Annex 7F

Detailed Results of CORMIX Modelling

CONTENTS

1 INTRODUCTION

This document provides information on the major assumptions for near field dispersion modelling exercise conducted for the discharge of cooled water and treated sewage effluent in operation phase.

For the discharge of cooled water, this exercise will provide indication on the near field mixing behavior of the cooled water plume from Project so that can be properly captured in the far field water quality modelling exercise using Delft3D WAQ. To ensure conservative assessment, the Delft3D WAQ model simulation would only take into account the vertical profile of the cooled water discharged. The horizontal dispersion predicted by the near field model would be omitted in the far field water quality model and all loading would be distributed only to the grid cell where the outfall is located.

For the discharge of treated sewage effluent, this exercise aims to estimation the number of dilution can be achieved at the nearest WSR for hydrotest water for the purpose of assessment of potential water quality impact. Further modelling using far field Delft3D model is not considered necessary in view of the relatively small discharge rate and openness of the marine water near the Project site.

2 MODEL SETUP

2.1 PROPOSED EFFLUENT CHARACTERISTICS

The assumed characteristics of the effluent for cooled water and treated sewage effluent discharge are presented below.

Table 2.1 Effluent Characteristics to be Considered

Determinand	Cooled Water	Treated Sewage Effluent
Flow Rate (m^3/s)	5.556	14.4 m^3/day = 0.0016667
Salinity (mg/L)	Ambient	0
Temperature (°C)	9°C below Ambient	Ambient
Other constituents	Total residue chlorine at 0.5 mg/L	Pollutants in sewage (1)

Note (1): This exercise considered the number of dilution that can be achieved by near field mixing. Detailed discussion on the resulted on concentration in pollution would be discussed in the main text of the water quality assessment.

2.2 DESIGN OF SUBMARINE OUTFALL

The design specifications of the outfalls for hydrotest water, cooled water and treated sewage effluent are shown below in *Table 2.2*.

Table 2.2 Designs of Outfalls for Cooled Water and Treated Sewage Effluent

Parameter	Information
Cooled Water	
Diffuser	No; Single port discharge
Port area of discharge port	Design not available; Modelled as 5.556 m^2 (1)
Configuration of discharge port	Single port
Location of diffuser from the nearest coastline	The outfall is located at the FSRU vessel.
Discharge Depth	10 m
Treated Sewage Effluent	
Diffuser	No; Single port discharge
Port area of discharge port	Design not available; Modelled as 0.006667 m^2 (1)
Configuration of discharge port	Single port
Location of diffuser from the nearest coastline	The outfall is located at the FSRU vessel.
Discharge Depth	Surface

Note:

(1) The design for discharge port size is not available at the time when the CORMIX simulation was conducted. The modelled values were chosen to be on the conservative side. Larger diameter of discharge port would result in slower initial jet velocity and thus less initial mixing and therefore the modelled discharge port size was chosen to be larger than normally required.

2.3 *INPUT VALUES FOR NEAR FIELD MODELLING*

The input parameters for near field modelling are summarized below. All the hydrodynamic conditions adopted were derived from the corresponding Delft3D FLOW scenarios.

Table 2.3 Ambient Condition Inputs for CORMIX Modelling

Parameter		**Scenarios**	
		D10 / D50 / D90	**W10 / W50 / W90**
		Dry season	**Wet season**
Cooled Water and Treated Sewage Effluent			
Ambient Conditions	Ambient Velocity (1)	D10: 0.053 m/s D50: 0.158 m/s D90: 0.284 m/s	W10: 0.110 m/s W50: 0.163 m/s W90: 0.262 m/s
	Water Depth at discharge outfall	15 m (0)	
	Average Surface (1) Water Density	1024.05 kg/m^3 (Non-stratified)	1017.64 kg/m^3
	Average Bottom (1) Water Density		1021.42 kg/m^3
	Ambient Wind Speed	5 m/s (Typical wind speed for dry and wet seasons from Delft3D Update Model)	

Note:

(1) The water density is derived from simulated temperature and salinity from the baseline scenario of the Delft3D FLOW modelling of the corresponding scenario at the outfall locations. Ambient velocity is also derived from simulation results of Delft3D Flow modelling.

(2) Smaller water depth within the Project site area was adopted for the model. This is to ensure conservative assessment by limiting the vertical mixing.

2.4 *MODELLING SCENARIOS*

The near field dispersion was modelled for combinations of different vertical density profile and ambient current velocity for each outfall locations. Based on the input information above, total of twelve (12) model runs were carried out for each season as listed below.

Table 2.4 Summary of Near-field Model Scenarios

Scenario ID	**Plant**	**Seasons**	**Percentile of Current Velocity**
D10-1	Cooled Water	Dry Season	10th
D50-1		Dry Season	50th
D90-1		Dry Season	90th
W101		Wet Season	10th
W50-1		Wet Season	50th
W90-1		Wet Season	90th
D10-2	Treated Sewage Effluent	Dry Season	10th
D50-2		Dry Season	50th
D90-2		Dry Season	90th
W10-2		Wet Season	10th
W50-2		Wet Season	50th
W90-2		Wet Season	90th

3 MODELLING PREDICTIONS

3.1 COOLED WATER

The predicted vertical profiles of cooled water plume at the edge of near field region by the CORMIX modelling under various scenarios are presented below in *Table 3.2*.

The modelling results of near field dispersion predicted cooled water from the regasification unit would be well mixed vertically in the water column within the near field region. Since the cooled water plume would have small negative buoyancy (same salinity but lower temperature as the ambient seawater), the plume covers most of the lower part of the water column in both seasons. The cooled water plume covers the entire water column for scenarios D10-2, D50-2 and W10-2, while the cooled water plume covers a notable portion of the water column in the remaining scenarios. The more stratified condition in wet season was predicted to result in weaker vertical mixing and the plume thickness of the cooled water would be slightly thinner under the 90^{th}-percentile ambient current velocity scenario.

The near field dispersion modelling prediction would be incorporated in the Delft3D WAQ far field modelling as required in paragraph 4 of Appendix D-1 of the EIA Study Brief. Based on the combined results of prediction for discharge from the existing outfall, the top plume level would be 13.4 m and 13.5m above the seabed level in the dry and wet seasons respectively and the bottom plume level would be at the seabed level in both seasons. Since in the Delft3D simulation the whole water column is divided in the 10 layers with even thickness, the predicted effluent plume for discharge from the existing outfall in both seasons should be put in the 2^{nd} to 10^{th} layers (i.e. water surface is the 1^{st} layer) of the water column.

3.2 TREATED SEWAGE EFFLUENT

The predicted number of dilution achieved as well as vertical profiles of treated sewage effluent plume at 200 m downstream of the outfall (i.e. approximate distance to the nearest WSR, MPD-5) by the CORMIX modelling under various scenarios are presented below in *Table 3.3*.

Owning to the very low discharge rate (0.0016667 m^3/s = 1.6667 L/s), the dilution of plume of treated sewage effluent is predicted to be very high within short distance downstream of the outfall. It is predicted that at around 200 m downstream of the outfall, the sewage effluent plume would be on average diluted by 1974 times already in both seasons. The plume is also predicted to occupy the less than 3% of the top layer of the water column as a result of its positive buoyancy.

Results indicate the number of dilution achieved at the nearest observation point MPD-5 of the proposed South Lantau Marine Park, which represents the southeast corner of the marine park about 200 m away from the discharge outfall at the FSRU Vessel, would be around 1,974, and the discharge plume would constitute only about 3% or less of the top layer of the water column. The potential contribution of pollutants from the discharge of treated sewage effluent to the nearest WSR is summarized in *Table 3.1*. As a result of the very small discharge rate and relative openness of the surrounding waters, the discharge of treated sewage effluent from the FSRU Vessel is predicted to result in negligible elevation of pollutants at the nearest WSR about 200 m downstream of the outfall. The predicted elevation in pollutants is very low when compared with the applicable WQO and / or the baseline level. No unacceptable water quality impact from the discharge of treated sewage effluent is therefore expected.

Table 3.1 Predicted Elevation of Water Quality Pollutants at the Nearest Observation Point of Proposed South Lantau Marine Park MPD-5 associated with the Discharge of Treated Sewage Effluent

Parameters (Unit)	**WPCO Discharge Standard (1)**	**Number of Dilution Achieved (2)**	**Concentration in Effluent Plume at MPD-5**	**Maximum Plume Thickness (3)**	**Concentration for Entire Water Column at MPD-5**	**WQO (4)**	**Baseline (5)**
Suspended Solids (mg L^{-1})	500	1974	0.25	3%	<0.01	< 30% Elevation	4.1
Biochemical Oxygen Demand (mg L^{-1})	500	1974	0.25	3%	<0.01	N/A	0.8
Total Residual Chlorine (mg L^{-1})	1	1974	0.0005	3 %	<0.000015	0.02	N/A
Total Nitrogen (mg L^{-1})	100	1974	0.05	3%	<0.01	0.1 (for TIN)	0.2 (TIN)
E. coli (count/100mL)	4000	1974	2	3%	<1	N/A	2

Notes:

(1) WPCO discharge standards for effluents discharged into the marine waters of Southern WCZ.

(2) Results for the worst-case among two seasons, i.e. wet season, were adopted for calculation.

(3) Results for the worst-case among two seasons, i.e. dry season, were adopted for calculation.

(4) Table 7.1 of main text referred.

(5) Table 7.2 of main text referred.

Table 3.2 Vertical and Horizontal Extent of Effluent Plume at the Edge of Near Field Region for Discharge of Cooled Water

Plant	Scenarios	Probability	Distance from Discharge Port to the Edge of Near Field Region (m)	Top Level above seabed of Effluent Plume (m)	Bottom Level above seabed of Effluent Plume (m)	Effluent Plume Thickness (m)
Cooled Water	D10-2	0.2	41.7	15.0	0.0	15.0
	D50-2	0.6	117.13	15.0	0.0	15.0
	D90-2	0.2	12.21	6.8	0.0	6.8
	W10-2	0.2	77.22	15.0	0.0	15.0
	W50-2	0.6	139.1	15.0	0.0	15.0
	W90-2	0.2	14.54	7.7	0.0	7.7
			Dry weighted average	13.4	0.0	13.4
			Wet weighted average	13.5	0.0	13.5

Table 3.3 Vertical and Horizontal Extent of Effluent Plume at 200 m Downstream of the Outfall for Discharge of Treated Sewage Effluent

Plant	Scenarios	Probability	Downstream Distance (m)	Number of Dilution Achieved	Top Level above seabed of Effluent Plume (m)	Bottom Level above seabed of Effluent Plume (m)	Effluent Plume Thickness (m)
Treated Sewage Effluent	D10-1	0.2	200	19258.9	15.0	13.6	1.4
	D50-1	0.6	200	2003.3	15.0	14.8	0.2
	D90-1	0.2	200	1024.3	15.0	14.8	0.2
	W10-1	0.2	200	3898.3	15.0	14.7	0.3
	W50-1	0.6	200	1646.1	15.0	14.8	0.2
	W90-1	0.2	200	1034.3	15.0	14.8	0.2
			Dry weighted average	5258.6	15.0	14.6	0.4
			Wet weighted average	1974.2	15.0	14.8	0.2