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1. INTRODUCTION

1.1 The VISJET model was used to simulate the near-field plume behaviour of the outfall discharges within a relatively short distance from the effluent discharge location. Hence, the zone of initial dilution (ZID) and vertical structure of the plume could be located. For a surface plume, initial dilution is defined as the dilution obtained at the centre line of the plume when the sewage reaches the surface. For a trapped plume, initial dilution is defined as the dilution obtained at the center line of the plume where the plume reaches the maximum rise height when the vertical momentum / buoyancy of the plume becomes zero.

1.2 The initial dilution obtained from the near field model was used to assess the TRC and CBP impact in the near field. Detailed assessment of the TRC and CBP impact is provided under the Human Health and Ecological Risk Assessment in Section 6 of the EIA report. The near field results were also used to determine where the effluent loading from the SCISTW outfall would be placed within the far field model (both horizontally and vertically). The near field modelling was carried out with reference to the approach adopted in the EEFS. Details of the modelling approach are presented in the "EEFS Working Paper No. 7 Scenarios Simulation / Prediction Results (Final)".

2. MODEL INPUT

2.1 Key input to the near-field model include:

- Outfall diffuser configuration
- Ambient current speed
- Vertical density profile
- Effluent flow rate

2.2 Details of the outfall diffuser configuration adopted for the near field modelling are given in **Table A5-1-1**. **Attachment 1** shows the submarine outfall of SCISTW.

Table A5-1-1 Diffuser Configuration of SCISTW Outfall

Description	Value	Remark
Modelling diffuser length (m)	1200	
Outfall diameter (m)	3.24	
Riser separation (m)	52	
No. of risers	24	
Riser height (m)	1.5	
Ports per riser	8	The horizontal angles of discharge for 8 ports are 0^o, 45^o, 90^o, 135^o, 180^o, 225^o, 270^o and 315^o.
Riser radius (m)	0.13	
Port diameter (m)	0.25	Port diameters ranges from 0.225m to 0.275m. An average value of 0.25m is adopted for modeling.

2.3 Vertical density profiles were derived for the SCISTW outfall under the EEFS using the data from EPD's routine water quality monitoring for the period from 1994 to 2002. Four density profiles were available from the EEFS for one dry season profile (D1) and three wet season profiles, representing three degrees of wet season stratification, namely W1, W2 and W3 respectively. **Table A5-1-2** shows the density profiles for D1, W1, W2 and W3 and their probabilities of occurrence. Details of the vertical density profiles are given in the "EEFS Working Paper No. 7". Based on the EEFS, the total water depth was assumed to be 17 m.

Table A5-1-2 Density Profile of SCISTW Outfall

Depth (m)	D1 (σ_t)	W1 (σ_t)	W2 (σ_t)	W3 (σ_t)
1	22.14	19.99	17.23	15.45
2	22.20	20.03	17.35	15.65
3	22.21	20.12	17.59	16.08
4	22.22	20.26	17.81	16.60
5	22.25	20.39	18.07	17.14

Depth (m)	D1 (σ_t)	W1 (σ_t)	W2 (σ_t)	W3 (σ_t)
6	22.27	20.60	18.48	17.78
7	22.27	20.86	18.99	18.54
8	22.29	21.08	19.34	19.36
9	22.29	21.27	19.71	20.02
10	22.29	21.39	19.92	20.39
11	22.29	21.39	20.43	20.99
12	22.32	21.39	20.65	21.26
13	22.32	21.39	20.65	21.26
14	22.32	21.39	20.65	21.26
15	22.32	21.39	20.65	21.26
16	22.32	21.39	20.65	21.26
17	22.32	21.39	20.65	21.26
Probabilistic Occurrence:	**0.58**	**0.08**	**0.25**	**0.08**

2.4 Measurements of ambient current velocity were conducted under the EEFS. The current data were analyzed for different vertical depths under the EEFS and were calculated as 10, 50 and 90 percentile values for both dry and wet seasons, namely V10, V50 and V90 respectively as shown in **Table A5-1-3**. It is assumed that the outfall would be perpendicular to the orientation of the predominant current direction.

Table A5-1-3 Ambient Current Velocity at SCISTW Outfall

Depth (m)	Dry V10 (cm/s)	Dry V50 (cm/s)	Dry V90 (cm/s)	Wet V10 (cm/s)	Wet V50 (cm/s)	Wet V90 (cm/s)
0-6	9.3	24.2	45.7	9.0	24.0	46.0
>6	8.4	22.1	43.0	8.0	22.0	43.0
Probabilistic Occurrence:	**0.2**	**0.6**	**0.2**	**0.2**	**0.6**	**0.2**

3. MODELLING SCENARIOS

3.1 The near field impact was modelled for different combinations of vertical density profile and ambient current velocity for 2009, 2013, 2020 and ultimate scenarios. For each assessment year, a set of three effluent flow rates, Q10, Q50 and Q90 were used, all based on the percentile of occurrence. The Q50 flow rate (the flow rate below which 50 percent of all effluent flow rates occur) was based on the average flow rate. The Q10 flow rate (the flow rate below which 10 percent of all flow rates occur) was calculated using a Q10 to Q50 ratio of 0.60. The Q90 flow rate was calculated using a Q90 to Q50 ratio of 1.28. These ratios are based on the findings from EEFS which are also in line with the actual measurement of effluent flow from SCISTW in 2004 and 2005. Based on the EEFS, the Q10 was representative of the flow rates that occurred between the 0 and 20 percentile (20 percent) and the Q90 was representative of the flow rates that occurred between the 80 and 100 percentile (20 percent) whereas the Q50 was representative of the remaining 60 percent. **Table A5-1-4** below summarizes the adopted effluent flows.

Table A5-1-4 Effluent Flow Adopted in Near-Field Model

Scenarios	ID	% of occurrence	Total Flow (m^3/d)	Flow per Riser (m^3/s)	Flow Per Port (m^3/s)
2009	Q10	20	945,780	0.4561	0.0570
	Q50	60	1,576,300	0.7602	0.0950
	Q90	20	2,017,567	0.9730	0.1216
2013	Q10	20	996,660	0.4806	0.0601
	Q50	60	1,661,100	0.8011	0.1001
	Q90	20	2,126,105	1.0253	0.1282
2020	Q10	20	1,404,960	0.6775	0.0847
	Q50	60	2,341,600	1.1292	0.1412
	Q90	20	2,997,103	1.4454	0.1807
Ultimate	Q10	20	1,680,000	0.8102	0.1013
	Q50	60	2,800,000	1.3503	0.1688

Scenarios	ID	% of occurrence	Total Flow	Flow per Riser	Flow Per Port
			(m^3/d)	(m^3/s)	(m^3/s)
	Q90	20	3,584,000	1.7284	0.2160

Note: Flows are divided equally amongst the risers and ports in the SCISTW outfall.

3.2 Based on the ambient density profile and current velocity, a total of 36 model runs was carried out under each scenario as listed in **Table A5-1-5** to **Table A5-1-8.**

Table A5-1-5 Summary of Proposed Model Runs for Scenario 2009

Run ID	Effluent Flow		Density Profile		Ambient Current Velocity		Joint Probability of occurrence
	ID	Probability of occurrence	ID	Probability of occurrence	ID	Probability of occurrence	
S1-1	Q10	0.2	D1	0.58	Dry V10	0.2	0.0232
S1-2	Q50	0.6	D1	0.58	Dry V10	0.2	0.0696
S1-3	Q90	0.2	D1	0.58	Dry V10	0.2	0.0232
S1-4	Q10	0.2	D1	0.58	Dry V50	0.6	0.0696
S1-5	Q50	0.6	D1	0.58	Dry V50	0.6	0.2088
S1-6	Q90	0.2	D1	0.58	Dry V50	0.6	0.0696
S1-7	Q10	0.2	D1	0.58	Dry V90	0.2	0.0232
S1-8	Q50	0.6	D1	0.58	Dry V90	0.2	0.0696
S1-9	Q90	0.2	D1	0.58	Dry V90	0.2	0.0232
S1-10	Q10	0.2	W1	0.08	Wet V10	0.2	0.0032
S1-11	Q50	0.6	W1	0.08	Wet V10	0.2	0.0096
S1-12	Q90	0.2	W1	0.08	Wet V10	0.2	0.0032
S1-13	Q10	0.2	W1	0.08	Wet V50	0.6	0.0096
S1-14	Q50	0.6	W1	0.08	Wet V50	0.6	0.0288
S1-15	Q90	0.2	W1	0.08	Wet V50	0.6	0.0096
S1-16	Q10	0.2	W1	0.08	Wet V90	0.2	0.0032
S1-17	Q50	0.6	W1	0.08	Wet V90	0.2	0.0096
S1-18	Q90	0.2	W1	0.08	Wet V90	0.2	0.0032
S1-19	Q10	0.2	W2	0.25	Wet V10	0.2	0.01
S1-20	Q50	0.6	W2	0.25	Wet V10	0.2	0.03
S1-21	Q90	0.2	W2	0.25	Wet V10	0.2	0.01
S1-22	Q10	0.2	W2	0.25	Wet V50	0.6	0.03
S1-23	Q50	0.6	W2	0.25	Wet V50	0.6	0.09
S1-24	Q90	0.2	W2	0.25	Wet V50	0.6	0.03
S1-25	Q10	0.2	W2	0.25	Wet V90	0.2	0.01
S1-26	Q50	0.6	W2	0.25	Wet V90	0.2	0.03
S1-27	Q90	0.2	W2	0.25	Wet V90	0.2	0.01
S1-28	Q10	0.2	W3	0.08	Wet V10	0.2	0.0032
S1-29	Q50	0.6	W3	0.08	Wet V10	0.2	0.0096
S1-30	Q90	0.2	W3	0.08	Wet V10	0.2	0.0032
S1-31	Q10	0.2	W3	0.08	Wet V50	0.6	0.0096
S1-32	Q50	0.6	W3	0.08	Wet V50	0.6	0.0288
S1-33	Q90	0.2	W3	0.08	Wet V50	0.6	0.0096
S1-34	Q10	0.2	W3	0.08	Wet V90	0.2	0.0032
S1-35	Q50	0.6	W3	0.08	Wet V90	0.2	0.0096
S1-36	Q90	0.2	W3	0.08	Wet V90	0.2	0.0032

Table A5-1-6 Summary of Proposed Model Runs for Scenario 2013

Run ID	Effluent Flow		Density Profile		Ambient Current Velocity		Joint Probability of occurrence
	ID	Probability of occurrence	ID	Probability of occurrence	ID	Probability of occurrence	
S2-1	Q10	0.2	D1	0.58	Dry V10	0.2	0.0232
S2-2	Q50	0.6	D1	0.58	Dry V10	0.2	0.0696
S2-3	Q90	0.2	D1	0.58	Dry V10	0.2	0.0232
S2-4	Q10	0.2	D1	0.58	Dry V50	0.6	0.0696
S2-5	Q50	0.6	D1	0.58	Dry V50	0.6	0.2088
S2-6	Q90	0.2	D1	0.58	Dry V50	0.6	0.0696
S2-7	Q10	0.2	D1	0.58	Dry V90	0.2	0.0232
S2-8	Q50	0.6	D1	0.58	Dry V90	0.2	0.0696
S2-9	Q90	0.2	D1	0.58	Dry V90	0.2	0.0232
S2-10	Q10	0.2	W1	0.08	Wet V10	0.2	0.0032
S2-11	Q50	0.6	W1	0.08	Wet V10	0.2	0.0096
S2-12	Q90	0.2	W1	0.08	Wet V10	0.2	0.0032
S2-13	Q10	0.2	W1	0.08	Wet V50	0.6	0.0096
S2-14	Q50	0.6	W1	0.08	Wet V50	0.6	0.0288
S2-15	Q90	0.2	W1	0.08	Wet V50	0.6	0.0096
S2-16	Q10	0.2	W1	0.08	Wet V90	0.2	0.0032
S2-17	Q50	0.6	W1	0.08	Wet V90	0.2	0.0096
S2-18	Q90	0.2	W1	0.08	Wet V90	0.2	0.0032
S2-19	Q10	0.2	W2	0.25	Wet V10	0.2	0.01
S2-20	Q50	0.6	W2	0.25	Wet V10	0.2	0.03
S2-21	Q90	0.2	W2	0.25	Wet V10	0.2	0.01
S2-22	Q10	0.2	W2	0.25	Wet V50	0.6	0.03
S2-23	Q50	0.6	W2	0.25	Wet V50	0.6	0.09
S2-24	Q90	0.2	W2	0.25	Wet V50	0.6	0.03
S2-25	Q10	0.2	W2	0.25	Wet V90	0.2	0.01
S2-26	Q50	0.6	W2	0.25	Wet V90	0.2	0.03
S2-27	Q90	0.2	W2	0.25	Wet V90	0.2	0.01
S2-28	Q10	0.2	W3	0.08	Wet V10	0.2	0.0032
S2-29	Q50	0.6	W3	0.08	Wet V10	0.2	0.0096
S2-30	Q90	0.2	W3	0.08	Wet V10	0.2	0.0032
S2-31	Q10	0.2	W3	0.08	Wet V50	0.6	0.0096
S2-32	Q50	0.6	W3	0.08	Wet V50	0.6	0.0288
S2-33	Q90	0.2	W3	0.08	Wet V50	0.6	0.0096
S2-34	Q10	0.2	W3	0.08	Wet V90	0.2	0.0032
S2-35	Q50	0.6	W3	0.08	Wet V90	0.2	0.0096
S2-36	Q90	0.2	W3	0.08	Wet V90	0.2	0.0032

Table A5-1-7 Summary of Proposed Model Runs for Scenario 2020

Run ID	Effluent Flow		Density Profile		Ambient Current Velocity		Joint Probability of occurrence
	ID	Probability of occurrence	ID	Probability of occurrence	ID	Probability of occurrence	
S3-1	Q10	0.2	D1	0.58	Dry V10	0.2	0.0232
S3-2	Q50	0.6	D1	0.58	Dry V10	0.2	0.0696
S3-3	Q90	0.2	D1	0.58	Dry V10	0.2	0.0232
S3-4	Q10	0.2	D1	0.58	Dry V50	0.6	0.0696
S3-5	Q50	0.6	D1	0.58	Dry V50	0.6	0.2088
S3-6	Q90	0.2	D1	0.58	Dry V50	0.6	0.0696
S3-7	Q10	0.2	D1	0.58	Dry V90	0.2	0.0232
S3-8	Q50	0.6	D1	0.58	Dry V90	0.2	0.0696
S3-9	Q90	0.2	D1	0.58	Dry V90	0.2	0.0232
S3-10	Q10	0.2	W1	0.08	Wet V10	0.2	0.0032
S3-11	Q50	0.6	W1	0.08	Wet V10	0.2	0.0096
S3-12	Q90	0.2	W1	0.08	Wet V10	0.2	0.0032
S3-13	Q10	0.2	W1	0.08	Wet V50	0.6	0.0096
S3-14	Q50	0.6	W1	0.08	Wet V50	0.6	0.0288
S3-15	Q90	0.2	W1	0.08	Wet V50	0.6	0.0096
S3-16	Q10	0.2	W1	0.08	Wet V90	0.2	0.0032
S3-17	Q50	0.6	W1	0.08	Wet V90	0.2	0.0096
S3-18	Q90	0.2	W1	0.08	Wet V90	0.2	0.0032
S3-19	Q10	0.2	W2	0.25	Wet V10	0.2	0.01
S3-20	Q50	0.6	W2	0.25	Wet V10	0.2	0.03
S3-21	Q90	0.2	W2	0.25	Wet V10	0.2	0.01
S3-22	Q10	0.2	W2	0.25	Wet V50	0.6	0.03
S3-23	Q50	0.6	W2	0.25	Wet V50	0.6	0.09
S3-24	Q90	0.2	W2	0.25	Wet V50	0.6	0.03
S3-25	Q10	0.2	W2	0.25	Wet V90	0.2	0.01
S3-26	Q50	0.6	W2	0.25	Wet V90	0.2	0.03
S3-27	Q90	0.2	W2	0.25	Wet V90	0.2	0.01
S3-28	Q10	0.2	W3	0.08	Wet V10	0.2	0.0032
S3-29	Q50	0.6	W3	0.08	Wet V10	0.2	0.0096
S3-30	Q90	0.2	W3	0.08	Wet V10	0.2	0.0032
S3-31	Q10	0.2	W3	0.08	Wet V50	0.6	0.0096
S3-32	Q50	0.6	W3	0.08	Wet V50	0.6	0.0288
S3-33	Q90	0.2	W3	0.08	Wet V50	0.6	0.0096
S3-34	Q10	0.2	W3	0.08	Wet V90	0.2	0.0032
S3-35	Q50	0.6	W3	0.08	Wet V90	0.2	0.0096
S3-36	Q90	0.2	W3	0.08	Wet V90	0.2	0.0032

Table A5-1-8 Summary of Proposed Model Runs for Ultimate Scenario

Run ID	Effluent Flow		Density Profile		Ambient Current Velocity		Joint Probability of occurrence
	ID	Probability of occurrence	ID	Probability of occurrence	ID	Probability of occurrence	
S4-1	Q10	0.2	D1	0.58	Dry V10	0.2	0.0232
S4-2	Q50	0.6	D1	0.58	Dry V10	0.2	0.0696
S4-3	Q90	0.2	D1	0.58	Dry V10	0.2	0.0232
S4-4	Q10	0.2	D1	0.58	Dry V50	0.6	0.0696
S4-5	Q50	0.6	D1	0.58	Dry V50	0.6	0.2088
S4-6	Q90	0.2	D1	0.58	Dry V50	0.6	0.0696
S4-7	Q10	0.2	D1	0.58	Dry V90	0.2	0.0232
S4-8	Q50	0.6	D1	0.58	Dry V90	0.2	0.0696
S4-9	Q90	0.2	D1	0.58	Dry V90	0.2	0.0232
S4-10	Q10	0.2	W1	0.08	Wet V10	0.2	0.0032
S4-11	Q50	0.6	W1	0.08	Wet V10	0.2	0.0096
S4-12	Q90	0.2	W1	0.08	Wet V10	0.2	0.0032
S4-13	Q10	0.2	W1	0.08	Wet V50	0.6	0.0096
S4-14	Q50	0.6	W1	0.08	Wet V50	0.6	0.0288
S4-15	Q90	0.2	W1	0.08	Wet V50	0.6	0.0096
S4-16	Q10	0.2	W1	0.08	Wet V90	0.2	0.0032
S4-17	Q50	0.6	W1	0.08	Wet V90	0.2	0.0096
S4-18	Q90	0.2	W1	0.08	Wet V90	0.2	0.0032
S4-19	Q10	0.2	W2	0.25	Wet V10	0.2	0.01
S4-20	Q50	0.6	W2	0.25	Wet V10	0.2	0.03
S4-21	Q90	0.2	W2	0.25	Wet V10	0.2	0.01
S4-22	Q10	0.2	W2	0.25	Wet V50	0.6	0.03
S4-23	Q50	0.6	W2	0.25	Wet V50	0.6	0.09
S4-24	Q90	0.2	W2	0.25	Wet V50	0.6	0.03
S4-25	Q10	0.2	W2	0.25	Wet V90	0.2	0.01
S4-26	Q50	0.6	W2	0.25	Wet V90	0.2	0.03
S4-27	Q90	0.2	W2	0.25	Wet V90	0.2	0.01
S4-28	Q10	0.2	W3	0.08	Wet V10	0.2	0.0032
S4-29	Q50	0.6	W3	0.08	Wet V10	0.2	0.0096
S4-30	Q90	0.2	W3	0.08	Wet V10	0.2	0.0032
S4-31	Q10	0.2	W3	0.08	Wet V50	0.6	0.0096
S4-32	Q50	0.6	W3	0.08	Wet V50	0.6	0.0288
S4-33	Q90	0.2	W3	0.08	Wet V50	0.6	0.0096
S4-34	Q10	0.2	W3	0.08	Wet V90	0.2	0.0032
S4-35	Q50	0.6	W3	0.08	Wet V90	0.2	0.0096
S4-36	Q90	0.2	W3	0.08	Wet V90	0.2	0.0032

3.3 There are 24 risers for the SCISTW outfall. Thus, modelling all 24 risers would produce 192 sets of output information (8 jets per riser). Following the approach adopted under the EEFS, the number of risers to be analyzed for the outfall was reduced to 5 for each model run to simplify the modelling effort. As it is assumed in the near field model that the flow rate for each individual jet and each individual riser would be the same, the results obtained from modelling 5 risers would be the same as those from modelling all the 24 risers given that the ambient conditions were assumed to be the same for all the risers.

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4. MODEL RESULTS

Model Output

4.1 Key model outputs include initial dilution, the plume depth, the plume half width, the plume thickness and the downstream distance at the edge of the ZID. **Table A5-1-10** to **Table A5-1-13** summarize the results from the VISJET simulations. Merging of plumes from adjacent risers was only found in 6 out of 144 model runs (namely run ID S3-12, S3-21, S3-30, S4-12, S4-21 and S4-30). Merging of plumes from adjacent jets on individual riser was observed in nearly all model runs. The plume merging would reduce the initial dilution. The composite dilution of merged jets was determined by the VISJET model.

4.2 The predicted composite initial dilution was corrected for the background concentration build up due to the tidal effects based on the “EEFS Working Paper No. 7”. Explanation of the background build up correction is extracted from Section 7.5.4 of the “EEFS Working Paper No. 7” as follows:

“*The basic assumption of any near field model is that the effluent plume is mixed with clean water. In actuality this is not true, particularly in a tidally mixed environment. It is known that the ebbing tide takes estuarine water out towards the open ocean, mixes and then returns on the following flood tide. This returning mixed water never returns as completely new ocean water. If this were so, one would never observe a build up of pollutants in an estuarine environment. In the case of the HATS, a portion of the effluent that was discharged into the receiving water on the ebbing tide remains with incoming flood tide after mixing with the off shore waters. This remaining concentration is referred to as “background build up”, which must be accounted for or else risk that the calculated initial dilutions will be overestimated.*

The HATS far field model was used to account for this background build up under the EEFS. This build up was quantified by performing a conservative tracer run on the effluent from the SCISTW outfalls. A conservative tracer, i.e. without decay or reaction, was used. The initial concentration of the tracer in the effluent was set to be 1000 mg/l. The direct results of this far field tracer run cannot be used to determine the dynamics of the near field (less than 50 to 100 meters of the outfalls), due to the lack of vertical and horizontal grid resolution needed for accurate simulation of the latter. The average annual results of the far field tracer run can provide the necessary details to supplement the near field modelling to incorporate the background build up. It should be noted that the results from the grid cell into which the tracer is loaded is not representative of the true background build up as this cell will always contain the background build up plus the continuous tracer loading, therefore, the necessary far field tracer results were taken from a cell located adjacent to the outfall grid cells.”

4.3 The average tracer background build up concentrations for the SCISTW effluent were updated under this Study for the corrections. The far field HATS model was used to predict the background build up concentrations for the four different time horizons (2009, 2013, 2020 and ultimate) and for both dry and wet seasons. **Table A5-1-9** shows an example of background build up correction for the minimum initial dilution in the ultimate year. The corrected initial dilutions for the other model runs are included in **Table A5-1-10** to **Table A5-1-13**.

Table A5-1-9 Example of Background Build Up Correction

Year	Minimum Initial Dilution[1]	Initial Tracer Concentration in Effluent [2] (mg/L)	Average Tracer Concentration (mg/L)		Corrected Initial Dilution [5]
			Dry Season [3]	Wet Season [4]	
	(A)	(B)	(C)	(D)	(E)
Ultimate	49.6 (round up to 50)	1000	9.105	9.196	34.4 (round up to 34)

Note:
1. Minimum initial dilution predicted by VISJET model for the ultimate year. This dilution occurred under the dry season scenario (run ID S4-3)
2. Effluent tracer concentration assumed in the far field modelling.
3. Average background buildup concentration for dry season under the ultimate scenario predicted by the far field model.
4. Average background buildup concentration for wet season under the ultimate scenario predicted by the far field model.
5. The average background buildup concentration for dry season was used for the correction in this case as the minimum dilution occurred under the dry season scenario. Corrected Initial Dilution, (E) = (B) ÷ {[1 x (B) + ((A) – 1) x (C)] ÷ (A)}

Table A5-1-10 Summary of Results from VISJET Simulations for Scenario 2009

Run ID	Effluent Flow		Density Profile		Ambient Current Velocity		Joint Prob. of Occurrence	Initial Dilution[1]	Corrected Initial Dilution [2]	Average Plume Depth (m)	Average Plume Thickness (m)	Average Plume Half-Width per Riser (m)	Downstream Distance at Edge of ZID (m)
	ID	Prob.	ID	Prob.	ID	Prob.							
S1-1	10	0.2	D1	0.58	Dry V10	0.2	0.0232	91	58	2.2	9.9	11.9	21
S1-2	50	0.6	D1	0.58	Dry V10	0.2	0.0696	79	53	4.2	8.0	10.4	14
S1-3	90	0.2	D1	0.58	Dry V10	0.2	0.0232	66	**47**	4.3	8.8	12.8	16
S1-4	10	0.2	D1	0.58	Dry V50	0.6	0.0696	198	88	3.3	11.6	10.4	70
S1-5	50	0.6	D1	0.58	Dry V50	0.6	0.2088	197	88	2.0	12.4	13.1	84
S1-6	90	0.2	D1	0.58	Dry V50	0.6	0.0696	197	88	1.8	14.1	14.9	92
S1-7	10	0.2	D1	0.58	Dry V90	0.2	0.0232	317	105	4.0	11.4	9.6	153
S1-8	50	0.6	D1	0.58	Dry V90	0.2	0.0696	264	99	3.6	12.0	11.3	145
S1-9	90	0.2	D1	0.58	Dry V90	0.2	0.0232	251	97	3.4	12.4	12.5	145
S1-10	10	0.2	W1	0.08	Wet V10	0.2	0.0032	80	57	6.2	12.2	8.9	15
S1-11	50	0.6	W1	0.08	Wet V10	0.2	0.0096	90	62	5.6	14.3	11.8	16
S1-12	90	0.2	W1	0.08	Wet V10	0.2	0.0032	100	67	5.3	16.0	13.5	20
S1-13	10	0.2	W1	0.08	Wet V50	0.6	0.0096	119	75	8.2	9.1	7.4	38
S1-14	50	0.6	W1	0.08	Wet V50	0.6	0.0288	118	74	7.8	10.9	9.6	38
S1-15	90	0.2	W1	0.08	Wet V50	0.6	0.0096	115	73	7.7	11.7	10.9	34
S1-16	10	0.2	W1	0.08	Wet V90	0.2	0.0032	176	94	8.7	8.4	6.6	91
S1-17	50	0.6	W1	0.08	Wet V90	0.2	0.0096	160	89	8.4	9.4	8.2	84
S1-18	90	0.2	W1	0.08	Wet V90	0.2	0.0032	155	87	8.3	10.1	9.2	79
S1-19	10	0.2	W2	0.25	Wet V10	0.2	0.01	66	50	8.9	10.1	7.6	13
S1-20	50	0.6	W2	0.25	Wet V10	0.2	0.03	78	56	8.4	14.3	10.6	14
S1-21	90	0.2	W2	0.25	Wet V10	0.2	0.01	98	66	8.2	17.0	12.3	17
S1-22	10	0.2	W2	0.25	Wet V50	0.6	0.03	75	55	10.7	6.8	5.8	25
S1-23	50	0.6	W2	0.25	Wet V50	0.6	0.09	78	56	10.9	7.5	7.8	26
S1-24	90	0.2	W2	0.25	Wet V50	0.6	0.03	80	57	10.4	9.8	9.2	25
S1-25	10	0.2	W2	0.25	Wet V90	0.2	0.01	101	67	11.1	5.9	5.0	56
S1-26	50	0.6	W2	0.25	Wet V90	0.2	0.03	100	67	10.9	7.1	6.5	55
S1-27	90	0.2	W2	0.25	Wet V90	0.2	0.01	101	67	10.8	7.8	7.5	54
S1-28	10	0.2	W3	0.08	Wet V10	0.2	0.0032	64	48	9.2	10.6	7.3	12
S1-29	50	0.6	W3	0.08	Wet V10	0.2	0.0096	80	57	8.7	14.7	10.0	13
S1-30	90	0.2	W3	0.08	Wet V10	0.2	0.0032	86	61	8.6	15.9	12.7	17
S1-31	10	0.2	W3	0.08	Wet V50	0.6	0.0096	73	54	10.6	6.7	5.8	24
S1-32	50	0.6	W3	0.08	Wet V50	0.6	0.0288	76	55	10.4	8.9	7.8	25
S1-33	90	0.2	W3	0.08	Wet V50	0.6	0.0096	78	56	10.4	9.7	9.1	24
S1-34	10	0.2	W3	0.08	Wet V90	0.2	0.0032	101	67	11.0	5.9	5.0	55
S1-35	50	0.6	W3	0.08	Wet V90	0.2	0.0096	100	67	10.9	7.1	6.5	53
S1-36	90	0.2	W3	0.08	Wet V90	0.2	0.0032	100	67	10.8	7.8	7.5	53

Note:
1. Values calculated by VISJET model.
2. Initial dilution was corrected using the background buildup concentration predicted by the far field model for year 2009 (see S4.2 and S4.3). Bolded and shaded values indicated minimum initial dilution. The minimum dilution occurred under a different model run after the correction because the background buildup concentration for dry season was predicted to be larger than that for the wet season in year 2009.

Table A5-1-11 Summary of Results from VISJET Simulations for Scenario 2013

Run ID	Effluent Flow		Density Profile		Ambient Current Velocity		Joint Prob. of Occurrence	Initial Dilution[1]	Corrected Initial Dilution [2]	Average Plume Depth	Average Plume Thickness	Average Plume Half-Width per Riser	Downstream Distance at Edge of ZID
	ID	Prob.	ID	Prob.	ID	Prob.				(m)	(m)	(m)	(m)
S2-1	10	0.2	D1	0.58	Dry V10	0.2	0.0232	82	53	3.3	6.7	10.5	17
S2-2	50	0.6	D1	0.58	Dry V10	0.2	0.0696	76	55	4.2	8.3	10.7	15
S2-3	90	0.2	D1	0.58	Dry V10	0.2	0.0232	64	**48**	4.3	8.3	12.8	16
S2-4	10	0.2	D1	0.58	Dry V50	0.6	0.0696	183	94	3.3	11.3	10.6	67
S2-5	50	0.6	D1	0.58	Dry V50	0.6	0.2088	199	99	2.3	13.5	13.4	86
S2-6	90	0.2	D1	0.58	Dry V50	0.6	0.0696	195	97	1.7	14.3	15.3	91
S2-7	10	0.2	D1	0.58	Dry V90	0.2	0.0232	313	120	3.9	11.5	9.7	154
S2-8	50	0.6	D1	0.58	Dry V90	0.2	0.0696	260	111	3.6	12.1	11.5	144
S2-9	90	0.2	D1	0.58	Dry V90	0.2	0.0232	248	109	3.4	12.4	12.8	145
S2-10	10	0.2	W1	0.08	Wet V10	0.2	0.0032	80	57	6.2	12.3	9.1	15
S2-11	50	0.6	W1	0.08	Wet V10	0.2	0.0096	91	62	5.5	14.9	12.0	17
S2-12	90	0.2	W1	0.08	Wet V10	0.2	0.0032	102	67	5.2	16.3	13.9	21
S2-13	10	0.2	W1	0.08	Wet V50	0.6	0.0096	119	74	8.1	9.3	7.6	38
S2-14	50	0.6	W1	0.08	Wet V50	0.6	0.0288	118	74	7.8	11.3	9.8	39
S2-15	90	0.2	W1	0.08	Wet V50	0.6	0.0096	117	73	7.6	12.4	11.3	35
S2-16	10	0.2	W1	0.08	Wet V90	0.2	0.0032	172	91	8.6	8.5	6.7	90
S2-17	50	0.6	W1	0.08	Wet V90	0.2	0.0096	159	88	8.4	9.6	8.4	83
S2-18	90	0.2	W1	0.08	Wet V90	0.2	0.0032	154	86	8.3	10.3	9.5	79
S2-19	10	0.2	W2	0.25	Wet V10	0.2	0.0100	68	51	8.9	10.7	7.9	13
S2-20	50	0.6	W2	0.25	Wet V10	0.2	0.0300	83	58	8.4	15.0	11.0	14
S2-21	90	0.2	W2	0.25	Wet V10	0.2	0.0100	100	66	8.2	17.0	12.7	18
S2-22	10	0.2	W2	0.25	Wet V50	0.6	0.0300	75	54	10.6	6.9	6.0	25
S2-23	50	0.6	W2	0.25	Wet V50	0.6	0.0900	80	57	10.4	9.2	8.1	26
S2-24	90	0.2	W2	0.25	Wet V50	0.6	0.0300	80	57	10.3	9.9	9.5	26
S2-25	10	0.2	W2	0.25	Wet V90	0.2	0.0100	100	66	11.0	6.0	5.1	56
S2-26	50	0.6	W2	0.25	Wet V90	0.2	0.0300	100	66	10.9	7.2	6.7	55
S2-27	90	0.2	W2	0.25	Wet V90	0.2	0.0100	101	67	10.8	8.0	7.8	54
S2-28	10	0.2	W3	0.08	Wet V10	0.2	0.0032	64	48	9.1	10.9	7.6	12
S2-29	50	0.6	W3	0.08	Wet V10	0.2	0.0096	84	59	8.7	15.4	10.4	14
S2-30	90	0.2	W3	0.08	Wet V10	0.2	0.0032	91	62	8.5	16.1	12.1	18
S2-31	10	0.2	W3	0.08	Wet V50	0.6	0.0096	73	53	10.6	6.9	6.0	24
S2-32	50	0.6	W3	0.08	Wet V50	0.6	0.0288	79	56	10.4	9.1	8.0	25
S2-33	90	0.2	W3	0.08	Wet V50	0.6	0.0096	79	56	10.3	9.8	9.4	25
S2-34	10	0.2	W3	0.08	Wet V90	0.2	0.0032	101	67	11.0	6.0	5.1	55
S2-35	50	0.6	W3	0.08	Wet V90	0.2	0.0096	100	66	10.8	7.2	6.7	53
S2-36	90	0.2	W3	0.08	Wet V90	0.2	0.0032	101	67	10.8	8.0	7.7	53

Note:
1. Values calculated by VISJET model.
2. Initial dilution was corrected using the background buildup concentration predicted by the far field model for year 2013 (see S4.2 and S4.3). Bolded and shaded values indicated minimum initial dilution.

Table A5-1-12 Summary of Results from VISJET Simulations for Scenario 2020

Run ID	Effluent Flow		Density Profile		Ambient Current Velocity		Joint Prob. of Occurrence	Initial Dilution[1]	Corrected Initial Dilution [2]	Average Plume Depth	Average Plume Thickness	Average Plume Half-Width per Riser	Downstream Distance at Edge of ZID
	ID	Prob.	ID	Prob.	ID	Prob.				(m)	(m)	(m)	(m)
S3-1	10	0.2	D1	0.58	Dry V10	0.2	0.0232	87	48	4.3	8.3	9.6	14
S3-2	50	0.6	D1	0.58	Dry V10	0.2	0.0696	60	39	4.3	8.1	13.4	17
S3-3	90	0.2	D1	0.58	Dry V10	0.2	0.0232	53	**36**	4.5	8.6	14.9	20
S3-4	10	0.2	D1	0.58	Dry V50	0.6	0.0696	193	70	2.7	12.8	12.3	78
S3-5	50	0.6	D1	0.58	Dry V50	0.6	0.2088	193	70	1.5	14.5	16.1	90
S3-6	90	0.2	D1	0.58	Dry V50	0.6	0.0696	172	67	1.2	14.9	18.2	78
S3-7	10	0.2	D1	0.58	Dry V90	0.2	0.0232	273	78	3.7	11.8	10.8	146
S3-8	50	0.6	D1	0.58	Dry V90	0.2	0.0696	240	75	3.2	12.5	13.4	144
S3-9	90	0.2	D1	0.58	Dry V90	0.2	0.0232	227	74	2.9	13.1	15.1	145
S3-10	10	0.2	W1	0.08	Wet V10	0.2	0.0032	87	54	5.7	14.2	11.0	15
S3-11	50	0.6	W1	0.08	Wet V10	0.2	0.0096	104	60	5.1	16.5	14.8	22
S3-12	90	0.2	W1	0.08	Wet V10	0.2	0.0032	106	60	4.9	17.0	17.5	26
S3-13	10	0.2	W1	0.08	Wet V50	0.6	0.0096	117	64	7.9	10.3	9.0	38
S3-14	50	0.6	W1	0.08	Wet V50	0.6	0.0288	121	65	7.6	13.5	12.0	38
S3-15	90	0.2	W1	0.08	Wet V50	0.6	0.0096	132	68	7.4	14.7	14.0	42
S3-16	10	0.2	W1	0.08	Wet V90	0.2	0.0032	162	75	8.5	9.2	7.8	85
S3-17	50	0.6	W1	0.08	Wet V90	0.2	0.0096	157	74	8.2	10.8	10.0	80
S3-18	90	0.2	W1	0.08	Wet V90	0.2	0.0032	158	74	8.1	11.9	11.6	81
S3-19	10	0.2	W2	0.25	Wet V10	0.2	0.0100	76	49	8.5	13.7	9.9	13
S3-20	50	0.6	W2	0.25	Wet V10	0.2	0.0300	94	56	8.1	17.0	13.5	20
S3-21	90	0.2	W2	0.25	Wet V10	0.2	0.0100	118	64	8.1	17.0	14.9	24
S3-22	10	0.2	W2	0.25	Wet V50	0.6	0.0300	77	50	10.5	8.4	7.3	26
S3-23	50	0.6	W2	0.25	Wet V50	0.6	0.0900	84	52	10.3	10.0	10.1	27
S3-24	90	0.2	W2	0.25	Wet V50	0.6	0.0300	95	57	10.3	12.1	11.8	31
S3-25	10	0.2	W2	0.25	Wet V90	0.2	0.0100	100	58	10.9	6.8	6.1	55
S3-26	50	0.6	W2	0.25	Wet V90	0.2	0.0300	103	59	10.8	8.3	8.3	53
S3-27	90	0.2	W2	0.25	Wet V90	0.2	0.0100	107	61	10.7	9.5	9.6	54
S3-28	10	0.2	W3	0.08	Wet V10	0.2	0.0032	73	48	8.8	12.9	9.3	12
S3-29	50	0.6	W3	0.08	Wet V10	0.2	0.0096	106	61	8.5	17.0	12.2	19
S3-30	90	0.2	W3	0.08	Wet V10	0.2	0.0032	99	58	8.4	17.0	14.0	22
S3-31	10	0.2	W3	0.08	Wet V50	0.6	0.0096	75	49	10.5	8.3	7.2	24
S3-32	50	0.6	W3	0.08	Wet V50	0.6	0.0288	85	53	10.3	10.0	9.9	26
S3-33	90	0.2	W3	0.08	Wet V50	0.6	0.0096	94	56	10.3	12.0	11.7	30
S3-34	10	0.2	W3	0.08	Wet V90	0.2	0.0032	99	58	10.9	6.8	6.1	54
S3-35	50	0.6	W3	0.08	Wet V90	0.2	0.0096	102	59	10.7	8.3	8.2	52
S3-36	90	0.2	W3	0.08	Wet V90	0.2	0.0032	105	60	10.7	9.5	9.5	52

Note:
1. Values calculated by VISJET model.
2. Initial dilution was corrected using the background buildup concentration predicted by the far field model for year 2020 (see S4.2 and S4.3). Bolded and shaded values indicated minimum initial dilution.

Table A5-1-13 Summary of Results from VISJET Simulations for Ultimate Scenario

Run ID	Effluent Flow		Density Profile		Ambient Current Velocity		Joint Prob. of Occurrence	Initial Dilution[1]	Corrected Initial Dilution [2]	Average Plume Depth	Average Plume Thickness	Average Plume Half-Width per Riser	Downstream Distance at Edge of ZID
	ID	Prob.	ID	Prob.	ID	Prob.				(m)	(m)	(m)	(m)
S4-1	10	0.2	D1	0.58	Dry V10	0.2	0.0232	62	40	4.3	6.7	10.9	16
S4-2	50	0.6	D1	0.58	Dry V10	0.2	0.0696	55	37	4.6	5.7	15.1	22
S4-3	90	0.2	D1	0.58	Dry V10	0.2	0.0232	50	**34**	4.7	5.8	16.9	25
S4-4	10	0.2	D1	0.58	Dry V50	0.6	0.0696	213	73	2.8	14.2	13.3	96
S4-5	50	0.6	D1	0.58	Dry V50	0.6	0.2088	207	72	1.4	16.0	17.8	106
S4-6	90	0.2	D1	0.58	Dry V50	0.6	0.0696	188	70	1.0	16.7	20.3	92
S4-7	10	0.2	D1	0.58	Dry V90	0.2	0.0232	259	77	4.5	12.5	11.0	136
S4-8	50	0.6	D1	0.58	Dry V90	0.2	0.0696	245	76	3.8	13.9	14.1	146
S4-9	90	0.2	D1	0.58	Dry V90	0.2	0.0232	255	77	3.4	15.1	16.3	163
S4-10	10	0.2	W1	0.08	Wet V10	0.2	0.0032	90	50	5.5	14.9	12.1	17
S4-11	50	0.6	W1	0.08	Wet V10	0.2	0.0096	107	54	5.0	17.0	16.7	24
S4-12	90	0.2	W1	0.08	Wet V10	0.2	0.0032	89	49	4.7	17.0	19.5	28
S4-13	10	0.2	W1	0.08	Wet V50	0.6	0.0096	118	57	7.8	11.3	9.9	38
S4-14	50	0.6	W1	0.08	Wet V50	0.6	0.0288	129	59	7.5	14.5	13.4	41
S4-15	90	0.2	W1	0.08	Wet V50	0.6	0.0096	141	62	7.3	16.3	15.5	44
S4-16	10	0.2	W1	0.08	Wet V90	0.2	0.0032	147	63	8.4	9.6	8.8	73
S4-17	50	0.6	W1	0.08	Wet V90	0.2	0.0096	157	65	8.1	11.5	11.1	80
S4-18	90	0.2	W1	0.08	Wet V90	0.2	0.0032	164	66	8.0	12.8	13.0	81
S4-19	10	0.2	W2	0.25	Wet V10	0.2	0.0100	85	48	8.2	15.1	11.1	14
S4-20	50	0.6	W2	0.25	Wet V10	0.2	0.0300	120	57	7.9	17.0	14.5	22
S4-21	90	0.2	W2	0.25	Wet V10	0.2	0.0100	79	46	7.9	17.0	16.6	26
S4-22	10	0.2	W2	0.25	Wet V50	0.6	0.0300	81	47	10.2	9.4	8.3	26
S4-23	50	0.6	W2	0.25	Wet V50	0.6	0.0900	95	51	10.1	11.8	11.6	30
S4-24	90	0.2	W2	0.25	Wet V50	0.6	0.0300	104	53	10.0	12.8	13.5	34
S4-25	10	0.2	W2	0.25	Wet V90	0.2	0.0100	104	54	10.7	7.4	6.9	56
S4-26	50	0.6	W2	0.25	Wet V90	0.2	0.0300	109	55	10.6	9.4	9.4	55
S4-27	90	0.2	W2	0.25	Wet V90	0.2	0.0100	136	61	10.5	10.3	11.0	55
S4-28	10	0.2	W3	0.08	Wet V10	0.2	0.0032	85	48	8.7	15.4	10.4	14
S4-29	50	0.6	W3	0.08	Wet V10	0.2	0.0096	121	57	8.4	17.0	13.5	20
S4-30	90	0.2	W3	0.08	Wet V10	0.2	0.0032	117	57	8.4	17.0	15.3	24
S4-31	10	0.2	W3	0.08	Wet V50	0.6	0.0096	76	45	10.4	9.0	8.1	23
S4-32	50	0.6	W3	0.08	Wet V50	0.6	0.0288	91	50	10.3	11.5	11.2	28
S4-33	90	0.2	W3	0.08	Wet V50	0.6	0.0096	98	52	10.5	12.5	13.2	31
S4-34	10	0.2	W3	0.08	Wet V90	0.2	0.0032	99	52	10.8	7.3	6.8	53
S4-35	50	0.6	W3	0.08	Wet V90	0.2	0.0096	104	53	10.7	9.1	9.1	51
S4-36	90	0.2	W3	0.08	Wet V90	0.2	0.0032	109	55	10.6	10.4	10.7	53

Note:
1. Values calculated by VISJET model.
2. Initial dilution was corrected using the background buildup concentration predicted by the far field model for the ultimate year (see S4.2 and S4.3). Bolded and shaded values indicated minimum initial dilution.

4.4 It is noted that all the predicted minimum dilution rates occurred in the dry season under the 90%ile effluent flow (Q90) with the smallest ambient current (V10). **Table A5-1-14** summarizes the initial dilution factors.

Table A5-1-14 Summary of VISJET Initial Dilution Factors

	Ultimate Year	2020	2013	2009
Minimum	34	36	48	47
5%ile	39	46	50	49
10%ile	46	49	53	53

Input to the Far Field Model

4.5 The near field modeling results were used to determine the appropriate vertical and horizontal grid cell(s) into which the Project discharge would be allocated into the far field 3D model. Under each of the four assessment years, two weighted averages of the plume depth were calculated for wet (W1, W2 and W3) and dry seasons (D1) respectively based on their joint probabilities of occurrence as shown in **Table A5-1-5**. Two weighted averages of the plume thicknesses were also calculated for wet (W1, W2 and W3) and dry seasons (D1) respectively. The weighted average plume depths and plume thicknesses for dry and wet seasons were used to determine the appropriate vertical grid cell(s) into which the Project discharge would be allocated.

4.6 The number of horizontal grid cell(s) of the far field model to be used for loading input was based on the average dimensions of the ZID. Under each of the four assessment years, the average of all the downstream distances predicted amongst the 36 model runs was used as the average width of the ZID. The average of all the plume width results predicted amongst the 36 model runs was used for calculating the average length of the ZID. It is assumed that the ZID would be the same in dry and wet seasons for far field modelling. **Table A5-1-15** illustrates the calculation.

Table A5-1-15 Summary of Results for Far Field Model

Scenario	Weighted Average Plume Depth (m below surface)	Weighted Average Plume Thickness (m)	Average Half Plume Width (m)	Average Downstream Distance (m)	Average Dimension of ZID (m)
2009	Dry: 2.8	Dry: 11.6	10	48	1220 ii x 96 iii
	Wet: 9.8	Wet: 9.4			
2013	Dry: 3.0	Dry: 11.9	10	48	1220 ii x 96 iii
	Wet: 9.6	Wet: 10.0			
2020	Dry: 2.5	Dry: 12.7	12	49	1224 ii x 98 iii
	Wet: 9.5	Wet: 11.4			
Ultimate	Dry: 2.6	Dry: 13.4	13	51	1226 ii x 102 iii
	Wet: 9.3	Wet: 12.4			

Notes:
i. Total joint probabilities of occurrence for dry season is based on the density profile “D1” and for wet season, “W1 to W3”
ii. Length of ZID = 1200 (diffuser length) + average half plume width x 2
iii. Width of ZID = average downstream distance x 2

4.7 Based on the predicted dimension of ZID, pollution loading from the Project discharge would be evenly distributed to 6 grid cells of the water quality model along the alignment of the diffuser for all the modelling scenarios. The vertical allocation of pollution load would be based on the average plume depth and average plume thickness. Given that the HATS model is a 3 dimensional model which consists of 10 evenly distributed vertical layers and the total water depth assumed in the VISJET modelling was 17 m, the pollution loads for dry season were specified in the first to fifth layer from the surface for 2009 and first to sixth layer for the remaining scenarios whilst for the wet season, the pollution loads were allocated in the fourth to ninth layer from the surface for 2009, and third to ninth layer for 2013 and 2020; and second to tenth layer from the surface for the ultimate scenario.