APPENDIX 7.4 METHODOLOGY FOR CUMULATIVE ECOLOGICAL RISK IMPACT ASSESSMENTS

Assessment Approach

1.1 The assessment approach for the cumulative risk impact was same as the one for the Ecological Risk Assessment (ERA) for the chlorination by-products (CBPs), which has been discussed in **Appendix 7.1**.

Problem Formulation

1.2 The objective, scope, Site Conceptual Model and assessment endpoints of the cumulative risk impact assessment are same to those for ERA, which have been presented in **Section 7** and **Appendix 7.1**.

1.3 The cumulative risk impact assessment focused on assessing the potential risks/impacts to ecological resources due to chronic exposure to the CBPs and other pollutants present in the HATS effluent discharge.

Identification of COPC and Selection of COC

Identification of COPC

1.4 A comprehensive chemical analysis was conducted under the HATS EEFS Ecological and Health Risk Assessment (2004) to determine the pollutant concentrations in HATS CEPT effluent (Stage 1 and Stage 2A) and CEPT plus Biological Aerated Filters (BAF) effluent (Stage 2B). One hundred of analytes including metals, inorganic pollutants, organic pollutants, pesticides and organo-metallics were identified as COPC and analyzed.

Selection of COC

1.5 A number of selection rules were established in HATS EEFS Ecological and Health Risk Assessment (2004) for selection of COCs and determination of COC effluent concentrations for risk assessments. COCs selected for Project Scenarios 1 to 3 and Scenario 4 for cumulative risk impact assessment are presented in **Tables 1** and **2** respectively.

Table 1 Results of COCs Selection for Scenarios 1 to 3

	Selected as COC for				
COPC	**ERA – Aquatic Life**	**ERA – Marine Mammals**	**Max. Conc. in CEPT Effluent (µg/L)***	**Max. Conc. in Ambient Seawater (µg/L)***	**Note**
Aluminium	Yes	Yes	15.9	15.6	
Antimony	Yes	Yes	0.721	0.258	
Arsenic			1.2	1.36	
Barium	Yes	Yes	23.2	6.65	
Chromium III	Yes	Yes	9.58	0.28	
Copper	Yes	Yes	8.59	0.02	
Lead	Yes	Yes	0.128	0.055	
Mercury			9.58ng/L	0.06ng/L	A
Nickel	Yes	Yes	26.2	0.77	
Selenium	Yes	Yes	0.31	0.07	
Silver	Yes	Yes	0.182	0.006	
Tin	Yes	Yes	0.844	0.14	
Vanadium	Yes	Yes	29.5	1.73	
Zinc	Yes	Yes	14.1	2.37	
Ammonia	Yes	Yes	22,000	230	
Sulphide	Yes	Yes	4,900	48	
TCDD (I-TEQ)	Yes	Yes	0.1pg/L	0.039pg/L	
Toluene	Yes	Yes	12	<1	
Diazinon	Yes	Yes	0.048	<0.01	
Malathion	Yes	Yes	0.031	<0.01	

Note: * Dissolved concentration of metal for ecological risk assessment
A) Rinsate blank of dissolved mercury is greater than 20% of sample value

Table 2 Results of COCs Selection for Scenario 4

	Selected as COC for				
COPC	**ERA – Aquatic Life**	**ERA – Marine Mammals**	**Max. Conc. in secondary treated Effluent (µg/L)***	**Max. Conc. in Ambient Seawater (µg/L)***	**Note**
Aluminium			6.7	15.6	
Antimony	Yes	Yes	0.782	0.258	
Arsenic			1.0	1.36	
Barium	Yes	Yes	23.7	6.65	
Chromium III	Yes	Yes	8.44	0.28	
Copper	Yes	Yes	6.63	0.02	
Lead			0.055	0.055	
Mercury			1.61ng/L	0.06ng/L	A
Nickel	Yes	Yes	22.3	0.77	
Selenium	Yes	Yes	0.13	0.07	
Silver	Yes	Yes	0.099	0.006	
Tin	Yes	Yes	0.457	0.14	
Vanadium	Yes	Yes	31.3	1.73	
Zinc	Yes	Yes	9.79	2.37	
Ammonia	Yes	Yes	4,200	230	
Sulphide	Yes	Yes	53	48	
TCDD (I-TEQ)	Yes	Yes	0.062pg/L	0.039pg/L	
Toluene			<1	<1	
Diazinon	Yes	Yes	0.058	<0.01	
Malathion	Yes	Yes	0.015	<0.01	

Note: * Dissolved concentration of metal for ecological risk assessment
A) Rinsate blank of total and dissolved mercury is greater than 20% of sample value

Exposure Assessment

Ecological Risk Assessment – Aquatic Life

1.6 The exposure assessment is same to the one for ERA – Aquatic Life for CBPs.

1.7 **Table 3** summarized the averaging time of different TRVs and the corresponding dilution factor for COC concentration calculation.

Table 3 Averaging Time of TRVs and Corresponding Dilution Factor

TRV Averaging Time	**Dilution Factor at Edge of ZID**	**Dilution Factor at Edge of Mixing Zone**
Daily	Minimum dilution factor in dry and wet season	Minimum dilution factor in dry and wet season
4-day	Minimum dilution factor in dry and wet season[a]	Minimum 4-day dilution factor in dry and wet season
Annual	Annual weighted average dilution factor	Annual weighted average dilution factor
"To be complied at least 90% of occasions"	10 %tile dilution factor in dry and wet season[b]	10 %tile dilution factor in dry and wet season[b]
Seasonal[c]	The lower value of weight average dilution factor estimated for dry season and that of wet season	The lower value of weight average dilution factor estimated for dry season and that of wet season

Note: [a] Minimum dilution factor was adopted as a conservative estimate
[b] Dilution factor exceeded 90% of the time (i.e. 10% of values are below this value)
[c] For COC without water quality standard/criteria, which TRV was derived from toxicity data

Ecological Risk Assessment – Marine Mammals

1.8 The exposure assessment is same to the one for ERA – Marine Mammals for CBPs

1.9 Bioconcentration factor and food chain multiplier for COCs were presented in **Table 4**.

Table 4 Bioconcentration Factor and FCM

COC	Water-to-fish Bioconcentration Factor[a]	Trophic Level 4 FCM[b]	Water-to-aquatic invertebrates Bioconcentration Factor	Trophic Level 3 FCM[b]
Aluminum	2.7	1.0	0.13[c]	1.0
Antimony	40	1.0	7[d]	1.0
Barium	633	1.0	200[d]	1.0
Chromium (III)	19	1.0	0.11[c]	1.0
Copper	710	1.0	3,718[d]	1.0
Lead	0.09	1.0	5,059[d]	1.0
Nickel	78	1.0	28[d]	1.0
Selenium	129	1.0	1,262[d]	1.0
Silver	87.7	1.0	298[d]	1.0
Tin	138	1.0	138[e]	1.0
Vanadium	N/A	-	N/A	-
Zinc	2,060	1.0	4,758[d]	1.0
Ammonia	N/A	-	N/A	-
Sulphide	N/A	-	N/A	-
Dioxins and furans (TEQ)	34,400	27	1,560[d]	14
Toluene	171	1.0	11.6[c]	1.0
Diazinon	171	1.0	94.3[c]	1.2
Malathion	13.1	1.0	6.12[c]	1.0

N/A: Not Available

Note: [a] Also refer to Table 3 of Appendix 6II.3.

[b] The FCMs were developed using K_{ow} values reported in USEPA (1995), as in USEPA (1999b).

[c] No recommended BCF value identified. Regression equation was used to calculate the BCF values (Southworth *et al.* (1978), as in USEPA (1999b)).

[d] Recommended BCF value in USEPA (1999b).

[e] MW (1998).

Ecological Effects Characterization (for ERA – Aquatic Life)

1.10 The ecological effects of COC exposure to aquatic life were characterized by comparing the COC concentrations in the seawater at the edge of the ZID and the edge of the mixing zone to the TRV for aquatic life. TRVs for COCs were derived from water quality criteria/standards for protection of aquatic life when available; for COCs without such criteria/standards, toxicity values obtained from the scientific literature were used to derive TRVs. Details on the TRV derivation process were presented in **Annex B**; derived TRVs for risk calculations were presented in **Table 5**.

Table 5 Derived TRVs for Aquatic Life

COC	TRV for ecological resources (µg/L)	Averaging Time
Aluminium	1500	Annual average
Antimony	4300	Annual average
Barium	5000	Seasonal average
Chromium III	27.4	Annual average
Copper	5	Not to exceed at 10% of occasions
Lead	8.1	4-day average
Nickel	5	Not to exceed at 10% of occasions
Selenium	71	4-day average
Silver	1.4	Annual average
Tin	81.6	Seasonal average
Vanadium	100	Annual average
Zinc	20	Not to exceed at 10% of occasions
Ammonia	910	Annual average
Sulphide	100	Seasonal average
TCDD	0.000038	Seasonal average
Toluene	40	Annual average
Diazinon	0.01	Annual average
Malathion	0.02	Annual average

[a] No recommended UF factor to convert subchronic lethal level to chronic NOEC; the adopted UF of 0.01 was considered to be conservative.

Ecological Effects Characterization (for ERA – Marine Mammals)

1.11 The ecological effects of COC exposure to marine mammals were characterized by comparing the COC daily dose to the toxicity reference doses for the marine mammals, which were derived by reviewing the toxicological effects data from various scientific literature, database and guidelines. Details on the toxicity reference dose derivation process were presented in **Annex C**; derived toxicity reference dose for risk calculations were presented in **Table 6**.

Table 6 Derived Toxicity Reference Dose for Marine Mammals

COC	Toxicity Reference Dose Derived (mg/kg/d)
Aluminum	6.125
Antimony	0.015625
Barium	1.875
Chromium (III)	342.125
Copper	1.5
Lead	1
Nickel	5
Selenium	0.02625
Silver	2.7775
Tin	2.925
Vanadium	0.02625
Zinc	20
Ammonia	5.15
Sulphide	No toxicological data available
Dioxins and furans (TEQ)	8.875E-6
Toluene	3.25
Diazinon	1.5
Malathion	4.4875

Risk/Hazard Characterization

1.12 The risk/hazard characterization for the cumulative risk impact was same as the risk assessments for the CBPs.

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