CB(1) 2318/03-04(05)

Follow-up actions arising from the 28 June 2004 EA Panel Meeting :

Item 1 **To consider extending the consultation period for the Consultation Document for the HATS Stage 2 to end 2004**

Government Response: Having considered Members' view, we agreed to extend the consultation period for HATS Stage 2 from 20 October to 20 November 2004.

Item 2 **To provide a quantitative analysis on the effect of ferric chloride used in the Chemically Enhanced Primary Treatment (CEPT) on the water quality of the harbour.**

Government Response : Iron is one of the most abundant metals in Earth crust. Its presence in natural fresh waters can range from 0.5 to 50 mg/L. Data collected in 2003 indicate that the iron content of the CEPT effluent was between 0.4 – 0.8 mg/L and the addition of ferric chloride (i.e. Iron (III) chloride) did not result in any increase in the iron content of the treated effluent when compared with that of the raw sewage. This is due to the very effective operation of the plant which fully utilizes the chemical dosed.

The chloride content of the effluent is high due to the use of sea water for flushing. Thus, adding ferric chloride to the sewage for coagulation purpose does not alter the chloride content of the effluent in any material manner.

Item 3 **To advise how the problem of chlorination will be dealt with if chlorine is used as a disinfectant for CEPT treated flow.**

Government Response: The key concern with chlorination on the environment is the toxicity generated by the total residual chlorine (TRC), which includes the free chlorine and chloramines. To deal with this concern, we have included dechlorination in the design. By the addition of sodium bisulphite, TRC in the CEPT effluent can be completely removed. Our assessment is that the TRC criteria established by the United States Environmental Protection Agency (USEPA) can be met at the initial dilution zone of the HATS discharge.

The other concern with chlorination is the formation of chlorinated organic compounds, mainly the trihalomethanes (THM) and haloacetic acids (HAA). Our trials indicated that the level of THM and HAA after chlorination would be around 0.1 mg/L, which is comparable with the WHO drinking water guideline of 0.06 – 0.2 mg/L for THM and 0.05 – 0.1 mg/L for HAA. Moreover, neither THM nor HAA would result in bioaccumulation through the food chain. Hence, there should not be any potential environmental impact arising from chlorination. The detailed analysis can be found in the **Annex**.

Overall, we do not consider that the use of a chlorination / dechlorination system for disinfecting treated effluent will cause any unacceptable environmental problems. In fact, there are over 500 such disinfection installations in the US and chlorination is regarded as an effective disinfection methodology by the USEPA for treating drinking water, treated effluent and reclaimed waters.

Item 4 **To seek the views of the three local members of the former IRP on the findings of the trials and studies relating to the HATS Stage 2**

Government Response: The three local members of the former IRP were in fact members of the HATS Monitoring Group. Moreover, the Government’s recommendations on the way forward for HATS Stage 2 have been consistent with the recommendations of the IRP and have received the endorsement of the Monitoring Group in principle.

Item 5 **To advise the design parameters, including the changes in population and commercial activities, adopted in the planning of HATS Stage 2**

Government Response: As HATS Stage 2 is a very complex project involving different components such as deep tunnels and sewage treatment works, it involves a large number of design parameters concerning flows, hydraulics, treatment processes, material storage, etc. Details of such parameters can be found in the Final Report and the Technical Note No.18 of the Environmental and Engineering Feasibility Study, both of which are available at the website http://www.cleanharbour.gov.hk/.

Turning to the specific questions of Members, the key design parameters related to populations are highlighted below :

Population :
6.27 million (residential)
3.85 million (employment)

Average daily flow :
2.8 million m^3/d

We plan the HATS Stage 2 facilities with a clear objective to cater for the long-term population growth and development needs on both sides of the harbour. The population projections were specifically prepared by the Planning Department for the HATS project. They reflect the “full development” situation in the HATS catchment areas at an unspecified time after the year 2016. “Full development” refers to a scenario whereby the HATS catchments are assumed to accommodate the highest population allowed under the current planning standards and guidelines. As at Year 2000, the residential population and employment population within the HATS catchments were about 4.46 million and 2.55 million respectively. The ultimate population scenario assumed for HATS Stage 2 under the “full development” situation will result in a residential population of 6.27 million and an employment population of 3.85 million. As the HATS catchments are already fairly well-developed, we do not envisage that there would be any further drastic increase in population beyond the full development scenario. That said, we will review the projections from time to time to make sure that they remain realistic in the years to come.

<u>**Annex**</u>

Exerpt on Chlorination Disinfection

Assessment of the Water Quality Implications of Phased Implementation of HATS Stage 2

6 Water Quality Impact associated with Chlorine Disinfection

6.1 Environmental Implications

Provision of disinfection to treated sewage before discharge can substantially reduce the pathogen levels in the receiving waters, thus minimizing the health risks to humans and marine mammals from sewage-borne infection. Chlorine is an effective disinfectant for reducing pathogen levels in treated sewage. However, there are concerns with chlorination, which are largely related to formation and toxicity of total residual chlorine (TRC), and chlorination by-products (CBPs) formed by reactions between chlorine and other substances present in the effluent. TRC includes free residual chlorine of undissociated and dissociated hypochlorite when chlorine is dissolved in water, plus combined residual chlorine of chloramines formed by reacting with ammonia. “CBPs” refer to chlorinated organic compounds (or total organic halogen) formed by the action of chlorine on the total organic carbon fraction of wastewater. The two largest identified fractions of CBPs mostly formed by chlorination are trihalomethanes (THM) and haloacetic acids (HAA) (EPD, 2000).

TRC is recognized as being highly toxic to aquatic life. Much attention on chlorinated wastewater has focused on TRC toxicity. Environment Canada (CEPA, 2003) specified that the proposed risk management objective for controlling inorganic chloramines and chlorinated wastewater effluents from existing discharges with sewage flow not less than 5,000 m^3/day during 2004 is to achieve and maintain a TRC concentration at not more than 0.02 mg/L in the effluent released to surface water. The US Environmental Protection Agency (USEPA, 1986) established national water quality criteria for TRC of 0.0075 mg/L as a four-day average and 0.013 mg/L as a one-hour average for saltwater species. In the EEFS, water quality criteria of 0.013 mg/L and 0.008 mg/L as daily maxima at the edge of the initial dilution zone and at the edge of mixing zone respectively were established for TRC as two of the assessment criteria for the HATS discharges (CDM, 2002).

CBPs, on the other hand, are generally considered of concern to human health. THMs are suspected as being carcinogens and are strictly monitored in drinking water (USEPA, 1999). The Stage 1 Disinfectants/Disinfection Byproducts Rule published by the USEPA regulates the total THM[1] and HAA[2] at a maximum allowable annual average level of 0.08 mg/L and 0.06 mg/L respectively for drinking water when chlorine is added as a disinfectant in water treatment process (USEPA, 1998). The drinking water guidelines in Australia (NHMRC, 1996), based on health considerations, establish guideline values of 0.25 mg/L for THM, and 0.1 to 0.15 mg/L for individual HAA. Human health ambient water quality criteria of individual THM are also developed by the USEPA to protect human health. The range of criteria for protection of human health from consumption of organisms is 0.013 to 0.47 mg/L (USEPA, 2002). The USEPA is currently reviewing the human health ambient water quality criteria for chloroform and the

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[1] THM includes chloroform, bromodichloromethane, dibromochloromethane, and bromoform.

[2] HAA includes monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid, and dibromoacetic acid.

proposed criterion for consumption of organism only is 2.4 mg/L versus the current criterion of 0.47 mg/L (USEPA, 2003).

Dechlorination is commonly applied after chlorine disinfection to minimize the toxic effects of TRC. The mechanism is to add dechlorination agents such as sodium bisulphite[3] to the chlorinated effluent so as to convert any TRC in the effluent to the stable chloride form. The conversion process is almost instantaneous once the dechlorination agent is added. A literature review (EPD, 2000) has concluded that most dechlorination agents would not induce toxicity in the effluent. The major concern with dechlorination is to avoid significant overdosing of sulphite because excess sulphite can react with dissolved oxygen in the wastewater to produce sulphates. This may lead to reduced DO and low pH levels in the effluent (USEPA, 2000).

6.2 Toxicity of Residual Chlorine

TRC in wastewater effluents is usually the main toxicant suppressing the diversity, size and quantity of fish in streams receiving chlorinated secondary effluent (Paller et al., 1983). A local study using four marine organisms from three different trophic levels found the LC_{50}/IC_{50}[4] values for chlorine toxicity to range from 0.027 to 1.8 mg/L. NOEC values ranged from 0.02 to 1.21 mg/L. Overseas data shows the LC_{50} of marine fish generally ranges from 0.025 to 2.5 mg/L (CEST, 2000). In the SSDS EIA Study (EPD, 2000), aquatic toxicity data for chloramines, THM and HAA obtained from the USEPA AQUIRE database and Aquatic Sciences and Water Resources Abstracts was reviewed. The EC_{50}/LC_{50} values of chloramines ranged from 0.06 to 1 mg/L. The chloramines are seen to have aquatic toxicity levels of the same order of magnitude as residual chlorine.

Humans are more tolerant to TRC. Residual chlorine levels in drinking water systems may be of the order of 1 mg/L in order to maintain an effective disinfectant residual within the distribution system. The USEPA's drinking water standard for chlorine is 4 mg/L (USEPA, 1998). In Australia (NHMRC, 1996), the guideline value for chlorine in drinking water is 5 mg/L.

6.3 Toxicity of Chlorination By Products

Available toxicity data shows that THM and HAA are less toxic to aquatic life than chloramines (EPD, 2000), and thus less toxic than TRC. As reviewed by the SSDS EIA Study (EPD, 2000), the EC_{50}/LC_{50} values[5] for THM and HAA were from 7.1 to 758 mg/L and 0.22 to 9,300 mg/L respectively. The bioaccumulation data[6] are shown below.

CBPs		Bioaccumulative Potential[7]
THM	Chloroform	log K_{ow}: 1.97
	Bromoform	log K_{ow}: 2.37
	Bromodichloromethane	nd
	Dibromochloromethane	log K_{ow}: 2.24

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[3] Sodium bisulphite is a sulphite salt commonly used in dechlorination.

[4] LC_{50}, IC_{50}, EC_{50} and NOEC are toxicity endpoints used in the quantification of an observed toxicity effect e.g. lethal effect, inhibition of growth and mobility, no observed effects, etc.

[5] Please refer to Table A2.7.10, SSDS EIA Study Final Report.

[6] From the latest online Chemical Database Management System, Chemwatch Package, CD 2004/1

[7] The bioaccumulative potential of an organic chemical reflects the tendency of a chemical to be taken up and retained by an aquatic organism, both from water and through food, which then results in higher concentration of that chemical in an organism than in its environment. Log K_{ow} is a common term to classify chemicals as bioaccumulative.

CBPs		Bioaccumulative Potential[7]
HAA	Dibromoacetic acid	nd
	Dichloroacetic acid	log K_{ow}: -0.14-1.39
	Monobromoacetic acid	nd
	Monochloroacetic acid	log K_{ow}: 0.22
	Trichloroacetic acid	log K_{ow}: 0.1 to 1.96

Note: nd = no data
K_{ow} = octanol/water partition coefficient – the ratio of a chemical's solubility in *n*-octanol and water at equilibrium.

In Canada[8], chemicals with log $K_{ow} \geq 5$ are defined as bioaccumulative. Available bioaccumulative data given in the table above show the reported log K_{ow} are less than 3, which implies the CBPs are unlikely to be bioaccumulated by the aquatic organisms and biomagnified along the food chain.

The toxicity of CBPs to humans may generally be assessed against the established drinking water standards and guidelines. The following table presents a summary of the information reviewed previously (EPD, 2000).

CBP Class	Acute Short-Term Health Advisories (mg/L)		USEPA Drinking Water Limits (mg/L)		WHO Drinking Guidelines (mg/L)	ADWG (mg/L)
	ADWG	EPA	MCL (MRDL)	MCLG (MRDLG)		
Chloramines	N/AV	1	(4)	(4)	N/AV	3
THM	1	2 to 6	0.08*	0 to 0.06	0.06 to 0.2	0.25
HAA	N/AV	1 to 4	0.06**	0 to 0.3	0.05 to 0.1	0.1 to 0.15

Note: Range of values given if source provided data for >1 chemical in a class
ADWG = Australian Drinking Water Guidelines 1996, National Health and Medical Research Council
EPA = USEPA 10-day Health Advisory for a 10 kg Child from: Drinking Water Regulations and Health Advisories, October 1996
MCL/MRDL = Maximum Contaminant Level / Maximum Residual Disinfectant Level under Stage 1 Disinfectants/Disinfection Byproducts Rule, issued by USEPA in 1998. MCLs are enforceable standards
MCLG/MRDLG = Maximum Contaminant Level Goal / Maximum Residual Disinfectant Level Goal under Stage 1 Disinfectants/Disinfection Byproducts Rule, issued by USEPA in 1998 and revised in May 2000. MCLGs allow for a margin of safety and are non-enforceable public health goals
WHO = World Health Organization, Guidelines for Drinking Water Quality, Health Criteria and Supporting Information, 1996
Chloramines (as Cl_2) are considered as disinfectants used to control microbes
N/AV = Not available
* Value is for total THM
** Value is for total HAA

6.4 Toxicity of Dechlorination Agent

Dechlorination is typically accomplished by sulfonation (i.e. adding sulphur dioxide or sulphite salts) (USEPA, 2000). Sodium bisulphite is adopted as the dechlorination agent in the schematic design and engineering perspective detailed in another report on the Phased Implementation of HATS[9]. The bisulphite available in the market consists chiefly of sodium metabisulphite, which for all practical purposes possesses the same properties as true bisulphite. Available toxicity data on aquatic life retrieved from the USEPA's[10] on-line Ecotoxicology Database (ECOTOX) shows

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[8] An online reference: http://www/ec/gc.ca/toxics/TSMP/en/criteria.cfm
[9] EEFS Technical Note No. 18 prepared by CDM International Inc.
[10] An on-line reference: http://www.epa.gov/ecotox

the EC_{50}/LC_{50} values of sodium bisulphite range from 59 to 241 mg/L; whereas the log K_{ow} value for sodium metabisulphite is –3.7, implying that the risk of bioaccumulation in aquatic species is low (Chemwatch, 2004).

Human toxicity information obtained from the on-line Hazardous Substances Databank (HSDB)[11] indicates low direct toxicity for this chemical. Ingestion by humans of 4 to 5.8 g/day will likely cause abdominal pain whereas ingestion of 1 g/day appears to be well tolerated. Ingestion of 10 mg bisulphite/Kg/day for 25 days by healthy volunteers failed to elicit any change in neurophysiologic, biochemical, or clinical chemistry parameters. There is inadequate evidence for the carcinogenicity in humans of sulphur dioxide, sulphites, bisulphites and metabisulfites and the USEPA has not developed any human toxicological indices for these chemicals.

6.5 Projected Effluent Quality for Risk Assessment

6.5.1 Results from SSDS EIA Study

Due to different reaction kinetics, the reactions between chlorine (provided by hypochlorite) and ammonia present in the wastewater, to form chloramines, are faster than those resulting in formation of CBPs, making chloramines dominate over CBPs in terms of concentration in chlorinated wastewater effluents. The SSDS EIA Study (EPD, 2000) reported that with chlorine dosage of 17-22 mg/L and ammonia nitrogen (NH_3-N) concentration of 15 to 25 mg/L[12] in the CEPT effluent, chloramines, rather than free chlorine would be the main component for chlorination. Approximately 1% of the chlorine dose is expected to form CBPs for primary and secondary treated effluent. Thus CBPs would likely be in the range of 0.17 to 0.22 mg/L in the effluent.

6.5.2 Results from DSD's pilot trial in June 2000

The Drainage Services Department (DSD) conducted a pilot trial in June 2000 to evaluate different dosing methods: "Multi Point Dosing" (MPD) and "Single Point Dosing" (SPD) for the purpose of optimizing chlorine doses in the disinfection process.

The trial showed that for CEPT effluent samples treated with 25 mg/L sodium hypochlorite, the concentrations of total THMs were 66 and 96 µg/L respectively for MPD and SPD. For CEPT effluent samples treated with 20 mg/L of sodium hypochlorite, the concentration of THMs formed were 35 and 36 µg/L for MPD and SPD respectively. This implies that the THMs formed are equivalent to around 0.3% of the chlorine dosed.

6.5.3 Results from SSDS Stage II Preliminary Project Feasibility Study

Disinfection trials were conducted with a chlorine dose of 15 mg/L and a contact time of 60 minutes on CEPT effluent within the HATS catchment (EPD, 2001). The results showed the concentration of the HAA for chlorinated wastewater was in the range of 60 to 90 µg/L, equivalent to around 0.4 to 0.6 % of the chlorine dosed. The predominant HAA formed was dichloroacetic acid which was typically in the range of 30 to 60 µg/L. Next was trichloroacetic acid with the concentration ranging from 13 to 25 µg/L. Other HAAs were of minute quantities. While the data was collected before full commissioning of Stage 1 in 2001, it provides some indications from the

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[11] A database of the National Library of Medicine's TOXNET system (http://toxnet.nlm.nih.gov)

[12] CEPT is not effective in removing ammonia present in sewage. The ammonia concentration in the effluent is largely the same as in the incoming sewage.

local perspective concerning CBP formation in CEPT effluent disinfected by chlorine, and serves to reaffirm the estimate in the SSDS EIA (EPD, 2000) that approximately 1% of the chlorine dose is expected to form CBPs.

6.5.4 Results from DSD's study in 2002

In 2002 DSD conducted a bench scale chlorination study (DSD, 2003) to evaluate the TRC levels and *E.coli* reduction rates under different chlorine doses and contact times for CEPT effluent from the SCISTW.

Chlorine doses were aimed at achieving a three-log *E.coli* reduction[13] (i.e. the amount of *E.coli* remaining after the disinfection process would be around 1.0E+4 counts per 100mL). With chlorine doses from 10 to 20 mg/L and a contact time of 20 minutes, the TRC remaining in the effluent was found to range from less than 0.1 mg/L[14] to 7.3 mg/L[15].

6.5.5 Design Criteria proposed by the EEFS Consultant

The chlorination design criteria for the phased facilities at SCISTW proposed by the EEFS consultant are as follows:

(i) Chemical used: Sodium hypochlorite solution to be generated thro on-site electrolysis of seawater, and Sodium bisulphite;
(ii) Design concentration of chemicals: Sodium hypochlorite 0.2%, Sodium bisulphite 38%;
(iii) Range of design doses: Sodium hypochlorite 10 - 20 mg/L, Sodium bisulphite 2 - 4 mg/l;
(iv) Peaking factors used: 1.5 (process);
(v) Design contact time: 20 minutes at peak process design flow (1.5x2.8 million m^3/d);
(vi) *E.coli* concentration in the effluent: 20,000 counts/100ml as geometric mean and 300,000 counts/100mL as 95 percentile;
(vii) TRC concentration in effluent: 0.2 mg/L as 95 percentile and 0.4 mg/L as a maximum;
(viii) NH_3-N concentration in CEPT effluent: 18 mg/L assumed in the water quality modeling.

6.5.6 Estimated Effluent Concentration used in Risk Assessment

Based on the results of studies reviewed in the above sections, the effluent concentrations of TRC, CBPs (i.e. THM and HAA) and sodium bisulphite are estimated as follows:

Chemical or Class	Effluent concentration at the point of discharge (mg/L)
TRC[a]	0.1 – 7.3
CBPs[b]	0.2

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[13] Modeling results indicates that, at this level of *E.coli* reduction, the SCISTW effluent's impact on the Tsuen Wan beaches is likely to be insignificant.

[14] The test was conducted on 26 Sept 2002. The chlorine dose and contact time were 16mg/L and 20 minutes respectively.

[15] The test was conducted on 8 Oct 2002. The chlorine dose and contact time were 20mg/L and 20 minutes respectively.

Sodium bisulphite[c]	4

Note: a. The concentrations assume no dechlorination, and are based on DSD's trial data mentioned in Section 6.5.3 taking a conservative approach. The numerical data in fact represent TRC which contains chloramines plus free residual chlorine.

b. It is assumed that 1% of the chlorine dose of 20 $mgCl_2$/L is consumed in the production of CBPs (e.g., THM and HAA).

c. It is conservatively assumed that the dechlorination chemical is not consumed. The assumed numerical value is the same as the EEFS consultant's maximum design dose.

6.6 Aquatic Life Impacts

To protect aquatic life from the adverse toxic effects of TRC, the EEFS has established criteria stating the concentration should not exceed 0.013 mg/L at the edge of the initial dilution zone and 0.008 mg/L at the edge of the mixing zone.

While there are no established criteria for the ecological assessment of CBPs and dechlorination agent, the aquatic toxicity data for THM/HAA and sodium bisulphite reported in Sections 6.3 and 6.4 respectively are used to semi-quantitatively evaluate the potential aquatic life risks. In general, a concentration level (i.e. a level of concern) based on the lowest aquatic toxicity data (i.e. the most toxic end-point) and a safety factor of 100 to build in conservatism for unquantified uncertainty in the effect and exposure estimates or measurements should afford adequate protection to aquatic life.

6.6.1 Discharge at SCISTW

6.6.1.1 Likely impacts caused by TRC

From the near-field modeling results obtained in the EEFS, the estimated minimum initial dilution at the edge of the zone of initial dilution (ZID) for the SCI outfall is at 34.3:1. In order not to exceed the criterion of 0.013 mg/L, the effluent concentration of TRC in the treated sewage should not be greater than 0.44 mg/L[16] (i.e. 0.013 mg/L x 34.3).

The TRC concentration also needs to comply with the criterion of 0.008 mg/L at the edge of mixing zone. The edge of the mixing zone is interpreted to be at the nearest sensitive receiver, namely the Ma Wan Fish Culture Zone. Based on model predictions in the EEFS, the minimum dilution between the point of discharge and the marine fish culture zone at Ma Wan is at least 100:1. Therefore if the treated sewage contains TRC concentration of 0.44 mg/L and discharges at the SCI outfall, the concentration at the edge of the mixing zone would be 0.0044 mg/L, substantially below the 0.008 mg/L criterion.

If the TRC concentration in the treated sewage without dechlorination exceeds the maximum allowable effluent concentration of around 0.4 mg/L, the risks of TRC to aquatic life would extend beyond the ZID. Dechlorination can, on the other hand, reduce TRC concentration to confine the risk within the ZID which is estimated to have a size of about 0.4 km^2.

6.6.1.2 Likely impacts caused by CBPs in terms of THM and HAA

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[16] Field data collected under the EEFS and other studies indicate that background TRC level in the harbour waters was below the detection limit. Since the sample size for the "below detection limit" findings is sufficiently large, the EEFS consultant assumed zero background concentration of TRC for their risk assessment of the IRP options. The same assumption has been adopted in this assessment.

The estimated concentration of CBPs in the effluent is 0.2 mg/L based on a maximum design chlorine dosage of 20 mg/L required for disinfection. Once they are discharged at the SCI outfall, the concentration at the edge of the ZID would be 0.0058 mg/L (i.e. divides 0.2 mg/L by 34.3) which is less than one-thousandth of the lowest aquatic toxicity data of 7.1 mg/L for THM and the majority of HAA listed in the SSDS EIA Study (EPD, 2000). It is also lower than the drinking water standards listed in Section 6.3.

It is noted that the SSDS EIA (EPD, 2000) also reported an aquatic toxicity data of 0.22 mg/L for bromoacetic acid (one member within the group of HAA) specifically for an algae in freshwater environment. Based on data in Section 6.5.3, the HAAs formed are predominantly dichloroacetic acid and trichloroacetic acid which collectively account for 70% to 95% of the HAAs formed. For the purpose of a desk top evaluation, assuming that the CBPs concentration estimated above comprises only HAAs and that all the remaining fraction of HAAs is bromoacetic acid, the most conservative estimate on the amount of such acid formed will be in the range of 0.01 mg/L to 0.06 mg/L. At the ZID, this concentration will be further diluted to about 125 times lower than the said toxicity data. When local data is available, these conservative assumptions may be further reviewed and validated.

6.6.1.3 Likely impacts caused by the dechlorination agent

For the sodium bisulphite used as the dechlorination agent, the effluent concentration is assumed to be 4 mg/L, which is a very conservative assumption as it implies it does not react and remains in the effluent. The concentration after initial dilution would be 0.12 mg/L (i.e. 4 mg/L is divided by 34.3). This would be substantially lower than the lowest aquatic toxicity data of 59 mg/L by around 500 times.

6.6.2 Discharge at Lamma

Based on modeling results from the EEFS, the outfall at Lamma would have a larger dilution than the SCI outfall. Although the Lamma outfall can achieve a minimum dilution of 119:1, it is prudent to apply the same design criteria for the chlorination and dechlorination system at SCISTW to Lamma. That is, to maintain the maximum TRC concentration in the effluent at around 0.4 mg/L for a potential sewage discharge of 0.6 million m^3/day so as to afford greater protection to the important habitats for marine mammals, in particular the finless porpoise, in the southern waters of Hong Kong.

As such, because of the substantially higher dilution achievable at the Lamma outfall location, the TRC concentration should be able to comply with the criteria established at the edges of ZID and mixing zone. For CBPs and sodium bisulphite, their concentrations would be lowered than their respective levels of concern after the initial dilution.

6.7 Human Health Impacts

The most likely direct human exposure to the treated sewage after discharge would be occasional accidental ingestion of small amounts of seawater while swimming or engaging in other water-related activities. In order to semi-quantitatively evaluate the potential human health risks, it is therefore considered the standards provided by the acute, short-term health advisories are more pertinent than drinking water standards[17] for setting the guideline values. The standards are listed in Section 6.3.

For TRC and CBPs, the guideline values were taken as the low end of the acute, short-term advisories for chloramines and THM/HAA. In effect, the guideline value is 1 mg/L for both the TRC and CBPs.

For sodium bisulphite, neither an acute short-term advisory nor a drinking water standard is available. Since the available human toxicity information discussed in Section 6.4 shows an ingestion of 1 g/day was tolerated and a continuous ingestion of 10 mg/Kg/day (approximately 0.6 g/day for an average human adult of 60 Kg) for 25 days by healthy volunteers failed to elicit any change in neurophysiologic, biochemical, or clinical chemistry parameters, a conservatively safe daily dose of 0.1 g/d was assumed for this assessment. As such, a guideline value of 1000 mg/L was calculated with the assumed daily dose of 0.1 g/d, and then dividing by an incidental water ingestion rate of 0.1 L/d (i.e. [0.1 g/d]/[0.1 L/d] = 1 g/L = 1,000 mg/L).

Assessing against the guideline values for human health derived above, it can be shown that even if no dechlorination was provided, the estimated effluent concentrations of TRC, CBPs and sodium bisulphite would be below the guidelines values after the initial dilution. The results are presented in the following table:

Chemical or Class	Estimated effluent concentration (mg/L)		Guideline values for human health (mg/L)
	At point of discharge	At edge of ZID[a]	
TRC	0.4 (7.3)[b]	0.01 (0.2)	1
CBPs	0.2	0.006	1
Sodium bisulphite	4	0.1	1,000

Note: a. A minimum initial dilution of 34.3:1 for SCI outfall is used to represent the worst case scenario.
b. Figure in parenthesis represents the likely highest TRC concentration estimated for treated sewage without dechlorination.

Thus the risk is expected to be insignificant for normal exposure (e.g. swimming or other recreational or occupational exposure) that occurs outside the ZID. Some risk related to TRC may be possible, if a person were to come into very close contact with the water adjacent to the outfall diffusers. This seems a rather unlikely scenario however. The risk of CBPs and sodium bisulphite to humans is quite minimal, even for undiluted effluent.

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[17] The drinking water standards are typically based on the assumption that the human receptors are each drinking two litres of water every day (containing the concerned chemical) throughout their life.

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