CONTENTS

ANNEXES

Annex 6A	*Water Quality Method Statement*	
	Appendix 6A	*Information on the Model Inputs*
	Appendix 6B	*Information on CORMIX Model*
Annex 6B	*Construction Phase Model Results – Hydrodynamics*	
Annex 6C	*Model Results for the Construction Scenarios (Suspended Solids)*	
Annex 6D	*Predicted Concentrations of Nutrients and Elutriate Test Results*	
Annex 6E	*Construction Phase Model Results – Wastewater Discharges*	
Annex 6F	*Operational Phase Model Results – Hydrodynamics*	
Annex 6G	*Operational Phase Model Results – Cooled Water Discharges*	
Annex 6H	*Operational Phase Model Results – Total Residual Chlorine*	
Annex 6I	*Operational Phase Model Results – Wastewater Discharges*	

6 WATER QUALITY ASSESSMENT

6.1 INTRODUCTION

This Section describes the impacts on water quality from the construction and operation of the proposed Liquefied Natural Gas (LNG) terminal at Black Point.

Computer modelling has been used to predict impacts to water quality from the construction and operation of the proposed LNG terminal and associated facilities. Impacts have been assessed with reference to the relevant environmental legislation and standards.

6.2 LEGISLATIVE REQUIREMENTS AND EVALUATION CRITERIA

The following relevant legislation and associated guidance are applicable to the evaluation of water quality impacts associated with the Project.

- *Water Pollution Control Ordinance (WPCO)*; and,
- *Environmental Impact Assessment Ordinance (Cap. 499. S.16), Technical Memorandum on Environmental Impact Assessment Process (EIAO-TM), Annexes 6 and 14.*

Apart from these statutory requirements, the *Practice Note for Professional Persons, Construction Site Drainage (ProPECC PN 1/94)*, issued by ProPECC in 1994, also provides useful guidelines on the management of construction site drainage and prevention of water pollution associated with construction activities.

6.2.1 Water Pollution Control Ordinance

Under the *WPCO*, Hong Kong waters are divided into 10 Water Control Zones (WCZs), each of which has a set of statutory Water Quality Objectives (WQOs) designed to protect the marine environment and its users.

The proposed LNG terminal is located within the Deep Bay WCZ (*Figure 6.1*). As the terminal is also in close proximity to the North Western WCZ in which sensitive receivers may be affected by the proposed works, the applicable WQOs of the North Western WCZ are also calculated and provided in *Table 6.1*.

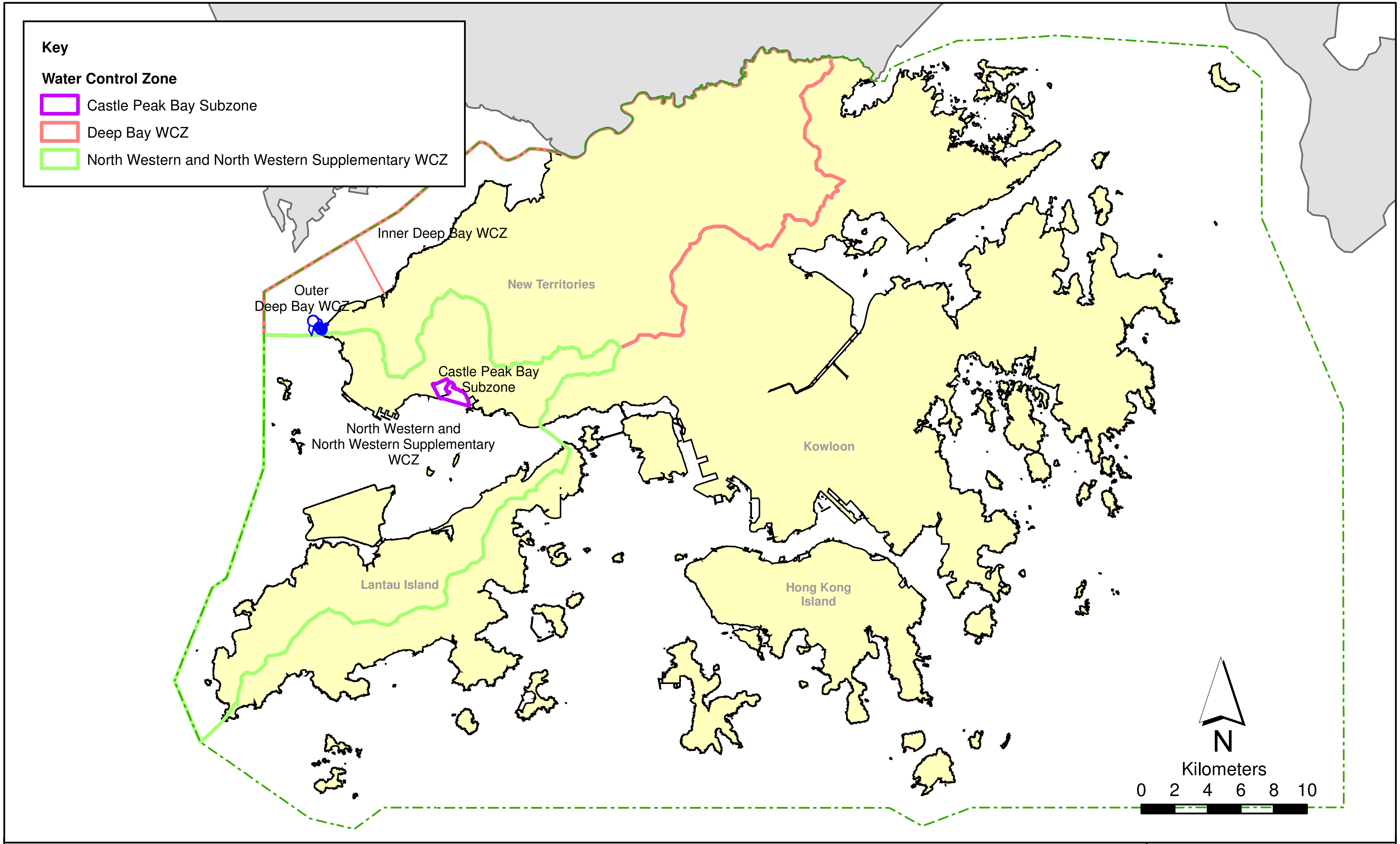

Figure 6.1

The Proposed LNG Terminal and the Water Control Zones

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Table 6.1 Water Quality Objectives Applicable to the Study

Water Quality Objective	Deep Bay WCZ	North Western WCZ
A. AESTHETIC APPEARANCE		
a) Waste discharges shall cause no objectionable odours or discolouration of the water.	Whole zone	Whole zone (including North Western Supplementary Zone)
b) Tarry residues, floating wood, articles made of glass, plastic, rubber or of any other substances should be absent.	Whole zone	Whole zone (including North Western Supplementary Zone)
c) Mineral oil should not be visible on the surface. Surfactants should not give rise to a lasting foam.	Whole zone	Whole zone (including North Western Supplementary Zone)
d) There should be no recognisable sewage-derived debris.	Whole zone	Whole zone (including North Western Supplementary Zone)
e) Floating, submerged and semi-submerged objects of a size likely to interfere with the free movement of vessels, or cause damage to vessels, should be absent.	Whole zone	Whole zone (including North Western Supplementary Zone)
f) Waste discharges shall not cause the water to contain substances which settle to form objectionable deposits.	Whole zone	Whole zone (including North Western Supplementary Zone)
B. BACTERIA		
a) The level of *Escherichia coli* should not exceed 610 per 100 mL, calculated as the geometric mean of all samples collected in one calendar year..	Secondary Contact Recreation Subzone and Mariculture Subzone	Secondary Contact Recreation Subzone and North Western Supplementary Zone
b) The level of *Escherichia coli* should not exceed 180 per 100 mL, calculated as the geometric mean of all samples collected from March to October inclusive in one calendar year. Samples should be taken at least 3 times in a calendar month at intervals of between 3 and 14 days.	Yung Long Bathing Beach Subzone	Bathing Beach Subzone
D. DISSOLVED OXYGEN		
a) Waste discharges shall not cause the level of dissolved oxygen to fall below 4 mg per litre for 90% of the sampling occasions during the year; values should be taken at 1 metre below surface.	Inner Marine Subzone excepting Mariculture Subzone	-

Water Quality Objective	**Deep Bay WCZ**	**North Western WCZ**
b) Waste discharges shall not cause the level of dissolved oxygen to fall below 4 mg per litre for 90% of the sampling occasions during the year; values should be calculated as water column average. In addition, the concentration of dissolved oxygen should not be less than 2 mg per litre within 2 metres of the seabed for 90% of the sampling occasions during the year.	Outer Marine Subzone excepting Mariculture Subzone (water column average specified as arithmetic mean of at least 2 measurements at 1 metre below surface and 1 metre above seabed)	Marine Waters (water column average specified as arithmetic mean of at least 3 measurements at 1 metre below surface, mid-depth and 1 metre above seabed); and North Western Supplementary Zone
c) The dissolved oxygen level should not be less than 5 mg per litre for 90% of the sampling occasions during the year; values should be taken at 1 metre below surface.	Mariculture Subzone	-
E. pH		
a) The pH of the water should be within the range of 6.5 - 8.5 units. In addition, waste discharges shall not cause the natural pH range to be extended by more than 0.2 units.	Marine waters excepting Yung Long Bathing Beach Subzone	Marine waters (including North Western Supplementary Zone) excepting Bathing Beach Subzones
b) The pH of the water should be within the range of 6.0 - 9.0 units for 95% of samples. In addition, waste discharges shall not cause the natural pH range to be extended by more than 0.5 units.	Yung Long Bathing Beach Subzone	Bathing Beach Subzones
F. TEMPERATURE		
Waste discharges shall not cause the natural daily temperature range to change by more than 2.0 °C.	Whole zone	Whole zone (including North Western Supplementary Zone)
G. SALINITY		
Waste discharges shall not cause the natural ambient salinity level to change by more than 10%.	Whole zone	Whole zone (including North Western Supplementary Zone)
H. SUSPENDED SOLIDS		
a) Waste discharges shall neither cause the natural ambient level to be raised by 30% nor give rise to accumulation of suspended solids which may adversely affect aquatic communities.	Marine waters	Marine waters (including North Western Supplementary Zone)

Water Quality Objective	**Deep Bay WCZ**	**North Western WCZ**
I. AMMONIA		
The un-ionized ammoniacal nitrogen level should not be more than 0.021 mg per litre, calculated as the annual average (arithmetic mean).	Whole zone	Whole zone (including North Western Supplementary Zone)
J. NUTRIENTS		
a) Nutrients shall not be present in quantities sufficient to cause excessive or nuisance growth of algae or other aquatic plants.	Inner and Outer marine Subzones	Marine waters (including North Western Supplementary Zone)
b) Without limiting the generality of objective (a) above, the level of inorganic nitrogen should not exceed 0.3 mg per litre, expressed as annual water column average (arithmetic mean of at least 3 measurements at 1m below surface, mid-depth and 1m above seabed).	-	Castle Peak Bay Subzone
c) Without limiting the generality of objective (a) above, the level of inorganic nitrogen should not exceed 0.7 mg per litre, expressed as annual mean.	Inner Marine Subzone	-
d) Without limiting the generality of objective (a) above, the level of inorganic nitrogen should not exceed 0.5 mg per litre, expressed as annual water column average.	Outer Marine Subzone (water column average specified as arithmetic mean of at least 2 measurements at 1 metre below surface and 1 metre above seabed)	Marine waters (including North Western Supplementary Zone) excepting Castle Peak Bay Subzone (water column average specified as arithmetic mean of at least 3 measurements at 1m below surface, mid-depth and 1m above seabed)
K. 5-DAY BIOCHEMICAL OXYGEN DEMAND		
a) Waste discharges shall not cause the 5-day biochemical oxygen demand to exceed 5 milligrams per litre.	Yuen Long & Kam Tin (Lower) Subzone and other inland waters	Inland waters (except the subzones stated in b))
b) Waste discharges shall not cause the 5-day biochemical oxygen demand to exceed 3 milligrams per litre.	Yuen Long & Kam Tin (Upper) Subzone, Beas Subzone, Indus Subzone, Ganges Subzone and Water Gathering Ground Subzones	Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) Subzones and Water Gathering Ground Subzones
L. CHEMICAL OXYGEN DEMAND		
a) Waste discharges shall not cause the chemical oxygen demand to exceed 30 milligrams per litre.	Yuen Long & Kam Tin (Lower) Subzone and other inland waters	Inland waters (except the subzones stated in b))

Water Quality Objective	**Deep Bay WCZ**	**North Western WCZ**
b) Waste discharges shall not cause the chemical oxygen demand to exceed 15 milligrams per litre.	Yuen Long & Kam Tin (Upper) Subzone, Beas Subzone, Indus Subzone, Ganges Subzone and Water Gathering Ground Subzones	Tuen Mun (A), Tuen Mun (B) and Tuen Mun (C) Subzones and Water Gathering Ground Subzones
M. TOXINS		
a) Waste discharges shall not cause the toxins in water to attain such levels as to produce significant toxic, carcinogenic, mutagenic or teratogenic effects in humans, fish or any other aquatic organisms, with due regard to biologically cumulative effects in food chains and to interactions of toxic substances with each other.	Whole zone	Whole zone (including North Western Supplementary Zone)
b) Waste discharges shall not cause a risk to any beneficial uses of the aquatic environment.	Whole zone	Whole zone (including North Western Supplementary Zone)
N. PHENOLS		
Phenols shall not be present in such quantities as to produce a specific odour, or in concentration greater than 0.05 mg per litre as C_6H_5OH.	Yung Long Bathing Beach Subzone	Bathing Beach Subzones
O. TURBIDITY		
Waste discharges shall not reduce light transmission substantially from the normal level.	Yung Long Bathing Beach Subzone	Bathing Beach Subzones

6.2.2 *Technical Memorandum Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters*

All discharges during both the construction and operational phases of the proposed development are also required to comply with the *Technical Memorandum Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters (TM)* issued under *Section 21* of the *WPCO*.

The *TM* defines acceptable discharge limits to different types of receiving waters. Under the *TM*, effluents discharged into the drainage and sewerage systems, inshore and coastal waters of the WCZs are subject to pollutant concentration standards for specified discharge volumes. These are defined by the Environmental Protection Department (EPD) and are specified in licence conditions for any new discharge within a WCZ.

The proposed LNG terminal at Black Point will be required to comply with *Table 8 of the TM - Standards for effluents discharged into the coastal waters of Deep Bay Water Control Zone.*

6.2.3 *Technical Memorandum on Environmental Impact Assessment Process (EIAO-TM)*

Annexes 6 and *14* of the *EIAO-TM* provide general guidelines and criteria to be used in assessing water quality impacts.

The *EIAO-TM* recognises that, in the application of the above water quality criteria, it may not be possible to achieve the WQO at the point of discharge as there are areas which are subjected to greater impacts (which are termed by the EPD as the **mixing zones**) where the initial dilution of the discharge takes place. The definition of this area is determined on a case-by-case basis. In general, the criteria for acceptance of the mixing zone are that it must not impair the integrity of the water body as a whole and must not damage the ecosystem.

6.2.4 *Suspended Solid Impacts*

The Water Quality Objective (WQO) for suspended solids in marine waters of the North Western WCZ and the Deep Bay WCZ states that:

> *Waste discharges shall neither cause the natural ambient level to be raised by 30% nor give rise to accumulation of suspended solids, which may adversely affect aquatic communities*

Analysis of EPD routine water quality data from the years of 1996 to 2006 has been undertaken to determine the allowable increase in suspended solids concentrations within the WCZ. Data have been analysed from the EPD monitoring stations that are in the proximity of the proposed works (*Figure 6.2*).

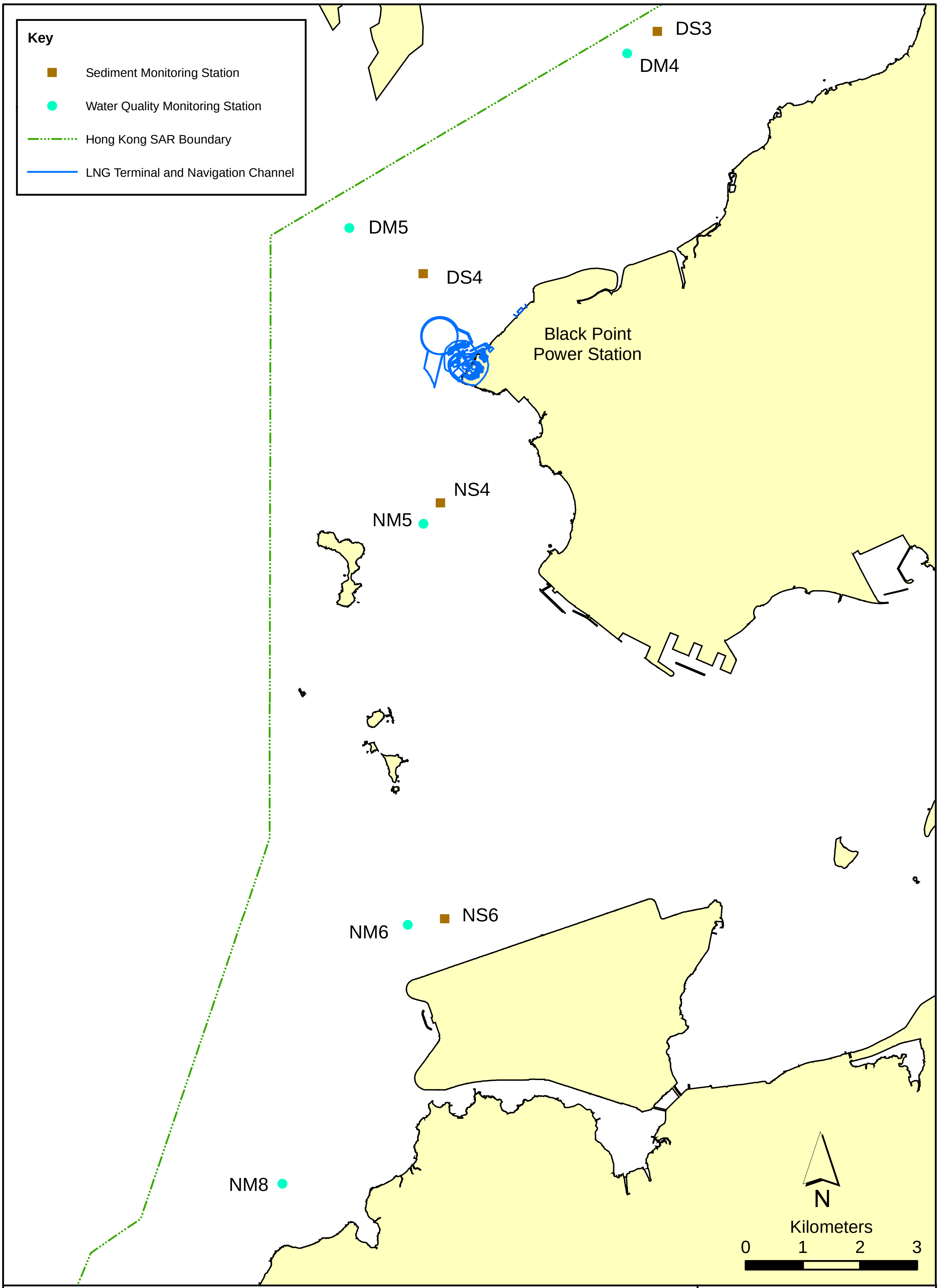

FIGURE 6.2

EPD Routine Water and Sediment Quality Monitoring Stations
in the Vicinity of the Proposed LNG Terminal
at Black Point

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WQO for SS in Deep Bay Water Control Zone

Suspended solids data from EPD monitoring station DM4 and DM5, have been analysed to determine the allowable increase at the sensitive receivers close to the shore approach at Black Point within the outer Deep Bay WCZ. For those sensitive receivers within the inner Deep Bay WCZ, the SS criterion will make reference to station DM4.

WQO for SS North Western Water Control Zone

Suspended solids data from EPD monitoring stations NM5 andNM6 have been analysed to determine the allowable increase at the sensitive receivers close to LNG Terminal and Associated Facilities.

SS Criterion for Seawater Intakes

The power station intakes have specific requirements for intake water quality. The applicable criteria for the Black Point Power Station and Castle Peak Power Station seawater intakes are temperature between 17 and 32°C and SS levels below 764 mg L^{-1}, respectively. It is reasonable to adopt on SS assessment criterion of **700 mg L^{-1}** for these two seawater intakes.

There are no particular criteria specified for the industrial intake at Tuen Mun Area 38 and the Airport intakes (1) and hence the WQOs were used as the criteria for these intakes.

The Water Supplies Department (WSD) has a set of standards for the quality of abstracted seawater (*Table 6.2*). Water quality at the WSD seawater intakes has been assessed against these standards, in addition to the WQOs.

Table 6.2 WSD Water Quality Criteria for Abstracted Seawater

Parameter	Criterion
Colour (HU)	< 20
Turbidity (NTU)	< 10
Threshold Odour No.	< 100
Ammoniacal Nitrogen (mg L^{-1})	< 1
Suspended Solids (mg L^{-1})	< 10 (20 is the upper threshold)
Dissolved Oxygen (mg L^{-1})	> 2
5-day Biochemical Oxygen Demand (mg L^{-1})	< 10
Synthetic Detergents (mg L^{-1})	< 5
E. coli (cfu 100mL^{-1})	< 20,000

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(1) It was confirmed with the Airport Authority that the WQOs were suitable to be used as the criterion for the intakes at the Airport.

SS Criterion for Fish Culture Zones

There is a general water quality protection guideline for suspended solids (SS), which has been proposed by AFCD (1). The guideline requires the maximum SS levels remain below **50 mg L^{-1}**. This criterion has been adopted in previous approved EIA Reports (2) (3).

6.2.5 *Sediment Quality*

Dredged sediments destined for marine disposal are classified according to a set of regulatory guidelines (*Management of Dredged / Excavated Sediment, ETWBTC No. 34/2002*) issued by the Environment, Transport and Works Bureau (ETWB) in August 2002. These guidelines comprise a set of sediment quality criteria, which include organic pollutants and other substances. The requirements for the marine disposal of sediment are specified in the *ETWBTC No. 34/2002*. Marine disposal of dredged materials is controlled under the *Dumping at Sea Ordinance 1995*.

6.2.6 *Other Assessment Criteria*

Sediment Deposition

Impacts to artificial reefs (ARs) have been assessed with regard to sediment deposition. The assessment criterion of **200 g m^{-2} day^{-1}**, has been used in approved EIA Reports (4) and has been adopted here.

Dissolved Oxygen

The release of sediment into the water column or the effluent discharge due to the Project may consume the dissolved oxygen (DO) in the receiving water. The oxygen depletion resulting from the dredging operations or the effluent discharge will be assessed against the WQO. The allowable change in DO levels in each WCZ has been calculated based on the EPD routine water quality monitoring data for the period 1996 to 2006.

The DO assessment criterion, for each sensitive receiver is discussed in *Section 6.3.5, Part 3*.

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(1) City University of Hong Kong (2001) Agreement No. CE 62/98, Consultancy Study on Fisheries and Marine Ecological Criteria for Impact Assessment, Final Report, for the Agriculture, Fisheries and Conservation Department, Hong Kong SAR Government.

(2) ERM – Hong Kong, Ltd (2002) EIA for the Proposed Submarine Gas Pipeline from Cheng Tou Jiao Liquefied Natural Gas Receiving Terminal, Shenzhen to Tai Po Gas Production Plank, Hong Kong. Final EIA Report. For the Hong Kong and China Gas Co., Ltd.

(3) Maunsell (2001) EIA for Tai Po Sewage Treatment Works - Stage V. Final EIA Report. For Drainage Services Department, Hong Kong SAR Government.

(4) ERM – Hong Kong, Ltd (2000) EIA for Construction of an International Theme Park in Penny's Bay of North Lantau together with its Essential Associated Infrastructures - Environmental Impact Assessment. Final EIA Report. For Civil Engineering Department, Hong Kong SAR Government.

In addition, the WQO that is specific to Fish Culture Zones is set at no less than **5 mg L^{-1}** measured at 1 m below the water surface (*Table 6.1*).

Dissolved Metals and Organic Compounds

There are no quantitative standards for dissolved metals in the marine waters of Hong Kong. It is proposed to make reference to the relevant UK water quality standards (1). This approach has been adopted in approved EIA Reports, i.e., *EIA for Decommissioning of Cheoy Lee Shipyard at Penny's Bay* (2), *EIA for Disposal of Contaminated Mud in the East Sha Chau Marine Borrow Pit* (3) and *EIA for Wanchai Development Phase II* (4).

Water sampling was conducted for dissolved metals and organic compounds for the assessment. The results are presented in *Annex 6D, Part 3*, which showed that the concentrations of the dissolved metals in the marine water column at all sampling stations are below the reporting limits, with the exception of copper and arsenic. This means that the ambient concentrations of these dissolved metals are very low. For copper, the mean concentration has been calculated for each WCZ. *Table 6.3* shows the assessment criteria and the respective allowable increases in dissolved metal concentrations.

There are no existing legislative standards or guidelines for total PCBs, total PAHs and TBT and hence reference has been made to the USEPA water quality criteria (5), Australian water quality guidelines (6), and international literature (7) , respectively. The assessment criteria for total PCBs, total PAHs and TBT are 0.03 µg L^{-1}, 3.0 µg L^{-1} and 0.1 µg L^{-1} , as shown in *Table 6.3*.

Similarly, there are no legislative standards or guidelines in Hong Kong for chlorinated pesticides and the assessment criteria are in accordance with the USEPA water quality criteria.

(1) Her Majesty's Inspectorate of Pollution (HMIP) (1994). Environmental Economic and BPEO Assessment Principals for Integrated Pollution Control.

(2) Maunsell (2002). EIA for Decommissioning of Cheoy Lee Shipyard at Penny's Bay. For Civil Engineering Department, Hong Kong SAR Government.

(3) ERM – Hong Kong (1997). EIA for Disposal of Contaminated Mud in the East Sha Chau Marine Borrow Pit. For Civil Engineering Department, Hong Kong SAR Government.

(4) Maunsell (2001). EIA for Wanchai Development Phase II - Comprehensive Feasibility Study. For Territory Development Department, Hong Kong SAR Government.

(5) United States Environmental Protection Agency (2006). National Recommended Water Quality Criteria.

(6) Australian and New Zealand Environment and Conservation Council (1992). Australian Water Quality Guidelines for Fresh and Marine Waters.

(7) Salazar, M.H. and Salazar, S.M. (1996). "Mussels as Bioindicators: Effects of TBT on Survival, Bioaccumulation, and Growth under Natural Conditions" in Organotin, edited by M.A. Champ and P.F. Seligman. Chapman & Hall, London.

Table 6.3 *Summary of Assessment Criteria and the Allowable Increases for Dissolved Metals due to the Project*

Parameter	Assessment Criterion (µg L^{-1})	Ambient Concentration [a] (µg L^{-1})	Allowable Increase (µg L^{-1})
Arsenic	25.0	1.8	23.2
Cadmium	2.5	0.1	2.4
Chromium	15.0	0.5	14.5
Copper	5.0	0.9	4.1
Lead	25.0	0.5	24.5
Mercury	0.3	0.1	0.2
Nickel	30.0	1.4	28.6
Silver	2.3	0.5	1.8
Zinc	40.0	6.2	33.8
Total PCBs	0.03 [b]	-	-
Total PAHs	3.0 [b]	-	-
TBT	0.1 [b]	-	-
Alpha-BHC	0.0049 [c]	-	-
Beta BHC	0.017 [c]	-	-
Gamma BHC	0.16 [b]	-	-
Delta-BHC	- [d]	-	-
Heptachlor	0.053 [b]	-	-
Aldrin	1.3 [b]	-	-
Heptachlor epoxide	0.053 [b]	-	-
Alpha Endosulfan	0.034 [b]	-	-
p, p'-DDT	0.13 [b]	-	-
p, p'-DDD	0.00031 [c]	-	-
p, p'-DDE	0.00022 [c]	-	-
Endosulfan sulfate	89 [c]	-	-

Notes:

(a) The ambient concentrations were derived from the water sampling results for this project.

(b) The water quality criteria were derived from the USEPA water quality criteria. The Criteria Maximum Concentration (CMC) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect. CMC is used as the criterion of the respective compounds in this study.

(c) No saltwater criteria for this chlorinated pesticide were defined by USEPA. The water quality criterion to protect human health for the consumption of aquatic organisms is provided for reference.

(d) No water quality criteria for delta-BHC were defined by USEPA.

Residual Chorine

As discussed in the *Project Description* (*Section 3, Part 3*) the water system used to warm up the LNG will require the use of chlorine as an antifoulant. The resultant discharge to the marine environment will contain total residual chlorine. The criterion value of **0.01 mg L^{-1}** (daily maximum) at the edge of the mixing zone has been chosen as the criterion against which to assess the results from the modelling of chlorine dispersion. This is also the criterion adopted in the previously approved EIA Report for the 1,800 MW Gas-fired Power Station at Lamma Extension (1).

6.3 BASELINE CONDITIONS AND WATER QUALITY SENSITIVE RECEIVERS

6.3.1 Hydrodynamics

In general, long period swell waves generated in the South China Sea propagate into Hong Kong waters, with energy dissipation due to refraction, diffraction, shoaling, wave breaking, bottom friction and shielding due to offshore islands. This results in wave energy reduction inshore of the outer islands and into shallower Hong Kong waters. It also gives Hong Kong a distinctive two peak frequency distribution, where one peak represents offshore swells and the other the shorter period inshore wind-driven waves. The NE Monsoon is generally stronger and more persistent than the SW Monsoon. The highest percentage of strong winds and hence waves are generated from north to southeast.

Current velocities are influenced by the semi-diurnal tidal regime of the South China Sea and the freshwater flows of the Pearl River Delta during the wet season. The further upstream of the Pearl River Estuary the greater the tidal distortion, shorter floodtide, longer ebb, and the greater the effect of fresh water flows.

North Western Water Control Zone

The North Western WCZ is situated at the mouth of the Pearl River Estuary and, as such, is heavily influenced by the freshwater flows from the hinterland. The area shows distinct seasonality as a result of the seasonal influx of freshwater from the Pearl River. The estuarine influence is especially pronounced in the wet summer months when the freshwater flows are greatest and strong salinity and temperature stratification is prominent. During the winter months water conditions are more typically marine (with lower nutrient levels and higher DO levels) and salinity and other parameters vary less with depth. Ebb tide currents are towards the southeast where the flood tide currents move to the northwest. Current velocities in areas near to Sha Chau have been predicted in previous studies to reach up to 2.0 ms^{-1} (2).

Deep Bay Water Control Zone

The Black Point landing point is surrounded by a shallow and sediment-laden water body in the Outer Deep Bay region between Hong Kong and Shenzhen. Deep Bay has a surface area of approximately 112 km^2 (11,200 ha) with a

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(1) ERM - Hong Kong Ltd (1999). EIA for 1,800 MW Gas-fired Power Station at Lamma Extension. Final EIA Report. For the Hongkong Electric Co., Ltd.

(2) ERM-Hong Kong, Ltd (2004) Detailed Site Selection Study for a Proposed Contaminated Mud Disposal Facility within the Airport East/East of Sha Chau Area. Agreement No. CE 12/2002 (EP). Environmental Impact Assessment and Final Site Section Report, for Civil Engineering and Development Department, Hong Kong SAR Government.

length of about 15 km and an average depth of 3 m (1). The hydrodynamic regime of the Deep Bay area is unidirectional and the current direction reverses during ebb and flood tides. Tidal flow is dynamic and complex in the Deep Bay areas due to the seasonal influx of freshwater from the Pearl River to the Urmston Road. The Urmston Road is one of the main flow routes into and out of the Pearl River Estuary and carries significant volumes of water on each tide (2).

6.3.2 *Water Quality*

Water quality has been determined through a review of EPD routine water quality monitoring data collected between 1996 and 2006 (March). This dataset provides Hong Kong's most comprehensive long term water quality monitoring data and allows an indication of temporal and spatial change in marine water quality in Hong Kong.

Deep Bay Water Control Zone

On the basis of the 1996 to 2006 monitoring data, Dissolved Oxygen (DO) levels in Deep Bay the WCZ are exhibiting a decline from 1996 to 2003 followed by an increase, whereas, Total Inorganic Nitrogen (TIN) and Unionised Ammonia have been increasing over time. An increasing trend of SS levels between 1998 and 2001 is observed; however, between 2002 and 2006 SS levels have been declining. It is noted that the range of values recorded is high and values up to 62 mg L^{-1} at DM5 and 66 mg L^{-1} at DM4 have been recorded. Water quality within the Deep Bay WCZ is generally compliant with the WQOs. The exception has been TIN, the levels of which have exceeded the WQO of < 0.5 mg L^{-1} in all years. The increased levels in *E. coli* have been attributed to discharges from the Pearl River Estuary (*Table 6.4*).

North Western Water Control Zone

The water quality in the North Western WCZ is influenced by effluent discharges from sewage treatment works, such as those at Siu Ho Wan and Pillar Point and Pearl River Delta flows in general. Data collected between 1996 and 2006 indicate that there have been elevations of SS and Unionised Ammonia. A decreasing trend for DO is observed from 1996 to 2003 and an increase is found afterwards. In terms of compliance with the WQOs, no exceedances have been recorded, with the exception of TIN, which exceeds the WQO of 0.5 mg L^{-1} on a continual basis, especially at NM5 and NM6 (*Table 6.4*). It is noted from reviewing the data for SS that the range of values recorded is high and values up to 81 mg L^{-1} at NM5 and 73 mg L^{-1} at NM8 have been recorded. Of these monitoring stations, NM5 recorded the highest geometric mean of *E. coli*, 520 cfu 100mL^{-1}.

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(1) Scott Wilson (2003). Extension of Existing Landfills and Identification of Potential New Waste Disposal Sites. For the Environmental Protection Department, Hong Kong SAR Government.

(2) ERM-Hong Kong, Ltd (1993). EIA of the Proposed 6000MW Thermal Power Station at Black Point: Key Issue Assessment-Marine Water Quality, Final Report, prepared for Castle Peak Power Company Limited.

6.3.3 *Water Quality of Marine Parks*

The Agriculture, Fisheries and Conservation Department (AFCD) commenced a routine water quality monitoring programme in 1999 to collect baseline water quality data from existing and proposed Marine Parks/Marine Reserves in Hong Kong. The water quality monitoring results for the Sha Chau and Lung Kwu Chau Marine Park (1999 – 2005) are summarised in *Table 6.5*.

It is apparent from the data that the mean values of suspended sediment range from 9.7 to 37.2 mg L^{-1}.

Table 6.4 EPD Water Quality Monitoring Data 1996 - 2006 in the Deep Bay and North Western Water Control Zones

Water Quality Parameter	Deep Bay WCZ		North Western WCZ	
	DM4	DM5	NM5	NM6
Temperature (ºC)	23.9 (14.4 - 32.8)	23.6 (14.4 - 31.1)	23.4 (15.5 - 30.3)	23.5 (15.1 - 29.8)
pH	7.9 (6.3 - 9.0)	7.9 (6.2 - 8.7)	8.0 (7.3 - 8.7)	8.1 (6.9 - 8.5)
Dissolved Oxygen (mg L^{-1}) Depth-averaged	6.0 (0.6 - 10.2)	5.9 (2.6 - 10.0)	5.9 (2.3 - 9.2)	6.4 (3.3 - 11.8)
Dissolved Oxygen (mg L^{-1}) Bottom	6.1 (2.9 - 10.2)	5.7 (2.6 - 10.0)	5.5 (2.3 - 8.8)	6.3 (3.3 - 11.8)
Dissolved Oxygen (% sat.) Depth-averaged	82.2 (8.8 - 144.9)	81.2 (37.7 - 136.0)	80.4 (32.7 - 130.0)	87.2 (47.1 - 170.2)
Dissolved Oxygen (% sat.) Bottom	82.5 (40.1 - 144.9)	79.1 (37.7 - 122.1)	76.1 (32.7 - 110.3)	86.5 (47.1 - 167.4)
5-day Biochemical Oxygen Demand (mg L^{-1})	1.1 (<0.1 - 3.7)	0.9 (<0.1 - 4.9)	0.8 (<0.1 - 4.1)	0.9 (<0.1 - 4.9)
Suspended Solids (mg L^{-1})	14.3 (2.4 - 66.0)	11.1 (1.1 - 62.0)	12.3 (1.6 - 81.0)	9.6 (0.9 - 48.0)
Total Inorganic Nitrogen (mg L^{-1})	1.02 (0.13 - 2.77)	0.67 (0.14 - 2.46)	0.56 (0.03 - 2.30)	0.51 (0.01 - 1.74)
Unionised Ammonia (mg L^{-1})	0.012 (0.000 - 0.050)	0.007 (0.000 - 0.028)	0.006 (0.000 - 0.027)	0.005 (0.000 - 0.027)
Chlorophyll-a (microgram L^{-1})	3.2	2.3	2.5	3.4

Water Quality Parameter	Deep Bay WCZ		North Western WCZ	
	DM4	DM5	NM5	NM6
	(<0.2 - 63.0)	(<0.2 - 49.0)	(<0.2 - 28.0)	(<0.2 - 44.0)
Escherichia coli (cfu 100mL^{-1})	222 (2 - 9,500)	408 (4 - 41,000)	520 (4 - 28,000)	27 (<1 - 4,200)

Notes:

1. Data presented are depth averaged calculated by taking the means of three depths, i.e. surface (S), mid-depth (M) and bottom (B), except as specified.
2. Data presented are annual arithmetic means except for *E. coli*, which are geometric means.
3. Data enclosed in brackets indicate the ranges regardless of the depths.
4. Shaded cells indicate non-compliance with the WQOs.
5. Outliers have been removed.

Table 6.5 Summary of Water Quality in the Sha Chau & Lung Kwu Chau Marine Park (1)

Water Quality Parameter	Sha Chau and Lung Kwu Chau Marine Park			
	N Lung Kwu Chau	N Sha Chau	Pak Chau	SE Sha Chau
	(1999 – 2005)	(1999 – 2000)	(1999 – 2005)	(1999 – 2000)
Temperature (°C)	24.1	24.3	24.1	24.3
Salinity (ppt)	24.7	23.9	25.1	25.1
pH	7.9	8.1	7.9	8.1
Dissolved Oxygen (mg L^{-1})	6.2	5.8	6.2	5.8
Turbidity (NTU)	1.1	1.1	1.2	1.3
Suspended Solids (mg L^{-1})	20.3	9.7	37.2	10.0
BOD_5 (mg L^{-1})	1.1	0.8	1.2	0.7
Ammonia Nitrogen (mg L^{-1})	0.2	0.2	0.2	0.2
Unionized Ammonia (mg L^{-1})	0.050	0.029	0.071	0.030
Nitrite Nitrogen (mg L^{-1})	0.29	0.34	0.29	0.33
Nitrate Nitrogen (mg L^{-1})	1.50	3.77	1.38	3.68
Total Inorganic Nitrogen (mg L^{-1})	1.38	0.54	1.31	0.56
Total Kjeldahl Nitrogen (mg L^{-1})	2.26	3.98	2.37	3.81

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(1) AFCD (2005). Marine Park Water Quality Report. Web site: www.afcd.gov.hk.

Water Quality Parameter	**Sha Chau and Lung Kwu Chau Marine Park**			
	N Lung Kwu Chau	**N Sha Chau**	**Pak Chau**	**SE Sha Chau**
	(1999 – 2005)	**(1999 – 2000)**	**(1999 – 2005)**	**(1999 – 2000)**
Total Nitrogen (mg L^{-1})	5.18	14.82	5.13	16.21
Orthophosphate Phosphorus (mg L^{-1})	0.27	0.06	0.13	0.05
Total Phosphorus (µg L^{-1})	0.74	0.10	0.65	0.09
Silica (mg L^{-1})	1.02	1.16	1.02	1.10
Chlorophyll-a (µg L^{-1})	2.59	2.59	2.09	2.78
Phaeo-pigment (µg L^{-1})	1.90	1.07	1.81	1.09
E. coli (CFU/100 mL)	343	54	201	58
Faecal Coliforms (CFU/100 mL)	1298	117	1070	114

Notes:
Data presented are depth averaged calculated by taking the means of three depths, i.e. surface (S), mid-depth (M) and bottom (B), except as specified.

6.3.4 *Sediment Quality*

EPD Sediment Quality Monitoring

EPD collects sediment quality data as part of the marine water quality monitoring programme. There are four relevant monitoring stations in the vicinity of the proposed Black Point LNG terminal, i.e., Stations NS4 and NS6 in the Northwestern WCZ and Stations DS3 and DS4 in the Deep Bay WCZ. The locations of these stations are shown in *Figure 6.2*.

Data for these stations obtained from the EPD and are presented in *Table 6.6*. The data represent the range of values obtained over the period 1996 to 2005. As with the water quality data, this dataset provides Hong Kong's most comprehensive long term sediment quality monitoring data and provides an indication of temporal and spatial change in marine sediment quality in Hong Kong.

The values for metals, Polycyclic Aromatic Hydrocarbons (PAHs) and Polychlorinated Biphenyls (PCBs) may also be compared to the relevant sediment quality criteria specified in *Environment Transport & Works Bureau Technical Circular No 34/2002 Management of Dredged/Excavated Sediment (ETWBTC 34/2002)*.

A comparison of the data with the sediment quality criteria (i.e., Lower Chemical Exceedance Level (LCEL) and Upper Chemical Exceedance Level (UCEL)) shows that the levels of arsenic (expressed as the arithmetic mean) for Stations DS3 and DS4 have exceeded the LCEL and hence they are classified as Category M. Although the maximum values of arsenic recorded at NS4 and NS6 and copper and zinc at DS3 have exceeded the LCELs, their mean values were below the UCELs. Sediment with only one contaminant concentration (arithmetic mean) exceeding the LCEL levels and none exceeding the UCEL would not be expected to present a threat to the marine environment.

Ground Investigation Works

In addition to the background data presented above, a ground investigation and marine sediment sampling survey, which is presented in the *Waste Management* section (*Section 7, Part 3*), was conducted within the proposed dredging areas at Black Point and those areas associated with the proposed utilities. A combination of grab samples and vibrocore samples was taken. Vibrocore samples were taken down to the proposed dredging depth. The contaminants tested include all the contaminants stated in *Table 1 - Analytical Methodology* in *Appendix B* of *ETWBTC No 34/2002*, plus PCBs and 12 Chlorinated Pesticides.

Tier III biological screening was also performed on samples with one or more contaminant levels exceeding the LCEL (1). The ecotoxicological-testing programme featured a suite of tests that include three phylogenetically distinct species (amphipod, polychaete and bivalve larvae) which interact with bedded sediments in different ways. The objective of the bioassays was to determine if there are any potential risks of toxicological impacts from the sediment to the marine biota, and whether there is any difference in the toxicity of the sediment samples taking from the Project site and the reference station (collected from a clean area in Port Shelter, New Territories).

Based on the results, which are presented in detail in the *Waste Management* section (*Section 7*, *Part 3*), a total of 0.66 Mm^3 of sediments would be dredged along the seawall, berthing trench and intake/outfall. Majority of sediments to be dredged (about 0.62 Mm^3) was uncontaminated and hence could be disposed of at a Type 1 open sea disposal site. A small portion of sediments to be dredged (about 0.04 Mm^3) were found to be category M contaminated but passed the biological screening and hence could be disposed at Type 1 open sea dedicated site.

In addition, elutriate tests have also been undertaken. The results of the elutriation test are presented and discussed in *Section 6.6* and *Annex 6D*, *Part 3*.

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(1) LCEL and UCEL are Dredged/Excavated Sediment Quality Criteria for the Classification prescribed under *ETWBTC No 34/2002* and are presented in *Table 7.3.*

Table 6.6 Summary of EPD Sediment Quality Monitoring Data Collected between 1996 and 2005

Parameter	Deep Bay WCZ		North Western WCZ		Sediment Quality Criteria	
	DS3	**DS4**	**NS4**	**NS6**	**LCEL**	**UCEL**
COD (mg kg^{-1})	14,885	14,540	13,635	13,300	-	-
	(7,700 - 18,000)	(8,800 - 20,000)	(6,700 - 19,000)	(7,400 - 20,000)		
Total Carbon (% w/w)	0.5	0.6	0.6	0.5	-	-
	(0.4 - 0.8)	(0.3 - 1.3)	(0.3 - 0.8)	(0.4 - 0.8)		
Ammonia Nitrogen (mg kg^{-1})	4.9	6.3	14.2	4.3	-	-
	(0.2 - 20.0)	(<0.05 - 36.0)	(0.2 - 39.0)	(0.1 - 16.0)		
TKN (mg kg^{-1})	316	285	275	269	-	-
	(150 - 470)	(110 - 820)	(160 - 530)	(140 - 480)		
Total Phosphorous (mg kg^{-1})	208	165	145	150	-	-
	(100 - 320)	(77 - 270)	(92 - 220)	(73 - 260)		
Total Sulphide (mg kg^{-1})	44	15	23	6	-	-
	(2 - 160)	(<0.2 - 76)	(<0.2 - 77)	(<0.2 - 38)		
Arsenic (mg kg^{-1})	16	14	12	11	12	42
	(8 - 20)	(8 - 19)	(9 - 18)	(6 - 22)		
Cadmium (mg kg^{-1})	0.2	0.1	0.1	0.1	1.5	4
	(<0.1 - 0.4)	(<0.1 - 0.2)	(<0.1 - 0.2)	(<0.1 - 0.2)		
Chromium (mg kg^{-1})	43	32	28	28	80	160
	(23 - 53)	(14 - 50)	(20 - 44)	(15 - 45)		
Copper (mg kg^{-1})	48	26	23	17	65	110
	(12 - 77)	(6 - 64)	(17 - 42)	(7 - 34)		
Lead (mg kg^{-1})	54	40	39	30	75	110
	(30 - 69)	(18 - 68)	(29 - 47)	(17 - 49)		

Parameter	Deep Bay WCZ		North Western WCZ		Sediment Quality Criteria	
	DS3	**DS4**	**NS4**	**NS6**	**LCEL**	**UCEL**
Mercury (mg kg^{-1})	0.12	0.07	0.08	0.06	0.5	1
	(<0.05 - 0.18)	(<0.05 - 0.15)	(<0.05 - 0.23)	(<0.05 - 0.15)		
Nickel (mg kg^{-1})	28	19	18	18	40	40
	(14 - 37)	(7 - 31)	(13 - 30)	(9 - 28)		
Silver (mg kg^{-1})	0.5	0.4	0.4	0.4	1	2
	(<0.2 - 0.8)	(<0.2 - 0.5)	(<0.2 - 0.5)	(<0.2 - 0.5)		
Zinc (mg kg^{-1})	145	96	96	74	200	270
	(69 - 230)	(36 - 180)	(67 - 110)	(34 - 120)		
Total PCBs (µg kg^{-1})	18	18	18	18	23	180
	(18 - 18)	(18 - 18)	(18 - 18)	(18 - 18)		
Low Molecular Wt PAHs (µg kg^{-1})	92	91	92	90	550	3,160
	(90 - 96)	(90 - 94)	(90 - 99)	(90 - 94)		
High Molecular Wt PAHs (µg kg^{-1})	83	60	59	29	1,700	9,600
	(29 - 151)	(16 - 254)	(21 - 139)	(16 - 84)		

Notes:

1. Data presented are arithmetic mean and data presented in bracket indicate the minimum and maximum data range of each parameter.
2. Low Molecular Wt PAHs include acenaphthene, acenaphthylene, anthracene, fluoreneand phenanthrene.
3. High Molecular Wt PAHs include benzo[a]anthracene, benzo[a]pyrene, chrysene, dibenzo[a,h]anthracene, fluoranthene, pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, indeno[1,2,3- c,d]pyrene and benzo[g,h,I]perylene.
4. LCEL = Lower Chemical Exceedance Level
5. UCEL = Upper Chemical Exceedance Level
6. Shaded cells indicate exceedance of LCEL

6.3.5 *Water Quality Sensitive Receivers*

The construction and operation phases of the proposed LNG terminal have the potential to affect local water quality. The Sensitive Receivers (SRs) that may be affected by changes in water quality are identified in accordance with the *EIAO-TM*. For each of the sensitive receivers, established threshold criteria or guidelines have been utilised for establishing the significance of impacts to water quality.

The surrounding environment in the vicinity of the proposed LNG terminal at Black Point is shown in *Figure 6.3*. The locations of the potential water quality sensitive receivers are provided in *Figure 6.4*. The shortest distances from the identified water quality sensitive receivers to the proposed LNG terminal are detailed in *Table 6.7*. The SS and DO assessment criteria for the sensitive receivers are presented in *Tables 6.8* and *6.9*, respectively.

A summary of each of the sensitive receivers is presented and the evaluation criteria are also described.

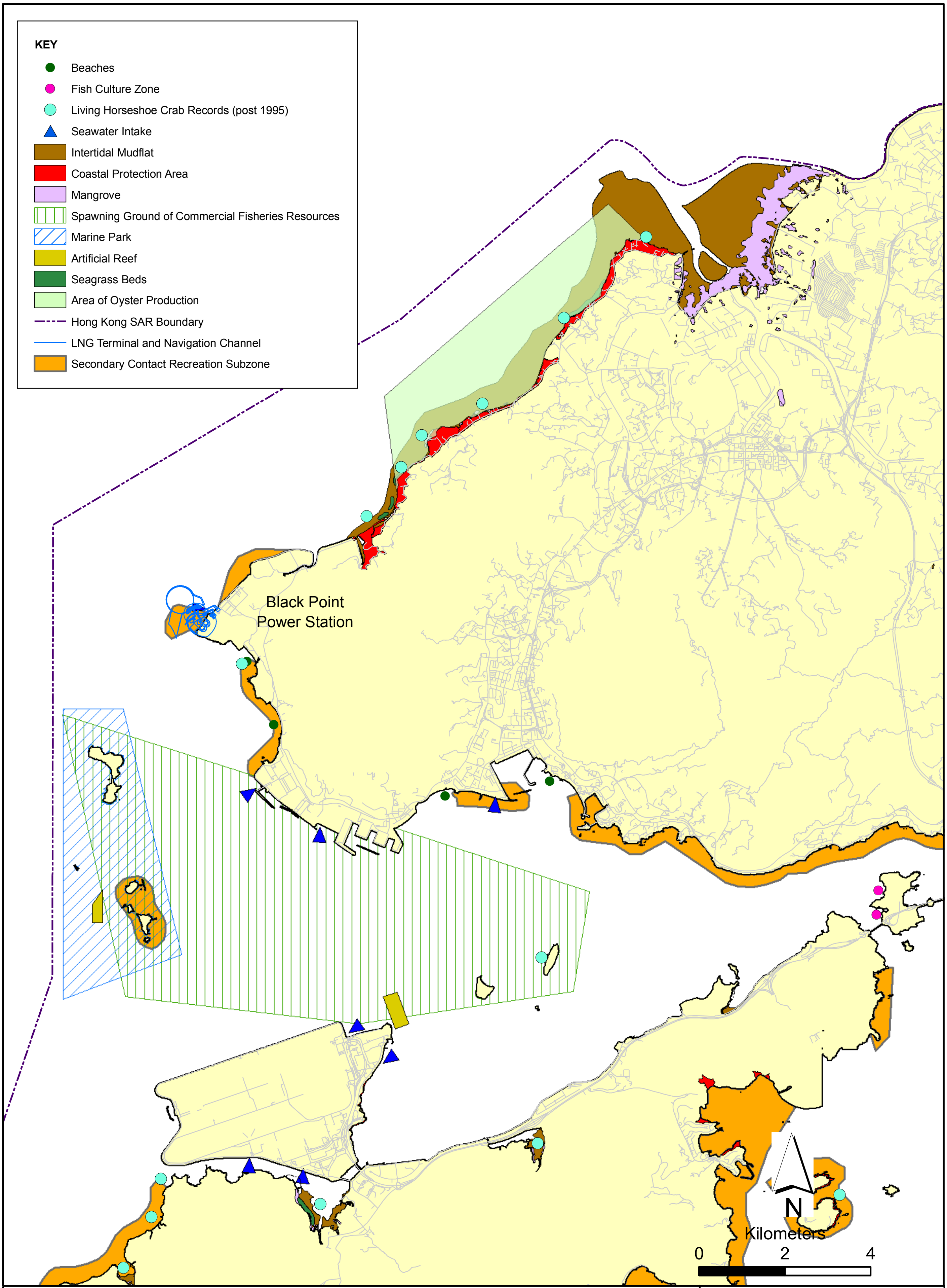

FIGURE 6.3

Surrounding Environment in the Vicinity of the Proposed LNG Terminal at Black Point

File: EIA/0018180_Wtr_Sen_Recvr_BP.mxd
Date: 04/102006

Environmental Resources Management

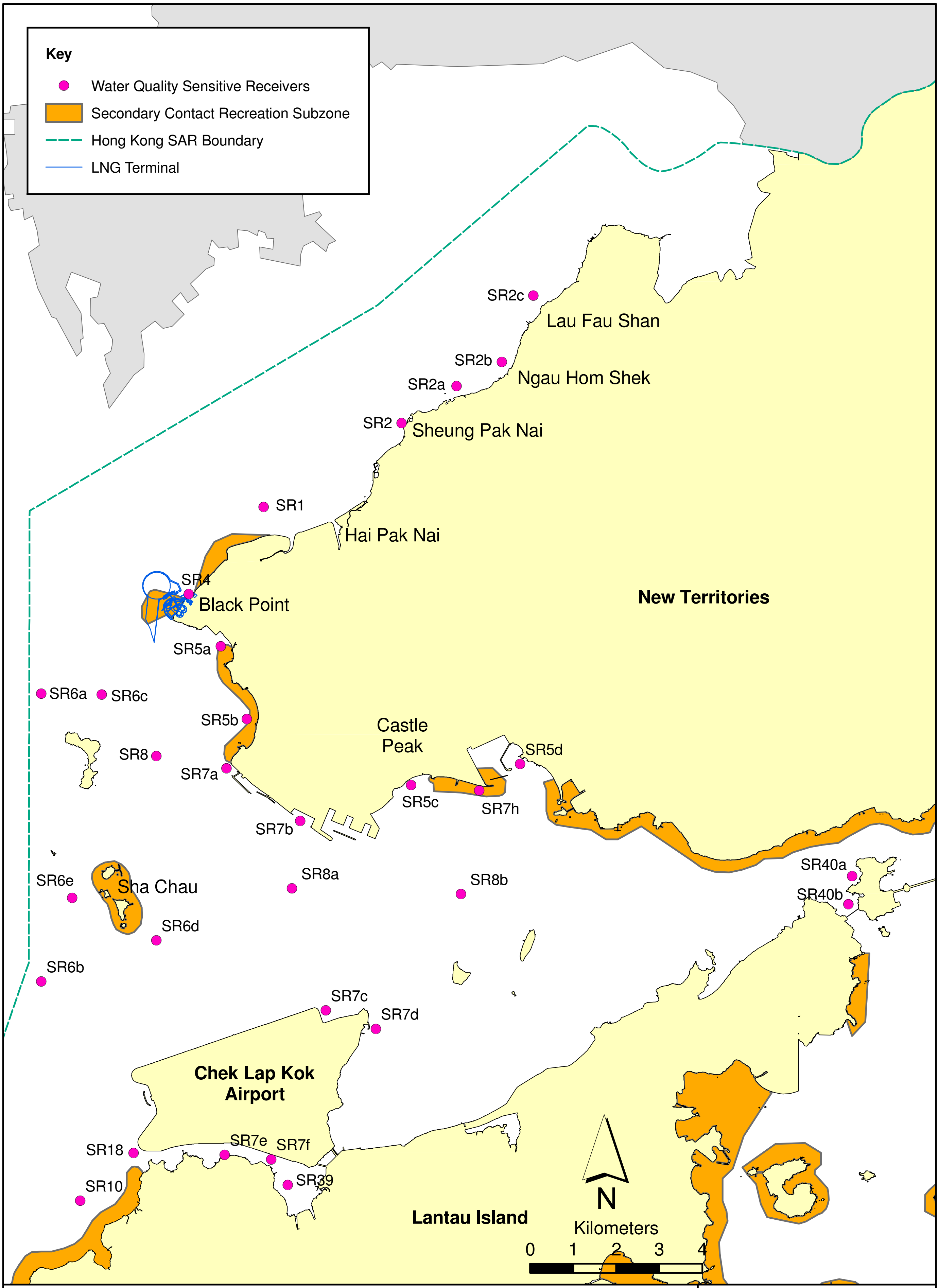

FIGURE 6.4

Water Quality Sensitive Receivers
in the Vicinity of the
Proposed LNG Terminal at Black Point

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Date: 07/09/2006

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Table 6.7 Shortest Distance to Water Quality Sensitive Receivers (SRs) around Proposed LNG Terminal at Black Point

Sensitive Receiver	**Name**	**ID**	**Shortest Distance to the LNG terminal**	**Assessment Criteria**
Fisheries and Marine Ecological Sensitive Receivers				
Fisheries Resources				
Spawning/ Nursery Grounds	Fisheries Spawning Ground in North Lantau	SR8	2.6 km	• Water Quality Objectives (WQO)
		SR8a	6.3 km	• Water Quality Objectives (WQO)
		SR8b	8.9 km	• Water Quality Objectives (WQO)
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR6e	6 km	• Water Quality Objectives (WQO) • Deposition Rate below 200 mg L^{-1}
	Airport	SR7d	>10 km	• Water Quality Objectives (WQO) • Deposition Rate below 200 mg L^{-1}
Fish Culture Zone	Ma Wan	SR40a-b	>10 km	• Water Quality Objectives (WQO)
Oyster Bed	Lau Fau Shan	SR2c	9.9 km	• Water Quality Objectives (WQO)
Marine Ecological Resources				
Seagrass Beds	Pak Nai	SR2	6.25 km	• Water Quality Objectives (WQO)
	Ngau Hom Shek	SR2a	7.5 km	• Water Quality Objectives (WQO)
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR6a	2.75 km	• Water Quality Objectives (WQO)
		SR6b	8.1 km	• Water Quality Objectives (WQO)
		SR6c	1.6 km	• Water Quality Objectives (WQO)
		SR6d	6.75 km	• Water Quality Objectives (WQO)
Intertidal Mudflats	Pak Nai	SR1	2.6 km	• Water Quality Objectives (WQO)

Sensitive Receiver	**Name**	**ID**	**Shortest Distance to the LNG terminal**	**Assessment Criteria**
Mangroves	Pak Nai	SR2	6.25 km	- Water Quality Objectives (WQO)
	Ngau Hom Shek	SR2b	8.3 km	- Water Quality Objectives (WQO)
Horseshoe Crab Nursery Grounds	Pak Nai	SR1	2.6 km	- Water Quality Objectives (WQO)
	Between Ngau Hom Shek and Pak Nai	SR2a	7.5 km	- Water Quality Objectives (WQO)
	Sham Wat Wan	SR10	> 10 km	- Water Quality Objectives (WQO)
	Sha Lo Wan	SR18	> 10 km	- Water Quality Objectives (WQO)
	Tung Chung Bay	SR39	> 10 km	- Water Quality Objectives (WQO)
Water Quality Sensitive Receivers				
Gazetted Beaches	Butterfly Beach	SR5c	6.6 km	- Water Quality Objectives (WQO)
	Tuen Mun Beaches	SR5d	9.4 km	- Water Quality Objectives (WQO)
Non-gazetted Beaches	Lung Kwu Sheung Tan	SR5a	1.5 km	- Water Quality Objectives (WQO)
	Lung Kwu Tan	SR5b	2.7 km	- Water Quality Objectives (WQO)
Secondary Recreation Subzone	Deep Bay WCZ	SR4	Immediate vicinity	- Water Quality Objectives (WQO)
	NW WCZ	SR5b	2.7 km	- Water Quality Objectives (WQO)
		SR5c/SR7h	>10 km	- Water Quality Objectives (WQO)
Seawater Intakes	Black Point Power Station	SR4	Immediate vicinity	- Water Quality Objectives (WQO) - Temperature between 17-32 °C - SS elevations less than 700 mg L^{-1}
	Castle Peak Power Station	SR7a	3.25 km	- Water Quality Objectives (WQO) - Temperature between 17-32 °C - SS elevations less than 700 mg L^{-1}
	Tuen Mun Area 38	SR7b	5.2 km	- Water Quality Objectives (WQO)

Sensitive Receiver	Name	ID	Shortest Distance to the LNG terminal	Assessment Criteria
	Airport	SR7c	> 10 km	• Water Quality Objectives (WQO)
		SR7d	> 10 km	
		SR7e	> 10 km	
		SR7f	> 10 km	
	Tuen Mun WSD	SR7h	> 10 km	• WSD Water Quality Criteria

Notes:

1. Distances are approximate and will depend on the final design of the alignment of the submarine utilities which will be determined during the detailed design stage.
2. Refer to next two tables for the details of the WQO criteria for SS and DO at each station.

Table 6.8 Ambient Level and Allowable Increase in SS at Sensitive Receivers (SRs) around Proposed LNG Terminal at Black Point

Sensitive Receiver	**Name**	**ID**	**Respective EPD Monitoring Station**	**Relevant Depth**	**Suspended Solids (mg L^{-1})**					
					Annual		**Dry (Nov to Mar)**		**Wet (Apr to Oct)**	
					Ambient Level	**WQO Allowable Increase**	**Ambient Level**	**WQO Allowable Increase**	**Ambient Level**	**WQO Allowable Increase**
Fisheries and Marine Ecological Sensitive Receivers										
Fisheries Resources										
Spawning/ Nursery Grounds	Fisheries Spawning Ground in North Lantau	SR8	NM5	Depth-averaged	23.2	7.0	27.2	8.2	18.6	5.6
		SR8a	NM5	Depth-averaged	23.2	7.0	27.2	8.2	18.6	5.6
		SR8b	NM5	Depth-averaged	23.2	7.0	27.2	8.2	18.6	5.6
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR6e	NM5	Depth-averaged	23.2	7.0	27.2	8.2	18.6	5.6
	Airport	SR7d	NM3	Depth-averaged	17	5.1	15.6	4.7	17.4	5.2
Fish Culture Zone	Ma Wan	SR40a-b	NM3	Depth-averaged	17	5.1	15.6	4.7	17.4	5.2
Oyster Production	Lau Fau Shan	SR2c	DM4	Surface[5]	21.7	6.5	23.6	7.1	12	3.6
Marine Ecological Resources										
Seagrass Beds	Pak Nai	SR2	DM4	Surface[4]	21.7	6.5	23.6	7.1	12	3.6
	Ngau Hom Shek	SR2a	DM4	Surface[4]	21.7	6.5	23.6	7.1	12	3.6
	Tung Chung Bay	SR39	NM8	Surface[4]	17.5	5.3	21.5	6.5	12	3.6

Sensitive Receiver	Name	ID	Respective EPD Monitoring Station	Relevant Depth	Suspended Solids (mg L^{-1})					
					Annual		Dry (Nov to Mar)		Wet (Apr to Oct)	
					Ambient Level	WQO Allowable Increase	Ambient Level	WQO Allowable Increase	Ambient Level	WQO Allowable Increase
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR6a-d	NM5	Depth-averaged	23.2	7.0	27.2	8.2	18.6	5.6
Intertidal Mudflats	Pak Nai	SR1	DM4	Surface [4]	21.7	6.5	23.6	7.1	12	3.6
Mangroves	Pak Nai	SR2	DM4	Surface [4]	21.7	6.5	23.6	7.1	12	3.6
	Ngau Hom Shek	SR2b	DM4	Surface [4]	21.7	6.5	23.6	7.1	12	3.6
	Tung Chung Bay	SR39	NM8	Surface [4]	17.5	5.3	21.5	6.5	12	3.6
Horseshoe Crab Nursery Grounds	Pak Nai	SR1	DM4	Depth-averaged	32.4	9.7	32.2	9.7	19.9	6.0
	Ngau Hom Shek	SR2a	DM4	Depth-averaged	32.4	9.7	32.2	9.7	19.9	6.0
	Sham Wat Wan	SR10	NM8	Depth-averaged	28.3	8.5	29.7	8.9	21.7	6.5
	Sha Lo Wan	SR18	NM6	Depth-averaged	20.8	6.2	25.9	7.8	16.0	4.8
	Tung Chung Bay	SR39	NM8	Depth-averaged	28.3	8.5	29.7	8.9	21.7	6.5
Water Quality Sensitive Receivers										
Gazetted Beaches	Butterfly Beach	SR5c	NM5	Depth-averaged	23.2	7.0	27.2	8.2	18.6	5.6
	Tuen Mun Beaches	SR5d	NM3	Depth-averaged	17	5.1	15.6	4.7	17.4	5.2
Non-gazetted Beaches	Lung Kwu Sheung Tan	SR5a	NM5	Depth-averaged	23.2	7.0	27.2	8.2	18.6	5.6

Sensitive Receiver	Name	ID	Respective EPD Monitoring Station	Relevant Depth	Suspended Solids (mg L^{-1})					
					Annual		Dry (Nov to Mar)		Wet (Apr to Oct)	
					Ambient Level	WQO Allowable Increase	Ambient Level	WQO Allowable Increase	Ambient Level	WQO Allowable Increase
	Lung Kwu Tan	SR5b	NM5	Depth-averaged	23.2	7.0	27.2	8.2	18.6	5.6
Secondary Contact Recreation Subzone	Deep Bay WCZ	SR4	DM5	Depth-averaged	22.6	6.8	32.0	9.6	20.2	6.1
	NW WCZ	SR5b	NM5	Depth-averaged	23.2	7.0	27.2	8.2	18.6	5.6
Seawater Intakes	Tuen Mun Area 38	SR7b	NM3	Bottom	51.0	15.3	47.4	14.2	32.8	9.8
	Airport	SR7c-f	NM6	Bottom	25.5	7.7	29.6	8.9	29.4	8.8
	Tuen Mun WSD	SR7h	NM3	Bottom	51.0	15.3	47.4	14.2	32.8	9.8

Notes:

1. The tolerance criterion of 700 mg L^{-1} was adopted for the seawater intakes at Black Point Power Station and Castle Peak Power Station.
2. Ambient level is calculated as 90th percentile of the EPD routine monitoring data (1996-2006) at respective EPD station close to the WSRs.
3. Allowable increase is calculated as 30% of the ambient SS levels in accordance with the WQO.
4. These intertidal sensitive receivers occur at the water surface and are in fact completely unsubmerged for a substantial proportion of the time. Tidal range in Hong Kong is 2.5 m and this is the maximum depth these sensitive receivers would be submerged during the tidal cycle. It is considered that water quality reflecting surface conditions is appropriate for these periodically submerged sensitive receivers.

Table 6.9 Ambient Level and Allowable Increase in DO at Sensitive Receivers (SRs) around Proposed LNG Terminal at Black Point

Sensitive Receiver	**Name**	**ID**	**Respective EPD Monitoring Station**	**Relevant Depth**	**Dissolved Oxygen (mg L^{-1})**					
					Annual		**Dry (Nov to Mar)**		**Wet (Apr to Oct)**	
					Ambient Level	**Allowable Change**	**Ambient Level**	**Allowable Change**	**Ambient Level**	**Allowable Change**
Fisheries and Marine Ecological Sensitive Receivers										
Fisheries Resources										
Spawning/Nursery Grounds	Fisheries Spawning Ground in North Lantau	SR8	NM5	Depth-averaged	8	-4	7.9	-3.9	6.8	-2.8
		SR8a	NM5	Depth-averaged	8	-4	7.9	-3.9	6.8	-2.8
		SR8a	NM5	Depth-averaged	8	-4	7.9	-3.9	6.8	-2.8
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR6e	NM5	Depth-averaged	8	-4	7.9	-3.9	6.8	-2.8
	Northeast Airport	SR7d	NM3	Depth-averaged	5.8	-1.8	6.6	-2.6	5.2	-1.2
Fish Culture Zone	Ma Wan	SR40a-b	NM3	Depth-averaged	5.8	-0.8	6.6	-1.6	5.2	-0.2
Oyster Production Farm	Pak Nai	SR2c	DM4	Surface [5]	7.6	-3.6	7.6	-3.6	7.3	-3.3
Marine Ecological Resources										
Seagrass Beds	Pak Nai	SR2	DM4	Surface [5]	7.6	-3.6	7.6	-3.6	7.3	-3.3
	Ngau Hom Shek	SR2a	DM4	Surface [5]	7.6	-3.6	7.6	-3.6	7.3	-3.3
	Tung Chung Bay	SR39	NM8	Surface [5]	7.9	-3.9	8	-4	7.9	-3.9

Sensitive Receiver	**Name**	**ID**	**Respective EPD Monitoring Station**	**Relevant Depth**	**Dissolved Oxygen (mg L^{-1})**					
					Annual		**Dry (Nov to Mar)**		**Wet (Apr to Oct)**	
					Ambient Level	**Allowable Change**	**Ambient Level**	**Allowable Change**	**Ambient Level**	**Allowable Change**
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR6a-d	NM5	Depth-averaged	8	-4	7.9	-3.9	6.8	-2.8
Intertidal Mudflats	Pak Nai	SR1	DM4	Surface [5]	7.6	-3.6	7.6	-3.6	7.3	-3.3
Mangroves	Pak Nai	SR2	DM4	Surface [5]	7.6	-3.6	7.6	-3.6	7.3	-3.3
	Ngau Hom Shek	SR2b	DM4	Surface [5]	7.6	-3.6	7.6	-3.6	7.3	-3.3
Horseshoe Crab Nursery Grounds	Pak Nai	SR1	DM4	Depth-averaged	7.5	-3.5	7.6	-3.6	7.3	-3.3
	Ngau Hom Shek	SR2a	DM4	Depth-averaged	7.5	-3.5	7.6	-3.6	7.3	-3.3
	Sham Wat Wan	SR10	NM8	Depth-averaged	7.9	-3.9	8	-4	7.9	-3.9
	Sha Lo Wan	SR18	NM6	Depth-averaged	8.1	-4.1	8.1	-4.1	8	-4
	Tung Chung Bay	SR39	NM8	Depth-averaged	7.9	-3.9	8	-4	7.9	-3.9
Water Quality Sensitive Receivers										
Gazetted Beaches	Butterfly Beach	SR5c	NM5	Depth-averaged	8	-4	7.9	-3.9	6.8	-2.8
	Tuen Mun Beaches	SR5d	NM3	Depth-averaged	5.8	-1.8	6.6	-2.6	5.2	-1.2
Non-gazetted Beaches	Lung Kwu Sheung Tan	SR5a	NM5	Depth-averaged	8	-4	7.9	-3.9	6.8	-2.8
	Lung Kwu Tan	SR5b	NM5	Depth-averaged	8	-4	7.9	-3.9	6.8	-2.8

Sensitive Receiver	**Name**	**ID**	**Respective EPD Monitoring Station**	**Relevant Depth**	**Dissolved Oxygen (mg L-1)**					
					Annual		**Dry (Nov to Mar)**		**Wet (Apr to Oct)**	
					Ambient Level	**Allowable Change**	**Ambient Level**	**Allowable Change**	**Ambient Level**	**Allowable Change**
Secondary Contact Recreation Subzone	Deep Bay WCZ	SR4	DM5	Depth-averaged	7.4	-3.4	7.7	-3.7	6.6	-2.6
	NW WCZ	SR5b	NM5	Depth-averaged	8	-4	7.9	-3.9	6.8	-2.8
Seawater Intakes	Tuen Mun Area 38	SR7b	NM5	Bottom	8	-6	7.6	-5.6	6.2	-4.2
	Airport	SR7c-f	NM6	Bottom	8.2	-6.2	8.3	-6.3	7.6	-5.6
	Tuen Mun WSD [7]	SR7h	NM3	Bottom	6.1	-4.1	6.5	-4.5	5.8	-3.8

Notes:

1. Ambient level is calculated as 90th percentile of the EPD routine monitoring data (1996-2006) at respective EPD station close to the WSRs.
2. For depth-averaged, surface layer and middle layer, allowable change is calculated as WQO criterion of 4 mg L^{-1} minus the ambient level, with the exception for the Fish Culture Zone.
3. For Fish Culture Zone, the WQO criterion of not less than 5 mg L^{-1} was adopted.
4. For bottom layer, allowable change is calculated as WQO criterion of 2 mg L^{-1} minus the ambient level.
5. These intertidal sensitive receivers occur at the water surface and are in fact completely unsubmerged for a substantial proportion of the time. Tidal range in Hong Kong is 2.5 m and this is the maximum depth these sensitive receivers would be submerged during the tidal cycle. It is considered that water quality reflecting surface conditions is appropriate for these periodically submerged sensitive receivers.
6. There is no DO criterion for Black Point Power Station, Castle Peak Power Station intakes.
7. Tuen Mun WSD intake has a DO criterion of more than 2 mg L^{-1}.

Fisheries Resources

The following fisheries resources have been identified as water quality sensitive receivers:

- Commercial Fisheries Spawning Grounds/Nursery Areas;
- Artificial Reef Deployment Sites; and,
- Fish Culture Zones.

Brief descriptions of these sensitive receivers are presented below.

Commercial Fisheries Spawning Grounds/Nursery Areas

The waters of Northwest Lantau have been identified as important fisheries spawning/nursery grounds for commercial fisheries in Hong Kong (1).

To date there are no legislated water quality standards for spawning and nursery grounds in Hong Kong. Guideline values have been identified for fisheries and selected marine ecological sensitive receivers as part of the AFCD study (2), *Consultancy Study on Fisheries and Marine Ecological Criteria for Impact Assessment*. The AFCD study recommends a maximum SS concentration of 50 mg L^{-1} (based on half of the No Observable Effect Concentration). Although a maximum concentration is recommended, the study acknowledges that site-specific data should be considered on a case-by-case basis.

With regard to the water quality modelling, impacts to these and other transitory or mobile sensitive receivers were not plotted as discrete points, rather, an assessment of potential impacts was undertaken through a review of the modelling results and is discussed separately in the *Fisheries Impact Assessment* (*Section 10, Part 3*).

Artificial Reef Deployment Sites

There are two gazetted Artificial Reef Deployment Sites (ARs):

- the Sha Chau and Lung Kwu Chau AR site (situated within the Sha Chau and Lung Kwu Chau Marine Park);
- the Airport AR site (located at the northeast of the Hong Kong International Airport) (*Figure 6.3*).

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(1) ERM-Hong Kong, Ltd (1998). Fisheries Resources and Fishing Operations in Hong Kong Waters. Final Report. For the Agriculture, Fisheries and Conservation Department, Hong Kong SAR Government.

(2) City University of Hong Kong (2001) Agreement No. CE 62/98, Consultancy Study on Fisheries and Marine Ecological Criteria for Impact Assessment, Final Report, for the Agriculture, Fisheries and Conservation Department, Hong Kong SAR Government.

The Sha Chau and Lung Kwu Chau AR site and the Airport AR site are approximately 6 km and over 10 km from proposed terminal, respectively. The ARs have been deployed to act as a fisheries resource enhancement tool, to encourage growth and development of a variety of marine organisms, and to provide feeding opportunities for the Indo-Pacific Humpback Dolphin (see *Section 9, Part 3: Marine Ecological Impact Assessment*).

There is no specific water quality criterion for the AR sites, thus the WQOs criteria have been adopted. AR sites will be treated as discrete assessment points in the model.

Fish Culture Zones

There is one fish culture zone (FCZ) in the North Western waters, the Ma Wan North and East. This FCZ is over 10 km from the proposed terminal. The only Water Quality Objective (WQO) that is specific to FCZs is for dissolved oxygen, which is set at no less than 5 mg L^{-1}. In addition to dissolved oxygen, there is a general water quality protection guideline for suspended solids (SS), which has been proposed by AFCD (1). The guideline requires the SS levels remain below 50 mg L^{-1}. This maximum concentration value has been used in an endorsed EIA Report (2) under the *EIAO* and has, therefore, been taken as the assessment criterion.

In the water quality modelling works, the FCZ was included as two discrete points for evaluation in the assessment against the above criteria and guideline.

Oyster Production Area

There is an area of oyster production along the coast of Deep Bay in Hong Kong waters. The shallowness of Deep Bay as a result of silt carried down from the Pearl River and typical estuarine conditions within Deep Bay enhances oyster cultivation.

There is no specific water quality criterion for the oyster production area, thus the WQOs have been adopted.

The area nearest to the works site was included as a point in the model. If no non-compliances are found at the point, it was assumed that there will be no impacts to the area beyond it.

Marine Ecological Resources

The following *Marine Ecological Resources* have been identified as water quality sensitive receivers.

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(1) City University of Hong Kong (2001) Op Cit.

(2) ERM – Hong Kong, Ltd (2002) EIA for the Proposed Submarine Gas Pipeline from Cheng Tou Jiao Liquefied Natural Gas Receiving Terminal, Shenzhen to Tai Po Gas Production Plank, Hong Kong. Final EIA Report. For the Hong Kong and China Gas Co., Ltd.

- Marine Park; and
- Seagrass Beds, Mangroves, Intertidal Mudflats and Horseshoe Crabs;

Marine Park

The Sha Chau and Lung Kwu Chau Marine Park, designated specifically for the protection of the Indo-Pacific Humpback Dolphin (*Sousa chinensis*), lies within the study area (*Figure 6.3*). There are no specific legislative water quality criteria for Marine Parks and the water quality at this sensitive receiver is typically compared with the WQO. For the water quality assessment, discrete points have been plotted at a number of locations along the boundaries of the Marine Park.

Seagrass Beds, Mangroves, Intertidal Mudlfats & Horseshoe Crabs

Seagrass beds, mangroves and areas where horseshoe crabs are known to breed are identified (*Figure 6.3*). There are no specific legislative water quality criteria for these habitats and hence water quality impacts are assessed against compliance with the WQO. These habitats have been plotted as discrete points for evaluation.

Other Water Quality Sensitive Receivers

The following additional water quality sensitive receivers have been identified and included in the assessment.

- Bathing Beaches;
- Seawater Intakes.

Bathing Beaches

There are several gazetted beaches identified and a number of non-gazetted bathing beaches (*Figure 6.3*). Gazetted beaches include the beaches at Tuen Mun. Non-gazetted beaches are located at Lung Kwu Sheung Tan and Lung Kwu Tan. The closest non-gazetted beach to the proposed terminal is Lung Kwu Sheung Tan, at a distance of approximately 1.5 km. The closest gazetted bathing beach is Butterfly Beach at a distance of approximately 6.6 km from the proposed terminal. Bathing beaches have been plotted as discrete points for evaluation in the water quality assessment.

Water quality impacts at gazetted and non-gazetted bathing beaches have been determined based on the compliance with the WQOs (*Table 6.8*).

Seawater Intakes

There are eight seawater intakes identified as potential sensitive receivers, namely those at Black Point Power Station, Castle Peak Power Station, Tuen Mun Area 38, the Airport and Tuen Mun WSD.

Both power station intakes have specific requirements for intake water quality. The applicable criteria for temperature and SS for the Black Point Power Station and Castle Peak Power Station seawater intakes are between 17 and 32°C and between 30 and 764 mg L^{-1}, respectively. These values have, therefore, been taken as the assessment criteria. There are no particular criteria specified for the Tuen Mun Area 38 and the Airport intakes and hence WQOs have been adopted (*Table 6.8*). For theTuen Mun WSD, there WSD intake specific water quality criteria have been applied (*Table 6.2*).

The intakes have been plotted as discrete points for evaluation in the water quality assessment.

6.4 POTENTIAL SOURCES OF IMPACT

Potential sources of impacts to water quality as a result of the project may occur during both the construction and operation phases. Each is discussed in turn below.

6.4.1 Construction Phase

The major construction activities associated with the proposed project that may cause impacts to water quality involve the following:

- Dredging and filling for reclamation and seawall formation for the LNG terminal at Black Point;
- Dredging for the approach channel, turning basin and jetty box near the terminal for LNG carriers;
- Piling for the jetty near the terminal for LNG carriers;
- Sewage discharges due to the on-site workforce;
- Site runoff and pollutants entering the receiving waters and/or water drainage system;
- Hydrotest water discharges; and,
- Oil spills due to accidental events.

6.4.2 Operational Phase

The potential impacts to water quality arising from the operation of the proposed facility have been identified as follows:

- Changes to the hydrodynamic regime through the reclamation of the terminal site;
- Maintenance dredging of the navigation areas for the LNG carrier causing a temporary increase in SS concentrations in the water column;

- Discharge of cooled water from the regasification process resulting in a decrease in temperature and the input of antifoulants into the surrounding waters;
- Surface run-off from the terminal site;
- Sewage discharges due to the operational workforce;
- Vessel discharges;
- LNG Spillage due to accidental events; and,
- Oil Spills due to accidental events.

6.5 *WATER QUALITY IMPACT ASSESSMENT METHODOLOGY*

6.5.1 *General Methodology*

The methodology employed to assess the above impacts is presented in the *Water Quality Method Statement* (*Annex 6A, Part 3*) and has been based on the information presented in the *Project Description* (*Section 3, Part 3)*.

Impacts due to the dispersion of fine sediment in suspension during the construction of the proposed LNG terminal and associated facilities have been assessed using computational modelling. Mitigation measures, as proposed in *Section 6.8* such as the use of silt curtain, were assumed to be absent for modelling the worst case scenario.

The simulation of operational impacts on water quality has also been studied by means of computational modelling. The models have been used to simulate the effects of cooled water discharges on temperature and water quality (due to antifoulants).

Full details of the scenarios examined in the modelling works are provided in *Annex 6A*. As discussed previously, the water quality sensitive receivers as well as the water quality modelling output points in the vicinity of the proposed LNG terminal at Black Point are presented in *Figure 6.4*.

6.5.2 *Uncertainties in Assessment Methodology*

Uncertainties in the assessment of the impacts from suspended sediment plumes should be considered when drawing conclusions from the assessment. In carrying out the assessment, the worst case assumptions have been made in order to provide a conservative assessment of environmental impacts. These assumptions are as follows:

- The assessment is based on the peak dredging and filling rates. In reality, these will only occur for short period of time; and,
- The calculations of loss rates of sediment to suspension are based on conservative estimates for the types of plant and methods of working.

The conservative assumptions presented above allow a prudent approach to be applied to the water quality assessment.

The following uncertainties have not been included in the modelling assessment.

- *Ad hoc* navigation of marine traffic;
- Near shore scouring of bottom sediment; and
- Access of marine barges back and forth the site.

It is noted that the above present mechanisms through which minor localised and short term elevations in SS levels may occur during construction. Elevations of this type will be picked up and monitored during the water quality monitoring programme for the construction works which is presented in *Section 6.10*.

6.6 CONSTRUCTION PHASE WATER QUALITY IMPACT ASSESSMENT

6.6.1 Suspended Solids

The potential main impacts to water quality arising from this project during the construction phase relate to disturbances to the seabed, re-suspension of some marine sediment, and potential physico-chemical changes in the water column.

Assessment of Concurrent Construction Phase Activities

As discussed in the *Water Quality Method Statement* (*Annex 6A*), during the construction phases, a number of marine activities have the potential to occur simultaneously. In order to assess the cumulative potential impacts to water quality as a result of activities running concurrently, a total of two scenarios have been developed (*Table 6.10*). It should be noted that of these two scenarios, one is simply an alternative to assess the impact of using alternative dredging plant (i.e., trailing suction hopper dredger versus grab dredger).

The selected scenarios represent periods during the construction programme when the maximum number of activities may take place at any given time.

The results of these scenarios have been presented in *Annex 6C*. Data were extracted from the modelling results to determine the predicted levels of suspended sediment at each of the sensitive receivers. The maximum and mean elevations of SS at the relevant depth for the respective sensitive receivers are presented under each scenario. The 90th percentile elevations of SS are also presented as the WQO is measured as the 90th percentile of background conditions.

The determination of the acceptability of any elevation in SS levels has been based on the WQO or specific tolerance criteria. It should be noted that elevations in the SS level due to concurrent operations have been assessed as the maximum concentrations at relevant water depths over a full 15 day spring-neap tidal cycle in both the dry and wet season, as required by the EIA Study Brief (*ESB-126/2005*).

Each scenario shown in *Table 6.10* will be discussed in the subsequent paragraphs. The tentative construction programme and indicative construction sequence are enclosed in *Annex 6A*. *Figure 6.5* shows the dredging areas at seawall and approach channel and basin and *Figure 6.6* shows a cross-section of the sloping seawall.

It should be noted that these scenarios are highly conservative for the following reasons.

- The sandfilling for the reclamation will primarily be carried out behind a partially constructed seawall (an opening at the seawall will be allowed for marine access), which can serve to shelter the works area from tidal currents and hence reduce the transport of fine sediment in suspension away from the works area.

- Nine emission points have been defined with sediment loss occurring simultaneously. It will be, however, unlikely to have dredgers/pelican barge operating at the same time on the site (see *Annex 6A*).

- The grab dredgers at the approach channel and turning basin are defined as stationary points close to the coast, which is considered to conservatively assess the impacts to the inshore ecological sensitive receivers. In reality, the grab dredgers will move farther off shore and will have less impact to the coastal sensitive receivers.

- The sandfilling works for the seawall trench are assumed to be continuous within a whole spring-neap cycle. In fact, the sandfilling works will be completed within a shorter period (about a week).

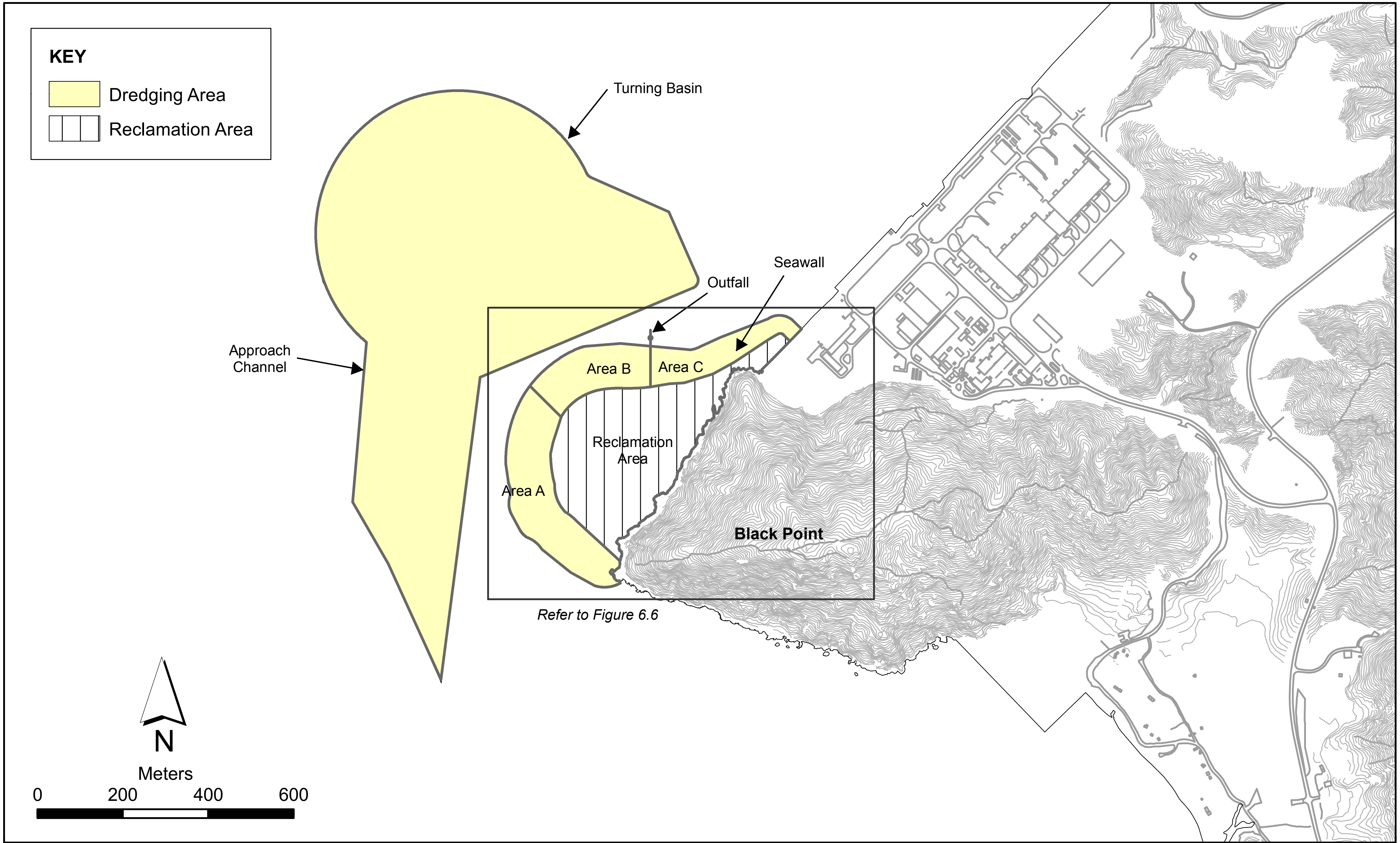

Figure 6.5

Marine Works at Black Point

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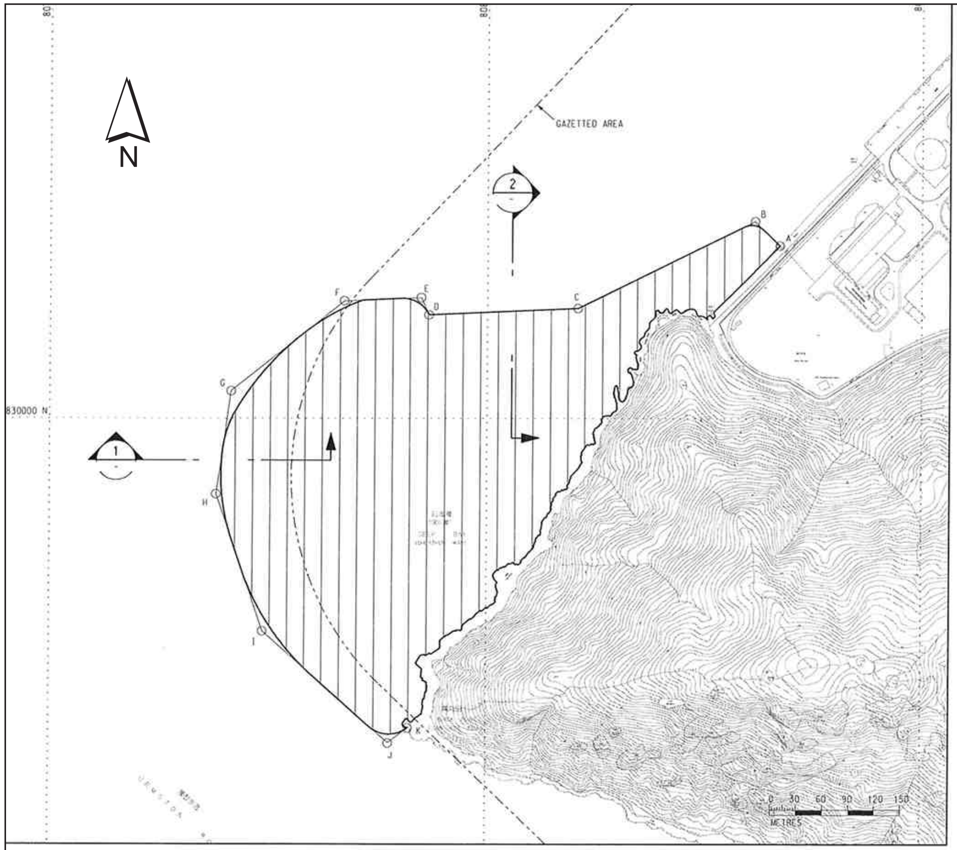
Environmental Resources Management

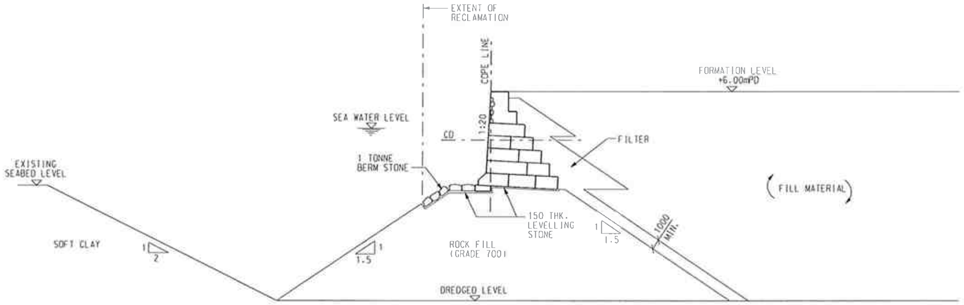
ERM



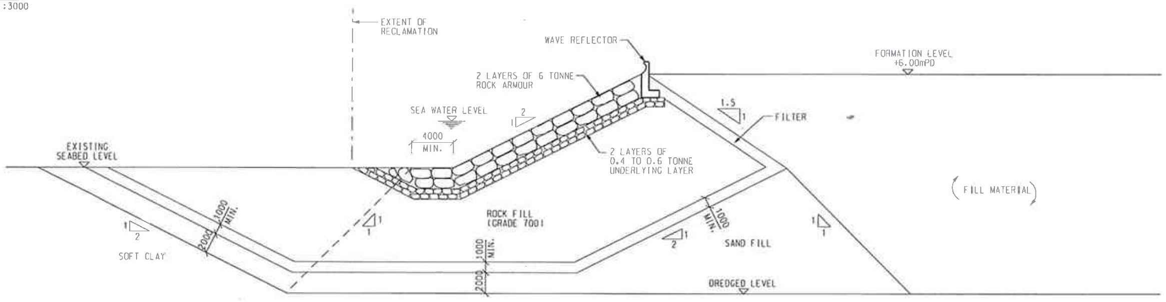
PLAN
SCALE 1:3000

RECLAMATION SETTING-OUT CO-ORDINATES

POINT	EASTING	NORTHING
A	808335.890	830197.757
B	808307.477	830225.611
C	808103.871	830126.087
D	807933.285	830118.629
E	807924.560	830138.267
F	807836.605	830134.422
G	807707.231	830031.304
H	807690.441	829912.893
I	807744.105	829755.665
J	807889.186	829627.242
K	807911.296	829644.379



SECTION 2
SCALE 1 : 250



SECTION 1
SCALE 1 : 250

Figure 6.6

Black Point Reclamation Area and Sections

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Environmental
Resources
Management

ERM

Table 6.10 Construction Phase Scenarios Examined in the Water Quality Impact Assessment

Scenario ID (report)	Tasks	Details of Construction Activities	No. of Plant and Plant Type	Code	
Scenario 1a	Seawall	Dredging underneath seawall (Area A and B)	1 no. Grab Dredger	BP	01
	Seawall	Dredging underneath seawall (Area C)	1 no. Grab Dredger	BP	02
	Seawall	Sand fill for seawall trench (Area A and B)	1 no. Pelican Barge	BP	15
	Reclamation	Sand fill for reclamation area	1 no. Pelican Barge	BP	17
	Jetty Box	Grab Dredging at Jetty Box	1 no. Grab Dredger	BP	07
	Approach Channel and Turning Basin	Grab Dredging at Approach Channel & TB at Area D	1 no. Grab Dredger	BP	08a
	Approach Channel and Turning Basin	Grab Dredging at Approach Channel & TB at Area E	1 no. Grab Dredger	BP	09a
	Approach Channel and Turning Basin	Grab Dredging at Approach Channel & TB at Area F	1 no. Grab Dredger	BP	10a
	Cooled Water Outfall	Grab Dredging under outfall	1 no. Grab Dredger	BP	12
Scenario 1b	Seawall	Dredging underneath seawall (Area A)	1 no. Grab Dredger	BP	01
	Seawall	Dredging underneath seawall (Area C)	1 no. Grab Dredger	BP	02
	Seawall	Sand fill for seawall trench (Area A and B)	1 no. Pelican Barge	BP	15
	Reclamation	Sand fill for reclamation area	1 no. Pelican Barge	BP	17
	Jetty Box	Grab Dredging at Jetty Box	1 no. Grab Dredger	BP	07
	Approach Channel and Turning Basin	TSHD Dredging at Approach Channel & TB at Area D	1 no. TSHD	BP	08b
	Approach Channel and Turning Basin	Grab Dredging at Approach Channel & TB at Area E	1 no. Grab Dredger	BP	09b
	Approach Channel and Turning Basin	Grab Dredging at Approach Channel & TB at Area F	1 no. Grab Dredger	BP	10b
	Approach Channel and Turning Basin	Grab Dredging at Approach Channel & TB at Area G	1 no. Grab Dredger	BP	11
	Cooled Water Outfall	Grab Dredging under outfall	1 no. Grab Dredger	BP	12

Notes:

1. Grab dredger refers to a closed grab dredger with a minimum grab size of 8 m^3.
2. TSHD denotes Trailing Suction Hopper Dredger with hopper capacity of 8,000 m^3.
3. TB denotes Turning Basin.

Scenario 1a

Scenario 1a allows the assessment of impacts through all concurrent activities, including dredging underneath the seawall, at the jetty box, the approach channel and turning basin and the outfall, as well as sandfilling for sloping the seawall trench and reclamation. All dredging works have been modelled assuming the use of closed grab dredgers.

Modelling results indicate that SS elevations will be compliant with the WQO at all sensitive receivers in both seasons, with the exception of SR5a (non-gazetted beach at Lung Kwu Sheung Tan). The exceedance is mainly due to the sandfilling works for reclamation.

Table 6.11 shows that the maximum SS elevation in the dry season will exceed the WQO; however, it is predicted that the mean and 90th percentile SS levels will not exceed the WQO. This indicates that the non-compliance will be transient. This is evidenced in the time-series plots shown in *Annex 6C*.

The contour plots (*Annex 6C)* show a mixing zone radius (SS > 5 mg L^{-1}) of less than 1 km in both the dry and wet seasons. The SS plume will not reach the sensitive receivers which are beyond Ha Pak Nai.

As described above, the assessment is highly conservative. The sandfilling works for the reclamation, in reality, will be conducted behind a constructed seawall. The seawall will be above the high water level and will have an opening of 50 - 100 m for barge access. The opening is less than 10% of the total length of the seawall and hence it is considered it could effectively prevent the sediment from flushing out of the site.

In case the seawall trench is filled by sand, the dispersion of the sediment plume could be restrained by installation of silt curtain around the sandfilling area. SS elevations will thus be reduced substantially from those predicted in this assessment.

It is also expected that deployment of cage type silt curtains enclosing the dredging areas next to the grab dredgers will further reduce the sediment dispersion.

The predicted SS level at SR5a after adoption of silt curtains is shown in *Table 6.15* in *Section 6.8.1*. No unacceptable water quality impacts would be expected to occur for this worst case set of assumptions.

Scenario 1b

Scenario 1b is the same as Scenario 1a except for the approach channel and turning basin for which an alternative dredging plant, a Trailing Suction Hopper Dredger (TSHD), is assumed to be used.

Modelling results indicate that SS elevations will be compliant with the WQO at all sensitive receivers in both seasons (*Table 6.12*), with the exception of SR5a (non-gazetted beach at Lung Kwu Sheung Tan). Again, it is anticipated that the sandfilling works for reclamation will contribute about 71% of SS elevations at SR5a.

Similar to Scenario 1a, it is predicted that the dry season maximum SS level will exceed the criterion, whereas the mean and 90th percentile SS will remain well below the WQO. It is concluded that the non-compliance will be transient. This is evidenced in the time-series plots shown in *Annex 6C*.

The contour plots (*Annex 6C*) show a mixing zone radius (mean SS > 5 mg L^{-1}) of less than 1 km in both the dry and wet seasons. The SS plume hence will not reach the sensitive receivers which are beyond Ha Pak Nai.

Scenario 1b is also considered to be highly conservative since the sandfilling works for the reclamation will be conducted behind a constructed seawall which could serve as a barrier against sediment transport. The seawall will be above the high water level and will have an opening of 50 - 100 m for barge access. The opening is less than 10% of the total length of the seawall and hence it is considered it could effectively prevent the sediment from flushing out of the site.

In case the seawall trench is filled by sand, the dispersion of the sediment plume could be restrained by installation of silt curtain around the sandfilling area. Therefore, SS elevations will be reduced substantially from those predicted in this assessment.

Deployment of cage type silt curtains enclosing the dredging areas next to the grab dredgers will further reduce the sediment dispersion.

The predicted SS level at SR5a after adoption of silt curtains is shown in *Table 6.15* in *Section 6.8.1*. No unacceptable elevations of the SS level would be expected to occur as a result of this worst case set of assumptions.

Table 6.11 Predicted SS Elevation (mg L^{-1}) in Scenario 1a

Sensitive Receiver	Name	ID	Relevant Water Depth (a)	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
						Max (c)	Max (c)	Max (d)	Max (d)	90%-tile	90%-tile
Intertidal Mudflats	Pak Nai	SR01	s	7.1	3.6	0.75	0.5	0.02	0.02	0.04	0.03
Horseshoe Crab Nursery Grounds	Pak Nai	SR01	a	9.7	6	3.4	4.52	0.29	0.15	1.18	0.24
Seagrass Beds/Mangroves/Oyster Farm	Pak Nai	SR02	s	7.1	3.6	0	0.03	0	0	0	0
Seawater Intakes	Black Point Power Station	SR04	b	700 (b)	700 (b)	198.56	187.81	12.51	10.76	33.41	27.48
Non-gazetted Beaches	Lung Kwu Sheung Tan	SR05a	a	8.2	5.6	12.04 (e) (f)	2.36	0.49	0.11	1.19	0.29
Non-gazetted Beaches	Lung Kwu Tan	SR05b	a	8.2	5.6	6.79	3.08	0.26	0.26	0.55	0.74
Gazetted Beaches	Butterfly Beach	SR05c	a	8.2	5.6	0.06	0	0	0	0	0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06a	a	8.2	5.6	0.52	0.31	0.08	0.04	0.23	0.12
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06b	a	8.2	5.6	0.28	0.35	0.03	0.03	0.1	0.11
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06c	a	8.2	5.6	1.29	1.43	0.23	0.17	0.6	0.41
Marine Park	Designated Sha Chau	SR06d	a	8.2	5.6	0.79	0.75	0.09	0.08	0.3	0.22

Sensitive Receiver	**Name**	**ID**	**Relevant Water Depth (a)**	**Allowable Elevation**		**Predicted SS Elevation (mg L^{-1})**					
				Dry	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
						Max (c)	**Max (c)**	**Max (d)**	**Max (d)**	**90%-tile**	**90%-tile**
	and Lung Kwu Chau										
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR06e	a	8.2	5.6	0.27	0.25	0.04	0.03	0.12	0.09
Seawater Intakes	Castle Peak Power Station	SR07a	b	700 (b)	700 (b)	14.77	12.94	1.11	1.04	3.23	2.72
Seawater Intakes	Tuen Mun Area 38	SR07b	b	14.2	9.8	4.43	3.77	0.38	0.29	1.61	0.88
Seawater Intakes	Airport	SR07c	b	8.9	8.8	0.35	0.16	0.02	0.02	0.07	0.04
Seawater Intakes	Airport	SR07d	b	8.9	8.8	0.04	0.13	0	0	0.01	0
Artificial Reef Deployment Area	Northeast Airport	SR07d	a	8.9	8.8	0.03	0.11	0	0	0	0
Seawater Intakes	Airport	SR07e	b	8.9	8.8	0	0.06	0	0	0	0
Seawater Intakes	Airport	SR07f	b	8.9	8.8	0	0	0	0	0	0
Spawning/Nursery Grounds	Fisheries Spawning Ground in North Lantau	SR08	a	8.2	5.6	1.51	1.58	0.27	0.26	0.71	0.71
Horseshoe Crab Nursery Grounds	Sham Wat Wan	SR10	a	8.9	6.5	0.33	0.2	0.03	0.02	0.09	0.05

Notes:

a. s = surface, m = middle, b = bottom, a = depth-averaged

b. The tolerance assessment criterion of 700 mg L^{-1} was adopted for these seawater intakes.

c. "Max" denotes maximum values recorded at a relevant water depth at the sensitive receiver over a complete spring-neap cycle simulation

d. "Mean" denotes arithmetic mean values recorded at a relevant water depth at the sensitive receiver over a complete spring-neap cycle simulation

e. Shaded cells mean non-compliance with the WQO.

f. Contribution of each individual activities are 10.4% from grab dredging for seawall, 7.7% from sandfilling for seawall trench, 9.8% from grab dredging for approach channel

Sensitive Receiver	Name	ID	Relevant Water Depth [(a)]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
						Max (c)	Max (c)	Max (d)	Max (d)	90%-tile	90%-tile

and turning basin, 4.5% from grab dredging for outfall and 67.6% from sandfilling for reclamation.

Table 6.12 Predicted SS Elevation (mg L^{-1}) in Scenario 1b

Sensitive Receiver	Name	ID	Relevant Water Depth (a)	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
						Max (c)	Max (c)	Max (d)	Max (d)	90%-tile	90%-tile
Intertidal Mudflats	Pak Nai	SR01	s	7.1	3.6	0.75	0.58	0.02	0.02	0.04	0.04
Horseshoe Crab Nursery Grounds	Pak Nai	SR01	a	9.7	6	3.65	4.97	0.32	0.17	1.26	0.32
Seagrass Beds/Mangroves/Oyster Farm	Pak Nai	SR02	s	7.1	3.6	0	0.03	0	0	0	0
Seawater Intakes	Black Point Power Station	SR04	b	700 (b)	700 (b)	201.21	187.33	12.44	10.6	32.66	27.46
Non-gazetted Beaches	Lung Kwu Sheung Tan	SR05a	a	8.2	5.6	12.91 (e) (f)	2.4	0.49	0.11	1.2	0.29
Non-gazetted Beaches	Lung Kwu Tan	SR05b	a	8.2	5.6	7.37	3.07	0.27	0.26	0.55	0.72
Gazetted Beaches	Butterfly Beach	SR05c	a	8.2	5.6	0.07	0	0	0	0	0
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06a	a	8.2	5.6	0.54	0.32	0.08	0.04	0.24	0.12
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06b	a	8.2	5.6	0.29	0.35	0.03	0.03	0.11	0.11
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06c	a	8.2	5.6	1.06	1.18	0.24	0.17	0.63	0.43
Marine Park	Designated Sha Chau	SR06d	a	8.2	5.6	0.84	0.74	0.1	0.08	0.31	0.22

Sensitive Receiver	**Name**	**ID**	**Relevant Water Depth (a)**	**Allowable Elevation**		**Predicted SS Elevation (mg L^{-1})**					
				Dry	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
						Max (c)	**Max (c)**	**Max (d)**	**Max (d)**	**90%-tile**	**90%-tile**
	and Lung Kwu Chau										
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR06e	a	8.2	5.6	0.28	0.26	0.04	0.03	0.13	0.09
Seawater Intakes	Castle Peak Power Station	SR07a	b	700 (b)	700 (b)	15.51	14.78	1.16	1.11	3.45	2.9
Seawater Intakes	Tuen Mun Area 38	SR07b	b	14.2	9.8	4.7	3.97	0.41	0.31	1.7	0.91
Seawater Intakes	Airport	SR07c	b	8.9	8.8	0.35	0.16	0.02	0.02	0.07	0.04
Seawater Intakes	Airport	SR07d	b	8.9	8.8	0.04	0.13	0	0	0.01	0
Artificial Reef Deployment Area	Northeast Airport	SR07d	a	8.9	8.8	0.03	0.11	0	0	0	0
Seawater Intakes	Airport	SR07e	b	8.9	8.8	0	0.06	0	0	0	0
Seawater Intakes	Airport	SR07f	b	8.9	8.8	0	0	0	0	0	0
Spawning/Nursery Grounds	Fisheries Spawning Ground in North Lantau	SR08	a	8.2	5.6	1.47	1.58	0.27	0.27	0.72	0.73
Horseshoe Crab Nursery Grounds	Sham Wat Wan	SR10	a	8.9	6.5	0.33	0.2	0.03	0.02	0.08	0.05

Notes:

a. s = surface, m = middle, b = bottom, a = depth-averaged

b. The tolerance assessment criterion of 700 mg L^{-1} was adopted for these seawater intakes.

c. "Max" denotes maximum values recorded at a relevant water depth at the sensitive receiver over a complete spring-neap cycle simulation.

d. "Mean" denotes arithmetic mean values recorded at a relevant water depth at the sensitive receiver over a complete spring-neap cycle simulation.

e. Shaded cells mean non-compliance with the WQO.

f. Contribution of each individual activities are 11.0% from grab dredging for seawall, 8.1% from sandfilling for seawall trench, 4.8% from grab and TSHD dredging for

Sensitive Receiver	Name	ID	Relevant Water Depth [(a)]	Allowable Elevation		Predicted SS Elevation (mg L^{-1})					
				Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
						Max [(c)]	Max [(c)]	Max [(d)]	Max [(d)]	90%-tile	90%-tile

approach channel and turning basin, 4.8% from grab dredging for outfall and 71.4% from sandfilling for reclamation.

6.6.2 *Sediment Deposition*

The majority of SS elevations in water have been predicted to remain within relatively close proximity to the dredging works and, as such, the majority of sediment has been predicted to settle within relatively close proximity to the works areas. The simulated deposition rates at the artificial reefs (ARs), i.e., SR6e and SR7d during the dry and wet seasons have been assessed. The predicted deposition levels at the sensitive receivers are negligible at < 1.1 g m^{-2} day^{-1} which is well below the assessment criterion of 200 g m^{-2} day^{-1} and will not cause any adverse impacts.

6.6.3 *Dissolved Oxygen Depletion*

The dispersion of sediment due to dredging operations is not expected to impact the general water quality of the receiving waters. Due to the low nutrient content of sediments (see *Section 7*, *Part 3: Waste Management*), the elevation in SS levels is not expected to cause a pronounced increase in oxygen demand and, therefore, the effect on dissolved oxygen (DO) is anticipated to be minor. The effects of increased SS concentrations as a result of the proposed works on levels of dissolved oxygen, biochemical oxygen demand and nutrients (as unionised ammonia) are predicted to be minimal. Effects will be transient, localised in extent and of a small magnitude. As such, no adverse impacts to water quality through sediment release are expected to occur.

In order to verify the above assessment, the depletion of dissolved oxygen has been calculated. The degree of oxygen depletion exerted by a sediment plume is a function of the sediment oxygen demand of the sediment, its concentration in the water column and the rate of oxygen replenishment. The impact of the sediment oxygen demand (SOD) on dissolved oxygen concentrations has been calculated based on the following equation (1):

$$DO_{Dep} = C * SOD * K * 10^{-6}$$

where DO_{Dep} = Dissolved oxygen depletion (mg L^{-1})

C = Suspended solids concentration (mg L^{-1})

SOD = Sediment oxygen demand (mg kg^{-1})

K = Daily oxygen uptake factor (set as 1 (2))

By reviewing the EPD sediment quality monitoring data and a recently approved EIA Report (3) which used 15,000 mg kg^{-1} for the North Western

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(1) ERM - HK Ltd (1997). EIA for Disposal of Contaminated Mud in the East of Sha Chau Marine Borrow Pit. For Civil Engineering Department of the SAR Government.

(2) Mouchel (2002). EIA for Permanent Aviation Fuel Facility. For Hong Kong Airport Authority.

(3) Mouchel (2002). *Op. Cit.*

WCZ, the sediment oxygen demand used in this study is 20,000 mg kg^{-1} for the Deep Bay WCZ and the North Western WCZ.

In the abovementioned EIA Report, K was set to be 1, which means instantaneous oxidation of the sediment oxygen demand. This was a conservative prediction of DO depletion since oxygen depletion is not instantaneous and will depend on tidally averaged suspended sediment concentrations.

It is worth noting that the above equation does not account for re-aeration which would tend to reduce impacts of the SS on the DO concentrations in the water column. The proposed analysis, which is on the conservative side, will not, therefore, underestimate the DO depletion. Further, it should be noted that, for sediment in suspension to exert any oxygen demand in the water column will take time and, in the meantime, the sediment will be transported and mixed or dispersed with oxygenated water. As a result, the oxygen demand and the impact on DO concentrations will diminish as the suspended sediment concentrations decrease.

The most sensitive receivers to DO depletion are likely to be the ecological and fisheries aquatic species. The calculated results showed that the predicted oxygen depletion at these WSRs is predicted to be compliant with the WQO criterion as they would be < 0.1 mg L^{-1}. The sediment plumes predicted in the model are thus unlikely to deteriorate dissolved oxygen conditions in the receiving waters and will not affect the WSRs.

Contour plots of maximum DO depletion are shown in *Annex 6C*. It shows that the DO is depleted by less than 1 mg L^{-1} for most of construction works with exception for the sandfilling works and those non-stationary works, i.e. TSHD dredging for approach channel and turning basin (code BP 08b). Interpreting the maximum plots for the moving sources should be in caution. The maximum SS level plots for those moving sources are gestalt image and may not be representative of any given moment in time. The time in which each grid cell's maximum occurred is independent of the other grid cells. For the sandfilling works, the impacts would be substantially reduced when the seawall in reality is to be in place, as aforementioned in *Section 6.6.1*, to minimise the spread of sediment and hence DO depletion.

The contour plots also show that the DO depletion plume will not extend to the fisheries spawning ground in northwest Lantau and ecological resources in inner Deep Bay and hence no adverse water quality impacts on these sensitive receivers are expected.

6.6.4 Nutrients

An assessment of nutrient release during dredging has been carried out based on the SS modelling results for the unmitigated worst case works scenario and the sediment testing results for the dredging area. In the calculation it has assumed that all TIN and unionised ammonia (NH_3-N) concentrations in the sediments are released to the water. This is a highly conservative assumption and will result in the overestimation of the potential impacts.

The increase in TIN concentrations at all sensitive receivers would be less than 0.03 mg L^{-1}, which is considered to be a minimal effect on the water quality. The dredging works will not result in a non-compliance with the WQO.

The maximum predicted SS concentration at each SR is multiplied by the maximum concentration of TIN in sediment (mg kg^{-1}) in the corresponding WCZ to give the maximum increase in TIN (mg L^{-1}). The calculations of TIN are shown below.

Deep Bay WCZ	**NW WCZ**
Max SS * 142 * 10^{-6}	Max SS * 100 * 10^{-6}

Ammoniacal Nitrogen (NH_4-N) is the sum of ionised ammoniacal nitrogen and unionised nitrogen (NH_3-N). Under normal conditions of Hong Kong waters, more than 90% of the ammoniacal nitrogen would be in the ionised form. For the purpose of assessment, a correction (as a function of temperature, pH, and salinity) has been applied based on the EPD monitoring data, i.e. temperature of 24 degrees Celsius, salinity of 28 ppt and pH of 8 which represent the typical conditions of Hong Kong waters. From this it derived that NH_3-N constitutes 5% of ammoniacal nitrogen. In view that the mineralisation of the organic nitrogen will also contribute to ammonia, the calculations of NH_3-N are based on maximum TKN concentrations (mg kg^{-1}) in the sediment in each WCZ. Note that it is a highly conservative approach since it is assumed that 100% of organic nitrogen will be mineralised to ammonium but this is unlikely to occur in reality.

The maximum SS concentration at each SR is multiplied by the following factors to predict the maximum NH_3-N elevations.

Deep Bay WCZ	**NW WCZ**
Max SS * 2,600 * 10^{-6} * 5%	Max SS * 2,100 * 10^{-6} * 5%

The results (see *Annex 6D*) indicate that the increase in NH_3-N elevations due to the dredging works would be negligible comparing with the ambient concentrations. The total concentrations of NH_3-N at the water quality sensitive receivers are predicted to be well below the WQO criterion of 0.021 mg L^{-1} with marginal exceedance at seawater intake of Black Point Power Station. Since it is neither an ecological sensitive receiver nor a bathing beach, the marginal exceedance will not cause significant adverse impact on the intake. In overall it is anticipated that the impacts of the SS elevations due to the dredging works on the nutrient levels are minimal and acceptable.

6.6.5 *Heavy Metals and Micro-Organic Pollutants*

Elutriate tests were carried out to assess the potential for a release of heavy metals and micro-organic pollutants from the dredged marine mud. The test results have been assessed and compared to the relevant water quality standards shown in *Annex 6D, Part 3*. The results show that most dissolved metal concentrations for all samples are below the reporting limits, with the exception of copper. In addition, all dissolved metal concentrations are found to be well below the water quality standards. The results also show that all PAHs, PCBs, TBT and chlorinated pesticides are all below the reporting limits. This indicates that the leaching of these pollutants is unlikely to occur. Unacceptable water quality impacts due to the potential release of heavy metals and micro-organic pollutants from the dredged sediment are not expected to occur.

6.6.6 *Piling Works*

The LNG jetty will be located to the north of Black Point. There will be two installation methods for the piling works (see *Part 3 – Section 3: Project Description*), namely bored piles and percussive piles.

Bored Piles

For the bored piles, a permanent casing will be driven into the seabed and the excavation of the marine soil will then take place inside. After the removal of marine soil, an I-beam will be put inside the casing, followed by concreting. Since the excavation of mud will be carried out inside the casing, it is anticipated that any release of the sediment will be trapped within the casing. In addition, the quantity of the excavated marine mud is expected to be minimal and the mud will be disposed of by a barge and is unlikely to cause unacceptable impacts to the surrounding water.

Percussive Piles

The percussive piles will comprise steel piles below seabed level and cast *in situ* reinforced concrete piles above seabed level. This is achieved by driving steel tubes down to required design soil resistances then filling the tubes from just below seabed level. No soil or sediment excavation will be carried out. It is expected that the piling works will cause limited disturbance to the sediments and are unlikely to cause unacceptable impacts to the receiving water.

6.6.7 *Wastewater Discharges*

Wastewater from temporary on-site facilities will be controlled to prevent direct discharges to marine waters adjacent to the reclamation. Wastewater may include sewage effluent from toilets and discharges from on-site kitchen facilities.

The options for dealing with sewage generated from a construction site work force are as follows.

- **Option 1, Septic Tank Soakaway**: This is considered acceptable for small quantities of sewage and where the ground conditions are suitable with appropriate soakaway capacity. It is considered that a septic tank is unlikely to be accepted for a flow rate of approximately 240m^3 day^{-1}. This option is therefore discounted for a centrally located treatment facility for the entire site although it may be considered for a small number of workers at an isolated location.

- **Option 2, Collect and Convey to a Public STW**: This is a commonly adopted approach by contractors, in the more urbanised areas of Hong Kong, where there is no public sewer and a septic tank soakaway is not viable. Black Point is fairly remote and therefore if the anticipated sewage volume is actually realised the contractor may not consider this option to be cost effective. However, in reality the actual sewage flow generated from the construction work force is likely to be much less than 150 L head^{-1} day^{-1}. Furthermore, the number of workers is considered a conservative and may be less than 1,600. In these cases the contractor may find disposal to a public STW cost effective. This would be seen as a secure means of sewage disposal without the risk of the contractor failing to operate a temporary STW appropriately.

- **Option 3, Provision of Temporary STW to Serve the Work Force**: Due to the remoteness of the site and the relatively large sewage volume the contractor may choose to construct a temporary STW. The sewage will be discharged from a seabed outfall to the north of Black Point (*Figure 6.7*). For the purpose of the EIA, it is recommended that plans should be made for the most onerous scenario and the assumption that the anticipated larger sewage flow may be generated and that the contractor adopts this option.

From a water quality point of view, the worst case scenario is the discharge of the treated water into the sea and hence for the assessment purpose Option 3 has been assessed. Modelling has been conducted to determine the dispersion of treated wastewater discharges during the construction phase, as described in the *Water Quality Method Statement* (*Annex 6A, Part 3*). The results (*Annex 6E, Part 3*) indicate that the impacts are negligible. No non-compliances with the WQO are predicted to occur in either the dry or wet seasons.

During the early stages of construction, i.e. site formation, it will be necessary to remove the sewage from site to a Public STW as the reclamation will not be in place. However, during the construction of the process facility which requires the maximum workforce and the longest site duration, it is recommended that an on-site plant be established at the location shown in

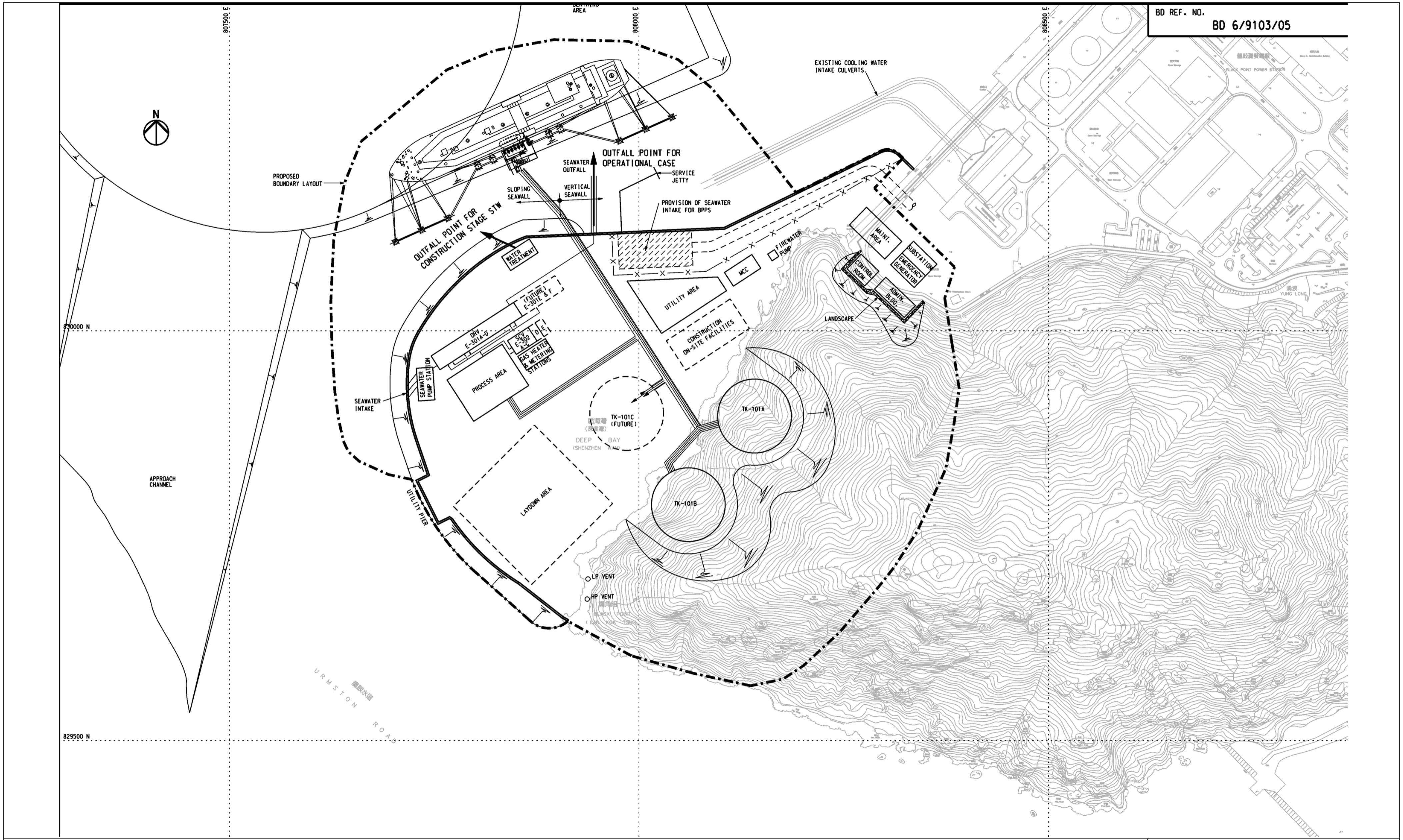

Figure 6.7

Black Point Outfall Point for Sewage Treatment

Environmental Resources Management

ERM

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Figure 6.7. The discharge will be transferred to the outfall location on the north side during operation.

6.6.8 Land Based Construction Activities

During land based construction activities for the LNG terminal and for the access roads, the primary sources of potential impacts to water quality will be from pollutants in site run-off which may enter marine waters.

Due to limited space at the Black Point site, all excavated soil will be transported off-site initially. It is intended that this material will be reused as fill within the reclamation at a level above +2.5mPD. The excavated soil therefore needs to be stored temporarily off-site (see details in *Part 3 – Section 7: Waste Management*).

A drainage system will be constructed around the land based working sites for the tanks. However, such drainage system can only be constructed after slope cutting works which are required for site formation. The drainage system will collect the site runoff and prevent it from running into the surrounding water.

With the proper implementation of mitigation measures, described in (*Section 6.8.2*), it is anticipated that no adverse water quality impacts would arise from the land based works.

6.6.9 Vessel Discharges

Construction vessels have the potential for the following liquid discharges:

- Uncontaminated deck drainage;
- Potentially contaminated drainage from machinery spaces; and
- Sewage/grey water.

Deck drainage is likely to be uncontaminated and is not likely to impact water quality. Other sources of possible impacts to water quality may arise from discharges of hydrocarbons (oil and grease) from machinery space drainage and Biochemical Oxygen Demand (BOD) and microbiological constituents associated with sewage/grey water. These waste streams are all readily amenable to control as part of appropriate practice on vessels. Possible impacts associated with construction vessel discharges are therefore considered to be minor.

No solid wastes will be permitted to be disposed of overboard by vessels during construction works, thus impacts from such sources will be eliminated.

6.6.10 *Hydrotest Water*

Before installation of the tank wall insulation, raw freshwater will be needed to hydrotest the LNG tanks. Approximately 28 million gallons (~ 106,000 m^3) for a LNG tank with a net capacity of 160,000 m^3 with about 0.25 million gallons of additional water would be required for each successive tank tested. The discharge flow rate will be approximately 1,800,000 gallons per day (~ 6,814 m^3 day^{-1}) for the bulk pumping operation, with substantially lower rates being achieved when removing the final amounts of water from the tank bottom via a settlement pond. There are two tanks in total and hence with the abovementioned flow rate it takes about 1 mouth to discharge all the hydrotest water.

The potential additive to this water will be low concentrations of chlorine (approximately 0.05 mg L^{-1}). It is expected that the water will be discharged into the existing BPPS cooling water outfall, which will comply with the WQO/discharge licence requirements. Given the relatively small volume of water from the tanks relative to the volume and flow rate in the cooling water outfall system, the hydrotest tank water will dilute and disperse rapidly without causing notable changes to water quality.

6.7 *OPERATION PHASE WATER QUALITY IMPACT ASSESSMENT*

6.7.1 *Hydrodynamics*

Changes to water quality, sedimentation and erosion processes would arise if there was a significant change to the hydrodynamic regime of the Black Point coastline due to the reclamation works and seawall construction at the headland.

Figures BP_B01-B08 in *Annex 6B, Part 3* show the current velocity under the baseline conditions and *Figures BP_F01-08* in *Annex 6F, Part 3* show the current velocity under the post-project conditions.

Modelling results show that the presence of the reclamation is likely to alter tidal currents and introduce a localised sheltering effect in the vicinity of the existing intake of the Black Point Power Station.

The approach channel and the turning basin will be located to the north of Black Point and will be dredged to approximately -15.0mPD. The results of modelling current velocities (*Figures BP_F01-08* in *Annex 6F*) indicated that hydrodynamic changes due to the deepened seabed level are negligible.

Mathematical modelling has been carried out to examine the flushing capacity of Deep Bay. The methodology and model results are presented in *Section 4 of Appendix 6A* in *Annex 6A*. The model results show that the relative change of flushing capacity in inner Deep Bay due to the presence of the reclamation with respect to the baseline ranges from -2.4% (decrease) to +1.1%

(increase). The results also indicate that for Deep Bay as a whole there is a marginal increase of the flushing in the dry season and a marginal decrease of the flushing in the wet season. In conclusion, the change in flushing capacity, and hence in water quality, due to the reclamation at Deep Bay is minimal. No adverse impacts to water quality as a result of these minor changes in hydrodynamics are expected to occur.

6.7.2 *Suspended Solids*

Maintenance Dredging

To the extent practical, the selection of the approach channel for the LNG carrier was based on the availability of the required charted water depth. The intent is to reduce the dredging quantities and hence potential impacts to water quality. Sedimentation associated with the approach channel and turning basin is predicted to be approximately 50 to 100 kiloton year^{-1}, which is equivalent to approximately 10 to 20 cm year^{-1}. According to these estimates, maintenance dredging is expected to be required once every four to five years and will be restricted to specific small areas.

Apart from the low frequency of the maintenance dredging, the scale of the maintenance dredging would be much less than the initial dredging works for the approach channel and turning basin which has been assessed in the previous section. Hence, it can be expected that no unacceptable adverse impacts would arise from maintenance dredging. Although increases in suspended solids in the water column may occur, these would be expected to be compliant with applicable standards and any associated impacts are expected to be of a relatively low magnitude, temporary and localised to the works area.

6.7.3 *Temperature*

Cooled Water Discharge

During the operation of the LNG terminal, there will be cooled water discharges from the terminal outfall as seawater will be used in the Open Rack Vaporizers. Cooled water with a temperature of approximately 12.5°C below ambient will be discharged at the seawater outfall, which is located close to the seabed in the vicinity of the LNG carrier jetty. There are no water quality sensitive receivers in the immediate vicinity of the proposed discharge point.

The maximum flow rate of the discharge is expected to be equivalent to 18,000 m^3 hr^{-1}. Compliance with the WQO ($\Delta \pm 2$ °C from ambient) must be achieved at sensitive receivers.

The results from the cooled water discharge modelling are included in *Annex 6G, Part 3* and have been presented as contour plots showing impacts of cooled water discharges in the vicinity of the outfall. *Figures BP_G01-G02* show the maximum temperature (reduction) differences between the maximum operational discharges and the baseline, representing the most conservative case.

It can be seen from the contour plots that the maximum temperature reduction of < -2 °C will extend 3 km to the north-east in the wet season where no obvious temperature differential is predicted in the dry season. In the wet season, it is anticipated that the temperature differences are confined to the middle or bottom layer, with little impact to the surface layer of the water column. This is expected as the discharge of cooled water is close to the bottom and the relatively higher density of the cooled water results in weak vertical mixing. The contour plots also show that the maximum flow will mainly occur offshore with little extent to artificial shore to the north of the outfall. No sensitive receivers, especially ecological sensitive receivers, are expected to be affected as the plume does not impinge on any natural coastlines. No non-compliance with the WQO (± 2 °C) has been predicted at the sensitive receivers in either the dry or wet seasons. The results indicate that the dispersion of cooled water is rapid and not expected to cause an unacceptable impact.

To reduce the influence of cooled water discharge on the surrounding waters, the relatively large plume could be reduced by decreasing the temperature delta from -12.5 °C to -8.5 °C. Based on initial model results, a temperature delta of -8.5 °C could reduce the size of the plume of $\Delta < -2$ °C by up to 80% in certain areas. This provides an indication that decreasing the Δ of the temperature of the discharge could reduce the spatial WQO exceedances.

6.7.4 *Residual Chlorine Dispersion*

To counteract settling and actively growing fouling organisms, the LNG cooled water circuits will be dosed with antifoulants. An efficient anti-biofouling system will be designed to prevent the growth of micro and macrofouling organisms on surfaces that are immersed in or in contact with seawater. Antifoulant control in the once through seawater is critical since marine growth in the piping and equipment must be controlled. This includes the Open Rack Vaporizers (ORVs) which will become fouled and lose heat transfer efficiency if algae or marine animals are allowed to build up on the heat transfer panels within these units. More importantly, marine growth will promote pitting corrosion. Biological control must not only render the incoming biological material incapable of growth, but it must carry a residual concentration through the system to protect it from new growth caused by airborne biological agents or prior contamination that could possibly cause growth in the system.

Sodium Hypochlorite

Chlorine, typically in the form of sodium hypochlorite, is commonly used as an antifouling agent in plants worldwide where seawater is used for cooling/warming. Sodium hypochlorite is an antifoulant that has been researched intensively. In once-through systems sodium hypochlorite is the most important antifoulant that is applied. Sodium hypochlorite is generated in a sodium hypochlorite generator by passing electrical current through seawater causing it to form sodium hypochlorite and small amounts of hydrogen. The hydrogen is vented to a safe location which is 2 to 3 meters above any personnel or adjacent equipment which should not be a problem since hydrogen is lighter than air and will readily disperse upward in a dilute form that is below the Lower Explosive Limit (LEL) for hydrogen. Hydrogen readily disperses since it is lighter than air. The sodium hypochlorite generators can be controlled to only generate as much sodium hypochlorite as required. Sodium hypochlorite will provide free residual chlorine in the seawater that can be adjusted to carry over to the ORVs providing them with protection from air borne algae that could cause algae growth on the ORVs.

The ORV residual chlorine discharge will comply with a limit of 0.3 mg L^{-1} maximum. This limit will be maintained by controlling sodium hypochlorite feed automatically using residual chlorine monitors in the discharge. When chlorine (or hypochlorite) is added to seawater a series of chemical reactions occurs. The end product of these reactions includes a wide range of halogenated organic compounds. Using a low level of chlorine to prevent settlement of marine organism, rather than killing them, reduces the likelihood of halogenated organics being formed.

According to the Integrated Pollution Prevention and Control (IPPC), Reference Document on the application of Best Available Techniques to Industrial Cooling Systems (BREF) (2001), "Sodium hypochlorite is the most commonly oxidising antifoulant used in large once-through systems. It can be produced on marine sites by electrolysis of seawater. This process, called electrochlorination, avoids the transport and storage of dangerous chlorine gas or solution. The consumption of sodium hypochlorite as active chlorine demand is generally lower in and around saltwater systems than on freshwater systems, because of a higher level of dissolved and particulate organic matter in fresh water. Due to its higher bromide content, the formation of halogenated organics in seawater is reported to be lower than in freshwater (rivers), but no publications could confirm this."

Other Alternatives

There are a number of alternatives to sodium hypochlorite for controlling biological growth that have been considered, including:

- Ultra Violet (UV) Light;
- Ozone;
- Chlorine Dioxide;
- Copper Systems; and

- Commercial antifoulants.

Ultra Violet (UV) Light

A non-chemical alternative to sodium hypochlorite is the use of UV light to control biological growth in the seawater cooling system. UV light serves as an antifoulant by damaging a microorganism's DNA structure, inhibiting its ability to reproduce or killing the organism outright. UV treatment does not require chemicals nor does it produce harmful reaction products.

According to the Integrated Pollution Prevention and Control (IPPC), Reference Document on the application of Best Available Techniques to Industrial Cooling Systems (BREF) (2001), "UV-light may also offer possibilities in recirculating systems as a supplementary technique. UV-light alone however, cannot attack the biofouling that has settled on the surfaces of the Cooling Water System. In order to be effective, relatively clear cooling water is needed, since the light must be able to penetrate into the water column."

While UV light has been a useful technique for treating certain cooling water systems, there are several issues that limit its applicability to the treatment of the Project's ORV system. There is a notable lack of operational experience with UV treatment in subsurface marine applications. Monitoring the operation and changing the UV lights once every 5,000 hours would be difficult when the system is located at 15 - 25 m below sea level. Silt and other materials present in the seawater would foul the lights, requiring frequent cleaning for it to remain effective at these depths. Expensive additional pre-treatment of the water might even be necessary to ensure that the UV light penetrates the water column. As a direct, non-chemical process, UV light does not provide residual biological control which is necessary to protect the ORVs.

While the environmental effects of UV light are expected to be less harmful then halogenated antifoulants, the technique requires special care, is expensive, is unproven in subsurface marine applications, does not provide residual fouling protection and is not applicable in all situations. UV-light alone cannot attack the biofouling that has settled on the surfaces of the ORV since it does not provide residual biological control. Thus, UV light is not considered technically acceptable for this application.

Ozone

In recent years, ozone has been employed as an alternative to chlorine disinfection in potable water and wastewater applications. Ozone kills microorganisms by damaging or destroying the cell wall. Ozone can be generated onsite with electricity using commercially available ozone generators which use either a Pressure Swing Absorption (PSA) unit or liquid oxygen tank to provide a pure or enriched source of oxygen.

According to the Integrated Pollution Prevention and Control (IPPC), Reference Document on the application of Best Available Techniques to Industrial Cooling Systems (BREF) (2001), "With the relatively smaller volumes of recirculating wet systems alternative treatments are successfully applied, such as ozone, but they require specific process conditions and can be quite costly."

There are several notable environmental and safety issues that limit the applicability of ozone for the proposed use. Corrosion is a particularly complex problem with ozone treatment. As a strong oxidant, ozone accelerates the corrosion of metals in water, damaging any pipes and equipment not made of corrosion-resistant materials. Without corrosion protection measures, ozone could accelerate the corrosion of the vaporizers causing them to have a shortened lifespan and possible failure. Correcting this problem would necessitate the use of exotic metallurgy, introducing the risk of putting metallic ions to the seawater which could also damage the ORVs.

Ozone production requires a considerable amount of energy and is relatively expensive due to the fact that the efficiency of the ozone generators is very low. The ozone generators would require an ozone destruction unit (fired unit) to destroy any excess ozone production which would be harmful to the atmosphere. This destruction unit is also expensive and would represent an additional source of NOX emissions. Additionally, ozone, like UV, does not provide residual biological control since it is very reactive and will be consumed in the first few seconds after application.

In terms of safety, ozone is a noxious gas which can damage lung function. Any uncontrolled ozone release from a generator or destruction unit would represent a potential hazard to site workers.

Ozone is preferably used in very clean recirculating cooling systems, and it is noted that its high reactivity makes ozone unsuitable for application in once-through system or long line systems. Ozone is not practical in this application due to the lack of experience of this size unit, corrosion concerns, lack of residual biological control, high costs, increased NOx emissions and potential environmental hazard from ozone releases.

Chlorine Dioxide

Chlorine dioxide is an effective biological control agent normally used in applications onshore where ammonia or other agents make the use of free chlorine ineffective. Unlike UV light or ozone, chlorine dioxide does provide a residual that would protect the ORVs. Chlorine dioxide must be generated onsite using special equipment.

According to the Integrated Pollution Prevention and Control (IPPC), Reference Document on the application of Best Available Techniques to Industrial Cooling Systems (BREF) (2001), "Chlorine dioxide (ClO_2) has been considered as an alternative to hypochlorite (HOCl) for seawater conditions and as a freshwater biocide due to its effectiveness as a disinfectant and to its strong reduction in the formation of organohalogenated by-products in the effluent. It has been reported as an effective and economical application in cooling water systems for control of micro-organisms at relatively low dosages."

There are several notable environmental and safety issues that limit the applicability of chlorine dioxide for the proposed use. The generation of chlorine dioxide would depend on the delivery of hazardous chemicals to the site. The generation equipment would consume a large area of space along with chemical storage. As a consequence, capital and operating costs for a chlorine dioxide system would be considerably higher than those for a conventional sodium hypochlorite system.

While some residual antifouling capacity is beneficial, chlorine dioxide can leave undesirable residuals that are much more persistent in the environment than free chlorine. Since chlorine dioxide is resistant to oxidation and reaction with ammonia, it will persist in the seawater much longer than the other options. Chlorine dioxide can react with other compounds to form undesirable by-products such as aldehydes, ketones and quinones or epoxydes under certain circumstances. Some aldehyde and eopxydes are known to be carcinogens or mutagens which may persist past the mixing zone upon discharge into the open sea. Since chlorine dioxide is not widely used for this purpose, the impacts of undesirable side reactions with organic compounds that form undesirable disinfection by-products are not as well studied.

The environmental and safety risks of using chlorine dioxide prevent this option from being further considered for this application.

Copper Systems

Copper systems use copper ions to control biological growth by inhibiting the attachment of fouling organisms to process piping and equipment surfaces. The copper ions are supplied by the electrolysis of seawater which eliminates the need to transport and store hazardous chemicals.

According to notes on copper ion treatment provided in the Integrated Pollution Prevention and Control (IPPC), Reference Document on the application of Best Available Techniques to Industrial Cooling Systems (BREF) (2001), "…the residual concentration of the lethal copper compounds need further examination as the discharge to the receiving water could cause harmful effects."

There are several notable operational and environmental issues that limit the applicability of copper ions for the proposed use. One basic concern is that copper ion treatment is not a common technique and that to our knowledge none of the LNG terminal operators have experience operating this unconventional control system. Another concern is that existing copper ion treatment has not yet been attempted in a system that contains aluminium. As such, there is the potential that an undesirable reduction-oxidation reaction may take place between the copper ions and the aluminium in the ORVs, accelerating the corrosion of the vaporizers.

While copper is commonly used as a protective coating for vessels, the proposed application would introduce considerable amounts of the metal directly into the marine environment. The concentrations of copper at the seawater outfall could potentially reach toxic levels of concern given the high volume of ORV throughput and the duration of the project.

Given the uncertainty of ORV corrosion and the introduction of a non-biodegradable metal to the marine environment, copper ion treatment is not considered technically acceptable for this application.

Commercial Antifoulants

One chemical company produces an antifoulant that is a catatonic surfactant that is short-lived in plant systems and the environment because of rapid absorption onto anionic substrates and sediments in natural aquatic ecosystems.

Mussels do not detect this chemical as a noxious compound, and they do not close their shells. This allows the mussels to be killed quickly, with significant mortality in 4 to 24 hours. The agent causes detachment of adults and is effective on molluscs at all life stages. It also effectively controls microfouling organisms, barnacles, hydrozoa, bryozoa, bacteria, fungi, algae, Asiatic clams, and bacterial, fungal, and algal slime. The agent is compatible with stainless steel, copper alloys, most plastics and rubbers, chrome alloys, aluminium, and FRP piping.

There are several notable operational and environmental issues that limit the applicability of this antifouling agent for the proposed use. The chemical is corrosive to skin and is flammable, making it a hazard to handle. The high residual levels after discharge along with the extremely high cost of this material make it operationally and environmentally unsuitable for this application. As such, the chemical is not considered suitable for this application due to its potential negative effects on sea life and excessive cost.

Summary

To conclude, UV and ozone generator options are not recommended because they do not provide the required residual biological control for the ORVs along with other operational difficulties. Although chlorine dioxide provides residual control, it uses hazardous chemicals and will consume considerable space for producing the chlorine dioxide and chemical storage and unloading in addition to operator safety issues. The proposed commercial antifoulant is not considered suitable for this application due to its potential negative effects on sea life and excessive cost.

Copper ion treatment is currently not in wide use and there is limited operating experience for this unconventional system. Additionally, the potential corrosion problems with the copper-aluminium interaction on the Open Rack Vaporizers (ORV's) are unknown and are therefore currently not viewed as a viable option.

The one viable option remaining is sodium hypochlorite. It is a safe, proven option that has been used successfully for many years on many once through seawater applications with ORVs. For most applications, a carefully designed sodium hypochlorite system offers the most complete and comprehensive technique for the reduction of both macrofouling and microfouling.

Careful design can also dramatically reduce the environmental impact of modern sodium hypochlorite systems. This includes a properly designed chlorine monitor to control the residual chlorine levels in the system with care being taken to choose an instrument that has the proper operating range to provide maximum sensitivity throughout all foreseeable operational scenarios.

Residual chlorine in the marine environment can be harmful to marine organisms only if concentrations exceed tolerance levels. It has been found that harmful effects begin to occur at concentrations above 0.02 mg L^{-1} in water (1). The discharge limit for residual chlorine is 1.0 mg L^{-1} according to EPD's *Technical Memorandum for Effluents* issued under *Section 21 Water Pollution Control Ordinance*, *Cap 358*. There is no value specified in the WQOs for the Deep Bay WCZ, nor for any other WCZ. The criterion value of **0.01 mg L^{-1}** (daily maximum) at the edge of the mixing zone has been chosen as the criterion against which to assess the results from the computer modelling of chlorine dispersion, which is also the criterion adopted in the previously approved EIA Report for the 1,800 MW Gas-fired Power Station at Lamma Extension (2).

The water quality impacts due to chlorine discharges have been assessed using computational modelling (see *Water Quality Method Statement* in *Annex 6A, Part 3*). The results from the chlorine simulations are presented as contour plots of mean and depth averaged chlorine concentrations for the spring and neap tidal periods in the wet and dry seasons. The contour plots are provided in *Annex 6H, Part 3*. *Figures BP_H01-08* present the maximum operational discharges while *Figures BP_H09-16* show the fluctuating flow

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(1) Langford, TE (1983) Electricity Generation and the Ecology of Natural Waters. Liverpool University Press, Liverpool.

(2) ERM - Hong Kong, Ltd (1999) EIA for a 1,88MW Gas-fired Power Station at Lamma Extension. Final EIA Report. For The Hongkong Electric Co., Ltd.

operational discharges. Both discharge rates appear to result in a similar pattern of residual chlorine dispersion.

The model used the assumption that the terminal would discharge total residual chlorine at a maximum concentration of 0.3 mg L^{-1}. This concentration is similar to that for most power stations in Hong Kong and is below the EPD's limit of 1.0 mg L^{-1} (1) but it is not optimal for long term functioning of the ORV system at the LNG terminal.

The model results for the 0.3 mg L^{-1} discharge concentration have shown that the dispersion of the residual chlorine was confined to the immediate vicinity of the outfall point.

The dispersion results obtained for the dry season have shown that the residual chlorine is well-mixed in the whole water column. In the wet season, the majority of the residual chlorine is likely to be contained within the bottom layer and the middle layers, with no chlorine in the surface layer. This indicates that the release of the chlorine near to the seabed with the presence of freshwater from the Pearl River Delta in the wet season and the relatively higher density of the cooled water in which the chlorine is discharged, results in weak vertical mixing.

Based on the predictions, the maximum extent of the > 0.01 mg L^{-1} contour is < 50 m (bottom layer) from the discharge point during the dry season and < 70 m (bottom layer) during the wet season, resulting from the 0.3 mg L^{-1} chlorine discharge (*Figure BP_H01* and *Figure BP_H05*). These areas were defined as the "mixing zones". Due to their small extent, and the fact that no sensitive receivers would be affected, no unacceptable impacts from residual chlorine discharge to water quality are expected to occur.

Due to the small extent of the mixing zones, and the fact that no sensitive receivers would be affected, no unacceptable impacts from residual chlorine discharge to water quality are expected to occur.

6.7.5 On-site Wastewater Discharges

During the operation of the LNG receiving terminal, it is expected that there will be a workforce of about 100 people. It has been conservatively estimated that an average of approximately 35 m^3 of sewage would be produced by this workforce per day (*Annex 6A, Part 3*).

A sewage treatment system will be provided for the treatment of wastewater. A sanitary waste system consisting of a collection system will be provided. Due to the low number of operational staff in the terminal, the volume of the sewage generated would be limited and would be treated on-site before being discharged in accordance with the EPD's required standards under the *Water Pollution Control Ordinance*.

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(1) Technical Memorandum for Effluents, Section 21 Water Pollution Control Ordinance, Cap 358.

Modelling has been conducted to assess the dispersion of treated wastewater discharges during the operation phase. Modelling methods are discussed in the *Water Quality Method Statement* (*Annex 6A*). The location of the sewage discharge is shown in *Figure 6.7*. The results (see *Annex 6I*) indicate that the impacts of the wastewater discharges are negligible. No non-compliance with the WQO is predicted to occur in either the dry or wet seasons throughout the operation phase.

6.7.6 *Vessel Discharges*

No adverse impacts are expected to occur from vessel discharges during the operation phase, as with the construction phase (*Section 6.6.9*).

No ballast water from the LNG carrier will be discharged in Hong Kong waters. The LNG carrier will arrive at the Hong Kong terminal loaded with LNG and with empty ballast water tanks. Ballast water will be taken into the LNG carrier ballast tanks at the terminal simultaneously during the LNG discharge.

The handling of ballast water by the LNG carrier will always be in accordance with *IMO resolution A.868(20)* adopted by the IMO assembly in November 1997. This requires the LNG carrier to have the ability to change all ballast water at sea between discharge port and load port. In addition, the provisions of the *Convention for the Control and Management of Ship's Ballast Water and Sediments* adopted 13 February 2004 (which entered into force at a later date) will also be fully complied with.

6.7.7 *Accidental Spill of LNG*

An LNG release would be vaporized quickly into the atmosphere and would not be expected to impact water or sediment quality. If spilled onto the LNG Terminal jetty deck or into the ocean (LNG is less dense than water), LNG would boil rapidly (due to exposure to higher ambient temperatures). Due to the material's density and turbulence created by the rapid boiling, an LNG spill would vaporize rapidly, leaving no environmental residue.

It is worth noting that there is a sump at the berth large enough to capture and manage a major spill from the unloading lines and contain it on the site. Other leaks at the terminal are designed to be routed to containment basins for evaporation and treatment and would not reach the sea. Therefore an LNG spill would be only associated with the unloading arms, which are hanging over the sea, outside of the spill containment area. It should also be noted that the LNG terminal has an emergency shutdown system (PERC) that continuously monitors the mooring system and motions of the unloading arms. Upon sensing any irregularities in either of these systems, the unloading operation is automatically shutdown. This system has quick operating shutoff valves that among other places are located at the unloading arm connection to minimize the possibility of a LNG spill. The system can also be actuated manually by the terminal operator who is always present at the dock during unloading or the ship's cargo master who is also present. Thus, if the ship were to break from its mooring, the LNG transfer would shutdown instantly without loss of cargo.

A leak from the unloading arms has a frequency of 4 x10^{-3} per year, while a full rupture has a frequency of 4 x10^{-5} per year (for details refer to *Part 2 - Section 13.5*). Other elements of the LNG Receiving Terminal have an even lower frequency of leakage and hence the leak from the unloading arms is examined. To investigate the effects of a spill on water quality, a full bore rupture scenario was modelled. It was assumed that unloading arms part when an extremely high atypical wave due to a passing ship causes the LNG Carrier to break free from its moorings.

The pumping rate during carrier unloading is 601 kg s^{-1} (equivalent to 1.3 m^3 s^{-1}) per unloading arm. For the purpose of modelling, if a rupture occurs, a 30s release of LNG is assumed. This is based on the closing time of the emergency shutdown valves (ESV) and the reaction time of personnel to activate the emergency shutdown device (ESD). However, the inventory of LNG between ESVs is about 80m^3. A release would therefore consist of the inventory plus 30s of pumping, a total of about 120 m^3. The modelling assumes this is released at a constant rate of 1.3 m^3 s^{-1} for 92s. In reality, once the ESVs close, the discharge rate will decrease beyond 30s and be caused by gravity draining only. The modelling approach is therefore conservative.

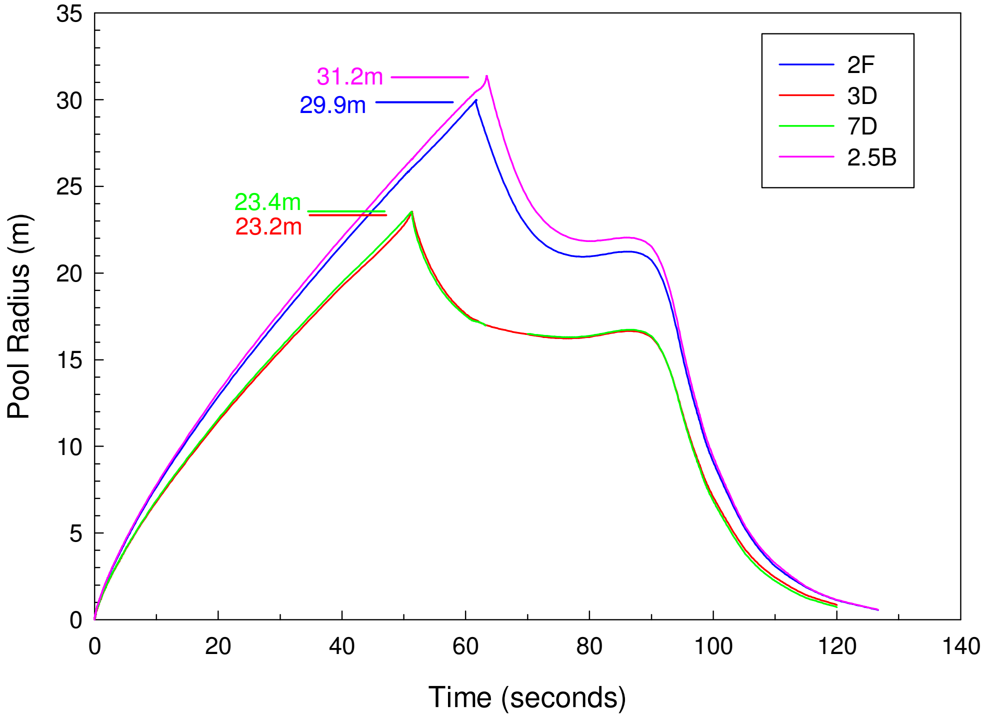
The spill is further assumed to take place on water and is allowed to spread isotropically without confinement. Modelling was performed using PHAST for four weather conditions covering a range of atmospheric stability classes of B through to F, and a range of wind speeds from 2m s^{-1} to 7m s^{-1}. The model includes the effects of gravitational spreading, surface tension forces and vaporisation rate in calculating the pool size. The PHAST model was adopted as it is used in the Quantitative Risk Assessments (QRAs) for the terminal and marine transit of the LNG Carrier.

The results (*Figure 6.8*) show transient pool behaviour, growing to maximum size after about 1 minute and completely vaporising after 2 minutes. The liquid rainout fraction is about 20% whereas 80% of LNG would be vaporised (conservatively a release height of 1 m was specified in the modelling) but the extent depends on weather conditions. This factor explains the difference in the four curves. The results show that the pool size is likely to be affected by atmospheric stability and less so by wind speed. The pool size radius is in a range of 23 m and 31 m, which is considered to be small. It is hence anticipated that substantial vaporisation, which is caused by turbulent mixing and heat transfer from the air to vaporise the LNG, will take place before the LNG reaches the water.

Similarly, results of the QRA of the LNG Carrier transit have indicated that in the highly unlikely event of a breach of containment of the double hull of the LNG Carrier the spill would have a maximum radius of 85 m in the worse case event. This has been determined through mathematical modelling, again using the PHAST model for consistency.

In summary, should an accidental spill of LNG occur on the sea surface the LNG will not mix with water or dissolve in water but will stay on the surface and evaporate rapidly leaving no residue. The LNG spill will cause immediate cooling of the surface water which will rapidly return to normal temperature due to the buffering effect of the ocean. Hence no impacts to water quality would be expected in the unlikely event of an accidental spill of LNG on the water.

Figure 6.8 LNG Pool Size for a Spill from the Unloading Arm



Notes:
"2F" denotes a wind speed of 2 m s^{-1} under stable air-turbulence conditions.
"3D" denotes a wind speed of 3 m s^{-1} under neutral air-turbulence conditions.
"7D" denotes a wind speed of 7 m s^{-1} under neutral air-turbulence conditions.
"2.5B" denotes a wind speed of 2.5 m s^{-1} under unstable air-turbulence conditions.

6.7.8 *Accidental Spill of Fuel from LNG Carrier*

In the unlikely event of an accident, the special design of the storage tanks well prevents the fuel from leaking into the sea. Fuel for propulsion and ship services is carried in storage tanks installed inside double hulls at the forward end and the aft end of the vessel. The forward storage tanks are located aft of the fore peak tank and forward ballast tank or bow thruster room at a distance about 10 to 20 m from the bow to afford protection against collision. The outboard sides and bottoms of all fuel tanks are separated from the hull sides and bottom with abutting ballast tanks or void spaces so that any potential oil tank boundary leakage will not reach the sea. In addition, hull bottom or side damage will not impair the tank boundary thus preventing pollution of the sea. This feature constitutes double hull protection and hence minimises the likelihood of failure as far as reasonably practicable.

It is considered that a spillage of fuel is highly unlikely given the above; however, the Study Brief requires that a potential scenario is examined.

Uncertainty of Fuel Spill

There is uncertainty as to how much fuel will actually be contained within the ship's fuel storage system for every voyage; however, the following factors have to be taken into account:

- LNG tanks not filled to capacity;
- Protective location of fuel tanks; and
- Geometric factor of fuel tanks.

Therefore, although the worst case analysis of the largest single tank being breached was modelled, the frequency of such an event is very small and hence in the unlikely event of such an event arising the quantity of fuel released will be lower than that modelled. In the model, it is assumed that all oil is released from a fulfilled tank and the protection features of the tank are not considered in the model despite it is unlikely to occur.

Impact Assessment

Should any rupture of the tank occur it is essential to implement emergency contingency plans to effectively control and clean up accidental spillages at short notice and to minimise the quantities of fuel reaching water sensitive receivers. This is the purpose of carrying out a mathematical modelling assessment of the behaviour of a hypothetical fuel spill. The modelling assumptions are presented in *Annex 6A*.

It is important to note that the modelling is based on a multiplicity of conservative parameter inputs to identify the extreme range of plume movement that might be credibly predicted. The output is intended to facilitate implementation of an effective contingency plan to ensure best practices in controlling accidental oil spillages, notwithstanding the very low likelihood of such an event ever occurring in practice.

The most conservative case considered is the holing of the largest single tank containing fuel on board a 215,000 m^3 class LNG Carrier, which is a carrier class considered in the MQRA. This worst case scenario considers only the consequence on water quality and as it does not consider the low frequency it is extremely conservative in nature.

In the model, it is assumed that a spill occursalong the Urmston Road prior to reaching the Black Point site. This scenario was chosen due to the proximity of the spill to the CPPS and the Marine Park at Lung Kwu Chau and Sha Chau.

In order to examine the dispersion pattern and movement of an oil plume, it is assumed that no evaporation and emulsification is allowed and consequently a highly conservative case has been simulated. The modelling has been conducted using the Oil module of the particle tracking (PART) model of the Delft 3D suite of models.

It is assumed that necessary contingency actions will be implemented within 24 hours after the release and hence a summary of the fuel spill travel route over the 24 hour period is shown in *Tables 6.13* and *6.14*.

Table 6.13 ***Movement of Fuel Spill (Dry Season)***

Location	**The nth hour after Release**
Urmston Road near Castle Peak (release point)	0 – 3
North coast of the Brothers	4 – 8
Urmston Road and Northeast of the Airport	9 – 13
Open water to the north of the Brothers	14
Northeast of Lantau	15
Ma Wan	16
North of Tsing Yi	17 – 24

Table 6.14 ***Movement of Fuel Spill (Wet Season)***

Location	**The nth hour after Release**
Urmston Road near Castle Peak (release point)	0 – 4
Open water to the north of the Brothers	5
North coast of the Brothers	6
Northeast of Lantau	7 – 8
Between northeast of Lantau and Ma Wan	9 – 11
Between northeast of Lantau and the Brothers	12 – 19
Between northeast of Lantau and Ma Wan	20 – 23
Northeast of Lantau	24

For the dry season, it is evident that the contingency actions should be implemented to control and contain the fuel plume within 16 hours, before it disperses to the Ma Wan fish culture zone.

For the wet season, the plume is likely to move much faster but not farther than Ma Wan. In order to control and contain the plume, it is recommended that the contingency actions should be implemented within 10 hours.

6.7.9 *Contaminated Site Run-off*

Measures have been put in place to ensure the management and control of day-to-day activities at the terminal that involve the use of potentially contaminating materials, such as fuel and lube oils etc. These measures are presented and discussed in *Section 14*. The measures will ensure that surrounding marine waters are not affected by contaminants in run-off from the site.

6.8 *WATER QUALITY MITIGATION MEASURES – CONSTRUCTION PHASE*

The water quality modelling works have indicated that for both the dry and wet seasons, the works can proceed at the recommended working rates without causing unacceptable impacts to water quality sensitive receivers. In instances where there are exceedances of the applicable standards, they have been predicted to be transient and therefore not of concern.

Unacceptable impacts to water quality sensitive receivers have been avoided through the adoption of the following measures.

- **Siting:** A number of locations were studied for the LNG terminal, with the principal aim of avoiding direct impacts to sensitive receivers.

- **Reduction in Indirect Impacts:** The LNG terminal is located at a sufficient distance from water quality sensitive receivers so that the dispersion of sediments from the construction works does not affect the receivers at levels of concern (as defined by the WQO and tolerance criterion).

- **Adoption of Acceptable Working Rates**: The modelling work has demonstrated that the selected working rates for the dredging operations will not cause unacceptable impacts to the receiving water quality. Details regarding the working rates for different scenarios are presented in *Section 3.3 of Annex 6A, Part 3*.

In addition to these pro-active measures that have been adopted for the proposed Project, the following operational constraints and good site practice measures for dredging and construction run-off are also recommended. It should be noted that there is no requirement for constraints on the timing or sequencing of the works, as all concurrent scenarios have been demonstrated not to cause adverse water quality impacts.

6.8.1 *Dredging and Filling*

The impacts to water quality from the loss of sediment to suspension was assessed in terms of the maximum rates of dredging and/or filling during the construction of the seawall, reclamation and approach channel and turning basin. The assessment was carried out based on the predicted loss rates of fine sediment to suspension from the different types of plant working on the site during the times of maximum dredging and/or filling. The highest loss rate was predicted to occur during the time at which the maximum rate of dredging was occurring. The maximum loss rate should then be limited to the values adopted in the Study and it was predicted that this rate of loss would not give rise to adverse impacts. It is therefore recommended that the maximum loss rate during the dredging works be kept at these limits.

The following measures shall apply at all times:

- No overflow is permitted from the trailer suction hopper dredger but the Lean Mixture Overboard (LMOB) system will be in operation at the beginning and end of the dredging cycle when the drag head is being lowered and raised.

- Dredged marine mud will be disposed of in a gazetted marine disposal area in accordance with the *Dumping at Sea Ordinance* (*DASO)* permit conditions.

- Disposal vessels will be fitted with tight bottom seals in order to prevent leakage of material during transport.

- Barges will be filled to a level, which ensures that material does not spill over during transport to the disposal site and that adequate freeboard is maintained to ensure that the decks are not washed by wave action.

- After dredging, any excess materials will be cleaned from decks and exposed fittings before the vessel is moved from the dredging area.

- The contractor(s) will ensure that the works cause no visible foam, oil, grease, litter or other objectionable matter to be present in the water within and adjacent to the dredging site.

- If installed, degassing systems will be used to avoid irregular cavitations within the pump.

- Monitoring and automation systems will be used to improve the crew’s information regarding the various dredging parameters to improve dredging accuracy and efficiency.

- Control and monitoring systems will be used to alert the crew to leaks or any other potential risks.

- When the dredged material has been unloaded at the disposal areas, any material that has accumulated on the deck or other exposed parts of the vessel will be removed and placed in the hold or a hopper. Under no circumstances will decks be washed clean in a way that permits material to be released overboard.

- Dredgers will maintain adequate clearance between vessels and the seabed at all states of the tide and reduce operations speed to ensure that excessive turbidity is not generated by turbulence from vessel movement or propeller wash.

- Deploy silt curtain to minimise the elevation of suspended solids to nearby sensitive receivers (1). Details of silt curtain installation should be proposed by the contractor prior to the commencement of dredging/sandfilling works and submitted to the IEC for approval.

- During dredging operations, cage type silt curtains will be installed to enclose the dredging areas next to the grab dredgers.

- A constructed seawall will be in place before the commencement of the sandfilling works for reclamation. The seawall will be above the high water level and will have an opening of 50 - 100 m for barge access.

- In case the seawall trench is filled by sand, the dispersion of the sediment plume will be restrained by installation of silt curtain around the sandfilling area.

As discussed in *Section 6.6*, it is expected that the construction works are generally environmentally acceptable for most sensitive receivers. They will give rise to short-term exceedances at one sensitive receiver, i.e., non-gazetted beach at Lung Kwu Sheung Tan (SR5a). *Table 6.15* presents the predicted SS values at SR5a after applying the above mitigation measures including construction a seawall, installation of stand type silt curtains around the sandfilling areas, and deployment of cage type silt curtains around the dredging areas next to the grab dredgers.

As seen from *Table 6.15*, no WQO exceedance is predicted if the deployment of the proposed mitigation measures is in place during dredging and filling works.

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(1) It should be noted that the Black Point site is not the preferred option (see Part 4 of the EIA Report) and hence the details of silt curtain will not be provided at this stage. Should the site be further pursued, details of silt curtain will be provided to EPD for approval prior to the commencement of works.

Table 6.15 Predicted SS Elevations after Implementation of Mitigation Measures

Sensitive Receiver	**Name**	**ID**	**Scenario**	**WQO Allowable Elevation**		**Without Mitigation Measures Maximum Predicted SS Elevation (mg L^{-1})**		**Proposed Mitigation Measures**	**Reduction Factor of Cage Type Curtain and Seawall(c)**	**With Cage Type Curtain and Seawall Maximum Predicted SS Elevation(mg L^{-1})**		**Reduction Factor of Stand Type Curtain**	**With Stand Type Curtain Maximum Predicted SS Elevation (mg L^{-1})**	
				Dry	**Wet**	**Dry**	**Wet**			**Dry**	**Wet**		**Dry**	**Wet**
Non-gazetted Beach	Lung Kwu Sheung Tan	SR5a	1a	8.2	5.6	12.04 (a)	2.36	• Seawall (with a 50-100 m opening) in place prior to the sandfilling works; • stand type silt curtain around the sandfilling area; and • cage type silt curtain next to grab dredger	75%	3.7	-	60%	3.1	-
Non-gazetted Beach	Lung Kwu Sheung Tan	SR5a	1b	8.2	5.6	12.91 (b)	2.4	• Seawall (with a 50-100 m opening) in place prior to the sandfilling works; • stand type silt curtain around the sandfilling area; and • cage type silt curtain next to grab dredger	75%	4.0	-	60%	3.4	-

Sensitive Receiver	Name	ID	Scenario	WQO Allowable Elevation		Without Mitigation Measures Maximum Predicted SS Elevation (mg L^{-1})		Proposed Mitigation Measures	Reduction Factor of Cage Type Curtain and Seawall(c)	With Cage Type Curtain and Seawall Maximum Predicted SS Elevation(mg L^{-1})		Reduction Factor of Stand Type Curtain	With Stand Type Curtain Maximum Predicted SS Elevation (mg L^{-1})	
				Dry	Wet	Dry	Wet			Dry	Wet		Dry	Wet

Notes:

a. Approximate SS contribution from the marine construction activities is 24.7%from all dredging activities and 7.7% from sandfilling for seawall trench and 67.6% from sandfilling for reclamation.

b. Approximate SS contribution from the marine construction activities is 20.6%from all dredging activities and 8.1% from sandfilling for seawall trench and 71.4% from sandfilling for reclamation.

c. Seawall is a physical barrier of low permeability and hence its sediment reduction factor is likely to be higher than that of a cage type silt curtain. Despite, for assessment purpose, it is assumed that seawall has the same sediment reduction factor as that of cage type silt curtain.

6.8.2 *Land Based Construction Activities*

Appropriate on-site measures are defined to reduce potential impacts, which will be sufficient to prevent adverse impacts to water quality from land based construction activities. These measures are appropriate for general land based construction activities.

Construction Run-off

- Prior to the commencement of the site formation earthworks, surface water flowing into the site from uphill will be intercepted through perimeter channels at site boundaries and safely discharged from the site via adequately designed sand/silt removal facilities such as sand traps.

- Channels, earth bunds or sand bag barriers will be provided on site to direct stormwater to silt removal facilities. The design of silt removal facilities will make reference to the guidelines in *Appendix A1* of *ProPECC PN 1/94*.

- The surface runoff or extracted ground water contaminated by silt and suspended solids will be collected by the on-site drainage system and discharged into storm drains after the removal of silt in silt removal facilities.

- Unprotected partially formed soil slopes will be temporarily protected by plastic sheetings, suitably secured against the wind, at the end of each working day.

- Earthworks to form the final surfaces will be followed up immediately with surface protection and drainage works to prevent erosion caused by rainstorms.

- Appropriate surface drainage will be designed and provided where necessary. All slope drainage will be designed to the Geotechnical Manual for Slopes published by the Geotechnical Engineering Office of The Civil Engineering and Development Department.

- Temporary trafficked areas and access roads formed during construction will be protected by coarse stone ballast or equivalent. These measures shall prevent soil erosion caused by rainstorms.

- Drainage systems, erosion control and silt removal facilities will be regularly inspected and maintained to ensure proper and efficient operation at all times and particularly following rainstorms. Deposited silt and grit will be removed regularly.

- Measures will be taken to reduce the ingress of site drainage into excavations. If trenches have to be excavated during the wet season, they will be excavated and backfilled in short sections wherever practicable. Water pumped out from trenches or foundation excavations will be discharged into storm drains via silt removal facilities.

- Open stockpiles of construction materials (for example, aggregates, sand and fill material) of more than 50 m^3 will have measures in place to prevent the washing away of construction materials, soil, silt or debris into any drainage system.

- Manholes (including newly constructed ones) will be adequately covered and temporarily sealed so as to prevent silt, construction materials or debris being washed into the drainage system.

- The precautions to be taken at any time of year when rainstorms are likely together with the actions to be taken when a rainstorm is imminent or forecasted and actions to be taken during or after rainstorms are summarised in *Appendix A2* of *ProPECC PN 1/94*.

- Oil interceptors will be provided in the drainage system where necessary and regularly emptied to prevent the release of oil and grease into the storm water drainage system after accidental spillages.

- Temporary and permanent drainage pipes and culverts provided to facilitate runoff discharge will be adequately designed for the controlled release of storm flows.

- The temporary diverted drainage will be reinstated to the original condition when the construction work has finished or when the temporary diversion is no longer required.

Boring and Drilling Water

- Water used in ground boring and drilling for preparation of blasting or rock / soil slope stabilization works will be re-circulated to the extent practicable after sedimentation. When there is a need for final disposal, the wastewater will be discharged into storm drains via silt removal facilities.

Wastewater from Building Construction

- Wastewater generated from concreting, plastering, internal decoration, cleaning work and other similar activities, will undergo large object removal by installing bar traps at the drain inlets. It is not considered necessary to carry out silt removal due to the small quantities of water involved. Similarly, pH adjustment of such water is not considered necessary due to the small quantities and the fact that the water is only likely to be mildly alkaline.

Wastewater from Site Facilities

- During the early stages of work, portable chemical toilets will be used and the effluent will be shipped offsite until the temporary sewage treatment work (STW) plant is operational.

- Sewage from toilets, kitchens and similar facilities will be discharged into a foul sewer. Wastewater collected from canteen kitchens, including that from basins, sinks and floor drains, will be discharged into foul sewers via grease traps. The foul sewer will then lead to the temporary STW plant prior to effluent discharge to the ocean.

- Vehicle and plant servicing areas, vehicle wash bays and lubrication bays will, as far as practical, be located within roofed areas. The drainage in these covered areas will be connected to foul sewers via an oil/water interceptor.

- Oil leakage or spillage will be contained and cleaned up immediately. Waste oil will be collected and stored for recycling or disposal, in accordance with the *Waste Disposal Ordinance*.

Storage and Handling of Oil, Other Petroleum Products and Chemicals

- Fuel tanks and chemical storage areas will be provided with locks and be sited on sealed areas.

- The storage areas of oil, fuel and chemicals will be surrounded by bunds or other containment device to prevent spilled oil, fuel and chemicals from reaching the receiving waters.

- The Contractors will prepare guidelines and procedures for immediate clean-up actions following any spillages of oil, fuel or chemicals.

- Surface run-off from bunded areas will pass through oil/water separators prior to discharge to the stormwater system.

Wastewater from Concrete Batching Plant

- Wastewater generated from the washing down of mixer trucks and drum mixers and similar equipment should be recycled wherever practicable. To prevent pollution from wastewater overflow, the pump sump of any wastewater recycling system will be provided with a standby pump of adequate capacity.

- Under normal circumstances, surplus wastewater from the concrete batching will be treated in silt removal and pH adjustment facilities before it is discharged into foul sewers. Discharge of this wastewater into storm drains will require more elaborate treatment and regular testing checks. Surface run-off will be separated from the concrete batching plant as much as possible and diverted to the stormwater drainage system. Surface run-off contaminated by materials in the concrete batching plant will be adequately treated before disposal into stormwater drains.

6.9 WATER QUALITY MITIGATION MEASURES – OPERATION PHASE

6.9.1 *Hydrodynamics*

The hydrodynamic modelling has predicted that the reclamations of the marine works and structures will have minimal effects on hydrodynamics and water quality. Mitigation measures are not considered to be necessary.

6.9.2 *Cooled Water and Residual Chlorine Discharge*

For the cooled water discharge, it is proposed that the cooled water with a temperature of approximately 8.5 °C, instead of 12.5 °C, below ambient should be discharged at the seawater outfall.

Regarding the residual chlorine discharge, the relatively low concentration of antifoulant combined with the high degree of mixing inherent in the coastal margin will result in rapid dilution of the effluent to non-significant concentrations and hence mitigation measures are considered unnecessary.

6.9.3 *Storage and Handling of Oil, Other Petroleum Products and Chemicals*

- Fuel tanks and chemical storage areas should be provided with locks and be sited on sealed areas.

- The storage areas of oil, fuel and chemicals should be surrounded by bunds or other containment device to prevent spilled oil, fuel and chemicals from reaching the receiving waters.

- Guidelines and procedures will be established for immediate clean-up actions following any spillages of oil, fuel or chemicals.

- Surface run-off from bunded areas should pass through oil/grease traps prior to discharge to the stormwater system.

Other measures are detailed in *Section 14* to prevent groundwater contamination.

6.9.4 *Wastewater*

- Sewage from toilets, kitchens and similar facilities should be discharged into a foul sewer. Wastewater collected from canteen kitchens, including that from basins, sinks and floor drains, should be discharged into foul sewers via grease traps. The foul sewer will then lead to the sewage treatment plant prior to effluent discharge to the ocean.

- Vehicle and plant servicing areas, vehicle wash bays and lubrication bays should, as far as possible, be located within roofed areas. The drainage in these covered areas should be connected to foul sewers via a petrol interceptor.

- Oil leakage or spillage should be contained and cleaned up immediately. Waste oil should be collected and stored for recycling or disposal, in accordance with the *Waste Disposal Ordinance*.

6.10 ENVIRONMENTAL MONITORING AND AUDIT (EM&A)

6.10.1 Construction Phase

Water quality monitoring and auditing is recommended for the construction phase. The specific monitoring requirements are detailed in the *Environmental Monitoring and Audit Manual* (EM&A) associated with this EIA Report.

6.10.2 Operation Phase

As no unacceptable impacts have been predicted to occur during the operation of the LNG terminal at Black Point, monitoring of marine water quality during the operational phase is not considered necessary. It is noted that the operational discharges from the terminal will require a license under the *WPCO* which stipulates regular effluent monitoring as part of the license conditions.

6.11 RESIDUAL ENVIRONMENTAL IMPACTS

It is predicted that there would be WQO exceedance at the non-gazetted beach at Lung Kwu Sheung Tan without applying any mitigation measures. However, no exceedance will occur if the deployment of the proposed mitigation measures is in place during dredging and filling works (see *Table 6.15*). Therefore, it is expected that no residual environmental impacts will result from the construction works.

Given the immediate dilution of the cooled water discharges from the terminal outfall and that the limited volume of sewage generated would be treated on site before being discharged in accordance with the EPD's required standards, residual environmental impacts during the operation phase are not expected.

6.12 CUMULATIVE IMPACTS

At present there are no committed projects that could have cumulative impacts with the construction of the terminal at Black Point.

6.13 CONCLUSIONS

This Section of the EIA has described the impacts on water quality arising from the construction and operation of the proposed LNG terminal. The purpose of the assessment was to evaluate the acceptability of predicted impacts to water quality.

Computer modelling has been used to simulate the loss of sediment to suspension during the construction phase and the impacts due to cooled water discharges during the operation phase. The results and findings of the computer modelling have been provided and summarized.

Potential impacts arising from the proposed dredging works are predicted to be largely confined to the specific works areas. The predicted elevations of suspended sediment concentrations are transient in nature and not predicted to cause adverse impacts to water quality at the sensitive receivers.

During the operation phase, adverse impacts to water quality are not expected to occur as the area affected by the cooled water discharge is extremely small and in the immediate vicinity of the discharge point.

Annex 6A

Water Quality Method Statement

CONTENTS

1 INTRODUCTION

This *Method Statement* presents information on the approach for the water quality assessment and modelling works for the study. The methodology has been based on the following three focus areas, as follows:

- Model Selection;
- Input Data; and,
- Scenarios.

1.1 INTERPRETATION OF THE REQUIREMENTS: KEY ISSUES AND CONSTRAINTS

The objectives of the modelling exercise are to assess:

- Effects of construction, which comprises the study of the dispersion of sediments released during construction;

- Effects of operation due to reclamations (affecting flows and potentially water quality due to changing flows); discharges (potentially affecting temperatures and water quality due to chlorine or other antifoulants); and maintenance dredging (potentially increasing suspended solids in water column);

- Any residual impacts, which include any change in hydrodynamic regime; and

- Any cumulative impacts due to other projects or activities within the study area.

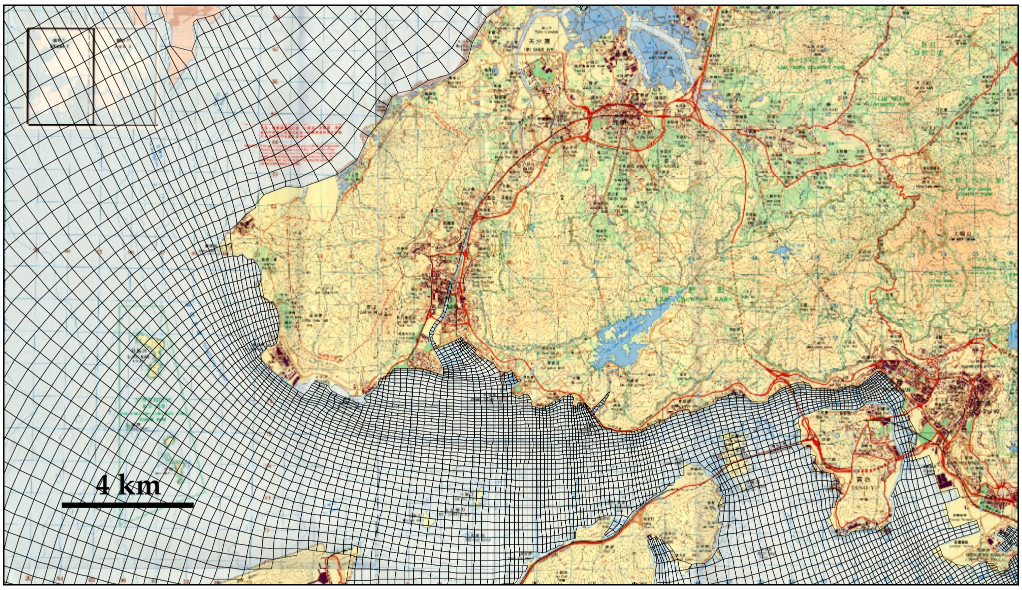
The construction and operational effects have been studied by means of mathematical modelling using existing models that have been set up by WL | Delft Hydraulics (Delft) on behalf of the Environmental Protection Department (EPD) or approved by the EPD for use in environmental assessments.

1.2 MODEL SELECTION

The existing Western Harbour Model of the Delft 3D water quality (WAQ) and hydrodynamic suite of models have been used to simulate effects on hydrodynamics and water quality. These models have been calibrated as part of the Landfill Extension Study.

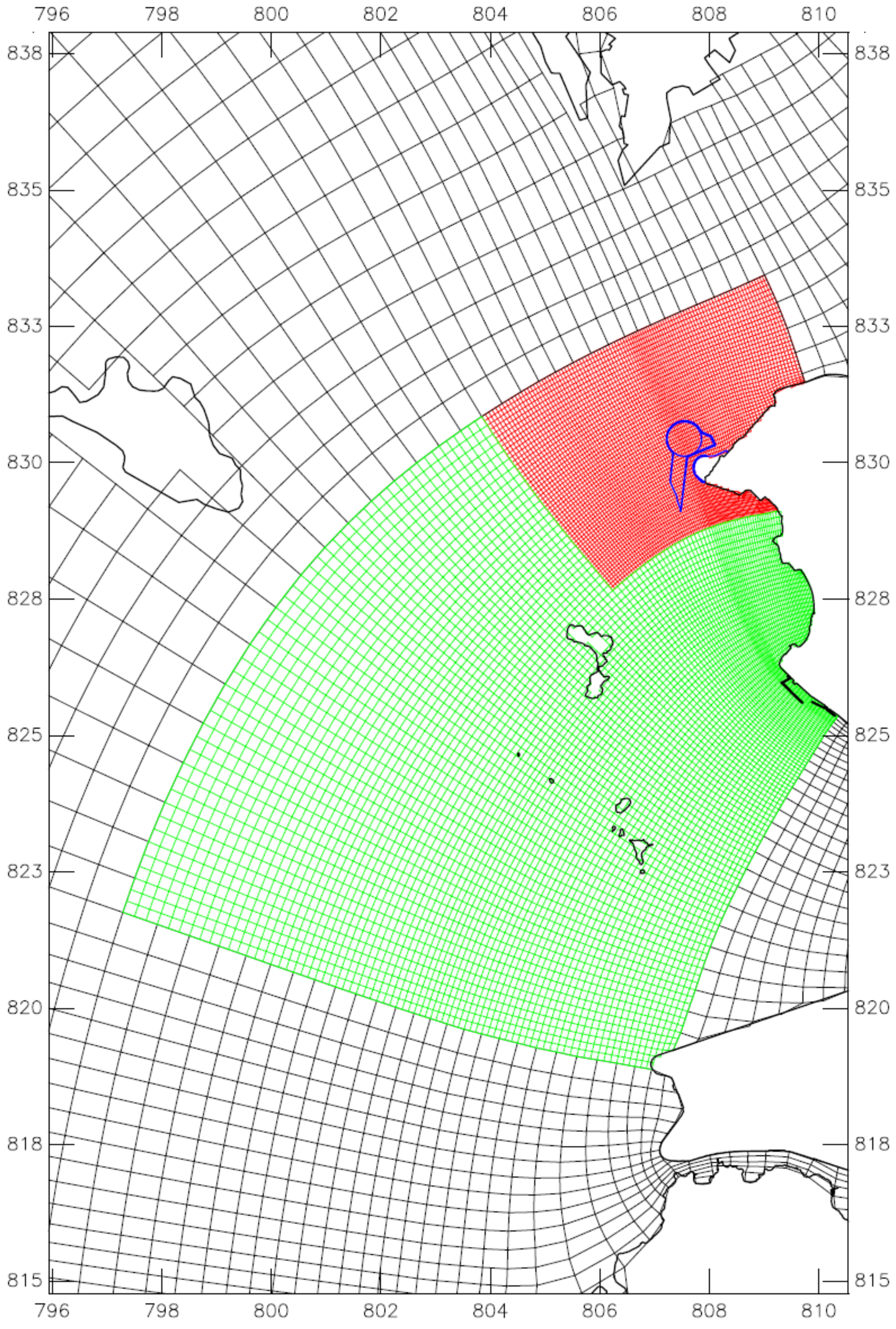
The WAQ model has been used to simulate water quality impacts during construction and operation of the facility. The existing Update model has the required spatial extent. The existing grid of the model in the vicinity of Black Point is shown in *Figure A1.1*.

Figure A1.1 *Model Grid of the Update Model in the Vicinity of Black Point*



As seen in *Figure A1.1*, the grid size of the existing model near the site is in the order of about 300m. The extent of the reclamation at the site is such that it covers approximately one grid cell. It was therefore considered appropriate to carry out refinement of the water quality and hydrodynamic grids to provide improved resolution (less than 75m) in some of the key areas of interest. The refinements of the model grid of the Update Model in the vicinity of Black Point are shown in *Figure A1.2*.

Figure A1.2 Model Grid of the Update Model in the Vicinity of Black Point



1.3 *COASTLINE & BATHYMETRY*

Hydrodynamic data have been obtained using coastline and bathymetry for a time horizon representative of the construction and operation of the facility (i.e., 2007 onwards). *Figure A1.3a and A1.3b* show the bathymetry and coastline during construction phase, whereas *Figure A1.4* during the operational phase at the Black Point site.

Figure A1.3a Bathymetry and Coastline in the Vicinity of Black Point (2007 onwards)

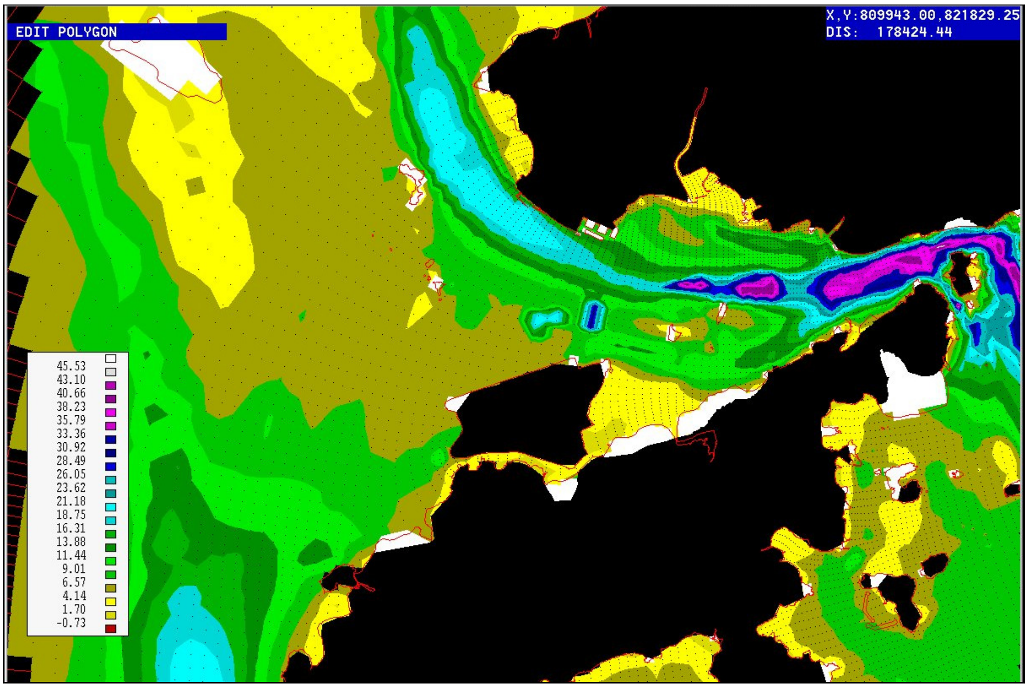


Figure A1.3b   Coastline Used in the Model for the Project Area (2007 onwards)

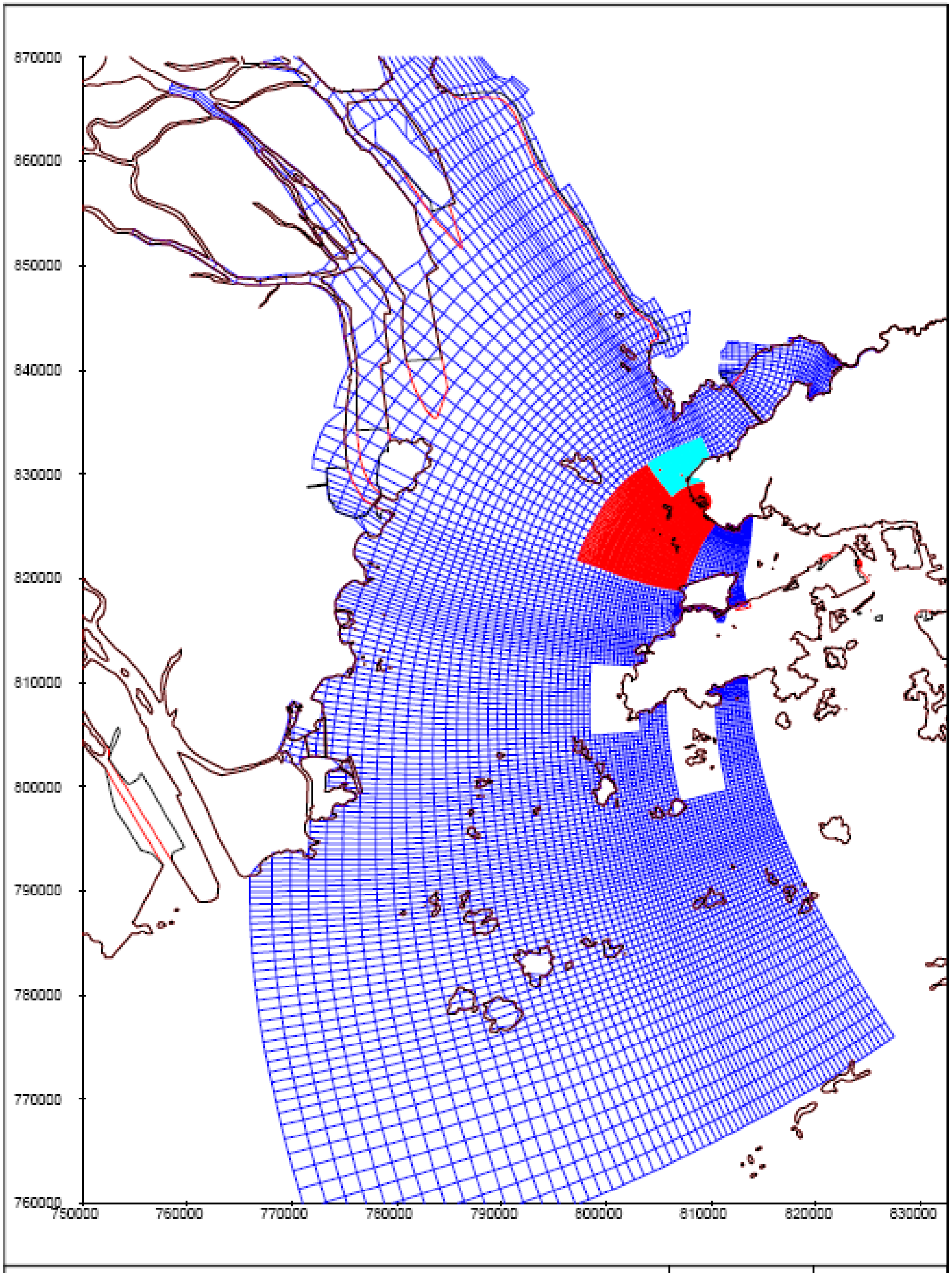
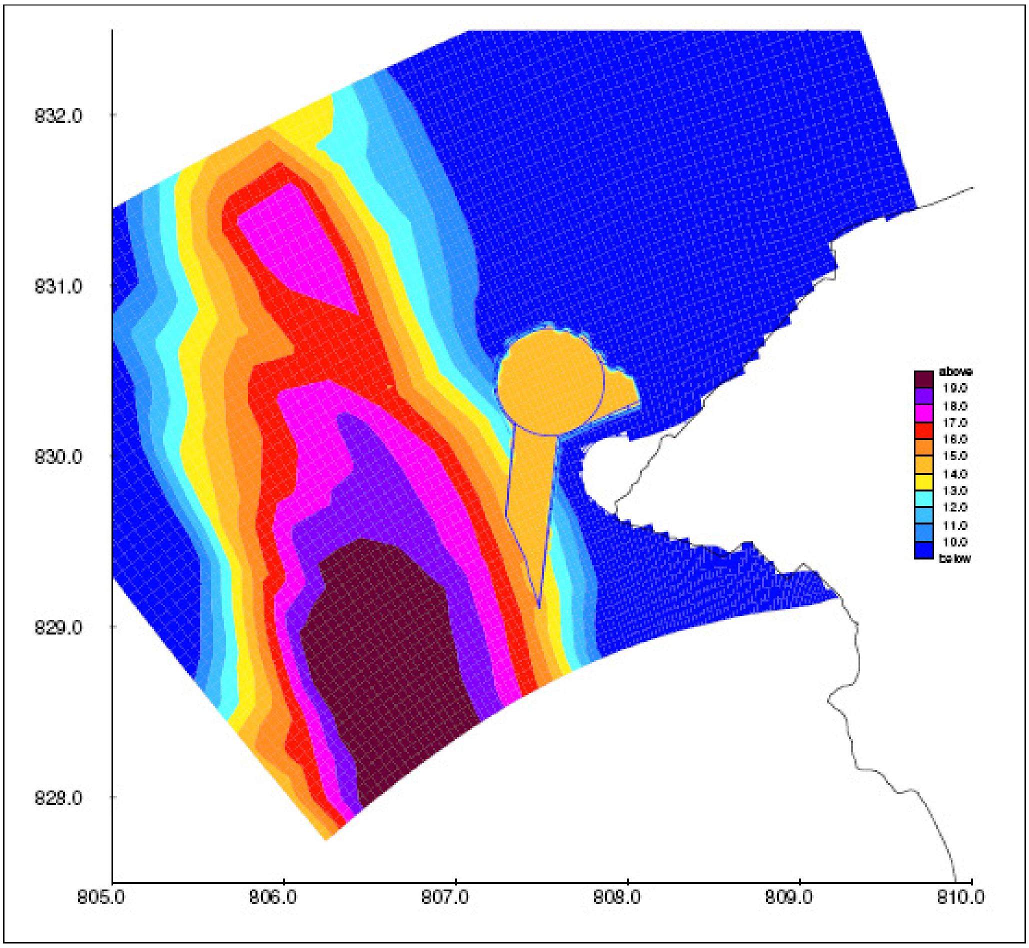


Figure A1.4 Operational Bathymetry at Black Point



1.4 VECTOR INFORMATION

The current patterns in the project area prior to the commissioning of the Project are presented in *Figures BP_B01-B08* in *Annex 6B*. The current patterns in the project area after the completion of the Project are presented in *Figures BP_F01_F08* in *Annex 6F*.

Under the pre-project condition, the plots indicate that, in general, for the area in around the LNG terminal at Black Point current velocities rarely exceed 1.0 m s^{-1} in the dry and wet seasons. Maximum current velocities appear at the surface layer to be in the order of 1.4 m s^{-1} during both seasons, in areas predominantly offshore, or to the north-west of Black Point.

Under the post-project condition, the plots indicate that, in general, maximum current velocities appear at the surface layer to be in the order of 1.3 m s^{-1} in the dry season, in the area of the approach channel turning basin. In the wet season, maximum current velocities appear at the surface layer to be in the order of 1.5 m s^{-1}, in the area of the southern approach channel. In the turning basin, the maximum current velocities are predicted to be 1.1 m s^{-1}.

1.5 *INFORMATION ON MODEL INPUTS*

Details on the model input parameters are presented in *Appendix 6A* in Annex 6A.

1.6 *UNCERTAINTIES IN ASSESSMENT METHODOLOGIES*

Uncertainties in the assessment of the impacts from suspended sediment plumes should be considered when drawing conclusions from the assessment. In carrying out the assessment, the worst case assumptions have been made in order to provide a conservative assessment of environmental impacts. These assumptions are as follows:

- The assessment is based on the peak dredging and filling rates. In reality, these will only occur for short period of time; and,
- The calculations of loss rates of sediment to suspension are based on conservative estimates for the types of plant and methods of working.

The conservative assumptions presented above allow a prudent approach to be applied to the water quality assessment.

The following uncertainties has not included in the modelling assessment.

- *Ad hoc* navigation of marine traffic;
- Near shore scouring of bottom sediment; and
- Access of marine barges back and forth the site.

2 WATER SENSITIVE RECEIVERS

The water quality sensitive receivers (SRs) have been identified in the EIA (*Part 2 - Section 6: Water Quality Assessment*) in accordance with *Annex 14* of the *Technical Memorandum* on EIA Process (*EIAO, Cap.499, S.16*). These SRs are illustrated in *Figure A2.1* and listed in *Table A2.1*. For the assessment purpose, water modelling output points (MPs and SRs) at some representative locations are selected for further analysis and they are listed in *Tables A2.1 and A2.2* and also presented in *Figure A2.1*.

Table A2.1 Water Quality Sensitive Receivers (WSRs) around Proposed LNG Terminal at Black Point

Sensitive Receiver	**Name**	**Water Quality Modelling Output Location**	**Included in the Model**
Fisheries Resources			
Spawning/ Nursery Grounds	Fisheries Spawning Ground in North Lantau	SR8	Yes
		SR8a-b	No
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR6e	Yes
	Airport	SR7d	Yes
Fish Culture Zone	Ma Wan	SR40a-b	No
Oyster Bed	Lau Fau Shan	SR2c	No
Marine Ecological Resources			
Seagrass Beds	Pak Nai	SR2	Yes
	Ngau Ho Shek	SR2a	No
	Tung Chung Bay	SR39	Yes
Marine Parks	Designated Sha Chau and Lung Kwu Chau	SR6a-d	Yes
Intertidal Mudflats	Pak Nai	SR1	Yes
Mangroves	Pak Nai	SR2	Yes
	Ngau Ho Shek	SR2b	No
	Tung Chung Bay	SR39	Yes
Horseshoe Crab Nursery Grounds	Pak Nai	SR1	Yes
		SR2a	No
		SR10	Yes
		SR18	Yes
		SR39	Yes
Others			
Gazetted Beaches	Butterfly Beach	SR5c	Yes
Non-gazetted Beaches	Lung Kwu Sheung Tan	SR5a	Yes

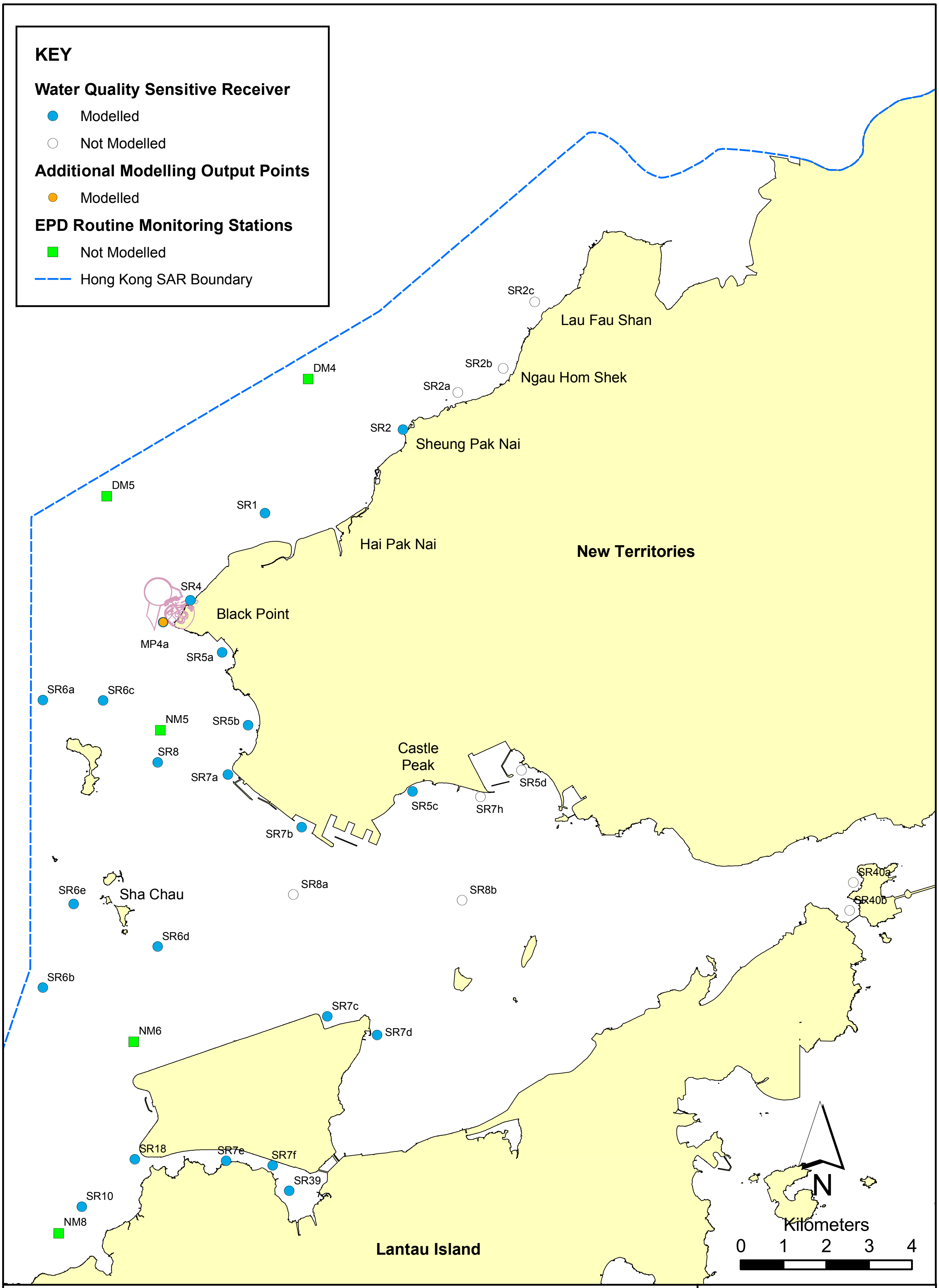


FIGURE A2.1

Water Quality Sensitive Receivers and
Additional Modelling Output Points in the Vicinity of
the Proposed LNG Terminal at Black Point

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Sensitive Receiver	Name	Water Quality Modelling Output Location	Included in the Model
	Lung Kwu Tan	SR5b	Yes
Seawater Intakes	Black Point Power Station	SR4	Yes
	Castle Peak Power Station	SR7a	Yes
	Tuen Mun Area 38	SR7b	Yes
	Airport	SR7c-f	Yes
	Tuen Mun WSD	SR7h	No

Table A2.2 *Water Quality Modelling Output Points (MPs) around Proposed LNG Terminal at Black Point*

Sensitive Receiver	Name	Water Quality Modelling Output Location	Included in the Model
Seawater Intakes	Operational Phase LNG Intake	MP4a	Yes

Table A2.3 *EPD Routine Water Quality Monitoring Stations in the Vicinity of the Project Area*

EPD Monitoring Stations	Respective WCZ	Included in the Model
Seawater Intakes	Operational Phase LNG Intake	Yes

3 CONSTRUCTION PHASE

For the construction phase the WAQ model has been used to **directly** simulate the following parameters:

- suspended sediments; and
- sediment deposition.

It is assumed that the worst-case construction phase impacts will be at the commencement of dredging, when there is no depression formed to trap sediments disturbed during dredging.

Note that DO, TIN and NH_3-N are calculated based on the modelled maximum SS concentrations as shown in *Section 6: Water Quality Impact Assessment*.

3.1 WORKING TIME

The estimation of programme for dredging activity at Black Point is based on the assumption of a 16 working hours per day with 6 working days per week. An arrangement of 24 working hours and 7 working days is unlikely to be feasible for Black Point due to the potential noise impact generated by barges travelling at night to the villages located in close proximity to the route of Black Point and the dumping sites at South Cheung Chau.

3.2 OVERVIEW OF DREDGING PLANTS

3.2.1 Grab Dredgers

Grab dredgers will be utilised in the dredging works for the reclamation works at the terminal as well as the navigation channel, turning circle and berthing box. Also the submarine water mains and some of the sections of the submarine pipeline may need to be pre-trenched and this is likely to be done utilising a grab dredger.

Grab dredgers may release sediment into suspension by the following mechanisms:

- Impact of the grab on the seabed as it is lowered;
- Washing of sediment off the outside of the grab as it is raised through the water column and when it is lowered again after being emptied;
- Leakage of water from the grab as it is hauled above the water surface;
- Spillage of sediment from over-full grabs;
- Loss from grabs which cannot be fully closed due to the presence of debris;
- Release by splashing when loading barges by careless, inaccurate methods; and
- Disturbance of the seabed as the closed grab is removed.

In the transport of dredging materials, sediment may be lost through leakage from barges. However, dredging permits in Hong Kong include requirements that barges used for the transport of dredging materials have bottom-doors that are properly maintained and have tight-fitting seals in order to prevent leakage. Given this requirement, sediment release during transport is not proposed for modelling and its impact on water quality is not addressed under this Study.

Sediment is also lost to the water column when discharging material at disposal sites. The amount that is lost depends on a large number of factors including material characteristics, the speed and manner in which it is discharged from the vessel, and the characteristics of the disposal sites. As impacts due to disposal operations at potential disposal sites have been assessed under separate studies, they are not addressed further in this document.

The modelling of dredging using grabs has assumed a loss rate of 17 kg m^{-3} dredged sediment. This rate is representative of grab dredgers (with a closed grab size of approximately 8 m^3 minimum) working in areas without debris. It is possible that the contractor may utilise a larger grab in the construction. The loss rate for a larger grab is lower than for a smaller grab.

Generally, a split-bottom barge could have a capacity of 900 m^3. A bulk factor of 1.3 would normally be applied, giving a dredging rate of 700 m^3 per barge. The hopper dry density for an 800 to 1,000 m^3 capacity barge is around 0.75 to 1.24 ton m^{-3}. Assuming 16 working hours per day for Black Point, with allowance on the demobilisation of filled barge and remobilisation of empty barges, a maximum of 7 barges could be filled per day. Therefore, the average daily dredging rate would be approximately 4,900 m^3. The use of grab with bigger size (16 m^3) can increase the daily dredging rate to a maximum of 6,500 m^3, though it is not readily available for all the dredging and reclamation contractors in the local market.

Assuming the worse case, when the grabs are just commencing dredging in relatively shallow water and hence a higher production output, the maximum daily rate of production will be about 8,000 m^3 day^{-1} (0.14 m^3 s^{-1}), giving a rate of release (in kg s^{-1}) for the dredger as follows:

Loss Rate (kg s^{-1})

*= Dredging Rate (m^3 s^{-1}) * Loss Rate (kg m^{-3})*

*= 0.14 m^3 s^{-1} * 17 kg m^{-3}*

= 2.36 kg s^{-1}

The average release rates will, in fact, be somewhat less than those indicated above. The instantaneous dredging (and loss) rates will also decrease as the depth increases. This is because the assumed dredging production rates are instantaneous rates that will not be maintained due to delays for breakdowns, maintenance, crew changes and time spent relocating the dredgers. The release rates that are to be modelled therefore represent conservative worst-case conditions that will not prevail for any great length of time.

A review of the vector plots at the sites allowed identification of areas that would disperse sediment further than other areas due to higher current velocities. These areas were consequently chosen as the locations of the sources of sediment in the model.

3.2.2 *Trailing Suction Hopper Dredgers*

Trailing Suction Hopper Dredgers (TSHD) will be used mainly for the navigation channels and turning circle.

The hopper dry density for a TSHD is typically 0.75 ton m^{-3}. TSHD could dredge at a faster rate than grab dredgers (typical dredging rate of 5,400 m^3 per trip per TSHD with a maximum dredging rate up to 7,200 m^3 per trip depending on the vessel size).

For the modelling scenarios it has been assumed that the Contractor will utilise a small (<5,000 m^3) to medium (5,000 – 10,000 m^3) TSHD. The suggested size of trailer dredger is approximately 8,000 m^3, which commonly operate in Hong Kong.

The rate of loss for trailer dredgers is 7 kg m^{-3} dredged which is considered to be a conservative assumption and at the upper end of measured loss rates for TSHD (1) (2), and assumes that no overflow is permitted but the Lean Mixture Overboard (LMOB) system is in operation at the beginning and end of the dredging cycle when the drag head is being lowered and raised from the seabed. Assuming that no more than one dredger operates simultaneously and the loading time for each dredging trip is approximately 0.75 hour a loss rate (in kg s^{-1}) is calculated as follows:

$$\text{Loss Rate (kg } s^{-1})$$

$$= \text{Dredging Rate Per Trip } (m^3\ s^{-1}) * \text{Loss Rate (kg } m^{-3})$$

$$= 7{,}200\ m^3\ trip^{-1} / 0.75\ hr / 3600\ s\ hr^{-1} * 7\ kg\ m^{-3}$$

$$= \mathbf{18.67\ kg\ s^{-1}}$$

For the THSD working at Black Point the modelling has assumed that the trailer will dispose at the South Cheung Chau which would introduce the travelling time to and from the site to be 3.32 hours and a cycle time would be approximately 5.32 hours. This would equate to 3 trips per day, which means a daily dredging rate of 21,600 m^3 day^{-1} (3).

During dredging the drag head will sink below the level of the surrounding seabed and the seabed sediments will be extracted from the base of the trench formed by the passage of the draghead. The main source of sediment release is the bulldozing effect of the draghead when it is immersed in the mud. This mechanism means that sediment is lost to suspension very close to the

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(1) Kirby, R and Land J M (1991). The impact of Dredging - A Comparison of Natural and Man-Made Disturbances to Cohesive Sedimentary Regimes. Proceedings CEDA-PIANC Conference (incorporating CEDA Dredging Days), November 1991, Amsterdam. Central Dredging Association, the Netherlands.

(2) Environment Canada (1994). Environmental Impacts of Dredging and Sediment Disposal. Les Consultants Jaques Beraube Inc for the Technology Development Section, Environmental Protection Branch, Environment Canada, Quebec and Ontario Branch.

(3) The maximum dredging rate for THSD per day is 21,600 m^3. Three trips can be conducted per day and the dredging rate for each trip is 7,200 m^3.

level of the surrounding seabed and a height of 1 m has been adopted for the initial location of sediment release in the model.

3.3 CONSTRUCTION SCENARIOS

3.3.1 Scenario 1a

Scenario 1a simulates dredging works at seawall, jetty box, approach channel and turning basin and outfall as well as sandfilling works for seawall trench and reclamation (*Figure A3.1*). The total dredged volume is approximately 3.15 Mm^3. All dredging works will be carried out by grab dredgers while sandfilling works is conducted by a pelican barge.

Dredging Works for Seawall Areas

It is estimated that dredged volume under the seawall is approximately 0.63 Mm^3. Two grab dredgers in total will be used for the construction, starting from each end of the seawall in reverse direction. Hence in the water quality model two moving emission sources, BP01 and BP02, initially locate at the ends of dredging underneath seawall in Area A and Area C respectively, moving towards Area B (*Figure A3.1*). All the releases are continuously emitted in the whole water column with an emission rate of **2.36 kg s^{-1}** (refer to *Section 3.2.1* for detailed calculations).

Dredging Works for Jetty Box, Approach Channel and Turning Basin

The estimated dredged volume along the approach channel/turning basin and berthing area is approximately 2.52 Mm^3 in total. *Figure A3.1* shows the dredging area of the approach channel and turning basin which is divided into three areas, namely Area D, Area E and Area F. A jetty box which is inside Area E will be dredged as well.

Three stationary sources, BP08a, BP09a and BP10a, are assumed in the model to represent the grab dredgers in Areas D, E and F respectively and another stationary source, BP07, represents a grab dredger at the jetty box. The most conservative case is simulated as making the four sources close to other sources. In reality, the grab dredgers will move away from each other and will not retain this proximity to others for a period as long as modelled. In addition, the dredging works at jetty box may be conducted before dredging for Area E and thus concurrent dredging for jetty box and Area E is unlikely to occur.

All the *releases* are continuously emitted in the whole water column with *an* emission rate of **2.36 kg s^{-1}** (refer to *Section 3.2.1* for detailed calculations).

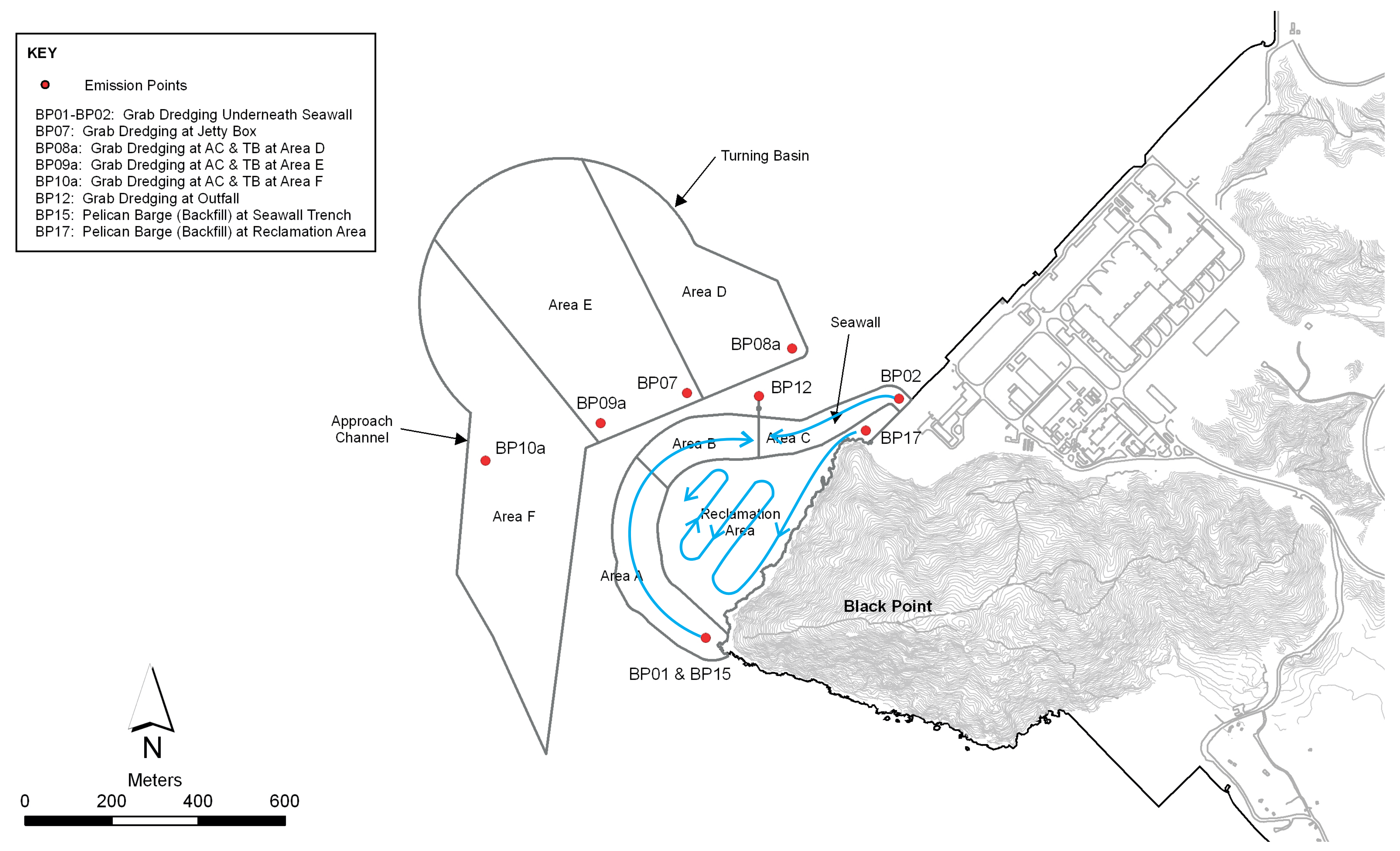

Figure A3.1

Emission Points Defined in the Model for Scenario 1a

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Dredging Works for Submarine Outfall

As shown in *Figure A3.1*, the dredging will be carried under seawater outfall. A stationary point, BP12 is defined in the model which is assumed to be a continuous emission with rate of **2.36 kg s^{-1}** (refer to *Section 3.2.1* for detailed calculations) at the whole water column.

Backfilling for Seawall Trench

Sandfilling for sloping seawall trench (represented by Areas A and B in *Figure A3.1*) by a pelican barge (rainbowing) is simulated by assuming a filling rate of 50,000 m^3 day^{-1} with working hours to be 16 per day.

The fill material will be marine sand which generally has a fine content ranging from 2% to 10%. As the source of material could not be confirmed at the time of this EIA compiled, the upper bound of the fine content, i.e. 10% is assumed for the conservative case.

With a representative dry density of the sand fill taken as 1,938 kg m^{-3}, the loss rate in kg s^{-1} (continuous emission in the whole water column) is calculated as follows:

Loss Rate (kg s^{-1})

*= Percentage Loss Rate * Filling Rate (m^3 s^{-1}) * Dry Density of Sand Fill (kg m^{-3})*

*= 1% * 50,000 m^3 day^{-1} * 1/16/3600 day s^{-1} * 1,938 kg m^{-3}*

= 16.8 kg s^{-1}

A moving source, BP15, is assumed in the model moving along the same trajectory as BP01 which covers Areas A and B. Note that there is no sand filling works for the vertical seawall which locates at the north-eastern side of Black Point. In addition, the backfilling operations for the reclamation will be carried out behind a completely constructed seawall and hence it is not considered in the model simulations.

Backfilling for Reclamation Area

Backfilling for reclamation area is assumed to be filled with marine sand by a pelican barge (rainbowing). On the same basis of backfilling for the seawall trench, a continuous emission of **16.8 kg s^{-1}** (in the whole water column) is assumed in the model. An indicative trajectory of the moving source, BP17, is shown in *Figure A3.1*.

3.3.2 *Scenario 1b*

Scenario 1b simulates the same construction activities as those modelled in Scenario 1a. The difference between Scenario 1b and 1a is a TSHD will be used for dredging at an area of approach channel and turning basin (Area D shown in *Figure A3.2*).

As indicated in *Figure A3.2,* the approach channel and turning basin will be divided into four areas, Areas D, E, F and G. Area D is proposed to be dredged by a TSHD whereas Areas E to G will be dredged by a grab dredger. For each trip travelled by the TSHD, the loss rate will be **18.67 kg s^{-1}** (refer to *Section 3.2.2* for detailed calculations).

A moving source, BP08b, is assumed in the model and it will start at the utmost south of the area and move at a speed of 0.3 m s^{-1} in north-eastern direction following the angle of the approach channel. In order to account for the disposal events as aforementioned in *Section 3.2.2*, the emission is assumed to be instantaneous with a 0.75 hour dredging followed by 1.25-hour on-site idle time and a 3.32-hour disposal whereas disposal will be at South Cheung Chau.

3.3.3 *Construction Programme and Sequence*

Tentative construction programme and indicative construction sequence are shown in *Figures A3.3* and *A3.4* respectively.

KEY

● Emission Points

BP01-02: Grab Dredging underneath Seawall
BP07: Grab Dredging at Jetty Box
BP08b: TSHD Dredging at AC & TB at Area D
BP09b: Grab Dredging at AC & TB at Area E
BP10b: Grab Dredging at AC & TB at Area F
BP11: Grab Dredging at AC & TB at Area G
BP12: Grab Dredging at Outfall
BP15: Pelican Barge (Backfill) at Seawall Trench
BP17: Pelican Barge (Backfill) at Reclamation Area

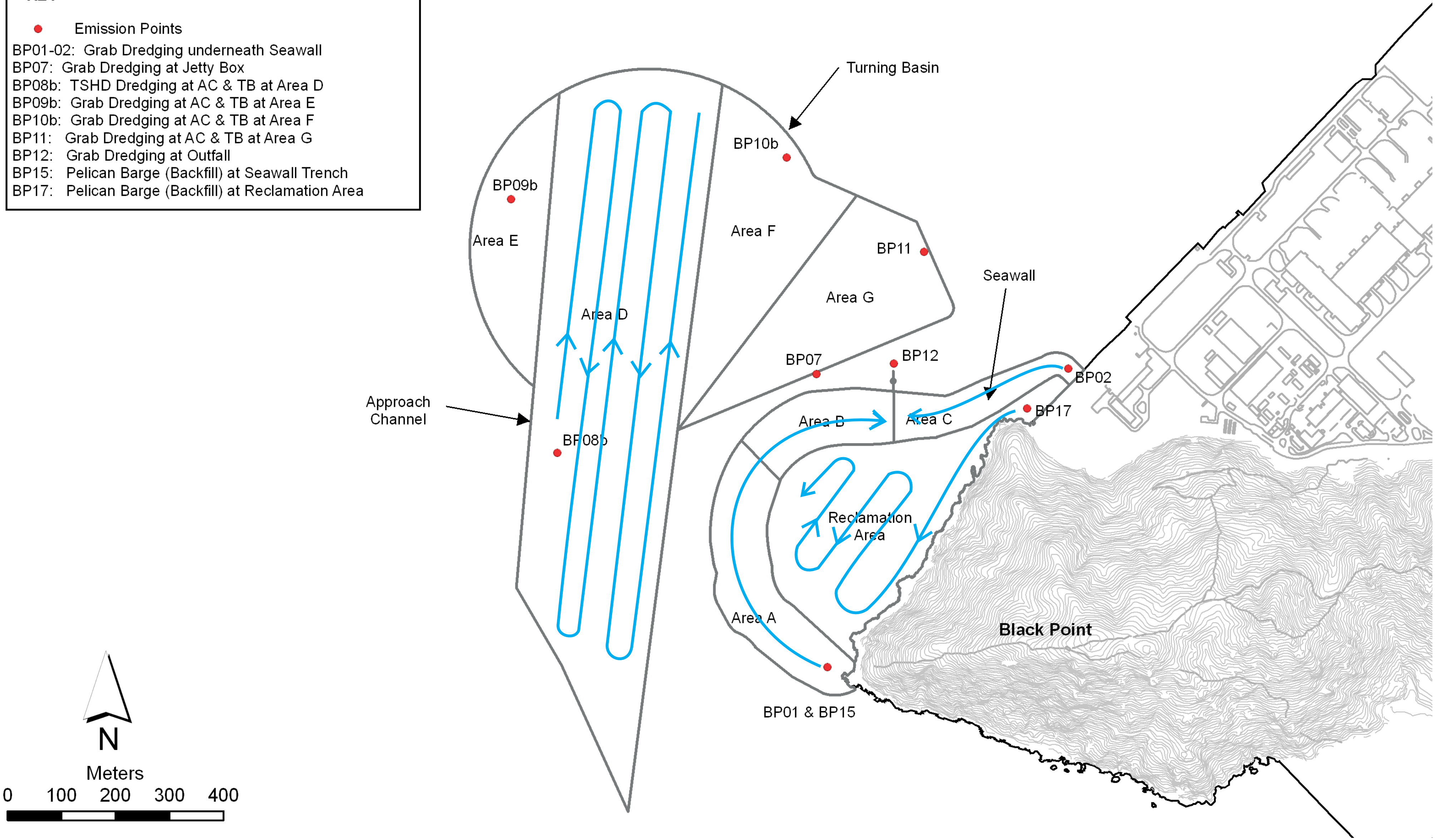

Figure A3.2

Emission Points Defined in the Model for Scenario 1b

FILE: 0018180z12
EIA/0018180_Emission_Pt_Approach-channel_BP_Scen1b.mxd
DATE: 05/10/2006

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Figure A3.3 Tentative Construction Programme

Task Name	Respective Scenario	Respective ID Code		Month																		
			M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20
Reclamation Works - Seawall																						
Dredging Underneath Seawall (Area A and B)	1a and 1b	BP01				■	■	■														
Dredging Underneath Seawall (Area C)	1a and 1b	BP02				■	■															
Sandfill for Sloping Seawall Trench (Area A and B)	1a and 1b	BP15						■	■													
Reclamation Works - Reclamation																						
Area A1 - Placing Sandfill	1a and 1b	BP17								■												
Area A2 - Placing Sandfill	1a and 1b	BP17								■												
Area B1 - Placing Sandfill	1a and 1b	BP17								■												
Area B2 - Placing Sandfill	1a and 1b	BP17										■										
Area C1 - Placing Sandfill	1a and 1b	BP17									■											
Area C2 - Placing Sandfill	1a and 1b	BP17										■										
Main Jetty (Using Grab Dredgers)																						
Dredging at Jetty Box	1a	BP07													■							
Dredging at Approach Channel and Turning Basin at Area D	1a	BP08a													■	■	■	■	■	■	■	
Dredging at Approach Channel and Turning Basin at Area E	1a	BP09a														■	■	■	■	■	■	
Dredging at Approach Channel and Turning Basin at Area F	1a	BP10a													■	■	■	■	■	■	■	
Main Jetty (Using Grab Dredgers and a TSHD)																						
Dredging at Jetty Box		BP07													■							
Dredging at Approach Channel and Turning Basin at Area D	1b	BP08b													■	■	■					
Dredging at Approach Channel and Turning Basin at Area E	1b	BP09b														■	■	■	■	■		
Dredging at Approach Channel and Turning Basin at Area F	1b	BP10b													■	■	■	■	■	■		
Dredging at Approach Channel and Turning Basin at Area G	1b	BP11													■	■	■	■	■	■		
Outfall Construction																						
Dredging Under Outfall	1a and 1b	BP12																■	■			

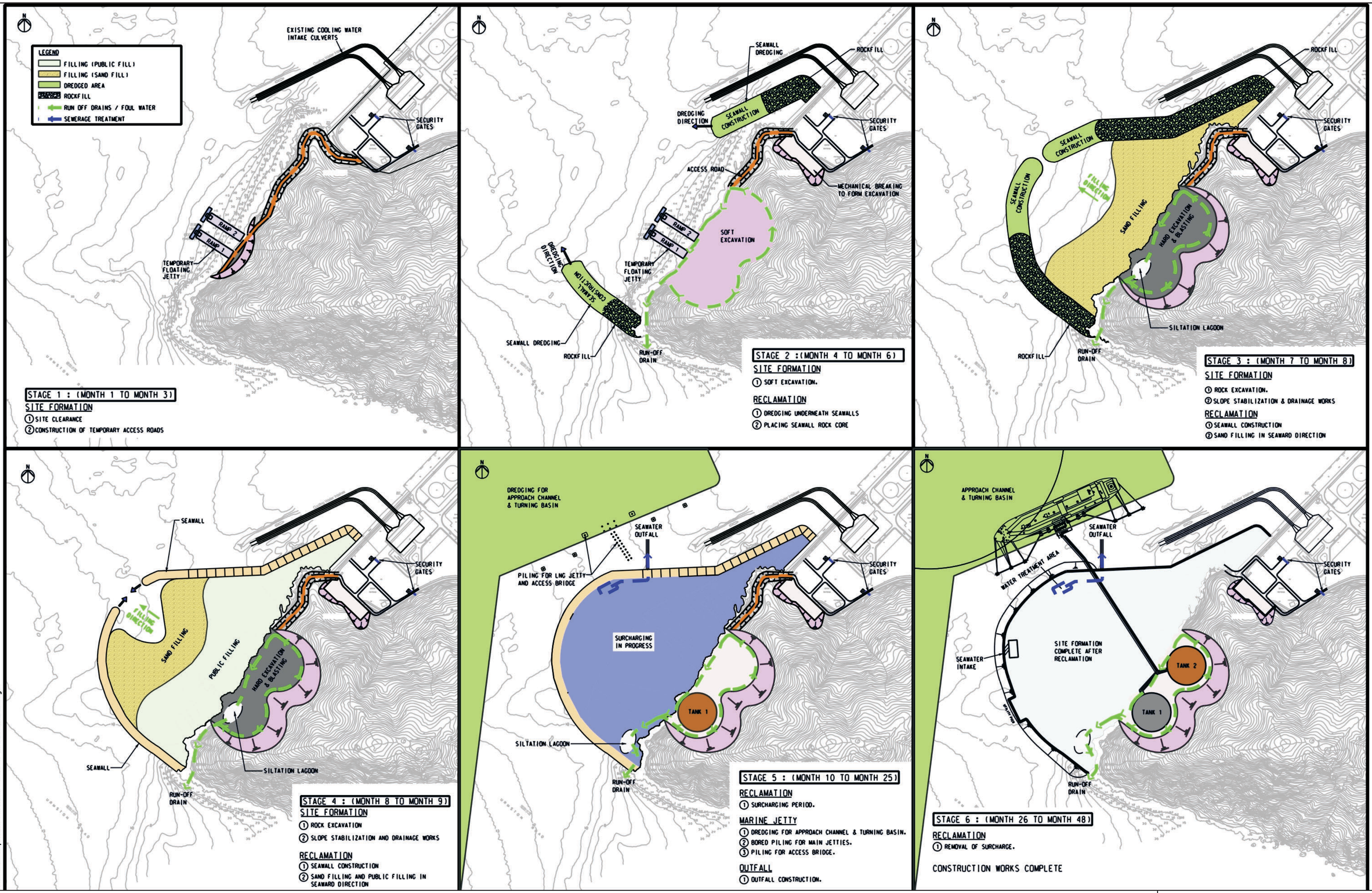

Figure A3.4

Black Point Indicative Construction Sequence

FILE: 0018180z9
DATE: 05/10/2006

Environmental
Resources
Management

ERM

3.4 SEWAGE DISCHARGE

During construction of the LNG receiving terminal the maximum work force is estimated to be around 1,600 people maximum. Based on *Table 2* of the *Drainage Service Department's (DSD's) Sewerage Manual* for domestic type sewage, the unit flow factor for an employed population is 150 L per head per day. A calculation of the Average Dry Weather Flow (ADWF) is given in *Table A3.1*. According to the Sewerage Manual, a peaking factor of 6 should be applied to the average flow to determine the peak flow which is shown in *Table A3.1*.

Table A3.1 ***Calculation of Sewage Flow LNG Construction Phase***

Population	**Unit Flow Factor (L/head/day)**	**Average Dry Weather Flow (m^3/day)**	**Peak Flow (6 x ADWF) (m^3/day)**
1,600	Domestic Type 150 L/head/day	240	1,440
	Total	***240***	***1,440***

From the above, the effluent discharge consent standard, based on the ADWF, can be obtained from *Table 8* of the *TM* and is summarised in *Table A3.2*. As the sewage from the LNG Plant is of domestic sewage type, the parameters as shown in *Table A3.1* and *Table A3.2* are applicable to the sewage treatment process. The other parameters that comprise restrictions on chemicals are not a concern for domestic type sewage and are therefore considered. For oil and grease this requires to be controlled by fitting grease traps to the sewage outlets from the kitchens. The design load of the sewage discharge is the same as the effluent discharge standard and also shows in *Table A3.2*.

Table A3.2 ***Effluent Discharge Standard and Design Load for the Sewage Treatment Works during Construction Phase***

Site	**Corresponding WCZ**	**BOD (mg/L)**	**SS (mg/L)**	**Total Nitrogen (mg/L)**	***E.Coli* (count/100mL)**
Black Point	Deep Bay	20	50	100	1,000

The sewage discharge location is shown in *Figure 6.7* in *Part 3 - Section 6: Water Quality Impact Assessment*. The outfall will be a single pipe, without diffusers, with a diameter of 1.83 m located near the seabed.

4 *OPERATIONAL PHASE*

For the study of operational effects, the approach requires several steps:

1) Running a near-field model (i.e., CORMIX) for the operational discharges, and any existing discharges in the vicinity (eg Black Point Power Station discharge) to characterise the initial mixing of the effluent discharge. The results of the near-field model has been used to define the manner in which the discharge would be included in the far-field hydrodynamic and the water quality models (at which depth, the number of cells over which the discharge will be distributed). The results from the CORMIX analysis has also provided information of the near field dispersion and dilution of the effluent plumes and hence chlorine and/or other biocide concentrations.

   Details of CORMIX simulation is presented in *Appendix 6B* in this Annex.

2) Adapting the hydrodynamic model for the new conditions, including the reclamations and discharges.

3) Running the hydrodynamic model for the specified conditions (wet/dry season). Both sites can be implemented within one hydrodynamic run for a dry and wet seasons spring-neap cycle, since there will be no significant interaction between the effects of the two sites.

4) Running the water quality model (i.e., Delft3D-WAQ). The objectives are twofold:

   a) to qualitatively assess the concentrations of residual chlorine or other biocides: to this end up to 5 decayable tracers may be defined, which will be released from the two candidate sites (the analysis has been carried out assuming that the background concentration is zero); and

   b) to qualitatively assess the potential changes in water quality as a result of changes in the circulation near the project sites: to this end up to 5 conservative, ie non-decayable, tracers have been defined, which will be discharged from a number of locations representing main pollution sources (e.g. Hong Kong as a whole, major point sources in the vicinity of the candidate sites).

The general water quality is the result of transport phenomena and transformation and retention processes. The operation of the project may locally affect the transport patterns. Transformation and retention processes are not affected. Consequently, validation of the Delft3D-WAQ model is not required. The analysis under 4b) requires the running of a baseline scenario to assess the pre-project conditions.

4.1 *THERMAL AND ANTIFOULANT DISCHARGE*

Stored LNG will need to be re-gasified in order for it to be conveyed along the gas pipeline to the point of use. This will be accomplished via LNG Vaporisers, which will either utilise piped seawater (in open rack vaporisers) or hot combustion gases (in so-called submerged combined vaporisers) to raise the temperature of the LNG to ambient, thereby causing it to re-gasify. Once vaporised the LNG gas is then regulated for pressure and piped to the consumer (1).

- *Open Rack Vaporisers* - In open-rack vaporisers (ORVs) downward seawater flows over the exterior of the vaporizer panels, which internally channel an upward flow of high-pressure LNG. LNG will then be vaporized by exchanging heat with seawater in the ORV's. The seawater falls over the panels to a trough below and is then discharged back to the sea. The seawater will pass through a series of screens to remove debris to prevent blockage or damage to the seawater pumps. Upon leaving the vaporisers, the (cooled) seawater will be collected in a sump and discharged back to the sea via a submarine outfall. The design seawater temperature drop is 12.5°C at the discharge point.

- *Submerged Combined Vaporisers* - In Submerged Combined Vaporisers (SCVs), LNG flows through tubes that are submerged in a heated water bath.

The present design intention for the terminal is that the gas will be vaporised using ORV, with a SCV unit as back-up.

The seawater discharge is expected to have a decreased temperature of approximate Δ 12.5°C at the discharge point. The flow rate is expected to be equivalent to 18,000 m^3 hr^{-1} (peak flow).

The dosing level of Chlorine is expected to be at approximately 3 mg L^{-1}. Residual Chlorine level is expected to be 0.3 mg L^{-1}. Residual chlorine is known to decay rapidly in the marine environment, as the chlorine demand of the receiving waters is likely to be high. A preliminary review of literature on chlorine decay has indicated that there are a number of factors that determine decay, including reactivity of organic matter, temperature, (UV) light, pH and salinity. However, chlorine decay has been studied mostly for freshwater systems and in distribution system. The discharge of residual chlorine has been modelled based on both the peak flow of 18,000 m^3 hr^{-1} and the seasonal varied flow as shown in *Table A4.1*.

---

(1) The LNG terminal is assumed to connect to the Black Point Power Station. Should the site location require a subsea pipeline to Black Point, the pipeline will be installed in accordance with the Marine Department and Civil Engineering Department's requirements.

Table A4.1 Cooling Water Discharge Flow Rate

Hour	Summer (m^3 hr^{-1})	Winter (m^3 hr^{-1})
0	13500	9000
1	13500	6750
2	11250	4500
3	11250	4500
4	11250	4500
5	11250	4500
6	11250	4500
7	11250	6750
8	15750	9000
9	18000	11250
10	18000	15750
11	18000	18000
12	18000	18000
13	18000	18000
14	18000	18000
15	18000	18000
16	18000	18000
17	18000	18000
18	18000	18000
19	18000	18000
20	18000	18000
21	18000	18000
22	18000	15750
23	15750	11250

Based on this review, a conservative rate of decay has been taken as first order decay (ie 100 day^{-1}) at 30°C. As chlorine will be discharged in cooled water from the gas warming vapourisation system, a similarly conservative temperature dependency of 1.0996 has been used in the modelling (1).

4.2 SEWAGE DISCHARGE

During operation of the LNG receiving terminal the maximum work force is estimated to be around 100 people maximum. Based on *Table 2* of the *Drainage Service Department's (DSD's) Sewerage Manual*, the unit flow factor for an employed population is 60 L per head per day.

However, this unit flow rate does not comprise wastewater generated from staff showers or any canteen facilities to be provided. Considering the nature of the work and remote locations, some of the work force may use shower facilities and also canteen facilities will be required. In this case subject to discussion and agreement with Environmental Protection Department (EPD) a commercial unit flow factor may be applied to the work force on top of the employed population unit flow factor. *Table A4.1* shows a calculation of the Average Dry Weather Flow (ADWF) and the peak flow for which a peaking factor of 6 is applied.

---

(1) McClellan, John N., David A. Reckhow, John E. Tobiason, James K. Edzwald: A Comprehensive Kinietic Model for Chlorine Decay and Chlorination Byproduct Formation, Department of Civil and Environmental Engineering, University of Massachusetts/Amherst,

Table A4.1 Calculation of Sewage Flow LNG Operational Phase

Population	Unit Flow Factor (L/head/day)	Average Dry Weather Flow (m^3/day)	Peak Flow (6 x ADWF) (m^3/day)
100	Employed Population 60L/head/day	6.0	36.0
100	Commercial Activities	29.0	174.0
	Total	*35.0*	*210.0*

From the above, the effluent discharge standard, based on the ADWF, can be obtained from *Table 8* of the *TM* and is summarised in *Table A4.2*. As the sewage from the LNG Plant is of domestic sewage type, the parameters as shown in *Table A4.1* and *Table A4.2* are applicable to the sewage treatment process. The other parameters that comprise restrictions on chemicals are not a concern for domestic type sewage and are therefore considered. For oil and grease this requires to be controlled by fitting grease traps to the sewage outlets from the kitchens. The design load of the sewage discharge is decided to be same as the effluent discharge standard (*Table A4.2*).

Table A4.2 Effluent Discharge Standard and Design Load for the Sewage Treatment Works during Operational Phase

Site	Corresponding WCZ	BOD (mg/L)	SS (mg/L)	Total Nitrogen (mg/L)	*E.Coli* (count/100mL)
Black Point	Deep Bay	20	50	100	1,000

The sewage discharge location is shown in *Figure 6.7* in *Part 3 - Section 6: Water Quality Impact Assessment*. The outfall will be a single pipe, without diffusers, with a diameter of 1.83 m located near the seabed.

4.3 *MAINTENANCE DREDGING*

The study has considered the following three steps that steer sedimentation. Two types of material have been taken into account, i.e. mud (cohesive) and sand (non-cohesive). Mud is transported in suspension and sand is transported as suspended load or bed load, depending on the grain size and wave/current conditions.

1) To estimate the rate of sediment supply, data on bed composition in the vicinity of the LNG terminals (if available also sediment cores), data on suspended sediment concentration (preferably also during or just after typhoons) and data on the sediment load and the extent of the sediment transport of Pearl River has been analysed. From the mineralogical composition, sediment sources can be identified.

http://www.ecs.umass.edu/cee/reckhow/publ/84/acschapter/html

2) The current velocity in and around the navigation channel and the resulting bed shear stress. To this end, results from existing hydrodynamic model simulations can be used.

   - The influence of waves has been evaluated based on a combination of wave climate data analysis from measurements, existing wave model results and desk analysis.

   - An analysis of recirculation patterns by wind and tide to identify transport pathways. The tidal excursion length is also an important parameter to consider.

   - Based on available data, it has been assessed what the effect of seasonal variations is and what the importance of density-driven effects is, e.g. salinity, fluid mud, temperature.

3) From the analysis on sediment supply and transport, an estimate can be made on the sedimentation rate in the navigation channel and in the neighbourhood of the terminal. From the average and maximum shear stress in the trench induced by currents and waves, the sediment trapping efficiency can be estimated. The product of supply and trapping efficiency yields the sedimentation rate.

Following the above approach, the frequency of the maintenance dredging has been estimated. For the impact assessment of the maintenance dredging, the qualitative assessment has been conducted (discussed in the *Section 6 – Water Quality Impact Assessment*) since the scale of the maintenance dredging would be much less than the dredging works for the approach channel and turning basin during construction phase which has been modelled as described in the previous section.

4.4 ACCIDENTAL FUEL SPILLAGE

4.4.1 *Locations*

A release point (808583 easting, 825632 northing) is defined. A spill occurring along the Urmston Road prior to reaching the Black Point site is assumed in the model. This location is selected due to its proximity to CPPS and also the Marine Park at Lung Kwu Chau/Sha Chau.

4.4.2 *Fuel Type*

Based on the information, it is assumed that the fuel is Heavy Fuel Oil (HFO i.e., 100% No 6).

4.4.3 *Volume to be spilled*

The most conservative case scenario was modelled, i.e. the largest single HFO storage tank from a 210 km^3 SSD propulsion vessel which is 5,043 m^3. The inventory released should equate to 60% of the tank contents.

4.4.4 *Discharge Rate*

It is assumed the large carrier will be used and its large collision event has a release rate of 8,060 kg s^{-1}, even though the small carrier will also be adopted in reality, giving a large collision event having a lower release rate of 7,720 kg s^{-1}.

4.4.5 *Model Selection*

The oil spillage has been simulated using hydrodynamic and particle tracking models (oil module of Delft3D-PART) to assess the movement of the oil spill. This Delft3D-PART forms part of the well-calibrated Delft 3D suite of models, as described in *Section 1* of this Annex. This particle tracking model has been adopted in the EIA of Permanent Aviation Fuel Facility (1).

4.4.6 *Key Modelling Assumptions*

Fuel spill is modelled by surface particles (floating since the density of the oil is less than that of the water). The initial radius is calculated on the basis of the Fay and Hoult equation (2) that calculates the extent of the patch after gravitational spreading. This spreading occurs in a matter of minutes rather than hours. The radius is related to the density difference between the oil and the water and the volume of spilled oil). The spill as used in the present case, of heavy fuel oil would lead to an initial patch of a diameter of 440 m. This implies a thickness of about 5 mm. In addition, no evaporation rate and emulsification is assumed in the model. The wind data at Cheung Chau and Sha Chau as shown in *Annex 13A3* in *Section 13* is used in the model.

4.4.7 *Scenarios*

The PART model has been simulated for the dry and wet seasons with typical real time wind time series. The simulations were run for periods of 5 days to capture the transport route of the oil spill in the first 24 hours to facilitate the development of an emergency contingency plan.

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(1) Mouchel Asia Ltd (2002). EIA of Permanent Aviation Fuel Facility. For Airport Authority Hong Kong. Final Report.

(2) Fay, J. and D. Hoult, 1971. Physical processes in the spread of oil on a water surface, Report DOT-CG-01 381-A, U.S. Coast Guard, Washington, D.C.

5 CUMULATIVE IMPACTS

At present there are no committed projects that could have cumulative impacts with the construction of the terminal at Black Point. No projects are planned to be constructed in sufficient proximity to the Project to cause cumulative effects and hence, cumulative impacts are not expected to occur.

6 INPUT PARAMETERS

6.1 SEDIMENT PARAMETERS

For simulating sediment impacts the following general parameters has been used:

Settling velocity – 0.5 mm s^{-1}

Critical shear stress for deposition – 0.2 N m^{-2}

Critical shear stress for erosion – 0.3 N m^{-2}

Minimum depth where deposition allowed – 1 m

Resuspension rate – 30 g m^{-2} d^{-1}

Wave calculation method – Tamminga

Chezy calculation method – White/Colebrook

Bottom roughness – 0.001 m (1)

Fetch for wave driven erosion – 35 km

Depth gradient effect on waves – absent

The above parameters have been used to simulate the impacts from sediment plumes in Hong Kong associated with uncontaminated mud disposal into the Brothers MBA (2) and dredging for the Permanent Aviation Fuel Facility at Sha Chau (3). The critical shear stress values for erosion and deposition were determined by laboratory testing of a large sample of marine mud from Hong Kong as part of the original WAHMO studies associated with the new airport at Chek Lap Kok.

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(1) The particular formulations used express the bottom roughness by the so-called Nikuradse roughness coefficient, which has the dimension m. (Nikuradse, J., 1932: Gesetzmassigkeiten der turbulenten Stromungen in glatten Rohren. Frosch. Ver. Deutscher Ing. No. 356.)

(2) Mouchel (2002a). Environmental Assessment Study for Backfilling of Marine Borrow Pits at North of the Brothers. Environmental Assessment Report.

(3) Mouchel (2002b). Permanent Aviation Fuel Facility. EIA Report. Environmental Permit EP-139/2002.

7 SCENARIOS

7.1 CONSTRUCTION PHASE

The scenarios are constructed in accordance with the tentative construction programme (*Figure A3.3*). To simulate conservative worse cases, all the potential concurrent activities would be simulated at the same time regardless the reality that they may not all occur simultaneously.

The proposed scenarios for the construction phase of the Black Point Option are presented in *Table A7.1*. *Table A7.2* summarises the inputs defined in the water quality model.

Table A7.1 Scenarios of the Construction Works for Black Point Option

Scenario ID (report)	Tasks	Details of Construction Activities	No. of Plant and Plant Type	Code	
Scenario 1a	Seawall	Dredging underneath seawall (Area A and B)	1 no. Grab Dredger	BP	01
	Seawall	Dredging underneath seawall (Area C)	1 no. Grab Dredger	BP	02
	Seawall	Sand fill for seawall trench (Area A and B)	1 no. Pelican Barge	BP	15
	Reclamation	Sand fill for reclamation area	1 no. Pelican Barge	BP	17
	Jetty Box	Grab Dredging at Jetty Box	1 no. Grab Dredger	BP	07
	Approach Channel and Turning Basin	Grab Dredging at Approach Channel & TB at Area D	1 no. Grab Dredger	BP	08a
	Approach Channel and Turning Basin	Grab Dredging at Approach Channel & TB at Area E	1 no. Grab Dredger	BP	09a
	Approach Channel and Turning Basin	Grab Dredging at Approach Channel & TB at Area F	1 no. Grab Dredger	BP	10a
	Cooled Water Outfall	Grab Dredging under outfall	1 no. Grab Dredger	BP	12
Scenario 1b	Seawall	Dredging underneath seawall (Area A)	1 no. Grab Dredger	BP	01
	Seawall	Dredging underneath seawall (Area	1 no. Grab Dredger	BP	02

Scenario ID (report)	Tasks	Details of Construction Activities	No. of Plant and Plant Type	Code	
		C)			
	Seawall	Sand fill for seawall trench (Area A and B)	1 no. Pelican Barge	BP	15
	Reclamation	Sand fill for reclamation area	1 no. Pelican Barge	BP	17
	Jetty Box	Grab Dredging at Jetty Box	1 no. Grab Dredger	BP	07
	Approach Channel and Turning Basin	TSHD Dredging at Approach Channel & TB at Area D	1 no. TSHD	BP	08b
	Approach Channel and Turning Basin	Grab Dredging at Approach Channel & TB at Area E	1 no. Grab Dredger	BP	09b
	Approach Channel and Turning Basin	Grab Dredging at Approach Channel & TB at Area F	1 no. Grab Dredger	BP	10b
	Approach Channel and Turning Basin	Grab Dredging at Approach Channel & TB at Area G	1 no. Grab Dredger	BP	11
	Cooled Water Outfall	Grab Dredging under outfall	1 no. Grab Dredger	BP	12

Table A7.2 Summary of Modelling Inputs

Code	Emission Point	Working Plant	Dredging/ Filling Rate	Operation Duration	Loss Type	Loss Rate	Loss Rate	Input Layer
			m3/day/plant	hours	-	kg/m3	kg/s	-
SCENARIO 1a								
Dredging underneath Seawall								
BP 01	Dredging underneath seawall (Area A and B)	Grab Dredger (a)	8,000	16	Continuous	17	2.36	whole column
BP 02	Dredging underneath seawall (Area C)	Grab Dredger (a)	8,000	16	Continuous	17	2.36	whole column
Sandfilling for Seawall								
BP 15	Sand fill for seawall trench (Area A and B)	Pelican Barge	50,000	16	Continuous	1%	16.8	whole column
Sandfilling for Reclamation								
BP 17	Sand fill for reclamation	Pelican Barge	50,000	16	Continuous	1%	16.8	whole column
Dredging for Approach Channel, Turning Basin								
BP 07	Dredging at jetty box	Grab Dredger (a)	8,000	16	Continuous	17	2.36	whole column
BP 08a	Dredging at approach channel & turning basin at Area D	Grab Dredger (a)	8,000	16	Continuous	17	2.36	whole column
BP 09a	Dredging at approach channel & turning basin at Area E	Grab Dredger (a)	8,000	16	Continuous	17	2.36	whole column
BP 10a	Dredging at approach channel & turning basin at Area F	Grab Dredger (a)	8,000	16	Continuous	17	2.36	whole column
Dredging for Outfall								
BP 12	Dredging under outfall	Grab Dredger (a)	8,000	16	Continuous	17	2.36	whole column
SCENARIO 1b								
Dredging underneath Seawall								
BP 01	Dredging underneath seawall (Area A and B)	Grab Dredger (a)	8,000	16	Continuous	17	2.36	whole column
BP 02	Dredging underneath seawall (Area C)	Grab Dredger (a)	8,000	16	Continuous	17	2.36	whole column
Sandfilling for Seawall								
BP 15	Sand fill for seawall trench (Area A and B)	Pelican Barge	50,000	16	Continuous	1%	16.8	whole column
Sandfilling for Reclamation								
BP 17	Sand fill for reclamation	Pelican Barge	50,000	16	Continuous	1%	16.8	whole column

Code	Emission Point	Working Plant	Dredging/ Filling Rate	Operation Duration	Loss Type	Loss Rate	Loss Rate	Input Layer
			m3/day/plant	hours	-	kg/m3	kg/s	-
Dredging for Approach Channel, Turning Basin								
BP 07	Dredging at Jetty Box	Grab Dredger (a)	8,000	16	Continuous	17	2.36	whole column
BP 08b	Dredging at approach channel & turning basin at Area D	TSHD (b)	7,200	0.75	Piecewise	7	18.67	bed layer (c)
BP 09b	Dredging at approach channel & turning basin at Area E	Grab Dredger (a)	8,000	16	Continuous	17	2.36	whole column
BP 10b	Dredging at approach channel & turning basin at Area F	Grab Dredger (a)	8,000	16	Continuous	17	2.36	whole column
BP 11	Dredging at approach channel & turning basin at Area G	Grab Dredger (a)	8,000	16	Continuous	17	2.36	whole column
Dredging for Outfall								
BP 12	Dredging under outfall	Grab Dredger (a)	8,000	16	Continuous	17	2.36	whole column

Notes:

(a) Grab dredger refers to closed grab dredger with a minimum grab size of 8 m^3.

(b) For TSHD, with hopper capacity of 8,000 m^3, the duration stated refers to the operation time per trip and each dredging event will last for around 0.8 hour.

(c) Bed layer refers to the bottom 10% of the water column.

Appendix 6A

Information on the Model Inputs

CONTENTS

1 *METHODOLOGY USED FOR THE GRID REFINEMENT*

The applied grid refinements have been realised in the Delft3D-FLOW model by means of the so-called domain decomposition technique. The FLOW model grid has subsequently been adopted without further aggregation in the water quality models.

Domain decomposition is a technique in which a model domain is subdivided into several smaller model domains, which are called sub-domains. Domain decomposition allows for local grid refinement, both in horizontal direction and in vertical direction. Grid refinement in horizontal direction means that in one sub-domain smaller mesh sizes (fine grid) are used than in other sub-domains (coarse grid) (see *Figure A1.1*).

The FLOW computations are carried out separately on the sub-domains. The communication between the sub-domains takes place along internal open boundaries, or so-called dd-boundaries. The resulting equations are solved simultaneously for all boundaries.

In the current model, 5 horizontally refined sub-domains are distinguished. The division in sub-domains is based on the requirements for horizontal model resolution in order to represent the coastline and bathymetry near the project sites and to adequately simulate physical processes.

The domain decomposition approach implemented in Delft3D-FLOW is based on a subdivision of the domain into non-overlapping sub-domains. An efficient iterative method is used for solving the discretised equations over the sub-domains. A direct iterative solver is used for the continuity equation, which is comparable to the single domain implementation. For the momentum equations, the transport equation and the turbulence equations the so-called additive Schwarz method is used, which allows for parallelism over the sub-domains. Upon convergence, this type of iteration process is comparable to the corresponding iterative solution methods in the single domain code, and features a comparable robustness. As witnessed by numerical experiments carried out during the development of the technique, the differences introduced by separating domains turn out to be of insignificance.

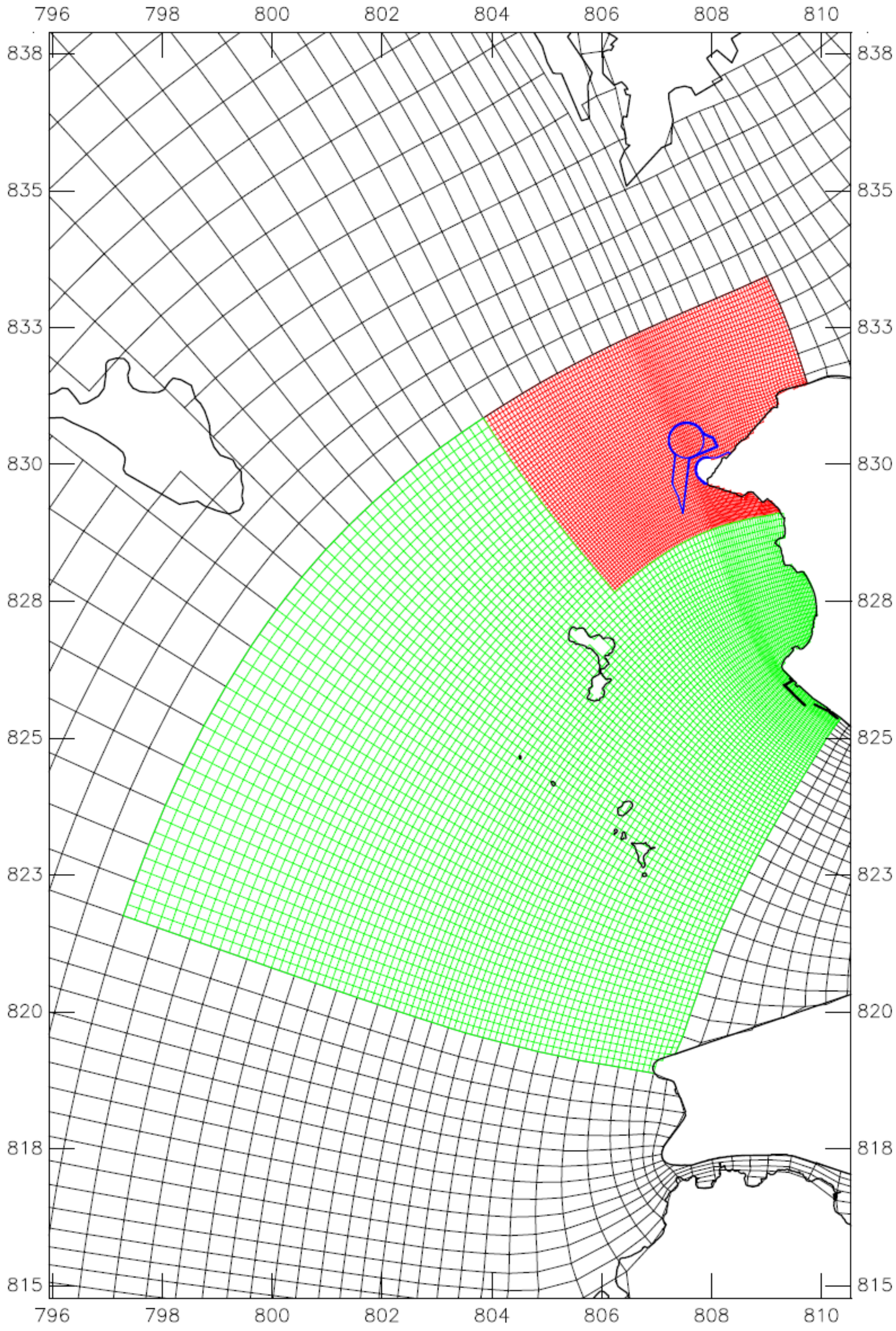


Figure A1.1 Refinement of Model Grid of the Model in the Vicinity of Black Point

2 VERIFICATION OF THE GRID REFINEMENT

The verification of the correct implementation of the grid refinement has been carried out by graphically comparing the results from the original, unrefined model with the refined model. This has been done for two locations:

- A location near the intake point of Black Point Power Station, inside the refined domain around the Black Point site.

The results are shown in *Figures A2.1* (wet season) and *Figures A2.2* (dry season). The comparison includes the water level (top graph), the current speed (second graph), the surface and bottom salinity (third graph) and the surface and bottom temperature (bottom graph). The comparison has been carried out for both the wet and the dry season simulations.

The results clearly demonstrate that the overall behaviour of both models is consistent, while the results are slightly different in the details. This is exactly as it would be expected from a locally refined model.

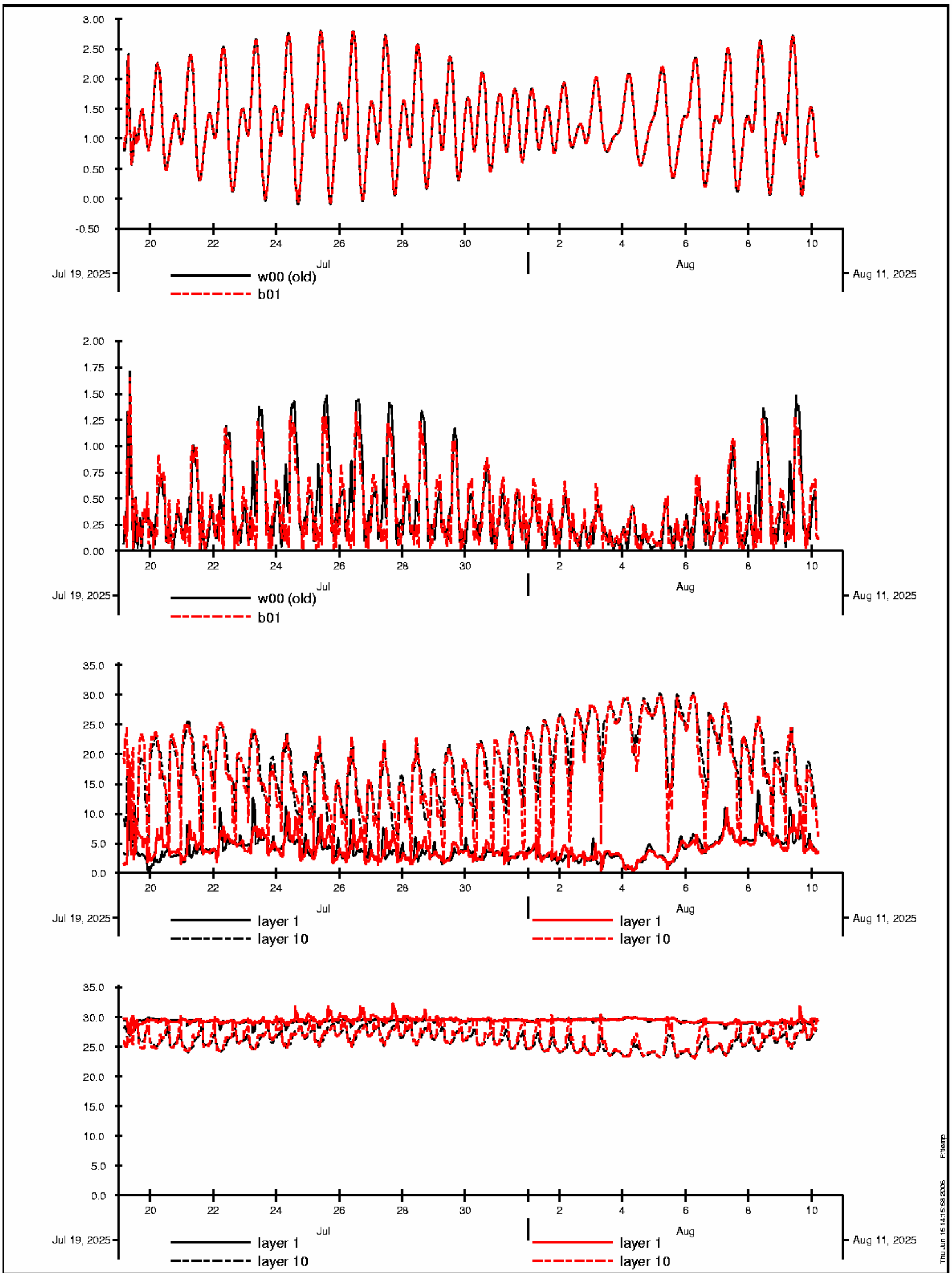


Figure A2.1 *Comparison (Wet Season) between Unrefined Model (in black) and Refined Model (in red) at the Black Point Power Station Intake in (Top graph: Water Level; Second graph: Current Speed; Third graph: Surface (layer 1) and Bottom (layer 10) Salinity; and Bottom graph: Surface (layer 1) and Bottom Temperature)*

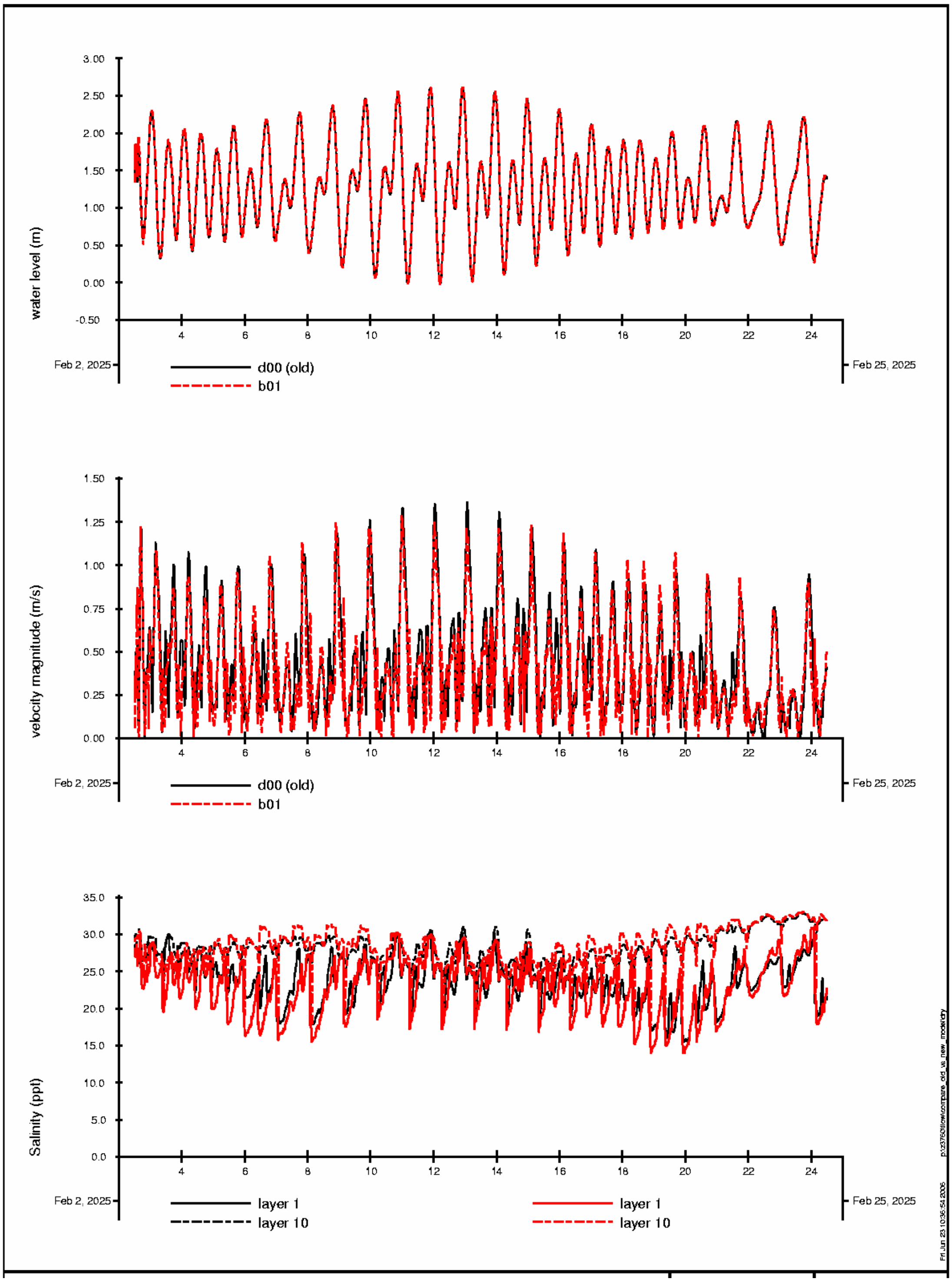


Figure A2.2 Comparison (Dry Season) between Unrefined Model (in black) and Refined Model (in red) at the Black Point Power Station Intake in (Top graph: Water Level; Second graph: Current Speed; Bottom graph: Surface (layer 1) and Bottom (layer 10) Salinity

3 DETAILS OF HYDRODYNAMIC SIMULATIONS

All hydrodynamic scenarios are simulated for a spring-neap-cycle during the dry season and a spring-neap-cycle during the wet season. The simulated periods are:

- Dry season: simulation period from 2 February 12:00h to 22 February 12:00h, simulation period 20 days, time step 30 seconds.
- Wet season: simulation period from 19 July 04:00h to 10 August 04:00h, simulation period 22 days, time step 30 seconds.

Adequate spin-up has been provided for salinity and temperature by means of initial conditions files (as shown by verification results). The first 5 days of both simulation periods are also used as spin-up, and are not used for the assessments purpose.

The wind has been set to typical seasonally averaged values:

- Dry season: northeast, 5 m s^{-1}.
- Wet season: southwest, 5 m s^{-1}.

The rivers have been set to typical seasonal values:

	Dry ($m^3 s^{-1}$)	Wet ($m^3 s^{-1}$)
Humen	1248	7442
Jiaomen	527	4732
Hongqili	128	1535
Hengmen	136	2805
Deep Bay	2.5	16

4 DEEP BAY FLUSHING CAPACITY ASSESSMENT

4.1 INTRODUCTION

As part of the project, one of the objectives of the modelling exercise is to assess "any residual impacts, which include any change in hydrodynamic regime" due to construction and operation of the LNG. In this respect, the construction of the Black Point Terminal may affect the circulation of water in the Deep Bay due to changes in coastline morphology, bathymetry and project related discharges. This, in turn, may induce a change in the flushing efficiency, and hence, in the water quality of the Deep Bay.

The objective of this study is "to assess, by modelling, the impact of the Black Point Terminal on the flushing efficiency of the Deep Bay".

In that respect, we propose to perform a set of tracer simulations. It is suggested to add a tracer in the Shenzhen river discharge, and to calculate the concentration of this tracer without the terminal (Case 1: Baseline), and with the terminal (Case 2: Operation Phase). The simulations for both cases would be done during neap-spring cycles in the dry and wet seasons.

4.2 MODELLING METHODOLOGY

4.2.1 *Model selection*

The study is based on the already existing hydrodynamic simulations using the Delft3D hydrodynamic model (FLOW). The tracer simulations have been done using the Delft3D water quality model (WAQ), and have used the output from the FLOW simulations as hydrodynamic inputs into WAQ.

4.2.2 *Model inputs*

The study assesses the flushing capacity of Deep Bay by looking at the concentrations inside Deep Bay as a result of a constant tracer release in Shenzen River. When a (dynamic) equilibrium is reached, the amount of tracer entering Deep Bay will be the same as the amount of tracer leaving Deep Bay. The rate of flushing however will determine the tracer concentrations inside Deep Bay: if the flushing is effective the concentrations are low, if the flushing is not effective the concentrations are high. By comparing the concentrations before and after the implementation of the project it can be known whether the flushing has been affected, i.e., a concentration increase indicates a reduction of the flushing while a concentration decrease indicates an increased flushing.

The situation prior to the project implementation is represented by the **Baseline flow calculation**, while the situation after the project implementation is represented by the **Operational flow calculation** (Seasonal Varied Flow).

Simulations have been carried out for typical wet season and typical dry season conditions. The duration of the run is one neap-spring cycle. The time series output data have been acquired with a time step of 10 minutes. The output stations are chosen as the locations of the sensitive receivers (SRs) around Black Point (as identified in the EIA study, *Part 2, Section 6: Water Quality Impact Assessment*). On top of this, a series of additional output stations has been defined (see *Figure A4.1*), as well as a monitoring area to evaluate the average tracer concentration over the whole water volume of Inner Deep Bay (see area east of the read line, *Figure A4.1*).

In this exercise, the boundary conditions are set to zero with respect to the tracer concentration. The Shenzhen River constitutes the only source of tracer. The flow of the Shenzhen River has been attributed a constant tracer concentration of 1 g m^{-3}.

The simulations are given sufficient spin-up to reach a dynamic equilibrium in the system.

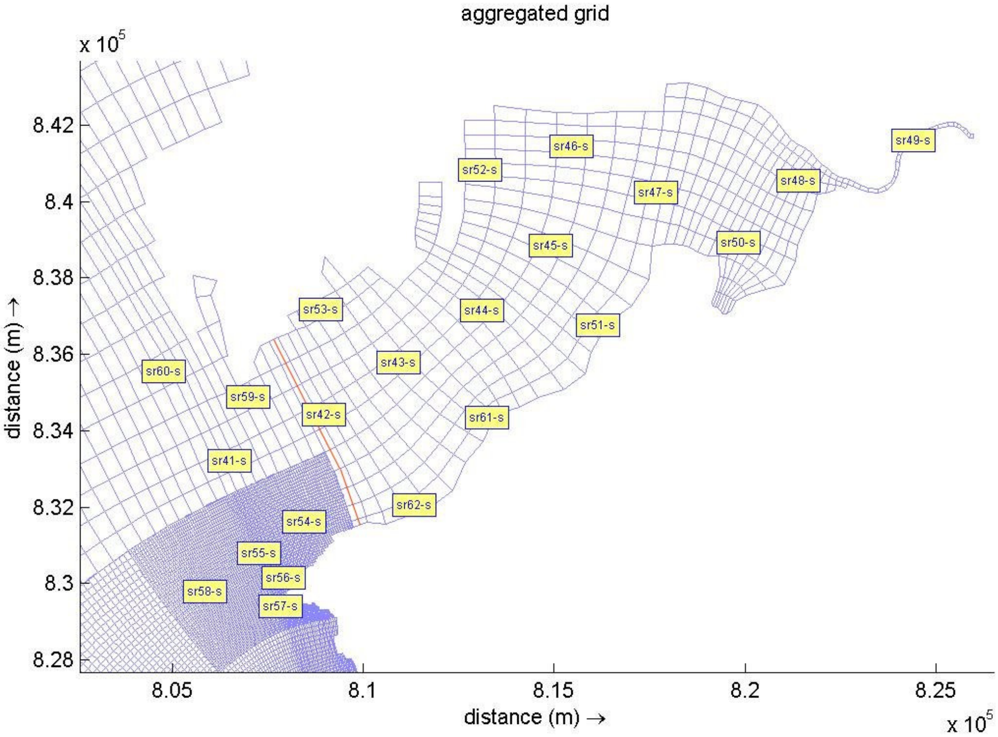


Figure A4.1 *Stations and area (east of red line) for time series output*

4.3 MODELLING RESULTS

The results of the simulations are presented as a time-averaged over the last week of the simulation (after the dynamic equilibrium has been obtained), before and after the implementation of the project, in the dry and wet seasons, see *Table 4.1*.

Table 4.1 ***Tracer concentration at SR's under baseline conditions, and relative change due to project implementation***

Station	**Baseline**		**Ope/Bas** [1, 2]	
	Dry	**Wet**	**Dry**	**Wet**
	Concentration (mg L^{-1})		**Relative Change**	
Deep Bay	0.0123	0.0114	0.997	1.005
sr52-surf	0.0119	0.0132	0.998	1.024
sr45-surf	0.0128	0.0109	0.989	1.019
sr51-surf	0.0175	0.0043	1.000	1.001
sr46-surf	0.0212	0.0228	1.000	1.007
sr47-surf	0.0326	0.0240	0.999	1.010
sr50-surf	0.0532	0.0545	1.000	1.001
sr48-surf	0.1448	0.0910	1.000	1.001
sr49-surf	0.6155	0.1562	1.000	1.000

Notes:

1. Ope = Operational Flow Calculation
2. Bas = Baseline Flow Calculation

The results show that for Deep Bay as a whole there is a marginal increase of the flushing during the dry season, indicated by a decrease of the concentration. During the wet season there is a marginal decrease of the flushing, indicated by an increase of the concentration.

Looking at those individual SRs which show tracer concentrations higher than 1% of the discharge concentration, it can be seen that a similar picture as for Deep Bay as a whole: a small increase of the flushing during the dry season and a small decrease of the flushing during the wet season. At individual SRs the maximum concentration change is -1.1% during the dry season and 2.4% during the wet season.

From the modelling results as shown above, it is thus considered that the change in flushing capacity due to the reclamation at outer Deep Bay is minimal.

Appendix 6B

Information on CORMIX Model

CONTENTS

1 CORMIX SIMULATIONS

1.1 INTRODUCTION

The effluent from the LNG terminal will be discharged through the outfall located to the north of Black Point. The outfall is a single pipe with a diameter of 1.83 m, without diffusers.

The aim of the CORMIX modelling is to determine the near field mixing characteristics. These characteristics will be used to set the manner in which the discharge is introduced in the 3D hydrodynamic model.

1.2 CONDITIONS AROUND THE OUTFALL LOCATIONS

From the information that was provided is derived that the outfall is located at (807995, 830190) (Hong Kong 1980 coordinate system). The hydrodynamic conditions were determined for the wet and dry seasons. These conditions were taken from existing baseline computation (*Tables 1.1* and *1.2*).

When currents are relatively low during the wet season, the Near Field Region (NFR) is about 100 m and for higher currents about 200 m. At the edge of the NFR the plume has a width of the order of 5-10 m. In the wet season calculations, the plume at the end of the NFR is in the order of 2.5-4 m thick and is near the bottom (which is about half the total water depth). The discharge cells are about 40 * 65 m. Hence, the discharge during the wet season should be covering about 2 grid cells around the discharge location. The effluent should be discharge in the lower half of the water column.

For the dry season the effluent mixes over the entire depth when currents are higher (mid tide conditions), whilst under lower currents the effluent sinks towards the bed and at the edge of the mixing zone the layer thickness is about 3 m thick. The size of the plume is approximately similar to the plume under wet season conditions. Thus the horizontal distribution of the discharge cells may be the same for the dry as wet season conditions.

Table 1.1 Wet Season Conditions

Bottom -7 mPD

	Neap tide			**Spring tide**		
	HW	**LW**	**Mid**	**HW**	**LW**	**Mid**
Depth (m)	9.2	7.5	8.4	9.8	7	8.4
T_{bot} (°C)	25	27.5	26.5	25.5	28.4	27
S_{bot} (ppt)	24	14	16	22	8.5	13
ρ_{bot} (kg m^{-3})	1015.1	1006.9	1008.7	1013.5	1002.5	1006.3
T_{surf} (°C)	30	29.5	29.5	29	29.5	29.5
S_{surf} (ppt)	2	5	5	9	5	5
ρ_{surf} (kg m^{-3})	997.2	999.6	999.6	1002.7	999.6	999.6
V_{bot} (m s^{-1})	0.3	0.25	0.7	0.4	0.45	0.5
V_{surf} (m s^{-1})	0.4	0.65	1.5	0.85	0.35	0.95
T_{out} (°C)	19	20	19.5	18.75	20.45	19.75
S_{out} (ppt)	13	9.5	10.5	15.5	6.75	9
ρ_{out} (kg m^{-3})	1008.2	1005.4	1006.2	1010.2	1003.2	1005.0

Notes:

(a) "bot" denotes the bed

(b) "surf" denotes the surface

(c) "out" denotes the effluent characteristics

Table 1.2 *Dry Season Conditions*

Bottom (from model) -7 m PD

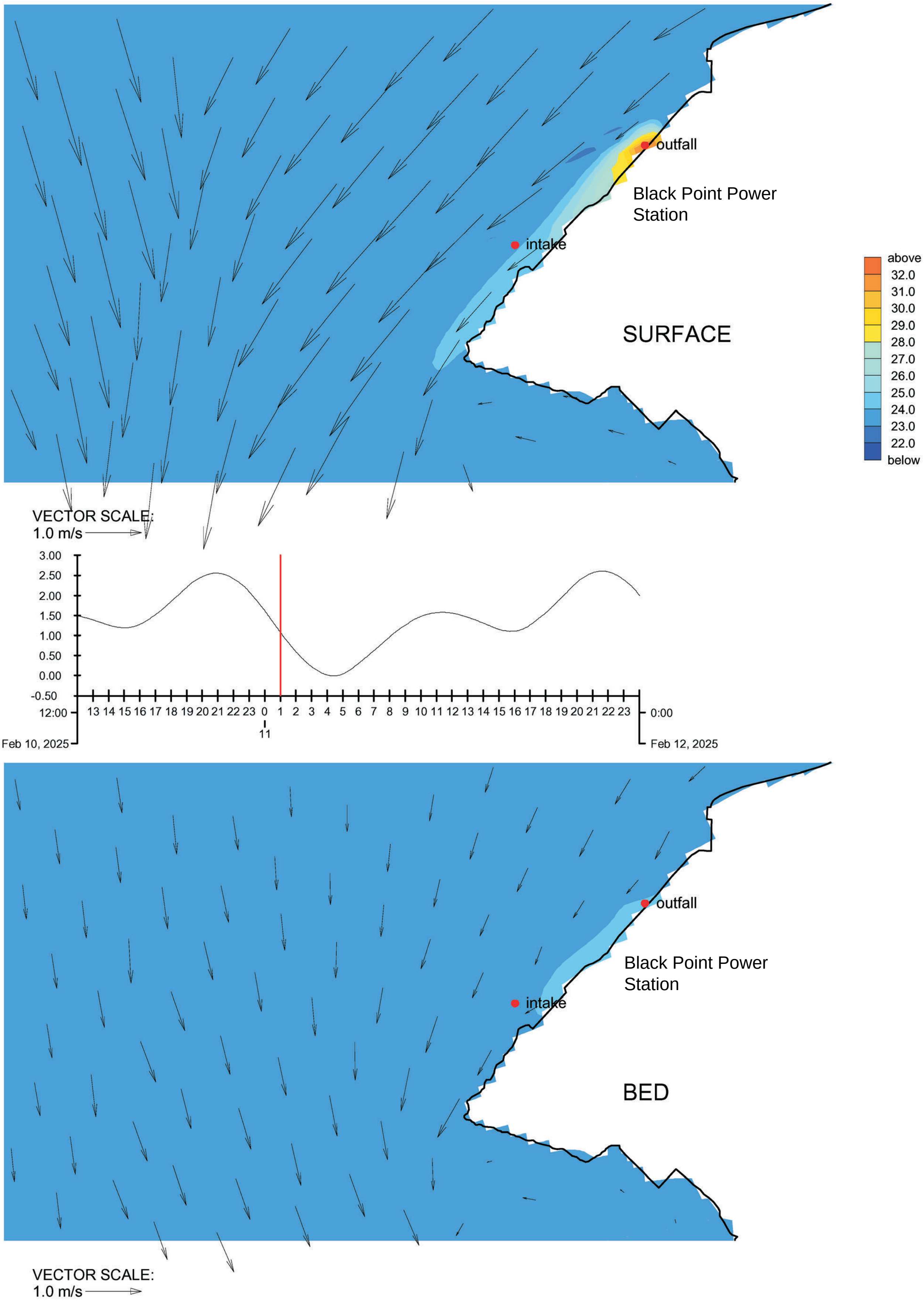
	Neap tide			**Spring tide**		
	HW	**LW**	**Mid**	**HW**	**LW**	**Mid**
Depth (m)	8.8	7.6	8.2	9.6	7	8.3
T_{bot} (°C)	23	23	23	23	23	23
S_{bot} (ppt)	28.5	29	28.5	31.5	25.5	28.5
ρ_{bot} (kg m^{-3})	1019.1	1019.5	1019.1	1021.4	1016.8	1019.1
T_{surf} (°C)	25	23.5	23	23.5	24	23
S_{surf} (ppt)	25	26.5	25	29.5	24.5	25
ρ_{surf} (kg m^{-3})	1015.9	1017.4	1016.4	1019.7	1015.8	1016.4
V_{bot} (m s^{-1})	0.15	0.1	0.4	0.1	0.3	0.9
V_{surf} (m s^{-1})	0.4	0.2	0.9	0.35	0.5	1.5
T_{out} (°C)	15.5	14.75	14.5	14.75	15	14.5
S_{out} (ppt)	26.75	27.75	26.75	30.5	25	26.75
ρ_{out} (kg m^{-3})	1019.5	1020.4	1019.7	1022.5	1018.2	1019.7

Notes:

(d) "bot" denotes the bed
(e) "surf" denotes the surface
(f) "out" denotes the effluent characteristics

Annex 6B

Construction Phase Model Results - Hydrodynamics



Velocity Vector (m/s) and Temperature (Degree Celsius)

Dry Season, Mid-ebb, Surface (upper) & Bottom (lower)

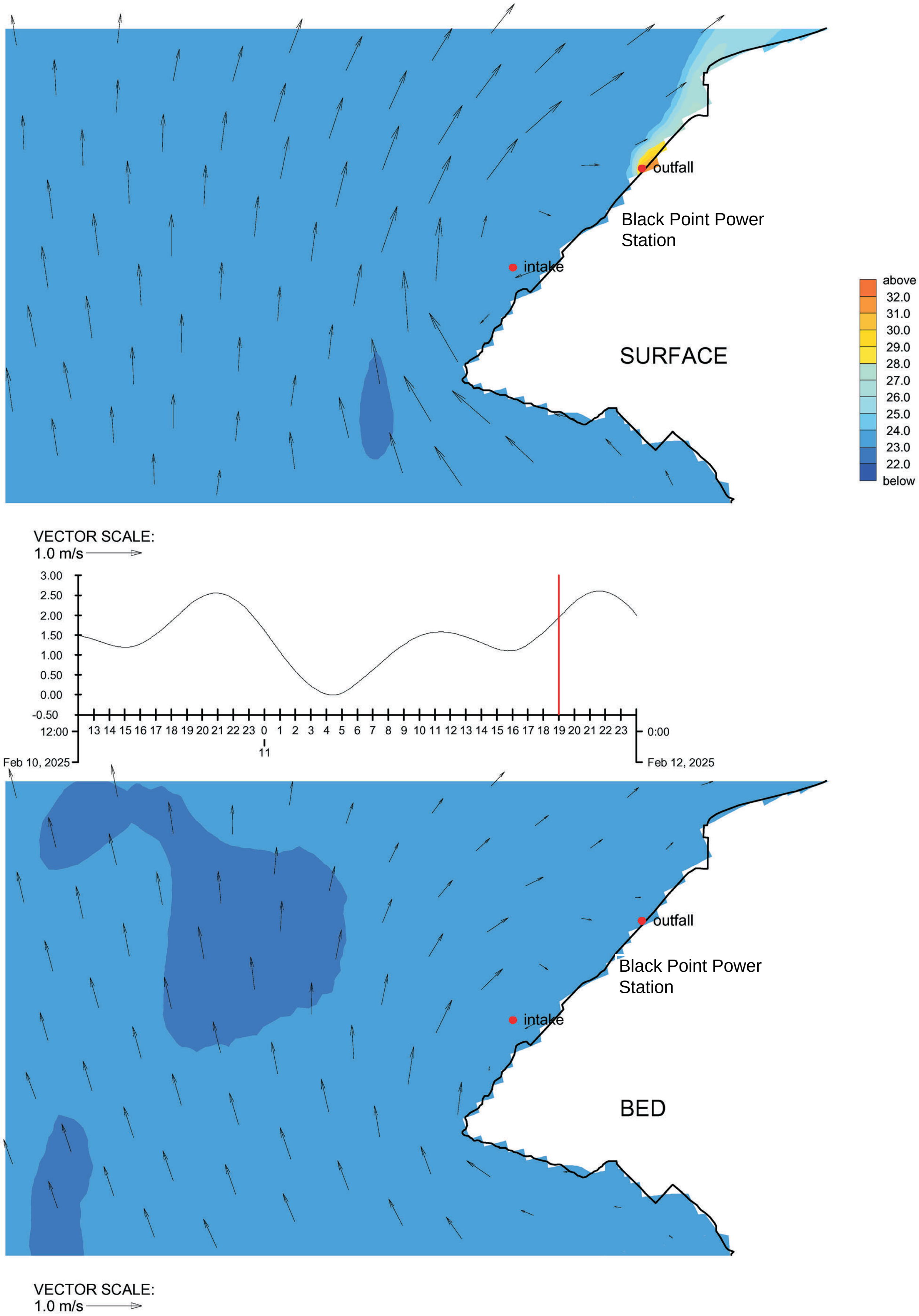
Pre-project situation,2007

Black Point

WL | delft hydraulics

0018180_eia63

Fig. BP_B01



Velocity Vector (m/s) and Temperature (Degree Celsius)

Dry Season, Mid-flood, Surface (upper) & Bottom (lower)

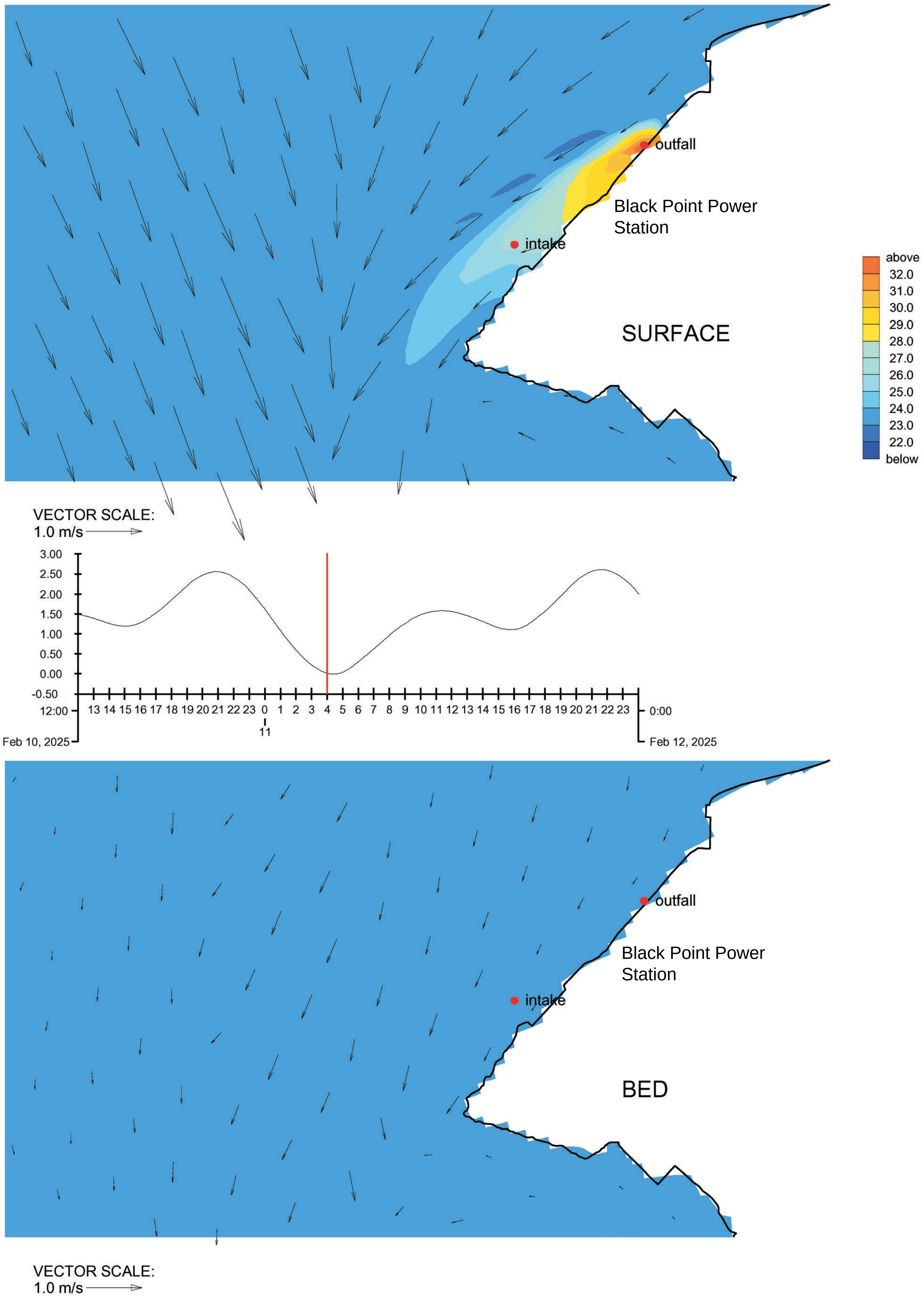
Pre-project situation, 2007

Black Point

WL | delft hydraulics

0018180_eia63a

Fig. BP_B02



Velocity Vector (m/s) and Temperature (Degree Celsius)

Dry Season, Low Water, Surface (upper) & Bottom (lower)

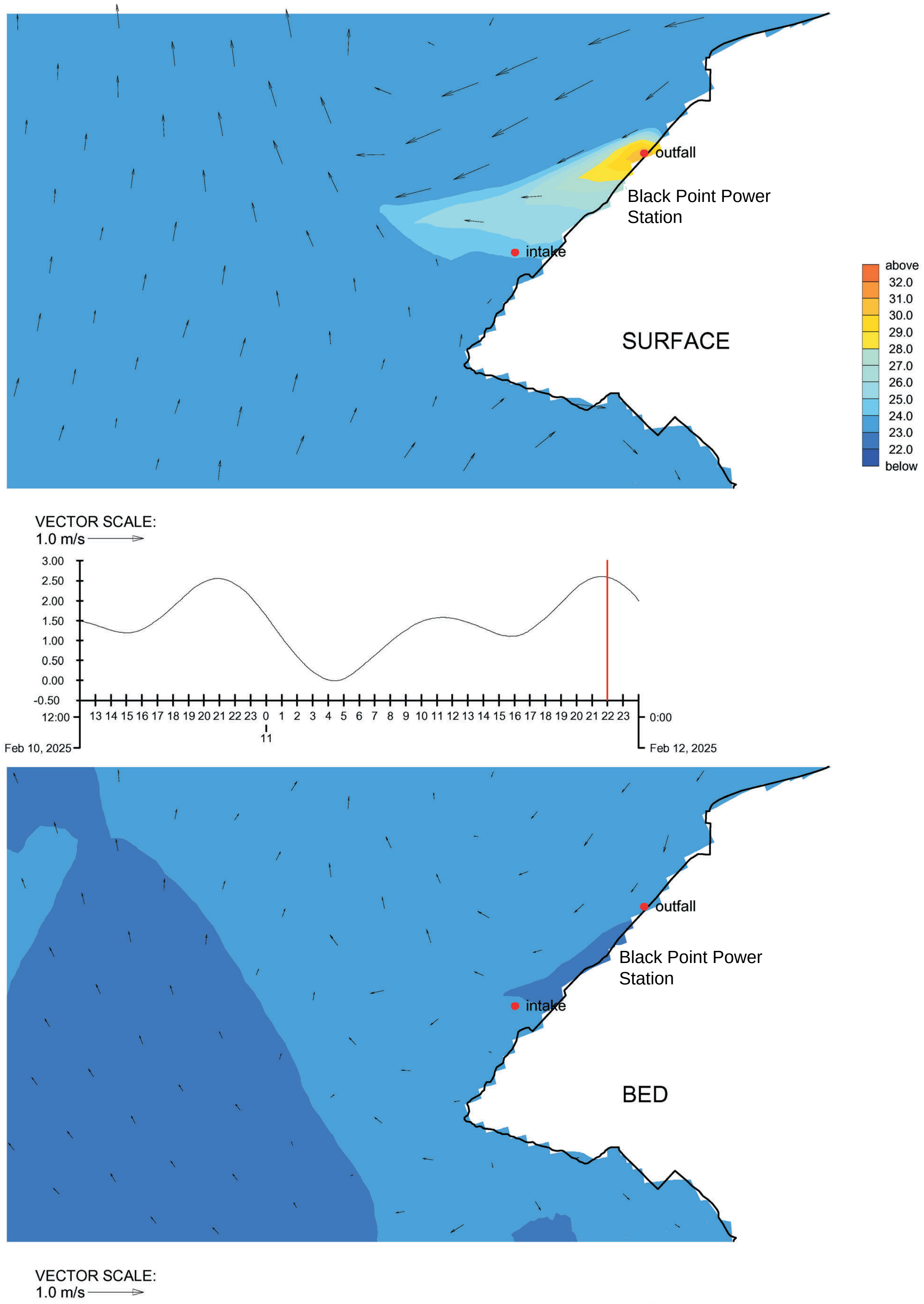
Pre-project situation, 2007

Black Point

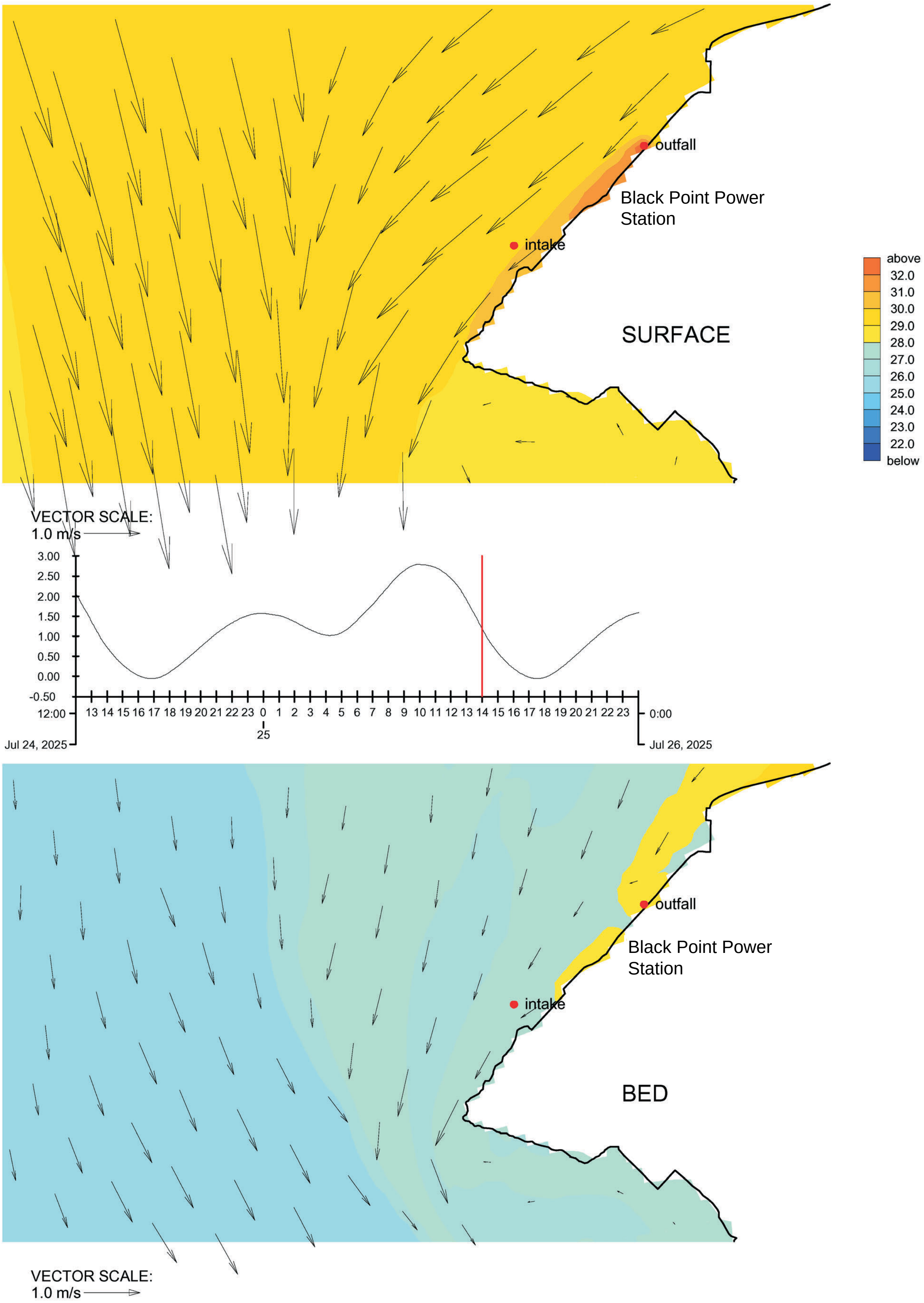
WL | delft hydraulics

0018180_eia63b

Fig. BP_B03



Velocity Vector (m/s) and Temperature (Degree Celsius) Dry Season, High Water, Surface (upper) & Bottom (lower) Pre-project situation, 2007	Black Point	
WL | delft hydraulics	0018180_eia63c	Fig. BP_B04



Velocity Vector (m/s) and Temperature (Degree Celsius)

Wet Season, Mid-ebb, Surface (upper) & Bottom (lower)

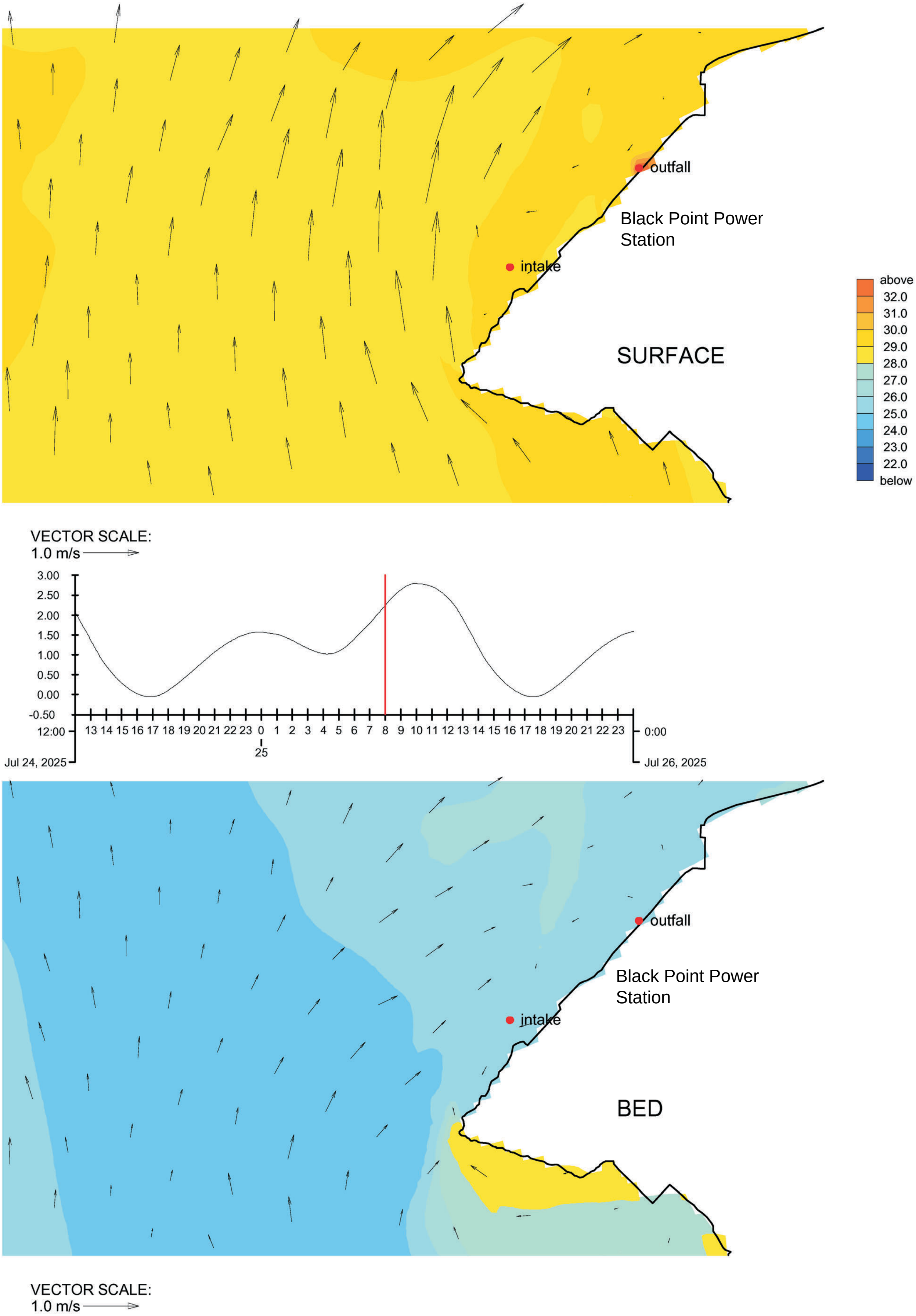
Pre-project situation, 2007

Black Point

WL | delft hydraulics

0018180_eia63d

Fig. BP_B05



Velocity Vector (m/s) and Temperature (Degree Celsius)

Wet Season, Mid-flood, Surface (upper) & Bottom (lower)

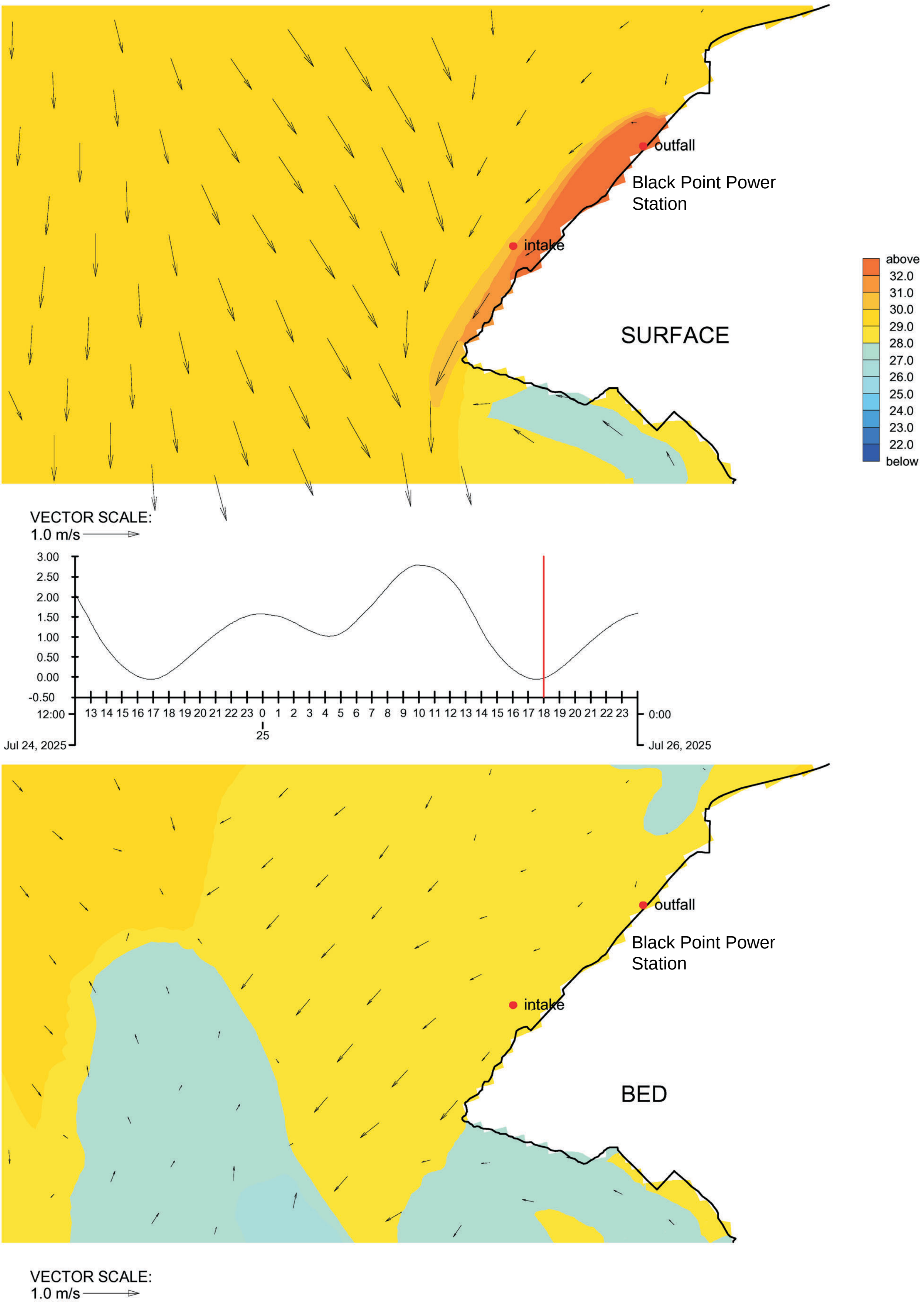
Pre-project situation, 2007

Black Point

WL | delft hydraulics

0018180_eia63e

Fig. BP_B06



Velocity Vector (m/s) and Temperature (Degree Celsius)

Wet Season, Low Water, Surface (upper) & Bottom (lower)

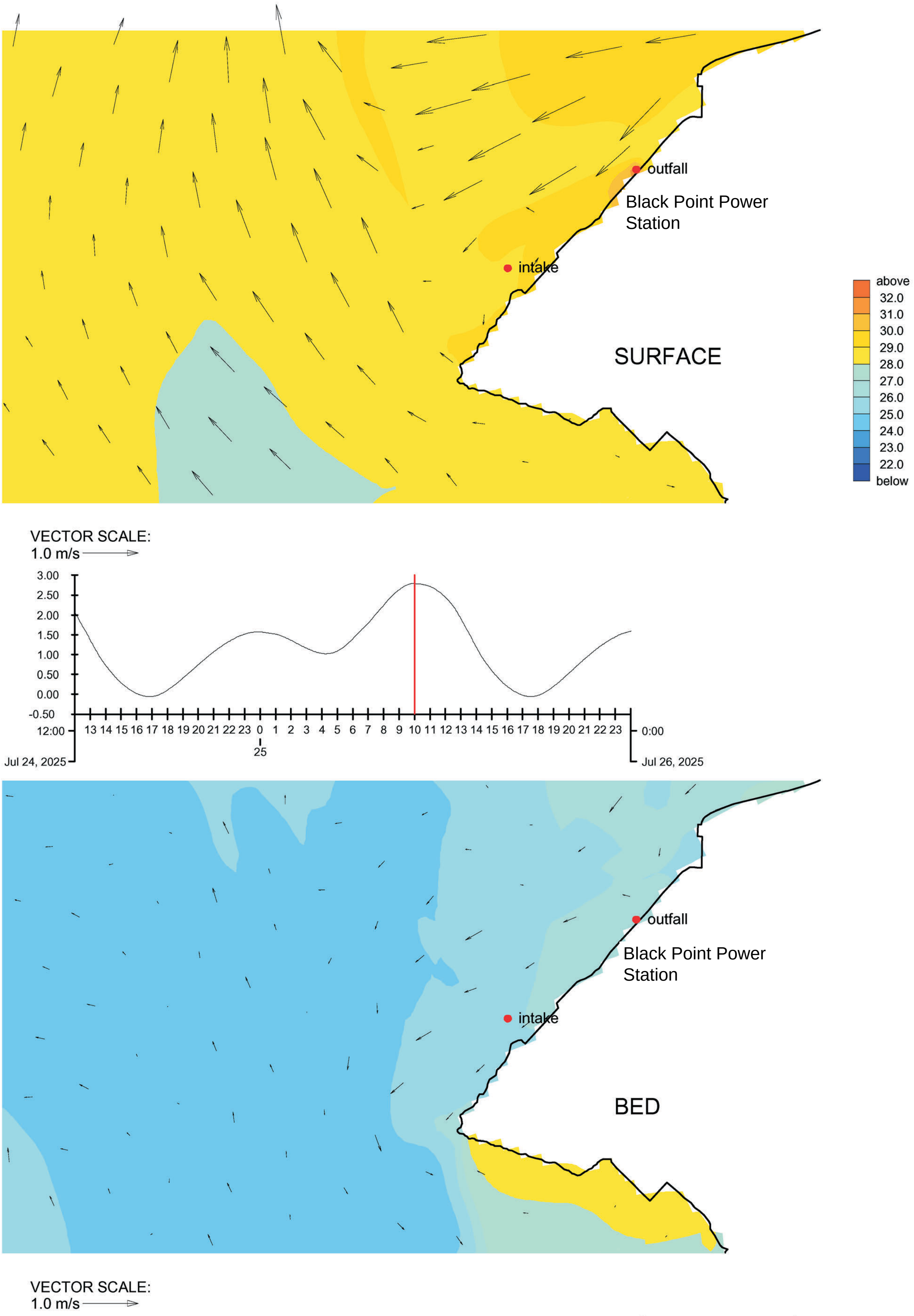
Pre-project situation, 2007

Black Point

WL | delft hydraulics

0018180_eia63f

Fig. BP_B07



Velocity Vector (m/s) and Temperature (Degree Celsius)

Wet Season, High Water, Surface (upper) & Bottom (lower)

Pre-project situation, 2007

Black Point

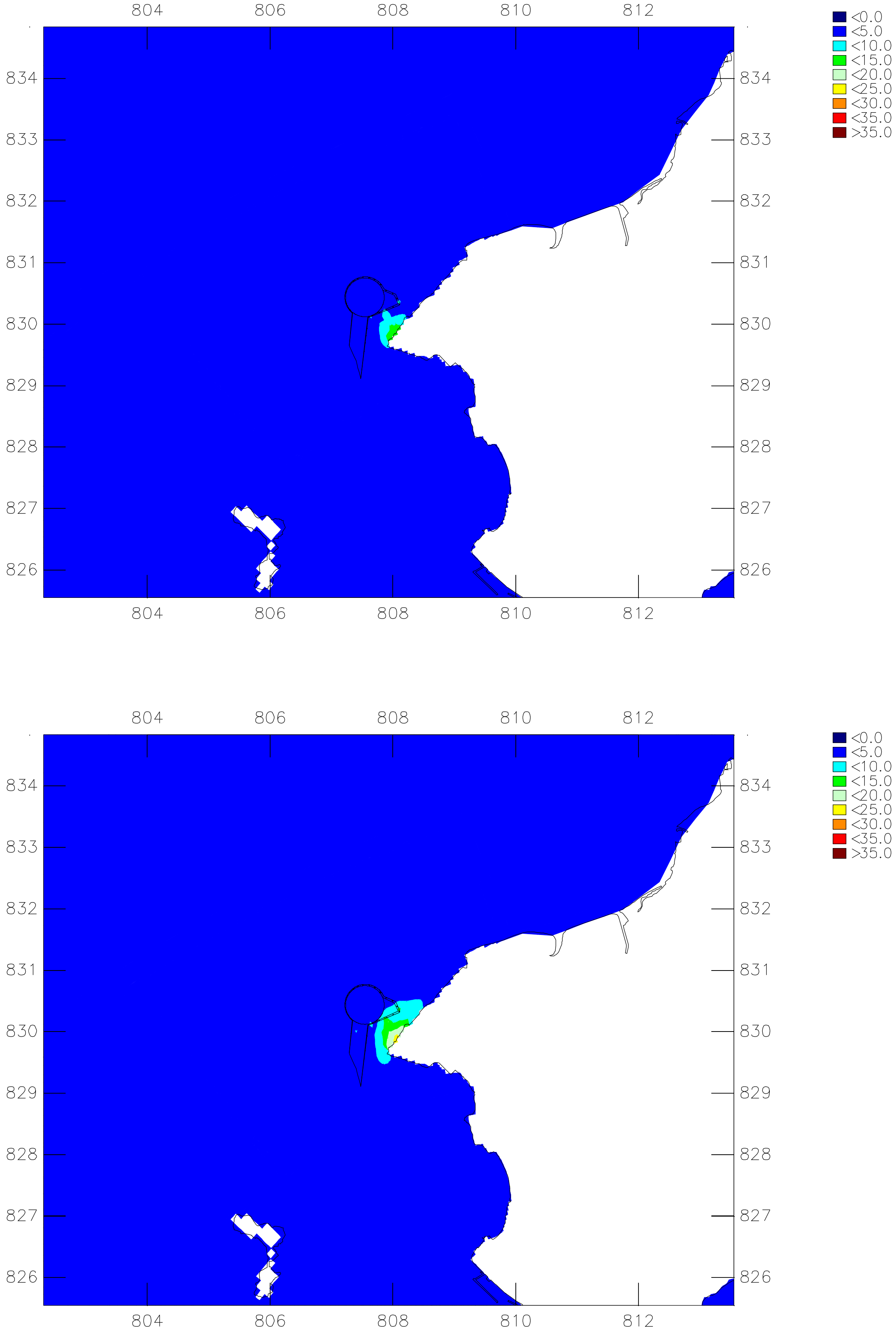
WL | delft hydraulics

0018180_eia63g

Fig. BP_B08

Annex 6C

Model Results for the Construction Scenarios (Suspended Solids)



Suspended Solids (mg/L) – mean over a complete spring-neap cycle

Marine Construction Works at Black Point

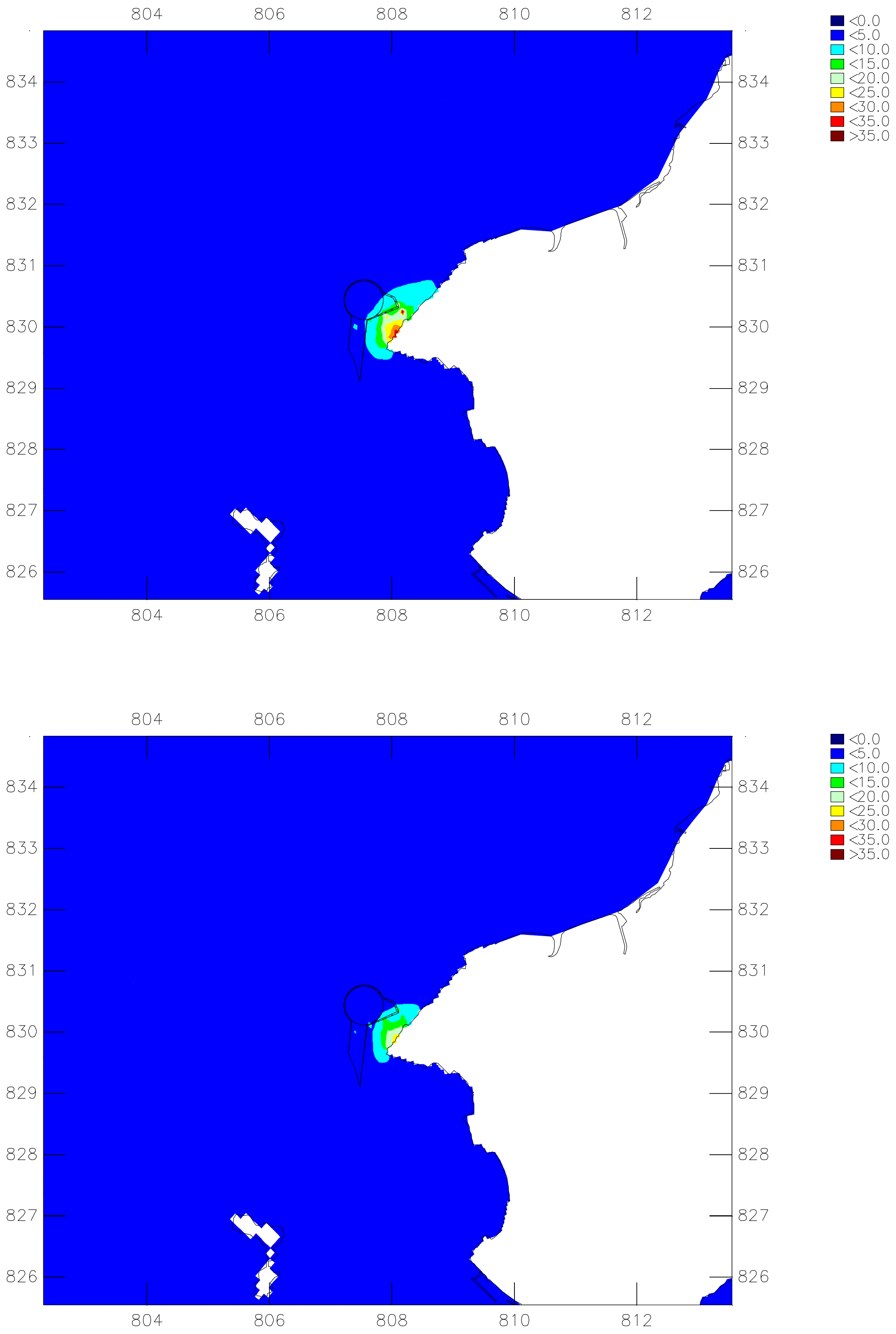
Upper plot: surface layer – Lower plot: middle layer

Dry Season

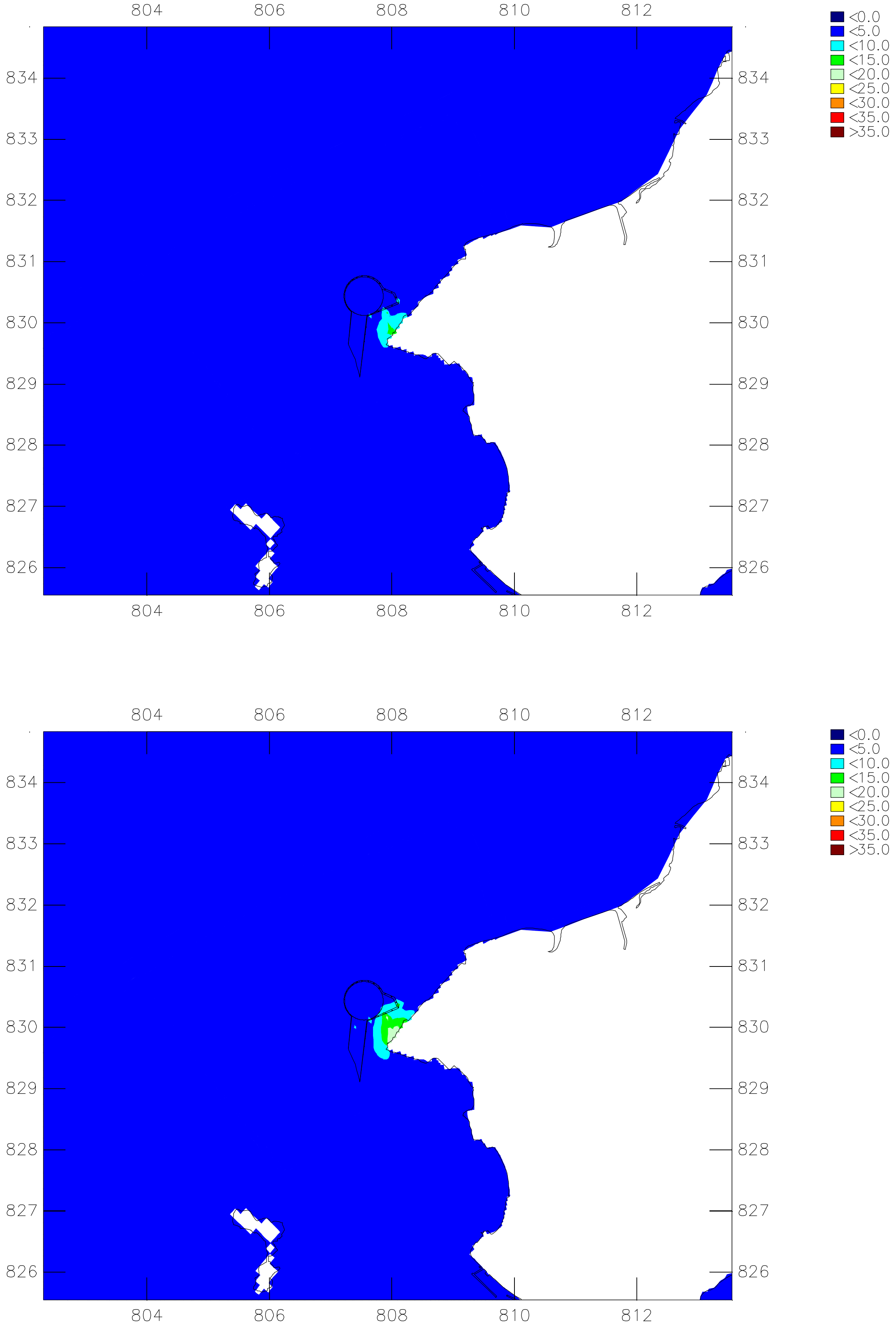
Scenario 1a

WL | Delft Hydraulics – ERM

Fig. BP_C01a



Suspended Solids (mg/L) – mean over a complete spring-neap cycle Marine Construction Works at Black Point Upper plot: bottom layer – Lower plot: depth average	Dry Season Scenario 1a	
WL | Delft Hydraulics – ERM		Fig. BP_C01b



Suspended Solids (mg/L) – mean over a complete spring-neap cycle

Marine Construction Works at Black Point

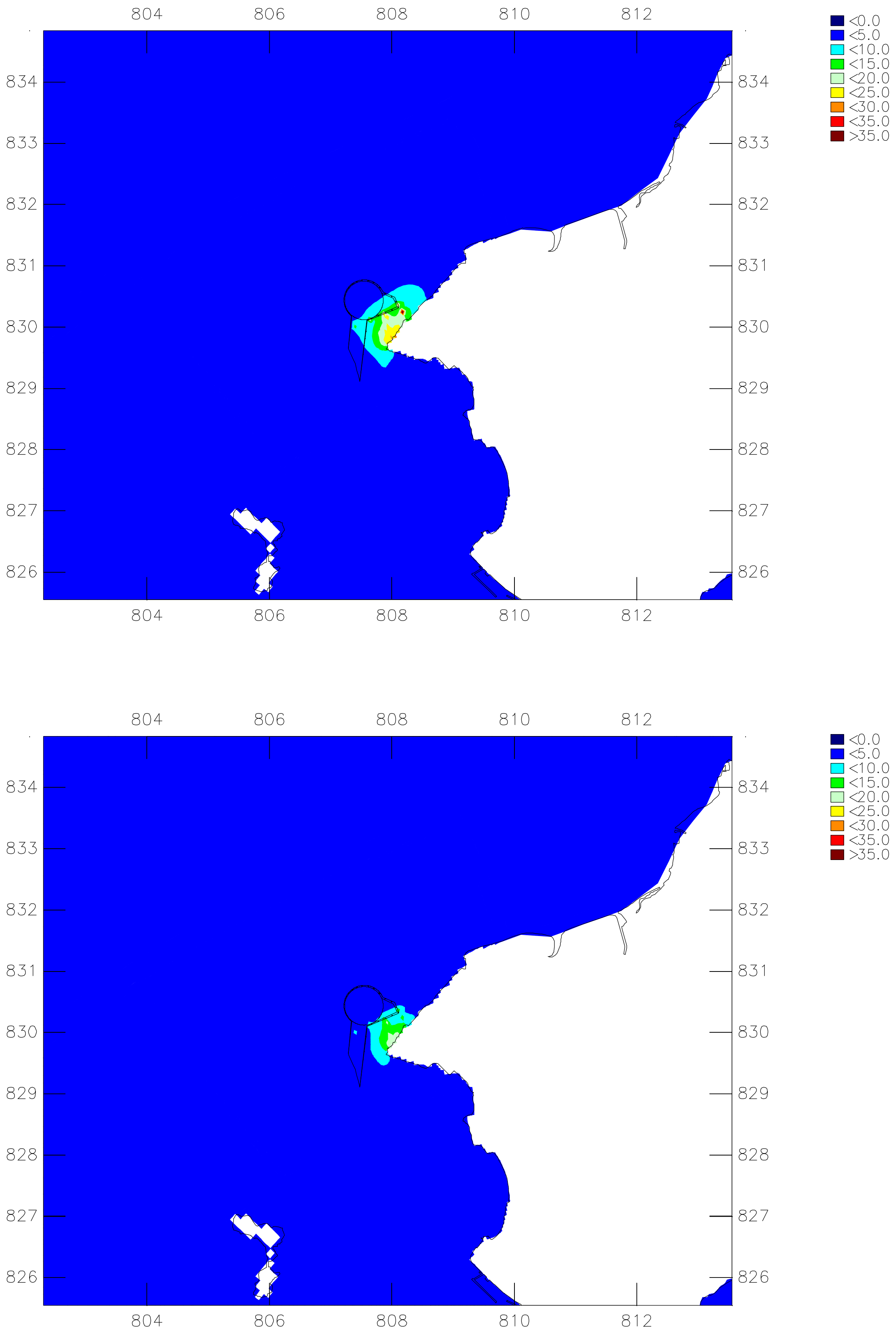
Upper plot: surface layer – Lower plot: middle layer

Wet Season

Scenario 1a

WL | Delft Hydraulics – ERM

Fig. BP_C01c



Suspended Solids (mg/L) – mean over a complete spring-neap cycle

Marine Construction Works at Black Point

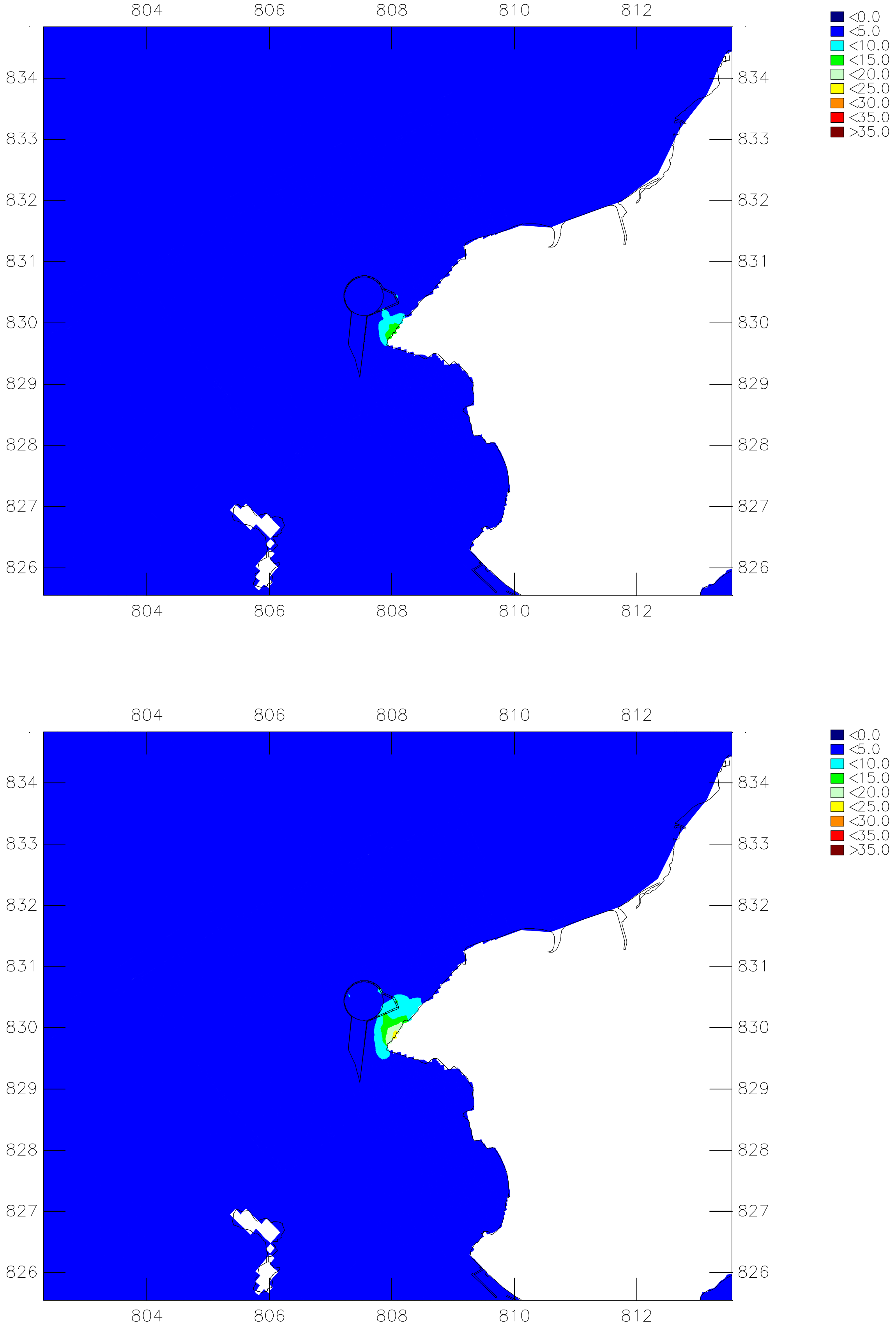
Upper plot: bottom layer – Lower plot: depth average

Wet Season

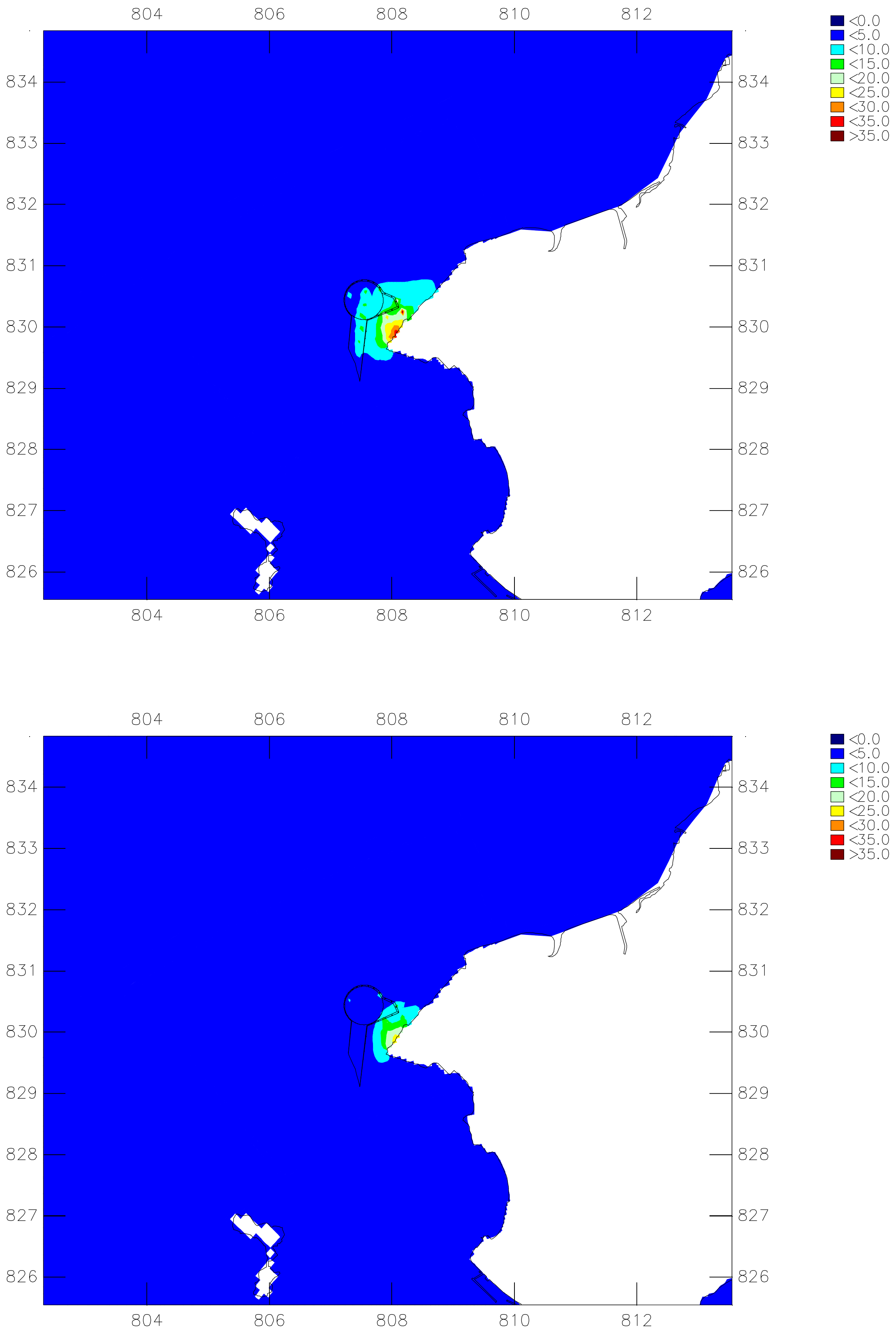
Scenario 1a

WL | Delft Hydraulics – ERM

Fig. BP_C01d



Suspended Solids (mg/L) – mean over a complete spring-neap cycle Marine Construction Works at Black Point Upper plot: surface layer – Lower plot: middle layer	Dry Season Scenario 1b
WL | Delft Hydraulics – ERM	Fig. BP_C01e



Suspended Solids (mg/L) – mean over a complete spring-neap cycle

Marine Construction Works at Black Point

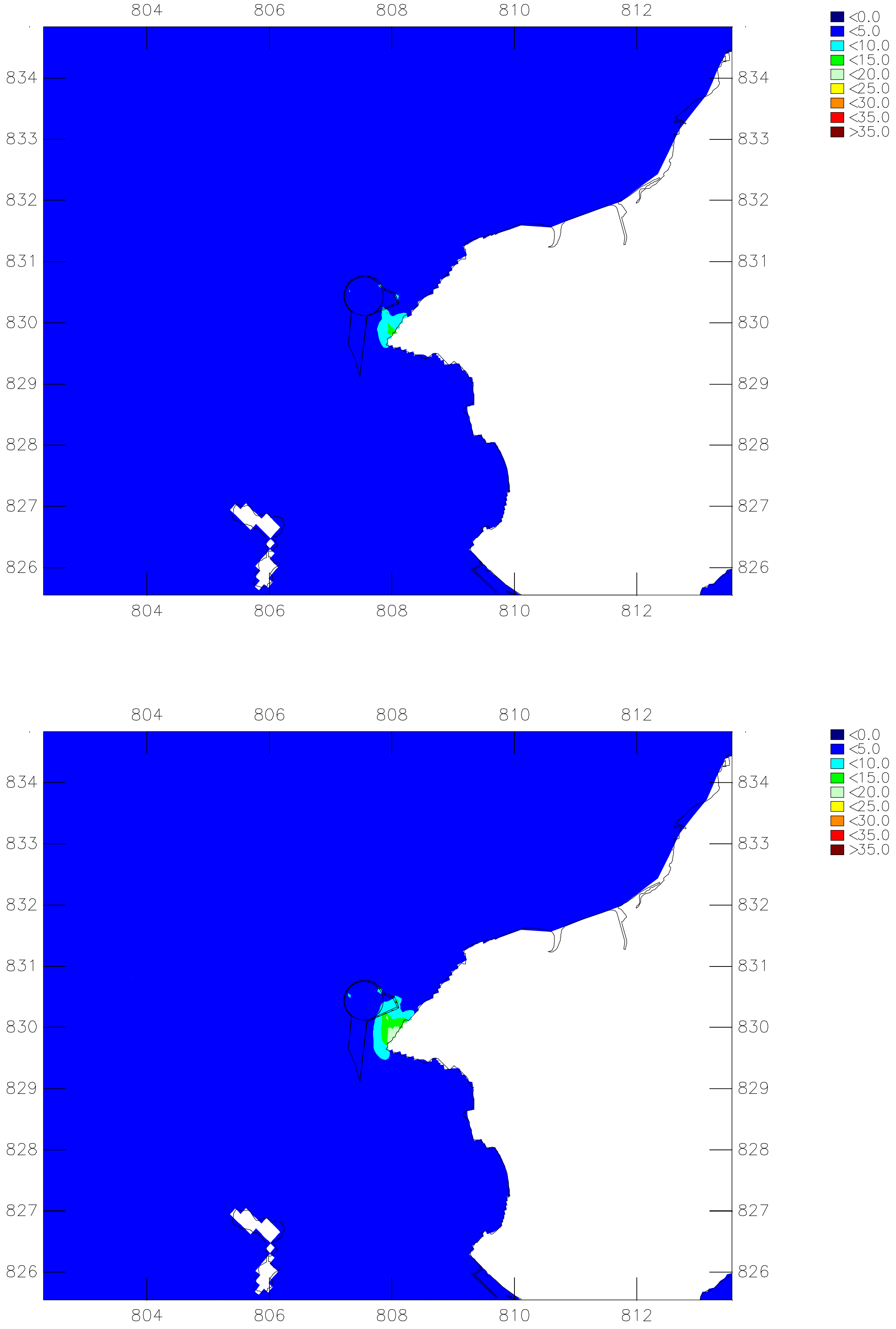
Upper plot: bottom layer – Lower plot: depth average

Dry Season

Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C01f



Suspended Solids (mg/L) – mean over a complete spring-neap cycle

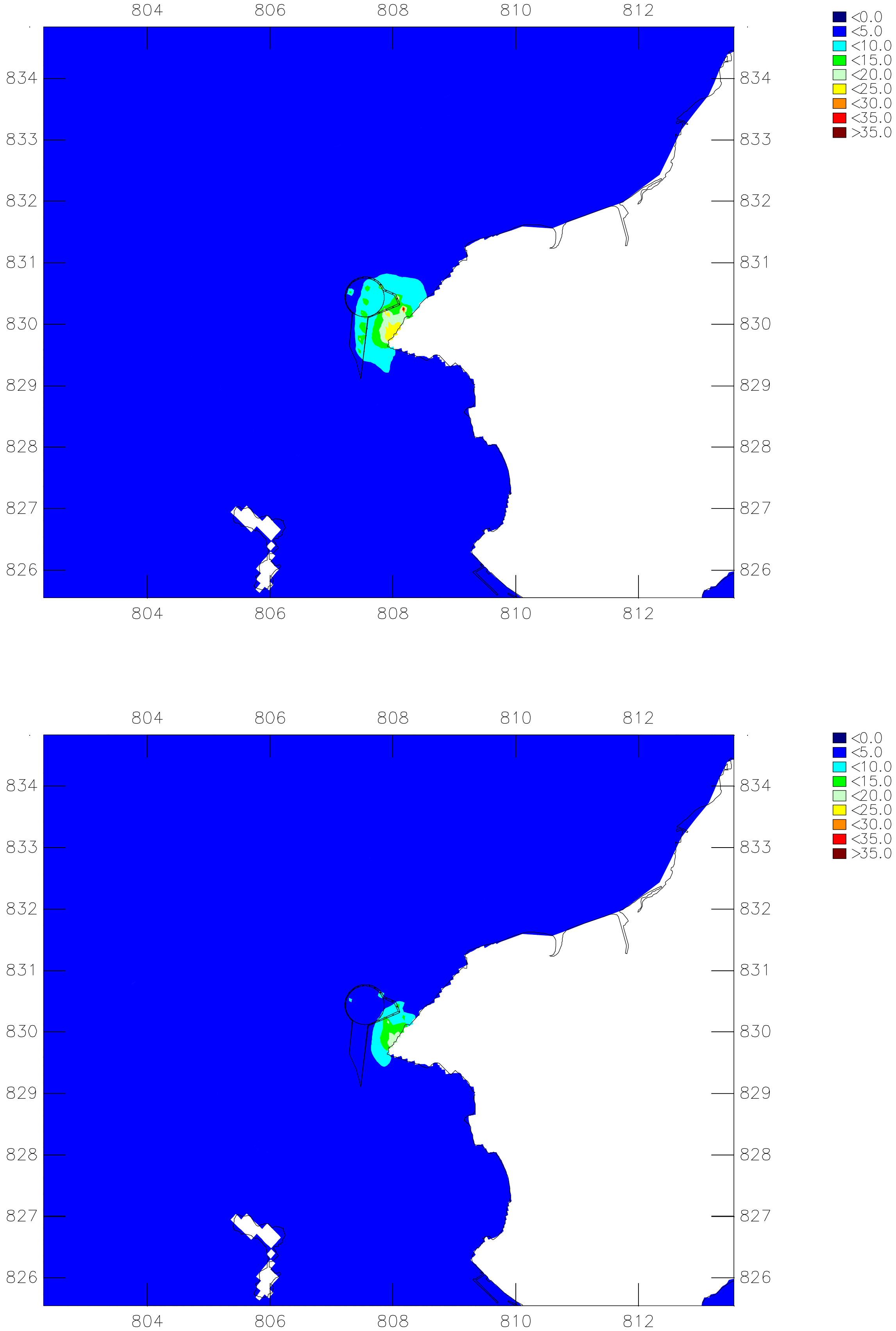
Marine Construction Works at Black Point

Upper plot: surface layer – Lower plot: middle layer

Wet Season	
Scenario 1b	

WL | Delft Hydraulics – ERM

Fig. BP_C01g



Suspended Solids (mg/L) – mean over a complete spring-neap cycle

Marine Construction Works at Black Point

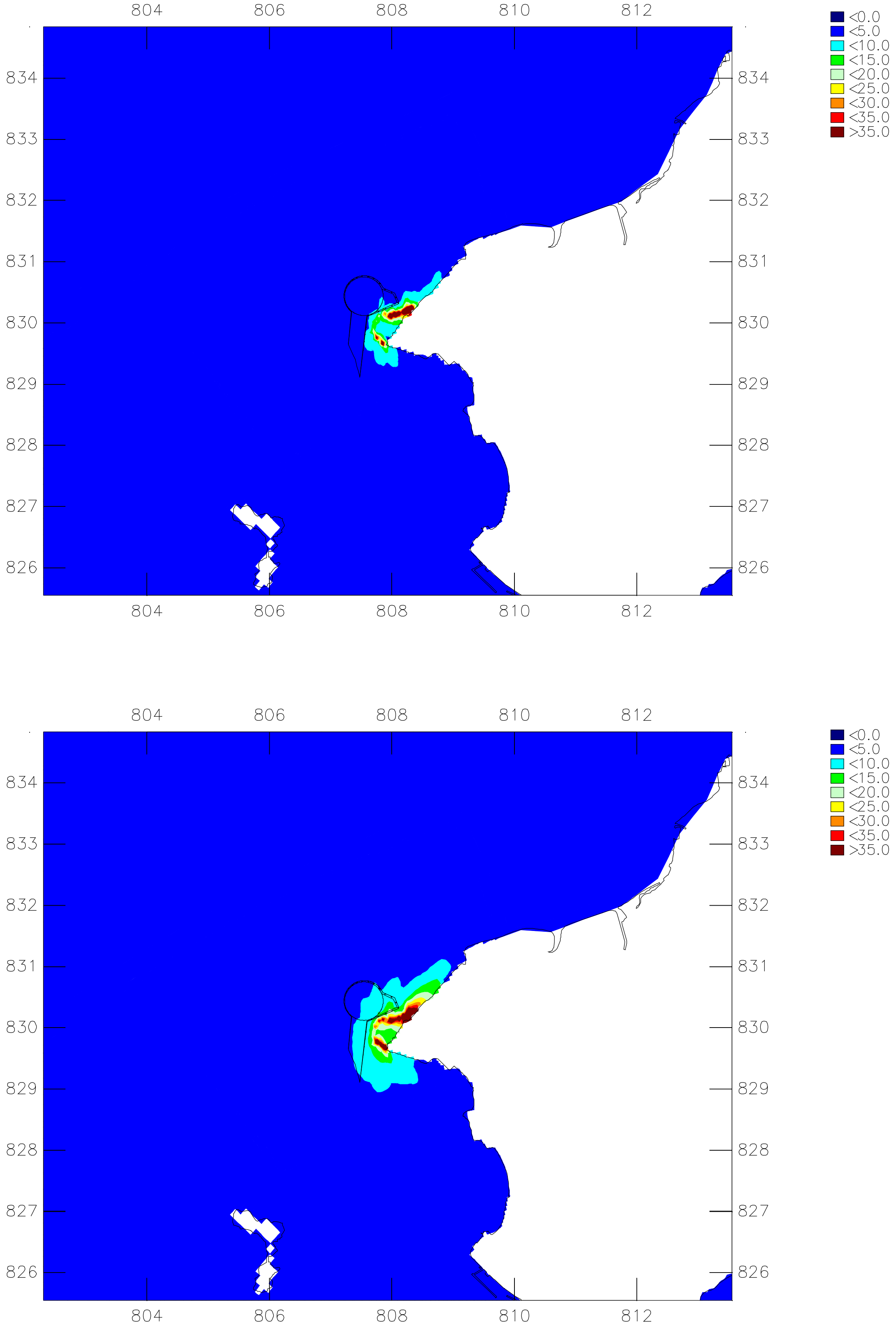
Upper plot: bottom layer – Lower plot: depth average

Wet Season

Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C01h



Suspended Solids (mg/L) — max. over a complete spring-neap cycle

BP 01, BP02

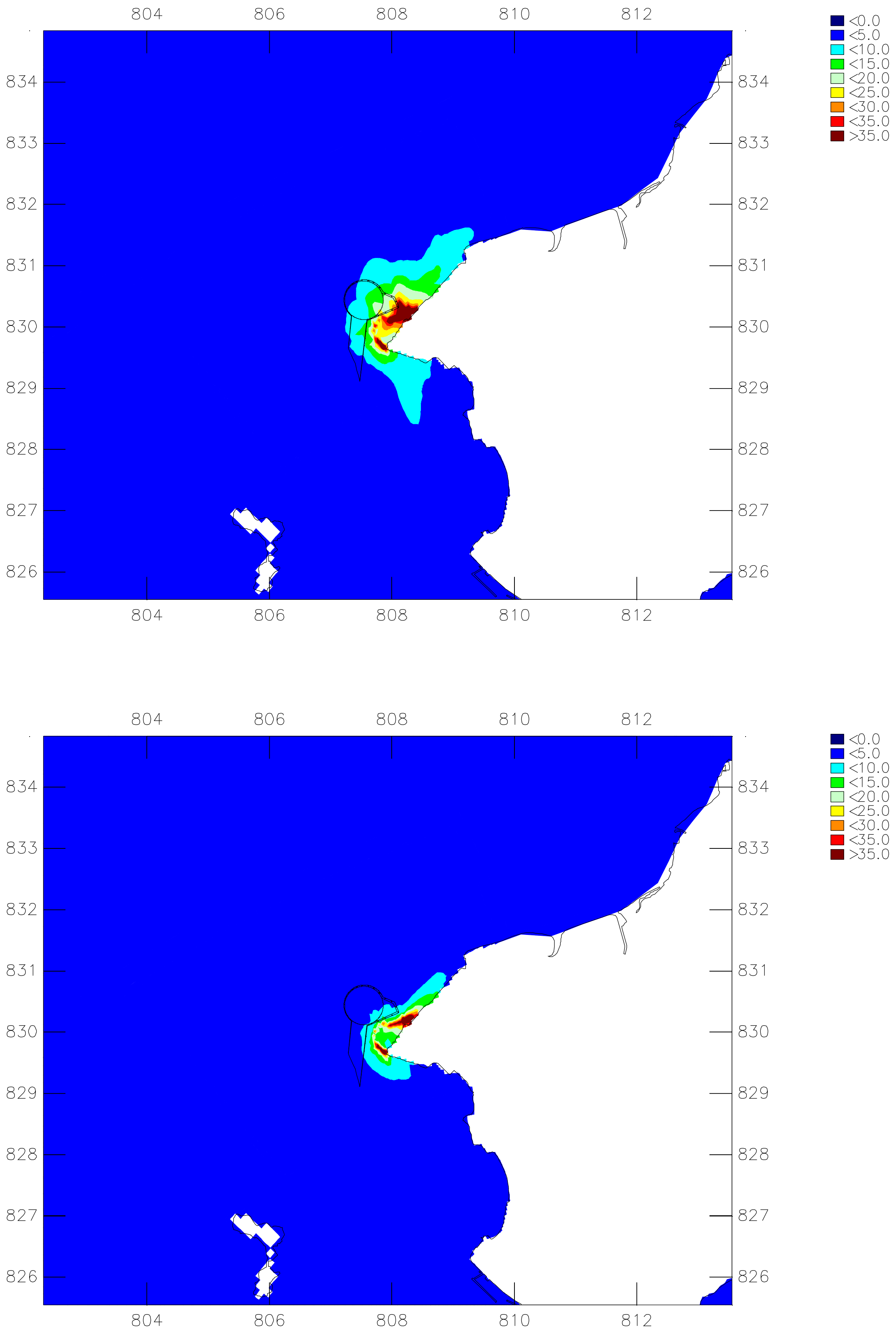
Upper plot: surface layer — Lower plot: middle layer

Dry Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics — ERM

Fig. BP_C01a_max



Suspended Solids (mg/L) — max. over a complete spring-neap cycle

BP 01, BP02

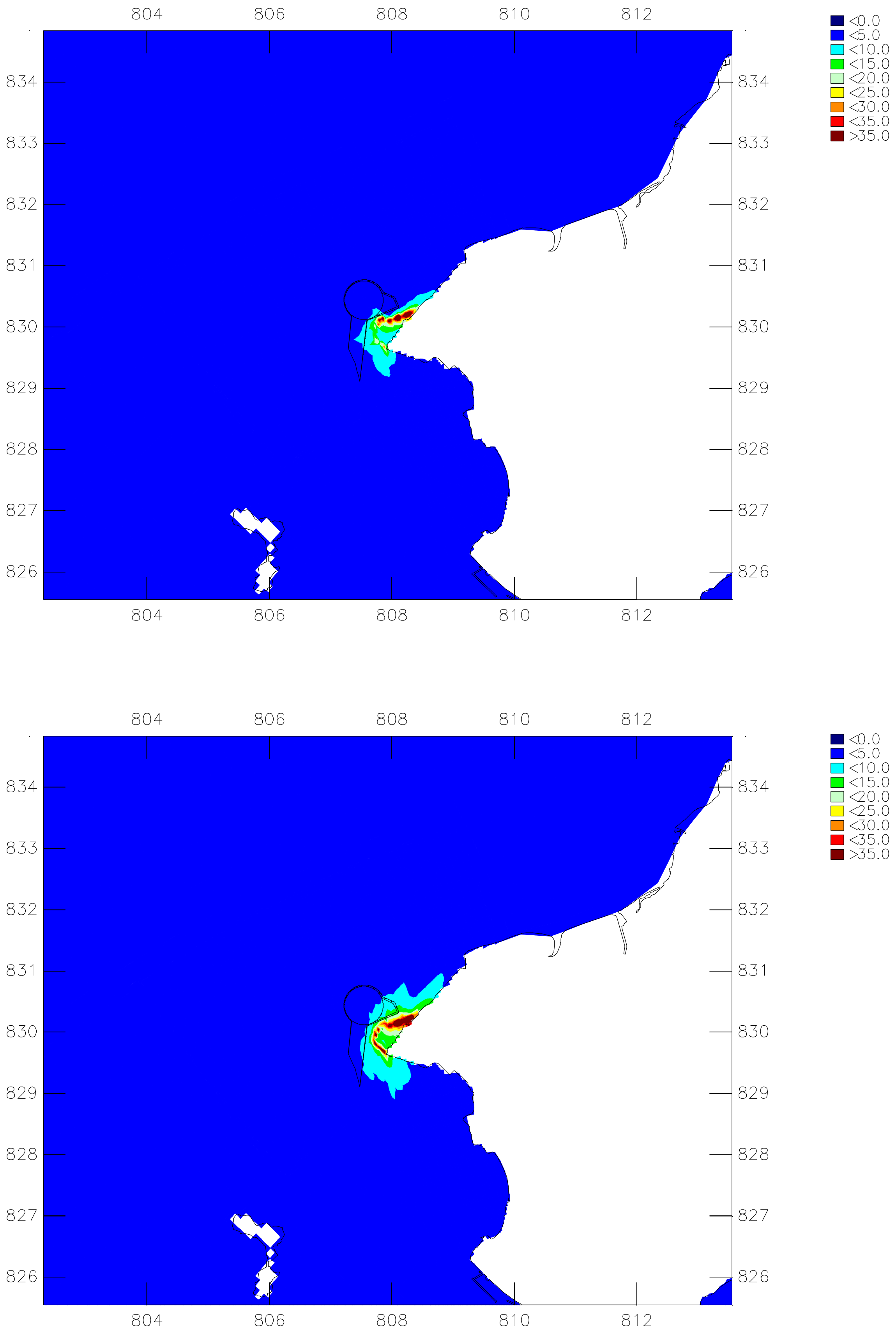
Upper plot: bottom layer — Lower plot: depth average

Dry Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics — ERM

Fig. BP_C01b_max



Suspended Solids (mg/L) – max. over a complete spring-neap cycle

BP 01, BP02

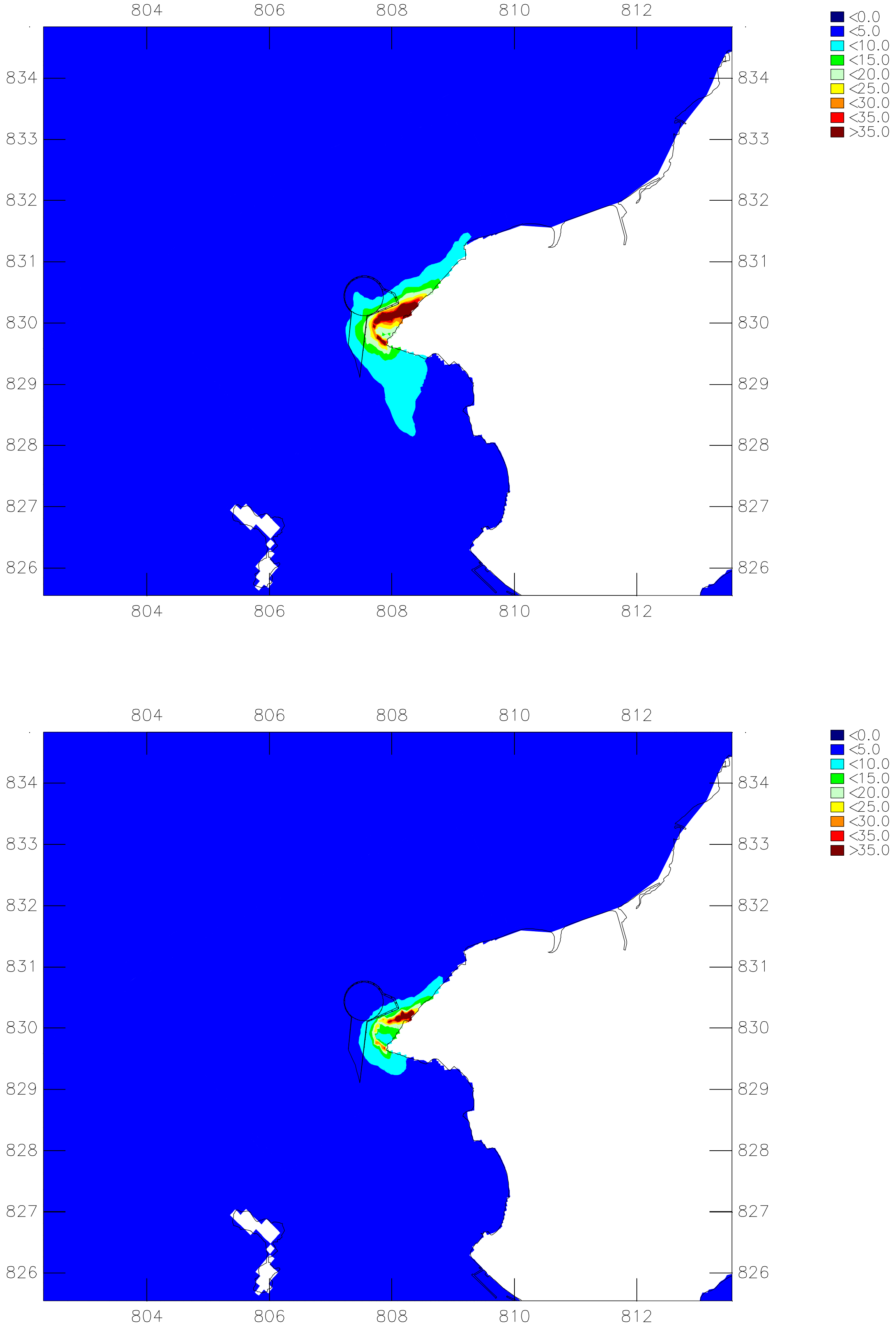
Upper plot: surface layer – Lower plot: middle layer

Wet Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C01c_max



Suspended Solids (mg/L) – max. over a complete spring-neap cycle

BP 01, BP02

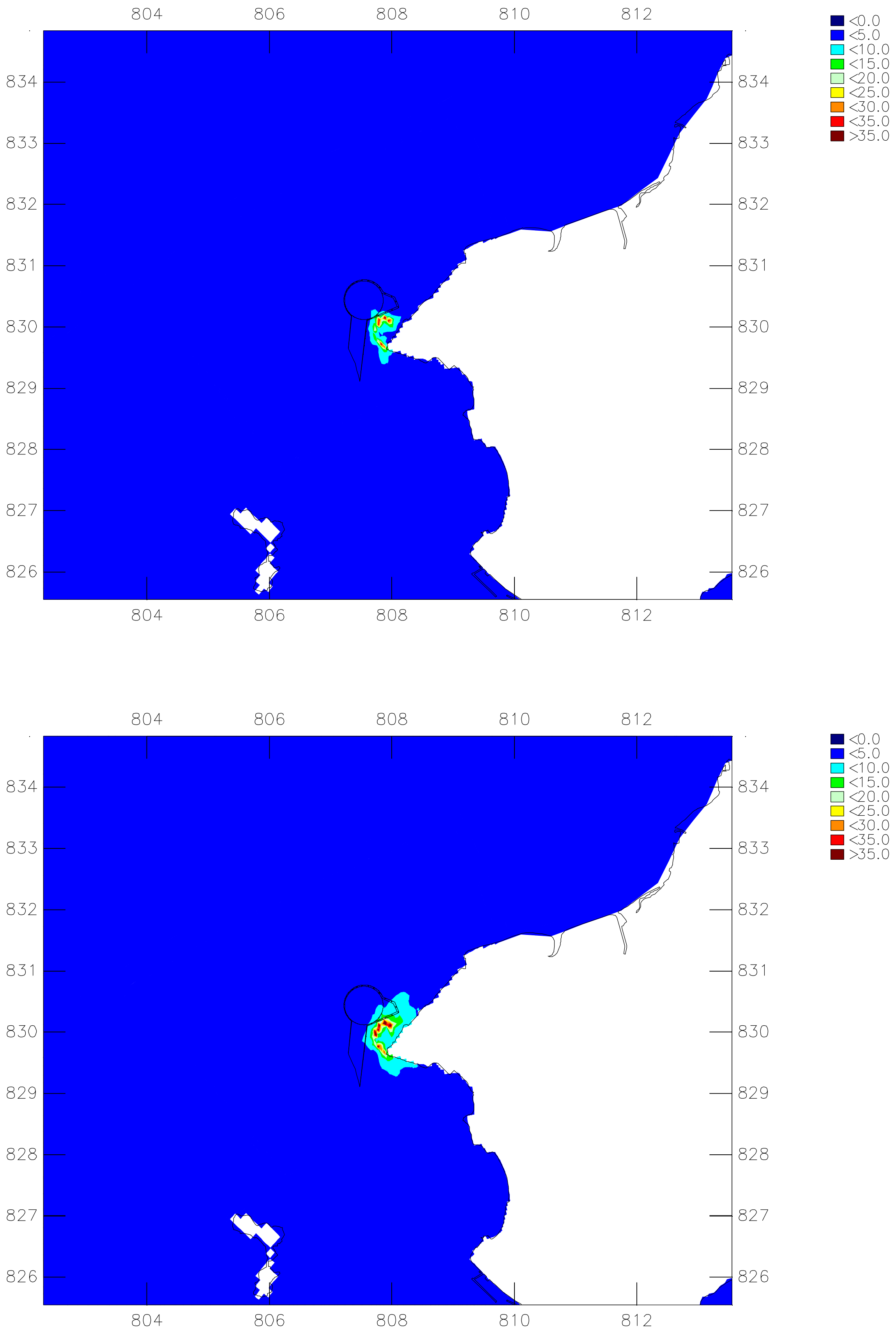
Upper plot: bottom layer – Lower plot: depth average

Wet Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C01d_max



Suspended Solids (mg/L) – max. over a complete spring-neap cycle

BP 15

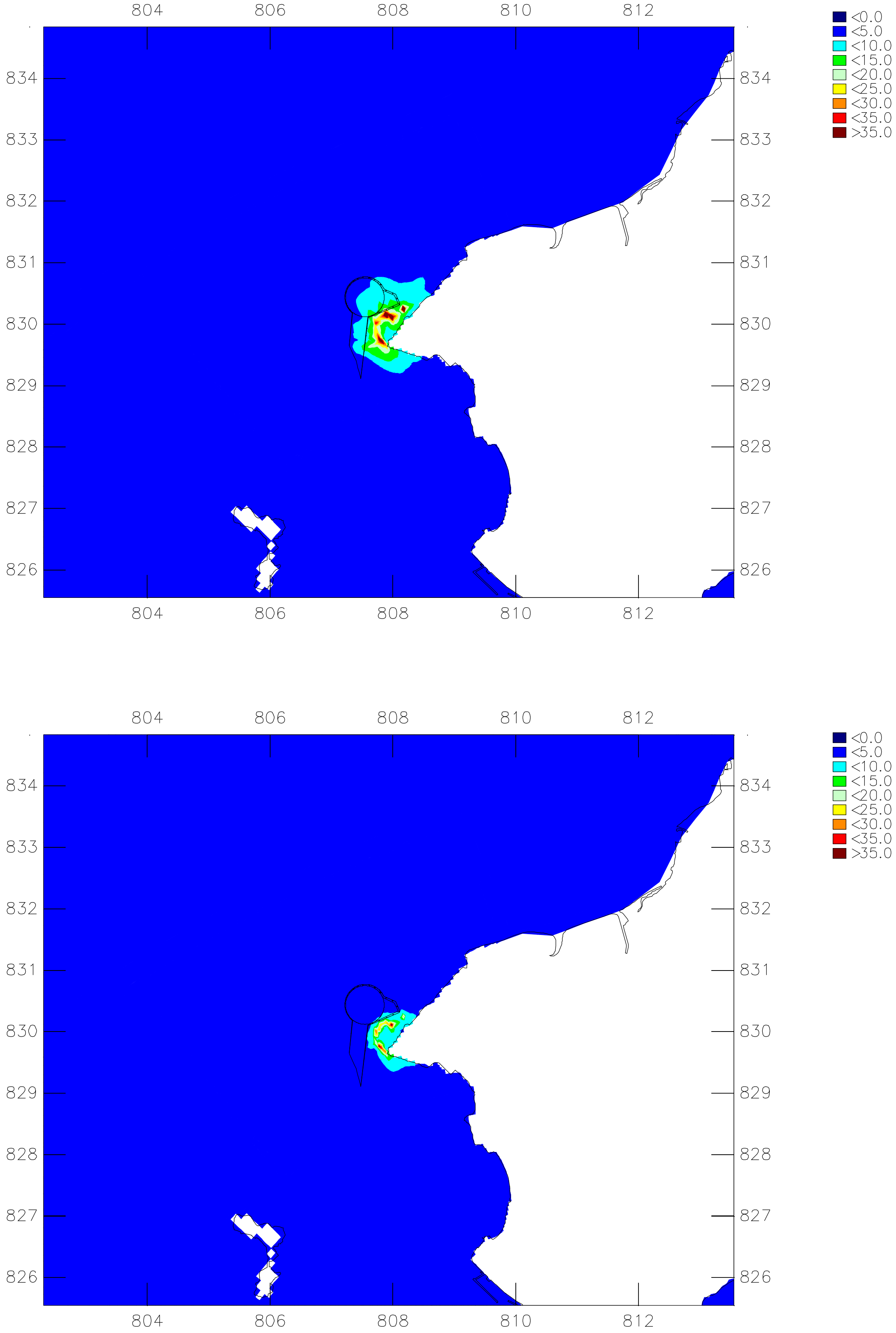
Upper plot: surface layer – Lower plot: middle layer

Dry Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C01e_max



Suspended Solids (mg/L) — max. over a complete spring-neap cycle

BP 15

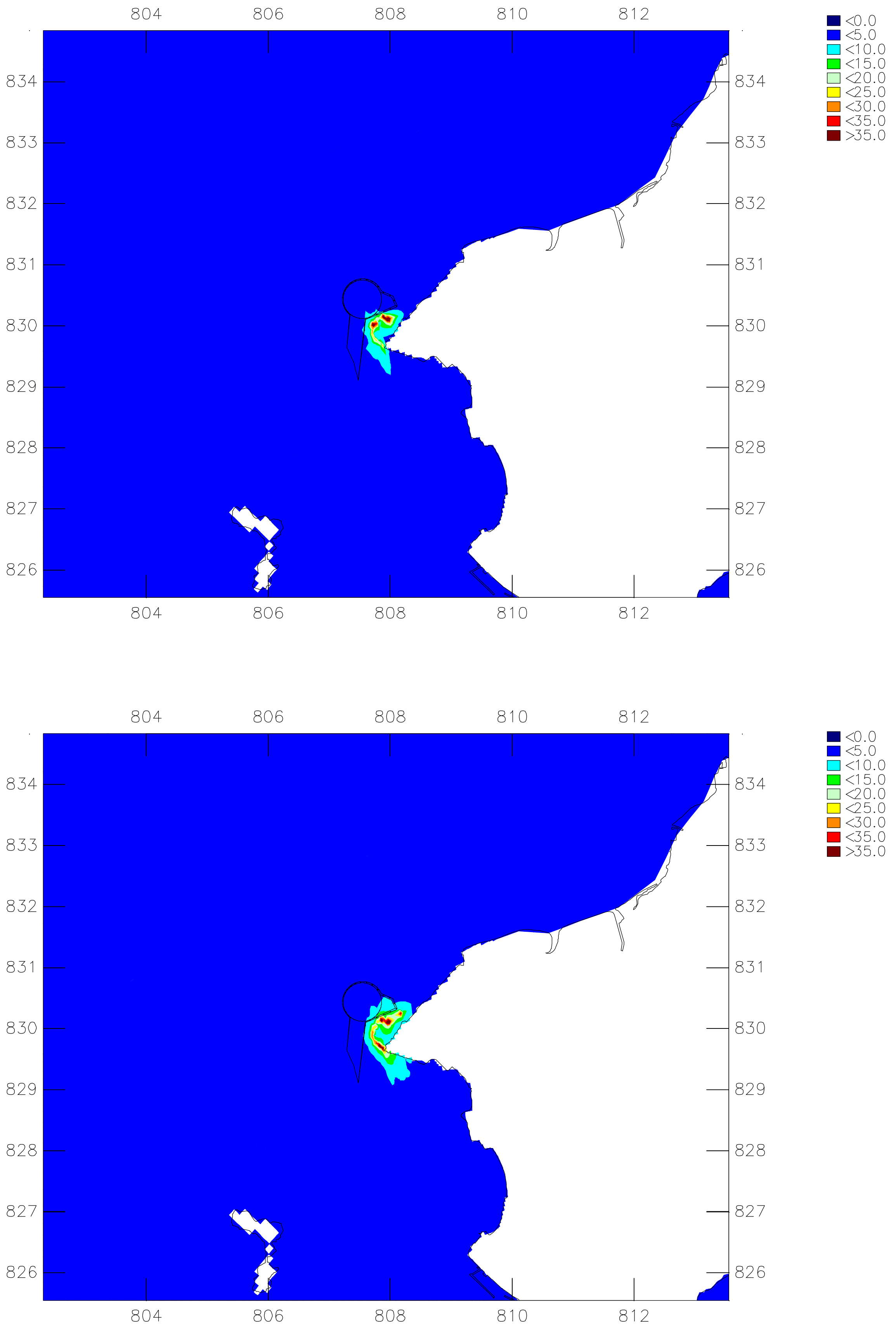
Upper plot: bottom layer — Lower plot: depth average

Dry Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics — ERM

Fig. BP_C01f_max



Suspended Solids (mg/L) – max. over a complete spring-neap cycle

BP 15

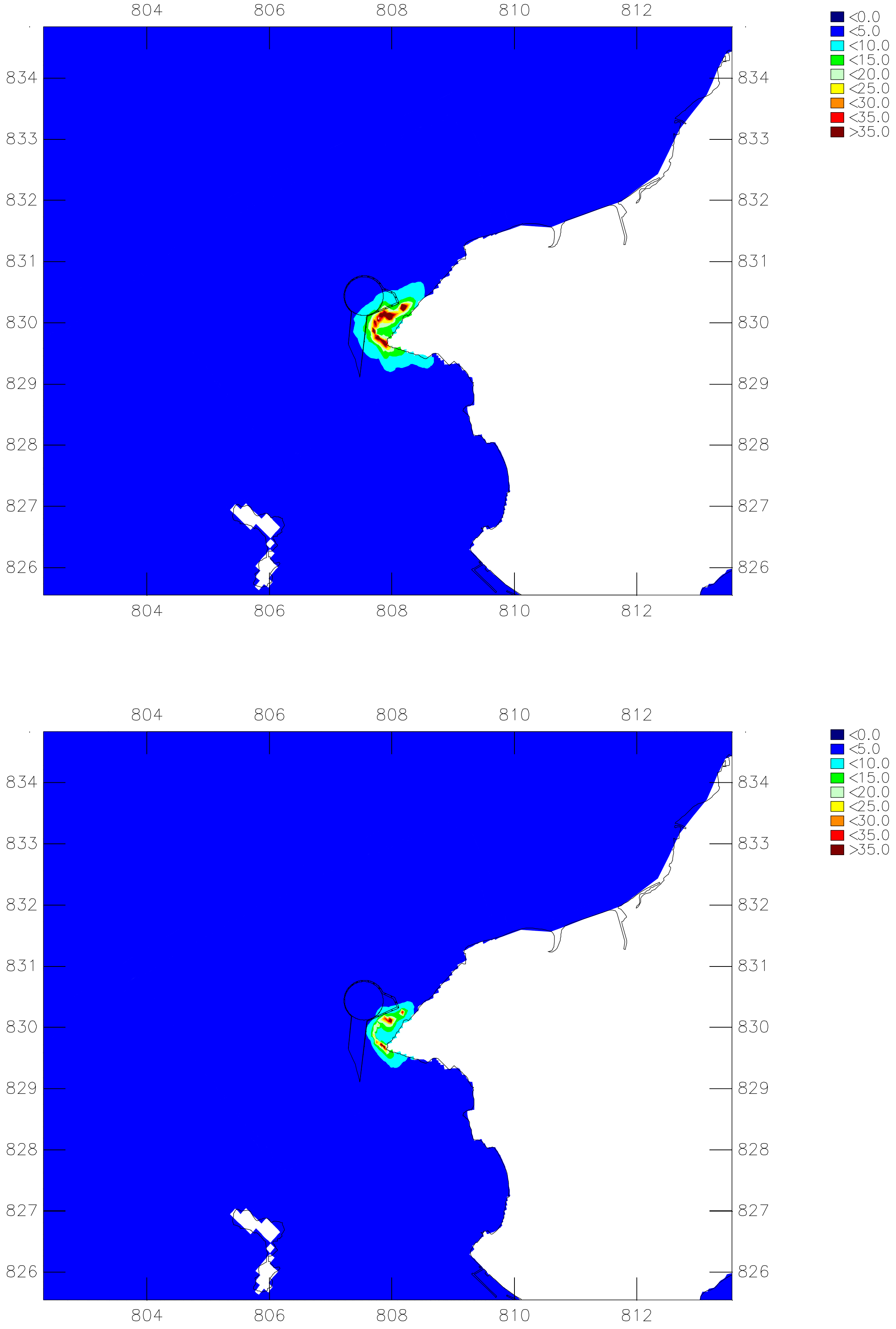
Upper plot: surface layer – Lower plot: middle layer

Wet Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C01g_max



Suspended Solids (mg/L) – max. over a complete spring-neap cycle

BP 15

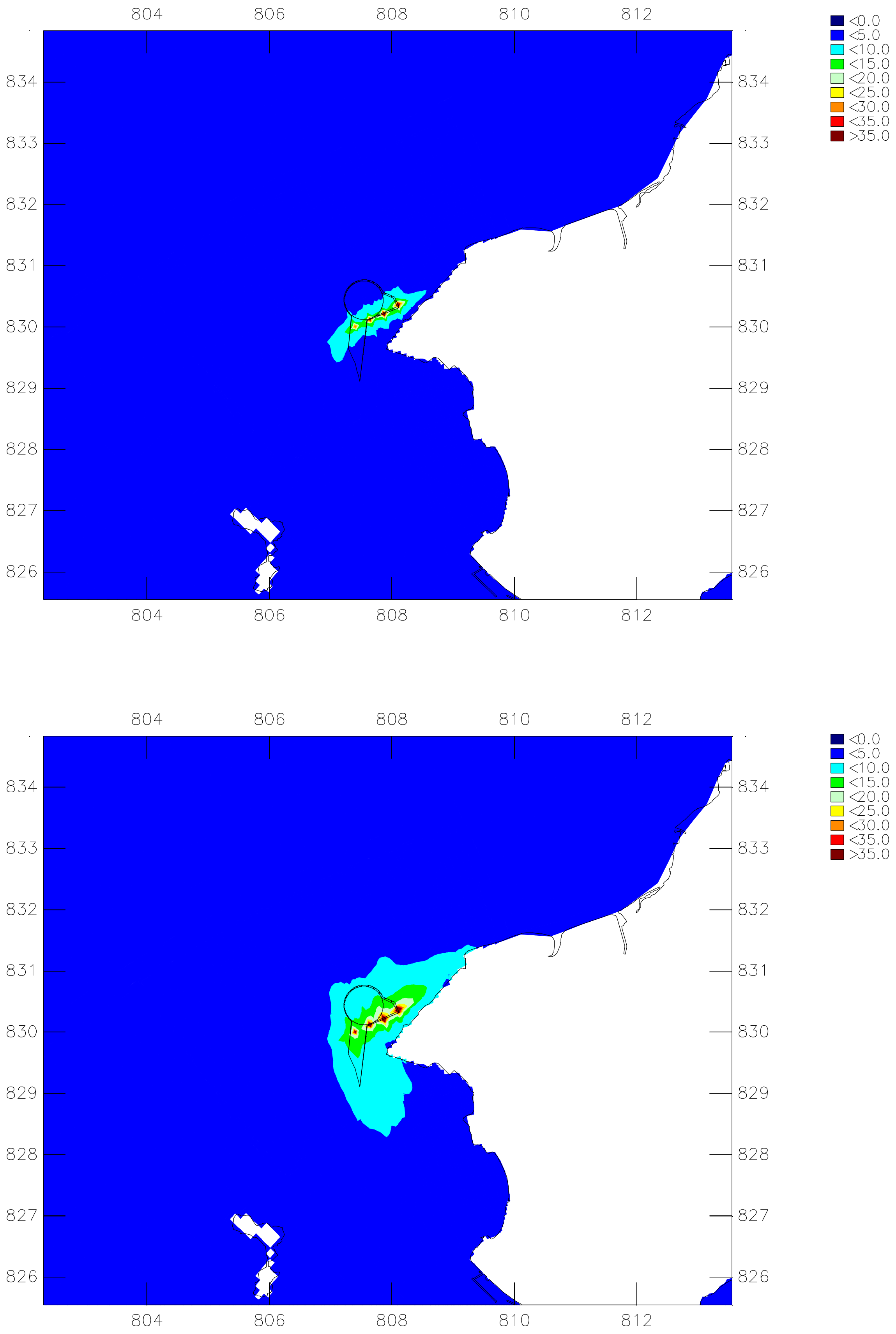
Upper plot: bottom layer – Lower plot: depth average

Wet Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C01h_max



Suspended Solids (mg/L) – max. over a complete spring-neap cycle

BP 07, 08a, 09a, 10a

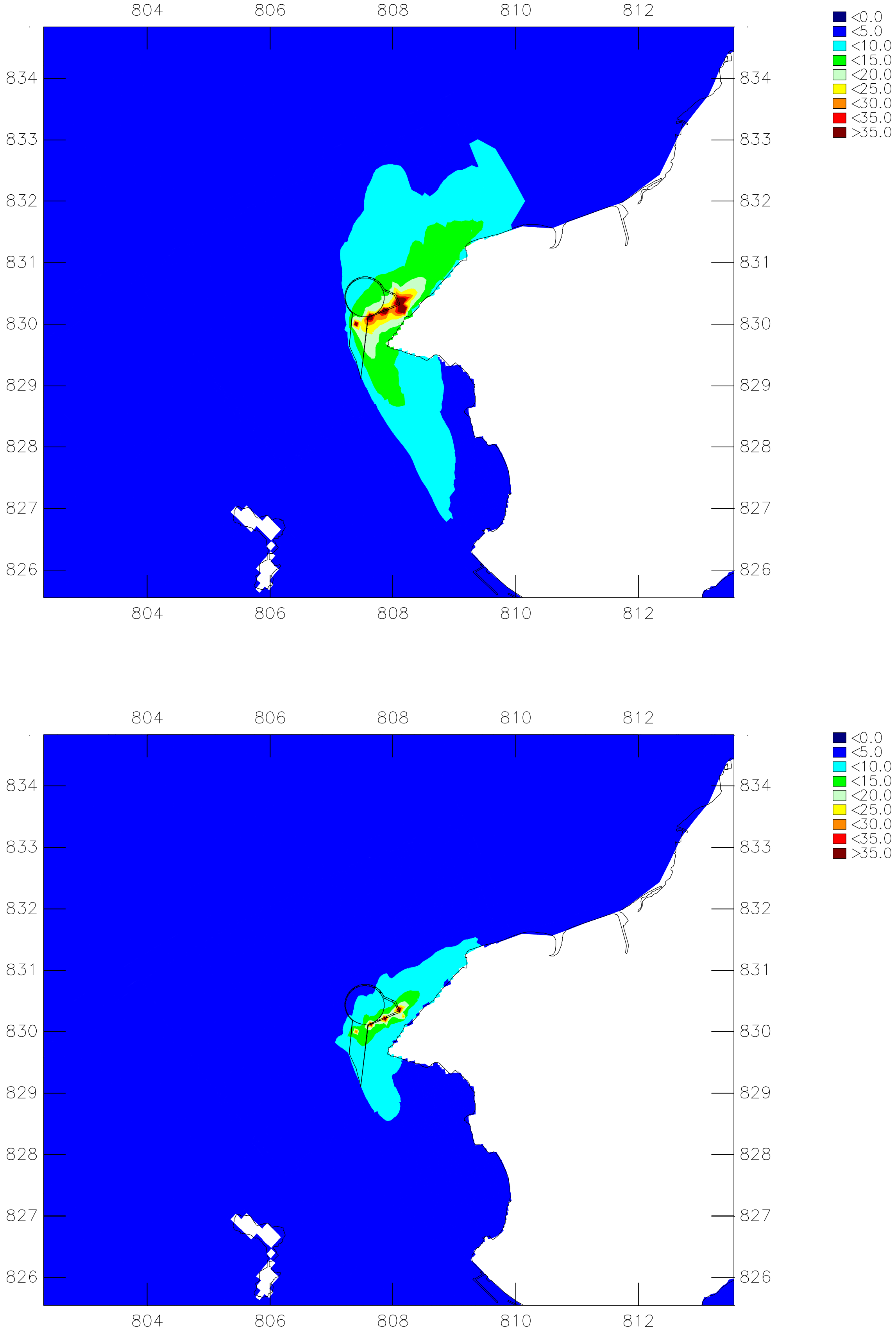
Upper plot: surface layer – Lower plot: middle layer

Dry Season

Scenario 1a

WL | Delft Hydraulics – ERM

Fig. BP_C01i_max



Suspended Solids (mg/L) – max. over a complete spring-neap cycle

BP 07, 08a, 09a, 10a

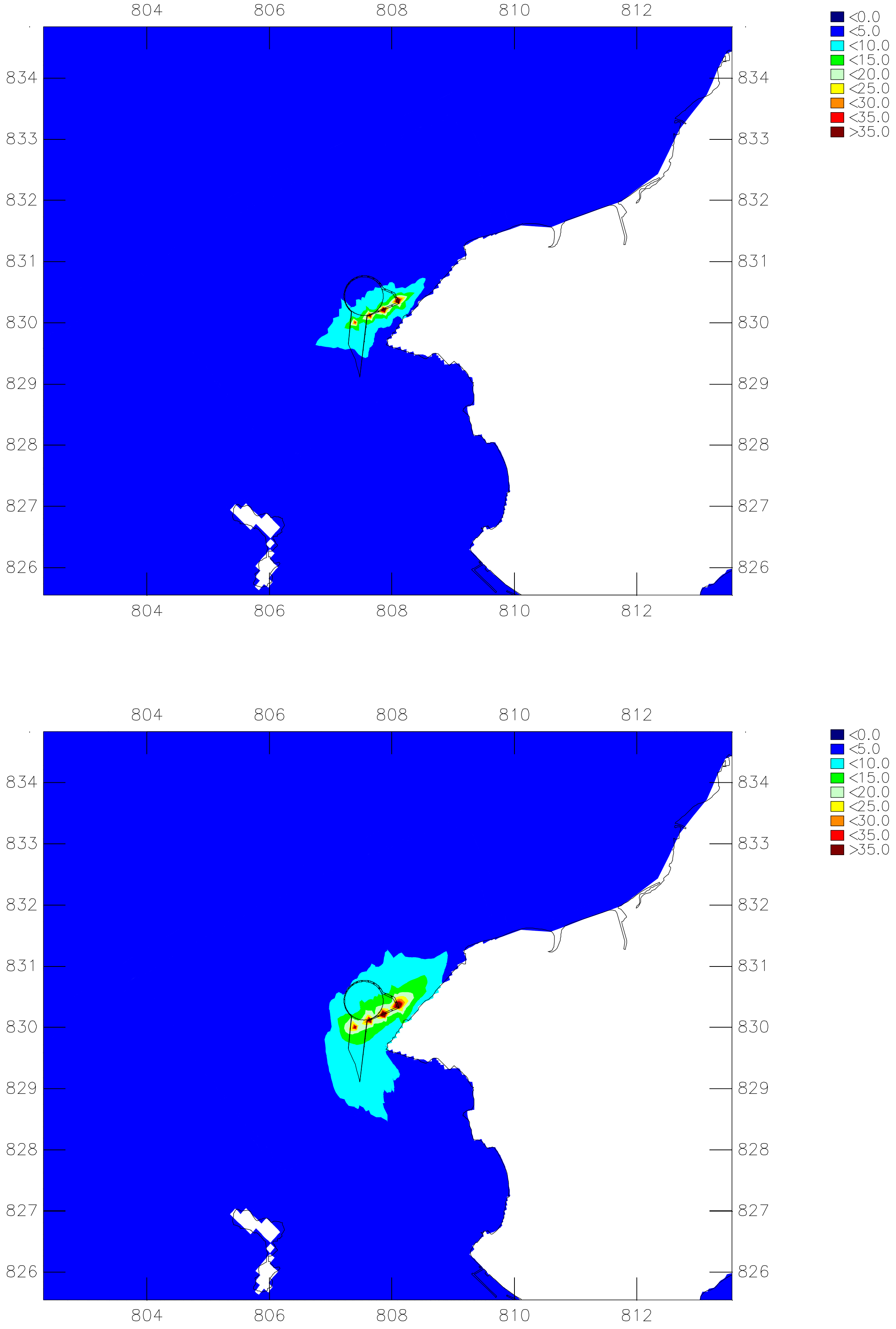
Upper plot: bottom layer – Lower plot: depth average

Dry Season

Scenario 1a

WL | Delft Hydraulics – ERM

Fig. BP_C01j_max



Suspended Solids (mg/L) – max. over a complete spring-neap cycle

BP 07, 08a, 09a, 10a

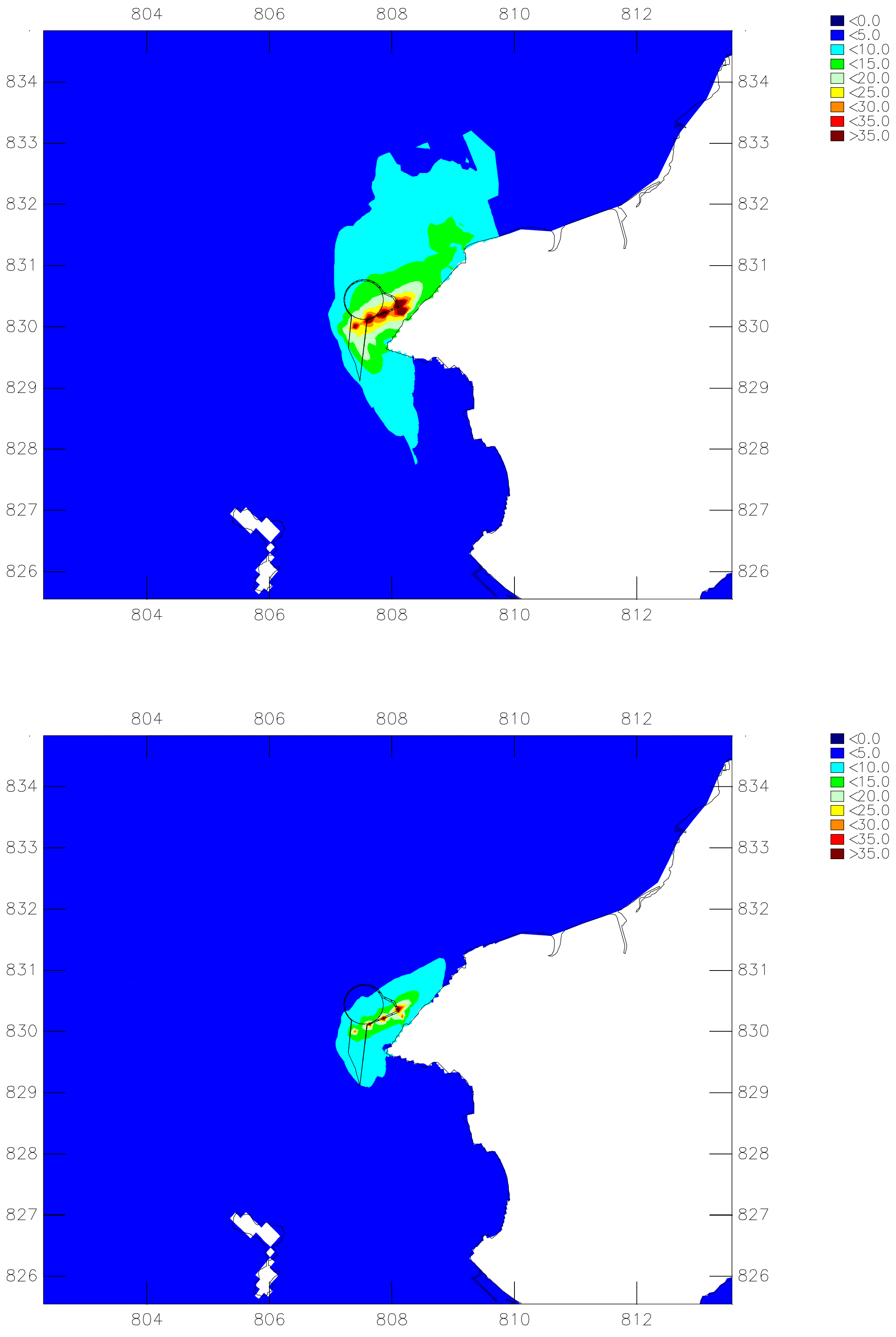
Upper plot: surface layer – Lower plot: middle layer

Wet Season

Scenario 1a

WL | Delft Hydraulics – ERM

Fig. BP_C01k_max



Suspended Solids (mg/L) — max. over a complete spring-neap cycle

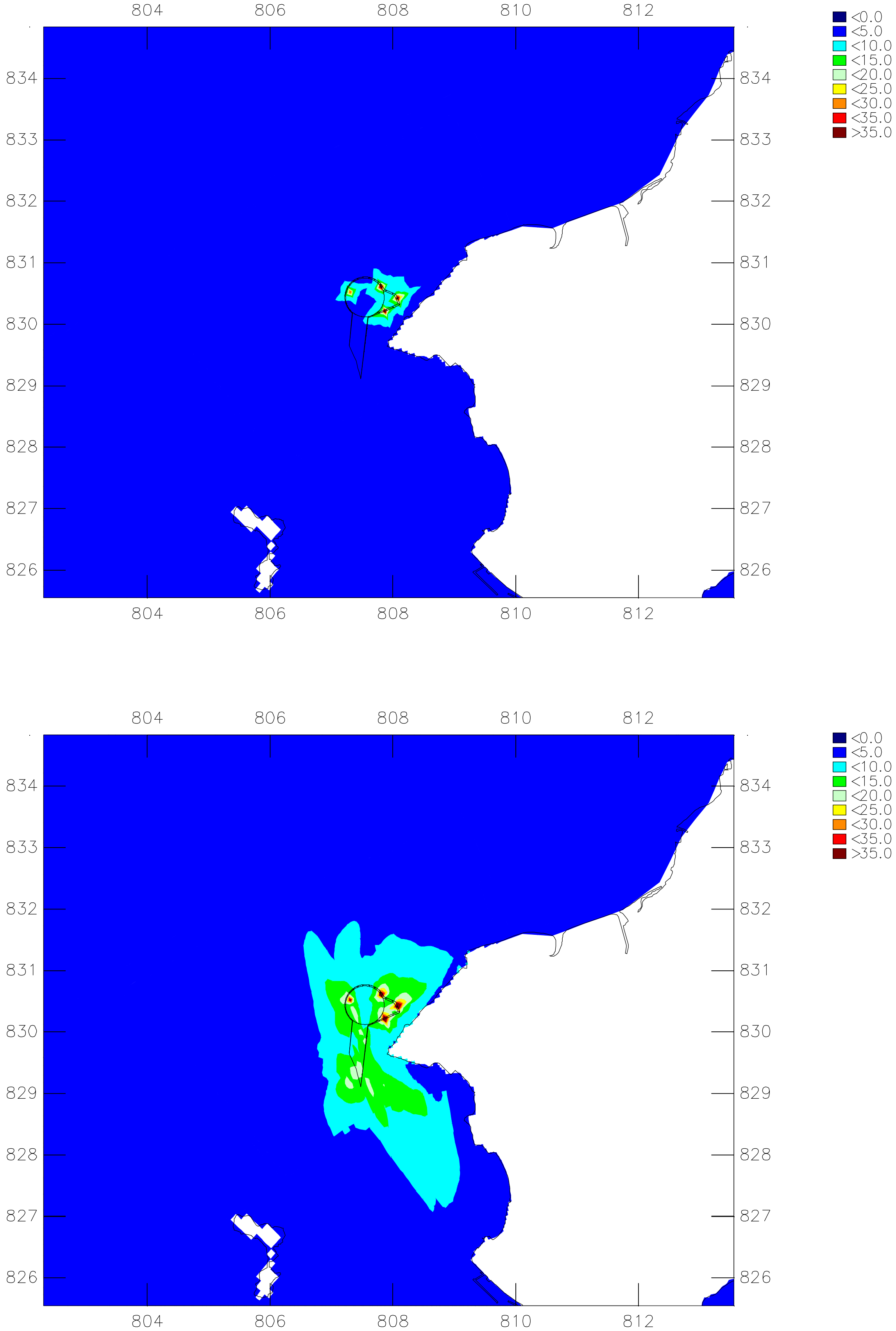
BP 07, 08a, 09a, 10a

Upper plot: bottom layer — Lower plot: depth average

Wet Season	
Scenario 1a	

WL | Delft Hydraulics — ERM

Fig. BP_C01l_max



Suspended Solids (mg/L) – max. over a complete spring-neap cycle

BP 07, 08b, 09b, 10b, BP11

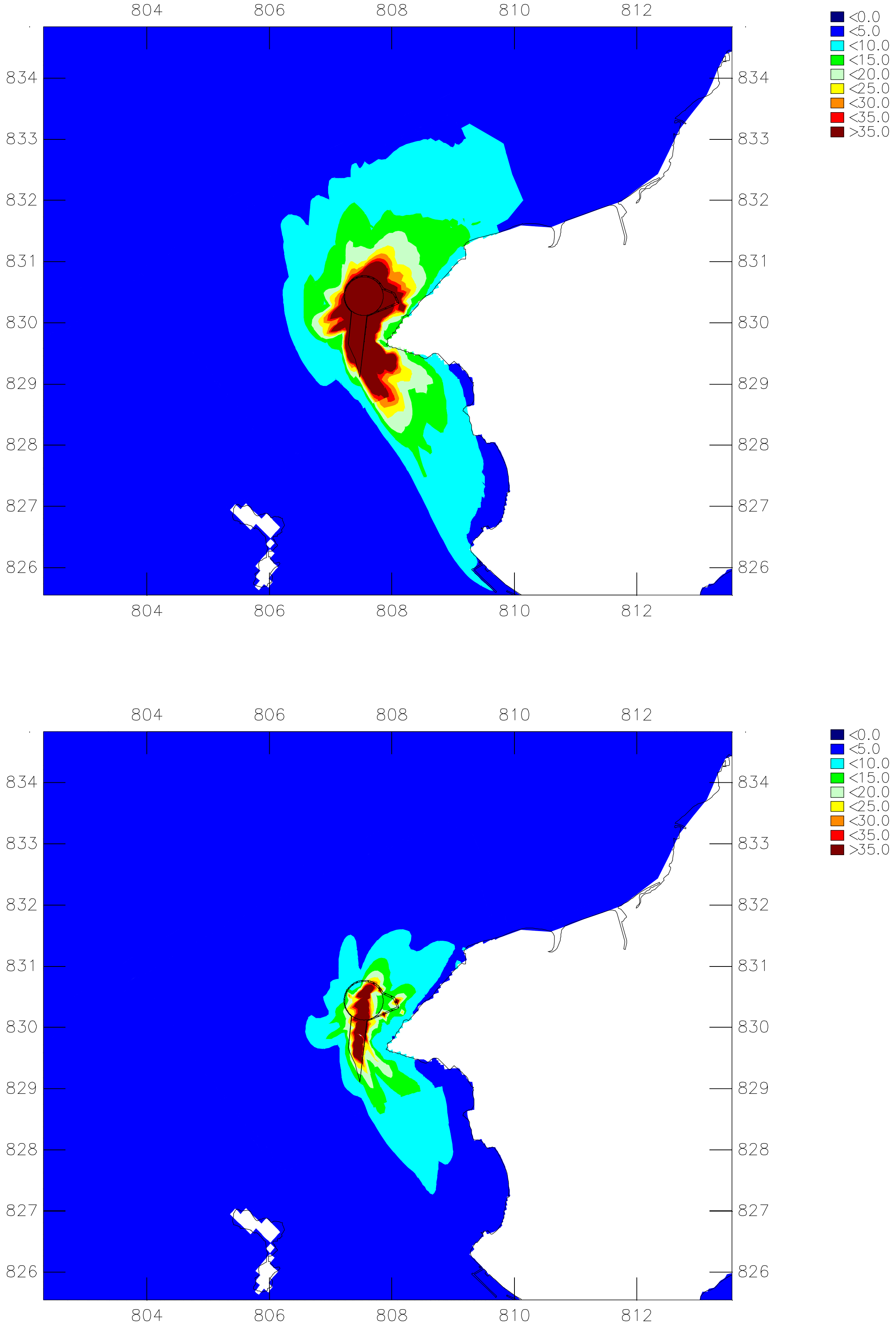
Upper plot: surface layer – Lower plot: middle layer

Dry Season

Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C01m_max



Suspended Solids (mg/L) – max. over a complete spring-neap cycle

BP 07, 08b, 09b, 10b, BP11

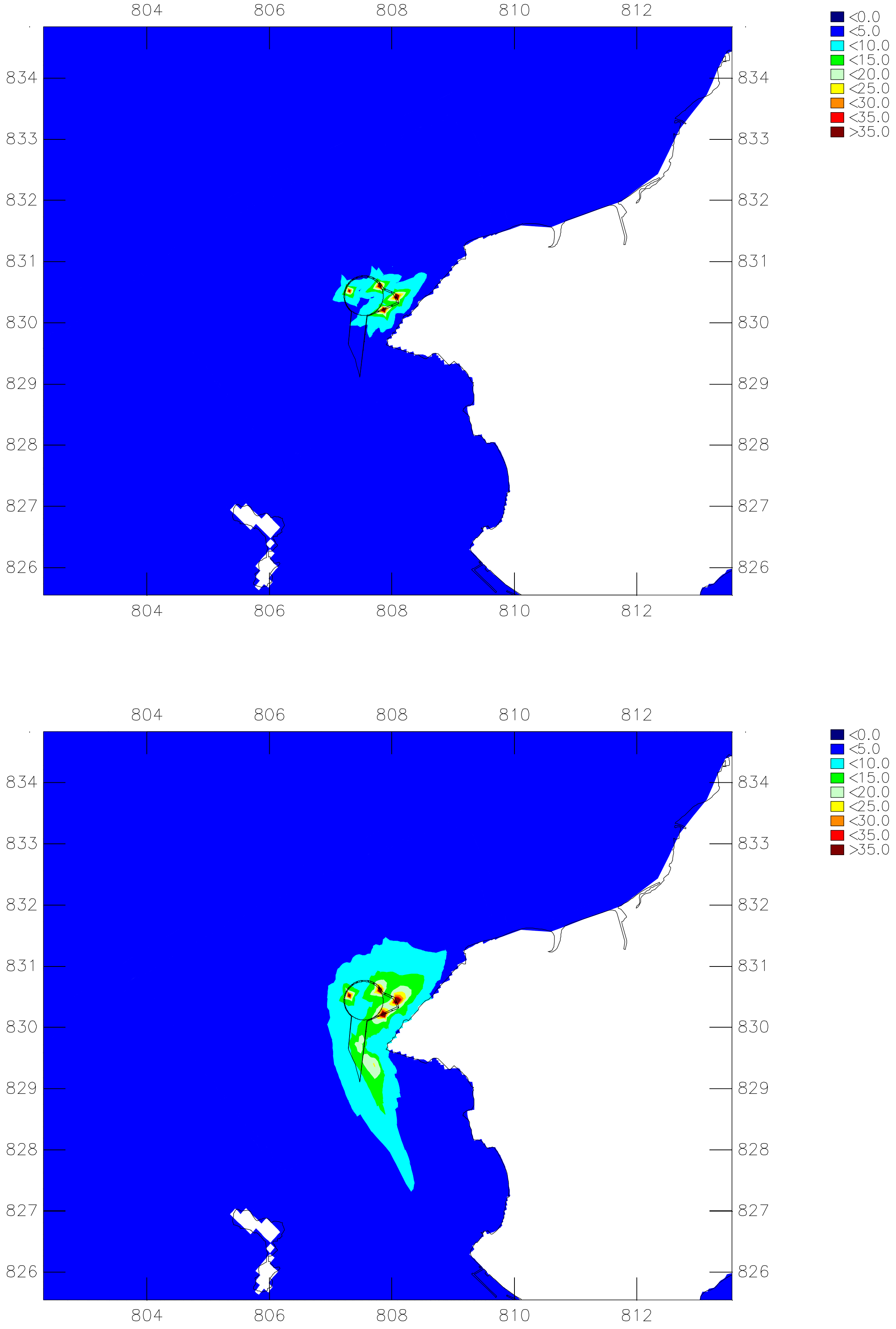
Upper plot: bottom layer – Lower plot: depth average

Dry Season

Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C01n_max



Suspended Solids (mg/L) – max. over a complete spring-neap cycle

BP 07, 08b, 09b, 10b, BP11

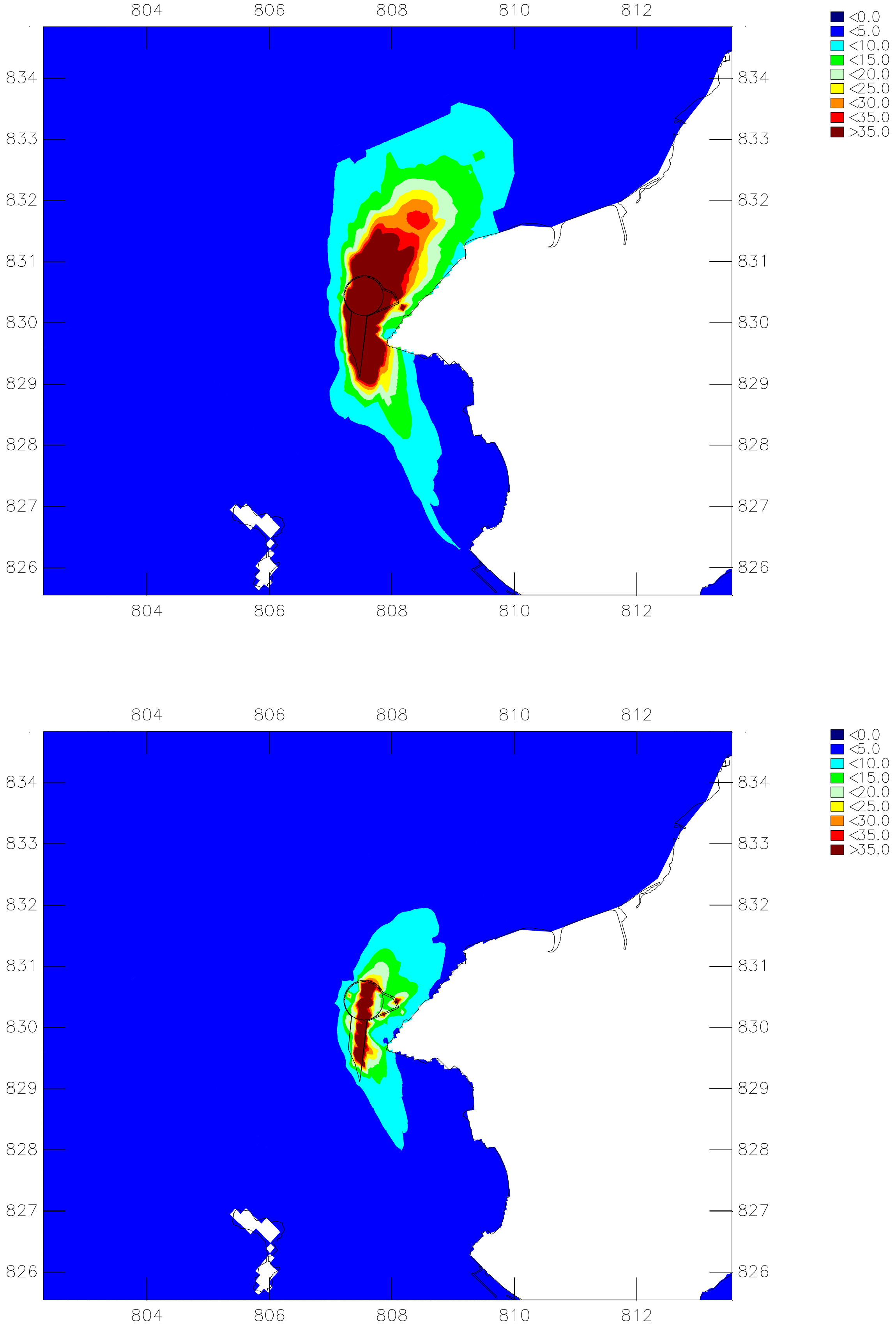
Upper plot: surface layer – Lower plot: middle layer

Wet Season

Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C01o_max



Suspended Solids (mg/L) – max. over a complete spring-neap cycle

BP 07, 08b, 09b, 10b, BP11

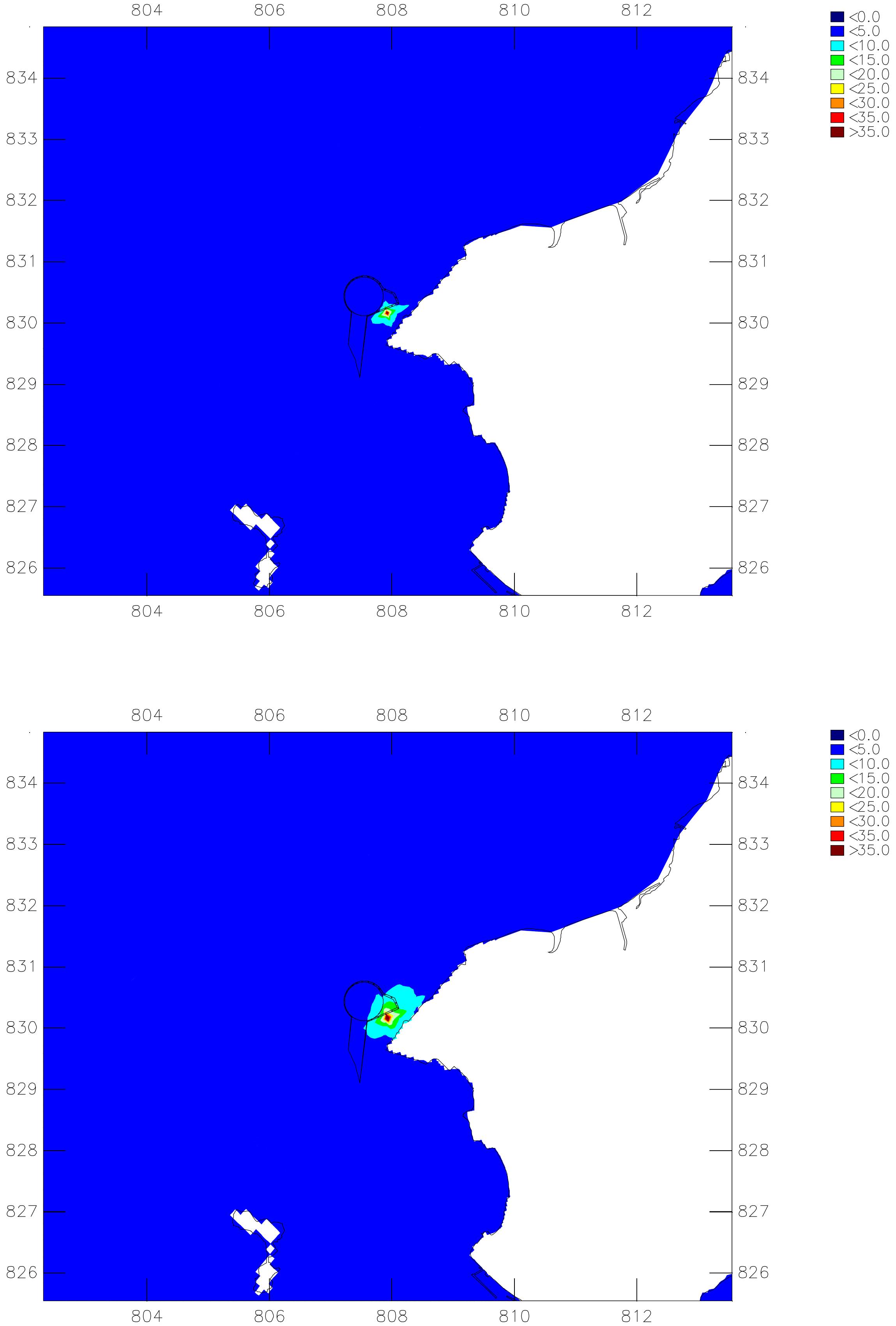
Upper plot: bottom layer – Lower plot: depth average

Wet Season

Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C01p_max



Suspended Solids (mg/L) – max. over a complete spring-neap cycle

BP 12

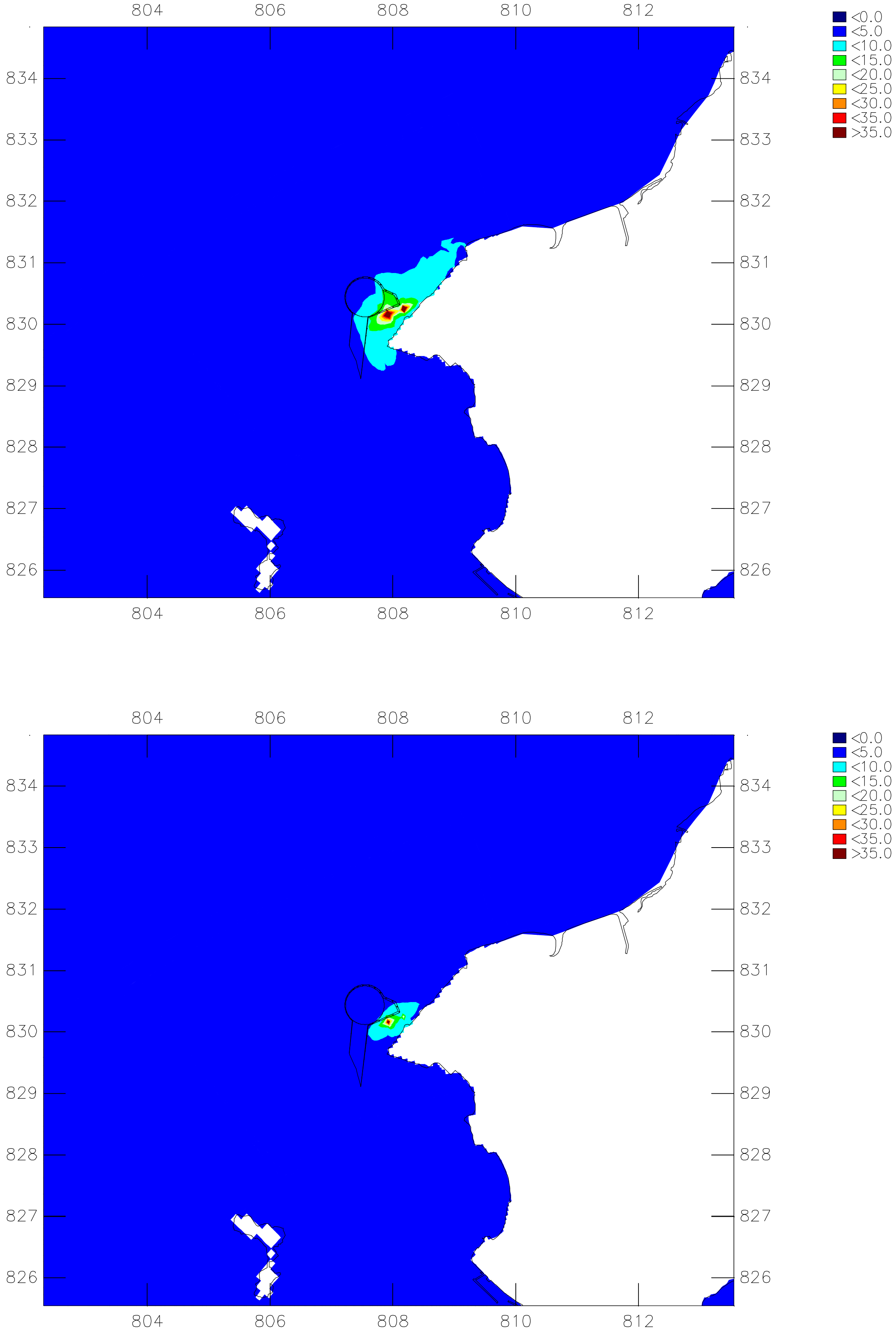
Upper plot: surface layer – Lower plot: middle layer

Dry Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C01q_max



Suspended Solids (mg/L) – max. over a complete spring-neap cycle

BP 12

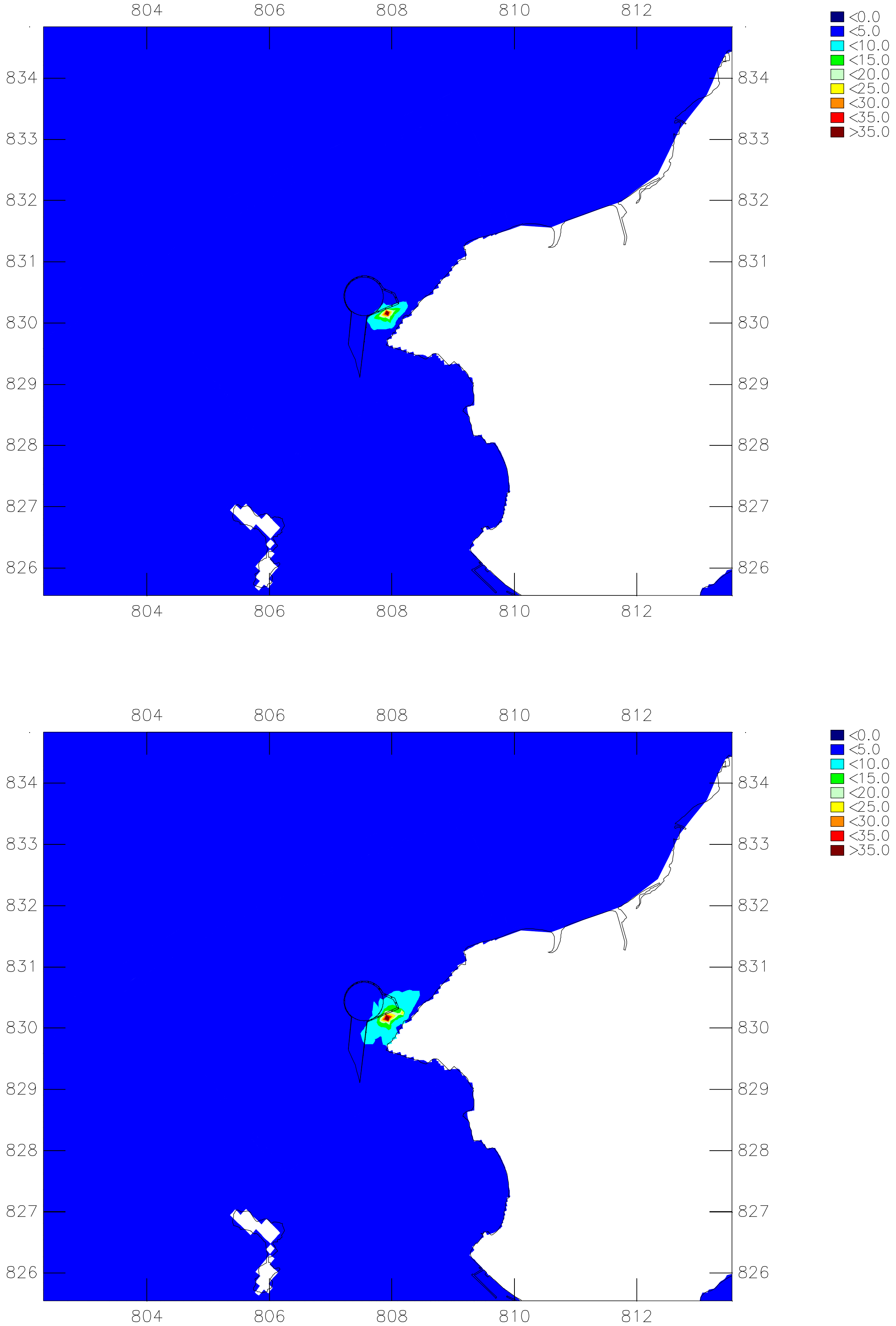
Upper plot: bottom layer – Lower plot: depth average

Dry Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C01r_max



Suspended Solids (mg/L) – max. over a complete spring-neap cycle

BP 12

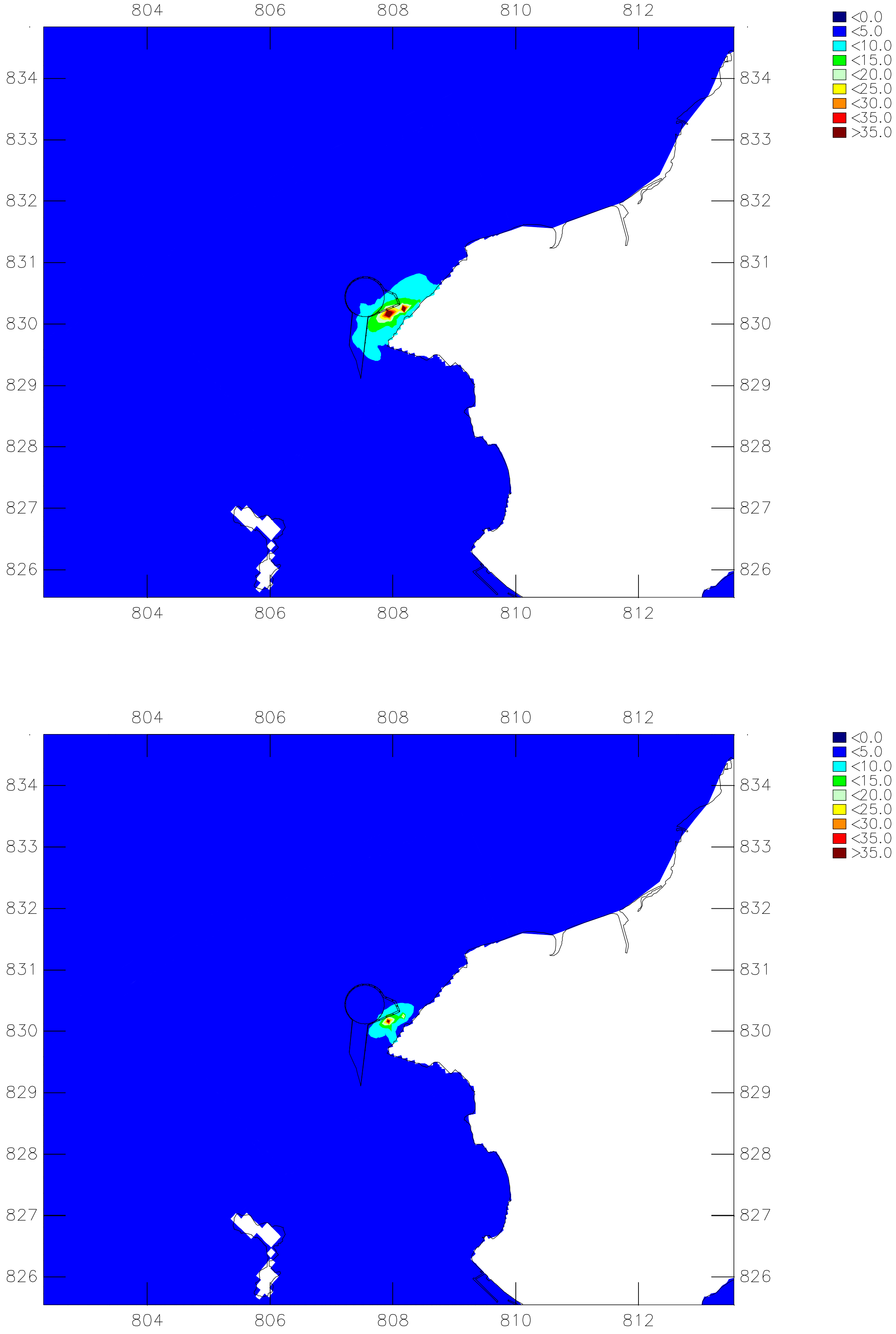
Upper plot: surface layer – Lower plot: middle layer

Wet Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C01s_max



Suspended Solids (mg/L) – max. over a complete spring-neap cycle

BP 12

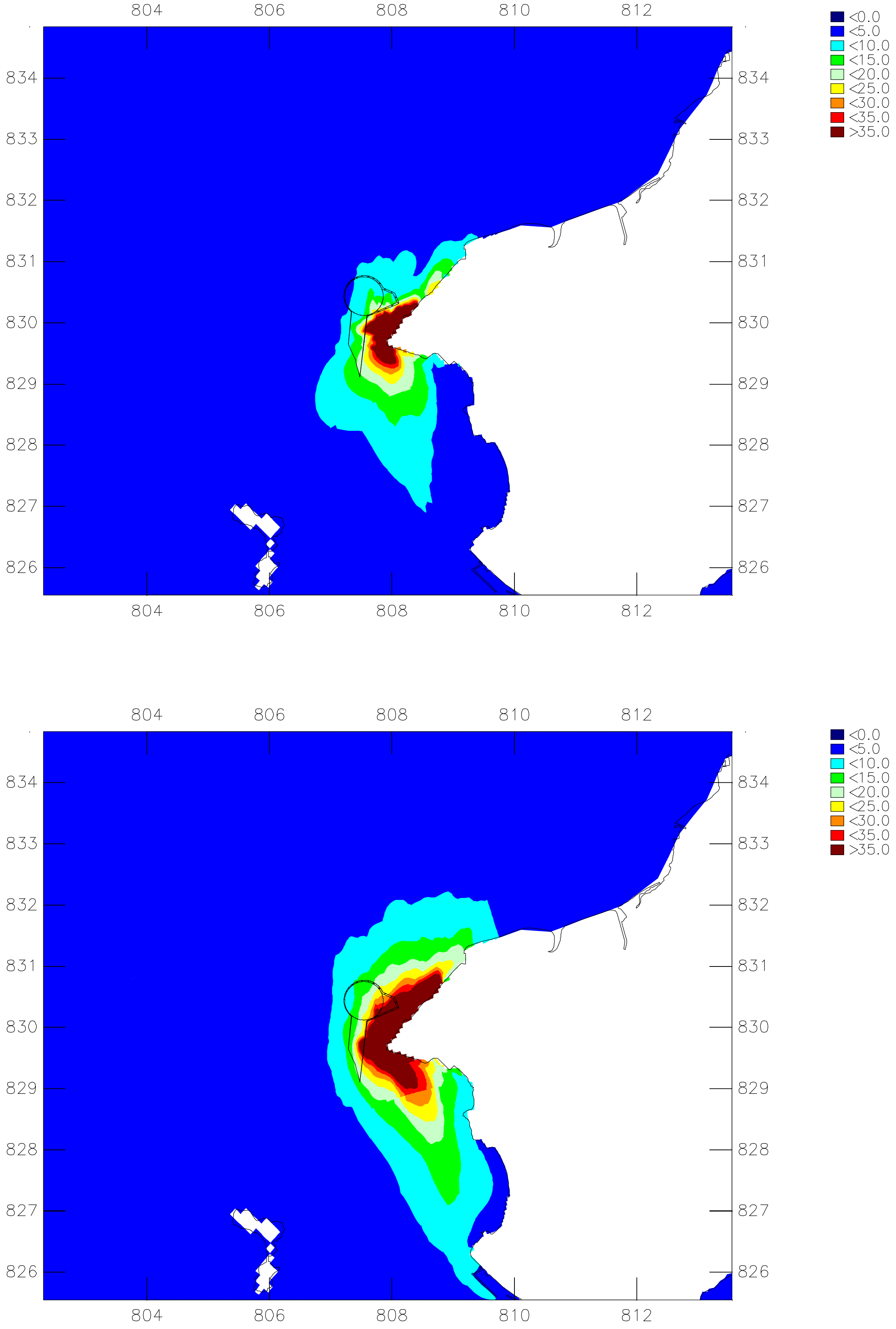
Upper plot: bottom layer – Lower plot: depth average

Wet Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C01t_max



Suspended Solids (mg/L) – max. over a complete spring-neap cycle

BP 17

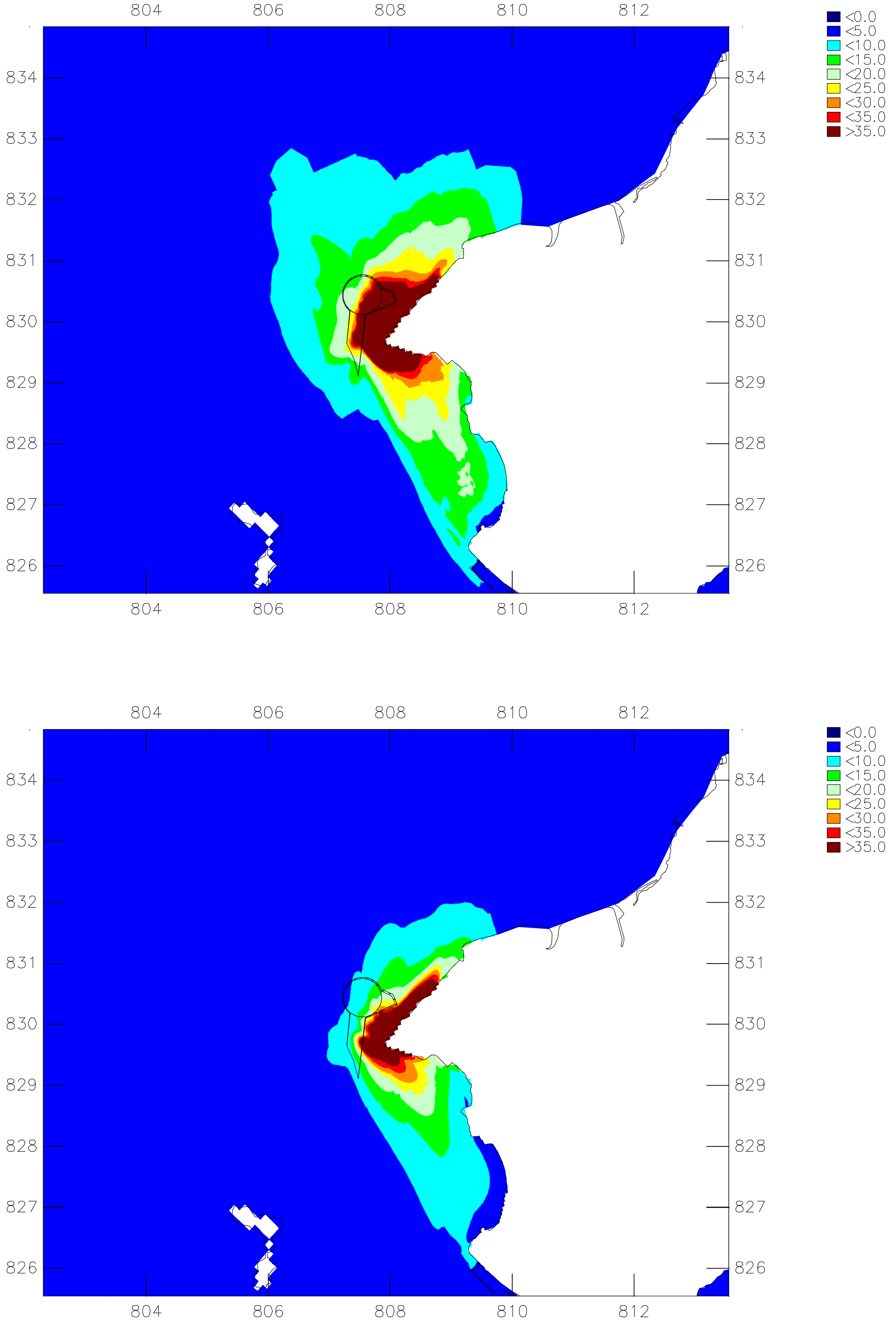
Upper plot: surface layer – Lower plot: middle layer

Dry Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C01u_max



Suspended Solids (mg/L) – max. over a complete spring-neap cycle

BP 17

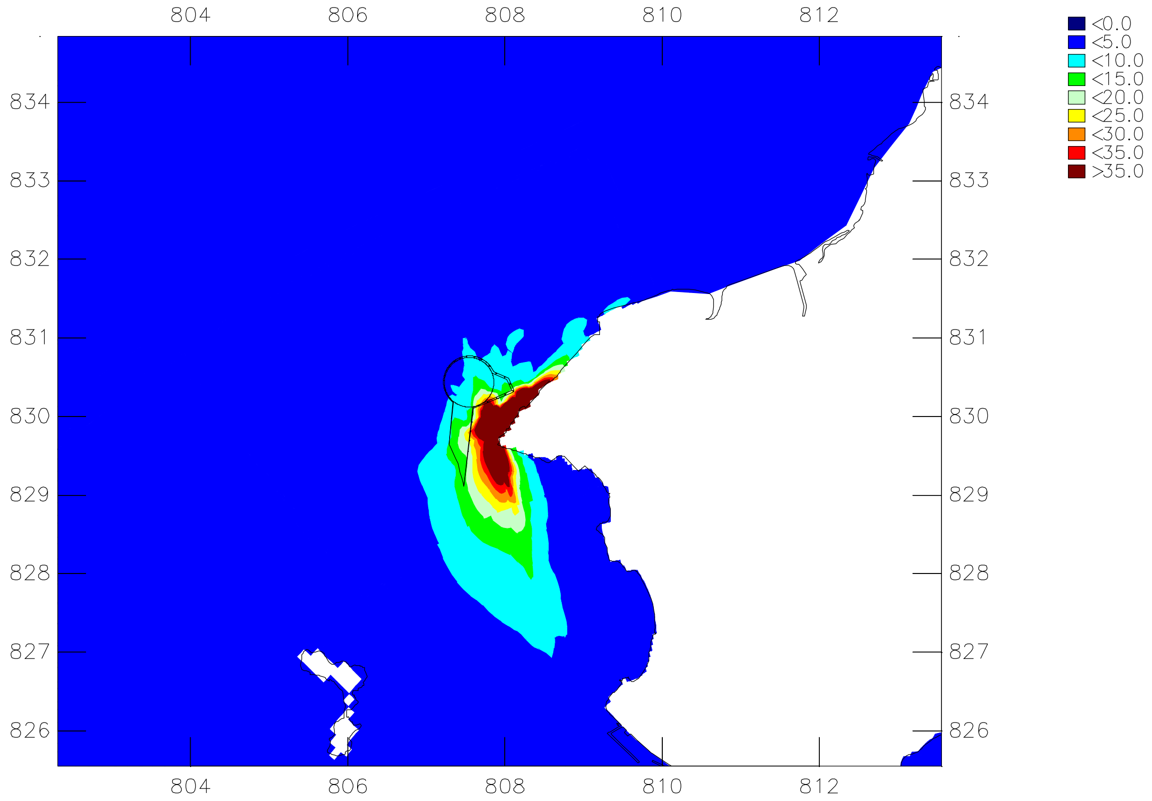
Upper plot: bottom layer – Lower plot: depth average

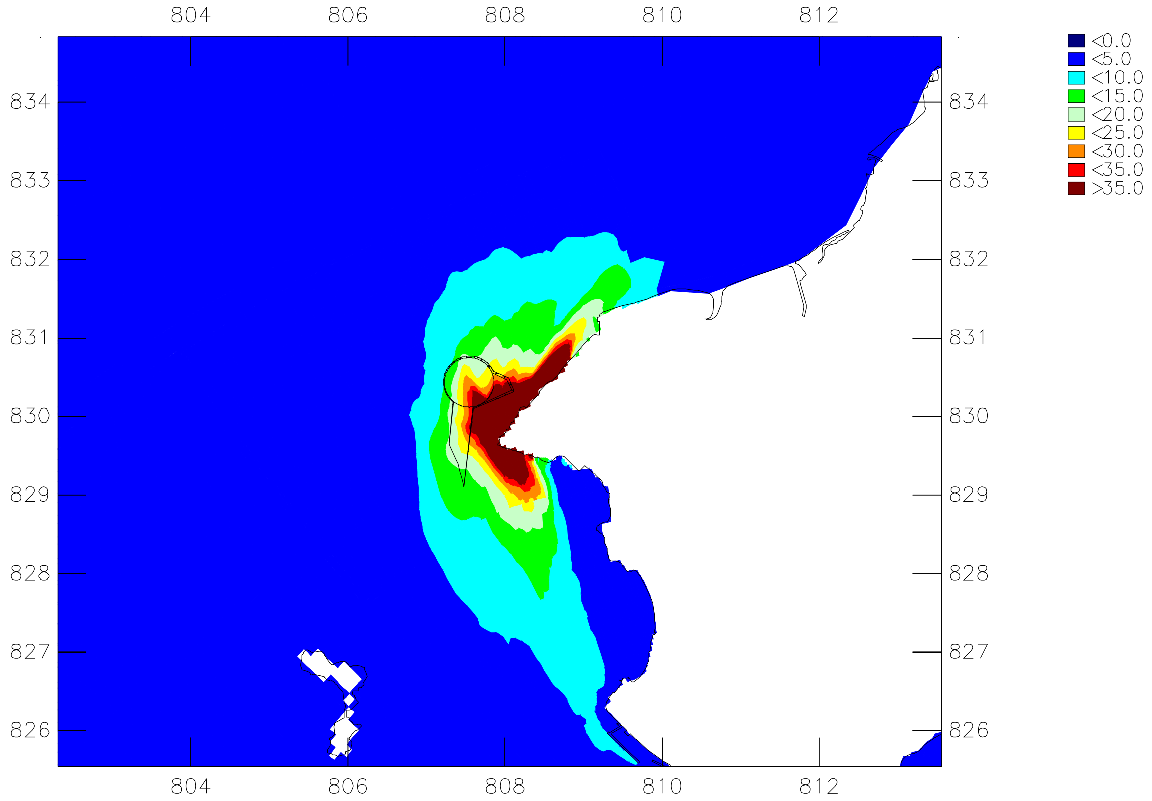
Dry Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C01v_max





Suspended Solids (mg/L) – max. over a complete spring-neap cycle

BP 17

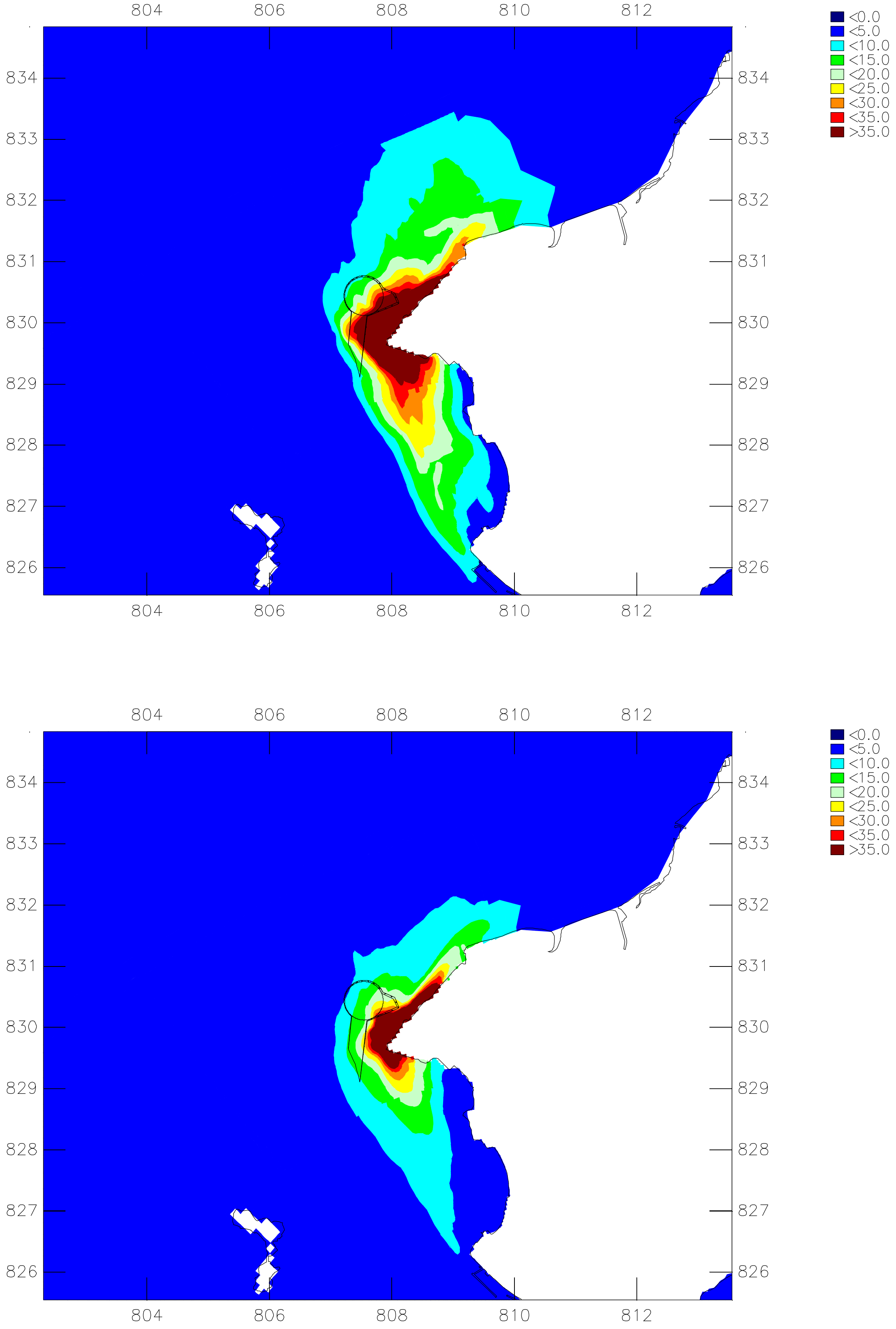
Upper plot: surface layer – Lower plot: middle layer

Wet Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C01w_max



Suspended Solids (mg/L) – max. over a complete spring-neap cycle

BP 17

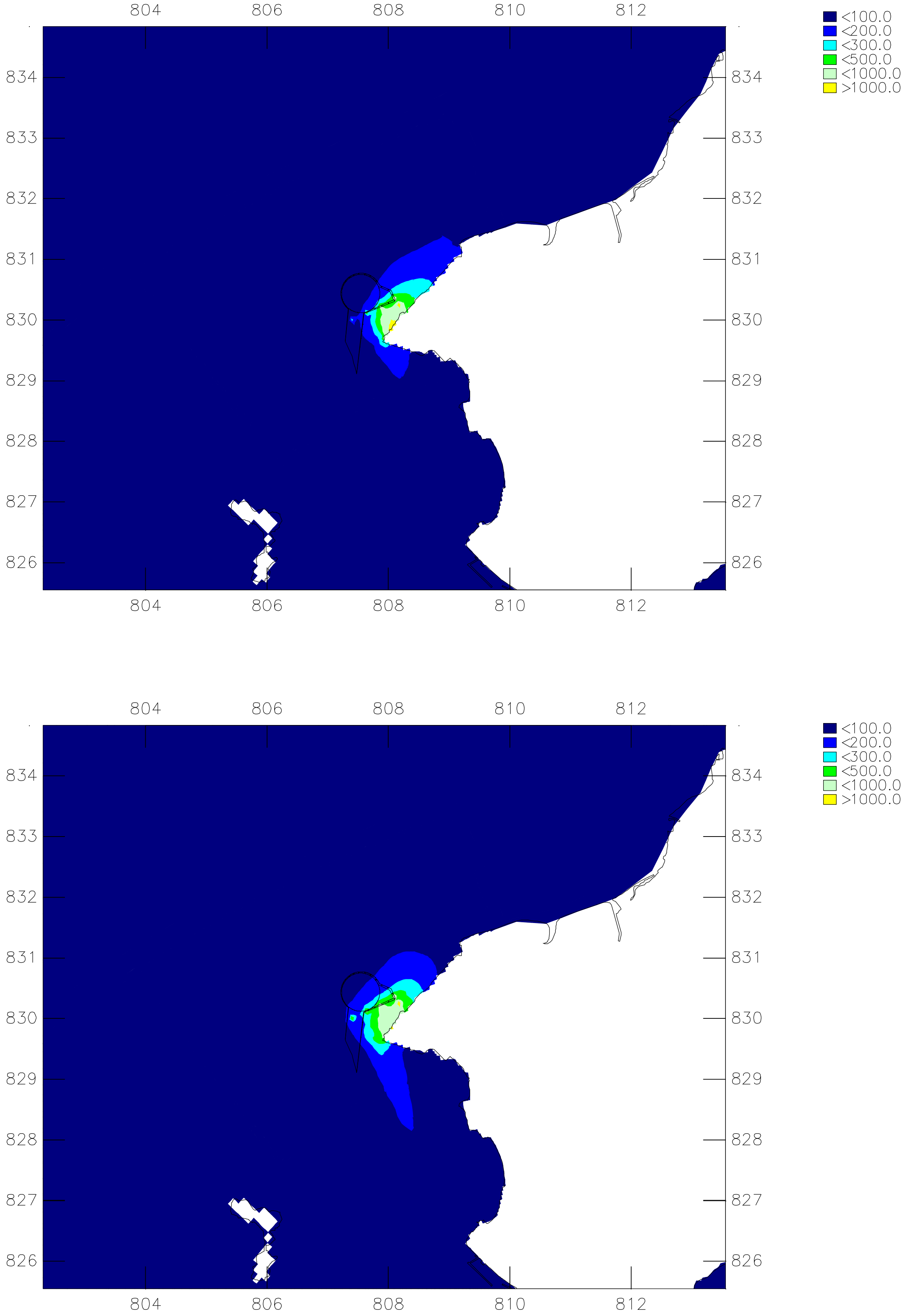
Upper plot: bottom layer – Lower plot: depth average

Wet Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C01x_max



Deposition (g/m2/d) – mean over a complete spring-neap cycle

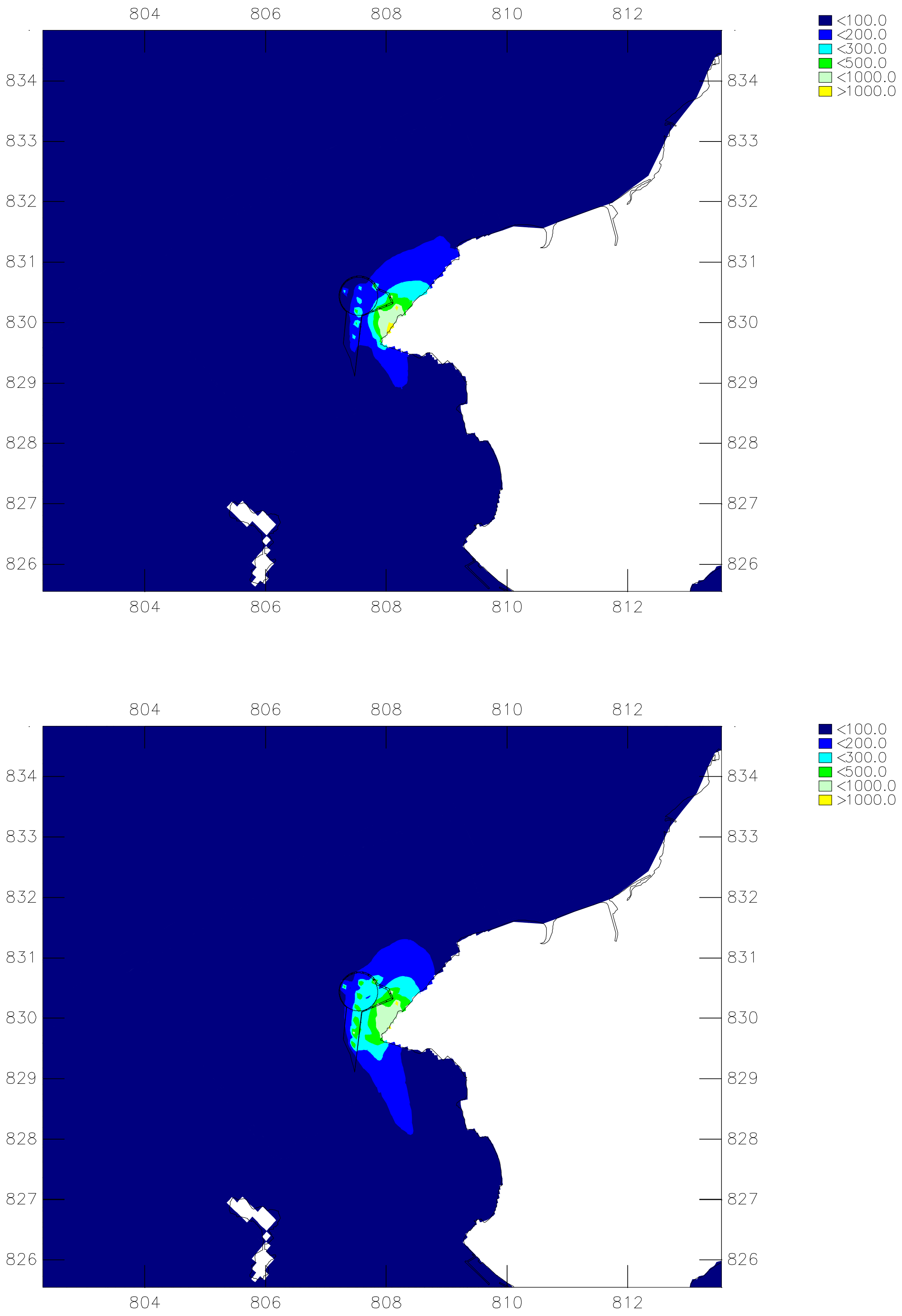
Marine Construction Works at Black Point

Upper plot: dry season – Lower plot: wet season

Scenario 1a

WL | Delft Hydraulics – ERM

Fig. BP_C02a



Deposition (g/m2/d) – mean over a complete spring-neap cycle

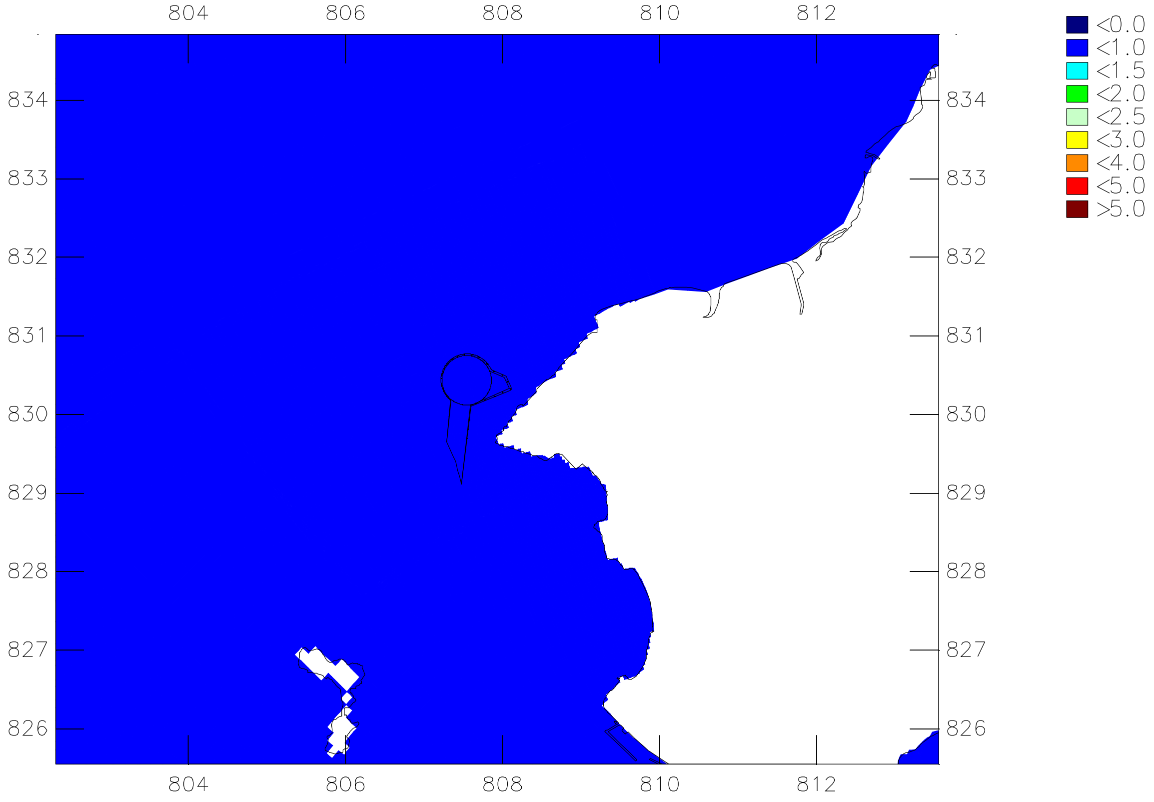
Marine Construction Works at Black Point

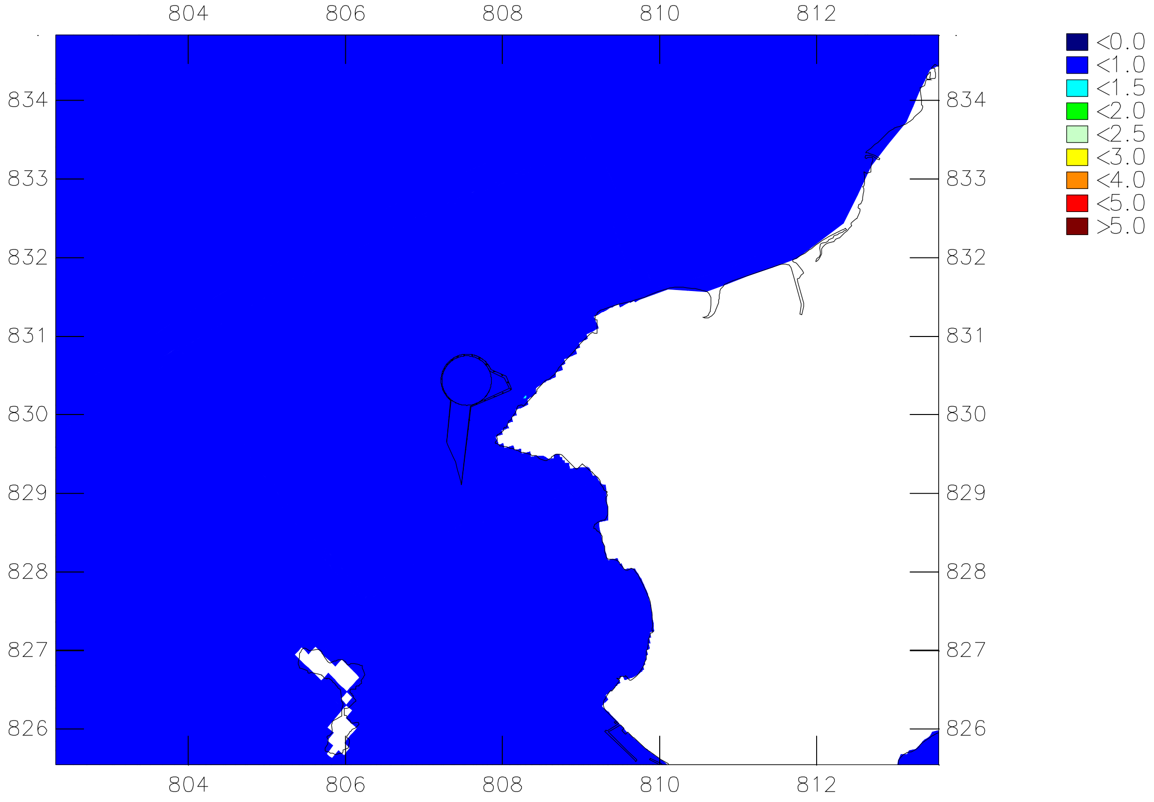
Upper plot: dry season – Lower plot: wet season

Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C02b





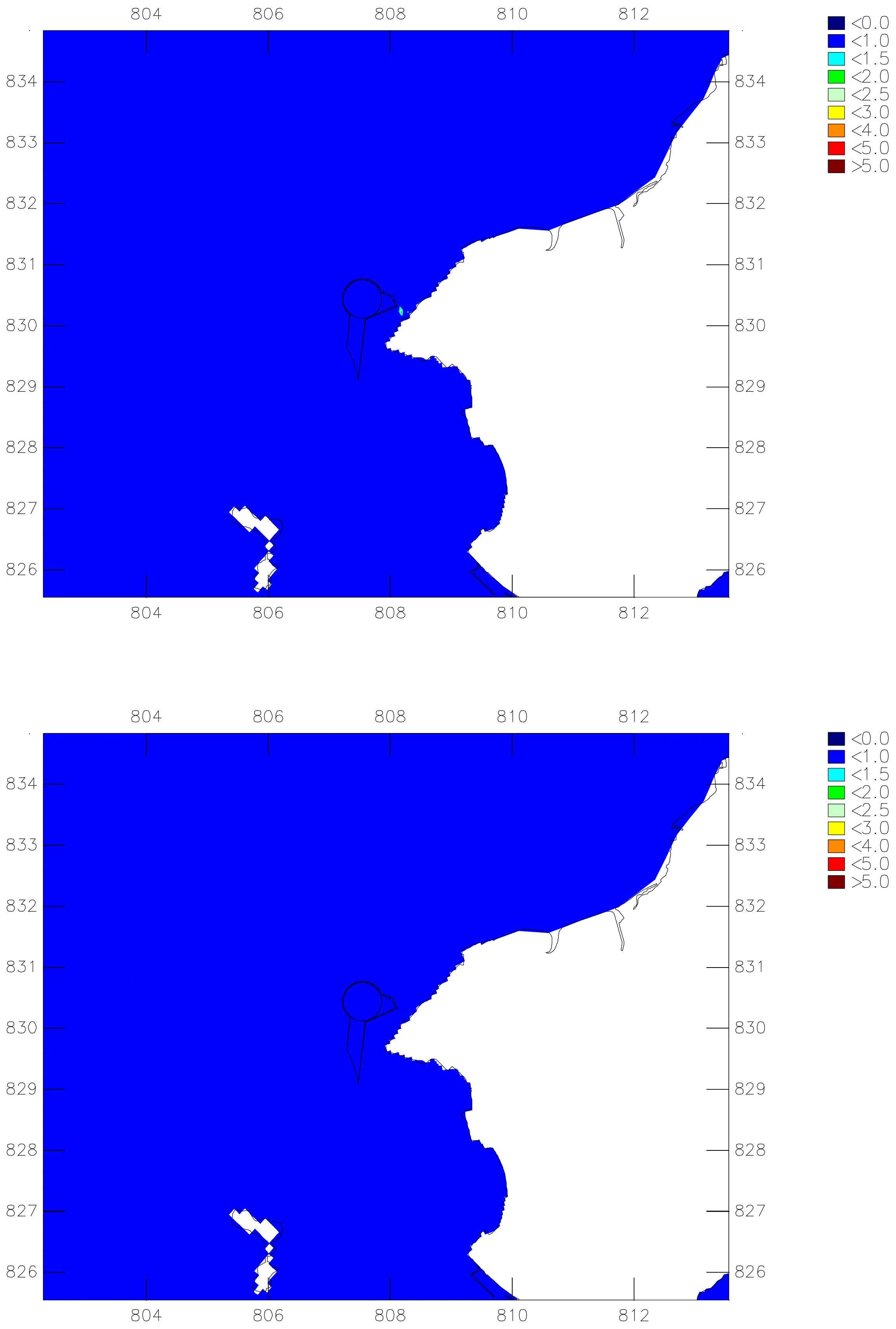
DO decrease (mg/L) – max. over a complete spring neap cycle
BP01, BP02
Upper plot: surface layer – Lower plot: middle layer

Dry Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C04a



DO decrease (mg/L) – max. over a complete spring neap cycle

BP01, BP02

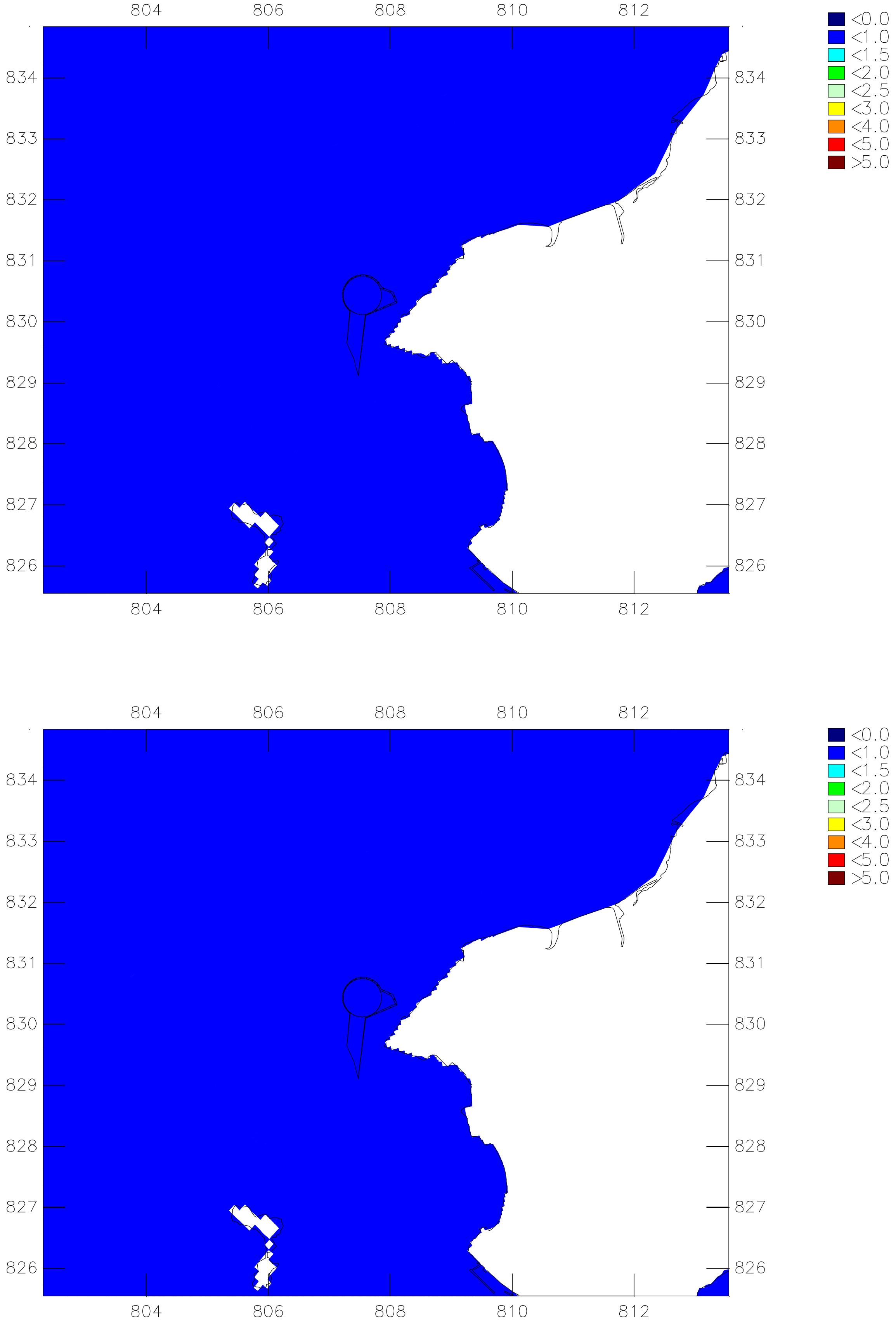
Upper plot: bottom layer – Lower plot: depth average

Dry Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C04b



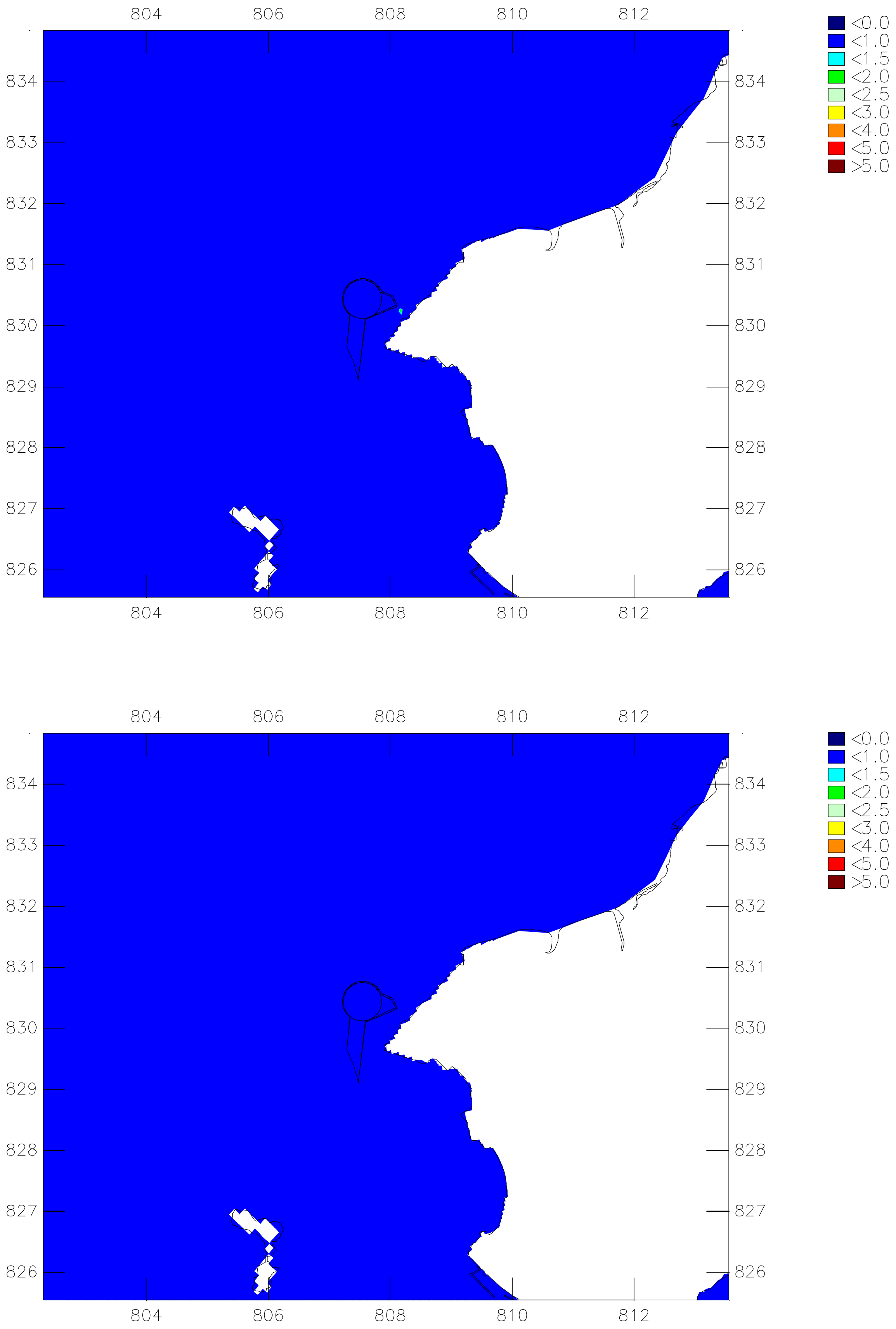
DO decrease (mg/L) – max. over a complete spring neap cycle
BP01, BP02
Upper plot: surface layer – Lower plot: middle layer

Wet Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C04c



DO decrease (mg/L) – max. over a complete spring neap cycle

BP01, BP02

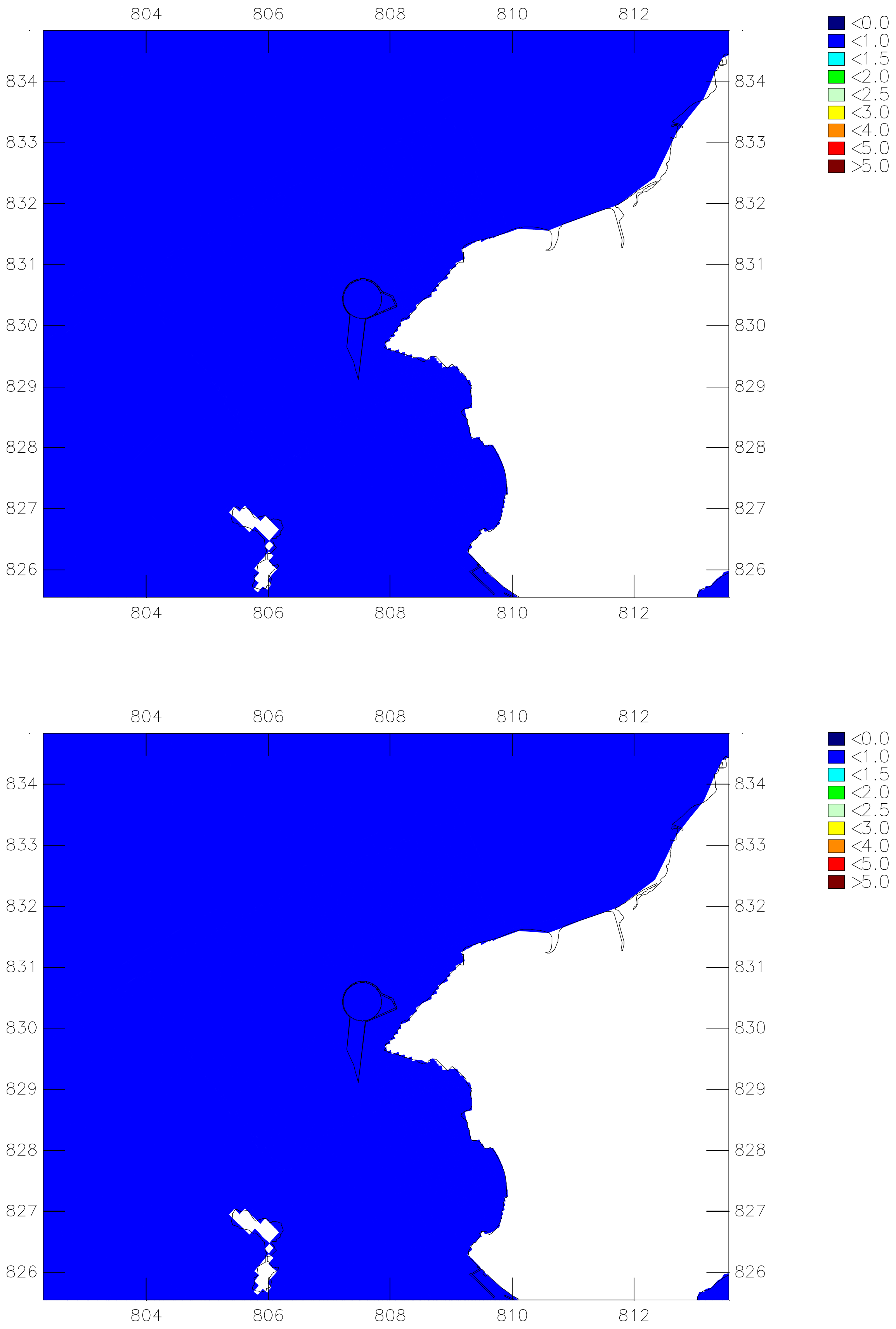
Upper plot: bottom layer – Lower plot: depth average

Wet Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C04d



DO decrease (mg/L) – max. over a complete spring neap cycle

BP15

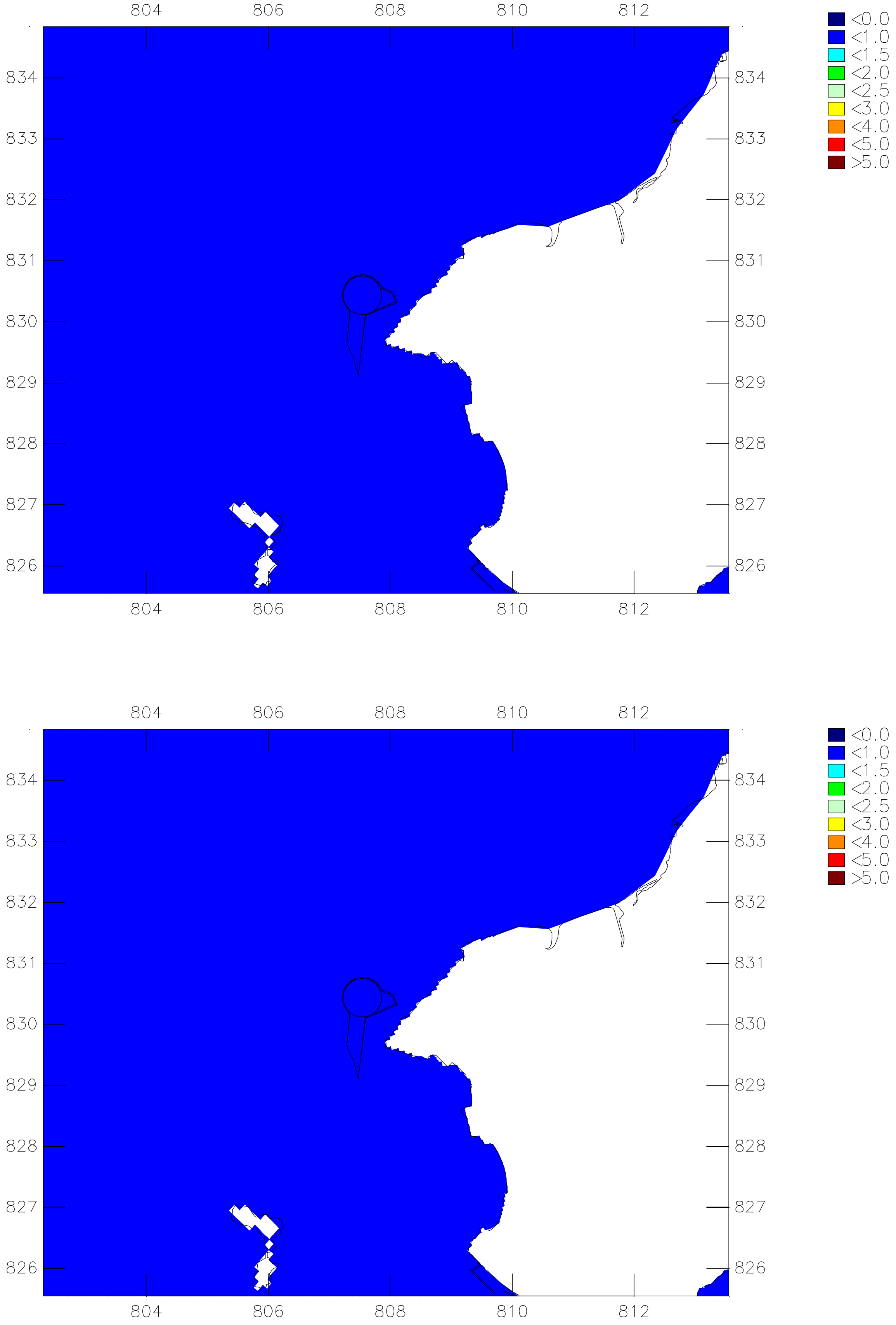
Upper plot: surface layer – Lower plot: middle layer

Dry Season

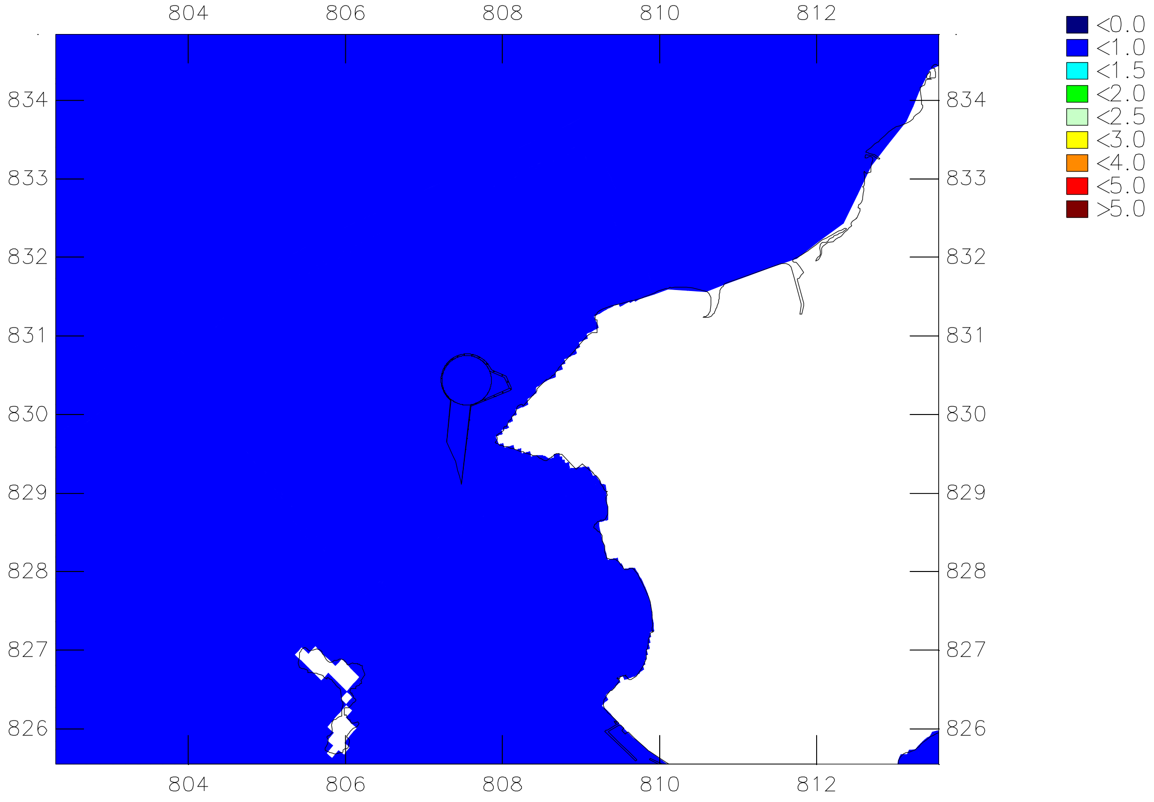
Scenario 1a / Scenario 1b

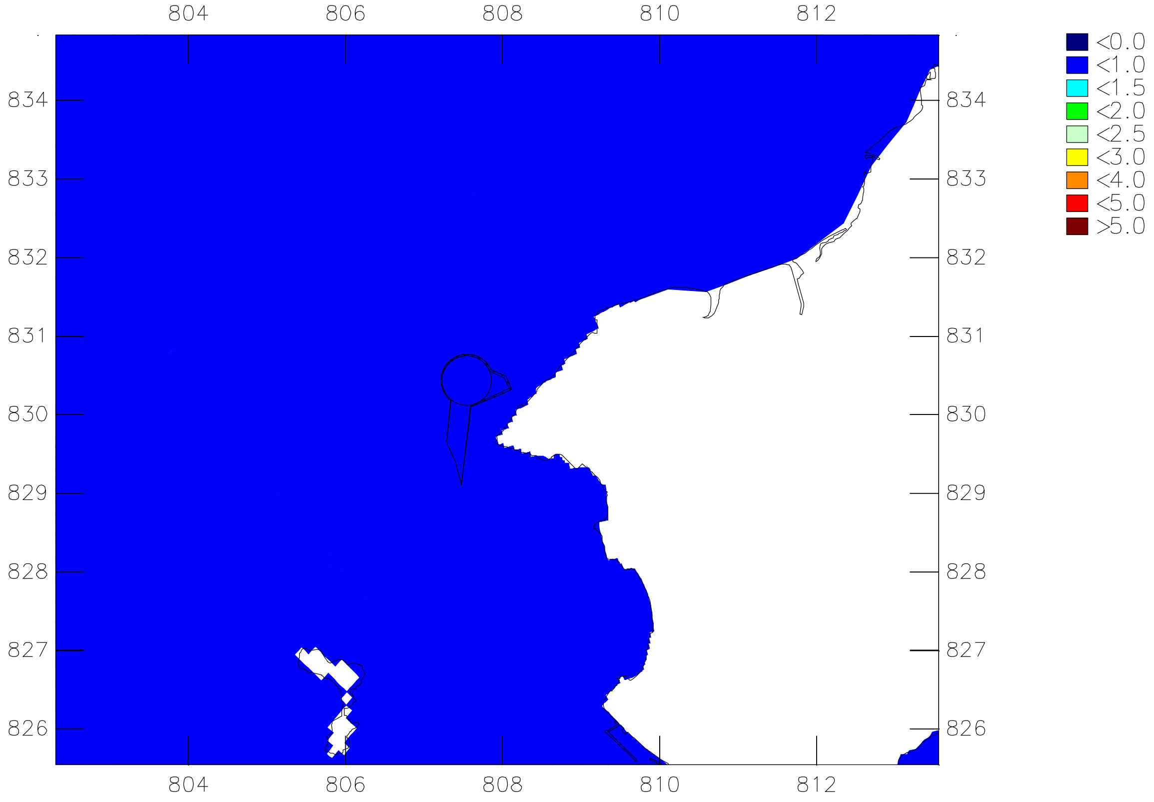
WL | Delft Hydraulics – ERM

Fig. SK_C04e



DO decrease (mg/L) – max. over a complete spring neap cycle BP15 Upper plot: bottom layer – Lower plot: depth average	Dry Season Scenario 1a / Scenario 1b
WL | Delft Hydraulics – ERM	Fig. BP_C04f





DO decrease (mg/L) – max. over a complete spring neap cycle

BP15

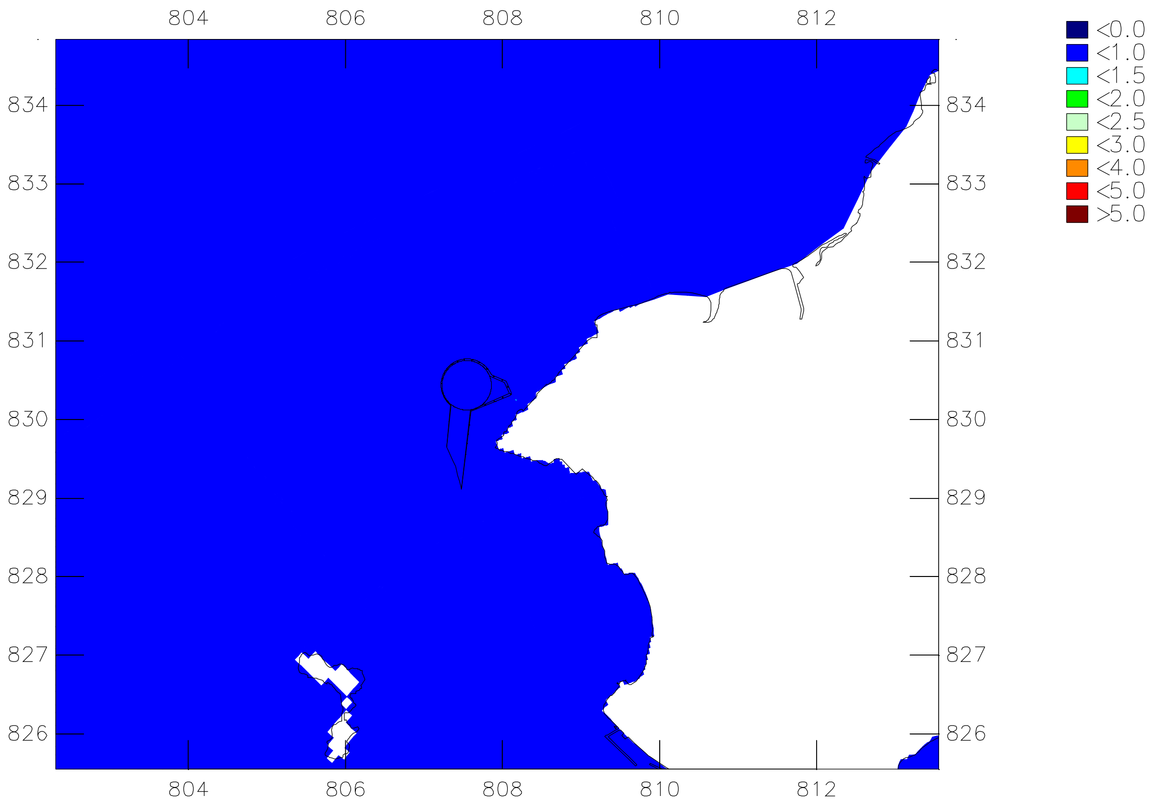
Upper plot: surface layer – Lower plot: middle layer

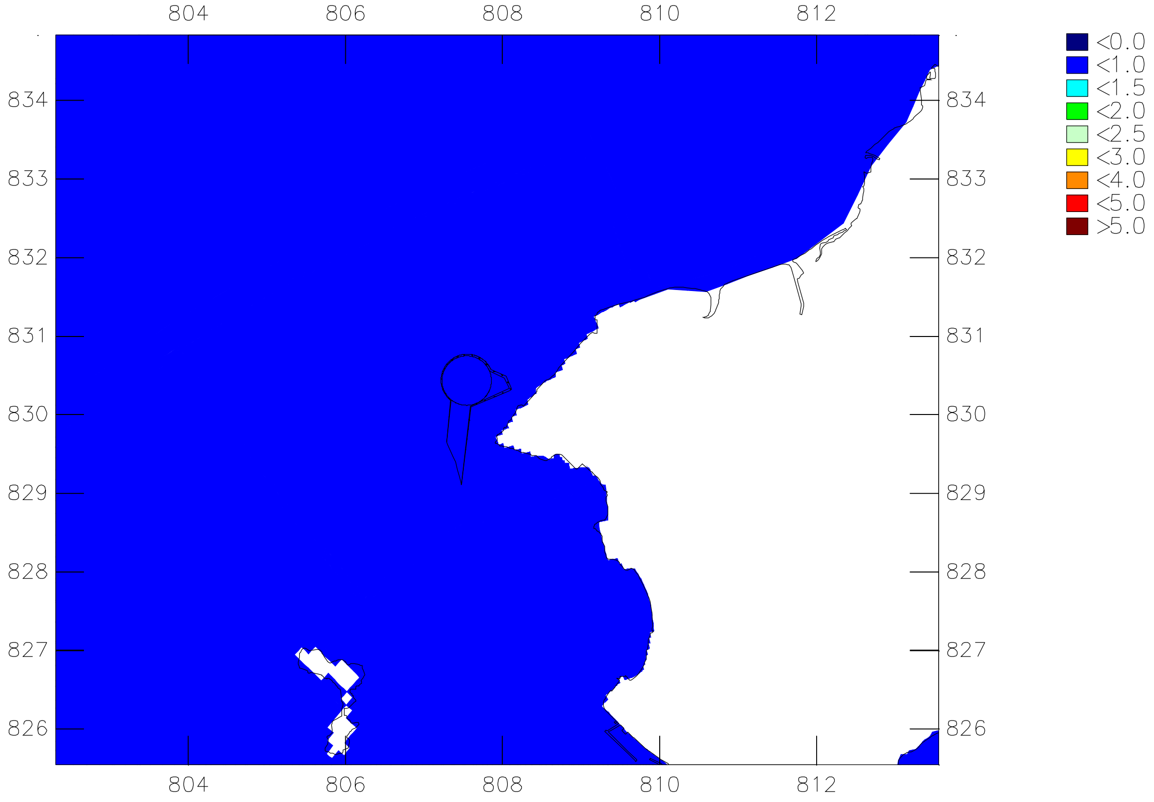
Wet Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C04g





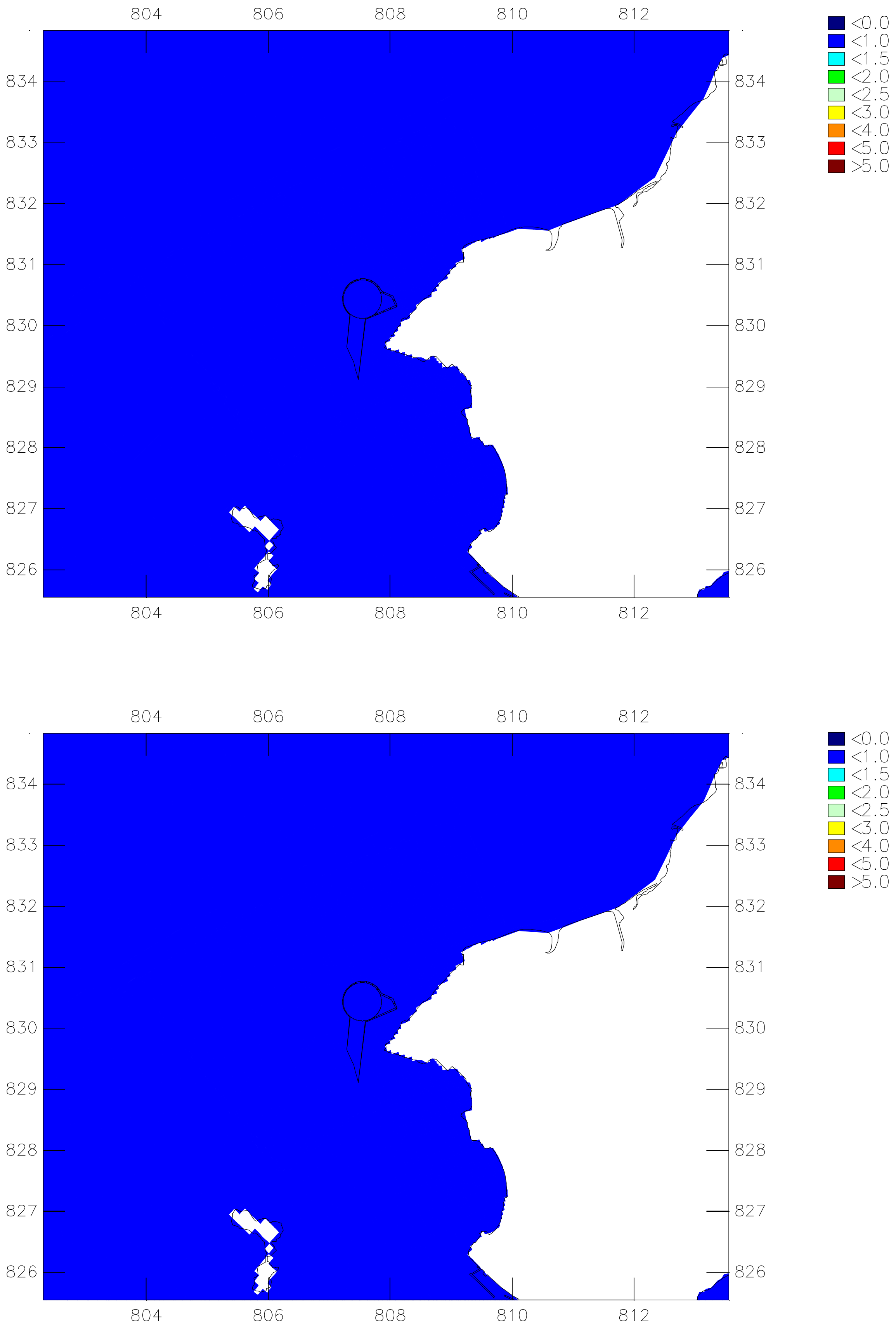
DO decrease (mg/L) – max. over a complete spring neap cycle
BP15
Upper plot: bottom layer – Lower plot: depth average

Wet Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C04h



DO decrease (mg/L) – max. over a complete spring neap cycle

BP07, BP08a, BP09a, BP10a

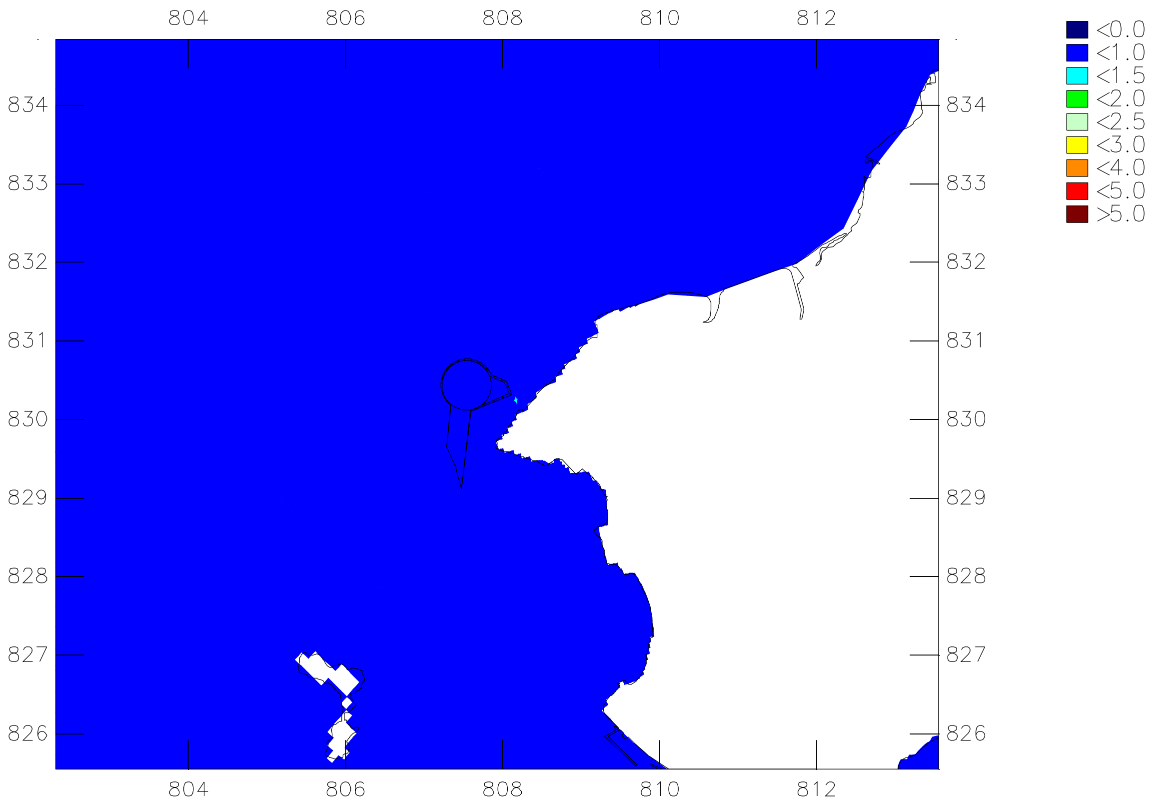
Upper plot: surface layer – Lower plot: middle layer

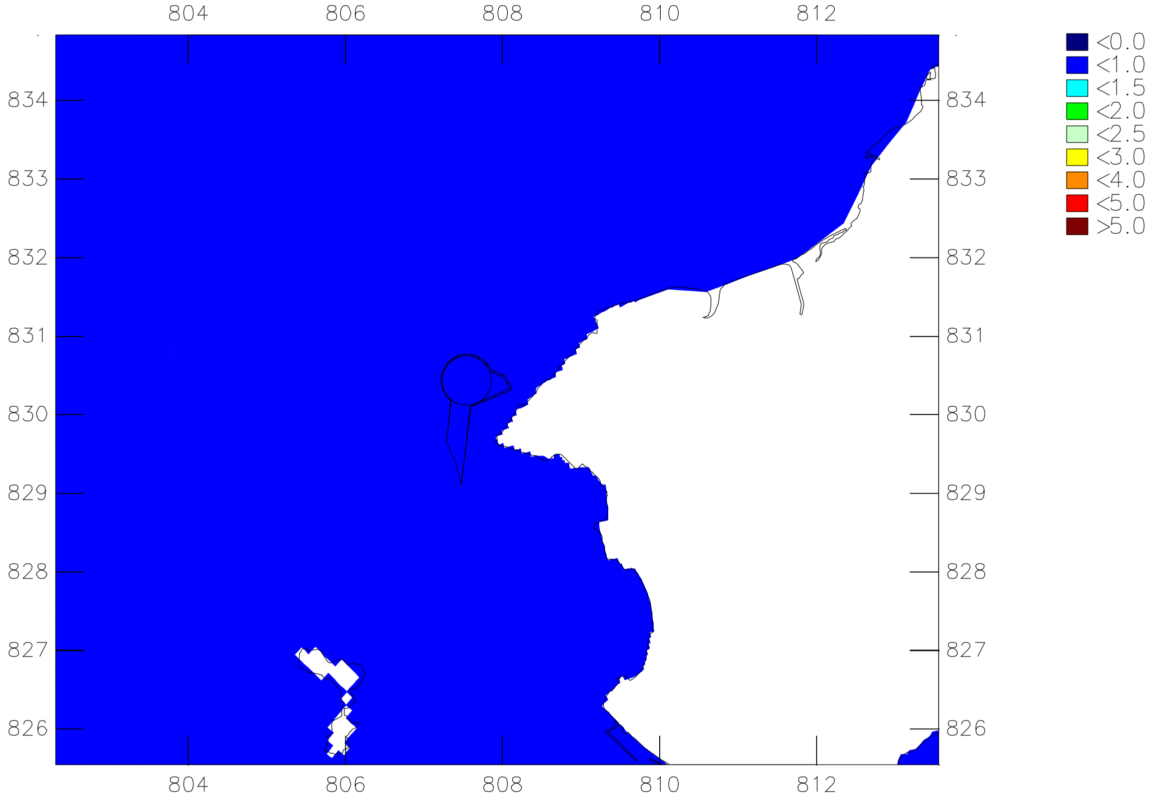
Dry Season

Scenario 1a

WL | Delft Hydraulics – ERM

Fig. BP_C04i





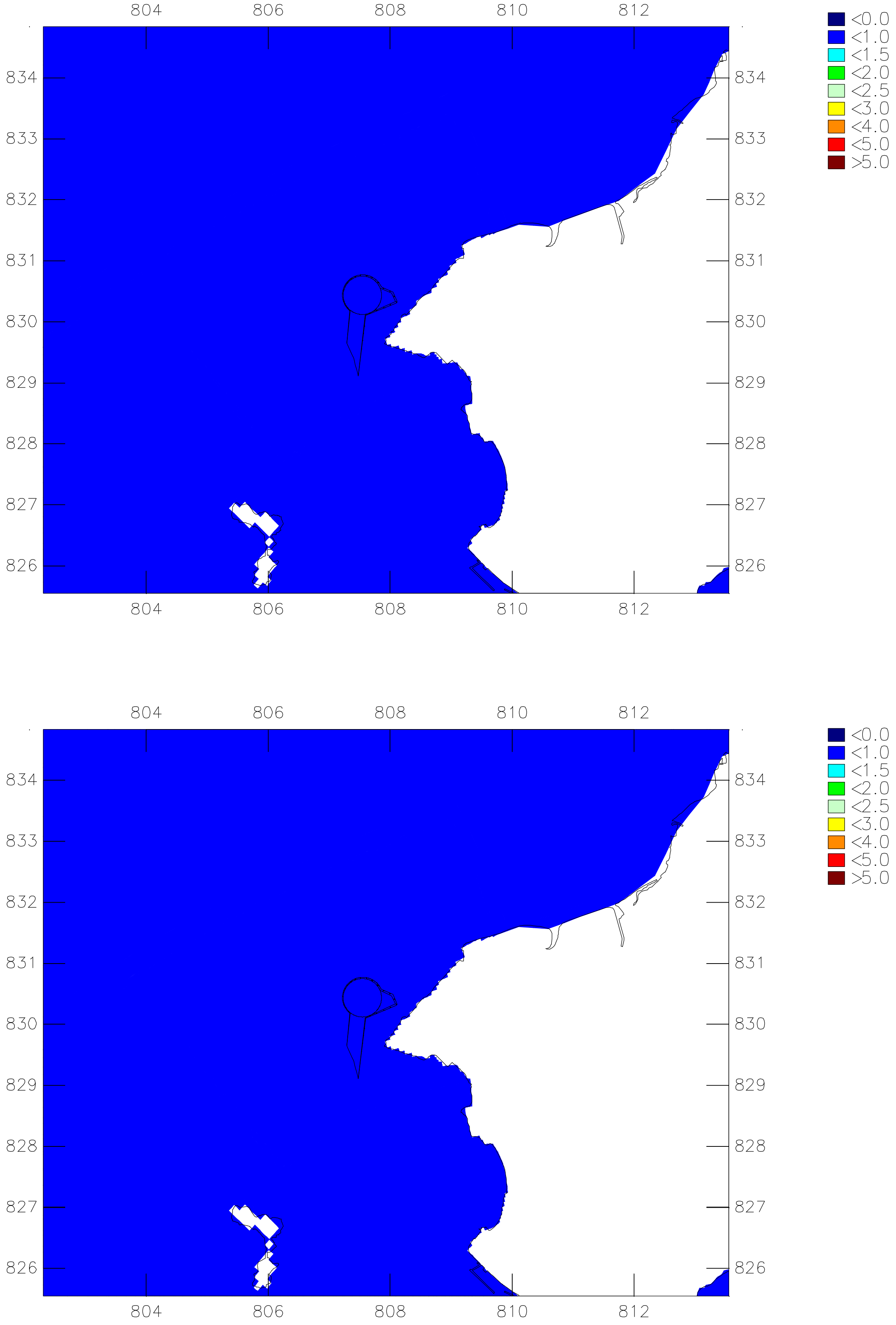
DO decrease (mg/L) – max. over a complete spring neap cycle
BP07, BP08a, BP09a, BP10a
Upper plot: bottom layer – Lower plot: depth average

Dry Season

Scenario 1a

WL | Delft Hydraulics – ERM

Fig. BP_C04j



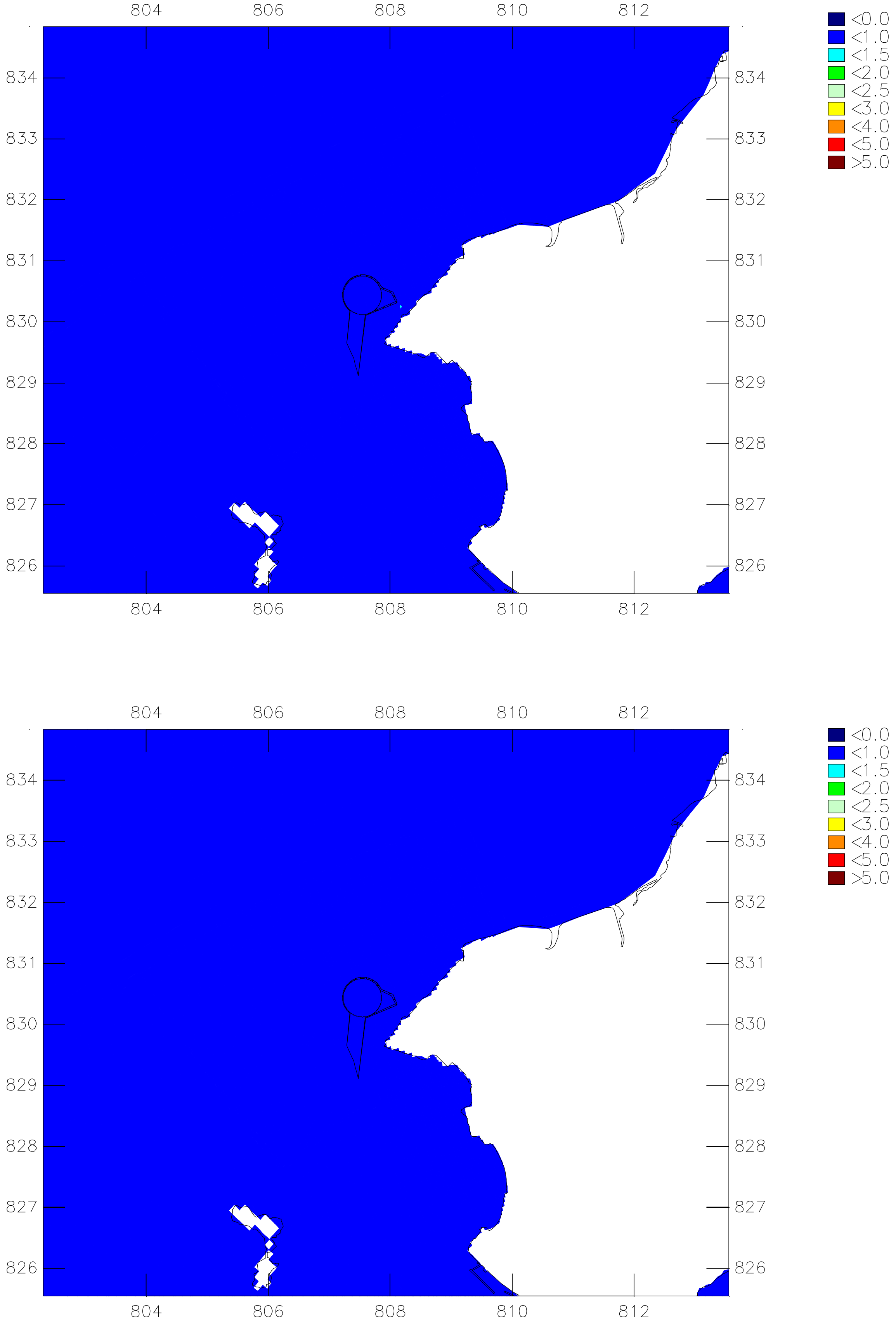
DO decrease (mg/L) – max. over a complete spring neap cycle
BP07, BP08a, BP09a, BP10a
Upper plot: surface layer – Lower plot: middle layer

Wet Season

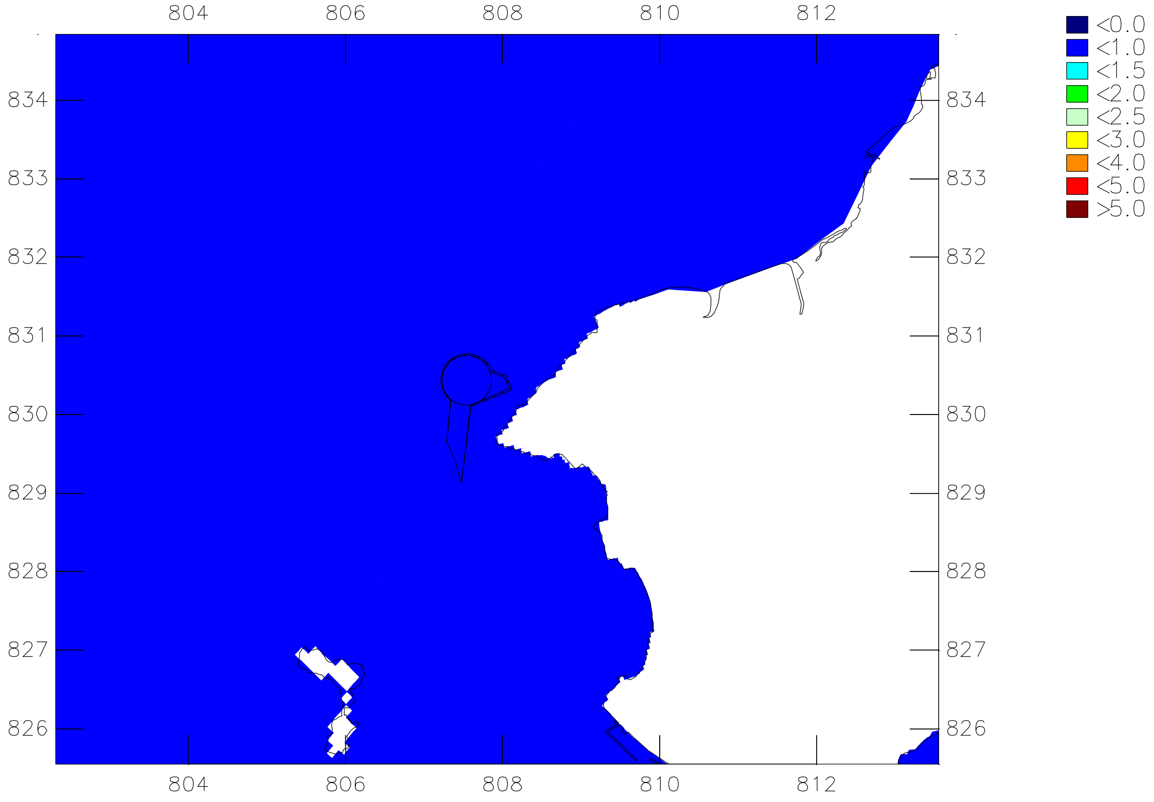
Scenario 1a

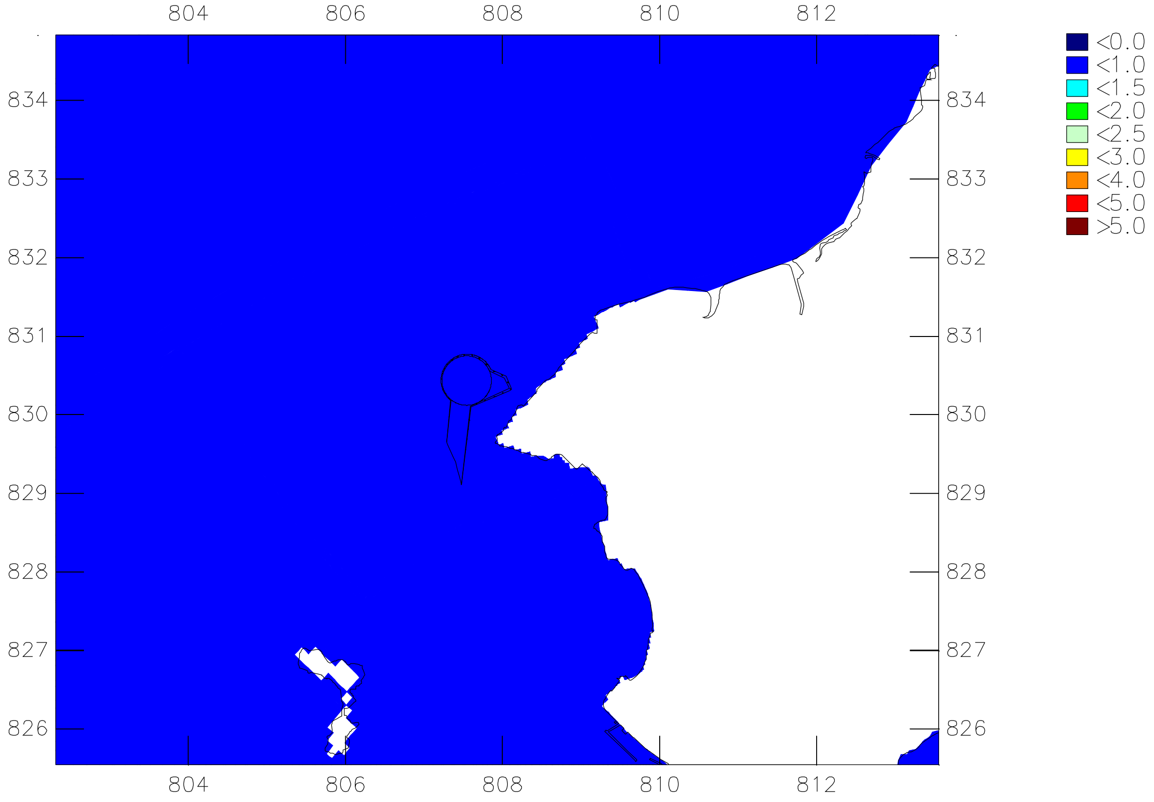
WL | Delft Hydraulics – ERM

Fig. BP_C04k



DO decrease (mg/L) – max. over a complete spring neap cycle BP07, BP08a, BP09a, BP10a Upper plot: bottom layer – Lower plot: depth average	Wet Season	
	Scenario 1a	
WL | Delft Hydraulics – ERM		Fig. BP_C04l





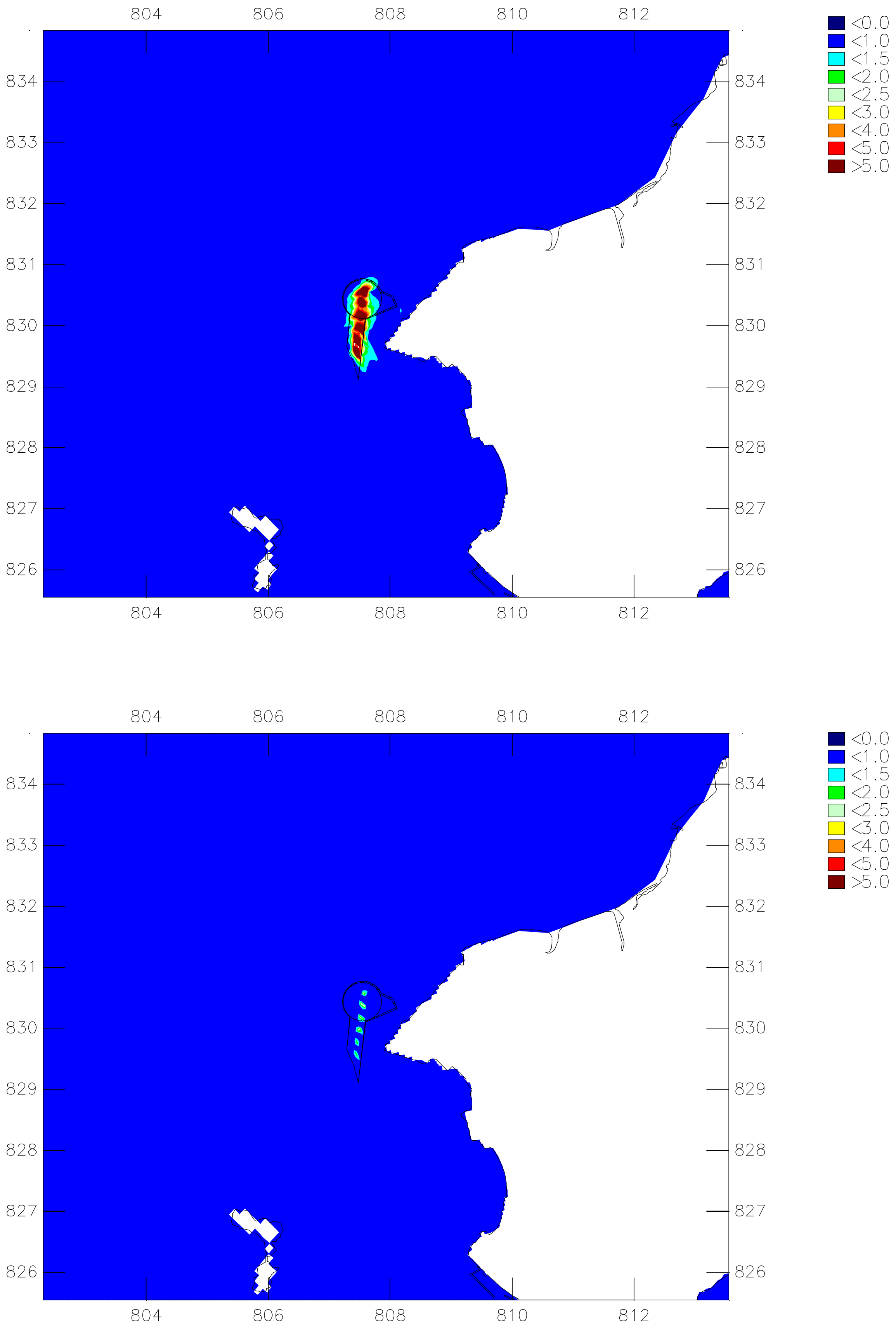
DO decrease (mg/L) – max. over a complete spring neap cycle
BP07, BP08b, BP09b, BP10b, BP11
Upper plot: surface layer – Lower plot: middle layer

Dry Season

Scenario 1a

WL | Delft Hydraulics – ERM

Fig. BP_C04m



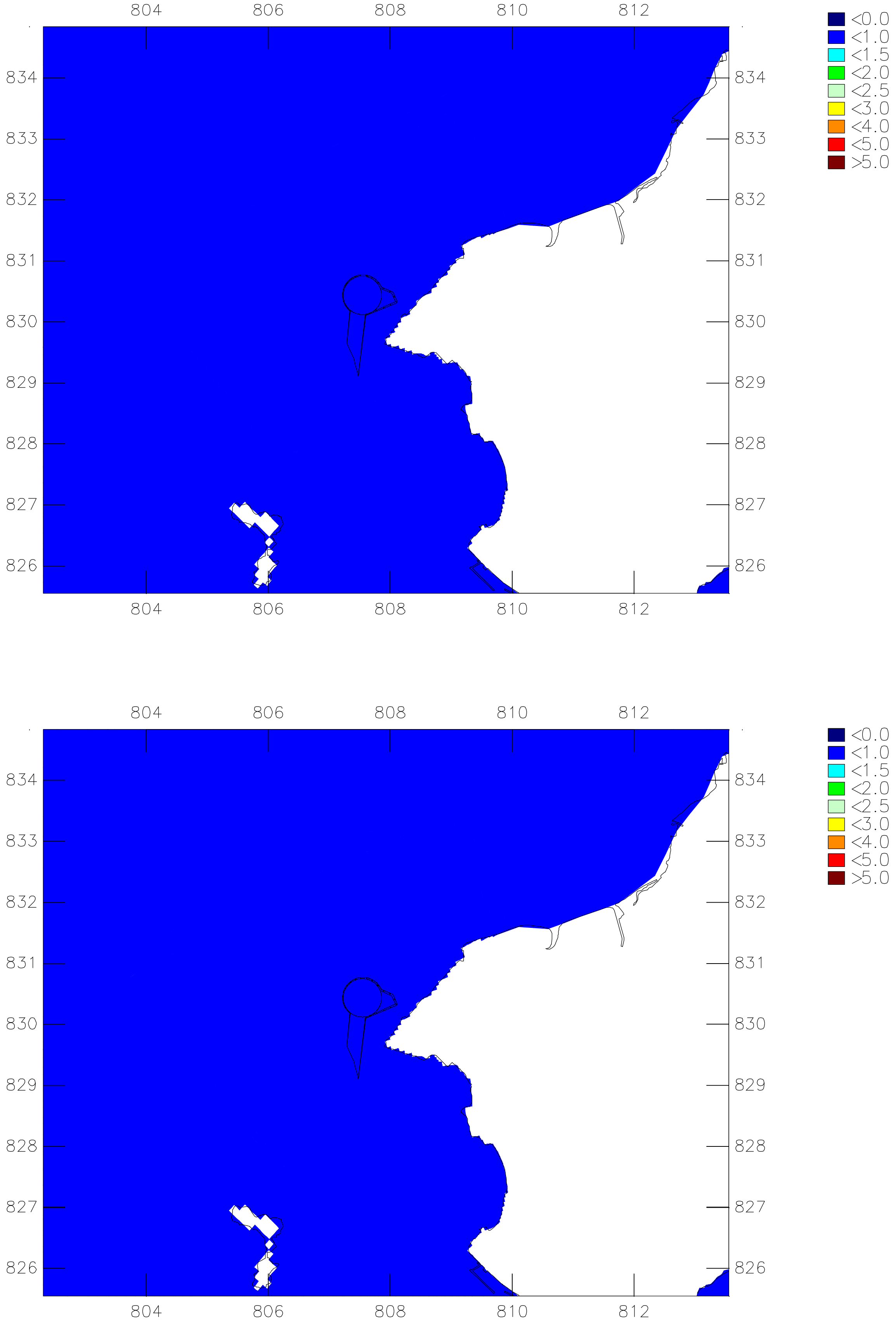
DO decrease (mg/L) – max. over a complete spring neap cycle
BP07, BP08b, BP09b, BP10b, BP11
Upper plot: bottom layer – Lower plot: depth average

Dry Season

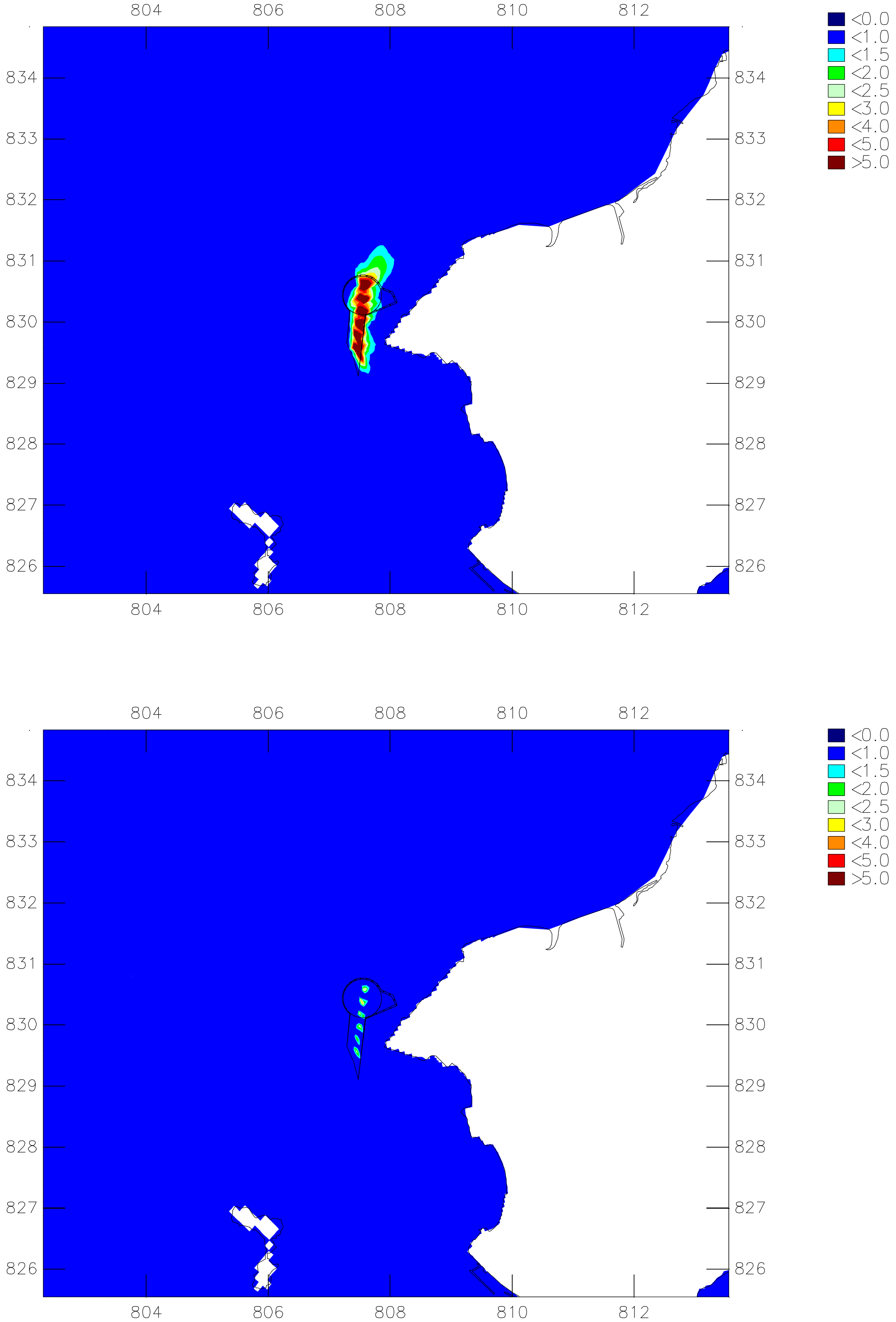
Scenario 1b

WL | Delft Hydraulics – ERM

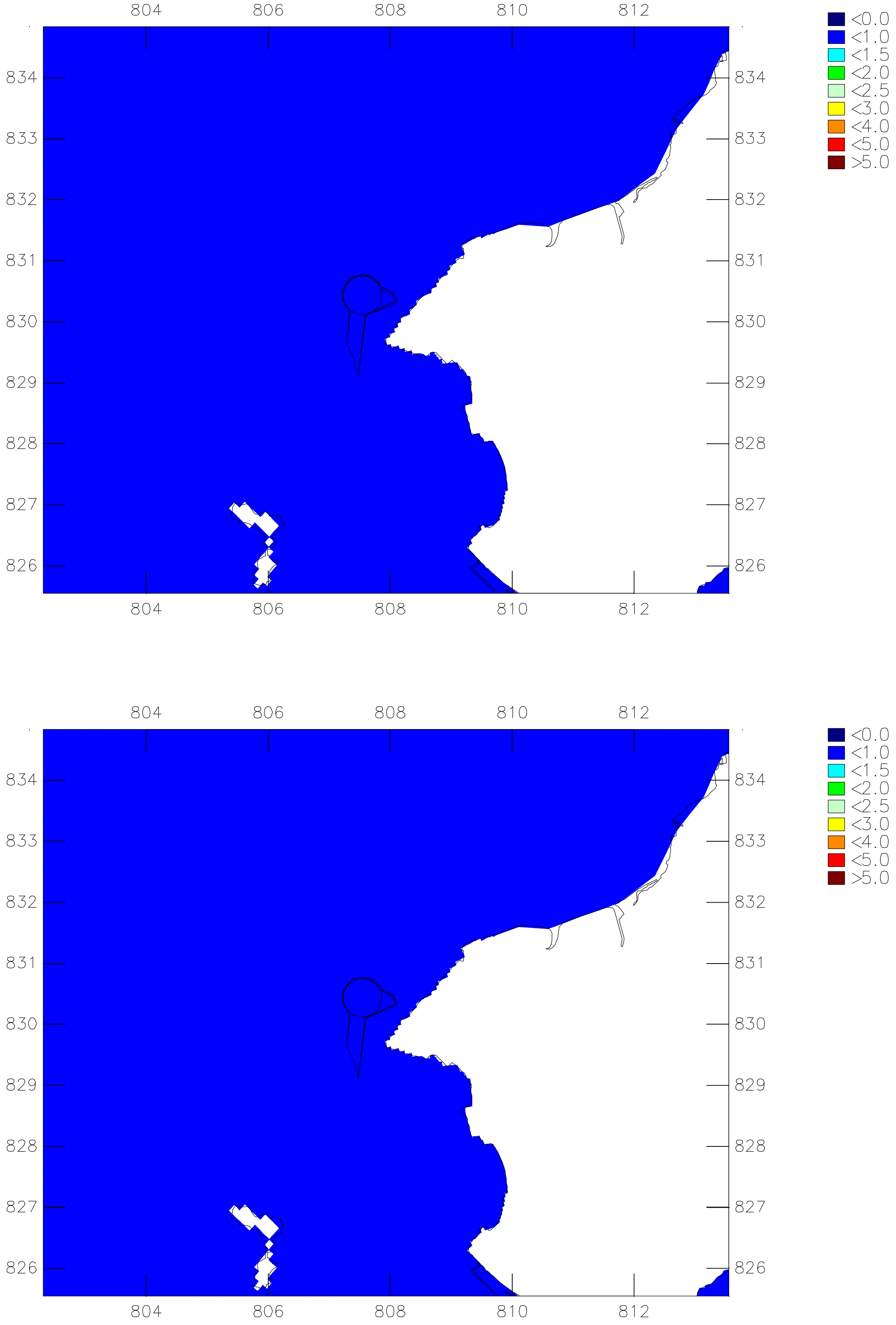
Fig.BP_C04n



DO decrease (mg/L) – max. over a complete spring neap cycle BP07, BP08b, BP09b, BP10b, BP11 Upper plot: surface layer – Lower plot: middle layer	Wet Season Scenario 1b
WL | Delft Hydraulics – ERM	Fig. BP_C04o



DO decrease (mg/L) – max. over a complete spring neap cycle BP07, BP08b, BP09b, BP10b, BP11 Upper plot: bottom layer – Lower plot: depth average	Wet Season Scenario 1b
WL | Delft Hydraulics – ERM	Fig. BP_C04p



DO decrease (mg/L) – max. over a complete spring neap cycle

BP12

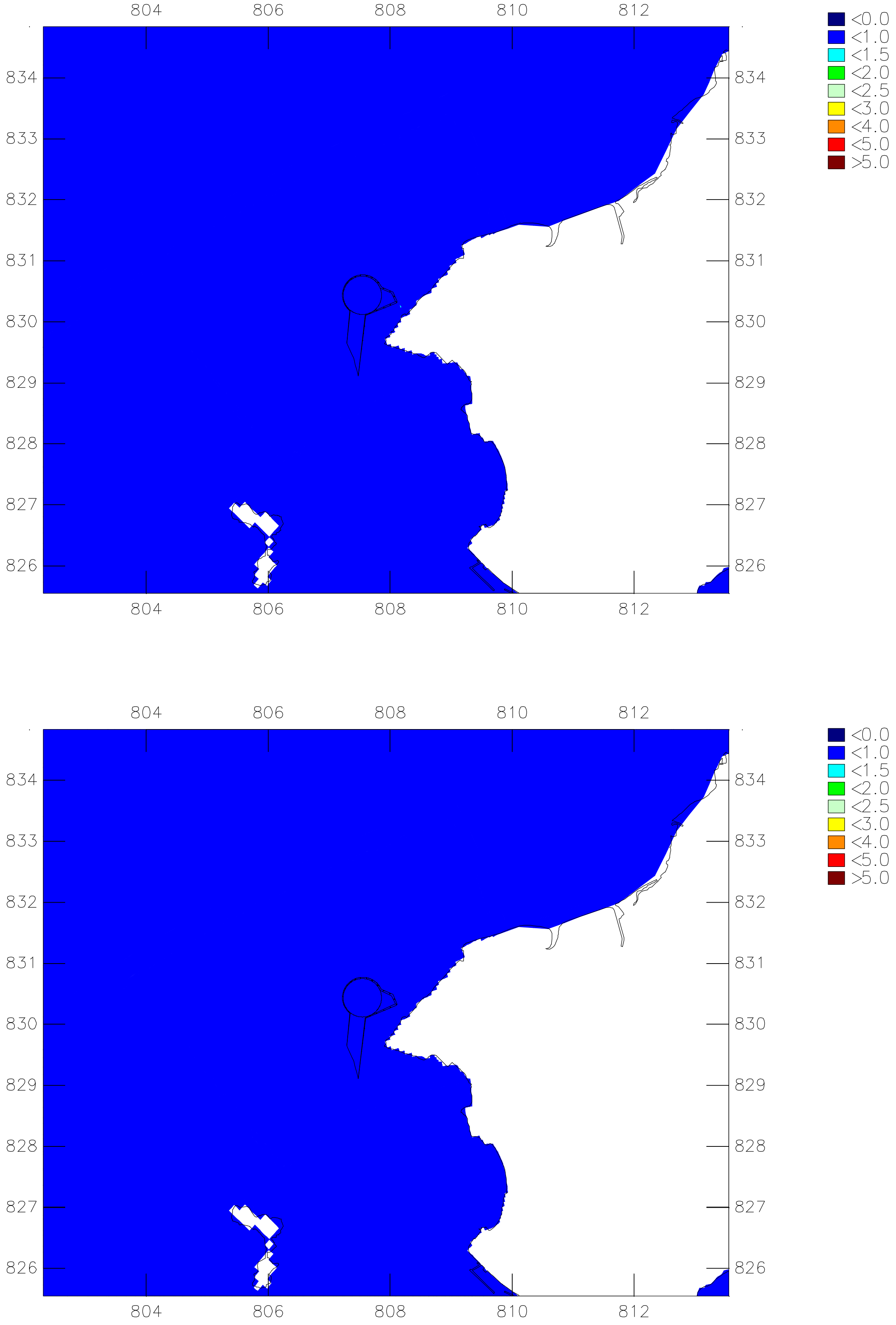
Upper plot: surface layer – Lower plot: middle layer

Dry Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C04q



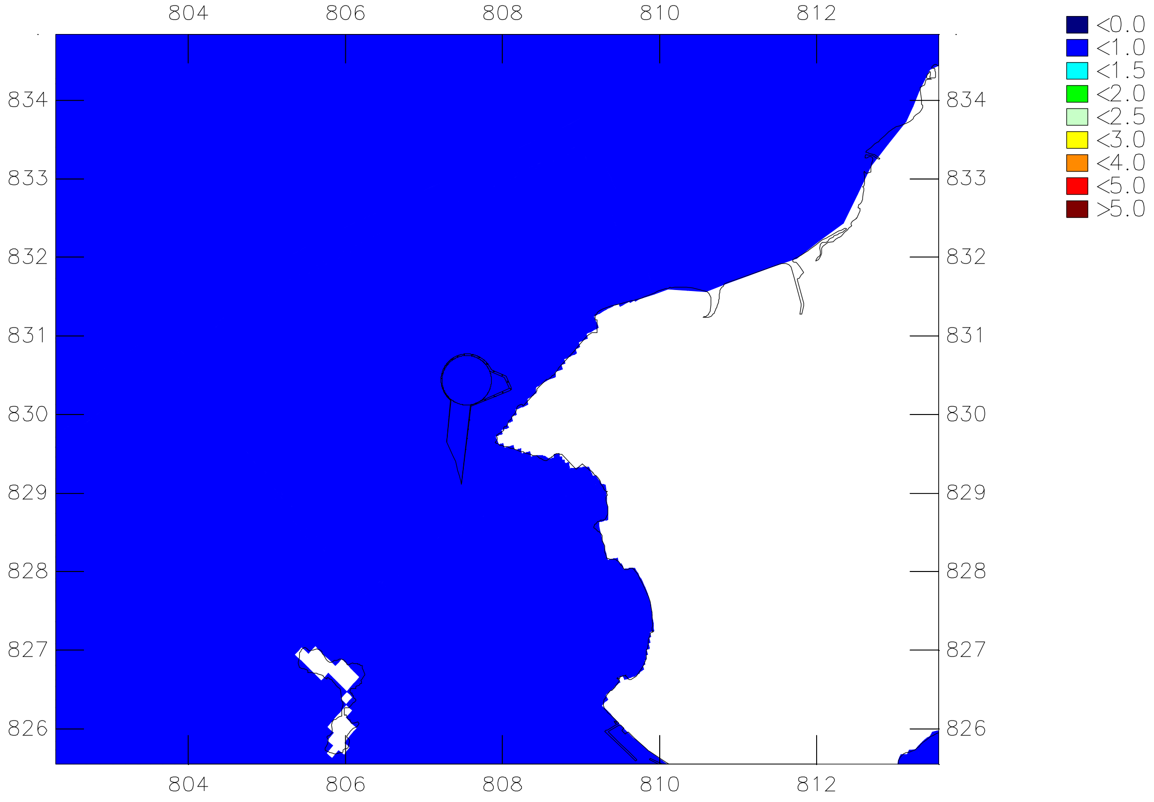
DO decrease (mg/L) – max. over a complete spring neap cycle
BP12
Upper plot: bottom layer – Lower plot: depth average

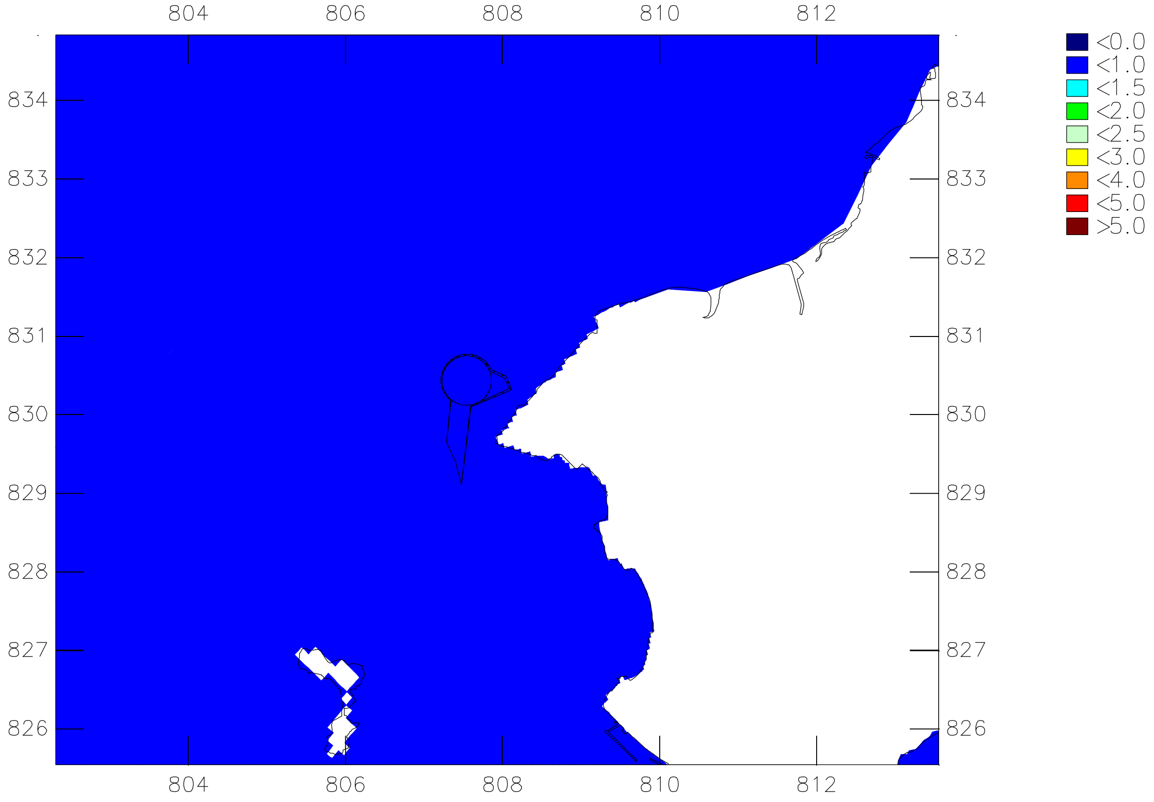
Dry Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C04r





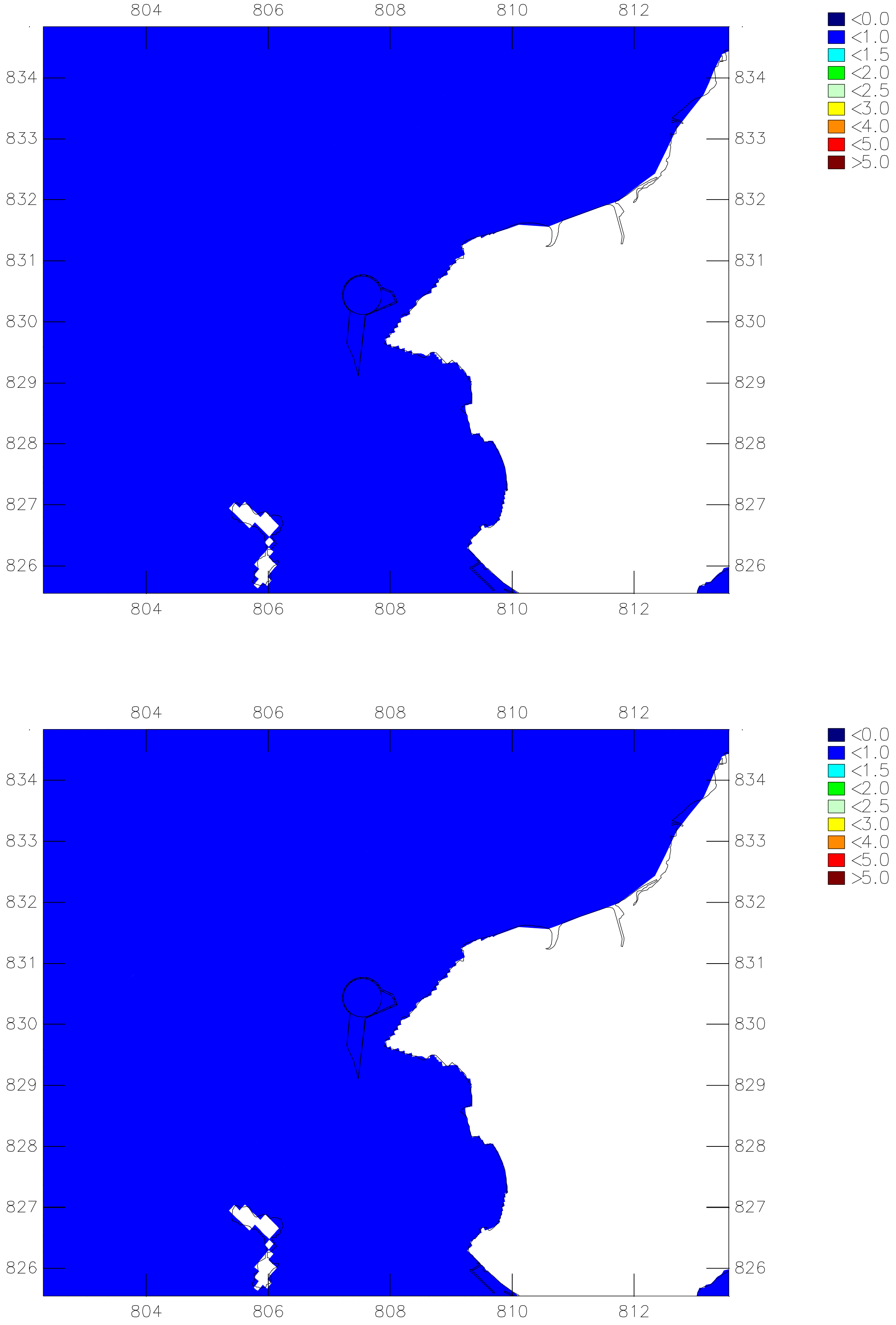
DO decrease (mg/L) – max. over a complete spring neap cycle
BP12
Upper plot: surface layer – Lower plot: middle layer

Wet Season

Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C04s



DO decrease (mg/L) – max. over a complete spring neap cycle

BP12

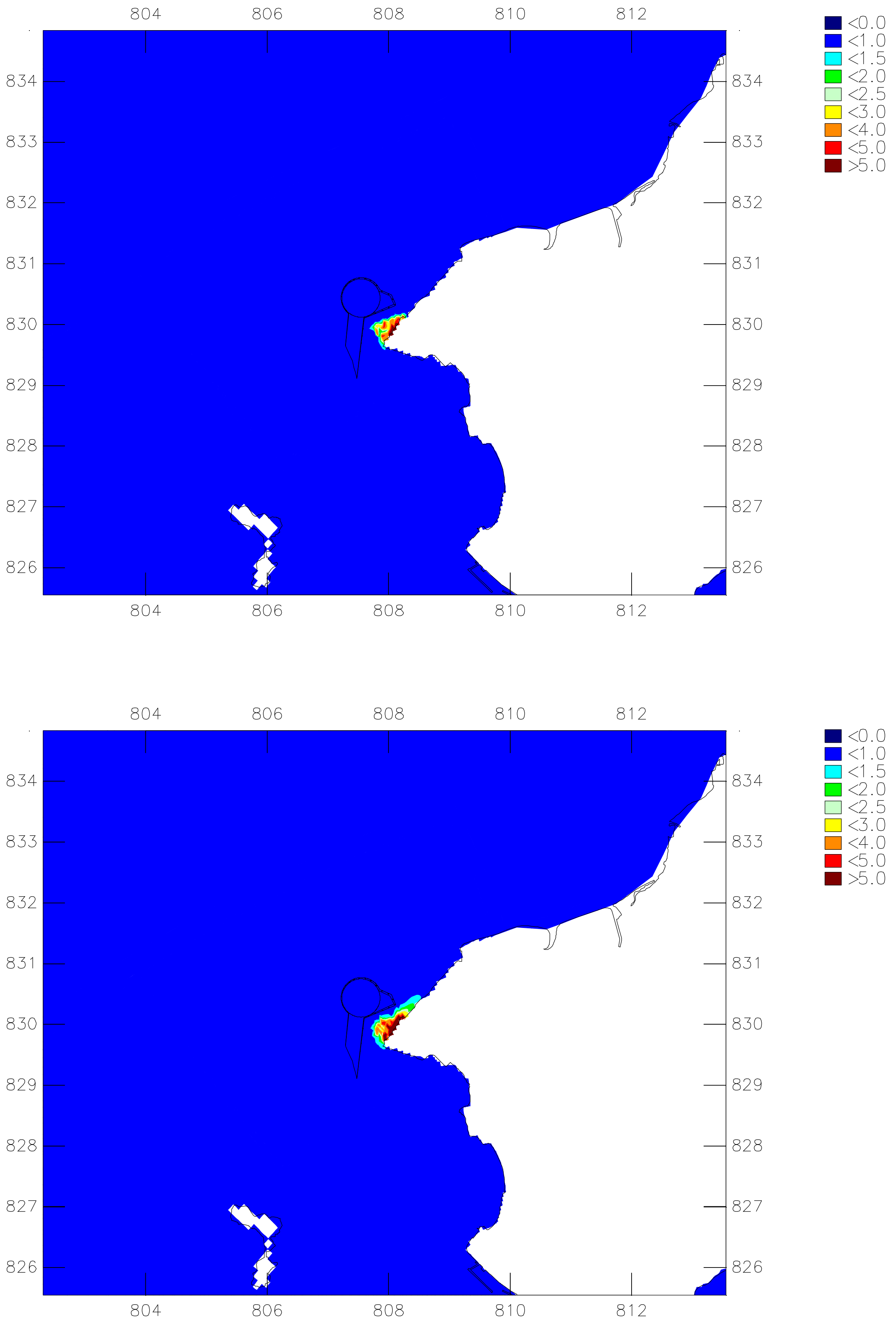
Upper plot: bottom layer – Lower plot: depth average

Wet Season

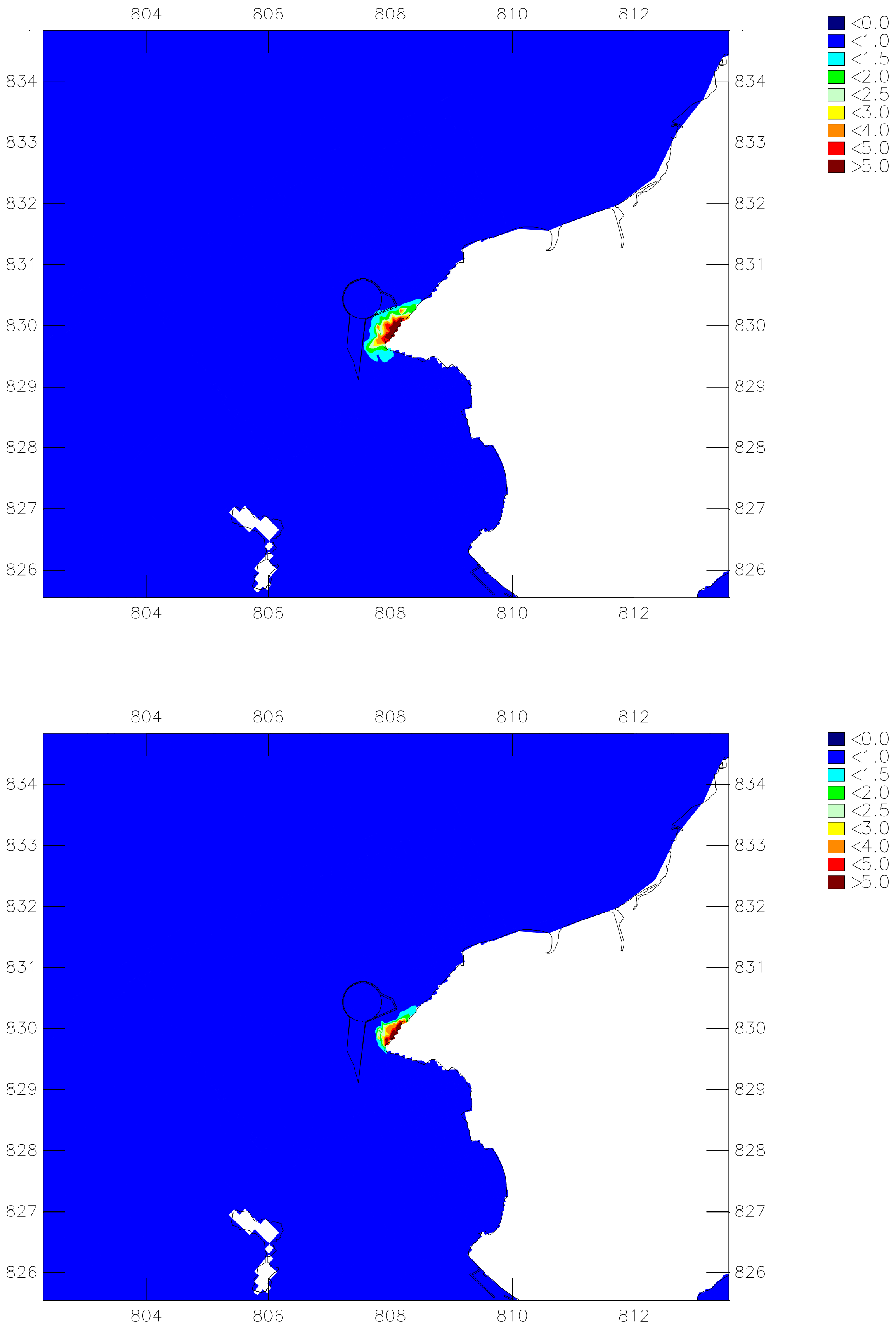
Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C04t



DO decrease (mg/L) – max. over a complete spring neap cycle BP17 Upper plot: surface layer – Lower plot: middle layer	Dry Season	
	Scenario 1a / Scenario 1b	
WL | Delft Hydraulics – ERM		Fig. BP_C04u



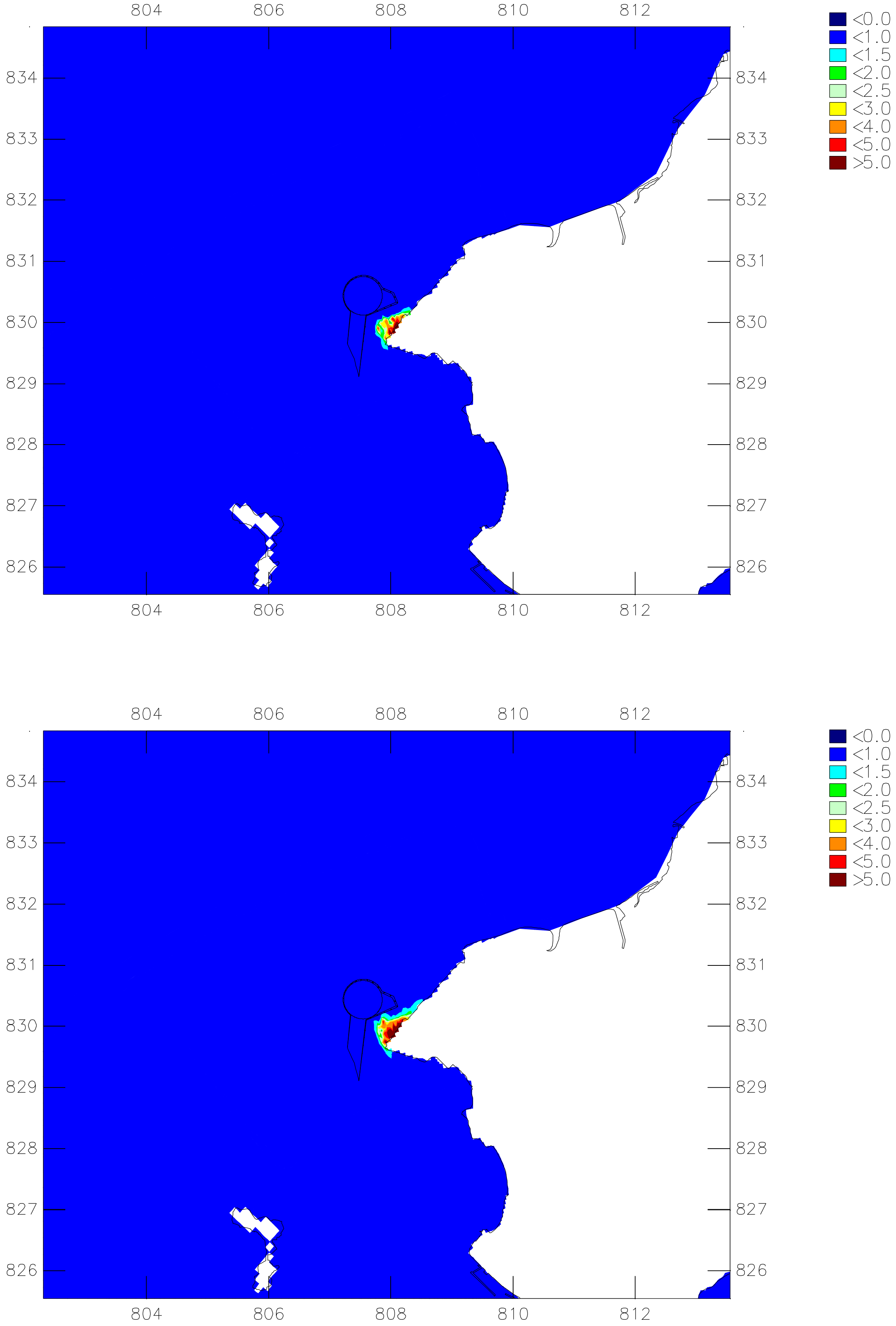
DO decrease (mg/L) – max. over a complete spring neap cycle
BP17
Upper plot: bottom layer – Lower plot: depth average

Dry Season

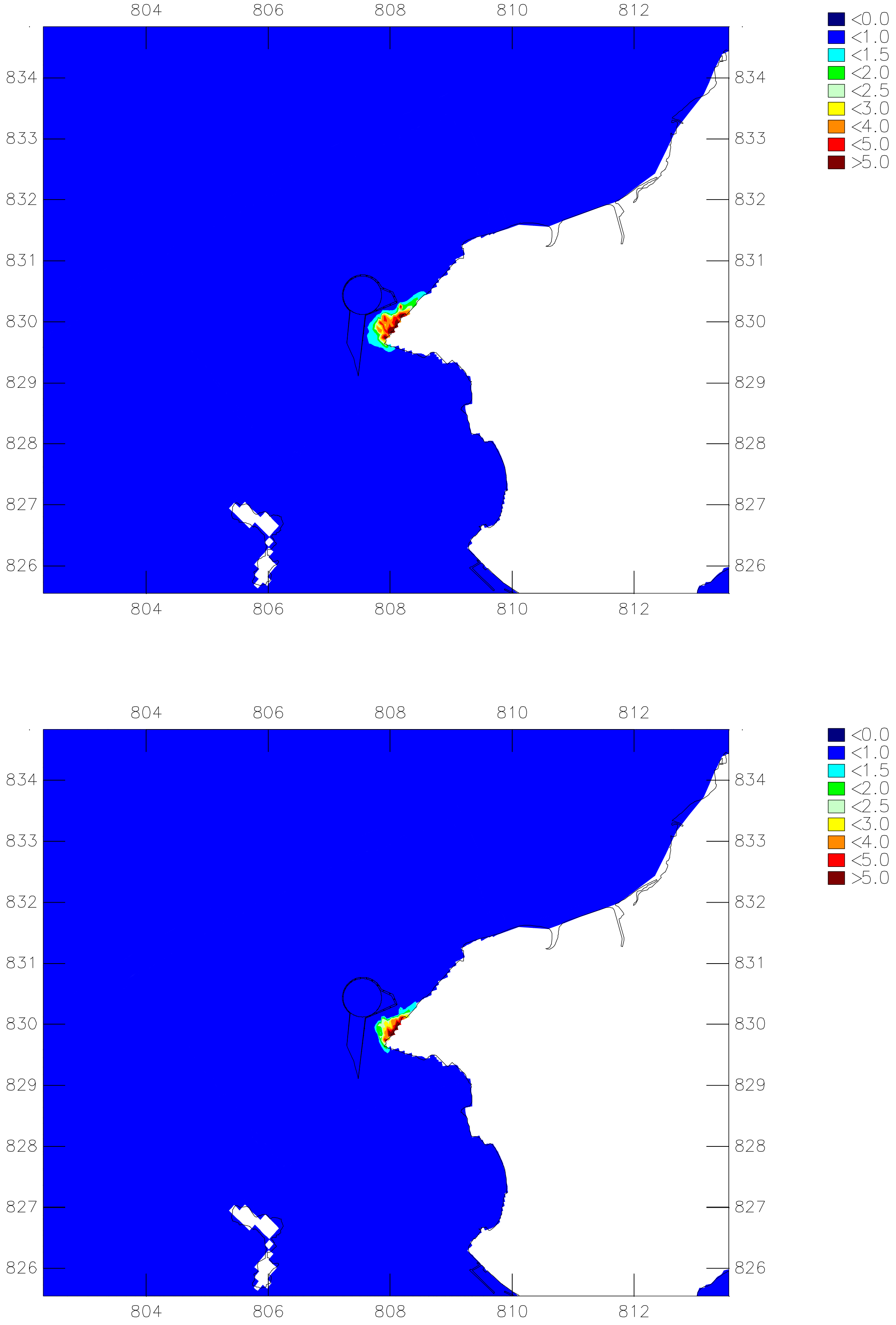
Scenario 1a / Scenario 1b

WL | Delft Hydraulics – ERM

Fig. BP_C04v



DO decrease (mg/L) – max. over a complete spring neap cycle BP17 Upper plot: surface layer – Lower plot: middle layer	Wet Season Scenario 1a / Scenario 1b
WL | Delft Hydraulics – ERM	Fig. BP_C04w



DO decrease (mg/L) – max. over a complete spring neap cycle

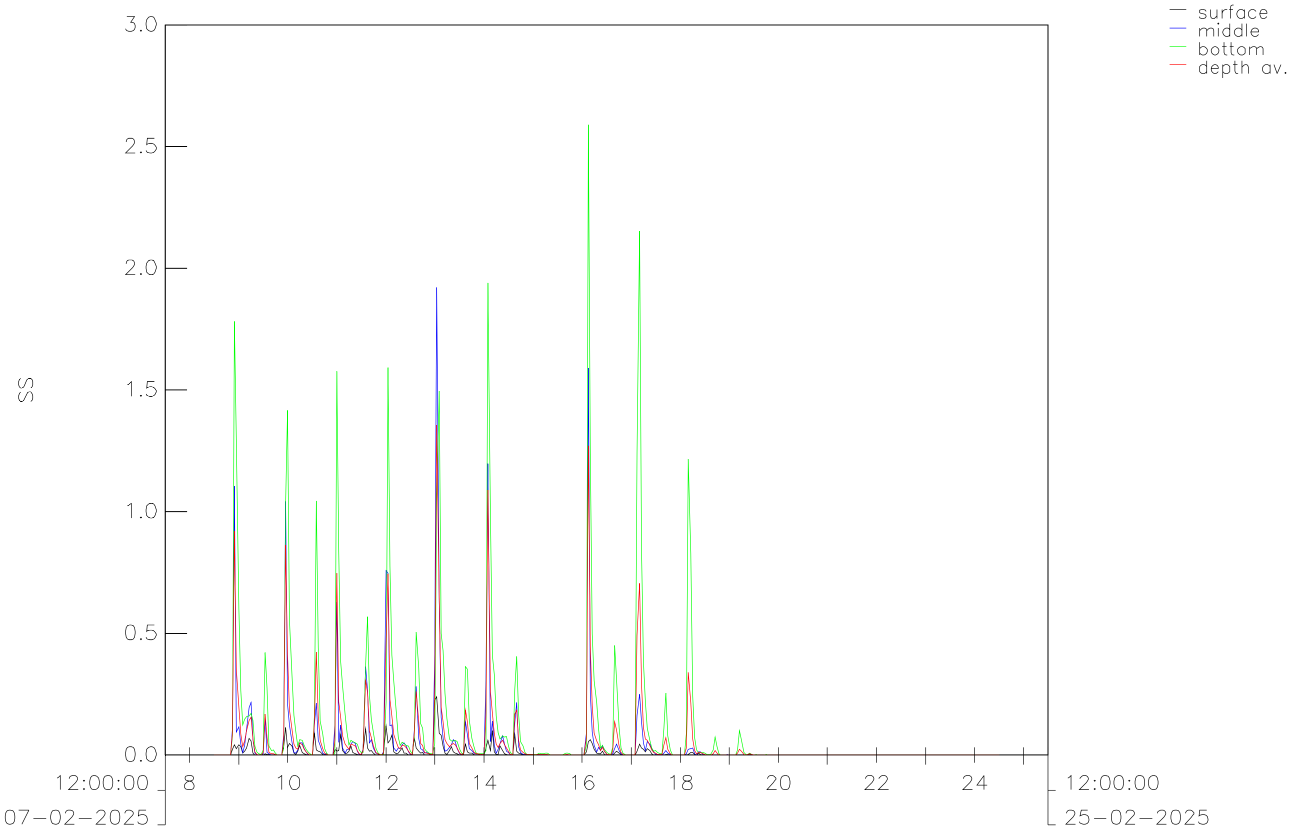
BP17

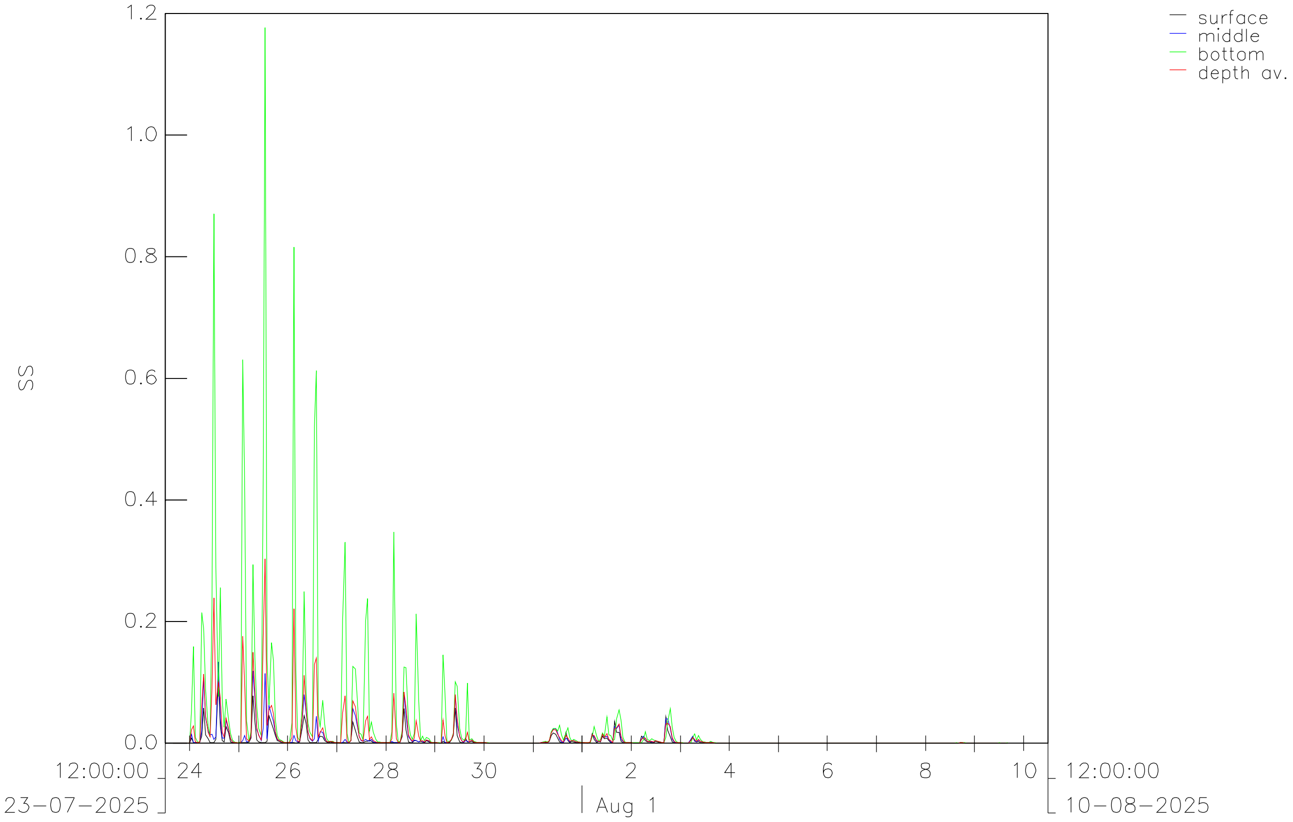
Upper plot: bottom layer – Lower plot: depth average

Wet Season	
Scenario 1a / Scenario 1b	

WL | Delft Hydraulics – ERM

Fig. BP_C04x



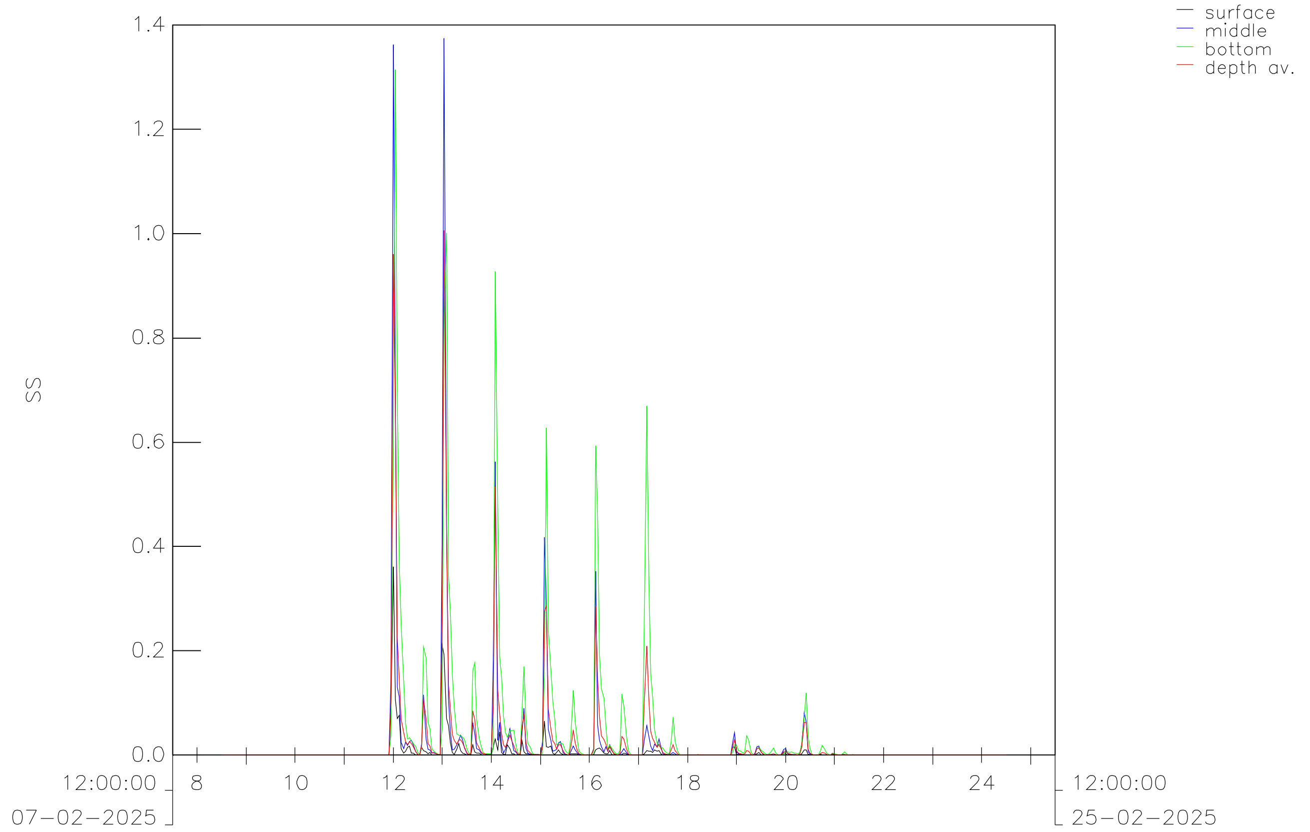


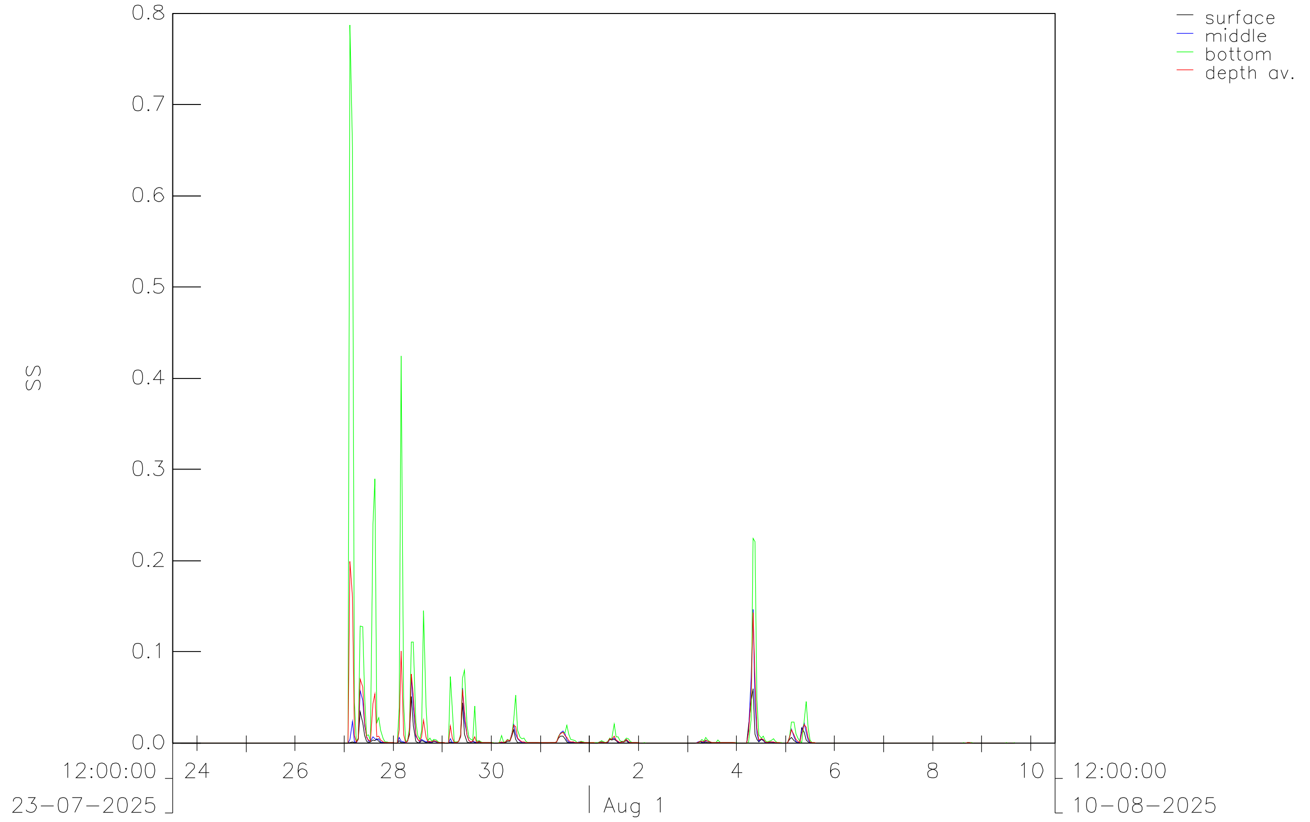
Construction Impacts – **Scenario 1a**
SS elevations (mg/L) at sr5a over a Spring–Neap cycle
dry (top) and wet (bot) season

SS01, SS02, SS32, BP01, BP02

WL | Delft Hydraulics – ERM

Fig BP_C05a



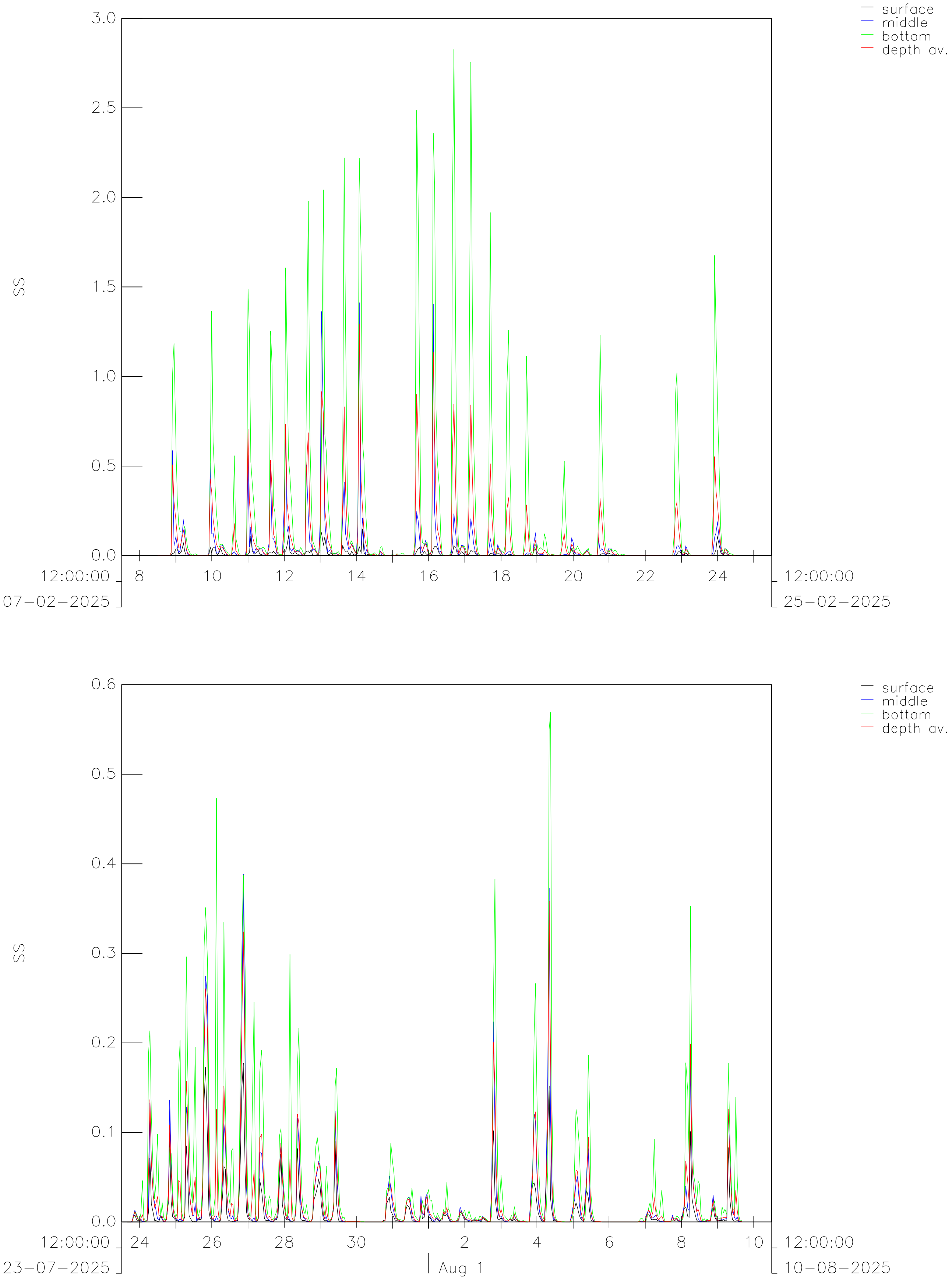


Construction Impacts — Scenario 1a
SS elevations (mg/L) at sr5a over a Spring-Neap cycle
dry (top) and wet (bot) season

SS06a, SS07a, SS8, BP15

WL | Delft Hydraulics — ERM

Fig BP_C05b

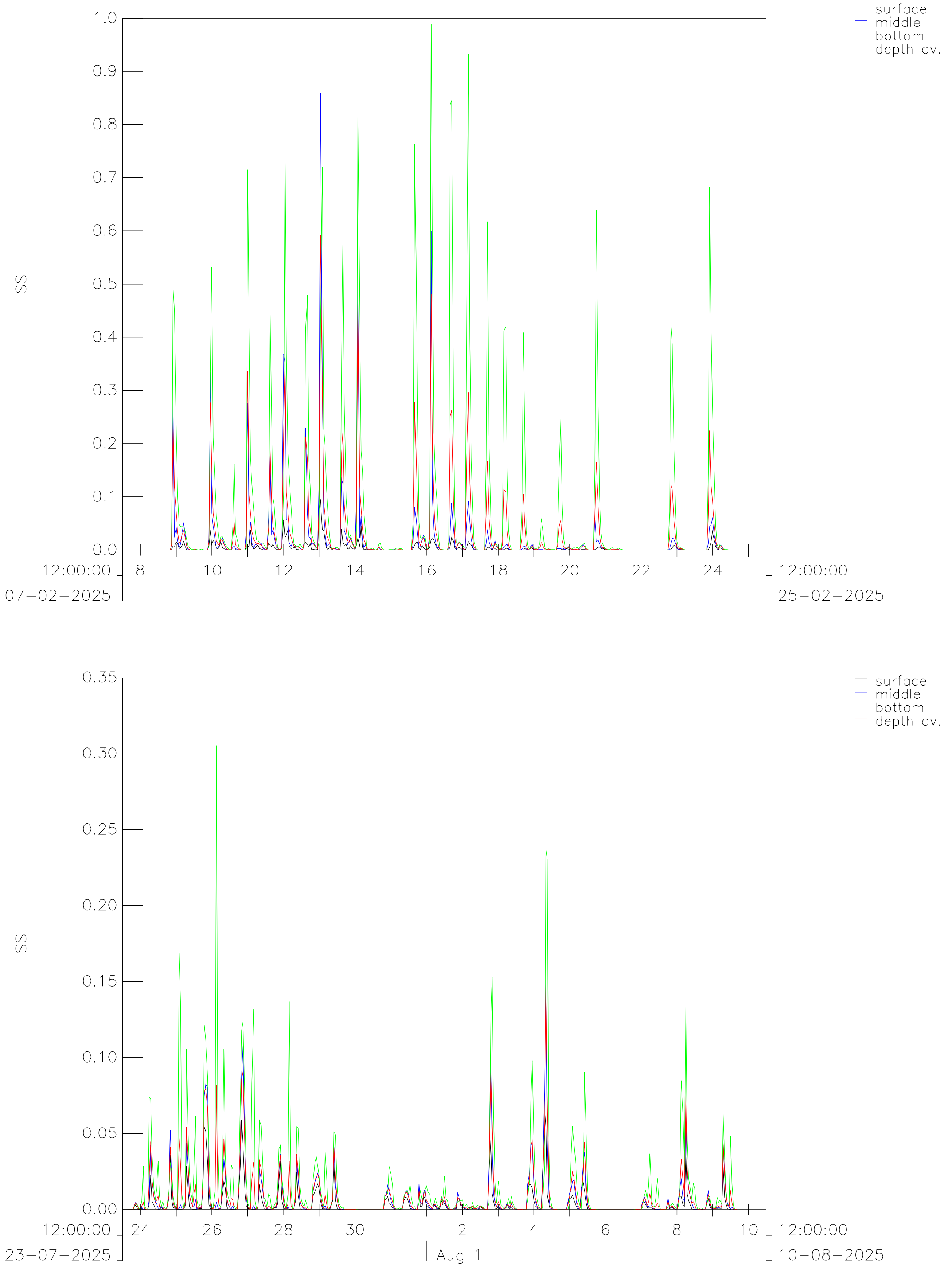


Construction Impacts — Scenario 1a
SS elevations (mg/L) at sr5a over a Spring-Neap cycle
dry (top) and wet (bot) season

SS09, SS10, BP07, BP08a, BP09a
and BP10a

WL | Delft Hydraulics — ERM

Fig BP_C05c

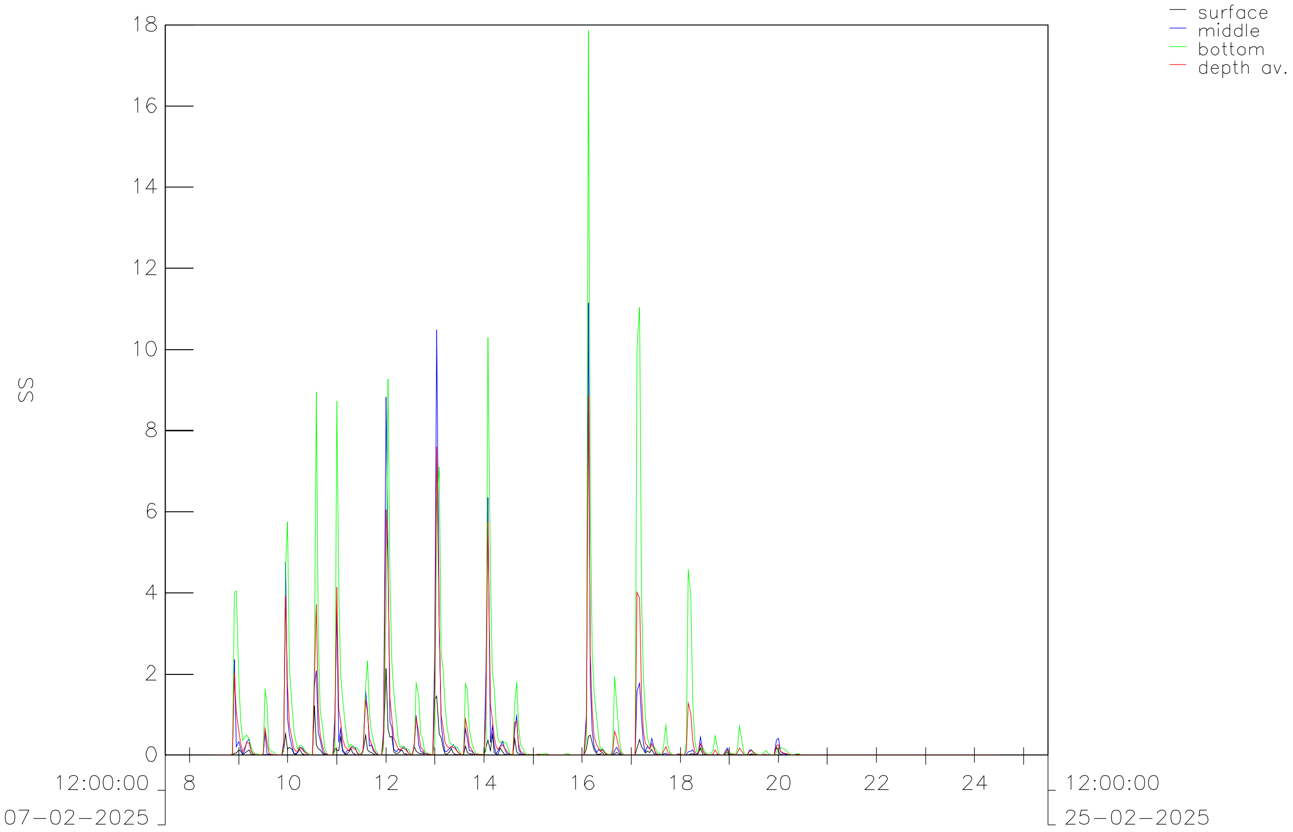


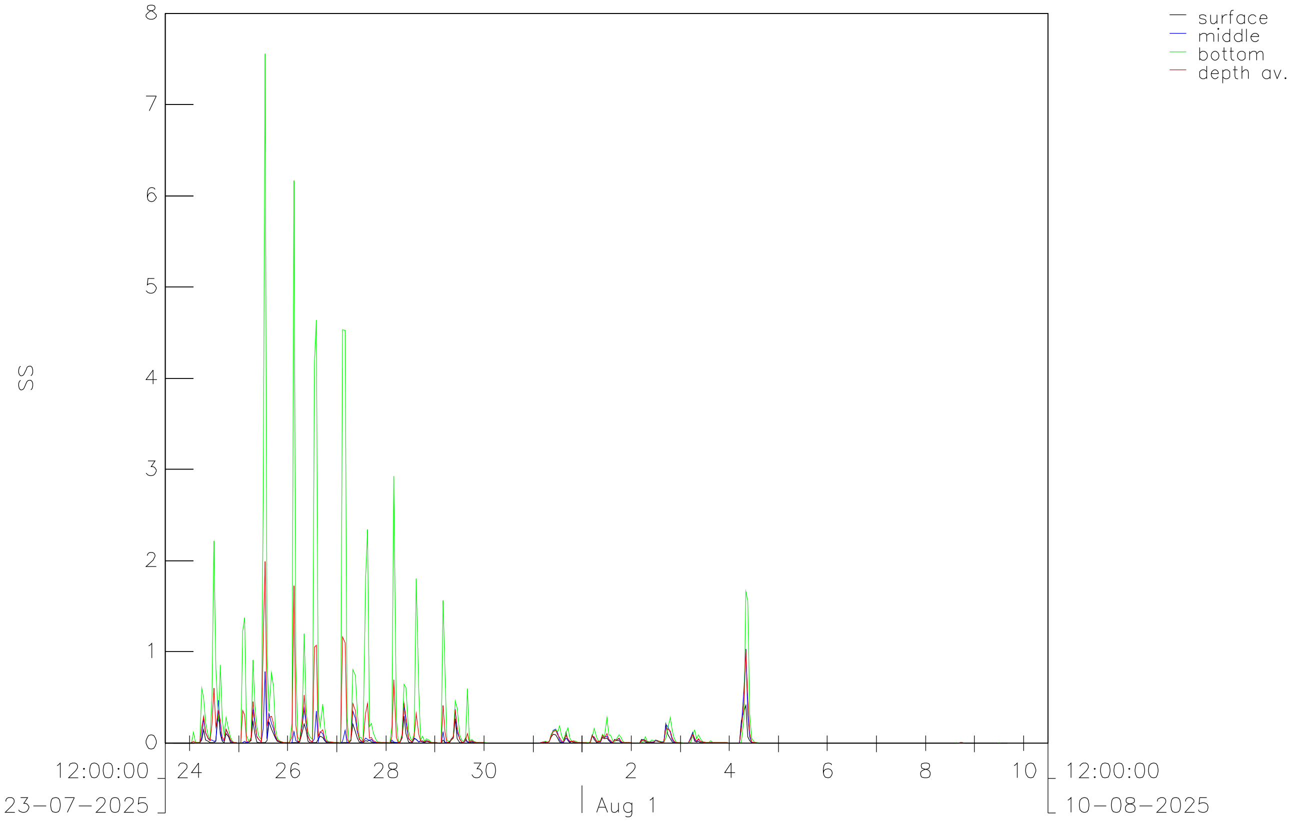
Construction Impacts – Scenario 1a
SS elevations (mg/L) at sr5a over a Spring-Neap cycle
dry (top) and wet (bot) season

SS03, SS04a, SS05a, SS21, BP12

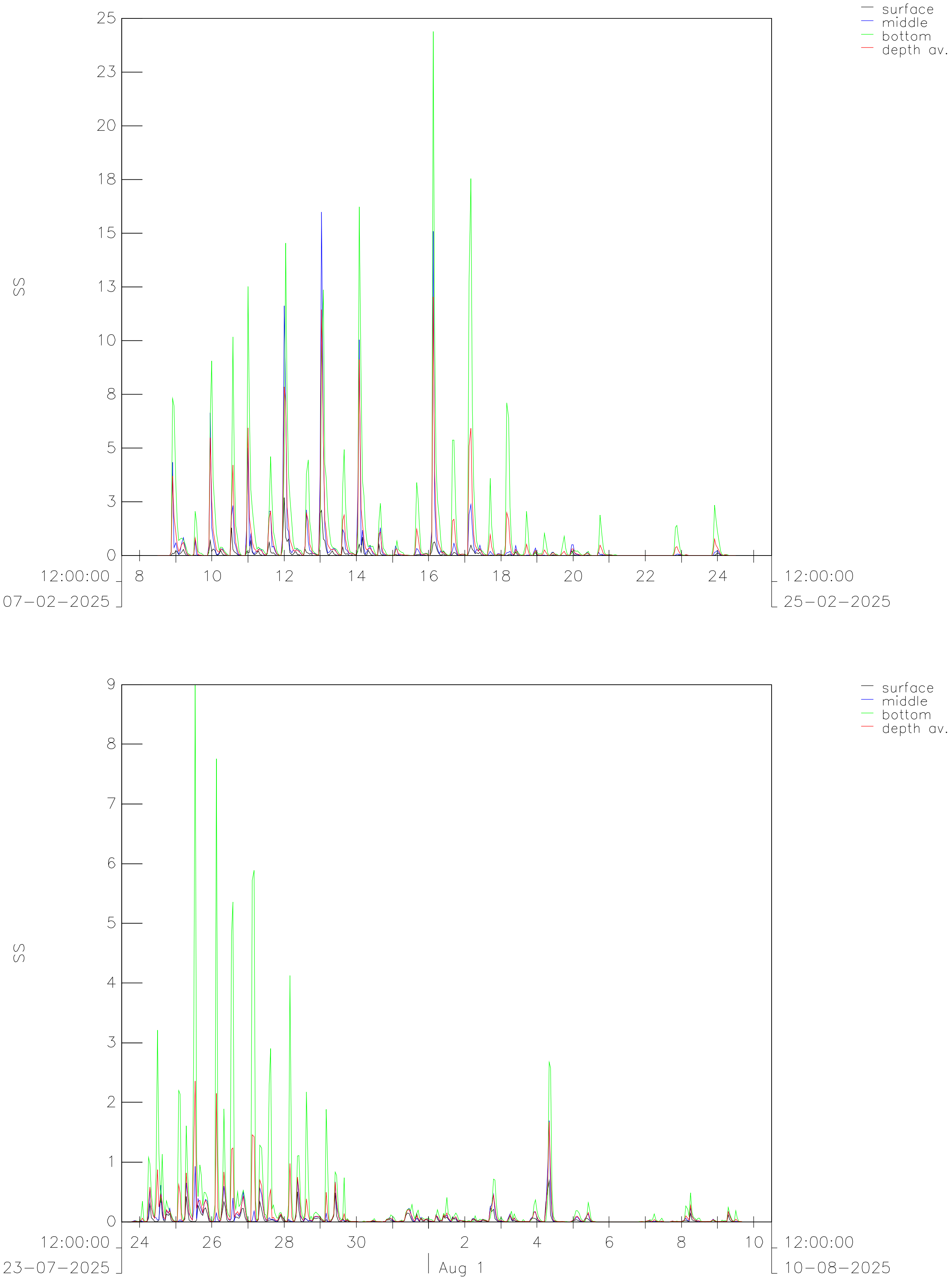
WL | Delft Hydraulics – ERM

Fig BP_C05d





Construction Impacts – **Scenario 1a** SS elevations (mg/L) at sr5a over a Spring-Neap cycle dry (top) and wet (bot) season	SS14, SS15, SS28, BP17	
WL | Delft Hydraulics – ERM		Fig BP_C05e



Construction Impacts – **Scenario 1a**

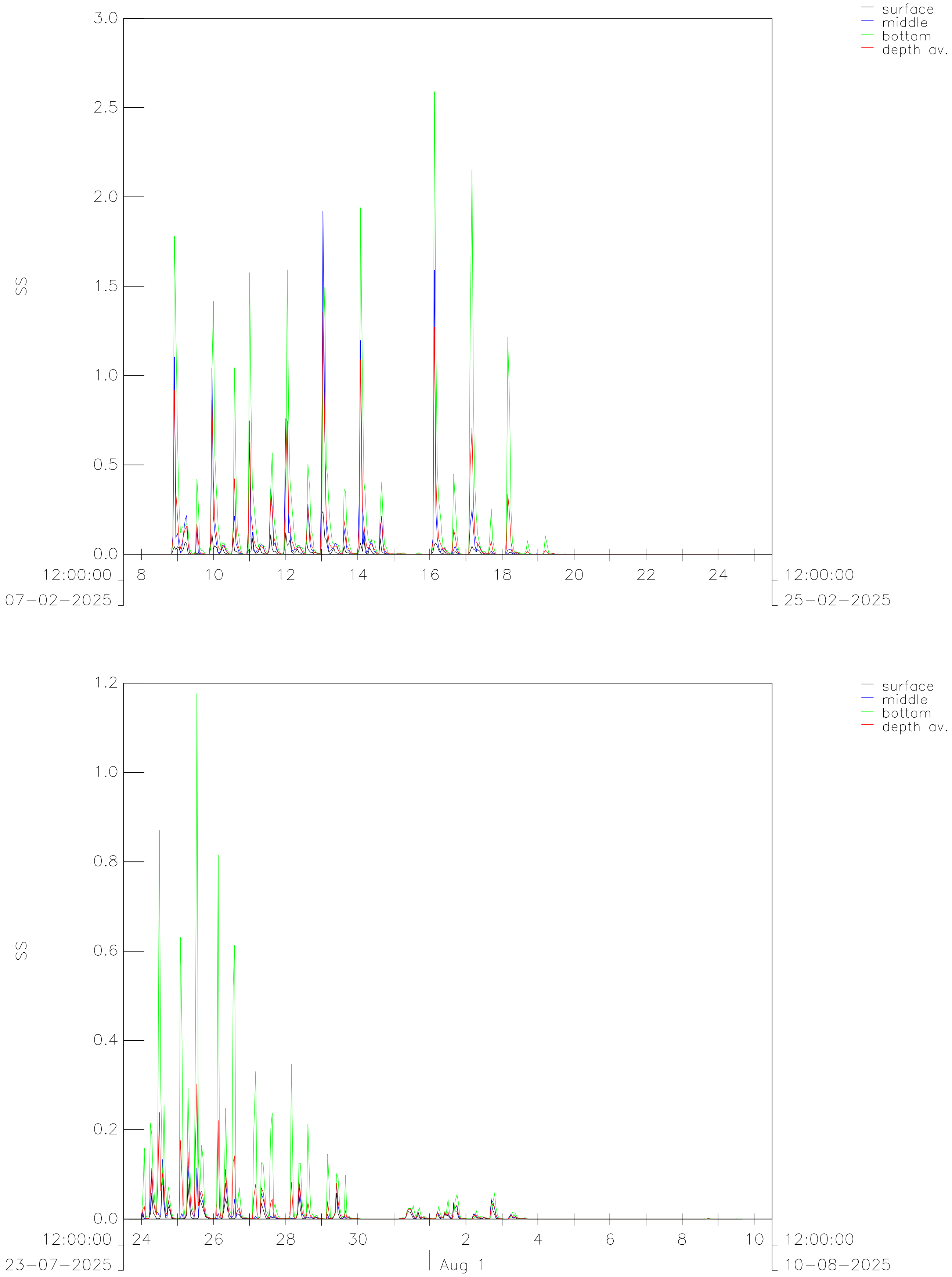
SS elevations (mg/L) at sr5a over a Spring-Neap cycle

dry (top) and wet (bot) season

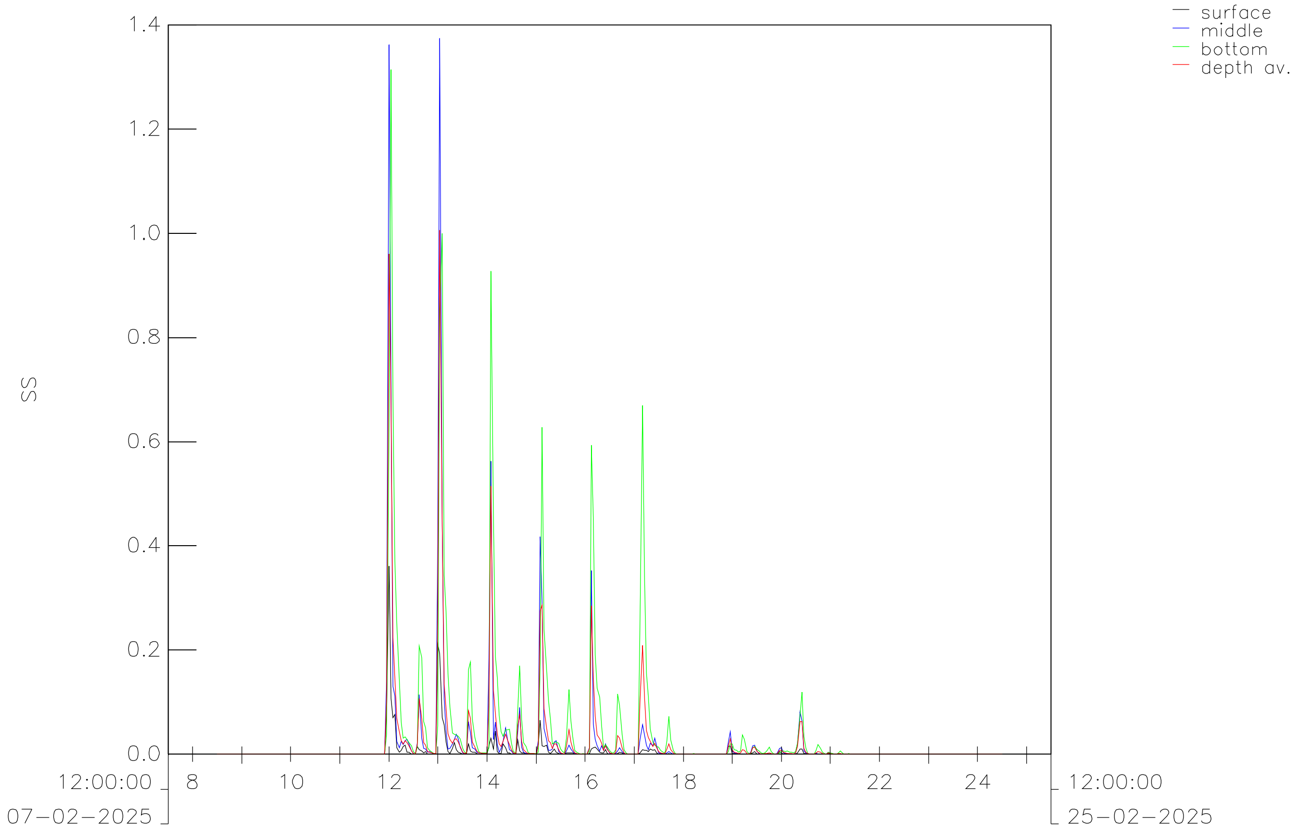
All Codes

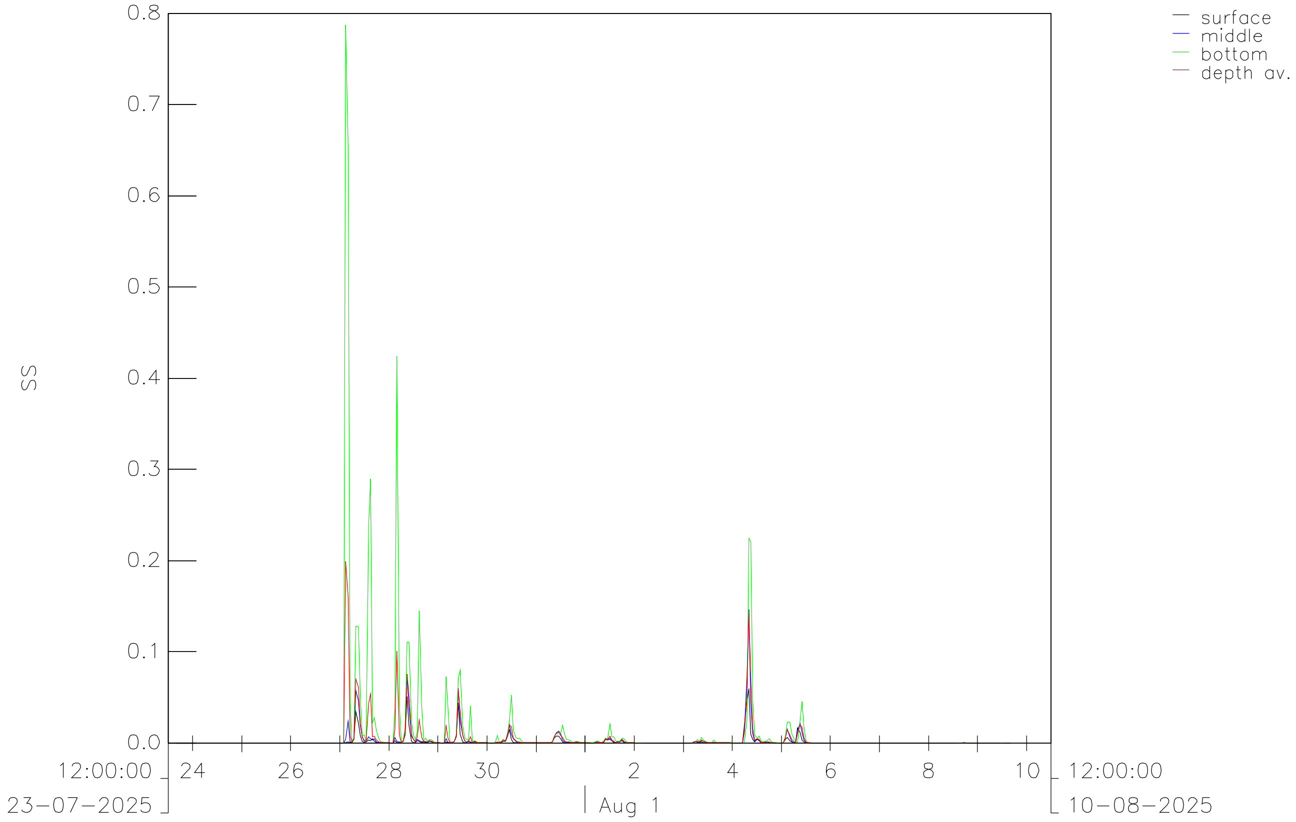
WL | Delft Hydraulics – ERM

Fig BP_C05f



Construction Impacts – **Scenario 1b** SS elevations (mg/L) at sr5a over a Spring–Neap cycle dry (top) and wet (bot) season		
	SS01, SS02, SS32, BP01, BP02	
WL | Delft Hydraulics – ERM		Fig BP_C05g



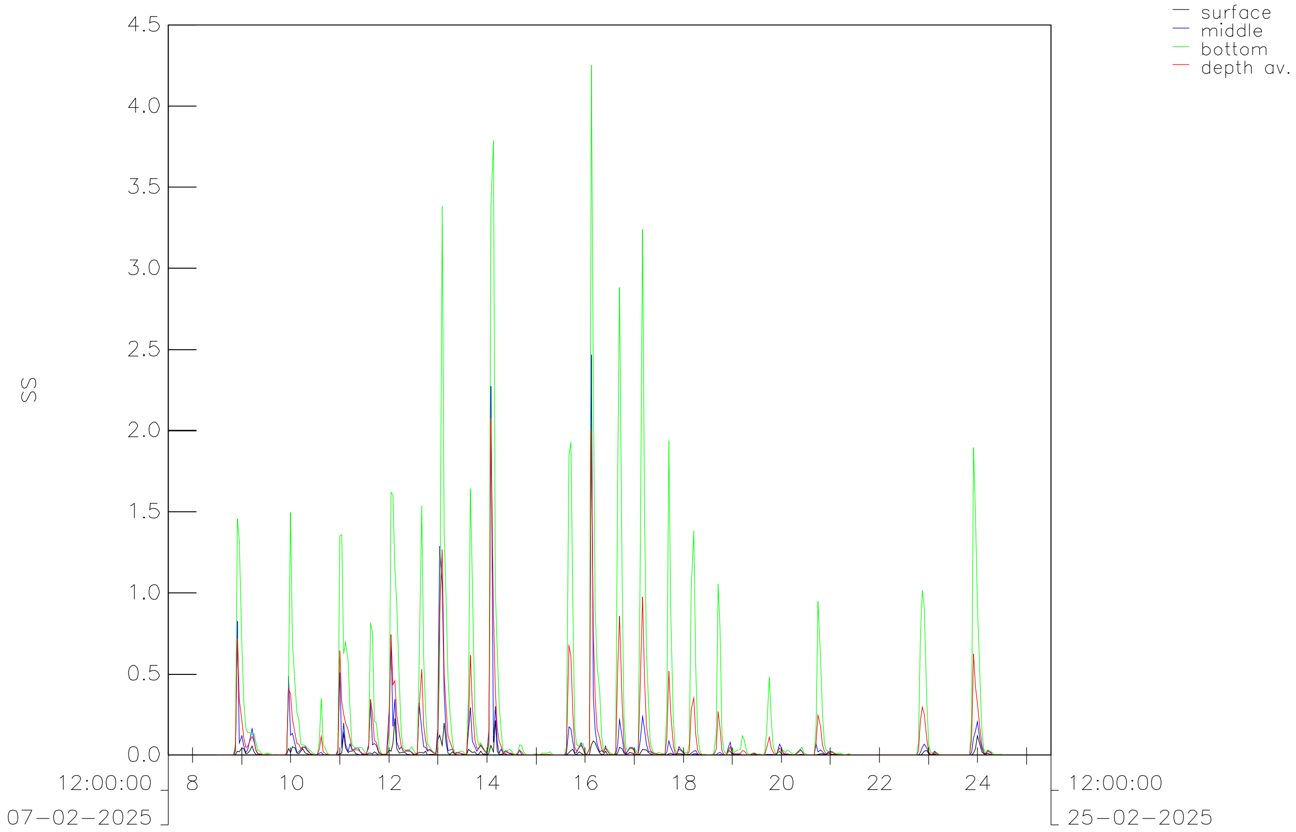


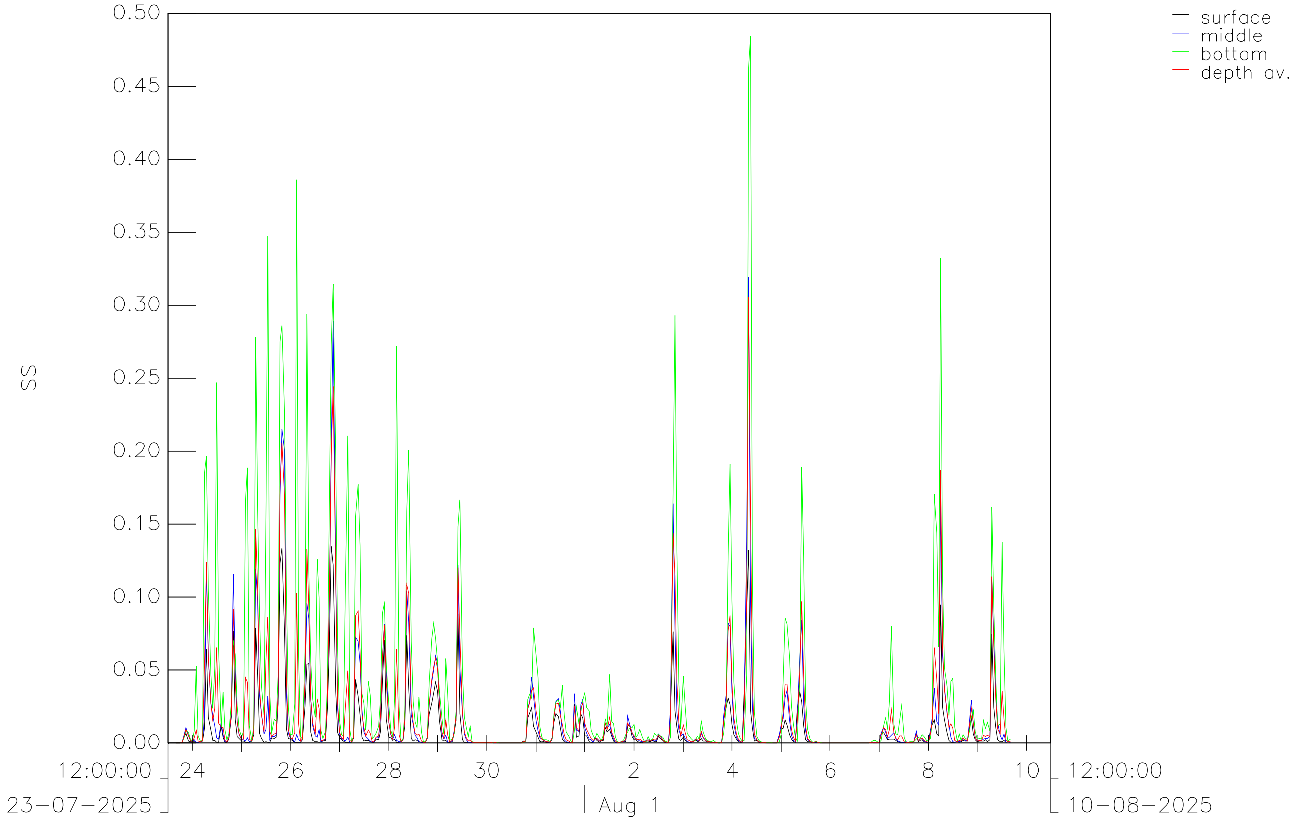
Construction Impacts – Scenario 1b
SS elevations (mg/L) at sr5a over a Spring-Neap cycle
dry (top) and wet (bot) season

SS06a, SS07a, SS8, BP15

WL | Delft Hydraulics – ERM

Fig BP_C05h





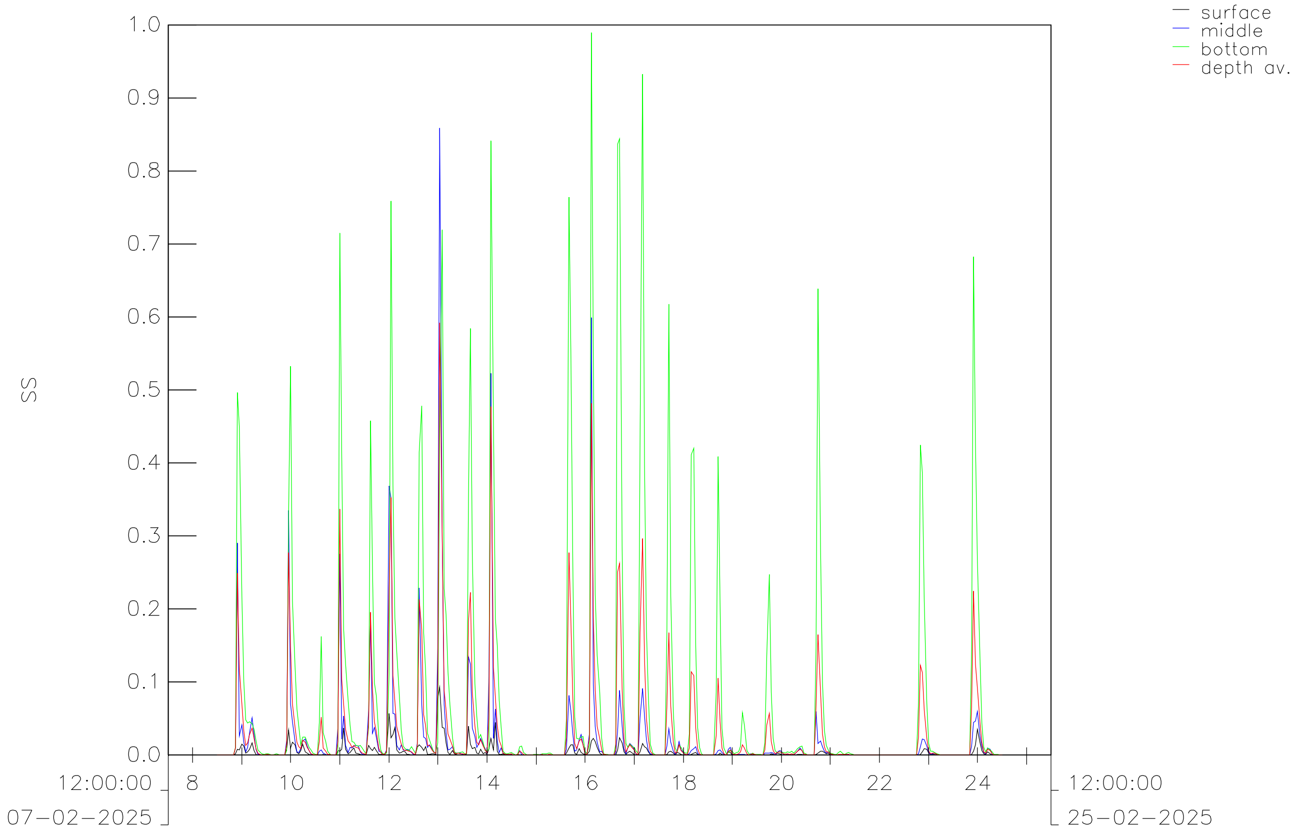
Construction Impacts – Scenario 1b
SS elevations (mg/L) at sr5a over a Spring-Neap cycle
dry (top) and wet (bot) season

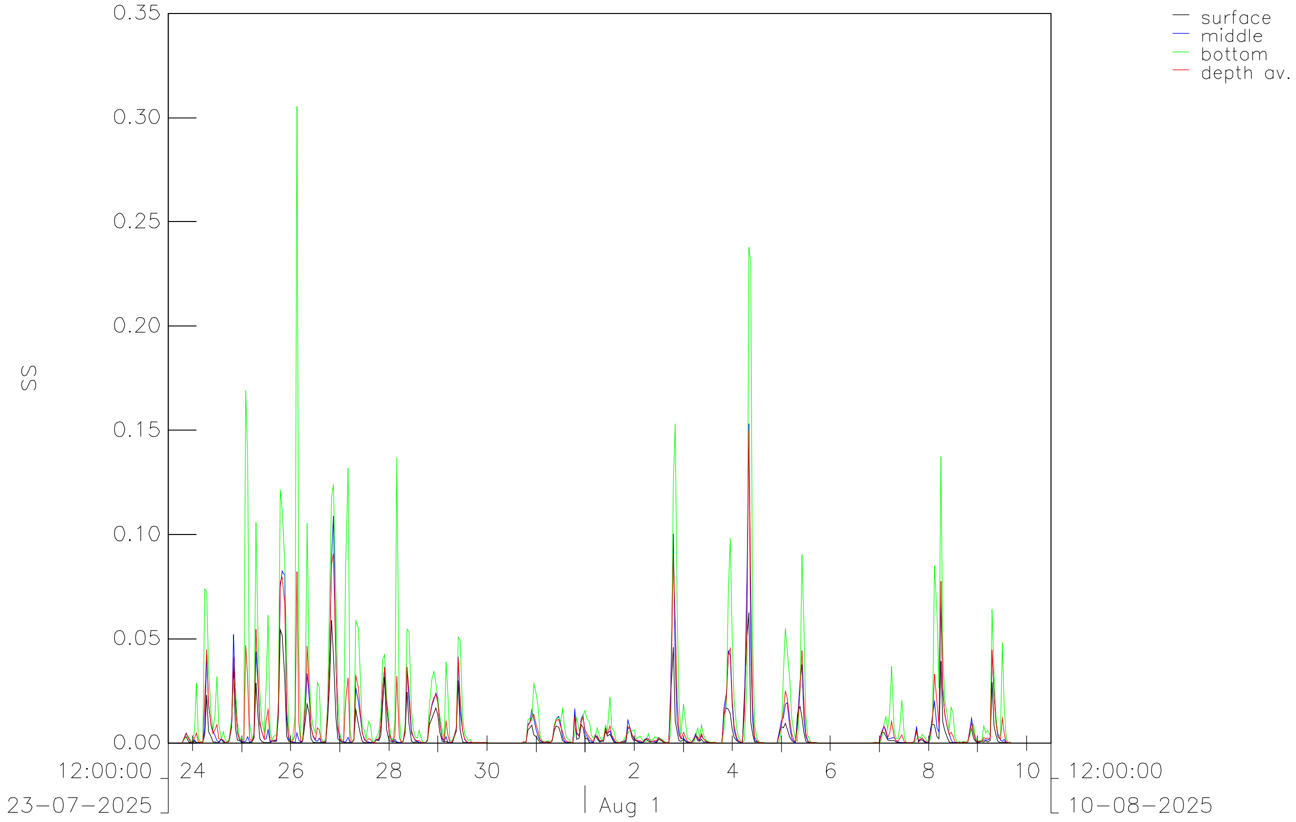
SS09, SS10, BP07, BP08b, BP09b

WL | Delft Hydraulics – ERM

BP10b, BP11

Fig BP_C05i



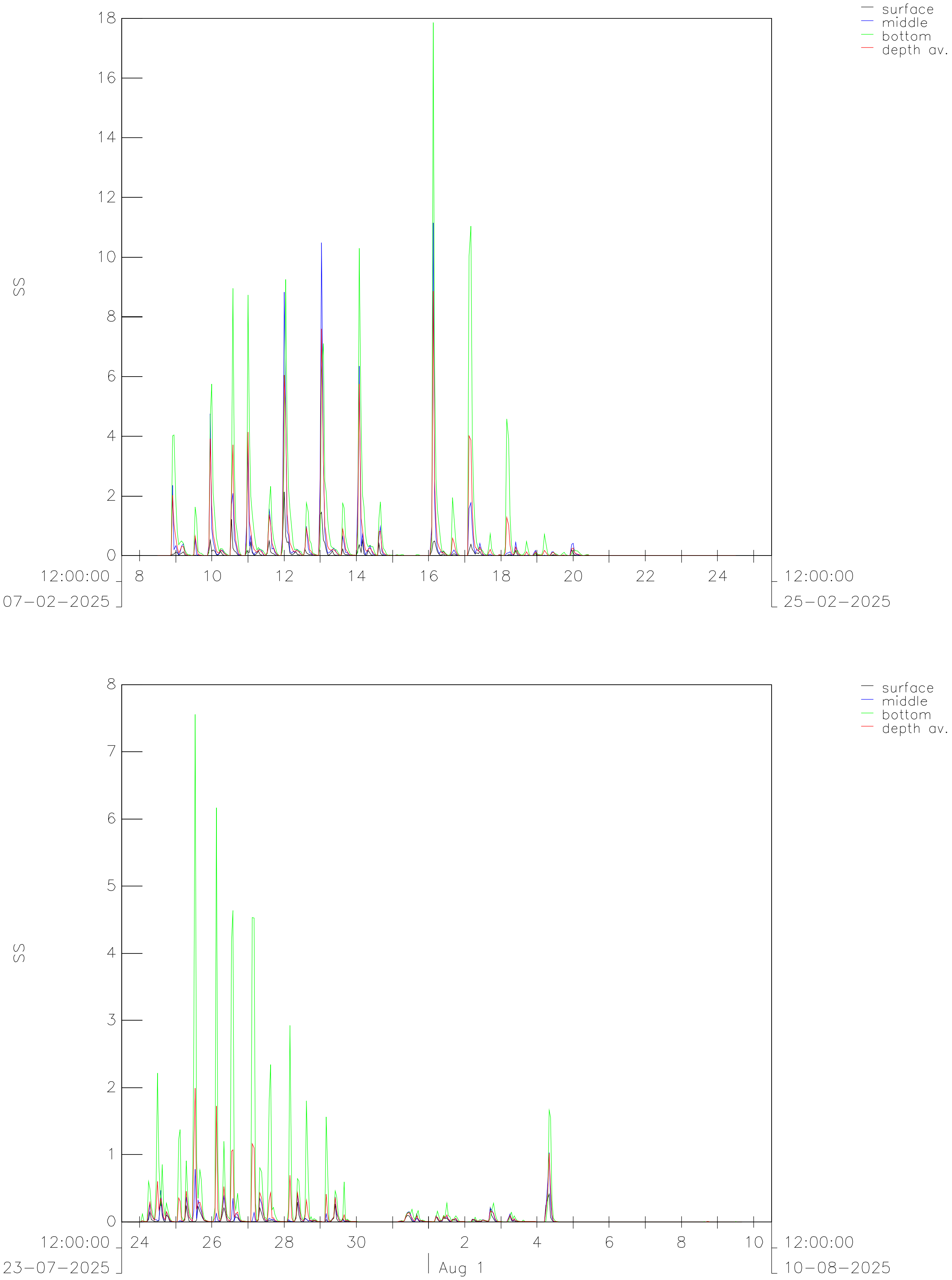


Construction Impacts – **Scenario 1b**
SS elevations (mg/L) at sr5a over a Spring-Neap cycle
dry (top) and wet (bot) season

SS03, SS04b, SS05b, SS21, BP12

WL | Delft Hydraulics – ERM

Fig BP_C05j

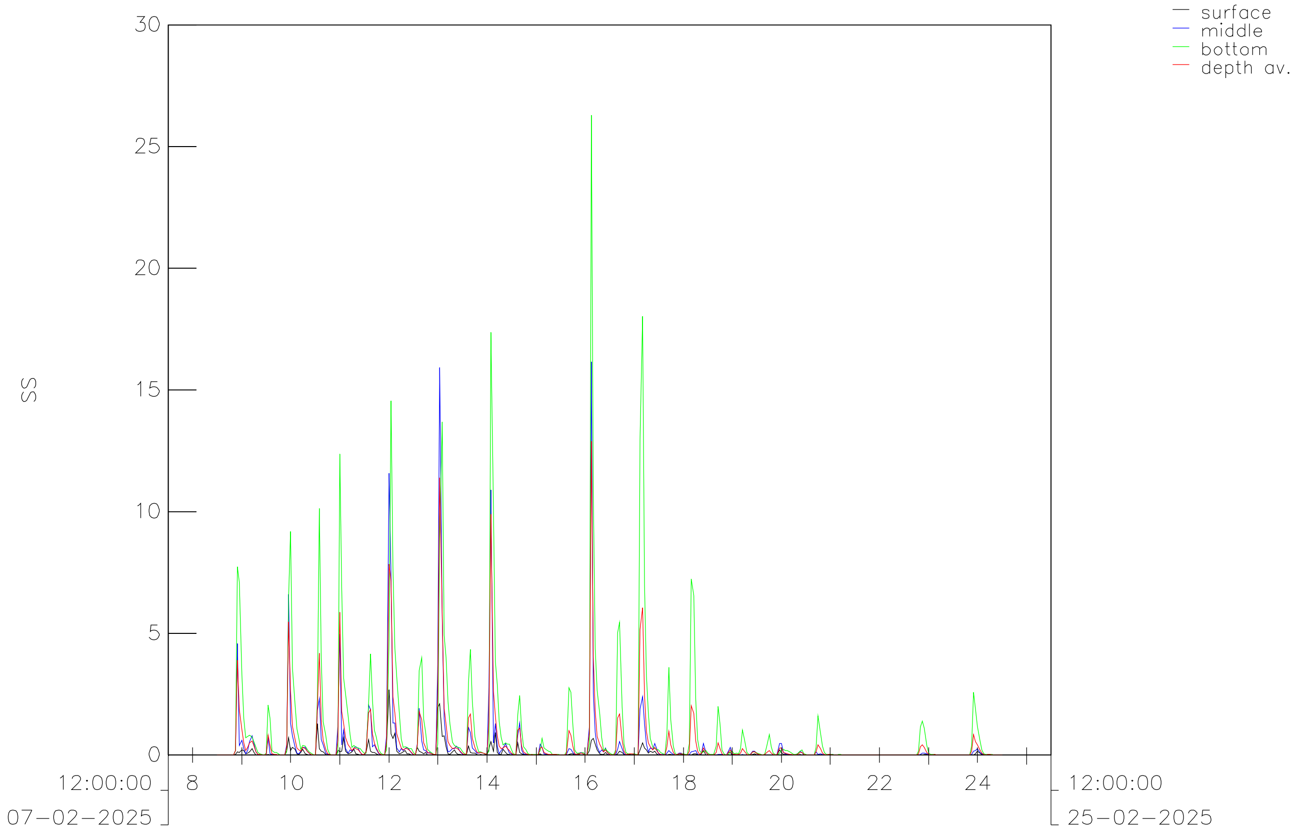


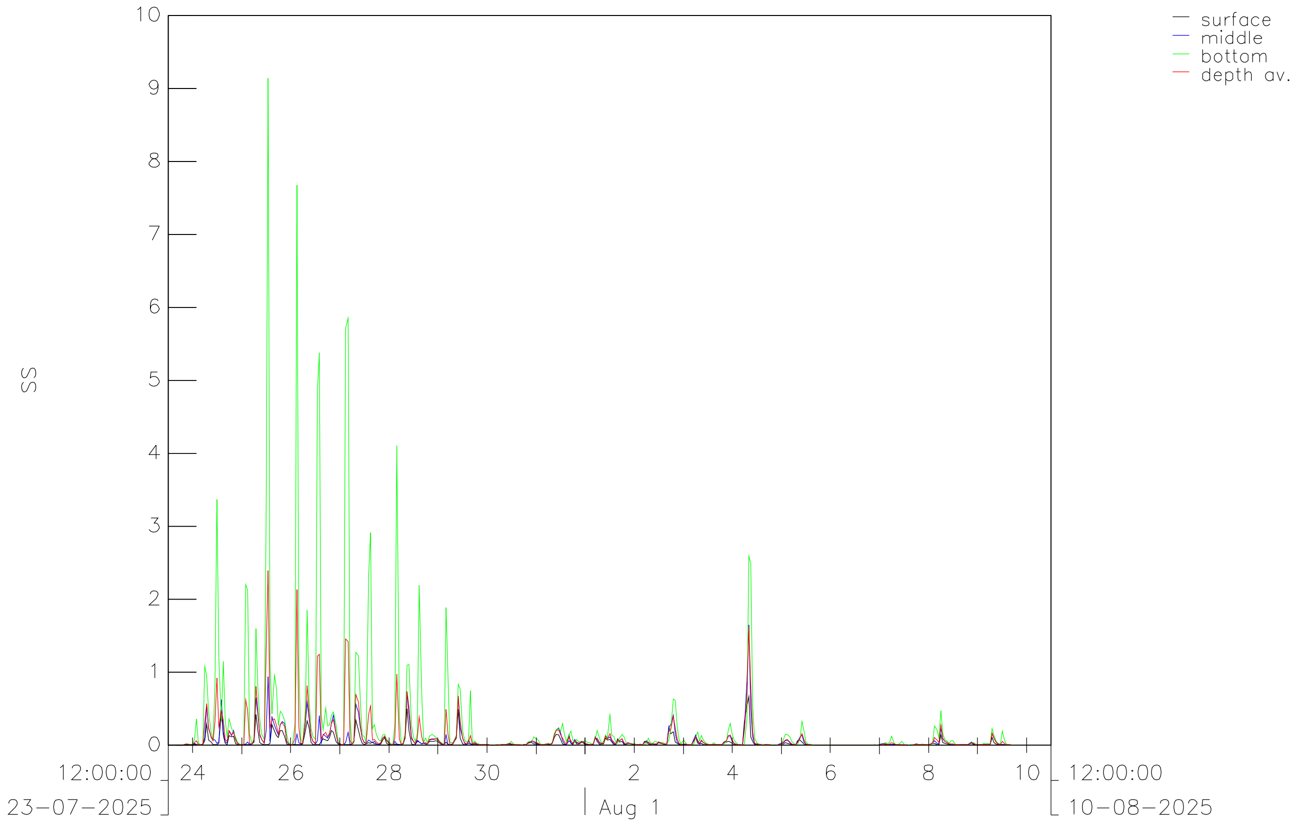
Construction Impacts – Scenario 1b
SS elevations (mg/L) at sr5a over a Spring-Neap cycle
dry (top) and wet (bot) season

SS14, SS15, SS28, BP17

WL | Delft Hydraulics – ERM

Fig BP_C05k





Construction Impacts – **Scenario 1b**
SS elevations (mg/L) at sr5a over a Spring-Neap cycle
dry (top) and wet (bot) season

All Codes

WL | Delft Hydraulics – ERM

Fig BP_C05l

Annex 6D

Predicted Concentration of Nutrients and Elutriate Test Results

Table D.1 Predicted TIN Concentrations (mg L^{-1}) as a Result of SS Release due to the Works

Sensitive Receiver	Name	ID	Relevant Depth [1]	Max TIN Conc. In Sediment (mg kg^{-1})	Scenario 1a		Scenario 1b	
					Dry	**Wet**	**Dry**	**Wet**
					Max	**Max**	**Max**	**Max**
Intertidal Mudflats	Pak Nai	SR01	s	142	0.000107	0.000071	0.000000	0.000082
Horseshoe Crab Nursery Grounds	Pak Nai	SR01	a	142	0.000483	0.000642	0.000000	0.000706
Seagrass Beds/Mangroves/Oyster Farm	Pak Nai	SR02	s	142	0.000000	0.000004	0.000000	0.000004
Seawater Intakes	Black Point Power Station	SR04	b	142	0.028196	0.026669	0.028572	0.026601
Non-gazetted Beaches	Lung Kwu Sheung Tan	SR05a	a	100	0.001204	0.000236	0.001291	0.000240
Non-gazetted Beaches	Lung Kwu Tan	SR05b	a	100	0.000679	0.000308	0.000737	0.000307
Gazetted Beaches	Butterfly Beach	SR05c	a	100	0.000006	0.000000	0.000007	0.000000
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06a	a	100	0.000052	0.000031	0.000054	0.000032
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06b	a	100	0.000028	0.000035	0.000029	0.000035
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06c	a	100	0.000129	0.000143	0.000106	0.000118
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06d	a	100	0.000079	0.000075	0.000084	0.000074
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR06e	a	100	0.000027	0.000025	0.000028	0.000026
Seawater Intakes	Castle Peak Power Station	SR07a	b	100	0.001477	0.001294	0.001551	0.001478
Seawater Intakes	Tuen Mun Area 38	SR07b	b	100	0.000443	0.000377	0.000470	0.000397

Sensitive Receiver	Name	ID	Relevant Depth [1]	Max TIN Conc. In Sediment (mg kg^{-1})	Scenario 1a		Scenario 1b	
					Dry	Wet	Dry	Wet
					Max	Max	Max	Max
Seawater Intakes	Airport	SR07c	b	100	0.000035	0.000016	0.000035	0.000016
Seawater Intakes	Airport	SR07d	b	100	0.000004	0.000013	0.000004	0.000013
Artificial Reef Deployment Area	Northeast Airport	SR07d	a	100	0.000003	0.000011	0.000003	0.000011
Seawater Intakes	Airport	SR07e	b	100	0.000000	0.000006	0.000000	0.000006
Seawater Intakes	Airport	SR07f	b	100	0.000000	0.000000	0.000000	0.000000
Spawning/Nursery Grounds	Fisheries Spawning Ground in North Lantau	SR08	a	100	0.000151	0.000158	0.000147	0.000158
Horseshoe Crab Nursery Grounds	Sham Wat Wan	SR10	a	100	0.000033	0.000020	0.000033	0.000020

Table D.2 Predicted Unionised Ammonia Concentrations (mg L^{-1}) as a Result of SS Release due to the Works

Sensitive Receiver	**Name**	**ID**	**Relevant Depth** ^{1}	**Max TKN Conc. In Sediment (mg kg^{-1})**	**Scenario 1a**		**Scenario 1b**	
					Dry	**Wet**	**Dry**	**Wet**
					Max	**Max**	**Max**	**Max**
Intertidal Mudflats	Pak Nai	SR01	s	2600	0.000098	0.000065	0.000000	0.000075
Horseshoe Crab Nursery Grounds	Pak Nai	SR01	a	2600	0.000442	0.000588	0.000000	0.000646
Seagrass Beds/Mangroves/Oyster Farm	Pak Nai	SR02	s	2600	0.000000	0.000004	0.000000	0.000004
Seawater Intakes	Black Point Power Station	SR04	b	2600	0.025813	0.024415	0.026157	0.024353
Non-gazetted Beaches	Lung Kwu Sheung Tan	SR05a	a	2100	0.001264	0.000248	0.001356	0.000252
Non-gazetted Beaches	Lung Kwu Tan	SR05b	a	2100	0.000713	0.000323	0.000774	0.000322
Gazetted Beaches	Butterfly Beach	SR05c	a	2100	0.000006	0.000000	0.000007	0.000000
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06a	a	2100	0.000055	0.000033	0.000057	0.000034
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06b	a	2100	0.000029	0.000037	0.000030	0.000037
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06c	a	2100	0.000135	0.000150	0.000111	0.000124
Marine Park	Designated Sha Chau and Lung Kwu Chau	SR06d	a	2100	0.000083	0.000079	0.000088	0.000078
Artificial Reef Deployment Area	Sha Chau and Lung Kwu Chau	SR06e	a	2100	0.000028	0.000026	0.000029	0.000027
Seawater Intakes	Castle Peak Power Station	SR07a	b	2100	0.001551	0.001359	0.001629	0.001552
Seawater Intakes	Tuen Mun Area 38	SR07b	b	2100	0.000465	0.000396	0.000494	0.000417
Seawater Intakes	Airport	SR07c	b	2100	0.000037	0.000017	0.000037	0.000017

Sensitive Receiver	Name	ID	Relevant Depth [1]	Max TKN Conc. In Sediment (mg kg^{-1})	Scenario 1a		Scenario 1b	
					Dry	Wet	Dry	Wet
					Max	Max	Max	Max
Seawater Intakes	Airport	SR07d	b	2100	0.000004	0.000014	0.000004	0.000014
Artificial Reef Deployment Area	Northeast Airport	SR07d	a	2100	0.000003	0.000012	0.000003	0.000012
Seawater Intakes	Airport	SR07e	b	2100	0.000000	0.000006	0.000000	0.000006
Seawater Intakes	Airport	SR07f	b	2100	0.000000	0.000000	0.000000	0.000000
Spawning/Nursery Grounds	Fisheries Spawning Ground in North Lantau	SR08	a	2100	0.000159	0.000166	0.000154	0.000166
Horseshoe Crab Nursery Grounds	Sham Wat Wan	SR10	a	2100	0.000035	0.000021	0.000035	0.000021

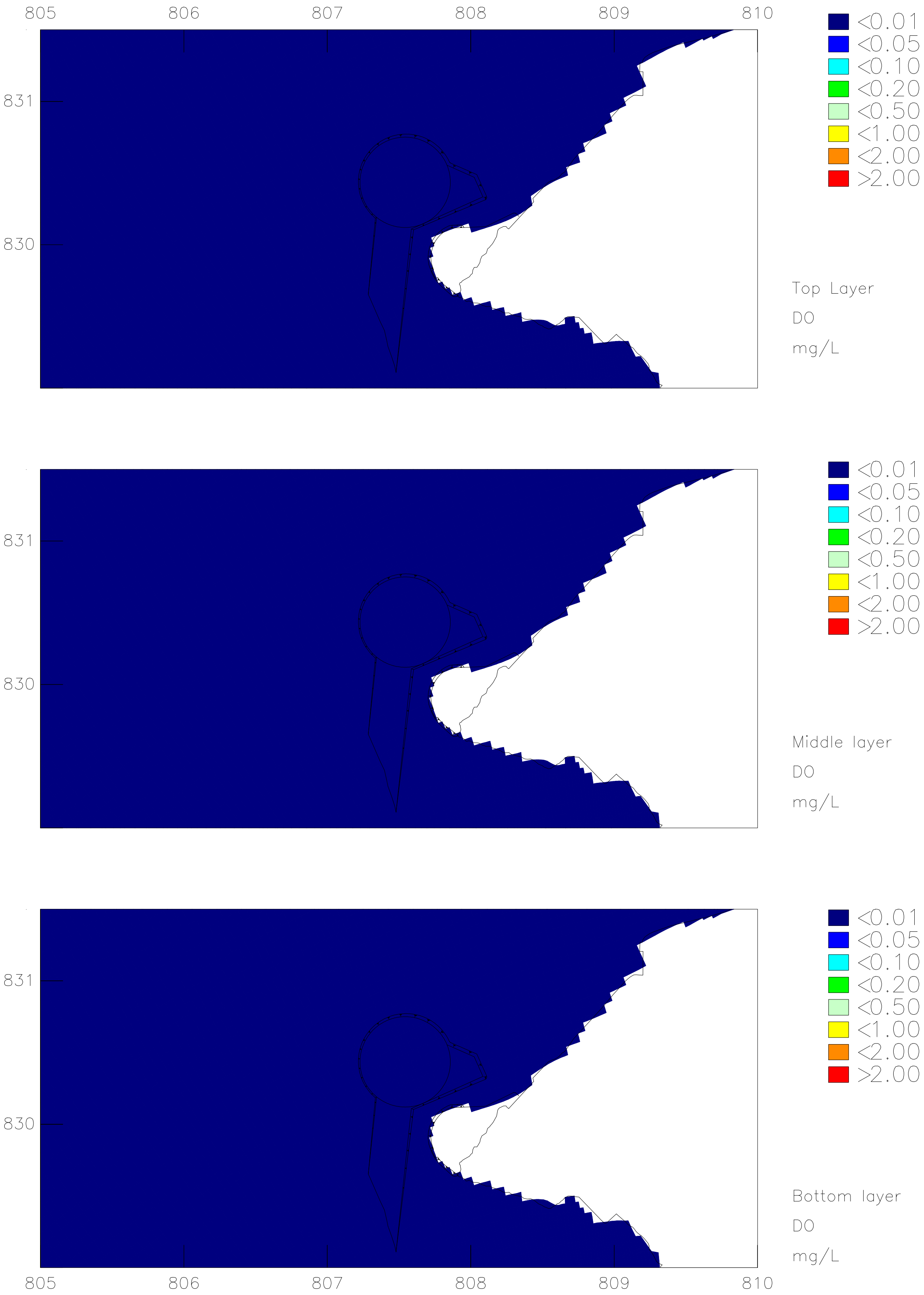
Table D.3 Elutriate Results at Black Point

Parameters		**Unit**	**Reporting Limit**	**Black Point**				
				GV1	**GV2**	**GV3**	**GV4**	**GV5**
Heavy Metals	Cadmium (Cd)	ug/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	Chromium (Cr)	ug/L	5	<5	<5	<5	<5	<5
	Copper (Cu)	ug/L	1	2.2	2.4	2.6	2.7	2.8
	Nickel (Ni)	ug/L	2	<2	<2	<2	<2	<2
	Lead (Pb)	ug/L	2	<2	<2	<2	<2	<2
	Zinc (Zn)	ug/L	10	<10	<10	<10	<10	<10
	Mercury (Hg)	ug/L	0.2	<0.2	<0.2	<0.2	<0.2	<0.2
	Arsenic (As)	ug/L	1	1.2	<1	<1	<1	<1
	Silver (Ag)	ug/L	1	<1	<1	<1	<1	<1
Ammonia (Un-ionized)		mg-N/L	0.01	0.03	0.03	0.14	<0.01	<0.01
TKN		mg-N/L	0.1	0.9	2.1	9.3	0.8	<0.1
Nitrate		mg-N/L	0.05	0.22	0.18	0.1	0.5	0.85
Nitrite		mg-N/L	0.05	0.09	0.05	0.06	0.273	0.2
Ammoniacal Nitrogen		mg-N/L	0.1	0.62	0.88	3.9	0.54	<0.1
Ortho-Phosphate		mg-P/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Total Phosphorous		mg-P/L	0.1	0.22	<0.1	<0.1	<0.1	<0.1
PAHs (Low Molecular Weight)	Naphthalene	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Acenaphtylene	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Acenaphtene	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Fluorene	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Phenanthrene	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Anthracene	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
PAHs (High Molecular Weight)	Benzo(a)anthracene	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Benzo(a)pyrene	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Chrysene	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Dibenz(ah)anthracene	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Fluoranthene	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Pyrene	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Benzo(b)fluoranthene	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Benzo(k)fluoranthene	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Indeno(1,2,3-cd)pyrene	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Benzo(ghi)perylene	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
PCB	PCB 8	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	PCB 18	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	PCB 28	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	PCB 44	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	PCB 52	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	PCB 66	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	PCB 77	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	PCB 101	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	PCB 105	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	PCB 118	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	PCB 126	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	PCB 128	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Parameters		Unit	Reporting Limit	Black Point				
				GV1	GV2	GV3	GV4	GV5
	PCB 138	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	PCB 153	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	PCB 169	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	PCB 170	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	PCB 180	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	PCB 187	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Total PCB	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Tributyltin (TBT)		ug/L	0.015	<0.015	<0.015	<0.015	<0.015	<0.015
Chlorinated Pesticides	Alpha-BHC	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Beta BHC	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Gamma BHC	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Delta-BHC	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Heptachlor	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Aldrin	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Heptachlor epoxide	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Alpha-Endosulfan	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	p, p'-DDT	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	p, p'-DDD	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	p, p'-DDE	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Endosulfan sulfate	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Annex 6E

Construction Phase Model Results - Wastewater Discharges

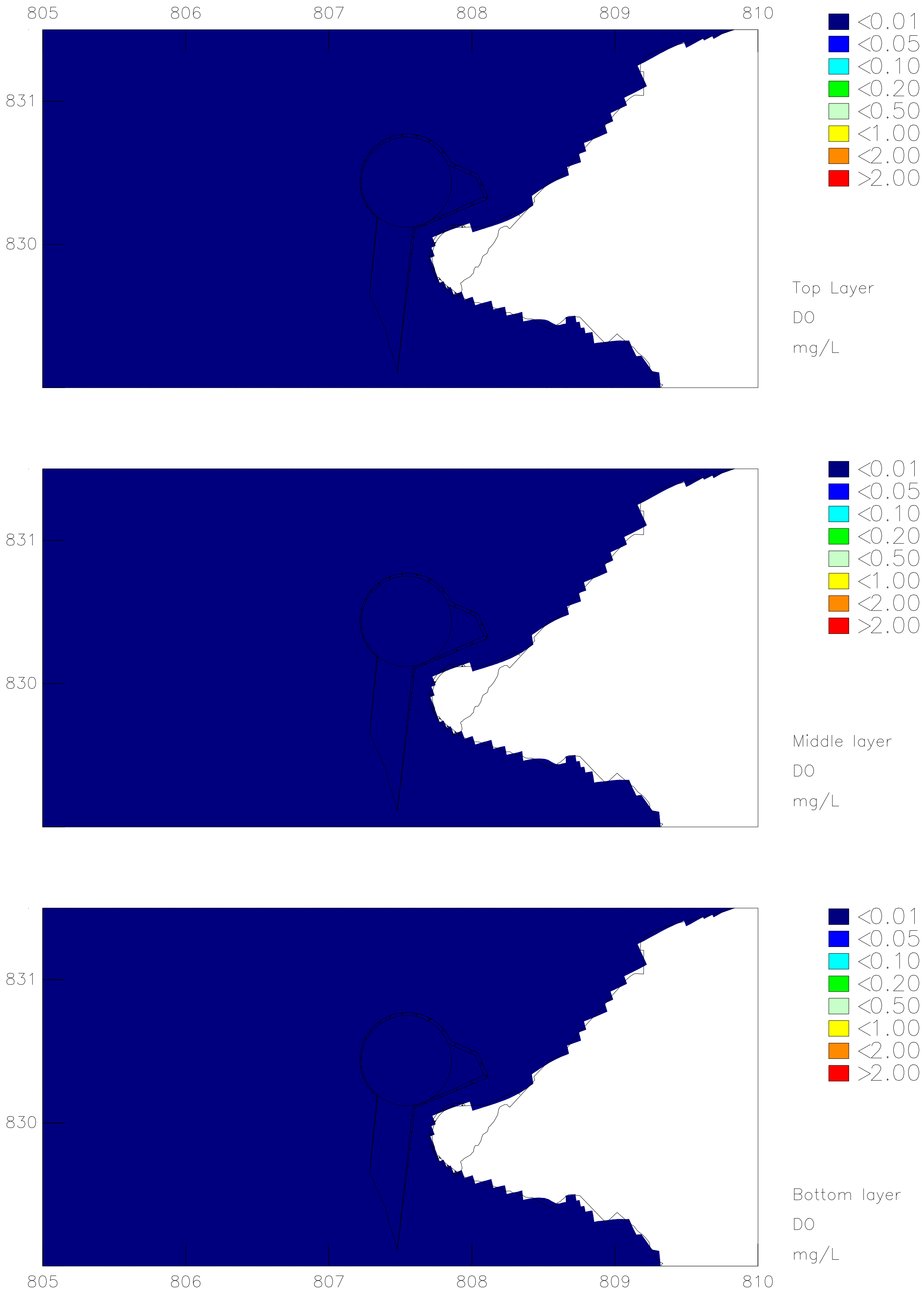


DO (mg/L) maximum decrease
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E01

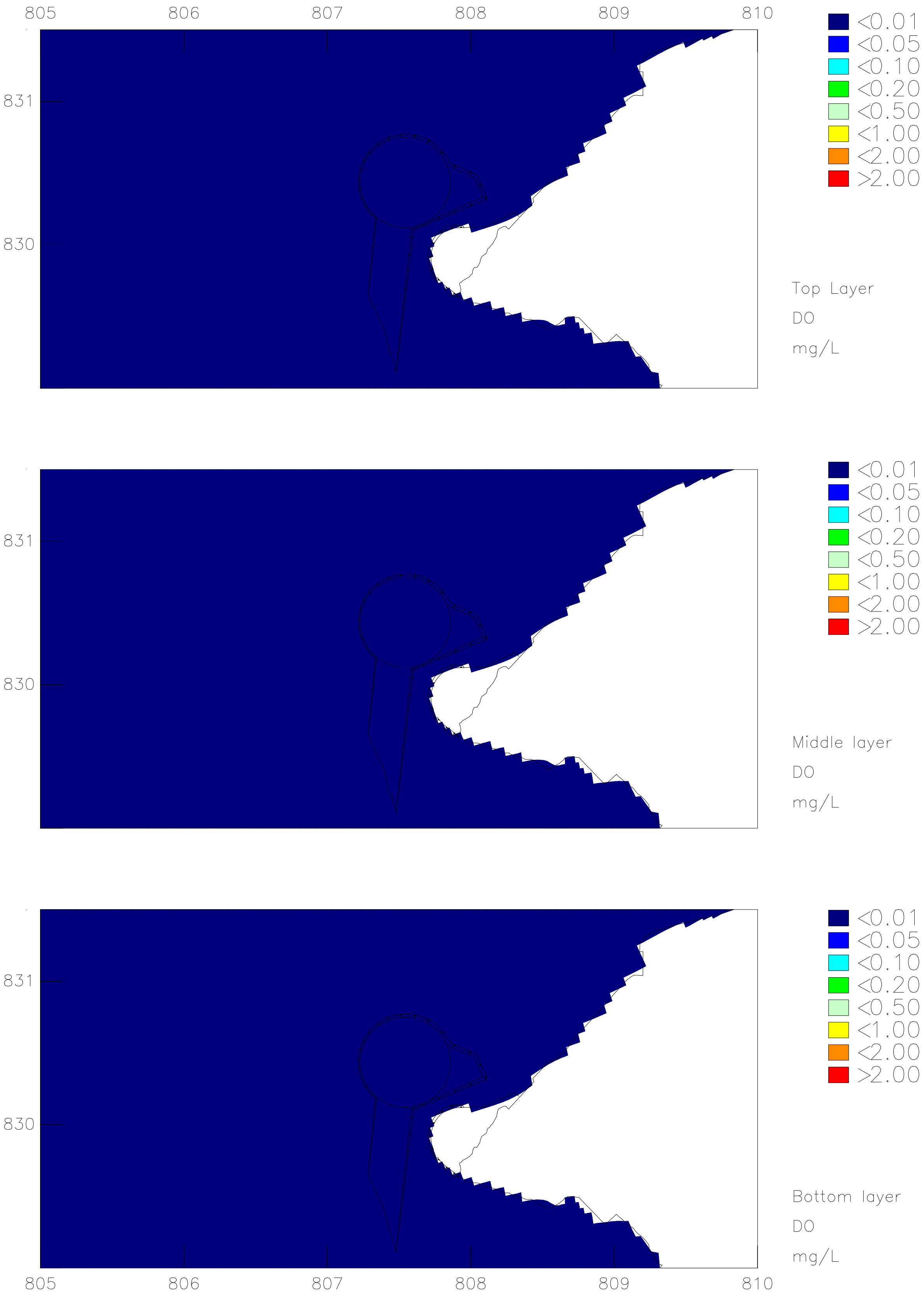


DO (mg/L) mean decrease
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E02

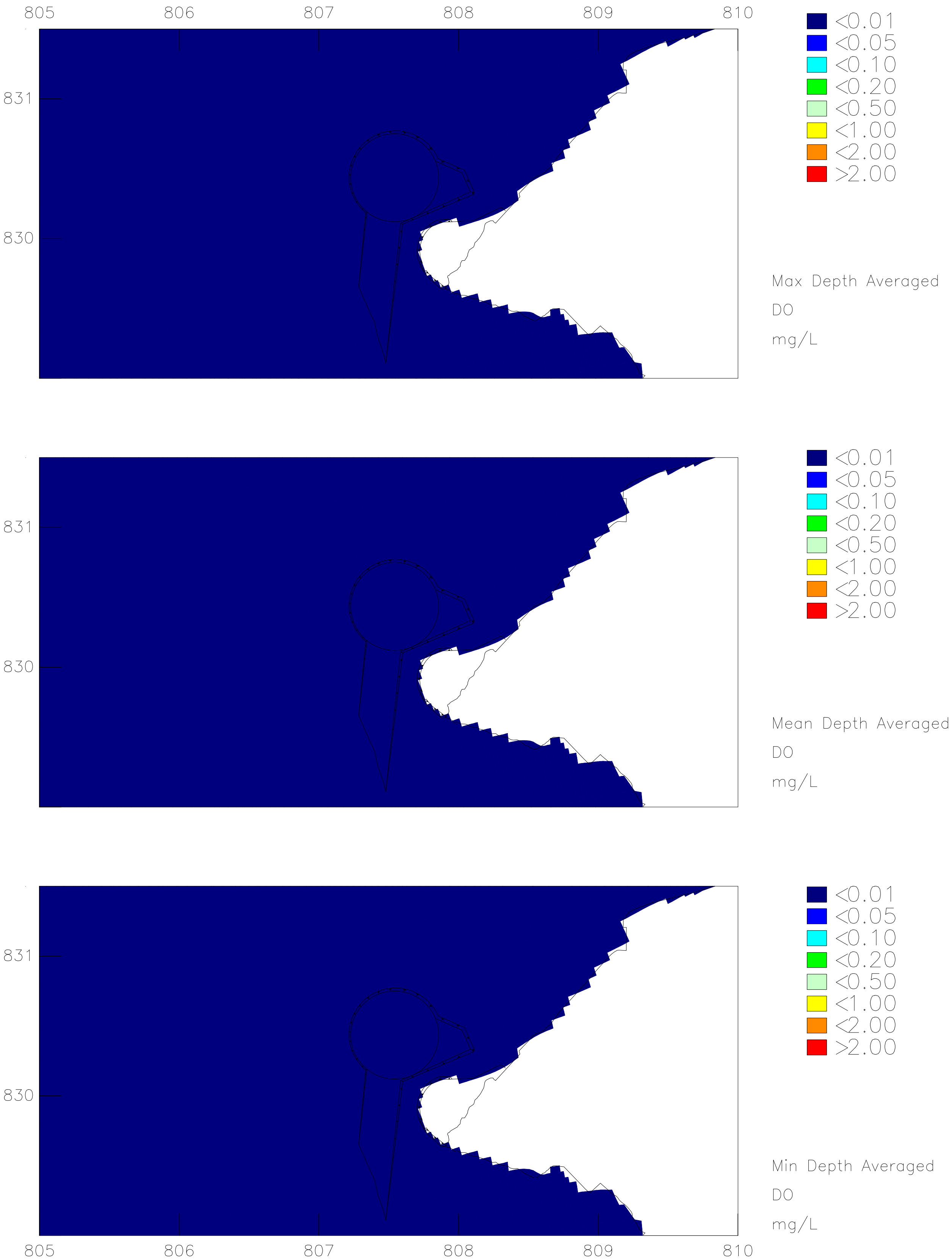


DO (mg/L) minimum decrease
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E03

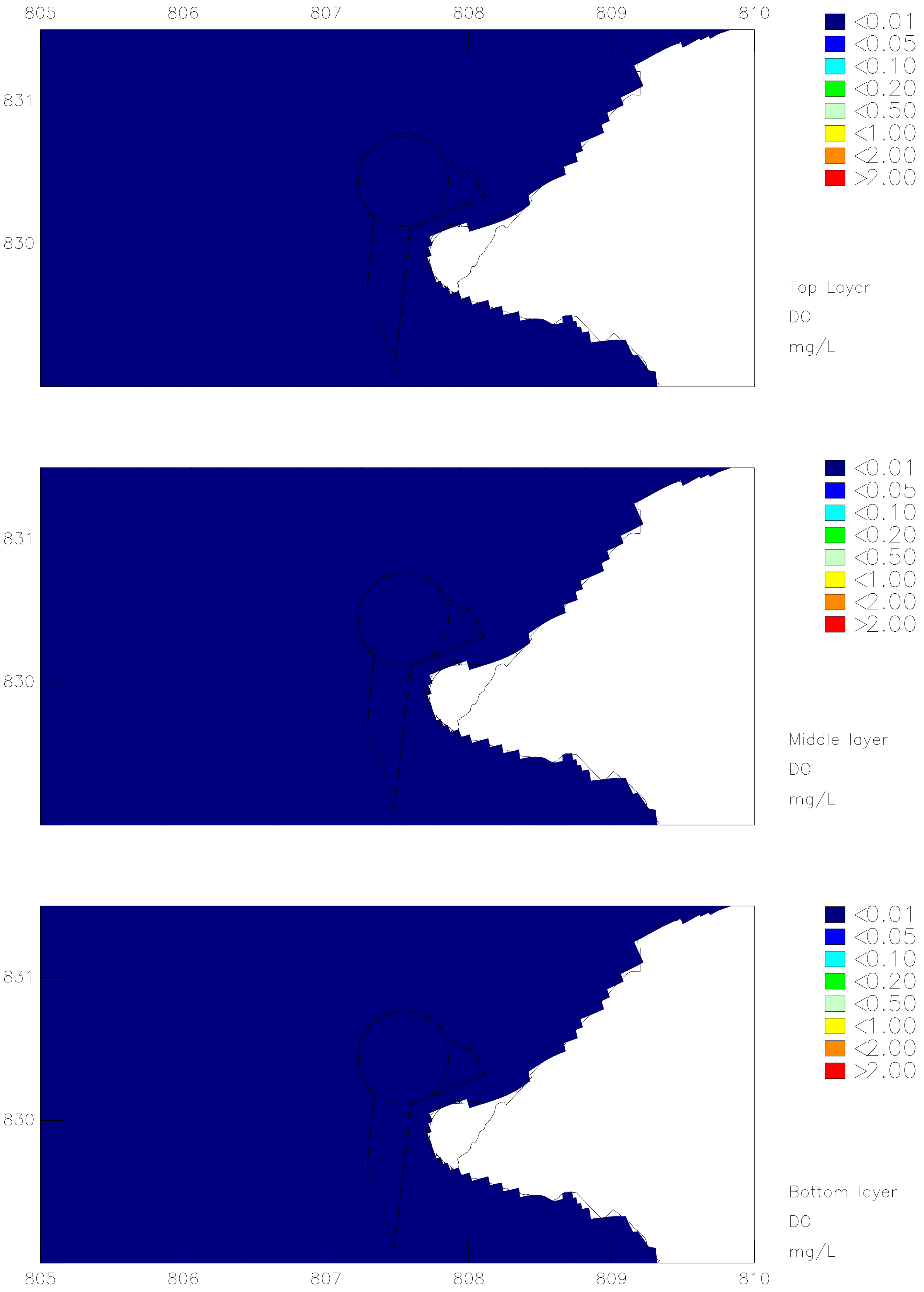


DO (mg/L)
Black Point Sewage emission – Construction
Maximum, Mean and Minimum depth averaged decrease

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E04

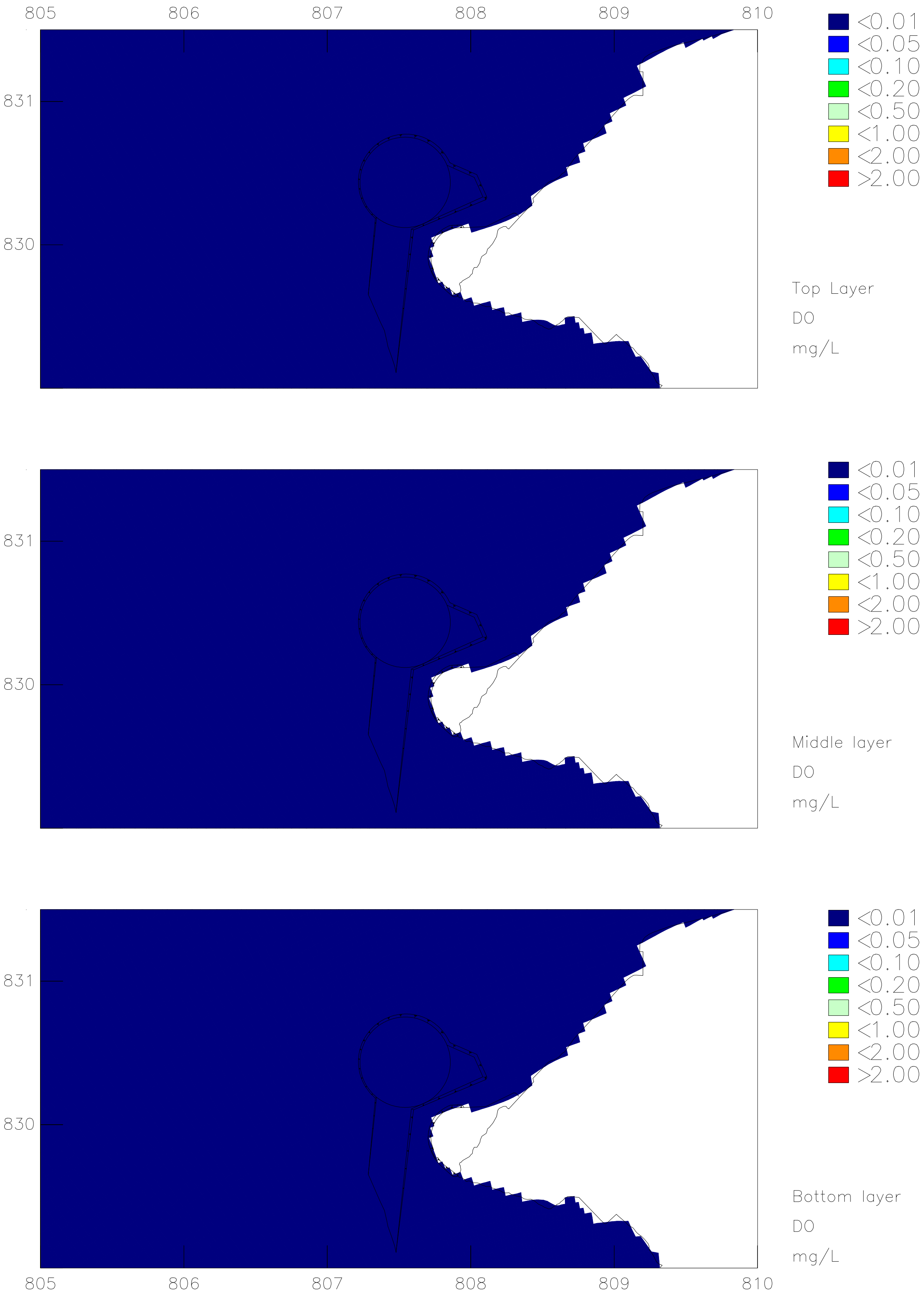


DO (mg/L) maximum decrease
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E05

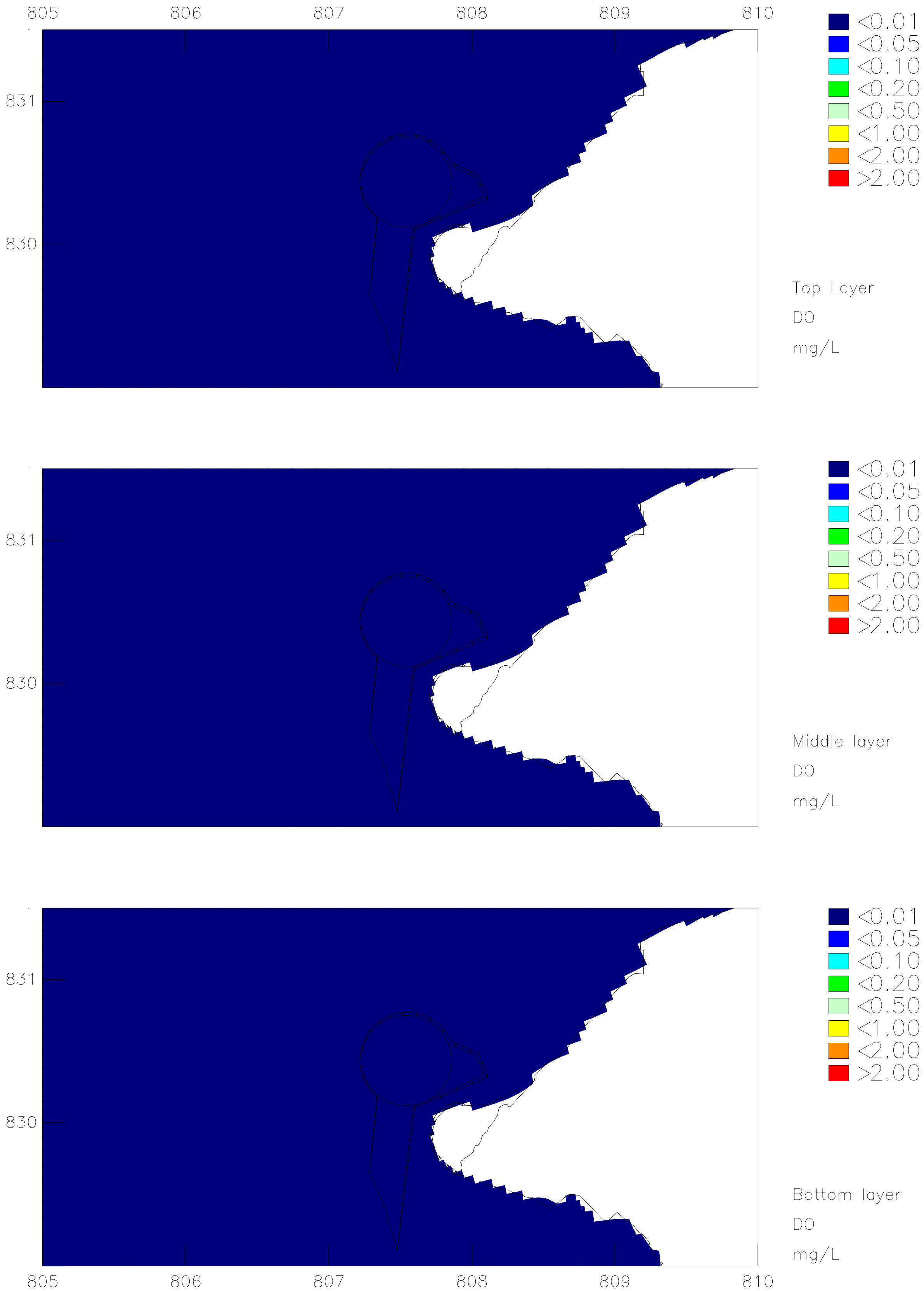


DO (mg/L) mean decrease
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E06

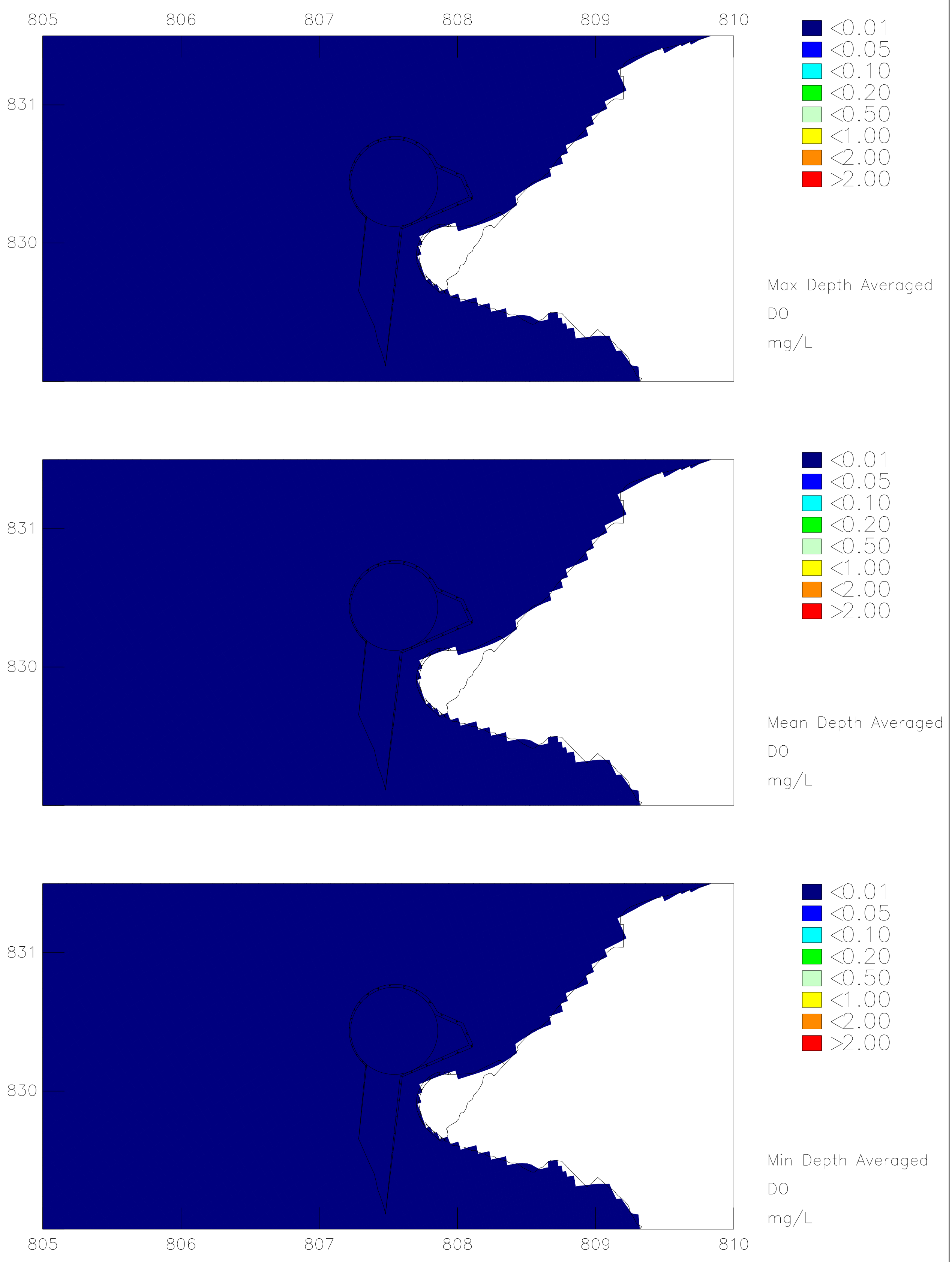


DO (mg/L) minimum decrease
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E07

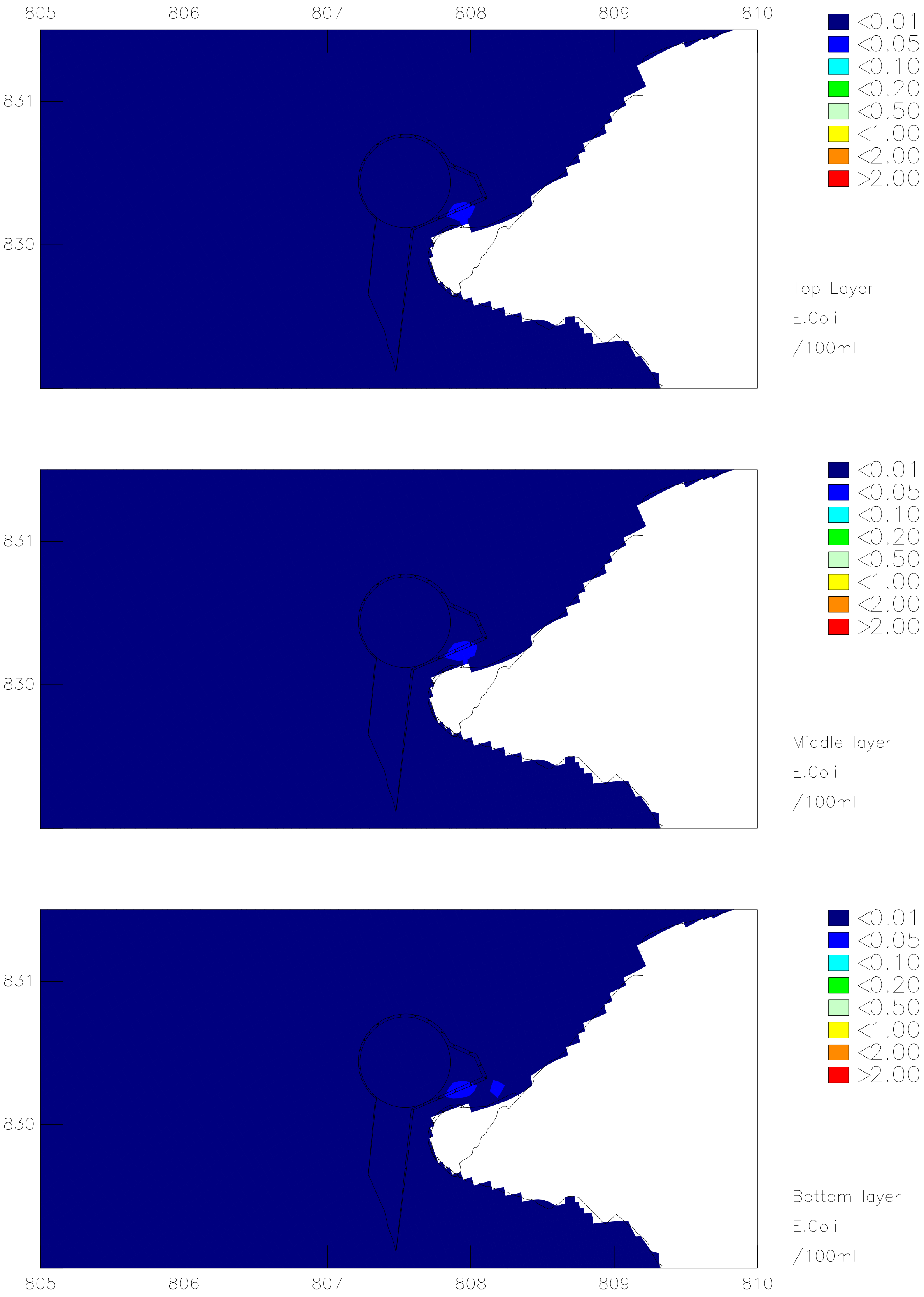


DO (mg/L)
Black Point Sewage emission – Construction
Maximum, Mean and Minimum depth averaged decrease

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E08

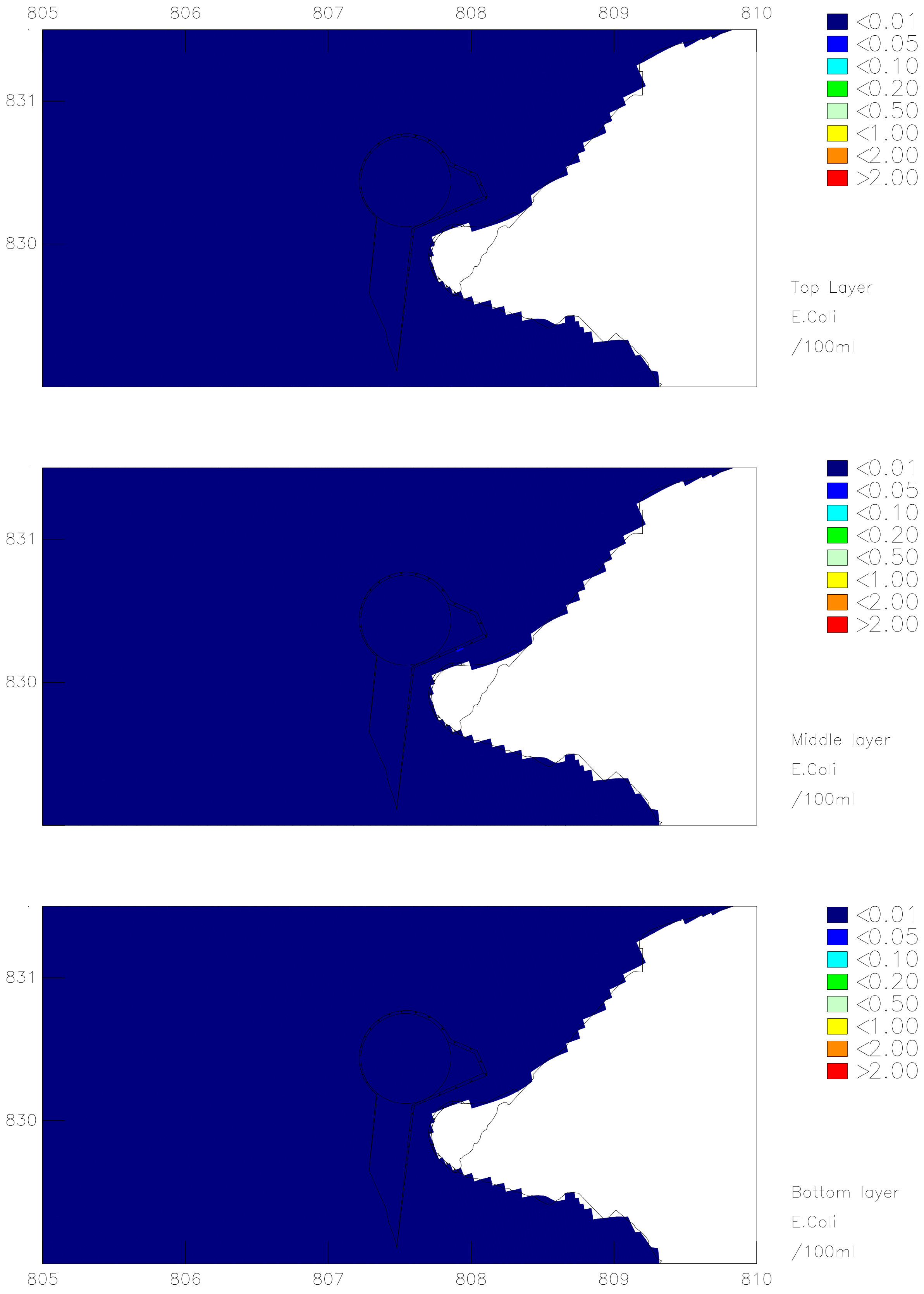


E.Coli (/100ml) maximum increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E09

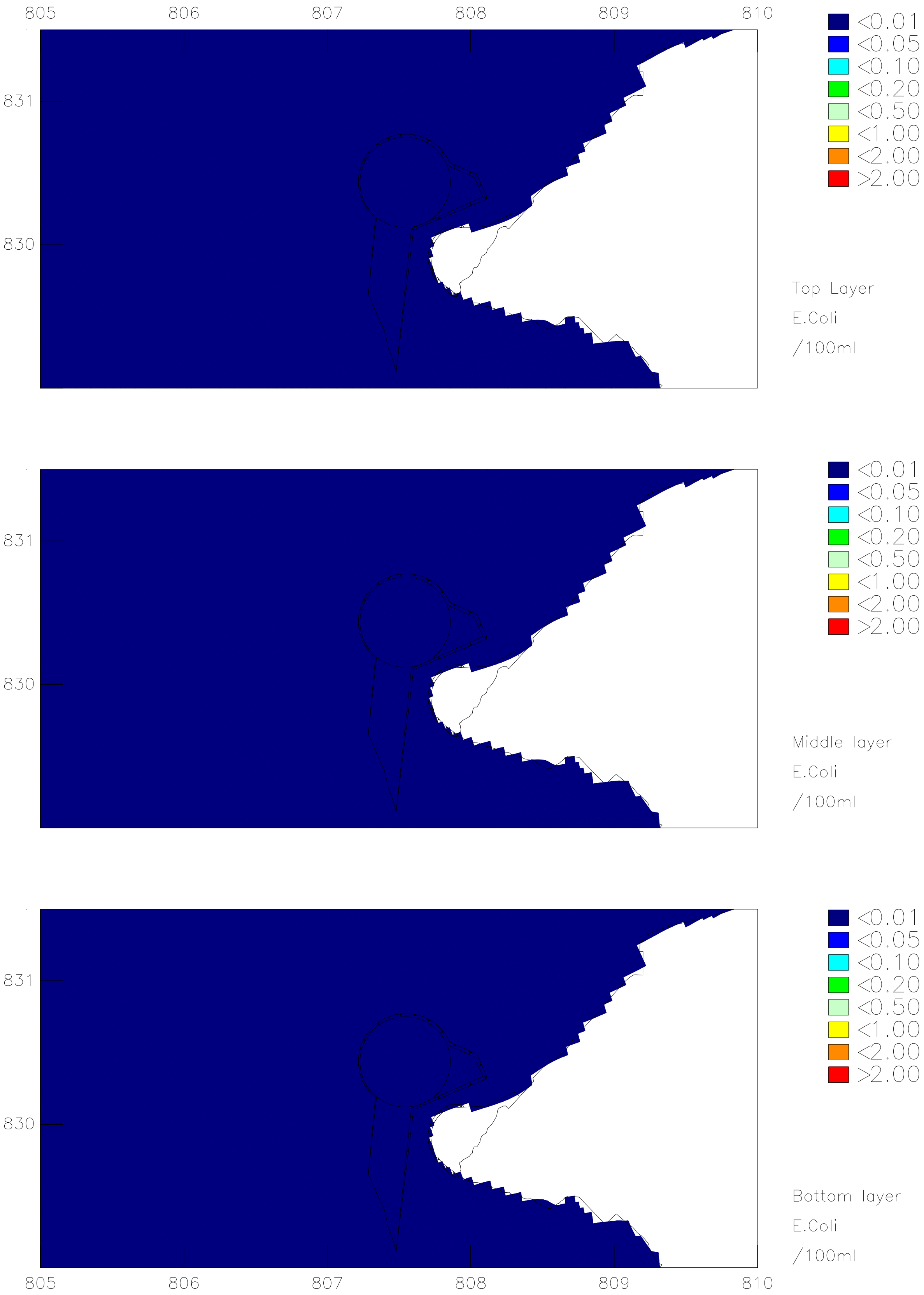


E.Coli (/100ml) mean increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E10

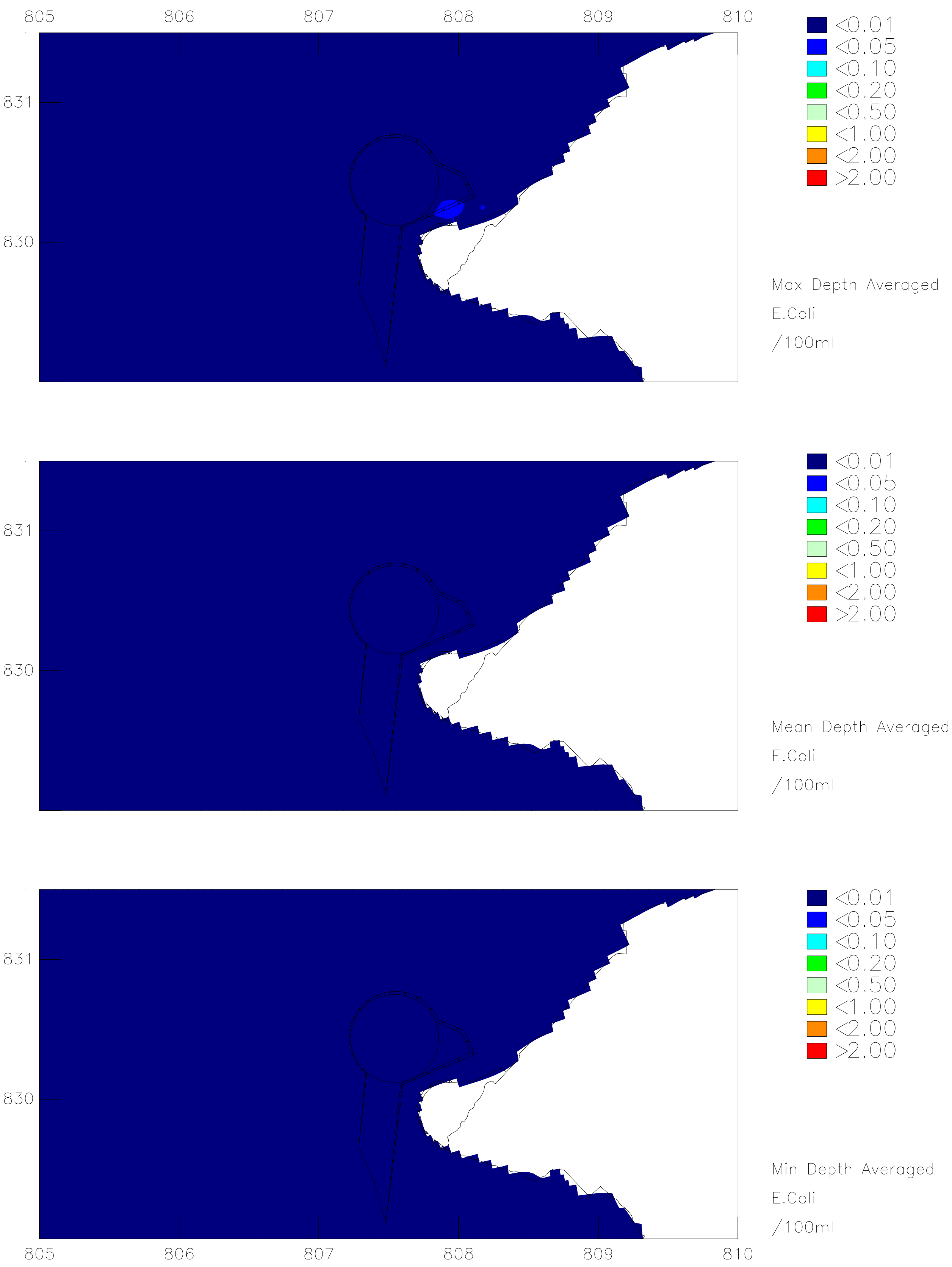


E.Coli (/100ml) minimum increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E11

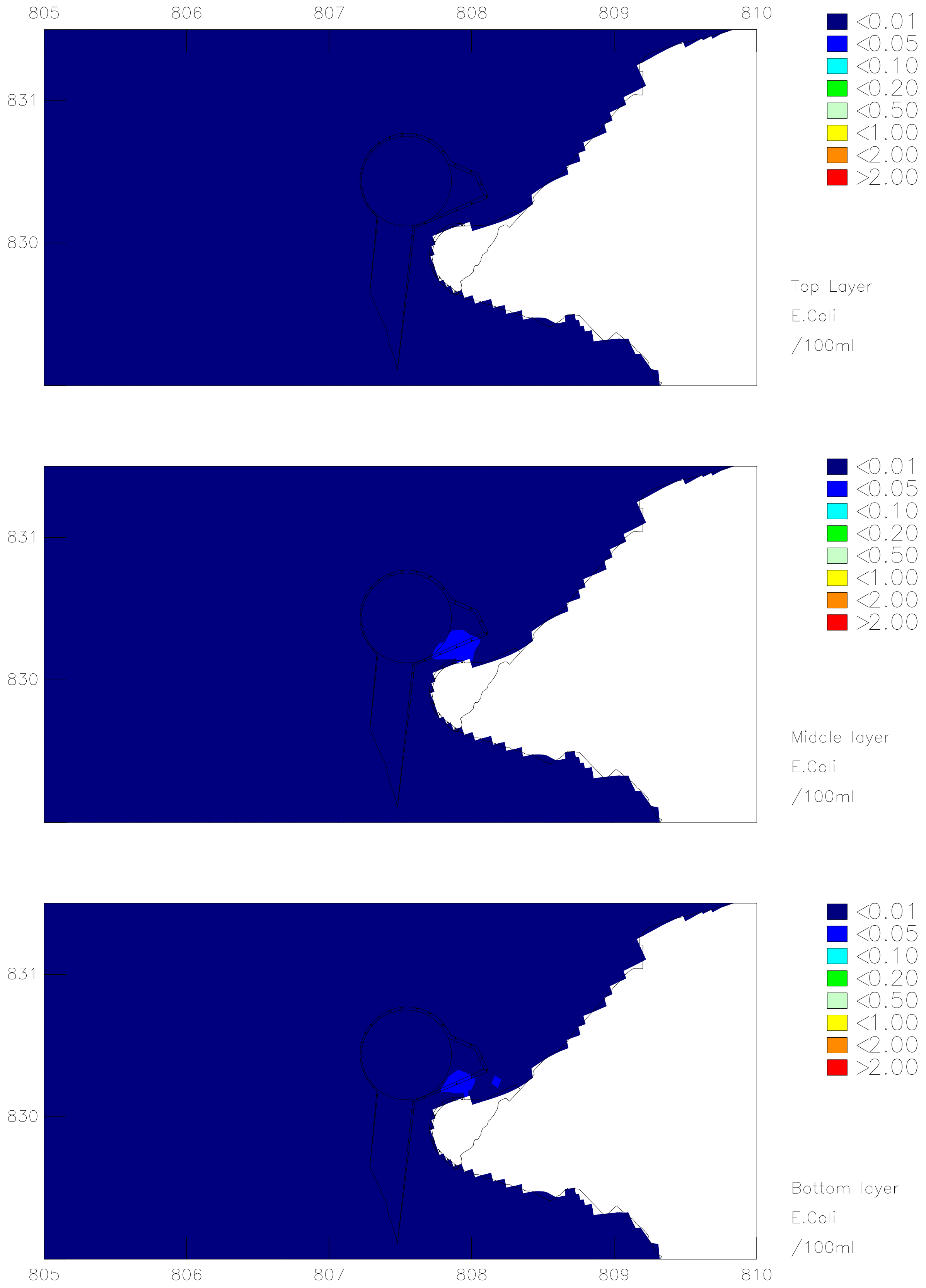


E.Coli (/100ml)
Black Point Sewage emission – Construction
Maximum, Mean and Minimum depth averaged increase

WL | Delft Hydraulics – ERM

Dry Season

Fig. BP_E12

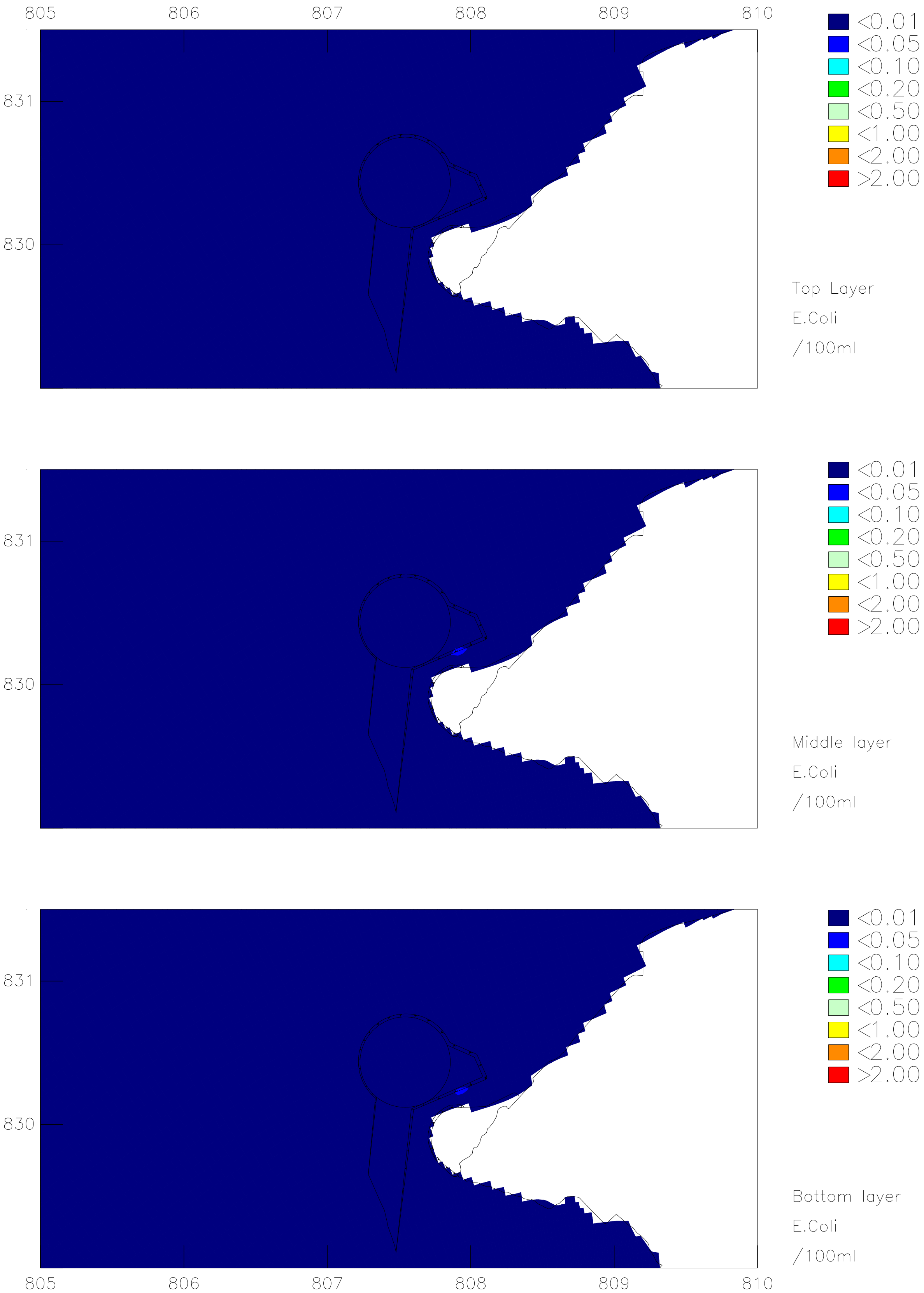


E.Coli (/100ml) maximum increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E13

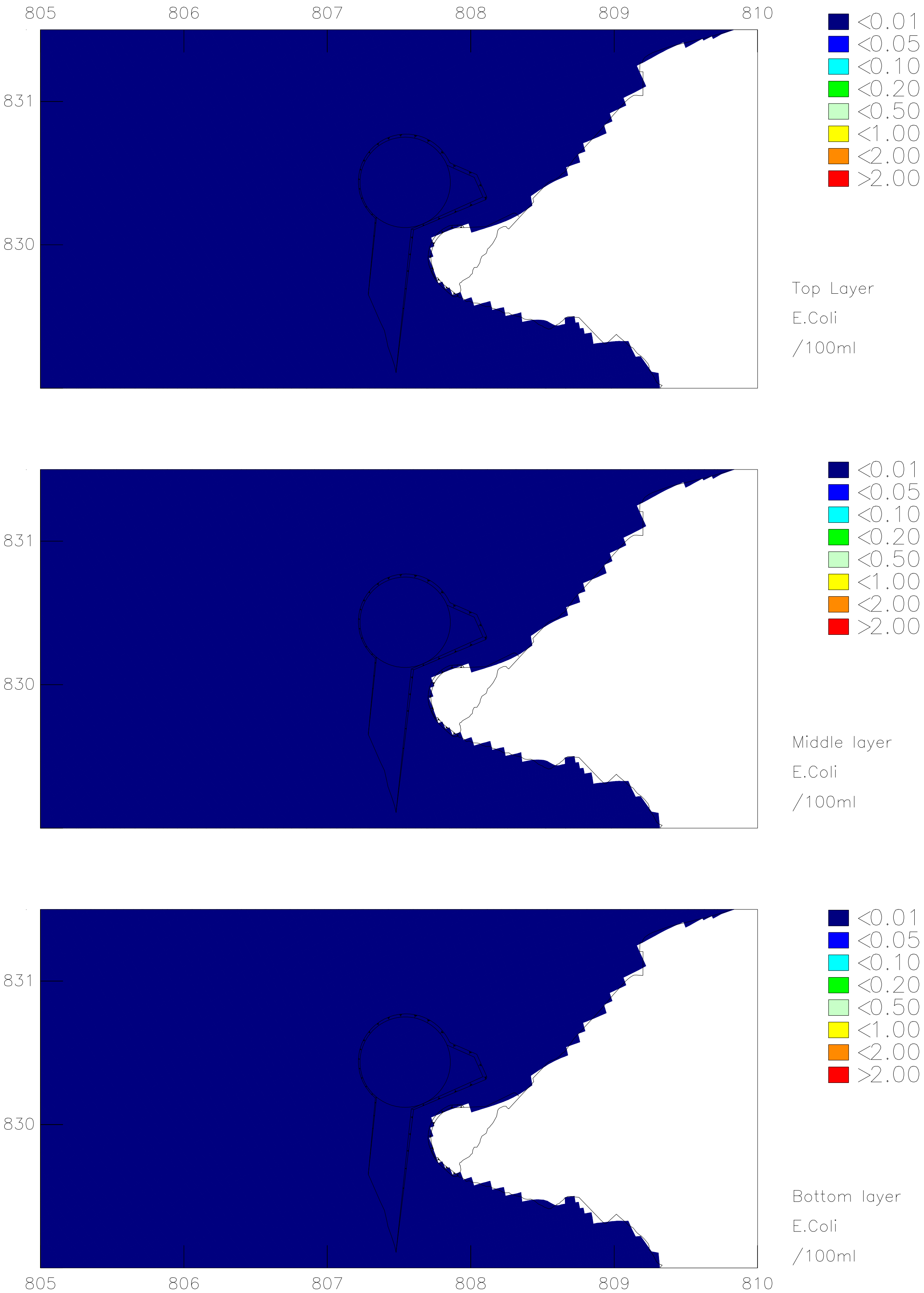


E.Coli (/100ml) mean increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E14

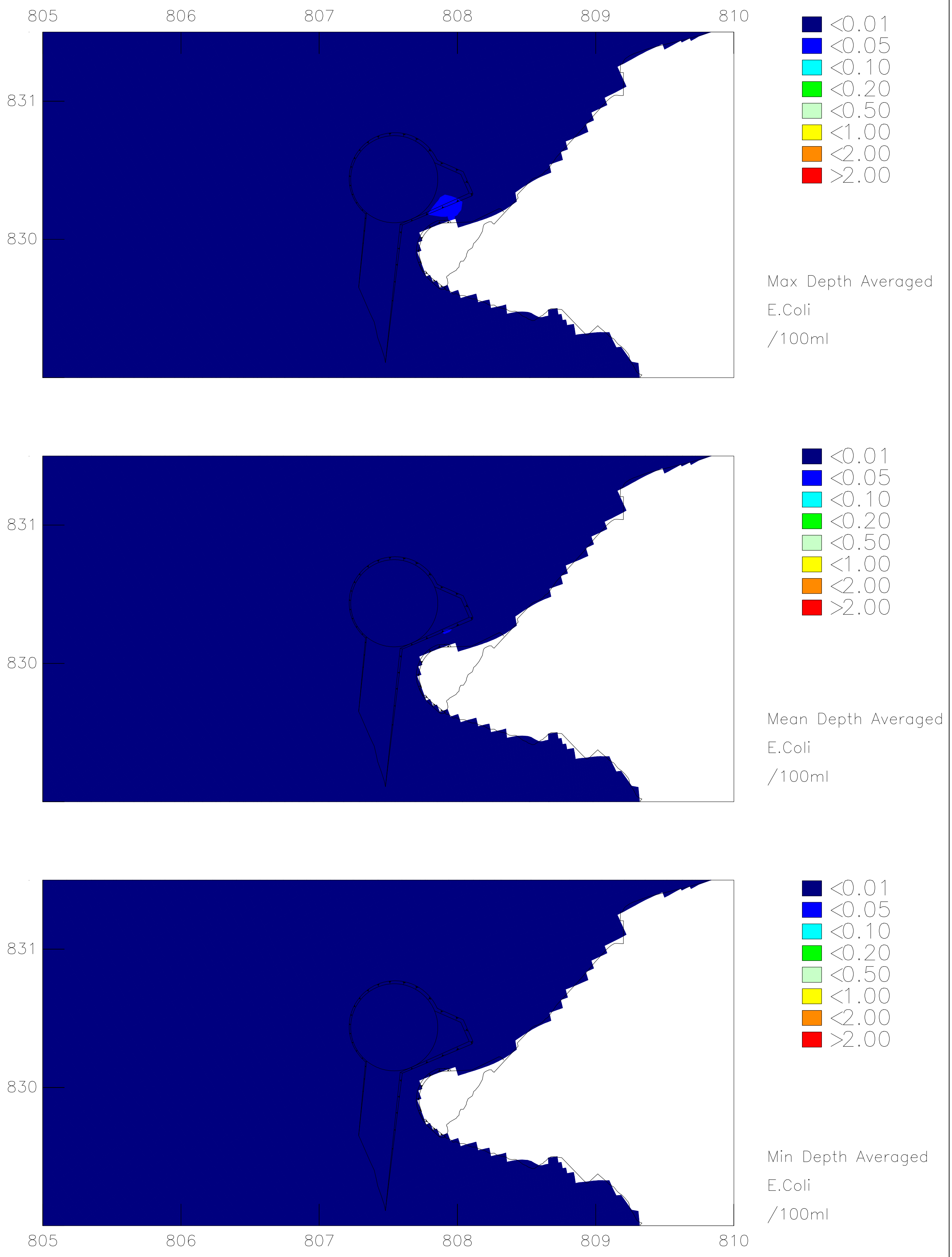


E.Coli (/100ml) minimum increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E15

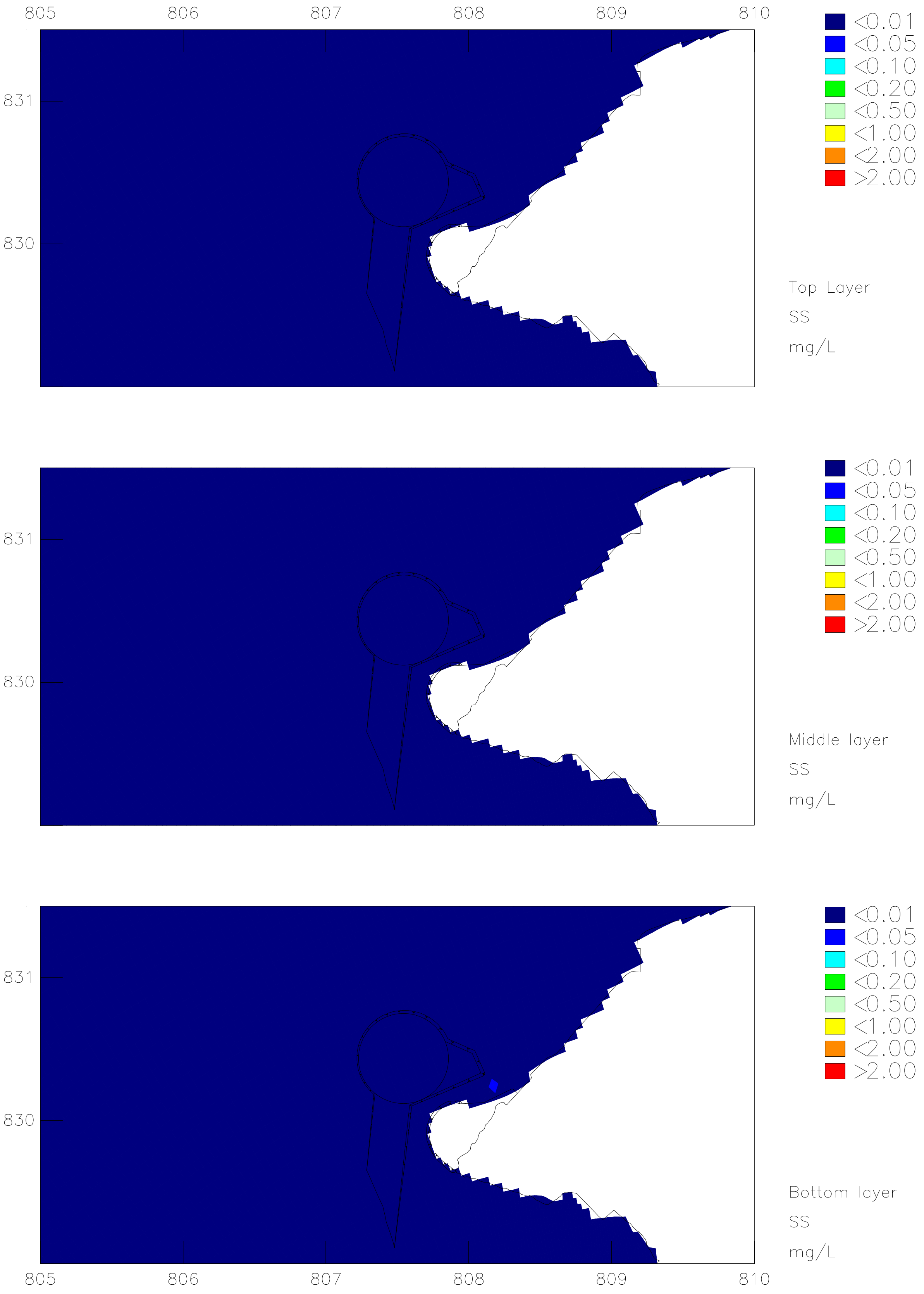


E.Coli (/100ml)
Black Point Sewage emission – Construction
Maximum, Mean and Minimum depth averaged increase

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E16

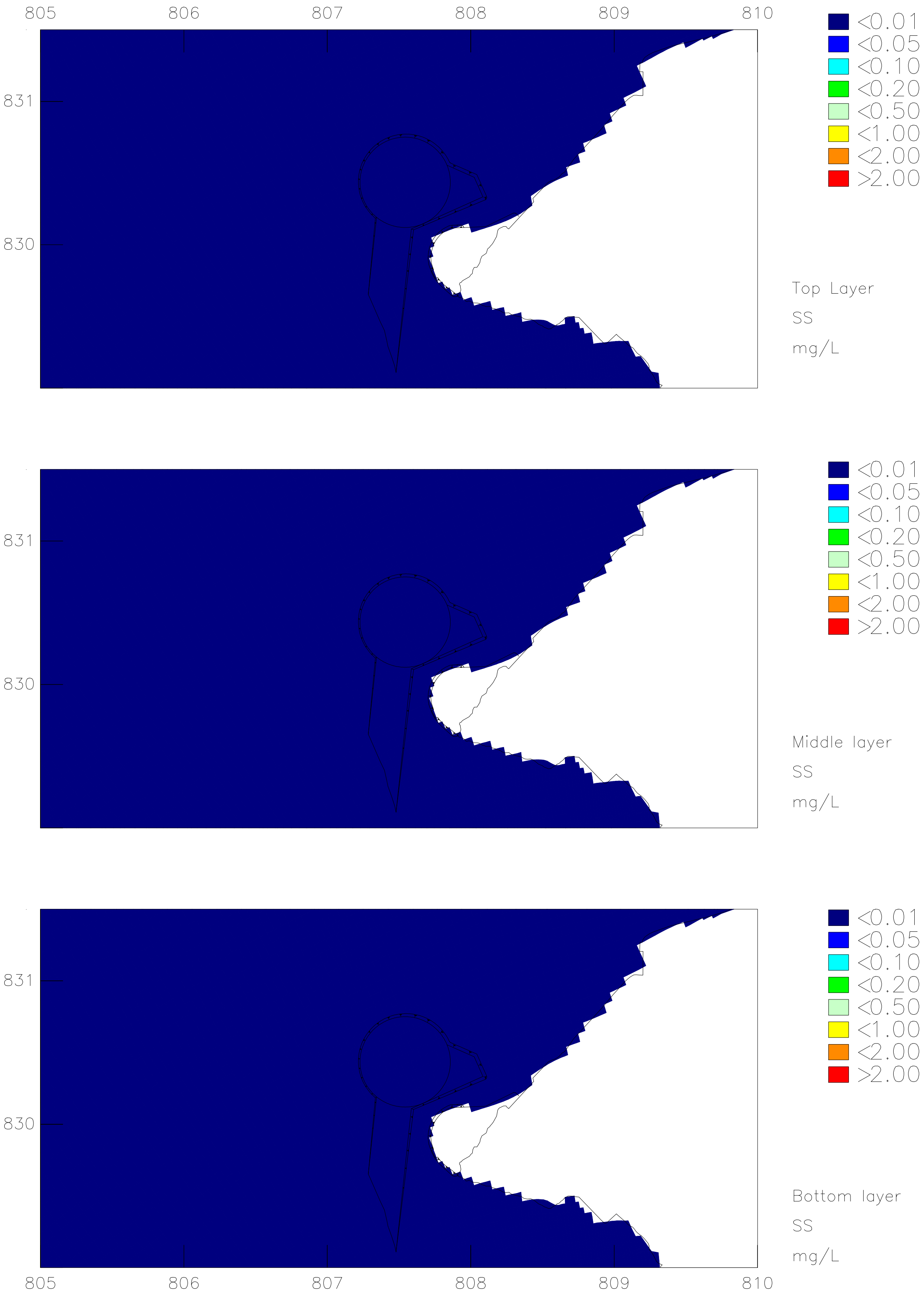


SS (mg/L) maximum increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E17

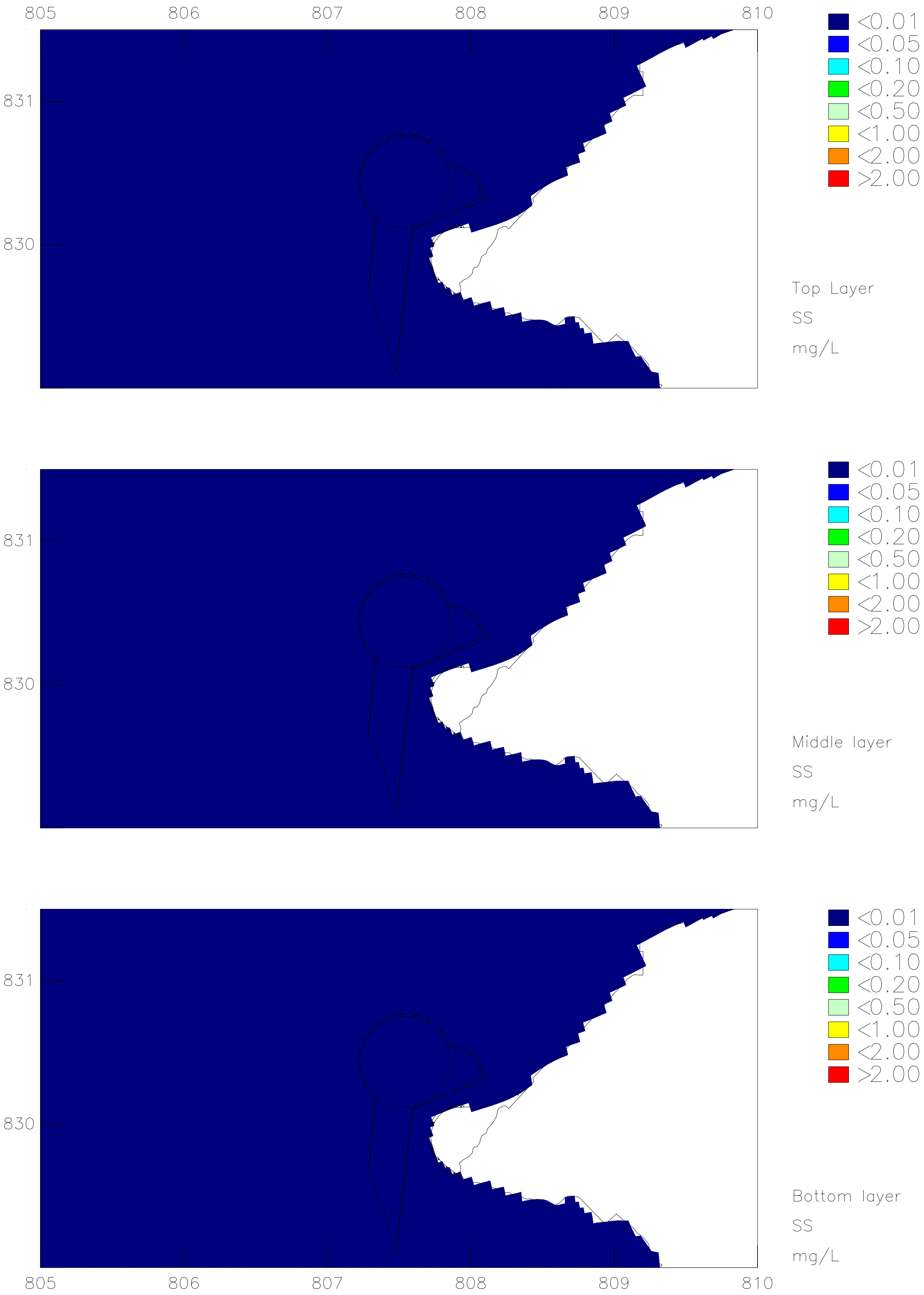


SS (mg/L) mean increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E18

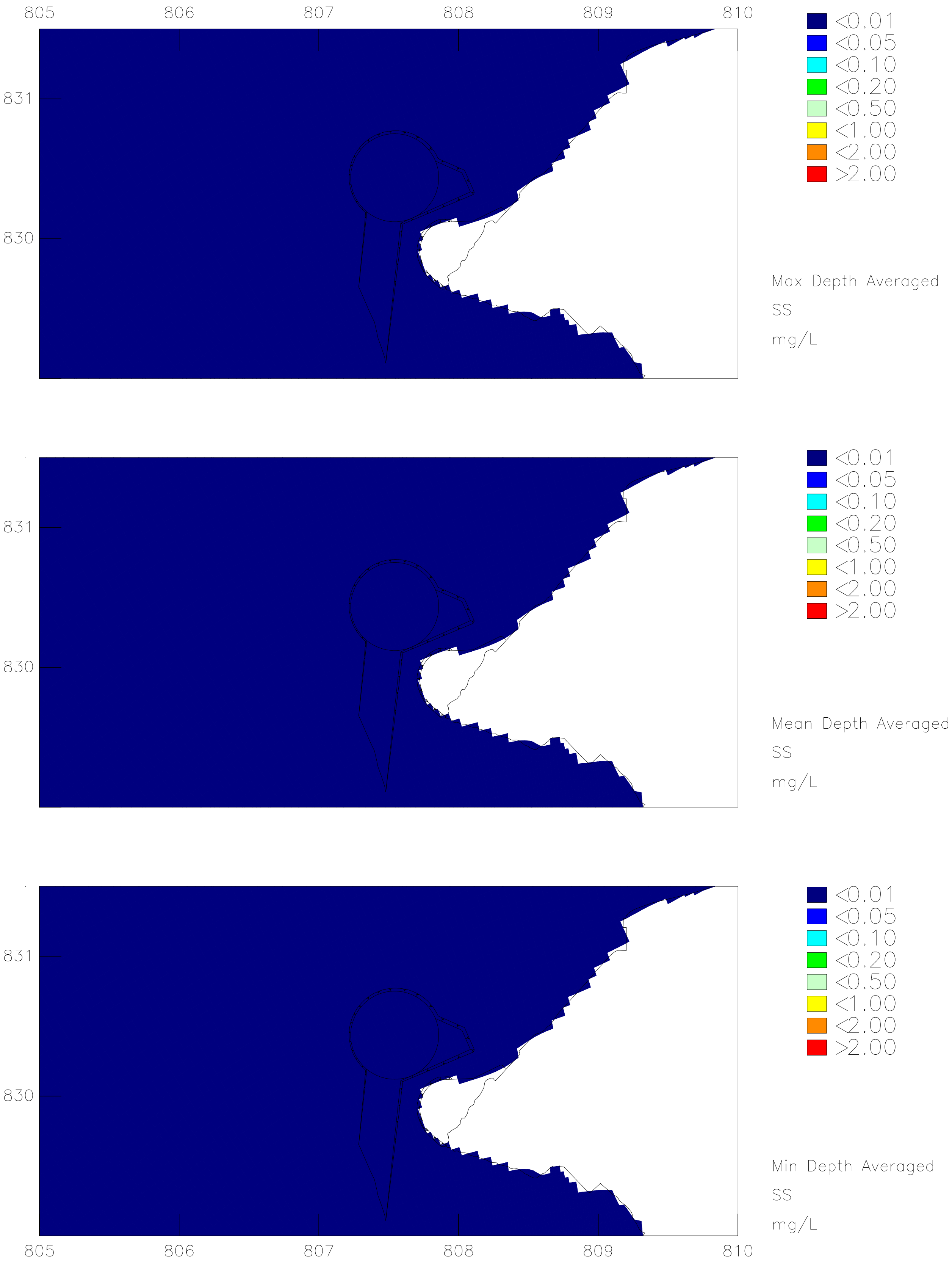


SS (mg/L) minimum increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E19

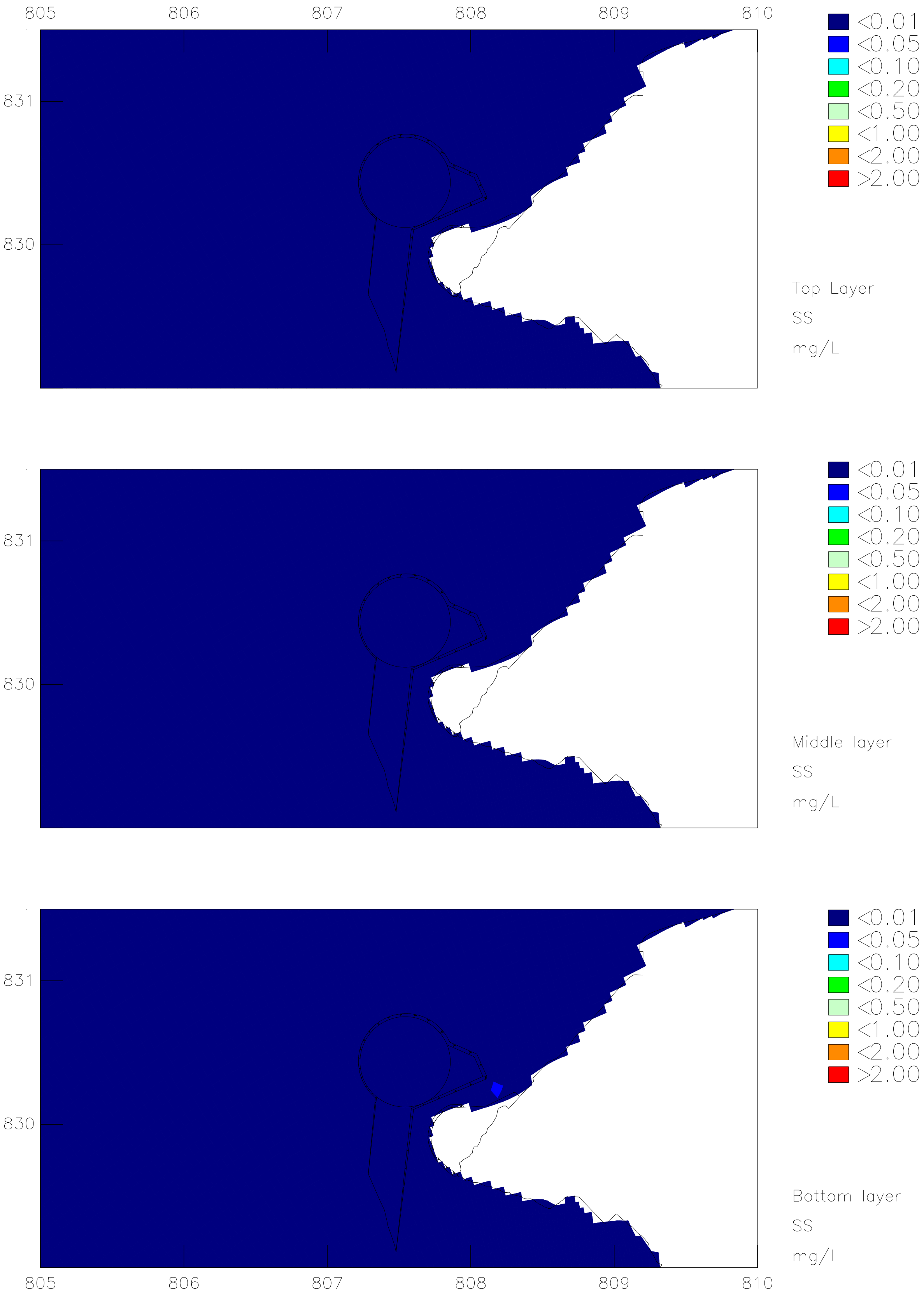


SS (mg/L)
Black Point Sewage emission – Construction
Maximum, Mean and Minimum depth averaged increase

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E20

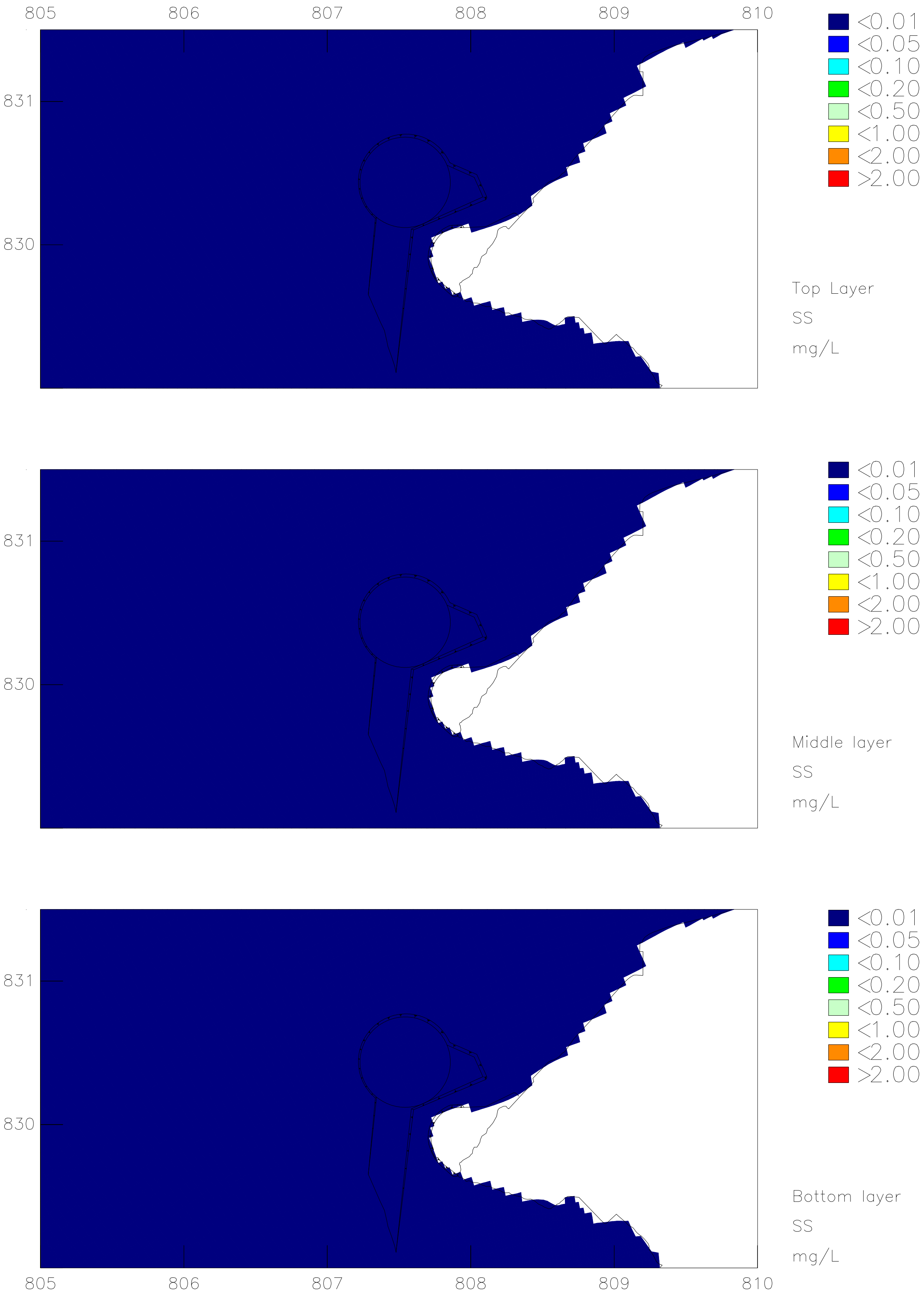


SS (mg/L) maximum increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

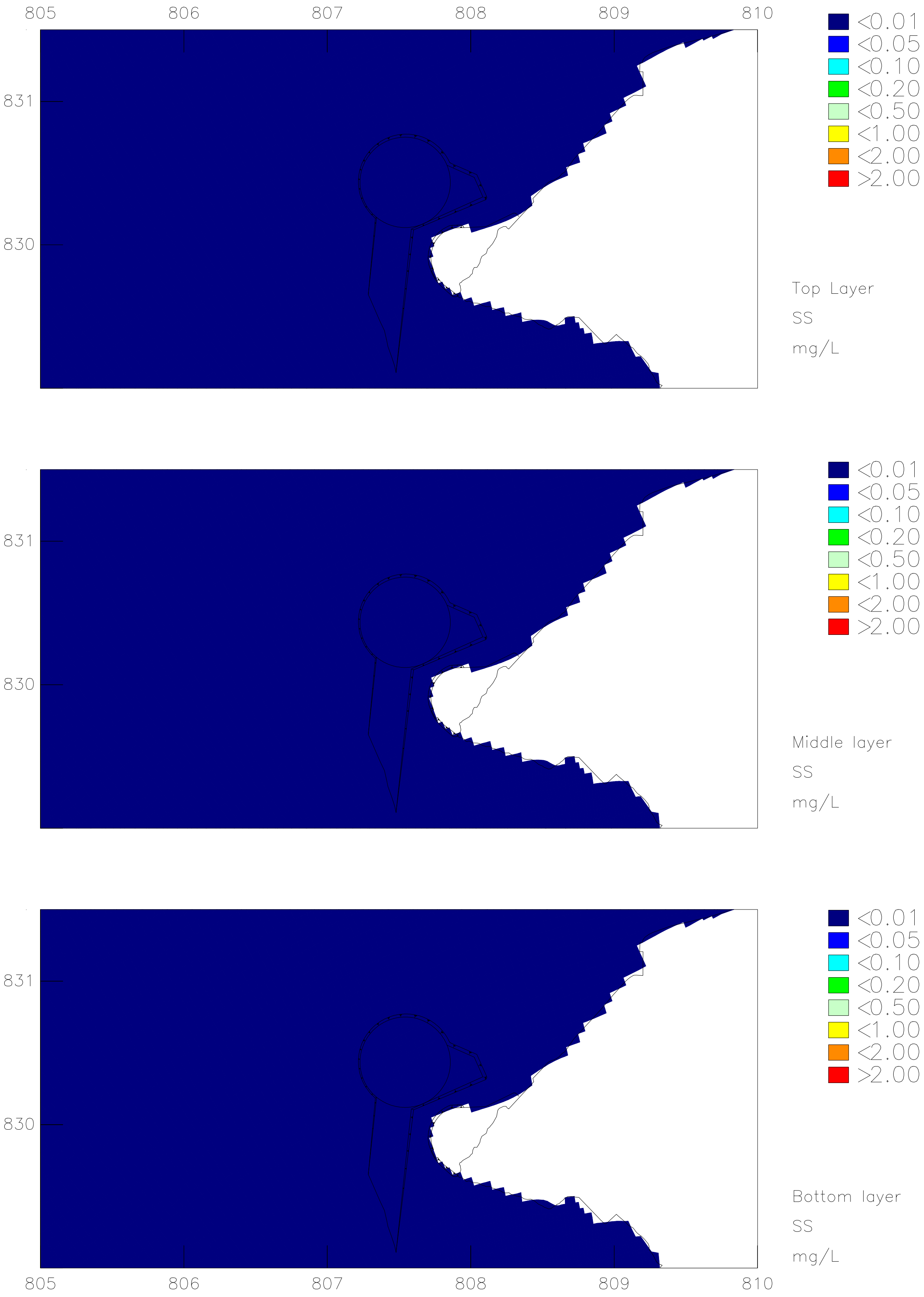
Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E21



SS (mg/L) mean increase Black Point Sewage emission – Construction Top, Middle and Bottom layer		
	Wet Season	
WL | Delft Hydraulics – ERM		Fig. BP_E22

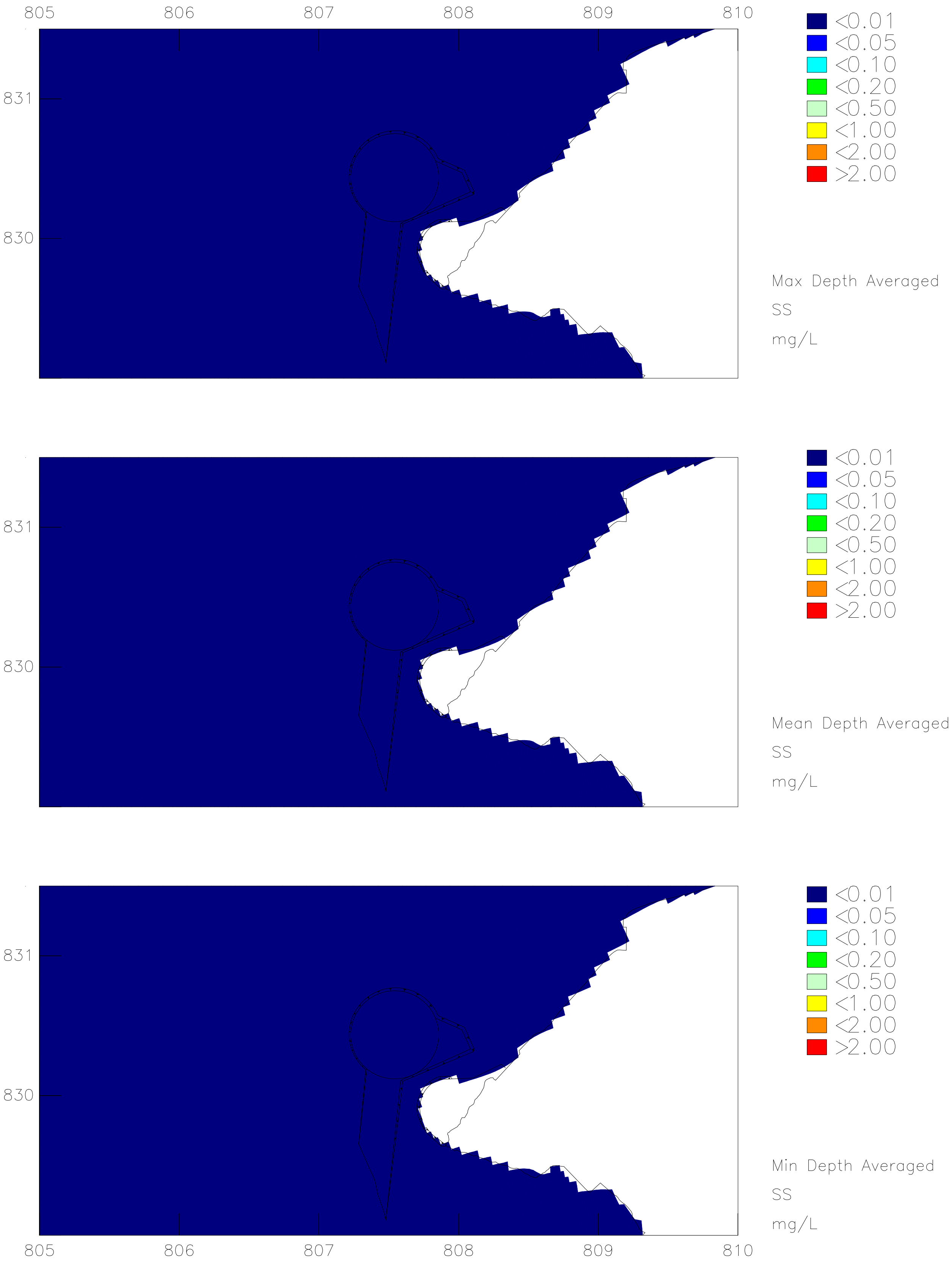


SS (mg/L) minimum increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E23

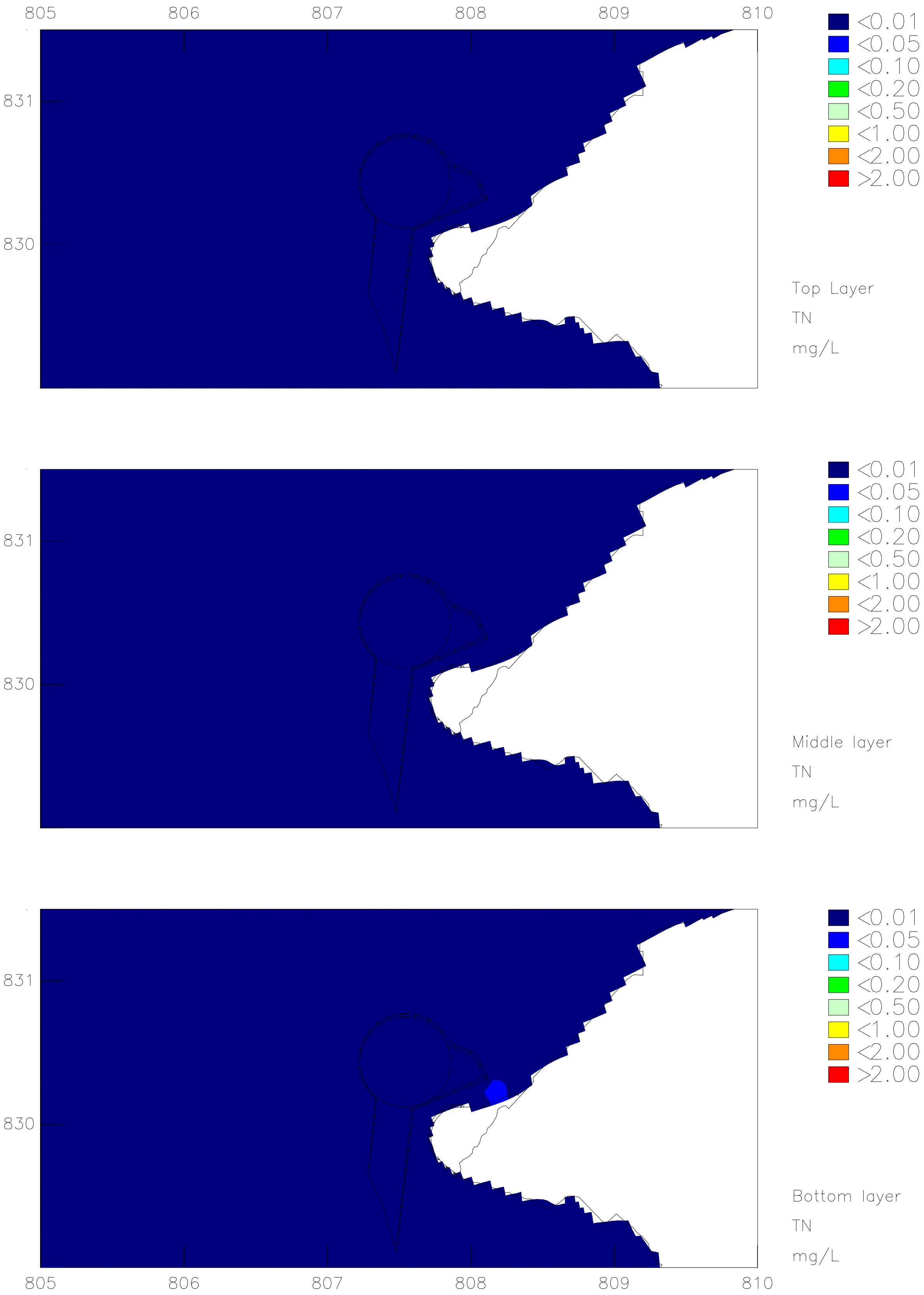


SS (mg/L)
Black Point Sewage emission – Construction
Maximum, Mean and Minimum depth averaged increase

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E24

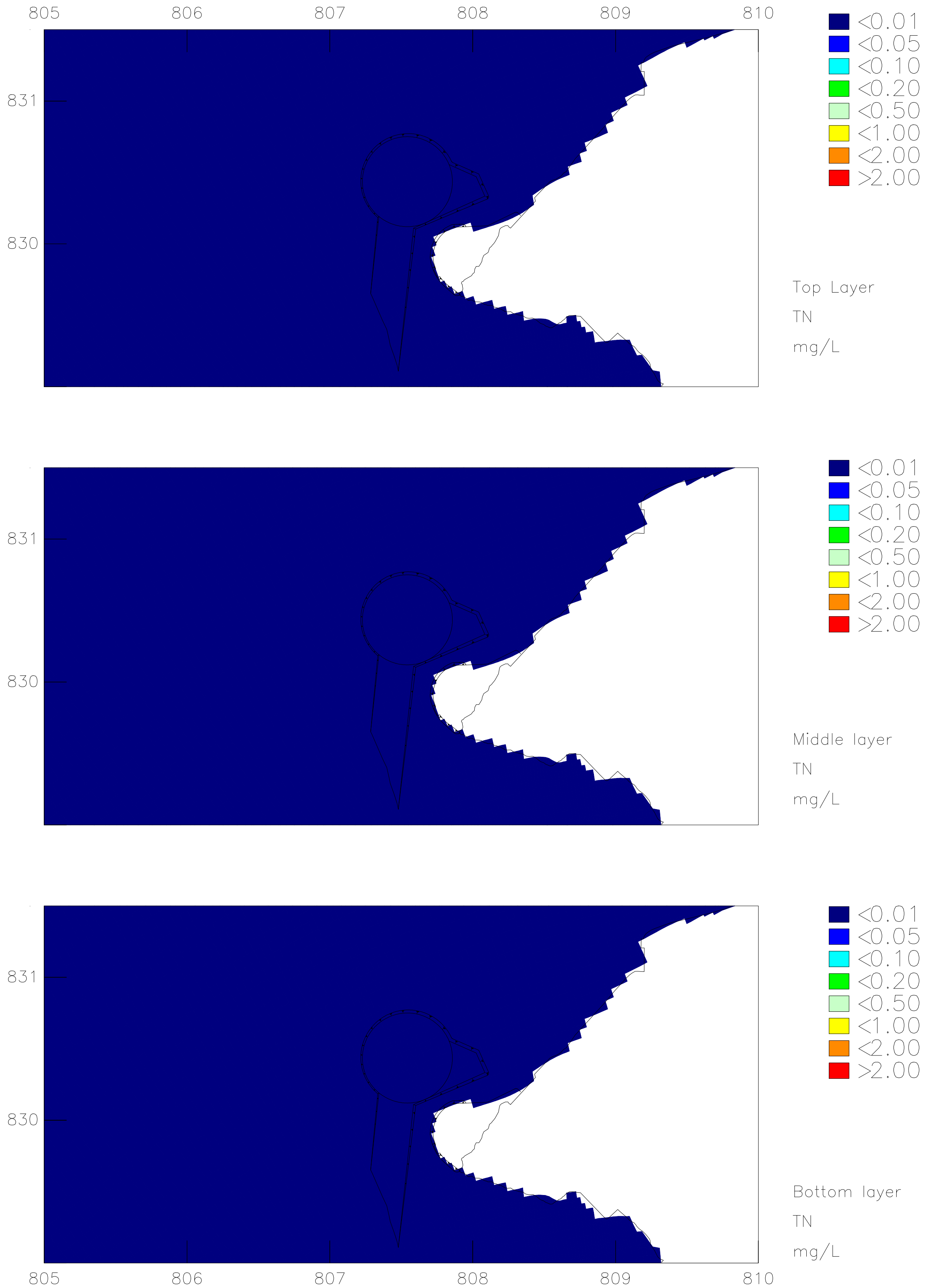


TN (mg/L) maximum increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E25

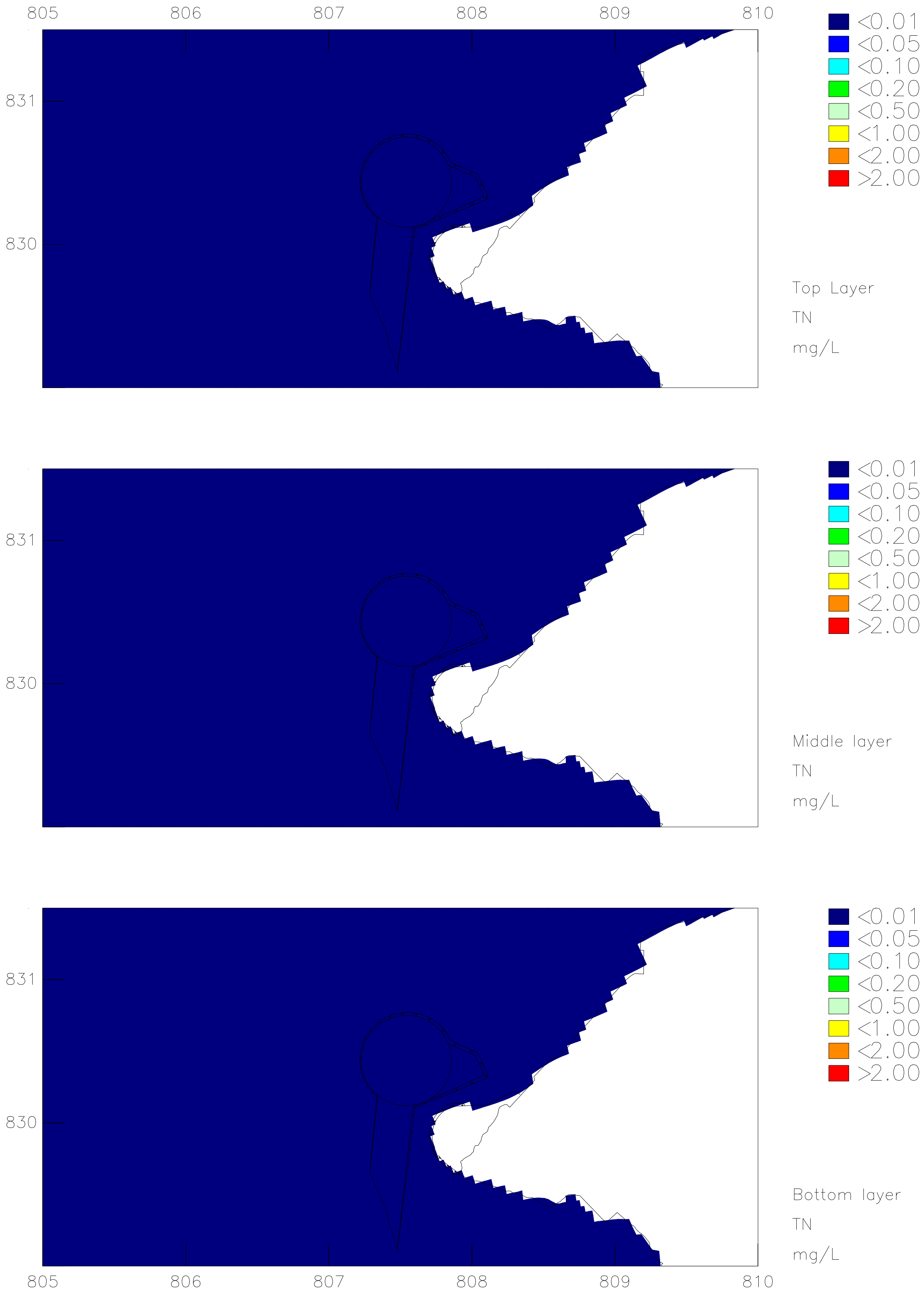


TN (mg/L) mean increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E26

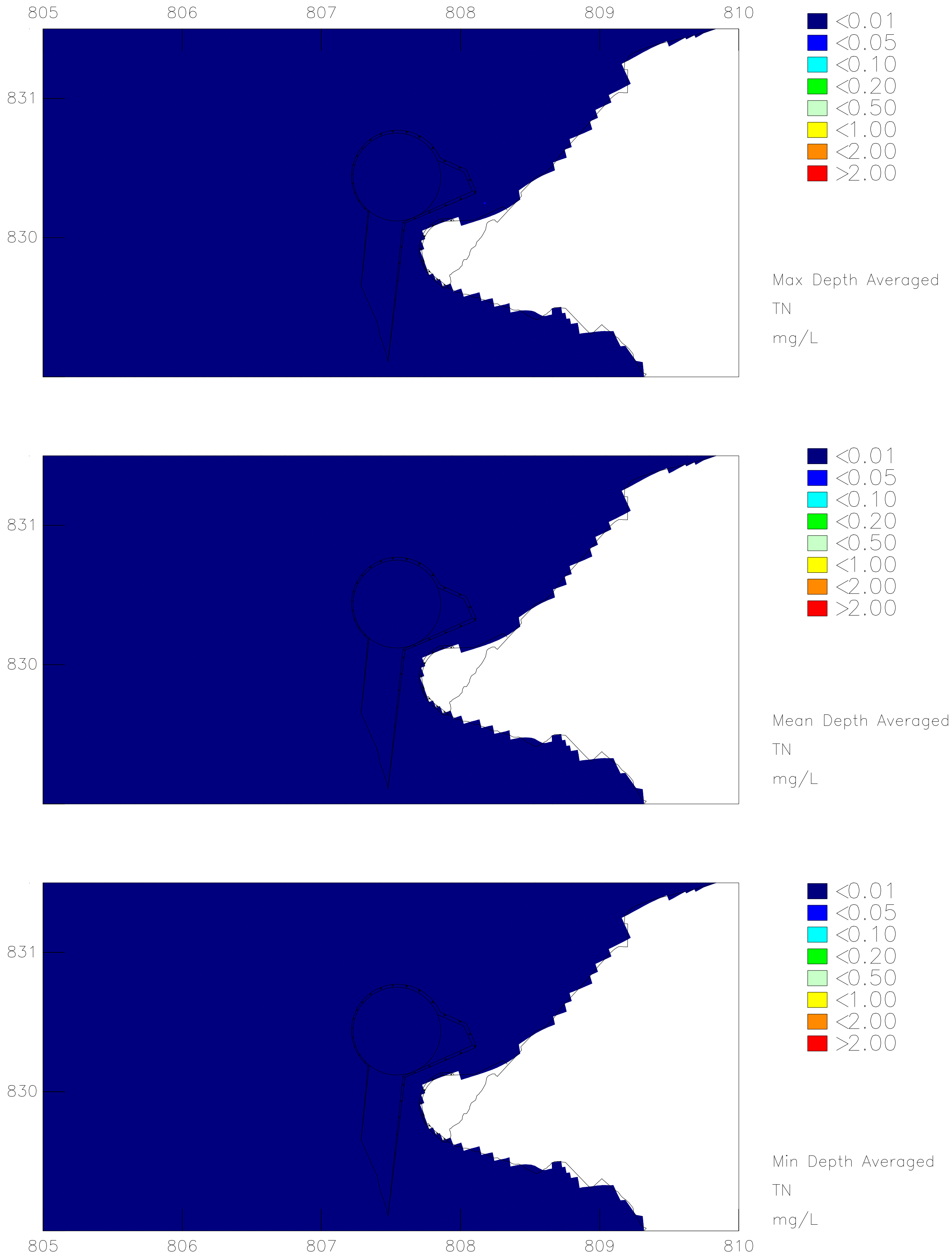


TN (mg/L) minimum increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E27

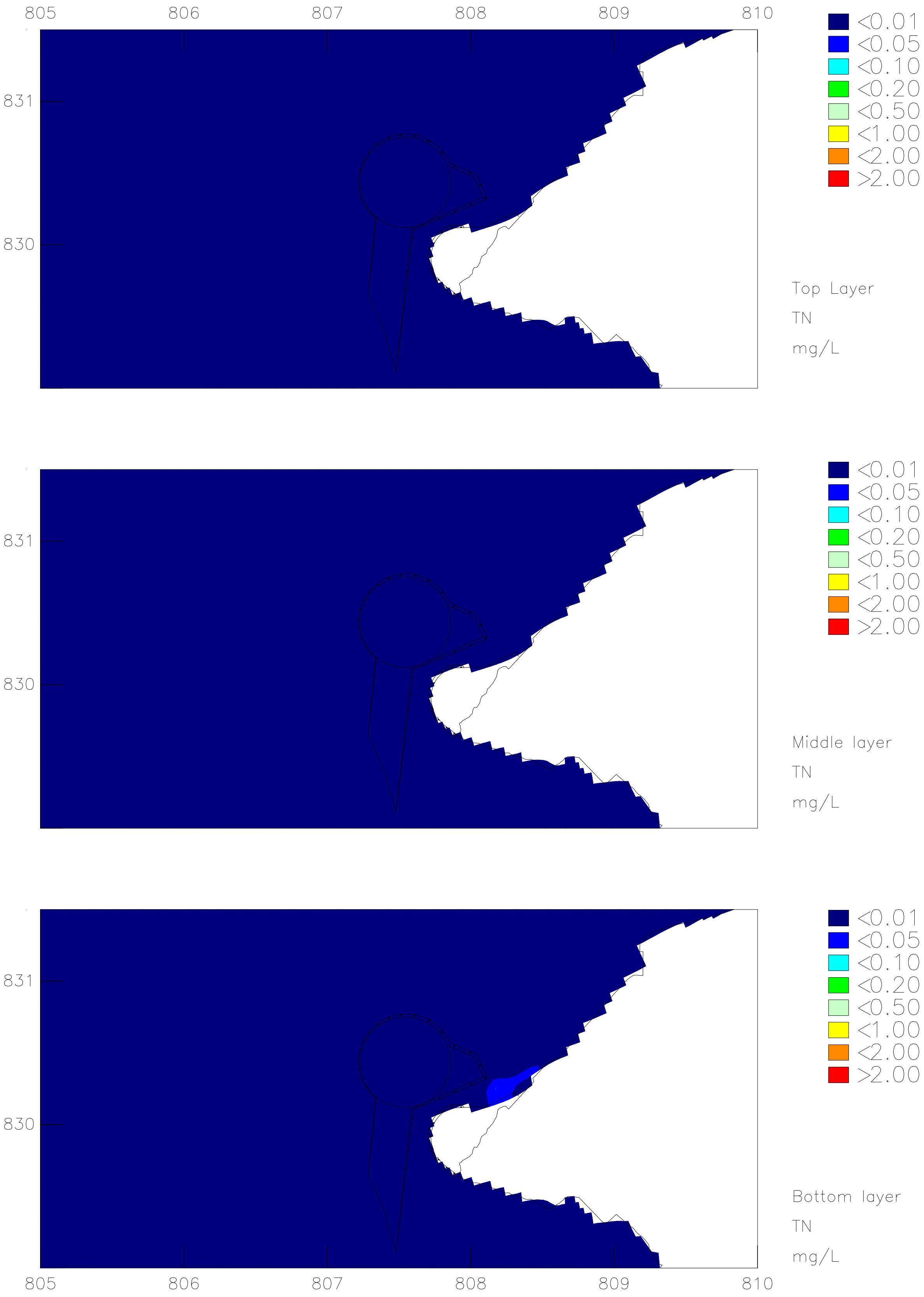


TN (mg/L)
Black Point Sewage emission – Construction
Maximum, Mean and Minimum depth averaged increase

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E28

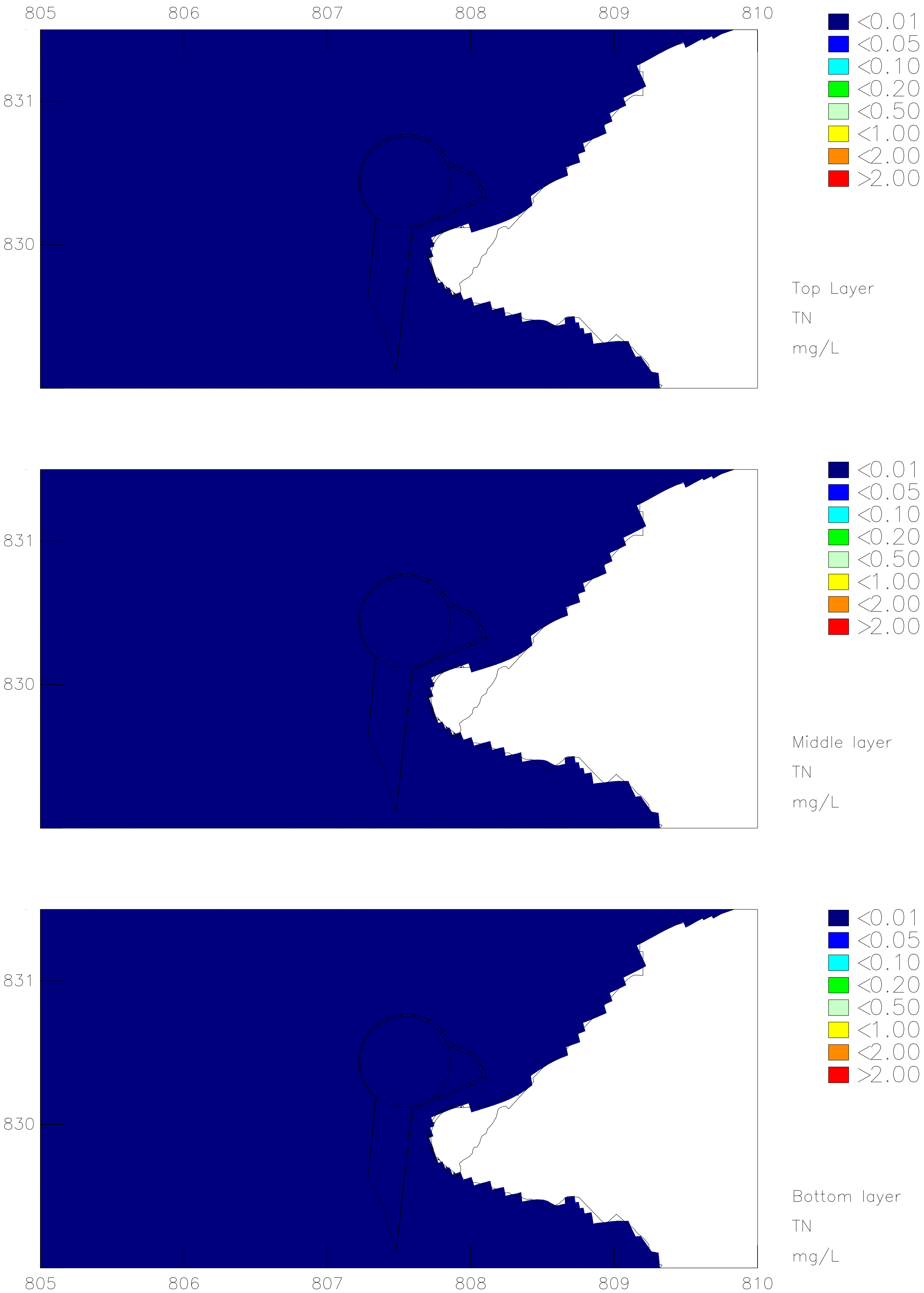


TN (mg/L) maximum increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E29

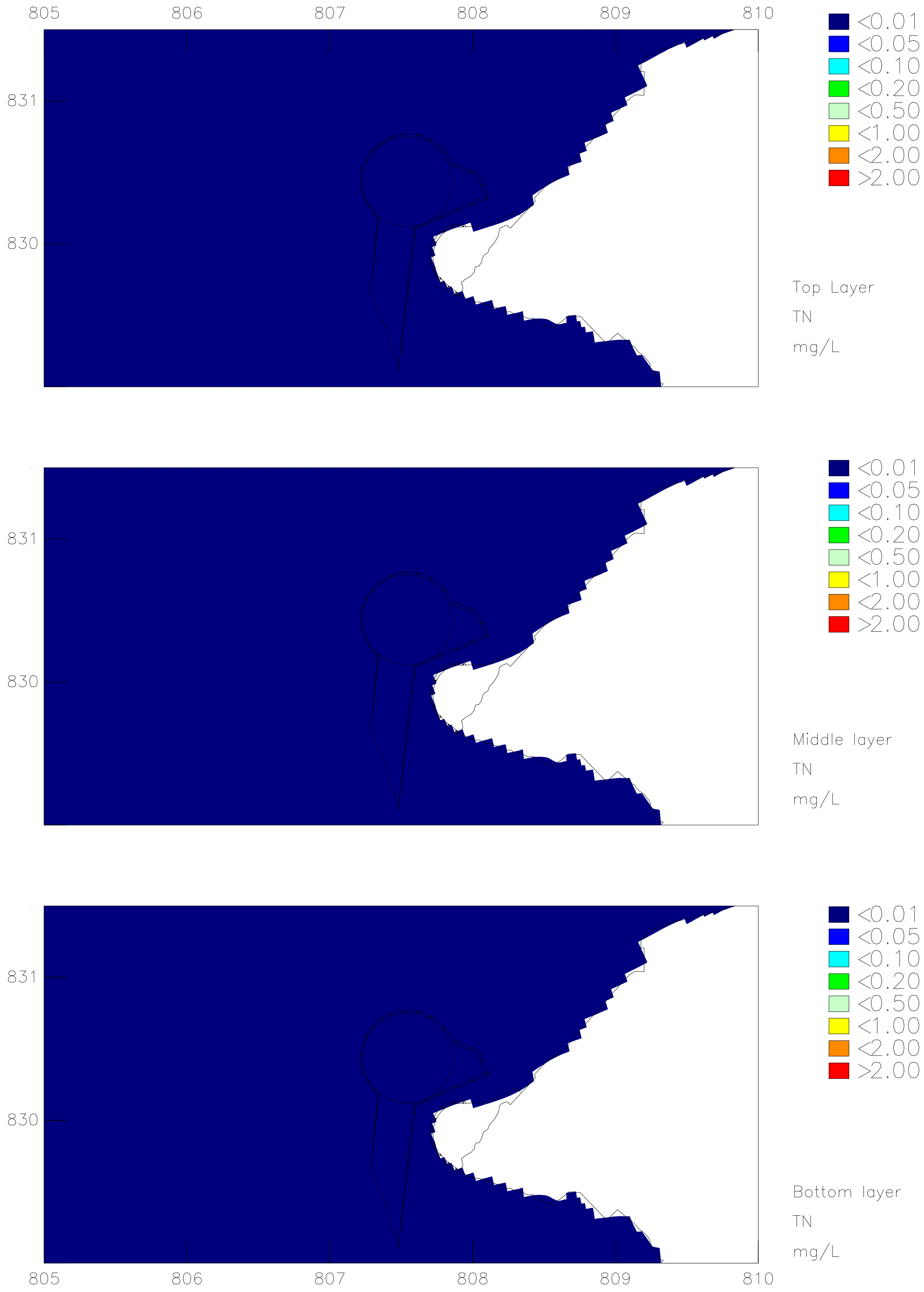


TN (mg/L) mean increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E30

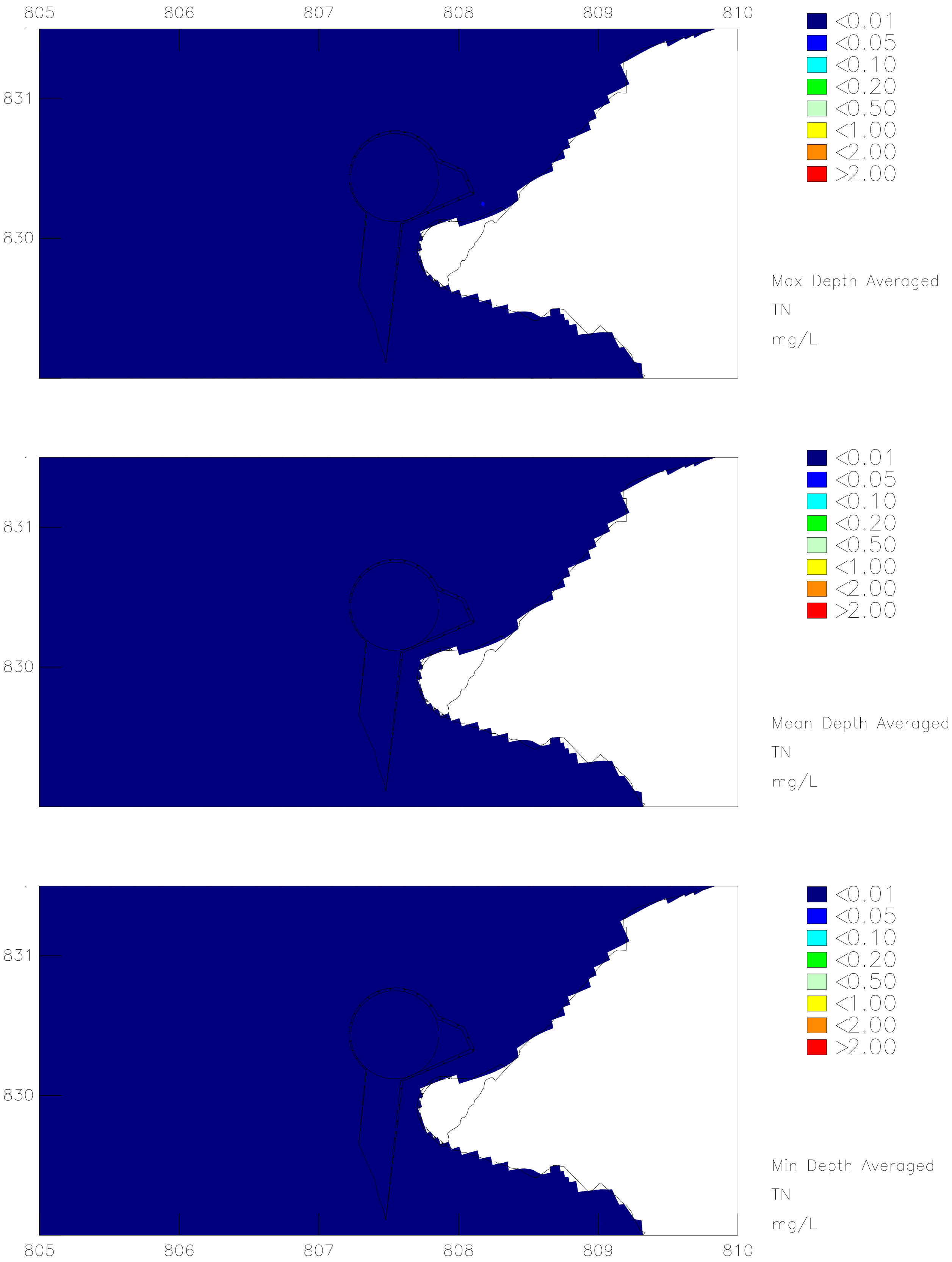


TN (mg/L) minimum increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E31

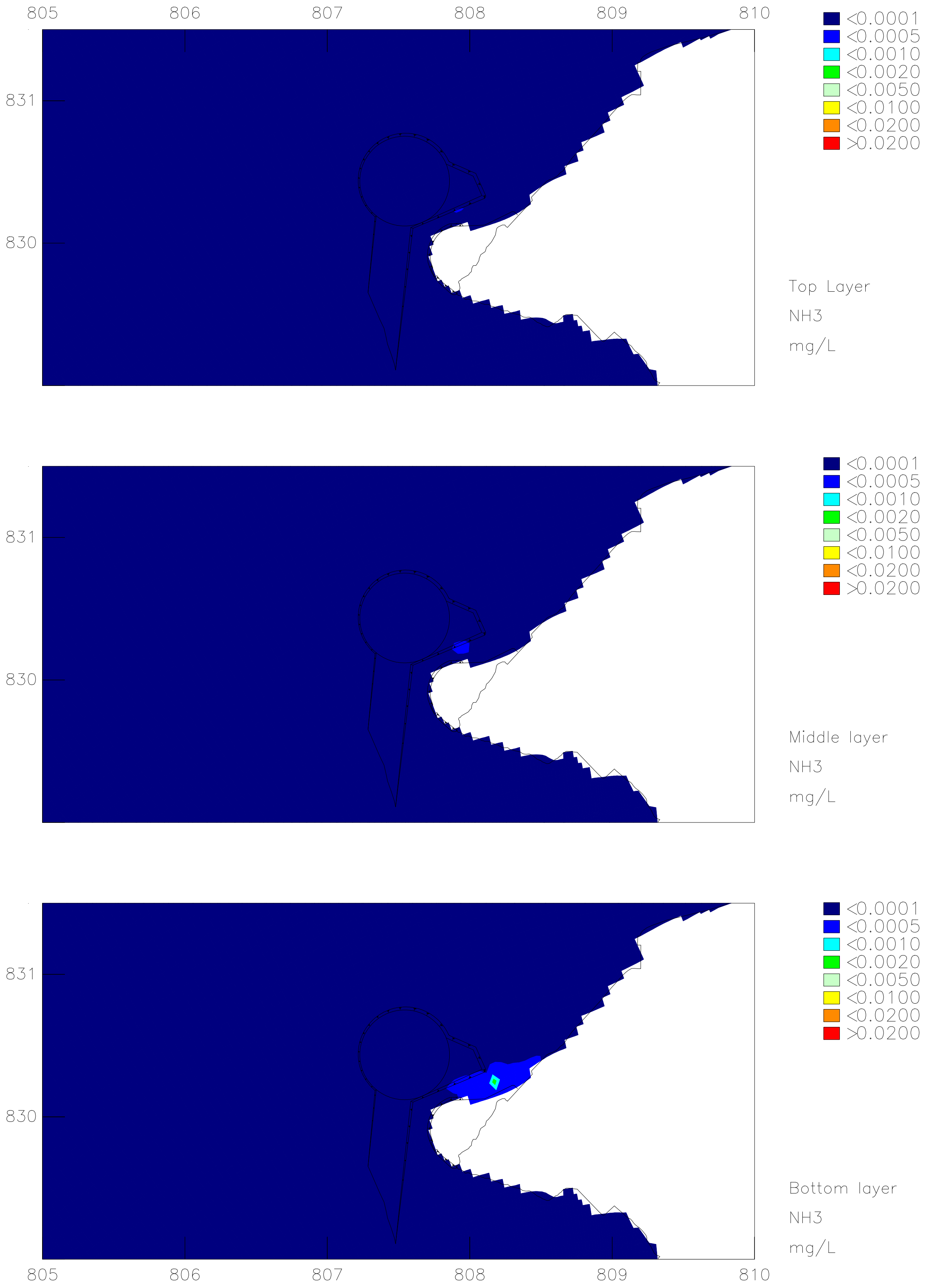


TN (mg/L)
Black Point Sewage emission – Construction
Maximum, Mean and Minimum depth averaged increase

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E32

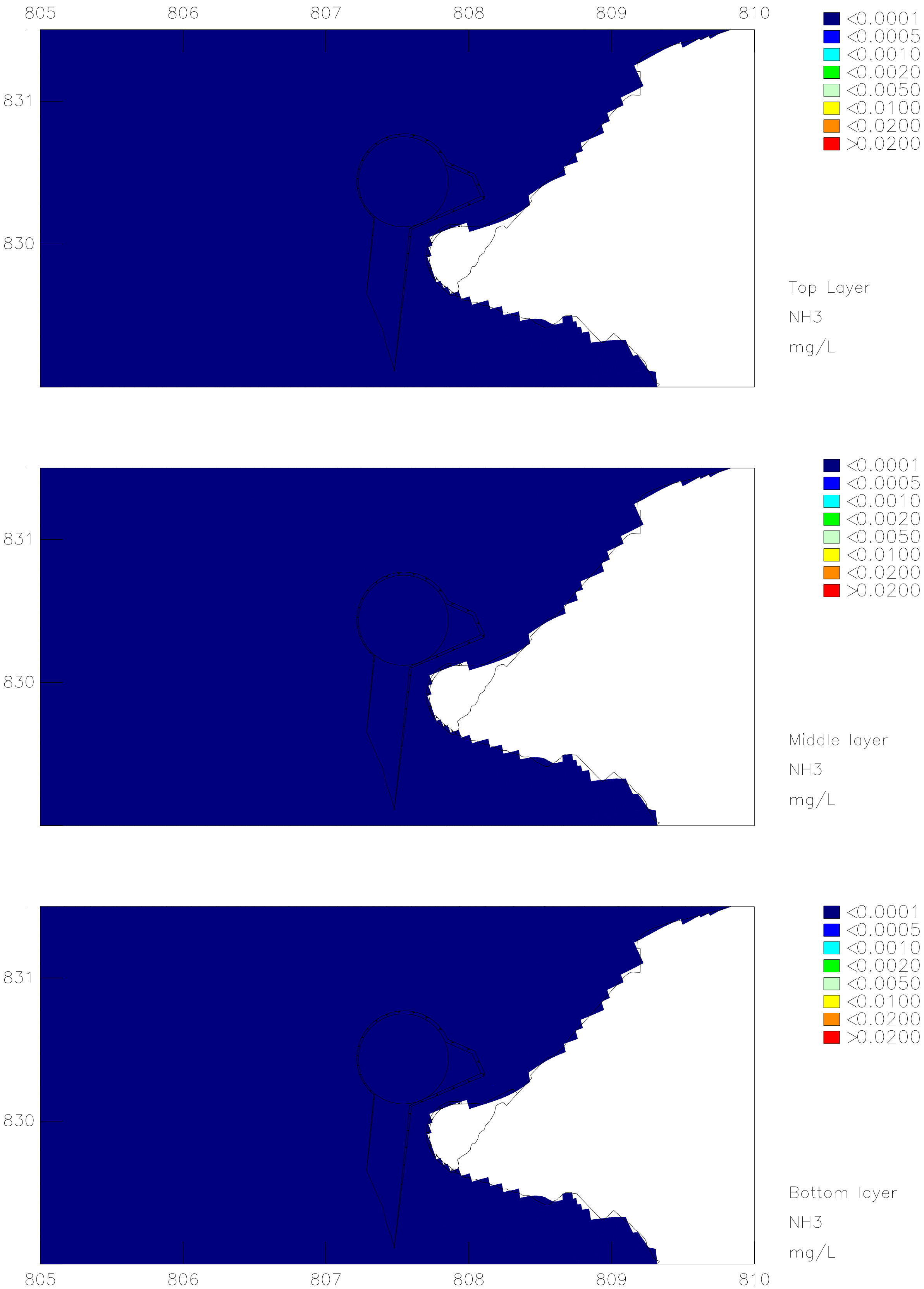


NH3 (mg/L) maximum increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E33

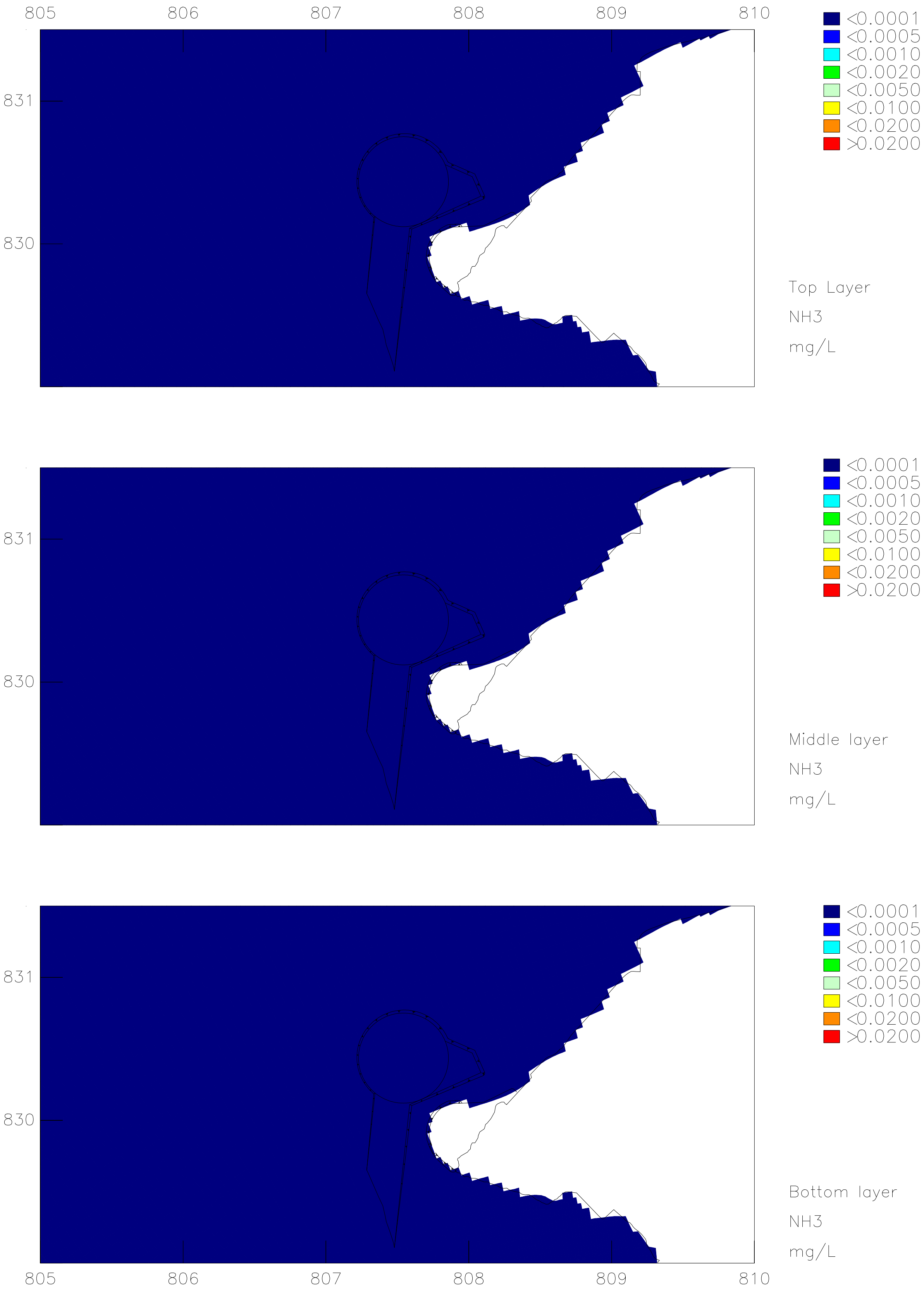


NH3 (mg/L) mean increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E34

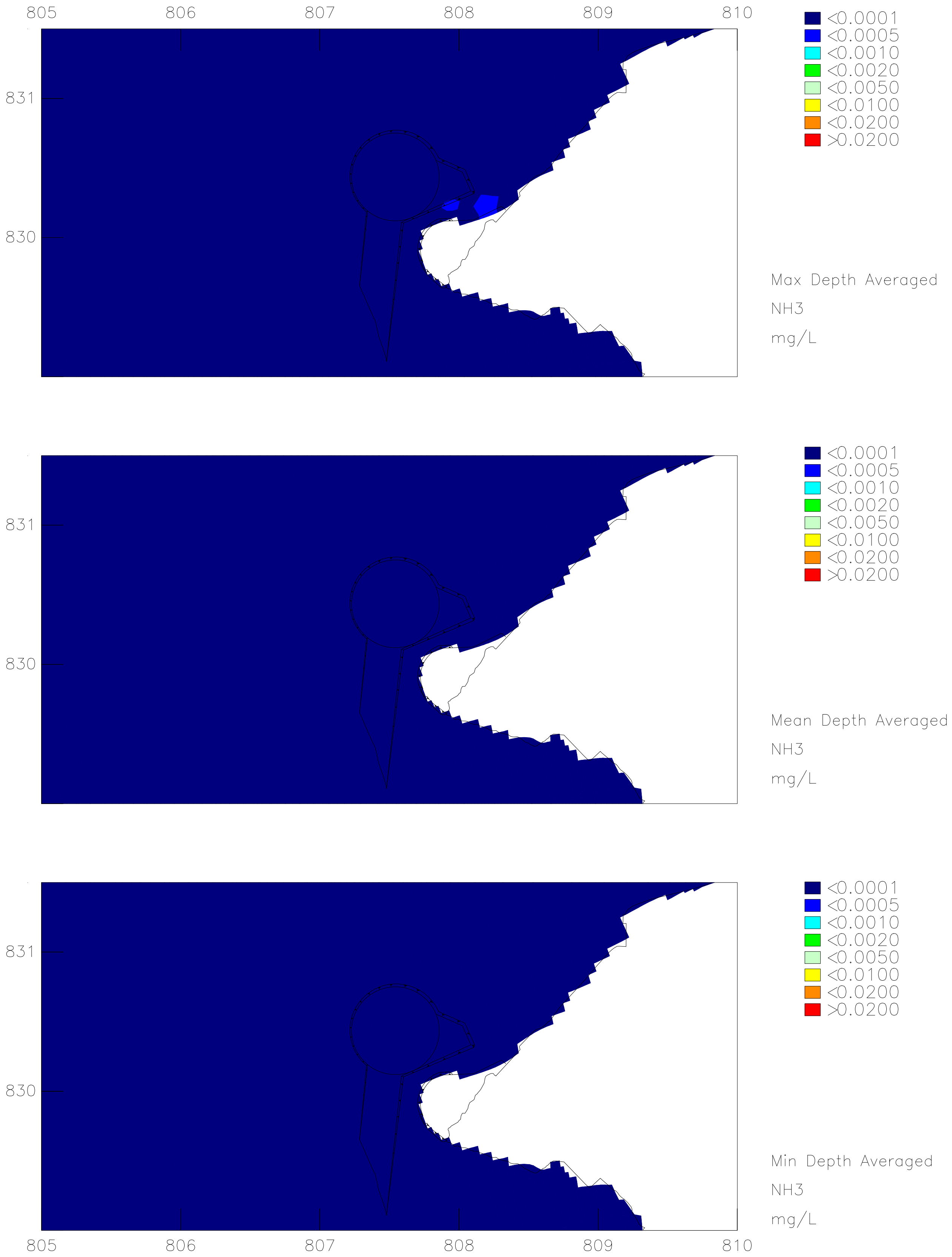


NH3 (mg/L) minimum increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E35

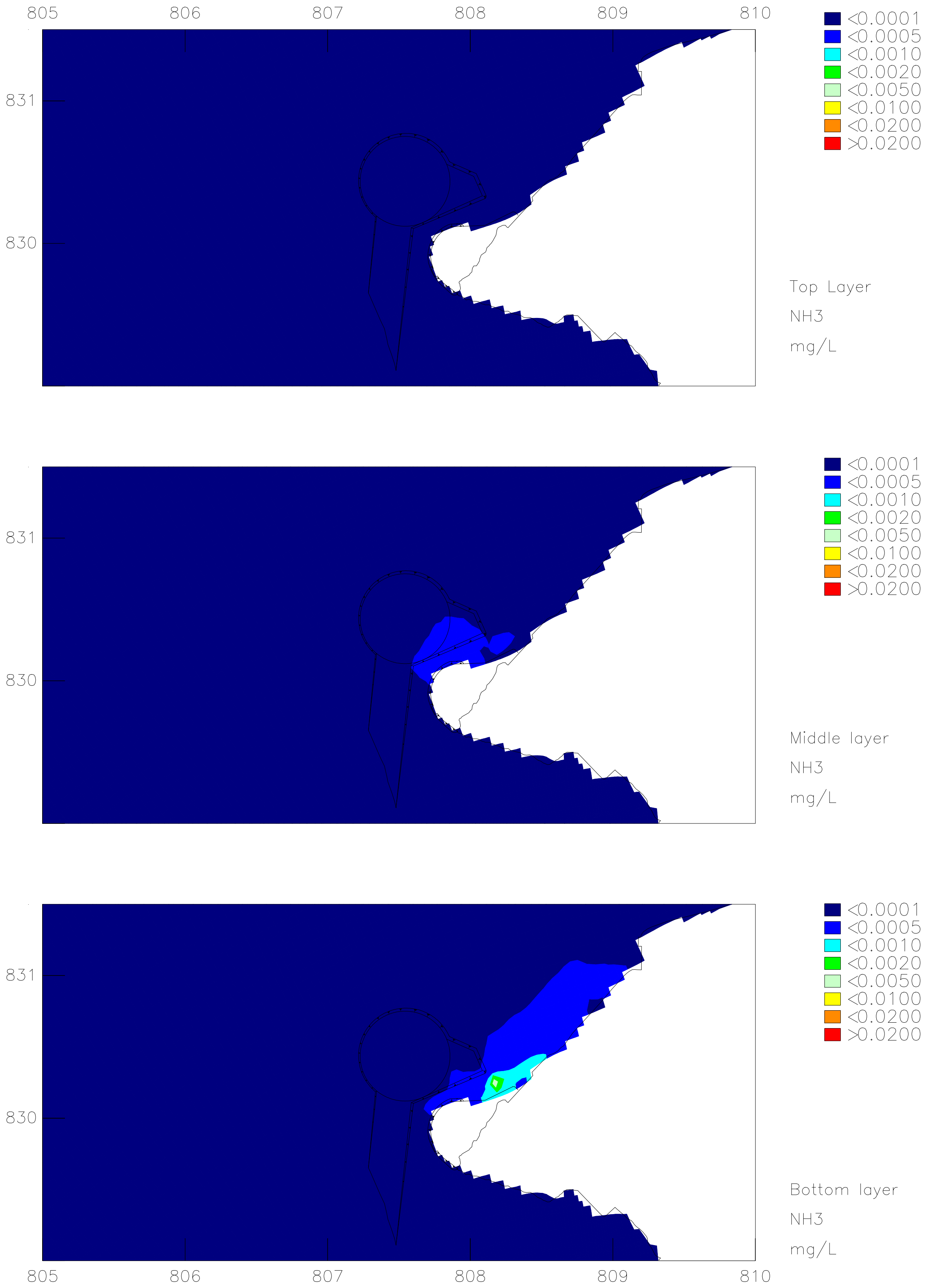


NH3 (mg/L)
Black Point Sewage emission – Construction
Maximum, Mean and Minimum depth averaged increase

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E36

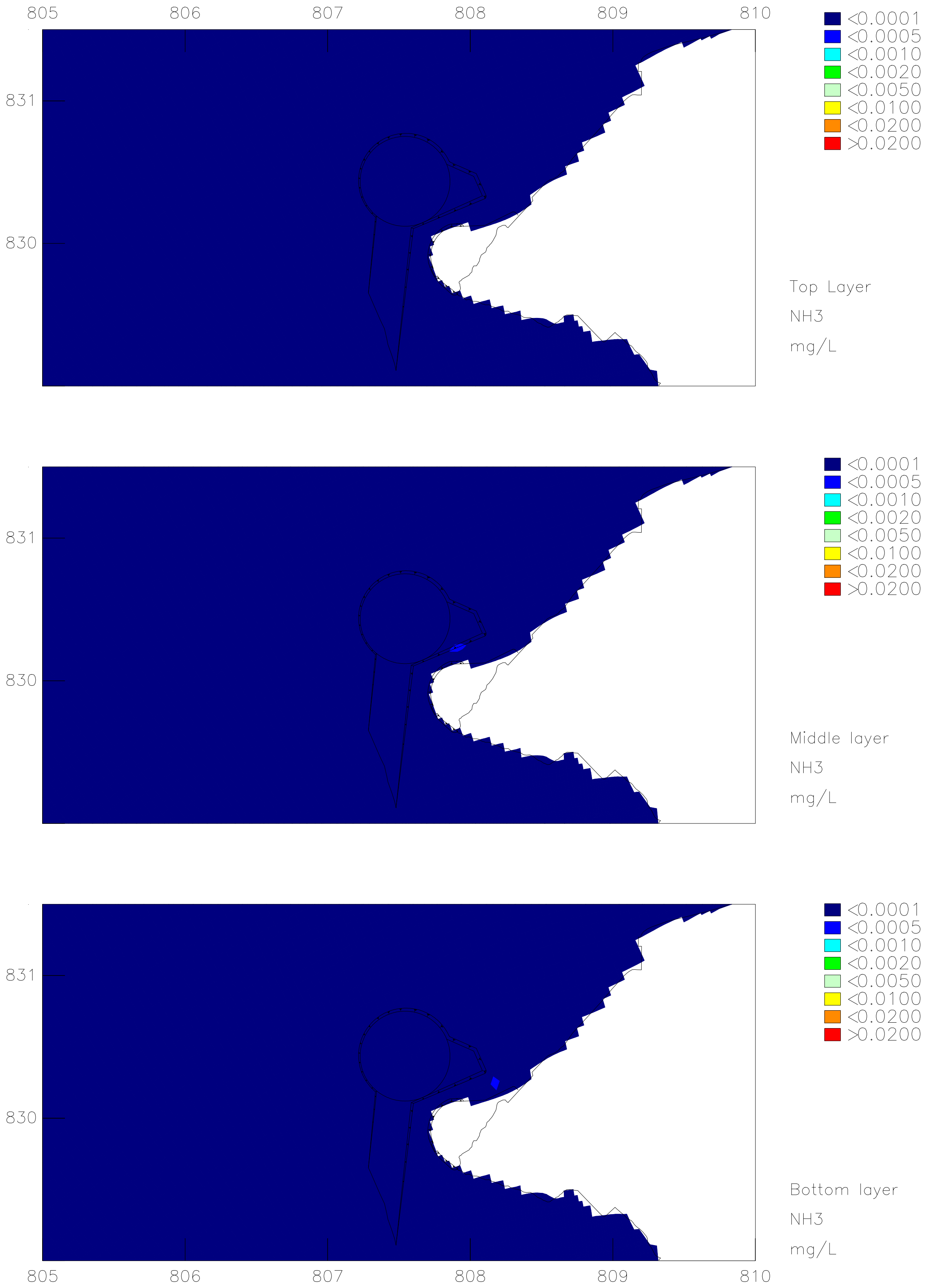


NH3 (mg/L) maximum increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E37

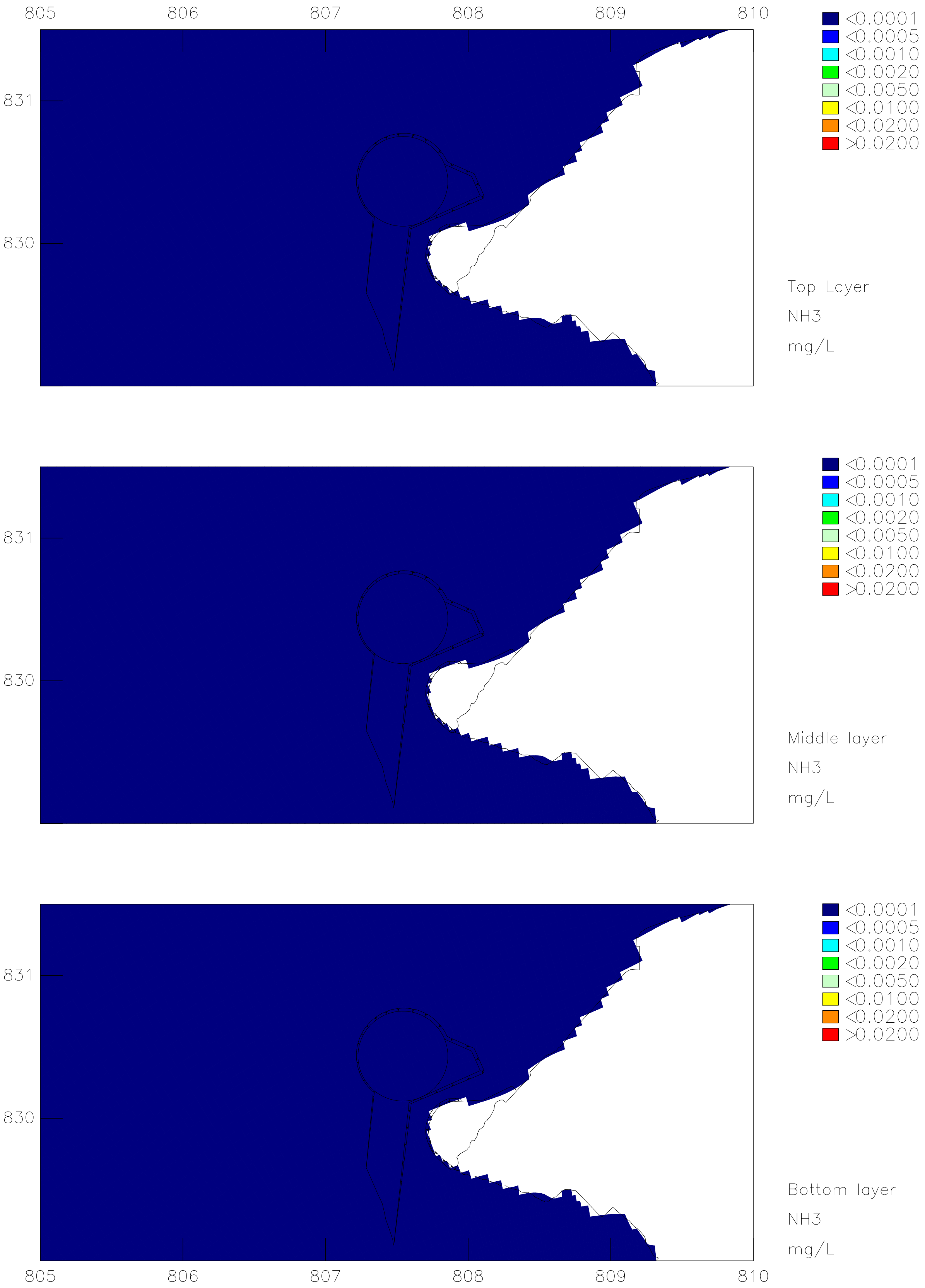


NH3 (mg/L) mean increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E38

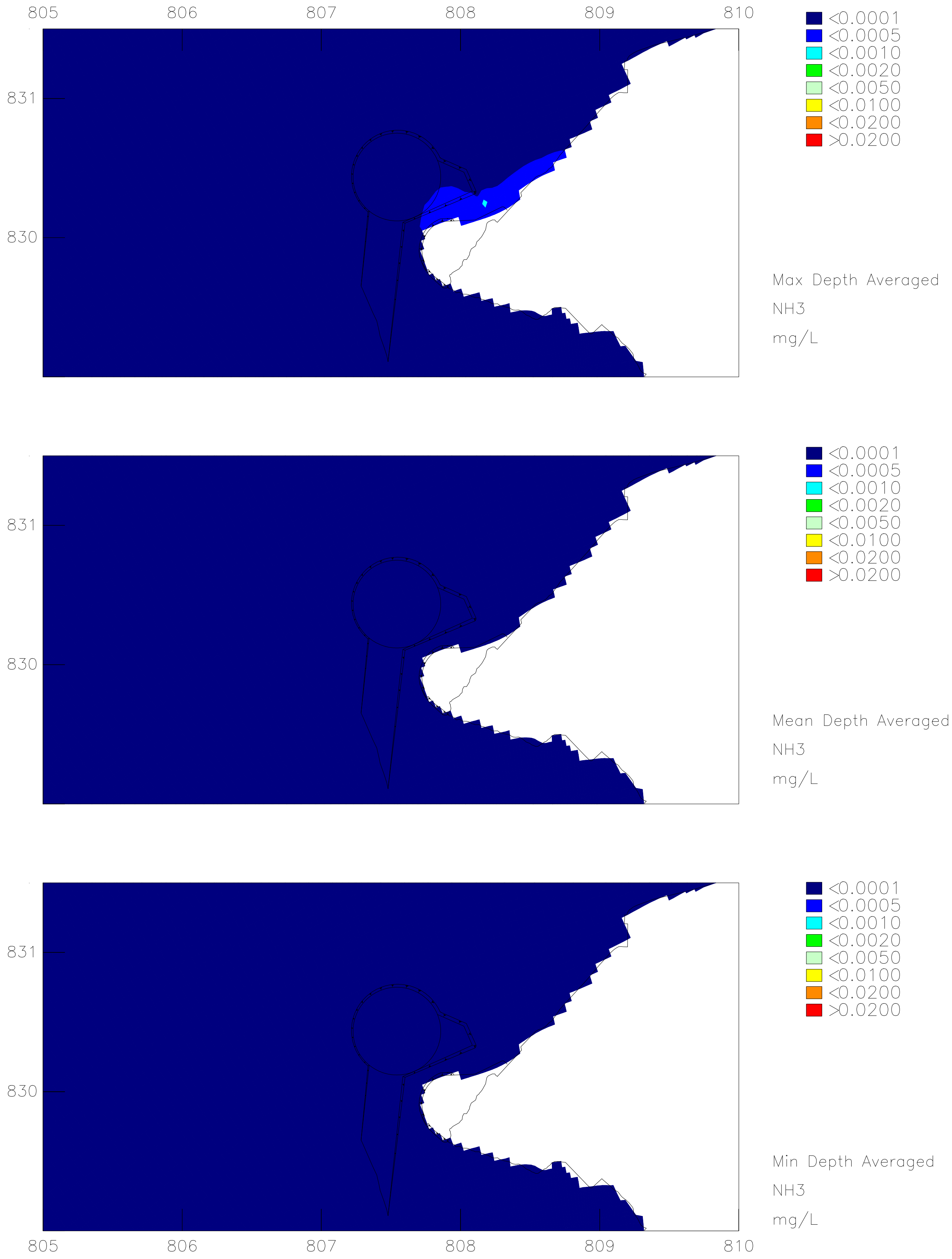


NH3 (mg/L) minimum increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E39

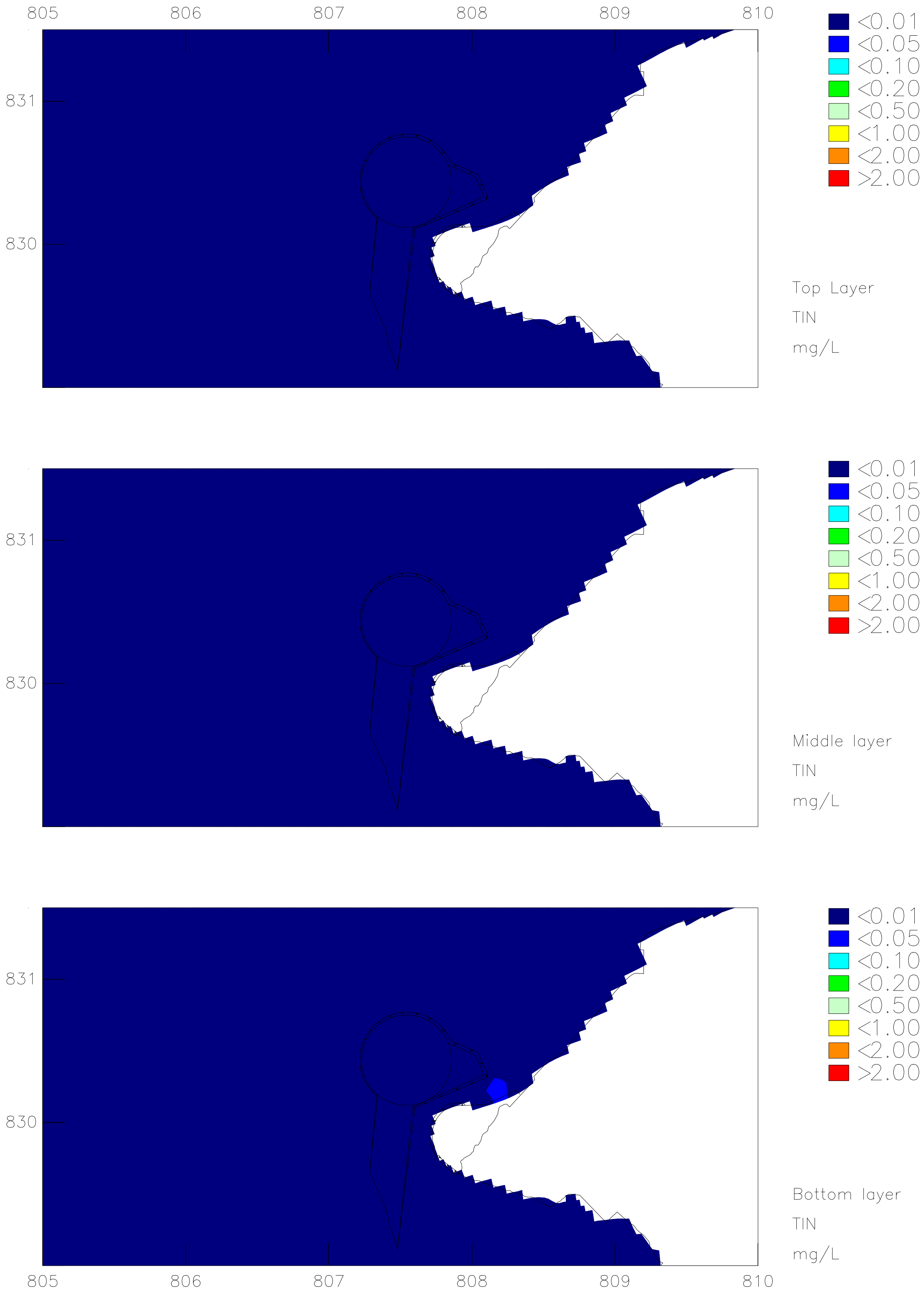


NH3 (mg/L)
Black Point Sewage emission – Construction
Maximum, Mean and Minimum depth averaged increase

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E40

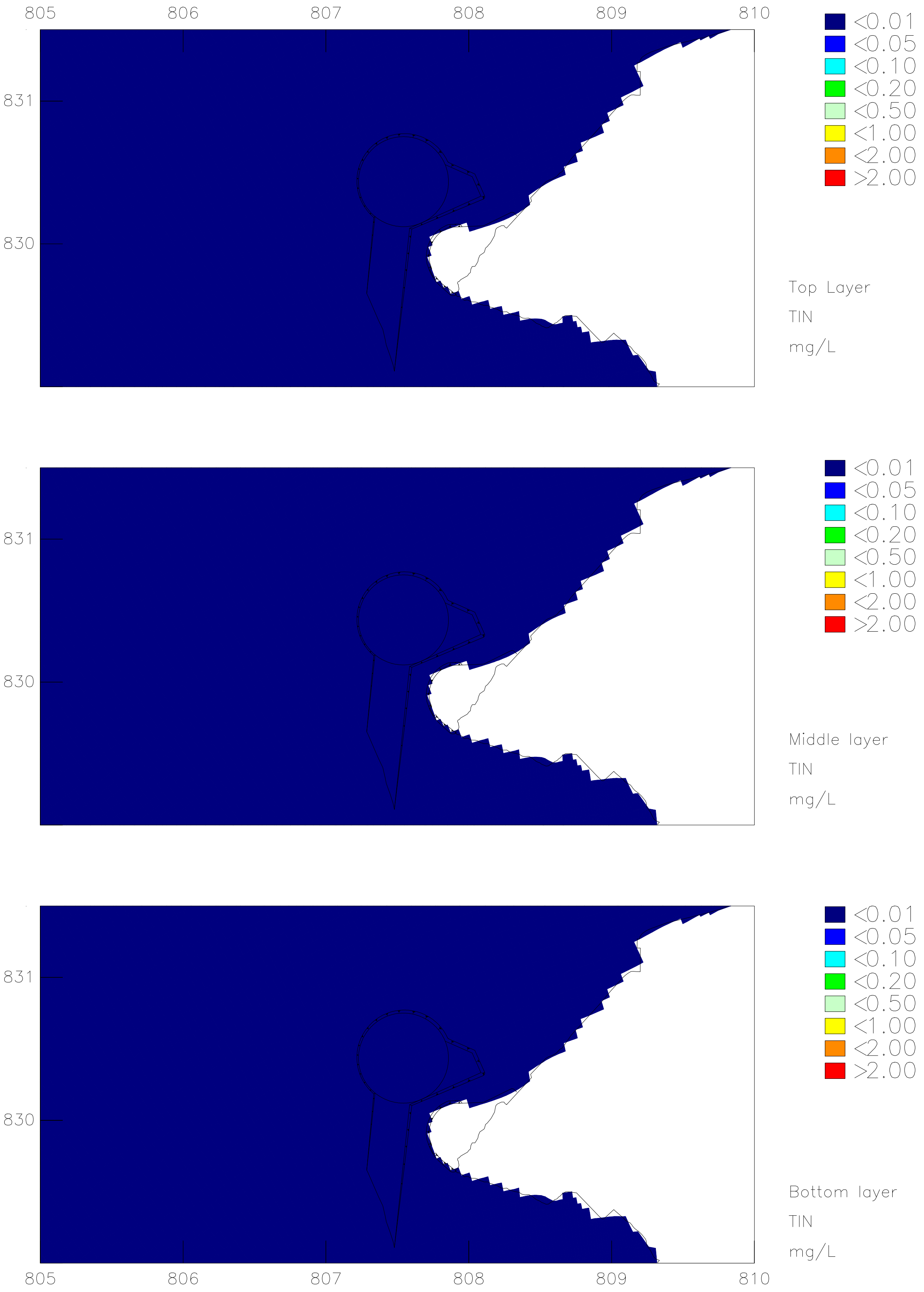


TIN (mg/L) maximum increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E41

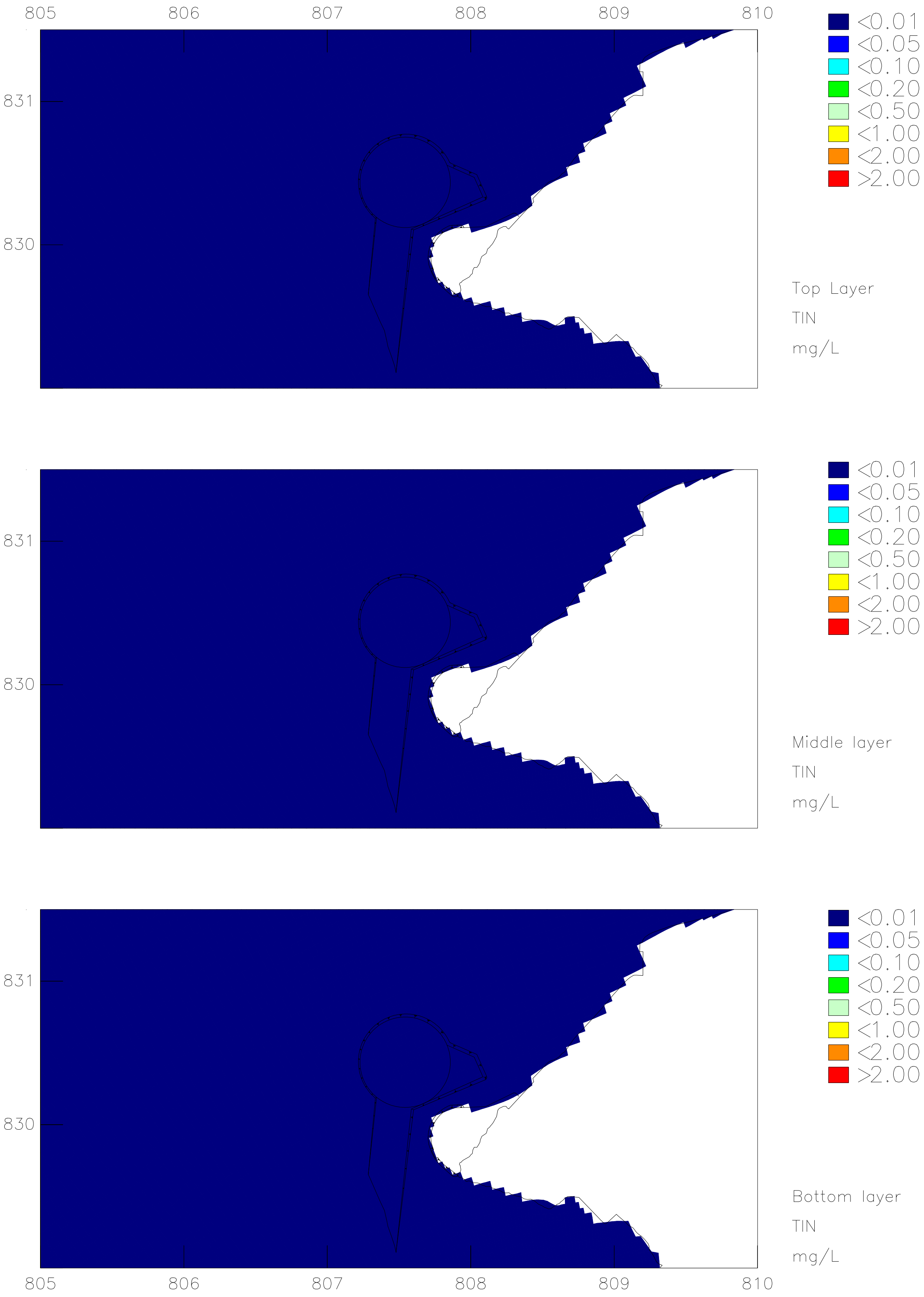


TIN (mg/L) mean increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E42

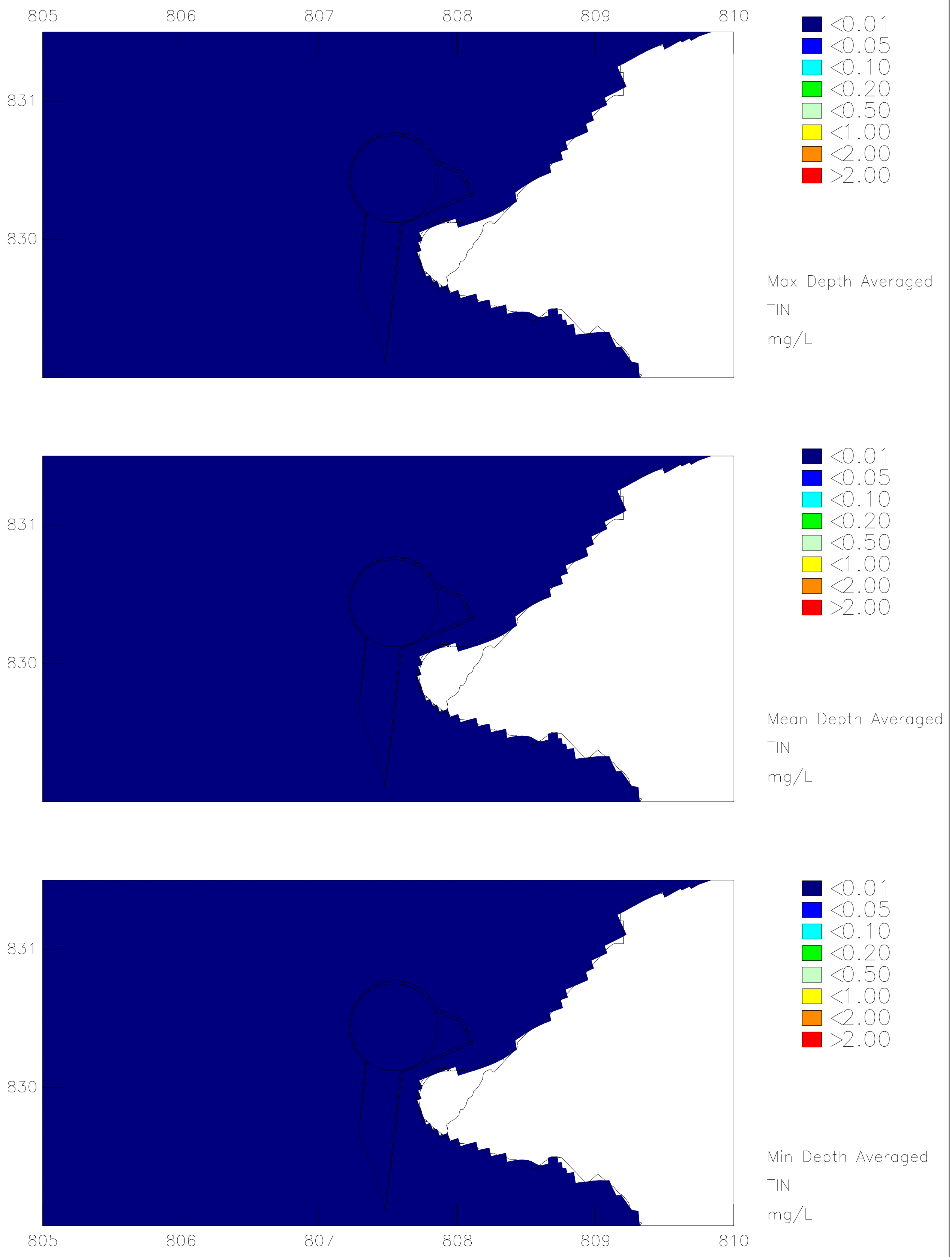


TIN (mg/L) minimum increase
Black Point Sewage emission - Construction
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics - ERM

Fig. BP_E43

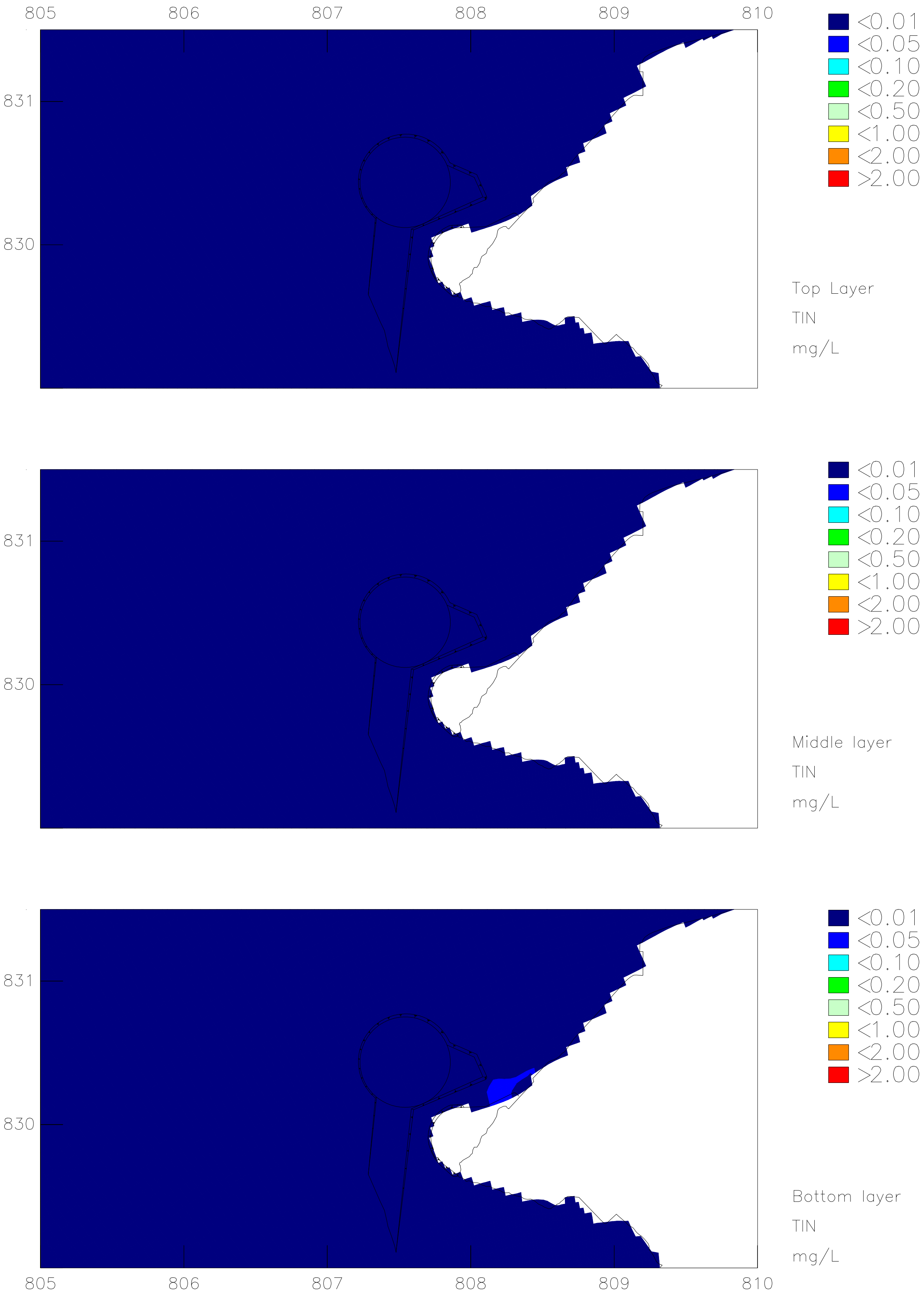


TIN (mg/L)
Black Point Sewage emission – Construction
Maximum, Mean and Minimum depth averaged increase

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_E44

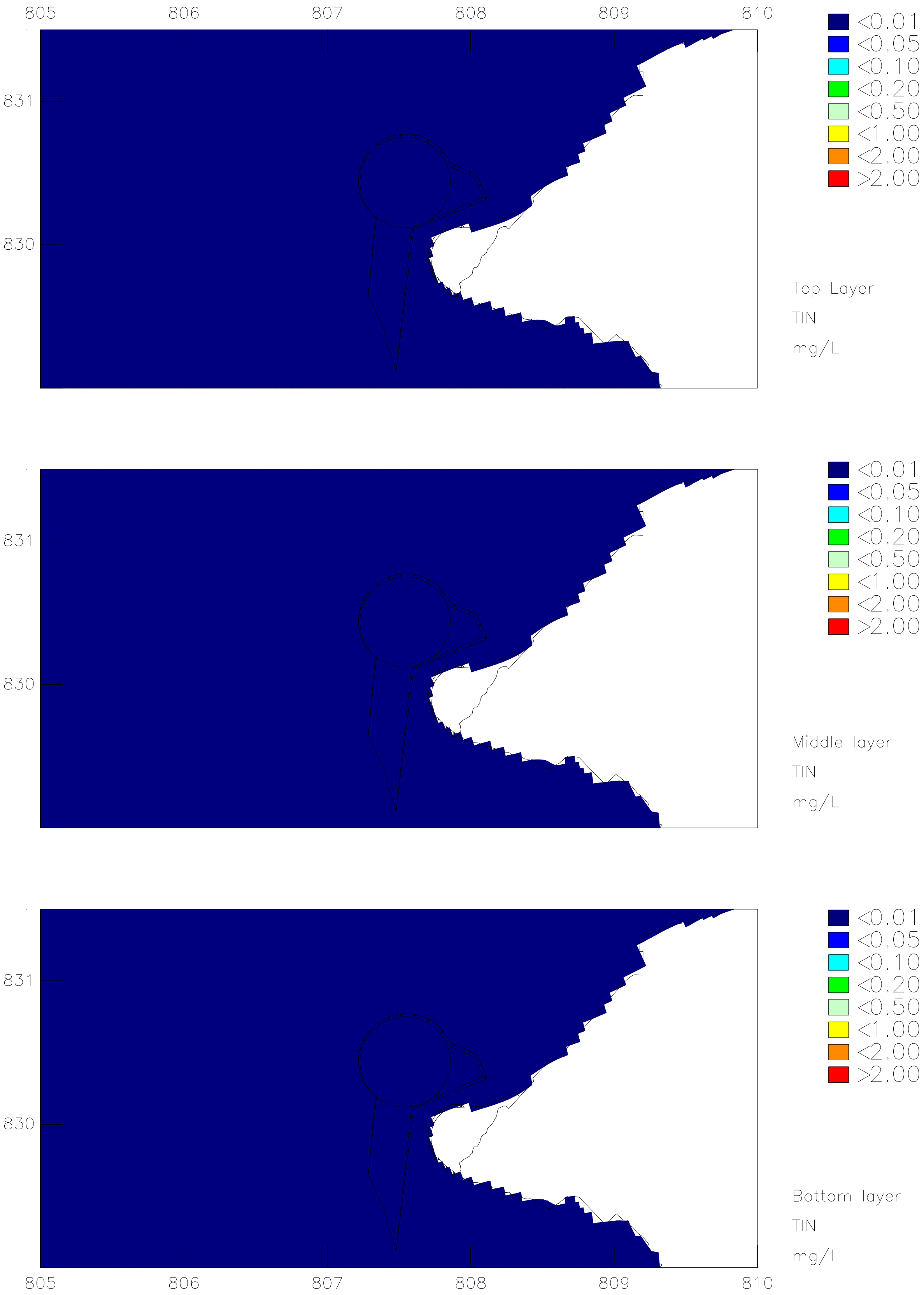


TIN (mg/L) maximum increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E45

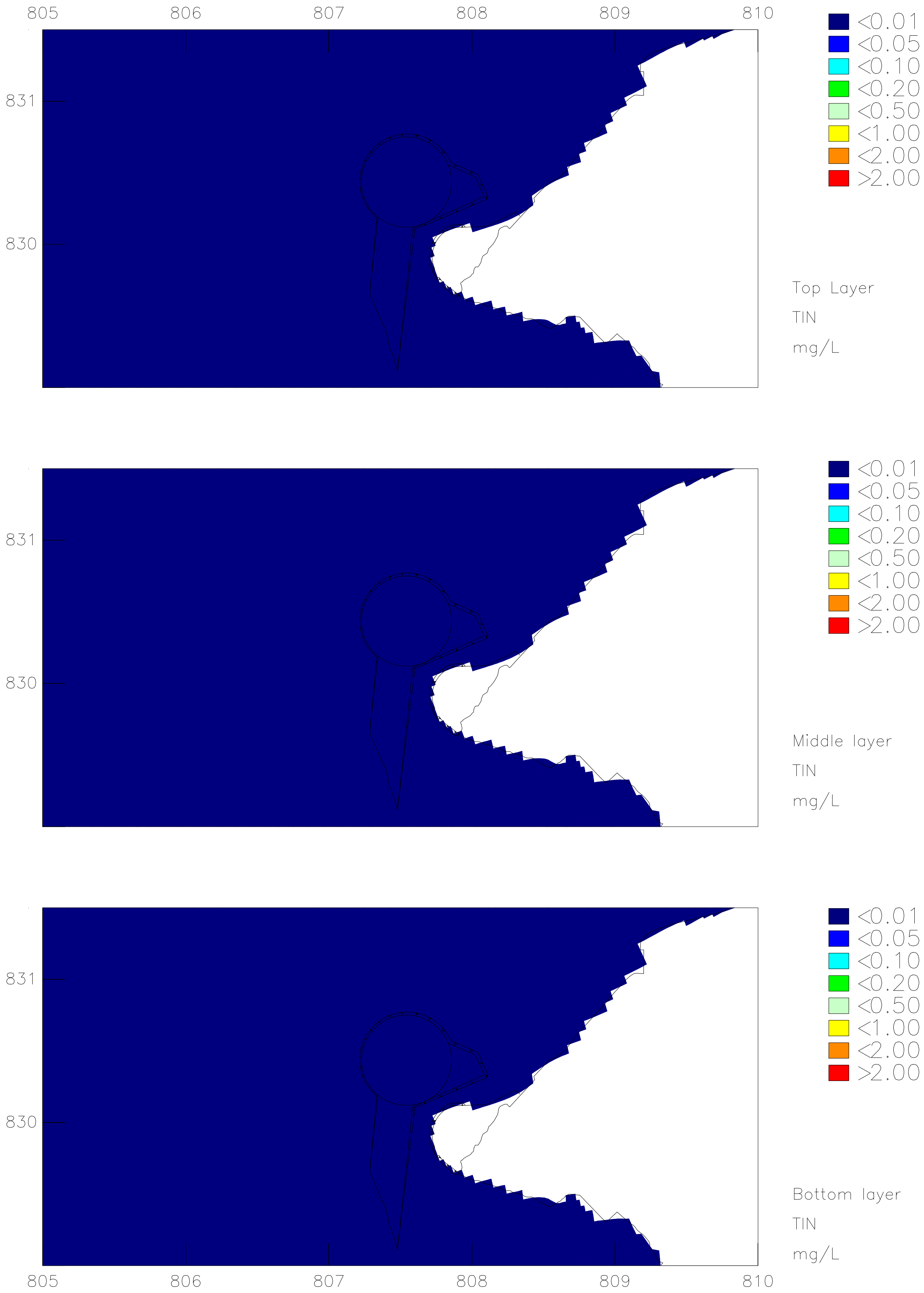


TIN (mg/L) mean increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E46

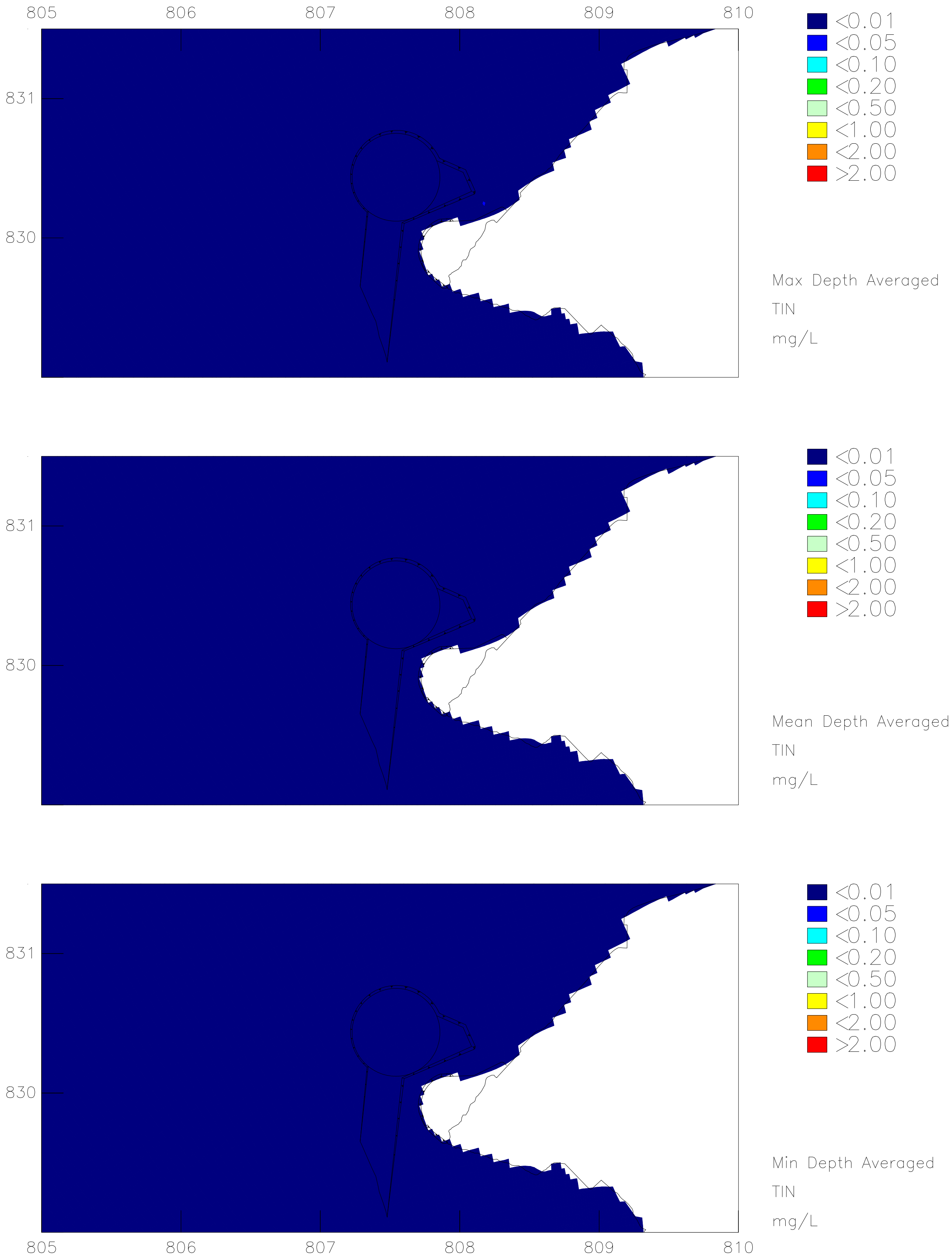


TIN (mg/L) minimum increase
Black Point Sewage emission – Construction
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E47



TIN (mg/L)
Black Point Sewage emission – Construction
Maximum, Mean and Minimum depth averaged increase

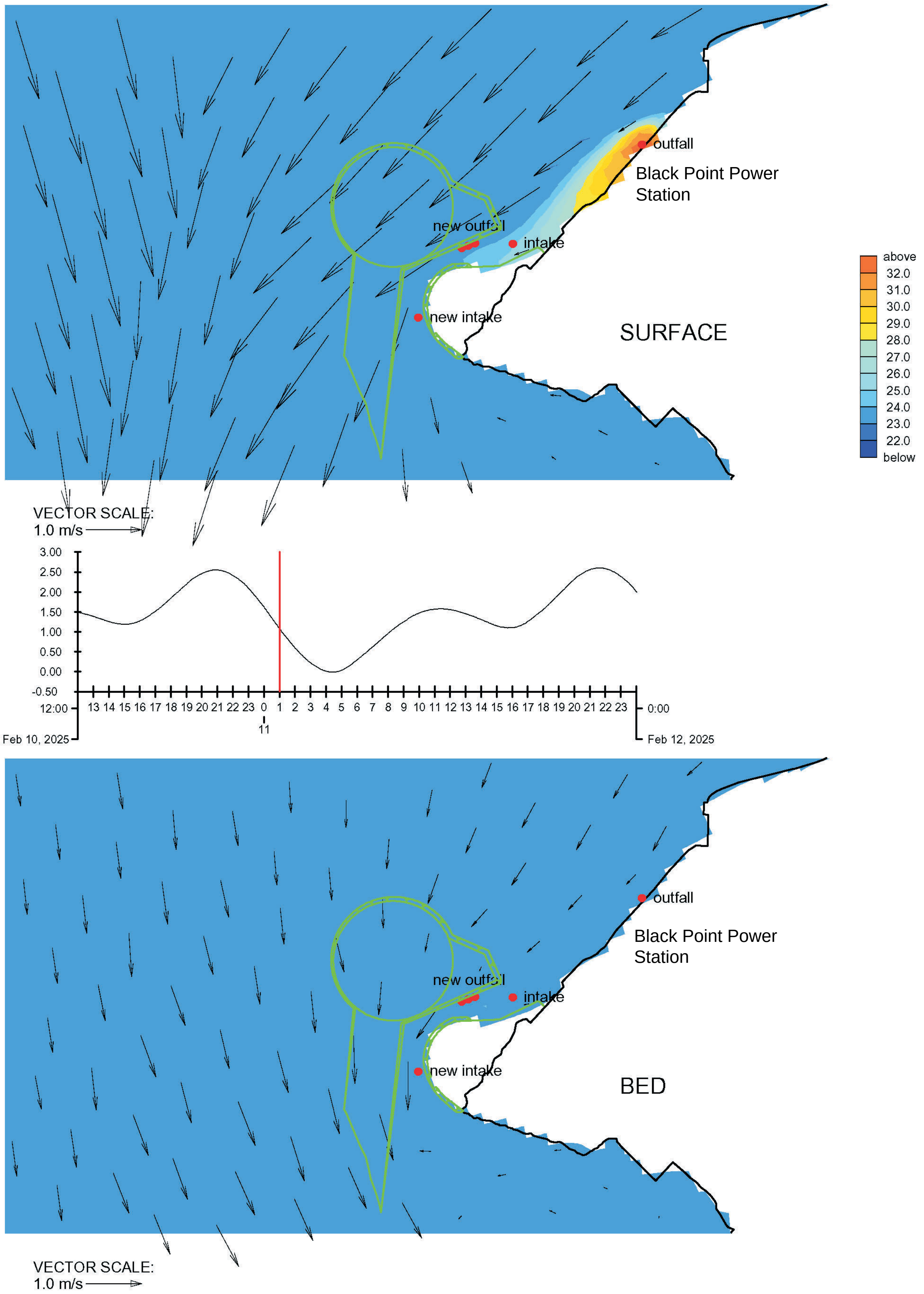
Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_E48

Annex 6F

Operational Phase Model Results - Hydrodynamcis



Velocity Vector (m/s) and Temperature (Degree Celsius)

Dry Season, Mid-ebb, Surface (upper) & Bottom (lower)

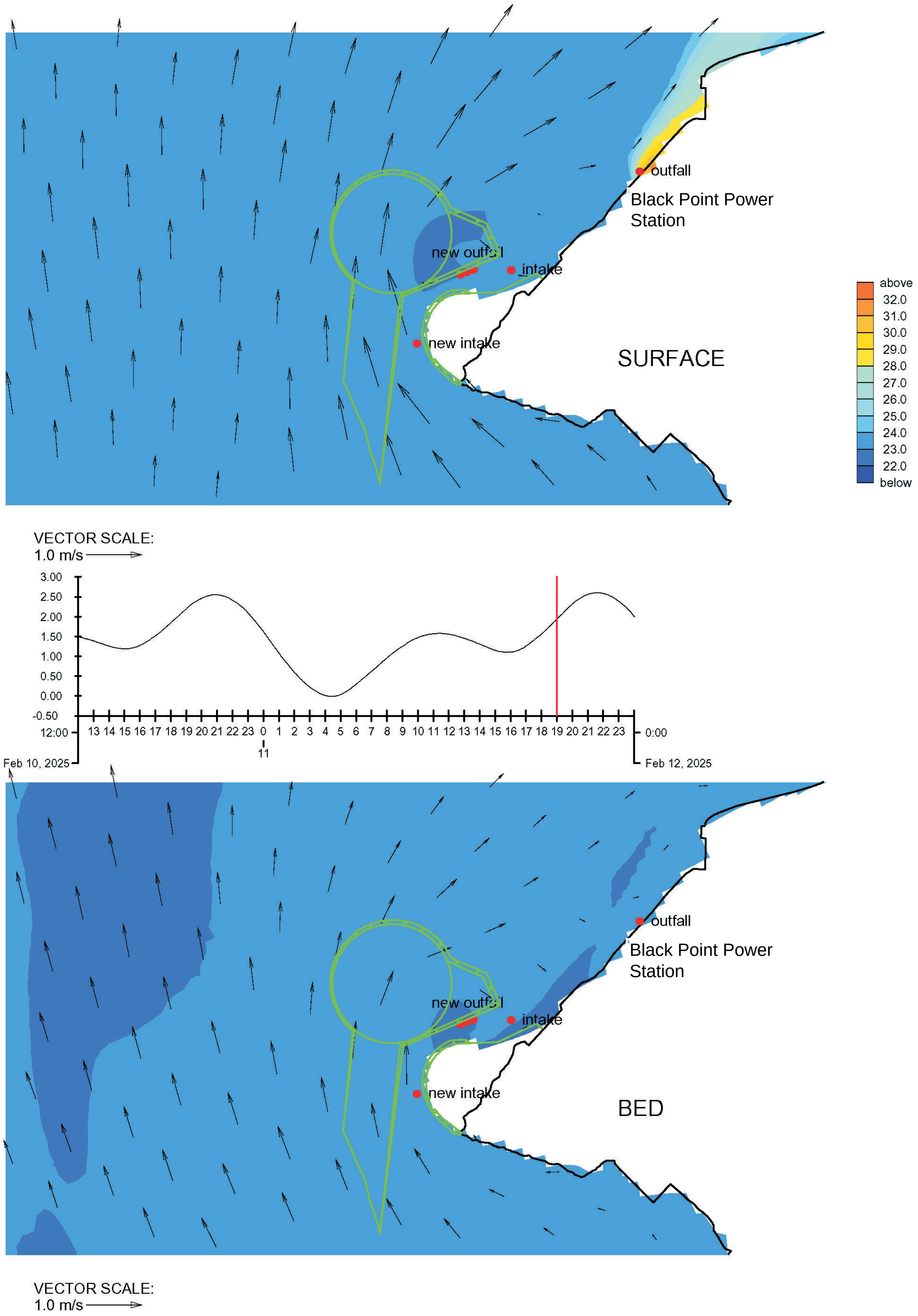
Maximum project related discharges, 2011

Black Point

WL | delft hydraulics

0018180_eia57

Fig. BP_F01



Velocity Vector (m/s) and Temperature (Degree Celsius)

Dry Season, Mid-flood, Surface (upper) & Bottom (lower)

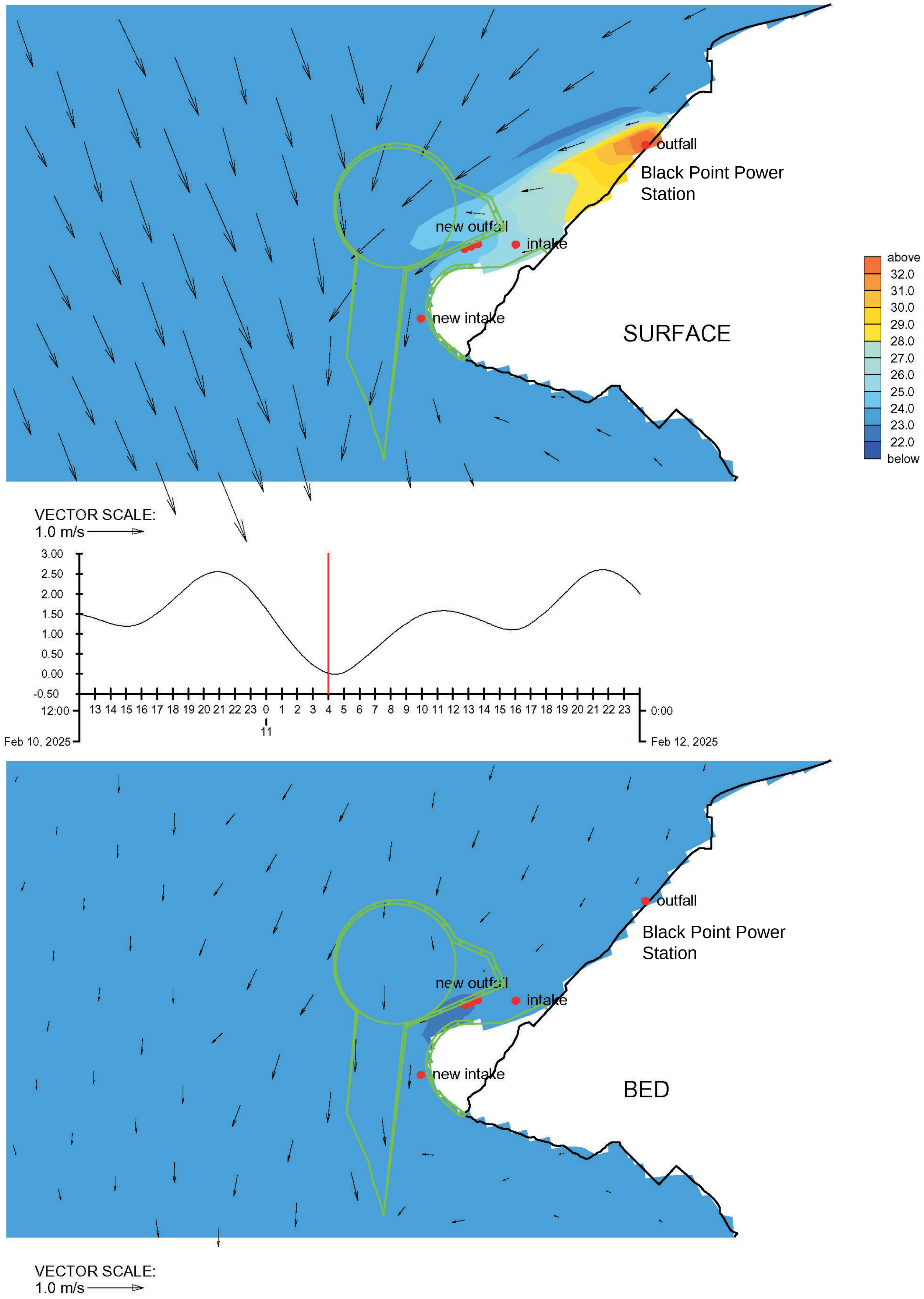
Maximum project related discharges, 2011

Black Point

WL | delft hydraulics

0018180_eia57a

Fig. BP_F02



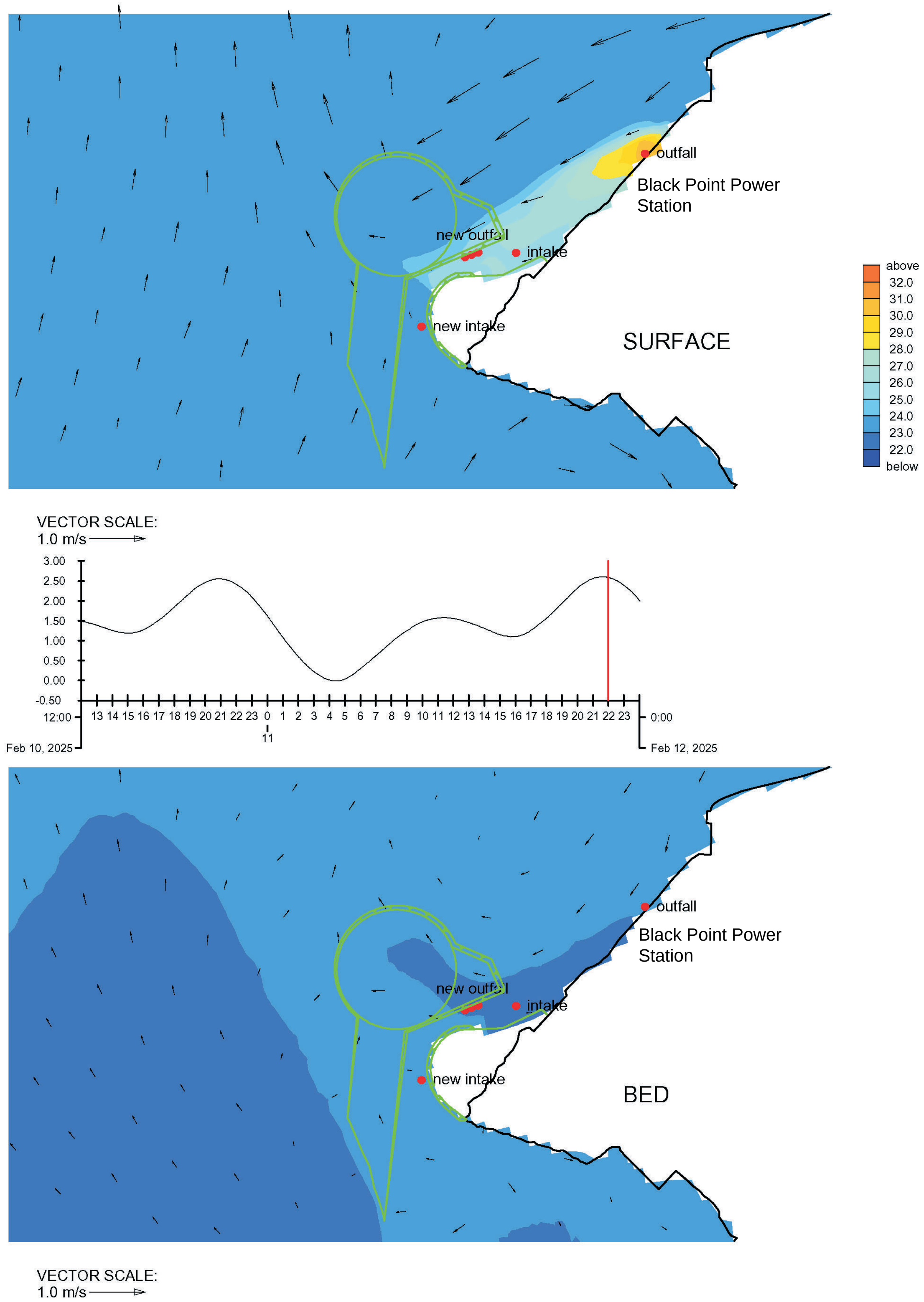
Velocity Vector (m/s) and Temperature (Degree Celsius)

Dry Season, Low Water, Surface (upper) & Bottom (lower)

Maximum project related discharges, 2011

Black Point	
0018180_eia57b	Fig. BP_F03

WL | delft hydraulics



Velocity Vector (m/s) and Temperature (Degree Celsius)

Dry Season, High Water, Surface (upper) & Bottom (lower)

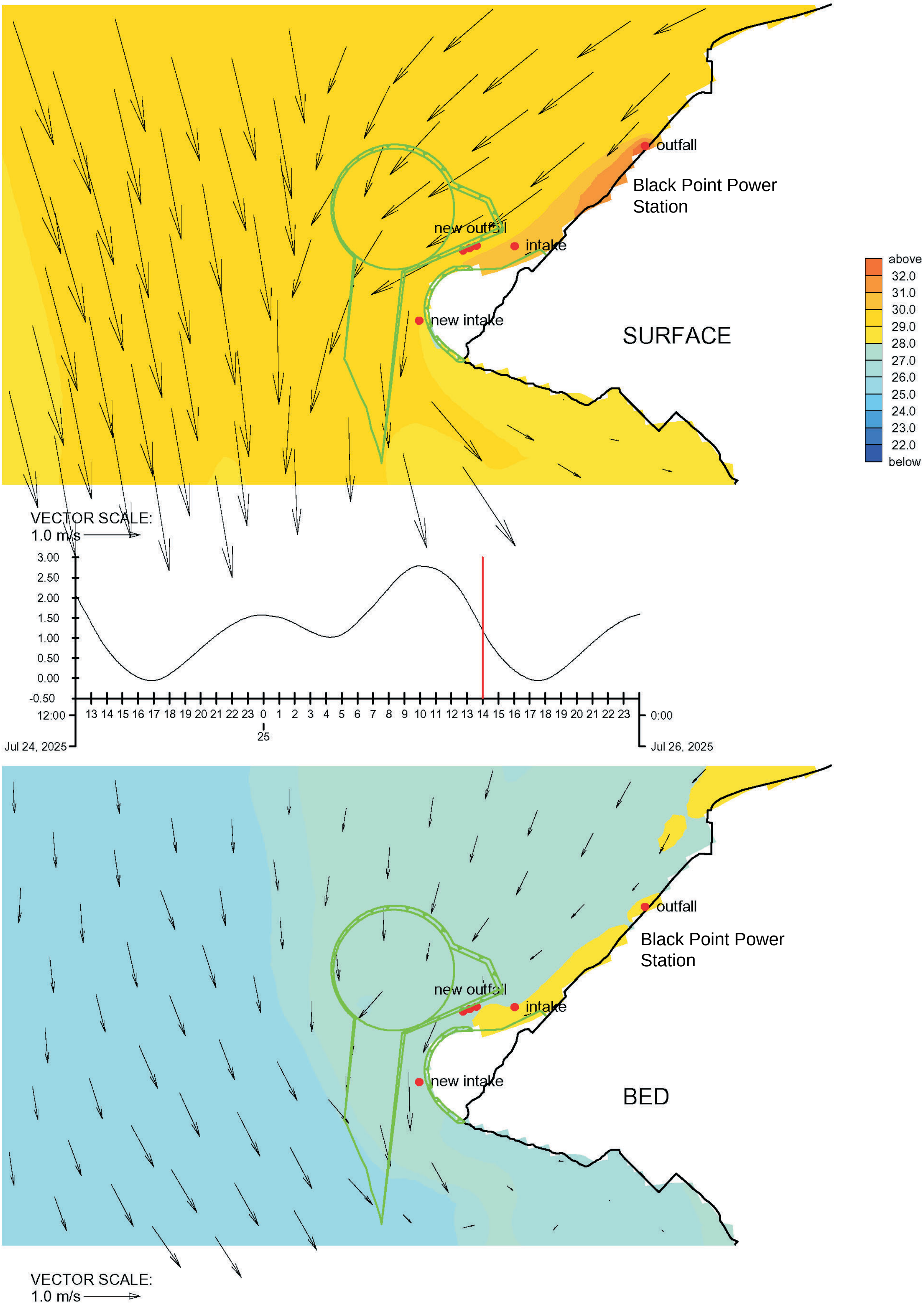
Maximum project related discharges, 2011

Black Point

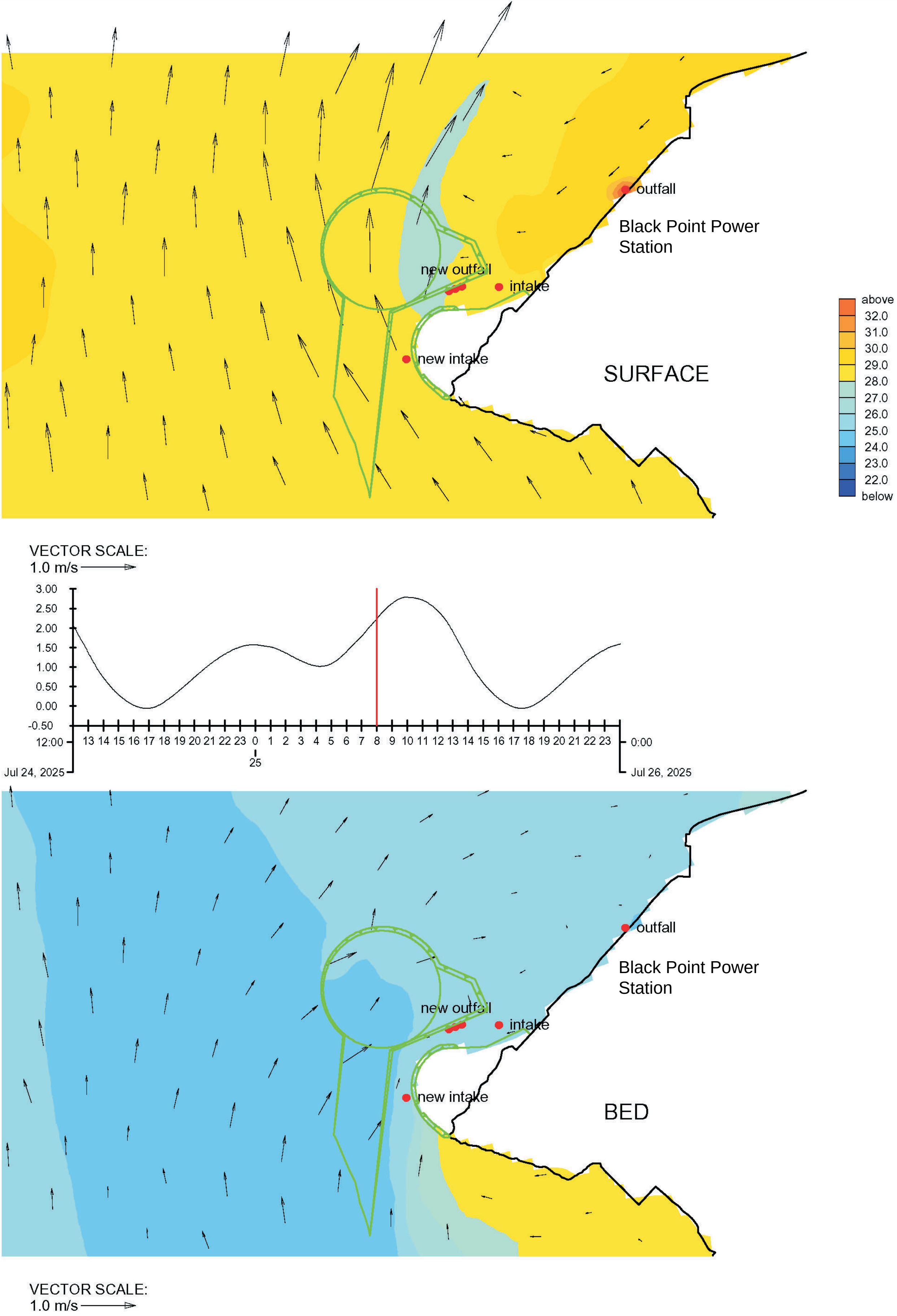
WL | delft hydraulics

0018180_eia57c

Fig. BP_F04



Velocity Vector (m/s) and Temperature (Degree Celsius) Wet Season, Mid-ebb, Surface (upper) & Bottom (lower) Maximum project related discharges, 2011		
	Black Point	
WL | delft hydraulics	0018180_eia57d	Fig. BP_F05



Velocity Vector (m/s) and Temperature (Degree Celsius)

Wet Season, Mid-flood, Surface (upper) & Bottom (lower)

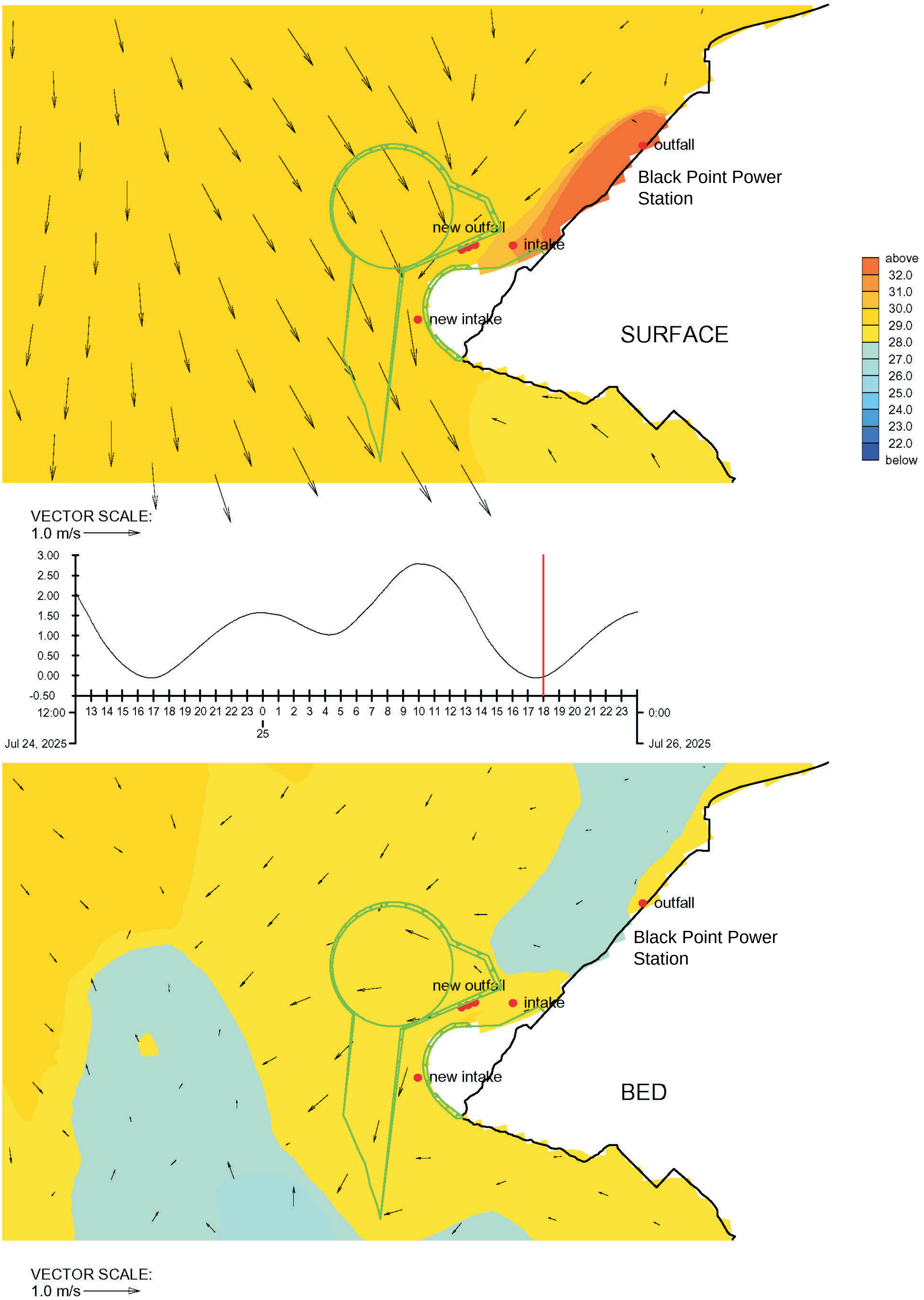
Maximum project related discharges, 2011

Black Point

WL | delft hydraulics

0018180_eia57e

Fig. BP_F06



Velocity Vector (m/s) and Temperature (Degree Celsius)

Wet Season, Low Water, Surface (upper) & Bottom (lower)

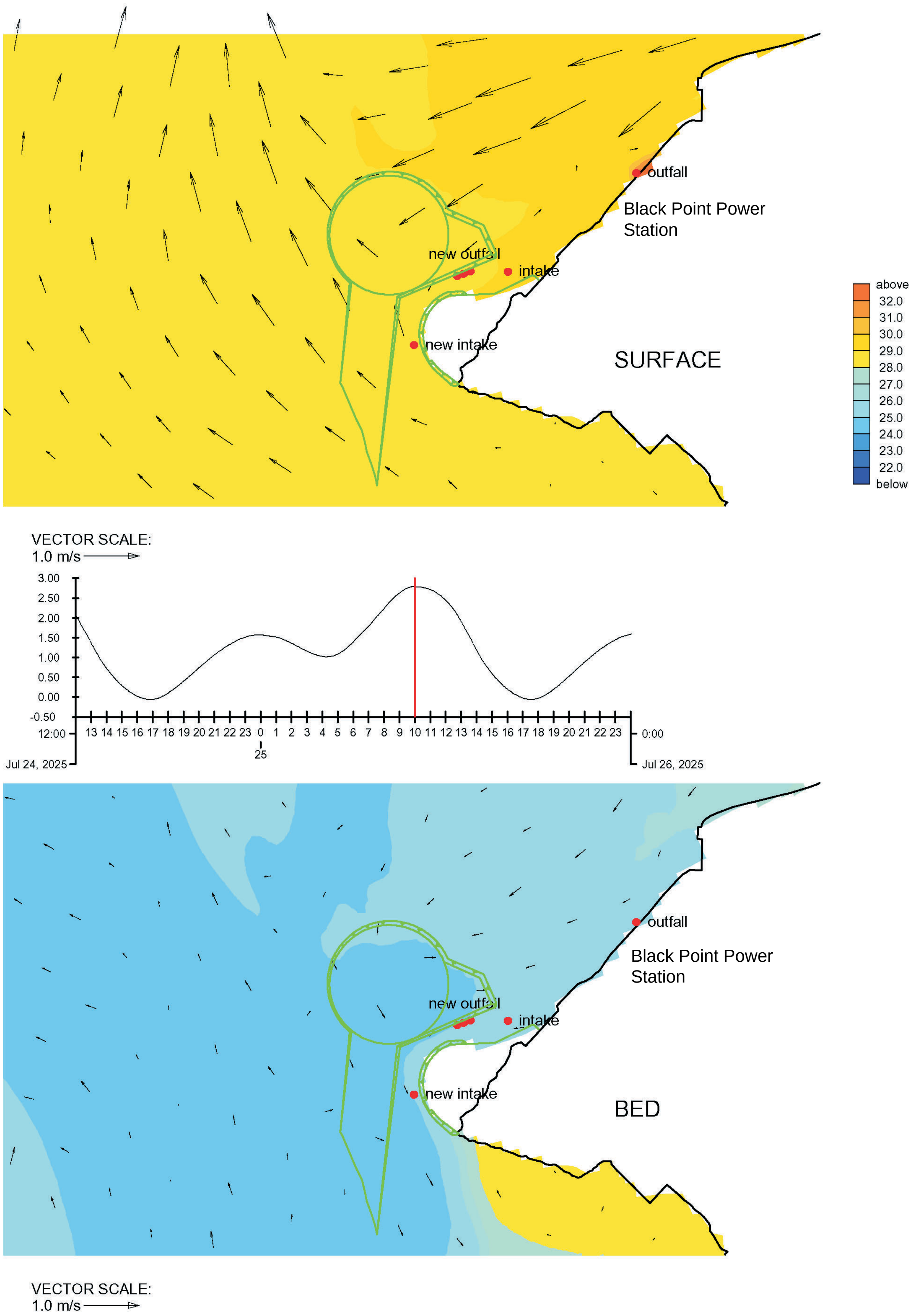
Maximum project related discharges, 2011

Black Point

WL | delft hydraulics

0018180_eia57f

Fig. BP_F07



Velocity Vector (m/s) and Temperature (Degree Celsius)

Wet Season, High Water, Surface (upper) & Bottom (lower)

Maximum project related discharges, 2011

Black Point

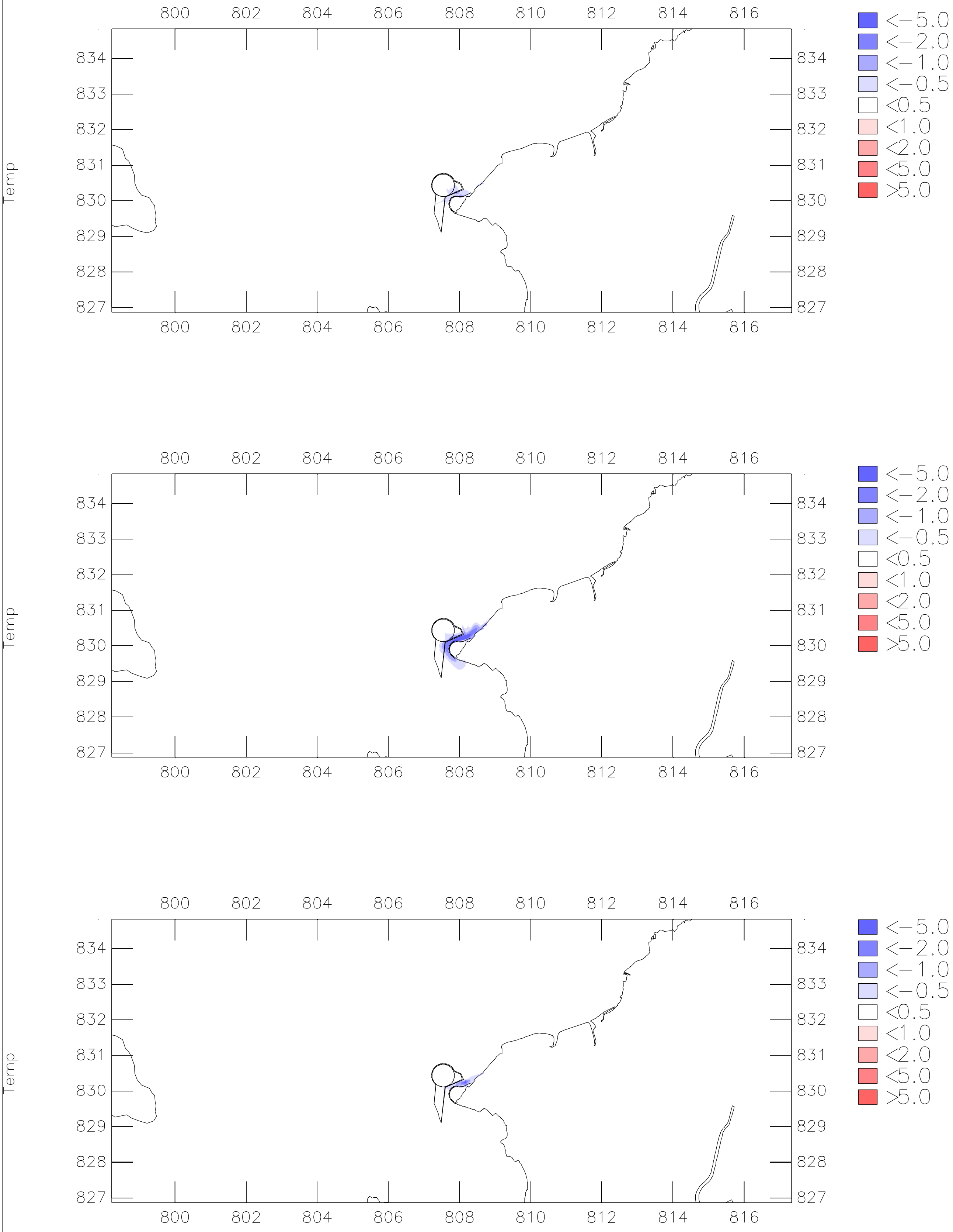
WL | delft hydraulics

0018180_eia57g

Fig. BP_F08

Annex 6G

Operational Phase Model Results - Cooled Water Discharges



Maximum Reduction in Temperature relative to baseline (deg.C)

Maximum discharge: −12.5 deg.C − Black Point

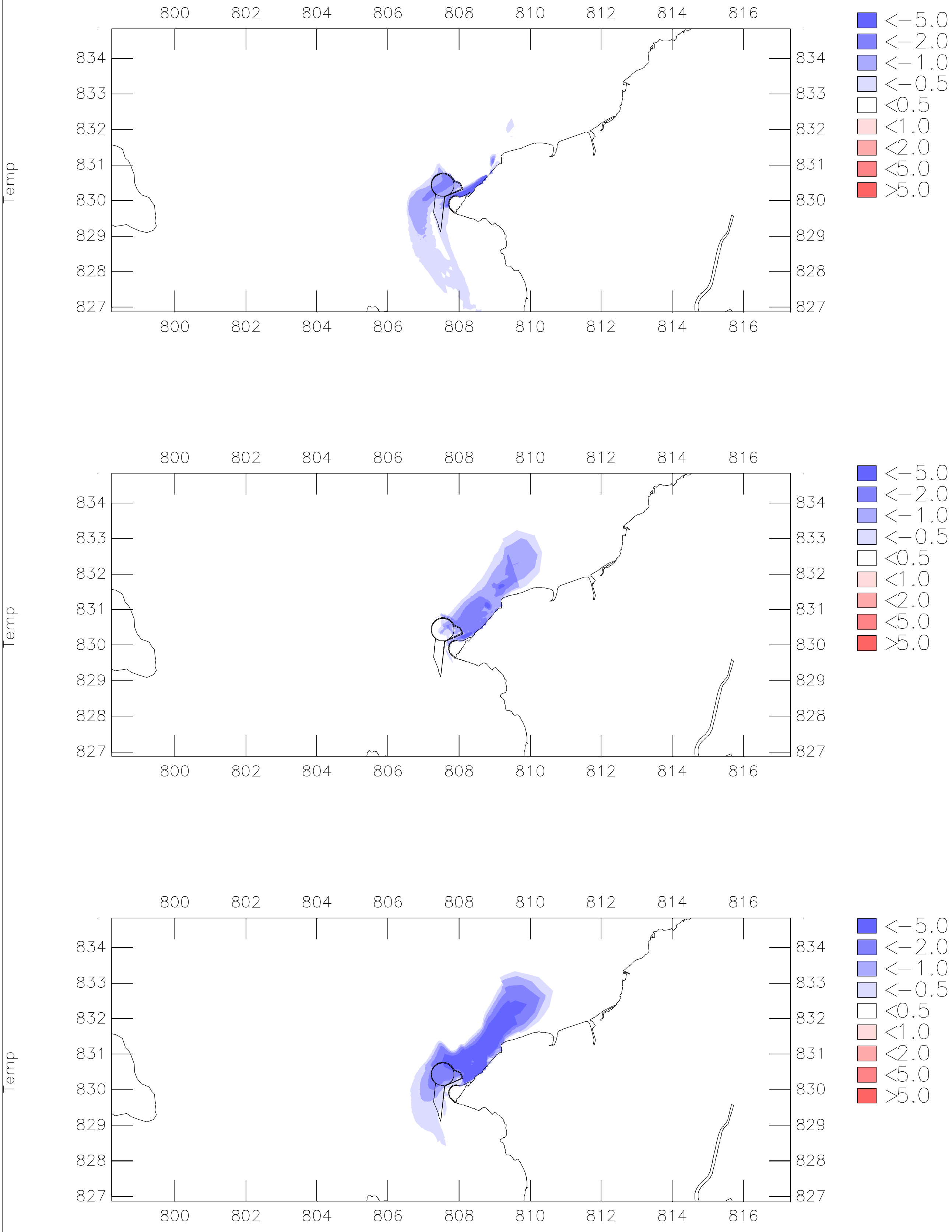
Surface (upper), Bottom (middle), Depth−average (lower)

Maximum Operational Flow

Dry Season

WL | Delft Hydraulics − ERM

Figure_BP-G01



Maximum Reduction in Temperature relative to baseline (deg.C)

Maximum discharge: −12.5 deg.C − Black Point

Surface (upper), Bottom (middle), Depth−average (lower)

WL | Delft Hydraulics − ERM

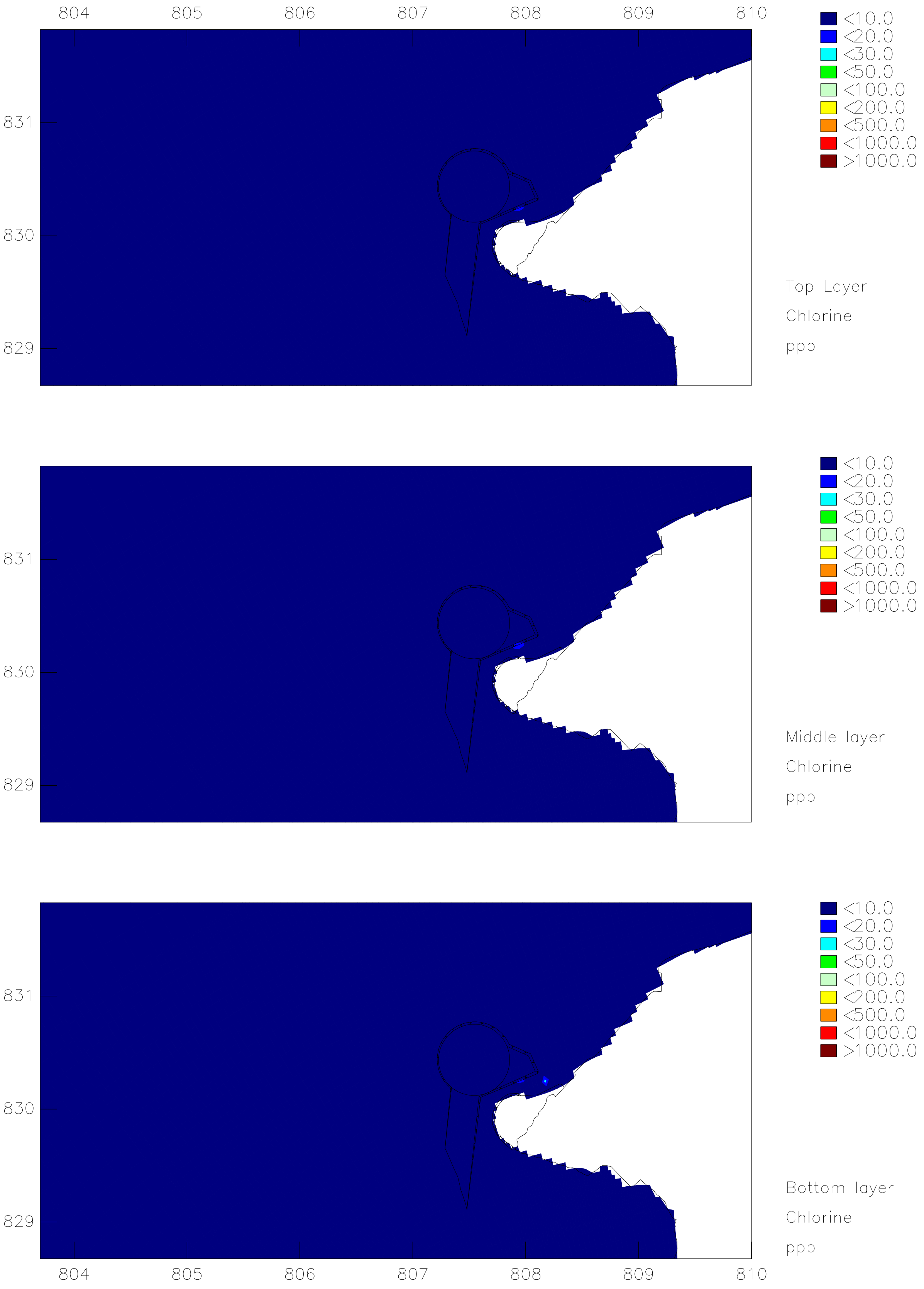
Maximum Operational Flow

Wet Season

Figure_BP-G02

Annex 6H

Operational Phase Model Results - Total Residual Chlorine



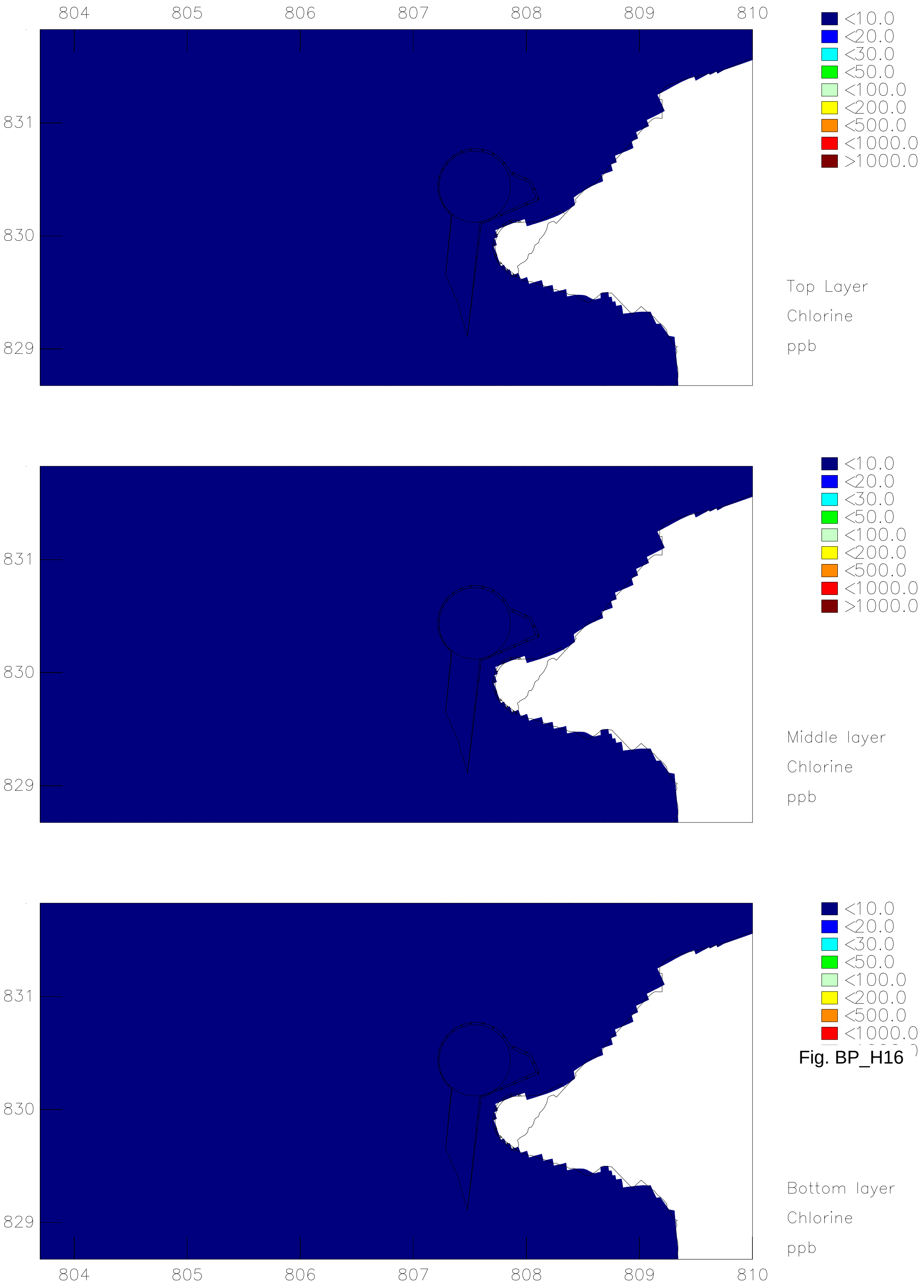
Total Residual Chlorine (ppb) maximum elevation
Black Point LNG emission – Maximum Flow
Top, Middle and Bottom layer

0.3 ppm TRC discharge

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_H01



Top Layer
Chlorine
ppb

Middle layer
Chlorine
ppb

Bottom layer
Chlorine
ppb

Fig. BP_H16

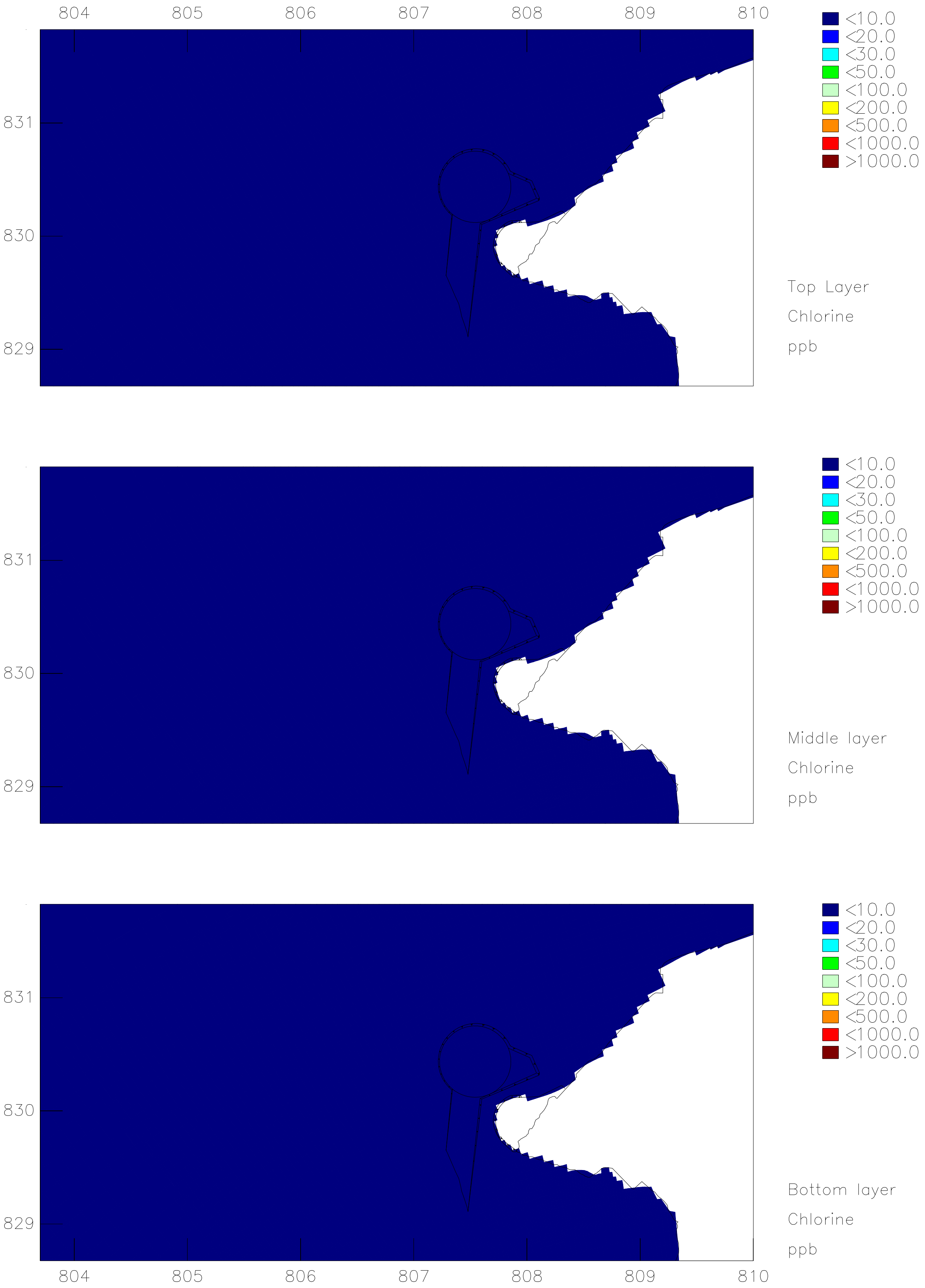
Total Residual Chlorine (ppb) mean elevation
Black Point LNG emission – Maximum Flow
Top, Middle and Bottom layer

0.3 ppm TRC discharge

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_H02



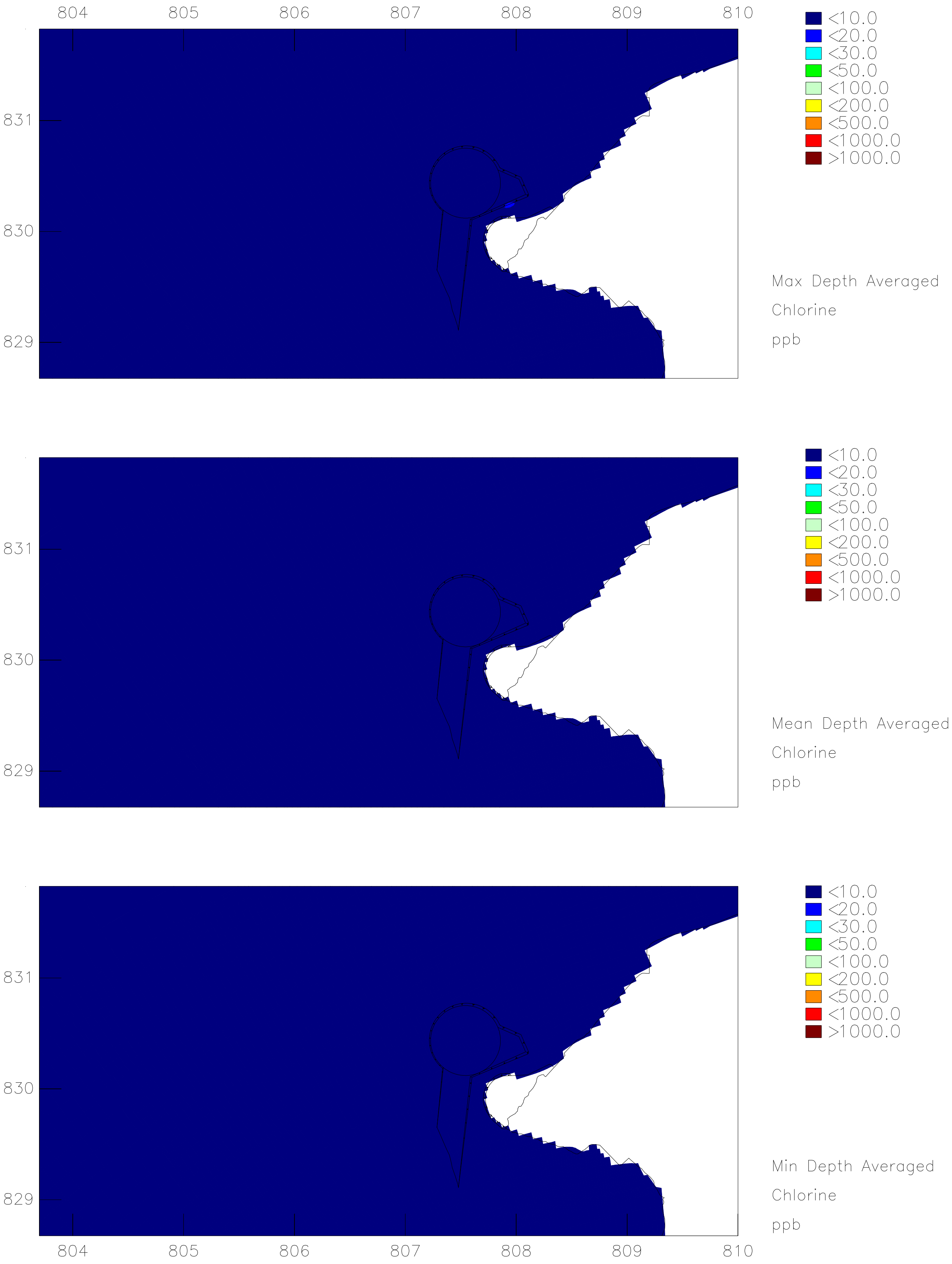
Total Residual Chlorine (ppb) minimum elevation
Black Point LNG emission – Maximum Flow
Top, Middle and Bottom layer

0.3 ppm TRC discharge

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_H03



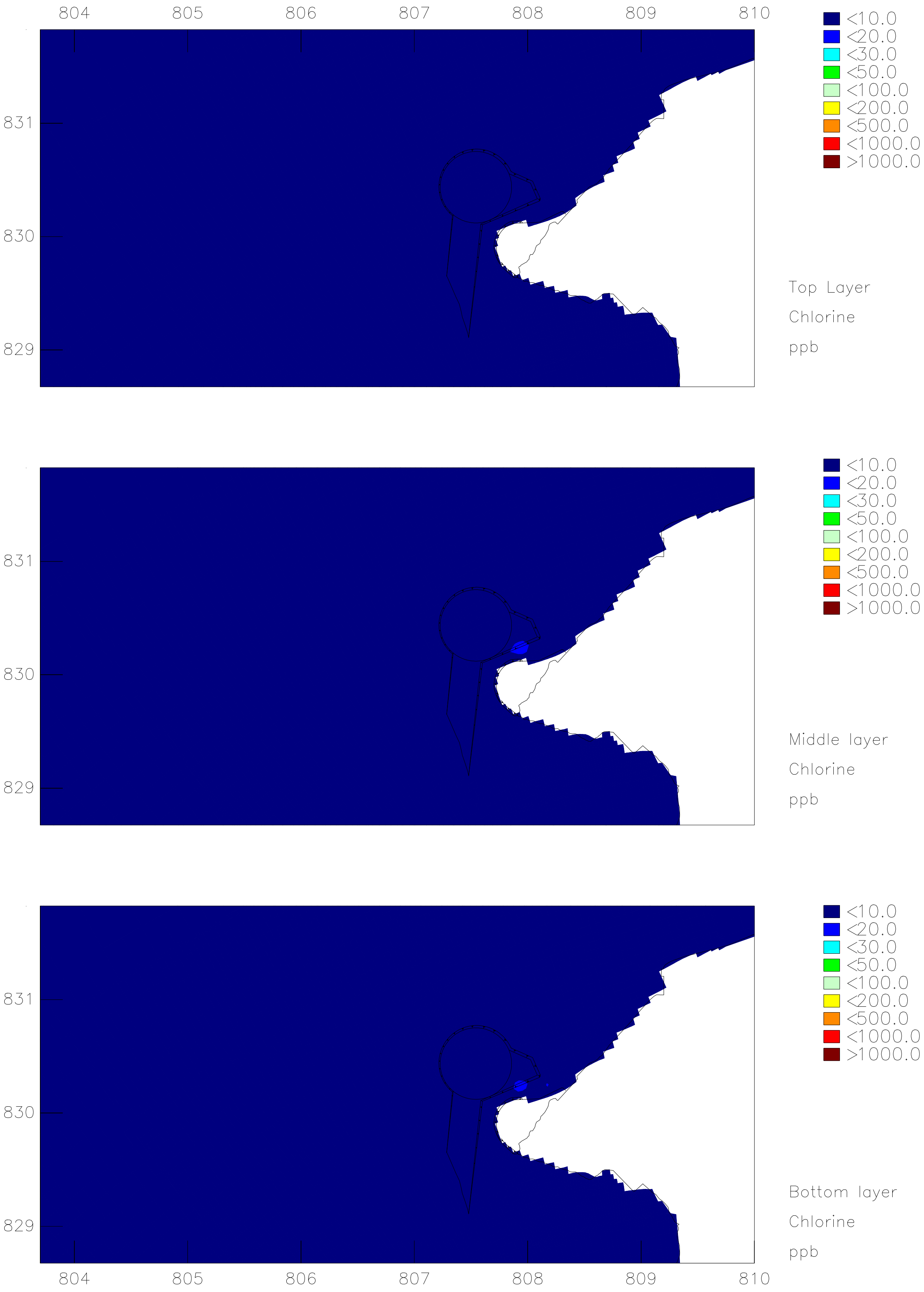
Total Residual Chlorine (ppb)
Black Point LNG emission – Maximum Flow
Maximum, Mean and Minimum depth averaged elevation

0.3 ppm TRC discharge

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_H04



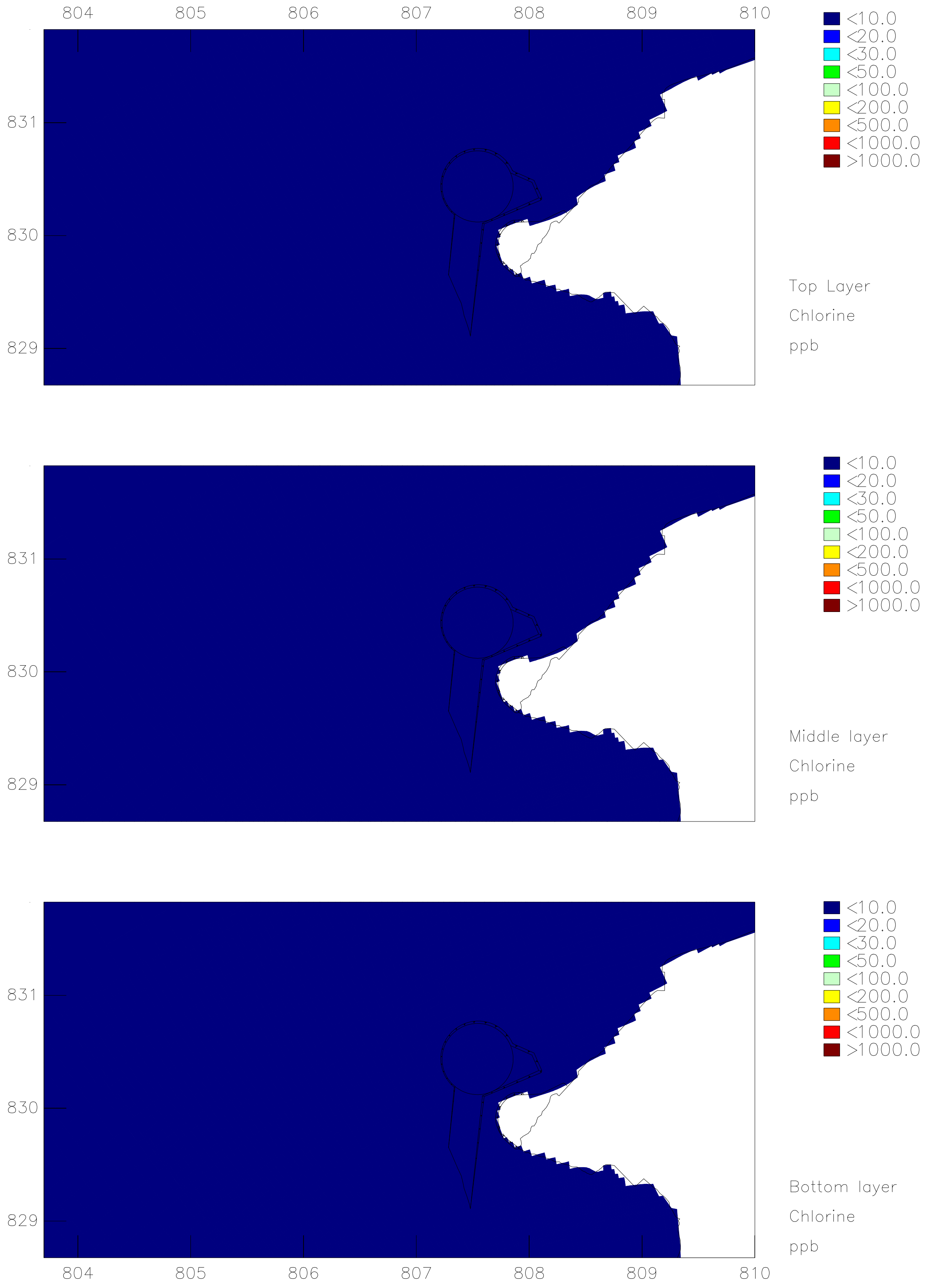
Total Residual Chlorine (ppb) maximum elevation
Black Point LNG emission – Maximum Flow
Top, Middle and Bottom layer

0.3 ppm TRC discharge

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_H05



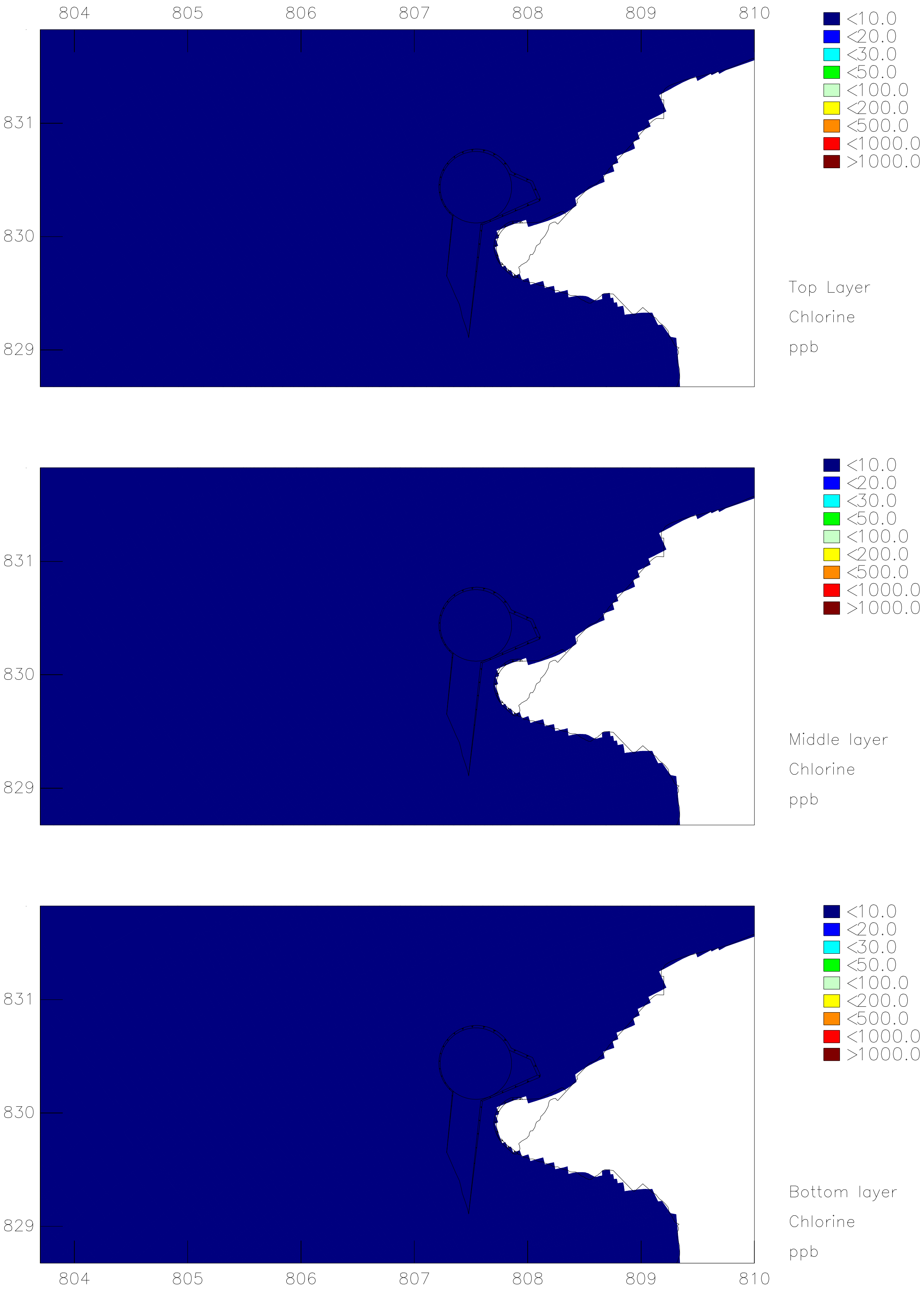
Total Residual Chlorine (ppb) mean elevation
Black Point LNG emission – Maximum Flow
Top, Middle and Bottom layer

0.3 ppm TRC discharge

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_H06



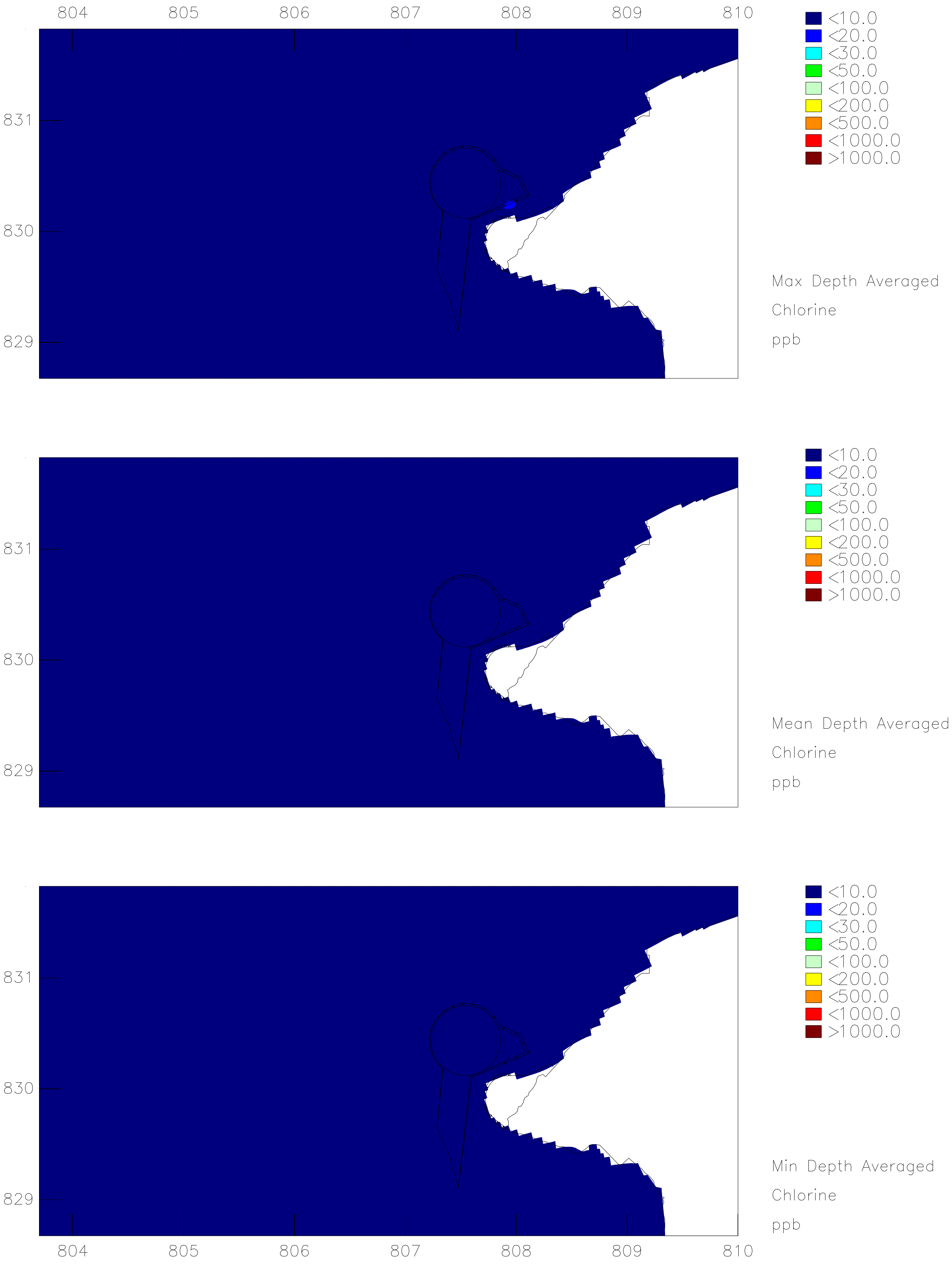
Total Residual Chlorine (ppb) minimum elevation
Black Point LNG emission – Maximum Flow
Top, Middle and Bottom layer

0.3 ppm TRC discharge

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_H07



Max Depth Averaged
Chlorine
ppb

Mean Depth Averaged
Chlorine
ppb

Min Depth Averaged
Chlorine
ppb

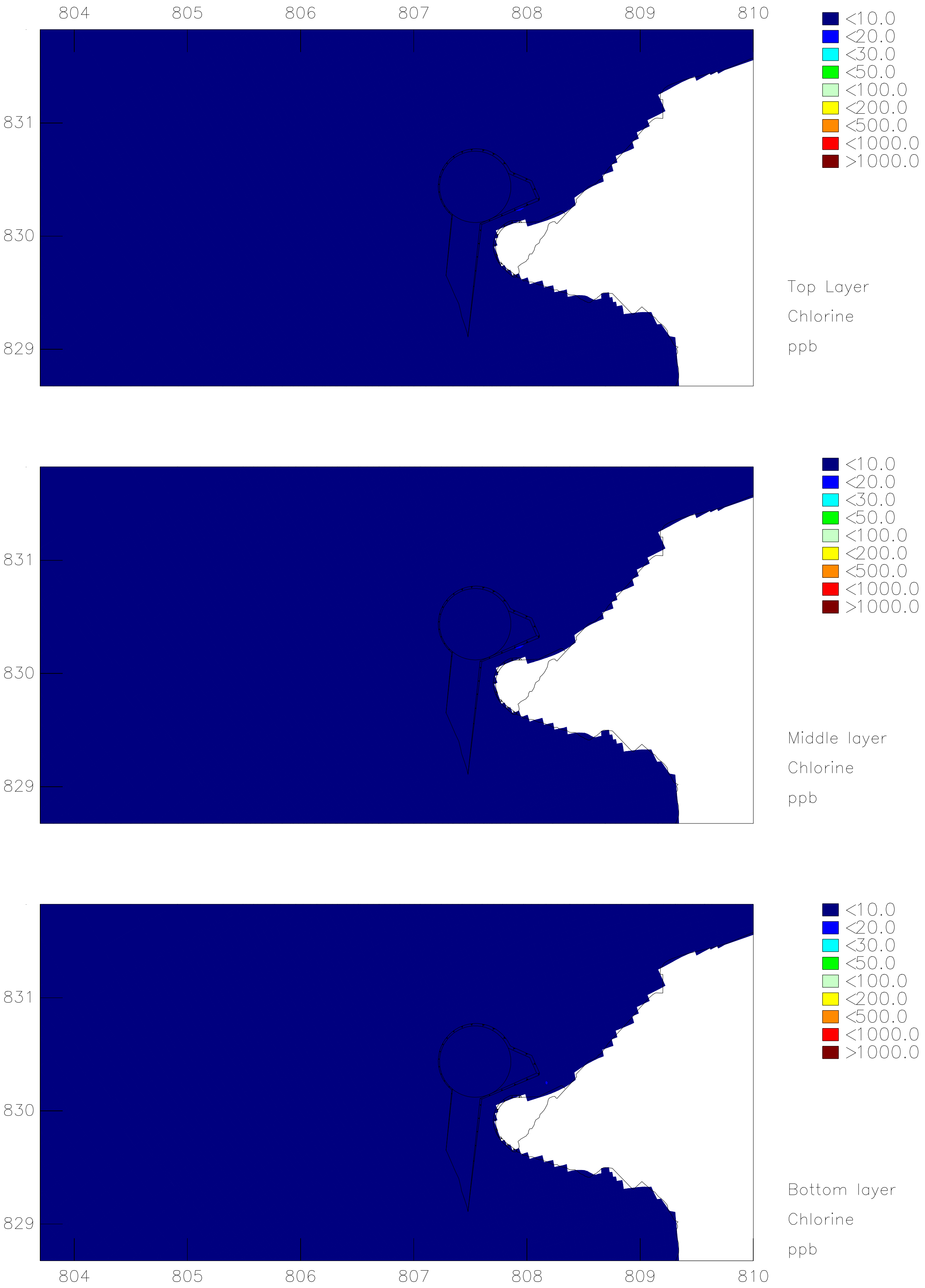
Total Residual Chlorine (ppb)
Black Point LNG emission – Maximum Flow
Maximum, Mean and Minimum depth averaged elevation

0.3 ppm TRC discharge

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_H08



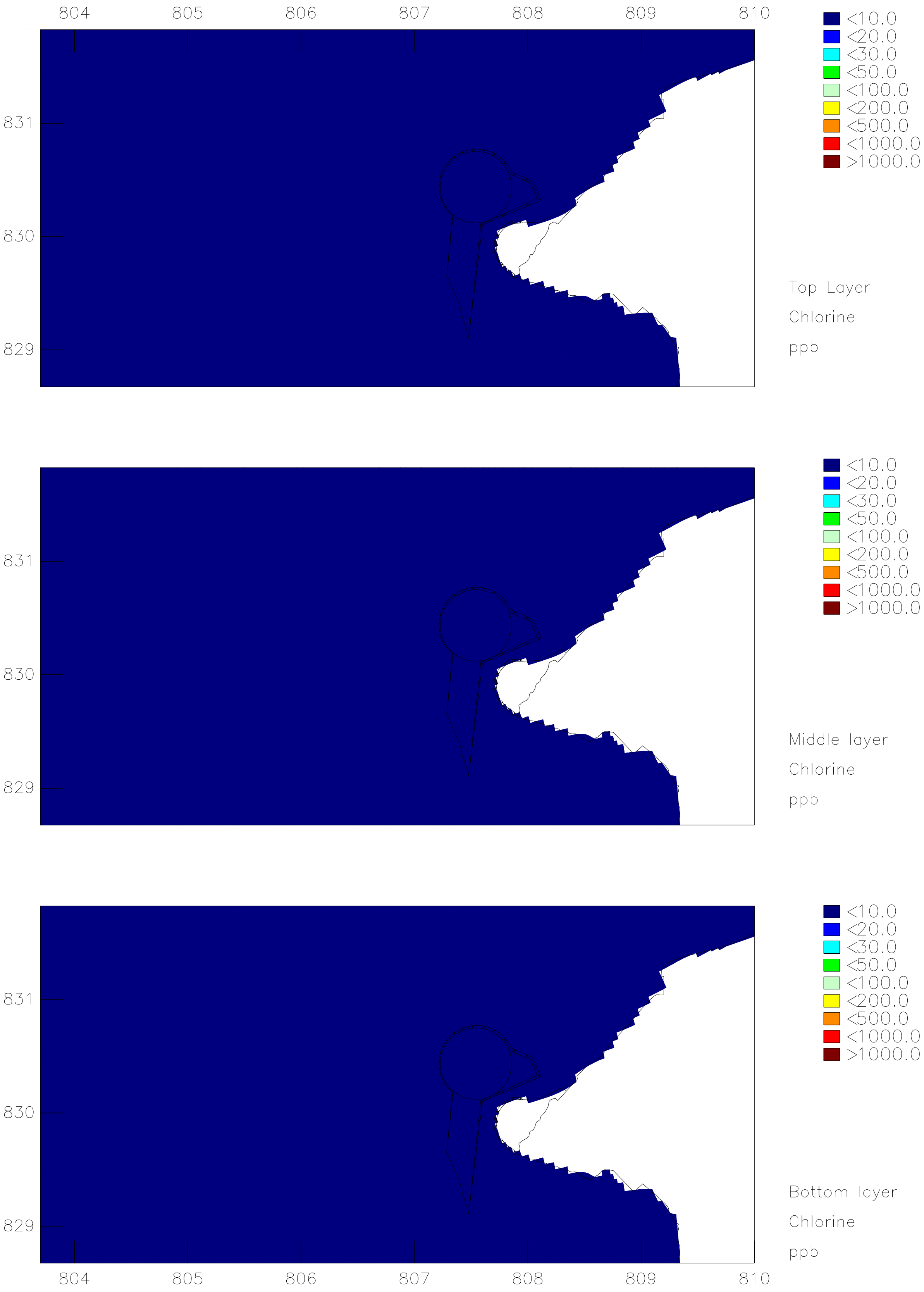
Total Residual Chlorine (ppb) maximum elevation
Black Point LNG emission – Seasonal Varied Flow
Top, Middle and Bottom layer

0.3 ppm TRC discharge

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_H09



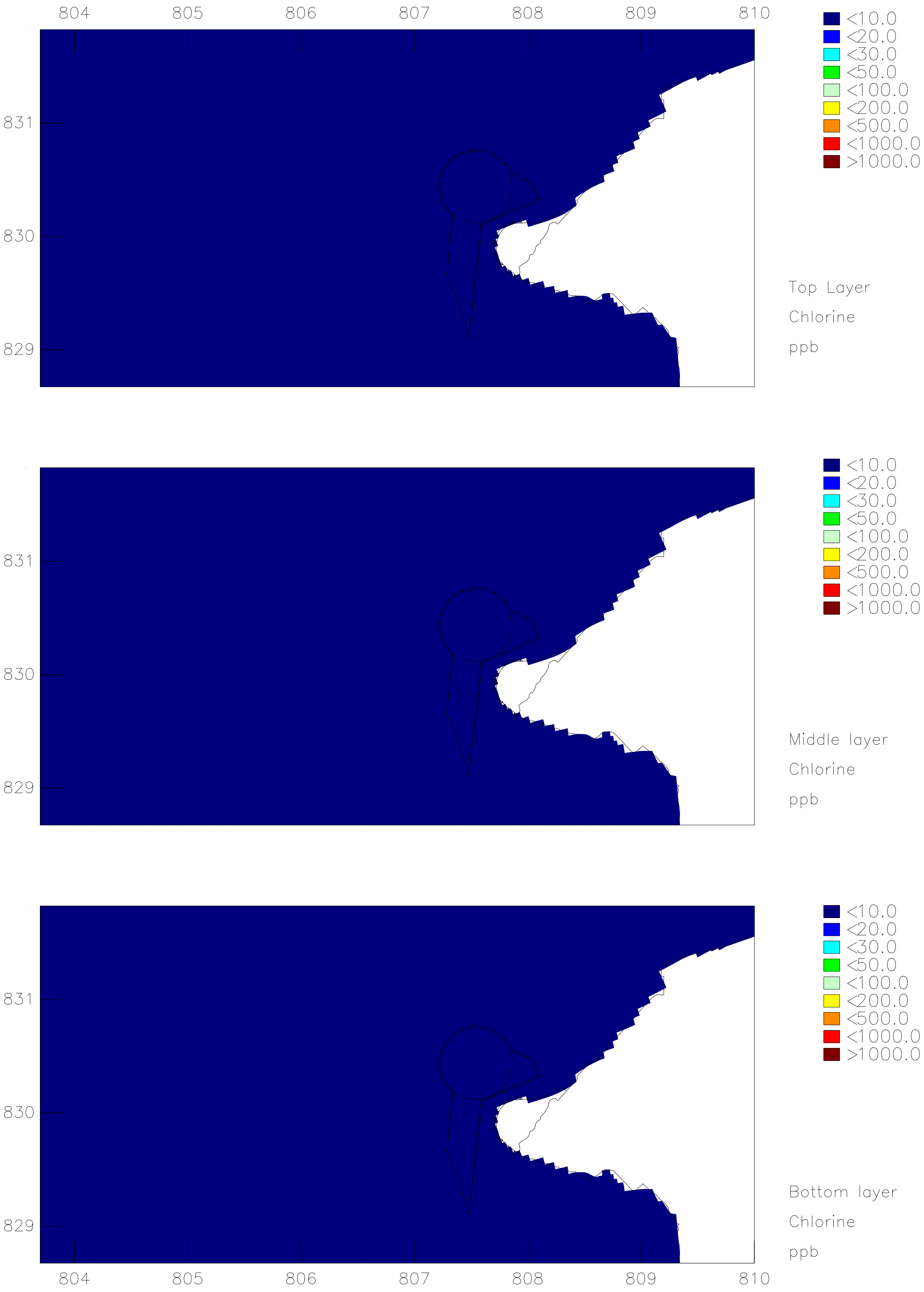
Total Residual Chlorine (ppb) mean elevation
Black Point LNG emission – Seasonal Varied Flow
Top, Middle and Bottom layer

0.3 ppm TRC discharge

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_H10



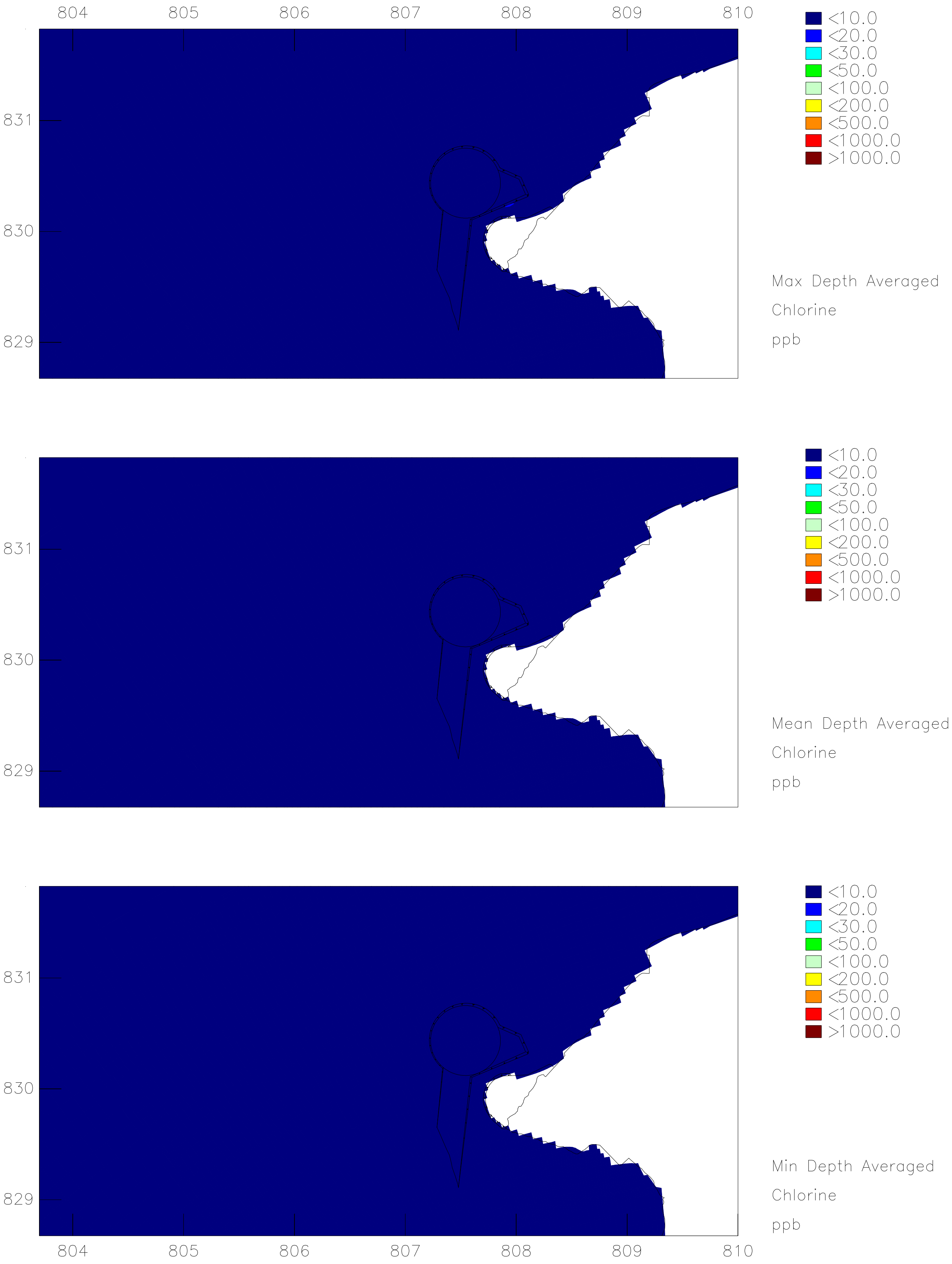
Total Residual Chlorine (ppb) minimum elevation
Black Point LNG emission – Seasonal Varied Flow
Top, Middle and Bottom layer

0.3 ppm TRC discharge

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_H11



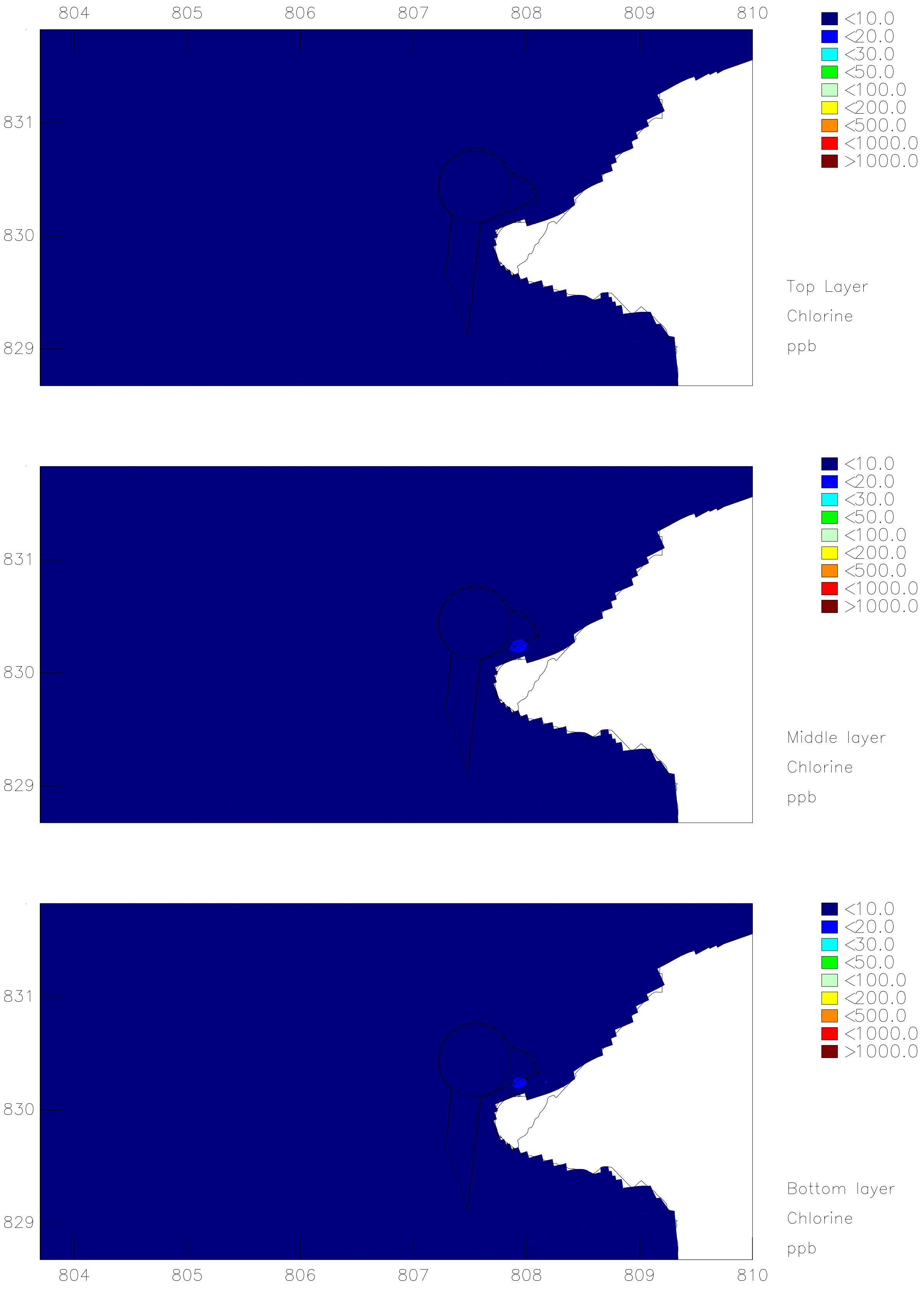
Total Residual Chlorine (ppb)
Black Point LNG emission – Seasonal Varied Flow
Maximum, Mean and Minimum depth averaged elevation

0.3 ppm TRC discharge

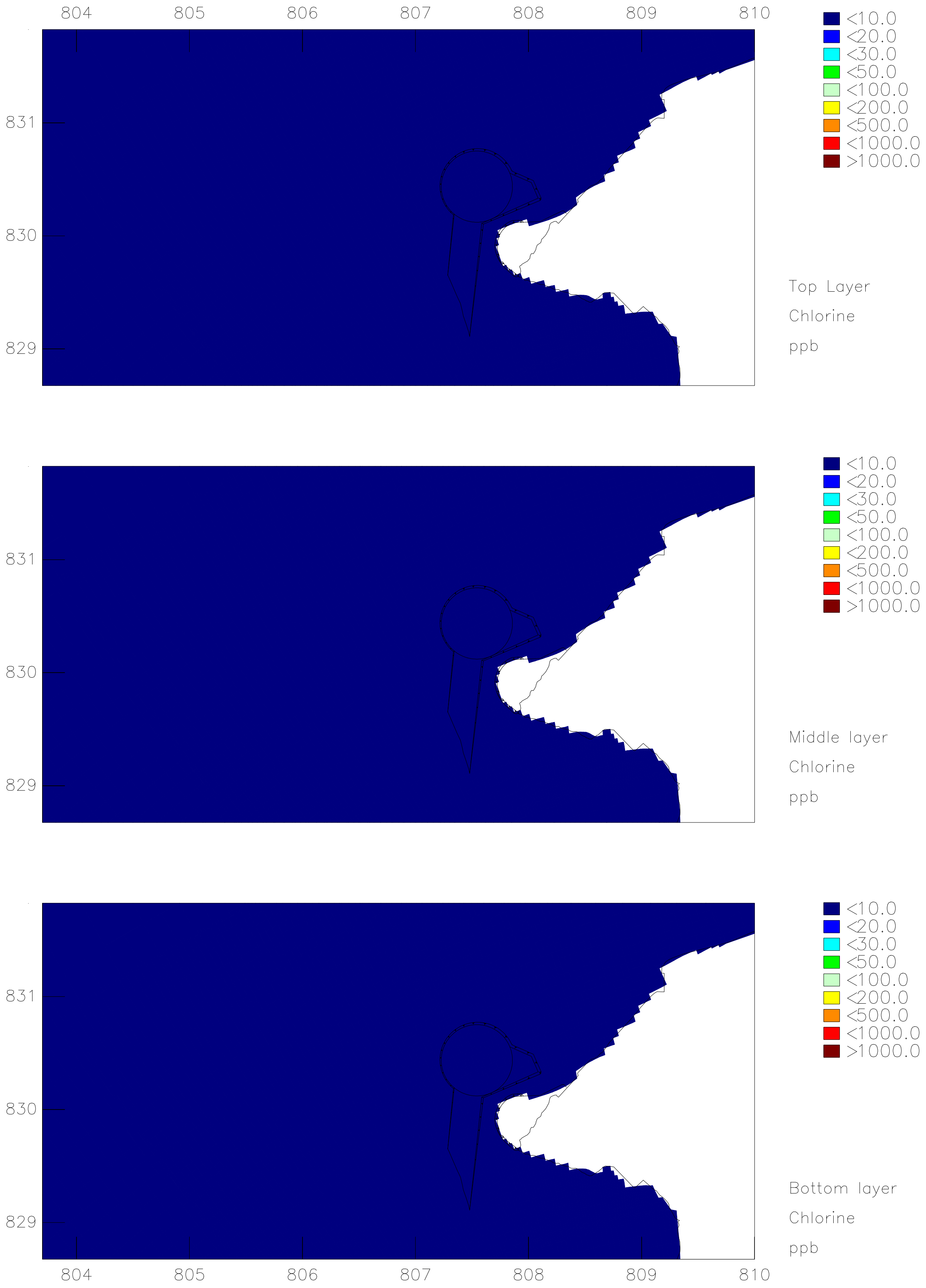
Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_H12



Total Residual Chlorine (ppb) maximum elevation Black Point LNG emission – Seasonal Varied Flow Top, Middle and Bottom layer	0.3 ppm TRC discharge Wet Season
WL | Delft Hydraulics – ERM	Fig. BP_H13



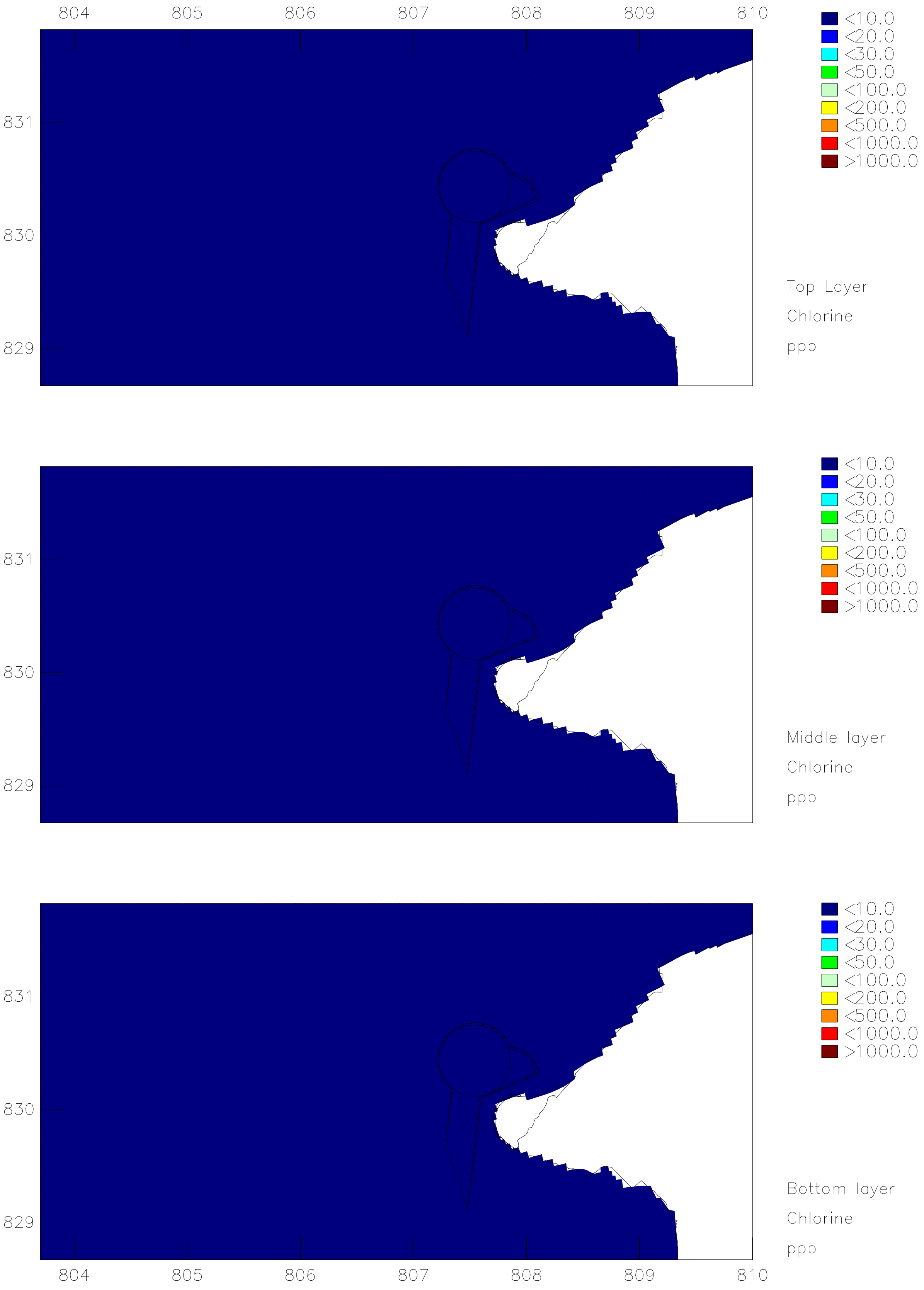
Total Residual Chlorine (ppb) mean elevation
Black Point LNG emission – Seasonal Varied Flow
Top, Middle and Bottom layer

0.3 ppm TRC discharge

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_H14



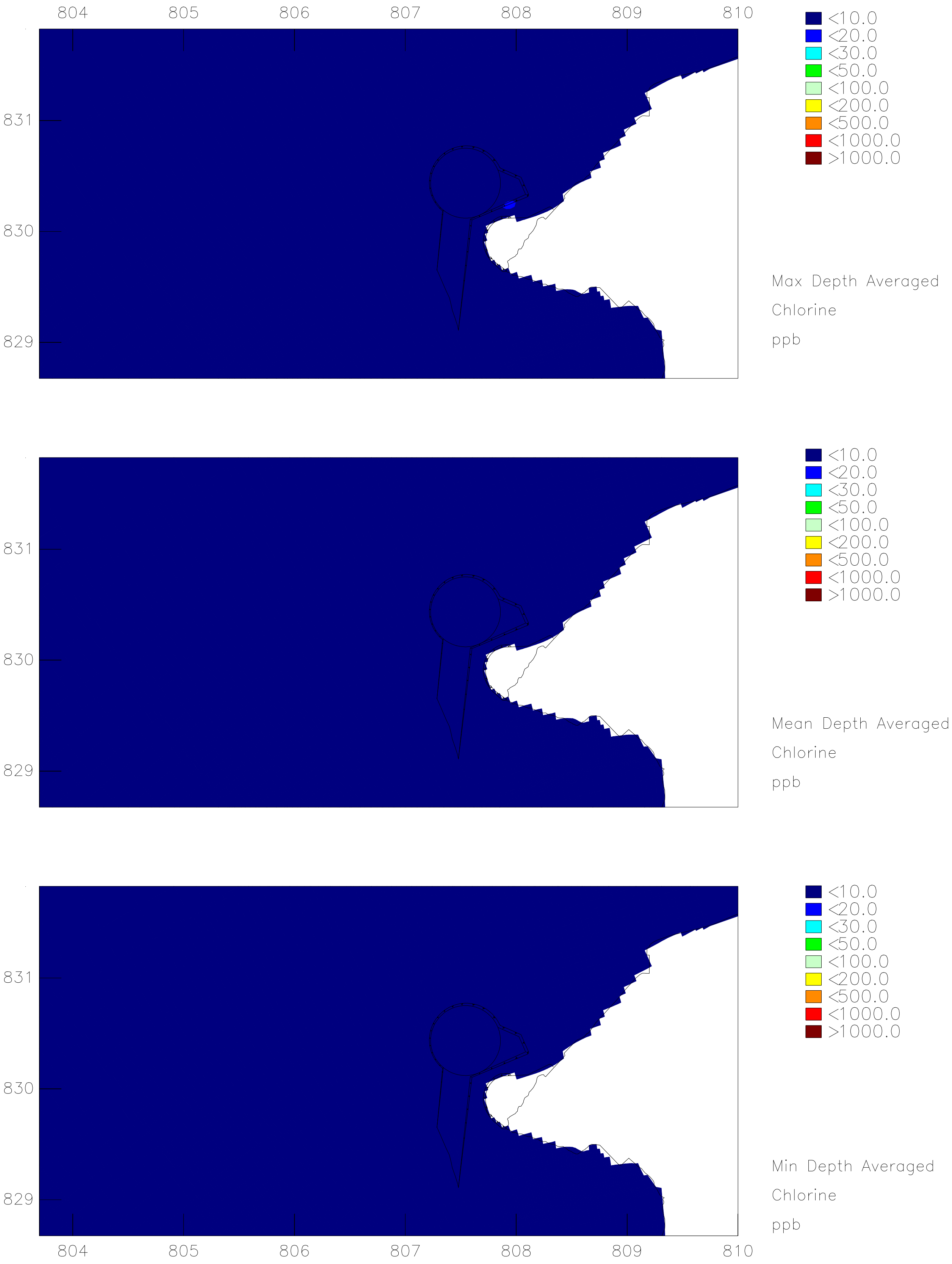
Total Residual Chlorine (ppb) minimum elevation
Black Point LNG emission – Seasonal Varied Flow
Top, Middle and Bottom layer

0.3 ppm TRC discharge

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_H15



Total Residual Chlorine (ppb)
Black Point LNG emission – Seasonal Varied Flow
Maximum, Mean and Minimum depth averaged elevation

0.3 ppm TRC discharge

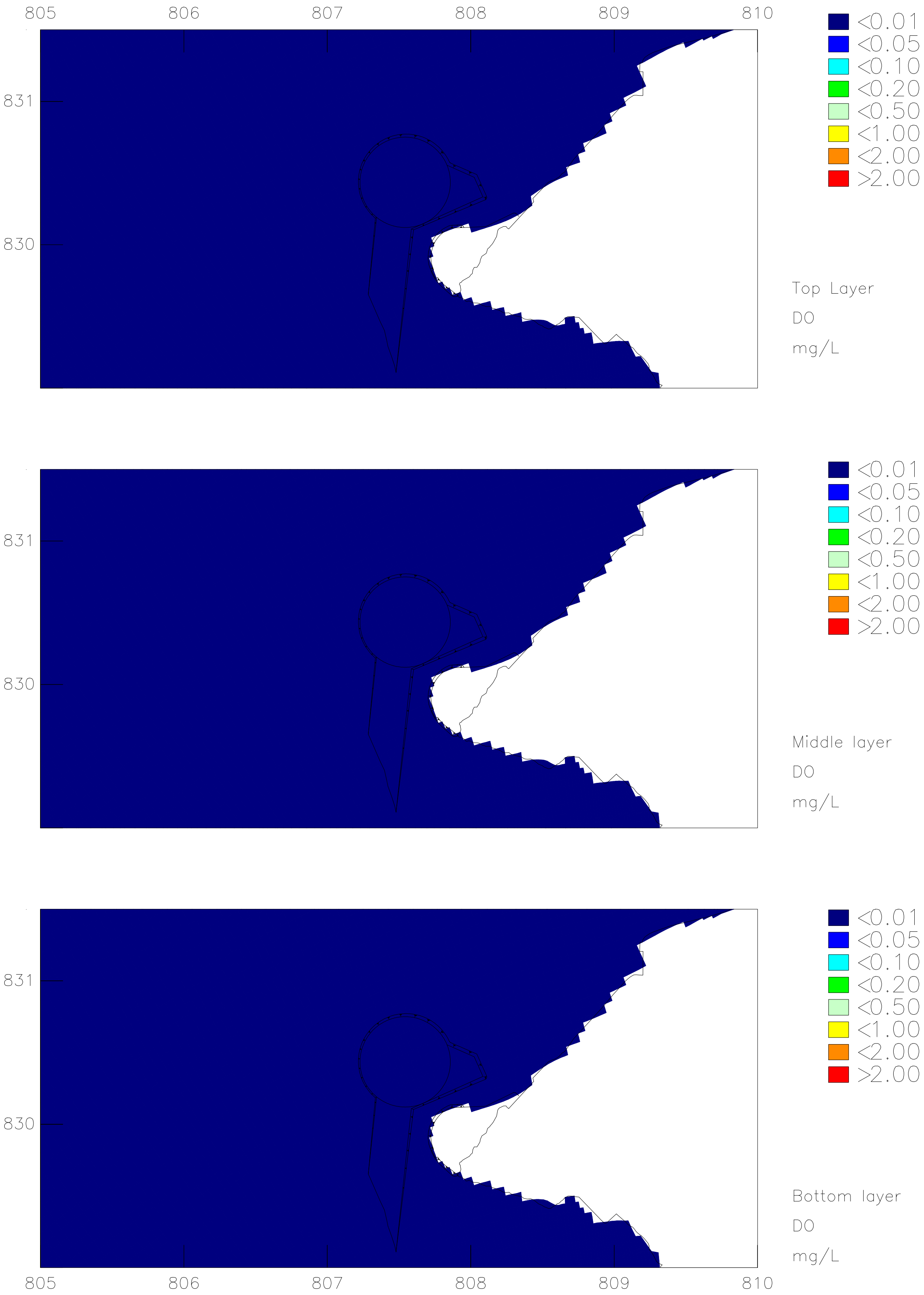
Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_H16

Annex 6I

Operational Phase Model Results - Wastewater Discharges

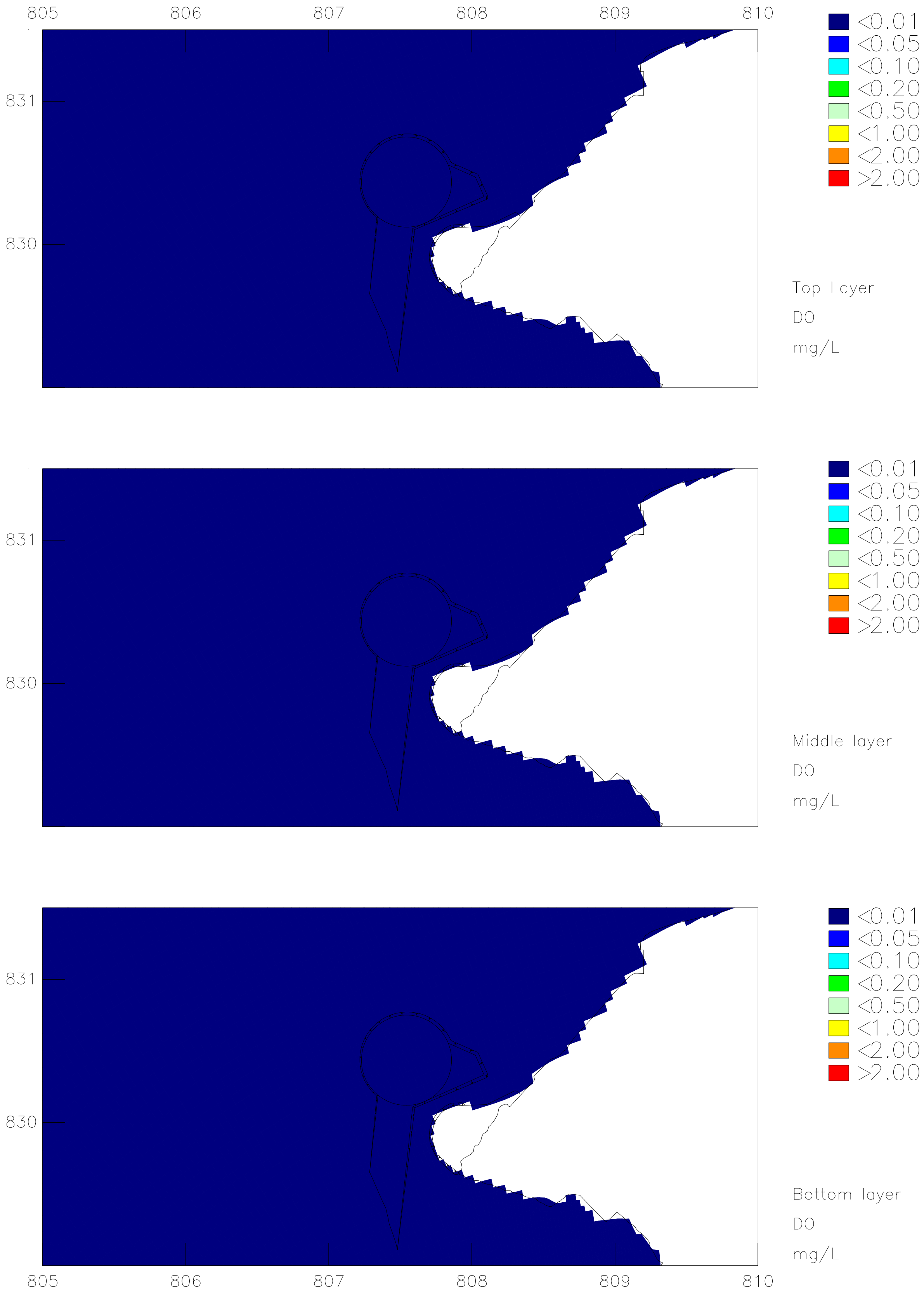


DO (mg/L) maximum decrease
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I01

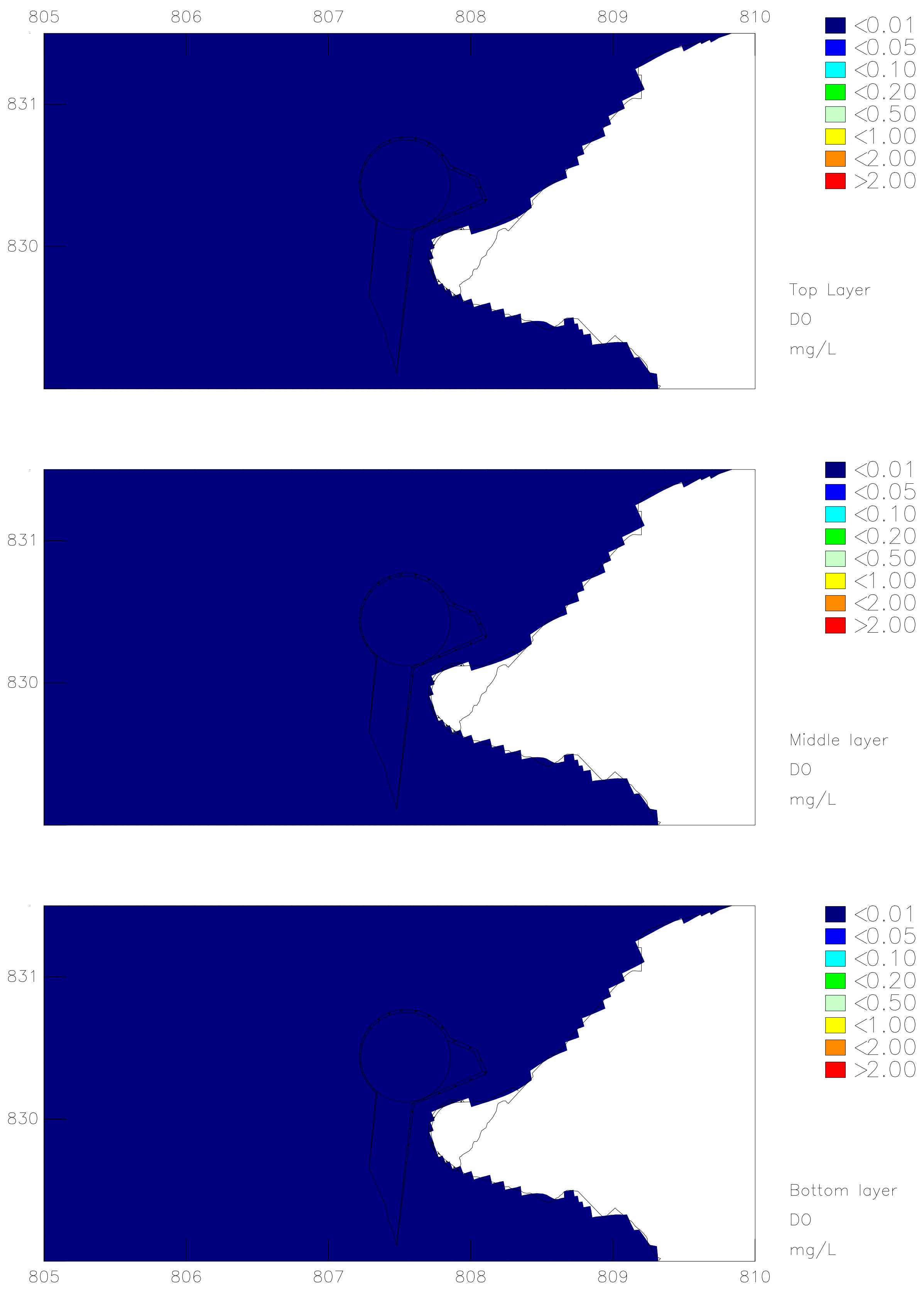


DO (mg/L) mean decrease
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I02

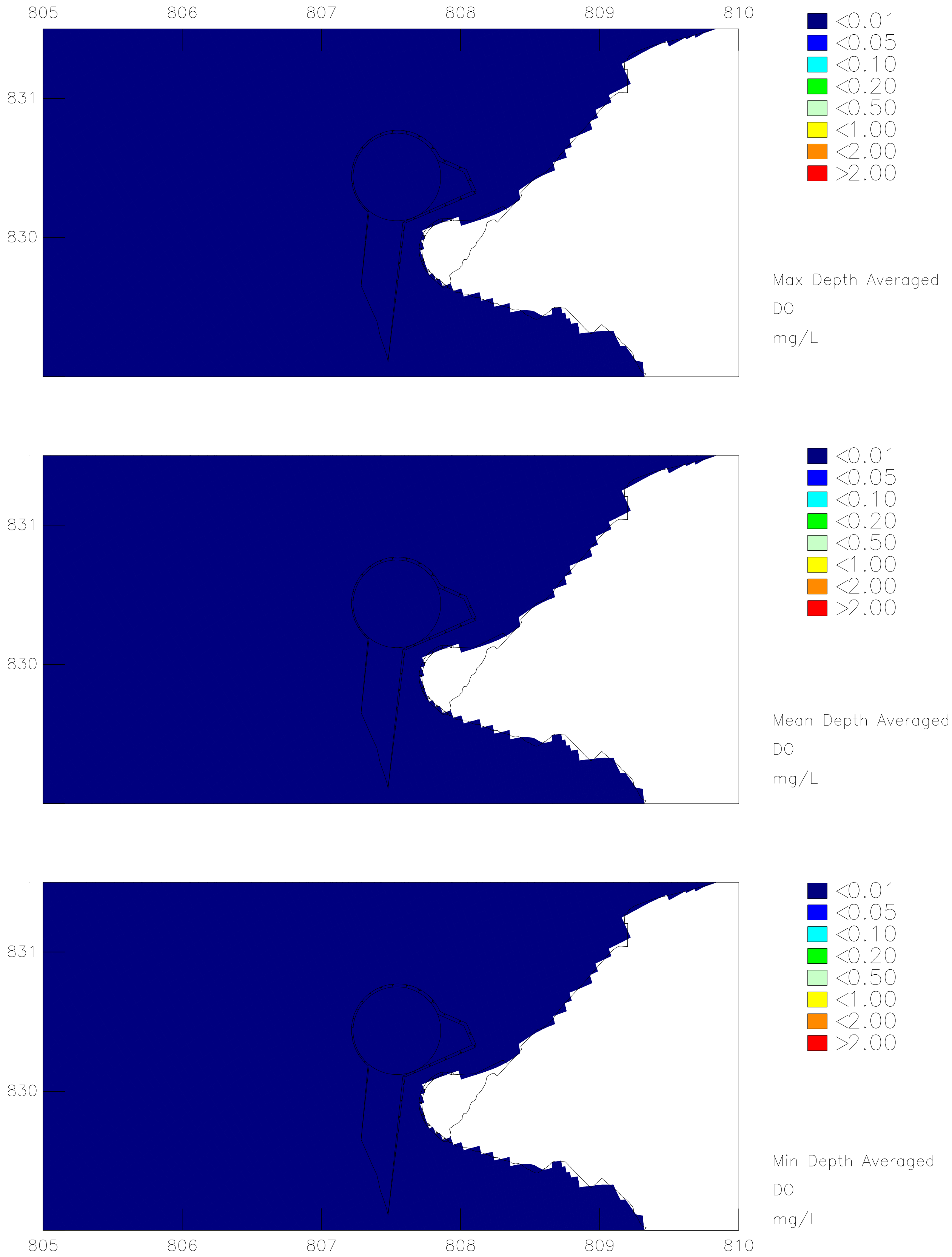


DO (mg/L) minimum decrease
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I03

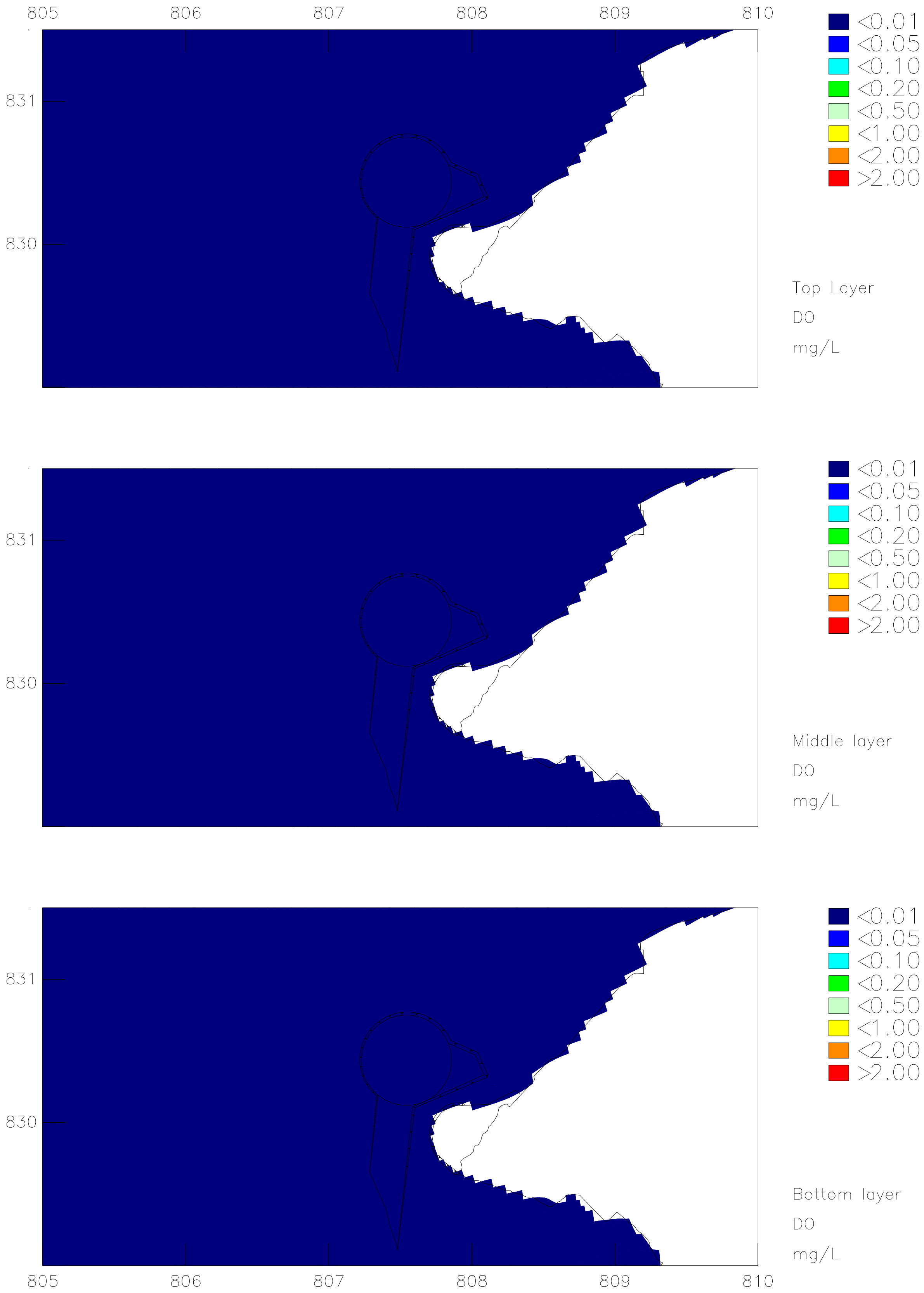


DO (mg/L)
Black Point Sewage emission – Operational
Maximum, Mean and Minimum depth averaged decrease

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I04

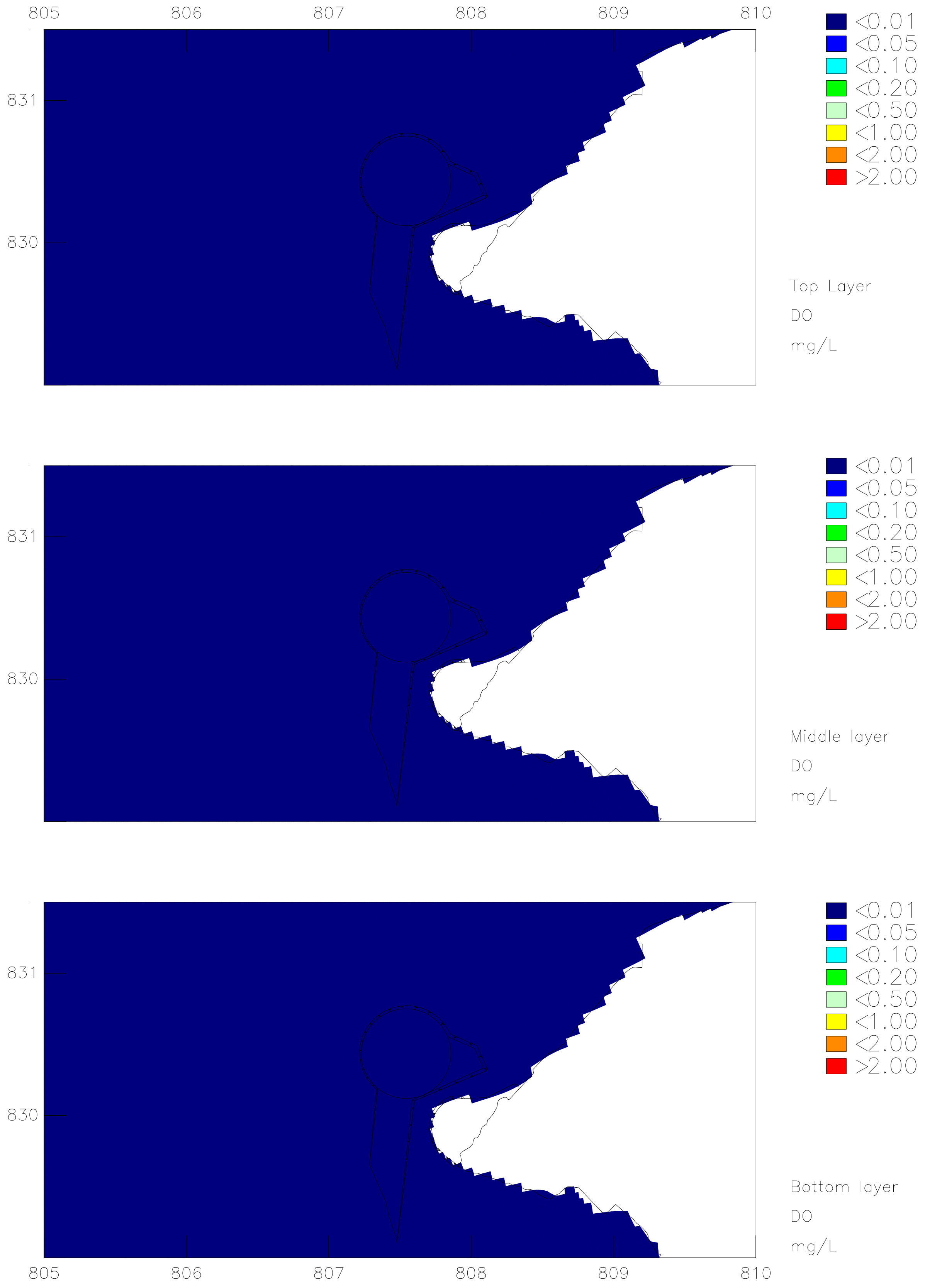


DO (mg/L) maximum decrease
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I05

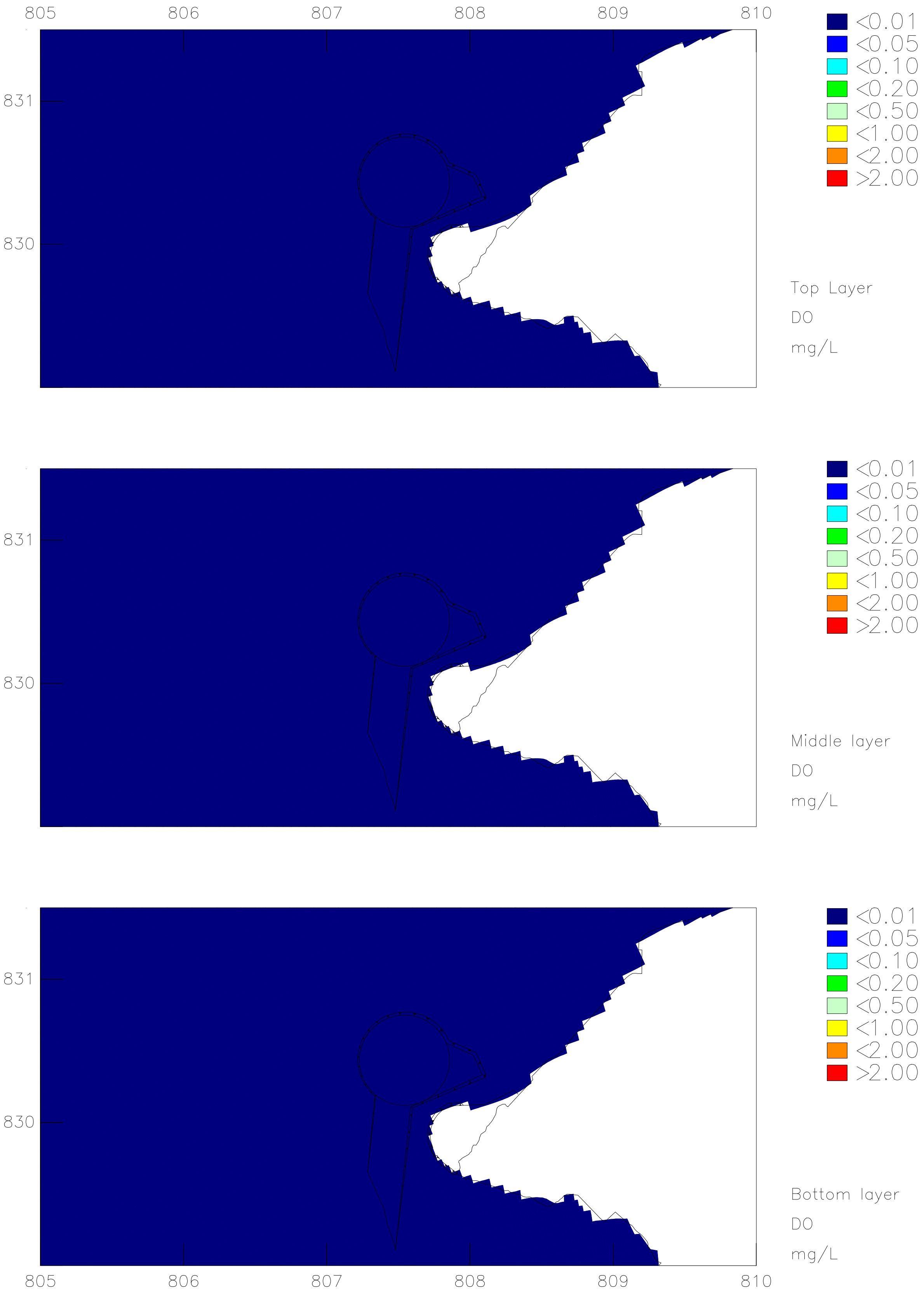


DO (mg/L) mean decrease
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I06

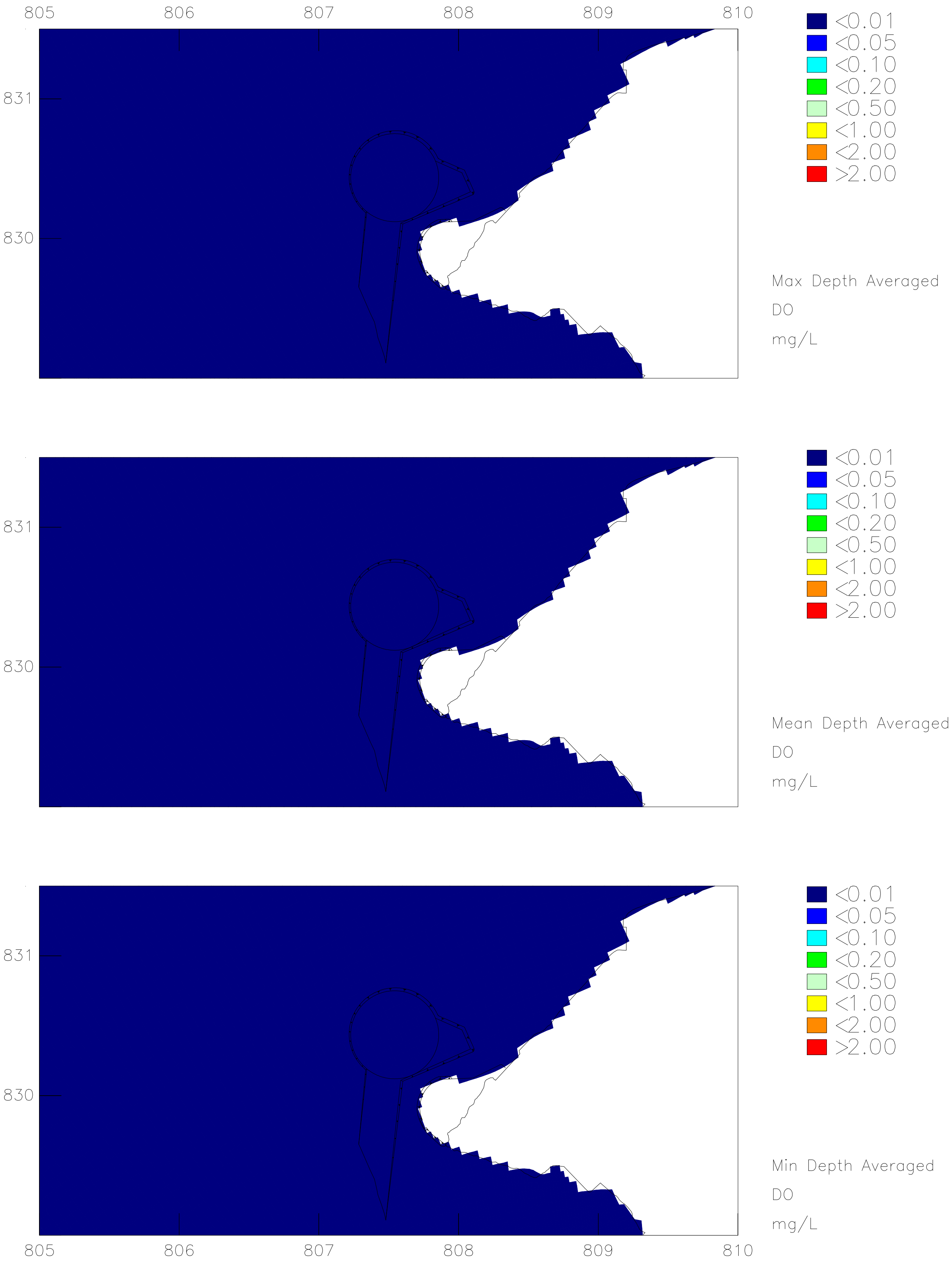


DO (mg/L) minimum decrease
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I07

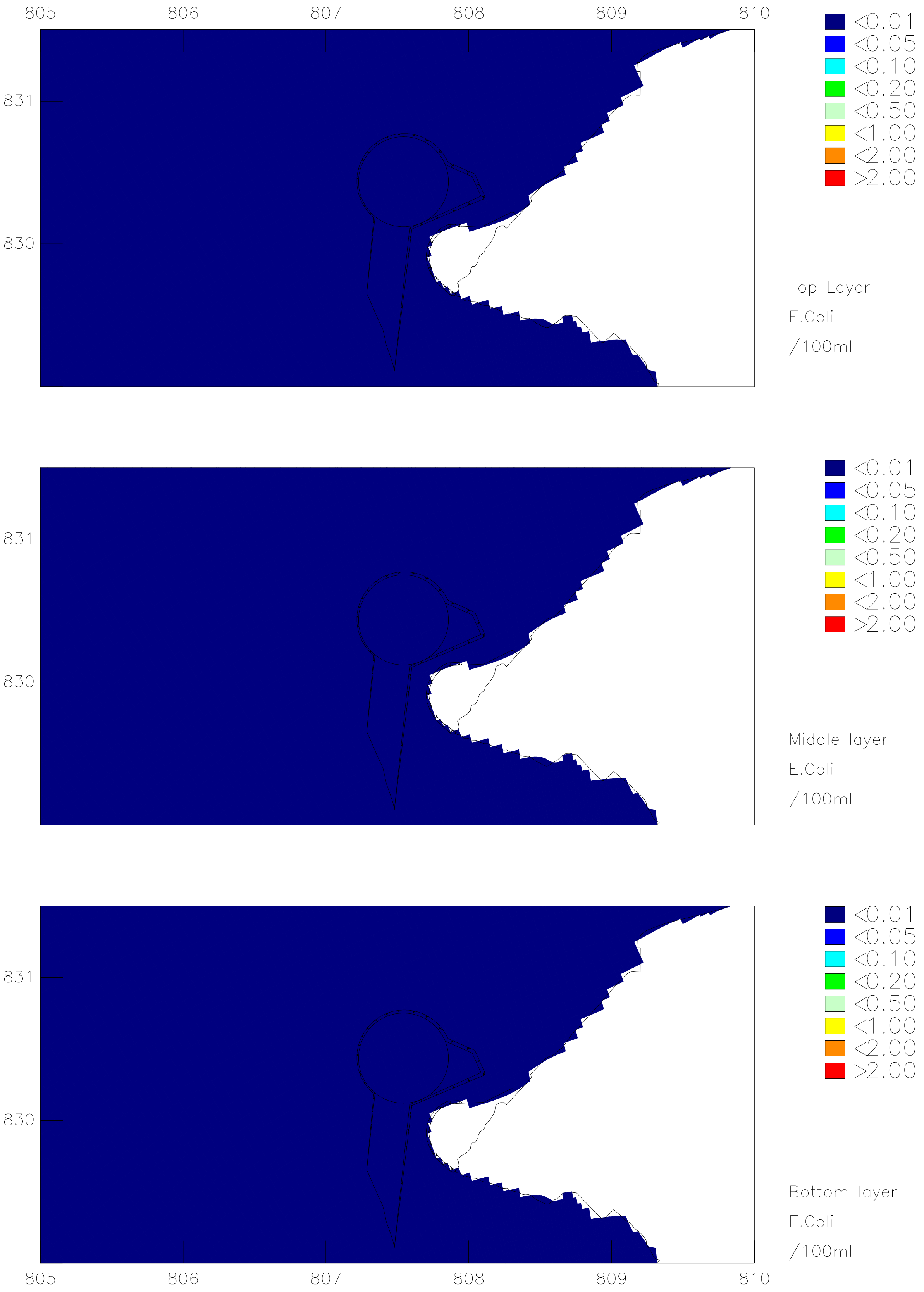


DO (mg/L)
Black Point Sewage emission – Operational
Maximum, Mean and Minimum depth averaged decrease

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I08

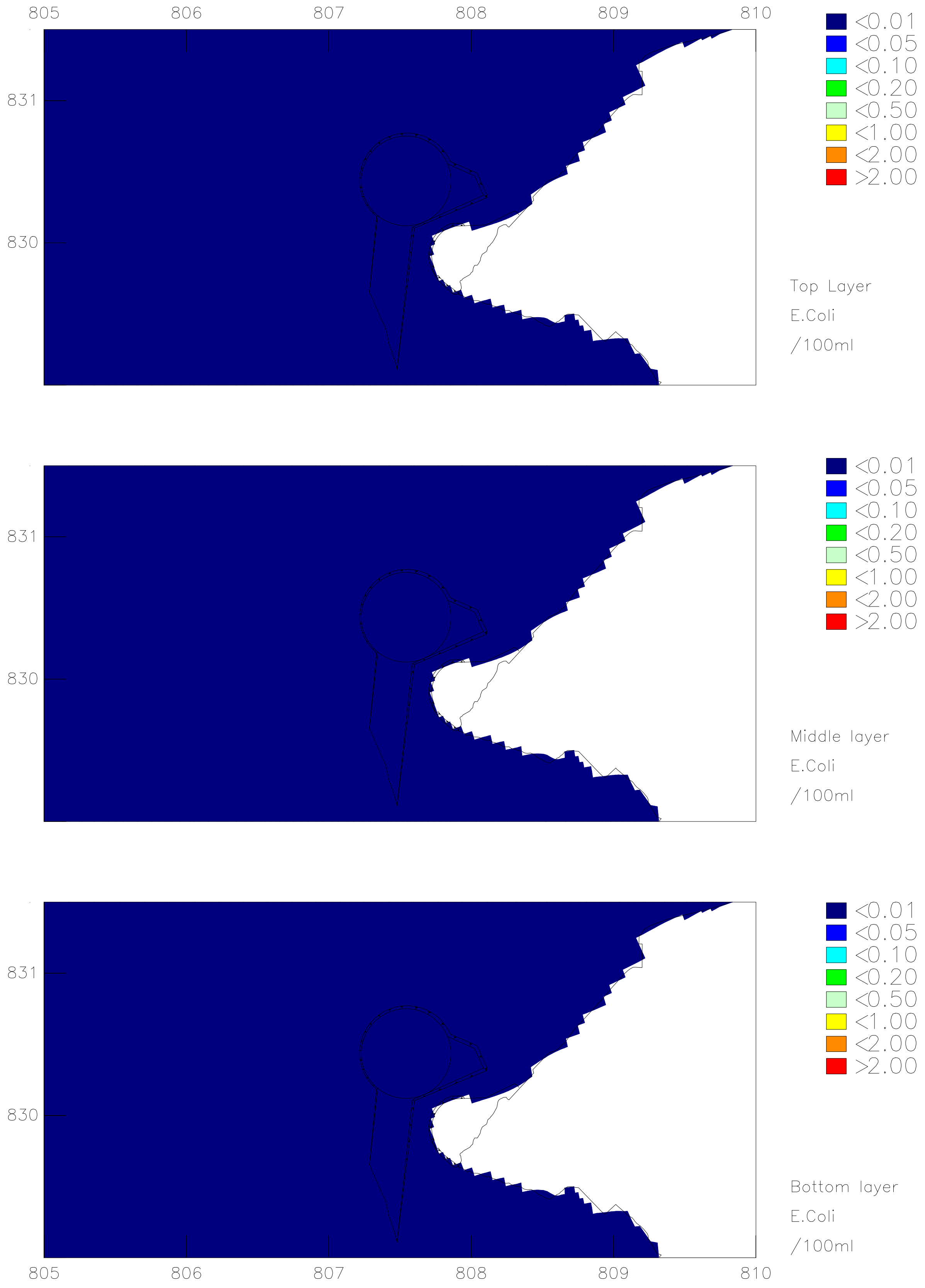


E.Coli (/100ml) maximum increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I09

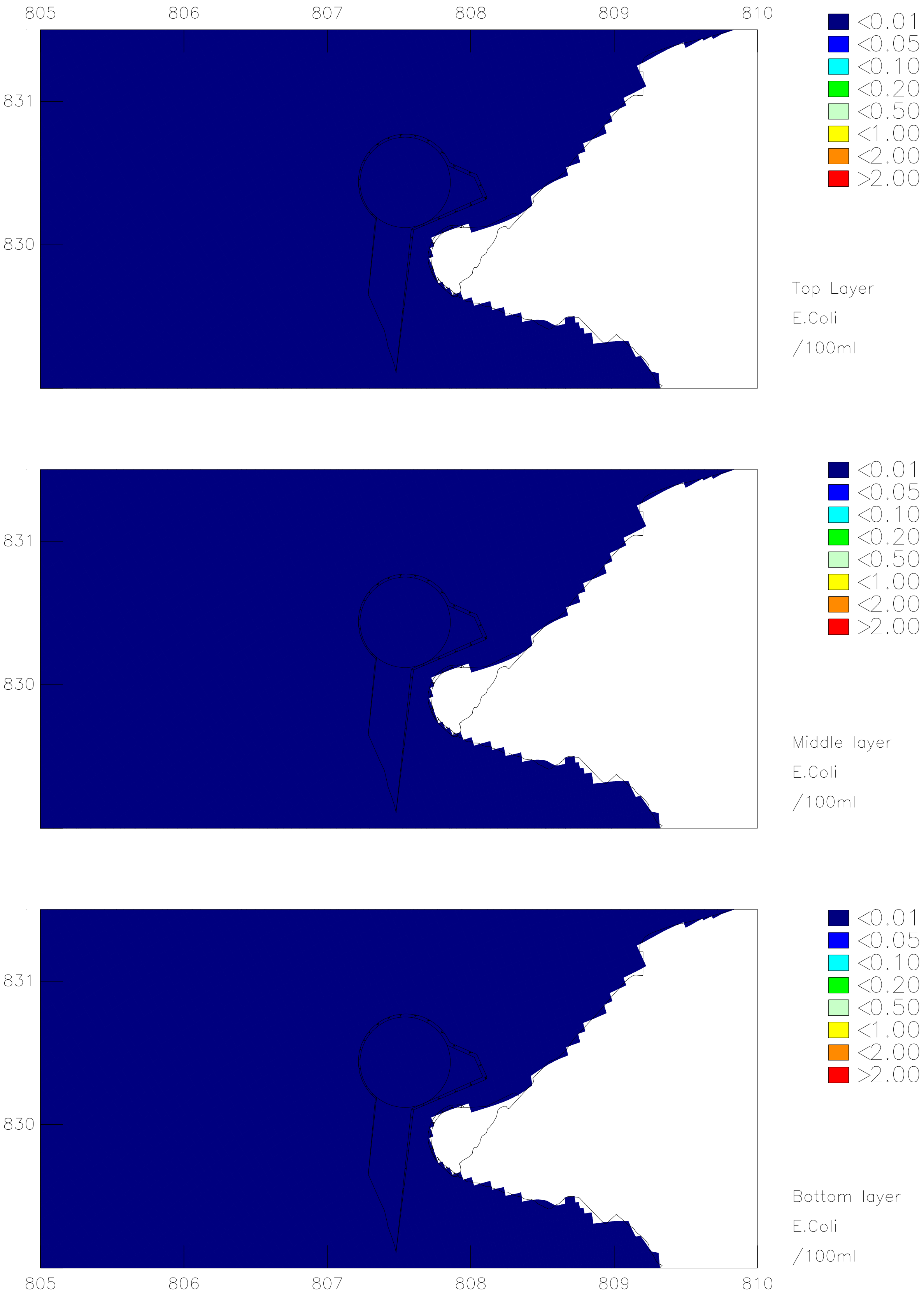


E.Coli (/100ml) mean increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I10

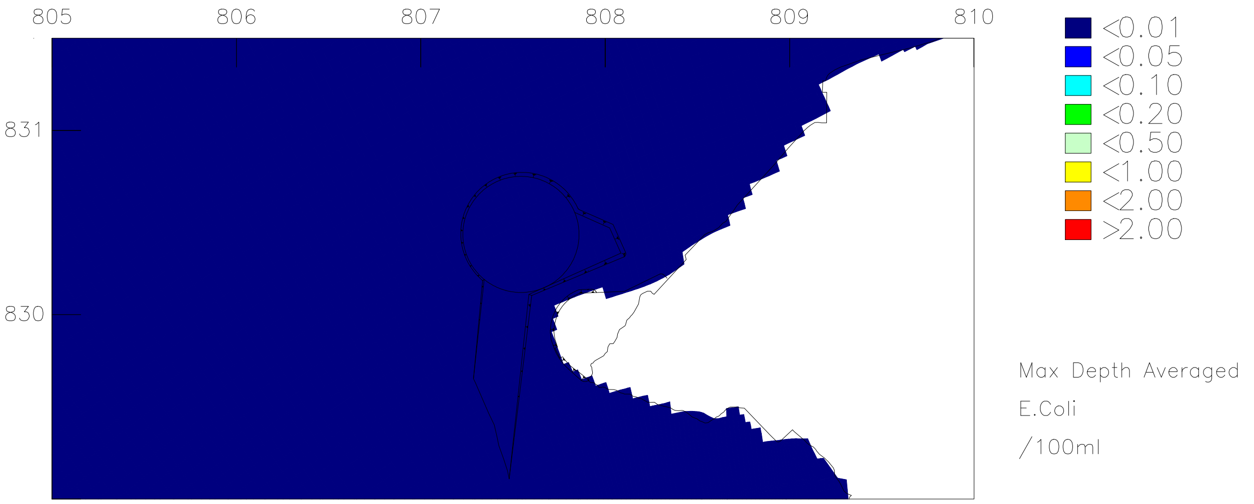


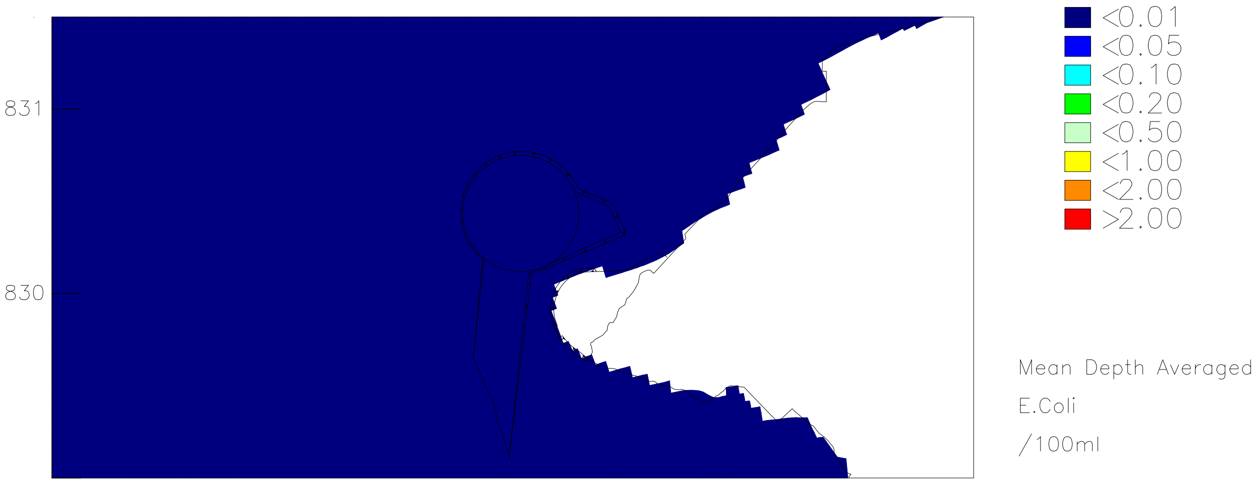
E.Coli (/100ml) minimum increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

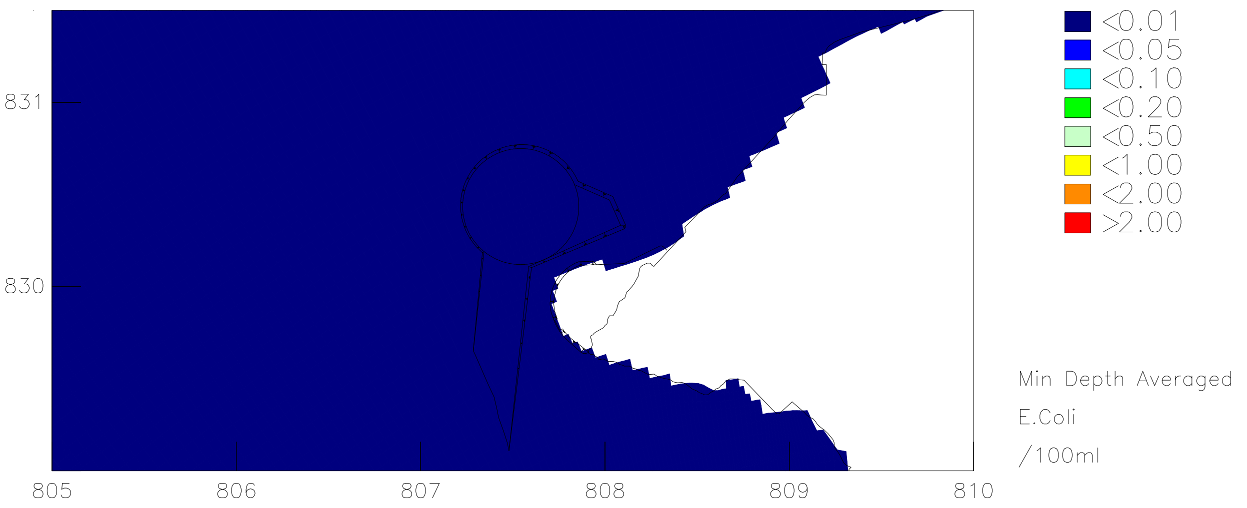
Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I11





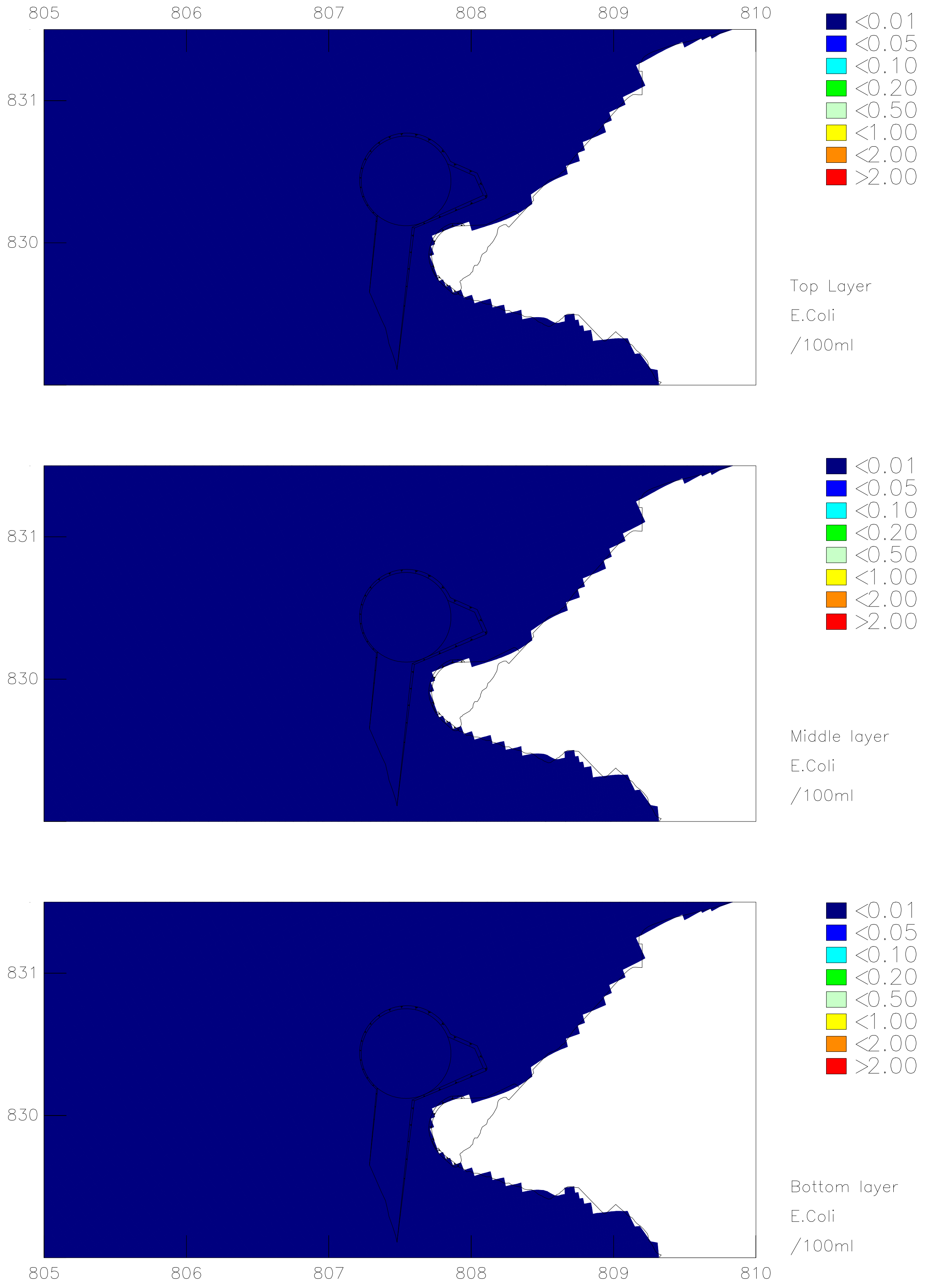


E.Coli (/100ml)
Black Point Sewage emission – Operational
Maximum, Mean and Minimum depth averaged increase

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I12

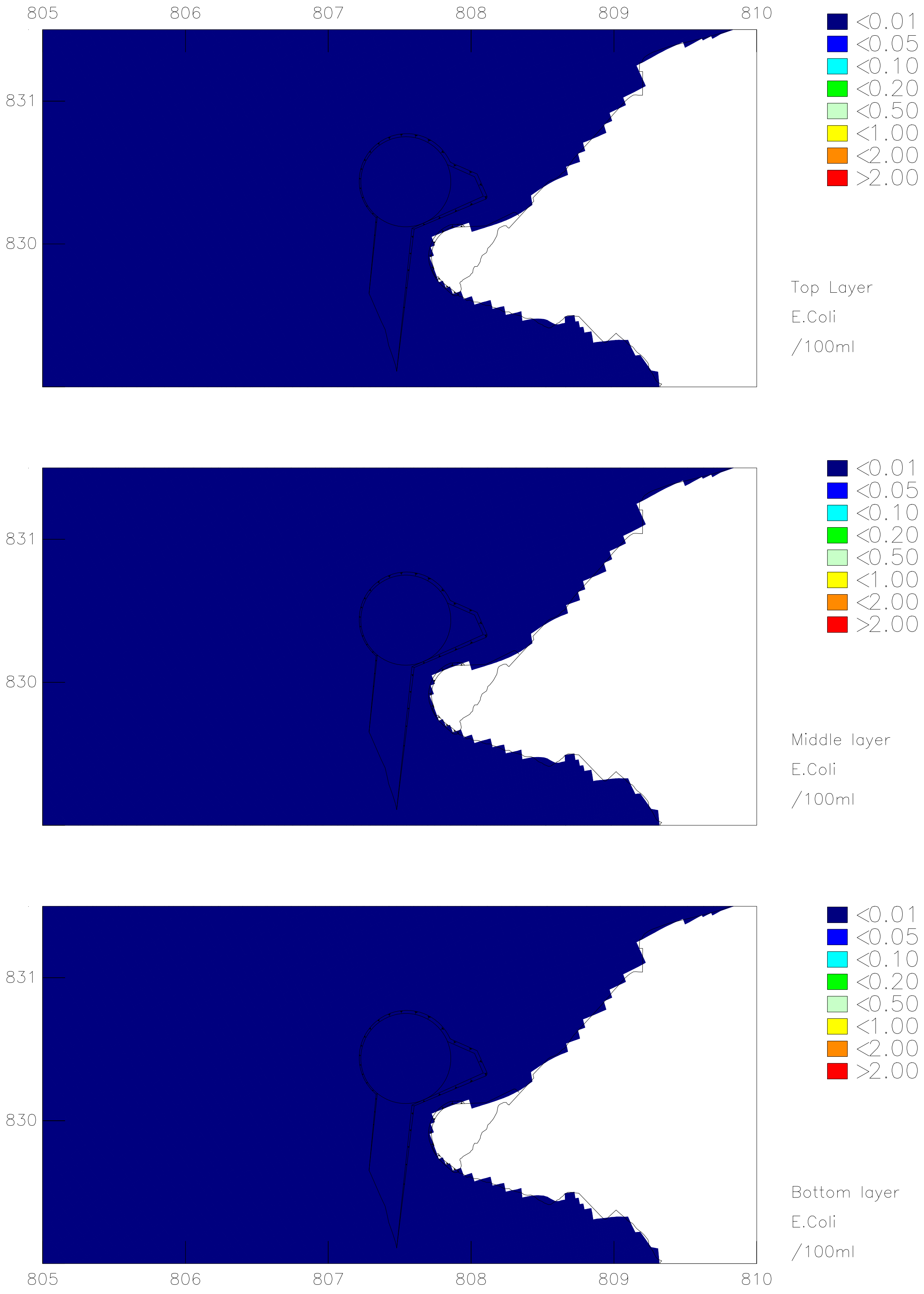


E.Coli (/100ml) maximum increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I13

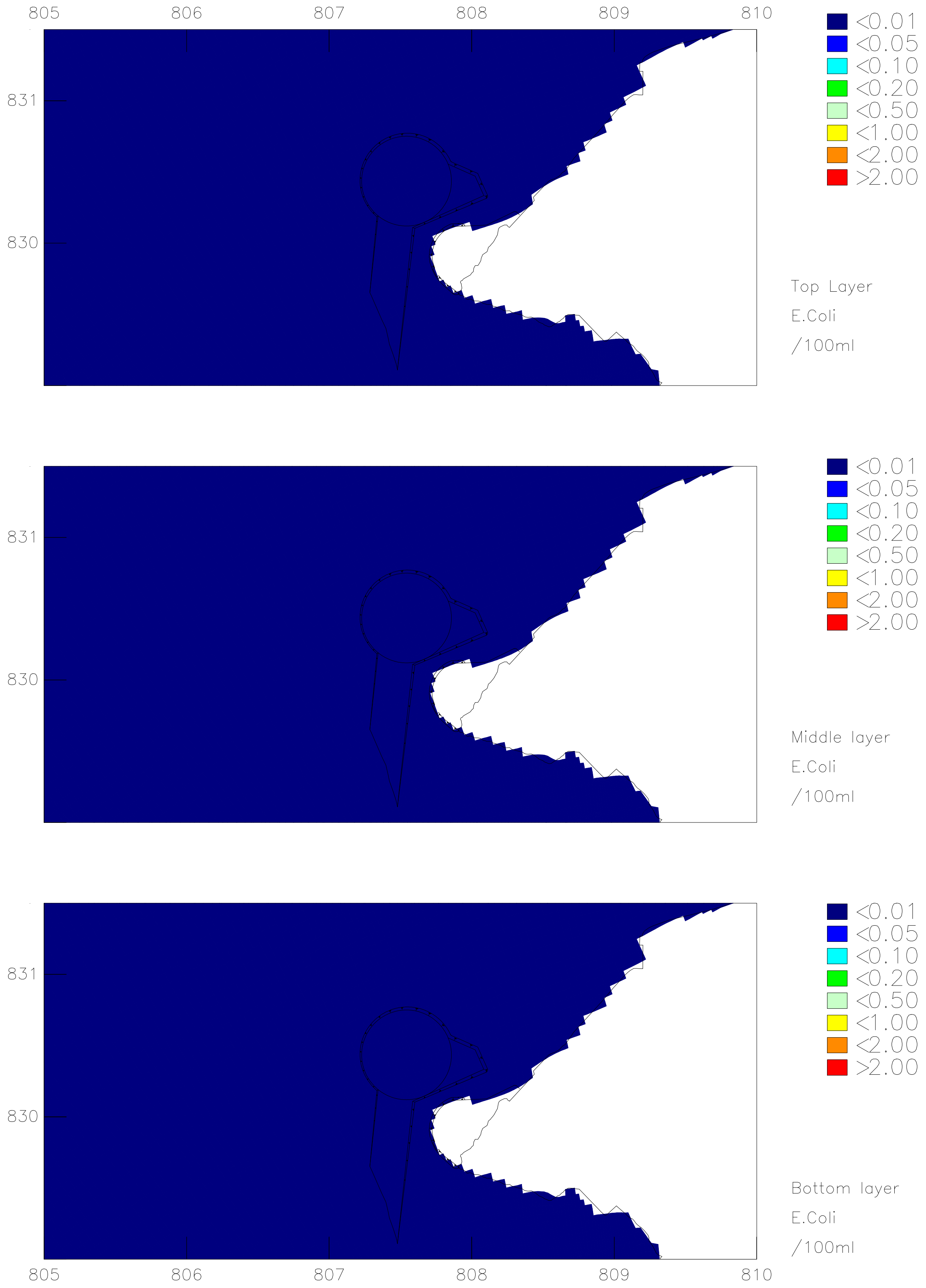


E.Coli (/100ml) mean increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I14

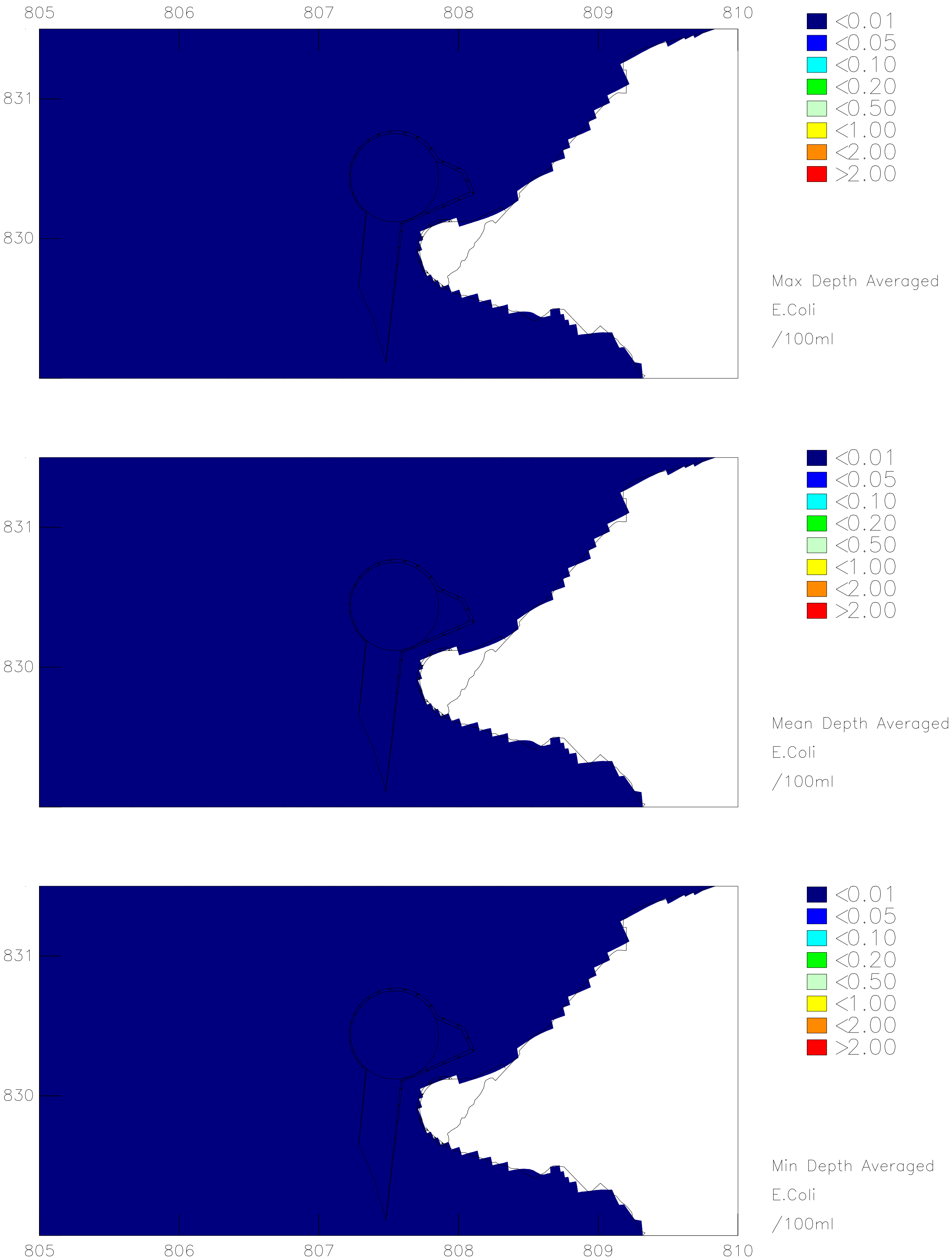


E.Coli (/100ml) minimum increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

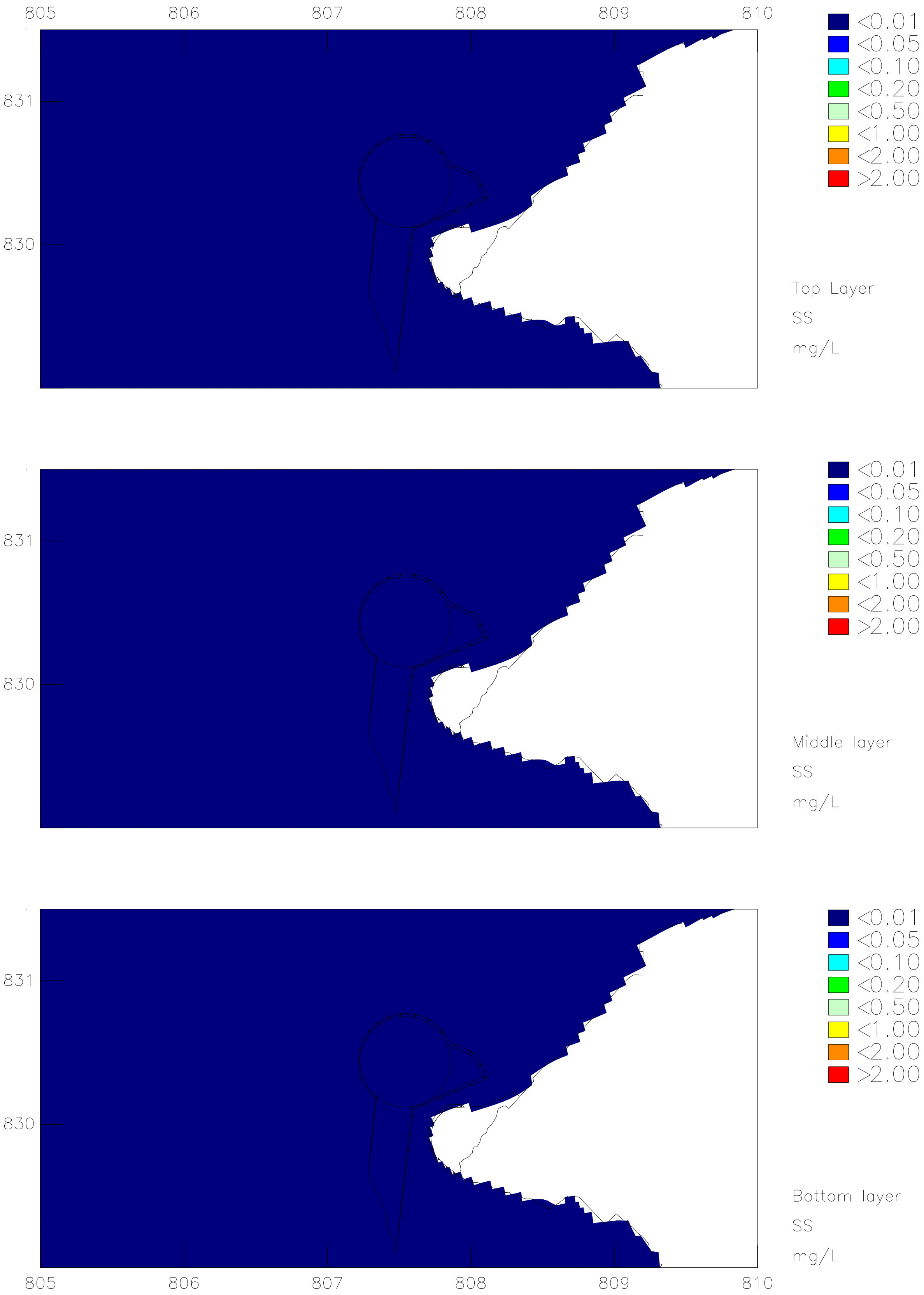
Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I15



E.Coli (/100ml) Black Point Sewage emission – Operational Maximum, Mean and Minimum depth averaged increase	Wet Season	
WL | Delft Hydraulics – ERM		Fig. BP_I16

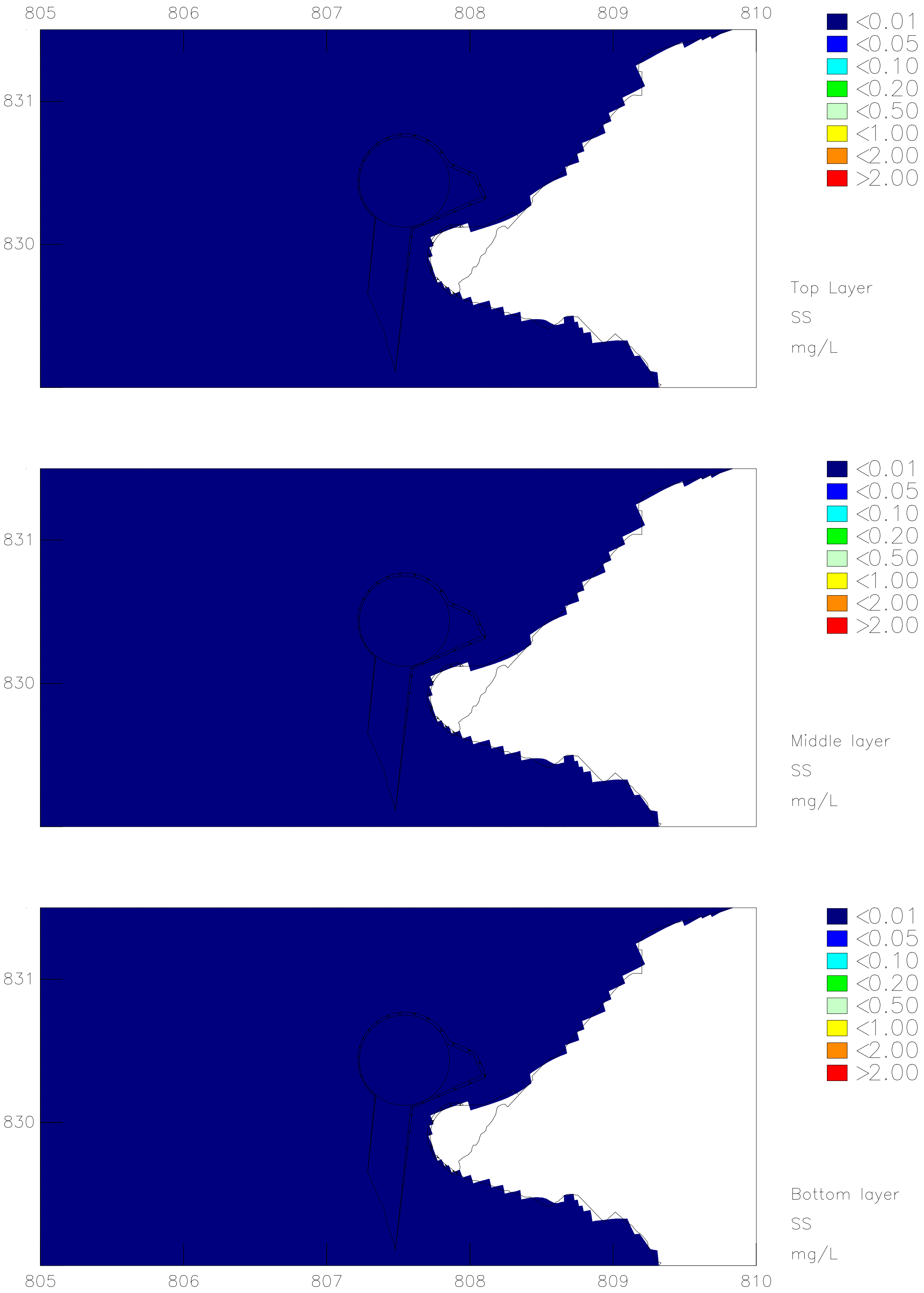


SS (mg/L) maximum increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I17



SS (mg/L) mean increase

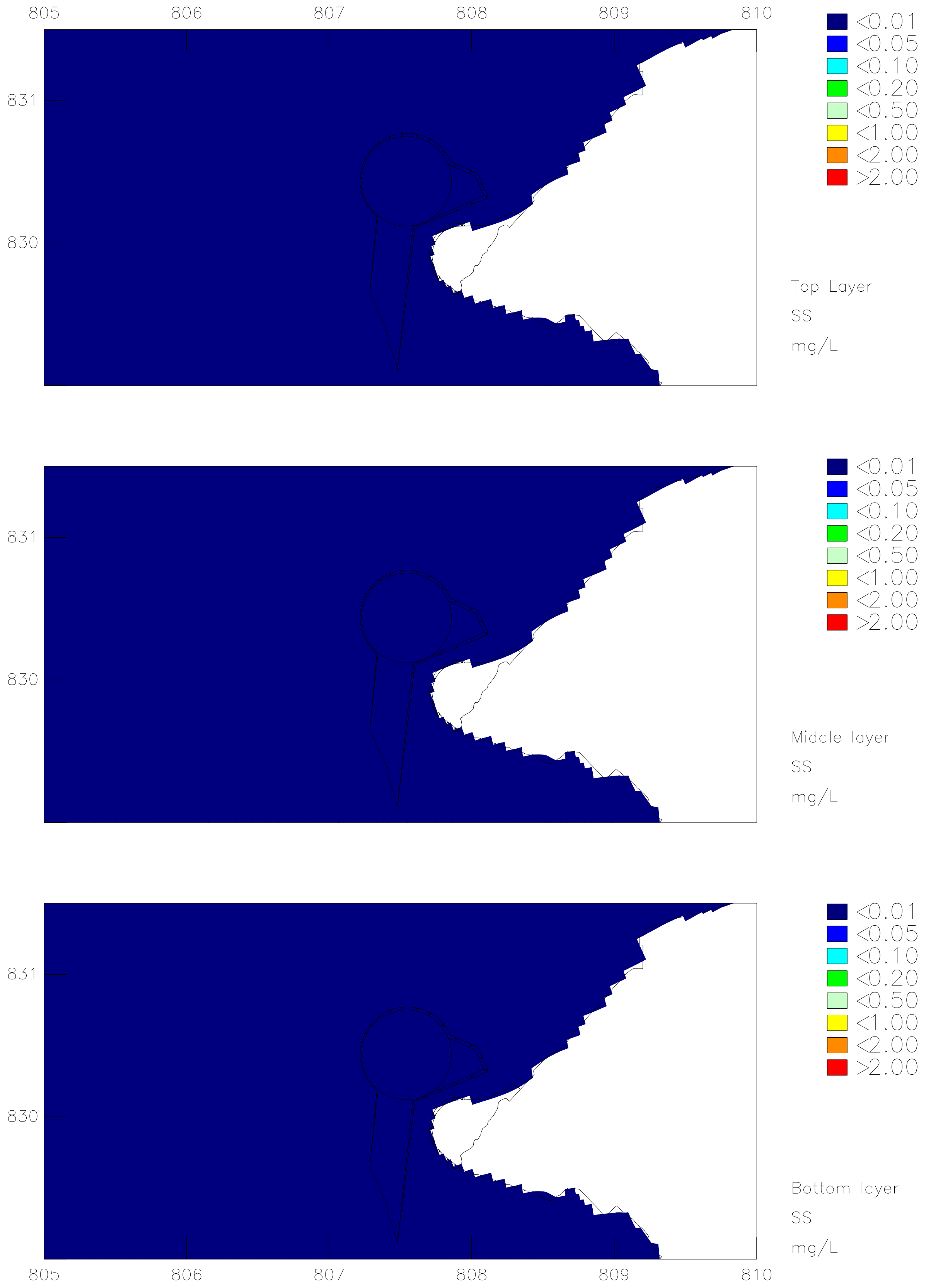
Black Point Sewage emission – Operational

Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I18

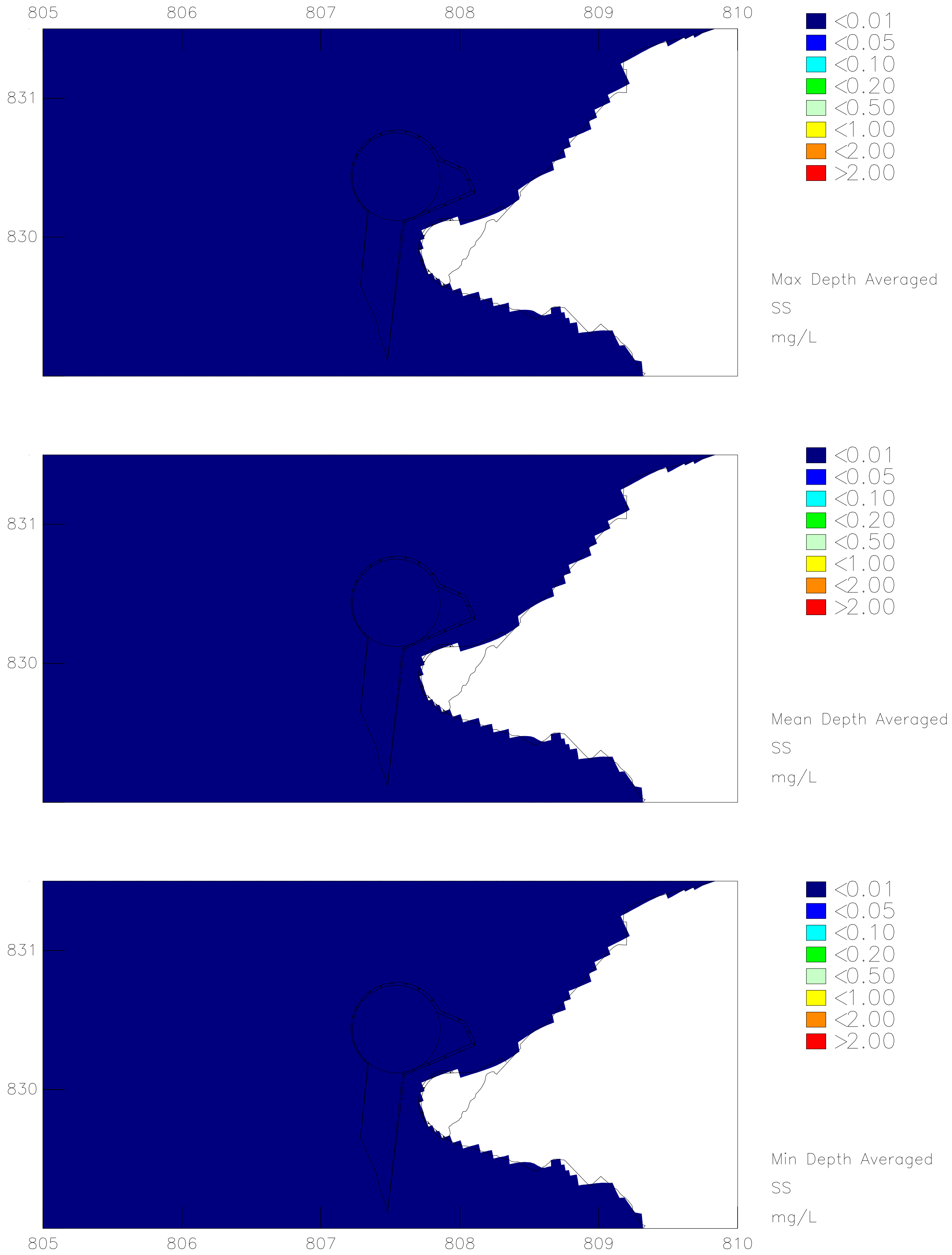


SS (mg/L) minimum increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I19

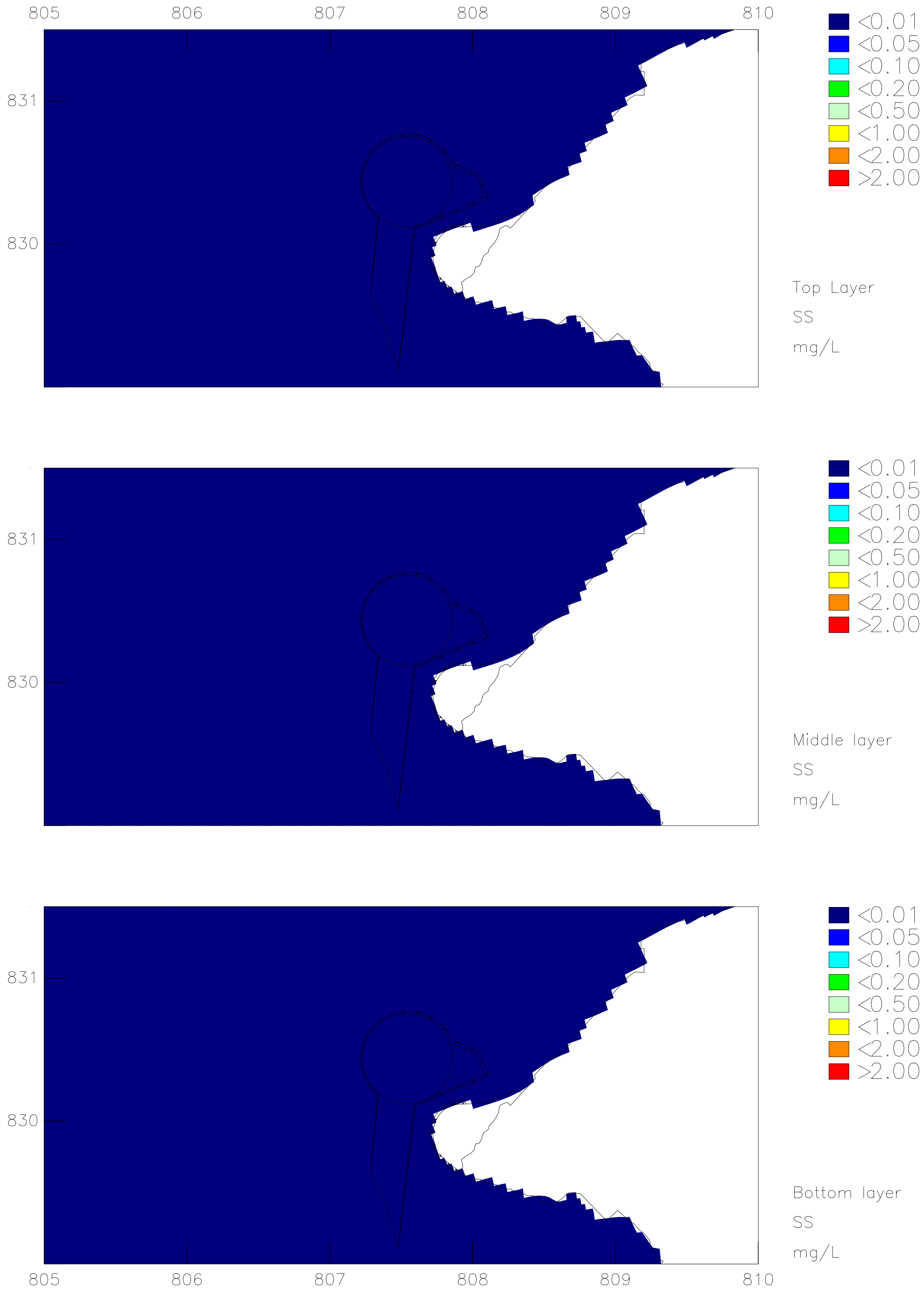


SS (mg/L)
Black Point Sewage emission – Operational
Maximum, Mean and Minimum depth averaged increase

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I20

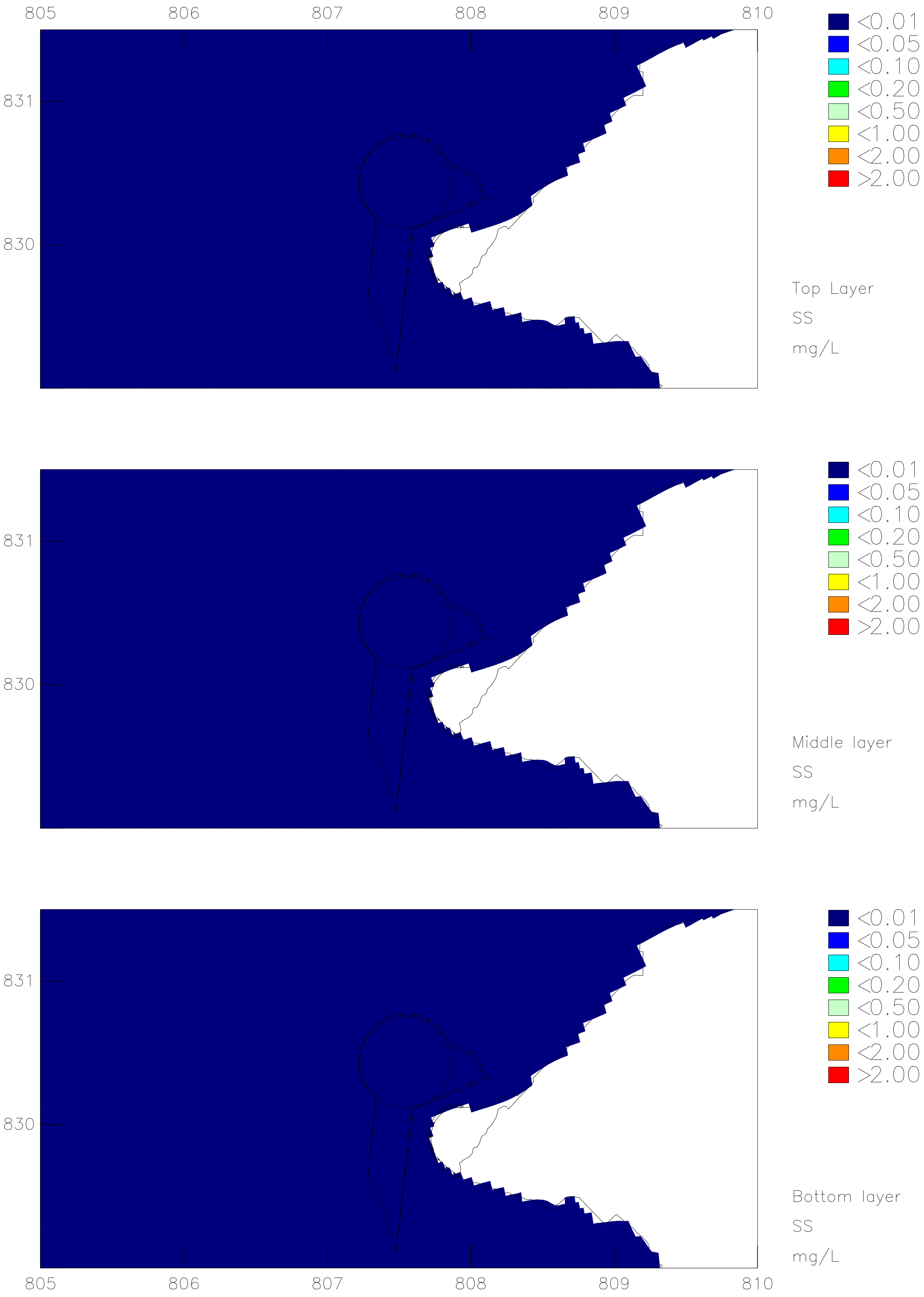


SS (mg/L) maximum increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I21

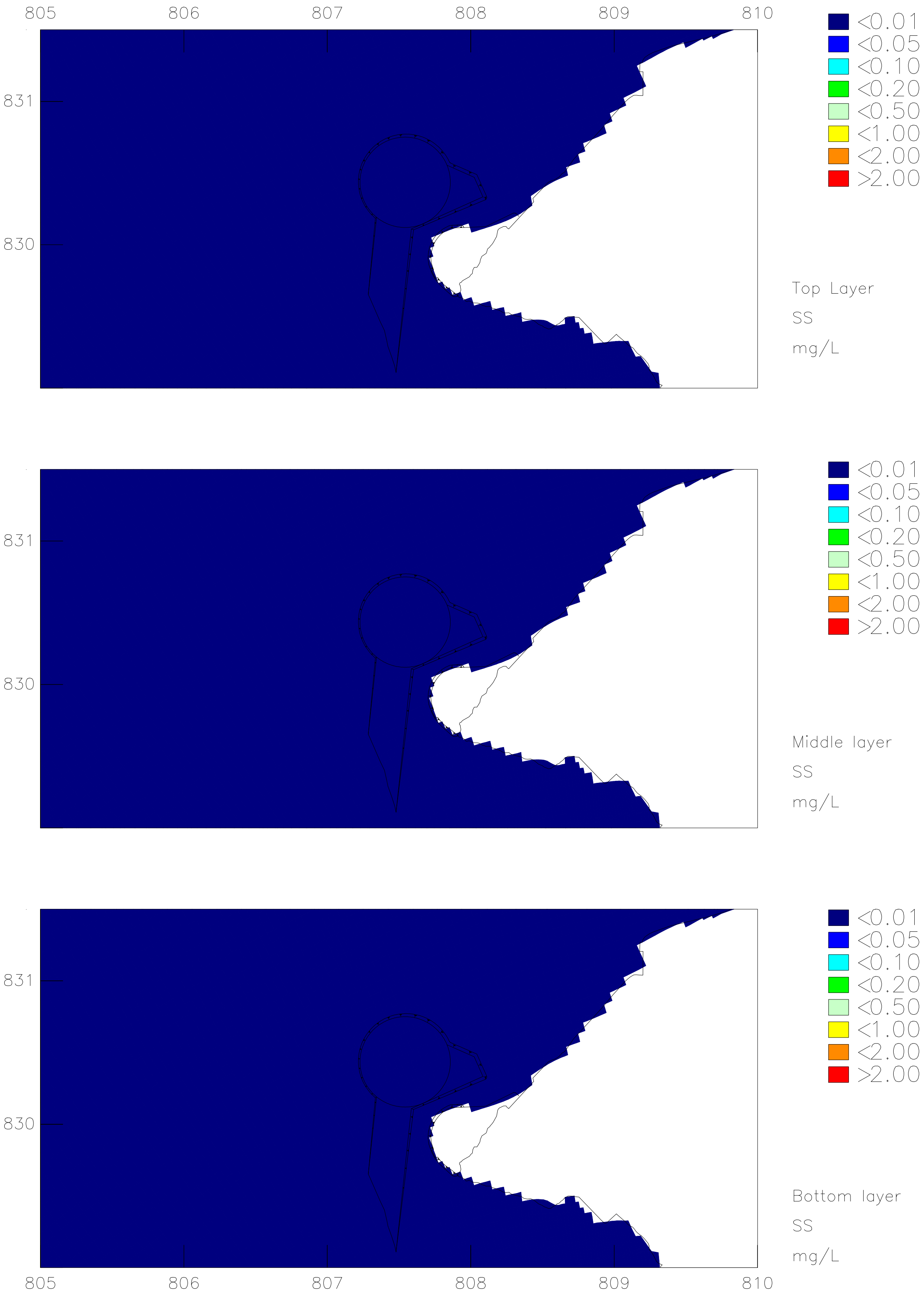


SS (mg/L) mean increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I22

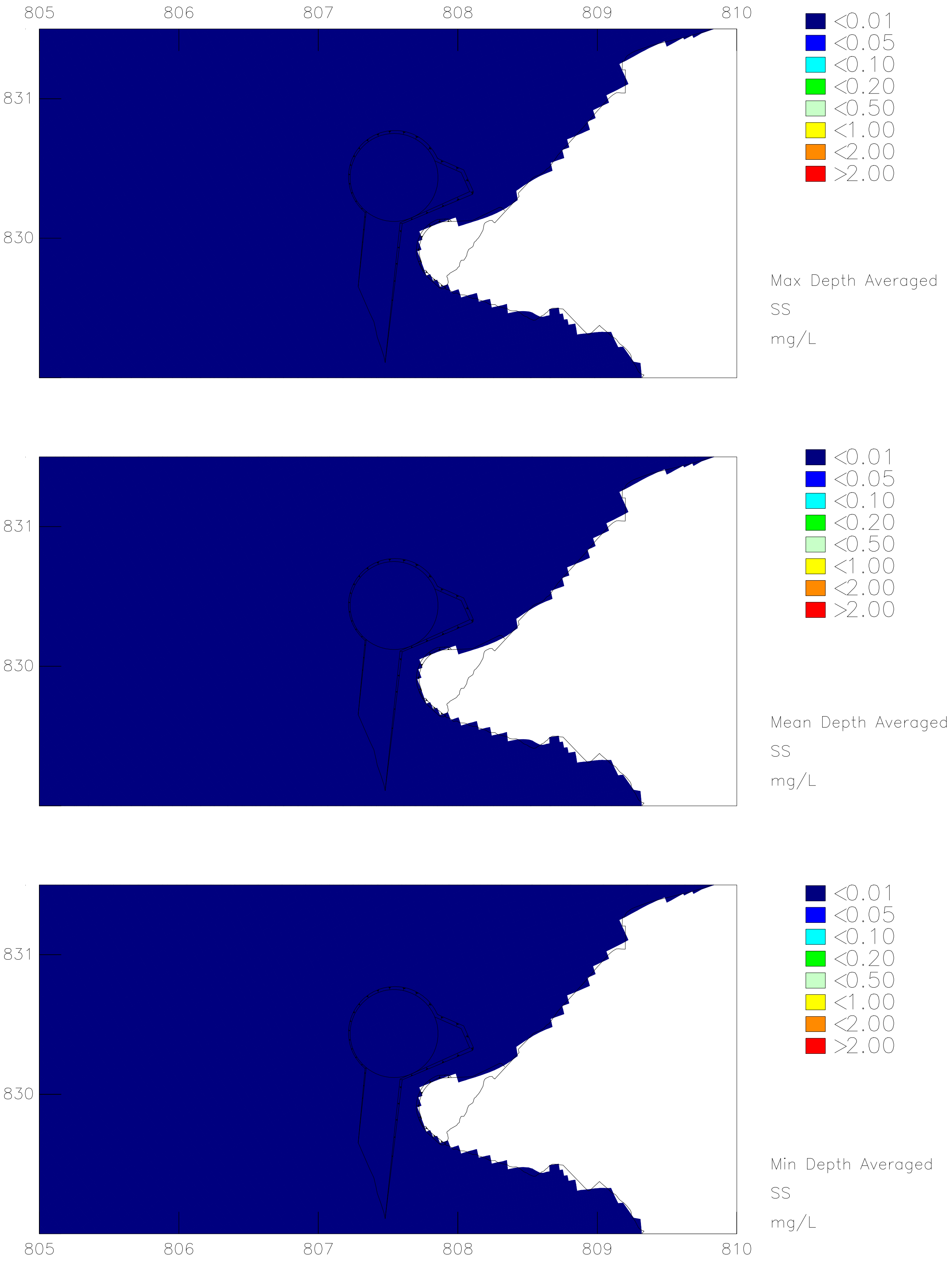


SS (mg/L) minimum increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I23

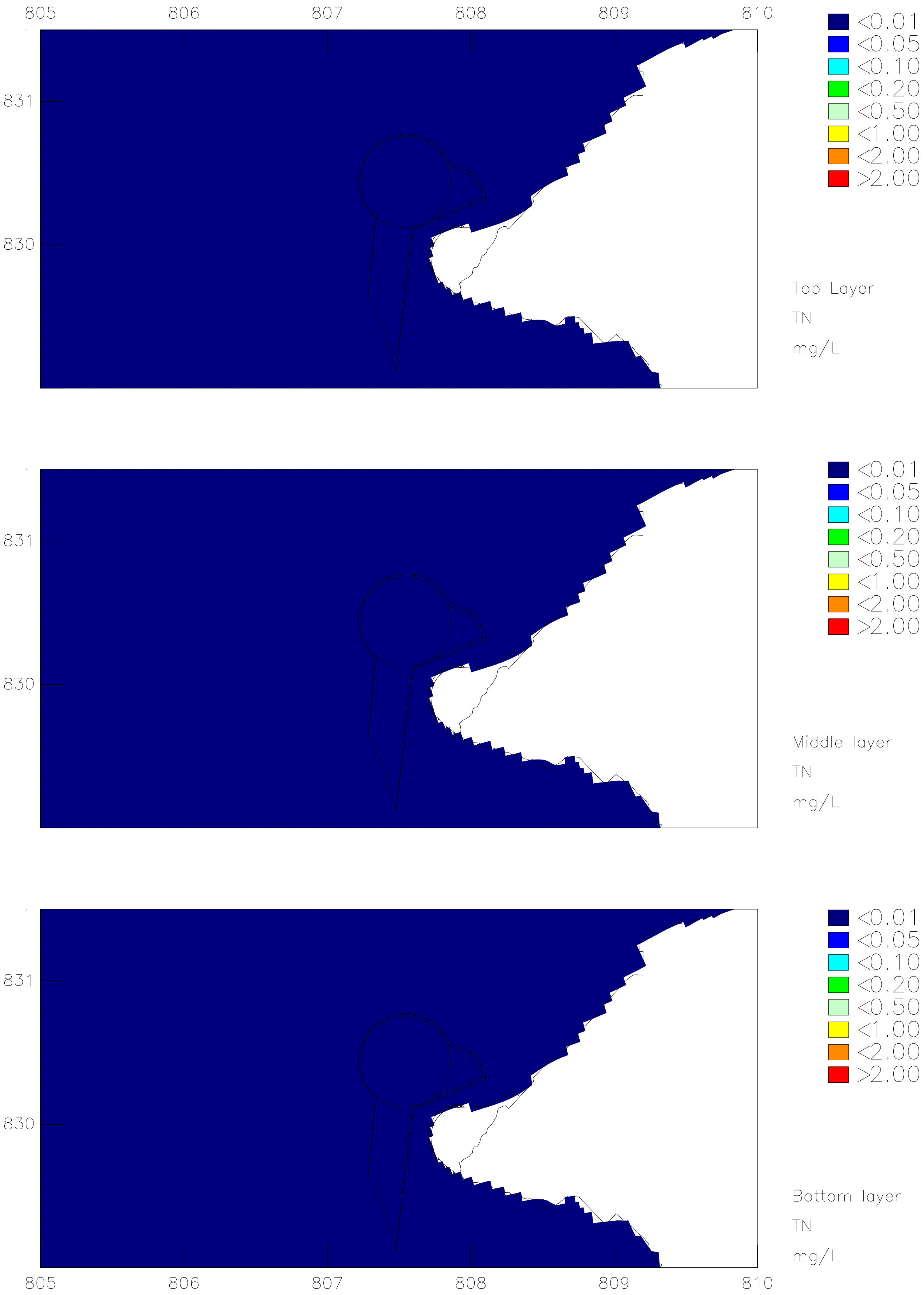


SS (mg/L)
Black Point Sewage emission – Operational
Maximum, Mean and Minimum depth averaged increase

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I24

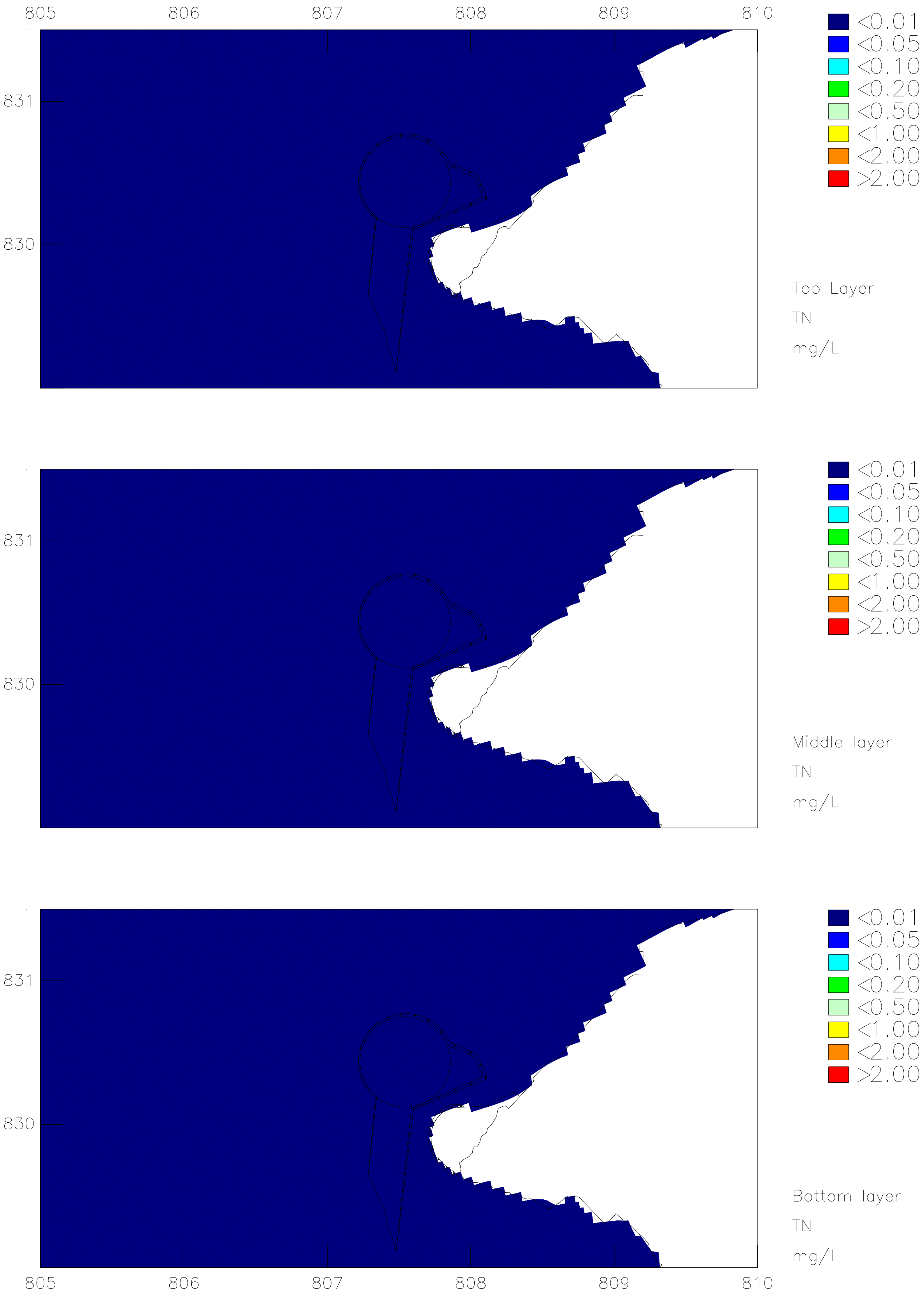


TN (mg/L) maximum increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I25

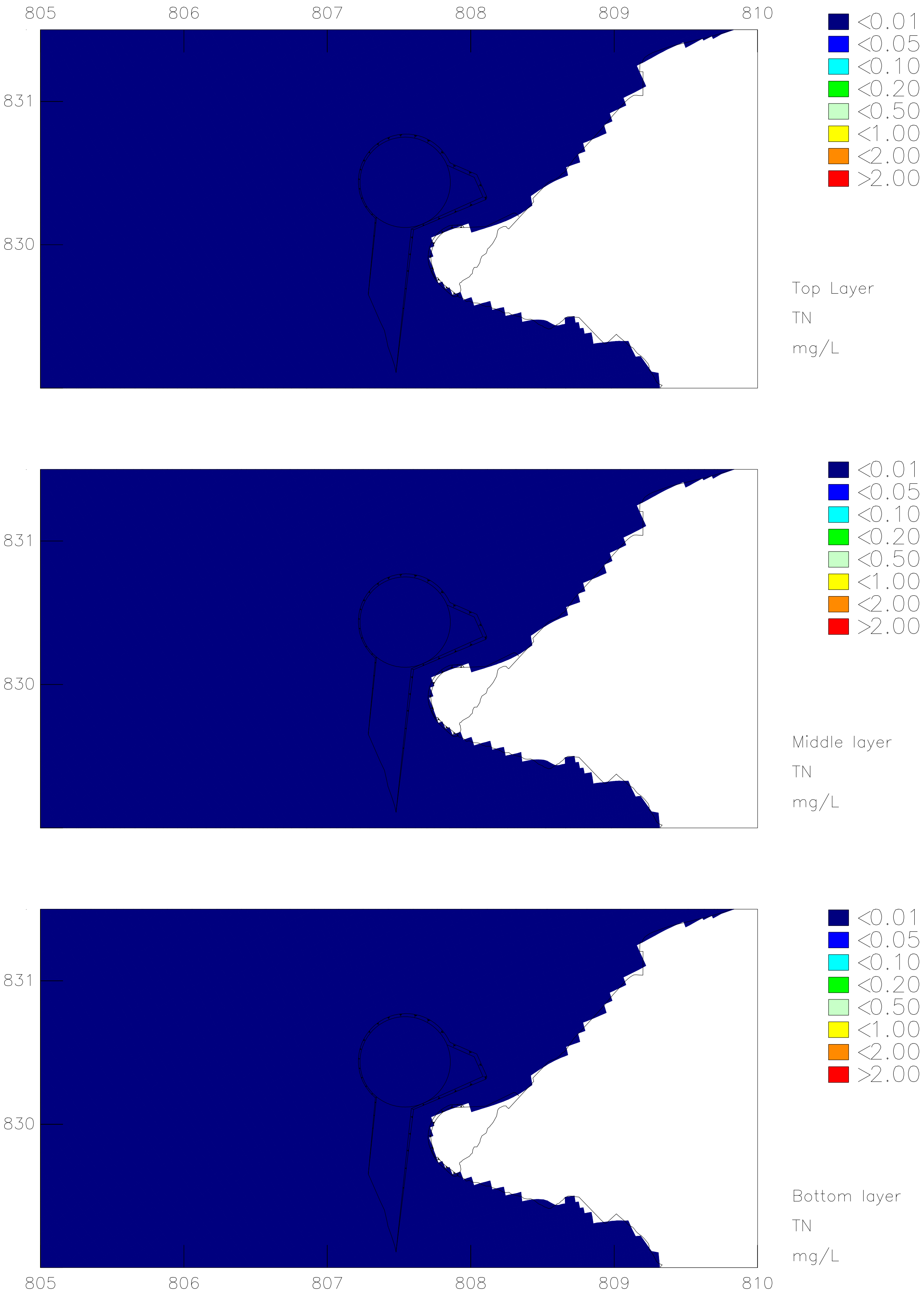


TN (mg/L) mean increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I26

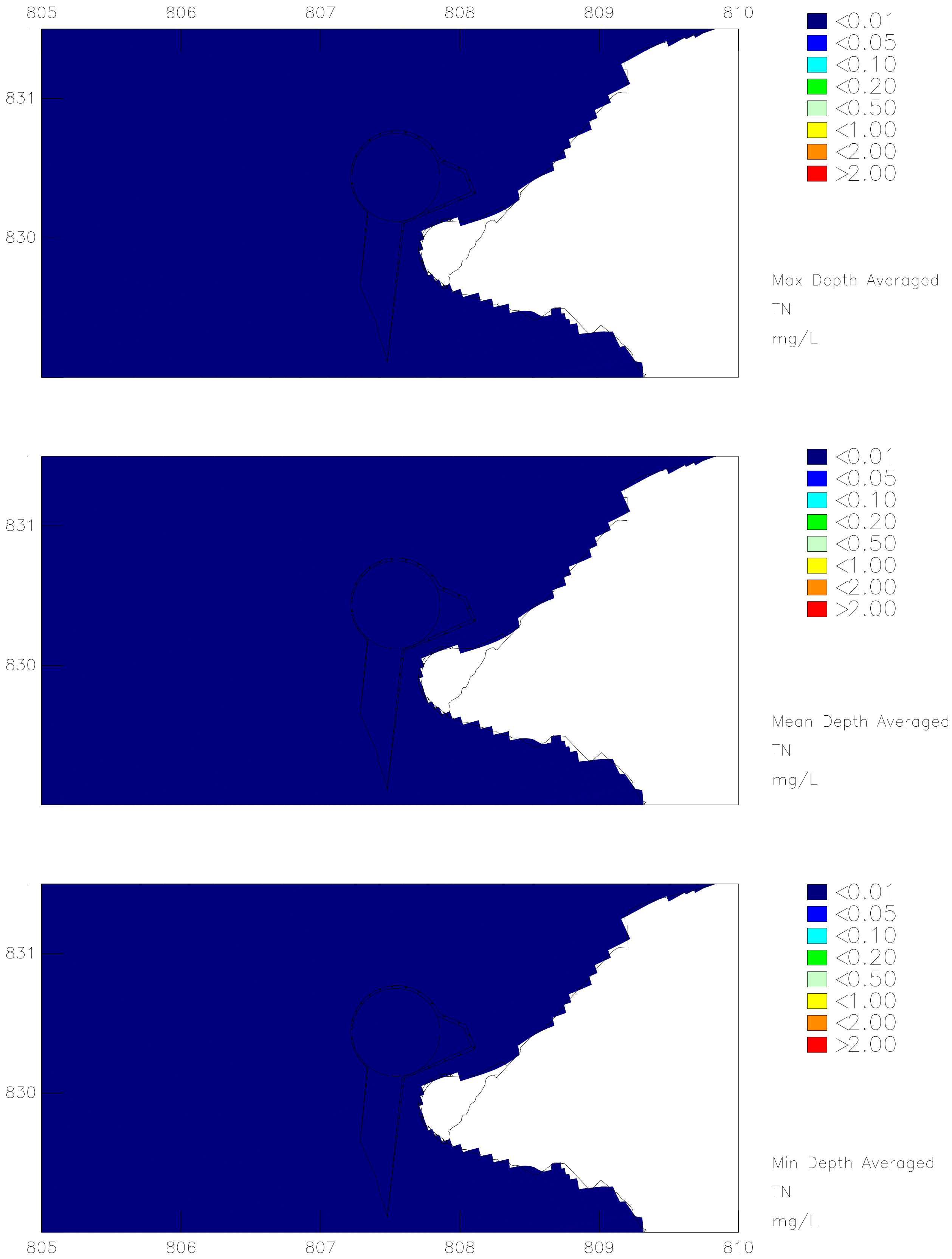


TN (mg/L) minimum increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I27

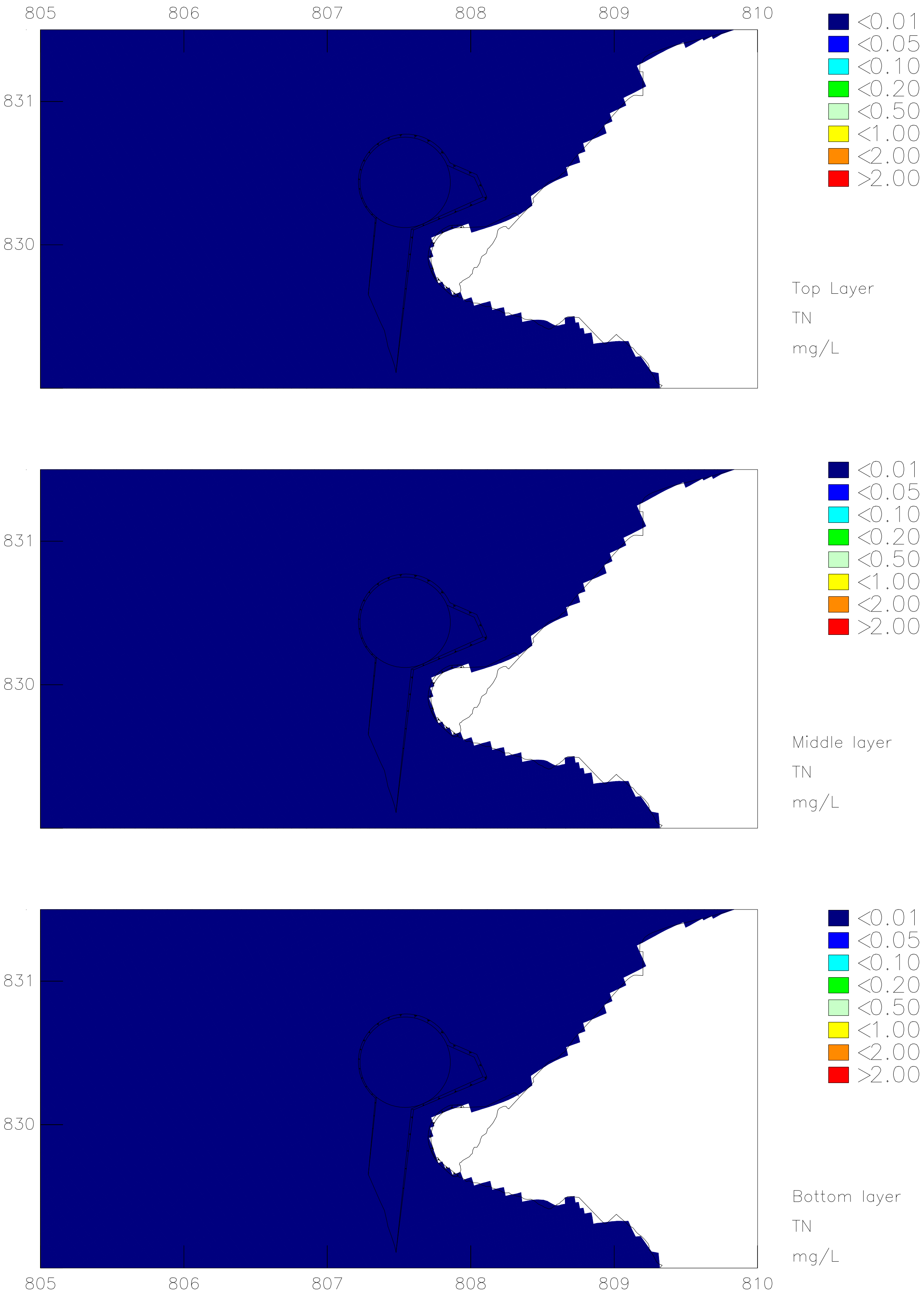


TN (mg/L)
Black Point Sewage emission – Operational
Maximum, Mean and Minimum depth averaged increase

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I28

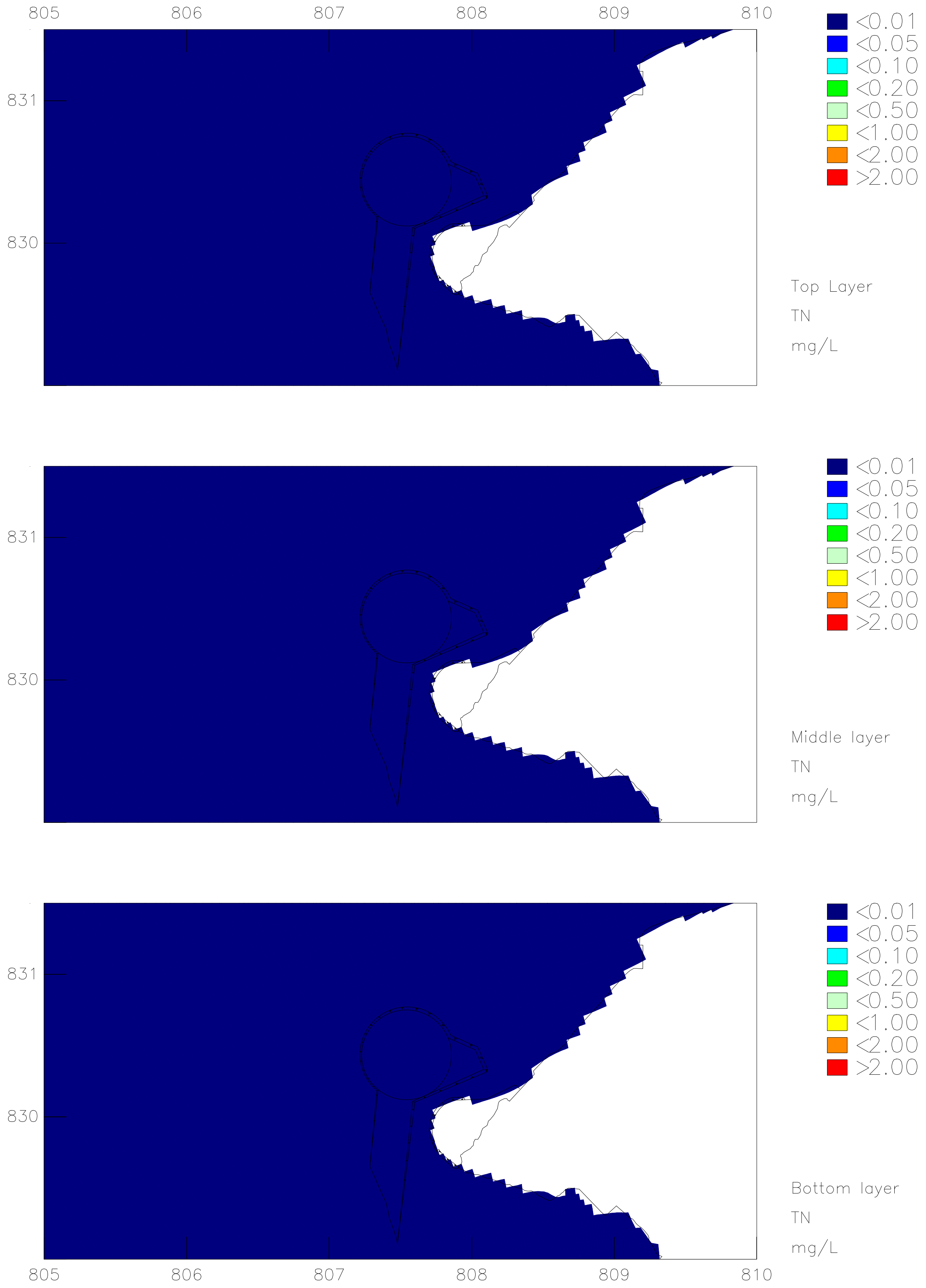


TN (mg/L) maximum increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I29

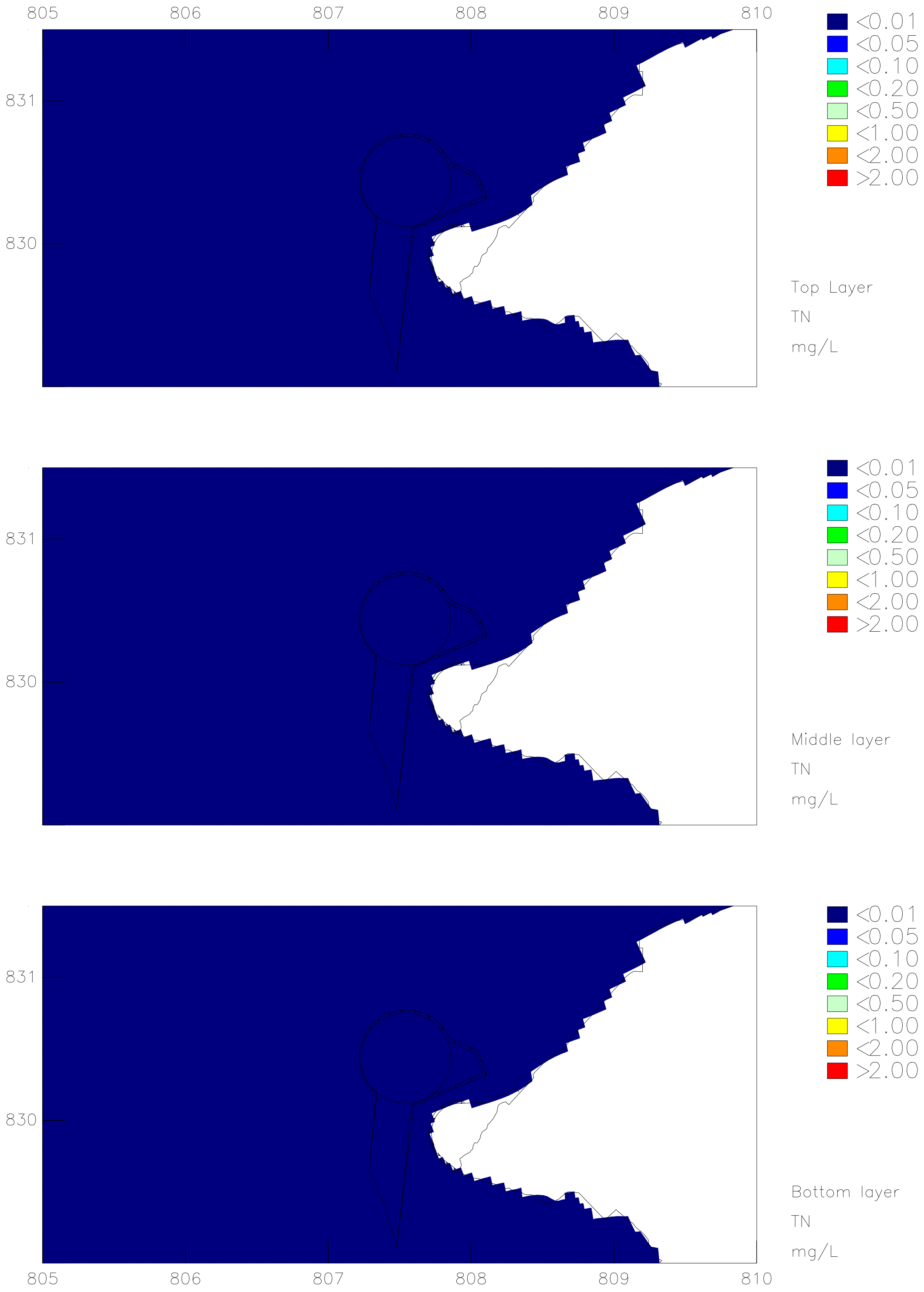


TN (mg/L) mean increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I30

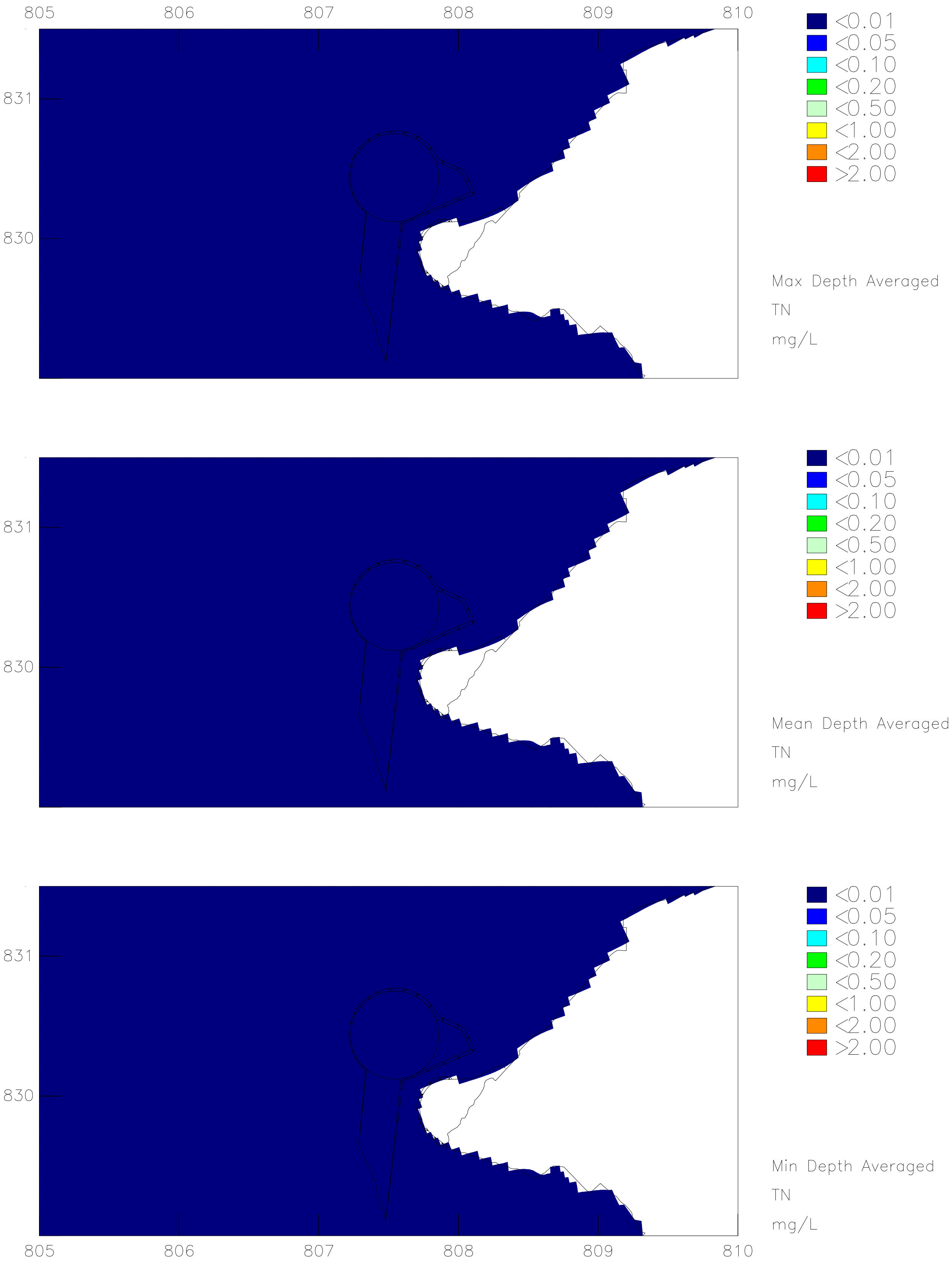


TN (mg/L) minimum increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I31

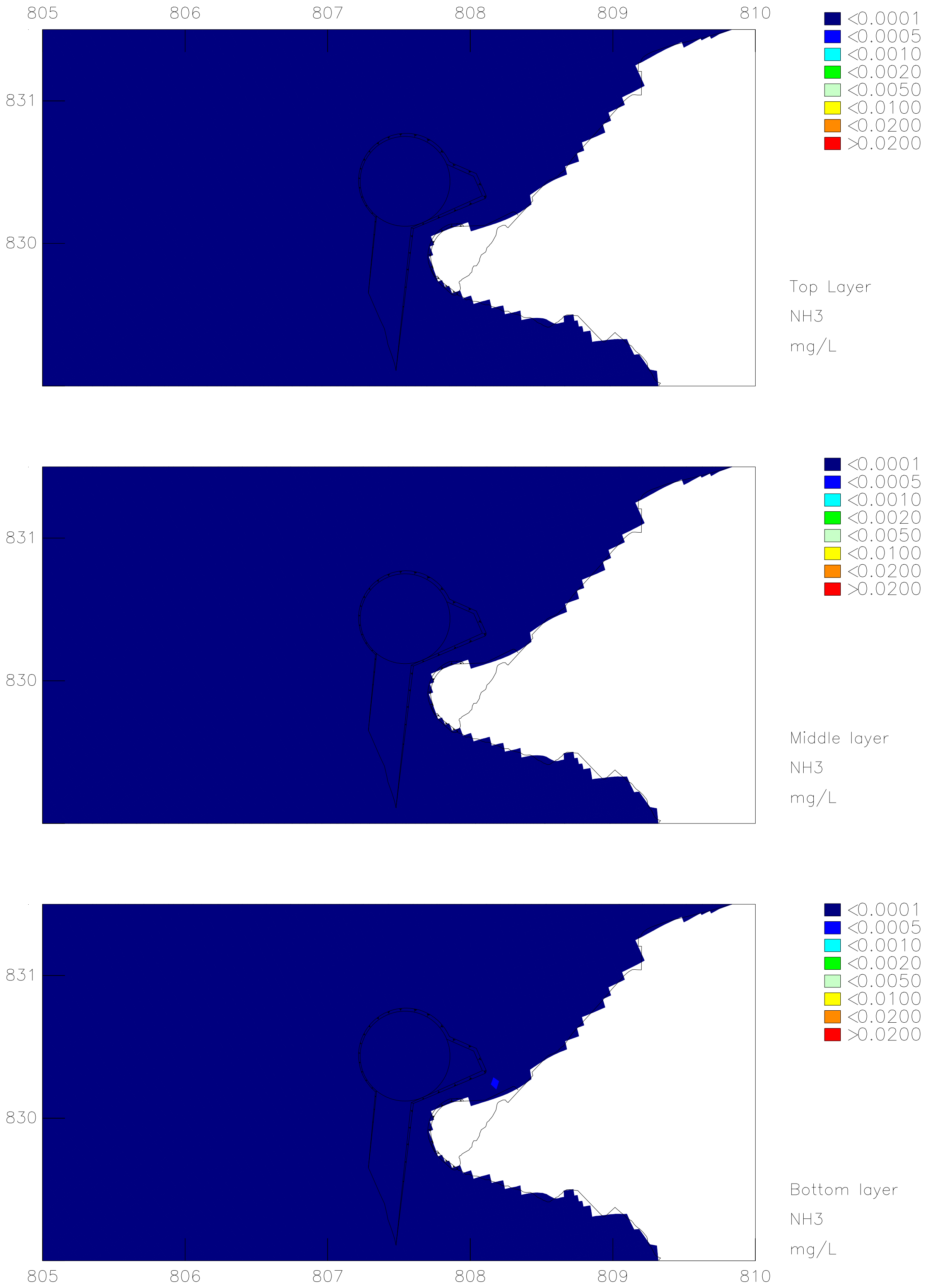


TN (mg/L)
Black Point Sewage emission – Operational
Maximum, Mean and Minimum depth averaged increase

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I32

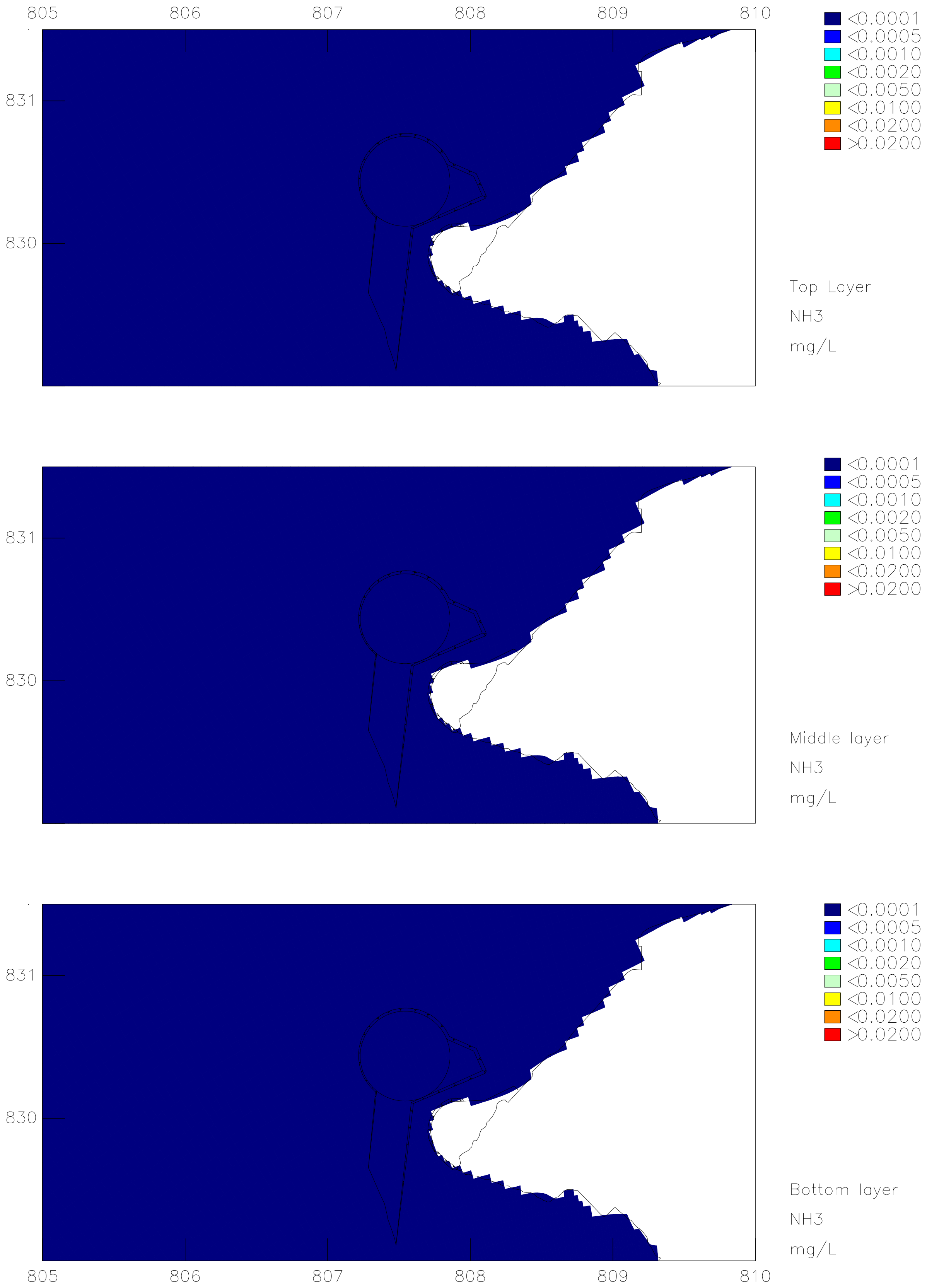


NH3 (mg/L) maximum increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I33

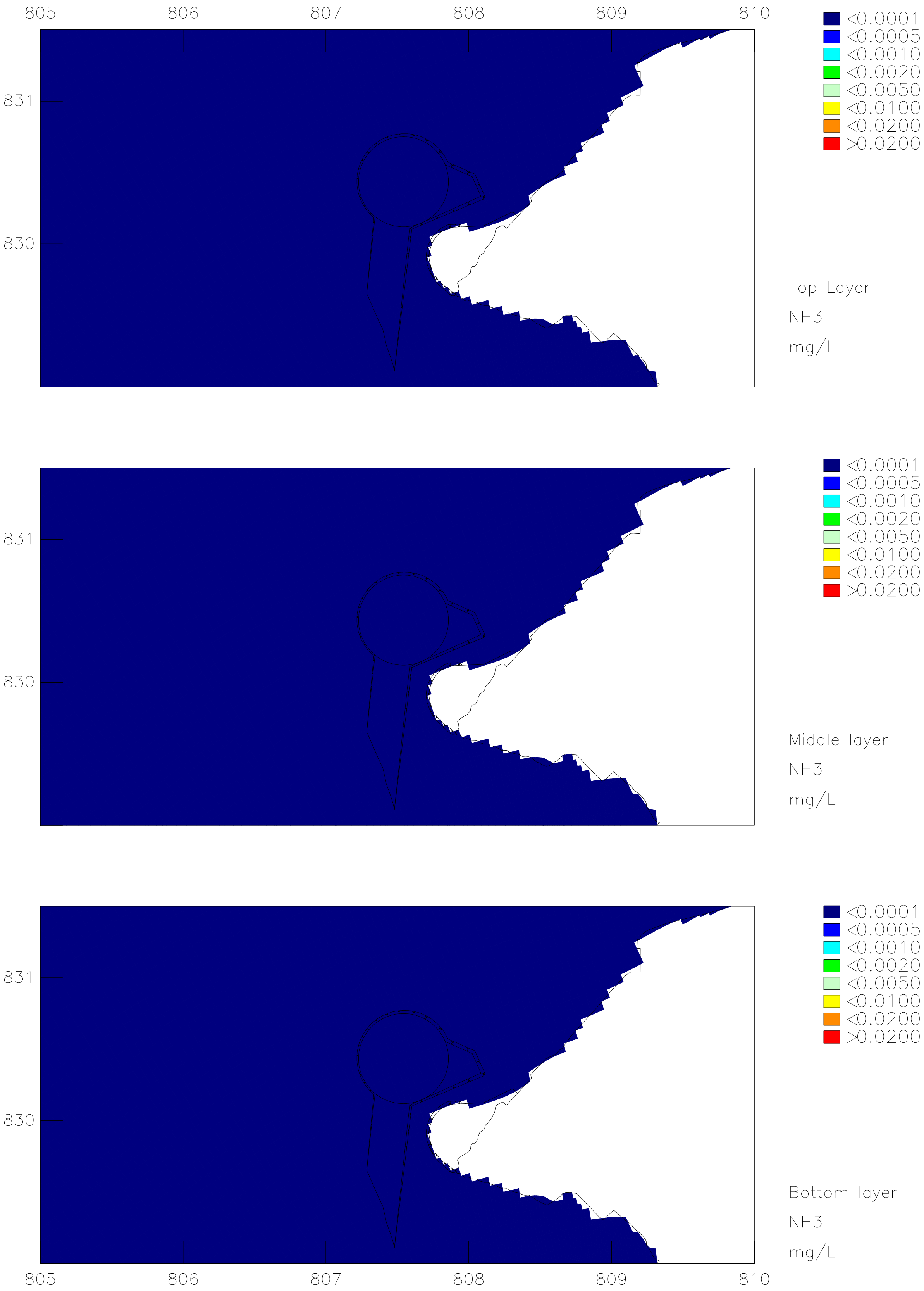


NH3 (mg/L) mean increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I34

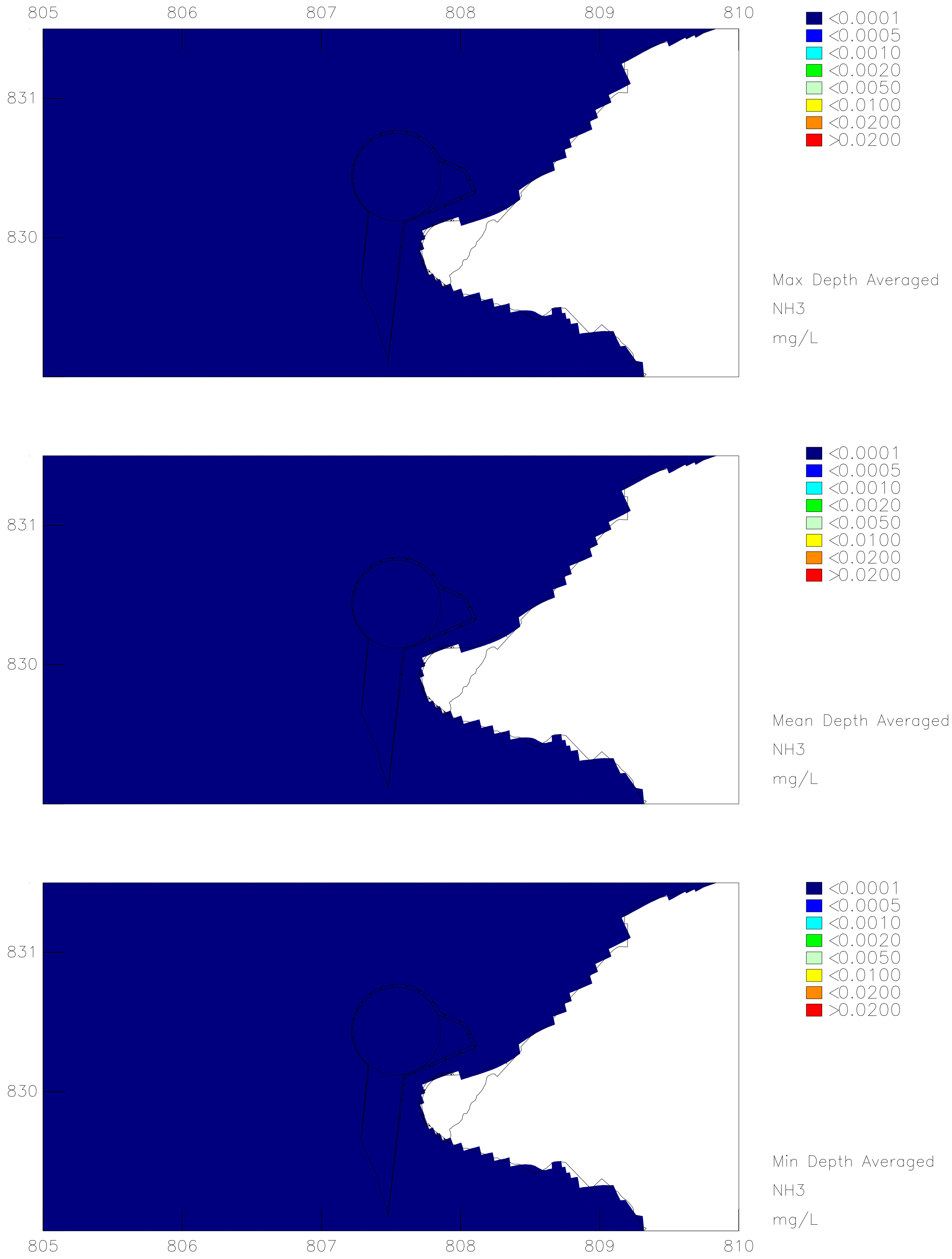


NH3 (mg/L) minimum increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I35

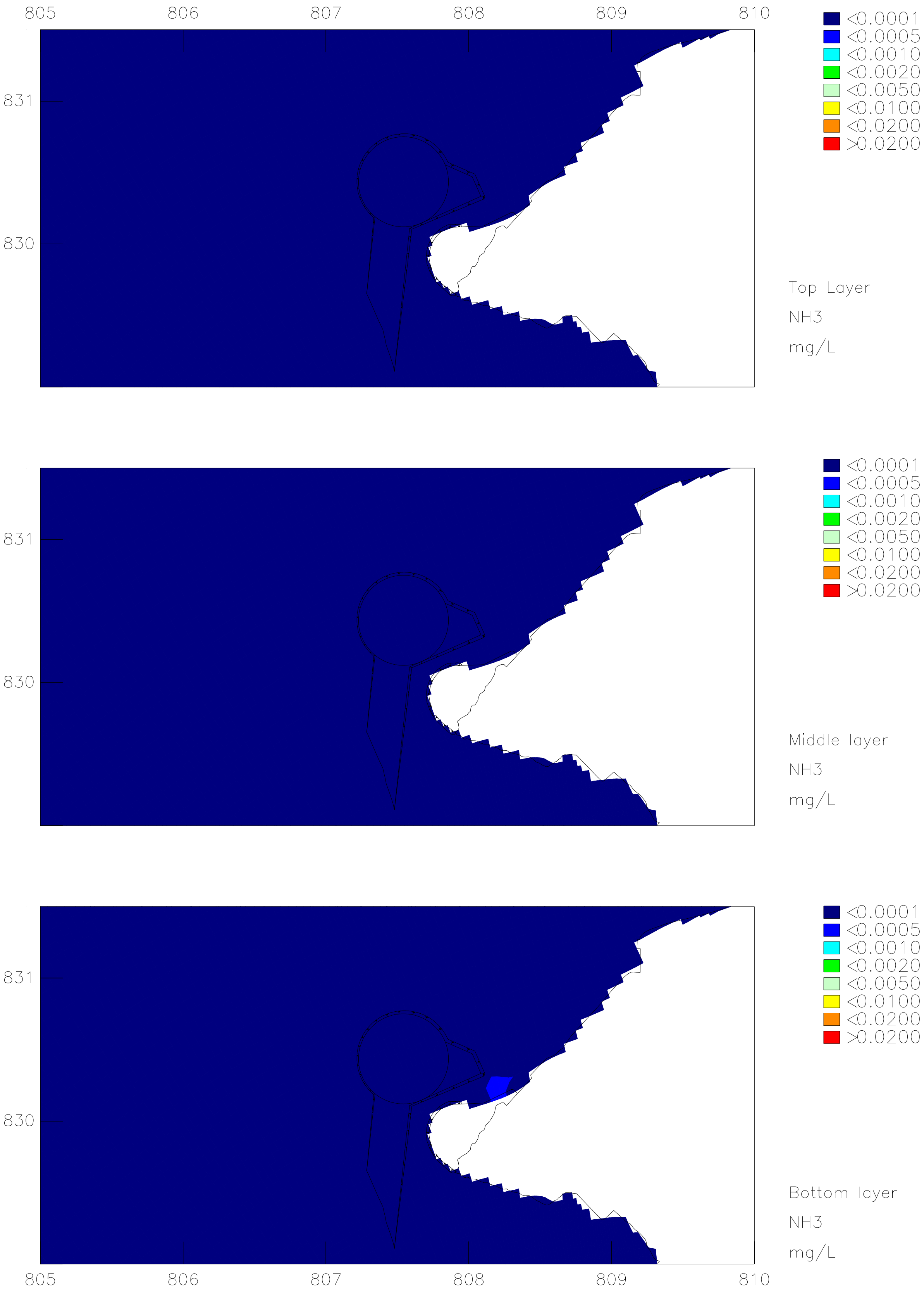


NH3 (mg/L)
Black Point Sewage emission – Operational
Maximum, Mean and Minimum depth averaged increase

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I36

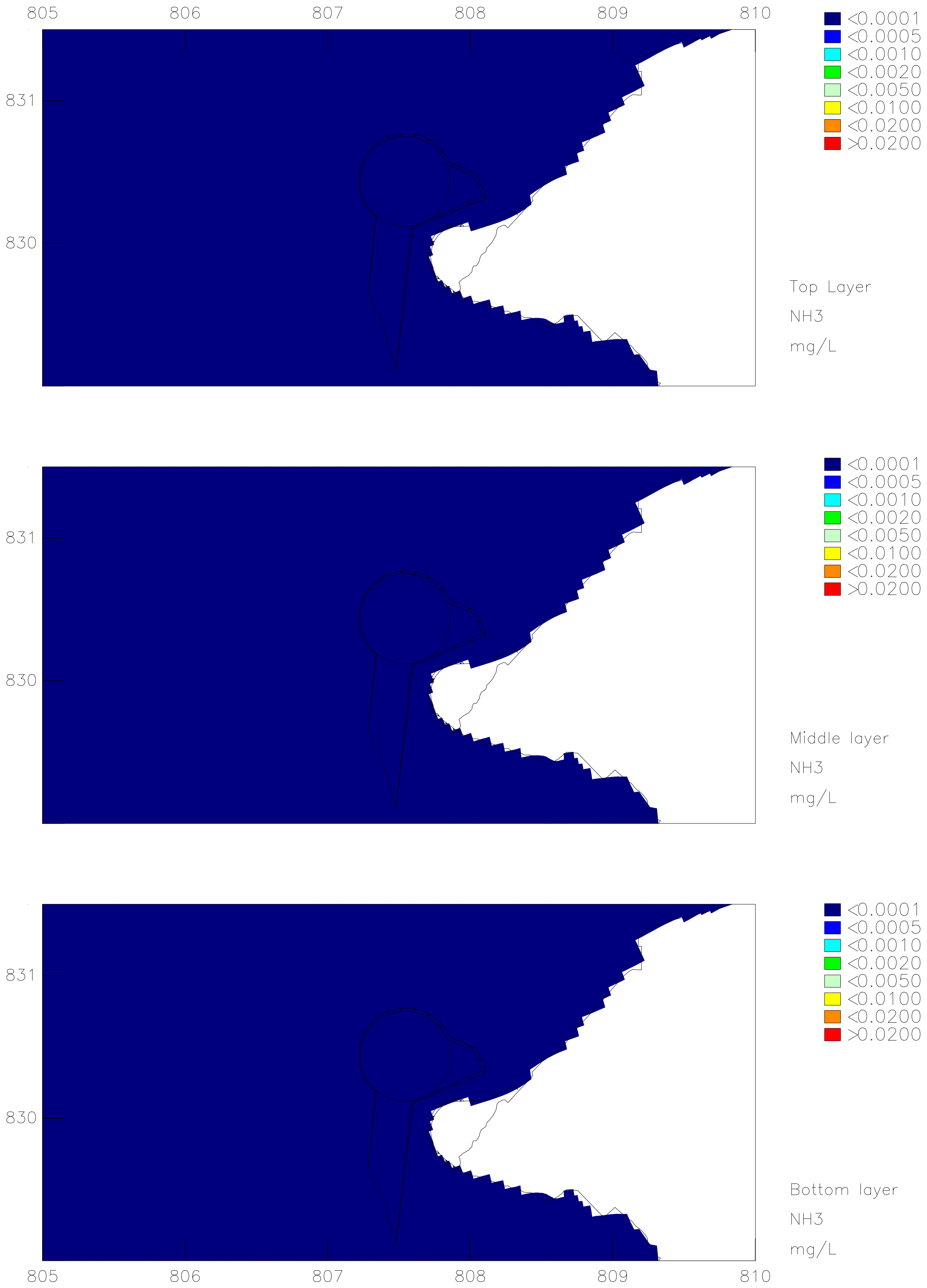


NH3 (mg/L) maximum increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I37

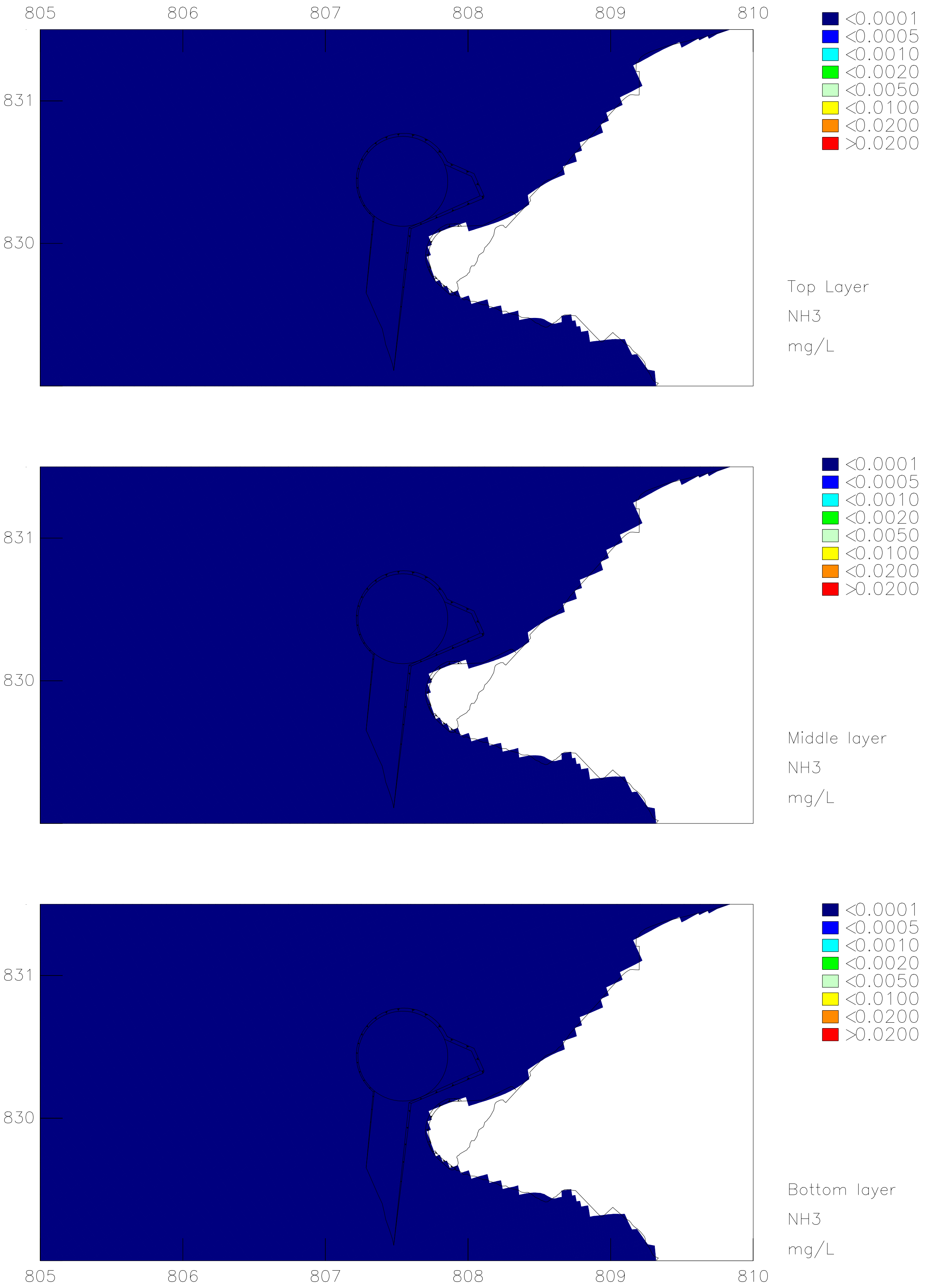


NH3 (mg/L) mean increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I38

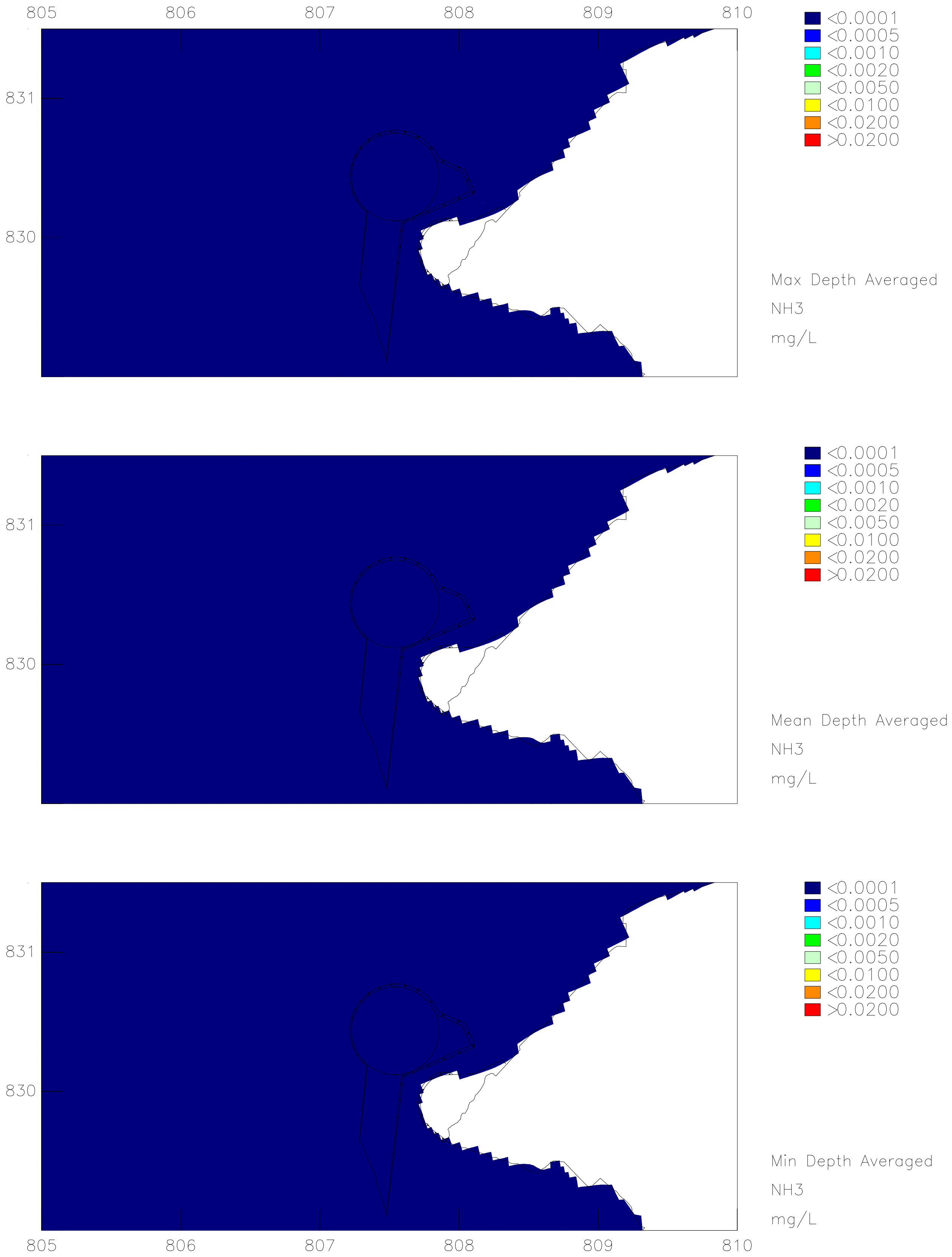


NH3 (mg/L) minimum increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I39

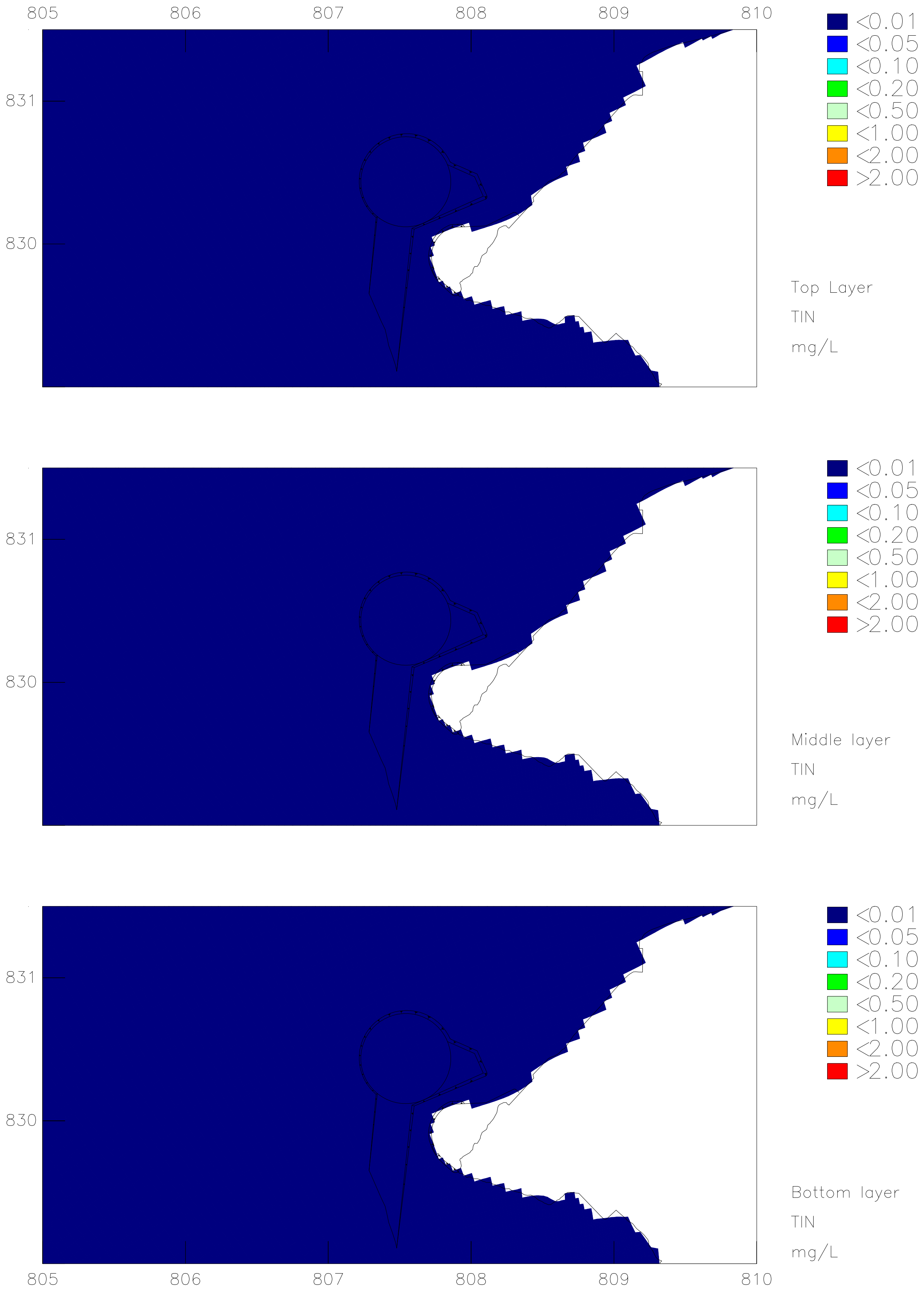


NH3 (mg/L)
Black Point Sewage emission – Operational
Maximum, Mean and Minimum depth averaged increase

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I40

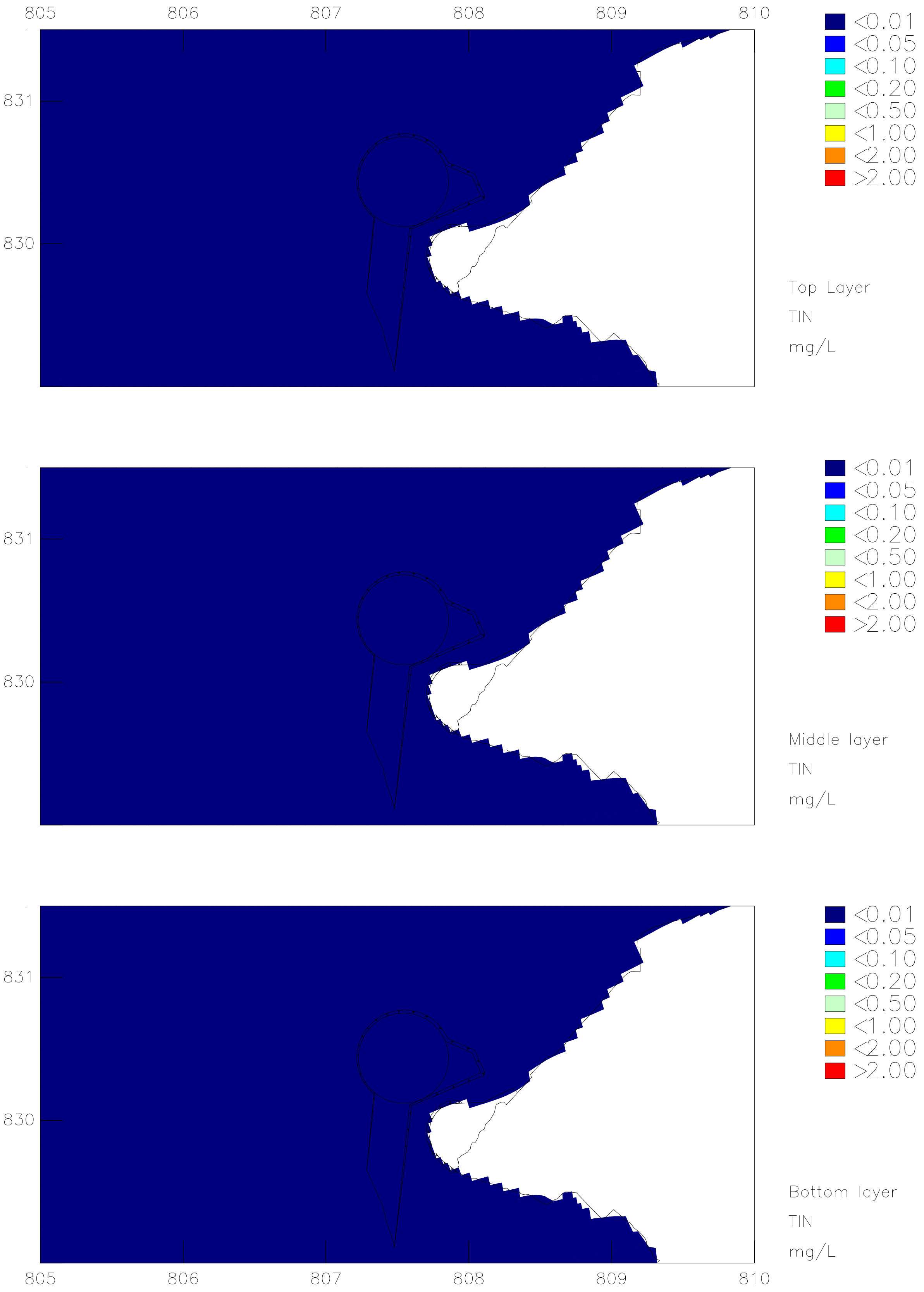


TIN (mg/L) maximum increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I41

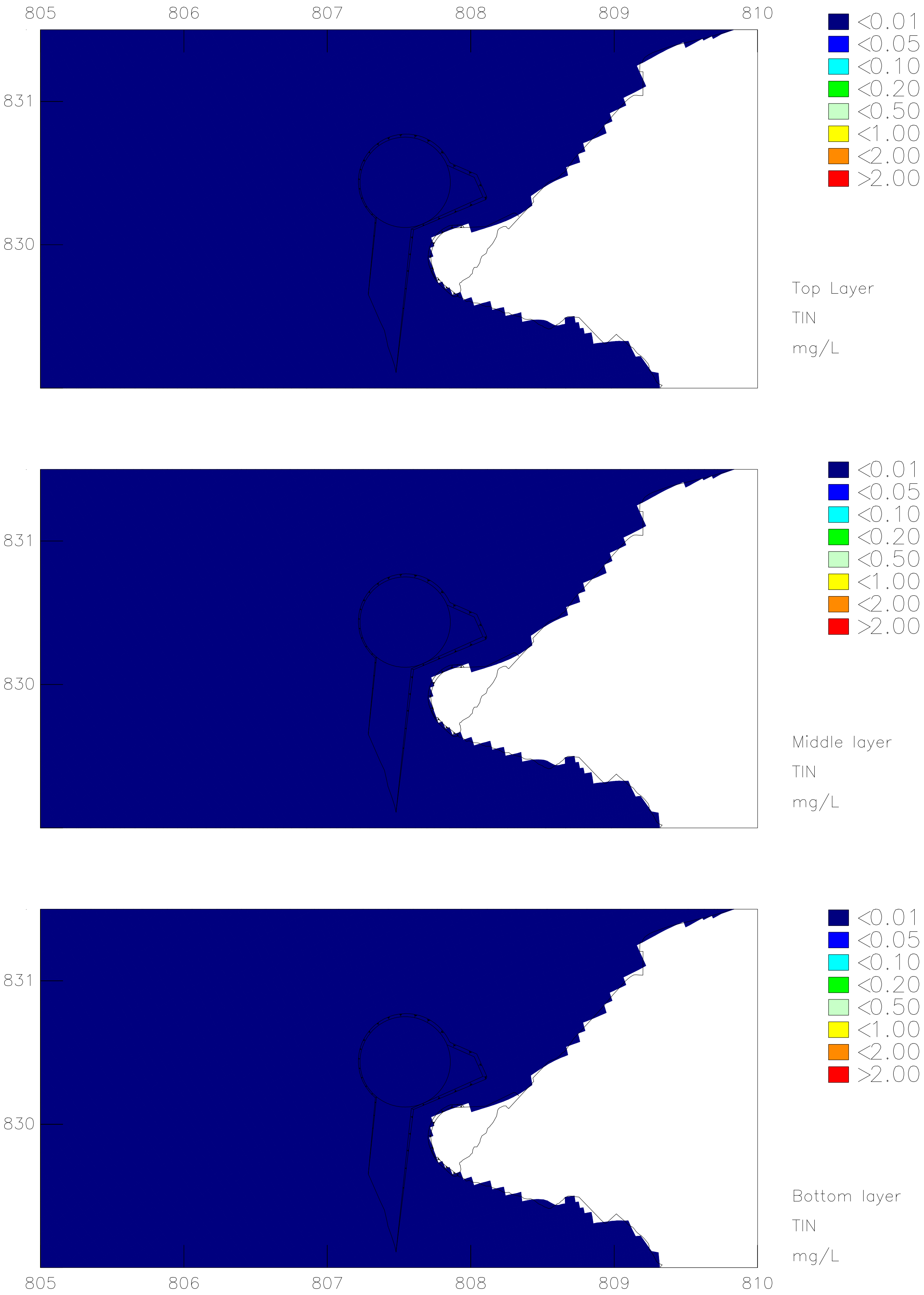


TIN (mg/L) mean increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I42

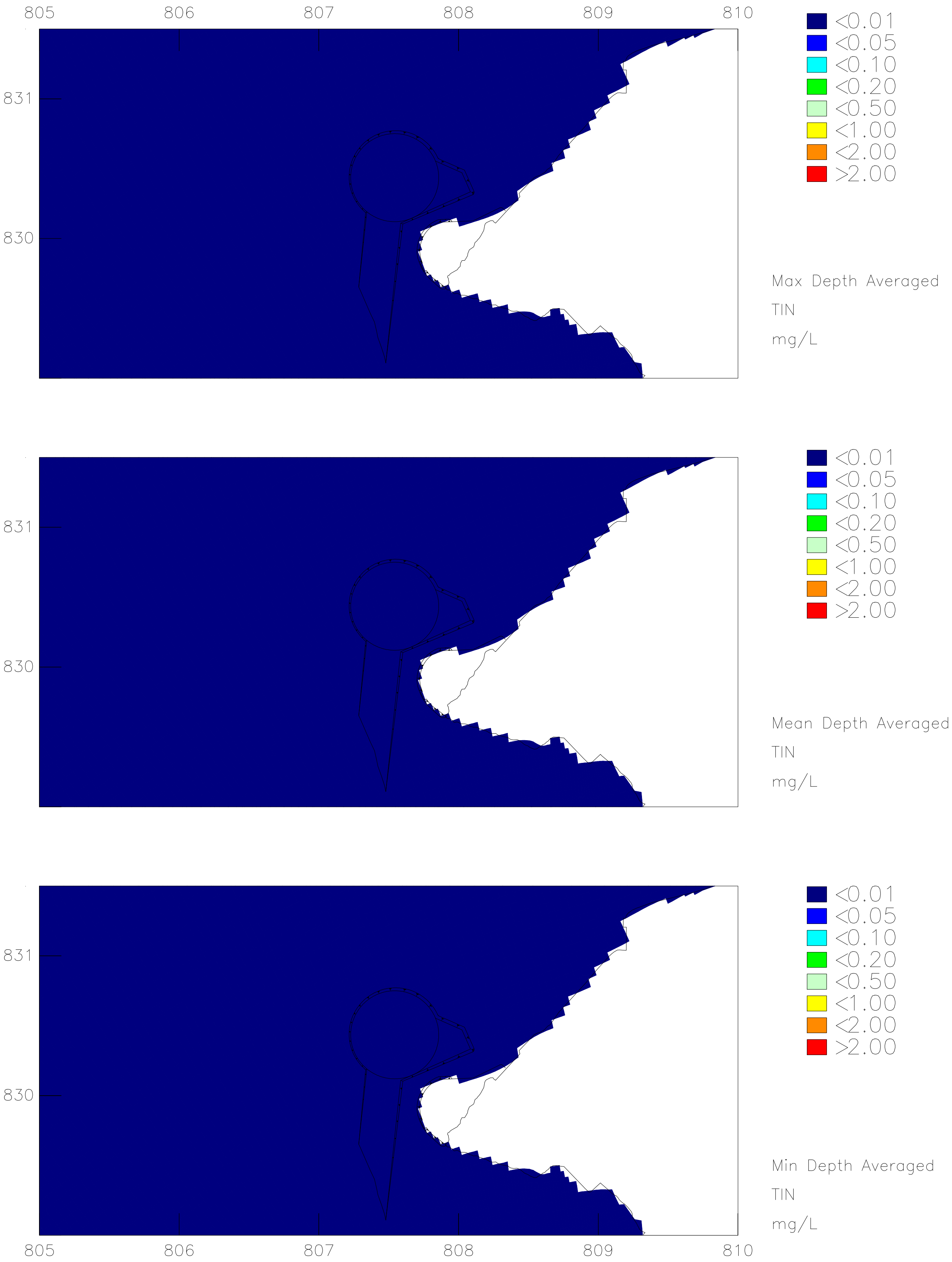


TIN (mg/L) minimum increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I43

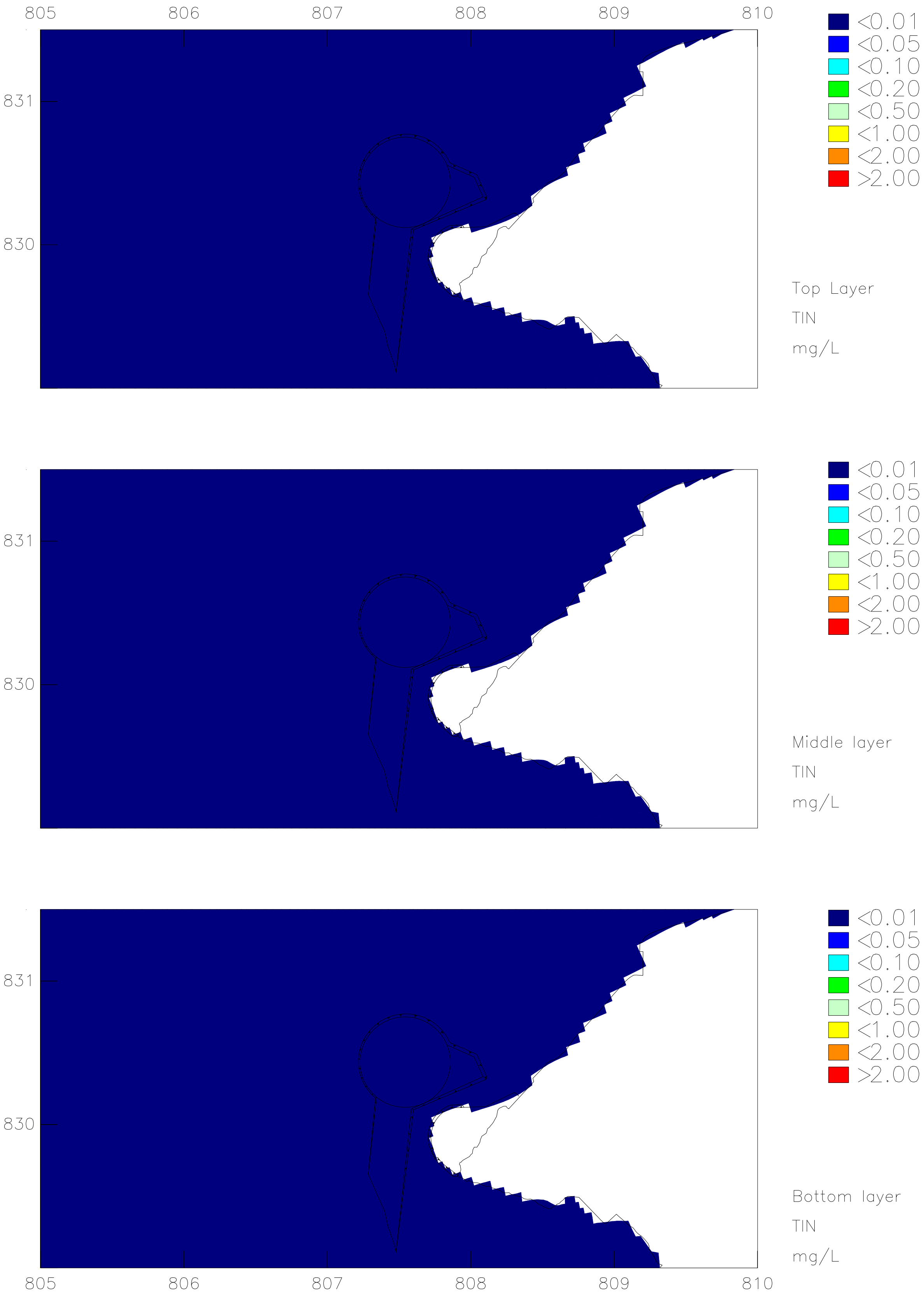


TIN (mg/L)
Black Point Sewage emission – Operational
Maximum, Mean and Minimum depth averaged increase

Dry Season

WL | Delft Hydraulics – ERM

Fig. BP_I44

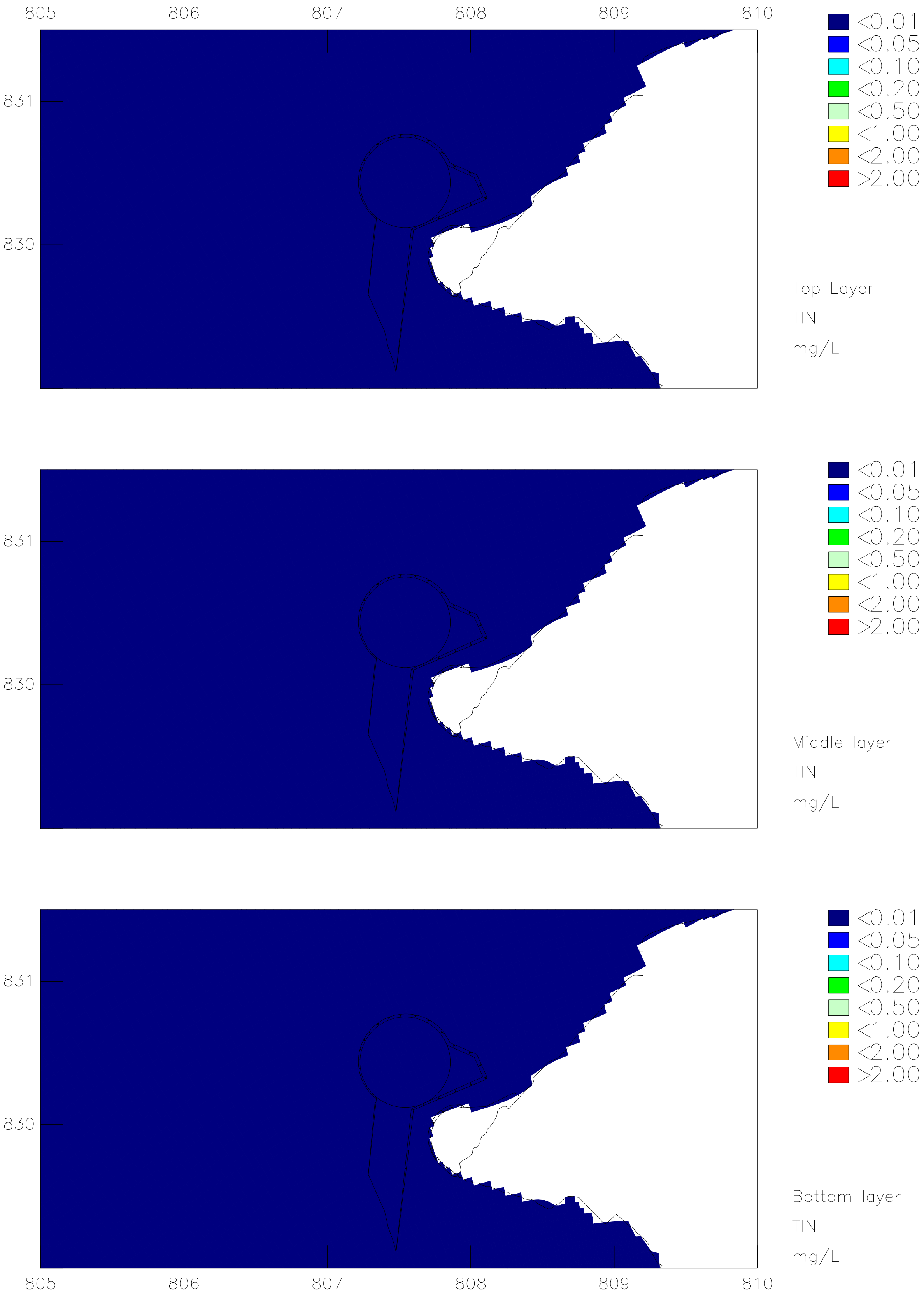


TIN (mg/L) maximum increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I45

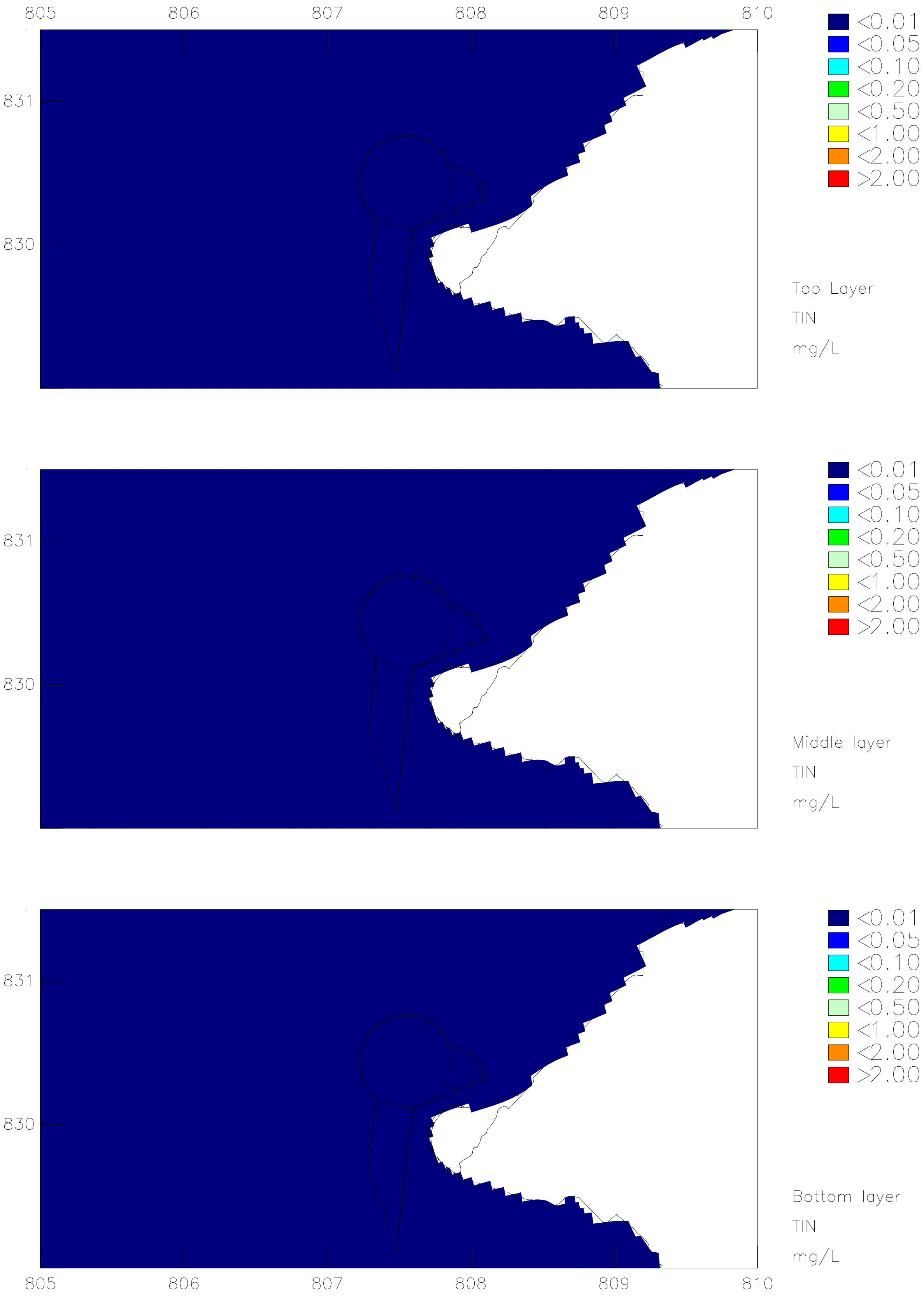


TIN (mg/L) mean increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I46

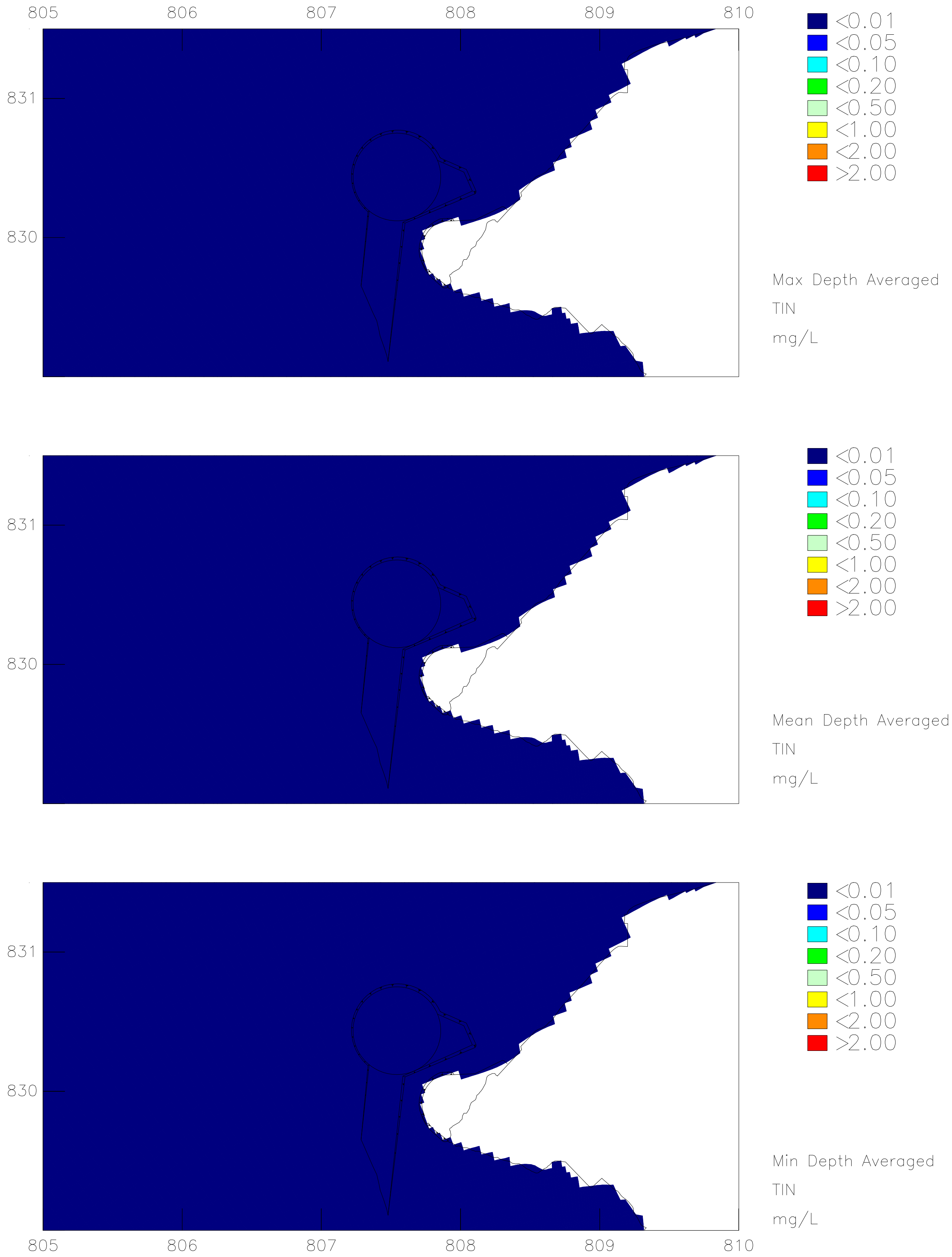


TIN (mg/L) minimum increase
Black Point Sewage emission – Operational
Top, Middle and Bottom layer

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I47



TIN (mg/L)
Black Point Sewage emission – Operational
Maximum, Mean and Minimum depth averaged increase

Wet Season

WL | Delft Hydraulics – ERM

Fig. BP_I48