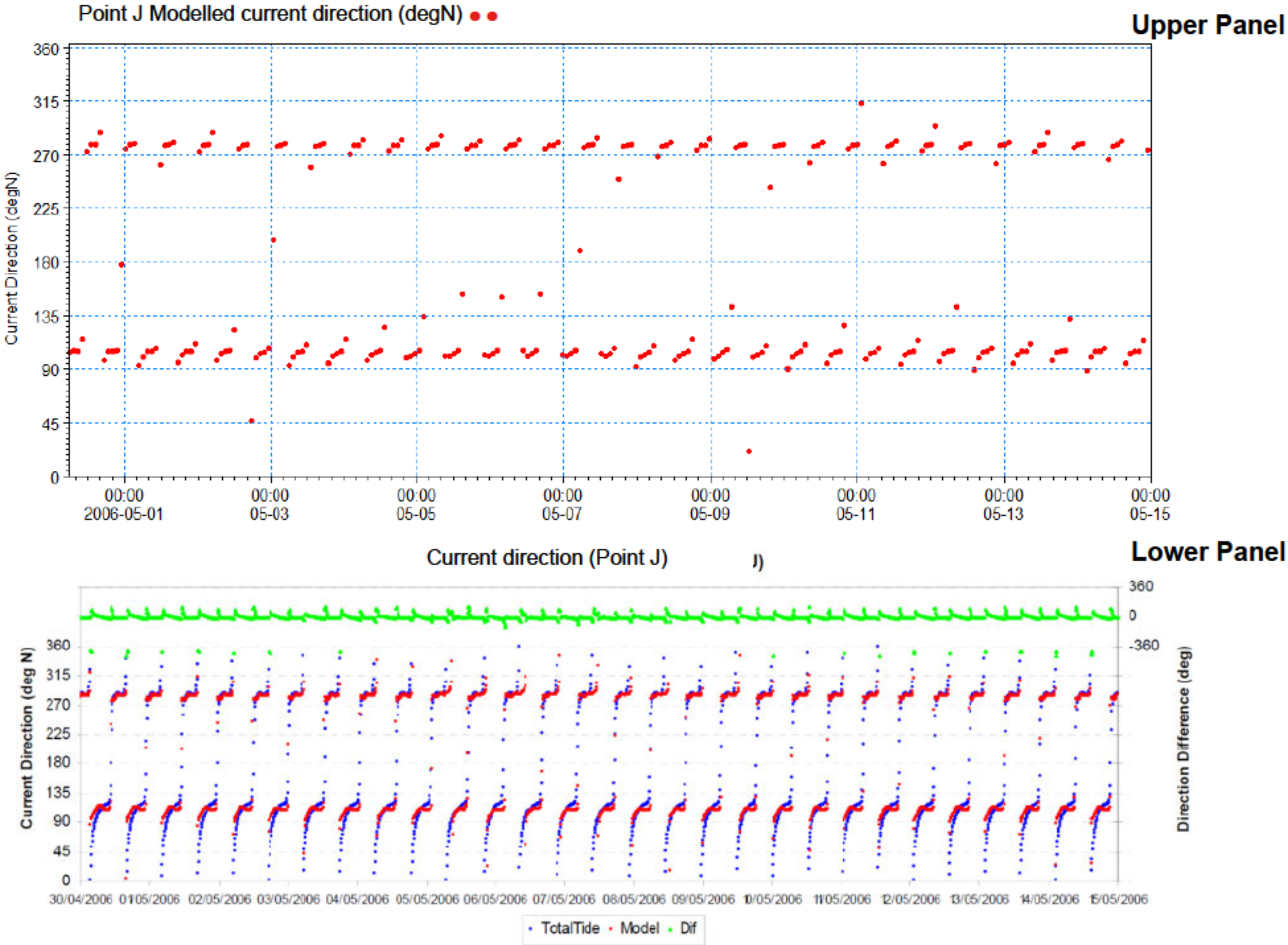

Figure 4-10: Comparison of modelled (Upper Panel) and measured (Lower Panel) current direction at Point J within Solent (red and green dots in Lower Panel were related to modelled data by ABPmer)

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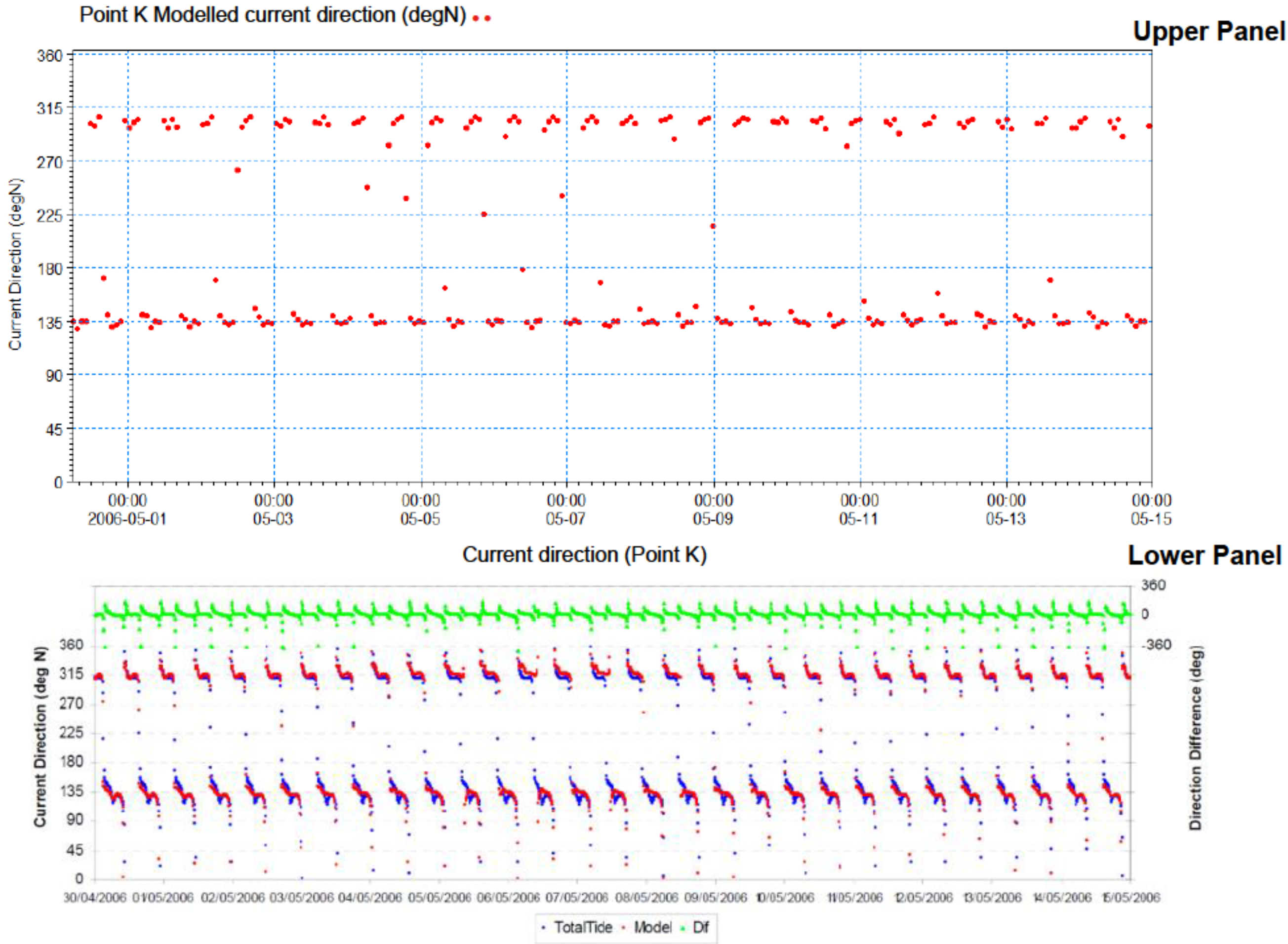

Figure 4-11: Comparison of modelled (Upper Panel) and measured (lower Panel) current direction at Point K within Solent (red and green dots in Lower Panel were related to modelled data by ABPmer)

Overall, calibration of the Isle of Wight and Solent model is considered satisfactory and gives confidence that the model is able to appropriately represent water levels and currents within the Solent.

5 Dispersion model

5.1 Model set-up

Ambient salinity and temperature were derived based on 5-year Coastal Sampling Data provided by Southern Water and obtained from the Environment Agency. **Figure 5-1** shows the sampling locations used. Average temperature, salinity and resultant density for summer (April till September), winter (October till March), April-May and July-August periods were calculated based on all provided sampling locations and are presented in **Table 5.1**, with the highest values outlined in red.

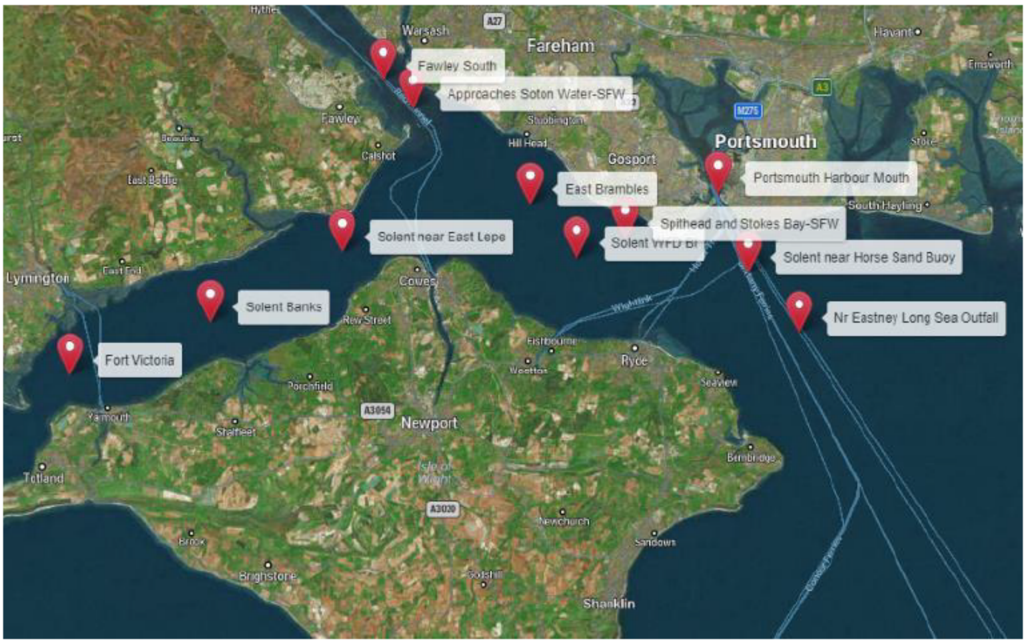

Figure 5-1: Refence map of Coastal Sampling Data locations

Table 5.1: Average ambient water temperature, salinity and density within Solent

Period	Temperature (°C)	Salinity (PSU)	Density (kg/m^3)
Summer	16.5	33.9	1024.8
Winter	8.9	33.5	1026.0
April-May	12.1	33.4	1025.3
July-August	19.3	34.1	1024.3

The model was simulated for the existing and future flow scenarios for a period of one month, i.e. July 2020, to allow sufficient time for far-field dispersion and dilution. The month of July was chosen, as representing highest average ambient water temperature and salinity within the Solent, as presented in **Table 5.1**. Such scenario represents the worst case, as generally summer conditions result in water quality issues, e.g. blooms associated with nutrient increases. It is worth noting that the total peak output of approximately 60Ml/d of recycled water would only occur during severe drought conditions.

Boundary conditions for the local 3D model were derived from the Regional 2D English Channel Model. The vertical model mesh was set to 10 layers distributed equidistant across the water depth. Furthermore, model mesh around the Eastney LSO locations was also refined.

The effluent outlet was set in the model as simple source at coordinates of 466790 (Easting) and 93250 (Northing). A constant discharge rate was applied with the source set in layer 1 (closest to the seabed). Discharge conditions, i.e. flow rate, salinity and permitted parameters concentrations are presented in **Table 3.1** and **Table 3.2** in **Section 3**. Wind conditions specified in the model are discussed in **Section 5.2**.

5.2 Sensitivity tests

Wind conditions within the Solent were analysed based on open data version of the Met Office Integrated Data Archive System (MIDAS) for land surface station data. This data contains land surface observations data from the Met Office station network available to the public and provided under an Open Government Licence.

The data was obtained for a point within the Solent (50.808ºN, 1.211ºW, 9m height above ground) for an available period between July 1973 and February 2015. **Figure 5-2** presents a wind rose of the obtained Solent point data, showing that the dominant wind direction is from south-west. Based on the data, 10th percentile wind speed of 10m/s was calculated, representing moderate windy conditions.

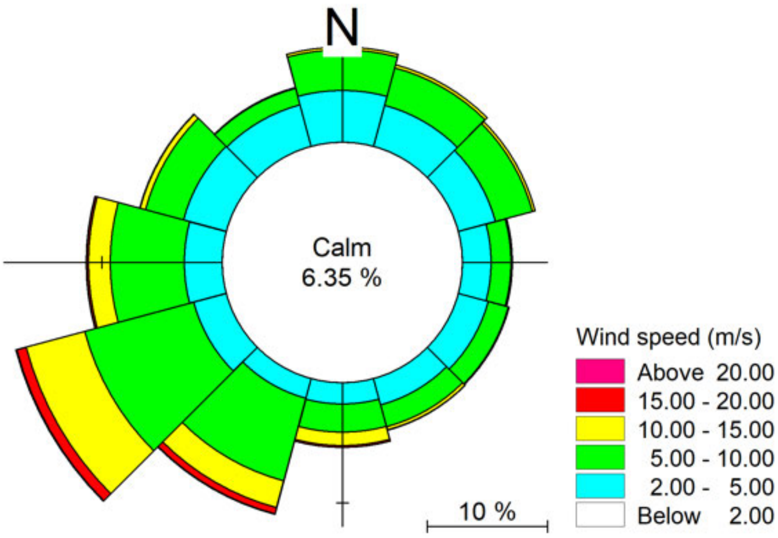

Figure 5-2: Rose plot of wind conditions within Solent (based on MIDAS data)

To determine the wind conditions that would likely result in the greatest dispersion of the effluent and/or would encourage the plume into environmentally sensitive areas along coast/harbours, sensitivity tests were run using the model. Four wind directions were tested, i.e. wind from south-east (120degN), south-west (240degN) and south (108degN), and no-wind (calm) conditions. These directions were chosen as wind from southerly directions could potentially 'push' the plume from the location of the discharge point towards the coast/harbours.

Results of the sensitivity tests (provided in **Appendix B**) showed that wind had a limited impact on the plume extent and dispersion, with wind from south-east direction resulting in marginally worst case scenario, where the plume extended further towards the coast/harbours. Therefore, 10m/s wind speed from 120degN direction was applied to all model runs for the existing and future flow scenarios.

5.3 Model results

The model results presented here represent the calculated difference (change) in water quality parameters between the existing and future 60Ml/day flow scenario. In addition, results for the existing Budds Farm flow scenario compared to ambient (baseline) conditions are also provided to aid interpretation of the results for the WRP future 60Ml/day flow scenario assessed against existing flow. It should be noted that the numerical model can produce infinitely small results which are beyond sensitivity of any measurements and may be beyond accuracy of the model itself. In order to illustrate the potential extent of the plume, for each modelled parameter, relatively small intervals of change in concentration were chosen with an arbitrarily and consistently selected cut-off value. That was to aid interpretation of the area of influence and illustrate potential extent and direction of the plume.

The model results show very little variation between the vertical layers, with marginally bigger extent of higher change in the lower layers closer to discharge point, whereas marginally bigger extents of the lower change in the upper layers due to positive buoyancy of the plume. This is demonstrated by the results of change in total nitrogen concentration for all 10 vertical layers presented in **Appendix C** and applies to all modelled water quality parameters. Overall, it was concluded that the results for layer 5 (middle of the water column) are representative and were therefore presented in the main report in Section 5.3 for all considered water quality parameters.

5.3.1 Salinity

Figure 5-3 presents the difference in salinity between the existing Budds Farm flow and the ambient conditions. The legend indicates negative numbers i.e. effluent salinity is lower than ambient water salinity, therefore resulting in salinity deficit when compared with baseline conditions. **Figure 5-3** shows that the salinity change is limited and mostly within -0.015 to -0.05 PSU deficit.

Figure 5-4 shows the difference in salinity between the 60Ml/day operational flow scenario and the existing flow scenario (i.e. is a differential plot). The legend indicates positive numbers i.e. effluent salinity increases and is closer to the baseline salinity in the Solent due to reduced wastewater (predominantly freshwater) flows being diverted to the WRP. However, overall, the salinity changes are very small and in the region of 0.01 – 0.05 PSU for the future 60Ml/day scenario. This is demonstrated in

Table 5.2 which shows maximum and minimum salinity readings at two Environment Agency monitoring points in the Solent (based on last 10 samples at these locations) and compared with modelled change in salinity at the two points. Therefore, these predicted very small changes are considered to be within baseline variation.

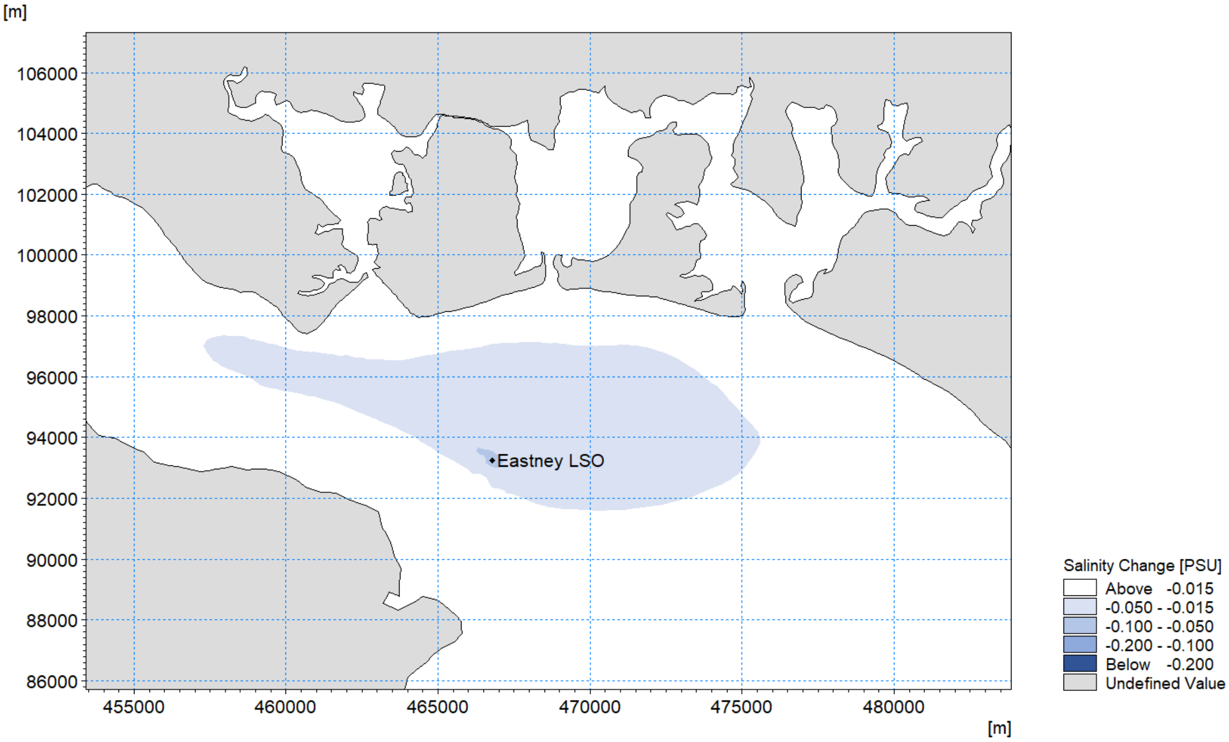

Figure 5-3: Change in salinity from baseline (ambient) for the existing discharge scenario

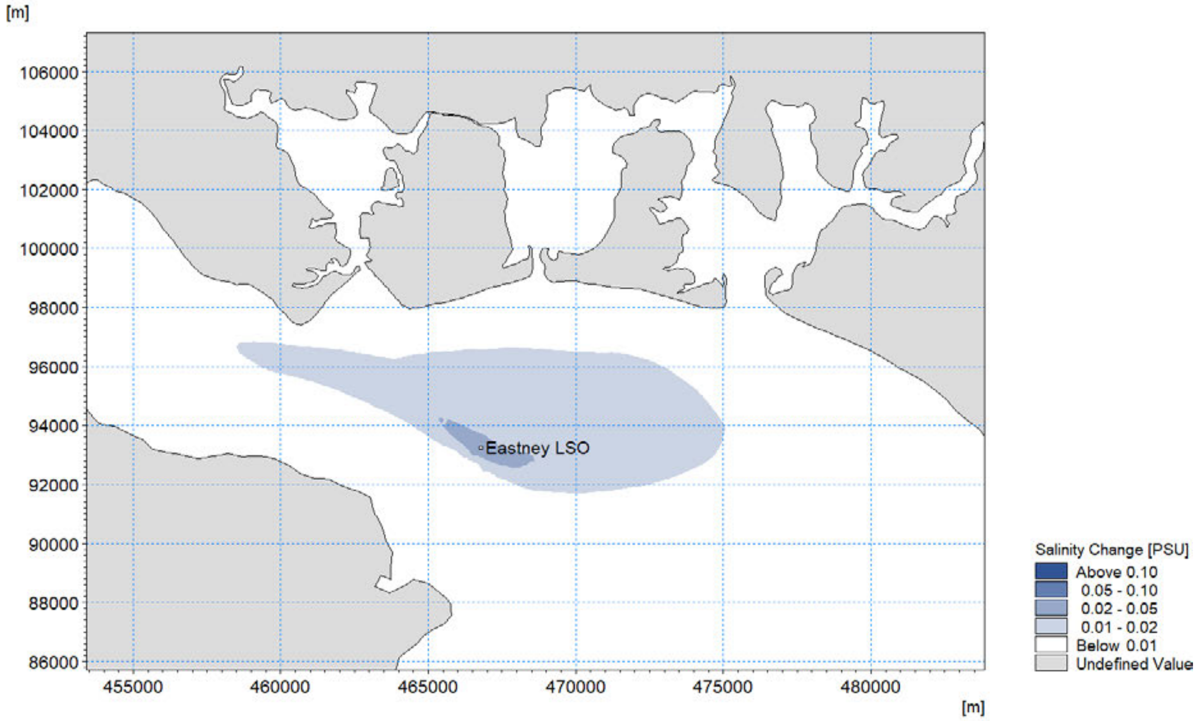

Figure 5-4: Change in salinity from existing for the 60Ml/d discharge scenario

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Table 5.2 Salinity data from two data points in the Solent collected by the Environment Agency (Open WIMS data) and modelled salinity change at the two locations

Sampling site name	Location	Maximum (PSU)	Minimum (PSU)	Range (PSU)	Sampling period	Modelled change (PSU)
						60Ml/d
Nr Eastney Long Sea Outfall	easting northing: 466500 93300 (approximately 294m away from Eastney LSO)	32.74	32.74	1.75	12 Feb 2020 to 4 Feb 2022	0.029
Solent Near Horse Sand Buoy	easting northing: 464200 96000 (approximately 3.8km away from Eastney LSO)	34.51	33.09	1.42	2 Dec 2020 to 10 Jun 2022	0.011

5.3.2 Total nitrogen

Figure 5-5 presents difference in total nitrogen concentration between the existing Budds Farm flow and the ambient (baseline) conditions. The baseline assumed no total nitrogen, therefore **Figure 5-5** shows excess (change) in concentration as a result of the Budds Farm flows. **Figure 5-5** shows that the total nitrogen change is limited and mostly within 0.001 to 0.01 mg/l excess.

Figure 5-6 shows the difference in total nitrogen concentrations between the 60Ml/d operational flow scenario and the existing flow scenario. The results show a decrease in total nitrogen concentrations when compared to the existing scenario (i.e. reflected as negative numbers in the legend). This is because a lower volume of treated wastewater is being discharged when the WRP is operating. Overall, the decreases in concentrations are very small and in the region of 0.001 and 0.006mg/l, likely to be within baseline variation. This is demonstrated in **Table 5.3** which shows maximum and minimum total nitrogen readings at two Environment Agency monitoring points in the Solent (based on last 10 samples at these locations) and compared with modelled change in total nitrogen concentration at the two locations.

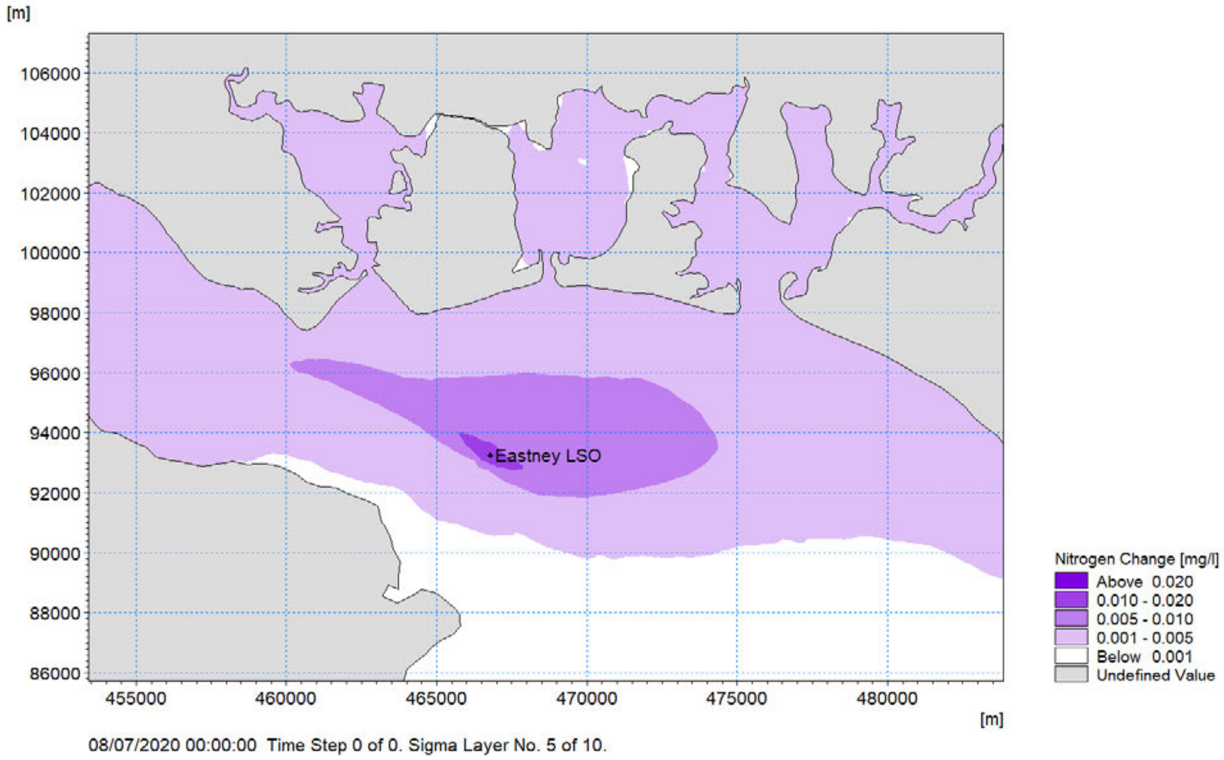

Figure 5-5: Change in nitrogen concentration from baseline for the existing discharge scenario

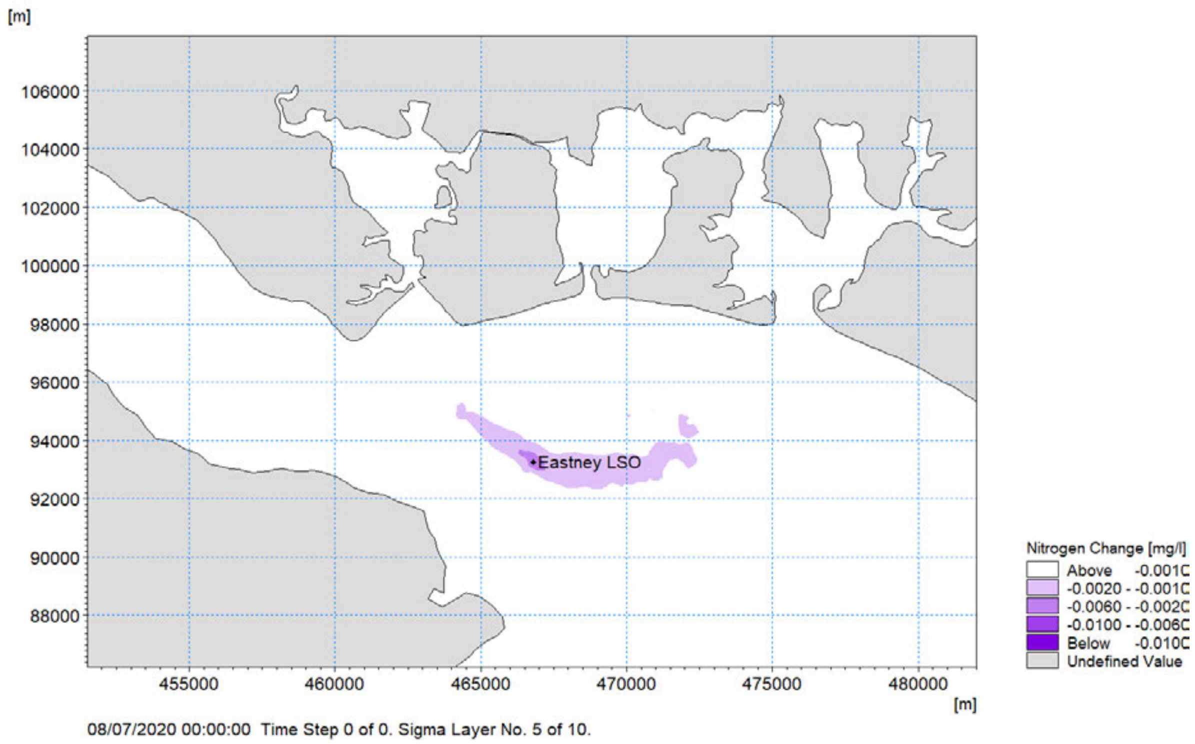

Figure 5-6: Change in nitrogen concentration from existing for the 60Ml/d discharge scenario

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Table 5.3 Total nitrogen data from two data points in the Solent collected by the Environment Agency (Open WIMS data) and modelled change in total nitrogen concentration at the two locations

Sampling site name	Location	Maximum (mg/l)	Minimum (mg/l)	Range (mg/l)	Sampling period	Modelled change (mg/l)
						60Ml/d
Nr Eastney Long Sea Outfall	easting northing: 466500 93300	0.42	0.007	0.41	12 Feb 2020 to 4 Feb 2022	-0.003
Solent Near Horse Sand Buoy	easting northing: 464200 96000	0.35	<0.007	0.34	2 Dec 2020 to 10 Jun 2022	-0.001

5.3.3 Suspended solids concentrations

Figure 5-7 presents difference in suspended solids concentration between the existing Budds Farm flow and the ambient (baseline) conditions. The baseline assumed no suspended solids, therefore **Figure 5-7** shows excess (change) in suspended solids concentration as a result of the Budds Farm flows. **Figure 5-7** shows that the suspended solids change is limited and mostly within 0.001 to 0.05 mg/l excess.**Figure 5-8** shows the difference in suspended solids concentrations between the 60Ml/d operational flow scenario and existing flow scenario. The results show an increase in concentration between the 60Ml/d and existing scenarios. As for nitrogen concentration results, the magnitude of increase in concentrations of suspended solids between the existing and future flow scenario are very small, in the region of 0.0008 and 0.002mg/l, likely to be within natural variation of receiving waters.

Measurements of suspended solids concentrations are not available at the sampling locations chosen for salinity and total nitrogen. However, information available in the Environmental Statement for the Port of Southampton (ABPMer, date unknown) states that the mean total suspended solid concentrations measured in the Solent between 2003 and 2007 ranges between 9 and 17mg/l, with minimum concentrations measured in the Spithead and Stokes Bay Shellfish water (in the Solent) and maximum concentrations found in the Central Solent Shellfish Water, respectively. As a consequence, the concentration changes reflected in the model output are well within the range of concentrations experienced within the Solent. Therefore, these very small changes are considered to be within baseline variation.

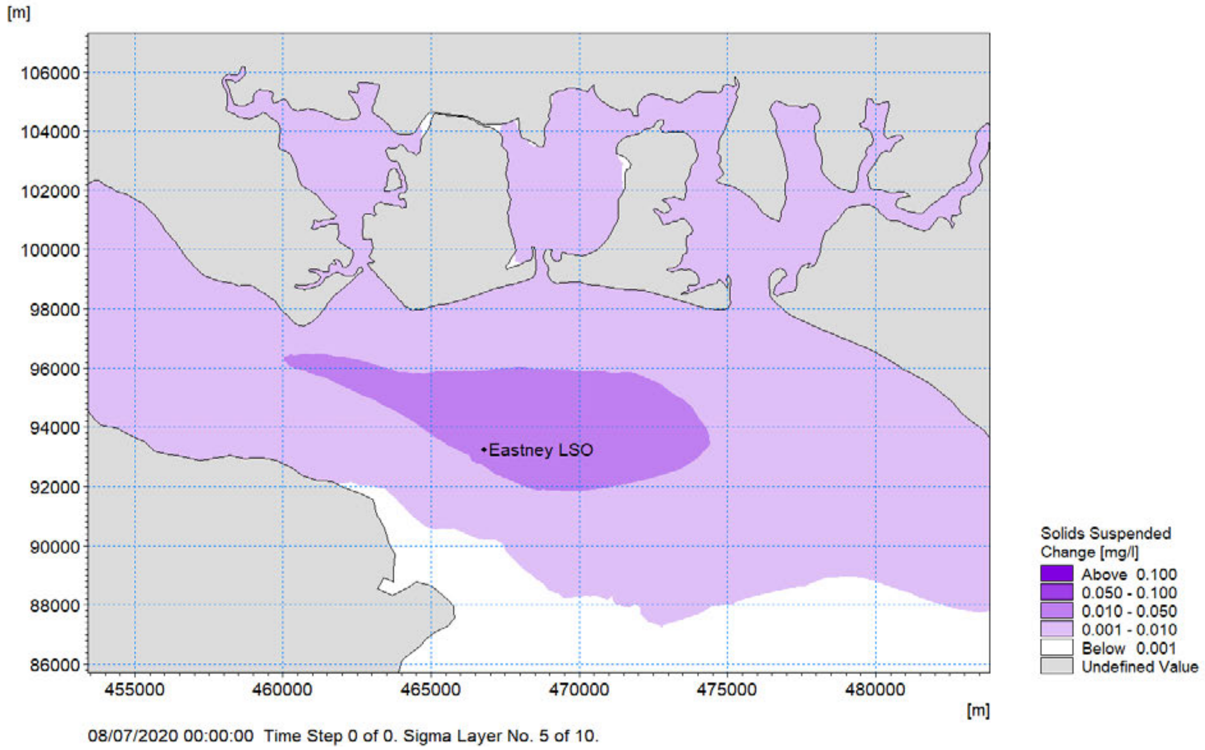

Figure 5-7: Change in suspended solids concentration from baseline for the existing discharge scenario

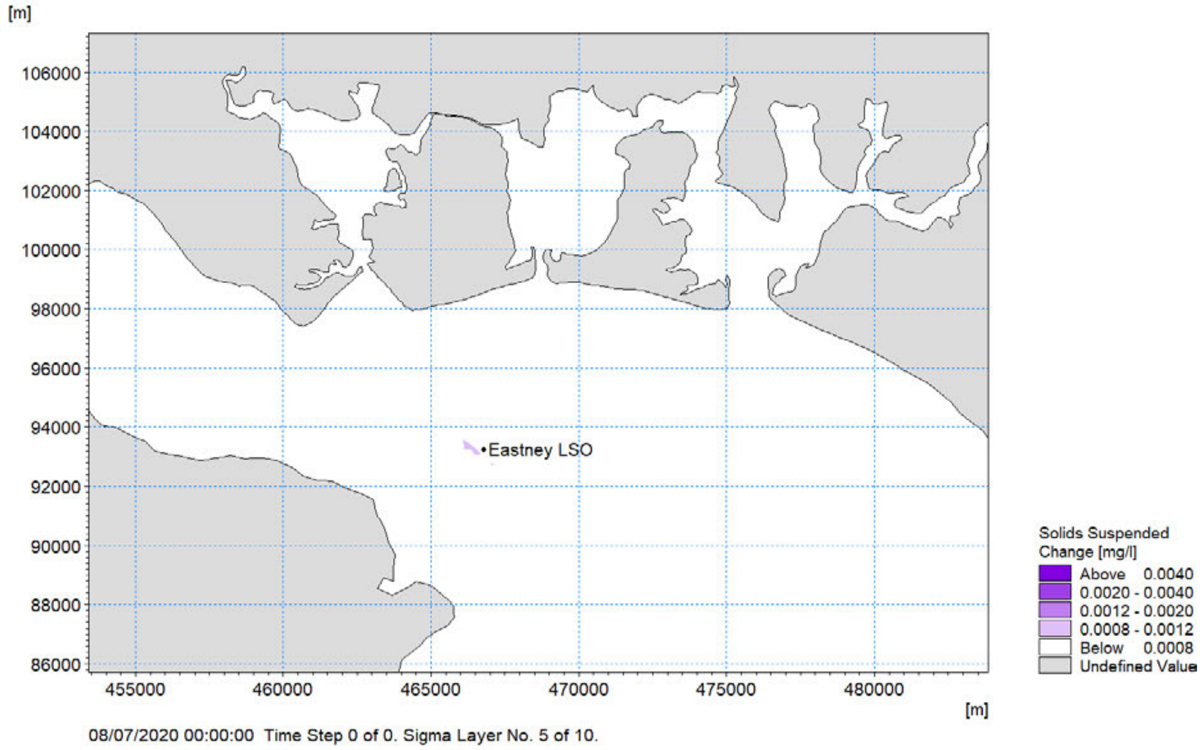

Figure 5-8: Change in suspended solids concentration from existing for the 60Ml/d discharge scenario

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5.3.4 Iron

Figure 5-9 presents difference in iron concentration between the existing Budds Farm flow and the ambient (baseline) conditions. The baseline assumed no iron, therefore **Figure 5-12** shows excess (change) in iron concentration as a result of the Budds Farm flows. **Figure 5-12** shows that the iron change is limited and mostly within 0.0001 to 0.00051 mg/l excess.

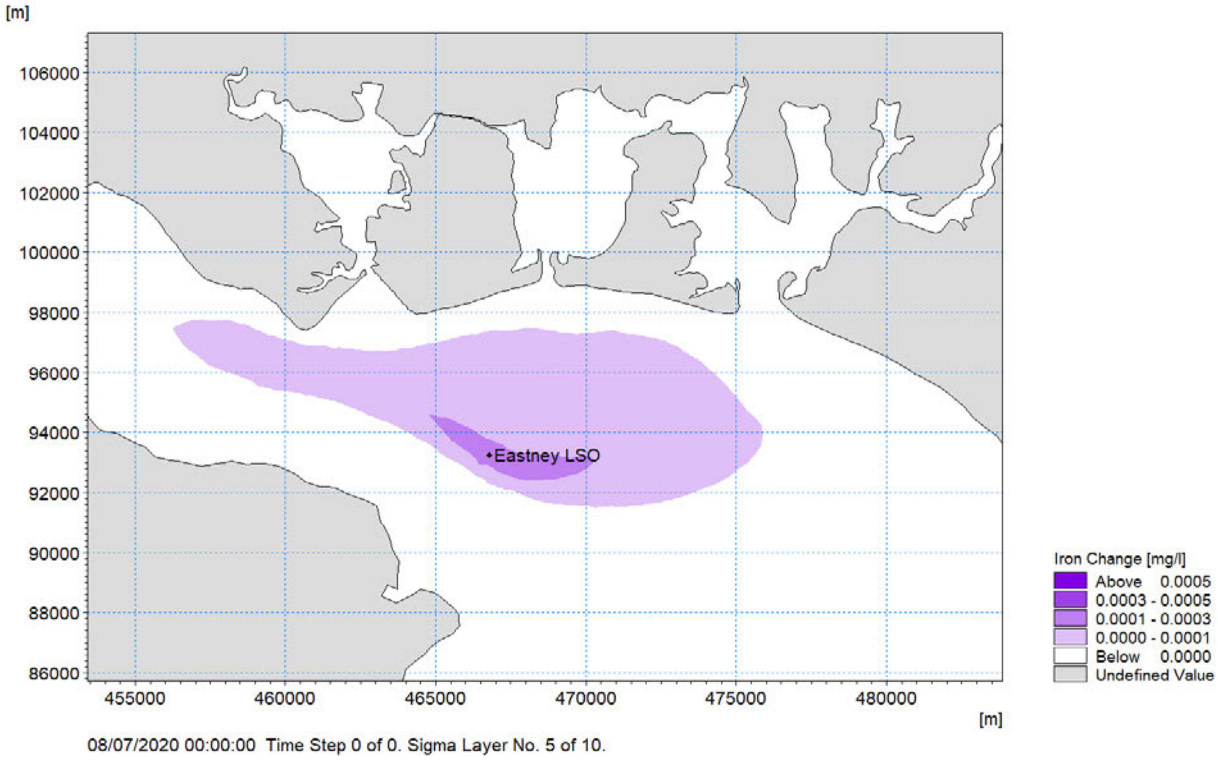

Figure 5-9: Change in iron concentration from baseline for the existing discharge scenario

Figure 5-10 shows the difference in iron concentrations between the 60Ml/d operational flow scenario and existing flow scenario. The results show a decrease in concentrations (i.e. reflected as negative numbers in the legend). Overall, the decreases in iron concentrations are very small and in the region of 0.000012 and 0.00005mg/l. Environment Agency sampling data is relatively limited for this parameter, but data does exist for the Solent Near Horse Sand Buoy monitoring point as shown in **Table 5.4** and compared with modelled change in iron concentration at that location. **Table 5.4** shows that the values predicted by the model are very small and likely to be within baseline variations of iron concentrations in the Solent (based on last 10 samples at these locations).

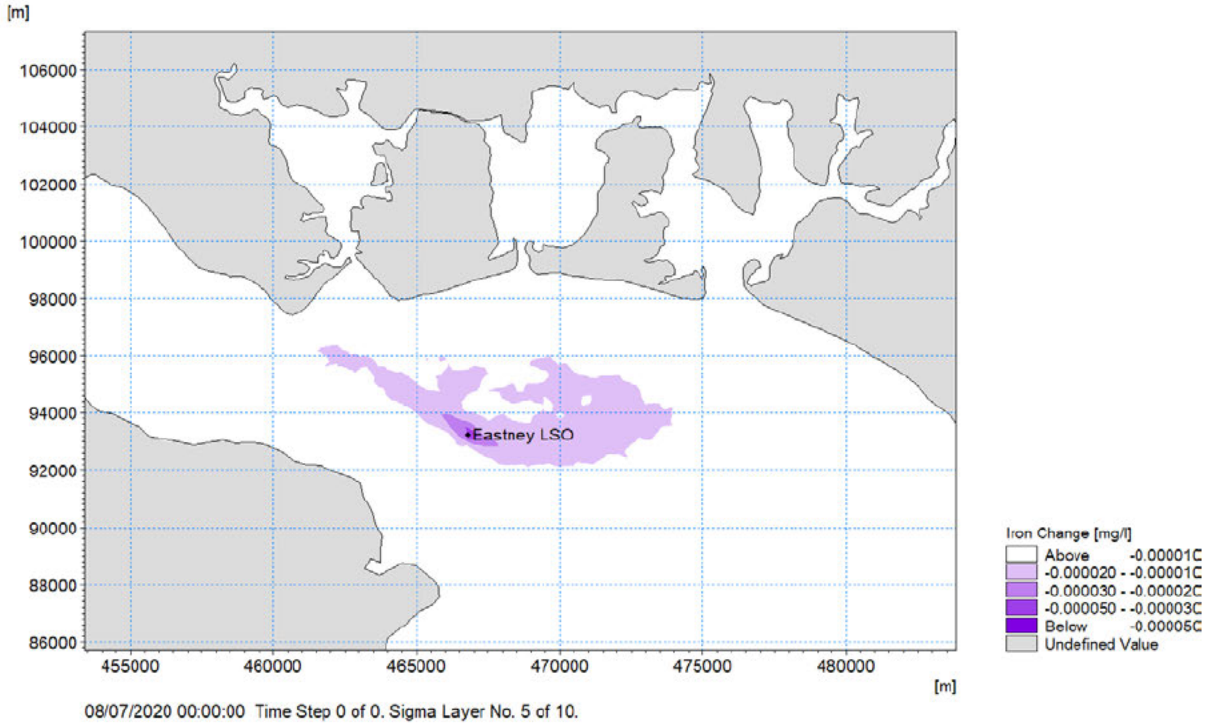

Figure 5-10: Change in iron concentration from existing for the 60Ml/d discharge scenario

Table 5.4 Iron data from the Solent Near Horse Sand Buoy monitoring point collected by the Environment Agency (Open WIMS data) and modelled change in iron concentration at that location

Sampling site name	Location	Maximum (µg/l)	Minimum (µg/l)	Range (µg/l)	Sampling period	Modelled change (mg/l)
						60Ml/d
Solent Near Horse Sand Buoy	easting northing: 464200 96000	30.3	<3	27.0	11 Feb 2003 to 17 Feb 2004	-0.000008

5.3.5 Biological Oxygen Demand (BOD)

Figure 5-11 presents difference in BOD concentration between the existing Budds Farm flow and the ambient (baseline) conditions. The baseline assumed no BOD, therefore **Figure 5-15** shows excess (change) in BOD concentration as a result of the Budds Farm flows. **Figure 5-15** shows that the BOD change is limited and mostly within 0.001 to 0.005 mg/l excess.

Figure 5-12 shows the difference in BOD concentrations between the 60Ml/d operational flow scenario and existing flow scenario. The results show an increase in concentrations with very small change in a region of 0.0005 and 0.0012mg/l.

The Environment Agency do not regularly monitor for this parameter therefore context to this predicted change can be provided by consideration of the magnitude of change in concentrations within the existing wastewater discharge. A snapshot of data collected as part of permit requirements for Budds Farm final effluent (sampling data for Budds Farm Wastewater Treatment Works for 2021 at the Urban Waste Water Treatment Regulations sample point) is presented in **Table 5.5** for BOD and is also compared with modelled BOD change at the Eastney LSO location. **Table 5.5** demonstrates that the modelled output concentration changes are very small compared to variations likely to be experienced in the existing final effluent. As a result, the modelled changes are unlikely to be significant.

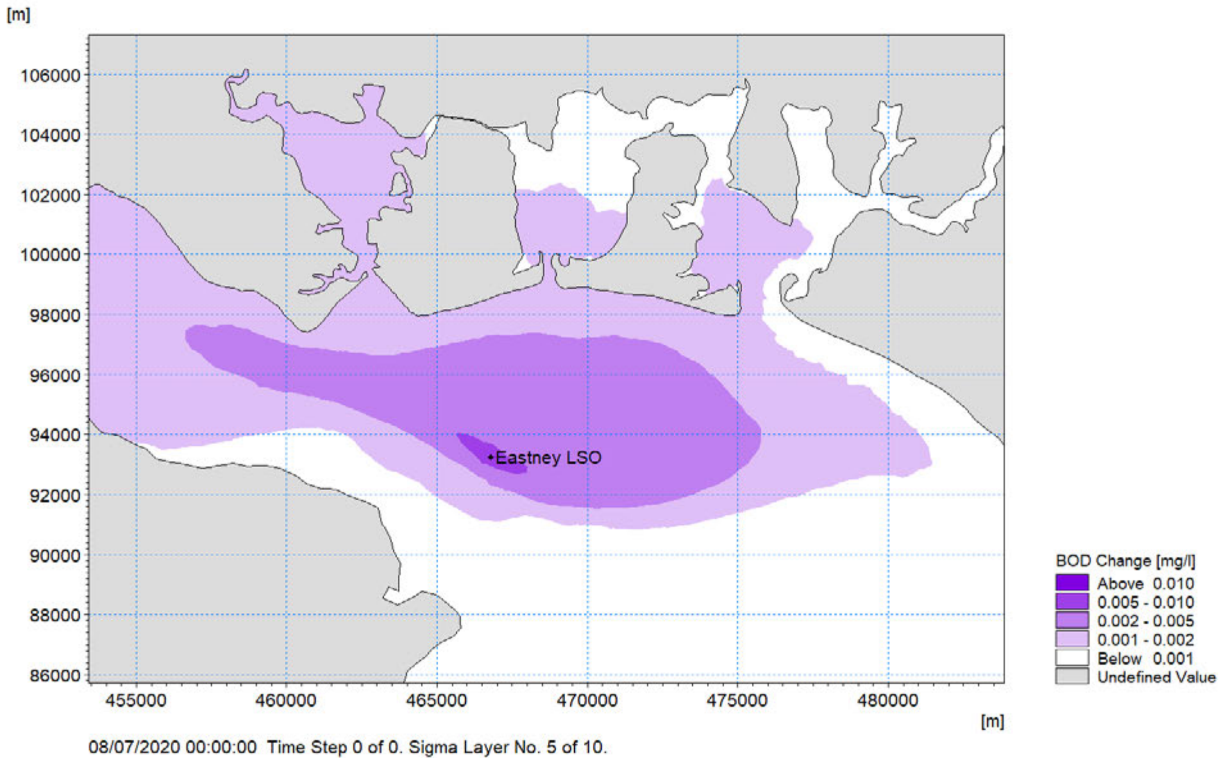

Figure 5-11: Change in BOD concentration from baseline for the existing discharge scenario

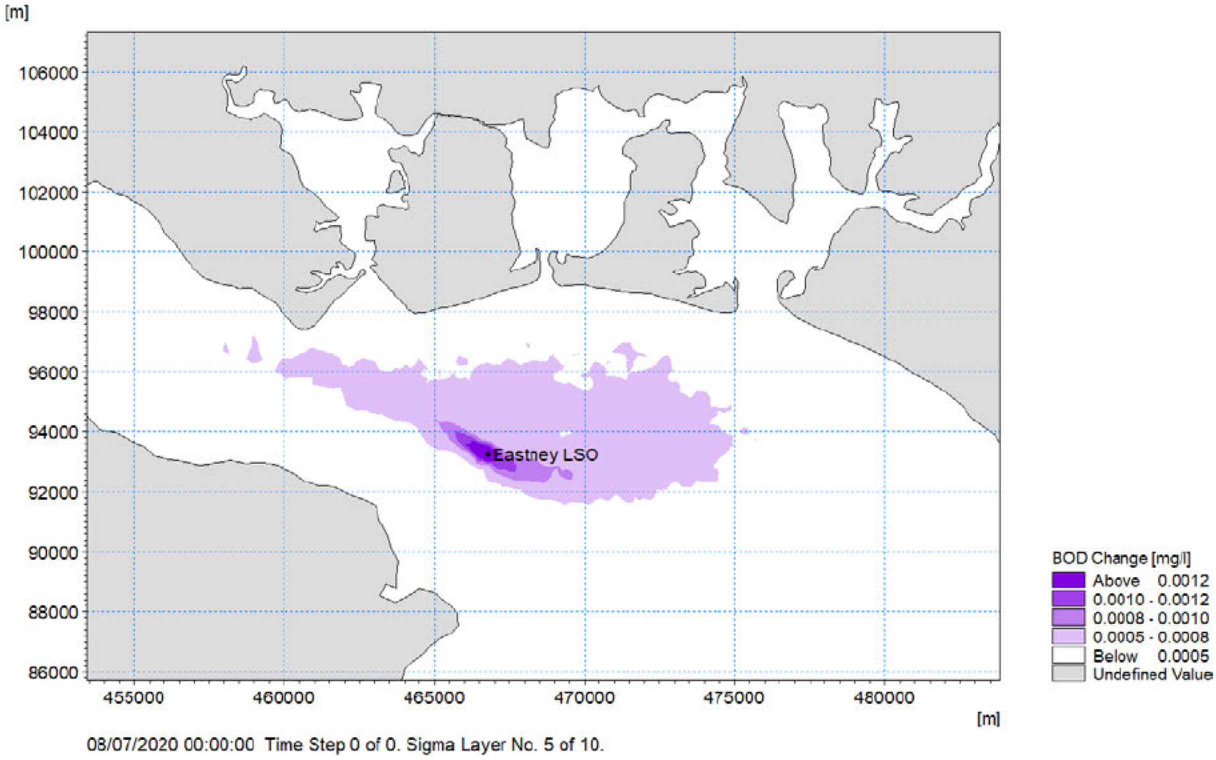

Figure 5-12: Change in BOD concentration from existing for the 60Ml/d discharge scenario

Table 5.5 BOD data from existing wastewater discharge and modelled change in BOD (at Eastney LSO)

Sampling site name	Location	Maximum (mg/l)	Minimum (mg/l)	Range (mg/l)	Sampling period	Modelled change (mg/l)
						60Ml/d
Budds Farm WTW UWWTR Final Effluent (17276)	UWWTR sampling point	9.7	2.23	7.5	01/2021 - 12/2021	0.0015

5.3.6 Chemical Oxygen Demand (COD)

Figure 5-13 presents difference in COD concentration between the existing Budds Farm flow and the ambient (baseline) conditions. The baseline assumed no COD, therefore **Figure 5-18** shows excess (change) in COD concentration as a result of the Budds Farm flows. **Figure 5-18** shows that the COD change is limited and mostly within 0.01 to 0.1 mg/l excess.

Figure 5-14 shows the difference in COD concentrations between the 60Ml/d operational flow scenario and existing flow scenario. The results show a decrease in concentrations with very small change in a region of 0.005 and 0.015mg/l.

As for BOD, the Environment Agency do not regularly monitor this parameter and therefore context to this predicted change can be provided by consideration of the magnitude of change in concentrations experienced in the existing treated wastewater discharge. A snapshot of data collected as part of permit requirements for Budds Farm (sampling data for Budds Farm Wastewater Treatment Works for 2021 at the

Urban Waste Water Treatment Regulations sample point) is presented in **Table 5.6** for COD and is also compared with modelled COD change at the Eastney LSO location. **Table 5.6** demonstrates that the modelled output concentration changes are very small compared to variations likely to be experienced in the existing final effluent. As a result, the modelled changes are unlikely to be significant.

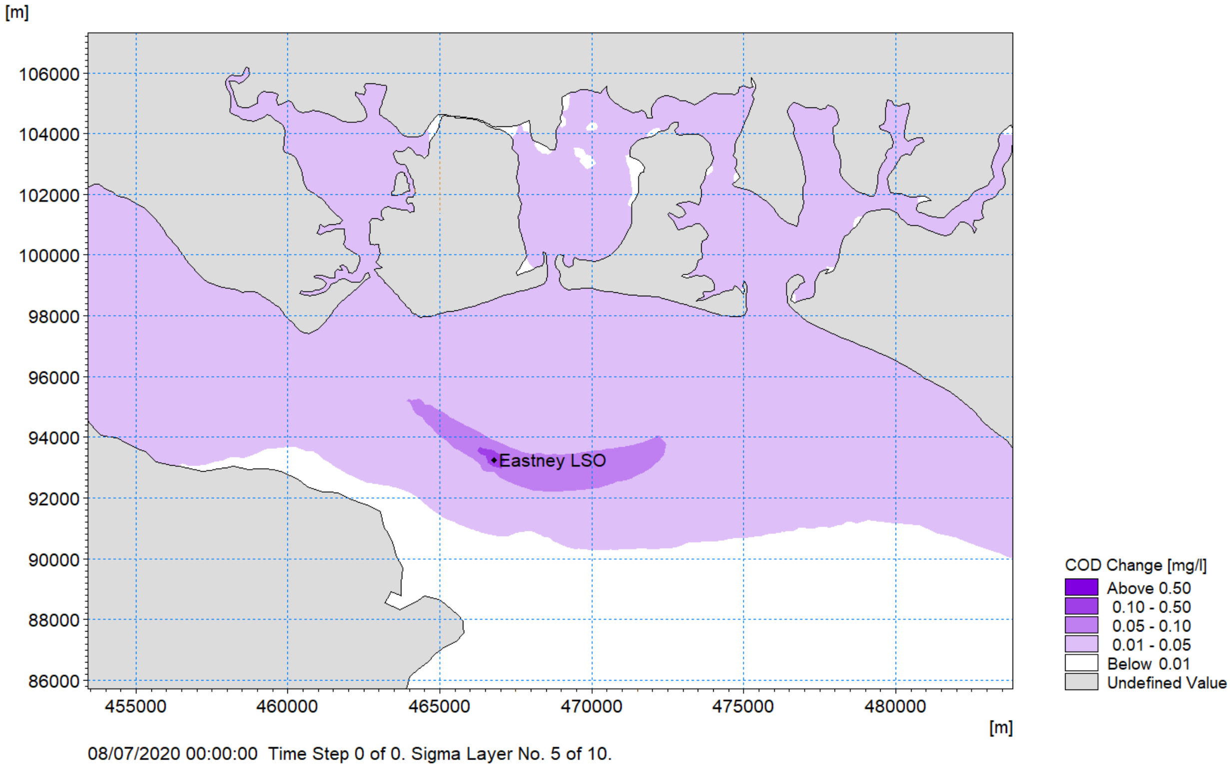

Figure 5-13: Change in COD concentration from baseline for the existing discharge scenario

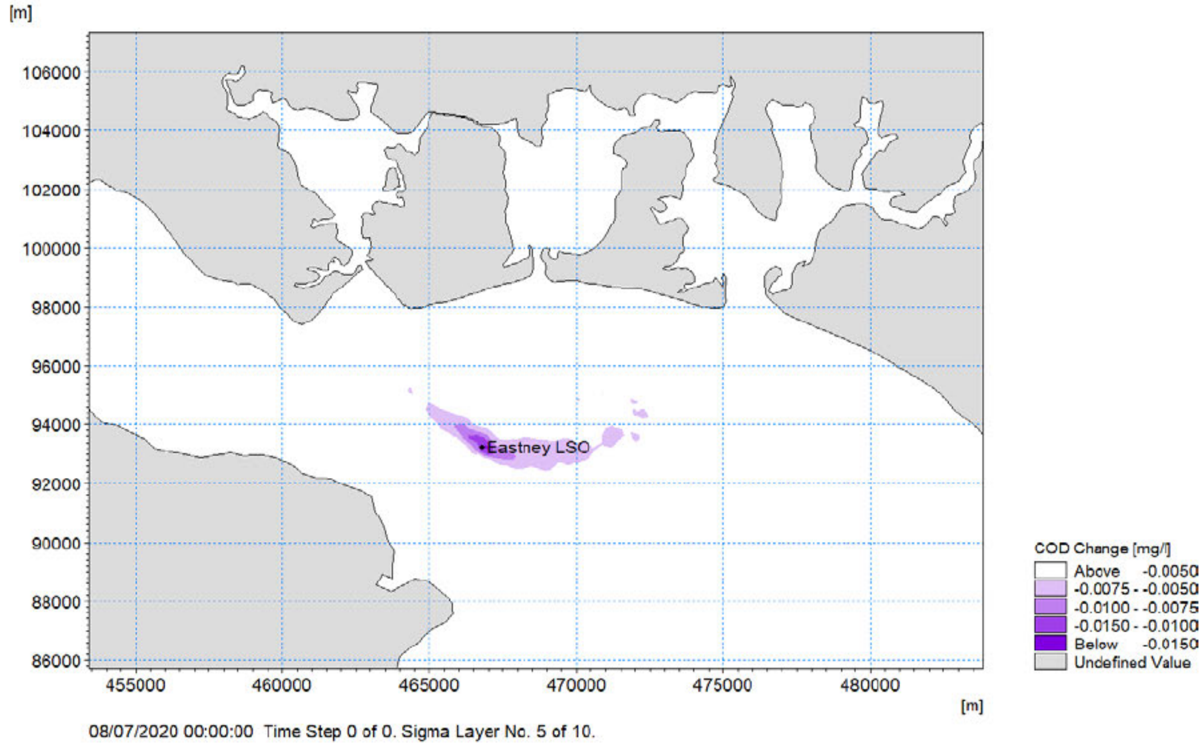

Figure 5-14: Change in COD concentration from existing for the 60Ml/d discharge scenario

Table 5.6 COD data from existing wastewater discharge and modelled change in COD (at Eastney LSO)

Sampling site name	Location	Maximum (mg/l)	Minimum (mg/l)	Range (mg/l)	Sampling period	Modelled change (mg/l)
						60Ml/d
Budds Farm WTW UWWTR Final Effluent (17276)	UWWTR sampling point	74.0	26.3	47.7	01/2021 - 12/2021	-0.012

6 Conclusions

Updated dispersion modelling was undertaken to inform the environmental assessments associated with the proposed Hampshire Water Transfer and Water Recycling Project. For that purpose, RHDHV's Isle of Wight and Solent model was utilised. The model has been updated and validated against measured and predicted tide levels and currents within Solent. Results of the model calibration showed reasonably good agreement between the predicted and measured water levels and currents. Although the model slightly underpredicted water level at high tides during spring tides, the relatively small difference (less than 10%) was deemed to be insignificant for the purposes of this study. It was therefore considered that the model was able to accurately predict tidal and current conditions within the Solent.

The updated and calibrated Isle of Wight and Solent model was then used to model dispersion of the existing treated wastewater discharge from Budds Farm WTW and the future WRP reject stream conditions to assess the impact of the proposed future flows and water quality parameters.

Results of the dispersion modelling undertaken for the proposed WRP discharge show that the differences in the selected water quality parameters are very small between the existing Budds Farm WTW discharge and the future discharge with water recycling in place (60Ml/d operational flow scenario). Parameters considered were identified as part of a study into likely WRP discharge characteristics and changes to the existing wastewater associated with diversion of treated flows and included salinity, suspended solids concentrations, iron, total nitrogen, BOD and COD.

Context to the modelled output was provided using either Environment Agency monitoring data or historical Environmental Statements (ES) for each parameter selected, demonstrating that all predicted parameter changes are so small that they are likely to be outweighed by baseline variations experienced within the Solent. Additionally, the marine environment within which the LSO discharges is well mixed, again demonstrated in the modelled output of the 10 vertical layers which showed that only marginally larger differences were noted at sea surface.

Overall, therefore the modelling demonstrates that the changes to the existing Budds Farm WTW discharge with the WRP in place, regardless as to WRP flow are extremely small for all assessed parameters.

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Appendix A: Model Calibration Results

Figure A- 1 to **Figure A- 4** show comparison of modelled (Upper Panel) and measured (Lower Panel) current speeds at Points I, J, K and L within Solent, respectively.

Results in **Figure A- 1** show good agreement between the modelled (Upper Panel) and measured (Lower Panel) current speeds at Point I within Solent, with peak speeds at spring tide around 1m/s and around 0.6 m/s for neap tides.

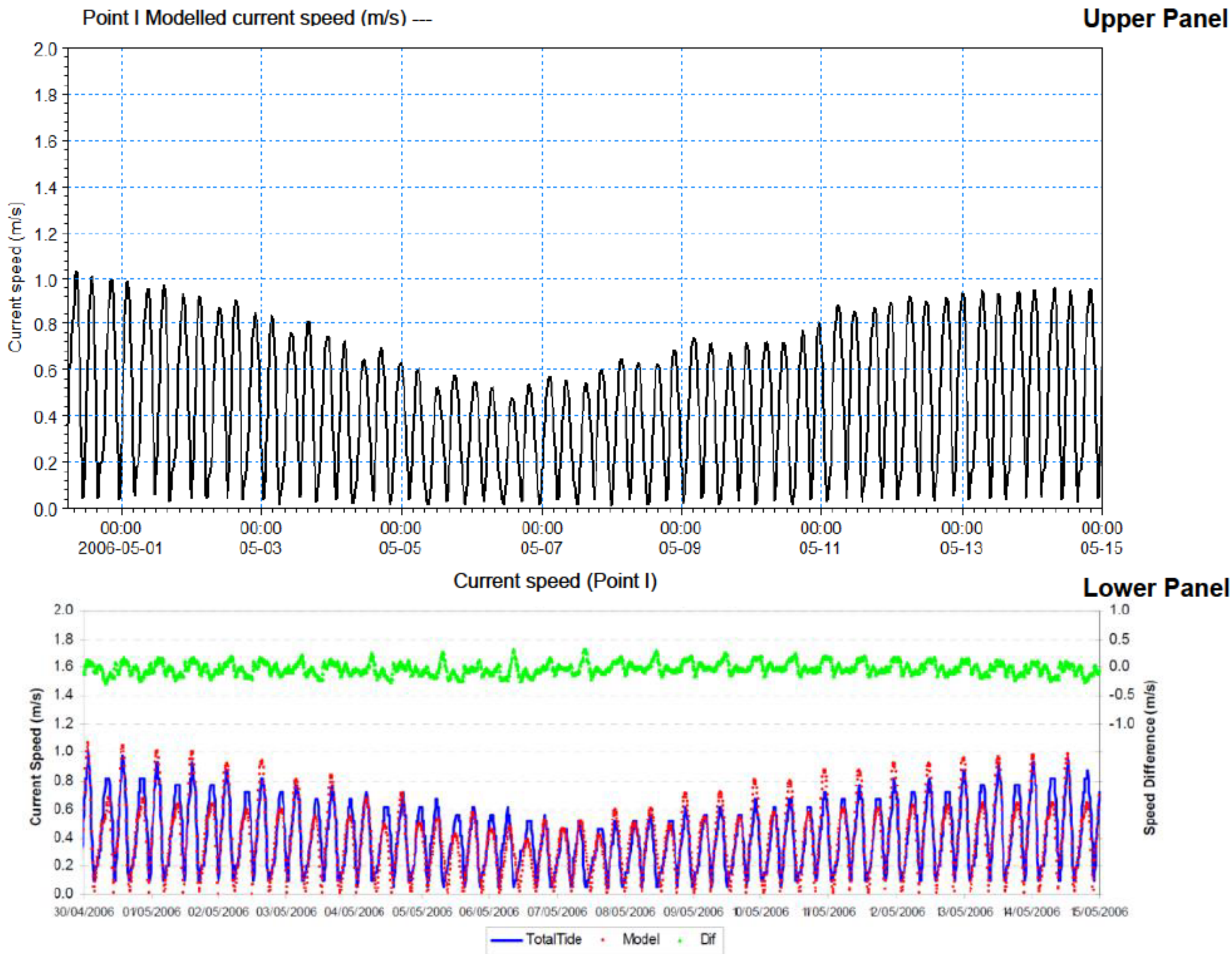

Figure A- 1: Comparison of modelled (Upper Panel) and measured (Lower Panel) current speeds at Point I within Solent (red and green dots in Lower Panel were related to modelled data by ABPmer)

Results in **Figure A- 2** and **Figure A- 3** show good agreement between the modelled (Upper Panel) and measured (Lower Panel) current speeds at Point J and Point K within Solent, with peak speeds at spring tide around 0.8m/s and around 0.4 m/s for neap tides.

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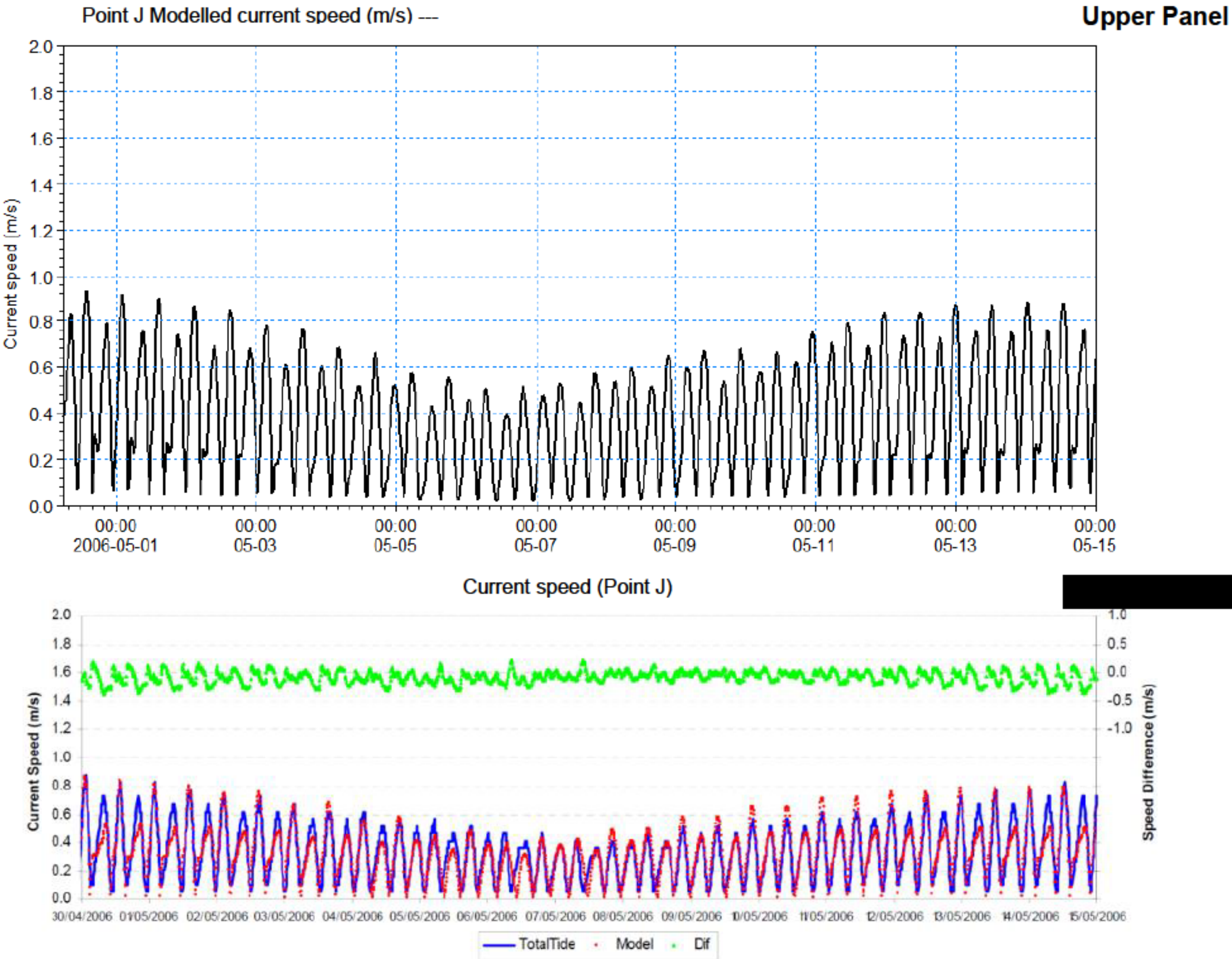

[redacted]

Figure A- 2: Comparison of modelled (Upper Panel) and measured (Lower Panel) current speeds at Point J within Solent (red and green dots in Lower Panel were related to modelled data by ABPmer)

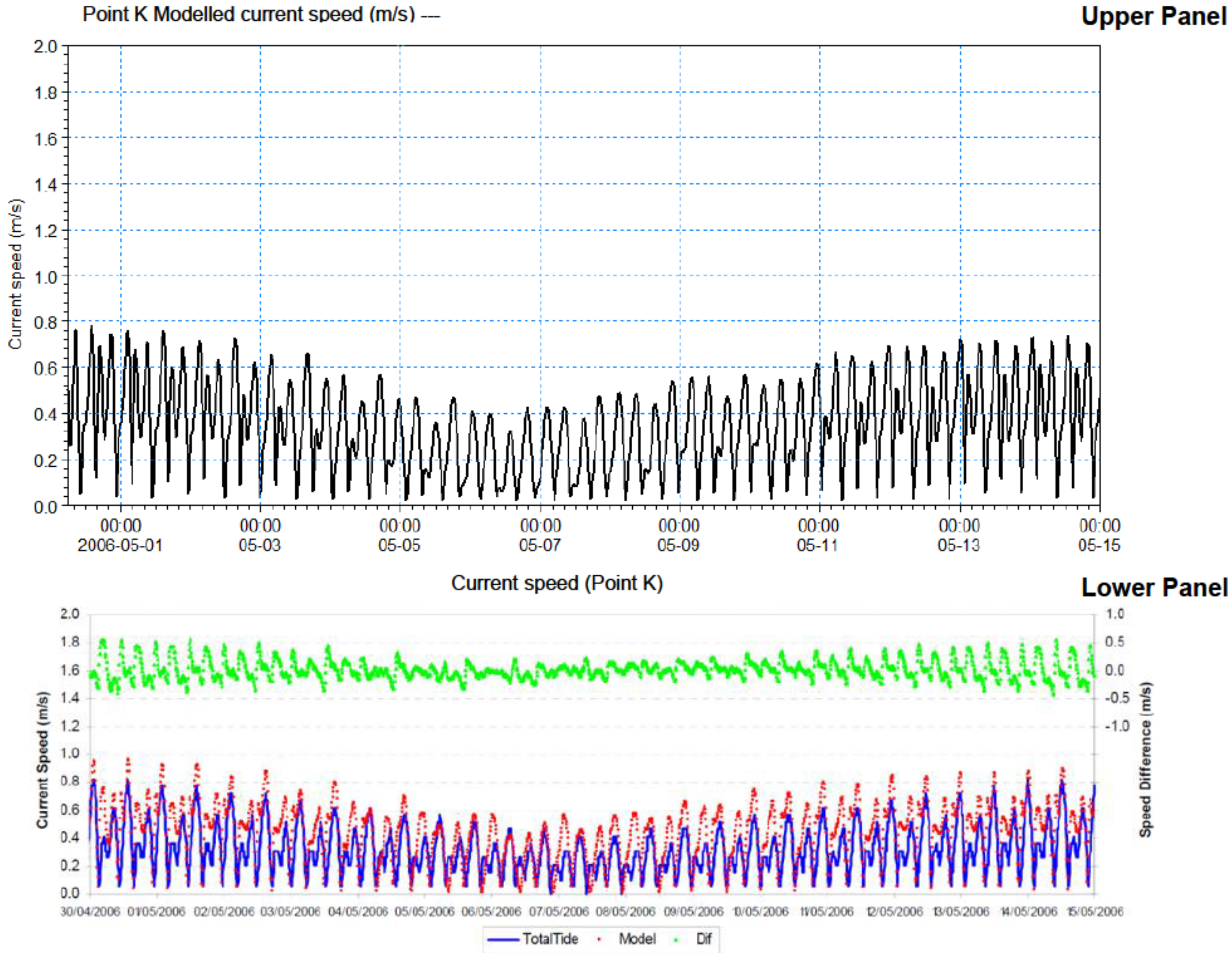

Figure A- 3: Comparison of modelled (Upper Panel) and measured (Lower Panel) current speeds at Point K within Solent (red and green dots in Lower Panel were related to modelled data by ABPmer)

For Point L within the Solent, results in **Figure A- 4** show that peak modelled (A) current speeds at spring tide are around 0.9m/s and around 0.5 m/s for neap tides, whereas measured (B) current speeds are around 0.8 m/s and 0.4 m/s, respectively. This suggests slight overprediction of the current speeds at this location. However, the difference is not significant, and marginally greater current speeds would likely encourage more movement of the effluent, and therefore produce slightly more conservative results of the dispersion modelling.

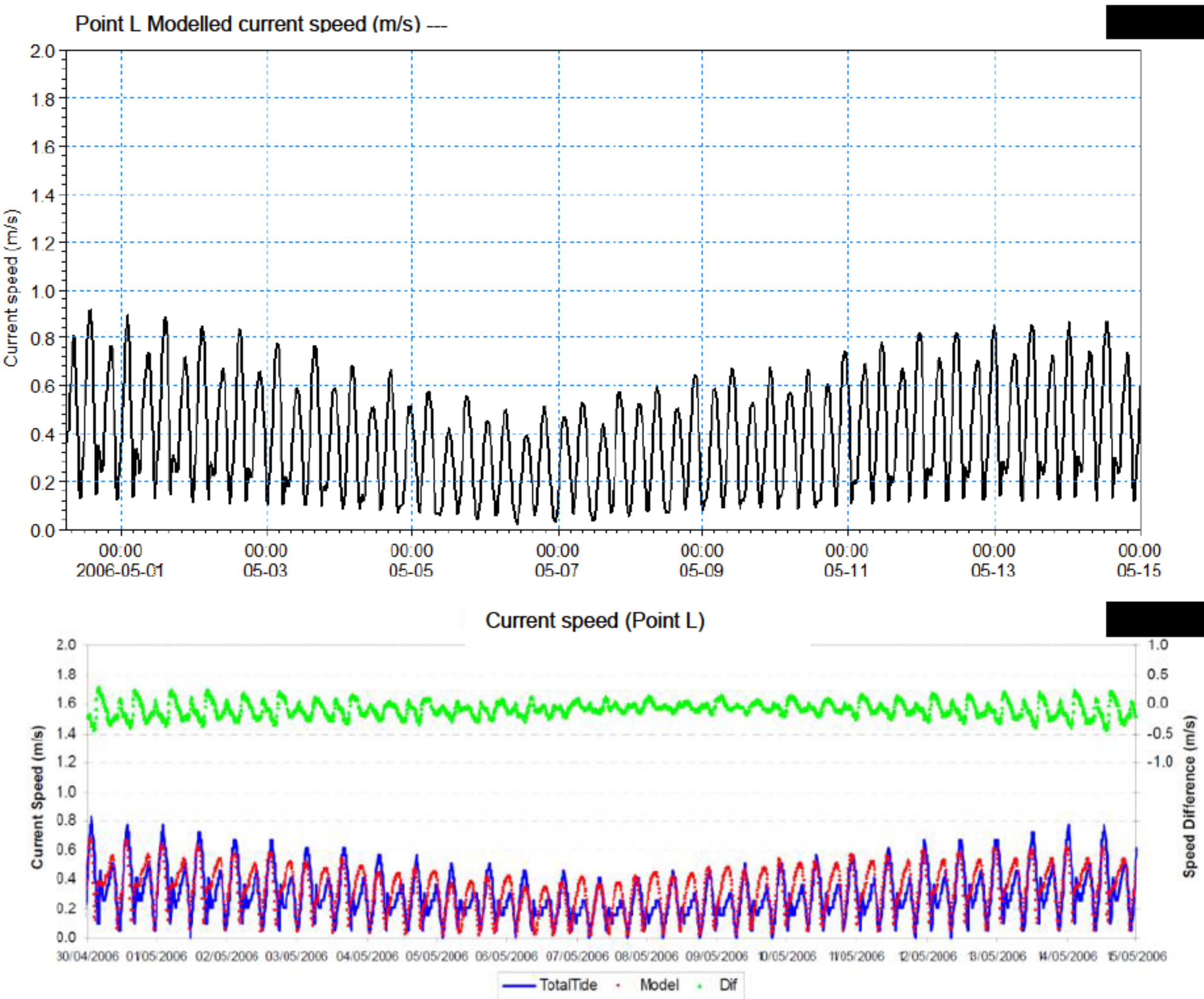

Figure A- 4: Comparison of modelled (Upper Panel) and measured (Lowe Panel) current speeds at Point L within Solent (red and green dots in Lower Panel were related to modelled data by ABPmer)

Figure A- 5 to **Figure A- 8** show comparison of modelled (A) and measured (B) current direction at Points I, J, K and L within Solent, respectively. Overall, there is a good agreement between modelled and measured current direction for all considered points.

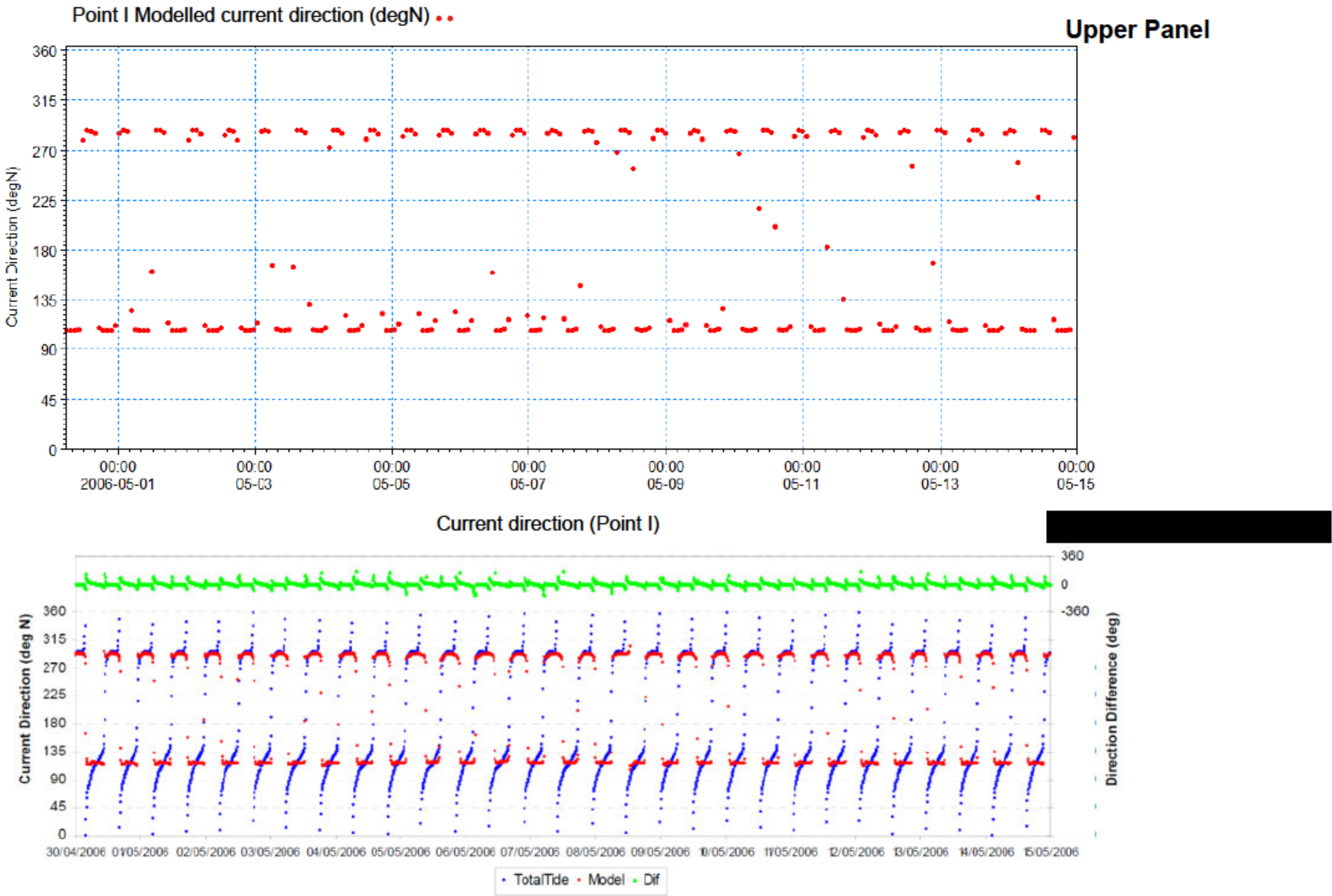

Figure A- 5: Comparison of modelled (Upper Panel) and measured (Lower Panel) current direction at Point I within Solent (red and green dots in Lower Panel were related to modelled data by ABPmer)

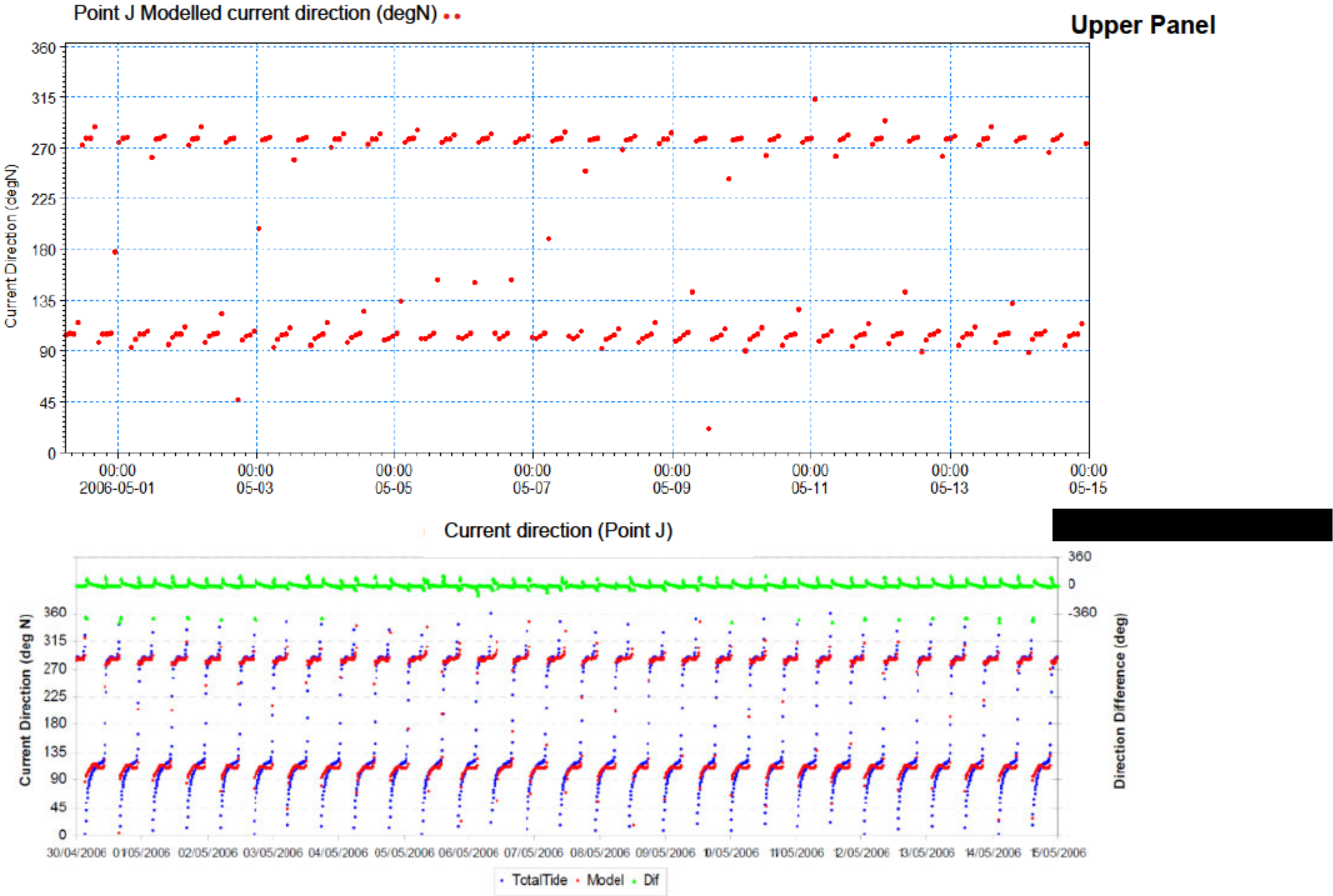

Figure A- 6: Comparison of modelled (Upper Panel) and measured (Lower Panel) current direction at Point J within Solent (red and green dots in Lower Panel were related to modelled data by ABPmer)

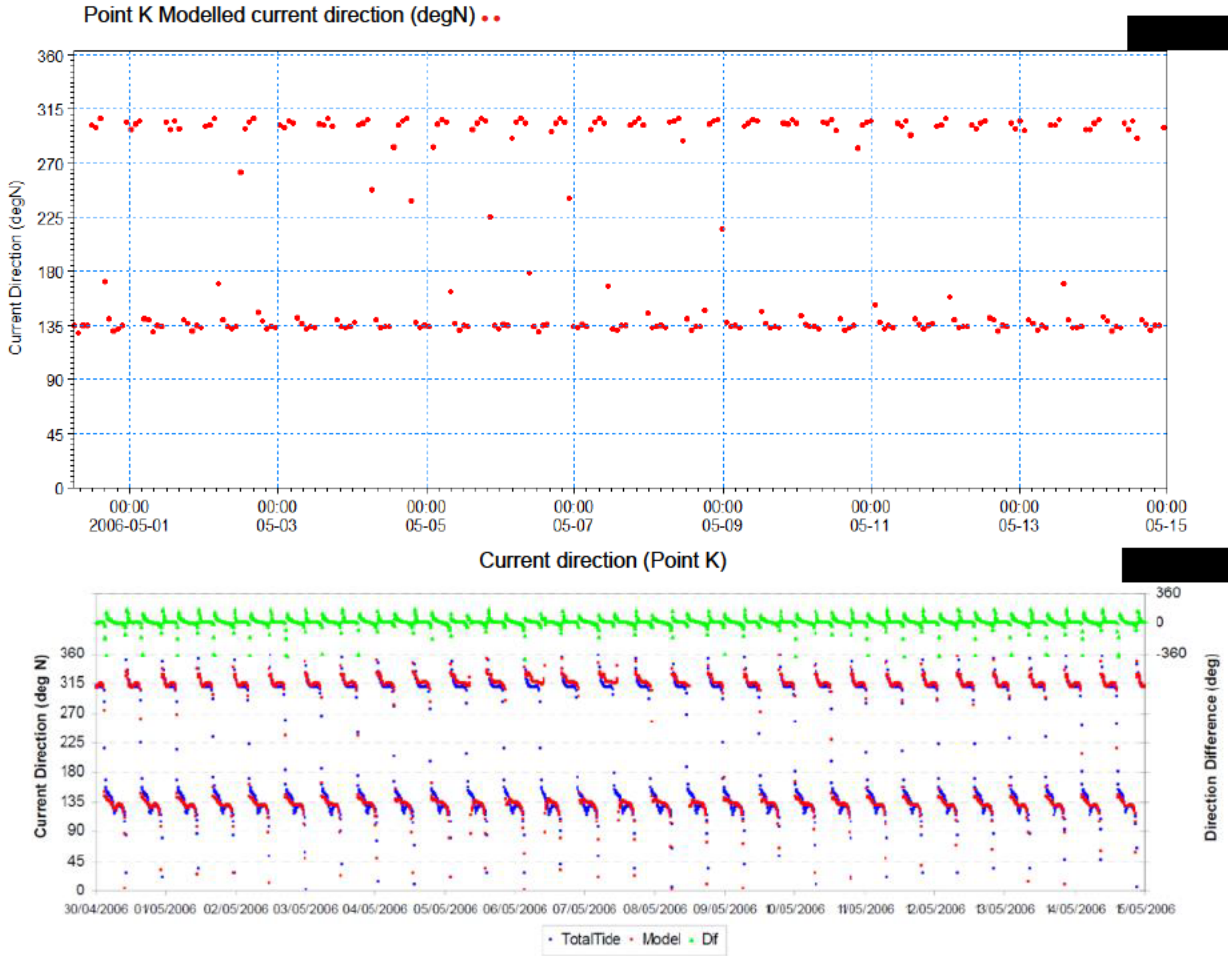

Figure A- 7: Comparison of modelled (Upper Panel) and measured (Lower Panel) current direction at Point K within Solent (red and green dots in Lower Panel were related to modelled data by ABPmer)

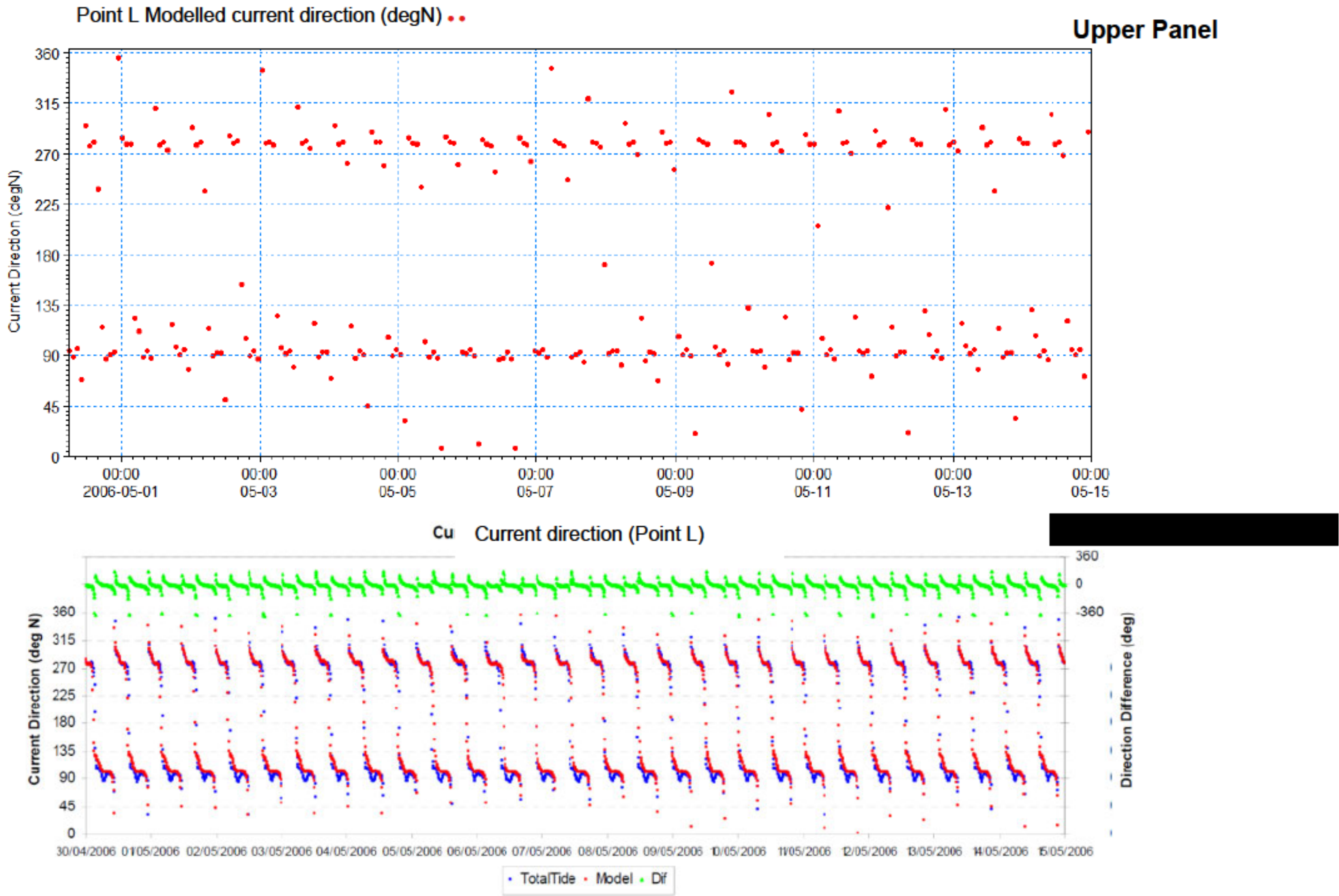

Figure A- 8: Comparison of modelled (Upper Panel) and measured (Lower Panel) current direction at Point L within Solent (red and green dots in Lower Panel were related to modelled data by ABPmer)

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Appendix B: Sensitivity Tests Model Results

Figure B- 1 to **Figure B- 4** show salinity deficit resulted from the existing Budds Farm discharge (when compared to ambient water salinity) for the four assessed wind conditions, i.e. no wind (calm conditions), wind from south-east, wind from south and wind from south-west, respectively. These sensitivity results are based on a two-weeks model simulation.

Results show that wind from south-east results in very similar plume extent to no wind scenario, although it pushed the plume slightly more into the harbours, whereas the other two wind conditions result in smaller plume extents. Therefore, it was concluded that the wind from south-east directions represent the worst case scenario when assessing impact of the discharge on water quality along the coast and in the harbours.

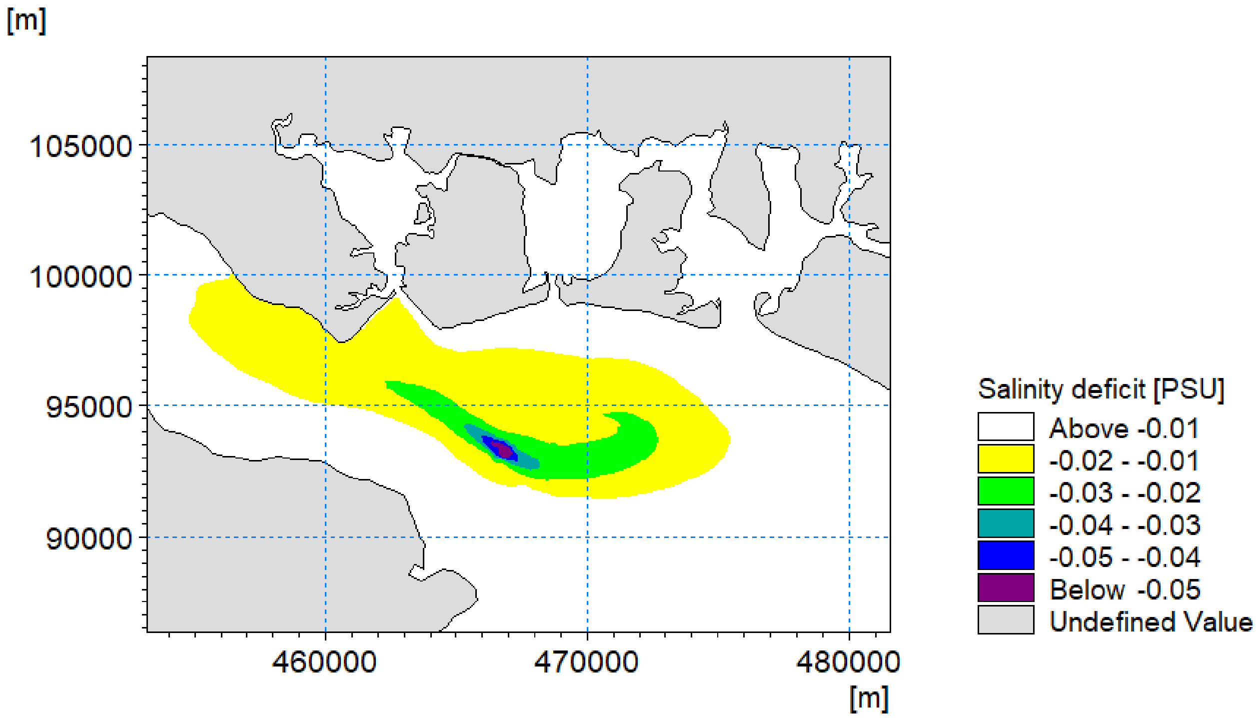

Figure B- 1: Salinity deficit (compared to ambient water) from existing Budds Farm discharge – no wind (calm conditions)

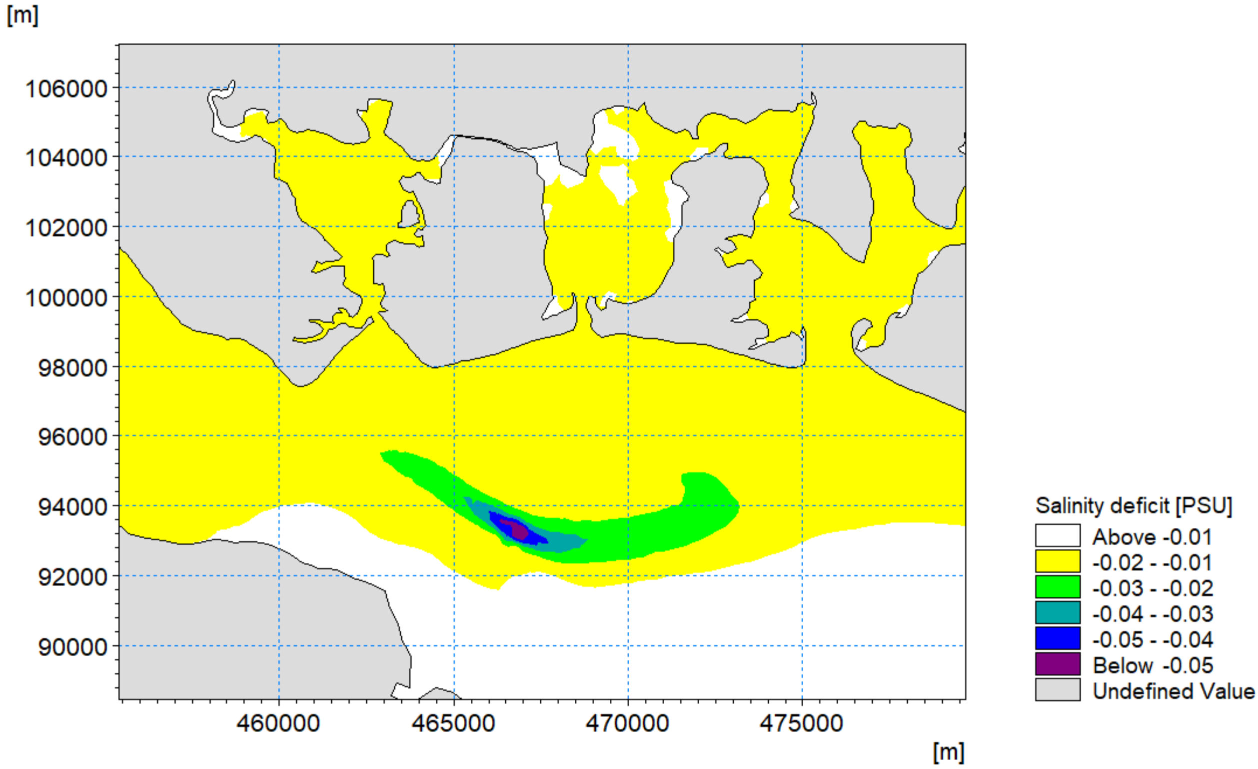

Figure B- 2: Salinity deficit (compared to ambient water) from existing Budds Farm discharge – wind from south-east

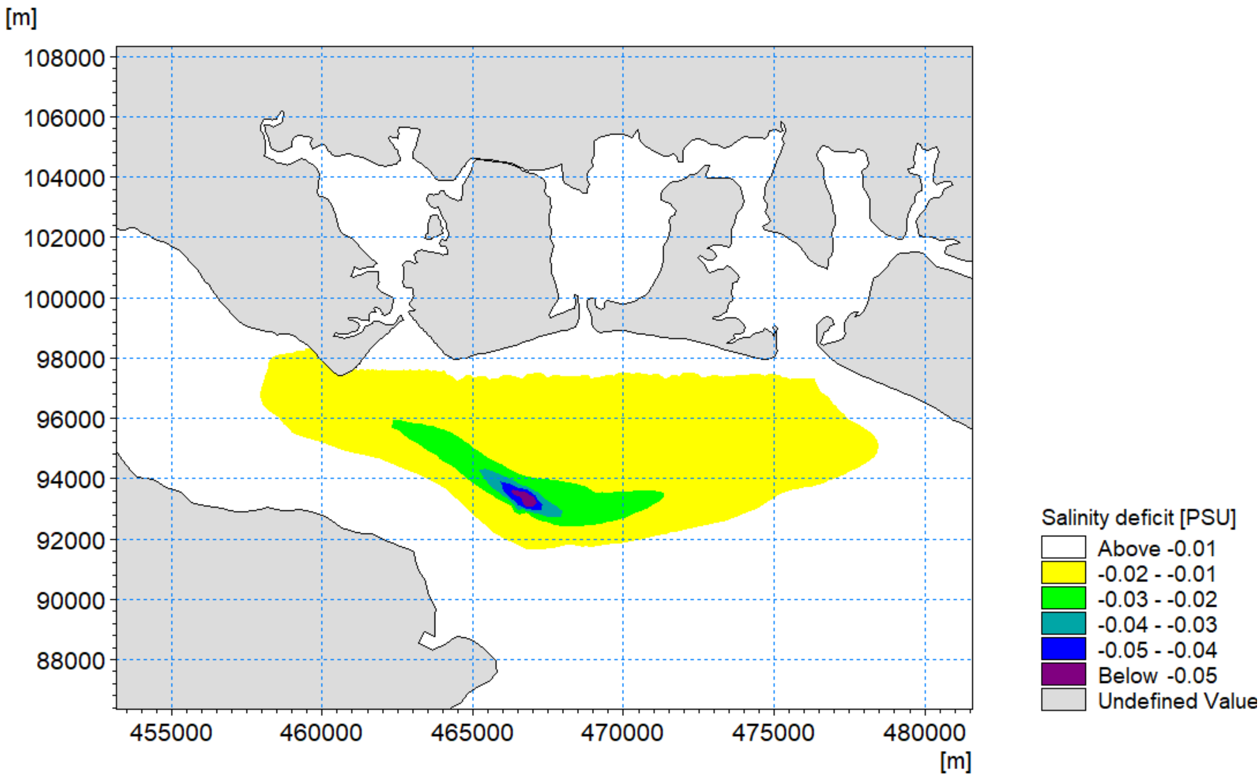

Figure B- 3: Salinity deficit (compared to ambient water) from existing Budds Farm discharge – wind from south

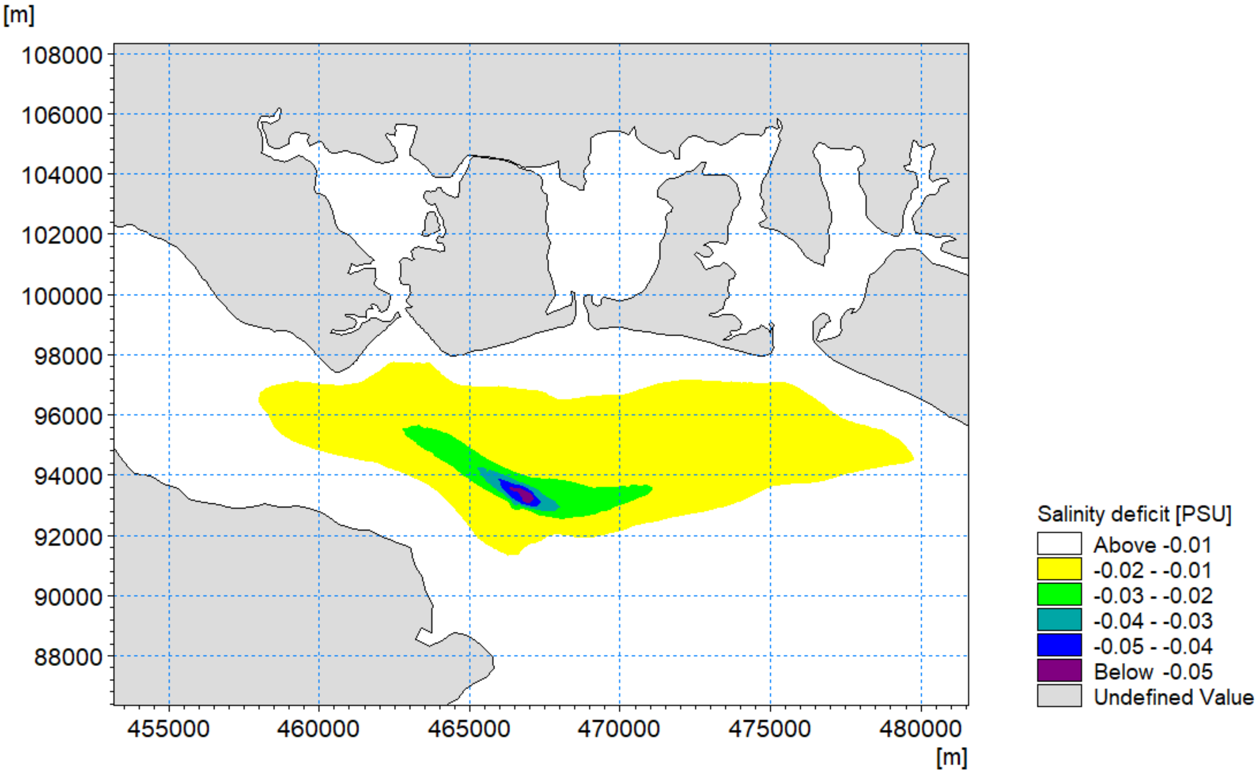

Figure B- 4: Salinity deficit (compared to ambient water) from existing Budds Farm discharge – wind from south-west

Appendix C: Model Results – all vertical layers

Figure C 1 to **Figure C 10** show change in total nitrogen concentrations between the 60Ml/d operational flow scenario and the existing flow scenario (i.e. are differential plots) for all 10 vertical layers representing water column. The results show a decrease in total nitrogen concentrations when compared to the existing scenario (i.e. reflected as negative numbers in the legend). This is because less wastewater is being discharged when the WRP is operating.

Results show very little variation between the vertical layers, with marginally bigger extent of higher change in the lower layers closer to discharge point, whereas marginally bigger extents of the lower change in the upper layers due to positive buoyancy of the plume. Overall, it was concluded that the results for layer 5 (middle of the water column) are representative and were therefore presented in the main report in Section 5.3 for all considered water quality parameters.

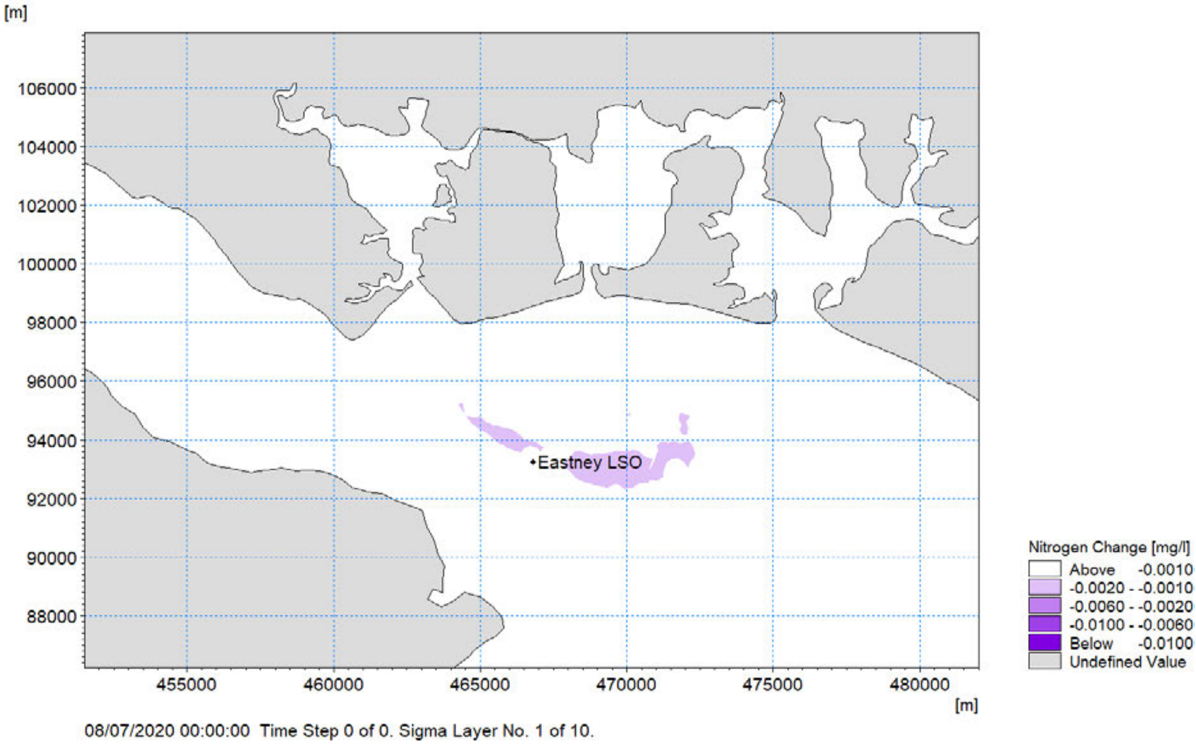

Figure C 1: Change in nitrogen concentration from existing for the 60Ml/d discharge scenario – Layer 1 (near seabed)

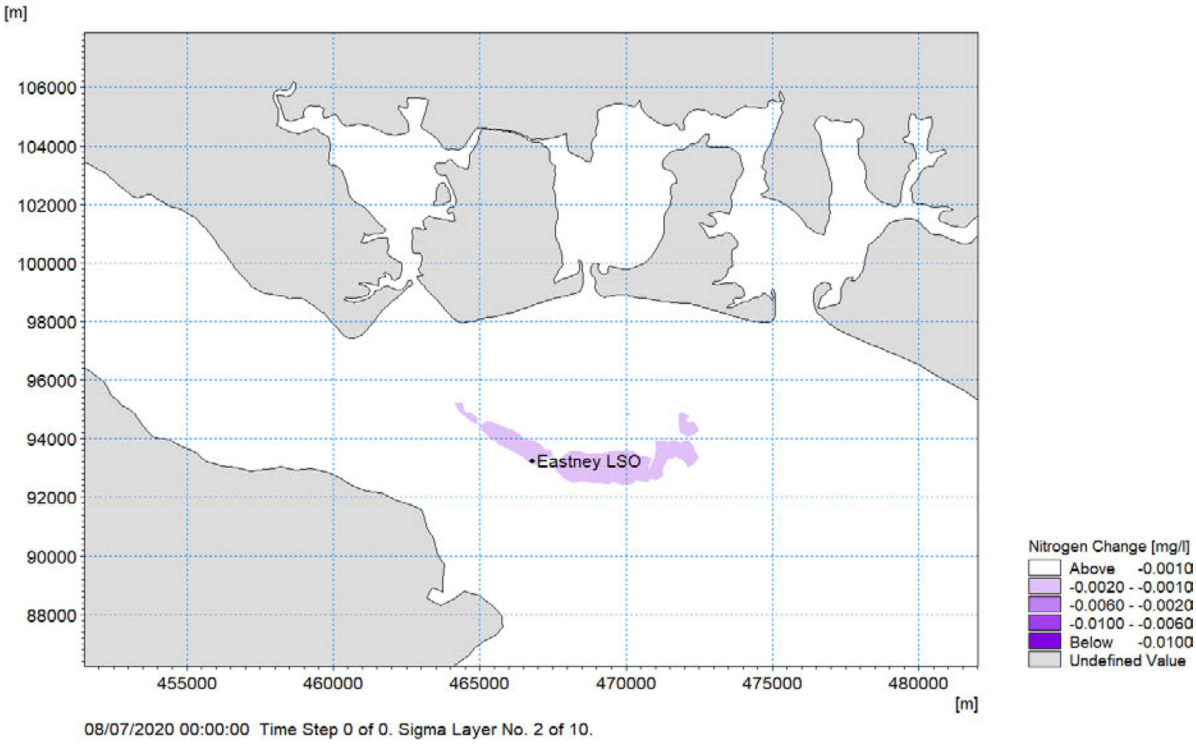

Figure C 2: Change in nitrogen concentration from existing for the 60Ml/d discharge scenario – Layer 2

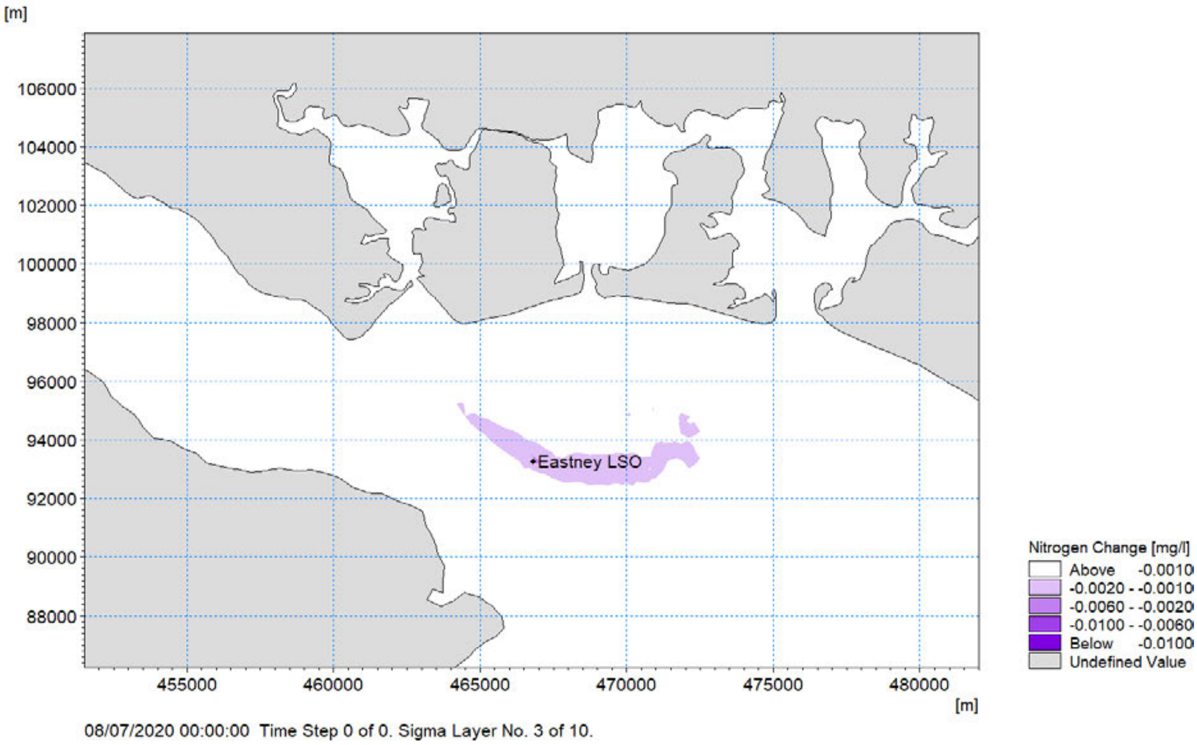

Figure C 3: Change in nitrogen concentration from existing for the 60Ml/d discharge scenario – Layer 3

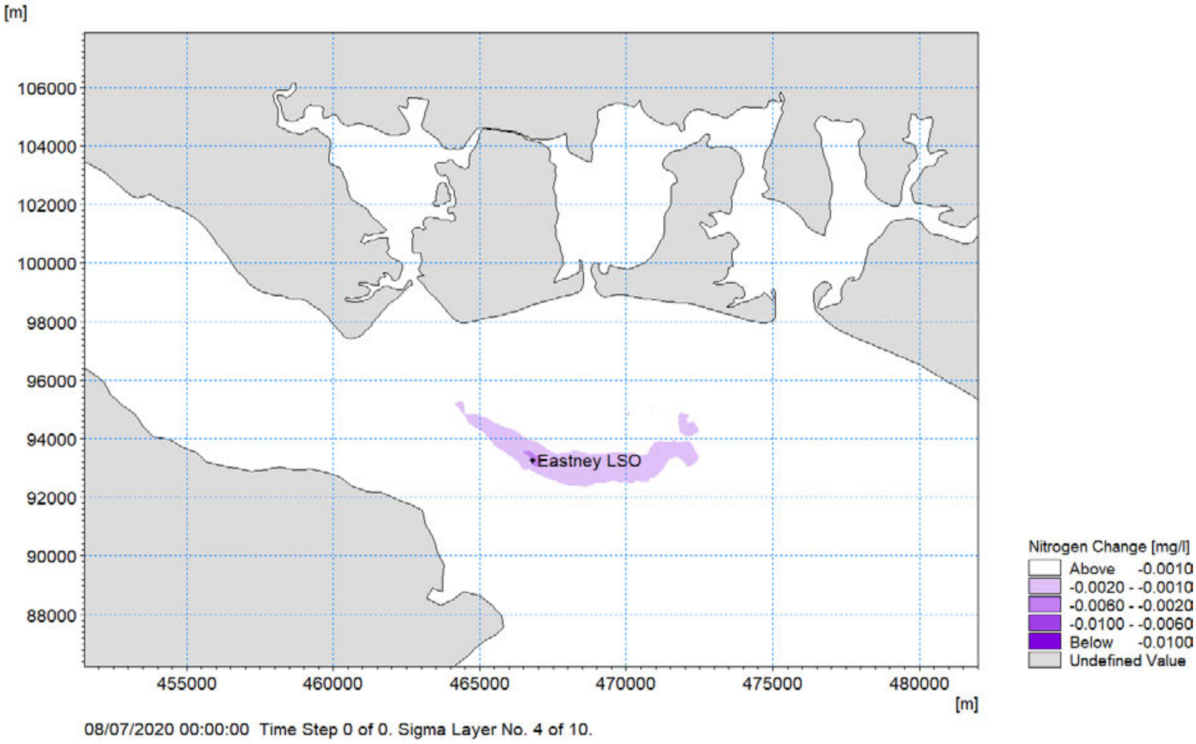

Figure C 4: Change in nitrogen concentration from existing for the 60Ml/d discharge scenario – Layer 4

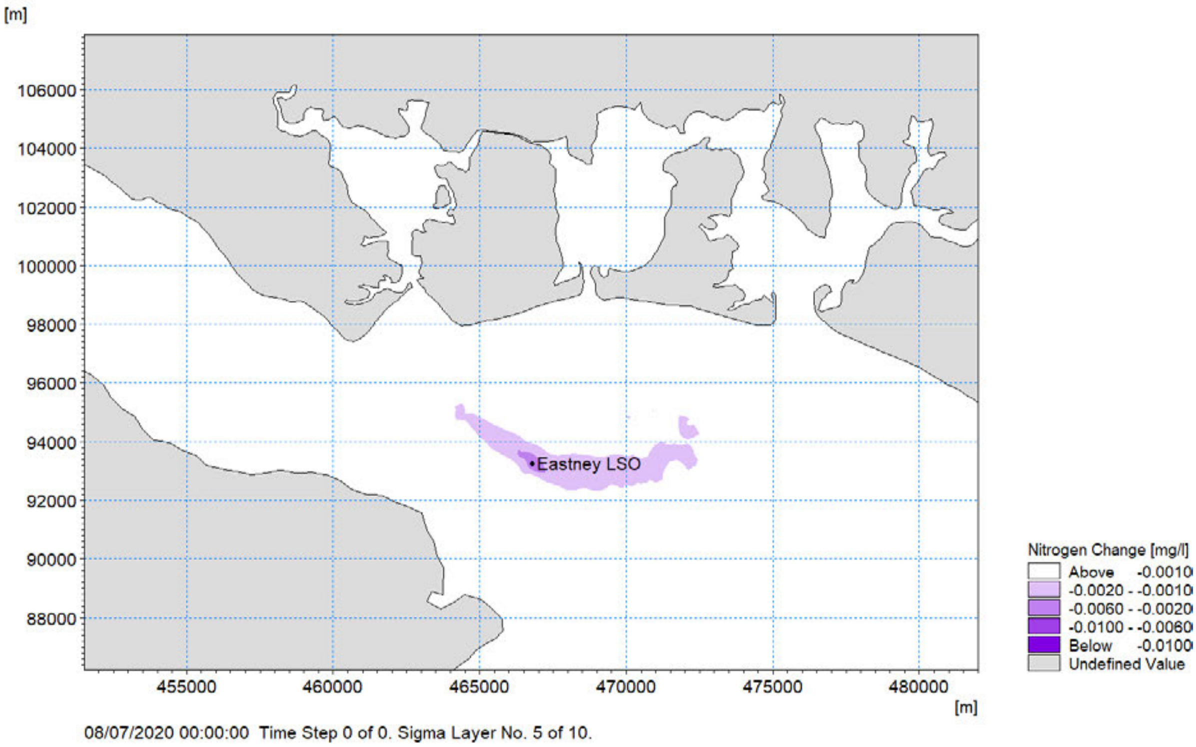

Figure C 5: Change in nitrogen concentration from existing for the 60Ml/d discharge scenario – Layer 5 (middle of the water column)

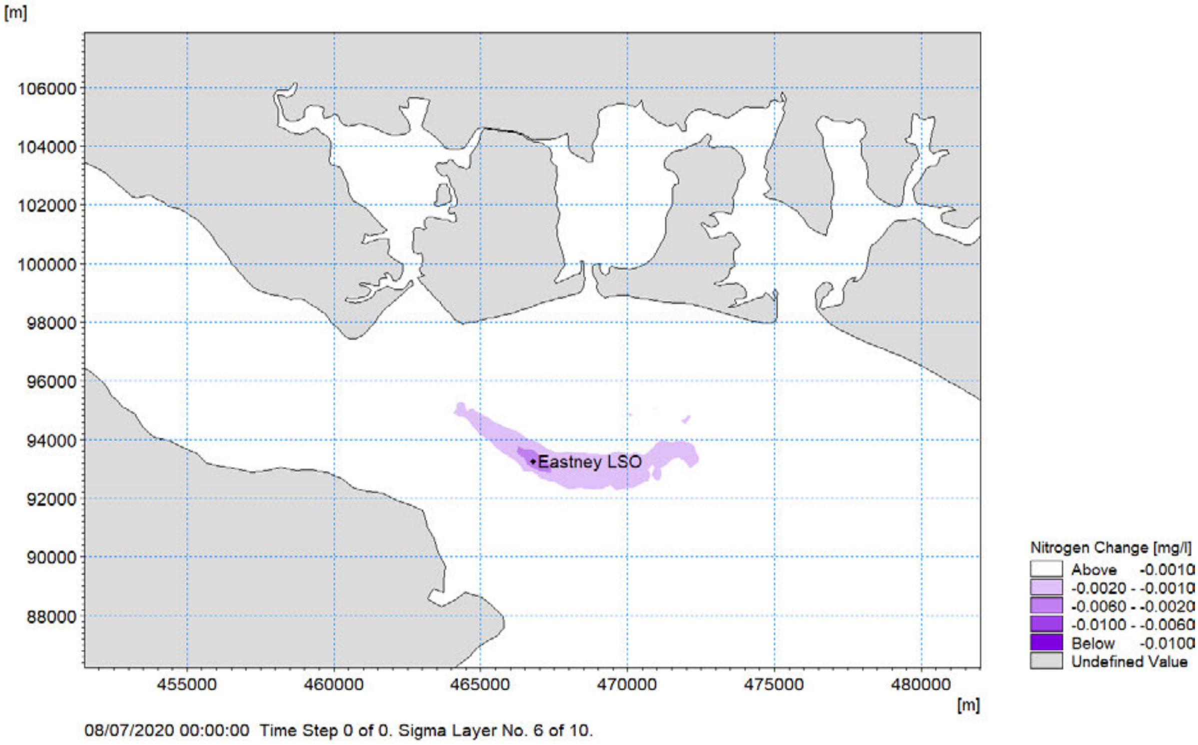

Figure C 6: Change in nitrogen concentration from existing for the 60Ml/d discharge scenario – Layer 6

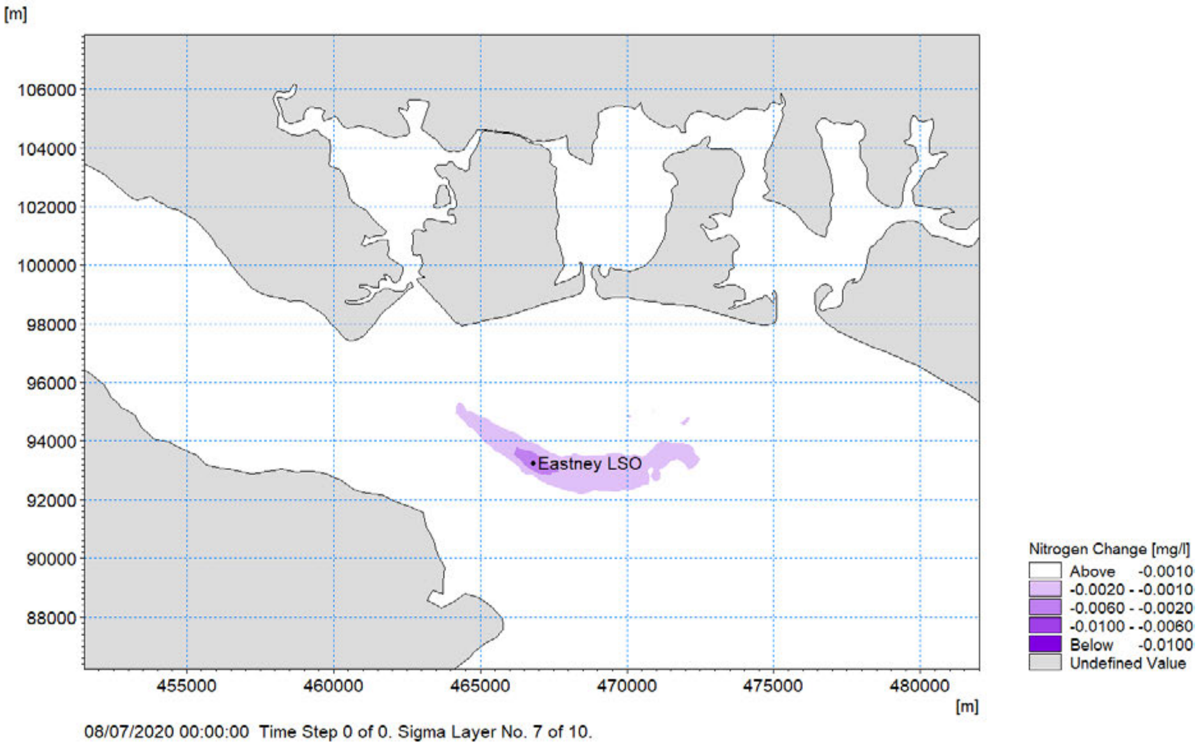

Figure C 7: Change in nitrogen concentration from existing for the 60Ml/d discharge scenario – Layer 7

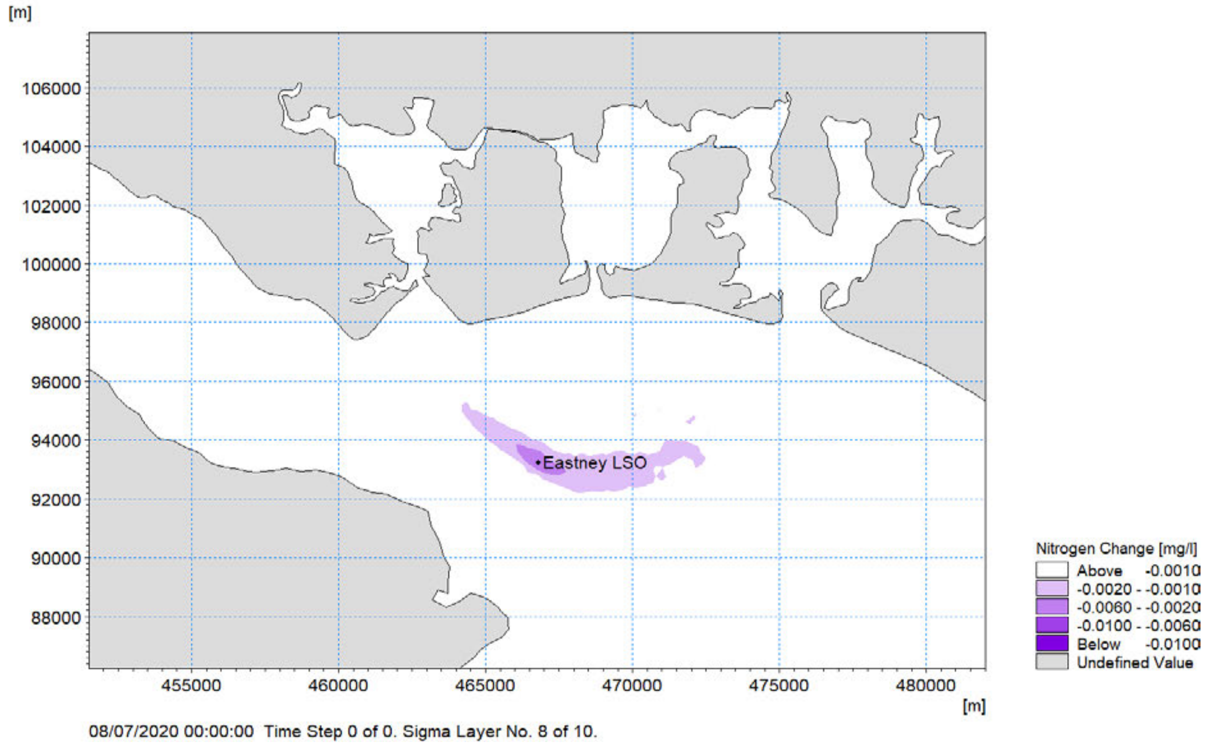

Figure C 8: Change in nitrogen concentration from existing for the 60Ml/d discharge scenario – Layer 8

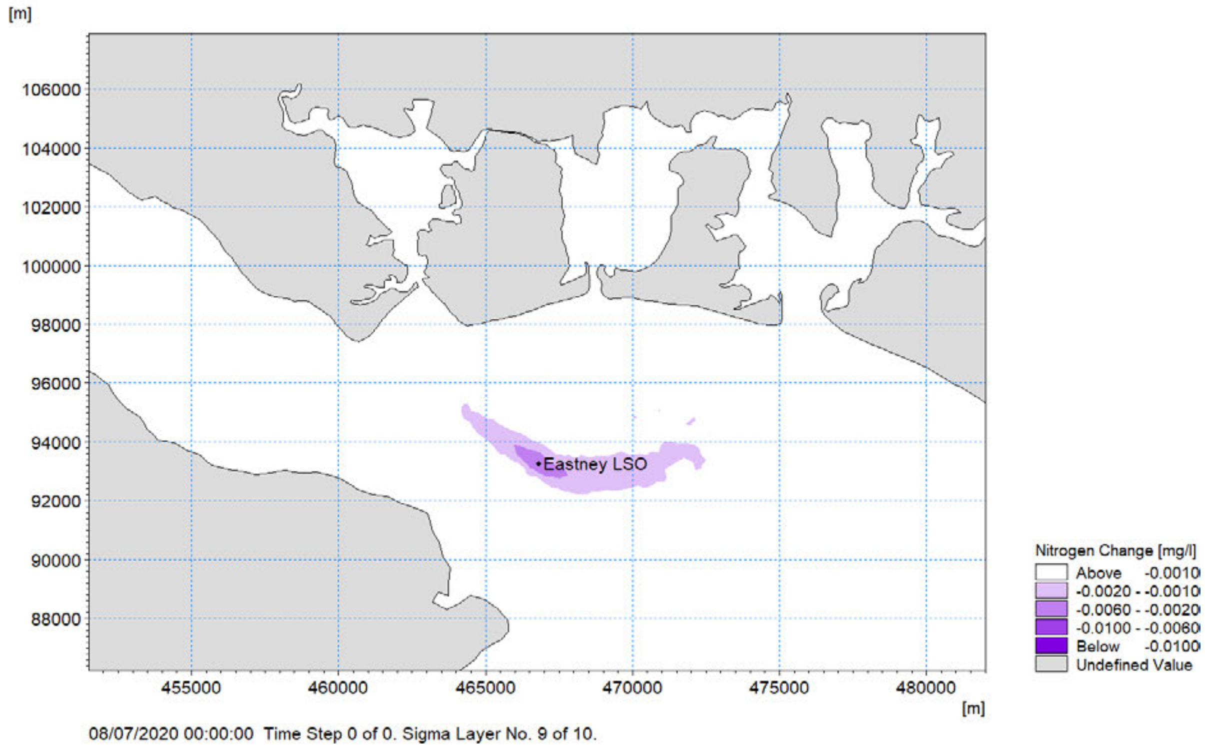

Figure C 9: Change in nitrogen concentration from existing for the 60Ml/d discharge scenario – Layer 9

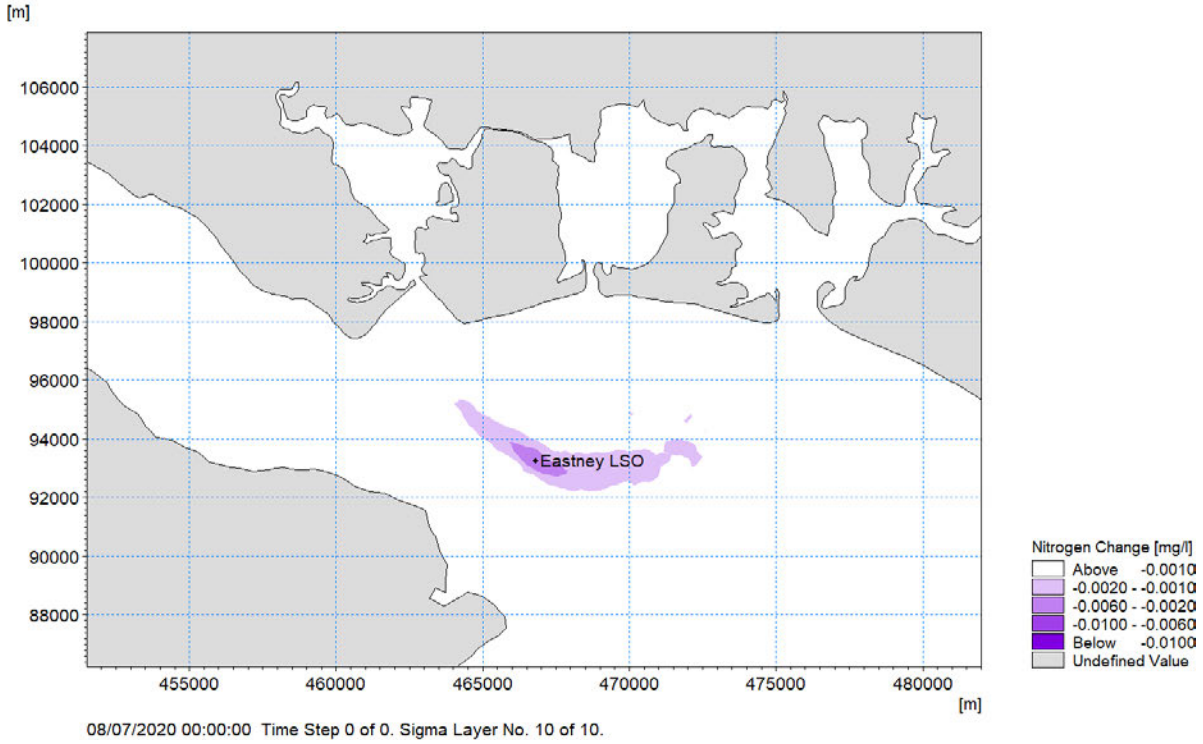

Figure C 10: Change in nitrogen concentration from existing for the 60Ml/d discharge scenario – Layer 10 (near water surface)