Z3350

To : BV
From : Jos van Gils
Subject : EIA Hong Kong West Drainage Tunnel, Water Quality Modelling Study: Modelling results
Date : September, version 5
Cc :
Action: For your information

Introduction

Black and Veatch, Hong Kong, have commissioned Delft Hydraulics to carry out water quality model simulations in order to assess the impacts of the projected HK West Drainage Tunnel on the marine waters in the vicinity of the discharge point. The approach towards the simulations is discussed in a memo called "EIA Hong Kong West Drainage Tunnel, Water Quality Modelling Study; Method Statement" (hereafter called "Method Statement"). The present memo discusses the simulation results.

The current version 4 is written on the basis of the modified simulation results, which have been obtained in March 2005 after comments by EPD. The key modification at that time was the inclusion of the discharged fresh water in the hydrodynamics simulations. The present results are modified after a modification of the pollutant concentrations in the discharge.

Definition of simulations

General

The definition of the simulations is discussed in the Method Statement. In addition to that memo, the present memo provides some additional details, as well as some deviations to the Method Statement (version 10, 24 August 2004).

Land boundary

The model land boundary has been made compatible with the following developments (reference: memo PW/DT/GEN0/10, Chief Engineer Port Works CEDD, dated 16 August 2004):

- Helipads at Peng Chau and Yung Shue Wan;
- Central reclamation Phase III;
- Wan Chai Development Phase II;
- Stage 2 reclamation at Tuen Mun Area 38;
- Container Terminal nr. 9;
- District Open Space and Government Institution and Community Facilities, North Tsing Yi.

It should be noted that some of these developments are so small that the have to be considered "sub-grid" in view of the model's spatial resolution.

Simulated water quality scenarios

The following scenarios have been simulated:

1. 1/50 year discharge, taking place at ebb tide (spring tide conditions).
2. 1/50 year discharge, taking place at flood tide (spring tide conditions).
3. 1/2 year discharge, taking place at ebb tide (spring tide conditions).
4. 1/2 year discharge, taking place at flood tide (spring tide conditions).

Vertical dispersion coefficient

The vertical dispersion coefficient determines the degree of vertical mixing of the discharge water and the associated pollutants in the ambient waters. This value has been set to a relatively low value, representative of conditions with reduced vertical due to density differences between the discharged water and the ambient water. The selected value is 10^{-5} m^2/s.

Sedimentation/erosion parameters

Following the Method Statement, the following parameters have been selected.

Parameter	**Value**
Critical shear stress for sedimentation (Pa)	0.05
Critical shear stress for erosion (Pa)	0.1
Roughness parameter (m)	0.02
Chezy coefficient ($m^{1/2}/s$)	55

The roughness parameter and the Chezy coefficient are used to derive the shear stress acting on the sediment by the flowing water.

Discharge point

The discharge point is located at the following co-ordinates (see also). The discharge takes place at the water surface.

	X	**Y**
West Drainage Tunnel Outfall	831109	813610

Co-ordinates in Hong Kong Local co-ordinate system

Observation points

The table below specifies the exact position of the selected observation points. See also .

Observation point	**X**	**Y**
Kennedy Town (WSD Intake)	830562	816041
Queen Mary Hospital (Intake)	830606	814583
Wah Fu Estate (Intake)	831880	812419
Cyberport (WSD Intake)	831603	813044

Observation point	X	Y
Pak Kok (Coral)	830185.81	811427.69
Green Island (Coral)	829687.19	816012.44
Lo Tik Wan (Coral)	831061act	810916.13
Sok Kwu Wan (Coral)	833076	809064
Lo Tik Wan (FCZ)	831366.31	809206.5
Sok Kwu Wan (FCZ)	831549.5	807822.44
VM8 (Monitoring Station)	830364.19	817092.19
WM1 (Monitoring Station)	830685.44	812441.25
WM2 (Monitoring Station)	827882	816189
SM3 (Monitoring Station)	833462.94	809640.75
SM4 (Monitoring Station)	832319.88	808221.81
O_W-portal-Outfall	831109	813610

Co-ordinates in Hong Kong Local co-ordinate system

Discharge definition

The discharges as a function of time for the 1/2 years and the 1/50 years events are shown in Figure 1.

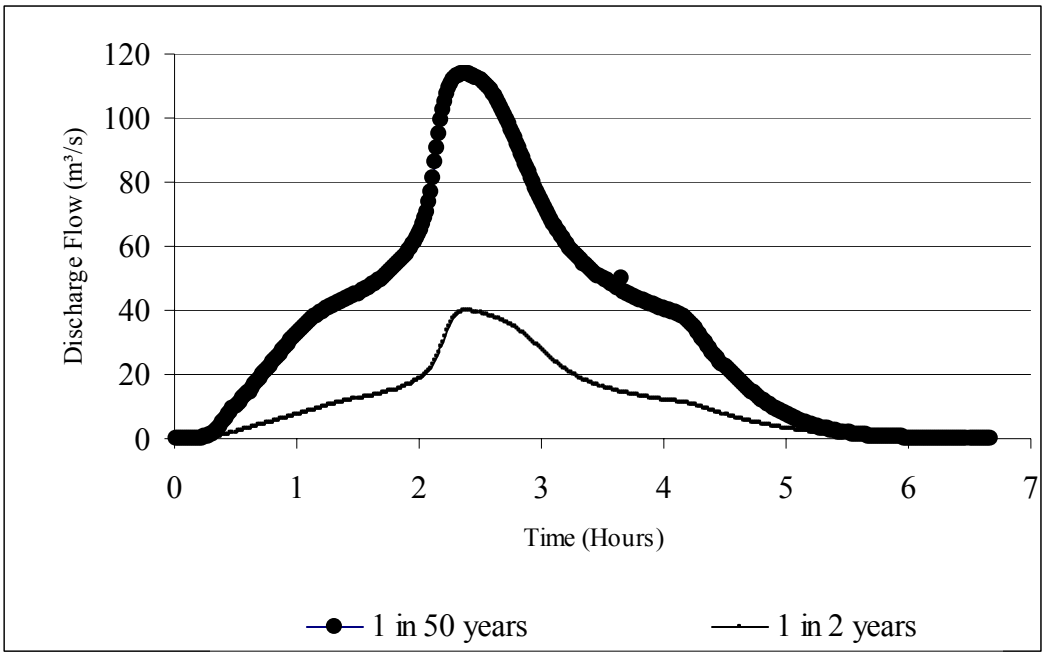

Figure 1: Discharge hydrographs

The total discharged volume is 269,641 m^3 for the 1/2 years event and 841,442 m^3 for the 1/50 year event.

Pollutant concentrations in the discharge

The simulations have been carried out for two pollutants: suspended solids and E-coliforms. Furthermore, the impact of the discharge on the salinity has been caculated.

The table below presents the pollutant concentrations in the discharges.

Scenario	Salinity (ppt)	E Coliforms (cfu/100 ml)	Suspended Solids (mg/l)
1/2 years event	0.1	425	124
1/50 years event	0.1	140	124

Although the total water volume is much smaller in the 1/2 years scenario than in the 1/50 years scenario, the total amount of E.coli discharged in both scenarios is by approximation the same, due to the higher pollutant concentration.

Water levels and currents at the discharge point

The definition of the "ebb" and "flood" discharges was based on a simulated water level time series at the regular EPD water quality monitoring station WM1 (see Figure 2). The "flood" discharge was started on 25 July at 5.00h, while the "ebb" discharge was started on 25 July at 11.00h.

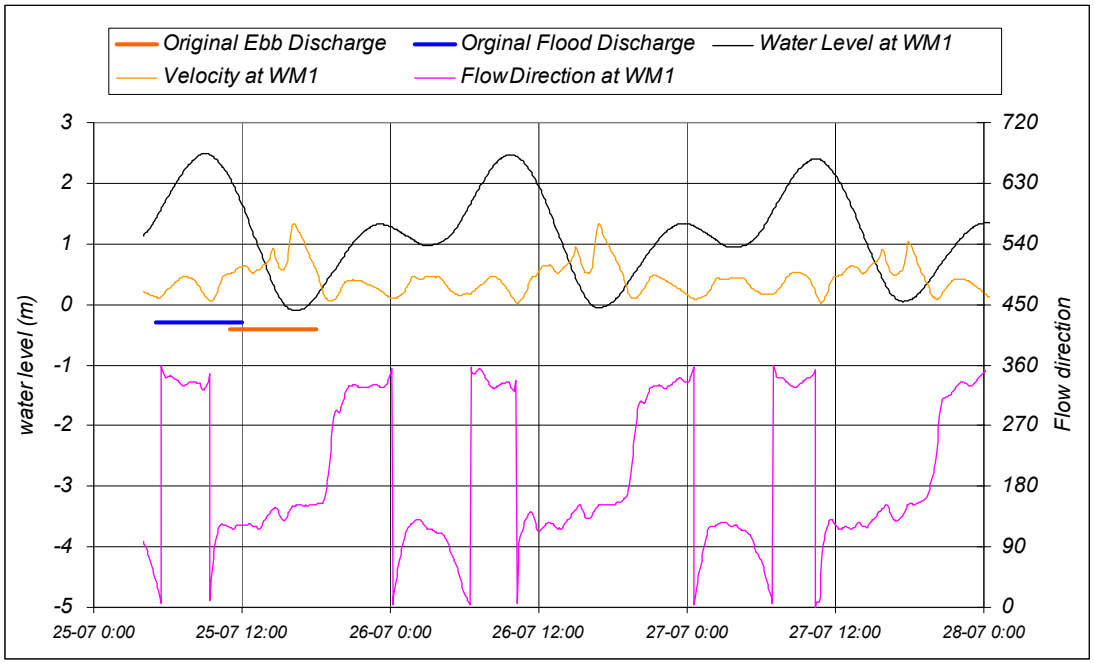

Figure 2: Timing of discharges related to ambient flow conditions (at station WM1)

Figure 2 shows the water level, the flow velocity and the flow direction at station WM1 during the simulation period, as well a the discharge periods. It can be observed that during the flood

discharges the flow direction in Lamma channel is predominantly northwest (≈ 320º) while during the ebb discharges the flow direction in Lamma channel is predominantly southeast (≈ 120-150º).

Presentation of the results

General

The discharge events cause very short episodes of elevated pollutant concentrations. For this reason, we have chosen to characterise the impacts of the discharge by the *maximum value occurring at a certain location, at any time during the event.* These maximum values are presented as a contour map, which gives a clear picture of the area potentially affected, and the level of the potential pollution impact.

It is not possible to define pollutant concentration percentiles (e.g. 10% exceedance values). The definition of percentiles presumes the definition of a certain reference period, which is impossible in the case of a short event. For all scenarios the following contour plots are presented:

- the maximum concentration of suspended solids in g/m^3 (depth averaged);
- the maximum deposition of suspended solids in g/m^2;
- the maximum concentration of *E.coli* in cfu/100ml (depth averaged);
- the minimum salinity in ppt (surface layer).

In addition to the abovementioned contour plots, the results are presented in the form of maximum concentrations occurring at specific observation points (sensitive receivers). This provides a more concrete indication of the potential impact on these sensitive receivers. To allow a real worst case assessment, the concentrations near the water surface are presented at sensitive receivers. The calculated concentrations are *excess* concentrations, which should be added to the background. At the end of this memo, the background conditions will be characterised and the excess concentrations will be evaluated in view of the background.

Maximum concentrations at selected observation points

The tables below provide the results.

Water Quality at Sensitive Receivers during a 2-year Storm Event

Location	Flood Tide		Ebb Tide	
	SS (g/m^3)	EColi (cfu/100ml)	SS (g/m^3)	EColi (cfu/100ml)
Green Island (Coral)	0.03	0.00	0.14	0.04
Lo Tik Wan (Coral)	0.02	0.00	0.01	0.00
Pak Kok (Coral)	0.01	0.00	0.01	0.00
Sok Kwu Wan (Coral)	0.02	0.00	0.01	0.00
Lo Tik Wan (FCZ)	0.00	0.00	0.01	0.00
Sok Kwu Wan (FCZ)	0.00	0.00	0.00	0.00
Cyberport (WSD Intake)	11.00	35.83	4.05	13.03
Kennedy Town (WSD Intake)	0.16	2.41	0.01	0.96
Queen Mary Hospital (Intake)	7.66	25.64	23.90	70.85
Wah Fu Estate (HA Intake)	13.16	28.84	3.71	15.68
SM3 (Monitoring Station)	0.04	0.30	1.06	3.35
SM4 (Monitoring Station)	0.00	0.00	0.01	0.00
VM8 (Monitoring Station)	0.00	0.00	0.01	0.19
WM1 (Monitoring Station)	0.00	0.02	3.69	13.98
WM2 (Monitoring Station)	0.00	0.00	0.01	0.00
Western Portal Outfall	96	320	26	88

Water Quality at Sensitive Receivers during a 50-year Storm Event

Location	Flood Tide		Ebb Tide	
	SS (g/m^3)	EColi (cfu/100ml)	SS (g/m^3)	EColi (cfu/100ml)
Green Island (Coral)	0.16	0.01	0.47	0.10
Lo Tik Wan (Coral)	0.06	0.00	0.04	0.00
Pak Kok (Coral)	0.04	0.00	0.03	0.00
Sok Kwu Wan (Coral)	0.04	0.00	0.03	0.00
Lo Tik Wan (FCZ)	0.02	0.00	0.02	0.00
Sok Kwu Wan (FCZ)	0.00	0.00	0.01	0.00
Cyberport (WSD Intake)	21.33	20.87	13.31	13.77
Kennedy Town (WSD Intake)	6.94	9.86	0.72	1.74
Queen Mary Hospital (Intake)	27.06	23.81	57.44	56.91
Wah Fu Estate (HA Intake)	22.49	15.97	9.87	8.83
SM3	1.71	2.99	3.30	6.33
SM4	0.00	0.00	0.01	0.03
VM8	0.01	0.03	0.04	0.16
WM1	0.08	0.09	8.26	13.46
WM2	0.02	0.00	0.03	0.00
Western Portal Outfall	210	232	76	85

Change in Salinity at Ecological Sensitive Receivers for 2-year Storm Events

Site	Baseline Salinity (ppt)		Maximum Cumulative Salinity (ppt)		Maximum % Change in Reduction of Salinity	
	Ebb	Flood	Ebb	Flood	Ebb	Flood
Green Island	35.00	35.14	34.90	35.04	0.28	0.29
Lo Tik Wan	35.72	36.03	35.65	35.80	0.22	0.28
Pak Kok	34.51	34.51	34.18	34.21	0.94	0.87
Sok Kwu Wan	35.99	35.36	35.91	35.27	0.22	0.23

Change in Salinity at Ecological Sensitive Receivers for 50-year Storm Events

Site	Baseline Salinity (ppt)		Maximum Cumulative Salinity (ppt)		Maximum % Change in Reduction of Salinity	
	Ebb	Flood	Ebb	Flood	Ebb	Flood
Green Island	35.33	34.27	35.21	34.27	0.33	0.00
Lo Tik Wan	36.00	35.89	35.90	35.84	0.25	0.17
Pak Kok	34.51	32.25	34.18	32.10	0.94	0.47
Sok Kwu Wan	35.99	35.99	35.90	35.91	0.24	0.22

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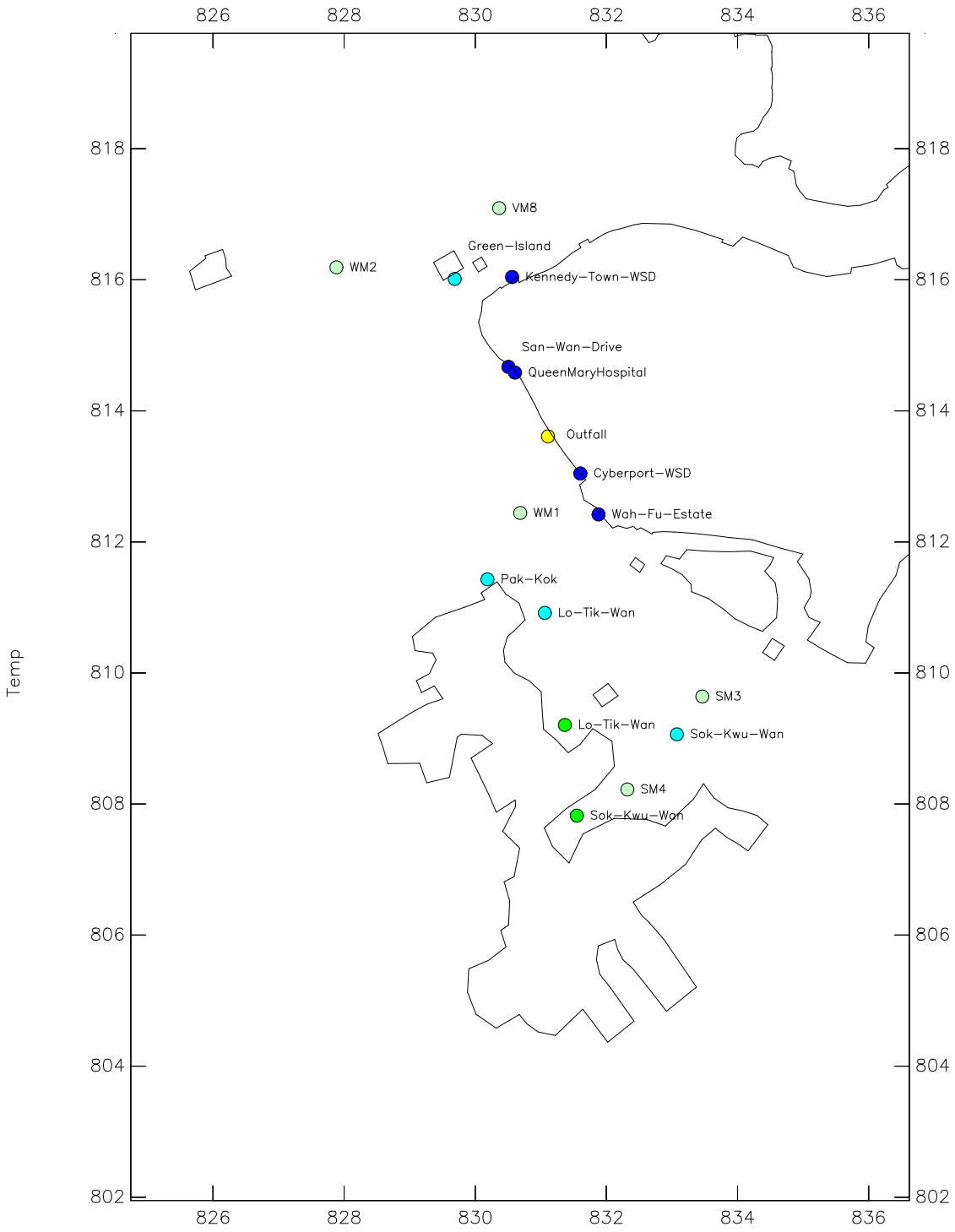
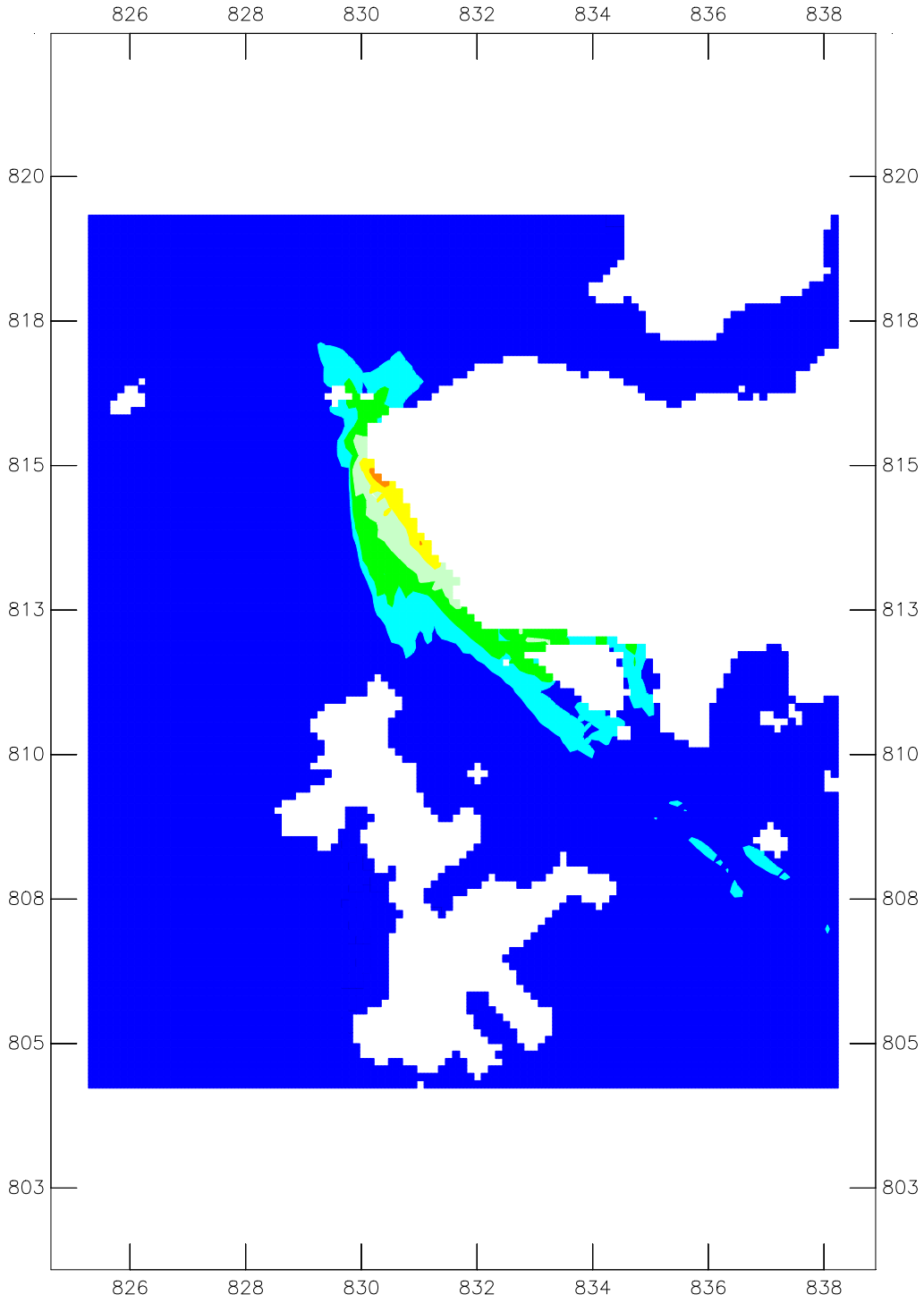
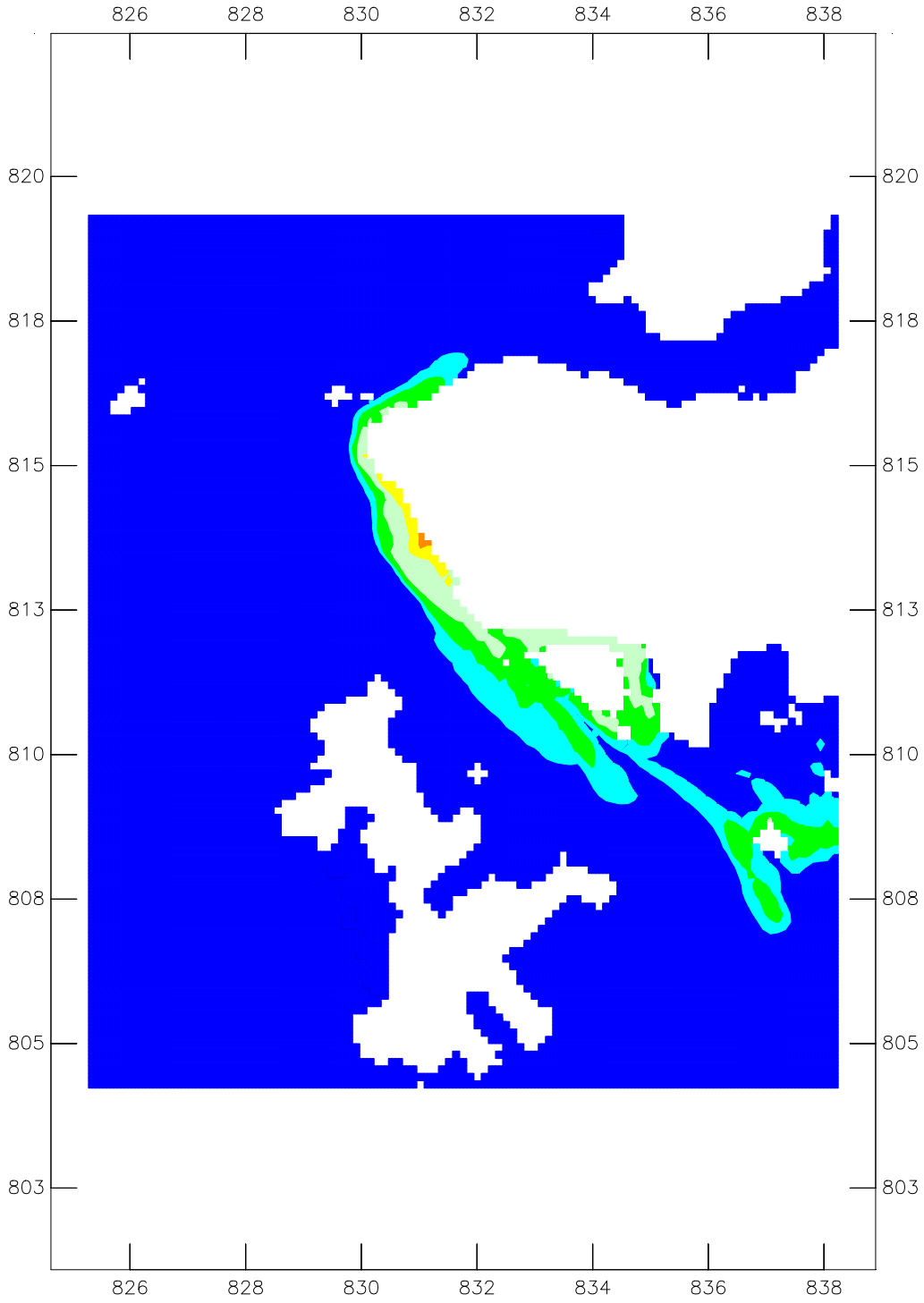


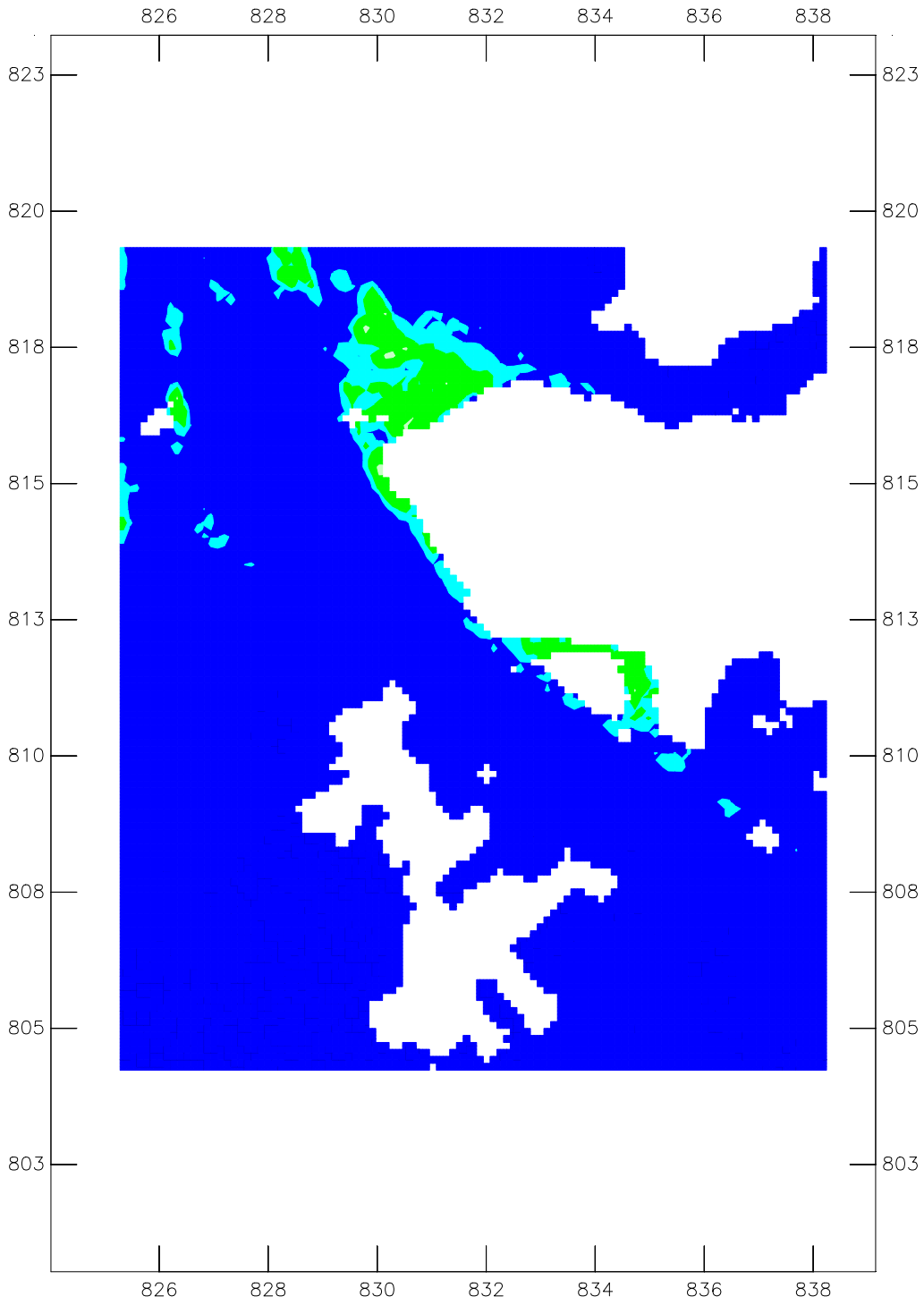
Relevant locations: Yellow: outfall, Blue: intakes, Light blue: coral zones Light green: monitoring stations, Green: marine parks	Z3350	
	Delft3D	
WL | Delft Hydraulics		



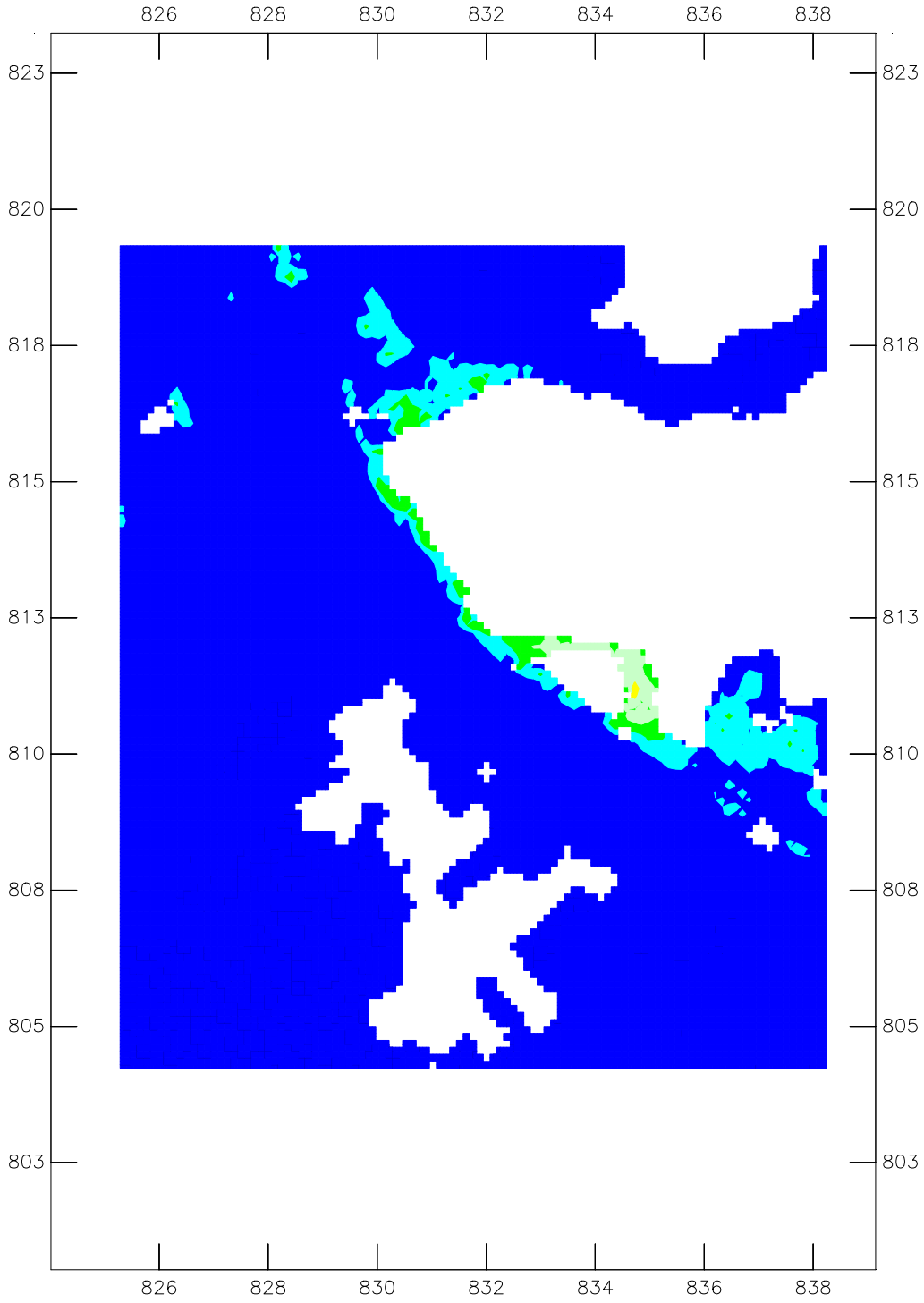
Project: Hong Kong – West Drainage Tunnel Maximum concentration of suspended solids in the water column (g/m3) (vertically averaged concentration)	Z3350
	1/50 years storm – ebb tide
WL | Delft Hydraulics	Delft3D–PART

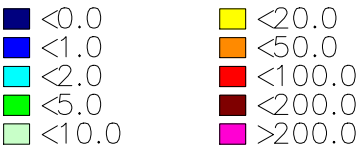


Project: Hong Kong – West Drainage Tunnel Maximum concentration of suspended solids in the water column (g/m3) (vertically averaged concentration)	Z3350	
	1/50 years storm – flood tide	
WL | Delft Hydraulics	Delft3D–PART	



Project: Hong Kong – West Drainage Tunnel Maximum deposition rate (g/m2/d)	Z3350
	1/50 years storm – ebb tide
WL | Delft Hydraulics	Delft3D–PART





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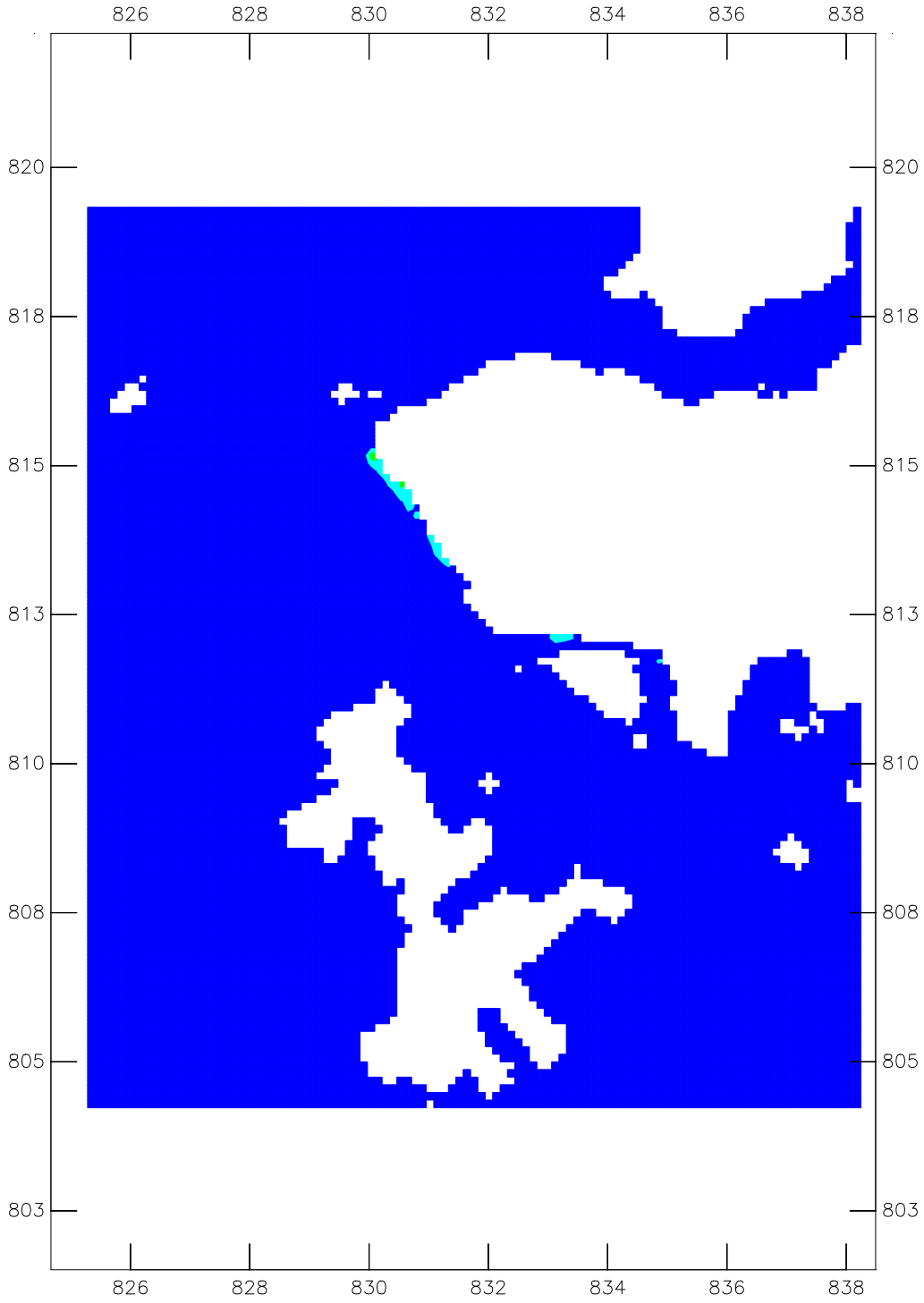

Project: Hong Kong – West Drainage Tunnel Maximum concentration of E. Coli in the water column (CFU/100ml) (vertically averaged concentration, geometric)	z3350
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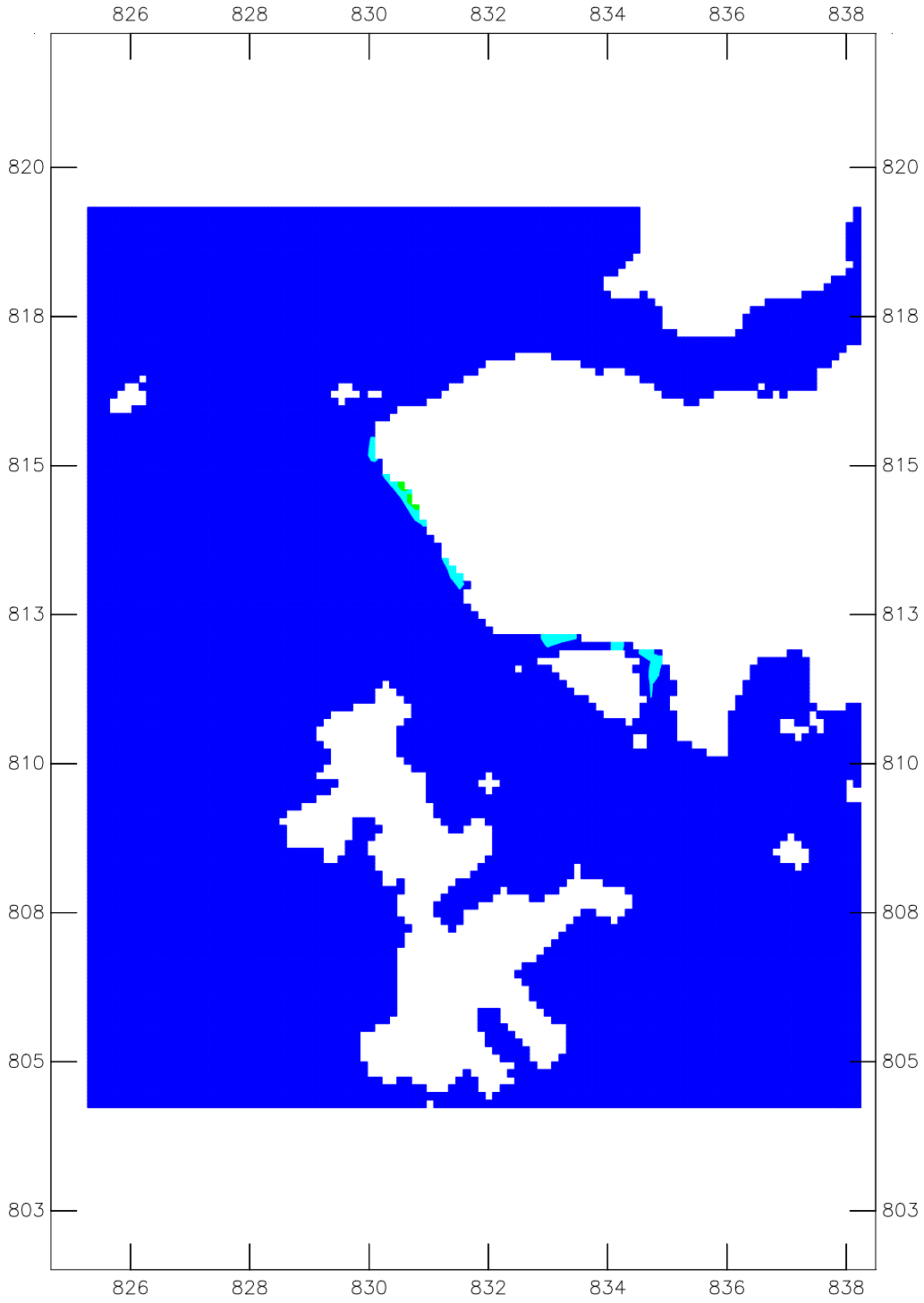

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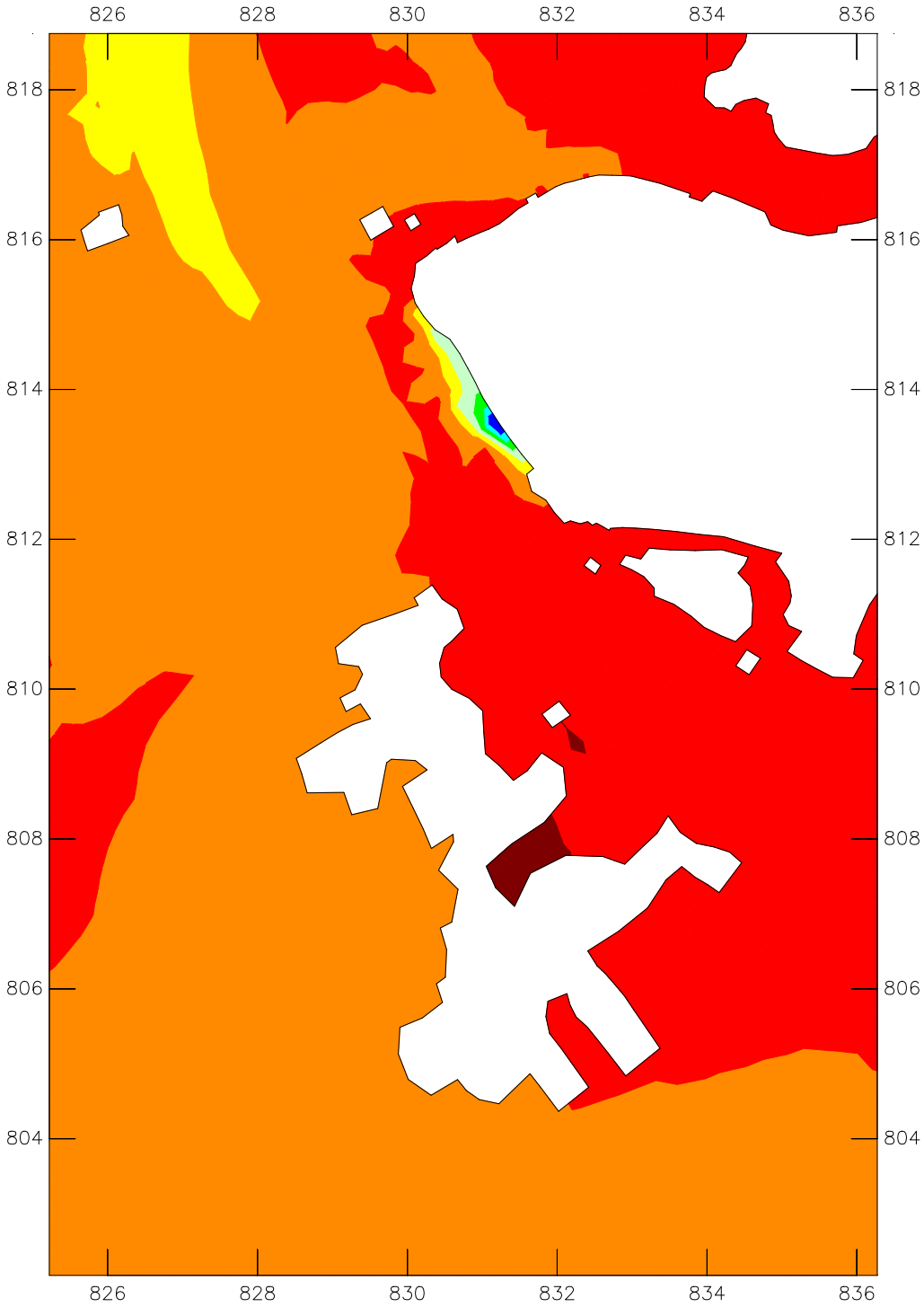
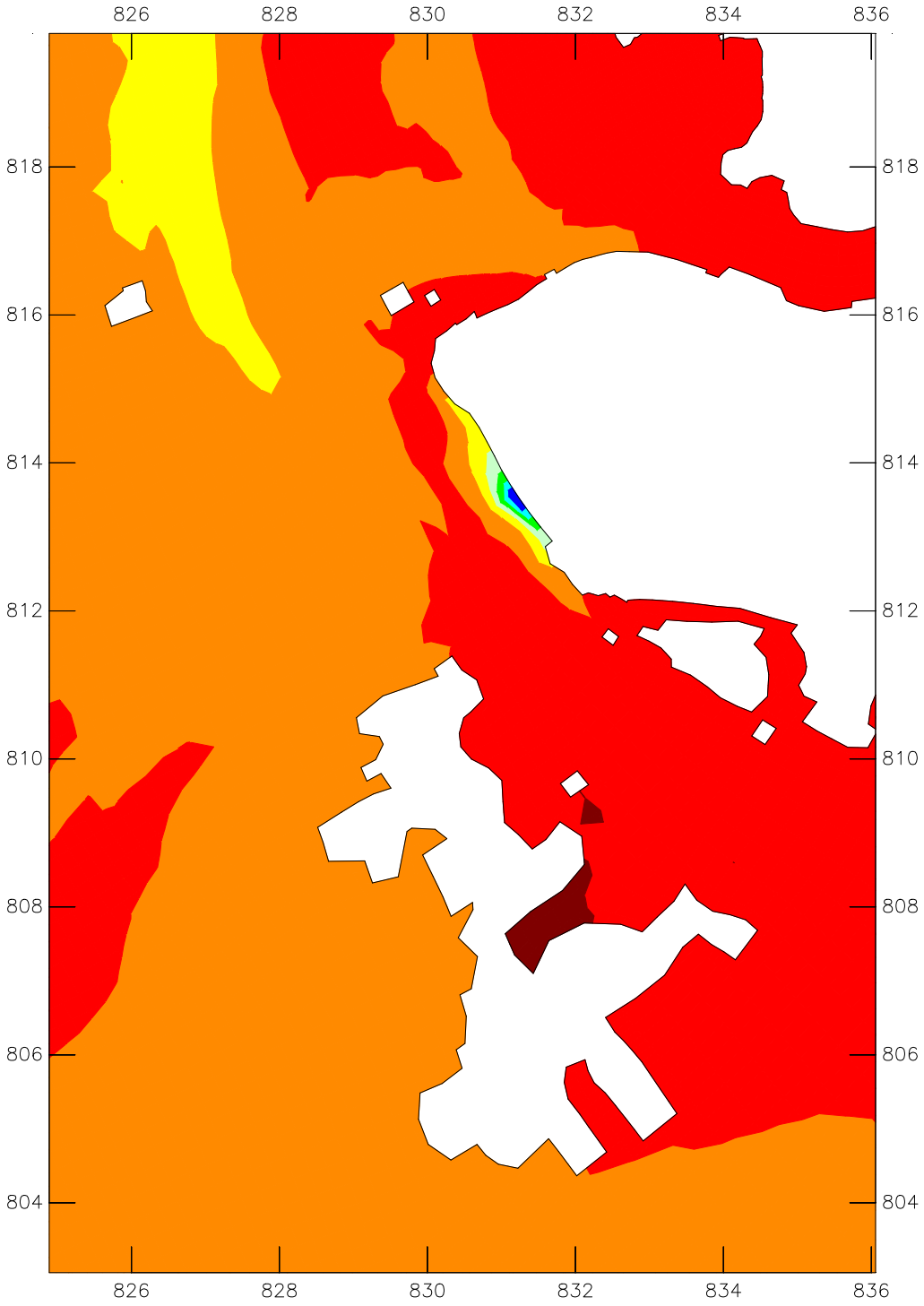


Project: Hong Kong – West Drainage Tunnel Salinity – minimum value top layer (ppt)	z3350	
	1/50 years storm – ebb tide	
WL | Delft Hydraulics	Delft3D	



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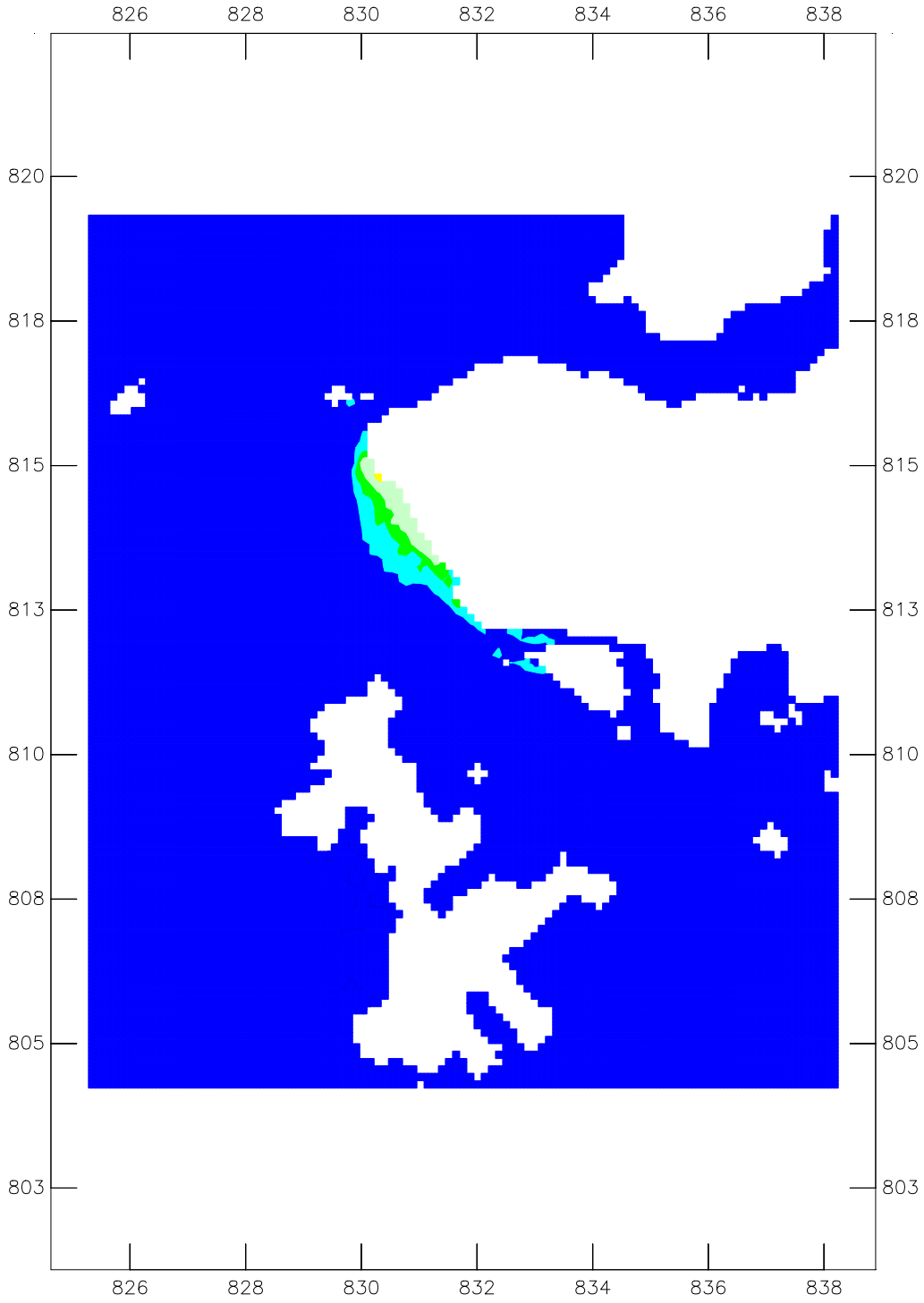
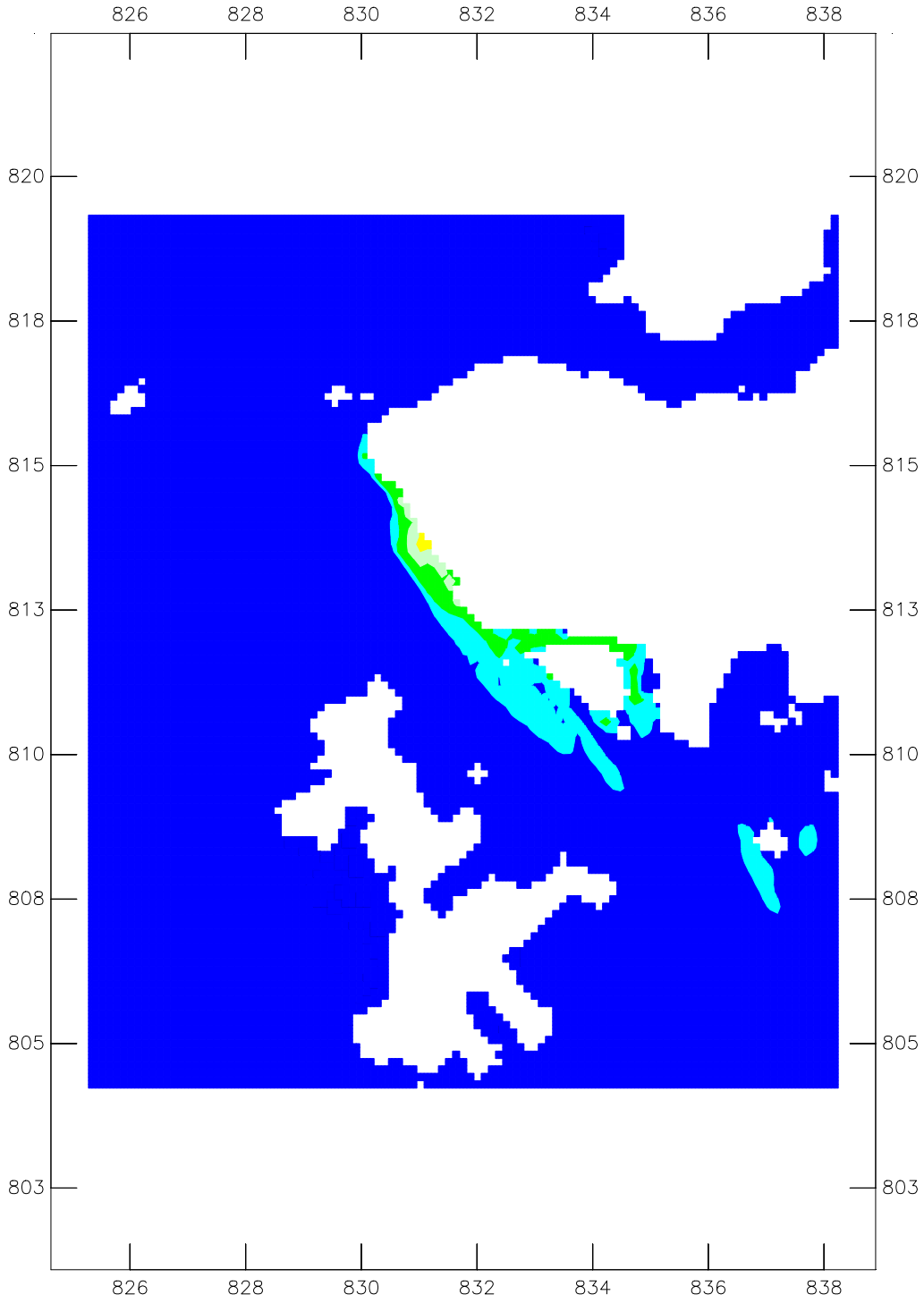


Project: Hong Kong – West Drainage Tunnel Maximum concentration of suspended solids in the water column (g/m3) (vertically averaged concentration)	Z3350
	1/2 years storm – ebb tide
WL | Delft Hydraulics	Delft3D–PART



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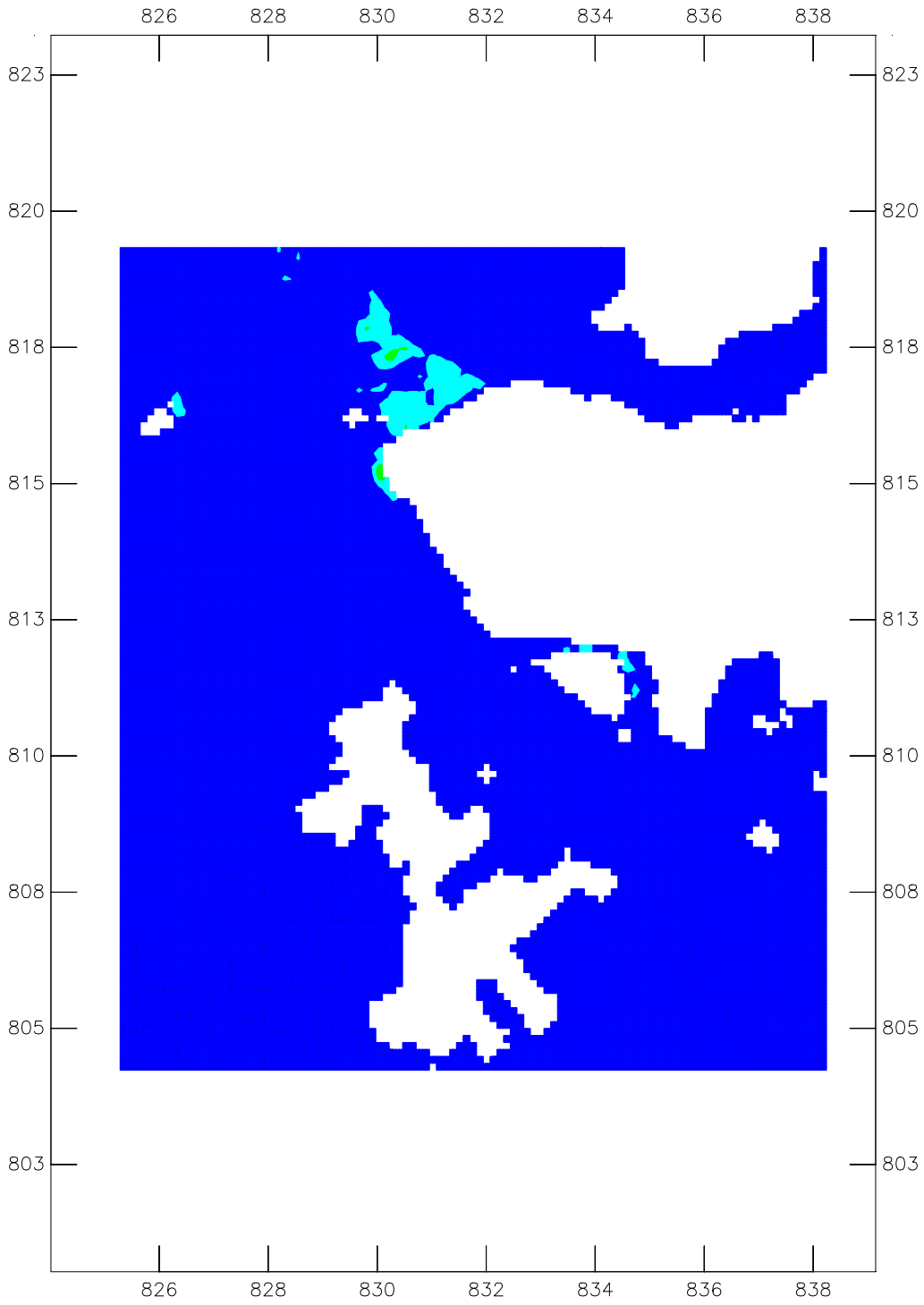

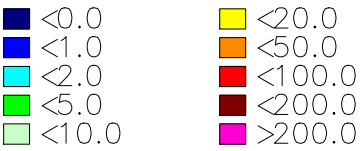

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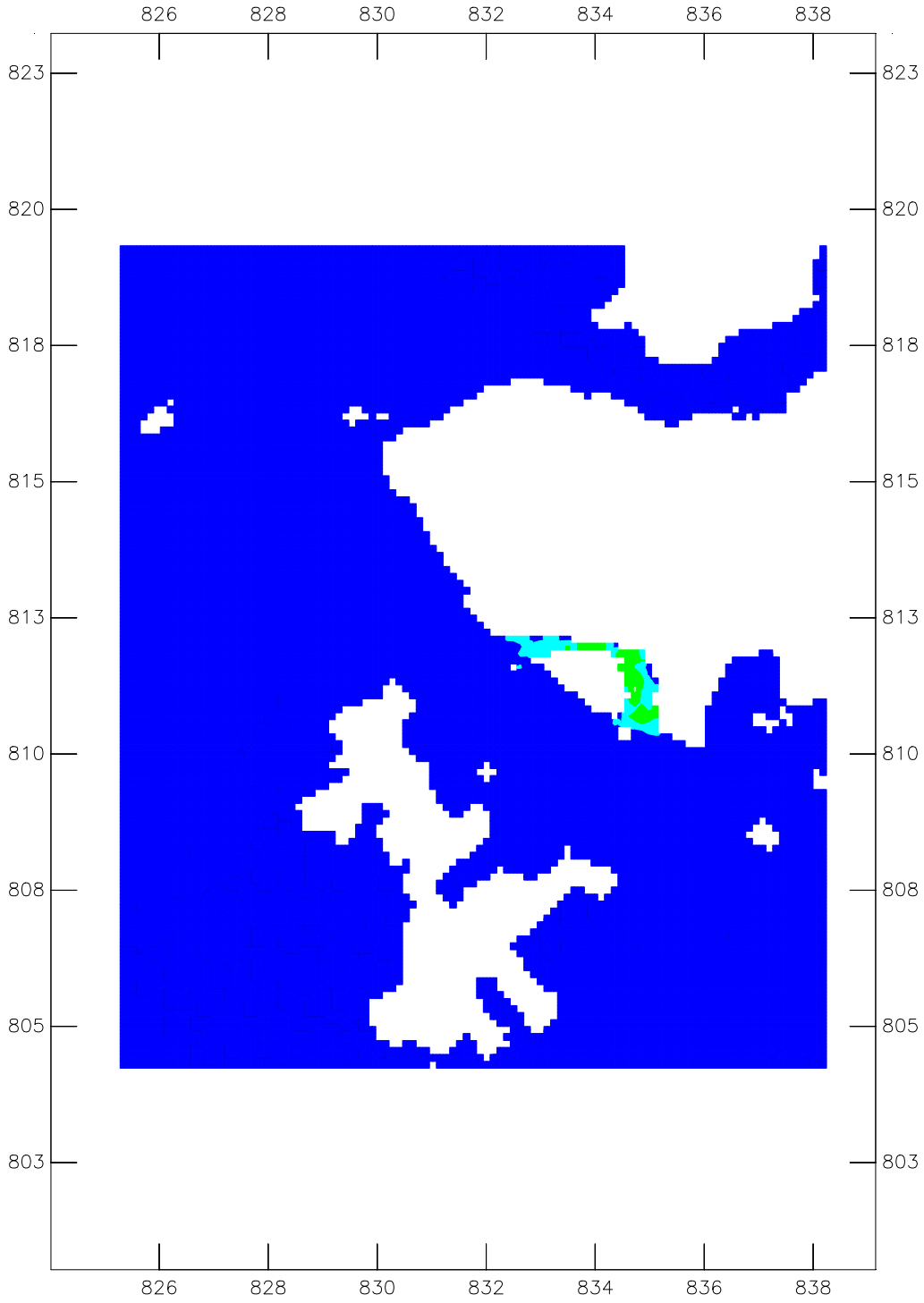

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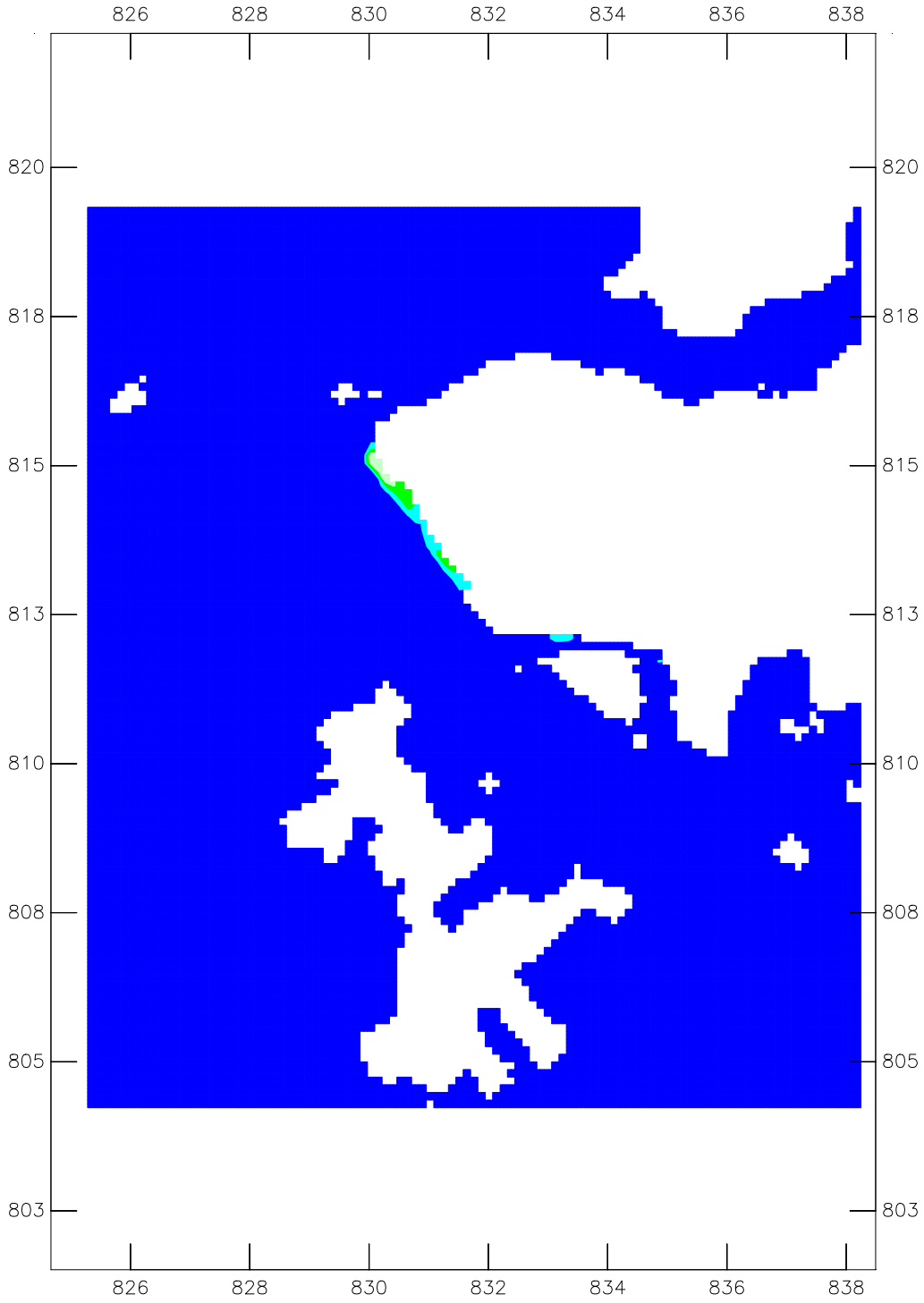

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	1/2 years storm – ebb tide	
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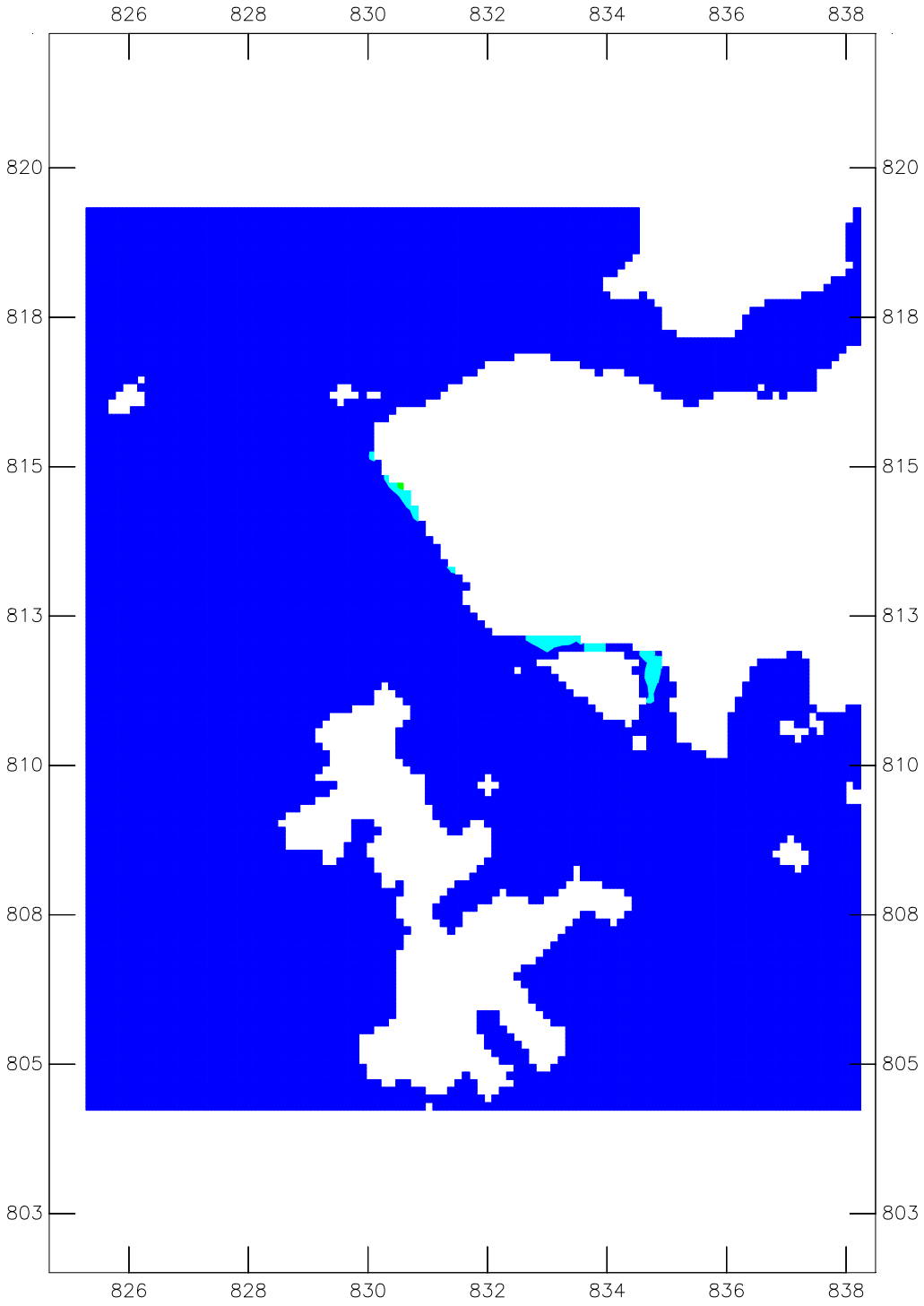

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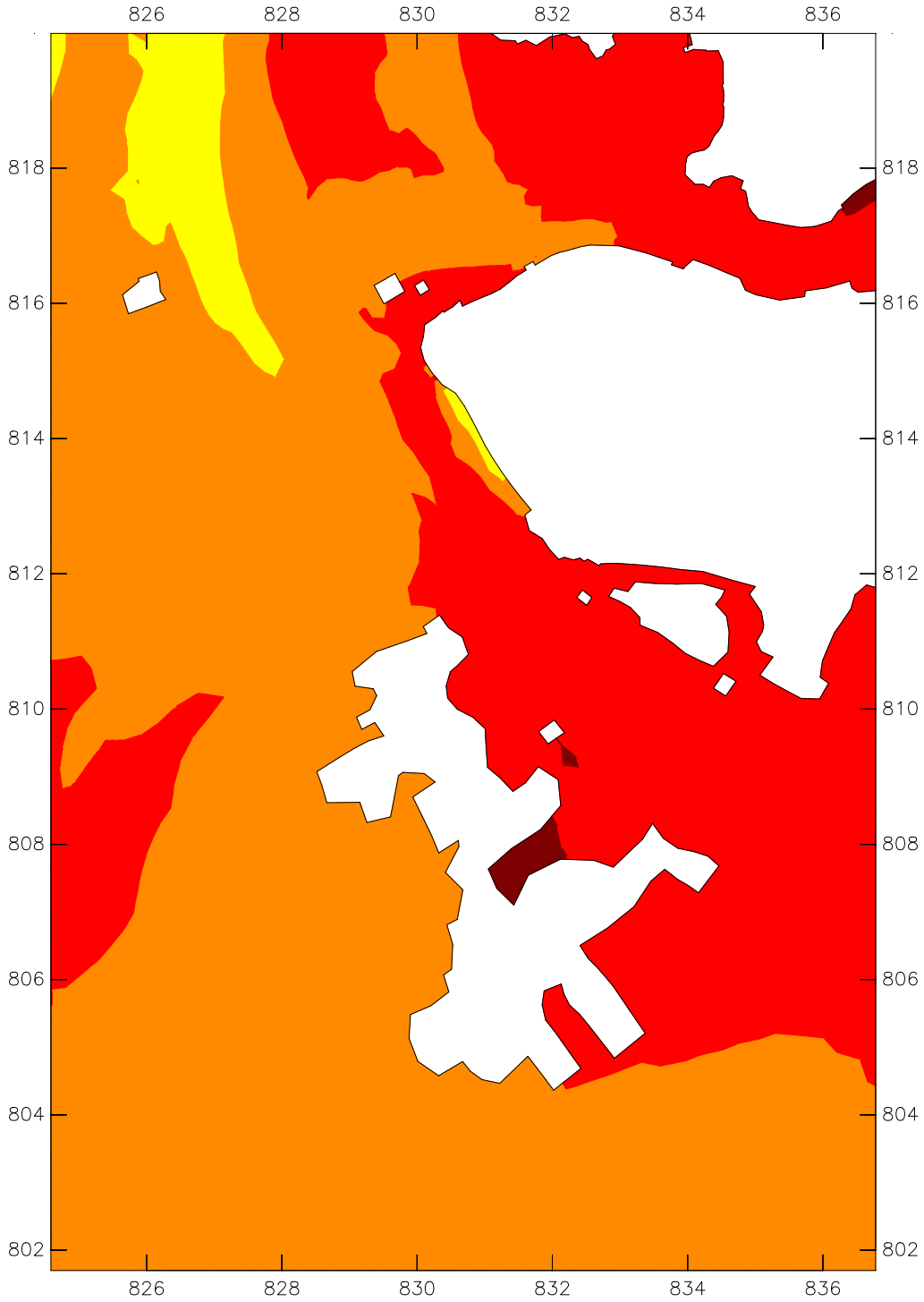
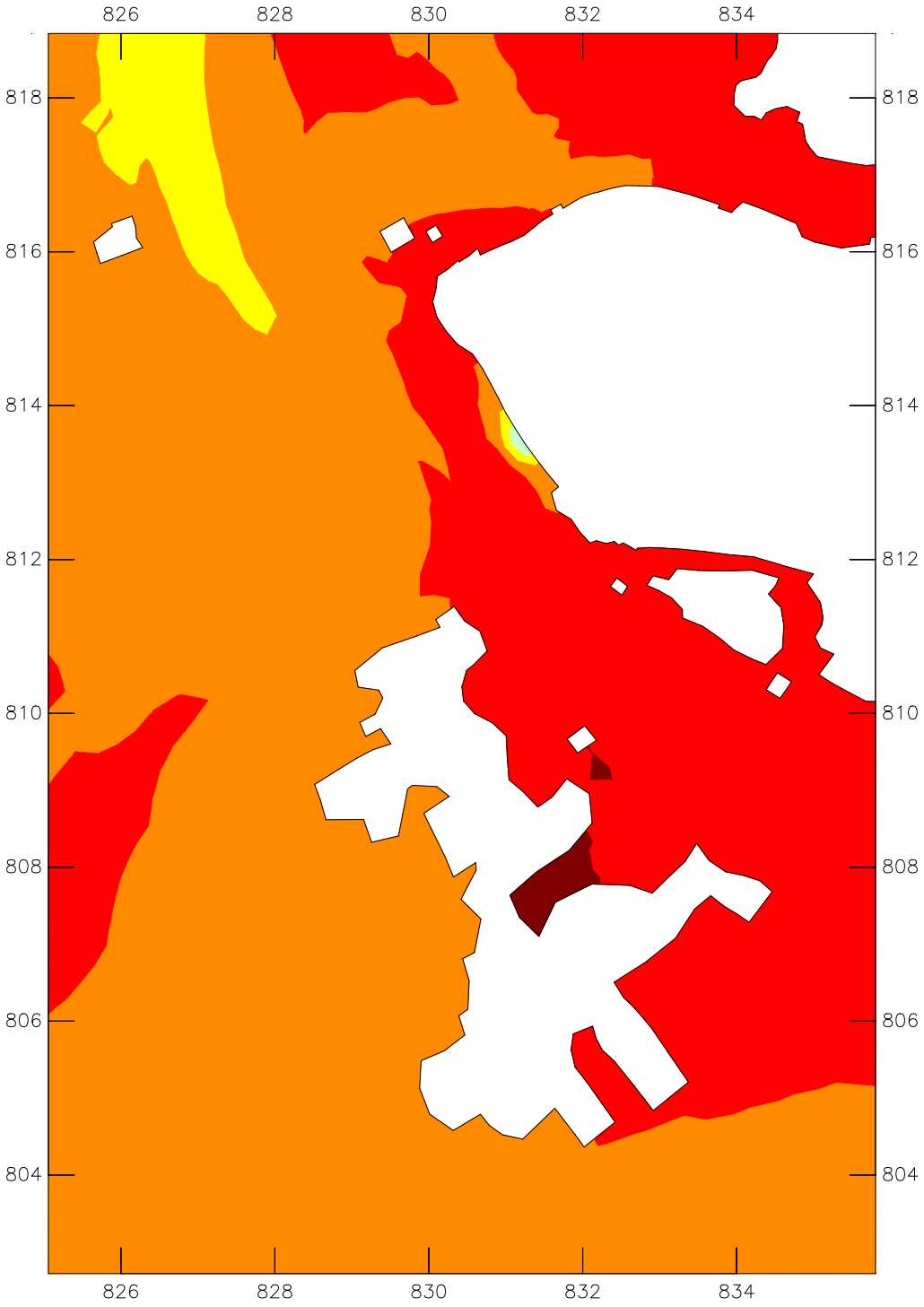


Project: Hong Kong – West Drainage Tunnel Salinity – minimum value top layer (ppt)	z3350	
	1/2 years storm – ebb tide	
WL | Delft Hydraulics	Delft3D	



Project: Hong Kong – West Drainage Tunnel Salinity – minimum value top layer (ppt)	z3350	
	1/2 years storm – flood tide	
WL | Delft Hydraulics	Delft3D	

Chart 1a - SS (1 in 50 year, Spring Ebb Tide) at Intake Sensitive Receivers

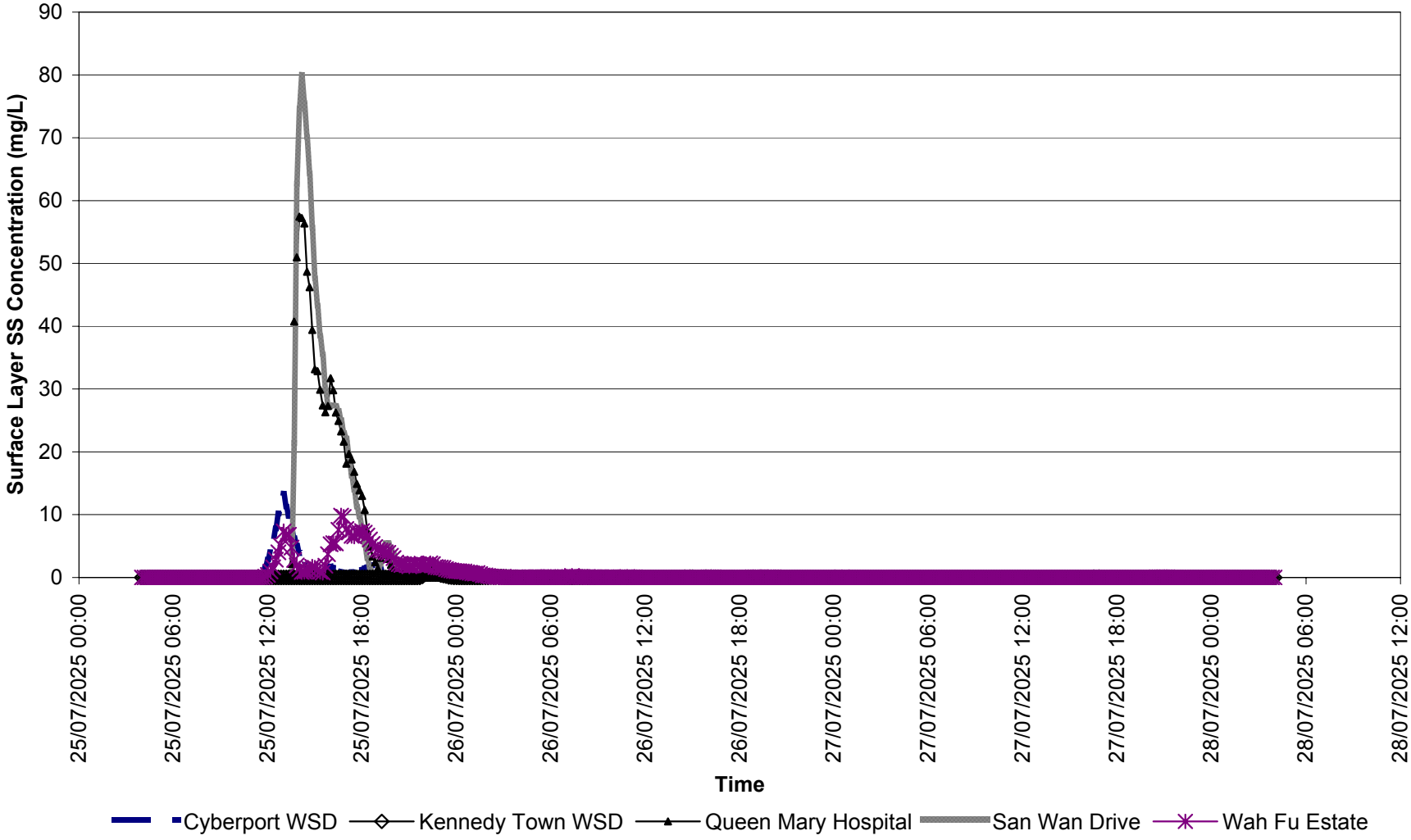


Chart 1b - SS (1 in 50 year, Spring Flood Tide) at Intake Sensitive Receivers

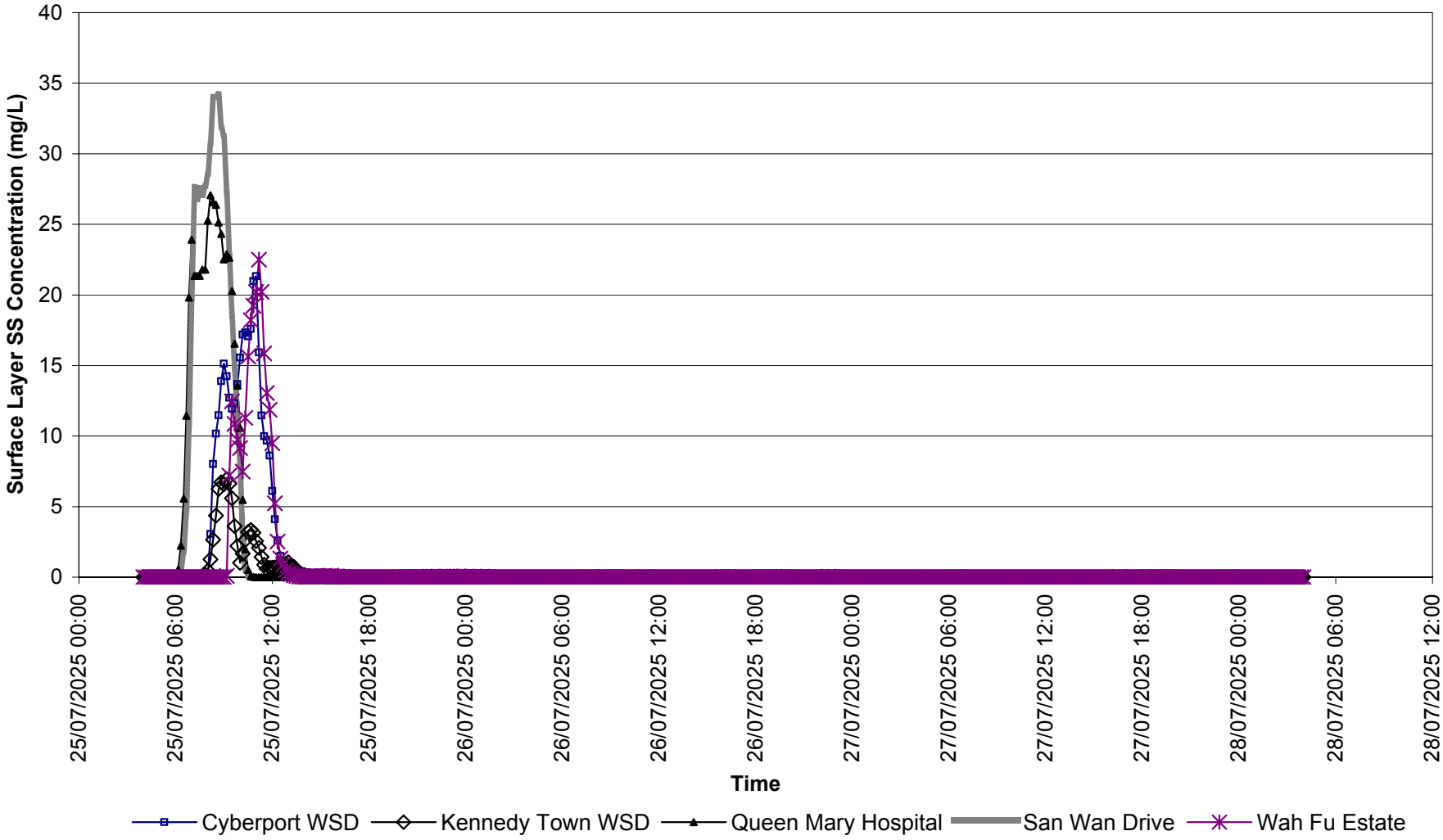


Chart 2a - SS (1 in 50 year, Spring Ebb Tide) at Fish Culture Zone Sensitive Receivers

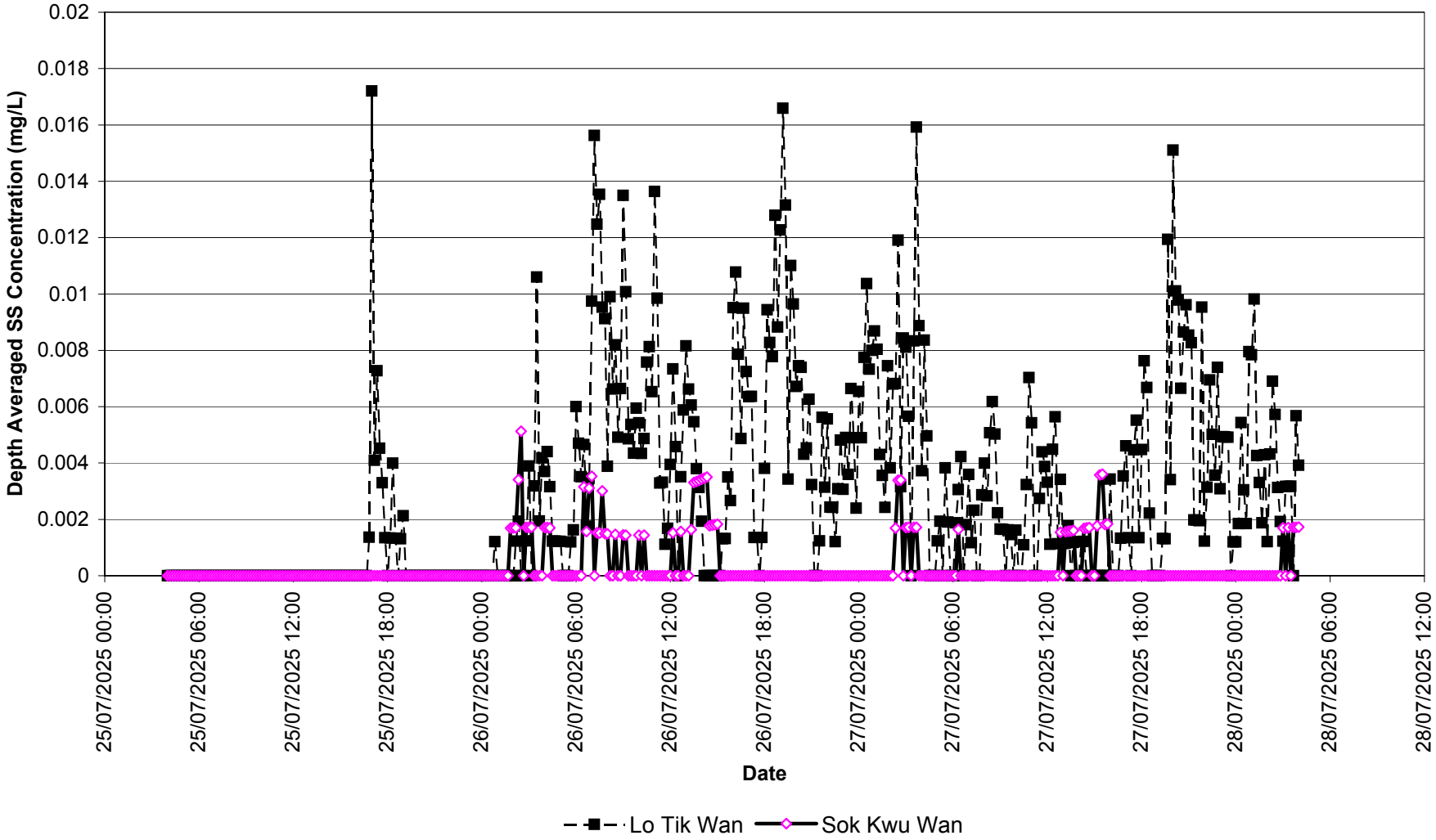


Chart 2b - SS (1 in 50 year, Spring Flood Tide) at Fish Culture Zone Sensitive Receivers

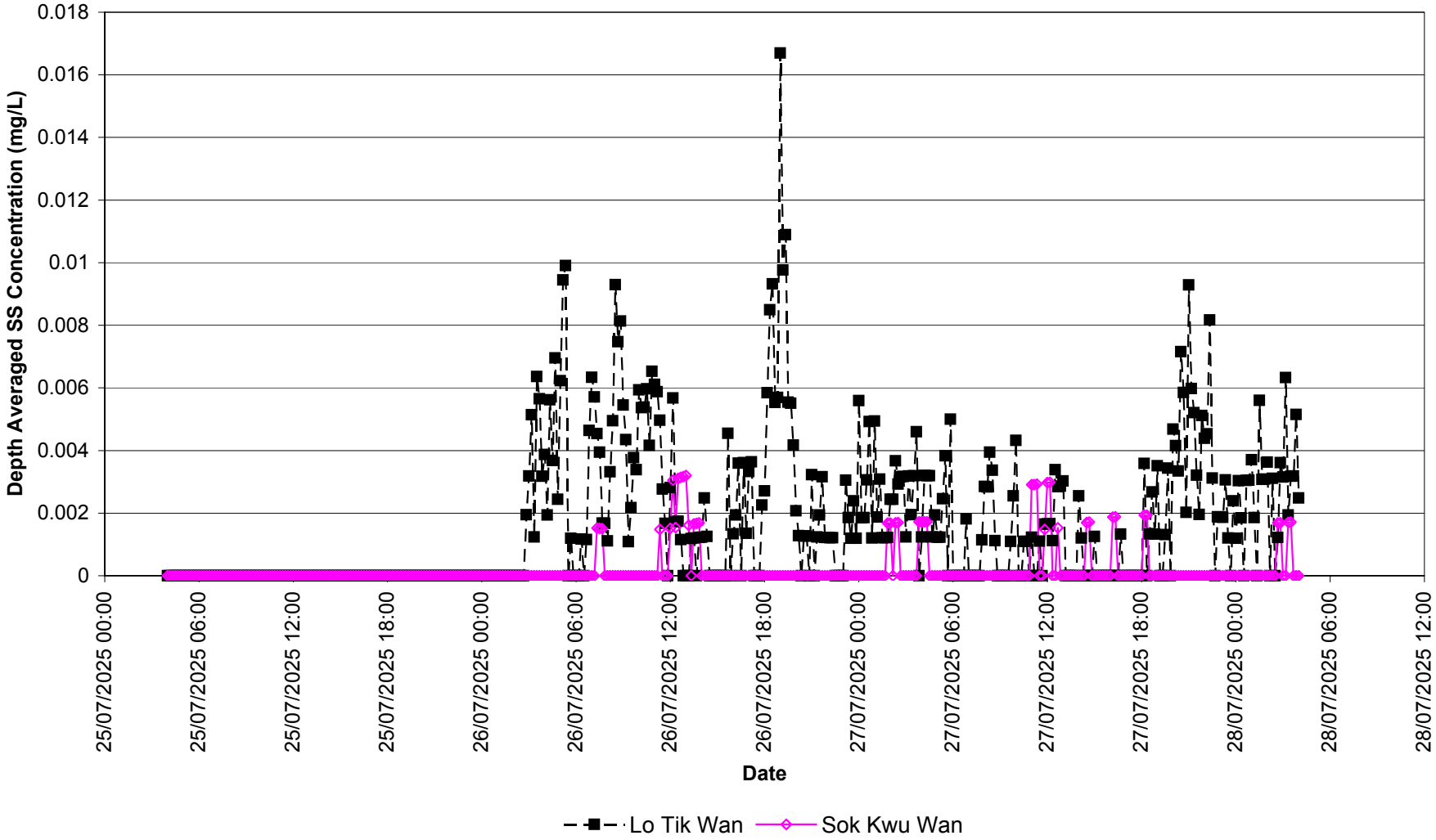


Chart 3a - SS (1 in 50 year, Spring Ebb Tide) at Coral Sensitive Receivers

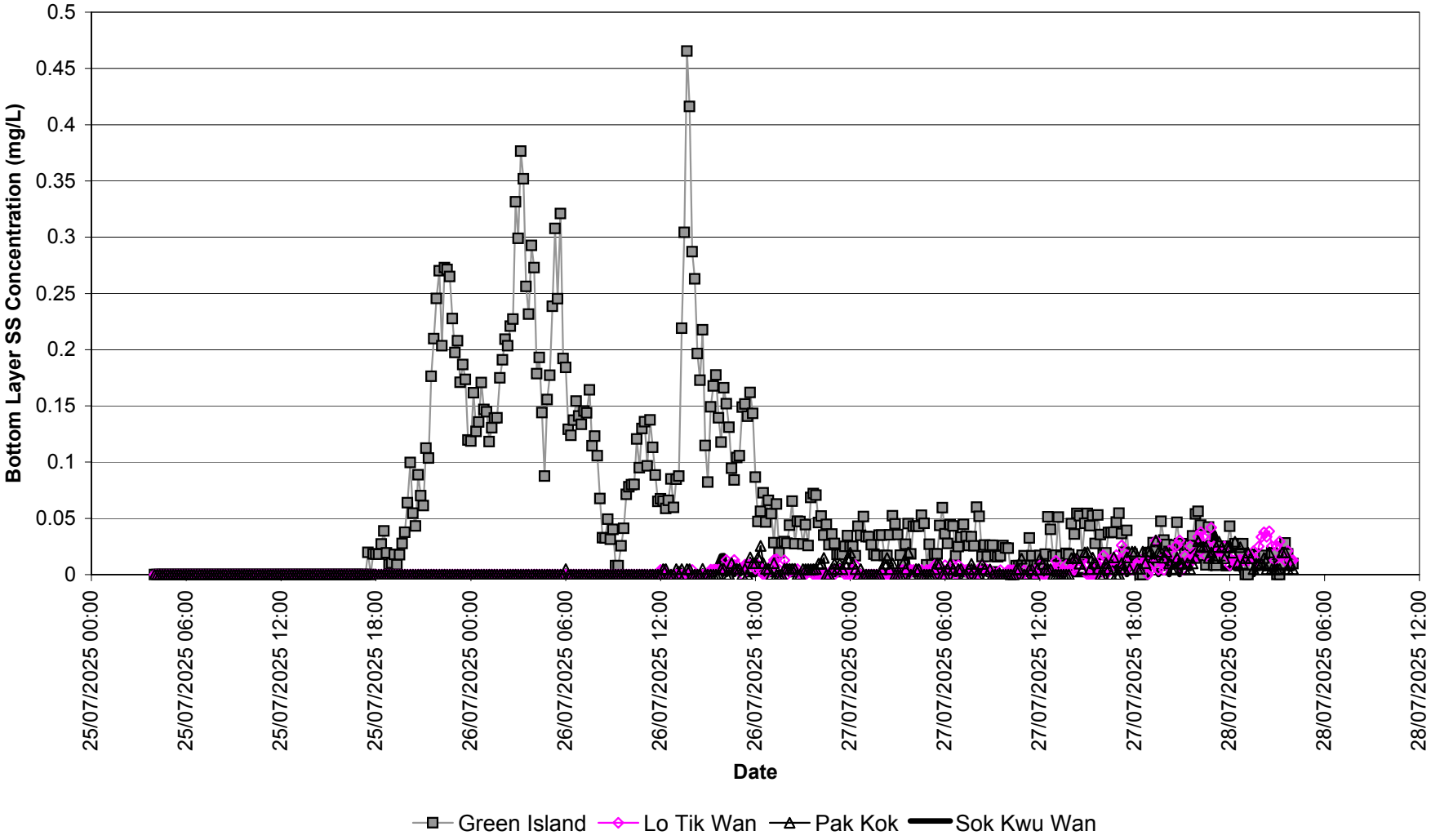


Chart 3b - SS (1 in 50 year, Spring Flood Tide) at Coral Sensitive Receivers

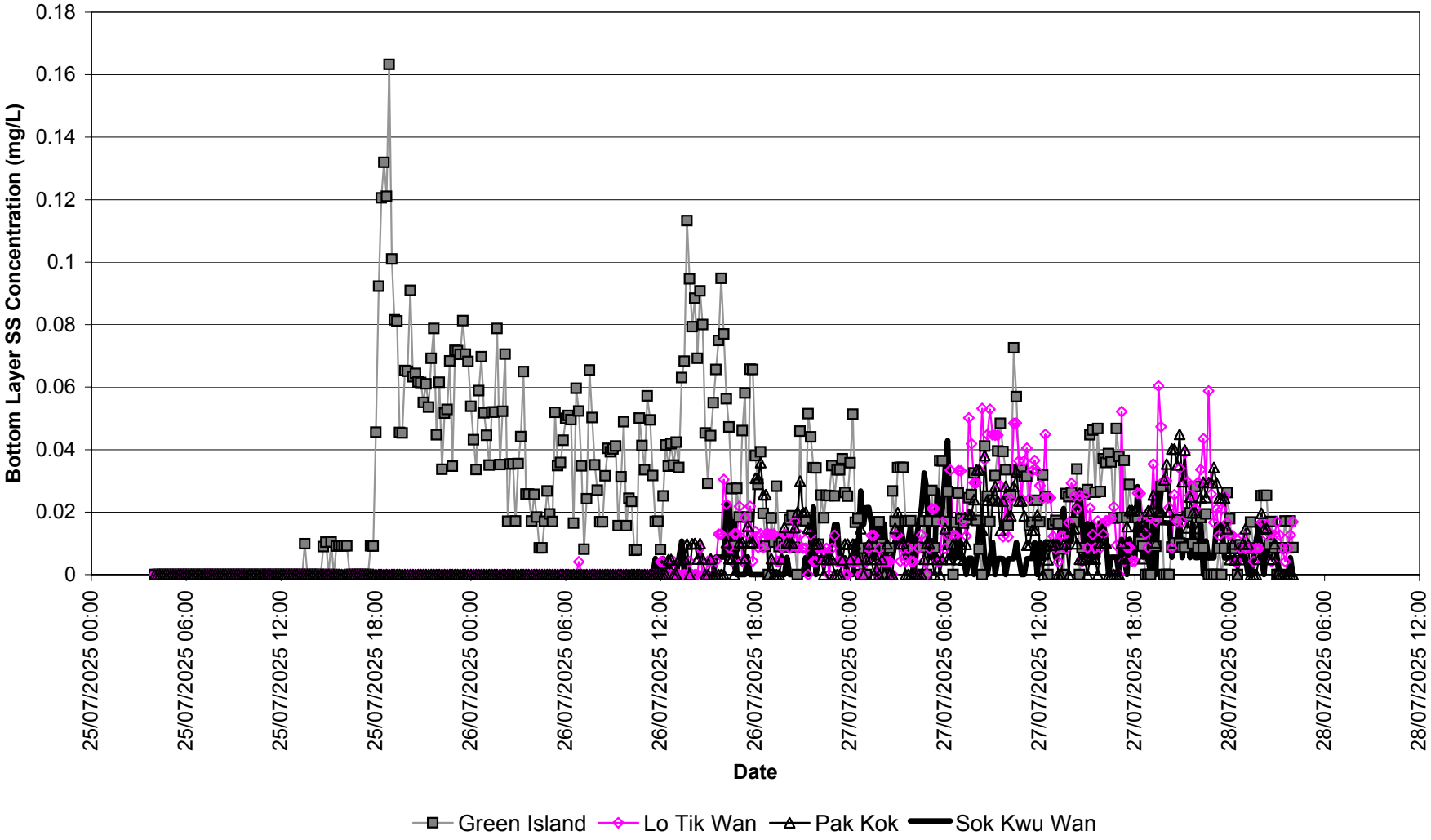


Chart 4a - SS (1 in 50 year, Spring Ebb Tide) at EPD Monitoring Stations

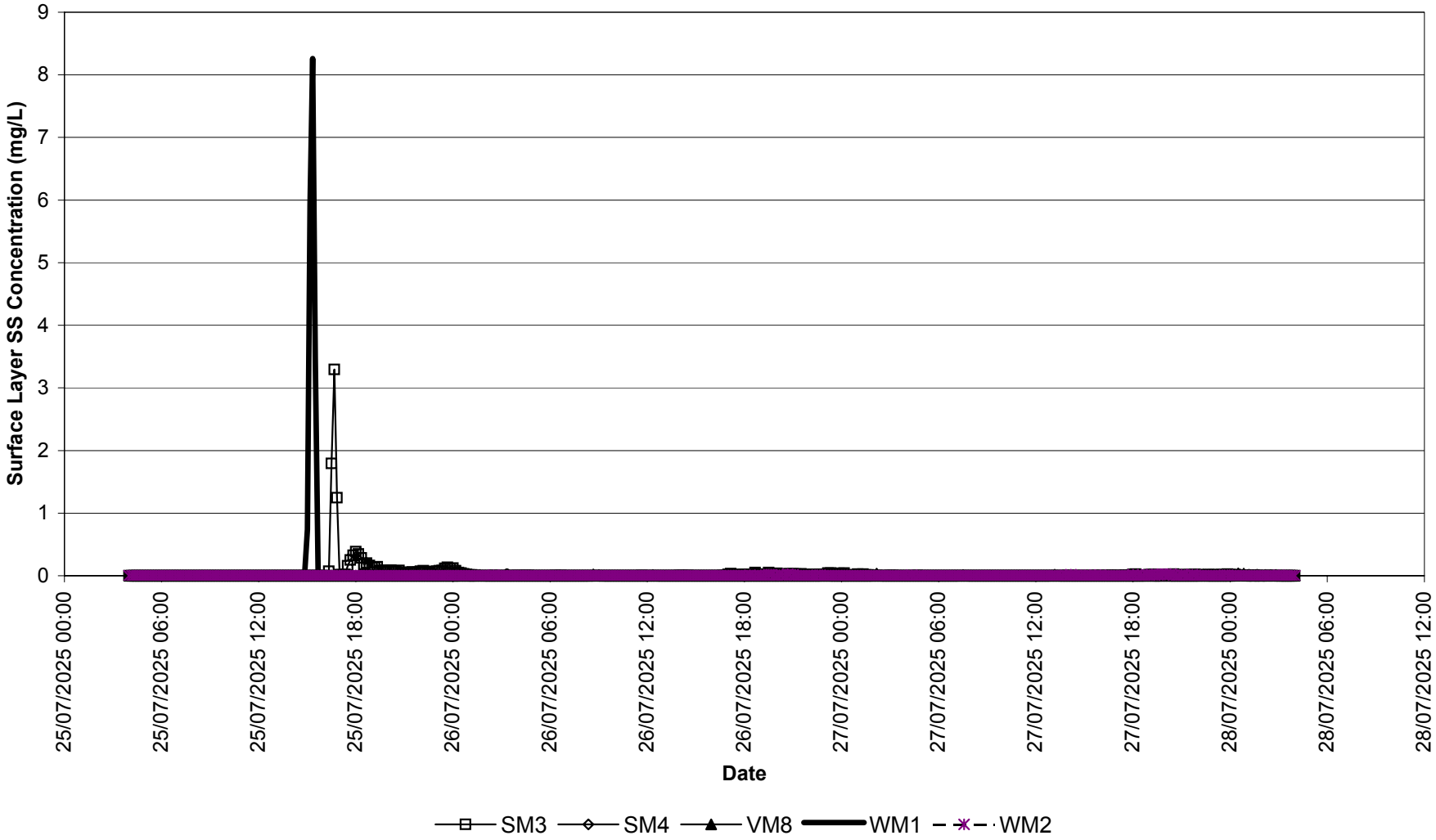


Chart 4b - SS (1 in 50 year, Spring Flood Tide) at EPD Monitoring Stations

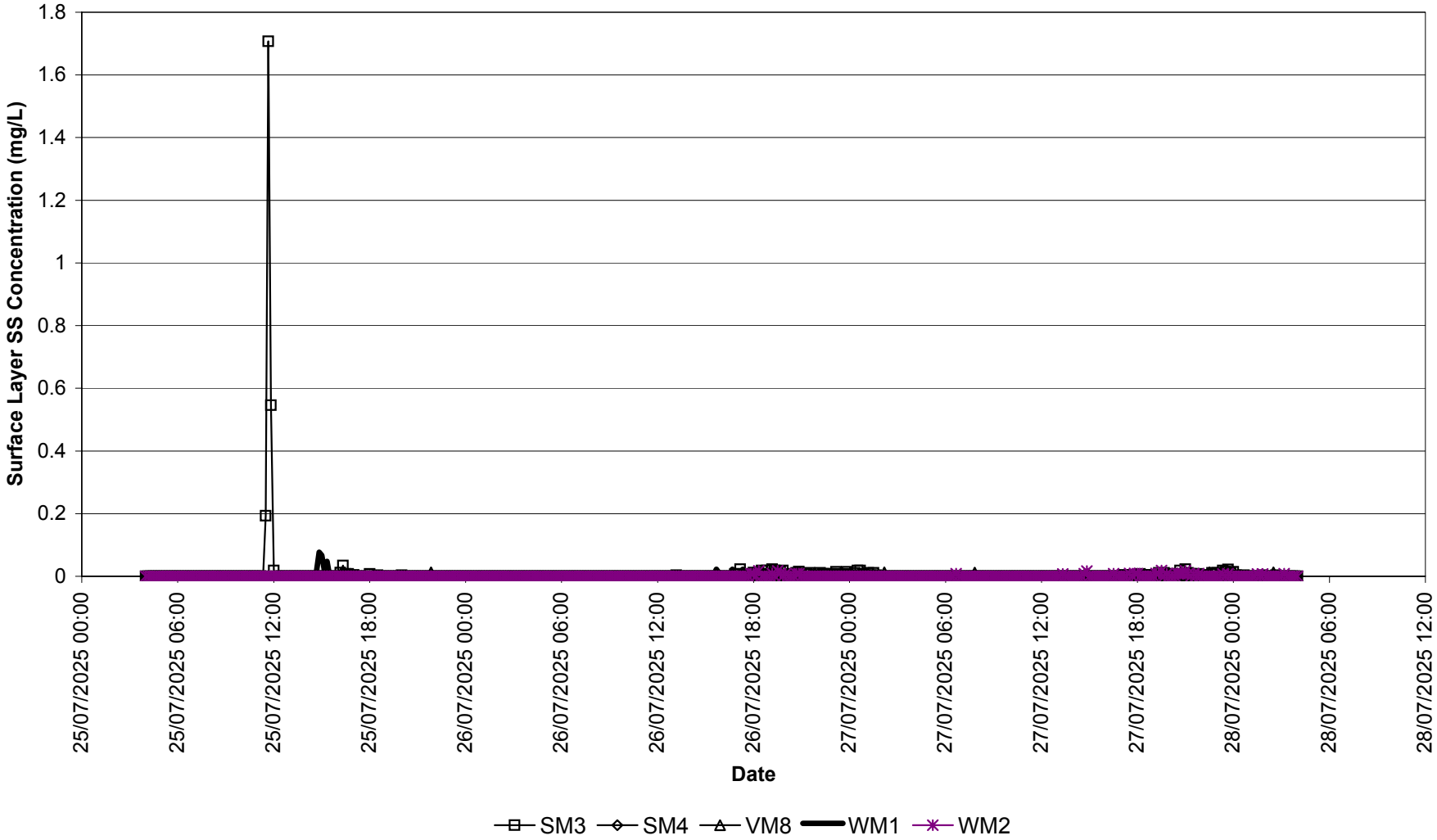


Chart 5a - *E. coli* (1 in 50 year, Spring Ebb Tide) at Intake Sensitive Receivers

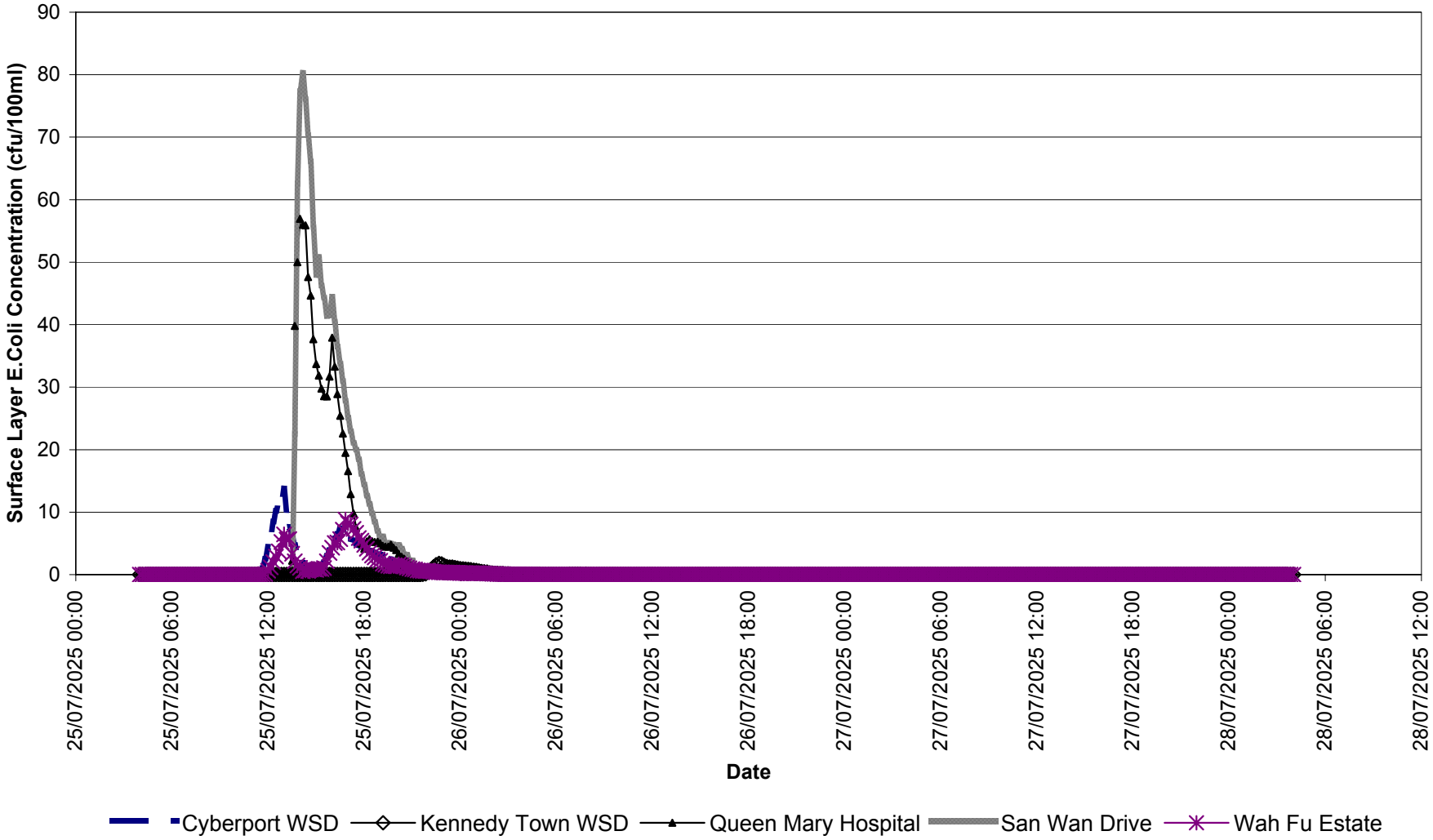


Chart 5b - *E. coli* (1 in 50 year, Spring Flood Tide) at Intake Sensitive Receivers

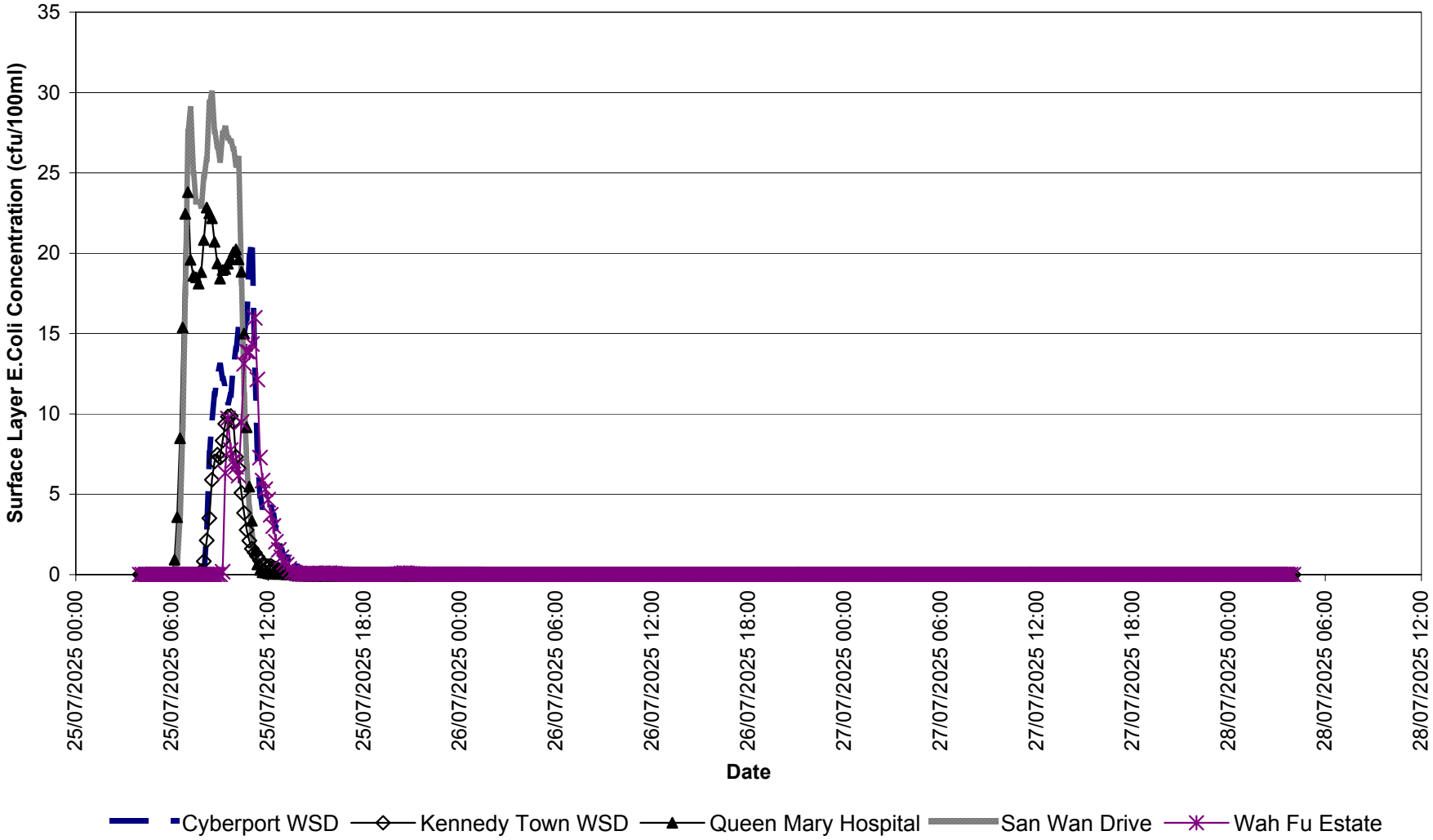


Chart 6a - *E. coli* (1 in 50 year, Spring Ebb Tide) at Fish Culture Zone Sensitive Receivers

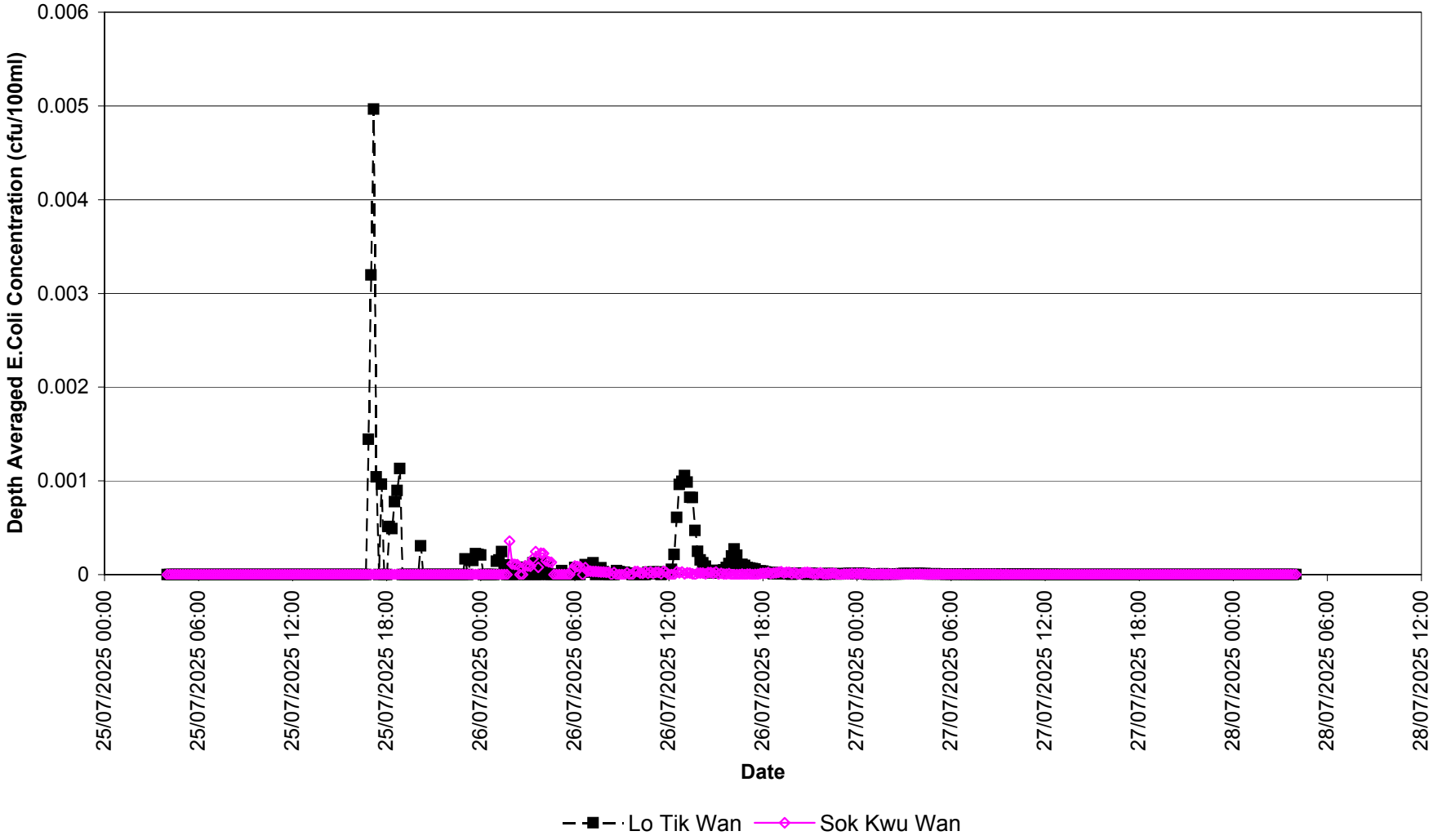


Chart 6b - *E. coli* (1 in 50 year, Spring Flood Tide) at Fish Culture Zone Sensitive Receivers

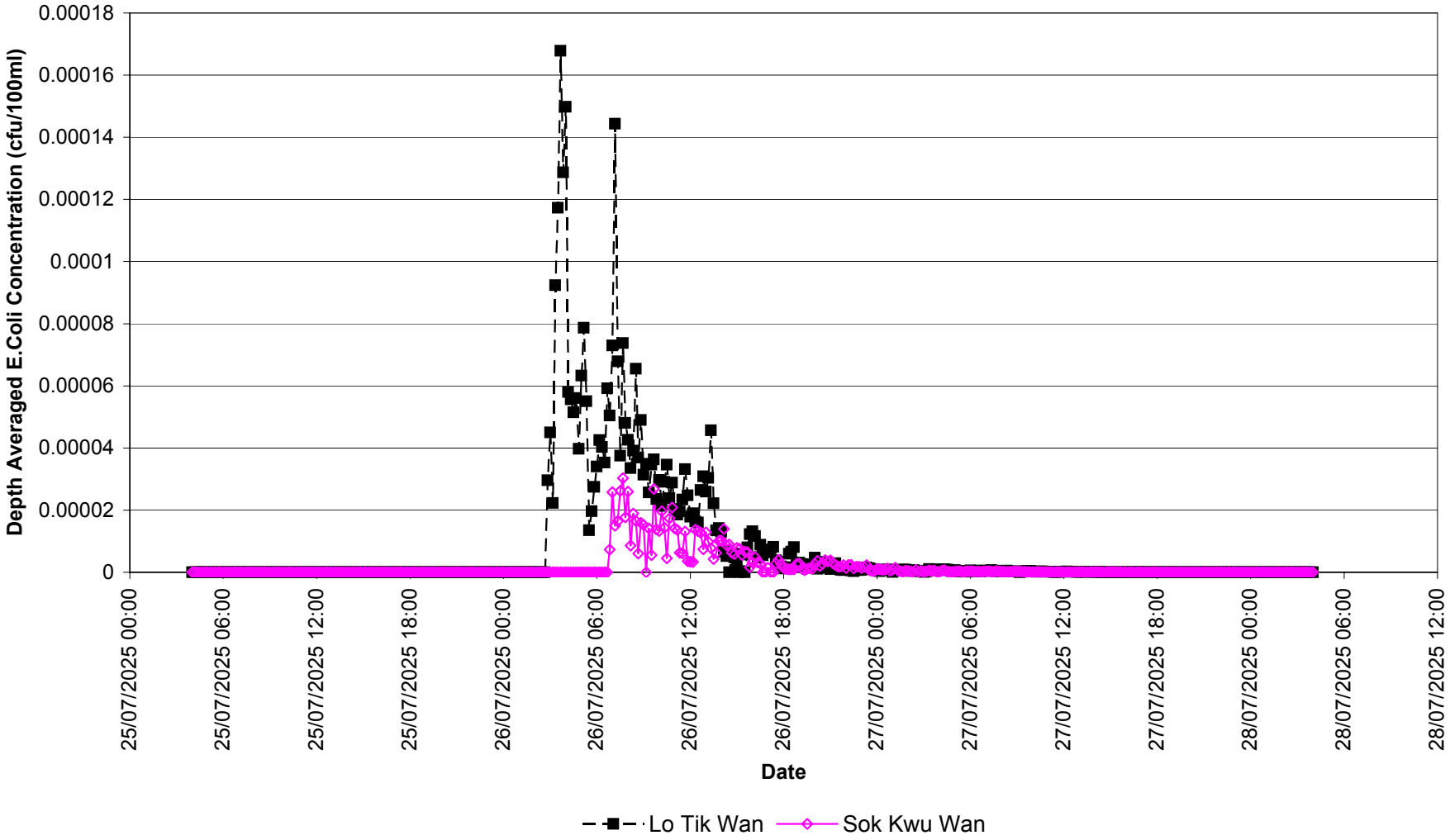


Chart 7a - *E. coli* (1 in 50 year, Spring Ebb Tide) at Coral Sensitive Receivers

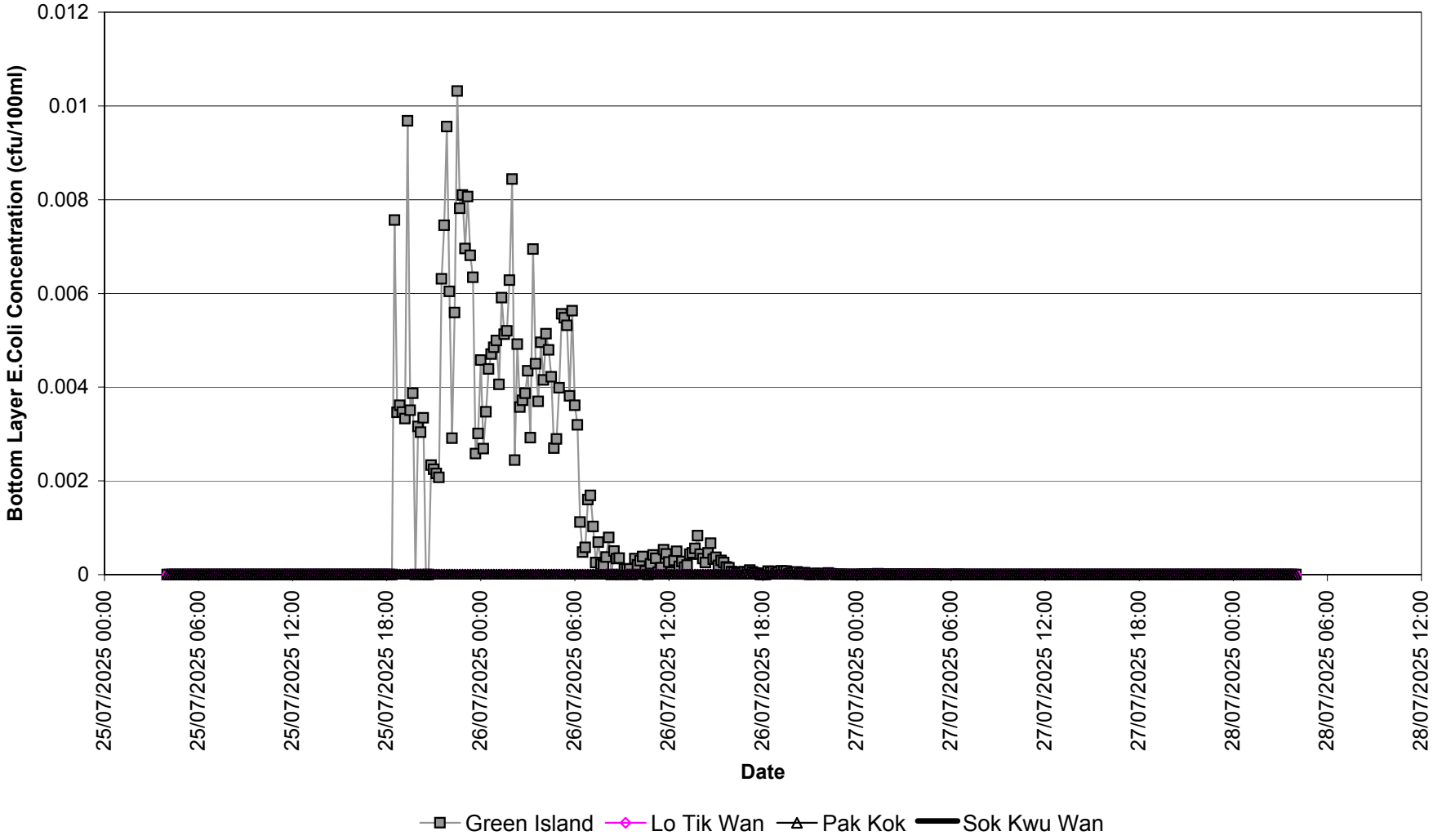


Chart 7b - *E. coli* (1 in 50 year, Spring Flood Tide) at Coral Sensitive Receivers

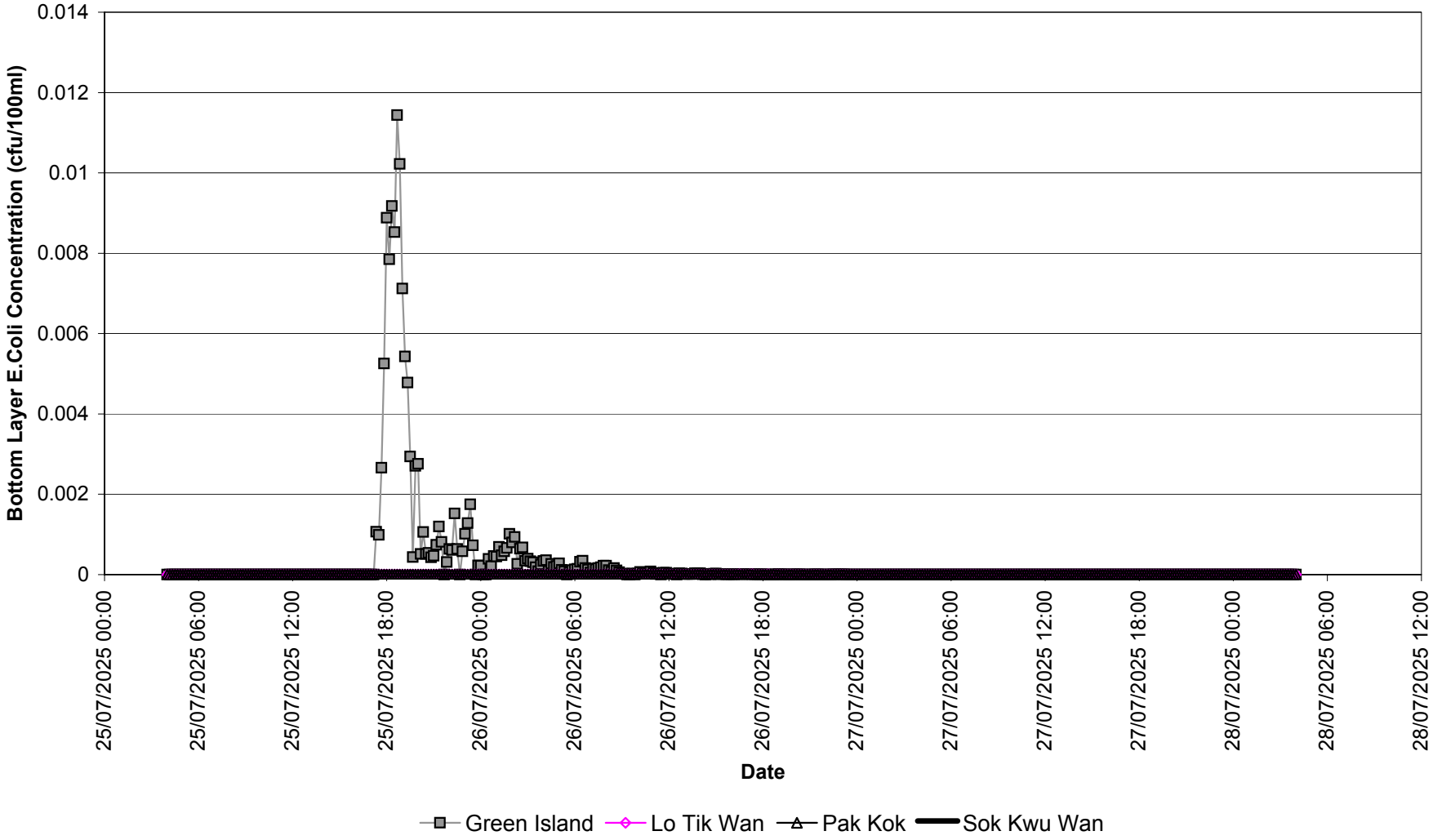


Chart 8a - *E. coli* (1 in 50 year, Spring Ebb Tide) at EPD Monitoring Stations

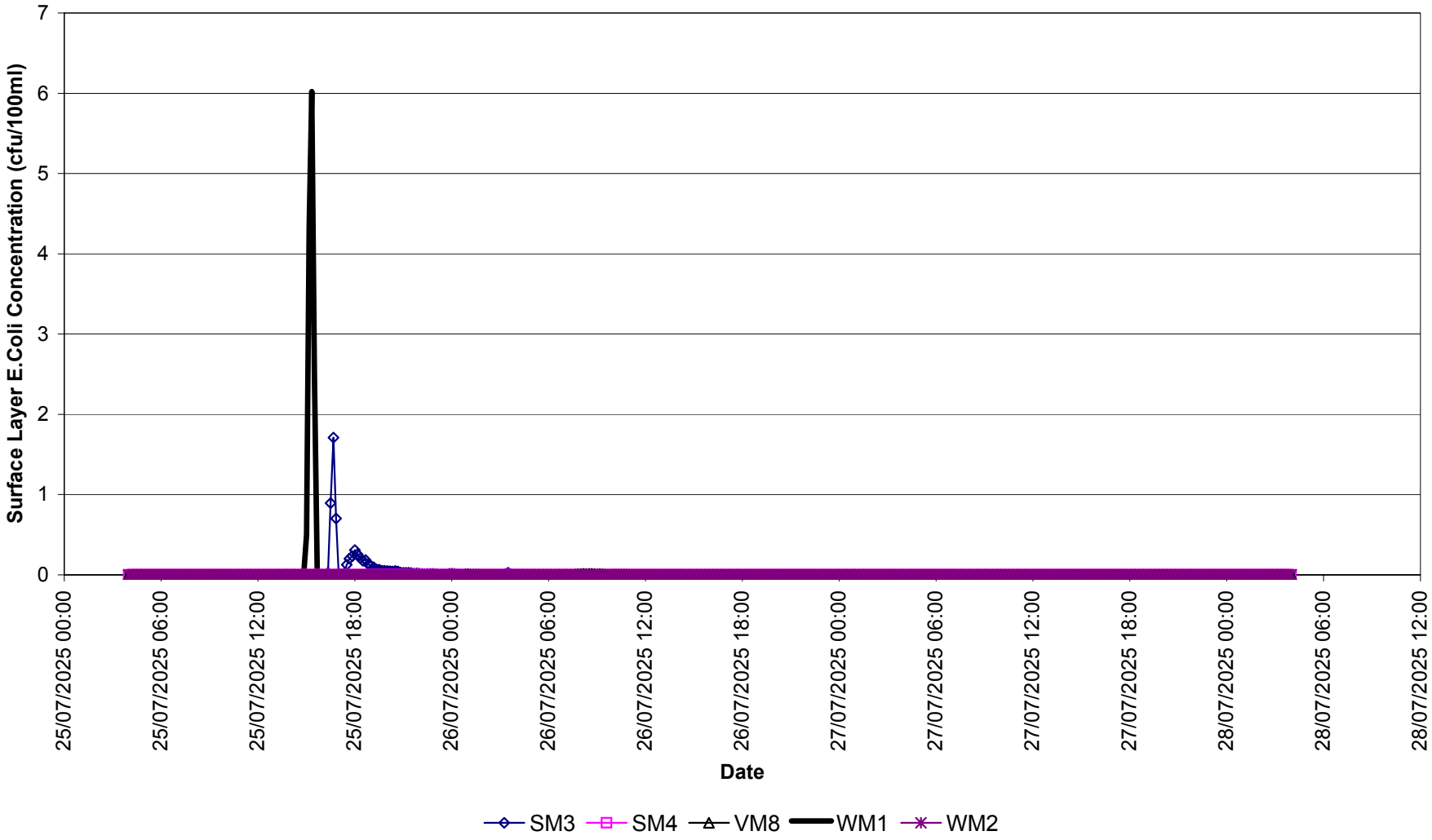


Chart 8b - *E. coli* (1 in 50 year, Spring Flood Tide) at EPD Monitoring Stations

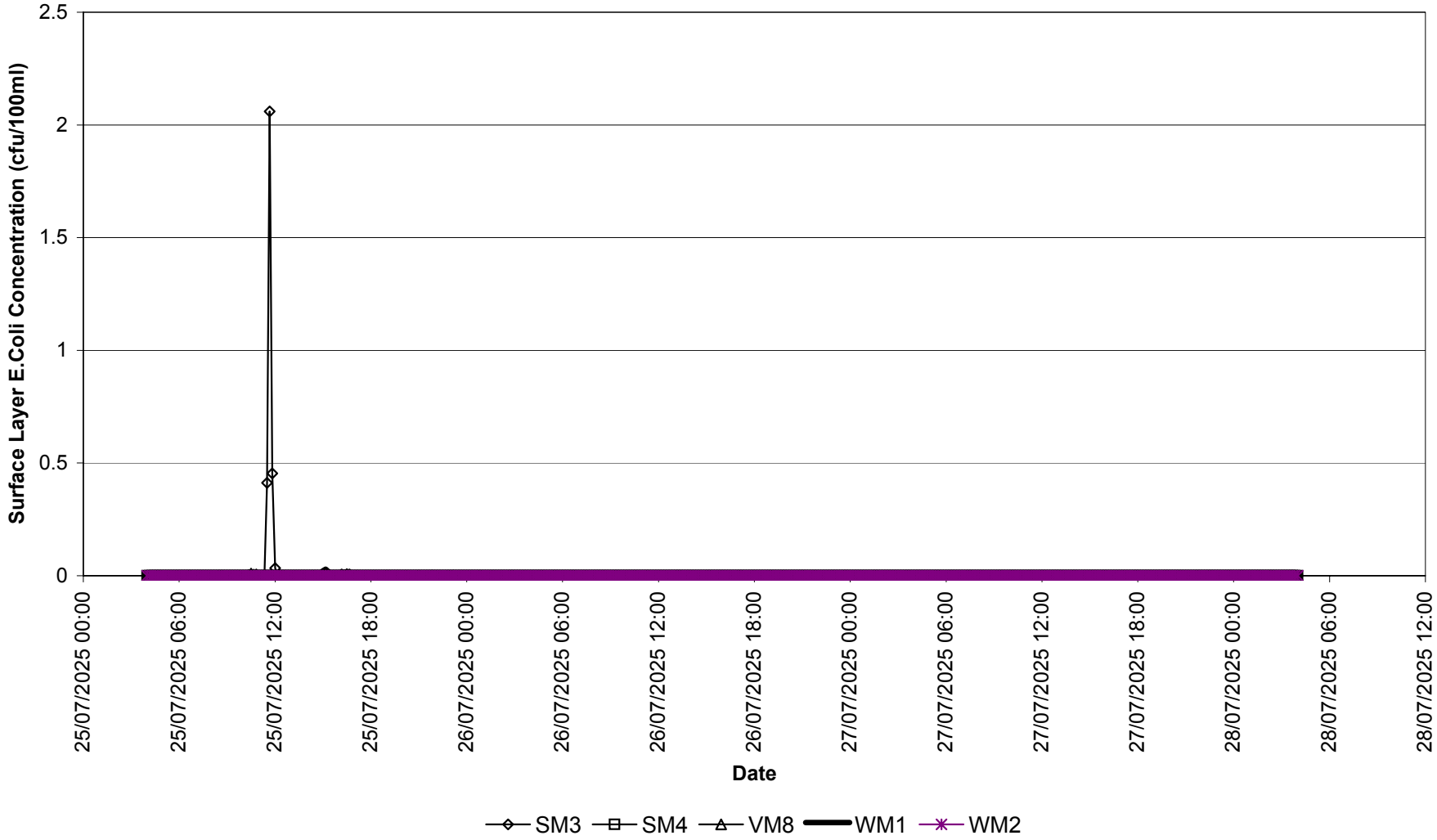


Chart 9a - Salinity (1 in 50 year, Spring Ebb Tide) at Green Island Coral

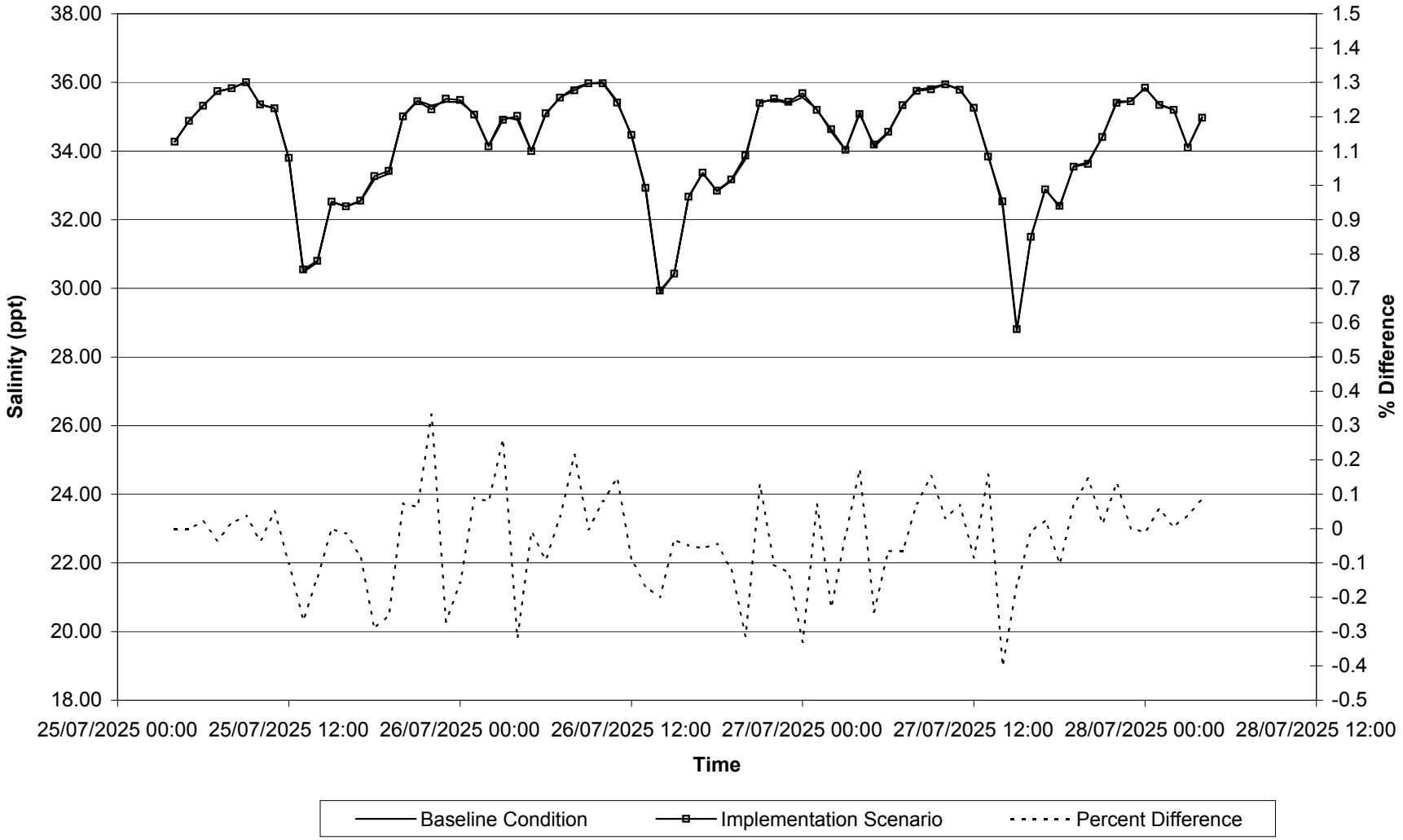


Chart 9b - Salinity (1 in 50 year, Spring Flood Tide) at Green Island Coral

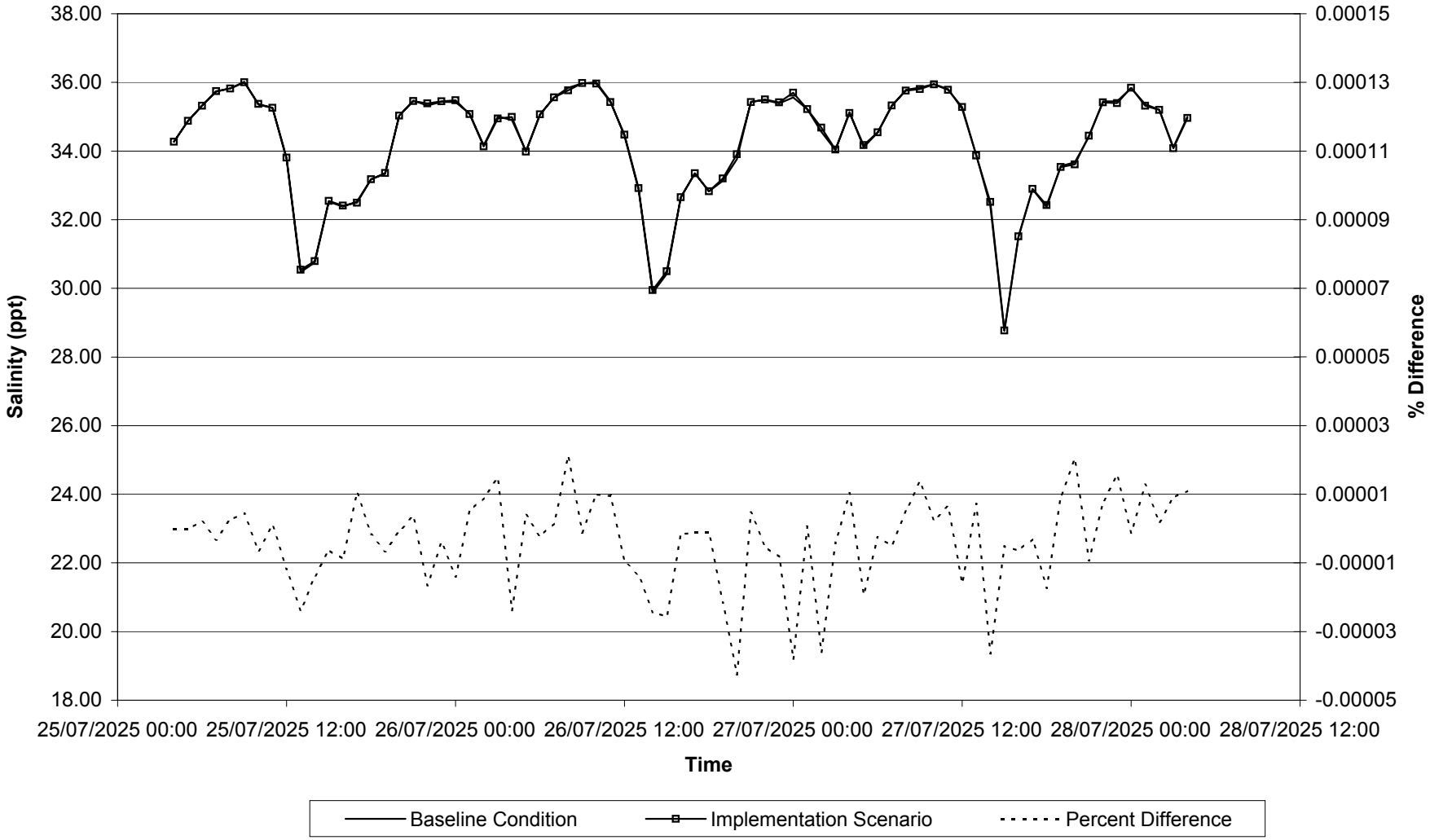


Chart 10a - Salinity (1 in 50 year, Spring Ebb Tide) at Lo Tik Wan Coral

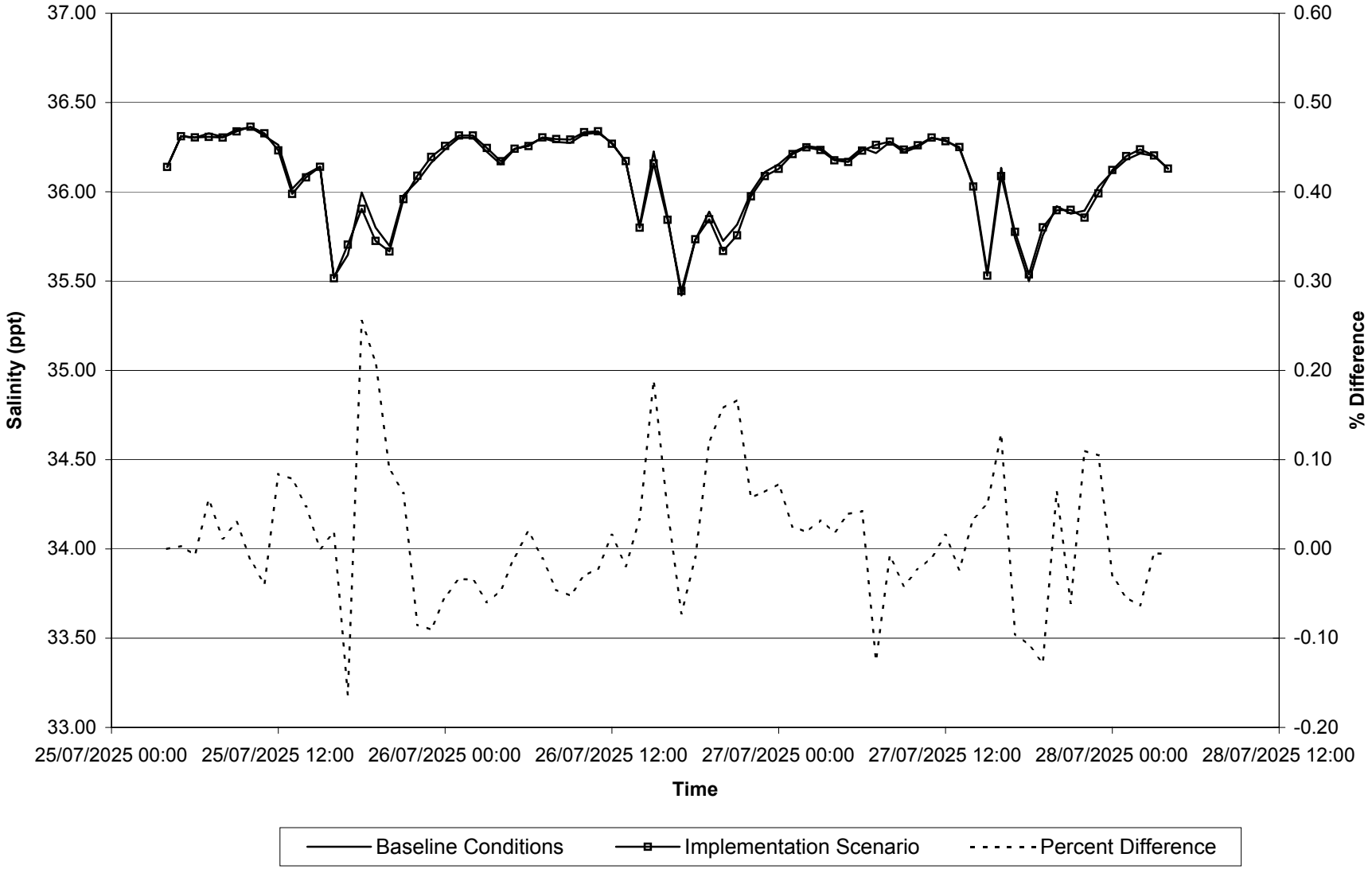


Chart 10b - Salinity (1 in 50 year, Spring Flood Tide) at Lo Tik Wan Coral

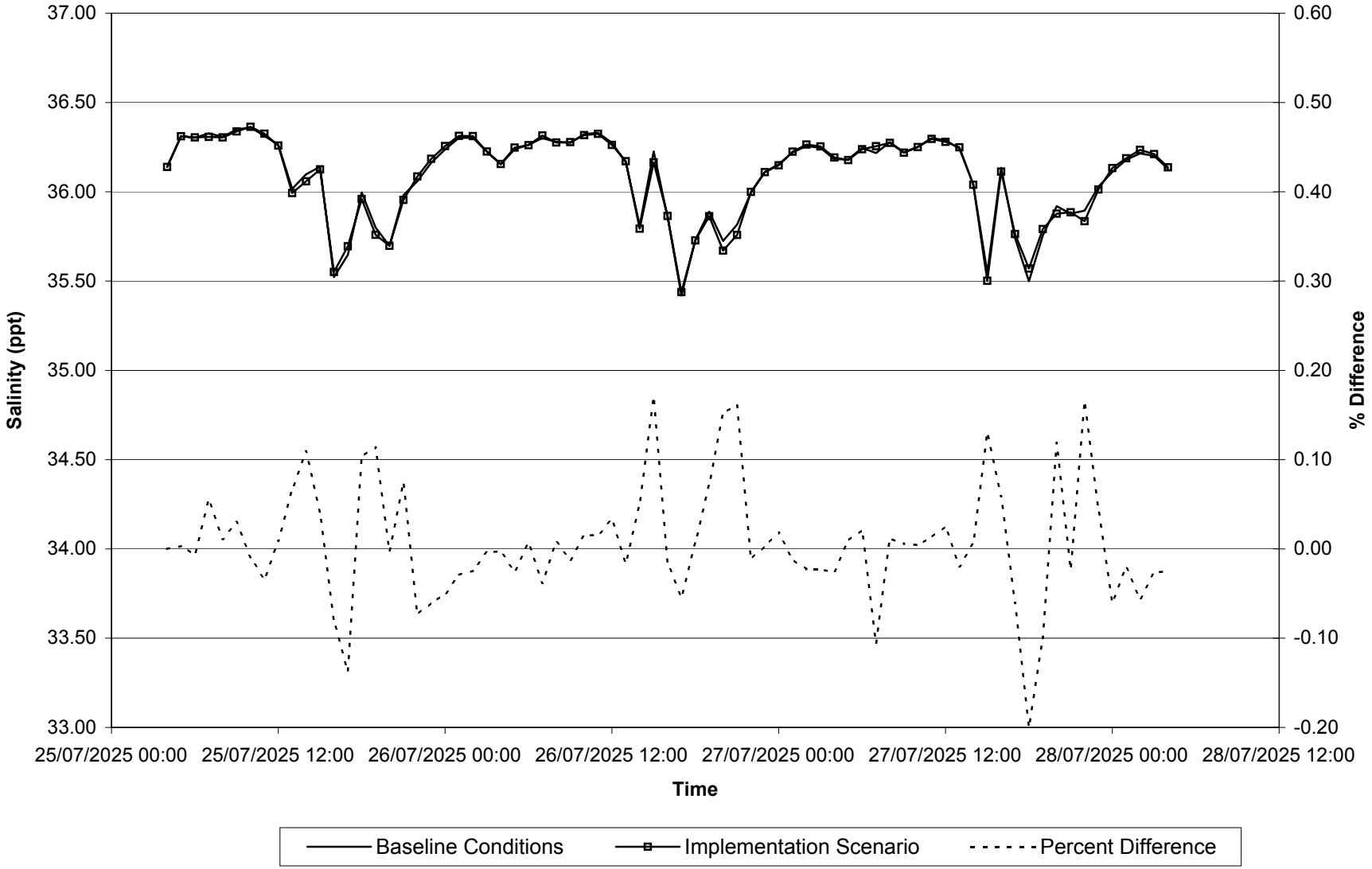


Chart 11a - Salinity (1 in 50 year, Spring Ebb Tide) at Pak Kok Coral

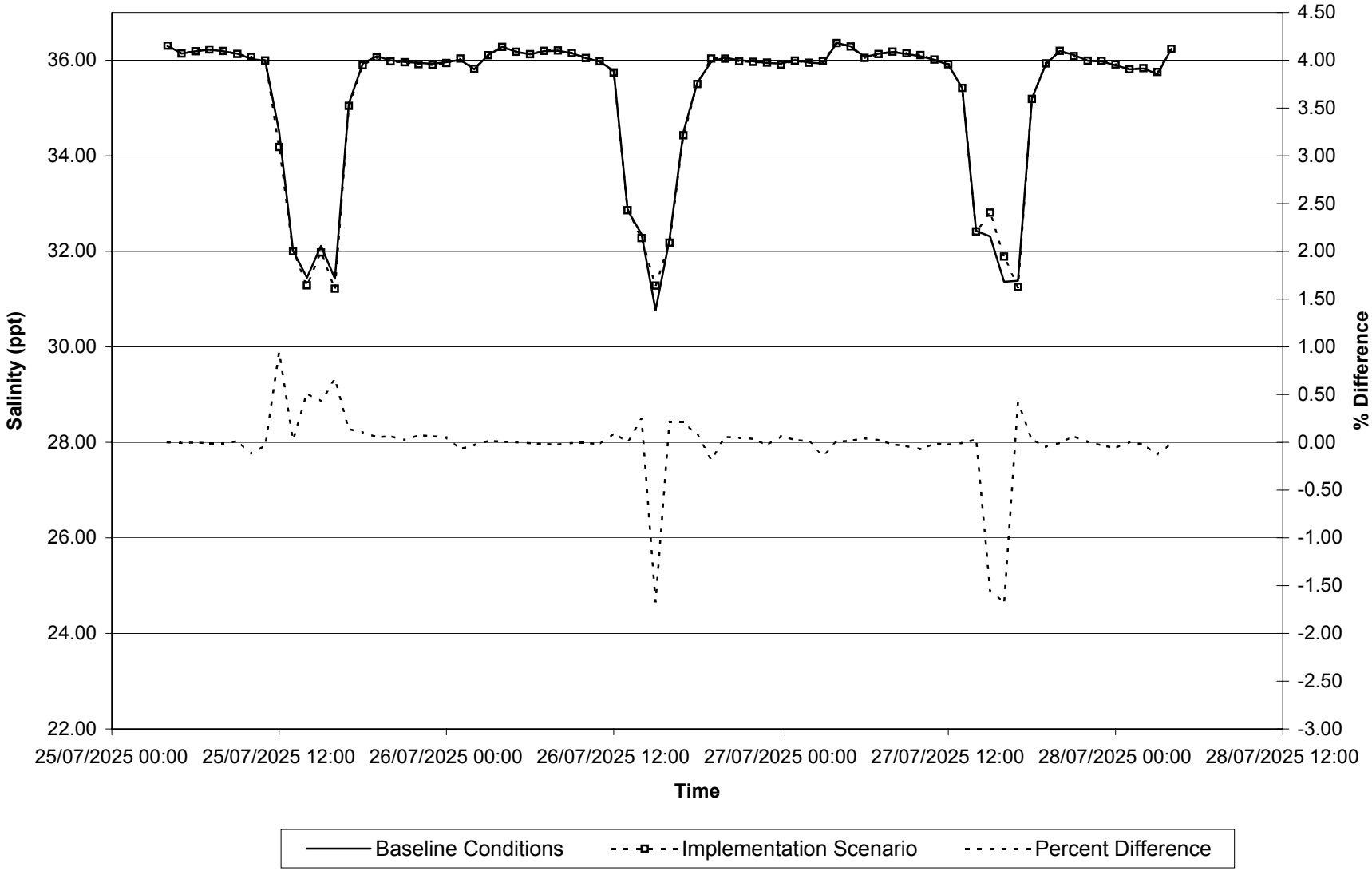


Chart 11b - Salinity (1 in 50 year, Spring Flood Tide) at Pak Kok Coral

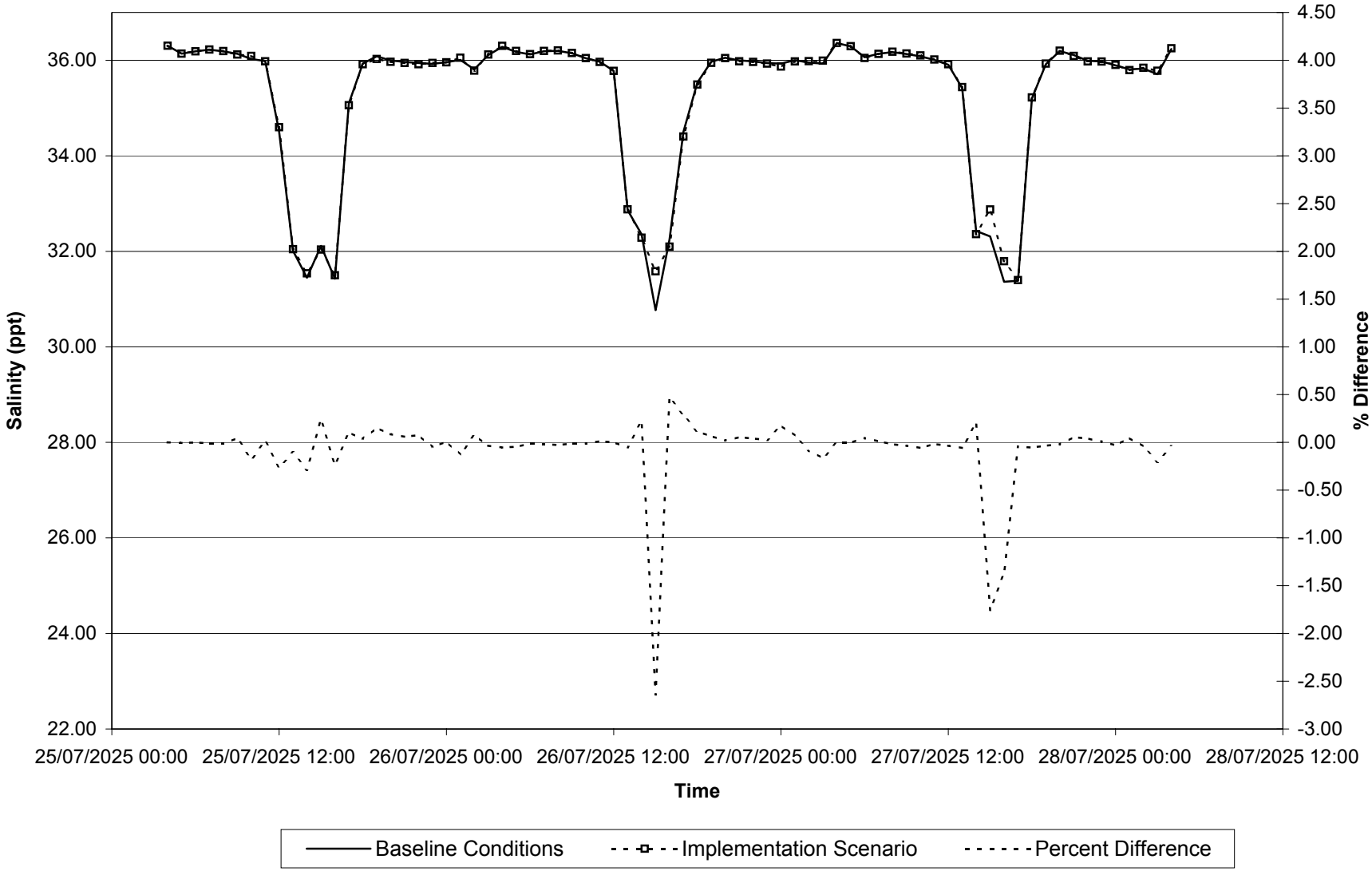


Chart 12a - Salinity (1 in 50 year, Spring Ebb Tide) at Sok Kwu Wan Coral

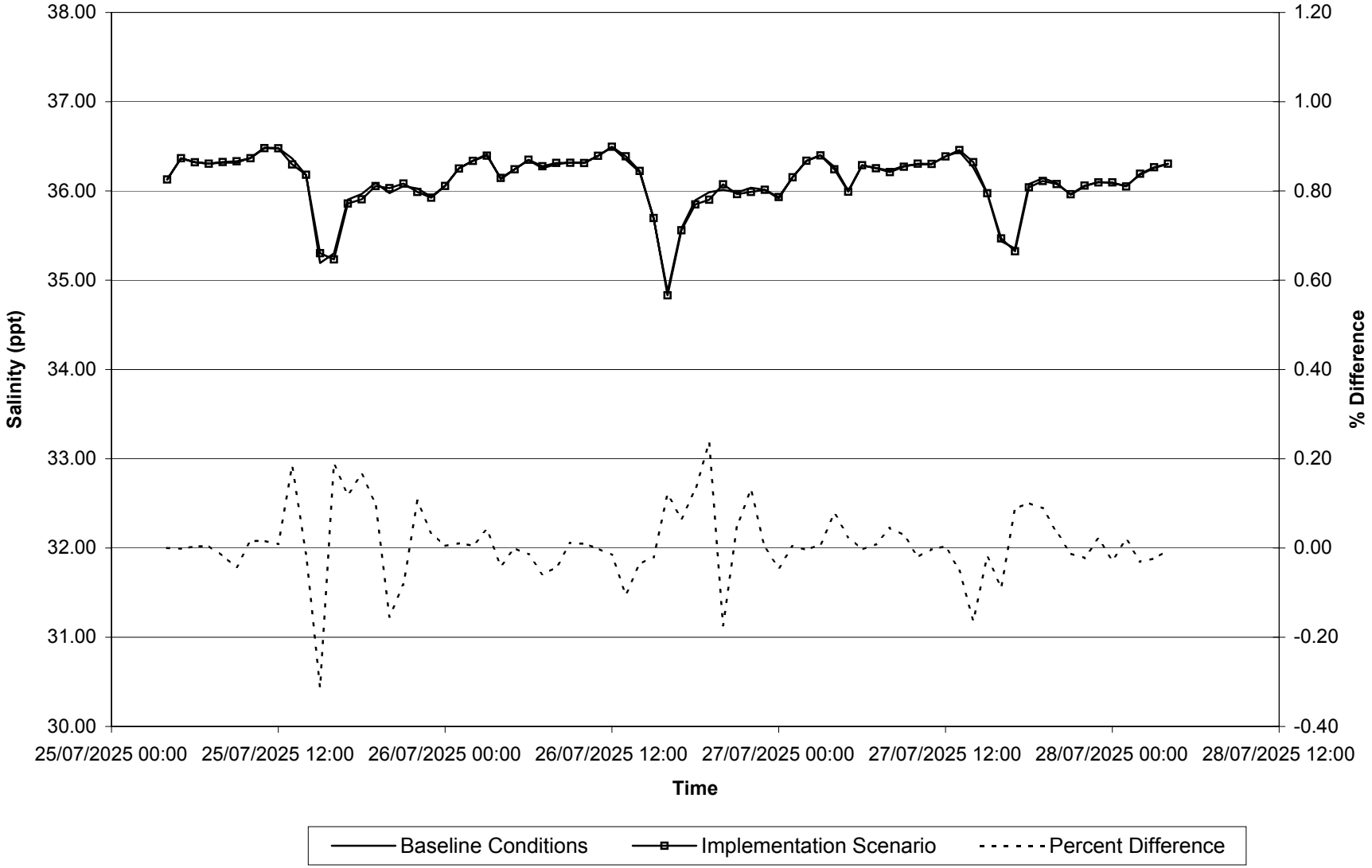


Chart 12b - Salinity (1 in 50 year, Spring Flood Tide) at Sok Kwu Wan Coral

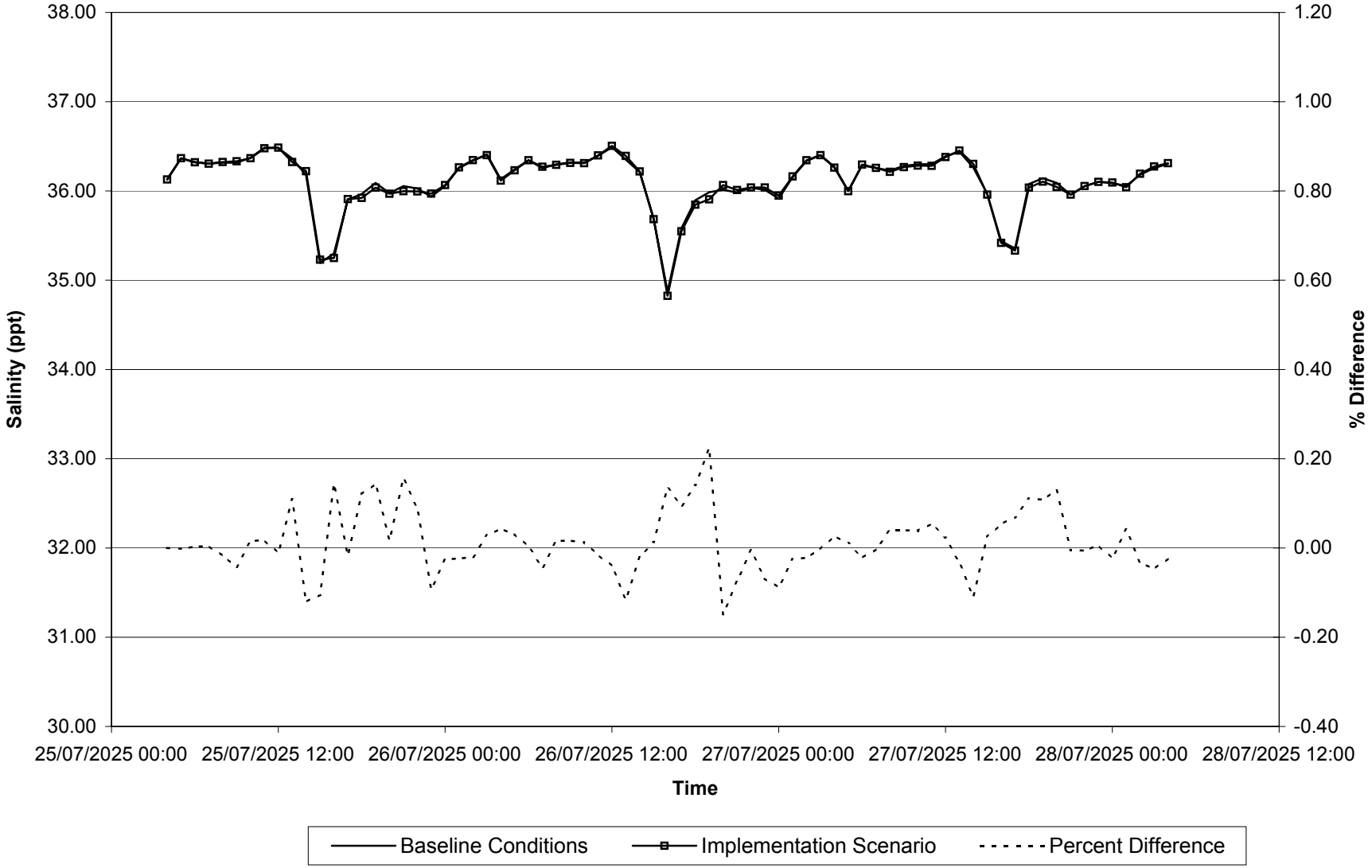


Chart 13a - SS (1 in 2 year, Spring Ebb Tide) at Intake Sensitive Receivers

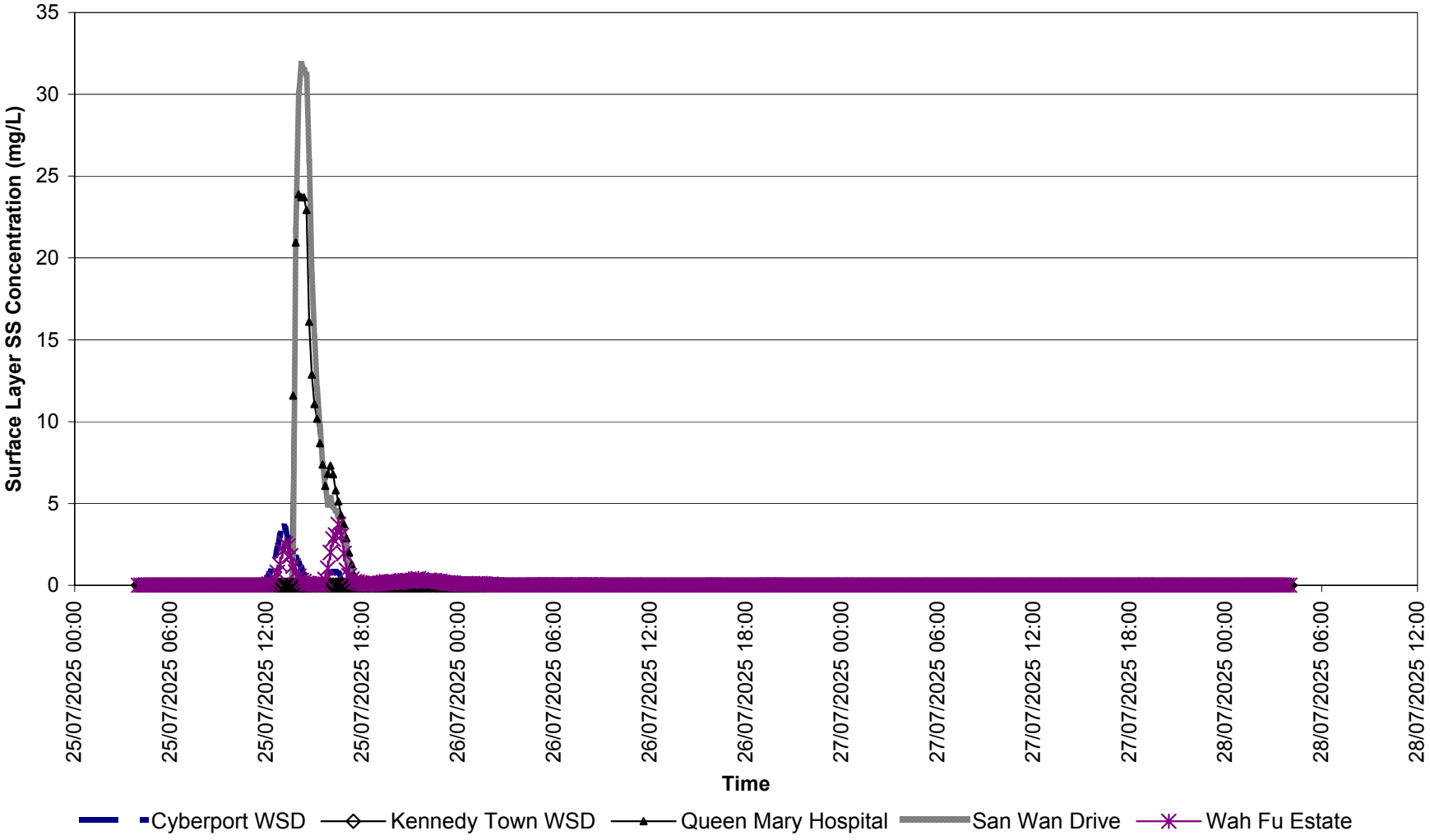


Chart 13b - SS (1 in 2 year, Spring Flood Tide) at Intake Sensitive Receivers

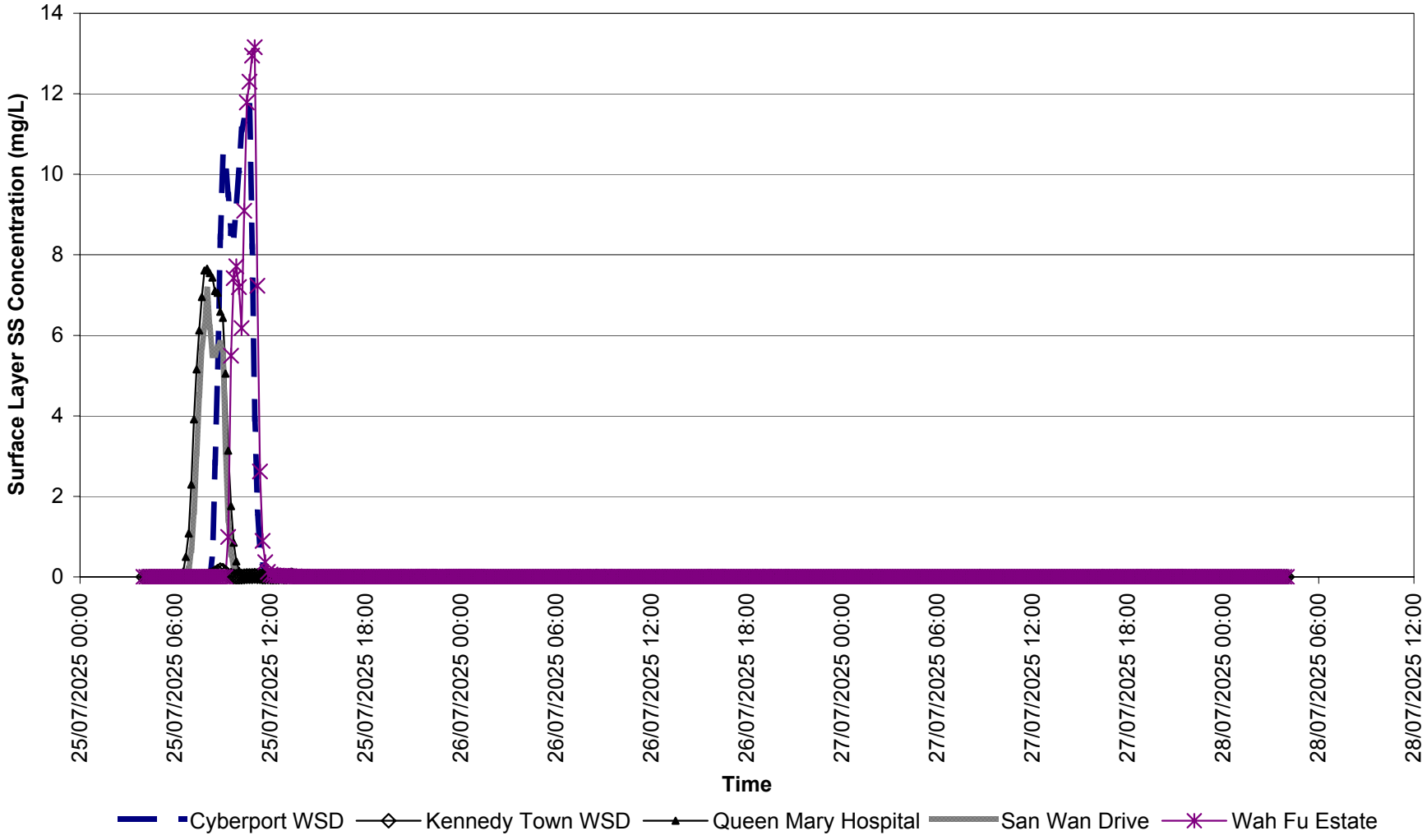


Chart 14a - SS (1 in 2 year, Spring Ebb Tide) at Fish Culture Zone Sensitive Receivers

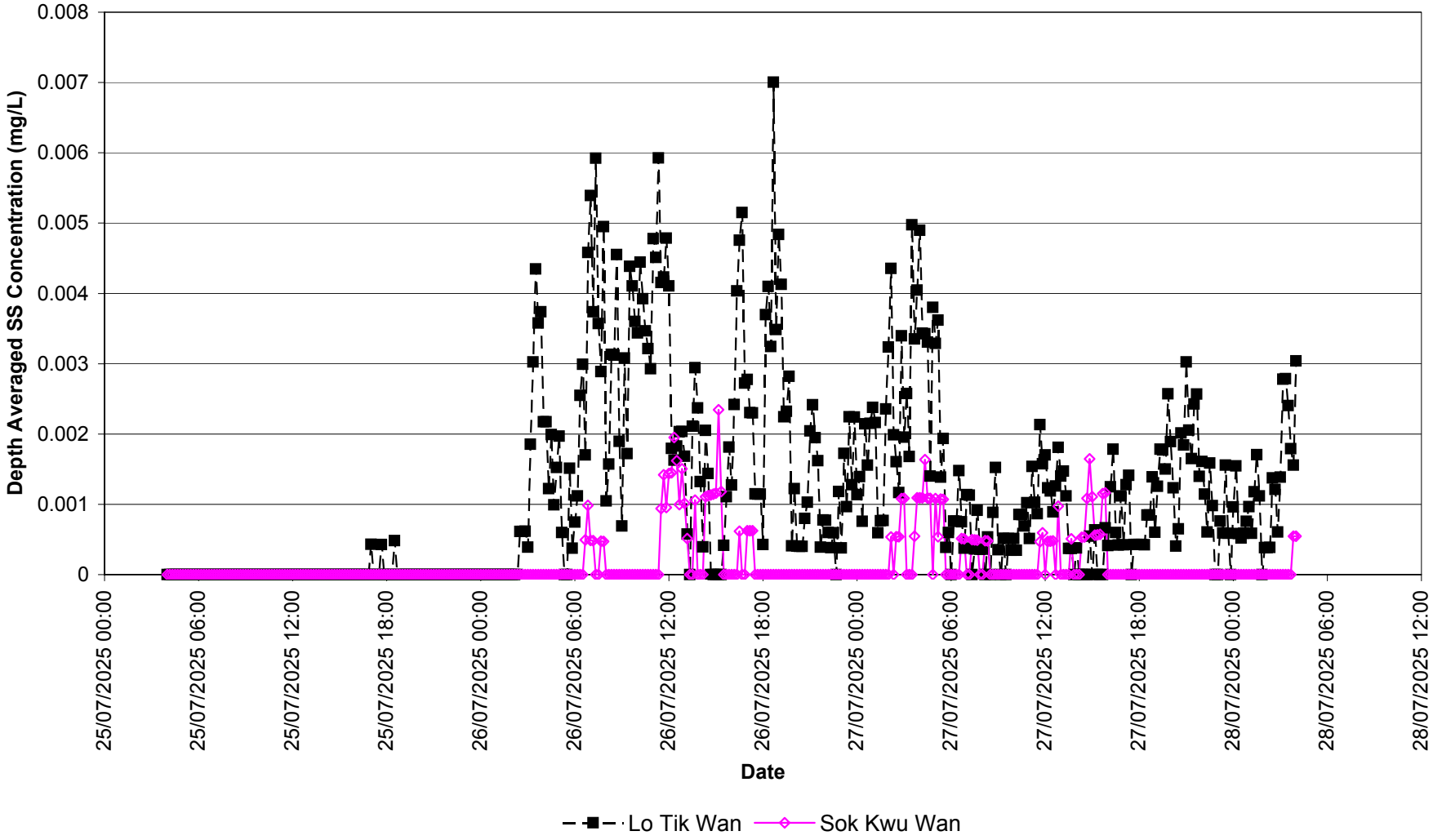


Chart 14b - SS (1 in 2 year, Spring Flood Tide) at Fish Culture Zone Sensitive Receivers

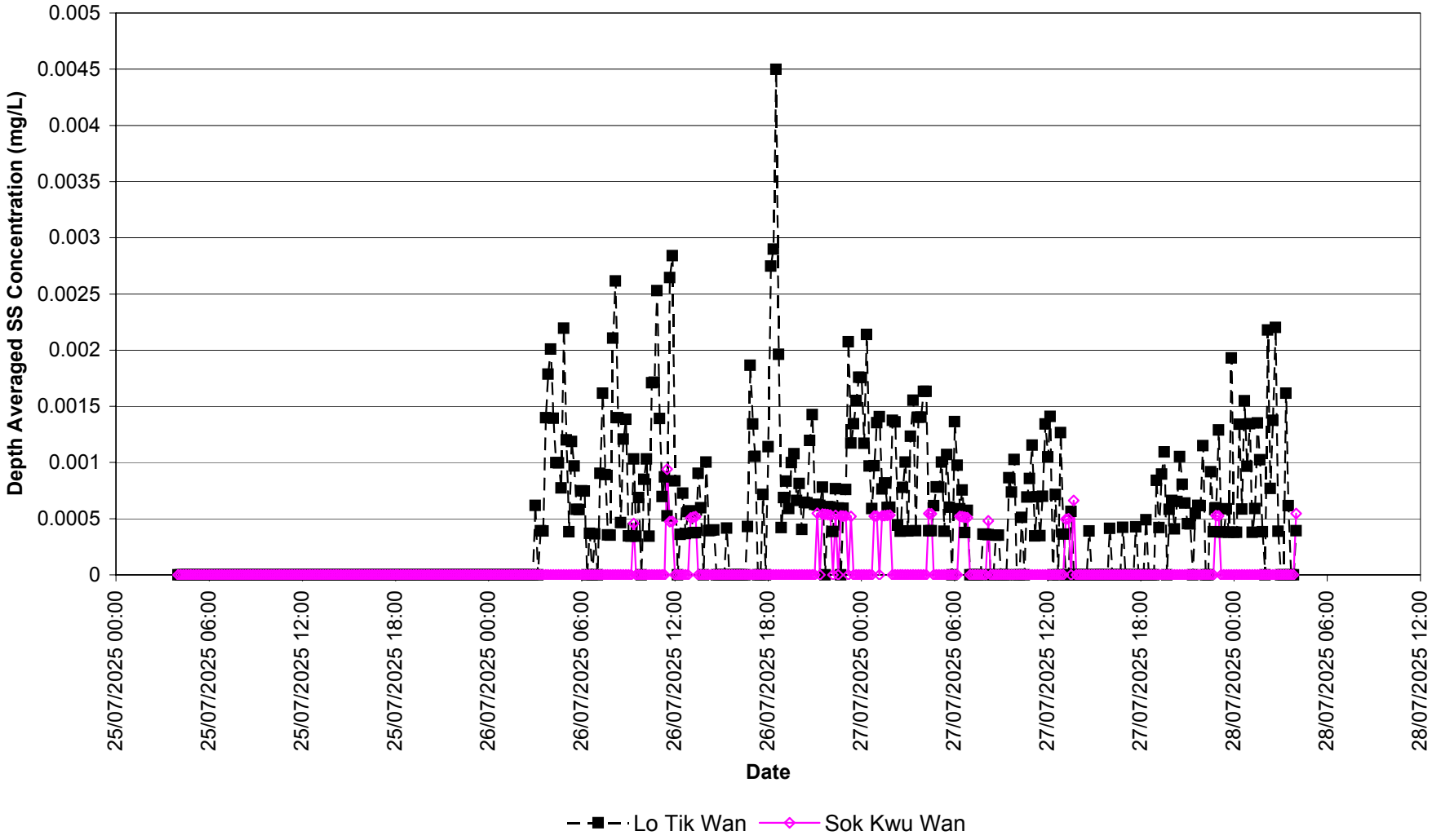


Chart 15a - SS (1 in 2 year, Spring Ebb Tide) at Coral Sensitive Receivers

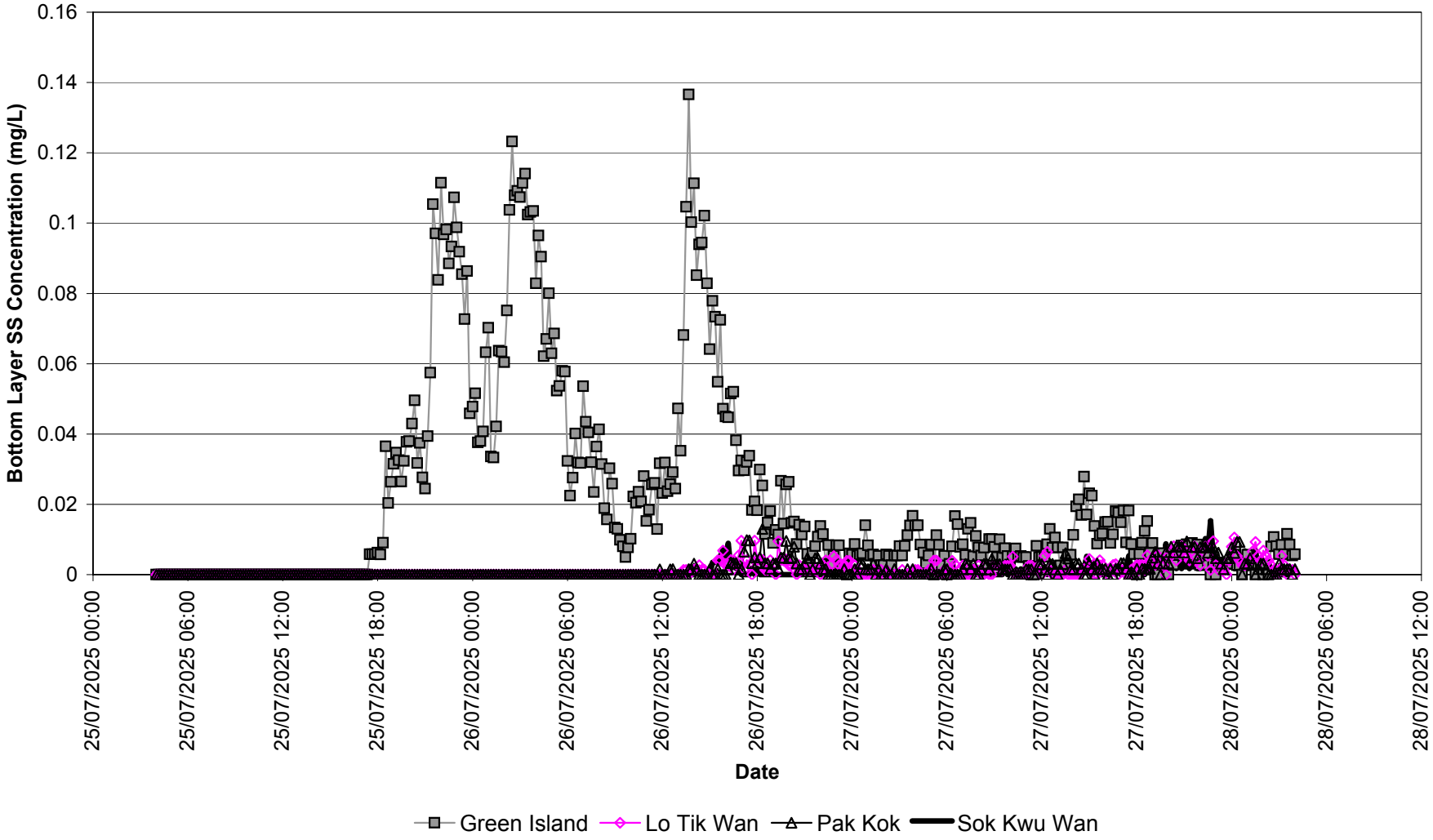


Chart 15b - SS (1 in 2 year, Spring Flood Tide) at Coral Sensitive Receivers

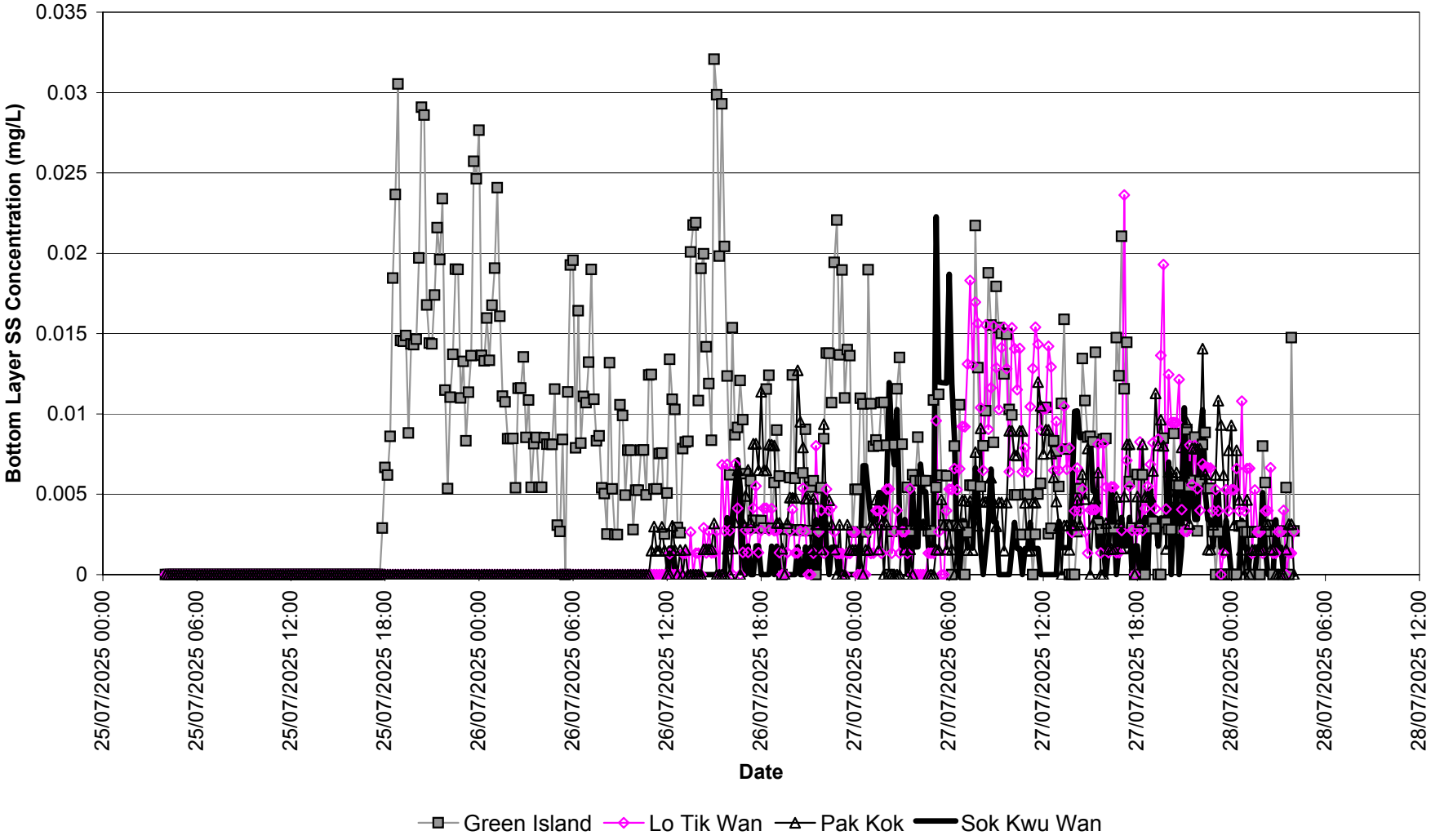


Chart 16a - SS (1 in 2 year, Spring Ebb Tide) at EPD Monitoring Stations

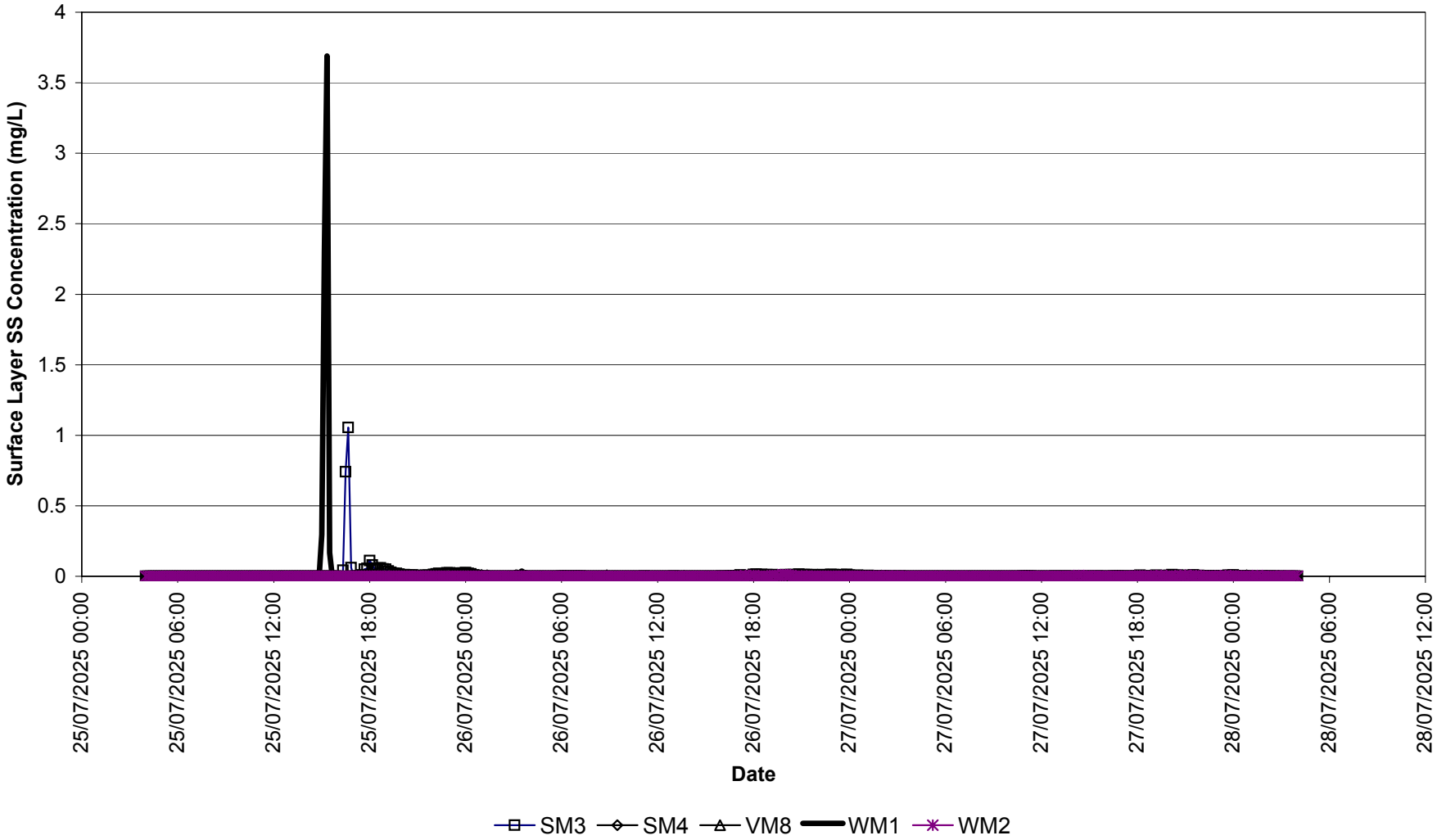


Chart 16b - SS (1 in 2 year, Spring Flood Tide) at EPD Monitoring Stations

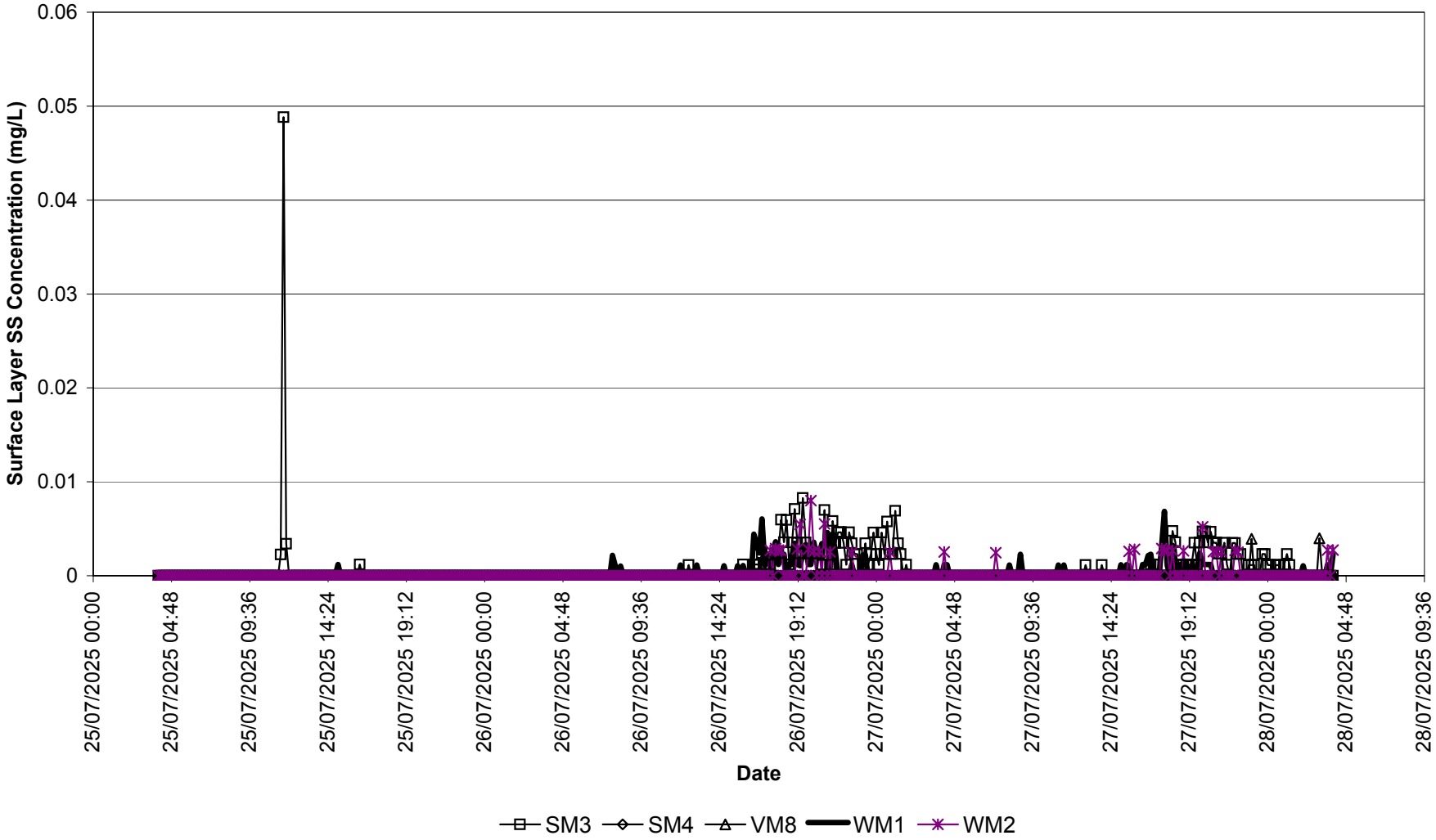


Chart 17a - *E. coli* (1 in 2 year, Spring Ebb Tide) at Intake Sensitive Receivers

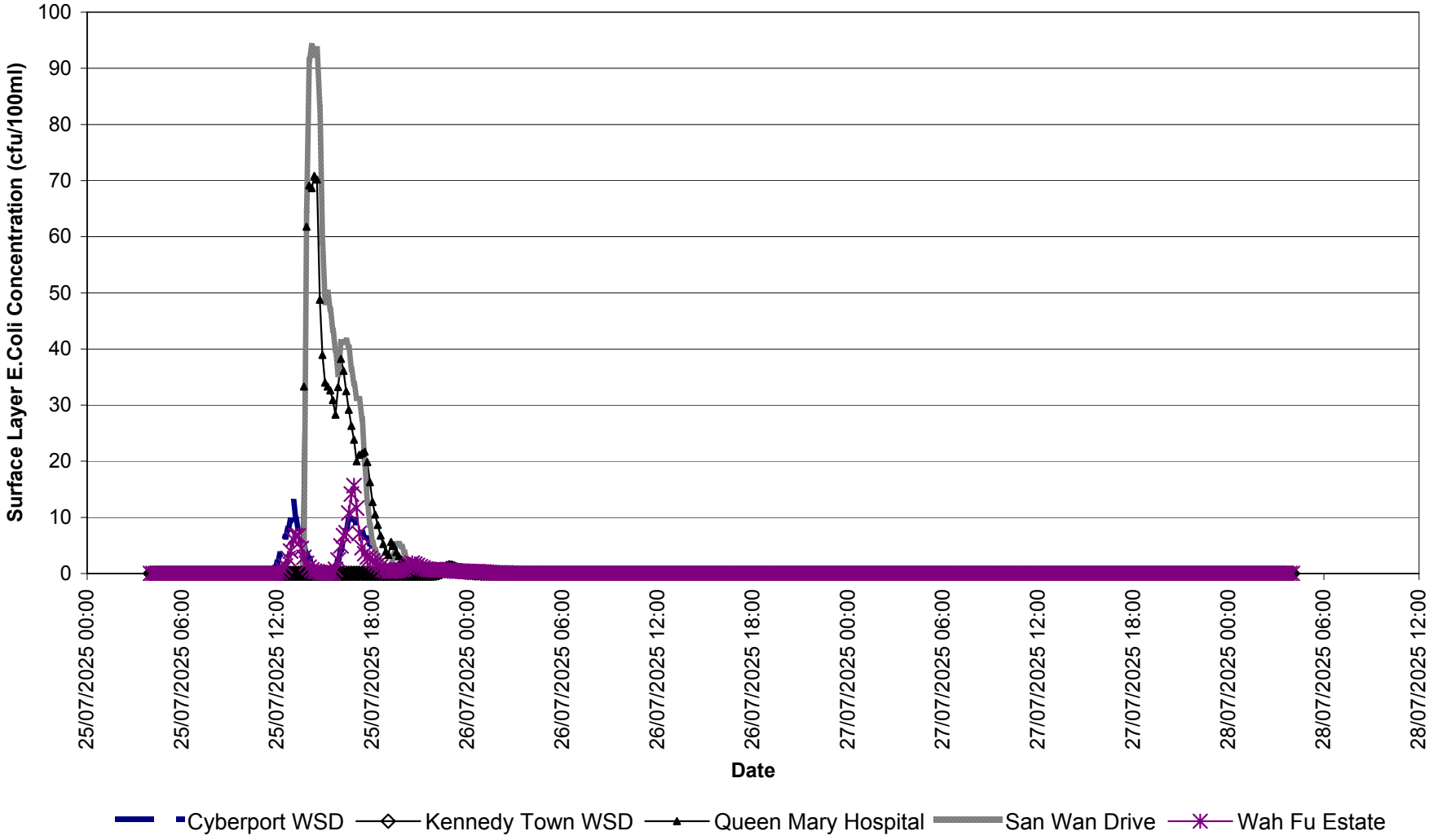


Chart 17b - *E. coli* (1 in 2 year, Spring Flood Tide) at Intake Sensitive Receivers

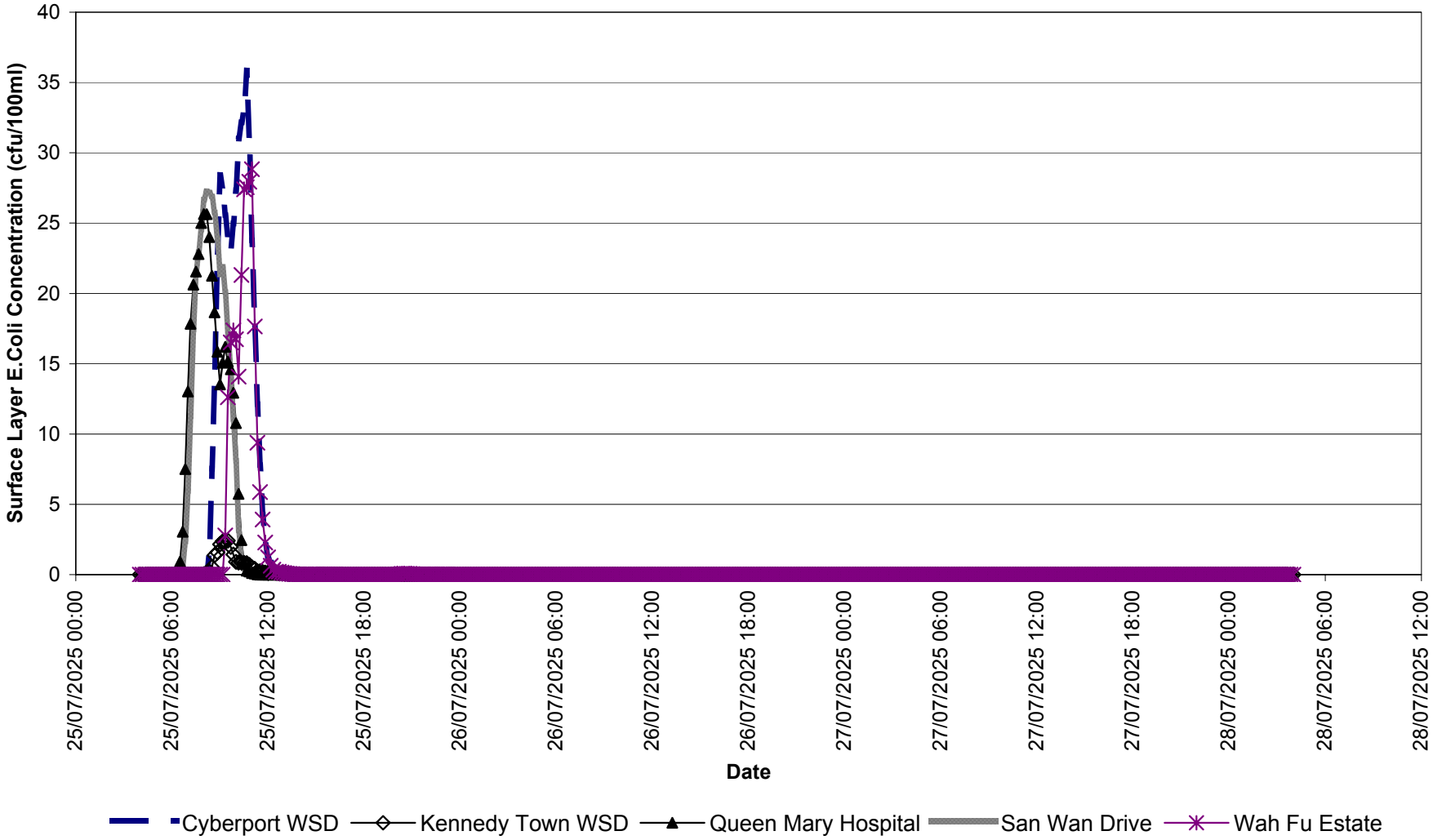


Chart 18a - *E. coli* (1 in 2 year, Spring Ebb Tide) at Fish Culture Zone Sensitive Receivers

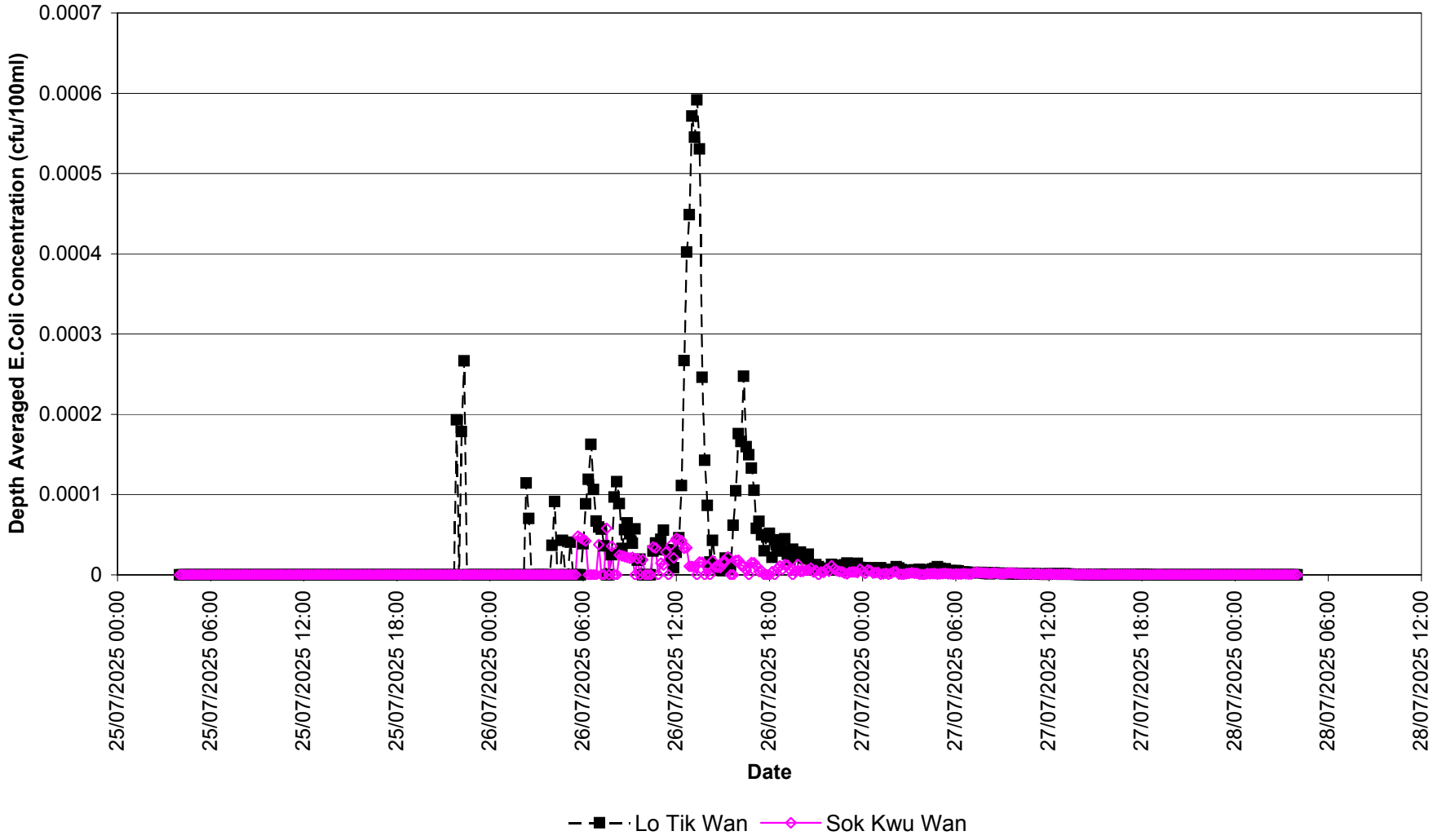


Chart 18b - *E. coli* (1 in 2 year, Spring Flood Tide) at Fish Culture Zone Sensitive Receivers

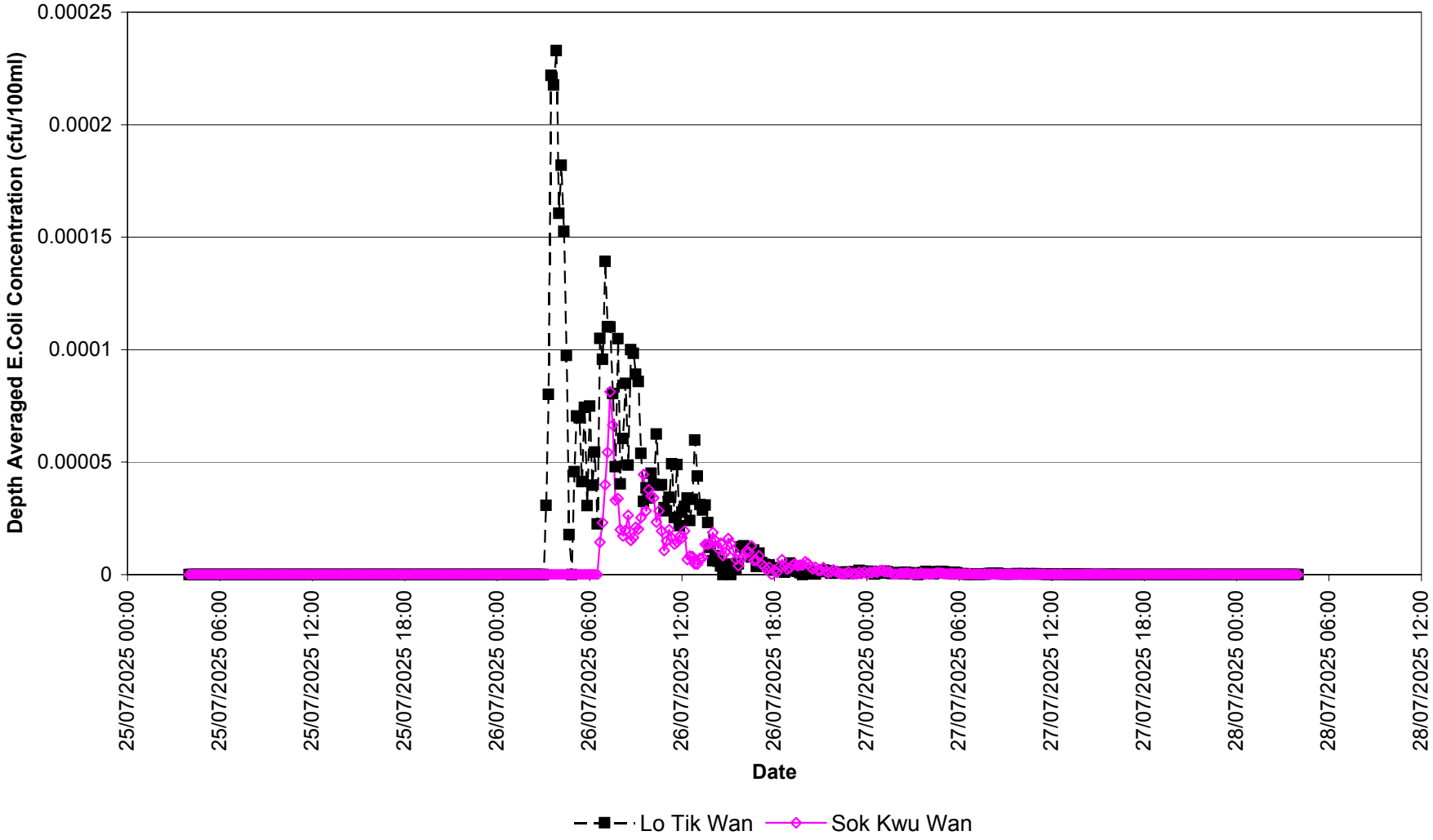


Chart 19a - *E. coli* (1 in 2 year, Spring Ebb Tide) at Coral Sensitive Receivers

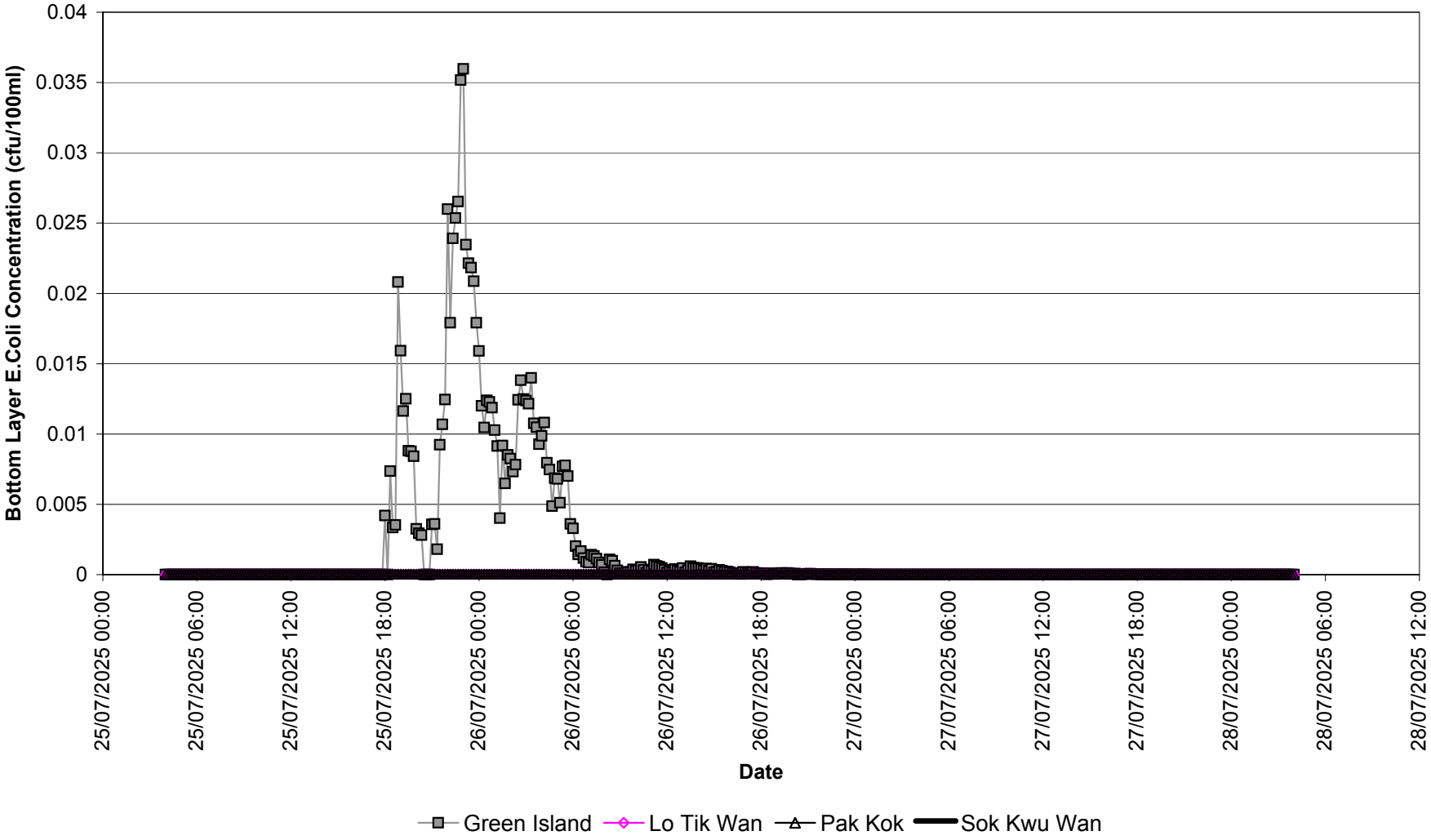


Chart 19b - *E. coli* (1 in 2 year, Spring Flood Tide) at Coral Sensitive Receivers

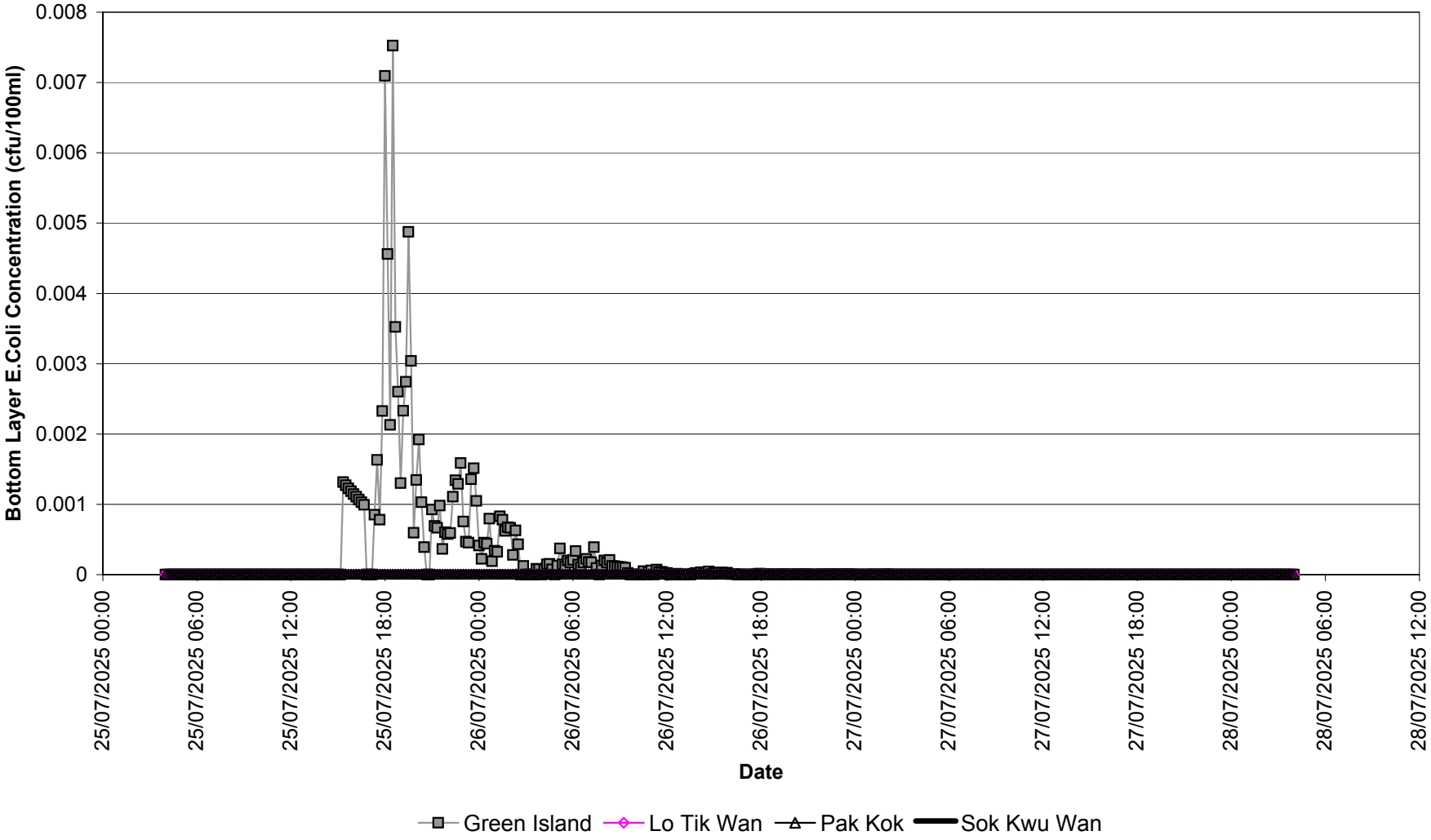


Chart 20a - *E. coli* (1 in 2 year, Spring Ebb Tide) at EPD Monitoring Stations

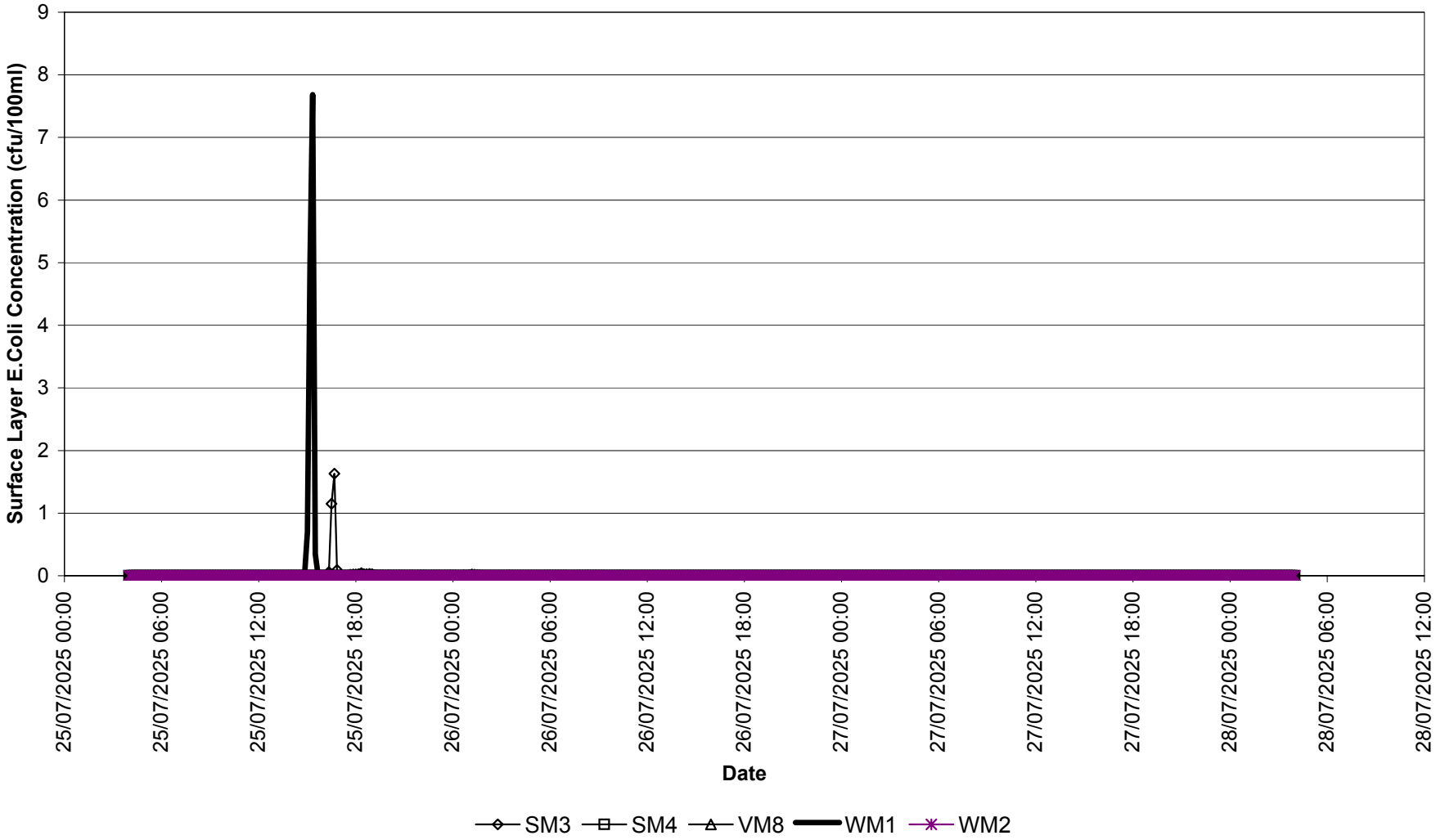


Chart 20b - *E. coli* (1 in 2 year, Spring Flood Tide) at EPD Monitoring Stations

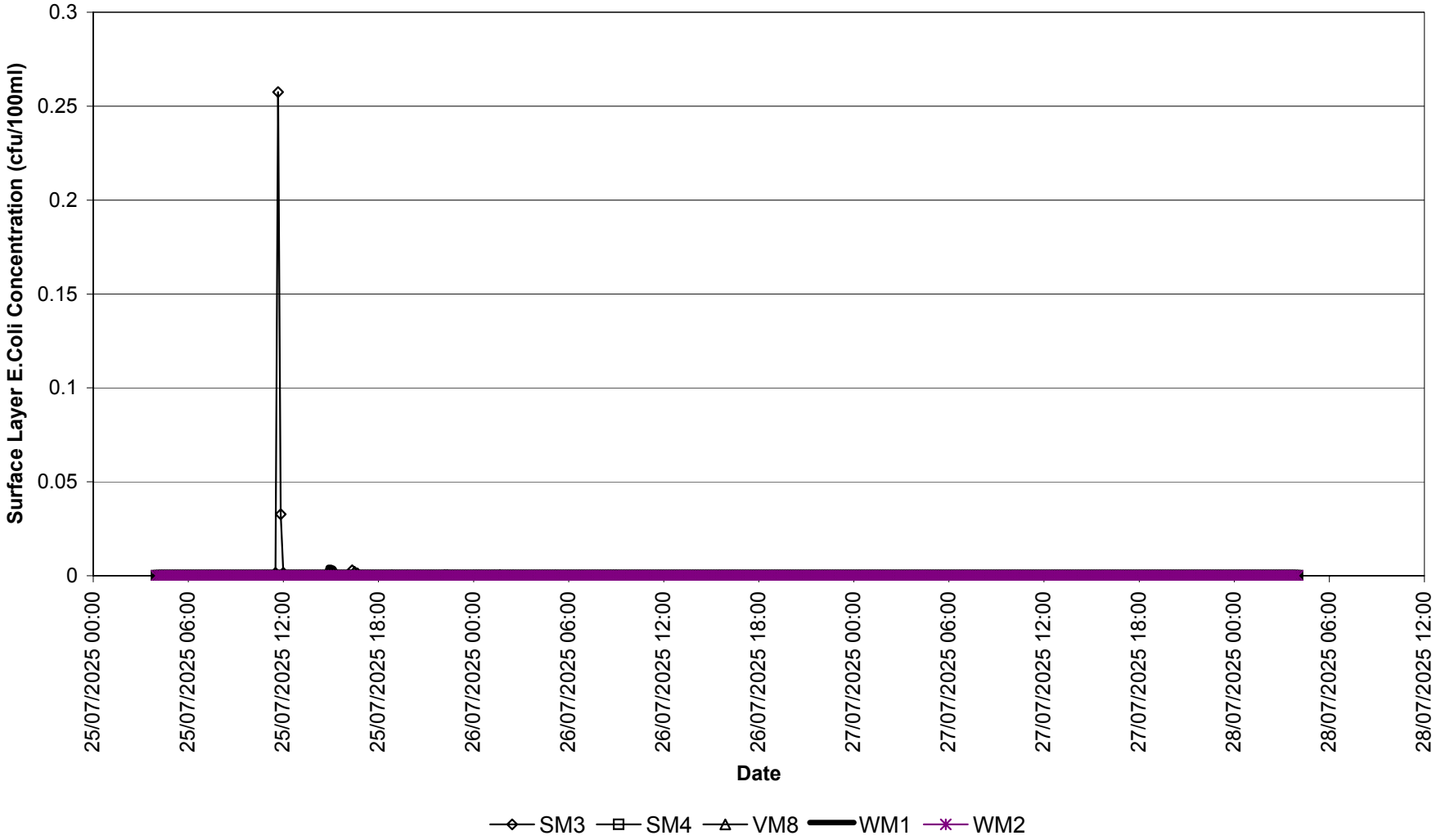


Chart 21a - Salinity (1 in 2 year, Spring Ebb Tide) at Green Island Coral

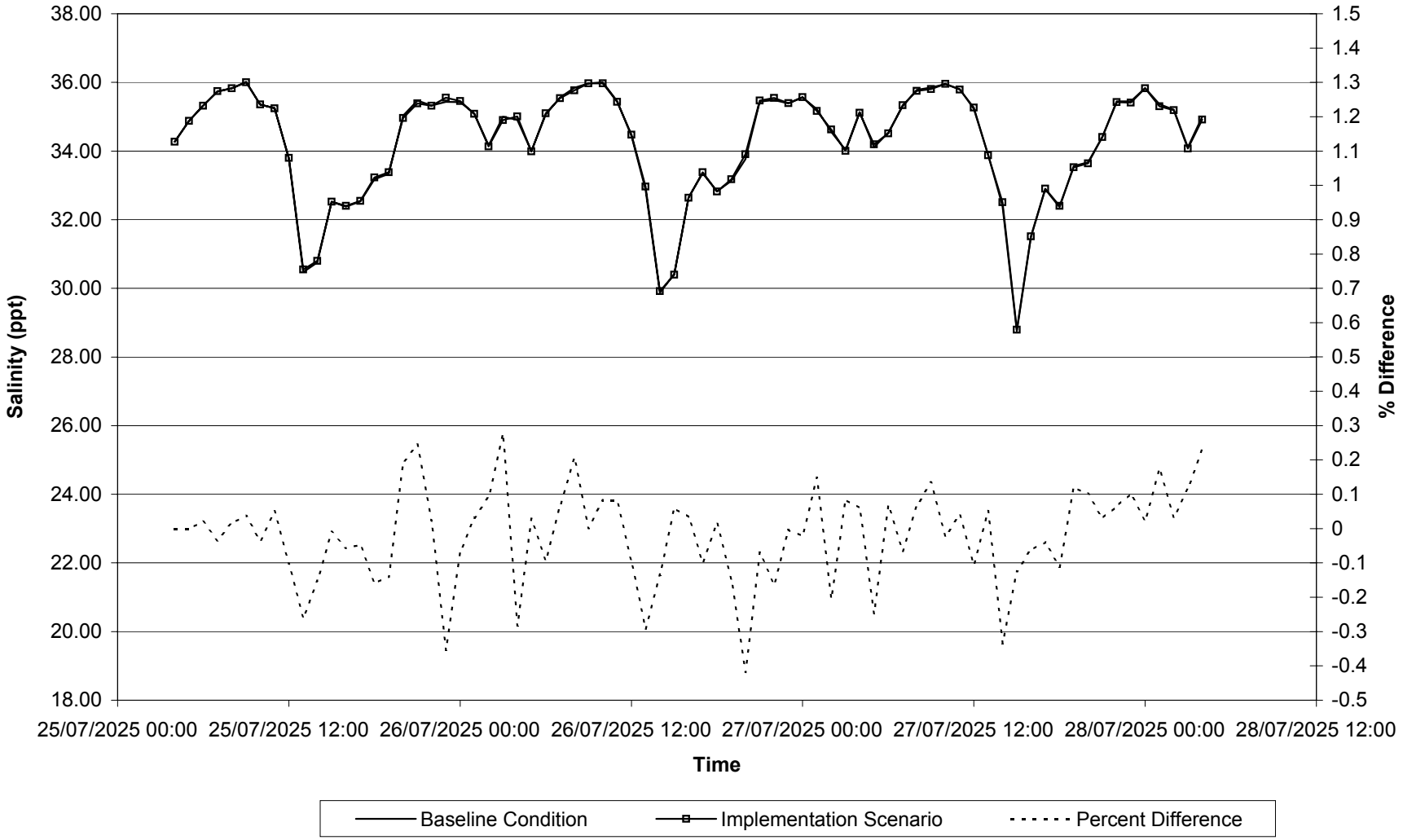


Chart 21b - Salinity (1 in 2 year, Spring Flood Tide) at Green Island Coral

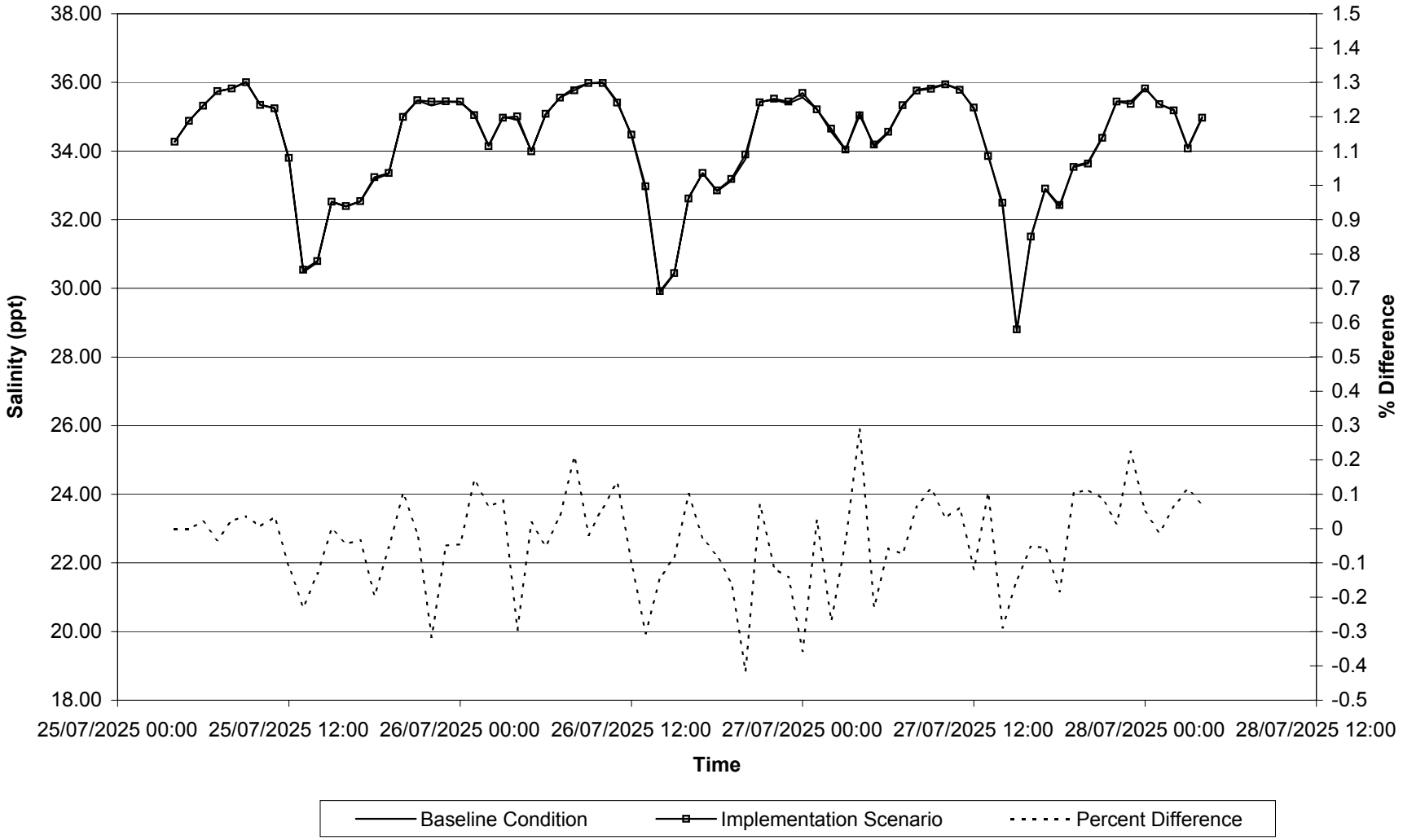


Chart 22a - Salinity (1 in 2 year, Spring Ebb Tide) at Lo Tik Wan Coral

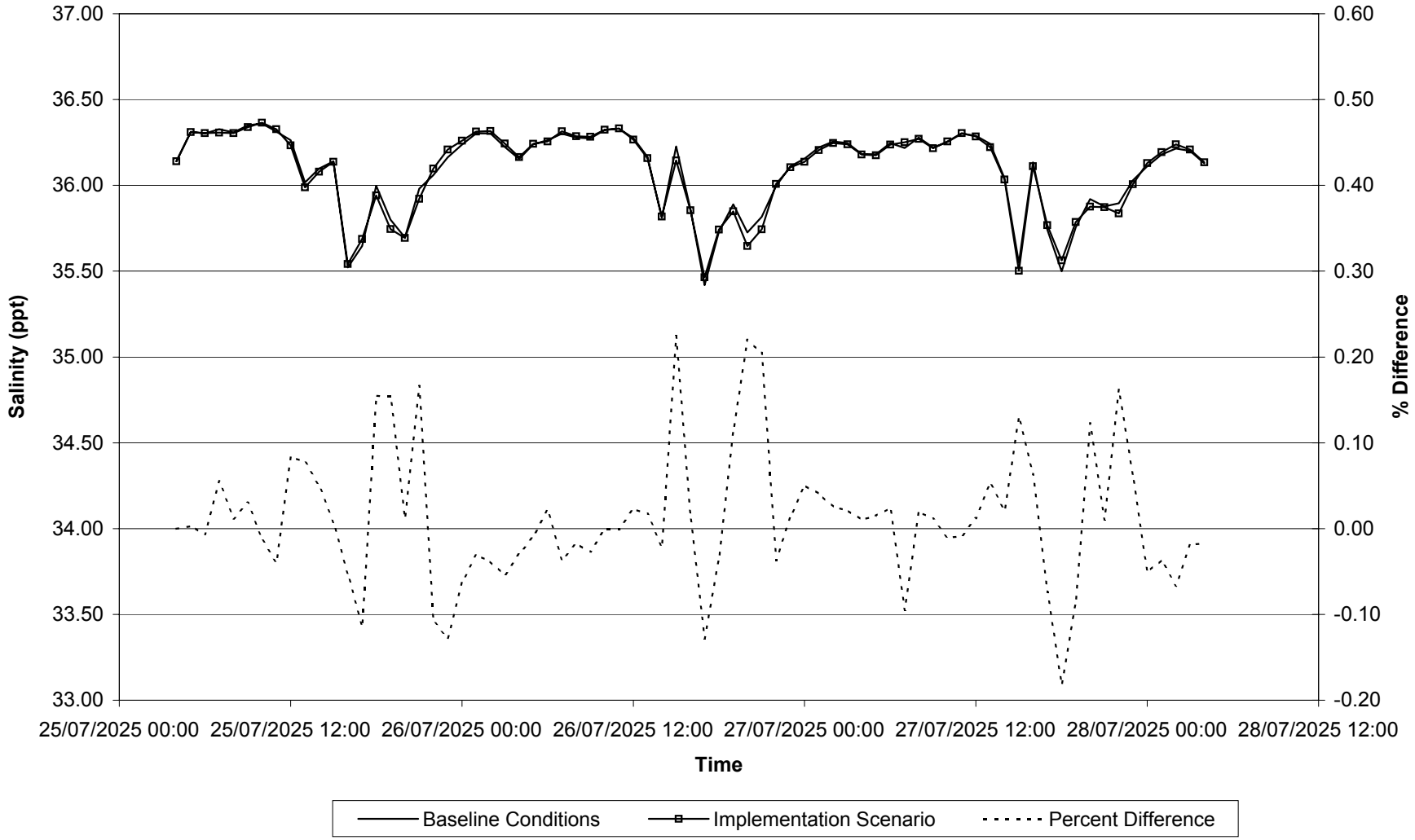


Chart 22b - Salinity (1 in 2 year, Spring Flood Tide) at Lo Tik Wan Coral

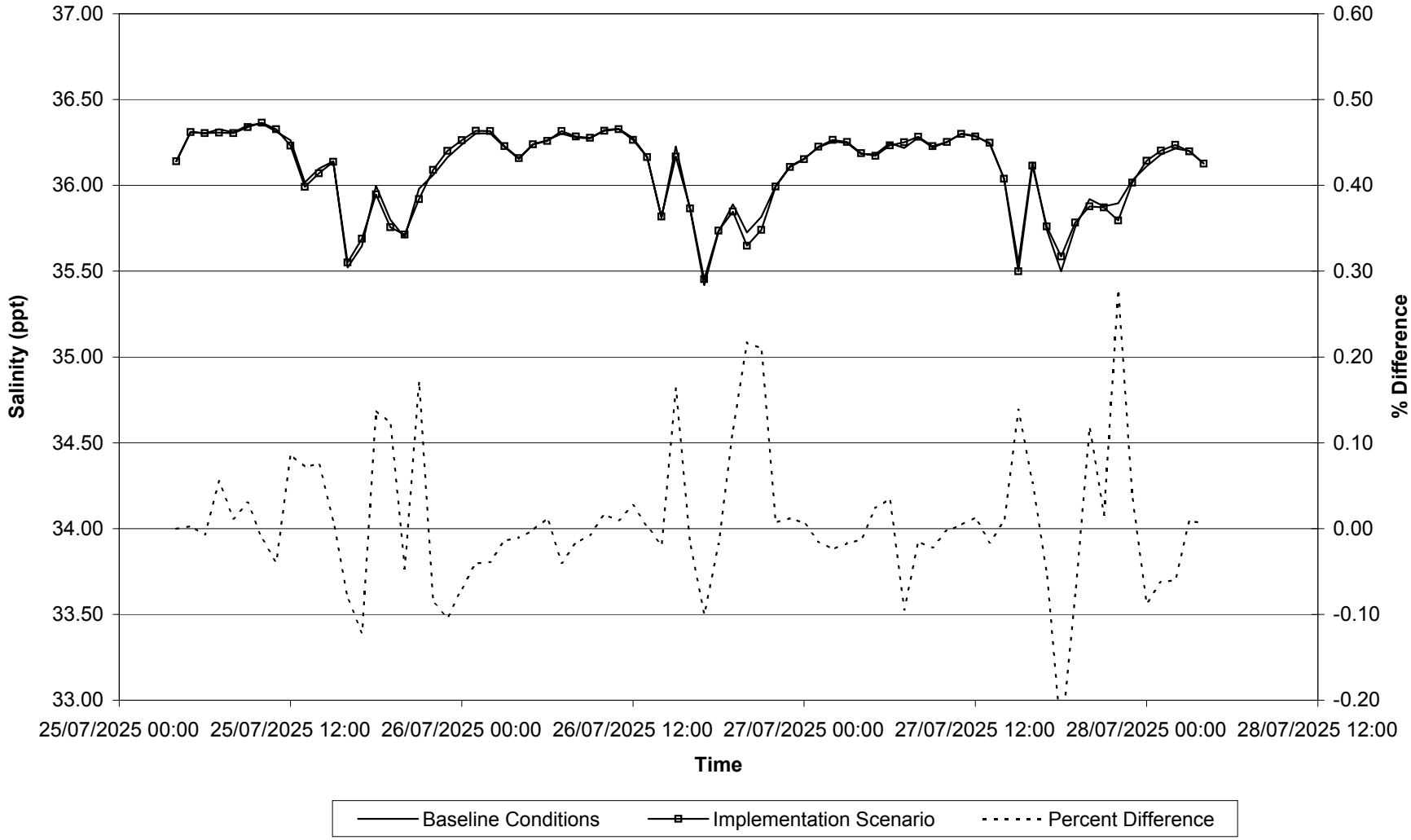


Chart 23a - Salinity (1 in 2 year, Spring Ebb Tide) at Pak Kok Coral

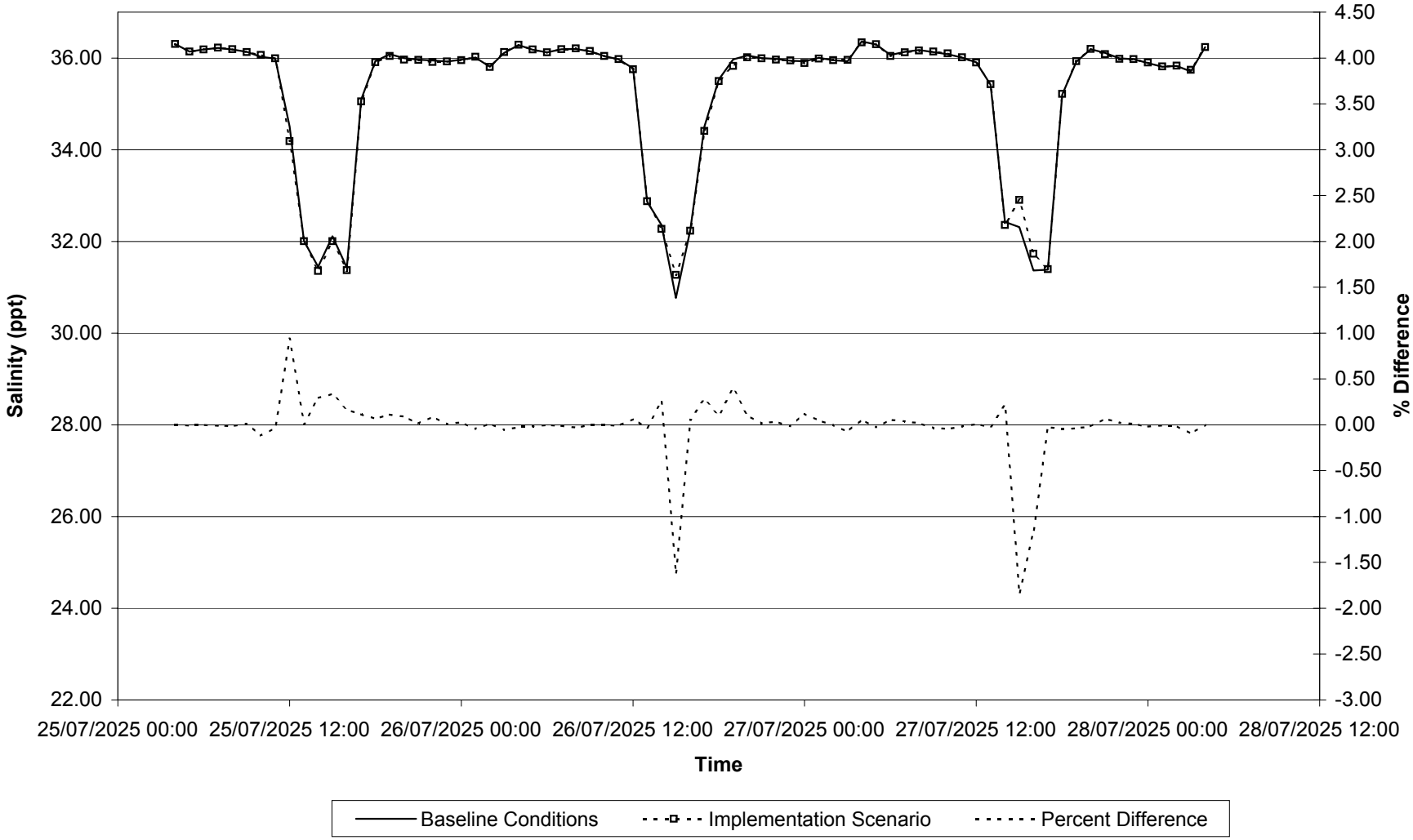


Chart 23b - Salinity (1 in 2 year, Spring Flood Tide) at Pak Kok Coral

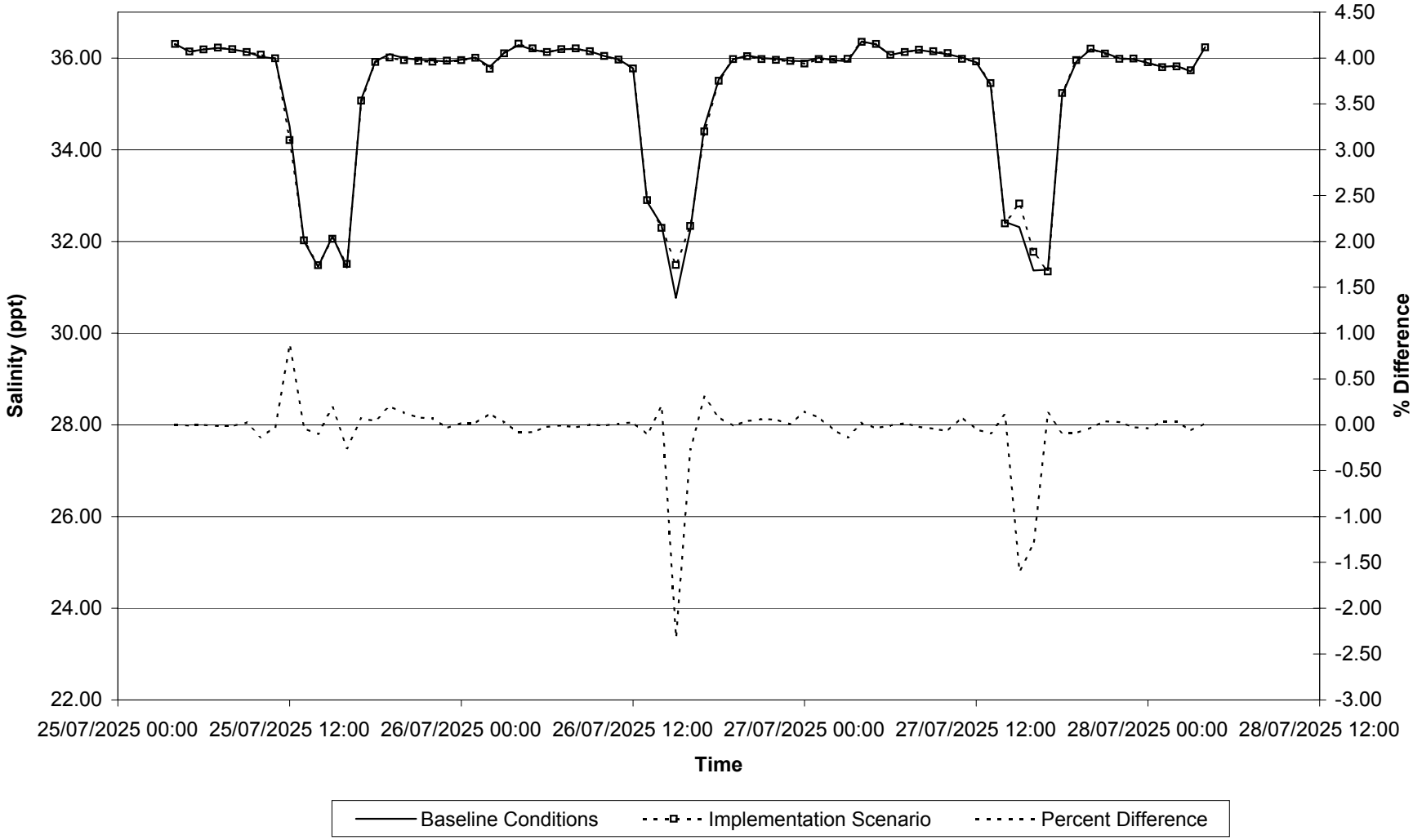


Chart 24a - Salinity (1in 2 year, Spring Ebb Tide) at Sok Kwu Wan Coral

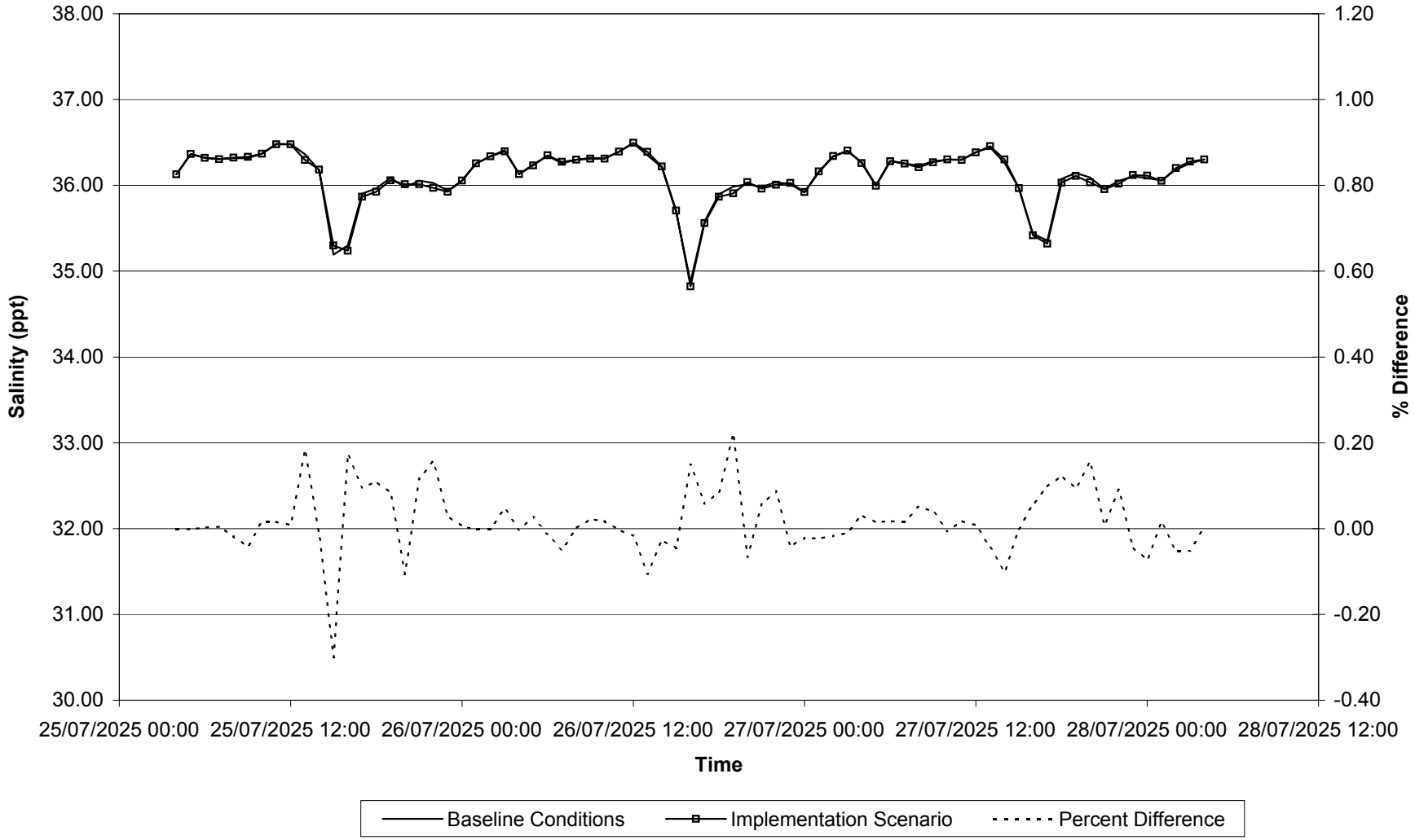


Chart 24b - Salinity (1 in 2 year, Spring Flood Tide) at Sok Kwu Wan Coral